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REGION II
101 MARIETTA ST., N.W.
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Report Nos.: 50-269/88-24, 50-270/88-24, and 50-287/88-24

Licensee: Duke Power Company
422 South Church Street
Charlotte, NC 28242

Docket Nos.: 50-269, 50-270, and 50-287

License Nos.: DPR-38, DPR-47, and DPR-55

Facility Name: Oconee 1, 2, and 3

Inspection Conducted: August 22-26, 1988

Inspector: Susan S. Adamovitz — 9/19/88
S. S. Adamovitz — Date Signed

Accompanying Personnel: W. J. Ross

Approved by: John B. Kahle — 9/19/88
J. B. Kahle, Section Chief — Date Signed
Division of Radiation Safety and Safeguards

SUMMARY

Scope: This routine, unannounced inspection was conducted in the areas of plant chemistry, corrosion, and pipe wall thinning.

Results: In the areas inspected, violations or deviations were not identified. The licensee was continuing, through the effectiveness of plant components and chemistry control, to prevent degradation of steam generator tubes. During the past year thousands of pounds of sludge (iron corrosion products) had been removed from the OTSGs of Units 1 and 2; consequently all three units can operate without power penalties caused by this sludge (tube hole blockage). The licensee had expanded surveillance programs to prevent pipe wall thinning. Implementation of chemistry control remained good, but had not yet benefited from actions designed to upgrade analytical capabilities.

REPORT DETAILS

1. Persons Contacted

Licensee Employees

J. Batton, Engineer, Support Engineer
*L. Benge, Staff Coordinator, Chemistry
J. Birins, Secondary Laboratory Supervisor, Chemistry
B. Carney, Supervisor, Support Engineering
M. Garrison, Primary Laboratory Supervisor, Chemistry
M. Hipps, Steam Generator Engineer, Maintenance Services
D. Mason, Engineer, General Office Nuclear Production Maintenance
*J. Sevic, Station Chemist
*M. Tuckman, Station Manager

Other licensee employees contacted during this inspection included chemistry technicians.

NRC Resident Inspector

*P. Skinner

*Attended exit interview

2. Plant Chemistry (79701)

This inspection was a continuation of a program designed to assess the licensee's capability to prevent degradation of the primary coolant pressure boundary, in particular, as well as other plant systems and components through corrosion/erosion mechanisms. During previous inspections at the Oconee site it was observed that protection of the primary coolant pressure boundary, including the tubes of the once-through-steam-generators (OTSGs), had been effective as the result of system designs and chemistry control. The major areas of concern were evidence of extensive general corrosion of carbon steel pipe in the secondary coolant system and subsequent transport of iron corrosion products to the OTSGs that detrimentally affected power operation. Since the last inspection in this area (Inspection Report Nos. 50-269, 270, 287/86-29 dated November 13, 1986), general corrosion has been identified throughout the industry as a principal cause of pipe wall thinning and pipe rupture (IE Notice 86-106, etc). Consequently, the scope of this inspection module has been expanded to cover corrosion throughout a nuclear power plant. Emphasis has been placed on the prevention of corrosion through proper choice of materials, effective design and operation of components, implementation of an adequate surveillance program, as well as controlling chemistry in the primary, secondary, and auxiliary water system.

a. Plant Status

Since the last inspection in this area, all three units had gone through refueling outages during which the licensee had completed the following activities: assessed the integrity of the major components of the secondary coolant system; performed preventive maintenance where needed; and had chemically cleaned the OTSGs in Units 1 and 2. As the result of these activities all power limitations caused by flow restrictions in the OTSGs, were removed. At the time of the current inspection, Unit 3 was in a refueling outage while the other units were operating.

b. Review of the Effectiveness of Components

By means of an audit of chemistry control data for Unit 1 during the last year and discussions with cognizant licensee personnel, the inspector reviewed the effectiveness of components in the balance of plant in preventing corrosion since the chemistry inspection in November 1986. This review also included activities directed towards prevention and/or correction of degradation caused by corrosion.

(1) Main Condensers

The inspector established that water from Lake Keowee used for condenser cooling and service water continued to exhibit a high level of chemical purity and to be free of micro and macro organisms that would degrade the integrity of stainless steel heat condenser or exchanger tubes. No condenser leaks had resulted from corrosion; however, mechanical damage to condenser tubes was still occurring as the result of fatigue, steam erosion, and tube-tube sheet wear. Consequently, the scope of the eddy current surveillance program had been increased during refueling outages - mostly to include more peripheral tubes where steam cutting was most prevalent. During the last eddy current testing of Unit 2 condensers in February 1988, 8157 condenser tubes (out of a total of 50,400 tubes) were inspected and 41 tubes were preventively plugged because of denting. Six additional tubes were plugged due to defects that may have been caused by steam erosion.

During the last year, because of the absence of inleakage of condenser cooling water, the quality of the water in the condenser hotwells had remained high (e.g., cation conductivity of 0.13 - 0.18 umho/cm in Unit 1). The licensee was attempting to reduce this level of contamination through increased surveillance for condenser leaks.

Air inleakage had been maintained below 10 SCFM by varying the flow of condenser cooling water as the temperature of the lake water changed; thereby, minimizing tube vibration that could cause a tube-tube support plate leak. Typically, the rate of air inleakage was highest at the beginning of a fuel cycle.

(2) Service Water System

As discussed in Section 9.2.2.1 of the Oconee FSAR, lake water is also used in the Low Pressure and High Pressure Service Water Systems. Because of the purity of the lake water the licensee had not encountered degradation of pipes (e.g., carbon steel, stainless steel) through fouling by silt or organic material or as the result of corrosion induced by micro or macro-organisms. However, the inspector was informed that there had been a build up of silt on the raw water side of service water heat exchangers. Consequently, corrosion/erosion had not affected the operation of the components included in the Service Water System.

During this part of the review, however, the inspector became aware that the Low Pressure Service Water cooled the shell side of the Decay Heat Removal Coolers (heat exchanger). Consequently the heat exchanger tubes represented the primary coolant pressure boundary. The licensee was fully knowledgeable of this design and had installed a radiation monitor and isolation valve on the service water discharge line to isolate discharge if a leak occurred in a heat exchanger tube. The inspector alerted the licensee to the various types of corrosion within service water heat exchangers, especially under stagnant conditions, that had occurred in plants within the NRC Region II. Again, the licensee was aware of these potential problems and was depending on the surveillance and maintenance programs to prevent degradation of these heat exchangers and safety related piping.

(3) Water Treatment Plant

The inspector established that highly purified water (specific conductivity of approximately 0.055 umho/cm) was still being produced at a rate of 225 gpm. Condensate makeup water was being stored under deaerated conditions in the Upper Surge Tank until needed. Consequently, makeup water was not considered to be a pathway for ingress of potentially corrosive contaminants into the secondary coolant.

(4) Condensate Cleanup System

The filter-demineralizers used to polish the condensate had been operated with minimal problems during the past year. The inspector was informed that the polisher tubes were precoated when the differential pressure exceeded 20 psid, or when the cation conductivity exceeded 0.2 umho/cm or at the end of 25 days of operation. Specified limits had been set for the purity of the polisher effluent as well as for final feedwater, downstream of the feedwater heaters. These specifications were consistent with those recommended by the Steam Generator Owners Group (SGOG) and the Electric Power Research Institute (EPRI).

(5) Feedwater Heaters

The licensee had initiated a program to replace carbon steel heater tubes with stainless steel in an effort to improve heat exchange efficiency and to enable the tubes to be eddy current tested.

(6) Steam Generators

During the last refueling outages (October 1987, February 1988, and August 1988), the integrity of the OTSG tubes was established by eddy current testing (ECT) 52% of these tubes, including 100% of the outer ten peripheral rows. These examinations were performed on Units 1 and 2 before the OTSGs were chemically cleaned; and then, to a lesser extent, after cleaning had been completed. A review of test results from Unit 1 revealed that although there had been approximately 500 indications of debris in each OTSG and a total of 2318 indications of tube damage (e.g., wear on inner and outer diameters, "dings" or distortions, and fritting) only 11 tubes needed to be plugged in OTSG "A" and 68 tubes in OTSG "B". (To date 0.7 percent of the tubes in OTSG "A" and 2.9 percent of the tubes in OTSG "B" had been plugged). Most of the indications were found in the peripheral region between the ninth and fifteenth tube support plate and in the tube lane at the fifteenth tube support plate.

Tube damage, as identified by ECT, had been attributed to mechanical (high cycle fatigue) rather than chemical mechanisms, and, since the damage appeared to be concentrated in specific regions of the OTSGs (at the end of the tube lane), the licensee was strengthening the tube in these regions through the insertion of sleeves in an effort to prevent through-wall leaks.

During the last refueling outages for Units 1 and 2, the licensee had performed chemical cleaning of the OTSGs in an effort to eliminate blockages of tube-tube support plate openings and, thereby, regain design flow rate of water through the secondary side of the OTSGs. The inspector had observed the cleaning of one OTSG in Unit 1 (see Inspection Report No. 50-269/87-40 dated October 9, 1987). In addition, sludge lancing had been performed on the four OTSGs in these two units to augment chemical cleaning. The OTSGs in Unit 1 were lanced prior to chemical cleaning while lancing was performed on the Unit 2 OTSGs post chemical cleaning.

The inspector was informed that post cleaning lancing had been more effective because the residual "mud" was more easily moved by the hydrolaser lance than was the original flake or crystalline type of magnetite sludge.

The total amounts of magnetite removed from the four OTSGs were:

1A	-	3374 lbs
1B	-	3349 lbs
2A	-	4830 lbs
2B	-	5239 lbs

These amounts were indicative that large amounts of magnetite had been removed from OTSG tubes and structural components as well as from the tube-tube support plate openings. Although only the lower region of the OTSGs (through the lower nine of fifteen tube support plates) had been subjected to the cleaning process, design flow had been restored through all four OTSGs.

(7) Conclusions

The licensee's surveillance programs had identified continuing degradation of OTSG tubes caused by fatigue in the uppermost tube lanes; however, other types of tube degradation had changed only slightly during the last fuel cycles for Units 1 and 2 (the results of the ECT performed on Unit 3 during the current outage were not available). The licensee had been strengthening the upper portions of vulnerable tubes by inserting tube sleeves and had plugged other degraded tubes. None of the tube degradations nor the previous tube leakers were attributed to chemical corrosion. This exemplary condition is attributed to the following factors: the effectiveness of the condenser and water treatment plant as barriers against ingress of potentially corrosive contaminants; the low content of corrosive ions in the condenser cooling water that minimized contamination whenever mechanical failures of the condenser tubes had occurred; and the effectiveness of the condensate polishers, not only in removing trace contaminants from the condensate but also in maintaining resin leakage to essentially undectable levels.

During this part of the inspection emphasis was placed on the integrity of the Decay Heat Removal Heat Exchangers as well as the OTSGs. The licensee had expanded both surveillance and preventative maintenance programs to identify degradation before tube failure occurred. Likewise, as will be discussed later, additional actions, including increased surveillance, had been implemented to minimize pipe thinning and transport of corrosion products (magnetite) to the OTSGs.

c. Effectiveness of the Licensee's Chemistry Program

Through discussions with members of the Chemistry staff, observation of activities in the primary, secondary and the instrument laboratories and through review of procedures the inspector evaluated selected elements of the licensee's chemistry program. In addition, the inspector monitored the analyses of non-radiological cross-check samples prepared for the NRC by Brookhaven National Laboratory. The results of this phase of the inspection are described as follows:

(1) Staffing - There were no major changes in personnel that staffed the primary and secondary chemistry laboratories since the last inspection in this area.

(2) Procedures - The basic procedures for primary laboratory sampling (Oconee Nuclear Station Chemistry Manual Chapter 3.10) and for secondary laboratory sampling (Manual Chapter 3.8) continued to endorse and reference guidelines recommended by the SGOG and EPRI. In addition to Technical Specification limitations on primary chemistry, Manual Chapter 3.10 also contained much more stringent administrative limits on potentially corrosive chemistry parameters such as chloride, fluoride, and oxygen. Also, in an effort to reduce the possibility of primary side stress-induced cracking of the OTSG tubes an administrative upper limit on hydrogen dissolved in the reactor water had been reduced from 50 cc/kg to 40 cc/kg. The chemistry staff was familiar with information published by EPRI related to possibility of reducing out-of-core radiation levels caused by activation products such as cobalt-58 and cobalt-60 by controlling the pH of the reactor coolant. Coordination of lithium hydroxide and boric acid had been modified to achieve a slightly higher pH, 7.2, in an effort to lower dose rates in the OTSGs. To achieve the same purpose procedures had been revised to inject hydrogen peroxide into the reactor coolant during shutdown for refueling outages to attain "crud bursts" that also resulted in reduced radiation levels, especially in the OTSGs. The inspector was informed that the use of hydrogen peroxide during shutdown for the Unit 1 refueling outage in October 1987, represented the first time this procedure had been used in a B&W nuclear power plant.

Chemistry of the secondary coolant system continued to be monitored principally by the use of online instrumentation (sodium, oxygen, cation conductivity, and pH) located at the hotwells, effluent of the condensate polisher, final feedwater, and moisture separator and heater drain. Chloride was being monitored only in the MSR drain where the impurities in the feedwater were concentrated through steam carry-over. The licensee had not yet installed an online ion chromatograph that had been planned for 1987.

(3) Facilities and Instrumentation

In anticipation of the installation of the proposed online ion chromatographic system the secondary chemistry laboratory had been increased in size approximately fifty percent.

The primary chemistry laboratory had not changed since the last chemistry inspection and was still considered to be satisfactory. The chemistry staff's manually operated ion chromatograph and two atomic absorption spectrophotometers were still located in the cramped space noted in the last chemistry inspection. During this inspection period the operation of these instruments, usually by two or three technicians, was further complicated by radioactive contamination of the limited floor space. The inspector was told that plans were being made to transfer some or all of these instruments to the primary laboratory when the online ion chromatograph was installed and operable.

The inspector and chemistry personnel again discussed the need to include sulfate as a diagnostic chemistry variable in such samples as polisher effluent (to monitor resin leakage), final feedwater, and MSR drains. Inasmuch as the manual ion chromatograph was typically being used only one or two days a week additional sulfate could be readily measured with this instrument. Likewise the SGOG guidelines recommend that chloride be monitored in final feedwater to prevent concentrations from exceeding 5 ppb. The manual ion chromatorgraph could be used for this measurement also.

(4) Layup Procedures

Chemistry Manual Chapter 3.8 provided specifications for laying up the OTSGs under wet (AVT Chemistry Controlled) conditions. These specifications were observed to be consistent with SGOG guidelines. The inspector discussed with chemistry supervisory personnel recent industry experience with wet and dry methods of layup during extended outages and the advantages of developing procedures for layup of the entire secondary and primary coolant systems in anticipation of such an outage.

(5) Quality Control

The inspector devoted a relatively large part of this inspection reviewing the Chemistry Quality Control Program and monitoring the analyses of NRC cross-check samples by the licensee's chemistry personnel.

The Oconee Chemistry Department participates in an interlaboratory cross check program using "round-robin" samples prepared by personnel at the licensee's Training Center. The inspector reviewed the results obtained by Oconee personnel as well as by the chemistry personnel of seven outside laboratories both in and outside of the Duke organizations. After reviewing data acquired through this 'round-robin' program the following observations were made by the inspector:

- Oconee reported triplicate results for the fluoride, chloride, boron, lithium, and iron and additional results for silica. Results for fluoride, chloride, and silicon were in parts per billion (ppb) while the other results were in parts per million. Because ion-selective electrodes were used to measure fluoride and chloride these results had been reported with a lower limit of detection of 50 ppb; however, some samples contained measurable amounts; i.e., greater than 50 ppb. Typical concentrations of these ions encountered in a PWR are less than 20 ppb and must be determined by ion chromatography.

- The Oconee results for boron were essentially identical in all cases. This level of precision is attributed to the precision of the titrimetric analysis using the Mettler Memotitrator System and a single titre for the titrant, sodium hydroxide, but does not include any human factors.

- A consensus average of all results from seven laboratories was used as the "correct" value for each chemistry variable. The use of consensus average is considered to be biased by the procedure and instrumentation used and to be inferior to an "average" obtained through replicate analyses at a laboratory whose results are traceable to the National Bureau of Standards.

The inspector requested that the cross-check samples that had been prepared by the Brookhaven National Laboratory be analyzed in triplicate by three different analysts. The purpose of this cross-check program was to evaluate the accuracy and precision of the licensee's measurements, and where appropriate, to identify causes of errors (e.g., comprehension and technique of analysts, adequacy of procedures, and calibration of reagents and instruments). These samples contained the following chemical species in ppm concentrations: fluoride, chloride, sulfate, boron, iron, sodium, lithium, ammonia, hydrazine, and silica. The licensee chose not to analyze for sodium or ammonia. Because of the chemistry technicians' normal work load all of the samples could not be completed during the inspection. The final results will be transmitted to the inspector for review and inclusion in a subsequent inspection report. This action will be tracked as Inspector Followup Item (IFI) 50-269, 270, and 287/88-24-01, Analysis of Non-Radiological Cross-Check Samples. Based on a preliminary review of partial results it appeared that, except for data obtained by ion chromatography most of the results were within five percent of the Brookhaven values, that were obtained from seven replicates. The inspector observed that difficulties were being encountered in the use of the manual ion-chromatograph for the determination of fluoride, sulfate, and chloride. Since this instrument has become indispensable for achieving the stringent chemistry control recommended by the SGOG, the inspector concluded that increased attention to, and training in, ion chromatography would make this method of analysis more useful and effective.

Also, the inspector considered the licensee's inability to determine sodium in the cross-check samples to be a deficiency. Because of the importance of sodium as a chemical indicator of condenser leaks, efficiency of condensate polishers, and potential for caustic corrosion the licensee should have a manual method for determining sodium. Such a method could be used as a backup for online sodium analyzers, for calibration of these analyzers, and for analyzing grab samples.

(6) Conclusions

During this part of the inspection no violations or deviations were identified. To the extent control data were examined it was concluded that Technical Specifications related to chemistry (specifically the reactor coolant) had been met. Also the licensee's chemistry program met the intent of NRC Generic Letter 85-02 in that it was based on the guidelines recommended by the SGOG. Likewise, the upgraded surveillance programs for the main condensers and OTSGs were also consistent with the goals of this Generic Letter.

The chemistry program was being implemented in a satisfactory manner by mature supervisors and a stable, well trained staff. However, the inspector concluded that full advantage of such state-of-the-art analytical methods as ion chromatography and atomic absorption spectrometry was not being achieved. However, improvements in this area are expected when an online ion chromatographic system has been installed. Such a system will require increased understanding of theory, operation, and calibration.

d. Prevention of Pipe Wall Thinning

The inspector reviewed actions being taken by the licensee in response to IE Notice 86-106, et al, relating to the rupture of a feedwater line at the Surry Nuclear Plant, and other NRC Notices and Bulletins concerning pipe wall thinning. The licensee was addressing these issues by implementing a new surveillance program wherein the Corporate Design Engineering Department, using parameters consistent with EPRI guidance, defines regions that may be vulnerable to erosion/corrosion and wall thinning. These regions are placed in one of three priorities for ultrasonic testing. Approximately 100-150 joints had been tested each refueling outage and five to ten joints, e.g., elbows, reducers, had been replaced.

The inspector and chemistry staff personnel discussed options available for minimizing thinning of carbon steel pipe through control of secondary coolant chemistry. The licensee was already maintaining the pH of water throughout the hotwell-condensate-feedwater-OTSG chain within a band of 9.3-9.6 in an effort to reduce general (acidic) corrosion. As additional measures, the inspector emphasized the importance of proper layup conditions during refueling outages and monitoring of corrosion product transport pathways during startup from extended outages.

3. Information Notices (92701)

a. (Closed) Information Notice 88-22, Disposal of Sludge From Onsite Treatment Facilities. The inspector reviewed documentation which showed that the Information Notice had been received and assigned for evaluation.

b. (Closed) Information Notice 88-31, Steam Generator Tube Rupture Analysis Deficiency. The inspector reviewed documentation which indicated that the notice had been received and evaluated. The problem referenced in the Information Notice was not relevant to Oconee because of its OTSG design.

4. Collocated Environmental TLDS (25022)

Temporary Instruction TI 2500/22 describes the collection of measurement results for collocated NRC/licensee environmental TLDs. The inspector discussed the data required for the program described in TI 2500/22 with licensee representatives. The required information was received and will be forwarded to Region I as required by the TI.

5. Exit Interview

The inspection scope and results were summarized on August 26, 1988, with those persons indicated in Paragraph 1. The inspector described the areas inspected and discussed the inspection results. Proprietary information is not contained in this report. Dissenting comments were not received from the licensee.