



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

Report Nos.: 50-369/92-05 and 50-370/92-05

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

Docket Nos.: 50-369 and 50-370

License Nos.: NPF-9 and NPF-17

Facility Name: McGuire 1 and 2

Inspection Conducted: January 27-31, February 4-6, 1992

Inspector:

N. Economos
N. Economos

3/6/92
Date Signed

Accompanying Personnel: K. Karwoski, NRR
C. V. Dodd, Oakridge National Laboratory

Approved by:

J. J. Blake
for J. J. Blake, Chief
Materials and Processes Section
Engineering Branch
Division of Reactor Safety

3/9/92
Date Signed

SUMMARY

Scope:

To follow steam generator (S/G), recovery from a tube leak forced plant outage by observing eddy current (EC), inspection activities and steam generator tube analysis. Also to assess the licensee's EC program and related corrective measures taken to assure S/G tube integrity before returning to power.

Results:

The inspectors identified programmatic weaknesses which included (a) lack of conservatism in the EC analysis guidelines (b) no administrative control to address the manner in which information on pluggable tubes is conveyed from the ISI group to the Maintenance Engineering group responsible for tube disposition, (c) no administration controls to address the Maintenance Engineering group's role and authority in determining which tubes get plugged. A notice of violation (NOV), was issued for violating Technical Specification (TS) requirements 4.4.5.3 and 4.4.5.4 in that tube R47-C46 was returned to service with a defect that exceeded T.S. limits, 50-369/92-05-01 "S/G tube R47-C46 Returned to Service with Defect that Exceeded TS Limits, (paragraph 2).

The licensee showed considerable engineering strength as evidence by the concerted effort to initiate and conduct a very comprehensive inspection and analysis of S/G tubes in order to assure tube integrity and plant safety.

REPORT DETAILS

1. Persons Contacted

Licensee Employees

J. Baumann, Supervisor Level III Eddy Current Examiner
F. Bulgin, Technical Services, NDE Supervisor
C. B. Cheezem, Manager Inservice Inspection, QA
G. Gilbert, Safety Assurance Manager
*S. Hendrix, Engineering Supervisor
*P. Herran, Manager Engineering
*T. McConnell, Station Manager
*T. McMeekin, Vice President, McGuire Nuclear Station
*B. Lowery, Maintenance Engineer, Steam Generators General Offices
*D. Mayers, Maintenance Engineer, Steam Generators General Offices
*K. Mullen, Compliance Associate Engineer
R. Sheffield, Level II Examiner NDE
B. Travis, Manager, Components

Other licensee employees contacted during this inspection included technical support, QA, and administrative personnel.

Other Organizations

Westinghouse Electric Corporation (W)
Dr. W. R. Junker, Fellow Scientist, Material Reliability

Electric Power Research Institute (EPRI)
S. Brown, Eddy Current Testing Consultant

NRC Resident Inspectors

*K. VanDoorn, Senior Resident Inspector
*T. Cooper, Resident Inspector

*Attended exit interview

2. Recovery from S/G "D" tube leak, (Unit - 1) (73753)

By review of licensee reports and through discussions with site management the inspector ascertained that Unit-1 restarted operations, following the seventh refueling outage, on December 12, 1991. On January 6, 1992 plant monitors/chemistry determined a two gallon per day (gpd), leak in S/G "D". The leak rate increased to 8 gpd on January 13 and remained constant until January 16, when it increased to about 235 gpd. At that time the licensee shut down the plant to investigate the problem.

The licensee's investigation of S/G "D", disclosed that two tubes were leaking. The major source of the leak, was found on the cold leg side of this S/G in tube R47-C46 about five inches above the 20th tube support plate (TSP). The other leaking tube (R36-C30), was found on the hot leg side of this S/G. The leak in this tube emanated from one of the two welds (top), used to bond a previously installed sleeve to the tube, and was measured at about two drops/minute; this rate remained constant when pressure was increased to 575 psi. This tube was investigated/evaluated and subsequently removed from service.

a. Historical Background on R47-C46 Tube

By review of previous eddy current data and through discussions with cognizant licensee personnel, the inspectors ascertained the following:

- ° The March 1989 EC examination with bobbin probe showed no evidence of an indication in the area of interest - freespan region between TSP(s) 20 and 19.
- ° During the 1990 refueling outage a similar examination showed no evidence of a defect in this area. It should be noted that a closer review of the bobbin data by the W consultant disclosed the presence of a possible indication seen on the 35 KHz absolute channel. The consultant suggested that this could have been a "precursor" that may have been caused by a ferromagnetic deposit on the tube surface or a ferromagnetic region in the tube. In addition, the consultant noted that the above mentioned signal could be due to random noise.
- ° During the last refueling outage in September of 1991, the subject tube was again examined by bobbin coil and the results analyzed under site approved EC and Analysis Guidelines, Revision 1, July 10, 1991, "Main Guidelines". A review of the analysis records dated October 1, 1991 showed that, an indication was identified in the area of interest, that it was analyzed by a primary and a secondary analyst with differing interpretations. The primary analyst interpreted the EC signal as a manufacturer's burnish mark (MBM) with high signal-to-noise ratio and a voltage amplitude of 1.7 volts. The secondary analyst interpreted the same signal as an 85% through wall indication (crack), with a voltage amplitude of 1.7 volts. It is the inspector's understanding that the lead analyst reviewed the data and characterized the indication as an MBM with a high signal-to-noise ratio. The plant returned to power on or about December 12, 1991 and continued to operate for approximately three weeks when the initial evidence of a possible tube leak in S/G "D" was detected.

b. Corrective Action

On January 27, 1992, at the McGuire site the inspector met with technical personnel to discuss plant status, plans for corrective action and observe related activities. Some of the major elements relative to these activities were as follows:

- ° The licensee had identified, by data review, approximately seventy seven (77), tubes with bobbin indications, (MBM/signal-to-noise) similar to tube R47-C46, and was taking the conservative approach to remove them from service. These tubes were located in all four steam generators.
- ° Perform a video scan inside the subject tube to observe crack morphology.
- ° Inspect approximately 60 tubes around the vicinity of the subject tube for information purposes.
- ° Examine with RPC, all bobbin coil indications, in S/G "D", identified as MBM(s) and freespan degradation.
- ° Tubes that were not earmarked for plugging, including those exhibiting anti-vibration wear, preheater wear, tube-sheet below F* and freespan indications confirmed with RPC to be within acceptable limits.
- ° Re-examine with RPC the entire length on the cold leg side of R47-C46 to look for other crack like indications.
- ° Conduct ultrasonic examination to determine size and crack length in R47-C46.

Following the aforementioned RPC examination on tube R47-C46, the licensee informed the inspector that three additional axial cracks were found in the freespan region between the 14th and 15th TSP(s) of this tube. The more pronounced of the three cracks was about 1 to 1.5 inches long and was analyzed as being 60% through wall with a voltage amplitude of approximately 0.46 volts. The other two cracks were analyzed as being about 20 to 30% through wall. A review of historical data, disclosed no evidence of indication during the 1990 cutage EC examination. A breakdown of the historical data is as follows:

	<u>1990</u>	<u>1991</u>	<u>1992</u>
No. 1			
At 14th TSP, -5.20"	Nothing observed by bobbin probe in this area	Small signal observed, analyzed as an MBM and dispositioned as a no detectable defect (NDD)	Analysis of RPC data acquired following shut-down shows a 60% through wall crack with 0.46 volts.

	<u>1990</u>	<u>1991</u>	<u>1992</u>
No. 2 At 14th TSP, -4.7F"	Nothing observed by bobbin probe in this area	Small signal observed, dispositioned as NDD	Analysis of RPC data acquired following shut- down shows crack 40% through wall
No. 3 At 14th TSP Near #2 crack	Nothing observed by bobbin probe	Nothing observed by bobbin probe	Weak crack like signal 40% through wall

As a result of these findings licensee management and technical staff met and decided on a significant revision to the initial inspection plan discussed earlier in this report. The revised inspection plan was as follows:

- ° Develop revised, conservative criteria for analyzing bobbin coil data including; (a) report all indications of degradation regardless of depth and with no minimum voltage threshold, (b) research and report any positive crack-like responses displayed on the 100 Mhz absolute vertical strip chart, (c) report any indication on the differential channel shown and confirmed in the defect plane, (d) delete characterization code "MBM" and the 5 to 1 signal to noise criterion.
- ° Train and qualify by test all analysts on the new criteria.
- ° Review all 1991 refueling outage bobbin coil probe data using the new criteria.

Also in order to prevent overplugging, the licensee established the following methodology to further screen indications identified in the above process:

- ° Reanalyze all S/G "D" 1991 bobbin coil probe data.
- ° All indications, identified from the bobbin coil probe data in S/G "D" to be 100 percent EC tested with the MRPC. Analysis of this data and existing bobbin coil data to be done by recognized inhouse and/or industry technical experts. Use this detail analysis to validate one of the following processes to determine the tubes to be removed from service.
 - (1) MRPC test all indications called from the bobbin coil reanalysis that can not be resolved by detailed expert review.
 - (2) Perform a historical review of past bobbin coil data to identify any indications that have changed over time.

- ° Tubes with suspect indications from this process are to be plugged or MRPC tested to determine if the tube can remain in service.
- ° Use process 1 or 2, above or a combination of the two, to analyze the tubes in the remaining three S/G(s) in Unit 1, to effectively remove all suspect tubes from service.

In addition to the above, the licensee selected, at random, 13 tubes made from the heat of material (#3838), used to produce tube 47-46 and 12 tubes from the same heat of material (#3835) used to produce tube 18-25 in S/G "B", which leaked in 1989.

These 25 tubes were examined extensively with bobbin coil over their full length and with MRPC over the entire length of the cold leg. This examination was performed to determine whether a correlation could be established between heat of material and the subject failures. Following a thorough and complete analysis of historical and current data by technical experts, it was determined that no correlation could be established on the basis of heat of material.

At this point, it should be noted that a reanalysis under the revised guidelines showed that the depth of the major indication between the 14th and 15th TSP(s) was 85 percent through wall rather than the 60 percent through wall depth reported earlier. Results of an ultrasonic examination of the crack at the 20th TSP showed the axial crack extended over a length of about 3.5 inches, while the actual through wall length was about .25 inches. A better assessment of this failure will be made when the tube is pulled during the next refueling outage.

On January 31, 1992, the inspector met with licensee management and provided them with an overview of observations, concerns and findings. During the course of this meeting, the inspector informed the licensee that a potential Technical Specifications violation had been identified in that a defective tube was placed in service. More specifically technical specifications 4.4.5.3, and 4.4.5.4 require that steam generator tubes with wall degradation equal to or greater than 40 percent of nominal wall thickness be taken out of service.

Contrary to the above, on October 1, 1991, tube R47-C46 in steam generator (S/G) D, was examined and analyzed as having a potential defect of approximately 85 percent through wall depth, but was returned to service on December 12, 1991. While in service the subject tube developed a through wall leak and caused the plant to shutdown on January 16, 1992.

In addition to this violation the inspector expressed concern over the lack of guidelines, or a written procedure, to address the transfer of information on tubes flagged for plugging from ISI to Maintenance Engineering, who is in charge of tube disposition. The

inspector stated that this whole area would be revisited upon his return to the site on the following week, February 4, 1992.

On February 4, 1992, Messrs C. Dodd and K. Karwinski accompanied the inspector to the site in order to observe specific areas of technical interest and analytical aspects/criteria of the inspection. These areas included review of historical and current data, review of Main Guidelines and revised criteria and discussions of examination findings with technical experts responsible for final review of MRPC results. Upon completion of this work effort, Mr. Dodd made several recommendations to the licensee which included the following:

- ° EC data from other Duke plants should be reviewed for possible crack like indications which may have been categorized as MBM(s) and/or signal to noise ratio responses.
- ° The Zetec three coil pancake probe should be used for this inspection since it does a better job at distinguishing between axial cracks and other type of degradation.
- ° A formal written procedure should be developed for the MRPC to determine which tubes have cracks.
- ° Develop a formalized procedure for plugging so that defective tubes do not get left off the plugging list.
- ° Some consideration should be given towards the reduction of workday hours from the present 12 hour shift. These extended workdays could lead to fatigue-related errors by analysts.
- ° A probe wear standard should be developed and automatically applied during the inspection to guard against probe wobble, believed to be present in some of the earlier scans.
- ° Because of the apparent rapid crack growth rate phenomenon observed in tube 47-46, a reduced operating cycle on the order of six months would be prudent.

The reanalysis work effort in S/G "D" resulted in the identification of approximately 285 tubes with a total of about 360 indications requiring further examination with the MRPC probe. The licensee's plan was to examine each tube from the site of the indication up to the nearest landmark structure, i.e., tube support plate. This examination was still in progress at the completion of this inspection. However, through discussions with cognizant personnel the inspector ascertained that out of the 285 tubes, 220 had been examined and analyzed by analysts and about 50 by the technical experts. Out of these, no crack like indications had been identified.

Following completion of this inspection on February 6, 1992, the licensee informed Region II by telephone that 31 tubes had been

plugged in S/G "D". The licensee also stated that approximately 300 tubes had been identified for MRPC in each of the remaining three S/G(s) and, that as a result of this test approximately 30 tubes were plugged in each of the remaining three steam generators.

In conclusion, this inspection has disclosed several examples of programmatic weaknesses and a failure to follow procedures which resulted in the Technical Specifications violation discussed earlier. These examples include the following:

- ° McGuire Unit 1 Guidelines Rev. 1 lacked conservatism in allowing indications representing through-wall degradation with signal-to-noise ratio less than or equal to five (5) to be identified in terms of flaw type and not to require determination and documentation of through-wall crack depth. Consequently an axial crack equal to approximately 85 percent through wall was documented as a manufacturer's burnish mark which eventually resulted in a leaky tube.
- ° Eddy Current resolution analysts (primary and secondary) and the Level III examiner, responsible for administering the program, showed a lack of sensitivity in view of an obvious and serious problem, in that they failed to request additional testing on tube 47-46, when the secondary analyst's interpretation of the signal indicated a real possibility of an 85 percent through-wall indication (crack). Furthermore the inspector ascertained that Maintenance Engineering requested additional testing (MRPC), of the area in question in order to help determine the disposition of this tube. The inspector understands that although the examination (MRPC) was performed, the results were not relayed back to the interested party. This resulted in a defective tube being returned to service in violation of TS requirements.
- ° Through discussions with cognizant personnel, the inspector ascertained that there are no administrative controls to address the manner in which information on pluggable tubes is conveyed from the ISI group to the Maintenance Engineering group responsible for tube disposition. In addition, the inspector ascertained that there are no administrative controls to address the Maintenance Engineering group's role and authority in determining which tubes do or do not get plugged.

In response to these concerns, the licensee indicated that their Human Factors group was reviewing this whole issue. Except for the violation discussed earlier in this report no other violations or deviations were identified.

3. Eddy Current Inspection of Unit 2 S/G Tubes

The EC examination of S/G tubes in Unit 2 was in progress in parallel with the Unit 1 reanalysis effort. The licensee used the same screening process to identify axial crack indications in the freespan regions of these generators.

Following the end of this inspection the licensee reported finding three tubes with tight cracks similar to those in tube 47-46. The cracks were located on the cold leg side of S/G "C" and in the same relative location as those in S/G "D" of Unit 1. Specific information about these tubes are as follows:

Tube	Location TSP	TWD
R18 - C10	21 - .09"	58%
R5 - C29	21 - 1.2"	distorted indication in dent region
R18 - C5	21 - 1.7"	92%

The licensee indicated these tubes were removed from service and will undergo failure analysis.

Within the areas inspected no violations or deviations were identified.

4. Licensee Action on Previously Inspection Findings

(Closed) Inspector Followup Item 91-26-01, Reshooting Radiographs to Verify Full Coverage of Areas of Interest

This item was identified because ISI radiographs on certain mainsteam welds were shot in a manner that precluded the inspector from verifying complete coverage of the area of interest. To resolve the issue the licensee reexamined the welds ultrasonically. The inspector's review of the records showed the code-required, weld volume and adjacent material were of sound quality. Therefore the item was closed.

5. Exit Interview

The inspection scope and results were summarized on February 6, 1992, with those persons indicated in paragraph 1 above. The inspector described the areas inspected and discussed in detail the inspection results listed below. No dissenting comments were received from the licensee. Proprietary information is not contained in this report.

(Open) Notice of Violation, No. 50-369/92-05-01, S/G Tube R47-C46 Returned to Service with Defect that Exceeded TS Limits, paragraph 2.