Browns Ferry Nuclear Plant
Unit 2, Cycle 10

CORE OPERATING LIMITS REPORT (COLR)

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Nuclear Fuel Division
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1. INTRODUCTION

This Core Operating Limits Report for Browns Ferry Unit 2, Cycle 10 is prepared in accordance with the requirements of Browns Ferry Technical Specification 6.9.1.7. 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 10 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 Specification 3.5.I)

b. Linear Heat Generation Rate (LHGR) Limit
(Technical Specification 3.5.J)

c. Minimum Critical Power Ratio Operating Limit (OLMCPR)
(Technical Specification 3.5.K/4.5.K)

d. Average Power Range Monitor (APRM) Flow Biased Rod Block Trip Setting
(Technical Specification 2.1.A.1.c and Table 3.2.C)

e. Rod Block Monitor (RBM) Trip Setpoints
(Technical Specification Table 3.2.C)

2. APLHGR LIMIT (TECHNICAL SPECIFICATION 3.5.I)

The APLHGR limits for full power and flow conditions for each type of fuel as a function of exposure are shown in Figures 1-8. The APLHGR limits for the GE9B, GE11 and 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 9. Similarly, adjustments for reduced flow operation are performed using the MAPFAC(F) corrections given in Figure 10. 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.

3. LHGR LIMIT (TECHNICAL SPECIFICATION 3.5.J)

The LHGR limit for unit 2 cycle 10 is fuel type dependent , as shown below:

Fuel Type	LHGR Limit
GE7B (BP8X8R)	13.4 kw/ft
GE9B (GE8X8NB)	14.4 kw/ft
GE11	14.4 kw/ft
GE13	14.4 kw/ft

4. OLMCPR (TECHNICAL SPECIFICATION 3.5.K/4.5.K)

a. 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 11, 12, 13, and 14. The actual OLMCPR(100) value is dependent upon the scram time testing results, as described below:

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

$\tau_A = 0.90$ sec (Specification 3.3.C.1 scram time limit to 20% insertion from fully withdrawn)

$$\tau_B = 0.710 + 1.65 \left[\frac{N}{n}\right]^{\frac{1}{2}} (0.053)$$

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

where; n = Number of surveillance rod tests performed to date in cycle (including BOC test).

τ_i = Scram time to 20% insertion from fully withdrawn of the i^{th} rod.

N = Total number of active rods measured in Specification 4.3.C.1 at BOC.

b. For the performance of Surveillance Requirement 4.5.K.2.a (prior to initial scram time measurements for the cycle),

$$\tau = 1.0$$

c. For the performance of Surveillance Requirement 4.5.K.2.b, τ shall be determined in accordance with 4.a above.

d. For off-rated power and flow conditions, power-adjusted and flow-adjusted operating limits are determined from Figures 15 and 16, respectively. The most limiting power-dependent or flow-dependent value is taken as the OLMCPR for the off-rated condition.

5. APRM FLOW BIASED ROD BLOCK TRIP SETTING (TECHNICAL SPECIFICATION 2.1.A.1.c AND TABLE 3.2.C)

The APRM Rod Block trip setting shall be:

$S_{RB} \leq (0.66W + 66\%)$ Allowable Value

$S_{RB} \leq (0.66W + 64\%)$ Nominal Trip Setpoint (NTSP)

where:

S_{RB} = Rod Block setting in percent of rated thermal power (3293 MWt)

W = Loop recirculation flow rate in percent of rated

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 (TECHNICAL SPECIFICATION TABLE 3.2.C)

The RBM trip setpoints and applicable power ranges shall be as follows:

RBM Trip Setpoint	Allowable Value (AV)	Nominal Trip Setpoint (NTSP)	
LPSP	27%	25%	
IPSP	62%	60%	
HPSP	82%	80%	
LTSP - unfiltered - filtered	121.7% 120.7%	120.0% 119.0%	(1),(2)
ITSP - unfiltered - filtered	116.7% 115.7%	115.0% 114.0%	(1),(2)
HTSP - unfiltered - filtered	111.7% 110.9%	110.0% 109.2%	(1),(2)
DTSP	90%	92%	

Notes: (1) These setpoints are based upon a MCPR operating limit of 1.34 using a safety limit of 1.10. This is consistent with a MCPR operating limit of 1.30 using a safety limit of 1.07, as reported in references 6, 7, and 8.

(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).

7. REFERENCES

1. NEDE-24011-P-A-13, "General Electric Standard Application for Reactor Fuel", August 1996.

2. NEDE-24011-P-A-13-US, "General Electric Standard Application for Reactor Fuel (Supplement for United States)", August 1996.

3. J11-03144SRLR Rev. 1, "Supplemental Reload Licensing Report for Browns Ferry Nuclear Plant Unit 2 Reload 9 Cycle 10", September 1997.

4. J11-03144MAPL Rev. 0, "Lattice-Dependent MAPLHGR Report for Browns Ferry Nuclear Plant Unit 2 Reload 9 Cycle 10", August 1997.

5. NEDC-32774P Rev. 1, "Safety Analyses for Browns Ferry Nuclear Plant Units 1, 2, and 3 Turbine Bypass and End-of-Cycle Recirculation Pump Trip Out-Of-Service", dated September 1997.

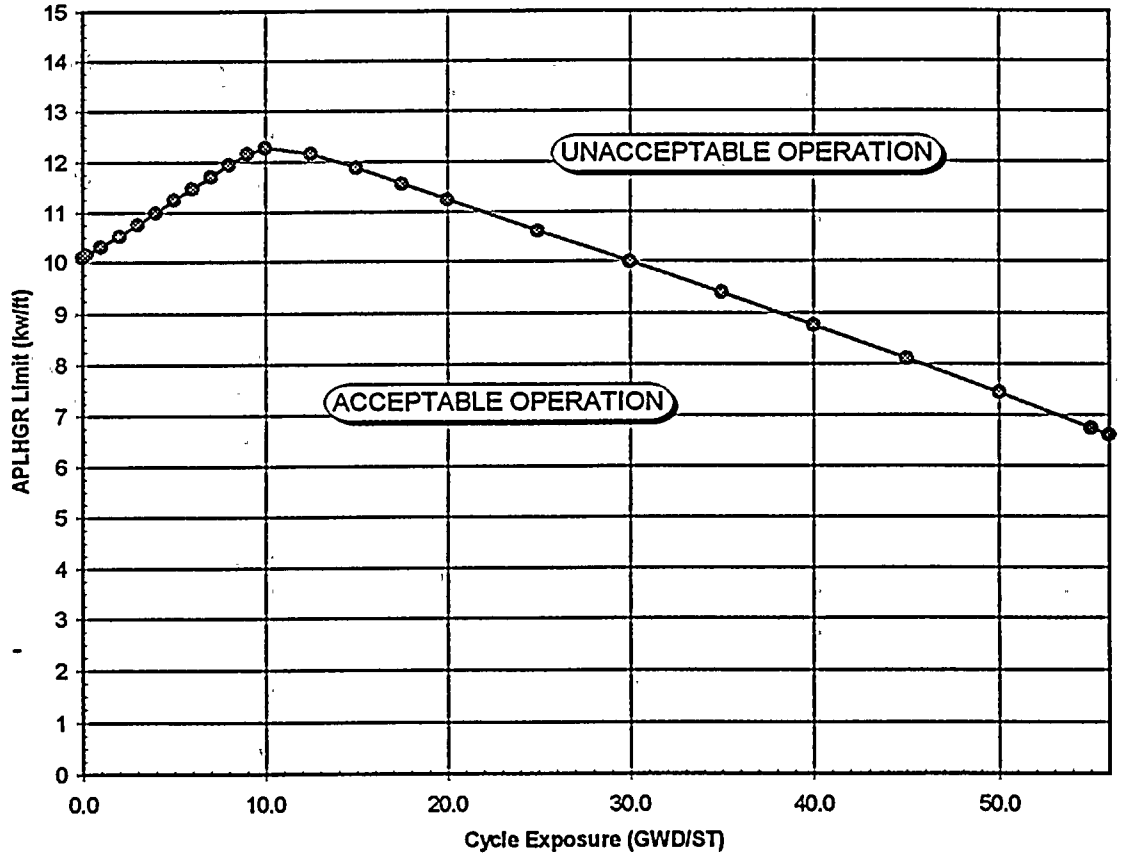
6. NEDC-32433P, "Maximum Extended Load Line Limit and ARTS Improvement Program Analyses for Browns Ferry Nuclear Plant Unit 1, 2, and 3", dated April 1995.

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

8. EDE-28-0990 Rev. 2 Supplement F, "PRNM (APRM, RBM, and RFM) Setpoint Calculations [ARTS/MELLL (NUMAC) - Current Rated Condition] for Tennessee Valley Authority Browns Ferry Nuclear Plant", dated Sept. 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]

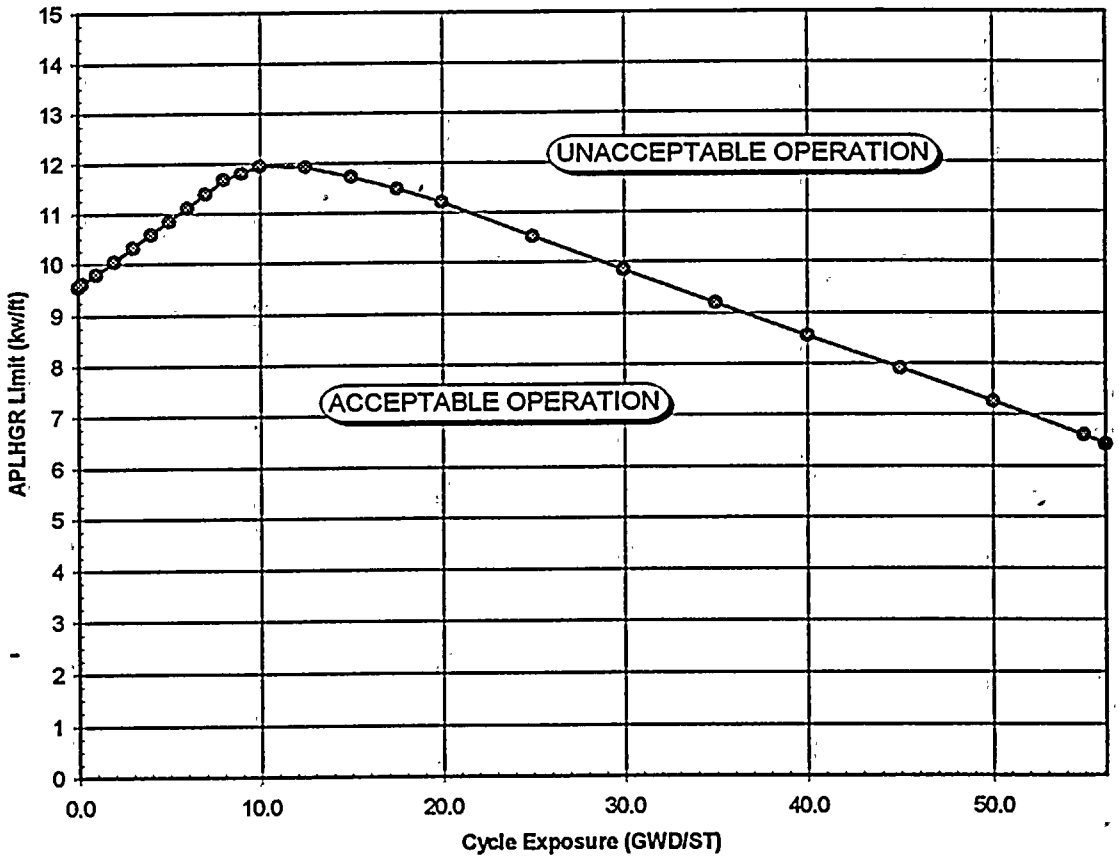
Figure 1
APLHGR Limits for Bundle Type GE13-P9HTB384-12G4.0
(GE13)



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	10.6
0.2	10.15	8.0	11.95	30.0	9.99
1.0	10.31	9.0	12.16	35.0	9.39
2.0	10.52	10.0	12.28	40.0	8.76
3.0	10.75	12.5	12.16	45.0	8.11
4.0	10.99	15.0	11.88	50.0	7.44
5.0	11.25	17.5	11.56	55.0	6.74
6.0	11.48	20.0	11.24	55.98	6.60

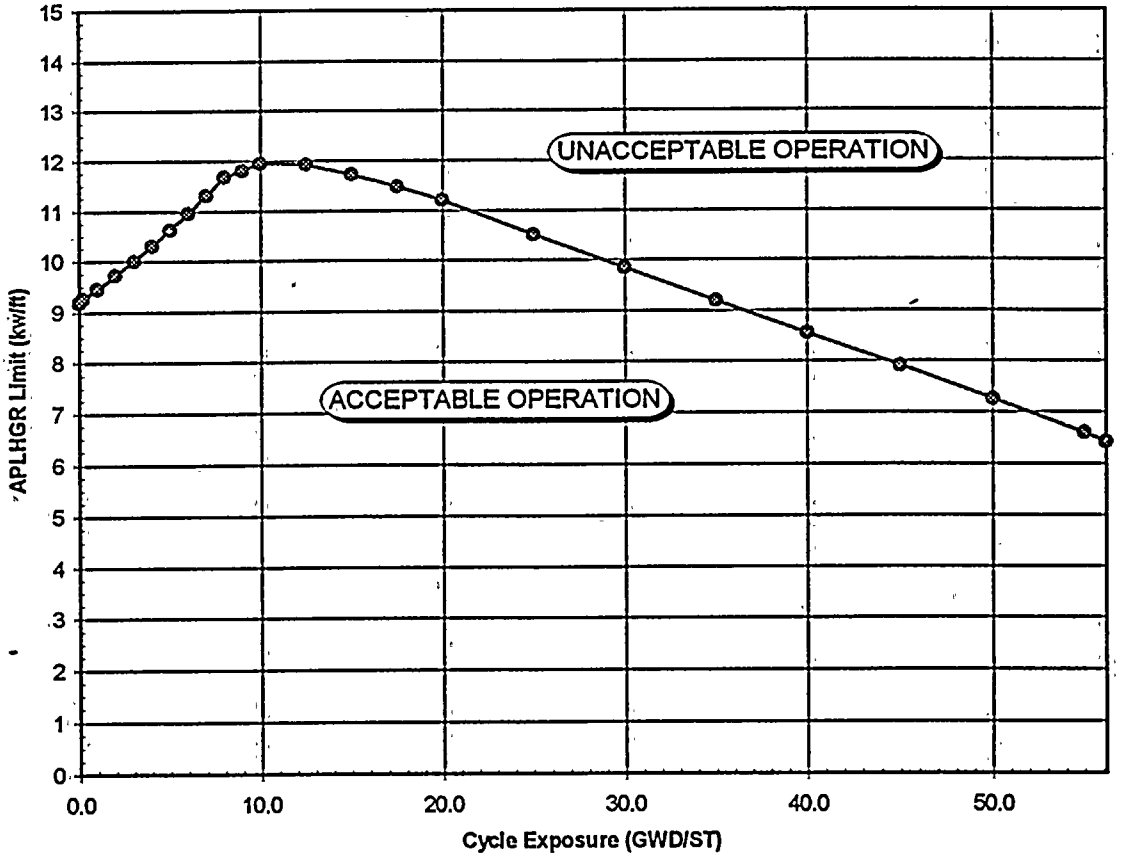
Figure 2
APLHGR Limits for Bundle Type GE11-P9HUB366-12G4.0
(GE11)



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	9.55	7.0	11.39	25.0	10.51
0.2	9.62	8.0	11.67	30.0	9.84
1.0	9.80	9.0	11.81	35.0	9.19
2.0	10.05	10.0	11.95	40.0	8.55
3.0	10.32	12.5	11.92	45.0	7.91
4.0	10.58	15.0	11.72	50.0	7.26
5.0	10.84	17.5	11.48	55.0	6.59
6.0	11.11	20.0	11.20	56.17	6.42

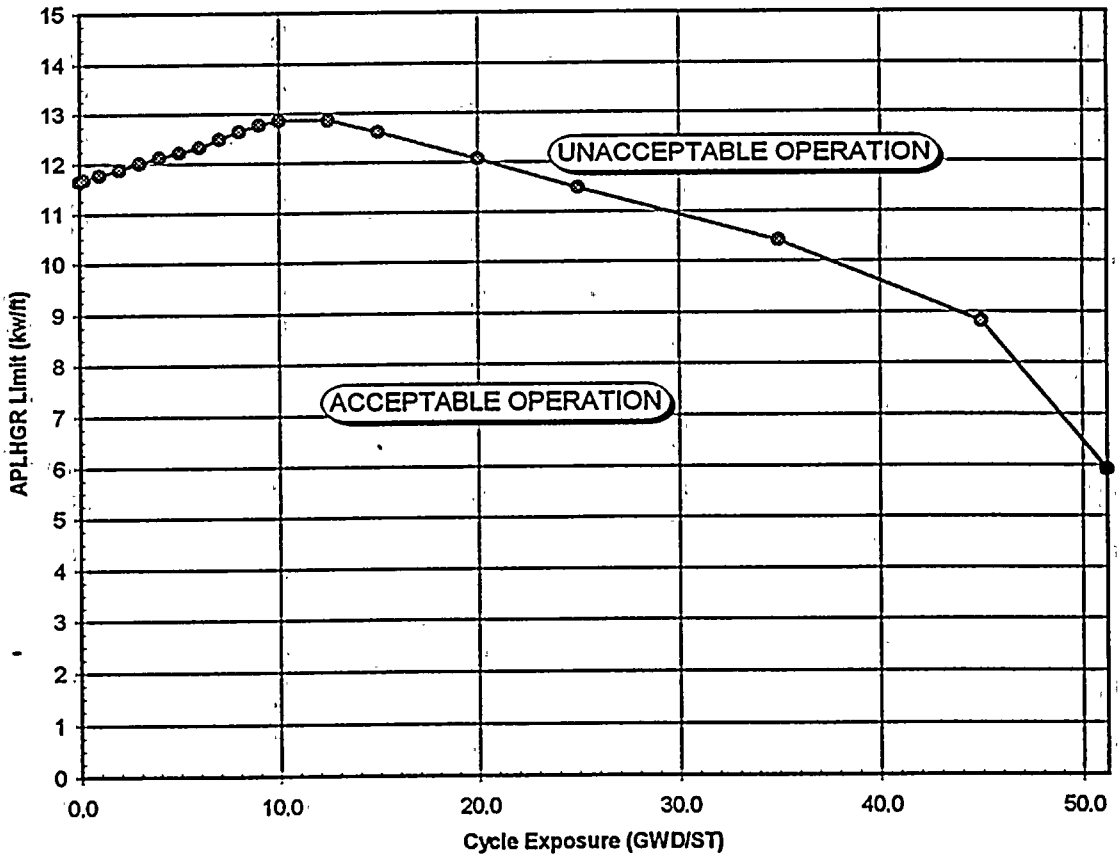
Figure 3
APLHGR Limits for Bundle Type GE11-P9HUB367-14GZ
(GE11)



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	9.18	7.0	11.31	25.0	10.51
0.2	9.27	8.0	11.67	30.0	9.84
1.0	9.45	9.0	11.81	35.0	9.19
2.0	9.72	10.0	11.95	40.0	8.55
3.0	10.00	12.5	11.92	45.0	7.91
4.0	10.30	15.0	11.72	50.0	7.26
5.0	10.62	17.5	11.48	55.0	6.59
6.0	10.95	20.0	11.20	56.17	6.42

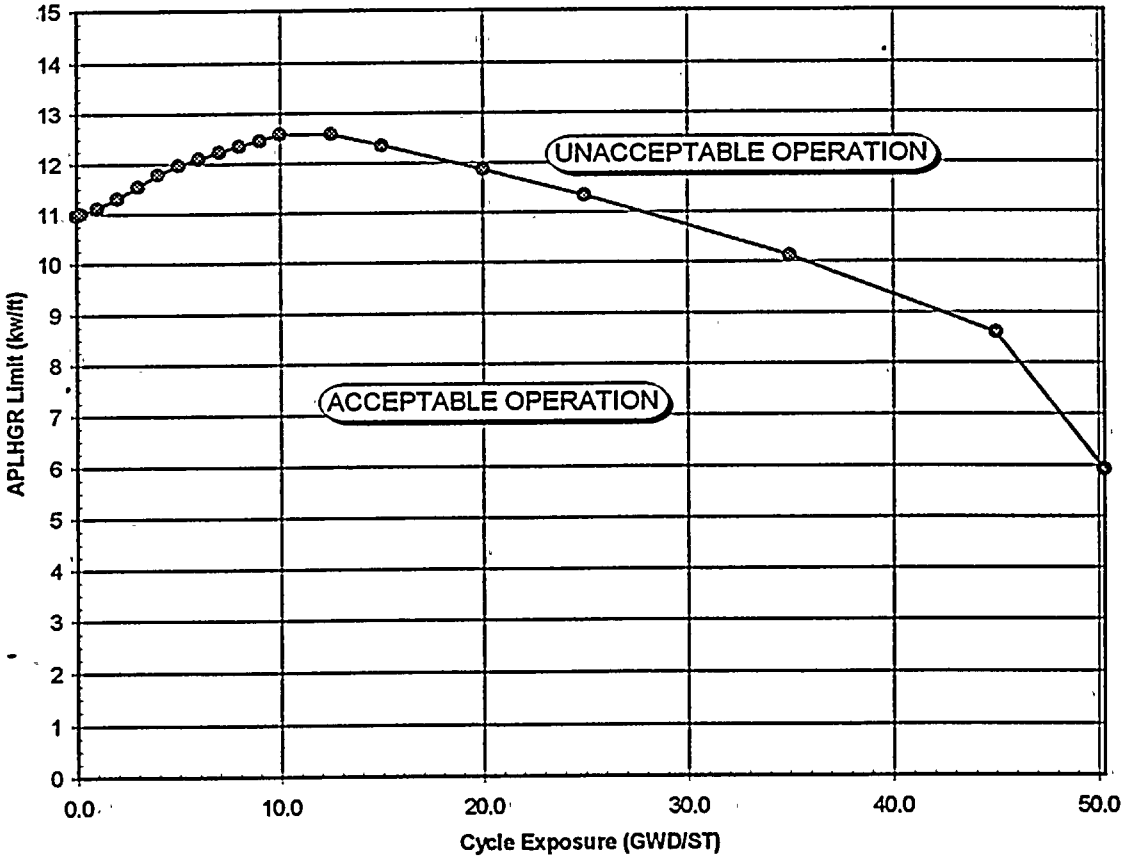
Figure 4
APLHGR Limits for Bundle Type GE9B-P8DWB319-9GZ
(GE8X8NB)



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	11.64	7.0	12.49	35.0	10.41
0.2	11.68	8.0	12.65	45.0	8.81
1.0	11.77	9.0	12.77	51.2	5.91
2.0	11.88	10.0	12.86		
3.0	12.01	12.5	12.86		
4.0	12.12	15.0	12.62		
5.0	12.22	20.0	12.06		
6.0	12.32	25.0	11.47		

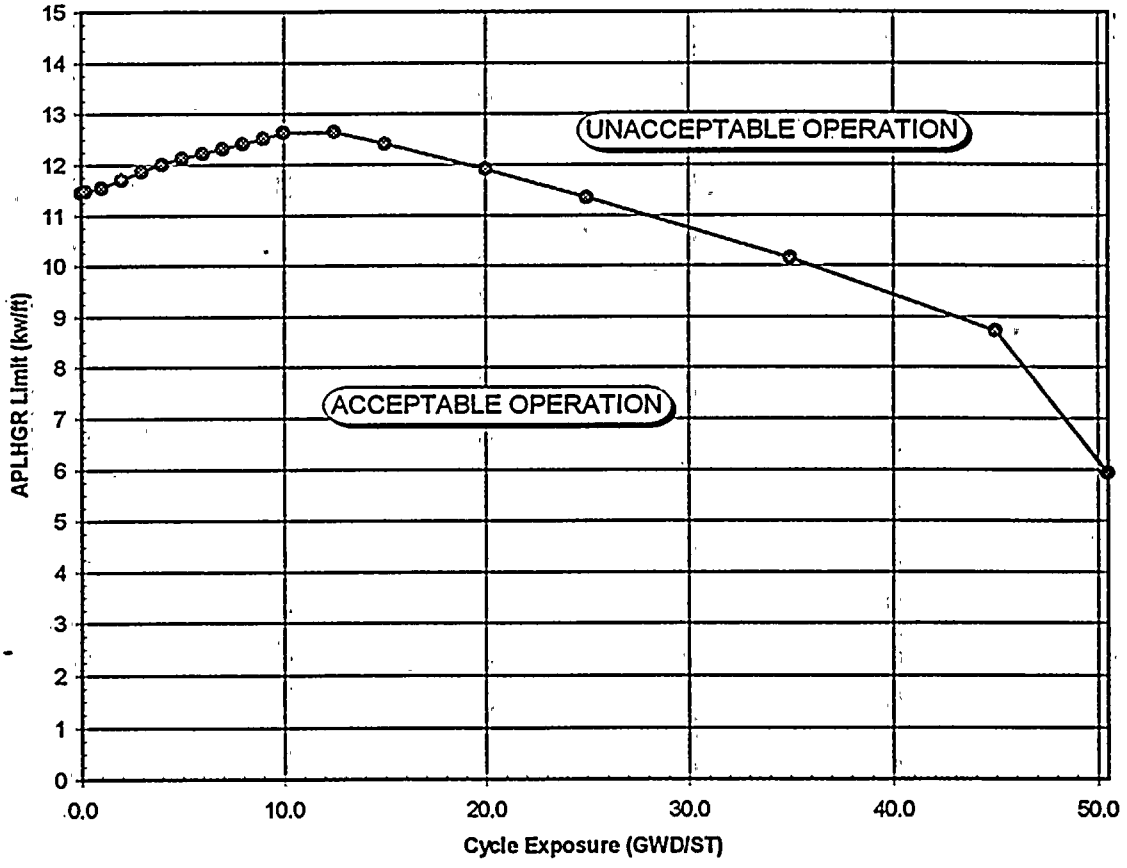
Figure 5
APLHGR Limits for Bundle Type GE9B-P8DWB325-10GZ
(GE8X8NB)



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	10.97	7.0	12.23	35.0	10.12
0.2	11.00	8.0	12.35	45.0	8.60
1.0	11.11	9.0	12.46	50.27	5.92
2.0	11.31	10.0	12.58		
3.0	11.54	12.5	12.58		
4.0	11.79	15.0	12.35		
5.0	11.97	20.0	11.86		
6.0	12.10	25.0	11.33		

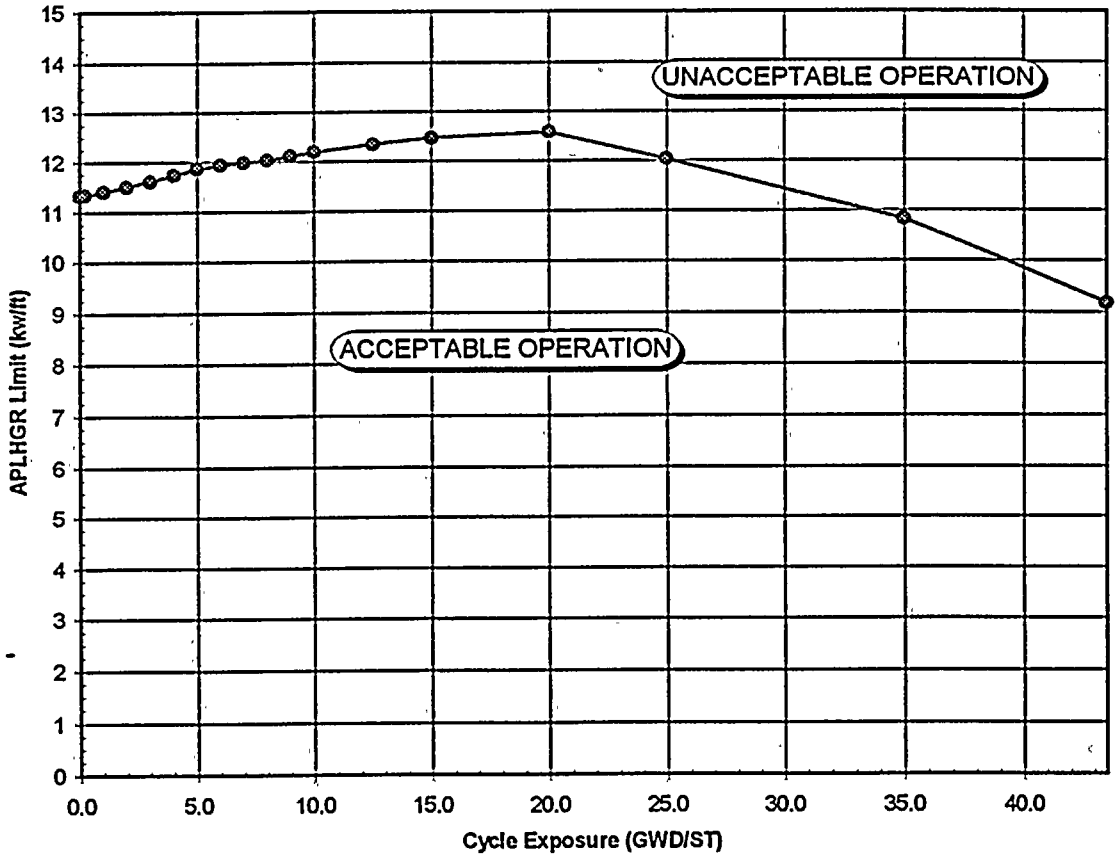
Figure 6
APLHGR Limits for Bundle Type GE9B-P8DWB326-7GZ
(GE8X8NB)



Most Limiting Lattice
for Each Exposure Point

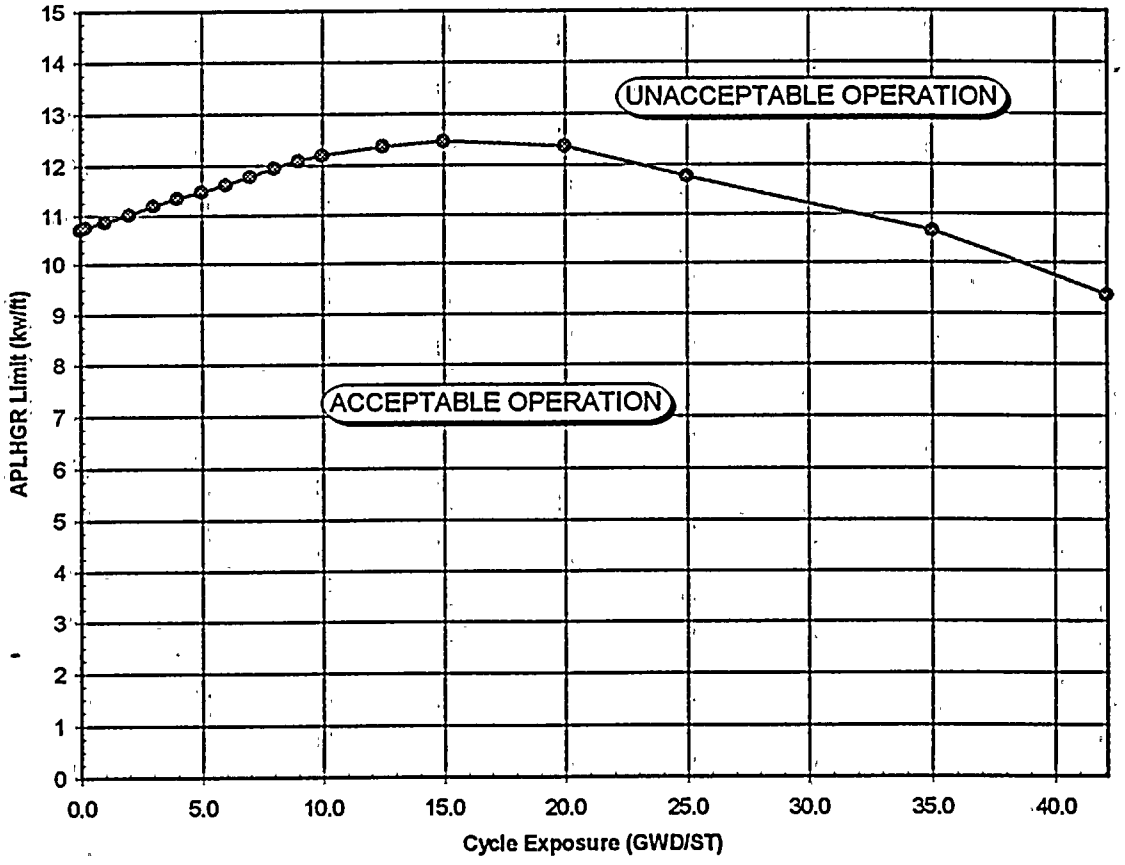
Average Planar Exposure (GWD/ST)	LHGR Limit (kw/ft)	Average Planar Exposure (GWD/ST)	LHGR Limit (kw/ft)	Average Planar Exposure (GWD/ST)	LHGR Limit (kw/ft)
0.0	11.45	7.0	12.31	35.0	10.15
0.2	11.47	8.0	12.41	45.0	8.72
1.0	11.55	9.0	12.51	50.49	5.93
2.0	11.70	10.0	12.63		
3.0	11.87	12.5	12.64		
4.0	12.01	15.0	12.41		
5.0	12.13	20.0	11.91		
6.0	12.22	25.0	11.35		

Figure 7
APLHGR Limits for Bundle Type BP8DRB301L
(BP8X8R)



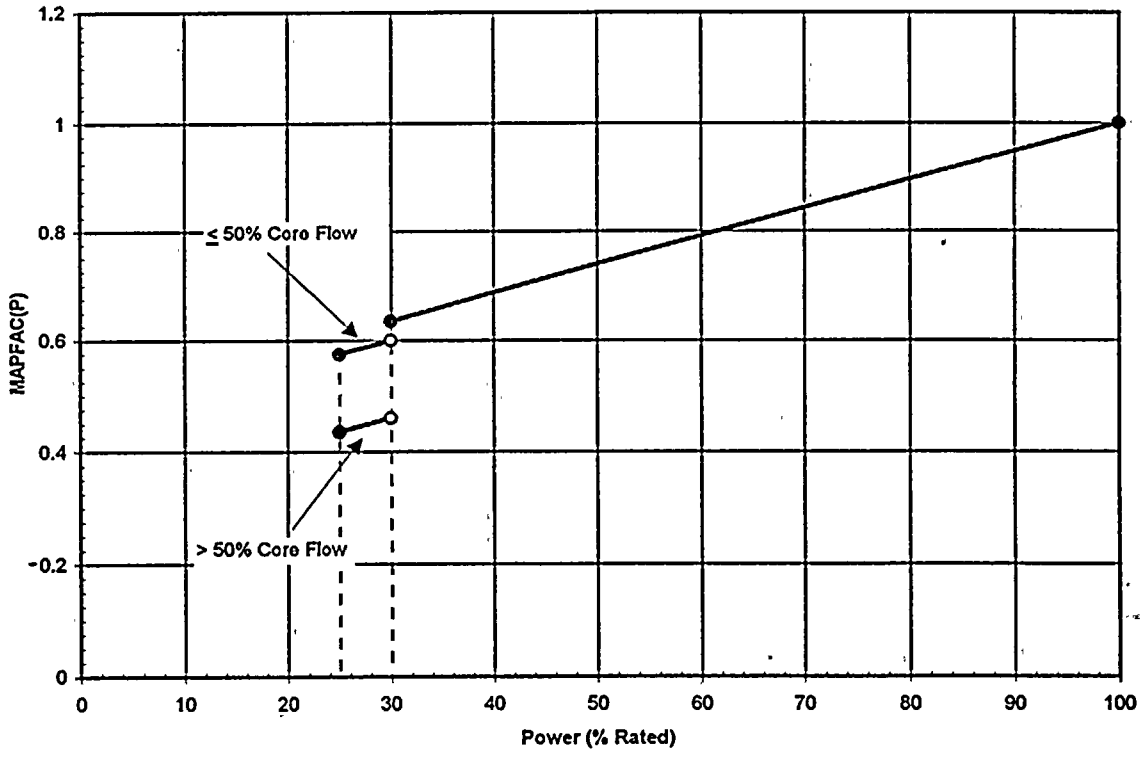
Average Planar Exposure (GWD/ST)	LHGR Limit (kw/ft)	Average Planar Exposure (GWD/ST)	LHGR Limit (kw/ft)	Average Planar Exposure (GWD/ST)	LHGR Limit (kw/ft)
0.0	11.32	7.0	11.98	35.0	10.82
0.2	11.33	8.0	12.03	43.52	9.17
1.0	11.40	9.0	12.11		
2.0	11.50	10.0	12.19		
3.0	11.61	12.5	12.34		
4.0	11.73	15.0	12.47		
5.0	11.86	20.0	12.58		
6.0	11.93	25.0	12.03		

Figure 8
APLHGR Limits for Bundle Type BP8DRB299
(BP8X8R)



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	10.71	7.0	11.78	35.0	10.65
0.2	10.75	8.0	11.95	42.13	9.36
1.0	10.86	9.0	12.09		
2.0	11.01	10.0	12.20		
3.0	11.19	12.5	12.37		
4.0	11.35	15.0	12.47		
5.0	11.47	20.0	12.37		
6.0	11.62	25.0	11.77		

Figure 9
Power Dependent MAPLHGR Factor - MAPFAC(P)



MAPLHGR(P) = MAPFAC(P) x MAPLHGRstd

MAPLHGRstd = Standard MAPLHGR Limits

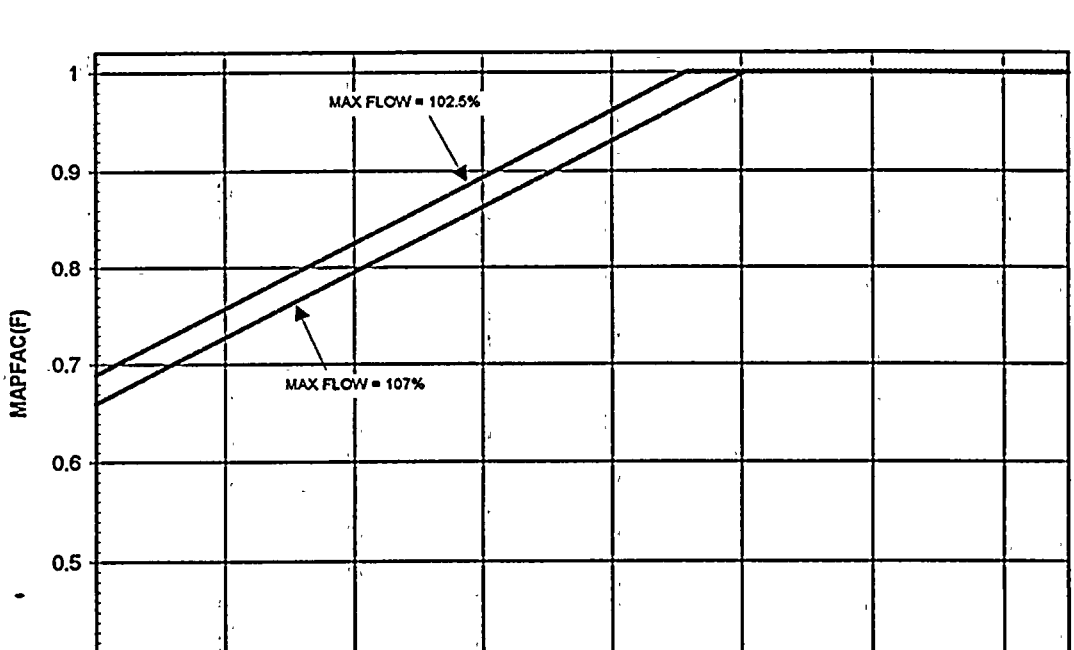
For 25% ≥ P : NO THERMAL LIMITS MONITORING REQUIRED

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

Figure 10
Flow Dependent MAPLHGR Factor - MAPFAC(F)



MAPLHGR(F) = MAPFAC(F) x MAPLHGRstd

MAPLHGRstd = Standard MAPLHGR Limits

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

Wc = % Rated Core Flow

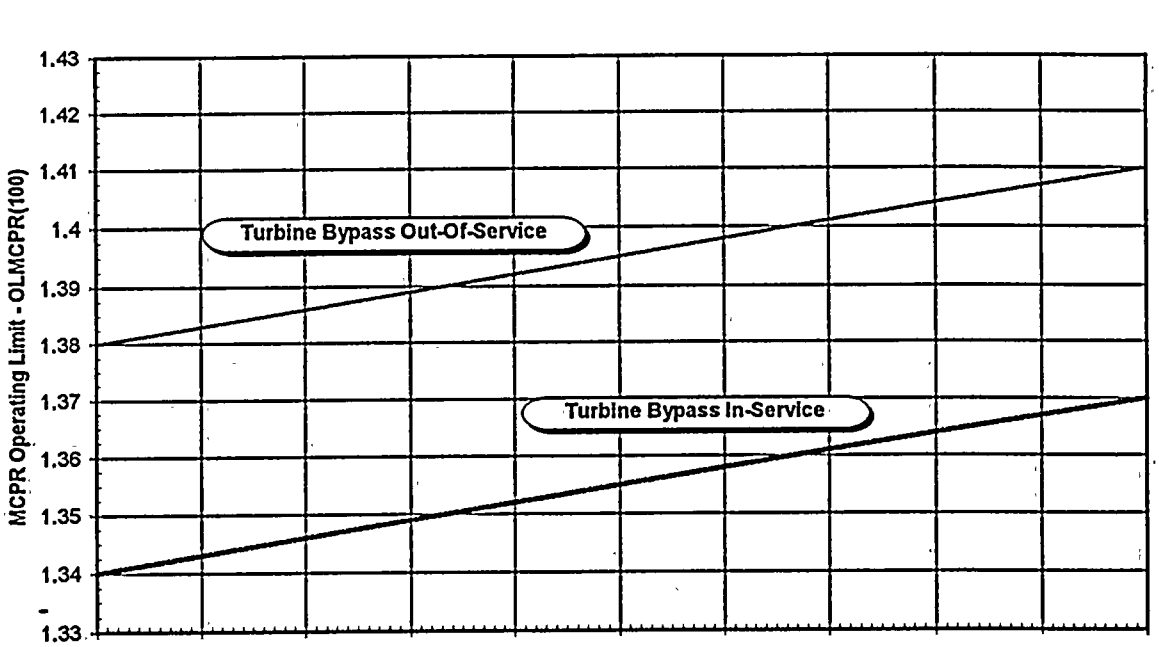
Af and Bf are Constants Given Below:

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.

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).

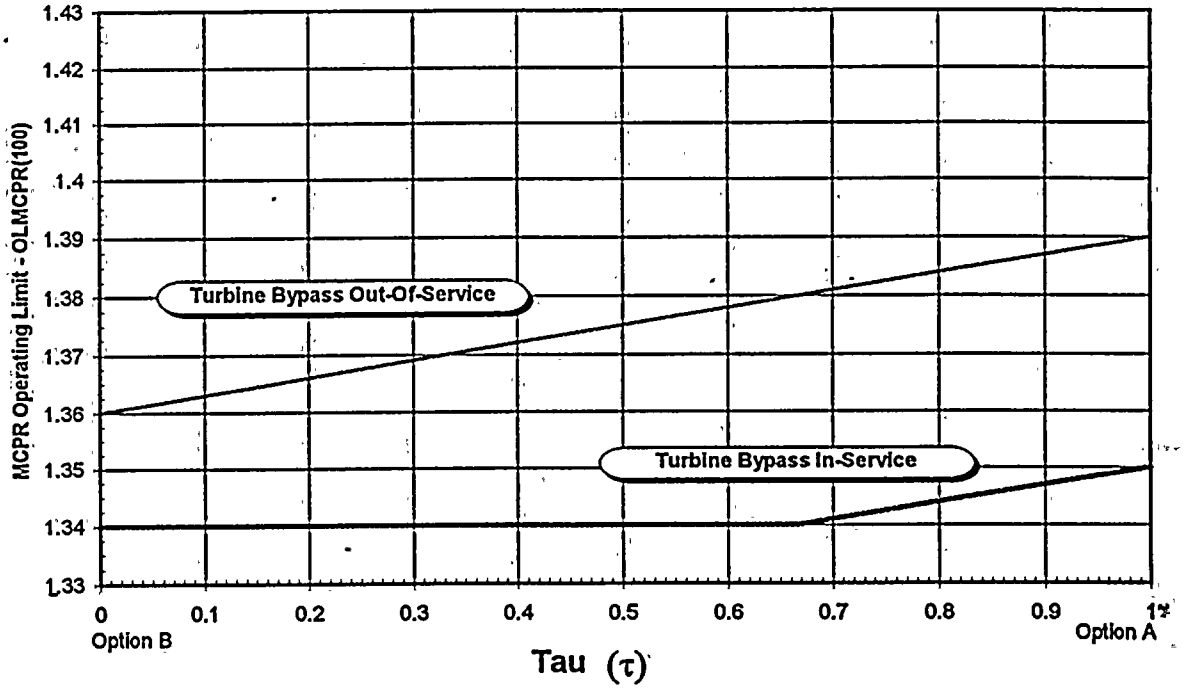
Figure 11
MCPR Operating Limit for GE13



Exposure Range	Out-Of-Service	Option A Tau=1.0	Option B Tau=0.0
BOC10 to EOC10	na	1.37 (1)	1.34
BOC10 to EOC10	Turbine Bypass	1.41	1.38

Notes
1. Use this value at BOC10 prior to performing scram time testing.

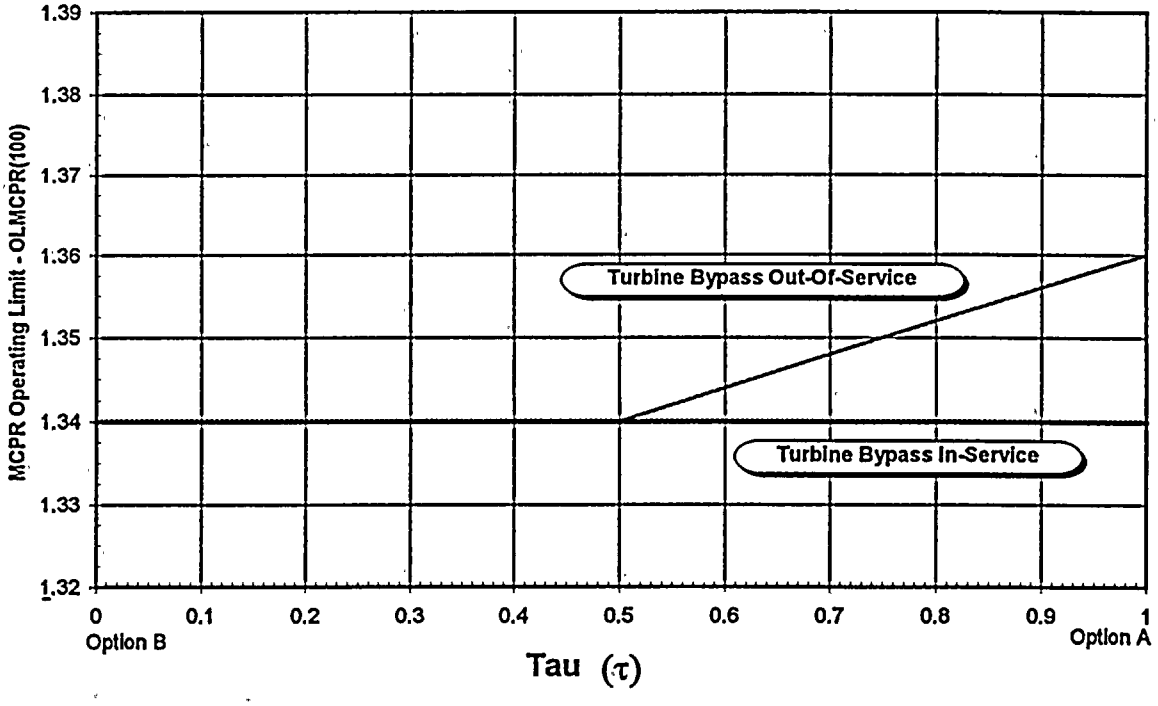
Figure 12
MCPR Operating Limit for GE11



Exposure Range	Out-Of-Service	Option A Tau=1.0	Option B Tau=0.0
BOC10 to EOC10	na	1.35 (1)	1.34
BOC10 to EOC10	Turbine Bypass	1.39	1.36

Notes
1. Use this value at BOC10 prior to performing scram time testing.

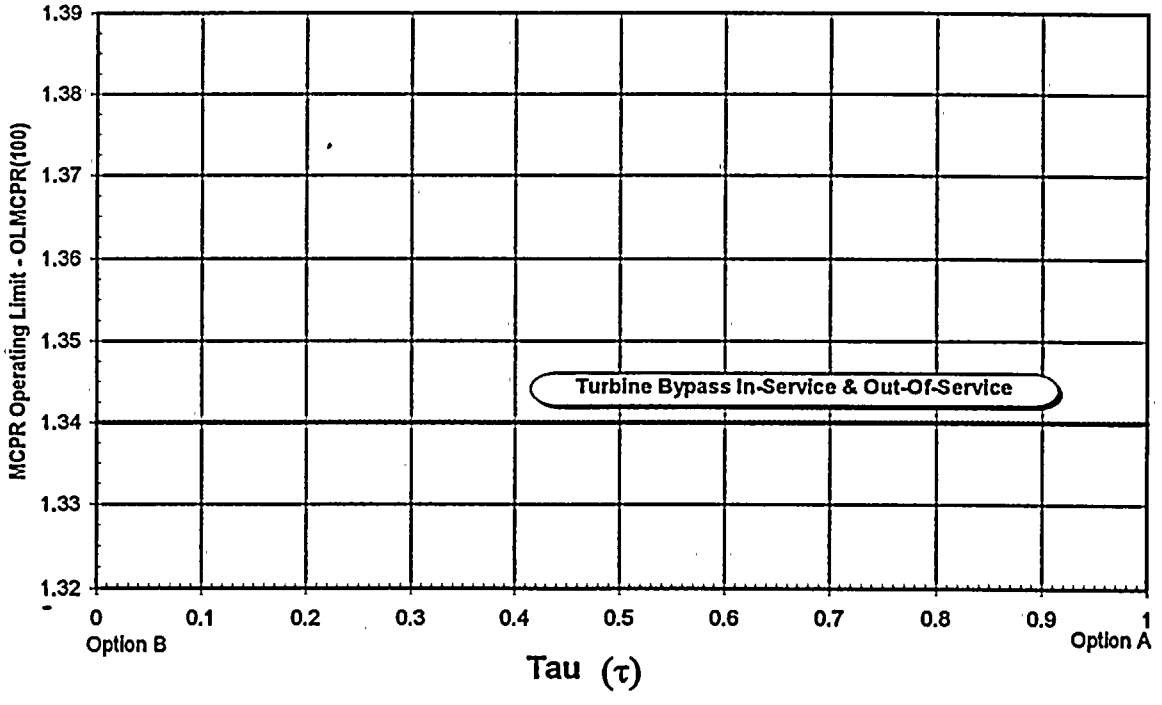
Figure 13
MCPR Operating Limit for GE9B (GE8X8NB)



Exposure Range	Out-Of-Service	Option A Tau=1.0	Option B Tau=0.0
BOC10 to EOC10	na	1.34 (1)	1.34
BOC10 to EOC10	Turbine Bypass	1.36	1.34

Notes
1. Use this value at BOC10 prior to performing scram time testing.

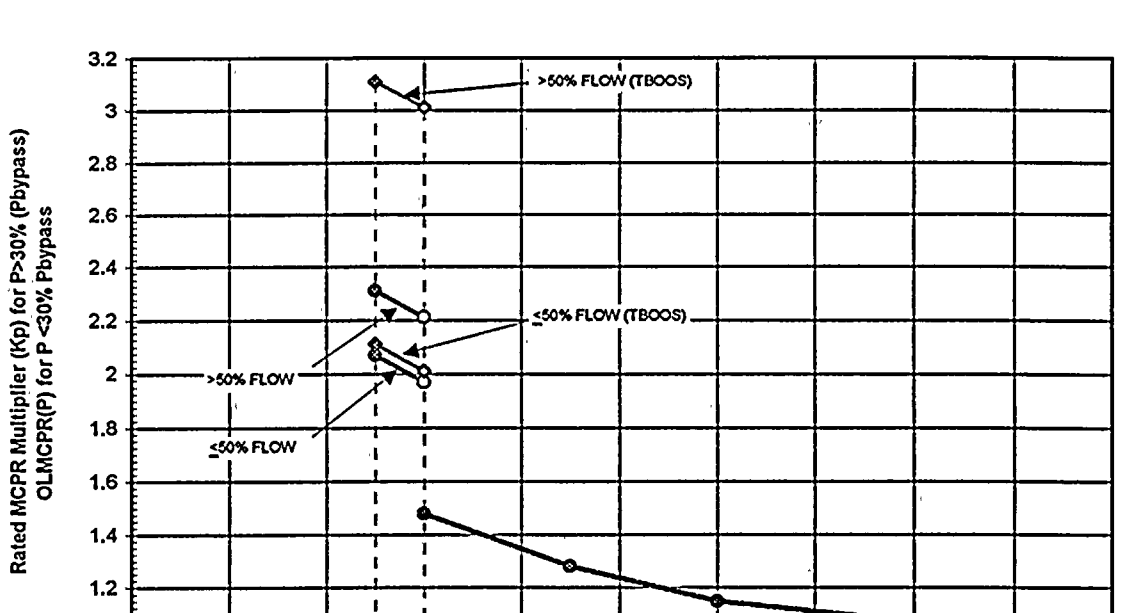
Figure 14
MCPR Operating Limit for GE7B (BP8X8R)



Exposure Range	Out-Of-Service	Option A Tau=1.0	Option B Tau=0.0
BOC10 to EOC10	na	1.34 (1)	1.34
BOC10 to EOC10	Turbine Bypass	1.34	1.34

Notes
1. Use this value at BOC10 prior to performing scram time testing.

Figure 15
Power Dependent MCPR(P) Limits



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

For P ≤ 25% : NO THERMAL LIMITS MONITORING REQUIRED

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

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

Turbine Bypass In-Service

Kbyp = 1.97 For ≤ 50% CORE FLOW

Kbyp = 2.21 For > 50% CORE FLOW

Turbine Bypass Out-Of-Service

Kbyp = 2.01 For ≤ 50% CORE FLOW

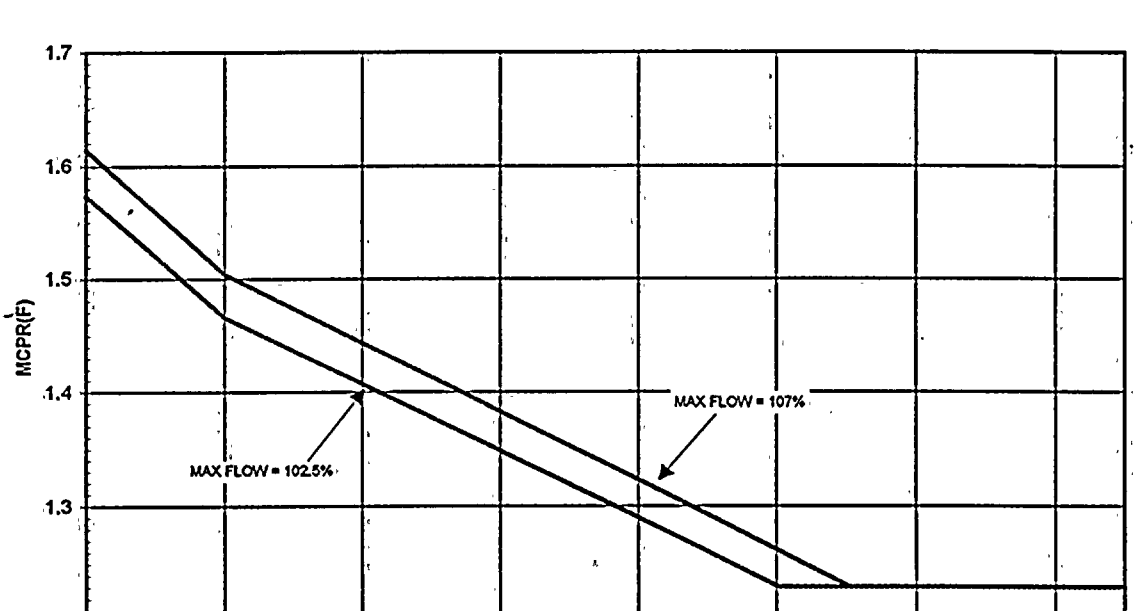
Kbyp = 3.01 For > 50% CORE FLOW

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)

Figure 16
Flow Dependent MCPR Operating Limit - MCPR(F)



For Wc < 40% : MCPR(F) = (Af*Wc/100 + Bf)*[1+0.0032(40-Wc)]

For Wc ≥ 40% : MCPR(F) = MAX(1.23, Af*Wc/100 + Bf)

Wc = % Rated Core Flow

Af and Bf are Constants Given Below:

Maximum Core Flow (% Rated)	Af	Bf
102.5	-0.587	1.701
107.0	-0.603	1.745

These values bound both Turbine Bypass 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).