ENCLOSURE 4

ADVANCED NUCLEAR FUELS CORPORATION

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HATCH 9X9 LEAD FUEL ASSEMBLIES

SAFETY ANALYSIS REPORT

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1.0 INTRODUCTION

Evaluations have been performed to define the impact upon the core performance as a result of inserting four (4) 9x9 lead fuel assemblies (LFA's) manufactured by Advanced Nuclear Fuels Corporation (ANF) into the Hatch Unit 2 Nuclear Station. In addition, justifications are provided which demonstrate that application of GE P8DRB284H 8x8 operating limits, as defined in the Technical Specifications to these lead fuel assemblies, is acceptable and will not result in decreasing the reactor's margin to safety during operation with the ANF 9x9 assemblies.

The insertion of only four ANF 9x9 assemblies will have negligible effects upon the core-wide transient performance relative to the core fully loaded without the four ANF lead fuel assemblies. As such, the analyses of the core transient performance used to establish the current Hatch Technical Specification limits for a core loaded without the four ANF 9x9 LFA's applies directly to the core loaded with the four ANF 9x9 assemblies replacing four P8DRB284H 8x8 assemblies. This includes the analyses of anticipated plant transients, LOCA, and stability which are used to support ARTS, extended load line, single loop operation, increased core flow, and feedwater temperature reduction.

The maximum k_∞ of an ANF 9x9 LFA is slightly less than a GE P8DRB284H 8x8 assembly. Therefore, existing fuel storage limits for GE fuel bound those necessary for the ANF 9x9 LFA's.

Analyses performed for GE P8DRB284H 8x8 fuel to determine the effects of core related events, such as control rod withdrawal, control rod drop, and fuel assembly misloading, also apply to the ANF 9x9 assemblies by virtue of the 9x9 assemblies meeting compatibility requirements of reactivity and hydraulic demand.

The evaluations provided herein thus provide assessments of the 9x9 assemblies relative to the GE P8DRB284H 8x8 assemblies and justify application of the current Hatch Technical Specifications for that fuel to the ANF 9x9 fuel assemblies.

2.0 FUEL MECHANICAL DESIGN ANALYSIS

The expected operating requirements of Hatch Unit 2 are bounded by the assumed power history in ANF's fuel mechanical design analyses[1]. Fuel design issues related to operational occurrences and accident analysis (fuel centerline melting, clad rupture, LOCA-seismic response) have been evaluated for full reloads in Susquehanna and found acceptable by the NRC[2]. These evaluations also assure that the four ANF 9x9 LFA's will meet operating and safety design requirements of the Hatch 2 nuclear plant.

3.0 THERMAL HYDRAULIC DESIGN ANALYSIS

3.1 Hydraulic Compatibility

Component hydraulic resistances for the ANF 9x9 and GE 8x8 fuel assemblies have been determined in single phase flow tests of full scale assemblies which were identical in mechanical design to the Hatch LFA's and GE 8x8 fuels. Hydraulic compatibility of the ANF 9x9 and GE 8x8 coresident fuel types[3] has been demonstrated.

3.2 Thermal Margin Performance

Analyses of the limiting BWR/4 transients have shown that the bundle power needed to produce transition boiling in the 9x9 fuel is higher than that for the GE 8x8 bundle. Table 1 shows that the 9x9 fuel must be operated at a higher bundle power than the GE 8x8 fuel in order to reach the MCPR operating limit. Therefore, applying GE 8x8 MCPR operating limits to ANF 9x9 fuel will keep the 9x9 bundle powers to levels lower than would be needed to reach their actual MCPR limit. ANF analyses in support of extended operating domains for a BWR/4 show the equivalence of 8x8 and 9x9 MCPR limits throughout extended operating domains. It follows that monitoring the ANF 9x9 LFA's based on GE 8x8 MCPR limits adequately protects the ANF 9x9 LFA's from boiling transition.

3.3 Single Loop Operation

ANF analysis of a typical BWR/4 with a full ANF 9x9 reload in Single Loop Operation (SLO) has shown that the most limiting transient with regard to thermal margin is bounded by the 104% power/100% flow generator load rejection without bypass valve operation. This analysis showed that single loop operation is unaffected by the introduction of the ANF 9x9 LFA's. In addition, monitoring these ANF 9x9 assemblies with GE P8DRB284H limits for SLO results in a conservative estimate of the margin to critical power for the 9x9 fuel in single loop operation.

4.0 NUCLEAR DESIGN ANALYSIS

4.1 Standby Liquid Control System

The neutronic impact of replacing four of the 560 fuel assemblies with ANF 9x9 LFA's which demonstrate similar reactivity characteristics will be negligible on the standby liquid control system reactivity worth.

4.2 Cold Shutdown Margin

Infinite assembly calculations at 0 MWd/MTU show the ANF 9x9 LFA's to have approximately 0.6 mk higher cold uncontrolled reactivity relative to GE P8DRB284H 8x8 fuel. This results in a control cell reactivity less than 0.2 mk higher than an all P8DRB284H 8x8 loaded control cell, which is a negligible contribution to cold shutdown margin. For exposures greater than 2,000 MWd/MTU the 9x9 LFA design has slightly lower cold uncontrolled reactivity than for the GE 8x8 reference fuel. This results in a slight increase in cold shutdown margin for a control cell with an ANF 9x9 fuel assembly in place of an 8x8 assembly at exposures greater than 2,000 MWd/MTU. Thus, the cold shutdown margin evaluations performed for control cells containing all 8x8 fuel apply to control cells containing the ANF 9x9 LFA without significantly reducing the calculated cold shutdown margin.

4.3 Fuel Pool Criticality

The maximum k_{∞} of an ANF 9x9 LFA is approximately 2 mk less than a GE P8DRB284H 8x8 assembly. Therefore, spent fuel storage critical limits existing for GE 8x8 fuel bound those required for ANF 9x9 LFA's.

5.0 ANTICIPATED OPERATIONAL OCCURRENCES

Operation of the four ANF 9x9 LFA's using GE P8DRB284H MCPR operating limits is conservative. Analyses of the limiting BWR/4 transients have shown that the ANF 9x9 bundle power at the Technical Specification MCPR operating limit is higher than for a GE 8x8 bundle.

5.1 Overpower Events

The limits in effect for GE P8DRB284H fuel will conservatively protect the ANF 9x9 LFA's for overpower events. In the event of an overpower transient, more than 30 percent margin exists to ANF 9x9 transient LHGR limits(1). This compares to GE 8x8 fuel, where approximately 20 percent margin exists for overpower transient LHGR limits.

5.2 Control Rod Withdrawal Error

Infinite assembly calculations of the control rod worth for the ANF 9x9 LFA's and GE P8DRB284H 8x8 fuel indicate that the worth of the withdrawn rod for the module containing the ANF 9x9 fuel will not exceed the value obtained for a similar module containing all GE 8x8 fuel. Thus, the Δ CPR values for the ANF 9x9 fuel design will not be substantially different than those obtained for GE 8x8 fuel and are within the variation that is seen between specific reactor cycles for a reactor which utilizes GE 8x8 fuel.

5.3 Fuel Mislocation Error

The consequences of the mislocation of an ANF 9x9 LFA are no more limiting than that associated with the GE 8x8 fuel. This is substantiated by a comparison of the reactivity values between the two fuel types. The 9x9 values are comparable and in most cases less than that associated with GE 8x8 fuel, thus the change in local power due to the mislocation of a 9x9 fuel assembly is no greater than that obtained by the mislocation of a GE 8x8 assembly. Thus, the mislocation Δ MCPR for the ANF 9x9 fuel design is not significantly different from those for the GE 8x8 fuel.

5.4 Fuel Rotation Error

The consequences of the fuel rotation error have been evaluated comparing the ANF 9x9 LFA design to GE P8DRB284H 8x8 design. The results indicate an increase in Δ CPR for the rotated ANF 9x9 LFA of up to 0.06 relative to rotated 8x8 GE P8DRB284H fuel assembly. Typically the rotated 8x8 fuel assembly has not been the limiting event for Hatch, and more than 0.06 ΔCPR margin has existed to the MCPR operating limit. If necessary, selection of non-limiting core locations for the four ANF 9x9 LFA's can be used to preclude any concern relative to thermal limits for the fuel rotation error.

6.0 POSTULATED ACCIDENTS

6.1 Loss-Of-Coolant Accident

The appropriate bundle power limit derived from a LOCA analysis is the peak bundle-planar power because heatup is primarily a planar phenomena, not an axial phenomena. The bundle is contained in a channel and the peak clad temperature (PCT) is primarily governed by rod-to-rod and rod-to-channel radiation, and local convection to droplets. Presently, the peak bundle-planar power determined from the LOCA analysis is converted to a Maximum Average Planar LHGR limit (MAPLHGR) by dividing by the number of heated rods in a bundle; this MAPLHGR limit is used as the LOCA monitoring limit. Alternatively, this peak bundle-planar power could be directly used as the LOCA monitoring limit; in this report this alternate limit is termed equivalent planar power.

ANF 9x9 fuel has equivalent or improved LOCA-ECCS performance when compared to both ANF 8x8 and GE 8x8 fuel for two fundamental reasons. First, because of its lower LHGR's for the same planar power, ANF 9x9 fuel has less stored energy than 8x8 fuel. Secondly, ANF 9x9 fuel has better heat transfer characteristics because of the greater surface area per unit volume. Of further benefit is that ANF fuel has a larger upper tie plate flow area than GE fuel, resulting in less restrictive countercurrent flow limiting characteristics.

Table 2 provides a comparison on an equivalent basis of average planar power limits for ANF 9x9 and GE 8x8 fuel for a typical BWR/4. The table shows that the ANF fuel is less restrictive than GE fuel. This remains the case regardless of bundle exposure. As a result of this comparison, it is concluded that the APLHGR limits for the GE 8x8 fuel (P8DRB284H) will conservatively bound the use of ANF 9x9 fuel in Hatch 2 for all bundle exposures. These limits will assure that the criteria specified in 10 CFR 50.46 will be satisfied for the four ANF 9x9 LFA's.

Generic analysis has shown that for plant LOCA-ECCS performance consideration, BWR/4's can be grouped into two major subgroups--those with loop selection logic (i.e., plants that have not incorporated low pressure coolant injection [LPCI] system modification) and those which have LPCI modification(4). Since Hatch falls into the latter subgroup and ANF has performed a LOCA analysis for a BWR/4 with LPCI modifications(2), ECCS performance differences can be considered insignificant.

6.2 Control Rod Drop Accident

The consequences of a control rod drop accident have been determined by ANF to be a function of dropped rod worth, Doppler reactivity, delayed neutron fraction, and fuel rod local peaking. A comparison of these parameters between the ANF 9x9 and GE 8x8 fuel indicates that the deposited enthalpy for the ANF 9x9 fuel will have a value comparable to that calculated for the GE 8x8 fuel and maintain sufficient margin to the limit of 280 cal/gm.

6.3 Fuel Handling Accident

A comparison of the radiological consequences of fuel handling accidents with 8x8 and 9x9 fuel for a typical BWR/4 showed less radioactivity released for the 9x9 fuel.

7.0 TECHNICAL SPECIFICATIONS

7.1 Limiting Safety System Settings

The four ANF 9x9 LFA's will not materially affect the safety limits of Hatch 2 operation.

7.2 Limiting Conditions for Operation

ANF analysis of a typical BWR/4 has shown that the ANF 9x9 bundle power at the MCPR operating limit is higher than for a GE 8x8 bundle. It follows that application of GE P8DRB284H MCPR limits to the ANF 9x9 LFA's adequately protects the LFA's from boiling transition.

Restricting the ANF 9x9 LFA's to the planar power consistant with GE APLHGR limits protects ANF 9x9 APLHGR and LHGR limits. As discussed in the previous section, GE APLHGR limits for P8DRB284H fuel type in Hatch Unit 2 are more restrictive than ANF 9x9 APLHGR limits. ANF 9x9 APLHGR limits are more restrictive or equivalent to (depending on exposure) ANF 9x9 LHGR limits.

Figure 1 provides a comparison of APLHGR limits for ANF 9x9 and GE P8DRB284H 8x8 fuel. In order to provide comparative bases between 8x8 and 9x9 arrays, the equivalent planar power is shown as the APLHGR limit times the number of fuel rods per assembly. Figure 2 provides a comparison of ANF 9x9 LHGR limits and the maximum LHGR allowed by monitoring to GE APLHGR limits for P8DRB284H fuel.

7.3 Surveillance Requirements

Stability tests have been performed on the Commonwealth Edison Company's Dresden Unit 2 reactor with ANF 9x9 LFA's in core. The results of these tests indicate that the ANF LFA's have no measurable impact on local stability.

Additionally, the Pennsylvania Power and Light Company's Susquehanna Unit 2 reactor was analyzed and tests performed for stability with a core containing a full ANF 9x9 reload (approximately 42 percent of the total core loading). Results of these analyses and tests indicate the core is very stable; a decay ratio of 0.33 was measured at the right hand boundary of the SIL 380 Detect and Suppress region.

The Hatch Unit 2 mechanical core design and analyzed power/flow map are the same as those for Susquehanna. The nuclear design of the Hatch LFA's is such that the thermal hydraulic stability is no worse than the fuel tested in Susquehanna. Therefore, the local and core-wide stability of the LFA's in Hatch 2 meets the requirements of GDC 12.

8.0 REFERENCES

(1) "Generic Mechanical Design for Exxon Nuclear Jet Pump BWR Reload Fuel," XN-NF-85-67(P)(A), Rev. 1, September 1986.

(2) Safety Evaluation by the Office of Nuclear Reactor Regulation Supporting Amendment 31 to Facility Operating License No. NPF-22, Pennsylvania Power and Light Company, Susquehanna Steam Station Unit 2, Docket No. 50-388.

(3) "Hatch Lead Assembly Compatibility Report - Mechanical, Thermal and Neutronic Design for ANF 9x9 Fuel Assemblies," XN-NF-87-77(P), Rev. 0.

(4) General Electric Licensing Topical Report, Generic Reload Fuel Application, NEDO-24011-2.

TABLE 1 COMPARISON OF MCPR LIMITS
(BASED ON TYPICAL BWR/4)

FUEL TYPE	BUNDLE POWER AT MCPR LIMIT (MW)
ANF 9x9	6.7
GE 8x8	6.5

TABLE 2 COMPARISON OF APLHGR LIMITS
(BASED ON TYPICAL BWR/4)

	PEAK APLHGR LIMIT (KW/FT)	EQUIVALENT PLANAR POWER (APLHGR LIMIT * NO. OF FUEL RODS) (KW/FT)
GE 8x8 (BWR/4)	12.2	756
ANF 9x9 (BWR/4)	10.2	806

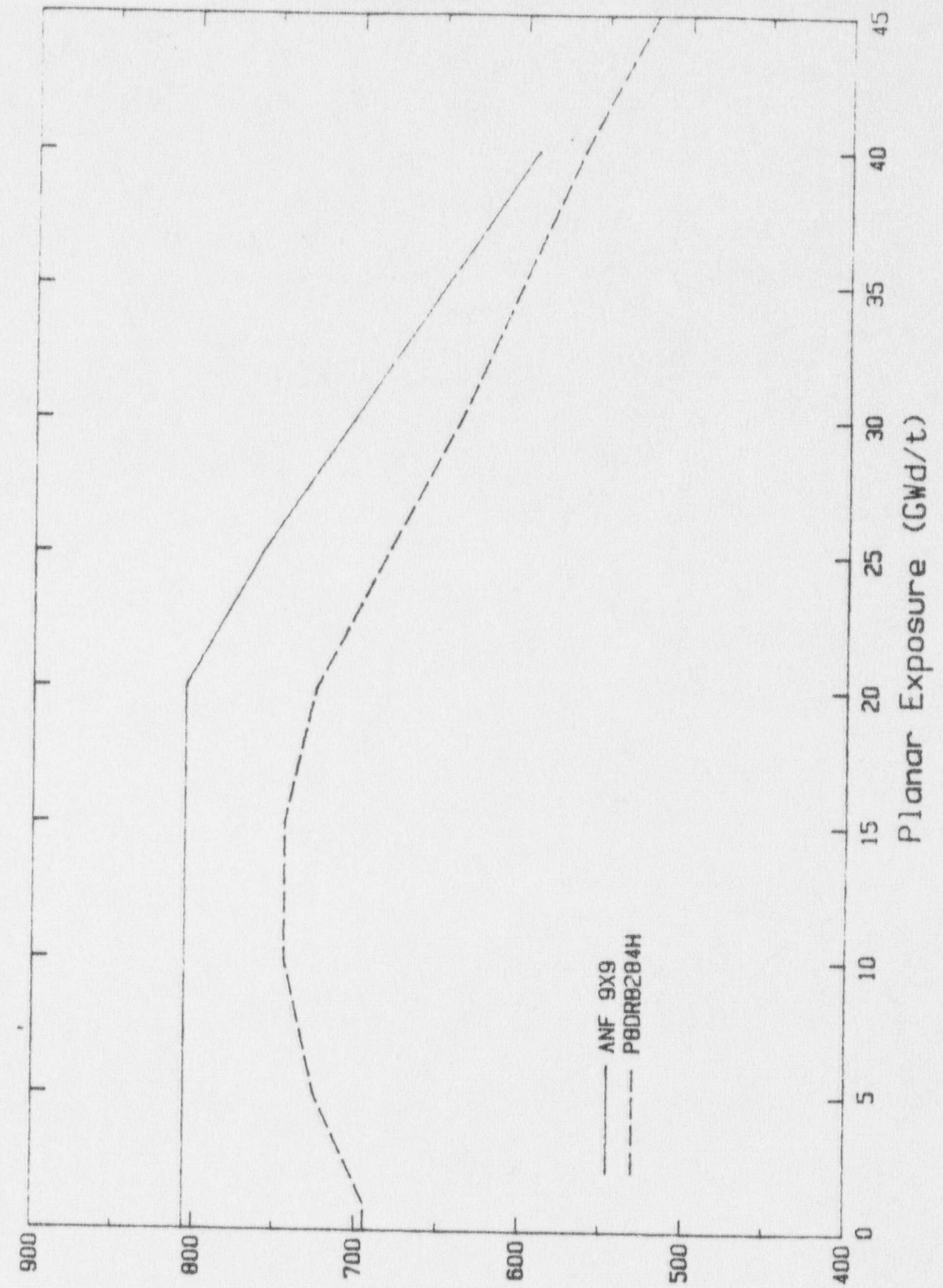

Figure 1 APLHGR Limit Comparison On Total Planar Power Basis

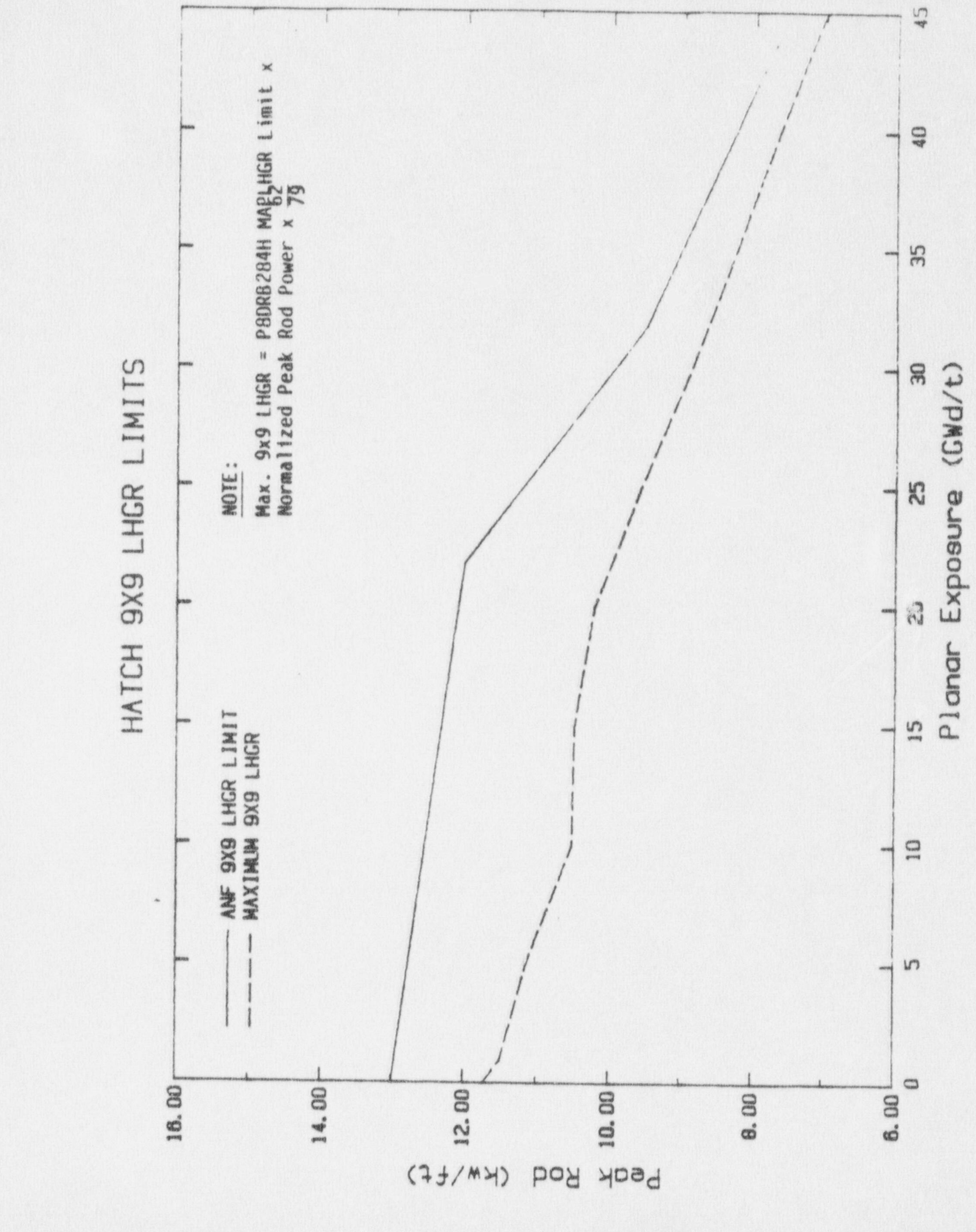

Figure 2 ANF 9x9 LHGR Compared To Limit

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