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

November 28, 2011

10 CFR 50.73

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

Browns Ferry Nuclear Plant, Unit 3
Facility Operating License No. DPR-68
NRC Docket No. 50-296

Subject: **Licensee Event Report 50-296/2011-003-00**

The enclosed Licensee Event Report provides details of an automatic reactor scram due to a main turbine generator load reject. The Tennessee Valley Authority is submitting this report in accordance with 10 CFR 50.73(a)(2)(iv)(A), a condition that resulted in automatic actuation of the Reactor Protection System.

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 296/2011-003-00 - Automatic Reactor Scram Due to a Main Turbine Generator Load Reject

cc (w/ Enclosure):

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

IE22
NRR

ENCLOSURE

Browns Ferry Nuclear Plant
Unit 3

Licensee Event Report 296/2011-003-00
Automatic Reactor Scram Due to a Main Turbine Generator Load Reject

---

See Attached

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 3	05000296	1 of 6

4. TITLE: Automatic Reactor Scram Due to a Main Turbine Generator Load Reject

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
09	28	2011	2011	- 003 -	00	11	28	2011	FACILITY NAME: N/A	DOCKET NUMBER: 05000

9. OPERATING MODE	11. THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: *(Check all that apply)*			
1	☐ 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)
10. POWER LEVEL	☐ 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)
100	☐ 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)*
Eric Bates, Licensing Engineer	256-614-7180

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
X	TB	SCN	X000	Y					

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

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

On September 28, 2011, at 0414 hours Central Daylight Time, Browns Ferry Nuclear Plant (BFN) Unit 3 automatically scrammed due to a main turbine generator load reject. Seven safety relief valves cycled due to the reactor pressure transient. All systems responded to the turbine trip as expected. No Emergency Core Cooling System or Reactor Core Isolation Cooling System reactor water level initiation set points were reached. Primary containment isolation and initiation signals for groups 2, 3, 6, and 8 were received as expected. Reactor water level was automatically controlled by the Feedwater System.

The immediate cause of this event was a piece of the BFN Unit 3 isolated-phase bus (IPB) C debris screen that broke free from the remainder of the screen. Once free in the Unit 3 IPB C duct, airflow pushed the screen segment downstream until it contacted the Unit 3 IPB C and the Unit 3 IPB C duct at the same time. The screen segment caused a momentary ground that tripped the main turbine generator neutral overvoltage relay.

The root cause of the screen failure was identified as an excessive number of weld repairs on the BFN Unit 3 IPB C debris screen.

The corrective action to prevent recurrence is to verify installation of a non-welded debris screen in BFN Units 1, 2, and 3 IPB A, B, and C ducts.

FACILITY NAME (1)	DOCKET (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
Browns Ferry Nuclear Plant Unit 3	05000296	2011	-- 003	-- 00	2 of 6

NARRATIVE

I. PLANT CONDITION(S)

Browns Ferry Nuclear Plant (BFN) Unit 3 was at approximately 100 percent power when the event occurred.

II. DESCRIPTION OF EVENT

A. Event

On September 28, 2011, at 0414 hours Central Daylight Time (CDT), BFN Unit 3 automatically scrammed due to a main turbine generator load reject. Seven safety relief valves (S/RVs) [SB] cycled due to the reactor pressure transient. All systems responded as expected to the turbine trip. There were no Low Pressure Coolant Injection System (LPCI) [BO], Core Spray System (CS) [BG], High Pressure Coolant Injection System (HPCI) [BJ], or Reactor Core Isolation Cooling System (RCIC) [BN] reactor water level initiation set points reached. Primary containment isolation and initiation signals from groups 2, 3, 6, and 8 were received as expected. Reactor water level was automatically controlled by the Feedwater System [SJ].

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

There were no inoperable structures, components, or systems that contributed to this event.

C. Dates and Approximate Times of Major Occurrences

1969	BFN Unit 3 isolated-phase bus (IPB) C debris screen [SCN] was installed.
1972-1985	BFN Unit 3 IPB C debris screen repaired by welding at various intersections.
September 28, 2011 at 0414 CDT	BFN Unit 3 automatically scrammed due to a main turbine generator load reject.
September 29, 2011 at 1751 CDT	Temporary alteration control form TACF 3-11-007-262 was authorized to remove the BFN Unit 3 IPB A, B, and C debris screens.
September 30, 2011 at 0218 CDT	BFN Unit 3 entered Mode 1.

D. Other Systems or Secondary Functions Affected

There were no other systems or secondary functions affected.

NARRATIVE

E. **Method of Discovery**

BFN Unit 3 reactor automatically scrammed due to a main turbine generator load reject.

F. **Operator Actions**

Operations personnel entered emergency operating instruction 3-EOI-1 on reactor water level and abnormal operating instruction 3-AOI-100-1 for the reactor scram.

G. **Safety System Responses**

Seven S/RVs cycled due to the reactor pressure transient. Primary containment isolation and initiation signals for groups 2, 3, 6, and 8 were received. Reactor water level was automatically controlled by the Feedwater System.

III. CAUSE OF THE EVENT

A. **Immediate Cause**

The immediate cause of this event was a piece of the BFN Unit 3 IPB C debris screen found downstream in the bus duct [BDUC]. The debris screen caused a phase to ground fault on the BFN Unit 3 IPB C.

B. **Root Cause**

The root cause was identified as an excessive number of weld repairs on the BFN Unit 3 IPB C debris screen.

C. **Contributing Factors**

A contributing factor was identified as failure to implement lessons learned from previous industry operating experience (OE).

IV. ANALYSIS OF THE EVENT

Description of System

The IPB duct system is a 3 phase assembly in which each phase conductor is enclosed in a metal housing, and an air space is located between each phase to eliminate faults. The IPB duct assembly is used as a cooling system to minimize heat flow as current travels from the main turbine generator [GEN] to the large power transformers [XFMR]. This current generated heat is minimized via a forced cooling system.

The cooling system is designed with two fans [FAN] and two motors [MO]. Each fan operates independently and produces approximately 48,000 standard cubic feet per minute (scfm) air flow. As a result, each individual fan is able to provide the necessary air flow to eliminate overheating the system. Each fan assembly has gravity and inlet dampers [DMP]. The gravity dampers are located directly above the fans and are provided to prevent backflow to the non-energized fan. The inlet dampers are used to control the capacity of the fan. The debris screens are located farther downstream of the inlet dampers. They are installed to prevent foreign material from entering the bus duct and causing a catastrophic failure.

NARRATIVE

Analysis of the Event

The Tennessee Valley Authority (TVA) is submitting this report in accordance with 10 CFR 50.73(a)(2)(iv)(A), a condition that resulted in automatic actuation of the Reactor Protection System.

The failed Unit 3 IPB C debris screen and the intact Unit 3 IPB B debris screen were removed and sent to TVA Central Laboratory for failure analysis. Laboratory analysis indicated multiple crack initiation sites at welded intersections on the BFN Unit 3 IPB C debris screen. The repair welding at various intersections allowed discontinuities to be introduced. Under repetitive cyclic loading, these discontinuities become sites for fatigue initiation due to residual tensile stress present as well as a high dislocation density. Some of the fatigue initiation sites were not in weld metal of the intersections; however, the degree of residual stresses from the welding process makes the screen intersection corners highly likely to initiate cracks.

On a micro-scale, repetitive cyclic loading from flow induced vibration creates sharp peaks (extrusions) and troughs (intrusions) which result from dislocations moving under load. The end result is the formation of a crack tip which is then driven by cyclic stresses. This phenomenon was confirmed by laboratory analysis which showed fatigue striations. These striations on the fracture surface represent one stress cycle and were present at the welded intersections. Another contributor to the crack propagation is the residual stress left from the heating and cooling cycles of welding multiple intersections.

Once various intersections began failing by fatigue, the neighboring intersections were loaded incrementally more until they began failing. The end result is that the final intersections were overloaded and the screen segment broke away from the rest of the screen. Once free in the Unit 3 IPB C duct, airflow pushed the screen segment downstream until it contacted the Unit 3 IPB C and the Unit 3 IPB C duct at the same time. The screen segment caused a momentary ground that tripped the main turbine generator neutral overvoltage relay due to the screen being electrically conductive. This was confirmed by Power System Operations Oscillography that demonstrated the neutral bus was gaining voltage from C phase at the time of the automatic scram. The automatic scram occurred as a result of the tripping of the main turbine generator neutral overvoltage relay.

Extent of Condition

During the BFN Unit 3 forced outage, BFN Unit 3 IPB A, B, and C debris screens were removed by TACF 3-11-007-262. The BFN Unit 3 debris screens will be replaced with non-welded screens during the next Unit 3 refueling outage.

The extent of condition includes the BFN Units 1 and 2 IPB A, B, and C debris screens. The extent of condition for these six screens will be addressed by verifying installation of non-welded debris screens and, if applicable, replacing the existing welded screens with a non-welded debris screen.

There are also screens above the Unit Service Station Transformer (USST) for BFN Units 1, 2, and 3 buses A and B. These six screens are also part of the extent of

NARRATIVE

condition. The extent of condition for these screens will be addressed by inspecting the screens (and replacing, if necessary) during the next applicable refueling outage for each unit followed by a determination of the inspection preventive maintenance (PM) frequency based on the results of the initial inspections.

Extent of Cause

The cause of the failure was an excessive number of weld repairs on the BFN Unit 3 IPB C debris screen that occurred sometime during the 1970s or 1980s. Since the BFN Unit 3 IPB C debris screen was welded, BFN has required any repair to cracks be submitted to the weld engineering supervisor for review. In addition, multiple repairs (3 or more) to the same component require review and approval from site engineering. The Base Metal Evaluation process has also been implemented which affords the opportunity to note any abnormal conditions or instances of materials not meeting specifications and must be reviewed and approved by site engineering in order to reuse materials. These processes are credited for addressing the extent of cause relative to excessive weld repair.

V. ASSESSMENT OF SAFETY CONSEQUENCES

When the BFN Unit 3 scram occurred, all control rods fully inserted. All systems responded as expected. The plant was supplied from offsite power and was in normal shutdown configuration. There were no LPCI, CS, HPCI, or RCIC reactor water level initiation set points reached. Reactor water level was automatically controlled by the Feedwater System. The main steam isolation valves were open with decay heat being removed via steam to the main condenser [SG] using the bypass valves.

Therefore, TVA 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 immediate corrective action was to remove the BFN Unit 3 IPB A, B, and C debris screens.

B. Corrective Actions

1. Revise Electrical Preventive Instruction EPI-0-242-BUS001 to include an inspection of the debris screens with the first inspection taking place one outage after implementation of the new screens. Any welded intersections, cracks, or deformation should be the basis for screen replacement.
2. Initiate and create a PM activity to perform a debris screen inspection once every four years.
3. Implement Operating Experience Extractor at BFN to improve review methods and implementation of OE.

NARRATIVE

4. Perform an inspection of BFN Units 1, 2, and 3 USST debris screens. Any welded intersections, cracks, or deformation should be the basis for screen replacement.
5. Initiate and create/revise a PM activity to perform a USST screen inspection using Electric Power Research Institute's Nuclear Maintenance Applications Center: Isolated Phase Bus Maintenance Guide and inspection data as a guide to set PM frequency.
6. Perform welding surveillances of at least 10 existing bus duct or sheet metal welds. Note any excessive number of weld repairs and document the results of the surveillances.
7. This event will be added to the engineering OE block training module.

C. **Corrective Actions to Prevent Recurrence**

Verify installation of a non-welded debris screen in BFN Units 1, 2, and 3 IPB A, B, and C ducts.

VII. ADDITIONAL INFORMATION

A. **Failed Components**

The failed component was the BFN Unit 3 IPB C debris screen.

B. **Previous Similar Events**

In February 1997, a section of BFN Unit 1 bus duct cooling fan exhaust ductwork broke out of the aluminum exhaust duct. The section was sent to TVA Central Laboratory for analysis. The analysis concluded that fatigue cracking was initiated from the weld root on the inside of a corner on the duct. The failure mechanism was identified to be low cycle fatigue.

C. **Additional Information**

The corrective action document for this report is Problem Evaluation Report 440359.

D. **Safety System Functional Failure Consideration**

This event was not a safety system functional failure in accordance with NEI 99-02.

E. **Scram With Complications Consideration**

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

VIII. COMMITMENTS

There were no commitments.