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Subject: **Vermont Yankee Nuclear Power Station**
License No. DPR-28 (Docket No. 50-271)
Core Operating Limits Report for Cycle 25

In accordance with Section 6.6.C of the Vermont Yankee Technical Specifications, enclosed is the Core Operating Limits Report (COLR) for Cycle 25. This report presents the cycle-specific operating limits for Cycle 25 of the Vermont Yankee Nuclear Power Station.

If you have any questions concerning this transmittal, please contact me at (802) 258-4236.

Sincerely,

James M. DeVincentis
Manager, Licensing

Enclosure

cc: USNRC Region 1 Administrator
USNRC Resident Inspector – VYNPS
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Vermont Department of Public Service

A001

Vermont Yankee Nuclear Power Station

Cycle 25

Core Operating Limits Report

Revision 0

October 2005

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REVISION RECORD

Cycle	Revision	Date	Description
25	0	10/2005	Cycle 25 revision.

ABSTRACT

This report presents Cycle 25 specific operating limits at current license thermal power (1593 thermal megawatts)for the operation of the Vermont Yankee Nuclear Power Station as specified in Technical Specification 6.6.C. The limits included in the report are average planar linear heat generation rate, linear heat generation rate, minimum critical power ratio, and thermal-hydraulic stability exclusion region.

The requirement of Technical Specifications Table 3.2.5 pertaining to the rod block monitor (RBM) setpoint equation maximum value of N for single loop and dual loop operation are included in this report.

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1.0 INTRODUCTION

This report provides the cycle-specific limits for operation of the Vermont Yankee Nuclear Power Station in Cycle 25. It includes the limits for the average planar linear heat generation rate, linear heat generation rate, minimum critical power ratio, and thermal-hydraulic stability exclusion region. If any of these limits are exceeded, action will be taken as defined in the Technical Specifications.

As specified in Technical Specifications Table 3.2.5, the rod block monitor (RBM) setpoint equation maximum value of N for single loop and dual loop operation are included in this report.

This Core Operating Limits report for Cycle 25 has been prepared in accordance with the requirements of Technical Specifications 6.6.C. The core operating limits have been developed using the NRC-approved methodologies listed in References 3.1 through 3.4. The methodologies are also listed in Technical Specification 6.6.C. The bases for these limits are in References 3.5 through 3.8.

2.0 CORE OPERATING LIMITS

The Cycle 25 operating limits have been defined using NRC-approved methodologies. Cycle 25 must be operated within the bounds of these limits and all others specified in the Technical Specifications.

2.1. Average Planar Linear Heat Generation Rate Limits (APLHGR) (T.S. 3.11.A)

APLHGR is applicable to a specific planar height and is equal to the sum of the linear heat generation rate (LHGR) for all of the fuel rods in the specific bundle at the specific height divided by the number of fuel rods in the fuel bundle at the height.

The maximum APLHGR (MAPLHGR) limit is a function of reactor power, core flow, fuel type, and average planar exposure. The cycle dependent limits are developed using NRC approved methodology described in References 3.1 and 3.3. 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 3.1 and 3.3 will be met.

Tables 2.1-1 through 2.1-10 provide a limiting composite of MAPLHGR values for each fuel type, which envelope the lattice MAPLHGR values employed by the process computer (Reference 3.6). When hand calculations are required, these MAPLHGR values are used for all lattices in the bundle.

For single recirculation loop operation, the limiting values shall be the values from these Tables listed under the heading "Single Loop Operation." These values are obtained by multiplying the values for two loop operation by 0.82 (Reference 3.6).

The power and flow dependent MAPLHGR limits (MAPFAC multipliers) are identical to the LHGR limits (LHGRFAC multipliers) in Figure 2.3-1 and 2.3-2 since the power and flow dependent LHGRFAC multiplier are sufficient to provide adequate protection for the off-rated conditions from an ECCS-LOCA. Therefore, a specific power and flow dependent MAPLHGR limit (MAPFAC multipler) is not required.

2.2. Minimum Critical Power Ratio (MCPR) Limits (T.S. 3.11.C)

MCPR is the smallest Critical Power Ratio (CPR) that exists in the core for each type of fuel and shall be equal to, or greater than the Operating Limit MCPR (OLMCPR), which is a function of Core Thermal Power, Core Flow, Fuel Type, and Scram Time (Tau).

The rated Operating Limit MCPR at steady-state rated power and increased core flow operating conditions is derived from the cycle specific fuel cladding integrity Safety Limit MCPR and the delta CPR, as determined from the most limiting transient event. The rated OLMCPR will ensure that the Safety Limit MCPR is not exceeded during any abnormal operational occurrence (AOO) (Reference 3.6).

The rated OLMCPR for two loop and single loop operation is documented in Table 2.2-1 and is dependent on scram time (Tau) surveillance data at position 36 (Reference 3.5).

Determination of Tau:

i. First, τ_{ave} shall be determined:

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

where:

n = number of scram time tests thus far this cycle,

N_i = number of active rods measured in surveillance i, and

τ_i = average scram time to position 36 dropout of all rods measured in surveillance i.

ii. Second, τ_B shall be determined:

$$\tau_B = \mu + 1.65 \sqrt{\left(\frac{N_1}{\sum_{i=1}^{n} N_i}\right)} \sigma$$

where:

μ = 0.830 = mean of the distribution for average scram insertion time to position 36 dropout used in the ODYN Option B analysis.

σ = 0.019 = standard deviation of the distribution for average scram insertion time to position 36 dropout used in the ODYN Option B analysis.

N_1 = number of active rods measured during the first surveillance test at BOC.

iii. Third, determine the OLMCPR, as follows:

If $\tau_{ave} \leq \tau_B$, then $OLMCPR_{Option\,B}$ from Table 2.2.1 may be used.

If $\tau_{ave} > \tau_B$, then a new OLMCPR shall be calculated:

$$OLMCPR_{New} = OLMCPR_{Option\,B} + \frac{\tau_{ave} - \tau_B}{\tau_A - \tau_B}\left(OLMCPR_{Option\,A} - OLMCPR_{Option\,B}\right)$$

where:

$OLMCPR_{Option\ A}$ = Option A OLMCPR from Table 2.2.1 based on Option A analysis using full core scram times listed in Technical Specification 3.3.C.1.2.

$OLMCPR_{Option\ B}$ = Option B OLMCPR from Table 2.2.1 based on Option B analysis described in Reference 3.1.

τ_A = 1.096 seconds = Technical Specification 3.3.C.1.2 core average scram time to drop-out of position 36.

The OLMCPR is the greater of the flow and power dependent MCPR operating limits, MCPR (F) and MCPR (P).

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

The flow dependent MCPR operating limits, MCPR (F) is provided in Figure 2.2-2.

For core thermal powers less than 30%, the power dependent MCPR operating limit, MCPR (P), is provided in Figure 2.2-1. For core thermal powers equal to or greater than 30%, MCPR (P) is the product of the rated OLMCPR presented in Table 2.2-1 and the K (P) factor presented in Figure 2.2-1.

Cycle exposure dependent limits are provided through the end of rated exposure point, which is expected to be the maximum exposure attainable at full power during ICF operation. Coastdown operation is allowable down to 40% rated CTP.

For single recirculation loop operation, the MCPR limits at rated flow shall be the values from Table 2.2-1 listed under the heading, "Single Loop Operation." The single loop values are obtained by adding 0.02 to the two loop operation values (TS 1.1.A.1).

2.3. Linear Heat Generation Rate (LHGR) Limits (T.S. 3.11.B)

LHGR is 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 basis and licensing limits for the fuel will be satisfied.

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 Reference 3.1 to ensure the cladding will not exceed its yield stress and that the fuel thermal-mechanical design criteria will not be violated during any postulated transient events.

During reactor power operation, the LHGR of any rod in any fuel bundle at any axial location shall not exceed the rated power and rated core flow limits ($LHGR_{std}$) for each fuel and rod type as a function of fuel rod nodal exposure listed in Reference 3.7.

The LHGR limits for the fuel pin axial locations with no gadolinium and maximum gadolinium concentration listed in Reference 3.7 are expected to operate near the LHGR limits.

There are also fuel pins with axial locations that have gadolinium concentrations that are less than the maximum concentration anywhere in the bundle. The LHGR limits for these axial locations range uniformly between the case of no gadolinium and the most limiting gadolinium concentration.

For other than rated power and flow conditions (below 25% core thermal power thermal limit calculation is not required), the applicable limiting LHGR values for each fuel type is the smaller of the power and flow dependent LHGR limits multiplied by the applicable power and flow adjustment factor or the LHGR limit multiplied by 0.82 when in single loop operation.

LHGR limit = MIN (LHGR (P), LHGR (F)).

Power-dependent LHGR limit, LHGR (P), is the product of the LHGR power dependent LHGR limit adjustment factor, LHGRFAC (P), shown in Figure 2.3-1 and the $LHGR_{std}$.

LHGR (P) = LHGRFAC (P) x $LHGR_{std}$

The flow-dependent LHGR limit, LHGR (F), is the product of the LHGR flow dependent LHGR limit adjustment factor, LHGRFAC (F), shown in Figure 2.3-2 and the $LHGR_{std}$.

LHGR (F) = LHGRFAC (F) x $LHGR_{std}$

2.4. Thermal-Hydraulic Stability Exclusion Region (T.S. 3.6.J)

For Cycle 25, based on decay ratios at the most limiting point on the power/flow, the predominate oscillation mode is core-wide. Normal plant operation is not allowed inside the bounds of the exclusion region defined in Figure 2.4-1. These power and flow limits are applicable for Cycle 25. Operation inside of the exclusion region may result in a thermal-hydraulic oscillation. Intentional operation within the buffer region is not allowed unless the Stability Monitor is operable. Otherwise, the buffer region is considered part of the exclusion region (Reference 3.6).

The coordinates of the Exclusion Region are as follows:

Point	Power (%)	Flow (%)
A	82.32	55.28
B	38.81	31.22

The equation for the boundary is as follows:

$$P = P_B \left(\frac{P_A}{P_B} \right)^{\frac{1}{2}\left[\frac{W - W_B}{W_A - W_B} + \left(\frac{W - W_B}{W_A - W_B} \right)^2 \right]}$$

where,

P	=	a core thermal power value on the Exclusion Region boundary (% of rated),
W	=	the core flow rate corresponding to power, P, on the Exclusion Region boundary (% of rated),
P_A	=	core thermal power at State Point A (% of rated),
P_B	=	core thermal power at State Point B (% of rated),
W_A	=	core flow rate at State Point A (% of rated),
W_B	=	core flow rate at State Point B (% of rated),

The range of validity of the fit is: 31.22% ≤%Flow ≤55.28%

The coordinates of the Buffer Region are as follows:

Point	Power (%)	Flow (%)
C	86.91	60.28
D	33.81	30.88

The generic equation used to generate the 5% buffer zone exclusion region boundary is:

$$P = P_D \left(\frac{P_C}{P_D} \right)^{\frac{1}{2}\left[\frac{W - W_D}{W_C - W_D} + \left(\frac{W - W_D}{W_C - W_D} \right)^2 \right]}$$

where,

P	=	a core thermal power value on the Buffer Zone boundary (% of rated),
W	=	the core flow rate corresponding to power, P, on the 5% Buffer Zone boundary (% of rated),
P_C	=	core thermal power at State Point C (% of rated),
P_D	=	core thermal power at State Point D (% of rated),
W_C	=	core flow rate at State Point C (% of rated),
W_D	=	core flow rate at State Point D (% of rated),

The range of validity of the fit is: 30.88% ≤%Flow ≤60.28%.

2.5. Power/Flow Map

Power operation, with respect to Core Thermal Power/Total Core Flow combinations, is allowed within the outlined area of Figure 2.4-1. This area is bounded by the following lines:

- Minimum Pump Speed Line; This line approximates operation at minimum pump speed. Plant start-up is performed with the recirculation pumps operating at approximately 20% speed. Reactor power level will approximately follow this line during the normal control rod withdrawal sequence.

- Minimum Power Line; This lines approximates the interlock that requires recirc pump speed to be at a minimum in terms of feedwater flow. This interlock ensures NPSH requirements jet pumps and recirculation pumps are met.

- Natural Circulation Line; The operating state the reactor follows along this line for the normal control rod withdrawal sequence in the absence of recirculation pump operation.

- Exclusion Region - The exclusion region is a power/flow region where an instability can occur. The boundary for the exclusion region is established through use of an analysis procedure which is demonstrated to be conservative relative to expected operating conditions.

- 5% Buffer Region Boundary; The Buffer Region is determined by adjusting the endpoints of the Exclusion Region and increasing the flow on the highest rod line by 5% and decreasing power on the natural circulation line by 5%.

- Rated Power Line and MELLLA Boundary; These lines provide the upper power limit and operating domain assumed in transient analyses.

- ICF Boundary; This line represents the highest allowable analyzed core flow. The analysis in Reference 3.4 supports the maximum attainable core flow being 107% of rated core flow.

- 108% rod line; this line represents the ELLLA operating boundary and is the maximum load line allowed in single loop operation.

2.6. Single Loop Operation

SLO was not analyzed for operation in the MELLLA region. The power/flow operating condition for Single Loop Operation (SLO) is core power less than 1239 MWTh (77.77%CTP), core flow less than 26.35 M#/hr (54.9%) and maximum rod line less than 108%. (References 3.2 and 3.9)

2.7. Rod Block Monitoring

The Rod Block Monitor (RBM) control rod block functions are no longer credited in the Rod Withdrawal Error (RWE) Analysis and, as such, do not affect the MCPR Operating Limit. The RBM setpoints are based on providing operating flexibility in the MELLLA region (T.S. Bases 3.2). The rod block monitor (RBM) setpoint equation maximum value of N for single loop and dual loop operation are listed in Table 2.2-2.

Table 2.1-1

MAPLHGR Limits for GE14-P10DNAB426-16G6.0-100T-150-T6-2682
Fuel Bundle No. 2682

Average Planar Exposure (GWd/ST)	MAPLHGR (kW/ft)	
	Two Loop Operation	Single Loop Operation[1]
0.00	12.82	10.51
19.12	12.82	10.51
57.61	8.00	6.56
63.50	5.00	4.10

Technical Specification References: 3.6.G.1a and 3.11.A.

[1] MAPLHGR for single loop operation is obtained by multiplying MAPLHGR for two loop operation by 0.82.

Table 2.1-2

MAPLHGR Limits for GE14-P10DNAB390-14GZ-100T-150-T6-2683
Fuel Bundle No. 2683

Average Planar Exposure (GWd/ST)	MAPLHGR (kW/ft)	
	Two Loop Operation	Single Loop Operation[1]
0.00	12.82	10.51
19.12	12.82	10.51
57.61	8.00	6.56
63.50	5.00	4.10

Technical Specification References: 3.6.G.1a and 3.11.A.

[1] MAPLHGR for single loop operation is obtained by multiplying MAPLHGR for two loop operation by 0.82.

Table 2.1-3

MAPLHGR Limits for GE14-P10DNAB388-17GZ-100T-150-T6-2684
Fuel Bundle No. 2684

Average Planar Exposure (GWd/ST)	MAPLHGR (kW/ft)	
	Two Loop Operation	Single Loop Operation[1]
0.00	12.82	10.51
19.12	12.82	10.51
57.61	8.00	6.56
63.50	5.00	4.10

Technical Specification References: 3.6.G.1a and 3.11.A.

[1] MAPLHGR for single loop operation is obtained by multiplying MAPLHGR for two loop operation by 0.82.

Table 2.1-4

MAPLHGR Limits for GE14-P10DNAB422-16GZ-100T-150-T6-2862
Fuel Bundle No. 2862

Average Planar Exposure (GWd/ST)	MAPLHGR (kW/ft)	
	Two Loop Operation	Single Loop Operation[1]
0.00	12.82	10.51
19.12	12.82	10.51
57.61	8.00	6.56
63.50	5.00	4.10

Technical Specification References: 3.6.G.1a and 3.11.A.

[1] MAPLHGR for single loop operation is obtained by multiplying MAPLHGR for two loop operation by 0.82.

Table 2.1-5

MAPLHGR Limits for GE14-P10DNA383-13G6.0-100T-150-T6-2863
Fuel Bundle No. 2863

Average Planar Exposure (GWd/ST)	MAPLHGR (kW/ft)	
	Two Loop Operation	Single Loop Operation[1]
0.00	12.82	10.51
19.12	12.82	10.51
57.61	8.00	6.56
63.50	5.00	4.10

Technical Specification References: 3.6.G.1a and 3.11.A.

[1] MAPLHGR for single loop operation is obtained by multiplying MAPLHGR for two loop operation by 0.82.

Table 2.1-6

MAPLHGR Limits for GE14-P10DNAB388-17GZ-100T-150-T6-2864
Fuel Bundle No. 2864

Average Planar Exposure (GWd/ST)	MAPLHGR (kW/ft)	
	Two Loop Operation	Single Loop Operation[1]
0.00	12.82	10.51
19.12	12.82	10.51
57.61	8.00	6.56
63.50	5.00	4.10

Technical Specification References: 3.6.G.1a and 3.11.A.

[1] MAPLHGR for single loop operation is obtained by multiplying MAPLHGR for two loop operation by 0.82.

Table 2.1-7

MAPLHGR Limits for GE14-P10DNAB383-17G6.0-100T-150-T6-2865
Fuel Bundle No. 2865

Average Planar Exposure (GWd/ST)	MAPLHGR (kW/ft)	
	Two Loop Operation	Single Loop Operation[1]
0.00	12.82	10.51
19.12	12.82	10.51
57.61	8.00	6.56
63.50	5.00	4.10

Technical Specification References: 3.6.G.1a and 3.11.A.

[1] MAPLHGR for single loop operation is obtained by multiplying MAPLHGR for two loop operation by 0.82.

Table 2.1-8

MAPLHGR Limits for GE14-P10DNAB394-7G5.0/6G4.0-100T-150-T6-2566
Fuel Bundle No. 2566

Average Planar Exposure (GWd/ST)	MAPLHGR (kW/ft)	
	Two Loop Operation	Single Loop Operation[1]
0.00	12.82	10.51
19.12	12.82	10.51
57.61	8.00	6.56
63.50	5.00	4.10

Technical Specification References: 3.6.G.1a and 3.11.A.

[1] MAPLHGR for single loop operation is obtained by multiplying MAPLHGR for two loop operation by 0.82.

Table 2.1-9

MAPLHGR Limits for GE14-P10DNAB394-8G5.0/6G4.0-100T-150-T6-2595
Fuel Bundle No. 2595

Average Planar Exposure (GWd/ST)	MAPLHGR (kW/ft)	
	Two Loop Operation	Single Loop Operation[1]
0.00	12.82	10.51
19.12	12.82	10.51
57.61	8.00	6.56
63.50	5.00	4.10

Technical Specification References: 3.6.G.1a and 3.11.A.

[1] MAPLHGR for single loop operation is obtained by multiplying MAPLHGR for two loop operation by 0.82.

Table 2.1-10

MAPLHGR Limits for GE14-P10DNAB394-12G5.0-100T-150-T6-2596
Fuel Bundle No. 2596

Average Planar Exposure (GWd/ST)	MAPLHGR (kW/ft)	
	Two Loop Operation	Single Loop Operation[1]
0.00	12.82	10.51
19.12	12.82	10.51
57.61	8.00	6.56
63.50	5.00	4.10

Technical Specification References: 3.6.G.1a and 3.11.A.

[1] MAPLHGR for single loop operation is obtained by multiplying MAPLHGR for two loop operation by 0.82.

Table 2.2-1

Cycle 25 Rated MCPR Operating Limits (OLMCPR)

Option	Cycle Exposure Range	Two Loop Operation[2]	Single Loop Operation[1]
Option A	0 to 12611 MWd/St	1.49	1.51
	Beyond 12611 MWd/St	1.59	1.61
Option B	0 to 12611 MWd/St	1.40	1.42
	Beyond 12611 MWd/St	1.42	1.44

Source: References 3.6.

1 The MCPR operating limit is increased by 0.02 for single loop operation.
2 The two loop MCPR operating limits bound ICF operation throughout the cycle.

Table 2.2-2
RBM Setpoint [3]

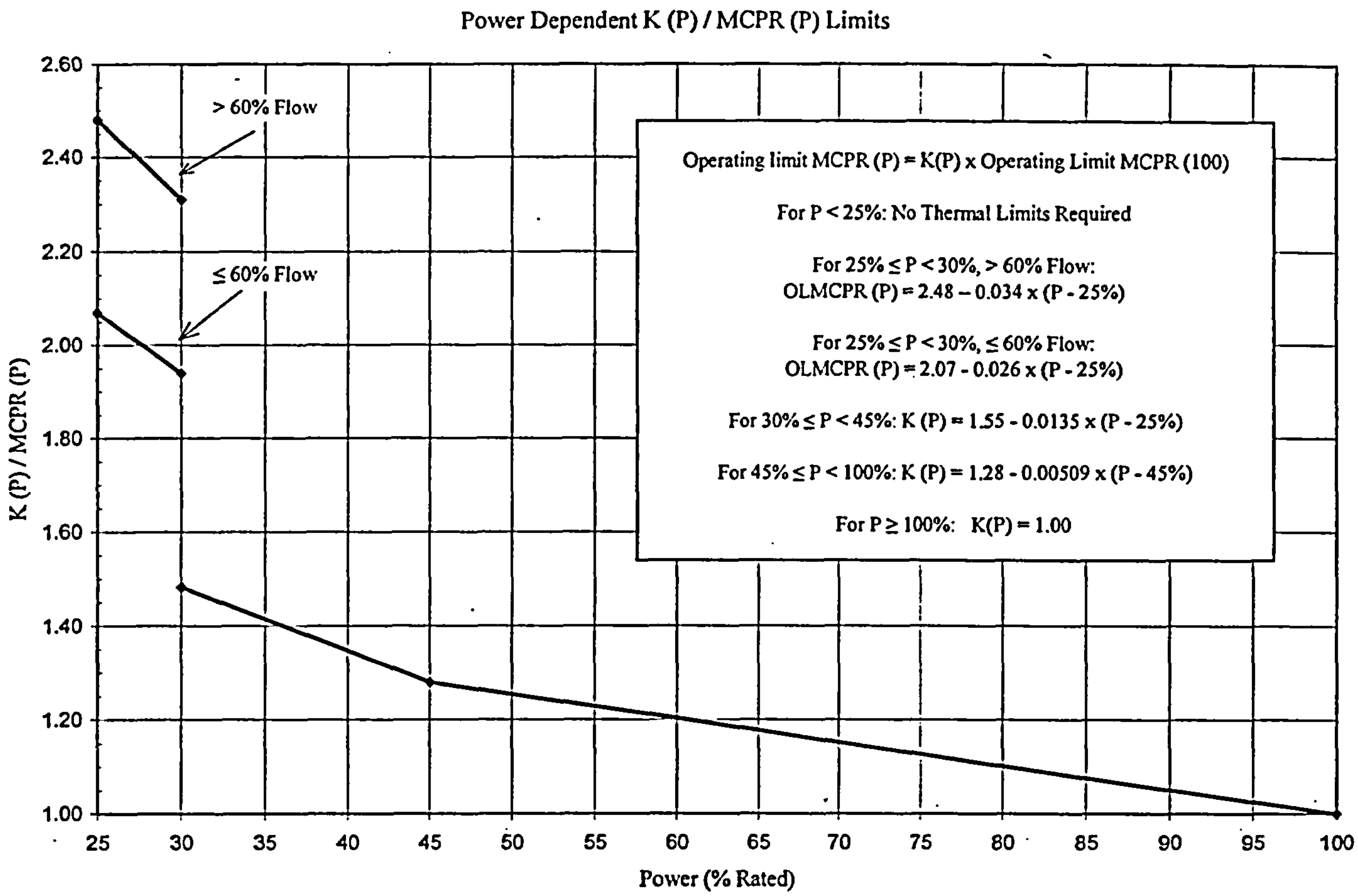
Dual Loop Operation Maximum Value of "N" in RBM Setpoint Equation – 62.

Single Loop Operation Maximum Value of "N" in RBM Setpoint Equation – 68.

Source: Reference 3.8

Technical Specification References: Table 3.2.5.

3 The Rod Block Monitor (RBM) trip setpoints are determined by the equation shown in Table 3.2.5 of the Technical Specifications.



<u>Figure 2.2-1</u>

<u>Power Dependent K (P) / MCPR (P) Limits</u>
(Technical Specification Reference 3.11.C)

Flow Dependend MCPR Operating Limit MCPR(F)

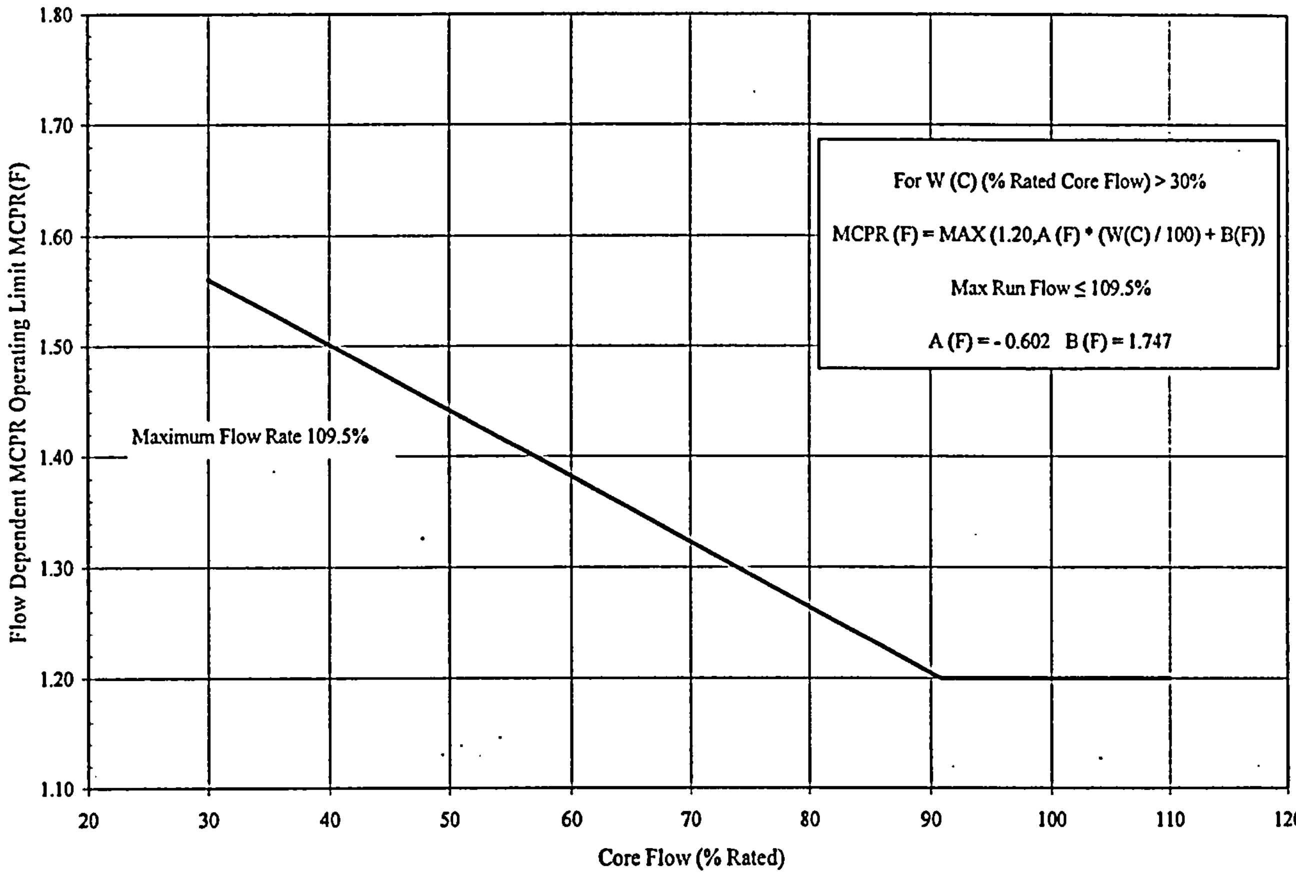


Figure 2.2-2

Flow Dependent MCPR Operating Limit MCPR (F)
(Technical Specification Reference 3.11.C)

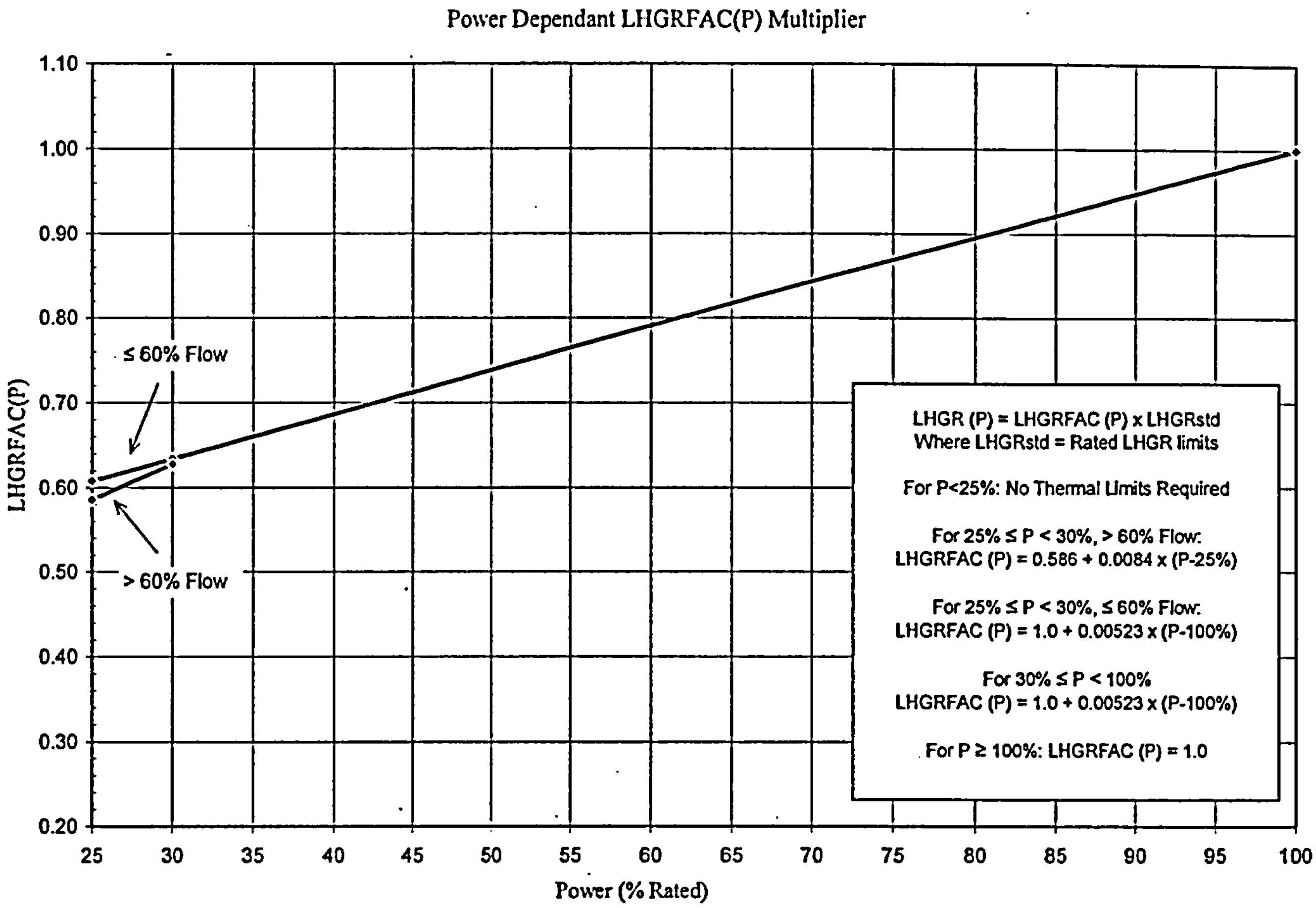


Figure 2.3-1

Power Dependent LHGRFAC (P) Multiplier
(Technical Specification Reference 3.11.B)

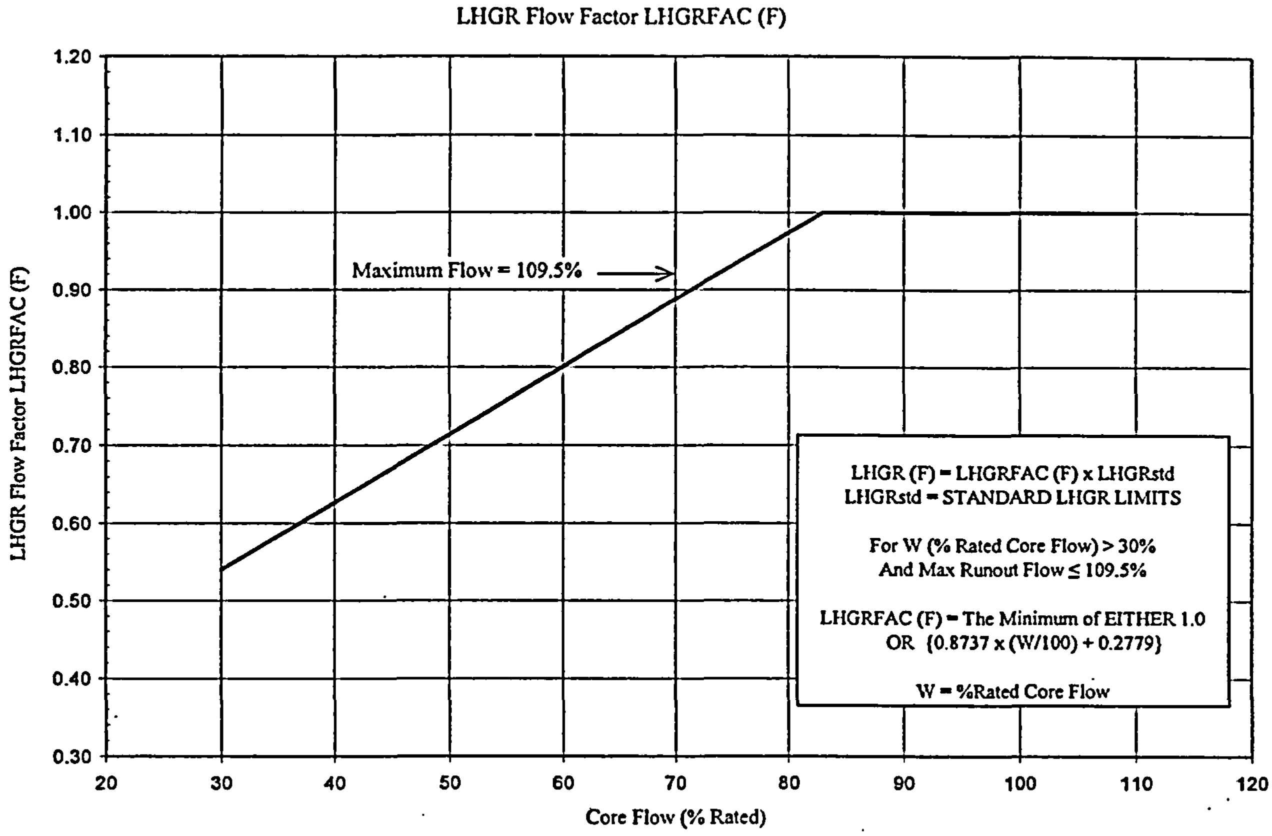


Figure 2.3-2

LHGR Flow Factor LHGRFAC (F)
(Technical Specification Reference 3.11.B)

CYCLE 25 POWER/FLOW MAP

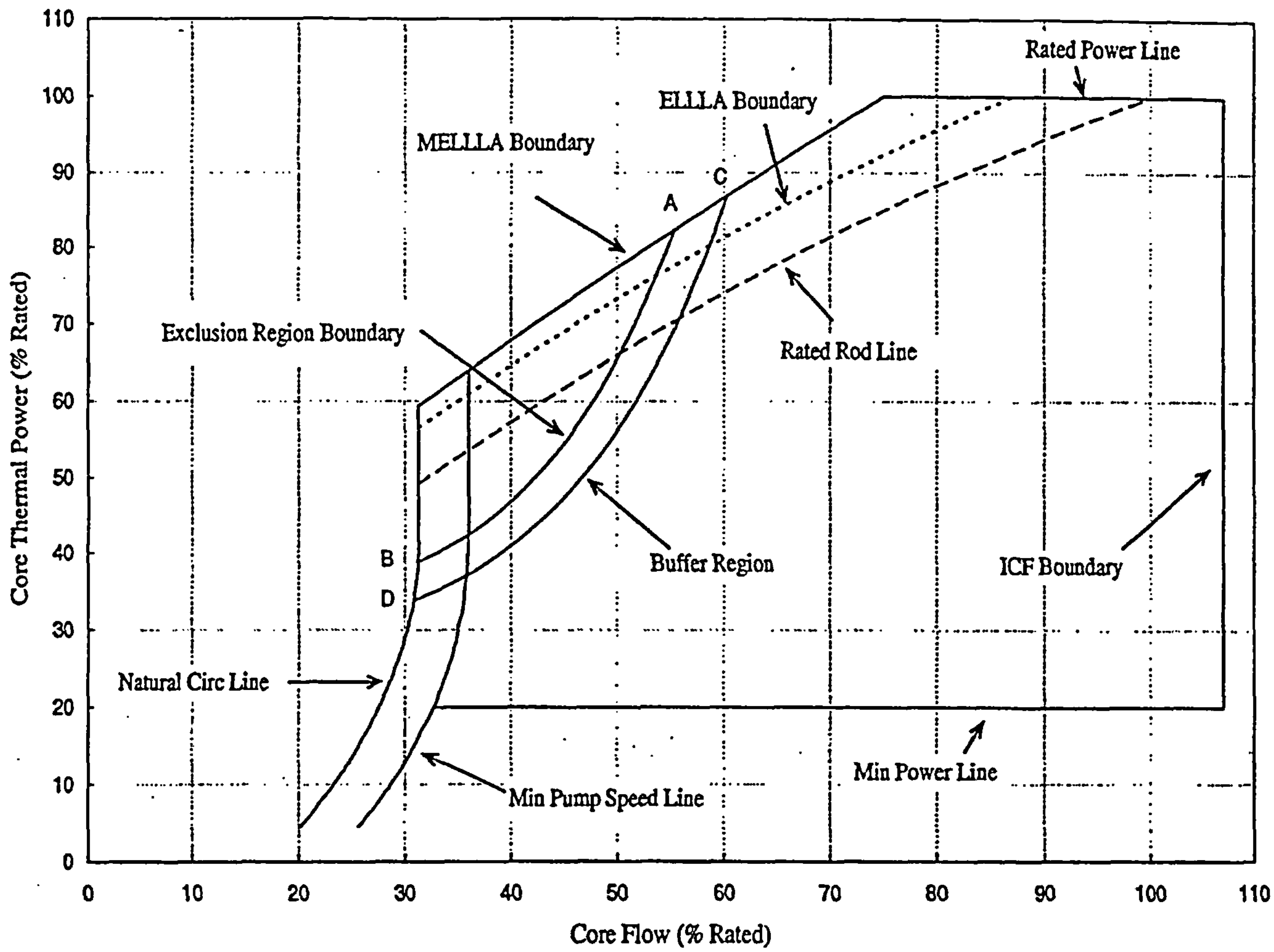


Figure 2.4-1

<u>Limits of Power/Flow Operation</u>
(Technical Specification Reference 3.6.J)

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