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SUBJECT: Forwards response to NRC 980820 RAI re GL 96-06 related to piping integrity for waterhammer & two phase flow concerns. Util believes that concerns addressed by subject GL are beyond design & licensing bases for plant.

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SUSQUEHANNA STEAM ELECTRIC STATION
"RESPONSE FOR ADDITIONAL INFORMATION"
RELATED TO GENERIC LETTER 96-06
PLA-4999

Docket Nos. 50-387
and 50-388

References: 1) USNRC to R. G. Byram, "Request for Additional Information (RAI) Regarding Response to Generic Letter (GL) 96-06 for the Susquehanna Steam Electric Station, Units 1and 2," dated August 20, 1998.

2) R. G. Byram to USNRC, "120-Day Response to Generic Letter 96-06," dated January 29, 1997 (PLA-4551)

3) R. G. Byram to USNRC, "Additional Information Related to the 120 Day Generic Letter Response," dated May 9, 1997 (PLA-4618)

4) R. G. Byram to USNRC, "Follow-Up Response to the 120 Day Generic Letter 96-06 Response," dated June 30, 1997 (PLA-4636).

The purpose of this letter is to provide PP&L, Inc.'s (PP&L) attached response to the NRC's "Request for Additional Information" to Generic Letter 96-06 (reference 1). A narrative response is provided to the questions related to piping integrity for waterhammer and two phase flow concerns, and explains that PP&L has concluded that these scenarios do not adversely impact the Susquehanna SES design/licensing basis. Specific answers are provided to piping integrity concerns related to thermally-induced overpressurization.

PP&L believes that the concerns addressed by the Generic Letter are beyond the design and licensing bases for the Susquehanna SES. We also believe that based on plant design and the lack of safety significance associated with the systems and penetrations of concern, there is no risk significance related to the concerns identified in the Generic Letter.

As a result of our evaluation of Generic Letter 96-06, PP&L has instituted procedural revisions to resolve overpressurization concerns with the demineralized water line penetrations, revised emergency operating procedures (EOP's) to preclude the potential for a water hammer in the drywell cooling system following a LOCA, and is continuing to evaluate a modification to the drywell cooling system sump line penetrations, consistent with current NRC interpretation of ASME code design guidance. As part of this evaluation, we are using recently released Regulatory Guide 1.174, "An Approach For Using Probabilistic Risk Assessment in Risk Informed Decisions on Plant-Specific Changes to the Licensing Basis," to establish the risk significance of this modification. Our current plan is to complete this evaluation in the second quarter of 1999.

PP&L will provide the results of our evaluation upon completion.

Questions concerning this response should be directed to J. M. Kenny at (610) 774-7535.

Sincerely,

R. G. Byram

Attachment

copy: NRC Region I
Mr. S. T. Barr, NRC Acting Resident Inspector
Mr. V. Nerses, NRC Sr. Project Manager

POTENTIAL FOR DRYWELL COOLING WATER HAMMER & 2-PHASE FLOW (Reference RAI Questions 1 Through 11)

PP&L's responses to Generic Letter 96-06 indicated that the drywell cooling system at Susquehanna SES (SSES) is non-safety related and automatically isolates on a loss of coolant accident (LOCA). We also indicated that the Emergency Operating Procedures (EOP's) at SSES allow the operators to use the drywell coolers during implementation of the EOP's, if they are available. To complete their reviews of this issue as it relates to water hammer/two phase flow, NRC has requested the following information:

- Description of the "worst case" scenario/s for water hammer or two phase flow that could occur in the drywell cooling system; description of the measures to eliminate the potential for water hammer, two phase flows; and descriptions of any plant modifications or procedural changes.
- Discussion of the utilization of NUREG – 5220, "Diagnosis of Condensation - Induced Water hammer."
- Identification and justification for computer codes used; identification and justification for assumptions, and input parameters for any analyses performed; and identification and justification for operating restrictions.
- Confirmation that design specifications are not exceeded; and confirmation that the system will continue to perform its design-basis functions.
- Explanation of engineering judgement.
- Simplified diagrams of affected systems.

Background

The SSES drywell cooling system is a non-safety-related system that is used to maintain containment temperatures within acceptable limits during normal plant operations. The drywell cooling system is not credited in any SSES design basis accident analyses. In addition, this system is not credited in the SSES Individual Plant Evaluation (IPE), and hence is not a factor in determining overall plant risk.

The only safety-related function of the drywell cooling system is to automatically isolate under conditions which are indicative of a LOCA: low reactor vessel level or high drywell pressure. This isolation function is accomplished via two independent and redundant isolation valves on each of the loop supply and return lines. At each containment penetration, one valve is located inside the primary containment, and one is located outside. The stroke times for the inboard and outboard containment isolation valves are 6 and 40 seconds respectively. Therefore, the design basis safety-related function of the drywell cooling system is completely fulfilled shortly after the start of a design basis LOCA - within seconds of an isolation signal.

During scenarios where the drywell cooling system automatically isolates, the SSES emergency operating procedures (EOPs) allow for system restoration to aid in the control of primary containment temperatures. The recovery procedures require that various system controls be over ridden. Included in this process is the "bypassing" of the LOCA isolation signal(s), which allows for the re-opening of the containment isolation valves. Intentionally defeating this engineered safety feature is considered acceptable only when a true design basis accident (i.e., LOCA) is not in progress. Therefore, when the drywell cooling restoration procedure is implemented, the system has already successfully fulfilled its safety function, and subsequent operational actions related to implementation of the SSES EOPs do not conflict with the design and licensing basis of the plant.

In order to assure consistency between the SSES design / licensing bases and operational procedures, revisions to the emergency support procedures which govern the recovery of the drywell cooling system following an automatic containment isolation have been made. These revisions, which were added as a result of Generic Letter 96-06 reviews, prohibit the re-opening of the system's containment isolation valves if there is evidence that a design basis LOCA has occurred, or if primary containment radiation levels are above normal. Therefore, any potential, within our licensing/design basis, for a drywell cooling water hammer or two-phase flow condition during a design basis accident has been eliminated.

Discussion

PP&L does not consider any potential (real or postulated) for two-phase flow to be of concern, as originally identified in the 120 day response. This is primarily due to the fact that the drywell coolers are not credited in any accident analyses, and thus, any impact which two-phase flow may have on the effectiveness of the coolers is of no consequence. If two-phase flow occurred after system restoration, any adverse impacts on system operation would likely be detected by in-plant operators, and the system would be secured. Also, with the system in normal operation, it is estimated that containment temperatures would need to be in excess of 270°F to result in the theoretical possibility of two-phase flow. It is therefore concluded that this potential does not represent a viable threat to containment integrity. Additionally, any loads induced by two-phase flow are expected to be minimal and bounded by the impact loads of a water hammer.

Although it is considered a very remote possibility, there is a potential for water hammer during the emergency restoration of drywell cooling. This "worst case" scenario, which is beyond our licensing/design basis, is described in PP&L's 120 day response to the Generic Letter.

During normal plant operation, the drywell coolers are supplied by the reactor building chilled water (RBCW) system. However, during recovery after a containment isolation, the system will be aligned to its alternate heat sink: the reactor building closed cooling water (RBCCW) system. This is due to the fact that in the event of a containment isolation, with or without a loss of offsite power (LOOP), RBCW system flow to the drywell coolers and reactor recirculation pumps is terminated. The isolation of these flow paths results in a low RBCW system flow condition, which in turn, causes the RBCW/RBCCW swap valves to align the containment loads to RBCCW. This response has been observed during some inadvertent containment isolation events.

Therefore, when evaluating the potential for water hammer, it is appropriate to postulate that the drywell coolers are aligned to RBCCW. Diagrams of the RBCCW and RBCW systems are provided in the SSES FSAR as Figures 9.2-2 and 9.2-13a&b respectively. In addition, a simplified schematic diagram of the RBCW/RBCCW system configuration is shown in Figure 1 (attached).

A conservative, straightforward methodology was utilized to determine the peak forces induced by the postulated water hammer. This methodology, which is outlined below, employs fundamental physical relationships, as published in "Fluid Transients", Wylie & V.L. Streeter, 1978 McGraw-Hill Inc, and is consistent with the methodology outlined in NUREG/CR-5220.

The first step in determining the loads induced by the postulated water hammer was to determine the velocity of the fluid front. If voids were to form in the drywell cooling piping, the source of inventory to refill the piping would be the RBCCW head tank. The rate at which the system refills would be limited by multiple flow restrictions; the most limiting of which would be the 2" tie-line between the head tank and the RBCCW system piping.

The flow rate through this tie-line was estimated using the fundamental fluid flow methodologies of Crane Technical Paper No. 410. Actual SSES piping lengths were used and the configuration that provides the highest flow rate was assumed. The following relationship was used to calculate the "refill" flow rate:

$$q = .0438 * d^2 * (h_L / K)^{1/2}$$

Where:	q	=	volumetric flow rate	(ft^3/sec)
	d	=	pipe inner diameter	(in)
	h_L	=	static head	(ft)
	K	=	resistance coefficient	(dimensionless)

The fluid velocity in the drywell cooling lines was then calculated, based on the pipe size and class, and used to determine the pressure rise in the piping with the following equations, which were obtained from "Fluid Transients", Wylie & V.L. Streeter, 1978 McGraw-Hill Inc:

$$\Delta p = -\rho a \ \Delta V$$

and,

$$a = (K_m \ / \ \rho)^{1/2}$$

where	Δp =	pressure change	(lb_f/ft^2)
	ρ =	density of water	($slug/ft^3$)
	a =	wave speed	(ft/sec)
	ΔV =	velocity change	(ft/sec)
	K_m =	water modulus of elasticity of	(lb_f/ft^2)

By applying this methodology, the maximum pressure spike was calculated to be less than 48 psi, which would not result in a system pressure in excess of the design value. The design pressure of the penetration piping is 150 psig, and the design pressure of the system piping inside containment is 100 psig. In addition, the peak load induced by the water hammer was estimated as the product of the pressure change and the pipe flow area. This approach, which is consistent with that outlined in NUREG/CR-5220, revealed that the peak piping load induced upon collapse of the postulated void would be 2360 pounds-force.

The effect of the postulated water hammer loads on the drywell cooling supply and return containment penetrations was then evaluated using PP&L's ME101 computer program. This finite element program was used in the original design of numerous SSES piping systems. For additional information regarding this program, refer to Section 3.9A.1 of the SSES FSAR.

A review of the drywell cooling containment penetration isometric drawings indicated a high degree of similarity between these containment penetration lines. Therefore, one supply line and one return line, judged to be the most limiting of the drywell cooling penetrations, were modeled. Since a static method was employed, a load factor of two (2) was applied to the water hammer load discussed above. That is, a static force of 4,800 pounds was used. Forces of this magnitude were applied to each of the piping segments adjacent to the containment penetration in order to produce maximum bending moments. In addition, for further conservatism, cases were evaluated in which no credit was taken for piping supports.

Since this event is considered "beyond design basis", concurrent seismic and hydrodynamic loads were not considered. However, pressure and dead weight loads were combined with the stresses induced by the postulated water hammer. The most limiting stress derived was 30,121 psi, which is approximately 84% of the ASME Code faulted allowable stress of 36,000 psi. Therefore, the water hammer event will not produce pipe stresses which exceed Code faulted allowables and the drywell cooling supply and return lines could withstand the predicted water hammer loads without jeopardizing the integrity of the containment penetration.

Conclusions

Based on the discussion presented above, the following conclusions are drawn regarding the design and licensing bases of the SSES drywell cooling system, as well as the potential for water hammer and two-phase flow:

1) The drywell cooling system is a non-safety-related system that is not credited in SSES design basis accident analyses, nor the SSES IPE. As a result it is not safety-related, nor risk-significant.

2) During a design basis loss of coolant accident, the drywell cooling system will automatically isolate several seconds after a containment isolation signal occurs. Upon isolation, the design basis safety function of the system is fulfilled.

3) SSES emergency operating support procedures allow for the restoration of the coolers. However, procedural controls are in place which prohibit system restoration under true LOCA conditions. Thus, all events during which the drywell coolers would be restored are beyond the design basis of the plant.

4) A conservative, beyond design basis scenario was evaluated to determine the impact on the SSES containment boundary resulting from a water hammer, which is postulated to occur during the recovery of drywell cooling after an automatic isolation.

5) The physical loads induced by such a postulated water hammer have been conservatively calculated and found to be less than 2400 pounds. Additional conservative analyses have concluded that piping stresses induced by this event are within ASME Code faulted allowables. Therefore, the restoration of drywell cooling does not result in a threat to the integrity of the SSES primary containment.

6) Issues which stem from the potential for two-phase flow, as identified in Generic Letter 96-06, are not applicable to the design or licensing basis, nor safety of the SSES units, since:

   a) the onset of two-phase flow is judged to be extremely unlikely, since containment temperatures would need to be well in excess of 270°F;
   b) the effectiveness of the drywell coolers is not accounted for in any design or licensing basis analyses (the only scenarios which would pose the potential for this phenomenon are beyond the design basis of the SSES units), and
   c) any loads induced by two-phase flow are expected to be bounded by the loads induced by the postulated water hammer.

POTENTIAL FOR THERMALLY INDUCED OVERPRESSURIZATION (Reference RAI Questions 12 Through 14)

QUESTION 12

For those penetrations that are susceptible to thermally-induced overpressure and were found to be acceptable by engineering evaluation, provide the following information:

a. The applicable design criteria for the piping and the valves, including the required load combinations

b. A drawing of the piping run between the isolation valves, including lengths and thicknesses of the piping segments and the type and thickness of insulation

c. The maximum-calculated temperature and pressure for the pipe run. Describe, in detail, the method used to calculate these pressure and temperature values. This should include a discussion of the heat transfer model used in the analysis and the basis for the heat transfer coefficients used in the analysis.

RESPONSE

As identified in PP&L's 120 day response and additional information related to the 120 day response for the Generic Letter, although plastic deformation of piping can limit, and even completely offset the effects of induced pressurization, this approach was not used as the principal basis for determining operability of susceptible penetrations. PP&L will not utilize ASME "Appendix F" evaluations for resolution of Generic Letter 96-06 concerns, since the use of "Appendix F" evaluations is not a universally accepted approach for the resolution of the concerns. The actions PP&L has taken to address the final resolution to the pressurization concerns are identified in the responses to questions 13 and 14 below.

Part A

As described in our two 120 day response submittals to Generic letter 96-06, and in Table 3.2-3 of the SSES FSAR, the design criteria for susceptible penetration piping, pipe supports and valves, is the ASME Code, 1971 Edition with Addenda through Winter 1972. In addition, the applicable design basis load combinations are identified in Table 3.9-6 of the SSES FSAR.

Parts B and C

Parts B and C of this question request that piping drawings be provided, methodologies be discussed, and inputs be identified. PP&L has not credited the plastic deformation methodology of Appendix F for piping. As such, no analyses or drawings are available which address the information requested by parts B and C of this question. Detailed isometric drawings of the susceptible penetrations can be provided if requested.

QUESTION 13

For those penetrations that are susceptible to thermally-induced overpressure and were found acceptable based on leakage through isolation valves, provide the following information:

a. A description of the applicable design criteria for the piping and the valves, including the required load combinations

b. A drawing of the valve. Provide the pressure at which the valve was determined to lift off its seat or leak and describe the method used to estimate this pressure. Discuss any sources of uncertainty associated with the estimated lift off or leakage pressure

c. The calculated maximum stress in the piping run based on the estimated lift off or leakage pressure.

RESPONSE

The actions PP&L has taken to address the final resolution to the pressurization concerns are identified in our 120 day response and the follow-up response related to the 120 day response for Generic Letter 96-06. For the susceptible penetrations, PP&L has taken credit for valve leakage in certain cases (drywell floor sump) to determine operability. However, for long term resolution, PP&L is performing a risk evaluation, in accordance with Regulatory Guide 1.174, of these configurations in order to establish a final licensing and design basis position. This work is currently scheduled to be completed in the second quarter of 1999.

QUESTION 14

The non-safety-related drywell floor sump system discharge piping is a closed-loop system inside the containment and was identified as susceptible to thermally-induced pressurization. You indicated that the system is protected from overpressure because the check valves will leak, and that such leakage is confirmed by the operational history. Provide additional information regarding the leakage of these valves including the method of measuring the leakage and the quantity of the leakage measured. Also provide a comparison of the measured leakage with the leakage necessary to prevent overpressurization of the piping.

RESPONSE

To assure consistency with current NRC interpretation of ASME Code guidelines PP&L is considering a modification to the penetration associated with the drywell floor drain sump pump discharge lines to incorporate overpressure protection. However, we consider any modification to be a conservative enhancement to the design, not a licensing basis commitment, since we consider the pressurization to be extremely unlikely for the reasons described below.

The design configuration of the non-safety-related drywell floor drain sump pump discharge lines (one per unit) are susceptible to thermally induced pressurization during design basis accidents. Although extremely unlikely, the worst case postulated breach could result in a credible release path from the drywell to the reactor building (secondary containment). During the occurrence of a design basis accident, such a failure is extremely unlikely since all four pump discharge check valves, which are not maintained as part of an LLRT boundary, must be leak-tight. During the worst case (i.e., highest containment temperature increase), that occurs during a small break LOCA, it is estimated that a total leakage of 29 cc/min, or 7.25 cc/min per discharge check valve would completely offset the effects of pressurization.

The leakage through these valves has never been quantitatively measured via rigorous plant testing, however it is improbable that all four check valves would be leak tight to the point where severe overpressurization would occur. This engineering judgement is based on the service condition of these non-safety related check valves, and previous operational problems.

In addition, in order for an overpressure condition to occur, the containment isolation valves must also be leak-tight. The results of the most recent LLRTs for these valves reveal a minimum path leakage of 519 sccm and 174 sccm for Units 1 and 2 respectively. Although these leakages represent pneumatic test results, they correspond to relatively low test pressures (i.e., approximately 45 psig). It is therefore expected that leakage past the isolation valves would significantly aid in offsetting the effects of thermal pressurization.

Considering the multiple leakage pathways described above, it is reasonable to conclude that while the design of the drywell sump pump discharge lines is susceptible to thermally induced pressurization, sufficient pressurization to create a breach is not expected. Even though thermally induced pressurization during a design basis event is extremely unlikely, PP&L is continuing to evaluate a modification to incorporate overpressure protection into the design of the drywell sump lines. Our current plan is to complete this evaluation in the second quarter of 1999.

FIGURE 1

Simplified Diagram of RBCW / RBCCW System Configuration During Emergency Restoration