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SUBJECT: Provides info re util evaluation of component cooling water sys,per NRC 890814 request.

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January 4, 1990

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D. C. 20555

Gentlemen:

Subject: Docket Nos. 50-361 and 50-362
Component Cooling Water System
TAC Nos. 71194 and 71195
San Onofre Nuclear Generating Station
Units 2 and 3

This letter provides information regarding SCE's evaluation of the Component Cooling Water (CCW) system which was requested in the NRC's August 14, 1989 letter. In addition, this letter identifies additional modifications which SCE has committed to implement to improve the CCW system design.

By letter dated December 16, 1988 SCE submitted the "Component Cooling Water System Operability Assessment" report which documented a comprehensive evaluation of the San Onofre Units 2 and 3 CCW system. This report identified modifications which were being evaluated by SCE to improve the CCW design. The NRC's August 14, 1989 request was the result of the NRC's review of this report.

SCE has completed the evaluations identified in the December 16 report. The responses to the NRC requests for information are provided below. The response to Item 3 includes a commitment to implement specific modifications to minimize the potential for system voiding. In addition, other system modifications will be implemented to enhance the capability to monitor system leakage and optimize the location and design of the hook-up connections for the fire water tanker. These plant betterment items will be implemented by the end of the Cycle 6 refueling outages for both units. Also, to improve maintainability of the critical to non-critical loop isolation valves, block valves will be installed. This plant betterment item will be implemented by the end of the Cycle 7 refueling outages for both units.

The following are the responses to each of the items identified in the NRC's August 14, 1989 letter:

A001
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1. ITEM

On page VI-4 of your report, you state that a critical crack is postulated to occur in the non-seismic piping during a safe shutdown earthquake (SSE), rather than a guillotine break. This does not conform with the Staff's position that a guillotine break must be assumed. Please reanalyze the system response to a SSE assuming the non-seismic piping sustains a single, worst-case guillotine break.

RESPONSE

This item was responded to in SCE's July 25, 1989, letter is currently being reviewed by the NRC Staff.

2. ITEM

On page VI-4 of your report, you state that high level in the surge tank is the worst case initial condition for a SSE, since the nitrogen volume will be at a minimum. It is not obvious that a higher water inventory is a worse initial condition than a lower inventory. Please provide analyses to substantiate this assumption.

RESPONSE

As part of the analysis of the CCW System, high and low surge tank levels were evaluated to determine the initial conditions which would result in the worst case for the CCW system subsequent to a Design Basis Earthquake. These analyses are provided in Enclosure 1 and are summarized as follows:

The surge tank pressure is a function of the nitrogen inventory in the tank free volume. The nitrogen pressure is directly related to the pump NPSH. As the nitrogen pressure is lowered, the available pump NPSH is also decreased. When the initiating event occurs, it is conservative to assume high water level in the surge tank in order to minimize the tank free volume. This will cause the nitrogen mass in the tank to be at a minimum. The resultant pressure decay will thus be greater due to the nitrogen expansion into a larger free volume in the surge tank as the water level decreases. The tank free volume increase is due to the system loss of water inventory subsequent to the initiating event. System outflow is assumed to occur through the non-critical loop as a result of a pipe failure and is terminated upon isolation of the non-critical loop. The analysis conservatively assumes isolation occurs when the isolation signal is generated by the level instrumentation in the surge tank upon reaching low-low level. Therefore, a high water level in the surge tank is a more severe initial condition than a low water level due to the larger free volume nitrogen expansion and resultant greater pressure decay and pump NPSH reduction. The analysis concluded that even for these conditions there is adequate NPSH for the CCW pumps.

3. ITEM

On page VI-5 of your report, you state that you will evaluate upgrading the CCW system to be less susceptible to water hammer in lieu of pursuing more detailed analyses of the effects of water hammer. In a telephone conversation on February 9, 1989, you stated that a parametric study was underway which would evaluate modifications to eliminate the formation of voids. This study was scheduled to be completed in May or June of this year. Please provide the results of this study for our review.

RESPONSE

SCE has performed parametric studies and transient analyses to evaluate the combination of parameter variations which will reduce or eliminate the potential formation of voids in the CCW System which could lead to water hammer. These evaluations established the sensitivity of the system response to various parameters. These evaluations are described in Enclosure 2 to this letter. As indicated in Enclosure 2, the potential for system voiding subsequent to a Design Basis Earthquake and/or high energy line break event can be minimized by providing a seismically qualified backup nitrogen system to the surge tank, relocating the throttle valves downstream of the containment emergency air coolers, and by optimizing the surge tank water level setpoints. Therefore, as indicated in SCE's December 16, 1988 report, in lieu of pursuing additional analysis of this postulated phenomenon, SCE will proceed with engineering to implement these modifications.

4. ITEM

On page VI-4 of your report, you state that 20.9 seconds is the maximum closure time for the critical loop/non-critical loop isolation valves. Yet LER 88-008-001 for Unit 2 states on Page 4, that the IST criteria for these valves needed to be reduced to 14.5 seconds. Please provide the analysis which concluded that 20.9 seconds is an acceptable value.

RESPONSE

CCW system analysis considered isolation valve closure times ranging from 14.5 to 20.9 seconds. The valve closure time was varied to determine how this factor affects the CCW System subsequent to a high energy line break or Design Basis Earthquake. This analysis, which is provided in Enclosure 1, concluded that even with a 20.9 second valve closure time, adequate NPSH would be available for the CCW pumps subsequent to the postulated initiating events. Consequently, as reported in our December 16, 1988 report, a reduced valve closure time of 14.5 seconds is

not required. The transient analysis prepared to address Item 3 has, based on the preliminary results obtained thus far, reached the same conclusion.

If you have any questions regarding this information, please let us know.

Very truly yours,

1CCWLTR.JLR2
Enclosure

cc: J. B. Martin, Regional Administrator, NRC Region V
C. Caldwell, NRC Senior Resident Inspector, San Onofre Units 1, 2 and 3

CCW SYSTEM RESPONSE FOLLOWING DBE AND/OR HELB EVENTS - EFFECTS OF INITIAL SURGE TANK WATER LEVEL AND CRITICAL TO NON-CRITICAL LOOP ISOLATION VALVE CLOSURE TIME

I. INTRODUCTION

An engineering analysis was performed to determine the response of the CCW system following a Design Basis Earthquake (DBE) or a High Energy Line Break (HELB) event. As part of the analysis, both high and low initial surge tank water levels were evaluated to determine which of the two initial conditions would be more severe as a result of pressure decay in the surge tank subsequent to the postulated initiating events. The analysis concluded that an initial high water level and lower bound nitrogen pressure in the surge tank would result in a greater pressure decay in the surge tank and thus a greater reduction in available NPSH for the CCW pump. Results of analysis show that, even with these conservative initial conditions, the available NPSH exceeds the required NPSH for pump operability.

The analysis also evaluated three different isolation valve closure times (14.5, 19.8, and 20.9 seconds) for isolation of the critical to non-critical loop isolation valves to determine the effect on available pump NPSH following the initiating events. The results of the analysis show that even with the slowest closure time of 20.9 seconds, adequate NPSH would be available to ensure CCW pump operability.

II. SEQUENCE OF EVENTS

For a DBE event, the following scenario was postulated:

- o The surge tank is operating at its lower bound nitrogen pressure of 42.1 psia (this is a conservative assumption which accounts for instrument setpoint inaccuracies; normal surge tank pressure is at 50± psia).
- o The surge tank is at high water level for one case and at low level for the second case.
- o A DBE occurs which induces a critical crack in a 12" line to the boric acid concentrator. The system starts losing water at a rate of 410 gpm.

- The system continues to lose inventory until the low-low water level in the surge tank is reached.
- Upon reaching the low-low level, a signal is generated to close the critical to non-critical loop isolation valves. The valves take 20.9 seconds to close plus a system response time delay of 1.3 seconds. Two other cases of valve closure times at 14.5 and 19.8 seconds were also analyzed.

III. METHOD OF ANALYSIS

In analyzing the consequences of a DBE event, the following methodology was applied:

1. Calculate the reduction in surge tank nitrogen pressure that occurs due to the loss of water inventory from initial level to low-low level.

2. Based on the surge tank pressure at low-low level, establish the minimum absolute pressure at the highest elevations in both critical and non-critical loop piping downstream of cooled components to determine whether system pressures exceed water vapor pressure. If system high point pressures are less than the water vapor pressure, water column separation (voiding) and associated partial draining of affected elevated piping would be expected to occur prior to the surge tank water elevation dropping to the low-low level.

3. If water column separation is determined to exist, calculate the elevation of the water column surface existing when the surge tank reaches low-low level.

4. Calculate the surge tank water level and nitrogen pressure at the time the non-critical loop isolation valves are closed. If water column separation has been identified, calculate the water column elevation in the critical loop at the time the non-critical loop isolation valves are closed.

5. Calculate the available NPSH to the CCW pump at the time the critical loop is isolated from the non-critical loop.

A similar methodology was followed for the evaluation of the HELB event.

In addition to the DBE and HELB events being analyzed separately, an analysis was performed to determine the system response if the assumption was made that a HELB occurs following a DBE event. For this evaluation, it was assumed that after the DBE, a reactor line would experience a guillotine break which would cause the rupture of three 4" lines in the non-critical loop of the CCW system. The effects of initial surge tank level, valve closure time and system leakage were also evaluated for this scenario.

IV. CALCULATIONS

A. LOW VS. HIGH INITIAL SURGE TANK LEVEL

After the DBE event, the loss of water inventory will depressurize the surge tank in accordance with the following relationship (assuming an initial low water level in the surge tank):

$$Plll = Pll \frac{(Vst - Vll)}{(Vst - Vlll)}$$

where

Plll = surge tank pressure at low-low level
Pll = surge tank pressure at low level, 42.1 psia
Vst = total surge tank volume, 6658 gal.
Vll = water volume at low level, 3096 gal.
Vlll = water volume at low-low level, 1701 gal.

Substituting, the following results are obtained:

$$Plll = (42.1) \frac{6658-3096}{6658-1701} = 30.3 \text{ psia}$$

If the surge tank is assume to be at the high water level at the start of the event, the surge tank pressure at low-low level will be:

$$Plll = Phl \frac{Vst-Vhl}{Vst-Vlll}$$

where

Phl = surge tank pressure at high level, 42.1 psia

Vhl = water volume at high level, 4956 gal

Substituting the surge tank pressure at low-low level will be:

$$P111 = (42.1) \frac{6658-4956}{6658-1701} = 14.5 \text{ psia}$$

These results show that an initial high water level in the surge tank will result in lower pressure in the surge tank and in the critical loop when the low-low level is reached, minimizing available NPSH for the CCW pump.

B. IMPACT OF VALVE CLOSURE TIME

The requirement for a 14.5 second closure time for the critical/non-critical loop isolation valves identified in LER 88-008-001 for Unit 2 was based on a CCW surge tank outlet block valve control configuration that automatically isolated the surge tank from the CCW system on low-low surge tank water level. The faster valve closure was needed to avoid losing CCW pressure control and water inventory following secondary failure of non-critical CCW piping induced by HELP in containment. Plant Facility Changes 2-88-029 (Unit 2) and 3-88-030 (Unit 3) later deleted the automatic closure of the surge tank outlet block valves HV-6225 and HV-6505 on low-low surge tank water level. The analysis results described in the report, "Component Cooling Water System Operability Assessment," submitted to the NRC December 16, 1988, reflect the present configuration.

These analyses show that the additional system water loss following a HELB with a 20.9 second critical/non-critical loop isolation valve closure time, compared to a 14.5 second valve closure time, does not prevent meeting CCW pump NPSH requirements. This conclusion is reached both before and after experiencing four hours' system leakage from the critical loop at 6 gpm following non-critical loop isolation. The amount of water inventory lost while the valves are closing was calculated as follows:

$$Vt = \frac{Qt}{60}$$

where

- Vt = water lost out of surge tank during valve closure
- Q = flow rate out of the surge tank following a HELB, 2160 gpm
- t = valve closure time, 22.2 seconds (including a 1.3 second system response delay)

This conservatively assumed a constant surge tank pressure and flow rate for the entire duration of the isolation valve closure.

Substituting, the following results are obtained:

$$Vt = (2160) \frac{22.2}{60} = 799.2 \text{ Gallons}$$

If the valve closure time is assumed to be 15.8 (including a 1.3 second system response delay) this number becomes:

$$Vt = (2160) \frac{15.8}{60} = 569 \text{ gallons}$$

It was estimated that during valve closure after the HELB, another 200 gallons were lost out of the critical loop which had to be made up by the surge tank. Therefore, the total water lost out of the surge tank just after isolating the critical loop was 1000 gallons and 769 gallons for the 22.2 and 15.8 valve closure times, respectively. The final surge tank pressure when the valves close was conservatively calculated as follows:

$$Pf = \frac{Phl\ (Vst-Vhl)}{Vst-(Vll\ -\ Vt)}$$

Substituting for the 22.2 second closure time, the final surge tank pressure is:

$$Pf = (42.1) \frac{6658-4956}{6658 - (1701-1000)} = 12.0 \text{ psia}$$

For the 15.8 second closure time, the final surge tank pressure is:

$$Pf = 42.1 \frac{6658-4956}{6658 - (1701-769)} = 12.5 \text{ psia}$$

From the above, it can be seen that these valve closure times have only a small impact on final surge tank pressure when the critical loop is isolated. At a surge tank pressure of 12.0 psia, the available NPSH is approximately 34 feet; the required NPSH for the CCW pumps is 27.1 feet. Therefore, even with the slower valve closure time, there is adequate NPSH to ensure pump operability.

V. CONCLUSIONS

From the calculations above, it can be seen that an initial high surge tank water level induces the largest depressurization of the surge tank. This minimizes the available NPSH for the pump subsequent to the initiating event. The calculations also show that non-critical loop isolation valve closure time has a small effect on the final surge tank pressure after isolation occurs. Similar results were obtained in the evaluation of the HELB and the combined DBE/HELB events. The analysis also shows that adequate pump NPSH is maintained four hours after the initiating event has occurred assuming continuous system leakages following isolation of the critical loop of up to 6 gpm for the DBE and HELB events. This allowable leakage would be up to 3 gpm for the combined DBE/HELB events due to the additional inventory loss and more severe conditions of the event.

Enclosure 2

SUMMARY OF PARAMETRIC

REVIEW & TRANSIENT ANALYSIS PROGRAM

BACKGROUND

In the comprehensive review of Component Cooling Water (CCW) conducted by SCE in 1988, the potential for voiding and water hammer was raised as a concern. In our report to the NRC in December, 1988, we identified the circumstances required to create this concern and our assessment that the resulting conditions would not impact the functionality of the CCW system. We also noted that in lieu of pursuing more detailed analysis, we would evaluate means of upgrading the CCW system to be less susceptible to water hammer conditions. Subsequent telephone discussions with the NRC staff briefly described our program to conduct this evaluation. A more detailed description of this program follows.

PARAMETRIC REVIEW

The initial program consisted of a parametric study to assess how void formation varies as a function of CCW operating parameters and to identify potential upgrades. The study investigated the effects of variations in surge tank level setpoints, non-critical loop (NCL) isolation valve closure time, initial nitrogen pressure in the surge tank and CCW flow to the containment emergency fan coolers. This review also examined the benefits of seismically upgrading the NCL, seismically upgrading the nitrogen supply to the surge tank, and increasing the size of the surge tank outlet piping.

The parametric review was performed by hand calculations and with a number of simplifying assumptions (for example, break flow rates were not varied as a function of system pressure). From the parametric review, it was concluded that the susceptibility to water hammer could be reduced by varying some of the parameters noted above. However, selection of the best combination of modifications required improved modeling techniques due to limitations of the hand calculation methodology. For example, the parametric study showed that surge tank setpoint changes would be of benefit but the steady state analyses were not sufficient to establish new system operating setpoints. Additionally, the simplified methodology was not adequate to permit evaluation of other potential modifications, such as relocation of the emergency air cooler throttle valves. Accordingly, a computerized transient analysis model was developed to further investigate the effects of combined parameter variations on the system transient response.

HYDRAULIC TRANSIENT ANALYSIS

The scenarios used for the hydraulic transient analysis were developed from the results of the parametric study to conservatively assess CCW void formation. The transient analysis evaluated two initiating events that either singly, or in combination, could lead to void formation.

First, a DBE was postulated, which results in a single critical crack in the CCW NCL piping. The crack was postulated to occur in the largest piping section (12 inch) in the non-seismic portion of the NCL. Crack size was determined using the standard methodology for critical cracks in moderate energy piping. Since the normal surge tank nitrogen and makeup water supplies are not seismically qualified, no credit is taken for their availability. As a result of inventory loss through the crack in the NCL, surge tank water level decreases until the NCL isolation valves are closed at the low-low level setpoint.

Second, a High Energy Line Break (HELB) interaction causing rupture of the NCL inside containment is postulated to occur prior to NCL isolation. The HELB piping interaction/jet impingement on CCW piping results in the rupture of three 4-inch NCL supply lines to the RCPs P001 and P003. As a result of inventory loss through the ruptured NCL lines, surge tank level drops until the NCL isolation valves are closed due to a low-low signal, or due to a containment isolation signal.

For the combined event (DBE/HELB) it is postulated that the DBE occurs prior to the LOCA.

The transient analysis currently in progress is evaluating changes in both CCW system operating parameters as well as CCW system configuration. Examples of the changes being considered include combinations of the following:

1. Increasing surge tank nitrogen pressure by 5 to 10 psig.

2. Lowering the surge tank high level setpoint from 21 feet to 20 feet or 17.5 feet

3. Raising the surge tank low-low level setpoint from 14 feet to 17 feet

4. Upgrading the non-seismic portion of the NCL to withstand the DBE.

5. Relocating the emergency air cooler (EAC) throttle valves from immediately downstream of the EACs to a lower elevation to increase local system pressures.

6. Adding a seismically qualified backup nitrogen source.

PRELIMINARY HYDRAULIC TRANSIENT RESULTS

Preliminary results of the analyses performed to date support the following conclusions:

- The effects of short term system voiding can be reduced by relocating the EAC throttle valves which maintain a back pressure between the containment coolers and the downstream piping. By relocating these valves further downstream (at a lower elevation), both the size and duration of the system voiding in response to the pipe break transient are reduced.

- Maintaining a constant nitrogen pressure in the surge tank by providing a seismically qualified, backup nitrogen system minimizes the potential for void formation.

- Reducing the closing time of the NCL isolation valve by 30% does not have a significant impact on void size or duration.

- Raising the surge tank low-low level setpoint by 2 to 3 feet also serves to reduce the size/duration of system voiding and is especially beneficial when used in combination with a constant nitrogen pressure.

- Size and duration of voids are reduced if each initiating event (DBE or HELB) is considered separately.

- Seismic upgrade of the NCL does not eliminate the potential for void formation because the HELB case is more severe for short-term void formation.

Preliminary results indicate that with relocation of the throttle valves downstream of the containment emergency air coolers, a seismically qualified backup nitrogen system, and minor modifications to the operating parameters of the CCW surge tank (nitrogen pressure, level setpoints), system voiding of the CCW system can be minimized. With these modifications, the analyses show that the sudden large outflow of water due to a break results in short-term system transients and small voids lasting for a few seconds. These short-term voids result from rapid system pressure oscillations that extend below the fluid vapor pressure at specific locations in the system. These transient pressure oscillations are not expected to result in system voiding of any significant magnitude or duration, and therefore are not expected to lead to water hammer conditions.

SUMMARY

The results of the work completed to date have indicated that system voiding and, therefore, water hammer susceptibility, can be minimized by providing a seismically qualified backup nitrogen system to the surge tank, relocating the throttle valves downstream of the containment emergency air coolers and by optimizing the surge tank level setpoints. Therefore, as indicated in SCE's December 16, 1988, report, in lieu of pursuing additional analysis of this postulated phenomenon, SCE will proceed with engineering to implement these modifications.

ENCL1&2