Computer Modeling for Nozzle Examinations - Cost Saving Technology

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Regulatory Information Conference (RIC)
March 13, 2019
Outline

- Background
- Solution
- Application
- Benefits/Cost Savings
- Summary
Background – Ultrasonic Testing (UT)

- Instrument sends a voltage to a transducer (crystal)
- Transducer generates sound wave in component
- Sound wave reflects from flaws
- Echoes hit transducer, which converts them to electrical signals
- Instrument displays waveform of response amplitude versus time (A-scan)
- Detects conditions throughout the thickness of the component
- Can detect defects, measure length, and measure depth
Background - Problem

- Ultrasonic examination only works well when sound actually travels back to the probe.
- For complex configurations such as reactor pressure vessel, steam generator and pressurizer nozzles, ultrasonic probe angle and location selection is not trivial and requires modeling.
Solution – Computer Modeling

- Using analytic equations to describe the nozzle geometry, EPRI developed a computer model to determine the probe parameters necessary for flaw detection and sizing.
- The essential flaw parameters are determined based on experimental data acquired on EPRI nozzle mockups:
  - Nominal inspection angles (angles at the flaw)
  - Maximum misorientation angles
  - Maximum metal path length
Solution - Computer Modeling

Skew Angle Variation is Often Necessary for Complex Configurations
Application - Computer Modeling for Nozzle Examinations

• What it is
  – In general, NDE computer modeling is the systematic application of mathematics to document the performance of NDE examinations.
  – Nozzle modeling is used:
    • to define the essential variables during successful Appendix VIII performance demonstrations
    • as a tool by the performance demonstration administrator, ISI vendors, and utilities
    • to reduce the cost and complexity of demonstrations
  – EPRI has developed 3D computer models to assist in the complicated task of nozzle inner radius and nozzle-to-shell weld Examinations.
Application - Computer Modeling for Nozzle Examinations

• What it is
  – UT Examination Technique Design
    • Postulate flaw location on inside surface
    • Shoot 3D ray from flaw to outside surface
    • Determine probe position, angle, and skew to detect flaw on inside surface
  – UT Examination Technique Evaluation
    • Shoot rays from inside examination surface
    • For each position on inside surface, model returns best solution for the given UT probe position, angle and skew on the outside surface
    • Result is a coverage plot of the examination volume
    • Assesses adequacy of ISI vendor UT techniques
Application - Computer Modeling for Nozzle Examinations

- Use Model to Determine Probe Information
- Place Probe on Nozzle
- Ultrasonic A-scan & Data Image

Flaw Response
Computer Modeling for Nozzle Examinations

Benefits
- Demonstration sample design optimization was used to meet budget constraints (reduced the number of mockups)
- Demonstration sample UT fingerprinting accomplished at a significant saving
- Extending applicability of performance demonstrations eliminates need of building special “One-of-a-kind” samples
Computer Modeling for Nozzle Examinations

- In general mockups can cost $100,000 to $1 million each and take years to build.
- The EPRI computer models have been used to develop or assess examination techniques for over 300 nozzles.
- Cost savings are estimated to be approximately $200K per nozzle.
- EPRI has provided computer modeling for the majority of the utilities in the US and abroad.
Summary

- EPRI has developed mathematical models to assist inspectors in conducting ultrasonic examinations of nozzles.
- Nozzle modeling defines the examination parameters required (transducer probe skew, scan surface, radial position and metal path) to provide adequate coverage of the examination volume.
- These models have saved the industry millions of dollars over the past several years.
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