UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
SAM NUNN ATLANTA FEDERAL CENTER
61 FORSYTH STREET SW SUITE 23T85
ATLANTA, GEORGIA 30303-8931
June 12, 2002

Duke Energy Corporation
ATTN: Mr. W. R. McCollum
Vice President
Oconee Site
7800 Rochester Highway
Seneca, SC 29672

SUBJECT: OCONEE NUCLEAR STATION - NRC SPECIAL INSPECTION REPORT 50-269/02-10, 50-270/02-10, AND 50-287/02-10

Dear Mr. McCollum:

This refers to the special inspection conducted from April 15 to May 16, 2002, at your Oconee 1, 2, and 3 reactor facilities and at the eddy current test facilities located at the McGuire station. The enclosed report documents the inspection findings which were discussed on May 16, 2002, with members of your staff.

The inspection focused upon your staff's activities related to the discovery of a previously plugged once-through steam generator tube that was found to be circumferentially severed during steam generator examinations conducted during the Unit 1 twentieth refueling outage. The inspector reviewed selected procedures and records, observed activities, and interviewed personnel.

Based on the results of this inspection, no findings of significance were identified. The inspector concluded there was reasonable assurance that the Oconee Unit 1 steam generators would perform their design basis functions for the remainder of the current operating cycle.

In accordance with 10 CFR 2.790 of the NRC's "Rules of Practice," a copy of this letter and its enclosure will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Document system (ADAMS). ADAMS is accessible from the NRC web site at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

Sincerely,

\RA

Harold O. Christensen, Acting Director
Division of Reactor Safety

Docket Nos.: 50-269, 50-270, 50-287
License Nos.: DPR-38, DPR-47, DPR-55

Enclosure: (See page 2)

Enclosure: NRC Inspection Report 50-269/02-10,
50-270/02-10, 50-287/02-10 w/Attachments

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U.S. NUCLEAR REGULATORY COMMISSION
REGION II

Docket Nos:	50-269, 50-270, 50-287
License Nos:	DPR-38, DPR-47, DPR-55
Report Nos:	50-269/02-10, 50-270/02-10, 50-287/02-10
Licensee:	Duke Energy Corporation
Facility:	Oconee Nuclear Station, Units 1, 2, and 3
Location:	7800 Rochester Highway Seneca, SC 29672
Dates:	April 15 - May 16, 2002
Inspector:	J. Blake, Senior Project Manager
Approved by:	M. Lesser, Chief, Engineering Branch 2 Division of Reactor Safety

Enclosure

SUMMARY OF FINDINGS

IR 05000269-02-10, IR 05000270-02-10, IR 05000287-02-10, on 4/15 -5/10/2002, Duke Energy Corporation, Oconee Nuclear Station, Units 1, 2, & 3, Steam Generator severed tube special inspection.

On April 12, 2002, the licensee determined that there was a severed, previously plugged, tube in the 1B Once-Through (OTSG) Steam Generator at the secondary side of the lower tubesheet, which had resulted in wear indications on three adjacent tubes. This was suspected of being a new failure mechanism for OTSG tubes with the potential for generic implications. This report documents the five-day special inspection (as prescribed in the attached Special Inspection Charter) to determine if any generic implications existed, and whether the licensee was conducting an adequate root cause and extent of condition investigation in order to consider the OTSGs in all three Oconee to be operable for the remainder of their current operating cycles.

Inspection Results

Cornerstone: Barrier Systems

The inspector did not identify any performance issues associated with the severed plugged tube that had caused wear degradation to adjacent inservice and plugged tubes in the "B" steam generator. An NRC review of past eddy current inspection results of affected tubes indicated that the wear that was found on adjacent tube R77-T123 in 1999 (the reason that it was plugged) could have been considered to be a precursor to the condition discovered during the recent outage, but that wear indication had been relatively slow to develop and would not have been considered to be a significant threat at the time.

The inspector concluded that the licensee's extent-of-condition and root cause investigation conclusions that the severed tube was most likely an isolated case, caused by the introduction of a unknown contaminant during startup of the unit, were appropriate. The licensee did not identify any other plugged tubes that exhibited the characteristics that were indicative of the severed tube in the Oconee "B" steam generator or in the Three Mile Island (TMI) Unit 1 "B" steam generator, as described in NRC Information Notice 2002-02: Recent Experience With Plugged Steam Generator Tubes. For tubes that were plugged with explosive or welded plugs which would have been extremely difficult to remove, the licensee ensured that adjacent tubes were stabilized, or there was a two-plugged-tube boundary adjacent to the uninspected tube.

- No findings of significance were identified.

- The inspector concluded there was reasonable assurance the Oconee OTSGs would perform their design basis functions for the remainder of the current operating cycles.

Report Details

Event Summary

On April 12, 2002, during performance of steam generator eddy current inspections for the twentieth refueling outage (1R20) of Oconee Unit 1, the licensee identified signs of outside diameter wear, about six-inches in length, at the lower tubesheet (LTS) secondary face on a tube (R77-T123), which had been previously removed from service in 1991 with no signs of wear. The tube was one of the sample of previously plugged tubes selected for plug removal and full-length eddy current inspection in response to industry and NRC concerns regarding the discovery of wear indications and a severed tube at the upper tubesheet (UTS) secondary face of a Three Mile Island (TMI) Unit 1 steam generator during the Fall 2001 refueling outage.

The licensee also removed the plug from an adjacent tube (R78-T123) for eddy current testing and also found outside diameter wear near the LTS secondary face of this tube. A review of historical inspection and plugging data showed that this tube (R78-T123) had been removed from service in 1999 due to wear indications at the LTS secondary face. Re-examination of the historical eddy current data showed that the indications on R78-T123 could be traced back to the 1995 refueling outage.

The location of the affected tubes, (near the periphery of the tube bundle) and the pattern and location of the wear indications, led the licensee to suspect a loose part or a severed tube adjacent to the two damaged tubes. The licensee entered the corrective action program by initiating PIP O-02-02096, describing the suspected condition of a severed tube, R78-T124, which had been plugged with an explosive plug in the LTS prior to Unit 1 hot functional testing in 1971. Because explosive plugs are extremely difficult to remove, and the location of the affected tubes was adjacent to a manway on the secondary side of the steam generator, the licensee expanded the scope of the inspection to include a secondary side visual inspection to determine if the wear was caused by a loose part or a severed tube.

Visual inspection confirmed that tube R78-T124 was severed at the LTS secondary face, and that the tube could be displaced radially using the visual inspection equipment. Based on the direction and velocity of the feedwater flow at this location, it would be expected that the severed tube would be displaced toward tubes R77-T123 and R78-T123 during operation. The visual inspection also showed a small wear mark on adjacent tube R79-T127. This indication was also confirmed by rotating coil eddy current inspection.

When the severed tube was confirmed, the licensee assigned a chief investigator and teams to investigate and resolve the issue. The licensee performed in situ pressure testing of the tubes R77-T123 and R78-T123, and removed a section of the severed tube for metallurgical examination. As a result of the pressure testing, the licensee determined that tubes R77-T123 and R78-T123 met the structural performance criterion of three times normal operating differential pressure (3ΔP). 3ΔP is a steam generator tube integrity limit discussed in the Nuclear Energy Institute's (NEI's) guidelines, NEI 97-06, "Steam Generator Program Guidelines." 3ΔP is a limit acceptable to the NRC and allows a licensee to conclude that a steam generator tube has adequate structural integrity with sufficient safety margin.

Again, due to the difficulty in removal of exploded plugs, and the location of the severed tube adjacent to a secondary side manway, the licensee elected to remove the portion of tube between the LTS and the first support plate, through the secondary side manway. Removal in this manner also involved the harvest of similar segments of seven other tubes including tubes R77-T123 and R78-T123 which had the wear indications, and five tubes located between the severed tube and the manway, tubes R78-T126, R78-T125, R77-T126, R77-T125, and R77-T124.

Historical records showed that the lower end of tube R78-T124 was plugged in 1971 prior to service and hot functional testing. This tube was one of twelve tubes in Row 78 which were plugged at the lower end so that First of a Kind (FOAK) thermocouple instrumentation could be installed in order to determine temperature distributions in the OTSG design during operation. The instrumented tubes included tubes in columns 3, 9, 16, 24, 33, 48, 79, 94, 103, 111, 118, and 124. At the end of the first operating cycle in 1974, the FOAK instrumentation was removed and the upper end of the twelve tubes were sealed with explosive plugs. The UTS explosive plugs were backed up with welded plugs in 1993 because of concerns about potential degradation of the UTS explosive plugs.

During the review of the history of this OTSG the licensee also learned that there had been problems during hot functional testing. Loose parts from the Reactor Vessel were transported to the primary face of the UTS of both steam generators and did extensive damage to the tube ends of the tubes in OTSG A. The FOAK instrumentation in OTSG B was also damaged and had to be reinstalled. After repairs were complete in OTSG A, as well as the reinstallation of the FOAK instrumentation in OTSG B, felt plugs were apparently shot through the tubes with compressed air to remove any loose parts and machining particles inside the tubes. The plugs were shot from the primary side of the LTS and collected on the primary side of the UTS.

There was no eddy current history available for tube R78-T124 since it was removed from active service prior to hot functional testing for the FOAK thermocouple testing, and completely removed from service after the first fuel cycle. The inspection histories for the two adjacent damaged tubes indicate that R78-T124 probably severed between 1991 and 1995. This was based on the fact that tube R77-T123 had no detectable wear in the LTS area when it was plugged in 1991 and tube R78-T123 showed the possible initiation of LTS indications in 1995, prior to being plugged in 1999 due to growth of these indications.

On April 19, 2002, the NRC initiated a special inspection in response to this event. The special inspection independently reviewed the licensee's investigation, root cause evaluation, and extent of condition analysis.

4. OTHER ACTIVITIES

OA3 Event Follow-up

.1 Once-Through Steam Generator Tube Failure Investigation

a. Inspection Scope

The inspector interviewed licensee personnel including the Eddy Current Level III, site and corporate Steam Generator Engineers, the Steam Generator Engineering Consultant, and the Manager of Steam Generator Maintenance and Engineering. The inspector reviewed the results of the current and historical eddy current examinations of tube R77-T123 and R78-T123, and the remote video tapes and live camera shots of the examination of the secondary side of tube R78-T124. The inspector reviewed the metallurgical examination data and metallographic photographs for the harvested tube sections and the fracture face of tube R78-T124. The inspector also reviewed historical and anecdotal records for installation of the FOAK instrumentation in OTSG B prior to hot functional testing and the reinstallation of the instrumentation after it was damaged during the hot functional tests.

b. Observations and Findings

The licensee noted that the failed tube was found as a result of augmented inspections, scheduled as a result of the severed tube found in the TMI OTSG, as described in Information Notice 2002-02, “Recent Experience with Plugged Steam Generator Tubes.” The licensee also noted that the location of the tube sever in the Oconee OTSG was unexpected, because the focus of the inspection was in the upper regions of the tube bundle, in the area of high flow velocities with higher potential for fatigue failures. The lower regions of the OTSG in the area of feedwater inlet, and comparatively lower flow rates were not considered to be at risk for fatigue type failures.

After the discovery of the severed tube in the Oconee OTSG, the licensee reconsidered the action of the fluid surrounding the tubes and determined that the cross-flow forces, (proportional to the product of the fluid density and the velocity) on the tubes by the feedwater sweeping across the lower tubesheet were higher than the cross-flow forces exerted by the higher velocity steam at the upper tubesheet.

The review provided the inspector with an understanding of probable causes and conditions involved with the separation of tube R78-T124 and the affects it had or could have had on the surrounding tubes. The reconsideration of the cross-flow forces at the lower tubesheet were communicated to the Office of Nuclear Reactor Regulation (NRR) for review of generic implications applicable to other OTSGs and to recirculating SGs.

.2 Steam Generator Management Program

a. Inspection Scope

The inspector assessed the licensee's steam generator management program through a review of SGMEP 105, "OTSG Specific Assessment of Potential Degradation Mechanisms" Revision 3, applicable to Oconee Unit 1 End Of Cycle (EOC) 20, and "Duke Power Eddy Current Analysis Guidelines for Duke Power Company's Once-Through Steam Generators (OTSG)" Revision 4, dated March 21, 2002.

SGMEP 105 was reviewed to assess the significance that the licensee had assigned to the potential for a severed tube in the Oconee OTSGs, and what type of sampling plan was assigned to inspection for evidence of a possible failure of a previously plugged tube.

The analysis guidelines were reviewed to assess the guidance given to the bobbin coil data analysts to focus their attention in areas where indications of wear might indicate a potential severed tube.

b. Observations and Findings

The licensee's inspection plan and guidance for the 1R20 outage included sufficient detail for the inspector to conclude that it was extremely unlikely that indications of tube swelling and associated tube degradations would be missed. The inspector noted that the licensee's decision to inspect the entire length of tubes unplugged as a result of augmented inspections due to the TMI tube failure led to the unexpected discovery of the severed tube at the Oconee lower tubesheet.

.3 Root Cause Analysis

a. Inspection Scope

The inspector met with licensee personnel assigned to the recovery team, the root cause team, and the independent review team for discussions involving activities associated with the discovery and investigation of the severed tube. Activities reviewed included the decisions and review process for the identification and capture of tubes with similar plugging histories; removal and analysis of sample tube segments removed from the 1B OTSG; eddy current analysis of tube segments left in the OTSG after sample removal; and reviews of current and historical eddy current and plugging data.

b. Observations and Findings

Based on the laboratory analysis of the harvested segment of the severed tube, the licensee concluded that the failure of tube R78-T124 was caused by intergranular attack (IGA) from the inside (ID) of the tube. The majority of the fracture surface of the tube was granular in appearance, with a very thin shear lip at the outside (OD) surface for a portion of the circumference. In addition to the circumferential failure, the licensee noted a discolored circular area on the inside surface of the tube near the fractured end, which was determined to be a patch of intergranularly-attacked material, several mils in depth.

The laboratory was unable to find any traces of corrosive elements on the inside surfaces or in the crevices of the failed tube, noting that the tube had probably severed before 1995, and the inside of the tube had been exposed to repeated flushing of secondary water since that time.

Based on the analysis of the pulled tube and the inspection results from other tubes in the OTSG, the licensee concluded that the failure of this tube from ID-initiated IGA was an isolated case caused by the introduction of an unknown corrosive material into tube during the time between plugging the bottom of the tube prior to hot functional testing of the unit and the plugging of the top of the tube during the first refueling outage.

At the time of the inspection, the licensee was still in the process of completing the root cause analysis, although the majority of the investigation had been conducted. The inspector independent review of the results of the laboratory investigations and the completed inspection of the steam generators did not raise any issues concerning the licensee's preliminary conclusion that this was likely an isolated case brought on by unusual circumstances in the history of the tube.

.4 Prior Opportunities for Identification

a. Inspection Scope

The inspector reviewed the inspection history for the OTSG tubes surrounding the severed tube, to determine if there had been prior opportunities to identify the severed tube. The plugging of tube R78-T123 in 1999, due to wear indications at the lower tubesheet secondary face, could be considered as a missed opportunity to discover the severed tube.

b. Observations and Findings

At the time that tube R78-T123 was plugged, the licensee noted that the location of tube R78-T123 near the perimeter of the tube bundle supported a conclusion that the wear had been caused by a loose part. A review of eddy current data also showed that the R78-T123 wear was first noticeable in 1995; which indicated that the rate of the wear was fairly slow. The tube was also noted to be one of three in-service tubes located in the midst of a group of previously plugged tubes, and as the other unplugged tubes did not show any wear, the licensee was able to conclude at that time that the cause of the wear was not mobile and that there was no immediate threat to other in-service tubes.

The inspector agreed that the plugging of tube R78-T123 in 1999, due to wear indications at the lower tubesheet secondary face, could be considered as a missed opportunity to discover the severed tube. The inspector also considered the fact that the industry's and the licensee's major inspection focus in the recent past has been on the more aggressive environment in the upper regions of the OTSGs, and concluded that licensee's decision not to aggressively pursue the cause of the wear on the tube was justified at the time.

4OA6 Management Meetings

Exit Meeting Summary

The inspector presented the inspection results to Mr. W. Foster and other members of licensee management via Tele-conference on May 16, 2002. The licensee's management acknowledged the findings presented.

The licensee's representatives were aware that some proprietary information had been reviewed by the inspector, however, no proprietary information is contained in this report.

PARTIAL LIST OF PERSONS CONTACTED

Licensee
J. Batton, Steam Generator Engineer, Recovery Team Leader
K. Davis, Corporate Eddy Current Level III
W. Foster, Safety Assurance Manager
R. Jones, Station Manager
B. Lowery, Steam Generator Engineer, Root Cause Team Leader
D. Mayes, Engineering Consultant, Independent Review Team Leader
W. McCollum, Site Vice President, Oconee Nuclear Station
L. Nicholson, Regulatory Compliance Manager
M. Sample, Manager of Steam Generator Maintenance and Engineering

NRC
S. Freeman, Acting Senior Resident Inspector
M. Lesser, Branch Chief, Division of Reactor Safety, Engineering Branch 2

ITEMS OPENED, CLOSED, AND DISCUSSED

None

LIST OF ACRONYMS

B&W	Babcock and Wilcox
EOC	End of Cycle
FOAK	First of a Kind Engineering
ID	Inside Diameter
LTS	Lower Tubesheet
NEI	Nuclear Energy Institute
NRC	Nuclear Regulatory Commission
NRR	Office of Nuclear Reactor Regulation
OD	Outside Diameter
OTSG	Once Through Steam Generator
PIP	Problem Investigation Process
Rxx-Txxx	Row No. and Tube No. used for location and identification
RFO	Refueling Outage
TMI	Three Mile Island
UTS	Upper Tubesheet

LIST OF DOCUMENTS REVIEWED

Procedures

SGMEP 105, "OTSG Specific Assessment of Potential Degradation Mechanisms" Revision 3, applicable to Oconee Unit 1 EOC 20,
Duke Power Eddy Current Analysis Guidelines for Duke Power Company's Once-Through Steam Generators (OTSG)" Revision 4, dated March 21, 2002.
NDE-701, "Multifrequency Eddy Current Examination of Steam Generator Tubing At McGuire, Catawba and Oconee Nuclear Stations" Revision 3, dated August 31, 2001.
NDE-703, "Evaluation of Eddy Current Data for Steam Generator Tubing," Revision 1, dated August 31, 2001

Drawings

Drawing #: 1209407 rev 12 DCN 6007584, "Oconee Unit 1 Hardware Repair Status Post EOC19, SG B Primary Face Outlet.
Drawing #: 1209406 rev 11 DCN 6007584, "Oconee Unit 1 Hardware Repair Status Post EOC19, SG B Primary Face Inlet.
Drawing #: 1209404 rev 12 DCN 6007584, "Oconee Unit 1 Hardware Repaire Status Post EOC19, SG A Primary Face Inlet.
Drawing #: 1209405 rev 13 DCN 6007584, "Oconee Unit 1 Hardware Repaire Status Post EOC19, SG A Primary Face Outlet.

Problem Investigation Process Reports (PIPs)

PIP O-02-02096, describing the suspected condition of a severed tube, R78-T124,

Other Documents Reviewed

Preliminary Condition Monitoring Operational Assessment for ONS-1 EOC-20, April 23, 2002
Initial Observations of Oconee 1 Pulled Tubes

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
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April 19, 2002

MEMORANDUM TO: Jerome J. Blake, Lead Inspector
Special Inspection Team
Engineering Branch 2
Division of Reactor Safety

FROM: Luis A. Reyes, Regional Administrator **/RA/**

SUBJECT: SPECIAL INSPECTION CHARTER

A Special Inspection (SI) has been established to inspect and assess the degraded condition of the Oconee Unit 1 Once Through Steam Generators (OTSG) as reported by the licensee on April 15, 2002. The specific issue of concern is: Is the severed tube found in the "B" OTSG for Oconee Unit 1 an isolated case or an indication of a new generic concern for steam generators?

The inspection will be conducted by: Jerome J. Blake, Sr. Project Manager, Engineering Branch 2. The objectives of the inspection are to: (1) determine the facts surrounding the degraded condition of the Oconee "B" OTSG; (2) evaluate the licensee's response to this condition; and (3) obtain information to assess the generic aspects of the degraded condition.

For the period during which you are conducting this inspection and documenting the results, you will report directly to me. The guidance of NRC Inspection Procedure 93812, "Special Inspection," and Management Directive 8.3, "NRC Incident Investigation Procedures," apply to your inspection. If you have any questions regarding the objectives of the attached charter, contact me.

Attachment: Special Inspection Charter

cc w/attachment:
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H. Berkow, NRR
R. Correia, NRR
L. Lund, NRR
K. Karwoski, NRR
M. Shannon, RII
C. Casto, RII
M. Lesser, RII

Attachment 2