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

April 5, 2001

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

Gentlemen:

In the Matter of ) Docket No. 50-260
Tennessee Valley Authority )

**BROWNS FERRY NUCLEAR PLANT (BFN) - UNIT 2 - CORE OPERATING LIMITS REPORT FOR UNIT 2 CYCLE 12 OPERATION**

In accordance with the requirements of Technical Specification 5.6.5.d, enclosed is the BFN Unit 2 Cycle 12 Core Operating Limits Report.

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

Sincerely,

T. E. Abney
Manager of Licensing
and Industry Affairs

Enclosure
cc: See page 2

D030

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ENCLOSURE

TENNESSEE VALLEY AUTHORITY
BROWNS FERRY NUCLEAR PLANT (BFN)
UNIT 2

CORE OPERATING LIMITS REPORT (COLR)
FOR CYCLE 12 OPERATION

(SEE ATTACHED)

# Browns Ferry Nuclear Plant
# Unit 2, Cycle 12

# CORE OPERATING LIMITS REPORT
# (COLR)

TENNESSEE VALLEY AUTHORITY
Nuclear Fuel Division
BWR Fuel Engineering Department

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PORC Chairman

# Revision Log

| Revision | Date | Description | Affected Pages |
|---|---|---|---|
| 0 | 3/14/2001 | Initial Release for New Cycle | All |

## 1. INTRODUCTION

This Core Operating Limits Report for Browns Ferry Unit 2, Cycle 12 is prepared in accordance with the requirements of Browns Ferry Technical Specification 5.6.5. The core operating limits presented here were developed using NRC-approved methods (References 1 and 2). Results from the reload analyses for Browns Ferry Unit 2, Cycle 12 are documented in Reference 3.

The following core operating limits are included in this report:

a. Average Planar Linear Heat Generation Rate (APLHGR) Limit
(Technical Specifications 3.2.1 and 3.7.5)

b. Linear Heat Generation Rate (LHGR) Limit
(Technical Specification 3.2.3)

c. Minimum Critical Power Ratio Operating Limit (OLMCPR)
(Technical Specifications 3.2.2, 3.3.4.1, and 3.7.5)

d. Average Power Range Monitor (APRM) Flow Biased Rod Block Trip Setting
(Technical Requirements Manual Section 5.3.1 and Table 3.3.4-1)

e. Rod Block Monitor (RBM) Trip Setpoints and Operability
(Technical Specification Table 3.3.2.1-1)

f. Shutdown Margin (SDM) Limit
(Technical Specification 3.1.1)

## 2. APLHGR LIMIT (TECHNICAL SPECIFICATIONS 3.2.1 AND 3.7.5)

The APLHGR limits for full power and flow conditions for each type of fuel as a function of exposure are shown in Figures 1-5. The APLHGR limits for the GE13 assemblies are for the most limiting lattice (excluding natural uranium) at each exposure point. The specific values for each lattice are given in Reference 4.

These APLHGR limits are adjusted for off-rated power and flow conditions using the ARTS factors, MAPFAC(P) and MAPFAC(F). The reduced power factor, MAPFAC(P), is given in Figure 6. Similarly, adjustments for reduced flow operation are performed using the MAPFAC(F) corrections given in Figure 7. Both factors are multipliers used to reduce the standard APLHGR limit. The most limiting power-adjusted or flow-adjusted value is taken as the APLHGR operating limit for the off-rated condition.

The APLHGR limits in Figures 1-5 are applicable for both Turbine Bypass In-Service and Out-Of-Service. The off-rated power and flow corrections in Figures 6 and 7 bound both Turbine Bypass In-Service and Out-Of-Service operation. No corrections are required to the APLHGR limits for TBOOS for either rated or off-rated operation.

The APLHGR limits in Figures 1-5 are applicable for both Recirculation Pump Trip (RPT) In-Service and Out-Of-Service. The off-rated power and flow corrections in Figures 6 and 7 bound both RPT In-Service and Out-Of-Service operation. No corrections are required to the APLHGR limits for RPTOOS for either rated or off-rated operation.

For Single Recirculation Loop Operation (SLO), the most limiting of either the SLO multiplier or the off-rated MAPFAC correction is used to reduce the exposure dependent APLHGR limit. The SLO multiplier to be applied to this cycle is 0.84 (reference 3). It is not necessary to apply both the off-rated MAPFAC and SLO multiplier corrections at the same time.

## 3. LHGR LIMIT (TECHNICAL SPECIFICATION 3.2.3)

The LHGR limit is fuel type dependent. For Unit 2 Cycle 12 there is only one fuel type in the core. The limit for this type is shown below:

| Fuel Type | LHGR Limit |
|---|---|
| GE13 | 14.4 kw/ft |

## 4. OLMCPR (TECHNICAL SPECIFICATIONS 3.2.2, 3.3.4.1, AND 3.7.5)

a. **Rated Limits - OLMCPR(100):** The MCPR Operating Limit for rated power and flow conditions, OLMCPR(100), is equal to the fuel type and exposure dependent limit shown in Figures 8 and 9. These figures apply to GE13 fuel which is the only fuel type in the Unit 2 Cycle 12 Core.

Figure 8 applies to exposure up to 2000 MWD/ST prior to EOR (end of full power capability at rated flow with normal feedwater temperature) after which Figure 9 shall be used. It is acceptable to use the more restrictive Figure 9 limits at any point in the cycle.

As noted in Figures 8 and 9, an adder of 0.03 is applied for single loop operation.

The actual OLMCPR(100) value is dependent upon the scram time testing results, as described below (ref. 10):

$$\tau = 0.0 \quad \text{or} \quad \frac{\tau_{ave} - \tau_B}{\tau_A - \tau_B}, \quad \text{whichever is greater}$$

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 SR3.1.4.1

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

b. **Startup Limits:** Option A OLMCPR limits ($\tau$=**1.0**) shall be used prior to the determination of $\tau$ in accordance with SR 3.1.4.1.

c. **Off-Rated Limits:** For off-rated power and flow conditions, power-adjusted and flow-adjusted operating limits are determined from Figures 10 and 11, respectively. The most limiting power-dependent or flow-dependent value is taken as the OLMCPR for the off-rated condition.

d. **Equipment Out-Of-Service OLMCPR Limits:** Rated power OLMCPR(100) limits are provided for Recirculation Pump Trip out-of-service (RPTOOS), Turbine Bypass out-of-service (TBOOS), and the combined RPTOOS/TBOOS condition in Figures 8 and 9 (reference 5). Additionally an off-rated MCPR(P) correction from Figure 10 (reference 5) shall be applied for TBOOS when the power is below Pbypass.

e. **Single Loop Operation (SLO) Limits:** As noted in section 4.a above, a correction of 0.03 is to be applied to the OLMCPR(100) limits for SLO as described in the footnote of Figures 8 and 9. The same adder applies to the off-rated MCPR(F) limit as noted in the footnote to Figure 11 and to the OLMCPR value below Pbypass from Figure 10.

## 5. APRM FLOW BIASED ROD BLOCK TRIP SETTING (TECHNICAL REQUIREMENTS MANUAL SECTION 5.3.1 AND TABLE 3.3.4-1)

The APRM Rod Block trip setting shall be:

$S_{RB} \leq (0.66(W-\Delta W) + 61\%)$ Allowable Value

$S_{RB} \leq (0.66(W-\Delta W) + 59\%)$ Nominal Trip Setpoint (NTSP)

where:

$S_{RB}$ = Rod Block setting in percent of rated thermal power (3458 MWt)

$W$ = 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 shall be as follows (refs. 7-9):

| RBM Trip Setpoint | Allowable Value (AV) | Nominal Trip Setpoint (NTSP) | |
|---|---|---|---|
| LPSP | 27% | 25% | |
| IPSP | 62% | 60% | |
| HPSP | 82% | 80% | |
| LTSP - unfiltered<br>- filtered | 118.7%<br>117.7% | 117.0%<br>116.0% | (1),(2) |
| ITSP - unfiltered<br>- filtered | 113.7%<br>112.9% | 112.0%<br>111.2% | (1),(2) |
| HTSP - unfiltered<br>- filtered | 108.7%<br>107.9% | 107.0%<br>106.2% | (1),(2) |
| DTSP | 90% | 92% | |

Notes: (1) These setpoints are based upon a MCPR operating limit of **1.25** using a safety limit of 1.07, as reported in references 6, 7, and 8. These setpoints bound the cycle specific minimum Option B MCPR operating limit of 1.29.

(2) The unfiltered setpoints are consistent with a nominal RBM filter setting of 0.0 seconds (reference 8). The filtered setpoints are consistent with a nominal RBM filter setting $\leq$ 0.5 seconds (reference 7).

The RBM setpoints in Technical Specification Table 3.3.2.1-1 are applicable when:

| THERMAL POWER (% Rated) | Applicable MCPR (1) | Notes from Table 3.3.2.1-1 | |
|---|---|---|---|
| $\geq$ 27% and < 90% | < 1.70<br>< 1.75 | (a), (b), (f), (h)<br>(a), (b), (f), (h) | dual loop operation<br>single loop operation |
| $\geq$ 90% | < 1.40 | (g) | dual loop operation (2) |

Notes: (1) The MCPR values shown correspond to a SLMCPR of 1.07 for dual recirculation loop operation and 1.10 for single loop operation.

(2) Greater than 90% rated power is not attainable in single loop operation.

## 7. SHUTDOWN MARGIN (SDM) LIMIT (TECHNICAL SPECIFICATION 3.1.1)

The core shall be subcritical with the following margin with the strongest OPERABLE control rod fully withdrawn and all other OPERABLE control rods fully inserted.

**SDM $\geq$ 0.38% dk/k**

## 8. REFERENCES

1. NEDE-24011-P-A-14, "General Electric Standard Application for Reactor Fuel", June 2000.

2. NEDE-24011-P-A-14-US, "General Electric Standard Application for Reactor Fuel (Supplement for United States)", June 2000.

3. J11-03718-10-SRLR Rev. 0, "Supplemental Reload Licensing Report for Browns Ferry Nuclear Plant Unit 2 Reload 11 Cycle 12", January 2001.

4. J11-03718-10-MAPL Rev. 0, "Lattice-Dependent MAPLHGR Report for Browns Ferry Nuclear Plant Unit 2 Reload 11 Cycle 12", January 2001.

5. NEDC-32774P Supplement 1 Revision 0, "Browns Ferry Nuclear Plant Units 1, 2, and 3 Turbine Bypass and End-of-Cycle Recirculation Pump Trip Combination Mode Out-Of-Service", dated February 2001.

6. NEDC-32433P, "Maximum Extended Load Line Limit and ARTS Improvement Program Analyses for Browns Ferry Nuclear Plant Unit 1, 2, and 3", dated April 1995.

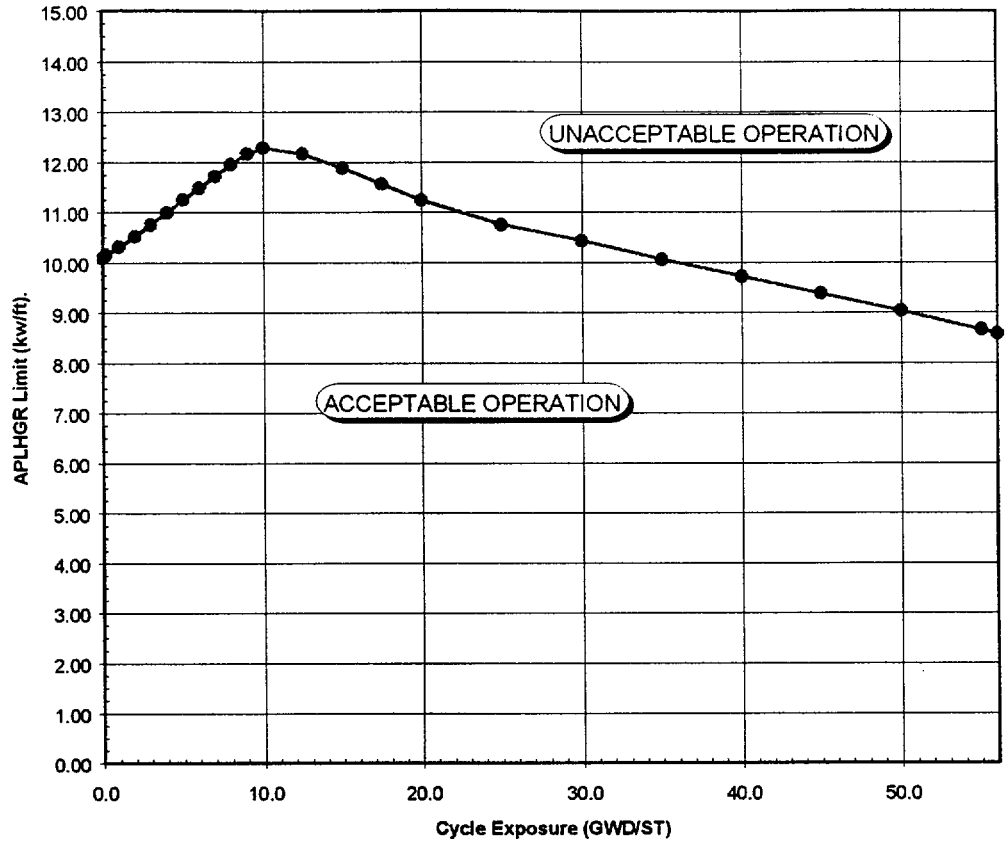
7. EDE-28-0990 Rev. 3 Supplement E, "PRNM (APRM, RBM, and RFM) Setpoint Calculations [ARTS/MELLL (NUMAC) - Power-Uprate Condition] for Tennessee Valley Authority Browns Ferry Nuclear Plant", dated October 1997.

8. 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", dated October 1997.

9. GE Letter LB#: 262-97-133, "Browns Ferry Nuclear Plant Rod Block Monitor Setpoint Clarification - GE Proprietary Information", dated September 12, 1997. [L32 970912 800]

10. GE Letter JAB-T8019a, "Technical Specification Changes for Implementation of Advanced Methods", dated June 4, 1998. [L32 980608 800]

# Figure 1
## APLHGR Limits for Bundle Type GE13-P9HTB384-12G4.0
(GE13)



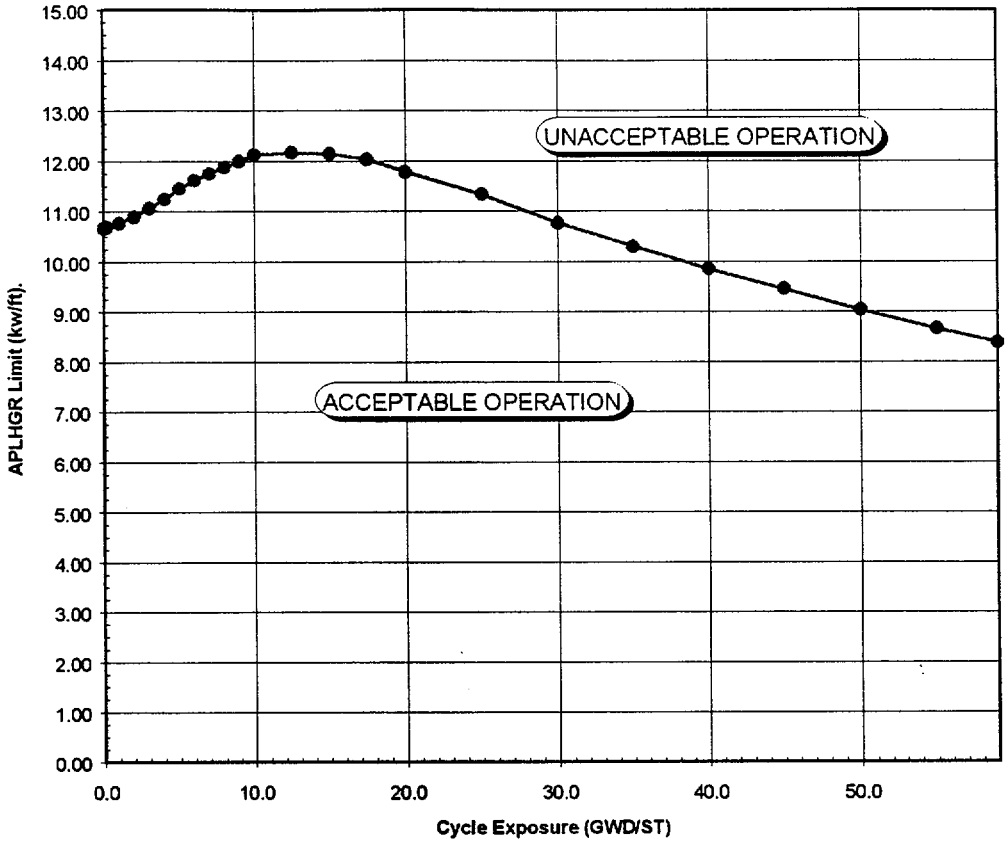

Most Limiting Lattice
for Each Exposure Point

| Average Planar Exposure (GWD/ST) | LHGR Limit (kw/ft) | Average Planar Exposure (GWD/ST) | LHGR Limit (kw/ft) | Average Planar Exposure (GWD/ST) | LHGR Limit (kw/ft) |
|---|---|---|---|---|---|
| 0.0 | 10.09 | 7.0 | 11.71 | 25.0 | 10.75 |
| 0.2 | 10.15 | 8.0 | 11.95 | 30.0 | 10.43 |
| 1.0 | 10.31 | 9.0 | 12.16 | 35.0 | 10.06 |
| 2.0 | 10.52 | 10.0 | 12.28 | 40.0 | 9.72 |
| 3.0 | 10.75 | 12.5 | 12.16 | 45.0 | 9.38 |
| 4.0 | 10.99 | 15.0 | 11.88 | 50.0 | 9.03 |
| 5.0 | 11.25 | 17.5 | 11.56 | 55.0 | 8.66 |
| 6.0 | 11.48 | 20.0 | 11.24 | 55.98 | 8.58 |

**These values apply to both Turbine Bypass In-Service and Out-Of-Service.**
**These values apply to both Recirculation Pump Trip In-Service and Out-Of-Service.**

**The APLHGR limits shown are for dual recirculation loop operation. For single loop operation, these values should be multiplied by the most limiting of either 0.84 or the MAPFAC correction, as described in Section 2.**

# Figure 2
## APLHGR Limits for Bundle Type GE13-P9DTB406-13GZ
(GE13)



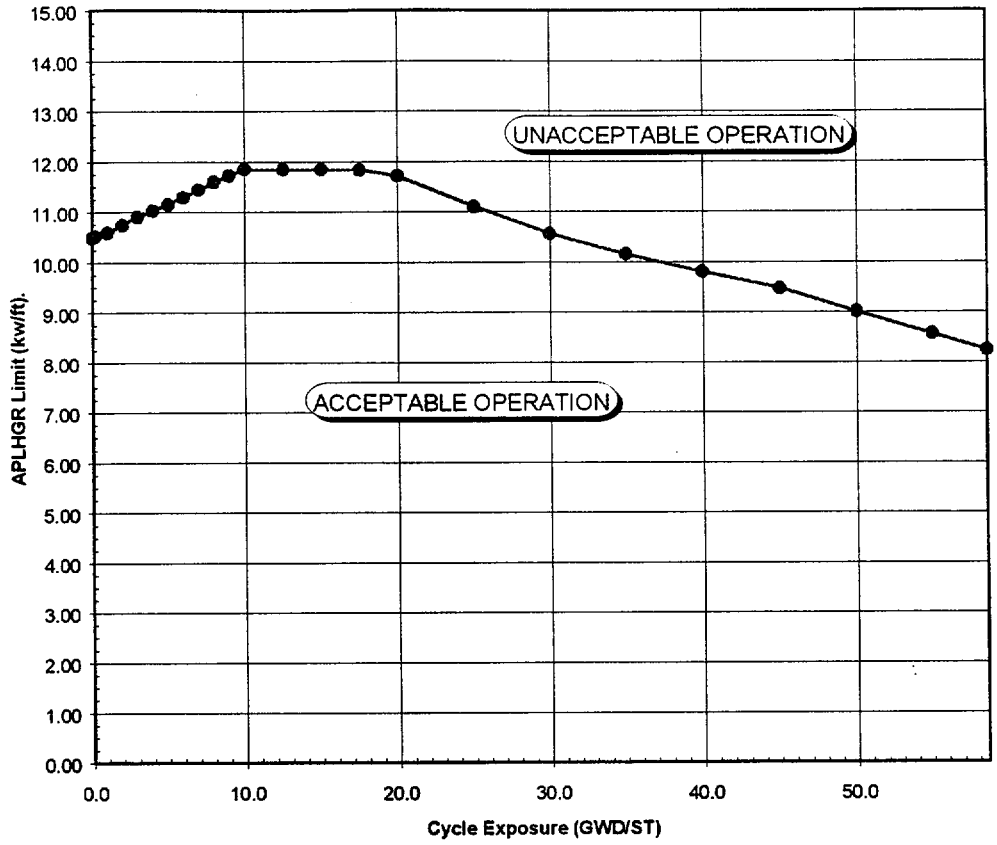

Most Limiting Lattice
for Each Exposure Point

| Average Planar Exposure (GWD/ST) | LHGR Limit (kw/ft) | Average Planar Exposure (GWD/ST) | LHGR Limit (kw/ft) | Average Planar Exposure (GWD/ST) | LHGR Limit (kw/ft) |
|---|---|---|---|---|---|
| 0.0 | 10.66 | 7.0 | 11.75 | 25.0 | 11.33 |
| 0.2 | 10.69 | 8.0 | 11.87 | 30.0 | 10.76 |
| 1.0 | 10.76 | 9.0 | 11.99 | 35.0 | 10.29 |
| 2.0 | 10.89 | 10.0 | 12.12 | 40.0 | 9.85 |
| 3.0 | 11.06 | 12.5 | 12.16 | 45.0 | 9.45 |
| 4.0 | 11.24 | 15.0 | 12.14 | 50.0 | 9.03 |
| 5.0 | 11.45 | 17.5 | 12.03 | 55.0 | 8.66 |
| 6.0 | 11.61 | 20.0 | 11.78 | 59.01 | 8.38 |

**These values apply to both Turbine Bypass In-Service and Out-Of-Service.**
**These values apply to both Recirculation Pump Trip In-Service and Out-Of-Service.**

**The APLHGR limits shown are for dual recirculation loop operation. For single loop operation, these values should be multiplied by the most limiting of either 0.84 or the MAPFAC correction, as described in Section 2.**

# Figure 3
## APLHGR Limits for Bundle Type GE13-P9DTB401-14GZ
(GE13)



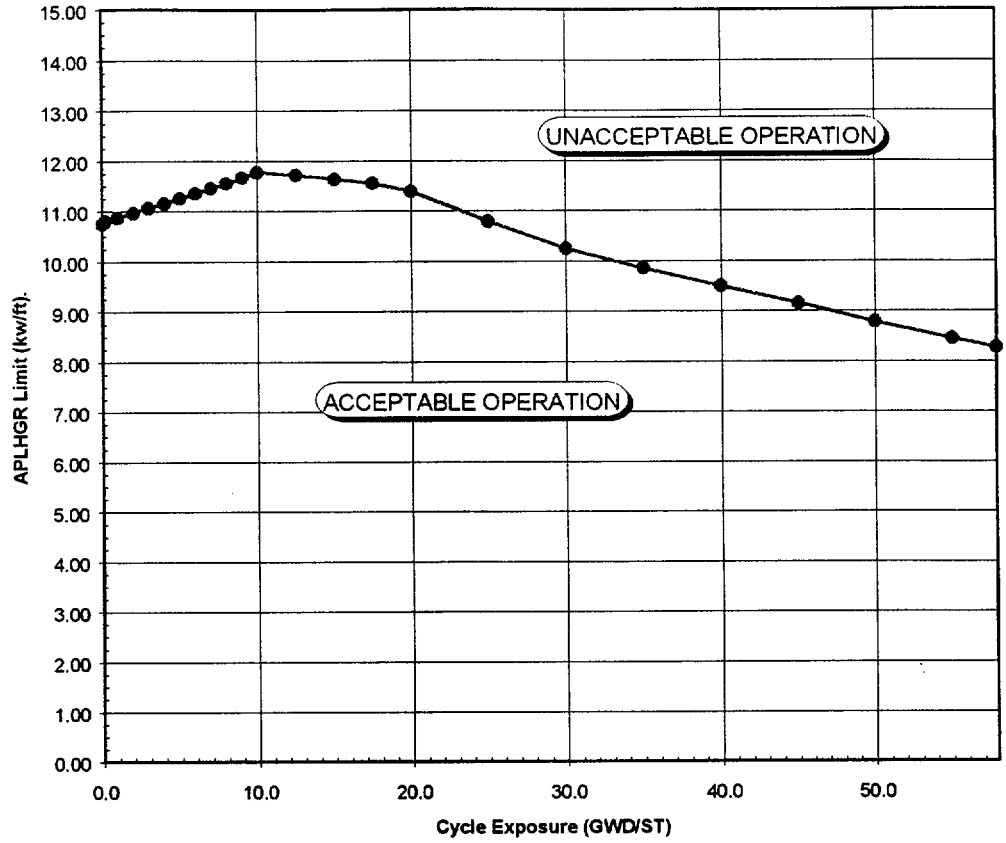

Most Limiting Lattice
for Each Exposure Point

| Average Planar Exposure (GWD/ST) | LHGR Limit (kw/ft) | Average Planar Exposure (GWD/ST) | LHGR Limit (kw/ft) | Average Planar Exposure (GWD/ST) | LHGR Limit (kw/ft) |
|---|---|---|---|---|---|
| 0.0 | 10.49 | 7.0 | 11.44 | 25.0 | 11.10 |
| 0.2 | 10.52 | 8.0 | 11.59 | 30.0 | 10.55 |
| 1.0 | 10.59 | 9.0 | 11.72 | 35.0 | 10.15 |
| 2.0 | 10.74 | 10.0 | 11.85 | 40.0 | 9.80 |
| 3.0 | 10.90 | 12.5 | 11.84 | 45.0 | 9.47 |
| 4.0 | 11.02 | 15.0 | 11.84 | 50.0 | 9.01 |
| 5.0 | 11.15 | 17.5 | 11.83 | 55.0 | 8.56 |
| 6.0 | 11.29 | 20.0 | 11.71 | 58.59 | 8.23 |

**These values apply to both Turbine Bypass In-Service and Out-Of-Service.**
**These values apply to both Recirculation Pump Trip In-Service and Out-Of-Service.**

**The APLHGR limits shown are for dual recirculation loop operation. For single loop operation, these values should be multiplied by the most limiting of either 0.84 or the MAPFAC correction, as described in Section 2.**

# Figure 4
## APLHGR Limits for Bundle Type GE13-P9DTB391-13GZ
(GE13)



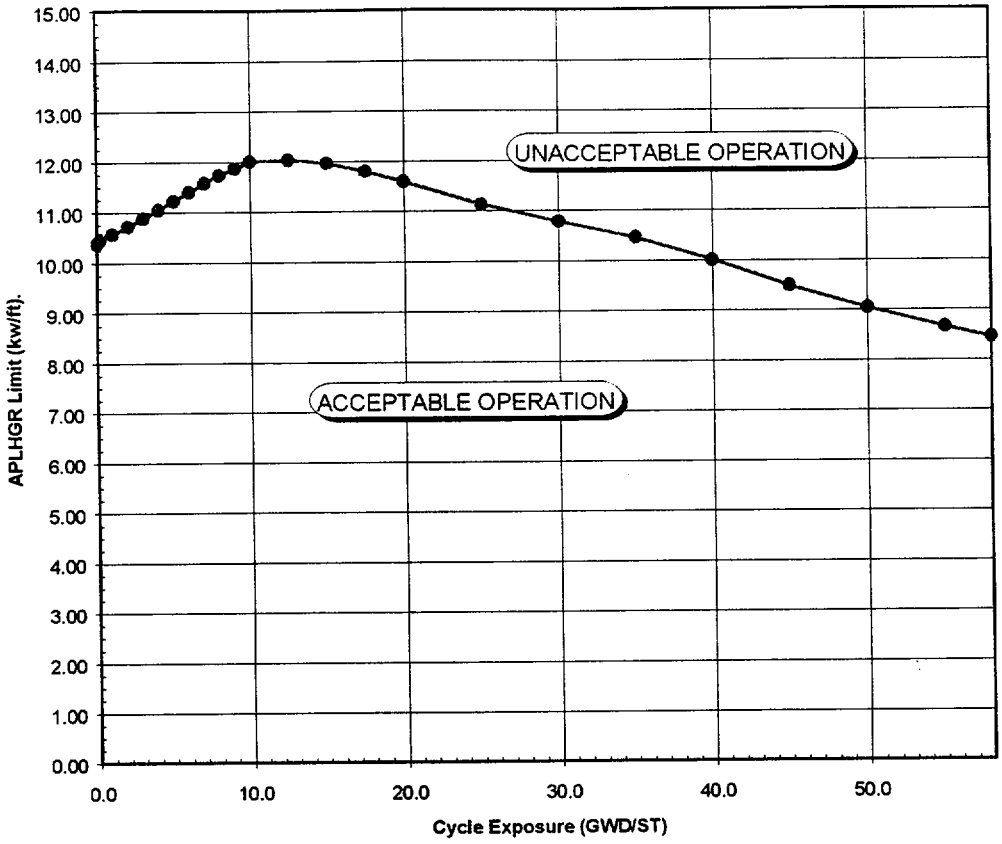

Most Limiting Lattice
for Each Exposure Point

| Average Planar Exposure (GWD/ST) | LHGR Limit (kw/ft) | Average Planar Exposure (GWD/ST) | LHGR Limit (kw/ft) | Average Planar Exposure (GWD/ST) | LHGR Limit (kw/ft) |
|---|---|---|---|---|---|
| 0.0 | 10.75 | 7.0 | 11.45 | 25.0 | 10.79 |
| 0.2 | 10.80 | 8.0 | 11.55 | 30.0 | 10.24 |
| 1.0 | 10.87 | 9.0 | 11.66 | 35.0 | 9.85 |
| 2.0 | 10.96 | 10.0 | 11.77 | 40.0 | 9.49 |
| 3.0 | 11.06 | 12.5 | 11.71 | 45.0 | 9.15 |
| 4.0 | 11.15 | 15.0 | 11.63 | 50.0 | 8.78 |
| 5.0 | 11.25 | 17.5 | 11.55 | 55.0 | 8.45 |
| 6.0 | 11.35 | 20.0 | 11.39 | 57.82 | 8.27 |

**These values apply to both Turbine Bypass In-Service and Out-Of-Service.**
**These values apply to both Recirculation Pump Trip In-Service and Out-Of-Service.**

**The APLHGR limits shown are for dual recirculation loop operation. For single loop operation, these values should be multiplied by the most limiting of either 0.84 or the MAPFAC correction, as described in Section 2.**

# Figure 5
## APLHGR Limits for Bundle Type GE13-P9DTB412-2G7.0/11G5.0
(GE13)



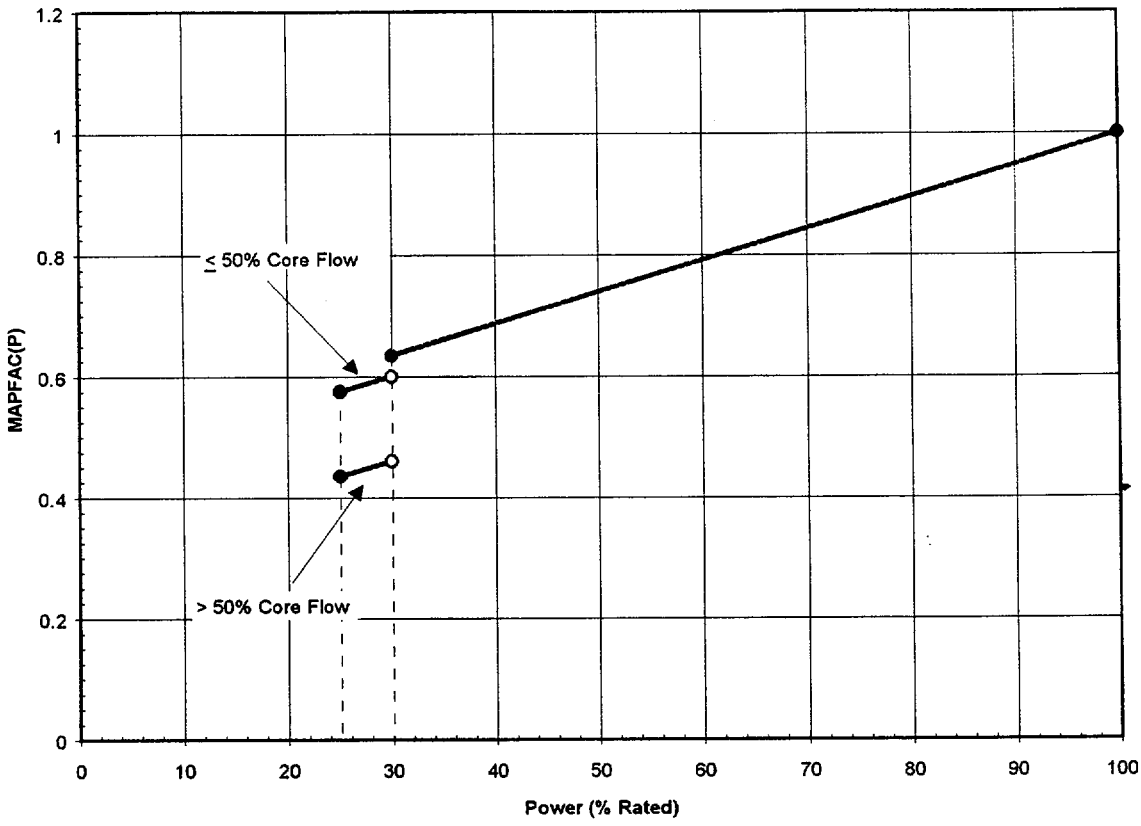

Most Limiting Lattice
for Each Exposure Point

| Average Planar Exposure (GWD/ST) | LHGR Limit (kw/ft) | Average Planar Exposure (GWD/ST) | LHGR Limit (kw/ft) | Average Planar Exposure (GWD/ST) | LHGR Limit (kw/ft) |
|---|---|---|---|---|---|
| 0.0 | 10.38 | 7.0 | 11.58 | 25.0 | 11.12 |
| 0.2 | 10.45 | 8.0 | 11.73 | 30.0 | 10.78 |
| 1.0 | 10.57 | 9.0 | 11.86 | 35.0 | 10.46 |
| 2.0 | 10.72 | 10.0 | 12.00 | 40.0 | 10.01 |
| 3.0 | 10.88 | 12.5 | 12.03 | 45.0 | 9.49 |
| 4.0 | 11.05 | 15.0 | 11.96 | 50.0 | 9.04 |
| 5.0 | 11.22 | 17.5 | 11.80 | 55.0 | 8.66 |
| 6.0 | 11.40 | 20.0 | 11.59 | 57.99 | 8.45 |

**These values apply to both Turbine Bypass In-Service and Out-Of-Service.**
**These values apply to both Recirculation Pump Trip In-Service and Out-Of-Service.**

**The APLHGR limits shown are for dual recirculation loop operation. For single loop operation, these values should be multiplied by the most limiting of either 0.84 or the MAPFAC correction, as described in Section 2.**

# Figure 6
## Power Dependent MAPLHGR Factor - MAPFAC(P)




**MAPLHGR(P) = MAPFAC(P) x MAPLHGRstd**

**MAPLHGRstd = Standard MAPLHGR Limits**

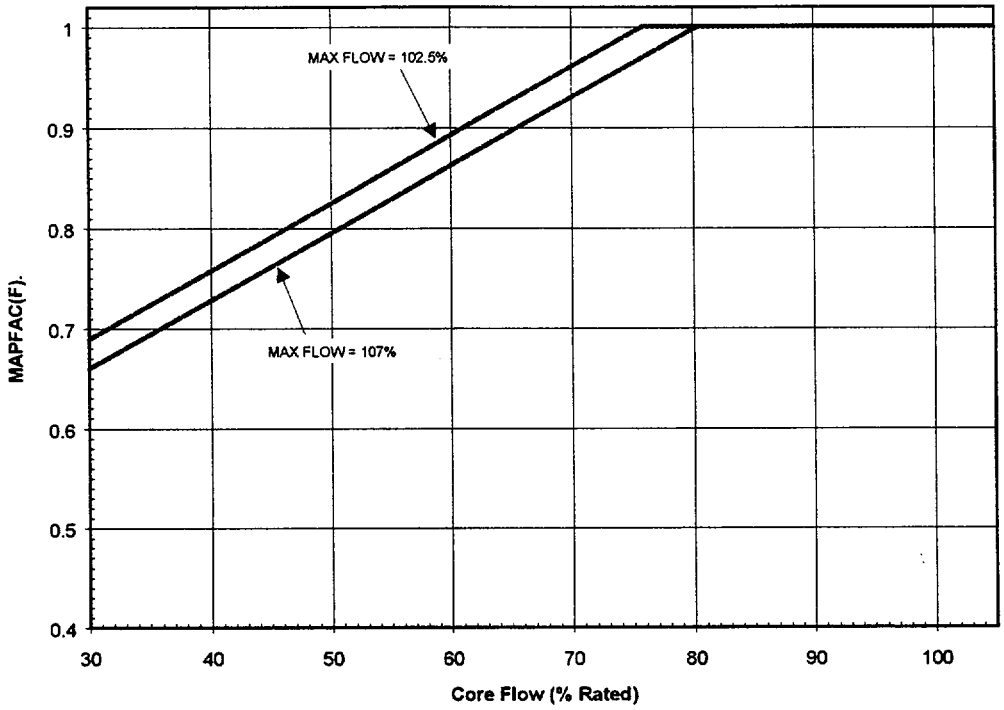
**For 25% > P : NO THERMAL LIMITS MONITORING REQUIRED**
**NO LIMITS SPECIFIED**

**For 25% ≤ P < 30% : MAPFAC(P) = 0.60 + 0.005(P-30%) For ≤ 50% CORE FLOW**
**: MAPFAC(P) = 0.46 + 0.005(P-30%) For > 50% CORE FLOW**

**For 30% ≤ P : MAPFAC(P) = 1.0 + 0.005224(P-100%)**

**These values bound both Turbine Bypass In-Service and Out-Of-Service**
**These values bound both Recirculation Pump Trip In-Service and Out-Of-Service**

# Figure 7
## Flow Dependent MAPLHGR Factor - MAPFAC(F)




**FOR Wc (% Rated Core Flow) >= 30%**

**MAPLHGR(F) = MAPFAC(F) x MAPLHGRstd**

**MAPLHGRstd = Standard MAPLHGR Limits**

**MAPFAC(F) = MINIMUM( 1.0 , Af * Wc /100 + Bf)**

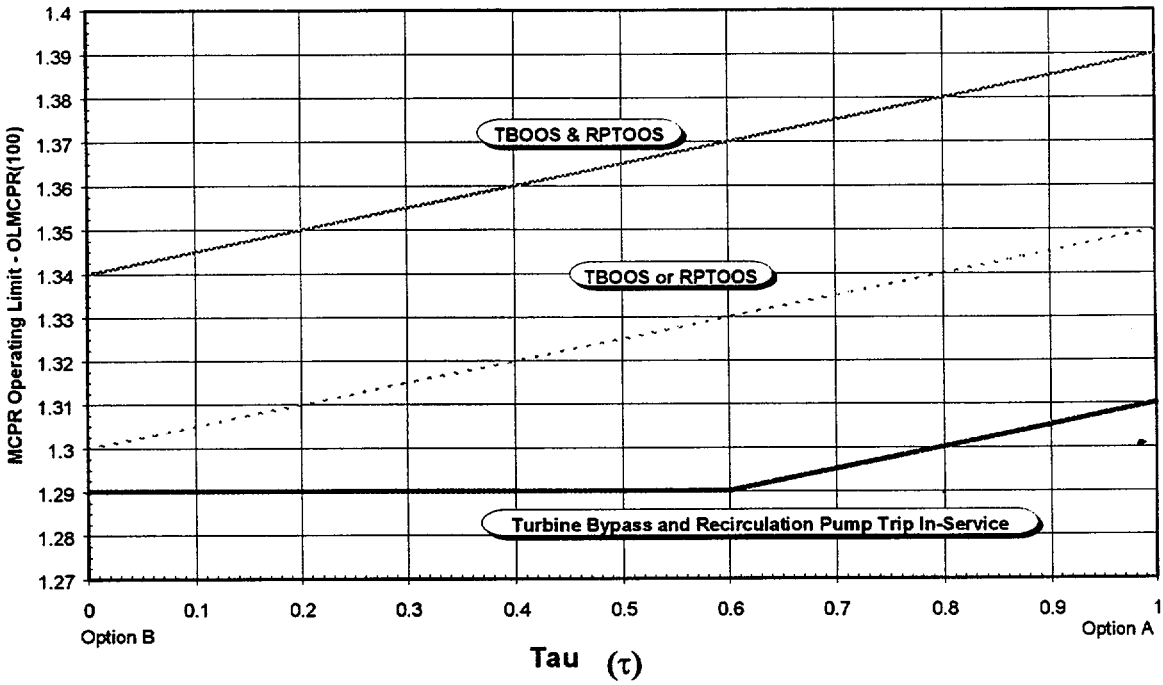
**Af and Bf are Constants Given Below:**

| Maximum Core Flow (% Rated) | Af | Bf |
|---|---|---|
| 102.5 | 0.6784 | 0.4861 |
| 107.0 | 0.6758 | 0.4574 |

**These values bound both Turbine Bypass In-Service and Out-Of-Service.**
**These values bound both Recirculation Pump Trip In-Service and Out-Of-Service.**

**The 102.5% maximum flow line is used for operation up to 100% rated flow.**
**The 107% maximum flow line is used for operation up to 105% rated flow (ICF).**

# Figure 8
## MCPR Operating Limit for All GE13 Bundles
***For Cycle Exposures up to EOR-2000 MWD/ST (see note 3)***



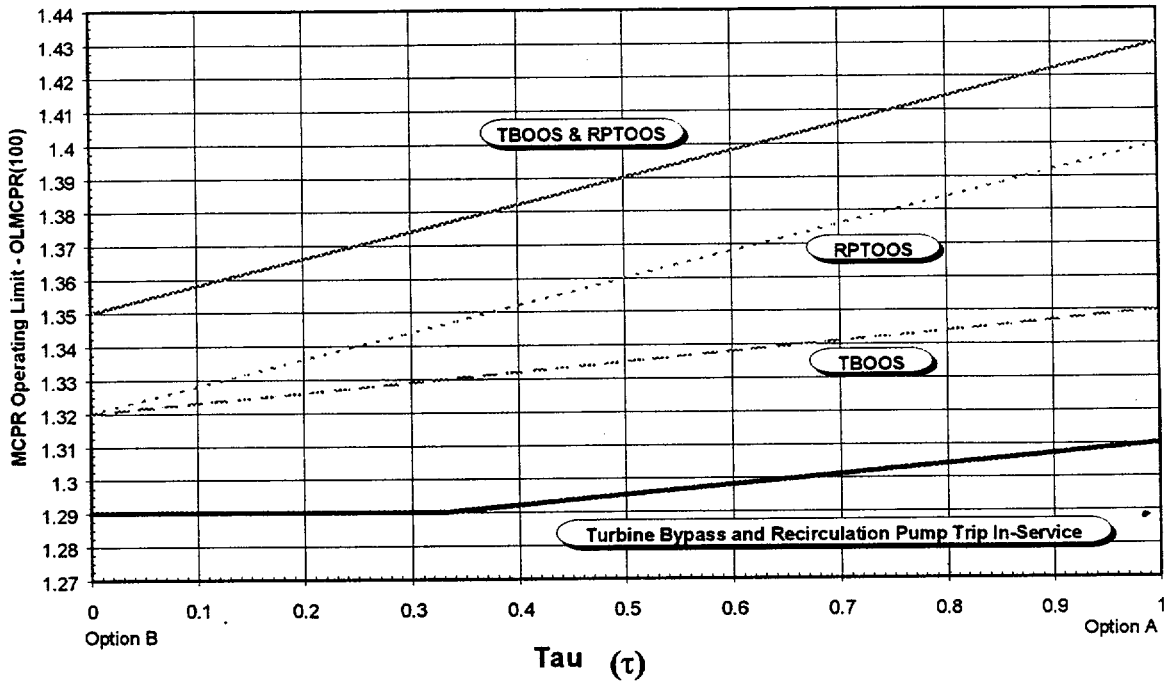

| Exposure Range | Out-Of-Service | Option A (1) Tau=1.0 | Option B Tau=0.0 |
|---|---|---|---|
| BOC12 to (EOR-2000 MWD/ST) | na | 1.31 | 1.29 |
| BOC12 to (EOR-2000 MWD/ST) | Turbine Bypass (TBOOS) | 1.35 | 1.30 |
| BOC12 to (EOR-2000 MWD/ST) | Recirculation Pump Trip (RPTOOS) | 1.35 | 1.30 |
| BOC12 to (EOR-2000 MWD/ST) | TBOOS and RPTOOS | 1.39 | 1.34 |

Notes
1. Use this value prior to performing scram time testing per SR 3.1.4.1.
2. The values shown are for dual recirculation loop operation (1.07 SLMCPR). Increase any value shown by 0.03 for Single Loop Operation (SLO:SLMCPR=1.10).
3. EOR refers to the end of Full Power Capability at Rated Flow with normal Feedwater Heating.

# Figure 9

## MCPR Operating Limit for All GE13 Bundles

***Optional for All Cycle Exposures - Required after EOR-2000 MWD/ST is reached (see note 3)***

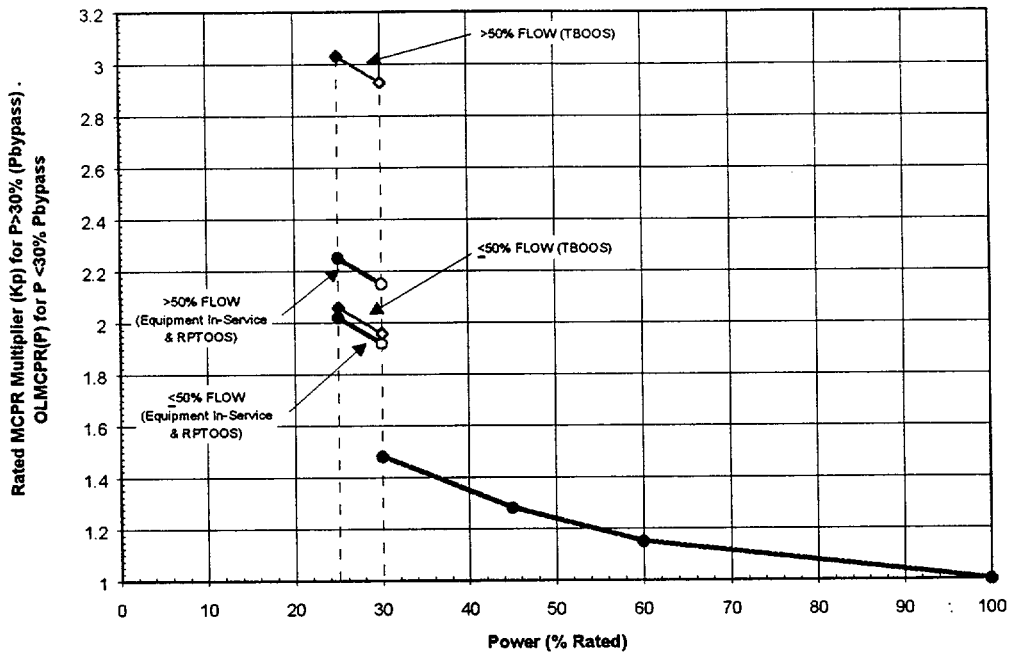



| Exposure Range | Out-Of-Service | Option A (1) Tau=1.0 | Option B Tau=0.0 |
|---|---|---|---|
| BOC12 to (EOR-2000 MWD/ST) | na | 1.31 | 1.29 |
| BOC12 to (EOR-2000 MWD/ST) | Turbine Bypass (TBOOS) | 1.35 | 1.32 |
| BOC12 to (EOR-2000 MWD/ST) | Recirculation Pump Trip (RPTOOS) | 1.40 | 1.32 |
| BOC12 to (EOR-2000 MWD/ST) | TBOOS and RPTOOS | 1.43 | 1.35 |

Notes

1. Use this value prior to performing scram time testing per SR 3.1.4.1.
2. The values shown are for dual recirculation loop operation (1.07 SLMCPR). Increase any value shown by 0.03 for Single Loop Operation (SLO:SLMCPR=1.10).
3. EOR refers to the end of Full Power Capability at Rated Flow with normal Feedwater Heating.

# Figure 10
## Power Dependent MCPR(P) Limits




**OPERATING LIMIT MCPR(P) = Kp * OLMCPR(100)**

**For P < 25% : NO THERMAL LIMITS MONITORING REQUIRED**
**NO LIMITS SPECIFIED**

**For 25% ≤ P < Pbypass : (Pbypass = 30%)**

**: Kp = [Kbyp + 0.02(30%-P)]/OLMCPR(100)**

**Turbine Bypass and RPT In-Service, or RPT Out-Of-Service (RPTOOS)**

**Kbyp = 1.92 For ≤ 50% CORE FLOW**
**Kbyp = 2.15 For > 50% CORE FLOW**

**Turbine Bypass Out-Of-Service (TBOOS)**

**Kbyp = 1.96 For ≤ 50% CORE FLOW**
**Kbyp = 2.93 For > 50% CORE FLOW**

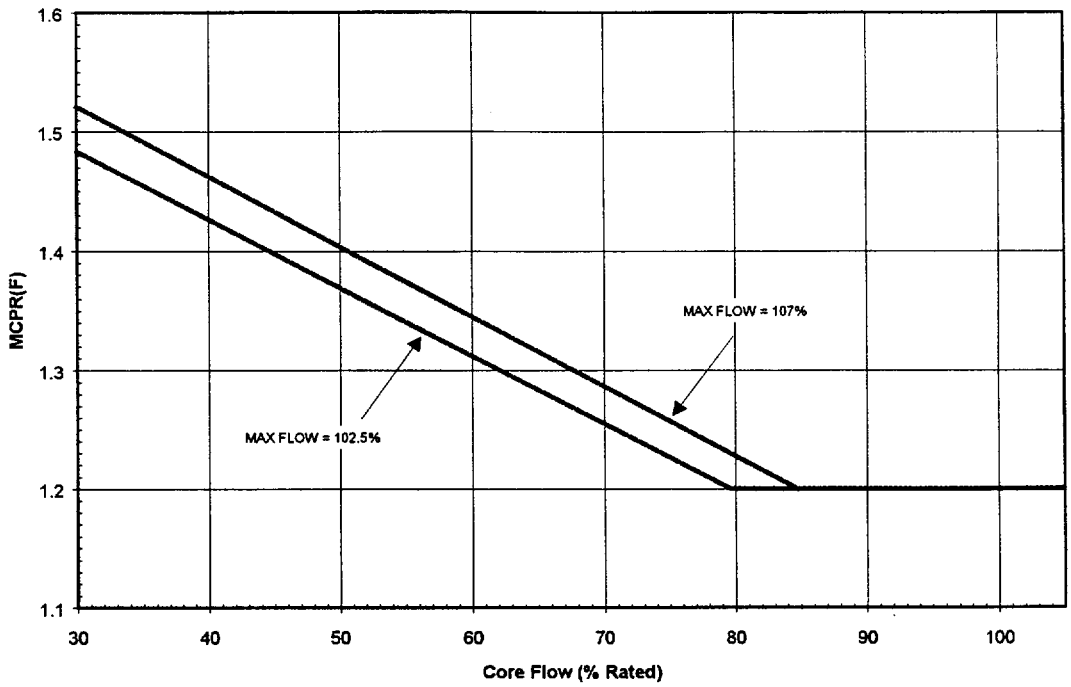
**For 30% ≤ P < 45% : Kp = 1.28 + 0.01340(45%-P)**

**For 45% ≤ P < 60% : Kp = 1.15 + 0.00867(60%-P)**

**For 60% ≤ P : Kp = 1.00 + 0.00375(100%-P)**

**Note: The OLMCPR below Pbypass is based upon the dual recirculation loop SLMCPR of 1.07. Add 0.03 to the OLMCPR in Single Loop Operation (SLO - SLMCPR=1.10).**

# Figure 11
## Flow Dependent MCPR Operating Limit - MCPR(F)




**For Wc ≥ 30% : MCPR(F) = MAX(1.20, Af*Wc/100 + Bf)**

**Wc = % Rated Core Flow**

**Af and Bf are Constants Given Below:**

| Maximum Core Flow (% Rated) | Af | Bf |
|---|---|---|
| 102.5 | -0.571 | 1.655 |
| 107.0 | -0.586 | 1.697 |

**These values bound both Turbine Bypass In-Service and Out-Of-Service.**
**These values bound both Recirculation Pump Trip In-Service and Out-Of-Service**

**The 102.5% maximum flow line is used for operation up to 100% rated flow.**
**The 107% maximum flow line is used for operation up to 105% rated flow (ICF).**

**This figure is based upon the dual recirculation loop operation SLMCPR of 1.07.**
**Add 0.03 to these values for Single Loop Operation (SLO - SLMCPR=1.10).**