



Tennessee Valley Authority, Post Office Box 2000, Decatur, Alabama 35609-2000

March 17, 2016

10 CFR 50.73

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

Browns Ferry Nuclear Plant, Unit 2
Renewed Facility Operating License No. DPR-52
NRC Docket No. 50-260

Subject: **Licensee Event Report 50-260/2015-002-01**

Reference: Letter from TVA to NRC, "Licensee Event Report 50-260/2015-002-00,"
dated November 16, 2015

On November 16, 2015, the Tennessee Valley Authority (TVA) submitted Revision 0 to Licensee Event Report (LER) 50-260/2015-002-00 (Reference). After further review of the condition, the causal analysis and past operability evaluation have been revised. These changes are detailed in the enclosed LER revision. In addition, the LER was revised for clarity and consistency.

The enclosed Licensee Event Report provides details of High Pressure Coolant Injection System Inoperable due to Manual Isolation of Steam Leak. The Tennessee Valley Authority is submitting this report in supplemental accordance with Title 10 of the Code of Federal Regulations 50.73(a)(2)(v)(D), as an event or condition that could have prevented the fulfillment of the safety function of structures or systems that are needed to mitigate the consequences of an accident.

There are no new regulatory commitments contained in this letter. Should you have any questions concerning this submittal, please contact J. L. Paul, Nuclear Site Licensing Manager, at (256) 729-2636.

Respectfully,

A handwritten signature in black ink, appearing to read "S. M. Bono", is written over the typed name and title.

S. M. Bono
Site Vice President

Enclosure: Licensee Event Report 50-260/2015-002-01 – High Pressure Coolant
Injection System Inoperable due to Manual Isolation of Steam Leak

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cc (w/ Enclosure):

NRC Regional Administrator - Region II
NRC Senior Resident Inspector - Browns Ferry Nuclear Plant

ENCLOSURE

**Browns Ferry Nuclear Plant
Unit 2**

Licensee Event Report

High Pressure Coolant Injection System Inoperable due to Manual Isolation of Steam Leak

See Enclosed

NRC FORM 366 (11-2015)		U.S. NUCLEAR REGULATORY COMMISSION			APPROVED BY OMB NO. 3150-0104		EXPIRES 10/31/2018																																											
LICENSEE EVENT REPORT (LER)										Estimated burden per response to comply with this mandatory collection request: 80 hours. Reported lessons learned are incorporated into the licensing process and fed back to industry. Send comments regarding burden estimate to the FOIA, Privacy and Information Collections Branch (T-5 F53), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by internet e-mail to Infocollects.Resource@nrc.gov, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOF-10202, (3150-0104), Office of Management and Budget, Washington, DC 20503. If a means used to impose an 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.																																								
1. FACILITY NAME Browns Ferry Nuclear Plant (BFN), Unit 2					2. DOCKET NUMBER 05000260					3. PAGE 1 of 7																																								
4. TITLE: High Pressure Coolant Injection System Inoperable due to Manual Isolation of Steam Leak																																																		
5. EVENT DATE			6. LER NUMBER			7. REPORT DATE			8. OTHER FACILITIES INVOLVED																																									
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Licensee Contact Joe D. Wilson, Jr., Licensing Engineer										TELEPHONE NUMBER (Include Area Code) (256) 614-7154																																								
13. COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT																																																		
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ABSTRACT (Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines)																																																		
<p>On September 16, 2015, at approximately 0156 Central Daylight Time (CDT), a large steam leak occurred in Unit 2 High Pressure Coolant Injection (HPCI) Room. Operators manually closed 2-FCV-73-3 (HPCI Outboard Isolation Valve) to isolate steam and declared the single train HPCI system inoperable. During the time period that the HPCI system was inoperable, other systems were available to provide the required safety functions. Following repairs, HPCI was declared operable at approximately 1045 CDT on September 19, 2015. Subsequent evaluation determined that HPCI would have met its 8-hour mission time with the identified condition.</p> <p>The cause of the steam leak was degradation of the valve packing on 2-FCV-73-16 (HPCI Turbine Steam Supply Valve) due to installation of improper packing material in April 2013. The steam leak initiators were mechanical extrusion of packing material and high temperature acid corrosion of the valve stem. Following steam leak initiation, catastrophic packing failure occurred due to steam induced high temperature degradation of the PTFE (Teflon) graphite braided packing. The two root causes were conflicting guidance in the Valve Packing Program procedure and the lack of necessary procedural guidance for the station to appropriately address invisible, superheated steam packing leaks. Corrective actions include revising the applicable procedures.</p>																																																		

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NARRATIVE

I. Plant Operating Conditions Before the Event

At the time of discovery, Browns Ferry Nuclear Plant (BFN) 2 was operating in Mode 1 at approximately 100 percent rated thermal power.

II. Description of Events**A. Event:**

On September 16, 2015, at approximately 0156 Central Daylight Time (CDT), Operations personnel in the Main Control Room (MCR) received fire alarms for the Unit 2 High Pressure Coolant Injection (HPCI) [BJ] Room following a report of significant steam in that room. At approximately 0200, MCR operators closed 2-FCV-73-3 (HPCI Steam Line Outboard Isolation Valve) [FCV] to isolate steam leak and declared HPCI inoperable per Technical Specification (TS) Limiting Condition for Operation (LCO) 3.5.1 Emergency Core Cooling Systems (ECCS) - Operating, Condition C. The large steam leak occurred immediately after 2-FCV-73-16 (HPCI Turbine Steam Supply Valve) [FCV] was stroked open and closed following performance of quarterly HPCI surveillance.

At approximately 0910 CDT on September 16, 2015, 8 hour event notification 51398 was made to the NRC in accordance with 10 CFR 50.72(b)(3)(v)(D), due to the failure of a single train system affecting accident mitigation.

The steam leak was caused by failure of the valve packing on 2-FCV-73-16. Following repairs, HPCI was declared operable at approximately 1045 CDT on September 19, 2015.

B. Status of structures, components, or systems that were inoperable at the start of the event and that contributed to the event:

There were no structures, components, or systems that were inoperable at the start of the event and that contributed to the event.

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C. Dates and approximate times of occurrences:

February 13, 2013	Work Order created to implement design change to replace the Flowserve - Anchor / Darling Double Disc Gate Valve with a Crane - GE / Kalsi Sentinel Gate Valve for 2-FCV-73-16
March 20, 2013	Valve Packing Data Sheet developed to replace the ARGO Style 6000 Composite End Packing Rings with AP Style 5000 Braided Packing Rings.
April 2013	Field work - Implemented design change to replace the Flowserve - Anchor / Darling Double Disc Gate Valve with a Crane - GE / Kalsi Sentinel Gate Valve for 2-FCV-73-16.
June 17, 2015, 0652 CDT	Operators identified a small packing leak on 2-FCV-73-16 valve.
June 18, 2015, 2108 CDT	Valve was stroked during quarterly surveillances.
September 16, 2015, 0153 CDT	Declared Unit 2 HPCI operable upon completion of quarterly surveillance.
September 16, 2015, 0156 CDT	Fire alarms for the Unit 2 HPCI Room and phone calls alerted the Main Control Room to the steam leak from 2-FCV-73-16 valve packing which occurred when the valve was stroked open and closed for performance of quarterly surveillance.
September 16, 2015, 0200 CDT	Closed 2-FCV-73-3 valve and declared Unit 2 HPCI inoperable.
September 16, 2015, 0910 CDT	NRC was notified via Event Notification 51398.
September 19, 2015, 1045 CDT	HPCI was declared operable.

D. Manufacturer and model number (or other identification) of each component that failed during the event:

No component failures were identified that occurred during the event. Valve packing for Crane 10 X 8 X 10 inch Flex Wedge disc gate valve (2-FCV-73-16) failed due to incompatible packing material used for the design and application AP Style 5000 Graphite/PTFE (Teflon) Braided Packing Rings.

E. Other systems or secondary functions affected:

There were no other systems or secondary systems affected.

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F. Method of discovery of each component or system failure or procedural error:

The method of discovery was self-revealing by sudden development of large steam leak.

G. The failure mode, mechanism, and effect of each failed component, if known:

The AP Style 5000 Graphite/PTFE (Teflon) Braided Packing Rings failed, due to steam leak induced degradation following an incompatible application per the design.

H. Operator actions:

MCR operators isolated the steam leak by closing an upstream valve and declared HPCI inoperable.

I. Automatically and manually initiated safety system responses:

There were no automatic or manual safety system responses associated with this event.

III. Cause of the event**A. The cause of each component or system failure or personnel error, if known:**

Mechanical extrusion (skirting) of the AP Style 5000 Graphite/PTFE (Teflon) Braided Packing Rings was initiated by larger than anticipated stem to bore clearance and high temperature acidic corrosion of the 17-4 PH Stainless Steel valve stem. This resulted in an active steam leak which degraded the PTFE/graphite structure of the rings and led to a complete packing failure.

B. The cause(s) and circumstances for each human performance related root cause:

There were two human performance related root causes: (1) error in selecting the type of valve packing, and (2) management of the level of urgency to repair the initial steam leak from the packing.

The replacement valve for 2-FCV-73-16 was installed in April 2013 and a Valve Packing Data Sheet was developed for the non-equivalent packing material. Due to conflicting guidance in the Valve Packing Program procedure, the packing material deviated from the valve vendor specifications regarding packing equivalence within design.

Due to the effect of rapid steam expansion at constant enthalpy, the steam leak, which was identified in June 2015, was superheated and invisible. The Leak Reduction Program procedure assigns a severity level to a steam leak based on the visible size of the plume. Therefore, an invisible superheated steam leak would be assigned the lowest severity level. Based on the procedure for Work Management Prioritization - On Line, the work order was assigned a low priority due to being classified as a minor packing leak and the repair was scheduled for the normal system maintenance period in December 2015. A higher classification of steam leak severity would have procedurally driven the packing leak repair to occur within three weeks, which was well before the larger leak occurrence in September 2015.

IV. Analysis of the event:

The Tennessee Valley Authority (TVA) is submitting this report in accordance with Title 10 of the Code of Federal Regulations (10 CFR) 50.73(a)(2)(v)(D), as an event or condition that could

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have prevented the fulfillment of the safety function of structures or systems that are needed to mitigate the consequences of an accident.

On June 17, 2015, operators identified a small packing leak on 2-FCV-73-16. Routine inspections by the system engineer and others indicated that the packing leak rate remained steady between June 2015 and the development of the large steam leak on September 16, 2015. The inadequacy of procedures for Leak Reduction Program and Work Management Prioritization challenged the station's ability to resolve the initial valve packing leak in a timely manner. On September 16, 2015, the packing failed causing significant steam leak in the Unit 2 HPCI room. Operators manually closed 2-FCV-73-3 (HPCI Steam Line Outboard Isolation Valve) to isolate the steam leak and declared the HPCI system inoperable.

The cause of the steam leak was determined to be degradation of the valve packing on 2-FCV-73-16 due to installation of improper packing material in April 2013. Mechanical extrusion (skirting) of the AP Style 5000 Graphite/PTFE (Teflon) Braided Packing Rings initiated by larger than anticipated stem to bore clearance, and high temperature acidic corrosion of the 17-4 PH Stainless Steel valve stem resulted in an active steam leak which degraded the PTFE/graphite structure of the rings and led to a complete packing failure. For the new model replacement valve for 2-FCV-73-16, which was installed in April 2013, the Valve Packing Data Sheet was developed to show a non-equivalent packing material which deviated from the valve vendor specifications, due to conflicting guidance in the Valve Packing Program procedure. The Valve Packing Data Sheet was developed to replace the AP Style 6000 Composite End Packing Rings with AP Style 5000 Braided Packing Rings. The investigation into the disintegration of the AP Style 5000 rings determined that high temperature and high velocity impingement of the steam caused the Teflon in the packing to rapidly break down, leaving only the feathery graphite material. The graphite portions of the braids were then destroyed by the high energy steam and were blown out of the stuffing box. Fluoride leaching from the Teflon formed hydrofluoric acid in the presence of water or steam at temperatures between 450 and 610 degrees F, which corroded the 17-4 PH stem material. The corrosion presence on the valve stem further damaged the packing material as the valve was stroked. When the valve stem was inspected in January 2016, a 360 degree circumferential corrosion ring was found on the valve stem at the bottom of the stuffing box in the location of the first ring of AP Style 5000 braid.

Based on the Past Operability Evaluation, the HPCI system would not have automatically isolated on HPCI room high temperature or experienced component failure due to the valve packing failure during the required eight hour mission time. HPCI would have been available and functional before, during, and after the initiating event until the point that the steam supply was electively isolated.

V. Assessment of Safety Consequences

The HPCI system was available and functional for the system's mission time. At the time of the event, Operations initiated elective actions to isolate steam from the HPCI system for protection of personnel and equipment in the absence of a transient. The HPCI system was rendered inoperable but still available to perform its safety functions for mitigation of the consequences of an accident until completion of the valve packing corrective maintenance within the TS LCO 3.5.1 Condition C required 14-day completion time. In the event of an emergency, the RCIC (Reactor Core Isolation Cooling) system remained operable, and all other ECCS and ADS

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(Automatic Depressurization System) systems were available during this event to facilitate core cooling.

A conservative engineering analysis showed that an automatic isolation to HPCI steam would not have occurred. The analytical report demonstrates that the HPCI system would not have auto-isolated as a result of high room temperature over the mission time of eight hours, nor would the steam leak have caused environmental-based component failure during this time period. While accounting for instrument inaccuracy, the analysis assumed the worst case steam flow between the bonnet and the stem, with no flow restriction provided by packing. The conservative assumption bounds the actual conditions of the packing failure, because two of five packing rings remained in the stuffing box during the event. The report additionally details that the steam leak would not have caused component failure due to collateral heat damage during this time period. HPCI was rendered inoperable by the elective actions of control room personnel and not by the steam leak. HPCI could have injected water into the Reactor Vessel Valve with the steam leak present for the duration of its eight hour mission time if personnel had not manually isolated the steam supply.

Based on the above, the safety significance of this event was minimal.

A. Availability of systems or components that could have performed the same function as the components and systems that failed during the event:

During this event, all other ECCS, including Automatic Depressurization System, were available to mitigate abnormal and accident conditions. Upon declaration of HPCI inoperability, Reactor Core Isolation Cooling System was verified as operable.

B. For events that occurred when the reactor was shut down, availability of systems or components needed to shutdown the reactor and maintain safe shutdown conditions, remove residual heat, control the release of radioactive material, or mitigate the consequences of an accident:

This event did not occur when the reactor was shut down.

C. For failure that rendered a train of a safety system inoperable, an estimate of the elapsed time from discovery of the failure until the train was returned to service:

Since steam leak isolation on September 16, 2015 at approximately 0200 CDT, the estimated elapsed time of inoperability is approximately 80.75 hours, until the system was declared operable at approximately 1045 CDT on September 19, 2015.

VI. Corrective Actions:

Corrective Actions are being managed by TVA's Corrective Action Program under Condition Report (CR) 1114188. The following three Corrective Actions to Prevent Recurrence (CAPRs) are planned:

1. Revise the Valve Packing Program procedure to provide guidance for the identification of acceptable packing materials allowed for critical or safety related valves and the process for documenting engineering equivalency evaluations for valve packing changes when required for non-equivalent packing material. Related to this CAPR is a corrective

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action to create a station specific specification to document acceptable packing applications, provide guidance for new packing changes, and provide clarification for when an equivalency evaluation is required when a packing change is requested.

2. Revise Leak Reduction Program procedure to provide guidance for station personnel to quantify, classify, and promptly resolve invisible superheated steam packing leaks similar to the 2-FCV-73-16 valve packing leak.
3. Revise the procedure for On Line Work Management Prioritization to provide the necessary guidance for station personnel and leadership to appropriately quantify, classify, and promptly resolve invisible, superheated steam packing leaks similar to the 2-FCV-73-16 leak.

VII. Additional Information:**A. Previous Similar Events at the same plant:**

CR 1040647 was initiated on June 17, 2015, to document the small steam leak from the packing of 2-FCV-73-16 described in this LER. Resolution of this CR potentially could have led to identification of the cause of the large steam leak prior to its occurrence.

A search of BFN LERs for Units 1, 2, and 3 within the last five years revealed the following event. LER 50-260/2012-002-00 - Unit 2 High Pressure Coolant Injection System Rendered Inoperable Due to an Inoperable Primary Containment Isolation Valve reported a steam leak on June 7, 2012, from a leak sealant injection port in the valve packing area. It was estimated that the allowable primary containment leak rate was exceeded. The resolution of the packing injection port leak would not have prevented the 2-FCV-73-16 valve packing leak.

B. Additional Information:

There is no additional information.

C. Safety System Functional Failure Consideration:

This event is considered a safety system functional failure, because it could have prevented fulfillment of the HPCI System safety functions to mitigate the consequences of an accident.

D. Scram with Complications Consideration:

This event did not result in a reactor scram.

VIII. COMMITMENTS

There are no new commitments.