NRC FORM 366 (4-95) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB NO. 3150-0104
EXPIRES 04/30/98

ESTIMATED BURDEN PER RESPONSE TO COMPLY WITH THIS MANDATORY INFORMATION COLLECTION REQUEST: 50.0 HRS. REPORTED LESSONS LEARNED ARE INCORPORATED INTO THE LICENSING PROCESS AND FED BACK TO INDUSTRY. FORWARD COMMENTS REGARDING BURDEN ESTIMATE TO THE INFORMATION AND RECORDS MANAGEMENT BRANCH (T-6 F33), U.S. NUCLEAR REGULATORY COMMISSION, WASHINGTON, DC 20555

LICENSEE EVENT REPORT (LER)

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

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Browns Ferry Unit 3	05000296	1 OF 8

TITLE (4)

Loss of Offsite Power on Unit 3 During Refueling Outage Resulting From a Shorted Component

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
03	05	97	97	-- 001 --	00	04	04	97	NA	
									FACILITY NAME	DOCKET NUMBER
									NA	

OPERATING MODE (9)	N
POWER LEVEL (10)	000

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more) (11)

	20.2201(b)		20.2203(a)(2)(v)		50.73(a)(2)(i)		50.73(a)(2)(viii)
	20.2203(a)(1)		20.2203(a)(3)(i)		50.73(a)(2)(ii)		50.73(a)(2)(x)
	20.2203(a)(2)(i)		20.2203(a)(3)(ii)		50.73(a)(2)(iii)		73.71
	20.2203(a)(2)(ii)		20.2203(a)(4)	X	50.73(a)(2)(iv)	X	OTHER
	20.2203(a)(2)(iii)		50.36(c)(1)		50.73(a)(2)(v)		Specify in Abstract below or in NRC Form 366A
	20.2203(a)(2)(iv)		50.36(c)(2)		50.73(a)(2)(vii)		

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER (Include Area Code)
Steven W Austin, Licensing Engineer	(205) 729-2070

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

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS		CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS

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)

On March 5, 1997, at 1040 hours Central Standard Time, (CST) Unit 3 received engineered safety feature system actuations due to a loss of offsite power. The loss of power was the result of the loss of both the Athens and Trinity 161 KV power lines. Emergency Diesel Generators 3A, 3C, and 3D automatically started and tied to their respective shutdown boards. At 1122 hours CST, BFN declared a Notification of Unusual Event (NUE) for Unit 3 due to a loss of offsite power greater than 15 minutes and notified NRC in accordance with 10 CFR 50.72(a)(3). At 1136 hours CST, following the restoration of the offsite power to Unit 3, BFN terminated the NUE, and in accordance with 10 CFR 50.72 (c)(1)(iii) notified NRC. The root cause of this event was the sensitivity of the auxiliary tripping relays. TVA has replaced the relays involved in the event with less sensitive relays. TVA is currently replacing other Westinghouse AR type relays in similar applications with less sensitive relays. This event is being reported accordance with 10 CFR 50.73 (a)(2)(iv), as any event or condition that resulted in manual or automatic actuation of any engineered safety feature including the reactor protection system.

FACILITY NAME (1)	DOCKET	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
Browns Ferry Unit 3	05000296	97 --	001 --	00	2 of 8

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

I. PLANT CONDITIONS

Unit 1 was shutdown and defueled. Unit 2 was at 100 percent power (3290 megawatts thermal) and unaffected by the event. Unit 3 was shutdown in a scheduled refueling outage with the reactor head removed. The refueling cavity was flooded and the fuel gates were removed. No fuel movement was ongoing at the time of the event and the control rods [AA] were fully inserted. The Unit 3 500 KV [EL] Transformer Bank was out of service for planned maintenance, so it was relying on the 161 KV [EL] power system for offsite power.

II. DESCRIPTION OF EVENT

A. Event

On March 5, 1997, at 1040 hours Central Standard Time (CST), Unit 3 received engineered safety feature system actuations (ESF) [JE] due to a loss of offsite power. The loss of power was the result of the loss of both the Athens and Trinity 161 KV power lines. This was followed by the start of Emergency Diesel Generators (EDGs) [EJ].

At approximately 1039 hours CST, following initial installation of an Emergency Bearing Oil Pump [P][SL] for the 3B Reactor Feed Pump [SJ], as part of a Feedwater System upgrade, the pump was successfully electrically bumped to verify correct pump rotation. Following successful verification of pump rotation, the pump was given a start signal. Within a few seconds it became visually apparent that an electrical fault had occurred within the pump motor [MO], and it was shutdown from a local panel.

At 1040 hours CST, due to the fault in the pump motor, the Athens and Trinity 161 KV power lines tripped resulting in a loss of offsite power to Unit 3. Emergency Diesel Generators 3A, 3C, and 3D automatically started and tied to their respective shutdown boards. Emergency Diesel Generator 3B and its respective shutdown board was under administrative hold for planned maintenance activities and did not respond to the event. Additionally, the loss of offsite power resulted in the Unit 3 reactor scram signal and the initiation of several unplanned ESF actuations. This included de-energization of the Unit 3 Reactor Protection System (RPS) [JC]. The loss of RPS resulted in actuation or isolation of the Primary Containment Isolation System [JE] (PCIS) systems/components.

- PCIS Group 1, Main Steam Line Drain Isolation Valve [SB] [ISV] close signal
- PCIS Group 2, Shutdown cooling mode of Residual Heat Removal [BO] system; Drywell floor drain isolation valve, Drywell equipment drain sump isolation valve [WP]

- PCIS Group 3, Reactor Water Cleanup [CE]
- PCIS Group 6, Primary Containment Purge and Ventilation [JM]; Unit 3 Reactor Zone Ventilation [VB]; Refuel Zone Ventilation [VA]; Standby Gas Treatment (SGT) [BH] system; Control Room Emergency Ventilation (CREV) [VI]
- PCIS Group 8, Transverse Incore Probe [IG] withdrawal signal

Additionally, the Spent Fuel Pool Cooling System [DA] Pumps tripped on undervoltage.

The affected systems were returned to pre-event alignment by 1138 hours CST. All systems responded as expected during the loss of offsite power and subsequent reactor scram signal.

This event is reportable in accordance with 10 CFR 50.73 (a)(2)(iv), as any event or condition that resulted in manual or automatic actuation of any engineered safety feature including the reactor protection system.

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

During the event, the Unit 3 Main Bank 500 KV Transformer was out of service for planned maintenance, and Unit 3 was relying on the 161 KV power lines for offsite power. Had the Unit 3 Main Bank 500 KV Transformer been in service during the event, the loss of the 161 KV power lines would not have resulted in the loss of offsite power to Unit 3.

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

March 5, 1997 at 1040 CST	Unit 3 experienced a loss of offsite power resulting in a full reactor scram signal.
March 5, 1997 at 1122 CST	TVA declared a Notice of Unusual Event (NUE) on Unit 3 due to a loss of offsite power. TVA made a one hour notification in accordance with 10 CFR 50.72(a)(3).
March 5, 1997 at 1131 CST	TVA made a 4 hour nonemergency notification to NRC in accordance with 10 CFR 50.72(b)(2)(ii).

March 5, 1997 at 1136 CST — Following successful restoration of offsite power, TVA terminated the NUE. Follow-up notification for termination of the NUE was made in accordance with 10 CFR 50.72 (c)(1)(iii).

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

None.

E. **Method of Discovery:**

The Unit 3 operator received numerous main control room alarms indicating the loss of the 161 KV Athens and Trinity power lines. This was followed by indications that a full reactor scram signal had been generated, and EDGs 3A, 3C, and 3D had started and tied to their respective shutdown boards.

F. **Operator Actions:**

Operator actions taken during this event were as expected. Operations responded to the loss of offsite power to Unit 3 using the applicable portions of Abnormal Operating Instructions 0-AOI-57-1A; Loss of Offsite Power (161 And 500 KV)/Station Blackout, 3-AOI-99-1; Loss Of Power to One RPS Bus, 3-AOI-100-1; Reactor Scram and Emergency Plan Implementing Procedure (EPIP), EPIP-1, Emergency Classification Procedure.

G. **Safety System Responses:**

The safety systems listed in section IIA of this report responded to the loss of offsite power as designed.

III. CAUSE OF THE EVENT

A. **Immediate Cause:**

The loss of offsite power and subsequent scram were initiated by a failure of a conductor in the Emergency Bearing Oil Pump for the 3B Reactor Feed Pump. The conductor came in contact with the rotor in the motor thus causing a ground fault in a 250 volt Non-1E direct current (VDC) [EI] circuit.

The failure was the result of poor craftsmanship. An individual [contract, electrician] terminating the power leads for the 3B Reactor Feed Pump Emergency Bearing Oil Pump did not exhibit due care in his work. After terminating the power feed conductors to the motor conductors, the individual replaced them into the motor housing.

This type of motor does not have a termination box, and the conductors are normally terminated and then placed back in the motor housing. In placing the conductors back in the housing, the electrician allowed one of the conductors to be placed into the rotor portion of the motor. Subsequently, when the motor was started, the resulting contact of the conductor with the rotor severed the conductor causing a ground in the motor power circuit.

The motor involved in the event is a 7.5 horsepower 250 VDC motor. During the event, no breaker tripped or fuse cleared as a result of the ground fault. TVA determined analytically that a fault current of approximately 450 amps for 0.2 seconds occurred. Under these conditions, this is an expected response.

B. Root Cause:

The root cause of this event was the sensitivity of the auxiliary tripping relays [94]. These relays, (Westinghouse AR type) are 250 VDC fast acting relays used as tripping relays in the circuits involved in this event.

TVA's investigation into this event has determined that based on vendor information Westinghouse AR type relay can operate in approximately 2 milliseconds at current as low as 20 milliamperes. The relay can operate due to transient current flow caused by a ground on a circuit with long cable runs where capacitance has developed which can discharge through ground.

Initially personnel responding to the event found no indication of protective relay [94] operation. Furthermore, there was no indication that the protective relays that would normally operate due to a fault on the 161 KV system had operated. However, upon further investigation, lockout relays were found tripped at the cooling tower switchgear. Personnel found the ground switches in the 161 KV switchyard for both the Athens and the Trinity lines closed indicating the auxiliary tripping relays had operated and the main breakers open.

C. Contributing Factors:

Circuit capacitance of the field cables contributed in the event. TVA believes that the relay actuation occurred because of the ground in the 3B Reactor Feed Pump Emergency Bearing Oil Pump motor resulting in a transient voltage to actuate the auxiliary relays. TVA developed an equivalent circuit of the schematic and modeled the circuit utilizing computer software. By simulating the event, TVA found that this type of relay would actuate with a ground at the 3B Reactor Feed Pump Emergency Bearing Oil Pump motor followed by separation of the motor conductor.

The computer simulation indicated that the current that caused relays to operate was through the capacitance to ground in long field cables (approximately 2000-4500 feet) into the grounded 3B Reactor Feed Pump Emergency Bearing Oil Pump motor conductor through the motor field inductance (field, armature or both) and through the relay coil. The capacitance to ground discharged when the grounded motor leads separated which resulted in a voltage spike on the control circuit causing the operation of four AR type relays. TVA has determined based on field testing that the minimum operating voltage for this type of relay is 59 volts DC.

Additionally, TVA has found that a transient on one 250 non-1E VDC circuit has the potential to trip both the Athens and Trinity 161 KV power lines. The motor that failed was powered from battery board 4, the same battery board that supplied control power to the Athens and Trinity protective relays. The failed motor conductor placed a ground on the battery board, resulting in a transient which operated protective relays.

This operation resulted in the loss of both the Athens and Trinity 161 KV power lines and operation of two 500 KV power circuit breakers. The operation of the two 500 KV power circuit breakers had no impact on plant operation.

IV. ANALYSIS OF THE EVENT

Browns Ferry is analyzed in Chapter 14 of the Updated Final Safety Analysis Report for a loss of offsite power assuming a starting point of greater than 100% reactor power. In this instance, the loss of offsite power occurred while Unit 3 was in scheduled refueling outage. Consequently, this event had minimal impact on Unit 3 and no impact on Unit 2 operation. Additionally, affected components functioned as designed. Thus, this event is bounded by the plant safety analysis and had no impact on the safety of the plant, its personnel, or the public.

V. CORRECTIVE ACTIONS

A. Immediate Corrective Actions:

Offsite power was restored to Unit 3. Other affected systems were returned to their pre-event status. The motor was inspected and meggered to verify no internal damage. The motor conductors were reterminated and the pump successfully operated.

Modifications activities associated with DC pump motor installation was stopped. TVA Modifications Management met with the appropriate craft personnel to discuss the event, emphasizing the significance of the event, reinforcing safety and quality craftsmanship.

FACILITY NAME (1)	DOCKET	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
Browns Ferry Unit 3	05000296	97	-- 001	-- 00	7 of 8

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

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

TVA has replaced the relays that were involved in the loss of offsite power with less sensitive relays. TVA is currently replacing the Westinghouse AR type relays in similar applications with less sensitive relays.

TVA will evaluate the current 161 KV and 500 KV protective relay functions for possible design changes[1].

VI. ADDITIONAL INFORMATION

A. **Failed Components:**

None.

B. **Previous LERs on Similar Events:**

LER 259/85003 discusses an event in which a perturbation on a non-1E 250 VDC power system actuated relays and resulting in start of EDGs. On February 5, 1985, during functional testing of the protective relays for the Unit 2 Station Service Transformers [XPT] and Main Generator [GEN], a voltage spike was generated when connecting test equipment which resulted in the operation of high speed tripping relays. This resulted in the tripping of the both 161 KV lines (two 500 KV Power Circuit Breakers) and a brief undervoltage condition on Shutdown Boards C and D. This resulted in Units 1 and 2 EDGs C and D starting. Because the undervoltage condition was brief, the EDGs did not tie to the Shutdown Boards.

The cause of this event was attributed to the 250 VDC battery board bus filter being inoperable. The investigation team was able to repeat the event with the battery board bus filter inoperable. However, with the 250 VDC battery board bus filter operable, the voltage spike would not actuate the relays. The Westinghouse AR type fast acting relays could have contributed in this event. An evaluation of the relays was performed to see if they need replacement or desensitized. This evaluation resulted in a design change request that was not implemented. Based on the cause and contributing factors of this event, TVA determined BFN could be safely operated without replacement of these type relays.

---

1 TVA does not consider this corrective action a Regulatory Commitment. TVA's corrective action program will track completion of the action.

FACILITY NAME (1)	DOCKET	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
Browns Ferry Unit 3	05000296	97	-- 001	-- 00	8 of 8

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

VII. COMMITMENTS

TVA will complete the replacement of the Westinghouse AR type relays in similar applications with less sensitive relays by June 1, 1997.

Energy Industry Identification System (EIIS) system and component codes are identified in the text with brackets (e.g., [XX]).