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DRESDEN UNIT 2 LOCA ANALYSIS USING THE ENC EXEM/BWR EVALUATION MODEL

MAPLHGR RESULTS

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION AND SUMMARY

This document presents the Maximum Average Planar Linear Heat Generation Rate (MAPLHGR) results from a LOCA analysis performed for the Dresden Unit 2 reactor. These results were obtained using the NRC approved Exxon Nuclear Company EXEM[1] jet pump BWR ECCS evaluation model, including the EXEM/BWR model changes[2] approved by the NRC Staff[3] for fuel rod swelling and rupture. The generic jet pump BWR 3 LOCA break spectrum analysis was described in XN-NF-81-71(A)[4], and showed the limiting break for a BWR 3 on a generic basis to be a double-ended guillitone (DEG) configuration in the recirculation piping on the suction side of the pump (PS) with a discharge coefficient of 1.0 (C_D=1.0). This limiting break formed the basis of the MAPLHGR heatup analyses reported herein.

Heatup analyses were performed for Dresden Unit 2 Cycle 9 of the ENC XN-1 8x8 reload fuel in Dresden Unit 2 using blowdown boundary conditions from the limiting 1.0 DEG/PS break. The MAPLHGR results for the heatup analysis are shown in Table 1.1 and Figure 1.1. The calculations were performed according to the requirements of 10 CFR 50 Appendix K. The MAPLHGR limits defined in Table 1.1 satisfy the ECCS criteria specified by 10 CFR 50.46[5].

The analysis encompasses Dresden Unit 2 Cycle 9 only, since the revised ENC fuel performance model, RODEX2, is expected to be approved by the NRC in time for application to future Dresden Unit 2 cycles with ENC fuel.

Table 1.1 Dresden Unit 2 MAPLHGR Summary

Assembly Average Burnup GWD/MTM	MAPLHGR kw/ft
0.	13.0
12.	13.0

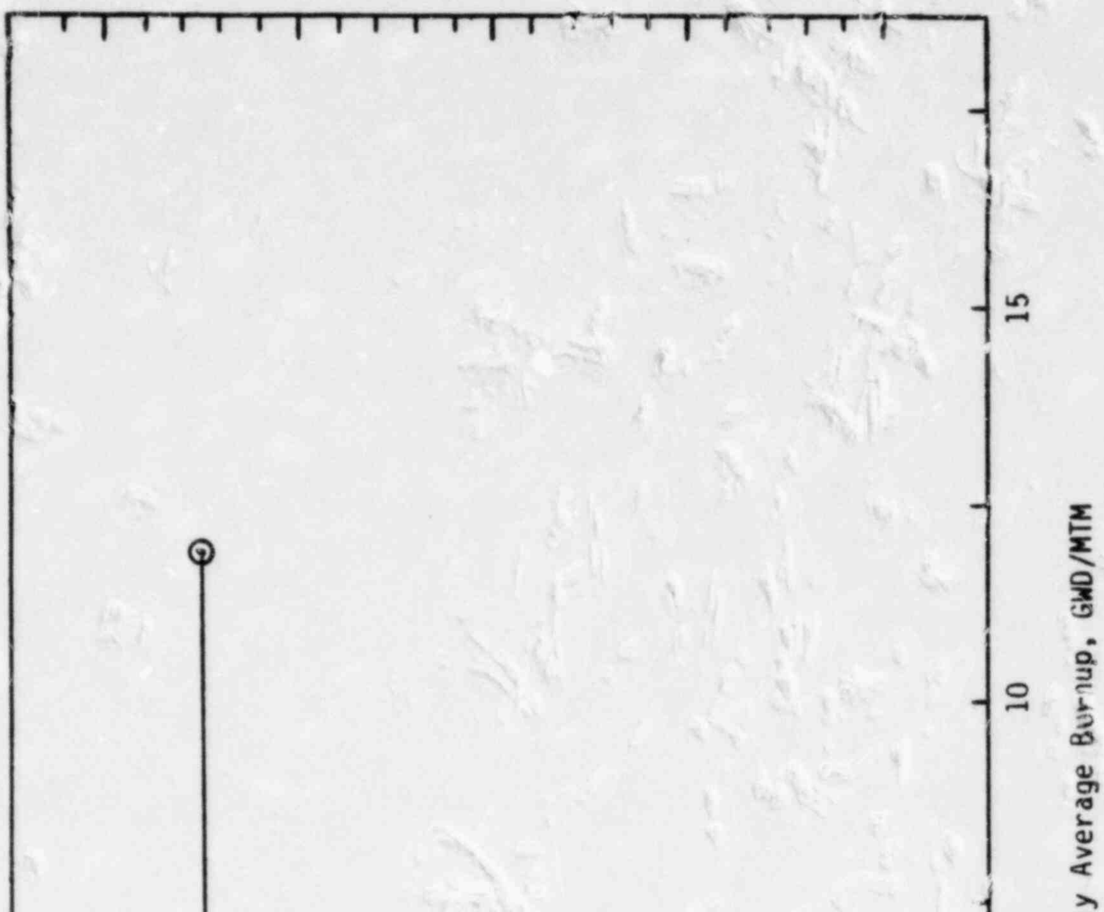

Figure 1.1 Dresden Unit 2 MAPLHGR Assembly Average Burnup

2.0 JET PUMP BWR ECCS EVALUATION MODEL

The evaluation model used for the Dresden Unit 2 LOCA analysis is the ENC EXEM[1] code package for jet pump BWR plants. EXEM is made up of the GAPEX[6], RELAX[7], FLEX[8], and HUXY/BULGEX[9,10] codes. The EXEM code package was modified to EXEM/BWR[2] with the NRC approval[3] of the cladding swelling and rupture model based on NUREG-0630. The fuel initial stored energy and exposed fuel fission gas release calculations are performed with the GAPEX code. The FLEX code performs the reactor system refill/reflood calculation from the time of rated core spray until liquid is entrained in the core midplane during the core reflood process. The HUXY/BULGEX code performs the hot assembly heatup, clad swelling and rupture calculations.

The RELAX blowdown calculation determines the reactor system behavior during the initial portion of the reactor system depressurization transient. A separate RELAX/HOT CHANNEL computation is used to calculate cladding-to-coolant heat transfer coefficients and coolant thermodynamic properties for the maximum power assembly. For this calculation, time-dependent boundary conditions are derived from the RELAX/BLOWDOWN analysis. This blowdown calculation also supplies reactor system conditions at the time of rated lower pressure core spray flow to initialize the system refill/reflood transient calculation.

The FLEX system refill/reflood analysis predicts the latter segment of the reactor depressurization, lower plenum refill, core reflood, and the time at which the reflooding liquid is entrained to the maximum power plane in the core (time of hot node reflood). The time of hot node reflood is an input parameter for the heatup calculation.

The HUXY/BULGEX heatup calculation uses calculated parameters from GAPEX (fuel stored energy and fission gas release), RELAX (time of rated spray, decay power, heat transfer coefficients and coolant temperatures) and FLEX (time of hot node reflood) to determine the peak clad temperature (PCT) and the percent oxidation of cladding. A symmetric center peaked axial power profile was used. Through a series of heatup calculations at different burnups, the plant MAPLHGR limits are determined.

Dresden Units 2 and 3 reactor system data appropriate for this analysis are given in Table 2.1. ENC reload fuel is compatible hydraulically and neutronically with the NSSS vendor fuel. The FLEX refill/reflood calculation was performed with the leakage holes and leakage paths minimized to conservatively bound the Dresden Unit 2 Cycle 9 mixed core as well as future cores.

Table 2.1 Dresden Units 2 and 3 Reactor System Data

Primary Heat Output, MW	2577.5*
Total Reactor Sytem Volume, ft^3	20160.
Total Reactor Flow Rate, lb/hr.	98.0×10^6
Active Core Flow Rate, lb/hr	87.27×10^6
Nominal Reactor System Pressure, (upper plenum), psia	1017.
Reactor Inlet Enthalpy, BTU/lb	525.3
Recirculation Loop Flow Rate, lb/hr	17.11×10^6
Steam Flow Rate lb/hr	9.95×10^6*
Feedwater Flow Rate, lb/hr	9.95×10^6*
Rated Recirculation Pump Head, ft.	570.
Rated Recirculation Pump Speed, rpm	1670.
Moment of Inertia, lbm-ft^2/rad	10950.
Recirculation Suction Pipe I.D., in.	25.78
Recirculation Discharge Pipe I.D., in.	25.46
Fuel Assembly Rod Diameter, in**	0.484
Fuel Assembly Rod Pitch, in**	0.641
Active Core Height, in**	145.24

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* 102% of rated power

** ENC fuel parameters

3.0 RESULTS

The MAPLHGR results for the Dresden Unit 2 reactor have been calculated using the break shown to be limiting in the generic BWR 3 break spectrum analyses[4]: a double-ended guillotine break (DEG) with a discharge coefficient of 1.0 in the recirculation suction piping. The blowdown and refill/reflood calculations for this break are presented in the BWR 3 break spectrum analysis report. That analysis used Dresden Units 2 and 3 plant specific system data.

A bounding hot channel calculation has been performed for this MAPLHGR analysis in which the fuel stored energy has been maximized over the exposure range of interest for ENC XN-1 8x8 fuel. The maximum fuel stored energy occurs at an assembly average burnup of 0 GWD/MTM. This bounding hot channel calculation provides heat transfer coefficients, fluid temperature and fluid quality at the plane of interest for the HUXY/BULGEX calculations. These hot channel calculated parameters are shown in Figures 3.1 through 3.3. Figure 3.4 is a heatup vs. time plot calculated by the HUXY/BULGEX code at an assembly average burnup of 12 GWD/MTM for the XN-1 8x8 fuel design.

The HUXY/BULGEX calculated results and corresponding MAPLHGR limits for ENC XN-1 8x8 reload fuel are shown in Table 3.1 and Figure 1.1. These results conform to the NRC requirements specified by 10 CFR 50.46. Table 3.1 shows the average burnup of the hot assembly (not planar burnup), MAPLHGR, peak local metal-water reaction, and peak clad temperature.

Table 3.1 Dresden Unit 2 LOCA Analysis Results for ENC XN-1 8x8 Reload Fuel

Assembly Average Burnup (GWD/MTM)	MAPLHGR (kw/ft)	Local MWR (%)	PCT (^{o}F)
0.	13.0	.8	1900
12.	13.0	.7	1856

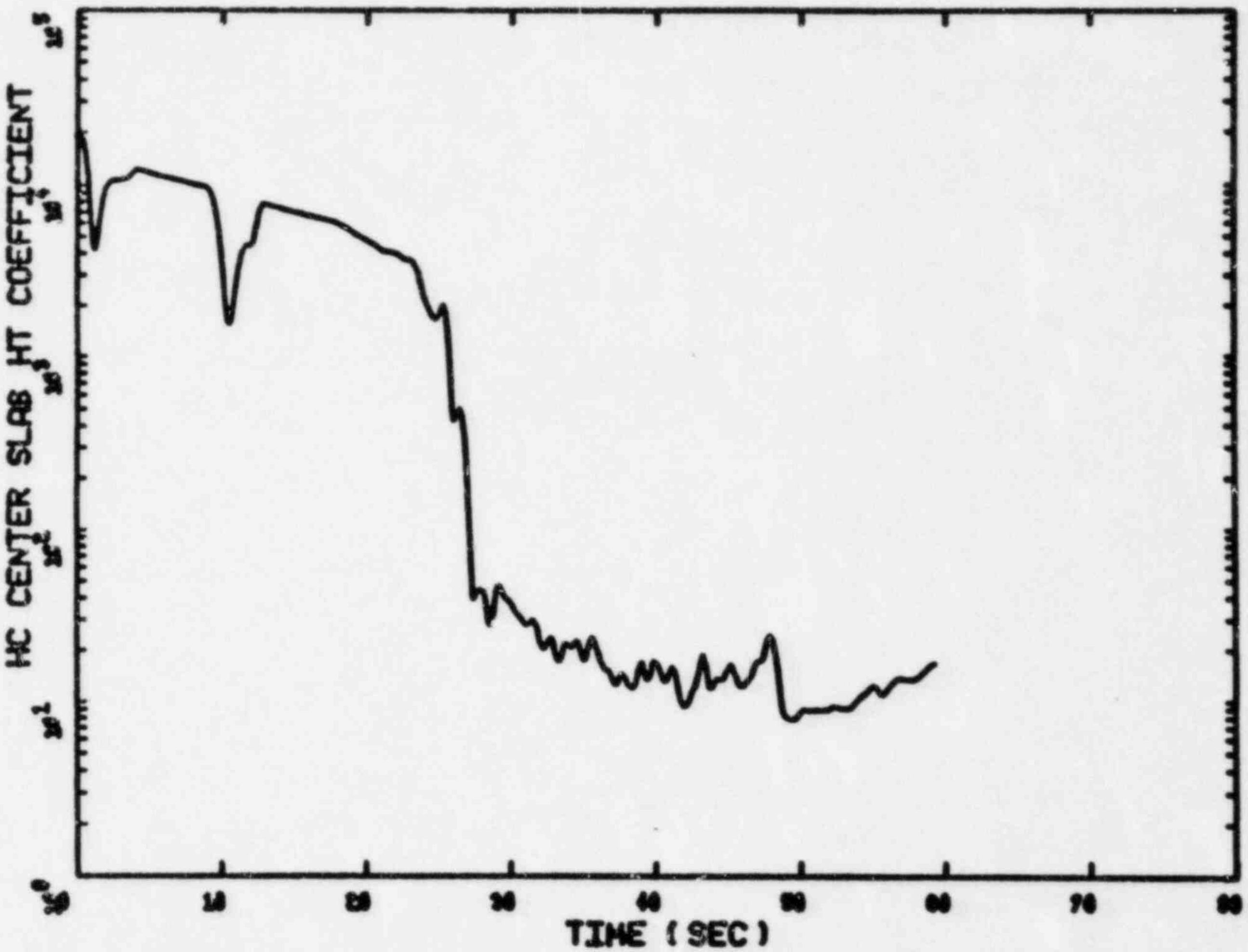


Figure 3.1 Blowdown Hot Channel Center Slab Heat Transfer Coefficient for 8x8 Fuel, BTU/hr-ft^2-^{o}F

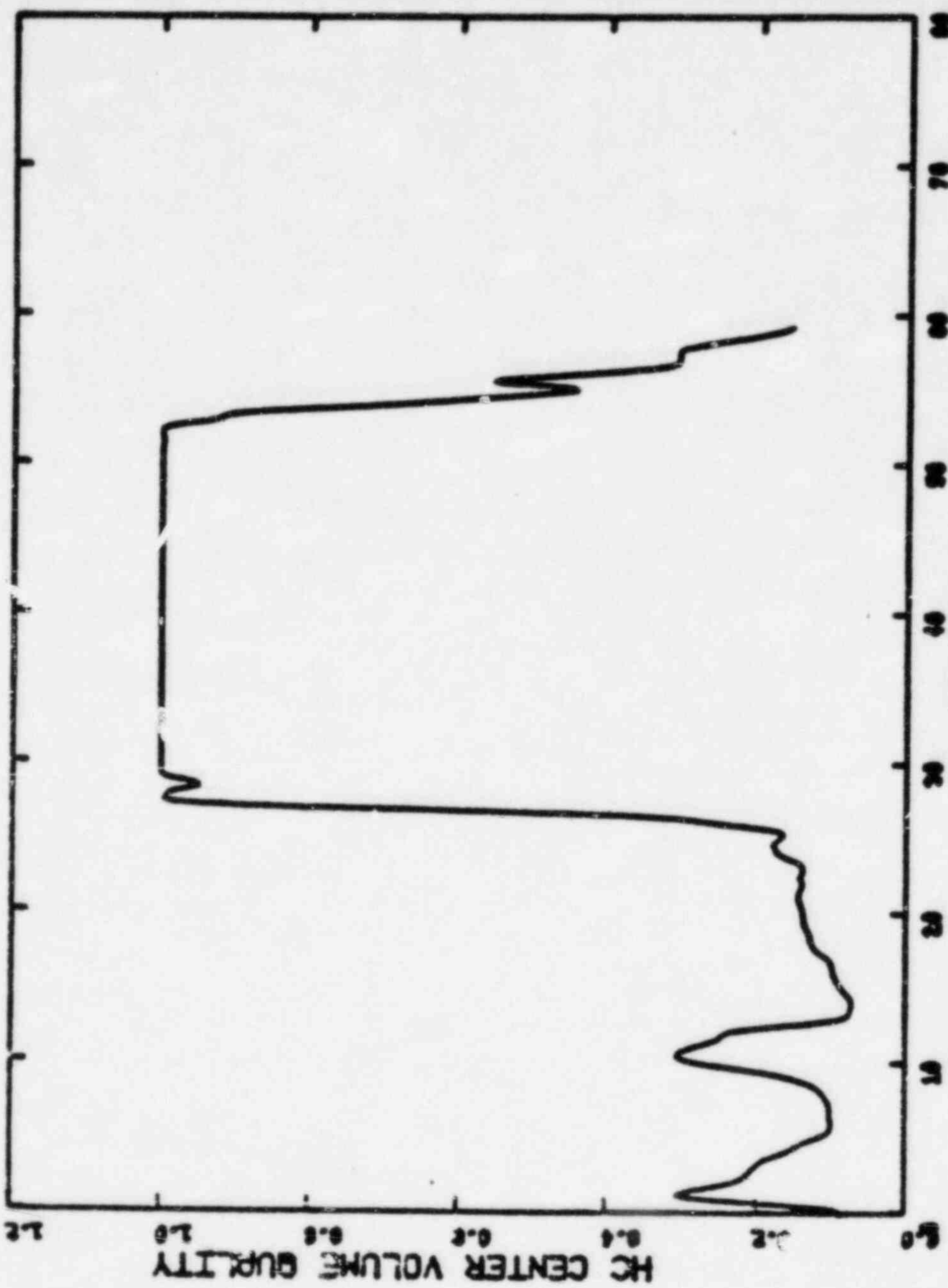


Figure 3.2 Blowdown Hot Channel Center Volume Quality for 8x8 Fuel

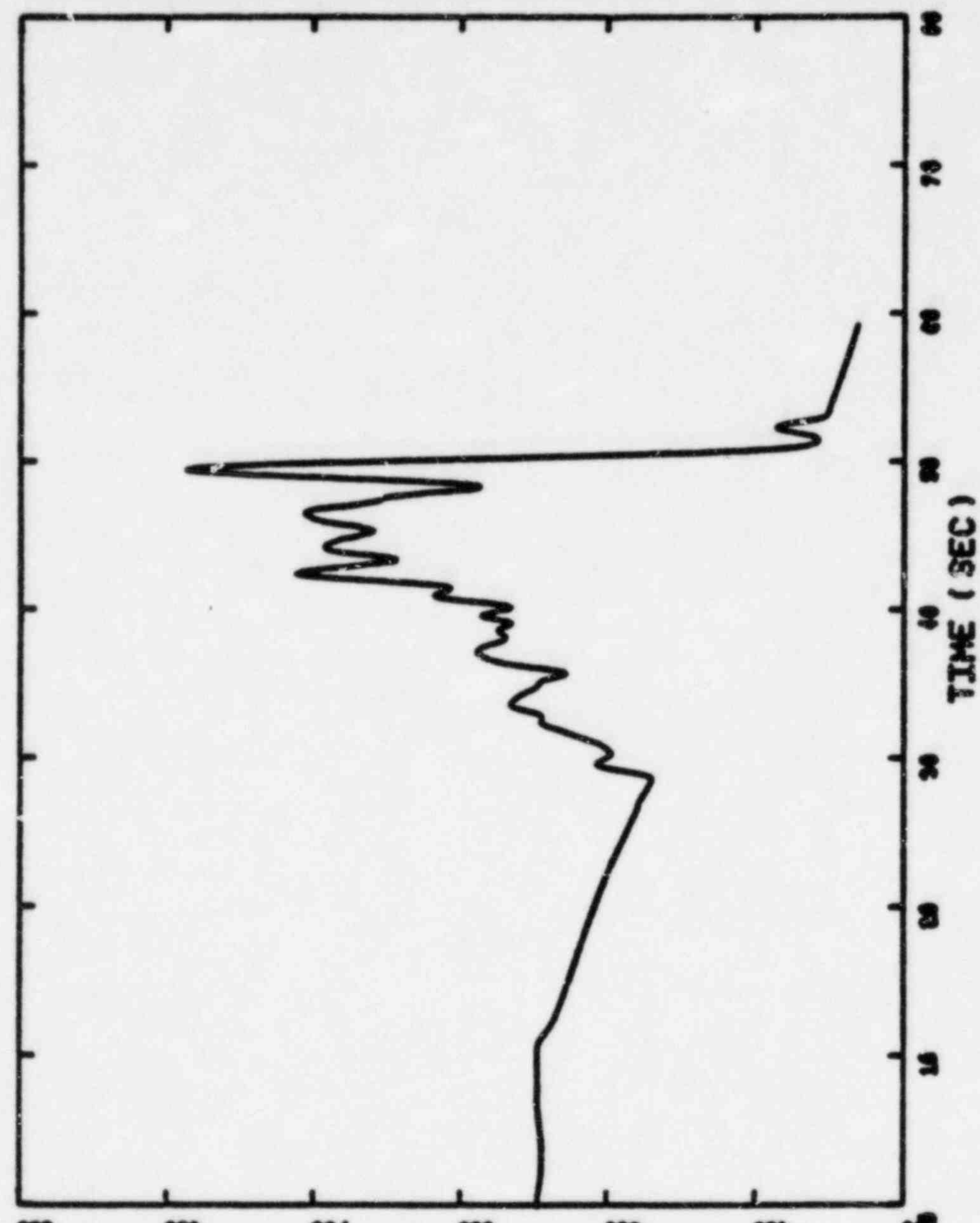
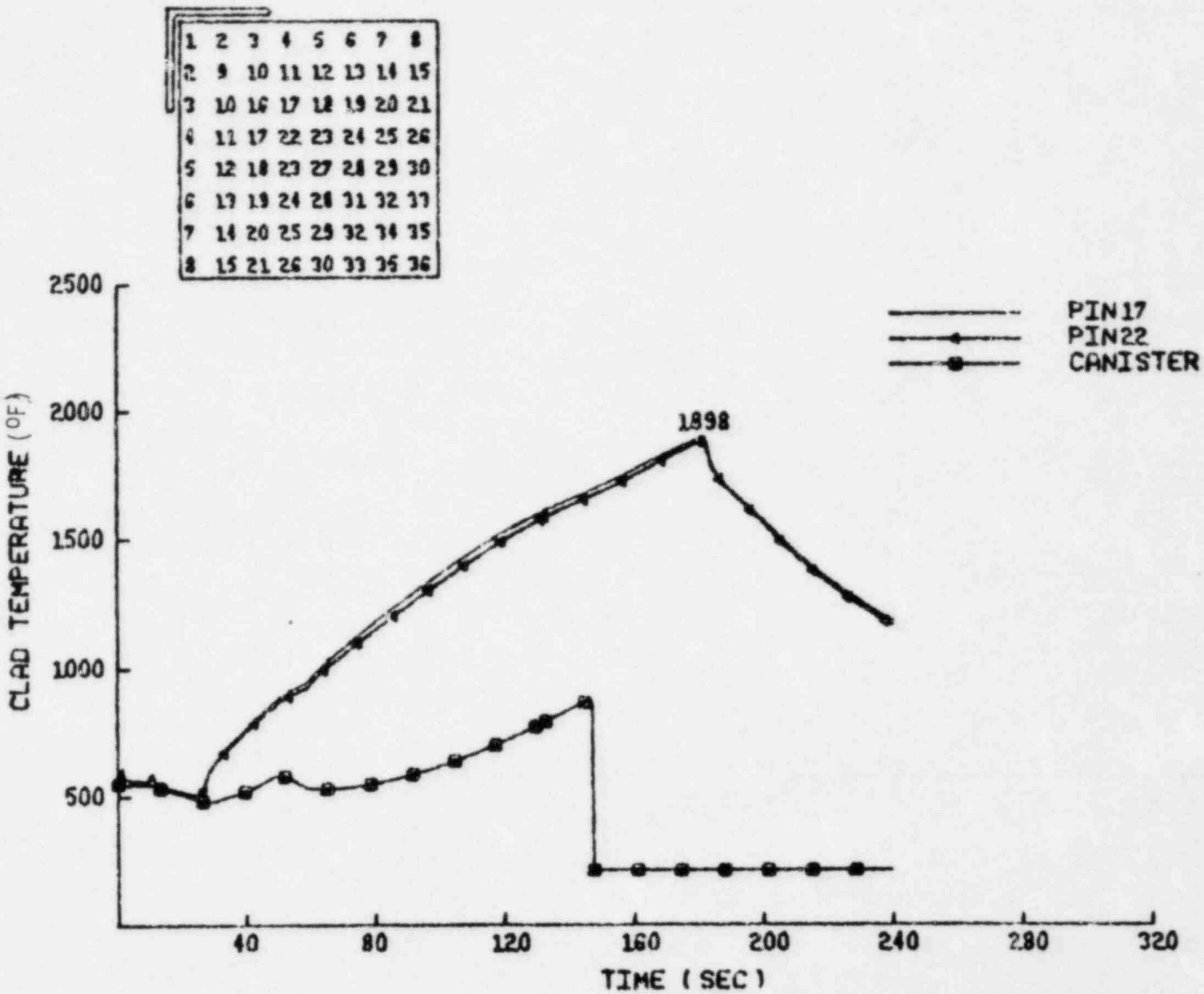


Figure 3.3 Blowdown Hot Channel Center Volume Coolant Temperature for 8x8 Fuel, °F

DRESDEN 2*GAD-HUXY* 1.0 DEG/PS8 * BOL*



4.0 CONCLUSIONS

A LOCA-ECCS analysis has been performed for the Dresden Unit 2 reactor using the EXEM/BWR ECCS Evaluation Model in conformance with Appendix K of 10 CFR 50. The limiting break was identified as the 1.0 DEG break in the recirculation suction piping[4]. The limiting Maximum Average Planar Linear Heat Generation Rates (MAPLHGR) based on this break were developed for ENC fuel for the exposures given in Tables 1.1 and 3.1, and Figure 1.1. These limits apply for ENC XN-1 8x8 reload fuel.

Operation of the Dresden Unit 2 reactor with ENC fuel within the limits defined by Table 1.1 assures that the Dresden Unit 2 Emergency Core Cooling System will meet the acceptance criteria as required in 10 CFR 50.46. That is:

1. The calculated peak fuel element clad temperature does not exceed the 2200°F limit.
2. The amount of fuel element cladding that reacts chemically with water or steam does not exceed 1% of the total amount of zircaloy in the reactor.
3. The cladding temperature transient is terminated at a time when the core geometry is still amenable to cooling. The hot fuel rod cladding oxidation limit of 17% is not exceeded during or after quenching.
4. The system long-term cooling capabilities provided for previous cores remains applicable to ENC fuel.

5.0 REFERENCES

(1) Exxon Nuclear Company, "Exxon Nuclear Methodology for Boiling Water Reactors, Volume 2, "EXEM: ECCS Evaluation Model Summary Description", XN-NF-80-19(A), Revision 1, Volume 2 dated June 1981.

(2) Exxon Nuclear Company, "Exxon Nuclear Company ECCS Cladding Swelling and Rupture Model", XN-NF-82-07(A), Revision 1, dated November 1982.

(3) United States Nuclear Regulatory Commission, "Safety Evaluation Report on XN-NF-82-07, Revision 1: Exxon Nuclear Company ECCS Cladding Swelling and Rupture Model", October 14, 1982.

(4) Exxon Nuclear Company, "Generic Jet Pump BWR 3 LOCA Analysis Using the ENC EXEM Evaluation Model", XN-NF-81-71(A), dated October 1981.

(5) 10 CFR 50.46 and Appendix K of 10 CFR 50, "Acceptance Criteria for Emergency Core Cooling Systems for Light Water Cooled Nuclear Power Reactors", Federal Register, Volume 39, Number 3, dated January 4, 1984.

(6) Exxon Nuclear Company, "GAPEX: A Computer Program for Predicting Pellet-to-Cladding Heat Transfer Coefficients", XN-73-25, dated August 1973.

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(8) Exxon Nuclear Company, "FLEX: A Computer Code for Jet Pump BWR Refill and Reflood Analysis", XN-NF-80-19(A), Volume 2B, Revision 1, dated June 1981.

(9) Exxon Nuclear Company, "HUXY: A Generalized Multirod Heatup Code with 10 CFR 50 Appendix K Heatup Option - User's Manual", XN-CC-33(A), Revision 1, dated November 1, 1975.

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MAPLHGR RESULTS

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