Eddy Current Signal Analysis of the Loose Parts on the SG Tubes

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Introduction (1)

Loose Parts (Foreign Objects) -

1. “Any object not part of a system or component per design. Including loose items that have the potential to cause damage to systems and components”

2. “Pieces of material located within the SG where it does not belong. The material could have originated from outside of the SG or from within the SG and could be metallic or non-metallic.”
   - By EPRI SG G/L Rev. 7
Additionally, this document recognizes the improved performance of new SG tubing materials in the absence of foreign objects and in the presence of good chemistry controls.

Historical possible loose parts are examined through the area of interest ..., “

Peripheral tubes, including tubes adjacent to no-tube lane regions, are included or added to a sample plan or considered a separate sample plan when there is reason to expect that loose parts are present or were introduced into the SG secondary side. “

Loose part wear damage mechanism is included in QDA practical examination, rev. 7”
Developments of the ETSS for LP(1)

Why ETSS?, Why LP Standard Tubes? (1)

- Newly employed inspection planning wrt the SGMP
- Need screening and surveillance methodology for the loose parts inflow esp. to the unexpected free span area
- Potential for the unexpected SG tube degradation due to the loose parts
- Urgent to develop loose part indication detection and characterization technique
- Need for the Eddy Current inspection guidelines and its revision
- Improvement of the SG tube eddy current confidence level
Developments of the ETSS for LP(2)

Why ETSS?, Why LP Standard Tubes? (2)

Phase Rotational Relationship bt’n LP Materials in the RPC Test
Developments of the ETSS for LP(3)

Flow Chart for LP Detection by Bobbin Coils ... Confirmed by RPC
Developments of the ETSS for LP(4)

Note

- The screening area includes the support structure and the free span area.
- Screen the long strip chat in the lower freq. differential channel (usu. Ch. 7, 20kHz)
- If needed, make process channel, P7 with 90 to 120 deg. for screening both mag. & non-mag. LP materials. (Currently the deg. of TSP is 90. in Ch. 7)
- Verify the distorted signal in the 300 kHz (mid. Range freq.) diff. Ch., whether it’s flaw or not. If defects, review the analysis history
- If not defects, resolve the PLP, deposit or non-relevant signal after the additional RPC retest
- Additionally, 150kHz diff. Ch. can be applicable in the case of non-ferromagnetic.
LP Standard Tubes(1)

- Reference standard tubes are needed for detection and characterization of the multiple variations of the specimens:
  - Cracking
  - Surface Roughness
  - Conductivity & Permeability Variations
  - Other materials’ Conditions

- How about LP? In the absence of LP STD tubes:
  - Experienced based LP data analysis
  - Trigger human errors
LP Standard Tubes(2)

LP STD tubes and manufacturing processes are under patent pending.
LP Standard Tubes (3)

Soft sludge manufacturing process
LP Standard Tubes(4)

Hard sludge manufacturing process
LP Standard Tubes(5)

Bobbin Coil Strip Chart

MRPC Strip Chart

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TORONTO
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EC Signal Analysis of Loose Parts(1)

Drill Metal Chip
L: 18mm
W: 8mm
T: 0.1mm
EC Signal Analysis of Loose Parts(2)

Drill Metal Chip
L: 6mm
W: 2mm
T: 0.1mm
EC Signal Analysis of Loose Parts (3)

DSI Detected in the unexpected area > suspected the affect of the LP > inspection expanded > confirmed LP
EC Signal Analysis of Loose Parts(4)
EC Signal Analysis of Loose Parts(5)
EC Signal Analysis of Loose Parts (6)

The assumed trace of the LP
EC Signal Analysis of Loose Parts

Normal neighboring structure signal (Stay Tie Rod) is not recordable. But even labor consuming, proactive attitude is necessary.
EC Signal Analysis of Loose Parts(8)
EC Signal Analysis of Loose Parts(9)
EC Signal Analysis of Loose Parts (10)
Conclusion & Remarks

• The methodology for detection and characterization of loose part in the secondary side of the SG tubes, presented in the ETSS was successful and verified its effectiveness by Bobbin and MRPC EC Graphics.

• In order to effectively detect the loose part per ETSS, the main screening frequency is the lowest 20kHz differential and MRPC can provide the tools for precise determining the loose part contact status and characterization.

• For the detection of the wear defect (loose part indication) induced by loose part can be surely detectable by applying +PT MRPC probe.

• In the case of the ferro and non-ferro magnetic materials, the phase angle of the simulated TSR (Tube Support Ring) of the 20kHz differential channel can be adjusted currently 90 deg. to 120 deg. This effectiveness has been shown.

• For the characterization of the loose part material, it is imperative to apply loose part standard tubes in the site steam generator inspection.