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Duane Arnold Energy Center
Operated by Nuclear Management Company, LLC

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NG-03-0249

Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Mail Station 0-P1-17
Washington, D.C. 20555-0001

Subject: Duane Arnold Energy Center
Docket No: 50-331
Op. License No: DPR-49
Licensee Event Report #2003-001-00
File: A-120

Dear Sirs:

Please find attached the subject Licensee Event Report (LER) submitted in accordance with 10CFR50.73. There are no new commitments contained within this report. Should you have any questions regarding this report, please contact this office.

Sincerely,

Mark Peifer,
Site Vice President

cc: Mr. James Dyer
Regional Administrator, Region III
U.S. Nuclear Regulatory Commission
801 Warrenville Road
Lisle, IL 60532

NRC Resident Inspector – DAEC
IRMS

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IE22

NRC FORM 366 (1-2001)	U.S. NUCLEAR REGULATORY COMMISSION	APPROVED BY OMB NO. 3150-0104 EXPIRES 7-31-2004
LICENSEE EVENT REPORT (LER) (See reverse for required number of digits/characters for each block)		Estimated burden per response to comply with this mandatory information collection request 50 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, NEOB-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

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TITLE (4)
Manual Reactor Scram and Reactor Coolant Chemistry Excursion Due to Punctured Main Condenser Tube Caused by Failed Condenser Deflector Plate

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MO	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REV NO	MO	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
02	01	2003	2003	– 001 –	00	03	27	2003	FACILITY NAME	DOCKET NUMBER

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

OPERATING MODE (9)	1							
POWER LEVEL (10)	093							
			20 2201(b)		20 2203(a)(3)(ii)		50.73(a)(2)(ii)(B)	50.73(a)(2)(ix)(A)
			20.2201(d)		20.2203(a)(4)		50.73(a)(2)(iii)	50.73(a)(2)(x)
			20.2203(a)(1)		50.36(c)(1)(i)(A)	X	50.73(a)(2)(iv)(A)	73.71(a)(4)
			20 2203(a)(2)(i)		50.36(c)(1)(ii)(A)		50 73(a)(2)(v)(A)	73.71(a)(5)
			20.2203(a)(2)(ii)		50 36(c)(2)		50 73(a)(2)(v)(B)	OTHER Specify in Abstract below or in NRC Form 366A
			20 2203(a)(2)(iii)		50 46(a)(3)(ii)		50.73(a)(2)(v)(C)	
			20.2203(a)(2)(iv)		50.73(a)(2)(i)(A)		50.73(a)(2)(v)(D)	
			20.2203(a)(2)(v)		50.73(a)(2)(i)(B)		50.73(a)(2)(vii)	
			20 2203(a)(2)(vi)		50 73(a)(2)(i)(C)		50 73(a)(2)(viii)(A)	
			20 2203(a)(3)(i)		50.73(a)(2)(ii)(A)		50 73(a)(2)(viii)(B)	

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER (Include Area Code)
Keith Young, Performance Assessment Manager	319-851-7229

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX
E	SG	HX	F175	N					

SUPPLEMENTAL REPORT EXPECTED (14)				EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
	YES (If yes, complete EXPECTED SUBMISSION DATE).	X	NO				

ABSTRACT (Limit to 1400 spaces, i e., approximately 15 single-spaced typewritten lines) (16)

At 2242 on January 31, 2003, while operating the plant at 93% power, Control Room operators began receiving a series of conductivity alarms. Conductivity levels in the condenser hotwell, reactor feedwater and reactor coolant systems exceeded action levels established in plant procedures. After starting a normal reactor shutdown in response to those procedures, a manual reactor scram was inserted at 0233 on February 1, 2003, due to the rate and magnitude of the continued conductivity increases. The plant was cooled down and Mode 4 (Cold Shutdown) was reached at 1620 the same day. The cause of the chemistry transient was a punctured tube in the main condenser, which allowed water from the Main Circulating water system to leak into the Condensate system. A condenser steam deflector plate was found broken off inside the condenser, and was the cause of the punctured tube. The deflector plate experienced a fatigue failure due to sustained plant operation with a feedwater heater dump valve controlling heater water level; a condition created by the failure of the heater's drain valve. Corrective actions include repair of the heater drain valve, restoration of chemistry parameters, removal of the punctured tube, plugging of other damaged tubes, repairs to the condenser deflector plate, and follow-up inspections of deflector plates in other parts of the condenser. Extensive evaluations were performed for reactor vessel internal components, nuclear fuel, and other plant systems for adverse effects from the chemical excursion. The evaluations concluded there was minimal impact from this event. There was no impact on public health and safety as a result of this event.

I. Description of Event:

On January 31, 2003, at 2242, with the plant operating at 100% electrical (93.6% thermal) power, Control Room operators received a condensate system filter demineralizer "Influent High Conductivity" alarm on Panel 1C80, A-6. Alarm response procedures directed entry into Abnormal Operating Procedure (AOP) 639, "Reactor Water/Condensate High Conductivity." At 2309, condenser hotwell conductivity indicated 0.13 µmhos/cm, which is above Action Level 1 (0.10 µmhos/cm) of Plant Chemistry Procedure (PCP) 1.9, "Water Chemistry Guidelines."

Condenser hotwell, reactor feedwater, and reactor coolant conductivity indications continued to increase, resulting in additional Control Room alarms. At 0037 on February 1, operators entered Technical Requirements Manual (TRM) LCO 3.4.1 Condition A, "Any chemistry parameter not within the limits of Table T3.4.4-1 in Mode 1," and initiated required actions.

At 0054 on February 1, after PCP 1.9 Action Level 3 (>10 µmhos/cm) was exceeded for hotwell conductivity, an orderly plant shutdown was commenced to meet the requirements of having the plant in Mode 3 within 12 hours and Mode 4 within 36 hours. The decision to perform a normal shutdown, rather than isolate the reactor and use safety systems for core cooling was based on a "Note" in AOP 639, which led operators to believe the leak was small.

At 0142, operators entered TRM LCO 3.4.1 Condition D, Conductivity [of reactor coolant] >10.0 µmhos/cm at 25 degrees C in Mode 1, which also requires the plant to be in Mode 3 within 12 hours and Mode 4 within 36 hours. With reactor coolant conductivity exceeding PCP 1.9 Action Level 3 (>5.0 µmhos/cm) and increasing, operators manually scrammed from approximately 50% power at 0233.

Reactor coolant chemistry continued to degrade after the manual scram until the Main Circulating water system was secured at 1353 and the Condensate and Feedwater systems were secured at 1356 on February 1. With contaminant levels exceeding the ranges of installed instrumentation, grab samples of reactor coolant were analyzed. The 1050 sample had the lowest recorded pH (4.6) and the highest conductivity (232 µmhos/cm), and the 1410 sample had the highest recorded chloride (21,445 ppb) and sulfate (93,870 ppb) readings. The plant was placed in Mode 4, Cold Shutdown, at 1620 on February 1, 2003 and, after a forced outage to complete repairs to the condenser and restore chemistry parameters, returned to service at 1402 on February 15, 2003.

II. Cause of Event:

The direct cause of the chemistry excursion was leakage of circulating water into the main condenser hotwell through a punctured condenser tube. The tube was punctured by impact of a deflector plate installed over the condenser penetration fed by the 1E005B Low Pressure Feedwater Heater dump line.

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II. Cause of Event (continued):

The deflector plate is designed to protect the condenser tubes from direct impact of the water/steam mixture from the dump line. The deflector plate broke free inside the condenser following over 3 months of dump valve operation for heater water level control. The force of the continuous heater dump flow led to fatigue failure of the deflector plate near the attachment welds. The broken deflector plate also dented and scored several other tubes, damaged two sections of steam baffle plates in the condenser, and bent a third section of the steam baffle plates.

Root Causes of this event include human performance circumstances related to engineering work practices and management decision making, insufficient management and supervisory oversight and review, ineffective use of operating experience, and ineffective corrective actions. Other factors that contributed to the severity of the chemistry excursion included: inadequate operations and chemistry department procedures, less then adequate operator simulator training, and needed improvements in operator knowledge of chemistry fundamentals.

Work practices, management decision making, and management systems:

On October 5, 2002, Control Valve (CV)-1339 failed (indicated open, but had low flow) during plant operation. CV-1339 is the low-pressure feedwater heater (1E005B) drain valve and functions to control water level in the feedwater heater. The feedwater heater dump valve CV-1340 assumed level control as a result of the consequential high level in the heater. The CV-1339 failure (determined during the forced outage associated with this event) was caused by a broken anti-rotation pin between the valve stem and plug, which resulted in separation between the stem and plug.

The following morning, October 6, 2002, engineering personnel (utility non-licensed) made a presentation of troubleshooting plans for CV-1339 to plant management. This presentation and the subsequent Action Request (AR) Screening Team review of this issue included discussions regarding continued operation with the CV-1340 dump valve controlling feedwater heater level. After the failure of the condenser deflector plate, it was estimated that the steam/water flow rates through the dump valve were 10-12 times higher than the deflector plate nominal design flow. Erosion of condenser internals had been considered by engineering personnel, but no formal evaluation of flow rates and condenser design was performed or documented. Operating Experience (OE) information was not researched as an input to this decision. Post-event research found applicable OE of an identical event that would have heightened awareness of this failure mode. Corrective actions from a September 2002 event (LER 2002-003) to improve use of OE either had not been implemented or were ineffective at preventing this event.

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II. Cause of Event (continued):

The engineering position was questioned by management involved in the decision, but not in sufficient depth to recognize the lack of rigor behind it. Also, the engineering input was not reviewed or questioned by engineering management and supervision. As a result, the decision was made by plant management to continue operating with dump valve CV-1340 controlling feedwater heater water level until the next refuel outage which was 5 months away (scheduled for March 2003). This decision led to the fatigue failure of the deflector plate and consequential tube puncture and chemical excursion in the Reactor Coolant System.

Operations and Chemistry procedures:

Neither Abnormal Operating Procedure (AOP) 639, "Reactor Water/Condensate High Conductivity," nor Plant Chemistry Procedure (PCP) 1.9, "Water Chemistry Guidelines," provided adequate guidance for handling this event. These procedures provide guidance for a small condenser tube leak and for multiple tube ruptures large enough to cause hotwell level to increase. However, guidance was not provided for an intermediate-size leak such as that experienced in this event. Also, there was no guidance provided for leaks that result in the introduction of contaminants at levels significantly higher than those contained in the TRM.

Some of the action levels in the TRM and procedures do not provide sufficient margin between the specified actions (shutting down the plant in an orderly manner) and the maximum permissible values allowed by the fuel warranty. For example, the action level of TRM LCO 3.4.1 Condition D (>10 μmhos/cm in the reactor coolant) is the same value as the fuel warranty extreme limit for reactor coolant above 212 degrees F. Thus the procedure action to begin a shutdown when the fuel warranty extreme limit has been exceeded does not provide margin to avoid reaching the fuel warranty extreme limit.

Simulator training:

Mirroring the procedures, abnormal operation scenarios used in simulator training do not provide the operating crews examples of intermediate-sized condenser tube leaks. The scenarios do not address tube failures such as that experienced in this event. In addition, in one scenario, the event is terminated once the decision is made to start shutting down the reactor because Chemistry Action Level 3 is exceeded.

Operator knowledge of chemistry fundamentals:

Operator knowledge of the specific threat to the reactor and fuel warranty limits associated with chloride levels experienced during this transient needs improvement. Specifically, based on interview results, operators were unaware of how these chemical contaminants affect the development of intergranular stress corrosion cracking (IGSCC) or the other factors that, in conjunction with these contaminants, accelerate the development of IGSCC. These factors manifested during the event response by the delay in isolating the source of the in-leakage and the non-aggressive time to reach Mode 4, Cold Shutdown.

III. Assessment of Safety Consequences:

Condenser tube damage:

The initiating event and direct cause of the chemistry excursion was a punctured main condenser tube, located in the D-H tube bundle of the 1E007B Main Condenser High Pressure Shell, which established a path for circulating water to flow into the condenser hotwell, and from there into the condensate, feedwater, reactor coolant, and other systems. Initial tube inspections indicated four other tubes had signs of denting, restrictions, or wear, therefore, additional inspections were performed. The results of these additional 28 tube (internal) inspections were satisfactory. A steam side inspection was done in parallel with this effort.

The condenser steam side inspections indicated that the tube puncture resulted from impact by the steam deflector plate that had been welded to the condenser wall over the 10-inch diameter discharge opening into the condenser from the 1E005B Low Pressure Feedwater Heater dump line. Until the event, the 10-inch by 18-inch by 5/8-inch thick deflector plate was held in place by fillet welds along the top (18-inch) side to the condenser wall, by fillet welds on one end to a rectangular plate welded perpendicular to the wall, and on the other end by fillet welds to an I-beam inside the condenser, so that the bottom side of the plate was held out at a 60-degree angle from the condenser wall. The orientation of the plate was designed to deflect flow downward toward the condenser false bottom, to prevent direct impingement on the condenser tubes.

The broken deflector plate also dented and scored other tubes on the bottom row of the D-H bundle, broke free two sections of the steam baffle plates that had been welded to the tube bundle supports in the condenser, and bent a third section of the steam baffle plates. The deflector plate and the two broken baffle plates were found lying on the (false) bottom of the condenser. A dent was also found in the tube support plate pipe support nearest the deflector plate. In addition, steam impingement was evident on the bottom row of tubes, the first two rows of tubes vertically up the south side of the C-G bundle, and on the first two tube rows in the bottom section of the C-G bundle.

Chemistry parameters and possible resin intrusion:

The cause of the low reactor pH (4.6) is unknown. Industry experience suggests that the low reactor coolant pH could have resulted from the introduction of resin into the reactor vessel, or possibly from instrumentation error or sample analysis technique. However, the chemistry technician reanalyzed the grab sample with the low pH and received the same results. Resin intrusion was essentially eliminated as a cause for the low pH through demineralizer testing.

III. Assessment of Safety Consequences (continued):

Possible physical effects of the chemistry excursion on reactor components and plant systems:

Evaluations were performed by vendors and industry experts to determine the physical effects of the chemistry excursion on reactor fuel, reactor internal components, and plant systems. The scope of the evaluations included the effects of the chemistry excursion on reactor internals and associated piping, the Control Rod Drive (CRD) System, the reactor fuel, and the Reactor Recirculation Pump Seals. The conclusion of these evaluations was, in view of the crack mitigation measures in place at DAEC, such as Hydrogen Water Chemistry, Noble Metals Chemical Addition, and Zinc injection, the chemistry excursion had minimal effect on the systems and components evaluated.

Therefore, overall, this event had no impact on public health and safety. Potential consequences to plant components were minimal. Primary Containment Isolation System (PCIS) isolations occurred as expected in response to reactor water level fluctuations after the manual reactor scram. There were no other systems, structures, or components inoperable at the start of this event that contributed to its severity. Variations in plant operating modes would not have increased event severity.

IV. Corrective Actions:

Equipment repairs and plant recovery actions:

The failed feedwater heater drain valve CV-1339 was repaired (CWO A60803).

The punctured tube was removed from the tube bundle and other tubes that showed signs of damage were plugged (OTH026351 and OTH026380).

The broken deflector plate was replaced and other damaged baffle plates inside the condenser were repaired (CWO A58717, OTH026351 and OTH026380).

Chemistry Parameters were restored to within acceptable values and the plant returned to operation at 1402 on February 15, 2003.

Additional condenser deflector plate inspections will be performed during Refuel Outage (RFO) 18 (OTH026383).

As an added barrier, Operating Instruction (OI) 646, the procedure which includes dump valve operation, was revised prior to plant re-start to require an engineering evaluation for prolonged dump valve operation (PWR 20467).

IV. Corrective Actions (continued):

Corrective actions to address root causes and contributing factors:

Work practices, management decision making, and management systems:

Clearly define the expectations for scope and rigor of engineering analysis and evaluation for systems and equipment and define expectations for engineering manager/supervisor oversight of work (CA026666 and CA026674).

Implement improvements to the OE program including revised expectations for OE use, program performance monitoring tools, and tracking/timeliness for reviews. (CA026683, CA026685, CA026686, and CA026688).

Operations and Chemistry procedures:

Revise PCP 1.9 to provide appropriate guidance to Chemistry Technicians regarding supplemental sampling if action levels are exceeded, guidance for operational responses with action levels that provide sufficient margins to prevent exceeding fuel warranty limits, and specify the fuel warranty chemistry limits (CA026667).

Review other chemistry procedures that provide operational guidance in the form of action levels or limits to ensure adequacy of guidance. Revise these procedures as needed based on this review (CA026675).

Revalidate AOP 639 for all steps, to confirm that the procedure adequately covers all event types and severity levels (CA026673).

Simulator training:

Validate simulator modeling to confirm the adequacy of intermediate levels of a condenser tube leak, the parameters used to determine concentrating effects in the reactor pressure vessel, and Circulating Water system impurity assumptions. Revise the modeling as needed based on this validation (CA026681).

Operator knowledge:

Conduct a needs analysis for operator and Shift Technical Advisor (STA) training programs to determine the level of chemistry fundamentals knowledge and training needed to support chemistry-related tasks, including response to chemistry-related events (CA026689).

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V. Additional Information:

Previous Similar Occurrences:

This event marks the fourth plant shutdown since 1995 due to condenser tube leaks. The three previous leaks in May 1995, August 1997, and May 2002 occurred in the Main Condenser Low Pressure Shell (1E007A), and were similar to each other in regard to failure modes and the location of the tube leaks. None of these previous leaks resulted in a reportable event.

Inspections performed for these previous tube leaks concluded that foreign material, most likely Cooling Tower debris, lodged inside the tubes just past the tube sheets and resulted in flow turbulence and abrasions that led to leaks (AR 31041). In contrast, this event occurred in the High Pressure Shell, the tubes were damaged near the center of their length, and the failure mode is different. Based on these differences, corrective actions assigned from the previous three events are not expected to have prevented this event. Comparisons were also made between the current tube damage locations and the locations of tube staking performed during RFO-17 for power uprate. This review indicated no relationship between the tube damage in this event and the tube staking performed during RFO-17.

DAEC LER 2002-003 involved an extended outage of the Reactor Core Isolation Cooling (RCIC) system. Though the events themselves are un-related, the root causes have similarities. One root cause from the RCIC event was ineffective use of industry Operating Experience (OE). Some corrective actions to address the issue with use of OE were not yet implemented at the time of this event and others were ineffective in achieving desired behavioral changes.

EIIS System and Component Codes:

Condenser System: SG
Low Pressure Heater Drains and Vents Systems: SM
Condensate and Feedwater Chemistry Control System: KD
Control Rod Drive: AA

This event is being submitted pursuant to 10CFR50.73(a)(2)(iv)(A).
Event notification (EN) 39552.