WEF-19-ASCA-GENE-NTD-4203 R01

PWR Steam Generator Secondary Maintenance Strategy

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SYP, October 30th 2019

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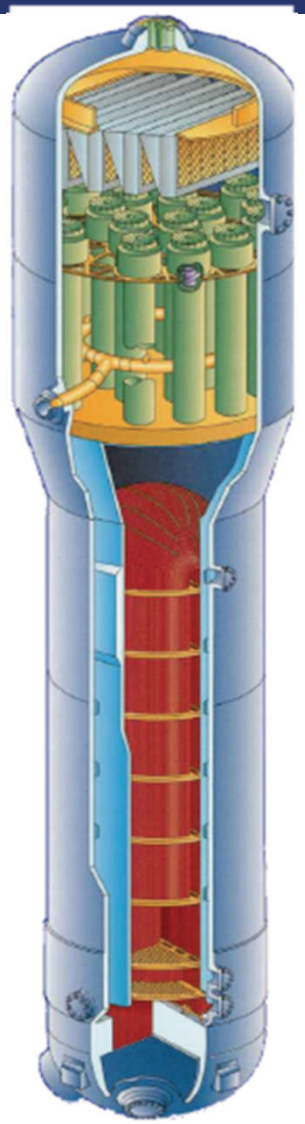

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Background: Deposits

- **Deposits at the top of the tubesheet?**
  - **Fouling**
  - **Hard collars**
  - **Copper**

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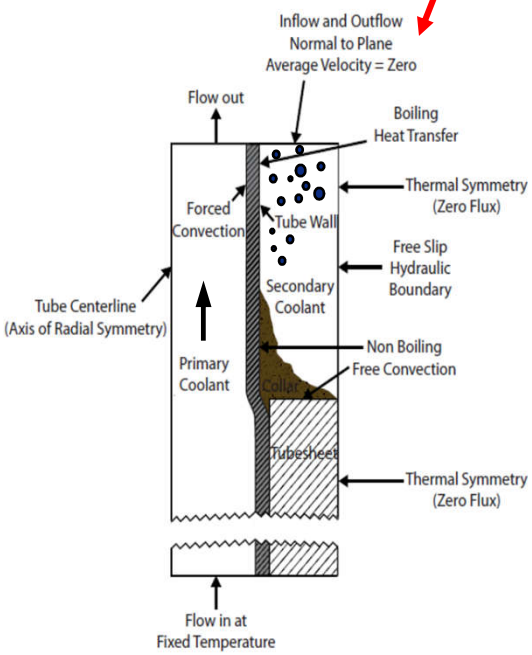
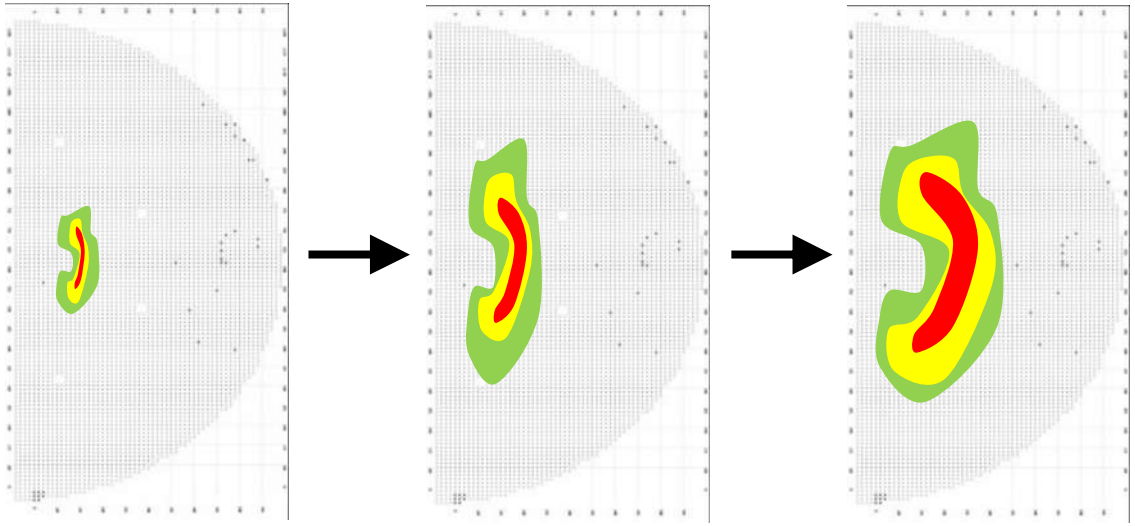
Background: Hard Collar

- TTS “kidney” zone – “Conventional Hard collar area”
- TTS collars :
  - Intergranular Attack / Stress corrosion cracking (IGA/SCC)
  - Denting





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Introduction

Current TTS maintenance strategies are based on focusing primarily **on fouling and hard collars only on "kidney zone".**

However, this model could be questioned as, despite the implementation of the qualified preventive technics, Lesson Learned on several European utilities shows that it could lead to **deficient results with IGA/SCC/denting phenomena.**

The industry challenge is to have a more predictive maintenance strategy / Long Term Operation Strategy.

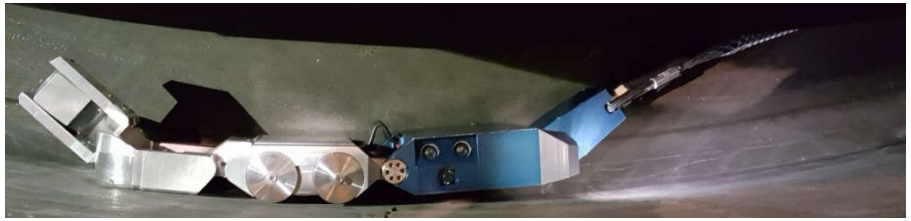
Current Maintenance model and technologies: overall

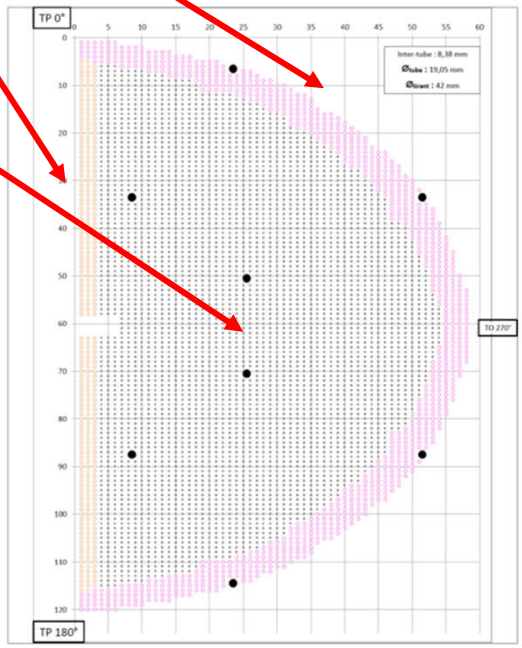
- Only lancing technologies are used as TTS cleanliness technologies,
- Same cleaning and inspection program is applied whatever the SG cleanliness,

- Some utilities initiated to adapt the cleaning program in the kidney zone.

Current Maintenance model and technologies: Inspection Model

- EC inspection from primary side,
- Visual inspection from secondary side:
  - Systematic no tube inspection,
  - Systematic 100% or fixed (in-bundle tubesheet inspection)





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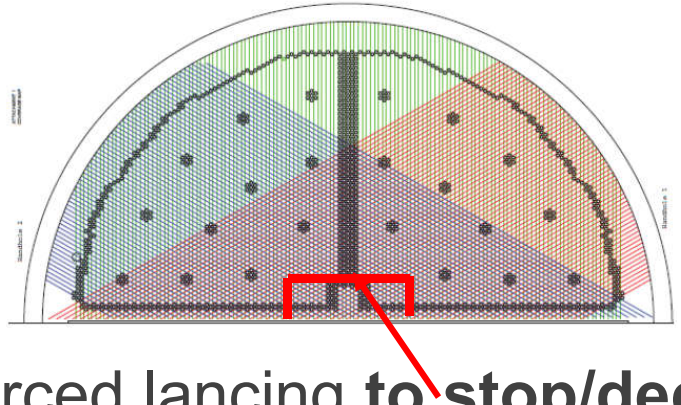
Current Maintenance model and technologies: Cleaning Model

- Systematic Conventional lancing to extract **Fouling,**



- Systematic Reinforced lancing **to stop/decrease the kidney zone** on the full kidney area,
- Systematic/Case by case High pressure lancing **to stop/decrease the kidney zone**.

Current Maintenance model and technologies: Result

This current strategy leads to some case with ISA/SCC phenomena with no other solutions than:

- EPRI SGOG chemical cleaning:

- Continuous High Pressure lancing campaigns.

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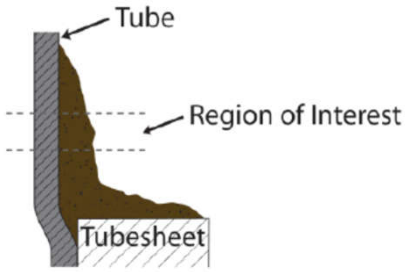
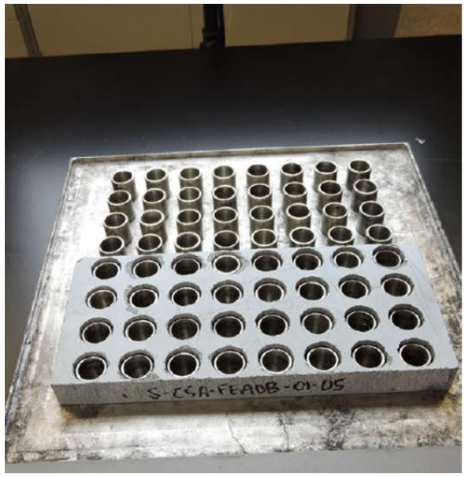
Current Maintenance model and technologies: Why so much difficulties?

- Challenge of caracterizing hard collar deposits:
  - Main parameters: hardness and Compressive strenght,
  - High Amplitud on these main parameters:
    - local hardness measurements : 100 Hv – 2000 Hv,
    - Compressive strenght: 100-300 MPa
  - Heterogeneous material: mix of iron oxides, metal ferrites, and other metals and metal oxides (Al, Si, nickel, manganese, magnesium, lead. (Pb).
  - There was no correlation between the collar hardness and the radial distance from the steam generator tube.



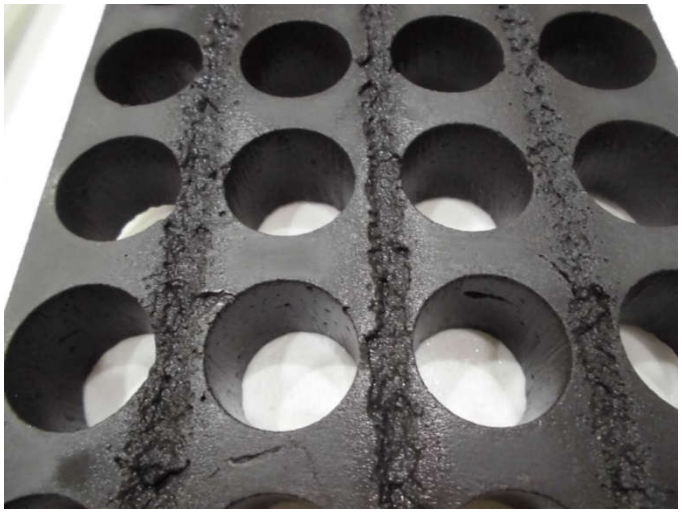
Current Maintenance model and technologies: Why so much difficulties?

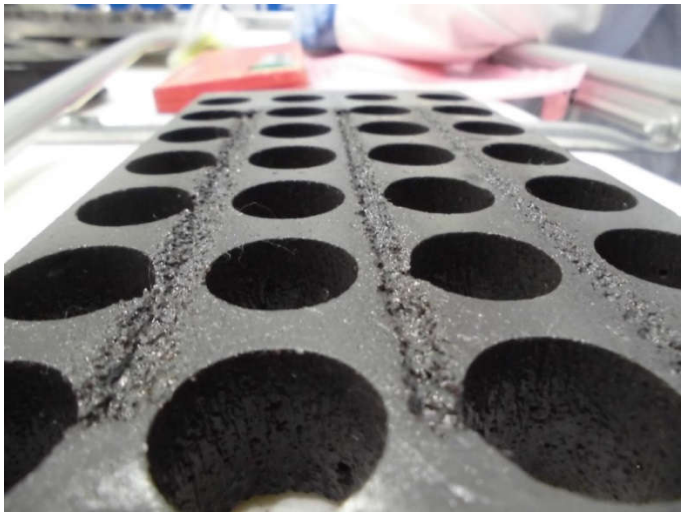
- Lot of influent parameters for efficient sludge lancing:
  - jet pressure,
  - nozzle offset distance,
  - jet impingement angle,
  - nozzle diameter,
  - jet traverse speed on sludge disruption,
  - Get access to deposits



Current Maintenance model and technologies: Why so much difficulties?

- High and very specific operative conditions are required to succeed in laboratory for more challenged cases





Test 5
P: 8700 psi (600 bar)
Offset: 10 mm offset
Jet Incidence: 90°
Nozzle Dia.: 1.02 mm

# of Passes: 9
Equiv. Traverse Rate: 59 mm/min
Damage Width: 20.6 mm
Damage Depth: 22.1 mm
% Thru Thickness: 100%

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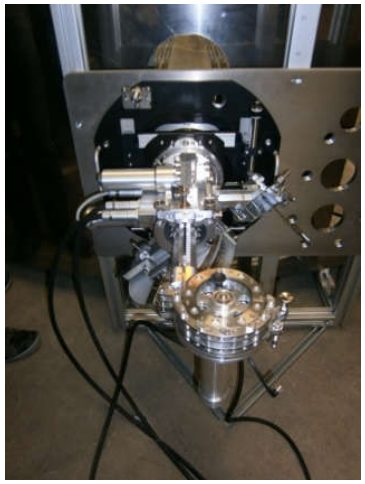
New Approach: Main principles and Challenges

- Preventive rather than Curative by actionning not only on the « kidney » zone but also and the TTS hard collar creation,
- « No more than Necesary » by decreasing, cancelling the poor added value technologies,
- Program adapted to the SG cleanliness situation,
- Results from Asia (systematic chemical cleaning),
- Limit pressure impact in tubes not to damage them (risks with high pressure lancing),
- Action even in « shadow » area,
- No schedule/Cost impact.

New Maintenance Strategy: Inspection model

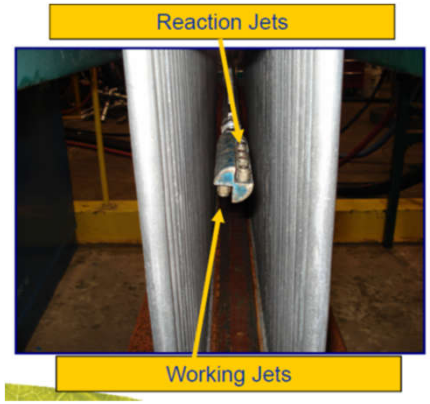
- EC inspection from primary side,
- Visual inspection from secondary side:
  - **Systematic** no tube inspection for FME reasons,
  - **Sampling** in-bundle tubesheet inspection to evaluate hard sludge evolution.



	Before	After	Comments
No tube inspection	Systematic	Systematic	FME reasons
In-bundle inspection	100% or fixed program	Sampling based on last SG inspection	could lead to optimization

New Maintenance Strategy : Cleaning model

- **Evolutive** Conventional Lancing program based on SG cleanliness status to extract **Fouling**,
- **Evolutive** Reinforced lancing **to stop/decrease the kidney zone** only on zone with collar,
- **Recurrent** chemical cleanings each 3-5 outages before lancing not only for **kidney zone** but also for **TTS collar to eliminate IGA/SCC risk,**
- **Stop high pressure lancing.**



	Before	After	Comments
Conventional lancing	Fixed program	Evolutive based on past outage quantity of extracted sludge	could lead to optimization
Reinforced lancing	Fixed or evolutive program	Evolutive based on last inspection	could lead to optimization
High Pressure lancing / Chemical Cleaning	Systematic/Case by case	Each 3-5 outages based on deposit progress	no impact

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New Maintenance Strategy : Fast Chemical Cleaning

- Chemical Process with prove efficiency,
- Very low level of corrosion (<15 µm),
- Low environmental impact (low quantity of waste and gaseous emission),
- Very limited footprint (2*20’ containers outside containment),
- Short schedule: 30h max on SG (rather than high pressure lancing),

- Plant heat to be used during the chemical process,
- Injecting/draining by plant pipes,
- Collaborative needed utilities/vendor on local regulation, plant configuration, waste management.

-> Overcome challenge: have a efficient technology for hard collar without impacting outage schedule.

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Conclusion

Based on this maintenance strategy model on PWR steam generator secondary, the recommendation shall lead to:

- Challenge old practises,
- Maximize/improve the steam generator performance without affecting the outage schedule,
- Executing maintenance for Long-Term Operation success.

This industry Challenge could be overcome with full collaboration/transparency between utilities and maintenance service vendors.

Thank you for your attention!

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