

Discrimination between Carbon Steel Loose Part and Magnetite Scale on Secondary Side of Steam Generator Tubes from MRPC Probe Eddy Current Signals

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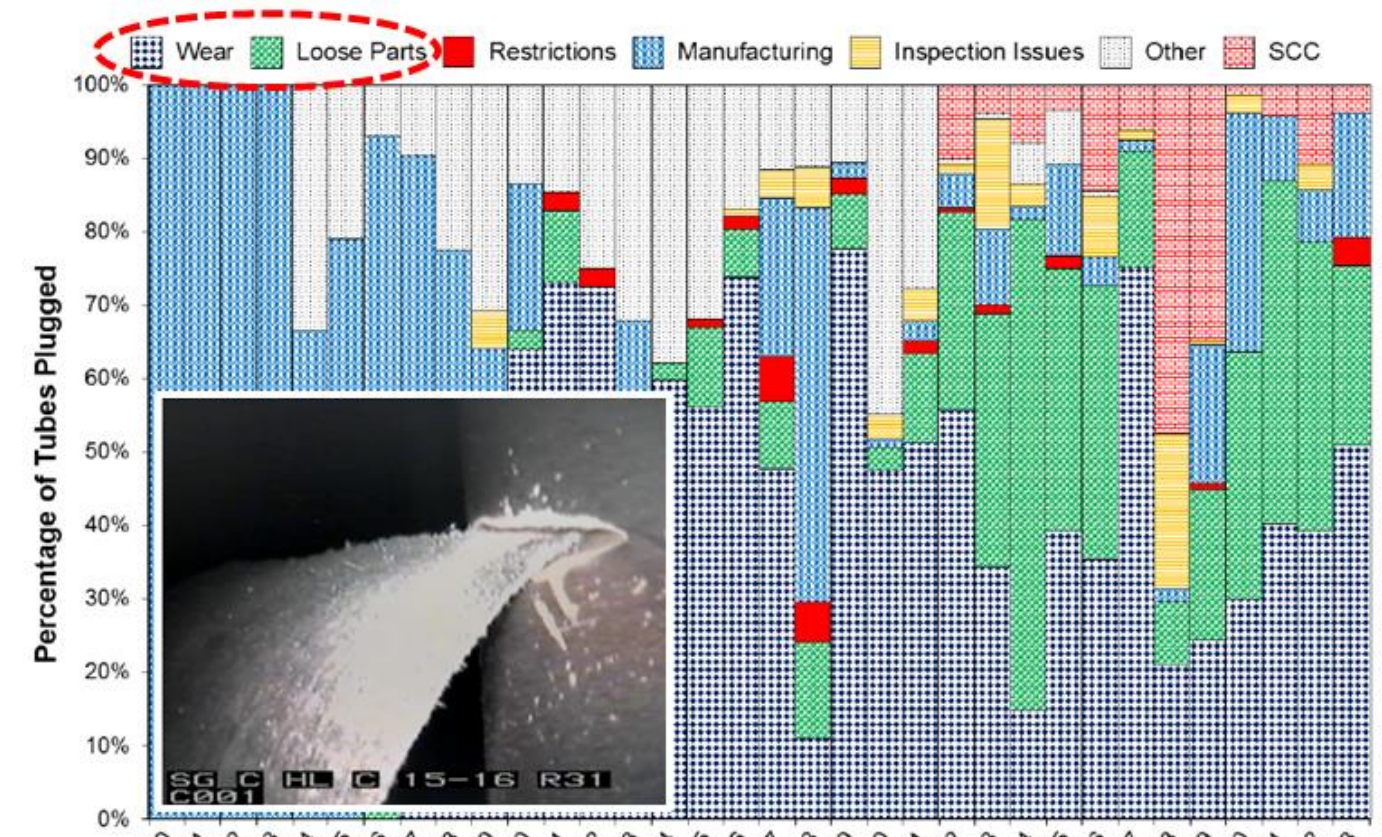
Background

- Degradation modes of mechanical damage other than corrosion are becoming prevalent in SG tubes of NPPs, especially for the new or replaced SGs with more corrosion resistant tubing materials of alloy 690.

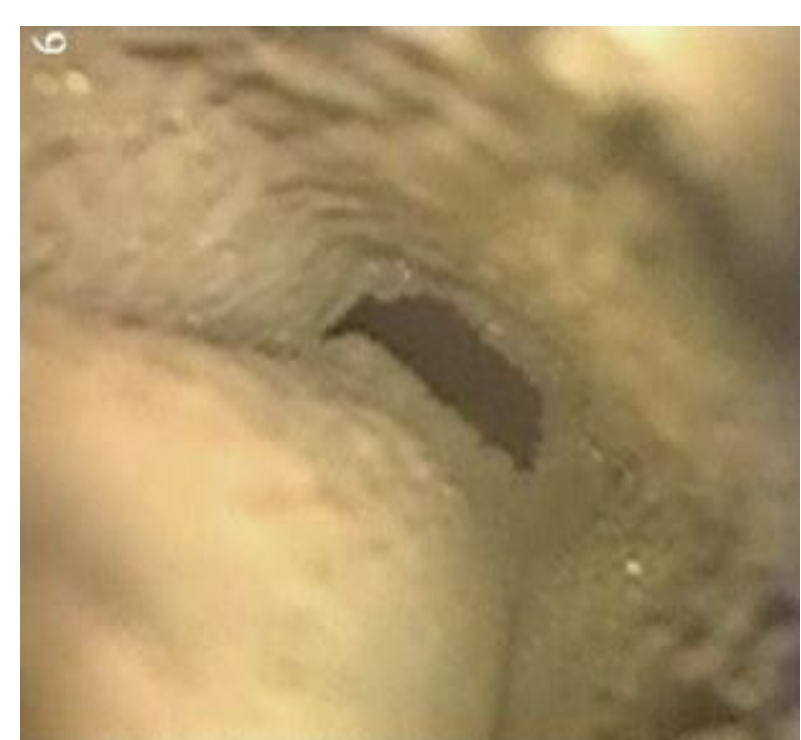
- Tube wears by foreign objects on secondary side of SGs challenge tube integrity which can lead to primary to secondary leakage of coolant and unscheduled shutdown of NPPs.

- Earlier detection and subsequent retrieval of foreign objects by ECT is becoming more important for a preventive measure.

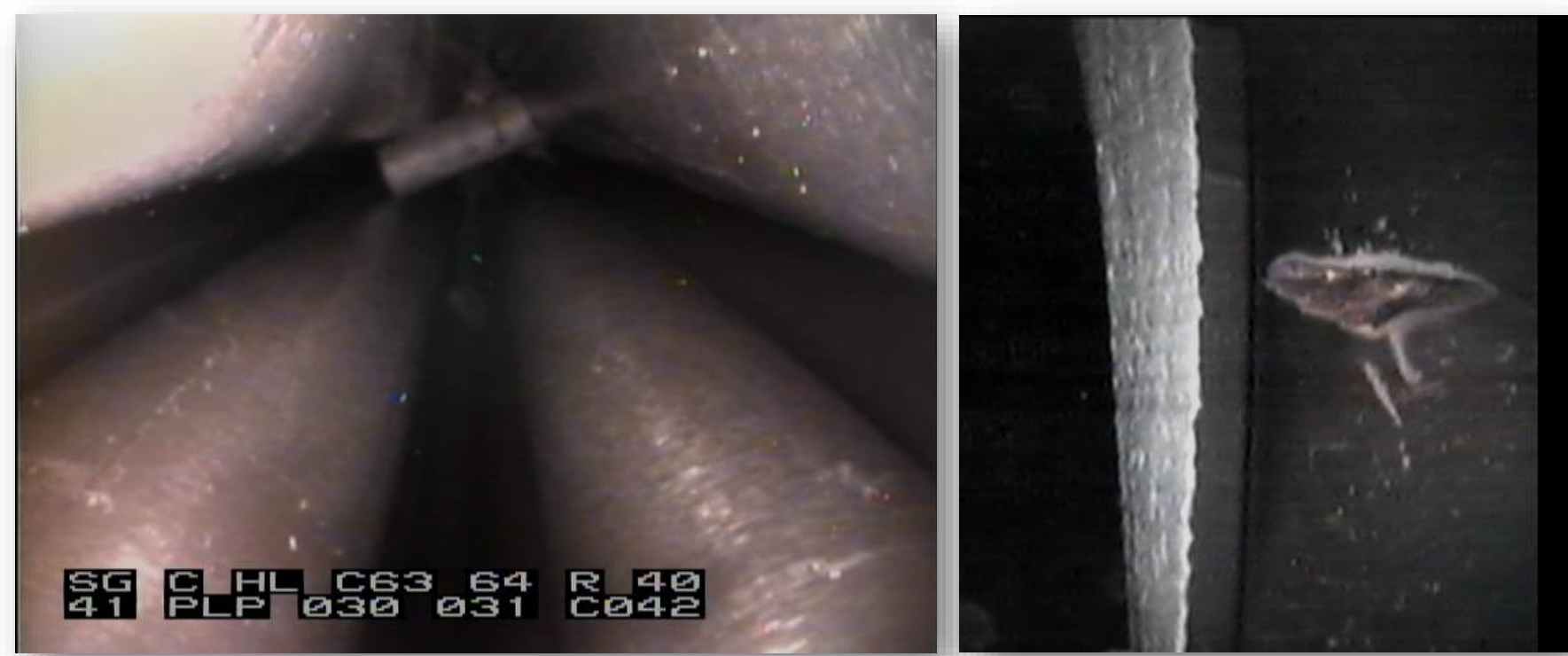
- A loose part of concern on secondary side of SG should be discriminated reliably from magnetite scales in MRPC probe eddy current signal analysis.



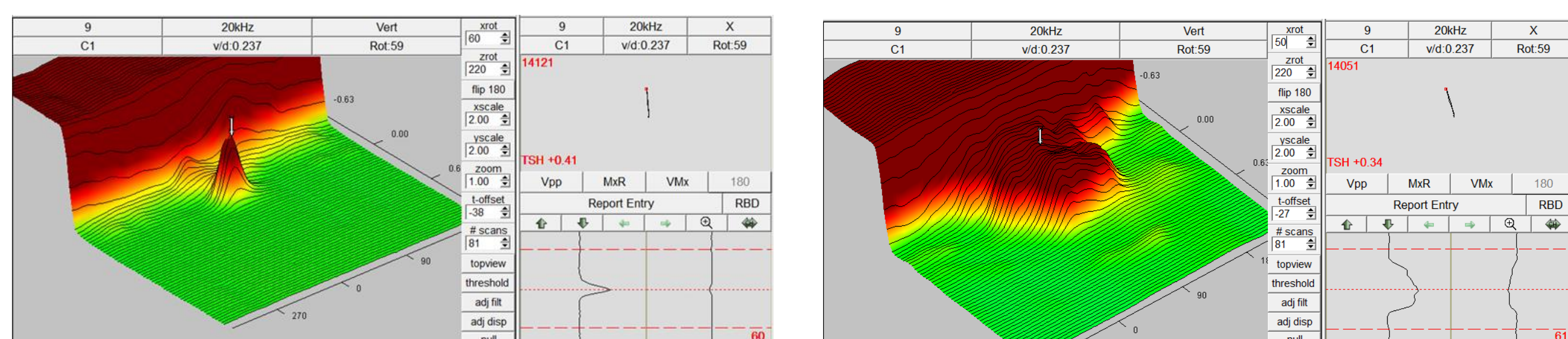
<Plugging of alloy 600TT SG Tubes in US>



<Magnetite Scales>



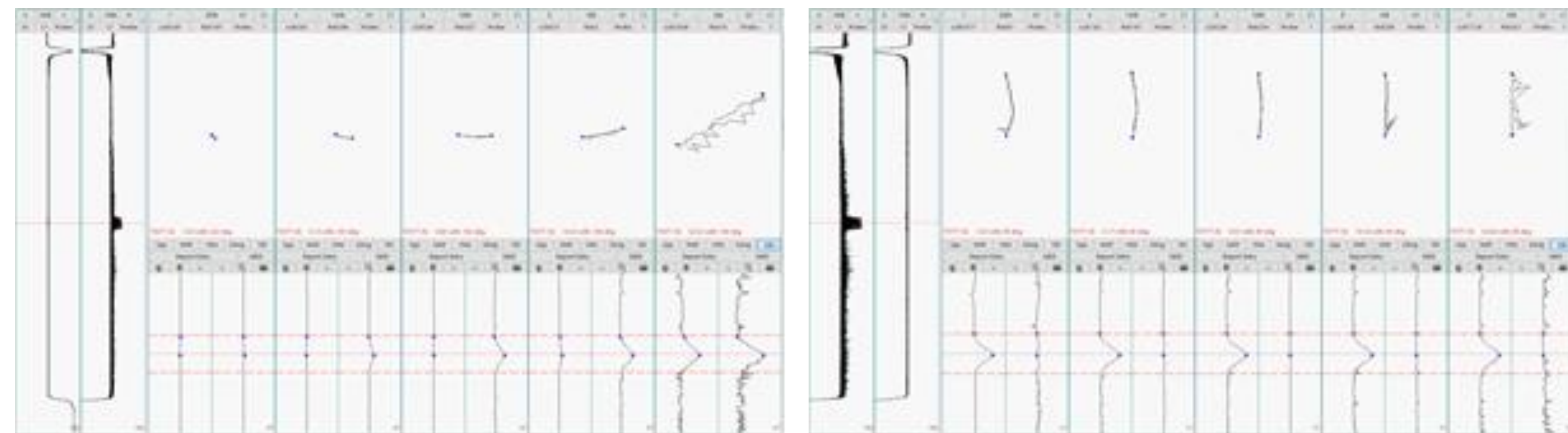
<Suspended Metallic Loose Part and Tube Wear>



<Loose Part ? or Scales ?>

Results

- Calibration of Carbon Steel Loose Part Signals for Comparison

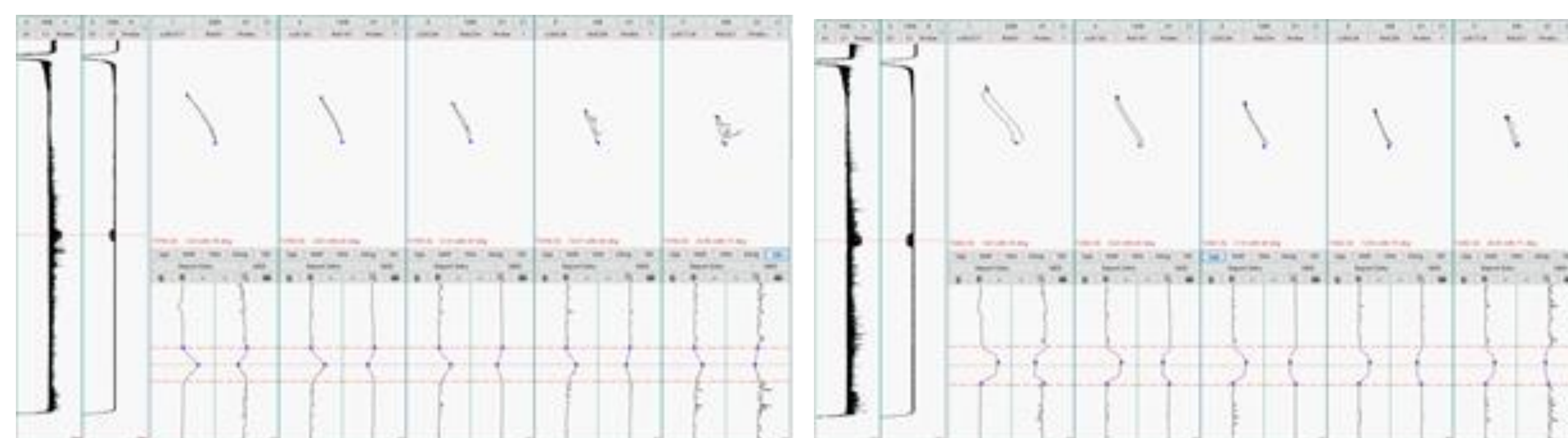


<Calibration done by Industry Procedure>

<Calibration done by Present Study>

⇒ Phase angles and Amplitudes changes with Test Frequency For Comparison, Signals from Carbon Steel adjusted at 90°

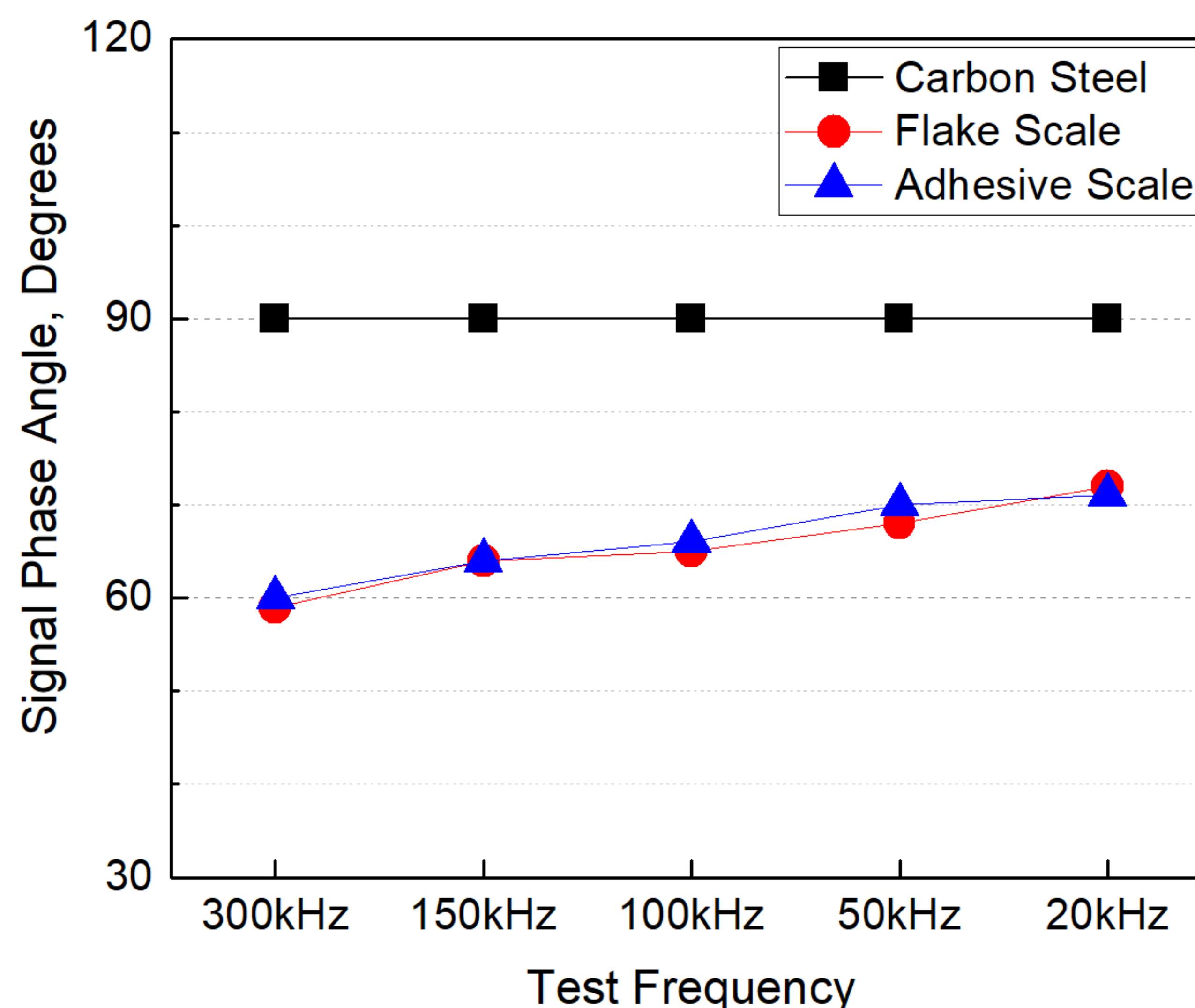
- Characteristics of Flake and Adhesive Scale Signals



<Flake Type Scale Signals>

<Adhesive Type Scale Signals>

- Quantitative Comparison of Phase Angles



<Changes of Relative Phase Angles from MRPC Probe Pancake Coil Signals>

⇒ Phase Angles of Magnetite Scales consistently lower by 20~30° at all Test Frequencies

Experiments

- Instrument

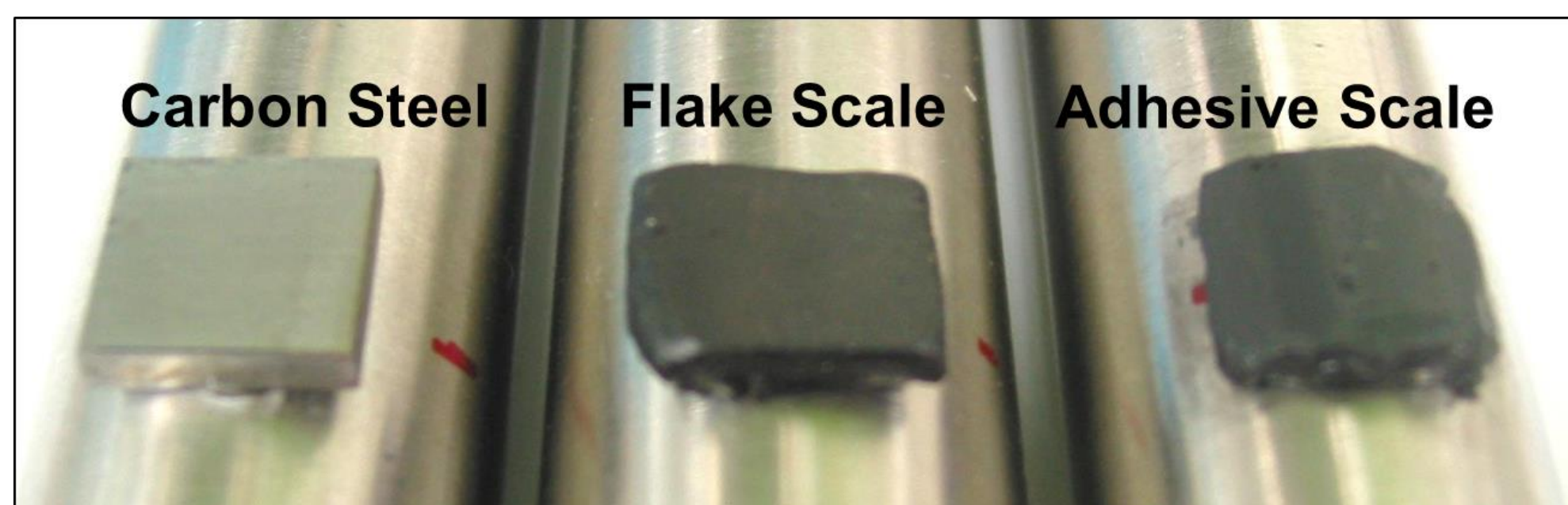
- ECT instruments

: ZETEC MIZ-70 Data Acquisition Unit & EddyNet Data Analysis System
: ZRPS-DH3 MRPC Probe, Test Frequency of 300, 150, 100, 50 & 20 kHz

- Manufacturing of Mock-up Tube Specimens

- SG Tube : 0.75" OD, 0.042" T alloy 690TT

- Carbon Steel Loose Part Machined from SA-106 Gr.B Pipe, Two Types of Flake and Adhesive Scales Compacted from Magnetite Powders with Glue
- Same Volumetric Dimension of 10mm W x 10mm L x 2mm T



<Mock-up Tubes for Carbon Steel Loose Part and Magnetite Scales >

Summary

- A carbon steel loose part and magnetite scales on the surfaces of steam generator tubes could be distinguished by the phase angle of MRPC probe pancake coil signals.
- The phase angles from magnetite scales showed lower values by 20~30 degrees than those from carbon steel at all test frequency conditions.
- Thus, a foreign object of carbon steel would be discriminated from magnetite scales by a careful field analysis of phase angles from MRPC pancake coil eddy current signals