CORE OPERATING LIMITS REPORT

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NOTE: The Term Lead Use Assembly (LUA) corresponds to the Term Lead Test Assembly (LTA) discussed in Technical Specification 5.2.C.

## 1.0 INTRODUCTION

This report provides the cycle-specific limits for operation of the Cooper Nuclear Station through Cycle 16. It includes the limits for the Rod Block Monitor Upscale Set Point, Average Planar Linear Heat Generation Rate (APLHGR), Linear Heat Generation Rate (LHGR), and Minimum Critical Power Ratio (MCPR). If any of these limits are exceeded, the action will be taken as defined in the Technical Specifications.

These core operating limit values have been determined using the NRC-approved methodologies given in Revision 10 to Reference 1 and are established such that all applicable limits of the plant safety analysis are met.

## 2.0 CORE OPERATING LIMITS

Cooper Nuclear Station shall be operated within the bounds of the below limits. The applicable Technical Specifications are referenced in each subsection.

### 2.1 Rod Block Monitor Upscale Setpoint

Technical Specifications Table 3.2.C states that the Rod Block Monitor (RBM) upscale (Power Referenced) trip level setting is determined from the following:

| Lowest Rated MCPR Limit: | LTSP (LPSP ≤ P < IPSP) | ITSP (IPSP ≤ P < HPSP) | HTSP (HPSP ≤ P) |
|---|---|---|---|
| ≥ 1.20 | ≤ 117.0/125 | ≤ 111.2/125 | ≤ 107.4/125 |
| ≥ 1.25 | ≤ 120.0/125 | ≤ 115.2/125 | ≤ 110.2/125 |
| ≥ 1.30 | ≤ 123.0/125 | ≤ 118.0/125 | ≤ 113.2/125 |

LPSP, IPSP, and HPSP are the power level setpoints listed on Table 3.2.C.

The lowest rated MCPR limit to be used with this table for Cycle 16 is ≥ 1.20. The trip level settings associated with this MCPR limit have been generically calculated and verified to bound the Rod Withdrawal Error Analysis for Cycle 16 operation.

Technical Specifications Reference: 3.2.C.

### 2.2 Average Planar Linear Heat Generation Limits

The limiting APLHGR value for the most limiting lattice (excluding natural uranium) for each fuel type as a function of Planar Average Exposure and core power and flow is calculated by taking the value from Figure 1, 2, 3, 4, 5, or 6, and multiplying it by the smaller of the MAPLHGR Flow Factor, $MAPFAC_F$ from Figure 7, or the Power-Dependent MAPLHGR Factor, $MAPFAC_P$ from Figure 8. On Figure 7, use the curve associated with a maximum core flow of 102.5 percent, which is the mechanical RRMG scoop tube limit specified in OPL-7. APLHGR values were determined with the SAFE/REFLOOD LOCA methodology

and are given in References 2 and 3, while the $MAPFAC_P$ and $MAPFAC_P$ were determined in Reference 6.

The fuel types referred to in Figures 1, 2, 5, and 6 consists of multiple combinations of enriched uranium and gadolinia called lattices with each having its own calculated maximum APLHGR (MAPLHGR) value. Hence, these fuel types have multiple MAPLHGR limiting values at a given planar exposure. The MAPLHGR values for these lattices, along with the axial location of each lattice in the bundle, are considered proprietary information by General Electric and are given in Reference 4 as a function of planar average exposure.

The MAPLHGR limits referred to above are for two recirculation loop operations. For single loop operation, the limiting APLHGR value is obtained as explained by the note at the bottom of Pages 5 through 10.

Technical Specification Reference: 3.11.A.

2.3 Linear Heat Generation Rate Limits

These limits are equivalent to the design LHGR, limiting power density, and maximum allowable LHGR referred to in the Technical Specifications. There are different LHGR limits for different fuel types. These limits are given in Table 1.

Technical Specification References: 1.0.A.4
2.1.A.1.a
2.1.A.1.d
3.11.B

2.4 Minimum Critical Power Ratio Limits

The operating limit MCPR (OLCPR) values, which are a function of core thermal power, core flow, fuel type, scram time ($\tau$), and fuel exposure are calculated as follows:

2.4.1 For core thermal power $\geq$ 25 percent and $<$ 30 percent of rated power, the OLMCPR is equal to the power dependent MCPR ($MCPR_P$) from Figure 8.

2.4.2 For core thermal power $\geq$ 30 percent of rated power, the OLMCPR is the greater of either:

2.4.2.1 The applicable flow dependent MCPR ($MCPR_F$) determined from Figure 10, or

2.4.2.2 The appropriate scram time ($\tau$) dependent MCPR at rated power from Figures 11 through 18, multiplied by the applicable power dependent MCPR multiplier ($K_P$) from Figure 9.

Technical Specification Reference: 3.11.C

## 3.0 REFERENCES


1. NEDE-24011-P-A-10, February 1991, General Electric Standard Application for Reactor Fuel. (The approved revision at the time the reload analyses were performed.)

2. Supplemental Reload Licensing Submittal for Cooper Nuclear Station Reload 15, Cycle 16, 23A7199 Revision 0, February 1993.

3. NEDO-24045, Loss-of-Coolant Accident Analysis Report for Cooper Nuclear Power Station.

4. NEDE-24045P Supplement 1, Loss-of-Coolant Accident Analysis Report for Cooper Nuclear Power Station.

5. Letter (with attachment), R. H. Buckholz (GE) to P. S. Check (NRC) dated September 5, 1980, Response to NRC Request for Information on ODYN Computer Model.

6. NEDC-31892P, Revision 1, May 1991, Extended Load Line Limit and ARTS Improvement Program Analyses for Cooper Nuclear Station Cycle 14.

7. Letter (with attachment), T. H. Black (GE) to Paul Ballinger (NPPD) dated April 26, 1994, Revised Impact Evaluation of One Turbine Bypass Valve out-of-service on MCPR for Cooper Nuclear Station (CNS), Cycle 16.

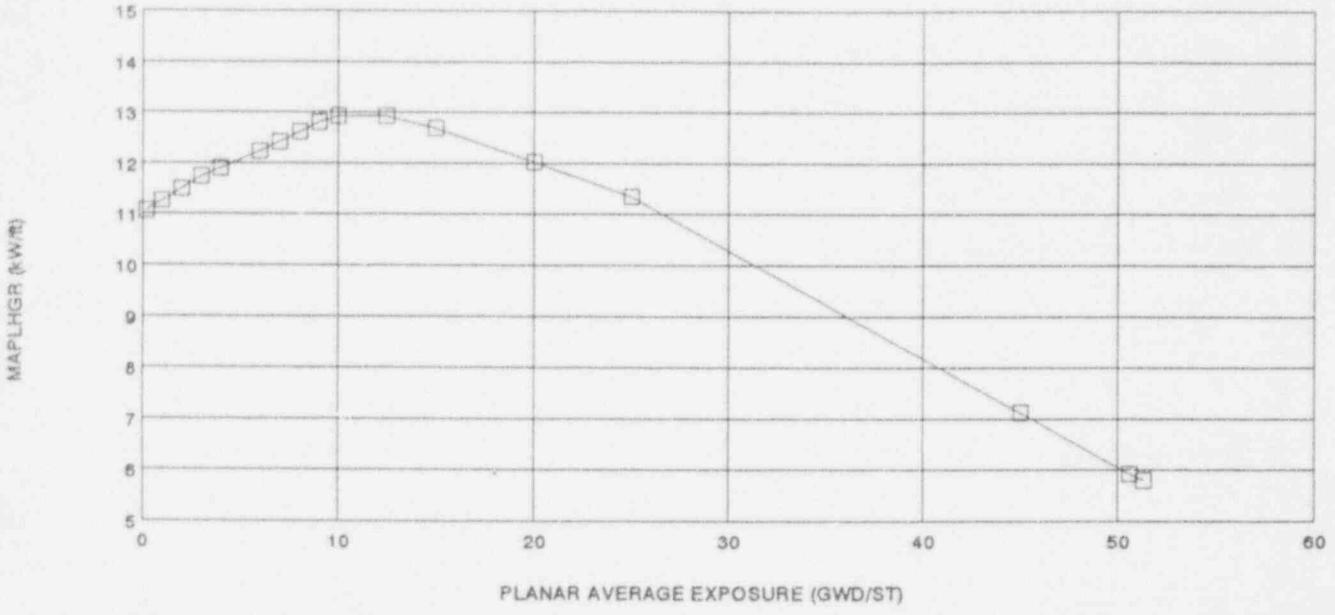
Table 1

LHGR Limits for Cycle 16

| Fuel Type | LHGR Limit (kW/Ft) |
|---|---|
| BP8DRB283 | 13.4 |
| GE 8x8 NB (3.02%, 3.20%, and 3.48%) | 14.4 |
| GE 11 LUA | 14.4 |

Figure 1

Maximum Average Planar Linear Heat Generation Rate (MAPLHGR) versus Exposure with LPCI Modification and Bypass Holes Plugged, 3.02% GE8X8NB Fuel



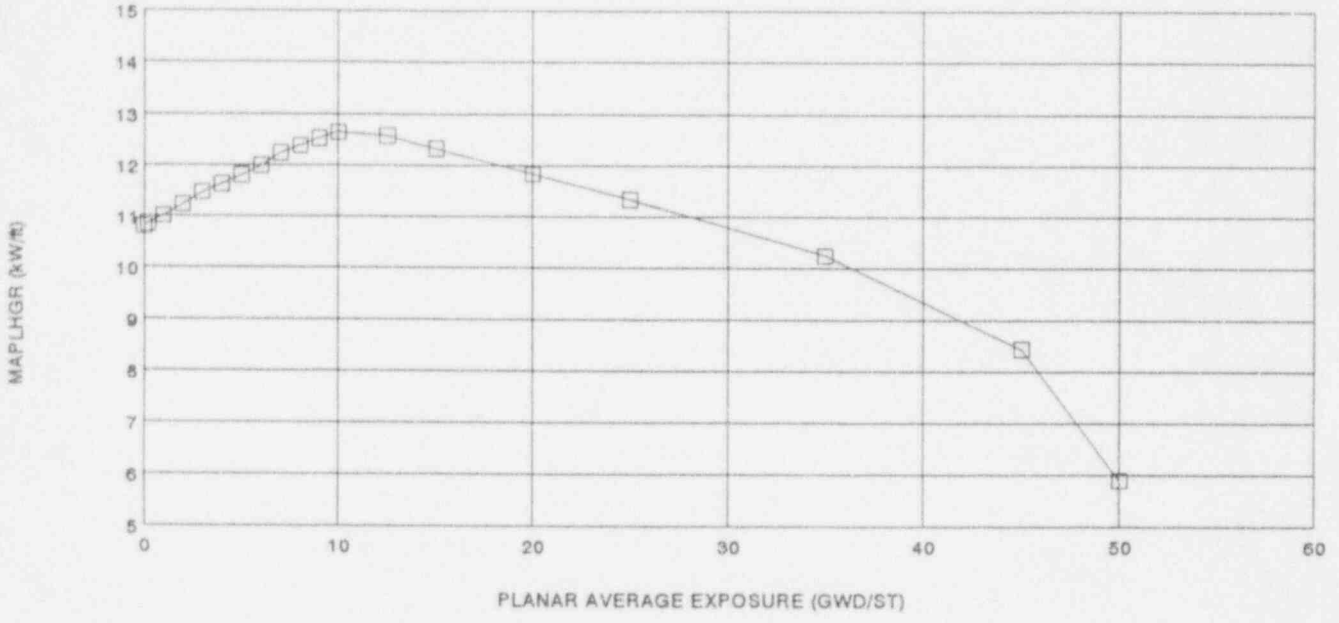

DATA COORDINATES

| GWD/ST | kW/ft |
|---|---|
| 0.2 | 11.07 |
| 1.0 | 11.26 |
| 2.0 | 11.49 |
| 3.0 | 11.73 |
| 4.0 | 11.90 |
| 6.0 | 12.23 |
| 7.0 | 12.41 |
| 8.0 | 12.61 |
| 9.0 | 12.80 |
| 10.0 | 12.93 |
| 12.5 | 12.93 |
| 15.0 | 12.69 |
| 20.0 | 12.02 |
| 25.0 | 11.35 |
| 45.0 | 7.12 |
| 50.6 | 5.92 |
| 51.3 | 5.80 |

Note: When in single loop operation, a MAPLHGR factor of 0.75 is substituted for the LOCA analysis factors of 1.0 and 0.86 contained in the flow dependent MAPLHGR factor curves in Figure 7.

Figure 2

Maximum Average Planar Linear Heat Generation Rate (MAPLHGR) versus Exposure with LPCI Modification and Bypass Holes Plugged, 3.20% GE8X8NB Fuel



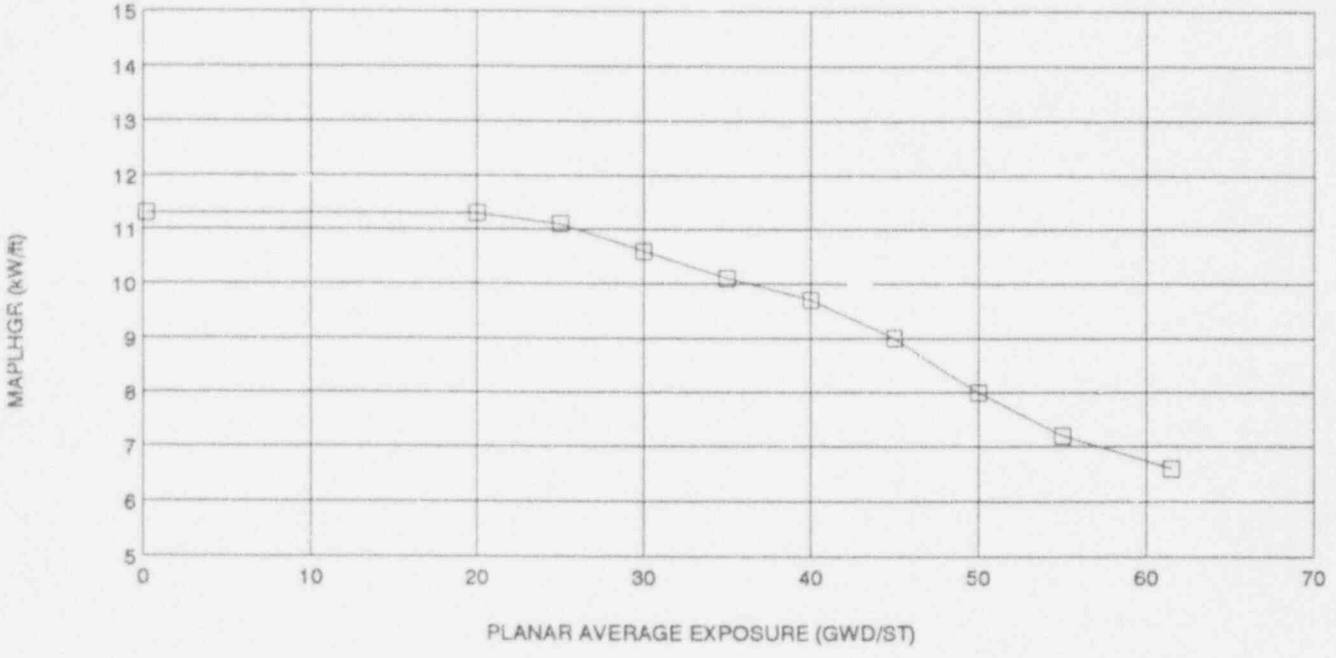

DATA COORDINATES

| GWD/ST | kW/ft |
|---|---|
| 0.0 | 10.80 |
| 0.2 | 10.85 |
| 1.0 | 11.01 |
| 2.0 | 11.23 |
| 3.0 | 11.47 |
| 4.0 | 11.63 |
| 5.0 | 11.80 |
| 6.0 | 11.99 |
| 7.0 | 12.23 |
| 8.0 | 12.38 |
| 9.0 | 12.52 |
| 10.0 | 12.64 |
| 12.5 | 12.57 |
| 15.0 | 12.32 |
| 20.0 | 11.83 |
| 25.0 | 11.34 |
| 35.0 | 10.25 |
| 45.0 | 8.44 |
| 50.0 | 5.90 |

Note: When in single loop operation, a MAPLHGR factor of 0.75 is substituted for the LOCA analysis factors of 1.0 and 0.86 contained in the flow dependent MAPLHGR factor curves in Figure 7.

Figure 3

Maximum Average Planar Linear Heat Generation Rate (MAPLHGR) versus Exposure with LPCI Modification and Bypass Holes Plugged, GE11 LUA Fuel



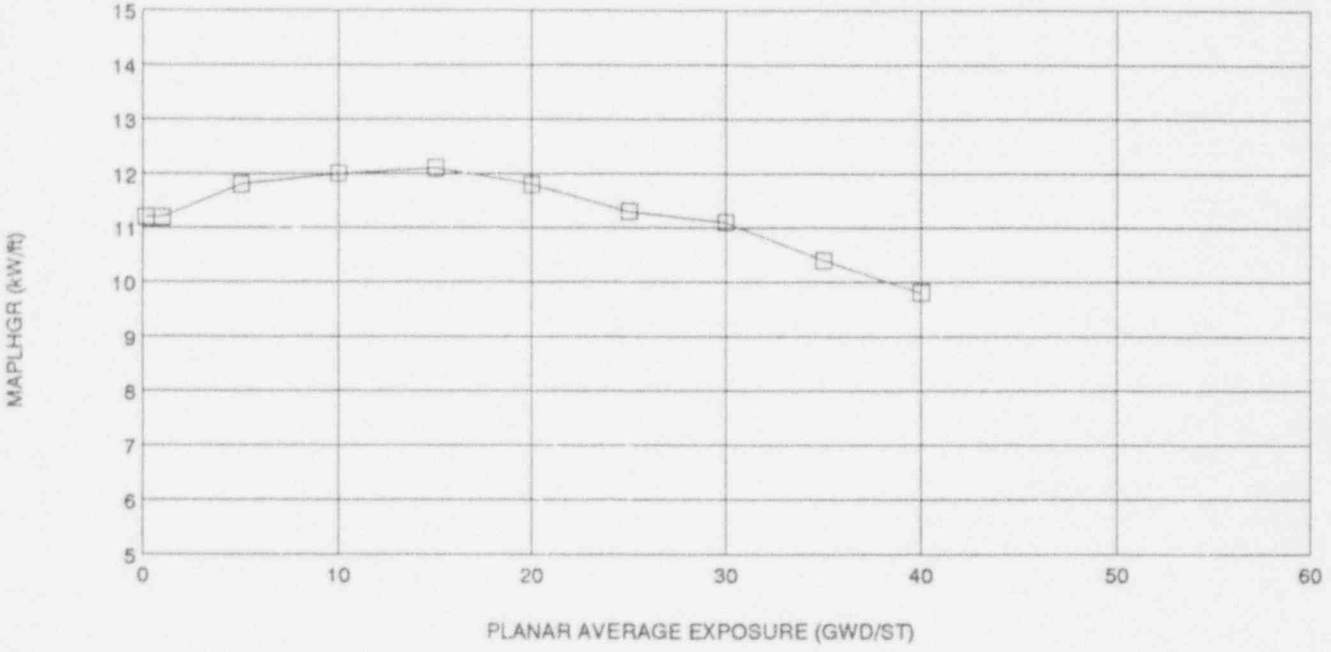

DATA COORDINATES

| GWD/ST | kW/ft |
|---|---|
| 0.2 | 11.3 |
| 20.0 | 11.3 |
| 25.0 | 11.1 |
| 30.0 | 10.6 |
| 35.0 | 10.1 |
| 40.0 | 9.7 |
| 45.0 | 9.0 |
| 50.0 | 8.0 |
| 55.0 | 7.2 |
| 61.5 | 6.6 |

Note: When in single loop operation, a MAPLHGR factor of 0.75 is substituted for the LOCA analysis factors of 1.0 and 0.86 contained in the flow dependent MAPLHGR factor curves in Figure 7.

Figure 4

Maximum Average Planar Linear Heat Generation Rate (MAPLHGR) versus Exposure with LPCI Modification and Bypass Holes Plugged, BP8DRB283 Fuel



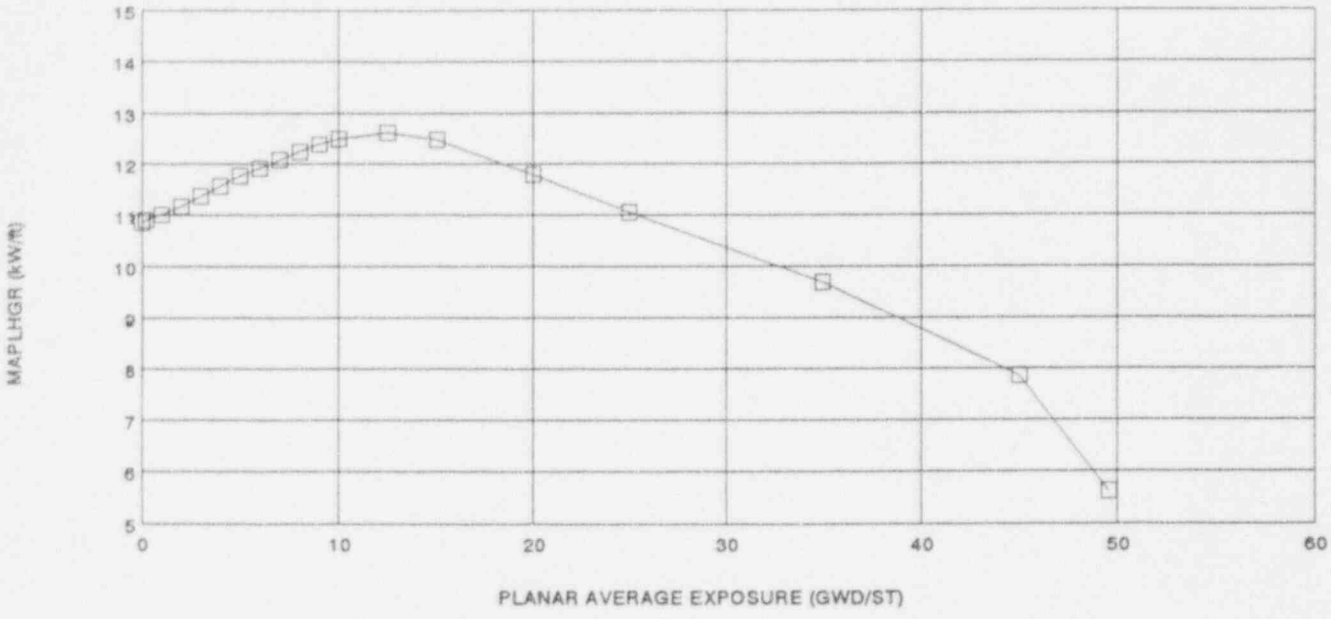

DATA COORDINATES

| GWD/ST | kW/ft |
|---|---|
| 0.2 | 11.2 |
| 1.0 | 11.2 |
| 5.0 | 11.8 |
| 10.0 | 12.0 |
| 15.0 | 12.1 |
| 20.0 | 11.8 |
| 25.0 | 11.3 |
| 30.0 | 11.1 |
| 35.0 | 10.4 |
| 40.0 | 9.8 |

Note: When in single loop operation, a MAPLHGR factor of 0.77 is substituted for the LOCA analysis factors of 1.0 and 0.86 contained in the flow dependent MAPLHGR factor curves in Figure 7.

Figure 5

Maximum Average Planar Linear Heat Generation Rate (MAPLHGR) versus Exposure with LPCI Modification and Bypass Holes Plugged, 3.48% w/11GZ GE8X8NB Fuel



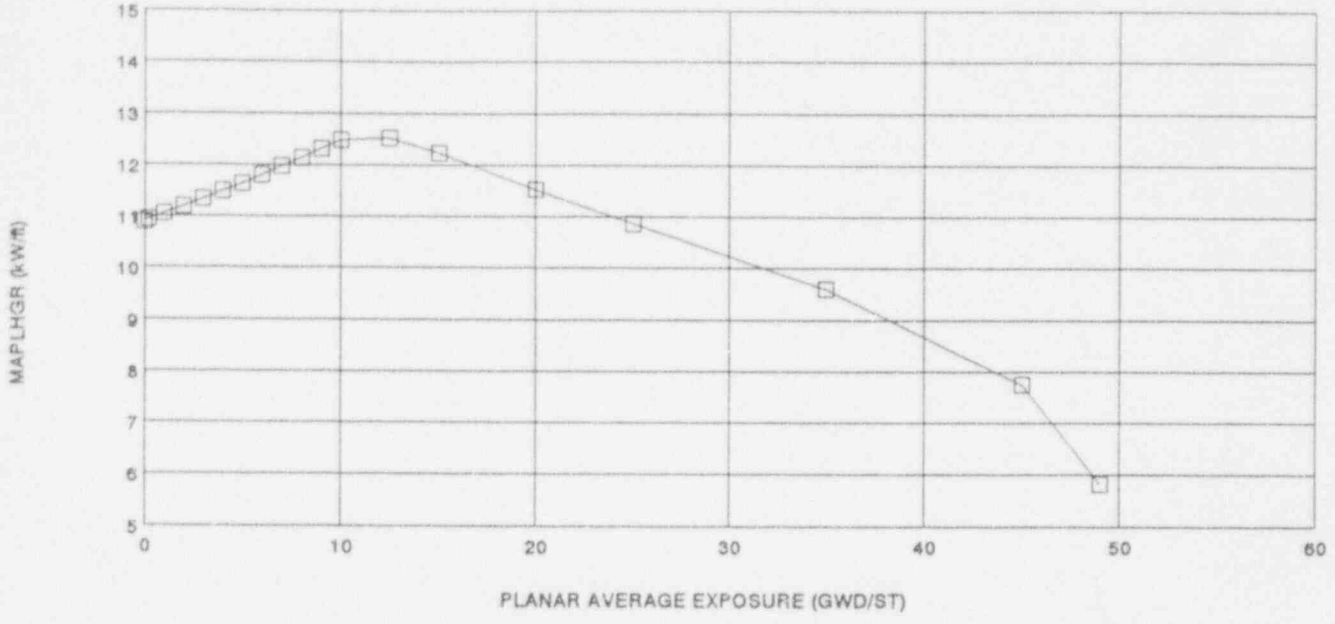

DATA COORDINATES

| CWD/ST | kW/ft |
|---|---|
| 0.0 | 10.85 |
| 0.2 | 10.90 |
| 1.0 | 11.01 |
| 2.0 | 11.17 |
| 3.0 | 11.36 |
| 4.0 | 11.56 |
| 5.0 | 11.76 |
| 6.0 | 11.91 |
| 7.0 | 12.07 |
| 8.0 | 12.23 |
| 9.0 | 12.38 |
| 10.0 | 12.48 |
| 12.5 | 12.61 |
| 15.0 | 12.47 |
| 20.0 | 11.79 |
| 25.0 | 11.05 |
| 35.0 | 9.69 |
| 45.0 | 7.86 |
| 49.6 | 5.62 |

ote: When in single loop operation, a MAPLHGR factor of 0.75 is substituted for the LOCA analysis factors of 1.0 and 0.86 contained in the flow dependent MAPLHGR factor curves in Figure 7.

Figure 6

Maximum Average Planar Linear Heat Generation Rate (MAPLHGR) versus Exposure with LPCI Modification and Bypass Holes Plugged, 3.48% w/12GZ GE8X8NB Fuel



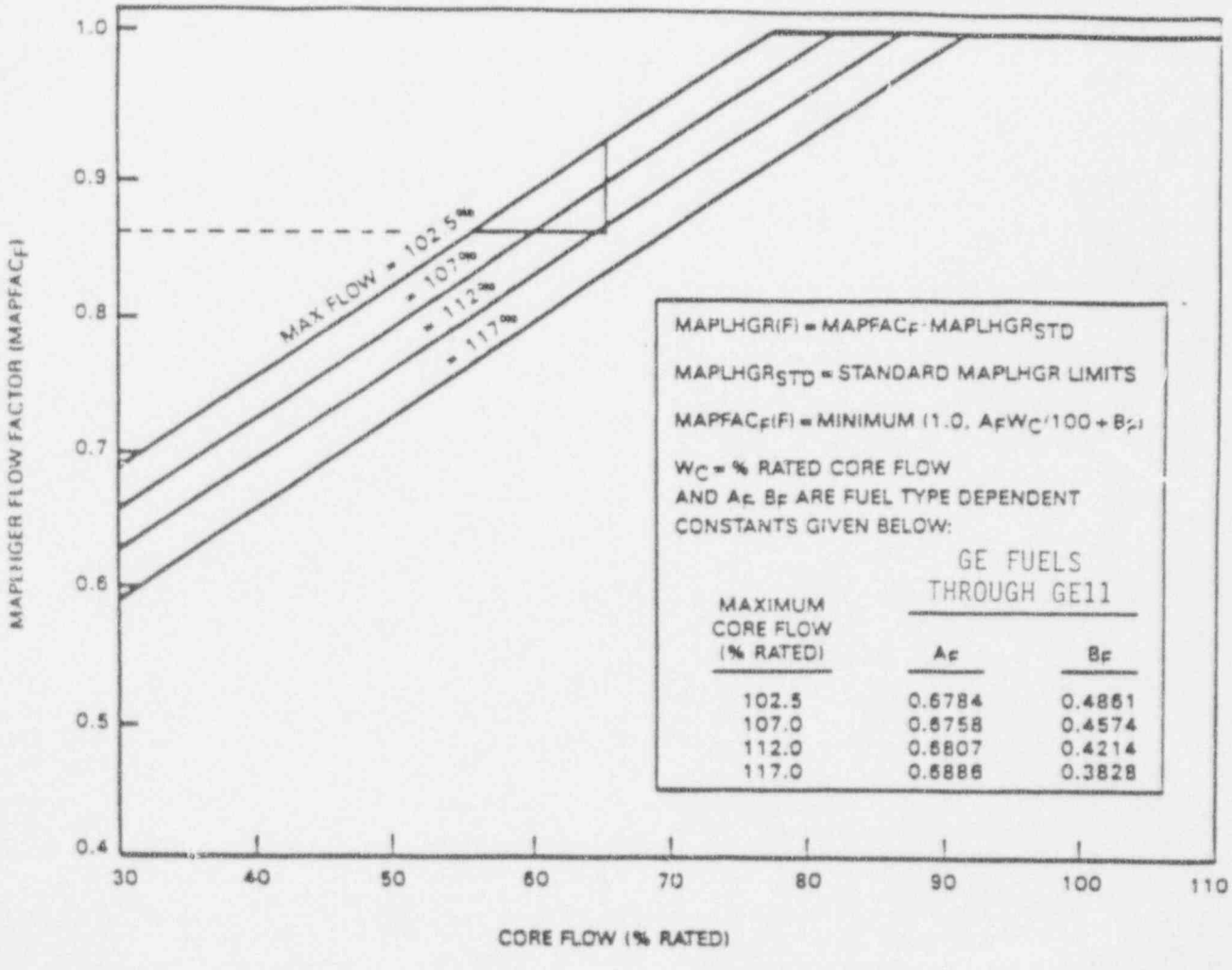

DATA COORDINATES

| GWD/ST | kW/ft |
|---|---|
| 0.0 | 10.89 |
| 0.2 | 10.94 |
| 1.0 | 11.05 |
| 2.0 | 11.19 |
| 3.0 | 11.34 |
| 4.0 | 11.49 |
| 5.0 | 11.64 |
| 6.0 | 11.80 |
| 7.0 | 11.97 |
| 8.0 | 12.14 |
| 9.0 | 12.31 |
| 10.0 | 12.49 |
| 12.5 | 12.52 |
| 15.0 | 12.23 |
| 20.0 | 11.53 |
| 25.0 | 10.86 |
| 35.0 | 9.60 |
| 45.0 | 7.75 |
| 49.0 | 5.83 |

Note: When in single loop operation, a MAPLHGR factor of 0.75 is substituted for the LOCA analysis factors of 1.0 and 0.86 contained in the flow dependent MAPLHGR factor curves in Figure 7.

Figure 7

Flow Dependent MAPLHGR Factor
($MAPFAC_F$)




| MAXIMUM CORE FLOW (% RATED) | GE FUELS THROUGH GE11 | |
|---|---|---|
| | $A_F$ | $B_F$ |
| 102.5 | 0.6784 | 0.4861 |
| 107.0 | 0.6758 | 0.4574 |
| 112.0 | 0.6807 | 0.4214 |
| 117.0 | 0.6886 | 0.3828 |

Figure 8

Power Dependent MAPLHGR Factor
($MAPFAC_p$)

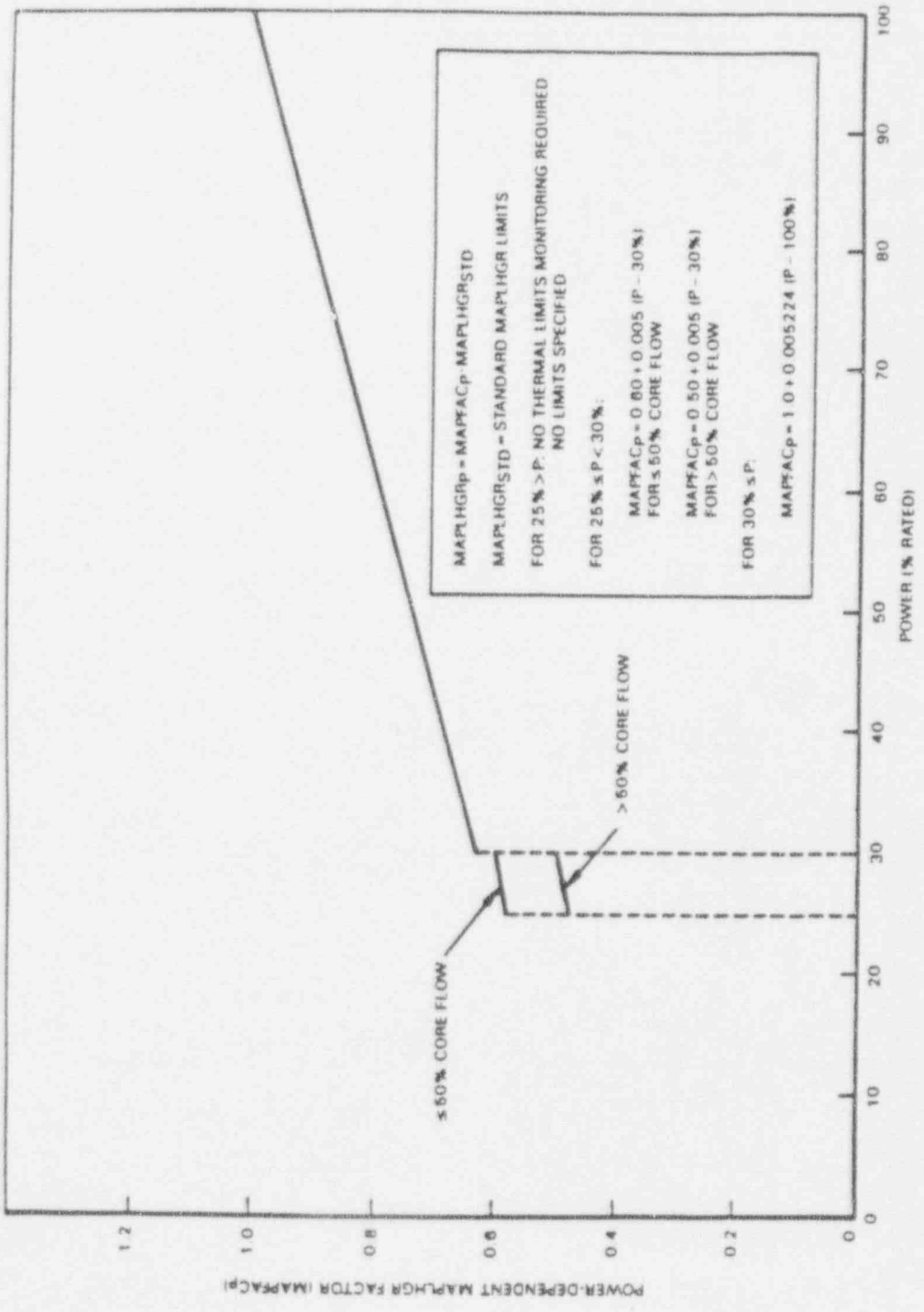





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Figure 9

Power Dependent MCPR Limits
($MCPR_p$ and $K_p$)

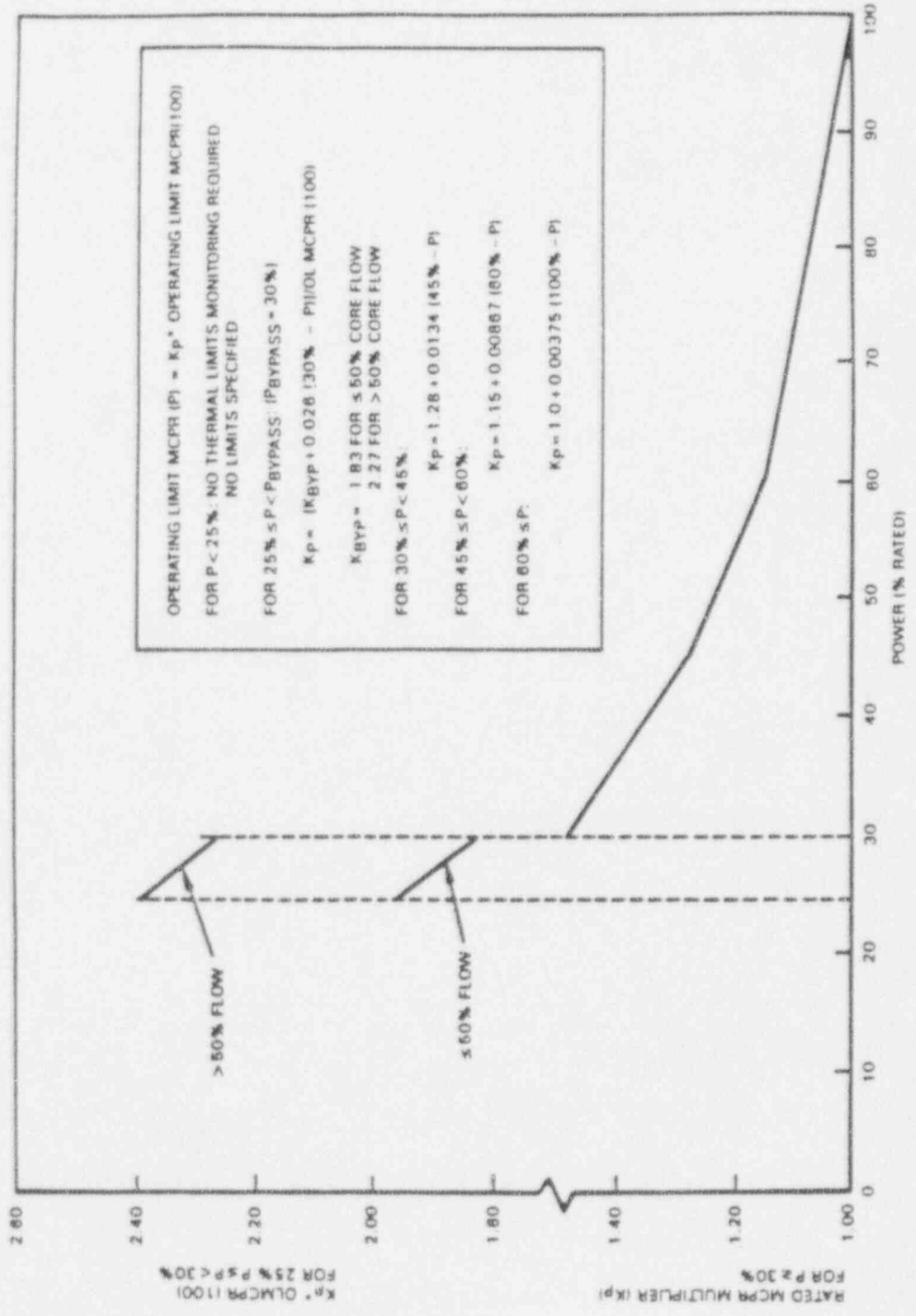


Figure 10

Flow Dependent MCPR Limits
($MCPR_f$)

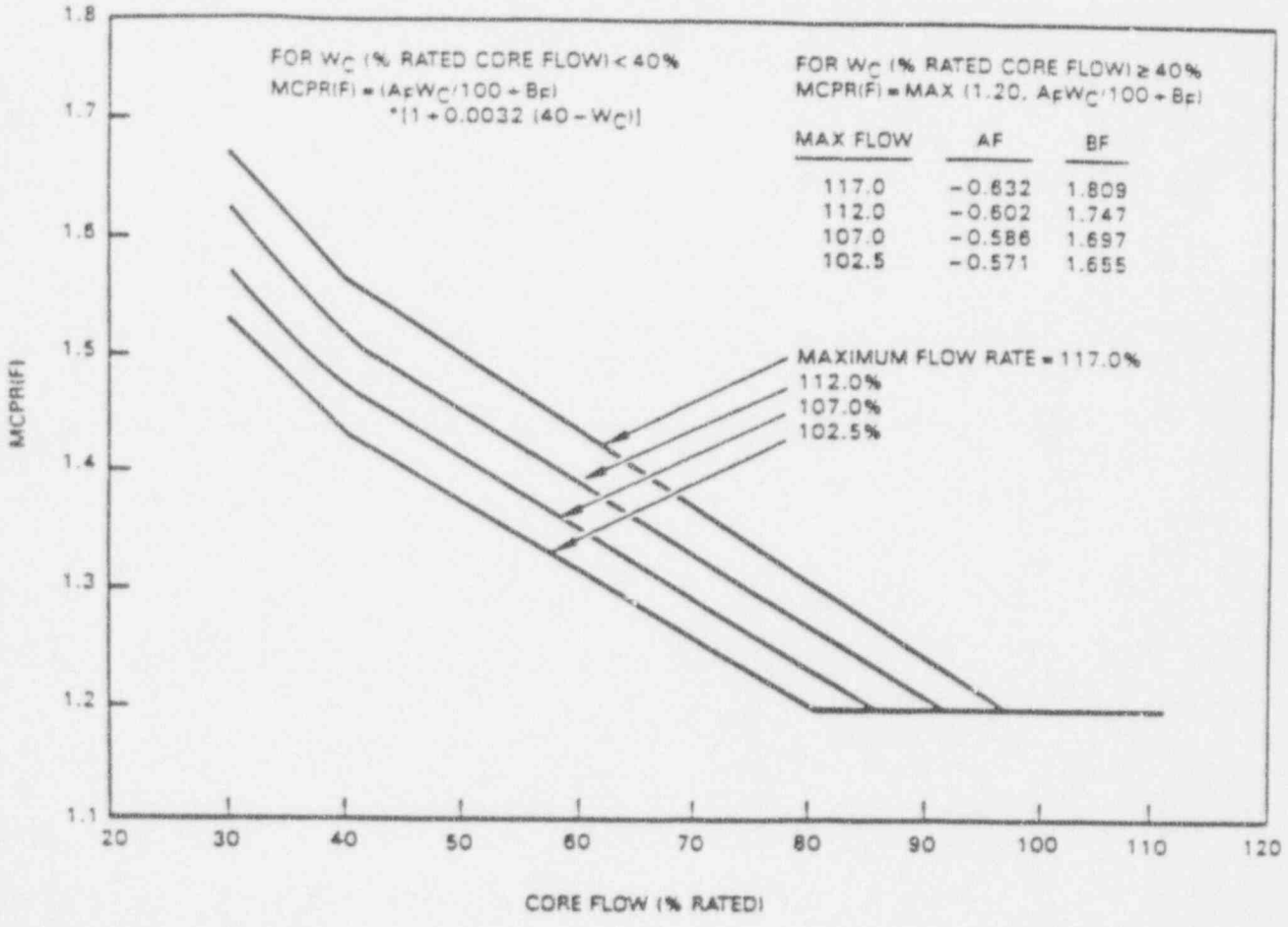
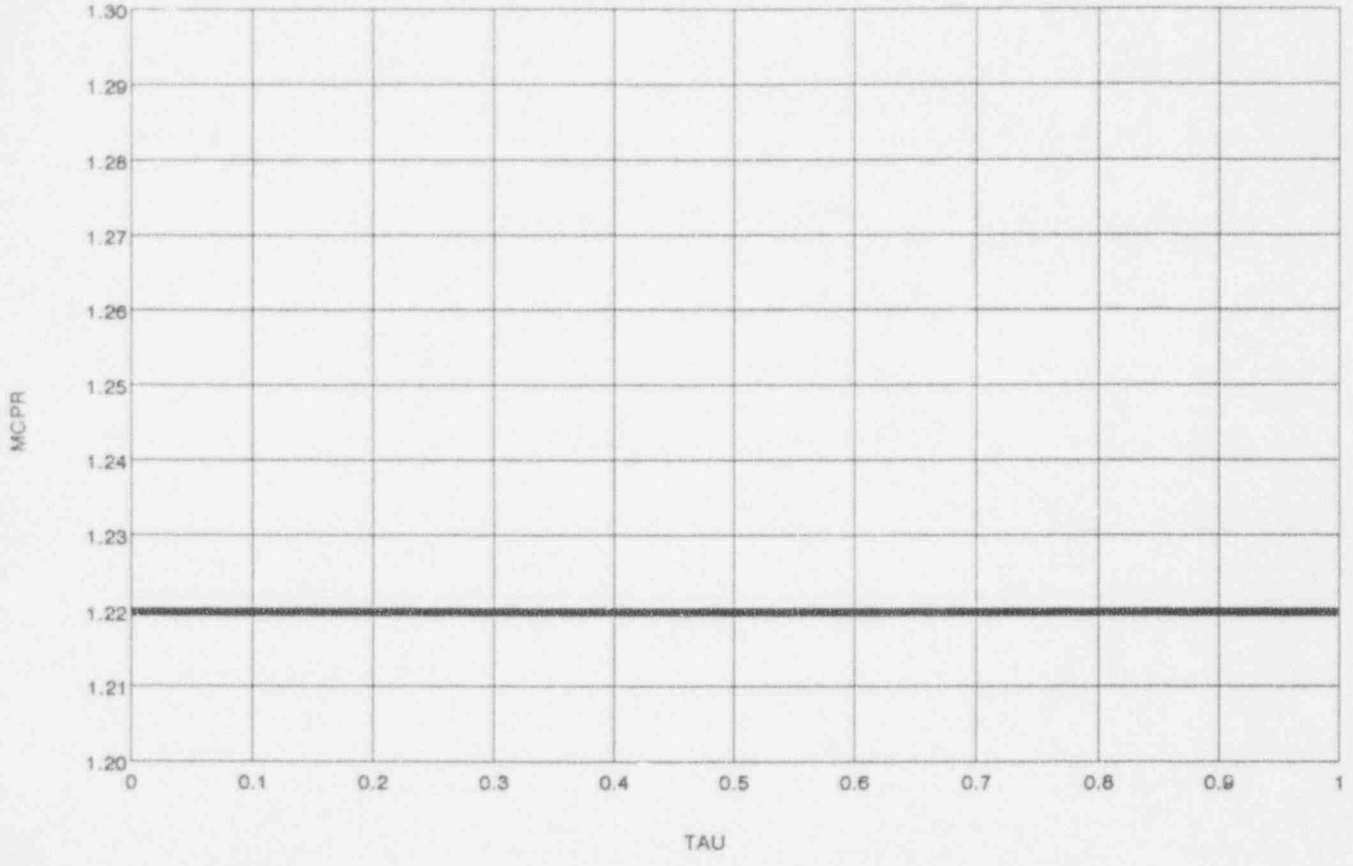


Figure 11

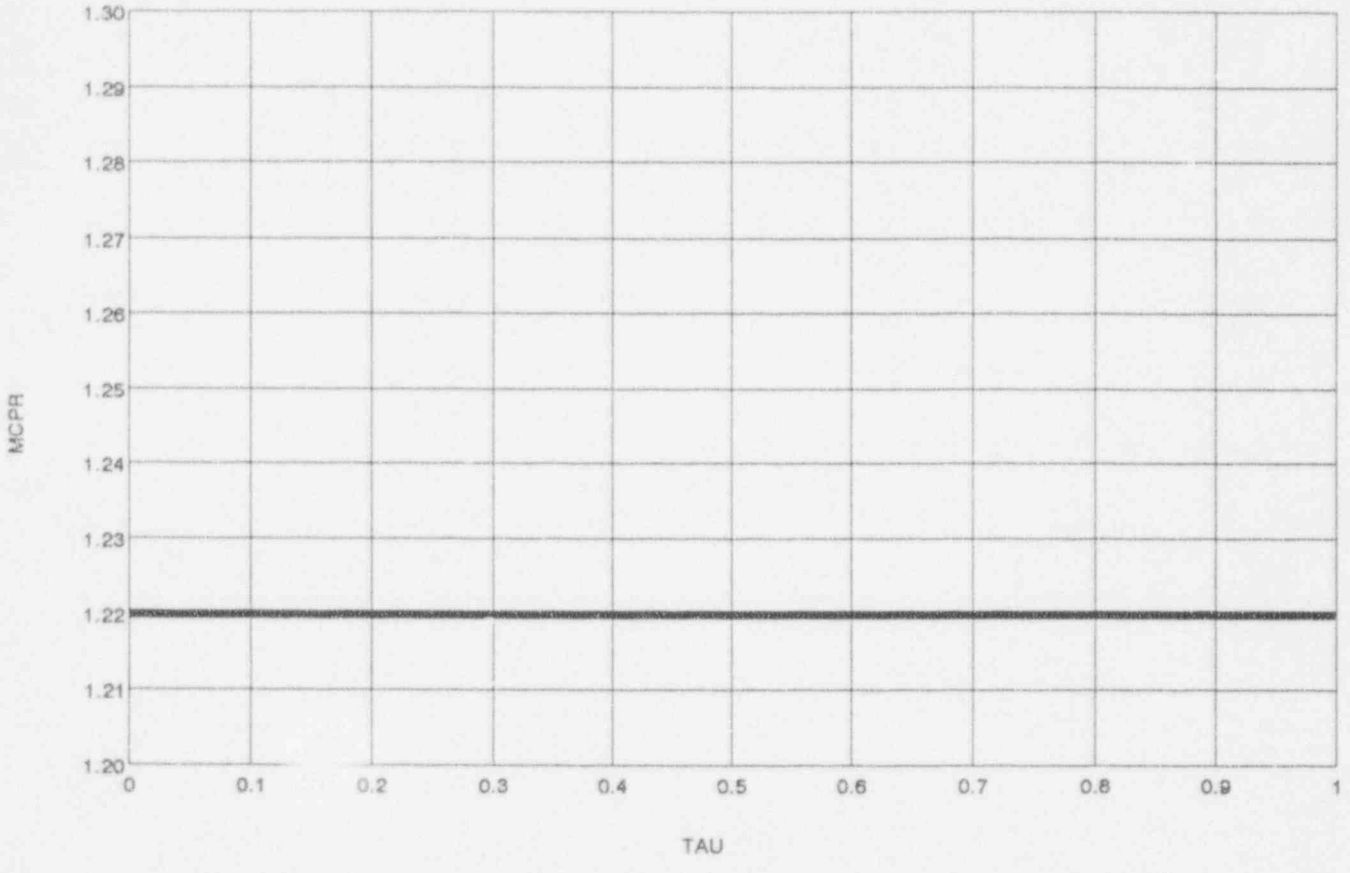
Minimum Critical Power Ratio (MCPR) versus Tau (based on tested measured scram time as defined in Reference 5), GE8X8NB Fuel




Exposure Range: BOC16 to EHFP16 - 2205 MWd/MT

Figure 12

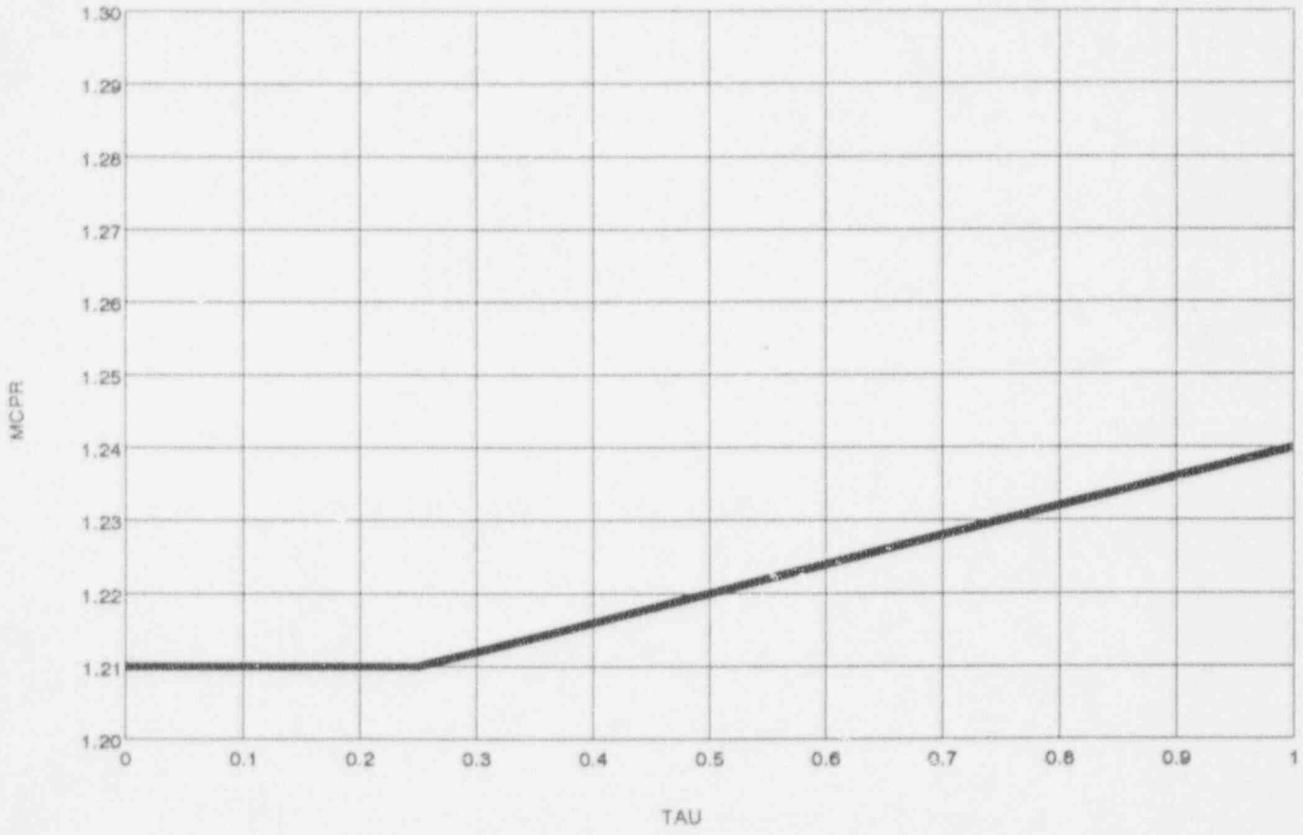
Minimum Critical Power Ratio (MCPR) versus Tau (based on tested measured scram time as defined in Reference 5), GE8X8NB Fuel




Exposure Range: EHFP - 2205 MWd/MT to EOC16

Figure 13

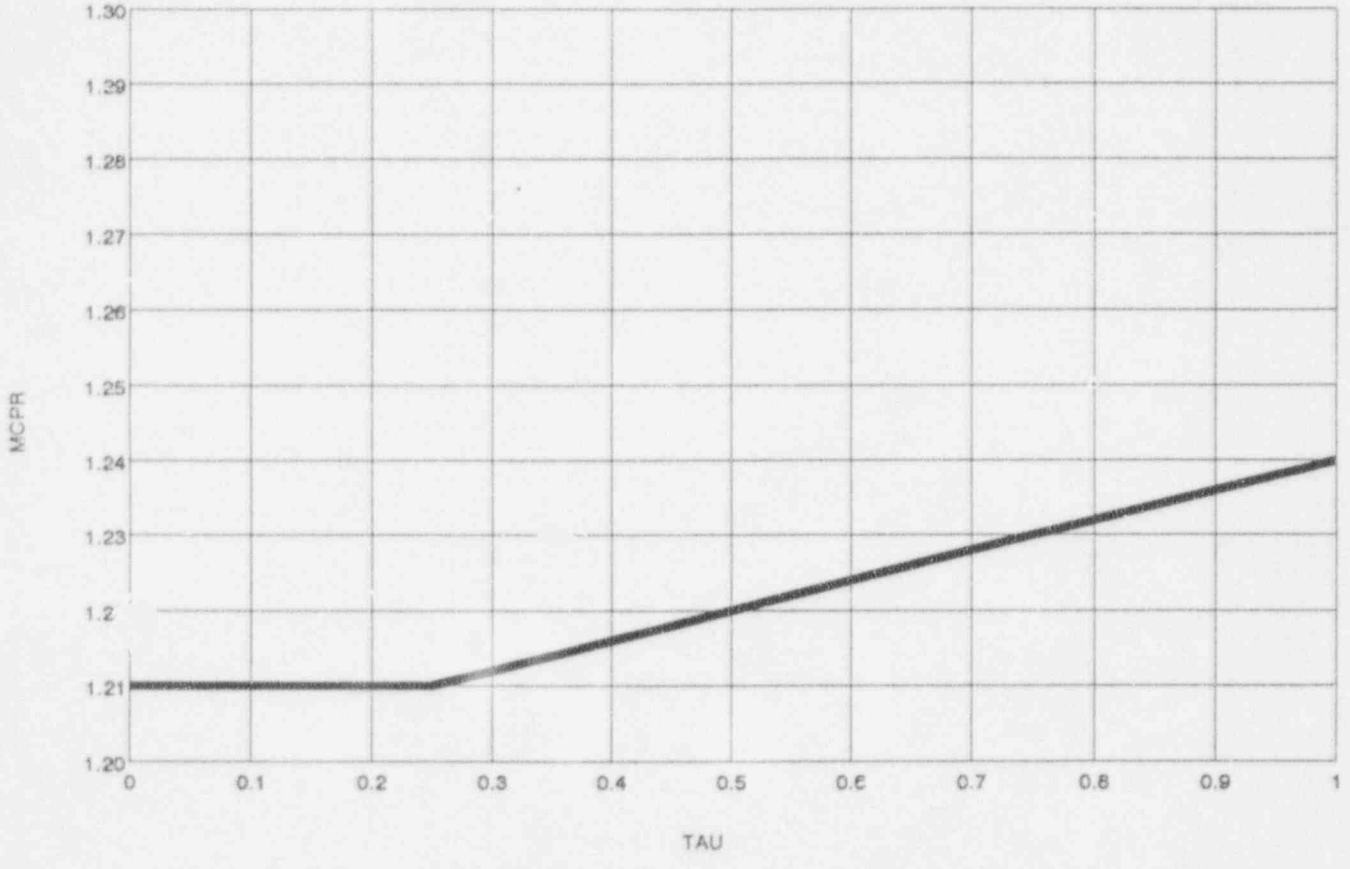
Minimum Critical Power Ratio (MCPR) versus Tau (based on tested measured scram time as defined in Reference 5), GE11 LUA Fuel




Exposure Range: BOC16 to EHFP16 - 2205 MWd/MT

Figure 14

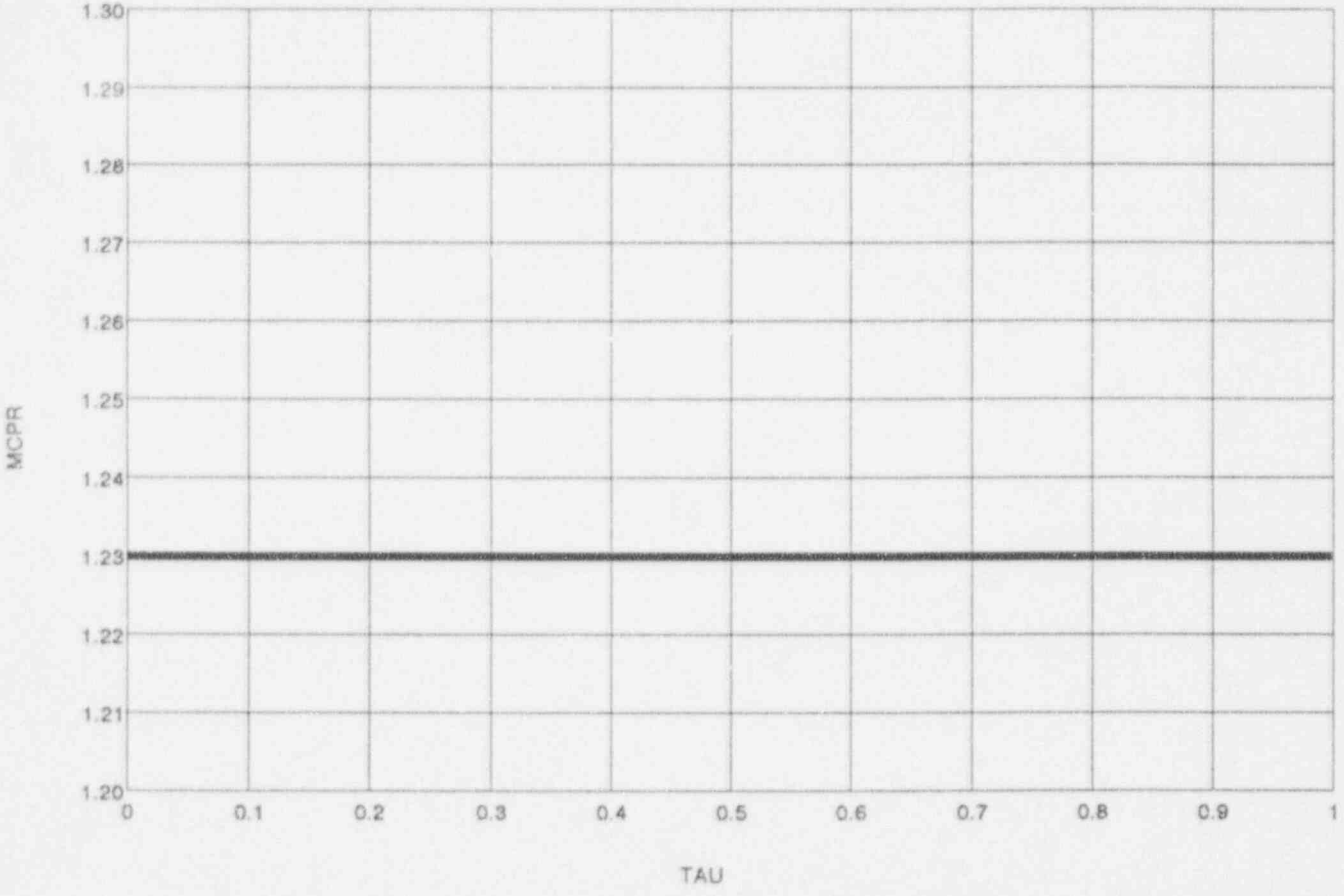
Minimum Critical Power Ratio (MCPR) versus Tau (based on tested measured scram time as defined in Reference 5), GE11 LUA Fuel




Exposure Range: EHFP16 - 2205 MWd/MT to EOC16

Figure 15

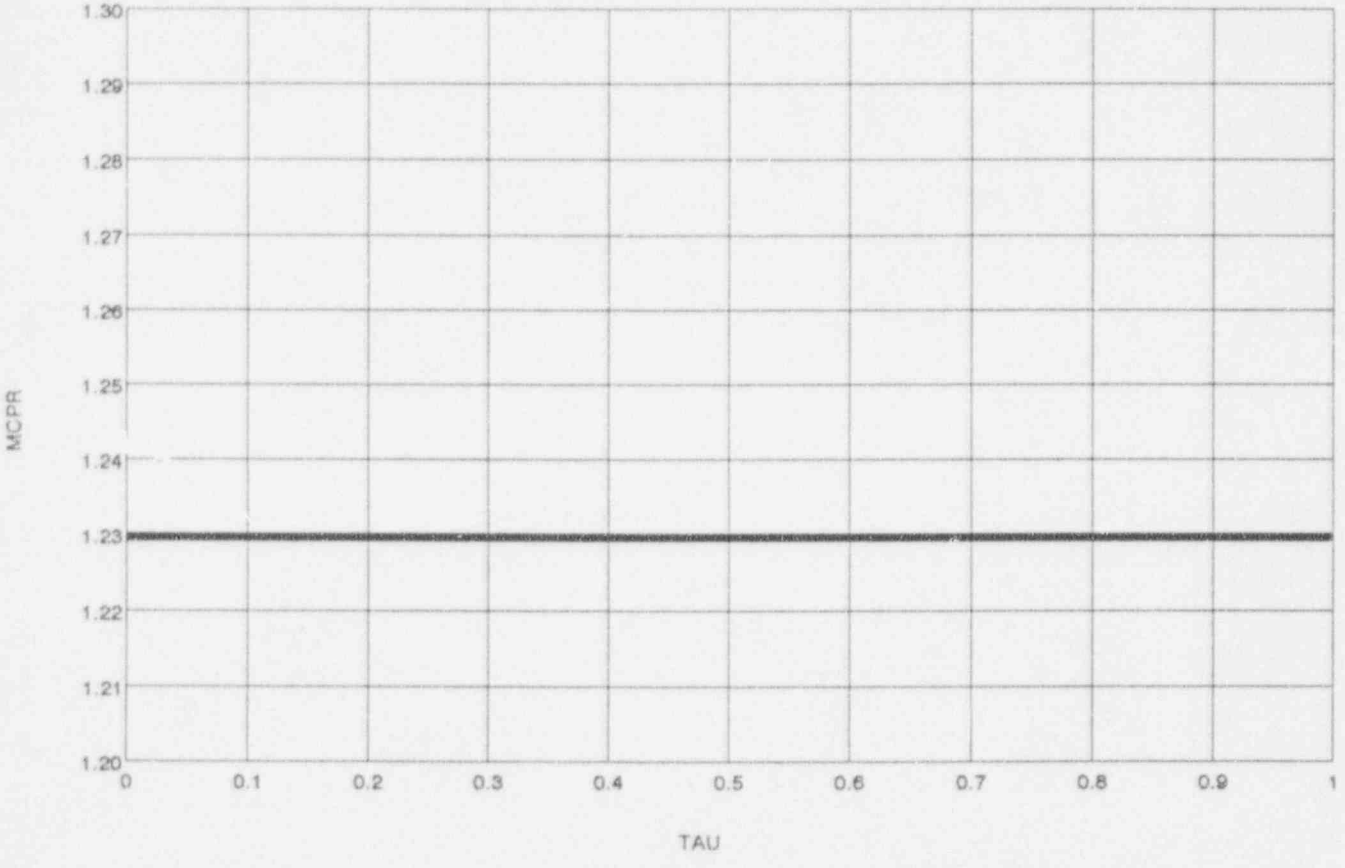
Minimum Critical Power Ratio (MCPR) versus Tau (based on tested measured scram time as defined in Reference 5), BP8DRB283 Fuel




Exposure Range: BOC16 to EHFP16 - 2205 MWd/MT

Figure 16

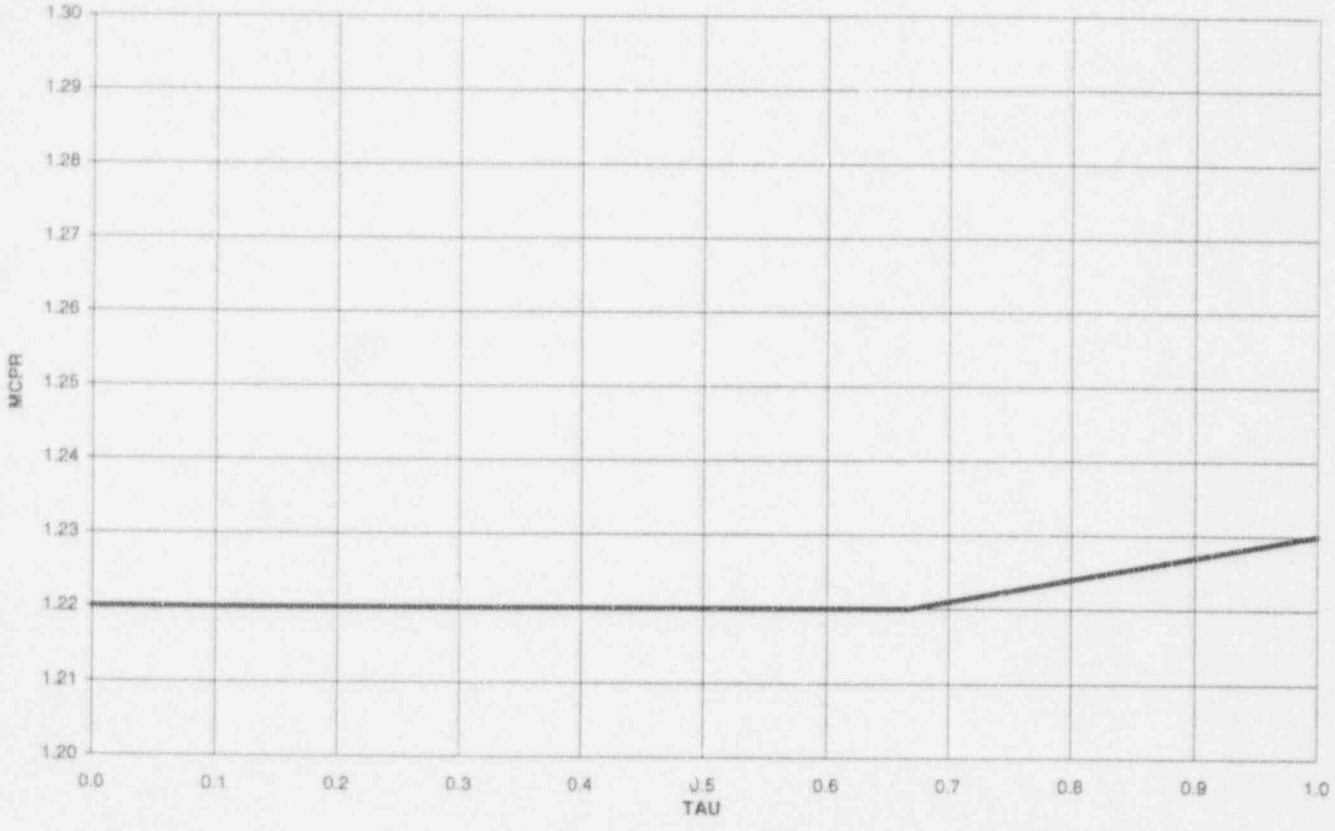
Minimum Critical Power Ratio (MCPR) versus Tau (based on tested measured scram time as defined in Reference 5), BP8DRB283 Fuel




Exposure Range: EHFP16 - 2205 MWd/MT to EOC

Figure 17

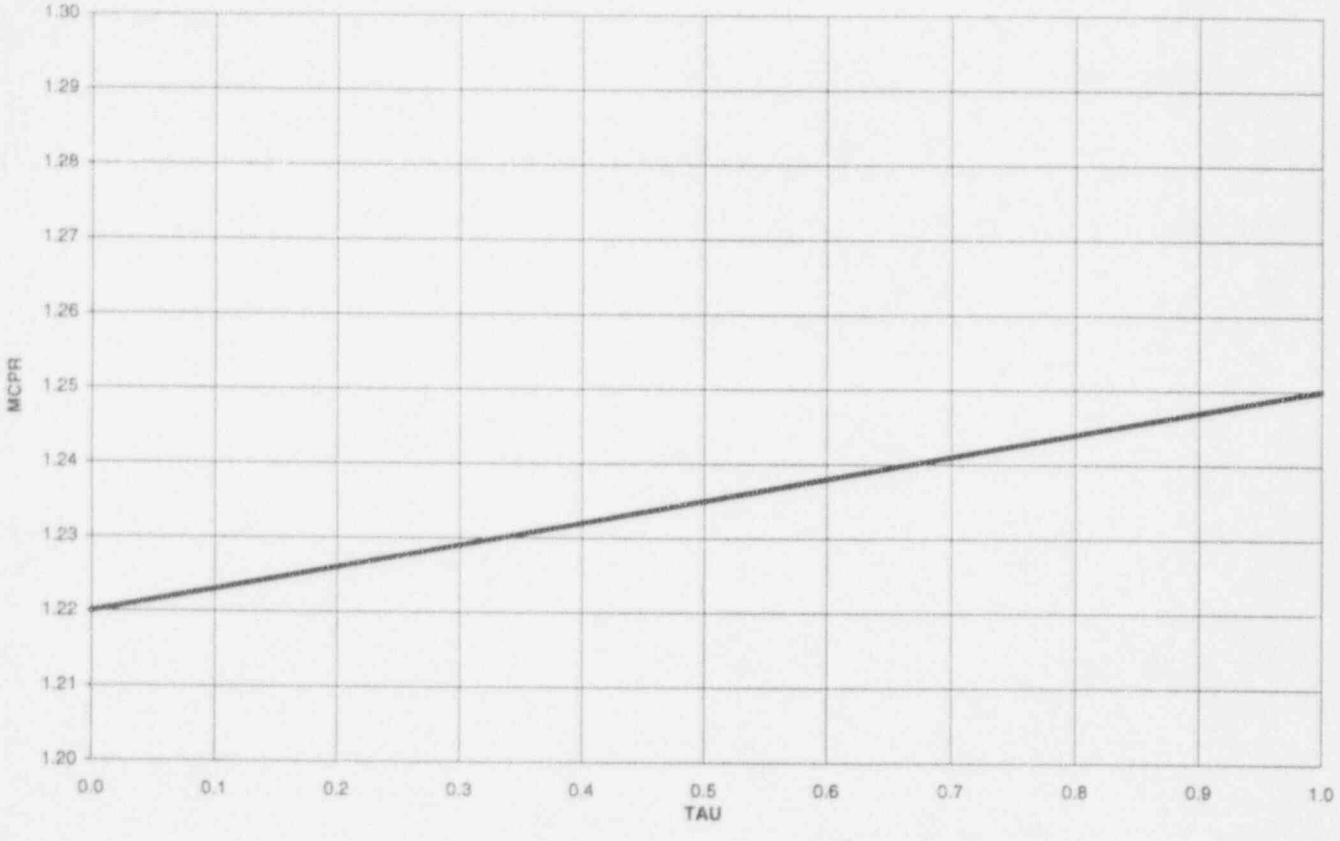
Minimum Critical Power Ratio (MCPR) versus Tau with one Turbine Bypass Valve Unavailable, (based on tested measured scram time as defined in Reference 5), GE8X8NB Fuel




Exposure Range: BOC16 to EOC16

Figure 18

Minimum Critical Power Ratio (MCPR) versus Tau with one Turbine Bypass Valve Unavailable, (based on tested measured scram time as defined in Reference 5), GE11 LUA Fuel




Exposure Range: BOC16 to EOC16