FERMI 2

CORE OPERATING LIMITS REPORT

CYCLE 2

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1.0 INTRODUCTION AND SUMMARY

This report provides the cycle specific plant operating limits for Fermi 2 Cycle 2 as required by Technical Specification 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 (Reference 1). These methods were used to generate the limits in this report which are contained in Reference 2.

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

APLHGR = AVERAGE PLANAR LINEAR HEAT GENERATION RATE

MCPR = MINIMUM CRITICAL POWER RATIO

LHGR = LINEAR HEAT GENERATION RATE

2.0 AVERAGE PLANAR LINEAR HEAT GENERATION RATE

TECH SPEC IDENT	OPERATING LIMIT	FIGURES
3/4.2.1	APLHGR	1, 2, 3, 4

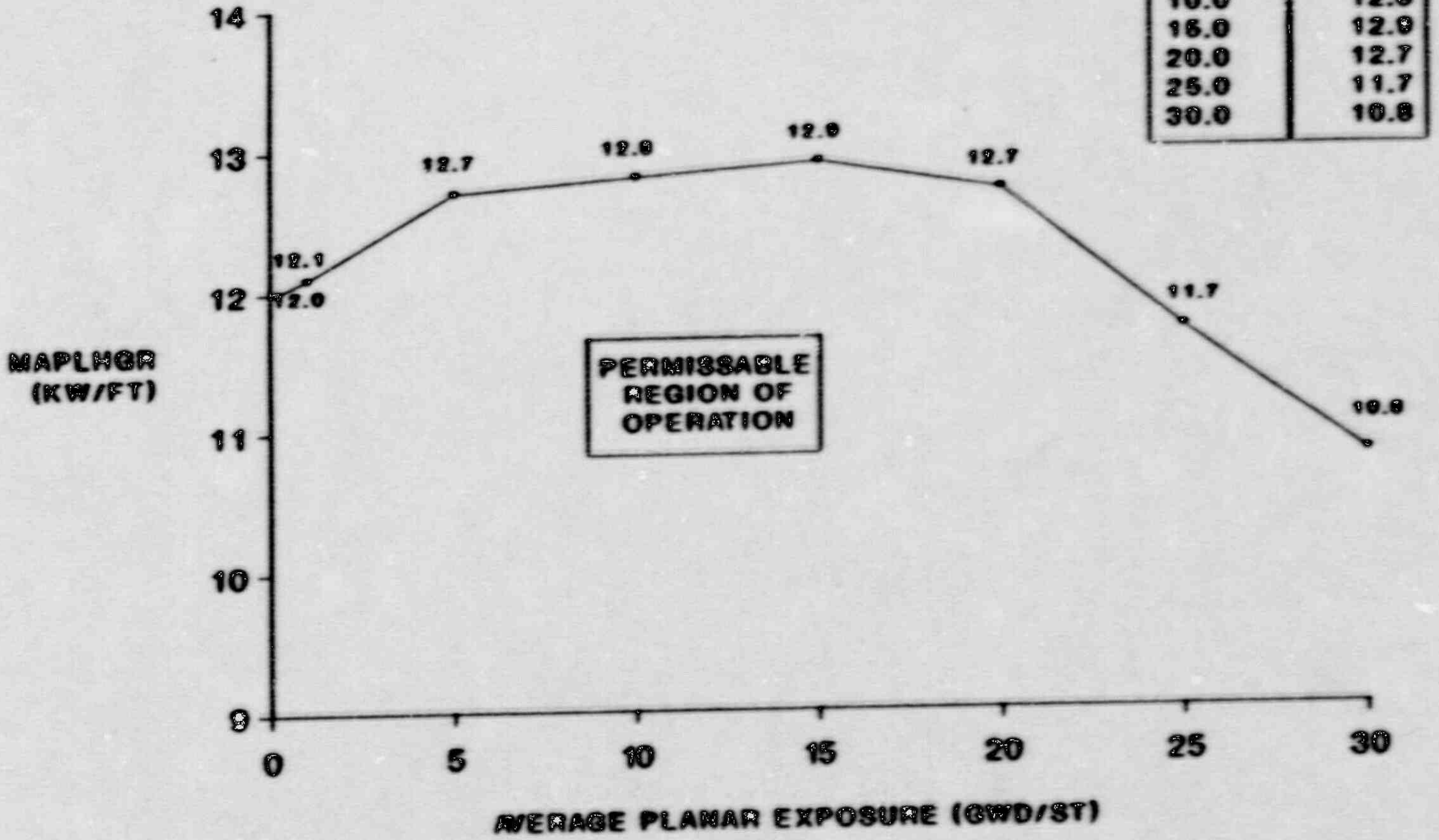
2.1 Definition

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 for all fuel rods in the specified bundle at the specified height divided by the number of fuel rods in the fuel bundle.

2.2 Determination of APLHGR Limit

The APLHGR limits are a function of fuel type and average planar exposure. The limits are developed to ensure gross cladding failure will not occur following a loss of coolant accident (LOCA). The APLHGR limit ensures that the steady state power level in the fuel bundle during a LOCA will not exceed a peak clad temperature as specified in 10CFR50.46(b)(1). Figures 1, 2, 3, and 4 contain the APLHGR limits for each fuel type as a function of average planar exposure. Since fuel types may contain more than one lattice type (axially), the curves represent the most limiting lattice type for that fuel type.

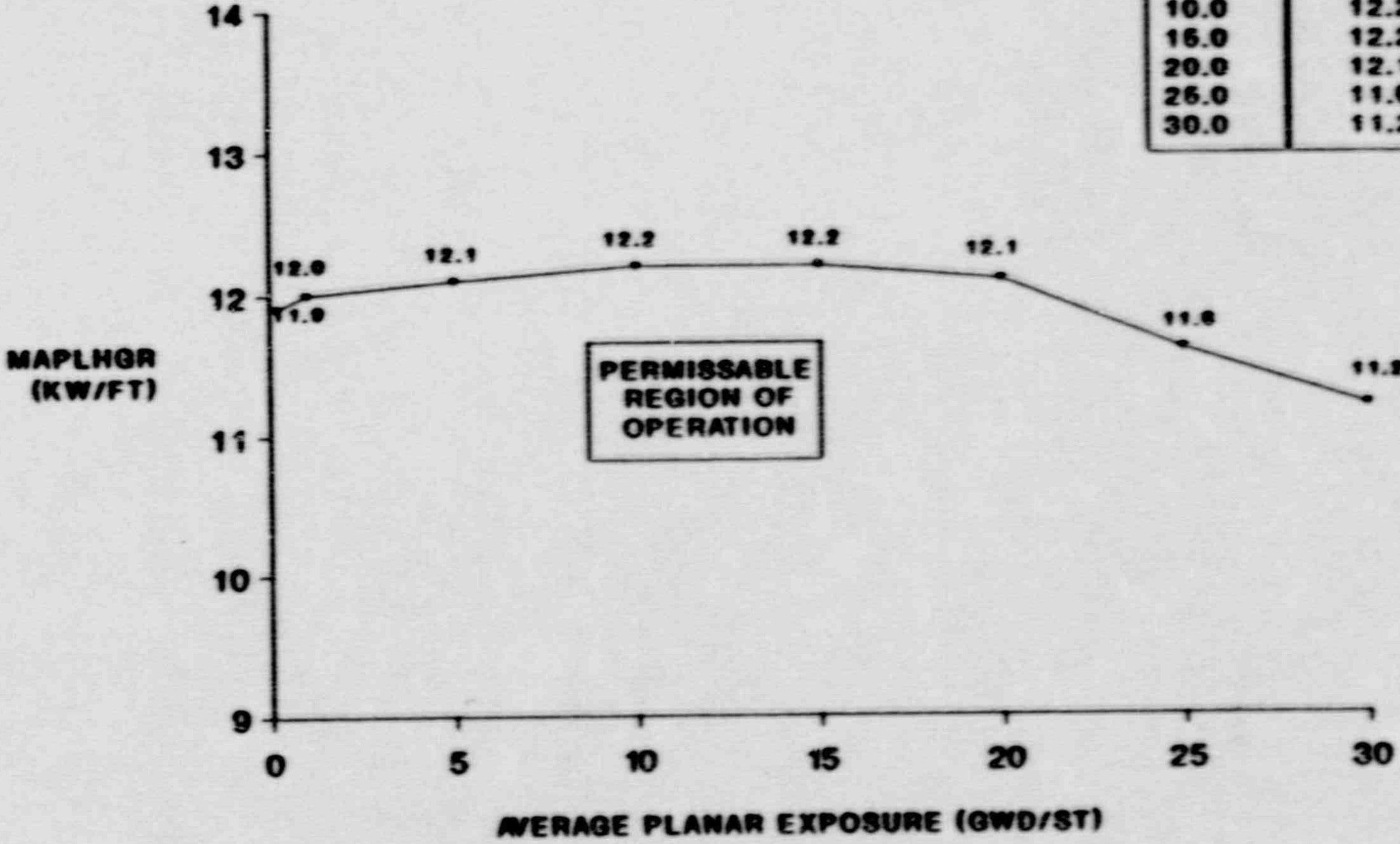
GWD/ST	KW/FT
0.2	12.0
1.0	12.1
5.0	12.7
10.0	12.8
15.0	12.9
20.0	12.7
25.0	11.7
30.0	10.8



MAXIMUM AVERAGE PLANAR LINEAR HEAT GENERATION RATE (MAPLHGR) VERSUS AVERAGE PLANAR EXPOSURE, FUEL TYPE 8CR183

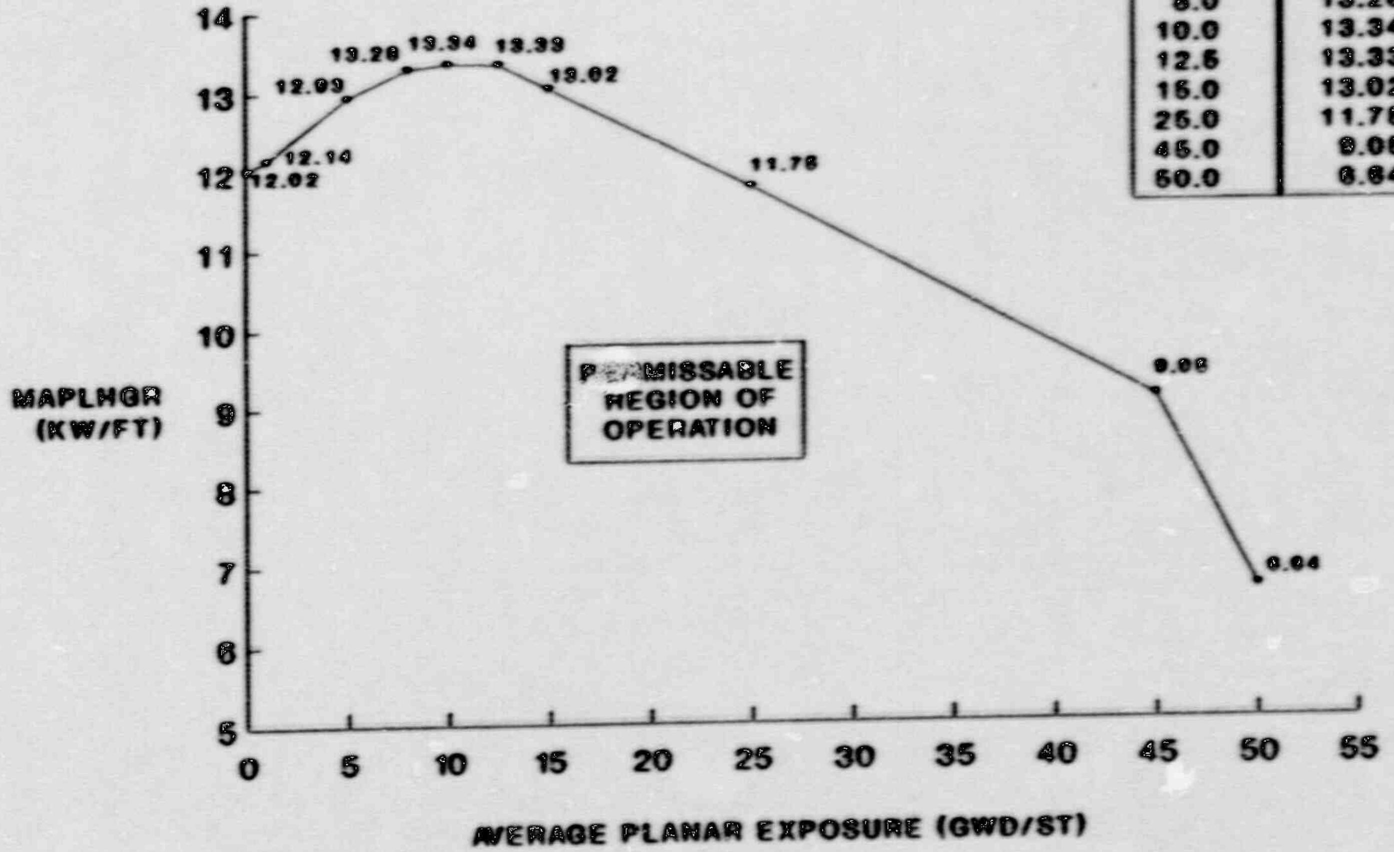
FIGURE 1

GWD/ST	KW/FT
0.2	11.9
1.0	12.0
5.0	12.1
10.0	12.2
15.0	12.2
20.0	12.1
25.0	11.8
30.0	11.2



MAXIMUM AVERAGE PLANAR LINEAR HEAT GENERATION RATE (MAPLHGR)
VERSUS AVERAGE PLANAR EXPOSURE,
FUEL TYPE 8CR233

FIGURE 2

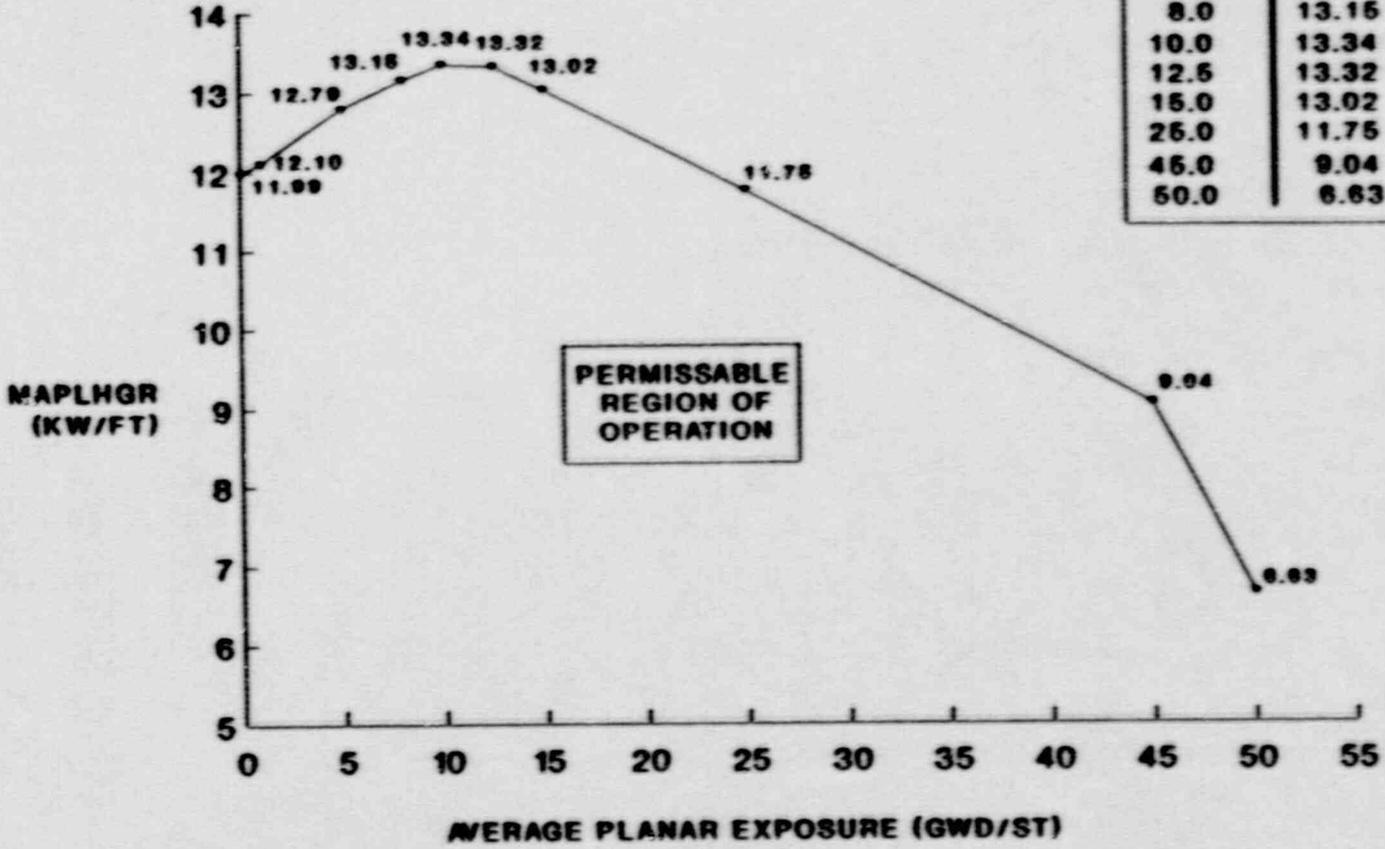


GWD/ST	KW/FT
0.0	12.02
1.0	12.14
5.0	12.93
8.0	13.28
10.0	13.34
12.5	13.33
15.0	13.02
25.0	11.76
45.0	9.06
50.0	6.84

MAXIMUM AVERAGE PLANAR LINEAR HEAT GENERATION RATE (MAPLHGR)
VERSUS AVERAGE PLANAR EXPOSURE,
FUEL TYPE BC318D

FIGURE 3

GWD/ST	KW/FT
0.0	11.99
1.0	12.10
5.0	12.79
8.0	13.15
10.0	13.34
12.5	13.32
15.0	13.02
25.0	11.75
45.0	9.04
50.0	6.63



MAXIMUM AVERAGE PLANAR LINEAR HEAT GENERATION RATE (MAPLHGR) VERSUS AVERAGE PLANAR EXPOSURE, FUEL TYPE BC318E

FIGURE 4

3.0 MINIMUM CRITICAL POWER RATIO

TECH SPEC IDENT	OPERATING LIMIT	FIGURES
3/4.2.3	MCPR	5, 6, 7, 8

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 (Reference 1) 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 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 at three different core average exposures to determine which will cause the largest reduction in CPR. The result is an Operating Limit MCPR as a function of exposure and τ, and based on a predicted end-of-cycle (EOC) exposure of 14,700 MWD/ST. If the predicted EOC exposure is modified, the exposure range for each OLMCPR figure may need to be changed.

The purpose of the K_f factor is to define operating limits at other than rated core flow conditions. The K_f factor ensures that the Safety Limit MCPR will not be violated during a slow flow increase transient.

The applicable exposure dependent OLMCPR at rated flow times the K_f factor yields the required OLMCPR. K_f is calculated using Equation 3.4 or 3.5 and shown graphically in Figure 8, and τ is calculated using Equation 3.1.

3.2.1 Calculation of τ

The value of τ shall be determined within 72 hours after the conclusion of each scram time surveillance test by using the following equations:

$$\tau = \frac{(\tau_{ave} - \tau_B)}{\tau_A - \tau_B}, \qquad \text{Eq. 3.1}$$

where,

τ_A = 1.096 seconds, control rod average scram insertion time limit to notch 36 per Technical Specification 3.1.3.3,

$$\tau_B = 0.813 + 1.65\left[\frac{N_1}{\sum_{i=1}^{n} N_i}\right]^{1/2} 0.018, \qquad \text{Eq. 3.2}$$

$$\tau_{ave} = \frac{\sum_{i=1}^{n} N_i \tau_i}{\sum_{i=1}^{n} N_i}, \qquad \text{Eq. 3.3}$$

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,
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 Technical Specification Surveillance Requirement 4.1.3.2.a.

NOTE: Set τ equal to 1.0 prior to completion of the initial scram time measurements for the cycle in accordance with Technical Specification Surveillance Requirement 4.1.3.2.a.

Set τ equal to 0.0 if τ less than 0.0.

3.2.2 Calculation of K_f

The K_f flow correction factor is shown in Figure 8. However, the value of K_f shall be calculated by one of the following equations:

For $40\% < WT \leq 100\%$,

$$K_f = MAX\ [1.0,\ A + B * WT / 100.0] \qquad \text{Eq. 3.4}$$

For $WT \leq 40\%$,

$$K_f = [A + B * WT / 100.0\ ] * [1.0 + 0.0032 * (40.0 - WT)] \qquad \text{Eq. 3.5}$$

where,

WT = Core Flow (Percent of Rated Flow), and

A and B are given in Table 1.

TABLE 1

FLOW CORRECTION FACTOR COEFFICIENTS

	Scoop Tube Mechanical High Speed Stop Setpoint	A	B
Manual Flow Control	102.5%	1.3308	-0.441
	107.0%	1.3528	-0.441
	112.0%	1.3793	-0.441
	117.0%	1.4035	-0.441
Automatic Flow Control		1.4410	-0.441

3.2.3 Calculation of Operating Limit MCPR

When the THERMAL POWER is greater than or equal to 25% of RATED THERMAL POWER the Operating Limit MCPR is determined from Figures 5, 6, or 7 as follows:

A. For operation in the Control Cell Core (CCC) Rod Pattern*, the Operating Limit MCPR is equal to the Curve A value for the τ calculated according to Equation 3.1 times the K_f factor calculated according to the applicable Equation 3.4 or 3.5.

B. For operation in the Non-Control Cell Core (Non-CCC) Rod Pattern*, the Operating Limit MCPR is equal to the Curve B value for the τ calculated according to Equation 3.1 times the K_f factor calculated according to the applicable Equation 3.4 or 3.5.

C. For operation in either Rod Pattern* and with either the main turbine bypass system inoperable or the moisture separator reheater inoperable per Technical Specification 3.7.9, the Operating Limit MCPR is equal to the Curve C value for the τ calculated according to Equation 3.1 times the K_f factor calculated according to the applicable Equation 3.4 or 3.5.

D. For operation in either Rod Pattern* and with both the main turbine bypass system inoperable and the moisture separator reheater inoperable per Technical Specification 3.7.9, the Operating Limit MCPR is equal to the Curve D value for the τ calculated according to Equation 3.1 times the K_f factor calculated according to the applicable Equation 3.4 or 3.5.

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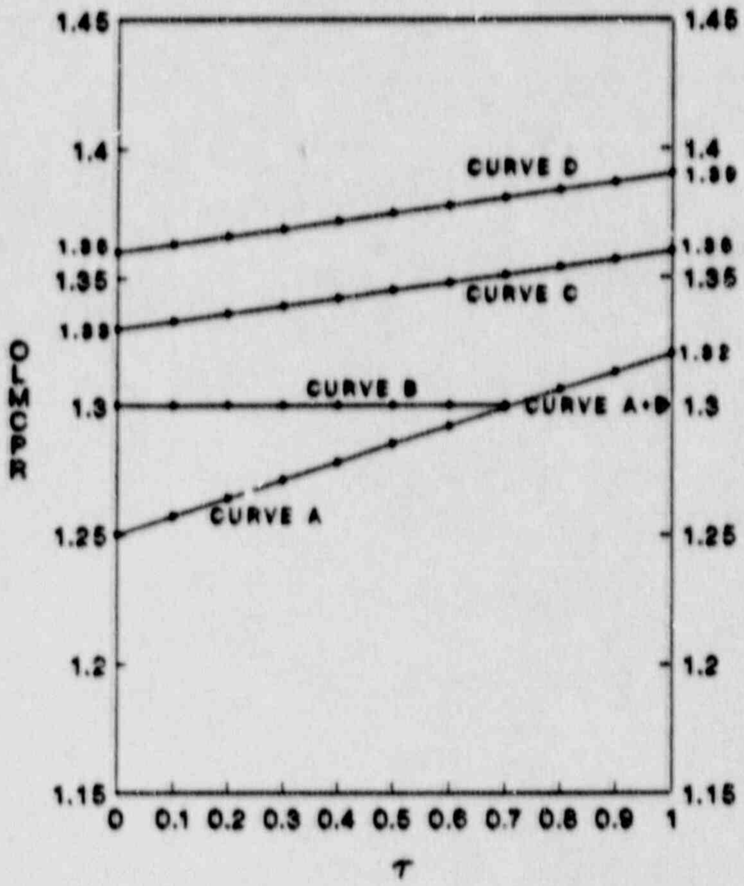
* Two Rod Patterns are defined:

1. The CCC (Control Cell Core) Rod Pattern is operation with any rod pattern consistent with the following restrictions:

   a. A2 sequence and peripheral rods are unrestricted.
   b. A1 sequence rods must be between positions 36 and 48, inclusively.
   c. All other rods must be at either positions 46 or 48.
   d. Normal control rod operability checks, coupling checks, scram time testing, and friction testing of non-CCC control rods do not require the utilization of the more restrictive non-CCC Rod Pattern MCPR limits.

2. The Non-CCC Rod Pattern is operation with any other rod pattern.



CURVE A - MCPR limit for CCC Rod Pattern with both turbine bypass and moisture separator reheater in service.

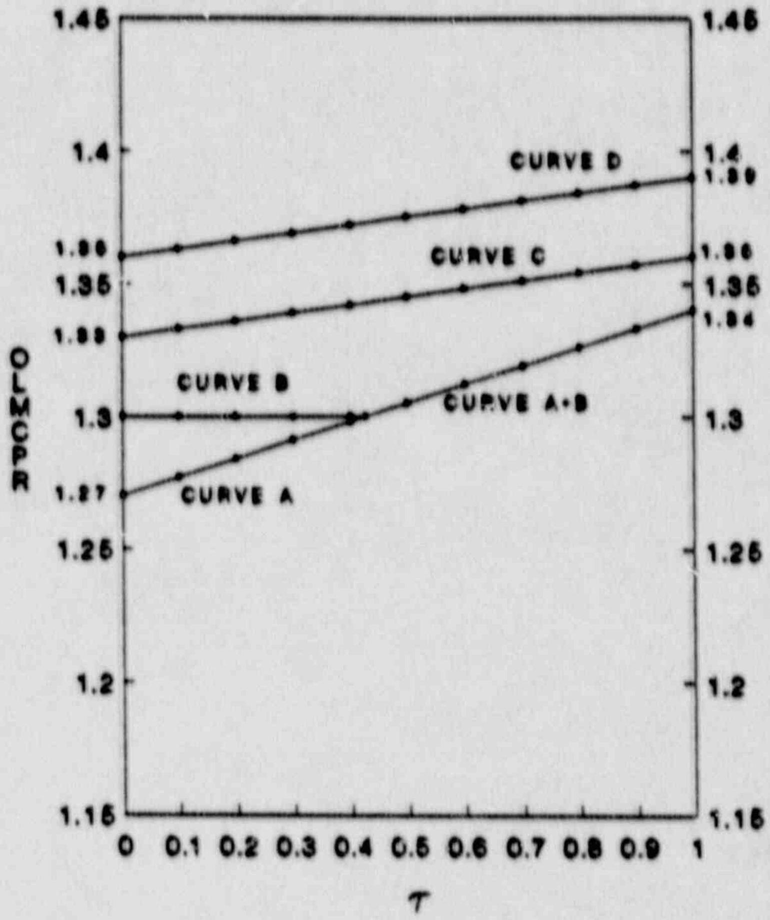
CURVE B - MCPR limit for Non-CCC Rod Pattern with both turbine bypass and moisture separator reheater in service.

CURVE C - MCPR limit for both CCC and Non-CCC Rod Patterns with either turbine bypass or moisture separator reheater out of service.

CURVE D - MCPR limit for both CCC and Non-CCC Rod Patterns with both turbine bypass and moisture separator reheater out of service.

BOC TO 12,700 MWD/ST,
OPERATING LIMIT MINIMUM CRITICAL POWER RATIO (OLMCPR)
VERSUS τ AT RATED FLOW

FIGURE 5



CURVE A - MCPR limit for CCC Rod Pattern with both turbine bypass and moisture seperator reheater in service.

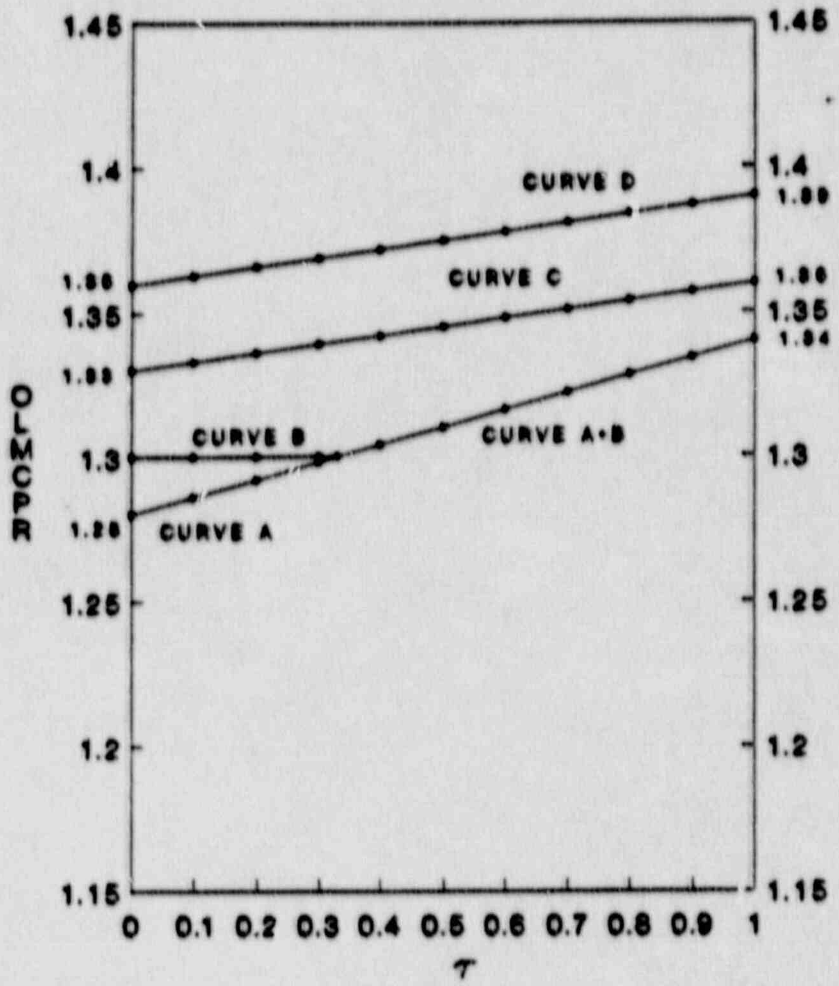
CURVE B - MCPR limit for Non-CCC Rod Pattern with both turbine bypass and moisture seperator reheater in service.

CURVE C - MCPR limit for both CCC and Non-CCC Rod Patterns with either turbine bypass or moisture seperator reheater out of service.

CURVE D - MCPR limit for both CCC and Non-CCC Rod Patterns with both turbine bypass and moisture seperator reheater out of service.

12,700 MWD/ST TO 13,700 MWD/ST, OPERATING LIMIT MINIMUM CRITICAL POWER RATIO (OLMCPR) VERSUS τ AT RATED FLOW

FIGURE 6



CURVE A - MCPR limit for CCC Rod Pattern with both turbine bypass and moisture separator reheater in service.

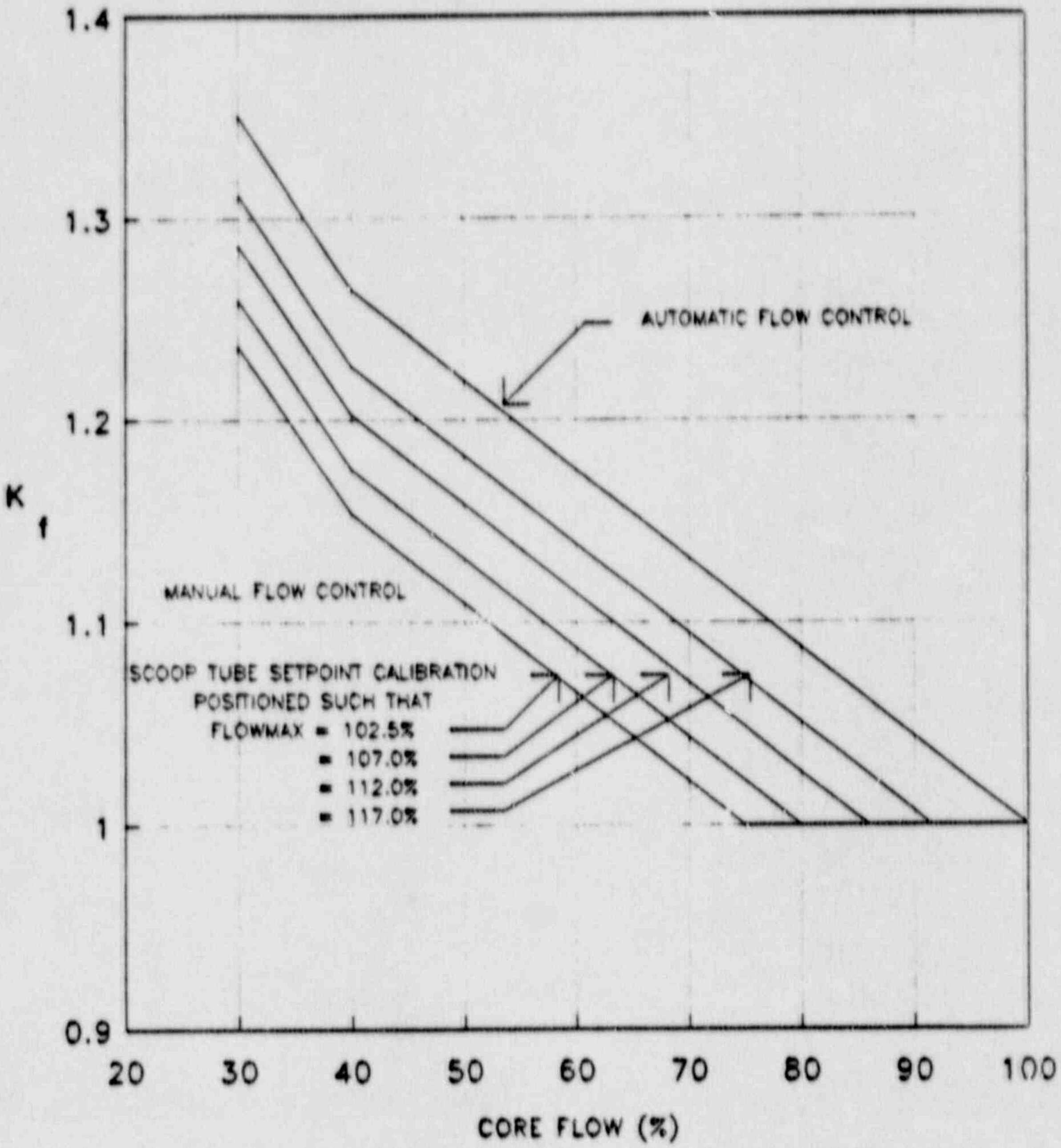
CURVE B - MCPR limit for Non-CCC Rod Pattern with both turbine bypass and moisture separator reheater in service.

CURVE C - MCPR limit for both CCC and Non-CCC Rod Patterns with either turbine bypass or moisture separator reheater out of service.

CURVE D - MCPR limit for both CCC and Non-CCC Rod Patterns with both turbine bypass and moisture separator reheater out of service.

13,700 MWD/ST TO EOC
OPERATING LIMIT MINIMUM CRITICAL POWER RATIO (OLMCPR)
VERSUS τ AT RATED FLOW

FIGURE 7



FLOW CORRECTION (K_f) FACTOR

FIGURE 8

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. If the stress exceeds the yield stress of the cladding material, the cladding will crack. The LHGR limit assures that at any exposure, 1% plastic strain on the clad is not exceeded. This limit is a function of fuel type and is presented in Table 2.

TABLE 2

LHGR LIMITS FOR VARIOUS FUEL TYPES

FUEL TYPE	LHGR LIMIT
BCR183	13.4 KW/FT
BCR233	13.4 KW/FT
BC318D	14.4 KW/FT
BC318E	14.4 KW/FT

5.0 REFERENCES

1. "General Electric Standard Application for Reactor Fuel (GESTAR II)," NEDE-24011-P-A, Revision 9, September 1988.

2. "Supplemental Reload Licensing Submittal for Fermi Power Plant Unit 2 Reload 1, Cycle 2, GE Nuclear Energy, 23A5949, Revision 0, March 1989.