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SUBJECT: Provides util written responses to questions re RPV water level project vent mod insp.

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SUSQUEHANNA STEAM ELECTRIC STATION
RPV WATER LEVEL PROJECT –
VENT MODIFICATION INSPECTION
PLA-4288 FILES A17-8/R41-2

Docket Nos. 50-387
and 50-388

Dear Sir:

In August, 1994 a 10CFR50.59 Inspection of the Susquehanna Steam Electric Station (SSES) Water Level Instrumentation -- Vent Modification was conducted by members of the NRC Staff supported by a contractor from Brookhaven National Laboratories (BNL). Due to the short duration of this inspection, the BNL inspector requested copies of calculations performed by Pennsylvania Power & Light (PP&L) to allow for a more detailed review. This contractor has recently completed his review, resulting in the following five questions. The purpose of this letter is to provide PP&L's written response to these questions, by restating the specific questions followed by its response.

Question 1. The analyses and tests were performed with no leakage path taken into account. A leak in the reference leg should be used.

The objective of the test program was to ensure that non-condensable gases would not accumulate in the new condensing chambers, leading to high non-condensable concentrations in the reference leg. The test measured the final non-condensable concentrations in the chambers, and from that value calculated the resulting non-condensable concentration that would accumulate in the reference leg.

The reason for not modeling a leak in the reference leg was that doing so would be non-conservative for the chamber non-condensable gas concentration measurements, since it would provide an additional removal mechanism for non-condensables.

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Question 2. How will the non-condensable gas be purged during startup?

The upper chambers are purged prior to startup by pumping demineralized water into the instrumentation legs, assuring that chamber level is established. Lower chambers are purged when level indication channel discrepancies exist which may indicate that the reference leg level is low.

Some non-condensable gas will remain in the chamber after purging, but will be at atmospheric pressure. When the vessel is pressurized, this gas will remain at a partial pressure of 14.7 psia while the surrounding steam pressure will exceed 1000 psia. A non-condensable gas partial pressure of 14.7 converts to a reference leg equivalent non-condensable gas concentration of approximately 90 ppmv, which is well below the 150 ppmv limit set forth by the BWROG Test program.

Question 3. These comments/questions deal with the analysis:

a. **The analysis for the steam flow rate in the vent to steam test should account for two phase flow, such as possible friction and condensation.**

The original PP&L upper chamber steam flow rate calculation (EC-062-1004) accounted for two-phase flow effects by assuming that the flow was 100% quality, which is conservative, since two-phase friction pressure drop is a maximum for the all steam condition. (Ref. "The Thermal Hydraulics of Boiling Water Reactors", R.T. Lahey, F.J. Moody, pp 267, 282, 2nd edition, 1993.) This drop is obtained by applying the two-phase friction multiplier to the pressure drop calculated for saturated liquid flow. In addition, the friction factor was arbitrarily increased by 10% to add conservatism to the calculation.

The upper chamber flow calculations ignored additional effects of condensation in the vent line because condensation has the effect of increasing flow through the chamber by providing a lower pressure in the vent line. Makeup flow for the steam condensed in the vent line is supplied from the steam lead through the chamber. This occurs because the chamber steam inlet has a larger flow area and a shorter length than the vent line, and because the chamber is at a higher pressure than the vent line termination into the reactor head vent. Accounting for the vent line condensation would significantly increase the calculated chamber vent flow and reduce the conservatism in the calculation.

PP&L Calculation EC-062-1006 established the minimum allowable flow rate through the upper condensing chamber which would assure that the chamber gas space would never approach a reference leg equivalent non-condensable gas concentration of 150 ppmv. This calculation determined that the chamber flow was on the order of 5×10^{-3} lbm/hr. Therefore it is only necessary to establish a positive flow through the vent line to assure that the chamber gas space non-condensable gas concentration is less than 150 ppmv reference leg equivalent.

Two phase flow effects are only important during the first hours of startup when the main steam line flow is marginal. After this time, main steam flow exceeds the required value by several orders of magnitude. EC-062-1006 conservatively determined that a main steam line flow of 525 lbm/hr is sufficient to induce the required minimum condensing chamber flow of 5×10^{-3} lbm/hr. The main steam flow when the vessel first starts producing steam and the MSIVs are opened was determined in PP&L memorandum SA-0214 to be 1972 lbm/hr or approximately 3.8 times the required 525 lbm/hr. This, coupled with the fact that the calculation conservatively used the steam flow friction pressure drop calculation to determine vent line flow, assures that the system will function during the early phases of startup.

b. The effect of the level instrumentation delay should be investigated for ATWS, startup, and plant transients.

PP&L memorandum SA-0217 documented a review performed to determine the effects of the increased instrumentation time delay on IPE, EOPs, SBO Rule, ATWS Rule, Maintenance Rule, IPEEE and the Plant Reliability model. It was concluded that the modification would have no impact on the listed Rules and events.

PP&L letter PLI-76865 provided the results of an evaluation of the effects on LOCA and plant transients. The conclusions of this evaluation state:

> "The increased delay times were determined above to be insignificant or were explicitly considered in the reload licensing analyses for U2 cycle 7 (i.e. MCPR operating limits and ASME overpressure analysis) and will be considered for future reload analyses."

Further, PP&L contracted General Electric Co. to evaluate the impact of the increased time delay on the feedwater control system. GE made the following statement in Memo FPA94-005:

> "Increasing the time delay of the reactor vessel water level signal from 0.25 to 1.0 second will not cause a significant change of the transient or steady state performance of the feedwater control system."

Based on the above discussion, time delay effects were evaluated and it was concluded that they did not adversely impact plant performance under all operating conditions.

c. **The reviewer has a concern about using a one-dimensional analysis for the vent leg, when the flow may not be one-dimensional.**

One dimensional analysis was used in the evaluation of the process by which the non-condensable gases are dissolved back into the reactor vessel fluid at the vent to variable leg interface. PP&L does not have a concern with using one dimensional analysis because the vent leg pipe is ½" schedule 80, with a length of approximately five feet from the condensing chamber to the liquid vapor interface. On this basis, the effects of any multi-dimensional behavior are and have been evaluated to be insignificant. In addition, the test program showed that the modification performed as, or better than, expected; therefore, any limitations of the analysis have been proven by the test.

Question 4. These comments/questions are for the test:

a. **Need to compare heat transfer areas in the vent leg for the test and proposed installed configuration. It seems that the test used a smaller vent line than the one installed.**

The vent leg geometries are discussed in sections 3.2.2 and 3.2.3 of the test report. For the vent to variable test, the critical parameters for the vent leg geometry are the length, slope, and diameter of the pipe above the reactor water level. The pipe below the water level does not affect the condensation rate, nor does it affect the way the non-condensable gas enters the water.

For all the proposed lower chamber modifications, the vent leg above the water level consists of a sloped section attached to the exit of the condensing chamber followed by an approximate 90° (five diameter bend) to a vertical section of pipe. The chamber elevation, water level elevation, and the bend are the same for each lower chamber modification. The most conservative vent leg geometry is then the one with the shortest horizontal section, since the least amount of condensation will occur in this leg. This configuration was chosen for the test. The size of the vent line tested was ½" as shown in drawing VAR-3 page 1 in the final report and the installed line in the plant is also a ½" line.

The steam vent geometry is not critical for this test because the vent line is downstream from the chamber and also, does not provide a path for any condensate formed in the vent line to return to the chamber. Therefore, the vent line should not have any adverse impact on the build-up of non-condensable gases in the chamber, and merely serves as a conduit for flow through the steam inlet and chamber. The modification installed a 1" vent line for the upper chambers, and this size line was used in the tests.

The vent line configurations used in the test for both modifications are the same as those used in the tests. The tested vent line sizes are not different than those installed at SSES and the bases for the chosen configurations are discussed in detail in the test report.

b. **The tests were performed with temperature measurements of the condensing chamber gas space. It would be useful to have similar measurements in the plant.**

This was discussed by the water level team to determine if an in-situ test or laboratory test should be performed. The team concluded that the laboratory test would offer more information on the modification performance (e.g.: temperature, concentrations) and would allow for testing flexibility.

The tests concluded that for a SSES bounding configuration the vent modifications performed as expected. The test program was performed to prevent having to perform in-situ proof of performance testing. Temperature monitoring in the plant was considered not necessary since the test program concluded that the modification was effective.

c. **Acceptance criteria for allowing a non-condensable concentration of 150 ppmv in the reference leg. Needs to be demonstrated or a reference provided.**

This value was determined in the BWROG degas test program performed by Continuum Dynamics. The results of this test program were documented in CDI report 93-05 ("Testing of Prototypical Boiling Water Reactor Water Level Instrumentation Reference Leg De-Gassing"). The report states "The test program identified a dissolved gas concentration below which insignificant level errors occur (nominally 150 ppm by volume)".

This report was transmitted to the NRC in a letter from the BWROG (BWROG-94007) dated 1/12/94.

d. **Need to document the comparison between the test rig and the installed modification. This is important since no in-situ testing will be performed. This is also important for the vent to steam test when the flow through the condensing chamber depends on condensation in the chamber and vent line, as well as losses in the lines.**

The bases used in determining the design of the test rig are documented in sections 3.2.2 and 3.2.3 of the test program final report. The configurations were chosen such that they would provide bounding worst case scenarios.

Bounding geometries would represent those that had the strongest tendency to remove non-condensable gas from the condensate return flow in the steam inlet. Non-condensable gas is released from the return condensate flow because the partial pressure of non-condensable gas in the steam inlet is less than the concentration in the chamber; hence, the dissolved gas in the condensate return is not in equilibrium with the partial pressure of the gas in the steam inlet line. This release is accelerated in turbulent flows, such as would be caused by sloped pipe segments or at nucleation sites, which would increase with increased length. Therefore, the test configuration was chosen as that which would have the longest steam inlet length and largest slope at SSES. This was done for both the upper and lower chambers.

The lengths and slopes were determined from a review of SSES drawings. The geometry of the reference leg is not critical because the test monitored the non-condensables in the vapor space of the chamber. The reference legs used in the tests were the same one inch pipe used in the plant, but were truncated at approximately five feet.

The vent line geometries were discussed in the response to question 4.a. The comparison between the installed and tested configurations is discussed in detail in sections 3.2.2 and 3.2.3 of the final report. The configurations were obtained from actual SSES and proposed modification data, and provide bounding configurations for SSES.

The flow through the upper condensing chamber has been discussed in the response to question 3.a.

e. **The upper chamber vent tests were limited in scope. The basis for not performing test with mixture of steam and non-condensables and for not maintaining the same configuration as in the plant needs to be provided. Also, can there be a build-up of non-condensables in the chamber which will prevent gas purging?**

The entrainment flow tests were performed with a nitrogen supply due to the limited steam production rate of the boiler. A scaling analysis was performed as discussed in section 2.2.1 of the test report to correlate the nitrogen flow rates to actual steam flow rates.

The low steam flow tests used a steam flow from the boiler, with nitrogen being used to provide a high initial non-condensable concentration in the chambers. The boiler water was not injected with a high concentration of non-condensables in this test as was done for the vent to variable tests. The reason for this was that the tests were performed to prove that the chambers would be cleared of non-condensables. The steam flow cleared the chambers of a high initial non-condensable concentration in a relatively short time. The added non-condensable concentration in the boiler water would be insignificant for the purposes of this test.

For the upper chambers, non-condensable gas is removed by positive steam flow. We have determined that sufficient steam flow will exist to ensure the chambers are purged when the vessel starts producing steam and the MSIV's are opened. Therefore, for the upper chambers, there is no upper limit of non-condensable gas concentration which will prevent the chambers from being purged.

The test configurations have been discussed in the response to question 4.d.

Question 5. During a March 8, 1995 telecon between the NRC, PP&L and the BNL contractor, an additional question was raised as to the relative condensation rates and why they are not proportional to the condensing chamber and vent areas.

The specific guidance given by S. Levy, Inc. with reference to these areas is that

$$(A_v + A_c) / A_v \langle 10$$

which reduces to

$$\frac{A_c}{A_v} \langle 9$$

where A_v = condensation area of the vent and A_c = condensation area of the chamber.

The condensing chamber is roughly a piece of 18" long 3" schedule 80 piping, with an ID of 2.9". The condensation area (ignoring end effects and the small amount of water on the bottom) is then

$$A_c = \pi \ (2.9)(18) = 164 \ in.^2$$

The vent pipe is ½" schedule 80 piping (ID = 0.546") and, in the test program, the length from the condensing chamber outlet to the normal water level was 57.75". Therefore, the vent condensing area is

$$A_v = \pi \ (0.546)(57.75) = 99.1 \ in.^2$$

Therefore, the condensation rate ratio of the condensing chamber to the vent ought to be

$$CondensationRatio = \frac{A_c}{A_v} = 164 \ in.^2 / 99.1 \ in.^2 = 1.66$$

The measured condensation ratio was

$$CondensationRatio = \frac{\dot{m}_c}{\dot{m}_v} = \frac{2.8\, lbm / hr.}{1.6\, lbm / hr.} = 1.75$$

Therefore, agreement with the theory is very good, and the resultant area ratio is well within the specification set by S. Levy, Inc.

The above information was presented, discussed, and found acceptable during the March 8, 1995 telecon. As stated previously, this letter is documenting PP&L's response to the follow-on questions. If additional information is needed, please contact Mr. A. K. Maron at (610) 774-7852.

Very truly yours,

R. G. Byram

cc: NRC Region I
Ms. M. Banerjee, NRC Sr. Resident Inspector - SSES
Mr. C. Poslusny, Jr., Sr. Project Manager - OWFN

50-387/388

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

March 28, 1995

James Kenny
Supervisor Licensing
Pennsylvania Power and Light Company
2 North Ninth Street
Allentown, Pennsylvania 18101

Dear Mr. Kenny:

Thank you for agreeing to share Pennsylvania Power and Light Company's experiences and insights regarding the NRC's cost beneficial licensing action program during the public workshop to be held here on April 13. As you know, the workshop is being sponsored by the Office of Nuclear Reactor Regulation to provide a forum for the NRC and industry representatives to exchange views, and share information on both the NRC's Cost Beneficial Licensing Action (CBLA) and Technical Specification Improvement Programs (TSIP). The staff feels that both these programs provide a substantial reduction of unnecessary regulatory burden and can enhance safety by allowing staff and industry resources to be directed to programs and activities that have higher safety significance.

A workshop announcement and invitation with a preliminary program agenda, workshop information sheet, area map, Two White Flint North Auditorium location map, list of hotels, and workshop registration form is enclosed.

Your willingness to take time out of your busy schedule to attend the workshop and help inform others about cost beneficial licensing actions is very much appreciated. The NRC would like to encourage greater participation in these programs, and your comments will provide an important perspective for others attending the workshop.

If you have any questions or comments in advance of the workshop, please do not hesitate to contact Gene Imbro, Director, RRG/CBLA Programs at (301) 415-2969 or Elizabeth Doolittle of his staff at (301) 415-1247.

Again, thank you in advance for your participation.

Sincerely,

WTRussell

William T. Russell, Director
Office of Nuclear Reactor Regulation

Enclosure:
Workshop Announcement and Invitation