(18)

Go through pictures with Jamie - this appears to be significant

300kHz → 1 MHz

└ keep for show + ~~tell~~ -

Optimization of Eddy Current Inspection Techniques for Inner Diameter-Initiated Stress Corrosion Cracking

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Optimization of Eddy Current Inspection Techniques

- Eddy-current test techniques can be optimized for specific degradation modes.
- Design, construction and qualification* can be done rapidly.
- For inner diameter-initiated defects, the flaw signals can be enhanced and noise signals from OD sources can be reduced.

* EPRI Appendix H qualification

Background

- Recent industry experience of not detecting inner diameter-initiated stress-corrosion cracks (i.e., PWSCC) during SG tube eddy current inspections.
- Nondetected PWSCC flaws led to a SG tube failure.
- One contributing factor included the influence of tube OD deposits on the ability to detect PWSCC flawlike indications.
- Inspection techniques can be optimized to deal with plant-specific situations (e.g., high noise from OD deposits).

Reducing the Effect of OD Noise Signals

- As frequency increases, OD signals decrease.

- Smaller probes limit field penetration thus also resulting in smaller OD signals and increasing sensitivity to ID signals.

- computed the effect of adding a layer of copper on the OD of an Inconel tube. Demonstrates how noise reduction can be achieved with a simple increase in frequency.

- Modeled an 0.080-inch pancake coil.

- As the frequency increases, the magnitude of the impedance change due to the addition of the copper decreases and the phase is shifted.

- The magnitude of the impedance change at 1 MHz is a small fraction of the change at 300 kHz, and the phase shift is about 90°.

- Because operating at high frequencies over long lengths of cable can result in problems, going to even higher frequencies to obtain even better results may be problematic.

- we looked also at other impedance changes caused by calibration notches and lift-off.

- The figure shows the impedance for an 0.080-inch coil at 300 kHz. The variation produced by a copper backing was added to the tube and the response due to an increase in lift off of 0.010-inches is shown. The impedance change produced by a 20% ID notch and a 100% through wall notch are also shown.

- At 300 kHz, the response to the 20% notch, the copper and the lift off are all in the same direction.

- at 1 MHz, there is more phase separation between lift off and the 20% ID notch. Also, the copper signal is much smaller and its phase shift is nearly horizontal.

- Both the lift off signal and the amplitude of the 20% notch increase with increasing frequency; thus the use of a +Point probe can reduce this potential problem.

Probe Construction and Field Application

- Zetec constructed a small, high-frequency plus-point probe and delivered them within a week to the utility.
- EPRI performed an Appendix H qualification for the high frequency probe.

What about license qual?

- Results at this plant found that the flaw signal increased some and the OD noise signal decreased dramatically; thus improving S/N ratio.

- Tube inspected with the midrange plus-point probe at 40 kHz . A 70% deep defect is barely visible.

- Tube inspected with the 0.075-inch high-frequency plus-point probe at 800 kHz. The defect is easily seen.

- The noise signal amplitude decreased with frequency and its phase shift rotated horizontal at about 800 kHz.

- The defect signal amplitude increased as the coil size decreased

- The defect signal increased as the frequency increased.

- Voltage measured on notch standard with 100% notch set at 20 volts at different frequencies for the smaller high-frequency plus-point probe.

- increase in signal for each notch at each frequency

- Noise signal variation with frequency for midrange probe

- noise signal reduced with increasing frequency and the phase rotates

- Noise signal variation with frequency for high-frequency probe

- Noise signal reduced with frequency and overall smaller because of the smaller probe size

Summary

- Eddy-current test techniques can be optimized for specific degradation modes.

- Design, construction and qualification can be done rapidly.

- For inner diameter-initiated defects, the flaw signals can be enhanced and noise signals from OD sources can be reduced.

Regulatory Perspective

- The staff has requested that NEI/EPRI consider several closely related issues including expanding the guidelines on data quality, examination of small radius u-bends, and use of high frequency probes.

- Other papers at this meeting discuss these subjects.

- NRC will be dealing with this topic as part of various documents that are under development and utilities can expect some feedback from the NRC staff on this issue over the summer and fall.

Regulatory Perspective, continued

- Feedback will be provided in the following contexts:
  - Staff evaluation of the root cause of the Indian Point 2 tube failure
  - Regional inspection of circumstances leading up to Indian Point 2 tube failure
  - NRC "Indian Point 2 Lessons Learned" task group findings
  - NRC implementation of the recommendations of the "IP2 Lessons Learned" task group