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ACTION:

PRELIMINARY EVUALATION OF THE ATTACHED REPORT INDICATES LEAD RESPONSIBILITY FOR FOLLOW-UP AS SHOWN BELOW:

IE [X] NRR [ ] NMSS [ ] OTHER [ ]

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May 8, 1980

NS-TMA-2245

80-219-000

Mr. V. Stello, Director
Office of Inspection and Enforcement
U. S. Nuclear Regulatory Commission
1717 H Street
Washington, D. C. 20555

Subject: Centrifugal Charging Pump Operation Following Secondary Side High Energy Line Rupture

Dear Mr. Stello:

This letter is to confirm the telephone conversation of May 8, 1980 between Westinghouse and Mr. Ed Blackwood of Division of Reactor Operations Inspection, Office of Inspection and Enforcement, regarding notification made pursuant to Title 10 CFR Part 21.

A review of the Westinghouse Safety Injection (SI) Termination Criteria following a secondary side high energy line rupture (feedline or steamline rupture at high initial power levels) has revealed a potential for consequential damage of one or more centrifugal charging pumps (CCPs) before the SI termination criteria are satisfied and CCP operation terminated. Such consequential damage may adversely impact long-term recovery operations for the initiating event and is not permitted by design criteria. This concern exists for plants which utilize the CCPs as Emergency Core Cooling System (ECCS) pumps, where the CCPs are automatically started, and where the CCP miniflow isolation valves are automatically isolated upon safety injection initiation. Attachment A identifies plants potentially subject to this concern. A summary of the concern and recommendations follow.

Following a secondary side high energy line rupture and associated reactor trip, Reactor Coolant System (RCS) pressure and temperature initially decrease. Safety injection is actuated and the CCPs start to increase RCS inventory. Reactor Coolant System pressure and temperature subsequently increase due to the loss of secondary inventory, steamline and feedline isolation, RCS inventory addition and reactor core decay heat generation. The accident scenario may vary with rupture size and specific plant design, but it will develop into a RCS heatup transient with accompanying increase in RCS pressure. As RCS pressure increases, the pressurizer power-operated relief valves (PORVs) are designed to limit RCS pressure to 2350 psia. Although these valves are normally available, they are not designed as safety-related equipment. It can be postulated that, due to either loss of offsite power, adverse environment inside containment, the pressurizer PORV in manual mode, or the PORV block valve in a closed position, due to PORV leakage, the pressurizer PORVs may not be operable. As a result of the RCS heatup and inventory increase, the RCS pressure could rise to the pressurizer safety valve setpoint of 2500 psia within approximately 200 seconds and remain at that pressure until transient "turnaround." Transient "turnaround" can occur between 1800 and 4200 seconds depending on operator action and available equipment. During the initial portion of this transient, the SI termination criteria may not be satisfied. Consequently, the RCS pressure can reach the pressurizer safety valve relief pressure before CCP operation is terminated. During this period, the minimum flow required for CCP operation must be satisfied by flow to the RCS since the CCP miniflow isolation valves are automatically closed on safety injection initiation. This requires that the CCPs be able to deliver their minimum required flow to the RCS at the safety valve setpoint pressure.

To evaluate this concern, Westinghouse has developed a calculational method and has reviewed typical CCP head versus flow performance curves and other representative plant parameters. The calculational method considers the effects of safety valve relief setpoint accuracy, RCS piping resistance, ECCS piping resistance, number of CCPs operating, technical specification allowable CCP head degradation, and uncertainties associated with in-plant verification testing. The analyses for two CCP operation, the best estimate condition, is similar to the analysis for one CCP operation except that the flowrate used to determine ECCS piping line loss must ensure the minimum flow through each pump. For example, at a specific required head, the pump with the higher developed head may be required to deliver greater than the minimum flow in order to permit the lower head pump to meet the minimum flow requirement. This generic evaluation indicates that sufficient flow to satisfy CCP minimum flow requirements to avoid pump degradation may not be ensured for a secondary system high energy line rupture under the conditions described above.

Based on the generic evaluation, Westinghouse recommends that operating plants perform a plant specific evaluation to assess this concern. Attachment B provides the Westinghouse calculational method and a sample calculation which can be used in this evaluation. Based on Westinghouse generic review, satisfactory results may not be obtained. Should a plant specific concern be identified, the following recommendations have been developed and can be tailored to specific plant applications for the interim until necessary design modifications can be implemented. The interim modifications consist of system alignment and operating procedure changes to provide backup to the pressurizer PORVs in ensuring that CCP minimum flow requirements are satisfied. In conjunction with the interim modifications, it is recommended that plants, (a) review the pressurizer PORV operations to maximize the availability of these valves to limit challenges to the pressurizer safety valves, and (b) review the maintenance operations and technical specifications for the backup (i.e., third) charging pump to maximize its availability for long-term recovery from a secondary side rupture. These recommendations, in combination with the interim modifications described below, are considered sufficient to address this concern in the interim until necessary design modifications can be implemented.

Interim Modification I

This interim modification is preferred and requires that component cooling water be supplied to the seal water heat exchanger following safety injection initiation in order to provide cooling for CCP miniflow.

1. Verify that CCP miniflow return is aligned directly to the CCP suction during normal operation with the alternate return path to the volume control tank isolated (lock closed).

2. Remove the safety injection initiation automatic closure signal from the CCP miniflow isolation valves.

3. Modify plant emergency operating procedures to instruct the operator to:

   a. Close the CCP miniflow isolation valves when the actual RCS pressure drops to the calculated pressure for manual reactor coolant pump trip.

   b. Reopen the CCP miniflow isolation valves should the wide range RCS pressure subsequently rise to greater than 2000 psig.

Interim Modification II

This modi ication is an alternative for plants in which component cooling water is not supplied to the seal water heat exchanger following safety injection initiation. Since miniflow cooling is not provided, this alternative directs miniflow to the volume control tank to permit the CCP minimum flow requirements to be satisfied with cool uncirculated water. The volume control tank acts as a surge tank to collect miniflow following safety injection initiation with excess flow directed to a holdup tank via the volume control tank relief valve.

1. Align the CCP miniflow to the volume control tank during normal operation with the miniflow return path direct to the CCP suction isolated (lock closed). Verify that the volume control tank relief valve and discharge line capacity exceeds the miniflow requirements of all CCPs plus the reactor coolant pump seal return flow.

2. Same as Interim Modification I, Item 2.

3. Same as Interim Modification I, Item 3.

Based on the generic evaluation, Westinghouse has initiated efforts to perform additional plant specific analyses for non-operating plants and to develop design modifications to resolve any identified concerns. The modifications will be designed to safety-related standards and will be compatible with Westinghouse SI termination criteria and standardized technical specifications.

If you require further information, please call Ray Sero (412-373-4189) of my staff.

Very truly yours,

T. M. Anderson, Manager
Nuclear Safety Department

TMA/jaw

Attachments

ATTACHMENT A

OPERATING PLANTS

3-Loop

Beaver Valley 1
Farley 1
Surry 1 & 2
North Anna 1 & 2

4-Loop

Cook 1 & 2
Salem 1 & 2
Trojan
Zion 1 & 2
Sequoyah 1

NON-OPERATING PLANTS

Beaver Valley 2
Farley 2
Shearon Harris 1, 2, 3 & 4
Virgil Summer

Braidwood 1 & 2
Byron 1 & 2
Calloway 1 & 2
Catawba 1 & 2
Comanche Peak 1 & 2
Diablo Canyon 1 & 2
Jamesport 1 & 2
Haven
Marble Hill 1 & ?
McGuire 1 & 2
Millstone 3
Seabrook 1 & 2
Sequoyah 2
Sterling
Vogtle 1 & 2
Watts Bar 1 & 2
Tyrone
Wolf Creek

MINIMUM CENTRIFUGAL CHARGING PUMP FLOW
DURING TWO PUMP PARALLEL SAFETY INJECTION OPERATION

In order to ensure that minimum pump flow is maintained during parallel safety injection operation of two centrifugal charging pumps (CCPs), Westinghouse provides below a sample calculation utilizing actual plant data and determines what actual CCP developed head at the miniflow flowrate must be available.

Step 1: Individually determine the developed head of each CCP at the miniflow flowrate of 60 gpm from field test data. (two pumps for 4-loop plants and three pumps for 3-loop plants)

Sample: Maximum developed head pump
2571.4 psid = 5940 ft. @ 60 gpm

Minimum developed head pump
2554.1 psid = 5900 ft. @ 60 gpm

Step 2: Correct the pump head for testing error. Add the appropriate error in determining the above measured developed head, i.e., instrument error plus reading error, to the maximum developed head and subtract this error from the minimum developed head.

Sample: Pressure instrument accuracy of ± 0.5 percent x span of measuring instrument of 3000 psig = 15 psi (35 ft. of head), plus 10 psi (23 ft.) reading accuracy = 58 ft.

The resultant CCP developed heads at miniflow which can be supported are a maximum developed head of 5998 ft. for the maximum head pump, and a minimum developed head of 5842 ft. for the minimum head pump.

Step 3: Determine total CCP flow. Construct a pump curve for the maximum head pump that is parallel to the actual "as-built" vendor pump curve and passes through the above determined developed head at the miniflow flowrate which is the measured developed head plus the determined measurement accuracy. (See attachment Figure 1.)

Use this head versus flow curve to determine the flow delivered by the maximum head pump (strong pump) at the developed head of the minimum head pump (weak pump) at the miniflow flowrate (i.e., 5842 ft. as determined in Step 1).

Sample: As illustrated in Figure 1, the delivered flow of the strong pump at 5842 ft. is 150 gpm. Therefore, the total flow from both CCPs which guarantees that the weak CCP will be delivering at least 60 gpm is 210 gpm (150 gpm + 60 gpm).

Step 4: Determine Injection Piping Head Loss. The head loss due to friction in the safety injection/RCP seal injection piping is determined as follows:

The Δh_f is equal to the strong CCP developed head at runout flow. This resistance is established during the CCP flow balance testing which limits CCP flow to the runout limit. The injection piping resistance (k) is equal to the developed head of the strong CCP at its runout flow divided by the (runout flowrate)^2.

e.g. $$k = \frac{\text{developed head}}{(\text{runout flowrate})^2} = \frac{\Delta h}{Q^2} = \frac{1500 \text{ ft.}}{(550 \text{ gpm})^2}$$

$$k = 4.96 \times 10^{-3} \text{ ft./gpm}^2$$

The resistance of the injection piping (Δh_f), at the total CCP flow required to maintain 60 gpm through the weak CCP is:

$$\Delta h_f = kQ^2 \text{ or } \Delta h_f = (4.96 \times 10^{-3} \frac{\text{ft.}}{\text{gpm}^2})\ (210 \text{ gpm})^2 = 219 \text{ ft.}$$

Step 5: Determine head loss through the Reactor Coolant System. Consider that the reactor coolant pumps are operating, therefore, the pressure drop from the CCP cold leg injection nozzles through the reactor vessel to the pressurizer surge line off the hot leg at full RCS flow are to be included. This pressure drop is approximately 50 psid (116 ft.) for 4-loop plants and 48 psid (111 ft.) for 3-loop plants. This pressure drop must be overcome by the CCPs in order to deliver flow to the RCS at the hot leg/ pressurizer pressure.

Step 6: Determine the elevational head between the RWST and the pressurizer safety valves.

e.g.	RWST elevation	- 160 ft.
	CCP suction elevation	- 100 ft.
	RCS cold leg injection nozzle elevation	- 126 ft.
	Pressurizer safety valve elevation	- 187 ft.
	RWST to CCP suction	- 60 ft.
	minus CCP suction to RCS	- (-26 ft.)
	minus RCS to pressurizer safety valves (61 ft. assuming a full pressurizer) corrected for density difference	- (-44 ft.)
		-10 ft.

Thus, in this example the CCPs must provide an additional 10 ft. of elevational head.

Step 7: Calculate the pressurizer safety valve relief pressure.

e.g. relief pressure = safety valve nominal relief pressure + 1% setting tolerance

relief pressure = 2485 psig + 25 psig = 2510 psig (5798 ft.)

Step 8: Determine the maximum RCS pressurizer pressure at which 60 gpm minimum flow is maintained through the weak CCP.

Maximum RCS pressure = (CCP developed head at total CCP flowrate) - (injection piping head loss) - (head loss through RCS) - (elevation head loss)

Maximum RCS pressure = 5842 ft. - 219 ft. - 116 ft. - 10 ft. = 5497 ft. = 2380 psig

Comparing this pressure to the pressurizer safety valve relief pressure (Step 7) of 2510 psig, it is evident that the 60 gpm flow required for the weak CCP will not be maintained.

FIGURE 1

CENTRIFUGAL CHARGING PUMP
TOTAL FLOW DETERMINATION