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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AUXILIARY FEEDWATER SYSTEMS AT

JOSEPH M. FARLEY NUCLEAR PLANT, UNIT NO. 1

DOCKET NO. 50-348

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 (AFW) system in the mitigation of 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 and near-term operating license plants having nuclear steam supply systems (NSSS) designed by Westinghouse (NUREG-0611). Our evaluations of these system designs are contained in the NUREGs along with 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 the AFW system design or related procedures in order to assure the safe operation of these plants, and (2) to identify other system characteristics of the AFW systems which, on a long term basis, may require system modifications. To accomplish these objectives we:

(1) Reviewed plant specific AFW system design 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.

We concluded that the implementation of the recommendations identified during this review will considerably improve the reliability of the AFW Systems for each operating plant.

The following plant specific recommendations did not apply to this plant: GS-1, GS-2, GS-3, GS-8, GL-1, GL-2 and GL-4. The basis for these recommendations can be found in Appendix III of NUREG-0611, and the system description which determined the basis for not applying these recommendations can be found in Appendix X of NUREG-0611.

During our licensing reveiws of the AFW System for Farley Nuclear Plant, Unit No. 2, several other design modifications were identified. These modifications are also evaluated herein as applicable to Unit No. 1.

II. Implementation of Our Recommendations

A. Short Term Recommendations

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

-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; and,

-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."

In response to our recommendation in its November 20, 1979 letter the licensee reported it has developed and implemented procedures that include criteria to inform the operator when to transfer to the alternate source and include actions required to protect the auxiliary feedwater system pumps against self-damage before water flow is initiated. Based on the licensee's implementation of these procedures we conclude that the licensee's response to this recommendation is acceptable.

2. 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 alternating current power source. If manual AFW system initiation or flow control is required following a complete loss of alternating current 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 alternating current 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 alternating current power to monitor pump gearing and/or lube oil temperatures. If necessary, this operator would operate the turbine-driven pump in an on-off-mode until alternating current power is restored. Adequate lighting powered by direct current 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).

The licensee in its letter dated November 20, 1979, stated that a lic nsing basis for the AFW system was that the turbine driven pump be capable of one hour of operation independent of all AC power. The steam admission valves require both DC power and an operable air supply for the valves to open and allow turbine operation. These valves are provided with air reservoirs of sufficient capacity to open the valves and allow turbine operation. Although the licensing basis was one hour of turbine operation, two hour turbine operation was used as the orginal design basis.

In our letter dated April 8, 1980, we requested the licensee to perform appropriate periodic testing to demonstrate that the air reservoirs meet the minimum requirements (2 hours) since the air reservoirs are relied on to perform a safety function following a loss of air or a loss of all AC power. If the air reservoirs cannot meet the two hour requirement, we required that the licensee establish emergency procedures for manually initiating and controlling the system independent of any AC power source. The licensee in its letter dated May 27, 1980, agreed to perform periodic testing of the air reservoirs and to establish appropriate emergency procedures if the reservoirs do not meet the two hour requirement.

Based on the licensee's commitment to perform periodic tests to demonstrate two hour capability of the air reservoir system and its further commitment to establish emergency procedures if the two hour requirement cannot be met we conclude that the licensee's response to this recommendation is acceptable.

3. 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:

-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.

-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.

The licensee in letter dated November 20, 1979, and May 27, 1980, stated that administrative controls have been implemented and written into appropriate plant procedures or directive which require that after maintenance which could affect valve alignment or after a

refueling outage a system valve lineup verification will be performed by a second individual who holds a reactor operator's license.

The licensee, by letter dated November 20, 1979, also committed to propose a change to the Technical Specifications to require that a flow test be performed to verify that each AFW pump will deliver flow to each steam generator following an extended cold shutdown. This change will be done with the Unit No. 1 Technical Specification upgrade to agree with the Unit No. 2 Technical Specification which includes this surveillance.

The licensee's response meets the requirements of this recommendation and is acceptable.

B. Additional Short Term Recommendations

1. Recommendation - The licensee should provide redundant level indications 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.

   In response to this recommendation by letters dated November 20, 1979, and May 27, 1980, the licensee has committed to install redundant safety grade (Class IE) instrumentation and power supplies. Based on the licensee's commitment to install a redundant safety grade condensate storage tank level indication system we conclude that the response is acceptable.

2. Recommendation (This recommendation has been revised from the orginal recommendation in NUREG-0611) - The licensee should perform a 48-hour endurance test on all AFW system pumps, if such a test or continous 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.

   In letter dated May 27, 1980, the licensee provided the results of the endurance tests for both the motor driven and turbine driven pumps. The results included (a) a description of the test method and how the tests were instrumented, (b) a description of how the test conditions compared to design operating conditions, (c) plots of bearing or bearing oil temperatures vs. time for each bearing demonstrating that limits

were not exceeded, (d) plots of pump room ambient temperature and humidity vs. time, and (e) a statement confirming that the pump vibration did not exceed allowable limits during the tests.

We have reviewed the test method and test results and conclude that no design limits were exceeded during the 48 hour tests. We, therefore, conclude that the licensee has met this recommendation, and the AFW pumps are acceptable for long term operation.

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

> "Safety-grade indication of auxiliary feedwater flow to each steam generator shall be provided in the control room.
>
> The auxiliary feedwater flow instrument channels shall be powered from the emergency buses consistent with satisfying the emergency power diversity requirements for the auxiliary feedwater system set forth in Auxiliary Systems Branch Technical Position 10-1 of the Standard Review Plan, Section 10.4.9."

Our evaluation enclosed with our letter of April 3, 1980 concluded that the licensee has satisfied this short term Lesson Learned requirement. The long-term review will be part of item II.E.1.2 of NUREG-0737.

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 re-align the valves in the AFW system train from the test mode to its operational alignment.

In a letter dated November 20, 1979, the licensee stated that this recommendation does not apply to the Farley design.

Since two pumps are always available during testing of either train and since local realignment of valves is not necessary during periodic tests, we agree with the licensee that this recommendation is not applicable to the Farley Nuclear Plant.

C. Long Term Recommendations

1. 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 alternating current power source for at least two hours. Conversion of direct current power to alternating current is acceptable.

As indicated in the evaluation of GS-5 above, the Farley AFW system turbine driven pump is designed to be automatically initiated and controlled for at least two hours independent of any AC power.

The licensee's commitment to perform periodic tests to demonstrate that the two hour requirement is met meets the requirement for the short and long term aspect of this recommendation. We, therefore, conclude that the licensee's response to this recommendation is acceptable.

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

We are continuing the review of the licensee responses as Item II.E.1.2 of NUREG-0737. Thus, II.E.1.1 is considered as complete with part of it being done with Item II.E.1.2.

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

As a result of recent staff reviews of operating plant Auxiliary Feedwater Systems (AFWS), the staff concluded that the design bases and criteria provided by licensees for establishing AFWS requirements for flow to the steam generator(s) to assure adequate removal of reactor decay heat are not well defined or documented.

We required that the licensee provide AFWS flow design bases information as applicable to the design bases transients and accident conditions for the Farley plant.

By letter dated April 1, 1980, the licensee provided responses to this recommendation. These responses included results of analyses where necessary to show that sufficient AFW flow could be delivered by the Farley AFW system design to meet the minimum heat removal requirements following any design basis transient or accident and assuming the worst case single active failure. These analyses also bounded the heat removal requirements following a complete loss of all AC power assuming the turbine driven AFW pump is available since it operates independently of AC power.

We have reviewed the licensee's responses and the results of their analyses which show that the minimum required flow can be met by one 350 gpm motor driven pump and that the maximum allowable flow of 880 gpm following a steam line rupture will not be exceeded based on the AFW system design. Based on our review we conclude that the Farley AFW system design meets the minimum flow requirements and, therefore, the licensee's response to this recommendation is acceptable.

E. Electric Power for Auxiliary Feedwater Solenoid Valves

On July 11, 1980, it was discovered that there is no train separation of the electric power to the solenoid operated flow control valves of the auxiliary feedwater (AFW) system at Farley Unit No. 1. During normal power operations these redundant valves (two to each steam generator) are kept closed by maintaining the solenoid valves energized continuously. To provide the AFW function, the soldenoids must release when electric power is interrupted, to allow the valves to open. The electric power for all these solenoids (total of six) is obtained from a single power supply - train "A" battery charger.

Failure of the battery charger may cause its output voltage to increase to values greater than twice the normal voltage of 130 VDC. If such high voltage damages the solenoids (by overheating or some other mechanism), they could fail to release when AFW is needed.

By letter of July 11, 1980, when this potential for loss of function for AFW was discussed with the licensee, it agreed to interim measures pending resolution of this potential problem. By letter of July 29, 1980, the licensee proposed a long-term solution and a slightly different set of interim measures. The following addresses the electrical aspects of this matter.

Evaluation

This design deficiency was discovered during our review of the AFW automatic start and flow measurement capabili es (TMI Actic Plan Item II.E.1.2) for Farley Unit No. 2, a near-term operating license application. On July 11, 1980, we determined that the Farley Unit No. 1 design is identical to Farley Unit No. 2 in this regard.

Therefore, the following interim measures were agreed to by our staff and the licensee on July 11, 1980:

1 Each of the solenoid valves would be immediately cycled to demonstrate that damage had not already occurred.

2. Equalization charging of the battery would not be conducted.

3. The d.c. bus voltage would be checked hourly. If the voltage were found to be abnormally high, operability of the solenoid valves would be immediately determined.

4. The continued operability of the AFW system would be demonstrated by cycling each solenoid valve each day.

The solenoid coils in the AFW system are ASCO model HT 8320A108. The ASCO catalog inciates the normal operating voltage to be 102-125 VDC and also indicates that the units are capable of operating for short periods at 10% over the nominal voltage. The purchase specification to ASCO asked that the units be operable from 90-140 VDC. This type solenoid is a high temperatur design, rated for a maximum continuous coil temperature of 180°C. The coil is constructed of magnet wire interwoven with fiberglass thread and some epoxy, as a binder. The coil is impregnated with a silicone varnish.

The licensee conducted field tests between July 12 and July 15, 1980 to determine how three solenoid coils similar to those with the AFW control valves withstand over-voltage conditions. The coils were exposed to voltage spikes up to 180 volts for durations varying up to five minutes. The coils were then exposed to continuous voltage of 248 VDC for 24 hours. No failures were reported. While these tests were field tests on a limited sample and the quality assurance procedures of an independent testing laboratory may not have been fully adhered to, the test results are nonetheless envouraging. On the basis of these tests results, the licensee was allowed to relax the voltage surveillance from hourly to once per shift starting on July 17, 1980.

The battery charger is an Exide 3-Phase model UPC 130-3-600. While some discussions with the manufacturer have been held by the Farley Architect-Engineer (Bechtel), the maximum voltage that a battery charger failure could cause to be produced is not well established. It appears that values of 272 V RMS or more could be achieved.

The licensee has confidence that most valves from over-voltage are not likely to damage the soldenoids. However, the information to date does not establish definitely that solenoid damage will not occur. Since the failure of these solenoids can be postulated by the failure of the single power supply, this concern had to be resolved.

By letter of July 29, 1980 the licensee proposed to modify the power scheme for the solenoid valves. The licensee proposed to power a number of the solenoids from a separate power supply. Such an approach allows an over-voltage failure to be acceptable if the solenoid valves from the other supply are not affected. Thus, the AFW function can be assured.

The AFW system provides water via two electric motor-driven pumps and one steam turbine driven pump. Each steam generator receives AFW flow via a motor-pump path and via a turbine-pump path. The electric power to the motors is divisionalized between train "A" and train "B". The steam flow to the turbine also involves d.c. powered controls. It is not a simple matter to assign d.c. power to the solenoid valves in such a way that adequate AFW flow can be assured for the case of loss of either d.c. train and for the case of over-voltage to solenoid valves. For these reasons Farley Unit No. 2 fuel loading license issued on October 23, 1980 was conditioned as follows:

> "Auxiliary Feedwater Initiation and Indication (II.E.1.2)
>
> Prior to installation, Alabama Power Company shall submit a description of the design modifications to provide train separation of the power supply for the auxiliary feedwater flow control solenoid valves. Prior to operation above zero power, the revised power supply shall be installed and operable."

By letter of September 8, 1980 the licensee provided the description of a proposed redesign into two trains of emergency power for the AFW system solenoid valves on Unit No. 2. Our review of this system for Unit No. 2 is documented in SER Supplement No. 5, Section 22.3. Later by letter of April 27, 1981 the licensee advised that the September 8, 1980 letter applies also to Unit No. 1. We were advised via telecon on May 21, 1981 by Mr. Ron George of the licensee staff that Unit No. 1 modifications were completed during the refueling outage which ended in late March 1981.

Conclusion

Based on the timely interim actions taken by the licensee to preclude a potential AFW System problem, we find that those actions were appropriate. Since the permanent system modifications will provide two independent power supplies for the AFW system solenoid valves, and since the design is identical to that reveiwed and found acceptable for Unit No. 2, it, likewise, is acceptable for Unit No. 1.

F. Control System Modifications for AFW System

Changes in the control systems for the AFW system were proposed by the applicant during the Unit No. 2 license review in response to NRC requirements established as a result of the investigations into the TMI-2 accident. Following our review of these proposed changes, we concluded that a further in-depth review of the system was warranted.

A site visit was conducted on October 22, 1980 for this additional review. Based on this review of the control and protection systems for the AFW system, we identified a munber of concerns and positions on the design of these systems. Subsequently, Alabama Power Company provided a commitment to implement modifications necessary to meet our position or to provide for our review and concurrence alternate designs to satisfy our concerns. A summary of these concerns and corrective actions to be taken are as follows:

1. Control valves are provided in the AFW system which are used to regulate AFW flow to maintain the desired steam generator level when the system is in use. Two valves are provided for each steam generator corresponding to the redundant sources of AFW; one regulates flow from the motor driven feed pumps, the other regulates flow from the turbine driven feed pump. On automatic initiation of the AFW system, redundant protection system channels provide signals to fully open each control valve. Subsequently operator action is taken to reset this action to permit manual control of AFW flow. The manual controls require electrical power to regulate flow. However, a single power source is provided for all of the control valves. Thus a loss of the single power source would cause all control valves to open and result in a loss of the capability to regulate AFW flow from either of the redundant sources of AFW. In addition, the redundant protection system channels which open the control valves on automatic initiation, operate in a manner such that on a loss of electrical power to either channel the control valves fail in the open position. This would also preclude the valves from properly regulating the AFW flow.

   The licensee has committed that during the third refueling outage (about March 1982), the design of the AFW system will be modified to remove the power source dependence. The power source dependence could have resulted in failures in the capability to regulate AFW flow. Separate power sources will be provided for the manual control of the valves associated wtih the redundant sources of AFW. The licensee also committed that the protection system channels will be modified such that a loss of electricl power to either of the redundant channels will not cause the control valves to fail open to preclude the capability of the valves to be manually controlled.

   Since other manual actions can be taken to offset the impact on plant operations that such failure modes would have, we find the schedule for implementing the modifications to be acceptable. However, in the interim operator action will be taken to assure plant safety. Such actions as controlling the speed of the turbine driven pump, tripping the motor driven pumps, and local manual control of the valves using their hand wheels, are acceptable means to recover from the effects of these failure modes.

2. The protection system for the automatic initiation of the AFW system includes features to start AFW pumps and to open the AFW control valves. The system design is such that the opening of the AFW control valves associated with the motor driven pump requires that the selector switches for these control valves be in a specific position to fulfill their safety function (opening) for some of the automatic initiation signals. The AFW system is used initially during each unit startup. The operating sequence then requires that the main feedwater system be placed in operation for supply of feedwater as the AFW system flow is terminated. At this time the selector switches for the AFW control valves may be in the modulate position. This would prevent the AFW control valves from opening when a safety injection signal is reset (if the valve modulator control is in the fully closed position). Plant operating procedures require that the selector switches for the AFW control valves be placed in the positions to ensure that the safety action of these valves is not bypassed during power operation.

   The licensee has committed that during the third refueling outage (about March 1982), the protection system logic will be modified such that all automatic initiation signals for the AFW system will automatically open the motor driven pump discharge control valves regardless of the position of the valve operating mode switches. In the interim, the administrative controls for this system will be enhanced by revised operating procedures which include sign-off actions for placing the system selector switches in the mode required for proper response.

   In the interim, we find that the action taken to enhance the administrative controls for this system provides adequate assurance that the system will not be operated in a mode which could defeat the safety function for these control valves. We find that the proposed design modifications will then provide a control system which would eliminate the potential for operating modes which could bypass the safety function of the control valves. This is an acceptable long-term solution.

3. Air accumlators are provided for the turbine driven AFW pump steam admission valves. Air is required for steam admission valve operation to start the pump. However, the normal air supply is from the non-safety grade instrument air system. This design uses check valves to isolate the accumulators from the normal air supply to assure the availability of the accumulator air supply. This design uses check valves to isolate the accumulators from the normal air supply to assure the availability of the accumulator air supply. We have asked the licensee to

address the concerns raised in the Office of Inspection and Enforcement Bulletin 80-01 which advised utilities of generic concerns with such designs. We have also requested a clarification on the basis for the difference in the design of these systems for Units 1 and 2. Specifically, we noted that these systems do not include features which would facilitate periodic surveillance of their operability.

We find that in the short term, Technical Specifications modifications to require perindic testing the accumulator systems are adequate to address our concerns. We will take appropriate action to reflect these requirements in the upgraded Technical Specifications for Unit 1 similar to the Technical Specifications issued with the Operating License for Unit No. 2.

Conclusion

In summary, our review revealed aspects of the design of the AFW control system for which modifications could be implemented to enhance the reliability and tolerance of the system to failures. In view of the interim administrative measures which are being taken before these modifications are implemented, we find the proposed implementation schedule to be acceptable. We will add a condition to the operating licensee to reflect the schedule for completion of this action as proposed by the licensee.

Date: June 17, 1981