PILGRIM NUCLEAR POWER STATION

CORE OPERATING LIMITS REPORT

(CYCLE 8)

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RECORD OF REVISIONS

Revision	Effective Date	Description
8A	Effective date based on issuance of license amendment by NRC.	Applicable for use during Cycle 8 operation.

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1.0 INTRODUCTION

This report provides the cycle-specific limits for operation of the Pilgrim Nuclear Power Station (PNPS) during Cycle 8. In this report, Cycle 8 will frequently be referred to as the present cycle.

Although this report is not part of the PNPS Technical Specifications, the Technical Specifications refer to this report for the applicable values of the following fuel-related parameters:

	Reference Technical Specification
APRM Flux Scram Trip Setting (Run Mode)	Table 3.1.1
APRM Rod Block Trip Setting (Run Mode)	Table 3.2.C-2
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Average Planar Linear Heat Generation Rate (APLHGR)	3.11.A
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If any of the core operating limits in this report are exceeded, actions will be taken as defined in the referenced Technical Specification.

The core operating limits in this report have been established for the present cycle using the NRC-approved methodology provided in the documents listed both in Section 5.0, References, and in Technical Specification 6.9.A.4. These limits are established such that the applicable limits of the plant safety analysis are met.

2.0 INSTRUMENTATION TRIP SETTINGS

2.1 APRM Flux Scram Trip Setting (Run Mode)

Reference Technical Specifications: Table 3.1.1, 3.1.B.1

When the mode switch is in the run position, the average power range monitor (APRM) flux scram trip setting (S_S) shall be:

$$S_S \leq 0.58\ W + 62\%$$

Where, S_S = APRM flux scram trip setting in percent of rated thermal power (1998 MW_t).

W = Percent of drive flow required to produce a rated core flow of 69 Mlb/hr.

2.1 APRM Flux Scram Trip Setting (Run Mode), Continued

In the event of operation with a maximum fraction of limiting power density (MFLPD) greater than the fraction of rated power (FRP), the APRM flux scram trip setting shall be modified as follows:

$$S_S \leq (0.58\ W + 62\%) \left[\frac{FRP}{MFLPD}\right]$$

Where, FRP = Fraction of rated thermal power (1998 MW_t).

MFLPD = Maximum fraction of limiting power density, where the limiting power density is 13.4 KW/ft for all fuel.

The ratio of FRP to MFLPD shall be set equal to 1.0 unless the actual operating value is less than the design value of 1.0, in which case the actual operating value will be used.

The APRM flux scram trip setting is valid only for operation using two recirculation loops. Operation with one recirculation loop out of service is restricted by License Condition 3.E.

In accordance with Technical Specification Table 3.1.1, Note 15, for no combination of loop recirculation flow rate and core thermal power shall the APRM flux scram trip setting be allowed to exceed 120% of rated thermal power.

2.2 APRM Rod Block Trip Setting (Run Mode)

Reference Technical Specifications: Table 3.2.C-2, 3.1.B.1

When the mode switch is in the run position, the average power range monitor (APRM) rod block trip setting (S_{RB}) shall be:

$$S_{RB} \leq 0.58\ W + 50\%$$

Where, S_{RB} = APRM rod block trip setting in percent of rated thermal power (1998 MW_t).

W = Percent of drive flow required to produce a rated core flow of 69 Mlb/hr.

2.2 APRM Rod Block Trip Setting (Run Mode), Continued

In the event of operation with a maximum fraction of limiting power density (MFLPD) greater than the fraction of rated power (FRP), the APRM rod block trip setting shall be modified as follows:

$$S_{RB} \leq (0.58\ W + 50\%) \left[\frac{FRP}{MFLPD}\right]$$

Where, FRP = Fraction of rated thermal power (1998 MW_t).

MFLPD = Maximum fraction of limiting power density, where the limiting power is 13.4 KW/ft for all fuel.

The ratio of FRP to MFLPD shall be set equal to 1.0 unless the actual operating value is less than the design value of 1.0, in which case the actual operating value will be used.

The APRM rod block trip setting is valid only for operation using two recirculation loops. Operation with one recirculation loop out of service is restricted by License Condition 3.E.

2.3 Rod Block Monitor Trip Setting

Reference Technical Specification: Table 3.2.C-2

The rod block monitor trip setting (S_M) shall be:

$$S_M \leq (0.65\ W + 42\%) \left[\frac{FRP}{MFLPD}\right]$$

Where, S_M = Rod block monitor trip setting in percent of rated thermal power (1998 MW_t).

W = Percent of drive flow required to produce a rated core flow of 69 Mlb/hr.

FRP = Fraction of rated thermal power (1998 MW_t).

MFLPD = Maximum fraction of limiting power density, where the limiting power density is 13.4 KW/ft for all fuel.

For core flows of 100% or greater, the rod block monitor trip setting shall not exceed 107% power.

3.0 CORE OPERATING LIMITS

3.1 Average Planar Linear Heat Generation Rate (APLHGR)

Reference Technical Specification: 3.11.A

During power operation with both recirculation pumps operating, the APLHGR for each type of fuel as a function of average planar exposure shall not exceed the applicable limiting value shown in Figures 3.1-1 through 3.1-3. The top curves on these figures are applicable for core flow greater than or equal to 90% of rated core flow. The lower curves are applicable for core flow less than 90% of rated core flow.

The core loading pattern for each type of fuel in the reactor vessel is shown for the present cycle in Figure 4.0-1.

3.2 Linear Heat Generation Rate (LHGR)

Reference Technical Specification: 3.11.B

During reactor power operation, the LHGR of any rod in any fuel assembly at any axial location shall not exceed 13.4 KW/ft. This limit is applicable for all fuel assemblies loaded in the core in the present cycle.

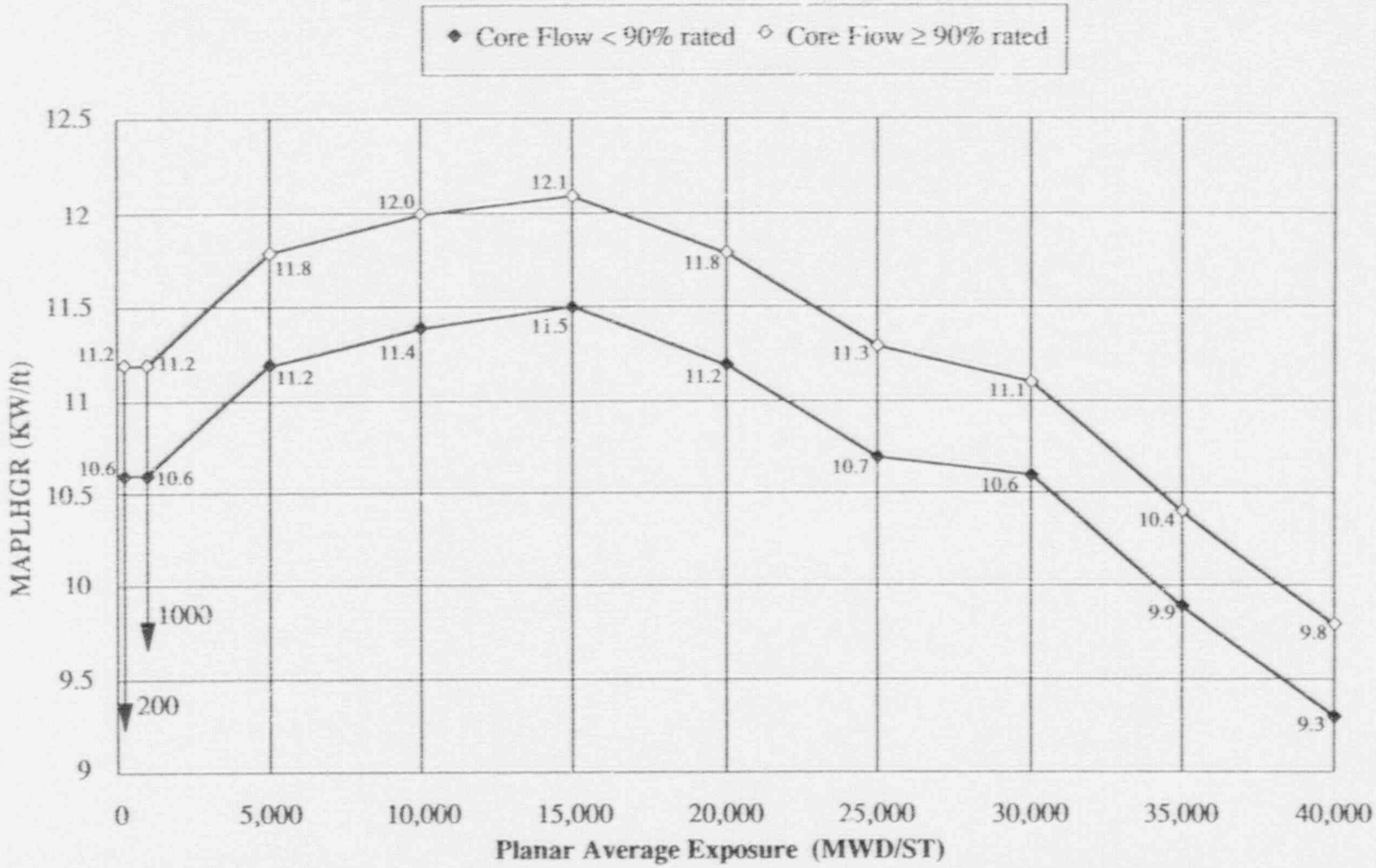


FIGURE 3.1-1
Maximum Average Planar Linear Heat Generation Rate (MAPLHGR) for Fuel Types P8DRB282 and BP8DRB282

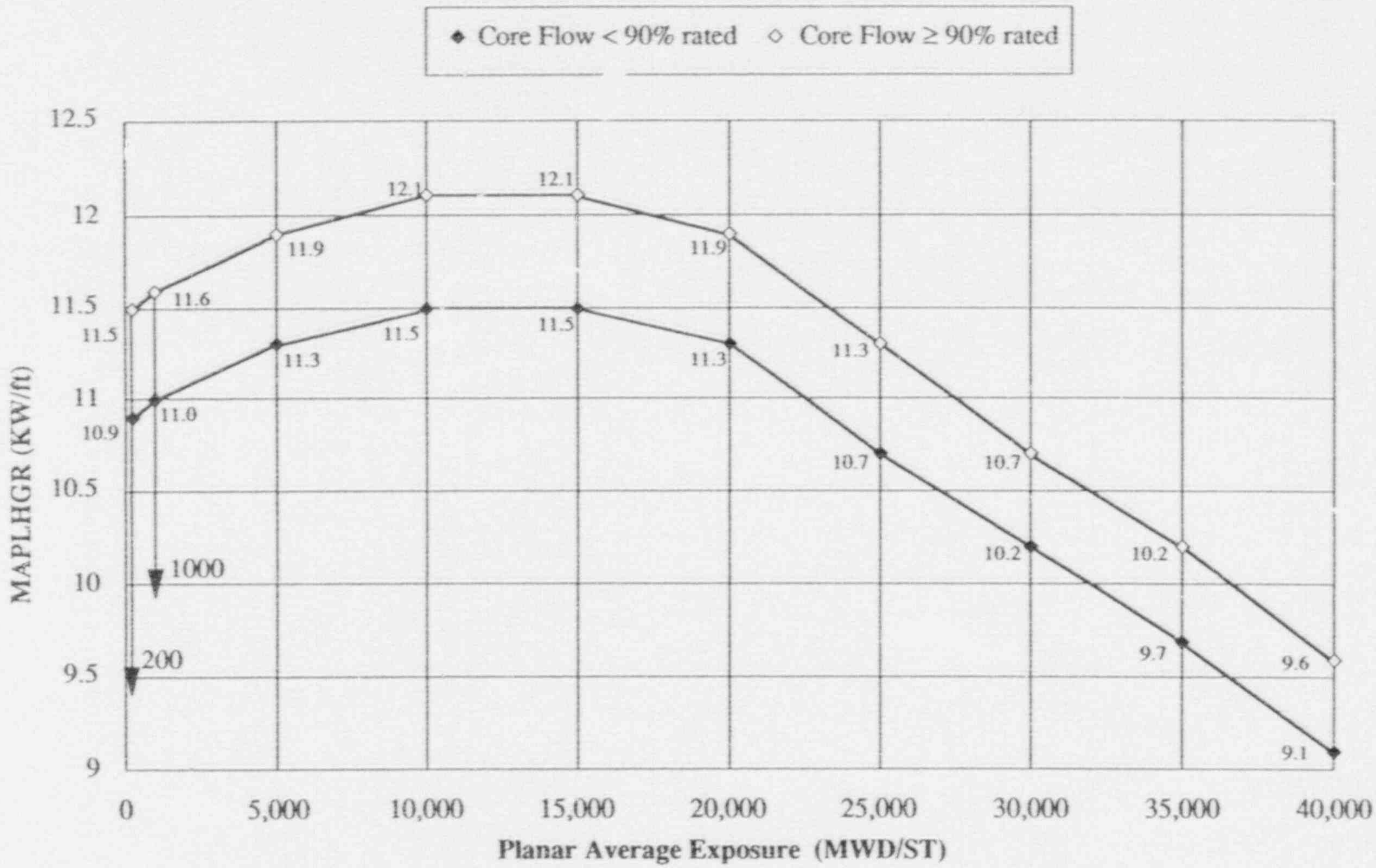


FIGURE 3.1-2

Maximum Average Planar Linear Heat Generation Rate (MAPLHGR) for Fuel Type P8DRB265H

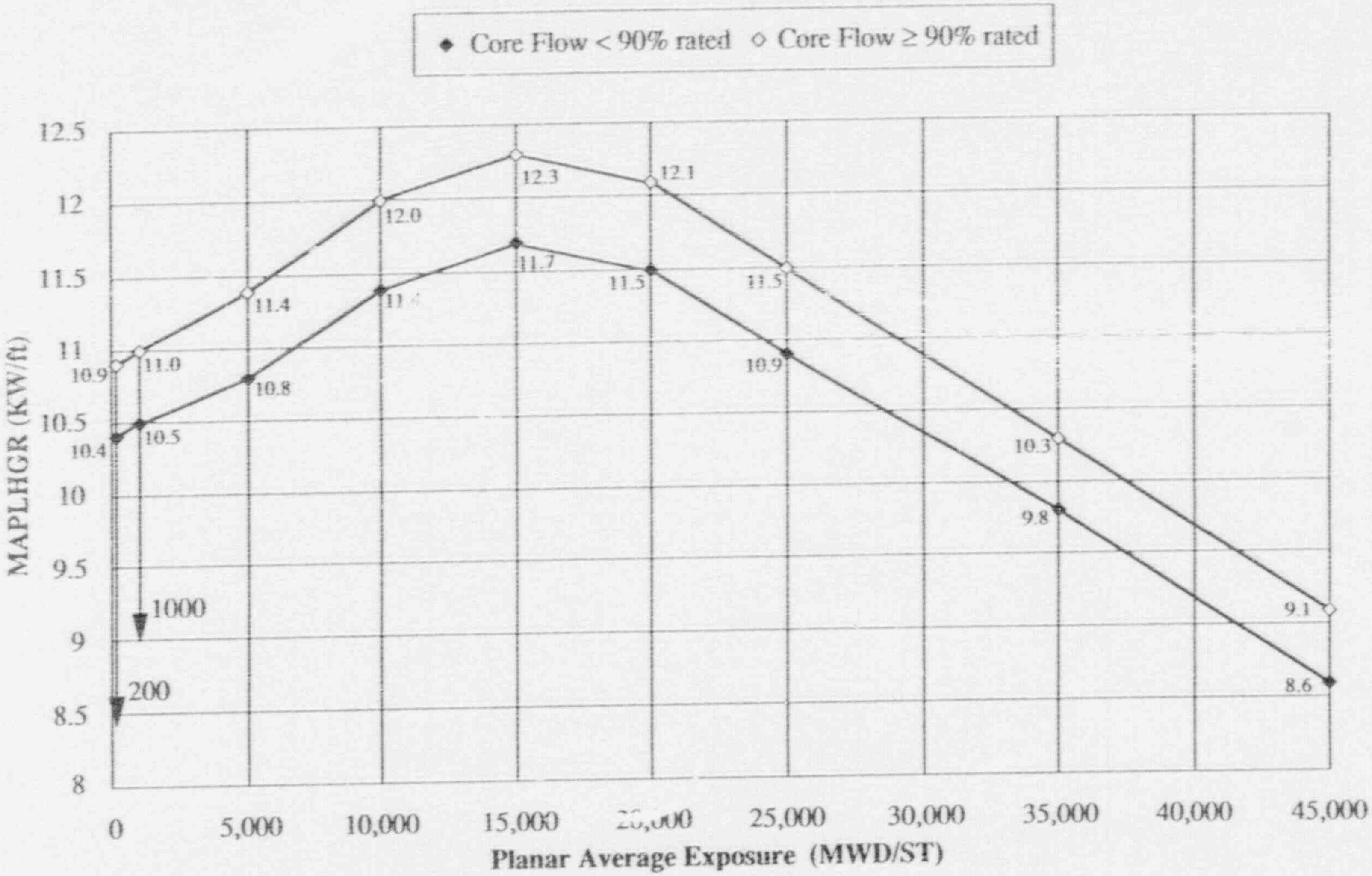


FIGURE 3.1-3

Maximum Average Planar Linear Heat Generation Rate (MAPLHGR) for Fuel Type BP8DRB300

3.3 Minimum Critical Power Ratio (MCPR)

Reference Technical Specification: 3.11.C

During power operation, MCPR shall be greater than or equal to the MCPR operating limits provided in Table 3.3-1. These MCPR operating limits are a function of the average scram insertion time (τ), which is calculated as described below.

For core flows other than rated, the MCPR operating limits in Table 3.3-1 shall be multiplied by the factor K_f, which is given in Figure 3.3-1. As an alternative method providing equivalent thermal-hydraulic protection at core flows other than rated, the calculated MCPR may be divided by K_f, with the MCPR operating limits in Table 3.3-1 left unchanged.

The value of the average scram insertion time (τ) in Table 3.3-1 shall be equal to 1.0, unless it is calculated from the results of the surveillance testing of Technical Specification 4.3.C, as follows:

$$\tau = \frac{\tau_{ave} - \tau_B}{1.275 - \tau_B}$$

Where, τ_{ave} = Average scram time to the 30% insertion position $= \dfrac{\sum_{i=1}^{n} N_i \tau_i}{\sum_{i=1}^{n} N_i}$

τ_B = Adjusted analysis mean scram time $= \mu + 1.65 \left[\dfrac{N_1}{\sum_{i=1}^{n} N_i} \right]^{1/2} \sigma$

n = Number of surveillance tests performed to date in the present cycle

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

3.3 <u>Minimum Critical Power Ratio (MCPR), Continued</u>

τ_i = Average scram time to the 30% insertion position of all rods measured in the i^{th} surveillance test

μ = Mean of the distribution for average scram insertion time to the 30% position = 0.945 sec

σ = Standard deviation of the distribution for average scram insertion time to the 30% position = 0.064 sec

TABLE 3.3-1

MCPR OPERATING LIMITS

Average Scram Insertion Time (τ)	MCPR Operating Limit
For operation from the Beginning of Cycle (BOC) to BOC + 7,953 MWD/ST:	
All values of τ	1.48
For operation from BOC + 7,953 MWD/ST to the End of Cycle:	
$\tau \leq 0.0$	1.41
$0.0 < \tau \leq 0.1$	1.42
$0.1 < \tau \leq 0.2$	1.43
$0.2 < \tau \leq 0.3$	1.44
$0.3 < \tau \leq 0.4$	1.45
$0.4 < \tau \leq 0.5$	1.46
$0.5 < \tau \leq 0.6$	1.47
$0.6 < \tau \leq 0.7$	1.48
$0.7 < \tau \leq 0.8$	1.49
$0.8 < \tau \leq 0.9$	1.50
$0.9 < \tau \leq 1.0$	1.51

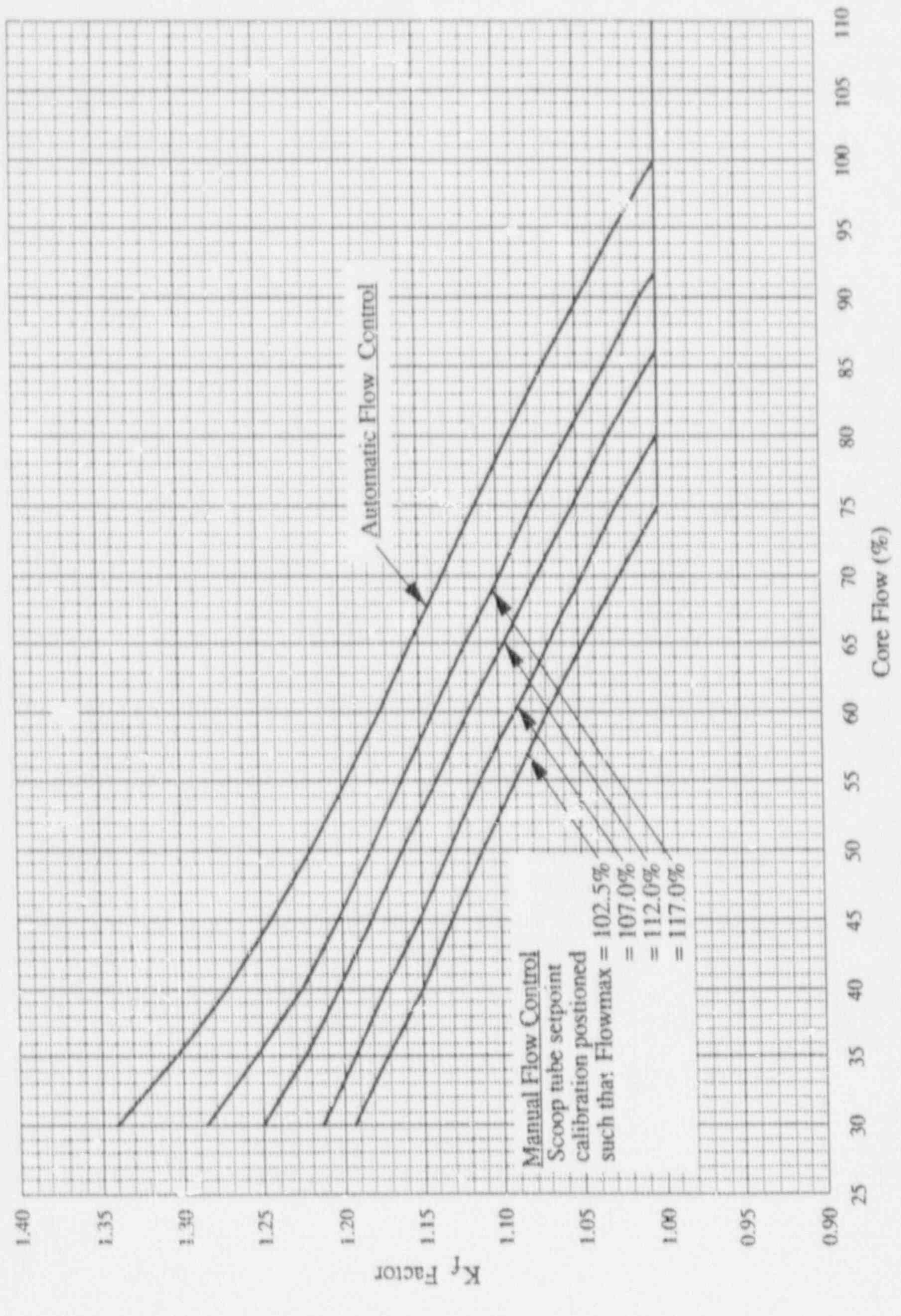


FIGURE 3.3-1
K_f Factor

3.4 Power/Flow Relationship During Powr Operation

Reference Technical Specification: 3.11.D

The power/flow relationship shall not exceed the limiting values shown on the Power/Flow Operating Map in Figure 3.4-1.

4.0 REACTOR VESSEL CORE DESIGN

Reference Technical Specification: 5.2

The reactor vessel core for the present cycle consists of 580 fuel assemblies of the types listed below. The core loading pattern for each type of fuel is shown for the present cycle in Figure 4.0-1.

Fuel Type	Cycle Loaded	Number
Irradiated		
P8DRB282	5	24
P8DRB265H	6	60
P8DRB282	6	112
P8DRB282	7	160
BP8DRB282	7	32
New		
BP8DRB300	8	192
Total		580

The reactor vessel core contains 145 cruciform-shaped control rods. The control materials used are either boron carbide powder (B_4C) compacted to approximately 70% of theoretical density or a combination of boron carbide powder and solid hafnium.

5.0 REFERENCES

5.1 NEDE-24011-P-A-8-US, "General Electric Standard Application for Reactor Fuel," May 1986.

5.2 NEDO-21696, "Loss of Coolant Analysis Report for Pilgrim Nuclear Power Station," August 1977 with errata and addenda through No 5, dated October 1986.

5.3 Amendment 14 to NEDE-24011-P-A, "General Electric Standard Application for Reactor Fuel," December 27, 1987, for MCPR safety limit.

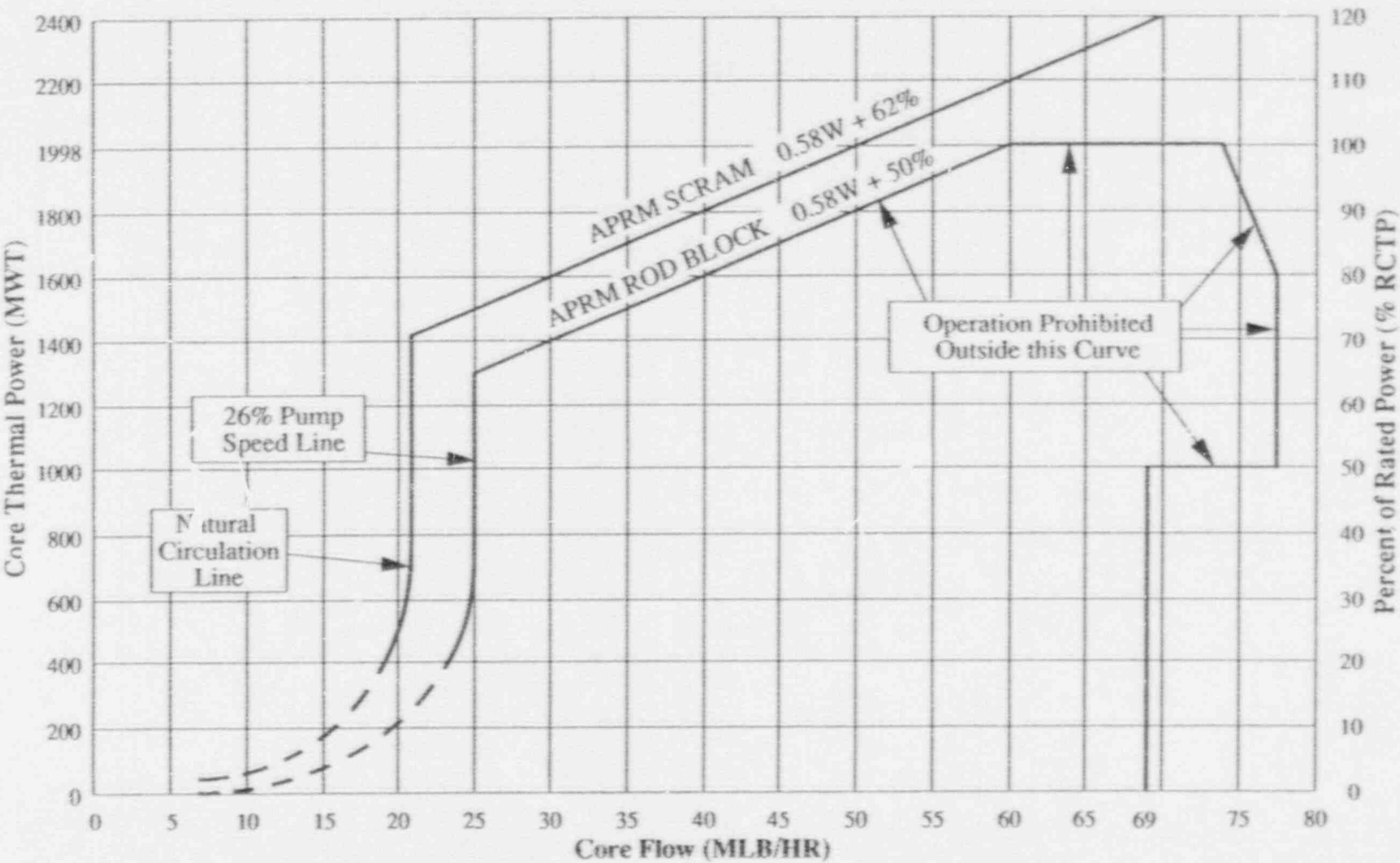
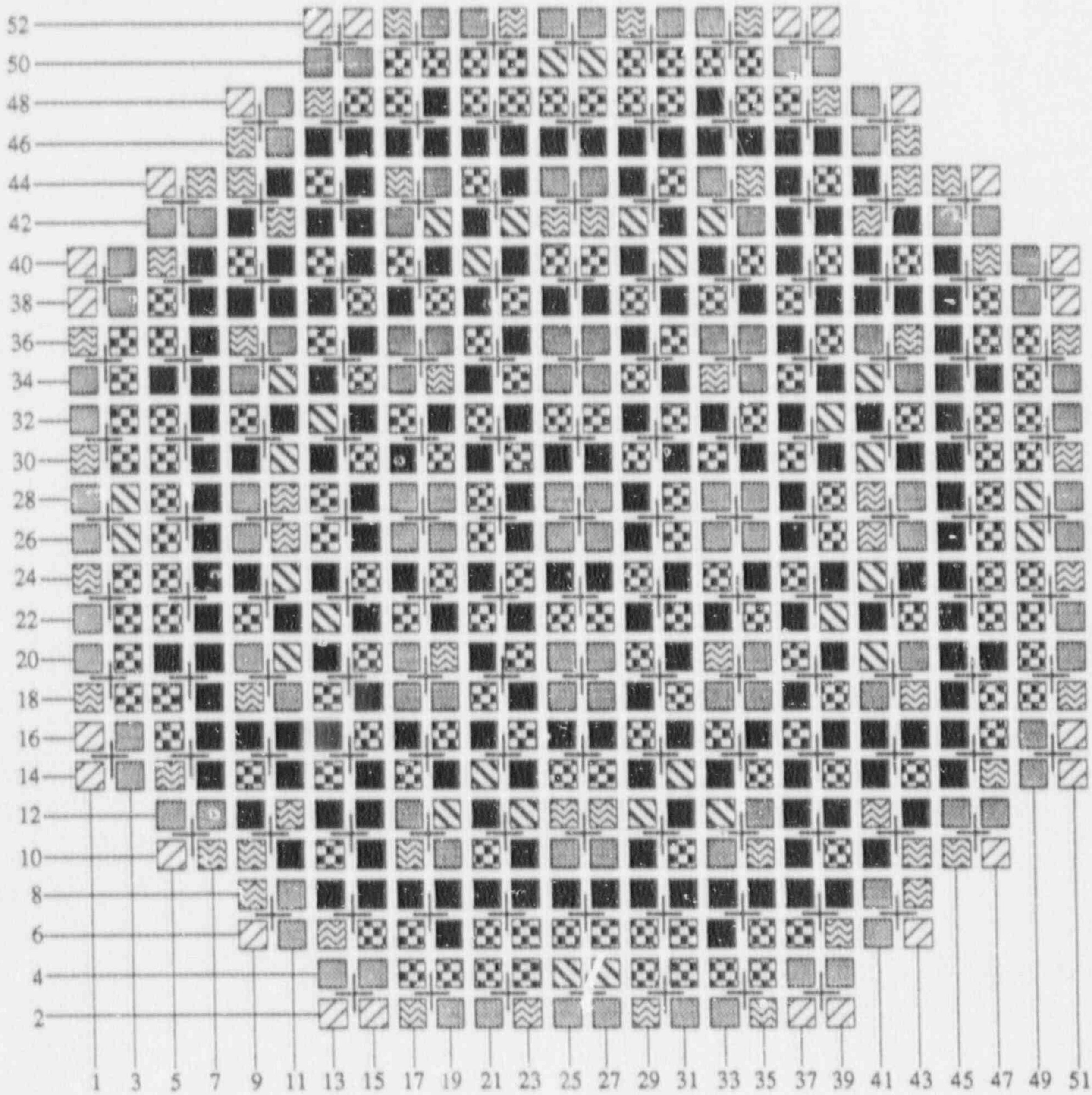


FIGURE 3.4-1
Power/ Flow Operating Map



Fuel Types

- P8DRB282, Cycle 5
- P8DRB265H, Cycle 6
- P8DRB282, Cycle 6
- BP8DRB282, Cycle 7
- P8DRB282, Cycle 7
- BP8DRB300, Cycle 8

FIGURE 4.0-1

Reactor Vessel Core Loading Pattern