CATEGORY

REGULATORY INFORMATION DISTRIBUTION SYSTEM (RIDS)

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FACIL:50-250 Turkey Point Plant, Unit 3, Florida Power and Light C 05000250

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SUBJECT: LER 96-010-00:on 960924,manual reactor shutdown occurred. Due to multiple ROD drops.2AC power cabinet DC power supplies,CRDMs cabling & connectors,F-12 & K-4 output fuses were checked.W/961022 ltr.

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FPL

OCT 22 1996

L-96-264
10 CFR 50.73

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

Re: Turkey Point Unit 3
Docket No. 50-250
Reportable Event: 96-010
Manual Reactor Shutdown due to Multiple Rod Drops

The attached Licensee Event Report 250/96-010 is being provided in accordance with 10 CFR 50.73(a)(2)(i)(A).

If there are any questions, please contact us.

Very truly yours,

R. J. Hovey
Vice President
Turkey Point Plant

CLM

attachment

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 3	05000250	1	OF	9

TITLE (4) MANUAL REACTOR SHUTDOWN DUE TO MULTIPLE ROD DROPS

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	24	96	96	010	00	10	22	96		

OPERATING MODE (9)	1	10 CFR 50.73(a)(2)(i)(A)
POWER LEVEL (10)	100	

LICENSEE CONTACT FOR THIS LER (12)

	Telephone Number
C.L. MOWREY, COMPLIANCE SPECIALIST	(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	RG	W120	Y					
B	IG	DET	W120	Y					

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

ABSTRACT (16)

On September 24, 1996, at about 0255, control rod F-12, in Control Bank C Group 2, dropped for no apparent reason. Fifteen minutes later, a second rod in Control Bank C Group 2 dropped (rod K-4). Power was reduced by ramping down the turbine generator and borating the reactor coolant system. After the unit was off line, unit shutdown was completed by fully inserting all rods.

The cause of the event was a failed Rod Control System regulation card in the 2AC power cabinet. The failure appears to be random. Plant parameters related to the dropped rods responded as expected; the health and safety of the public was not affected.

The failed card and other suspect cards have been replaced. Additional cooling in the power cabinets, and in the room, is being evaluated. The set point for the room high temperature alarm will be lowered; the thermostat for the room has been lowered.

The NRC Operations Center was notified at 0352 on September 24, 1996, in accordance with 10 CFR 50.72 (b)(i)(A), Initiation of a Shutdown Required by Technical Specifications.

I. DESCRIPTION OF THE EVENT

On September 24, 1996, FPL's Turkey Point Unit 3 was operating in Mode 1 at 100%. At about 0255, control rod F-12 [AA:rod], in Control Bank C Group 2, dropped for no apparent reason. Rod F-12 was fully inserted with no indication of binding or ratcheting. No rod movement was in progress at the time.

Fifteen minutes later, while taking action as directed by the off-normal procedure for a dropped rod, a second rod in Control Bank C Group 2 dropped (rod K-4). Rod Position Indication [IU:zi] for Rod K-4 was observed to exhibit some oscillations near 228 steps, then Rod K-4 fell with no observable binding or ratcheting. No alarms were received for this rod drop.

Turkey Point procedures allow the recovery of one or two dropped rods; if three or more rods drop, a reactor trip is required. Since the cause of the two rod drops was not immediately apparent, the decision was made to shut down the unit. Power was reduced by ramping down the turbine generator [TB:tg] and borating the reactor coolant system [AB]. After the unit was off line, unit shutdown was completed by fully inserting all rods.

As power was reduced, two additional problems were noted:

1. Intermediate range [IG] channel N-36 was observed to be reading low at 10E-11 amps, and Intermediate range channel N-35 was holding at 1-E-5 amps. Both intermediate range channels should have tracked the power reduction to about 10E-10 amps. Both channels were declared out of service.

2. Steam flow indication [JB:fi] on the 3A steam generator [SB:sg] was observed to be very erratic at low load (less than 150 MWe). 3A main feedwater regulating valve [JB;:fcv] oscillations were observed, and the Reactor Control Operator took manual control of the valve earlier than is usually necessary during a unit shutdown.

Unit 3 was stabilized in Mode 3 (Hot Standby). Unit 3 was returned to service on September 27, 1996. The NRC Operations Center was notified at 0352 on September 24, 1996 as required by 10 CFR 50.72 (b)(i)(A), Initiation of a Shutdown Required by Technical Specifications.

II. SYSTEM DESCRIPTION

The Rod Cluster Control Assemblies (RCCAs or rods) are used to add negative reactivity to the reactor core. During reactor startup, RCCAs are withdrawn from the reactor core. To shut down the reactor, RCCAs are inserted into the core. There are 45 RCCAs. In addition to the rods, reactivity is also controlled by controlling the boric acid concentration in the reactor coolant system.

RCCA movement is effected through the use of a Control Rod Drive Mechanism (CRDM). Each RCCA has an associated CRDM, located on the reactor head. The CRDM is used to position the rod within the core. The CRDM uses magnetic forces to lift and hold the rod. To move the RCCA up or down, one step at a time, the Rod Control System sequentially energizes and de-energizes three coils in the CRDM. The three coils are the stationary gripper, the moveable gripper and the lift coil. To hold the RCCA in place, the system maintains a current through the stationary gripper coil.

The Rod Control System is a solid state electronic control system located in the 3B Motor Control Center (MCC) Room. It consists of four power cabinets, one logic cabinet, and a DC hold cabinet. The logic cabinet generates current regulating signals which are used by the power cabinets, based upon the speed, direction and selected bank control input signals. The power cabinets generate and deliver power to the CRDM coils, based upon the signals received from the logic cabinet. Power to the system is delivered via the Reactor Trip Breakers from the motor-generator sets located in the cable spreading room.

The forty-five CRDMs are divided among the four power cabinets. Each cabinet supports three groups of CRDMs. Only one group may be moved at a time while the other groups are held stationary. Dropped rods F-12 and K-4 belong to Control Bank C group 2, which is powered by the 2AC cabinet. The 2AC cabinet powers 12 rods in all. Four rods are in Control Bank A group 2, four rods are in Shutdown Bank A group 2, and four are in Control Bank C group 2. Only two of the four rods in Control Bank C group 2 dropped.

For a rod to fall, the stationary gripper mechanism must release its grip on the RCCA lead screw. To do this, the magnetic forces generated by the gripper coil must fall below the gripper opening spring force. The magnetic force generated by the coil is directly proportional to the current in the coil. It is therefore reasonable to assume that the rods dropped because sufficient stationary current was not maintained for rods F-12 and K-4.

The stationary current for each rod group is generated in the power cabinet by three Silicon Controlled Rectifiers (SCRs). These SCRs rectify three phase AC power and supply each CRDM stationary gripper coil with 4.4 amps to hold, or 8 amps to engage (when stepping). The SCRs are gated by the firing card, which is in turn controlled by the phase control card. The phase control card receives an error signal from the regulation card and senses the phase relationship of the three phase AC input power. The regulation card senses the stationary coil currents and compares these signals to a reference signal developed by the regulated 24 Vdc power supply. The resulting error signal is sent to the phase card, which controls the gating of the SCRs at the proper time in the AC cycle to control the current applied to the stationary coil. Rod groups not selected for movement are held at a minimum current level of 4.4 amps.

III. CAUSE OF THE EVENT

The cause of the event has been determined to be a failed Rod Control System regulation card in the 2AC power cabinet. The firing card, regulation card, and phase control cards were returned to Westinghouse for dynamic testing. When subjected to moderate heating (85°F), as would be expected in normal service, the regulation card failed. The failure was isolated to the auctioneering differential amplifier section of the card. This resulted in an error signal of insufficient magnitude. The error signal is used by the phase control card to determine when to gate the SCRs to control the current applied to the stationary gripper coil. A reduced error signal would cause a lower than normal current to be applied to the stationary gripper coil. A sufficiently low stationary current would permit a rod to drop. This failure mode is consistent with the dropped rod scenario in that it resulted in the inability to properly regulate stationary gripper currents.

Testing of the phase control card at the same elevated temperature (85°F) also produced a failure. The failure was present for phase A signals only and was observed on two tests, but did not repeat during the eight subsequent tests. Although this card requires repairs, its failure was not as prevalent as the multiple and repeatable regulation card failures. The contribution from this card to event root cause is considered possible but not probable, based upon the function of the card and the lack of repeatability of the failure.

No observable failures have been documented, during testing of the firing card.

The Westinghouse test report provides additional test details. Westinghouse's design basis document identifies that the rod control system is designed to operate in a temperature environment ranging between 10°C and 40°C with an ambient room temperature of 25°C (77°F). Ambient room temperature readings in the (Unit 4) 4B MCC room measured 73°F (Unit 4 was operating). Temperature readings taken inside two rod control power cabinets (1AC & 2AC) for Unit 4 measured 98.6°F. The temperature probe was positioned about a quarter of an inch above the center of the rod control card cage. The rack door was closed as much as possible during measurements. Thermography data taken of a regulation card in another Unit 4 power cabinet indicated a nominal temperature of 104°F.

Temperature inside the 1AC rod control power cabinet for Unit 3 measured 107.4°F. Ambient room temperature in the (Unit 3) 3B MCC room measured 75.5°F. There is a control room annunciator associated with MCC room temperature [VI:ta]; its present set point is 102°F.

In May of 1995, it was discovered that the 3B MCC room air conditioning was operating at reduced capacity. The condensing unit was replaced in December, and a Request for Engineering Assistance was generated due to the deteriorating condition of the evaporator unit and its inaccessibility. During the time of reduced air conditioning capacity (about six months), the 3B MCC room temperature approached 80°F. Any adverse consequence of this increased temperature is most likely to result in accelerated aging.

Effects associated with the elevated 3B MCC room temperatures cannot be quantified. In general the effect of elevated temperatures on electronic equipment is accelerated component aging. Electrolytic capacitors and semiconductor devices are especially susceptible. Failures due to accelerated aging are fairly unpredictable and are random in nature.

This failure is considered a random isolated incident.

Intermediate Ranges N-35 and N-36

N-35 was found to have low resistance between its signal cable center conductor and inner shield. This was isolated to the detector itself which was replaced on 09/25/96. N-36 required an adjustment of its compensating voltage.

3A Steam Generator Steam Flow Erratic Indication

The cause of the erratic loop signal appears to have been incompletely filled transmitter sensing lines. Calibration of the sensor loop was checked, and the transmitter sensing lines were refilled. Loop performance was monitored during the subsequent startup, and no problems were noted.

III. ANALYSIS OF THE EVENT

Turkey Point's Updated Final Safety Analysis Report (UFSAR) discussed dropped rod(s) as described in the following paragraphs.

A dropped rod event is a Condition II event that is assumed to be initiated by a single electrical or mechanical failure which causes any number and combination of rods from the same group of a given bank to drop to the bottom of the core. The resulting negative reactivity insertion causes nuclear power to rapidly decrease. An increase in the hot channel factor may occur due to the skewed power distribution representative of a dropped rod configuration. The Departure from Nucleate Boiling (DNB) design basis is met for the combination of power, hot channel factor, and other system conditions which exist following the dropped rod.

Following a dropped rod event in manual rod control (or with automatic rod withdrawal defeated), the plant will establish a new equilibrium condition. The equilibrium process is monotonic, in that, there is no power overshoot without control bank withdrawal. The Turkey Point units have disabled the automatic rod withdrawal capability.

Nuclear models are used to calculate the hot channel factors resulting from the drop of various control rods for a given core design. These values are compared to the maximum allowable hot channel factor described above. If the calculated hot channel factors are less than the allowable, the DNB design basis is met. A dropped rod event is modeled as a negative reactivity insertion corresponding to the reactivity worth of the dropped rod(s) regardless of the actual configuration of the rod(s) that drop. The system transient is calculated by assuming a constant turbine load demand at the initial value (no turbine runback) and no bank withdrawal. A spectrum of dropped rod worths from 50 pcm to 1500 pcm was analyzed. The analysis is presented for typical cases of 300 pcm and 1000 pcm.

Nuclear power decreases initially due to the negative reactivity insertion of the dropped rod(s) and then increases due to the effects of moderator and Doppler reactivity feedback. Due to the negative feedback, the core heat flux increases to match the secondary steam load. The heat flux returns to the initial value for a 300 pcm rod drop, since there is no turbine runback and steam flow remains constant at the initial value. For the 1000 pcm case, the RCS cooldown causes a reduction in steam pressure, such that the steam flow is limited by the full opening of the turbine throttle control valves. Thus, the core heat flux reaches equilibrium with the secondary load at a power somewhat below the initial full power value.

A computer analysis of nuclear response was performed which considered all credible combinations of dropped rods for Turkey Point. This includes single rods as well as multiple rods from the same group which are wired through the same control cabinet. In addition, control and shutdown bank drops were analyzed. The results of this analysis show that hot channel factors resulting from these rod drops for the Turkey Point core designs are less than the maximum allowable values determined in the thermal-hydraulic statepoint analysis. Thus, the DNB design basis is met. The results show that the limiting rod worths for these cycles in terms of minimum margin to the allowable hot channel factor occur in the range of 300-600 pcm. Worths in this range correspond to the drop of two or three RCCA's, and are considerably more limiting than the dropped banks.

An analysis of all credible dropped rod events for Turkey Point Units 3 and 4 verifies that the DNB Ratio (DNBR) remains above the limit value for both the standard and optimized fuel types. Therefore FPL has concluded that a dropped rod event would not have an adverse impact on plant safety.

The analysis presented in the UFSAR (Revision 12) is specifically for Unit 3 Cycle 9 and Unit 4 Cycle 10. The RCCA Drop analysis is redone each cycle to ensure that the new cycle results show that a dropped RCCA event does not adversely affect the core and that the DNBR remains above the limit value.

Because the conditions of the actual event were bounded by the assumptions and results of the analysis in the UFSAR, this event did not compromise the health or safety of plant personnel or the general public.

This event is reportable under the requirements of 10 CFR 50.73(a)(2)(i)(A).

IV. CORRECTIVE ACTIONS

1. The 2AC power cabinet DC power supplies, the CRDMs, cabling and connectors, the F-12 and K-4 output fuses were checked. The 2AC power cabinet components for Control Bank C stationary grippers were inspected for loose connections, foreign material, spread card cage pins, etc. No relevant problems were found.

2. A Control Bank C group 2 stepping test was performed, with satisfactory results.

3. The affected firing card, regulation card, and phase control cards were replaced.

4. FPL will evaluate the need for additional cooling for the power cabinets in order to lower temperatures in the card cage area of the cabinets.

5. Redesign or replacement of the 3B MCC air handler for better maintainability will be evaluated.

6. The 3B MCC Hi Temperature Alarm set point will be lowered to provide additional margin for early warning of air conditioning problems. The appropriate plant documentation and procedures will be revised to support the change.

7. Intermediate range N-35 detector [IG:det] was replaced. Intermediate range N-36 required an adjustment of its compensating voltage.

8. Calibration of the 3A Steam Generator steam flow sensor loop was checked, and the transmitter sensing lines were refilled. Loop performance was monitored during the subsequent startup, and no problems were noted.

9. Other failures in the Turkey Point rod control system, as well as related industry events are discussed in the next section. These failures were evaluated by the Event Response Team which addressed the failure reported herein; the Team determined that other rod control failures were random in nature, and not limited to any card or component.

V. ADDITIONAL INFORMATION

A. Similar Events: Another utility experienced numerous dropped rods circa 1991, 4 of which resulted in reactor trips. Their personnel performed extensive system testing and determined the root cause of the failures to be the firing cards. They found the firing cards to be a source of extreme, damaging heat. Heat generated by these cards, resulted in poor solder connections, lifting circuit board traces and deteriorating transistors. In addition, they found heat degraded components on the regulation cards which are mounted in close proximity to the firing cards. That utility's solution was the total replacement of the firing cards. FPL has not experienced rod control failures due to overheating by firing cards. Review of other NPRDS events revealed other industry rod control failures to be random in nature, and not limited to any card or component.

B. LER 251/94-004 documented an automatic reactor trip when power failed in the 1AC control cabinet, and 12 rods dropped. The power failure was the result of a combination of a tripped breaker and a faulty power supply internal to the control cabinet.

LER 250/95-004 resulted from an urgent failure alarm on the Unit 3 2AC cabinet when Control bank C movement was demanded. A manual reactor trip signal brought the Unit off line. Power supplies PS 3 and PS 4 in power cabinet 2AC and PS 4 in power cabinet 2BD were found to have degraded to the point of failure.

The power supplies reported in the two LERs described above were replaced with more reliable ones. Their failures were not related to overheating.

LER 250/95-007 was written to report a reactor trip as a result of four dropped rods. The cause of the dropped rods was water intrusion into rod control power cabinet 2BD. The design of an air conditioner evaporator drip pan drain was found to be inadequate for the level of humidity in the room.

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