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ANALYSIS OF DRESDEN UNITS 2 AND 3 OPERATION
WITH ONE RELIEF VALVE OUT OF SERVICE

Prepared by: D.R. Swope
D. R. Swope
BWR Safety Analysis

Reviewed by:
R. E. Collingham, Manager
BWR Safety Analysis

Approved by: R. B. Stout
R. B. Stout, Manager
Licensing & Safety Engineering

Approved by:
G. A. Sofer, Manager
Fuel Engineering & Technical Services

naa

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1.0 INTRODUCTION

In the analysis reported herein, the operation of Dresden Units 2 and 3 with one relief valve (RV) out-of-service is considered. The impact of such operation on the maximum average planar linear heat generation rate (MAPLHGR) and the minimum critical power ratio (MCPR) limits is determined for each of the fuel types currently present in the reactors.

Each of the plants has a pilot actuated combination safety/relief valve (S/RV), four solenoid actuated RVs and safety valves. The purpose of the relief valves and the safety valves is to prevent overpressurizing of the reactor vessel. The relief valves are also designed to depressurize the reactor vessel if certain abnormal conditions occur so that core spray and LPCI systems can operate. These conditions might occur during plant transients or postulated accidents.

Only the relief valves and the relief function of the combination safety/relief valve are considered to fail in this analysis. The potential effect of one RV out-of-service is to change the pressure response of the system during such a transient or accident. This may, in turn, impact the MAPLHGR or MCPR limits. The limiting ASME overpressurization transient analysis for these plants is the closure of the MSIV which did not take credit for any relief valve operation, only safety valve operation; thus, reanalysis of the overpressurization transient is not required to support a relief valve out-of-service.

Presented here then is the evaluation of the impact of operation with one RV out-of-service on the MAPLHGR and MCPR limits. The limiting postulated small break accident is analyzed to evaluate the MAPLHGR limit since RVs do not actuate in large breaks. The limiting load rejection transient is analyzed for the MCPR limit evaluation.

2.0 SUMMARY

2.1 LOSS OF COOLANT ACCIDENT

Small break LOCA analyses were separately performed for ENC 8x8 fuel and GE P8x8R fuel in the Dresden Units 2 and 3 to determine MAPLHGR limits during operation with one relief valve out-of-service. A MAPLHGR multiplier of 0.891 was calculated for ENC fuel, which, if applied to the MAPLHGR limits on ENC fuel for normal operation whenever the plant is operated with one relief valve out-of-service, will assure that 10 CFR 50.46 criteria are met in the event of a LOCA. Table 3.1 presents the resulting MAPLHGR limits for ENC fuel.

For GE P8x8R fuel, a MAPLHGR multiplier of 0.96, when applied to the lower MAPLHGR limits on GE fuel, was confirmed to provide assurance of compliance with the 10 CFR 50.46 criteria. Table 3.2 presents the resulting MAPLHGR limits for GE fuel.

A comparison of Tables 3.1 and 3.2 indicate that when the MAPLHGR multiplier for ENC fuel with one relief valve out-of-service is applied to the higher ENC MAPLHGR limits, it results in a higher allowed MAPLHGR than for the GE fuel under the same conditions. Note that limits on GE fuel are expressed as a function of average planar exposure whereas limits on ENC fuel are expressed as a function of bundle average exposure.

2.2 TRANSIENT ANALYSIS

The load rejection transient event, which yields the most limiting thermal margin with all RV's in service, was analyzed to determine the impact of operation of Dresden Units 2 or 3 with one RV out-of-service. There was no impact on thermal margin (MCPR) limits because relief valve pressure settings were not attained until after the time of minimum MCPR. A minimal impact on peak pressure was found and no pressure limits were exceeded. Thus, no technical specification changes are required to protect thermal margin criteria during such operation.

3.0 LOSS OF COOLANT ACCIDENT

3.1 ANALYTICAL APPROACH

A potential for increase in the calculated peak cladding temperature (PCT) for a LOCA while operating with one RV out-of-service exists only if the RV is actuated to depressurize the coolant system. A large break LOCA will not be affected because the break itself rapidly reduces the system pressure and the Automatic Depressurization System (ADS), of which the RVs are a part, is not required to operate. During a small break of less than approximately 0.2 ft^2, the ADS may be required to reduce system pressure to the point where the low pressure ECCS systems can operate. If the worst case single failure is assumed, in this case, of the High Pressure Coolant Injection system (HPCI), the transient is dominated by the time required to depressurize the system. With an RV out-of-service, this time will increase, resulting in a higher PCT than if all RVs were functioning.

A previous analysis, prepared by the General Electric Company (GE) for the Quad Cities Units 1 and 2(1), indicated that the most limiting small break with one RV out-of-service is a 0.05 ft^2 recirculation line break with a failure of the HPCI. The GE calculations showed that MAPLHGR reductions are needed to assure compliance with the 2200°F PCT limit.

The Quad Cities plants and the Dresden Units 2 and 3 are all BWR/3's with similar performance characteristics. The reactor vessel water level, system pressure and heat transfer coefficient (HTC) reported in the GE analysis for Quad Cities were judged to be applicable to the Dresden Units as boundary conditions for the small break LOCA calculation with one RV out-of-service. The NRC approved ENC EXEM/BWR Evaluation Model was applied for the fuel heatup calculation, using the system boundary conditions from the Quad Cities analysis. The system pressure was used directly in the heatup calculation, and to calculate the fluid saturation temperature for the heatup calculation. The water level was used to specify the quality at the plane of interest for the heatup calculation, and the heat transfer coefficient was used directly.

The first task in this analysis was a heatup calculation of the GE fuel as a comparison of the ENC model with the GE model. This calculation was identical to the GE Quad Cities heatup calculation except the ENC EXEM/BWR heatup model, HUXY(2), was used. The RODEX2(3) fuel properties code was used to determine the exposed fuel rod properties at the start of the transient. An exposure of 15,000 MWD/MTM was used since this is the most limiting exposure for GE P8x8R fuel. The fuel rod properties thus obtained were input along with the boundary conditions from the GE Quad Cities report, to the HUXY code which performs the actual heatup calculation. The local power peaking distribution as predicted by XFYRE(4) for GE fuel at this exposure was used.

The second task in this analysis was to perform a similar heatup calculation of ENC fuel. This was accomplished in a manner identical to the above procedure, obtaining fuel properties from RODEX2 and the local power distribution from an XFYRE calculation at an exposure of 15,000 MWD/MTM, and system boundary conditions from the GE Quad Cities report.

3.2 RESULTS

The system conditions of the limiting small break(1) are as follows. After break initiation (at zero time) and scram on high drywell pressure, the water level drops below the top of the active fuel at approximately 260 s. The core level which would experience the highest PCT uncovers at about 313 s. LPCI flow begins at 540 s., and rewetting of the plane of interest occurs at about 590 s. These event times determine the heat transfer coefficient (HTC) to be applied in the heatup analysis and correspond to the times when the HTC changed as reported by GE in Figure 2 of Reference 1: an HTC of 10,000 Btu/hr-ft^2-F is used until uncovery at 313 s., a HTC of 0.0 between 313 s. and 589 s., and an HTC of 25 Btu/hr-ft^2-F after reflood at 589 s.

Figure 3.1 shows the ENC calculation of PCT for GE fuel. Points from the GE calculation (Figure 2 of Reference 1) are plotted on Figure 3.1 for comparison. The GE and ENC calculations give essentially identical results between 0 and 313 s. when the heatup begins, and very good agreement through the heatup period and beyond the time of PCT. The PCT calculated by GE is approximately 2200°F while that calculated by ENC is 2195°F. The ENC calculation used the same MAPLHGR as the GE calculation (11.58 kw/ft).

Figure 3.2 shows the heatup calculation for ENC fuel at the same MAPLHGR of 11.58 kW/ft. The PCT is 2173°F, 22°F below the PCT predicted by HUXY for GE fuel. The limiting ENC rod 22, is a lower powered rod than the limiting GE rod 27, and has a lower initial stored energy than does the GE rod (100°F lower fuel average temperature). This difference in stored energy is only about 20°F by the time of uncovery and then, due to higher power in the GE rod, increases again during the heatup to about 30°F at the time of PCT. The clad temperatures are identical until the time of uncovery and tend to follow the fuel average temperature during the heatup. All ENC rods with power similar to the limiting GE rod are nearer the canister wall (the limiting GE rod being as far away as possible) and realize better radiative heat transfer during the latter part of the heatup. This can be seen in the plot of the clad temperature of the highest powered ENC rod 13, in Figure 3.2.

3.3 MAPLHGR MULTIPLIER

A MAPLHGR multiplier for ENC fuel is calculated from the normal MAPLHGR(5) in the same manner as was done for GE fuel in Reference 1:

$$\text{Multiplier} = \frac{11.58}{(\text{Maximum MAPLHGR})} = \frac{11.58}{13.} = 0.891$$

For the 9x9 LTAs in Dresden Unit 2, MAPLHGR limits for normal operation were determined by inverse proportion to the number of fueled rods as compared with ENC 8x8 fuel at the same planar power. Thus, the MAPLHGR multiplier calculated above for ENC 8x8 fuel will also be applied to the 9x9 LTAs. Applying this multiplier over the full range of exposure yields the results presented in Table 3.1 for ENC fuel.

Since the ENC heatup calculation for GE P8x8R fuel was virtually identical to that reported by GE in Reference 1, the MAPLHGR multipliers reported in Reference 1 are shown to also be valid for GE fuel in Dresden Units 2 and 3. These multipliers are:

for GE 8x8 fuel, 0.99;
for GE 8x8R fuel, 0.97;
and for GE P8x8R fuel, 0.96.

Applying these multipliers over the range of exposures yields the results in Table 3.2 for GE fuel.

Table 3.1 MAPLHGR for ENC Fuel with Relief Valve Out-of-Service

Bundle Average Exposure MWD/MTM	8x8		9x9	
	Normal MAPLHGR kW/ft	Reduced MAPLHGR kW/ft	Normal MAPLHGR kw/ft	Reduced MAPLHGR kw/ft
0	13.0	11.58	10.24	9.12
10000	13.0	11.58	10.24	9.12
15000	13.0	11.58	10.24	9.12
18000	12.85	11.45	10.12	9.01
20000	12.6	11.22	9.92	8.84
25000	11.95	10.64	9.41	8.38
30000	11.2	9.98	8.82	7.86
35000	10.45	9.31	8.23	7.33

Table 3.2 MAPLHGR for GE Fuel with Relief Valve Out-of-Service

Average Planar Exposure* MWD/MTM	Reduced MAPLHGR		
	8x8	8x8R	P8x8R
200	10.99	11.29	11.00
1000	11.19	11.29	11.10
5000	11.78	11.48	11.38
10000	11.98	11.58	11.58
15000	12.08	11.58	11.58
20000	11.88	11.38	11.38
25000	11.38	10.99	10.81
30000	10.49	10.41	10.24

* Note: An average planar exposure of 30000 MWD/MTM corresponds approximately to a bundle average exposure of 25000 MWD/MTM.

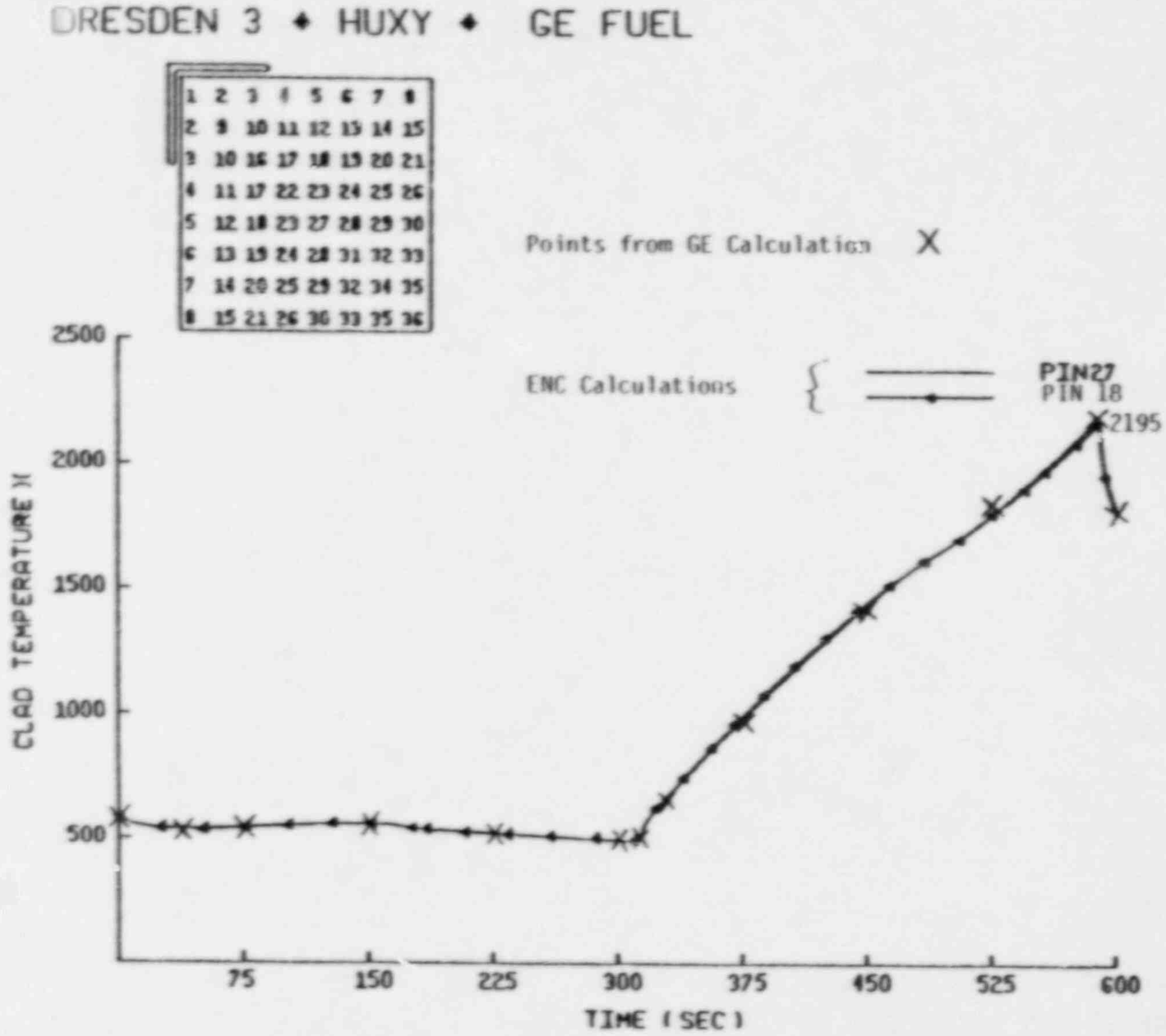


Figure 3.1 GE P8x8R Hot Assembly Heatup, 0.05 ft^2 Break With One Relief Valve Out of Service

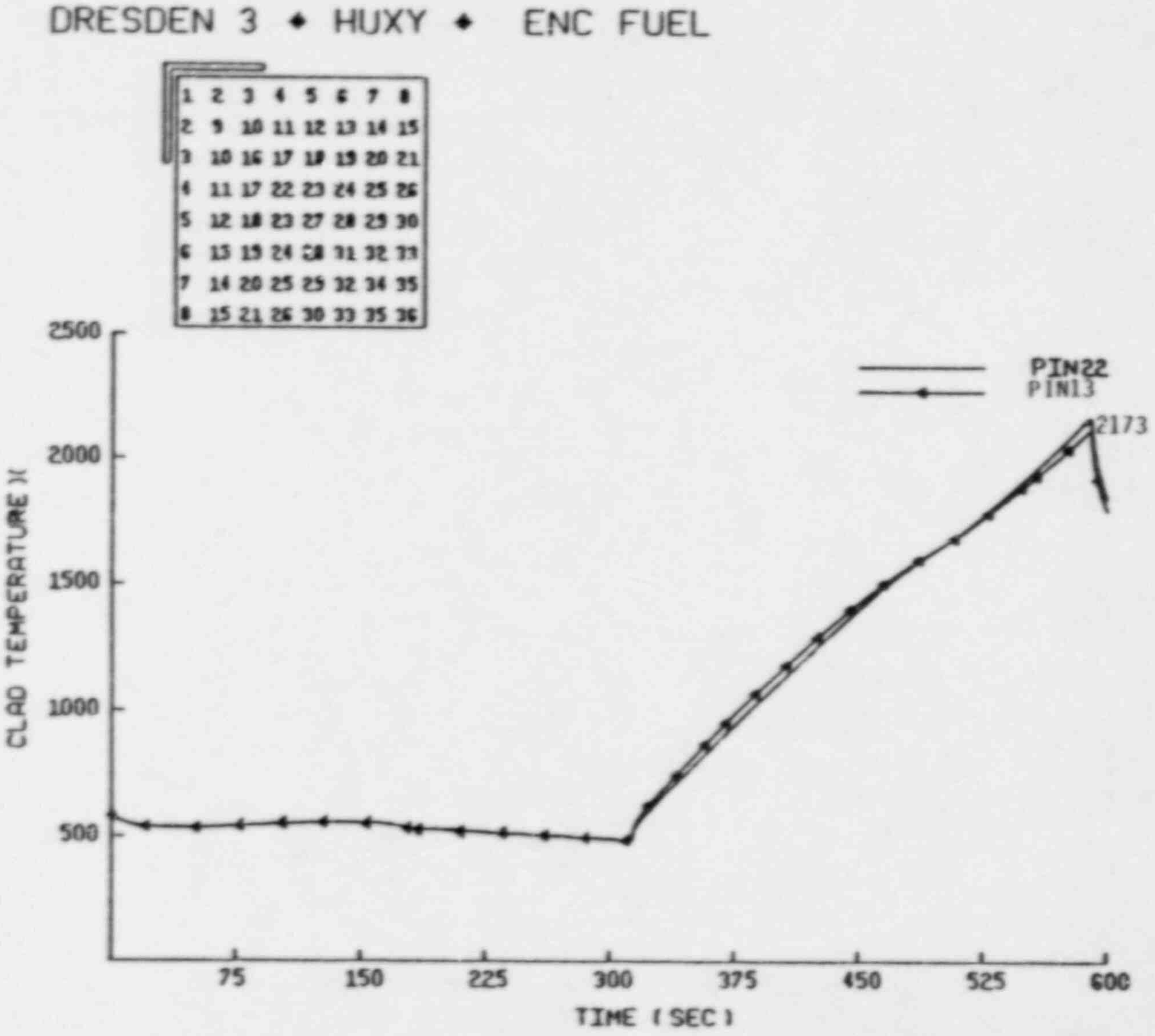


Figure 3.2 ENC Fuel Hot Assembly Heatup, 0.05 ft^2 Break With One Relief Valve Out of Service

4.0 TRANSIENT ANALYSIS

4.1 ANALYTICAL APPROACH

Operation of Dresden Units 2 or 3 with one RV out-of-service could affect the maximum change in the critical power ratio (ΔCPR) in the event of an abnormal operating transient. Previous ENC analyses(6) for the Dresden reactors found that the transient which gave the most limiting ΔCPR was the load rejection without bypass transient (LRWB). If an RV is out-of-service there is the potential for a larger ΔCPR because of higher pressure and associated reactivity during the LRWB event.

The COTRANSA BWR plant transient analysis code was previously applied for an extensive study(6) of the LRWB event, including sensitivity studies relating the calculated ΔCPR to important input parameters. The COTRANSA input data was modified to analyze the LRWB event assuming the plant was being operated with an RV out-of-service. It was then possible to determine if the prediction of CPR was affected by the assumption of one RV out-of-service.

A total of four COTRANSA calculations were made during this study. The first calculation was made assuming that the S/RV was out-of-service with respect to its relief mode. This valve has the highest capacity of all the RVs. It is set to open in its relief mode at 1149.7 psia, but if the relief function is out-of-service it will open in its safety mode at 1161.2 psia. This calculation was made assuming the nominal values for the input parameters describing the initial conditions prior to the transient and other boundary conditions important to the analysis of an LRWB transient.

In the second analysis, one of the two valves with the lowest opening pressure was assumed to fail. The opening setting for this valve is 1129.7 psia. Nominal conditions were also used in this calculation.

A separate calculation was not made for a failure of either of the final two RVs. These valves open at the same pressure as the S/RV but have a lower capacity and will therefore have less impact on the transient than will the S/RV. They have the same capacity as the two valves with lowest opening pressure, but will open later and again have less impact.

The third and fourth calculations were identical to the first and second calculations respectively, except three parameters were varied as specified in Reference 7 to create a "worst case" situation in terms of the ΔCPR calculation. These three parameters are the rate of travel of the control rods, the delay time between the scram signal and the beginning of the movement of the control rods, and weighting of the relative reactivity feedback functions of the moderator density and the control rods. The minimum specified control rod velocity, 100 cm/s (nominal 140 cm/s), and the maximum specified scram delay, 290 msec (nominal 223 msec), were modeled consistent with Reference 7. Also, the weighting of the relative reactivity feedback of the control rods was reduced 20% while the moderator density feedback function was increased 10%. These changes would tend to increase the ΔCPR and cause the time at which the lowest CPR occurs to be later in the transient. Therefore, the effect of reduced RV capacity on the Δ CPR calculation was bounded.

4.2 RESULTS

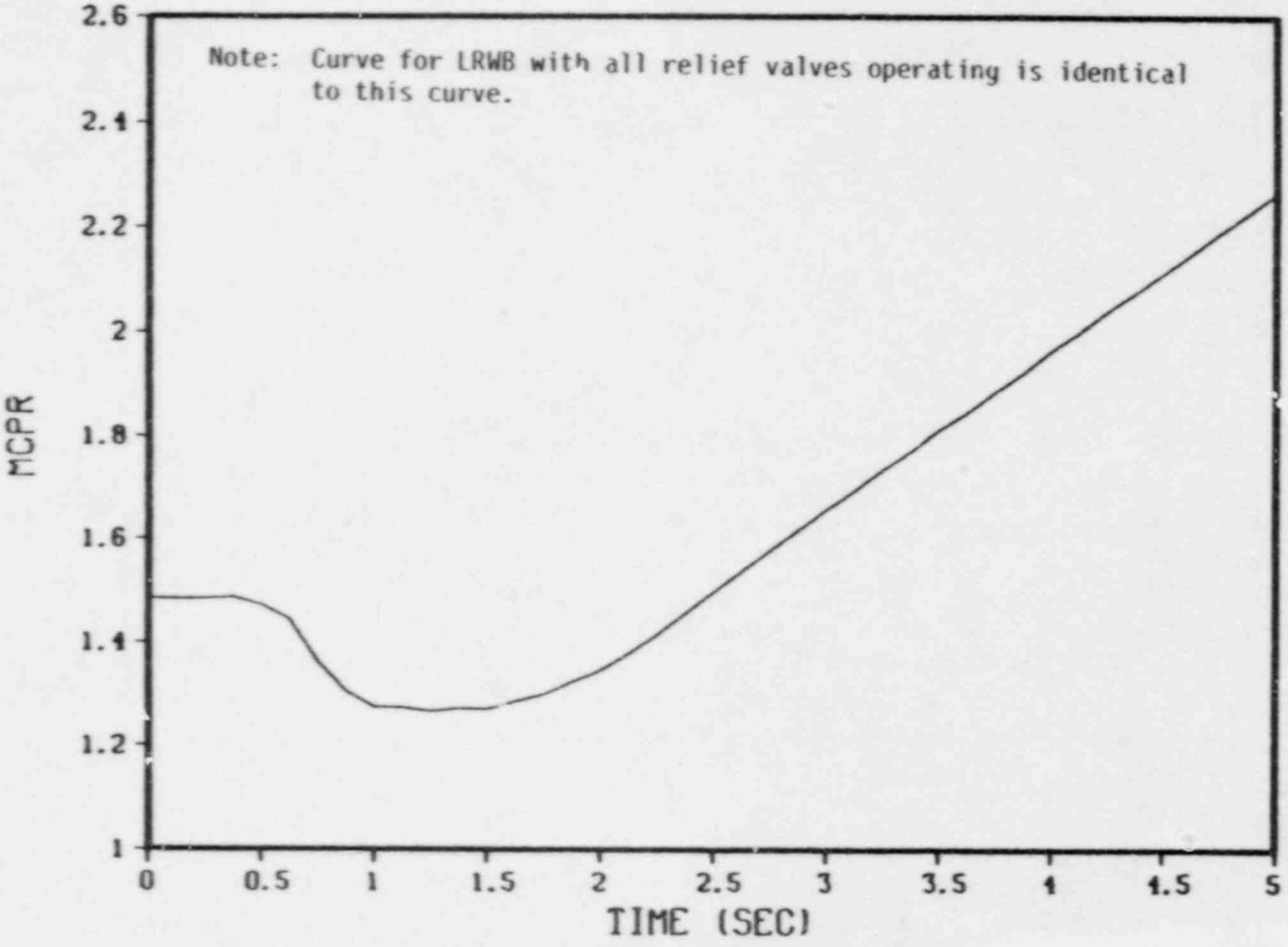
In the previous studies of plant transients for Dresden Units 2 and 3, the time of lowest CPR for the LRWB event was always around 1.0 s., and in no case was it later than 1.2 s. By contrast, the RVs started to open after 1.8 s. The four COTRANSA calculations made for this study, therefore, are identical to the corresponding calculations of the previous studies up until the relief valves begin to open (Figures 4.1 and 4.2). Since this time is well beyond the time of lowest CPR calculated for ENC 8x8 and 9x9 fuel and GE fuel, the previous HUXY-XCOBRA calculations of maximum [illegible]PR apply also to cases with one RV out-of-service. The analyses herein [illegible] carried past the time of relief valve openings to confirm that the time of lowest CPR did not occur later in the transient.

The limiting overpressurization transient for Dresden 2 and 3(6) is the MSIV closure which did not take credit for the relief valve operation. Thus, it does not need to be rerun. The peak pressures during the LRWB are presented here only for informational purposes. A peak pressure of 1270 psia at 3.75 s. occurred in the analysis with all the RVs operating normally. The peak pressure was 1271 psia at 3.87 s. for the case with the S/RV out-of-service in its relief function and 1275 psia at 4.0 s. for the case with the low-opening-pressure RV out-of-service. Thus, no significant differences in the peak pressure were noted for the three analyses.

In the two worst case calculations, the peak pressures were somewhat higher. A peak pressure of 1301 psia was predicted for the case with the S/RV out-of-service and a peak pressure of 1313 psia was calculated in the analyses with the RV out-of-service, both at 4.0 s.

4.3 CONCLUSIONS

These results indicate that with one RV out-of-service there is no effect on ΔCPR calculated for a LRWB transient for Dresden Units 2 and 3, and therefore no impact on the MCPR operating limit considering all fuel types currently installed in these plants.



Note: Curve for LRWB with all relief valves operating is identical to this curve.

Figure 4.1 MCPR vs. Time, Load Rejection Without Bypass with One Relief Valve Out-of-Service

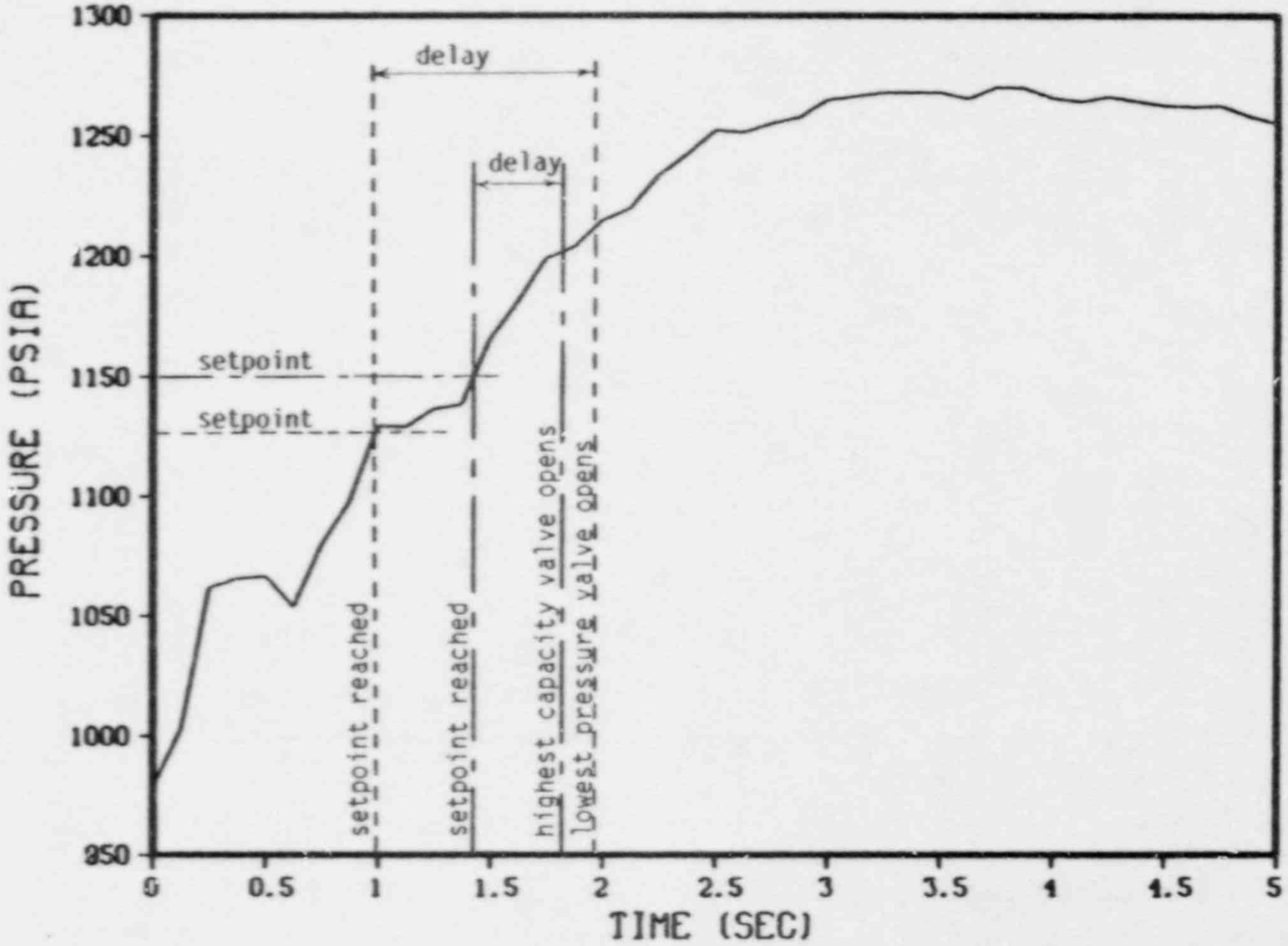


Figure 4.2 Steam line Pressure at Relief Valves vs. Time During the LRWB Transient with All Relief Valves Operating

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