IOWA ELECTRIC LIGHT AND POWER COMPANY
DUANE ARNOLD ENERGY CENTER

CYCLE 12

CORE OPERATING LIMITS REPORT

Revision 1

April, 1992

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1.0 Core Operating Limits Report

This CORE OPERATING LIMITS REPORT for Cycle 12 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 (Reference 1) and are documented in References 2 and 3. The Cycle 12 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, August, 1986*

3. Supplemental Reload Licensing Submittal for Duane Arnold Energy Center, Reload 11, Cycle 12, 23A7143, Rev 0, February, 1992

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

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

6. GE Fuel Bundle Designs, NEDE-31152P, December 1988*

* Approved revision number at time reload fuel analysis 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 1-6 multiplied by the smaller of the two MAPFAC factors determined from Figures 7 and 8.

   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 1-6 multiplied by the smaller of the two MAPFAC factors determined from Figures 8 and 9.

   c. Tables 1-6 provide the MAPLHGR values (KW/ft) for the exposure points (GWd/St) used in the SAFER/GESTR-LOCA analysis. Tables 1-6 correspond to Figures 1-6 respectively.

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

   a. The LHGR of any rod in any GE8x8EB or GE8x8NB-3 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 ($25\% \leq p < 30\%$), the Operating Limit MCPR is given by Figure 10. For core thermal power greater than or equal to 30% of rated ($P \geq 30\%$), the Operating Limit MCPR is the greater of either:

   i) The applicable flow-dependent MCPR determined from Figure 11, or

   ii) The appropriate RATED POWER MCPR from Figure 12 multiplied by the applicable power-dependent MCPR multiplier determined from Figure 10.

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

* Cycle 12 MCPR limits are applicable to all DAEC fuel types.

4. Reload Fuel Bundles

FUEL TYPE	CYCLE LOADED	NUMBER
GE8B-P8DQB303	9	16
GE8B-P8DQB299	9	24
GE8B-P8DQB303	10	56
GE8B-P8DQB324	10	64
GE10-P8HXB321	11	40
GE10-P8HXB317	11	64
GE10-P8HXB321	12	24
GE10-P8HXB316	12	80

TABLE 1

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

Fuel type: GE8B-P8DQB303 (GE8x8EB)

Planar Average Exposure (GWd/ST)	Linear Heat Generation RATE (KW/ft)
0.0	11.5
0.2	11.5
2.0	11.8
4.0	12.3
6.0	12.7
8.0	13.0
10.0	13.2
12.5	13.2
15.0	12.9
20.0	12.3
42.0	9.6
50.0	8.1

* 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: GE8B-P8DQB299 (GE8x8EB)

Planar Average Exposure (GWd/ST)	Linear Heat Generation RATE (KW/ft)
0.0	11.1
0.2	11.1
2.0	11.4
4.0	11.9
6.0	12.6
8.0	12.9
10.0	13.3
12.5	13.3
15.0	12.8
20.0	12.3
42.0	9.5
50.0	8.0

* 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: GE8B-P8DQB324 (GE8x8EB)

Planar Average Exposure (GWd/ST)	Linear Heat Generation RATE (KW/ft)
0.0	11.2
3.0	11.9
7.0	12.5
10.0	13.1
12.5	13.1
20.0	12.1
25.0	11.4
35.0	10.1
45.0	8.5
50.0	6.0

* 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-P8HXB321 (GE8x8NB-3)

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 5

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

Fuel type: GE10-P8HXB317 (GE8x8NB-3)

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 6

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

Fuel type: GE10-P8HXB316 (GE8x8NB-3)

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
51.0	5.85

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

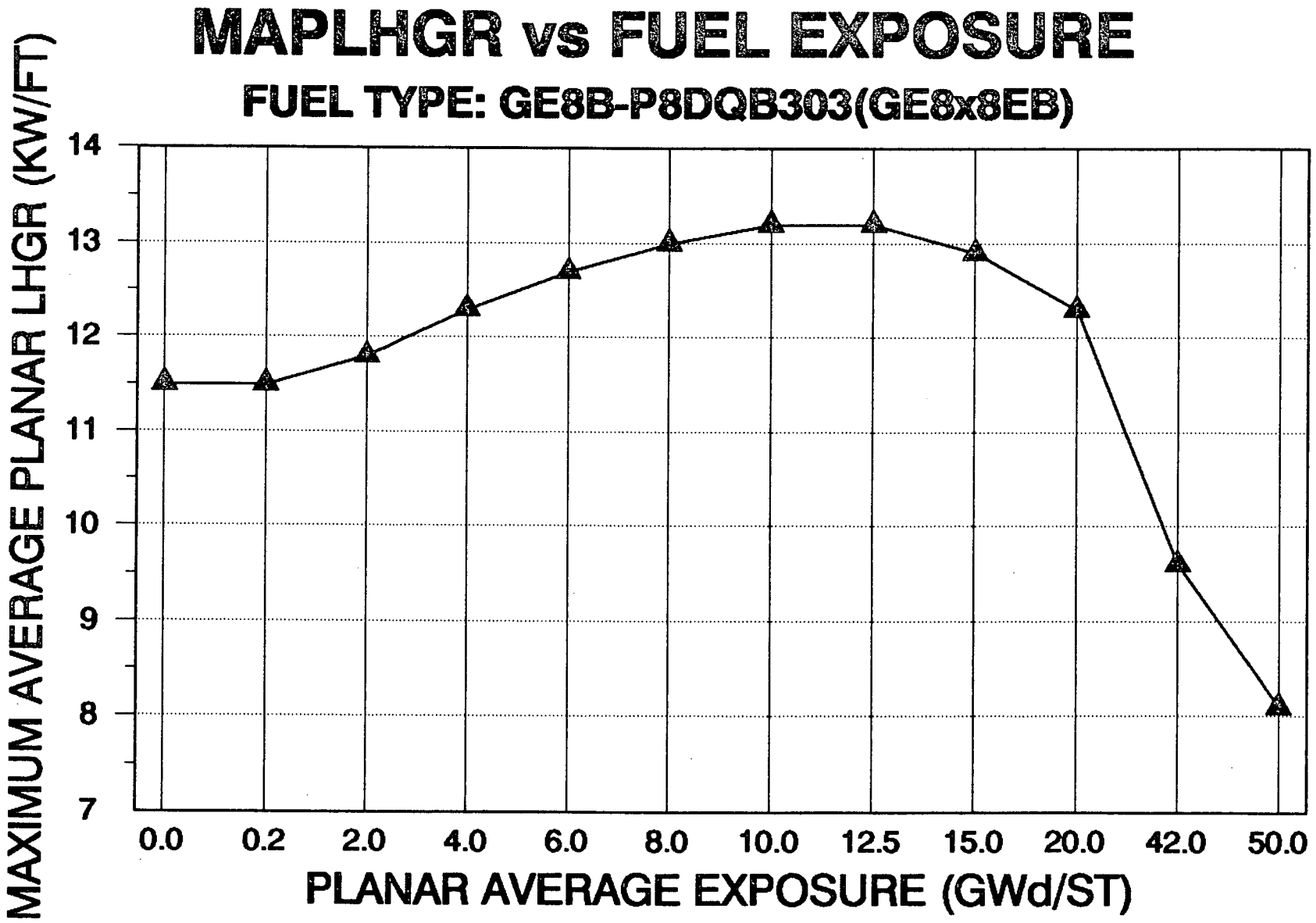

MAPLHGR vs FUEL EXPOSURE
FUEL TYPE: GE8B-P8DQB303(GE8x8EB)
MAXIMUM AVERAGE PLANAR LHGR (KW/FT)
14
13
12
11
10
9
8
7
0.0
0.2
2.0
4.0
6.0
8.0
10.0
12.5
15.0
20.0
42.0
50.0
PLANAR AVERAGE EXPOSURE (GWd/ST)

FIGURE 1

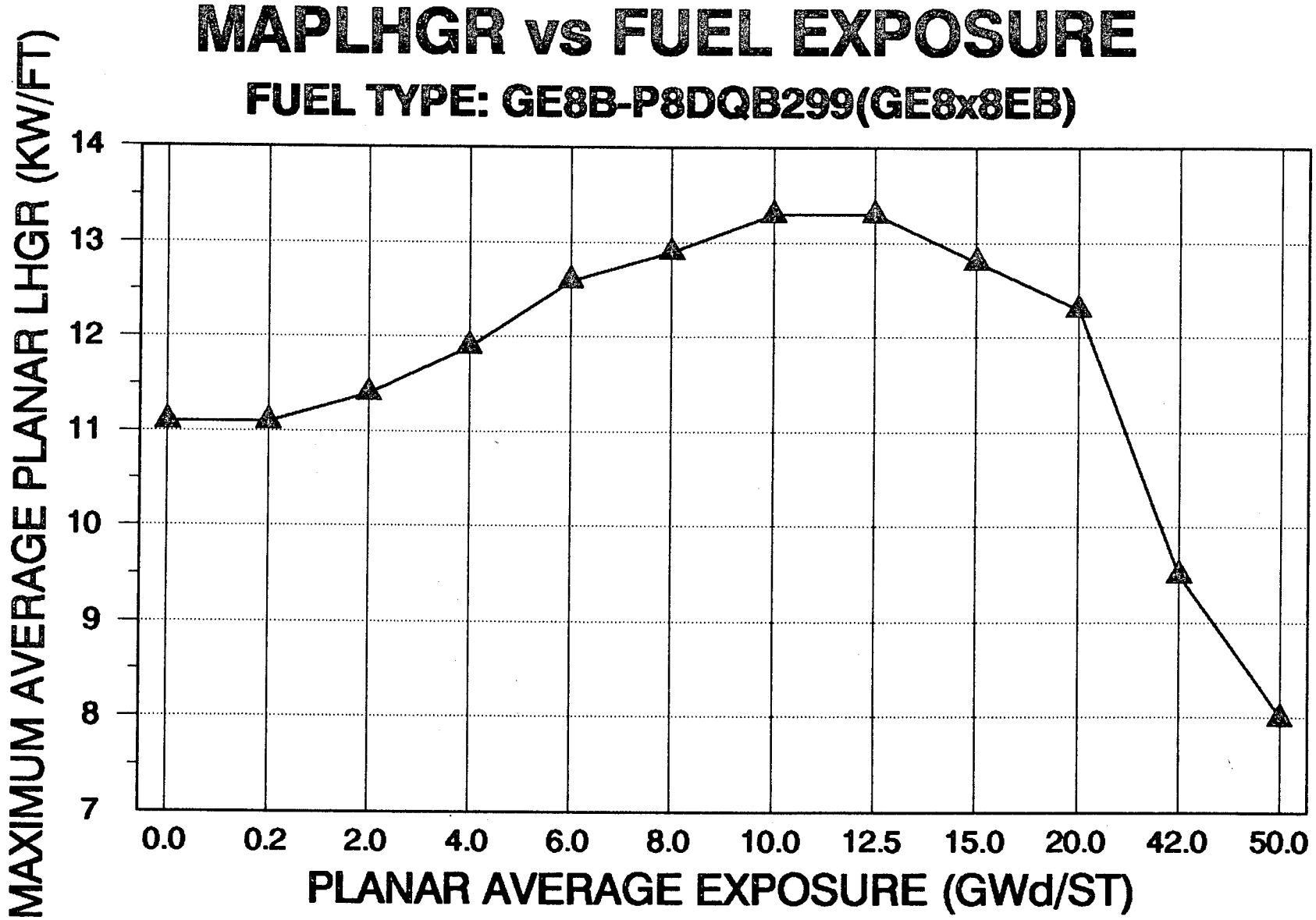

MAPLHGR vs FUEL EXPOSURE
FUEL TYPE: GE8B-P8DQB299(GE8x8EB)
MAXIMUM AVERAGE PLANAR LHGR (KW/FT)
14
13
12
11
10
9
8
7
0.0
0.2
2.0
4.0
6.0
8.0
10.0
12.5
15.0
20.0
42.0
50.0
PLANAR AVERAGE EXPOSURE (GWd/ST)

FIGURE 2

MAPLHGR vs FUEL EXPOSURE

FUEL TYPE: GE8B-P8DQB324(GE8x8EB)

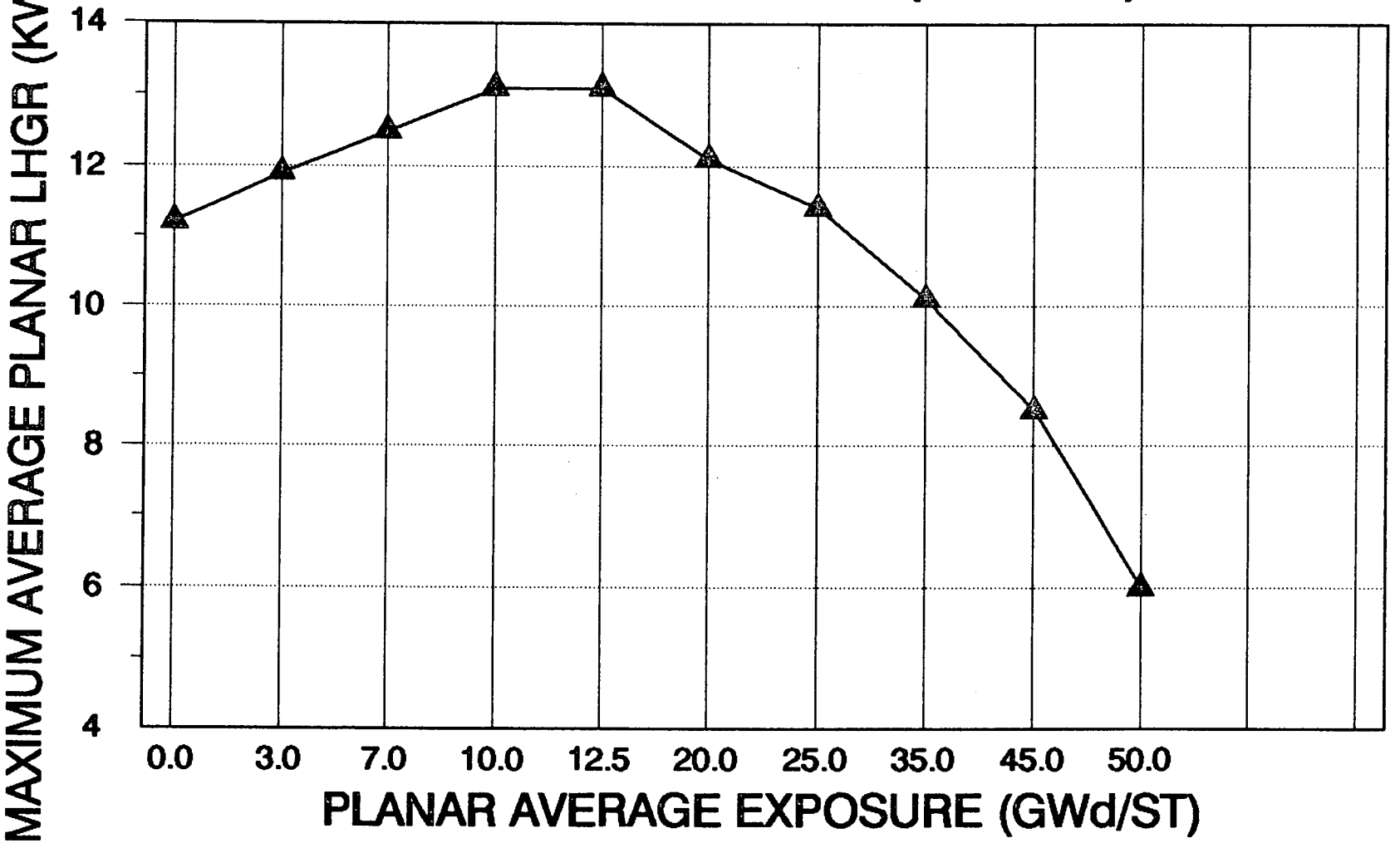


FIGURE 3

MAPLHGR vs FUEL EXPOSURE

FUEL TYPE: GE10-P8HXB321 (GE8x8NB-3)

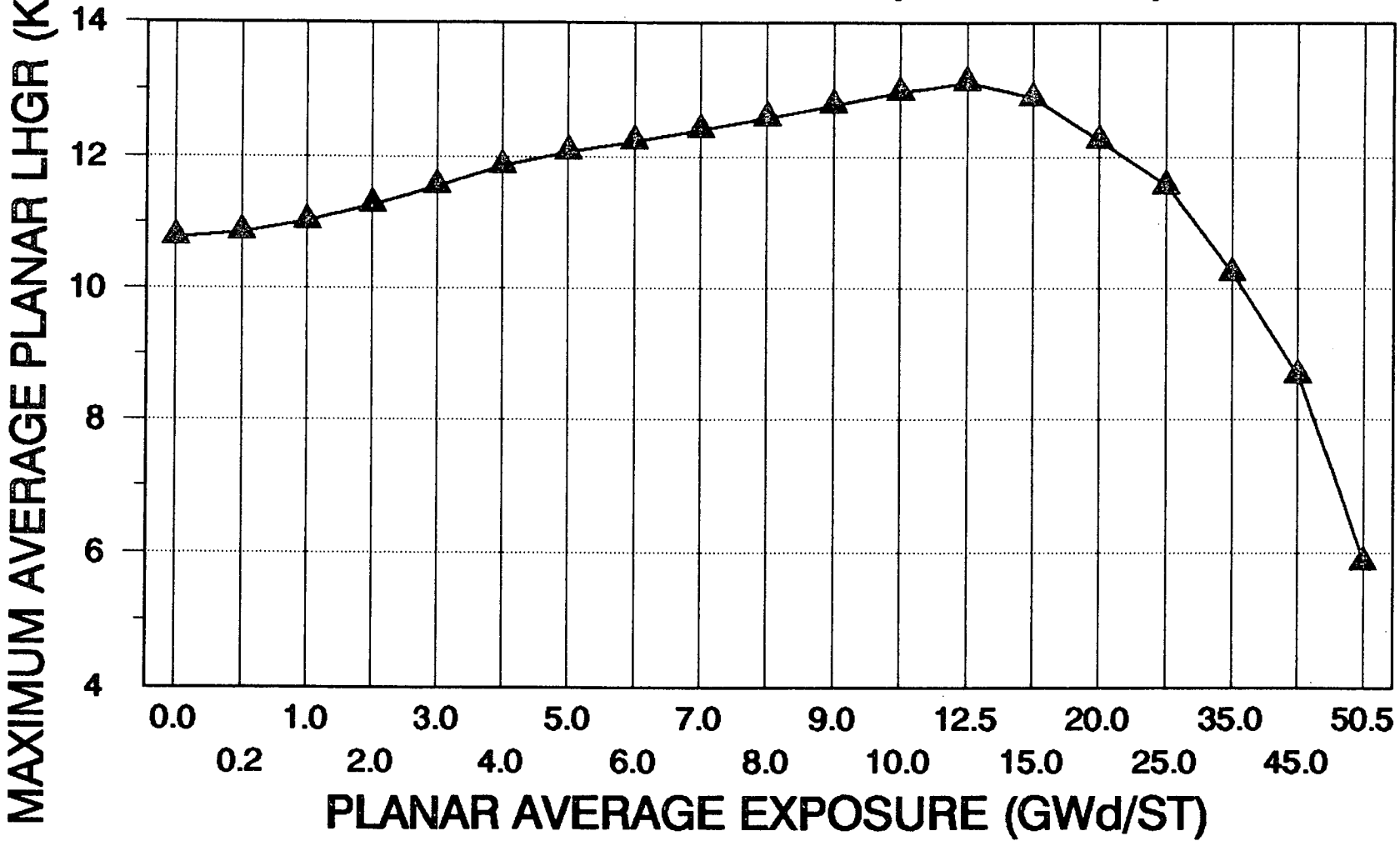


FIGURE 4

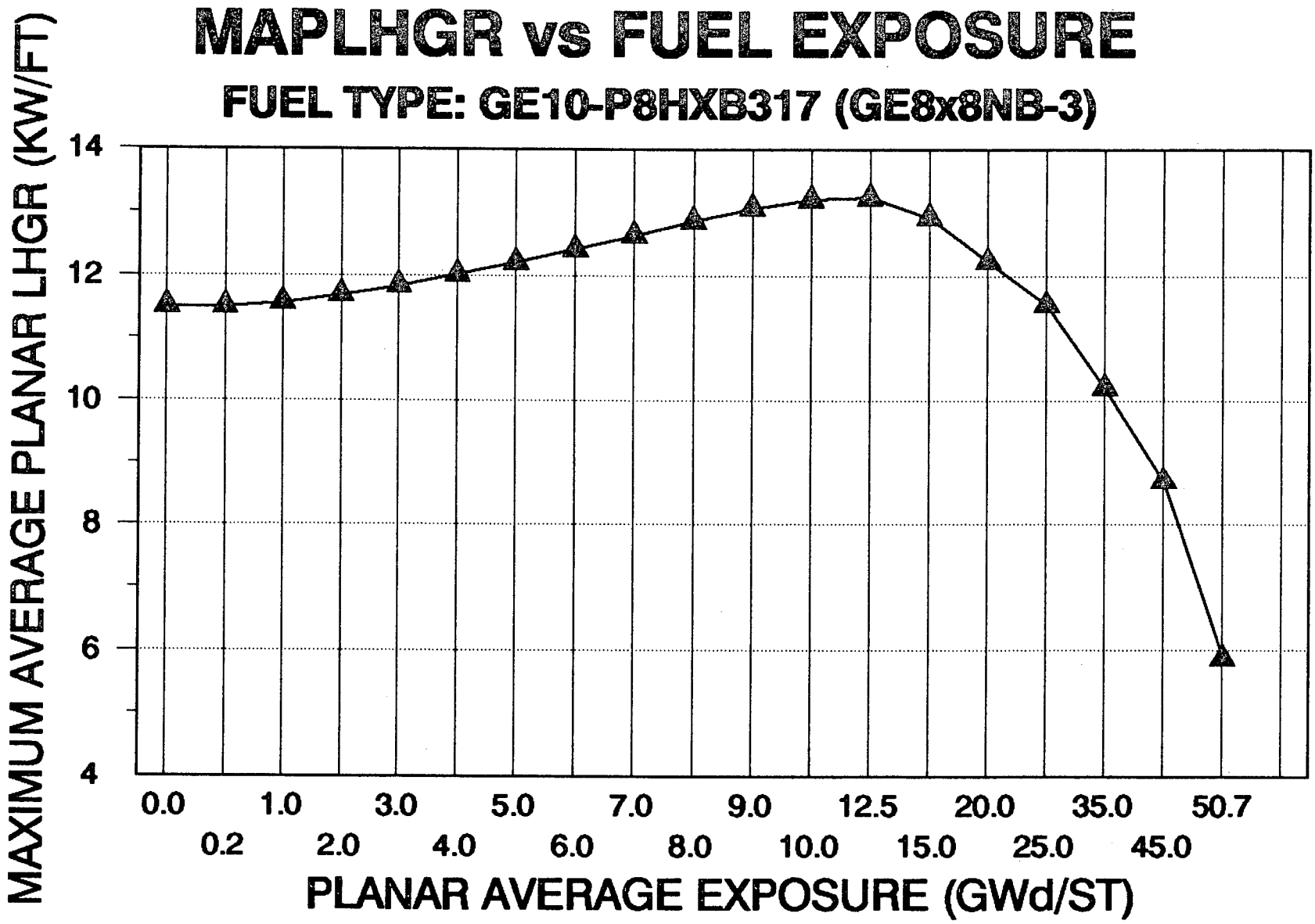

MAPLHGR vs FUEL EXPOSURE
FUEL TYPE: GE10-P8HXB317 (GE8x8NB-3)
MAXIMUM AVERAGE PLANAR LHGR (KW/FT)
14
12
10
8
6
4
0.0
0.2
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
12.5
15.0
20.0
25.0
35.0
45.0
50.7
PLANAR AVERAGE EXPOSURE (GWd/ST)

FIGURE 5

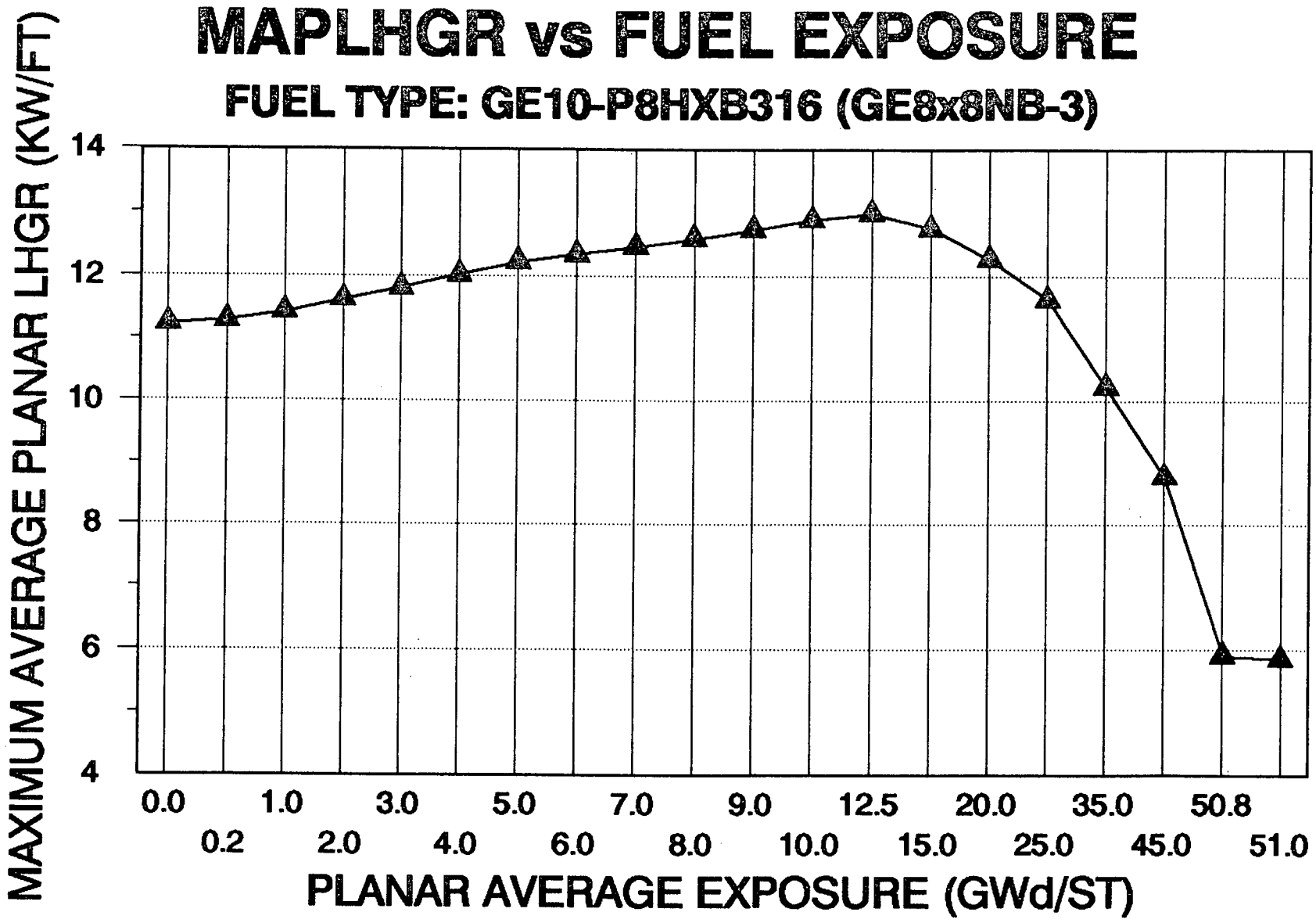

MAPLHGR vs FUEL EXPOSURE
FUEL TYPE: GE10-P8HXB316 (GE8x8NB-3)
MAXIMUM AVERAGE PLANAR LHGR (KW/FT)
14
12
10
8
6
4
0.0
0.2
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
12.5
15.0
20.0
25.0
35.0
45.0
50.8
51.0
PLANAR AVERAGE EXPOSURE (GWd/ST)

FIGURE 6

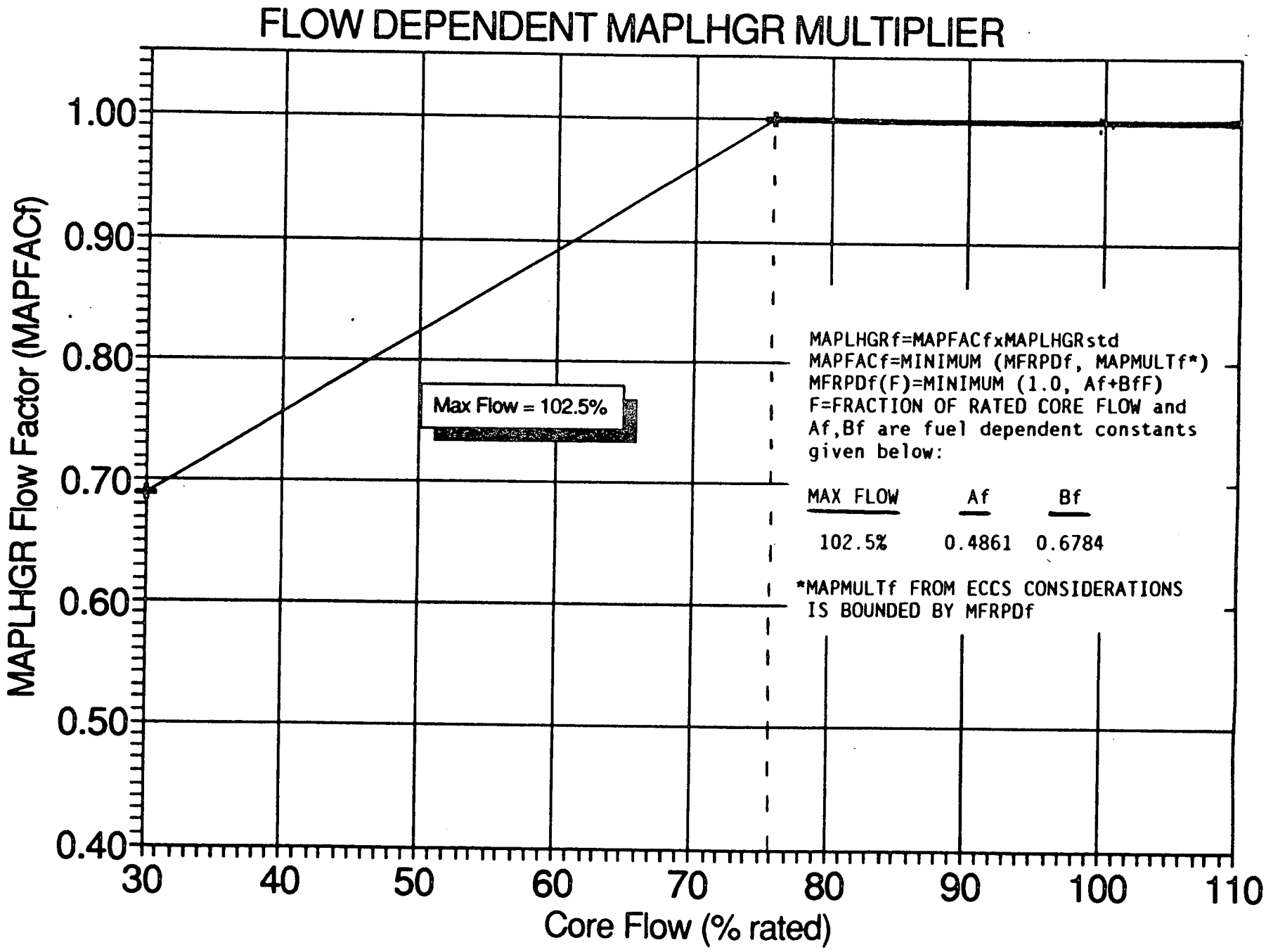

FLOW DEPENDENT MAPLHGR MULTIPLIER
MAPLHGR Flow Factor (MAPFACf)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
30
40
50
60
70
80
90
100
110
Core Flow (% rated)
Max Flow = 102.5%
MAPLHGRf=MAPFACfxMAPLHGRstd
MAPFACf=MINIMUM (MFRPDf, MAPMULTf*)
MFRPDf(F)=MINIMUM (1.0, Af+BfF)
F=FRACTION OF RATED CORE FLOW and
Af,Bf are fuel dependent constants
given below:
MAX FLOW Af Bf
102.5% 0.4861 0.6784
*MAPMULTf FROM ECCS CONSIDERATIONS
IS BOUNDED BY MFRPDf

FIGURE 7

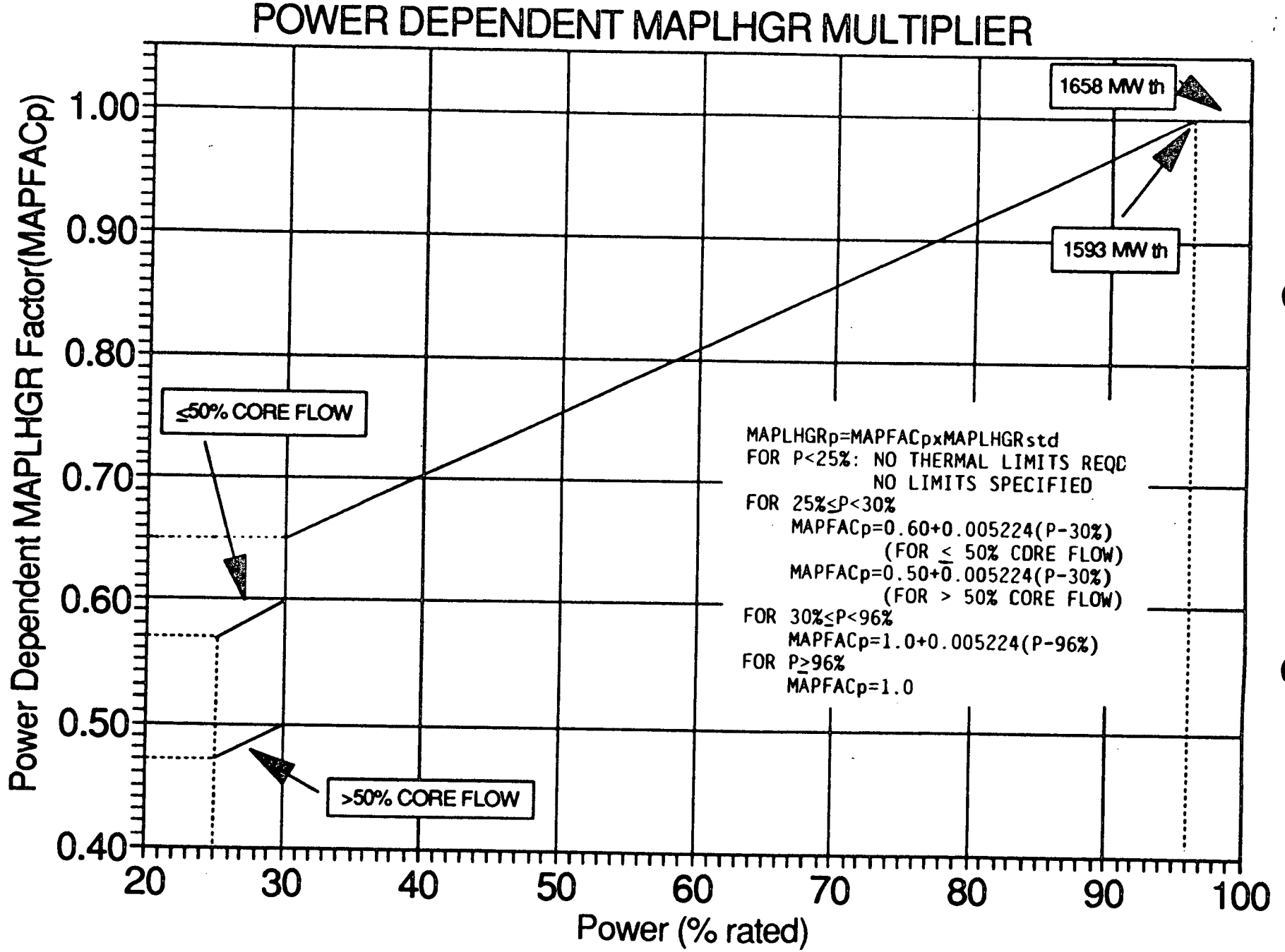

POWER DEPENDENT MAPLHGR MULTIPLIER
Power Dependent MAPLHGR Factor(MAPFACp)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
20
30
40
50
60
70
80
90
100
Power (% rated)
1658 MW th
1593 MW th
≤50% CORE FLOW
>50% CORE FLOW
MAPLHGRp=MAPFACpxMAPLHGRstd
FOR P<25%: NO THERMAL LIMITS REQD
NO LIMITS SPECIFIED
FOR 25%≤P<30%
MAPFACp=0.60+0.005224(P-30%)
(FOR ≤ 50% CORE FLOW)
MAPFACp=0.50+0.005224(P-30%)
(FOR > 50% CORE FLOW)
FOR 30%≤P<96%
MAPFACp=1.0+0.005224(P-96%)
FOR P≥96%
MAPFACp=1.0

FIGURE 8

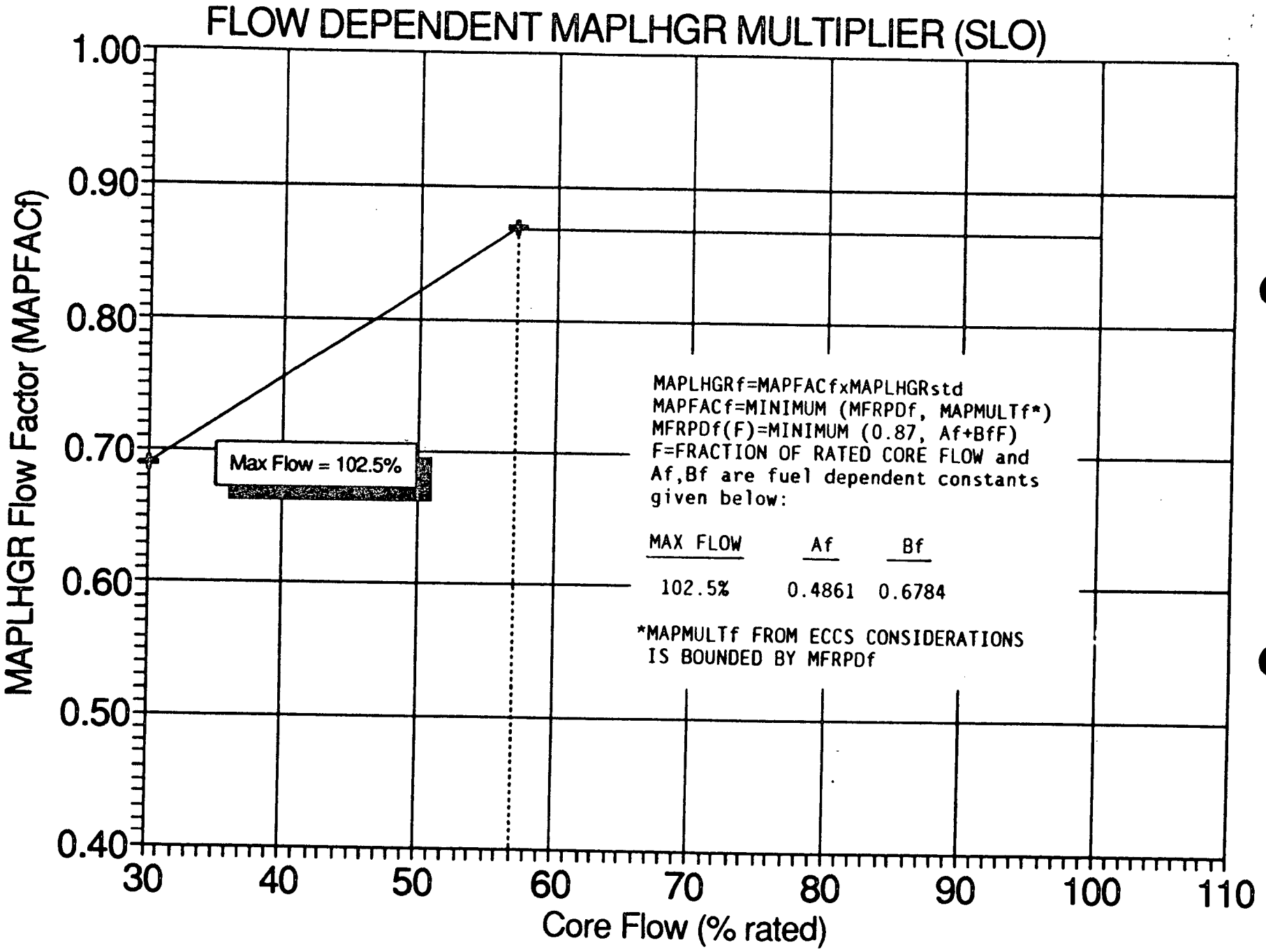

FLOW DEPENDENT MAPLHGR MULTIPLIER (SLO)
MAPLHGR Flow Factor (MAPFACf)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
30
40
50
60
70
80
90
100
110
Core Flow (% rated)
Max Flow = 102.5%
MAPLHGRf=MAPFACfxMAPLHGRstd
MAPFACf=MINIMUM (MFRPDf, MAPMULTf*)
MFRPDf(F)=MINIMUM (0.87, Af+BfF)
F=FRACTION OF RATED CORE FLOW and
Af,Bf are fuel dependent constants
given below:
MAX FLOW Af Bf
102.5% 0.4861 0.6784
*MAPMULTf FROM ECCS CONSIDERATIONS
IS BOUNDED BY MFRPDf

FIGURE 9

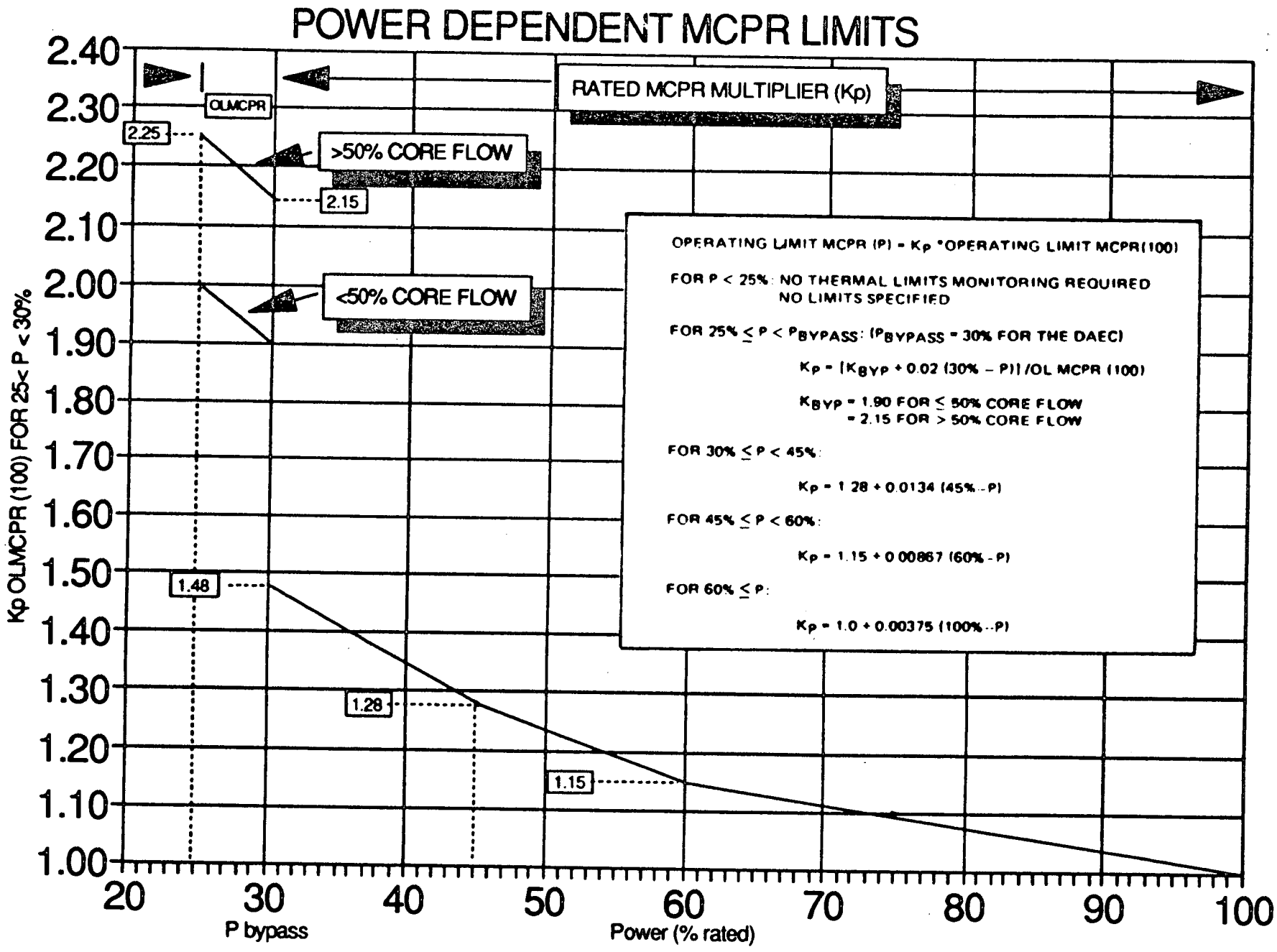

POWER DEPENDENT MCPR LIMITS
RATED MCPR MULTIPLIER (Kp)
OLMCPR
2.25
>50% CORE FLOW
2.15
<50% CORE FLOW
1.48
1.28
1.15
OPERATING LIMIT MCPR (P) = Kp *OPERATING LIMIT MCPR(100)
FOR P < 25%: NO THERMAL LIMITS MONITORING REQUIRED
NO LIMITS SPECIFIED
FOR 25% ≤ P < PBYPASS: (PBYPASS = 30% FOR THE DAEC)
Kp = [KBYP + 0.02 (30% - P)] /OL MCPR (100)
KBYP = 1.90 FOR ≤ 50% CORE FLOW
= 2.15 FOR > 50% CORE FLOW
FOR 30% ≤ P < 45%:
Kp = 1.28 + 0.0134 (45% - P)
FOR 45% ≤ P < 60%:
Kp = 1.15 + 0.00867 (60% - P)
FOR 60% ≤ P:
Kp = 1.0 + 0.00375 (100% - P)
Kp OLMCPR (100) FOR 25< P < 30%
2.40
2.30
2.20
2.10
2.00
1.90
1.80
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
20
30
40
50
60
70
80
90
100
P bypass
Power (% rated)

FIGURE 10

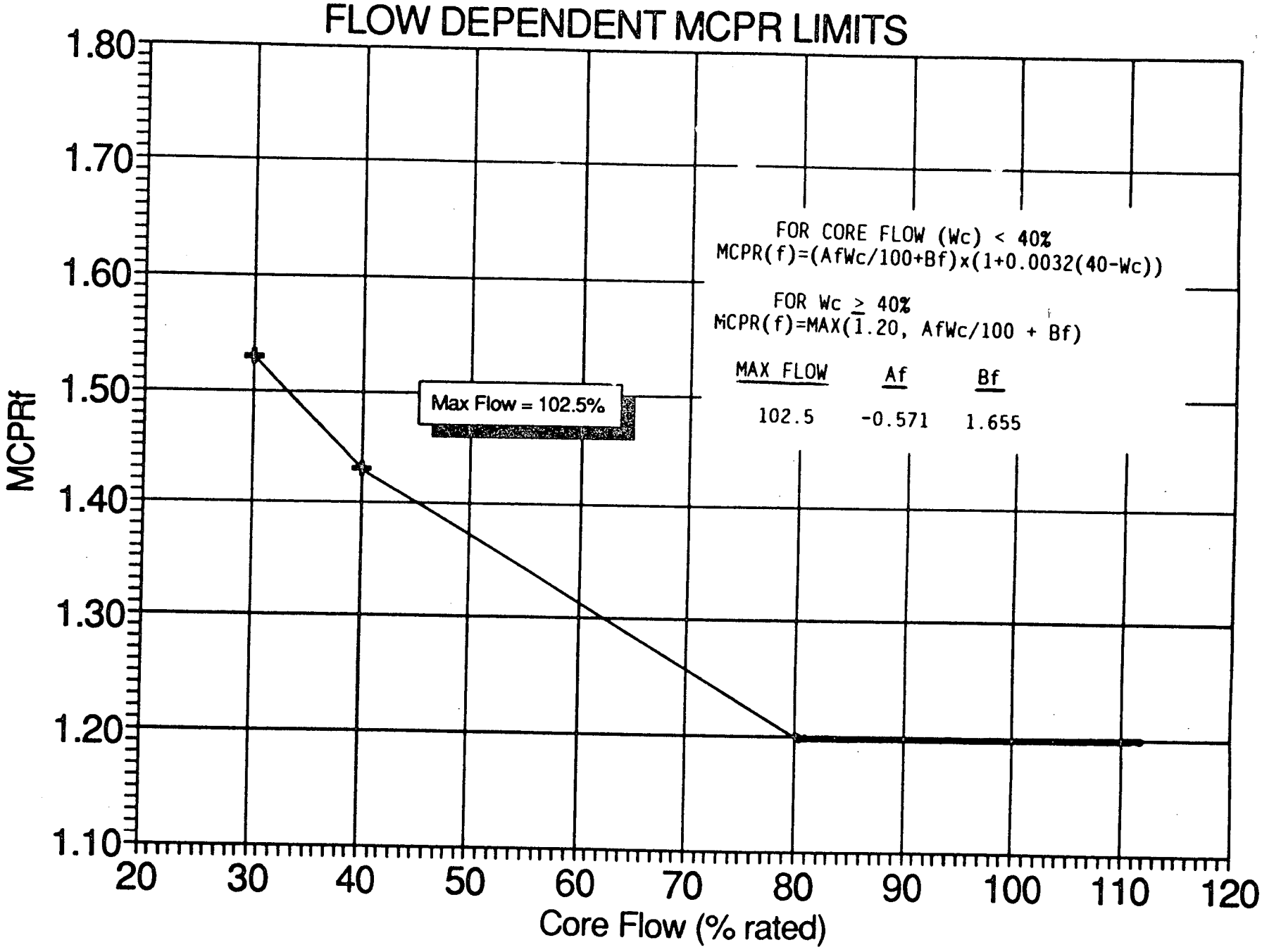
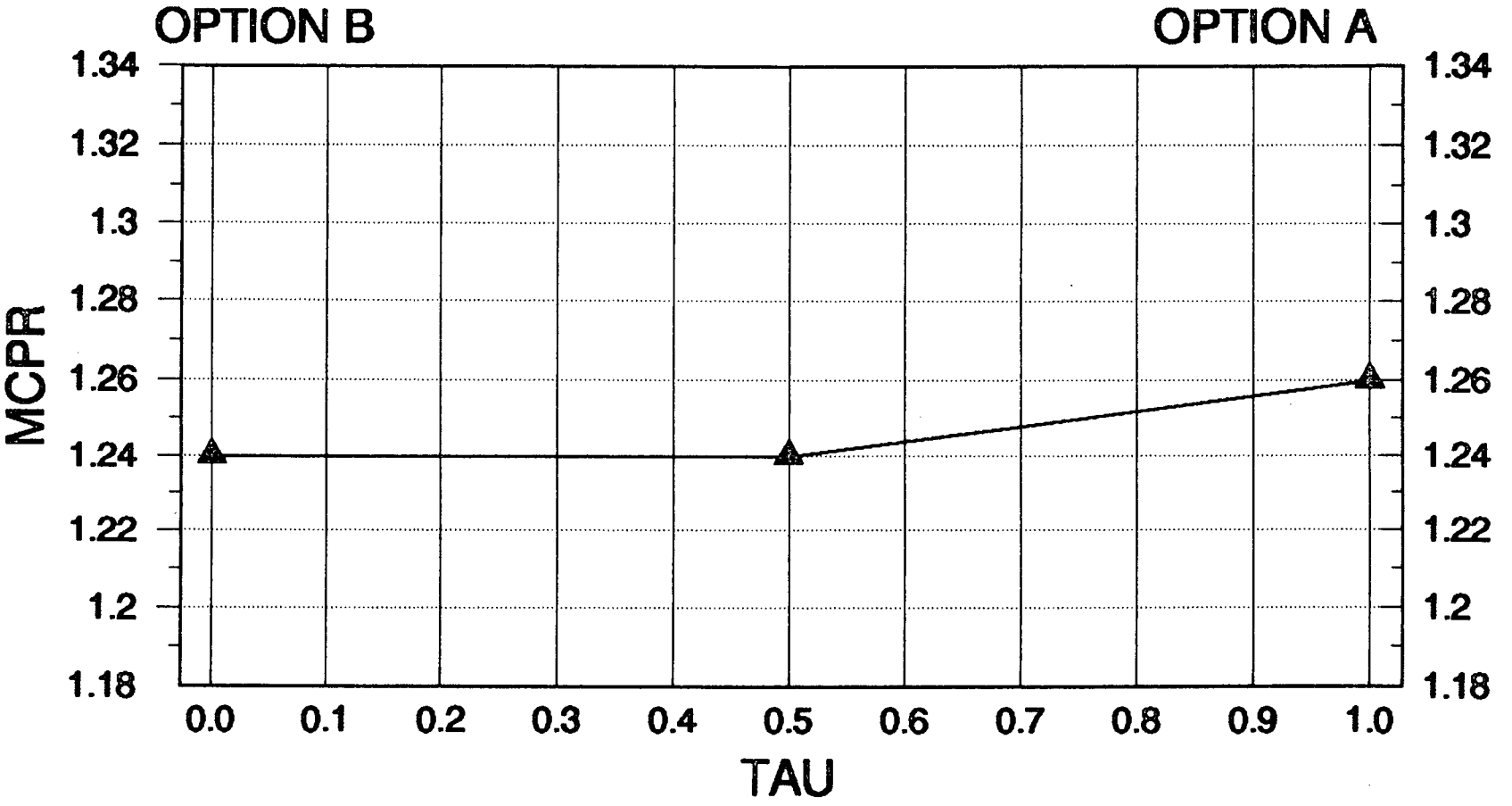

FLOW DEPENDENT MCPR LIMITS
MCPRf
1.80
1.70
1.60
1.50
1.40
1.30
1.20
1.10
20
30
40
50
60
70
80
90
100
110
120
Core Flow (% rated)
Max Flow = 102.5%
FOR CORE FLOW (Wc) < 40%
MCPR(f)=(AfWc/100+Bf)x(1+0.0032(40-Wc))
FOR Wc ≥ 40%
MCPR(f)=MAX(1.20, AfWc/100 + Bf)
MAX FLOW Af Bf
102.5 -0.571 1.655

FIGURE 11

MCPR vs TAU



Note: For Tau less than zero, use Tau equal to zero for MCPR determination.

FIGURE 12