TECHNICAL EVALUATION REPORT

# AUXILIARY FEEDWATER SYSTEM AUTOMATIC INITIATION AND FLOW INDICATION

VIRGINIA ELECTRIC AND POWER COMPANY
NORTH ANNA UNIT 1

NRC DOCKET NO. 50-338

NRC TAC NO. 43191

NRC CONTRACT NO. NRC-03-79-118

FRC PROJECT C5257

FRC ASSIGNMENT 9

FRC TASK 288

*Prepared by*


Franklin Research Center
The Parkway at Twentieth Street
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FRC Group Leader: K. Fertner


*Prepared for*

Nuclear Regulatory Commission
Washington, D.C. 20555

Lead NRC Engineer: R. Kendall

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CONTENTS

# 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 safety-grade automatic initiation circuitry and flow indication are provided at North Anna Unit 1. Although not in the scope of this review, the steam generator level indication available at North Anna Unit 1 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 established that the auxiliary eedwater (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 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, 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 control-grade requirements for the AFW system, 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, it required auxiliary feedwater flow indication in the control room in accordance with 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] and formalized in the letter of October 31, 1980 [6]. The October 31 letter incorporated in one document, NUREG-0737 [7], all TMI-related items approved by the commission for implementation. 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 North Anna Unit 1, Virginia Electric and Power Company (VEPCO), provided its initial response to Reference 3 on October 24, 1979 [8]. In this response, VEPCO indicated that the AFW system at North Anna Unit 1 was automatically initiated and contained auxiliary feedwater flow indication. Later, further correspondence was issued between VEPCO and the NRC relating to the implementation of NUREG-0578 [9-13]. On December 15, 1980 [14], VEPCO provided its response to the requirements of NUREG-0737. On July 10, 1981 [15], the NRC forwarded a request for additional information in order for FRC to complete this review; VEPCO responded to this request on August 3, 1981 [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 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 were to 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 from NUREG-0578, Section 2.1.7.b [3], as clarified by NUREG-0737, Section II.E.1.2 [7]:

"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 [18]."

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 flow rate indicators. These flow indication systems should be environmentally qualified; powered from a highly reliable, battery backed non-class 1E power source; periodically testable; part of the plant's QA 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" [19].

# 3. TECHNICAL EVALUATION

## 3.1 GENERAL DESCRIPTION OF AFW SYSTEM

North Anna Unit 1 is a Westinghouse-designed three-loop nuclear power plant and is essentially identical to North Anna Unit 2. The AFW system supplies water to the secondary side of the steam generators for reactor decay heat removal when normal feedwater sources are unavailable. The AFW system consists of one turbine-driven pump (700 gpm) and two motor-driven pumps (350 gpm each).

Auxiliary feedwater flow to the steam generators is automatically initiated when preset levels of any of several monitored parameters are exceeded. The two motor-driven pumps each discharge through an individual automatic pressure control valve (PCV) into two discharge headers. Either header may supply any steam generator, but both are normally aligned so that each pump supplies a single steam generator. A third header normally provides a flow path from the turbine-driven pump to steam generator A, but can also be cross-connected to either of the AFW headers to supply any steam generator.

Each steam generator is supplied through a normally open, air-operated or motor-operated valve; these valves do not receive any automatic initiation signals. In the event of a pump or piping component failure, the AFW system may be realigned using remote and manually operated valves to ensure flow to at least one good steam generator.

Steam generator level is controlled manually from the control room or the auxiliary shutdown panel by operating the appropriate PCVs in the motor-driven pump discharge headers.

## 3.2 AUTOMATIC INITIATION

### 3.2.1 Evaluation

The AFW system at North Anna Unit 1 is designed as an engineered safeguards system to seismic Category I, Class 1E, and the automatic initiation signals and circuits are designed to comply with the single failure criterion of IEEE Std 279-71 [17].

The North Anna Unit 1 AFW automatic initiation system consists of two independent actuation trains. The circuits are powered from emergency ac buses, except the motor-driven pump breaker control and turbine steam admission valves, which are powered from the 125-V dc bus. The redundant channels are physically separated and electrically independent. A review of the automatic initiation circuitry revealed no credible single failure that would inhibit the automatic initiation system from providing AFW flow to at least one good steam generator. The scope of the single failure analysis in this report was limited to the redundancy of power supplies, diversity of actuating signals, and independence and redundancy of automatic initiation circuits.

The motor-driven pumps are powered by independent ac emergency buses. The loading of the motor-driven pumps to their respective 4 kV emergency buses is part of the post-accident automatic load sequencing.

The turbine-driven pump receives its steam through either of two parallel air-operated (fail open) steam admission valves which are supplied from lines that tap off upstream of each steam generator isolation valve.

The following signals are used for automatic initiation of the AFW system motor-driven or turbine-driven pumps:

- o low-low steam generator level (2 out of 3 channels on either steam generator)
- o loss of offsite power
- o trip of all main feedwater pumps
- o safety injection.

In addition, the AFW system may be manually initiated from the control room or the auxiliary shutdown panel.

The AFW system and components are tested in accordance with technical specifications. The proper operation of the AFW pumps is checked at least every 31 days, the motor-driven pumps are tested 72 hours prior to plant heat-up, and the turbine-driven pump is tested 72 hours prior to plant startup. Every 18 months each pump is verified to start on receipt of each of the automatic initiation signals. The automatic initiation logic is tested monthly.

The system design allows one channel to be bypassed for maintenance, testing, and calibration during power operation without initiating a protective action. Any time a channel is bypassed, the bypass is accompan'.d by a partial trip alarm and channel status light actuation in the control room. There are no operating bypasses associated with the AFW system. If some part of the system has been administratively bypassed or taken out of service, indication is provided in the control room.

The only interaction between the AFW system automatic initiation circuits and normal system control functions occurs in the narrow-range steam generator level instrumentation. These level instruments are used for both protection (reactor trip and AFW initiation) and normal control functions (narrow-range channel III only) in the main feedwater system. The control signals are separated from the protection signals by isolation transformers such that a malfunction in the control circuits will have no effect on the protection signals.

The following individual alarms are provided on the main control board bench section to alert the operator that the AFW equipment may not operate properly:

- AFW turbine train A or B not in auto
- AFW protection logic in test
- AFW pump pressure control valve not open
- low-low steam generator level (3 channels each)
- AFW pump A trip
- AFW pump B trip.

The following are the air-operated AFW control valve alarms:

- motor-driven pump supply to steam generator A or B not fully closed
- motor-driven pump supply to steam generator C not fully open.

The following are the motor-operated AFW control valve alarms:

- Motor-driven pump supply to steam generator A or C not fully closed

- o Motor-driven pump supply to steam generator B or turbine-driven pump supply to steam generator A not fully open.

A review of the automatic and manual initiation circuitry and signals revealed that no single failure to either circuit train would inhibit the capability for manual initiation from the control room or the auxiliary shutdown panel. The environmental qualification of safety-related electrical and mechanical components, including AFW system circuits and components, is being reviewed separately by the NRC and is not within the FRC scope of review.

### 3.2.2 Conclusion

The initiation signals, logic, and associated circuitry of the automatic initiation feature of the AFW system of North Anna 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.

## 3.3 FLOW INDICATION

### 3.3.1 Evaluation

The capability to evaluate the performance of the AFW system at North Anna Unit 1 is provided by:

- o auxiliary feedwater flow rate (1 channel per steam generator)
- o narrow-range steam generator level (3 channels each)
- o wide-range steam generator level (1 channel each)
- o AFW pump discharge and suction pressure
- o AFW pump status indicators
- o discharge valve position indicators
- o pump current and voltage
- o condensate storage tank level.

The Licensee has stated that the AFW flow indication for each steam generator is safety grade. The individual flow indication circuitry is powered from separate vital buses. AFW flow indication at North Anna Unit 1 is not designed to accommodate a single failure; however, safety-grade wide-range steam generator level indication is provided as a backup. The AFW flow indicators are testable from the transmitter to the indicator. The overall accuracy of the feed flow loops is within ±10%. The flow indication channels are tested in accordance with technical specifications.

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

### 3.3.2 Conclusion

It is concluded that the auxiliary feedwater flow instrumentation at North Anna 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 DESCRIPTION OF STEAM GENERATOR LEVEL INDICATION

Steam generator level indication at North Anna Unit 1 consists of three safety-grade narrow range level channels and one safety-grade wide-range level channel per steam generator. The level transmitters and their power supplies are as follows:

STEAM GENERATOR A

| Channel | Transmitter | Vital Bus |
|---|---|---|
| Wide Range | LT-1477 | 1-II |
| Narrow Range I | LT-1474 | 1-I |
| Narrow Range II | LT-1475 | 1-II |
| Narrow Range III | LT-1476 | 1-III |

STEAM GENERATOR B

| Channel | Transmitter | Vital Bus |
|---|---|---|
| Wide Range | LT-1487 | 1-III |
| Narrow Range I | LT-1484 | 1-I |
| Narrow Range II | LT-1485 | 1-II |
| Narrow Range III | LT-1486 | 1-III |

STEAM GENERATOR C

| Channel | Transmitter | Vital Bus |
|---|---|---|
| Wide Range | LT-1497 | 1-IV |
| Narrow Range I | LT-1494 | 1-I |
| Narrow Range II | LT-1495 | 1-II |
| Narrow Range III | LT-1496 | 1-III |

Calibration and testing is performed once every 18 months for narrow-range level channels and once every 24 months for wide-range level channels.

The wide-range channels for all three steam generators are indicated individually on one stripchart recorder. Narrow-range channels I and II for all three steam generators are indicated on vertical gages. Narrow-range channel III for all three steam generators are indicated on both a vertical gage and a stripchart recorder.

## 4. CONCLUSIONS

The initiation signals, logic, and associated circuitry of the North Anna Unit 1 auxiliary feedwater system comply with the long-term safety-grade requirements of NUREG-0578, Section 2.1.7.a [3], and the subsequent clarification issued by the NRC.

The auxiliary feedwater flow instrumentation at North Anna Unit 1 complies with the long-term safety-grade requirements of NUREG-0578, Section 2.1.7.b [3], and the subsequent clarification issued by the NRC.

## F. REFERENCES


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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.

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