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United States Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555-001

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Paducah Gaseous Diffusion Plant (PGDP) - Docket No. 70-7001 - Event Report ER-97-08

Pursuant to 10 CFR 76.120 (c)(2), enclosed is the required 30-day written report for the failure of autoclave containment valves (XV-532 and CV-533, 1 East, C-337-A) to close in less than ten seconds. This was initially reported on April 25, 1997 (NRC No. 32224). Enclosure 2 is a list of commitments made in this report.

Should you require further information on this subject, please contact Bill Sykes at (502) 441-6796.

Sincerely,

Steve Polston
General Manager
Paducah Gaseous Diffusion Plant

SP:WES:JNH:mcl

Enclosure

cc: NRC Region III
NRC Senior Resident Inspector, PGDP

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EVENT REPORT ER-97-08

DESCRIPTION OF EVENT

On April 24, 1997, it was discovered that valves XV-532 and CV-533 on autoclave 1 East located in Building C-337A were not operating properly. The two valves are the inner and outer containment valves on the steam sample header and are required by the Technical Safety Requirements(TSR) to close within ten seconds if called upon to perform their safety function. Both valves appeared to be sticking when going to the closed position. The autoclave was in mode 5 at this time which is a mode that requires the valves to be operable. The two valves were declared inoperable and the autoclave was removed from service. NRC was notified of the event, as required by 10 CFR76.120, on April 25, 1997. (Refer to NRC Notification Worksheet No. 32224)

BACKGROUND

The valves that failed to close in the required time, XV-532 and CV-533, are ¾-inch ball valves with pneumatic actuators manufactured by Worcester Controls (Model No. 1539SNM2-4). The actuators for the ball valves are a fail-close, air-to-open/ spring-to-close type configuration. Springs are used once air has been vented to provide the necessary torque to force the valve closed.

These valves are part of the autoclave containment boundary in the conductivity system. The conductivity valves are the first two valves encountered after exiting through the conductivity system penetration. The autoclave containment is required, by TSR LCO 2.2.3.1, to be operable in containment mode (Mode 3), autoclave closed mode(Mode 4), and heating/feeding/heeling mode(Mode 5). Autoclave containment is initiated by the autoclave high pressure isolation system which is required to be operable by TSR LCO 2.2.3.1. The autoclave high pressure isolation system causes the autoclave to go into the containment

mode and sound an alarm if the internal pressure of the autoclave reaches 15 psig. The containment valves are required by TSR SR 2.2.3.1-2 to close within ten seconds of the autoclave high pressure switch actuation.

Steam is continuously sampled by a conductivity cell to detect a small UF_6 release inside the autoclave. Upon detection of a release by the conductivity cell, the autoclave containment is initiated. The failure of both valves to close results in a degradation of the containment boundary. If the autoclave were required to change to its containment mode by an internal UF_6 release, the conductivity penetration would still be partially open, allowing the resulting reaction products to exit to the environment via the conductivity drain. The conductivity drain is open to the atmosphere.

INVESTIGATION

One of the valves which failed to close in the required timeframe was disassembled and examined. The valve contained a buildup of corrosion products from the steam system which appeared to degrade free travel of the valve ball. The valve contained six springs in the air-to-open/spring-to-close actuator. The six-spring configuration corresponds to a minimum supply air pressure of 40 psig to open the valve. However, since these valves were being operated with plant air at approximately 80-85 psig, they should have been configured with additional springs to provide more torque for closing.

The history of the specification/procurement of this valve was reviewed by the investigation team. The valve was specified by Design Engineering (under ESO 17867) to replace the existing globe valves which were no longer being manufactured. The Engineering Specification, Section 15101, which provides guidance for valve selection in Steam and Condensate service, listed recommended valves for this type of service. However, the ball valve was not listed as one of the recommended valves. The ball valve was selected based on its service in other types of

industries. A rigorous equivalency evaluation, comparable to those prepared in accordance with today's procedures, was not found in the project folder.

The original plan was to replace the valves in C-333A and use the valves which were removed as spares for C-337A; but later, this direction was changed with the new ball valves being installed in C-337A first. Engineering Specification Data Sheet (ESDS) DS-CMD-16289-64, Rev. 0, was first issued on November 2, 1993, to define the specifications for this ball valve, its actuator, and the associated limit switches. The description section on the data sheet for the actuator calls for "pneumatic actuator, Model 1539SNML." This data sheet does not specify the pressure of the air supply to be used with the actuator to open the valve. Air-to-open/spring-to-close actuators are sized to the amount of air required to open the valve. The spring size corresponds to how fast the valve will close. The model number, as stated above, contains no specific numbers for air supply pressure and corresponding spring tension. Based on vendor documentation,this would default to an actuator designed for 80 psig air supply pressure. The original globe valves in the autoclaves in both C-333A and C-337A had been configured to operate with a 40 psig air supply. Ball valves were ordered utilizing Engineering Specification Data Sheet DS-CMD-16289-64, Rev. 0, and received in the March/April timeframe of 1994. Upon discovering that the ball valves procured required 80 psig air supply, instead of 40 psig as previously designed, the principle engineer for the engineering project obtained approval for design changes in C-337A to accomodate the actuator requirement of 80 psig air supply to open the valve. These changes included removing the pressure regulator and replacing the solenoid valves for the valve air supply. Work was completed on April 10, 1995, to replace the XV-532 and CV-533 globe valves with ball valves, on both positions 1-East and 1-West in C-337A, operating with 80 psig air supply. By September 1995, the XV-532 and CV-533 globe valves were replaced with ball valves in the remaining eight autoclaves in C-337A.

On September 15, 1995, during a Configuration Management

initiative to upgrade the quality of data sheets for Category 1 Safety System items in C-333A and C-337A, Engineering revised ESDS DS-CMD-16289-64 to Rev. 3, and modified the Description section for the actuator to specify the model as "1539SNM2-120A-4." This model number corresponds to an air supply of 40 psig to open the valve. Additionally, the phrase "40 psig" was added to the Description section as part of the initiative to upgrade the data sheet. The corresponding inspection plan was also modified to reflect this new model number. The engineer who revised this data sheet indicated that he walked down the valve, but did so in C-333A, where the globe valves with 40 psig actuators were still installed. He took this action under the mistaken belief that both the C-333A and C-337A facilities were identical in air supply pressure to the valve. The first lot of valves procured under the specifications of ESDS DS-CMD-16289-64, Rev. 3, was received on December 12, 1996.

The investigation team also reviewed the maintenance history of the XV-532 and CV-533 valves. The first reported instance of problems with these valves opening/closing was on December 12, 1995, on Autoclave 1 East with valve XV-532. The valve actuator was replaced under Work Package BUE701 without an investigation into the root cause. However, within two weeks, the valve was exhibiting similar problems. The actuator was changed again under Work Package BUE520 on December 27, 1995. These problems with valve opening/closing occurred prior to receipt of the 40 psig actuators.

Work Package BUE504 documents the replacement of the actuator on valve XV-532 on Autoclave 1 West in C-337A on October 22, 1996, but gives no details related to the symptoms of the problem. The actuator on XV-532 was replaced again on 1 East on January 7, 1997. This actuator may have been a 40 psig actuator, since the first lot of 40 psig actuators was received on December 12, 1996. On April 12, 1997, during the pressure decay test on 1 East, valve CV-533 would not open. The pressure decay test was aborted and the actuator was replaced on April 13, 1997. By April 19, 1997, CV-533 was exhibiting problems opening again. Electrical and Instrument Maintenance adjusted the valve linkage that

controls the limit switches and the autoclave was returned to service. A cylinder was loaded to feed in 1 East. In approximately eight hours into the cycle, CV-533 was exhibiting the same problem. The system was declared inoperable and Maintenance performed functional testing on both XV-532 and CV-533, but could not recreate the problem. It is suspected that corrosion product buildup on the surface of the ball coupled with the undersized spring prevented operation of the hot ball valve. Once the ball valve had cooled down, clearances opened up, thereby allowing valve operation with the same applied force. The system was declared operable again on April 21 and reloaded with another cylinder. During this cycle also, CV-533 exhibited problems opening again during the heeling cycle. Maintenance changed the air actuator on CV-533 on April 23, 1997. Another cylinder was placed in 1 East. During the heat cycle, both XV-532 and CV-533 failed to operate properly. Both valves failed to close within ten seconds, which was declared a reportable event. During this series of problems, neither Maintenance nor Operations was aware of the impact that temperature had on the results of the valve timing tests. Each time, prior to returning the system to service, the valve timing surveillance tests were conducted with acceptable results. Each time the system demonstrated, under cold conditions, that the valves would close in less than ten seconds. Therefore, Maintenance and Operations concluded that the problem had been eliminated by the adjustment/repairs Maintenance had made and the system was returned to service.

The investigation team also reviewed the vendor documentation on Preventive Maintenance requirements for this type of valve and concluded that based on the vendor documentation guidance, preventive maintenance would not be required.

CAUSES OF EVENT

The direct cause of the failure of the valves to close was that the torque applied by the actuator springs was inadequate to close the valve. The actuator was configured with a number of

springs designed for an air supply of 40 psig, but was operating at 80 psig and should have been configured with more springs to apply additional torque. Additionally, the buildup of coating on the valves from the steam system hampered their closing, by requiring additional torque to overcome the resistance from the buildup.

Upon discovery of the 40 psig actuators in the failed valve, the autoclaves were surveyed for similar problem valves. The following valves with actuators configured for 40 psig air supply were replaced with actuators configured for 80 psig air supply: (a) C-337A: XV-532 and CV-533, 1 East; CV-533, 1 West; (b) C-333A: XV-532 and CV-533, 2 North; XV-532 and CV-533, 2 South. Completed Action No. 4 reflects the replacement of these actuators. Valves XV-532 and CV-533 on 1 West will also be cleaned to remove the buildup of corrosion products. (Corrective Action 1) Additionally, on May 1, 1997, Engineering issued Rev. 5 of ESDS DS-CMD-16289-64 which included revised descriptions for the actuator to reflect the requirement for 80 psig air supply.(Completed Action No. 3) All twenty-two ball valves procured under ESDS DS-CMD-16289-64 Rev. 3 were located and isolated by Engineering to ensure the 40 psig configuration ball valve was not used again. (Completed Action No. 5)

The root cause of the event is that the design of the valve designated to replace the globe valves in the conductivity system did not adequately evaluate/define the specifications for the actuator to ensure that the actuator could consistently close the containment valve in less than 10 seconds under system conditions. The lack of consideration for the actuator characteristics is evidenced by (a) No designation of the steam supply pressure on the ESDS. There is a correlation between this value and the size/number of springs configured in the actuator which, in turn, determines the amount of torque that can be exerted to close the valve. (b) No designation on the ESDS for valve closing requirements. (c) No specified air pressure in the model number of the valve. Vendor defaulted to 80 psig.(d) Project plan expected to receive valves with actuators configured

for 40 psig, since no planned actions in the project to modify the facility supply pressure.

Additionally, the original design did not follow the Engineering Specifications for selection of the replacement valve. The ball valve was not one of the recommended valves for steam service in our operating environment according to the Engineering Specifications, Section 15101. In specifying the valve replacement, Engineering considered size constraints for our existing cabinets, pressure and temperature requirements and use of this valve in other industries. They also obtained two valves to install for testing prior to the full procurement. There was, however, no rigorous documented equivalency evaluation required or performed to ensure the valves met our requirements. Completed Action No. 1 reflects the issuance of the procedure UE3-EG-EG1077,"Equivalency/Substitution Evaluation Process," to establish the process of equivalency evaluations. Additionally, Corrective Action No. 2 will perform an equivalency evaluation on the ball valves to ensure the long term reliability of that valve. If the results of the evaluation indicate that the ball valve does not provide long term reliability, additional actions will be established. Pending the outcome of the evaluation, Corrective Action No. 3 will revise the Engineering Specification for "Steam and Steam Condensate" to reflect the use of the ball valve for the conductivity lines. In considering the issue generically, plug valves are also used as containment valves in the high pressure isolation system of the autoclaves and are also a valve which is not listed as a recommended valve for the Steam and Steam Condensate service. Likewise, an equivalency evaluation will be completed on this valve also. (Corrective Action No. 2)

Coupled with the lack of original design specifications for the actuator was the incident which allowed the 40 psig actuators to be procured. The reason that these 40 psig actuators were procured was the change to the Engineering Specification Data Sheet from an 80 psig actuator (by default) to a 40 psig actuator. This inadvertent change can be attributed to a lack of control in the creation and modification of Engineering Data

Sheets that existed at the time of the event. Since the time of the modification of this data sheet, Engineering has issued Engineering procedure CP3-EG-EG1076, "Preparation and Control of Engineering Specification Data Sheet," which defines the process and requires a technical review by an independent qualified engineer. (Completed Action No. 2)

A contributing cause of the failure is unanticipated degradation of valve performance over time due to buildup of coating on the valves from the steam system. The manufacturer's literature shows this valve to be fully acceptable for steam service. Also, based on the vendor documentation, it was reasonable to conclude that no preventive maintenance would be required related to the buildup of corrosion products. However, due to the nature of the plant steam (e.g. 40 year old piping, corrosion inhibitors commensurate with this age), the buildup of coating on valves was more rapid than anticipated/expected. Corrective Action No. 5 addresses this issue by determining the need for a preventive/predictive maintenance task/schedule for periodic timing surveillances or for the periodic inspection and cleaning, as required, of the ball valve used in the autoclave conductivity lines. Since the autoclave containment plug valves are also a generic concern, similar requirements for these plug valves will also be determined. (Corrective Action No. 6)

A second contributing cause is less than adequate corrective actions. After the April 13 incident of CV-533 exhibiting problems opening (which resulted in the replacement of the actuator), the same problem occurred during four successive feeding cycles between April 19 and April 24. The final incident involved the failure of both valves to close, the situation which prompted the issuance of this event report. Each time, the system was declared inoperable and Maintenance either made a change and/or performed functional testing, and the system was returned to service after passing its valve timing surveillance test. During this series of problems, neither Maintenance nor Operations was aware of the impact that temperature had on the results of the valve timing tests. The testing did not duplicate the problem since it was not completed under system conditions of

elevated temperatures. Corrective Action No. 7 addresses this by reviewing current surveillance procedures for valve timing tests to determine if testing occurs under operating conditions or the equivalent and determine if environmental conditions are important. This action also requires an action plan to be developed to address any deficiencies identified.

Additionally, XV-532 had exhibited problems opening/closing four times on various autoclaves prior to the April incidents. There is currently no trending of failures by valve type to provide information to management to promote proactive corrective actions that will prevent reportable failures. Corrective Action No. 4 addresses this issue through Engineering's Reliability program which will establish a system of data trending and preventive maintenance effectiveness analysis.

COMPLETED CORRECTIVE ACTIONS

1. On April 8, 1996, Engineering issued UE3-EG-EG1077, "Equivalency/Substitution Evaluation Process."

2. On December 31, 1996, Engineering issued procedure CP3-EG-EG1076, "Preparation and Control of Engineering Specification Data Sheets."

3. On May 1, 1997, Engineering issued Rev. 5 of ESDS DS-CMD-16289-64 which included a change to the Description of the actuator to reflect 80 psig air supply. Engineering Evaluation EV-C-814-97-017, Rev. 0, was written to support this revised ESDS.

4. On May 9, 1997, Maintenance replaced the following actuators which were configured for 40 psig air supply with actuators configured for 80 psig:
   C-337A: 1 East,XV-532; 1 East, CV-533; 1 West CV-533
   C-333A: 2 North, XV-532 and CV-533; 2 South, XV-532 and CV-533.

5. On May 16, 1997, Engineering isolated all twenty-two ball valves procured under ESDS DS-CMD-16289-64 Rev. 3. These valves will be shipped off-site for modification.

CORRECTIVE ACTIONS PLANNED

1. By August 1, 1997, Operations will clean or replace valve XV-532 and CV-533 on 1 West in C-337A.

2. By August 22, 1997, Design Engineering will prepare an engineering evaluation (under the design change ESO Z78670) to formally evaluate the long-term reliability of the ball and plug valves for this safety related (steam) application. If the evaluation is negative (i.e. ball or plug valves are not recommended for long term reliability), additional actions will be established.

3. By September 22, 1997, pending the outcome of Action 2, Engineering will revise the Engineering Specification 15101, "Steam and Steam Condensate," to reflect the use of ball and/or plug valves for the conductivity lines.

4. By September 30, 1997, Engineering will perform data trending and preventive maintenance effectiveness analysis through the use of system engineering tasking.

5. By November 30, 1997, Engineering will determine the need, through evaluation of trending data, to create/establish Preventive/Predictive Maintenance (PM) tasks for periodic cleaning or periodic timing surveillance of the ball valves (XV-532 and CV-533) used in the autoclave conductivity system for the C-333A and C-337A Feed Facilities.

6. By February 26, 1998, Engineering will determine the need, through evaluation of trending data, to create/establish Preventive/Predictive maintenance tasks for periodic cleaning or periodic timing surveillance for the plug valves

on the autoclave high pressure isolation system for the C-333A and C-337A Feed Facilities.

7. By January 28, 1998, Engineering will review the current surveillance procedures for valve timing tests to determine if the surveillances are being performed in all the operating environments in which the equipment will be required to perform its intended safety function. Where deficiencies are noted, Engineering will determine if environmental conditions impacted timing tests. By the above date, an action plan will be developed to correct any identified deficiencies.

EXTENT OF EXPOSURE OF INDIVIDUALS TO RADIATION OR TO RADIOACTIVE MATERIALS

No individuals were exposed to radiation or radioactive materials as a result of the failure of these containment valves to close in 10 seconds.

LESSONS LEARNED

(a) The impact of corrosion products from the steam supply system should be considered in the design of system, structures, and components and in determining the need for preventive maintenance on autoclave containment valves.
(b) Operating conditions should be considered, where deemed important, in the design of valve timing surveillance tests to ensure the test reflects expected performance of the valve.
(c) Adequate review/control of changes to Engineering Specification Data Sheets for safety system components is essential, since an error in an ESDS can cause a component to be procured which may not be able to perform its intended safety function.
(d) When deviating from Engineering Specifications for valve procurement, equivalency evaluations should be performed to provide adequate documentation of long-term reliability of the component.

Event Report ER-97-08
List of Commitments

COMPLETED CORRECTIVE ACTIONS

1. On April 8, 1996, Engineering issued UE3-EG-EG1077, "Equivalency/Substitution Evaluation Process."

2. On December 31, 1996, Engineering issued procedure CP3-EG-EG1076, "Preparation and Control of Engineering Specification Data Sheets."

3. On May 1, 1997, Engineering issued Rev. 5 of ESDS DS-CMD-16289-64 which included a change to the Description of the actuator to reflect 80 psig air supply. Engineering Evaluation EV-C-814-97-017, Rev. 0, was written to support this revised ESDS.

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5. On May 16, 1997, Engineering isolated all twenty-two ball valves procured under ESDS DS-CMD-16289-64 Rev. 3. These valves will be shipped off-site for modification.

CORRECTIVE ACTIONS PLANNED

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2. By August 22, 1997, Design Engineering will prepare an engineering evaluation (under the design change ESO Z78670) to formally evaluate the long-term reliability of the ball

and plug valves for this safety related (steam) application. If the evaluation is negative (i.e. ball or plug valves are not recommended for long term reliability), additional actions will be established.

3. By September 22, 1997, pending the outcome of Action 2, Engineering will revise the Engineering Specification 15101, "Steam and Steam Condensate," to reflect the use of ball and/or plug valves for the conductivity lines.

4. By September 30, 1997, Engineering will perform data trending and preventive maintenance effectiveness analysis through the use of system engineering tasking.

5. By November 30, 1997, Engineering will determine the need, through evaluation of trending data, to create/establish Preventive/Predictive Maintenance (PM) tasks for periodic cleaning or periodic timing surveillance of the ball valves (XV-532 and CV-533) used in the autoclave conductivity system for the C-333A and C-337A Feed Facilities.

6. By February 26, 1998, Engineering will determine the need, through evaluation of trending data, to create/establish Preventive/Predictive maintenance tasks for periodic cleaning or periodic timing surveillance for the plug valves on the autoclave high pressure isolation system for the C-333A and C-337A Feed Facilities.

7. By January 28, 1998, Engineering will review the current surveillance procedures for valve timing tests to determine if the surveillances are being performed in all the operating environments in which the equipment will be required to perform its intended safety function. Where deficiencies are noted, Engineering will determine if environmental conditions impacted timing tests. By the above date, an action plan will be developed to correct any identified deficiencies.