

QA RECORD

Browns Ferry Nuclear Plant
Unit 2, Cycle 9

CORE OPERATING LIMITS REPORT
(COLR)

TENNESSEE VALLEY AUTHORITY
Nuclear Fuel Division
BWR Fuel Engineering Department

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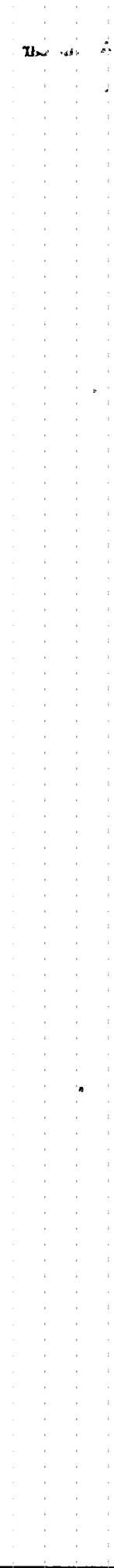
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Revision Log

<u>Revision</u>	<u>Date</u>	<u>Description</u>	<u>Affected Pages</u>
0	3/14/96	Initial Release	All



1. INTRODUCTION

This Core Operating Limits Report for Browns Ferry Unit 2, Cycle 9 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 9 are documented in Reference 3.

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. Average Power Range Monitor (APRM) Flow Biased Rod Block Trip Setting
(Technical Specification 2.1.A.1.c, Table 3.2.C, and Specification 3.5.L)
- e. Rod Block Monitor (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 - 8. The APLHGR limits for the GE9B (GE8X8NB) and the GE11 bundles are for the most limiting lattice at each exposure point. The specific values for each lattice are given in Reference 4.

3. LHGR LIMIT (TECHNICAL SPECIFICATION 3.5.J)

The LHGR limit for unit 2 cycle 9 is fuel type dependent, as shown below:

<u>Fuel Type</u>	<u>LHGR Limit</u>
P8X8R/BP8X8R	13.4 kw/ft
GE8X8NB/GE11	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 - 3 multiplied by the K_f shown in Figure 4, where;

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

$$\tau_A = 0.90 \text{ sec} \quad (\text{Specification 3.3.C.1 scram time limit to 20\% insertion from fully withdrawn})$$

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

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

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

τ_i = Scram time to 20% insertion from fully withdrawn of the i^{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, τ 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:

$$S_{RB} \leq (0.58W + 57\%)$$

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:

$$\leq (0.66W + 46\%)$$

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 112 percent rated reactor power.

7. REFERENCES

1. NEDE-24011-P-A-11, "General Electric Standard Application for Reactor Fuel," November 1995.
2. NEDE-24011-P-A-11-US, "General Electric Standard Application for Reactor Fuel -- U.S. Supplement," November 1995.
3. J11-02761SRLR, Rev. 2, "Supplemental Reload Licensing Report for Browns Ferry Nuclear Plant Unit 2 Reload 8 Cycle 9," March 1996.
4. J11-02761MAPL, Rev. 0, "Lattice-Dependent MAPLHGR Report for Browns Ferry Nuclear Plant Unit 2 Reload 8 Cycle 9," January 1996.

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)
0.00	11.64
0.20	11.68
1.00	11.77
2.00	11.88
3.00	12.01
4.00	12.12
5.00	12.22
6.00	12.32
7.00	12.49
8.00	12.65
9.00	12.77
10.00	12.86
12.50	12.86
15.00	12.62
20.00	12.06
25.00	11.47
35.00	10.41
45.00	8.81
51.20	5.91

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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)
0.00	10.97
0.20	11.00
1.00	11.11
2.00	11.31
3.00	11.54
4.00	11.79
5.00	11.97
6.00	12.10
7.00	12.23
8.00	12.35
9.00	12.46
10.00	12.58
12.50	12.58
15.00	12.35
20.00	11.86
25.00	11.33
35.00	10.12
45.00	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)
0.00	11.45
0.20	11.47
1.00	11.55
2.00	11.70
3.00	11.87
4.00	12.01
5.00	12.13
6.00	12.22
7.00	12.31
8.00	12.41
9.00	12.51
10.00	12.63
12.50	12.64
15.00	12.41
20.00	11.91
25.00	11.35
35.00	10.15
45.00	8.72
50.49	5.93

Table 4
APLHGR Limits for Bundle Type BP8DRB301L
(BP8X8R)

Average Planar Exposure (GWD/ST)	APLHGR Limit (kw/ft)
0:00	11.32
0.20	11.33
1.00	11.40
2.00	11.50
3.00	11.61
4.00	11.73
5.00	11.86
6.00	11.93
7.00	11.98
8.00	12.03
9.00	12.11
10.00	12.19
12.50	12.34
15.00	12.47
20.00	12.58
25.00	12.03
35.00	10.82
43.52	9.17

Table 5
APLHGR Limits for Bundle Type BP8DRB299
(BP8X8R)

Average Planar Exposure (GWD/ST)	APLHGR Limit (kw/ft)
0.00	10.71
0.20	10.75
1.00	10.86
2.00	11.01
3.00	11.19
4.00	11.35
5.00	11.47
6.00	11.62
7.00	11.78
8.00	11.95
9.00	12.09
10.00	12.20
12.50	12.37
15.00	12.47
20.00	12.37
25.00	11.77
35.00	10.65
42.13	9.36

Table 6
APLHGR Limits for Bundle Type P8DRB284L
(P8X8R)

Average Planar Exposure <u>(GWD/ST)</u>	APLHGR Limit <u>(kw/ft)</u>
0.20	11.20
1.00	11.30
5.00	11.80
10.00	12.00
15.00	12.00
20.00	11.80
25.00	11.20
30.00	10.80
35.00	10.20
40.00	9.50
45.00	8.80

Table 7
APLHGR Limits for Bundle Type GE11-P9HUB366-12G4.0
(GE11)

Most Limiting Lattice
for Each Exposure Point

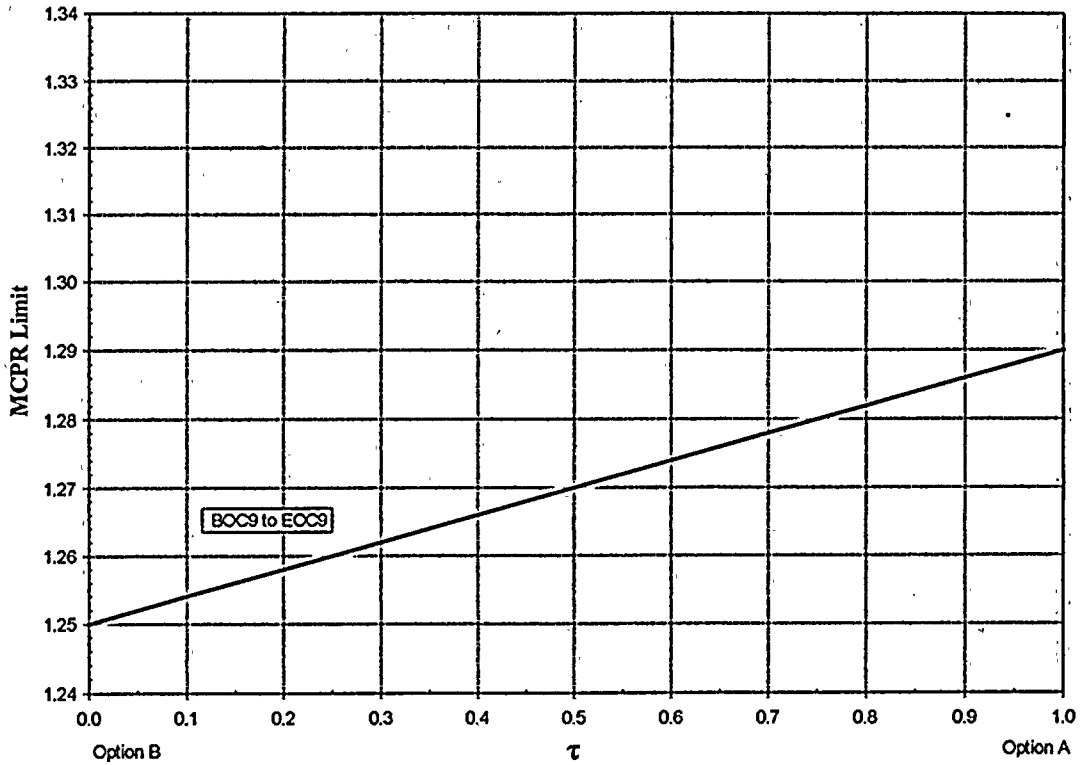
Average Planar Exposure (GWD/ST)	APLHGR Limit (kw/ft)
0.00	9.55
0.20	9.62
1.00	9.80
2.00	10.05
3.00	10.32
4.00	10.58
5.00	10.84
6.00	11.11
7.00	11.39
8.00	11.67
9.00	11.81
10.00	11.95
12.50	11.92
15.00	11.72
17.50	11.48
20.00	11.20
25.00	10.51
30.00	9.84
35.00	9.19
40.00	8.55
45.00	7.91
50.00	7.26
55.00	6.59
56.17	6.42

Table 8
APLHGR Limits for Bundle Type GE11-P9HUB367-14GZ
(GE11)

Most Limiting Lattice
for Each Exposure Point

Average Planar Exposure (GWD/ST)	APLHGR Limit (kw/ft)
0.00	9.18
0.20	9.27
1.00	9.45
2.00	9.72
3.00	10.00
4.00	10.30
5.00	10.62
6.00	10.95
7.00	11.31
8.00	11.67
9.00	11.81
10.00	11.95
12.50	11.92
15.00	11.72
17.50	11.48
20.00	11.20
25.00	10.51
30.00	9.84
35.00	9.19
40.00	8.55
45.00	7.91
50.00	7.26
55.00	6.59
56.17	6.42

Figure 1
MCPR Operating Limit for P8X8R/BP8X8R



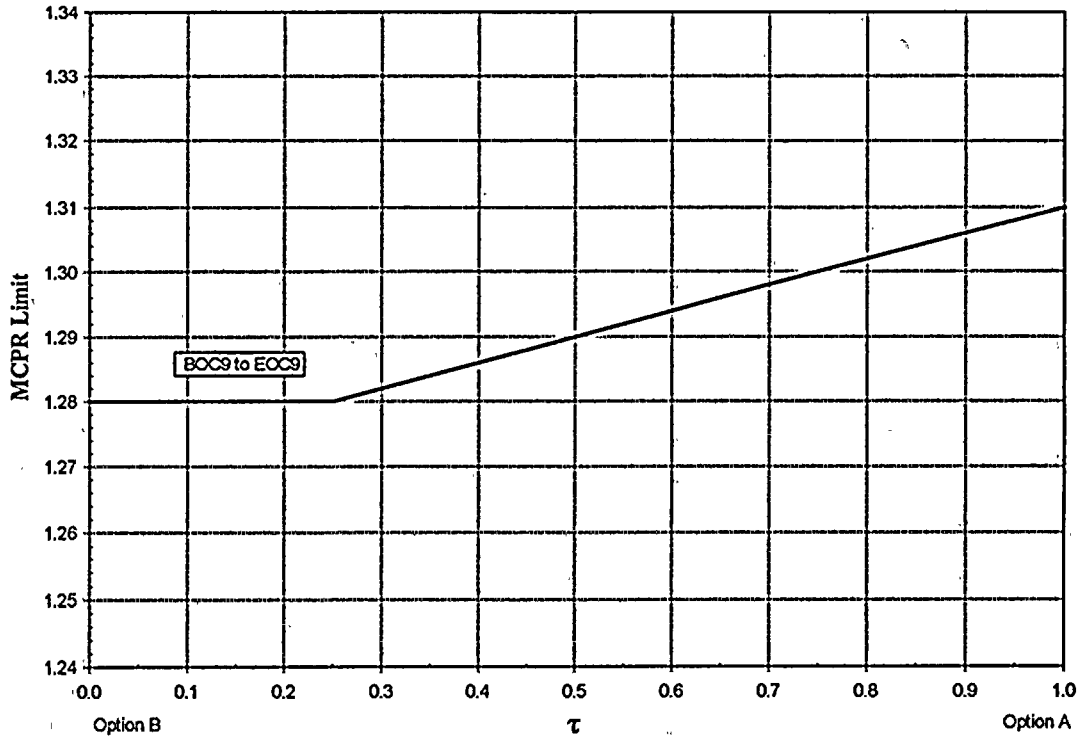
Exposure Range
BOC9 to EOC9

Option A (Tau=1.0)
1.29 *

Option B (Tau=0.0)
1.25

* Use this value at BOC9 prior to performing scram time testing.

Figure 2
MCPR Operating Limit for GE8X8NB



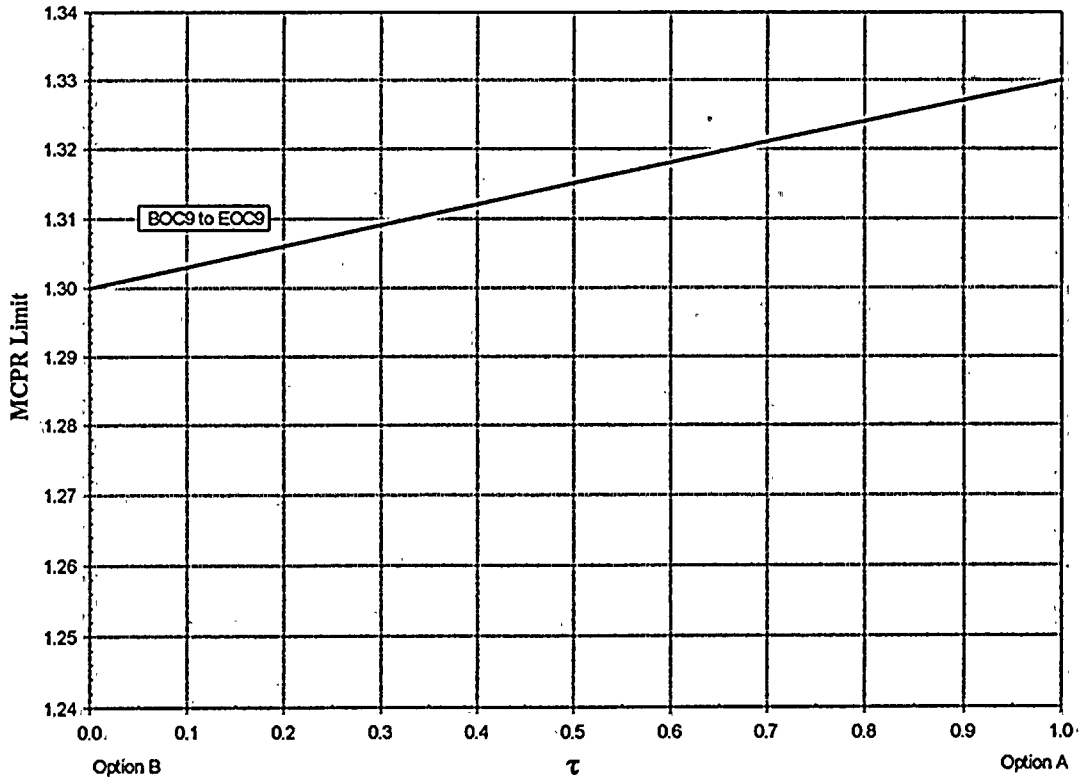
Exposure Range
BOC9 to EOC9

Option A (Tau=1.0)
1.31 *

Option B (Tau=0.0)
1.28

* Use this value at BOC9 prior to performing scram-time testing.

Figure 3
MCPR Operating Limit for GE11



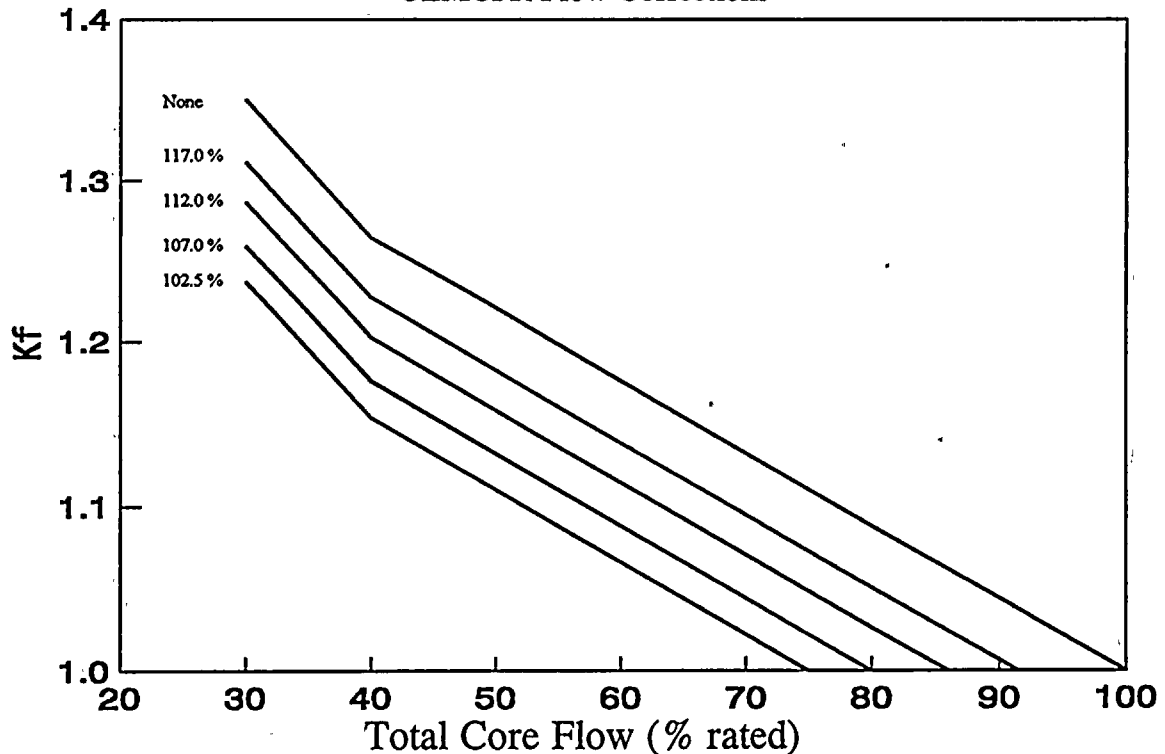
Exposure Range
BOC9 to EOC9

Option A (Tau=1.0)
1.33 *

Option B (Tau=0.0)
1.30

* Use this value at BOC9 prior to performing scram time testing.

Figure 4
GEXL-Plus K_f 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

Note: Flow Corrections are given for P8X8R, BP8X8R, and GE8X8NB bundles. These corrections are conservative when compared to GE11 flow corrections which do not have the additional correction factor of $[1.0 + 0.0032 * (40 - WT)]$ below 40% flow.

