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November 4, 2003
PY-CEI/NRR-2743L

United States Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555

Perry Nuclear Power Plant
Docket Number 50-440
LER 2003-004-00

Ladies and Gentlemen:

Enclosed is Licensee Event Report (LER) 2003-004, Emergency Service Water Pump Upper Shaft Coupling Sleeve Failure. This event report is submitted in accordance with 10CFR50.73(a)(2)(i)(B), as an operation or condition prohibited by Technical Specifications.

There are no regulatory commitments contained in this submittal. 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 Higaki, Manager-Regulatory Affairs, at (440) 280-5294.

Very truly yours,

Enclosure
cc: NRC Region III Administrator
NRC Senior Resident Inspector - PNPP
NRR Project Manager - PNPP

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
Emergency Service Water Pump Upper Shaft Coupling Sleeve Failure

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 05000 440
09	05	03	2003	-- 004 --	00	11	04	03	FACILITY NAME	DOCKET NUMBER 05000 440

9. OPERATING MODE	1	11. THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check all that apply)							
10. POWER LEVEL	100		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)		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)		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)	✓	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)
Dale L. Miller, Compliance Engineer	(440) 280-5466

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
B	BI	P	G200	Y					

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

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

On September 1, 2003, at 1717 hours with the plant operating in Mode 1 at 100 percent power, emergency service water (ESW) pump A was declared inoperable due to indications that the pump had failed. It was later determined that a pump shaft coupling had failed and that it would take longer than the Technical Specification (TS) Limiting Condition for Operation (LCO) completion time to complete repairs. A Notice of Enforcement Discretion (NOED) was requested of the NRC in order to obtain replacement parts, complete repairs and perform testing of the pump. The NOED for a 72 hour duration was verbally approved on September 4, 2003. At 0517 hours on September 5, 2003 the LCO for TS 3.7.1 and 3.8.1 expired and the plant entered the NOED. After completion of repairs, ESW A pump was declared operable at 1855 hours on September 5, 2003. The root cause of the coupling sleeve failure is stress corrosion cracking. This event is considered to have a low to moderate safety significance. Since the Actions of the TSs were not satisfied when the NOED was entered, this is a reportable event in accordance with 10CFR50.73(a)(2)(i)(B), any operation or condition that was prohibited by the plant's TSs.

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NARRATIVE *(If more space is required, use additional copies of NRC Form 366A)* (17)

I) INTRODUCTION

The emergency service water (ESW) [BI] system at the Perry Nuclear Power Plant (PNPP) is comprised of three independent subsystem loops A, B and C. These open subsystem loops take suction from and return to Lake Erie. Each loop is supplied by a separate pump, which is operated from a preferred power source or a standby diesel generator (DG) [EK]. The loops supply ESW to the following equipment. The ESW loops A & B supply cooling water to residual heat removal (RHR) [BO], standby DG and emergency closed cooling (ECC) [CC] water heat exchangers [HX], plus a fuel pool heat exchanger [DA-HX]. The C loop supplies cooling water to the high pressure core spray (HPCS) [BG] diesel generator and the HPCS pump room cooler. The ESW loops run intermittently for plant evolutions such as waste discharges, chemical treatments, ESW testing and testing of supported systems. The ESW loops only normally run for extended periods to support plant operations such as shutdown cooling during outages and when necessary to support operation of control complex chillers and ventilation trains.

On September 1, 2003, at 1717 hours with the PNPP operating in Mode 1 at 100 percent power, ESW pump A [BI-P] was declared inoperable due to indications that the pump had failed. It was later determined that a pump shaft coupling had failed. A Notice of Enforcement Discretion (NOED) was requested of the NRC and was verbally approved (reference PNPP letter PY-CEI/NRR-2735L) on September 4, 2003 to be able to obtain replacement parts, complete repairs and perform testing of the pump. The duration of the NOED was 72 hours. At 0517 hours on September 5, 2003 the Limiting Condition of Operation for Technical Specifications (TS) 3.7.1, ESW System – Divisions 1 and 2, and 3.8.1, AC Sources – Operating, expired and the plant entered the NOED. After completion of repairs, ESW A pump was declared operable at 1855 hours on September 5, 2003. Since TS 3.7.1, Actions A.1 and B.1, and TS 3.8.1, Actions B.4 and F.1 were not satisfied, this is a reportable event in accordance with 10CFR50.73(a)(2)(i)(B), any operation or condition that was prohibited by the plant's TSs.

II) EVENT DESCRIPTION

The ESW A pump was started at 1635 hours on September 1, 2003. At 1717 hours, after 42 minutes of operation, ESW A pump (Gould model VIT 20X30 BLC, 2 stage, 800 hp, 1185 rpm) indicated a loss of flow. The local pump discharge pressure instrument was observed to be indicating 20 psig, which was in agreement with the control room indication. The motor shaft was observed to be rotating. A maintenance engineer observed the motor current locally at the pump motor breaker to be 30 amps versus the normal running current of 91 to 97 amps. The control room staff observed all ESW A flow indications for RHR A, ECC A and Division 1 DG at 0 gpm with the motor still running. Computer data was reviewed for ESW A bearing temperatures, pump status and ESW A flows. This data indicated an immediate step change in flow rates correlating with a drop in stator temperature and initial drop in bearing temperatures. Motor bearing temperatures began to rise since cooling flow is from the pump discharge and flow was lost. It was later discovered that the upper pump shaft bearing failed from heat damage due to lack of cooling water flow before the ESW A motor was turned off at 1728 hours. The ESW A motor was meggered and indicated satisfactory results. The motor winding resistance was taken with a digital multi-meter and this data was acceptable. No motor protective trips occurred due to a fault.

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II) EVENT DESCRIPTION (continued)

An evaluation of the motor concluded that the motor was not affected by the pump coupling sleeve failure and was ready to return to service with no mechanical or electrical issues. Pump disassembly revealed that the top pump shaft coupling sleeve had failed. The coupling sleeve cracked into two pieces. The originating crack was axial and originated at one corner of the machined slot for the key and propagated to the opposite corner at the other end. Examination of the pump bowl indicated the first and second stage impellers showed no signs of being hit with a foreign object. No mechanical binding (rubbing in the impeller area, either axially or radially) was found in the pump assembly to induce coupling sleeve failure or explain why the coupling sleeve had failed.

III) CAUSE OF EVENT

The root cause of the coupling sleeve failure is stress corrosion cracking (SCC). The three components necessary for SCC, unfavorable environment, susceptible material, and high tensile stress were present in the coupling sleeve.

Examination of the failed coupling sleeve upon disassembly of the pump revealed that the pump coupling sleeve was incorrectly installed on the pump shaft. Finite element stress analysis of the pump shaft, split ring and coupling sleeve was performed. The stress analysis of the ESW pump coupling sleeve assembly indicated that improper installation of the coupling sleeve on the shaft increases the peak stresses in the hoop direction at the keyway by approximately 35 percent.

Laboratory analysis identified the initiation points of cracking in the coupling sleeve to be at either pits or manganese sulfide (MnS) inclusions near the theoretical peak stress locations. The coupling sleeve was manufactured from free machining (sulfur intentionally added) stainless steel ASTM A582, type 416 material. The part was furnished with a hardness of Rockwell C27 to C28, which corresponds to a tempering temperature below 1000°F. Martensitic stainless steels are susceptible to stress corrosion cracking when tempered between 800 and 1000°F. Type 416 stainless steel contains sulfur for machineability and results in high concentrations of MnS, which makes type 416 more prone to pitting than many other types of stainless steel. The laboratory analysis of the removed ESW A pump coupling material identified unfavorable heat treatment that made the material more susceptible to SCC.

An unfavorable environment was present due to the location of the failed coupling on the pump shaft that is exposed to raw lake water when operating. The failed coupling was located on the ESW A pump shaft approximately 17 feet above the normal water line when the pump is not operating. When the pump is not operating, the top two shaft coupling sleeves are exposed to air admitted into the piping through a vacuum breaker. The failed coupling is closest to the motor and is likely to see higher loads from the motor as torque is transmitted through the pump bearings.

The contributing causes to the stress corrosion cracking failure of the pump coupling sleeve include the improper coupling installation that created elevated tensile stress during operation, increased susceptibility of the material due to an unfavorable heat treatment, and an unfavorable environment.

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IV) SAFETY ANALYSIS

The following systems were considered inoperable as a result of the failure of ESW A pump.

- Low Pressure Core Spray
- Reactor Core Isolation Cooling
- Division 1 Emergency Diesel Generator
- Residual Heat Removal A in the low pressure coolant injection, suppression pool cooling, shutdown cooling and containment spray modes of operation
- Control Room HVAC Train A
- Hydrogen Analyzer A
- Emergency Closed Cooling A
- Combustible Gas Mixing Compressor A

The ESW B and C subsystems were operable and available to perform their design function.

ESW A pump was determined to be inoperable and unavailable to perform its intended function on September 1, 2003. A mission time of 24 hours is required for the success of the ESW function with respect to the probabilistic safety assessment model. The ESW A pump operated for more than 24 hours following the loss of offsite power (LOOP) outage on August 14, 2003. It is assumed that the train would have been available to perform its intended function prior to the August 14 event. After the LOOP recovery, ESW A was shutdown on August 23 at 2037 hours and was subsequently intermittently run for approximately 9 hours prior to the failure of the pump on September 1. The window of vulnerability for the pump was determined by subtracting an additional 15 hours from the time the pump was shutdown following the LOOP recovery. Thus, it is assumed that ESW A was unavailable to perform its intended function (mission time of 24 hours) from August 23 at 0537 hours until the time the ESW A pump shaft was repaired and declared available by the Shift Manager on September 5, 2003, at 1628 hours. Therefore, ESW A was considered to be unavailable for a vulnerability window of approximately 13.5 days.

The Core Damage Frequency (CDF) for the baseline Probabilistic Risk Assessment (PRA) model (internal events only) is 5.904E-06 per year. With ESW A pump unavailable, a CDF of 2.840E-05 per year was calculated. For the 13.5 days the ESW A pump was assumed to be unavailable, the incremental conditional core damage probability (ICCDP) was 8.32E-07.

The Incremental Conditional Large Early Release Probability (ICLERP) was obtained from a model that includes internal flooding. For ESW A being unavailable for 13.5 days, the ICLERP was computed to be 1.56E-07. This indicates that the unavailability of ESW A for 13.5 days also had an impact on LERP (i.e., ICLERP greater than 5.0E-08).

The PNPP does not have PRA models for seismic, fire, or external flooding. In development of the Individual Plant Evaluation - External Events a seismic margin analysis was performed. Fire was addressed through FIVE (Fire-Induced Vulnerability Evaluation) and external flooding has been addressed via a thorough assessment documented in Chapter 2.4 of the Updated Final Safety Analysis Report. External events (fire, seismic, & external flooding) are considered to have a negligible effect on the ICCDP and the ICLERP with the ESW A pump unavailable.

IV) SAFETY ANALYSIS (continued)

For common cause failure, an event must occur that causes simultaneous failure of similar equipment. In this scenario the similar equipment would be the ESW B and ESW C pumps. Stress-corrosion cracking was the likely cause for the ESW A pump failure. Several factors have to be present to set the conditions that would lead to this type of failure. Stress-corrosion cracking is time dependent. While a common mode failure is possible, it is unlikely that more than one pump would fail simultaneously since the ESW pumps had different operating and maintenance histories.

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

V) CORRECTIVE ACTIONS

This event was entered into the PNPP corrective action program (Condition Report 03-05065).

A rebuild of the ESW A pump was completed on September 5, 2003, and the pump was declared operable at 1855 hours that day. Four new coupling sleeves were installed and the correct coupling sleeve installation was verified.

A rebuild / replacement of the ESW A pump is being planned for the Division I outage, scheduled for March 2004. A complete pump except for the discharge head is ordered. An engineering change is to upgrade the materials for the impellers, diffuser bowls, suction bell, pump shafts and coupling sleeves. A revision to the purchase specification for ESW A pump is planned to provide certified material test reports (CMTR's) for all shafts, coupling sleeves and split rings. One hundred percent nondestructive examination (NDE) on the coupling sleeves is being specified.

A limited boroscopic examination of the ESW C pump is being planned for the next Division III outage, currently scheduled for November 2003 to confirm that the installed coupling is the threaded design. Pump shaft and coupling parts have been ordered as a contingency in case pump shaft coupling maintenance is necessary based on the condition of the pump shaft couplings at the time of the examination. Parts on order are of the threaded coupling design.

A rebuild of the ESW C pump is being planned for the first Division 3 outage in 2004 (currently scheduled for April 2004), if pump shaft coupling maintenance is not performed at the time of the November 2003 examination. A complete pump, except for the discharge head, is ordered for the rebuild with keyed shaft coupling sleeves. The purchase order for the ESW C pump is to be revised to provide CMTR's for all shafts, coupling sleeves, and split rings. One hundred percent NDE on the coupling sleeves after final heat treatment is being specified. The maximum hardness of the coupling sleeves is expected to be Rockwell C23.

A limited boroscopic examination of the ESW B pump is being planned for the next Division II outage, scheduled for April 2004 to verify the correct installation of the four-pump shaft coupling sleeves. Based on the findings of this examination, the next ESW B pump rebuild can be scheduled, which would also implement an engineering change to upgrade materials. The latest

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V) CORRECTIVE ACTIONS (continued)

scheduled date for the pump rebuild would be Refuel Outage (RFO) 11, approximately 4 years from RFO9.

Procedure GMI-039, "Disassembly of Emergency Service Water Pumps," has been revised (revision 6) to provide more explicit instructions on pump disassembly and re-assembly, paying particular attention to shaft coupling sleeve installation on the ESW pumps A & B.

Procedure GMI-040, "Disassembly of Div 3 Emergency Service Water Pump," is being revised to provide more explicit instructions on pump disassembly and reassembly, paying particular attention to the shaft coupling for both threaded and sleeve style installation on the ESW pump C.

Procedure GMI-041, "Disassembly of Emergency Service Water Screen Wash Pump," is being revised to provide more explicit instructions on pump disassembly and reassembly, paying particular attention to shaft coupling sleeve installation, on the ESW Screen Wash Pumps A & B.

The ESW C pump coupling sleeves (8) in the warehouse have been quarantined/placed on hold until proper material properties are verified. Review of the CMTR's showed these coupling sleeves have a hardness of Rockwell C30.

An industry search on emergency core cooling system (ECCS) pump failures is planned to look at the frequency of complete pump tear-downs, determine the parameters used to evaluate if pump rebuilds are required and to determine the periodicity for replacing shafts, couplings and bearings.

After the next disassembly and rebuild of the ESW C pump, the documented condition of the removed pump couplings and an analysis of the couplings at the FirstEnergy Corporation Beta Laboratory should provide input as to when the next ESW C pump rebuild should be scheduled. The condition of the ESW C pump should also provide input to an evaluation of when the ESW traveling screen pump A and B should be scheduled for future rebuilds.

VI) PREVIOUS SIMILAR EVENTS

A review of LERs over the past 6 years did not identify any reportable condition that resulted from the failure of a pump coupling.

A word search was performed to identify Condition Reports at the PNPP relating to pumps or coupling sleeves. This review did not identify any Martensitic or type 416 stainless steel couplings that failed due to stress corrosion cracking in raw water service. No evidence of a previous ESW pump coupling sleeve failure was found.

VII) COMMITMENTS

No regulatory commitments were identified in this report.

Energy Industry Identification System Codes are identified in the text by square brackets [XX].