Attachment 7

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DRESDEN AND QUAD CITIES

NUCLEAR POWER PLANTS

SUPPLEMENT TO NEDO-21778-A

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ABSTRACT

An evaluation of the transient vessel pressure rise due to a control rod drop accident applicable to the Dresden 2/3 and Quad Cities 1/2 plants is made for various initial vessel water levels and temperatures. The results demonstrate maximum pressure rises less than those reported in a similar analysis for a generic plant.

1. INTRODUCTION

In an evaluation of BWR fracture toughness requirements (Reference 1), a bounding analysis for the transient vessel pressure rise due to a Control Rod Drop Accident (CRDA) was performed on a generic basis. The results of this analysis were successfully used to justify a modification of the requirements for the minimum permissible temperature of the Reactor Pressure Vessel (RPV) when the core is critical, as set forth in paragraph IV.A.2.c of 10CFR50, Appendix G. Although the analysis indicated a maximum calculated RPV pressure rise of 12.5 psi, a value of 25 psi was used to provide margin in justifying relaxed minimum RPV temperature requirements.

The purpose of this analysis is to demonstrate agreement with the 25 psi value for a CRDA specifically evaluated for the Dresden 2/3 and Quad Cities 1/2 plants, over a range of initial vessel water levels and temperatures. The results of this analysis would then show that no operator action to alter vessel conditions (such as opening the vessel head vent) is necessary over this range of shutdown conditions. By demonstrating compliance with 10CFR50 Appendix G, the vessel pressure and temperature criticality limits are deemed valid for the Dresden and Quad Cities plants.

The assumptions used in this analysis are the same as those reported in section 3.2.4 of the previous evaluation, with the exception that the volume of water assumed to be heated by the energy release due to the CRDA is that from the bottom of the active fuel (BAF) to the normal water level within the core shroud. The earlier analysis assumed a water volume from the top of active fuel (TAF) to the normal water level within the core shroud. This is reasonable since the in-core water is expected to be involved in the heat transfer process; in fact, the in-core water must be heated first before the water above the TAF could heat up. It should be noted, however, that this assumption is still conservative since all the water outside the core shroud and below the core is excluded.

2. DISCUSSION

The CRDA at shutdown was determined (reference 1) to be the limiting transient with regard to overstress of the RPV from a malfunction during the control of reactivity. Due to the large time constant for the process of heat transfer to the water, no significant nuclear-to-mechanical energy conversion is possible, based on the experimental results reported in section 3.2.3 of reference 1. Therefore, the only transient pressure rise due to a CRDA is due to steam formation in the vessel.

A conservative value of 6530 MW-sec net energy deposition (including prompt moderator heating effects) in the fuel was used in reference 1 for a typical reactor, assuming a peak fuel enthalpy of 280 cal/gm. This value for the net energy deposition is also used in the current analysis, although values of approximately 4000 MW-sec are more typical for the Dresden and Quad Cities plants.

The initial conditions assumed in this analysis are given in Table 1. The air content is such that a conservatively high initial pressure of 60 psia exists in the RPV. As determined in reference 1, the highest system pressure rises due to a CRDA are obtained for highest initial partial pressures of air, due to the expansion of additional air.

The analysis performed to obtain the resultant pressure rise due to a CRDA is based on the following assumptions:

(1) The water and vapor initially exist in a state of saturated equilibrium.

(2) The energy generated in the CRDA is transferred to the bulk water inside the shroud and above the BAF, thereby raising the bulk water temperature, and vaporizing a portion of the water which creates a new state of saturated equilibrium.

(3) Only the volume of water in the region from the BAF to the normal water level inside the core shroud is heated. This assumption is based on a lower bound estimate of water volume affected by recirculation flow which mixes the water.

(4) The air and water vapor behave as ideal gases.

(5) There is perfect mixing between the air and vapor.

(6) Maximum pressure rise is obtained by assuming no recondensation of water vapor created due to the CRDA.

(7) Heat transfer with the vessel wall and internals is ignored.

TABLE 1

INITIAL CONDITIONS FOR PRESSURE RISE CALCULATIONS

Parameter	Value
Temperature of System (Water and Air)	100°F-175°F
Pressure of system (saturation pressure of water plus air pressure)	60 psia
RPV water level	Normal Water Level, High Water Level, Main Steam Line Elevation, and 780 inches above vessel bottom
Free volume above water level (air and water vapor)	6635.1 ft^3, 6358.5 ft^3, 4595.6 ft^3 and 384 ft^3
Volume of water	3047 ft^3

3. RESULTS AND CONCLUSIONS

The maximum resultant pressure rise due to a CRDA is calculated to be 15.8 psi, corresponding to a 175°F initial RPV temperature and a vessel water level at 780 inches above vessel bottom. Since changes in vapor pressure are more sensitive to changes in the saturation temperature at higher temperatures, the maximum pressure rise is expected for a higher initial RPV temperature. Also, the maximum analyzed water level gives the minimum steam and air mass, at the same initial pressure (60 psia). Given the same energy addition, this will result in higher pressure rises due to increased expansion of air, although this effect is secondary compared to the effect of higher initial RPV temperatures for large initial air volumes. However, as the air volume gets very small the pressure rise approaches the case of no air, where relatively small temperature (hence specific volume) changes result in large pressure changes, since water is nearly incompressible.

The results for all cases analyzed are summarized in figure 1. Here the sensitivity to initial RPV temperature is seen. A 17 percent increase in temperature (°F) gives an increase in pressure rise of up to 28 percent. The sensitivity to initial water level appears as a 2.5 percent increase in pressure rise for a 10 percent increase in water level for large initial air volumes. However, as the initial air volume is reduced to small values, the pressure rise due to the CRDA is much more sensitive to initial water level.

Since the maximum RPV pressure rise due to a CRDA for the Dresden and Quad Cities plants is found to be less than the value of 25 psi reported in reference 1 over a range of shutdown conditions, the conclusions of reference 1 apply to the Dresden and Quad Cities plants over this range of shutdown conditions. Therefore, the justification for relaxed minimum RPV temperature requirements during criticality presented in reference 1 applies to the Dresden and Quad Cities plants over the range of shutdown conditions analyzed and no change is required in the present criticality limits.

CECO CRDA VESSEL PRESSURE RISE

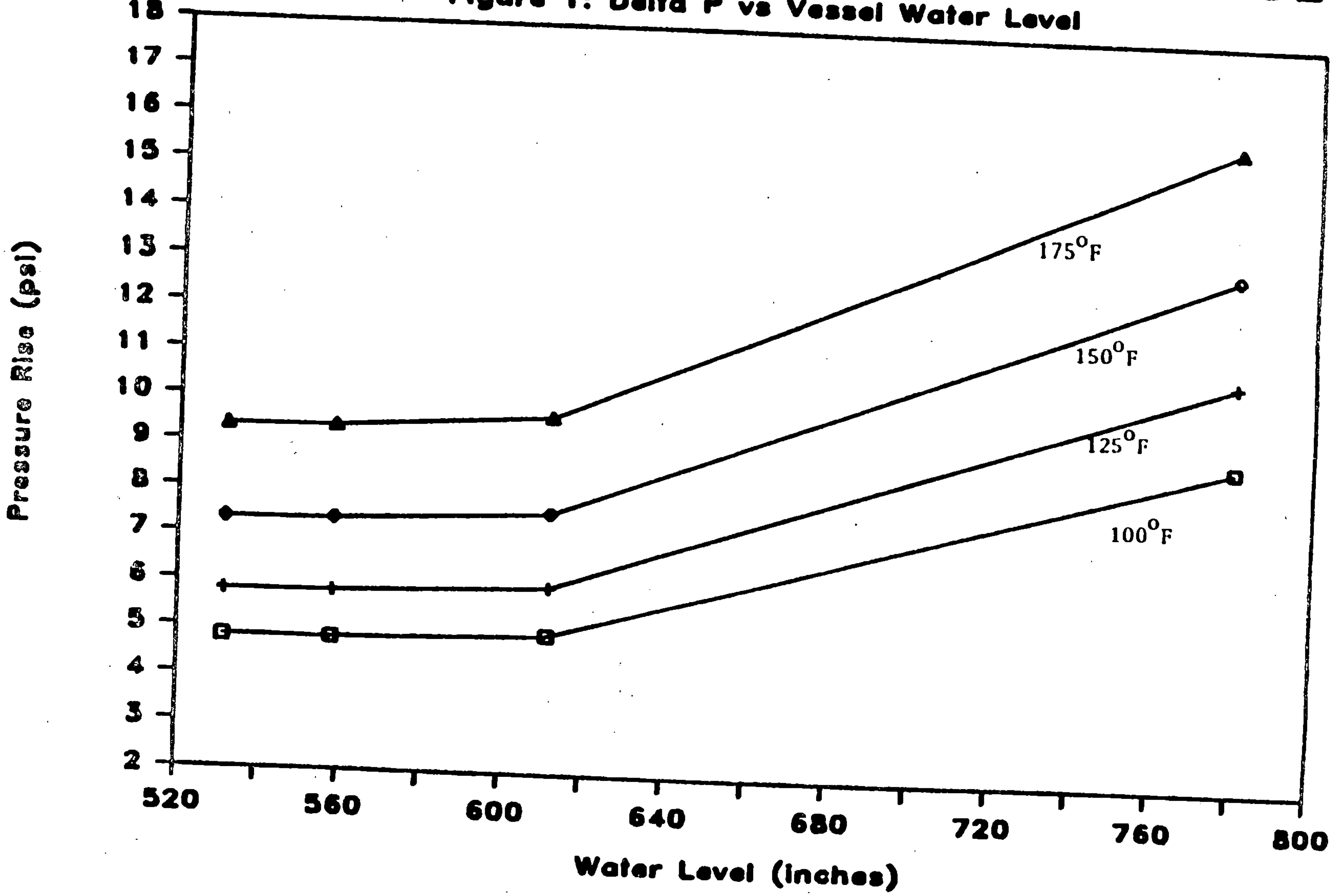

Figure 1: Delta P vs Vessel Water Level

4. REFERENCES

1. F.E. Cooke, et.al., "Transient Pressure Rises Affecting Fracture Toughness Requirements For Boiling Water Reactors", Licensing Topical Report, NEDO-21778-A, December 1978.

Dresden/EHH