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Fermi 2

Technical Requirements Manual

Volume I

Detroit
Edison

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FERMI 2

CORE OPERATING LIMITS REPORT

CYCLE 10

REVISION 1

Prepared by:	B. L. Myers Technical Expert - Nuclear Fuel	8/25/2004 Date
Reviewed by:	T. W. Morrison Station Nuclear Engineer	8/25/2004 Date
	P. R. Kiel COLR Checklist Reviewer	8/25/04 Date
Approved by:	TMFR-04-0138 for R. A. Gailliez Supervisor - Reactor Engineering	8/25/04 Date

August 2004

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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 10, as required by Technical Specification 5.6.5. The analytical methods used to determine these core operating limits are those previously reviewed and approved by the Nuclear Regulatory Commission in GESTAR II.

The cycle specific limits contained within this report are valid for the full range of the licensed operating domain.

OPERATING LIMIT	TECHNICAL SPECIFICATION
APLHGR	3.2.1
MCPR	3.2.2
LHGR	3.2.3
RBM	3.3.2.1

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
3.2.1	APLHGR

2.1 Definition

The AVERAGE PLANAR LINEAR HEAT GENERATION RATE (APLHGR) shall be applicable to a specific planar height and is equal to the sum of the LINEAR HEAT GENERATION RATEs (LHGRs) for all the fuel rods in the specified bundle at the specified height divided by the number of fuel rods in the fuel bundle at the height.

2.2 Determination of MAPLHGR Limit

The maximum APLHGR (MAPLHGR) limit is a function of reactor power, core flow, fuel type, and average planar exposure. The limit is developed, using NRC approved methodology described in References 1 and 2, to ensure gross cladding failure will not occur following a loss of coolant accident (LOCA). 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 during dual loop operation is calculated by the following equation:

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

where:

$$MAPLHGR\ (P) = MAPFAC\ (P) \times MAPLHGR_{STD}$$

$$MAPLHGR\ (F) = MAPFAC\ (F) \times MAPLHGR_{STD}$$

Within four hours after entering single loop operation, the MAPLHGR limit is calculated by the following equation:

$$MAPLHGR_{LIMIT} = \text{MIN}\ (MAPLHGR\ (P),\ MAPLHGR\ (F),\ MAPLHGR\ (SLO))$$

where:

$$MAPLHGR\ (SLO) = 0.73 \times MAPLHGR_{STD}$$

$MAPLHGR_{STD}$, 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. When hand calculations are required, $MAPLHGR_{STD}$ shall be determined by interpolation from Table 1. MAPFAC(P), the core 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

Exposure GWD/ST	MAPLHGR KW/FT
0.0	13.42
19.72	13.42
27.22	12.29
63.50	8.90

This MAPLHGR Limit Array applies to all Cycle 10 fuel

Fuel Types

14 = GE11-P9CUB380-12GZ-100T-146-T6
15 = GE11-P9CUB378-4G6/8G5-100T-146-T6-3955
16 = GE11-P9CUB396-13GZ-100T-146-T6-3954
17 = GE11-P9CUB380-11GZ-100T-146-T6-2542
18 = GE11-P9CUB404-12GZ-100T-146-T6-2543
19 = GE11-P9CUB408-12GZ-100T-146-T6-2604
20 = GE11-P9CUB380-12GZ-100T-146-T6-2605

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 ≤ 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 ≤ 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:

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

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
110	0.67874	0.4358

*As limited by the Recirculation System MG Set mechanical scoop tube stop setting.

3.0 MINIMUM CRITICAL POWER RATIO

TECH SPEC IDENT	OPERATING LIMIT
3.2.2	MCPR

3.1 Definition

The MINIMUM CRITICAL POWER RATIO (MCPR) shall be the smallest Critical Power Ratio (CPR) that exists in the core for each type of fuel. The CPR is that power in the assembly that is calculated by application of the appropriate correlation(s) to cause some point in the assembly to experience boiling transition, divided by the actual assembly operating power.

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 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. Three 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 Section 3.3.2.

The OLMCPR shall be calculated by the following equation:

$$OLMCPR = \mathrm{MAX}(MCPR(P), MCPR(F))$$

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 to account for increased uncertainties in core flow measurement and TIP measurement, but the OLMCPR does not change. This is due to the fact that sufficient conservatism exists in the power-dependent MCPR operating limits to allow for the increase in the SLMCPR without requiring a corresponding increase in the OLMCPR.

3.3 Calculation of MCPR(P)

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

$$MCPR(P) = K_P \times OLMCPR_{100/105}$$

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

$OLMCPR_{100/105}$ shall be determined by interpolation from Table 3, and τ shall be calculated by using Section 3.3.2.

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

CONDITION	EXPOSURE (MWD/ST)		$OLMCPR_{100/105}$
Both Turbine Bypass and Moisture Separator Reheater OPERABLE	BOC to 8800	$\tau = 0$	1.30
		$\tau = 1$	1.37
	8800 to 10300	$\tau = 0$	1.32
		$\tau = 1$	1.39
	10300 to EOC	$\tau = 0$	1.35
		$\tau = 1$	1.46
Either Turbine Bypass or Moisture Separator Reheater INOPERABLE	BOC to EOC	$\tau = 0$	1.40
		$\tau = 1$	1.51
Both Turbine Bypass and Moisture Separator Reheater INOPERABLE	BOC to EOC	$\tau = 0$	1.43
		$\tau = 1$	1.54

3.3.1 Calculation of K_P

The core power-dependent MCPR 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,

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

where: K_{BYP} **= 1.92 for core flow $\leq$ 50 Mlbs/hr**
= 2.25 for core flow > 50 Mlbs/hr

When turbine bypass is INOPERABLE,

$$K_P = \frac{(K_{BYP} + (0.055 \times (30 - P)))}{OLMCPR_{100/105}}$$

where: K_{BYP} **= 2.28 for core flow $\leq$ 50 Mlbs/hr**
= 3.06 for core flow > 50 Mlbs/hr

For $30 \leq P < 45$:

$$K_P = 1.28 + (0.0134 \times (45 - P))$$

For $45 \leq P < 60$:

$$K_P = 1.15 + (0.00867 \times (60 - P))$$

For $60 \leq P \leq 100$:

$$K_P = 1.0 + (0.00375 \times (100 - P))$$

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

3.3.2 Calculation of τ

The value of τ, which is a measure of the conformance of the actual control rod scram times to the assumed average control rod scram time in the reload licensing analysis, shall be calculated by using the following equation:

$$\tau = \frac{(\tau_{ave} - \tau_B)}{\tau_A - \tau_B}$$

where: τ_A = 1.096 seconds

$$\tau_B = 0.830 + 0.019 \times 1.65 \sqrt{\frac{N_1}{\sum_{i=1}^{n} N_i}} \text{ seconds}$$

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

n = number of surveillance tests performed to date in cycle,

N_i = number of active control rods measured in the ith surveillance test,

τ_i = average scram time to notch 36 of all rods measured in the ith surveillance test, and

N_1 = total number of active rods measured in the initial control rod scram time test for the cycle (Technical Specification Surveillance Requirement 3.1.4.4).

The value of τ shall be calculated and used to determine the applicable $OLMCPR_{100/105}$ value from Table 3 within 72 hours of the conclusion of each control rod scram time surveillance test required by Technical Specification Surveillance Requirements 3.1.4.1, 3.1.4.2, and 3.1.4.4. Prior to performance of the initial scram time measurements for the cycle, a τ value of 1.0 shall be used to determine the applicable $OLMCPR_{100/105}$ value from Table 3.

3.4 Calculation of MCPR(F)

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

$$MCPR(F) = \mathrm{MAX}(1.21, (A_F \times \frac{WT}{100} + B_F))$$

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
110	-0.6012	1.743

*As limited by the Recirculation System MG Set mechanical scoop tube stop setting.

4.0 LINEAR HEAT GENERATION RATE

TECH SPEC IDENT	OPERATING LIMIT
3.2.3	LHGR

4.1 Definition

The LINEAR HEAT GENERATION RATE (LHGR) shall be the heat generation rate per unit length of fuel rod. It is the integral of the heat flux over the heat transfer area associated with the unit length. By maintaining the operating LHGR below the applicable LHGR limit, it is assured that all thermal-mechanical design bases and licensing limits for the fuel will be satisfied.

4.2 Determination of LHGR Limit

The maximum LHGR limit is a function of reactor power, core flow, fuel and rod type, and fuel rod nodal exposure. The limit is developed, using NRC approved methodology described in References 1 and 2, to ensure the cladding will not exceed its yield stress and that fuel thermal-mechanical design criteria will not be violated during any postulated transient events. The LHGR limit ensures the fuel mechanical design requirements as defined in References 1 and 2 will be met.

TABLE 5
STANDARD LHGR LIMITS FOR VARIOUS FUEL TYPES

Uranium Only Fuel Rods		Most Limiting Gadolinia Bearing Fuel Rods	
Exposure GWD/ST	LHGR KW/FT	Exposure GWD/ST	LHGR KW/FT
0.0	14.40	0.0	12.30
13.24	14.40	10.32	12.30
27.22	12.29	23.44	10.50
63.50	8.90	57.51	7.60

The LHGR Limit Arrays apply to all Cycle 10 fuel

Fuel Types

14 = GE11-P9CUB380-12GZ-100T-146-T6
15 = GE11-P9CUB378-4G6/8G5-100T-146-T6-3955
16 = GE11-P9CUB396-13GZ-100T-146-T6-3954
17 = GE11-P9CUB380-11GZ-100T-146-T6-2542
18 = GE11-P9CUB404-12GZ-100T-146-T6-2543
19 = GE11-P9CUB408-12GZ-100T-146-T6-2604
20 = GE11-P9CUB380-12GZ-100T-146-T6-2605

The LHGR limit during dual loop operation is calculated by the following equation:

$$LHGR_{LIMIT} = \text{MIN}\ (LHGR\ (P), LHGR\ (F))$$

where:

$$LHGR\ (P) = LHGRFAC\ (P) \times LHGR_{STD}$$

$$LHGR\ (F) = LHGRFAC\ (F) \times LHGR_{STD}$$

$LHGR_{STD}$, the standard LHGR limit, is defined at a power of 3430 MWt and flow of 105 Mlbs/hr for each fuel and rod type as a function of fuel rod nodal exposure and is presented in Table 5. Table 5 contains only the most limiting Gadolinia LHGR limit for the maximum allowed Gadolinia concentration of the applicable fuel product line. When hand calculations are required, $LHGR_{STD}$ shall be determined by interpolation from Table 5. LHGRFAC(P), the core power-dependent LHGR limit adjustment factor, shall be calculated by using Section 4.2.1. LHGRFAC(F), the core flow-dependent LHGR limit adjustment factor, shall be calculated by using Section 4.2.2.

4.2.1 Calculation of LHGRFAC(P)

The core power-dependent LHGR limit adjustment factor, LHGRFAC(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,

$$LHGRFAC(P) = 0.606 + 0.0038\ (P - 30)$$

For core flow > 50 Mlbs/hr,

$$LHGRFAC\ (P) = 0.586 + 0.0038\ (P - 30)$$

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

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

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

For core flow > 50 Mlbs/hr,

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

For $30 \leq P \leq 100$:

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

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

4.2.2 Calculation of LHGRFAC(F)

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

$$LHGRFAC(F) = \mathrm{MIN}(1.0,\ A_F \times \frac{WT}{100} + B_F)$$

where:

WT = Core flow (Mlbs/hr).
A_F = Given in Table 6.
B_F = Given in Table 6.

TABLE 6 FLOW-DEPENDENT LHGR LIMIT COEFFICIENTS

Maximum Core Flow* (Mlbs/hr)	A_F	B_F
110	0.67874	0.4358

*As limited by the Recirculation System MG Set mechanical scoop tube stop setting.

5.0 CONTROL ROD BLOCK INSTRUMENTATION

TECH SPEC IDENT	SETPOINT
3.3.2.1	RBM

5.1 Definition

The nominal trip setpoints and allowable values of the control rod withdrawal block instrumentation 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 7 CONTROL ROD BLOCK INSTRUMENTATION SETPOINTS WITH FILTER

Setpoint	Trip Setpoint	Allowable Value
LPSP	27.0	28.4
IPSP	62.0	63.4
HPSP	82.0	83.4
LTSP	117.0	118.9
ITSP	112.2	114.1
HTSP	107.2	109.1
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

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