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APR 2 6 2011

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Mail Stop OP1-17
Washington, DC 20555

SUSQUEHANNA STEAM ELECTRIC STATION
LICENSEE EVENT REPORT 50-387/2011-003-00
LICENSE NO. NPF-14
PLA-6716 **Docket No 50-387**

Attached is Licensee Event Report (LER) 50-387/2011-003-00. The event involved a packing leak on the Unit 1 HPCI Steam Supply Inboard Isolation Valve that resulted in the containment isolation valve and HPCI being declared inoperable. This event was determined to be reportable under 10 CFR 50.73(a)(2)(i)(B) as a condition prohibited by Technical Specification and under 10 CFR 50.73(a)(2)(v)(D) as a condition that could have prevented the fulfillment of a safety function.

There were no actual consequences to the health and safety of the public as a result of this event.

No regulatory commitments are associated with this LER.

T. S. Rausch

Attachment

Copy: NRC Region I
Mr. P. W. Finney, NRC Sr. Resident Inspector
Mr. R. R. Janati, DEP/BRP
Mr. B. K. Vaidya, NRC Project Manager

NRC FORM 366 (10-2010) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB: NO. 3150-0104 EXPIRES:10/31/2013

Estimated burden per response to comply with this mandatory 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 FOIA/Privacy Section (T-5 F53), U. S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by internet e-mail to infocollects.resources@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 an 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)

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4. TITLE

HPCI Inoperability Due to Valve Packing Leak

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
										05000
02	25	2011	2011	- 003	- 00	04	26	2011	FACILITY NAME	DOCKET NUMBER 05000

9. OPERATING MODE

1

10. POWER LEVEL

99%

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

- ☐ 20.2201(b)
- ☐ 20.2201(d)
- ☐ 20.2203(a)(1)
- ☐ 20.2203(a)(2)(i)
- ☐ 20.2203(a)(2)(ii)
- ☐ 20.2203(a)(2)(iii)
- ☐ 20.2203(a)(2)(iv)
- ☐ 20.2203(a)(2)(v)
- ☐ 20.2203(a)(2)(vi)
- ☐ 20.2203(a)(3)(i)
- ☐ 20.2203(a)(3)(ii)
- ☐ 20.2203(a)(4)
- ☐ 50.36(c)(1)(i)(A)
- ☐ 50.36(c)(1)(ii)(A)
- ☐ 50.36(c)(2)
- ☐ 50.46(a)(3)(ii)
- ☐ 50.73(a)(2)(i)(A)
- ☒ 50.73(a)(2)(i)(B)
- ☐ 50.73(a)(2)(i)(C)
- ☐ 50.73(a)(2)(ii)(A)
- ☐ 50.73(a)(2)(ii)(B)
- ☐ 50.73(a)(2)(iii)
- ☐ 50.73(a)(2)(iv)(A)
- ☐ 50.73(a)(2)(v)(A)
- ☐ 50.73(a)(2)(v)(B)
- ☐ 50.73(a)(2)(v)(C)
- ☒ 50.73(a)(2)(v)(D)
- ☐ 50.73(a)(2)(vii)
- ☐ 50.73(a)(2)(viii)(A)
- ☐ 50.73(a)(2)(viii)(B)
- ☐ 50.73(a)(2)(ix)(A)
- ☐ 50.73(a)(2)(x)
- ☐ 73.71(a)(4)
- ☐ 73.71(a)(5)
- ☐ OTHER

Specify in Abstract below or in NRC Form 366A

12. LICENSEE CONTACT FOR THIS LER

FACILITY NAME	TELEPHONE NUMER *(Include Area Code)*
C. E. Manges, Jr., Senior Engineer - Nuclear Regulatory Affairs	(570) 542-3089

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	BJ	ISV	Anchor / Darling Co	Yes					

14. SUPPLEMENTAL REPORT EXPECTED

☐ YES *(If yes, complete 15. EXPECTED SUBMISSION DATE)* ☒ NO

15. EXPECTED SUBMISSION DATE

MONTH	DAY	YEAR

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

On February 25, 2011 at 2027, the Unit 1 High Pressure Coolant Injection (HPCI) Steam Supply Inboard Isolation Valve (HV155F002) was declared inoperable as a result of a packing leak. HPCI was subsequently declared inoperable at 2136 hours on February 25, 2011 as a result of closing the inoperable inboard isolation valve. Subsequently, the HPCI outboard isolation valve was also closed and deactivated. An 8-hour report was made since HPCI is a single train safety system and the event resulted in a loss of safety function. Since inspection of HV155F002 indicated that the grease was completely washed away from the valve stem and an engineering analysis showed inadequate margin to assure the valve would stroke under design basis conditions with no grease on the stem, a determination was made that HV155F002 was inoperable for some time prior to entry into LCO 3.6.1.3. As a result, this was a condition prohibited by Technical Specifications.

The root cause was determined to be a failure to recognize the implications of gland liner failure and the failure modes and mechanisms on the packing system during changes to gland design. Causal factors were less than adequate technical rigor during design of the gland liner and less than adequate attention to detail during fabrication of the liner.

Key corrective actions that are planned include: 1) replacing the brass lined packing gland with a bronze lined packing gland for each valve with a brass liner; 2) performing a design review of gland liner modification documents to ensure all design considerations for packing gland liners are appropriately addressed, and 3) revising applicable procedures to ensure that packing gland liners are inspected during all future re-packs.

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NARRATIVE

EVENT DESCRIPTION

During investigation of increasing drywell leakage while operating at approximately 99% power, the Unit 1 HPCI Steam Supply Inboard Isolation Valve (HV155F002) was identified as having a potential steam leak. HV155F002 is a primary containment isolation valve, and its operability was evaluated. The operability evaluation determined that the valve was inoperable and LCO 3.6.1.3 was entered on February 25, 2011 at 2027 hours. HPCI [EIIS Code: BJ] was subsequently declared inoperable and LCO 3.5.1 was entered at 2136 hours on February 25, 2011 due to isolation of the HPCI steam supply line. An 8-hour report was made since HPCI is a single train safety system and the event resulted in a loss of safety function.

A unit shutdown was planned to repair HV155F002, and on March 4, 2011, Unit 1 was shutdown. An ENS notification was made on March 4, 2011 at 2259 for a TS required shutdown. LCO 3.5.1 for HPCI was cleared at 0052 on March 5, 2011. This event does not have to be reported under 10CFR50.73(a)(2)(i)(A) as the completion of a plant shutdown required by the plant Technical Specifications since the plant returned to power prior to the end of the 14 days allowed by the HPCI Limiting Condition for Operation.

During initial containment walkdown, a substantial packing leak was identified on HV155F002. Steam was observed coming out of the packing gland at the top (12 o'clock) position along the valve stem. The containment walkdown did not identify any other leaks.

Since inspection of HV155F002 indicated that the grease was completely washed away from the valve stem, and an engineering analysis showed inadequate margin to assure the valve would stroke under design basis conditions with no grease on the stem, a determination was made that HV155F002 was inoperable for some time prior to entry into LCO 3.6.1.3 on February 25, 2011. As a result, this was a condition prohibited by Technical Specifications.

When the valve gland was removed, the mechanics observed that the gland liner had fractured and the lip of the liner was embedded in the washer at the top of the packing. The liner cylinder had moved up in the gland by about 3/16". As the packing was removed, the mechanics observed steam flow damage to the top washer and that a one inch section of circumferential arc of the top braided packing ring was missing. No obvious damage was observed with the remaining packing.

HV-155F002 was repacked with a new lined gland and the unit was started up and returned to service on March 10, 2011. Drywell leakage has remained at normal operational levels since the start up.

Valve Information and History

HV155F002 is a 10 inch Anchor Darling Gate Valve that has a horizontal stem orientation. The valve was modified in 1996 to have a brass liner insert in the packing gland. The purpose of this liner was to prevent damage to the valve stem if it contacted the gland surface.

The valve was repacked every two years since 1996 with the exception of 1998 and 2010 when the valve was retorqued to ensure packing integrity. The five repacks were all the result of poor packing performance. Changes in packing sets were made in an attempt to improve performance. The latest event in 2011 is also attributed to a failure of the packing system and required a sixth repack.

Background on Gland Liners

During the early 1990s, Susquehanna experienced scoring and damage of valve stems. The solution that was developed to address the scoring involved installing a liner in the packing gland to act as a sacrificial surface if the valve stem were to contact the gland. The changes were determined to be "Repair/Use-As-Is actions" based on the following:

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NARRATIVE

1. The packing gland is a non pressure retaining component (a tool to hold the packing rings in place).
2. The brass bushing is a consumable to protect the stem from excessive wear.
3. The vendor, Anchor-Darling concurs with this change
4. The 1/8 inch bushing will not affect the integrity of the gland per Anchor-Darling.

Implementation of the changes was via action plans added to work package instructions. A brass liner was installed in HV155F002 in 1996 using this process.

In 1998, a Replacement Item Evaluation (RIE) was developed for the liner installations. An RIE is a modification mechanism utilized in the Susquehanna modification process. The RIE addressed the impact to the safety of plant operation for a "bronze" liner and recommended use of phosphor bronze. The bronze was recommended due to low Zinc content so it would have lower susceptibility to Stress Cracking Corrosion.

In August 1998, NRC informed PPL of a valve concern. The valve concern was described as:

> "The NRC has received information that during the last refueling outage, valve maintenance work on safety related Anchor Darling motor operated valves was not performed under a Design Change Package and bypassed a safety evaluation. Specifically, brass liners were slide fitted into the gland followers on safety related Anchor Darling motor operated valves and the impact on motor operated valve operation was not determined if the brass liner gets stuck between the gland follower and the valve stem."

As a result of the concern, Susquehanna re-evaluated material concerns with the use of brass liners given that brass had been rejected in the RIE evaluation. The re-evaluation concluded that brass was acceptable, though bronze could be considered preferred. Impacts from corrosion were judged to be a long term effect and to have the same consequences as normal packing wear. There was no consideration made of the possible failure modes or the implications of a failed liner on the packing system.

Analysis of the Fractured Gland Liner

The fractured gland liner removed from HV155F002 was examined by In Service Inspection (ISI). Material analysis identified the liner as brass with a zinc content of 35%. ISI identified "overload shear fracture" as the failure mechanism. The width of the fractured lip of the liner was measured as 0.049 inches. This is significant, because the recess cut into the gland to receive this lip was cut at 0.062 inches. As a result, when the liner was installed in the gland, a gap of 0.013 inches was left that exposed the sharp edge of the gland (a fulcrum point) to the top packing item.

A liner replicate was examined using a scanning electron microscope. The examiner observed what appeared to be intergranular fracture in portions of the fractured lip, which would be consistent with stress-corrosion cracking. Other areas of this fracture surface showed the dimpled rupture that normally accompanies final overload. It appears that the fracture started as a Stress Corrosion Crack but finally failed under load.

Analysis of the stress acting on the lip of the gland liner was performed for both the as-designed and as-built configurations for the gland liner. The analysis concludes that it is feasible that the as-built configuration of the gland liner could have fractured as a result of normally applied loads imposed by the packing gland. The as-built lip thickness was found to be less that that shown in the work instructions for the installation work order. Had the liner been fabricated in accordance with the action plan, this analysis shows that the gland liner would likely not have failed.

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There was no indication of the liner being fractured or damaged when the valve was repacked in 2008, and the fracture is believed to have occurred sometime after this repack. In 2010, the gland follower was realigned by loosening the gland nuts one turn and tightening down on the high side to realign the follower. It is possible that gland loads exceeded normal loads during this repair.

Failure Mechanism

The width of the bottom lip of the brass liner allowed a 0.013 inch gap and exposed the top packing washer to a sharp edge. Under the load of the packing, system pressure, and stroking of the valve, the washer was weakened and distorted. The lip, weakened by Stress Corrosion Cracking, is believed to have fractured completely under load possibly during attempts in 2010 to straighten the cocked packing gland and follower. After the fracture, either as a result of system pressure or valve stroking, the liner cylinder moved axially up the gland. This resulted in loss of approximately 20% of the loading surface of the gland which increased the gap around the stem and allowed the packing to relax. Over time, as the packing displaced into the gap and the packing load on the stem was reduced below system pressure, a leak was initiated. As steam began to disintegrate the packing, the leak worsened with time.

CAUSE OF THE EVENT

The root cause was determined to be a failure to recognize the implications of gland liner failure and the failure modes and mechanisms on the packing system during changes to gland design. The gland liner function was not recognized as having a structural requirement, and this lack of understanding resulted in failure to address this event failure mode during change to the gland. This resulted in failure of the brass liner and subsequent failure of the HPCI Inboard Steam Isolation PCIV.

A causal factor was less than adequate technical rigor applied during design of the gland liner. Technical rigor did not include analysis of design considerations such as strength of material or susceptibility to stress corrosion cracking.

A second causal factor was less than adequate attention to detail during fabrication of the gland liner. When the gland liner and gland were evaluated, the liner lip dimension did not match the action plan in the work order.

ANALYSIS/SAFETY SIGNIFICANCE

Actual Consequences:

The actual consequences were an unscheduled forced outage and accrual of HPCI system out of service time. Engineering analysis determined there was inadequate margin to assure HV155F002 would stroke closed under design basis conditions with no grease on the stem, so the valve was inoperable for primary containment isolation. The outboard HPCI steam supply isolation valve, HV155F003 was still operable to isolate the penetration.

Potential Consequences:

Each occurrence of an initiating event has the potential to increase the initiating event frequency modeled in the station Probabilistic Risk Assessment (PRA). Thus, a potential consequence of similar recurring events is a change to the initiating event frequency resulting in an increase in baseline Core Damage Frequency (CDF).

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NARRATIVE

CORRECTIVE ACTIONS

The following are the key corrective action associated with this issue:

1. A review of the RIE was completed that ensured that the RIE appropriately addressed the failure of the liner material experienced on HV155F002. This review concluded that a liner constructed in accordance with the RIE would not experience the same failure mechanism.
2. The brass lined packing gland for the remaining valves will be replaced with a bronze lined packing gland for each valve with a brass liner during the 2011 (Unit 2), 2012 (Unit 1), and 2013 (Unit 2) outages.
3. A design review of the RIEs and associated instructions for installing gland liners will be reviewed to ensure that all design considerations for packing gland liners are appropriately addressed. The appropriate Engineering Change mechanism to use will be determined for any future applications after the Spring 2011 Unit 2 refueling outage.
4. Applicable procedures will be revised to ensure that packing gland liners are inspected during all future re-packs. Inspections will include the condition of the liner and verification that the liner is not loose and is flush with the packing gland on the surface contacting the packing.

PREVIOUS SIMILAR EVENTS

- LER 2009-001-00, Docket No. 387/License No. NPF-14
- LER 2006-005-00, Docket No. 387/License No. NPF-14
- LER 2006-003-00, Docket No. 387/License No. NPF-14