TECHNICAL EVALUATION REPORT

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

ROCHESTER GAS AND ELECTRIC CORPORATION
ROBERT E. GINNA NUCLEAR POWER PLANT

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Prepared by
Franklin Research Center
20th and Race Street
Philadelphia, PA 19103

Prepared for
Nuclear Regulatory Commission
Washington, D.C. 20555

Author: F. W. Vosbury

FRC Group Leader: K. S. Fertner

Lead NRC Engineer: R. Kendall
M. Wigdor

July 23, 1982

Reviewed by: J E K

Group Leader

Approved by: C J Crane

Project Manager

Department Director

Franklin Research Center
A Division of The Franklin Institute
The Benjamin Franklin Parkway, Phila., Pa. 19103 (215) 448-1000

8207270149

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FOREWORD

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Mr. F. W. Vosbury contributed to the technical preparation of this report through a subcontract with WESTEC Services, Inc.

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 the Robert E. Ginna Nuclear Power Plant. Although not in the scope of this review, the steam generator level indication available at the Ginna 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 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 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 AFW 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 the Robert E. Ginna Nuclear Power Plant, Rochester Gas and Electric Corporation (RG&E), provided its response to Reference 3 on October 17, 1979 [8]. In this response RG&E indicated that the Ginna plant was equipped with a safety-grade, automatically initiated AFW system, and that the existing flow indication for each generator complied with the requirements for a control-grade system. RG&E agreed to upgrade the AFW flow indication by January 1, 1981. Additional correspondence [9-13] was exchanged between RG&E and the NRC regarding the AFW system, the implementation of NUREG-0578, and the subsequent clarification issued by the NRC. On December 30, 1980 [14], RG&E provided its response to NUREG-0737 and included the design criteria to upgrade the AFW flow indication to safety-grade. On August 19, 1981 [15], the NRC sent a request for additional information to aid in the completion of this report. RG&E responded with the additional requested information on September 22, 1981 [13].

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. Control-grade systems were 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 AFW flowrate indicator and one wide-range steam generator level indicator for each steam generator or two flowrate 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 quality assurance program; and capable of display on demand.

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" [19].

3. TECHNICAL EVALUATION

3.1 GENERAL DESCRIPTION OF AUXILIARY FEEDWATER SYSTEM

The Ginna plant is a Westinghouse-designed, two-loop nuclear power plant. The AFW system consists of a main AFW system and a standby AFW system. The main AFW system consists of two motor-driven pumps (200 gpm each) and one turbine-driven pump (400 gpm). Normally, each motor-driven pump supplies one steam generator, but the alignment can be altered to allow either motor-driven pump to supply both steam generators. The turbine-driven pump normally supplies feedwater to both steam generators. Each pump supplies the steam generators through a normally closed, motor-operated, discharge valve. Only the flow from one motor-driven pump (200 gpm) is necessary to prevent the reactor coolant system from reaching the pressure required to actuate a relief valve.

The three main AFW pumps are located in the same room and could be rendered inoperable as a result of a high energy line break. The standby AFW system was installed to provide independent AFW system capability following such an event. The standby AFW system consists of two motor-driven pumps (200 gpm each) located in a plant area separate from the main AFW system. The standby AFW system is manually actuated and aligned so that each pump supplies one steam generator.

The water sources for the main AFW system are two 30,000-gallon condensate storage tanks (non-seismic), a 100,000-gallon condensate storage tank (non-seismic), and the service water system (seismic Category I). The water source for the standby AFW system is the service water system, which draws its water from Lake Ontario.

Steam generator level is controlled manually from the control room by adjusting the position of the main AFW pump motor-operated discharge valves.

3.2 AUTOMATIC INITIATION

3.2.1 Evaluation

The main AFW system at the Ginna plant is designed as an engineered safeguards system to seismic Category I (with the exception of the condensate storage tanks), Class 1E, and the automatic initiation signals and circuits are designed to comply with the requirements of IEEE Std 279-1971 [17].

The Ginna plant main AFW automatic initiation system consists of two independent actuation trains. The actuation circuits are powered from emergency dc buses. 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.

Both the main and standby AFW motor-driven pumps are powered by independent ac emergency buses. The loading of the main AFW motor-driven pumps onto their respective 480-Vac emergency buses is part of the post-accident automatic load sequencing. The standby AFW motor-driven pumps are interlocked with the main AFW motor-driven pumps so that both are not simultaneously loaded onto the emergency bus to prevent overloading during loss of offsite power.

The turbine-driven pump receives its steam through a motor-operated steam admission valve in each of two lines that tap off upstream of the steam generator isolation valves.

The following signals are used for automatic initiation of the main AFW system:

Motor-driven Pumps

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

Turbine-driven Pump

- o low-low steam generator level (2 out of 3 channels on both steam generators)
- o loss of voltage on both 4-kV buses

The main AFW system may be manually initiated from the control room by starting the motor-driven AFW pumps individually; upon pump start, the associated discharge valve opens.

The main AFW motor-driven pumps discharge valves open fully on pump start and then throttle down to limit flow to a maximum of 230 gpm to each steam generator. The automatic throttling conserves auxiliary feedwater and helps limit the cooldown rate. The turbine-driven pump discharge valve is normally open; in addition, when the turbine-driven pump is automatically initiated (steam admission valves open), the discharge valve receives an automatic actuation signal to ensure that it is fully open.

The main and standby AFW system and components are tested in accordance with technical specifications. Operation of the AFW pumps and motor-operated valves is checked monthly. Every 18 months each main AFW pump and main AFW motor-operated valve is verified to operate correctly 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. When a channel is bypassed for testing, the bypass is accompanied by a single channel alert and channel status light actuation in the control room. The automatic start of the main AFW motor-driven pumps resulting from the tripping of both main feedwater pumps may be defeated during startup or shutdown when the turbine generator is off the line. The defeat switch is automatically bypassed when the turbine is latched. This bypass is alarmed in the control room.

The only interaction between the main 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 main AFW initiation) and normal control functions (narrow-range channel I only) in the main feedwater system. The control signals are separated from the protection signals by isolation transformers so 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 to alert the operator that the main AFW equipment may not operate properly:

- o low-low steam generator level (3 channels each)
- o 2 out of 3 low-low steam generator levels (1 channel each)
- o 3 out of 3 low-low steam generator levels (1 channel each)
- o emergency shutdown equipment local control
- o safeguards breaker trip
- o safeguards equipment lock-off
- o main AFW bypass in defeat lockout
- o single channel alert
- o standby AFW pump C or D trip
- o standby AFW pump transfer switch off normal (1 channel each)
- o standby AFW pump high discharge flow (1 channel each)
- o standby AFW pump high discharge pressure (1 channel each)
- o standby AFW HVAC trouble.

No alarms are provided to monitor the power available to the steam admission valves or AFW discharge valves.

A review of the automatic and manual initiation circuitry and signals revealed that no single failure of 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 scope of this review.

3.2.2 Conclusion

The initiation signals, logic, and associated circuitry of the automatic initiation feature of the main AFW system of the Ginna plant 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.

In addition, the following point may effect the reliability of the AFW system:

- No alarms are provided to monitor the power available to the steam admission valves or AFW discharge valves.

3.3 FLOW INDICATION

3.3.1 Evaluation

The capability to evaluate the performance of the main and standby AFW systems at the Ginna plant is provided by the following indications:

- main AFW motor-driven pump flow to each steam generator (2 channels each)
- main AFW turbine-driven pump discharge flow (2 channels)
- main AFW turbine-driven pump flow to each steam generator (2 channels each)
- standby AFW motor-driven pump flow (1 channel each)
- main AFW pump discharge pressure
- standby AFW pump discharge pressure
- narrow-range steam generator level (3 channels each)
- wide-range steam generator level (1 channel each)
- main and standby AFW pump status indication
- main and standby AFW valve position indication
- condensate storage tank level (2 channels).

The Licensee has stated that the main AFW flow indication for each steam generator is safety-grade. The individual steam generator AFW flow circuitry is powered from separate battery-backed instrument buses. For each main AFW pump, there is a primary and secondary flow instrumentation channel. The primary channel indicates flow and, for the motor-driven pumps, controls the individual discharge valves. The secondary flow instrumentation indicates flow only. The primary and secondary channels are powered from opposite instrument buses. The primary and secondary flow indication is provided on the main control board by a dual-movement vertical-scale indicator.

Since the discharge header from the turbine-driven pump branches to supply both steam generators, an additional channel of safety-grade flow instrumentation is provided in each line. Safety-grade wide-range steam generator level indication is provided as a backup. The standby AFW system provides a single channel of safety-guide flow instrumentation for each pump. 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 scope of this review.

3.3.2 Conclusion

It is concluded that the AFW flow instrumentation at the Ginna plant 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 the Ginna plant 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-460	A
Narrow Range I	LT-461	A
Narrow Range II	LT-462	C
Narrow Range III	LT-463	D

STEAM GENERATOR B

Channel	Transmitter	Vital Bus
Wide Range	LT-470	B
Narrow Range I	LT-471	D
Narrow Range II	LT-472	A
Narrow Range III	LT-473	B

The steam generator level channels are checked each shift, tested monthly, and calibrated during refueling.

The wide-range channels for both steam generators are indicated individually on one stripchart recorder. Narrow-range channels for both steam generators are indicated on vertical gages.

4. CONCLUSIONS

The initiation signals, logic, and associated circuitry of the Robert E. Ginna Nuclear Power Plant 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.

In addition, the following points may affect the reliability of the AFW system:

- No alarms are provided to monitor the power available to the steam admission valves or AFW discharge valves.

The auxiliary feedwater flow instrumentation 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.

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," NRC, 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.

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"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.

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3. TECHNICAL EVALUATION

3.1 GENERAL DESCRIPTION OF AUXILIARY FEEDWATER SYSTEM

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The water sources for the main AFW system are two 30,000-gallon condensate storage tanks (non-seismic), a 100,000-gallon condensate storage tank (non-seismic), and the service water system (seismic Category I). The water source for the standby AFW system is the service water system, which draws its water from Lake Ontario.

Steam generator level is controlled manually from the control room by adjusting the position of the main AFW pump motor-operated discharge valves.

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The following signals are used for automatic initiation of the main AFW system:

Motor-driven Pumps

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

Turbine-driven Pump

- o low-low steam generator level (2 out of 3 channels on both steam generators)
- o loss of voltage on both 4-kV buses

The main AFW system may be manually initiated from the control room by starting the motor-driven AFW pumps individually; upon pump start, the associated discharge valve opens.

The main AFW motor-driven pumps discharge valves open fully on pump start and then throttle down to limit flow to a maximum of 230 gpm to each steam generator. The automatic throttling conserves auxiliary feedwater and helps limit the cooldown rate. The turbine-driven pump discharge valve is normally open; in addition, when the turbine-driven pump is automatically initiated (steam admission valves open), the discharge valve receives an automatic actuation signal to ensure that it is fully open.

The main and standby AFW system and components are tested in accordance with technical specifications. Operation of the AFW pumps and motor-operated valves is checked monthly. Every 18 months each main AFW pump and main AFW motor-operated valve is verified to operate correctly 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. When a channel is bypassed for testing, the bypass is accompanied by a single channel alert and channel status light actuation in the control room. The automatic start of the main AFW motor-driven pumps resulting from the tripping of both main feedwater pumps may be defeated during startup or shutdown when the turbine generator is off the line. The defeat switch is automatically bypassed when the turbine is latched. This bypass is alarmed in the control room.

The only interaction between the main 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 main AFW initiation) and normal control functions (narrow-range channel I only) in the main feedwater system. The control signals are separated from the protection signals by isolation transformers so 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 to alert the operator that the main AFW equipment may not operate properly:

- low-low steam generator level (3 channels each)
- 2 out of 3 low-low steam generator levels (1 channel each)
- 3 out of 3 low-low steam generator levels (1 channel each)
- emergency shutdown equipment local control
- safeguards breaker trip
- safeguards equipment lock-off
- main AFW bypass in defeat lockout
- single channel alert
- standby AFW pump C or D trip
- standby AFW pump transfer switch off normal (1 channel each)
- standby AFW pump high discharge flow (1 channel each)
- standby AFW pump high discharge pressure (1 channel each)
- standby AFW HVAC trouble.

No alarms are provided to monitor the power available to the steam admission valves or AFW discharge valves.

A review of the automatic and manual initiation circuitry and signals revealed that no single failure of 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 scope of this review.

3.2.2 Conclusion

The initiation signals, logic, and associated circuitry of the automatic initiation feature of the main AFW system of the Ginna plant 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.

In addition, the following point may effect the reliability of the AFW system:

- o No alarms are provided to monitor the power available to the steam admission valves or AFW discharge valves.

3.3 FLOW INDICATION

3.3.1 Evaluation

The capability to evaluate the performance of the main and standby AFW systems at the Ginna plant is provided by the following indications:

- o main AFW motor-driven pump flow to each steam generator (2 channels each)
- o main AFW turbine-driven pump discharge flow (2 channels)
- o main AFW turbine-driven pump flow to each steam generator (2 channels each)
- o standby AFW motor-driven pump flow (1 channel each)
- o main AFW pump discharge pressure
- o standby AFW pump discharge pressure
- o narrow-range steam generator level (3 channels each)
- o wide-range steam generator level (1 channel each)
- o main and standby AFW pump status indication
- o main and standby AFW valve position indication
- o condensate storage tank level (2 channels).

The Licensee has stated that the main AFW flow indication for each steam generator is safety-grade. The individual steam generator AFW flow circuitry is powered from separate battery-backed instrument buses. For each main AFW pump, there is a primary and secondary flow instrumentation channel. The primary channel indicates flow and, for the motor-driven pumps, controls the individual discharge valves. The secondary flow instrumentation indicates flow only. The primary and secondary channels are powered from opposite instrument buses. The primary and secondary flow indication is provided on the main control board by a dual-movement vertical-scale indicator.

Since the discharge header from the turbine-driven pump branches to supply both steam generators, an additional channel of safety-grade flow instrumentation is provided in each line. Safety-grade wide-range steam generator level indication is provided as a backup. The standby AFW system provides a single channel of safety-guide flow instrumentation for each pump. 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 scope of this review.

3.3.2 Conclusion

It is concluded that the AFW flow instrumentation at the Ginna plant 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 the Ginna plant 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-460	A
Narrow Range I	LT-461	A
Narrow Range II	LT-462	C
Narrow Range III	LT-463	D

STEAM GENERATOR B

Channel	Transmitter	Vital Bus
Wide Range	LT-470	B
Narrow Range I	LT-471	D
Narrow Range II	LT-472	A
Narrow Range III	LT-473	B

The steam generator level channels are checked each shift, tested monthly, and calibrated during refueling.

The wide-range channels for both steam generators are indicated individually on one stripchart recorder. Narrow-range channels for both steam generators are indicated on vertical gages.

4. CONCLUSIONS

The initiation signals, logic, and associated circuitry of the Robert E. Ginna Nuclear Power Plant 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.

In addition, the following points may affect the reliability of the AFW system:

- o No alarms are provided to monitor the power available to the steam admission valves or AFW discharge valves.

The auxiliary feedwater flow instrumentation 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.

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," NRC, July 1979.

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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, NRC, December 1980.

TECHNICAL EVALUATION REPORT

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

ROCHESTER GAS AND ELECTRIC CORPORATION
ROBERT E. GINNA NUCLEAR POWER PLANT

NRC DOCKET NO. 50-244

NRC TAC NO. 11706

NRC CONTRACT NO. NRC-03-79-118

FRC PROJECT C5257

FRC ASSIGNMENT 9

FRC TASK 287

Prepared by

Franklin Research Center
20th and Race Street
Philadelphia, PA 19103

Author: F. W. Vosbury

FRC Group Leader: K. S. Fertner

Prepared for

Nuclear Regulatory Commission
Washington, D.C. 20555

Lead NRC Engineer: R. Kendall
M. Wigdor

July 23, 1982

Reviewed by:

Group Leader

Approved by:

Project Manager

Department Director

Franklin Research Center
A Division of The Franklin Institute
The Benjamin Franklin Parkway, Phila., Pa. 19103 (215) 448-1000

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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.

Mr. F. W. Vosbury contributed to the technical preparation of this report through a subcontract with WESTEC Services, Inc.

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 the Robert E. Ginna Nuclear Power Plant. Although not in the scope of this review, the steam generator level indication available at the Ginna 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 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 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 AFW 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 the Robert E. Ginna Nuclear Power Plant, Rochester Gas and Electric Corporation (RG&E), provided its response to Reference 3 on October 17, 1979 [8]. In this response RG&E indicated that the Ginna plant was equipped with a safety-grade, automatically initiated AFW system, and that the existing flow indication for each generator complied with the requirements for a control-grade system. RG&E agreed to upgrade the AFW flow indication by January 1, 1981. Additional correspondence [9-13] was exchanged between RG&E and the NRC regarding the AFW system, the implementation of NUREG-0578, and the subsequent clarification issued by the NRC. On December 30, 1980 [14], RG&E provided its response to NUREG-0737 and included the design criteria to upgrade the AFW flow indication to safety-grade. On August 19, 1981 [15], the NRC sent a request for additional information to aid in the completion of this report. RG&E responded with the additional requested information on September 22, 1981 [13].

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. Control-grade systems were 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 AFW flowrate indicator and one wide-range steam generator level indicator for each steam generator or two flowrate 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 quality assurance program; and capable of display on demand.

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" [19].

3. TECHNICAL EVALUATION

3.1 GENERAL DESCRIPTION OF AUXILIARY FEEDWATER SYSTEM

The Ginna plant is a Westinghouse-designed, two-loop nuclear power plant. The AFW system consists of a main AFW system and a standby AFW system. The main AFW system consists of two motor-driven pumps (200 gpm each) and one turbine-driven pump (400 gpm). Normally, each motor-driven pump supplies one steam generator, but the alignment can be altered to allow either motor-driven pump to supply both steam generators. The turbine-driven pump normally supplies feedwater to both steam generators. Each pump supplies the steam generators through a normally closed, motor-operated, discharge valve. Only the flow from one motor-driven pump (200 gpm) is necessary to prevent the reactor coolant system from reaching the pressure required to actuate a relief valve.

The three main AFW pumps are located in the same room and could be rendered inoperable as a result of a high energy line break. The standby AFW system was installed to provide independent AFW system capability following such an event. The standby AFW system consists of two motor-driven pumps (200 gpm each) located in a plant area separate from the main AFW system. The standby AFW system is manually actuated and aligned so that each pump supplies one steam generator.

The water sources for the main AFW system are two 30,000-gallon condensate storage tanks (non-seismic), a 100,000-gallon condensate storage tank (non-seismic), and the service water system (seismic Category I). The water source for the standby AFW system is the service water system, which draws its water from Lake Ontario.

Steam generator level is controlled manually from the control room by adjusting the position of the main AFW pump motor-operated discharge valves.

3.2 AUTOMATIC INITIATION

3.2.1 Evaluation

The main AFW system at the Ginna plant is designed as an engineered safeguards system to seismic Category I (with the exception of the condensate storage tanks), Class 1E, and the automatic initiation signals and circuits are designed to comply with the requirements of IEEE Std 279-1971 [17].

The Ginna plant main AFW automatic initiation system consists of two independent actuation trains. The actuation circuits are powered from emergency dc buses. 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.

Both the main and standby AFW motor-driven pumps are powered by independent ac emergency buses. The loading of the main AFW motor-driven pumps onto their respective 480-Vac emergency buses is part of the post-accident automatic load sequencing. The standby AFW motor-driven pumps are interlocked with the main AFW motor-driven pumps so that both are not simultaneously loaded onto the emergency bus to prevent overloading during loss of offsite power.

The turbine-driven pump receives its steam through a motor-operated steam admission valve in each of two lines that tap off upstream of the steam generator isolation valves.

The following signals are used for automatic initiation of the main AFW system:

<u>Motor-driven Pumps</u>

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

Turbine-driven Pump

- o low-low steam generator level (2 out of 3 channels on both steam generators)
- o loss of voltage on both 4-kV buses

The main AFW system may be manually initiated from the control room by starting the motor-driven AFW pumps individually; upon pump start, the associated discharge valve opens.

The main AFW motor-driven pumps discharge valves open fully on pump start and then throttle down to limit flow to a maximum of 230 gpm to each steam generator. The automatic throttling conserves auxiliary feedwater and helps limit the cooldown rate. The turbine-driven pump discharge valve is normally open; in addition, when the turbine-driven pump is automatically initiated (steam admission valves open), the discharge valve receives an automatic actuation signal to ensure that it is fully open.

The main and standby AFW system and components are tested in accordance with technical specifications. Operation of the AFW pumps and motor-operated valves is checked monthly. Every 18 months each main AFW pump and main AFW motor-operated valve is verified to operate correctly 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. When a channel is bypassed for testing, the bypass is accompanied by a single channel alert and channel status light actuation in the control room. The automatic start of the main AFW motor-driven pumps resulting from the tripping of both main feedwater pumps may be defeated during startup or shutdown when the turbine generator is off the line. The defeat switch is automatically bypassed when the turbine is latched. This bypass is alarmed in the control room.

The only interaction between the main 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 main AFW initiation) and normal control functions (narrow-range channel I only) in the main feedwater system. The control signals are separated from the protection signals by isolation transformers so 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 to alert the operator that the main AFW equipment may not operate properly:

- o low-low steam generator level (3 channels each)
- o 2 out of 3 low-low steam generator levels (1 channel each)
- o 3 out of 3 low-low steam generator levels (1 channel each)
- o emergency shutdown equipment local control
- o safeguards breaker trip
- o safeguards equipment lock-off
- o main AFW bypass in defeat lockout
- o single channel alert
- o standby AFW pump C or D trip
- o standby AFW pump transfer switch off normal (1 channel each)
- o standby AFW pump high discharge flow (1 channel each)
- o standby AFW pump high discharge pressure (1 channel each)
- o standby AFW HVAC trouble.

No alarms are provided to monitor the power available to the steam admission valves or AFW discharge valves.

A review of the automatic and manual initiation circuitry and signals revealed that no single failure of 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 scope of this review.

3.2.2 Conclusion

The initiation signals, logic, and associated circuitry of the automatic initiation feature of the main AFW system of the Ginna plant 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.

In addition, the following point may effect the reliability of the AFW system:

- No alarms are provided to monitor the power available to the steam admission valves or AFW discharge valves.

3.3 FLOW INDICATION

3.3.1 Evaluation

The capability to evaluate the performance of the main and standby AFW systems at the Ginna plant is provided by the following indications:

- main AFW motor-driven pump flow to each steam generator (2 channels each)
- main AFW turbine-driven pump discharge flow (2 channels)
- main AFW turbine-driven pump flow to each steam generator (2 channels each)
- standby AFW motor-driven pump flow (1 channel each)
- main AFW pump discharge pressure
- standby AFW pump discharge pressure
- narrow-range steam generator level (3 channels each)
- wide-range steam generator level (1 channel each)
- main and standby AFW pump status indication
- main and standby AFW valve position indication
- condensate storage tank level (2 channels).

The Licensee has stated that the main AFW flow indication for each steam generator is safety-grade. The individual steam generator AFW flow circuitry is powered from separate battery-backed instrument buses. For each main AFW pump, there is a primary and secondary flow instrumentation channel. The primary channel indicates flow and, for the motor-driven pumps, controls the individual discharge valves. The secondary flow instrumentation indicates flow only. The primary and secondary channels are powered from opposite instrument buses. The primary and secondary flow indication is provided on the main control board by a dual-movement vertical-scale indicator.

Since the discharge header from the turbine-driven pump branches to supply both steam generators, an additional channel of safety-grade flow instrumentation is provided in each line. Safety-grade wide-range steam generator level indication is provided as a backup. The standby AFW system provides a single channel of safety-guide flow instrumentation for each pump. 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 scope of this review.

3.3.2 Conclusion

It is concluded that the AFW flow instrumentation at the Ginna plant 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 the Ginna plant 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-460	A
Narrow Range I	LT-461	A
Narrow Range II	LT-462	C
Narrow Range III	LT-463	D

STEAM GENERATOR B

Channel	Transmitter	Vital Bus
Wide Range	LT-470	B
Narrow Range I	LT-471	D
Narrow Range II	LT-472	A
Narrow Range III	LT-473	B

The steam generator level channels are checked each shift, tested monthly, and calibrated during refueling.

The wide-range channels for both steam generators are indicated individually on one stripchart recorder. Narrow-range channels for both steam generators are indicated on vertical gages.

4. CONCLUSIONS

The initiation signals, logic, and associated circuitry of the Robert E. Ginna Nuclear Power Plant 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.

In addition, the following points may affect the reliability of the AFW system:

- No alarms are provided to monitor the power available to the steam admission valves or AFW discharge valves.

The auxiliary feedwater flow instrumentation 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.

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