Tennessee Valley Authority, Post Office Box 2000, Spring City, Tennessee 37381

January 13, 2011

10 CFR 50.73

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

Watts Bar Nuclear Plant, Unit 1
Facility Operating License No. NPF-90
NRC Docket No. 50-390

Subject: **Licensee Event Report 390/2010-003, Manual Reactor Trip Due to High Main Bank Transformer Temperature**

This submittal provides Licensee Event Report (LER) 390/2010-003. This LER documents an instance where the operators manually tripped the reactor above 50% rated thermal power. The condition is reported as an LER in accordance with 10 CFR50.73(a)(2)(iv).

There are no regulatory commitments in this letter. Please direct any questions concerning this matter to Robert Clark, WBN Site Senior Licensing Engineer, at (423) 365-1818.

Respectfully,

D. E. Grissette
Site Vice President
Watts Bar Nuclear Plant

Enclosure
cc: See Page 2

Enclosure
cc (Enclosure):

NRC Regional Administrator - Region II

NRC Senior Resident Inspector - Watts Bar Nuclear Plant

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

LICENSEE EVENT REPORT (LER)

(See reverse for required number of digits/characters for each block)

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4. TITLE
Manual Reactor Trip Due to High Main Bank Transformer Temperature

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: N/A
11	14	2010	2010	- 003 -	0	01	13	2011	FACILITY NAME: N/A	DOCKET NUMBER: N/A

9. OPERATING MODE: 1

10. POWER LEVEL: 93.5%

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)
Robert Clark, Senior Licensing Engineer	(423) 365-1818

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
D	EL	CNTR	GE	Y					

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

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

At 06:45 Eastern Standard Time (EST) on 11/14/2010, Watts Bar Nuclear Plant, Unit 1 initiated a rapid load reduction in response to rising oil temperature in Main Bank Transformer 1A (MBT-1A). The high oil temperature in MBT-1A was attributed to a loss of forced-oil-air cooling due to a faulted motor starter which overloaded the control power transformer (CPT) that provided control power to the main bank cooling circuits. Loss of the CPT de-energized all six main bank coolers. Each main bank cooler has a circulating oil pump and four fans.

The load reduction rate was not sufficient to reverse the temperature rise, so a manual reactor trip was initiated at 06:52 EST to prevent exceeding the 80°C maximum oil temperature operating limit. Following the reactor/turbine trip the plant entered the appropriate shutdown procedures to stabilize the plant at Hot Standby Conditions. No overcooling transient occurred and no safety injection signals were initiated for this event.

The damaged components were replaced and additional corrective actions are being implemented to prevent recurrence. Corrective action included changes to the maintenance procedures and design changes to the main bank cooler circuits to eliminate single point vulnerabilities, to the extent practical.

This event is reportable as an LER in accordance with 10 CFR 50.73(a)(2)(iv).

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I. PLANT CONDITIONS:

Plant in Mode 1 at 93.5% rated thermal power (RTP).

II. DESCRIPTION OF EVENT:

A. Event

At 06:45 Eastern Standard Time (EST) with Unit 1 at 93.5% RTP a rapid load reduction was initiated in response to rising oil temperature in Unit 1 Phase A Main Bank Transformer (MBT-1A) [EIIS[1] Code EL]. The load reduction rate was not sufficient to reverse the temperature rise. A manual reactor trip was initiated at 06:52 EST when it was determined that no success path was available to reverse the increase in MBT-1A oil temperature before exceeding the 80°C maximum operating limit.

This event was documented in TVA's Corrective Action Program as Problem Evaluation Report (PER) 283515.

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

A loss of forced-oil-air cooling to MBT-1A occurred due to a faulted motor starter which overloaded the control power transformer (CPT) that provided control power to MBT-1A cooling circuits. Loss of the CPT de-energized all six MBT-1A coolers. Each cooler consists of one circulating oil pump and four fans.

C. Dates and Approximate Times of Major Occurrences

Date	Time (EST)	Event
11/14/2010	06:16	Received Main Transformer Abnormal Alarm in main control room. Dispatched Auxiliary Unit Operator (AUO) to investigate.
11/14/2010	06:26	AUO reported MBT-1A oil pump and cooling fans tripped.
11/14/2010	06:45	MBT-1A temperature increased to 75°C - Operators entered Abnormal Operating Instructions, AOI-39, Rapid Load Reduction.
11/14/2010	06:52	MBT-1A temperature increased to 77.5°C - Operators manually trip reactor and entered Emergency Operating Instructions, E-0, Reactor Trip or Safety Injection.
11/14/2010	06:54	Operators transitioned to Emergency Sub Procedures, ES-0.1, Reactor Trip Response.
11/14/2010	07:16	Operators transitioned to General Operating Instructions, GO-5, Unit Shutdown from 30% Reactor Power to Hot Standby.

[1] Energy Industry Identification System

II. DESCRIPTION OF EVENT (continued):

D. Other Systems or Secondary Functions Affected

Post trip, this event was aggravated by the following equipment failures:

Dual position indication of 1-FCV-3-236 (Steam Generator (SG)-1 Main Feedwater (MFW) Bypass Isolation Valve) rendered position indication indeterminate. The operators closed the No. 1 feedwater (FW) heater outlet isolation valves (FCV-3-10, 20, 30) from the main control room (MCR). The rapid response team determined the valve was fully closed. The problem was an indication issue only, and was corrected.

Following feedwater isolation and Main Feed Pump Turbine (MFPT) trip the MFPT-1B High Pressure (HP) Stop Valve (1-FCV-1-43) leaked as evidenced by increasing pressure in the MFPT-1B condenser. Operators manually closed MFPT-1B Steam Supply Valve 1-ISV-1-612 to isolate the leak and restore condenser vacuum.

Following feedwater isolation MFPT-1B Condenser Outlet Isolation Valve (1-FCV-2-216) failed to close on the automatic isolation signal generated from the loss of both MFPTs. MFPT-1B Condenser Inlet Isolation Valve (1-FCV-2-211) did automatically close as expected. Operators manually closed 1-FCV-2-216 using MCR hand switch.

Following reactor/turbine trip the Main Turbine Seal Oil Backup Pump did not auto-start on low seal oil pressure. The pump was placed into service manually within fifteen minutes of the reactor trip. There was no hydrogen leak from the main generator.

E. Method of Discovery

Received Main Transformer Abnormal Alarm in MCR.

F. Operator Actions

Shortly after receiving MCR abnormal alarm, MBT-1A temperature increased from 65°C to 70°C in approximately 5 minutes. Upon reaching 75°C the operators manually initiated turbine load reduction in accordance with AOI-39, Rapid Load Reduction. Turbine load reduction was limited to a maximum rate of 5% per minute. Reactor coolant system boron concentration was also increased to ensure control rod insertion and axial flux difference remained within Tech Specs limits. Despite turbine load reduction, MBT-1A temperature continued to increase towards the maximum operating limit of 80°C. When MBT-1A temperature reached 77.5°C the operators manually tripped the reactor to avoid equipment damage. Following reactor/turbine trip, the operators entered the following operating procedures to stabilize the plant at Hot Standby Conditions:

E-0 Reactor Trip or Safety Injection
ES-0.1 Reactor Trip Response
GO-5 Unit Shutdown from 30% Reactor Power to Hot Standby

G. Safety System Responses

Immediately following reactor trip, the Steam Dump Control System [EIIS Code J] automatically opened the condenser bypass valves [EIIS Code SB] to remove stored energy and residual heat from the Reactor Coolant System (RCS) [EIIS Code AB]. During plant cooldown to no-load equilibrium conditions, a main feedwater isolation signal was generated by the Solid State Protection System [EIIS Code JC] due to Reactor Trip coincident with low RCS T_{AVG}. The closure of the main feedwater isolation valves [EIIS Code SJ] generated a Main Feed Pump Turbine (MFPT) [EIIS Code JK] trip signal which then resulted in the automatic startup of the Auxiliary Feedwater System [EIIS Code BA]. No overcooling transients occurred and no safety injection signals were initiated for this event.

III. CAUSE OF EVENT

The most probable cause was determined to be a faulted motor starter (contactor) in MBT-1A cooling circuit. The armature coil overheated and shorted due to high surge current. The high surge current was attributed to mechanical binding of an auxiliary contact switch (GE Model CR105X) externally mounted to the contactor (GE Model CR305). The shorted coil overloaded the control power transformer (CPT) secondary windings which resulted in the loss of control power to all six MBT-1A coolers. The shorted contactor coil also caused the 480 Volt (V) supply breaker to Cooler Group 1 to trip due to a phase to phase or phase to ground fault. This conclusion is based on a Root Cause investigation and a series of tests performed at TVA Central Laboratories Services.

The analysis also indicated that at least four Single Point Vulnerabilities (SPVs) existed in the circuit design for the MBT coolers. The first SPV is that no redundant CPT was provided. The second SPV is related to improper fuse/breaker coordination i.e., the CPT is not properly protected from ground faults or short circuits due to oversized fuses. The fuses were originally sized to protect the wiring within the control panels from electrical faults and not the CPT itself. The third SPV is that the 480V circuit breakers on individual main bank coolers are not coordinated with the supply breakers in the instantaneous over current range. Thus a fault on an individual cooler could trip the supply breaker feeding all MBT coolers. Although, the system is designed to auto-transfer to an alternate 480V source, the same lack of breaker coordination could cause loss of the emergency power source. The fourth SPV is that the 480V auto-transfer scheme is not fully protected from single phasing i.e., if a 480V phase B circuit were to open no transfer to the alternate supply would occur.

IV. ANALYSIS OF THE EVENT

Following manual reactor trip, the steam dump and the pressurizer control system successfully performed their design function, thereby minimizing RCS and steam generator (SG) [EIIS Code SB] temperature and pressure transients. No pressurizer [EIIS Code AB] or SG Power Operated Relief Valves (PORVs) or Safety Valves lifted during the transient. Main Feedwater was successfully isolated following plant cool down to prevent a potential RCS overcooling transient. AFW system auto-start on trip of all MFPTs as designed following main feedwater isolation. Trip of all MFPTs is a non-safety related anticipatory trip signal use to preclude AFW auto-start on low-low SG level.

V. ASSESSMENT OF SAFETY CONSEQUENCES

The safety significance of this event (reactor/turbine trip) is low because there was no loss of safety function. This event is categorized in the WBN Updated Final Safety Analysis Report (UFSAR) Chapter 15 Accident Analyses as a Condition II event, a fault of moderate frequency. The event is specifically discussed in UFSAR Section 15.2.7, Loss of External Electrical Load and/or Turbine Trip, and Section 15.2.8, Loss of Normal Feedwater.

UFSAR Section 15.2.7 - Loss of External Electrical Load

Section 15.2.7 analysis contains several conservative assumptions which were not characteristic of the actual event. The UFSAR analysis assumes the following conditions:

- The analysis assumes a loss of offsite power to the station auxiliaries. The actual event had offsite power available.
- The analysis assumes a complete loss of steam load from full power without a direct reactor trip, primarily to show the adequacy of the pressure relieving devices and also to demonstrate core protection margins. In the actual event, a manual reactor trip occurred which initiated a Turbine Trip and a Main Feedwater Isolation Signal.

- The analysis assumes the initial operating conditions for reactor power, pressurizer pressure, and RCS temperatures are at their nominal values, consistent with steady-state full-power operation. Other assumptions in the analysis assumed the reactor is in manual control and the steam dump system and steam generator power-operated relief valves did not function. In the actual event the steam dumps and steam generator power-operated relief valves were available.
- The analysis assumes that main feedwater flow to the steam generators is assumed to be lost at the time of loss of external electrical load. The actual event had no loss of external electrical load.
- The analysis also assumes the event occurred at the beginning of core life after refueling and that the reactor trip is actuated by the first reactor protection system trip setpoint reached with no credit taken for the direct reactor trip on turbine trip. The actual event consisted of a manual reactor trip followed by a main turbine trip at an intermediated level of core life.

  Therefore, the actual event was bounded by the UFSAR safety analysis assumptions for this event.

UFSAR Section 15.2.8 - Loss of Normal Feedwater

Section 15.2.8 analysis contains several conservative assumptions which were not characteristic of the actual event. The UFSAR analysis assumes the following conditions:

- A loss of offsite power, a loss of the Chemical and Volume Control System, the AFW temperature is 120 degrees F, and the water level in the SGs is at conservatively low level. None of these conditions existed at the time of the event.
- The analysis assumes that the steam dumps and steam generator power-operated relief valves were unavailable. The steam dumps and steam generator power-operated relief valves were available and functioned as expected at the time of the event.
- The UFSAR assumes that the plant is initially operating at 100.2% (15.2.7) or 100.6% (15.2.8) of the Nuclear Steam Supply System (NSSS) power level while the actual manual reactor trip occurred at 93.5% of rated thermal power.

  Therefore, the actual event was bounded by the UFSAR safety analysis assumptions for this event.

VI. CORRECTIVE ACTIONS

This event was documented within TVA's Corrective Action Program as PER 283515.

A. Immediate Corrective Actions

Immediate Corrective Actions were taken to restore forced cooling to MBT-1A under Work Order 111640804. The oil in the MBT-1A, 1B and 1C was sampled and tested. The test results were evaluated by engineering and found to be acceptable. The damaged control power transformer (CTR-3), Cooler Group 1 Contactor (4-1) and its group selector relay were replaced including any circuit wiring that appeared damaged. Also, as a precaution, circuit breaker 1-BKR-244-A008C-3 which provides 480V power to control power transformer CTR-3 and circuit breaker 1-BKR-244-A001/52-1 which provides 480V power to Cooler Group 1 were replaced. Cooler Group 5 Contactor (4-5) and its group selector relay were also replaced due to observed discoloration. A visual inspection was performed for the contactors in MBT-1B and 1C with no deficiencies identified.

B. Corrective Actions to Prevent Recurrence

Corrective Actions to prevent recurrence include the following:

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1. Replace all MBT contactors and associated auxiliary contact switches with GE Model CR305 contactors and GE Model CR305X auxiliary contact switches.
2. Revise preventative maintenance procedures to manually manipulate contactors to verify that auxiliary contact switches are not binding on a periodic basis.
3. Add preventative maintenance requirement to periodically replace control power transformers, main bank contactors, and auxiliary contact switches.
4. Issue main bank cooler circuit design changes to eliminate to the extent practical all SPVs.

VII. ADDITIONAL INFORMATION

A. Failed Components

1. Cooler Group 1 Contactor 4-1 (GE Model CR305)
2. Control Power Transformer (CTR-3)
3. Fuse CLF 3 and 4
4. Damaged Wiring

B. Previous LERs on Similar Events

Watts Bar has experienced one similar event to the loss of all forced cooling to a Main Bank Transformer. On April 2, 2004 WBN encountered a loss of all forced cooling on MBT-1A. This was attributed to a CPT fault resulting from switching of the 2B 480V Unit Board from normal to alternate supply. When the CPT faulted all power was lost to the MBT control power relays thus resulting in a loss of all six cooler groups. While the failure mode was the same, the initiating failure differed from the event on November 14, 2010.

C. Additional Information:

None.

D. Safety System Functional Failure

This event did not involve a safety system functional failure as defined in NEI 99-02, Revision 5.

E. Loss of Normal Heat Removal Consideration

Main Feedwater Isolation following reactor/turbine trip is a design feature used to preclude potential RCS overcooling transients. Loss of normal heat removal during this event was expected and was properly mitigated by the automatic startup of the AFW System including operator actions to stabilize the plant at Hot Standby Conditions.

VIII.COMMITMENTS

None.