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U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Subject: **Vermont Yankee Nuclear Power Station**
License No. DPR-28 (Docket No. 50-271)
Core Operating Limits Report for Cycle 22

In accordance with Section 6.6.C of the Vermont Yankee Technical Specifications, enclosed is the Core Operating Limits Report (COLR) for Cycle 22. This report presents the cycle-specific operating limits for Cycle 22 of the Vermont Yankee Nuclear Power Station.

If you have any questions concerning this transmittal, please contact Mr. Jeffrey T. Meyer at (802) 258-4105.

Sincerely,

VERMONT YANKEE NUCLEAR POWER CORPORATION

Michael A. Balduzzi
Vice President, Operations

Enclosure

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

A001

Vermont Yankee Nuclear Power Station
Cycle 22
Core Operating Limits Report
Revision 0
March 2001

Prepared Ed Duda 3/26/2001
Reactor Engineer Date

Reviewed [signature] 3/26/2001
Reactor Engineer Date

Approved [signature] 4/16/01
Reactor Engineering Manager Date

Reviewed M. M. Houle Mtg. 2001-021 4/18/01
Plant Operations Review Committee Date

Approved [signature] 4/22/01
Plant Manager Date

Approved [signature] 4/23/01
Vice President of Operations Date

REVISION RECORD

Cycle	Revision	Date	Description
22	0	3/2001	Cycle 22 revision. Reviewed by PORC and approved by management.

ABSTRACT

This report presents the cycle-specific operating limits for the operation of Cycle 22 of the Vermont Yankee Nuclear Power Station. The limits are the maximum average planar linear heat generation rate, maximum linear heat generation rate, minimum critical power ratio, and thermal-hydraulic stability exclusion region.

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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 22. It includes the limits for the maximum average planar linear heat generation rate, maximum 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.

This Core Operating Limits report for Cycle 22 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 1 through 3. The methodologies are also listed in Technical Specification 6.6.C. The bases for these limits are in References 5 through 8.

2.0 CORE OPERATING LIMITS

The Cycle 22 operating limits have been defined using NRC-approved methodologies. Cycle 22 must be operated within the bounds of these limits and all others specified in the Technical Specifications.

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

During steady-state power operation, the Maximum Average Planar Linear Heat Generation Rate (MAPLHGR) for each fuel type, as a function of the average planar exposure, shall not exceed the limiting values shown in Tables 2.1-1 through 2.1-6. 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 5). The source of these values is identified on each table. These tables only list the limits for fuel types in Cycle 21.

The MAPLHGR values are usually the most limiting composite of the fuel thermal-mechanical design analysis MAPLHGRs and the Loss-of-Coolant Accident (LOCA) MAPLHGRs. The fuel thermal-mechanical design analysis, using the methods in Reference 1, demonstrates that all fuel rods in a lattice, operating at the bounding power history, meet the fuel design limits specified in Reference 1. The Vermont Yankee LOCA analysis, performed in conformance with the requirements of 10CFR50.46 and Appendix K demonstrates that the LOCA analysis MAPLHGR values are bounded at all exposure points by the thermal-mechanical design analysis MAPLHGR values.

The MAPLHGR actually varies axially, depending upon the specific combination of enriched uranium and gadolinia that comprises a fuel bundle cross section at a particular axial node. Each particular combination of enriched uranium and gadolinia is called a lattice type. Each lattice type has a set of MAPLHGR values that vary with fuel burnup. The process computer will verify that these lattice MAPLHGR limits are not violated. Tables 2.1-1 through 2.1-6 provide a limiting composite of MAPLHGR values for each fuel type, which envelope the lattice MAPLHGR values employed by the process computer. When hand calculations are required, these MAPLHGR values are used for all lattices in the bundle.

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

During steady-state power operation, the Minimum Critical Power Ratio (MCPR) shall be equal to, or greater than, the limits shown in Table 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).

For core flows other than the rated condition, the MCPR limit shall be the appropriate value from Table 2.2-1 multiplied by K_f, where K_f is given in Figure 2.2-1 as a function of the Recirc MG Set Stop setting. Interpolation between K_f curves is allowable, provided the curve used is conservative to the Recirc MG Set Stop setting.

Also listed is the maximum RBM rod block setpoint to which the designated MCPR limits apply. This value determines the RBM rod block clamp setpoint.

These limits are only valid for the fuel types in Cycle 22.

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

During steady-state power operation, the Linear Heat Generation Rate (LHGR) of any rod in any fuel bundle at any axial location shall not exceed the maximum allowable LHGR limits in Table 2.3-1. This table only lists the limits for fuel types in Cycle 22.

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

Normal plant operation is not allowed inside the bounds of the exclusion region defined in Figure 2.4-1, References 7 and 12. These power and flow limits are applicable for Cycle 22. 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.

The coordinates of the Exclusion Region are as follows:

Point	Power (%)	Flow (%)
A	73.5	50.3
B	31.8	30.6

The equation for the boundary is as follows:

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

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: 30.6% ≤%Flow ≤50.3%

The coordinates of the Buffer Region are as follows:

Point	Power (%)	Flow (%)
C	77.6	55.3
D	26.8	29.6

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

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

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: 29.6% ≤%Flow ≤55.3%.

2.5 Power/Flow Map

Power operation, with respect to Core Thermal Power/Total Core Flow combinations, is allowed within the boldly 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.

- 5% Buffer Region Boundary; The Buffer Region is determined by adjusting the endpoints of the 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%. Operational restrictions regarding the Exclusion and Buffer Regions are described in Section 2.4.

- High Flow Control Line; This line is defined by the path the plant would follow if a Dual Recirculation Pump Trip/Runback were to occur starting at the Extended Load Line Limit Analysis (ELLLA) Point, 100 %Power/87% Flow.

- Rated Power Line; This line provides an upper power limit assumed in transient analyses. The Rated Power line is equivalent to 1593 MW(th), or rated power for Vermont Yankee. The value is defined in the operating license and supplied in Technical Specifications.

- 107% Flow Line; This line represents the highest allowable analyzed core flow. The analysis in Reference 11 supports the maximum attainable core flow being approximately 107% of rated core flow.

- Minimum Power Line; This lines approximates the interlock that requires recirc pump speed to be at a minimum below 20% of feedwater flow. This interlock ensures NPSH requirements are met.

Additionally, up to approximately 20% Core Thermal Power, operation is allowed only at Minimum Pump Speed to ensure cavitation of Recirc Pumps and Jet Pumps does not occur.

Table 2.1-1

MAPLHGR Versus Average Planar Exposure for GE9B-BP8DWB354-12GZ-80U-150-T
Fuel Bundle No. 2153

Average Planar Exposure (GWd/ST)	MAPLHGR (kW/ft)	
	Two Loop Operation	Single Loop Operation[1]
0.00	10.96	8.98
0.20	11.04	9.05
1.00	11.18	9.16
2.00	11.40	9.34
3.00	11.63	9.53
4.00	11.81	9.68
5.00	12.01	9.84
6.00	12.14	9.95
7.00	12.26	10.05
8.00	12.37	10.14
9.00	12.46	10.21
10.00	12.52	10.26
12.50	12.40	10.16
15.00	12.10	9.92
20.00	11.40	9.34
25.00	10.72	8.79
35.00	9.44	7.74
45.00	7.24	5.93
48.20	5.67	4.64

The process computer utilizes exposure dependent MAPLHGR limits for each lattice type as provided in Reference 8. When hand calculations of MAPLHGR are performed, the limits shall not exceed the limits provided in the table above for this fuel type (Ref. 1).

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 Versus Average Planar Exposure for GE13-P9HTB380-12GZ-100T-146-T
Fuel Bundle No. 2278

Average Planar Exposure (GWd/ST)	MAPLHGR (kW/ft)	
	Two Loop Operation	Single Loop Operation[1]
0.00	10.64	8.72
0.20	10.71	8.78
1.00	10.85	8.89
2.00	11.04	9.05
3.00	11.23	9.20
4.00	11.43	9.37
5.00	11.64	9.54
6.00	11.82	9.69
7.00	11.96	9.80
8.00	12.12	9.93
9.00	12.27	10.06
10.00	12.44	10.20
12.50	12.57	10.30
15.00	12.24	10.03
17.50	11.90	9.75
20.00	11.54	9.46
25.00	10.82	8.87
30.00	10.12	8.29
35.00	9.43	7.73
40.00	8.76	7.18
45.00	8.10	6.64
50.00	7.44	6.10
55.00	6.77	5.55
57.48	6.43	5.27
57.58	6.42	5.26

The process computer utilizes exposure dependent MAPLHGR limits for each lattice type as provided in Reference 8. When hand calculations of MAPLHGR are performed, the limits shall not exceed the limits provided in the table above for this fuel type (Ref. 1).

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 Versus Average Planar Exposure for GE13-P9HTB379-13GZ-100T-146-T
Fuel Bundle No. 2279

Average Planar Exposure (GWd/ST)	MAPLHGR (kW/ft)	
	Two Loop Operation	Single Loop Operation[1]
0.00	10.64	8.72
0.20	10.69	8.76
1.00	10.81	8.86
2.00	10.99	9.01
3.00	11.18	9.16
4.00	11.36	9.31
5.00	11.49	9.42
6.00	11.63	9.53
7.00	11.78	9.65
8.00	11.92	9.77
9.00	12.07	9.89
10.00	12.22	10.02
12.50	12.33	10.11
15.00	12.23	10.02
17.50	11.90	9.75
20.00	11.54	9.46
25.00	10.82	8.87
30.00	10.11	8.29
35.00	9.42	7.72
40.00	8.75	7.17
45.00	8.09	6.63
50.00	7.43	6.09
55.00	6.76	5.54
57.50	6.42	5.26
57.56	6.40	5.24

The process computer utilizes exposure dependent MAPLHGR limits for each lattice type as provided in Reference 8. When hand calculations of MAPLHGR are performed, the limits shall not exceed the limits provided in the table above for this fuel type (Ref. 1).

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 Versus Average Planar Exposure for GE13-P9HTB388-13GZ-100T-146-T
Fuel Bundle No. 2365

Average Planar Exposure (GWd/ST)	MAPLHGR (kW/ft)	
	Two Loop Operation	Single Loop Operation[1]
0.00	10.85	8.89
0.20	10.93	8.96
1.00	11.06	9.06
2.00	11.25	9.22
3.00	11.45	9.38
4.00	11.63	9.53
5.00	11.78	9.65
6.00	11.92	9.77
7.00	12.06	9.88
8.00	12.2	10.00
9.00	12.32	10.10
10.00	12.44	10.20
12.50	12.42	10.18
15.00	12.22	10.02
17.50	11.95	9.79
20.00	11.64	9.54
25.00	10.93	8.96
30.00	10.23	8.38
35.00	9.55	7.83
40.00	8.87	7.27
45.00	8.21	6.73
50.00	7.54	6.18
55.00	6.86	5.62
57.86	6.46	5.29

The process computer utilizes exposure dependent MAPLHGR limits for each lattice type as provided in Reference 8. When hand calculations of MAPLHGR are performed, the limits shall not exceed the limits provided in the table above for this fuel type (Ref. 1).

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 Versus Average Planar Exposure for GE13-P9HTB388-13GZ1-100T-146-T
Fuel Bundle No. 2366

Average Planar Exposure (GWd/ST)	MAPLHGR (kW/ft)	
	Two Loop Operation	Single Loop Operation[1]
0.00	10.75	8.81
0.20	10.82	8.87
1.00	10.93	8.96
2.00	11.08	9.08
3.00	11.25	9.22
4.00	11.42	9.36
5.00	11.56	9.47
6.00	11.68	9.57
7.00	11.81	9.68
8.00	11.94	9.79
9.00	12.08	9.90
10.00	12.21	10.01
12.50	12.24	10.03
15.00	12.11	9.93
17.50	11.88	9.74
20.00	11.61	9.52
25.00	10.88	8.92
30.00	10.19	8.35
35.00	9.53	7.81
40.00	8.86	7.26
45.00	8.19	6.71
50.00	7.53	6.17
55.00	6.85	5.61
57.85	6.45	5.28

The process computer utilizes exposure dependent MAPLHGR limits for each lattice type as provided in Reference 8. When hand calculations of MAPLHGR are performed, the limits shall not exceed the limits provided in the table above for this fuel type (Ref. 1).

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 Versus Average Planar Exposure for GE13-P9DTB386-11G4.0/1G3.0-100T-146-T-2425
Fuel Bundle No. 2425

Average Planar Exposure (GWd/ST)	MAPLHGR (kW/ft)	
	Two Loop Operation	Single Loop Operation[1]
0.00	10.87	8.91
0.20	10.94	8.97
1.00	11.09	9.09
2.00	11.29	9.25
3.00	11.5	9.43
4.00	11.68	9.57
5.00	11.87	9.73
6.00	12.06	9.88
7.00	12.26	10.05
8.00	12.41	10.17
9.00	12.55	10.29
10.00	12.66	10.38
12.50	12.59	10.32
15.00	12.28	10.06
17.50	11.95	9.79
20.00	11.62	9.52
25.00	10.92	8.95
30.00	10.22	8.38
35.00	9.54	7.82
40.00	8.87	7.27
45.00	8.2	6.72
50.00	7.52	6.16
55.00	6.84	5.60
57.58	6.47	5.30

The process computer utilizes exposure dependent MAPLHGR limits for each lattice type as provided in Reference 8. When hand calculations of MAPLHGR are performed, the limits shall not exceed the limits provided in the table above for this fuel type (Ref. 1).

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

Vermont Yankee Nuclear Power Station
Cycle 22 MCPR Operating Limits

Value of "N" in RBM Equation (A)[1]	Average Control Rod Scram Time	Cycle Exposure Range	Two Loop Operation[3]	Single Loop Operation[2]
44%	Equal to or better than L.C.O. 3.3.C.1.1	0.0 to 7965 MWd/St	1.33	1.35
		7965 to 8965 MWd/St	1.34	1.36
		beyond 8965 MWd/St	1.36	1.38
	Equal to or better than L.C.O. 3.3.C.1.2	0.0 to 7965 MWd/St	1.37	1.39
		7965 to 8965 MWd/St	1.38	1.40
		beyond 8965 MWd/St	1.46	1.48

Maximum Allowable RBM Rod Block setpoint – 110% power.

Source: References 6 and 7.

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

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

2 The MCPR operating limits should be increased by 0.02 for the single loop operation.

3 The two loop MCPR operating limits bound ICF operation throughout the cycle.

Table 2.3-1

Maximum Allowable Linear Heat Generation Rate Limits

Fuel Type	Maximum Allowable Linear Heat Generation Rate (kW/ft)
GE9B-BP8DWB354-12GZ-80U-150-T	14.4
GE13-P9HTB380-12GZ-100T-146-T	14.4
GE13-P9HTB379-13GZ-100T-146-T	14.4
GE13-P9HTB388-13GZ-100T-146-T	14.4
GE13-P9HTB388-13GZ1-100T-146-T	14.4
GE13-P9DTB386-11G4.0/1G3.0-100T-146-T-2425	14.4

The process computer utilizes exposure dependent LHGR limits for each lattice type as provided in Reference 8.

Technical Specification References: 2.1.A.1a, 2.1.B.1, and 3.11.B.

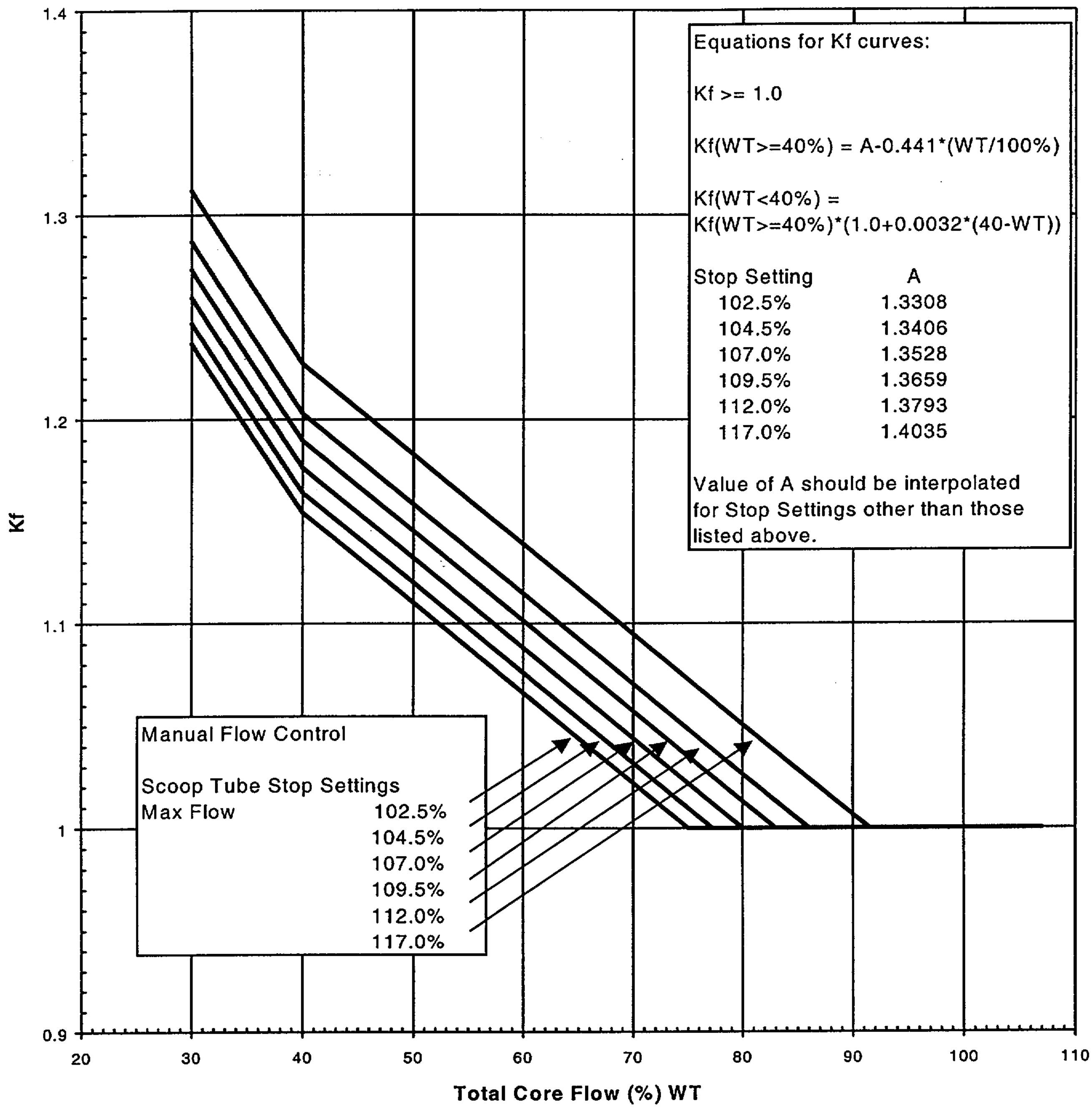

Figure 2.2-1

K_f vs. Total Core Flow
(Technical Specification Reference 3.11.C)

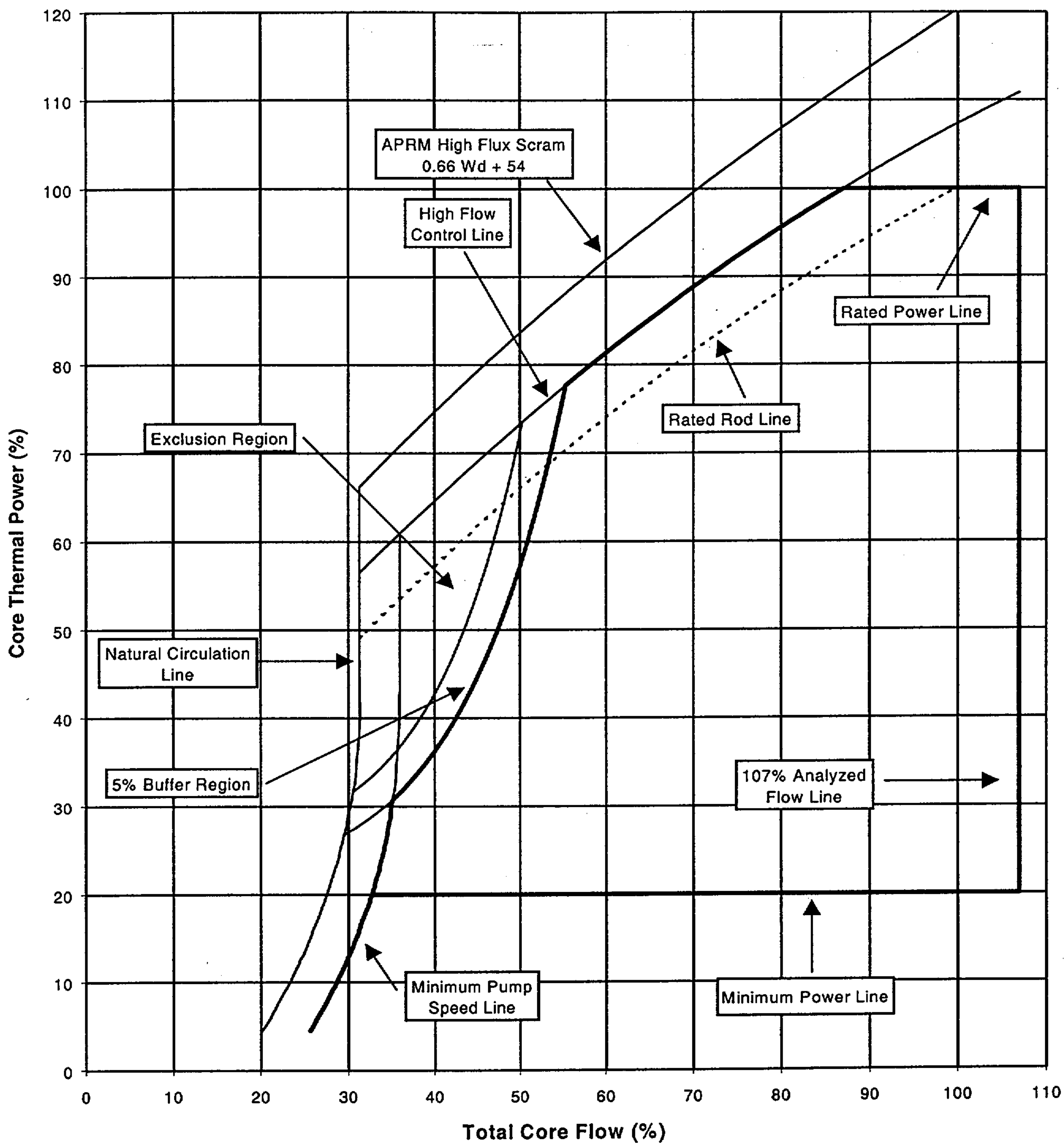

Figure 2.4-1

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

3.0 REFERENCES

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2. Report, General Electric Nuclear Energy, BWR Owners' Group Long-Term Stability Solutions Licensing Methodology, NEDO-31960, June 1991.

3. Report, General Electric Nuclear Energy, BWR Owners' Group Long-Term Stability Solutions Licensing Methodology, NEDO-31960, Supplement 1, March 1992.

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6. Report, Cycle Management Report for Vermont Yankee Nuclear Power Station Cycle 22, J11-03794CMR, Rev. 0, April 2001.

7. Report, Global Nuclear Fuel, Supplemental Reload Licensing Report for Vermont Yankee Nuclear Power Station Reload 21/Cycle 22, J11-03794SRLR, Rev. 1, March 2001.

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9.* Report, BWR Owners' Group Long-Term Stability Solutions Licensing Methodology," NEDO-31960-A, November 1995.

10.* Report, BWR Owners' Group Long-Term Stability Solutions Licensing Methodology," NEDO-31960-A, Supplement 1, November 1995.

11. Report, Vermont Yankee Nuclear Power Station Increased Core Flow Analysis, NEDC-32791P, February 1999.

12. Report, Option 1-D Stability Solution Analysis For the Vermont Yankee Nuclear Station Cycle 22 Reload, GENE-J11-03794-08-01, February 2001.

*References 9 and 10 are the generically approved documents for References 2 and 3, including the SER from Reference 4.