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AUTH.NAME AUTHOR AFFILIATION
FITZPATRICK,E. Indiana Michigan Power Co.
RECIP.NAME RECIPIENT AFFILIATION
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SUBJECT: Forwards follow-up info re final results of metallographic exam performed on sample of SG tubing removed during 1997 SG insp.Exam conducted in support of GL-95-05.

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Power Company
500 Circle Drive
Buchanan, MI 49107 1395

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Gentlemen:

Donald C. Cook Nuclear Plant Unit 1
STEAM GENERATOR TUBE INSPECTION
FOLLOW-UP TUBE SAMPLE REPORT

This letter and its attachment provide follow-up information concerning the final results of the metallographic examination performed on a sample of steam generator (SG) tubing removed during our unit 1 1997 SG inspection. This examination was conducted in support of generic letter 95-05. Preliminary results were included in our unit 1 SG ninety day tube inspection report submitted in our letter AEP:NRC:1166AI, dated July 21, 1997.

Sincerely,

J Brewer for

E. E. Fitzpatrick
Vice President

/vlb

Attachments

c: J. A. Abramson
A. B. Beach
MDEQ - DW & RPD
NRC Resident Inspector
J. R. Sampson

A001 /1

ATTACHMENT TO AEP:NRC:1166AN

STEAM GENERATOR TUBE INSPECTION
FOLLOW-UP TUBE SAMPLE REPORT

INTRODUCTION

During the Cook Nuclear Plant unit 1 1997 refueling outage, a steam generator (SG) tube sample was removed for the purpose of defect characterization and tube material data for compliance with generic letter 95-05, "Voltage Based Criteria for Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking".

Preliminary results from the then in progress inspection were presented in our ninety day SG inspection report, our letter AEP:NRC:1166AI, dated July 21, 1997. The examination has since been completed and the final report was recently issued.

Tube R8/C19 was removed from SG-12 to below the fourth tube support plate (TSP). Sections from the tube underwent a series of laboratory examinations. The primary area of interest for the examinations were the three TSP regions. A summary of the report findings are presented below.

EXAMINATION SUMMARY

Leak Testing

Helium leak testing of the three tube sections containing TSP intersections was performed. The inside diameter of the tubes was placed under a vacuum, while the outside diameter (OD) was placed under a helium blanket. The tubes were held at test conditions for ten minutes with no leakage observed. The leak detection limit was 1.6E-8 cc/sec.

Additionally, hydrostatic leak testing was performed on the two tube sections encompassing the first and second TSP regions. Test pressures simulated normal operation and steam line break conditions. Neither tube segment exhibited throughwall leakage.

Burst Testing

Burst testing of TSP and freespan regions indicated burst pressures in excess of 7,000 psi in all instances. These results are well in excess of the minimum NRC structural requirements (3 delta P) contained in RG 1.121.

Table 1 summarizes the results for each location. Note that the burst pressure for the first TSP region was confirmed to exceed 7,000 psi; however, operator error involving a mispositioned valve prevented a more accurate reading.

Table 1
Burst Test Data

Location	Burst Pressure (psi)
First TSP	> 7,000 *
Freespan	9,980
Second TSP	9,326

* Inadvertent burst due to operator error, 7,000 psi represents the minimum pressure certified by operator.

Eddy Current Testing

Laboratory eddy current testing was performed using the same probes and techniques utilized for the field examination.

Table 2 summarizes the results from the field and laboratory eddy current examinations, along with the results from the subsequent reviews of field data.

With the exception of the dents detected by the laboratory bobbin coil probe at 2H and 3H, which were not present in the field data, there were no significant differences between the field and laboratory eddy current signals.

Field eddy current data was re-reviewed, and the dent signals were confirmed to not have been present in the original data. It was concluded that the dents were a result of tube sample removal operations.

Table 2
Field and Laboratory Eddy Current Testing Comparison
Unit 1, SG-12, Tube R8/C19

Loc.	ECT - Field Results	ECT - Field Comments	ECT - Lab Results
1H	BC: DSI (1.16 volts) RPC: SAI (1.04 volts 111 phase angle)	OD 40% TW by phase angle using 400/ 100 kHz process channel; No dents; indication confirm-ed to be within TSP crevice	BC: DSI (4 volts, shallow OD IGA) RPC: SAI (1.11 volts, 115 phase angle)
2H	BC: DSI (0.87 volts) RPC: MAI (1.10 volts, 133 phase angle)	OD 40% TW by phase angle using 400/100 Khz process channel; No dents; Indication confirm-ed to be within TSP crevice	BC: Signal distorted by 16.69 volt dent RPC: MAI (0.88 volt 134 phase angle)
3H	NDD	No dents	BC: DNT (11.22 volts)

Key:

BC	=	Bobbin coil
DNT	=	Dent
DSI	=	Distorted signal at intersection
MAI	=	Multiple axial indication
NDD	=	No defect detected
OD	=	Outside diameter
RPC	=	Rotating pancake coil
SAI	=	Single axial indication
TW	=	Throughwall

Metallographical Examinations and Crack Depth Measurements

Metallographic examinations of the transverse sections from each of the three TSP regions indicated that shallow, OD-initiated, intergranular attack (IGA), and intergranular stress corrosion cracking (IGSCC) were present, and that the cracking was axially

aligned (no cellular IGA). The predominant defect morphology was characterized as axial, OD-originated IGSCC. Tube degradation was confined to the TSP regions.

Maximum crack depths observed during the metallographic examination of the three TSP regions were 41.6%, 36%, and 23.6% throughwall, respectively. Note that the later crack depth (23.6% at 3H) was observed after the tube had been swelled by approximately 10% radial strain to facilitate visual inspections. Therefore, it is not unexpected that this indication was not identified during the eddy current inspection as it was evidently at the lower threshold of eddy current detection based on the review of both the field and laboratory eddy current test results.

The maximum depths of the IGA/IGSCC on the burst rupture surfaces of the first and second TSPs was 50% and 40%, respectively. The following table summarizes the crack depth results from both metallographical and scanning electron microscope analysis.

Table 3
Summary of Crack Depth Measurements
(Inches, % Throughwall)

Location	Metallography		Scan Elec. Micr.	
	Typ.	Max.	Typ.	Max.
First TSP	0.0046 9.2%	0.021 41.6%	0.012 24.4%	0.025 50%
Second TSP	0.010 19.3%	0.018 36%	0.008 16%	0.020 40%
Third TSP	0.002 3.7%	0.012 23.6%	Not Measured	Not Measured

Other Examinations

Scanning electron microscope/electron dispersive spectroscopy and wavelength dispersive spectroscopy typically found aluminum, silicon, calcium, magnesium, manganese and iron oxides on the surface of the TSP regions, as well as the presence of low levels of lead and sulfur on the IGA/IGSCC and outer diameter surfaces of the tube. These results were confirmed through Auger/x-ray photoelectron spectroscopy analysis, which also indicated that nickel/chromium ratios were consistent with basically neutral pH conditions.

Tensile testing, microhardness, bulk chemistry, Huey testing, deposit analyses, and microstructural characterization did not indicate any abnormal conditions in the tube.

Conclusions

The above inspection results confirm that the dominant degradation mechanism is axially orientated outside diameter stress corrosion cracking that is confined within the TSP regions. No evidence of detectable crack-like circumferential indications were noted. These findings remain consistent with previous tube pull results and eddy current testing.