FERMI 2

CORE OPERATING LIMITS REPORT

CYCLE 4

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1.0 INTRODUCTION AND SUMMARY

This report provides the cycle specific plant operating limits, which are listed below, for Fermi 2, Cycle 4, as required by Technical Specifications 6.9.3. The analytical methods used to determine these core operating limits are those previously reviewed and approved by the Nuclear Regulatory Commission in GESTAR II.[1,2,3,4]

For the SVEA-96 lead fuel assemblies, an evaluation of the differences between SVEA-96 and the Cycle 3 GE9 reload bundles has been performed.[5] This evaluation determined the necessary adjustments which were needed to account for the physical differences between the two bundle types.

The cycle specific limits contained within this report are valid for the full range of the Maximum Extended Operating Domain (MEOD).[6,7]

OPERATING LIMIT	TECHNICAL SPECIFICATION
APLHGR	3/4.2.1
MCPR	3/4.2.3
LHGR	3/4.2.4
RBM	3/4.3.6

APLHGR = AVERAGE PLANAR LINEAR HEAT GENERATION RATE

MCPR = MINIMUM CRITICAL POWER RATIO

LHGR = LINEAR HEAT GENERATION RATE

RBM = ROD BLOCK MONITOR SETPOINTS

2.0 AVERAGE PLANAR LINEAR HEAT GENERATION RATE

TECH SPEC IDENT	OPERATING LIMIT
3/4.2.1	APLHGR

2.1 Definition

The AVERAGE PLANAR LINEAR HEAT GENERATION RATE (APLHGR) shall be applicable to a specific planar height and is equal to averaging the LINEAR HEAT GENERATION RATE over each fuel rod in the plane.

2.2 Determination of MAPLHGR Limit

The maximum APLHGR (MAPLHGR) limit is a function of reactor power, core flow, lattice type, and average planar exposure. The limit is developed to ensure gross cladding failure will not occur following a loss of coolant accident (LOCA) and that fuel thermal-mechanical design criteria will not be violated during any postulated transient events. The MAPLHGR limit ensures that the peak clad temperature during a LOCA will not exceed the limits as specified in 10CFR50.46(b)(1) and that the fuel design analysis criteria defined in References 1 and 2 will be met.

The MAPLHGR limit is calculated by the following equation:

$$MAPLHGR_{limit} = MIN\ (MAPLHGR(P),\ MAPLHGR(F)\ )$$

where:

$$MAPLHGR(P) = MAPFAC(P) * MAPLHGR_{STD}$$

$$MAPLHGR(F) = MAPFAC(F) * MAPLHGR_{STD}$$

$MAPLHGR_{STD}$, the standard MAPLHGR limit, is defined at a power of 3430 MWt and flow of 105 Mlbs/hr for each fuel type as a function of average planar exposure and is presented in Table 1. Since fuel types may contain more than one lattice type (axially), Table 1 represents the most limiting lattice type at each exposure point for that fuel type. When hand calculations are required as specified in Technical Specification 3/4.2.1, $MAPLHGR_{STD}$ shall be determined by interpolation from Table 1.

MAPFAC(P), the [illegible]e power-dependent MAPLHGR limit adjustment factor, shall be calculated by using Section 2.2.1.

MAPFAC(F), the core flow-dependent MAPLHGR limit adjustment factor, shall be calculated by using Section 2.2.2.

TABLE 1 FUEL TYPE-DEPENDENT STANDARD MAPLHGR LIMITS

Standard MAPLHGR Limit (KW/FT)

Exposure (GWD/ST)	Fuel Type 1	2	3	4	5	6	7	8
0.0			12.02	11.99	10.82	10.84	10.82	[illegible].73
0.2	12.00	11.90			10.90	10.92	10.90	[illegible]79
1.0	12.10	12.00	12.14	12.10	11.10	11.11	11.10	[illegible]
2.0					11.36	11.38	11.36	[illegible]
3.0					11.64	11.66	11.64	[illegible]
4.0					[illegible].94	11.88	11.94	12.2[illegible]
5.0	12.70	[illegible]	12.93	12.79	12.17	12.02	12.17	12.30
6.0					[illegible]2.30	12.18	12.30	12.40
7.0					[illegible]48	12.38	12.48	12.51
[illegible]			13.28	13.1[illegible]	12.68	12.61	12.68	12.62
[illegible]					1[illegible].88	12.84	12.88	12.68
[illegible]	12.80	1[illegible].20	13.34	13.34	13.04	13.02	13.04	12.70
12.5			13.33	13.32	13.07	13.07	13.07	12.57
15.0	12.90	12.20	13.02	13.02	12.83	12.83	12.83	12.17
17.5								11.78
20.0	12.70	12.10			12.18	12.18	12.18	[illegible]
25.0	11.70	11.60	11.75	11.75	11.54	11.54	11.54	[illegible]
30.0	10.80	11.20						9.[illegible]
35.0					10.26	10.26	10.26	[illegible].24
40.0	9.00	9.30						8.62
45.0			9.05	9.04	8.76	8.72	8.76	8.03
50.0			6.64	6.63				7.45
50.66						5.88		
50.76					5.88		5.88	
55.0								6.84
56.83								6.60

Fuel Types

1 = P8CIB176-4GZ-100M-150-T
2 = P8CIB219-4GZ-100M-150-T
3 = GE8B-P8CQB318-7GZ-100M-4WR-150-T
4 = GE8B-P8CQB318-7GZ1-100M-4WR-150-T
5 = GE9B-P8CWB321-9GZ-80M-150-T
6 = GE9B-P8CWB321-10GZ-80M-150-T
7 = SVEA-96
8 = GE11-P9CUB331-11GZ-100M-146-T

2.2.1 Calculation of MAPFAC(P)

The core power-dependent MAPLHGR limit adjustment factor, MAPFAC(P), shall be calculated by one of the following equations:

For $0 \leq P < 25$:

No thermal limits monitoring is required.

For $25 \leq P < 30$:

<u>With turbine bypass OPERABLE,</u>

For core flow $\leq$ 50 Mlbs/hr,

$$MAPFAC(P) = 0.606 + 0.0038(P-30)$$

For core flow $>$ 50 Mlbs/hr,

$$MAPFAC(P) = 0.586 + 0.0038(P-30)$$

<u>With turbine bypass INOPERABLE,</u>

For core flow $\leq$ 50 Mlbs/hr,

$$MAPFAC(P) = 0.490 + 0.0050(P-30)$$

For core flow $>$ 50 Mlbs/hr,

$$MAPFAC(P) = 0.438 + 0.0050(P-30)$$

For $30 \leq P \leq 100$:

$$MAPFAC(P) = 1.0 + 0.005224(P-100)$$

where: P = Core power (fraction of rated power times 100).

2.2.2 Calculation of MAPFAC(F)

The core flow-dependent MAPLHGR limit adjustment factor, MAPFAC(F), shall be calculated by the following equation:

$$MAPFAC(F) = MIN\ (1.0,\ A_F * \frac{WT}{100} + B_F)$$

where:

- WT = Core flow (Mlbs/hr).
- A_F = Given in Table 2.
- B_F = Given in Table 2.

TABLE 2 FLOW-DEPENDENT MAPLHGR LIMIT COEFFICIENTS

Maximum Core Flow (Mlbs/hr)	A_F	B_F
117.0	0.6886	0.3828
112.0	0.6807	0.4214
110.0	0.6800	0.4340
107.0	0.6758	0.4574
102.5	0.6784	0.4861

3.0 MINIMUM CRITICAL POWER RATIO

TECH SPEC IDENT	OPERATING LIMIT
3/4.2.3	MCPR

3.1 Definition

The CRITICAL POWER RATIO (CPR) shall be the ratio of that power in the assembly which is calculated by application of an NRC approved critical power correlation to cause some point in the assembly to experience boiling transition, divided by the actual assembly operating power.

The MINIMUM CRITICAL POWER RATIO (MCPR) shall be the smallest CPR that exists in the core.

3.2 Determination of Operating Limit MCPR

The required Operating Limit MCPR (OLMCPR) at steady-state rated power and flow operating conditions is derived from the established fuel cladding integrity Safety Limit MCPR of 1.07 and an analysis of abnormal operational transients. To ensure that the Safety Limit MCPR is not exceeded during any anticipated abnormal operational transient, the most limiting transients have been analyzed to determine which event will cause the largest reduction in CPR. Two different core average exposure conditions are evaluated. The result is an Operating Limit MCPR which is a function of exposure and τ. τ is a measure of scram speed, and is defined in Technical Specification Section 3/4.2.3.

The OLMCPR shall be calculated by the following equation:

$$OLMCPR = MAX\ (MCPR(P),\ MCPR(F))$$

MCPR(P), the core power-dependent MCPR operating limit, shall be calculated using Section 3.3.

MCPR(F), the core flow-dependent MCPR operating limit, shall be calculated using Section 3.4.

In case of **single loop operation**, the Safety Limit MCPR is increased by 0.01, but OLMCPR does not change.

3.3 Calculation of MCPR(P)

MCPR(P), the core power-dependent MCPR operating limit, shall be calculated by the following equation:

$$MCPR(P) = K_p * OLMCPR_{100/105}$$

$OLMCPR_{100/105}$ shall be determined by interpolation from Table 3, and τ shall by calculated by using Technical Specification Section 3/4.2.3.

K_p, the core power-dependent MCPR Operating Limit adjustment factor, shall be calculated by using Section 3.3.1.

TABLE 3 $OLMCPR_{100/105}$ AS A FUNCTION OF EXPOSURE AND τ

CONDITION	EXPOSURE (MWD/ST)		$OLMCPR_{100/105}$ 8X8 GE6, GE8, GE9	9X9 GE11	10X10 SVEA-96
Both Turbine Bypass and Moisture Separator Reheater **OPERABLE**	BOC to 7000	$\tau = 0$	1.26	1.32	1.53
		$\tau = 1$	1.28	1.38	1.55
	7000 to EOC	$\tau = 0$	1.28	1.38	1.55
		$\tau = 1$	1.32	1.46	1.62
Either Turbine Bypass or Moisture Separator Reheater **INOPERABLE**	BOC to EOC	$\tau = 0$	1.32	1.41	1.62
		$\tau = 1$	1.36	1.49	1.69
Both Turbine Bypass and Moisture Separator Reheater **INOPERABLE**	BOC to EOC	$\tau = 0$	1.34	1.44	1.65
		$\tau = 1$	1.37	1.52	1.70

3.. .1 Calculation of K_p

The core power-dependent MC.?R operating limit adjustment factor, K_p, shall be calculated by using one of the following equations:

For $0 \leq P < 25$:

No thermal limits monitoring is required.

For $25 \leq P < 30$:

When turbine bypass is OPERABLE,

$$K_P = \frac{K_{BYP} + (0.026 * (30-P))}{OLMCPR_{100/105}}$$

where: K_{BYP} = 1.9C **for core flow ≤ 50 Mlbs/hr**
= 2.23 **for core flow > 50 Mlbs/hr**

When turbine bypass is INOPERABLE,

$$K_P = \frac{K_{BYP} + (0.054 * (30-P))}{OLMCPR_{100/105}}$$

where: K_{BYP} = 2.2C **for core flow ≤ 50 Mlbs/hr**
= 3.03 **for core flow > 50 Mlb./hr**

For $30 \leq P < 45$:

$$K_P = 1.28 + (0.0134 * (45-P))$$

For $45 \leq P < 60$:

$$K_P = 1.15 + (0.00867 * (60-P))$$

For $60 \leq P \leq 100$:

$$K_P = 1.0 + (0.00375 * (100-P))$$

where: P = Core power (fraction of rated power times 100).

3.4 Calculation of MCPR(F)

MCPR(F), the core flow-dependent MCPR operating limit, shall be calculated by using one of the following equations:

For WT < 40 :

$$MCPR(F) = (A_F * \frac{WT}{100} + B_F) * (1.0 + 0.0032*(40-WT))$$

For WT $\geq$ 40 :

$$MAX\ (1.20,\ A_F * \frac{WT}{100} + B_F)$$

where: WT = Core flow (Mlbs/hr).

A_F = Given in Table 4.

B_F = Given in Table 4.

TABLE 4 FLOW-DEPENDENT MCPR LIMIT COEFFICIENTS

Maximum Core Flow (Mlbs/hr)	A_F	B_F
117.0	-0.632	1.809
112.0	-0.602	1.747
110.0	-0.600	1.731
[illegible]	-0.586	1.697
102.5	-0.571	1.655

4.0 LINEAR HEAT GENERATION RATE

TECH SPEC IDENT	OPERATING LIMIT
3/4.2.4	LHGR

4.1 Definition

The LINEAR HEAT GENERATION RATE (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.

4.2 Determination of LHGR Limit

The thermal expansion rates of UO_2 pellets and Zircaloy cladding are different in that, during heatup, the fuel pellet could come into contact with the cladding and create stress. By maintaining the operating LHGR below the limits stated in Table 5 and the operating MAPLHGR below those stated in Section 2.0, it is assured that all thermal-mechanical design bases and licensing limits for the fuel will be satisfied.

TABLE 5 LHGR LIMITS FOR VARIOUS FUEL TYPES

FUEL TYPE	LHGR LIMIT
P8CIB176-4GZ-100M-150-T	13.4 KW/FT
P8CIB219-4GZ-100M-150-T	13.4 KW/FT
GE8B-P8CQB318-7GZ-100M-4WR-150-T	14.4 KW/FT
GE8B-P8CQB318-7GZ1-100M-4WR-150-T	14.4 KW/FT
GE9B-P8CWB321-9GZ-80M-150-T	14.4 KW/FT
GE9B-P8CWB321-10GZ-80M-150-T	4.4 KW/FT
GE11-P9CUB331-11GZ-100M-146-T	14.4 KW/FT
SVEA-96	14.4 KW/FT

5.0 CONTROL ROD BLOCK INSTRUMENTATION

TECH SPEC IDENT	SETPOINT
3/4.3.6	RBM

5.1 Definition

The nominal trip setpoints and allowable values of the control rod withdrawal block instrumentation for use in Technical Specification 3/4.3.6 are shown in Table 6. These values are consistent with the bases of the APRM Rod Block Technical Specification Improvement Program (ARTS) and the MCPR operating limits.

TABLE 6 CONTROL ROD BLOCK INSTRUMENTATION SETPOINTS WITH FILTER

Setpoint	Trip Setpoint	Allowable Value
LPSP	27.0	28.6
IPSP	62.0	63.6
HPSP	82.0	83.6
LTSP	117.0	118.8
ITSP	112.2	114.0
HTSP	107.2	109.0
DTSP	94.0	92.3

where:

- LPSP Low power setpoint; Rod Block Monitor (RBM) System trip automatically bypassed below this level
- IPSP Intermediate power setpoint
- HPSP High power setpoint
- LTSP Low trip setpoint
- ITSP Intermediate trip setpoint
- HTSP High trip setpoint
- DTSP Downscale trip setpoint

6.0 REFERENCES

1. "General Electric Standard Application for Reactor Fuel (GESTAR II)," NEDE-24011-P-A, Revision 10.

2. "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-of-Coolant Accident - SAFER/GESTR Application Methodology," NEDE 23785-1-PA, Revision 1, October 1984.

3. "Fermi-2 SAFER/GESTR-LOCA, Loss-of-Coolant Accident Analysis," NEDC-31982P, July 1991, Errata and Addenda, April 1992.

4. "Supplemental Reload Licensing Submittal for Fermi Power Plant Unit 2 Reload 3, Cycle 4," GE Nuclear Energy, 23A7175, Revision 0, April 1992.

5. "Supplemental Lead Fuel Assembly Licensing Report, SVEA-96 LFAs to Fermi-2 Summary," ABB Atom, BR 90-003, October 1990.

6. Letter from G. D. Plotycia to J. E. Morrison, "Fermi-2, Cycle 4 Reanalysis with Modified Turbine Control Valve Position," GDP:92-198, September 10, 1992.

7. Letter from T. G. Colburn to W. S. Orser, "FERMI-2 - AMENDMENT NO. 87 TO FACILITY OPERATING LICENSE NO. NPF-43 (TAC NO. M82102)," September 9, 1992.