November 28, 2005

NG-05-2161
10 CFR 50.73

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555-0001

Duane Arnold Energy Center
Docket 50-331
License No. DPR-49

Licensee Event Report #2005-004-00

Please find attached the subject Licensee Event Report (LER) submitted in accordance with 10 CFR 50.73. This letter contains the following new commitments:

1. Duane Arnold Energy Center will perform an analysis of the effects on HPCI discharge piping heating caused by "turbulent penetration." This action is due March 17, 2006.
2. After completion of the analysis performed under commitment 1, existing Technical Specification Surveillance Requirements basis will be reviewed and revised based on the results of the analysis. This action is due April 28, 2006.

Should you have any questions regarding this report, please contact this office.

Gary D. Van Middlesworth
Site Vice President, Duane Arnold Energy Center
Nuclear Management Company, LLC

cc: Administrator, Region III, USNRC
Project Manager, DAEC, USNRC
Resident Inspector, DAEC, USNRC

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NRC FORM 366 (1-2001) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB NO. 3150-0104 EXPIRES 7-31-2004

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.

# LICENSEE EVENT REPORT (LER)

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

| FACILITY NAME (1) | DOCKET NUMBER (2) | PAGE (3) |
|---|---|---|
| Duane Arnold Energy Center | 05000331 | 1 of 5 |

**TITLE (4)**

Unplanned Inoperability of the High Pressure Coolant Injection Pump

| 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 |
| 09 | 29 | 2005 | 2005 | – 004 – | 00 | 11 | 28 | 2005 | FACILITY NAME | DOCKET NUMBER |

| | |
|---|---|
| OPERATING MODE (9) | 1 |
| POWER LEVEL (10) | 96 |

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

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 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) | | 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) | x | 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) |
|---|---|
| Robert Murrell, Regulatory Affairs | 319-851-7900 |

**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 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |

| 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)


On September 29, 2005, with the plant operating at 96% power in Mode 1, the High Pressure Coolant Injection (HPCI) system at the Duane Arnold Energy Center was declared inoperable following unsatisfactory venting results of the HPCI system injection piping. This venting was being performed to ensure the discharge piping was filled with water. Specifically, the venting operation was intended to satisfy Technical Specifications (TS) requirement that the system is full of water (SR 3.5.1.1) and to quantify any air accumulation in the system piping. During HPCI discharge line venting on September 29, 2005, a steady stream of water was not obtained for approximately 30 minutes and therefore, HPCI was declared inoperable for not being able to meet SR3.5.1.1.

To correct this issue, on October 12, 2005, an operability recommendation was completed and approved that concluded that HPCI was operable but degraded and non-conforming.

The cause of this event was the failure to take into account the effects of "turbulent penetration" into the original HPCI system design.

There were no actual safety consequences and no effect on public health and safety as a result of this event. This event is reportable under 10CFR50.73(a)(2)(v)(D).

# LICENSEE EVENT REPORT (LER)
TEXT CONTINUATION

| FACILITY NAME (1) | DOCKET NUMBER (2) | LER NUMBER (6) | | | PAGE (3) |
|---|---|---|---|---|---|
| | | YEAR | SEQUENTIAL NUMBER | REVISION NUMBER | |
| Duane Arnold Energy Center | 05000331 | 2005 | -- 004 -- | 00 | 2 of 5 |

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

I. Description of Event:

On September 29, 2005, the High Pressure Coolant Injection (HPCI) system at the Duane Arnold Energy Center was declared inoperable following unsatisfactory venting results of the HPCI system injection piping. This venting was being performed to ensure the discharge piping was filled with water. Specifically, the venting operation was intended to satisfy Technical Specifications (TS) Surveillance Requirement (SR) that the system is full of water (SR 3.5.1.1) and to quantify any air accumulation in the system piping. During HPCI discharge line venting on September 29, 2005, a steady stream of water was not obtained for approximately 30 minutes and therefore, HPCI was declared inoperable for not being able to meet SR3.5.1.1.

II. Assessment of Safety Consequences:

This report is being submitted pursuant to 10CFR50.73(a)(2)(v)(D).

This event did not affect the availability of other systems needed to maintain safe shutdown conditions, remove residual heat, control the release of radioactive material, or mitigate the consequences of an accident.

The HPCI system was declared unavailable on three separate occasions between September 29 and October 12. The total unavailability time for HPCI was 102 hours. When HPCI is out of service, core damage frequency (CDF) increases from the base value of 9.148E-06/yr to 1.728E-05/yr. Therefore, the incremental core damage probability (ICDP) was:

(1.728E-05/yr – 9.148E-06/yr) x (102 hrs) x (1 day / 24 hrs) x (1 yr / 365 days) = 9.47E-8

Section 11 of NUMARC 93-01 provides guidance for assessing risk resulting from performance of maintenance activities. Activities for which incremental core damage probability is less than 1.0E-06 are considered to be of minor consequence with regard to plant risk and do not warrant use of specific compensatory measures to reduce risk. The calculated value of ICDP for HPCI being unavailable for 102 hours is less than this threshold, and the activity is therefore considered to have an inconsequential impact on plant risk.

The value of 9.47E-8 for ICDP is conservative because it is assumed that HPCI was not capable of performing its intended function during the 102 hours for which it was declared to be unavailable. In fact, it was only incapable of starting automatically. If a valid HPCI initiation signal had occurred during the time it was said to be unavailable, the system could have been initiated manually simply by returning the HPCI Turbine Aux Oil Pump control from its Pull-to-Lock setting to Auto.

Therefore, there were no actual safety consequences associated with this event. There was no effect on public health and safety as a result of this event.

This event did result in a Safety System Functional Failure.

III. Cause of Event:

Prior to this event, DAEC had designed a vent rig to vent the HPCI discharge piping with the ability to quantify the amount of non-condensable gases vented. Utilizing a ⅛" ball valve, the rig was designed to quantify the volume of non-condensable gases. This configuration allowed for an accurate timing of the vent duration but created a high pressure drop across the ball valve. This vent rig had been successfully used on August 29, 2005. During the next performance of venting on September 29, 2005, a continuous stream of steam was vented from the discharge line for greater than 30 minutes. The only plant change from the August and September venting was the fact that the Condensate Storage Tank (CST), which is the preferred suction source for HPCI, was at a lower level in September than in August due to the need to adjust CST chemistry.

Investigation into this event revealed the existence of HPCI discharge piping temperatures higher than the original design. These elevated temperatures result in a steam void at the pipe elbow next to the HPCI discharge valve, MO 2312. As discussed above, the vent rig was designed for venting non-condensable gases, not to remove any existing steam void that may have been present and therefore, a continues stream of water was not achievable due to the fact that steam was being produced at the same rate that it was being vented.

The cause of the elevated temperatures was the fact that thermal energy was being conducted through the inject valve disc to the water on the pump side of the discharge line. This condition resulted in steam being produced on the low-pressure side of MO 2312's valve disc. The thermal energy was being delivered to MO 2312 via the phenomenon of "turbulent penetration." Therefore, the cause of this event was the fact that the HPCI system was designed with a lack of awareness to the "turbulent penetration" phenomenon and its effect on HPCI discharge piping.

Turbulent penetration (Corkscrew Convection) occurs if a high energy fluid in a large pipe passes across the opening of a smaller branch pipe to which it is connected. This results in fluid vibrations being induced resulting in eddy currents and thermal transport for a certain distance into the connected branch pipe. Thus, thermal penetration into a vertical line can induce circulation in a connected horizontal line which has stagnant and stratified fluid.

The thermal energy delivered in this manner can also induce a circulation loop in an isolated volume between two valves. The effect is to deliver thermal energy to a valve which is separated from the high-temperature and high-flow line by an intervening valve. This is what has been observed at DAEC. Turbulent penetration delivers thermal energy into the vertical section of the HPCI injection line which is connected to the feedwater line. This induces a circulation current that delivers thermal energy to the inject check valve, V23-0049. This in turn induces a circulation current in the space between V23-0049 and MO 2312. This has the effect of delivering thermal energy to MO 2312.

Further discussions regarding this phenomenon can be found in IAEA-TECDOC-1361, dated July 2003 and EPRI MRP-32, Thermal Fatigue Monitoring Guidance, dated April 2001.

IV. Corrective Actions:

An operability recommendation (OPR) was completed on October 12, 2005. This OPR concluded that HPCI was operable but degraded and non-conforming based on the following:

The HPCI System is fully capable of performing its safety functions and TS SR 3.5.1.1 is satisfied, as summarized below:

1. The steam volume near the MO2312 disk during standby readiness conditions has not cause a detrimental water hammer.

2. The steam volume near the MO2312 disk during standby readiness conditions does not delay HPCI injection because it is collapsed when MO2312 starts to open.

3. The HPCI quarterly surveillance test (STP 3.5.1-05) was performed on October 11, 2005 while monitoring pipe temperature and movement, in addition to the data from the transient recorder, and no evidence of water hammer was observed.

4. The non-conformance with design specifications for HPCI discharge pipe temperature has been evaluated, with the conclusion that the elevated temperatures have no affect on HPCI operability.

To provide additional assurance that the HPCI discharge piping is filled, the following compensatory measures were implemented and proceduralized:

1. HPCI suction will be lined up to the CST with level of 15 feet (minimum), or the HPCI Keep Fill System will be in service.

2. Periodic venting of the HPCI discharge piping, starting at an increased frequency and then extended out to the TS SR frequency based on experience.

3. Shiftly monitoring of HPCI discharge pipe temperature to assure that the existing void size is not changing.

Additionally, DAEC will perform an analysis of the effects on HPCI discharge piping caused by "turbulent penetration". This action will validate assumptions made in the operability recommendation regarding acceptable void size, minimum CST water level to assure operability, effects of pipe movement with determined void size and collapse under normal and automatic start scenarios, and a past operability determination. This action is due March 17, 2006.

After completion of the analysis, existing Technical Specification SR basis will be reviewed and revised based on the results of the analysis. This action is due April 28, 2006.

EIIS System and Component Codes:

N/A – There were no component failures.

V. Additional Information:

Previous Similar Occurrences:

A review of LERs at the DAEC over the last 3 years identified no LERs with similar events.