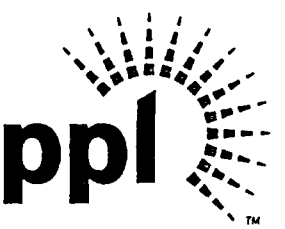
R. A. Saccone
Vice President - Nuclear Operations

PPL Susquehanna, LLC
769 Salem Boulevard
Berwick, PA 18603
Tel. 570.542.3959 Fax 570.542-1504
rasaccone@pplweb.com



JUL 26 2006

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

SUSQUEHANNA STEAM ELECTRIC STATION
LICENSEE EVENT REPORT 50-387/2006-003-00
PLA-6094 **Docket 50-387**

Attached is Licensee Event Report 50-387/2006-003-00. The events described in this report do not specifically meet the criteria established for required reporting. However, motor operated valve (MOV) stem nut degradation experienced on two valves at the Susquehanna Steam Electric Station is likely to be of general interest to the industry. Accordingly, this report is submitted under the Voluntary Reporting guidance described in Section 2.7 of NUREG-1022, Rev. 2.

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

No new regulatory commitments have been created through issuance of this report.

Robert A. Saccone
Vice President – Nuclear Operations

Attachment

IE22

cc: Mr. S. J. Collins
Regional Administrator
U. S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19408

Mr. A. J. Blamey
Sr. Resident Inspector
U. S. Nuclear Regulatory Commission
P.O. Box 35
Berwick, PA 18603-0035

Mr. R. Osborne
Allegheny Electric Cooperative
P. O. Box 1266
Harrisburg, PA 17108-1266

Mr. R. R. Janati
Bureau of Radiation Protection
Rachel Carson State Office Building
P. O. Box 8469
Harrisburg, PA 17105-8469

NRC FORM 366 (6-2004)

U.S. NUCLEAR REGULATORY COMMISSION

LICENSEE EVENT REPORT (LER)

(See reverse for required number of digits/characters for each block)

1. FACILITY NAME	2. DOCKET NUMBER	3. PAGE
Susquehanna Steam Electric Station – Unit 1	05000387	1 OF 5

4. TITLE Motor Operated Valve Stem Nut Failures

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
04	06	2006	2006	003	00	07	26	2006	FACILITY NAME	DOCKET NUMBER 05000

9. OPERATING MODE 4

10. POWER LEVEL 0%

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

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

12. LICENSEE CONTACT FOR THIS LER

FACILITY NAME	TELEPHONE NUMER *(Include Area Code)*
Eric J. Miller – Nuclear Regulatory Affairs	570-542-3321

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
E	BO	20	A391	Y					

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)*

This is a voluntary report of an event which does not specifically meet established reporting criteria. The situation discussed in this report is most closely related to the reporting criteria of 10CFR50.73(a)(2)(vii). During Susquehanna Unit 1's 14th Refueling Outage, two Motor Operated Valves (MOV) in the station's Generic Letter 89-10 program failed to stroke when called upon to do so. The first failure occurred on March 27, 2006 when the suppression pool suction valve for the 'D' Residual Heat Removal (RHR) pump failed to close during system functional testing. Similarly, on April 6, the suction valve for the 'C' RHR pump failed to stroke during system alignment. In both cases, the immediate cause of the valve failure was excessive wear on the internal stem nut threads of each valve. The failures did not cause RHR trains to become inoperable. Analysis has concluded that the visual inspection of valve stem grease for particulates is an ineffective means of monitoring long term stem nut thread wear. Additionally, routine preventive maintenance did not require periodic inspections of the stem nut itself. When inspections were performed, procedural guidance was not adequate. In response to these failures, Susquehanna has conducted inspections of those MOVs most susceptible to stem nut wear and has replaced stem nuts when appropriate. Additional inspections are planned. In the longer term, the station intends to incorporate changes to its MOV preventive maintenance program and to begin using MOV diagnostic data for monitoring stem nut thread wear.

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

EVENT DESCRIPTION

This is a voluntary report of an event which does not specifically meet established reporting criteria. The situation that will be discussed in the following paragraphs is most closely related to the reporting criteria of 10CFR50.73(a)(2)(vii) in that a common mode failure of two similar valves occurred during Susquehanna's 14th Refueling Outage for Unit 1. Because each valve had been successfully stroked earlier in the outage and because design basis conditions are bounded for these valves during testing under static conditions, engineering judgment has concluded that the valves would have performed their intended safety function during the operating cycle. Further, the valves were not being relied upon to fulfill any safety function when their ability to stroke came into question (Refueling Outage at 0% power). As such, the situation did not cause independent trains or channels "to become inoperable" as is specified in the reporting criteria for common mode failures.

During Susquehanna Unit 1's 14th Refueling Outage, two Motor Operated Valves (MOV) in the station's Generic Letter (GL) 89-10 program failed to stroke when called upon to do so. The first failure occurred on March 27, 2006 (Mode 5, 0% power) when the suppression pool suction valve for the 'D' Residual Heat Removal (RHR, EIIS Code BO) pump failed to close during system functional testing. Similarly, on April 6 (Mode 4, 0% power), the suction valve for the 'C' RHR pump failed to stroke during system alignment. In both cases, the immediate cause of the valve failure was excessive wear on the internal stem nut threads of each valve.

The stem nut of a Motor Operated Valve is the link between the motor actuator and valve. It transfers the rotational motion of the motor into lateral motion of the valve stem. Internal threads on the stem nut allow the stem nut to be threaded onto a valve's stem. Geared teeth on the outside surface of the stem nut allow the motor actuator to rotate the stem nut. As the stem nut rotates in a fixed position, the valve stem is moved in or out of the valve body depending on the direction of rotation.

CAUSE OF EVENT

Root causes for this event include:

Visual inspection of valve stems for evidence of stem nut thread wear was an ineffective means of monitoring long term stem nut thread wear.

Routine Preventive Maintenance activities to periodically inspect stem nuts did not exist.

Procedural guidance for inspection and acceptance of stem nut thread wear was not adequate.

ANALYSIS / SAFETY SIGNIFICANCE

The RHR valves that failed (HV151F004C and HV151F004D) are the Suppression Pool (EIIS Code: KE) suction valves for the 'C' and 'D' RHR pumps, respectively. When Open, these valves establish a Low Pressure Coolant Injection suction path for their respective RHR pumps. When Closed, the valves provide a Primary Containment (EIIS Code: NH) isolation function from the Suppression Pool, if required, following an accident. With the Unit shutdown for refueling at the time of the valve failures, there was no actual safety significance created by these events. The RHR pumps supported by the valves were not being relied upon to fulfill emergency injection requirements specified in Technical Specifications. Further, Primary Containment integrity was not required at the time either event occurred.

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

The potential consequences of an RHR F004 stem nut failure include impacts to the Emergency Core Cooling function of the RHR system or the Primary Containment isolation function of the subject valves depending on position at the time of failure. Additionally, the F004 valves are interlocked with the RHR Shutdown Cooling Mode Suction valves to prevent inadvertent draining of the Reactor Vessel (EIIS Code: AC). The interlock prevents both valves from being opened at the same time. Because position of the RHR F004 valves is determined by geared limit switches that open and close electrical contacts based on the number of motor/gear train rotations, valve position could be misrepresented as the motor/gear train continues to operate without a corresponding valve stem movement. Although other features associated with motor operated valve movement (for instance thermal overload trips/alarms) should alert operators if such a situation were present, a drain path from the Reactor to the Suppression pool would be a possibility if the situation somehow went unrecognized by control room operators.

The failure of two rising stem MOVs in Susquehanna's GL 89-10 program within two weeks of one another prompted an evaluation of all GL 89-10 rising stem MOVs to determine the extent of condition for potential stem nut failures at the station. MOV diagnostic traces were utilized to measure the time span required for threads to take-up clearance between the valve stem threads and the stem nut threads. This take-up of thread clearance occurs each time the valve stroke changes direction. Thread wear rates were calculated in cases where at least two tests existed. When only one test was available, thread clearance from that one test was assumed to be the total thread wear since startup. Wear rate was then determined by dividing thread clearance by the time since startup. This data was utilized to determine whether sufficient thread would remain through the next operating cycle. Where the data suggested it would be prudent, MOV stem nuts were inspected and/or replaced. Of twenty-nine stem nuts inspected, eighteen had wear that exceeded 50% of the original thread thickness. These inspections validated the use of MOV diagnostic data as a good, conservative means for predicting stem nut wear. Of those valves inspected at the time of this writing, all had actual stem nut thread wear equal to or less than predicted by use of MOV diagnostic data.

Analysis of Susquehanna's stem nut failures focused on numerous, distinct areas. Each is summarized below:

Periodic Performance Assessment

In December of 1995, Susquehanna Design Standard MDS-08, "Periodic Performance Assessment of SSES Motor Operated Valves" was issued. This document included a list of thirty three common MOV deficiencies that were initially provided by the NRC in Generic Letter 89-10. Stem nut wear is not among those deficiencies listed. In March of 1997, MDS-08 was revised to list stem nuts as a component with the potential for degradation. It was noted that detecting degradation is possible through 24 month visual inspection of the stem for evidence of stem nut wear and static diagnostic testing. It was also noted that 24 month stem lubrication mitigates degradation. Interviews have revealed that the "degradation" expected for stem nuts was an increase in friction between the stem nut and stem which would reduce overall valve thrust and could therefore reduce the ability of the MOV to perform its design basis function. Changes in friction would be captured as increases in the stem factor for each valve. The stem nut thread wear that occurred on HV151F004C and HV151F004D along with other valves in our MOV program has not resulted in any significant change to the stem factor or measured valve thrust. Wear of the stem nut threads without an increase in the coefficient of friction between the stem and stem nut was not specifically considered in the station's program. As a result, monitoring and trending of MOV diagnostic data did not identify that stem nut threads were wearing.

Preventive Maintenance Program

EPRI issued preventive maintenance (PM) guidelines for MOV actuators contain specific recommendations for periodic inspection of the stem, packing area and drive sleeve cavity for evidence of bronze filings for indication of severe stem nut wear. The EPRI PM Program Basis for MOVs, issued in December of 1996, lists "Stem/Stem nut thread damage" as a specific degradation mechanism to be addressed by a Preventive Maintenance Program. It identifies MOV diagnostic testing and detailed inspection of the MOV actuator as the strategy to deal with this degradation mechanism. The document also applies "criticality", "duty cycles," and "service condition" to recommend PM activity frequency. When this criteria is applied to the two Susquehanna valves that failed, the recommended PM frequency for detailed actuator inspections is every 16 years. Susquehanna took exception to the recommendations of this 1996 EPRI document for periodic detailed inspection of the MOV actuator. Susquehanna utilizes grease sample/MOV diagnostic testing results exclusively for scheduling of detailed actuator inspections. As a result of this decision, actuator overhauls for HV151F004D and HV151F004C were last completed in 1985 and 1986, respectively (20+ years ago).

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

Susquehanna maintains additional PM activities to perform two-year routine maintenance on each MOV in the MOV program. These activities included:

- External inspections of the MOV actuator for cleanliness/damage
- Collection of grease samples from the main gear case and motor pinion cavity
- Cleaning and lubrication of the valve stem if accessible
- Inspection of the valve stem and stem nut for damage (i.e. check the stem for galling of pitting and check the valve packing area for brass particles for stem nut damage/excessive wear)

It appears the last item was added to the 2-year PM based on a 1992 EPRI NMAC Lube Notes article on stem nut wear entitled, "Actuator Stem Nuts Can Fail Through Abrasion." This article states that, "...the stem and especially the nut must be examined now and then to make sure that excessive wear is not occurring. Taking a sample of the lubricant from the stem or nut and observing it for debris is a great way to judge the condition of the stem/stem nut interface."

In lieu of sampling the stem grease, a visual inspection of the stem for evidence of brass particles was added to the PM. It now appears that this type inspection is not, by itself, effective for monitoring long term stem nut thread wear. It should be noted that the EPRI recommendation to periodically examine the stem nut was not incorporated into the PM program.

Procedural Direction for Stem Nut Inspections

Procedural direction governing routine maintenance of the failed valves does not specifically call for inspection of stem nut threads. The procedure does not require measurement of or provide acceptance criteria for remaining stem nut thread. While there is reference to stem nut condition contained in the procedure, interviews have determined that this reference was concerned with the coefficient of friction between the stem and stem nut and its affect on overall actuator thrust; and not due to potential stem nut thread wear.

MOV Diagnostic Testing

Diagnostic testing is used at Susquehanna to periodically verify that a valve is capable of performing its design basis function and as a confirmatory test after certain maintenance or modification work is performed. Diagnostic testing acceptance criteria include stem factor, thrust, and maximum torque. Diagnostic testing results have not been used historically to determine the amount of stem nut thread wear at Susquehanna.

Response to First Failure (HV151F004D) Did Not Prevent Second Failure (HV151F004C)

Following the failure of HV151F004D, an investigation was immediately undertaken to assess the most probable cause of the valve failure and to determine the extent of condition that led to valve failure. The investigation concluded that the failure was due to long term wear of the valve stem nut and that other valves in the MOV program could be considered operable for the next operating cycle. This conclusion was primarily drawn following additional valve inspections that were conducted. While the failed HV151F004D valve stem was coated with grease that looked like a "golden slurry" from captured brass filings created as the stem nut deteriorated over time, evidence of brass shavings were not found during inspections of other valves (including HV151F004C) thought to be susceptible to wear. These inspection results led to a conclusion that the stem nut wear experienced on HV151F004D was an isolated event. In the specific case of HV151F004C, MOV diagnostic test data that might have suggested eminent failure was misinterpreted to signify a stem nut to lock nut gap, not stem nut thread wear. Additionally, F004C had low predicted wear rates and low stresses when compared to F004D. Finally, too high of a value was placed on inspections which did not show visual signs of brass in the stem grease.

Operating Experience Review

Susquehanna's review did not identify any generic studies or roll up reports highlighting stem nut thread wear as a significant issue. To the contrary, many such reports do not cite stem nut wear at all. There have been, however, a number of reported stem nut failures within the industry. These events suggest that visual inspection of valve stems for signs of stem nut wear is not, by itself, an effective means for monitoring long term wear of stem nuts. The events also indicate that proceduralized stem nut inspection criteria and the use of diagnostic data are useful tools for identifying degraded stem nut threads.

Physical Characteristics Affecting Stem Nut Thread Wear

Certain physical characteristics can affect the amount and rate of stem nut thread wear. These characteristics include stem nut material, applied loads, and usage (number of stem nut rotations). Additionally, fit and lubrication can also impact stem nut thread wear. Upon reviewing these potential wear factors, it was determined that most did not present unexpected or undue effect on valves HV151F004C and HV151F004D. This review did, however, indicate that improvements in Susquehanna's methods for lubricating valve stems are needed. The PM activity to lubricate valve stems does not require a valve stroke. There is, therefore, no assurance that the lubrication reaches the stem nut threads until the valve is next stroked.

CORRECTIVE ACTIONS

The following corrective actions have been completed:

- A wide-spread inspection of MOVs with indications of stem nut thread wear was undertaken to assess the condition of MOV stem nuts and to replace those stem nuts with worn threads.

The following corrective actions are planned:

- Inspections and stem nut replacements of additional MOVs will be performed.
- The current two year PM activity bases will be revised to clarify the intent and limitations of stem nut inspections. (Visual inspections are not effective in detecting long term stem nut wear).
- A new PM activity will be created that periodically inspects stem nuts on selected valves.
- A method and acceptance criteria for measurement of stem nut wear will be established.
- Detailed instructions for performance of stem nut inspections will be incorporated into existing procedures.
- Direction for monitoring and trending of stem nut thread wear using MOV diagnostic data will be proceduralized.
- Stem lubrication PM activities will be modified to include valve stroking.

ADDITIONAL INFORMATION

Failed Components: Suppression Pool Suction Valves for RHR pumps 'C' and 'D', HV151F004C and HV151F004D
Manufacturer: Anchor Darling Valve Company
Model: W8522332B