

Steam Generator Task Force Meeting



March 6, 2025

Agenda

1:00 pm	Welcome and Introductions	All Participants
1:10 pm	Opening Remarks	NRC and Industry
1:15 pm	Industry Presentation:	Industry
	<ol style="list-style-type: none">1. Recently Published Reports2. Status of Industry Guidance3. Interim Guidance4. NEI 03-08 Deviations5. Recent Operating Experience6. EPRI Study on Significance of International Experience with SG Tube Wear Caused by Deposits7. Status of ETSS Samples in Progress	

Agenda (continued)

2:25	Feedback on Steam Generator Inspection Reports	NRC
3:00 pm	Address Public Questions/Comments	NRC
3:15 pm	Adjourn	NRC



**Recently Published Reports
Helen Cothron**

Noise Monitoring for Alloy 690TT Steam Generators, 3002029284, August 2024

- This report reviews data from noise monitoring of 40 units with Alloy 690TT tubing to determine the benefits of measuring noise

Hydrazine Alternatives for PWR/PHWR: Impact on Resin Performance, 3002029320, October 2024

- EPRI is completing work to evaluate the application of DEHA in PWRs/PHWRs, the scope of which was identified from a technical gap analysis
- Among these gaps is the potential impact on resin performance as a result of exposure to DEHA and/or its decomposition products.
- The project team performed laboratory testing to evaluate the impact of DEHA exposure, and its decomposition products, on the performance of standard condensate polishing resin.

SG Digital Twin Progress Report: Prototype Web Application and Lessons Learned, 3002029290, October 2024

- This technical update provides a status report implementing the framework into a prototype software system.
- An early web application has been implemented on an EPRI-managed cloud tenant, incorporating plant data.
 - It features functionalities like interactive data visualization, correlation of diverse datasets in x-y plots, and predictive modeling of future SG performance as influenced by manually postulated maintenance decisions. Insights gained from this implementation are discussed for planned continuation of an SG DT.

Thermal-Hydraulic Condition Investigation in SGs with Helical Coil Tubes and Comparison with Recirculating and Once-Through SGs, 3002029379, December 2024

- This report provides a summary of the degradation mechanisms that are relevant for helical coil SGs and provides example fluid dynamics modeling of a segment of a helical coil bundle.
- For each of these efforts, a high level comparison is provided between helical coil SGs and conventional once-through and recirculating SG designs.
- A literature review is also provided to document the work that has been performed on helical coil SGs with a focus on both modeling and past experimental work.

Methods for Estimating SG Tube Support Plate Blockage, 3002029289, December 2024

- This report discusses the three methods for estimating TSP broached hole blockage providing the technical basis for each as well as discussion of advantages, disadvantages, and biases in each method.
- Recommendations for employing each method are also included as well as discussion of operating experience from plants utilizing these methods.

SG Deposit Characterization to Address Tube Wear Issues, 3002029280, December 2024

- Operating experience has raised the possibility that spalled tube scale can wear against steam generator tubing, resulting in fretting damage of the tubing.
- This operating experience may indicate that the physical properties of the tube scale are an important factor in the risk of significant tube wear.
- This report documents analyses of tube scale flakes collected during 31 different sludge lancing campaigns.
- Results are used to describe the overall distribution of scale properties as well as possible correlations among different properties.

Eddy Current Examination Technique Specification Sheet Equivalency Study for Alloy 800 SG Tubing, 3002029281, December 2024

- Effects of essential variables are compared between a selection of EPRI I600 ETSS and field I800 ETSS datasets.
- This would allow utilities with I800 tubing to leverage performance indices such as flaw sizing and POD from EPRI I600 ETSS data without having to duplicate the production, data acquisition, and destructive examination of the samples that were previously included in a qualified EPRI I600 ETSS.



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	1/20/23	None	2025	Small group will be convened to determine if more guidance is needed
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		Plan to publish 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		2025	Reviewed 2023 - No revision recommended
Secondary Water Chemistry Guidelines	8	3002010645	Sept 2017	6/27/2018	Published 2019, 2020, 2023	2025	Reviewed in 2024 - 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

No Interim Guidance and NEI 03-08 Deviations



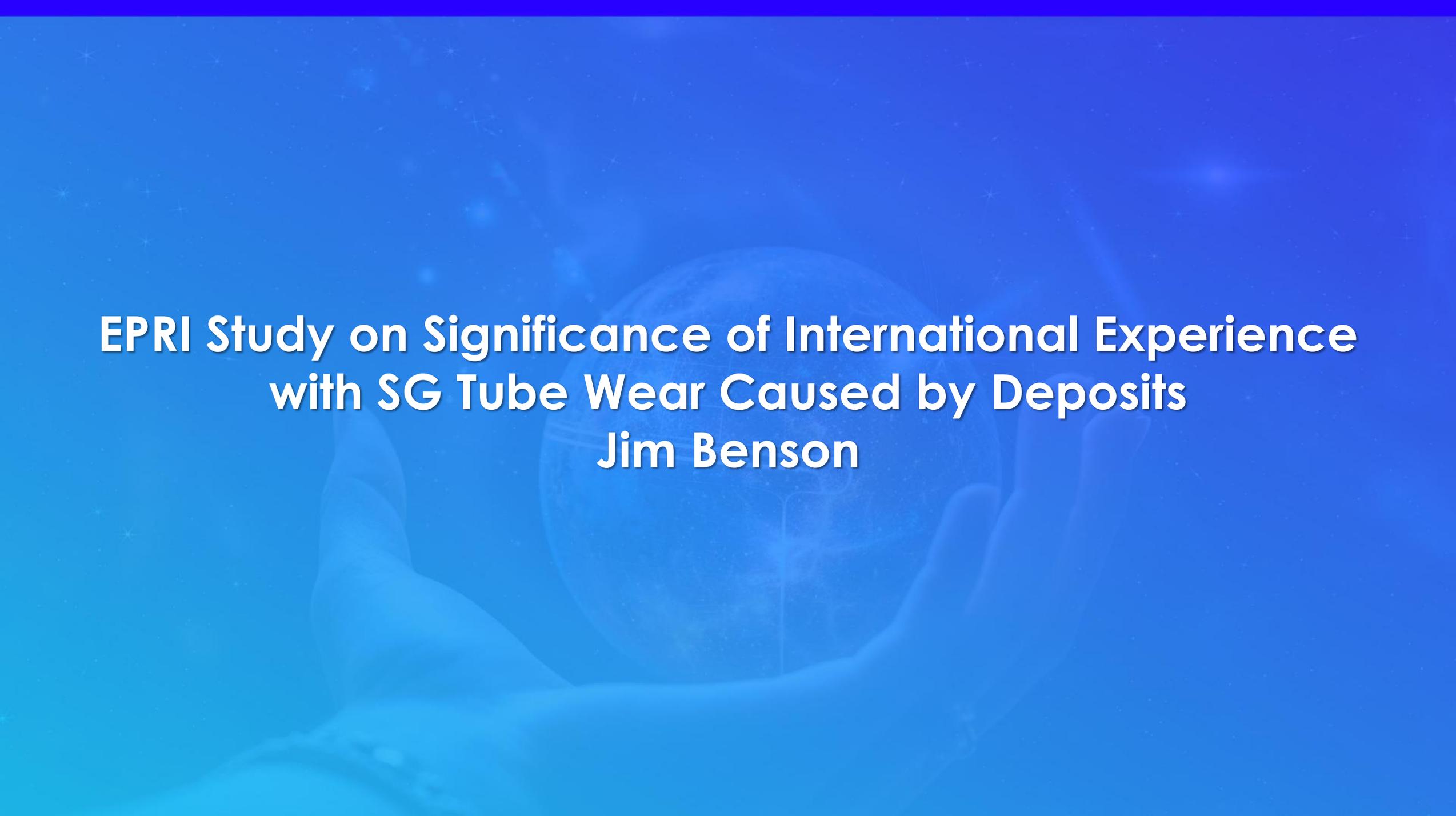
**Recent Operating Experience
Helen Cothron**

Update on Fall 2023 Operating Experience

- Two tubes failed performance criteria due to wear at TSPs
- Causal factors:
 - In the 2017 inspection a non-conservative sizing curve was used, which means the measured flaws were larger than reported. This caused the operational assessment and planned operating interval to be nonconservative
- This OE should be addressed in site-specific eddy current guidelines and/or analyst training
- SGMP is considering additional guidance to address the drivers

Small Group Has Been Assembled

- Reviewing the Integrity Assessment Guidelines
 - Provide checklists for important inputs and data for operational assessments
 - Strengthen requirements to ensure flaws are being sized accurately and provide checks
 - Strengthen requirements for wear in new SGs
 - Recommend the operational assessments to highlight sensitive parameters for fully probabilistic assessments
 - Provide more details in the guidelines for probabilistic assessments
- Detailed tube integrity training provided in February 2025
- Develop an OA software that can be used to check a vendor-supplied OA



**EPRI Study on Significance of International Experience
with SG Tube Wear Caused by Deposits
Jim Benson**

SG OE for Tube Wear from Deposit Flakes

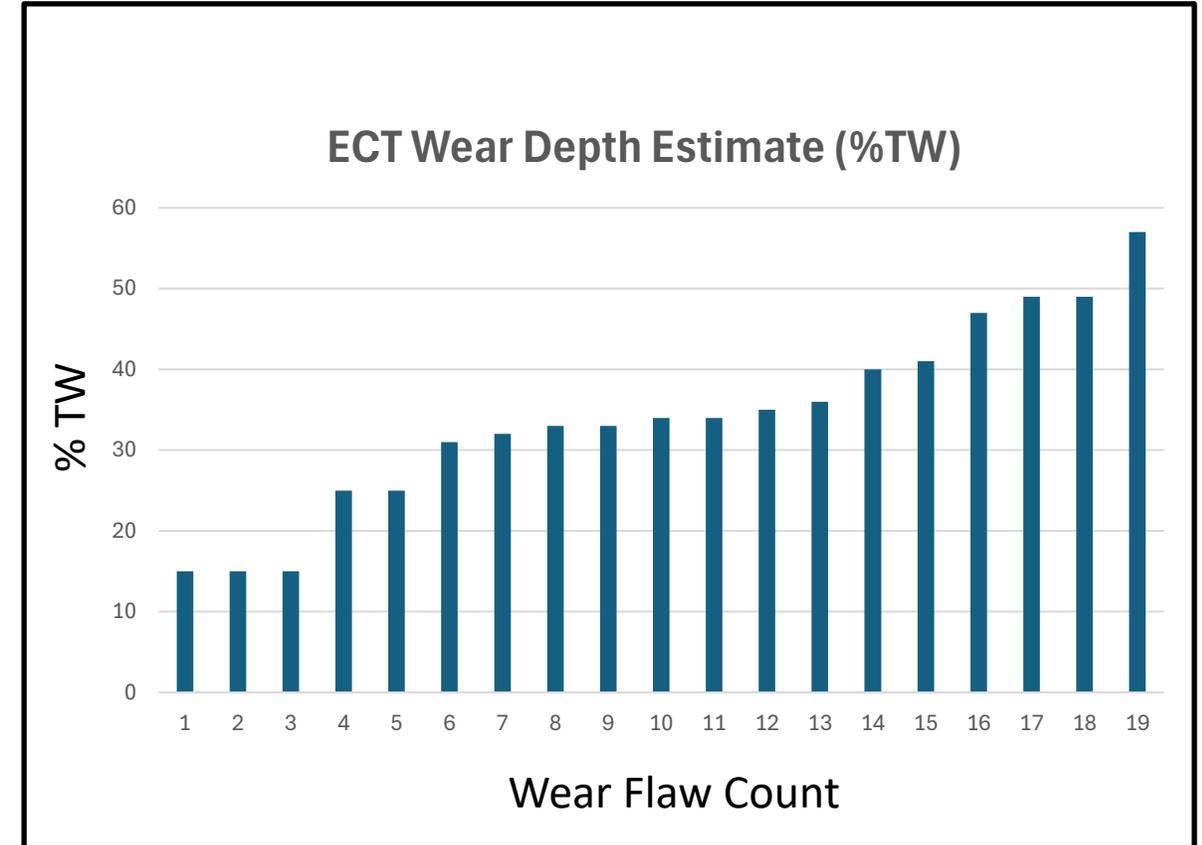
- Two units at one plant reported SG tube wear from apparent deposit flakes that had spalled off the tubes during operation
- This observation is believed to be the first reported industry case where deposit flakes have resulted in SG tube wear
- Utility investigations have resulted in a conclusion that a deposit flake that possesses the following characteristics can potentially result in tube wear:
 1. **A dense (<5%) porosity region****AND**
 2. **A dense layer thickness of $\geq 0.1\text{mm}$ ($100\mu\text{m}$ / $0.004''$)**

International SG OE

Tube Wear Believed to be from Flaked-Off SG Tube Deposits

Unit	Periodic Outage	SG	TSP*	Leg	ECT Wear Depth (%TW)
4	23	A	3		33
4	23	C	3		25
4	23	C	3		32
4	23	C	3		36
4	24	A	4	C	47
4	24	A	4	C	25
4	24	A	4	C	<20
4	24	A	3	C	33
4	24	A	3	C	40
4	24	B	4	C	49
4	24	B	3	C	<20
4	24	C	4	C	34
4	24	C	4	C	31
4	24	C	3	C	49
4	24	C	3	C	35
4	24	C	3	C	34
3	25	A	4	C	57
3	25	A	3	C	<20
3	25	B	2	H	41

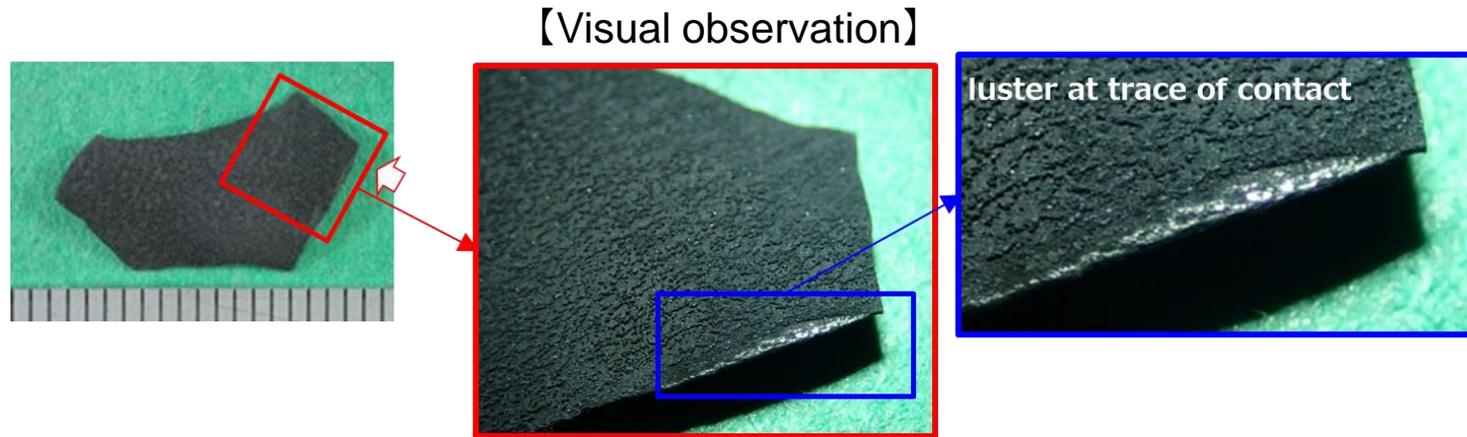
* - Indications located adjacent to TSP



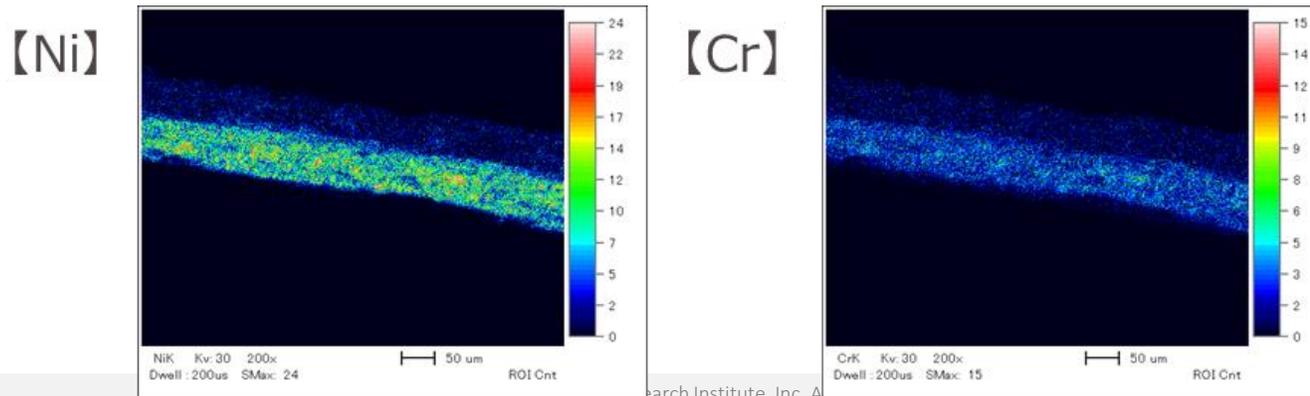
Note: For <20%TW indications, 15 %TW was used in this plot

Wear Investigation (Unit 4: 24th RFO)

- Scale presumed to have caused wear was identified from samples retrieved from SG-A and SG-B. (Below figure shows scale retrieved from SG-A)
 - Area of contact with the tube was observed.
 - Components at contact area constitute the tube base material



【Analysis of chemical composition】



Corrective Actions by the Utility

- The application of chemical cleaning is being performed to prevent the recurrence of tube scale resulting in tube wear by making dense deposit flakes more porous
- To monitor scale buildup, it is planned to retrieve scale during every periodic outage to verify the thickness of dense scale layers and to perform wear tests on the removed scale
- Chemical cleaning application is planned if the thickness of dense scale layers exceed a predetermined limit (e.g., 0.1mm)

EPRI Study on Characterization of Field SG Deposits

Objective

- Analyze tube deposit flakes collected during SG sludge lancing campaigns at multiple units.
- Document the analysis of industry tube scale so that PWR utilities have a better understanding of the potential for deposit flakes to result in SG tube wear
- Identify possible actions to reduce the potential for tube scale leading to SG tube wear

EPRI Study on Characterization of Field SG Deposits

Project Scope

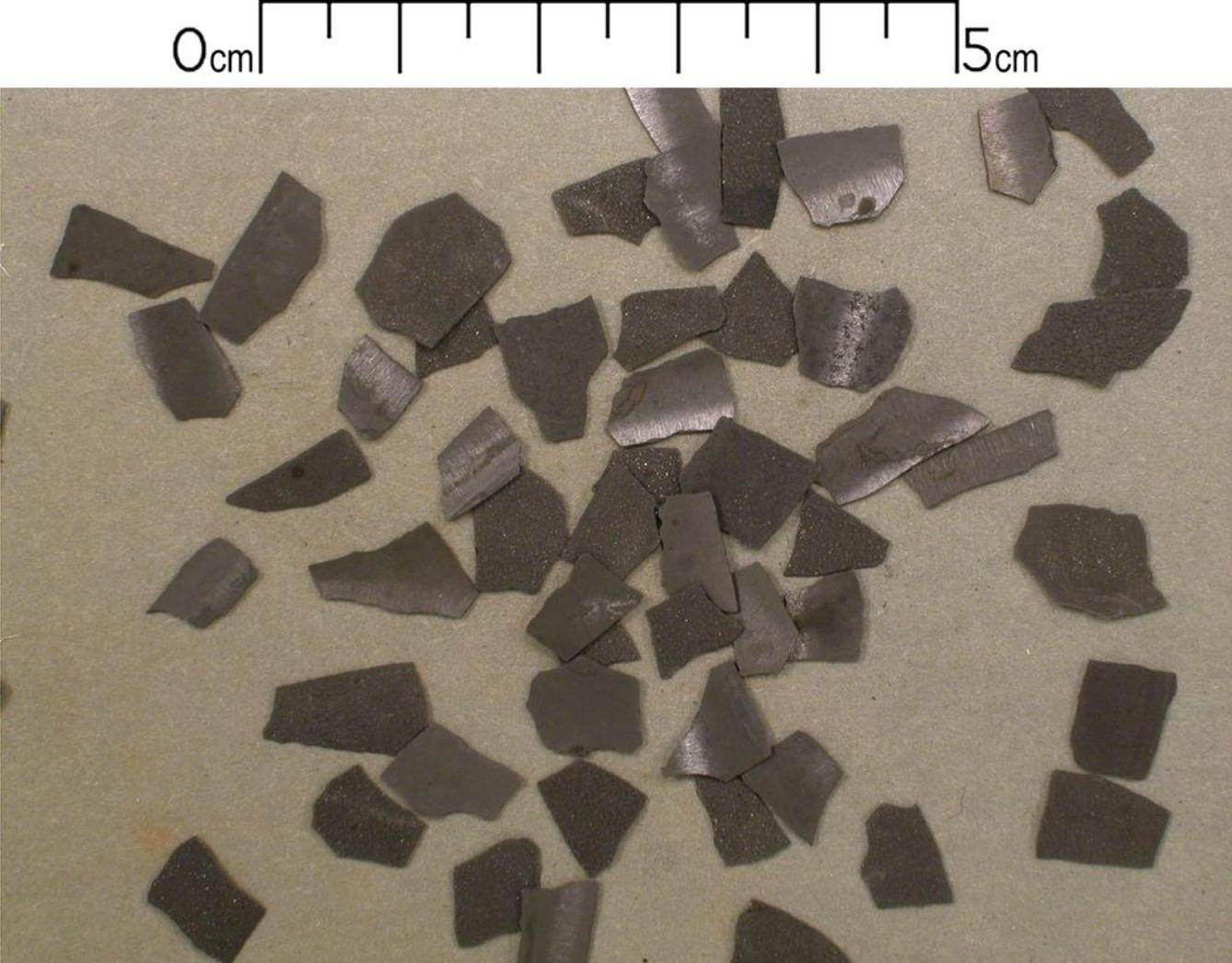
- Based on the first-time reporting of SG tube wear from spalled-off deposit flakes, examination of flakes from multiple plants was performed to determine the extent to which the industry may be at risk of having other plants experience a similar type of tube wear.
- 65* tube deposit flake samples from 31 SG sludge lancing campaigns were examined, from 15 different units
- Location of the 15 units: US (6), Asia (6) and Europe (3).
- SG tube material included: 600TT (8), 690TT (4), 800NG (2), 600 MA (1)

* Does not include 9 samples from post-lab-ASCA processes

Deposit Characterization

- **Characterize removed spalled-off SG tube OD deposit flakes**
 - Numerous Units
 - Provide diversity of SG designs, geographic locations, operating chemistry, and tubing materials
 - Multiple sludge lancing campaigns
 - Allows tracking of parameters over time
 - Different SG operating ages (EFPY)
 - Pre- and post- ASCA and EPRI/SGOG cleaning processes
 - Allows evaluation of the effects of SG chemical cleaning
- **Deposit characterization focused on wear issue:**
 - Porosity
 - Hardness
 - Composition
 - Thickness

Examples of SG Flakes Identified as Tube Scale



Example Deposit Flake Thickness Measurement

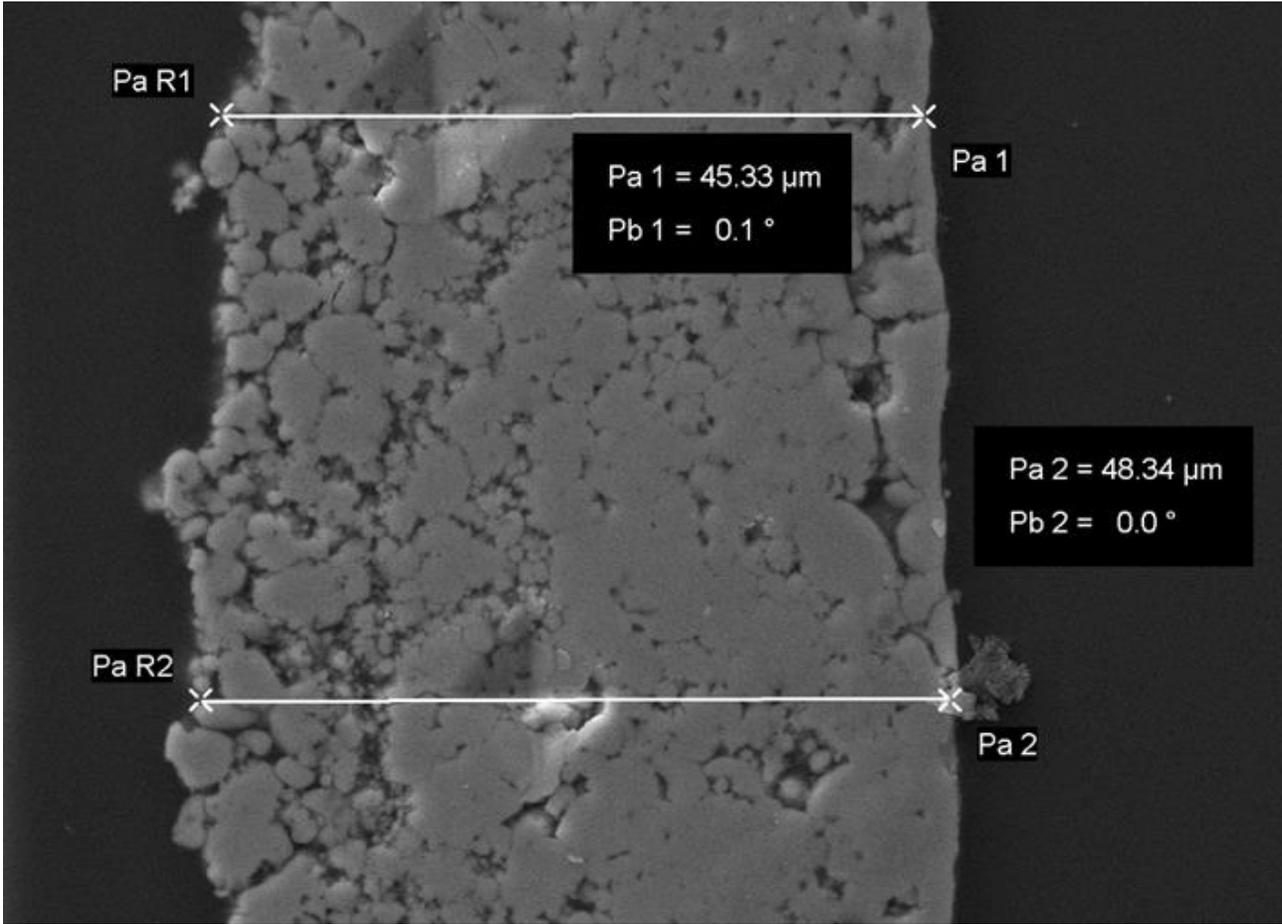


Illustration of the Portion of the Flake Examined

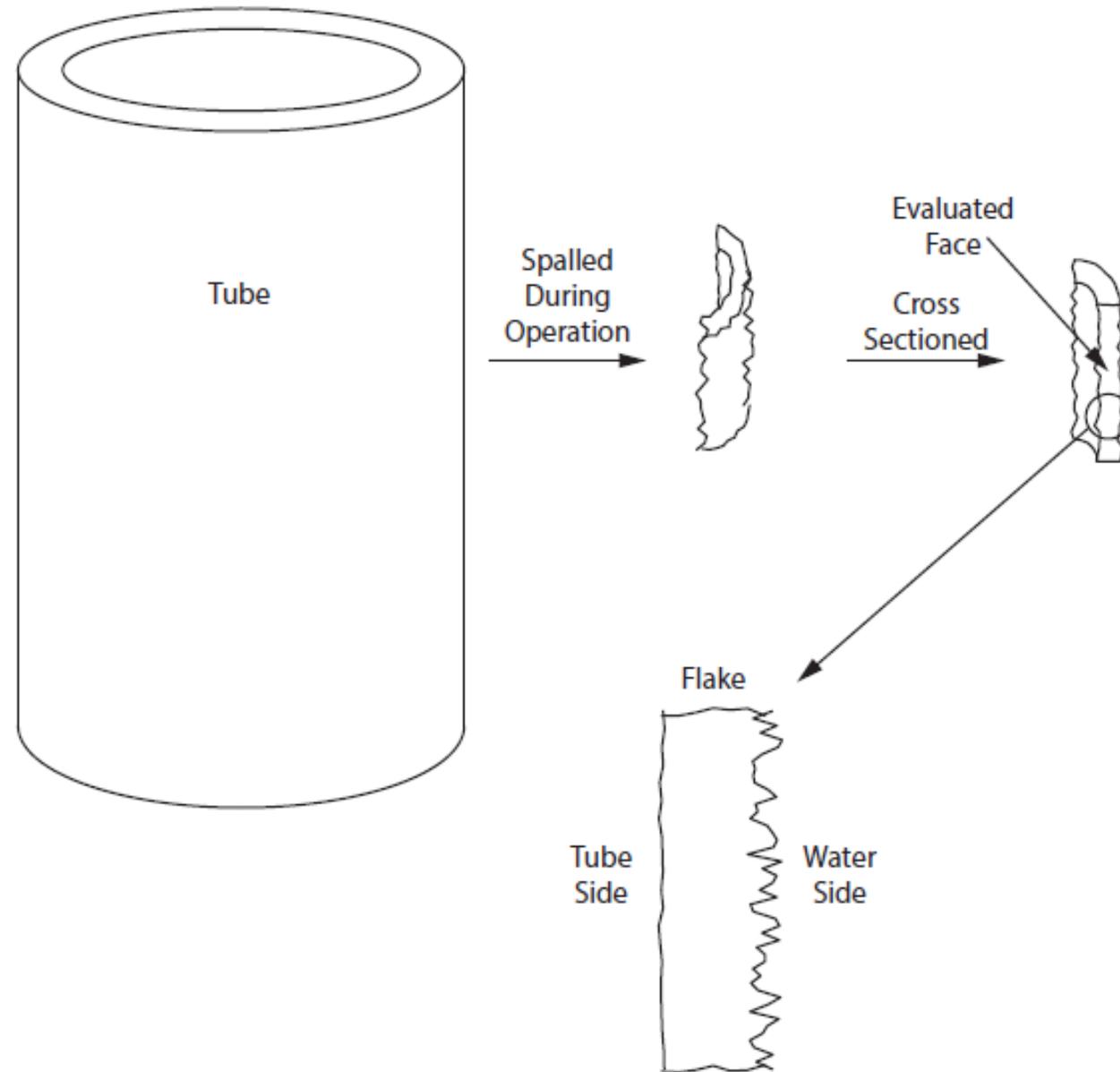
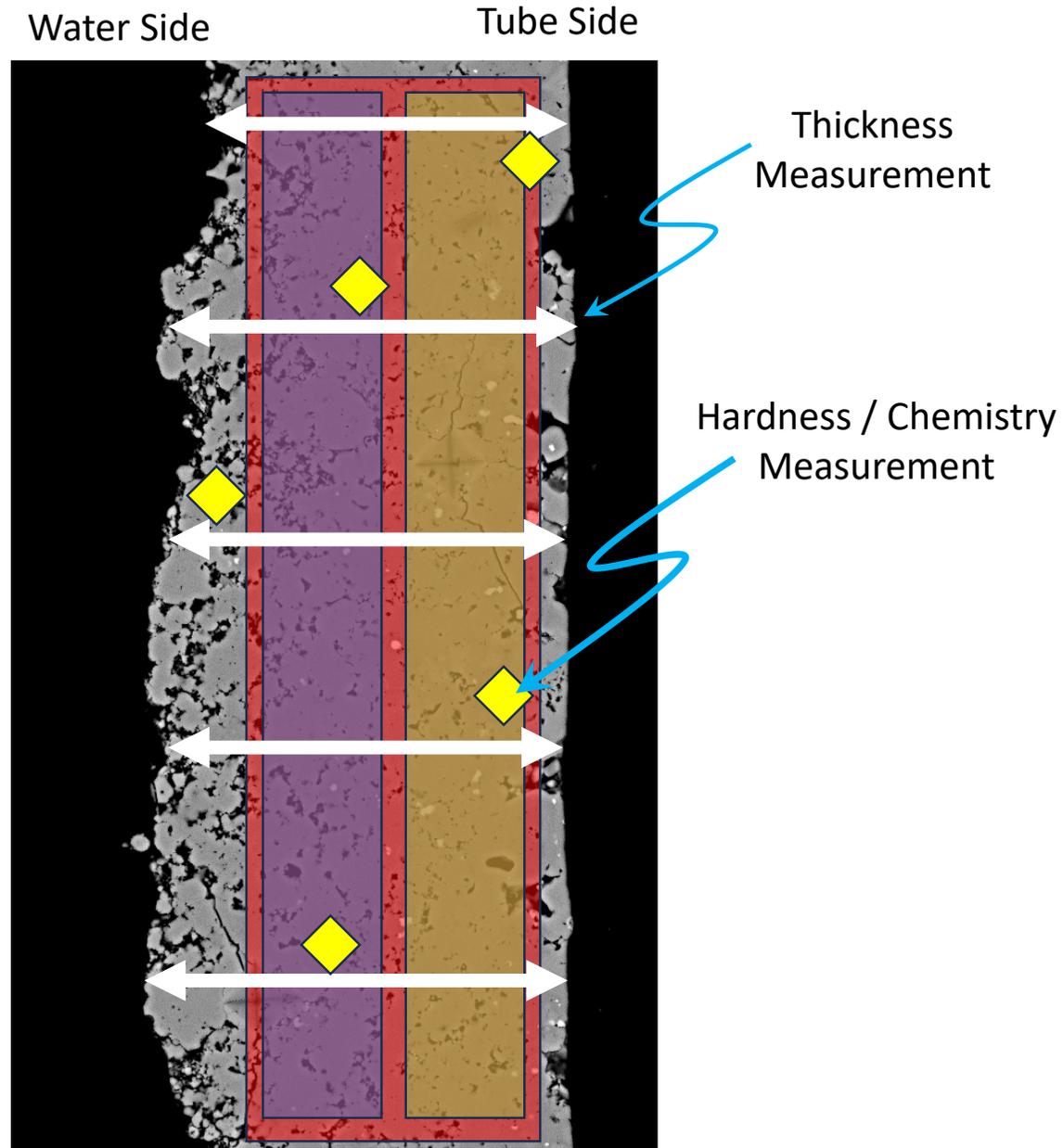
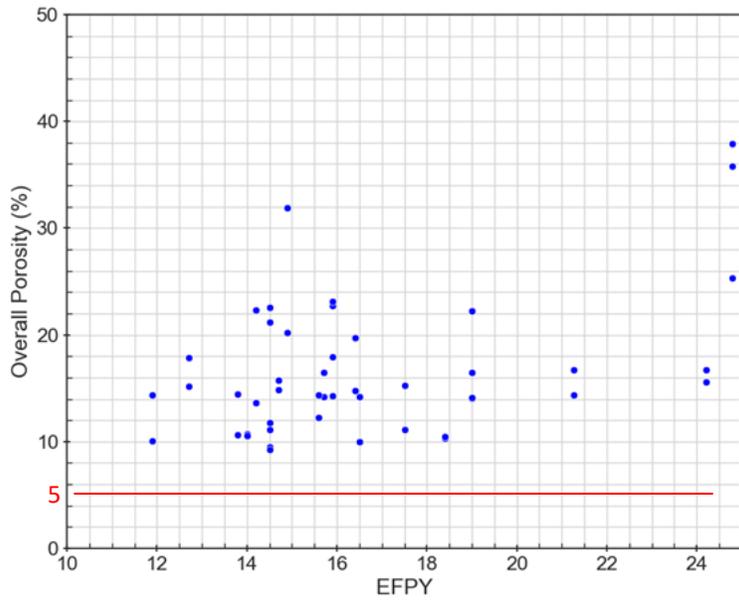


Illustration of Typical Analysis Locations

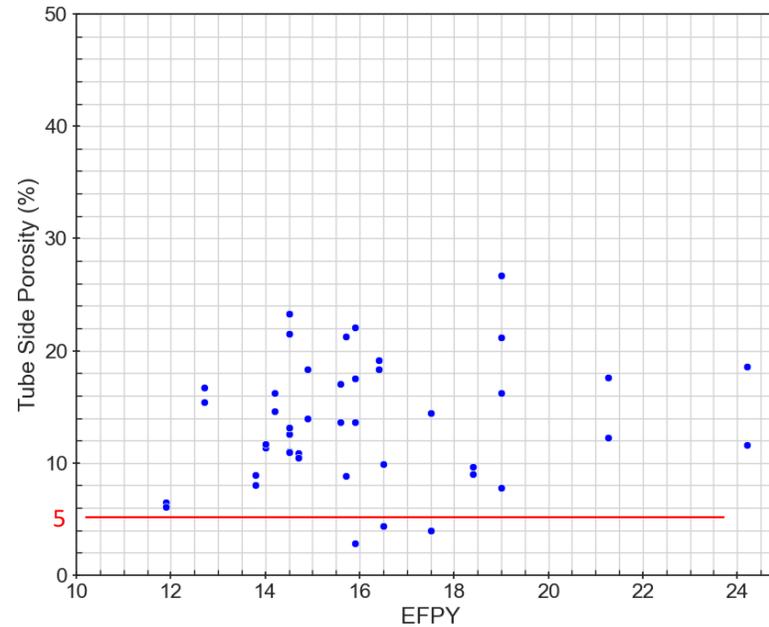


Porosity as a Function of Operating Time

- Flakes represent 15 different units

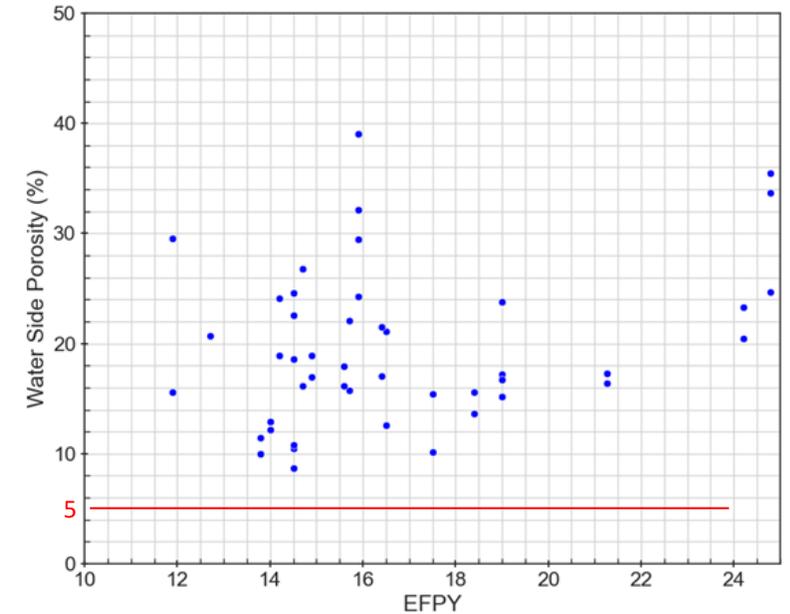


Overall Porosity



Tube Side Porosity

[Mode = 12%]

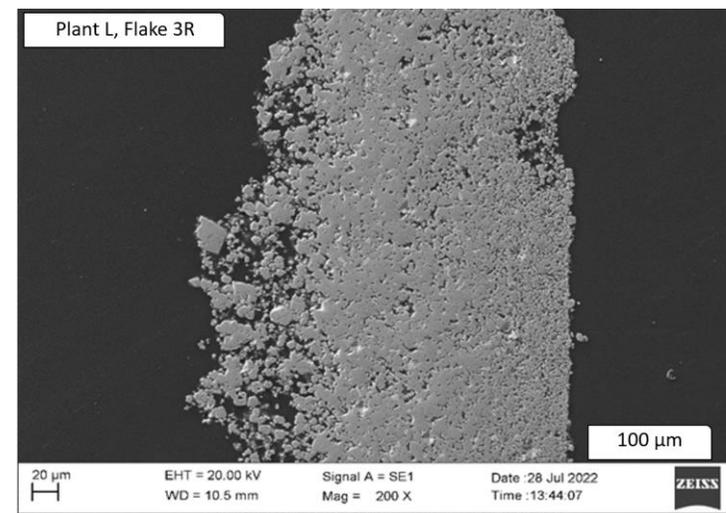


Water Side Porosity

[Mode = 18%]

Comparison of EPRI Flake Examination Results to Utility Criterion for Potential Wear

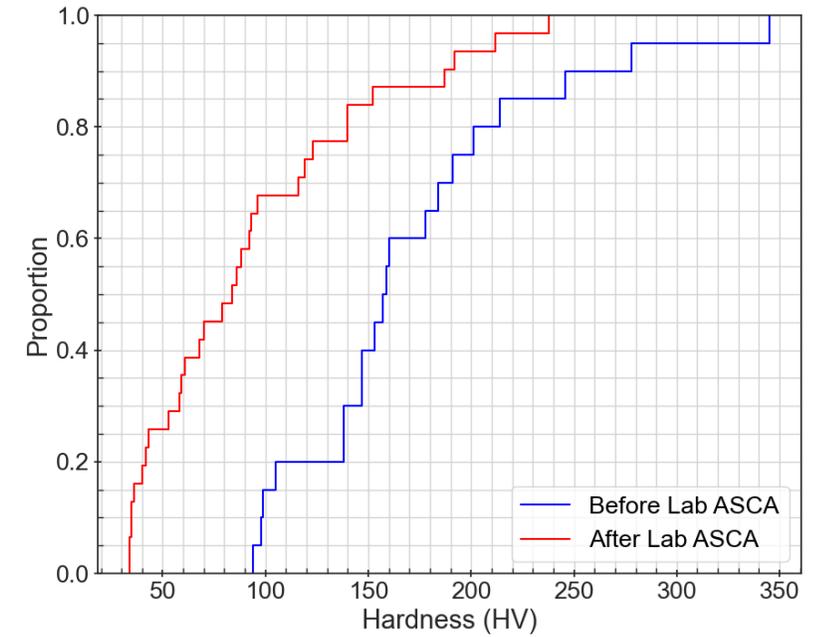
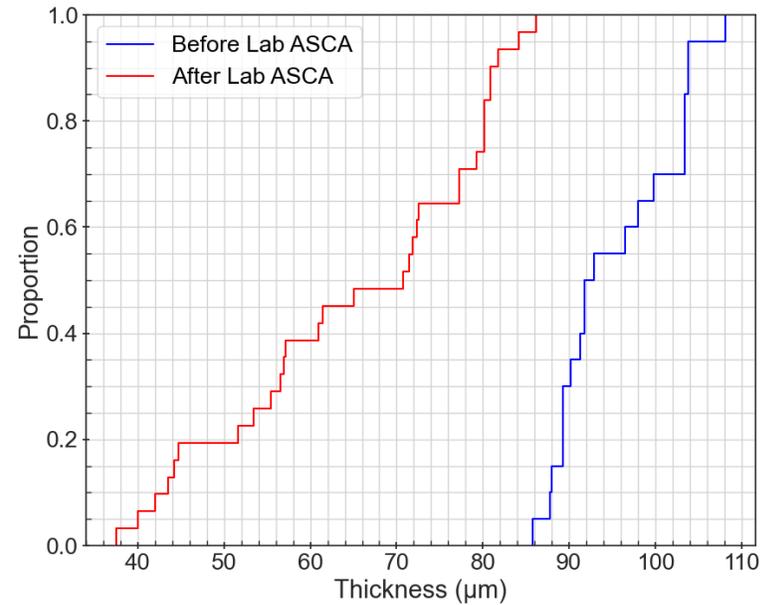
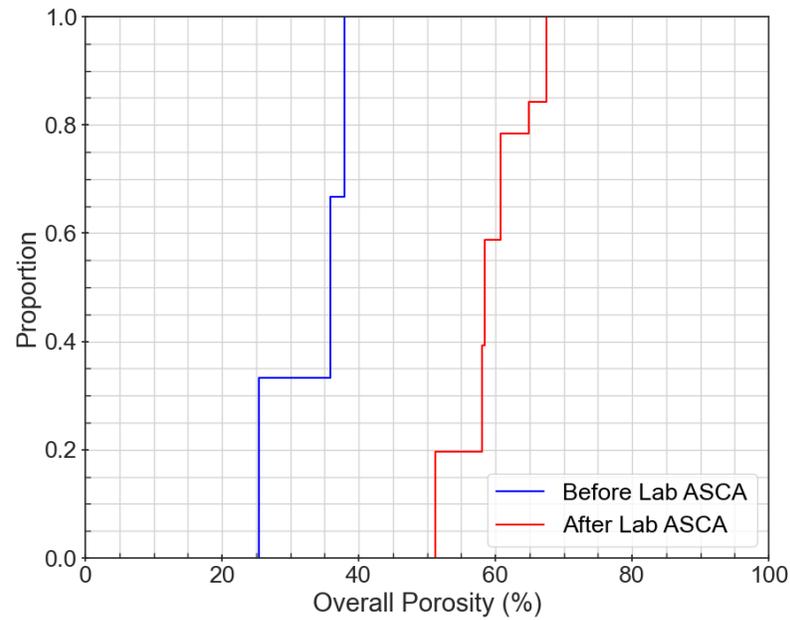
- Of the 65 flakes examined 3 flakes had porosity values of $\leq 5\%$.
- Only 1 of the 3 flakes exceeded the utility criterion containing a dense region of ≥ 0.1 mm (100 μ m) thick:
 - **Plant I, Flake 2** was < 100 μ m total thickness, so it does not meet the utility criterion.
 - **Plant M, Flake 4** was 100 μ m total thickness, but it was not dense over the total thickness.
 - **Plant L, Flake 3R** was about 200 μ m in total thickness and was dense in about two thirds of the thickness, so it met the utility criterion.



Change in Flake Attributes Following Chemical Cleaning Processes

Plant	CC Process	Lab/Field Process	Δ Porosity (Overall)	Δ Hardness	Δ Thickness
C	EPRI/SGOG	Field	↑	—	—
D	ASCA	Field	↑	↓	↓
C	ASCA	Lab	↑	↓	↑
H	ASCA	Lab	—	—	↓
O	ASCA	Lab	↑	↓	↓

Change in Flake Attributes Following Chemical Cleaning Processes (Plant O)

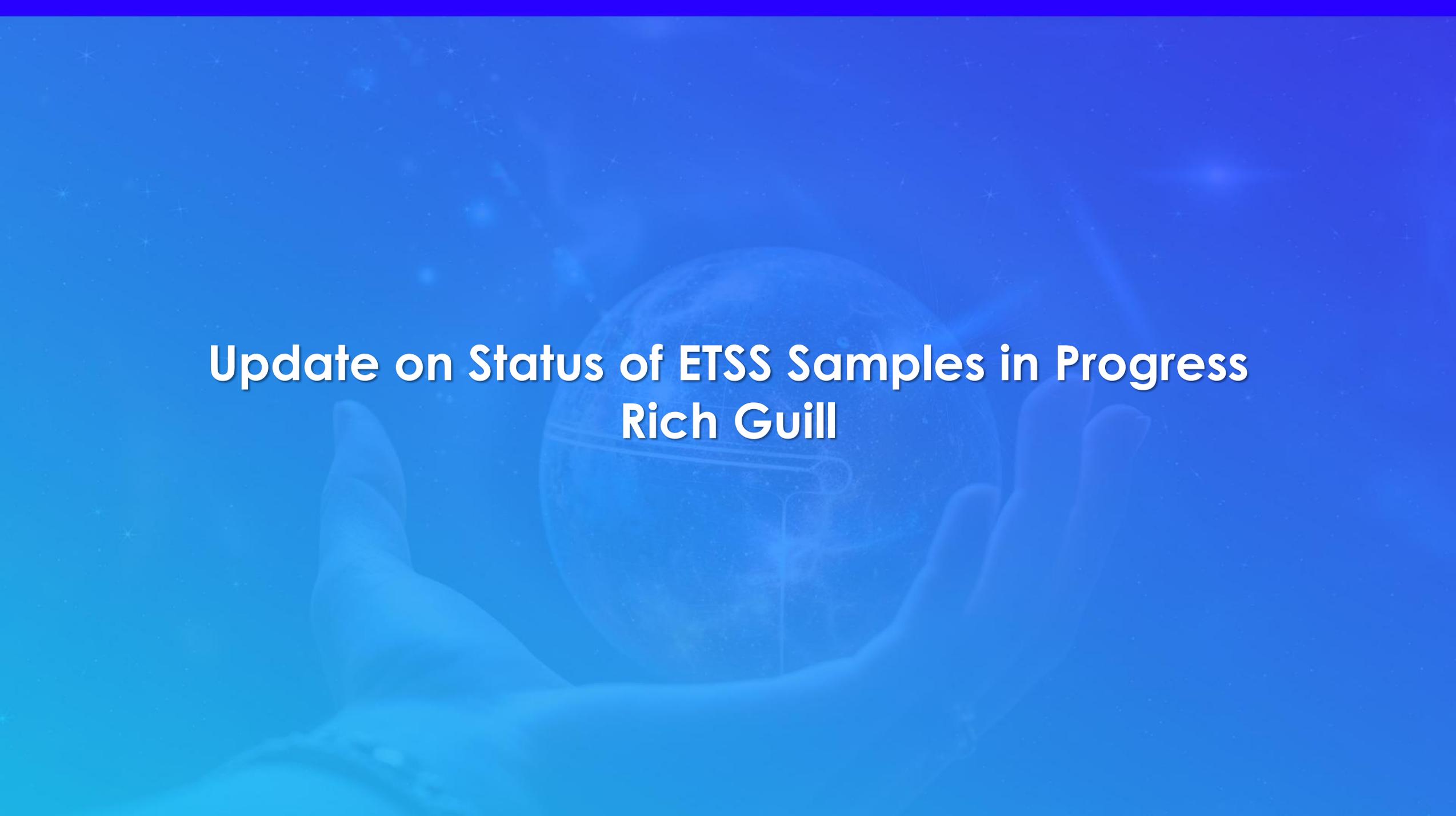


Effect of Chemical Cleaning

- A possible action to mitigate the risk of tube scale fretting wear of steam generator tubes is chemical cleaning to increase the porosity of the scale.
- In 4 of 5 plants in the EPRI study, there was an increase in flake porosity following chemical cleaning.

Summary

- One international PWR identified hard, dense deposit flakes at one plant site that caused wear on multiple SG tubes in 2 units
 - Investigations by the utility resulted in a conclusion that a deposit flake with a dense (<5%) porosity region of $\geq 0.1\text{mm}$ can potentially result in tube wear
- EPRI examined removed SG tube deposit flakes from throughout the industry to determine the extent to which low porosity flakes may exist
- The EPRI study identified 1 of 65 flakes examined as having a dense region with a thickness of $>0.1\text{mm}$
- Low risk of generic implications
- EPRI Technical Report:
 - *“Steam Generator Deposit Characterization to Address Tube Wear Issues”*
 - Deliverable # 3002029280
 - Publication date: December 2024



Update on Status of ETSS Samples in Progress
Rich Guill

Samples Destructively Analyzed to Support ETSS Development and MAPOD Calculations - Lab Cracks Available

- Destructive analysis lab finalized report on 12 Axial PWSCC and 17 Circumferential ODSCC samples
 - Reports provided to NRC
 - Completed phases of ETSS development:
 - SGMP QA process on Metallurgical report
 - Flaw injection process including eddy current analysis of data
 - Tube integrity analysis
- Destructive analysis of Circumferential PWSCC samples ongoing, scheduled for completion this summer
- Dominion Engineering cracks fabrication
 - Destructive analysis on Axial ODSCC samples completed and report provided to NRC
 - 26 cracks ranging from 20% - 100% TW
 - Axial PWSCC and Circumferential ODSCC flaw development ongoing



Updating Existing Axial PWSCC 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 have been reviewed by tube integrity peers to set priority
 - Both techniques are in development
 - Peer review planned for 2025

**Flaw Injection software utilized
(e.g., compressed crack length at expansion transition)**

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

20400.1	X-Probe 300 kHz OD Circ indications at Expansion Transitions, TC7700
20400.2	X-Probe 200 kHz OD Circ Indications at Expansion Transitions, TC7700
20406.1	RG3-4, 0.043" wall at 400 kHz and 0.049" wall at 270 kHz, OD Circ Indications, at Expansion Transitions, Miz 30 and Miz 70
20406.2	RG3-4, 0.043" wall at 270 kHz and 0.049" wall at 200 kHz, OD Circ Indications, at Expansion Transitions, Miz 70
21402.1	Circumferential ODSCC at expansion transitions, 115 MR Pancake, 300 kHz 0.043" wall and 200 kHz 0.050" wall
21410.1	Circumferential ODSCC at Expansion Transitions, Plus Point, 300 kHz 0.043" wall and 200 kHz 0.050" wall
24410.1	Intelligent Probe, 400/100 kHz Mix, Circ ODSCC at Expansion Transitions, MIZ 70

- Circ ODSCC
 - ETSSs have been reviewed by tube integrity peers to set priority
 - Both techniques are in development
 - New analysis process developed for Plus Point
 - Peer review planned for 2025

Flaw Injection software utilized



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