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

May 20, 2013

10 CFR 50.73

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

Browns Ferry Nuclear Plant, Unit 1
Facility Operating License No. DPR-33
NRC Docket No. 50-259

Subject: **Licensee Event Report 50-259/2013-002-00**

The enclosed Licensee Event Report provides details of a manual reactor shutdown due to decreasing condenser vacuum. The Tennessee Valley Authority is submitting this report in accordance with Title 10 of the Code of Federal Regulations (10 CFR) 50.73(a)(2)(iv)(A).

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

Respectfully,

K. J. Polson
Vice President

Enclosure: Licensee Event Report 50-259/2013-002-00 – Manual Reactor Shutdown Due to Decreasing Condenser Vacuum

cc (w/ Enclosure):

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

IE22
NRR

ENCLOSURE

Browns Ferry Nuclear Plant
Unit 1

Licensee Event Report 50-259/2013-002-00

Manual Reactor Shutdown Due to Decreasing Condenser Vacuum

See Enclosed

NRC FORM 366 (10-2010) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB NO. 3150-0104 EXPIRES 10/31/2013

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 FOIA/Privacy Section (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, NEOB-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.

LICENSEE EVENT REPORT (LER)

1. FACILITY NAME	2. DOCKET NUMBER	3. PAGE
Browns Ferry Nuclear Plant, Unit 1	05000259	1 of 7

4. TITLE: Manual Reactor Shutdown Due to Decreasing Condenser Vacuum

5. EVENT DATE			6. LER NUMBER			7. REPORT DATE			8. OTHER FACILITIES INVOLVED	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REV NO.	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
									N/A	05000
03	19	2013	2013	- 002 -	00	05	20	2013	FACILITY NAME: N/A	DOCKET NUMBER: 05000

9. OPERATING MODE

1

10. POWER LEVEL

080

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

☐ 20.2201(b)	☐ 20.2203(a)(3)(i)	☐ 50.73(a)(2)(i)(C)	☐ 50.73(a)(2)(vii)
☐ 20.2201(d)	☐ 20.2203(a)(3)(ii)	☐ 50.73(a)(2)(ii)(A)	☐ 50.73(a)(2)(viii)(A)
☐ 20.2203(a)(1)	☐ 20.2203(a)(4)	☐ 50.73(a)(2)(ii)(B)	☐ 50.73(a)(2)(viii)(B)
☐ 20.2203(a)(2)(i)	☐ 50.36(c)(1)(i)(A)	☐ 50.73(a)(2)(iii)	☐ 50.73(a)(2)(ix)(A)
☐ 20.2203(a)(2)(ii)	☐ 50.36(c)(1)(ii)(A)	☒ 50.73(a)(2)(iv)(A)	☐ 50.73(a)(2)(x)
☐ 20.2203(a)(2)(iii)	☐ 50.36(c)(2)	☐ 50.73(a)(2)(v)(A)	☐ 73.71(a)(4)
☐ 20.2203(a)(2)(iv)	☐ 50.46(a)(3)(ii)	☐ 50.73(a)(2)(v)(B)	☐ 73.71(a)(5)
☐ 20.2203(a)(2)(v)	☐ 50.73(a)(2)(i)(A)	☐ 50.73(a)(2)(v)(C)	☐ OTHER
☐ 20.2203(a)(2)(vi)	☐ 50.73(a)(2)(i)(B)	☐ 50.73(a)(2)(v)(D)	*Specify in Abstract below or in NRC Form 366A*

12. LICENSEE CONTACT FOR THIS LER

FACILITY NAME	TELEPHONE NUMBER *(Include Area Code)*
Christopher Bennett, Licensing Engineer	256-729-2475

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	SJ	PSF	X000	Y					

14. SUPPLEMENTAL REPORT EXPECTED

☐ YES *(If yes, complete 15. EXPECTED SUBMISSION DATE)* ☒ NO

15. EXPECTED SUBMISSION DATE

MONTH	DAY	YEAR
N/A	N/A	N/A

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

On March 19, 2013, at approximately 0402 hours Central Daylight Time, the Browns Ferry Nuclear Plant (BFN), Unit 1, reactor was manually scrammed due to decreasing condenser vacuum caused by a significant leak from the 1C feedwater heater level control line. Condenser vacuum was deteriorating and was approaching the turbine trip setpoint, at which time the reactor was manually scrammed. The main steam isolation valves remained open, reactor pressure was controlled with the main turbine bypass valves, and the reactor feedwater pumps were used to control reactor water level. All systems responded as expected to the scram. All control rods inserted into the core during the scram.

The root causes for this event were a combination of vibration from the dump valve opening with the vibration in the 4 inch drain line from leaking drain valves, and station personnel did not consistently consider risk when making decisions to replace the BFN, Unit 1, feedwater heater vent and drain valves.

The corrective actions to prevent recurrence are to design and implement a design change for the feedwater heater vent and drain header piping to provide increased support, and establish initial and continuing training requirements for leaders and craft that support their roles and responsibilities. Also, BFN has implemented a Strategic Performance Management process to reinforce and institutionalize conservative decision making principles.

NARRATIVE

I. Plant Operating Condition Before the Event

At the time of the event, Browns Ferry Nuclear Plant (BFN), Unit 1, was in Mode 1 at approximately 80 percent power.

II. Description of Events

A. Event:

On March 19, 2013, at approximately 0402 hours Central Daylight Time (CDT), the BFN, Unit 1, reactor was manually scrammed due to decreasing condenser [SH] vacuum. The cause of the decreasing vacuum was a significant leak on the 1C feedwater [SJ] heater level control line. A steam and water leak occurred near this line's penetration [PEN] to the main condenser. As extraction steam was isolated, condenser vacuum deteriorated and approached the turbine [TA] trip setpoint, at which time the reactor [RCT] was manually scrammed. All control rods fully inserted. Condenser vacuum recovered following the scram. The main steam isolation valves (MSIVs) [ISV] [SB] remained open, reactor pressure was controlled with the main turbine bypass valves, and the reactor feedwater pumps were used to control reactor water level. In response to the scram, all plant equipment responded as designed.

Also, as expected, Primary Containment Isolation System (PCIS) [JM] Groups 2, 3, 6, and 8 isolations were received due to low reactor water level. The PCIS consists of isolation valves that will automatically close as necessary to protect against the release of fission products, as well as to conserve reactor coolant. Upon receipt of these signals, all required components actuated as required.

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

A leak from the reactor feedwater heater vent and drain header connection to the C condenser caused a decrease in vacuum which led to the initiation of a manual scram.

C. Dates and approximate times of occurrences:

May 1, 2010	Work orders to replace the BFN, Unit 1, feedwater heater vent and drain valves were inappropriately cancelled.
March 19, 2013, at 0402 hours CDT	Reactor was manually scrammed due to decreasing condenser vacuum from a leak on the 1C feedwater heater level control line.
March 19, 2013, at 0737 hours CDT	The BFN reported the event to the NRC.
March 19, 2013, at 1530 hours CDT	The BFN, Unit 1, entered Mode 4.

FACILITY NAME (1)	DOCKET (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
Browns Ferry Nuclear Plant, Unit 1	05000259	2013	-- 002	-- 00	3 of 7

NARRATIVE

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

A section of leaking feedwater piping, BFN-1-MISC-003, caused a loss of condenser vacuum.

E. Other systems or secondary functions affected:

There were no other systems or secondary functions affected.

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

The steam and water leak on the section of feedwater piping was discovered by an assistant unit operator.

Due to the heater level control line piping leak, operations personnel observed decreasing condenser vacuum and decided to manually scram the reactor.

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

Failure of the feedwater heater 1C2 tubes caused increasing vibration at the feedwater heater vent and drain connection to the condenser. This failure was facilitated by vibration in the 4 inch drain line, from leaking drain valves which, with the additional vibration caused by the dump valve opening and flowing water through the 10 inch header directly adjacent to this 4 inch drain line, caused a high cyclic fatigue failure where the 4 inch drain line connects with 24 inch drain header. The resulting decrease in condenser vacuum led to the decision to manually scram the reactor before turbine trip setpoints were reached.

H. Operator actions:

Operations personnel initiated a manual reactor scram due to decreasing condenser vacuum. After initiating the manual reactor scram, Operations personnel entered Emergency Operating Instructions on Low Reactor Water Level. Also, Operations personnel responded to the scram in accordance with the Abnormal Operating Instructions.

I. Automatically and manually initiated safety system responses:

The BFN, Unit 1, reactor was manually scrammed due to the decreasing condenser vacuum. The MSIVs remained open, reactor pressure was controlled with the main turbine bypass valves, and the reactor feedwater pumps were used to control reactor water level. Also, as expected, Primary Containment Isolation System Groups 2, 3, 6, and 8 isolations were received due to low reactor water level. Upon receipt of the PCIS signals, all components actuated as required.

FACILITY NAME (1)	DOCKET (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
Browns Ferry Nuclear Plant, Unit 1	05000259	2013	-- 002	-- 00	4 of 7

NARRATIVE

III. Cause of the event

A. The cause of each component or system failure or personnel error, if known:

Direct Cause

The direct cause of the event was determined to be the failure of the 4 inch to 24 inch drain header connection due to high cyclic fatigue.

Root Cause

The root cause was determined to be the combination of vibration from the dump valve opening with the vibration in the 4 inch drain line from leaking drain valves. The dump valve opened due to the failure of the feedwater heater 1C2 tubes.

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

Root Cause

Station personnel did not consistently consider risk when making decisions. Work orders to replace the BFN, Unit 1, feedwater heater vent and drain valves were inappropriately cancelled in May of 2010. This exposed the BFN, Unit 1, to continued risk of failed piping downstream of these valves providing the potential for degraded, or loss of, condenser vacuum.

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)(iv)(A) as any event or condition that resulted in manual or automatic actuation of any of the systems listed in 10 CFR 50.73(a)(2)(iv)(B), including: Reactor Protection System (RPS) [JC] which includes a reactor scram or a reactor trip.

In February 2012, the BFN, Unit 1, feedwater heater vent and drain header connection to the 24 inch header to the condenser failed due to cyclic stress causing increasing air inleakage into the condenser. A temporary repair was completed to allow BFN, Unit 1, to continue operation until its next refueling outage the following fall. During the fall 2012 refueling outage, a permanent repair was completed on the connection; however, there was no maintenance performed on the isolation valves and relief valves that were leaking past their seats and allowing flow through the header.

The connection again failed due to cyclic stress on March 19, 2013. This failure occurred when 1C2 feedwater heater tube failures caused increased flow in the high level control header going to the same 24 inch header connected to the condenser. This increased flow caused a change or increase in the cyclic stress of the 4 inch connection, causing it to fail. High cycle fatigue will normally propagate a crack within hours, suggesting a change in the vibration characteristics. Vibration characteristics can change as a result of changing the forcing frequency, natural frequency, or force amplitude. A tube rupture, such as the multiple tube failures of the 1C2 high pressure feedwater heater, would cause more flow at a higher temperature and pressure through

a leaking shell side drain associated with the subject 4 inch line. Eddy current testing has identified at least 10 severed tubes and 7 damaged tubes in the 1C2 high pressure heater. The higher flow, temperature, and pressure would cause larger amounts of flashing in the 4 inch line resulting in changes in force amplitude and frequency. Additionally, a shift in the natural frequency may also have contributed to the supports loosening. These changes in force amplitude and frequency caused the stress at the heat affected zone to increase above the endurance limit and fail as a result of fatigue. This failure was significant enough to cause condenser vacuum to decrease to a point prompting Operations personnel to manually scram BFN, Unit 1.

V. Assessment of Safety Consequences

The RPS provides timely protection against the onset and consequences of conditions that threaten the integrity of the fuel barrier and the nuclear system process barrier, i.e. fuel cladding and Reactor Coolant System pressure boundary, respectively. The function of the RPS is to initiate a reactor scram when one or more monitored parameters exceed their specified limits to preserve the integrity of the fuel cladding and the Reactor Coolant System and minimize the energy that must be absorbed following a loss of coolant accident. This can be accomplished either automatically or manually.

In response to this condition, Operations personnel identified the decreasing condenser vacuum and initiated a manual reactor scram. The plant responded as designed and all safety systems remained in a standby readiness configuration. There were no Emergency Core Cooling System (ECCS) [BJ][BO][BM] or Reactor Core Isolation Cooling System [BN] reactor water level initiation set points reached and PCIS Groups 2, 3, 6, and 8 signals were received as expected. Upon receipt of these signals, all required components actuated as required.

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

The MSIVs remained open, reactor pressure was controlled with the main turbine bypass valves, and the reactor feedwater pumps were used to control reactor water level and remained available during the event. In response to the scram, all plant equipment responded as designed. All control rods inserted into the core during the scram. The failure of the feedwater heater control line could have resulted in a loss of feedwater. However, all ECCS systems remained operable to maintain adequate core cooling if there had been a loss feedwater.

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:

All safety systems remained available during this event and operated as required.

NARRATIVE

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:

There were no safety systems rendered inoperable as a result of this event.

Safe shutdown conditions were established and maintained. Therefore, TVA concluded that there was minimal safety significance for this event.

VI. Corrective Actions

Corrective Actions are being managed by TVA's corrective action program under Problem Evaluation Reports (PERs) 516455 and 698870.

Immediate Corrective Actions

Actions to correct the failure of the feedwater heater tubes have been completed. The piping connection from the 4 inch to 24 inch drain header was repaired. The feedwater heater C3 tube relief valve and the feedwater heater B1 and C1 tube side drain valves were replaced to reduce flow through the piping.

Interim Corrective Actions

Place temporary temperature monitoring equipment on the miscellaneous drain header and update the system monitoring plan to require bi-weekly monitoring and trending of selected points on the piping that will detect leaking drain valves, until such a time that the feedwater heater vent and drain header piping configuration and support plan can be designed and implemented.

Corrective Actions to Prevent Recurrence

1. Design and implement a design change for the feedwater heater vent and drain header piping to provide increased support that will reduce vibration in piping such that a failure will not occur at the connection of the 4 inch header to the 24 inch header to the condenser.
2. The BFN has implemented a Strategic Performance Management process to reinforce and institutionalize conservative decision making principles.
3. Establish initial and continuing training requirements, and develop and deliver training to provide expected behaviors for leaders and craft that support their roles and responsibilities in the areas of operational focus, nuclear safety culture, risk awareness, and conservative decision making.

VII. Additional Information:

A. Previous similar events at the same plant:

A search of BFN Licensee Event Reports (LERs) for Units 1, 2, and 3 for the last several years identified LER 50-296/2013-003-00, Automatic Reactor Shutdown Due to an Actuation of the Reactor Protection System from a Turbine Trip. This LER identified a similar condition concerning a reactor feedwater piping separation

NARRATIVE

causing low condenser vacuum and resulting in a turbine trip. The corrective actions reported in this LER are still being implemented, therefore they would not have prevented this event from occurring.

A search was performed on the BFN corrective action program. Similar PERs related to the condition which caused the event reported in this LER are PERs 206642, 268542, 511111, 514866, and 514959.

These PERs revealed issues with valve failures and inleakage with the same 4 inch drain line to 24 inch drain header weld pipe interface, where numerous organizations identified issues with the integrity of the welded pipe connection, but plant focus was on controlling inleakage and a "Broke/Fix" mentality that resulted in a lost opportunity to understand the failure mechanism and prevent a weld interface failure reoccurrence. These PERs were closed to either new or existing work orders and station response was a temporary repair with the development of an Operational Decision Making Issue to track and monitor rather than investigate and prevent.

On several past occasions, station personnel failed to recognize the risk associated with the leaking valves, 4 inch drain line design, and potential energy transfer to the 4 inch and 24 inch piping interface from a water to steam flash event.

This caused a missed opportunity to utilize available Operating Experience to prevent the BFN, Unit 1, scram event, and the excessive pipe movement which resulted ultimately in a repeat 360 degree circumferential failure of the 4 inch drain line at the tie in to the 24 inch drain header.

B. Additional Information:

There is no additional information.

C. Safety System Functional Failure Consideration:

In accordance with Nuclear Energy Institute (NEI) 99-02, this condition is not considered a safety system functional failure.

D. Scram with Complications Consideration:

In accordance with NEI 99-02, this event is not considered an unplanned scram with complications.

VIII. COMMITMENTS

There are no commitments.