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September 22, 1983

Dr. Thomas E. Murley
Regional Administrator, Region I
U.S. Nuclear Regulatory Commission
631 Park Avenue
King of Prussia, PA 19406

SUSQUEHANNA STEAM ELECTRIC STATION
FINAL REPORT OF A DEFICIENCY INVOLVING
EMERGENCY SERVICE WATER (ESW) SYSTEM WATER HAMMER
ERs 100450/100508 FILE 821-10 DOCKET NOS. 50-387
PLA-1812 AND 50-388

References: PLA-15258 dated 8/27/82
PLA-1604 dated 4/12/83

Dear Dr. Murley:

This letter serves to provide the Commission with a final report on a deficiency involving Water Hammer in the ESW System.

This deficiency was originally reported by telephone to Mr. S. Ebneter of NRC Region I by Mr. A. R. Sabol of PP&L on May 5, 1982. The referenced PLA-1604 provided the Commission with a third interim report on the subject deficiency. In PLA-1604 PP&L indicated that we anticipated submitting a final report in June, 1983. During subsequent discussions with NRC Resident Inspectors G. Rhoads and J. McCann on the ESW Water Hammer concerns, including project schedules for system analysis and corrective action determination, PP&L was granted an extension for submitting the final report.

The attachment to this letter contains a description of the deficiency, its cause, an analysis of safety implications and the corrective action taken and planned. This information is furnished pursuant to the provisions of 10CFR50.55(e).

Since the details of this report provide information relevant to the reporting requirements of 10CFR21, this correspondence is considered to also discharge any formal responsibility PP&L may have in compliance thereto.

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We trust the Commission will find this report to be satisfactory.

Very truly yours,

N. W. Curtis
Vice President-Engineering & Construction-Nuclear

JS:sab

Attachment
js/lt/i/124/a

Copy to:
Mr. Richard C. DeYoung (15)
Director-Office of Inspection & Enforcement
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Mr. G. McDonald, Director
Office of Management Information & Program Control
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Mr. Gary Rhoads
U.S. Nuclear Regulatory Commission
P.O. Box 52
Shickshinny, PA 18655

Records Center
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1100 Circle 75 Parkway, Suite 1500
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Mr. Robert L. Perch
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7920 Norfolk Avenue
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SSES PLA-1812
ERs 100450/100508 FILE 821-10

SUSQUEHANNA STEAM ELECTRIC STATION
WATER HAMMER IN THE EMERGENCY SERVICE WATER SYSTEM
FINAL REPORT

PURPOSE

This report supplements our previous Interim Report transmitted in our letter PLA-1604, dated April 12, 1983.

DESCRIPTION OF DEFICIENCY

During preoperational testing at Susquehanna Steam Electric Station, water hammer occurred in the ESW System, which resulted in damage to three pipe hangers. An investigation into the cause of the hanger failures revealed that there are certain operating and test conditions under which the ESW system could be subjected to water hammer.

The water hammer occurs as a result of the following sequence of events:

(1) ESW System in operation - ESW pumps are on and the 36" Motor Operated Bypass Valves to the spray pond are open.

(2) Loss of Offsite Power (LOOP) occurs - ESW pumps trip; 36" MOVs remain open; ESW piping begins to drain down to spray pond.

(3) Power supply transfers from offsite source to onsite emergency diesel generators.

(4) Approximately 10 seconds after the diesel generators receive a start signal, the 36" bypass valves begin to close. The ESW System continues to drain down to the spray pond during the nominal 30-second closure time of the valves.

(5) 55 seconds after the start of the diesel generators, the ESW pumps restart simultaneously.

The restart of the ESW pumps causes water to be accelerated through partially emptied ESW piping, resulting in water hammer. It was also determined that the potential for water hammer exists on ESW (loop A only) due to an inadequate 1" keep fill crosstie with service water.

As a result of the above-described events, the potential exists for the ESW System to experience stresses which exceed the design allowables during a water hammer event.

CAUSE

Non-simultaneous LOCA/LOOP was not a design basis for the plant.

Also, the water hammer can be caused from having ESW in service and experiencing a LOOP.

SAFETY IMPACT

Water hammer may cause degradation of the ESW System. If the ESW System degrades, the safe shutdown of the plant could be compromised. The safety function of the ESW System is the removal of heat from the ECCS equipment and the diesel generators. The loss of heat removal capability has an adverse affect on plant safety.

INTERIM FIX

See PLA 1604 for a description of the interim fix. The inadequate 1" keep fill crosstie has been corrected by modifying valve arrangements to allow for an additional 4" crosstie. Subsequently test OP-TY-054, "ESW Operability Test", was performed and no water hammer was observed.

CORRECTIVE ACTION

PP&L has evaluated vacuum breakers, a slow refill system, head tanks, check valves on ESW supply lines to the control structure chillers, accumulators, motor operated isolation valves on the lines to the control structure chillers and hanger modifications as possible solutions to the ESW water hammer problem. PP&L's evaluation of these alternatives indicated that the vacuum breaker alternative will yield acceptable stress levels, meet the cooling requirements for ESW and not overly complicate the control of ESW. The vacuum breakers will be installed during the first refueling outage on Unit 1.

The initial computer generated forcing function run for the vacuum breaker solution indicates that this case produces only a fraction of the unbalanced force that would exist without vacuum breakers. The addition of vacuum breakers introduces air into the piping system when the high points begin to drain. When the ESW pumps restart, the air is compressed by the water thus reducing the velocity of the two water interfaces.

The pressure spike that results from this scenario is caused by an overshooting of system pressure to dissipate the momentum of the water. This pressure spike rises very slowly (seconds) compared to the water hammer event without vacuum breakers (milliseconds). Accordingly, the unbalanced forces on the piping system are significantly reduced since the pressure difference from one end of a segment to the other end will be small. Actually the "water

hammer" - the meeting of the two water interfaces - is eliminated by the introduction of air into the system since the two water interfaces don't meet during the transient.

Other utilities contacted that have used vacuum breakers as a water hammer fix have not found it necessary to incorporate air relief valves. PP&L is investigating any Susquehanna unique features that may make air reliefs necessary.

COMMITMENT COMPLIANCE

PP&L letter PLA-1258 delineates the criteria for operation until the first refueling outage on Unit 1 and the criteria for the long term fix.

For operation until the Unit 1 first refueling outage, PP&L demonstrated by test that the piping stresses were below the allowables during the transient. The long term fix commits PP&L to demonstrating that all piping, hanger and anchor bolt loads for this event are within code and NRC allowables either by analysis or testing.

After the installation of the vacuum breakers water hammer related concerns are dismissed since the two water interfaces do not meet during the transient. However, to demonstrate that the vacuum breakers do eliminate water hammer concerns, an analysis is being done for "A" loop of ESW in the control structure chiller area. This analysis will calculate the piping, hanger and anchor bolt loads. PP&L expects that all these loads will be within code and NRC allowables for the existing piping and support system. PP&L will review the results of this analytical effort for ESW loop A and decide if further analyses must be performed for ESW loop B and for the ESW piping for the two direct expansion units on Unit 2. This decision will be made by October 31, 1983.

JUSTIFICATION FOR TWO UNIT OPERATION

Operation of Unit 2 until the startup of Unit 1 following its first refueling outage will be justified by demonstrating by test that the piping stresses do not exceed the allowables during the transient (the interim water hammer fix will be used during this period). The locations where high water hammer stresses are expected to occur on Unit 2 will be instrumented with pressure transducers and tests conducted prior to fuel load to show compliance with our piping stress commitment.

The control structure chiller area will not have any instrumented tests conducted on it. Acceptable water hammer loads were achieved in this area when the system was started in the following sequence:

- An ESW pump starts.

- The ESW pump discharge valve remains throttled until the system is filled.

- The ESW pump discharge valve is fully open before the bypass valve begins to open.

Acceptable loads were achieved before (TP-54-001 and BLP-24025) with this sequence of events (Unit 1 only). Piping loads in this area will continue to be acceptable when it is shown this starting sequence still occurs after Unit 2 is tied in.

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