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

Report Nos.: 50-269/85-16, 50-270/85-16, and 50-287/85-16

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: June 18-23, 1985

Inspector: W J Ross 7/2/85
W. J. Ross Date Signed

Approved by: B. R. Crowley for 7/2/85
J. J. Blake, Section Chief Date Signed
Engineering Branch
Division of Reactor Safety

SUMMARY

Scope: This routine, announced inspection involved 59 inspector-hours on site in the areas of steam generator cleaning.

Results: No violations or deviations were identified.

REPORT DETAILS

1. Persons Contacted

Licensee Employees

M. S. Tuckman, Station Manager
W. A. Haller, Corporate Manager, Technical Services
*C. W. Hendrix, Project Director
B. K. Jones, Project Shift Manager
E. L. Jackson, Project Shift Manager
M. A. Hipps, Project Shift Manager
J. Robinson, Project Coordinator
C. Cloninger, Project Coordinator
R. Eaker, Corporate Nuclear Chemistry Supervisor

Other licensee employees contacted included engineers and technicians.

Other Organizations

B. Stallings, Babcock and Wilcox (B&W)
J. Snider, B&W
N. M. Cole, MPR Company
S. Weem, MPR Company
*T. Scharton, Applied Nucleonics Company (ANC)
O. G. Leonard, ANC
B. Taylor, ANC

NRC Resident Inspector

J. Bryant

*Attended exit interview

2. Exit Interview

The inspection scope and findings were summarized on June 22-23, 1985, with those persons indicated in paragraph 1 above. The inspector described the areas inspected and discussed in detail the inspection findings. No dissenting comments were received from the licensee.

The licensee identified as proprietary some of the materials provided to/and reviewed by, the inspector during this inspection; however, this information is not discussed in this report.

3. Licensee Action on Previous Enforcement Matters

This subject was not addressed in the inspection.

4. Unresolved Items

Unresolved items were not identified during the inspection.

5. Steam Generator Cleaning (92706)

During this inspection Oconee Unit 2 was in a seven day outage while efforts were underway to remove corrosion product sludge from the secondary side of the two once-through-steam-generators (OTSGs) of this unit. The inspector monitored these activities, reviewed the safety evaluations that had been developed to show that the cleaning did not involve any unreviewed safety issues, discussed the theory and results of the activities with the licensee and the licensee's contractors, and verified that none of the experimental parameters exceeded the maximum values that were allowed in the safety evaluations.

The operability of the OTSGs in Units 1 and 2 has been continuously degrading as evidenced by an increasing pressure drop through the tube bundles (see Inspection Report Nos. 50-269, 270, 287/84-25, October 22, 1984). As the result of increasing blockage of flow through the broached holes in the lower (second through ninth) tube support plates, an increasingly greater head of water had to be maintained in the downcomer region of the steam generator to achieve the desired heat transfer from the tube bundle. The height of this water column is limited by Technical Specifications to prevent backflow through the aspiration ports (between the ninth and tenth tube support plates) and/or isolation of steam flow through the aspiration ports into the downcomer. At the end of the seventh fuel cycle for Unit 2 (March 1985) the downcomer water leg was ~82% of allowable height when the plant was at 100% power. During startup for the eighth fuel cycle, the levels in steam generators 'A' and 'B' reached 86% and 65% of the allowable range by the time power had been increased only to 75%. As a result of this significant degradation from the previous fuel cycle (especially for steam generator 'A') the licensee opted for an early shutdown and planned to use a recently developed method for eliminating the cause of flow reduction and to remove all sludge and other debris that could be transferred from the tubes and tube support plates to the lower tube sheet.

To facilitate this cleaning effort and the inspection of the third through sixth tube support plates the licensee cut a new hand hold in each OTSG between the fourth and fifth support plate. These OTSGs already had a manway and seven hand holds between the lower tube sheet and the first tube support plate.

During the March 1985 refueling outage the licensee used fiber optics and television cameras to establish the magnitude and characteristics of the observable sludge deposits in the broached holes and on the ligaments of the tube support plates, as well as on the surface of the lower tube sheet of OTSG 'A'. Based on these visual inspections, the flow reduction through the tube bundles was considered to be due to blockage of the broached holes in the tube support plates, caused by precipitation of magnetite (Fe_3 OH) from the steam/water mixture, especially in the regions of the second to sixth tube support plates. Consequently, Procedure TT/2/A/425/02, was developed to remove the sludge from the tube support plates by the 'water slapping' method discussed below. Safety evaluations of the method were developed by both B&W and by the MPR Company. The effectiveness of the cleaning method was to be monitored visually by the use of television cameras and fiber optics, using the handholds as entry ports. Finally, the licensee contracted B&W to design equipment for removing solid debris from the lower tube sheet after the 'water slapping' cleaning had been concluded.

The cleaning and lancing activities are summarized below.

a. 'Water Slapping' Cleaning

(1) Description

This hydraulic method involves pressure-pulse cleaning of the surfaces and holes in the tube support plates by loosening debris and removing it through mechanical action. The magnitude of the transient pressure pulses, or water swell velocity, is established through measurement of calibrated sonic signals that are emitted by hydrophones, which are mounted near each pulse source. Pulse pressure is increased as a function of water depth between the pulsers and the surface to be cleaned.

(2) Safety Evaluation

The effect of the water swell on the following components of an OTSG was determined in mock-up OTSG test facilities:

- steam generator tubes
- orifice plate assembly
- tube support plates
- shroud
- shell
- lower tube sheet
- linkages
- tie rods

Operating parameters for a water swell of 3 ft./sec. were established for Procedure TT/2/A/425/02 so that fatigue usage (from loads, displacements, and stresses) would not exceed maximum allowable stresses as calculated through the use of accepted

methods (Appendix I to Section III of the ASME Code, 1983 Edition). These calculations indicated that the stresses on the lower tube sheet and the shell would be negligible. The magnitude of the stress on OTSG tubes and tube support plates differed between safety evaluations; however, the licensee considered that the tubes would be the most highly stressed and limits were set for both tubes and tube support plates which were conservative to both safety analyses. The length of the cleaning procedure (i.e., actual water slapping) was restricted to a maximum of 30 hours per OTSG.

The B&W safety analysis showed that the shell, shroud, and tubes would see stresses which would be below the endurance limits of the appropriate ASME design factor curves. Both safety analyses showed that no physical damage to the OTSG components would occur except that any existing cracks in the inconel tubes might be opened, but not grow in size. These conclusions were based partially on experience obtained at two other nuclear plants where slightly different 'water slapping' procedures had been used. At these plants, additional methods for determining loads, displacement and stress had been used; i.e., accelerometers on OTSG tubes and strain gages on orifice plate clamps.

(3) Procedure

The 'water slapping' methodology was used on the second through ninth tube support plates. While maintaining an atmosphere of nitrogen above water level in the OTSGs during the cleaning, to minimize contact of the tubes and structural components with air, pressure buildup from the 'water slapping' procedure was controlled by venting the upper internal volume of the OTSG to air.

The 'water slapping' pulsers were adjusted and tested at the fourth tube support plate using optical (television cameras and fiber optics) and audio (hydrophone) equipment. While the tube support plates were being cleaned, the inspector verified that all hydrophone readings were being reviewed to insure that all boundary conditions, as specified in the safety evaluations, were being met.

A visual inspection of tube support plates 4, 5, and 6 was made at an early stage of the cleaning and the results were compared with the pre-cleaning inspection. Likewise, at the conclusion of the cleaning, the lower tube sheet was visually inspected to establish the efficiency of the cleaning procedure.

The inspector verified that a written procedure (MP/0/A/1800/1) was being followed to examine the internals of the OTSG for loose parts before the hand holds and manway were reclosed. The

licensee also informed the inspector that written procedures had been followed to prepare the steam generators for the cleaning (e.g., reset the orifice plates); however, these procedures were not reviewed.

(4) Results

Through the use of television cameras and fiber optics the licensee established that the 'water slapping' procedure had removed most of the sludge from the broached holes of the fourth through sixth tube support plates. Initial analyses of the fiber optics pictures indicated that most of the crystalline debris had also been removed from the surface areas of the tube support plates and tubes. The licensee proposes to review video tapes of these examinations to reach more quantitative conclusions. Sludge was also cleaned from those portions of the lower tube sheet which had been in contact with the water swell. The remainder of the visible portions of the lower tube sheet appeared to be covered with magnetite crystals. By means of specially designed fiber optics equipment the licensee was also able to estimate that the depth of sludge on the lower tube sheet and within the tube bundle varied up to several inches in depth.

The inspector established that the licensee followed a written procedure for the cleaning. Each step was performed under the control of a Shift Coordinator (who initialed each step as it was completed) and under the direction of a Shift Manager. All actions were controlled through an elaborate communications system and were followed through the use of television monitors and continuous telephone communication between the control trailer and the personnel inside the Containment Building. All activities were also monitored by the licensee's Health Physics personnel.

b. Sludge Lancing

The OTSGs at Oconee were fabricated by B&W and have tube bundles of a closely-packed, triangular configuration. Because of the limited width of the tube lanes, the OTSGs have not been amendable to lancing by techniques developed for recirculating steam generators. The inspector was informed that the equipment and procedure used on the Oconee Unit 2 OTSGs had been developed only very recently. Tests had been performed on mockups and test stands to ensure that the high-pressure jets of water (up to 3100 psi pump pressure) would not overly stress the OTSG tubes and to demonstrate that solids could be transferred by hydraulic action from the interior of the tube bundle to the annulus region. The same equipment, with jets designed for a recirculating steam generator, had recently been used successfully to clean the steam generators at the licensee's McGuire Nuclear Plant.

A written procedure was followed; however, a number of field modifications were made in an effort to improve the effectiveness of the lancing technique. Two television cameras were placed 180° apart in the annulus region to monitor the action of the water jets. The results were only partially successful, because the crystalline magnetite sludge tended to build up into increasingly deeper piles in front of the jet streams. Eventually the sludge pile became immovable. The licensee terminated the lancing on June 23, 1985 and, after removing all solids that had been transferred to the annulus region of the OTSG, began preparing for startup of Unit 2 the next day.

The inspector was informed that the licensee would consider the cleaning procedure to be successful if Unit 2 can again operate at full power. Blockage of the broached holes, in the future, through transport of the crystalline debris known to remain on the lower tube sheet is not considered to be as probable as blockage through further precipitation of iron oxide from the feedwater when nucleate boiling occurs in the broached holes.

During this inspection no violations or deviations were identified.