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December 13, 2005
JAFP-05-0185

United States Nuclear Regulatory Commission
Attn: Document Control Desk
Mail Station P1-137
Washington, D.C. 20555

Subject: **Docket No. 50-333**
**LICENSEE EVENT REPORT: LER-05-003-01 (CR-JAF-2005-02593)**

**Plant Shutdown Due to Through-Wall Crack in Torus**

Dear Sir:

LER-05-003 revision 0 was submitted in accordance with 10 CFR 50.73(a)(2)(i)(A), "The completion of any nuclear plant shutdown required by the plant's Technical Specifications" and 10 CFR 50.73(a)(2)(ii)(A), "The condition of the nuclear power plant, including its principal safety barriers, being seriously degraded."

The formal risk evaluation was completed subsequent to the submittal of the original LER. In addition, a calculation used to quantify leakage rates through the Torus crack was subsequently revised. The LER has been revised to incorporate the pertinent information from the risk evaluation and revised calculation.

There are no commitments contained in this report.

Questions concerning this report may be addressed to Mr. Jim Costedio at (315) 349-6358.

Very truly yours,

T. A. Sullivan

TAS:DD:dd
Enclosure

cc: USNRC, Region 1
USNRC, Project Directorate
USNRC Resident Inspector
INPO Records Center

IE22

NRC FORM 366 (6-2004) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB NO. 3150-0104 EXPIRES 6-30-2007

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 and FOIA/Privacy Service Branch (T-5 F52), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by internet e-mail to infocollects@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)

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4. TITLE

Plant Shutdown due to Through-Wall Crack in Torus

| 5. EVENT DATE | | | 6. LER NUMBER | | | 7. REPORT DATE | | | 8. OTHER FACILITIES INVOLVED | |
|---|---|---|---|---|---|---|---|---|---|---|
| MONTH | DAY | YEAR | YEAR | SEQUENTIAL NUMBER | REV NO | MO | DAY | YEAR | FACILITY NAME | DOCKET NUMBER |
| | | | | | | | | | N/A | 05000 |
| 06 | 27 | 05 | 05 | – 003 | – 01 | 12 | 13 | 05 | FACILITY NAME N/A | DOCKET NUMBER 05000 |

| 9. OPERATING MODE | 1 |
|---|---|
| 10. POWER LEVEL | 100 |

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

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 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) | X | 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) | X | 50.73(a)(2)(ii)(A) | | 50.73(a)(2)(viii)(B) | | | |

12. LICENSEE CONTACT FOR THIS LER

| NAME | TELEPHONE NUMBER (Include Area Code) |
|---|---|
| Mr. Darren Deretz, Sr. Regulatory Compliance Specialist | (315) 349-6851 |

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 |
|---|---|---|---|---|---|---|---|---|---|
| B | NH | TK | C310 | Y | | | | | |

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


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

On June 27, 2005, while the plant was operating at 100 percent power, inspectors discovered a small leak (1-2 drops/minute) through the Torus shell. A subsequent engineering evaluation determined that the Primary Containment was inoperable, the plant was shutdown in accordance with normal shutdown procedures. The declaration of containment inoperability resulted in entering the site emergency plan and declaring an Unusual Event (UE).

The plant's High Pressure Coolant Injection (HPCI) exhaust line, although consistent with original GE design specifications, does not include a HPCI turbine exhaust line sparger. A properly designed sparger is expected to reduce local Torus shell stresses resulting from HPCI turbine exhaust pressure pulses. The plant did not install a HPCI sparger due to inadequate information transfer to JAF from General Electric (GE) and other nuclear facilities regarding concerns with pressure instability and vibration inside the Torus.

As a result of this design deficiency, the Torus shell experienced localized stress, high cycle fatigue due to rapid condensation of the HPCI exhaust steam at the ring girder weld heat affected zone, resulting in a Torus shell through-wall crack.

As part of the corrective actions, an ASME Code repair was performed to repair the Torus shell. In addition, the HPCI exhaust line and ring girder gusset attachment will be modified as required to reduce the associated stresses.

There were no actual safety consequences associated with this event.

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

EIIS Codes in [ ]

**Event Description:**

On June 27, 2005, with the James A. FitzPatrick Nuclear Power Plant (JAF) operating at 100 percent power, a leak in the Torus [NH] shell was discovered in the vicinity of a Torus support between Bays "A" and "P" by inspectors involved in an unrelated Reactor Core Isolation Cooling (RCIC) [BN] Torus [NH] Suction piping inspection. The leak was subsequently characterized as slight weepage of approximately 1-2 drops per minute with streaking and a small puddle located below the leak.

Non-destructive examination of the leakage area determined that the leakage was from a small through-wall crack in the Torus shell. It is estimated that the Torus crack propagated through-wall during the most recent operation of the High Pressure Coolant Injection System (HPCI) [BJ] System (surveillance test) on May 16, 2005, as no Torus shell leakage was observed during a semi-annual contamination survey performed on April 19, 2005.

The initial operability determination performed in accordance with Generic Letter 91-18 determined that there was reasonable expectation of operability based on the crack size being below the critical crack length and the calculated potential leakage, due to crack growth during postulated events, would not exceed containment design basis limits. Subsequent to the initial operability determination, it was determined that the HPCI exhaust line was located near the crack location and further evaluation was required.

On June 30, 2005, further engineering analysis determined that operability of the primary containment was not assured and at 1929, the Shift Manager declared Primary Containment [NH] Inoperable and the Actions of TS 3.6.1.1 Condition A were entered. Since Primary Containment could not be restored to an operable status within the required 1 hour, TS 3.6.1.1, Condition B was entered and a plant shutdown was commenced. The declaration of containment inoperability resulted in entering the site emergency plan under Emergency Action Level (EAL) 9.1.4 and declaring an Unusual Event (UE). At the time of the event, the "A" Emergency Diesel Generator (EDG) [EK] was out of service for planned maintenance.

As the Primary Containment (Torus) was determined to be inoperable and the plant was subsequently shutdown, this report is submitted in accordance with 10 CFR 50.73(a)(2)(i)(A), "The completion of any nuclear plant shutdown required by the plant's Technical Specifications" and 10 CFR 50.73(a)(2)(ii)(A), "The condition of the nuclear power plant, including its principal safety barriers, being seriously degraded."

There were no immediate nuclear, radiological or personnel safety issues associated with this event. The plant was shutdown in accordance with normal shutdown procedures. The cracked area of the Torus shell was removed and the Torus shell was repaired in accordance with the applicable ASME Codes.

**Cause of Event:**

JAF's original HPCI exhaust line design, although consistent with the original GE design specifications, does not include a HPCI turbine exhaust line sparger. A properly designed and installed condensing sparger is expected to reduce the Torus shell stresses resulting from HPCI turbine exhaust pressure pulses (condensation oscillation).

As a result of this design deficiency, the Torus shell experienced localized stress, high cycle fatigue due to rapid condensation of the HPCI exhaust steam (condensation oscillation) at the ring girder weld heat affected zone, resulting in a Torus shell through-wall crack. [Cause Code B]

**Cause of Event:** (continued)

JAF did not install a HPCI sparger due to inadequate information transfer from General Electric (GE) and other nuclear facilities regarding concerns with pressure instability and vibration inside the Torus. Correspondence exists showing that GE was aware of concerns with this pressure instability and Torus vibration as early as 1972. This correspondence discussed the addition of HPCI turbine exhaust line spargers. Since 1972, ten of thirteen stations having Mark I containments and HPCI systems have installed condensing spargers on the HPCI turbine exhaust pipe. A review of related plant documentation (correspondence, reports and calculations) did not identify any information that would have prompted action to add a condensing sparger prior to or following initial plant operation. This inadequate information transfer was due to a lack of formality in sharing operating experience prior to the advent of GE Service Information Letters (SILs). [Cause Code X]

**Event Analysis:**

There were no immediate nuclear, radiological or personnel safety issues associated with this event. The plant was shutdown in accordance with normal shutdown procedures and the cracked area of the Torus shell was removed and the Torus shell was repaired in accordance with the applicable ASME codes.

The suppression chamber (Torus) is a steel pressure vessel (Primary Containment Pressure Boundary) in the shape of a Torus encircling the drywell, with a major diameter of approximately 108 feet and a cross-sectional diameter of 29 feet 6 inches. The Torus shell is stiffened by 16 internal ring girders located at the miter joints. The Torus is supported by 16 pairs of reinforced columns at the ring girder locations.

It is estimated that the Torus crack propagated through-wall during the most recent operation of the HPCI system (surveillance test) on May 16, 2005, as no Torus shell leakage was observed during a semi-annual contamination survey performed on April 19, 2005.

The following specific scenarios were considered to determine the safety significance of the identified condition:

Large Break LOCA (LBA)

Due to the rapid depressurization from the Design Basis Event, the HPCI system essentially does not operate, which means that the Torus shell local stresses at the crack location would not be increased by the HPCI exhaust induced condensation oscillation. There would be increased blowdown loads through the drywell to torus downcomers due to the higher pressures assumed in the LBA. The resultant Torus shell loads have been previously evaluated under the Mark I containment program. The Torus shell crack is calculated to grow but still remain stable and below the critical crack length. The critical crack length is the point at which point stable crack growth accelerates and becomes unstable. In addition, the resultant crack growth is less than that of the IBA. Consequently, the leakage rate from the resultant crack would be bounded by the leakage rate in the IBA.

Intermediate Break LOCA (IBA)

The Intermediate Break LOCA assumes 4 hours of HPCI operation and 20 psig containment pressure. In this scenario, HPCI is the primary source of makeup water to the reactor vessel. The Torus shell crack is calculated to grow but still remain stable and below the critical crack length. The resultant Torus shell crack corresponds to a leakage rate of approximately 7 gallons per minute (gpm) and is bounded by the Plant Transient case.

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**Event Analysis:** (cont.)

Small Break LOCA (SBA)

The small break LOCA assumes 8 hours of HPCI operation but containment pressure is less than that assumed for the IBA. As such, the loads through the downcomers are smaller which results in lower overall stresses on the Torus shell crack area. Consequently, the Torus shell crack and the resultant leakage is bounded by the Plant Transient case.

Station Blackout (SBO)

A station blackout (SBO) accident is one in which all normal (offsite) and emergency (onsite) AC power is lost. Such an accident renders balance of plant systems, containment heat removal systems, and most emergency core cooling systems and other make-up systems inoperable. In an SBO, emergency core cooling systems are therefore limited to steam-driven, dc-powered, or manually operated systems. These systems include RCIC, HPCI, the safety relief valves (SRVs)/automatic depressurization system (ADS), and the diesel-engine-driven fire pumps. The SBO analysis assumes 4 hour coping time duration. The crack growth associated with the SBO event is bounded by the Plant Transient case.

Anticipated Transient Without Scram (ATWS)

An ATWS event occurs when an anticipated transient is followed by a failure of the reactor protection system to scram the reactor. As a result, plant operators must achieve reactor subcriticality by controlling reactor power, pressure, and level. Containment overpressurization must also be prevented in ATWS events involving MSIV isolation.

The most challenging scenario would be an ATWS event with MSIV closure. This will cause rapid pressurization inside the reactor vessel as the core continues to generate steam at near-rated conditions. This pressure increase causes the SRVs to lift and a recirculation pump trip when reactor pressure reaches 1153 psig. The recirculation pumps will also trip when the decreasing water level reaches 105.4 inches above the top of active fuel (TAF). These two actions reduce reactor pressure by decreasing reactor power to 40 percent (as a result of reduced core inlet flow caused by the recirculation pump trip) and by venting steam to the Torus through the SRVs.

The MSIV closure interrupts steam supply to the feedpump turbines. This leads to continued core steaming and loss of core liquid level. When the reactor water level falls below 126.5 inches above TAF, HPCI and RCIC are initiated. The estimated duration of this ATWS sequence would be 4 hours. The reduced operating time and higher Torus water temperatures would result in a smaller crack size and leakage rate than for the IBA.

Plant Transients

Using the duration from the August 2003 loss of grid event, HPCI was in operation for a total of approximately 14.5 hours. This equates to approximately 434,000 condensation oscillation cycles. With extended HPCI operation beyond the first several hours, reactor pressure decreases and pool temperature rises. As reactor pressure decreases, the HPCI turbine mass flow rates and exhaust pressures decrease and Torus water temperatures increase. With HPCI loading at these lower pressures, the crack growth is below the critical crack length and resultant leakage rate is approximately 25 gpm.

**Event Analysis:** (cont.)

Flooding Considerations

The potential for piping system failures to impact other equipment due to flooding was considered in Appendix H of JAF's Individual Plant Examination (IPE). The level of concern is when the level reaches the RHR and Core Spray pump motors for each Crescent area (5 feet). The corresponding volume for the West Crescent area is 56,100 gallons and for the East Crescent area is 100,980 gallons.

For the Plant Transient case, flooding would be annunciated using level switches in the crescent areas. The floor drain sump pumps are rated at 100 gpm, but the ability to process water in the Radwaste system is limited by the floor drain filtration skid. The existing filtration skid has a maximum capacity of 40 gpm. In order to overcome the current system water processing capabilities, the leak would have to exceed 40 gpm. As the worst case leakage rate (Plant Transient) was calculated to be approximately 25 gpm, there is no flooding concern.

Conclusion

Based on the lab analysis of the Torus shell crack area and fracture mechanics evaluation, the Torus shell crack is calculated to grow in a stable fashion and remain below the critical crack length limit for all postulated cases. The resultant leakage for the bounding case was determined to be approximately 25 gpm. This relatively low leakage rate corresponds to onsite and offsite radiological conditions that are well within limits. In addition, there is ample makeup water supply to the Torus in excess of 25 gpm. Consequently, the safety significance of this event was minimal.

The Conditional Core Damage Probability (CCDP) for this event was 1.20E-07. As the CCDP is less than 1E-06, this event is not risk significant.

**Extent of Condition:**

As part of the extent of condition review of the through-wall crack in the Torus shell, a visual inspection of the remaining structural supports in the Torus was performed. No other leakage was identified during this examination. In addition, Non-Destructive Examination (NDE), using Magnetic Particle Testing (MT) and Ultrasonic Testing (UT) techniques, was performed in the areas where the HPCI and RCIC turbine exhaust lines discharge into the Torus. No additional indications of cracking were identified. A thorough evaluation of all Torus penetrations and associated piping was performed. The results of the review indicated that no additional Torus shell flaws could have occurred.

After the ASME code repair was performed on the Torus shell, the entire primary containment (drywell, torus and connecting vents) was pressurized to the containment peak calculated pressure of 45 psig. During this pressure test, all the accessible portions of the containment were subjected to a general visual examination. No defects in the repair weld area were detected nor was any leakage in the primary containment identified.

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**Corrective Actions:**

*Corrective Actions Completed Prior to this Report:*

1. Completed an ASME code repair of the Torus crack.
2. Completed a Root Cause Analysis (RCA) for this event.
3. Generated a Repetitive Task item to perform accelerated NDE on the high stress areas of the Torus shell in the vicinity of the HPCI turbine exhaust line and the RCIC turbine exhaust line, subsequent to turbine operation.

*Corrective Actions not yet Completed:*

1. Modify the HPCI turbine exhaust line and ring girder gusset attachment as required to reduce the stresses on the Torus shell due to condensation oscillation.

   ***(Due 11/1/2006)***

**Safety System Functional Failure Review:**

A review of this event determined that a safety system functional failure as defined by NEI 99-02, Revision 3, did not occur.

**Similar Events:**

There were no previous similar Torus crack events at JAF or within the industry.

**Failed Component Identification:**

| | |
|---|---|
| Manufacturer: | Chicago Bridge & Iron |
| Model Number: | NA |
| NPRDS Manufacturer Code: | C310 |
| NPRDS Component Code: | Torus |
| FitzPatrick Component ID: | 016 TORUS |

**References:**

1. Root Cause Analysis Report, JAF Condition Report CR-JAF-2005-02593, Torus leak discovered near the support between bays "A" and "P", dated August 16, 2005.