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TMTRM	TRM VOL I	90		1	IR	08/04/08		AFC

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<u>Location</u>	<u>Remove</u>	<u>Insert</u>
In Front of TRM Manual	<u>Title Page Rev 89 06/05/08</u>	<u>Title Page Rev 90 08/04/08</u>
Immediately following Title Page	<u>List of Effective Pages LEP-1 through LEP- 4 Rev 89 06/05/08</u>	<u>List of Effective Pages LEP-1 through LEP- 4 Rev 90 08/04/08</u>
Core Operating Limits Report	<u>Cycle 13, Rev 0 06/05/08</u>	<u>Cycle 13, Rev 1 08/04/08</u>

END

Fermi 2

Technical Requirements Manual

Volume I

Detroit
Edison

<i>ARMS - INFORMATION</i>			
DTC: TMTRM	File: 1754	DSN: TRM VOL I	Rev: 90
Date 08/04/2008	Recipient 935		

FERMI 2 - TECHNICAL REQUIREMENTS MANUAL VOL I

LIST OF EFFECTIVE PAGES

<u>Page</u>	<u>Revision</u>	<u>Page</u>	<u>Revision</u>
TRM i	Revision 76	TRM 3.3-31	Revision 31
TRM ii	Revision 73	TRM 3.3-32	Revision 31
TRM iii	Revision 31	TRM 3.3-33	Revision 31
TRM iv	Revision 76	TRM 3.3-34	Revision 31
TRM v	Revision 79	TRM 3.3-35	Revision 60
TRM vi	Revision 31	TRM 3.3-36	Revision 41
TRM 1.0-a	Revision 31	TRM 3.3-37	Revision 72
TRM 1.0-1	Revision 31	TRM 3.3-38	Revision 31
TRM 2.0-1	Revision 31	TRM 3.3-39	Revision 31
TRM 3.0-a	Revision 31	TRM 3.3-40	Revision 56
TRM 3.0-1	Revision 63	TRM 3.3-41	Revision 56
TRM 3.0-2	Revision 72	TRM 3.3-42	Revision 45
TRM 3.0-3	Revision 54	TRM 3.3-43	Revision 62
TRM 3.0-4	Revision 72	TRM 3.3-44	Revision 72
TRM 3.1-a	Revision 31	TRM 3.3-45	Revision 31
TRM 3.1-1	Revision 31	TRM 3.3-46	Revision 31
TRM 3.2-1	Revision 31	TRM 3.3-47	Revision 31
TRM 3.3-a	Revision 31	TRM 3.3-48	Revision 31
TRM 3.3-b	Revision 31	TRM 3.3-49	Revision 31
TRM 3.3-c	Revision 31	TRM 3.4-a	Revision 31
TRM 3.3-d	Revision 31	TRM 3.4-1	Revision 36
TRM 3.3-1	Revision 34	TRM 3.4-1a	Revision 71
TRM 3.3-2	Revision 59	TRM 3.4-1b	Revision 71
TRM 3.3-3	Revision 31	TRM 3.4-2	Revision 31
TRM 3.3-4	Revision 31	TRM 3.4-3	Revision 31
TRM 3.3-5	Revision 31	TRM 3.4-4	Revision 31
TRM 3.3-6	Revision 31	TRM 3.4-5	Revision 31
TRM 3.3-7	Revision 31	TRM 3.4-6	Revision 31
TRM 3.3-8	Revision 31	TRM 3.4-7	Revision 31
TRM 3.3-9	Revision 31	TRM 3.4-8	Revision 31
TRM 3.3-10	Revision 31	TRM 3.4-9	Revision 31
TRM 3.3-11	Revision 31	TRM 3.4-10	Revision 31
TRM 3.3-12	Revision 67	TRM 3.5-1	Revision 31
TRM 3.3-13	Revision 74	TRM 3.6-a	Revision 70
TRM 3.3-13a	Revision 67	TRM 3.6-1	Revision 60
TRM 3.3-14	Revision 67	TRM 3.6-2	Revision 67
TRM 3.3-15	Revision 31	TRM 3.6-3	Revision 31
TRM 3.3-16	Revision 31	TRM 3.6-4	Revision 55
TRM 3.3-17	Revision 31	TRM 3.6-5	Revision 87
TRM 3.3-18	Revision 52	TRM 3.6-6	Revision 33
TRM 3.3-19	Revision 31	TRM 3.6-7	Revision 31
TRM 3.3-20	Revision 31	TRM 3.6-8	Revision 31
TRM 3.3-21	Revision 59	TRM 3.6-9	Revision 85
TRM 3.3-22	Revision 31	TRM 3.6-10	Revision 31
TRM 3.3-23	Revision 31	TRM 3.6-11	Revision 31
TRM 3.3-24	Revision 31	TRM 3.6-12	Revision 31
TRM 3.3-25	Revision 31	TRM 3.6-13	Revision 71
TRM 3.3-26	Revision 31	TRM 3.6-14	Revision 31
TRM 3.3-27	Revision 31	TRM 3.6-15	Revision 31
TRM 3.3-28	Revision 76	TRM 3.6-16	Revision 31
TRM 3.3-29	Revision 76	TRM 3.6-17	Revision 31
TRM 3.3-30	Revision 31	TRM 3.6-18	Revision 31

FERMI 2 - TECHNICAL REQUIREMENTS MANUAL VOL I

LIST OF EFFECTIVE PAGES

<u>Page</u>	<u>Revision</u>	<u>Page</u>	<u>Revision</u>
TRM 3.6-19	Revision 31	TRM 3.8-13	Revision 61
TRM 3.6-20	Revision 31	TRM 3.8-14	Revision 46
TRM 3.6-21	Revision 31	TRM 3.8-15	Revision 31
TRM 3.6-22	Revision 31	TRM 3.8-16	Revision 31
TRM 3.6-23	Revision 31	TRM 3.8-17	Revision 43
TRM 3.6-24	Revision 58	TRM 3.8-18	Revision 33
TRM 3.6-25	Revision 31	TRM 3.9-a	Revision 31
TRM 3.6-26	Revision 31	TRM 3.9-1	Revision 31
TRM 3.6-27	Revision 31	TRM 3.9-2	Revision 65
TRM 3.6-28	Revision 31	TRM 3.9-3	Revision 80
TRM 3.6-29	Revision 31	TRM 3.9-4	Revision 88
TRM 3.6-30	Revision 31	TRM 3.9-5	Revision 31
TRM 3.6-31	Revision 31	TRM 3.10-1	Revision 31
TRM 3.6-32	Revision 70	TRM 3.11-a	Revision 31
TRM 3.6-33	Revision 31	TRM 3.11-1	Revision 31
TRM 3.6-34	Revision 31	TRM 3.12-a	Revision 31
TRM 3.6-35	Revision 31	TRM 3.12-1	Revision 75
TRM 3.7-a	Revision 73	TRM 3.12-2	Revision 31
TRM 3.7-b	Revision 31	TRM 3.12-3	Revision 31
TRM 3.7-1	Revision 60	TRM 3.12-4	Revision 89
TRM 3.7-2	Revision 70	TRM 3.12-5	Revision 53
TRM 3.7-3	Revision 70	TRM 3.12-6	Revision 53
TRM 3.7-4	Revision 73	TRM 3.12-7	Revision 31
TRM 3.7-5	Revision 31	TRM 3.12-8	Revision 57
TRM 3.7-6	Revision 31	TRM 3.12-9	Revision 40
TRM 3.7-7	Revision 31	TRM 3.12-10	Revision 31
TRM 3.7-8	Revision 31	TRM 3.12-11	Revision 49
TRM 3.7-9	Revision 31	TRM 3.12-12	Revision 31
TRM 3.7-10	Revision 44	TRM 3.12-13	Revision 75
TRM 3.7-11	Revision 31	TRM 3.12-14	Revision 31
TRM 3.7-12	Revision 72	TRM 3.12-15	Revision 31
TRM 3.7-13	Revision 31	TRM 3.12-16	Revision 75
TRM 3.7-14	Revision 31	TRM 3.12-17	Revision 31
TRM 3.7-15	Revision 83	TRM 3.12-18	Revision 75
TRM 3.7-16	Revision 31	TRM 3.12-19	Revision 31
TRM 3.7-17	Revision 31	TRM 3.12-20	Revision 75
TRM 3.7-18	Revision 77	TRM 3.12-21	Revision 31
TRM 3.7-19	Revision 31	TRM 3.12-22	Revision 31
TRM 3.7-20	Revision 79	TRM 3.12-23	Revision 31
TRM 3.8-a	Revision 31	TRM 3.12-24	Revision 31
TRM 3.8-1	Revision 31	TRM 3.12-25	Revision 31
TRM 3.8-2	Revision 31	TRM 3.12-26	Revision 75
TRM 3.8-3	Revision 73	TRM 3.12-27	Revision 31
TRM 3.8-4	Revision 31	TRM 3.12-28	Revision 31
TRM 3.8-5	Revision 31	TRM 3.12-29	Revision 78
TRM 3.8-6	Revision 50	TRM 3.12-30	Revision 31
TRM 3.8-7	Revision 50	TRM 4.0-1	Revision 31
TRM 3.8-8	Revision 50	TRM 5.0-a	Revision 31
TRM 3.8-9	Revision 50	TRM 5.0-1	Revision 31
TRM 3.8-10	Revision 50	TRM 5.0-2	Revision 31
TRM 3.8-11	Revision 50	TRM 5.0-3	Revision 31
TRM 3.8-12	Revision 31	TRM 5.0-4	Revision 31

FERMI 2 - TECHNICAL REQUIREMENTS MANUAL VOL I

LIST OF EFFECTIVE PAGES

<u>Page</u>	<u>Revision</u>	<u>Page</u>	<u>Revision</u>
TRM 5.0-5	Revision 31	TRM B3.4.6-1	Revision 31
TRM 5.0-6	Revision 31	TRM B3.4.7-1	Revision 31
TRM 5.0-7	Revision 31	TRM B3.5-1	Revision 31
TRM 5.0-8	Revision 31	TRM B3.6.1-1	Revision 31
TRM 5.0-9	Revision 31	TRM B3.6.2-1	Revision 67
TRM B1.0-1	Revision 31	TRM B3.6.3-1	Revision 87
TRM B2.0-1	Revision 31	TRM B3.6.4-1	Revision 31
TRM B3.0-1	Revision 63	TRM B3.6.5-1	Revision 31
TRM B3.0-2	Revision 63	TRM B3.6.6-1	Revision 70
TRM B3.0-2a	Revision 72	TRM B3.6.7-1	Revision 31
TRM B3.0-2b	Revision 72	TRM B3.6.8-1	Revision 31
TRM B3.0-2c	Revision 72	TRM B3.7.1-1	Revision 31
TRM B3.0-3	Revision 31	TRM B3.7.2-1	Revision 31
TRM B3.0-4	Revision 31	TRM B3.7.3-1	Revision 73
TRM B3.0-5	Revision 54	TRM B3.7.4-1	Revision 31
TRM B3.0-6	Revision 72	TRM B3.7.4-2	Revision 31
TRM B3.0-7	Revision 72	TRM B3.7.5-1	Revision 31
TRM B3.1-1	Revision 31	TRM B3.7.6-1	Revision 31
TRM B3.2-1	Revision 31	TRM B3.7.7-1	Revision 31
TRM B3.3.1-1	Revision 31	TRM B3.7.8-1	Revision 31
TRM B3.3.1-2	Revision 31	TRM B3.7.9-1	Revision 79
TRM B3.3.2-1	Revision 31	TRM B3.8.1-1	Revision 31
TRM B3.3.2-2	Revision 31	TRM B3.8.2-1	Revision 31
TRM B3.3.3-1	Revision 67	TRM B3.8.3-1	Revision 89
TRM B3.3.4-1	Revision 31	TRM B3.8.4-1	Revision 31
TRM B3.3.4-2	Revision 84	TRM B3.8.5-1	Revision 31
TRM B3.3.5-1	Revision 31	TRM B3.8.6-1	Revision 43
TRM B3.3.5-2	Revision 31	TRM B3.9.1-1	Revision 31
TRM B3.3.6-1	Revision 31	TRM B3.9.2-1	Revision 65
TRM B3.3.6-2	Revision 31	TRM B3.9.3-1	Revision 31
TRM B3.3.6-3	Revision 31	TRM B3.9.4-1	Revision 31
TRM B3.3.6-4	Revision 31	TRM B3.10-1	Revision 31
TRM B3.3.6-5	Revision 76	TRM B3.11.1-1	Revision 31
TRM B3.3.6-6	Revision 76	TRM B3.12.1-1	Revision 31
TRM B3.3.7-1	Revision 31	TRM B3.12.2-1	Revision 44
TRM B3.3.7-2	Revision 70	TRM B3.12.3-1	Revision 31
TRM B3.3.8-1	Revision 31	TRM B3.12.4-1	Revision 31
TRM B3.3.9-1	Revision 31	TRM B3.12.5-1	Revision 31
TRM B3.3.10-1	Revision 56	TRM B3.12.6-1	Revision 31
TRM B3.3.11-1	Revision 45	TRM B3.12.7-1	Revision 31
TRM B3.3.12-1	Revision 62	TRM B3.12.8-1	Revision 31
TRM B3.3.13-1	Revision 31		
TRM B3.3.14-1	Revision 31		
TRM B3.4.1-1	Revision 31		
TRM B3.4.1-2	Revision 71		
TRM B3.4.1-3	Revision 71		
TRM B3.4.1-4	Revision 71		
TRM B3.4.1-5	Revision 71		
TRM B3.4.2-1	Revision 31		
TRM B3.4.3-1	Revision 31		
TRM B3.4.4-1	Revision 31		
TRM B3.4.5-1	Revision 31		

FERMI 2 - TECHNICAL REQUIREMENTS MANUAL VOL I

LIST OF EFFECTIVE PAGES

CORE OPERATING LIMITS REPORT
COLR 13, Revision 1

Page Revision

Notation Page

1	1
2	1
3	1
4	1
5	1
6	1
7	1
8	1
9	1
10	1
12	1
13	1
14	1
15	1
16	1
17	1
18	1
19	1
20	1
21	1
22	1

FERMI 2

CORE OPERATING LIMITS REPORT

CYCLE 13

REVISION 1

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July 2008

TABLE OF CONTENTS

1.0 INTRODUCTION AND SUMMARY	4
2.0 AVERAGE PLANAR LINEAR HEAT GENERATION RATE	5
2.1 Definition	5
2.2 Determination of MAPLHGR Limit	5
2.2.1 Calculation of MAPFAC(P)	7
2.2.2 Calculation of MAPFAC(F)	8
3.0 MINIMUM CRITICAL POWER RATIO	9
3.1 Definition	9
3.2 Determination of Operating Limit MCPR	9
3.3 Calculation of MCPR(P)	10
3.3.1 Calculation of K_p	11
3.3.2 Calculation of τ	12
3.4 Calculation of MCPR(F)	13
4.0 LINEAR HEAT GENERATION RATE	14
4.1 Definition	14
4.2 Determination of LHGR Limit	14
4.2.1 Calculation of LHGRFAC(P)	16
4.2.2 Calculation of LHGRFAC(F)	17
5.0 CONTROL ROD BLOCK INSTRUMENTATION	18
5.1 Definition	18
6.0 BACKUP STABILITY PROTECTION REGIONS	19
6.1 Definition	19
7.0 REFERENCES	21
7.1 Source References	21
7.2 Basis References	21

LIST OF TABLES

TABLE 1	FUEL TYPE-DEPENDENT STANDARD MAPLHGR LIMITS	6
TABLE 2	FLOW-DEPENDENT MAPLHGR LIMIT COEFFICIENTS.....	8
TABLE 3	OLMCPR _{100/105} AS A FUNCTION OF EXPOSURE AND τ	10
TABLE 4	FLOW-DEPENDENT MCPR LIMIT COEFFICIENTS	13
TABLE 5	STANDARD LHGR LIMITS FOR VARIOUS FUEL TYPES	15
TABLE 6	FLOW-DEPENDENT LHGR LIMIT COEFFICIENTS	17
TABLE 7	CONTROL ROD BLOCK INSTRUMENTATION SETPOINTS WITH FILTER.....	18
TABLE 8	BSP REGION DESCRIPTIONS	19

LIST OF FIGURES

FIGURE 1	BSP REGIONS FOR NOMINAL FEEDWATER TEMPERATURE	20
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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 13, 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 (Reference 9).

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

<u>OPERATING LIMIT</u>	<u>TECHNICAL SPECIFICATION</u>
APLHGR	3.2.1
MCPR	3.2.2
LHGR	3.2.3
RBM	3.3.2.1
BSP REGIONS	3.3.1.1

APLHGR	=	AVERAGE PLANAR LINEAR HEAT GENERATION RATE
MCPR	=	MINIMUM CRITICAL POWER RATIO
LHGR	=	LINEAR HEAT GENERATION RATE
RBM	=	ROD BLOCK MONITOR SETPOINTS
BSP	=	BACKUP STABILITY PROTECTION

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 9 and 10, 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 9 and 10 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:

$$MAPLHGR (SLO) = 1.0 \times MAPLHGR_{STD}$$

The Single Loop multiplier is 1.0 since the offrated ARTS limits bound the single loop MAPLHGR limit. (Reference 2)

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. (Reference 2) 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

<u>GE11 Exposure</u> <u>GWD/ST</u>	<u>GE11 MAPLHGR</u> <u>KW/FT</u>	<u>GE14 Exposure</u> <u>GWD/ST</u>	<u>GE14 MAPLHGR</u> <u>KW/FT</u>
0.0	13.42	0.0	12.82
19.72	13.42	19.13	12.82
27.22	12.29	57.61	8.00
63.50	8.90	63.50	5.00

Fuel Types

- | | |
|---|---|
| 18 = GE11-P9CUB404-12GZ-100T-146-T6-2543 | 3 = GE14-P10CNAB380-10G5/4G4-100T-150-T6-2868 |
| 19 = GE11-P9CUB408-12GZ-100T-146-T6-2604 | 4 = GE14-P10CNAB381-7G5/8G4-100T-150-T6-2869 |
| 20 = GE11-P9CUB380-12GZ-100T-146-T6-2605 | 5 = GE14-P10CNAB381-7G6/8G4-100T-150-T6-2877 |
| 1 = GE14-P10CNAB400-16GZ-100T-150-T6-2787 | 6 = GE14-P10CNAB381-7G5/8G4-100T-150-T6-2869 |
| 2 = GE14-P10CNAB399-16GZ-100T-150-T6-2788 | 7 = GE14-P10CNAB381-16G5-100T-150-T6-2999 |

2.2.1 Calculation of MAPFAC(P)

The core power-dependent MAPLHGR limit adjustment factor, MAPFAC(P) (Reference 3), shall be calculated by one of the following equations:

For $0 \leq P < 25$:

No thermal limits monitoring is required.

For $25 \leq P < 30$:

With turbine bypass OPERABLE,

For core flow ≤ 50 Mlbs/hr,

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

For core flow > 50 Mlbs/hr,

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

With turbine bypass INOPERABLE,

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) (Reference 3), shall be calculated by the following equation:

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

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	0.6787	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) (Reference 2) 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. Cycle 13 operating limits are based on the Dual Loop SLMCPR of 1.08.

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 (Reference 2) is increased to account for increased uncertainties in core flow measurement and TIP measurement. OLMCPR will increase by 0.01 when operating in single loop.

3.3 Calculation of MCPR(P)

MCPR(P), the core power-dependent MCPR operating limit (Reference 3), 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 (Reference 2 and 8), 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}	
			Two Loop	Single Loop
Both Turbine Bypass and Moisture Separator Reheater OPERABLE	BOC to 6515	$\tau = 0$	1.33	1.34
		$\tau = 1$	1.44	1.45
	6515 to 8515	$\tau = 0$	1.39	1.40
		$\tau = 1$	1.50	1.51
	8515 to EOC	$\tau = 0$	1.43	1.44
		$\tau = 1$	1.60	1.61
Either Turbine Bypass or Moisture Separator Reheater INOPERABLE	BOC to EOC	$\tau = 0$	1.47	1.48
		$\tau = 1$	1.64	1.65
Both Turbine Bypass and Moisture Separator Reheater INOPERABLE	BOC to EOC	$\tau = 0$	1.50	1.51
		$\tau = 1$	1.67	1.68

3.3.1 Calculation of K_P

The core power-dependent MCPR operating limit adjustment factor, K_P (Reference 3), 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,

$$K_P = \frac{(K_{BYP} + (0.032 \times (30 - P)))}{OLMCPR_{100/105}}$$

where: $K_{BYP} = 2.16$ for core flow ≤ 50 Mlbs/hr
 $= 2.44$ for core flow > 50 Mlbs/hr

When turbine bypass is INOPERABLE,

$$K_P = \frac{(K_{BYP} + (0.076 \times (30 - P)))}{OLMCPR_{100/105}}$$

where: $K_{BYP} = 2.61$ for core flow ≤ 50 Mlbs/hr
 $= 3.34$ 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 (Reference 4), shall be calculated by using the following equation:

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

where: $\tau_A = 1.096$ 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 i^{th} surveillance test,

τ_i = average scram time to notch 36 of all rods measured in the i^{th} 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 (Reference 3), shall be calculated by using the following equation:

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

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
Two Loop	110	-0.601	1.743
Single Loop	110	-0.601	1.753

* 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 9 and 10, 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 Reference 1 will be met.

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

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

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. (Reference 1) 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.

TABLE 5
STANDARD LHGR LIMITS FOR VARIOUS FUEL TYPES

GE11 Uranium Only Fuel Rods		GE11 Most Limiting Gadolinia Bearing Fuel Rods	
Exposure	LHGR	Exposure	LHGR
<u>GWD/ST</u>	<u>KW/FT</u>	<u>GWD/ST</u>	<u>KW/FT</u>
0.0	14.40	0.0	12.74
13.24	14.40	10.59	12.74
27.22	12.29	23.99	10.87
63.50	8.90	58.81	7.88

GE14 Uranium Only Fuel Rods		GE14 Most Limiting Gadolinia Bearing Fuel Rods	
Exposure	LHGR	Exposure	LHGR
<u>GWD/ST</u>	<u>KW/FT</u>	<u>GWD/ST</u>	<u>KW/FT</u>
0.0	13.40	0.0	12.26
14.51	13.40	12.28	12.26
57.61	8.00	55.00	7.32
63.50	5.00	60.84	4.57

Fuel Types

18 = GE11-P9CUB404-12GZ-100T-146-T6-2543	3 = GE14-P10CNAB380-10G5/4G4-100T-150-T6-2868
19 = GE11-P9CUB408-12GZ-100T-146-T6-2604	4 = GE14-P10CNAB381-7G5/8G4-100T-150-T6-2869
20 = GE11-P9CUB380-12GZ-100T-146-T6-2605	5 = GE14-P10CNAB381-7G6/8G4-100T-150-T6-2877
1 = GE14-P10CNAB400-16GZ-100T-150-T6-2787	6 = GE14-P10CNAB381-7G5/8G4-100T-150-T6-2869
2 = GE14-P10CNAB399-16GZ-100T-150-T6-2788	7 = GE14-P10CNAB381-16G5-100T-150-T6-2999

4.2.1 Calculation of LHGRFAC(P)

The core power-dependent LHGR limit adjustment factor, LHGRFAC(P) (Reference 3), shall be calculated by one of the following equations:

For $0 \leq P < 25$:

No thermal limits monitoring is required.

For $25 \leq P < 30$:

With turbine bypass OPERABLE,

For core flow ≤ 50 Mlbs/hr,

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

For core flow > 50 Mlbs/hr,

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

With turbine bypass INOPERABLE,

For core flow ≤ 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) (Reference 3), shall be calculated by the following equation:

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

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	0.6787	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 7. These values are consistent with the bases of the APRM Rod Block Technical Specification Improvement Program (ARTS) and the MCPR operating limits. (References 2, 6, 7, & 16).

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 BACKUP STABILITY PROTECTION REGIONS

<p>TECH SPEC REFERENCE 3.3.1.1 Action Condition J</p>	<p>OPERATING LIMIT Alternate method to detect and suppress thermal hydraulic instability oscillations</p>
<p>TRM REFERENCE 3.4.1.1</p>	<p>OPERATING LIMIT Scram, Exit, and Stability Awareness Regions</p>

6.1 Definition

The Backup Stability Protection (BSP) Regions are an integral part of the Tech Spec required alternative method to detect and suppress thermal hydraulic instability oscillations in that they identify areas of the power/flow map where there is an increased probability that the reactor core could experience a thermal hydraulic instability. Regions are identified (refer to Table 8 and Figure 1) that are either excluded from planned entry (Scram Region), or where specific actions are required to be taken to immediately leave the region (Exit Region). A region is also identified where operation is allowed provided that additional monitoring is performed to verify that the reactor core is not exhibiting signs of core thermal hydraulic instability (Stability Awareness Region). (Reference 5)

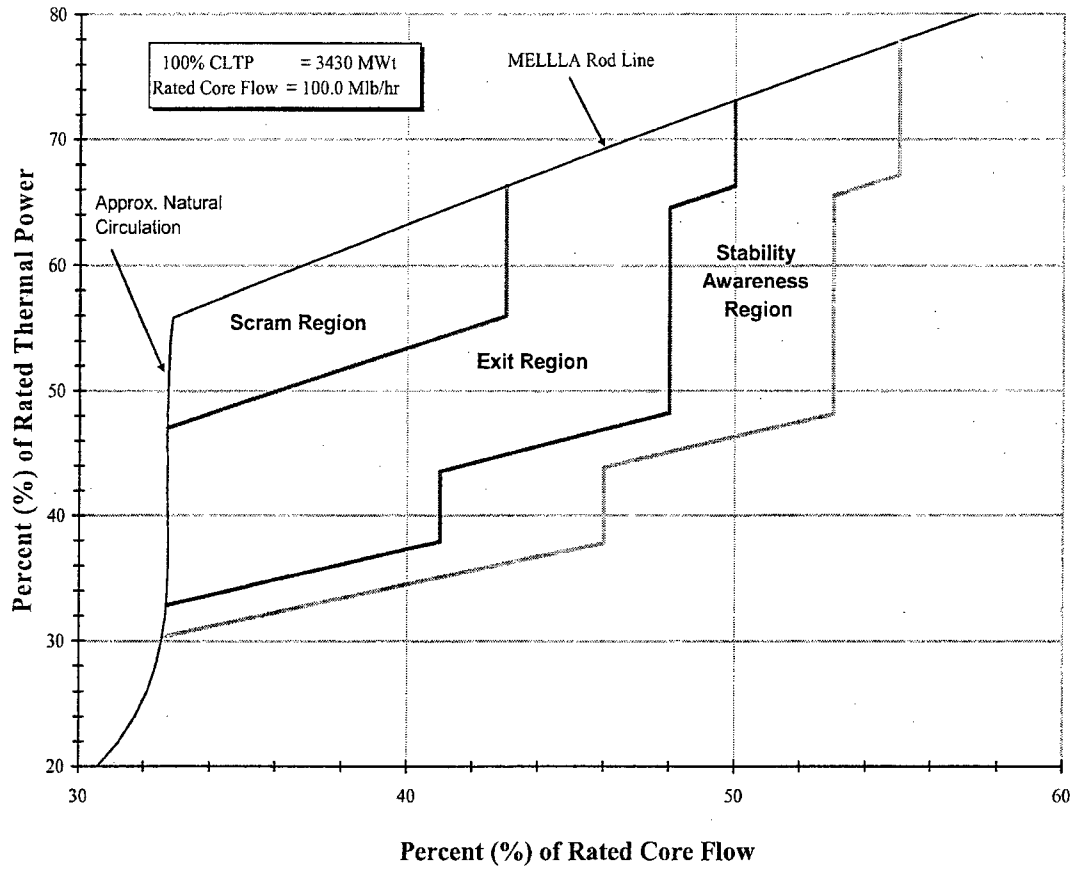
The boundaries of these regions are established on a cycle specific basis based upon core decay ratio calculations performed using NRC approved methodology. The Cycle 13 regions are valid to a cycle exposure of 11,760 MWd/st. (Reference 2)

These regions are only applicable when the Upscale Trip function of the Oscillation Power Range Monitoring System (OPRM) is inoperable. It must be noted that the Cycle 13 region boundaries defined in Table 8 and illustrated in Figure 1 are not applicable to operation with Feedwater Heaters Out-Of-Service (FWHOOS) or with Final Feedwater Temperature Reduction (FFWTR).

TABLE 8 BSP REGION DESCRIPTIONS

Scram Region:	> 96% Rod Line, < 43% Core Flow
Exit Region:	> 67% Rod Line, < 41% Core Flow
Not in Scram Region -and-	> 77% Rod Line, < 48% Core Flow
	> 103% Rod Line, < 50% Core Flow
Stability Awareness Region	> 62% Rod Line, < 46% Core Flow
Not in Scram or Exit Region	> 72% Rod Line, < 53% Core Flow
	> 98% Rod Line, < 55% Core Flow

FIGURE 1 - BSP REGIONS FOR NOMINAL FEEDWATER TEMPERATURE



7.0 REFERENCES

7.1 SOURCE REFERENCES

1. "Fuel Bundle Information Report for Enrico Fermi 2 Reload 12 Cycle 13," Global Nuclear Fuel, 0000-0040-7831-FIBR, Revision 0, June 2007 (LHGR Limits)
2. "Supplemental Reload Licensing Report for Enrico Fermi 2 Reload 12 Cycle 13," Global Nuclear Fuel, 0000-0040-7831-SRLR, Revision 0, June 2007 (MAPLHGR Limits, SLO Multiplier, MCPR Limits, SLMCPR)
3. "GE14 Fuel Cycle-Independent Analyses for Fermi Unit 2", GE-NE-0000-0025-3282-00 dated November 2004 (ARTS Limits)
4. Letter from Greg Porter to B. L. Myers, "Scram Times for Improved Tech Specs." GP-99014, October 22, 1999 containing DRF A12-00038-3, Vol. 4 information from G. A. Watford, GE, to Distribution, Subject: Scram Times versus Notch Position (TAU Calculation)
5. Evaluation Report, "BSP Stability Evaluation for Fermi 2 Cycle 13," GENE-0000-0066-4165-R0, June 2007 (BSP Limits)
6. CSCCD-C51 K622/C51 R809C Revision 2, "Programming for Rod Block Monitor (RBM-A) PIS # C51K622 and Operator Display Assembly (ODA) PIS # C51R809C" (RBM A Setpoints)
7. CSCCD-C51 K623/C51 R809D Revision 2, "Programming for Rod Block Monitor (RBM-B) PIS # C51K623 and Operator Display Assembly (ODA) PIS # C51R809D" (RBM B Setpoints)
8. "Cycle Management Report Supplement 1 for Fermi 2 Cycle 13" Global Nuclear Fuel, 0000-0075-2510, Supplement 1, June 2008 (OLMCPR Mid-Cycle Exposure)

7.2 BASIS REFERENCES

9. "General Electric Standard Application for Reactor Fuel (GESTAR II)," NEDE-24011-P-A, Revision 14 as amended by Amendment 25
10. "The GESTAR-I.OCA and SAFER Models for the Evaluation of the Loss-of-Coolant Accident

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