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Mr. J. F. O'Leary, Director
Directorate of Licensing
Office of Regulation
U.S. Atomic Energy Commission
Washington, D.C. 20545

Subject: Dresden Station Unit 3 - Supplement C to Second Reload License Submittal and Proposed Change to Facility Operating License DPR-25, AEC Dkt 50-249

Dear Mr. O'Leary:

The attached Supplement C to Second Reload License Submittal contains a detailed analysis of potential densification in the 8 x 8 fuel proposed for use in Dresden Unit 3. This is a further supplement to Reload 2 submittals dated September 14, 1973, and November 27, 1973.

Pursuant to Section 50.59 of 10 CFR 50 and Paragraph 3.B of the Facility Operating License DPR-25, Commonwealth Edison submits a proposed change to Appendix A of DPR-25. The purpose of the proposed change is to incorporate 8 x 8 fuel densification limits in the Technical Specifications. The bases for this change are the analyses in "Supplement C to Second Reload License Submittal." The proposed change is indicated on the attached revised Pages 81B, 81C, 85A, 85B and 85C.

Three signed original and 37 copies of the proposed change and Supplement C are provided for your use.

Very truly yours,

J. S. Abel
Nuclear Licensing Administrator
Boiling Water Reactors

SUBSCRIBED and SWORN to
before me this 6th day
of December, 1973.

Brenda Pannor
Notary Public

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DRESDEN UNIT 3

Supplement C to Second Reload License Submittal

ANALYSIS OF FUEL DENSIFICATION EFFECTS

This section presents results of the effects of densification in the 8 x 8 reload fuel as determined from application of the AEC Staff model for densification effects in BWR fuel. These analyses employ the same methods and basic assumptions that were used in analyses of GE BWR's having 7 x 7 fuel lattice designs as reported in Reference 1.

Power Spiking Analysis 8 x 8 Fuel Lattice

An analysis of potential local power spikes due to axial gaps in a fuel pellet column for GE BWR's employing an 8 x 8 fuel lattice design has been performed. This analysis employs the same method and basic assumptions that were used in the power spike analyses of GE BWR's having 7 x 7 fuel lattice designs as reported in Reference 1. The only changes to these assumptions as employed in the analysis are:

1. The allowance for irradiation induced cladding growth and axial strain caused by fuel/clad mechanical interaction employed to calculate maximum gap size in this analysis was, therefore,

$$\Delta L = \left[\frac{.965 - p_i}{2} + .0025 \right] Z$$

2. The magnitude of power spike versus gap size was recalculated for fuel rods of the 8 x 8 design, and is shown in Figure 1 for normal operating

conditions, and Figure 2 for cold zero void conditions.

3. The core power histogram employed was for a 13.4 KW/ft maximum design linear heat generation rate; see Figure 3.

Results of Power Spiking Analysis

Normal Operation

The results from this analysis are shown in Figure 4 with initial fuel density as a parameter. The line shown for an initial fuel density of 95% T.D. is considered to be most representative considering current GE data on manufactured fuel pellet densities. The power spike penalty shown on Figure 4 for several mean pellet densities as a function of axial position, is the required margin which must be maintained during normal operation between the actual peak operating condition and the peak design LHGR: i.e., 13.4 KW/ft. Maintaining this margin will assure, with better than 95% confidence, that no more than one rod will exceed the design peak LHGR due to the random occurrence of power spikes resulting from axial fuel column gaps. Consistent with GE's position on densification, previously discussed in NEDM 10735 and its supplements, the results of this analysis are considered to be a very conservative representation of the power peaking penalty required to accommodate potential axial fuel column gaps during normal operating conditions in GE BWR's.

Accident Effects

Since the results of the power spiking analysis for normal operation will be utilized to limit bundle power to assure that the random occurrence of power spikes will not result in exceeding the design peak LHGR, it is not believed necessary to separately consider power spikes in the analysis of transients or accidents which hava as an initial condition some form of normal operation. The control rod drop accident is unique in the respect that it begins at the cold condition, and is not affected by normal operating power level. Further, the existence of fuel column gaps can result in power spiking in the cold condition during a control rod drop which should thus be considered in the evaluation of this accident. For this purpose, a separate power spiking analysis has been performed using the same assumptions as indicated above, but employing a power spike versus gap size calculated to occur in the cold condition with zero voids (Figure 2). This analysis was performed for a conservative maximum gap size calculated employing a pellet average immersion density of 94.5% T.D (Reference 1), and a position near the top of the core in order to maximize the power spiking effect. This analysis yielded a 99% probability that any given fuel rod would have a power spike of $<5\%$.

Cladding Creep Collapse

Using the same conservative bases presented in Reference 1, the critical pressure ratio, i.e., ratio of collapse pressure to actual coolant pressure, was calculated. Figure 5 presents the clad mid-wall temperature versus time for the 8 x 8 reload fuel. No credit is taken for internal gas pressure due to released fission gas or volatiles. The internal pressure due to helium backfill at 1 atmosphere during fabrication is considered. The fuel characteristics for creep collapse calculations are as follows:

Clad O.D., in.	0.493
Clad Thickness, in.	0.034 ± 0.003
Peak LHGR, KW/ft	13.4
Fast Flux >1 Mev, n/cm^2-sec	4.37×10^{13}

Figure 6 gives the calculated critical pressure ratio. As evidenced by the curve, the calculated critical pressure ratio is always >1.0.

Density Data

The density data for the Dresden 3 8 x 8 reload fuel is summarized in Table 1. This data presents the mean and standard deviation of the distribution of individual pellet immersion densities and the standard deviation of the distribtuion of pellet boat mean.

TABLE 1

DRESDEN 3 8 x 8 RELOAD FUEL DENSITY SUMMARY

Mean Pellet Density, % T.D.	95.21
Standard Deviation of Pellet Densities, % T.D.	.73
Standard Deviation of Boat Densities, % T.D.	.53

Gap Conductance

As noted in Reference 1, the AEC model for densification effects in BWR fuel requires calculation of gap conductance based on applying certain bias to the interpretation of the gap conductance data supplied by General Electric. One element of this required bias is the application of a hypothetical densification penalty to the as-fabricated gap size based on the use of the measured pellet density data for a given fuel type. For the most critical rod position, it is required to assume a 2σ lower bound on initial pellet density. For the pellets at the same axial plane in the neighboring 62 fueled rods, it is required to assume a 2σ lower bound on initial mean pellet boat density. Table 2 provides pellet-clad gap size (g/D) as determined based on this model.

TABLE 2

.CALCULATED g/D for INSTANTANEOUS DENSIFICATION FOR DRESDEN 3 8 x 8 RELOAD FUEL

Fuel Type	8 x 8
MLHGR, KW/ft	13.4
Clad O.D. in.	0.493
Clad I.D., in.	0.425
Fuel O.D., in.	0.416
Cold Gap, mils	9
g/D, 62 rods	0.030
g/D, 63rd rod	0.032
g/D, batch average	0.027

Densification Effects on Loss of Coolant Accident Analysis

The postulated effects of densification, as required by the AEC, are evaluated in this section for the loss-of-coolant accident. Densification effects on other aspects of the safety analysis are documented in Reference 1.

As discussed in the topical report on densification (Ref. 1), there are four possible effects of fuel densification: (1) power spikes due to axial gap formation, (2) increase in LHGR, (3) creep collapse of the cladding and (4) changes in the fuel rod stored energy due to a postulated increase in the fuel peelet to clad radial gap. The most limiting of these effects for a loss-of-coolant accident is the change in the fuel rod stored energy. For this reason only the postulated effects of densification as they relate to changes in the stored energy of the fuel are to be considered in the analyses and are presented in this section.

The models and assumptions used in these analyses are those specified in the Interim Acceptance Criteria with the exception of the value of pellet-to-clad gap conductance. The selection of gap conductance is based on the more severe approach (outer bound) used in Reference 1 and involves the application of the 95-90 lower bound on gap conductance to all rods. The specific value of gap conductance used for each rod was dependent on the steady state operating linear heat generation rate. The assumptions and conditions concerning densification effects used in these analyses are the same as those in Reference 1 with the exception of fuel bundle geometry which is 8 x 8 for these analyses as compared to 7 x 7 for the Reference 1 analyses.

For the range of possible break sizes, the postulated design basis accident is the most severe in terms of accident consequences. Therefore an analysis of this accident bounds the maximum possible effect of lowered gap conductance on the loss-of-coolant accident.

If the peak cladding temperature per the outer-bound model exceeds 2300°F, a reduction in the MAPHLGR would be necessary to meet the IAC limit of 2300°F. The reduction necessary is shown in Figure 7 as a function of average bundle planar exposure for the 8 x 8 Reload 2 fuel. The use of Curve α in Figure 7 with the values of local peaking factors, resulted in the peak rod in the bundle being analyzed at the maximum allowable LHGR.

Curve γ shows the necessary reduction in the MAPLHGR to limit the cladding temperature to 2300°F over the complete range of exposures if the postulated effects of densification are analyzed according to the outer-bound model assumptions. Curve β shows a similar curve with the less severely conservative model assumptions. These assumptions have been discussed in Section 3.2.4 of Reference 1. Therefore the difference between Curve α and γ shows the maximum impact on plant operation due to the postulated effects of fuel densification.

The peak cladding temperatures versus time corresponding to the limitations described by Curve γ in Figure 1 are shown in Figure 8 for the 8 x 8 fuel.

REFERENCES:

1) "Fuel Densification Effects on General Electric Boiling Water Reactor Fuel", NEDM-10735, Supplements 6, 7, and 8 dated August 1973.

FIGURE 1

8x8 POWER SPIKE VERSUS GAP SIZE - NORMAL OPERATION

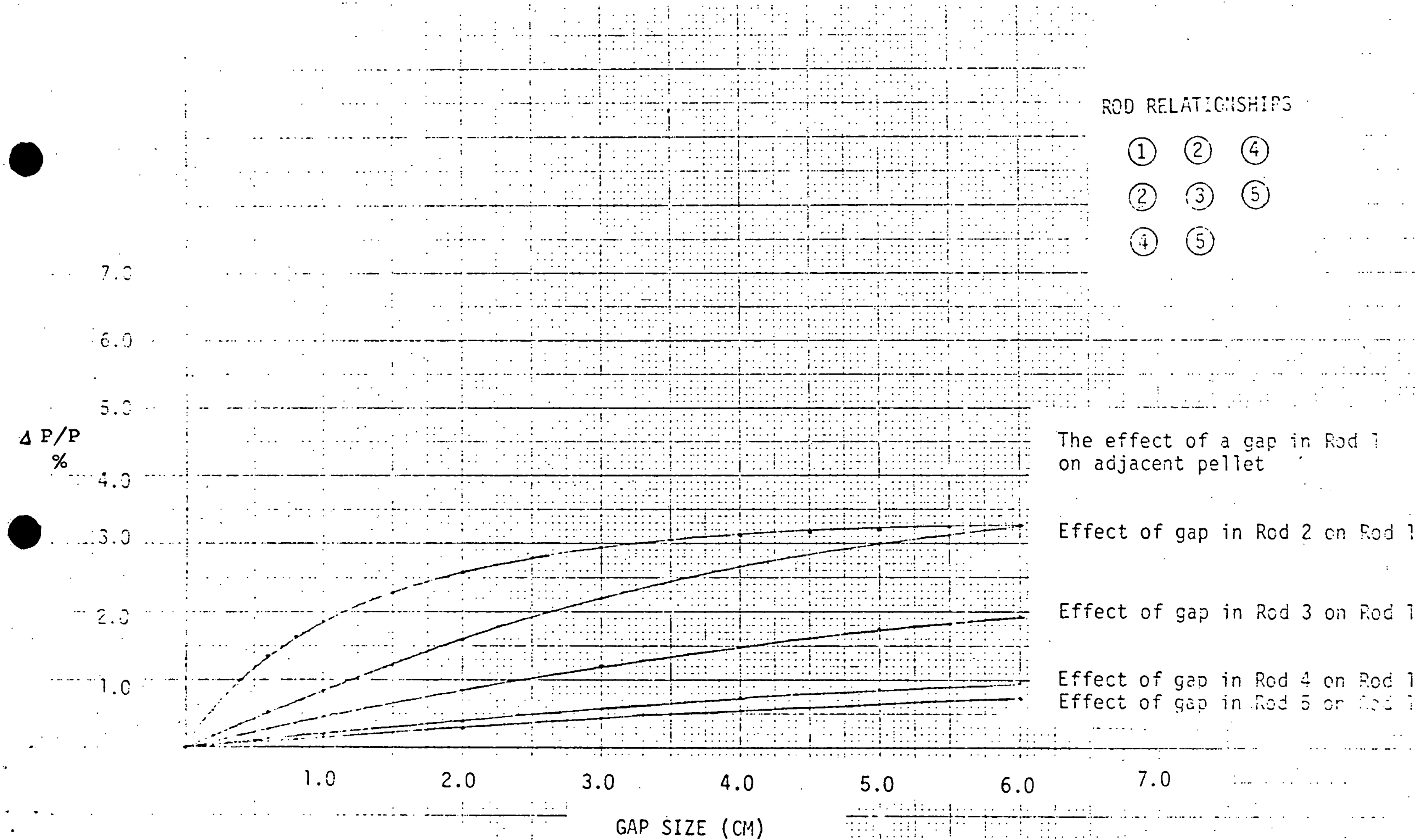


FIGURE 2

8x8 POWER SPIKE VERSUS GAP SIZE - COLD ZERO VOID CONDITION

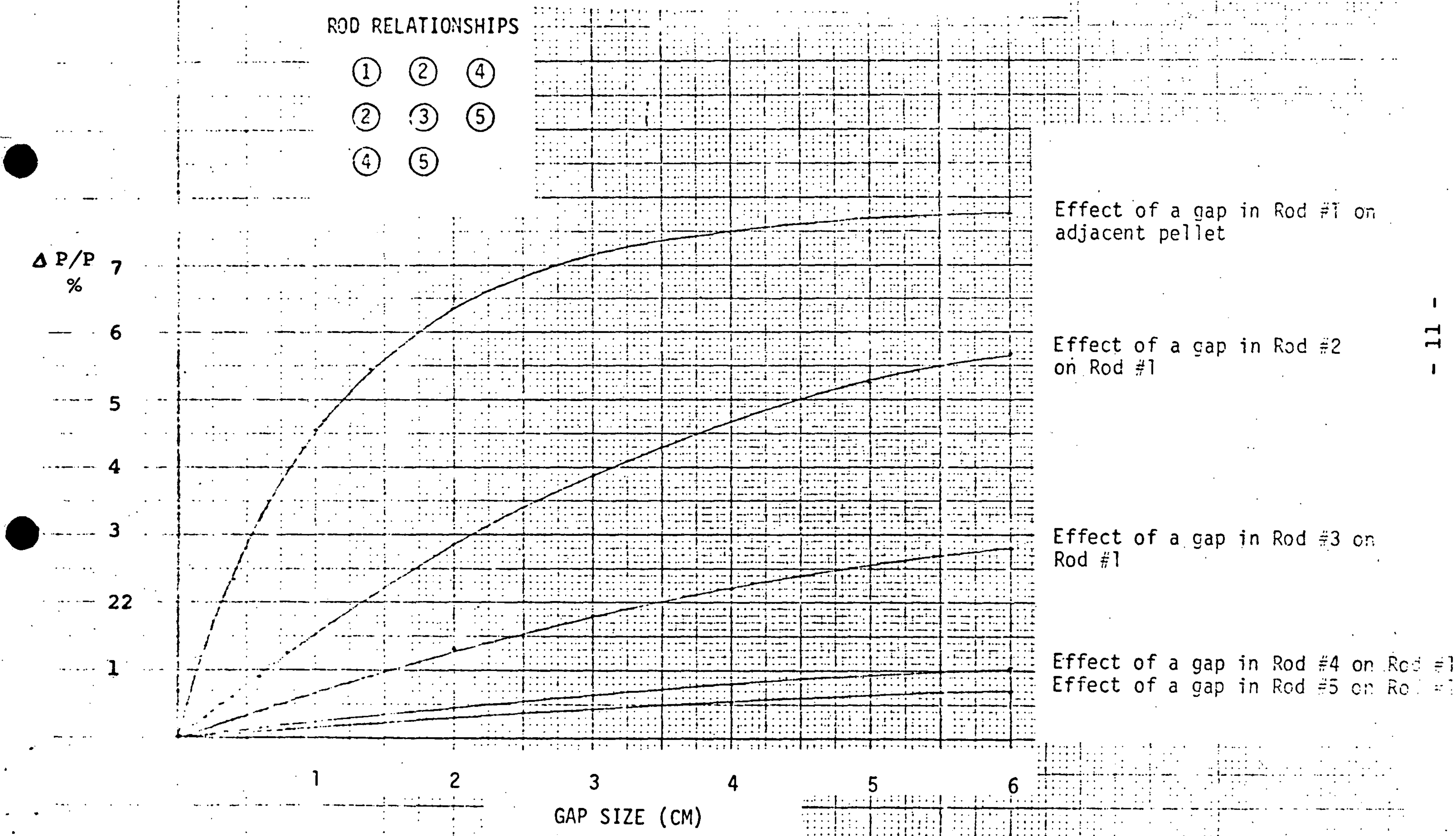


FIGURE 3

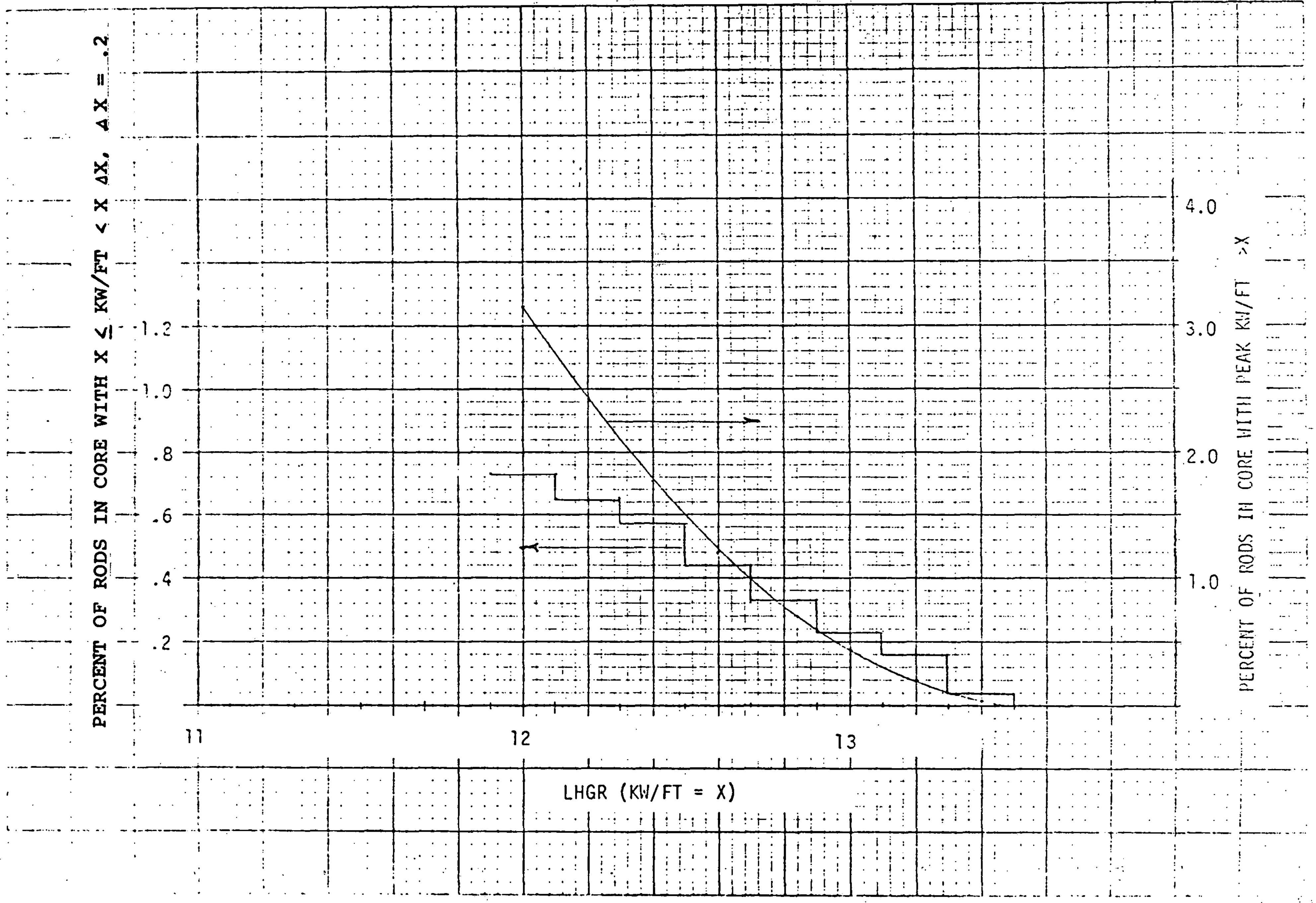

PERCENT OF RODS IN CORE WITH X ≤ KW/FT < X ΔX, ΔX = .2
1.2
1.0
.8
.6
.4
.2
11
12
13
LHGR (KW/FT = X)
4.0
3.0
2.0
1.0
PERCENT OF RODS IN CORE WITH PEAK KW/FT >X

FIGURE 4

8x8 POWER SPIKE PENALTY VS AXIAL POSITION - NORMAL OPERATION

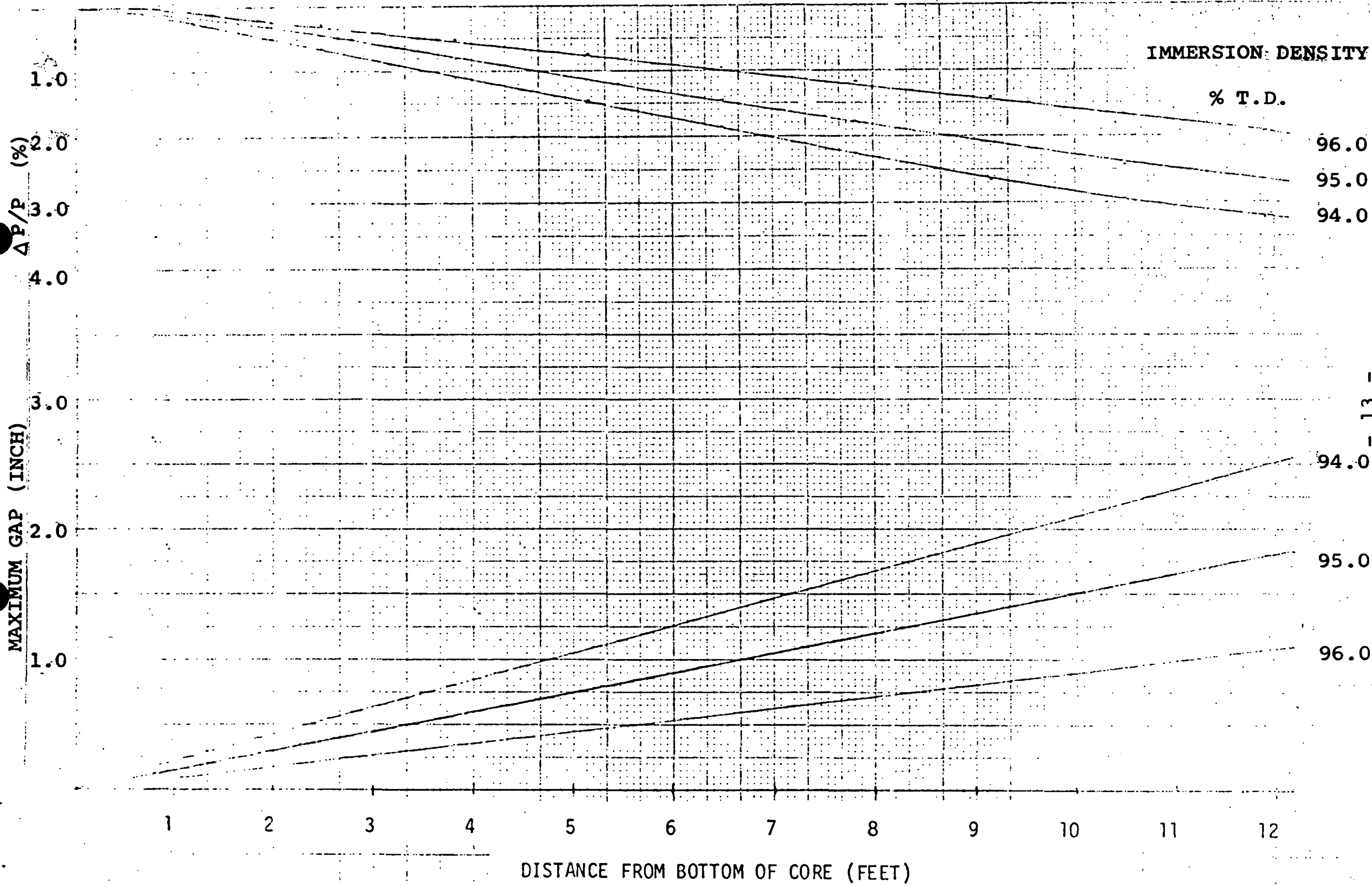


FIGURE 5

Cladding Average Temperature At a Fuel Column Axial Gap

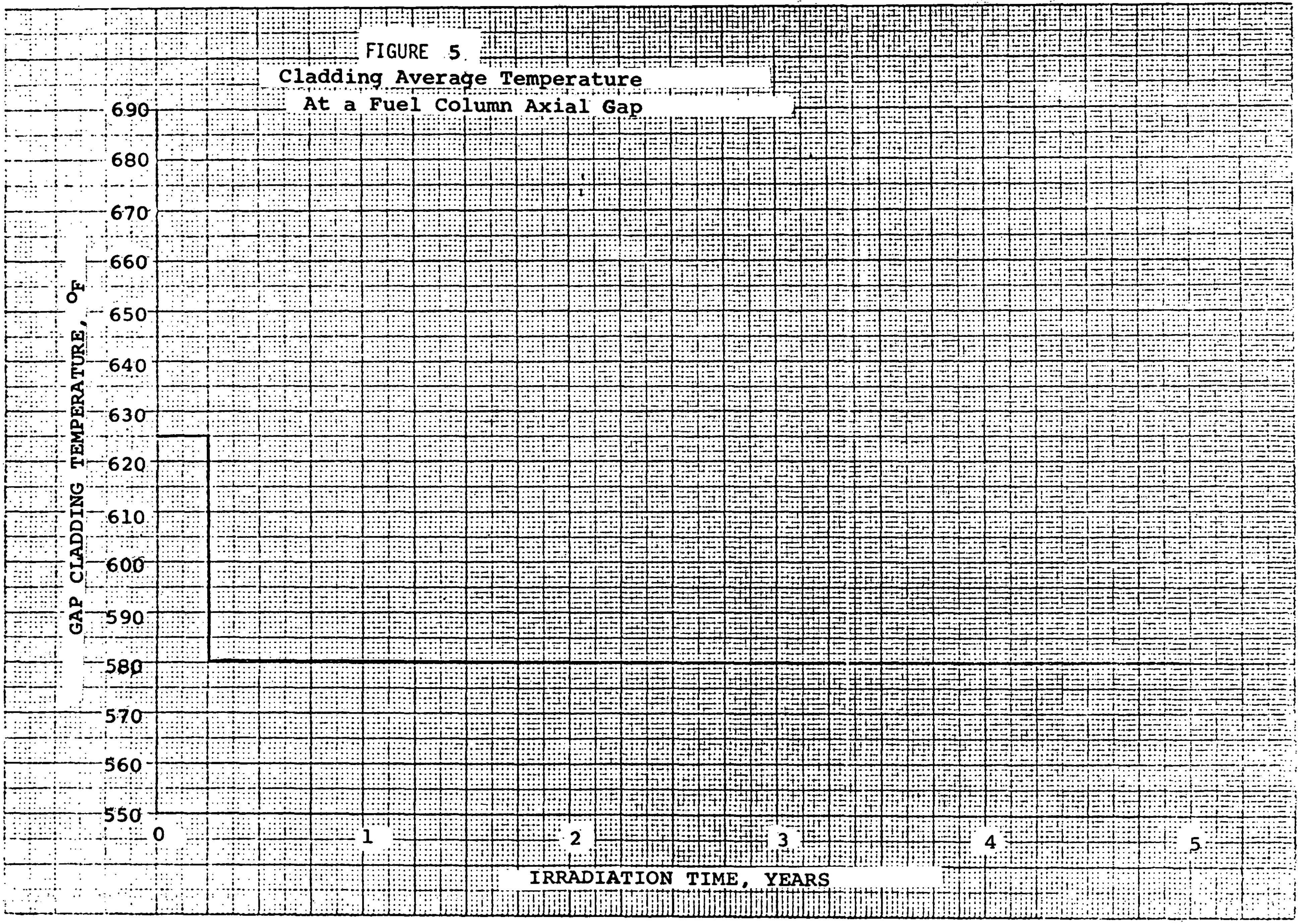
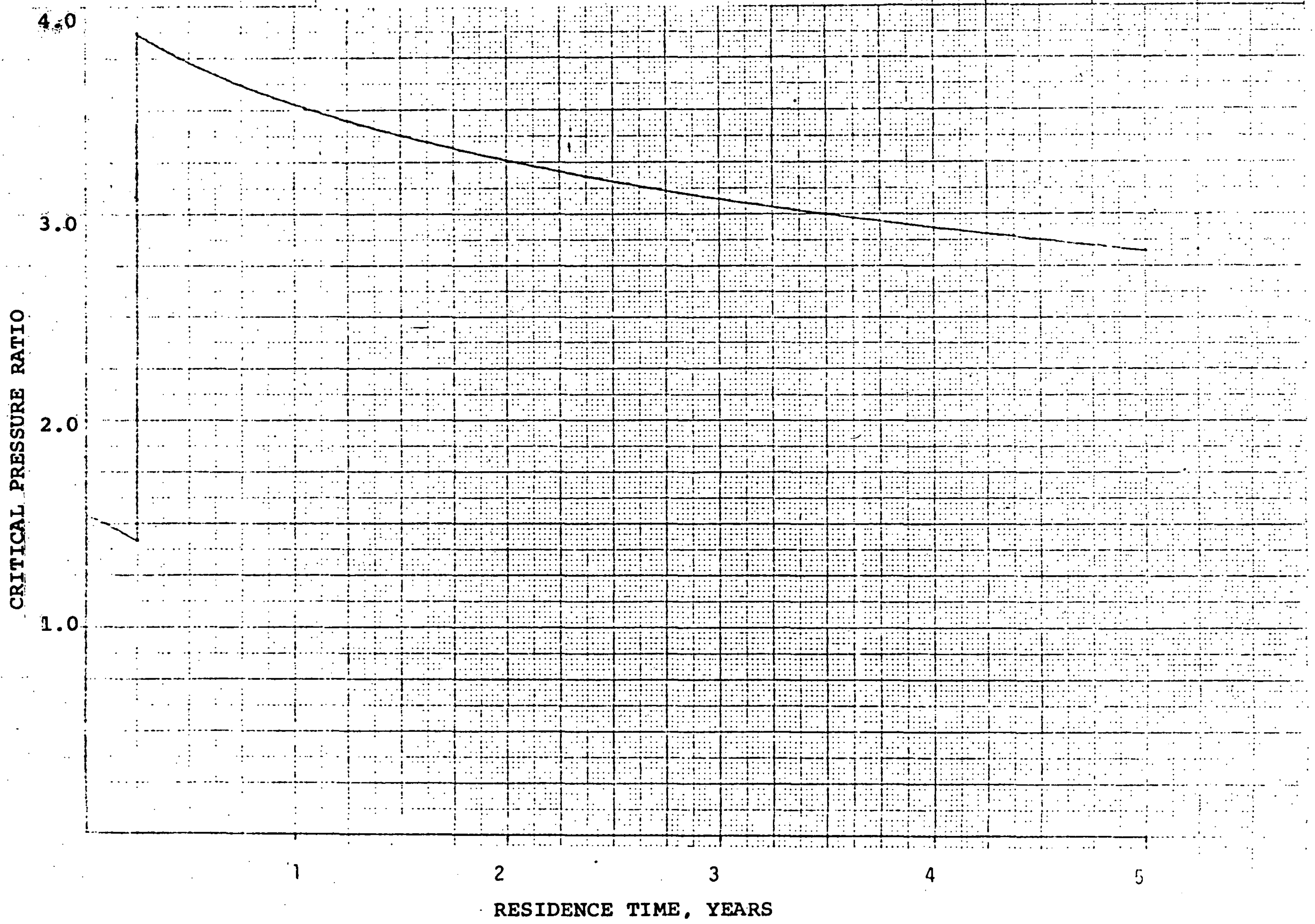


FIGURE 6

CLAD CRITICAL COLLAPSE PRESSURE RATIO VERSUS TIME
DRESDEN 3 8x8 RELOAD FUEL



PLANT J
DRESDEN UNIT 3

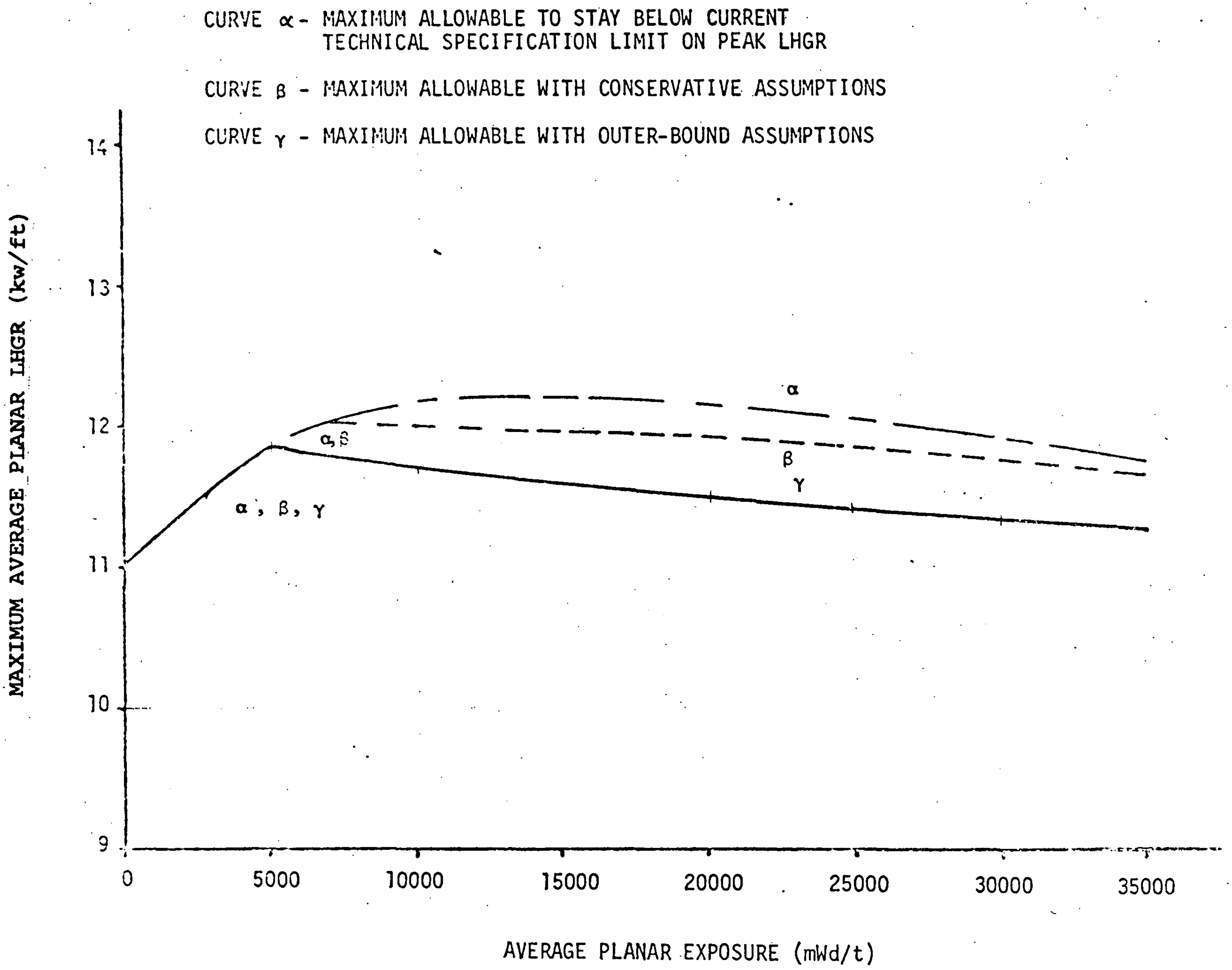


FIGURE 7 Maximum Allowable Average Planar LHGR Applicable to Fuel Type Reload 2 (8 x 8)

PLANT J
DRESDEN UNIT 3

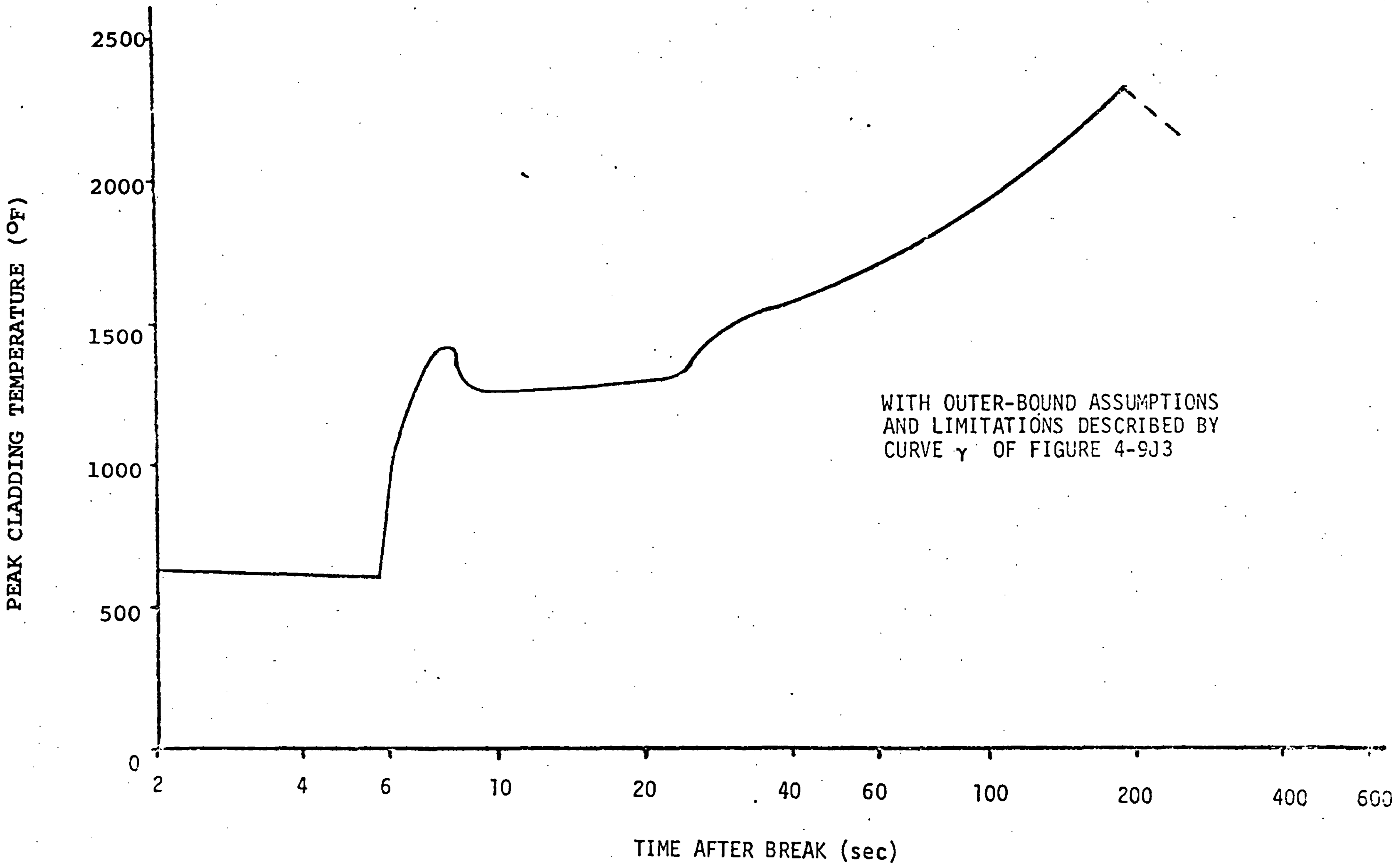


FIGURE 8 Design Basis LOCA; Worst Single Failure

TECHNICAL SPECIFICATION

PAGE CHANGES

81B
81C
85A
85B
85C

I. Average Planar LHGR

During steady state power operation, the average linear heat generation rate (LHGR) of all the rods in any fuel assembly, as a function of average planar exposure, at any axial location, shall not exceed the maximum average planar LHGR shown in Figure 3.5.1.

J. Local LHGR

During steady state power operation, the linear heat generation rate (LHGR) of any rod in any fuel assembly at any axial location shall not exceed the maximum allowable LHGR as calculated by the following equation:

$$LHGR_{max} \leq LHGR_{d} \left[1-\left(\frac{\Delta P}{P}\right)_{max}\left(\frac{L}{LT}\right)\right]$$

$LHGR_d$ = Design LHGR = 17.5 KW/ft for 7 x 7 lattice fuel = 13.4 kw/ft for 8 x 8 lattice fuel

$\left(\Delta P/P\right)_{max}$ = Maximum power spiking penalty = 0.038 for 7 x 7 fuel, 0.026 for 8 x 8 fuel

LT = Total core length = 12 ft

L = Axial position above bottom of core

I. Average Planar LHGR

Daily during reactor power operation, the average planar LHGR shall be checked.

J. Local LHGR

Daily during reactor power operation, the local LHGR shall be checked.

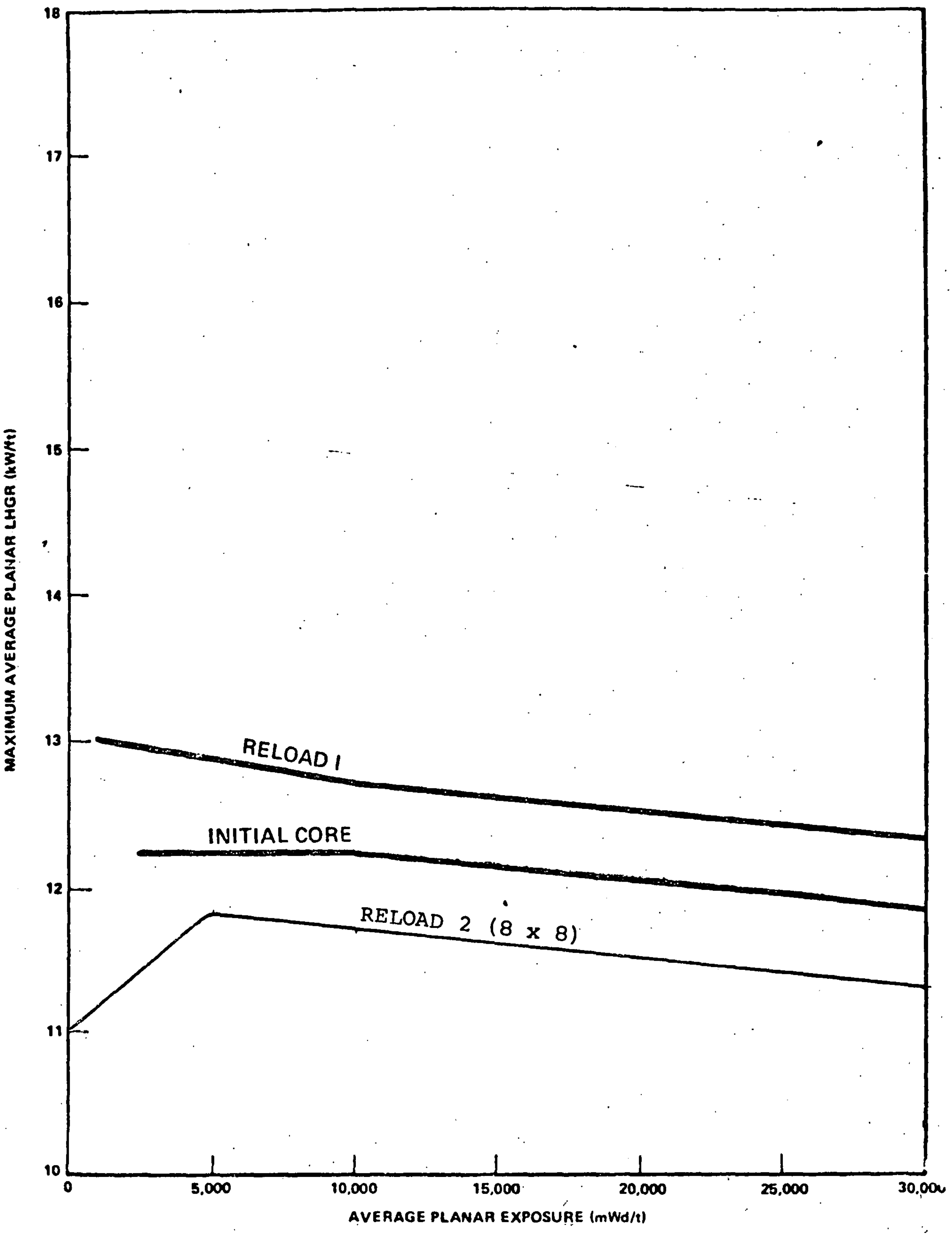


FIGURE 3.5.1 MAXIMUM ALLOWABLE PLANAR LHGR

3.5.I Average Planar LHGR

This specification assures that the peak cladding temperature following the postulated design basis loss-of-coolant accident will not exceed the 2300°F limit specified in the Interim Acceptance Criteria (IAC) issued in June 1971 considering the postulated effects of fuel pellet densification.

The peak cladding temperature following a postulated loss-of-coolant accident is primarily a function of the average heat generation rate of all the rods of a fuel assembly at any axial location and is only dependent secondarily on the rod to rod power distribution within an assembly. Since expected local variations in power distribution within a fuel assembly affect the calculated peak clad temperature by less than ±20°F relative to the peak temperature for a typical fuel design, the limit on the average linear heat generation rate is sufficient to assure that calculated temperatures are below the IAC limit.

The maximum average planar LHGR shown in Figure 3.5.1 for 7 x 7 lattice fuel is the same as that shown on the curve labeled "γ" (gamma) on Figures 4-9J1 and 4-9J2 of the GE topical report "Fuel Densification Effects on General Electric Boiling Water Reactor Fuel," NEDM-10735, Supplement 6, August 1973 and is the result of the calculations presented in Section 4.3.4 of the same report. These calculations were made to determine the effect of densification on peak clad temperature and were performed in accordance with the AEC Fuel Densification Model for BWR's which is attached to NEDM-10735, Supplement 6 as Appendix B. The maximum planar LHGR in Figure 3.5.1 for 8 x 8 lattice fuel is the same as that shown on the curve labeled "γ" (gamma) on Figure 7 of "Dresden Unit 3 Supplement C to Second Reload License Submittal", dated December 4, 1973.

The possible effects of fuel pellet densification were: (1) creep collapse of the cladding due to axial gap formation; (2) increase in the LHGR because of pellet column shortening; (3) power spikes due to axial gap formation; and (4) changes in stored energy due to increased radial gap size. Calculation show that clad collapse is conservatively predicted not to occur currently or prior to September 1974. Therefore, clad collapse is not considered in the analyses. Since axial thermal expansion of the fuel pellets is greater than axial shrinkage due to densification, the analyses of peak clad temperature do not consider any change in LHGR due to pellet column shortening. Although, the formation of axial gaps might produce a local power spike at one location on any one rod in a fuel assembly, the increase in local power density would be on the order of only 2% at the axial midplane. Since small local variations in power distribution have a small effect on peak clad temperature, power spikes were not considered in the analysis of loss-of-coolant accidents. Changes in gap size affect the peak clad temperature by their effect on pellet clad thermal conductance and fuel pellet stored energy. The pellet-clad thermal conductance assumed for each rod is dependent on the steady state operating linear heat generation rate and gap size. As specified in the AEC Fuel Densification Model for BWR's, the gap size was calculated assuming that the pellet densified from the measured pellet density to 96.5% of theoretical density. For the most critical rod, the two standard deviation lower bound on initial pellet density was assumed. For the other 48 rods for 7 x 7 and for the other 62 rods for 8 x 8, the two standard deviation lower bound on the initial mean "boat" pellet density was assumed.

The curves used to determine pellet-clad thermal conductance as a function of linear heat generation are based on experimental data and predict with a 95% confidence that 90% of the population exceed the predictions.

3.5.J Local LHGR

This specification assures that the linear heat generation rate in any rod is less than the design linear heat generation even if fuel pellet densification is postulated. The power spike penalty specified is based on the analysis presented in Section 3.2.1 of the GE topical report NEDM-10735 Supplement 6 for 7 x 7 lattice fuel, and "Dresden Unit 3 Supplement C to Second Reload License Submittal," dated December 4, 1973 for 8 x 8 lattice fuel, and assumes a linearly increasing variation in axial gaps between core bottom and top, and assures with a 95% confidence, that no more than one fuel rod exceeds the design linear heat generation rate due to power spiking.