TECHNICAL EVALUATION REPORT

AUXILIARY FEEDWATER SYSTEM AUTOMATIC INITIATION AND FLOW INDICATION (F-16, F-17)

FLORIDA POWER AND LIGHT COMPANY
TURKEY POINT UNITS 3 AND 4

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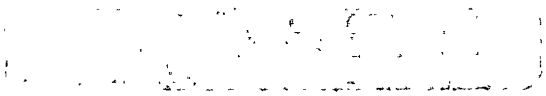

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FOREWORD

This Technical Evaluation Report was prepared by Franklin Research Center under a contract with the U.S. Nuclear Regulatory Commission (Office of Nuclear Reactor Regulation, Division of Operating Reactors) for technical assistance in support of NRC operating reactor licensing actions. The technical evaluation was conducted in accordance with criteria established by the NRC.

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1. INTRODUCTION

1.1 PURPOSE OF REVIEW

The purpose of this review is to provide a technical evaluation of the emergency feedwater system design to verify that both safety-grade automatic initiation circuitry and flow indication are provided at Turkey Point Units 3 and 4. In addition, the steam generator level indication available at these units is described to assist subsequent NRC staff review.

1.2 GENERIC ISSUE BACKGROUND

A post-accident design review by the U.S. Nuclear Regulatory Commission (NRC) after the March 28, 1979 incident at Three Mile Island (TMI) Unit 2 has established that the auxiliary feedwater (AFW) system should be treated as a safety system in a pressurized water reactor (PWR) plant. The designs of safety systems in a nuclear power plant are required to meet the general design criteria (GDC) specified in Appendix A of 10CFR50 [1].

The relevant design criteria for the AFW system design are GDC 13, GDC 20, and GDC 34. GDC 13 sets forth the requirement for instrumentation to monitor variables and systems (over their anticipated ranges of operation) that can affect reactor safety. GDC 20 requires that a protection system be designed to initiate automatically in order to assure that acceptable fuel design limits are not exceeded as a result of anticipated operational occurrences. GDC 34 requires that the safety function of the designed system, that is, the residual heat removal by the AFW system, can be accomplished even in the case of a single failure.

On September 13, 1979, the NRC issued a letter [2] to each PWR licensee that defined a set of short-term requirements specified in NUREG-0578 [3]. It required that the AFW system have automatic initiation and single failure-proof design consistent with the requirements of GDC 20 and GDC 34. In addition, AFW flow indication in the control room must be provided to satisfy the requirements set forth in GDC 13.

During the week of September 24, 1979, seminars were held in four regions of the country to discuss the short-term requirements. On October 30, 1979, another letter was issued to each PWR licensee providing additional clarification of the NRC staff short-term requirements without altering their intent [4].

Post-TMI analyses of primary system response to feedwater transients and reliability of installed AFW systems also established that, in the long term, the AFW system should be upgraded in accordance with safety-grade requirements. These long-term requirements were clarified in the letter of September 5, 1980 [5]. This letter incorporated in one document, NUREG-0737 [6], all TMI-related items approved by the commission for implementation at that time. Section II.E.1.2 of NUREG-0737 clarifies the requirements for the AFW system automatic initiation and flow indication.

1.3 PLANT-SPECIFIC BACKGROUND

In Reference 2, the NRC informed the Licensee, Florida Power and Light Company (FPL), that it would have to meet the requirements of NUREG-0578. Reference 4 clarified and reiterated this requirement.

On November 21, 1979 [7], FPL replied to the two NRC letters on the subject of short-term requirements. Comments in FPL's letter relative to the AFW system centered on interim control-grade automatic initiation and flow indication systems.

On January 14, 1980 [8], FPL provided detailed information on the AFW design, citing specific items of Sections 2.1.7.a and 2.1.7.b of NUREG-0578.

On February 3, 1981 [9], FPL sent a letter to the NRC describing proposed AFW system changes in detail.

On April 13, 1981 [10], FPL submitted a revision to the Turkey Point Technical Specifications to the NRC Director, Division of Licensing.

By letter dated July 23, 1981 [11], FPL submitted additional information concerning the Turkey Point Units 3 and 4 AFW system.

2. REVIEW CRITERIA

To improve the reliability of the AFW system, the NRC required licensees to upgrade the system, where necessary, to ensure timely automatic initiation when required. The system upgrade was to proceed in two phases. In the short term, as a minimum, control-grade signals and circuits were to be used to automatically initiate the AFW system. This control-grade system was to meet the following requirements of NUREG-0578, Section 2.1.7.a [3]:

"1. The design shall provide for the automatic initiation of the auxiliary feedwater system.

2. The automatic initiation signals and circuits shall be designed so that a single failure will not result in the loss of auxiliary feedwater system function.

3. Testability of the initiating signals and circuits shall be a feature of the design.

4. The initiating signals and circuits shall be powered from the emergency buses.

5. Manual capability to initiate the auxiliary feedwater system from the control room shall be retained and shall be implemented so that a single failure in the manual circuits will not result in the loss of system function.

6. The ac motor-driven pumps and valves in the auxiliary feedwater system shall be included in the automatic actuation (simultaneous and/or sequential) of the loads to the emergency buses.

7. The automatic initiating signals and circuits shall be designed so that their failure will not result in the loss of manual capability to initiate the AFW system from the control room."

In the long term, these signals and circuits were to be upgraded in accordance with safety-grade requirements. Specifically, in addition to the above requirements, the automatic initiation signals and circuits must have independent channels, use environmentally qualified components, have system bypassed/inoperable status features, and conform to control system interaction criteria, as stipulated in IEEE Std 279-1971 [12].

The capability to ascertain the AFW system performance from the control room must also be provided. In the short term, steam generator level indication and flow measurement were to be used to assist the operator in maintaining the required steam generator level during AFW system operation. This system was to meet the following requirements from NUREG-0578, Section 2.1.7.b [3]:

"1. Safety-grade indication of auxiliary feedwater flow to each steam generator shall be provided in the control room.

2. The auxiliary feedwater flow instrument channels shall be powered from the emergency buses consistent with satisfying the emergency power diversity requirements of the auxiliary feedwater system set forth in Auxiliary Systems Branch Technical Position 10-1 of the Standard Review Plan, Section 10.4.9 [13]."

The NRC staff has determined that, in the long term, the overall flowrate indication system for Westinghouse plants must include either one AFW flowrate indicator with one wide-range steam generator level indicator for each steam generator, or two flowrate indicators. The flowrate indication system must be environmentally qualified, powered from a highly reliable, battery-backed non-Class 1E power source, periodically testable, part of the plant's quality assurance program, and capable of display on demand.

The operator relies on steam generator level instrumentation and AFW flow indication to monitor AFW system performance. The requirements for this steam generator level instrumentation are specified in Regulatory Guide 1.97, Revision 2, "Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant and Environs Conditions During and Following an Accident" [14].

3. TECHNICAL EVALUATION

3.1 GENERAL DESCRIPTION OF THE AUXILIARY FEEDWATER SYSTEM

The auxiliary feedwater (AFW) system at Turkey Point Units 3 and 4 supplies water to the secondary side of the steam generator for reactor decay heat removal when normal feedwater sources are unavailable due to loss of offsite power or other malfunctions. The system consists of three steam turbine-driven pumps (600 gpm at 2775 feet of water) capable of supplying feedwater to any or all of the six steam generators in the two units. All three pumps are interconnected on the discharge side to two common discharge lines, one line to each unit. These common discharge lines each branch into three supply lines for the three steam generators in each unit. The AFW lines to each steam generator contain two normally closed, dc, air-operated flow control valves in parallel.

3.2 AUTOMATIC INITIATION

3.2.1 Evaluation

Auxiliary feedwater flow to the steam generators is automatically initiated when preset levels of any of the following parameters are exceeded:

Turbine-Driven Pumps

1. Safety injection (2 of 3)
2. Low steam generator level in any one steam generator (2 of 3)
3. Loss of voltage on both 4160 V buses
4. Loss of both main feedwater pumps.

All initiating signals and circuits are supplied from redundant, Class 1E, vital power supplies, as is the control power for all AFW valves. In addition, all ac-operated valves are automatically loaded onto the diesel generators.

The normal valve configuration for the AFW system is all AFW pump suction valves open, discharge flow control valves closed, and the steam admission

valves to the turbine-driven pumps closed. The steam admission valves to two of the three AFW pumps are being modified so that they are dc-operated; thus, two of the AFW pumps will start independently of ac power availability. However, all three AFW pumps are turbine-driven, and the AFW system, therefore, does not meet the pump power supply diversity requirement. The AFW pumps discharge control valves are dc solenoid/air-operated valves. The air supply for all valves is backed by a seismically qualified nitrogen supply that automatically initiates on loss of normal air supply.

The operation of any one AFW pump will provide the necessary capacity for removing decay heat to prevent overpressurization of the reactor coolant system and to maintain steam generator levels. All three AFW pumps start upon automatic system actuation, and automatic isolation of a leaking steam generator is a design feature of the system and is provided by the main steam isolation system.

The primary source of water for the AFW system is the 250,000-gal, Seismic Category 1, condensate storage tanks (CST) of both units. Sufficient water inventory (185,000 gal) is maintained in the tanks to bring the plant to hot standby, hold there for 15 hours, and subsequently cool down to the residual heat removal system entry temperature of 350°F. Indication of CST level is provided in the main control room, and annunciation and alarm of CST low water level is provided. The backup water supply for the AFW system uses water from the plant water treatment system to resupply the CST; this method could not be used if the CST were not available. The Licensee further stated that a non-safety-grade 500,000-gallon deaerated water storage tank is being constructed and will be available to supply the CSTs.

A review of initiation logic and wiring diagrams revealed no credible single malfunction that would prevent protective action at the system level when required. In addition, the Licensee has stated that the design of the AFW system initiation logic meets IEEE Std 279-1971 in that no single component failure will prevent the automatic start signal from being initiated, and the initiating signals and circuits are powered from safety-grade power supplies.

Manual operation of the AFW system is provided in the control room and at the local station. Each control circuit is independent so that a single failure in one train will not affect the redundant train. In addition, the automatic initiating circuits are designed to be electrically independent from the control room manual start circuit so that the failure of the automatic initiating signals does not affect the control room manual capability of AFW pumps. None of the protection signals for the automatic initiation of AFW are used as control signals; consequently, there is no control and protection system interaction.

Seismic requirements for the emergency feedwater system were not considered in the single failure analysis because the NRC will address this issue separately. A determination of whether components are qualified for accident and post-accident environments was not conducted. The environmental qualification of safety-related systems, including AFW system circuits and components, is being determined separately by the NRC and is not within the scope of this review. Review of the initiation circuit diagrams revealed no credible single malfunction that would prevent proper system action when required.

The electrical isolation and physical separation of elements of the proposed auxiliary feedwater actuation system design comply with the requirements of NUREG-0578 [3] and IEEE Std 279-1971 [12].

Concerning bypasses, the Licensee has stated the following:

Channel Bypasses

- Trip Channel Bypass - This bypass is provided for periodic testing of the system and to remove a channel from service due to a component failure. This bypass is manually initiated and manually removed. Only one channel can be bypassed at a time, and the coincidence logic is 2 of 2 while in test.

Operating Bypasses

- The Licensee has stated that the system contains no operating bypasses.

The design of the AFW control valves is such that the initiation signal operates a solenoid valve in series with the control air signal to each

control valve. There are no overrides in the control circuit for the solenoid valve; however, the air signal to the control valve can be controlled automatically or manually by the operator in the control room via hand indicating controllers mounted on the main control consoles 3 and 4. This design allows for considerable operational flexibility, but in effect allows the operator to override an actuation signal by taking manual control of the flow control valves and thus does not meet the requirements of IEEE Std 279-1971. The salient points are that where operating requirements necessitate automatic or manual bypass of a protective function, the design should be such that the bypass will be removed automatically whenever permissive conditions are not met; continuous indication of the bypass condition in the control room is required;.and a means for administratively controlling the bypass should be provided.

The AFW pump discharge lines and turbine-driven AFW pump steam supply lines for each unit combine into single lines through which all water and steam, respectively, from either unit must flow. A pipe break in either of these single flow paths would cause loss of the capability to provide AFW flow to all the steam generators of one unit. The Licensee has agreed to develop operating procedures to provide direction to the operators regarding isolation of AFW system steam supply lines or feedwater line piping breaks. Steam and feedwater piping modifications are also being developed to ensure redundancy in the common AFW discharge header and the common steam supply header to the AFW pump turbines.

The Turkey Point Technical Specifications require that each AFW pump be tested once each month. AFW flow is initiated by manually opening valves (from the control room) to admit steam to the AFW pump turbine and therefore establish AFW flow to the steam generators. Channel functional tests are required at least once every 62 days, and initiating signals and circuits are tested during the integrated safeguards test performed during each refueling outage.

3.2.2 Conclusion

It is concluded that the initiation signals, logic, and associated circuitry of the Turkey Point Units 3 and 4 AFW system comply with the long-term safety-grade requirements of Section 2.1.7.a of NUREG-0578 [3] and the subsequent clarification issued by the NRC with the following exceptions:

- Annunciation of channel bypasses, in the control room, is not provided.
- The manual bypass capability for controlling the AFW flow control valves should be designed in accordance with IEEE Std 279-1971, to provide automatic removal of the bypass when permissive conditions are not met, continuous indiction in the control room of the bypass condition, and a means for administratively controlling the bypass switch.

3.3 FLOW INDICATION

3.3.1 Evaluation

Each of the AFW pump headers to each steam generator is equipped with a flow transmitter with output indicated in the control room and locally at the AFW control valve location. In addition, wide-range, non-safety-grade steam generator level indication is provided. Both flow and level are continuously displayed in the control room.

The AFW flow indication system is powered from the vital bus syten, which is a Class 1E power source. The AFW flow signal is also used as an input to the AFW flow control system.

The Licensee has stated that the AFW flow indication system is part of the plant quality assurance program.

AFW flow indication system channel checks are performed every 12 hours and channel functional tests are performed monthly. Channel calibration is performed each refueling outage.

The environmental qualification of flow measurement and indication equipment is being reviewed separately by the NRC and is outside the scope of this review.

3.3.2 Conclusion

It is concluded that the sensors, transmitters, indicators, and recorders of the Turkey Points Units 3 and 4 AFW flow measurement system comply with the requirements of Section 2.1.7.b of NUREG-0578 and the subsequent clarification issued by the NRC.

3.4 DESCRIPTION OF STEAM GENERATOR LEVEL INDICATION

Steam generator level instrumentation at Turkey Point Units 3 and 4 serves several purposes in addition to control room panel indication. There are three safety-related measurement channels and two non-safety-related channels for each of the three steam generators in each nuclear unit. One non-safety-related channel in each steam generator employs a wide-range sensor for indication and recording only (one 3-pen recorder in the control room). Safety-related channels employ narrow-range sensors that provide signals for the following:

1. reactor trip, turbine trip, feedwater pump trip, and automatic initiation of AFW system based on low-low levels

2. turbine trip and feedwater pump trip based upon high-high levels

3. control of main feedwater flow control valves through an isolation device.

The remaining non-safety-related channel in each steam generator is available as an alternate means for control of the main feedwater flow control valves.

All safety-related channels are powered from emergency buses. All are independent and separated to the extent that cables are run in separate raceways.

Non-safety-related channels are powered from normal 120-Vac non-class 1E buses.

Low and high level alarms are provided on the main annunciator panels for each steam generator.

Safety-related channels are checked every 31 days as part of engineered safety features actuation system surveillance. Calibration is performed during scheduled refueling outages (12- to 18-month intervals).

Separate control room panel indicators are provided for each safety-related channel of measurement (nine for each nuclear unit). A selector switch permits the operator to record any one of the channels for each steam generator.

Table 1 lists the safety-related channels for all three steam generators of each nuclear unit; Table 2 lists non-safety-related narrow-range instrumentation for the three steam generators of each nuclear unit; and Table 3 lists non-safety-related wide-range instrumentation for the three steam generators of each nuclear unit.

Table 1

Safety-Related Level

Steam Generator	Instruments Tag No.	Instruments Channel	Transmitter Range (inches of water column)
1	LT-474	I	30.13-138.22
1	LT-475	II	" "
1	LT-476	II	" "
2	LT-484	II	" "
2	LT-485	II	" "
2	LT-486	II	" "
3	LT-494	II	" "
3	LT-495	II	" "
3	LT-496	II	" "

Table 2

Non-Safety-Related Level

Steam Generator No.	Level Instruments (Narrow Range)		
	Tag No.	Safety Channel	Transmitter Range (inches of water column)
1	LT-478	NSR	0-143
2	LT-488	"	"
3	LT-498	"	"

Table 3

Non-Safety-Related Level

Steam Generator No.	Level Instruments (Wide Range)	
	Tag No.	Transmitter Range (inches of water column)
1	LT-477	0-513
2	LT-487	"
3	LT-497	"

4. CONCLUSIONS

It is concluded that the initiation signals, logic, and associated circuitry of the Turkey Point Units 3 and 4 auxiliary feedwater system comply with the long-term, safety-grade requirements of Section 2.1.7.a of NUREG-0578 [3] and the subsequent clarification issued by the NRC with the following exceptions:

- o Annunciation of channel bypasses, in the control room, is not provided.
- o The manual bypass capability for controlling the AFW flow control valves should be designed in accordance with IEEE Std 279-1971, to provide automatic removal of the bypass when permissive conditions are not met, continuous indication in the control room of the bypass condition, and a means for administratively controlling the bypass switch.

It is concluded that the sensors, transmitters, indicators, and recorders of the Turkey Point Units 3 and 4 AFW flow measurement system comply with the requirements of Section 2.1.7.b of NUREG-0578 and the subsequent clarification issued by the NRC.

5. REFERENCES

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