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OPPD

Omaha Public Power District
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402/536-4000

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September 20, 1984
LIC-84-276

Mr. J. T. Collins, Regional Administrator
U.S. Nuclear Regulatory Commission
Region IV
611 Ryan Plaza Drive, Suite 1000
Arlington, Texas 76011

References: (1) Docket No. 50-285

(2) Letter from W. C. Jones to J. T. Collins dated June 19, 1984 (LIC-84-196)

Dear Mr. Collins:

Corrections to Steam Generator Tube Failure Report

Attached to the Omaha Public Power District's letter dated June 19, 1984 was the final report concerning the May 16, 1984 steam generator tube failure at Fort Calhoun Station. Four minor errors were discovered after submittal of the report.

Please find enclosed the corrected pages. The areas changed are indicated by vertical lines in the right hand margin. The changes are to correct minor errors and do not change the intent nor the conclusions of the report.

Please incorporate these pages into the final report of the Fort Calhoun Steam Generator Tube Failure.

Sincerely,

R. L. Andrews
Division Manager
Nuclear Production

RLA/CWN/rh-R

Attachments

cc: Mr. James R. Miller, Chief
U.S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Division of Licensing
Operating Reactors Branch No. 3
Washington, D.C. 20555

LeBoeuf, Lamb, Leiby & MacRae
1333 New Hamshire Avenue, N.W.
Washington, D.C. 20036

Mr. E. G. Tourigny, NRC Project Manager

Mr. L. A. Yandell, Senior Resident Inspector

IE01

3.0 STEAM GENERATOR INSPECTION HISTORY SUMMARY

3.1 Inspection Summary Prior to 1984

The Fort Calhoun Station utilizes two Combustion Engineering vertical U-tube steam generators, each of which contains 5,005 Inconel 600 tubes. The tubes are 0.75 inches outside diameter with 0.048 inch minimum wall thickness.

The Fort Calhoun Station has essentially always operated with a carefully maintained AVT secondary chemistry program. The periodic inspections utilizing visual and state of the art eddy current testing techniques of the steam generators have shown them to be in good condition. The District has endeavored to address operational problems in a timely manner. The results of all of the eddy current examinations prior to 1984 of the steam generator tubes have shown the generators to be in Technical Specification Category C-1.

A pre-operational ECT baseline inspection of 200 tubes per steam generator was performed in July 1973. Some mechanical imperfections were noted in the "A" generator.

225 tubes in each steam generator were ECT inspected at the first refueling outage in February 1975. No evidence of degradation or magnetite denting was noted at that time. The same was true of the inspection of 408 tubes in the "B" steam generator in November 1976.

An ECT inspection of the "A" steam generator in November 1977 was performed in order to assess the imperfection indications which had been discovered in 1973 and 1975. This inspection was limited to 165 tubes and was not intended to meet the requirements of Regulatory Guide 1.83. There was no evidence of deterioration or denting of the type related to magnetite growth at the drilled hole support plates.

500 tubes in the "A" steam generator were inspected in October 1978, using single frequency ECT. Some dent-like indications were observed, but evaluation showed no change with regard to the 1977 indications. One tube showed 38% degradation and two tubes showed less than 20% degradation. Although none of these tubes exceeded the plugging criteria, they were plugged as a precautionary measure. During the 1984 inspection, it was discovered that two tubes had actually been plugged and one end each of two adjacent tubes. The open end of these two tubes have been plugged. The first indications which were reported to the District as magnetite denting resulted from the inspection of 328 tubes in the "B" generator in October of 1981. This was the first inspection which utilized multi-frequency ECT techniques. All previouis exams had been done with single-frequency ECT. One tube was reported as having 28% degradation. This tube was not plugged, and it was reinspected in 1982. Evaluation of the indication at that time showed a dent, but no defect, at the point in question.

In December 1982, 308 tubes in the "A" generator and 302 tubes in the "B" generator were examined using multi frequency ECT. This inspection showed the presence of moderate dent-like indications in both generators. One tube in steam generator "A" showed 20% degradation. Two tubes in steam generator "B" indicated less than 20% degradation and one showed 25% degradation.

In addition to the eddy current examinations which are conducted from the primary sides of the steam generators, detailed secondary inspections are conducted at each refueling outage. These inspections involve a detailed crawl-through of the secondary sides of the steam generators to ascertain that all components are properly secured and in good condition, sludge and scaling sampling and analysis, inspection of steam generator internals from the handholes, and photographic documentation. The secondary inspections which have been conducted have shown the Fort Calhoun steam generators to be in good condition and without excessive amounts of deposits.

3.2 1984 Inspection Summary

3.2.1 Planned Outage Inspection

Plans for the March 1984 inspection involved a nominal 1,000 tubes in each steam generator, primarily for assessment of the extent and growth of denting in the No. 8 partial drilled hole support plates as the primary input to a decision to perform the rim cut modification. The actual number of tubes which were examined full length during this inspection were 1,454 in steam generator "A" and 1,034 in steam generator "B". Additional part length examinations were conducted to measure sludge height, and some tubes restricted the passage of an ECT probe and are not included in these totals. The inspection showed further dent-like indications, primarily at the No. 8 partial drilled hole support plate and in the batwing areas. Based on evaluation of this data, the District decided to perform the rim cut modification on the No. 8 partial drilled hole support plate. At the time of this inspection, the evaluation of the data showed no degradation indications in the "A" steam generator and one previously detected indication in the "B" steam generator. Four tubes in steam generator "A" and five tubes in steam generator "B" were plugged due to restriction to passage of a 0.540 inch ECT probe, which is consistent with Combustion Engineering's plugging recommendations for restricted tubes.

Following the performance of the rim cut modification, 120 peripheral tubes in steam generator "A" and 111 peripheral tubes in steam generator "B" were retested to determine if there had been any damage resulting from the performance of the rim cut. One tube in steam generator

In addition, those tubes from the March, 1984, program which were not retested otherwise with bobbin coil or pancake array probe ECT were retested using a 100 KHz absolute test for enhanced defect sensitivity. The original program used 800 KHz instead of 100 KHz in order to mix out ID tube noise and allow better determination of denting in the No. 8 partial support plates.

In addition to the failed tube, B-L29R84, the following tubes showed degradation or defect indications at the hot leg vertical support. The degree of degradation is also indicated.

A-L85R80	<20%
A-L85R82	28%
A-L94R75	<20%
A-L101R80	<20%
B-L85R86	42%
B-L102R77	22%
B-L104R75	26%

The following tubes from the above group which showed indications at the hot leg vertical support were inspected in December, 1982, with results as noted:

A-L101R80 - No Detectable Defect (NDD) at hot leg vertical support, no known dent

B-L102R77 - Dent at hot leg vertical support, NDD
B-L104R75 - NDD at hot leg vertical support, no known dent

From all of the ECT work which was performed, only four tubes showed a defect (> 40%) indication, two in each steam generator. Tube A-L37R18 showed possible evidence of wastage in an area several inches above the tube sheet, with 27% and 53% indications in the wastage area. This tube has not been inspected previously. Because of concerns about the presence of these indications, the District has elected to cut and remove a tube section which contains the indications for future metallurgical analysis. There is no evidence to suggest that this problem is related to the failure of tube B-L29R84 which occurred at the top of the tube bundle. Tube A-L64R85 has a 44% indication just below the #7 hot leg support. This tube was intended to be plugged in 1978, but only the hot leg end was plugged. Reinspection showed progression of the indication. Tube B-L85R86 has a 42% indication at the hot leg vertical support strap. Tube L29R84 is the failed tube.

A summary of all degradations or defect indications from the 1984 inspection programs is presented below: Further details are given in Tables 3 and 4. Permeability variations (PV) are also included.

6.0 CORRECTIVE ACTION TO REDUCE THE PROBABILITY OF THE FAILURE MECHANISM

The intergranular stress corrosion cracking (IGSCC) initiated on the outer diameter which lead to the tube failure was initiated by the simultaneous presence of three conditions:

A. A susceptible material condition

B. A significant tensile stress

C. An aggressive environment

(Refer to Section 4.1.4 for more information on IGSCC and the causative mechanism).

To reduce the likelihood of the simultaneous presence of these conditions, immediate corrective actions are being or have been taken to appropriately institute operational programs and techniques as briefly described below:

A. Material Condition

It may be possible to reduce the susceptibility of Alloy 600 through changes in the operating environment. The District will review available information to determine if changes in the physical operation of the station can provide an environment which is more resistant to IGSCC. This study will be completed in 6 months.

B. Tensile Stress

Development of procedures to arrest the dent growth rate is in progress. Results from industry experience with boric acid and hydrazine passivation treatments are being reviewed with other utilities and vendors of the Fort Calhoun turbine generator and NSSS. A chemistry program to arrest denting will be initiated upon completion of this review if it is determined that such a program will not produce undesirable secondary effects, e.g., increasing the likelihood of initiation of a turbine missile due to bucket or wheel failures.

During inspections this outage, profilometry data was collected to characterize dents and evaluate the strain in selected dented tubes in both steam generators. This data will be used in conjunction with repeated profilometry data from some of these same tubes to monitor the dent growth rate.

C. Chemical Environment

Several actions have been taken to control and monitor the chemical environment of the steam generator tubes:

1. Condenser Integrity Program

The chief source of impurities to the secondary system has been periodic low level condenser in-leakage. More restrictive administrative limits with the purpose of eliminating in-leakage during power operation are being adopted. In addition, programs involving surveillance of condenser tube degradation and failure mechanisms are being initiated. In conjunction with this assessment, the District will remove