UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION REPORT
OCONEE NUCLEAR STATION UNITS 1, 2 AND 3
IMPLEMENTATION OF RECOMMENDATIONS FOR AUXILIARY FEEDWATER SYSTEMS

I. Introduction and Background

The Three Mile Island Unit 2 (TMI-2) accident and subsequent investigations and studies highlighted the importance of the Auxiliary Feedwater System (AFWS) in the mitigation of severe transients and accidents. As part of our assessment of the TMI-2 accident and related implications for operating plants, we evaluated the AFW systems for all operating plants. Our evaluations for operating plants with Westinghouse and Combustion Engineering nuclear steam supply systems (NSSS) are contained in NUREGs-0611 and-0635, respectively. These NUREGs also contain our recommendations for each plant and the concerns which led to each recommendation.

The objectives of the evaluation were to: (1) identify necessary changes in AFW system design or related procedures at the operating facilities in order to assure the continued safe operation of these plants, and (2) to identify other system characteristics of the AFW system which, on a long term basis, may require system modifications. To accomplish these objectives we:

(1) Reviewed plant specific AFW system designs in light of current regulatory requirements (SRP) and,

(2) Assessed the relative reliability of the various AFW systems under various loss of feedwater transients (one of which was the initiating event of TMI-2) and other postulated failure conditions by determining the potential for AFW system failure due to common causes, single point vulnerabilities, and human error.

At our request Babcock and Wilcox (B&W) performed reliability studies on operating plants with B&W NSSSs using failure rate data and fault tree methodology similar to that of NUREGs-0611 and -0635. The resulting generic study for B&W Plants (BAW-1584) and plant specific reports were reviewed by the NRC Probabalistic Analysis Staff which concurred in the study method and results. Their recommendations and the generic recommendations in NUREGs-0611 and -0635 form the basis of our Safety Evaluation Report which follows.

We conclude that the implementation of the recommendations identified during this review will considerably improve the reliability of the AFW system for Oconee.

A. Short Term Recommendations

1. Recommendation GS-1 - The licensee should propose modifications to the Technical Specifications to limit the time that one AFW system pump and its associated flow train and essential instrumentation can be inoperable The outage time limit and subsequent action time should be as required in current Standard Technical Specifications; i.e., 72 hours and 12 hours, respectively.

   The existing Oconee Technical Specification for Secondary System Decay Heat Removal requires an inoperable emergency feedwater pump or emergency feedwater flow path to be restored within 60 hours or be in a hot shut-down condition within an additional 12 hours. This technical specification is acceptable with respect to recommendation GS-1. However, by letter dated April 17, 1981, the licensee proposed revision to this Technical Specification which includes 7 days and 12 hours as the outage time limit and subsequent action time, respectively, for one emergency feedwater

pump. Additionally, the licensee has proposed 60 hours and 12 hours as the outage time limit and subsequent action time, respectively, for two emergency feedwater pumps or one emergency feedwater flow path inoperable.

The staff is presently evaluating the April 17, 1981 request to extend the out of service time for a single emergency feedwater pump in light of the plant specific features. This evaluation has generic implications since other facilities have similar installations. The disposition of this issue will, therefore, be handled separately. Since the existing Technical Specifications have been found acceptable, the staff finds the Oconee Nuclear Station to be acceptable with respect to this recommendation.

2. Recommendation GS-2 - The licensee should lock open single valves or multiple valves in series in the AFW system pump suction piping and lock open other single valves or multiple valves in series that could interrupt all AFW flow. Monthly inspections should be performed to verify that these valves are locked and in the open position. These inspections should be proposed for incorporation into the surveillance requirements of the plant Technical Specifications. See Recommendation GL-2 for the longer-term resolution of this concern.

As evidenced by the piping and instrumentation diagram (p&id) for the Oconee emergency feedwater system, there are no single valves or multiple valves in series in the system pump suction or other single or multiple in series that could interrupt all emergency feedwater flow. By letter dated April 3, 1981 the licensee indicated that all local manual valves in the emergency feedwater pump suctions are locked open in accordance with the operating and performance procedures. Also, the Oconee emergency feedwater system p&id indicates that all local manual valves in the normal pump discharge flow paths to the steam generators are locked open. We

find the Oconee emergency feedwater system acceptable with respect to this recommendation.

3. Recommendation GS-3 - The licensee has stated that it throttles AFW system flow to avoid water hammer. The licensee should reexamine the practice of throttling AFW system flow to avoid water hammer.

   The licensee should verify that the AFW system will supply on demand sufficient initial flow to the necessary steam generators to assure adequate decay heat removal following loss of main feedwater flow and a reactor trip from 100% power. In cases where this reevaluation results in an increase in initial AFW system flow, the licensee should provide sufficient information to demonstrate that the required initial AFW system flow will not result in plant damage due to water hammer.

   Oconee has Once Through Steam Generators (OTSG) which have not experienced water hammer to date, and therefore, emergency feedwater (EFW) is not throttled to avoid water hammer. By letter dated July 23, 1980 the licensee stated that each OTSG is provided with a safety grade level control system. With this level control system the EFW system will supply on demand sufficient initial and subsequent flow to the necessary steam generators to assure adequate decay heat removal following loss of main feedwater flow and a reactor trip from 100% power. Therefore, the Oconee design is acceptable with respect to this recommendation.

4. Recommendation GS-4 - Emergency procedures for transferring to alternate sources of AFW supply should be available to the plant operators. These

procedures should include criteria to inform the operators when, and in what order, the transfer to alternate water sources should take place. The following cases should be covered by the procedures:

(1) The case in which the primary water supply is not initially available. The procedures for this case should include any operator actions required to protect the AFW system pumps against self-damage before water flow is initiated.

(2) The case in which the primary water supply is being depleted. The procedure for this case should provide for transfer to the alternate water sources prior to draining of the primary water supply.

The licensee's response to this recommendation was provided in a letter dated April 3, 1981. Oconee operating procedures have a requirement for a minimum water level in the primary water source tanks, therefore, low water level in the primary water source tanks is not ever expected to be a cause for suction water to be unavailable to the EFW pumps. The availability of the primary water source is assured by locking open of all manual valves in the pump suction paths and by double verification of valve alignment which is performed following the monthly testing. Additionally, in the Oconee design there are parallel suction paths from the primary water source tanks to the motor driven and to the turbine driven emergency feedwater pumps.

If a suction valve in one of these parallel paths were to block suction flow due to a mechanical failure, it is possible that either the motor driven EFW pumps or the turbine driven EFW pumps would be destroyed. However, this is a low probability occurrence. Additionally, one train

of EFW cross-connects from the other units on the discharge side of the pumps, and by the Standby Shutdown Facility. Therefore, separate procedures for case 1 are not considered necessary. We find the Oconee design acceptable with respect to case 1 of this recommendation.

For case 2 the licensee has provided a copy of the transfer procedures in the April 3, 1981 letter. These procedures will adequately provide for transfer to the alternate water source prior to draining of the primary water supply. The procedures inform the operator when and in what order the transfer to the alternate water source should take place. We find the licensee's response to this recommendation acceptable.

5. Recommendation GS-5 - The as-built plant should be capable of providing the required AFW flow for at least two hours from one AFW pump train, independent of any AC power source. If manual AFW system initiation or flow control is required following a complete loss of AC power, emergency procedures should be established for manually initiating and controlling the system under these conditions. Since the water for cooling of the lube oil for the turbine-driven pump bearings may be dependent on AC power, design or procedural changes shall be made to eliminate this dependency as soon as practicable. Until this is done, the emergency procedures should provide for an individual to be stationed at the turbine-driven pump in the event of the loss of all AC power to monitor pump bearing and/or lube oil temperatures. If necessary, this operator would operate the turbine-driven pump in an on-off mode until AC power is restored. Adequate lighting powered by direct current (DC) power sources and communications at local stations should also be provided if manual initiation and control of the AFW system is needed. (See Recommendation GL-3 for the longer-term resolution of this concern).

By letters dated April 3, 1981, June 1, 1981, and July 17, 1981, the licensee indicated that modifications are in progress to make the plant capable of providing the required emergency feedwater flow for at least two hours independent of any AC power source. Modifications for Units 2 and 3 are completed. Modifications for Unit 1 will be completed by the end of the refueling outage which began in late June 1981.

The modifications consist of 1) providing nitrogen bottle backups with a two hour supply to the control air system for the steam pressure regulating valves and for the emergency feedwater control valves, and 2) removing the AC dependencies of the cooling water supplies to the turbine-driven pumps.

We find the response to this recommendation acceptable.

6. Recommendation GS-6 - The licensee should confirm flow path availability of an AFW system flow train that has been out of service to perform periodic testing or maintenance as follows:

   (1) Procedures should be implemented to require an operator to determine that the AFW system valves are properly aligned and a second operator to independently verify that the valves are properly aligned.

   (2) The licensee should propose Technical Specifications to assure that, prior to plant startup following an extended cold shutdown, a flow test would be performed to verify the normal flow path from the primary AFW system water source to the steam generators. The flow test should be conducted with AFW system valves in their normal alignment.

By letter dated April 3, 1981, the licensee indicated that periodic testing of emergency feedwater systems is conducted monthly, and that procedures require a second independent verification of proper valve alignment prior to returning the system to operability. We find the response to the first part of this recommendation acceptable.

The existing surveillance Technical Specification for the emergency feedwater system does not require that a flow test in accordance with GS-6(2) be performed to verify the normal flow path from the primary emergency feedwater source to the steam generators. This recommendation had not been explicitly stated in the staff's November 14, 1980 request for information to which the licensee responded on April 3, 1981, and therefore, was not specifically addressed. The staff requests that the licensee propose a revision to the Technical Specifications to address this recommendation.

We will complete our review of this recommendation when this issue is resolved and provide our evaluation in a supplement to this SER.

7. Recommendation GS-7 - The licensee should verify that the automatic start AFW system signals and associated circuitry are safety-grade. If this cannot be verified, the AFW system automatic initiation system should be modified in the short-term to meet the functional requirements listed below. For the longer-term, the automatic initiation signals and circuits should be upgraded to meet safety-grade requirements, as indicated in Recommendation GL-5.

   (1) The design should provide for the automatic initiation of the AFW system flow.

   (2) The automatic initiation signals and circuits should be designed so that a single failure will not result in the loss of AFW system function.

(3) Testability of the initiation signals and circuits shall be a feature of the design.

(4) The initiation signals and circuits should be powered from the emergency buses.

(5) Manual capability to initiate the AFW system from the control room should be retained and should 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 AFW system should be included in the automatic actuation (simultaneous and/or sequential) of the loads to the emergency buses.

(7) The automatic initiation 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.

By letter dated June 3, 1981, the staff concluded that the Oconee Units 1, 2 and 3 EFWS automatic initiation systems are in conformance with the long term safety grade requirements pending receipt of acceptable Technical Specifications related to periodic testing of the initiation signals.

8. Recommendation GS-8 - The licensee should install a system to automatically initiate AFW system flow.

This recommendation does not apply to Oconee since Oconee has an automatically initiated emergency feedwater system.

9. Human Error During Test and Maintenance - The licensee should assure that plant procedures are written to reduce human induced common mode failures of all AFW system trains. For example, the licensee should implement staggered testing of AFW system trains, i.e., for planned testing, not more than one AFW train (or pump) should be tested by the same shift. As another example, consideration should be given to locking open valves C-575 and C-576 since closure of either valve may result in a non-recoverable failure of the electric pump train due to pump cavitation.

   By letter dated April 3, 1981, the licensee responded that periodic testing is normally performed on the 0800-1600 shift once per month. Due to 5 - shift rotation, the test would seldom be performed consecutively by the same personnel. Independent double verification prior to return to service also reduce the possibility of human error.

   Valves C-575 and 576 as well as all other manual suction valves are required to be locked open by procedure (Concerns with respect to mechanical failure of EFW suction valves are discussed in the evaluation of GS-4). We find the response to this recommendation acceptable.

10. Flow Blockage by Plugged Strainers - The licensee should assure that there are no temporary strainers in place in the AFW piping system that may cause flow blockages if plugged. Operating experience at several plants has shown this to be a potential common cause failure mechanism which could fail the entire AFWS. The suction strainers between the condensate storage tank and the pumps are an example.

By letter dated April 3, 1981, the licensee responded that after reviewing the flow diagrams and a physical walk down of the emergency feedwater piping system, including suction piping from the upper Surge Tanks and Condenser hotwells to the emergency feedwater pumps, the licensee confirmed that no strainers exist in the system. We find the response to this recommendation acceptable.

11. Turbine-Driven Pump Steam Availability - Regarding the availability of steam for the auxiliary turbine-driven pump, based on operator action in 15 and 30 minute intervals, if the steam supply for the AFWS turbine is the steam remaining in the steam lines after dryout of both steam generators, verify the adequacy of this steam supply to drive the turbine.

    By letter dated April 3, 1981, the licensee responded that the emergency feedwater pumps, which are automatically initiated by loss of main feedwater pump discharge pressure, will normally prevent dryout of both steam generators. However, should both steam generators dryout, alternate sources of both steam (to drive the turbine) and emergency feedwater are available from interconnections with the other two Oconee units. We find the response to this request acceptable.

B. Additional Short-Term Recommendations

1. Recommendation - The licensee should provide redundant level indication and low level alarms in the control room for the AFW system primary water supply, to allow the operator to anticipate the need to make up water or transfer to an alternate water supply and prevent a low pump suction pressure condition from occurring. The low level alarm setpoint should

allow at least 20 minutes for operator action, assuming that the largest capacity AFW pump is operating.

By letter dated April 3, 1981, the licensee stated that redundant computer alarms are initiated at a primary water tank level that assures at least 20 minutes for operator action, assuming that the largest emergency feedwater pump is operating. The licensee also stated that there are presently two differential pressure transmitters that provide redundant level indication in the control room. We find the response to this recommendation acceptable.

2. Recommendation - The licensee should perform a 48-hour endurance test on all AFW system pumps, if such a test or continuous period of operation has not been accomplished to date. Following the 48-hour pump run, the pumps should be shut down and cooled down and then restarted and run for one hour. Test acceptance criteria should include demonstrating that the pumps remain within design limits with respect to bearing/bearing oil temperatures and vibration and that pump room ambient conditions (temperature, humidity) do not exceed environmental qualification limits for safety-related equipment in the room. The licensee should provide a summary of the conditions and results of the tests. The summary should include the following: 1) A brief description of the test method (including flow schematic diagram) and how the test was instrumented (i.e., where and how bearing temperatures were measured). 2) A discussion of how the test conditions (pump flow, head, speed and steam temperature) compare to design operating conditions. 3) Plots of bearing/bearing oil temperature vs. time for each bearing of each AFW pump/driver demonstrating that

temperature design limits were not exceeded. 4) A plot of pump room ambient temperature and humidity vs. time demonstrating that the pump room ambient conditions do not exceed environmental qualification limits for safety-related equipment in the room. 5) A statement confirming that the pump vibration did not exceed allowable limits during tests.

By letter dated April 3, 1981, the licensee stated that Oconee Nuclear Station has three emergency feedwater pumps (one turbine-driven, two motor-driven) per unit. Each turbine-driven pump is essentially identical to the others. Likewise, each motor-driven pump is essentially identical. As such, it is presently not considered to be necessary to test all nine emergency feedwater pumps. Rather, one turbine-driven and one motor-driven pump will be run for 48-hours during a forthcoming outage. The test will conform, to the extent possible, to the test details provided by the Staff. Based on the results of these tests, Duke would determine if additional pump endurance tests are necessary.

This response is not adequate. The purpose of this recommendation is to demonstrate that each pump has the capability for continuous operation over an extended time period without failure. This recommendation is not limited to testing individual pump designs but is also intended for verifying proper pump unique characteristics such as the installation, alignment and bearing tolerances. We, therefore, request that the licensee perform the 48-hour endurance tests on all the emergency feedwater pumps as prescribed in our November 14, 1980, letter to William O. Parker.

We will complete our evaluation of this matter when the information is available and provide it in a supplement to this SER.

3. Recommendation - The licensee should implement the following requirements as specified by Item 2.1.7.b on page A-32 of NUREG-0578:

   (1) Safety-grade indication of AFW flow to each steam generator should be provided in the control room.

   (2) The AFW flow instrument channels should be powered from the emergency buses consistent with satisfying the emergency power diversity requirements for the AFW system set forth in Auxiliary Systems Branch Technical Position 10-1 of the Standard Review Plan, Section 10.4.9.

   By letter dated June 3, 1981, the staff found this recommendation to be satisfactorily resolved.

4. Recommendation - Licensees with plants which require local manual realignment of valves to conduct periodic tests on one AFW system train and which have only one remaining AFW train available for operation should propose Technical Specifications to provide that a dedicated individual who is in communication with the control room be stationed at the manual valves. Upon instruction from the control room, this operator would realign the valves in the AFW system from the test mode to its operational alignment.

   At Oconee when periodic tests on one AFW system train are conducted, there are two remaining AFW trains available for operation. Therefore, this recommendation does not apply to Oconee.

C. Long Term Recommendations

1. Recommendation GL-1 - For plants with a manual starting AFW system, the licensee should install a system to automatically initiate the AFW system flow. This system and associated automatic initiation signals should be designed and installed to meet safety-grade requirements. Manual AFW system start and control capability should be retained with manual start serving as backup to automatic AFW system initiation.

   Oconee has automatically initiated emergency feedwater systems as described in the evaluation of GS-7. Therefore, this recommendation does not apply to Oconee.

2. Recommendation GL-2 - Licensees with plant designs in which all (primary and alternate) water supplies to the AFW systems pass through valves in a single flow path should install redundant parallel flow paths (piping and valves).

   At Oconee the primary and alternate water source for the turbine driven pump passes through piping separate from the piping for the motor driven pumps. Therefore, this recommendation does not apply to Oconee.

3. Recommendation GL-3 - At least one AFW system pump and its associated flow path and essential instrumentation should automatically initiate AFW system flow and be capable of being operated independently of any AC power source for at least two hours. Conversion of DC power to AC power is acceptable.

The Oconee turbine driven emergency feedwater systems automatically initiate flow and, after completion of certain modifications described in the evaluation of GS-5, will be capable of being operated independently of any AC power source for at least two hours. Therefore, we find the Oconee design in conformance with the provisions of this recommendation pending completion of the modifications.

4. Recommendation GL-4 - Licensees having plants with unprotected normal AFW system water supplies should evaluate the design of their AFW systems to determine if automatic protection of the pumps is necessary following a seismic event or a tornado. The time available before pump damage, the alarms and indications available to the control room operator, and the time necessary for assessing the problem and taking action should be considered in determining whether operator action can be relied on to prevent pump damage. Consideration should be given to providing pump protection by means such as automatic switchover of the pump suctions to the alternate safety-grade source of water, automatic pump trips on low suction pressure, or upgrading the normal source of water to meet seismic Category I and tornado protection requirements.

By letter dated April 3, 1981, the licensee stated that the upper surge tanks (primary water source) and the associated piping from them to the emergency feedwater pump suctions are seismically qualified. These tanks contain a nominal 50,000 gallons which would provide 100 minutes of flow at hot shutdown based on 500 gpm per unit. Therefore, automatic protection of the pumps is not necessary following a seismic event.

By letter dated April 3, 1981, the licensee stated that the Oconee emergency feedwater system has not been designed to withstand the effects of tornado missiles. Duke Power also stated that if the feedwater system were unavailable due to the effects of tornado missiles, the existing Auxiliary Service System would be capable of providing an alternate means of removing heat via the steam generators. This system is a low pressure system and its use requires blowing down the steam generators via the steam generator atmospheric dump valves.

The April 3, 1981 letter also stated that the Standby Shutdown Facility (SSF) provides an additional assured means of providing heat removal from the steam generators. Duke Power did not indicate that the SSF Auxiliary Service Water System from the water source to the steam generators is tornado missile protected.

Therefore, the licensee has not indicated how the Oconee Nuclear Station can provide secondary side cooling water in the event of a tornado. We, therefore, request that Duke Power provide the necessary information to indicate how the emergency feedwater system, or an acceptable alternate system, meets the tornado missile protection requirements in SRP 10.4.9.

5. Recommendation GL-5 - Thelicensee should upgrade the AFW system automatic initiation signals and circuits to meet safety-grade requirements.

As described in the evaluation of GS-7, the Oconee emergency feedwater system has safety grade automatic initiation signals and circuits and, therefore, is acceptable pending the receipt of acceptable Technical Specifications related to testing the initiation signals.

6. Postulated High Energy Pipe Breaks - In the event of a postulated break in the main steam or main feed system inside or outside containment coupled with a single active failure, discuss how the Oconee AFW design limits or terminates AFW system flow to the depressurized steam generator and directs the minimum flow to the intact steam generator. If manual action is relied upon, verify that sufficient flow to the intact steam generator will occur in sufficient time to provide adequate core cooling.

By letter dated April 3, 1981, the licensee responded that in order to provide emergency feedwater flow to the intact steam generator and isolate the ruptured steam generator the operator must take manual action. The System is designed so that a single active failure of any of the emergency feedwater pumps or valves will not prevent the operator from directing sufficient flow to the intact steam generator. The operator has sufficient control room indication of steam generator level and pressure to take the actions necessary to provide sufficient flow to the intact steam generator in time to maintain adequate core cooling. We find the response to this request acceptable.

D. Recommendation "Basis for Auxiliary Feedwater System Flow Requirements"

In Enclosure 3 to our letter of November 14, 1980, we requested the licensee to provide certain information regarding the design basis for AFWS flow requirements.

By letter dated April 3, 1981, the licensee provided responses to this recommendation. This response is under staff review. An evaluation of this response will be provided in a supplement to this SER.

Dated: August 25, 1981