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FACIL:50-251 Turkey Point Plant, Unit 4, Florida Power and Light C 05000251
AUTH.NAME AUTHOR AFFILIATION
MOWREY,C.L. Florida Power & Light Co.
PLUNKETT,T.E. Florida Power & Light Co.
RECIP.NAME RECIPIENT AFFILIATION

SUBJECT: LER 94-004-00:on 940923,Unit 4 tripped automatically from rated power.Caused by faulty regulator transistor.Faulty backup power supply replaced & maint history for power supplies reviewed.W/941021 ltr.

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PRIORITY 1 DOCUMENT

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OCT 21 1994

L-94-245
10 CFR 50.73

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D. C. 20555

Gentlemen:

Re: Turkey Point Unit 4
Docket No. 50-251
Reportable Event: 94-004-00
Automatic Reactor Trip Due to Loss of Power to Rod Control Cabinet 1AC

The attached Licensee Event Report 251/94-004-00 is being provided in accordance with 10 CFR 50.73(a)(2)(iv).

If there are any questions, please contact us.

Very truly yours,

T. F. Plunkett
Vice President
Turkey Point Plant

TFP/CLM/cm

enclosure

cc: Stewart D. Ebneter, Regional Administrator, Region II, USNRC
Thomas P. Johnson, Senior Resident Inspector, Turkey Point Plant, USNRC

IE22
1/1

LICENSEE EVENT REPORT (LER)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
TURKEY POINT UNIT 4	05000251	1 OF 5

TITLE (4) AUTOMATIC REACTOR TRIP DUE TO LOSS OF POWER TO ROD CONTROL CABINET

EVENT DATE (5)			LER NUMBER(6)			RPT DATE (7)			OTHER FACILITIES INV. (8)	
MON	DAY	YR	YR	SEQ #	R#	MON	DAY	YR	FACILITY NAMES	DOCKET # (S)
09	23	94	94	004	00	10	21	94		

OPERATING MODE (9)	1
POWER LEVEL (10)	100%

10 CFR 50.73(a)(2)(iv)

LICENSEE CONTACT FOR THIS LER (12)

	TELEPHONE NUMBER
C. L. Mowrey, Operating Experience Feedback Engineer/Analyst	305-246-6204

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

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	NPRDS?	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	NPRDS?
B	AA	RJX	L045						

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

ABSTRACT (16)

On September 23, 1994, Unit 4 tripped automatically from 100% rated power. Personnel working in the 4C 4160 VAC bus switchgear inadvertently caused a bus lockout, resulting in a loss of the backup power supply to the rod control system. The normal power supply to the 1AC rod control cabinet (already degraded), also failed, and 12 rods dropped. The resultant pressure drop and negative flux difference lowered the OTΔT setpoint below actual ΔT, and the reactor tripped on OTΔT.

The C bus lockout was caused by the jarring of a differential relay, due to an interference between a breaker cubicle door and the wall of the switchgear room. The backup power supply failure was due to a faulty regulator transistor.

The reactor trip on OTΔT progressed as expected, and therefore did not impact the health and safety of the public.

The faulty backup power supply was replaced, and 15 similar power supplies were inspected. Maintenance history for the power supplies was reviewed. Replacement power supplies are being evaluated. The interference between the cubicle door and the wall is being removed. The differential relays, as well as others with the potential to cause a spurious bus lockout, are being relocated off the cubicle doors.

I. DESCRIPTION OF THE EVENT

On September 23, 1994, Florida Power & Light Company's (FPL) Turkey Point Unit 4 was running at 100% reactor power. Three FPL electricians (non-licensed utility personnel) were performing an 18 month inspection of breaker 4AC01 in the 4C 4160 VAC (non-vital) bus switchgear [EA:swgr, brkr]. Several times throughout the day, the electricians opened and closed the breaker cubicle door, accessing the cubicle to use DC power for testing. Care was taken with the door operations, and no events occurred. At about 2:47 p.m., a relay was jarred when they closed the door to cubicle 4AC01, generating a C bus lockout signal. Power was lost to the C bus loads, among them one of two auctioneered power supplies to the Rod Control System power cabinets [AA:cab, rjx]. Twelve rods dropped into the core, and an Overtemperature Delta-T (OTΔT) reactor trip was generated. The remaining rods tripped as expected.

With three exceptions, all plant equipment functioned as designed on the reactor trip. The 4A steam dump to atmosphere, valve CV-4-1606 [SB:pcv], should have opened automatically when the turbine tripped. The valve would not open in Automatic or in Manual, due to a leaking fitting. Relief valve RV-4-1418 [SJ: rv] opened as expected, but did not reseat. This valve relieves from the condensate header to the 4A steam generator feedwater pump. Turbine drain valve CV-4-3717 [SM: lcv] did not open automatically as it should have on the turbine trip.

The NRCOC was notified at 1603 on September 23, 1994. This event is being reported in accordance with 10 CFR 50.73(a)(iv), as an automatic actuation of the reactor protection system.

II. CAUSE OF THE EVENT

The immediate cause of the reactor trip was a lowering of the OTΔT trip setpoint to the actual core Δt, due to (1) the drop in Reactor Coolant System (RCS) [AB] pressure caused by the reduction in reactor power below turbine power, and (2) the large axial power imbalance (negative ΔI) caused by the dropped rods.

The intermediate cause of the trip was loss of both power supplies to the 1AC Rod Control Power Cabinet, resulting in the drop of all rods whose control rod drive mechanisms were controlled by the 1AC power cabinet. In each power cabinet, power supplies PS-1 and PS-2 are auctioneered together to provide 24 VDC to the power cabinet controls. Power supplies PS-3 and PS-4 are auctioneered together to provide -24 VDC to the power cabinet controls. PS-1 and PS-3 are fed from the Rod Drive Motor Generator set output. PS-2 and PS-4 are fed (ultimately) from the C bus.

The cause of the loss of the normal power to the 1AC cabinet was a faulty internal -24 VDC power supply. Power supply PS-3 in Cabinet 1AC was found at approximately -21 VDC when in parallel with PS-4 (both powered). When PS-4 was depowered (as it was when the C bus was lost), PS-3 was loaded and the output of PS-3 dropped to approximately -5 VDC. This shows that PS-4 was carrying the -24 VDC load during normal operation. Note that PS-3 was therefore running unloaded during normal operation, with PS-4 carrying the load. The unloaded -21 VDC output of PS-3 was not low enough to trigger the non-urgent failure alarm circuit in the Rod Control system. Normally this alarm would be triggered in the event of a failure of either of the two auctioneered power supplies.

When the 4C 4KV bus tripped, PS-4 was deenergized. PS-3 was supposed to pick up the load but dropped to approximately -5 VDC when loaded. This caused the -24 VDC normally supplied to the cabinet's five regulation cards to drop unacceptably low. As three of the five regulation cards are used to control the stationary gripper coils of twelve control rods, loss of the power supply caused the stationary gripper coils to deenergize, at which point the twelve control rods dropped into the core.

The root cause of the faulty power supply PS-3 was determined to be a faulty series regulator transistor, and appears to be an end-of-life failure. Sixteen of these power supplies are in use. Review of the maintenance history for the power supplies indicates one or two previous similar failures. Replacement power supplies with higher reliability are being evaluated.

The cause of the loss of normal power to the 1AC cabinet was a loss of the 4C bus as a result of the inadvertent actuation of the 187 4CBT1 Cø differential relay, when the door to breaker cubicle 4AC01 was bumped against a protruding bolt head.

The root cause of the jarring of the relay was inadequate clearance between the cubicle door and the wall of the switchgear room. When the Event Response Team evaluating the loss of the C bus entered the switchgear room and opened the 4AC01 cubicle door, contact was observed between the door and the west wall of the room. The switchgear room is built of a single sheet of stainless steel. The contact was with an overlap joint of the wall, and with a protruding bolt head on the overlap joint. The contact did not "torque" the door, but could cause sufficient jarring to actuate the relay. The team also noticed that the west wall, left of the door, was too hot to touch, while the right side of the door (where the 4AC01 cubicle is) was only warm. The sun had moved and the structures west of the 4C bus were shading the right side of the wall. It is probable that earlier, with direct sun on the right wall, the hotter right side would expand inward and cause binding of the door. If so, this effect would explain why door movements earlier in the day had not resulted in an event. The protruding bolt head described above was on a recently installed bolt, installed when the C bus switchgear was refurbished during the last refueling outage. The interference between the bolt head and the cubicle door was not recognized, although the sensitivity of the relays to jarring was known and publicized via signs on the switchgear cubicle warning of the consequences of jarring the relays. The signs were posted following a similar reactor trip about ten years ago, also caused by interference between the cubicle door and a protrusion.

III. ANALYSIS OF THE EVENT

Although a multiple control rod drop is not an event specifically analyzed in the Turkey Point Updated Final Safety Analysis Report, a single rod drop is analyzed, with two possible rod worths. These analyses show that a dropped rod worth 600 pcm will result in an equilibrated plant at about 84% power in about 75 seconds, whereas a dropped rod worth 75 pcm is expected to result in an OTΔT reactor trip in about 83 seconds. The OTΔT trip results from reactor power (and therefore ΔT) gradually increasing above turbine power, so that the OTΔT setpoint is reached.

In the event described in this report, the OTΔT setpoint dropped faster than the actual ΔT changed, when more than one quarter (12 of 45) control rods dropped into the core. The immediate suppression of flux into the bottom of the core caused the axial flux difference (ΔI) to become very negative. An axial power imbalance imposes a "penalty" on the OTΔT setpoint, because the setpoint is predicated on a relatively uniform axial power distribution. Simultaneously, the immediate drop in reactor power without a concurrent drop in turbine power resulted in a drop in RCS pressure as Tavg dropped. Decreasing pressure also imposes a penalty on the OTΔT setpoint, because lowering pressure lowers the reactor coolant boiling point, thereby increasing the potential for departure from nucleate boiling. The combination of penalties from the drop in RCS pressure and the large negative ΔI resulted in the OTΔT setpoint and the actual ΔT converging in about 2 seconds, resulting in the reactor trip.

The scenario described above is a specific application of the purpose for which the OTΔT reactor trip was designed, and it functioned as designed.

IV. CORRECTIVE ACTIONS

1. Plant response to the reactor trip was verified to be as predicted, using the emergency operating procedures.

2. Relief valve RV-4-1418 was replaced, and steam dump valve CV-4-1606 was repaired. The other steam dump valves were checked for similar problems; none were found.

3. Work Request # 94014247 was written to have CV-4-3717 repaired during the present refueling outage.

4. The operation of the C bus breaker cubicle doors was investigated along with any interference with the floor or walls. The only interference found was between the cubicle door and the west wall of the switchgear enclosure.

5. The AC portion of the phase differential relay (all three phases), along with the associated current transformers, was inspected. No problems were found.

6. The C bus was reenergized after the phase differential relay and the lockout were reset.

7. The differential relays will be checked during the present refueling outage to determine the amount of spring tension necessary to actuate the target relays on all three phases.

8. Clearance tags were hung on the breaker cubicle doors 4AC01 and 3AC01 to prevent them from being opened without permission of the Plant General Manager.

9. The 4C switchgear side heating and resultant warpage will be investigated during the refueling outage, with consideration for increasing the clearance between cubicle doors and the outer skin.

10. The phase differential relays, and other relays which can initiate a spurious bus lockout are being relocated off the breaker cubicle doors.

11. The faulty PS-3 power supply in rod control power cabinet 1AC was replaced, and the root cause has been determined. A determination will be made if periodic replacement of the power supply or its components is warranted. Replacement power supplies are being evaluated.

12. The maintenance history for the sixteen rod control power cabinet power supplies was reviewed; evidence was found of one or two similar failures. The other fifteen power supplies were inspected; none showed signs of failure.

V. ADDITIONAL INFORMATION

EIIS Codes are shown in the format [EIIS SYSTEM: IEEE component function identifier, second component function identifier (if appropriate)].

The failed power supply is manufactured by Lambda Electronics, with an expected mean time between failure, as defined by Lambda, of approximately five years.