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NOV 0 5 2001

U.S. Nuclear Regulatory Commission
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10 CFR 50.73

Gentlemen:

TENNESSEE VALLEY AUTHORITY - WATTS BAR NUCLEAR PLANT (WBN) UNIT 1 - DOCKET NO. 50-390 - FACILITY OPERATING LICENSE NPF-90 - LICENSEE EVENT REPORT (LER) 50-390/2001-002

The enclosed report provides details concerning a reactor trip as a result of loss of the 1-I Vital AC Inverter which caused the number 1 steam generator feedwater regulating valve to close. This event is being reported, in accordance with 10 CFR 50.73(a)(2)(iv)(A), as an event that resulted in an automatic actuation of engineered safety features including the reactor protection system and auxiliary feedwater system.

Sincerely,

W. R. Lagergren

Enclosure
cc: See page 2

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Enclosure

cc (Enclosure):

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NRC FORM 366 (7-2001) U.S. NUCLEAR REGULATORY COMMISSION	APPROVED BY OMB NO. 3150-0104 EXPIRES 7/31/2004
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TITLE (4)
Manual Reactor Trip Due to A Loss of the 1-I Vital AC Inverter

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
									NA	05000
09	04	2001	2001	-- 002 --	00	11	05	2001	FACILITY NAME NA	DOCKET NUMBER 05000

OPERATING MODE (9)	1	THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10CFR §: (Check one or more) (11)							
			20.2201(b)		20.2203(a)(3)(ii)		50.73(a)(2)(ii)(B)		50.73(a)(2)(ix)(A)
POWER LEVEL (10)	100		20.2201(d)		20.2203(a)(4)		50.73(a)(2)(iii)		50.73(a)(2)(x)
			20.2203(a)(1)		50.36(c)(1)(i)(A)	X	50.73(a)(2)(iv)(A)		73.71(a)(4)
			20.2203(a)(2)(i)		50.36(c)(1)(ii)(A)		50.73(a)(2)(v)(A)		73.71(a)(5)
			20.2203(a)(2)(ii)		50.36(c)(2)		50.73(a)(2)(v)(B)		OTHER
			20.2203(a)(2)(iii)		50.46(a)(3)(ii)		50.73(a)(2)(v)(C)		Specify in Abstract below or in NRC Form 366A
			20.2203(a)(2)(iv)		50.73(a)(2)(i)(A)		50.73(a)(2)(v)(D)		
			20.2203(a)(2)(v)		50.73(a)(2)(i)(B)		50.73(a)(2)(vii)		
			20.2203(a)(2)(vi)		50.73(a)(2)(i)(C)		50.73(a)(2)(viii)(A)		
			20.2203(a)(3)(i)		50.73(a)(2)(ii)(A		50.73(a)(2)(viii)(B)		

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER (Include Area Code)
Rickey Stockton, Licensing Engineer	(423) 365-1818

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX		CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX
B	EF	BLS	P319							

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

Abstract (Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines) (16)

While operating at 100% power, the Watts Bar Unit 1 reactor was manually tripped at approximately 1305 EDT on September 4, 2001, due to the level of steam generator (SG) number 1 approaching the Lo-Lo level setpoint. The immediate cause of the trip is considered to be the loss of the 1-I Vital AC Inverter which caused the SG number 1 feedwater regulating valve to close.

All control rods inserted properly in response to the reactor trip. The Auxiliary Feedwater (AFW) System actuated in response to the trip, as expected. However, subsequent to the initial actuation signal, additional operator action was required to start the 1A-A and 1B-B motor driven AFW pumps.

The root cause for this event was determined to be the failure of the 5 watt resistor R12 on the sensing and current limiting card installed in Vital Battery Charger 6-S. Corrective actions include the replacement of the blown inverter fuses, the replacement of the failed card with subsequent load testing performed, some operating instruction revisions to provide verification of AC input breaker closure and DC output before closing DC output breakers, and a revision to the procurement data sheet for sensing and current limit board requiring additional factory burn in of new boards.

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TEXT (If more space is required, use additional copies of NRC Form 366A) (17)

I. PLANT CONDITION(S)

Watts Bar Unit 1 was in power operation at approximately 100 percent reactor power.

II. DESCRIPTION OF EVENT

A. Event:

While operating at 100% power, the Watts Bar Unit 1 reactor (Energy Industry Identification System (EIIS) code RCT) was manually tripped at approximately 1305 EDT on September 4, 2001, due to the level of steam generator (SG) number 1 approaching the Lo-Lo level setpoint. The immediate cause of the trip is considered to be the loss of the 1-I Vital AC Inverter (EIIS code INVT) which caused the SG number 1 feedwater regulating valve (EIIS code V) to close. Subsequently, the maintenance power supply was used to restore power to the 120 V Vital AC board 1-I (EIIS code BD).

All control rods inserted properly in response to the reactor trip. The Auxiliary Feedwater (AFW) System actuated in response to the trip, as expected. However, subsequent to the initial actuation signal, additional operator action was required to start the 1A-A and 1B-B motor driven pumps.

Prior to the event, on June 28, 2001, the spare Battery Charger 6-S cards were replaced and a post maintenance test was performed. On September 4, 2001, during the performance of a preventative maintenance procedure, when Battery Charger 6-S (EIIS code BYC) was placed in parallel to Battery Charger I, maintenance personnel noticed that current and voltage had exceeded the system limits at charger 6-S. The increased charger voltage caused 1-I Inverter to fail. When the 1-I Vital AC Inverter failed, this caused deenergization of 120 V Vital AC Board 1-I which initiated the above chain of events.

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

None.

C. Dates and Approximate Times of Major Occurrences:

06/28/2001		Spare Battery Charger 6-S cards replaced and PMT run.
09/04/2001	0730	Electrical supervisor performs a pre-job brief for PM 0-CHGR-236-0006-S.
	0930	Electricians wiped the float and equalization pots with the charger being de-energized

0940	Clearance lifted on the 6-S charger.
1100	Operations conducts a pre-job briefing to switch from Charger I to 6-S Charger.
1245	Assistant Unit Operators (AUOs) place the 6-S charger in parallel with charger I.
1303	Electricians notice amps and voltage spike on charger 6-S and battery board I.
1303	AUOs opened the output breaker from Charger I (Normal sequence of evolution). Inverter 1-I failed causing deenergization of 120V Vital AC Bd 1-I.
1304	AUOs confirm the high voltage and amps on the 6-S charger.
1304	AUO obtain permission to reconnect charger I to battery board I and open the breaker for the 6-S Charger.
1304	Feedwater reg valve closes resulting in low feedwater flow.
1305	Control Room Operator manually trips reactor and TDAFW actuates.
1307	Operators manually start motor driven AFW pumps 1A-A and 1B-B.
1319	120V Vital AC Bd 1-I energized from maintenance power supply

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

None.

E. **Method of Discovery:**

This event was observed in the main control room by the conditions described above.

F. **Operator Actions:**

Personnel performance in response to this event was professional and no inappropriate personnel actions were identified. Main Control Room personnel responded appropriately to the plant transient per abnormal operating instructions. Upon turbine/reactor trip, Operations entered: 1) Emergency Procedure (E-0), "Reactor Trip or Safety Injection," 2) ES-0.1, "Reactor Trip Response," AOI-17, "Turbine Trip Response," and 3) General Operating Instruction GO-5, "Shutdown from 30% Power to Hot Standby" and GO-6, "Shutdown from Hot Standby."

Emergency and abnormal procedures were correctly followed, and the plant was placed in a stable condition in Mode 3. The operators demonstrated conservative decision making by tripping the reactor in response to the initial steam generator low level condition.

Although it did not impact the specific event, personnel performance during charger 6-S activities prior to the event did not meet management expectations. It was identified that Operations personnel did not involve Electrical Maintenance personnel in the prejob briefing to place Vital Battery Charger 6-S into service.

G. <u>Safety System Responses:</u>

Most of plant system responses were determined to have been appropriate and as expected for the plant conditions at the time with the loss of the 1-I Vital AC Inverter. However, included below is a discussion of the motor driven auxiliary feedwater system response during this event:

<u>Motor Driven Auxiliary Feedwater Pumps Failed to Actuate as Required:</u>

Below is a time line for events related to AFW. The time line is derived from the plant computer (PEDs) with selected times verified by Ronan (MCR Annunciator system).

13:05:06.73	Rx trip breakers are open.
13:05:08	S/G 1 and 4 meet low-low level point (17%).
13:05:08	Train B AFW level control valves are in modulate.
13:05:12	The Terry Turbine trip/throttle valve started opening.
13:05:33	The Main Feedwater pumps 1A and 1B Tripped.
13:05:46	AMSAC Actuated.
13:06:57	MDAFW pump A breaker is closed (Manual Actuation).
13:07:04	MDAFW pump B breaker is closed (Manual Actuation).
13:19:55	Vital A/C Board 1-I is re-energized.

For WBN, the AFW system consists of a turbine driven AFW (TDAFW) pump and two trains (Train A and Train B) of motor driven AFW (MDAFW) pumps. The design calls for the MDAFW and TDAFW pumps to start due to the loss of both Main Feedwater (MFW) pumps or an Anticipated Transient Without Scram (ATWS) Mitigation System Actuation Circuitry (AMSAC) actuation. In addition, the MDAFW pumps will actuate on low-low S/G level in any S/G and the TDAFW pump will actuate on low-low level in any two S/Gs. For this event, actuation of the TDAFW pump resulted from the required logic being met for SGs Number 1 and 4. Based on data obtained subsequent to the reactor trip, an auto start for the TDAFW train was initiated immediately after S/G low-low level setpoints were met.

Subsequent to the initial AFW actuation signal, additional operator action was required to start the 1A-A and 1B-B motor driven pumps. For the Train A MDAFW, the pump did not receive an auto start signal due to the loss of Vital Board 1-I. This resulted from the power for the signal generating circuit being lost with the Vital Board. The evaluation performed to establish the cause for the Train B MDAFW not starting found that the breaker for the pump did not close as required on the automatic signal initiated by the low SG level.

The following actions were taken to determine why the Train B MDAFW breaker did not close for an auto signal.

- The breaker was removed from the cubicle and taken to the test station and cycled seven times successfully.
- The 30RX contacts and 1X contacts were cleaned.
- The TTBB contacts for initiating an auto start for loss of both MFW pumps were jumpered to simulate an actual signal and a successful initiation for the Train B MDAFW pump start followed.
- Both main feedwater pumps were tripped for a planned actuation of all AFW pumps. All AFW pumps successfully started.

Through these tests, the breaker performed as designed. Subsequently, a K-T analysis was performed to further determine the cause for this condition. The K-T analysis developed two possible causes. First is the intermittent failure of the 1X or 30RX relays. There is history of failure for these relays at WBN prior to initial plant startup. The second is a cycling of the SG Low-Low Level trip outputs which energized and de-energized the solid state protection system (SSPS) (EIIS code JE/JG) slave relay contact in the pump start circuit so that a potential "relay race" was created. The result could be a motor lockout condition which would prevent the breaker from closing without operator action. This cycling of the SG level trip output was postulated, based on the available evidence, to be the result of "process noise," i. e., the level measurements cycling around the trip setpoint and reset point. Corrective actions address both potential causes.

III. CAUSE OF THE EVENT

A. Immediate Cause:

The immediate cause of the trip is considered to be the loss of the 1-I Vital AC Inverter which caused the number 1 SG feedwater regulating valve to close.

B. Root Cause:

The root cause of the reactor trip was the failure of the 5 watt resistor R12 on the sensing/current limiting card installed in charger 6-S. This failure was due to a poor termination

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between the resistor element and end cap during fabrication. The failure of the component resulted in the DC output of the charger rising to above system limits. At the time of the failure, Vital Charger 6-S, the standby power source was being placed into service for Vital Inverter 1-I. This high DC output voltage resulted in a high input to inverters 1-I and 2-I. Inverter 1-I input and output fuses were blown, while inverter 2-I continued without failure. This occurred because inverter 1-I is equipped with parallel 5 and 15 KVA constant voltage transformers (CVTs), (EIIS code XPT) which are more sensitive to high input voltage than the type used in inverter 2-I which utilizes a single 20 KVA CVT. The inverters are rated for a maximum input of 140 volts.

C. Contributing Factor:

A contributing cause to this event was that the sequencing contained in Standard Operating Instruction SOI-236.05 tied the charger to the Vital DC Board bus with no immediate verification of proper operation.

IV. ASSESSMENT OF SAFETY CONSEQUENCES

The 125V DC vital power system is composed of four redundant channels (Channels I and III are associated with Train A and Channels II and IV are associated with Train B) and consists of four lead-acid-calcium battery banks, six battery chargers (including two spare chargers), four distribution boards, battery racks and the required cabling, instrumentation and protective features. Each channel is electrically and physically independent from the equipment of all other channels so that a single failure in one channel will not cause a failure in another channel. Each channel consists of a battery charger which supplies normal DC power, a battery for emergency DC power, and a battery board which facilitates load grouping and provides circuit protection. These four channels are used to provide emergency power to the 120V AC vital power system which furnishes control power to the reactor protection system. No automatic connections are used between the four redundant channels.

Battery boards I, II, III, and IV have a charger normally connected to them and also have manual access to a spare (backup) charger for use upon loss of the normal charger. Each vital battery has adequate storage capacity to carry the required load continuously for at least 4 hours in the event of a loss of all AC power (station blackout) without an accident or for 30 minutes with an accident considering a single failure. Load shedding of non-required loads will be performed to achieve the required coping duration for station blackout conditions. Additionally, battery boards I, II, III, and IV have manual access to the fifth vital battery system. The fifth 125 VDC Vital Battery System is intended to serve as a replacement for any one of the four 125 VDC vital batteries during their testing, maintenance, and outages with no loss of system reliability under any mode of operation.

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On Sept 4th, Operations personnel responded to plant conditions by manually tripping the reactor, which initiated a turbine trip. Operators responded in accordance with Emergency Operating Instructions E-0, Reactor Trip; ES-0.1, Reactor Trip Response; AOI-17, Turbine Trip. The action of the operators was consistent with plant protection and the proper control of plant cooldown. There were no safety implications to the public related to the event. The only ESF equipment actuation was an AFW start resulting from the reactor trip. Required plant equipment responded within the design basis, and there were no abnormal radiological conditions throughout the event.

V. CORRECTIVE ACTIONS

A. Immediate Corrective Actions:

The plant was placed into a stable condition in Mode 3. A trip response team was assembled to determine root cause. Appropriate notifications were made in accordance with plant reporting requirements.

Troubleshooting of Vital Battery Charger 6-S determined that the Sensing and Current Limit Board had failed. The failed board was replaced and the charger was successfully load tested. A subsequent failure analysis was performed on the affected board. It was determined that the R12 resistor had failed.

Troubleshooting of Vital Inverter 1-I was performed. The only failed components were blown fuses which were replaced. The fuses blew as designed due to the high output voltages supplied to the inverter from the malfunctioning Vital Batter Charger 6-S.

The AC ripple voltage across the C1 and C6 filter capacitors in Vital Inverter 1-I was evaluated and found to be acceptable.

Reactor Trip Hazard labels have been installed on Vital Battery Chargers.

System Operating Instructions (SOIs) SOI-236.01, "125V Vital Battery Board I," SOI-236.02, "125V Vital Battery Board II," SOI-236.03, "125V Vital Battery Board III," SOI-236.04, "125V Vital Battery Board IV," SOI-236.05, "125V Vital Battery Board V," were revised to have AC input breaker closed and DC output checked before closing DC output breakers.

The Vital Battery Chargers 6-S and 7-S have been operated unloaded for seven days to provide additional assurance of the functionality of the sensing and current limit boards.

Operations management re-emphasized to their staff the requirements in SPP-8.1 that; all effected organizations should be included in the prejob briefing (note: would not have impacted event), the initial conditions of the equipment are to be known prior to manipulation of the equipment, and the operators should be cognizant of the normal operating parameters of equipment prior to manipulating controls and to always ensure that the equipment functions within expected parameters before proceeding to the next step in the instruction.

For the auxiliary feedwater system condition, both MDAFW pump's start circuitry was modified to incorporate a SG Low-Low level circuit seal-in to enhance reliability of the MDAFW pumps to start with a signal is received.

B. **Corrective Actions to Prevent Recurrence:**

These following actions are tracked under TVA's corrective action program and therefore not consider to be regulatory commitments.

The addition of high voltage cutout relays on the chargers will be evaluated.

System 236 maintenance procedures are being reviewed to ensure appropriate cautions and integration and the system 236 SOIs exist.

AOI-25.01 will be revised to address additional loads lost and control system response upon recovery from Vital Inverter 1-I during this event.

For the auxiliary feedwater system condition, the 30 RX and 1X relays are being replaced for each MDAFW pump.

VI. ADDITIONAL INFORMATION

A. **Failed Components:**

The root cause of the reactor trip was the failure of the 5 watt resistor R12 on the sensing/current limiting card installed in charger 6-S. This failure was due to a poor termination between the resistor element and end cap during fabrication. The failure of the component resulted in the DC output of the charger rising to above system limits.

Power Conversion Products (PCP), was contacted on September 5, 2001, in regard to the failed PCP sensing and sensing/current limiting card. The significant information pertaining to the cards that was obtained during the conversation is as follows:

- The cards are widely used.

- PCP is not aware of any abnormal failure history.
- Failure of new cards is very rare.
- Some of the cards have been in use for 25 years or longer without failing.
- The card is most likely to fail while being placed in service as opposed to after the card has been in service for a period of time.
- In service failures are most likely to occur in the first couple of days of operation.
- The chargers that have been in service for several weeks/months require no additional testing. The fact that the outputs are stable indicate proper operation.

Therefore, based on the above information, no additional action was necessary to test the sensing/current limiting cards in the in-service chargers. However, since the other standby charger 7-S had this card recently replaced and is the same age as the card that failed in the 6-S charger, a corrective action for this event was added to further test this card in the 7-S charger. Upon test of this card in the 7-S charger, it also failed due to the same resistor failure that occurred on the 6-S card. Both of the sensing and current limit boards that failed were from the same lot that were manufactured in the year 2000. Watts Bar received five total boards from this lot including the two that failed. One each of theses boards is located in Spare Vital Battery Chargers 6-S and 7-S and the fifth is located in the warehouse. As a result for the two failures from the same lot, new boards have been procured from the vendor with the specification for additional testing. After receiving the new boards, the old boards will be replaced and returned to the vendor. (This action is tracked under TVA's corrective action program and therefore is not consider to be a regulatory commitment.)

B. Previous LERs on Similar Events:

The manual reactor trip detailed in this report was necessary due to an impending loss of feedwater level to SG No. 1. This feedwater transient was caused by a loss of I-1 Vital Inverter. A review of the previous WBN Licensee Event Reports (LERs) for any events associated with a Vital Board/Battery Charger identified only LER 1999-006, dated August 24, 1999. This event occurred on July 27, 1999, with Unit 1 in Mode 1 and operating at approximately 100 percent reactor power. At this time, Operations personnel identified that battery charger 6-S was being supplied from an A train AC source while it was configured to supply battery board II, a B train board. This event did not involve any failed equipment or result in a reactor trip.

C. Additional Information:

None

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D. **Safety System Functional Failure:**

This event is not considered a safety system functional failure in accordance with NEI 99-02 in that the TDAFW pump could provide sufficient AFW flow for the event, and therefore, the functional capability of the overall system was not jeopardized.

E. **Loss Of Normal Heat Removal Consideration:**

This event did not result in loss of normal heat removal capability.

VII. COMMITMENTS

None.