

IOWA ELECTRIC LIGHT AND POWER COMPANY  
DUANE ARNOLD ENERGY CENTER

CYCLE 11

CORE OPERATING LIMITS REPORT

Revision 0

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## 1.0 Core Operating Limits Report

This CORE OPERATING LIMITS REPORT for Cycle 11 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 11 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 10, Cycle 11, 23A6450, Rev.1, August 1990.
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 1-7 multiplied by the smaller of the two MAPFAC factors determined from Figures 8 and 9.
- 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 1-7 multiplied by the smaller of the two MAPFAC factors determined from Figures 9 and 10.
- c. Tables 1-7 provide the MAPLHGR values (KW/ft) for the exposure points (Gwd/St) used in the SAFER/GESTR-LOCA analysis. Tables 1-7 correspond to Figures 1-7 respectively.

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

- a. The LHGR of any rod in any BP8x8R or ELTA fuel assembly shall not exceed 13.4 KW/ft, while 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 11. 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 12, or
  - ii) The appropriate RATED POWER MCPR from Figure 13 multiplied by the applicable power-dependent MCPR multiplier determined from Figure 11.
- 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 11 MCPR values were determined using an exposure dependent analysis. This analysis was used to help restore operating margin lost by the imposition of an MCPR channel bow penalty.

\*\*Cycle 11 MCPR limits are applicable to all DAEC fuel types.

4. Reload Fuel Bundles

FUEL TYPE	CYCLE LOADED	NUMBER
SRB-P8DRB299	8	1
GE6B-P8DRB299	8	4
GE6B-P8DRB301	8	11
GE8B-P8DQB303	9	40
GE8B-P8DQB299	9	88
GE8B-P8DQB303	10	56
GE8B-P8DQB324	10	64
GE10-P8HXB321	11	40
GE10-P8HXB317	11	64

# MAPLHGR vs FUEL EXPOSURE

Fuel Type: GE10-P8HXB321 (GE8x8NB-3)

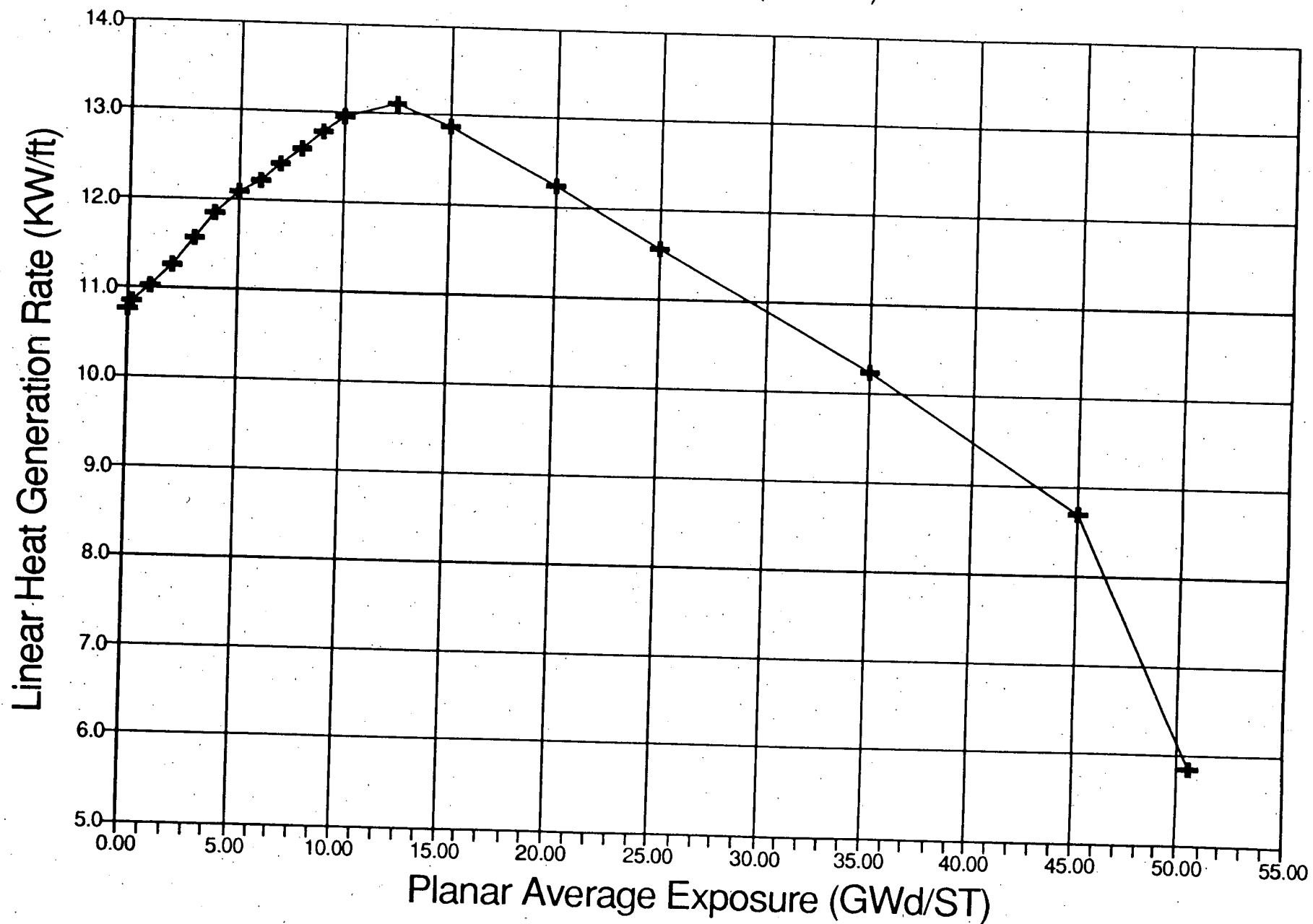


FIGURE 1

TABLE 1

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.

# MAPLHGR vs FUEL EXPOSURE

Fuel Type: GE10-P8HXB317 (GE8x8NB-3)

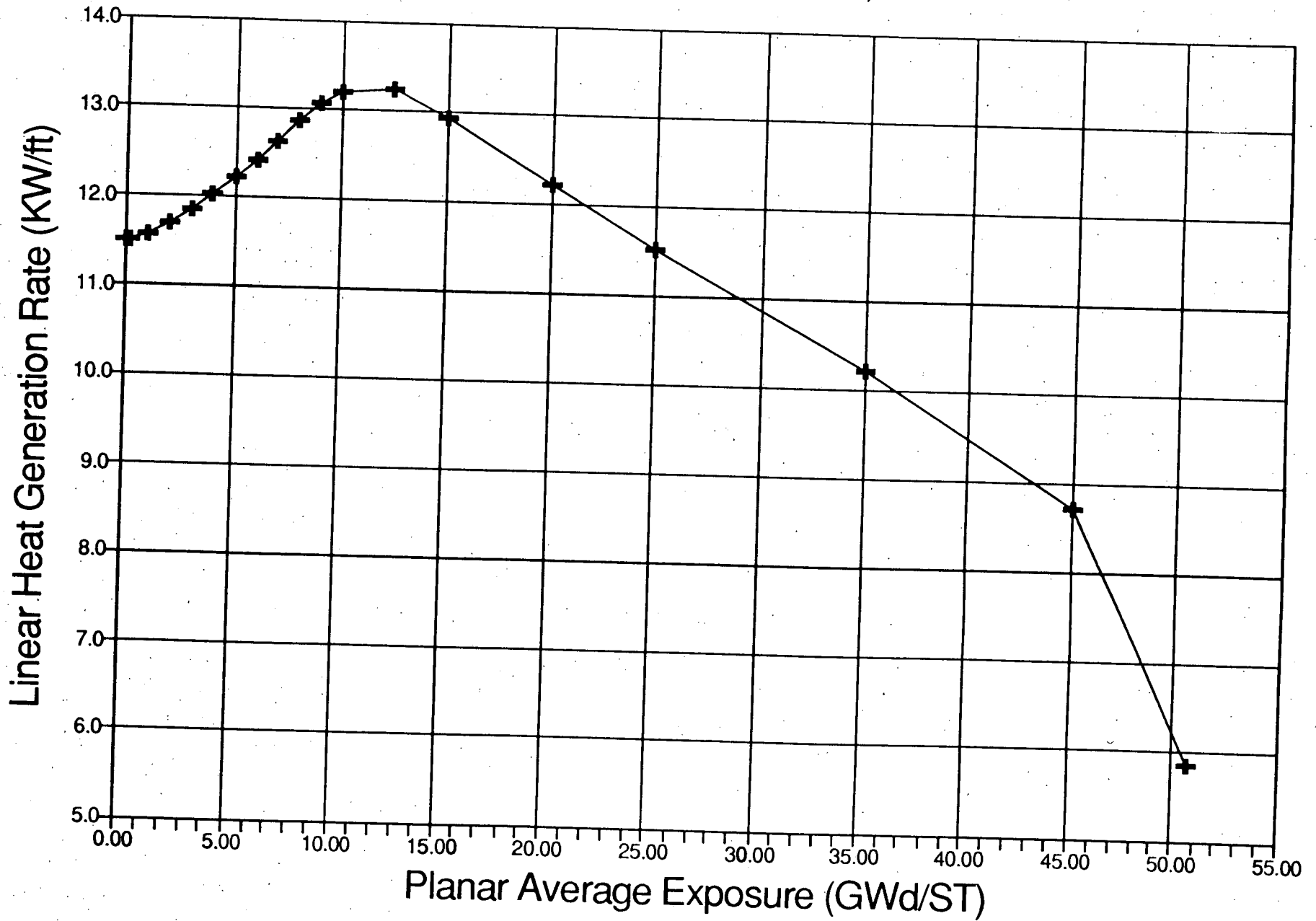


FIGURE 2

TABLE 2

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.



# MAPLHGR vs FUEL EXPOSURE

Fuel Type: GE6B-P8DRB301 (BP8x8R)

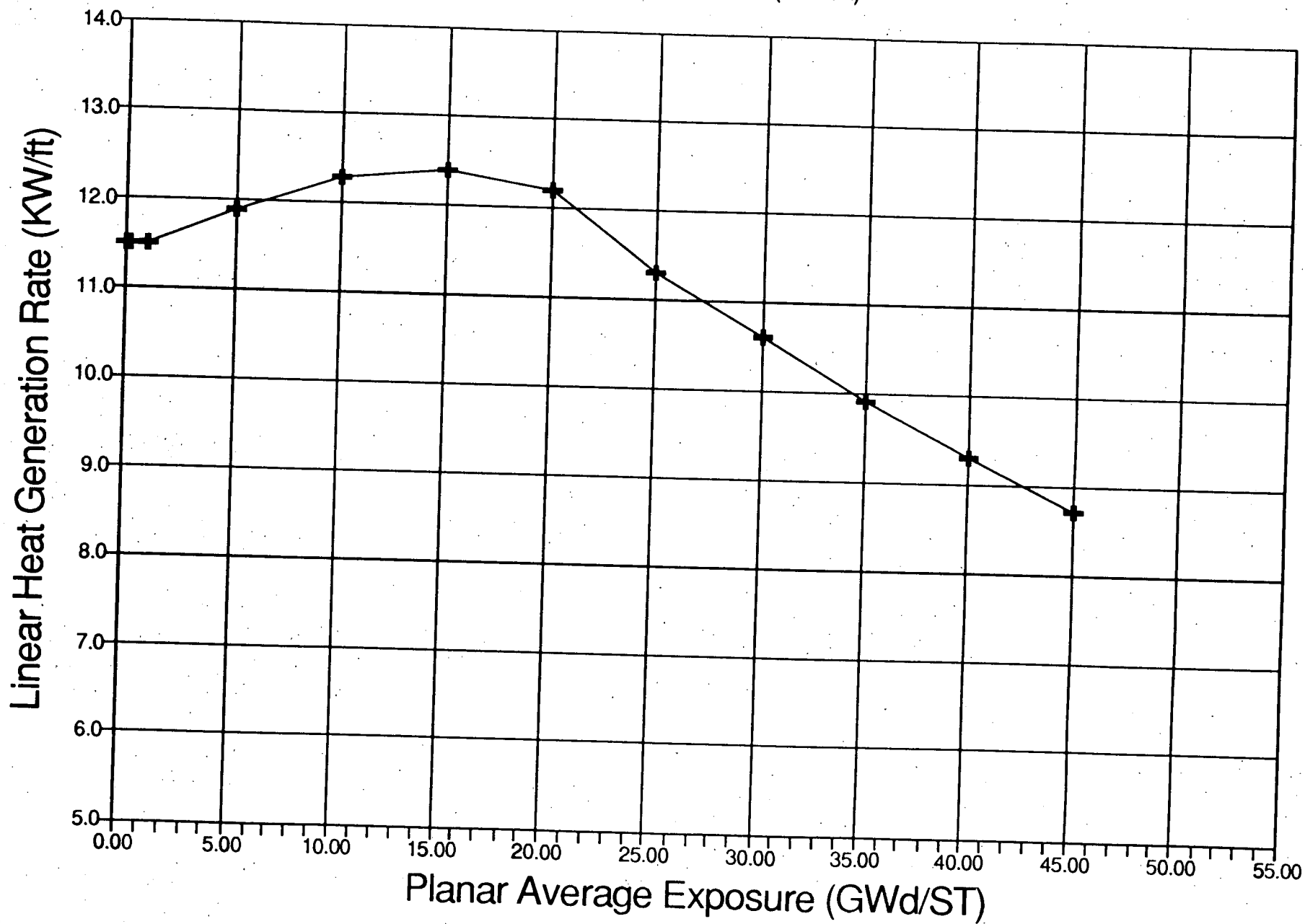


FIGURE 3

TABLE 3

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

Fuel type: GE6B-P8DRB301 (BP8x8R)	
Planar Average Exposure (GWd/ST)	Linear Heat Generation RATE (KW/ft)
0.0	11.5
0.2	11.5
1.0	11.5
5.0	11.9
10.0	12.3
15.0	12.4
20.0	12.2
25.0	11.3
30.0	10.6
35.0	9.9
40.0	9.3
45.0	8.7

\* 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:GE6B-P8DRB299(BP8x8R)and ELTA

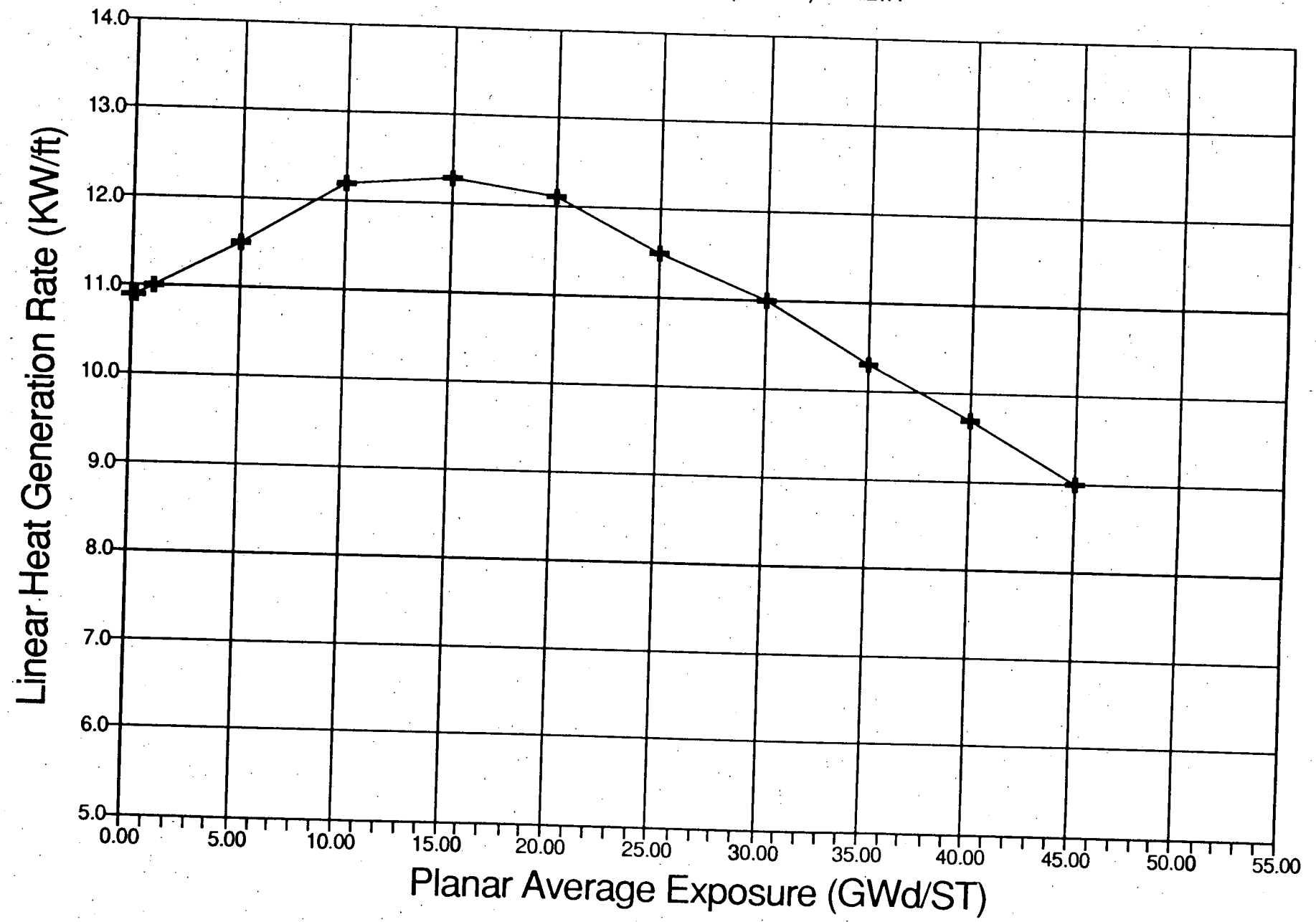


FIGURE 4

TABLE 4

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

Fuel type: GE6B-P8DRB299 (BP8x8R) and ELTA

Planar Average Exposure (GWd/ST)	Linear Heat Generation RATE (KW/ft)
0.0	10.9
0.2	10.9
1.0	11.0
5.0	11.5
10.0	12.2
15.0	12.3
20.0	12.1
25.0	11.5
30.0	11.0
35.0	10.3
40.0	9.7
45.0	9.0

\* 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)

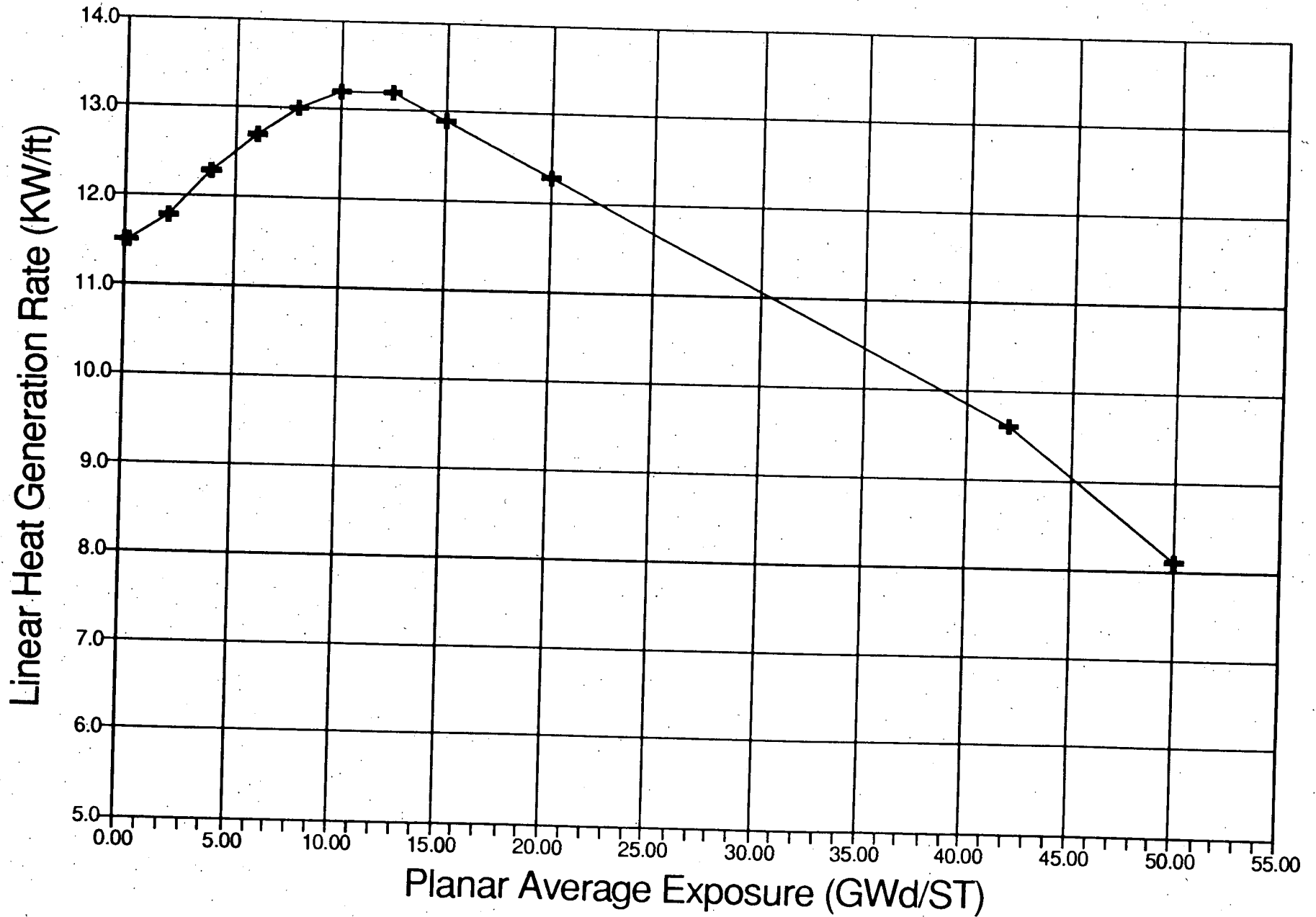


FIGURE 5

TABLE 5

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.

# MAPLHGR vs FUEL EXPOSURE

Fuel Type: GE8B-P8DQB299(GE8x8EB)

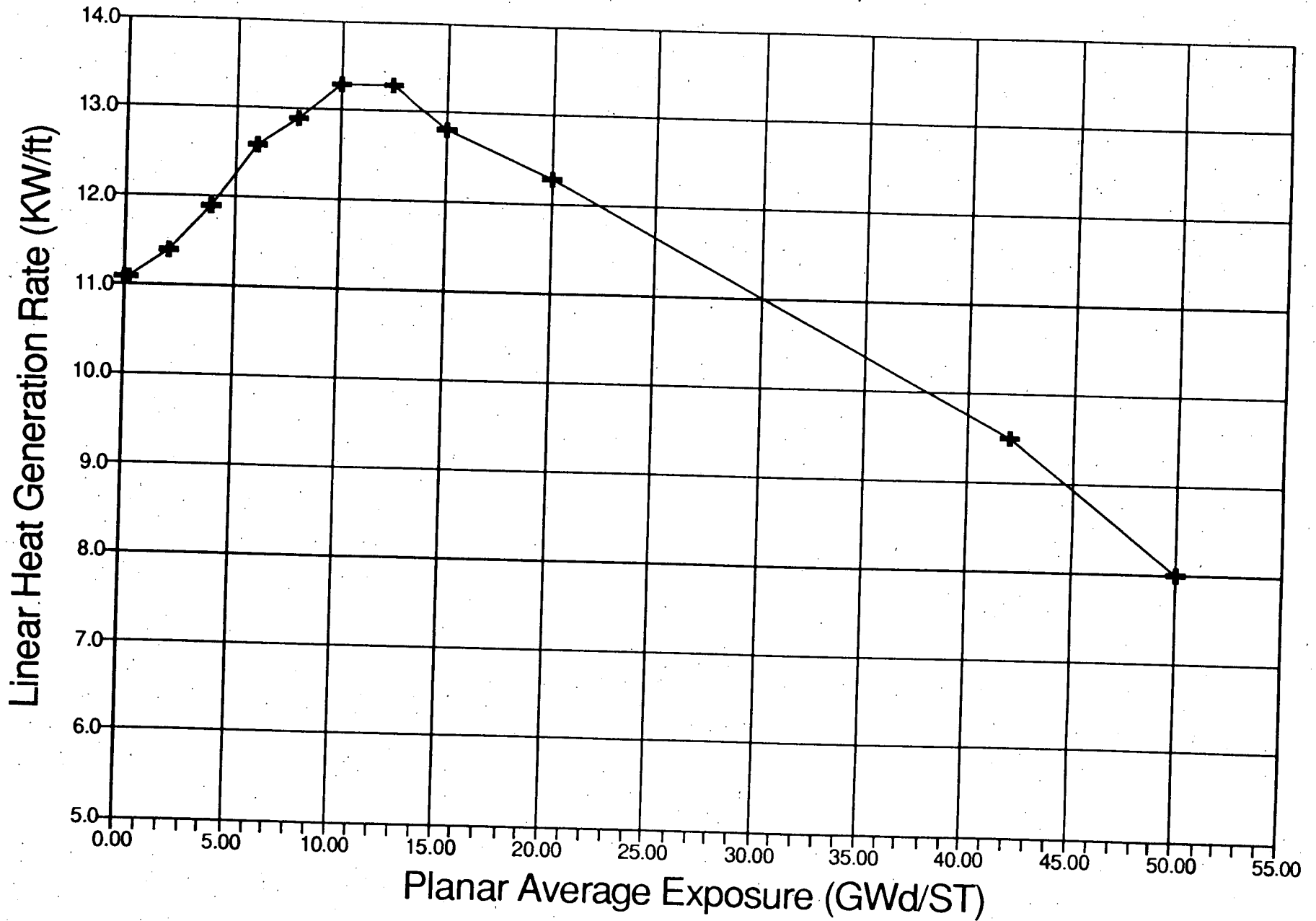


FIGURE 6

TABLE 6

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.



# MAPLHGR vs FUEL EXPOSURE

Fuel Type: GE8B-P8DQB324(GE8x8EB)

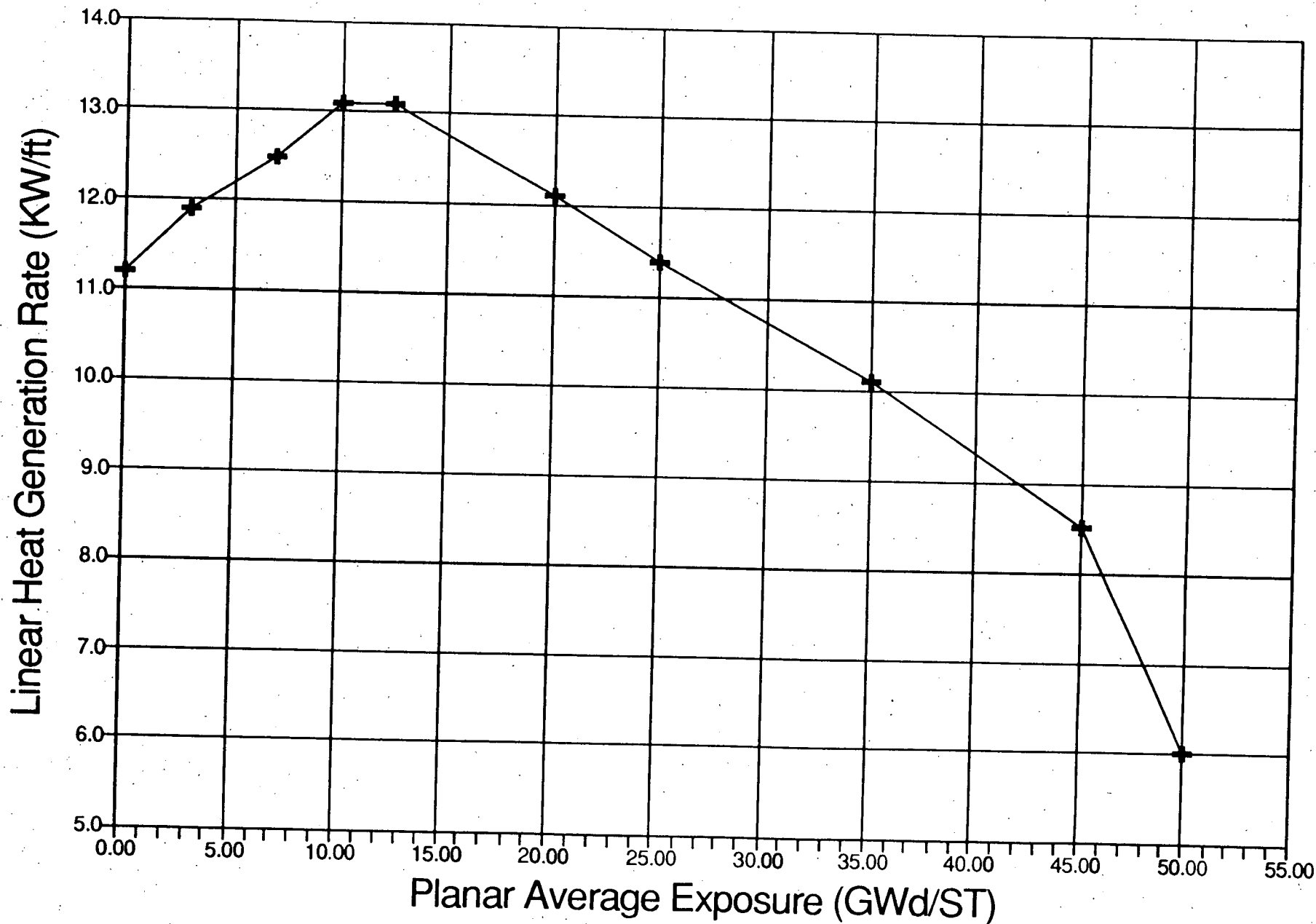


FIGURE 7

TABLE 7

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.

# FLOW DEPENDENT MAPLHGR MULTIPLIER

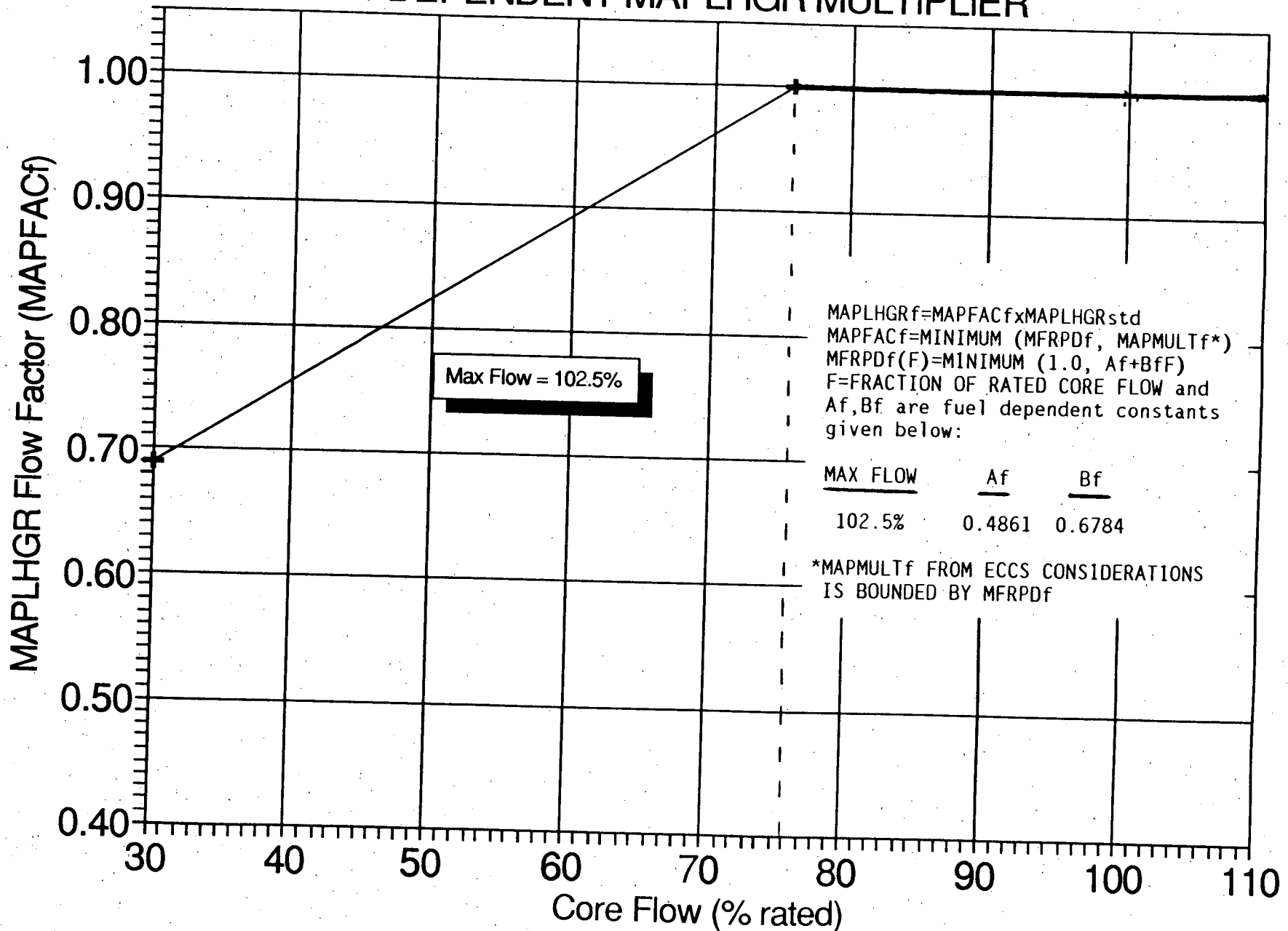


FIGURE 8

# POWER DEPENDENT MAPLHGR MULTIPLIER

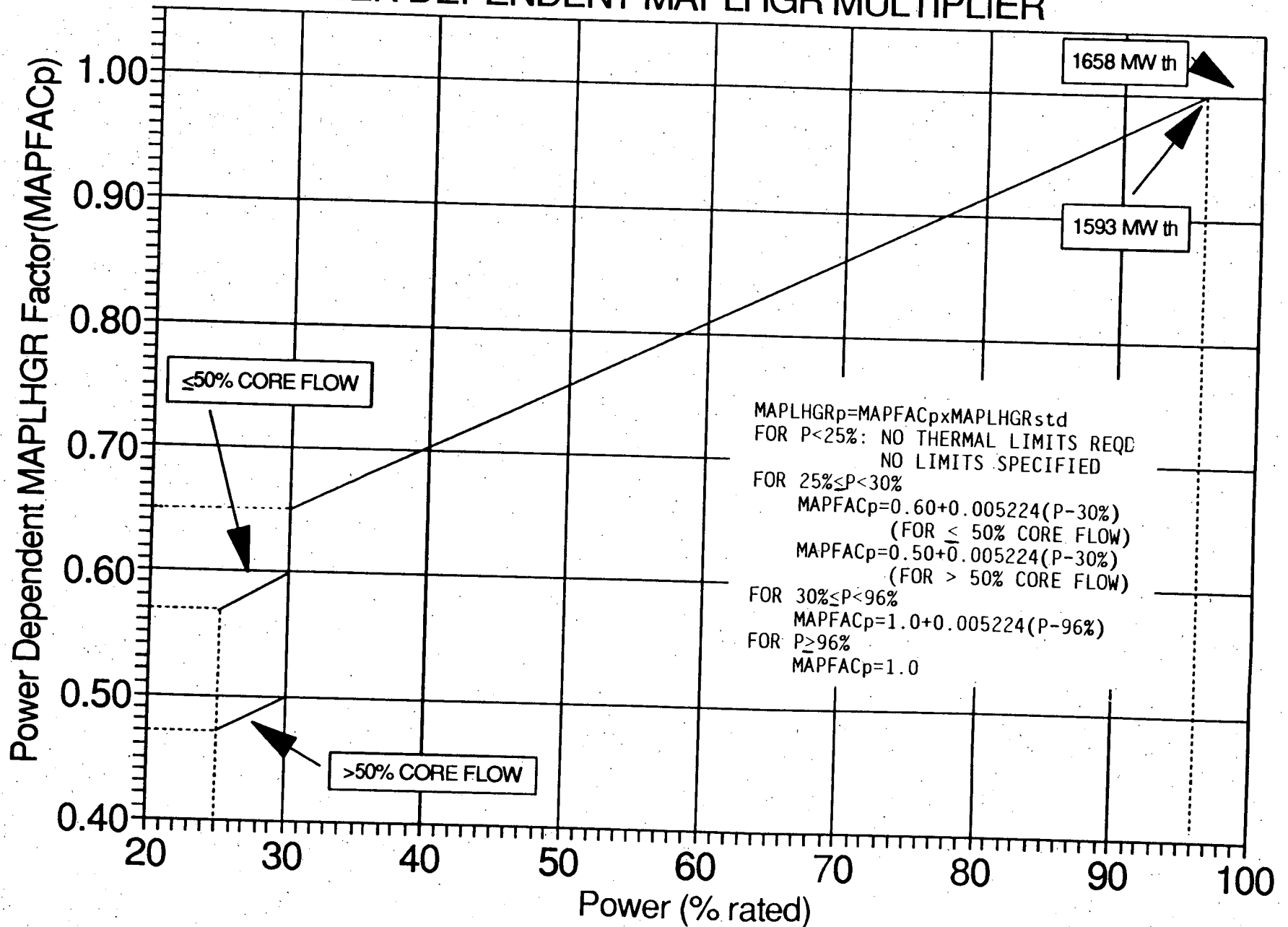


FIGURE 9

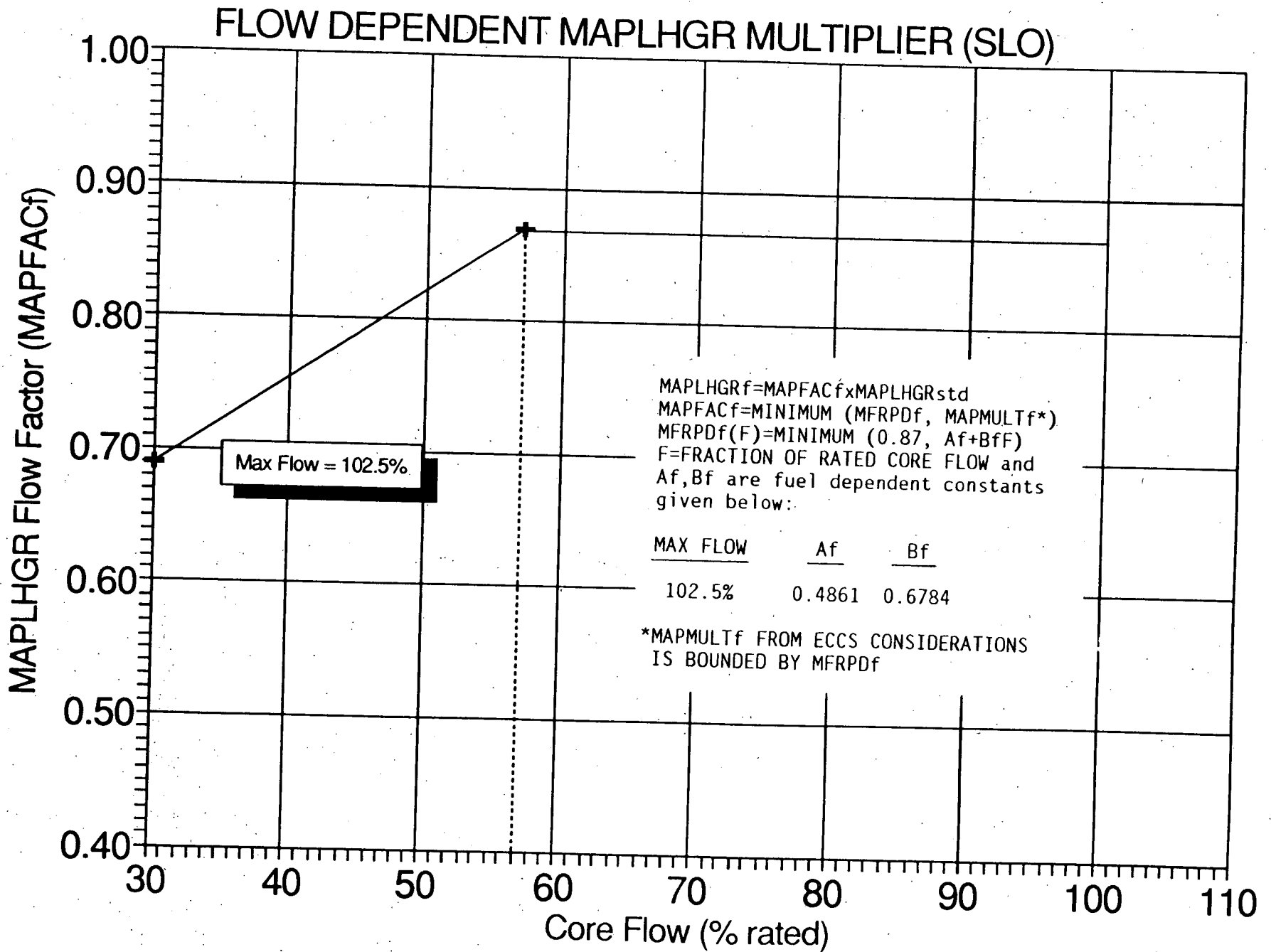


FIGURE 10

# POWER DEPENDENT MCPR LIMITS

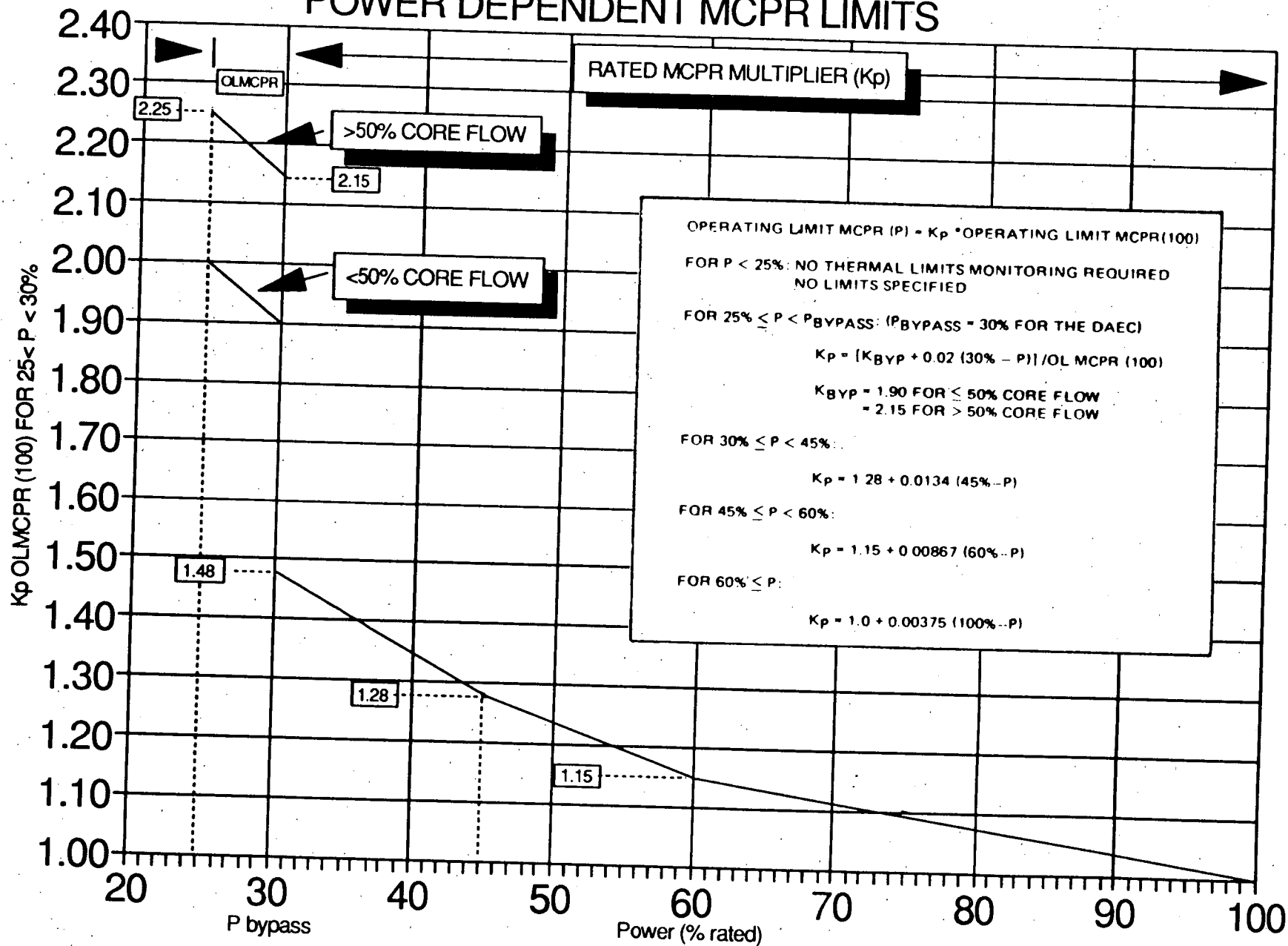


FIGURE 11

# FLOW DEPENDENT MCPR LIMITS

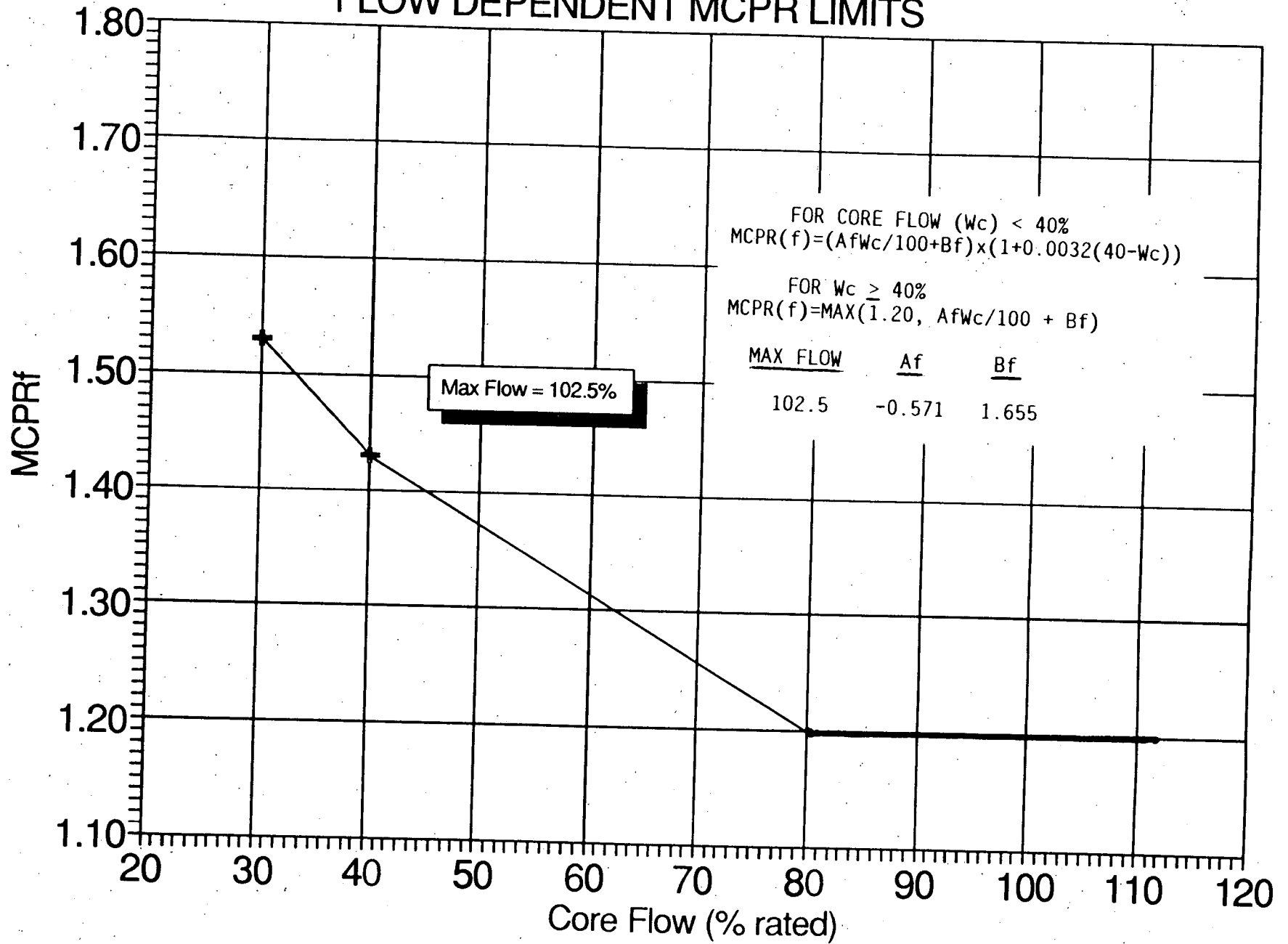
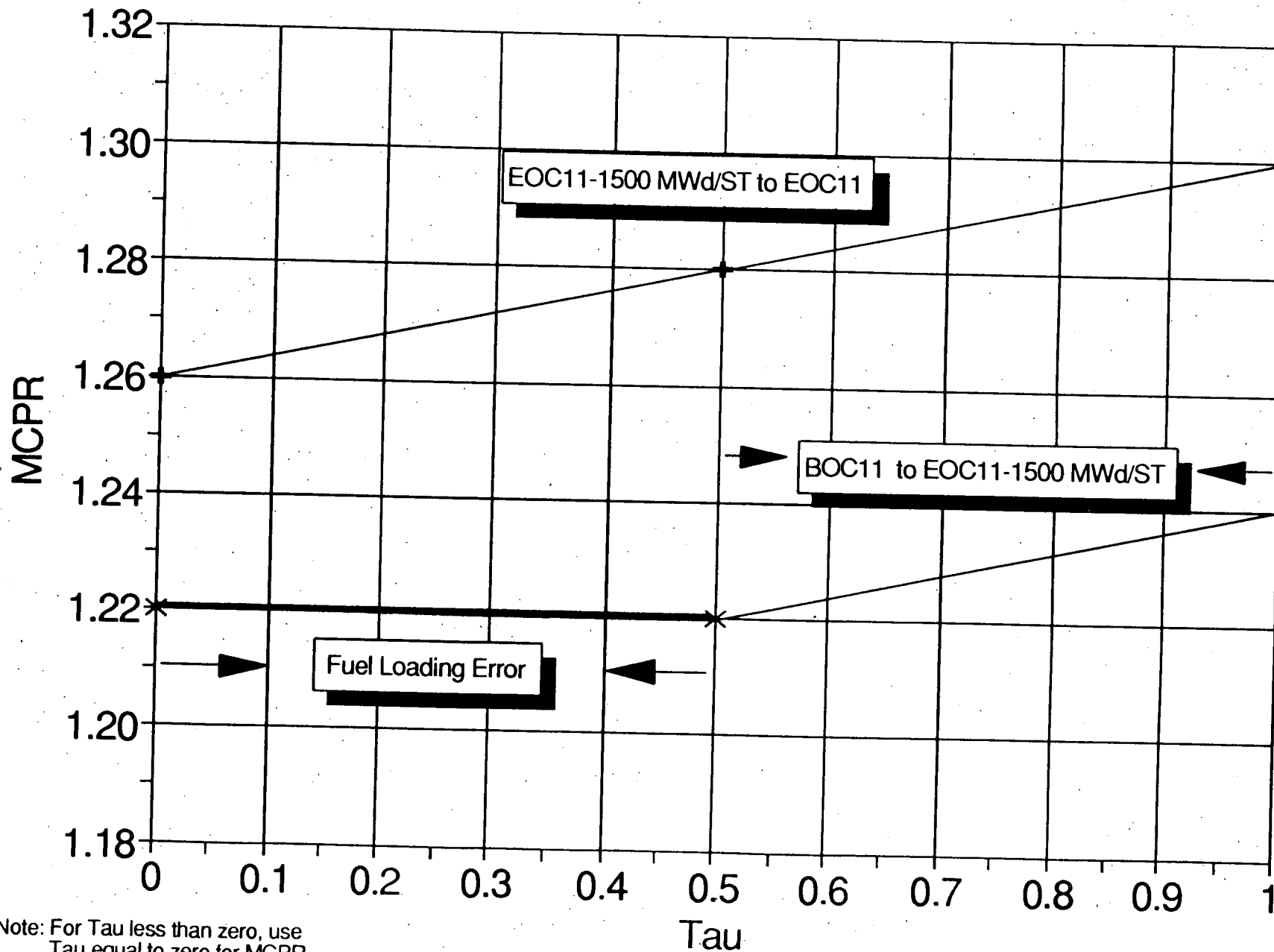


FIGURE 12

# M CPR vs TAU

Option B

Option A



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

FIGURE 13