



UNITED STATES
NUCLEAR REGULATORY COMMISSION

REGION II
101 MARIETTA STREET, N.W.
ATLANTA, GEORGIA 30303

Report No.: 50-302/85-10

Licensee: Florida Power Corporation
3201 34th Street, South
St. Petersburg, FL 33733

Docket No.: 50-302

License No.: DPR-72

Facility Name: Crystal River 3

Inspection Conducted: March 11 - 15, 1985

Inspector:

J. J. Blake
for W. J. Ross

3/29/85

Date Signed

Approved by:

J. J. Blake

3/29/85

Date Signed

J. J. Blake, Section Chief
Engineering Branch
Division of Reactor Safety

SUMMARY

Scope: This routine, unannounced inspection entailed 42 inspector-hours on site in the areas of plant chemistry and inservice testing of pumps and valves.

Results: No violations or deviations were identified.

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REPORT DETAILS

1. Persons Contacted

Licensee Employees

- *E. M. Howard, Director, Site Nuclear Operations
- P. F. McKee, Nuclear Plant Manager
- G. L. Boldt, Nuclear Plant Operations Manager
- P. Skramstad, Superintendent, Nuclear Chemistry and Radiation Protection
- *G. T. Cowles, Steam Generator Task Force
- A. Loubris, Plant Engineering/Turbine Inspection
- *W. G. Neuman, Nuclear Inservice Inspection
- *R. W. Pinner, Nuclear Chemistry Supervisor
- *J. L. Roberts, Nuclear Chemistry Manager
- D. Worley, Nuclear Chemistry

NRC Resident Inspectors

- T. Stetka
- J. Tedrow

*Attended exit interview

2. Exit Interview

The inspection scope and findings were summarized on March 15, 1985, with those persons indicated in paragraph 1 above. The inspector described the areas inspected and discussed in detail the inspection findings listed below. No dissenting comments were received from the licensee.

Unresolved Item No. 50-302/85-10-01 Acceptance of once-through steam generators (OTSGs) Cleaning Method [Paragraph 5.a.(5)]

The licensee informed the inspector that all information related to the method to be used to clean the once-through steam generators at Crystal River was to be considered proprietary and should not be divulged in an inspection report.

3. Licensee Action on Previous Enforcement Matters

This subject was not addressed in the inspection.

4. Unresolved Items

Unresolved items are matters about which more information is required to determine whether they are acceptable or may involve violations or deviations. A new unresolved item identified during this inspection is discussed in paragraph 5.a.(5).

5. Plant Chemistry (92706)

During a previous inspection (50-302/84-08, March 1984) the inspector assessed the effectiveness of the secondary water system and the licensee's water chemistry program in preventing degradation of the once-through-steam-generators (OTSGs) and the low-pressure turbine rotors. At the time of the current inspection the Crystal River Unit 3 (CR-3) had just completed its fifth fuel cycle and had shutdown for an outage that is planned to last approximately twenty weeks. The inspector reviewed the operational history of Cycle V with emphasis on problems that were attributed to the control of water chemistry. The inspector also reviewed modifications that are to be performed on the secondary cycle during this outage to upgrade the licensee's capability to control water chemistry to prevent corrosion and deterioration of the OTSGs and low-pressure turbines. Finally, a re-evaluation of the scope and performance of the licensee's water chemistry program was made, with emphasis on trends in key chemical parameters that are used by the licensee to control corrosion and to diagnose potential chemistry problems.

a. Reassessment of Plant Design and Operation

(1) Main Condenser

Through an audit of plant records the inspector established that CR-3 had experienced eight outages of 2 to 5 days and approximately a dozen power reductions from January 1, 1984 to the end of Cycle V. None of these outages or power reductions were attributed to chemistry problems. However, the licensee continued to have problems with inleakage of condenser cooling water and air into the secondary cycle during the first part of Cycle V. The inspector was informed that two additional condenser tubes (70-30 copper nickel alloy tubes) were plugged in 1984; however, the most effective measure taken to improve the integrity of the condenser was coating the condenser tube sheets with epoxy. The inspector observed that during most of Cycle V the cation conductivity of water in the two hotwell compartments was less than 0.1 umho/cm, thereby indicating very low levels of contamination by the saline condenser cooling water. An Amertap system for continually cleaning the condenser tubes is to be installed during the current outage (Outage V) to help protect against erosion or corrosion by solids or micro/macrobiological organisms. The inspector was also informed that parts of the carbon-steel Service Water Cooling System are being replaced during Outage V as the result of corrosion by the saline cooling water.

The licensee experienced ingress of air into the secondary cycle throughout Cycle V. The leaks have been attributed to various parts of the low pressure turbine and have affected the operation of the condenser air ejectors more than the dissolved oxygen concentration of the water in the hotwell - which has been maintained at less than 5 parts per billion (ppb). During

Outage V the licensee plans to repair or replace the leaking portions of the turbines in an effort to reduce air inleakage to 5 to 10 standard cubic feet per minute (SCFM). Because of the known correlation between air inleakage and the initiation of cracks in turbine disks and blades, the licensee will replace the first three disks on each rotor with new disks that are designed to minimize oxygen-induced stress corrosion. (See section 5.a.(7)).

(2) Condensate Storage Tank (CST)

Studies by the licensee have shown that the water in the CST is a source of ingress of contaminants into the condensate during normal makeup, and a pathway for contaminating the water in the once-through-steam generators when the OTSGs are fed by the emergency feedwater pumps. During the past year the licensee has begun adding Amerzine (hydrazine) to the water in the CST and has reduced the concentration of dissolved oxygen from several parts per million (ppm) to approximately 5ppb. The licensee plans to minimize the amount of solids (mostly iron oxides) in the CST water by constructing a new tank (during Outage VI in 1986) that will allow the water to be circulated and, thereby, decrease the potential for the tank walls to be corroded. In addition, the licensee is considering means for eliminating such corrosive ions as sulfate and phosphate in the CST water. The presence of these ions is attributed to the makeup water treatment plant that is located on the site of Crystal River Units 1 and 2.

(3) Condensate Polishers

During the past year the licensee has increased the useful life of the deep bed demineralizers by reducing the rate of contamination from condenser inleakage and from the CST. The inspector observed that during the past year the beds were used for up to three months before they needed to be changed out. Normally a bed is removed from service when the concentration of sodium in the effluent increases to 2.0 ppb. The inspector observed that the concentration of sodium in the hotwell was normally documented to be <1 ppb. The sodium concentration in the effluent of the polisher also tends to be <1 ppb until a resin bed is loaded. These polishers become loaded with ammonium ions in 3 to 15 weeks and, thereby, begin to have less affinity for sodium ions. The licensee informed the inspector that another source of contaminants in the OTSGs, resin fines from the resin demineralizers, had been reduced during the past year by replacing the type of ion-exchange resins that had been previously used. Decomposition of these resins in the OTSG produces corrosive sulfate species. During shutdown of the reactor at the end of Cycle V sulfate in concentrations as high as 763 ppb were observed as "hideout return" in the OTSG water. The licensee attributed these undesirably high concentrations to the poor quality of the

CST makeup water and to carryover of up to five pounds of resin per year from the condensate polishers.

(4) Deaerator

The inspector was informed that, during Outage V the deaerator heaters will be rebuilt in an effort to maximize the removal of dissolved oxygen from the feedwater. The inspector observed that during Cycle V this parameter had consistently been documented as less than the limit detectable by the licensee's analytical instrumentation (5 ppb).

(5) Once-Through-Steam-Generators

As reported previously (Inspection Report 84-08) the condition of the two OTSGs has become a major concern to the licensee because of increasing impedance to flow of coolant through the broached holes in tube support plates. The continual requirement for increasingly higher water levels in the OTSG downcomer regions to overcome the reduced flow rate finally caused the unit to be derated to a maximum of 94% full power at the end of Fuel Cycle V. Until recently the licensee had attributed the blockage of the flow path to the presence of "several thousand pounds" of iron oxide sludge - possibly made more adherent and potentially corrosive by the presence of copper oxide removed from the copper-nickel condenser tubes. However, this assessment has been revised as the result of recent cleaning of the OTSGs at the Arkansas Nuclear One (ANO-1).

The inspector was informed that the solid material that was removed, by a proprietary cleaning process, from ANO-1 consisted mainly of black iron oxide (magnetite) but also included a hard, scale-like material that was determined to be mainly silicates (quartz) with lesser amounts of carbonates and hydroxides of calcium, i.e., "boiler scale." The presence of these 'water-hardness' constituents had not been anticipated, and these parameters, except silica, are normally not monitored in the secondary cycle of a PWR.

The inspector was further informed that the same technique, with some procedural modifications, will be employed to unblock the flow paths in the CR-3 OTSGs. This proprietary technique was described in detail to the inspector, and the licensee is performing an analysis, per Section 50.59 of 10 CFR 50, to determine if the technique raises an unreviewed safety question. This analysis is to be completed approximately two weeks before the planned cleaning in late April or in May 1985. The licensee committed to inform the Senior Resident Inspector of the results of the analysis as soon as possible. Inasmuch as the inspector considers the cleaning technique to be unique and, except for ANO-1, untried, he has designated this subject an Unresolved Issue

(URI 50-302/85-10-01, Acceptance of OTSG Cleaning Method) pending resolution of the safety implications of the proposed technique.

In addition to cleaning the solids from the OTSGs the licensee also plans to drill two additional handholds in each OTSG to improve surveillance of the tubes and tube support plates. A safety analysis of this action is also being performed. Also the supports for the OTSG drain lines are to be increased so that greater flow can be achieved when these lines are used to 'blowdown' the OTSG - at power levels up to 15 percent of full power.

(6) Moisture Separator Reheaters (MSRs)

The inspector was informed that during Outage V the copper-nickel tube bundles in the MSRs will be replaced with stainless steel tubes. This modification is being taken to eliminate corrosion of the copper-containing tubes and transport of copper oxide or soluble copper species to the OTSG. The inspector considers this to be a positive action because experience with both OTSG and recirculating steam generators has shown that degradation (such as denting) of tubes and tube support plates is accelerated in the presence of copper. The licensee will continue to monitor the secondary cycle for copper, however, because of the high probability that copper will continue to be eroded or corroded from the copper-nickel condenser tubes.

(7) Low-Pressure Turbines

During the current refueling outage the licensee plans to remove the first three disks from each end of the low-pressure turbine rotors and replace them with disks that are less susceptible to stress corrosion cracking (SCC). This action is being taken to eliminate disks where numerous indications of cracking in the steeple regions were observed during the 1983 refueling outage (Outage IV). The licensee also hopes that the new disks will reduce the probability that SCC will be initiated in the keyway and bore regions of the disks. Cracking in these regions, as well as in other parts of low-pressure turbine disks (i.e., hubs, web faces, and rim attachment areas) has been attributed, by the turbine vendor, to a combination of factors besides the yield strength of the material; i.e., applied stresses and the presence of an environment that will result in corrosion. Air inleakage into the turbine or carryover of corrosive impurities in the steam (i.e., silica sulfate, chloride, and hydroxides) increases the probability that SCC will be initiated.

(8) Summary

It is the inspector's opinion that all of the licensee's actions described above will increase the protection against corrosion and failure of the OTSG tubes and low pressure turbine disks. Currently, a total of 33 OTSG tubes have had to be plugged to prevent potential primary to secondary leakage (6 in OTSG "A" and 27 in OTSG "B").

b. Scope and Adequacy of the Licensee's Water Chemistry Program

During this inspection the inspector again evaluated the licensee's water chemistry program against guidance developed by the Steam Generators Owners Group (SGOG) and the Electric Power Research Institute (EPRI). Special emphasis was placed on the licensee's capability to initiate corrective actions during abnormal chemistry events when the plant is operating and on the licensee's procedures for maximizing protection against corrosion of the secondary cycle during plant cooldown, shutdown, and startup. This evaluation was made primarily on the basis of a review of the following documents and from discussions with members of the Chemistry Section while the plant was being shutdown for Refueling Outage V.

- o CH-424 Secondary Coolant System's Chemistry Scheduling Program
- o CH-450 Chemistry Scheduling Procedure for Secondary Coolant system During Plant Startup and Shutdown
- o OP-209 Plant Cooldown
- o OP-208 Plant Shutdown
- o OP-202 Plant Heatup
- o OP-203 Plant Startup
- o OP-603 Condensate System
- o OP-605 Feedwater System
- o Policy Statement - Criteria and Action in Response to a Salt Leak (September 24, 1984)

(1) Adequacy of Procedures for Corrective Action

Although the SGOG/EPRI guidelines were not the basis for the licensee's water chemistry program, the program is very similar in most technical aspects, i.e., control and diagnosis of water chemistry parameters. In addition, most of the licensee's administrative policies are consistent with those recommended by SGOG/EPRI.

During this inspection the inspector noted that the licensee has continued to evaluate the adequacy of the overall program through internal review groups, discussions with other members of the B&W Owners Group, and through a comprehensive assessment performed by a contractor. Through these avenues most of the changes in the previous section of this report have been initiated, and a large number of recommendations are still under review. The inspector also observed that the policy statement relating to actions to be taken in case of a salt leak had been revised to include specified actions to be taken based on the degree to which the water in the hotwells becomes contaminated, i.e., based on cation conductivity and sodium concentration. These actions, however, are limited to the identification and isolation of the affected water box and subsequent repair or isolation of the failed section of the condenser. Instructions are not provided relative to control of water chemistry in condensate/feedwater train or for operating the plant in a manner to minimize the effect of corrosive impurities in the OTSG water.

The inspector discussed this issue with the licensee, with emphasis on the need for timely corrective action both to eliminate the source of inleakage and to reduce the potential for corrosion if the feedwater and OTSG water has been contaminated. The licensee informed the inspector that these concerns were being addressed further as part of an overall re-evaluation of protection being provided to the OTSGs.

(2) Procedures for Minimizing Corrosion During Plant Shutdown and Startup

The inspector reviewed the operating procedures listed above to establish the sequence of steps taken by Operations Personnel when the plant is cooled down or heated up through the various modes of operation and also, when the plant is in cold shutdown. The inspector verified that these procedures include provisions for controlling the chemistry of the reactor coolant as well as secondary coolant, primarily through the use of the Chemistry Section's monitoring program. These procedures also address the use of the condensate polishing system and OTSG drain lines for ensuring the quality of the feedwater train and OTSG water, specifically during startup. The Chemistry Procedures also provide steps to prevent contamination of the secondary side during shutdown, especially contamination by inleakage of air. Likewise, instructions for layup as well as criteria for water chemistry parameters during the layup period are given. During startup the procedures require a phased cleanup of the condensate/feedwater train to prevent the transport of solids (especially oxides of iron) into the OTSG. The inspector observed that the Chemistry Procedures were being supplemented by "Short Term

Instructions" that were developed specifically for terminating Fuel Cycle V. These "Short Term Instructions" reiterated and elaborated on the steps to be taken by Chemistry personnel and emphasized the sequence of actions to be taken and the criteria to be met during the various steps of the shutdown procedure. This instruction had been developed by the Secondary Chemistry Supervisor and had been reviewed and approved by the Chemistry Manager, the Superintendent of Nuclear Chemistry and Radiation Protection and the Operations Shift Supervisor.

It was the inspector's opinion that the licensee's water chemistry program covers all modes of plant operation and includes criteria, including limits on specified chemistry parameters, to minimize corrosion during layup, plant startup and shutdown, as well as during power operation.

c. Implementation of the CR-3 Water Chemistry Program

As part of its program to improve the control of the secondary water system, the licensee is planning to add two key personnel to its staff. One will be a chemical engineer who will work in areas related to system integrity and corrosion. The other will be a third Nuclear Chemistry Supervisor with oversight responsibilities on the back shifts.

The licensee has also initiated purchase orders for new analytical instrumentation that will enable more sensitive measurements of corrosive ions to be made. The inspector was informed that procedures would soon be developed for monitoring the condensate/feedwater train for chemical species (such as soluble silicates, calcium, and magnesium) that appear to contribute to the 'boiler scale' on the OTSG tubes and tube support plates. Procedures are also being developed for 'integrated sampling' of sub-ppb concentrations of potentially corrosive chemical species such as copper.

The inspector reviewed graphical trends of the chemistry parameters covered by Technical Specifications (chloride, fluoride, boron) and verified that these parameters had been maintained within required limits during Fuel Cycle V. Likewise, the key parameters in the secondary cycle (cation conductivity, dissolved oxygen, pH, iron, and silica) had also been trended. As mentioned earlier, except for a very limited number of analyses (some associated with power transients) these parameters were consistently below the limits specified as acceptable in Chemistry Procedure CH-424 and were at, or close to, the limit of detection of the procedures used for analysis.

During this part of the inspection no violations or deviations were identified.

6. Inservice Testing Of Pumps And Valves (92706)

The inspector continued the inspection begun previously (Inspection Report 84-14) to determine the licensee's compliance with the program developed to meet the requirements of Section XI of the ASME Boiler and Pressure Vessel Code (74S75). Although some action had been taken by the licensee in relation to the Violation and four Inspector Followup Items identified in inspection Report 84-14, the inspector did not consider that any of these items had been processed to the degree that they could be closed. The Summary Status List that was the subject of Violation 302/84-14-01 had been established; however, the list contained only the results of the most recent tests and could not be used for short or long-term trending. The licensee committed to expedite the transfer of relevant data to these lists.

The inspector attempted to evaluate the scope of the licensee's IST program, using the Decay Heat Removal System as an example. This exercise was unsuccessful because the coordinates of pumps and valves in the IST program could not be correlated with the plant drawings of this system. The inspector was informed that the drawings have been recently revised and the changes have not been factored into the IST program.

The inspector also attempted to audit the results of tests performed on the pumps in the Decay Heat Removal System using data in the files of the ISI Section. Although no discrepancies from specified reference values were found, the audit was flawed by the absence of several data packages in these unofficial files. The inspector was informed that a new member of the ISI staff was being assigned to the IST program and would be responsible for improving the usefulness of these files.