UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
101 MARIETTA STREET, N.W.
ATLANTA, GEORGIA 30303

Report No.: 50-302/84-08

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 at Crystal River site near Crystal River, Florida

Inspector: W J Ross 4/9/84
W. J. Ross Date Signed

Approved by: J J Blake 4/11/84
J. J. Blake, Section Chief Date Signed
Engineering Program Branch
Division of Engineering and Operational Programs

SUMMARY

Inspection on March 12-16, 1984

Areas Inspected

This routine, unannounced inspection involved 42 inspector-hours on site in the area of plant water chemistry.

Results

Of the area inspected, no violations or deviations were identified.

REPORT DETAILS

1. Persons Contacted

Licensee Employees

*P. F. McKee, Nuclear Plant Manager
*G. L. Boldt, Nuclear Plant Operations Manager
*S. L. Robinson, Acting Superintendent, Nuclear Chemistry and Radiation Protection (Chemistry)
P. Skramstad, Superintendent, Chemistry
*J. L. Roberts, Manager, Nuclear Chemistry
*R. M. Pianer, Supervisor, Nuclear Chemistry
D. T. Wilder, Supervisor, Nuclear Chemistry
*J. L. Bufe, Nuclear Compliance Specialist
S. Stewart, Engineer, Results Engineering
D. Tierney, Chemist, Units 1 and 2
W. Marshall, Shift Supervisor
L. Giles, Assistant Shift Supervisor
*R. E. Fuller, Manager, Site Nuclear Services
*R. Thompson, Engineer, Licensing
*W. A. Stephenson, Engineer, Operations
*D. E. Spires, Specialist, Nuclear Compliance
*S. D. Mansfield, Acting Supervisor, Nuclear Compliance
*W. H. Herbert, NTSC
*W. A. Clemons, Specialist, Nuclear Compliance
*P. G. Hughes, Engineer, Licensing

Other licensee employees contacted included three chemistry technicians.

NRC Resident Inspector

*T. Stetka

*Attended exit interview

2. Exit Interview

The inspection scope and findings were summarized on March 16, 1984, with those persons indicated in paragraph 1 above. The licensee acknowledged the inspection results with no dissenting comments.

(Open) Inspector Followup item 50-302/84-08 "Steam Generator Sludge Deposits".

3. Licensee Action on Previous Enforcement Matters

Not inspected.

4. Unresolved Items

Unresolved items were not identified during this inspection.

5. Plant Water Chemistry (92706)

The inspector compared the "as built" secondary water system of Crystal River Unit 3 (CR-3) with the description that is in the updated (1982) Final Safety Analysis Report (FSAR), especially Section 10.2. The inspector also assessed the effectiveness of the secondary water system and the licensee's water chemistry program in preventing degradation of the turbines and the primary coolant pressure boundary in the steam generators. This inspection consisted of three interrelated parts; i.e., and assessment of the design and operation of the major components of the secondary water cycle, an evaluation of the adequacy of the water chemistry program, and verification that the requirements of the CR-3 Technical Specifications and water chemistry program are being implemented.

a. Assessment of the Design and Operation of the Crystal River Unit 3 Secondary Cooling Water System.

The Crystal River Plant consists of three operating fossil fuel units (CR 1, 2, and 4), one fossil fuel unit under construction (Unit 5), and one nuclear unit (CR-3). CR-3 became operational in March 1977 and completed its fourth refueling in the spring of 1983. The inspector interviewed cognizant plant personnel to obtain background information related to all significant problems that had been observed during the operating life of this unit which may have affected the integrity of the primary coolant pressure boundary. The following summaries of the effectiveness of each of the major components of the secondary water system have been developed from the inspector's assessment of the design of the secondary system, as described in the FSAR, and the operational history of each component.

(1) Main Condenser

The CR-3 unit transfers waste heat energy through a condenser to a once-through circulating water system that uses water from the Gulf of Mexico as a heat sink. Because of the dilution effect of several fresh water rivers in the vicinity of the Crystal River Plant, the salinity of the circulating cooling water is approximately 50% of normal sea water. The main condenser has 41,672 tubes, made of 70-30 copper-nickel alloy, and a flow of 647,000 gpm with a $\Delta T \leq$ of 17.1°F. The condenser was constructed to maintain the concentration of dissolved oxygen in the two condenser hotwells (4 water boxes) at $\leq$ 5 ppb, however, inleakage of small amounts of sea water has been experienced, in three of the four water boxes, to the extent that load reductions have been required on 10 occasions during the current fuel cycle to prevent break-through of the condensate polishers.

In March 1983, the licensee inspected the tube and shell sides of the condenser to eliminate sources of inleakage. The shell side examination revealed considerable amounts of debris in the water boxes as well as structural damage to the water boxes and 19 severely damaged condenser tubes. As a result of eddy current testing 10% of the condenser tubes, 89% of the tubes tested were found to be free of wall loss of 40% or more. Approximately 1.5% of all tubes have been plugged because corrosion or dents have caused thinning of the 0.049 inch tubes walls by 40% or more.

During this inspection the licensee also observed that the "shot" method being used to clean the inner walls of the condenser tubes was not completely removing the mud that is continuously being deposited. This cleaning method consists of taking a water box out of service (and reducing plant power) while rubber balls are propelled by air pressure, through the condenser tubes. Each of the four sections of the condenser are cleaned on a frequency of 4 to 6 weeks. Chlorination is not employed to keep the condenser tubes clean.

In October 1983 the license again inspected the shell side of the condenser as the result of suspected tube failures and damage to the low-pressure heater casings as the result of weld washouts.

The inspector was informed that leakage had again been observed in January and February 1984 but currently appears to have ceased. (The licensee adds sawdust to the circulating cooling water to plug minor tube leaks).

The licensee is capable of detecting inleakage through the condenser by continuously monitoring the condensate at the discharge of the condensate pumps for conductivity, dissolved oxygen, pH, and turbidity and by analyzing grab samples from both hot wells and the intertie between the two hot wells. In addition, silica, sodium, and chloride are determined on a weekly frequency. The licensee has recently acquired a helium leak detector, to replace a less sensitive freon detector, to locate oxygen and sea water leaks in the secondary system.

The inspector considers that the licensee is taking appropriate measures to maintain the integrity of the condensers and has the capability to detect inleakage of air or circulating cooling water so that protective measures can be taken in a timely manner before the primary coolant boundary (i.e., steam generator tubes) is degraded.

(2) Condensate Makeup

Makeup water for both the reactor and secondary cooling water supplies is obtained from wells located near the Crystal River Plant. This water is purified in a treatment plant located on the site of Units 1 and 2. The inspector verified that the composition of this well water is periodically determined and steps are provided in the water treatment to remove all known mineral constituents. The purified water is stored on the site of Units 1 and 2 until either being pumped to the CR-3 Condensate Storage Tank (CST) or, after being deaerated, is pumped to the CR-3 Primary Water Storage Tank. The quality of the water in the CST is monitored weekly for specific and cation conductivity, iron, silica and phosphate.

During an audit of recent analyses the inspector noted that the cation conductivity and the total iron content of the CST water had varied widely and had been out of limit during much of the period. The licensee attributes these results to the fact that efficient cleanup of the CST water cannot be maintained because of a recent modification in the piping of the CST. This modification, which was made to assure a sufficient supply of emergency feedwater, permits only a fraction of the water in the CST to be transferred to the condensate demineralizers for cleanup, thereby preventing adequate mixing and cleaning of all the water in the CST.

The inspector was informed that the water in the CST is vented to the atmosphere, thereby allowing contamination from air. The inspector considers that the period of time that makeup water is stored in the CST has a detrimental effect on the quality of this water.

(3) Condensate Cleanup System

The inspector verified that the condensate cleanup system in CR-3 has been installed and is functioning as described in Section 10.2.1.5 of the FSAR. This system consists of six deep-bed demineralizer units fabricated by the Graver Water Conditioning Company. Five units are normally in operation when the plant is at full power, and are regenerated whenever the conductivity or sodium concentration in the effluent of each demineralized bed exceeds 3 umhos/cm or 2 ppb. respectively.

The licensee has opted to discard the depleted demineralizer resin rather than to regenerate it (with sodium hydroxide and sulfuric acid). This decision was based on the possibility that the feedwater might be contaminated by the regenerating chemicals or with resin particles when a regenerated resin bed was placed back in use.

The inspector observed that demineralizer beds were being replaced on a frequency of approximately one month. The licensee attributes this relatively short useful period principally to the continual inleakage of circulating cooling water that had been experienced during most of 1983 as well as to the need to clean up the condensate makeup water. The licensee believes that the usefulness of a demineralizer bed can be extended to two months or longer by eliminating the inleakage of saline water. The licensee has the capability to monitor the effectiveness of the condensate cleanup systems, as well as each resin bed, by periodically determining conductivity, silica, and sodium in the effluent during each shift.

The licensee informed the inspector that depletion of resin beds was of special concern during startup of the plant after extended outages or lay-up because the resins were rapidly coated with red iron oxide during the condensate/feedwater cleanup cycle. Several proposals are being investigated, related to improvement of lay-up procedures, to minimize formation of iron oxides and to achieve more effective operation of the demineralizers during the pre-startup period. The licensee is also studying the possibility of removing the bulk of insoluble iron oxides by some method other than the use of the condensate polishers as a filter.

The effort and expense involved with the frequent replacement and disposal of spent resin beds are further increased because these spent resins must be treated as low-level radioactive waste since they are contaminated with tritium. Very low levels of tritium exist in the condensate as the result of an apparent leak in the steam generator that cannot be located. This problem is discussed further in Section 5.a.(6).

The inspector confirmed that the licensee is aware of the water quality deficiencies associated with the condensate and the need for an efficient condensate cleaup system and demineralizer effluent monitoring program.

(4) Deaerator

In the secondary cycle of CR-3 the water that has been cleaned by the condensate polishers is pumped through low-pressure heaters into a deaerator where further removal of non-condensible gases is achieved. The deaerated water is piped to a storage tank where it serves as a source of suction for the two feedwater booster pumps. The inspector did not identify any design or operational problem associated with the operation of this system. The licensee monitors the influent to the deaerator for conductivity and pH and monitors the effluent for pH, sodium, and hydrazine.

(5) Feedwater Train

Water from the deaerator storage tank is pumped through two intermediate-pressure heaters, feedwater pumps, and two high-pressure heaters into the steam generator, or is recycled (bypassing the feedwater pumps) to the hotwell when the plant is in a pre-startup cleanup mode. Condensate from the high pressure and low pressure heaters is cycled back to the deaerator as is monitored for pH, silica, and sodium. The licensee adds ammonia and hydrazine to control the pH and dissolved oxygen concentration in the feedwater. The inspector established that there are no copper components in the feedwater heaters.

The quality of the feedwater is established daily (or more frequently) by monitoring conductivity, pH, dissolved oxygen, silica, and iron and by determining the concentrations of hydrazine, ammonia, copper, and lead on a weekly schedule. The inspector considers this surveillance to be adequate.

(6) Steam Generator

The two once-through-steam generators (OTSG) at CR-3 all have a carbon steel shell and inconel tubes and produces steam that is superheated to 60 °F. The licensee informed the inspector that, except for one incident in 1977, the OTSGs have operated without problems. During the initial fuel cycle a tube failure occurred in one OTSG as the result of disintegration of a burnable poison rod in the reactor and migration of debris to the steam generator. Although the degraded tube was isolated by plugging, the licensee has continued to find 1 to $2\times10^{-5}$ uci/gm of tritium in the secondary coolant and has not been successful in locating the source of the apparent primary to secondary leak. Tritium is now monitored daily in the condensate.

The OTSG are currently a major concern to the licensee, because of the presence of an estimated 4000-5000 pounds of sludge (total) on the lower tube support plates. Analyses of samples of this sludge, taken through feedwater nozzles during the fourth refueling outage in 1983, show that the sludge contains iron (25%) with minor (<1%) amounts of manganese and calcium. The sludge has the consistency of low density silt rather than flakes or heavy, compacted mud. The main effect of the sludge has been a reduction in the cross-sectional flow area in the broached openings of the 5 lowest tube support plates. These restrictions have caused the water level in the OTSG to rise continually until it is very close to the level (360 inches) permitted by Technical Specifications (TS 3.4.5) when the unit is at full power. This level is equivalent to 88.36% of the operating range of the water volume in the

OTSG. Inasmuch as the level has been increasing by 1 % to 2% per month, the licensee has requested that the Technical Specification level be increased to 95% so that the plant will not have to reduce power to stay within the currently allowed water level. This request is being reviewed by NRC.

The sludge does not appear to have coated the OTSG tubes or to have affected the overall efficiency of heat transfer.

The licensee, in collaboration with the vendor (Babcock and Wilcox), the Electric Power Research Institute, and the B&W Steam Generator Operators Group, is attempting to develop a method to remove sludge from the internals of OTSGs. One procedure that is under study is to use solutions of EDTA (Ethylenediamine titra-acetic acid) to selectively dissolve the sludge so that it may be flushed out of the OTSG by means of the small blowdown lines that are used whenever the plant is at less than 15% power. Blowdown of the solid sludge through these lines has not been successful.

The inspector was informed that phosphate hideout had been observed in the OTSGs during extended outages. This apparent anomaly is due to the fact that trace amounts of phosphate enter the secondary system of CR-3 when steam from CR-1 and CR-2 is used for startup, because these fossil units control feedwater chemistry with phosphates rather than with an all-volatile-treatment (AVT) system. The licensee has not attributed any corrosion of the secondary plant in CR-3 to the presence of phosphate.

The inspector will follow the licensee's activities related to removal of sludge from the OTSGs and prevention of future buildup of sludge. The action is designated Inspector Followup Item 301/84-08-01, "Steam Generator Sludge Deposits."

(7) Moisture Separator Reheaters

In plants with OTSGs that produce superheated steam, chemical impurities in the feedwater are entrained with steam to a much greater degree than in plants with recirculating steam generators. These impurities have been found to be concentrated, by a factor of ~ 10, in the moisture separator reheater drains. At CR-3 the licensee is cycling this drain water back to the hotwell for cleanup rather than adding it to the feedwater. Although this action entails a power penalty, it ensures a higher quality of feedwater.

(8) Turbines

The inspector was informed that during an inspection of the low-pressure turbine rotors in CR-3 during the refueling outage in 1983, no significant indications of corrosion were observed on either rotor, although two indications, that were thought to be minor scratches, were found on one rotor. Westinghouse has recommended that one turbine disc be reinspected during the next refueling. Several cracks were observed however in the blade region. Neither the licensee nor the vendor (Westinghouse) have attributed these cracks to off-normal chemistry conditions, although the cause of the cracks has not been investigated in depth.

(9) Summary

During this review of the components in the secondary coolant system the inspector did not identify any violation or deviation. Although the secondary system is still subject to degradation during extended outages and the quality of the condensate remains a concern, the licensee is directing considerable effort (and expense) to maintaining the quality of the feedwater at high level so that the primary water pressure boundary in the steam generator will be protected. Despite these efforts, several thousand pounds of sludge have been deposited in the lower portions of both OTSGs. It is evident that the probability of forced power reductions in the future will cause the licensee to take some kind of action to remove this sludge. The inspector will follow this action to determined if tube degradation has already occurred or will result from the removal o, the sludge.

The licensee is also aware of the potential for contaminating the feedwater (as well as the economic penalty associated with replacing demineralized resin beds) if the quality of the condensate is reduced by ingress of air or saline water. Likewise the licensee is aware of the potential of decontamination through the use of poor quality water from the CST for condensate makeup or as a source of suction for the emergency feedwater pumps.

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

The CR-3 Technical Specification (4.1.2.8,4.1.2.9,4.4.7 and 4.9.1.2.) identify the chemical parameters that must be monitored and controlled in the primary coolant. Likewise, Technical Specification 3/4. 7.1.6 was to establish the specific parameters, sampling points, acceptance criteria, and frequency of surveillance for the secondary system. However, during the review of the licensee's proposed program, the NRC determined that such specificity was not required in the Technical

Specifications, but, instead, the licensee should commit to including the elements of a water chemistry program in plant procedures. The inspector evaluated the scope and adequacy of the CR-3 water chemistry program primarily through a review of administrative, chemical and surveillance procedures, discussions with supervisory personnel, and assessment of the capability of the licensee to protect the integrity of the primary coolant pressure boundary (and the turbines) by implementing the requirements of these procedures.

The inspector verified that responsibilities have been designated and guidance and criteria have been provided for the following activities:

(1) Establishing and administering a staff to assure that activities involving chemistry are carried out. (Administrative Instruction AI-1500 - "Conduct of Chemistry and Radiation Protection Department)

(2) Establishing key parameter to be monitored during plant shutdown, startup, and operation (Chemistry CH-300 Series), especially the following procedures.

- CH-410 " Reactor Coolant, Reactor Coolant Makeup, and Decay Heat Removal System's Chemistry Scheduling Program"

- CH-450 " Chemistry Scheduling Procedure for Secondary Coolant System During Plant Startup and Shutdowns."

- CH-424- " Secondary Coolant Systems "Chemistry Scheduling Program"

- CH-418 " Secondary Coolant Support System Chemistry Scheduling Program"

(3) Developing, reviewing, approving, and revising chemical procedures

(4) Scheduling tests (CH-400 Series - "Scheduling" and SP-443 "Master Surveillance Plan")

(5) Training analysts

(6) Performing chemical measurements (CH-300 Series "Sampling", SP-700 series, and CH- 100 Series " Chemical Analyses")

(7) Providing calibrations and quality control (CH-406 "Laboratory Chemistry Analytical Quality Control Scheduling Program")

(8) Documenting, reviewing, and trending test results

(9) Taking corrective action on the basis of test results.

The inspector verified that the requirements of the CR-3 Technical Specifications are implemented by the Chemistry and Surveillance Procedures.

The inspector reviewed the scope of the surveillance programs for the primary and secondary water systems and concluded that the types of parameters being monitored, the location of sampling points, and the frequency of sampling required in CH-410, CH-450, CH-424 and CH-418 are adequate to detect contamination of the primary, secondary, and auxiliary water systems.

During this part of the inspection the inspector did not identify any violations or deviations.

c. Implementation of the CR-3 Water Chemistry Program.

The inspector reviewed and evaluated the extent to which the licensee is meeting the requirements of the Technical Specifications for the primary cooling system and is implementing the requirements of the procedures that constitute the secondary water chemistry program. This evaluation was based on discussions with plant personnel, review of written procedures in the CH-300, CH-100 and SP-700 series, observation of analyses and review of test results and trends. This part of the inspection is summarized as follows:

(1) The directives in the plant's Administrative Instructions, especially AI-1500, are being implemented by a Nuclear Chemistry and Radiation Protection Department under the direction of two superintendents who report to the Nuclear Plant Operations Manager. All activities pertaining to primary and secondary water chemistry are performed under the supervision of a Nuclear Chemistry Manager and two Nuclear Chemistry supervisors. The inspector did not evaluate activities related to radiochemistry or radwaste.

(2) The staff of the Nuclear Chemistry Group currently has a full complement of 19 technicians all of whom meet ANSI standards. The licensee has recently established a qualification program that uses both formal training courses and on-the-job-training to qualify each technician in all duties performed in the radiochemical, primary, and secondary labs.

(3) The licensee implements the CR-3 water chemistry program by means of a weekly schedule that is developed by the Nuclear Chemistry and Technical Specification Coordinating Groups. Each task is assigned daily by the Chief Technician in each laboratory and is performed with the aid of a Chemistry Procedure (or Surveillance Procedure for Technical Specification requirements) that is

available at points of sampling and analyses. The inspector audited all procedures related to the determination of boron and found them to be acceptable as to format, scope and clarity and based on procedures described in the Babcock and Wilcox Chemistry Manual or ASTM references. Each procedure contained guidance related to the following items: scope, principle, potential interference, definitions, reagents, special apparatus needed, quality control required, a step-wise procedure, calculations required, and other information such as calibration curves. Procedures that involved taking samples from process lines also identified the required lineup of valves.

(4) The inspector assessed the physical facilities that are available for sampling and analyzing samples and found them to be of adequate size and to be well maintained. The licensee has enhanced the efficiency of the laboratories by running lines for grab samples from all principal sampling points to sampling stations within the secondary laboratory or adjacent to the primary laboratory. By means of a "switchboard" configuration in the secondary laboratory, samples from ~20 sampling points can be converted to inline systems that are continuously monitored for hydrazine, sodium, dissolved oxygen, pH. conductivity and chloride. Conductivity of water in the hotwell and in the effluent of the condensate pumps is also continually monitored in the Control Room. During this inspection the licensee was installing a new ion-chromatograph as an on-line monitor for parameters in the primary coolant. Inasmuch as this instrument is on a mobile cart it can also be used at other sampling stations.

(5) The inspector verified that instruments and chemical reagents are being calibrated as required by the associated Chemical procedure.

(6) The inspector verified that the results of each analysis are being documented by the analyst who performed the test. The results of all analyses are submitted to Chemical Supervisor who reviews the results daily.

(7) Each analyst and his/her supervisor interpret the test results, and orally notify Operations if a result is outside its specified limit, or by means of a written Non-Conforming Operations Report if the parameter is controlled by Technical Specifications. The inspector audited the log books and daily chemistry data sheets in the Primary and Secondary Chemistry laboratories and observed that all audited results were either within specified limits or had been properly processed if out of limit. The inspector discussed selected out-of-limit results with licensee personnel to determined if the duration and magnitude of the discrepancy had been adequately analyzed and verified that such analyses had been performed.

The licensee informed the inspector that a management Policy Statement had recently been issued that establishes criteria relative to inleakage of saline water. These criteria are based on guidance published by the Steam Generator Operators Group and The Electric Power Research Institute (SGOG/EPRI) and define actions that are to be taken whenever action conductivity or sodium concentration exceeds specified limits.

(8) The licensee graphically trends the values of the most important parameters at each sample point. The inspector made use of these graphs to review the effectiveness of the design and operation of the secondary system in maintaining high quality condensate and feedwater. These graphs demonstrated the fluctuations in conductivity and ion concentration in the CST water caused by incomplete mixing of the water in this tank.

Summary

The inspector verified that, to the extent audited, the licensee had been implementing the surveillance and control requirements of the CR-3 Technical Specifications and is meeting the criteria of the management Policy Statement and other elements of the water chemistry program. The licensee is aware of sources of contamination and is upgrading its capability to monitor inleakage of air by means of a helium leak detector and to identify trace concentrations of impurities in the feedwater ( and reactor water) with an ion chromatograph.

The inspector did not identify any violations or deficiencies.

d. Post Accident Sampling System (PASS)

The inspector observed that the licensee's PASS was in place and capable of performing most of its functions. This system had recently been inspected and evaluated by the NRC.