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Round Robin Test for Crack-Sizing Methodology in Steam Generator Tubes

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1. Introduction

Steam generator tubes have an important safety role because they constitute one of the primary barriers between the radioactive and non-radioactive sides of the nuclear power plant. For this reason, the integrity of the tubing is essential in minimizing the leakage of water between the two sides of the nuclear power plant. There are four types of crack indication in steam generator tubing such as axial primary water stress corrosion cracking (PWSCC), axial outside diameter stress corrosion cracking (ODSCC), circumferential PWSCC, and circumferential ODSCC. The crack-sizing for the steam generator tubes during the in-service inspection was not performed until July 2005 in Korea. However it is necessary to evaluate the depth and length of the crack in order to complete the condition monitoring and the operational assessment of the Steam Generator Management Program. The currently available crack sizing techniques were introduced from Electric Power Research Institute (EPRI). Prior to applying to the field analysis, the round robin tests for theses techniques were carried out by the domestic analysts.

2. Crack Sizing Methodology for Eddy Current Data

EPRI ETSS (Examination Technique Specification Sheet) #96703.1 is used to evaluate the depth and length of axial PWSCC indications [1]. Voltage normalization is performed in the circumferential lissajous window and is set on the 100% axial notch at 20 volts. The phase angle calibration curve is used in circumferential lissajous window. ID (Inside Diameter) notches of 100%, 60% and 40% are used as the calibration points. The channel of 300 kHz is used to size the axial PWSCC indications.

The sizing methodology for the axial ODSCC is based on the report No. 00-TR-FWS-023 Rev.1 by Westinghouse [2]. The amplitude calibration curve is used in the main lissajous. OD notches of 100%, 60% and 40% are used in the calibration curve.

EPRI ETSS #96701.1 was developed to use in sizing the depth and length of circumferential PWSCC in the expansion transition [3]. However it is widely used in other locations of steam generator tubing. Voltage normalization is performed in the axial lissajous window and is set on the 100% circumferential notch at 20 volts. An additional process channel will be required for the amplitude curve. This channel will be a duplicate of the 300 kHz raw channel and the circumferential notch response will be in the positive direction. This channel will be used to establish the amplitude peak_peak measured response linear line curve based on the phase measurement. Each intersection will require a new linear peak_peak amplitude curve based on the voltage and the phase percent (%) at maximum amplitude. If the voltage at maximum amplitude from the indication exceeds the voltage of the notch set at 20 volts in the axial lissajous window, use a curve where 20 volts equals 100%. This provides a conservative approach. A phase curve is established on the raw channel using 100%, 60%, 40% and 0% values.

The sizing methodology for the circumferential ODSCC is based on the report EPRI TR-107197-P1 [4]. A phase angle curve is established in the axial lissajous window using 100%, 60%, 40% and 0% values. The summary for the sizing techniques of crack indications is shown in Table 1.

3. Round Robin Test Results

Prior to applying these techniques to the field analysis, the round robin tests were carried out by the domestic analysts. Eddy current data used in these tests were collected from the field inspections of the nuclear power plants in Korea. The results of the round robin tests are shown in Fig. 1 and Fig. 2. X-axis represents the analyzed maximum depth values of the indication by ISI vendor analysts. Y-axis represents the analyzed maximum depth values of the indication by KHNP analysts as the reference values. As shown in figures, the deviations for the circumferential indications are relatively large.

Table 1 Crack-Sizing Techniques for the Eddy Current Data of Steam Generator Tubing

Indication Type	Document	Calibration Curve	Lissajous Window
Axial PWSCC	EPRI ETSS #96703.1	Phase	Circ. Lissajous
Axial ODSCC	Westinghouse 00-TR-FWS-023	Amplitude	Main Lissajous
Circ. PWSCC	EPRI ETSS #96701.1	Amplitude Based on Max Depth Phase	Axial Lissajous
Circ. ODSCC	EPRI TR-107197-P1	Phase	Axial Lissajous

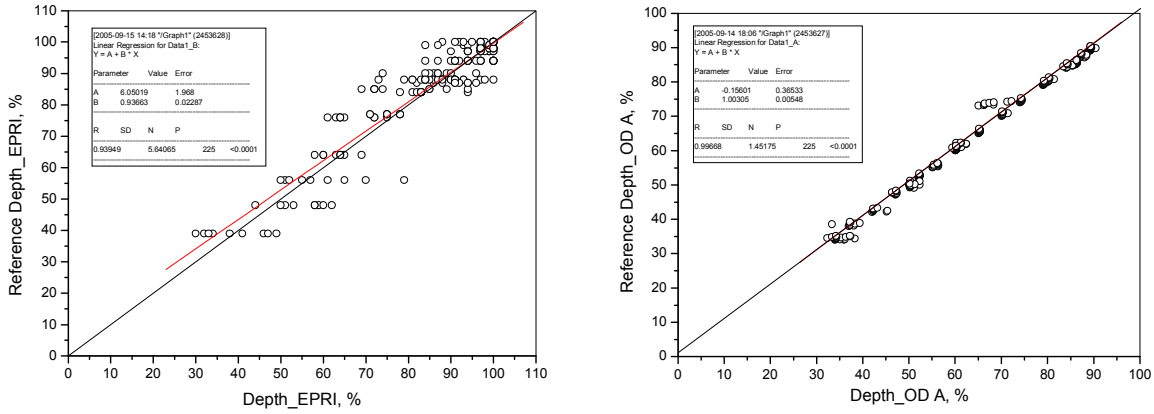

Fig. 1 Analyzed Maximum Depth Values for Axial PWSCC and Axial ODSCC

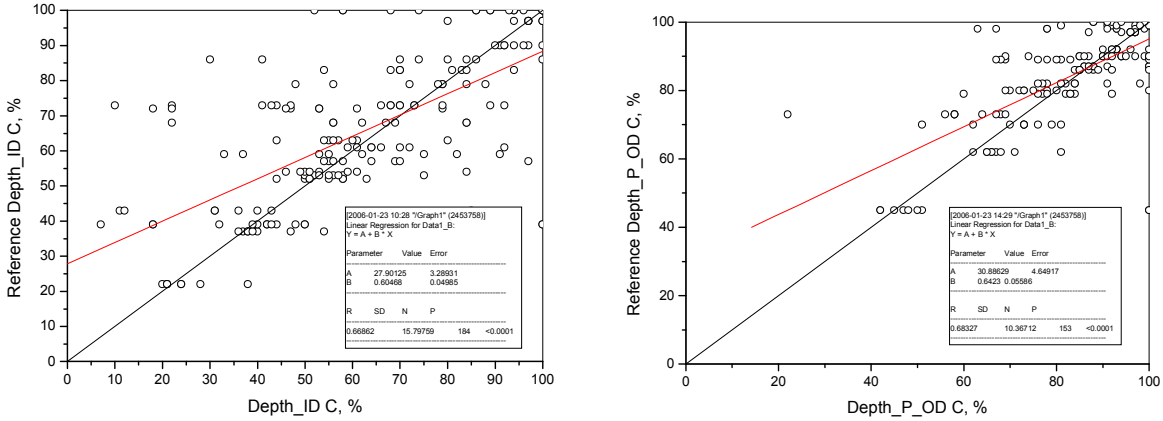

Fig. 2 Analyzed Maximum Depth Values for Circ. PWSCC and Circ. ODSCC

3. Conclusion

The crack-sizing for steam generator tubing during the in-service inspection was not performed until the Steam Generator Management Program applied to the field inspection in Korea. The currently available crack-sizing techniques were introduced from EPRI. Prior to applying the techniques to the field analysis, the round robin tests were carried out by the domestic analysts. The deviations of the length for all types of indication are reasonably acceptable. The deviations of the maximum depth for axial indications are small. The standard deviations of the maximum depth for axial ODSCC and PWSCC are 1.45 and 5.64, respectively. The correlation coefficients (R) of the maximum depth for axial ODSCC and PWSCC are 0.99 and 0.93, respectively. However the deviations of analysis results for the circumferential indications are relatively large. Therefore it is necessary to develop the new sizing techniques.

REFERENCES

[1] Electric Power Research Institute, Performance Demonstration Database: Appendix A, Examination Technique Specification Sheet ETSS #96703.1 Rev. 10, 2001.

[2] Westinghouse Electric Company, Plus-Point Coil Sizing Study for Axial Crack Profiling, Report No. 00-TR-FWS-023 Rev. 01, 2001.

[3] Electric Power Research Institute, Performance Demonstration Database: Appendix A, Examination Technique Specification sheet ETSS # 96701.1 Rev. 7, 2001.

[4] Electric Power Research Institute, Depth-Based Structural Analysis Methods for Steam Generator Circumferential Indications, EPRI TR-107197-P1, 1997.