

Browns Ferry Nuclear Plant  
Unit 2, Cycle 8

CORE OPERATING LIMITS REPORT  
(COLR)

TENNESSEE VALLEY AUTHORITY  
Nuclear Fuel Division  
BWR Fuel Engineering Department

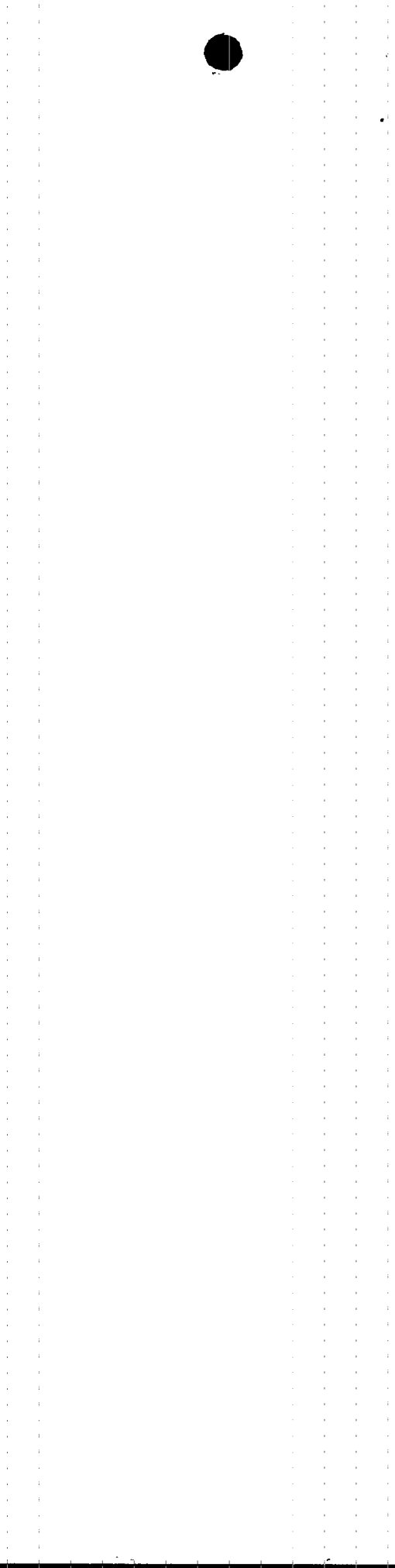
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## Revision Log

<u>Revision</u>	<u>Date</u>	<u>Description</u>	<u>Affected Pages</u>
0	10/03/94	Initial Release	All



## 1. INTRODUCTION

This Core Operating Limits Report for Browns Ferry Unit 2, Cycle 8 is prepared in accordance with the requirements of Browns Ferry Technical Specification 6.9.1.7. The core operating limits presented here were developed using NRC-approved methods (References 1 and 2). Results from the reload analyses for Browns Ferry Unit 2, Cycle 8 are documented in Reference 3.

The cycle 8 loading includes four Westinghouse QUAD+ demonstration assemblies. The locations of these assemblies satisfy the criteria specified in References 4 and 5. Evaluations performed by Westinghouse (Reference 5) show that the results of licensing analyses for the lead P8x8R fuel assembly bound those for the QUAD+ demonstration assemblies. Cycle specific analyses confirm this conclusion.

The following core operating limits are included in this report:

- a. Average Planar Linear Heat Generation Rate (APLHGR) Limit  
(Technical Specification 3.5.I)
- b. Linear Heat Generation Rate (LHGR) Limit  
(Technical Specification 3.5.J)
- c. Minimum Critical Power Ratio Operating Limit (OLMCPR)  
(Technical Specification 3.5.K/4.5.K)
- d. APRM Flow Biased Rod Block Trip Setting  
(Technical Specification 2.1.A.1.c, Table 3.2.C, and Specification 3.5.L)
- e. RBM Upscale (Flow Bias) Trip Setting and Clipped Value  
(Technical Specification Table 3.2.C)

## 2. APLHGR LIMIT (TECHNICAL SPECIFICATION 3.5.I)

The APLHGR limit for each type of fuel as a function of exposure is shown in Tables 1-7. The APLHGR limits for the GE9B bundles (GE8X8NB) are for the most limiting lattice at each exposure point. The specific values for each lattice are given in Reference 6.



### 3. LHGR LIMIT (TECHNICAL SPECIFICATION 3.5.J)

The LHGR limit for unit 2 cycle 8 is fuel type dependent , as shown below:

<u>Fuel Type</u>	<u>LHGR Limit</u>
P8X8R/BP8X8R/QUAD+	13.4 kw/ft
GE8X8NB	14.4 kw/ft

### 4. OLMCPR (TECHNICAL SPECIFICATION 3.5.K/4.5.K)

- a. The OLMCPR is equal to the fuel type and exposure dependent MCPR limit at rated flow and rated power shown in Figures 1-2 multiplied by the  $K_f$  shown in Figure 3, where;

$$\tau = 0.0 \quad \text{or} \quad \tau = \frac{\tau_{ave} - \tau_B}{\tau_A - \tau_B}, \quad \text{whichever is greater.}$$

$$\tau_A = 0.90 \text{ sec} \quad (\text{Specification 3.3.C.1 scram time limit to 20\% insertion from fully withdrawn})$$

$$\tau_B = 0.710 + 1.65 \left[ \frac{N}{\ln} \right]^{\frac{1}{2}} (0.053)$$

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

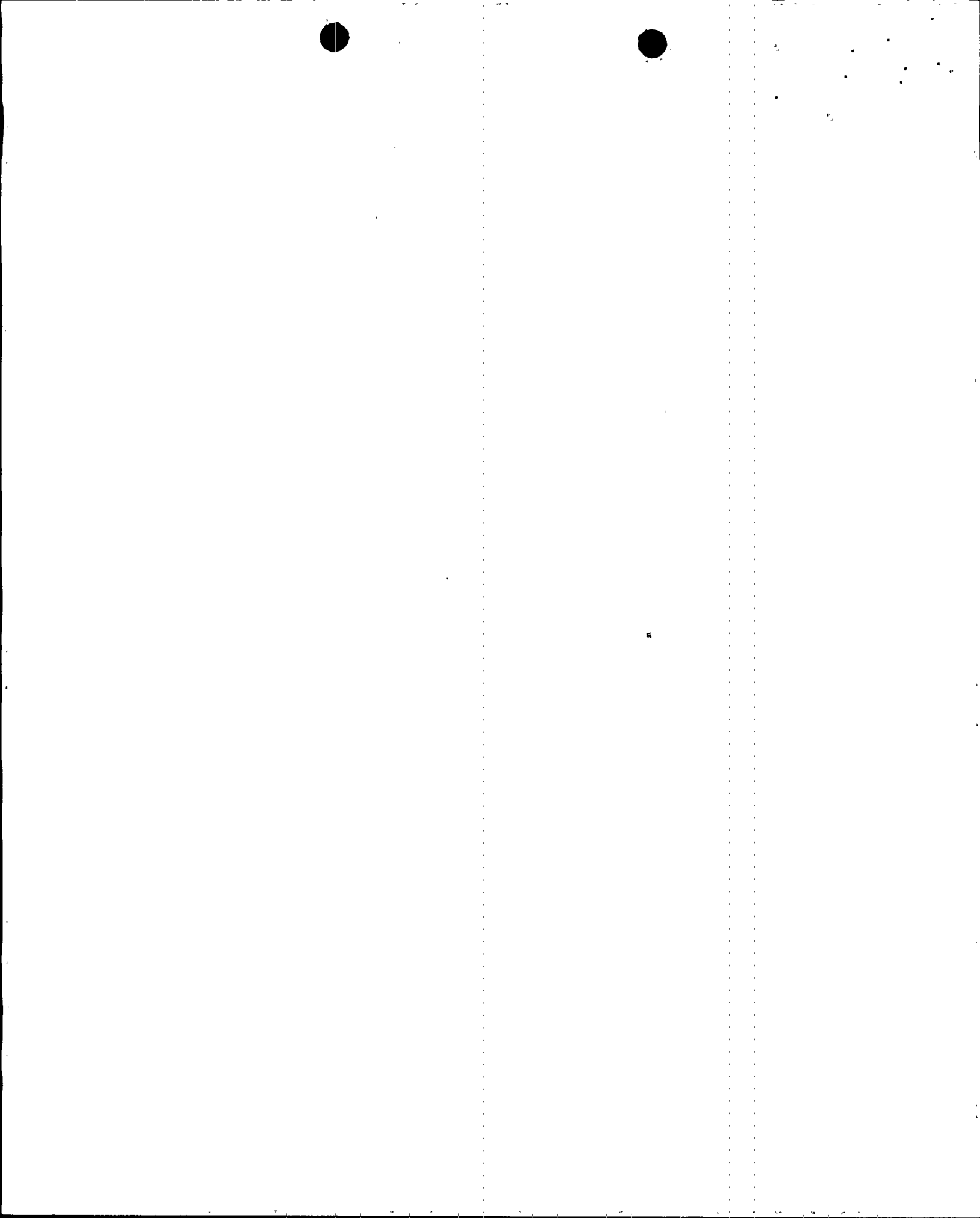
where;  $n$  = Number of surveillance rod tests performed to date in cycle (including BOC test).

$\tau_i$  = Scram time to 20% insertion from fully withdrawn of the  $i^{\text{th}}$  rod

$N$  = Total number of active rods measured in Specification 4.3.C.1 at BOC

- b. For the performance of Surveillance Requirement 4.5.K.2.a (prior to initial scram time measurements for the cycle),

$$\tau = 1.0$$





- c. For the performance of Surveillance Requirement 4.5.K.2.b,  $\tau$  shall be determined in accordance with 4.a above.

**5. APRM FLOW BIASED ROD BLOCK TRIP SETTING (TECHNICAL SPECIFICATION 2.1.A.1.c, TABLE 3.2.C, AND SPECIFICATION 3.5.L)**

The APRM Rod Block trip setting shall be:

$$S_{RB} \leq (0.58W + 50\%)$$

where:

$S_{RB}$  = Rod Block setting in percent of rated thermal power (3293 MWt)

$W$  = Loop recirculation flow rate in percent of rated

Note: Under certain conditions, the APRM Rod Block setting must be adjusted by FRP/CMFLPD. See Technical Specification 3.5.L.

**6. RBM UPSCALE (FLOW BIAS) TRIP SETTING AND CLIPPED VALUE (TECHNICAL SPECIFICATION TABLE 3.2.C)**

The RBM Upscale trip setting shall be:

$$\leq (0.66W + 43\%)$$

where:

Trip level setting is in percent of rated thermal power (3293 MWt)

$W$  = Loop recirculation flow rate in percent of rated

RBM upscale flow-biased setpoint clipped at 109 percent rated reactor power.



## 7. REFERENCES

1. NEDE-24011-P-A-10, "General Electric Standard Application for Reactor Fuel", February 1991.
2. NEDE-24011-P-A-10-US, "General Electric Standard Application for Reactor Fuel", March 1991.
3. 24A5153, Rev. 0, "Supplemental Reload Licensing Report for Browns Ferry Nuclear Plant Unit 2 Reload 7 Cycle 8," September 1994.
4. Safety Evaluation by the office of Nuclear Reactor Regulation Supporting Amendment No. 125 to Facility Operating License No. DPR-52, Tennessee Valley Authority, Browns Ferry Nuclear Power Plant, Unit 2, Docket No. 50-260.
5. WCAP-10507 dated March 1984, "QUAD+ Demonstration Assembly Report," Westinghouse Electric Corporation.
6. 24A5153AA, Rev. 0, "Lattice-Dependent MAPLHGR Report for Browns Ferry Nuclear Plant Unit 2 Reload 7 Cycle 8", September 1994.

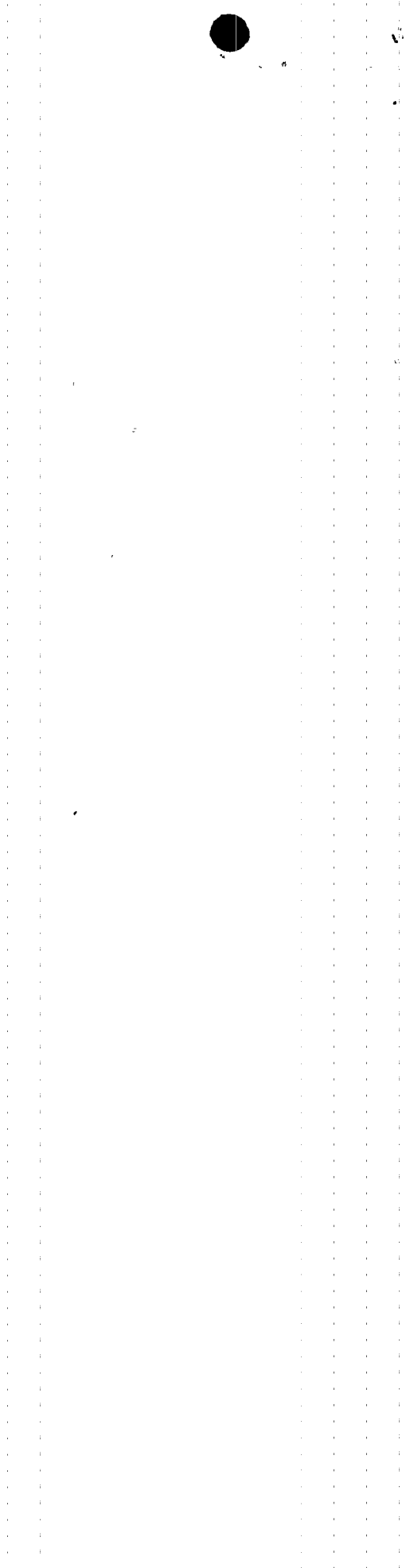


Table 1  
APLHGR Limits for Bundle Type GE9B-P8DWB319-9GZ  
(GE8X8NB)

Most Limiting Lattice  
for Each Exposure Point

Average Planar Exposure (GWD/ST)	APLHGR Limit kw/ft
0.0	11.64
0.2	11.68
1.0	11.77
2.0	11.88
3.0	12.01
4.0	12.12
5.0	12.22
6.0	12.32
7.0	12.49
8.0	12.65
9.0	12.77
10.0	12.86
12.5	12.86
15.0	12.62
20.0	12.06
25.0	11.47
35.0	10.41
45.0	8.81
51.20	5.91

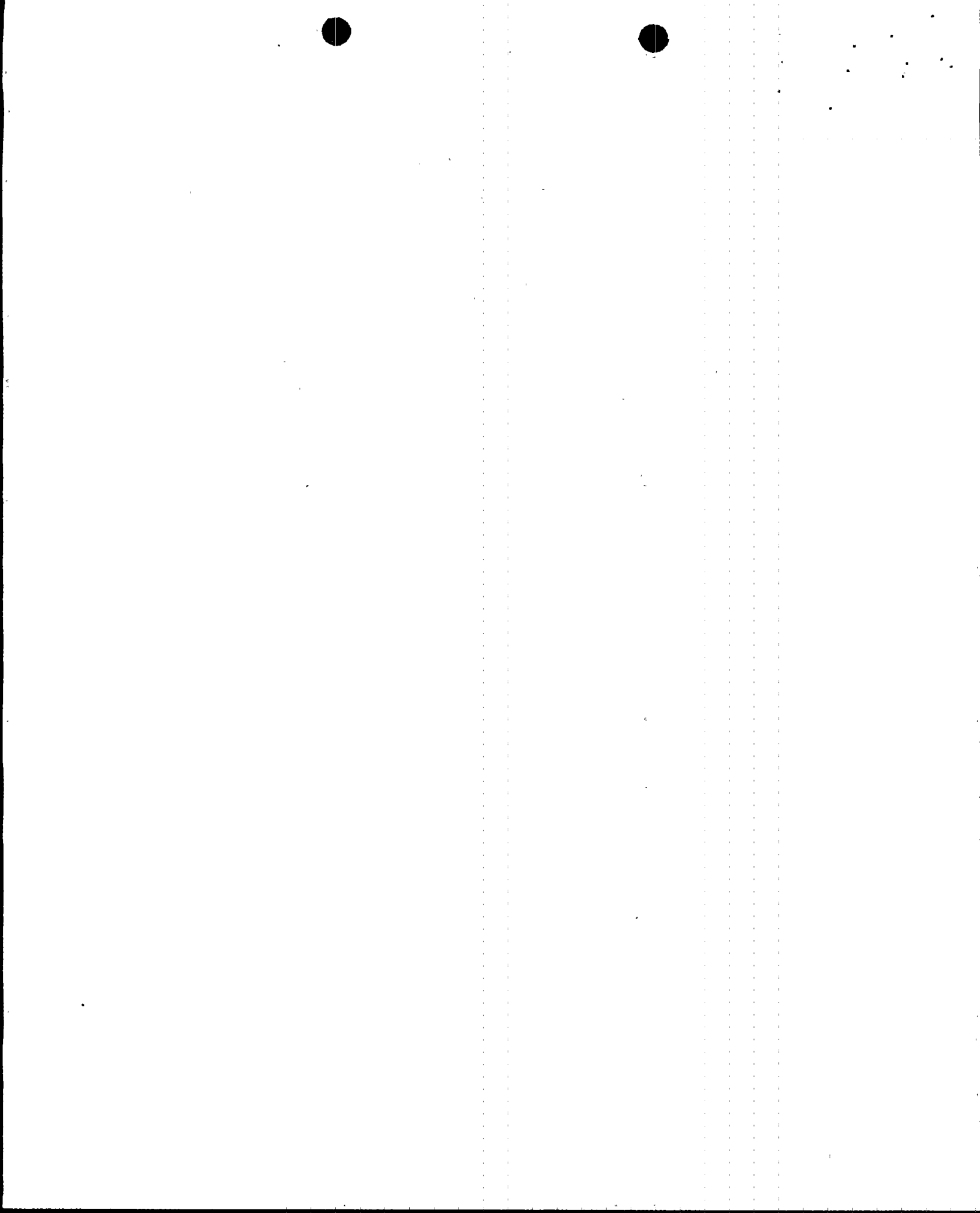


Table 2  
APLHGR Limits for Bundle Type GE9B-P8DWB325-10GZ  
(GE8X8NB)

Most Limiting Lattice  
for Each Exposure Point

Average Planar Exposure (GWD/ST)	APLHGR Limit kw/ft
0.0	10.97
0.2	11.00
1.0	11.11
2.0	11.31
3.0	11.54
4.0	11.79
5.0	11.97
6.0	12.10
7.0	12.23
8.0	12.35
9.0	12.46
10.0	12.58
12.5	12.58
15.0	12.35
20.0	11.86
25.0	11.33
35.0	10.12
45.0	8.60
50.27	5.92

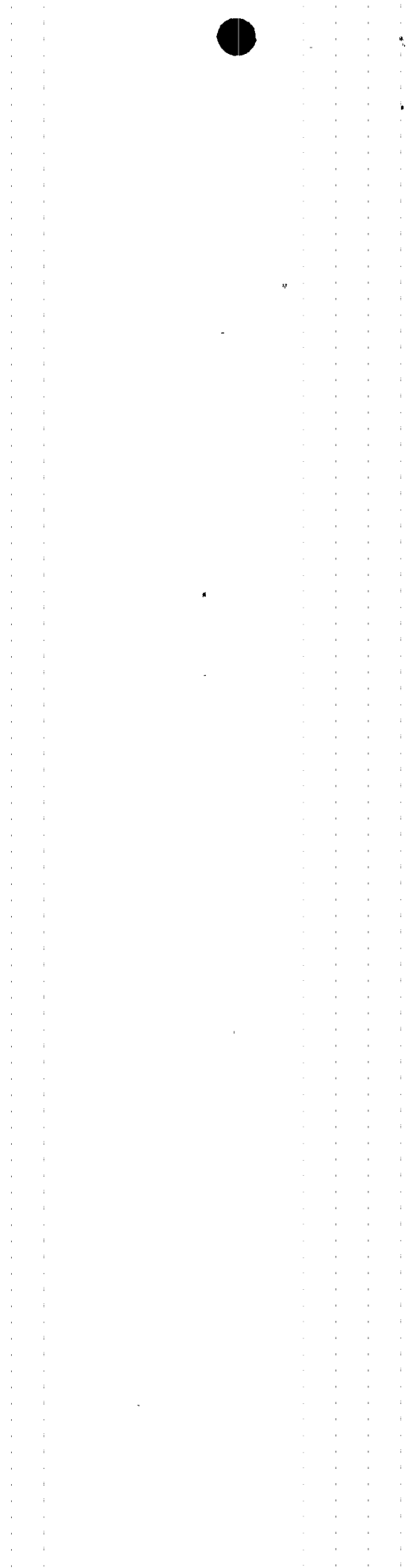




Table 3  
APLHGR Limits for Bundle Type GE9B-P8DWB326-7GZ  
(GE8X8NB)

Most Limiting Lattice  
for Each Exposure Point

Average Planar Exposure (GWD/ST)	APLHGR Limit kw/ft
0.0	11.45
0.2	11.47
1.0	11.55
2.0	11.70
3.0	11.87
4.0	12.01
5.0	12.13
6.0	12.22
7.0	12.31
8.0	12.41
9.0	12.51
10.0	12.63
12.5	12.64
15.0	12.41
20.0	11.91
25.0	11.35
35.0	10.15
45.0	8.72
50.5	5.93
51.4	5.87

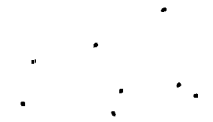


Table 4  
APLHGR Limits for Bundle Type BP8DRB301L  
(BP8X8R)

Average Planar Exposure (GWD/ST)		APLHGR Limit kw/ft
0.0		11.32
0.2		11.33
1.0	1.86	11.40
2.0	18.01	11.50
3.0	1.19	11.61
4.0		11.73
5.0	1.45	11.86
6.0	13.92	11.93
7.0	1.09	11.98
8.0	1.00	12.03
9.0		12.11
10.0	12.20	12.19
12.5	17.37	12.34
15.0		12.47
20.0		12.58
25.0	11.7	12.03
35.0		10.82
43.5		9.17



Table 5  
APLHGR Limits for Bundle Type BP8DRB299  
(BP8X8R)

Average Planar Exposure (GWD/ST)	APLHGR Limit kw/ft
0.0	10.71
0.2	10.75
1.0	10.86
2.0	11.01
3.0	11.19
4.0	11.35
5.0	11.47
6.0	11.62
7.0	11.78
8.0	11.95
9.0	12.09
10.0	12.20
12.5	12.37
15.0	12.47
20.0	12.37
25.0	11.77
35.0	10.65
42.1	9.36



Table 6  
APLHGR Limits for Bundle Type P8DRB284L  
and Westinghouse QUAD+ LTAs  
(P8X8R)

Average Planar Exposure (GWD/ST)	APLHGR Limit kw/ft
0.2	11.2
1.0	11.3
5.0	11.8
10.0	12.0
15.0	12.0
20.0	11.8
25.0	11.2
30.0	10.8
35.0	10.2
40.0	9.5
45.0	8.8

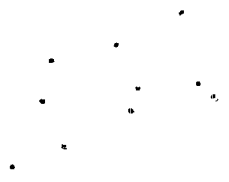




Table 7  
APLHGR Limits for Bundle Type P8DRB265H  
(P8X8R)

Average Planar Exposure (GWD/ST)	APLHGR Limit kw/ft
0.2	11.5
1.0	11.6
5.0	11.9
10.0	12.1
15.0	12.1
20.0	11.9
25.0	11.3
30.0	10.7
35.0	10.2
40.0	9.6

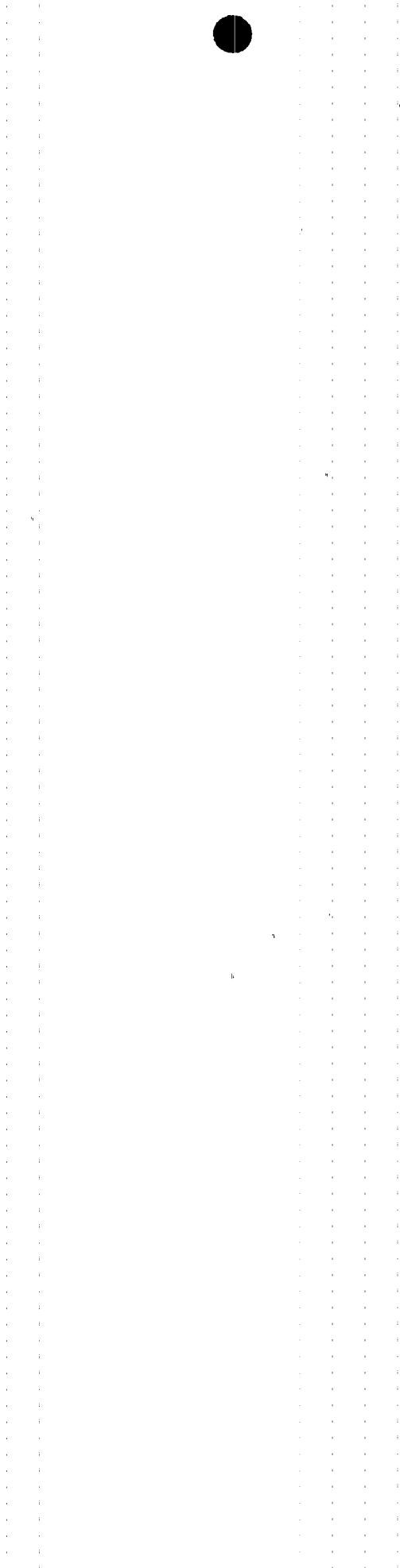
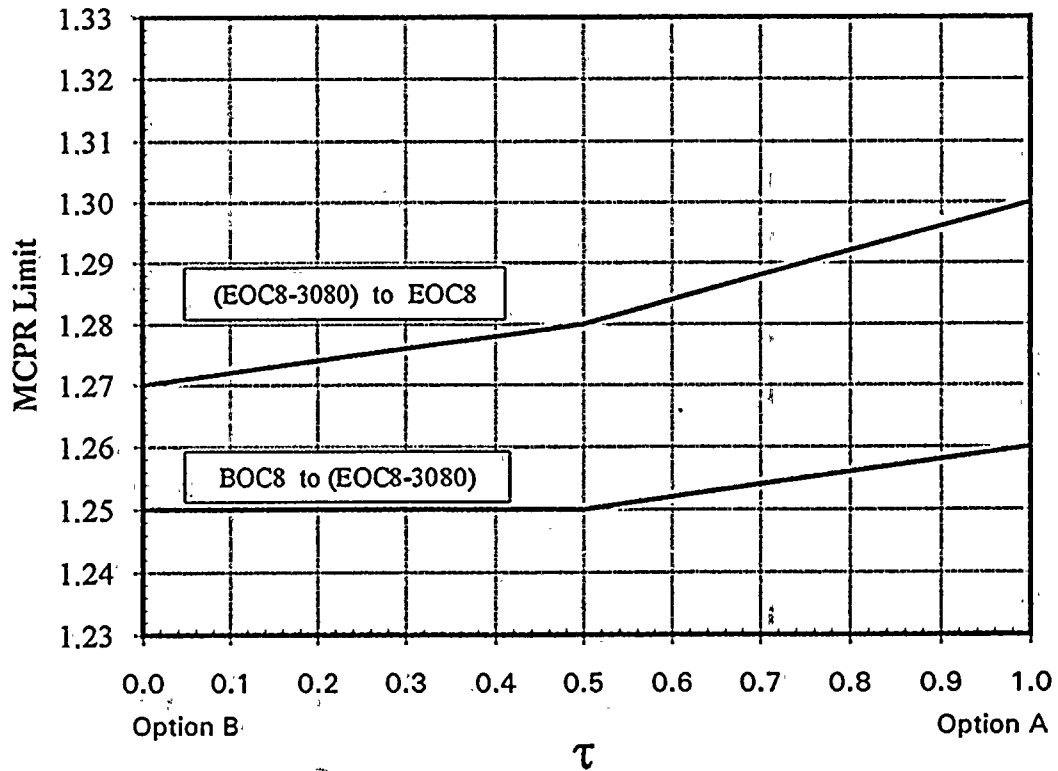


Figure 1  
MCPR Operating Limit for P8X8R/BP8X8R/QUAD+



<u>Exposure Range</u>	<u>Option A (Tau=1.0)</u>	<u>Option B (Tau=0.0)</u>
BOC8 to (EOC8-3080 MWD/ST)	1.26 *	1.25
(EOC8-3080 MWD/ST) to EOC8	1.30	1.27

\* Use this value at BOC8 prior to performing scram time testing.

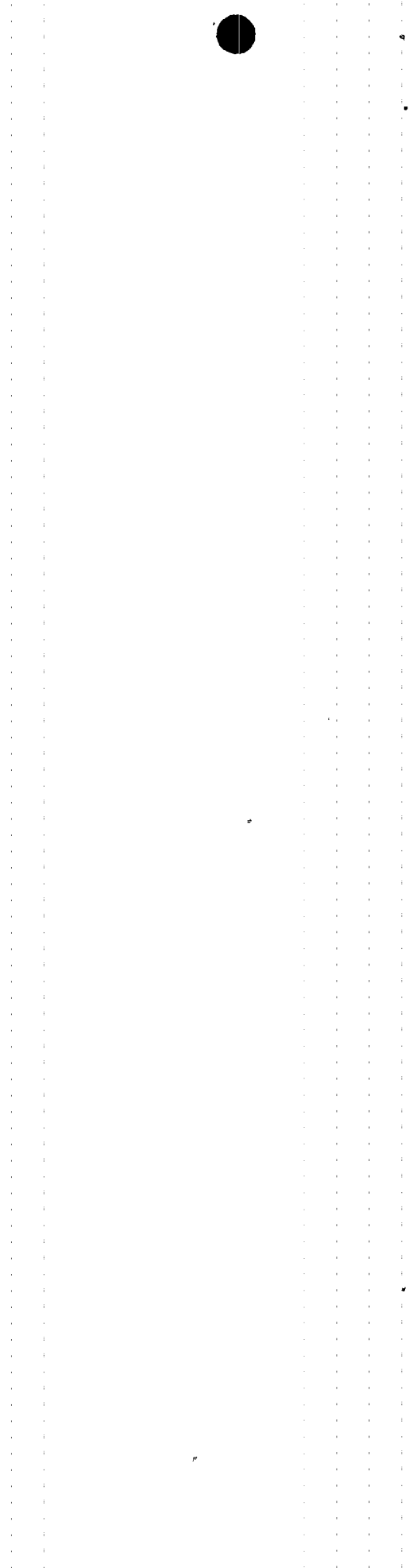
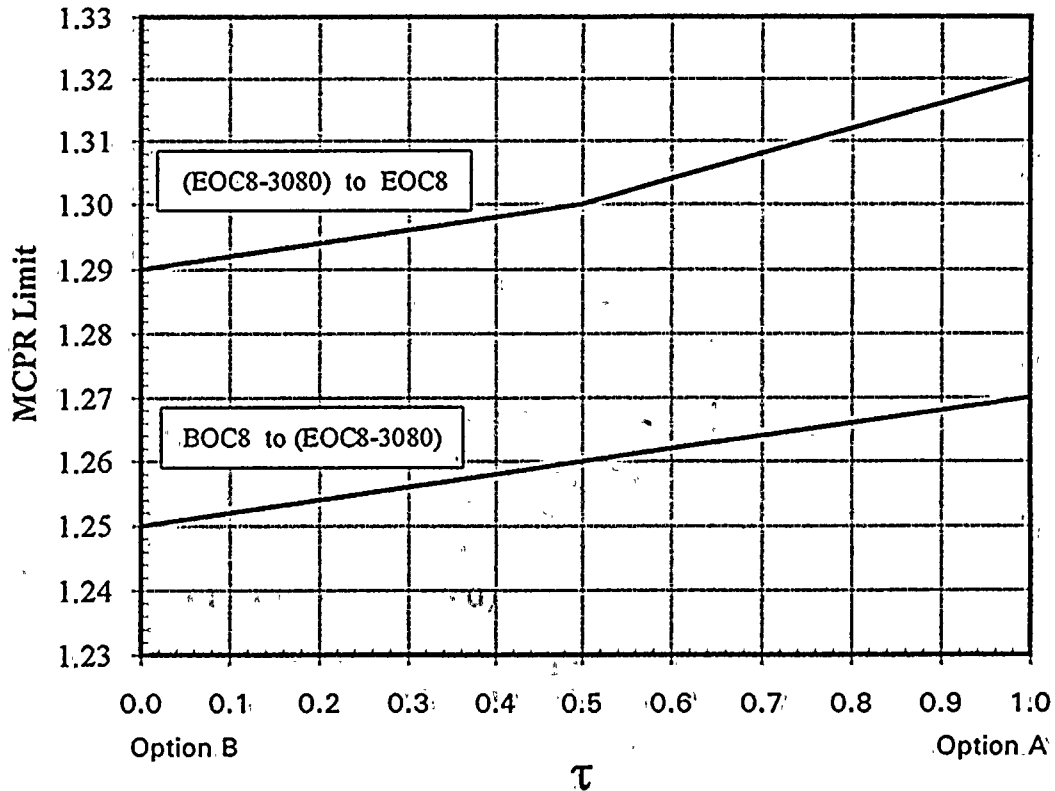


Figure 2  
MCPR Operating Limit for GE8X8NB



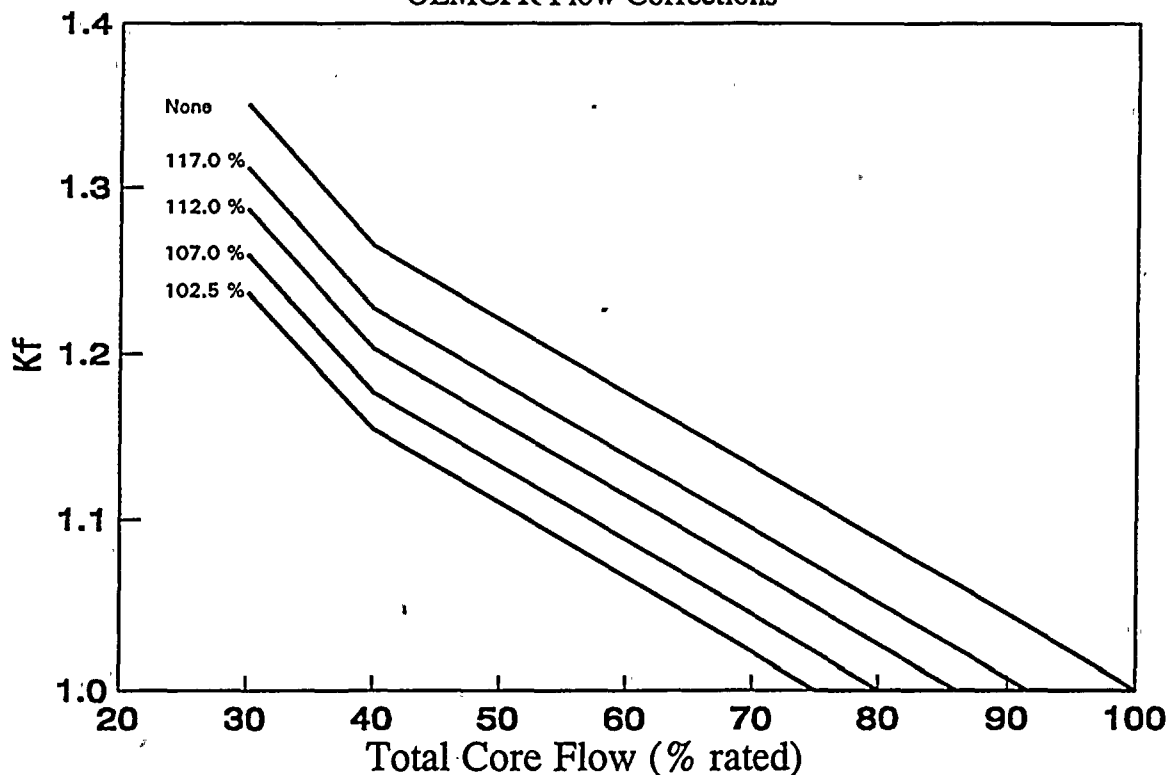
<u>Exposure Range</u>	<u>Option A (Tau=1.0)</u>	<u>Option B (Tau=0.0)</u>
BOC8 to (EOC8-3080 MWD/ST)	1.27 *	1.25
(EOC8-3080 MWD/ST) to EOC8	1.32	1.29

\* Use this value at BOC8 prior to performing scram time testing.



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Figure 3  
GEXL-Plus K<sub>f</sub> Curve  
OLMCPR Flow Corrections



For  $40\% < WT \leq 100\%$ ,  $K_f = \text{MAX} [ 1.0, A - 0.00441*WT ]$   
 $WT \leq 40\%$ ,  $K_f = [ A - 0.00441*WT ] * [ 1.0 + 0.0032*( 40 - WT ) ]$   
 $WT > 100\%$ ,  $K_f = 1.0$

where :  $WT$  = Percent of Rated Core Flow, and  
 $A$  = constant which depends on the Flow Control Mode and the Scoop Tube Setpoint as noted below.

<u>Flow Control Mode</u>	<u>Scoop Tube Setpoint</u>	<u>A</u>
MANUAL	102.5 %	1.3308
MANUAL	107.0 %	1.3528
MANUAL	112.0 %	1.3793
MANUAL	117.0 %	1.4035
AUTOMATIC	N/A	1.4410



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