UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
101 MARIETTA STREET, N.W.
ATLANTA, GEORGIA 30323

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Report No.: 50-395/86-01

Licensee: South Carolina Electric and Gas Company
Columbia, SC 29218

Docket No.: 50-395 License No.: NPF-12

Facility Name: Summer

Inspection Conducted: January 6-10, 1986

Inspector: W J Ross 1/31/86
W. J. Ross Date Signed

Approved by: for D. B Kyo 2/4/86
W. E. Cline, Section Chief Date Signed
Emergency Preparedness and Radiological
Protection Branch
Division of Reactor Safety

SUMMARY

Scope: This routine, unannounced inspection entailed 37 inspector-hours at the site during normal duty hours, in the areas of plant chemistry.

Results: No violations or deviations were identified.

REPORT DETAILS

1. Persons Contacted

Licensee Employees

*O. S. Bradham, Director, Nuclear Plant Operations
*B. G. Croley, Deputy Director, Nuclear Plant Operations
M. Browne, Manager, Technical Support
J. Archy, Maintenance Engineer
W. F. Bacon, Associate Manager/Chemistry
R. H. Burch, Chemistry Supervisor
*H. I. Donnely, Senior Licensing Engineer
*L. F. Faltus, Acting Plant Chemist
P. Krawczk, Chemistry Supervisor
A. Monroe, Licensing Engineer
B. C. Williams, Supervisor of Operations

Other licensee employees contacted included construction craftsmen, engineers, technicians, operators, mechanics, security force members, and office personnel.

NRC Resident Inspectors

R. Prevatte
P. C. Hopkins

*Attended exit interview

2. Exit Interview

The inspection scope and findings were summarized on January 10, 1986, with those persons indicated in paragraph 1 above. No dissenting comments were received from the licensee.

The licensee did not identify as proprietary any of the materials provided to or reviewed by the inspectors during this inspection.

3. Licensee Action on Previous Enforcement Matters

This subject was not addressed in the inspection.

4. Plant Chemistry (79501 and 79502)

As a result of its continuing concern for steam generator tube integrity, the NRC staff has recently issued recommended actions and review guidelines

that are directed toward the resolution of unresolved safety issues regarding this subject (see Generic Letter 85-02 dated April 17, 1985.) One recommended action is as follows:

> "Licensees and applicants should have a secondary water chemistry program (SWCP) to minimize steam generator tube degradation. The specific plant program should incorporate the secondary water chemistry guidelines in the Steam Generator Owners Group (SGOG) and Electric Power Research Institute (EPRI) Special Report EPRI-NP-2704, "PWR Secondary Water Chemistry Guidelines," October 1982, and should address measures taken to minimize steam generator corrosion, including materials selection, chemistry limits, and control methods. In addition, the specific plant procedures should include progressively more stringent corrective actions for out-of-specification water chemistry conditions. These corrective actions should include power reductions and shutdowns, as appropriate, when excessively corrosive conditions exist. Specific functional individuals should be identified as having the responsibility/authority to interpret plant water chemistry information and initiate appropriate plant actions to adjust chemistry, as necessary.
>
> The reference guidelines were prepared by the Steam Generator Owners Group Water Chemistry Guidelines Committee and represented a consensus opinion of a significant portions of the industry for state-of-the-art secondary water chemistry control."
>
> Reference
>
> Section 2.5 of NUREG-0844

In parallel action, the NRC Office of Inspection and Enforcement has developed two new Inspection Procedures to verify that the design of a plant provides conditions that ensure long term integrity of the reactor coolant pressure boundary and to determine a licensee's capability to control the chemical quality of plant process water in order to minimize corrosion and occupational radiation exposure.

The objectives of these new procedures were partially fulfilled during previous inspections (See Inspection Reports 50-395/83-37 and 50-395/85-01 dated January 12, 1984 and January 31, 1985). This followup inspection consisted of an evaluation of the degree to which the integrity of the steam generator had been maintained by chemistry control during 1985. All but two weeks of the second fuel cycle (9 months) fall within this period, and the second refueling outage ended on December 14, 1985. The licensee experienced two periods, in January and May 1985, when problems related to the steam generator forced the plant to shut down for more than a week each time. Otherwise, the power level remained near 100% most of the second fuel cycle.

Through an audit of plant records and discussions with plant personnel the inspector established that good control of the primary water chemistry had

been maintained throughout the second fuel cycle, and Technical Specification limits on key chemical parameters were met without difficulty. Likewise, after recovery from an intrusion of ion exchange resin into the steam generator on January 13, 1985, the secondary water chemistry was controlled within the limits recommended by the SGOG during the remainder of the fuel cycle. To a large degree this chemistry control (and the good condition of the steam generator internals that was observed during the second refueling outage) was made possible by the design and operation of the systems discussed below, in that ingress of corrosive contaminants was prevented.

a. Reassessment of Plant Design

(1) Integrity of the Main Condenser

During the last eight months of the nine-month second fuel cycle the inleakage of air through the condenser, turbine and associated pumps and other components was maintained at ~ 10 standard cubic feet per minute (SCFM) and the concentration of dissolved oxygen in the hotwell water kept to < 5 ppb. (During startup for the third fuel cycle air inleakage also had been kept to 10 SCFM or less). No condenser tube leaks occurred during the second fuel cycle. Consequently, the quality of the hotwell water remained very high (i.e., cation conductivity ≤ 0.2 umho/cm) during essentially all of the period from February to October 1985. During the subsequent refueling outage the hotwell and water boxes were cleaned and examined for corrosion. The inspector was informed that only minor, generalized corrosion of the water boxes was found.

The presence of clams in the Monticello reservoir is now considered a definite hazard, and plans are being made to chlorinate the service water to prevent blockage or damage to heat exchangers and other plant components that provide flow for this water. Similarly, the licensee is cognizant of corrosion problems that are being encountered as the result of microbiological-induced corrosion and is considering the use of a proprietary surveillance kit to monitor the lake water for detrimental microbiological species.

The inspector was also informed that the baffle plates on the shell side of the condenser had been strengthened during the last refueling outage to prevent these plates from being dislodged by steam and converted into fragments that might cause mechanical damage or failure of the condenser tubes.

(2) Efficiency of Makeup Water Treatment Plant

Inasmuch as condensate makeup water is required continually to replace water lost through steam generator blowdown and other causes the licensee continues to place emphasis on the quality of

the water produced by the water treatment (purification) plant. The inspector was informed that during the past year considerable effort was required to maintain the concentration of soluble organic material in the product water within specified limits (<100 ppb). The inspector's audit revealed that the total organic content (TOC) of the water from the Montecillo Reservoir normally was 1 to 1.5 ppm and was being reduced to 50 to 150 ppb in the water treatment process (the licensee's TOC analyzes cannot detect <50 ppb of TOC). In order to achieve the 100 ppb limit the activated carbon bed in the purification train has to be changed out more frequently than originally designed. Also, difficulties have been encountered in establishing a chlorination schedule that will provide the necessary oxidation of organic constituents of the source (lake) water without having the corrosive, gaseous chlorine pass through the cleanup demineralizers and into the storage tanks.

The effect of organic species in the feedwater and steam generator water has not been established; however, if the organic molecules ionize they complicate accurate determination of conductivity and, consequently, the control of water chemistry.

The licensee has not had any trouble reducing the concentrations of the inorganic ions in the makeup water to within the limits specified in chemistry Procedure OP-619, Chemistry Specifications for Makeup Water Tanks.

(3) Condensate Cleanup System

The purity of the feedwater during the second fuel cycle was controlled through steam generator blowdown since the condensate polishers must be by-passed when the power level exceeds 50%. Consequently, the composition of the condensate and feedwater was essentially identical; i.e., the cation conductivity trended downward from ~ 0.2 µmho/cm to ~0.10 µmho/cm as plant operation became more stable.

The auxiliary condensate cleanup loop (kidney loop) that was installed during the first refueling outage in 1984 was the cause of a significant resin intrusion into the steam generators in January 1985 and was subsequently by-passed during the remainder of the second fuel cycle. Although this loop was also used during startup for the third fuel cycle (in December 1985) it has again been taken out of use. Consequently, the condensate is not being polished when the power level of the plant is > 50 percent. Although the absence of polishing capability slows the rate of achieving maximum feedwater purity, the inspector observed that the cation conductivity of both the condensate and feedwater had been reduced to 0.20 µmho/cm, by blowdown, during the first week of January 1986. The licensee believes this continual decrease in cation conductivity is reflecting the removal of fluoride ions

that are being leached from the residues of new welds that were made in the moisture separator reheater during the refueling outage.

The inspector and licensee reviewed the detrimental effect of copper if it is transported from the moisture separator reheater tubes to the steam generators. Such transfer would most probably occur via the extraction steam lines and, therefore, bypass the condensate polishers even if they were in service. However, an audit of the licensee's analyses of copper in the feedwater indicates that copper is not being transferred in detectable (0.1 ppb) concentrations.

(4) Integrity of the Steam Generators

As was discussed earlier in this report, for the second time during the operational life of the plant a significant amount of ion exchange resin was transferred into the steam generators during startup for the second fuel cycle (January 1985). The steam generators were thereby subjected to a corrosive environment when the resins were thermally degraded to acid chloride and sulfate compounds (chloride and sulfate in the steam generator water peaked at 300 ppb and 5 ppm respectively). The licensee took the corrective actions recommended by the SGOG guidelines and reduced these peak concentrations to 20 ppb and 10 ppb in approximately four days. At the end of April 1985 the plant was shut down for three weeks while three leaking tubes in steam generator 'B' and one leaking tube in steam generator 'C' were investigated. The tubes had failed in the tangential region of the 'U' bend of the Row 1 tubes. Subsequently, all Row 1 tubes in 'B' were plugged; however, two small leaks (1.5 gallons per day (gpd) in 'B' and 0.25 gpd in 'C') could not be identified or located.

During the recent refueling outage the steam generators were sludge lanced and visually examined by means of fiber optics. The inspector was informed that very little solid was removed and that the tube sheet region appeared not to be coated with an oxide film.

Also, the steam generator tubes were subjected to eddy current testing for indications of cracking, thinning, and other forms of degradation. This examination revealed a significant number of cracks on the hot-leg side of the tubes and within the tube sheet. A total of 151 tubes were plugged to isolate all tubes where the crack indications exceeded 40% of the wall thickness. As a result, the margin for the number of tubes that may be plugged has been reduced to a point where additional plugging may require a reduction in the maximum power level of the plant in order to ensure adequate heat transfer through the steam generators.

The tube cracks appear to have been initiated on the primary water side and in regions where the tubes were not completely rolled against the tube sheet. Similar cracking of Inconel 600 alloy has been observed in the past at other plants and is attributed to high residual and applied stresses and long incubation times rather than to the chemical composition of the primary coolant. The licensee attempted to relieve high stress levels in the tube sheet region of ~ 50% of the steam generator tubes by roto-peening the inner surfaces of the tubes throughout the depth of the tube sheet.

The inspector was informed that discussions are being held between the licensee and the NRC Office of Nuclear Reactor Regulation related to the safety implication of the tube failures within the tube sheet. It is the licensee's position that Technical Specification requirements related to plugging of cracked tubes should be relaxed when the flawed tube section is enclosed within the tube sheet. The licensee has initiated other studies of the feasibility of repairing the cracked tubes rather than using plugs. The licensee is also considering reducing the temperature of the primary coolant (Tavg) as a means of reducing the rate of initiations and propagation of the stress induced cracks.

(5) Integrity of the Low Pressure Turbine Rotors

During the recent refueling outage the licensee inspected one low pressure rotor for cracks in the keyway and bore regions. No defects were found. Although this rotor was 'sand blasted' to facilitate the ultrasonic inspection, no lubricant was subsequently applied to protect the unpassivated steel surfaces against oxidation. The licensee thus avoided the problem encountered during the startup for the second fuel cycle when the protective lubricant was washed into the hotwell and caused the conductivity of the condensate to be out of specification.

(6) Summary

Subsequent to the resin intrusion incident in January 1985, the licensee was able to prevent further contamination of the secondary coolant and exceeded the control criteria recommended by the SGOG guidelines during the remainder of the fuel cycle. The cleanliness of the secondary system was reflected (1) in the licensee's capability to maintain high quality steam generator water without reliance on the condensate polishing system; (2) in the small amount of solids that were removed from the steam generators during the last refueling outage; and (3) in the brief time required to achieve high purity secondary water during startup for the third fuel cycle.

In spite of these accomplishments, the integrity of primary coolant pressure boundary is still being effected by two

types of stress corrosion of the steam generator tubes that are attributed to the design of the steam generator rather than to chemistry control.

b. Reassessment of the Licensee's Water Chemistry Program

During the inspector's site visit in January 1985 the licensee was revising all elements of the V. C. Summer water chemistry program so as to incorporate the guidance provided by the SGOG, Consequently, an evaluation of the adequacy of the licensee's program was deferred and was designated as Inspector Followup Item 85-01-01, Revised Secondary Water Chemistry Program. At the time of the current 1986 inspection the Administrative, Chemistry, and Operations Procedures, that contain the elements of the water chemistry program, had been revised and were being implemented. The following documents were reviewed to establish if the licensee's program provided the necessary guidance to achieve the goals of the SGOG and Generic Letter 85-02.

Station Administrative procedure:

- SAP-400 Chemistry Operations Manual, Revision 4, 1/28/85
- SAP-401 Secondary Water Chemistry program, Revision 1, 4/11/85

Chemistry procedures:

- CP-602 Chemistry Reporting, Revision 8, 11/6/85
- CP-608 Chemistry Group Quality Control, Revision 9, 11/26/85
- CP-612 Out of Specification Handling and Reporting, Revision 7, 11/5/85
- CP-614 Reactor Coolant Chemistry Control, Revision 6, 11/29/85
- CP-613 Steam Generator Chemistry Control Revision 9, 4/8/85
- CP-615 Feedwater and Condensate Chemistry Control, Revision 7, 3/7/85
- CP-619 Chemistry Specifications for Makeup Water Tanks, Revision 5, 11/25/85

Through the use of upper-tier guidance documents, SAP-400 and SAP-401, the licensee had endorsed and implemented most of the administrative and technical guidelines recommended by the SGOG. Specifically, the responsibility for controlling water chemistry and for protecting the steam generators relates to all plant personnel, and a defined 'chain-of-command' is documented. The licensee's program also includes the SGOG concepts of action levels and corrective actions that apply

especially to the Chemistry Group and to the Operations Department. The procedures followed by the Control Room Operators reference the Chemistry Procedures and SAP-401 that define these concepts; however, the details are not included in the Operations Procedures.

The Chemistry Procedures provide the detailed instruction and information (such as schedules of analyses, limits for control and diagnostic chemistry parameters, and quality control practices) needed to control the primary and secondary water chemistry in all modes of plant operation and during long-term lay up.

The inspector considers that the procedures listed above provide an acceptable framework for the licensee's water chemistry program and also meets much of the intent of Generic Letter 85-02. The inspector was informed that the lowest tier of procedures and instructions relate to specific analysis and to other actions that must be taken to meet the guidance in the documents listed above. These procedures have been based, in most cases, on standard references, such as the American Society for Testing Materials.

On the basis of information obtained during this inspection Inspector Followup Item 50-395/85-01-01 is closed.

c. Implementation of the Licensee's Water Chemistry program

During this site visit the inspector assessed the actions of the Chemistry Group through (1) interviews of Chemistry Supervisors and Specialists, (2) inspection of the chemistry laboratories and sampling rooms, (3) audit of control and diagnostic data acquired during the second fuel cycle, and (4) audit of licensee's quality control results.

(1) Staffing

The Chemistry Group consists of 20 Chemistry Specialists who are assigned to four laboratories (primary, secondary, oil, and sterile). The Specialists are also divided into five shifts that rotate their duties every three months. Consequently each Specialist is being qualified to handle all responsibilities in all four laboratories (including the counting of radioactive samples and operation of the water treatment plant). The Chemistry Supervisors, Plant Chemist, and Associate Manager have recently begun working ten-hours shifts, four days per week, as have most of the remaining plant employees other than Operations personnel.

During the past year the Plant Chemist was detailed out of the Chemistry Group. The Supervisor of the Primary Chemistry Laboratory was subsequently made Acting Plant Chemist.

The inspector's audit indicated that the Chemistry Group was implementing all of the sampling program required by Procedure

CP-602 and was performing the quality control measurements that are defined in Procedure CP-608. However, because of the practices and conditions discussed below the inspector believes that the chemistry staff is strained to provide the expertise and resources required to implement the rigorous chemistry control program that has been developed while also performing its radiochemical functions, and other operational duties including trouble shooting and maintenance.

- Because of the 4 day work schedule, one or more of the supervisory personnel will have dual responsibilities each work day.

- There are no chemists or chemical engineers on the Chemistry staff or in the licensee's General Office who are available to support the chemistry program or to assist the Associate Manager/Chemistry or to replace him during his absence.

- There is little opportunity for supervisory activities or on-the-job training during either the day or night shifts because of the work load.

- The 12.5 hour shifts worked by the Chemistry Specialists are not conducive to maintaining maximum alertness of these key personnel or for providing additional resources during an abnormal condition.

- The need to monitor the secondary water for trace levels of potential corrodants, as well as to analyze radioactive samples related to the primary coolant, requires that increased attention be given to laboratory housekeeping and to the maintenance of sophisticated analytical instruments.

(2) Laboratory Facilities

As part of his review of the licensee capabilities for protecting the integrity of the steam generator through timely reaction to an abnormal situation, the inspector re-evaluated the licensee's methods for controlling the water chemistry in the steam generators. The three most important chemistry variables (sodium, pH, and cation conductivity) are continually monitored by inline instrumentation, and the results are displayed on the sampling panel in the secondary chemistry laboratory. These monitors will provide the initial indication of abnormal condition in the condensate/feedwater/steam generator train; however, these indications are normally also verified through the analyses of grab samples, especially grab samples of the steam generator blowdown.

The licensee's laboratories were designed so that grab samples of the blowdown can be obtained only in the Primary Laboratory Sample

Room - as a safeguard against contamination and exposure to personnel if the blowdown becomes radioactive as the result of a primary to secondary leak through the steam generator tubes. Consequently, control of steam generator chemistry involves both primary and secondary laboratories and personnel. This situation is further aggravated by the fact that the Primary Laboratory Sample Room is contaminated to the extent that partial protective clothing (i.e., lab coat, shoe covers, and head cover) must be put on before this room is entered. The inspector did not find this clothing readily available.

Inasmuch as the Control Room Operator will depend on the Chemistry Staff to make recommendations for corrective actions if an abnormal secondary chemistry event occurs, the licensee should review Procedure CP-612 to ensure that both the Primary and Secondary Chemistry Specialists fully understand their responsibilities.

(3) Data Management

The results of all analyses are recorded in log books in each laboratory and then transferred to a computer data base. The inspector audited both digital and graphical presentations of these data to establish the degree of control that had been achieved during 1985. The licensee plans to improve the application of the computer for both short and long term trending of key chemical parameters of both the primary and secondary coolants.

(4) Summary

The inspector concluded that considerable advances have been made in the licensee's capability to provide the desired protection to the primary coolant pressure boundary. A more comprehensive understanding of factors related to material compatibility and chemical corrosion has been gained by the chemistry staff during the implementation of the SGOG guidelines and through the attendance of the Associate Manager/Chemistry at technical meetings during 1985. The condition of the secondary water system reflects good water chemistry control. The inspector did not identify any violations or deviations and all Technical Specifications related to the primary coolant had been met.

The inspector perceived one weakness in the plant chemistry program; i.e., the chemistry staff does not appear to have the resources, expertise, manpower, or time to do much more than implement the day-to-day control that is needed when the plant is in a stable condition. As has been shown during the past decade, protection against corrosion is an open-ended endeavor so that the Chemistry Group needs to continually improve its capabilities to understand and its resources to control water chemistry.