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

January 28, 1981

Docket No. 50-302

Mr. J. A. Hancock
Director, Nuclear Operations
Florida Power Corporation
P. O. Box 14042, Mail Stop C-4
St. Petersburg, Florida 33733

SUBJECT: NUREG-0737 Item II.E.1.2., Emergency Feedwater System Upgrade

Dear Mr. Hancock:

We have reviewed your preliminary Emergency Feedwater System Upgrade design description for Crystal River Unit No. 3 which was submitted by letter dated December 19, 1980. On the basis of this description and your presentation at our meeting with you on September 4, 1980, we have determined that the preliminary design description is acceptable in concept and that you should proceed with your design.

Since this activity will require our review and acceptance prior to implementation, you should provide design and analysis submittals on a timely basis to allow for our review and any revisions which may result from our review. Your submittals should not only identify those areas of compliance with applicable General Design Criteria, Standards, Codes and Standard Review Plans but those areas not in compliance, with justification for noncompliance.

Also, as discussed in our meeting of September 4, 1980, we have determined that your upgraded system must include a revised reliability analysis. In this respect, we have enclosed our evaluation of your December 22, 1979 reliability analysis of your present emergency feedwater system. You are requested to respond to our concerns, as stated in the enclosure, in your revised reliability analysis.

We request that you submit a plan that provides schedules for design and analysis submittals for our review, a schedule for submittal of Technical Specification which will be required, and a schedule for final implementation with time allowed for our review. This plan is requested witnin 30 days from receipt of this letter.

Sincerely,

Robert W. Reid, Chief
Operating Reactors Branch #4
Division of Licensing

Enclosure: Evaluation of AFWS
Reliability Evaluation

cc w/enclosure: See next page

Crystal River Unit No. 3
Florida Power Corporation

50-302

cc w/enclosure(s):

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ENCLOSURE 1

Crystal River Unit 3
Emergency/ Auxiliary Feedwater System Reliability Evaluation

1. Section 1.5 of the Crystal River Unit No. 3 AFW System Reliability Analysis defines the AFW system mission success criterion as attainment of flow from at least one AFW pump to at least one steam generator. We consider this definition to be incomplete. The criterion should include the requirement to deliver the AFW flow to the steam generator before the steam generator boils dry since that is the primary function of the AFW system. The success criterion should be revised and resubmitted accordingly.

   However, we do accept the discussion that proposes supplemental criteria; namely, maintaining adequate core cooling by use of an HPI pump. This supplemental criteria would then make AFW system reliability based on 15 and 30 minute operator action time applicable. However, it is not applicable for Case 3: LOAC, i.e. total ac power blackout since the HPI pumps require ac power. The AFW system reliability comparison for the 15 and 30 minute operator action time should be deleted for Case 3 in Figure 7 and in the figure in the Executive Summary section and submitted in a report supplement. It is noted that the staff AFW system reliability review of W and CE operating plants did not rely on this supplemental criteria.

2. Regarding the availability of steam for the auxiliary turbine-driven pump for the 15 and 30 minute cases, if the steam supply for the AFWS turbine is the steam remaining in the steam lines after generator dryout, verify the adequacy of this steam supply to driven the turbine.

3. Discuss the design range of steam supply and exhaust conditions for the AFW turbine.

4. In order for the staff to be able to confirm the assumptions made for the reliability assessment, discuss the following:

   (1) protective trips associated with the AFW turbine

   (2) the detailed valve arrangements and interlocks for both the supply and exhaust of the turbine

   (3) the normal alignment for the turbine; to atmosphere or otherwise.

5. The IREP study team found main steam lines in the space housing the two AFW pumps. Given a main steam line break in this area, discuss the likelihood of both pumps becoming inoperative.

Items 6 through 25 relate to the recommendations resulting from the staff's evaluation of the information provided by you regarding the simplified AFW system reliability analysis. The recommendations are categorized as generic and additional; as well as short-term and long-term.

SHORT TERM

6. Technical Specification Administrative Controls on Manual Valves-Lock and Verify Position (GS-2)

   The licensee should lock open single valves or multiple valves in series in the AFW system pump suction piping and lock open other single valves or

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

7. Emergency Procedures for Initiating Back-up Water Supplies (GS-4)

Emergency procedures for transferring to alternate source of AFW supply should be available to the plant operators. These procedures should include criteria to inform the operators when, and in what order, the transfer to alternate water sources should take place. The following cases should be covered by the procedures:

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

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

8. Emergency Procedures for Initiating AFW Flow Following a Complete Loss of Alternating Current Power (GS-5)

In the licensee's proposed plan to improve reliability of the AFW system at Crystal River 3 (attachment to December 27, 1979 letter), Florida Power

Corporation indicated it was working with the AFW pump manufacturer to eliminate the AC power dependency of the turbine-driven pump. The following recommendation should be met in the interim.

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

9. AFW System Flow Path Verification (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 Specification to assure that, prior to plant startup following a 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.

10. Non-Safety Grade, Non-Redundant AFW System Automatic Initiation Systems (GS-7)

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

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

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

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

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

(5) Manual capability to initiate the AFW system from the control room should be retained and should be implemented so that a single failure in the manual circuits will not result in the loss of system function.

(6) The ac motor-driven pumps and valves in the AFW system should be included in the automatic actuation (simultaneous and/or sequential) of the loads to the emergency buses.

(7) The automatic intiation 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.

ADDITIONAL SHORT TERM

11. Primary AFW Water Source Low Level Alarm (AS-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 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.

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.

12. AFW Pump Endurance Test (AS-2)

The licensee should perform a 48-hour endurance test on all AFW system pumps, if such a test or continuous period of operation has not been accomplished to date. Details for the test are outlined in Enclosure 2 titled, "Revision to Recommendation No. 2 of 'Additional Short Term Recommendation' Regarding Auxiliary Feedwater Pump Endurance Test." If endurance test has been performed, submit information as requested in test outline.

13. Indication of AFW Flow to the Steam Generators (AS-3)

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

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

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

14. Technical Specification Administrative Controls on Manual Valves - Lock and Verify Position (AS-4)

The licensee should lock open single valves or multiple valves in series in the cooling water system for the AFW pumps and other critical components and lock open other single valves or multiple valves in series that could interrupt all cooling water flow. Monthly inspection should be performed to verify that these valves are locked and in the open position. These inspections should be proposed for incorporation into the surveillance requirements of the plant Technical Specifications.

15. Training/Procedures on AFWS Interruption Due to Steam and Feedwater Line Break Detection and Mitigation System and ICS Faults

Because of the potentially significant interactions with the AFWS possibly resulting from the steam and feedwater line break and mitigation system and the ICS, information should be provided to the operating crews on means to detect and cope with AFWS interruptions caused by failures in these systems. Such information may be in the form of training and/or procedures. Training with respect to interruption caused by ICS faults may already be encompassed by requirements resulting from the Oconee event of November 10, 1979, and the Crystal River event of February 26, 1980.

16. Human Error During Test and Maintenance

The licensee should assure that plant procedures are written to reduce human induced common mode failures of all AFW system trains. For the specific example cited, the licensee should implement

staggered testing of AFW system trains, i.e., for planned testing, not more than one AFW train (or pump) should be tested by the same shift ever.

17. Flow Blockage by Plugged Strainers

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

18. Preventive Maintenance Scheduling

During periods when one AFW train is unavailable due to maintenance or repair, the reliability of the system is significantly affected. FPC states in its proposed plan to improve AFW reliability that "the effect of preventive maintenance on the AFW system reliability is an unavoidable contribution as it must be performed in accordance with the manufacturer's recommendation and FPC policy." The licensee should confirm that:

(1) The preventive maintenance schedules have been reviewed to determine whether all unnecessary or marginally beneficial procedures have been eliminated and the time between maintenance increased so as to minimize, to the extent practical, the time out for preventive maintenance.

(2) The preventive maintenance schedules have been reviewed to assure that the greatest extent practical their procedures will be conducted during periods of cold shutdown.

(3) The maintenance procedures have been reviewed to assure that the operability of at least one single working train is checked and confirmed before preventive maintenance is begun on the train to be serviced.

LONG TERM

19. Automatic Initiation of AFW Systems (GL-1)

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

20. Single Valves in the AFW System Flow Path (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.

If alternative (b) is selected, it should be determined whether the hot well should be the alternate water supply. The use of the hot well as the alternate supply is complicated by the fact that vacuum breaker valves must be opened prior to switchover. It is highly likely that this would result in the steam dump valves being closed (on loss of vacuum), forcing an atmospheric dump of S/G steam. A service water system maybe a better choice for the automatic switch over option.

Concerning the possibility of loss of suction, a review should be made of the valving design from the hot well to the pump suctions. Two normally closed dc operated valves (EFV-1 and 2) are now presently shown in the configuration. These valves are interlocked with the condenser vacuum breaker valves to ensure that they are not opened when vacuum is present. Nevertheless, these valves conceivably be opened by some fault while vacuum is present creating cavitation conditions at the AFW pumps suction and possibly diverting the CST inventory into the hot well. Consideration should be given to installing check valves in the lines coming from the hot well.

The licensee should propose Technical Specifications to incorporate appropriate periodic inspections to verify the valve positions into the surveillance requirements.

21. Elimination of AFW System Dependency on Alternating Current Power Following A Complete Loss of Alternating Current Power (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.

22. Prevention of Multiple Pump Damage Due to Loss of Suction Resulting From Natural Phenomena (GL-4)

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

23. Non-Safety Grade, Non-Redundant AFW System Automatic Initiation Signals (GL-5)

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

24. Eliminate Common Cooling Water Supply to AFS Pumps (plant specific)

In Florida Power Corporation's proposed plan to improve reliability of the AFW system at Crystal River Unit No. 3, the licensee indicated he was working on modifications to eliminate the turbine-driven AFW pump's AC dependency and to provide for diverse cooling supplies for the auxiliary feedwater pumps. Design and installation details should be submitted for review.

25. Interaction of AFW with Integrated Control System (ICS) and with Steam and Feedwater Line Break Detection and Mitigation Systems

The licensee should separate the ICS from AFW initiation and control, and reduce the interaction of the AFW with Steam and Feedwater Line Break Detection and Mitigation Systems. The potential for common cause failure of the AFW due to interactions with these two systems is discussed in NUREG-0667. The licensee should implement the following recommendations:

(1) the separation of the AFWS initiation and control from the ICS, and

(2) the reduction in adverse interaction of the steam and feedwater line break detection and mitigation systems with the AFWS.

26. Postulated High Energy Pipe Breaks

(1) In the event of a postulated break in the main steam or main feed system inside or outside containment, demonstrate that the Crystal River 3 plant has redundant instrumentation and controls to automatically limit or terminate AFW system flow to a depressurized steam generator and to direct the minimum required flow to the intact steam generator.

(2) The Crystal River 3 AFW system does not meet the high energy line break criteria in SRP 10.4.9 and Branch Technical Position 10-1; namely, that the AFW system should maintain the capability to supply

the required flow to the steam generator(s) assuming a pipe break anywhere in the AFW pump discharge lines concurrent with a single active failure.

The licensee should evaluate the postulated pipe breaks stated above and (a) determine any AFW system design changes or procedures necessary to detect and isolate the break and direct the required feedwater flow to the intact steam generator before it boils dry or (b) describe how the plant can be brought to a safe shutdown condition by use of other safety-grade systems which would be available following such postulated events. No operator action in less than 20 minutes should be assumed.

27. The licensee has indicated that the primary and backup water supplies (condensate storage tank, condensate hotwell and demineralized water tank) are not tornado protected. The licensee is requested (1) to define the extent of tornado missile protection for each of the tanks, and (2) to determine any AFW system changes necessary to comply with the SRP 10.4.9.

28. Additional information is needed to evaluate the water supply for the AFW system. The licensee is requested to provide information for each of the AFW sources.

    (1) Safety Classification and Seismic Category

    (2) available inventory

        - total

        - dedicated

(3) means to affect hook-up

- automatic
- manual
- time required for manual hook-up

(4) instrumentation available

- safety class
- location

29. The licensee is requested to provide:

(1) up to date P&IDs with symbol keys including condensate and steam side

(2) legible equipment layout drawing, including

- isometrics, if available
- identification of inhibits preventing accessibility to AFWS component and related electrical equipment

(3) list of normal valve states and loss-of-actuation power failure position.

30. Design Basis For AFW System Flow Requirements

The licensee is required to provide the AFWS flow design basis information required in Enclosure 3 for the Crystal River 3 design basis transients and accident conditions.

The response should include the following:

(1) List of all events needing AFW to mitigate the consequences.

(2) Justification that the bounding non-LOCA calculation will serve as a conservative basis for sizing the AFW system for non-LOCA core cooling considerations. In other words, show that the calculation will bound all of the non-LOCA events requiring AFW.

(3) The non-LOCA analysis should include a loss of feedwater event using FSAR type assumptions to maximize heat removal requirements (1.2 ANS decay heat, 2% power level measurement uncertainty, RCP heat input). The calculation should not take credit for "anticipatory reactor trip" since it will not occur under all conditions. Lifting of the PORV is not precluded; however, credit for pressure relief through the valve should not be assumed.

(4) For the small LOCA events, reference may be made to the B&W Report, "Evaluation of Transient Behavior and Small Reactor Coolant System Breaks in the 177 Fuel Assembly Plants dated May 7, 1979.

The acceptance criteria for the event will be:

1. Reactor Coolant System pressure remains less than 110% of design pressure (2750 psig).

2. No fuel failure (DNBR >1.30)

Revision to Recommendation No. 2 of "Additional Short Term Recommendations" Regarding Auxiliary Feedwater Pump Endurance Test

The licensee should perform an endurance test on all AFW system pumps. The test should continue for at least 48 hours after achieving the following test conditions:

- Pump/driver operating at rated speed

  and

- Pump developing rated discharge pressure and flow or some higher pressure at a reduced flow but not exceeding the pump vendor's maximum permitted discharge pressure value for a 48-hour test
- For turbine drivers, steam temperature should be as close to normal operating steam temperature as practicable but in no case should the temperature be less than 400°F.

Following the 48-hour pump run, the pumps should be shut down and allowed to cool down until pump temperatures reduce to within 20°F of their values at the start of the 48-hour test and at least 8 hours have elapsed. Following the cool down, the pumps should be 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 ambient pump room conditions (temperature, humidity) do not exceed environmental qualification limits for safety-related equipment in the room.

The licensee should provide a summary of the conditions and results of the tests. The summary should include the following: 1) A brief description of the test method (including flow schematic diagram) and how the test

was instrumented (i.e., where and how bearing temperatures were measured). 2) A discussion of how the test conditions (pump flow, head, speed and steam temperature) compare to design operating conditions. 3) Plots of bearing/bearing oil temperature vs. time for each bearing of each AFW pump/driver demonstrating that temperature design limits were not exceeded. 4) A plot of pump room ambient temperature and humidity vs. time demonstrating that the pump room ambient conditions do not exceed environmental qualification limits for safety-related equipment in the room. 5) A statement confirming that the pump vibration did not exceed allowable limits during tests.

Enclosure 3

Basis for Auxiliary Feedwater
System Flow Requirements

As a result of recent staff reviews of operating plant Auxiliary Feedwater Systems (AFWS), the staff concludes 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 require that you provide the following AFWS flow design basis information as applicable to the design basis transients and accident conditions for your plant.

1. a. Identify the plant transient and accident conditions considered in establishing AFWS flow requirements, including the following events:

   1) Loss of Main Feed (LMFW)
   2) LMFW w/loss of offsite AC power.
   3) LMFW w/loss of onsite and offsite AC power
   4) Plant cooldown
   5) Turbine trip with and without bypass
   6) Main steam isolation valve closure
   7) Main feed line break
   8) Main steam line break
   9) Small break LOCA
   10) Other transient or accident conditions not listed above

   b. Describe the plant protection acceptance criteria and corresponding technical bases used for each initiating event identified above. The acceptance criteria should address plant limits such as:

- Maximum RCS pressure (PORV or safety valve actuation)
- Fuel temperature or damage limits (DNB, PCT, maximum fuel central temperature)
- RCS cooling rate limit to avoid excessive coolant shrinkage
- Minimum steam generator level to assure sufficient steam generator heat transfer surface to remove decay heat and/or cool down the primary system.

2. Describe the analyses and assumptions and corresponding technical justification used with plant condition considered in 1.a. above including:

   a. Maximum reactor power (including instrument error allowance) at the time of the initiating transient or accident.

   b. Time delay from initiating event to reactor trip.

   c. Plant parameter(s) which initiates AFWS flow and time delay between initiating event and introduction of AFWS flow into steam generator(s).

   d. Minimum steam generator water level when initiating event occurs.

   e. Initial steam generator water inventory and depletion rate before and after AFWS flow commences - identify reactor decay heat rate used.

f. Maximum pressure at which steam is released from steam generator(s) and against which the AFW pump must develop sufficient head.

g. Minimum number of steam generators that must receive AFW flow; e.g. 1 out of 2?, 2 out of 4?

h. RC flow condition - continued operation of RC pumps or natural circulation.

i. Maximum AFW inlet temperature.

j. Following a postulated steam or feed line break, time delay assumed to isolate break and direct AFW flow to intact steam generator(s). AFW pump flow capacity allowance to accommodate the time delay and maintain minimum steam generator water level. Also identify credit taken for primary system heat removal due to blowdown.

k. Volume and maximum temperature of water in main feed lines between steam generator(s) and AFWS connection to main feed line.

l. Operating condition of steam generator normal blowdown following initiating event.

m. Primary and secondary system water and metal sensible heat used for cooldown and AFW flow sizing.

n. Time at hot standby and time to cooldown RCS to RHR system cut-in temperature to size AFW water source inventory.

3. Verify that the AFW pumps in your plant will supply the necessary flow to the steam generator(s) as determined by items 1 and 2 above considering a single failure. Identify the margin in sizing the pump flow to allow for pump recirculation flow, seal leakage and pump wear.