IES UTILITIES, INC.

Duane Arnold Energy Center

Cycle 14

CORE OPERATING LIMITS REPORT

Rev. 1

October 1995

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1.0 Core Operating Limits Report

This Core Operating Limits Report for Cycle 14 has been prepared in accordance with the requirements of Technical Specification 6.11.2. The core operating limits have been developed using NRC-approved methodology (Ref. 1) and are documented in References 2, 3 and 7. The Cycle 14 values for the core operating limits are provided in Section 3.0 of this report.

2.0 References

1. General Electric Standard Application for Reactor Fuel, NEDE-24011-P-A*

2. Duane Arnold Energy Center SAFER/GESTR-LOCA Loss-of-Coolant Accident Analysis, NEDC-31310P, Supp. 1, August 1993*

3. Supplemental Reload Licensing Submittal for Duane Arnold Energy Center, Reload 13, Cycle 14, 24A5171, Rev 1, August 1995

4. Duane Arnold Energy Center Single Loop Operation, NEDO-24272, July 1980

5. Average Power Range Monitor, Rod Block Monitor and Technical Specification Inprovement (ARTS) Program for the Duane Arnold Energy Center, NEDC-30813, December 1984

6. GE Fuel Bundle Designs, NEDE-31152P*

7. Application of the "Regional Exclusion with Flow-Biased APRM Neutron Flux Scram" Stability Solution (Option I-D) to the Duane Arnold Energy Center, GENE-A00-04021-01, September 1995

* Approved revision number at time reload fuel analyses are performed.

3.0 Core Operating Limits

1. Maximum Average Planar Linear Heat Generation Rate (MAPLHGR) - TS 3.12.A.

   a. The MAPLHGR for each fuel type as a function of average planar exposure shall not exceed the limiting value shown in Figures 1-5 multiplied by the smaller of the two MAPFAC factors determined from Figures 6 and 7.

   b. During SLO, the actual MAPLHGR for each type of fuel as a function of average planar exposure shall not exceed the limiting value shown in Figures 1-5 multiplied by the smaller of the two MAPFAC factors determined from Figures 7 and 8.

   c. Tables 1-5 provide the MAPLHGR values (KW/ft) for the exposure points (GWd/ST) used in the SAFER/GESTR-LOCA analysis. Tables 1-5 correspond to Figures 1-5 respectively.

2. Linear Heat Generation Rate (LHGR) - TS 3.12.B.

   a. The LHGR of any rod in any fuel assembly shall not exceed 14.4 KW/ft.

3. Minimum Critical Power Ratio (MCPR) -TS 3.12.C

   a. The MCPR shall be equal to or greater than the Operating Limit MCPR, which is a function of core thermal power, core flow, fuel type*, and scram time (Tau). For core thermal power greater than or equal to 25% of rated and less than 30% of rated (25% < P < 30%), the Operating Limit MCPR is given by Figure 9. For core thermal power greater than or equal to 30% of rated (P > 30%), the Operating Limit MCPR is the greater of either:

      i) The applicable flow-dependent MCPR determined from Figure 10, or

      ii) The appropriate RATED POWER MCPR from Figure 11 [including any penalty for a single Turbine Bypass Valve Out-of-Service (TBV-OOS) or the End-of-Cycle Recirculation Pump Trip (EOC-RPT) OOS], multiplied by the applicable power-dependent MCPR multiplier determined from Figure 9.

b. During SLO with core thermal power greater than or equal to 25% of rated, the SLO Operating Limit MCPR is determined by adding 0.03 to the Operating Limit MCPR determined above.

* Cycle 14 MCPR limits are applicable to all DAEC fuel types.

4.0 Reload Fuel Bundles

FUEL TYPE	CYCLE LOADED	NUMBER
GE10-P8HXB321-11GZ-70M-150-T	11	4
GE10-P8HXB317-7GZ-70M-150-T	11	4
GE10-P8HXB321-11GZ-70M-150-T	12	24
GE10-P8HXB316-8GZ-100M-150-T	12	80
GE10-P8DXB327-10GZ1-100M-150-T	13	56
GE10-P8DXB327-8GZ2-100M-150-T	13	72
GE10-P8DXB327-10GZ1-100M-150-T	14	88
GE10-P8DXB327-8GZ2-100M-150-T	14	40

5.0 Thermal-Hydraulic Stability - TS 3.3.F.3

a. Continued reactor operation within the "Exclusion Zone" on the power/flow map, as defined on Figure 12, is not permitted. The "Exclusion Zone" is used when the thermal-hydraulic stability monitor (SOLOMON) is operational.

b. Continued reactor operation within the "Buffer Zone" on the power/flow map, as defined on Figure 12, is not permitted when the thermal-hydraulic stability monitor (SOLOMON) is not operational.

TABLE 1

Linear Heat Generation Rate
as a function of
Planar Average Exposure*

Fuel type: GE10-P8HXB321-11GZ-70M-150-T

Planar Average Exposure (GWd/ST)	Linear Heat Generation Rate (KW/ft)
0.0	10.77
0.2	10.85
1.0	11.02
2.0	11.27
3.0	11.56
4.0	11.86
5.0	12.08
6.0	12.24
7.0	12.41
8.0	12.59
9.0	12.78
10.0	12.97
12.5	13.12
15.0	12.89
20.0	12.25
25.0	11.57
35.0	10.24
45.0	8.68
50.5	5.86

* These are nominal values to be used for manual calculations. The actual lattice-type dependent values are modeled in the process computer.

TABLE 2

Linear Heat Generation Rate
as a function of
Planar Average Exposure*

Fuel type: GE10-P8HXB317-7GZ-70M-150-T

Planar Average Exposure (GWd/ST)	Linear Heat Generation Rate (KW/ft)
0.0	11.50
0.2	11.50
1.0	11.56
2.0	11.69
3.0	11.84
4.0	12.02
5.0	12.21
6.0	12.42
7.0	12.64
8.0	12.87
9.0	13.07
10.0	13.21
12.5	13.24
15.0	12.93
20.0	12.23
25.0	11.54
35.0	10.21
45.0	8.71
50.7	5.86

* These are nominal values to be used for manual calculations. The actual lattice-type dependent values are modeled in the process computer.

TABLE 3

Linear Heat Generation Rate
as a function of
Planar Average Exposure*

Fuel type: GE10-P8HXB316-8GZ-100M-150-T

Planar Average Exposure (GWd/ST)	Linear Heat Generation Rate (KW/ft)
0.0	11.22
0.2	11.28
1.0	11.42
2.0	11.62
3.0	11.81
4.0	12.02
5.0	12.22
6.0	12.34
7.0	12.46
8.0	12.59
9.0	12.74
10.0	12.89
12.5	12.99
15.0	12.76
20.0	12.27
25.0	11.63
35.0	10.23
45.0	8.79
50.8	5.90

* These are nominal values to be used for manual calculations. The actual lattice-type dependent values are modeled in the process computer.

TABLE 4

Linear Heat Generation Rate
as a function of
Planar Average Exposure*

Fuel type: GE10-P8DXB327-10GZ1-100M-150-T

Planar Average Exposure (GWd/ST)	Linear Heat Generation Rate (KW/ft)
0.0	11.49
0.2	11.56
1.0	11.71
2.0	11.88
3.0	12.05
4.0	12.23
5.0	12.42
6.0	12.57
7.0	12.70
8.0	12.82
9.0	12.95
10.0	13.09
12.5	13.17
15.0	12.90
20.0	12.16
25.0	11.38
35.0	9.92
45.0	8.51
50.7	5 77

* These are nominal values to be used for manual calculations. The actual lattice-type dependent values are modeled in the process computer.

TABLE 5

Linear Heat Generation Rate
as a function of
Planar Average Exposure*

Fuel type: GE10-P8DXB327-8GZ2-100M-150-T	
Planar Average Exposure (GWd/ST)	Linear Heat Generation Rate (KW/ft)
0.0	11.72
0.2	11.77
1.0	11.88
2.0	11.96
3.0	12.04
4.0	12.10
5.0	12.17
6.0	12.24
7.0	12.31
8.0	12.39
9.0	12.47
10.0	12.56
12.5	12.57
15.0	12.33
20.0	11.81
25.0	11.29
35.0	10.20
45.0	8.48
50.1	5.90

* These are nominal values to be used for manual calculations. The actual lattice-type dependent values are modeled in the process computer.

MAPLHGR VS PAE

GE10-P8HXB321-11GZ-70M-150-T

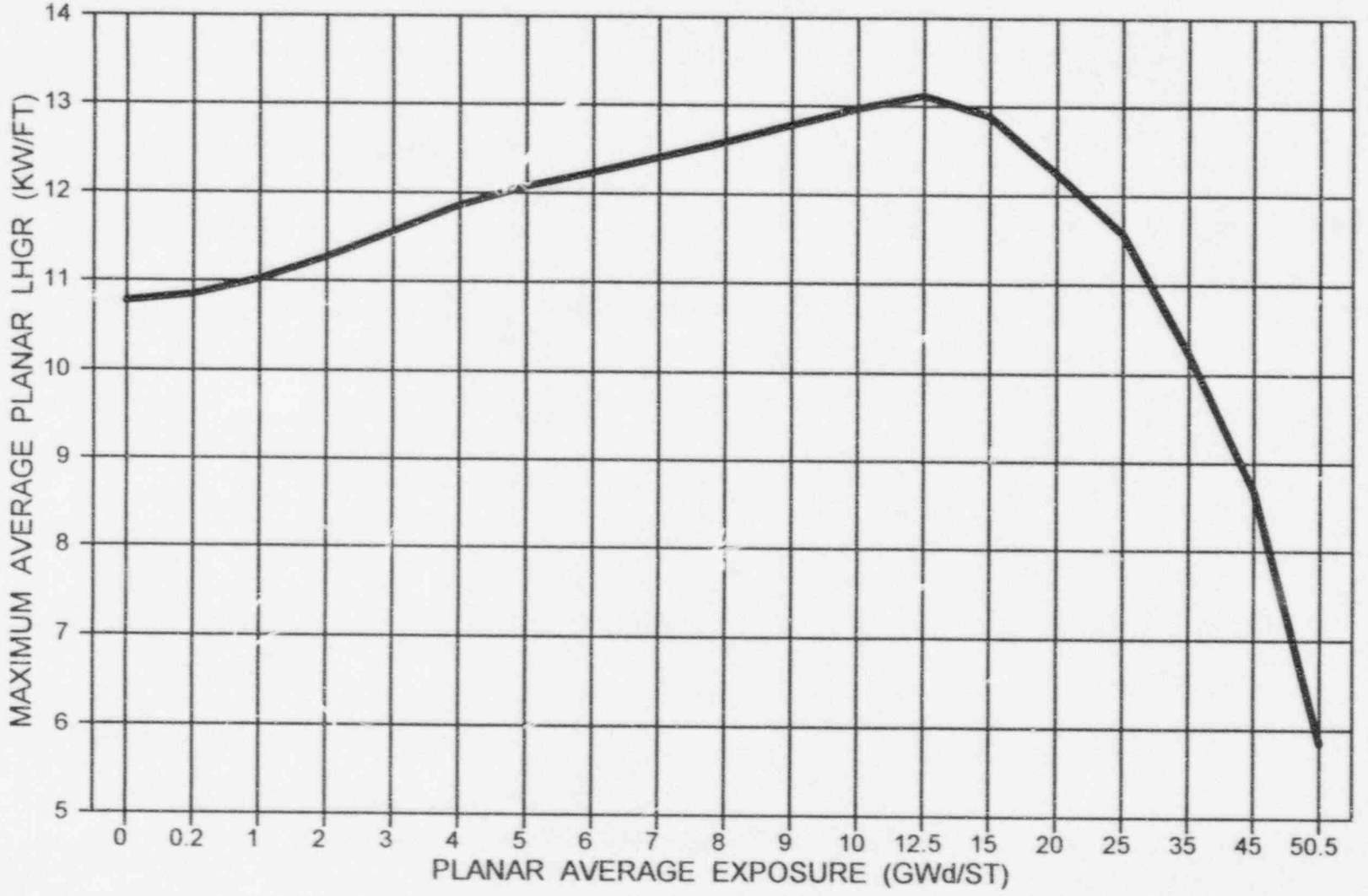

FIGURE 1

MAPLHGR VS PAE

GE10-P8HXB317-7GZ-70M-150-T

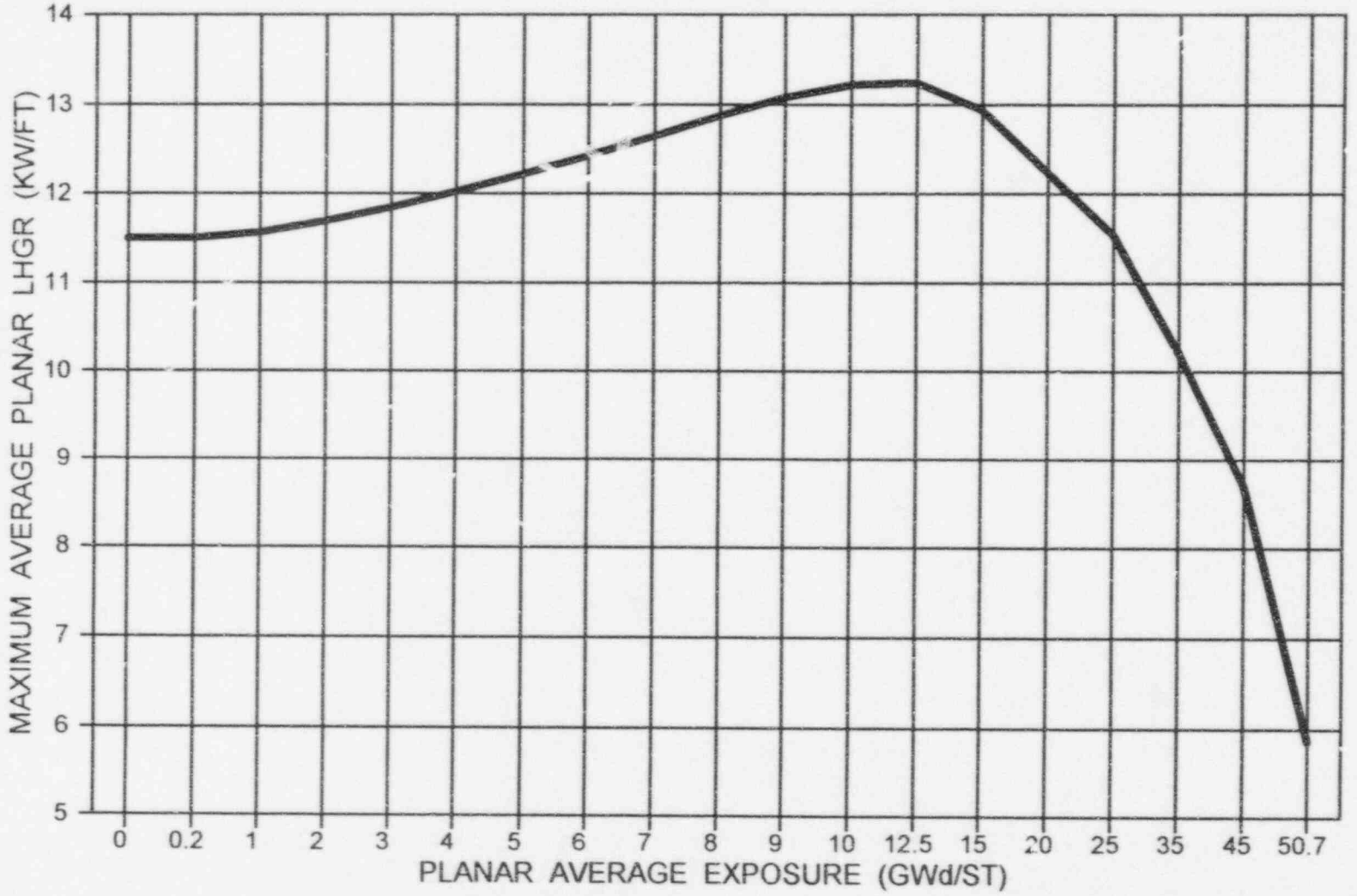

FIGURE 2

MAPLHGR VS PAE

GE10-P8HXB316-8GZ-100M-150-T

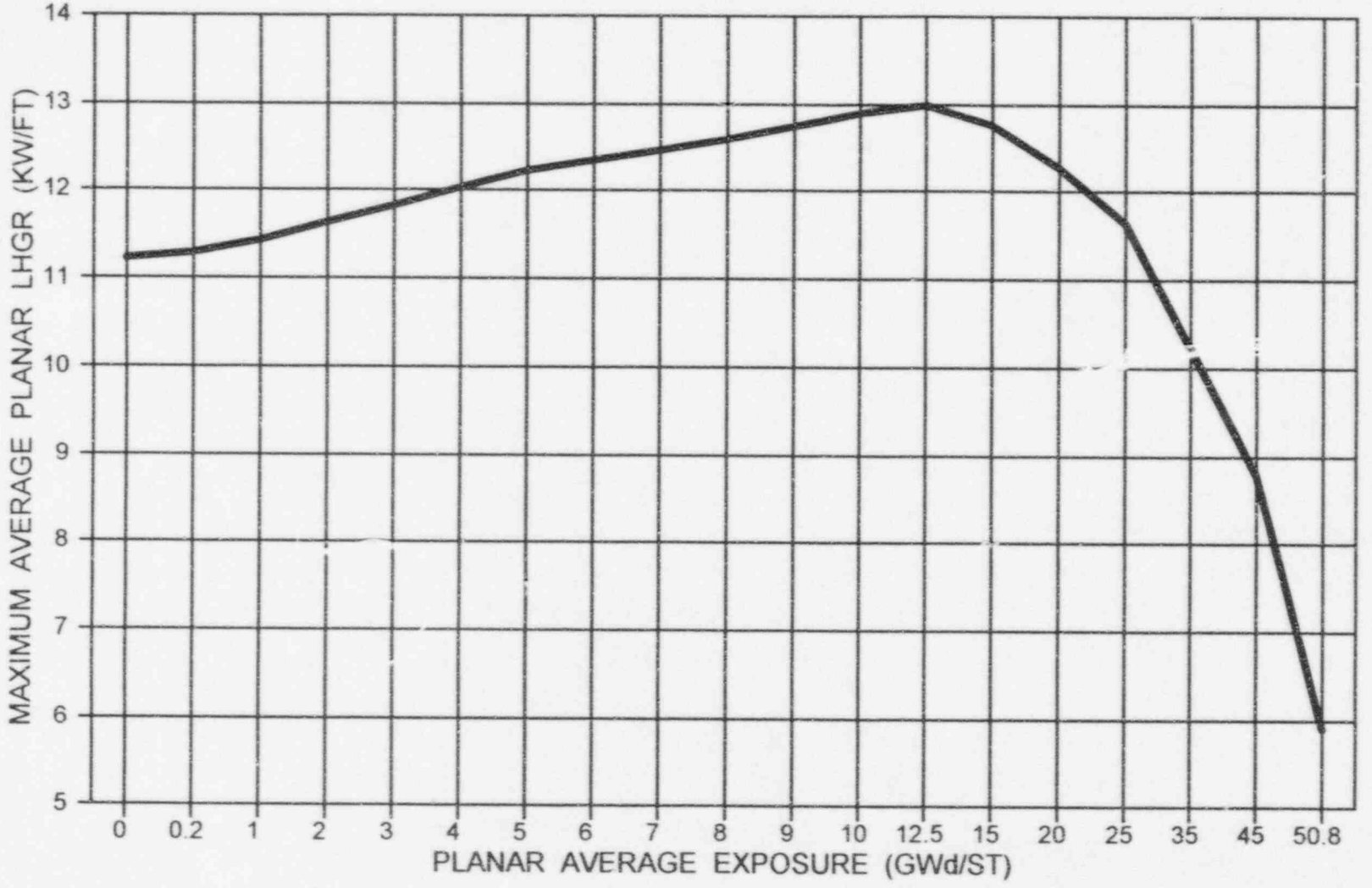

FIGURE 3

MAPLHGR VS PAE

GE10-P8DXB327-10GZ1-100M-150-T

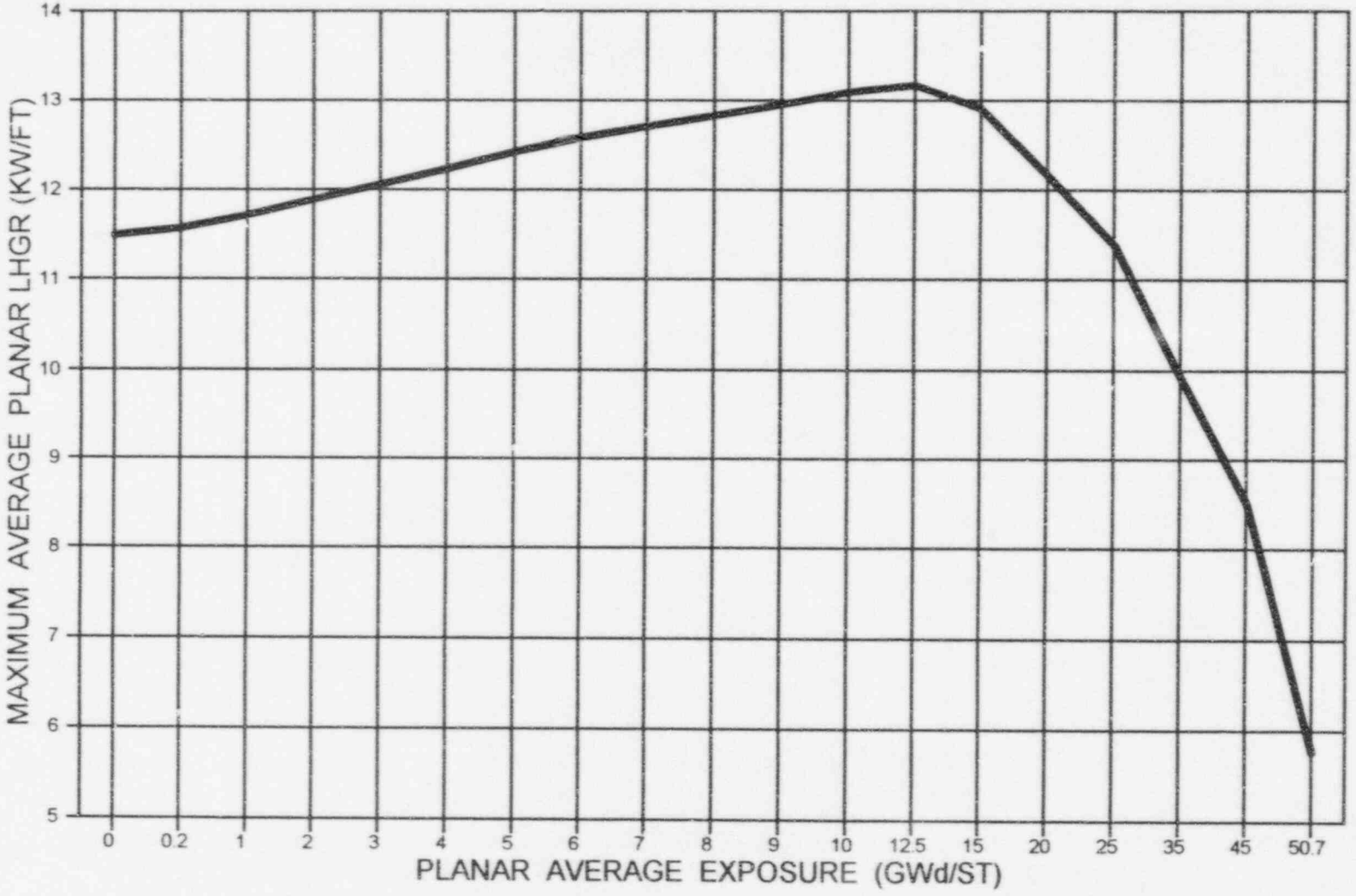

FIGURE 4

MAPLHGR VS PAE

GE10-P8DXB327-8GZ2-100M-150-T

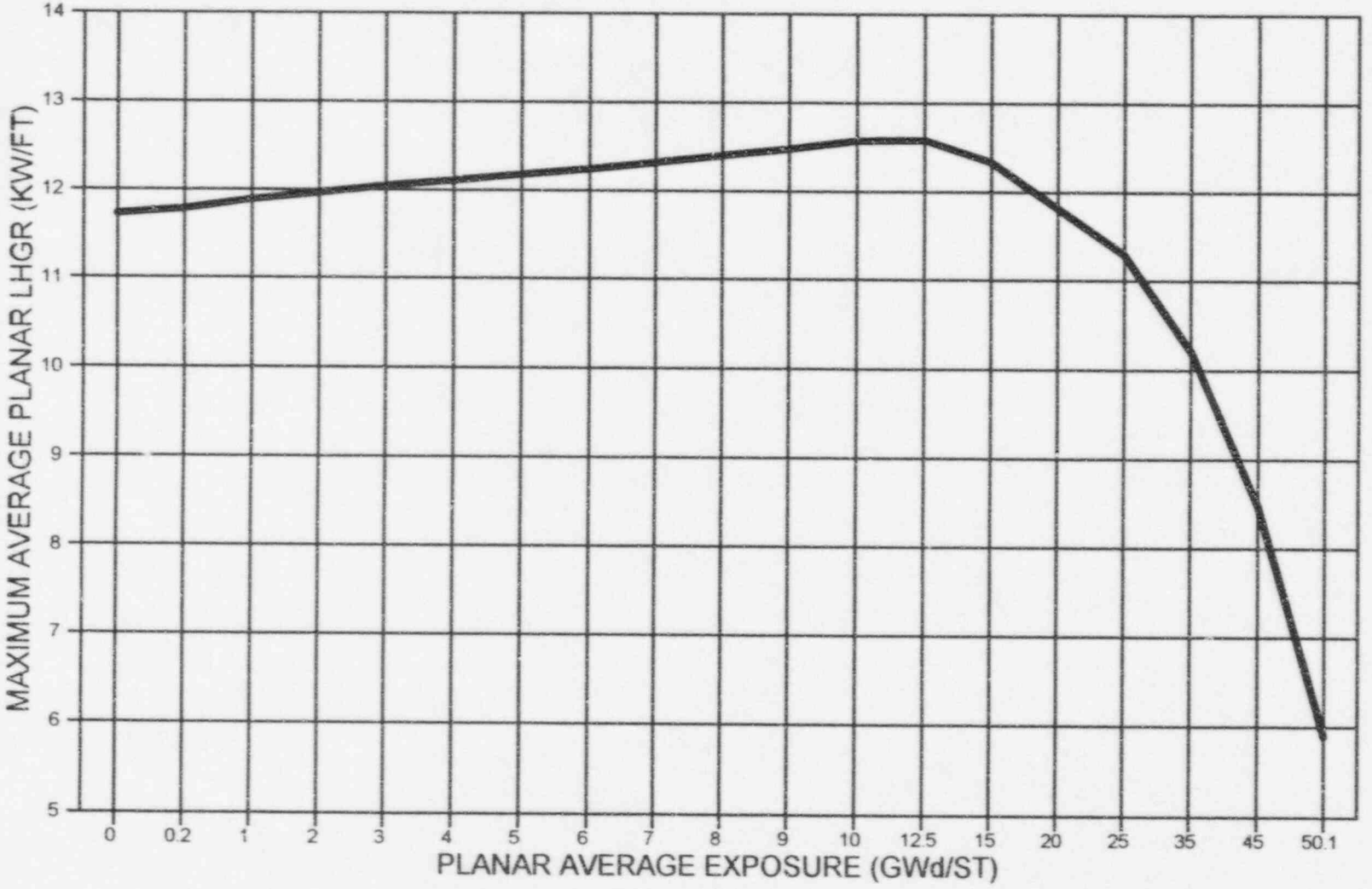

FIGURE 5

FLOW DEPENDENT MAPLHGR MULTIPLIER

TWO LOOP OPERATION

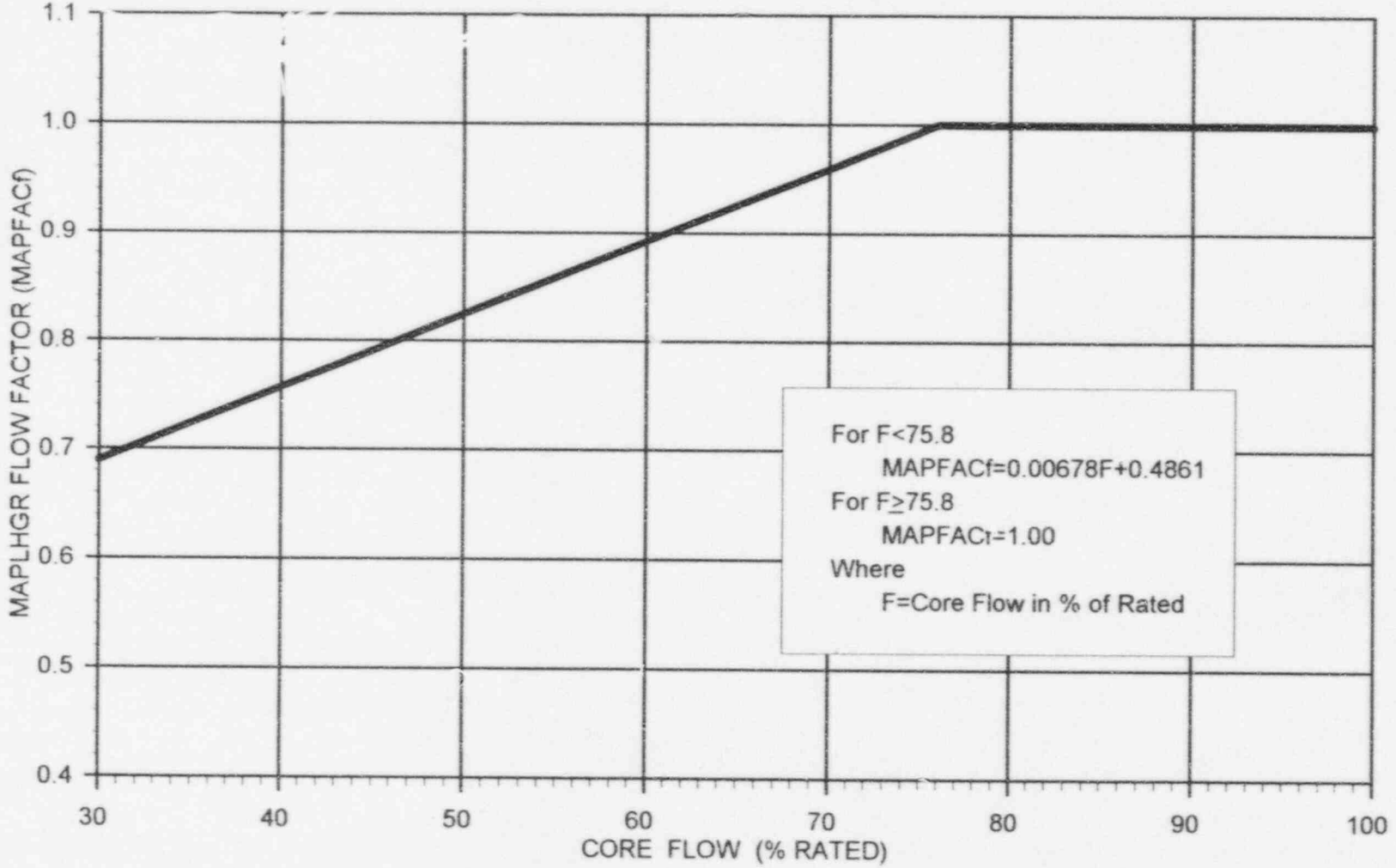

FIGURE 6

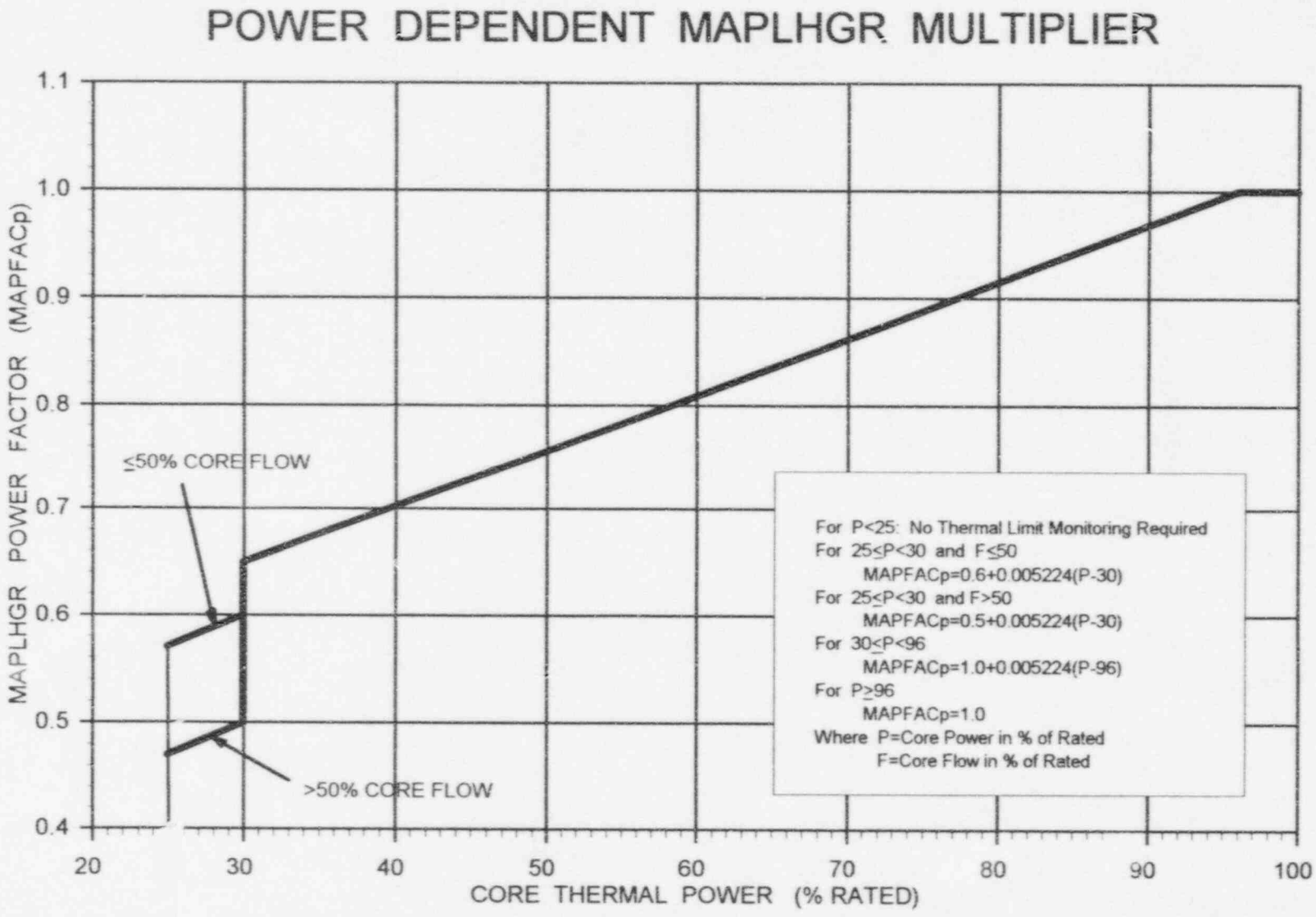
POWER DEPENDENT MAPLHGR MULTIPLIER
MAPLHGR POWER FACTOR (MAPFACp)
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
20
30
40
50
60
70
80
90
100
CORE THERMAL POWER (% RATED)
≤50% CORE FLOW
>50% CORE FLOW
For P<25: No Thermal Limit Monitoring Required
For 25≤P<30 and F≤50
MAPFACp=0.6+0.005224(P-30)
For 25≤P<30 and F>50
MAPFACp=0.5+0.005224(P-30)
For 30≤P<96
MAPFACp=1.0+0.005224(P-96)
For P≥96
MAPFACp=1.0
Where P=Core Power in % of Rated
F=Core Flow in % of Rated

FIGURE 7

FLOW DEPENDENT MAPLHGR MULTIPLIER

SINGLE LOOP OPERATION

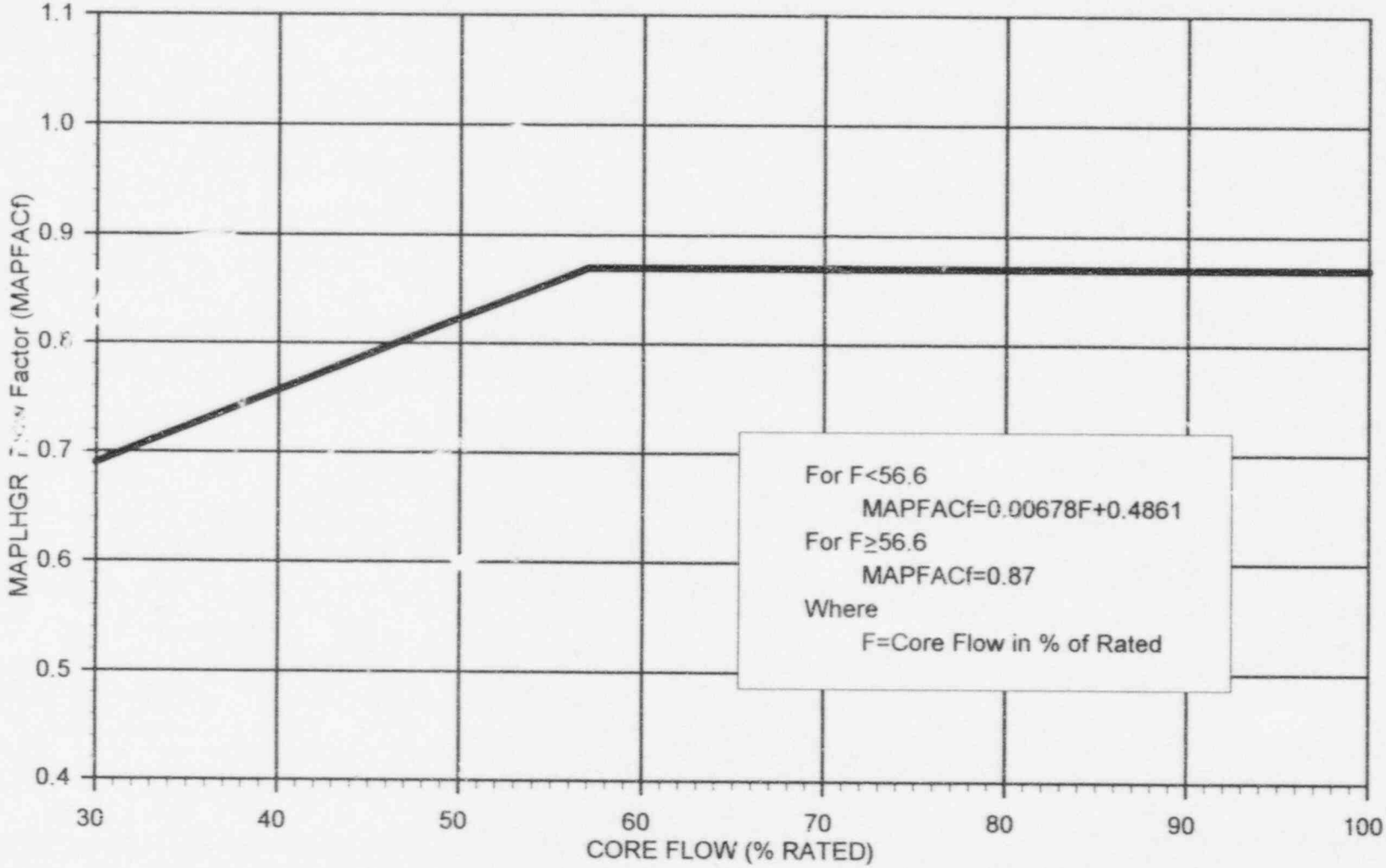

FIGURE 8

POWER DEPENDENT MCPR LIMITS

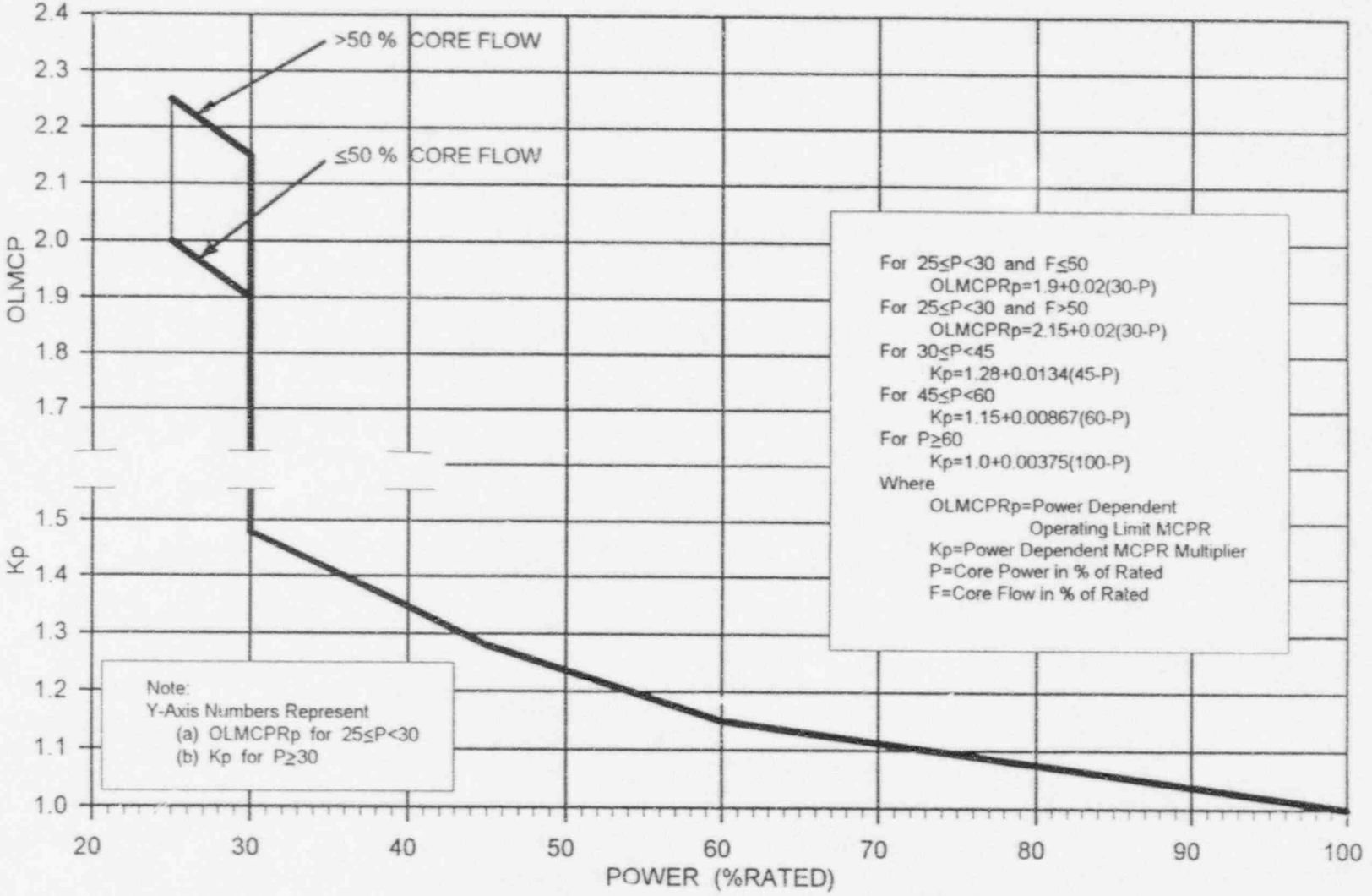

FIGURE 9

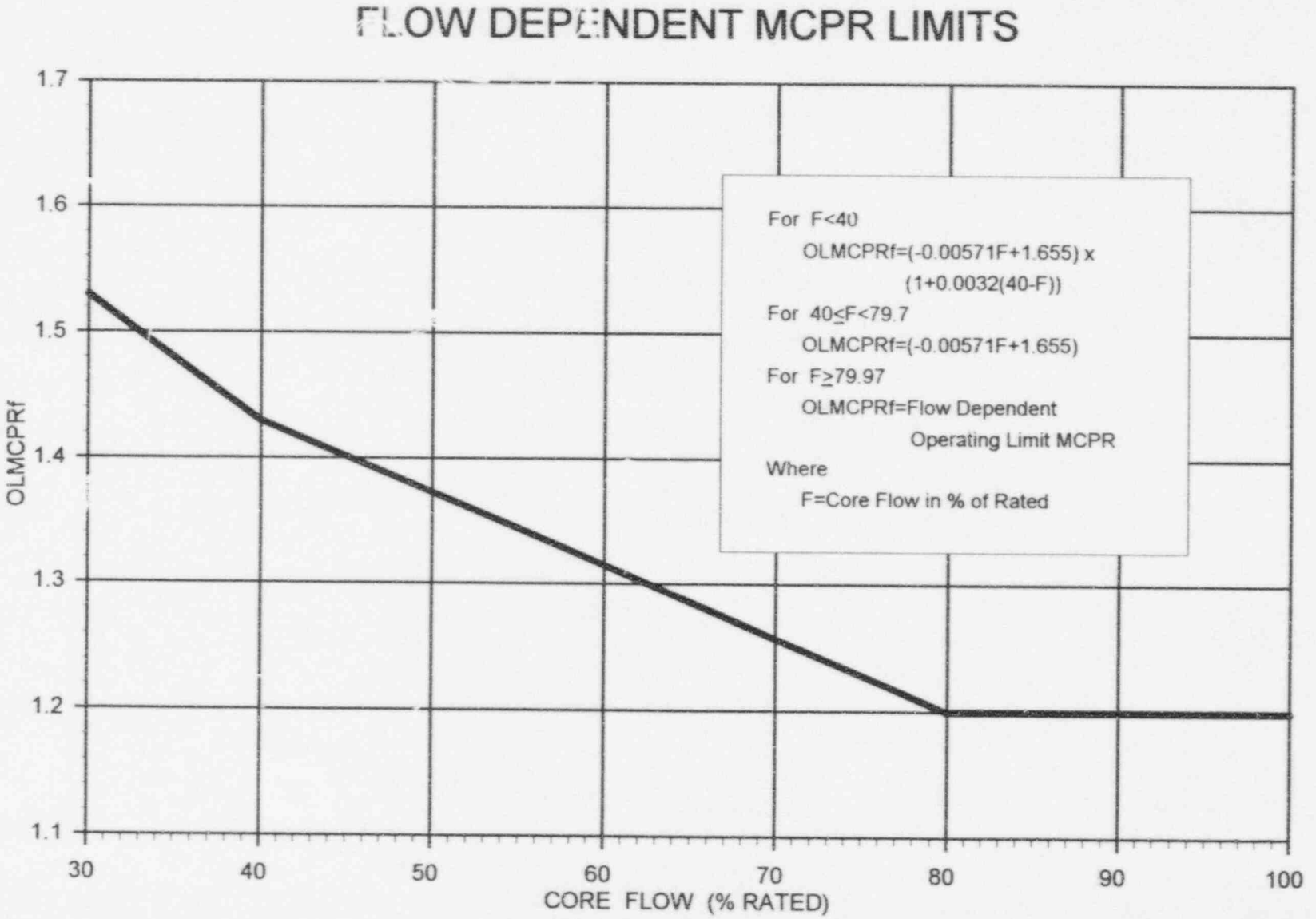
FLOW DEPENDENT MCPR LIMITS
1.7
1.6
1.5
1.4
1.3
1.2
1.1
OLMCPRf
30
40
50
60
70
80
90
100
CORE FLOW (% RATED)
For F<40
OLMCPRf=(-0.00571F+1.655) x
(1+0.0032(40-F))
For 40≤F<79.7
OLMCPRf=(-0.00571F+1.655)
For F≥79.97
OLMCPRf=Flow Dependent
Operating Limit MCPR
Where
F=Core Flow in % of Rated

FIGURE 10

MCPR vs TAU

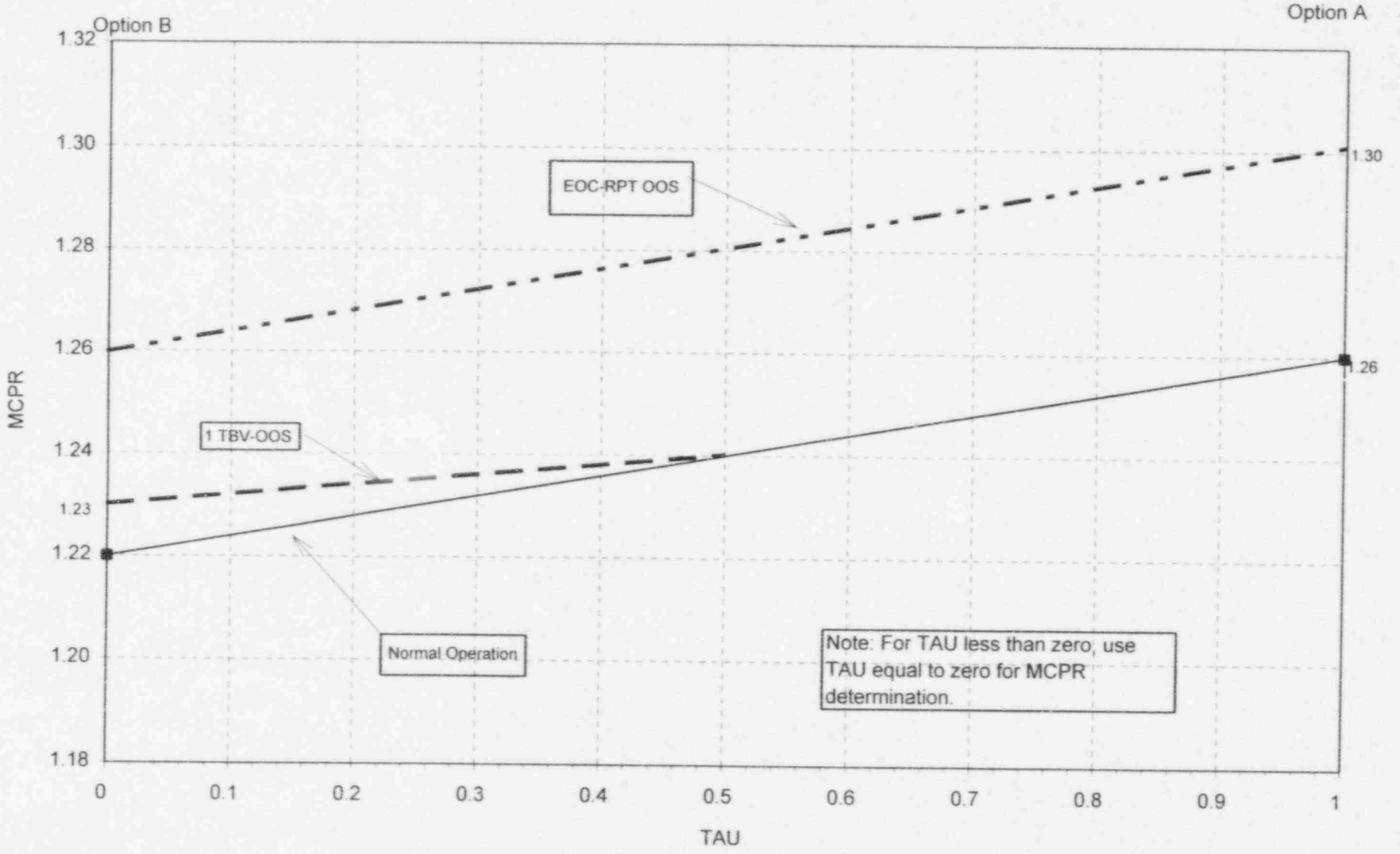

Figure 11

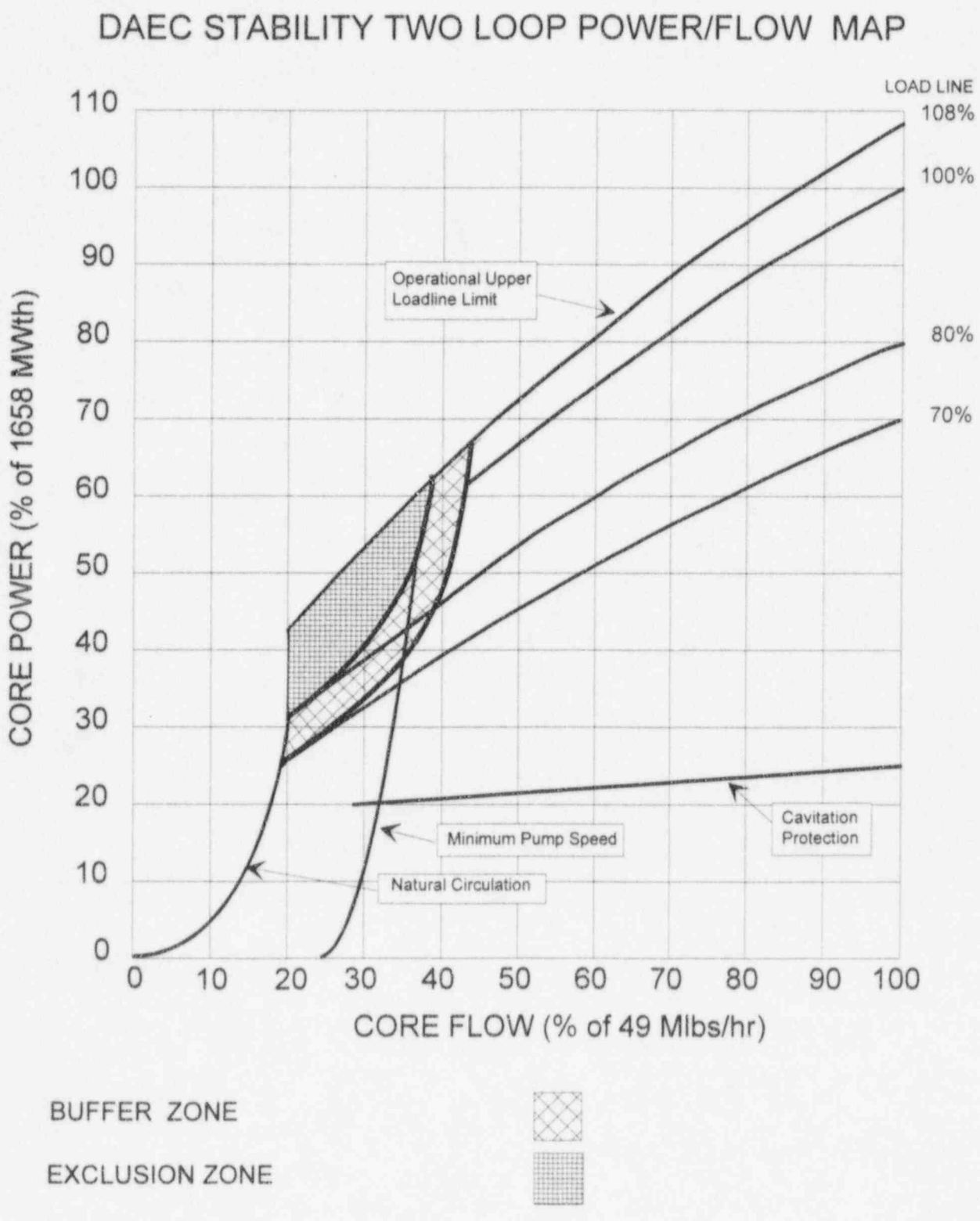
DAEC STABILITY TWO LOOP POWER/FLOW MAP
LOAD LINE
108%
100%
80%
70%
Operational Upper Loadline Limit
Cavitation Protection
Minimum Pump Speed
Natural Circulation
CORE POWER (% of 1658 MWth)
CORE FLOW (% of 49 Mlbs/hr)
0
10
20
30
40
50
60
70
80
90
100
110
BUFFER ZONE
EXCLUSION ZONE

Figure 12