TECHNICAL EVALUATION REPORT

AUXILIARY FEEDWATER SYSTEM AUTOMATIC INITIATION AND FLOW INDICATION

NORTHERN STATES POWER COMPANY
PRAIRIE ISLAND UNITS 1 AND 2

NRC DOCKET NO. 50-282, 50-306

NRC TAC NO. 42541, 42542

FRC PROJECT C5257

NRC CONTRACT NO. NRC-03-79-118

FRC TASKS 278
291

Prepared by

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Prepared for

Nuclear Regulatory Commission
Washington, D.C. 20555

Lead NRC Engineer: R. Kendall

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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 Prairie Island Units 1 and 2. In addition, the steam generator level indication available at Prairie Island 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 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, 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, semirars 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 Northern States Power Company responded to NRC requirements through letters [7-9], with supporting documents and logic diagrams, describing the AFW systems at the Prairie Island Units 1 and 2.

The Franklin Research Center (FRC) staff started a review of the AFW systems at the Prairie Island Units on September 10, 1980, based on the criteria described in Section 2 of this report. In a conference call among staff of the Licensee, FRC, and NRC on September 30, 1980, FRC requested more information, and the Licensee documented the additional information in a letter to the NRC dated December 18, 1980 [10].

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 [11].

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 Systems Branch Technical Position 10-1 of the Standard Review Plan, Section 10.4.9 [Ref. 12 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" [13].

3. TECHNICAL EVALUATION

3.1 GENERAL DESCRIPTION OF AFW SYSTEM

The Prairie Island Units 1 and 2 are Westinghouse-designed "two loop" nuclear power generating plants. The AFW systems for the two units are essentially identical. Each system consists of a turbine-driven pump capable of delivering feedwater to either or both steam generators and a motor-driven pump capable of delivering feedwater to either or both steam generators. The motor-driven pump discharge headers of each unit are interconnected by two normally closed valves. On opening of these valves, the Unit 1 pump can supply water to the Unit 2 steam generators or the Unit 2 pump can supply water to the Unit 1 steam generators. There is no interconnection between the discharge lines of the turbine-driven pumps of either unit.

The valves in the AFW system lines to the steam generators are motor-operated and are normally open. The steam admission valve in the steam supply line to the turbine is motor-operated and normally closed. Two steam supply valves, one from each steam generator, are motor-operated and normally open. Any of the motor-operated valves (MOVs) can be controlled from either the main control room or the hot shutdown panel (local station). The MOV position is indicated to the operator at both the remote and local stations.

3.2 AUTOMATIC INITIATION

3.2.1 EVALUATION

The AFW system automatic initiation circuits at Prairie Island Units 1 and 2 are part of the engineered safety features (ESF) instrumentation system and comply with the general functional requirements of IEEE Std 279-1971 [11]. The following signals are used for automatic initiation of the AFW system:

1. low-low water level in either steam generator
2. trip of both main feedwater pumps
3. safety injection

4. undervoltage on both 4.16-kV normal buses (turbine-driven pump only).

In addition, both local control (from the hot shutdown panel) and remote control (from the control room) can be used to manually initiate the AFW system.

The automatic initiation signals and circuits for the AFW systems at Prairie Island Units 1 and 2 comply with the single failure criterion of IEEE Std 279-1971. The scope of the single failure analysis was limited to the auxiliary feedwater initiation circuitry, electrical power sources, and control systems. The initiating signals and associated circuits are part of the ESF instrumentation system. They are powered from the essential buses. A two-train concept is used for redundancy. The Licensee has stated that the channels are independent and physically separated.

No single failure within the manual or automatic initiation systems will prevent initiation of AFW system by manual or automatic means. The AFW motor-driven pumps are included in the load restoration sequencing on the emergency buses. MOVs are not stripped from the emergency buses, i.e., they remain energized.

The AFW system and components are tested in accordance with technical specification requirements. On a monthly basis, the following components are tested:

1. MOVs
2. steam isolation valve to turbine-driven pumps
3. discharge pressure of AFW pumps
4. turbine pump overspeed trip alarm.

On a yearly basis, the operability of the AFW pumps and power-operated valves are checked by verifying that the pumps and associated valves operate on a normal start signal from the control room and safety injection signal during integrated safety injection test.

The Licensee has stated that the automatic initiation signals for the AFW system are generated by the ESF instrumentation system. The determination of adequate environmental qualification of the circuits and components is being reviewed separately by NRC staff and is beyond the scope of the present FRC task. No modifications have been proposed which would result in interaction of the AFW system safety functions with control functions.

There are no bypasses at the system level during periodic testing of the AFW system automatic initiation circuits for the Prairie Island plants. However, the AFW system can be put in local control from the hot shutdown panel, thus bypassing the automatic initiation circuitry. The Licensee has stated that, in this case, the local switch is annunicated, with an alarm, in the control room and the component is considered out of service when in local control. There is no particular administrative procedure for placing the control switch in local.

The only operating bypass is that provided by the "shutdown auto" position of the operating mode selector switch. This position is used during hot standby, hot shutdown, cooldown, cold shutdown, and heatup operations. This position blocks the automatic start of the auxiliary feedwater pumps when both main feedwater pumps are off. The purpose of the position is to allow operation of only one auxiliary feedwater pump during operations when one is more than sufficient, but to allow the safety-related automatic start signals (safety injection and low steam generator level) to remain operational if needed to start both pumps. "Shutdown auto" does not bypass the safety-related start signals.

3.2.2 CONCLUSION

Based on the evaluation documented in Section 3.2.1, it is found that the initiation signals, logic, and associated circuitry of the AFW systems at Prairie Island Units 1 and 2 comply with the long-term safety-related 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 capability to ascertain the performance of the AFW system at Prairie Island Units 1 and 2 is provided by the control room indication of auxiliary feedwater flow to each steam generator. In addition, separate instruments at the flow transmitter locations provide local indication in the auxiliary building. These local indicators are readily accessible to operators and are used for AFW system operability testing. The AFW system flow indication by itself does not satisfy the single failure criterion; however, each flow channel is backed by a steam generator level channel. The flow channels are powered from vital instrumentation buses.

The Licensee has stated that each flow channel is fully calibrated annually from the process input, on an established preventive maintenance program. Typical channel accuracy, using the square root of the sum of the squares method, is $\pm$ 2.3%.

The Licensee has not stated the safety-grade qualification of the components used in the flow channels. The determination of adequate qualification of the circuits and components is being reviewed separately by NRC staff and is beyond the scope of the present FRC task.

3.3.2 CONCLUSION

Based on the review detailed in the previous section, it is concluded that the flow channels of the AFW system at Prairie Island Units 1 and 2 comply with the long-term safety-related requirements of Section 2.1.7.b of NUREG-0578 and the subsequent clarification issued by the NRC.

3.4 STEAM GENERATOR LEVEL INDICATION DESCRIPTION

The Prairie Island Units 1 and 2 steam generator level instrumentation consists of four channels of level indication for each steam generator. There are three narrow-range channels and one wide-range channel. The narrow-range channels are used both for indicating protection functions and in the

automatic control system. The wide-range channel is used only for indication. Table 1 summarizes the indicators provided and the level reference points for steam generator level instrumentation.

All channels measure level as a function of the difference in pressure developed due to the weight of the water in the steam generator and that in a reference leg using a condensate pot. The level channels are calibrated annually.

Each steam generator level channel is powered from one of four instrument buses (inverters). Each inverter is powered from one of the Class 1E dc power systems. Power to the dc buses is normally supplied through the battery charger. The battery charger is fed from the 480-V ac vital bus with diesel backup. Upon a loss of vital ac supply to the battery charger, the inverter is powered from the associated battery.

The power supplies are divided into trains A and B associated with diesel generators Nos. 1 and 2, respectively. Instrument buses are numbered I, II, III, and IV. Protection channels are labeled red, white, blue, and yellow. Table 2 lists the source supplies for each steam generator level channel.

TABLE 1

UNIT 1 STEAM GENERATOR NOS. 11 AND 12 LEVEL INDICATION INSTRUMENTATION

Location	Instrument	Range
SG No. 11:		
Remote (Control Room)	LI-461, -462, -463 (Narrow Range)	0-100%
	LI-460 (Wide Range)	0-100%
	LR-460, -461 (Recorders)	0-100%
Local (Shutdown Panel)	LI-18016 (Wide Range)	0-100%
Computer	LT-24080, LT-24081, LT-24082 (Narrow)	0-100%
	LT-24083 (Wide)	0-100%
SG No. 12		
Remote (Control Room)	LI-471, -472, -473 (Narrow Range)	0-100%
	LI-470 (Wide Range)	0-100%
	LR-471, -470 (Recorders)	0-100%
Local (Shutdown Panel)	LI-18012 (Wide Range)	0-100%
Computer	LT-24084, LT-24085, LT-24086 (Narrow)	0-100%
	LT-24087 (Wide)	0-100%

Note: 1. Narrow range calibrated for water at operating temperature. Wide range calibrated for water at standard temperature and pressure.

2. Unit 2 level instrumentation is identical.

TABLE 2

POWER FEEDS TO STEAM GENERATOR LEVEL INDICATION CHANNELS

Tag No.	Function	Protection Channel	Instrument Bus	Power Train
460	Wide-Range Level	None	I	B
461	Narrow-Range Level	Red	I	B
462	Narrow-Range Level	Blue	III	A
463	Narrow-Range Level	Yellow	IV	B
470	Wide-Range Level	None	III	A
471	Narrow-Range Level	Yellow	IV	B
472	Narrow-Range Level	Red	I	B
473	Narrow-Range Level	White	II	A

4. CONCLUSIONS

The FRC review of the Prairie Island Units 1 and 2 AFW system automatic initiation circuits and flow instrumentation concludes that these systems comply with the long-term safety-grade requirements of NUREG-0578, Sections 2.1.7.a and 2.1.7.b [3] 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 requirements resulting from Three Mile Island Accident, September 5, 1980.

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

7. L. O. Mayer (Northern States Power Company), letter to Director of Nuclear Reactor Regulation (NRC), November 20, 1979.

8. L. O. Mayer (Northern States Power Company), letter to Director of Nuclear Reactor Regulation (NRC), December 28, 1979.

9. L. O. Mayer (Northern States Power Company), letter to Director of Nuclear Reactor Regulation (NRC), March 13, 1980.

10. L. O. Mayer (Northern States Power Company), letter to Director of Nuclear Reactor Regulation (NRC), December 18, 1980.

11. IEEE Std 279-1971, Criteria for Protection Systems for Nuclear Power Generating Stations, Institute of Electrical and Electronics Engineers, Inc., New York, New York.

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

13. 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.

14. IEEE Std 323-1974, Qualifying Class 1E Equipment for Nuclear Power Generating Stations, Institute of Electrical and Electronics Engineers, Inc., New York, New York.