TECHNICAL EVALUATION REPORT

AUXILIARY FEEDWATER SYSTEM AUTOMATIC INITIATION AND FLOW INDICATION

PUBLIC SERVICE ELECTRIC AND GAS COMPANY
SALEM UNIT 1

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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 Salem Unit 1. In addition, the steam generator level indication available at Salem Unit 1 is described to assist subsequent NRC staff review.

1.2 GENERIC ISSUE BACKGROUND

A post-accident design review by the Nuclear Regulatory Commision (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 general design criteria (GDC) specified in Appendix A of the 10 CFR Part 50 [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, 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 satisfying the requirements of GDC 20 and GDC 34. In addition, auxiliary feedwater flow indication in the control room shall 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 impact of 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 this 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

The Licensee of Salem Unit 1, Public Service Electric and Gas Company (PSE&G), provided its initial response to Reference 3 on October 12, 1979 [7]. In this response, PSE&G indicated that the AFW system at Salem Unit 1 was automatically initiated and contained auxiliary feedwater flow indication. Following several rounds of correspondence between PSE&G and the NRC [8-12], a meeting was conducted between PSE&G and NRC personnel on January 3, 1980 in which the Licensee's AFW system responses to NUREG-0578 for Salem Unit 1 were reviewed. Subsequently, PSE&G and the NRC exchanged further correspondence relating to the AFW system at Salem Unit 1 [13-16].

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 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 [17].

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 of NUREG-0578, Section 2.1.7.b:

"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 [Ref. 18 in this report]."

The NRC staff has determined that, in the long term, the overall flowrate indication system for Westinghouse plants should include at least one auxiliary feedwater flowrate indicator for each steam generator. The safety-grade flowrate indication system must satisfy the single failure criterion, be environmentally qualified, have as a design feature the capability to test the indicating channels, and conform to the control system interaction criteria, as stipulated in IEEE Std 279-1971.

The operator relies on steam generator level instrumentation, in addition to auxiliary feedwater flow indication, to determine 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" [19].

3. TECHNICAL EVALUATION

3.1 GENERAL DESCRIPTION OF AFW SYSTEM

The auxiliary feedwater (AFW) system at Salem Unit 1 supplies water to the secondary side of the steam generators for reactor decay heat removal when normal feedwater sources are unavailable. The system is equipped with one turbine-driven auxiliary feedwater pump and two motor-driven pumps. Steam for the turbine-driven pump is supplied by two of the four main steam lines, upstream of the steam generator stop valves. The motor-driven pumps receive power from 4-kV vital buses. Each motor-driven pump feeds two of the four steam generators. The turbine-driven pump feeds all four steam generators.

Auxiliary feedwater flow to the steam generators is automatically initiated when preset levels of any of several monitored parameters are exceeded. System valves are always aligned for normal operation; therefore, flow is initiated upon the start-up of any pump. Automatic start-up of the motor-driven pumps occurs upon loss of offsite power, loss of main feedwater flow, low-low level in one steam generator, or on a safeguards sequence signal.

Automatic start-up of the turbine-driven pump occurs on loss of offsite power, low-low level in two steam generators, or 4-kV bus undervoltage. Manual initiation of the system may be accomplished from either the control room or locally at the pumps. The operation of any one of the three pumps provides removal of decay heat from the steam generators at a rate sufficient to prevent overpressurization of the reactor coolant system and to maintain steam generator levels.

3.2 AUTOMATIC INITATION

3.2.1 EVALUATION

The AFW system at Salem Unit 1 is designed as an Engineered Safeguards System. It is designed Seismic Category I, Class 1E, and the automatic initiation signals and circuits comply with the single-failure criterion of IEEE Std 279-1971. A review of initiation circuit diagrams revealed no credible single malfunction that would prevent acceptable system action when required. The essential design features are the signals and circuits being

powered from emergency buses (A and B 125-V dc vital buses in the case of the motor-driven pumps and 28-V dc in the case of the turbine-driven pump), and the redundant channels being physically separated and electrically independent. Additionally, the motor-driven pumps and associated valves are powered by independent ac vital buses, while the electrical power necessary for the operation of the turbine-driven pump and its discharge valves is exclusively dc. The loading of the 600-hp, motor-driven pumps onto their respective 4-kV vital buses is part of the post-accident automatic load sequencing.

The quality of components used in the system is assured by safety-grade, seismic, and Class 1E requirements imposed upon the design, fabrication, and quality assurance of engineered safety feature (ESF) systems. Except for the steam generator narrow-range level instruments, AFW system components are either not located in areas subject to an adverse environment or are not required to function because there is redundant equipment in other areas.

The narrow-range steam generator level instruments have undergone environmental qualification testing. The environmental qualification of safety-related electrical and mechanical components, including AFW system circuits and components, is being reviewed by the NRC's Environmental Qualification Branch as part of its review of licensee responses to IE Bulletin No. 79-01B [20].

The only interaction between AFW system automatic initiation circuits and normal system control functions occurs in the narrow-range steam generator level instrumentation. These level instruments are used both for the protection function (AFW initiation) and normal control functions in the main feedwater control system. Each of these instruments is provided with a signal isolation device to separate the protection and control portions of the circuits. Detailed discussions of these isolation devices are provided in two Westinghouse Electric Corporation reports: WCAP-7824, "Isolation Test Process Instrumentation Isolation Amplifier, Westinghouse Computer and Instrumentation Division, Model 131-110" and WCAP-7672, "Solid State Logic Protection System Description."

The system is capable of being tested during both power operation and shutdown. The system is designed with the capability to perform channel

functional tests during power operation. Channel calibrations may also be conducted during plant operation.

The Licensee has stated that instrument channel checks are performed every 12 hours, channel functional tests are performed monthly, and instrument calibrations are conducted during each refueling outage.

Surveillance Procedure SP(O)4.7.1.2(b) is used to verify that (1) the turbine-driven pump throttle valve opens upon receipt of either a loss of offsite power signal or low-low water level signals from two steam generators and (2) that the motor-driven pumps start on receipt of a loss of both main feedwater pumps signal or a low-low water level signal from a steam generator, as well as to verify proper operation of the automatic valves in the flow path from the motor-driven pumps. Testing of the motor-driven pumps is performed with the plant in a hot-standby condition by actually tripping both main feedwater pumps and allowing the AFW system to initiate automatically. This testing procedure is performed at least once every 18 months.

Review of the initiation circuitry for the AFW system at Salem Unit 1 revealed no operational bypasses associated with this circuitry. Since there are three auxiliary feedwater pumps and since surveillance procedures allow testing of only one pump at a time, it is possible to maintain at least 100% of the required auxiliary feedwater flow at all times during testing or maintenance. Also, administrative controls are used to alert operators of the inoperability of a portion of the AFW system due to maintenance or testing of equipment. The unavailable equipment log and the tagging request procedure assure that the operators are aware of the system's out-of-service status. Technical specifications have been established to limit the out-of-service time.

Individual alarms are provided on the auxiliary annunciator system in the control room to alert the operator to conditions or potential conditions in which AFW system equipment may not operate properly. They include alarms for testing protection system logic, alarms for pump inoperability (such as loss of control power to a certain pump), alarms for valve inoperability (out of position or loss of power), and miscellaneous function alarms.

Finally, the review of circuitry schematics revealed no single failure to either the automatic initiation circuits or the manual initiation circuits that would prevent manual initiation of the system from the control room or locally at the auxiliary feedwater pumps.

3.2.2 CONCLUSION

The initiation signals, logic, and associated circuitry of the automatic initiation feature of the AFW system of Salem Unit 1 complies with the long-term, safety-grade requirements of NUREG-0578, Section 2.1.7.a, and the subsequent clarification issued by the NRC staff.

3.3 FLOW INDICATION

3.3.1 EVALUATION

The capability to ascertain the performance of the AFW system at Salem Unit 1 consists of auxiliary feedwater flow indication, steam generator narrow-range and wide-range level incication, auxiliary feedwater valve positions, AFW system pump discharge pressures, and AFW system pump status indicators. The Licensee has stated that safety-grade indication of auxiliary feedwater flow to each steam generator has been provided in the control room. The Licensee has further stated that these indicating channels are designed to meet the same criteria as the protection system indicators.

The protection system at Salem Unit 1 uses four separate, independent channels of instrumentation. The design incorporates physical and electrical separation of the four channels. Four 115-V ac vital instrument buses are provided for reactor protection and instrumentation circuits; each bus is normally supplied by a static inverter system. The input to the inverter can come from either an ac/dc power supply or the 125-V dc system, the latter of which is battery-backed. In addition, an alternate vital power source to each instrument bus is available.

The AFW flow instrument channels are testable, and since the AFW flow indicators provide no control function, there are no requirements for isolation devices to separate protection functions from control functions.

The Licensee has stated that channel functional tests and instrument calibrations are conducted during each refueling outage. Routine channel checks of these instruments are not conducted, since the system is generally not in operation.

The environmental qualification of the auxiliary feedwater flow indicators will also be reviewed by the Environmental Qualfication Branch as part of their review of licensee responses to IE Bulletin No. 79-01B.

3.3.2 CONCLUSION

It is concluded that the auxiliary feedwater flow instrumentation at Salem Unit 1 complies with the long-term safety-grade requirements of NUREG-0578, Section 2.1.7.b, and the subsequent clarification issued by the NRC.

3.4 STEAM GENERATOR LEVEL INDICATION DESCRIPTION

Steam generator level instrumentation at Salem Unit 1 consists of three safety-grade, narrow-range level channels (used to initiate protective functions) and one nonsafety-grade, wide-range level channel per steam generator. The nonsafety-grade, wide-range indicator has no protective or control functions associated with it and is used only for indicating and recording.

4. CONCLUSIONS

The initiation signals, logic, and associated circuitry of the automatic initiation feature of the AFW system at Salem Unit 1 comply with the long-term safety-grade requirements of NUREG-0578, Section 2.1.7.a, and the subsequent clarification issued by the NRC staff. The auxiliary feedwater flow instrumentation at Salem Unit 1 complies with the long-term safety-grade requirements of Section 2.1.7.b and the subsequent clarification issued by the NRC.

5. REFERENCES

1. Code of Federal Regulations, Title 10, Office of the Federal Register, National Archives and Records Service, General Services Administration, Revised January 1, 1980.

2. NRC generic letter to all PWR licensees regarding short-term requirements resulting from Three Mile Island Accident, September 13, 1979.

3. NUREG-0578, "TMI-2 Lessons Learned Task Force Status Report and Short-Term Recommendations," USNRC, July 1979.

4. NRC generic letter to all PWR licensees clarifying lessons learned short-term requirements, October 30, 1979.

5. NRC generic letter to all PWR licensees regarding short-term requirement resulting from Three Mile Island Accident, September 5, 1980.

6. NUREG-0737, "Clarification of TMI Action Plan Requirements," USNRC, November 1980.

7. F. P. Librizzi (PSE&G), Letter to D. G. Eisenhut (DOR), October 12, 1979.

8. D. G. Eisenhut (NRC), Letter to F. P. Librizzi (PSE&G), September 21, 1979.

9. F. P. Librizzi (PSE&G), Letter to D. G. Eisenhut (DOR), November 1, 1979.

10. A. Schwencer (NRC), Letter to F. P. Librizzi (PSE&G), December 10, 1979.

11. F. P. Librizzi (PSE&G), Letter to A. Schwencer (ORBI), December 14, 1979.

12. F. P. Librizzi (PSE&G), Letter to A. Schwencer (ORBI), December 27, 1979.

13. F. P. Librizzi (PSE&G), Letter to A. Schwencer (ORBI), February 4, 1980.

14. A. Schwencer (NRC), Letter to F. P. Librizzi (PSE&G), April 4, 1980.

15. F. P. Librizzi (PSE&G), Letter to A. Schwencer (ORBI), May 5, 1980.

16. F. P. Librizzi (PSE&G), Letter to S. A. Varga (ORBI), June 11, 1980.

17. IEEE Std 279-1971, Criteria for Protection Systems for Nuclear Power Generating Station, Institute of Electrical and Electronics Engineers, New York, NY.

18. NUREG-75/087, Standard Review Plan, Section 10.4.9, Rev. 1, USNRC, no date.

19. Regulatory Guide 1.97 (Task RS 917-4), "Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant and Environs Conditions During and Following an Accident," Rev. 2, USNRC, December 1980.

20. IE Bulletin 79-01B, "Environmental Qualfication of Class IE Equipment," USNRC, Office of Inspection and Enforcement, January 14, 1980.