

December 15, 1994

Florida Power and Light Company
ATTN: Mr. J. H. Goldberg
President - Nuclear Division
P. O. Box 14000
Juno Beach, FL 33408-0420

SUBJECT: MEETING SUMMARY - TURKEY POINT ENFORCEMENT CONFERENCE
TO DISCUSS EMERGENCY LOAD SEQUENCERS OUTSIDE DESIGN BASIS

Gentlemen:

This refers to the enforcement conference conducted at the NRC Region II Office in Atlanta on December 9, 1994. The purpose of the enforcement conference was to discuss the Turkey Point Units 3 and 4 emergency load sequencers being outside their design basis. A list of attendees and a copy of your handout are enclosed.

In accordance with Section 2.790 of NRC's "Rules of Practice," Part 2, Title 10, Code of Federal Regulations, a copy of this letter and its enclosures will be placed in the NRC Public Document Room.

Should you have any questions concerning this matter, please contact us.

Sincerely,

Orig signed by Ellis W. Merschoff

Ellis W. Merschoff, Director
Division of Reactor Projects

Docket Nos. 50-250, 50-251
License Nos. DPR-31, DPR-41

Enclosures: 1. List of Attendees
2. Handout

cc w/encls: See page 2

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SEND	OFC	RII	RII	RII		
TO	NAME	RSchin <i>RS</i>	KLandis <i>KOL</i>	DVerrelli <i>mv</i>		
PDR?	DATE	12/14/94	12/14/94	12/14/94	1/194	1/194
<input checked="" type="radio"/> Yes	<input type="radio"/> No	<input checked="" type="radio"/> Yes	<input type="radio"/> No	<input checked="" type="radio"/> Yes	<input type="radio"/> No	<input type="radio"/> Yes <input type="radio"/> No



List of Attendees

Florida Power and Light Company

J. H. Goldberg, President, Nuclear Division
T. F. Plunkett, Vice President, Turkey Point Plant
W. H. Bohlke, Vice President, Nuclear Engineering and Licensing
D. E. Jernigan, Plant General Manager
R. S. Kundalkar, Engineering Manager
E. J. Weinkam, Licensing Manager
C. R. Bible, Site Engineering Manager
D. C. Baker, Lead Licensing Engineer
C. Guey, Probabilistic Safety Assessment Engineer

Nuclear Regulatory Commission

S. D. Ebnetter, Regional Administrator, Region II (RII)
J. P. Jaudon, Deputy Director, Division of Reactor Projects (DRP), RII
B. S. Mallett, Acting Deputy Director, Division of Reactor Safety (DRS), RII
D. M. Verrelli, Chief, DRP Branch 2, RII
K. D. Landis, Chief, Reactor Projects Section 2B, DRP, RII
M. B. Shymlock, Chief, Plant Systems Section, DRS, RII
T. P. Johnson, Senior Resident Inspector, DRP, RII
B. B. Desai, Resident Inspector, DRP, RII
C. F. Evans, Regional Counsel, RII
B. Uryc, Director, Enforcement and Investigation Coordination Staff (EICS),
RII
L. J. Watson, Senior Enforcement Specialist, EICS, RII
R. P. Croteau, Licensing Project Manager, Office of Nuclear Reactor Regulation



Turkey Point Units 3 & 4

SEQUENCER LOGIC DEFECT

Enclosure 2



TURKEY POINT UNITS 3 & 4

SEQUENCER LOGIC DEFECT



AGENDA

- I. SUMMARY OF EVENT AND RESPONSE W. H. BOHLKE

- II. EVENT DESCRIPTION D. E. JERNIGAN

- III. SOFTWARE LOGIC DEFECT, ROOT CAUSE,
AND CORRECTIVE ACTIONS W. H. BOHLKE



TURKEY POINT UNITS 3 & 4

SEQUENCER LOGIC DEFECT



SUMMARY OF EVENT RESPONSE

- FPL IDENTIFIED TEST FAILURE.
 - ▶ IMMEDIATE STEPS TO ISOLATE DEFECT.
 - ▶ IMMEDIATE STEPS TO PLACE PLANT IN SAFE CONDITION.

- NATURE OF DEFECT.
 - ▶ SUBTLE ERROR.
 - ▶ LOGIC STEP INTERFERES WITH TRANSITION FROM TEST LOGIC TO ACCIDENT RESPONSE PROCESS LOGIC.

- SEQUENCERS A NECESSARY PART OF EMERGENCY POWER SYSTEM UPGRADE.
 - ▶ NEW SEQUENCERS REQUIRED WITH PRECISE TIMING FOR SHEDDING AND LOADING.
 - ▶ PROGRAMMABLE LOGIC CONTROLLERS (PLCs) BEST TECHNICAL APPROACH.
 - ▶ CONTINUOUS AUTO TEST CAPABILITY WAS CONSIDERED DESIRABLE.

- DEFECT INTRODUCED THROUGH UNIQUE AND ISOLATED DESIGN ERROR NOT DETECTED BY DESIGN REVIEW AND TESTING.



TURKEY POINT UNITS 3 & 4 SEQUENCER LOGIC DEFECT



SUMMARY OF EVENT RESPONSE (CONT.)

- OPERATIONS SUPERVISION PRO-ACTIVE IN DETERMINING SEQUENCER STATUS FOLLOWING TEST FAILURE.
- PLANT DEMONSTRATED CORRECT AND TIMELY ACTIONS BY OPERATORS DURING SIMULATOR EXERCISES IN INITIATING SAFETY INJECTION QUICKLY USING MEMORIZED STEPS IN ACCIDENT RESPONSE.
- CONSEQUENCES IN ACCIDENT ANALYSIS SPACE BOUNDED BY PREVIOUS ANALYSIS RESULTS.
- CONSEQUENCES IN PROBABILISTIC SAFETY ASSESSMENT (PSA) SPACE SHOW VERY SMALL INCREASE IN CORE DAMAGE FREQUENCY (CDF).
- COMPREHENSIVE AND EFFECTIVE CORRECTIVE ACTION UNDERWAY.
 - ▶ FIX DEFECT IN SEQUENCER LOGIC.
 - ▶ FOLD LESSONS LEARNED INTO ON-GOING FPL PROGRAM.





FPL

TURKEY POINT UNITS 3 & 4

SEQUENCER LOGIC DEFECT



EVENT DESCRIPTION

- **UNIT 3 - 100% POWER.**
- **UNIT 4 - MODE 5, REFUELING COMPLETED.**
- **4A SAFEGUARDS IN PROGRESS.**
- **ALL SEQUENCERS IN AUTO TEST MODE.**
- **UNIT 4 TRAIN A SI SIGNAL INITIATED AS PART OF SAFEGUARDS.**
- **4A AND 3B SI PUMPS STARTED, AS EXPECTED, AS DID ALL OTHER UNIT 4 TRAIN A LOADS.**
- **3A SI PUMP FAILED TO START.**
- **BASED ON 3A SEQUENCER STATUS, THE SEQUENCER HAD RECEIVED THE 4A SI INPUT SIGNAL BUT FAILED TO PROVIDE A SIGNAL FOR STARTING THE 3A SI PUMP.**



TURKEY POINT UNITS 3 & 4

SEQUENCER LOGIC DEFECT



TROUBLESHOOTING ACTIVITIES

- UNIT 4 SAFEGUARDS FAILURE PROMPTED DETAILED INVESTIGATION OF SEQUENCERS.
 - ▶ ENGINEERING PERFORMED DETAILED REVIEW OF LOGIC DIAGRAMS AND SOFTWARE LADDER DIAGRAMS FOR THE SEQUENCER PLC.
 - ▶ ENGINEERING, TECHNICAL, AND MAINTENANCE PERSONNEL PERFORMED MANUAL AND AUTO TESTING ON THE SEQUENCER SIMULATOR THAT DUPLICATED THE FAILURE.
 - ▶ THESE INDEPENDENT ANALYSES UNCOVERED A LOGIC PROBLEM IN THE SEQUENCER TEST SOFTWARE.

- A SIMILAR EVENT OCCURRED DURING PREPARATION FOR THE PREVIOUS UNIT 3 SAFEGUARDS.
 - ▶ A SPURIOUS 3A SI SIGNAL WAS GENERATED.
 - ▶ TRAIN A SAFEGUARDS EQUIPMENT WAS OBSERVED TO OPERATE EXCEPT FOR THE 4A SI PUMP.
 - ▶ THE OPERATORS RESET SI BY PROCEDURE AND RESET THE SEQUENCER PRIOR TO INVESTIGATION OF THE 4A SEQUENCER STATUS.
 - ▶ TROUBLESHOOTING ACTIVITIES COULD NOT DUPLICATE THE FAILURE MODE.
 - ▶ TWO SUSPECT RELAYS WERE REPLACED ALTHOUGH THE ROOT CAUSE OF THE FAILURE WAS INDETERMINATE.
 - ▶ SUBSEQUENT MANUAL TEST AND SAFEGUARDS TESTING WERE COMPLETED SATISFACTORILY.



TURKEY POINT UNITS 3 & 4

SEQUENCER LOGIC DEFECT



IMMEDIATE ACTIONS COMPLETED

- ALL SEQUENCERS PLACED IN SAFE CONDITION.
 - ▶ AUTO TEST FUNCTION SWITCHED OFF 11/3/94.
 - ▶ BASED ON REVIEW OF LOGIC DIAGRAMS.
 - ▶ BASED ON RESULTS OF SEQUENCER SIMULATOR TESTING.
 - ▶ PRECEDENT OF PREVIOUS SAFETY EVALUATION IN JANUARY 1992.

- SAFETY EVALUATION DEMONSTRATING OPERABILITY OF THE SEQUENCER WITH AUTO TEST OFF APPROVED BY PLANT NUCLEAR SAFETY COMMITTEE ON 11/4/94.
 - ▶ TEST OF ALL DESIGN BASIS SCENARIOS ON SEQUENCER SIMULATOR WITH TEST FUNCTION OFF.
 - ▶ REVIEW OF V&V DOCUMENTATION FOR TESTS WITH TEST FUNCTION OFF.

- NOTIFICATIONS MADE.
 - ▶ NRC - LER 94-005.
 - ▶ INPO NUCLEAR NETWORK.
 - ▶ VENDOR - UNITED CONTROLS INTERNATIONAL INCORPORATED (UCI).
 - ▶ ENGINEERING TECHNICAL ALERT.



TURKEY POINT UNITS 3 & 4

SEQUENCER LOGIC DEFECT



OPERATOR RESPONSE DURING SEQUENCER FAILURE DRILLS

- SPECIAL SIMULATOR DRILLS ON 11/4 AND 11/5/94.
 - ▶ 6 CREWS.
 - ▶ 3 SCENARIOS.
 - ◇ LOOP/LOCA (LB) WITH 3A AND 3B SEQUENCERS FAILED.
 - ◇ LB LOCA SAME AS ABOVE WITHOUT LOOP.
 - ◇ SB LOCA WITH ALL SI PUMPS DISABLED.
 - ▶ TIME REQUIRED TO ENERGIZE ALL AVAILABLE SAFEGUARDS EQUIPMENT (LOCA-ONLY SCENARIOS).
 - ◇ AVERAGE: 1 MINUTE 54 SECONDS.
 - ◇ RANGE: 1 MINUTE 5 SECONDS TO 3 MINUTES 15 SECONDS.

- DATA FROM ROUTINE SIMULATOR TRAINING DRILLS CONDUCTED IN JULY AND AUGUST 1994.
 - ▶ 15 CREWS.
 - ▶ SCENARIO: 3B SEQUENCER FAILED TO OPERATE IN RESPONSE TO LOOP/LOCA.
 - ▶ TIME TO ALIGN ALL REQUIRED SAFEGUARDS EQUIPMENT - 4 TO 5 MINUTES.



TURKEY POINT UNITS 3 & 4

SEQUENCER LOGIC DEFECT



SOFTWARE TEST LOGIC DEFECT

- LOOP WITH LOCA TEST SCENARIO STEPS WOULD PREVENT THE SEQUENCER FROM PROVIDING PROPER OUTPUT IN RESPONSE TO SOME VALID INPUTS.
 - ▶ LOGIC DEFECT LIMITED TO 5 OF 16 TEST STEPS.
- TEST LOGIC DEFECT PREVENTS PROCESSING A VALID LOCA (SI) SIGNAL ONLY.
 - ▶ FOLLOWING A LOCA, A FAILED SEQUENCER WOULD NOT START ONE COMPLETE TRAIN OF REQUIRED ENGINEERED SAFETY FEATURES EQUIPMENT AUTOMATICALLY.
 - ▶ TEST LOGIC DEFECT DOES NOT PROHIBIT MANUAL OPERATION OF ENGINEERED SAFETY FEATURES EQUIPMENT.
- SEQUENCER FUNCTIONS PROPERLY ON ALL VALID LOOP AND LOOP/LOCA SIGNALS INDEPENDENT OF TEST STEP OR MODE.
- WITH THE TEST SWITCH IN OFF POSITION, ALL VALID SIGNALS ARE PROCESSED AS REQUIRED.



TURKEY POINT UNITS 3 & 4

SEQUENCER LOGIC DEFECT



FIELD INPUT VS. TEST STEP MATRIX

TEST MODES ▶ FIELD INPUTS ▼	OFF	SEQUENCER STRIPPING TESTS					SEQUENCER SEQUENCING TESTS										
	TEST SWITCH OFF	1 BUS CLEAR RELAY	2 480V DEGR VOLT	3 480V UV W/SI	4 4 KV UV	5 SI W/SOL BUS	1 LOOP	2 LOOP LOCA 3A	3 LOOP LOCA OTHER UNIT	4 LOCA 3A	5 LOCA OTHER UNIT	6 LOOP LOCA W/HHCP CNCR	7 LOCA W/HHCP CNCR	8 LOOP LOCA W/HHCP < 13s	9 LOCA W/HHCP < 13s	10 LOOP LOCA W/HHCP > 13s	11 LOCA W/HHCP > 13s
1. LOOP																	
2. LOOP/LOCA CNCR																	
3. LOOP FOLLOWED BY LOCA																	
4. LOOP/LOCA OTHER UNIT CNCR																	
5. LOOP FOLLOWED BY LOCA OTHER UNIT																	
6. LOCA SAME TRAIN								X				X		X		X	
7. LOCA OTHER UNIT									X								
8. LOOP/LOCA W/HHCP CNCR																	
9. LOCA/LOCA W/HHCP < 13s																	
10. LOCA W/HHCP < 13s								X				X		X		X	
11. LOOP/LOCA W/HHCP > 13s																	
12. LOCA W/HHCP > 13s								X				X		X		X	

X - DEFECT WILL INHIBIT PROCESSING LOCA



TURKEY POINT UNITS 3 & 4

SEQUENCER LOGIC DEFECT



SAFETY SIGNIFICANCE

- THIS SITUATION POSED NO UNDUE RISK TO THE HEALTH AND SAFETY OF THE PUBLIC.
 - ▶ 5 UFSAR CHAPTER 14 ACCIDENT ANALYSES IMPACTED (LOCA AND MSLB SCENARIOS).
 - ◇ LB LOCA BOUNDED CORE RESPONSE. USING BEST ESTIMATE LOCA CASES, NO CORE DAMAGE WHEN MINIMUM SI (1 RHR AND 1 SI PUMP) INITIATED WITHIN 4 MINUTES.
 - ◇ MSLB BOUNDED CONTAINMENT PRESSURE RESPONSE. ANALYSIS DETERMINED A SMALL INCREASE IN CALCULATED PRESSURE (BOUNDED BY CONTAINMENT DESIGN PRESSURE) WITH NO CONTAINMENT SPRAY OR COOLERS. NOT SENSITIVE TO SI INITIATION.
 - ◇ EXPECTED OFF-SITE DOSE BOUNDED BY UFSAR ANALYSES.
 - ▶ PSA ANALYSIS CONCLUDED THAT INCREASE IN CDF IS NOT SIGNIFICANT.
 - ◇ ASSUMED OPERATOR RESPONSE TIME OF 4 MINUTES.
 - ◇ CDF INCREASED BY 2.0×10^{-6} , FROM 6.63×10^{-5} TO 6.83×10^{-5} /YR, OR ~ 3.2%.



TURKEY POINT UNITS 3 & 4

SEQUENCER LOGIC DEFECT



EXAMINATION OF RECENT SEQUENCER EVENTS

■ REVIEW OF INDUSTRY EVENTS:

- ▶ MILLSTONE (IN 93-011): TURKEY POINT TEST FEATURE INCAPABLE OF GENERATING A FALSE PROCESS SIGNAL. TURKEY POINT SEQUENCERS DESIGNED TO EXIT TEST MODE WHILE PROCESSING VALID INPUTS.

TEST TIMING CHANGE FROM 3 MINUTES TO 1 HOUR DID NOT AFFECT PROCESS LOGIC.

- ◊ INCREASE IN THE PROBABILITY THAT THE SEQUENCER WOULD NOT RESPOND TO A VALID FIELD INPUT WAS NOT SIGNIFICANT.
- ◊ NO NEW FAILURE MODES INTRODUCED.
- ▶ BEAVER VALLEY (IN 94-020): TURKEY POINT SEQUENCERS WERE TESTED FOR EMI/RFI AND CONTAIN ARC SUPPRESSION DEVICES AND POWER ISOLATORS.

■ MAY 1994 SPURIOUS SI EVENT:

- ▶ THE 4A SEQUENCER WAS RESET AND THE SI SIGNAL RESET BY PROCEDURE BEFORE THE SEQUENCER STATUS WAS OBSERVED.
- ▶ ADDITIONAL TESTING COULD NOT REPLICATE THE PROBLEM THEREFORE A PLC MALFUNCTION WAS RULED OUT AS A POTENTIAL ROOT CAUSE.
- ▶ OTHER HARDWARE ISSUES INVESTIGATED. TWO SUSPECT RELAYS REPLACED.
- ▶ SUBSEQUENT SAFEGUARDS COMPLETED SATISFACTORILY.



TURKEY POINT UNITS 3 & 4

SEQUENCER LOGIC DEFECT



ROOT CAUSE

- INTERACTION BETWEEN TEST LOGIC AND RECEIPT OF VALID INPUT SIGNAL WAS NOT RECOGNIZED BY DESIGNERS AND VERIFIERS.
 - ▶ LOGIC VERIFIED IN ONLY TWO STATES - TRANSITION LOGIC BETWEEN TESTING AND FIELD INPUT PROCESSING NOT REVIEWED.

- SHOP V&V AND ON-SITE TESTING PROGRAM DID NOT INCLUDE ALL STEPS OF THE SEQUENCER TEST LOGIC.
 - ▶ ALL SEQUENCER AUTO TEST STATES NOT TESTED BASED ON LOGIC REVIEWS.

 - ▶ PURPOSE OF ON-SITE TESTING WAS TO VALIDATE OVERALL SYSTEM RESPONSE.

- CONTRIBUTING FACTORS:
 - ▶ EMERGENCY POWER SYSTEM UPGRADE FOR TURKEY POINT NECESSITATED NEW SEQUENCERS.

 - ▶ SPECIFICATION FOR CONTINUOUS AUTO TESTING OF SEQUENCER LOGICS NECESSITATED A COMPLEX INTERFACE BETWEEN TEST LOGIC AND PROCESS LOGIC.



TURKEY POINT UNITS 3 & 4

SEQUENCER LOGIC DEFECT



CORRECTIVE ACTIONS

- IMMEDIATE CORRECTIVE ACTIONS AS PREVIOUSLY DESCRIBED.

- INDEPENDENT REVIEW TEAM ESTABLISHED. TASKS INCLUDE:
 - ▶ REVIEW IMMEDIATE ACTIONS PERFORMED.
 - ▶ RE-VERIFY V&V, DESIGN INTEGRATION, AND PRE-OPERATIONAL TESTING FOR PRESENT CONDITION - TEST MODE OFF.
 - ▶ INITIAL ASSESSMENT COMPLETED ON 11/30/94.

- ADDITIONAL SELF ASSESSMENT TEAM ESTABLISHED.

- INVESTIGATE OTHER SAFETY RELATED DIGITAL SYSTEMS AT TURKEY POINT AND ST. LUCIE.
 - ▶ EAGLE 21 REACTOR PROTECTION SYSTEM.
 - ▶ CONTAINMENT PARTICULATE AND GASEOUS RADIATION MONITORS.
 - ▶ VENDOR RESPONSES TO FPL LETTERS INDICATE NO PROBLEMS WITH THESE SYSTEMS - FPL TO REVIEW VENDOR RESPONSES.

- COMPLETE EVALUATION TO RE-INITIATE MANUAL TESTING BY DECEMBER 1994.



TURKEY POINT UNITS 3 & 4

SEQUENCER LOGIC DEFECT



SUMMARY OF EVENT RESPONSE

- FPL IDENTIFIED TEST FAILURE.
- NATURE OF DEFECT.
- SEQUENCERS ARE A NECESSARY PART OF EMERGENCY POWER SYSTEM UPGRADE.
- DEFECT INTRODUCED THROUGH UNIQUE AND ISOLATED DESIGN ERROR NOT DETECTED BY DESIGN REVIEW AND TESTING.
- OPERATIONS SUPERVISION PRO-ACTIVE IN DETERMINING SEQUENCER STATUS FOLLOWING TEST FAILURE.
- PLANT DEMONSTRATED CORRECT AND TIMELY ACTIONS BY OPERATORS DURING SIMULATOR EXERCISES IN INITIATING SAFETY INJECTION QUICKLY USING MEMORIZED STEPS IN ACCIDENT RESPONSE.
- CONSEQUENCES IN ACCIDENT ANALYSIS SPACE BOUNDED BY PREVIOUS ANALYSIS RESULTS.
- CONSEQUENCES IN PSA SPACE SHOW VERY SMALL INCREASE IN CDF.
- COMPREHENSIVE AND EFFECTIVE CORRECTIVE ACTION UNDERWAY.