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U.S. Nuclear Regulatory Commission
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License No. DPR-35

Response to Request for Additional Information Dated July 14, 1998 For Resolution of Generic Letter (GL) 96-06 Issues at Pilgrim Nuclear Power Station, Unit 1 (TAC No. M96851)

This letter responds to the NRC Request for Additional Information (RAI) dated July 14, 1998. The RAI requested further information to facilitate completion of the NRC's review of Pilgrim's January 28, 1998, 120 day response to Generic Letter 96-06, "Assurance of Equipment Operation and Containment Integrity During Design Basis Accident Conditions." The responses to the NRC's eleven questions are provided as an attachment to this letter.

This letter contains no commitments. Should the NRC require further information on this issue, please contact P.M.Kahler at (508) 830-7939.

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The GL96-06 RAI contained 11 specific requests for information. The following is Pilgrim Station's responses to the requests.

References:

1. NRC Generic Letter 96-06, "Assurance of Equipment Operability and Containment Integrity During Design-Basis Accident Conditions", dated September 30, 1996.

2. Letter from L.J. Olivier, BECo, to US NRC Document Control Desk, "120 Day Response to Generic Letter 96-06, Assurance of Equipment Operability and Integrity During Design-Basis Accident Conditions", dated January 28, 1997.

3. Letter from Alan B. Wang, US NRC. to L.J. Olivier, BECo, "Request for Additional Information for Resolution of Generic Letter (GL) 96-06 Issues at Pilgrim Nuclear Power Station, Unit 1 (TAC No. M96851)", dated July 14, 1998.

Requests 1, 2, 3, and 4

Note: To the extent that positive measures are implemented to eliminate the potential for waterhammer and two-phase flow conditions, question numbers 1, 2, 3, and 4 may not be applicable.

1. Provide a detailed description of the "worst case" scenarios for waterhammer and two-phase flow that could occur in the RBCCW system within the constraints imposed by the EOPs, taking into consideration the complete range of event possibilities, system configurations, and parameters. For example, all waterhammer types and water slug scenarios should be considered, as well as temperatures, pressures, flow rates, load combinations, and potential component failures. Additional two-phase flow considerations include:

- *the consequences of steam formation, transport, and accumulation;*
- *cavitation, resonance, and fatigue effects; and*
- *erosion considerations.*

Licensees may find NUREG/CR-6031, "Cavitation Guide for Control Valves," helpful in addressing some aspects of the two-phase flow analyses. (Note: it is important for licensees to realize that in addition to heat transfer considerations, two-phase flow also involves structural and system integrity concerns that must be addressed).

2. If a methodology other than that discussed in NUREG/CR-5220, "Diagnosis of Condensation-Induced Waterhammer," was used in evaluating the effects of waterhammer, describe this alternate methodology in detail. Also, explain why this methodology is applicable and gives conservative results (typically accomplished through rigorous plant-specific modeling, testing, and analysis).

3. *For both the waterhammer and two-phase flow analyses, provide the following information:*

   a. *Identify any computer codes that were used in the waterhammer and two-phase flow analyses and describe the methods used to bench mark the codes for the specific loading conditions involved (see Standard Review Plan Section 3.9.1).*

   b. *Describe and justify all assumptions and input parameters (including those used in any computer codes) such as amplifications due to fluid structure interaction, cushioning, speed of sound, force reductions, and mesh sizes, and explain why the values selected give conservative results. Also, provide justification for omitting any effects that may be relevant to the analysis (e.g., fluid structure interaction, flow induced vibration, erosion).*

   c. *Determine the uncertainty in the waterhammer and two-phase flow analyses, explain how the uncertainty was determined, and how it was accounted for in the analyses to assure conservative results.*

4. *Confirm that the waterhammer and two-phase flow loading conditions do not exceed any design specifications or recommended service conditions for the piping system and components, including those stated by equipment vendors; and confirm that the system will continue to perform its design-basis functions as assumed in the safety analysis report for the facility and that the containment isolation valves will remain operable.*

Response to Requests 1, 2, 3, and 4

As stated in Pilgrim Station's 120 Day Response to GL96-06, reference 2, an evaluation of the RBCCW System inside containment subject to heating during design basis loss-of-coolant accidents concluded the system is not susceptible to waterhammer or two-phase flow that would degrade the pressure boundary integrity or RBCCW safety-related heat removal performance. Therefore, detailed waterhammer and two-phase flow analyses were not performed. The evaluation performed was based on worst case design basis accident conditions that would affect RBCCW Loop B operation based on the assumption that Loop B met its design basis safety function for restarting after a LOCA coincident with a loss of off-site power. In response to the current request, the scenario has been expanded to include failure of Loop B to meet its design basis requirements and the possibility that subsequent operation of the system (after an assumed failure) may involve waterhammer events.

There are accident scenarios with active failures that prevent the RBCCW Loop B pumps from restarting at the appropriate times, such as failure of the Loop-B Emergency Diesel Generator. In the event that flow through the drywell coolers is interrupted for more than 94 seconds and drywell temperature and pressure conditions follow the worst case design basis accident profile, subsequent restart of the RBCCW pumps at times later than assumed for the design basis response could cause waterhammer within the drywell coolers.

Failure of all the RBCCW Loop B pumps to autostart within the design basis time is the consequence of an active single failure that also prevents Loop B from performing its safety function. The potential waterhammer from a delayed RBCCW pump restart may damage the pressure boundary of the drywell cooler due to its copper tubing construction. However, primary containment integrity is assured by the RBCCW system isolation valves outside containment. The probability of a LOCA followed within 600 seconds by a Loss-of Offsite Power (LOOP) with a concurrent diesel generator failure at Pilgrim is 2.7 E-9/year. This low probability coupled with the isolation valves ensures containment integrity is not credibly challenged by the postulated scenario.

Request 5

Describe positive measures that have been taken (or will be taken) to eliminate the potential for waterhammer and two-phase flow conditions in the RBCCW system, such as placing restrictions on use of the RBCCW system following an accident. Describe the worst-case scenario and how much margin will exist to boiling.

Response to Request 5

Since the evaluation summarized in reference 2 determined that waterhammer and two-phase flow conditions were not a concern during system response to design basis loss of coolant accidents, actions were not taken or planned to eliminate the potential for waterhammer and two-phase flow. As documented in reference 2, assuming a single failure of the first RBCCW pump to start at 45 seconds after the LOCA, the second pump would start at 75 seconds. The evaluation determined that a stable vapor bubble would not be formed within the cooler until 94 seconds after the LOCA. Thus, flow would be re-established 19 seconds prior to stable vapor bubble formation.

To further preclude the potential for water hammer or two-phase flow during response to beyond design basis scenarios, procedure 2.2.19.5, "RHR Modes of Operation for Transients," was revised to prevent operators from initiating flow through the coolers when the drywell temperature exceeds 250°F.

Request 6

Implementing measures to assure that waterhammer will not occur, such as restricting post-accident operation of the affected system, is an acceptable approach for addressing the waterhammer and two-phase flow concerns. However, all scenarios must be considered to assure that the vulnerability to waterhammer has been adequately addressed. Confirm that all scenarios have been considered such that the measures that have been established are adequate to address all situations.

Response to Request 6

Preventing the restoration of flow to the drywell coolers when drywell temperature exceeds 250°F bounds all scenarios. For the design basis LOCA with loss of off-site power, the RBCCW pumps restart automatically within sufficient time to prevent waterhammer with drywell temperature above 250°F, as described earlier, and this automatic action remains unchanged. For the expanded postulated scenario described earlier, there are time periods following a LOCA during which the RBCCW pumps may experience a delayed auto restart due to a failure. Should this occur before operators can reasonably take actions to prevent the restart and/or isolate the RBCCW drywell piping, there may be a water hammer that will damage the drywell coolers, requiring that the RBCCW isolation valves be closed.

Request 7

Discuss specific system operating parameters that must be maintained in order for the waterhammer and two-phase flow analyses to be valid (e.g., head tank pressure and level), and explain why it would not be appropriate to establish Technical Specification *requirements for these system parameters. Also, describe and justify reliance on any non-safety related instrumentation and controls in this regard.*

Response to Request 7

The design basis scenario requires that the RBCCW Loop B Surge Tank level be maintained greater than or equal to the low level alarm set point. The level in the tank is monitored by non-safety-related level switches which annunciate in the control room if the tank level is too high or too low. The tank level is maintained automatically by a non-safety-related level transmitter and control circuit.

The RBCCW Loop B piping is designated as "pressure boundary only (PBO)" safety-related seismic Class I. This designation means that the piping is designed and maintained such that the pressure boundary of the piping will remain intact to maintain RBCCW Loop B water inventory if a seismic event were to occur. Assuming the failure of a passive safety-related component in conjunction with an active single failure is beyond the PNPS design basis accident analysis.

Since the waterhammer could only occur if an active failure occurs such that none of the 3 RBCCW Loop B pumps restart within the design basis time limits, failure of the piping pressure boundary such that RBCCW Loop B water inventory is lost is beyond the accident analysis. Thus, the instrumentation is not required to respond to accidents and does not need to be safety-related.

The RBCCW Loop B Surge Tank level parameter does not satisfy the 10 CFR 50.36 Technical Specification Screening Criteria; therefore, Technical Specifications considerations are not appropriate.

Request 8

Confirm that a complete failure modes and effects analysis (FMEA) was completed for all components (including electrical and pneumatic failures) that could impact performance of the cooling water system and confirm that the FMEA is documented and available for review, or explain why a complete and fully documented FMEA was not performed.

Response to Request 8

A complete and fully documented FMEA was not performed and is not required. The drywell cooling water system is not credited to perform any safety-related heat removal function during design basis accident scenarios. Thus, FMEA related to the drywell cooler thermal performance is not required.

With respect to waterhammer or two-phase flow that could impact the performance (i.e. ability to maintain piping pressure boundary integrity) of the cooling water system piping inside the primary containment, a simplified analysis follows:

> The piping integrity is not challenged during a normal RBCCW system response to the design basis accident since flow through the drywell coolers is restarted before steam voids are created inside the coolers.
>
> Waterhammer or two-phase flow conditions are only possible if flow through the drywell coolers is interrupted for more than 94 seconds and the drywell temperature exceeds 261°F, and flow is then restarted. Once flow is restarted, the pressure of the water in the

drywell coolers will rise to the point where the water is repressurized to a subcooled liquid status, which collapses the steam voids and initiates a water hammer.

Thus, the only failure mechanisms of concern are those that prevent restart of all RBCCW Loop B pumps within the 94 seconds and concurrent loss of power to the open isolation valves with subsequent restart of the pumps with the valves open.

Request 9

Explain and justify all uses of "engineering judgment."

Response to Request 9

"Engineering judgment" was not used in the development of the GL96-06 response.

Request 10

Provide a simplified diagram of the affected systems, showing major components, active components, relative elevations, lengths of piping runs, and the location of any orifices and flow restrictions.

Response to Request 10

See the attached figure.

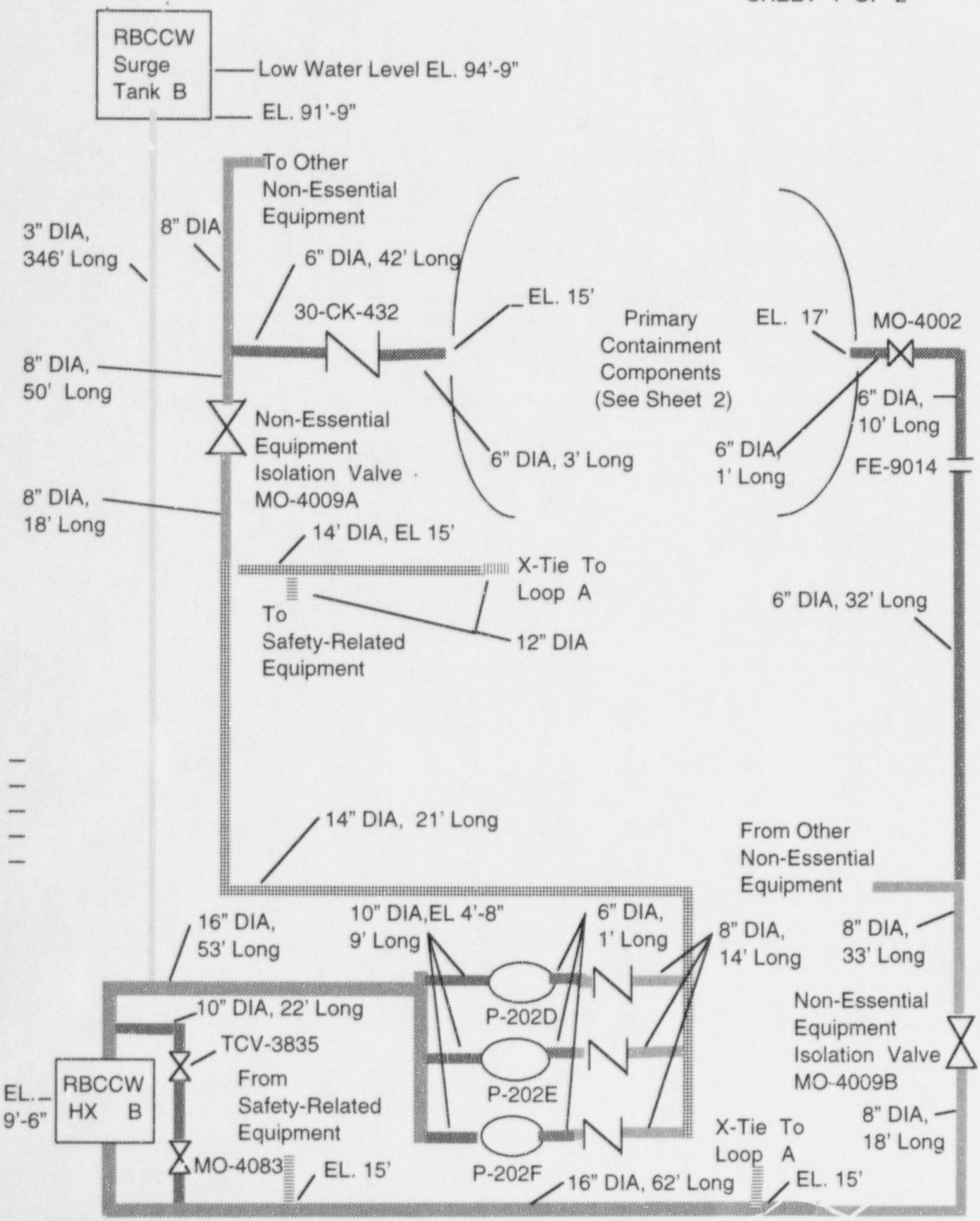
Request 11

Describe in detail any plant modifications or procedure changes that have been made or are planned to be made to resolve the waterhammer and two-phase flow issues, including schedules for completing these actions.

Response to Request 11

Procedure 2.2.19.5 was changed to prevent the resumption of RBCCW flow when drywell temperature exceeds 250°F. This will preclude flow that has the potential to cause waterhammer or two-phase flow conditions. No other changes are planned to address the postulated scenario in this response.

SIMPLIFIED RBCCW SYSTEM DRAWING



SIMPLIFIED RBCCW SYSTEM DRAWING