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

March 31, 2011

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 50-259/2010-004, Revision 1**

The enclosed Licensee Event Report provides details of a failure of a Residual Heat Removal System pump motor that was operating while the system was in shutdown cooling in support of a refueling outage. The Tennessee Valley Authority is submitting this report in accordance with 10 CFR 50.73(a)(2)(i)(B), as any operation or condition which was prohibited by the plant's Technical Specifications.

There are no 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 - Residual Heat Removal System Pump Motor Failure

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 - Residual Heat Removal System Pump Motor Failure

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See Attached

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

APPROVED BY OMB NO. 3150-0104 EXPIRES 10/13/2013

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: Residual Heat Removal System Pump Motor Failure

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	N/A
10	27	2010	2010	- 004 -	01	03	31	2011	FACILITY NAME: N/A	DOCKET NUMBER: N/A

9. OPERATING MODE

5

10. POWER LEVEL

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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)*
Mike Oliver, Licensing Engineer	256-729-7874

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	BO	MO	G080	Y					

14. SUPPLEMENTAL REPORT EXPECTED

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

15. EXPECTED SUBMISSION DATE

MONTH	DAY	YEAR
NA	NA	NA

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

On October 27, 2010, at approximately 1240 hours Central Daylight Time (CDT), the 1C Residual Heat Removal (RHR) pump motor tripped while in shutdown cooling (SDC). Operations personnel received reports of smoke coming from the 1C RHR pump room and responded in accordance with Emergency Plan Implementing Procedure (EPIP)-17, "Fire Response Procedure," and Abnormal Operating Instruction (AOI) 0-AOI-26-1, "Fire Response." By approximately 1245 hours CDT, Operations personnel declared the 1C RHR pump inoperable, and re-established SDC by placing the 1A RHR pump in SDC. Because there was no fire, Operations personnel exited 0-AOI-26-1 and EPIP-17.

Investigation results indicate that the failure to correct a degraded condition of the pump motor caused the motor to fail, which rendered the pump inoperable for greater than Technical Specifications allowed outage times.

The immediate cause of this event was a dynamic physical rotor/shaft bow that caused internal rubbing that led to the mechanical failure of the motor. The root cause was a dynamic rotor bow that was misdiagnosed and treated as a rotor unbalance condition during motor refurbishment.

The 1C RHR pump motor was replaced and tested successfully.

FACILITY NAME (1)	DOCKET (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REV NO.	
Browns Ferry Nuclear Plant Unit 1	05000259	2010	-- 004	-- 01	2 of 7

NARRATIVE

I. PLANT CONDITION(S)

At the time of the event, Browns Ferry Nuclear Plant (BFN) Unit 1 was in Mode 5, the reactor vessel was flooded up, and the moderator temperature was less than 100 degrees Fahrenheit. Loop I 1C Residual Heat Removal (RHR) [BO] pump was in service in shutdown cooling (SDC).

II. DESCRIPTION OF EVENT

A. Event:

On October 23, 2010, at 0900 hours Central Daylight Time (CDT), Unit 1 entered Refueling Outage 8. At 1433 hours CDT, Operations personnel placed Loop I of RHR in SDC in accordance with Operating Instruction (OI) 1-OI-74, "Residual Heat Removal System." On October 24, 2010, at 2117 hours CDT Unit 1 entered Mode 5.

On October 27, 2010, at 0131 hours CDT, Operations personnel secured the 1A RHR pump. The 1C RHR pump remained in service, providing SDC. At approximately 1240 hours CDT, the 1C RHR pump motor tripped. Operations personnel received reports of smoke coming from the 1C RHR pump room and responded in accordance with Emergency Plan Implementing Procedure (EPIP)-17, "Fire Response Procedure," and Abnormal Operating Instruction (AOI) 0-AOI-26-1, "Fire Response." By approximately 1245 hours CDT, Operations personnel declared the 1C RHR pump inoperable and re-established SDC by placing the 1A RHR pump in SDC. Because there was no fire, Operations personnel exited 0-AOI-26-1 and EPIP-17.

The review of the circumstances surrounding this event has found that the 1C RHR pump motor [MO] failed after approximately 94 hours of operation in SDC during the 2010 refueling outage, and after approximately 1400 hours total operating time since being refurbished to support the restart of Unit 1 in May of 2007.

The Tennessee Valley Authority (TVA) is submitting this report in accordance 10 CFR 50.73(a)(2)(i)(B), as any operation or condition which was prohibited by the plant's Technical Specifications. The past inoperability is based on the inability for the 1C RHR pump to complete its 30 day mission time. The exact date at which the 1C RHR pump would have failed to meet its mission time is difficult to determine with certainty. However, violations of TS LCOs 3.6.2.3, RHR Suppression Pool Cooling, 3.6.2.4, RHR Suppression Pool Spray, and 3.6.2.5, RHR Drywell Spray, most likely occurred since November 2007 based on pump run time records. Additionally, since that time, because the degraded condition was not recognized, LCO 3.0.4 was not met due to mode change. Based on NUREG-1022 guidance of event date reporting and based on knowledge that the event has been determined to be of very low safety significance, for reporting purposes, the discovery date will be retained as the event date.

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

None

NARRATIVE

C. **Dates and Approximate Times of Major Occurrences:**

October 23, 2010	0900 hours CDT	BFN Unit 1 entered Refueling Outage 8.
	1433 hours CDT	Operations personnel established SDC using Loop I 1A RHR pump.
	1517 hours CDT	Operations personnel placed 1C RHR pump in service to support Loop I SDC.
October 27, 2010	0131 hours CDT	Operations personnel secured 1A RHR pump from SDC.
	1240 hours CDT	1C RHR pump motor tripped.
	1245 hours CDT	Operations personnel declared 1C RHR pump inoperable and placed 1A RHR pump in service in SDC.
November 2010		1C RHR pump motor replaced.

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

None

E. **Method of Discovery**

Operations personnel received main control room indications that the 1C RHR pump motor tripped. They also received high motor winding temperature alarms on the 1C RHR pump motor.

F. **Operator Actions**

Operations personnel responded in accordance with applicable procedures and re-established SDC by placing the 1A RHR pump in SDC.

G. **Safety System Responses**

None

III. CAUSE OF THE EVENT

A. **Immediate Cause**

The immediate cause of this event was a dynamic physical rotor/shaft bow caused internal rubbing that led to the mechanical failure of the motor.

B. **Root Cause**

The root cause of the 1C RHR pump motor failure was concluded to be a physical bow in the rotor that was misdiagnosed and treated as residual unbalance during the 2004-5 overhaul of the 1C RHR pump motor for BFN Unit 1 Recovery.

NARRATIVE

The investigation established that an improper diagnosis of the abnormal vibrations of the motor while on the test stand was the origin of the 1C RHR pump motor failure. The personnel involved in the troubleshooting activities did not fully understand the problem and made the conscious decision to field balance the motor to bring the vibrations to within acceptance criteria. The decision to treat the symptoms as residual unbalance resulted in eventual motor failure.

Based on the 1C RHR pump motor failure, an assessment was made of all similar safety-related BFN motors (i.e., RHR, Core Spray (CS) [BM], and RHR Service Water/Emergency Equipment Cooling Water [BI] pump motors). No anomalies in oil samples, temperature readings, and vibration analyses were found in any of these pump motors that can be directly linked to the 1C RHR pump motor failure precursors.

C. Contributing Factors

1. Lack of a formal process and documentation of the 1C RHR pump motor condition during the refurbishment activities for the Unit 1 Recovery.
2. BFN was not effective in evaluating and further investigating data documenting changes in 1C RHR pump/motor parameters associated with vibration and oil sample results. The ineffectiveness was determined to be a result of a lack of interface and ownership between the associated engineers.
3. Perceived time pressure to meet the Unit 1 Recovery schedule.
4. Inadequate Lubrication Program oversight at BFN.

IV. ANALYSIS OF THE EVENT

The 1C RHR pump motor was shipped to the TVA Power Service Shop (PSS) for refurbishment in 2004. The 1C RHR pump motor was reinstalled at BFN in 2005. As part of the refurbishment process, the rotor was balanced separately from the stator. The balanced rotor was then installed in the vertically positioned stator for a no load test run. Although the rotor was balanced, the radial vibrations were found unacceptable.

The PSS disassembled the 1C RHR pump motor repeating the rebuild process. All fits and clearances were rechecked, new bearings installed, testing repeated, including a repeat of the rotor balance. The rotor balance was documented as being within an acceptable level. Again the balanced rotor was re-installed in the stator, the motor completely reassembled, and a no load test was performed. The vibrations were found unacceptable. The motor was then field balanced. Two weights totaling approximately 2.16 pounds were added to the upper bearing carrier. These weights were both located 180 degrees from the rotor/stator rub, which eventually caused the motor to fail.

The run speed radial vibrations during no load operation were reduced; however, the coast-down vibrations were elevated. A decision was made at that time to accept the 1C RHR pump motor even though it exhibited an odd characteristic, which was unlike any of the others and was not fully understood or analyzed. Upon return to service of

the 1C RHR pump increasing trends began in both vibration and lower bearing oil iron content.

In 2006, following an initial uncoupled run of the 1C RHR pump motor, the lower bearing oil samples indicated high iron content and required flushing. In 2007, the 1C RHR pump motor had undergone multiple lower bearing oil flushes and was just starting to exhibit a low level trend of abnormal vibration. Beginning in 2008, low level trends in vibration began to increase and corrective action documents were initiated to document the condition. In 2009, vibration and lower bearing oil iron content exhibited step increases. In 2010, vibration points exceeded administrative vibration limits.

On October 27, 2010, the 1C RHR pump motor breaker tripped on a time over current condition. The pump motor could not be turned during troubleshooting; therefore, it was removed and sent to the TVA PSS for disassembly, inspection, and testing to determine the cause of the failure. When the rotor was removed from the stator during the disassembly process, it was immediately visually apparent the rotor had contacted the stator. The upper and lower ball bearings were found intact and did not fail during this event. The motor passed all post-failure electrical testing with satisfactory results and post-failure mechanical inspections concluded that the failure was not initiated by the failure of a mechanical component in the motor. Further inspection revealed that the rotor was rubbing the stator due to a physical bow in the shaft, which had become severe enough to induce a heavy rub between the rotating and stationary components causing the failure. The extent of damage was severe enough that the motor could not be salvaged.

V. ASSESSMENT OF SAFETY CONSEQUENCES

Unit 1 was in Mode 5 and flooded up when the failure occurred. The applicable TS LCOs impacted by this inoperable RHR pump are discussed below.

To satisfy TS LCOs 3.6.2.3, 3.6.2.4, and 3.6.2.5, four RHR suppression pool cooling and spray and drywell spray subsystems are required to be operable during Modes 1, 2, and 3 to remove heat from these spaces, to absorb residual heat from the core, and to maintain containment pressures and temperatures within analyzed design limits.

For these LCOs, if one RHR subsystem is inoperable during Modes 1, 2, or 3, the inoperable subsystem must be restored to an operable status within 30 days. Any two of the four RHR subsystems are sufficient to provide required suppression pool cooling or condense the steam in the suppression pool or drywell airspace during the postulated design basis accident. With less than the required number of RHR subsystems operable, the potential exists that primary containment conditions could exceed design limits. In this condition, any two of the remaining three RHR subsystems are adequate to perform the required safety function.

The review of the circumstances surrounding this event has found that the 1C RHR pump motor failed after approximately 94 hours of operation in SDC during the 2010 refueling outage, and after approximately 1400 hours total operating time since being refurbished to support the restart of Unit 1 in May of 2007. Based on pump run time

records prior to failure and the 30-day mission time, it was determined that the pump was in a degraded condition since November 2007. At that time the condition would have prevented the pump from performing its intended safety functions during the system's required mission time. A PRA evaluation, using the average test and maintenance model, was performed and concluded that the Incremental Core Damage Probability Deficit and Incremental Large Early Release Frequency Deficit would classify the 1C RHR pump motor failure as Green, which represents very low safety significance.

Because the degraded condition was not recognized until the failure, TS LCO 3.0.4 was also not met with each applicable mode change since November 2007, which included several instances where reactor mode changes were made with this RHR pump inoperable.

To satisfy TS LCO 3.9.7, one RHR SDC subsystem is required to be operable during Mode 5 when flooded up to remove decay heat and sensible heat from the reactor coolant.

For this LCO, if one RHR subsystem is inoperable during Mode 5 when flooded up, an alternate method of decay heat removal must be verified as available within an hour. If this action is not met, loading of irradiated fuel assemblies into the RPV must be suspended and secondary containment must be restored immediately. Any one of the four RHR SDC subsystems can provide the required decay heat removal function. Upon discovery of the loss of SDC (i.e., the 1C RHR pump motor trip), the LCO was satisfied by placing the 1A RHR pump in service within the required completion time.

Based on this single failure and the inherent redundancy provided by ECCS and RHR subsystem design, the safety consequences review of this failure determined that the event was of very low safety significance though nuclear safety defense-in-depth was reduced.

VI. CORRECTIVE ACTIONS

A. Immediate Corrective Actions

The 1C RHR pump motor was replaced and post maintenance testing was successfully completed. TVA evaluated the remaining RHR pumps and found no similar predictive maintenance trends.

B. Corrective Actions to Prevent Recurrence

1. TVA will revise maintenance agreements to ensure adequate Engineering oversight and acceptance for maintenance and repair of safety related electric motors.
2. TVA will revise NETP-107, Medium Voltage Motor Testing and Maintenance Program, to include operating experience lessons learned and no load acceptance criteria.
3. TVA will identify the large motors that have been refurbished within the last five years and determine if any were accepted with a misdiagnosis similar to the 1C RHR pump motor. If any discrepancies or abnormal conditions occurred

NARRATIVE

during the refurbishment process due to issues seen in the 1C RHR pump motor root cause, TVA will expand the search to other safety related, critical components that have been refurbished by the PSS since the beginning of Unit 1 restart.

VII. ADDITIONAL INFORMATION

A. Failed Component

A General Electric motor (model number 5K6348XC23A, serial number FEJ604001) refurbished by the TVA PSS failed.

B. Previous LERs or Similar Events

None

C. Additional Information

Corrective action document for this report is Problem Evaluation Report 274840.

D. Safety System Functional Failure Consideration:

Because there is reasonable expectation that the safety functions of the RHR System could be fulfilled, this event is not a safety system functional failure.

E. Scram With Complications Consideration:

Because the unit was in Mode 5, Cold Shutdown, the event described was not a complicated scram according to NEI 99-02.

VIII. COMMITMENTS

None