Steam Generator Task Force Meeting

September 4, 2025

Agenda

1:00 pm	Welcome and Introductions	All Participants
1:10 pm	Opening Remarks	NRC and Industry
1:15 pm	Industry Presentation:	Industry

1. Recently Published Reports
2. Status of Industry Guidance
3. Interim Guidance
4. NEI 03-08 Deviations
5. Recent Operating Experience
6. Industry's perspective on reporting of secondary side activities (including what would cause a notification to the NRC?)
7. Status of SGMP project to develop a sizing technique to be used on the outside of the SG tubes

Agenda (continued)

2:25 pm	NRC presentation on the recently issued NUREGs 2191/2192, 2221 Supplement 1	NRC
3:00 pm	Address Public Questions/Comments	NRC
3:15 pm	Adjourn	

Recently Published Reports
Helen Cothron

Calculating Primary-to-Secondary Leakage After an Accident Condition: Upper Bound Faulted Leak Rate as a Function of Operational Leakage, 3002032144, May 2025

- This report presents the results of an investigation using an advanced probabilistic model to assess anticipated leakage under a range of accident conditions if the accident condition was entered while a measurable operational primary-to-secondary leakage was occurring.
- Accident condition leak rate statistics are evaluated relative to different pre-event operational leak rates, accident conditions, and SG design cases.

Hydrazine Alternatives for PWR/PHWR: Evaluation of Steam Generator Wet Layup Without an Oxygen Scavenger, 3002029321, June 2025

- Prior work (EPRI 3002020980) evaluated the possibility of steam generator wet layup with no oxygen scavenger and identified two technical gaps that would need to be addressed to provide the appropriate technical bases for a change to chemistry guidance:
  (1) an acceptable general corrosion rate of carbon steel and low alloy steel,
  (2) the susceptibility to crevice corrosion. This work evaluated the available information for closing these two technical gaps.

Methods for Estimating Steam Generator Tube Support Plate Blockage, R1, 3002032169, August 2025

- This is a revision to a report published last year to include additional operating experience
- This report discusses the three main methods for estimating tube support broached hole blockage.
- Provides the technical basis for each as well as discussion of advantages, disadvantages, and biases in each method.
- Includes recommendations for employing each method as well as discussion of operating experience from plants utilizing these methods.

Status of Industry Guidance
Kester Thompson

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	Revision in progress
EPRI SG In Situ Pressure Test Guidelines	5	3002007856	Nov 2016	8/31/17	None		Revision in progress
PWR SG Examination Guidelines	8	3002007572	June 2016	8/31/17	Published 2019 and 2021 – Included in revision		Revision complete – Guideline will be published in 2025

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		2027	Reviewed 2025 - No revision recommended
Secondary Water Chemistry Guidelines	8	3002010645	Sept 2017	6/27/2018	Published 2019, 2020, 2023	2027	Reviewed in 2025 - No revision recommended
PWR SG Primary-to-Secondary Leakage Guidelines	5	3002018267	Dec 2020	12/22/2021	None	2026	Reviewed in 2024 - No revision recommended

Recent Operating Experience

Industry's perspective on reporting of secondary side activities

Kester Thompson

Overview

- Utilities can operate longer between primary side inspections with the adoption of TSTF-577
- Some utilities perform secondary side inspections when primary side inspections are not performed
- Utilities are required by plant technical specifications to submit a SG Tube Inspection Report (which includes the results of secondary-side inspections), but only after primary side inspections are performed
- How can the NRC staff be informed of secondary side inspection and maintenance when a SG Tube Inspection Report is not required?

Background

Current inspection guidance in Section 03.04 of NRC IP 71111 Attachment 08 (ML23226A223)

3. If sufficient inspection resources exist (within baseline procedure estimates) and if site or industry experience indicates a potential for secondary-side internals structure degradation, review or observe secondary-side examinations. Review the licensee's corrective action taken in response to any observed degradation. Confirm that the licensee is conducting the secondary-side inspections in accordance with its governing documents (e.g., Steam Generator Management Program: Steam Generator Integrity Assessment Guidelines, Part 10).

4. If the licensee has identified loose parts or foreign material on the secondary side of the SG, review licensee corrective actions. Specifically, determine whether the licensee has performed or planned repairs or engineering evaluations of the affected SG tubes and has inspected the secondary side of the SG to remove foreign objects (if possible). If the foreign objects are inaccessible (and have not been removed), determine whether the licensee has performed an evaluation that considers the potential effects of object migration or tube fretting damage.

Background

- Section 03.04 of NRC IP 71111.08, provides guidance to Inspectors for SG Tube Inspection Activities, including SG secondary side work
  - Sub-sections 3 and 4 contain elements that are not specific to SG ECT Tube Inspections. It includes:
    - Secondary side internals structure degradation, secondary side examinations, loose parts or foreign material, performed or planned repairs, inaccessible (or irretrievable foreign objects)
- Currently, Section 03.04 (SG Tube Inspection Activities) applies to PWRs with scheduled SG tube inspection activities.

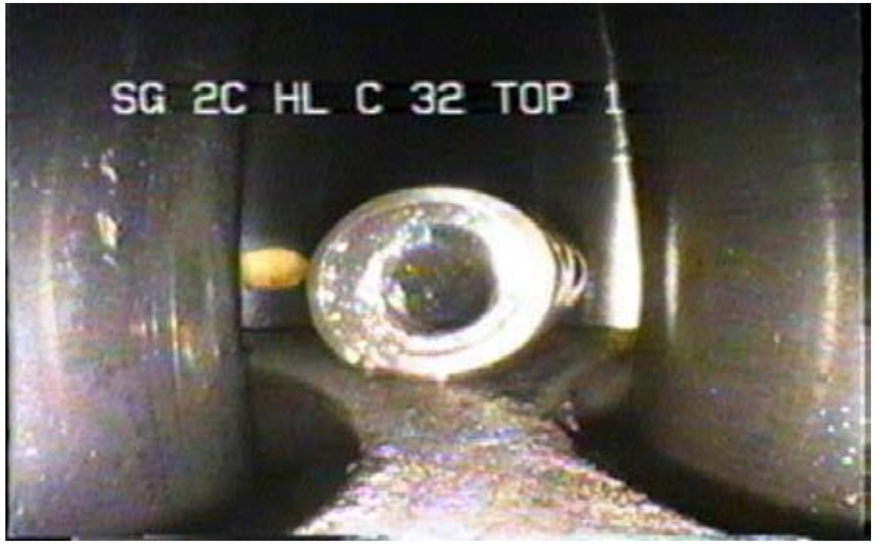
Industry Recommendations

1. Inspection guidance provided in sub-sections 3 and 4 of SG Tube Inspection Activities (03.04) may be used to develop a reporting criteria:
   - Criteria may be used by the ISI Inspector and may be applicable to all PWRs when primary-side inspections are not scheduled
   - Criteria may include the results of examination of SG Upper Internals as well as planned or performed repairs of components of the Upper Internals.
   - To implement this, a new section to IP 71111.08 could be added for a distinct Sample Type/Section. For example, Steam Generator Secondary Side Activities (03.05)
   - Specific Guidance for the new criteria (secondary-side activities) would provide a list of activities or results that require prompt notification by the Inspector to the staff at NRR

2. SGMP Integrity Assessment Guidelines is currently under revision by the industry
   - Recommend to the guideline revision committee to add a Recommendation to the SG Tube Inspection Report template:
     - Include the results of any past secondary-side activities since the prior SG Tube Inspection Report.

Update on Status of Secondary Sizing Technique
Rich Guill

Secondary Side Depth Sizing



- **Objective**
  - Develop a system capable of determining the size of wear scars from the secondary side of a SG
- **Background**
  - Foreign objects entering the secondary side of the SG during operation can cause tube OD surface wear damage
  - Design improvements of replacement SGs, including tube materials with improved corrosion resistance, have led to a reduction in the frequency of eddy current inspections
    - TSTF-577 allows utilities to increase the maximum time between SG tube eddy current inspections
      - Depending on tubing material, the time between inspections could extend to 96 EFPM

Secondary Side Depth Sizing – Would Avoid the Need for Primary Side Entry

- During outages when primary side SG eddy current (EC) inspections are not scheduled, SG secondary side visual inspections may be performed to identify and remove foreign objects
  - If tube wear is identified, it becomes essential to determine whether the tube requires repair or if it can be left in service

- A tool to measure wear from the secondary side of the tube eliminates the need for primary side entry
  - To date, no such NDE technique has been fully developed to perform a secondary side inspection or characterize wear scars

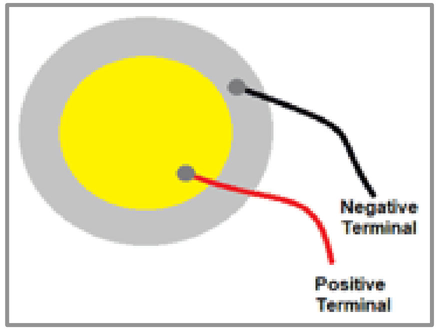
Possible Benefits of Performing SG Secondary Side Work During ECT "Skip" Outages

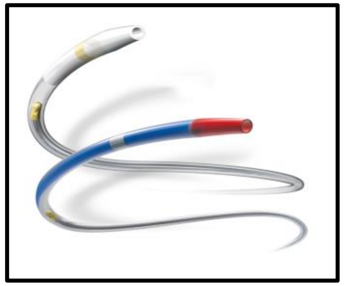
- With longer inspection intervals, allowed by TSTF-577, utilities are re-evaluating the intervals for performing secondary side inspections (SSI)
- Allows proactive cleaning and maintenance of SG secondary side before reactive approach must be taken
- Keeps secondary side clean from contaminants, that can lead to onset of cracking and other damage mechanisms
- Opportunity to remove foreign objects (FOs) that could lead to wear or tube leakage
  - Most recent primary-to-secondary leakage events have been caused by the presence of FOs

Investigation of potential methods for measuring tube wear from the SG secondary side

Technologies Researched

- Various methods of characterizing wear scars from the steam generator's secondary side were studied to determine the best technique for further development:
  - Ultrasonic guided waves
  - Polymer molding
  - Optical micrometer
  - Lasers
  - Piezoelectric Sensors
  - Acoustic Emission Testing
  - Pulsed Magnetic Field Leakage





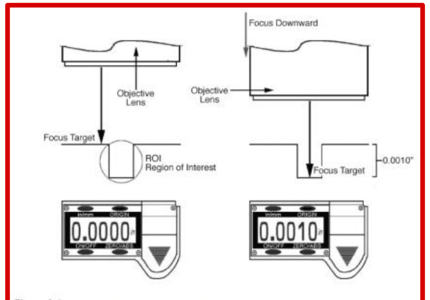
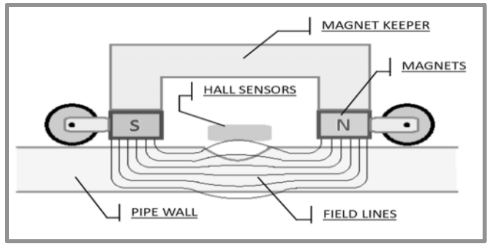
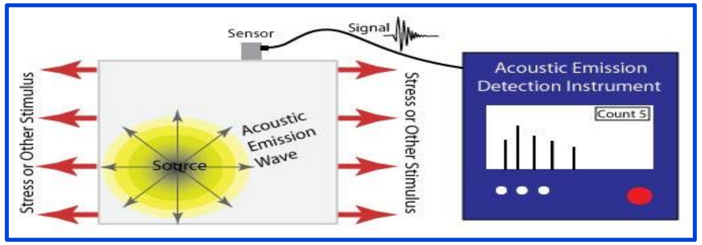


Figure 3-1
Detailed Diagram of How the Optical Micrometer Works





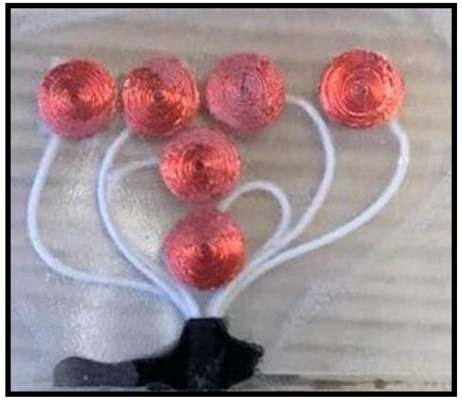
After researching over 30 potential non-destructive testing methods, an Eddy Current Array technique was chosen as the best method to quantifying flaw parameters

Investigate the Capabilities of Eddy Current Array Coil Technology

Eddy Current Array Feasibility Study

- Main goals for the Phase 1 study:
  - Determine the most appropriate coil size and configuration to perform wear depth sizing
  - Develop and produce a prototype Eddy Current Array (ECA) probe for inspection and sizing of tube wear
  - Validate the wear sizing performance of the ECA prototype

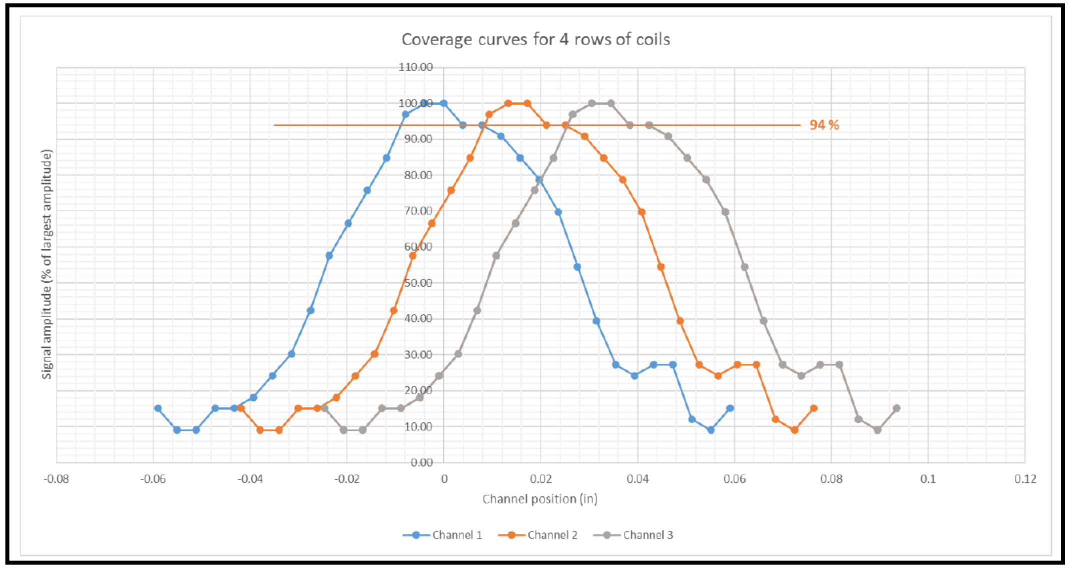
Eddy Current Array – Early Research



Single Element Prototype

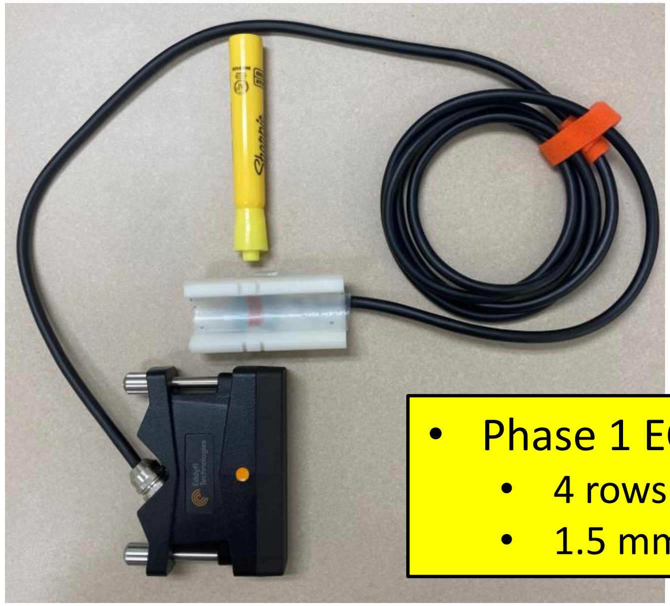
- Eddyfi was contracted for probe development
- A single element prototype was investigated to better assess the effect of EC test frequency on sizing accuracy
- Coil sets and dimensions were researched to give the highest accuracy without being excessively affected by EC noise

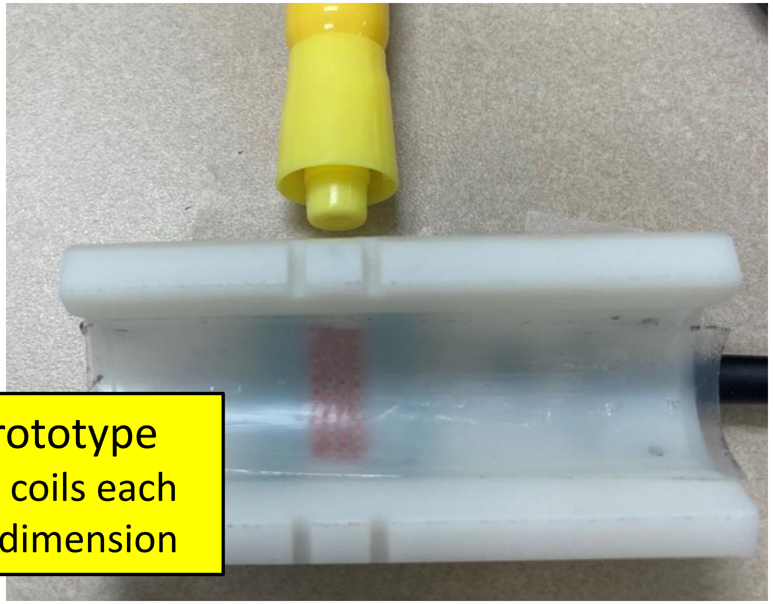
Eddyfi Ectane 2 Tester



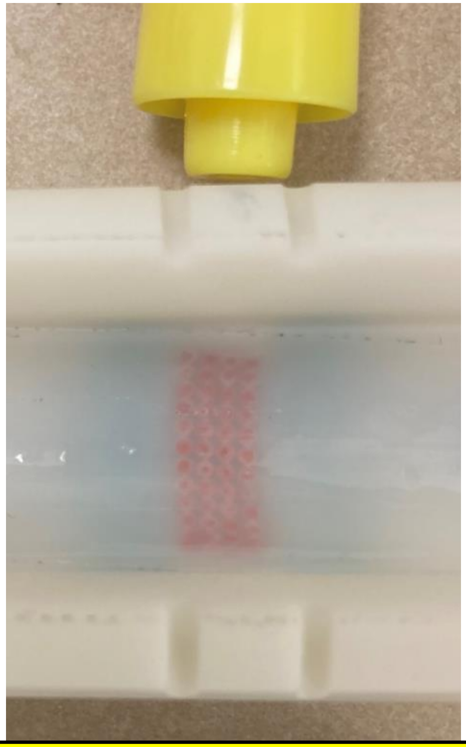
Four rows of coils produced a minimum signal amplitude of 94%

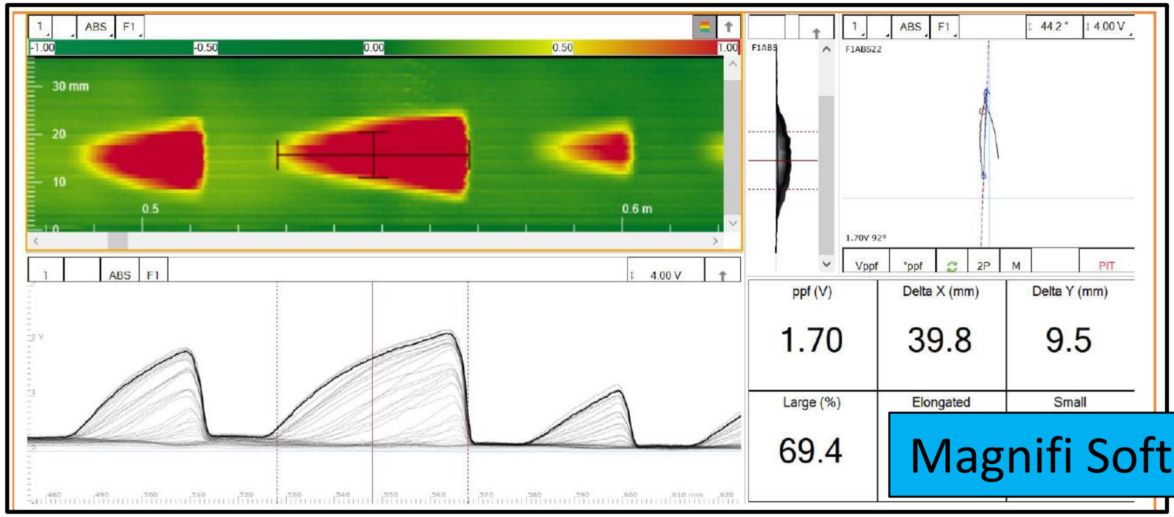
Eddy Current Array Prototype Probe (Phase 1)





- Phase 1 ECA prototype
  - 4 rows of 12 coils each
  - 1.5 mm coil dimension



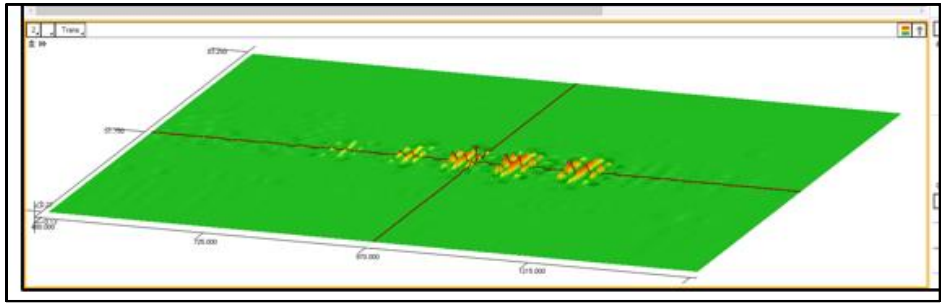


Magnifi Software layout

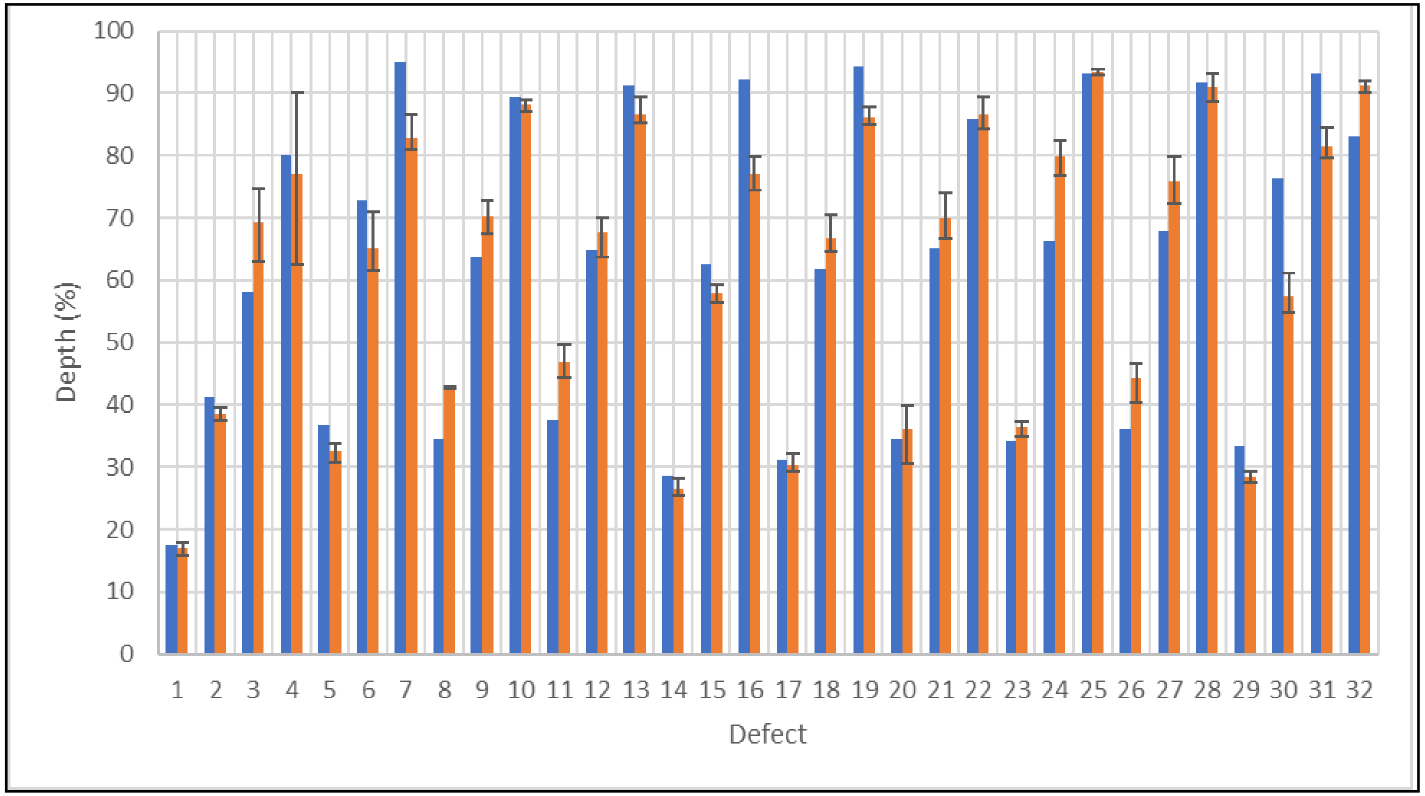
- Probe should ideally travel a full probe footprint distance before and after scar
  - Probe footprint indicated by notches marked on probe body (0.28”)

Dynamic Probe Measurements of Maximum Wear Scar Depth – Phase 1

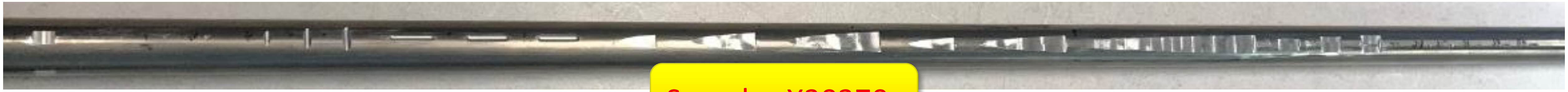
For all 32 wear scars evaluated, the ECA prototype depth sizing results provided an accuracy within ±15% TW compared to Met



Blue = Met Red = Measured



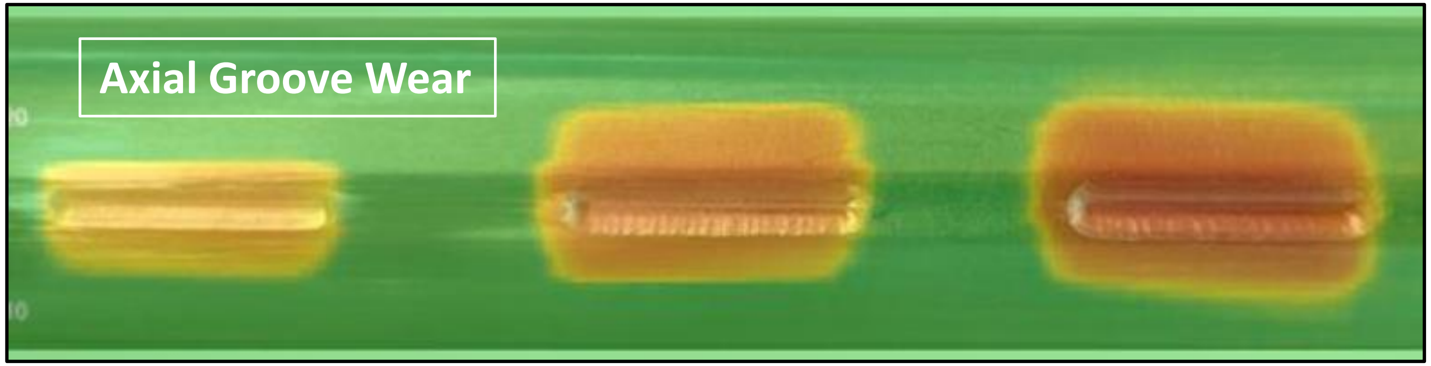
Note: Error range bars based on 3 separate ECA measurements

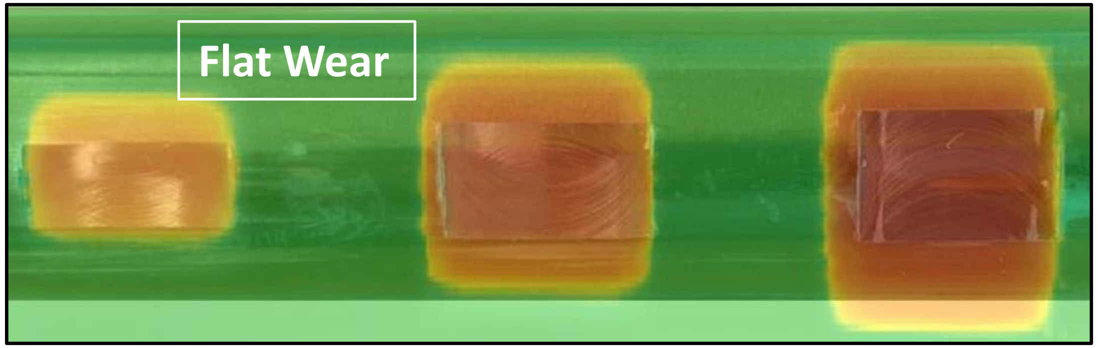


Samples X30370

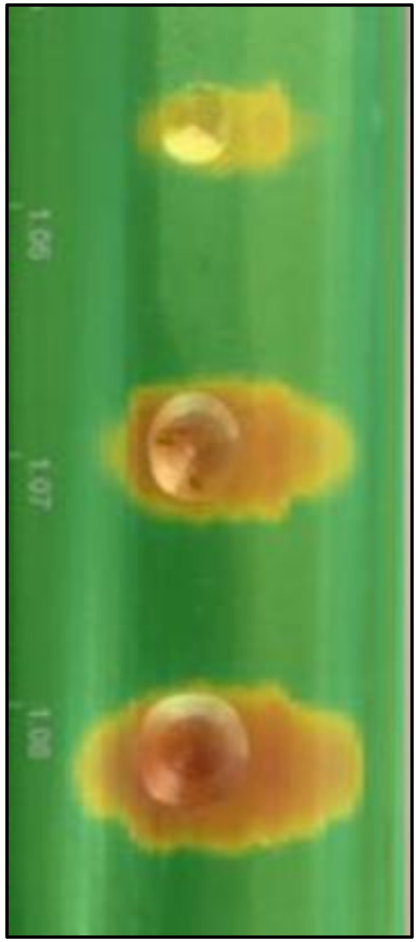
EPRI

Images Produces by Magnifi® Software with Wear Scar Superposed Over Defect Image





Tapered Round Hole Wear



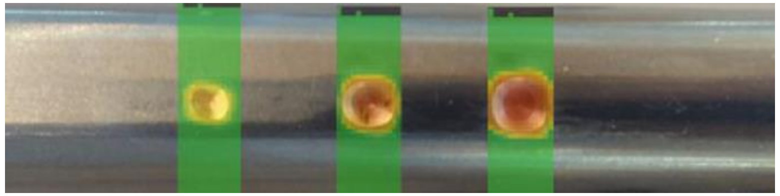
Developing Delivery System for a Secondary Side Probe Exam

- Framatome contracted for delivery system design
  - Design considerations
    - Tubesheet access - Will the probe get close enough to the wear scar?
    - Probe travel – Will probe need to travel in the tube Axial or Circ direction (or both)?
  - Framatome does not have an apparatus (e.g., arm coming off existing FOSAR equipment) that can deliver the probe
  - It was suggested to initially focus delivery system development on the outer most periphery tubes
  - If successful, then work to design a delivery system for tubes further into the bundle (e.g. four tube rows from periphery)

- Eddyfi challenged to determine if a "static" approach was feasible
    - This would eliminate having to acquire data at a known speed as the probe moves across the wear scar

Phase 2 - Eddyfi Static Probe Study

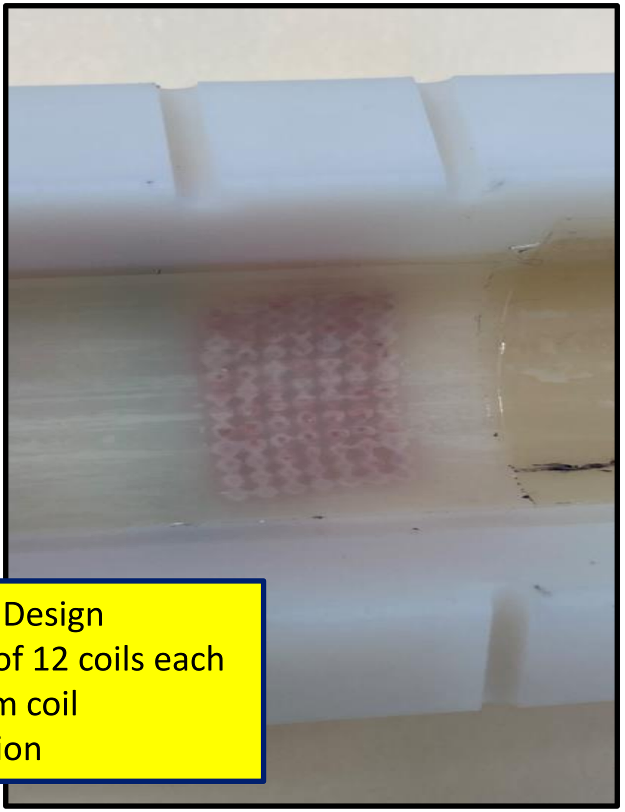
- Eddyfi conducted a feasibility study to evaluate the ability of a static probe approach to estimate wear scars depth
- Static tests were performed on selected wear scar defects
- The estimated maximum wear scar depths from the static tests were compared against the as-built depths of the wear scars
- Overall, 28 of 32 defect depths were sized within ± 15% of Met
- A redesign of the probe was planned to improve depth sizing accuracy



Potential Improvements to Static Approach

- Two modifications to the probe design were made to improve sizing performance

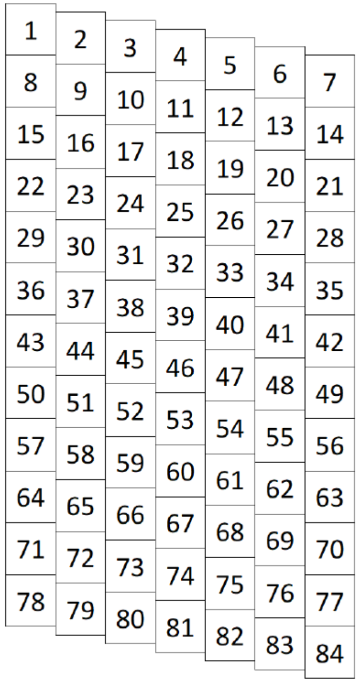
1. Redesign probe's coil arrangement by increasing the number of rows of coils from 4 to 7
   - Increased the physical footprint along the tube axis
     - Increased the probability the deepest point of the defect is scanned, especially for long narrow defects
2. Reduced the coil size from 1.5mm to 1.25mm
   - This will reduce the coil's field coverage, increasing the probability the deepest point of smaller defects are scanned



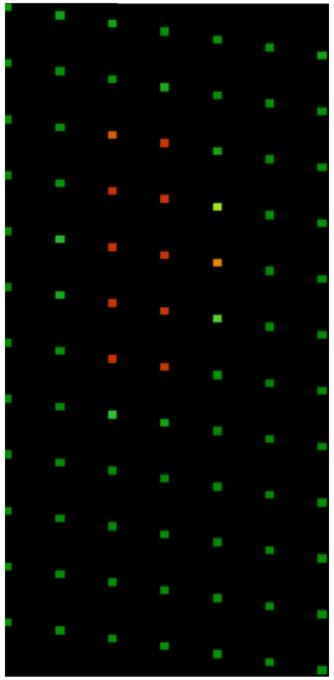
Modified Probe Design
- 7 rows of 12 coils each
- 1.25 mm coil dimension

Static Scan - Still Image of Defect

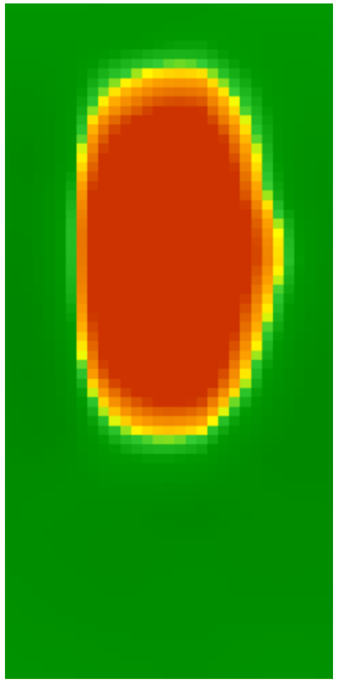
- Comparison of interpolated C-scan (right) with the schematics of the channel positions (left) and C-scan with only the detection coils activated (center)
  - Example of static C-scan where each colored square (center) represents the signal received by each coil when scanning a defect



Coil set and position



Each colored square represents the signal received by each coil

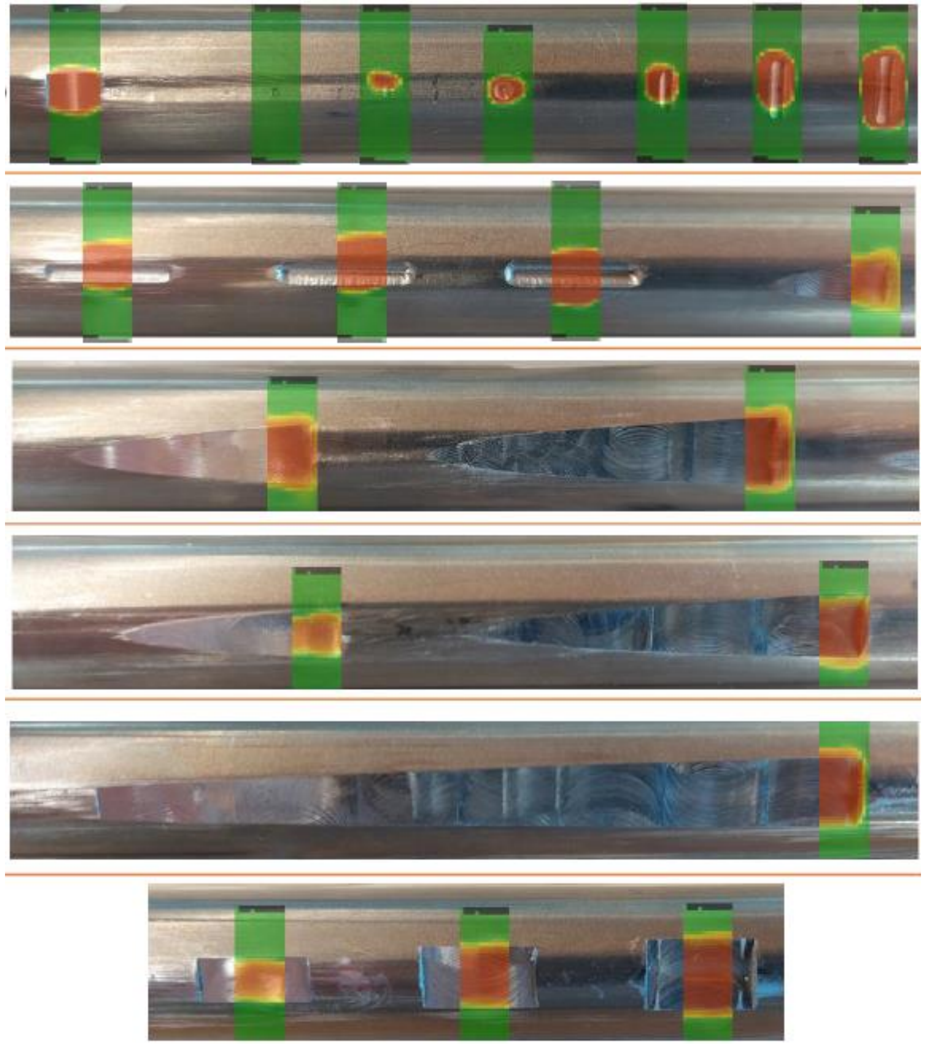


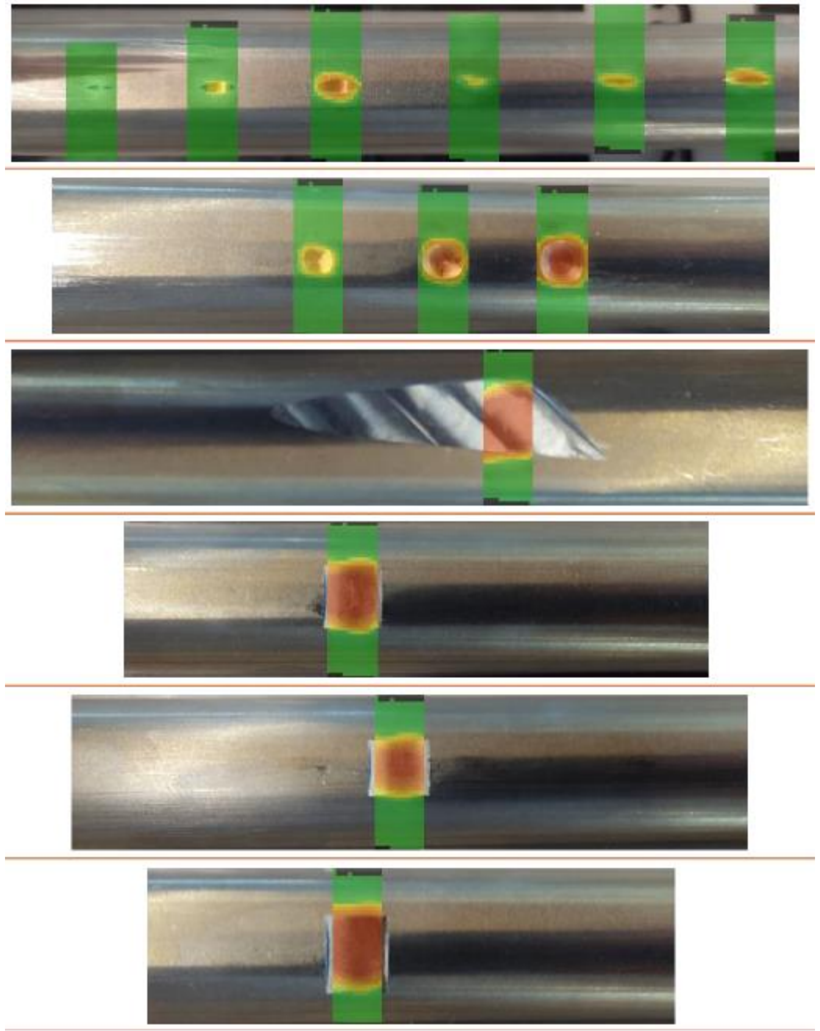
C-scan obtained using interpolated channels

EPRI

C-scans of All Defects, Machined Defects Superposed

- For large defects, only a portion could be covered by the probe in a single scan

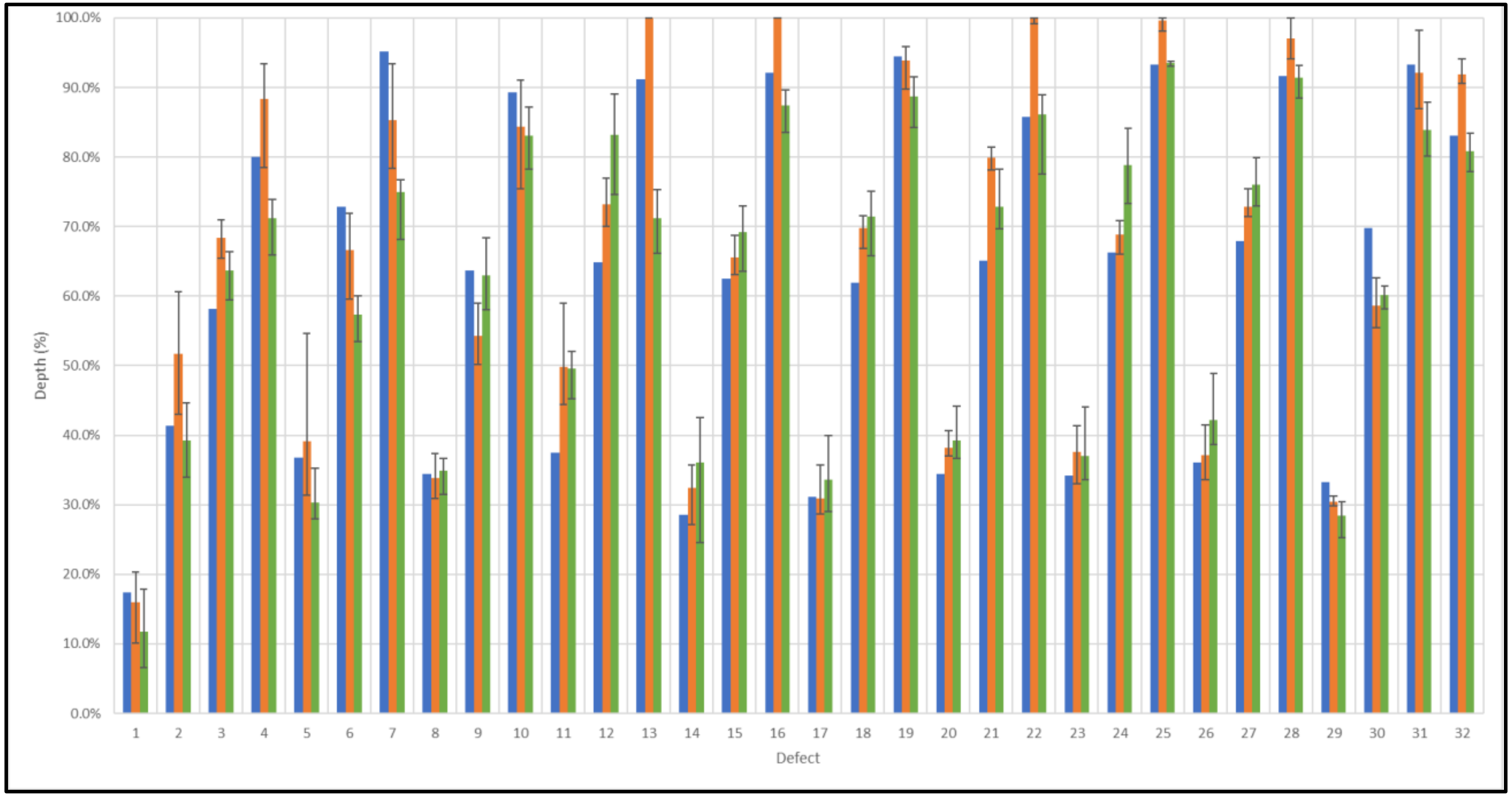




Comparison of Static Probe Measurements of Max Wear Scar Depth

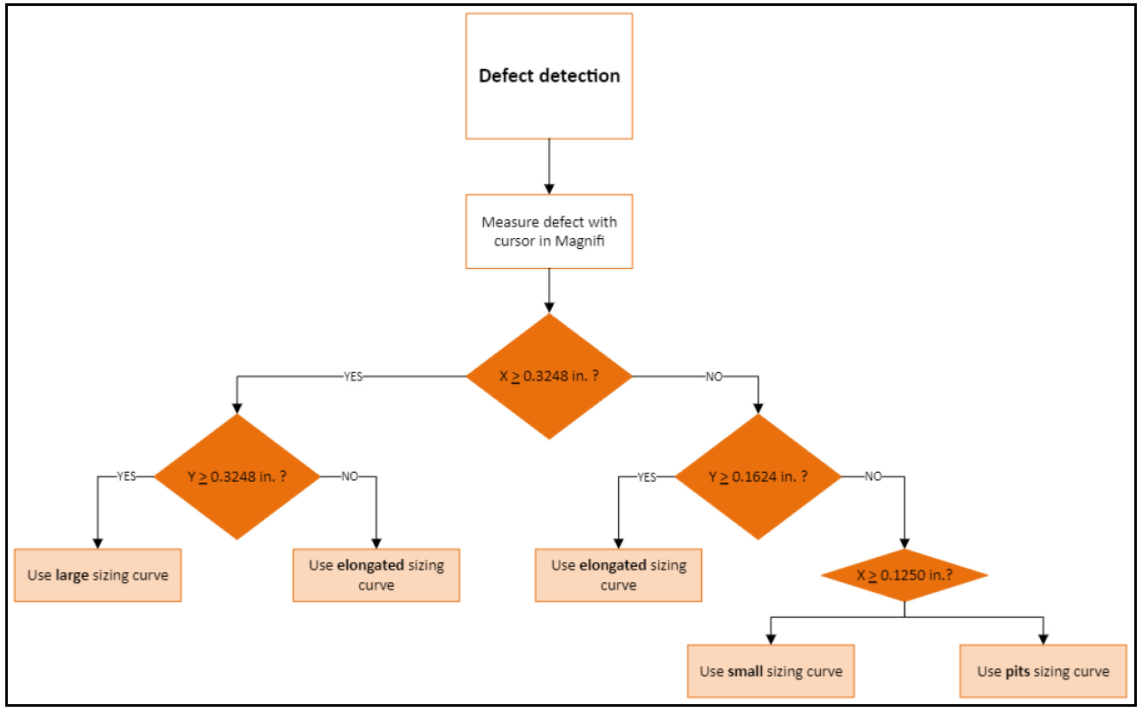
- Number of wear scars measured within ± 15%TW of the max wear scar depth:
  - Old Prototype: 28 of 32 (Flaws 6, 7,12 and 13 differed from metallurgical depth by more than 15%TW)
  - New Prototype: 32 of 32

Blue = Met   Red = Measured with new prototype   Green = Measured with old prototype



Wear Scar Depth Sizing Curves to be Developed for Improved Sizing Accuracy

- Depth Sizing Curves
  - Developed based on the average signal amplitude for each defect compared to the true depth
  - The dimensions of the wear scar will determine the appropriate sizing curve to be applied
    - The full width of the detect is considered
      - Manual process currently, will be automated in the future



Decision Tree to Choose Appropriate Sizing Curve as a Function of the Defect Dimensions

Considerations for a Probe Delivery System

- The EPRI/SGMP project team met with Eddyfi and Framatome in January 2025 to review and discuss both the probe design and the delivery system
  - Mockups were available to determine if probe redesign will be required and if existing FOSAR tools could be utilized for the delivery system
  - Future work will include:
    - Identifying the most common range of heights for FO-induced tube wear in the above tubesheet region
    - Determining the access requirements to reach the most areas where foreign object damage has occurred

Additional Considerations When Developing Delivery System for a Secondary Side Probe Exam

- Considering Framatome currently has no apparatus (e.g., arm coming off existing FOSAR equipment)
  - Design considerations
    - Probe delivery – At a minimum, the probe should be able to reach the above tubesheet region near the periphery of the SG tube bundle
    - Probe positioning – Positioned such that the maximum depth of the wear scar can be measured, even if multiple static data acquisitions on a single wear scar are needed
    - FOSAR tool - Semi rigid blade that can translate forward, change pitch and yaw
    - ECA probe - would be mounted or built into (TBD) the front of blade for inspection
    - Watertight, could be up to 0.5” of standing water in the area


Summary

- SGMP actively working to identify a method to accurately measure FO tube wear from the SG secondary side
- Although, the current technique shows promise, the depth sizing accuracy needs to be established and understood such that tube integrity decisions can be made
- Although an accurate wear sizing method has been demonstrated, the following obstacles still need to be addressed:
  - Development of a robotic system capable of delivering the test method to the desired tube location
    - Equipment size limitations due to small tube-to-tube gaps
      - Potential probe redesign
- Next project phase, currently both Eddyfi and Framatome are under contract
  - Initial results from both contractors are expected by the 2^{nd} quarter of 2026
- Sizing qualification(s)
  - The qualification process will fall under the existing Eddy Current Examination Technique Specification Sheet (ETSS) program
  - Inspection techniques used by all utilities and vendors in the United States to inspect their SG
    - Provides the method for qualification
      - Test instrument
      - Probe
      - Analysis approach, and for this technique,
      - Delivery system will need to be evaluated
    - The ETSS's are QA documents controlled by 10 CFR 50 Appendix B with part 21 notification

NUREGs 2191/2192, 2221 Supplement 1
NRC Staff

Public Comments

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