# Identification of Magnetite Scale in Eggcrate Support Plate Region of Steam Generator Tube from MRPC Probe Eddy Current Signals

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## 1. Introduction

The tube bundles in steam generators of commercial nuclear power plants are assembled in the support plate structure in order to reduce the vibration of tubes induced by the secondary side coolant flow and also, to maintain the gap between tubes of long free span. During operation of steam generator, magnetite scales, which are produced by the corrosion of secondary side carbon steel components, are deposited within the tube support plate region. The accumulation of scale depositions with operation time lead to the blockage of axial coolant flow holes (fouling) in the support plate, and also develop the environment of accelerated secondary side corrosion in steam generator tubes [1]. Therefore, it is required to diagnose the degree of scale build-up in the support plate region during periodic in-service inspections of steam generator tubes by eddy current tests, in order to evaluate the integrity of steam generator operation and determine the optimal point of time to apply the scale chemical cleaning process for degradation mitigation. In this work, characteristic of MRPC (Motorized Rotating Pancake Coil) probe eddy current test signals from magnetite scales in the eggcrate type support plate region are investigated using mock-ups, in order to find out that the deposited magnetite scale signals can be identified solely apart from the support plate structure signals.

## 2. Methods and Results

### *2.1 Manufacturing of Mock-up*

A mock-up of the eggcrate type support plate structure in steam generator of OPR-1000 was manufactured with AISI 409 stainless steel as shown in Fig. 1.

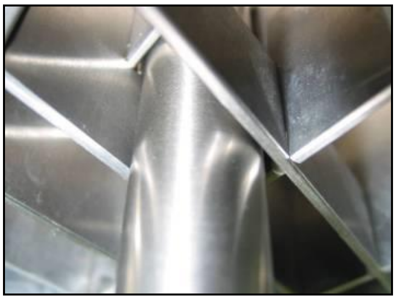

Fig. 1. Mock-up of eggcrate type tube support plate.

Magnetite scales of two types, flake and adhesive, were manufactured so that they had a bulk shape with same volumetric dimension [2]. The flake type scale simulates the condition where the hard scale has been in partial contact with the tube outer surface and support plate, and the adhesive type scale simulates the condition where the hard scale has been deposited tight on the tube outer surface. The scales were located on the outer surfaces of alloy 690 steam generator tubes, and inserted into the largest coolant flow hole up to the middle position of eggcrate support plate width as shown in Fig. 2

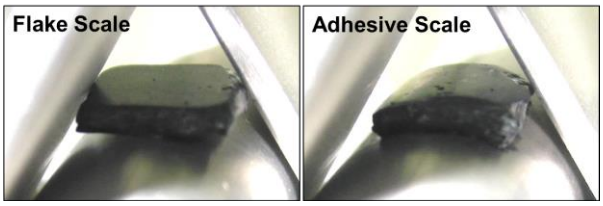


Fig. 2. Mock-ups of flake and adhesive type magnetite scales in the eggcrate type support plate region.

### *2.2 Eddy Current Test*

The mock-ups were inspected by using a ZETEC MIZ-70 eddy current data acquisition system with a ZRPS-DH3-E00.610 3-coil MRPC probe. A test frequency of 20 kHz was chosen considering the penetration depth of eddy current field, and the signals from the pancake coil were analyzed principally. The signals of tube support plate were calibrated to have a phase angle of 90 degrees, and the c-scan graphs of vertical and horizontal component distributions of eddy current signals acquired from mock-ups were analyzed respectively.

### *2.3 Results and Discussion*

Fig. 3 shows the c-scan graphs of MRPC probe pancake coil signals at 20kHz from the mock-up of flake type scale in the support plate. The c-scan graph of vertical component (upper graph) showed the geometry and distribution of both magnetite scale and eggcrate type support plate simultaneously, and it was impossible to discriminate between scale and support plate. However, in the c-scan graph of horizontal component (lower graph), the geometry and distribution of magnetite scale alone could be identified separately from the support plate. The amplitude of scale signal from peak to peak (Vpp) was measured to be 29.35 volts.

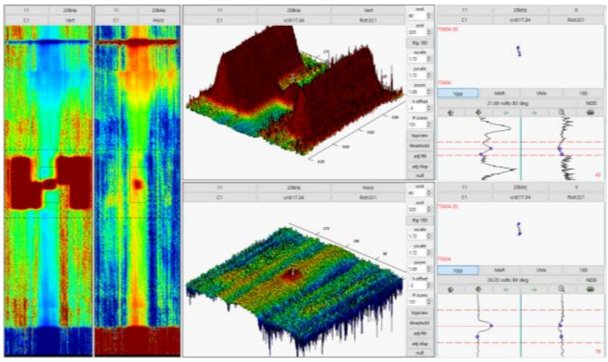

Fig. 3. MRPC probe pancake coil eddy current signal from mock-up of flake type scale in the eggcrate support plate.

C-scan graphs from the mock-up of adhesive type scale in the support plate were shown in Fig. 4, and it was found that almost the same results with those of Fig. 3 were observed. The amplitude of scale signal from peak to peak (Vpp) was 32.62 volts, which was similar to that of the flake type scale in Fig.3, and it was thought to reflect the same volumetric dimension of two type magnetite scales manufactured.

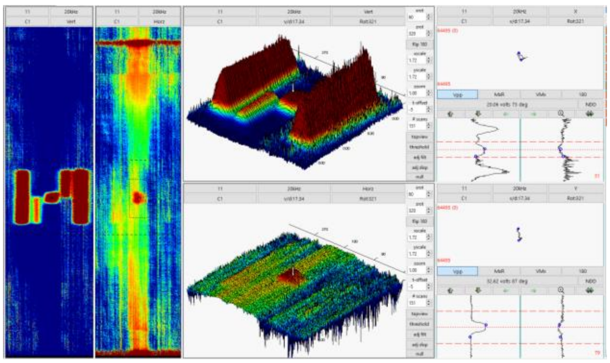

Fig. 4. MRPC probe pancake coil eddy current signal from mock-up for adhesive type scale in the eggcrate support plate.

These results implies that there are slight difference in the phase angles between magnetite scale and support plate signals. Thus, by applying the appropriate calibration process of phase angle rotation, which eliminate the support plate signals, the component of pure magnetite scale signals alone can be extracted and visualized. Finally, it is anticipated that both the distribution and the quantitative magnitude of magnetite scales deposited in the eggcrate support plate region can be evaluated by MRPC probe eddy current data analysis through this signal calibration technique.

## 3. Conclusions

Through the appropriate calibration process of phase angle rotation in the MRPC probe eddy current signal analysis, the magnetite scales deposited within the eggcrate support plate regions could be identified apart from the support plate structure. This signal analysis technique is expected to be applicable to the quantitative diagnosis of magnetite scale build-up in the support plate region during in-service inspection of steam generator tubes and the subsequent timely decision for performing the proactive degradation mitigation strategy such as chemical cleaning process of magnetite scales.

## ACKNOWLEDGEMENTS

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## REFERENCES

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