ARKANSAS NUCLEAR ONE - UNIT TWO

STEAM GENERATOR TUBING INSERVICE INSPECTION REPORT

FOR 2R4 REFUELING OUTAGE

INSPECTION SUMMARY

An inservice eddy current inspection was performed on a selected sample of tubes in the Arkansas Nuclear One Unit Two Steam Generators "A" and "B" during the period from March 22, 1985 through March 25, 1985. Since the previous test was concluded in October, 1983, the inspection frequency requirement (24 months per Technical Specification 4.4.5.3.a) was satisfied.

The inspection was conducted in accordance with Technical Specifications 4.4.5.1 and 4.4.5.2. The sample included a 3% random sample from the steam generators with exceptions as provided in Technical Specifications 4.4.5.2.a and 4.4.5.2.b.

In total, approximately 4.7% (399 tubes) of the tubes in the "A" steam generator and 4.7% (401 tubes) of the tubes in the "B" steam generator were inspected from the hot leg side. All but 7 of the 399 tubes tested in the "A" steam generator and all but 9 of the 401 tubes tested in the "B" steam generator were tested full length. The remaining 16 tubes were tested, at a minimum, over the U-bend and down the cold leg past the #11 and #10 drilled support plates. The multi-frequency method of eddy current testing was utilized during this inspection accumulating dent, flaw, and sludge depth data simultaneously. Details of the inspection methodology and equipment used are given in the attachment.

INSPECTION RESULTS

Minor tube wall degradation indications were observed during the data analysis for both "A" steam generator and "B" steam generator in both the hot and cold leg sides. No defective tubes ($\geq$ 40% throughwall degradation) were found.

Tables 1 and 2, attached, give a complete list of tube wall indications found in the "A" and "B" steam generators.

TABLE 1

LIST OF TUBES CONTAINING INDICATIONS

S/G "A" HOT SIDE

LINE	ROW	% INDICATION	LOCATION
73	121	< 20	#4+8"
89	59	< 20	#8+12"
103	91	< 20	#4+11.2"
103	91	< 20	#4+24"
103	91	23	#5+.9"
103	91	< 20	#5+19.4"
107	91	< 20	#5+6.1"
107	91	35	#5+18.2"

LIST OF TUBES CONTAINING INDICATIONS

S/G "A" COLD SIDE

LINE	ROW	% INDICATION	LOCATION
105	135	< 20	#4+21"
105	135	< 20	#8+12.9"

TABLE 2

LIST OF TUBES CONTAINING INDICATIONS

S/G "B" HOT SIDE

LINE	ROW	% INDICATION	LOCATION
78	132	< 20	#1+2.7"
92	86	< 20	#3+7.5"
93	69	28	#6+18.9"
93	83	< 20	#1+14.9"
93	89	< 20	#2+21.6"
96	82	< 20	#5+1"
97	73	< 20	#2+9.1"
105	135	21	16.7" from #3BW
107	117	24	11.1" from #1BW

LIST OF TUBES CONTAINING INDICATIONS

S/G "B" COLD SIDE

LINE	ROW	% INDICATION	LOCATION
93	69	< 20	#0+7.5"
122	20	< 20	#1+13.1"
110	32	< 20	#6+5.6

NOTE: BW stands for Bat Wing which is a vertical support at the top of the steam generator.

ATTACHMENT

METHODOLOGY

The inspection program satisfied the requirements of the USNRC Regulatory Guide 1.83, Revision 1, (July 1975), "Inservice Inspection of Pressurized Water Reactor Steam Generator Tubes." The inspection program was conducted in accordance with approved vendor-supplied procedures and the ANO-2 Technical Specifications.

The inspection program consisted of utilizing multi-frequency eddy current techniques to collect steam generator tube dent and defect data with the testing frequencies of multi-frequency eddy current tester setup as follows:

- Channel 1 Frequency at 400 KHz
- Channel 2 Frequency at 200 KHz
- Upper Mixer for Minimum Tube Support Plate Response
- Channel 3 Frequency at 400 KHz (low gain)
- Channel 4 Frequency at 100 KHz ABS

While conducting the inspection, the signal generated by the eddy current probe was fed into an eight channel tape recorder which recorded on magnetic tape all four frequencies (two channels each) of the multi-frequency tester.

Channel No. 1 of the eddy current test was set at 400 KHz. Based on past experience, this frequency provides for optimum response for tubing of the diameter and wall thickness of that used in the ANO-2 steam generators. The 400 KHz frequency constitutes a data base for these steam generators to which future inspections can be compared. The sensitivity of this channel was adjusted to allow for calibration to a standard containing known defects.

Channel No. 2 of the eddy current tester was set at 200 KHz. The output of this channel and the 400 KHz output from Channel No. 1 was fed into the upper mixers unit for the purpose of suppressing the tube support plate signals. A section of drilled carbon steel plate simulating the tube support plate was placed over the calibration standard. The mixer was then adjusted such that the signal generated by the tube support plate was eliminated. After adjustment and calibration, the output of the mixer provided only the signal originating within the tube itself. Therefore, any flaw indication generated by the tube in the area under the tube support plate would be more easily detectable.

Channel No. 3 of the eddy current tester was set at 400 KHz for detection of denting. The sensitivity of this channel was adjusted to a dent standard signal of known dimension.

Channel No. 4 of the eddy current tester was set at 100 KHz absolute. This data provides additional information to aid in defect detection and analysis.

The data from the inspection program was recorded on magnetic tape and on strip charts. These recordings were analyzed to evaluate the extent of tube wall anomalies and the results were recorded.

EQUIPMENT

The complete eddy current inspection system can be broken down into two categories, inspection equipment and probe positioning equipment. The eddy current inspection equipment consists of:

- Zetec MIZ-12 Multi-Frequency Eddy Current Tester with dual mixers

- 1 - 4 Channel Strip Chart Recorder (Gould 2400) or equivalent

- 1 - 8 Channel Hewlett-Packard Magnetic Tape Recorder or equivalent

- Eddy Current Test Probes (A560SF) or equivalent

- Calibration Standards (Defect Standard per ASME Section XI plus Dent Standard)

- A Supply of Magnetic Tape and Strip Chart Paper

- Zetec Digital Data Analyzer (DDA-4)

The probe positioning and drive system consists of:

- SM-4 Positioner and Templates

- A Closed Circuit Television System

- A Probe Drive Mechanism

- A Communication System

Special sensing probes fabricated for the specific tubing to be tested and designed to negotiate the bends in the tubing are used. The probes are attached to nylon tubing which is used to insert and withdraw the probe. The instrument leads and a stainless steel safety wire pass through the nylon tube.

The probe insertion and withdrawal mechanism is a device which ensures a constant probe speed when recording the eddy current test results. This is important in that accurate location of any eddy current indication is dependent on constant probe speed since tube length is correlated with strip chart speed.

The probe positioning device (SM-4) is a remote control mechanical arm which can be positioned to feed the probe into any tube in the steam generator. It consists of a mounting stanchion and two mechanical arms driven by stepping motors. A remote camera and lighting system is mounted on the SM-4 allowing the operator to see probe insertion and to identify the tube being tested. A tube sheet template is installed and removed in sections and is held in place on the tube sheet by template plugs which are forced into particular tubes. The SM-4 and templates provide a fast and easy means of positioning the probe and identifying the tube being tested. Test speed and probe positioning accuracy is of benefit when using this system on a large testing program.

ECT EQUIPMENT OPERATION

The MIZ-12 multi-frequency eddy current tester uses eddy currents as the probing media to measure variations in effective conductivity and/or permeability of the tube being tested. In non-magnetic materials, such as Inconel, conductivity is usually the only significant variable. When the effective conductivity decreases due to a discontinuity in the tube wall, the test coil voltage increases in direct relationship with the effective conductivity change. Thus, the amount of increase in coil voltage is related to the size of the discontinuity. The coil voltage is sinusoidal, thus it can be described with a single vector having magnitude and phase. The MIZ-12 system provides a method for reading out two quadrature components of the test coil voltage vector. In addition, the MIZ-12 multi-frequency eddy current tester is a highly versatile and compact eddy current inspection system. Utilizing a "Time Sharing" technique, the operator may test at up to four (4) frequencies simultaneously. The MIZ-12 contains two mixing circuits, giving the operator the ability to subtract out most undesirable data (i.e., noise, support signals, etc.). The CRT display allows the operator to view the mixer output as well as the test signals.

The response from the eddy current tester is fed through the memory oscilloscope to the tape recorder and then to the strip chart recorder. Audio input (microphone) is also provided to record the identity of the tube being tested at the start of each test. The recorded data can be analyzed with the aid of the Zetec DDA-4 digital data analyzer.

The defect and dent calibration standards used were ANO-85-1000 and ANO-85-1001 in-line standards. They are 3/4 O.D., Inconel-600 tubing with .048-inch average wall thickness including artificial (machined) defects and dents. The standards were made in accordance with the ASME Code, Section XI.

The data from the inspection program was recorded on magnetic tape and on strip charts. These recordings were analyzed to evaluate the extent of tube wall anomalies.