TECHNICAL EVALUATION REPORT

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

SACRAMENTO MUNICIPAL UTILITY DISTRICT
RANCHO SECO NUCLEAR GENERATING STATION

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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 auxiliary feedwater system design to verify that both safety-grade automatic initiation circuitry and flow indication are provided at the Rancho Seco plant. In addition, the steam generator level indication available at the Rancho Seco 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, AFW 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 Sacramento Municipal Utility District (SMUD) initially responded to the NRC requirements in a letter dated November 19, 1979 [7]. Detailed design information on the AFW system was submitted on November 17, 1980 [8]. Final design information was submitted on September 8, 1981 [9].

The review of the AFW system at the Rancho Seco plant was begun in September 1981, based on the criteria described in Section 2 of this report.

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 [10].

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 requirements from NUREG-0578, Section 2.1.7.b, as clarified by NUREG-0737, Section II.E.1.2-4:

"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 [11]."

The NRC staff has determined that, in the long term, the overall flowrate indication system for Babcock & Wilcox plants should include at least two AFW flowrate indicators per steam generator. The flowrate indication system should have independent channels, use environmentally qualified components, conform to single failure requirements, have the capability for periodic testing, and conform to control system interaction criteria as stipulated in IEEE Std 279-1971.

The operator relies on steam generator level instrumentation, in addition to AFW 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" [12].

3. TECHNICAL EVALUATION

3.1 GENERAL DESCRIPTION OF AUXILIARY FEEDWATER SYSTEM

The auxiliary feedwater (AFW) system at the Rancho Seco 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/motor-driven (combination) pump (840 gpm at 1150 psig) and one motor-driven pump (840 gpm at 1150 psig). Each pump is capable of feeding one or both steam generators. The pumps are interconnected on the discharge side by a crossover line, which contains two normally open, motor-operated valves.

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 Pump

1. loss of both main feed pumps
2. low level in either steam generator
3. loss of all four reactor coolant pumps (RCPs)
4. low pressure in either steam generator if main feedwater is isolated on this parameter
5. power/main feedwater flow ratio

B. Turbine-Driven Pump

1. loss of both main feed pumps
2. low level in either steam generator
3. loss of all four reactor coolant pumps (RCPs)
4. low pressure in either steam generator if main feedwater is isolated on this parameter
5. power/main feedwater flow ratio.

Normal valve lineup is such that either pump, one in each train, can supply AFW to the respective steam generator or one of the pumps can supply water to both steam generators via two normally open, motor-operated valves in the crossover line and a normally closed, motor-operated steam generator AFW

control valve. Both pumps can be manually started from the control room and the equipment cabinets. The operation of either pump 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 Rancho Seco plant is designed as a safety-grade system, 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. The two AFW trains are powered from diverse power sources. The motor-driven pump (P-319) train is powered from diesel generator-backed 4160-volt ac bus B. The turbine-driven/motor-driven pump (P-318) train derives its power from either the steam generator (via dc-operated steam admission valves) or 4160-volt ac bus A.

All of the valves associated with each pump train are normally open with the exception of the four flow control valves (two in each train, in parallel). These valves are air operated with control power from 120 volt ac, battery-backed buses A and B. The control air for these valves is supplied from qualified, redundant, control-grade air supply systems, with redundant valves in the same train being connected to a different air supply system. The AFW control valves (FV-20527, FV-20528, FV-X1, and FV-X2) fail full open on loss of control air, and fail half open on loss of control power. Thus, in order to lose AFW flow in either train, both air supplies must fail and both control valves must fail out of their fail-safe position.

The capability to manually initiate AFW flow is provided, and these manual initiation circuits meet single failure criteria. Both the motor-driven and turbine-driven pumps can be started from either the control room or local equipment cabinets. A single failure in the manual circuits will not result

in the loss of system automatic function, and a failure of the automatic initiating signals and circuits will not result in the loss of manual capability.

The automatic initiation signals and circuitry used at the Rancho Seco 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 protection functions.

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 and is beyond the scope of this review.

Automatic sequencing of AFW pump P-319 onto the emergency diesel generator is not a function of the AFW system design. Consequently, on loss of all ac power and a single failure of AFW pump P-318, AFW flow will not be automatically initiated. However, the Licensee has indicated that another diesel generator will be added and that AFW pump P-319 will be part of its automatic load sequencing scheme [9].

The primary source of water for the AFW system is the Seismic Category 1 condensate storage tank (T-358). Water is supplied from this tank via two 8-inch lines, one to each pump suction, with locked open manual valves (PWS-045 and -046). A reserve of 250,000 gallons is maintained within the tank and is verified by redundant, safety-grade level indication in the control room and internal standpipe. This volume is sufficient to remove decay heat for approximately 4 hours and to subsequently cool down to the decay heat removal system entry pressure. Safety-grade low level alarms are also provided to alert the operators. The secondary water sources are either the onsite reservoir or the Folsom South Canal. Suction must be manually transferred from the condensate storage tank to either the reservoir or the canal by opening locked closed, manual valves PWC-076 and PWC-079, closing manual valves MCM-057 and MCM-056, and either (1) operating the Folsom South

Canal transfer pumps or (2) opening motor-operated valve HV-43011 to obtain gravity flow from the onsite reservoirs.

Automatic isolation of AFW flow to a leaking steam generator is provided, in that a steam line break or feedwater line break that depressurizes a steam generator will cause the isolation of the main steam lines and main feedwater lines on the depressurized steam generator. If isolation of the steam generator main feed and main steam lines do not isolate the break, AFW flow will be isolated from the leaking steam generator so that AFW flow will be provided only to the intact steam generator. No single active failure will prevent AFW from being supplied to the intact steam generator or allow AFW to be supplied to the leaking steam generator.

Initiation and control of the AFW system is accomplished by the emergency feed initiation and control (EFIC) system. The EFIC system is designed to provide the following:

- o initiate AFW
- o control AFW
- o provide level rate control
- o isolate the main steam and main feed line of a depressurized steam generator
- o control the atmospheric dump valve.

Manual initiation of the system is accomplisned by depressing two manual trip switches. The use of two switches permits testing of the trip switches and also reduces the possibility of accidental manual initiation. A manual reset switch is provided; this switch functions not only as a system reset, but also as a system bypass. Operation of this manual reset (bypass) push button:

- o will have no effect on the trip logic so long as a trip condition does not exist.
- o will remove the trip from the trip bus only so long as the switch is depressed in the case of a one half trip (either bus, but not both tripped). This allows for testing the manual function.
- o will remove the trip from both buses so long as a full trip exists. This is accomplished by means of manual latching logic. If the initiating signal clears, the trip logic will revert to the automatic trip mode in preparation for tripping if a parameter returns to the trip region.

Channel bypasses exist in the EFIC system at the Rancho Seco plant to allow testing of the initiation logic, and are known as maintenance bypasses. Only one channel at a time is allowed in test and this is ensured by electrical interlock.

Status light indication is provided for the EFIC system (bypass, test, tripped, etc.); however, no annunciation is provided for the reset (override) condition of removing the trip from both buses so long as a full trip continues to exist.

The capability to monitor system operation is provided by direct position indication (open-shut) for all automatically operated and remote manual, power-operated valves as well as the following:

- o high steam generator level (for SGA and SGB)
- o low steam generator level (for SGA and SGB)
- o low source water level
- o low AFW pump discharge pressure (pump P-318 and P-319)
- o low AFW pump suction pressure (pump P-318 and P-319)
- o steam line valves HV-20569, HV-20596, and HV-30801 closed.

At present, the Rancho Seco Technical Specifications require the automatic AFW actuation control logic to be tested monthly and calibrated once every 18 months. Future test requirements are proposed to be monthly on the EFIC signals and circuits, with an 18-month calibration interval.

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 Rancho Seco 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 with the following exception:

- o No annunciation is provided for the override of the AFW system automatic initiation.

3.3 FLOW INDICATION

3.3.1 Evaluation

The performance of the AFW system at the Rancho Seco plant can be assessed by indication of AFW flow, steam generator startup range level, steam generator operating range level, AFW system valve position, and AFW pump status.

The Rancho Seco plant has one AFW flow channel per steam generator which is a sonic flow device located downstream of any cross connect to ensure indication of AFW flow delivered to each steam generator. The present flow indication system is control grade; however, the Licensee has agreed to provide a different safety-grade power supply for each flow detector, and to install an additional safety-grade AFW flow instrumentation system for each steam generator.

AFW flow rate is channel checked monthly, and calibrated each refueling outage.

3.3.2 Conclusion

The present AFW flow indication does not meet the long-term requirements of NUREG-0578, Section 2.1.7.b, and the subsequent clarification issued by the NRC. In order to comply with these requirements, a second safety-grade AFW flow indication channel per steam generator should be installed, and the present system upgraded to meet the requirements established in NUREG-0737, Section II.E.1.2 for Babock and Wilcox steam generators.

3.4 DESCRIPTION OF STEAM GENERATOR LEVEL INDICATION

Steam generator level instrumentation at the Rancho Seco plant consists of four safety-grade wide-range and four safety-grade narrow-range level transmitters (which provide indication, control, and protection) for each steam generator. These transmitters provide inputs to four EFIC channels. Each EFIC channel receives a wide-range and narrow-range input from each steam generator and will have local indication in the EFIC cabinet, as well as redundant indicators in the main control room.

The following sensor instruments will be available for each steam generator:

Type	No.	Range (inches of water)
Wide Range	1	0-650
Wide Range	2	0-292
Start-up Narrow Range	2	0-250 (388-in level)
Low Narrow Range	4	0-100 (285-in level)
Wide Range	4	0-394-- (402-in level)

4. CONCLUSIONS

Based on the evaluation in Section 3.2.1, it is concluded that the initiation signals, logic, and associated circuitry of the auxiliary feedwater (AFW) system at the Rancho Seco 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 with the following exception:

- No annunciation is provided for the override of the AFW system automatic initiation.

The present AFW flow indication does not meet the long-term, safety-grade requirements of Section 2.1.7.b of NUREG-0578 and the subsequent clarification issued by the NRC:

- In order to comply with these requirements, a second safety-grade AFW flow indication channel per steam generator should be installed, and the present system upgraded to meet the requirements established in NUREG-0737, Section II.E.1.2 for Babcock & Wilcox generators.

5. REFERENCES

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