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EVALUATION OF THE EFFECT ON PLANT OPERATION OF MSIV LOW TURBINE INLET PRESSURE ISOLATION SETPOINT CHANGE AT PILGRIM NUCLEAR POWER STATION

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ILLUSTRATIONS

1. INTRODUCTION

The purpose of this analysis is to document the evaluation of the effect on plant operation associated with reducing the main steam isolation valve (MSIV) low pressure isolation analytical limit* from the present setting of 880 psig to 750 psig at the Pilgrim Nuclear Power Station (PNPS).

The MSIV low pressure isolation setpoint is a part of the reactor vessel isolation control system, and its main purpose is to prevent excessive vessel depressurization. Lowering the setpoint introduces the possibility that the vessel will depressurize for a longer time period prior to isolation. Two items warrant consideration due to the extended depressurization time. First, the thermal gradient and resulting thermal stress imposed upon the vessel and internals will be larger due to the lowered isolation pressure setpoint. The results of the thermal stress evaluation and other safety issues are documented in Reference 1. Secondly, the extended vessel depressurization results in more coolant voiding and consequently the potential for a higher bulk water level swell. This document describes the analysis performed to evaluate the impact of the water level swell on plant operation for PNPS.

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*The term "analytical limit" is defined as the value of the sensed process variable established as part of the safety analysis, prior to which a desired action is to be initiated to prevent the process variable from reaching the associated design safety limit.

2. BACKGROUND

The single failure which produces the highest depressurization rate and consequently the maximum level swell is the Pressure Regulator Failure (open) transient. This failure results in the highest level swell when initiated from low power conditions. Under these conditions the low pressure MSIV isolation may occur when the water level in the vessel is above the steamline nozzle. Thus, the MSIV closure may result in some liquid being trapped in the steamlines between the vessel and the inboard MSIV. If this occurs, there is a potential that the safety relief valves (SRVs) may be required to open, discharging high pressure liquid or two phase flow.

Previous analyses (Reference 2) have been performed which conservatively estimate the quantity of trapped liquid in the steamlines due to the initiation of the Pressure Regulator Failure (open) transient from a low reactor power. These analyses were performed for a BWR plant with both full and partial bypass capacity, and at an MSIV low pressure isolation setpoint of 825 psig. The results of these analyses demonstrated that the quantity of trapped liquid in the steamlines was not sufficient to fill the portion of the steamline where the relief valves are mounted, thereby demonstrating that the SRVs would not be required to discharge high pressure liquid or two phase flow.

The probability of this transient occurring at low power levels, below 40%, is extremely low ($4x10^{-4}$/yr), mainly due to the infrequent operation at these low power conditions. For reactor powers of greater than 40% the probability increases to less than $6x10^{-2}$/yr (Reference 2). As the reactor power increases, however, the consequences of level swell are reduced because the depressurization rate caused by the Pressure Regulator Failure (open) transient is slower. This results in lower peak water level swells and a decrease in the predicted quantity of liquid trapped in the steamlines.

In conclusion, if it can be shown that the quantity of liquid trapped in the steamlines does not impact SRV performance, then no operational concerns will arise due to the reduction of the MSIV low pressure isolation analytical limit to 750 psig.

3. SUMMARY AND CONCLUSIONS

A Pressure Regulator Failure (open) transient was simulated for the PNPS from low power conditions with a MSIV low pressure isolation analytical limit of 750 psig. The intent of the analysis was to quantify the amount of liquid predicted to be trapped in the steamlines. From this analysis it was determined that the water level did not increase to the bottom of the steamline elevation. Hence, no liquid would be trapped in the steamlines as a result of the transient and consequently SRV performance is not impacted.

Therefore, it is concluded that reducing the MSIV pressure isolation analytical limit to 750 psig will not introduce any operational concerns at PNPS.

4. ANALYSIS

In order to determine if plant operation is impacted it is necessary to evaluate the quantity of trapped liquid in the steamlines with the reduction of the MSIV low pressure isolation limit from 880 psig to 750 psig. This is done by examining the results of the Pressure Regulator Failure (open) transient. The maximum amount of liquid predicted to be trapped in the steamline is obtained by initiating the transient from a low power condition. Thus, the analysis is bounding for all possible operating power/flow conditions.

4.1 Simulation of the Pressure Regulator Failure (Open) Event

The turbine at PNPS is provided with two pressure regulators. These two regulators have slightly different pressure setpoints such that one functions as a controlling regulator and the other as a backup pressure regulator. The controlling pressure regulator is used to control both the turbine control valves and the turbine bypass valves to maintain constant turbine inlet pressure. If either the controlling pressure regulator or the backup pressure regulator fails in an open direction, it will cause the main turbine control valves to respond by opening further, thus increasing steam flow and dropping turbine inlet pressure. In a short time, the pressure drops to the MSIV closure (MSIVC) setpoint which initiates isolation followed by a reactor scram. The depressurization of the reactor may also cause an increase of the bulk fluid void volume which can produce a level swell. If the resulting depressurization is rapid, the vessel water level may reach the high trip level (Level 8) before the turbine inlet pressure drops to the MSIV low pressure isolation setpoint. In this case, the high level trip initiates a main turbine stop valve closure (MTSVC) and possibly a feedwater pump trip. The MTSVC in turn initiates reactor scram. With MSIVC or MTSVC (whichever occurs first) the pressure decrease will ultimately be terminated by the MSIV low pressure isolation.

The severity of the water level swell is directly related to both the vessel depressurization rate and the initial power level assumed for the Pressure Regulator Failure (open) transient. The most severe water level swell is achieved when the Pressure Regulator Failure (open) transient is assumed to occur at initial conditions of 2% power/30% flow. The low power level is more severe because at a lower initial power there is proportionally less steam generation which produces a more rapid blowdown. This results in more flashing and a higher water level swell.

The GE thermal-hydraulic and nuclear kinetics coupled transient code, REDY (Reference 3), is used to evaluate the dynamic system response to the Pressure Regulator Failure (open) event previously discussed. The following basic assumptions and initial conditions are used:

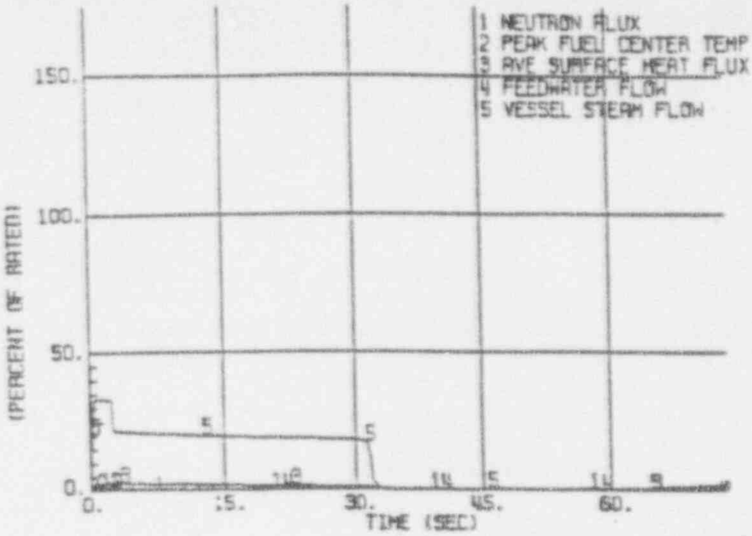
1. The initial reactor power is at 39.96 MWt (2% rated).
2. Initial dome pressure is 963 psia.
3. Initial core flow is 30% of rated core flow.
4. Conservative end-of-cycle scram, void and doppler reactivity are assumed, based on Cycle 7 fuel loading conditions.
5. The scram is initiated by the MSIV closure which actuates the position scram signal.
6. The MSIV closure time is 5 seconds.
7. The turbine bypass valves, with 25% capacity, are open for faster depressurization.
8. The pressure regulator upper limit is set at 125% of steam flow demand.

4.2 Results of the Pressure Regulator Failure (Open) Event

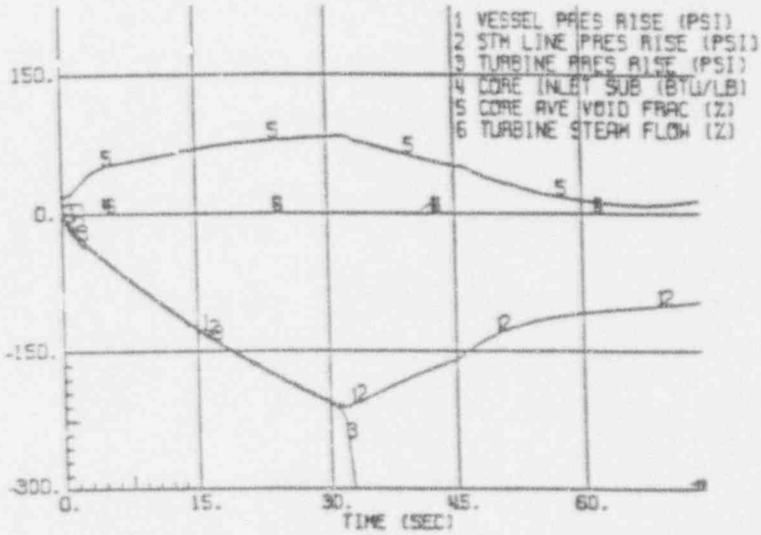
The results of the Pressure Regulator Failure (open) transient calculation are presented in Figure 4-1 for the MSIV low pressure isolation setpoint of 750 psig. In both figures the vessel steam flow (curve a.5) initially increases rapidly as the turbine control valves open due to the pressure regulator failing in the open direction. With the high steam outflow, the vessel depressurizes (curve b.1) which causes the water level to swell as the bulk fluid void volume is increased (curve c.1 represents the reactor water level inside the dryer skirt). At approximately 2.4 seconds, the water level reaches the high water level (Level 8) setpoint which initiates a MTSVC. A feedwater pump trip occurs shortly thereafter when the water level rises an additional foot to the trip setpoint. The vessel steamflow is reduced to that of the bypass flow due to the MTSVC and the vessel continues to depressurize until the low turbine inlet pressure is reached at 28 seconds. At this time the MSIV closure is initiated. This terminates the vessel depressurization and the level increase, in addition to initiating a reactor scram. After the MSIV closure the vessel begins to slowly repressurize and the reactor water level recedes.

Figure 4-2 shows the reactor water level response outside the dryer skirt relative to the location of the bottom of the steamline. The water level does not reach the steamline elevation during the course of the transient and hence no liquid will be trapped in the steamlines as a result of the MSIV closure.

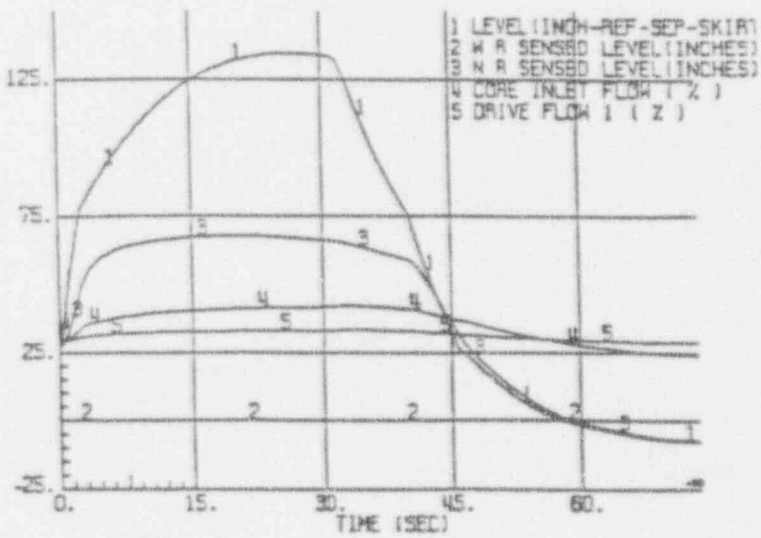
Therefore, from the results discussed above it is concluded that the plant operation at PNPS will not be impacted as a result of reducing the analytical limit of the MSIV low pressure isolation setpoint to 750 psig.



(a)



(b)



(c)

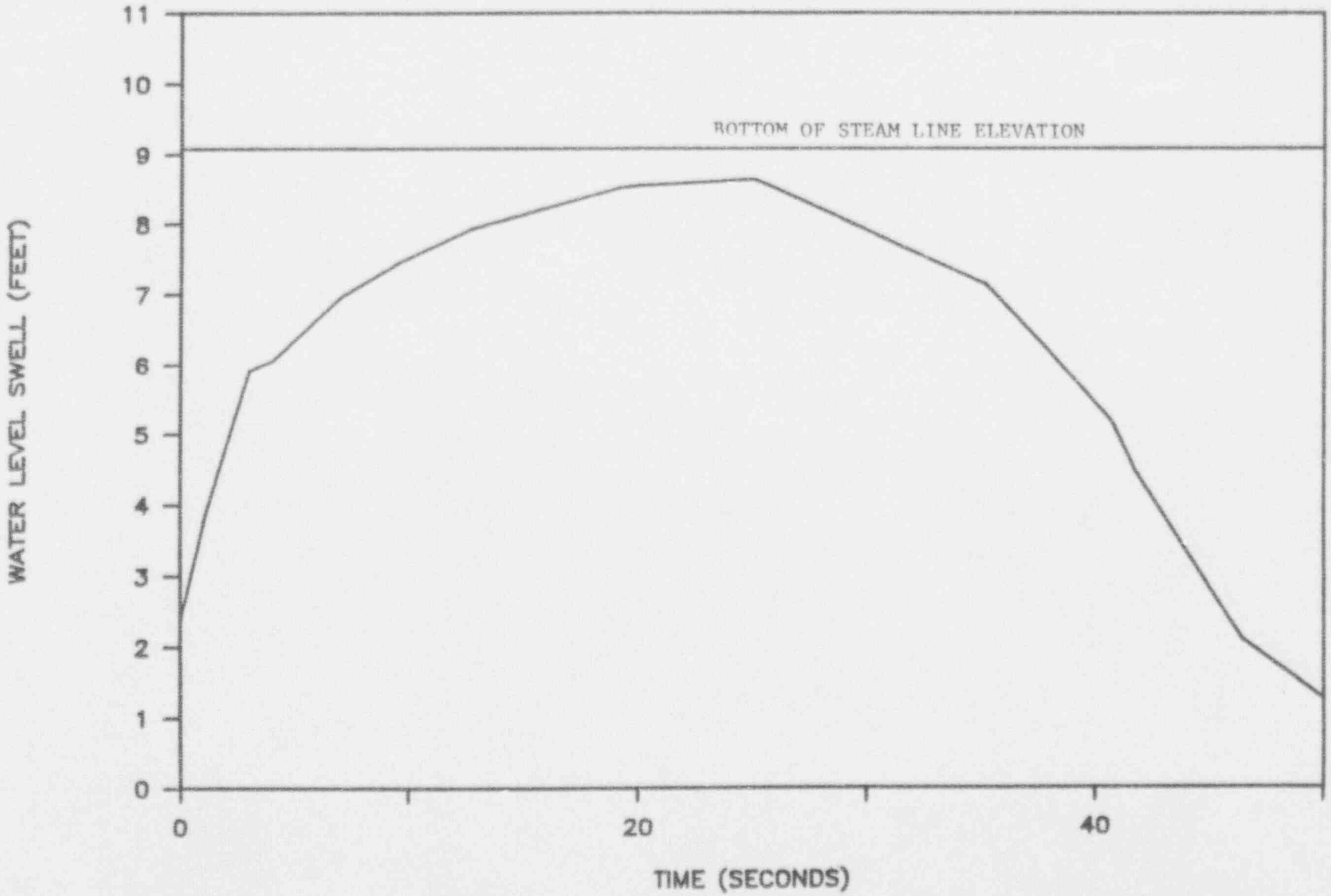
FIGURE 4-1

PRESSURE REGULATOR FAILURE (OPEN) RESPONSE WITH MSIV ISOLATION AT 750 PSIG FOR PILGRIM NUCLEAR POWER STATION

FIGURE 4-2

WATER LEVEL SWELL FOR PRESSURE REGULATOR FAILURE (OPEN)

2% INITIAL POWER, 30% CORE FLOW, PILGRIM NUCLEAR POWER STATION



5. REFERENCES

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2. D. B. Waters, BWR Owners Group, Chairman; letter to R. H. Vollmer, Nuclear Regulatory Commission, Director, dated September 17, 1980. "NUREG-0758 Requirement 2.1.2 - Performance Testing of BWR and PWR Relief and Safety Valves."

3. "Analytical Methods of Plant Transient Evaluations for the General Electric Boiling Water Reactor," General Electric Company, February 1973 (NEDO-10802).

Attachment E to BECo Letter #93-062