

July 24, 1998 GDP 98-1041

United States Nuclear Regulatory Commission Attention: Document Control Desk Washington, D.C. 20555-0001

Paducah Gaseous Diffusion Plant (PGDP) Docket No. 70-7001 Event Report ER-98-01, Rev. 3

Pursuant to SAR Section 6.9, Table 1, Criteria J.2, enclosed is the required 30-day written event report covering the actuation of the autoclave position 2 East, steam pressure control safety system in Building C-337-A. The Nuclear Regulatory Commission (NRC) was notified of the event on January 13, 1998 (NRC No. 33521). An interim report, relative to this event, was provided to NRC on February 11, 1998.

On February 1, 1998, a second event occurred involving the position 2 East, steam pressure control safety system in building C-337-A. NRC was notified of this event on February 2, 1998 (NRC No. 33637). An interim report, relative to the second event, was provided to NRC on March 2, 1998.

On March 20, 1998, Revision 1 to the investigation was provided to NRC, which combined the two event investigations above and advised that the determination of the root cause was continuing.

On May 2, 1998, a third event occurred involving the position 2 West, steam pressure contro! safety system in Building C-337-A. NRC was notified of this event on May 2, 1998 (NRC No. 34171). An interim report, relative to the third event, was provided to NRC on May 29, 1998.

On May 4, 1998, Revision 2 to the investigation was provided to NRC which updated information submitted on March 20, 1998 and advised that the determination of the root cause was continuing.

This final report combines three event investigations above and updates information submitted on May 4, 1998, Revision 2 Changes to the report are annotated by vertical lines in the right margin of this report. Enclosure 2 is a listing of the events and problem reports pertinent to the investigation. Enclosure 3 is a list of commitments made in this report.



P.O. Box 1410, Paducah, KY 4°001 Telephone 502-441-5803 Fax 502-441-5801 http://www.usec.com Offices in Livermore, CA Paducah, KY Portsmouth, OH Washington, DC United States Nuclear Regulatory Commission July 24, 1998 GDP 98-1041, Page 2

Any questions regarding this matter should be directed to Larry Jackson at (502) 141-6796.

Sincerely,

ulley

General Manager Paducah Gaseous Diffusion Plant

Enclosures: As Stated

cc: NRC Region III Office NRC Senior Resident Inspector, PGDP

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EVENT REPORT ER-98-01, Rev. 3

DESCRIPTION OF EVENT

This report provides information for three events (NRC No. 33521, 33637, 34171) related to malfunctions of the autoclave steam pressure/temperature control loop instrumentation.

In addition to the event reports due to safety system actuations, some related problems that are similar, but which did not result in reportable safety system actuations are included in this report.

The autoclaves were considered operable, even though the condition was recurring. The fa. lures are self-revealing and the pressure control system has two independent channels (P-514 and P-515) at which increasing pressure in the autoclaves will isolate the steam supply, before exceeding the safety limit for cylinder temperature/pressure. The first alarm and actuation occurs at ≤ 8 psig and only isolates the steam supply. The second alarm and actuation puts the autoclave into full containment at ≤ 15 psig. The autoclave shell pressure safety limit is 220 psig.

On January 12, 1998, at approximately 1710 hrs., the autoclave pressure increased to approximately 7 psig on autoclave position 2 East, Building C-337-A. A high autoclave steam pressure alarm was received in the Operations Monitoring Room (OMR) and the steam pressure control system actuated, as designed. The primary and secondary steam controllers were on automatic; the steam pressure digital reading was -3.75 psig on the steam controller; the strip chart recorder read approximately 6.5 psig (alarm set-point range 6.5 psig-7.5 psig); and the control valve was fully open. At 1755 hrs., according to procedure, the cylinder valve was closed and purged; the autoclave was jetted and opened; and the pigtail was disconnected. At 1825 hrs., autoclave position 2 East was removed from service (Mode 2). In summary, the steam pressure in the autoclave had increased to the alarm setpoint, due to a malfunction in the steam pressure/temperature control loop, and actuated the steam pressure control safety system, as designed. All safety systems performed, as designed, to place the autoclave in a safe condition. On January 13, 1998, at 0325 hrs., the Nuclear Regulatory Commission Headquarters (NRC-HQ) operations office was notified of this event, in accordance with Safety Analysis Report (SAR) Section 6.9, Table 1, Criteria J.2 (NRC No. 33521).

On January 22, 1998, autoclave position 2 East, Building C-337-A was declared operable after replacing a 6-pin connector suspected of failing, and successfully completing post-maintenance testing.

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On February 1, 1998, at 1920 hrs., the autoclave steam pressure increased to approximately 7 psig on position 2 East, Building C-337-A. The associated alarm was received in the OMR and the steam pressure control system actuated, as designed. The primary and secondary controllers were on automatic; the steam pressure digital reading was -3.75 psig on the steam controller; the strip chart recorder was approximately 7 psig; and the control valve was fully open. This was very similar to the first event on January 12, 1998. At 1950 hrs., the Plant Shift Superintendent (PSS) declared autoclave position 2 East inoperable. At 2015 hrs., according to procedure, the cylinder valve was closed and purged; the pigtail was disconnected after jetting and opening the autoclave; and the position was removed from service (Mode 2). In summary, a malfunction of the steam pressure/temperature control loop instrumentation caused the steam pressure in the autoclave to increase to the alarm set-point (approximately 7 psig), which resulted in an actuation of the steam pressure control safety system. All safety systems performed, as designed, to place the autoclaves in a safe condition. On February 2, 1998, at 0736 hrs., NRC-HQ office was notified of the event in accordance with SAR, Section 6.9, Table 1, Criteria J2 (NRC No. 33637).

On February 11, 1998, autoclave 2 East, Building C-337-A was declared operable after replacing a transducer suspected of failing and successfully completing post-maintenance testing.

On May 2, 1998, at approximately 0545 hrs., the autoclave steam pressure increased to approximately 7 psig on position 2 West, Building C-337-A. The associated alarm was received in the OMR and the steam pressure control safety system actuated, as designed. The primary and secondary controllers were on automatic; the steam pressure digital reading was normal on the steam controller; the strip chart recorder was approximately 7 psig; and the control valve was fully open. At 0607 hrs., the PSS declared autoclave position 2 West inoperable. At 0630 hrs., according to procedure, the cylinder valve was closed and purged; the pigtail disconnected after jetting and opening the autoclave; and the position was removed from service. A malfunction of the steam pressure/temperature control loop instrumentation, similar to two previous events (NRC No. 33521; 33637), caused the steam pressure in the autoclave to increase to the alarm set-point (approximately 7 psig), which resulted in the actuation of the steam pressure control safety system. All safety systems performed, as designed, to place the autoclave in a safe condition. On May 2, 1998, at 1500 hrs., NRC-HQ office was notified of the event in accordance with SAR, Section 6.9, Table 1, Criteria J2 (see NRC No. 34171).

On May 15, 1998, autoclave position 2 West, Building C-337-A was declared operable after replacing a transducer suspected of failing and successfully completing post-maintenance testing. The failed transducer was replaced by a redesigned transducer manufactured by Sensotec with a lengthened pressure tube and internal jumper wire insulation made of Teflon.

In addition to the three reportable events, other incidents involving erroneous demand signals to the steam controller are included in the investigation. Neither the reportable events, nor the non-reportable incidents challenged the 15-psig safety system setting.

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INVESTIGATION

The investigation focused on new equipment installed as part of the Instrument Upgrade Project (IUP) and which has been in service as early as October 1997. The equipment was procured as safety related items using the Commercial Grade Dedication process. The equipment satisfactorily passed post-modification testing required by the project prior to declaring the autoclaves operable.

The failure analysis was difficult because many of the instrument loop failures were intermittent. The analysis consisted of both destructive and non-destructive analysis and involved tests at PGDP and at the manufacturer. The analysis involved visits by the manufacturer's representatives to PGDP, as well as PGDP representative visits to the manufacturer.

The failure analysis included an investigation into the following potential problems with the P-514/P-515 autoclave instrument loops. The P-514 instrument loops did not result in any reportable events, but did demonstrate similar failures to the P-515 loops.

- 1. Pressure transducer failure due to internal short circuits as a result of manufacturer design or assembly, excessive heat during installation or normal operation, or excessive vibration;
- 2. Pressure transducer electrical connector failure due to assembly, insulation failure, or contaminants;
- 3. Amplifier failure due to electrical shorts to the shunt calibration resistor, component failure, or transient voltages;
- 4. Interconnecting cable failure;
- 5. Quality concerns with the manufacturer or PGDP dedication of the equipment.

As a result of the failure analysis, it was concluded that the cause for the failures were attributed to the following three generic causes.

- Mis-installed transducer connectors. Insulation on the connector wires were stripped back too far allowing for short circuits to occur as a result of normal vibrations from operating autoclaves.
- 2. Internal wires shorting to the transducer case and adjacent internal wires. Internal shorts were attributed to wire routing internal to the transducer and type of wire insulation used.

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3. Possible overheating of the transducers. This was identified by the manufacturer as a problem. However, testing conducted at PGDP to determine when overheating occurred, did not identify any time in which overheating could be occurring during installation or in the operating environment.

Actions have been taken to alleviate the three generic causes above. Cause number one will be eliminated by training new mechanics on proper installation of transducer connectors. Cause number two will be eliminated by the manufacturer. The internal wiring insulation will be changed from poly-nylon to Teflon and will be rerouted in transducers manufactured in the future to reduce the possibility of internal short circuits. Teflon insulation has a higher temperature rating and is more durable. Cause number three will be eliminated by the manufacturer's lengthening of the transducer process connection tube to preclude overheating during installation. Further, the transducer connectors will be upgraded to be capable of operating in an environment with higher heat over a sustained period.

An interim corrective action consisting of reconfiguring the steam controllers so controllers auctioneer high (steam controller will select larger value of the P-514/P-515 instrument loops) has been completed to preclude challenging the safety system. The expected date for completing the installation of the manufacturer's redesigned transducers is not known. Currently, PGDP is awaiting shipment of the transducers which will be installed, after they are received, during the autoclave quarterly Technical Safety Requirement (TSR) surveillance testing. The connectors will be replaced during the TSR surveillance testing on a quarterly basis with the transducer replacements after they are received.

The transducer failures have been evaluated against the reporting requirements of 10CFR21. The evaluation concluded that a deviation or failure to comply associated with the transducers, including design, analysis, inspection, testing, fabrication, or replacement parts, did not exist; therefore, the conditions for 10CFR21 reportability did not exist.

CAUSE OF EVENT

A. Direct Cause

The direct cause of the events was a malfunction of the steam pressure/temperature control loop instrumentation generated by an invalid low-pressure signal. This caused the system pressure in the autoclave to increase to alarm set-point, which resulted in the actuation of the steam pressure control safety system.

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B. Root Cause

- 1. A lack of training of new employees, as evident, on wire insulation on 6-pin connectors and strain relief stripped back too far and improper soldering. The exposed wiring and improper soldering afforded an opportunity for electrical short-circuits as a result of normal vibrations occurring during cylinder heating.
- Unexpected equipment failure due to pressure transducer electrical shorts. The poly-nylon
 insulation on the jumper wire inside the pressure transducer fail. 1 due to heat and/or
 vibrations over a sustained period. The pressure transducer connector also failed due to heat
 over a sustained period.

CORRECTIVE ACTIONS

- A. Completed Corrective Actions
 - On February 26, 1998, an inspection of all 6-pin connectors in Building C-333-A and C-337-A was completed, and those determined to be deficient, as a result of questionable soldering which was performed during the Instrument Upgrade Project (IUP), were subsequently replaced.
 - On March 25, 1998, vendor manual TM-06-999-9710, Rev. 1 was issued for the PT-514 and PT-515 amplifiers to indicate that the shunt calibration resistor is not to be installed or used on the amplifiers.
 - 3. On April 9, 1998, Engineering data sheet DS-CIE-16289-146, Rev. 3 was issued for the PT-514 and PT-515 amplifiers to ensure they do not have a shunt calibration resistor on them when issued to PGDP Stores.
 - 4. On April 19, 1998, Engineering data sheet DS-CIE-16289-143, Rev. 3 was issued for the PE-514 and PE-515 pressure transducers. This revision incorporated an increased length in the process tubing connection and a change in the part number from 060-B524-01 to 060-B524-01-01. The part number change indicates that the internal poly-nylon insulated jumper wire was changed to Teflon insulated wire. This change also revised the inspection plan to incorporate a zero offset and isolation check to verify they are within the manufacturer's recommendations.
 - 5. On April 30, 1998, a PGDP Engineer visited the manufacturer and verified that design improvements had been made to one of the first pressure transducers manufactured. This verification is documented in Engineering Notice EN-C-812-98-042, Rev. 0.

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- On April 30, 1998, shunt calibration resistors were removed from in-line amplifiers in plant Stores.
- 7. On May 15, 1998, two redesigned (lengthened processing tubing and Teflon insulated jumper wire) Sensotec transducers were installed and the autoclave placed into operation.
- By June 3, 1998, Maintenance changed relevant instrument Maintenance procedures to incorporate a requirement for testing P-514/P-515 instrument loops autoclave transducer's zero and leakage resistance.
- 9. On July 7, 1998, as an interim action to prevent challenging the safety system, autoclave steam controllers have been reconfigured so controllers auctioneer high which means the steam controller will select the larger valve of the P-514/P-515 instrument loops.
- 10. On July 17, 1998, data sheet DS-CIE-16289-267 was revised relative to the pressure transducer electrical connector to procure a connector with a longer service life. The existing connector, which is manufactured to meet the specifications of MIL-C-26482, Series 1 was changed to a connector which meets the specification of MIL-C-26482, Series 2.
- On July 21, 1998, Work Control completed a crew briefing for appropriate planners to assure familiarity with CP4-GP-IM6180, "Soldering Techniques and Printed Circuit Board Repair."

B. Planned Corrective Actions

- By September 10, 1998, Maintenance will complete crew briefings for appropriate field instrument mechanics involved in soldering to assure familiarity with CP4-GP-IM6180, "Soldering Techniques and Printed Circuit Board Repair."
- By October 29, 1998, Plant Training will perform a needs assessment on proper soldering of connectors; perform a task analysis on soldering techniques; evaluate CP4-GP-IM6180, "Soldering Techniques and Printed Circuit Board Repair"; and revise training module 203.22.02, "Soldering Techniques," to reflect task analysis results.
- 3. By November 4, 1998, Maintenance will remove the shunt calibration resistors from the inline amplifiers on autoclave position 1 West, Building C-337-A. This is the only remaining autoclave with shunt calibration resistors installed as part of the IUP.
- 4. By January 15, 1999, Instrument and Control Maintenance Group will modify the Training Development and Administrative Guide to assign training, as a result of corrective action 2, above.

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EXTENT EXPOSURE OF INDIVIDUALS TO RADIATION OR RADIOACTIVE MATERIALS None

LESSONS LEARNED

Poor workmanship could result in lack of equipment reliability.

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AUTOCLAVE STEAM PRESSURE DEFICIENCIES JANUARY 12, 1998 - MAY 2, 1998

	Report Number	Report Number	Problem	Location
1.	NRC 33521	1/12/98	Safety System Actuation P-515 Loop Failure (Connector/Transducer)	Bldg. C-337-A Psn. 2 East
2.	PR-CO-98-0581	1/30/98	Steam Cycle Terminated P-515 Loop Failure (Transducer)	Bldg. C-333-A Psn. 3 South
3.	NRC 33637	2/2/98	Safety System Actuation P-515 Loop Failure (Transducer)	Bldg. C-337-A Psn. 2 East
4.	PR-CO-98-1015	2/19/98	Invalid Steam Pressure Signal P-515 Loop Failure (Short-to-Shunt Resistor/ Transducer)	Bldg. C-333-A Psn. 2 North
5.	PR-CO-98-1157	2/24/98	6-pin Connector Short-circuit P-514 Loop Failure (Connector)	Bldg. C-337-A Psn. 2 West
6.	PR-CO-98-1509	3/10/98	Invalid Steam Pressure Signal P-515 Loop Failure (Transducer)	Bldg. C-333-A Psn. 2 North
7.	PR-CO-98-1690	3/18/98	Steam Cycle Terminated P-515 Loop Failure (Transducer)	Bldg. C-337-A Psn. 2 West

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AUTOCLAVE STEAM PRESSURE DEFICIENCIES JANUARY 12, 1998 - MAY 2, 1998 (cont.)

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Report Number	Report Number	Problem	Location
8. ATRC-98-2213	4/8/98	Invalid Steam Pressure Signal P-514 Loop Failure (Transducer)	Bldg. C-337-A Psn. 2 East
9. ATRC-98-2559	4/25/98	Invalid Steam Pressure Signal P-515 Loop Failure (Transducer)	Bldg. C-337-A Psn. 1 West
10. ATRC-98-2567	4/25/98	Invalid Steam Pressure Signal P-515 Loop Failure (Transducer)	Bldg. C-337-A Psn. 1 West
11. NRC 34171	5/2/98	Safety System Actuation P-515 Loop Failure (Transducer)	Bldg. C-337-A Psn. 2 West
12. ATRC-98-2736	5/2/98	Invalid Steam Pressure Signal P-514 Loop Failure (Transducer)	Bldg. C-337-A Psn. 1 West

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List of Commitments Event Report ER-98-01, Rev. 3

- By September 10, 1998, Maintenance will complete crew briefings for appropriate field instrument mechanics involved in soldering to assure familiarity with CP4-GP-IM6180, "Soldering Techniques and Printed Circuit Board Repair."
- By October 29, 1998, Plant Training will perform a needs assessment on proper soldering of connectors; perform a task analysis on soldering techniques; evaluate CP4-GP-IM6180, "Soldering Techniques and Printed Circuit Board Repair"; and revise training module 203.22.02, "Soldering Techniques," to reflect task analysis results.
- 3. By November 4, 1998, Maintenance will remove the shunt calibration resistors from the inline amplifiers on autoclave position 1 West, Building C-337-A. This is the only remaining autoclave with shunt calibration resistors installed as part of the IUP.
- 4. By January 15, 1999, Instrument and Control Maintenance Group will modify the Training Development and Administrative Guide to assign training, as a result of corrective action 2, above.