# SGTF / NRC Meeting

Virtual Meeting
February 23, 2023

# Agenda

| Time | Topic | Speaker |
|---|---|---|
| 1:00 pm | Welcome and Introductions | All Participants |
| 1:10 pm | Opening Remarks | NRC and Industry |
| 1:15 pm | Industry Presentation:<br>1. Recently Published Reports<br>2. Status of Industry Guidelines<br>3. Interim Guidance<br>4. Nuclear Energy Institute 03-08 Deviations<br>5. Recent Operating Experience – None to Report<br>6. Inspection Plans from EPRI TSTF-577 Implementation Letter (ML22200A268) Changes to implementation 100% for first inspection<br>7. SGMP ETSS Status<br>8. Eddy Current Simulation Software Status | Industry<br>H. Cothron<br>J. Mayo<br><br><br><br>S. Brown<br><br>R. Guill<br>J/ Benson |
| 2:45 pm | Break | All Participants |
| 3:00 pm | 1. Standard Technical Specification Section 5.6.7.c.2 – Reporting Tube Wear at Support Structures Less than 20 Percent Through-wall<br>2. NUREG-2191 Update Schedule | NRC |
| 3:20 pm | Address Public Questions/Comments | NRC |
| 3:30 pm | Adjourn | |

# Planning for SG Chemical Cleanings in PWRs, 3002020903, August 2022

- Comprehensive input listing and associated resources for what can be included in a secondary-side integrity assessment
- High-level methodology for performing a secondary side integrity assessment, utilizing collected inputs
- Process for determining the appropriate type and timing of chemical cleaning (including an example flow diagram for plant personnel to follow to execute the planning process)
- Discussion concerning how plants determine key values to assess the need to perform chemical cleaning on either a preventative or reactive basis
- Appendices containing plant examples of abbreviated secondary-side integrity assessments for planning for SG chemical cleanings

# Optimizing the Concentration of Titanium Dioxide for the Mitigation of Lead Stress Corrosion Cracking, 3002023844, August 2022

- Testing was performed using annealed Alloy 690TT and Alloy 800NG specimens manufactured from prototypic (unstressed) tubing material
  - PbSCC could not be accurately reproduced even in faulted conditions where both materials previously exhibited cracking.
  - This result suggests that properly fabricated operating materials are very resistant to PbSCC, even in faulted water chemistry containing lead.
- The heat of cold-worked Alloy 690TT plate used for this study was exposed to lead-containing solutions both with and without TiO2.
- The results of this testing will be used to develop protocols to determine how TiO2 can be qualified as a PbSCC inhibitor for plant use

# SG Secondary Side Inspection Maintenance Optimization Sourcebook, 3002023848, Sept 2022

- Steam Generator Degradation Database and other information was used in this report to provide consolidated guidance for balancing the cost of secondary side activities (for example, outage time, personnel dose, vendor costs) with the benefits (for example, better foreign object management, reduced risks of tube corrosion, improved heat transfer performance, and so on).
- New data analysis is provided to analyze the effects of adjusting SG maintenance frequencies on the effectiveness of those maintenance activities and on SG secondary side degradation
- Objective is to provide utilities with the technical bases needed to appropriately optimize the frequency of secondary side inspection and maintenance activities.

# PWR Dispersant Application Operating Experience Assessment, 3002020942, November 2022

- This report documents updated industry field experience with dispersant use through late 2020.
  - Evaluations on the use of cation conductivity measurements for Polyacrylic Acid (PAA) quantification
  - Evaluations of novel operations (such as batch/intermittent online addition and addition in the low pressure feedwater system)
  - Effects of PAA on resin performance and flowrate measurement accuracy.

# Primary-to-Secondary Leak Detection Limits and Confirmation Times for a SG Blowdown Rad Monitor System, 3002023847, November 2022

- The steam generator blowdown is a common location for placement of an online radiation monitor for leakage detection.
- The quantification of leak rate using this system is complicated by several factors
- This document provides discussion and analysis to compute the detection limit for leakage and ensure plants can meet the requirements in the *Guidelines*.

# SG Layup Sourcebook, 3002020943, November 2022

- This sourcebook is intended to provide utilities with the technical information to optimize layup practices given design and outage constraints.
- Information on SG layup practices was collected through an industry survey and industry webcast.
- The survey results and meeting minutes are documented
- Includes identification of best practices for the industry

# SG Tube Ding/Dent Characterization and Stress Corrosion Cracking Sizing Study, 3002023852, December 2022

- This report describes a methodology for performing depth and length sizing measurement of axial ODSCC at freespan dings and dents at quatrefoil TSP intersections.
- Sizing performance indices are included.
- Study of the physical ding or dent length as a function of the bobbin coil probe ding or dent signal amplitude is included.

# Simulation Model for Eddy Current Inspection Validation, 3002023849, December 2022

- This report presents the formulation of the computational model and the results of a simulation software tool, including a comparison of simulated eddy current data with acquired data.
- It describes the different features of the user interface that will allow a user to simulate eddy current inspection data of a specific defect and tube geometry.
- The model was shown to be capable of predicting the signals generated by commercial SG eddy current probes for various tube flaws.

# Generic Tube Degradation Predictions Revision 1, 3002023846, December 2022

- This revision updates the generic predictions to account for collective industry operating experience that has accrued during the past 10 years for Alloys 600TT and 690TT.
- Guidance has been added to aid operators in transitioning from generic to unit-specific forecasts—a topic of increasing importance as individual PWRs and PHWRs continue to accrue operating histories that may increasingly deviate from the predicted behavior of the corresponding generic units.

# Status of Industry Guidelines
# Jeremy Mayo, TVA, Chair SGTF

| Guideline Title | Current Rev # | Report # | Last Pub Date | Implementation Date(s) | Interim Guidance | Review Date | Comment |
|---|---|---|---|---|---|---|---|
| SG Integrity Assessment Guidelines | 5 | 3002020909 | Dec 2021 | 1/31/22 | None | 2025 | |
| EPRI SG In Situ Pressure Test Guidelines | 5 | 3002007856 | Nov 2016 | 8/31/17 | None | 2023 | Data will be checked in 2023 to determine if revision is needed |
| PWR SG Examination Guidelines | 8 | 3002007572 | June 2016 | 8/31/17 | Published 2019 and 2021 | | Revision in progress |
| PWR SG Primary-to-Secondary Leakage Guidelines | 5 | 3002018267 | Dec 2020 | 12/22/2021 | None | 2024 | |

| Guideline Title | Current Rev # | Report # | Last Pub Date | Implementation Date(s) | Interim Guidance | Review Date | Comments |
|---|---|---|---|---|---|---|---|
| **Primary Water Chemistry Guidelines** | **7** | **3002000505** | **April 2014** | **1/28/2015** | | **Review meeting planned for 2023** | **Decided not to start a revision in 2021** |
| **Secondary Water Chemistry Guidelines** | **8** | **3002010645** | **Sept 2017** | **6/27/2018** | **Published 2019, 2020** | **Review meeting planned for 2023** | **Decided not to start a revision in 2021** |

- No new interim guidance
- No NEI 03-08 deviations

# Inspection Plans from EPRI TSTF-577 Implementation Letter (ML22200A268)

# Changes to implementation 100% for first inspection

Steve Brown, Entergy, Chair SGMP RIC

# Inspection Plans for TSTF-577 – No Changes to Implementation of First 100% Inspection

| Plant Name | Amendment Approval or Submittal Date | Planned 100% Inspection |
|---|---|---|
| Plant 1 | Approved December 2021 | No Change |
| Plant 2 | Approved December 2021 | Completed Fall 2022 |
| Plant 3 | Approved January 2022 | No Change |
| Plant 4 | Approved March 2022 | No Change |
| Plant 5 | Approved May 2022 | Completed Fall 2022 |
| Plant 6 | Approved May 2022 | No Change |
| Plant 7 | Approved October 2022 | No Change |

# SGMP ETSS Status

# Samples Destructively Analyzed to Support MAPOD Calculations - Lab Cracks Available

- Destructive analysis lab has finalized report on 18 Axial PWSCC samples
  - SGMP QA process complete, ready for flaw injection process
- Destructive analysis lab has completed preliminary report on 20 Circumferential ODSCC samples
  - SGMP QA process ongoing
- 2023 Axial ODSCC destructive analysis process ongoing
- In 2023 the destructive analysis examination of Circumferential PWSCC samples will begin
- 2022-2023 Circumferential ODSCC flaw development

# Updating Existing Axial ETSSs – Transition Appendix H Techniques to Appendix I ETSSs (Using MAPOD)

| | |
|---|---|
| 20501.1 | X-Probe 300 kHz Axial PWSCC at Expansion Transitions, TC-7700 |
| 20501.2 | X-Probe 200 kHz Axial PWSCC at expansion transitions, TC-7700 |
| 20502.1 | X-Probe 300 kHz PWSCC axial indications at <2 volt dented support structures, TC-7700 |
| 20502.2 | X-Probe 200 kHz PWSCC axial Indications at < 2 volt dented support structures, TC-7700 |
| 20508.1 | RG3-4, 0.043" wall at 400 kHz, Axial PWSCC at Expansion Transitions, Miz 30 and Miz 70 |
| 20508.2 | RG3-4, 0.043" wall at 270 kHz, Axial PWSCC at Expansion Transitions, Miz 70 |
| 20509.1 | RG3-4 400 kHz axial PWSCC at dented support structures, Miz 30 |
| 20511.1 | Plus Point 200 and 300 kHz Axial PWSCC at expansion transitions, Miz 30 |
| 21503.1 | Axial PWSCC, .115 Pancake, at expansion transitions 300 kHz 0.043" wall and 200 kHz 0.050" wall |
| 21505.1 | Detections of Axial PWSCC at Expansion Transitions, 080 HF Pancake coil, 400 kHz |
| 21505.2 | Detections of Axial PWSCC at Expansion Transitions, 080 HF Pancake coil, 600 kHz |
| 24511.1 | Intelligent Probe, 400/100 kHz Mix, Axial PWSCC at Expansion Transitions, MIZ 70 |
| 96703.1 | PWSCC- Axial Sizing, Plus Point, 300 kHz Miz 30/TC-6700, Dented locations |

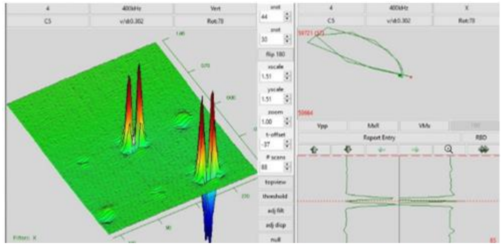
- Axial PWSCC
  - ETSSs will be reviewed by tube integrity peers to set priority
  - Flaw injection planned for spring 2023
  - Peer review planned for summer 2023

**Flaw Injection software will be utilized at certain locations (e.g., expansion transition)**

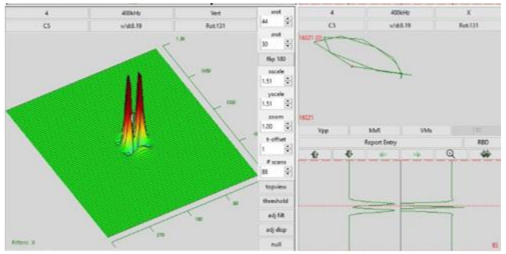
# Eddy Current Simulation Software

# Development of Simulation Software for SG Eddy Current Inspections

Acquired



Simulated



- **Objective**
  - Develop simulation modeling software to generate SG tube eddy current signals for various tube conditions (Flaws, Foreign Objects, Deposits)

- **Expected Benefits**
  - Simulation capabilities are available for specific designs of bobbin, rotating and array probes.
  - The software provides an inexpensive and fast method to simulate realistic field conditions and defect geometries without having to produce flawed tube specimens
  - The software is expected to be used for practical applications by utility engineers, inspection vendors, probe developers and NDE instructors
  - Can be used as a reverse engineering tool to determine the root cause of complex field data

# SGTSIM Capabilities – Tube, Probe and Defect Selection

- **Tube Geometry**
  - Freespan
  - TSP – Drilled

- **Probes**
  - Bobbin - Various probe diameters
  - RPC - Unshielded Pancake 0.115, +Point PP11A
  - RPC - Shielded Pancake 0.080
  - Array - 0.610 X-probe

- **Defect Geometry:**
  - Location - ID, OD
  - Defect Types - Rectangular, circular, groove
  - Real cracks with user defined depth profiles
    - Crack Orientation - Axial, Circumferential

# Report on Simulation Model Validation

EPRI

Steam Generator Management Program: Simulation Model for Eddy Current Steam Generator Inspection Model Validation

3002023849

Final Report, December 2022

2022 TECHNICAL REPORT

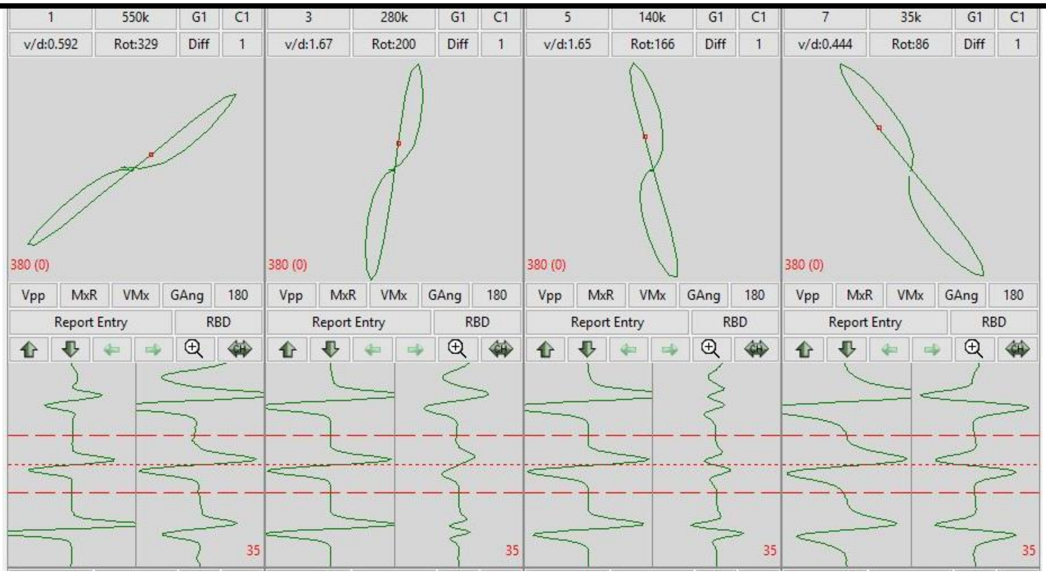
# Validation of ECT Simulation Software

- Data is acquired in the lab
- The specific probe and test parameters included in the acquired data are input into the simulation software
- The Simulated eddy current (EC) signals are compared to the Acquired EC signals
- Signal comparisons, at various modes and frequencies, include:
  - Signal shape
  - Signal phase
  - Signal amplitude

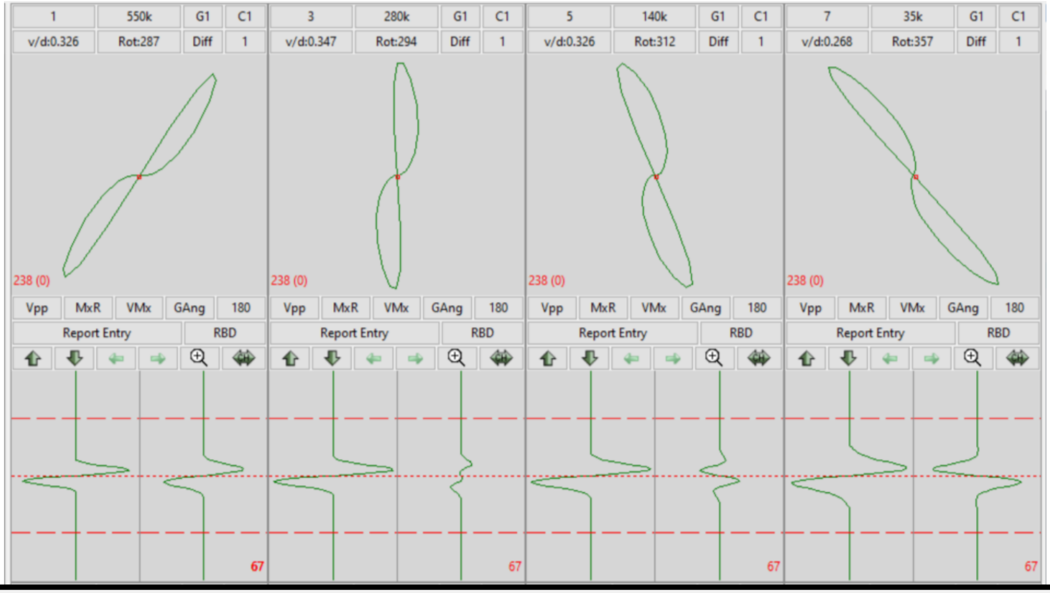
# SGTSIM Validation on Cal Standard Flaws

# Lissajous plot comparison of acquired and simulated differential channel data from 40% FBH for Bobbin 610 MR

**Acquired Data**

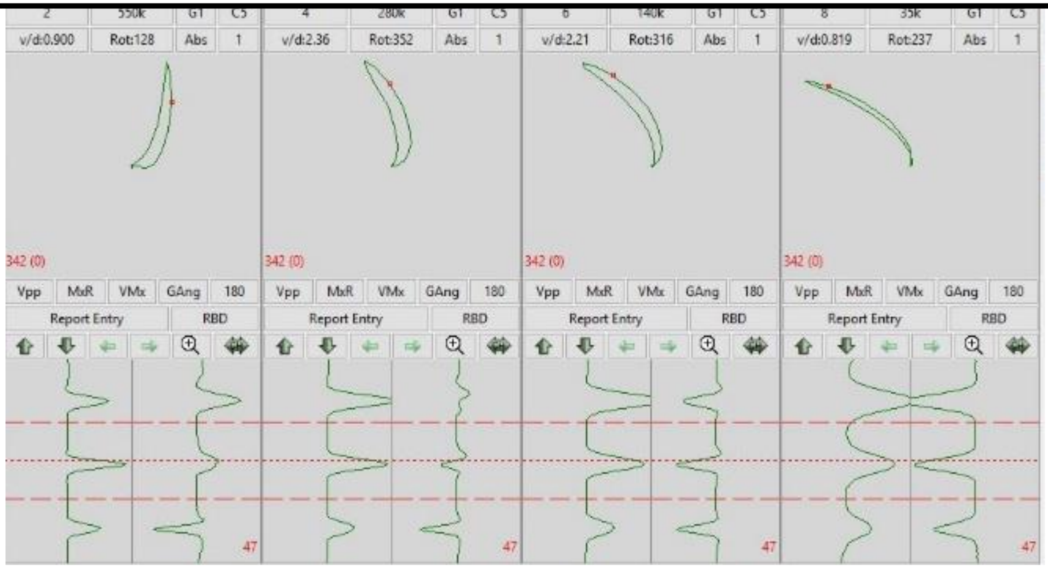



**Simulated Data**

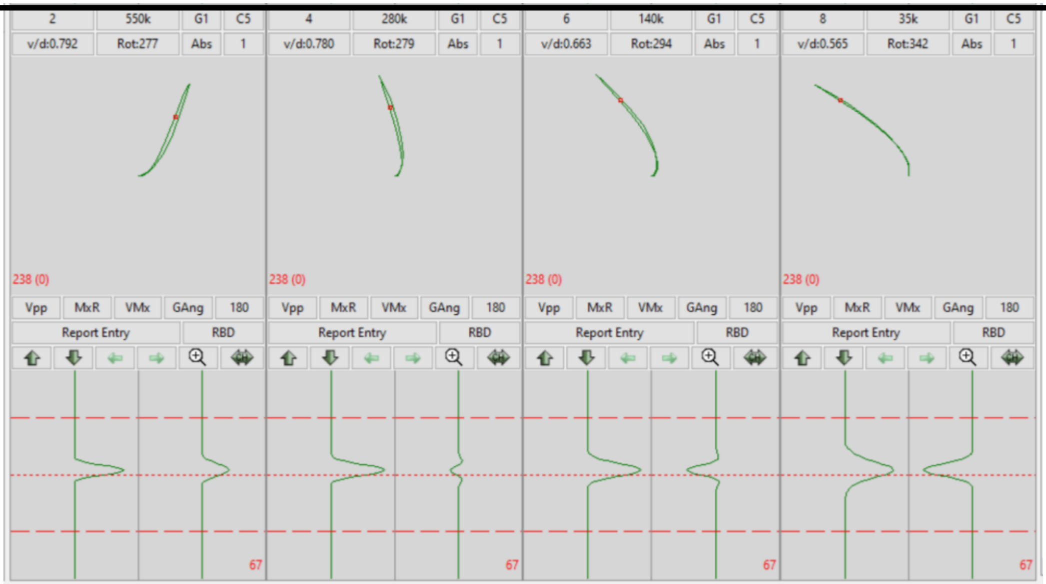


# Comparison of acquired and simulated absolute channel data from 40% FBH for Bobbin 610 MR

**Acquired Data**

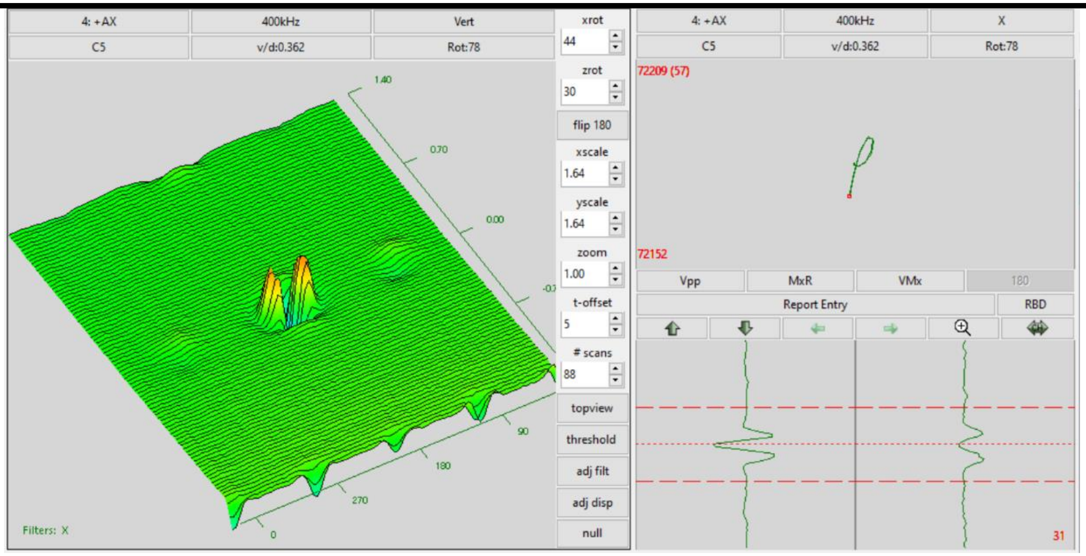



**Simulated Data**

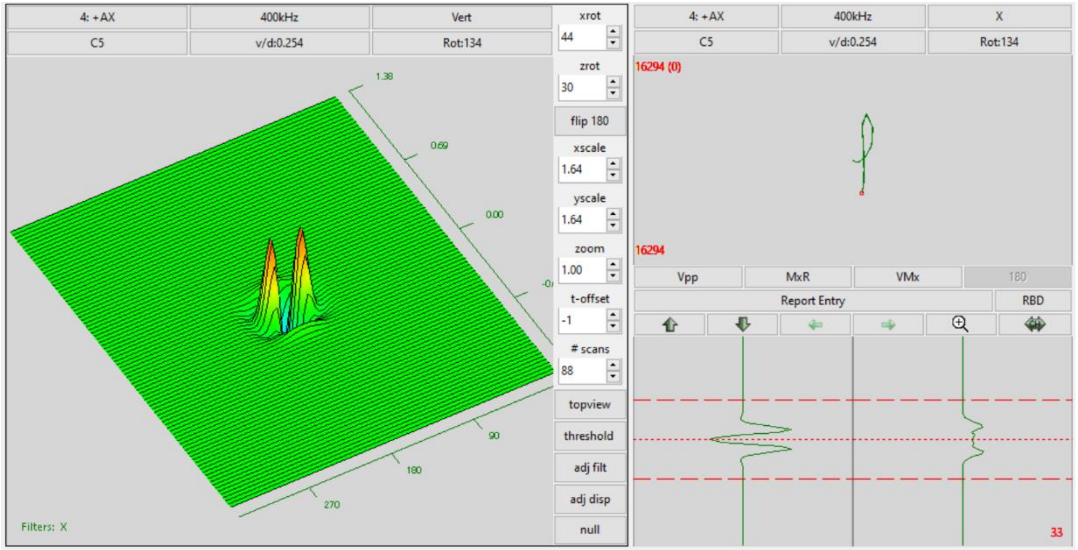


# Comparison of acquired and simulated data from 40% FBH for RPC +Point™

**Acquired Data**

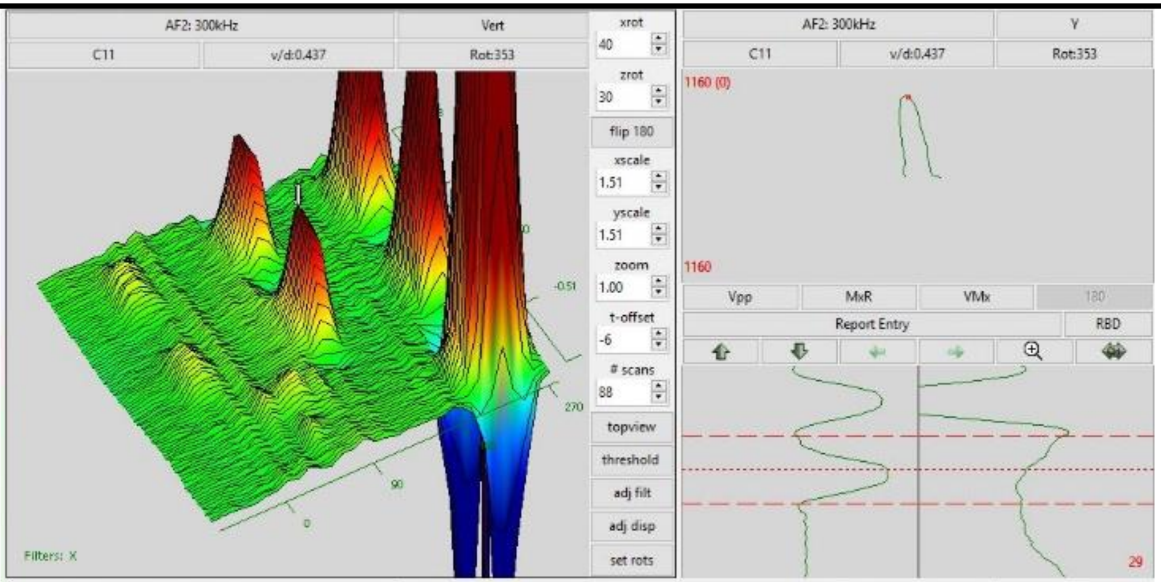



**Simulated Data**

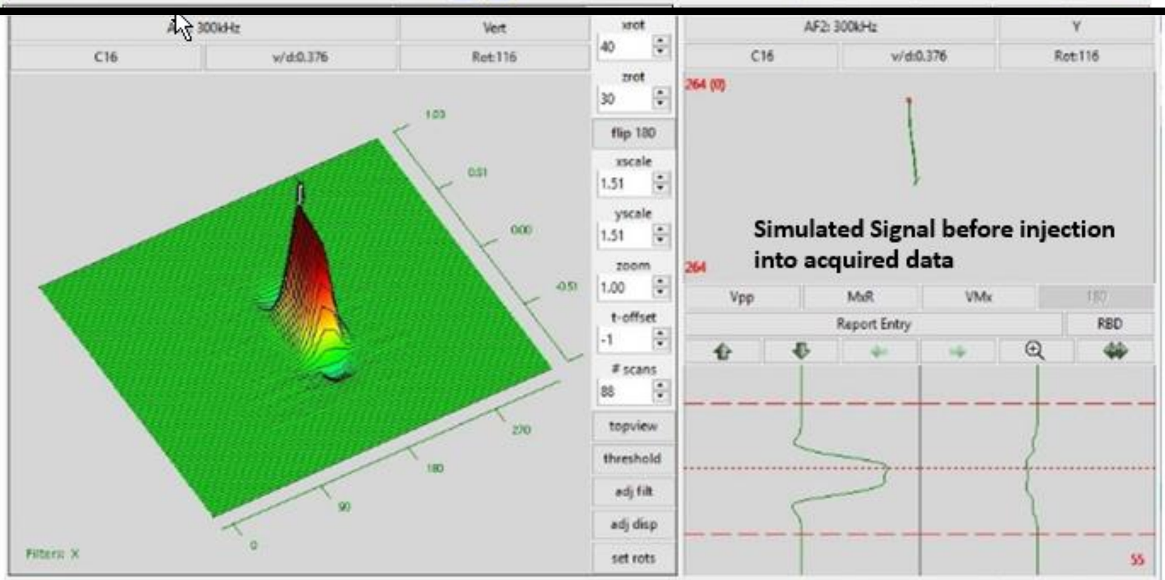


# Comparison of acquired and simulated data from 40% OD Ax EDM for Array 2x16

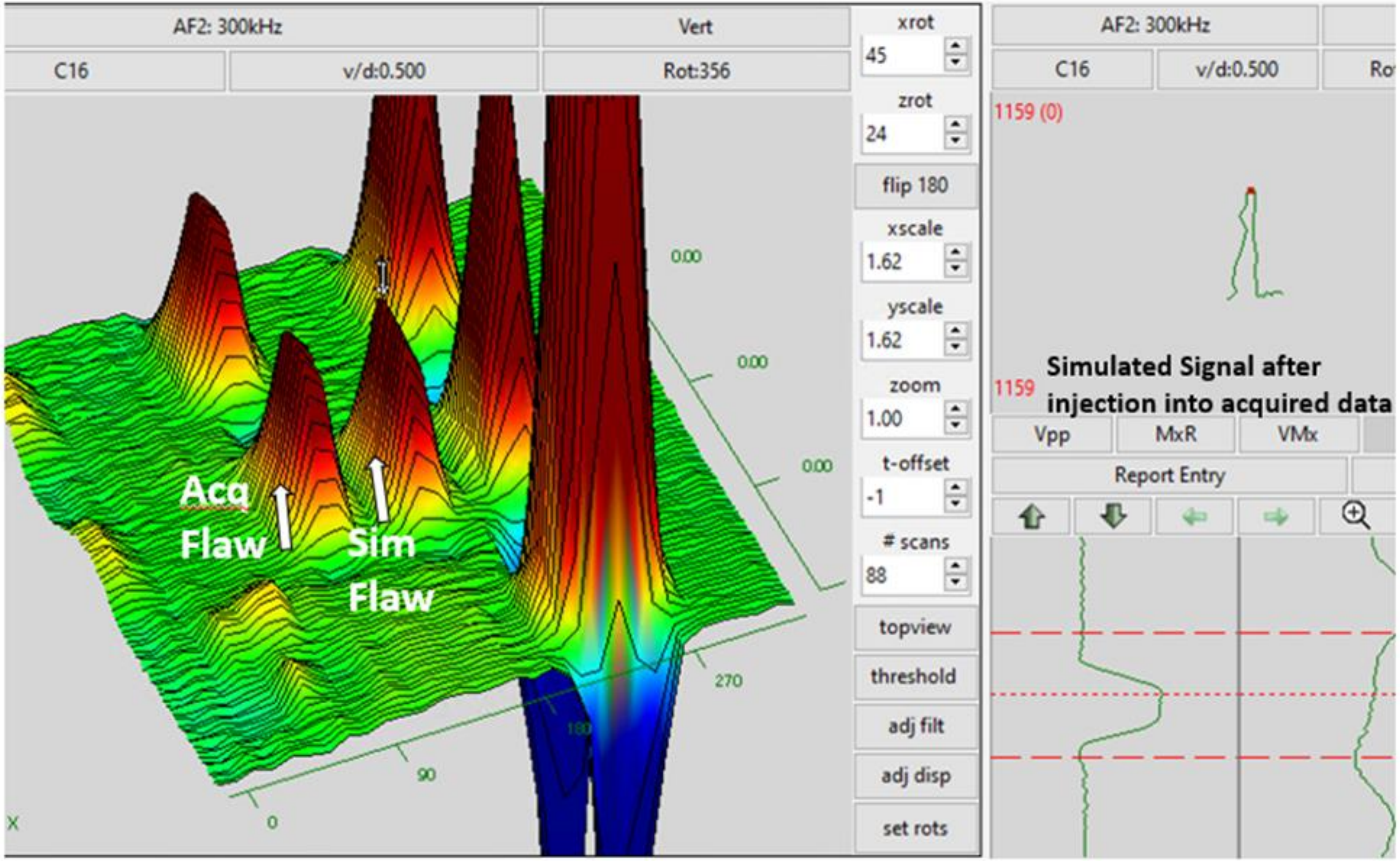
**Acquired Data**




**Simulated Data**

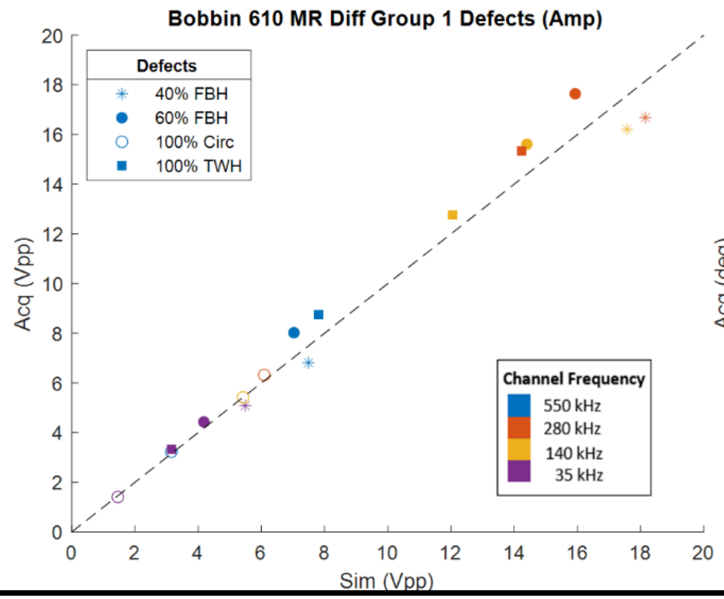


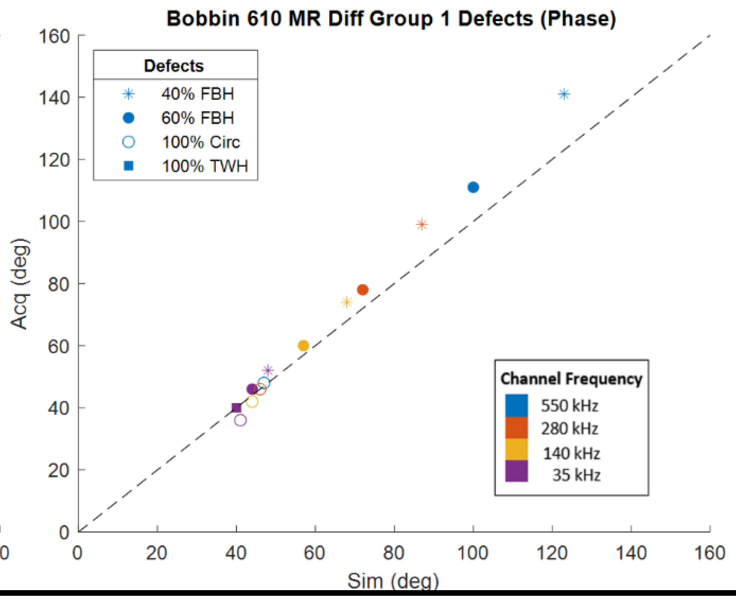
# Simulated 40% OD Ax EDM flaw signal injected into acquired data for Array 2x16



# Bobbin 610MR - Scatter Plot of Acquired vs. Simulated Flaws

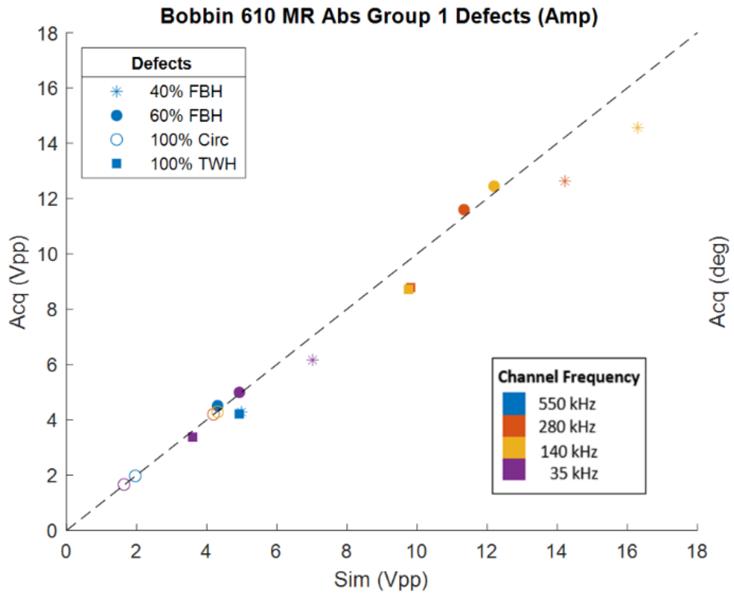
**Diff Channel (Volts)**

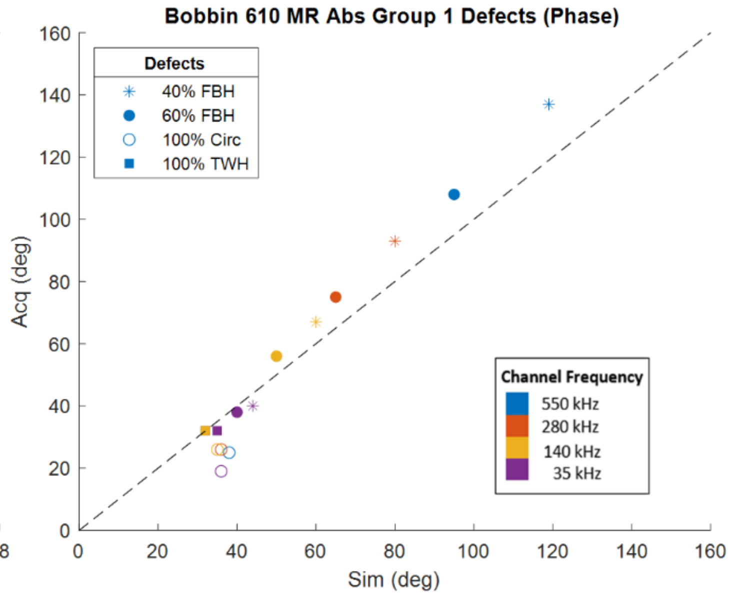



**Diff Channel (Phase)**

**Abs Channel (Volts)**

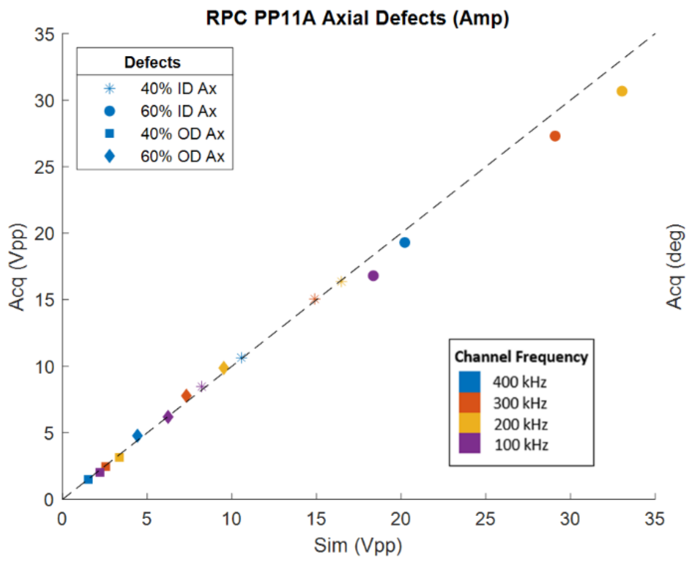


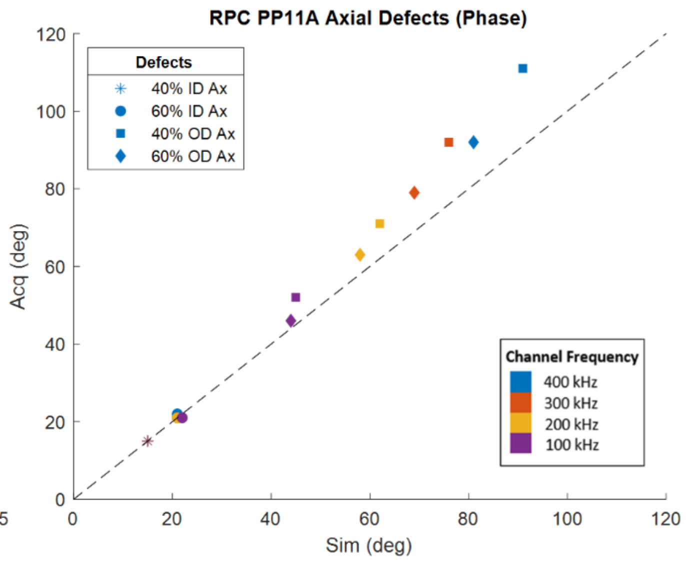




**Abs Channel (Phase)**

# +Point and Array - Scatter Plot of Acquired vs. Simulated Flaws

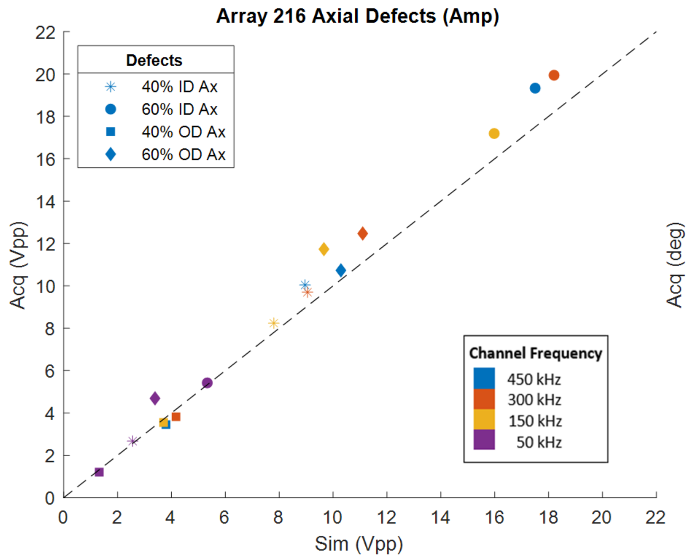
+Point (Volts)

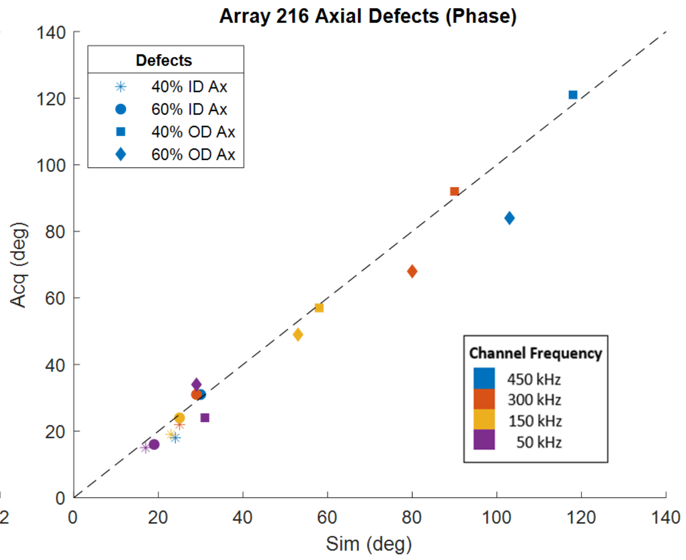



+Point (Phase)

Array (Volts)



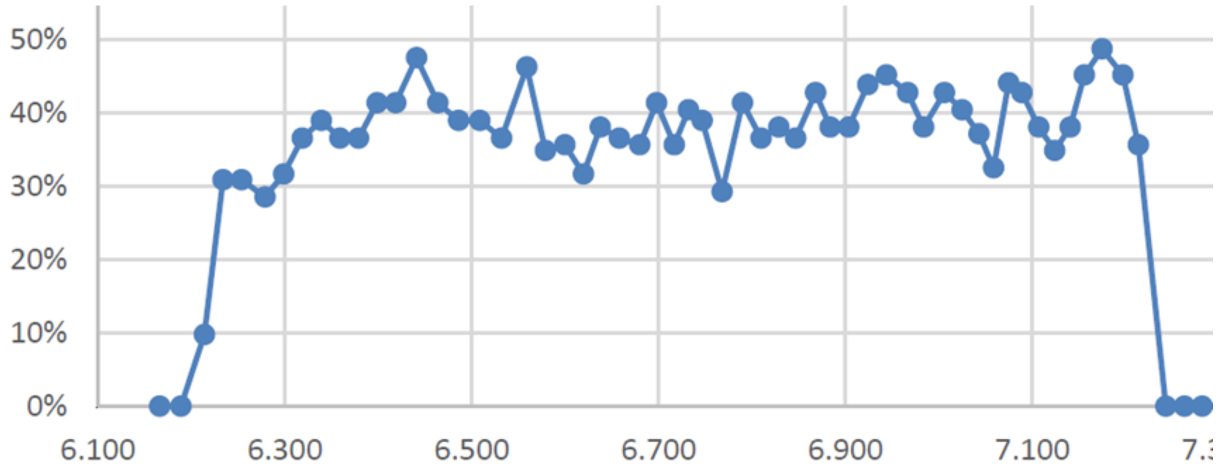

Array (Phase)

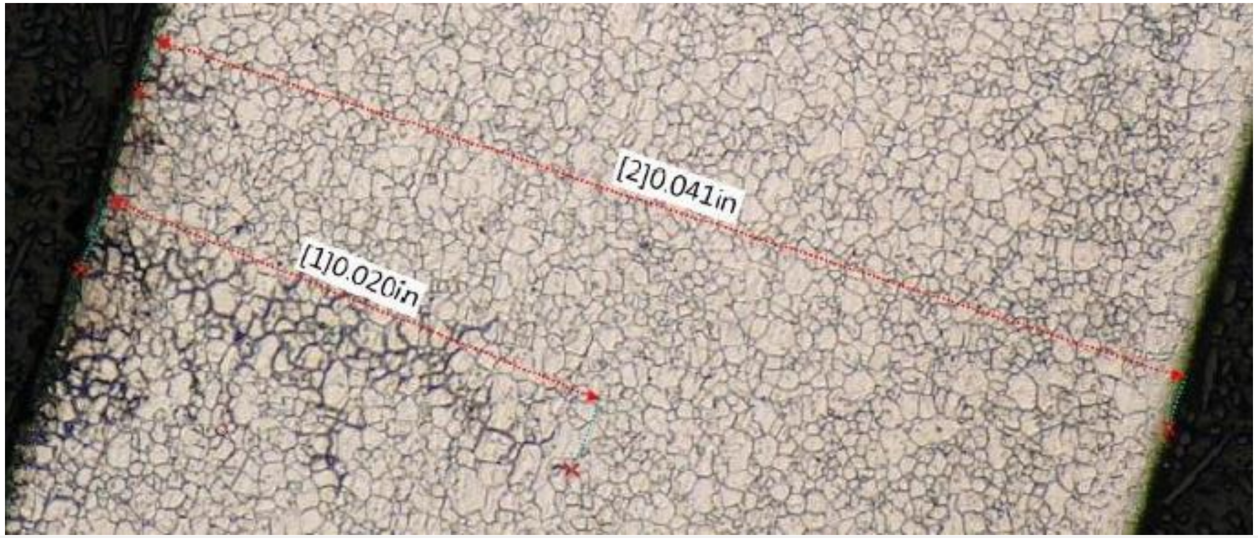
# SGTSIM Validation on Real Cracks

# SGTSIM Real Crack Simulation Module

- The “Real Crack” module is designed to create simulated eddy current signals representing cracks that are oriented either in an axial or a circumferential direction.
- Based on the availability of recent metallurgical data for twelve ID axial cracks, comparisons of acquired vs. simulated eddy current signals were made.
- When metallurgical data for ID circ, OD axial and OD circ cracks becomes available, comparisons of simulated vs. acquired eddy current crack signals are planned to be conducted.

# Met Crack Depth Profile and Photomicrograph for ID Axial Crack Specimen # 2205 Flaw 3



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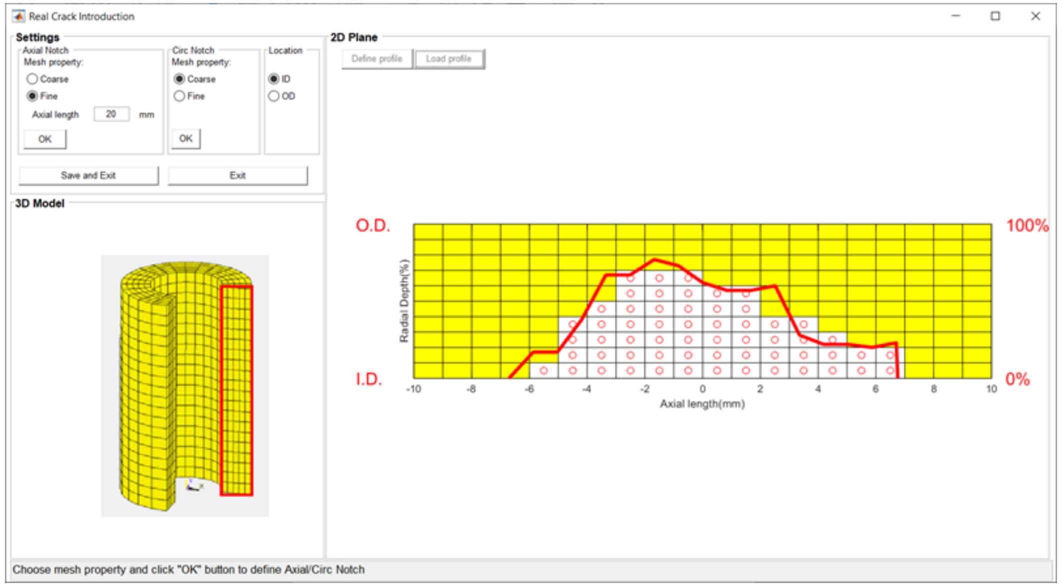
# Input Options for Simulating a Crack Signal with a Specific Depth Profile

1. Reading a Flaw Depth vs Location file from Excel into simulation software

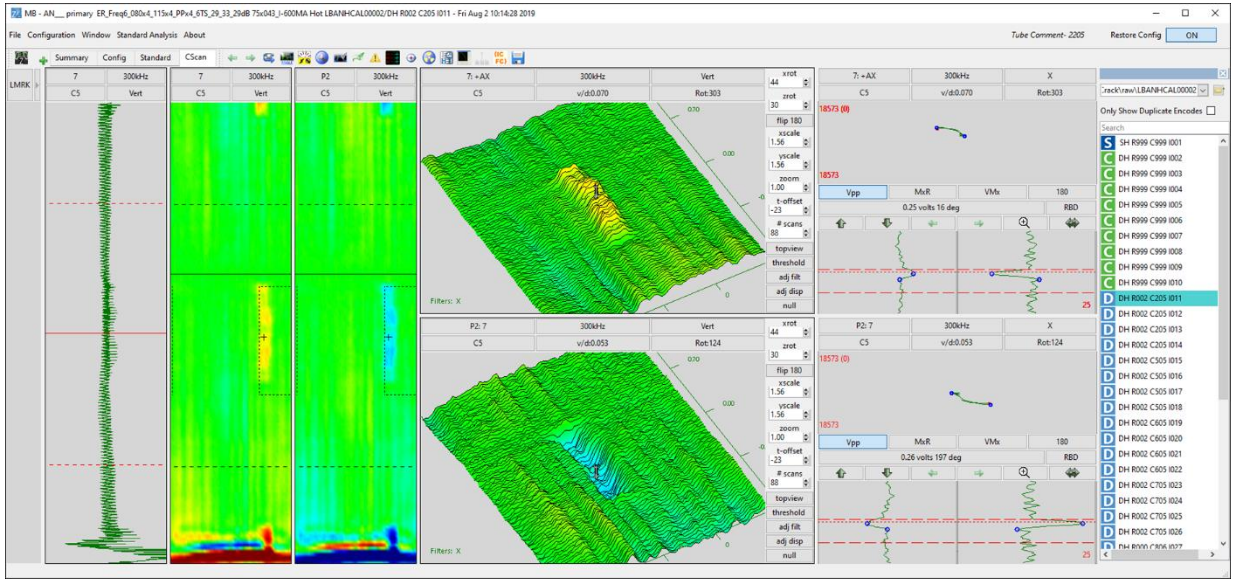
| Final Mount Height | Wall Thickness mils | Depth mils | % Through Wall | Distance From Marked End |
|---|---|---|---|---|
| 0.763 | - | 0 | 0% | 12.433 |
| 0.784 | - | 0 | 0% | 12.454 |
| 0.805 | 43 | 11 | 26% | 12.475 |
| 0.824 | 43 | 22 | 51% | 12.494 |
| 0.844 | 43 | 24 | 56% | 12.514 |

2. User can manually define the flaw depth profile to be simulated

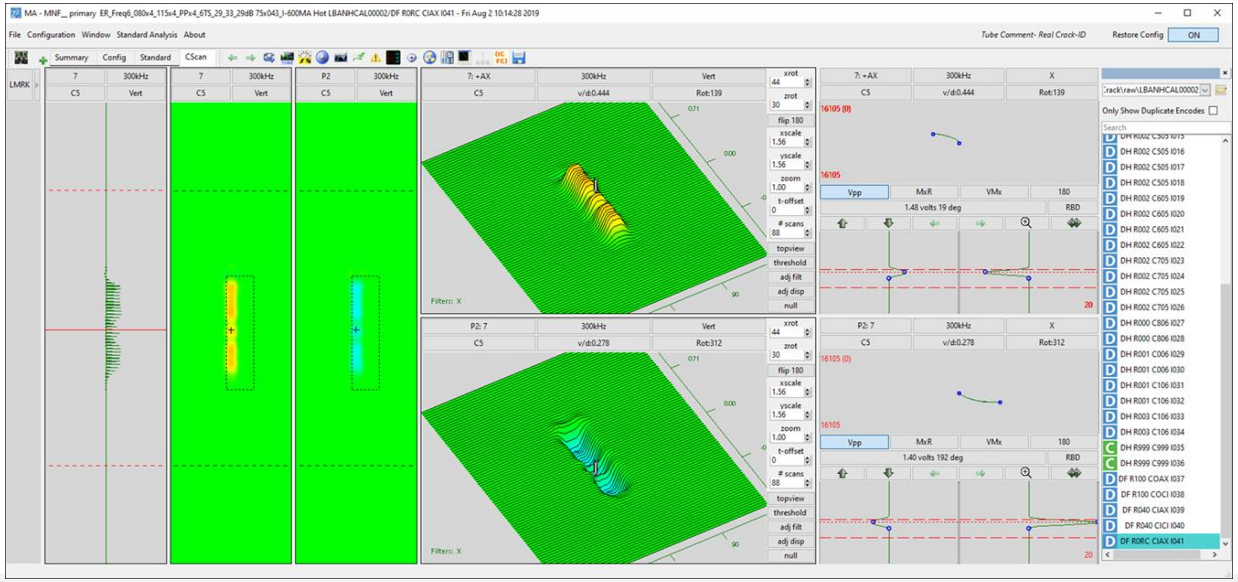


# Comparison of acquired and simulated data for #2205 Flaw 3 Real Crack profile using +Point™ probe coil at 300 kHz frequency

**Acquired Data**



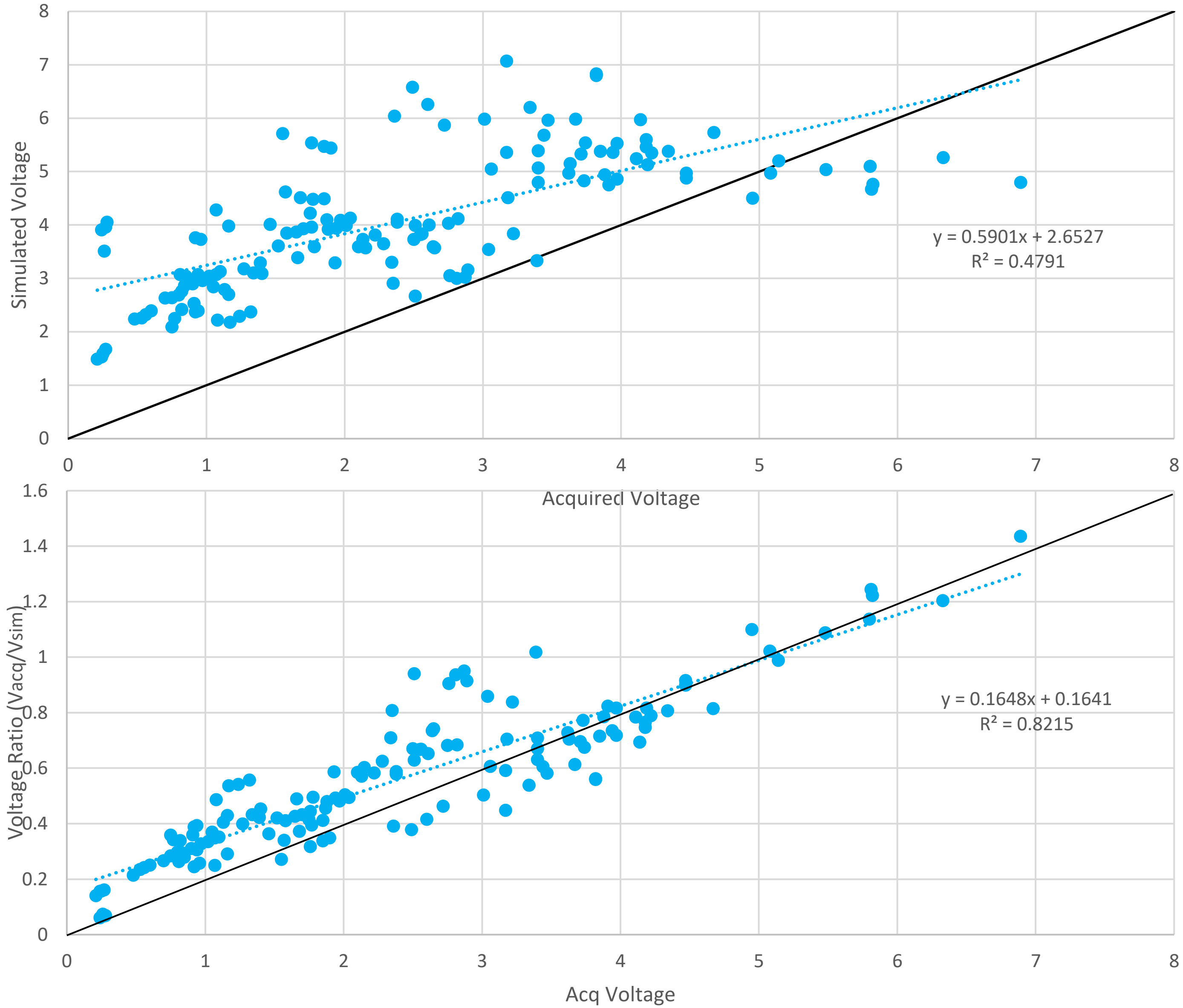
**Simulated Data**



# Simulated vs. Acquired Voltage (All RPC Coils) for All Cracks

**Simulated vs. Acquired Voltage**
(+Pt, 115 Pan, 080 Pan)

**Acquired/Simulated Voltage Ratio vs. Acquired Voltage**



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# Adjustments to Simulated Crack Signal Voltages

- The differences between simulated and acquired voltage values for crack signals can be attributed to the simulation software having a fixed crack width of 0.005 inches.
  - Field cracks with tighter widths can produce smaller amplitude signals
  - Field cracks with larger widths can produce larger amplitude signals.
- Based on the crack validation studies performed to date, adjustments to the simulated signal amplitudes can be made to account for cracks of various widths.

# 2022-2023 Deliverable Schedule

- Dec 2022: EPRI Technical Report (3002023849)
- Mar 2023: SGTSIM Version 6 (Beta) submittal to EPRI SQA
- May 2023: Release of SGTSIM Version 6 to Beta Testers
- August 2023: SGTSIM Version 6 (Final Release)

# Planned Tasks

- Develop additional array probe simulation models
- As lab cracks become available, validate the simulation code on:
  - ID Circ cracks
  - OD Axial cracks
  - OD Circ cracks
- Develop algorithms to produce simulated EC signals representing:
  - Foreign objects
  - OD tube deposits
  - Volumetric wear

# Summary

- A user-friendly software to create simulated eddy current data representing steam generator tube degradation has been developed.
- Simulated eddy current data, representing various probe designs (i.e., bobbin coil, rotating pancake coil, rotating +Point™ coil and array coils), has been successfully created with the EPRI simulation software.
- Parameters, that can be specified when creating an eddy current signal, include tube material, tube dimensions, tube conductivity, flaw dimensions, flaw orientation, flaw origin, and test frequency.
- The simulated data can be formatted so that it can be displayed within SG vendors' eddy current data analysis software.
- Comparison of acquired eddy current signals with simulated eddy current signals, representing flaws of defined dimensions, show promising results.

# Conclusions

- The software can be used by steam generator tube integrity engineers or NDE specialists involved with a utility’s steam generator inspection program.
- Some of the potential benefits of the software include:
  - Performing reverse engineering to assist in the analysis and understanding of complex signals encountered during field inspections
  - Providing a means to quickly generate eddy current signals representing user defined flaws that can be used for training and testing of eddy current data analyst personnel and automated data analysis software systems (QDA, AAPDD, SSPD)
  - Providing inexpensive means to generate signals that can be used to determine eddy current probe and system performance (ETSS), including Probability of Detection (POD) for SG tube flaws

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