TECHNICAL EVALUATION REPORT

AUXILIARY FEEDWATER SYSTEM AUTOMATIC INITIATION AND FLOW INDICATION

WISCONSIN PUBLIC SERVICE CORPORATION
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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 the Kewaunee Nuclear Power Plant. In addition, the steam generator level indication available at the Kewaunee plant is described to assist subsequent NRC staff review.

1.2 GENERIC ISSUE BACKGROUND

A post-accident design review by the 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 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 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, auxiliary feedwater flow indication in the control room should 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 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 Wisconsin Public Service Corporation (WPS) responded to NRC requirements through letters [7-13], with supporting information describing the AFW system of the Kewaunee Nuclear Power Plant and the modification implementation schedule for it. In Reference 14, the NRC stated that all of the TMI Lessons Learned Category "A" Items (except 2.1.7.a) were satisfied at the Kewaunee plant.

The Franklin Research Center (FRC) staff began a review of the AFW system at the Kewaunee plant in May 1981, based on the criteria described in Section 2 of this report. In Reference 15, the Licensee provided additional information, logic diagrams, electrical schematics, and flow diagrams, as requested, in support of FRC's AFW system review.

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 [16].

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:

"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 System Branch Technical Position 10-1 of the Standard Review Plan, Section 10.4.9 [17]."

The NRC staff has determined that, in the long term, the overall flowrate indication system for Combustion Engineering and Westinghouse plants should include at least one auxiliary feedwater flowrate indicator and one wide-range steam generator level indicator for each steam generator, or two flowrate indicators. The flowrate indication system should 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, 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" [18].

3. TECHNICAL EVALUATION

3.1 GENERAL DESCRIPTION OF AUXILIARY FEEDWATER SYSTEM

The auxiliary feedwater (AFW) system at the Kewaunee plant 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 one steam turbine-driven pump (240 gpm) capable of delivering feedwater to either or both steam generators. In addition, there are two motor-driven pumps (240 gpm each), each capable of supplying feedwater to either or both steam generators. These pumps are interconnected on the discharge side by a crossover pipe containing two normally open motor-operated isolation valves. The two motor-driven pumps are energized by separate safety feature buses, but are capable of being transferred manually to the other bus if the corresponding diesel generator fails to start.

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.

A. Motor-Driven Pumps

1. safety injection signal (ESF)
2. loss of bus voltage (blackout)
3. low-low level in either steam generator (2 of 3)
4. opening of both main feedwater pump circuit breakers

B. Turbine-Driven Pump

1. low-low level in both steam generators (2 of 3)
2. loss of voltage on both 4-kV buses. (RCP)

System valves are always aligned for normal operation; therefore, flow is initiated upon the startup of any pump. All three pumps can be manually started from the control room. The operation of any of the three pumps provides the capacity to remove decay heat from the steam generators at a rate sufficient to prevent overpressurization of the reactor coolant system and to

maintain steam generator levels. Consequently, the AFW system is capable of automatically initiating appropriate protective action with precision and reliability whenever a condition monitored by the system reaches a preset level.

The AFW system at the Kewaunee plant is designed as an engineered safeguards system, the entire system meets Safety Class I criteria, and the automatic initiation signals and circuits comply with the single-failure criterion of IEEE Std 279-1971. A review of initiation logic and wiring diagrams revealed no credible single malfunction that would prevent proper protective action at the system level when required. The diverse signals and redundant channels that provide automatic initiation are physically separated, electrically independent, and powered from emergency buses. In addition, the motor-driven pumps and associated valves are powered by independent ac emergency buses, while the electrical power necessary for the operation of the turbine-driven pump is exclusively dc. The loading of the 300-hp, motor-driven pumps onto their respective 4-kV vital buses is part of automatic load sequencing.

The AFW system can be manually initiated. The motor-driven pumps can be started either from the control room or local control panel, and the turbine-driven pumps can be started from the control room. A single failure will not prevent initiation by manual or automatic means.

The quality of components used in the AFW system is assured by safety-grade, seismic, and Class 1E requirements imposed upon the design, fabrication, and quality assurance of engineered safety features systems. The determination of adequate environmental qualification of all safety-related systems, including the AFW system, is being accomplished separately by the NRC, and is not within the FRC scope of review.

Automatic isolation of auxiliary feedwater flow to a leaking steam generator is not a feature of the AFW system at the Kewaunee plant. However, manual isolation of auxiliary feedwater flow to the affected steam generator can be accomplished by securing the appropriate auxiliary feedwater pump and

shutting the appropriate AFW system crossover valve (motor operated from the control room).

Monthly operational testing, as specified in the technical specification, of all auxiliary feedwater pumps, flow control valves, and steam admission valves is performed by manual starting of each pump and stroking of the valves. The initiating circuits are tested as follows:

Initiating Signal	Frequency
Safety Injection	Refueling
Blackout	Refueling
S/G Lo/Lo level	Each shutdown

Note: The Kewaunee Technical Specifications do not require testing of AFW auto initiation on loss of main feedwater (MFP circuit breaker).

The initiating signals for the automatic AFW system are tested as follows (Technical Specifications Section 4.8, Table 4.1-1):

Channel Description	Check	Calibrate	Test
Protective System Logic Channel Testing	NA	NA	M (includes auto load sequencer)
Steam Generator Level	S	R	M

The normal valve lineup in the AFW system at the Kewaunee plant is such that there are no normally closed valves in the suction or discharge lines. After maintenance, proper valve position is verified by testing the affected train. Position indication, in the form of status lights, is provided for automatic and remote operated valves in the AFW system. The following AFW system alarms are provided:

Pump running and the lube oil pressure is less than 10 psig

Pump running and the lube oil is still running

Pump running and pump discharge pressure is below 480 psi

Pump in pullout

Pump running and discharge valve is not fully open

Steam supply valve(s) to the turbine-driven pump is closed

Turbine throttle valve is not open

Either crossover valve is not fully open

Either local/remote switch is in local.

The automatic initiation signals and circuitry used at the Kewaunee plant comply with the IEEE Std 279-1971 requirements concerning control and protection system interaction, including the use of isolation amplifiers to transmit protection signal intelligence to other than protective functions.

Concerning operating bypasses and indication of bypasses, the Kewaunee FSAR contains the following statement:

> "The system is designed to permit any one analog channel through its bistable to be maintained, tested, and calibrated during power operation without system trip. Channel bypass and/or removal from operation facilitates these procedures.
>
> During such testing operations the active parts of the systems using 2/4 logic meet the single failure criterion, when the channel under test is either tripped or makes use of superimposed test signals which do not negate the detector signal.
>
> The protection system provides and displays information pertinent to system status and plant safety, as well as various test conditions when some part of the system has been bypassed or taken out of service. Trips are indicated and identified down to the channel level."

3.2.2 Conclusion

Based on the evaluation in Section 3.2.1, it is concluded that the initiation signals, logic, and associated circuitry of the AFW system at the Kewaunee plant 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.

3.3 FLOW INDICATION

3.3.1 Evaluation

The performance of the AFW system at the Kewaunee plant can be assessed by the auxiliary feedwater flow indication, three narrow-range and one wide-range steam generator level indications, AFW system valve position indication, auxiliary feedwater pump discharge pressure, and auxiliary feedwater pump status indicators.

The Licensee has proposed a design to upgrade the auxiliary feedwater flow indication system to safety grade. This modification includes replacing the flow transmitters and power supplies with qualified units and rerouting the cable involved so that separation appropriate for safeguard cable is maintained.

There will be one transmitter per train, and redundancy will be provided because only one train is necessary for decay heat removal. The new power supplies will be from separate vital instrument buses, one for each of the two trains. The indication will be separated from the power supply and transmitted via an isolation amplifier. Test jacks will be provided with the instrument rack for periodic test and calibration of the flow measurement system.

The present control room indicators will be used. These indicators provide a continuous display of auxiliary feedwater flow. The control room indicators are separated by a barrier appropriate for safeguards separation.

The environmental qualification of the auxiliary feedwater flow indicators will be reviewed separately by the NRC, and is not within the FRC scope of review.

3.3.2 Conclusion

Upon implementation of the proposed modification, the auxiliary feedwater flow instrumentation at the Kewaunee plant will comply with the long-term, safety-grade requirements of NUREG-0578, Section 2.1.7.b, and the subsequent clarification issued by the NRC and, therefore, is acceptable.

3.4 DESCRIPTION OF STEAM GENERATOR LEVEL INDICATION

Steam generator level instrumentation at the Kewaunee plant consists of three safety-grade, narrow-range level channels (which provide indication, control, and protection) and one control-grade, wide-range channel (which provides indication only) per steam generator. Each wide-range, control-grade level indication system is powered from a vital instrument bus which has diverse power sources. The narrow-range level indication systems are also energized from vital instrument buses.

4. CONCLUSIONS

The initiation signals, logic, and associated circuitry of the Kewaunee plant auxiliary feedwater automatic initiation system comply with the long-term safety-grade requirements of NUREG-0578, Section 2.1.7.a, and the subsequent clarification issued by the NRC.

Review of the auxiliary feedwater flow indication shows that the flow indication system will satisfy the long-term requirements of at least one auxiliary feedwater flowrate indicator for each steam generator upon implementation of the proposed modifications. In addition, the flow indication exceeds the NRC staff's design requirements in that the instrumentation is safety-grade and completely redundant.

5. REFERENCES

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

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