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PNP 2011-066

October 03, 2011

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

SUBJECT: Licensee Event Report 2011-005, Service Water Pump Shaft
Coupling Failure
Palisades Nuclear Plant
Docket 50-255
License No. DPR-20

REFERENCES: 10 CFR 50.73, 10 CFR 21.21

Dear Sir or Madam:

Licensee Event Report (LER) 2011-005 is enclosed. This LER is being submitted in accordance with 10 CFR 50.73(a)(2)(i)(B) as a condition prohibited by the plant's Technical Specifications and 10 CFR 21.21(c) for reporting defects, and failures to comply, associated with substantial safety hazards for dedicated items.

This letter contains no new commitments and no revisions to existing commitments.

Sincerely,

A handwritten signature in black ink, appearing to read "Anthony J Vitale".

AJV/tad

Enclosure: Licensee Event Report 2011-005

CC Administrator, Region III, USNRC
Project Manager, Palisades, USNRC
Resident Inspector, Palisades, USNRC

NRC FORM 366 U.S. NUCLEAR REGULATORY COMMISSION (10-2010)	APPROVED BY OMB NO. 3150-0104 EXPIRES 10/31/2013 Estimated burden per response to comply with this mandatory information collection request: 80 hours. 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, NEOF-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.
LICENSEE EVENT REPORT (LER) (See reverse for required number of digits/characters for each block)	

1. FACILITY NAME PALISADES NUCLEAR PLANT	2. DOCKET NUMBER 05000255	3. PAGE 1 of 4
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4. TITLE:
Service Water Pump Shaft Coupling Failure

5. EVENT DATE			6. LER NUMBER			7. REPORT DATE			8. OTHER FACILITIES INVOLVED	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REV NO	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
08	09	2011	2011	005	00	10	03	2011	FACILITY NAME	DOCKET NUMBER

9. OPERATING MODE 1	11. THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check all that apply)			
10. POWER LEVEL 100	<input type="checkbox"/> 20.2201(b)	<input type="checkbox"/> 20.2203(a)(3)(i)	<input type="checkbox"/> 50.73(a)(2)(i)(C)	<input type="checkbox"/> 50.73(a)(2)(vii)
	<input type="checkbox"/> 20.2201(d)	<input type="checkbox"/> 20.2203(a)(3)(ii)	<input type="checkbox"/> 50.73(a)(2)(ii)(A)	<input type="checkbox"/> 50.73(a)(2)(viii)(A)
	<input type="checkbox"/> 20.2203(a)(1)	<input type="checkbox"/> 20.2203(a)(4)	<input type="checkbox"/> 50.73(a)(2)(ii)(B)	<input type="checkbox"/> 50.73(a)(2)(viii)(B)
	<input type="checkbox"/> 20.2203(a)(2)(i)	<input type="checkbox"/> 50.36(c)(1)(i)(A)	<input type="checkbox"/> 50.73(a)(2)(iii)	<input type="checkbox"/> 50.73(a)(2)(ix)(A)
	<input type="checkbox"/> 20.2203(a)(2)(ii)	<input type="checkbox"/> 50.36(c)(1)(ii)(A)	<input type="checkbox"/> 50.73(a)(2)(iv)(A)	<input type="checkbox"/> 50.73(a)(2)(x)
	<input type="checkbox"/> 20.2203(a)(2)(iii)	<input type="checkbox"/> 50.36(c)(2)	<input type="checkbox"/> 50.73(a)(2)(v)(A)	<input type="checkbox"/> 73.71(a)(4)
	<input type="checkbox"/> 20.2203(a)(2)(iv)	<input type="checkbox"/> 50.46(a)(3)(ii)	<input type="checkbox"/> 50.73(a)(2)(v)(B)	<input type="checkbox"/> 73.71(a)(5)
	<input type="checkbox"/> 20.2203(a)(2)(v)	<input type="checkbox"/> 50.73(a)(2)(i)(A)	<input type="checkbox"/> 50.73(a)(2)(v)(C)	<input checked="" type="checkbox"/> OTHER Specify in Abstract below or in NRC Form 366A
<input type="checkbox"/> 20.2203(a)(2)(vi)	<input checked="" type="checkbox"/> 50.73(a)(2)(i)(B)	<input type="checkbox"/> 50.73(a)(2)(v)(D)		

12. LICENSEE CONTACT FOR THIS LER

FACILITY NAME Terry Davis	TELEPHONE NUMBER (Include Area Code) (269) 764-2117
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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	CPLG	H331	Y					

14. SUPPLEMENTAL REPORT EXPECTED <input type="checkbox"/> YES (If yes, complete 15. EXPECTED SUBMISSION DATE) <input checked="" type="checkbox"/> NO	15. EXPECTED SUBMISSION DATE	MONTH	DAY	YEAR

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

On August 9, 2011, at 1202 hours, service water system (SWS) pump, P-7C, failed to deliver discharge pressure. As a result, a 72-hour limiting condition for operation (LCO) was entered in accordance with Technical Specification (TS) 3.7.8 condition A, due to one or more SWS trains being inoperable. The TS 72-hour LCO was exited after approximately 63 hours on August 12, 2011, at 0309 hours when repairs and testing on P-7C had been completed.

Investigation into the failure revealed a broken pump shaft coupling. The failure mechanism of the coupling was determined to be intergranular stress corrosion cracking (IGSCC). A past operability evaluation concluded that, based on the failure mechanism of the coupling, P-7C would have been unable to operate satisfactorily for the required 30-day mission time. Therefore, P-7C was inoperable from July 10, 2011, until the coupling failed on August 9, 2011. During the period P-7C was considered inoperable, SWS pumps P-7B and P-7A were removed from service, on separate occasions for brief periods of times, for the performance of routine maintenance activities. The requirement of TS 3.7.8 condition C, that 100% of the required post accident SWS cooling capability be available, was met at all times during the 30-day period when P-7C was considered inoperable.

The cause of the IGSCC was due to inadequate coupling design specifications. P-7A and P-7B shaft couplings were replaced using newly designed couplings. Replacement of the shaft couplings on P-7C, with the new design, is scheduled. This event is reportable in accordance with 10 CFR 50.73(a)(2)(i)(B) as a condition prohibited by TS and 10 CFR 21.21(c) for reporting defects, and failures to comply, associated with substantial safety hazards for dedicated items.

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PLANT CONDITIONS

On August 9, 2011, at the time service water system (SWS) [BI] pump [P], P-7C, failed, the plant was in Mode 1, operating at approximately 100% power.

INTRODUCTION

The SWS provides a heat sink for the removal of process and operating heat from safety-related components during a design basis accident or transient. During normal operation or a normal shutdown, the SWS also provides this function for various safety-related and non-safety-related components. During post-accident conditions, with all other SWS and related system components operable, 100% of the required SWS post-accident cooling capability can be provided by any one SWS pump.

The SWS consists of three pumps, P-7A/B/C connected in parallel, taking suction from a common intake structure supplied by Lake Michigan. The discharge of the pumps flow into a common header before splitting into three headers (two critical headers for safety-related equipment and a single non-critical header for non safety-related equipment). The return piping from the three headers join into a common line and discharge to the cooling tower makeup basin.

The three SWS pumps are comprised of a two stage pump end with stainless steel (SS) impellers. The pump end is coupled to the motor through six line shafts, a packing shaft, and a motor shaft connected by eight couplings all of the same design.

The design specification of the line shaft couplings for the three SWS pumps was changed in December 2007. The design specification included information from previous engineering evaluations that changed coupling material from carbon steel to 416SS. The line shaft couplings for P-7A were replaced in April 2009. The line shaft couplings on P-7B were replaced in May 2010. The line shaft couplings for P-7C were replaced in June 2009.

On September 29, 2009, P-7C failed to deliver discharge pressure. The investigation into the failure revealed a broken coupling between the top line shaft and the packing shaft. An analysis determined that the coupling failed from intergranular stress corrosion cracking (IGSCC). There are three parameters that must be present for couplings to fail by the mechanism of IGSCC; susceptibility of material for IGSCC, a corrosive environment, and a stress intensity that exceeds the threshold for IGSCC on the pump shaft coupling. Inherent to the Palisades design is the corrosive environment (lake water) and the stress applied during pump operation. The failed coupling was determined to have been improperly heat treated, based on the high hardness value of the 416SS coupling, rendering it susceptible to IGSCC. Improper heat treatment was a result of issues within the quality control program of the vendor, HydroAire Services Inc.

EVENT DESCRIPTION

On August 9, 2011, at 1202 hours, P-7C, failed to deliver discharge pressure. A 72-hour limiting condition for operation (LCO) was entered in accordance with Technical Specification (TS) 3.7.8 condition A, due to one or more SWS trains being inoperable. Work to restore P-7C began immediately. During disassembly, it was determined that the line shaft coupling [CPLG] failed similarly to the failed coupling in the same pump in September, 2009.

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Replacement couplings from inventory stock were installed. The TS 72-hour LCO was exited after approximately 63 hours on August 12, 2011, at 0309 hours when repairs and testing on P-7C had been completed. The requirement of TS 3.7.8 condition C, that 100% of the required post accident SWS cooling capability be available, was met at all times during the 30-day period when P-7C was considered inoperable.

CAUSE OF THE EVENT

Investigation into the December 2007 design specification change, the September 2009 coupling failure, and industry operating experience (OE) revealed several causes for the IGSCC failure of the coupling in 2011.

- The 2007 design change specification to use 416SS in the Palisades SWS operating environment was faulted. Personnel involved in the design change process did not have sufficient metallurgical knowledge. Palisades did not obtain an adequate technical review by personnel with expertise in metallurgy.
- The root cause conducted after the 2009 coupling failure did not sufficiently investigate the base material properties of 416SS. Specifically, the toughness properties of the material in the corrosive environment of Lake Michigan water were not investigated. The coupling material is a quenched and tempered 416 martensitic SS with low toughness properties. This makes it particularly susceptible to IGSCC when subjected to the tensile stress and a corrosive environment (due to the presence of chlorides).
- Ineffective use of OE. Since 2004, there have been several examples of nuclear industry OE linking IGSCC susceptibility with high Rockwell hardness values and/or low material toughness in type 416SS when exposed to fresh water. Palisades did not translate this OE into effective specification, contract, inspection, testing, or oversight actions.

CORRECTIVE ACTIONS TAKEN

After the August 2011 failure, Palisades completed an engineering change (EC) to change the material of the service water pump couplings from 416SS to 17-4PH SS. This EC was based on a report provided to Palisades, by an independent vendor that evaluated similar failures in the industry, and recommendations from a team of metallurgy and pump experts.

A new design specification using 17-4PH SS for the material of the SWS pumps shaft couplings was developed and approved for all three SWS pumps. The new design specification for the coupling material was changed in order to minimize susceptibility to IGSCC. The 416SS shaft couplings on P-7A and P-7B were replaced with the 17-4PH SS design.

Past operability evaluations performed for P-7A and P-7B, due to the shaft coupling on the pumps being constructed of the same 416SS material, concluded the pumps could have met the required 30-day mission time. An independent laboratory confirmed there were no indications of IGSCC on the number 5, 6, and 7 couplings, those couplings considered to be most susceptible to IGSCC, removed from P-7A. There were indications of IGSCC identified on the number 5, 6, and 7 couplings removed from P-7B. However, the evaluation concluded the cracking on the couplings had not propagated to the point where P-7B would have been unable to meet the required 30-day mission time.

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CORRECTIVE ACTIONS TO BE TAKEN

Replacement of the 416SS shaft couplings that remain on P-7C with the 17-4PH SS design couplings.

Creation of an Engineering Standard that clearly identifies station requirements and expectations for material changes affecting installed plant equipment.

ASSESSMENT OF SAFETY CONSEQUENCES

No actual safety consequences resulted from this event. Operating service water pumps continued to meet all critical, non-critical and containment service water system cooling loads. Potential safety consequences of this event are of low safety significance: the equipment necessary to safely shutdown the reactor and maintain safe shutdown conditions under normal and emergency circumstances remained intact and available.

PREVIOUS SIMILAR EVENTS

LER 2010-001, Service Water Pump Shaft Coupling Failure.