TVA

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

November 16, 2012

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 50-259/2011-008-02, "High Vibrations on High Pressure Coolant Injection Booster Pump Thrust Bearings"**

References:
1. Letter from TVA to NRC, "License Event Report 50-259/2011-008, 'High Vibrations on High Pressure Coolant Injection Booster Pump Thrust Bearings'," dated September 19, 2011.
2. Letter from TVA to NRC, "Supplemental License Event Report 50-259/2011-008-01, 'High Vibrations on High Pressure Coolant Injection Booster Pump Thrust Bearings'," dated January 31, 2012.

In the Reference 1 and Reference 2 letters dated September 19, 2011, and January 31, 2012, respectively, the Tennessee Valley Authority (TVA) submitted a Licensee Event Report and a Supplemental Licensee Event Report containing details of an unexpected increase in vibrations on the Browns Ferry Nuclear Plant, Unit 1, High Pressure Coolant Injection Booster Pump thrust bearings. Additional analysis was performed and TVA has revised the causal analysis. The TVA is submitting this additional supplement to the Licensee Event Report in accordance with Title 10 of the Code of Federal Regulations (10 CFR) 50.73(a)(2)(i)(B), 10 CFR 50.73(a)(2)(v)(B), and 10 CFR 50.73(a)(2)(v)(D).

IE22
NRR

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 50-259/2011-008-02 – High Vibrations on High Pressure Coolant Injection Booster Pump Thrust Bearings

cc (w/ Enclosure):

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

ENCLOSURE

Browns Ferry Nuclear Plant,
Unit 1

Licensee Event Report 50-259/2011-008-02

High Vibrations on High Pressure Coolant Injection Booster Pump Thrust Bearings

---

See Enclosure

NRC FORM 366 (10-2010)	U.S. NUCLEAR REGULATORY COMMISSION	APPROVED BY OMB NO. 3150-0104	EXPIRES 10/31/2013

LICENSEE EVENT REPORT (LER)

1. FACILITY NAME	2. DOCKET NUMBER	3. PAGE
Browns Ferry Nuclear Plant Unit 1	05000259	1 of 13

4. TITLE: High Vibrations on High Pressure Coolant Injection Booster Pump Thrust Bearings

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: N/A	DOCKET NUMBER: 05000
07	23	2011	2011	- 008 -	02	11	16	2012	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)(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)
Paul A. Herrmann III, Licensing Program Manager	256-729-7479

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
E	BJ	P	B580	Y					

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

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

On July 20, 2011, Browns Ferry Nuclear Plant (BFN) personnel performed quarterly surveillance procedure 1-SR-3.5.1.7, "HPCI Main and Booster Pump Set Developed Head and Flow Rate Test at Rated Reactor Pressure." During this surveillance, BFN personnel recorded an unexpected increase in the vibration level on the High Pressure Coolant Injection (HPCI) booster pump thrust bearings. Upon performing a disassembly for inspection on July 23, 2011, the bearings were discovered to be in a tandem arrangement, which transmits thrust in only one direction (away from the gearbox). The correct bearing configuration is back-to-back. New bearings were installed in the proper configuration.

The Tennessee Valley Authority (TVA) has determined that this condition affected the HPCI system mission time and thus the operability of the HPCI system for an unknown period. Therefore, it was conservatively concluded that the BFN Unit 1 HPCI system was inoperable longer than allowed by Technical Specification 3.5.1 Actions. The TVA is reporting this event in accordance with 10 CFR 50.73(a)(2)(i)(B), as an operation or condition which was prohibited by the plant's Technical Specifications, and 10 CFR 50.73(a)(2)(v)(B) and (D), as an event or condition that could have prevented the fulfillment of the safety function of structures or systems that are needed to remove residual heat and to mitigate the consequences of an accident, respectively.

FACILITY NAME (1)	DOCKET (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
Browns Ferry Nuclear Plant Unit 1	05000259	2011	-- 008	-- 02	2 of 13

NARRATIVE

I. PLANT CONDITION(S)

Browns Ferry Nuclear Plant (BFN) Unit 1 was in Mode 1 at approximately 100 percent thermal power. BFN Units 2 and 3 were also in Mode 1 at 100 percent power.

II. DESCRIPTION OF EVENT

A. Event

During the July 20, 2011, performance of quarterly surveillance procedure 1-SR-3.5.1.7, "HPCI Main and Booster Pump Set Developed Head and Flow Rate Test at Rated Reactor Pressure," for the BFN Unit 1 High Pressure Coolant Injection (HPCI) system [BJ], vibration levels recorded on the outboard bearing of the BFN Unit 1 HPCI Booster Pump [P], BFN-1-PMP-073-0029, experienced a step increase as compared to previous recorded vibration levels. The vibration readings and results of an oil sample analysis determined that the outboard bearings had degraded. Inspection of the BFN Unit 1 HPCI booster pump bearings on July 23, 2011, determined the outboard bearings required replacement. The replacement of the HPCI booster pump bearings was completed on July 27, 2011. It has been determined that the outboard bearings were installed incorrectly during the previous rebuild in March 2005, which occurred as part of BFN Unit 1 Recovery/Restart effort.

The significant activities/events which preceded this event were as follows.

- The BFN Unit 1 HPCI system was operated for pressure and level control on April 27, 2011, through April 28, 2011, as a result of a reactor trip in combination with a loss of offsite power associated with a severe weather event. The BFN Unit 1 HPCI system operated for a total of 13 hours 47 minutes (approximately 14 hours), which included five starts, with the longest continuous operation being just over seven hours. Vibration data was not gathered during this event. The operating conditions for the HPCI system in this event were similar to past HPCI system service conditions.

- On May 16, 2011, maintenance alignment work was performed between the turbine and main pump, which is two couplings away from the booster pump. No maintenance activities were performed on the booster pump or the gearbox coupled to the booster pump.

- On May 20, 2011, while Operations personnel were preparing to vent the HPCI system discharge piping, the HPCI system testable check valve failed to fully seat and allowed the water side of the HPCI system to see full reactor pressure. This event is documented in Licensee Event Report (LER) 50-259/2011-006-00, "Loss of Safety Function (HPCI) Due to Primary Containment Isolation," dated

NARRATIVE

July 19, 2011. No HPCI system operation was associated with this event. The abnormal occurrence during this event is the overpressurization of the HPCI booster pump which had not previously been seen in the pump's prior service conditions.

- During the Post-Maintenance Testing (PMT) of the BFN Unit 1 HPCI system on May 27, 2011, for alignment work, vibration data was gathered with handheld instrumentation in accordance with surveillance procedure 1-SR-3.5.1.7. It should be noted that the HPCI system is not instrumented with vibration probes and the vibration data is collected only during the performance of the quarterly surveillance procedure. The vibration data collected during the May 27, 2011, surveillance exhibited a change in the HPCI booster pump vibration spectrum from the normal historical trends. The outboard bearing vibration is collected in three planes, horizontal (HH), vertical (HV) and axial (HA). All three vibration points increased, but the booster pump outboard bearing horizontal point HH had the highest vibration level in the alert range at 0.382 inches per second (ips). This compares to the approximately 0.20 ips historical vibration level from the BFN Unit 1 restart in 2007 until the quarterly surveillance performance on April 21, 2011, where the vibration level was 0.216 ips. The alert level for these vibration points is > 0.325 ips with action required above 0.700 ips. A second BFN Unit 1 HPCI system PMT run was performed on May 30, 2011, with comparable vibration readings in the alert range (i.e., 0.395 ips). On July 20, 2011, the vibration data was again collected during the performance of 1-SR-3.5.1.7. During this surveillance performance, the BFN Unit 1 HPCI booster pump outboard bearing HH vibration increased above the previous May 27, 2011, level, to a new value of 0.498 ips.

- On May 28, 2011, due to HPCI main pump vibration in the action required range, maintenance (including alignment and coupling inspections) of the HPCI system was performed. Couplings were inspected and the turbine was realigned to the main pump. No maintenance activities were performed on the HPCI booster pump.

BFN Unit 1 Technical Specifications (TS) Limiting Condition for Operation 3.5.1, "ECCS - Operating," requires the HPCI system to be operable in Modes 1, 2, and 3, except when reactor steam dome pressure is less than or equal to 150 pounds per square inch gauge (psig). With the HPCI system inoperable, TS 3.5.1 Required Action C.1 requires the Reactor Core Isolation Cooling (RCIC) system [BN] to be immediately verified to be operable and TS 3.5.1 Required Action C.2 requires the HPCI system to be restored to operable status within 14 days. If these TS 3.5.1 Actions are not met within these specified Completion Times, the unit is required to be in Mode 3 within 12 hours and reactor steam dome pressure reduced to less than or equal to 150 psig within 36 hours.

FACILITY NAME (1)	DOCKET (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
Browns Ferry Nuclear Plant Unit 1	05000259	2011	-- 008	-- 02	4 of 13

NARRATIVE

Based on causal analysis information, the initiating event of the high bearing vibration on the HPCI booster pump is considered to have occurred on May 20, 2011, when the HPCI system testable check valve failed to fully seat and allowed the water side of the HPCI system to see full reactor pressure. No previous HPCI booster pump bearing vibration issues had been detected when performing surveillances prior to this occurrence. This condition, an unexpected increase in HPCI booster pump thrust bearing vibration, is considered to affect the mission time of the HPCI system and thus the operability of the HPCI system.

As a result, the BFN Unit 1 HPCI system was inoperable longer than the 14-day period allowed by TS 3.5.1, Required Action C.2. The Tennessee Valley Authority (TVA) is reporting this event in accordance with 10 CFR 50.73(a)(2)(i)(B), as an operation or condition which was prohibited by the plant's Technical Specifications, and 10 CFR 50.73(a)(2)(v)(B) and (D), as an event or condition that could have prevented the fulfillment of the safety function of structures or systems that are needed to remove residual heat and to mitigate the consequences of an accident, respectively.

B. Inoperable Structures, Components, or Systems that Contributed to the Event:

The BFN Unit 1 HPCI booster pump is a Byron Jackson [B580] single stage, double suction pump that is designed to boost the pressure of the incoming water into the suction of the HPCI main pump. The HPCI booster pump has a single radial ball bearing on the inboard side of the pump and two angular contact bearings that function as the thrust bearings for the pump. The pump has a double suction hydraulically balanced impeller that is designed to produce no thrust loading at the best efficiency point during operation.

The BFN Unit 1 HPCI booster pump thrust bearings were discovered to be in a tandem arrangement, which transmits thrust in only one direction (away from the gearbox). The correct bearing configuration is back-to-back. Due to high HPCI booster pump thrust bearing vibration (attributed to the incorrect configuration of the HPCI booster pump thrust bearings and the overpressurization of the HPCI booster pump that occurred on May 20, 2011), the BFN Unit 1 HPCI System was considered to be incapable of meeting its required mission time and was therefore inoperable.

There are three of these type of pumps installed at BFN, one for each unit.

C. Dates and Approximate Times of Major Occurrences:

March 16, 2005	HPCI booster pump thrust bearings installed.

NARRATIVE

April 21, 2011	During performance of Surveillance, HPCI booster pump vibration in line with historical trends, 0.216 ips.
April 27 and 28, 2011	HPCI system operated for approximately 14 hours during the Severe Weather Event.
May 16, 2011	Alignment work performed between HPCI system turbine and main pump. HPCI booster pump unaffected by this activity.
May 20, 2011	During preparation for venting of the HPCI system, the HPCI system testable check valve failed to seat causing overpressurization on the water side of the HPCI system.
May 27, 2011	HPCI main pump vibration in action required range. HPCI booster pump vibration at this time was 0.382 ips.
May 28, 2011	Maintenance performed on HPCI system. However, no maintenance or alignment work performed on HPCI booster pump.
May 30, 2011	PMT Operability Check performed after HPCI system maintenance. HPCI booster pump vibration at this time was 0.395 ips.
July 20, 2011 at 0250 Central Daylight Time (CDT)	Quarterly surveillance procedure 1-SR-3.5.1.7 started.
July 20, 2011 at 1350 CDT	Procedure 1-SR-3.5.1.7 completed. Step increase in vibration observed on HPCI booster pump thrust bearings, 0.498 ips.
July 23, 2011 at 1054 CDT	Work started on replacing the HPCI Booster Pump thrust bearings.
July 23, 2011 at 2145 CDT	Inspection of HPCI booster pump bearings determines thrust bearings were installed incorrectly.
July 27, 2011 at 0638 CDT	Work completed on replacing the HPCI booster pump bearings. PMT performed after bearing replacement. HPCI booster pump vibration at this time was 0.178 ips.

NARRATIVE

October 19, 2011	Quarterly surveillance procedure performed. HPCI booster pump vibration at this time was 0.159 ips.

D. **Other Systems or Secondary Functions Affected**

There were no other systems or secondary functions affected by this event.

E. **Method of Discovery**

This event was discovered while performing surveillance procedure 1-SR-3.5.1.7.

F. **Operator Actions**

There were no operator actions.

G. **Safety System Responses**

There were no safety system responses.

III. CAUSE OF THE EVENT

A. **Immediate Cause**

The incorrect installation of the BFN Unit 1 HPCI booster pump outboard thrust bearings caused heavy wear to the inner races, light wear to the outer race, and cage damage from contact with the retainer ring and adjacent bearing inner race that led to the bearing degradation.

B. **Root Cause**

A lack of adequate governance and oversight of millright resources occurred during the BFN Unit 1 Recovery/Restart effort, which included the installation of the BFN Unit 1 HPCI booster pump outboard thrust bearings in March, 2005. This lack of governance and oversight led to the bearings being installed incorrectly and eventually to bearing degradation. During the BFN Unit 1 Recovery/Restart effort, the pump was completely overhauled with a new rotating element, seals, and bearings. There was minimal supervision, guidance, or oversight of the work practices used during that period. The BFN Unit 1 Recovery Team assigned their own resources to manage and provide oversight of contractor work practices.

FACILITY NAME (1)	DOCKET (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
Browns Ferry Nuclear Plant Unit 1	05000259	2011	-- 008	-- 02	7 of 13

NARRATIVE

C. Contributing Factors

1. Less than adequate procedure description did not specify the bearing configuration, thus leaving installation at the "skill of the craft" level. This constituted insufficient procedural guidance and work package direction.

2. The booster pump manual description and guidance on outboard thrust bearings installation orientation instructions was inadequate. The existing vendor manual documents do not provide specific guidance and/or picture instruction/orientation or directions on how to install the HPCI booster pump thrust bearings in the correct back-to-back configuration, thus leaving installation at the "skill of the craft" level.

IV. ANALYSIS OF THE EVENT

The BFN Unit 1 HPCI booster pump was rebuilt in March 2005 during the BFN Unit 1 Recovery/Restart effort, at which time a new rotating assembly with a five (5) vane impeller was installed. The bearings, mechanical seals, and other wear parts were all replaced during that time. Historically, the BFN Unit 1 HPCI booster pump vibration trend has been consistent with no indication of problems since the BFN Unit 1 restart, with peak vibration levels at 0.216 inches per second (ips). On April 27, 2011, all three units at BFN experienced reactor trips resulting from severe weather damage to the transmission system in the area. The BFN Unit 1 HPCI system was utilized for reactor pressure and level control during that time and ran for 13 hours 47 minutes during a two-day period. On May 16, 2011, alignment work was performed between the BFN Unit 1 HPCI turbine and main pump. This alignment work would not have affected the HPCI booster pump, due to the work being done two couplings away and on components separated from the booster pump by a speed reducer gearbox. On May 20, 2011, during preparation for venting of the BFN Unit 1 HPCI system discharge line, the HPCI system testable check valve failed to seat with the HPCI system in a standby condition causing an overpressurization of the water side of the HPCI system.

During the PMT of the BFN Unit 1 HPCI system on May 27, 2011, for alignment work, vibration data was gathered with handheld instrumentation in accordance with surveillance procedure 1-SR-3.5.1.7. The vibration data collected during the May 27, 2011, surveillance showed a change in the booster pump vibration spectrum from the normal historical trends. As previously described, the outboard bearing vibration is collected in three planes, horizontal (HH), vertical (HV) and axial (HA). All three-vibration points increased, but the HPCI booster pump outboard bearing horizontal point HH had the highest vibration level in the alert range at 0.382 ips. This compares to the 0.20 ips historical level from the BFN Unit 1 restart in 2007 until the quarterly surveillance on April 21, 2011, where the vibration level was 0.216 ips. The alert level for these vibration points is > 0.325 ips with action required above 0.700 ips. A second

FACILITY NAME (1)	DOCKET (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
Browns Ferry Nuclear Plant Unit 1	05000259	2011	-- 008	-- 02	8 of 13

NARRATIVE

Unit 1 HPCI PMT run was performed on May 30, 2011, with comparable vibration readings in the alert range (i.e., 0.395 ips).

On July 20, 2011, vibration data was again collected during the performance of procedure 1-SR-3.5.1.7. During this surveillance run, the BFN Unit 1 HPCI booster pump outboard bearing HH vibration increased above the previous May 27, 2011, level to a new value of 0.498 ips.

Analysis of the vibration data showed outboard bearing defects, specifically high ball pass frequency, and indication of a changing condition in the BFN Unit 1 HPCI booster pump thrust bearing. As a result, oil samples were collected from the inboard and outboard bearing housings and analysis showed high levels of wear metals in the outboard bearing oil. The oil contained 11 parts per million (ppm) Iron, 6 ppm Lead, 28 ppm Copper, and 47 ppm Zinc. These numbers would be less than 3 ppm in most normal oil samples. The booster pump thrust bearing consists of two angular contact ball bearings (SKF 7315 BECBM/BECBY) with brass cages. Based on this information, the copper, lead and zinc found in the oil samples were most likely coming from the HPCI booster pump bearing cages.

Given the increasing vibration trend and high wear metal content in the outboard bearing oil, the BFN Unit 1 HPCI system was taken out of service for maintenance on July 23, 2011, to replace the HPCI booster pump bearings. The outboard bearing is the thrust bearing and is designed to be configured in a back-to-back arrangement to take thrust in both axial directions. During the disassembly of the outboard bearing housing, a large amount of brass shavings and flakes was present in the bottom of the bearing housing. The oil ring retainer was contacting the outboard bearing cage and had rubbed a pronounced groove in the copper cage. Once the bearing housing was removed, it was discovered that the two angular contact ball bearings were configured in a tandem arrangement. The tandem arrangement is normally used in applications where thrust loads are to be seen in only one direction such as vertical motors. In their as-found configuration (tandem), the bearings would handle thrust in only one direction (away from gearbox). The correct configuration for this machine is a back-to-back configuration, which will accommodate thrust loading in both axial directions and provide axial stability for the rotating element. The incorrect installation was determined to be the cause of the bearing vibration issues. Disassembly of the bearings showed heavy wear to the inner races, light wear to the outer race, and cage damage from contact with the retainer ring and adjacent bearing inner race.

The booster pump vibration data was abnormal for the first time on May 27, 2011. Therefore, the initiating event occurred prior to that date. The surveillance data taken on April 21, 2011, demonstrated normal vibration levels, which places the initiating event between April 21, 2011 and May 27, 2011. The events that occurred between these two dates were approximately 14 hours of BFN Unit 1 HPCI system operation on April 27, 2011, through April 28, 2011, in response to the severe weather event, the

NARRATIVE

BFN Unit 1 HPCI system alignment work on May 16, 2011, and the BFN Unit 1 HPCI system overpressurization event on May 20, 2011.

1. During the approximately 14 hours of HPCI system operation in response to the severe weather event, the HPCI system operating conditions were similar to past service conditions. Therefore, this event is not considered to be the initiating event.

2. During the May 16, 2011, HPCI system alignment work, no maintenance activities were performed on the HPCI booster pump or the gearbox coupled to the HPCI booster pump. This maintenance activity would not have had an effect on the HPCI booster pump and is therefore not considered to be the initiating event.

3. During the HPCI system overpressurization on May 20, 2011, the HPCI booster pump was subjected to an overpressure condition that had not previously been seen in the pump's prior service conditions. It is probable that the HPCI booster pump rotated backwards for some time which likely stressed the incorrectly installed bearings and initiated the bearing degradation. Therefore, the May 20, 2011, HPCI system overpressurization event is considered to be the initiating event.

Based on the above information and considering the incorrect bearing installation, the rapid rate of bearing degradation, and the as-found condition of the thrust bearings, it is concluded that the BFN Unit 1 HPCI booster pump would not have been able to meet its mission time from May 20, 2011, until the successful vibration test was completed on July 27, 2011. Prior to May 20, 2011, the HPCI system would have performed its design function and met its mission time.

<u>Extent of Condition</u>

The extent of condition assessment includes all critical pumps with similar ball bearings as in the HPCI booster pump. The extent of condition is limited to the BFN Units 2 and 3 HPCI booster pumps, the BFN Units 1, 2, and 3 RCIC pumps, and the BFN Units 1, 2, and 3 Control Rod Drive (CRD) [AA] pumps.

The RCIC pumps have similar operating conditions, duty cycles, and similar thrust bearing design but are not susceptible to an incorrect thrust bearing installation because these pumps utilize a single unitized thrust bearing that cannot be installed with an incorrect orientation. During the recent U3R15 Refueling Outage (RFO), the BFN Unit 3 RCIC pump was disassembled and the thrust bearing was confirmed to be a unitized design and incapable of being installed backwards. Given this information, the BFN Units 1, 2, and 3 RCIC pumps will not be included in the extent of condition.

The CRD pumps have a similar thrust bearing design as the HPCI Booster Pumps and RCIC pumps but have very different operating conditions. The CRD pumps run

NARRATIVE

continuously and have accumulated significant run time hours since installation. The CRD pumps 1A, 1B, and 3B bearings are of the same design as the HPCI booster pump bearing, but have sufficient run time under thrust loads that would have shown an indication of problems to include elevated vibrations, increased bearing temperatures, and other failure modes. These pumps have not shown any symptoms to indicate improper thrust bearing installation and will be excluded from the extent of condition. The CRD pumps 2A and 3A have a single thrust bearing incapable of being installed backwards and will not be included in the extent of condition.

With respect to the extent of condition associated with the BFN Units 2 and 3 HPCI booster pumps, the following actions have been completed.

1. Oil samples have been collected from BFN Units 2 and 3 HPCI booster pumps. The oil samples indicated a very minor presence of wear metals.

2. The configuration of the thrust bearings installed in the BFN Units 2 and 3 HPCI booster pumps has been checked. The thrust bearings installed in the BFN Units 2 and 3 HPCI booster pumps have been visually verified to be in the correct configuration.

Extent of Cause

The extent of cause includes governance and oversight for installation of equipment by contractor personnel at units in Recovery, Construction, and during Construction Projects. As previously indicated, there was minimal supervision, guidance, and oversight of the work practices used by Recovery resources by TVA during the BFN Unit 1 Restart/Recovery. Instead, the BFN Unit 1 Recovery team assigned their own resources to manage and provide oversight of contractors. The current revision of BP-259, "Oversight of Supplemental Personnel Business Practice," now adequately addresses contractor oversight for TVA units in Operation or Recovery. Therefore, additional corrective action for these circumstances is not required.

V. ASSESSMENT OF SAFETY CONSEQUENCES

Under normal operating conditions, with the plant operating at 100 percent power, the BFN Unit 1 HPCI system is idle with steam constantly supplied to the turbine supply valve. Upon actuation, the steam turbine will spin the HPCI pump train (main pump and booster pump) up to rated conditions within 35 seconds consistent with safety analysis assumptions. If the BFN Unit 1 HPCI pump cannot provide the required flowrate of 5000 gallons per minute at rated pressure in this timeframe, the impacts on the loss-of-coolant

NARRATIVE

accident (LOCA) could potentially be more severe. A failure of the HPCI booster pump to supply water to the main pump will render the HPCI system incapable of meeting this requirement.

The HPCI system mission is to provide high pressure core cooling to protect the core as described above for a varying length of time subject to the specific event and condition. For a large break LOCA, rapid depressurization of the reactor vessel lowers the vessel below the low pressure operating point of the HPCI system (150 psig) creating a scenario where the mission time for HPCI system is negligible. The HPCI system and the Automatic Depressurization System (ADS) valves are not required to be operable with reactor steam dome pressure less than or equal to 150 psig.

The HPCI system, in conjunction with ADS, the Core Spray system [BM], and the Low Pressure Coolant Injection mode of the Residual Heat Removal system [BO] are designated as core standby cooling systems. Integrated operation of these core standby cooling systems limits fuel cladding temperatures over the spectrum of postulated break sizes in the nuclear system process barrier, including the design basis LOCA. The role of the HPCI system during integrated operations of the core standby cooling systems is to provide high pressure core cooling in the event of a LOCA, or reactor isolation and failure of the RCIC system.

For Design Basis Accidents, in the event of failure of HPCI system due to the HPCI booster pump, adequate core cooling is ensured by the operability of the redundant and diverse low pressure ECCS injection/spray subsystems in conjunction with ADS. Also, the RCIC system would automatically provide makeup water at most reactor operating pressures.

BFN Unit 1 Operations logs were reviewed to determine if ADS, low pressure ECCS, or the RCIC system were inoperable during the time period of the HPCI system inoperability. The results of the review are as follows

- For ADS, all ADS valves were operable during the time period and ADS initiation capability was maintained during this time period.

- For the low pressure ECCS subsystems, i.e., two Core Spray subsystems and two LPCI subsystems, at least three of the four low pressure ECCS subsystems were operable during the time period. Low pressure ECCS initiation capability was also maintained during this time period. With the HPCI system inoperable, three of the four operable low pressure ECCS subsystems and an operable ADS are capable of providing adequate core cooling in the event of a design basis accident or transient.

- For the RCIC system, the RCIC system was operable, except for a total of 19 minutes, during the time period. RCIC system initiation capability was maintained during this time period. No credit is taken in the safety analysis for RCIC system

NARRATIVE

operation. As a result, the impact on safety of the concurrent inoperability of the HPCI system and the RCIC system for a total time of 19 minutes is considered minimal.

Based on the above, during the time period that the HPCI system was inoperable, sufficient systems were available to provide the required safety functions to protect the health and safety of the public. Therefore, TVA has concluded that there was no significant reduction to the health and safety of the public for this event.

VI. CORRECTIVE ACTIONS

The corrective actions are being managed by TVA's corrective action program.

A. Immediate Corrective Actions

The BFN Unit 1 HPCI booster pump outboard bearings have been replaced and correctly configured in a back-to-back configuration.

B. Corrective Actions to Prevent Recurrence

BP-259, "NPG TCM Role and Oversight of Supplemental Personnel," has been revised to provide additional requirements on the TVA oversight of physical work performed by all supplemental contract personnel. Both the TVA units in Recovery and units under construction are included and not excluded from this procedural requirement. Additionally, corrective actions have been established to revise procedures and vendor manuals to clearly indicate the correct installation configuration for the HPCI booster pump bearings and to ensure appropriate guidance is contained in these documents.

VII. ADDITIONAL INFORMATION

A. Failed Components

BFN Unit 1 HPCI booster pump, BFN-1-PMP-073-0029.

B. Previous Similar Events

High vibrations were previously identified on BFN Unit 1 HPCI main pump and booster pump in Problem Evaluation Report (PER) 378921.

FACILITY NAME (1)	DOCKET (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
Browns Ferry Nuclear Plant Unit 1	05000259	2011	-- 008	-- 02	13 of 13

NARRATIVE

C. Additional Information

The corrective action documents for this report are specified in PERs 405165, 408067, and 568846.

D. Safety System Functional Failure Consideration:

This event constitutes a safety system functional failure according to NEI 99-02.

E. Scram With Complications Consideration:

This event was not a complicated scram according to NEI 99-02.

VIII. COMMITMENTS

There are no commitments associated with this LER.