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United States Nuclear Regulatory Commission
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Perry Nuclear Power Plant
Docket No. 50-440
LER 2003-005

Ladies and Gentlemen:

Enclosed is Licensee Event Report (LER) 2003-005, Technical Specification Violation/Loss of Safety Function Due to Air Bound Water-leg Pump. This LER was written to document conditions identified during LER 2003-002-001 preparation.

There are no regulatory commitments contained in this letter. Any actions discussed in this document that represent intended or planned actions, are described for the NRC's information, and are not regulatory commitments.

If you have questions or require additional information, please contact Mr. Vernon K. Higaki, Manager – Regulatory Affairs, at (440) 280-5294.

Very truly yours

Tom [signature]

for William R. Kanda
Enclosure: LER 2003-005
cc: NRC Project Manager
NRC Resident Inspector
NRC Region III

IE22

NRC FORM 366 (7-2001) U.S. NUCLEAR REGULATORY COMMISSION	APPROVED BY OMB NO. 3150-0104 EXPIRES 7-31-2004
LICENSEE EVENT REPORT (LER) (See reverse for required number of digits/characters for each block)	Estimated burden per response to comply with this mandatory information collection request: 50 hrs. Reported lessons learned are incorporated into the licensing process and fed back to industry. Send comments regarding burden estimate to the Records Management Branch (T-6 E6), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by internet e-mail to bjs1@nrc.gov, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202 (3150-0104), Office of Management and Budget, Washington, DC 20503. If a means used to impose information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

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4. TITLE
Technical Specification Violation/Loss of Safety Function Due to Air Bound Water-leg Pump

5. EVENT DATE			6. LER NUMBER			7. REPORT DATE			8. OTHER FACILITIES INVOLVED	
MO	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REV NO	MO	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
10	31	03	2003	005	0	12	29	2003	FACILITY NAME	DOCKET NUMBER

9. OPERATING MODE	1
10. POWER LEVEL	100%

11. THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check all that apply)

	20.2201(b)		20.2203(a)(3)(ii)		50.73(a)(2)(ii)(B)		50.73(a)(2)(ix)(A)
	20.2201(d)		20.2203(a)(4)		50.73(a)(2)(iii)		50.73(a)(2)(x)
	20.2203(a)(1)		50.36(c)(1)(i)(A)		50.73(a)(2)(iv)(A)		73.71(a)(4)
	20.2203(a)(2)(i)		50.36(c)(1)(ii)(A)		50.73(a)(2)(v)(A)		73.71(a)(5)
	20.2203(a)(2)(ii)		50.36(c)(2)	X	50.73(a)(2)(v)(B)		OTHER Specify in Abstract below or in NRC Form 366A
	20.2203(a)(2)(iii)		50.46(a)(3)(ii)	X	50.73(a)(2)(v)(C)		
	20.2203(a)(2)(iv)		50.73(a)(2)(i)(A)		50.73(a)(2)(v)(D)		
	20.2203(a)(2)(v)	X	50.73(a)(2)(i)(B)		50.73(a)(2)(vii)		
	20.2203(a)(2)(vi)		50.73(a)(2)(i)(C)		50.73(a)(2)(viii)(A)		
	20.2203(a)(3)(i)		50.73(a)(2)(ii)(A)		50.73(a)(2)(viii)(B)		

12. LICENSEE CONTACT FOR THIS LER

NAME	TELEPHONE NUMBER (Include Area Code)
Kenneth F. Russell (Compliance Engineer)	(440) 280-5580

13. COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT

CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX

14. SUPPLEMENTAL REPORT EXPECTED		15. EXPECTED SUBMISSION DATE	MONTH	DAY	YEAR
YES (If yes, complete EXPECTED SUBMISSION DATE).	NO				

16. ABSTRACT (Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines)

On September 11, 2003, it was determined that the division 1 feedwater leakage control system (FWLCS) piping and the low pressure core spray (LPCS) to residual heat removal (RHR) A crossover piping contained air. This condition resulted in air binding of the LPCS/RHR A water-leg pump on loss of power. This condition was previously reported in LER 2003-002. On October 31, 2003, it was determined that sufficient air had accumulated in the FWLCS line such that it would have prevented the division 1 FWLCS and the RHR A suppression pool cooling mode from performing their function. This condition was determined to be a piping design error that caused air bubbles to be stripped out of solution and migrate into the FWLCS. Procedures to periodically vent the affected piping were not in place. The condition is believed to have existed since initial plant operation. The air in the piping was estimated to take about 31 days following a refuel outage to reach the amount required to impact operability. Since the FWLCS and RHR A suppression pool cooling mode were inoperable longer than the required action completion time, this condition is reportable per 10CFR50.73(a)(2)(i)(B), as a condition prohibited by Technical Specifications. Also since the redundant division 2 equipment had been inoperable for maintenance on several occasions during this time, this condition is also reportable per 10CFR50.73(a)(2)(v)(B) and (C). Procedures to periodically vent the affected piping have been established. Design modifications are being initiated to reduce the accumulation of air in the FWLCS.

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INTRODUCTION

The condition identified in this report involves air binding in the water-leg pump for the division 1 emergency core cooling systems (ECCS) following a loss of power due to air buildup in the division 1 feedwater leakage control system (FWLCS) piping. This condition was previously identified in LER 2003-002.

A requirement of the ECCS is that cooling water flow to the reactor pressure vessel (RPV) be initiated rapidly when the system is called on to perform its function. The time delay between the signal to start the pump and the initiation of flow into the RPV can be minimized by keeping the ECCS pump discharge lines full. Additionally, if these lines were empty when the systems were called for, the large momentum forces associated with accelerating fluid into a dry pipe could cause physical damage to the piping. Therefore, the ECCS discharge line fill system is designed to maintain the pump discharge lines in a filled condition.

Since the ECCS discharge lines are elevated above the suppression pool, check or stop-check valves are provided near the pumps to prevent back flow from emptying the lines into the suppression pool. Past experience has shown that these valves will leak slightly, producing a small back flow that will eventually empty the discharge piping. To ensure that this leakage from the discharge lines is replaced and the lines are always kept filled, a water-leg pump is provided for each of the three ECCS divisions. The fill system, typical for each of the three ECCS divisions, consists of a water-leg pump that takes suction from the corresponding ECCS division's pump suction line(s) from the suppression pool and discharges downstream of the check valves on the ECCS pump discharge line.

Initial complete filling of the piping systems is accomplished using the combination of water-leg pumps, condensate water supply lines, maintenance drains, vents, and test connections that are available. Air is eliminated from the ECCS pump discharge lines when the fill system is placed into service by opening vents at piping high points until water begins to flow from the vents. A high point venting procedure is repeated, after initial fill of the system, any time it is suspected that the Residual Heat Removal (RHR) [BO] loops are not filled, such as when the water-leg pump is stopped and restarted, and following indication of low discharge line pressure. Pressure instrumentation provided on the ECCS pump's discharge line initiates an alarm in the control room when pressure in the discharge line is less than the hydrostatic head required to maintain the line full. Indication is also provided in the control room as to when the water-leg pumps are operating.

The FWLCS consists of two subsystems designed to eliminate through-line leakage in the feedwater piping by providing a positive seal for the stem, bonnet and seat of the outboard isolation valve on each feedwater line. The division 1 subsystem uses the low pressure core spray (LPCS) water-leg pump [BM-P] to supply sealing water through the bonnets of the outboard isolation valve. Following closure of the outboard isolation valve, the sealing water seals the stems, bonnets and seats, and isolates the feedwater lines.

Following a loss of coolant accident (LOCA), the FWLCS is manually initiated from the control room. The operator first verifies feedwater unavailability through low feedwater pressure (approximately 30 psig), then closes the outboard containment isolation valves with the key-lock switches, and opens one of the motor-operated FWLCS valves from the control room. The suppression pool sealing water from one of the water-leg pumps (or both if they are available) is routed to both outboard containment isolation valves.

When the FWLCS is initiated manually following a LOCA, there should be no demand for keep-fill water in the RHR and LPCS systems since these systems will be operating. Therefore, the water-leg pump should be totally dedicated to provide sealing water to the FWLCS. A single water-leg pump has the capacity to provide the necessary sealing water to the FWLCS.

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EVENT DESCRIPTION

At 1610 hours on August 14, 2003, the Perry Nuclear Power Plant (PNPP) experienced a loss of offsite power (LOOP) event and a subsequent reactor SCRAM. Events associated with this condition were reported as required via the Emergency Notification System (ENS) and in Licensee Event Report (LER) 2003-002. As a result of the LOOP event, power to low pressure core spray (LPCS) / residual heat removal (RHR) A water-leg pump , RHR B/C water-leg pump, Reactor Core Isolation Cooling (RCIC) [BN] water-leg pump, and High Pressure Core Spray (HPCS) [BG] water-leg pump, was momentarily interrupted. All four water-leg pumps restarted after the emergency diesel generators (EDGs)[EK] began supplying power to their respective electrical busses. At the same time that the water-leg pumps restarted, alarms were received for "RHR PUMP A DISCHARGE PRESSURE HI/LO" and "LPCS PUMP DISCHARGE PRESSURE LO." As a result of the alarms, RHR A and LPCS were made inoperable at 1847 hours when the Unit Supervisor placed them in secured status as directed by plant procedures. At 2145 hours, plant operators completed venting the LPCS/RHR A water-leg pump by opening the pump casing vent valve. An abnormal amount of air/gas was noted during the venting evolution. Following venting, the LPCS/RHR A water-leg pump was started and developed normal discharge pressure. The LPCS and RHR A systems were then filled and vented. Since the low pressure alarms cleared and the venting was completed, the RHR A system was declared operable at 2002 hours on August 15, 2003. LPCS was subsequently declared operable at 0318 hours on August 16, 2003.

On September 11, the team that was investigating the air-binding of the water-leg pump, identified that the division 1 FWLCS piping and the LPCS to RHR A crossover piping contained significant amounts of air. Approximately 7.5 standard cubic feet (SCF) of air was vented from the division 1 FWLCS high point vent. This volume was determined by measuring the flow rate and monitoring the time that air flow existed. Air was also vented from the crossover piping for 3 to 4 minutes. The other water-leg pumps, RCIC, HPCS, RHR B/C and the fire protection system water-leg pumps were vented to ensure operability. No significant air was found in these additional systems. On September 17, ultrasonic testing was performed on the accessible division 2 FWLCS piping which verified it did not contain any significant air pockets.

After identification of the air, the investigators determined air bubbles were being stripped from the water by an industry known phenomenon called "Air Stripping" and "Desorption" (Ref. SOER 97-01) and accumulating in the piping for the FWLCS. Calculations confirmed that the volume of the FWLCS piping, 8 cubic feet, was about the same as the volume of air that was vented, 7.5 cubic feet.

A corrective action to measure air volume, during periodic venting, was established to determine the rate that the air accumulates in the FWLCS piping. It was initially estimated that it took about 31 days for air to void the FWLCS piping. The current process requires the accumulation time between venting to be gradually increased. Currently the air accumulated, up to a period of 3 weeks, is small and does not impact operation of the system.

After identifying the manner in which the air accumulated in the FWLCS, it was determined that the FWLCS piping high point vent had not been included in the procedures to vent the piping.

An evaluation was performed to determine the impact of the air on FWLCS, LPCS and RHR A. On 10/31/03, it was determined that sufficient air had accumulated in the FWLCS line to cause air binding of the water-leg pump following a loss of power, which would have prevented the division 1 FWLCS from performing its function and that RHR A would have been inoperable for suppression pool cooling mode following a loss of power. Since LPCS and the low pressure coolant injection mode of RHR A start on power restoration with an initiation signal present, before the water-leg pump becomes air bound, operability

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was not affected.

When the water-leg pump loses power, the discharge pressure will decrease allowing the air bubble to expand, to as much as 8 cubic feet at atmospheric pressure, and enter the water-leg pump discharge header, the water-leg pump case, its suction piping and recirculation piping. When the pump is re-energized the water-leg pump might be unable to clear the air from the pump. The air in the FWLCS line is believed to have impacted system operability from about 31 days following each refuel outage.

The required action completion time for one inoperable FWLCS requires restoration in 30 days. One inoperable RHR suppression pool cooling subsystem requires restoration in 7 days. Since the FWLCS and RHR A suppression pool cooling mode were inoperable longer than the required action completion time, this condition is reportable per 10CFR50.73(a)(2)(i)(B), as a condition prohibited by Technical Specifications.

An additional review determined that RHR B (suppression pool cooling mode) had been inoperable on several occasions within the past 3 years and that Division 2 FWLCS had been inoperable when required on two occasions for maintenance within the last 3 years. These conditions are reportable per 10CFR50.73(a)(2)(v), as "Any event or condition that could have prevented the fulfillment of a safety function of structures or systems that are needed to: (B) Remove residual heat and (C) Control the release of radioactive material" respectively.

CAUSE OF EVENT

The cause for the air binding has been determined to be inadequate or incomplete design (piping configuration) whereby the LPCS/RHR A water-leg pump system generates air which collects in the division 1 feedwater leakage control system (FWLCS) piping.

The investigation team concluded that air bubbles are being generated in the system and are collecting at a system high point before being re-absorbed into the pumped fluid. Containment air in equilibrium with the suppression pool, is diffused throughout the LPCS suction piping. When pressure is reduced in the eye of the LPCS/RHR A water-leg pump impeller, and/or as water passes through the recirculation piping restricting orifice, air comes out of solution in the form of bubbles (air stripping). The bubbles are present in the pump discharge and are re-absorbed into the fluid as a function of time and turbulence of flow. The piping tap for the FWLCS system is located approximately one foot from the pump discharge. Due to the close proximity of the riser and the pump discharge the air does not have enough time to fully re-absorb. This vertical riser constitutes a dead leg, as there is only flow in the line when the FWLCS is placed into service. Air bubbles present in the discharge line would migrate up the FWLCS inlet piping thereby gradually forming a pressurized air bubble. This 1-1/2 inch schedule 80 piping is routed from the 574 foot elevation up to the 641 foot elevation encompassing several elbows and horizontal sections during its route. From there, the piping has a vertical riser down to elevation 623 feet. At the 623 foot elevation, a normally closed motor operated valve separates the division 1 water leg pump piping from the FWLCS piping supplying feedwater manual isolation valves. Equilibrium is obtained when the FWLCS riser is full of air and pressurized to pump discharge pressure (44 psig). The volume of the FWLCS piping was calculated to be approximately 2.0 cubic feet and system pressure at the inlet to the FWLCS piping approximately 44 psig.

When the LOOP event occurred, pumping power was lost. This allowed the air bubble located in the FWLCS to expand. Pressure of the bubble was reduced to equilibrium with the suppression pool (approximately 7 psig). This expanded bubble encompassed the water-leg pump suction preventing suppression pool water from flooding the pump suction area. With the loss of suction, the water leg pump became air bound. The team calculated that the air bubble entrapped by the FWLCS piping riser, when vented to atmosphere, would contain approximately 8 cubic feet. The air being generated within the

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water-leg pump system was verified by field venting. While venting could not determine the exact place within the system where the air was being generated, it was sufficient to confirm the presence of air. Field venting to prove air generation within the system was measured using an air flow meter. Venting at a LPCS suction line dead leg high point was also performed. These vents were performed initially to confirm the presence of air and also establish a reference value. Additional venting evolutions were then performed, initially on a weekly basis in order to confirm air was being generated within the water leg pump system.

Past venting procedures have failed to remove entrapped air from two high point locations in the division 1 FWLCS system and LPCS/RHR A water-leg pump piping. A review of historical system operating instructions for LPCS showed the FWLCS high point vent valve had not been included in the past filling and venting instructions.

SAFETY ANALYSIS

The air volume in the FWLCS was analyzed to determine its effects on the associated systems abilities to perform their functions during normal, transient and accident operations.

With the quantity of air found in the FWLCS piping, the division 1 FWLCS would have been inoperable following a loss of power and unable to perform its intended function. Following loss of power with sufficient duration, pressure would decrease in the piping and allow the air bubble to expand into the water-leg pump. The water-leg pump would have become air bound and unable to supply the necessary water.

If FWLCS had been initiated, which opens the FWLCS isolation valve, water pressure from the suppression pool would have been required to push air through the LPCS/RHR A water-leg pump until water filled the pump casing and pushed the air out. If the downstream pressure was greater than 7.5 psig, the pressure due to the height of water in the Suppression Pool would not push the air bubble through the water-leg pump. As pressure in the FWLCS decreased, suppression pool pressure would eventually have been able to prime the water-leg pump and allow it to start pumping. Under these conditions, the required injection times for Division 1 FWLCS would not be met, but the system might eventually function, depending on the FWLCS pressure decrease.

Both RHR A and LPCS were reviewed for past operability with respect to the USAR accidents. Of the USAR accidents reviewed, the LOOP/LOCA is considered bounding.

During a LOCA, when RHR A and LPCS are required to operate, they receive an immediate automatic initiation signal on high drywell pressure or low RPV water level and are required for vessel inventory and containment cooling.

In the case of the LOOP/LOCA, the automatic initiation signal is generated when the division 1 EDG is started, with a time delay to provide staggered electrical loading. LPCS and RHR A have a 10 and 15 second time delay (inclusive of the 10 second EDG start time) respectively, designed for coordinated loading of the division 1 EDG. The short time durations are not considered sufficient to allow respective system pressures to decay such that voids would be generated.

Similarly, for the small line break Inside drywell, manual depressurization is assumed to occur at 30 minutes with shutdown cooling initiated at 3 hours. The event is similar to the main steam isolation valve (MSIV) [SB-V] closure event, with the exception that it assumes the single failure of an RHR pump. If it was assumed that the accident single failure was RHR B, the RHR A pump is still operable because it would have started on high drywell pressure at T=0 or T=15 seconds if the diesel were required to provide power. The RHR A and LPCS pumps would start on minimum flow at the beginning of the event and would be

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operable.

Initially during a LOOP, the RHR A and LPCS systems are expected to be without keep fill during the time the diesels were starting and loading. In the event of a concurrent LOCA, high drywell pressure initiates the RHR A/LPCS pumps according to the diesel loading scheme. This short time period (~10-15 seconds) would have been insufficient to lose system pressure, cause system drain down and cause the systems to be inoperable. Therefore, these systems would not have become inoperable during the time period that the emergency diesel generators start and load these pumps onto the bus during a LOOP/LOCA. Based on these considerations, RHR A and LPCS are considered operable for USAR analyzed accidents.

When LPCS and RHR A are evaluated for the USAR transients, the relevant transient is the MSIV closure transient.

The assumptions provided in the calculation for this transient include:

- Suppression pool is initially at 95 degrees F.
- A plant transient causes the main steam isolation valves (MSIVs) to close. No credit for any steam bypass to the condenser is assumed.
- Safety relief valves (SRVs) [SB-RV] cycle in relief mode on reactor pressure to maintain RPV pressure and transfer decay heat to the suppression pool.
- RCIC is assumed to start at Level 2 (130 inches) and provides flow to the RPV.
- One RHR subsystem is placed in service (suppression pool cooling) at 10 minutes.
- A second RHR subsystem is placed in suppression pool cooling in 20 minutes.

An orderly shutdown/cooldown of the plant commences at 30 minutes after the event . Pressure (assumed at 1040 psia initially) is reduced at a rate of less than 100 degrees F/hr until the shutdown cooling (SDC) interlock is reached (approx. 2 hrs). For conservatism, the analysis is continued for an additional 30 minutes to 300 degrees F (67psia)

At 3 hrs, RHR is placed in SDC effectively ending pool heat-up.

The second RHR subsystem for suppression pool cooling would not have been available as a result of air binding.

Considering the above information, LPCS is considered operable for transients; however, RHR A is considered inoperable based on not being available as required for a transient condition involving a LOOP/MSIV closure in which RHR is required for suppression pool cooling.

Review of the plant log and the division 2 water-leg pump discharge pressure history identified two occasions when the pump was not available to provide the division 2 FWLCS function, one time for about 51 hours and an additional time for about 21 hours. RHR B (suppression pool cooling mode) has been inoperable on several occasions within the past 3 years for maintenance.

The conditional core damage probability (CCDP) for the LOOP event was discussed in previous LER 2003-002. The calculations in this LER are related to the effects of loss of mitigating systems due to the air bound

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water-leg pump. Due to the failure mechanisms, as discussed above, the LOOP/MSIV closure transient that requires operation of RHR in the suppression pool cooling mode is the transient of interest. This analysis provides a quantification of the risk in terms of the increase in the core damage frequency (CDF) associated with the added RHR A failure mode during a LOOP.

A version of the Perry PSA model that includes internal flooding was used to assess the increase in risk associated with the degradation of RHR A during a LOOP. Changes were made to the RHR A functional fault trees to emulate the vulnerability of RHR A during a LOOP. The increase in risk relative to the baseline configuration was used to determine the significance of the RHR vulnerability during a LOOP.

Fire assessment results from the EPRI Fire-Induced Vulnerability Evaluation (FIVE) evaluation in the Independent Plant Evaluation of External Events plus new conditional core damage probabilities computed with the PSA model were used to assess the impact to fire scenarios.

An estimation of the impact to seismic scenarios was made using data from NUREG-CR/1488.

The WinNucap Level 2 model was used to assess the impact to the large, early release frequency (LERF).

Results:

1. With the additional RHR A failure mode the increase in the CDF is about 9.2E-07 per year.

2. Including external events the increase in the CDF due to the additional RHR A failure mode is about 2.9E-06 per year.

   This assessment includes an estimation of the seismic contribution and results extrapolated from the conservative FIVE analysis that was performed for the IPEEE. The increase in the CDP associated with seismic events due to the additional RHR A failure mode is about 7.8E-09. The increase in the CDP due to fires is about 2.0E-06. The contribution due to external flooding is considered to be non-significant.

3. With the additional RHR A failure mode the increase in LERF is about 7.3E-08 per year.

In conclusion, the failure of the RHR A pump is considered to have a low to moderate safety significance.

CORRECTIVE ACTIONS

Periodic venting from the division 1 FWLCS and RHR A crossover vents was performed as an immediate corrective action, to ensure the continued operability of FWLCS, LPCS and RHR A. Further venting is being performed to determine the rate at which air is accumulating and venting frequency will be adjusted accordingly. Procedures were modified to include additional vent points. Design modifications are being initiated to reduce the accumulation of air in the FWLCS.

PREVIOUS SIMILAR EVENTS

No previous water-leg pump air binding event was identified to have occurred during the review of records for the previous 7 years at the PNPP.

Energy Industry Identification System (EIIS) codes are identified in the text in the format [xx].