UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
SACRAMENTO MUNICIPAL UTILITY DISTRICT	)	Docket No. 40-312 SP
(Rancho Seco Nuclear Generating Station)	)	

AFFIDAVIT OF ERNEST D. SYLVESTER

I Ernest D. Sylvester being duly sworn, depose and state that:

1. I am an employee of the U. S. Nuclear Regulatory Commission (NRC). My present position is Mechanical Engineer (Auxiliary Systems), Auxiliary Systems Branch, Division of Systems Integration within the Office of Nuclear Reactor Regulation. A copy of my professional qualifications is attached.

2. The purpose of my affidavit is to respond to the request for information from the Rancho Seco Atomic Safety and Licensing Appeal Board in the Board Order dated September 30, 1982. The Board noted that SMUD had submitted to the staff a revised reliability analysis of the proposed upgraded auxiliary feedwater system (AFWS) and that Brookhaven National Laboratory (BNL), under contract to the NRC, would complete its review of the SMUD reliability analysis by September 30, 1982. The Board requested the staff to provide to the Board the results of the staff reviews of the reliability analysis and the BNL report by December 1, 1982. I am duly authorized to provide the information requested by the Appeal Board.

3. The September 30, 1982 Board Order also stated the following: "We expect the staff's review to address specifically SMUD's asserted failure to meet the guidelines of Standard Review Plan 10.4.9, as discussed in the Sylvester Affidavit, supra, at 13. In particular, will SMUD's AFW system, as modified, meet the Standard Review Plan? If not, what precise section of the SRP is not satisfied, and does the staff regard such noncompliance as a safety problem?"
4. The enclosed Status Report provides the results of the staff review of the Rancho Seco AFWS reliability analysis and the review of the AFWS against the guidelines of Standard Review Plan (SRP) Section 10.4.9. These evaluations were required of Rancho Seco by Item II.E.1.1 of NUREG-0737 which also required a reevaluation of the AFWS flowrate design bases and criteria. The results of the flow rate evaluation are also provided in the Status Report.
5. The Status Report is divided into three major sections: Parts I, II and III. Part I provides our deterministic review of the Rancho Seco AFWS using the acceptance criteria and review procedures of SRP 10.4.9. Part II provides our review of three major areas identified in SRP 10.4.9 but not included in the Part I evaluation. These three areas were separated from the Part I discussion of SRP 10.4.9 because of their individual importance to the acceptability of the AFWS design. Sections A and B of Part II provide our evaluations of the AFWS relative to the short-term and long-term recommendations, respectively, that were identified in NUREGs 0611 and 0635. Part II, Section C is our evaluation of the licensee's AFWS reliability study and Part II, Section D is our evaluation of the licensee's AFWS flowrate design bases. Part III provides our conclusions with respect to the acceptability of the AFWS design and operation.

I hereby certify that the statements and opinions are true and correct to the best of my personal knowledge and belief.

Ernest D. Sylvester

Ernest D. Sylvester

Subscribed and sworn to before me
this 1st day of December 1982.

Notary Public

My commission expires: 7-1-86

STATEMENT OF PROFESSIONAL QUALIFICATIONS
ERNEST D. SYLVESTER

I have been with the U. S. Nuclear Regulatory Commission (NRC) since December 1976. Since September 1980 I have been a member of the Auxiliary Systems Branch, Division of Systems Integration. As a member of the branch I am responsible for performing technical reviews and evaluations for the functional capability of auxiliary systems and components as described in applications for construction permits and operating licenses for nuclear power plants, and as required for operating plants, to assure public health and safety and protection of the environment. I performed the operating license review of the Comanche Peak auxiliary systems designs. My current assignments include reviews of the McGuire safe shutdown capability in the event of postulated fires, proposed expansion of the North Anna spent fuel facility and safety concerns involving the Shoreham plant.

I have a M. S. Degree (1965) in Mechnical Engineering from Rensselaer Polytechnic Institute and a B. S. Degree (1960) in Mechanical Engineering from Michigan State University. I have completed NRC courses in boiling water and pressurized water reactor technology, radiation protection and reliability estimation.

From December 1976 to September 1980 I served as a senior systems engineering analyst in the Plant Systems Branch, Division of Operating Reactors, NRC. I performed reviews of the fire protection programs at 10 operating plants relative to ensuring safe shutdown capability in the event of postulated fires.

I prepared guidance documents for NRC staff use in evaluating fire protection programs and assisted in the development of fire protection regulations.

From August 1969 to December 1976, I served as an engineer at the Knolls Atomic Power Laboratory of the General Electric Company. I performed analyses to support the design of reactor systems for shipboard Naval reactor plants. I also developed and wrote casualty procedures for emergency core cooling systems and containment systems and operating procedures for other reactor plant systems.

From November 1965 to August 1969, I was a heat transfer engineer for the General Electric Company at their Valley Forge Space Power Division. I performed analyses and developed test programs for various nuclear space power systems and their components. I was responsible for the thermal design analysis and analytical support for testing of the SNAP-27 Lunar Module fuel cask (the container and re-entry shield for the SNAP-27 radioisotope fuel capsule) considering normal operation, possible re-entry abort and launch-pad fire ball situations.

From April 1964 to November 1965, I was an analytical engineer in the Missile Division of the Chyrsler Corporation. I provided analytical support to NASA on a design study of the transient phenomena occurring in the childown operation for orbital restart of rocket engine systems using cryogenic liquid propellants. I was responsible for developing an extensive computer program for this study.

From October 1960 to December 1963, I was an analytical engineer for Pratt and Whitney Aircraft. My responsibilities included heat transfer and fluid flow analyses for liquid metal cooled reactors and auxiliary systems for aircraft and space power plant applications.

STATUS REPORT

RANCHO SECO - AUXILIARY FEEDWATER SYSTEM

In accordance with the requirements of Item II.E.1.1 of NUREG-0660, "NRC Action Plan Developed as a Result of the TMI-2 Accident," and NUREG-0737, "Clarification of TMI Action Plan Requirements," the licensee is required to:

(1) Perform a simplified auxiliary feedwater (AFW) system reliability analysis that uses event-tree and fault-tree logic techniques to determine the potential for AFW system failure under various loss-of-main feedwater-transient conditions. Particular emphasis is given to determine potential failures that could result from human errors, common causes, single-point vulnerabilities and test and maintenance outages.

(2) Perform a deterministic review of the AFW system using the acceptance criteria of Standard Review Plan Section 10.4.9 and associated Branch Technical Position ASB 10-1 as principal guidance; and

(3) Reevaluate the AFW system flow rate design bases and criteria.

Our evaluation of the Rancho Seco auxiliary feedwater system (AFWS) against the requirements of Item II.E.1.1 is presented in two parts. Part I is our evaluation of the AFWS upgrade design against the criteria of the Standard Review Plan. Part II is our evaluation of the (1) AFWS against the criteria developed after the Three Mile Island Unit 2 accident and enumerated in NUREG-0611 and NUREG-0635, (2) the licensee's reliability analyses, and (3) the licensee's reevaluation of the design basis for the AFWS flow requirements. Our evaluation of the immediate actions required by the Commission shutdown order of May 7, 1979 was provided in a Safety Evaluation Report which was transmitted to the licensee by letter dated June 27, 1979. Nothing in our current review has resulted in a change to the conclusions expressed in the June 27, 1979 evaluation, i.e., operation of Rancho Seco with the existing AFWS is acceptable pending implementation of the proposed upgrade modifications. This conclusion is further reinforced by the planned addition of a safety-grade AFWS initiation system and a safety-grade flow indication system as recommended by Item II.E.1.2 of NUREG-0737. These latter modifications will be implemented during the refueling outage beginning January 1983, prior to the overall upgrade modifications. Our conclusions relative to overall AFWS acceptability based on our current evaluation are provided in Part III of this report.

PART I

A. We have reviewed the auxiliary feedwater system against the Acceptance Criteria of the Standard Review Plan (SRP) Section 10.4.9. These criteria are as follows:

   1. General Design Criteria 2, "Design Bases for Protection Against Natural Phenomena", as related to structures housing the system and the system itself being capable of withstanding the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods.

2. General Design Criteria 4, "Environmental and Missile Design Bases" with respect to structures housing the system and the system itself being capable of withstanding the effects of external missiles and internally generated missiles, pipe whip, and jet impingement forces associated with pipe break.

3. General Design Criterion 5, "Sharing of Structures, Systems and Components" as related to the capability of shared systems and components important to safety to perform required safety functions.

4. General Design Criterion 19, "Control Room," as related to the design capability of system instrumentation and controls for prompt hot shutdown of the reactor and potential capability for subsequent cold shutdown.

5. General Design Criterion 44, "Cooling Water," to assure:

   a. The capability to transfer heat loads from the reactor system to a heat sink under both normal operating and accident conditions.

   b. Redundancy of components so that under accident conditions the safety function can be performed assuming a single active component failure. (This may be coincident with the loss of offsite power for certain events.)

   c. The capability to isolate components, subsystems, or piping if required so that the system safety function will be maintained.

6. General Design Criterion 45, "Inspection of Cooling Water System," as related to design provisions made to permit periodic inservice inspection of system components and equipment.

7. General Design Criterion 46, "Testing of Cooling Water System," as related to design provisions made to permit appropriate functional testing of the system and components to assure structural integrity and leak-tightness, operability and performance of active components, and capability of the integrated system to function as intended during normal, shutdown, and accident conditions.
8. Regulatory Guide 1.26, "Quality Group Classification and Standards for Water-, Steam- and Radioactive Waste Containing Components for Nuclear Power Plants," as related to the quality group classification of system components.
9. Regulatory Guide 1.29, "Seismic Design Classification," as related to the seismic design classification of system components.
10. Regulatory Guide 1.62, "Manual Initiation of Protective Actions," as related to design provisions made for manual initiation of each protective action.
11. Regulatory Guide 1.102, "Flood Protection for Nuclear Power Plants," as related to the protection of structures, systems, and components important to safety from the effects of flooding.
12. Regulatory Guide 1.117, "Tornado Design Classification," as related to the protection of structures, systems, and components important to safety from the effects of tornado missiles.

13. Branch Technical Position (BTP) ASB 3-1, "Protection Against Postulated Piping Failure in Fluid Systems Outside Containment," as related to breaks in high and moderate energy piping systems outside containment.

14. Branch Technical Position (BTP) ASB 10-1, "Auxiliary Feedwater System Pump Drive and Power Supply Diversity for Pressurized Water Reactor Plants," as related to auxiliary feedwater pump drive and power supply diversity.

B. The following evaluation discusses the implementation of the acceptance criteria identified in SRP Section 10.4.9 and follows the format of the Review Procedures identified in SRP Section 10.4.9.

By letter dated September 8, 1981, the licensee submitted the design description of the upgraded auxiliary feedwater system (AFWS). The AFWS is designed to supply an independent source of water to the steam generators during accident and transient conditions in the event of a loss of main feedwater supply. The AFWS consists of two interconnected trains, capable of supplying auxiliary feedwater to either or both steam generators under automatic or manual initiation and control. One AFWS train is served by pump P-318, a combination turbine-driven/motor-driven pump with both the turbine and electric motor on a common shaft. Either motive source can drive the pump at its rated capacity of 840 gpm at 1150 psig with a normal recirculation flow of 60 gpm. The turbine driver is used as the primary motive source for this pump and is automatically initiated. The motor driver can only be manually initiated. The pump serving the other train, pump P-319, is a motor-driven pump which has the same rated capacity and recirculation flow as pump P-318. Pump P-319 is automatically initiated but must be manually loaded on the emergency bus. The discharge lines from the pumps are cross-connected by a full-flow line containing two normally-open motor operated valves in series. This cross-connect permits either pump to feed either or both steam generators. The primary water source for both AFW trains is the seismic Category I condensate storage tank. Alternative AFWS suction sources are available from the on-site reservoir and the Folsom South Canal. Piping from these alternative sources enters the cross-connect in the suction piping between locked closed manual valves. The alternative source is fed by transfer pumps from the Folsom South Canal or by gravity flow from the reservoir.

Rancho Seco is a one unit site, therefore General Design Criterion 5 is not applicable.

1. We have reviewed the licensee's submittal of September 8, 1981 in order to verify the acceptability of the AFWS design with respect to its classification and operating characteristics.

   a. [The licensee's submittal of September 8, 1981 states that the AFWS is designed to provide a minimum flow of 760 gpm to the steam generators at 1050 psi within 50 seconds of the system initiation signal. This information is contradicted by other information provided by the licensee by letter dated November 30, 1981. This is discussed in more detail in Part II, Section D of this report. Until this contradiction is resolved we cannot conclude that the AFWS meets the minimum performance requirements of General Design Criterion 44.]

   b. General Design Criterion 44 requires the capability to isolate components, subsystems, or piping so that the system safety function will be maintained. The AFWS feeds directly to the steam generators through six-inch discharge lines. The only connections between the main feed system and the AFWS are isolated by normally closed manual valves. Connections to the alternative water sources are isolated by locked closed manual valves. Therefore, we conclude that the AFWS meets the isolation requirements of General Design Criterion 44.

c. We have evaluated the upgraded AFWS design against the requirements of General Design Criteria 2 and the guidelines of Regulatory Guides 1.26 and 1.29 with respect to its seismic and quality group classification. The licensee indicated that the primary water source of the AFWS, i.e., the condensate storage tank, is designed to seismic Category I requirements. The existing AFWS design has been evaluated in accordance with Multiplant Action C-14, "Seismic Qualification of Auxiliary Feedwater System." The existing AFWS design was found to be acceptable for short-term operation. That is, although the existing design uses nonseismic Category I flow control valves, system function can be maintained by manual operation of valves. This is acceptable for a limited time until the valves are replaced with seismically-qualified valves as part of the AFWS upgrade modifications. [However the licensee has not indicated all the seismic or quality group classification changes that may result from the proposed upgrade. The licensee is requested to provide the seismic and quality group classification of all the components and piping for the AFWS shown in Figure 3.1-1 of the proposed upgrade design submittal of September 8, 1981.] We cannot conclude that the AFWS meets the requirements of General Design Criterion 2, and the guidelines of Regulatory Guides 1.26 and 1.29.

d. Provisions for AFWS testing and inspection are included in the design. Each AFW pump is equipped with a full flow recirculation line to the condensers which can be used for periodic functional testing purposes. Periodic testing of the AFWS pumps and valves is identified in the plant Technical Specifications. In addition, plant Technical Specifications require periodic inspection of all valves, including those that are locked, sealed, or otherwise-secured in position. Therefore, we conclude that the AFWS meets the requirements of General Design Criteria 45 and 46 with regard to design provisions for inservice inspection and functional testing.

2. We have reviewed the AFWS design for protection against the effects of natural phenomena, pipe breaks or cracks in fluid systems outside containment, single system component failures, loss of an onsite motive power source, or loss of offsite power.

a. We have evaluated the upgraded AFWS design against the requirements of General Design Criterion 2 with respect to the structures housing the system and the system itself being capable of withstanding the effects of earthquakes. [However, the licensee has not indicated the extent to which the proposed upgrade modifications meet the requirements of General Design Criterion 2. The licensee should verify that all AFWS essential components are located in seismic Category I structures or are provided with protection against failure of nonseismic Category I structures.] We cannot conclude that the AFWS meets the requirements of General Design Criterion 2 with respect to earthquakes.

b. We have evaluated the upgraded AFWS design against the requirements of General Design Criteria 2 and 4 with respect to the structure housing the system and the system itself being capable of withstanding the effects of tornadoes, floods, external missiles and internally generated missiles. The licensee has stated that:

> "System components and piping shall have sufficient physical separation or shielding to protect the essential portions of the system from the effects of internally and externally generated missiles.
>
> Functional capability of the system shall also be assured for fires and the maximum probable flood."

[However, the licensee has not indicated the extent to which the proposed upgrade modifications meet the above criteria. The licensee should identify all AFWS components which are not protected from tornadoes, floods, external missiles and internally generated missiles.] We can not conclude that the AFWS is adequately protected from tornadoes, floods, and missiles and meets the requirements of General Design Criteria 2 and 4 and the guidelines of Regulatory Guides 1.102 and 1.117. Fire protection will be evaluated as part of our review for Appendix R.

c. The AFW is not used for startup and normal shutdown; therefore, it is considered a moderate energy system for pipe breaks in the AFWS. The only high-energy piping in the system is located between the steam generators and the first upstream check valve. Sufficient redundancy is provided in the AFWS such that a pipe break in this location, along with a single active failure, would not preclude adequate system performance. [However, the potential for AFWS component flooding due to a pipe break in the alternative water source piping has not been discussed by the licensee. In addition, the licensee has not verified that the AFWS is adequately protected against the effects of a pipe break in other systems. The licensee should verify that all essential AFWS components are protected against the effects of pipe break in high and moderate energy lines. These include the effects of pipe whip, jet impingement and internal flooding.] We can not conclude that the AFWS meets the requirements of General Design Criterion 4 and the guidelines of BTP ASB 3-1 with respect to pipe breaks outside containment.

d. The AFWS can function automatically as required in the event of a loss of offsite power. The heat transfer path from the steam generators under this condition is to the atmosphere via the atmospheric dump valves. The turbine-driven pump receives main steam from connections to both main steam lines upstream of the main steam isolation valves. The AFWS steam supply lines are six-inch lines each containing a check valve, a locked open manual valve and a normally open AC motor-operated valve. Downstream of the motor-operated valves, the AFWS steam supply lines connect to provide a common supply to the AFW pump turbine. The common steam supply line contains a normally-closed DC motor-operated valve which opens on an emergency feedwater initiation signal. The motor-driven AFW pump also starts automatically on the emergency feedwater initiation signal. The motor driven pump will be modified to provide automatic loading on a diesel generator powered emergency bus on loss of offsite power. All of the valves associated with each pump train are normally open with the exception of the four flow control valves (two in each train, in parallel). These four flow control valves fail full open on loss of control air, and fail half-open on loss of control power. Control power for the redundant flow control valves in each train is supplied by redundant Class 1E power supplies. In a telephone conversation on November 12, 1982, the licensee stated that each flow control valve would be provided with a safety-related air accumulator to supply control air on loss of offsite power or loss of the service air system. [The licensee should formally document the provisions for safety grade control air and should verify that the air accumulators have sufficient capacity to supply control air for two hours following a loss of offsite power or loss of all AC power. See also Sections I.B.2.f and II.B.5 of this report.] Pending verification of the adequacy of the flow control valve control air system, we conclude that the AFWS meets the requirements of General Design Criterion 44 with respect to its ability to transfer heat from the reactor coolant system under accident conditions.

e. The AFWS is designed to accommodate a single failure in any active system component without loss of function. The AFWS consists of two trains, supplying both steam generators. Flow to either of the two steam generators from either AFWS train is adequate for emergency plant shutdown. The discharge lines from each AFWS pump are cross-connected to allow each pump to feed either or both steam generators. Each AFW pump is provided with a separate suction line from the condensate storage tank through check valves and locked open manual valves. A single active failure in one train will not prevent the redundant train from feeding both steam generators. Steam supply to the turbine driven pump is provided from both steam generators through separate normally open AC motor-operated valves feeding into a common steam supply line to the turbine. A failure of the single steam admission valve in the common steam supply line would not preclude system function because the other motor-driven pump would still be available. Each AFW pump is provided with a full-flow test line, containing a normally open motor-operated valve, connected to the pump discharge line. The individual test lines are connected to form a common recirculation line downstream of the motor operated valves. The common recirculation line contains a normally shut air operated valve that is opened for flow testing. In the event of an AFWS initiation signal occurring during testing this valve receives signals from redundant signal channels to close. In the event of failure of this valve (FWS-X5) to close, the operator can terminate recirculation flow by closing the motor operated valves in the individual flow test lines. Valve FWS-X5 is provided with position indication in the control room. Because normally shut manual valves isolate the AFWS from nonessential systems, isolability of the AFWS is not jeopardized by active valve failure. Thus, adequate feedwater is assured in the event of a postulated design basis accident concurrent with a single failure. We conclude that the AFWS meets the requirements of General Design Criterion 44 with respect to the single failure criterion.

9. AFW Train A pump, P-318, is a combination turbine-driven motor-driven pump with both the turbine and electric motor on a common shaft. AFW Train B pump, P-319, is a motor-driven pump with the same rated capacity as the Train A pump. The turbine-driven pump train provides a diverse means of assuring feedwater supply to the steam generator independent of all offsite or onsite AC power sources for at least two hours. The pump and turbine are not dependent on secondary support systems. The bearings

on the pump and turbine are lubricated by slinging oil from reservoirs near the bearings. Lube oil cooling is accomplished by heat transfer to the pumped fluid. Automatic actuation and control of the turbine train is provided with battery-backed DC power. The steam admission valve to the AFW pump turbine is a DC motor operated valve. The control power to the flow control valves are from redundant battery-backed buses. Control air to the flow control valves is discussed in Section I.B.2.d of this report. Pending verification of the adequacy of the flow control valve control air system, we conclude that the AFWS meets the power diversity position of BTP ASB 10-1.

g. The AFW pumps are automatically started on receipt of an emergency feedwater actuation signal. Automatic sequencing of the motor-driven AFW pump (P-319) onto the emergency diesel generator is not a function of the AFWS design. However, the licensee has indicated that another diesel generator will be added and that AFW pump P-319 will be part of its automatic load sequencing scheme. Steam generator water level is automatically controlled by the emergency feed initiation and control (EFIC) system or manually controlled by the operator from the control room. Therefore, we conclude that the AFWS provides instrumentation and control for prompt initiation of a shutdown in accordance with the requirements of General Design Criterion 19.

h. The capability to manually initiate AFW flow is provided; and these manual initiation circuits meet single failure criteria. Both the motor-driven and turbine-driven pumps can be started from either the control room or local equipment cabinets. A single failure in the manual circuits will not result in the loss of system automatic function, and a failure of the automatic initiating signals and circuits will not result in loss of manual capability. Therefore, we conclude that the AFWS meets the manual initiation guidelines of Regulatory Guide 1.62.

i. AFWS function is provided automatically in the event of a main feedwater or main steam line rupture. Both AFW pumps will automatically start and steam generator level will be automatically controlled for main feedwater line and steam line ruptures which depressurize the steam generators. Automatic isolation of AFW flow to a leaking steam generator is provided, in that a steam line break or main feedwater line break that depressurizes a steam generator will cause isolation of the main steam lines and main feedwater lines on the depressurized steam generator. If isolation of the steam generator main feed and main steam lines do not isolate the break, AFW flow will be isolated from the leaking steam generator so that AFW flow will be provided only to the intact steam generator. No single active failure in the upgraded AFWS design will prevent AFW flow from being supplied to the intact steam generator or allow AFW flow to be supplied to the leaking steam generator. However, a main steam rupture with failure of a single turbine stop valve could result in blowdown of both steam generators with consequent AFW pump runout. By letter dated November 3, 1982 the licensee was requested to evaluate this matter and propose a solution. Until this matter is resolved as part of Multiplant Action B-69, "Main Steam Line Break with Continued Feedwater Addition," we cannot conclude that the AFWS meets the requirements of General Design Criterion 44 with respect to its ability to transfer heat under accident conditions and provide isolation to assure system function.

j. As discussed in Sections I.B.1.a and II.D of this report, additional information is required to conclude that the AFWS provides adequate flow for the entire range of reactor operation. Therefore, we cannot conclude that the AFWS meets the decay heat removal requirements of General Design Criterion 44.

The auxiliary feedwater system includes all components and equipment from the condensate storage tank and connections to alternative water supplies to the connection with the steam generators including valves and cross-connections. Based on the review of the design and safety classification of the AFWS, and system performance requirements during normal, abnormal, and accident conditions, we do not have adequate information to conclude that the design of the AFWS and supporting systems is in conformance with all the

Commission's regulations as set forth in General Design Criteria 2, 4, 19, 44, 45 and 46, and meets all the guidelines contained in Regulatory Guides 1.26, 1.29, 1.62, 1.102, 1.117 and Branch Technical Positions ASB 10-1, and ASB 3-1. Areas of nonconformance are outlined in the above paragraphs.

PART II

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 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 having nuclear steam supply systems (NSSS) designed by Westinghouse (NUREG-0611) or Combustion Engineering (NUREG-0635). Our evaluations of these system designs are contained in the NUREGs along with our recommendations. The objectives of the evaluation were to: (1) identify necessary changes in AFW system design or related procedures 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 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.

We have applied the generic results and recommendations of the above described review to the Rancho Seco auxiliary feedwater system (AFWS) design. The detailed reliability analyses submitted by the licensee were also evaluated. And, we evaluated the licensee's design basis for AFWS flow requirements.

Section A of Part II is our evaluation of the present AFWS against our generic short-term recommendations. Section B is our evaluation of the AFWS upgrade design against our generic long-term recommendations. Section C is our evaluation of the reliability analysis provided by the licensee for the AFWS upgrade design. Section D is our evaluation of the design basis for the AFWS flow requirements.

A. Generic 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."

   By letter dated April 30, 1980, the licensee proposed modifications to Technical Specifications requiring that when two independent 100 percent capacity flow paths are not available, the capacity must be restored within 72 hours or the plant must be placed in a cooling mode which does not rely on steam generators within the next 12 hours. These modifications were approved by the staff and issued by letter, dated March 27, 1981. We conclude that the Technical Specifications are in compliance with our recommendations and are, therefore, acceptable.

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 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."

By letter dated April 30, 1980, the licensee proposed modifications to Technical Specifications requiring that all AFWS valves, including those that are locked, sealed, or otherwise secured in position, are to be inspected monthly to verify they are in the proper position. These modifications were approved by the staff and issued by letter dated March 27, 1981. We conclude that the Technical Specifications are in compliance with our recommendations and are, therefore, acceptable.

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 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 will not result in plant damage due to water hammer."

By letter dated April 29, 1982, the licensee transmitted a Licensee Event Report, which reported damage to the AFW header in both steam generators. At a meeting on June 24, 1982, the licensee and the Babcock and Wilcox Company presented their plan to retire-in-place the existing internal AFW header and to install an external AFW header on each of the two steam generators. The new design is a modified design of the external AFW header used at several other Babcock and Wilcox-designed plants. Details of the proposed design modifications were provided by a licensee letter dated August 3, 1982. and approved by the staff in a letter dated August 19, 1982, By letter dated August 18, 1982, the licensee committed to perform a water hammer test after installation of the new header arrangement. Pending verification that no water hammer occurred, we conclude that the design is acceptable.

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 operator 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 procedures for this case should provide for transfer to the alternate water sources prior to draining of the primary water supply."

By letter dated December 17, 1979, the licensee committed to modify Rancho Seco Emergency Procedures to include a reference to standard operating procedures which were to be modified to include procedures for obtaining AFW water from sources other than the condensate storage tank. The South Folsom Canal and the plant reservoir comprise the alternative AFW water sources. In response to the above licensee letter, the staff, in a letter dated February 26, 1980, requested the licensee to further review plant procedures and verify their adequacy for supplying water from the alternative sources, especially with regard to starting the South Folsom Canal transfer pumps. By letter dated November 30, 1981, the licensee verified that the procedures are in place and that they address operation of the transfer pumps. We therefore conclude that plant procedures are adequate to supply alternative water sources to the AFWS when the primary water supply is being depleted (Case 2). The low level alarm on the condensate storage tank allows 40 minutes to transfer to alternative water supplies. Because the transfer procedures require manual actions, there would not be time to effect the transfer when the primary water supply is not initially available. The licensee should verify that AFW pump damage will not occur before water flow is initiated for the conditions of Case 1 above.

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 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 possible. 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 bearing and/or lube oil temperatures. If necessary, this operator would operate the turbine-driven pump in a manual on-off mode until alternating current power is resotred. 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.)"

On loss of all AC power, the steam turbine-driven AFW pump will start as a result of the DC powered steam inlet valve opening. The lubrication and lube oil cooling for the turbine-driven AFW are independent of the availability of AC power. The flow control valves open automatically on loss of power to allow AFW flow to the steam generators;

however, the flow control valves must be throttled manually at the valves. By letter dated December 17, 1979, the licensee stated that AFWS operating procedure A.51 addresses local manual control of the AFW flow control valves. By letter dated February 26, 1980, the staff required that, for the short-term, the licensee verify that operating procedure A.51 requires an operator to be stationed at the flow control valves following the loss of all AC power, and that adequate lighting and communications with the control room are available to assure AFW operation for two hours independent of all AC power. By letter dated March 18, 1980, the licensee committed to the above staff requirement. However, by letter dated April 14, 1980, the licensee withdrew the commitment on the basis that loss of all AC power is not a design basis event for Rancho Seco. We conclude that the licensee's position does not meet the guidelines of Recommendation GS-5 and is, therefore, not acceptable. The licensee should implement the staff requirement as stated in our letter of February 26, 1980, discussed above.

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 start-up following refueling shutdown, or any cold shutdown of longer than 30 days duration 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 30, 1980, the licensee proposed modifications to Technical Specifications to include the above-required statements. The proposed Technical Specifications were approved by the staff by letter dated March 27, 1981. We conclude that the Technical Specifications are in compliance with our recommendations and are, therefore, acceptable.

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 auxiliary feedwater system flow.

(2) The automatic initiation signals and circuits should be designed so that a single failure will not result in the loss of auxiliary feedwater 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 auxiliary feedwater 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 alternating current motor-driven pumps and valves in the auxiliary feedwater 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."

Automatic initiation of the AFWS is currently provided by the nonsafety-related Integrated Control System (ICS). By Commission Order, dated May 7, 1979, the licensee was required to develop and implement operating procedures for initiating and controlling AFW flow independent of ICS control. Licensee-proposed procedures were reviewed by the staff and approved by letter dated June 27, 1979. By letter dated October 18, 1979, the licensee committed to install a safety-grade AFW initiation and control system independent of the ICS (refer to section II.B.5 of this report). By letter dated February 26, 1980, the staff required the licensee to:

(1) Actuate the AFW flow control valves using the existing design control signals, and

(2) Establish test procedures for performing channel functional tests of the existing automatic initiation circuitry every 31 days until the safety-grade initiation and control system is installed.

A licensee letter dated November 30, 1981, verified that the flow control valves were actuated and the required test procedures were established.

In the existing design, the motor-driven AFW is automatically initiated but must be manually loaded on an emergency power bus in the event of a loss of offsite power. The upgraded design calls for the addition of two more diesel generators and automatic loading of the AFW pumps onto the associated emergency busses. In the interim, the licensee proposes to provide for automatic loading of the motor-driven AFW pump onto the existing diesel generator-supplied emergency bus. By letter dated October 5, 1982, the licensee provided additional information to verify the acceptability of this interim action. Pending staff approval for the proposal to automatically load the motor-driven AFW pump on the existing emergency bus, we conclude that the existing initiation and control system is in conformance with this recommendation and is, therefore, acceptable.

8. Additional Short Term Recommendation 1 - "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 makeup water or transfer to an alternate water supply and prevent a low pump suction pressure condition from occuring. The low level alarm setpoint should allow at least 20 minutes for operator action, assuming that the largest capacity AFW pump is operating."

For long-term, the level indication and alarms must be safety grade with redundant sensors, detectors readouts, and alarms all the way from the CST to control room, including power supplies. Circuitry equipment and power supplies are required to be Class 1E.

As indicated in the licensee letter of December 17, 1979, the condensate storage tank level is indicated in the control room. Previously, in a letter dated June 27, 1979, the staff noted that condensate storage tank low level alarms in the control room provide 40 minutes for operator action to transfer to an alternative water source. The staff concluded that the alarms and operating procedures were adequate to assure timely transfer to an alternative source when the condensate storage tank supply is being depleted. In a letter dated March 18, 1980, the licensee committed to install safety-grade condensate storage tank level indication and alarms. The upgraded design will have redundant components including sensors and detectors, redundant control room readouts and alarms and redundant power supplies. Class 1E circuitry and power supplies will be used in all cases except for the alarm annunciator panels. Qualified Class 1E annunciator panels are not available for commercial reactor plant application. We conclude that the existing AFWS design and the proposed upgrade design are in conformance with the short-term and long-term parts of our recommendation respectively, and are acceptable with regard to condensate storage tank level indication and alarms.

9. <u>Additional Short-Term Recommendation 2 (This recommendation has been revised from the original recommendation in NUREG-0611)</u> - "The licensee should perform a 48-hour endurance test on all EFS 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 shutdown and cooled down and then restarted and run for one hour. Test acceptance criteria should include demonstrating that the pumps remain within design limits and that pump room ambient conditions (temperature, humidity) do not exceed environmental qualification limits for safety-related equipment in the room."

In June, 1979, the licensee submitted results from AFW pump endurance tests. In a letter dated February 26, 1980, the staff requested that additional information be provided with regard to these tests. This additional information was submitted by licensee letter dated May 14, 1980. Follow-up testing was performed in June, 1980, in which it was demonstrated the AFW pump turbine bearings would not exceed acceptable temperature limits. Therefore, we conclude that the pump testing is in conformance with this recommendation and is, therefore, acceptable.

10. Additional Short-Term Recommendation 3 - "The licensee should implement the following requirements as specified by Item 2.1.7.b 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.'"

By letter dated December 17, 1979, the licensee indicated that the existing AFWS obtains an indication of AFW flow from clamp-on ultrasonic flow meters on each AFWS train. Previously, by letter dated October 19, 1979, the licensee committed to provide a safety-grade flow indication system in the upgraded AFWS design. In a letter dated February 26, 1981, the staff required that a procedure for performing channel functional tests of the existing AFW flow indication system be established and implemented until the upgraded AFW flow indication system is installed. By letter dated November 30, 1981, the licensee verified that these procedures are in place. By letter dated September 8, 1981, the licensee provided the design description of the upgraded AFW flow indication system. The long-term design modifications were reviewed by the staff and found acceptable. The safety-grade flow indication system will be added during the refueling outage scheduled to start in January 1983. Therefore, we conclude that the AFW flow indication system is in compliance with this recommendation and is, therefore, acceptable.

11. <u>Additional Short-Term Recommendation 4</u> - "Licensees with plants which require local manual realignment of valves to conduct periodic tests on one AFW system train, and there is 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 train from the test mode to their operational alignment."

The existing AFWS design contains a full-flow recirculation line that diverts AFW pump discharge to the condenser during pump surveillance testing. By letter dated March 18, 1980, the licensee agreed to station an operator at manually-operated valve FWS-055 in the recirculation line during pump surveillance testing until the AFWS upgraded design is installed. By letter dated September 8, 1981, the licensee provided the design description of the upgraded AFWS configuration. Manually-operated valve FWS-055 will be replaced by a motor-operated valve that, if open for testing, will be shut automatically by AFW initiation signals. The valve will also be operable manually from the control room and will have valve position indication in the control room. Other motor-operated valves have been provided in each AFWS train to isolate the flow path to the condenser on failure of valve FWS-055 in the open position after an AFW initiation signal. We conclude that the test configuration of the AFWS is in compliance with this recommendation and is, therefore, acceptable.

B. Generic Long-Term Recommendations

The evaluation of the upgraded AFWS design, as described in the licensee submittal dated September 8, 1981, is provided below.

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 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."

The existing AFWS contains a control-grade automatic initiation system. The upgrade of this system to a safety-grade system is evaluated in Section II.B.5, "Recommendation GL-5," of this report.

2. Recommendation GL-2 - Licensees with plant designs in which the primary AFW system water supply passes through valves in a single flow path, but the alternate AFW system water supplies connect to the AFW system pump suction piping downstream of the above valve(s); should: (a) install redundant valves parallel to the above valve(s) or (b) provide automatic opening of the valve(s) from the alternate water supply upon low pump suction pressure.

Each AFW pump is provided with separate suction piping to the condensate storage tank. The suction piping to each pump has two locked-open manual valves and a check valve. We conclude that the AFWS suction piping is acceptable.

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 capability of the AFWS to operate for two hours in the event of a loss of all AC power is discussed in detail in Sections I.B.2.d and I.B.2.f of this report. Pending verification from the licensee that the flow control valves can be operated for two hours independent of AC power, we conclude that the AFWS is in compliance with this recommendation and is, therefore, acceptable.

4. Recommendation GL-4 - "Licensees having plants with unprotected normal AFW 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. Considerations 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."

The primary source of AFW water supplies is the condensate storage tank (CST) which is designed to seismic Category I requirements. However, as discussed in Section I.B.2.b of this report, the licensee has not discussed the ability of the CST to withstand the effects of tornadoes including tornado missiles. Loss of the CST due to a tornado while the AFW pumps are operating could result in loss of both pumps because of the delay involved in transferring to alternate water sources and the lack of automatic shutdown of the pumps on loss of suction. The licensee should verify that the CST is protected against tornadoes and tornado missiles or alternatively commit to provide one of the above-described methods of pump protection in the event of catastrophic damage to the CST.

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

An emergency feed initiation and control (EFIC) system has been provided as part of the AFWS upgrade. The EFIC system has been reviewed and found acceptable by the staff. The EFIC system is independent of the Integrated Control System. The safety-grade flow initiation system will be added during the refueling outage scheduled to begin January 1983. We conclude the EFIC system complies with this recommendation and is, therefore, acceptable.

C. <u>Auxiliary Feedwater System Reliability Evaluation</u>

In accordance with the requirements of NUREG-0660 and NUREG-0737, the licensee has performed a reliability study of the upgraded Rancho Seco auxiliary feedwater system (AFWS). The design description of the upgraded AFWS and the reliability study for the upgraded design were provided by the licensee in letters dated September 8, 1981 and January 18, 1982, respectively.

The licensee's reliability study was performed in a manner similar to that employed in the NUREG-0611 study using generic failure rate data as modified by Rancho Seco experience. The NUREG-0611 study considered the following three transient conditions for determining the reliability of the AFWS:

1. LMFW - Loss of Main Feedwater
2. LOOP - Loss of Offsite Power/Loss of Main Feedwater
3. LOCA - Loss of all AC Power/Loss of Main Feedwater

The licensee's evaluation does not present a separate value of AFWS unavailability for each of the three transients, but rather reports system unavailability averaged over the three initiating transient conditions.

Our contractor, Brookhaven National Laboratory (BNL), reviewed the licensee reliability study and performed an independent analysis. The BNL independent analysis used the NUREG-0611 methodology and data base. AFWS unavailability was calculated for LMFW, LOOP and LOAC transients, where unavailability as defined in NUREG-0611 is the probability per demand that the system will fail to perform its mission.

Mission success as used in the licensee analysis is attainment of adequate flow from at least one AFW pump to at least one steam generator. The licensee calculated values of unavailability considering that 20 minutes would be available for operator action to assure mission success by recovering from initial failures such as the automatic actuation signal failing to start pumps or correctly positioning misaligned valves. As discussed in NUREG-0667 mission success in 20 minutes will prevent core damage in Babcock and Wilcox (B&W) plants. However, NUREG-0667 also notes that for B&W plants, recovery from transients is sensitive to early starts of the AFWS because of the small heat sink provided by the B&W once through steam generator. This is acknowledged by the licensee in the AFWS upgrade design report of September 8, 1981 where the design flow requirements of the AFWS are given as a minimum acceptable flow of 760 gpm (1 pump) at a steam generator pressure of 1050 psi. This minimum flow is to be delivered in 50 seconds from receipt of an AFWS initiation signal to minimize the occurrence of steam generator boil-dry (see also Section II.D of this report). Because steam generator boil-dry is expected to occur in a very short time, BNL calculated AFWS unavailability for the case where no time is available for operator action as well as the case where 20 minutes would be available for manual recovery. Only the immediate action case is acceptable to the staff since the mission success criterion is based on preventing steam generator dryout.

Table 1 below presents the results of the AFWS unavailability for the three transient cases based on the BNL and licensee analyses. Because the licensee presented only one value of AFWS unavailability for all transient cases, BNL extracted three unavailabilities from the information in the licensee analyses in order to have a valid comparison for the three transients. The results are given below in Table 1:

TABLE 1: AFWS UNAVAILABILITY FOR THREE TRANSIENTS CASES

		BNL Estimate, Per Demand		Licensee Estimate, Per Demand
		No Operator Recovery	Operator Recovery	Operator Recovery
1.	LMFW	7.6×10^{-4}	2.6×10^{-4}	1.0×10^{-4}
2.	LOOP	1.5×10^{-3}	5×10^{-4}	3.6×10^{-4}
3.	LOAC	2.7×10^{-2}	1.3×10^{-2}	1.6×10^{-2}

AFWS Dominant Contributors

Table 2 shows estimates of the dominant contributors and Table 3 discusses contributing failure modes to the AFWS unavailability as presented in the BNL and licensee analyses. Many similarities exist between the two; however, the licensee did not consider several operator failures which were dominant contributors. These are maintenance errors that disable diesel generators, steam admission valves, and several pump discharge valves.

In the loss of main feedwater case, BNL estimates higher AFWS unavailability than the licensee because the licensee fails to consider two common cause failures: a) leakage from recirculation valve FWS-X5; and b) all steam generator level instruments miscalibrated by the same operator.

In the loss of offsite power case, the BNL AFWS unavailability is higher because BNL assumes: a) higher failure rates for the actuation system and diesel generator, b) a longer outage period for maintenance of turbine driven pump, and c) the unavailability of the steam admission valve after maintenance. In the loss of AC power case, the BNL and licensee unavailabilities are approximately the same.

Common Cause/Single Point Failures

The licensee did not discuss common cause failures explicitly; however, BNL found that all four level setpoints of steam generators could be miscalibrated by the same operator. This failure of the level setpoints could isolate all four flow control valves and block both AFW flow paths.

BNL and the licensee also found a single point failure at test valve FWS-X5 which, when large leakage developed, will cause AFW flow to bypass both steam generators.

Supporting System

The licensee reported that the AFW pumps, pump motor, and turbine are self-cooled and independent of service water system. BNL also examined the power supply and actuation systems which support AFWS.

CONCLUSIONS

We find that the AFWS unavailability of Rancho Seco Unit 1 is in the medium-to-low unavailability range according to the range presented in NUREG-0611. The AFWS unavailability fails to meet the numerical guideline presented in the Standard Review Plan (SRP) Section 10.4.9, which specifies an acceptable AFWS unreliability in the range of 10^{-5} to 10^{-4} per demand. The staff is currently evaluating the need for modifications to the auxiliary feedwater systems for Rancho Seco and other plants whose reliability does not meet the guidelines of SRP 10.4.9. A position in this regard is being developed by the staff. Although the addition of a third AFWS train and elimination of the common cause and single point failures may further improve the AFWS reliability to the acceptable range of the SRP 10.4.9 guideline, the proposed AFWS upgrade design represents a considerable and acceptable improvement over the existing design. We therefore conclude that, until a staff position is developed regarding further improvements in AFWS reliability, operation of Rancho Seco, with the proposed upgraded AFWS design, is acceptable.

TABLE 2

Dominant Contributors to AFWS Unavailability

Dual (turbine/motor) driven pump train

BNL Estimate	Licensee Estimate	Comments
Hardware[Δ]		
$5x10^{-4}$	$5x10^{-4}$	Turbine/motor pump fails to start.
$1x10^{-3}$	$5x10^{-3}$	Steam turbine driver fails to start.
$3.1x10^{-3}$	$3.9x10^{-3}$	Steam admission valve fails to operate.
$7x10^{-3}$	$\sim 3x10^{-4}$	Actuation signal failure, per train.
$5x10^{-3}$	*	Steam admission valve left disabled after maintenance.
$3.6x10^{-2}$	*	Diesel generator B fails to start because of hardware failure ($3x10^{-2}$) or in maintenance ($6x10^{-3}$).
$1x10^{-3}$	$8x10^{-4}$	Battery fails in the loss of all AC power transient.
Maintenance		
$5.8x10^{-3}$	$1.15x10^{-3}$	Turbine pump maintenance (motor driven is not considered here).
$2.1x10^{-3}$	*	Steam admission valve maintenance.
$2.1x10^{-3}$	*	Four parallel valves are under maintenance.

*Events did not appear in the licensee fault trees.

ΔAll failure rates are in per demand basis.

Motor driven pump train

BNL Estimate	Licensee Estimate	Comments
Hardware		
$1x10^{-3}$	$5x10^{-4}$	Motor driven pump fails to start.
$.5x10^{-3}$	*	Control circuit to pump left disabled after maintenance.
$7x10^{-3}$	$\sim 3x10^{-4}$	Actuation signal fails on demand per train.
$5x10^{-4}$	$3.3x10^{-3}$	Valve FWS046 left closed inadvertently.
$3.6x10^{-2}$	$1.93x10^{-2}$	Diesel generator A fails to start.
Maintenance		
$5.8x10^{-3}$	$2.3x10^{-5}$	Motor driven pump maintenance.
$2.1x10^{-3}$	*	Four parallel valves are under maintenance.
Common Cause Failure		
$1x10^{-4}$	*	Miscalibration by the same operator of all steam generator level setpoints.
Single Point Failure		
$2x10^{-4}$	*	Test line valve FWS-X5 fails open.

TABLE 3

Dominant Failure Modes

BNL Analysis

A. Loss of Main Feedwater (LMFW) Case

1. One pump under maintenance and hardware failure of second pump.
2. Failure of both actuation trains: control logic A (EFIC-A) actuates MDP and logic B (EFIC-B) actuates DDP (dual drive pump).
3. Leakage from test line valve FWS-X5 can divert AFW flow and potentially dry out the steam generators.
4. Miscalibration of all four steam generator level setpoints by the operator.
5. Hardware failure of both DDP and MDP.

B. Loss of Off-site Power (LOOP) Case

1. Diesel generator A failure or being maintained which disables MDP train while DDP train is unavailable due to maintenance or the steam admission valve failure.
2. Same as A.3, A.4.

C. Loss of All AC Power

1. Actuation channel B fails.
2. Turbine driven pump being maintained.
3. Steam admission valve fails to open.
4. Local control to steam admission valve fails.

Licensee Analysis

1. The motor driven pump (MDP) unavailability due to loss of off-site power and diesel generator A failure.
2. The dual drive pump (DDP) unavailability due to steam admission valve failure or hardware failure of the turbine driver.
3. Valve FWS-X5 fails to close after the test.
4. Miscalibration of all four steam generator level setpoints.
5. Valves FWS-045 and FWS-046 fail to reopen after pump maintenance.
6. The Feed-only-good-generator (FOGG) Logic fails due to miscalibration.

D. Auxiliary Feedwater Flow Requirements

The design basis event originally used for sizing the auxiliary feedwater system (AFWS) is loss of main feedwater (LMFW) with a concurrent loss of offsite power (LOOP), and subsequent loss of the reactor coolant pumps. The pertinent parameters for this accident relative to the AFWS are design flowrate and required time to full AFW flow. The design values which resulted from this original (FSAR) analysis are 780 gpm deliverable to the steam generator within 40 seconds of the initiation signal. The 40 second time was chosen tr allow the AFWS to inject feedwater and begin increasing steam generator level to the 50% operating range level required for natural circulation prior to completion of the reactor coolant pump coast-down. The design flowrate was selected to be equal to or greater than the decay heat generation rate at 40 seconds. As described in the licensee submittal of September 8, 1981, each AFW pump has a rated capacity of 840 gpm at 1150 psig with a normal recirculation flow of 60 gpm; thus the net flow rate to the steam generators is 780 gpm.

Following the Three Mile Island accident, the licensee provided an additional flow rate analysis which had been provided to the licensee in a letter from the Babcock and Wilcox Company (B&W) dated May 16, 1979. This new B&W analysis indicated that at 36 seconds after reactor trip, an AFW flow rate of 760 gpm would be adequate to remove decay heat, and at 40 seconds the minimum required flow rate would decrease to 748 gpm. In a letter dated February 26, 1980, the staff requested additional information from the licensee to verify that the criteria used to establish minumum AFW flow requirements would assure adequate decay heat removal. The licensee responded to this request by providing the "Rancho Seco Auxiliary Feedwater Flow Evaluation" in a letter dated November 30, 1981. Our evaluation of this document is provided below.

The licensee's submittal of November 30, 1981 has verified that the original design flow calculations are in accordance with staff guidelines for such evaluations. That is, the original minimum AFW flow of 780 gpm for the design basis event is shown to be adequate. The licensee also states that providing AFW flow within 40 seconds will avoid steam generator dryout, and thus, will promote the inception of natural circulation cooling of the reactor core before the end of reactor coolant pump coastdown. This information does not support the flow requirement of 760 gpm at 50 seconds after inition signal that is discussed in the upgraded AFWS design description submitted by the licensee's September 8, 1981 letter. The licensee has not provided sufficient information in the November 30, 1981 submittal to justify the use of 760 gpm as the minimum required flow.

By letter dated August 18, 1982, the licensee committed to test the modified AFW steam generator injection configuration. The purpose of the test is to verify that no waterhammer problems exist with the new piping configuration and to ensure that the required mimimum AFW flow to the steam generator is provided. The licensee should provide the results of the test to verify that 780 gpm can be delivered within 40 seconds to the steam generator at 1050 psi. Alternatively, the licensee should provide the results of an analysis, using the criteria provided by the staff's February 26, 1980 letter, to verify that 760 gpm supplied to the steam generator within 50 seconds is adequate to remove reactor decay heat, promote natural circulation cooling and preclude steam generator dryout.

Part III Conclusion

The staff evaluation of the design and operation of the existing and proposed upgrade design of the Rancho Seco auxiliary feedwater system is not complete. We cannot complete our review until the licensee provides the required additional information identified in Parts I and II above.

However, as noted in our evaluation, the Rancho Seco AFWS upgrade provides a significant improvement over the present design. Operation with the existing AFWS is acceptable in the interim since nothing in our current review has changed the conclusions in the staff's June 27, 1979 evaluation. This conclusion is further reinforced by the planned addition of a safety grade AFWS initiation systen and a safety-grade flow indication system during the refueling outage beginning January 1983.