ENCLOSURE 2

VSP-SNC-HT1-16-001

Edwin I. Hatch Nuclear Plant Unit 1 Cycle 28 Core Operating Limits Report, Version 1

Non-Proprietary Information

INFORMATION NOTICE

This is a non-proprietary version of Enclosure 1 of VSP-SNC-HT1-16-001, which has the proprietary information removed. Portions of the document that have been removed are indicated by white space inside open and closed bracket as shown here [[ ]].

SOUTHERN NUCLEAR OPERATING COMPANY
EDWIN I. HATCH NUCLEAR PLANT

Unit 1 Cycle 28
CORE OPERATING LIMITS REPORT

Version 1

Southern Nuclear Operating Company
Post Office Box 1295
Birmingham, Alabama 35242

Non-Proprietary Information

Edwin I. Hatch Nuclear Plant
Unit 1 Cycle 28 Core Operating Limits Report

TABLE OF CONTENTS

TABLES

FIGURES

1.0 INTRODUCTION

The Core Operating Limits Report (COLR) for Plant Hatch Unit 1 Cycle 28 is prepared in accordance with the requirements of Technical Specification 5.6.5. The core operating limits presented herein were developed using NRC-approved methods (References 1 through 6). Results from the reload analyses for the fuel in Unit 1 Cycle 28 are documented in References 3 through 5.

The following core operating limits are included in this report:

a. Average Planar Linear Heat Generation Rate (APLHGR) – Technical Specification 3.2.1

b. Minimum Critical Power Ratio (MCPR) – Technical Specification 3.2.2

c. Linear Heat Generation Rate (LHGR) – Technical Specification 3.2.3

Also included in this report are the licensed scram setpoints for the Period Based Detection Algorithm (PBDA) in the Oscillation Power Range Monitor (OPRM).

Based upon the reload analysis for this cycle, the following operability requirement is defined for Unit 1 operation.

TABLE 1-1

Main Turbine Bypass System Operability

System	Operability Requirement
Main Turbine Bypass System Operable (Technical Specification 3.7.7)	At least two bypass valves must be operable

From a fuel thermal limits perspective, the following limitations are placed on Unit 1 operation.

TABLE 1-2

Equipment-Out-of-Service Limitations

Equipment / Condition	Limitation
Single-Loop Operation (SLO)	• CTP must be ≤ 2000 MWth • Core Flow must be ≤ 56% of Rated

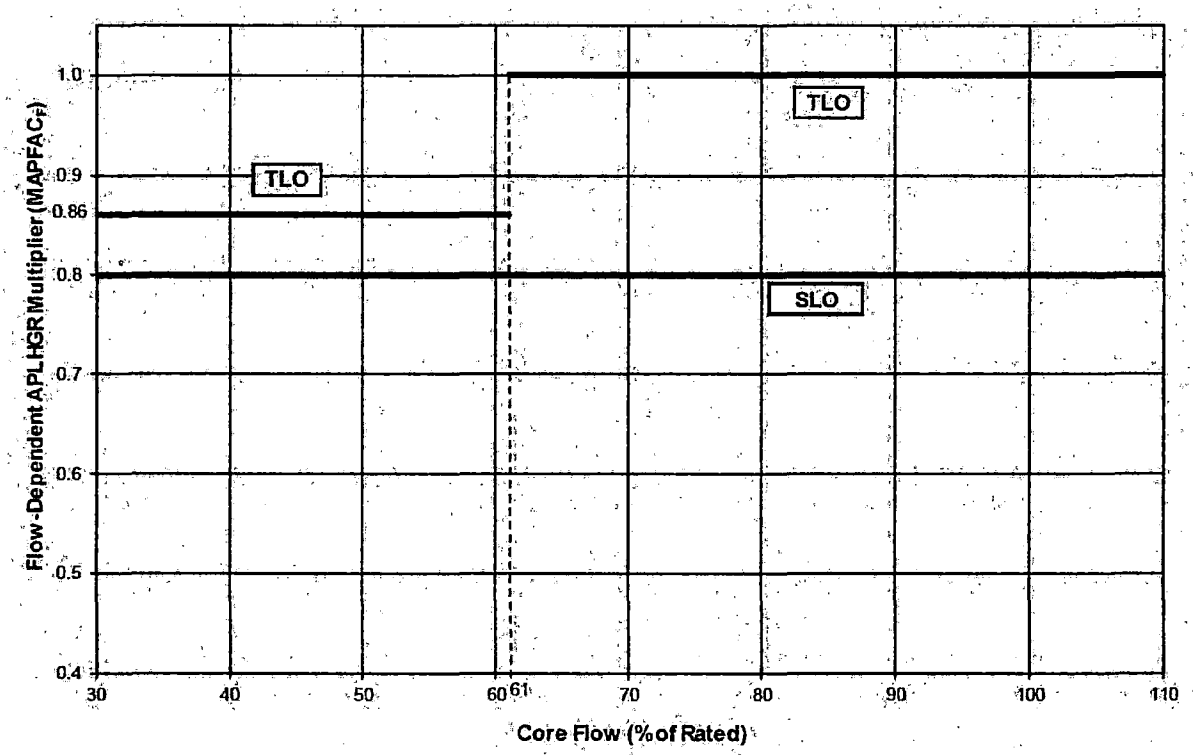
2.0 APLHGR LIMITS (Technical Specification 3.2.1)

For both two loop operation (TLO) and single loop operation (SLO), the APLHGR limit for each six inch axial segment of each fuel assembly in the core is the applicable fuel-type-specific APLHGR limit in Figure 2-2 multiplied by the fuel-type-specific flow-dependent multiplier, $MAPFAC_F$, taken from either:

a. Figure 2-1A for GE14C fuel

OR

b. Figure 2-1B for GNF2 fuel.

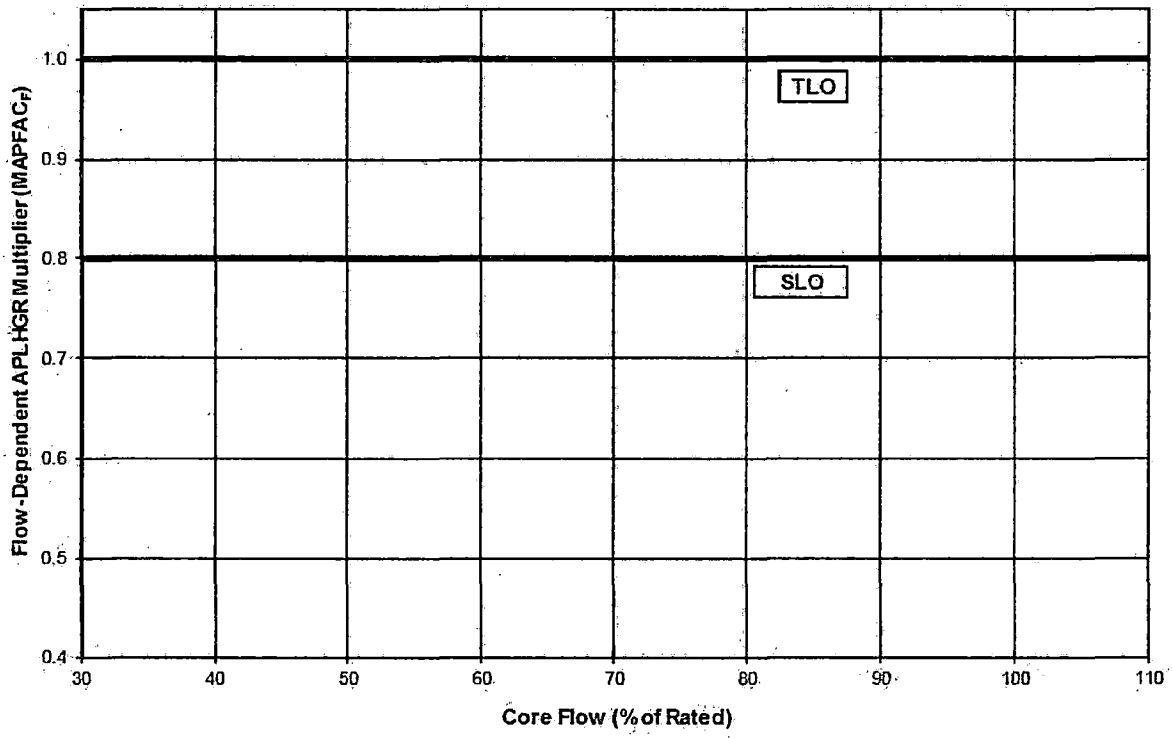


Operating Conditions		
F	SLO / TLO	MAPFAC$_F$
30 ≤ F ≤ 61	TLO	0.86
61 < F	TLO	1.00
30 ≤ F	SLO	0.80

F = Percent of Rated Core Flow

FIGURE 2-1A

GE14C Flow-Dependent APLHGR Multiplier (MAPFAC$_F$) versus Core Flow



Operating Conditions		
F	SLO / TLO	MAPFAC$_F$
30 ≤ F	TLO	1.00
30 ≤ F	SLO	0.80

F = Percent of Rated Core Flow

FIGURE 2-1B

GNF2 Flow-Dependent APLHGR Multiplier (MAPFAC$_F$) versus Core Flow

Average Planar Exposure (GWd/ST)	GE14C APLHGR Limit (kW/ft)
0.00	12.82
14.51	12.82
19.13	12.82
57.61	8.00
63.50	5.00

Average Planar Exposure (GWd/ST)	GNF2 APLHGR Limit (kW/ft)
0.00	13.78
17.15	13.78
60.78	6.87
63.50	5.50

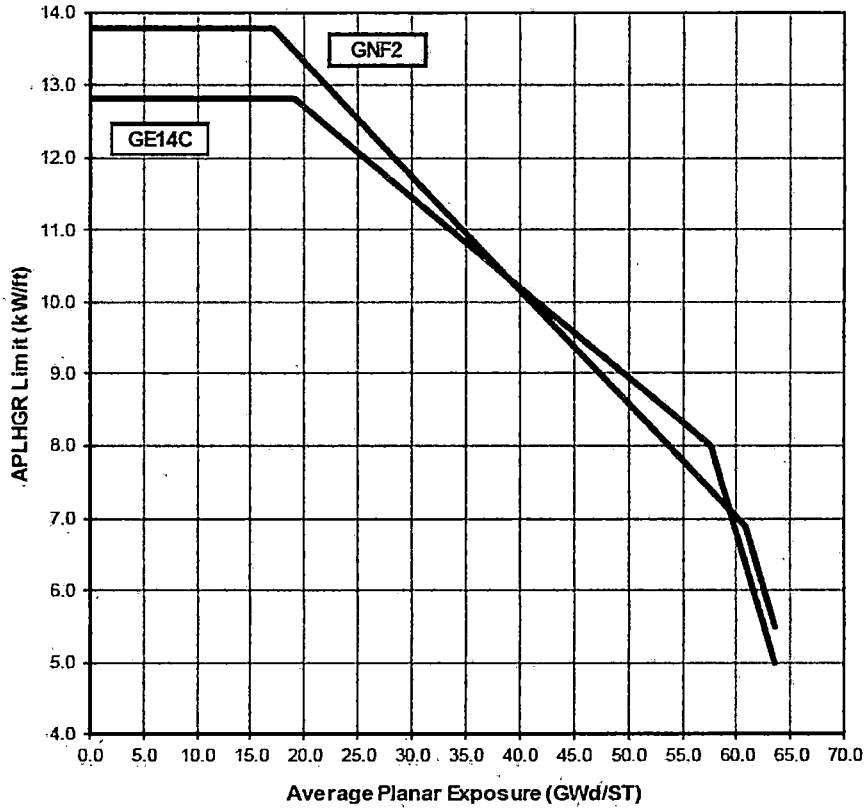


FIGURE 2-2

APLHGR Limit versus Average Planar Exposure

3.0 MCPR OPERATING LIMITS (Technical Specification 3.2.2)

The MCPR operating limits (OLMCPR) for each fuel type are a function of core power, core flow, average scram time, number of operating recirculation loops, EOC-RPT system status, operability of the main turbine bypass system, the status of the main turbine pressure regulator system, and cycle exposure. Cycle exposures are defined in Table 3-1.

The OLMCPRs for both two loop operation (TLO) and single loop operation (SLO) are determined as follows:

a. For 24% ≤ power < 45%, the greater of either:

   1) The flow-dependent MCPR limit, $MCPR_F$, as determined by Figure 3-1,

      OR

   2) The power-dependent MCPR limit, $MCPR_P$, as determined by Table 3-2.

b. For power ≥ 45%, the greater of either:

   1) $MCPR_F$, as determined by Figure 3-1,

      OR

   2) The product of the power-dependent multiplier, K_P, as determined by Table 3-3, and the rated-power OLMCPR, as determined by Table 3-4.

These limits apply to all modes of operation with feedwater temperature reduction, as well as operation with normal feedwater temperatures.

In the 3-4A and 3-4B figures, Option A scram time OLMCPRs correspond to $\tau = 1.0$, where τ is determined from scram time measurements performed in accordance with Technical Specifications Surveillance Requirements 3.1.4.1 and 3.1.4.2. Option B values correspond to $\tau = 0.0$. For scram times between Option A and Option B, the rated-power OLMCPR corresponds to τ. If τ has not been determined, Option A limits must be used.

The average scram time of the control rods, τ, is defined as:

$$\tau = 0, \underline{OR} \quad \frac{\tau_{ave} - \tau_B}{\tau_A - \tau_B}, \text{ whichever is greater.}$$

where: τ_A = 1.08 sec (Technical Specification 3.1.4, Table 3.1.4-1, scram time limit to notch 36).

$$\tau_B = \mu + 1.65 * \sigma * \left[\frac{N_1}{\sum_{i=1}^{n} N_i} \right]^{1/2}$$

where: μ = 0.822 sec (mean scram time used in the transient analysis).

σ = 0.018 sec (standard deviation of μ).

N_1 = total number of active rods measured in Technical Specifications Surveillance Requirement 3.1.4.1.

n = number of surveillance tests performed to date in the cycle.

N_i = number of active control rods measured in the i^{th} surveillance test.

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

where: τ_i = average scram time to notch 36 of all rods in the i^{th} surveillance test.

TABLE 3-1

Exposure Definitions

Exposure Label	Cycle Exposure	Definition
BOC	Beginning of Cycle Exposure	0 MWd/ST
MOC1	First Middle of Cycle Exposure	EOR - 6283 MWd/ST
MOC2	Second Middle of Cycle Exposure	EOR - 4283 MWd/ST
EOR	End of Rated Exposure	Projected end of rated power with all control rods out at rated core flow and rated feedwater temperature
EOC	End of Cycle Exposure	Exposure at cycle shutdown

TABLE 3-2

Power-Dependent MCPR Operating Flexibility Options

$MCPR_P$ from ≥ 24% to < 45% Power			
Equipment In or Out of Service			Figure #
EOC-RPT System In Service	Main Turbine Bypass System Operable*	Main Turbine Pressure Regulator System Status	
Yes/No	Yes	TLCO 3.3.13.a or b	3-2A
Yes/No	No	TLCO 3.3.13.a or b	3-2B
Yes/No	Yes/No	TLCO 3.3.13.c	3-2B

TABLE 3-3

Power-Dependent Multiplier Flexibility Options

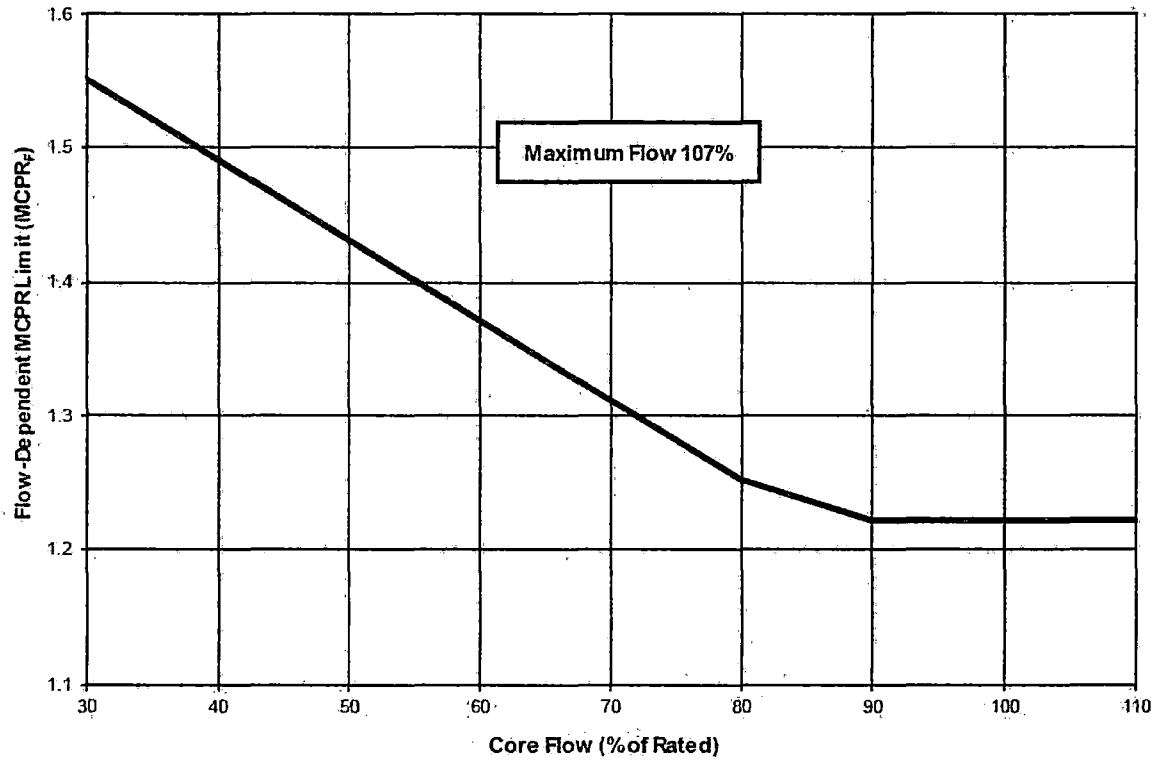
K_P for Power ≥ 45% of Rated			
Equipment In or Out of Service			Figure #
EOC-RPT System In Service	Main Turbine Bypass System Operable*	Main Turbine Pressure Regulator System Status	
Yes/No	Yes/No	TLCO 3.3.13.a or b	3-3A
Yes/No	Yes/No	TLCO 3.3.13.c	3-3B

* At least two bypass valves must be operable

TABLE 3-4

Rated-Power MCPR Operating Flexibility Options

Rated-power OLMCPRs		
Equipment In/Out of Service	**TLO**	**SLO**
Equipment In Service	Figure 3-4A-1	Figure 3-4B-1
EOC-RPT Out of Service	Figure 3-4A-2	Figure 3-4B-2
Main Turbine Bypass System Inoperable	Figure 3-4A-3	Figure 3-4B-3
EOC-RPT Out of Service & Main Turbine Bypass System Inoperable	Figure 3-4A-4	Figure 3-4B-4
Main Turbine Pressure Regulator System Status in TLCO 3.3.13.c	Figure 3-4A-1	Figure 3-4B-1
Main Turbine Pressure Regulator System Status in TLCO 3.3.13.c & EOC-RPT Out of Service	Figure 3-4A-2	Figure 3-4B-2
Main Turbine Pressure Regulator System Status in TLCO 3.3.13.c & Main Turbine Bypass System Inoperable	Figure 3-4A-3	Figure 3-4B-3
Main Turbine Pressure Regulator System Status in TLCO 3.3.13.c & EOC-RPT Out of Service & Main Turbine Bypass System Inoperable	Figure 3-4A-4	Figure 3-4B-4



$MCPR_F(TLO) = A + B*F$

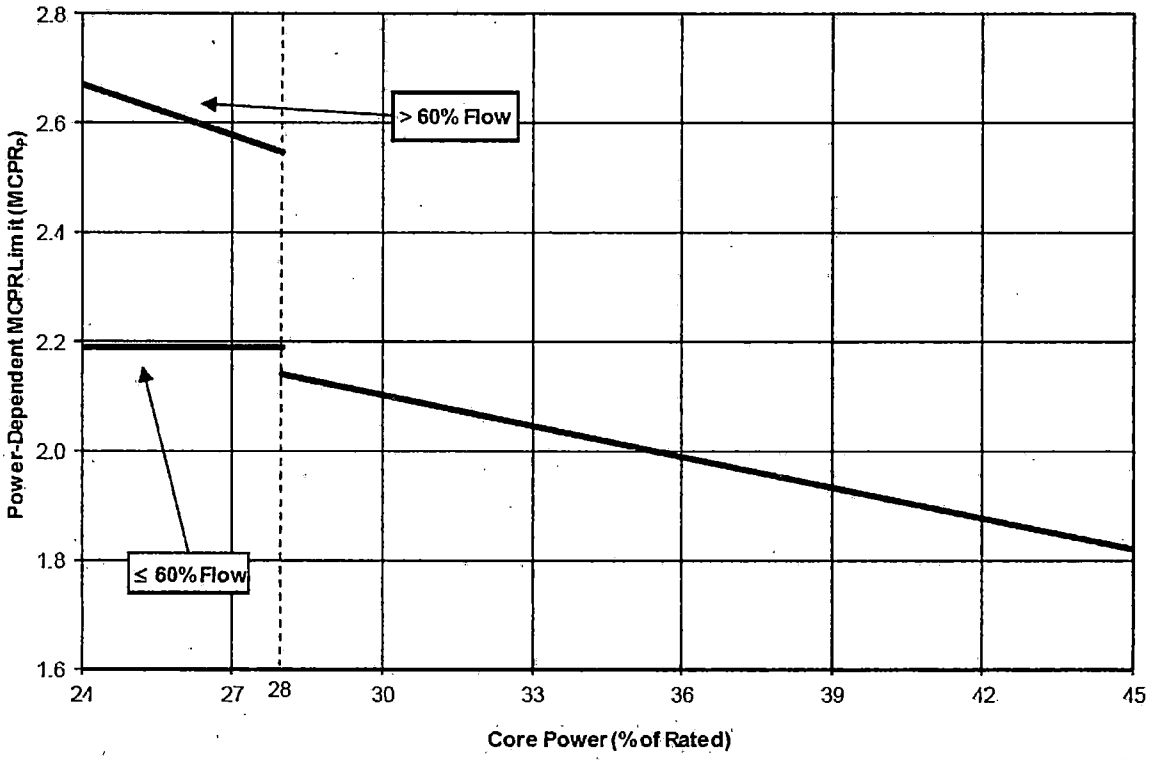
$MCPR_F(SLO) = MCPR_F(TLO) + 0.03$

Flow	A	B
30 ≤ F < 80	1.7294	-0.00598
80 ≤ F < 90	1.4830	-0.00290
90 ≤ F	1.2220	0.00000

F = Percent of Rated Core Flow

FIGURE 3-1

Flow-Dependent MCPR Limit ($MCPR_F$) versus Core Flow



$MCPR_P(TLO) = A + B*P$

$MCPR_P(SLO) = MCPR_P(TLO) + 0.03$

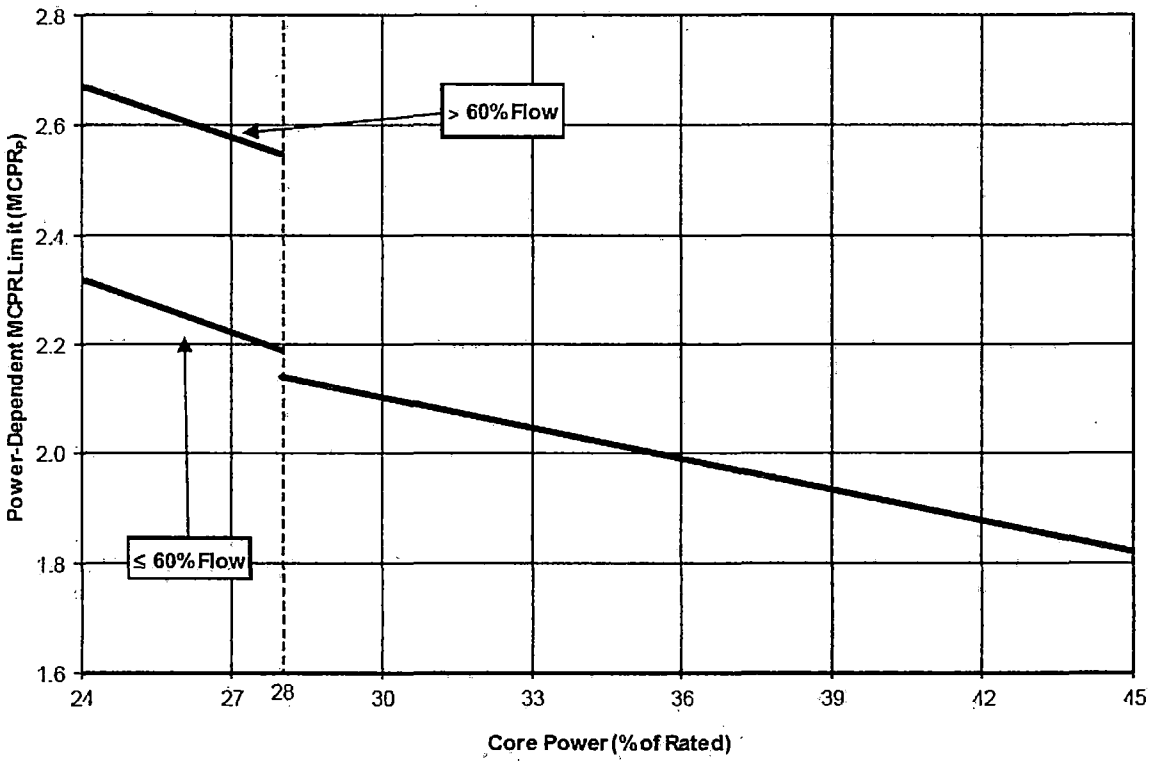
F	P	A	B
F ≤ 60	24 ≤ P < 28	2.1900	0.00000
F > 60	24 ≤ P < 28	3.3900	-0.03000
All	28 ≤ P < 45	2.6671	-0.01882

P = Percent of Rated Core Power

F = Percent of Rated Core Flow

FIGURE 3-2A

Power-Dependent MCPR Limit ($MCPR_P$) versus Core Power from 24% to 45% of Rated Core Power



$MCPR_P(TLO) = A + B*P$

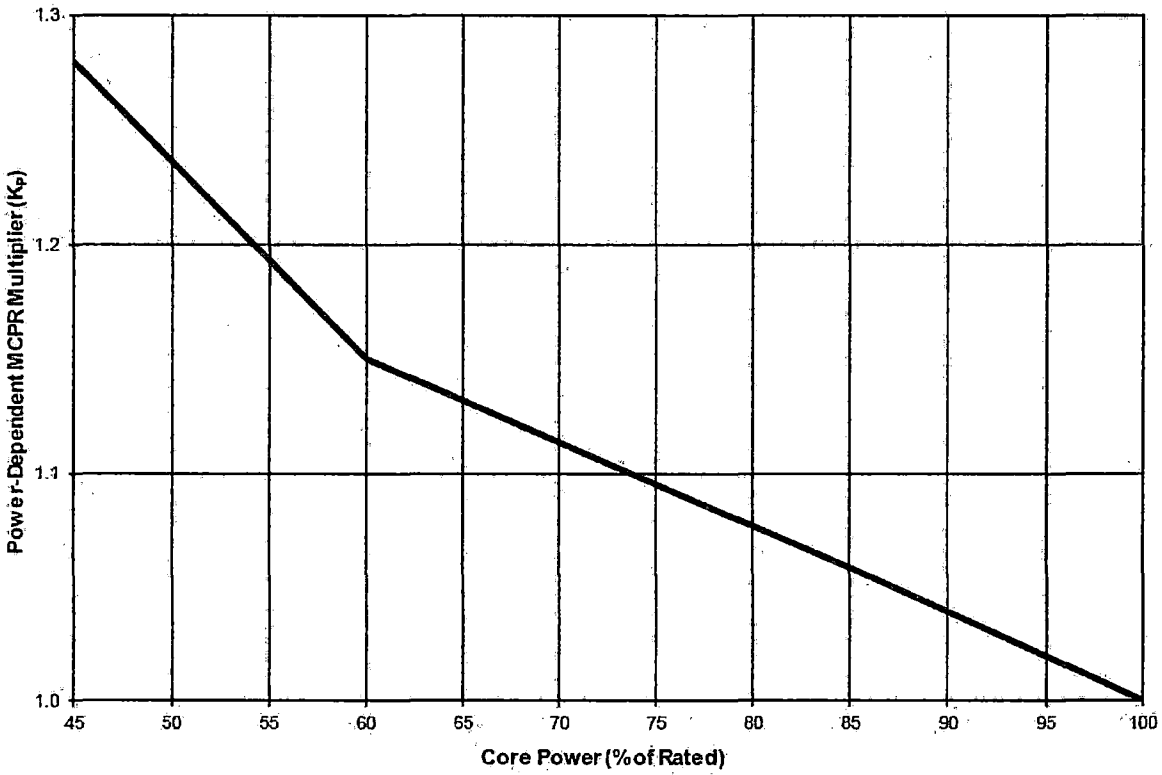
$MCPR_P(SLO) = MCPR_P(TLO) + 0.03$

F	P	A	B
F ≤ 60	24 ≤ P < 28	3.1000	-0.03250
F > 60	24 ≤ P < 28	3.3900	-0.03000
All	28 ≤ P < 45	2.6671	-0.01882

P = Percent of Rated Core Power
F = Percent of Rated Core Flow

FIGURE 3-2B

Power-Dependent MCPR Limit ($MCPR_P$) versus Core Power from 24% to 45% of Rated Core Power
(Main Turbine Bypass System Inoperable and/or Main Turbine Pressure Regulator System Status in TLCO 3.3.13.c)



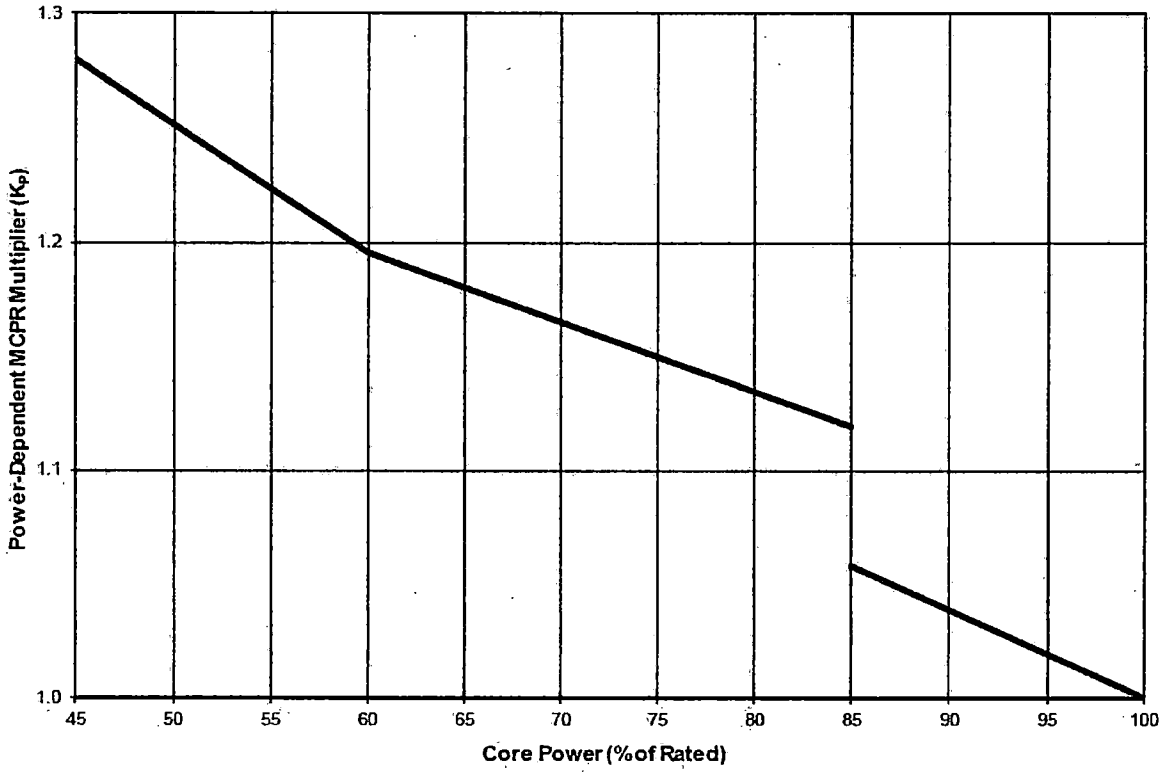
$K_P = A + B*P$

P	A	B
45 ≤ P < 60	1.6700	-0.00867
60 ≤ P < 85	1.3708	-0.00368
85 ≤ P	1.3867	-0.00387

P = Percent of Rated Core Thermal Power

FIGURE 3-3A

Power-Dependent MCPR Multiplier (K_P) versus Core Power



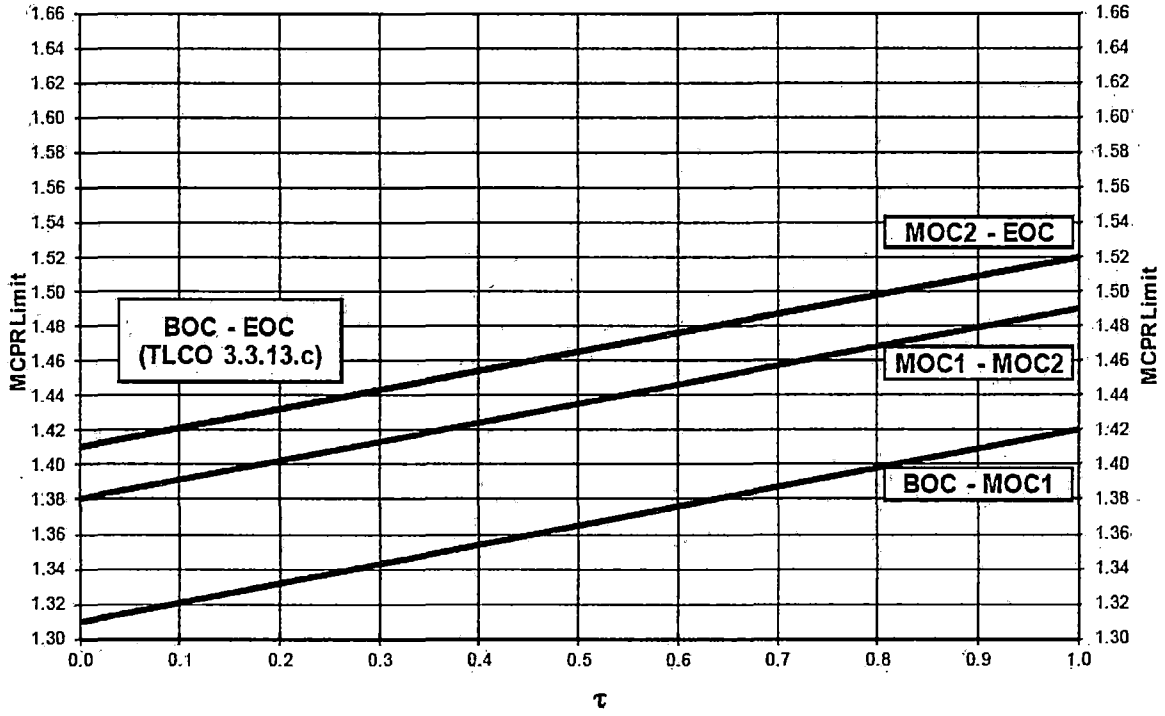
$K_P = A + B*P$

P	A	B
45 ≤ P < 60	1.5320	-0.00560
60 ≤ P < 85	1.3808	-0.00308
85 ≤ P	1.3867	-0.00387

P = Percent of Rated Core Thermal Power

FIGURE 3-3B

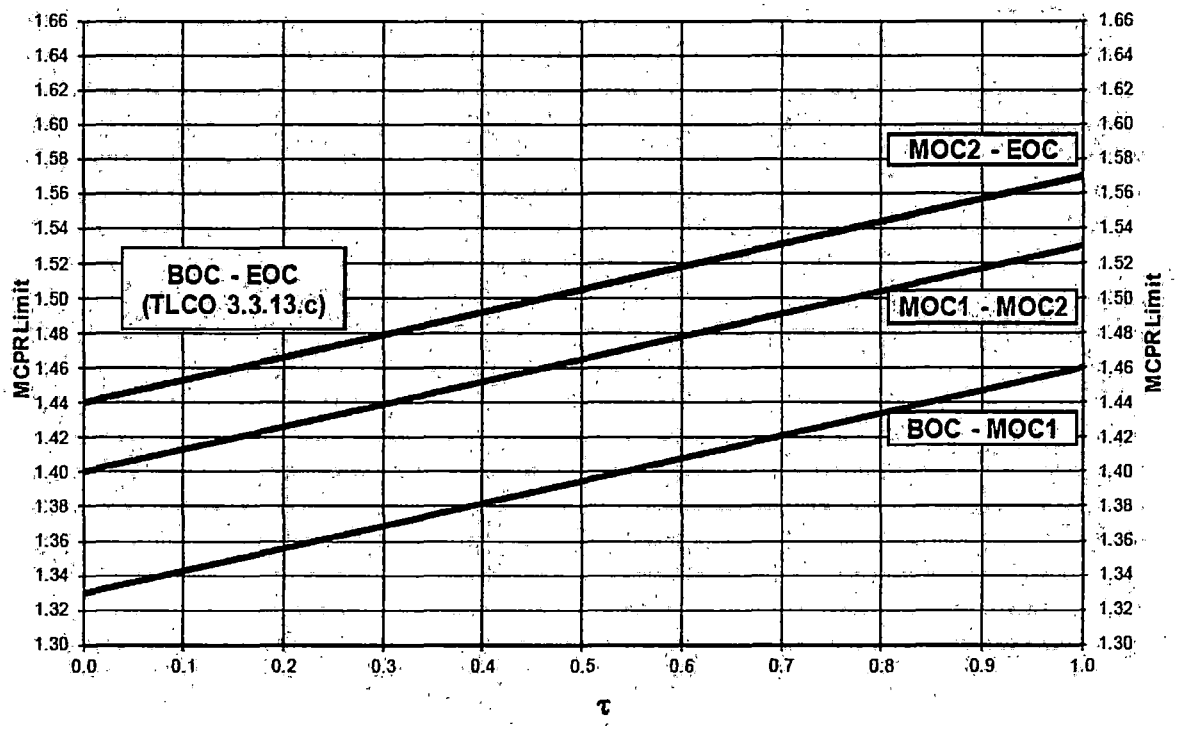
Power-Dependent MCPR Multiplier (K_P) versus Core Power
(Main Turbine Pressure Regulator System Status in TLCO 3.3.13.c)



Exposure Range	Main Turbine Pressure Regulator Status	$OLMCPR_{(TLO)}$	
		$\tau = 0.0$	$\tau = 1.0$
BOC - MOC1	TLCO 3.3.13.a or b	1.31	1.42
MOC1 - MOC2	TLCO 3.3.13.a or b	1.38	1.49
MOC2 - EOC	TLCO 3.3.13.a or b	1.41	1.52
BOC - EOC	TLCO 3.3.13.c	1.41	1.52

FIGURE 3-4A-1

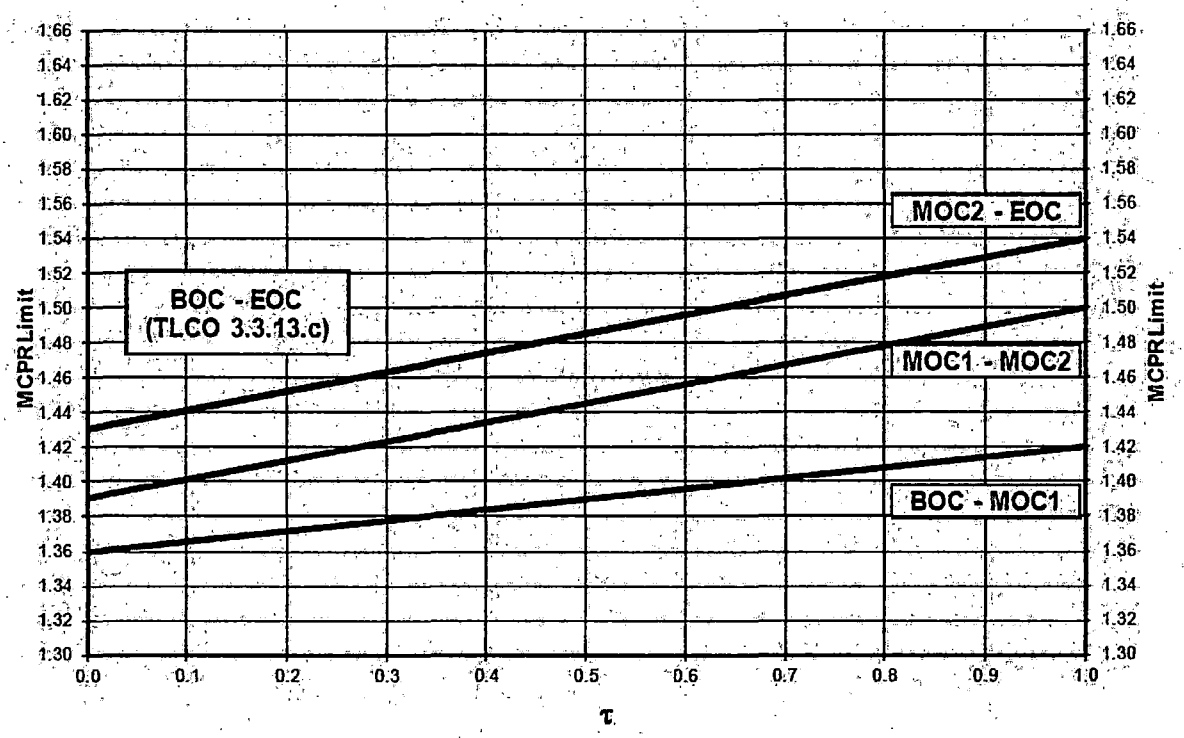
TLO MCPR Limits versus Average SCRAM Time



Exposure Range	Main Turbine Pressure Regulator Status	$OLMCPR_{(TLO)}$	
		$\tau = 0.0$	$\tau = 1.0$
BOC - MOC1	TLCO 3.3.13.a or b	1.33	1.46
MOC1 - MOC2	TLCO 3.3.13.a or b	1.40	1.53
MOC2 - EOC	TLCO 3.3.13.a or b	1.44	1.57
BOC - EOC	TLCO 3.3.13.c	1.44	1.57

FIGURE 3-4A-2

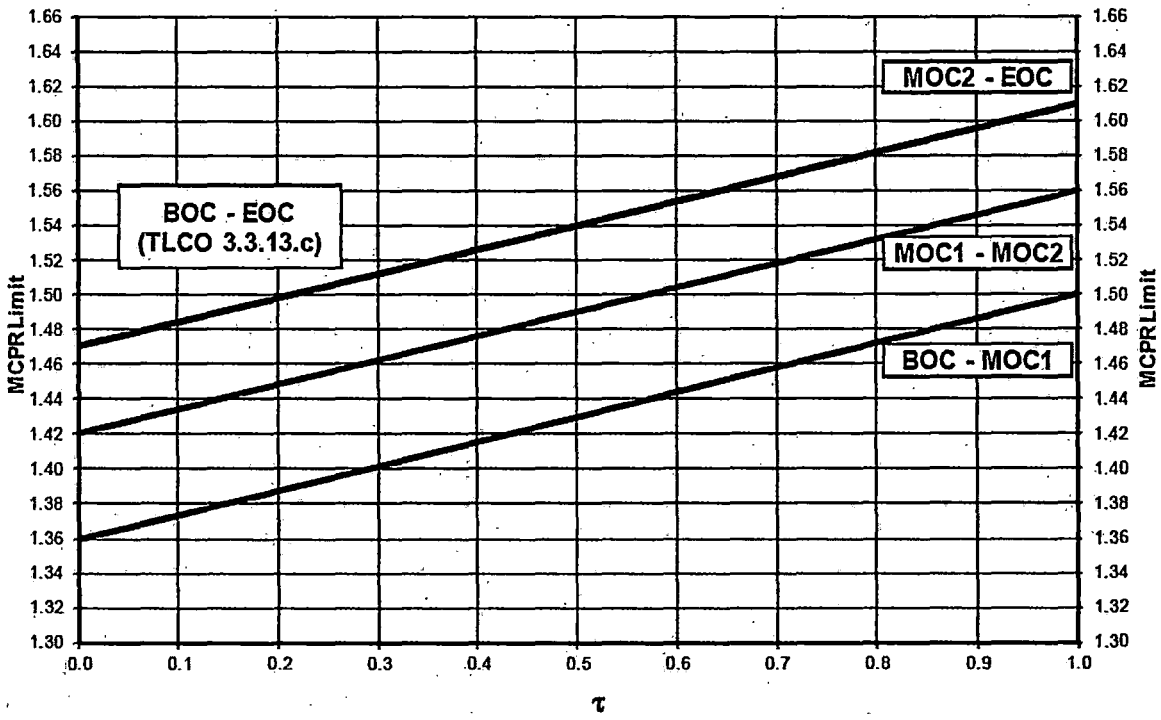
TLO MCPR Limits versus Average SCRAM Time
(EOC-RPT Out of Service)



Exposure Range	Main Turbine Pressure Regulator Status	$OLMCPR_{(TLO)}$	
		$\tau = 0.0$	$\tau = 1.0$
BOC - MOC1	TLCO 3.3.13.a or b	1.36	1.42
MOC1 - MOC2	TLCO 3.3.13.a or b	1.39	1.50
MOC2 - EOC	TLCO 3.3.13.a or b	1.43	1.54
BOC - EOC	TLCO 3.3.13.c	1.43	1.54

FIGURE 3-4A-3

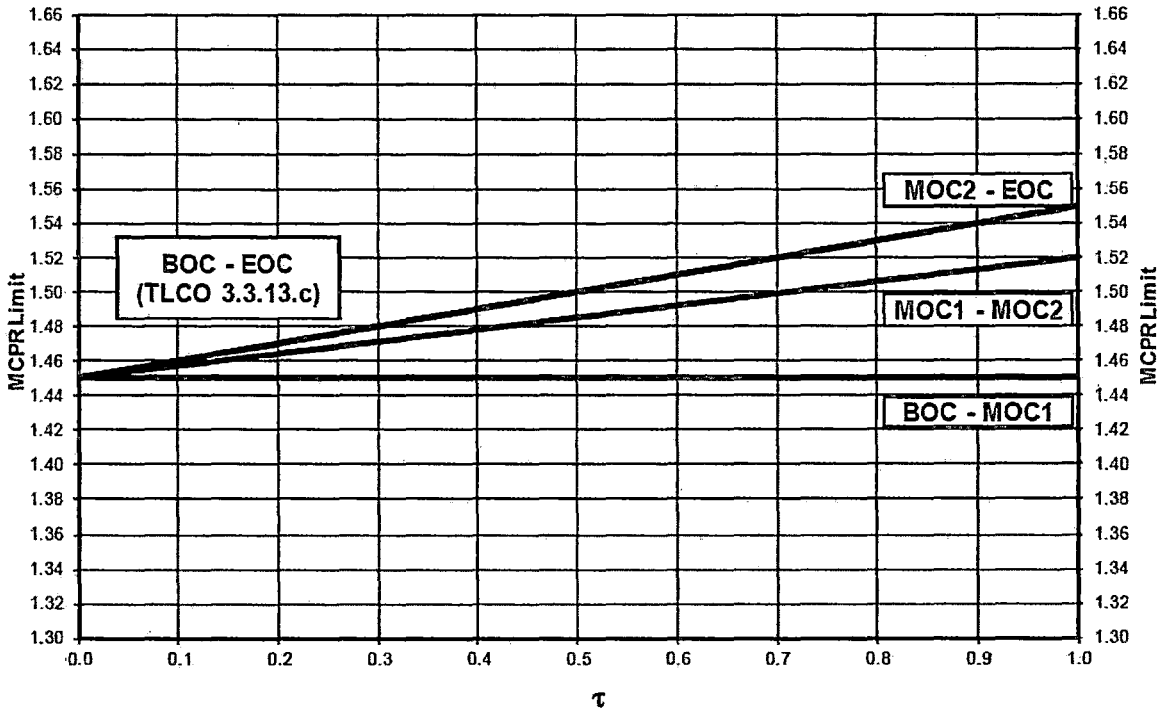
TLO MCPR Limits versus Average SCRAM Time
(Main Turbine Bypass System Inoperable)



Exposure Range	Main Turbine Pressure Regulator Status	$OLMCPR_{(TLO)}$	
		$\tau = 0.0$	$\tau = 1.0$
BOC - MOC1	TLCO 3.3.13.a or b	1.36	1.50
MOC1 - MOC2	TLCO 3.3.13.a or b	1.42	1.56
MOC2 - EOC	TLCO 3.3.13.a or b	1.47	1.61
BOC - EOC	TLCO 3.3.13.c	1.47	1.61

FIGURE 3-4A-4

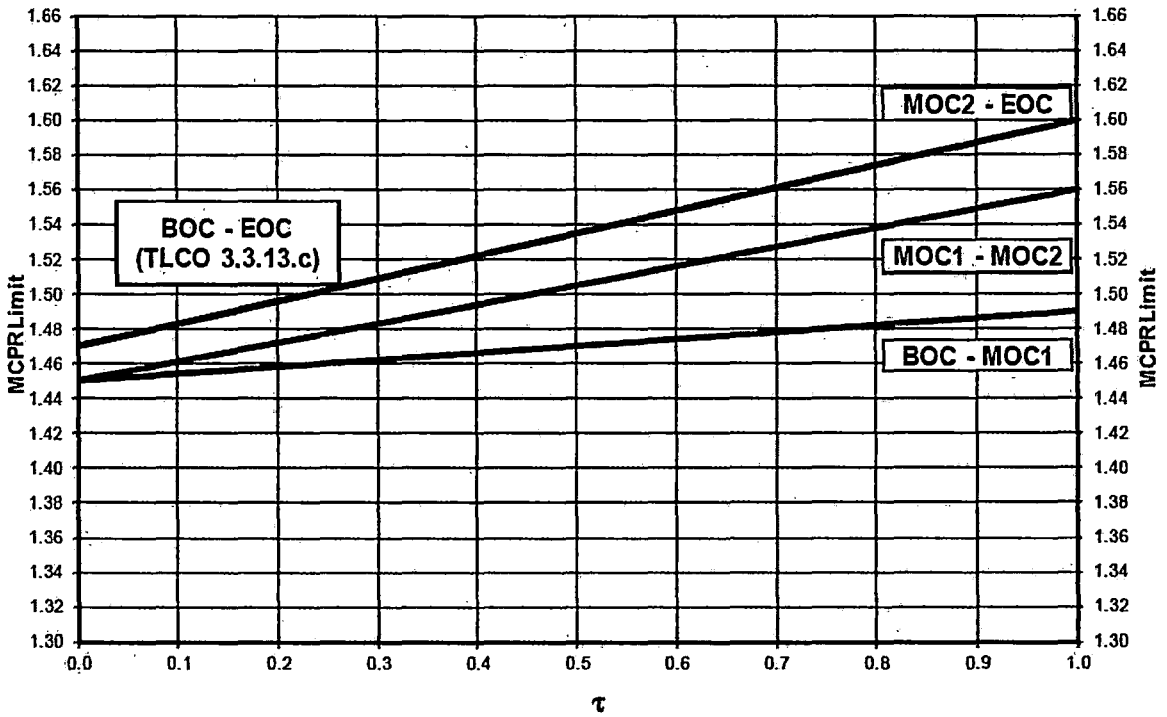
TLO MCPR Limits versus Average SCRAM Time
(EOC-RPT Out of Service and Main Turbine Bypass System Inoperable)



Exposure Range	Main Turbine Pressure Regulator Status	$OLMCPR_{(SLO)}$	
		$\tau = 0.0$	$\tau = 1.0$
BOC - MOC1	TLCO 3.3.13.a or b	1.45	1.45
MOC1 - MOC2	TLCO 3.3.13.a or b	1.45	1.52
MOC2 - EOC	TLCO 3.3.13.a or b	1.45	1.55
BOC - EOC	TLCO 3.3.13.c	1.45	1.55

FIGURE 3-4B-1

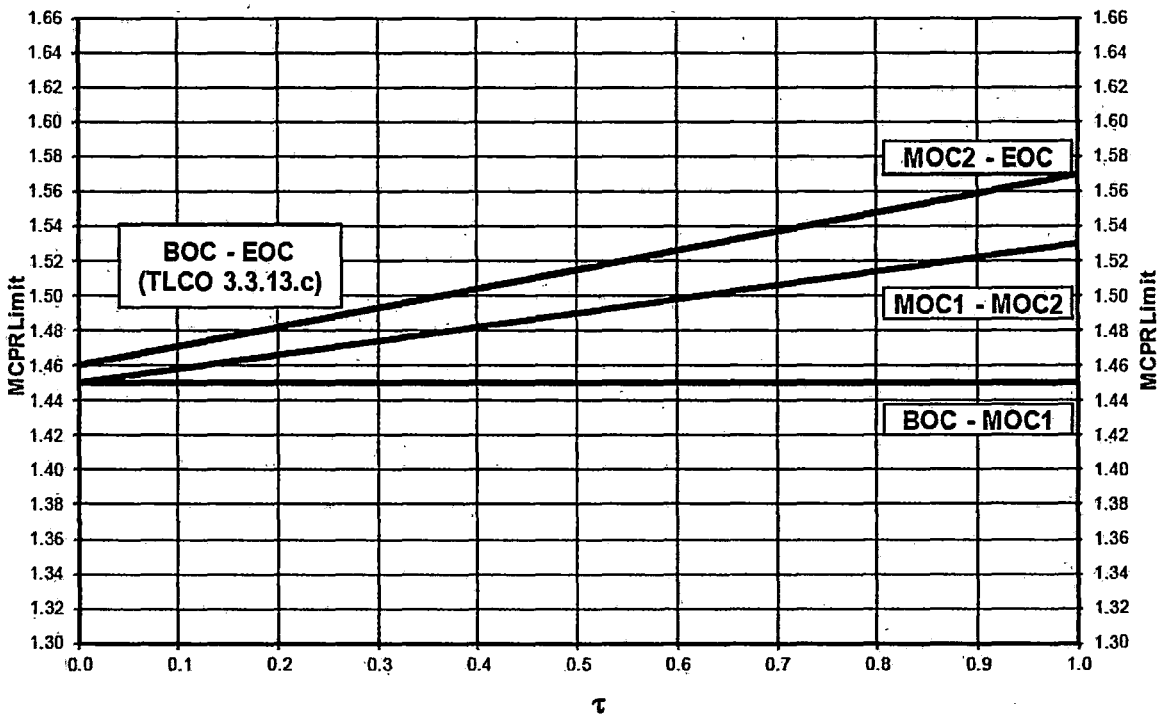
SLO MCPR Limits versus Average SCRAM Time



Exposure Range	Main Turbine Pressure Regulator Status	$OLMCPR_{(SLO)}$	
		$\tau = 0.0$	$\tau = 1.0$
BOC - MOC1	TLCO 3.3.13.a or b	1.45	1.49
MOC1 - MOC2	TLCO 3.3.13.a or b	1.45	1.56
MOC2 - EOC	TLCO 3.3.13.a or b	1.47	1.60
BOC - EOC	TLCO 3.3.13.c	1.47	1.60

FIGURE 3-4B-2

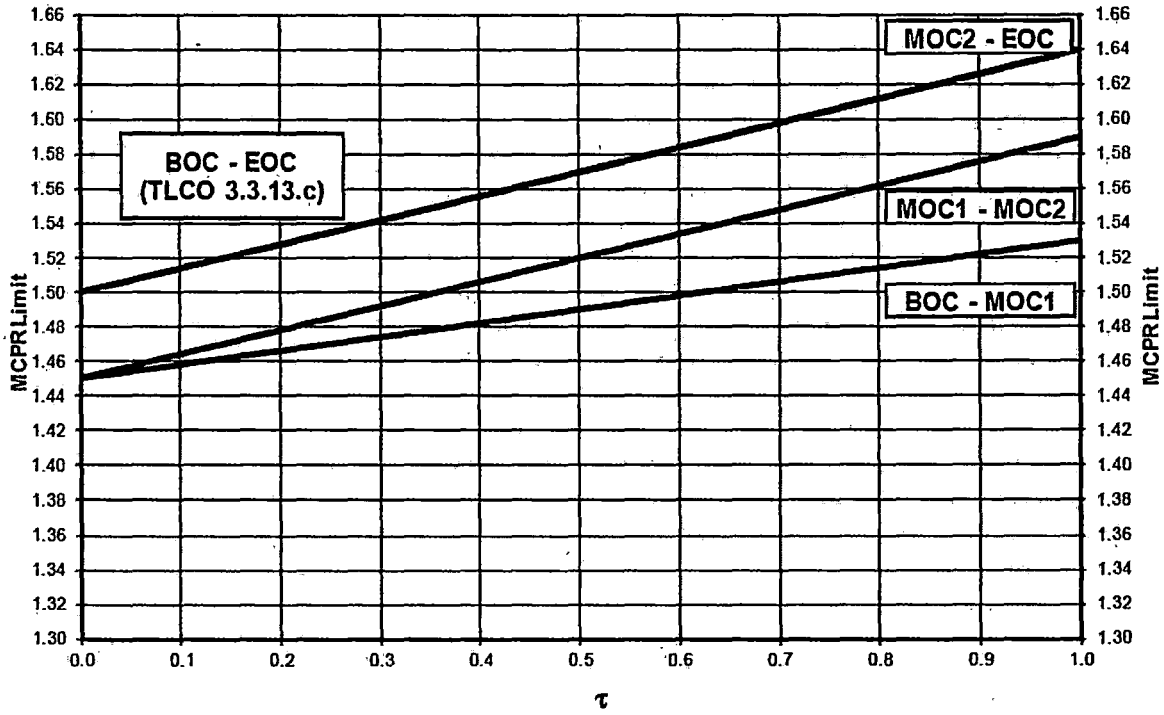
SLO MCPR Limits versus Average SCRAM Time
(EOC-RPT Out of Service)



Exposure Range	Main Turbine Pressure Regulator Status	$OLMCPR_{(SLO)}$	
		$\tau = 0.0$	$\tau = 1.0$
BOC - MOC1	TLCO 3.3.13.a or b	1.45	1.45
MOC1 - MOC2	TLCO 3.3.13.a or b	1.45	1.53
MOC2 - EOC	TLCO 3.3.13.a or b	1.46	1.57
BOC - EOC	TLCO 3.3.13.c	1.46	1.57

FIGURE 3-4B-3

SLO MCPR Limits versus Average SCRAM Time
(Main Turbine Bypass System Inoperable)



Exposure Range	Main Turbine Pressure Regulator Status	$OLMCPR_{(SLO)}$	
		$\tau = 0.0$	$\tau = 1.0$
BOC - MOC1	TLCO 3.3.13.a or b	1.45	1.53
MOC1 - MOC2	TLCO 3.3.13.a or b	1.45	1.59
MOC2 - EOC	TLCO 3.3.13.a or b	1.50	1.64
BOC - EOC	TLCO 3.3.13.c	1.50	1.64

FIGURE 3-4B-4

SLO MCPR Limits versus Average SCRAM Time
(EOC-RPT Out of Service and Main Turbine Bypass System Inoperable)

4.0 LHGR LIMITS (Technical Specification 3.2.3)

For both two loop operation (TLO) and single loop operation (SLO), the LHGR limit for each six inch axial segment of each fuel rod in the core is the applicable rated-power, rated-flow LHGR limit taken from Table 4-1 multiplied by the smaller of either:

a. The flow-dependent multiplier, $LHGRFAC_F$, as determined by Table 4-2,

OR

c. The power-dependent multiplier, $LHGRFAC_P$, as determined by Figure 4-2.

Table 4-1 shows the exposure-dependent LHGR limits for all fuel types in the core, as a function of initial gadolinium concentration in a six inch segment of a fuel rod. For exposures between the values shown in Table 4-1, the LHGR limit is based on linear interpolation. For illustration purposes, Figures 4-3A and 4-3B show the LHGR limits for fuel segments with the lowest (UO_2) and highest (UO_2+Gd_2O_3) initial Gd concentrations.

TABLE 4-1

LHGR Limits versus Peak Pellet Exposure

Fuel Type	Rod Segment Initial Wt-% Gd_2O_3	Pellet Maximum Power (kW/ft)	Pellet Exposure Knee 1 (GWd/ST)	Pellet Power Knee 2 (kW/ft)	Pellet Exposure Knee 2 (GWd/ST)	Pellet Power EOL (kW/ft)	Pellet Exposure EOL (GWd/ST)
GE14C	[[						
							]]
GNF2	[[						
							]]

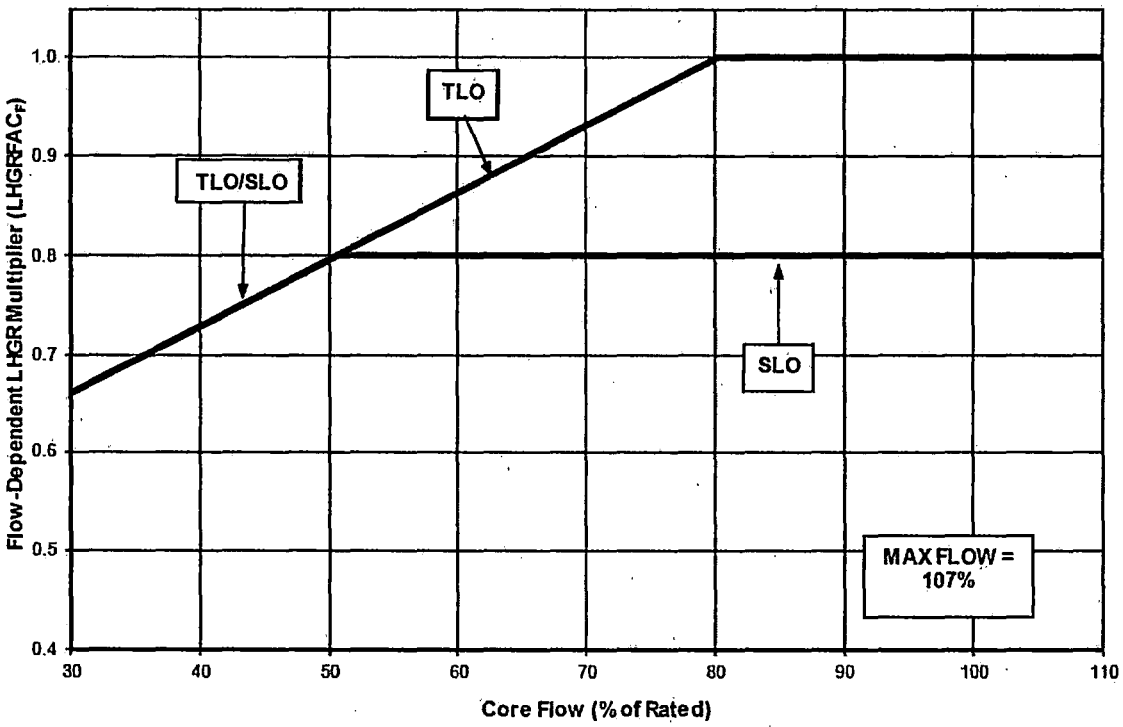
EOL = End of Life (maximum licensed pellet exposure)

TABLE 4-2

Flow-Dependent LHGR Operating Flexibility Options

$LHGRFAC_F$				
Fuel Type	**Equipment In or Out of Service**			**Figure #**
	EOC-RPT System In Service	Main Turbine Bypass System Operable*	Main Turbine Pressure Regulator System Status	
GE14C	Yes/No	Yes/No	TLCO 3.3.13.a or b or c	4-1A
GNF2	Yes/No	Yes	TLCO 3.3.13.a or b or c	4-1B
GNF2	Yes/No	No	TLCO 3.3.13.a or b or c	4-1C

* At least two bypass valves must be operable



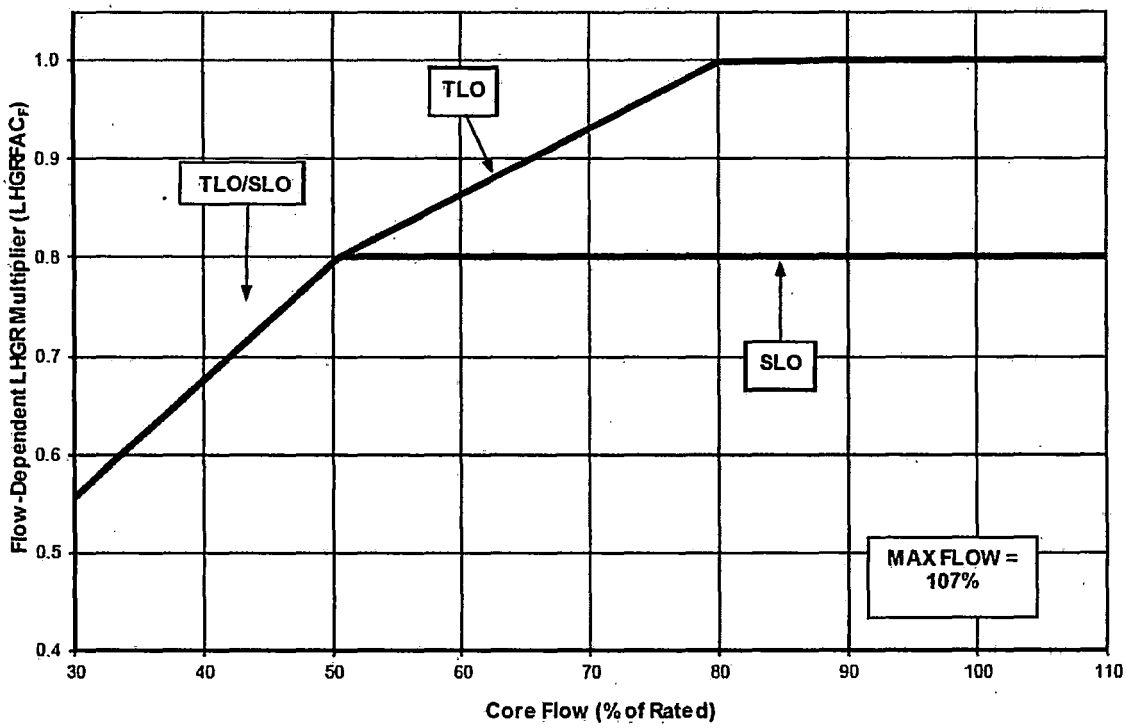
$LHGRFAC_F = A + B*F$

Operating Conditions		Values of Variables	
F	TLO / SLO	A	B
$30.00 \le F < 50.70$	TLO / SLO	0.4574	0.006758
$50.70 \le F < 80.29$	TLO	0.4574	0.006758
$50.70 \le F$	SLO	0.8000	0.000000
$80.29 \le F$	TLO	1.0000	0.000000

F = Percent of Rated Core Flow

FIGURE 4-1A

GE14C Flow-Dependent LHGR Multiplier ($LHGRFAC_F$) versus Core Flow



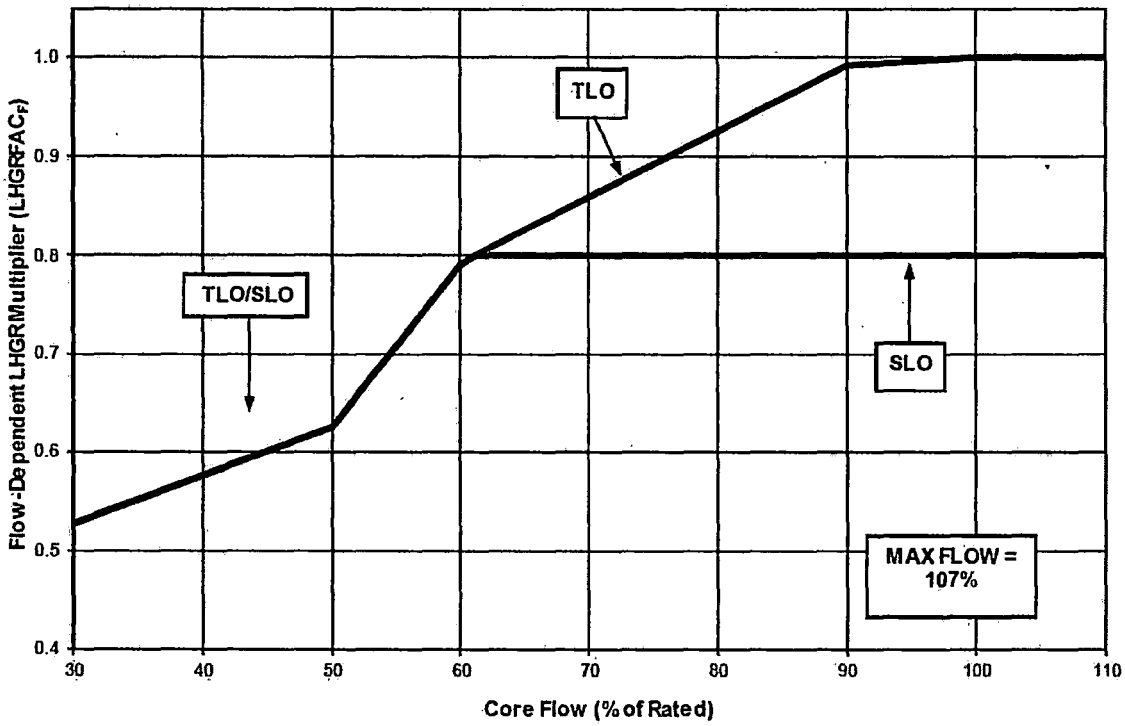
$LHGRFAC_F = A + B*F$

Operating Conditions		Values of Variables	
F	TLO / SLO	A	B
30.0 ≤ F < 50.0	TLO / SLO	0.2000	0.01190
50.0 ≤ F < 50.7	TLO / SLO	0.4567	0.00677
50.7 ≤ F < 80.0	TLO	0.4567	0.00677
50.7 ≤ F	SLO	0.8000	0.00000
80.0 ≤ F < 90.0	TLO	0.9820	0.00020
90.0 ≤ F	TLO	1.0000	0.00000

F = Percent of Rated Core Flow

FIGURE 4-1B

GNF2 Flow-Dependent LHGR Multiplier ($LHGRFAC_F$) versus Core Flow



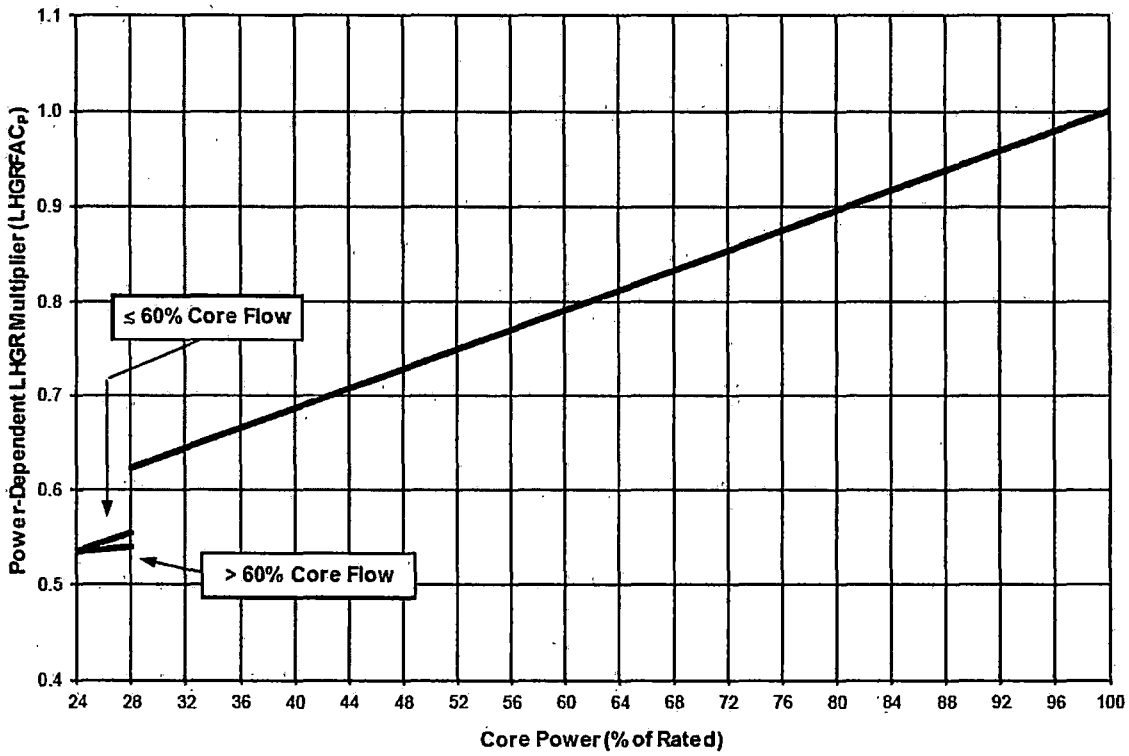
$LHGRFAC_F = A + B*F$

Operating Conditions		Values of Variables	
F	TLO / SLO	A	B
30.0 ≤ F < 50.0	SLO / TLO	0.380	0.0049
50.0 ≤ F < 60.0	SLO / TLO	-0.210	0.0167
60.0 ≤ F < 61.2	SLO / TLO	0.390	0.0067
61.2 ≤ F	SLO	0.800	0.0000
61.2 ≤ F < 90.0	TLO	0.390	0.0067
90.0 ≤ F < 100.0	TLO	0.930	0.0007
100.0 ≤ F	TLO	1.000	0.0000

F = Percent of Rated Core Flow

FIGURE 4-1C

GNF2 Flow-Dependent LHGR Multiplier ($LHGRFAC_F$) versus Core Flow
(Main Turbine Bypass System Inoperable)



$LHGRFAC_P = A + B*P$

Operating Conditions		Values of Variables	
P	F	A	B
24 ≤ P < 28	> 60	0.5050	0.001250
24 ≤ P < 28	≤ 60	0.4150	0.005000
28 ≤ P	All	0.4776	0.005224

P = Percent of Rated Core Thermal Power

F = Percent of Rated Core Flow

FIGURE 4-2

Power-Dependent LHGR Multiplier ($LHGRFAC_P$) versus Core Power

[[

]]

FIGURE 4-3A

GE14C LHGR versus Peak Pellet Exposure

[[

]]

FIGURE 4-3B

GNF2 LHGR versus Peak Pellet Exposure

5.0 PBDA AMPLITUDE SETPOINT

The amplitude trip setpoint in the Period Based Detection Algorithm in the OPRM system must be set equal to one of the licensed values reported in Table 5-1. This applies to instruments 1C51K615 A, B, C, and D.

TABLE 5-1

Licensed OPRM Setpoints

OPRM Setpoint
1.11
1.15

6.0 REFERENCES

1. NEDE-24011-P-A-22, "General Electric Standard Application for Reactor Fuel," November 2015, and the US Supplement, NEDE-24011-P-A-22-US, November 2015.

2. Global Nuclear Fuel Document GNF-003N1938-00, "Hatch 1 Cycle 28 Compliance to PRIME Limitations and Conditions," November 2015.

3. Global Nuclear Fuel Document 003N2016-SRLR, "Supplemental Reload Licensing Report for Hatch 1, Reload 27 Cycle 28," Revision 0, November 2015.

4. Global Nuclear Fuel Document 003N2033-FBIR, "Fuel Bundle Information Report for Hatch 1, Reload 27 Cycle 28," Revision 0, November 2015.

5. SNC Nuclear Fuel Document NFD-H-15-120 "Hatch-1 Cycle 28 Reload Licensing Analysis Report," Version 1, November 2015.

6. GNF Document DB-0012.05, "Fuel Rod Thermal-Mechanical Performance Limits for GE14 and GNF2," Revision 4, April 2014.