Attachment C

R. E. GINNA LOW TEMPERATURE OVERPRESSURE PROTECTION SYSTEM (LTOPS) SETPOINT PHASE II EVALUATION

FINAL REPORT

(NON-PROPRIETARY)

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WESTINGHOUSE ELECTRIC CORPORATION

INDEX

R. E. GINNA LOW TEMPERATURE OVERPRESSURE PROTECTION SYSTEM SETPOINT ANALYSIS

INTRODUCTION

USNRC Regulatory Guide 1.99 Revision 2, "Radiation Embrittlement of Reactor Vessel Materials," dated May, 1988 became official with it's publication in the Federal Register on June 8, 1988. The guide revises the general procedures acceptable to the NRC staff for calculating the effects of neutron radiation embrittlement of the low alloy steels currently used for light water cooled reactor vessels.

Appendix G of 10 CFR Part 50 provides the fracture toughness requirements for reactor pressure vessels under certain conditions. To ensure that the Appendix G limits are not exceeded during anticipated operational occurrence, technical specification pressure-temperature limits are provided during low temperature operations. The embrittlement algorithm specified by revision 2 of Regulatory Guide 1.99 is more conservative than revision 1, and requires that these limits be re-calculated.

The Low Temperature Overpressure Protection System (LTOPS) provides protection against exceeding the vessel ductility limits, as expressed by the Appendix G pressure-temperature limits, during cold shutdown, heatup, and cooldown operations. The limits resulting from implementation of the new revision to Regulatory Guide 1.99, requires that the LTOPS setpoints be re-evaluated. The purpose of this report is to document the re-evaluation.

This report also address the RHR System overpressure protection function of the R.E. GINNA LTOPS.

The organization of this report, apart from the introductory comments and the summary statement, is in three sections. The first and second sections describe, respectively, the justification for the design basis transients and the algorithm used for the setpoint analysis. The third section documents the analysis specific to R. E. Ginna.

Summary of Results

The basis for the R.E. GINNA specific LTOPS evaluations performed was established via a data exchange phase between Rochester Gas and Electric Co. and Westinghouse, as documented in References (a), (b), (e) and (f) and summarized in Parts 3.0 through 3.6 of this document. The setpoint evaluation is discussed in detail in Part 3.6 of this document.

The results of the evaluations have shown that a single PORV setpoint which will concurrently accommodate both the upper pressure limits (21 EFPY isothermal Appendix G and RHR System maximum pressure limits) and the lower pressure limit (the RCP No. 1 seal mininmum pressure requirements) cannot be identified. This situation is not unique to R.E. GINNA. A number of operating Westinghouse plants have a similar situation. To date, when this situation has arisen, the resolution in all cases has been to give precedence to the upper pressure limits, rather than the RCP No. 1 seal minimum pressure requirements and this is the approach taken herein for R.E. GINNA.

Giving precedence to the upper pressure limits yields the following results:

1. A PORV LTOPS setpoint of 424 psig or less will provide overpressure protection with regard to both the RHR System and the 21 EFPY isothermal Appendix G limits.

2. If the RHR System overpressure protection function of the LTOPS can be relinquished a PORV LTOPS setpoint of 537 psig or less will provide overpressure protection with regard to the 21 EFPY isothermal Appendix G limit.

1.0 DESCRIPTION OF THE LOW TEMPERATURE PRESSURE TRANSIENTS

Overpressure protection for the reactor coolant system (RCS) is achieved by means of self-actuated steam safety valves located high in the steam space of the pressurizer. These safety valves have a set pressure based on the RCS design pressure and are intended to protect the system against transients initiated in the plant when the RCS is operating near its normal temperature. To avoid brittle fracture at low reactor vessel metal temperatures, the allowable system pressure is progressively reduced from the nominal system design pressure as temperature is decreased. Therefore, supplemental overpressure mitigation provisions for the reactor vessel must be available when the RCS, and hence the reactor vessel, is at reduced temperatures. This supplemental protection, utilizing the power operated relief valves (PORVs), is known as the Low Temperature Overpressure Protection System (LTOPS).

The PORVs are designed to limit the RCS pressure during normal operational transients when the reactor is at power by discharging steam to the pressurizer relief tank (PRT), thus avoiding the need for the code safety valves to function. The flow capacity and stroke time of the PORVs is selected to avoid a reactor trip during a large step load decrease. In addition, the valves are utilized for pressure relief (water, gas, or a mixture) as a part of the LTOPS, and when performing this function will also discharge to the PRT. The setpoint for the LTOPS function is selected so that if one valve fails to actuate when required, the second valve will be able to mitigate the transient.

1.1 GENERAL DESCRIPTION

The LTOPS is designed to provide the capability, during relatively low temperature reactor coolant system operation, to prevent the RCS pressure from exceeding 10CFR50 Appendix G limits. The LTOPS is provided in addition to the administrative controls to prevent overpressure transients. The system is designed with redundant components to assure its performance in the event of the failure of any single active component. The power operated relief valves

located near the top of the pressurizer, together with additional actuation logic from the wide range pressurizer channels, are utilized to mitigate potential RCS overpressure transients.

1.2 OPERATION

During normal plant heatup, the RCS is operated in a water solid mode until the steam bubble is formed in the pressurizer. During these low-temperature low-pressure operating conditions, the LTOPS is armed and in a ready status to mitigate pressure transients. After the steam bubble is formed and the pressurizer water level is at its normal value for no-load operation, the LTOPS is disarmed and pressure surge control is provided by the steam bubble.

During a normal plant cooldown, the LTOPS is armed as the reactor coolant temperature is decreased below the preset value. At this time there is a steam bubble in the pressurizer and the water level is at the normal level for no-load operation. When the coolant temperature has been reduced to a relatively low temperature, the steam bubble may be quenched and the LTOPS is armed. From this point on in the cooldown, the plant is water solid and the LTOPS is in an active status ready to mitigate those pressure transients that might occur.

When the RCS is operated in the water solid mode, the pressure is automatically controlled by the low pressure letdown control valve in the Chemical and Volume Control System (CVCS). This valve senses the pressure in the letdown line and maintains the pressure at the selected control value by throttling the letdown flow from the RCS. At this time, the charging flow into the RCS is maintained at a constant value by placing the pump speed controller in nominal. It should be noted that the pressure being controlled is that in the letdown line which then indirectly controls the pressure in the RCS. However, if the pressure drop through the RHRS and the bypass line into the CVCS is changed by throttling of valves or changing the flow rate through the RHRS, the RCS pressure will also change since the location of the controlled pressure is in the letdown line.

1.3 POTENTIAL OVERPRESSURE TRANSIENTS

During the startup or shutdown of a plant, there are periods of time when the plant will be operating in the water-solid mode. This is done by bringing the pressurizer water-solid and controlling pressure via operator control of the charging and letdown system. When operating in these modes, RCS pressure control becomes fairly sensitive to any transients due to the relative incompressibility of water.

An important part of RCS overpressure protection during low temperature operation is the use of administrative controls. Operating procedures maximize the use of a pressurizer steam bubble, since the steam bubble reduces the maximum pressure reached for some transients, and slows the rate of pressure increases for others.

The types of transients that cause concern are those that cause a pressure increase in the RCS, potentially to the point of violating the Appendix G pressure-temperature limit. The type of transients that can cause this phenomena can be essentially divided into two categories:

a) mass input events characterized by net mass addition to a constant volume reactor coolant.
b) heat input events characterized by a net energy addition to a closed, essentially constant mass and volume reactor coolant.

1.3.1 Summary of Mass Input Transients

The most limiting mass injection case for R.E. GINNA is the charging/letdown mismatch with three positive displacement charging pumps. Technical Specifications limits on SI pump operability and discharge valve position eliminate the mass injection case due to a high head SI pump. No single operator action or inadvertent SI signal will result in SI injection.

1.3.2 Summary of Heat Input Transients

Base on the Ref(c) and (d) studies four credible heat injection mechanisms were idendified for consideration: actuation of pressurizer heaters, loss of RHR cooling, and two types of reactor coolant loop temperature asymmetry.

1.3.2.1 Actuation of Pressurizer Heaters

The inadvertent actuation of the pressurizer heaters when the pressurizer is filled solid will cause a slow rise in the water temperature with a consequent increase in pressure of the constant volume RCS, if the installed automatic pressure control equipment is not in service. Since the pressure transient is very slow, the operator should recognize and terminate the transient before an unacceptable pressure is reached. If the operator does not intervene and stop the transient, the pressure increase will be terminated by the LTOPS with little or no overshoot above the PORV setpressure. This case is not considered significant to the design of the LTOPS.

1.3.2.2 Loss of RHR Cooling

A loss of residual heat removal cooling while the pressurizer is filled solid could be caused by a loss of flow malfunction in the component cooling water or the service water systems, or the closure of the RHRS inlet isolation valves. The continual release of core residual heat into the reactor coolant, with no heat rejection into the environs, would cause a slow rise in the coolant temperature and pressure. Since the transient is slow, the operator should respond and either restore the RHRS isolation valves to their open position, restore cooling, or limit the RCS pressure by venting the pressurizer. This transient is not considered significant to the design of the LTOPS since it is a relatively slow transient compared to the heat input transient resulting from the startup of a reactor coolant pump in combination with an RCS/SG temperature asymmetry.

1.3.2.3 RCP Startup With Temperature Asymmetry

The first of the two types of temperature asymmetries to be considered occurs when the reactor coolant is at a relatively uniform warm temperature with little or no natural circulation and cold reactor coolant pump seal injection water continues to enter the system. The cooler injection water will settle in a pool in the loop seal below the pump inlet formed by the piping from the steam generator outlet and the pump inlet.

The pressure transient is initiated upon starting one reactor coolant pump. As the pump comes up to speed, the coolant flowrate slowly increases in the active loop and the pool of cold water will be drawn up into the pump and discharged out the cold leg piping. Simultaneously the pool of cold water in the inactive loop will flow backward through the steam generator at a flowrate significantly less than in the active loop. As this pool of cold water flows through the steam generator it's temperature will increase due to heat transfer from the secondary side of the steam generator. This causes expansion of the primary side water and an increasing pressure transient.

The second type of temperature asymmetry occurs when the reactor coolant has been cooled down without sufficient circulation, for instance by use of the residual heat removal loop not augmented by the flow from a reactor coolant pump. Under these circumstances the steam generator secondary side water and the primary side water in the steam generator tubes will remain at an average temperature higher than that of the reactor coolant. The pressure transient is initiated upon starting one reactor coolant pump. As the pump comes up to speed, the reactor coolant flowrate increases, washing the warmer water out of the tubes and replacing it with relatively cold water from the loops. As the colder loop water flows through the tubes it's temperature will increase due to heat transfer from the secondary side of the steam generator. This causes expansion of the primary side water and an increasing pressure transient.

The magnitude of the temperature difference between the steam generator secondary side water and the reactor coolant system depends on the previous plant operations which allow the asymmetry to develop. Ref(c) concludes that it is considered realistic to assume a maximum temperature difference of 50 Deg F as the design case since much higher temperature differences are difficult to develop and are easily recognized by the operator as abnormal conditions requiring special attention.

During normal plant heatup and cooldown operations, typically at least one reactor coolant pump is maintained in operation whenever the reactor coolant temperature is greater than approximately 160 Deg F. The large volumetric flow through the RCS, due to the operating reactor coolant pump, will maintain the RCS and steam generator secondary side in isothermal conditions, thus preventing the occurrence of the temperature asymmetries discussed above. When reactor coolant temperature decreases to approximately 160 Deg F all reactor coolant pumps may be stopped and plant cooldown continued via use of the residual heat removal loop only, leading to conditions conducive to the developement of the temperature asymmetries discussed above. Based on these considerations an arguement could be made that consideration of temperature asymmetry transients may be limited to reactor coolant system temperatures of 160 Deg F or less. However, operator error or equipment malfunction could result in deactivation of all recator coolant pumps at temperatures higher than 160 Deg F. Technical Specification permit operation at temperatures less than or equal to 330 Deg F with all reactor coolant pumps deactivated. Subsequent plant operations, as for example continued plant cooldown via use of the residual heat removal loop only, could lead to the development of the temperature asymmetries at temperatures higher than 160 Deg F. If the plant is operating at temperatures of 330 Deg F or less and the residual heat removal system were to be isolated, due to closure of the isolation valves, Technical Specification require the restart of a reactor coolant pump, if the residual heat removal system can not be restored to service within on hour. Based on

these considerations and recognizing the need for operational flexibility it is concluded that temperature asymmetry heat injection transients should be addressed over the entire range of RCS temperature applicable to LTOPS (RCS temperatures less than or equal to 330 Deg F), rather than limiting considerations of these events to RCS temperatures of 160 Deg F or less.

1.3.2.4 Relative Severity of the Heat Input Transients

Figure 1.1 compares the relative severity of the pressure transients resulting from the heat input cases discussed in the previous paragraphs, as analyzed for the Westinghouse Owners Group. From an inspection of the figure, it is evident that the heat input cases from pressurizer heaters and decay heat are less significant than those for the cases with a loop asymmetry. Therefore, these less significant cases are not considered for the setpoint analysis. Similarly, the loop seal (cross-over pipe) asymmetry case is seen to result in a relatively small pressure transient compared to the potential excursion possible from the steam generator/RCS temperature asymmetry cases. The R.E. GINNA "design basis" heat input event for the setpoint determination is therefore taken to be the temperature asymmetry between the steam generator and the RCS.

1.4 SUMMARY OF TRANSIENT EVALUATION

Based on the previous discussions, the LTOPS design basis transients for R.E. GINNA are selected to be:

a) the charging/letdown mismatch with three positive displacement charging pumps in operation.

b) the heat injection transient caused by the restart of a RCP with the steam generator secondary side water and primary side tube water 50 Deg F hotter than the rest of the RCS.

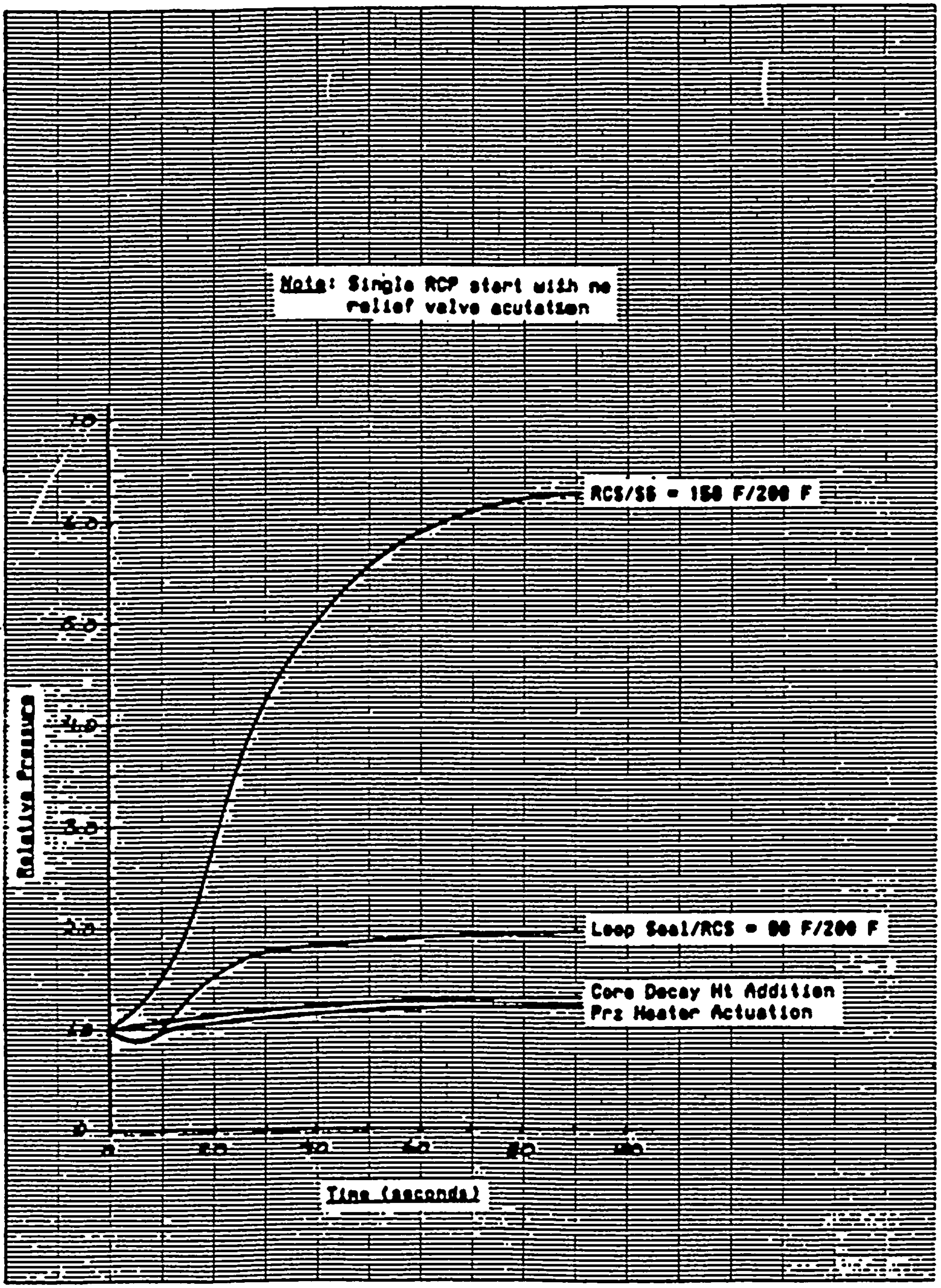

Figure 1.1 Relative RCS Pressure Transients Resulting From Heat Input Events

2.0 DESCRIPTION OF THE LTOPS SETPOINT ALGORITHM

The determination of the low temperature overpressure protection setpoint is based on a local version of the LOFTRAN code. The LOFTRAN code predicts plant transient thermal/hydraulic behavior by modeling the reactor coolant system, including the steam generators, pressurizer (including PORVs), and reactor coolant pumps, as well as the control and protection systems, selected valving, and some balance of plant systems. Two versions of the LOFTRAN code were utilized: the first version, used for the mass input calculations, collapses the several RCS loops into a single loop model; the second version, used for the heat input calculation, models each loop explicitly.

The selection of the proper LTOPS setpoint requires the consideration of a number of system parameters. Among these are the following:

1. Volume of the reactor coolant involved in the transient.
2. RCS pressure signal transmission delay.
3. Volumetric capacity of the relief valves vs. opening position.
4. Opening stroke time of the relief valves . If the pressure undershoot is important, the closure time is required.
5. Mass input rate into the RCS.
6. Heat transfer characteristics of the steam generators.
7. Initial temperature asymmetry between the RCS and steam generator secondary water.
8. Mass of steam generator secondary water.
9. RCP startup dynamics.
10. RCP No. 1 seal delta P requirements. Important if a lower setpoint limit is to be specified for RCP seal protection.
11. Appendix G pressure/temperature limits for the reactor vessel.