MIDDLE EAST TURBOMACHINERY SYMPOSIUM

Resolving Intermittent Vibration Spikes on Steam Turbines

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- Machine description
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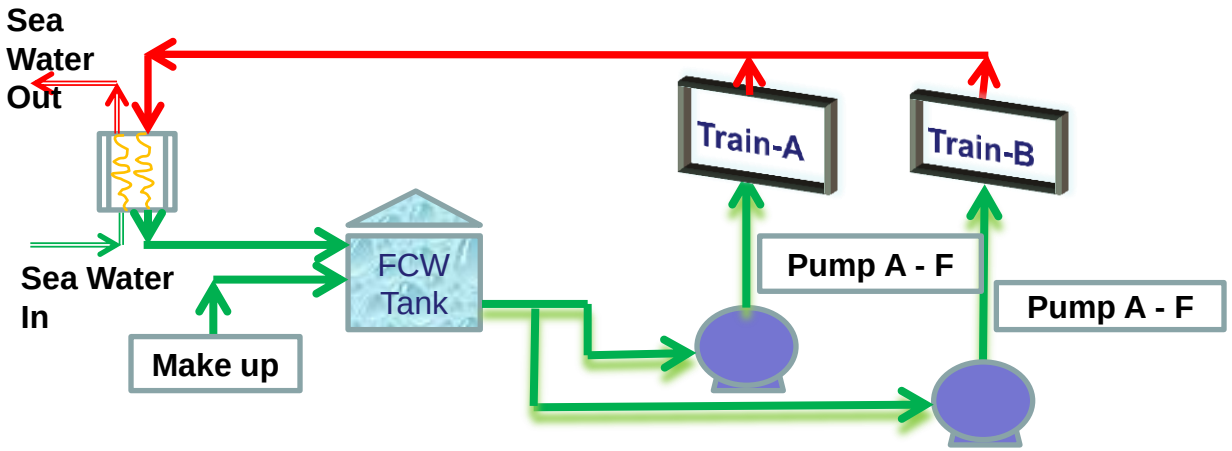
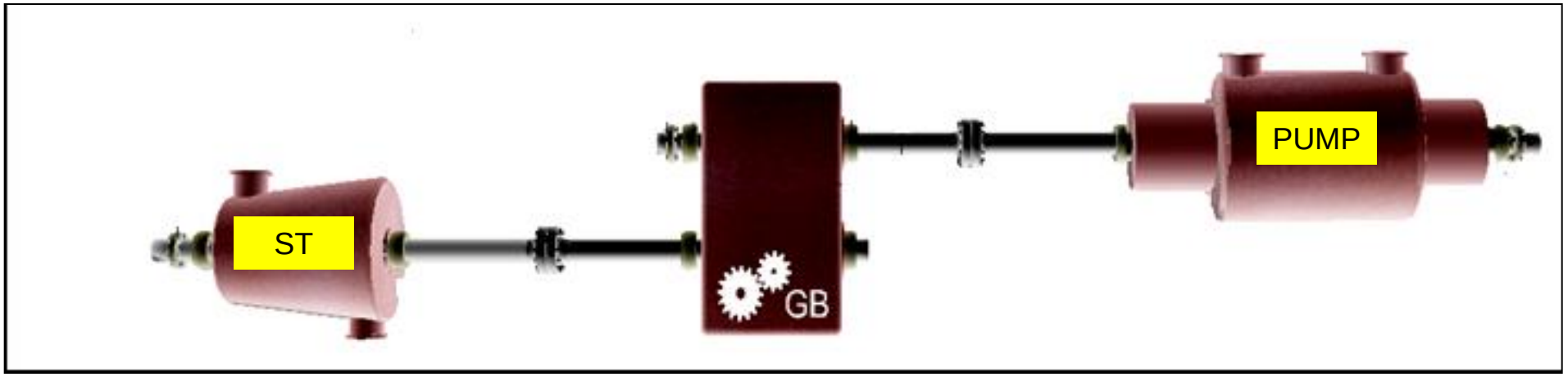
Background

- Six Fresh Cooling Water Pumps:
  - 4 Steam Turbines and 2 Motor driven pumps
  - Critical pumps in LNG production
- Intermittent vibration spikes - Proactive detection on three steam turbines using expert systems
- The condition deteriorated and sporadic steam turbine trip.
- Plant vulnerable to production loss



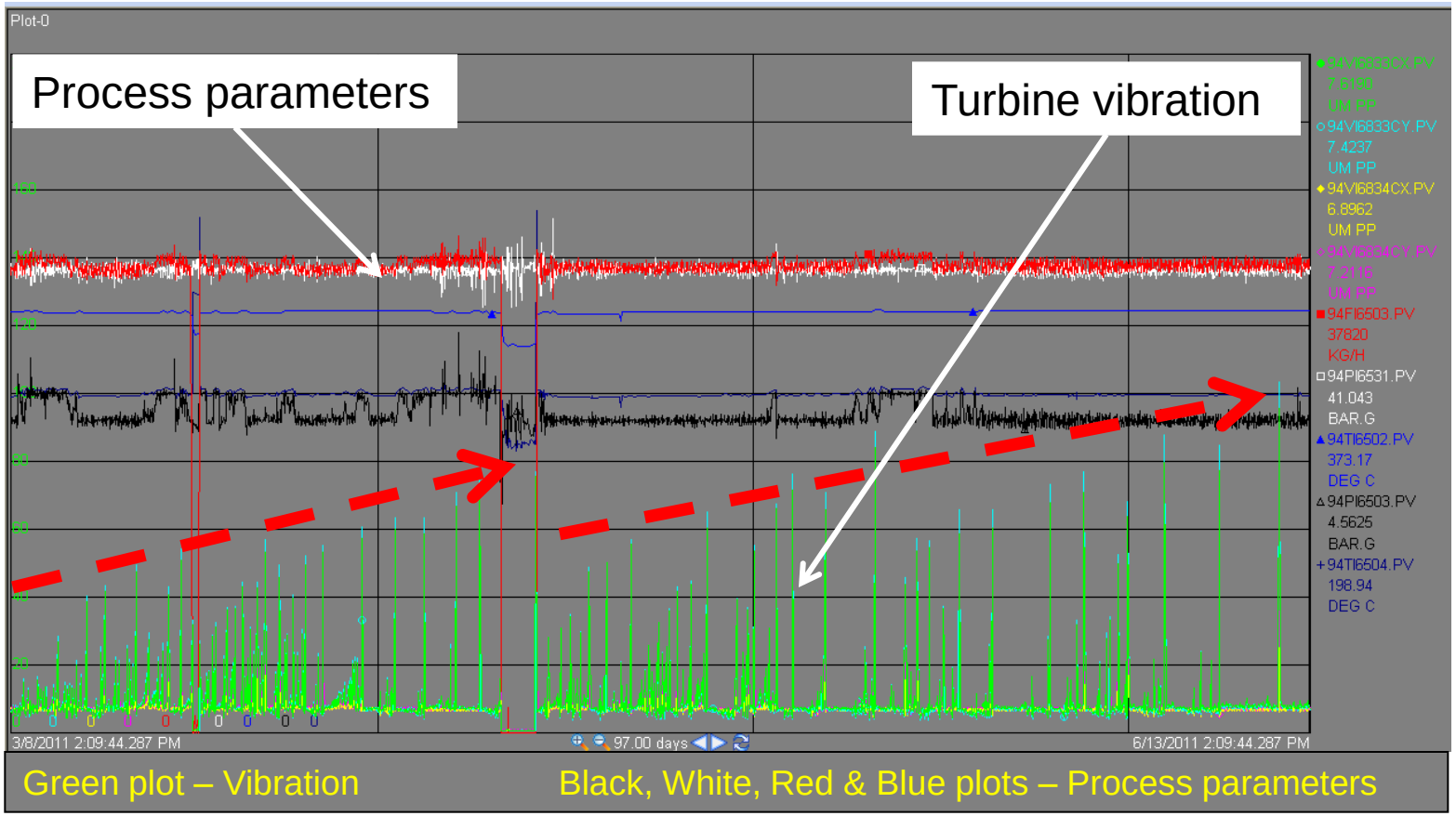
Schematic Diagram of Fresh Cooling Water System

Machine Description



Turbine Type:	Back pressure (5 stage)
Bearings:	Tilting pad
Seals:	Mechanical Labyrinth
Coupling:	Diaphragm
Power:	3840KW
Speed:	3602 RPM

Data Analysis

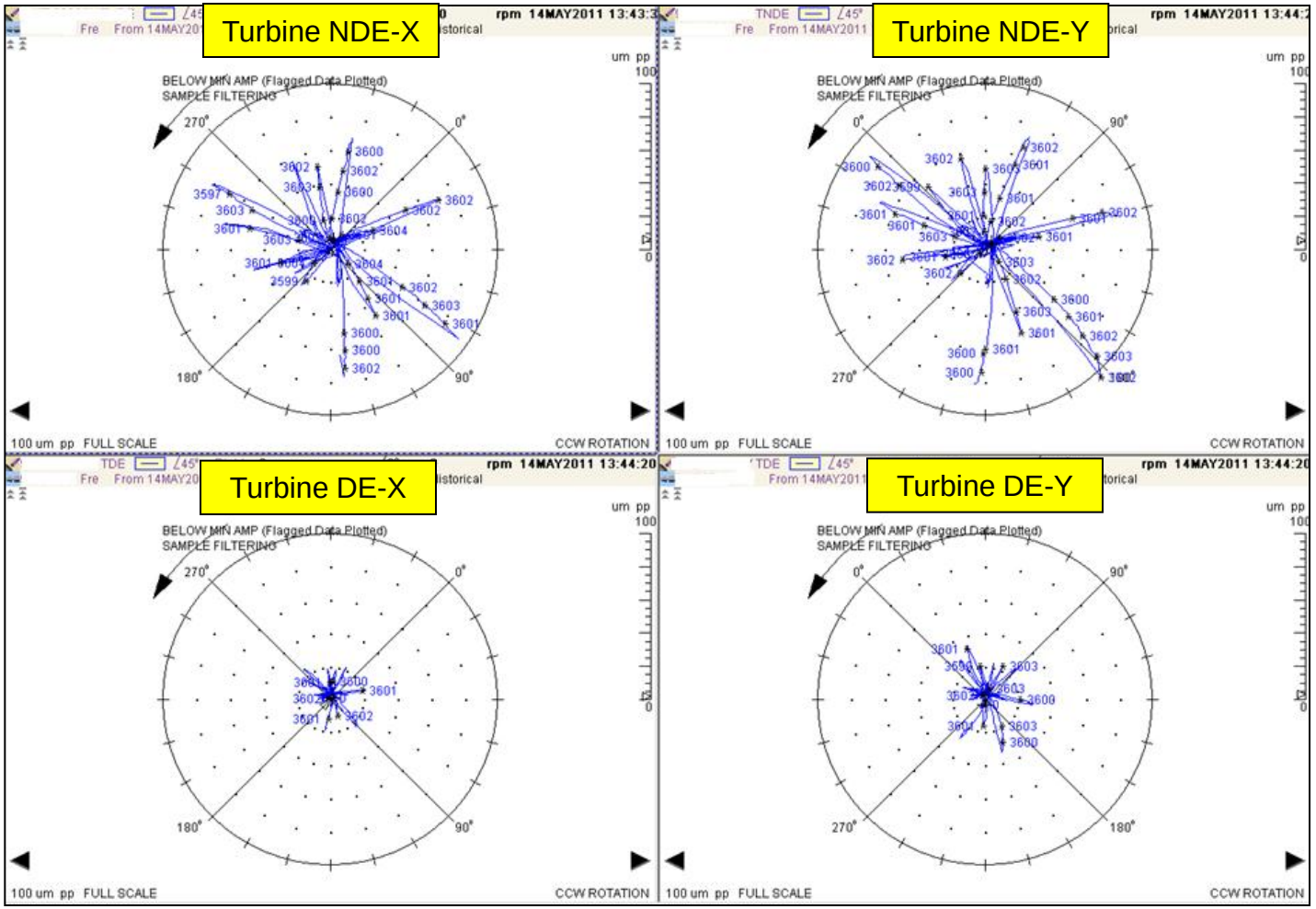


Overall Vibration vs. Process data

- Vibration is on the increasing trend and trips on high vibration
- No correlation with the process parameters

Data Analysis Cont'd..

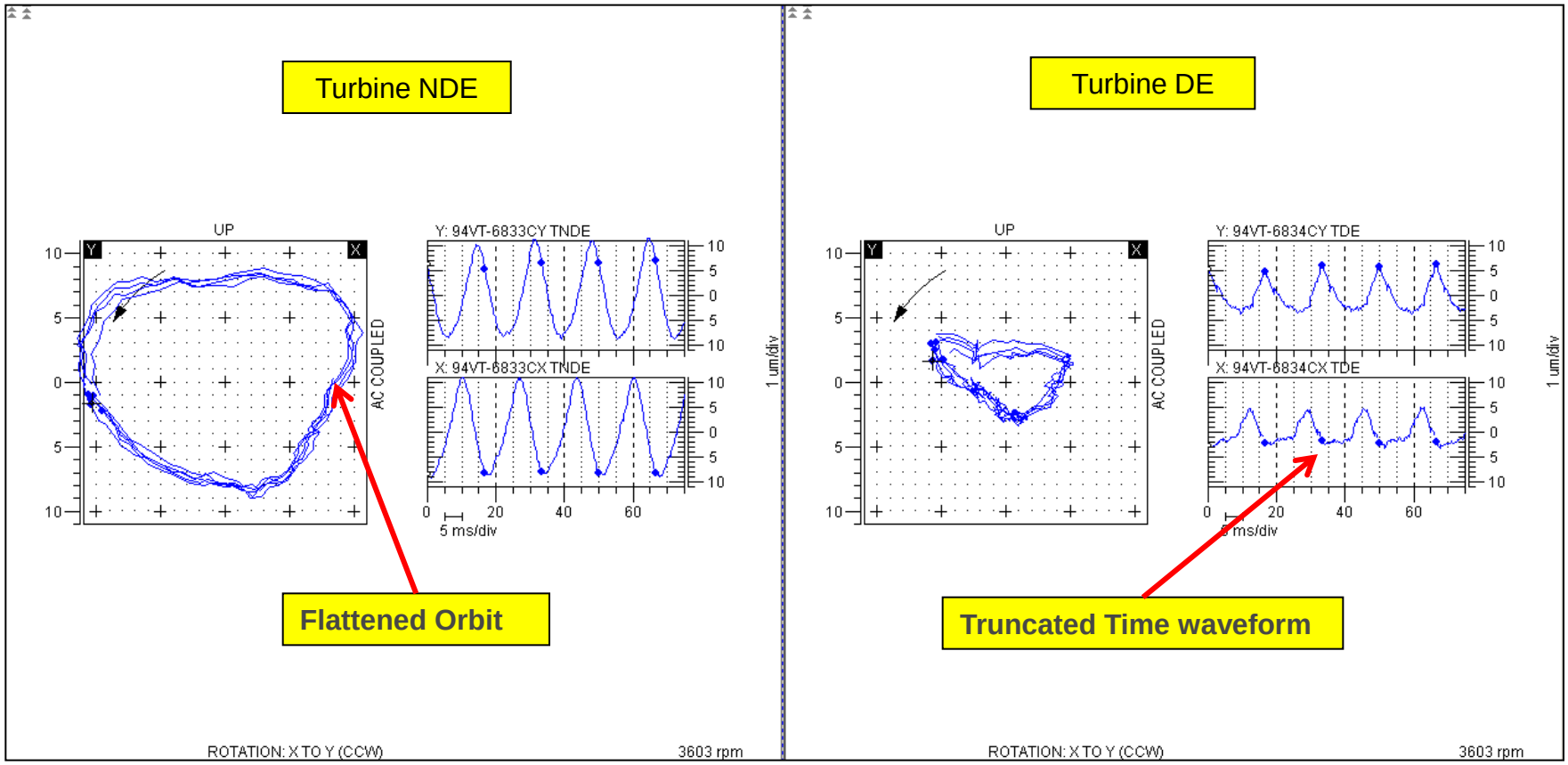
Polar Plot – 1X Amplitude & Phase Angle



Abnormal Behavior – Significant Phase Angle Change During Steady State (All Over 360^0)

Data Analysis Cont'd..

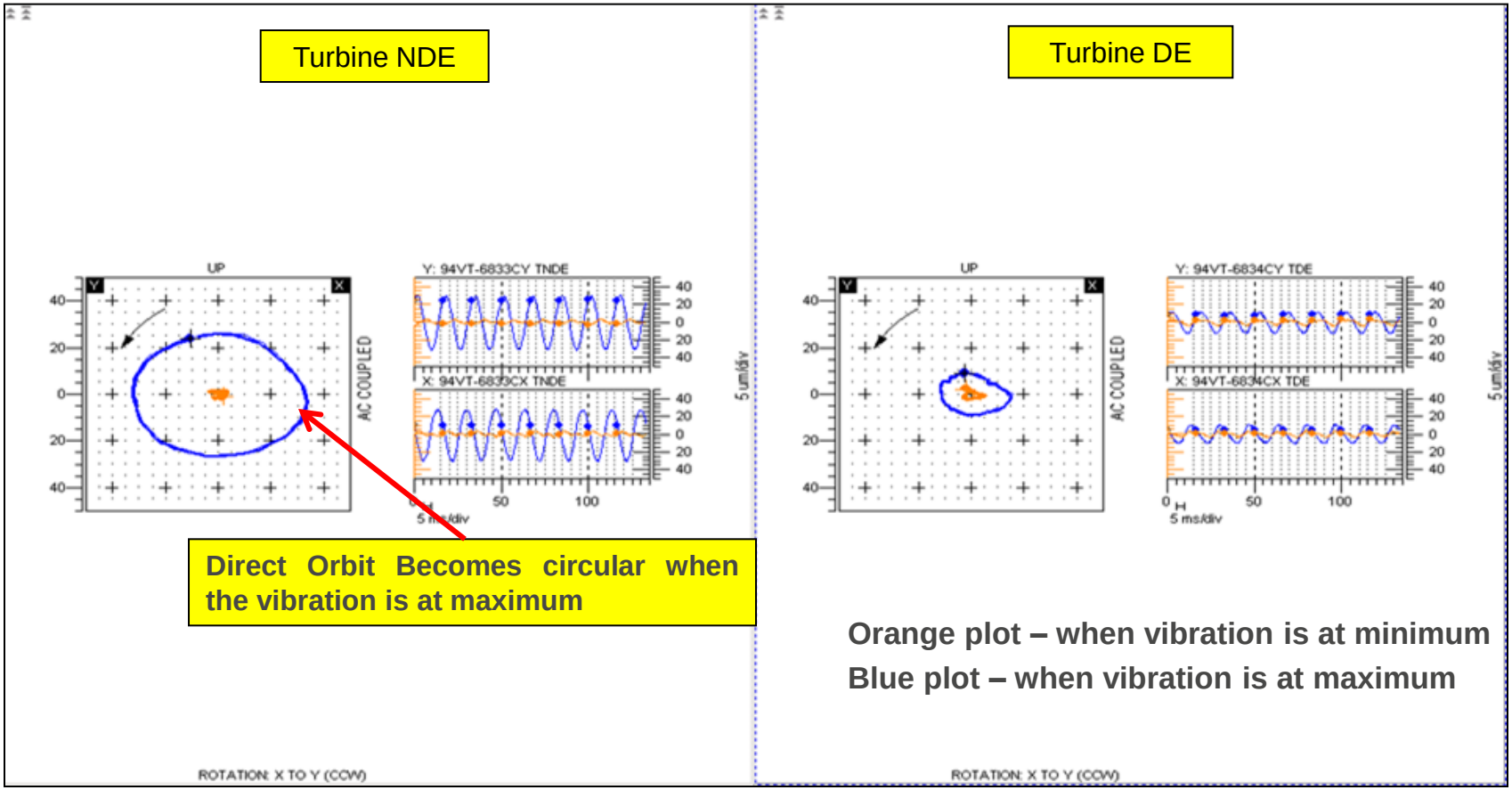
Direct Orbit Review During Vibration Excursion



Flattened Orbit & Truncated Time Waveform due to Rub

Data Analysis Cont'd..

Direct Orbit Overlay – Comparison of Low & High Vibration Amplitudes

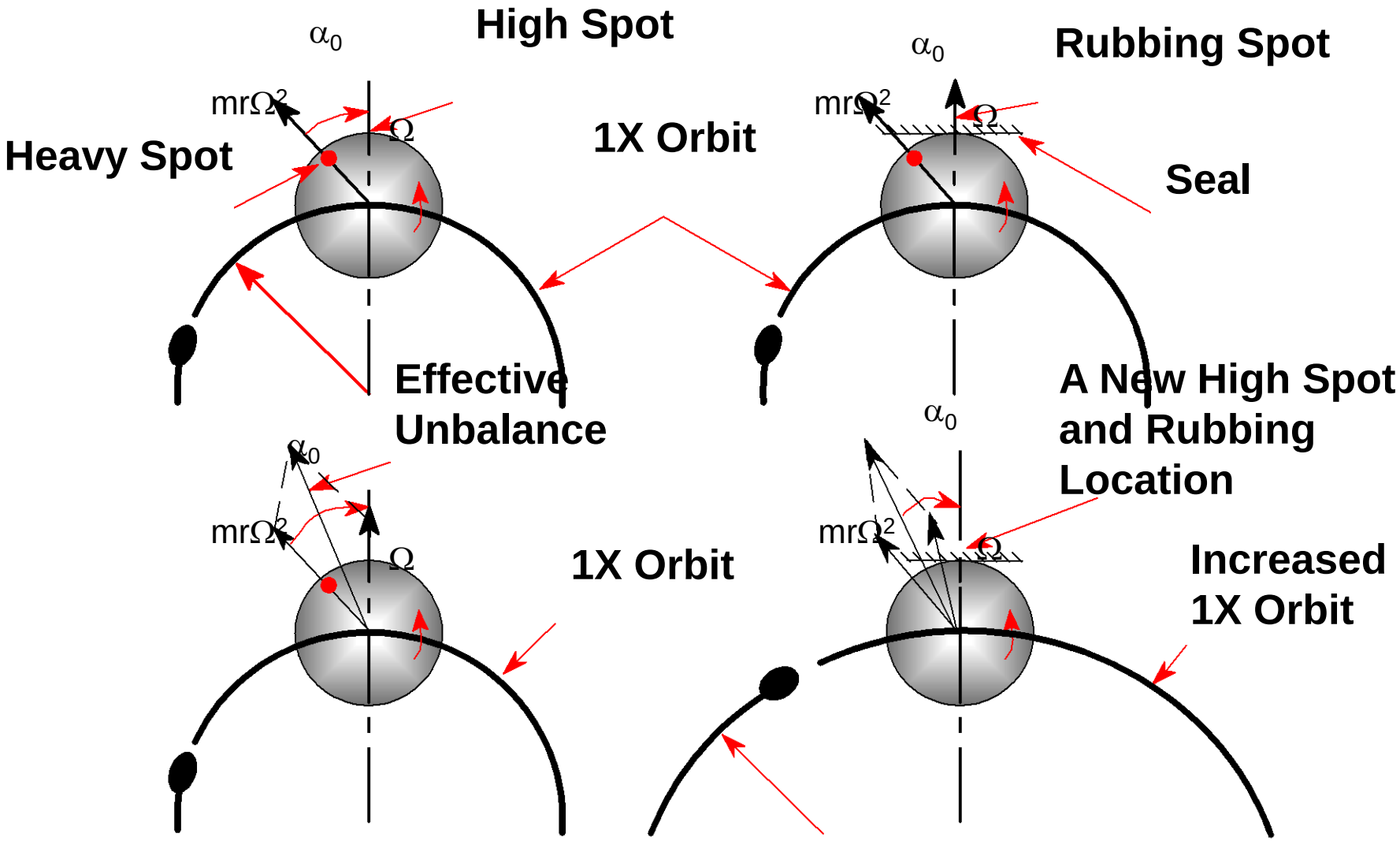


Significant change in the Orbit Shape & Amplitude

(Change in Balance Condition Due to Thermal Bow)

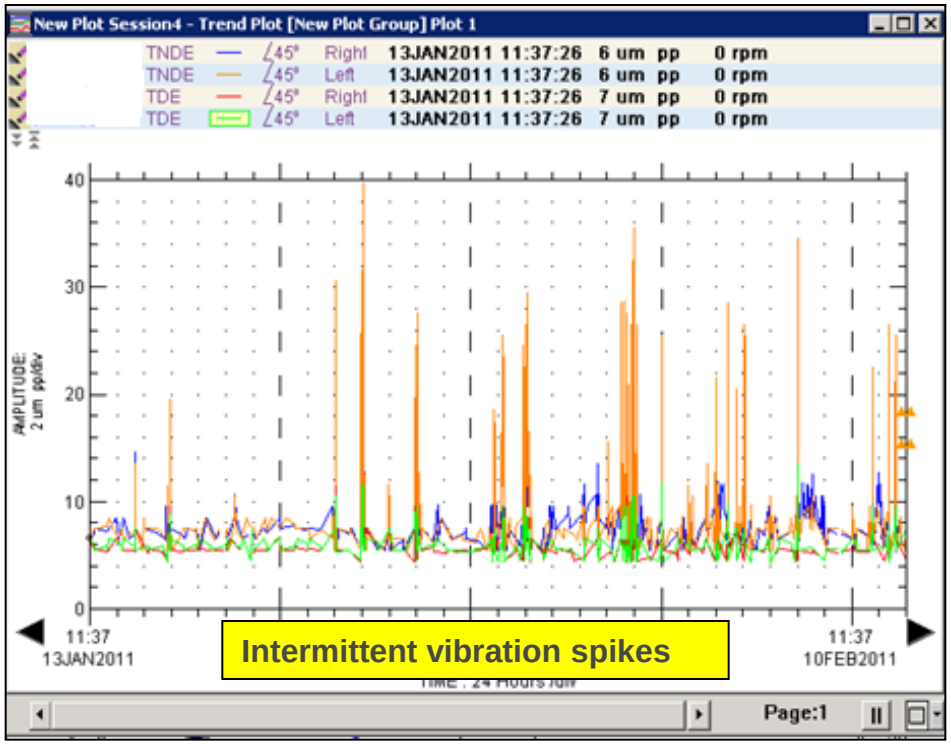
Data Analysis Cont'd..

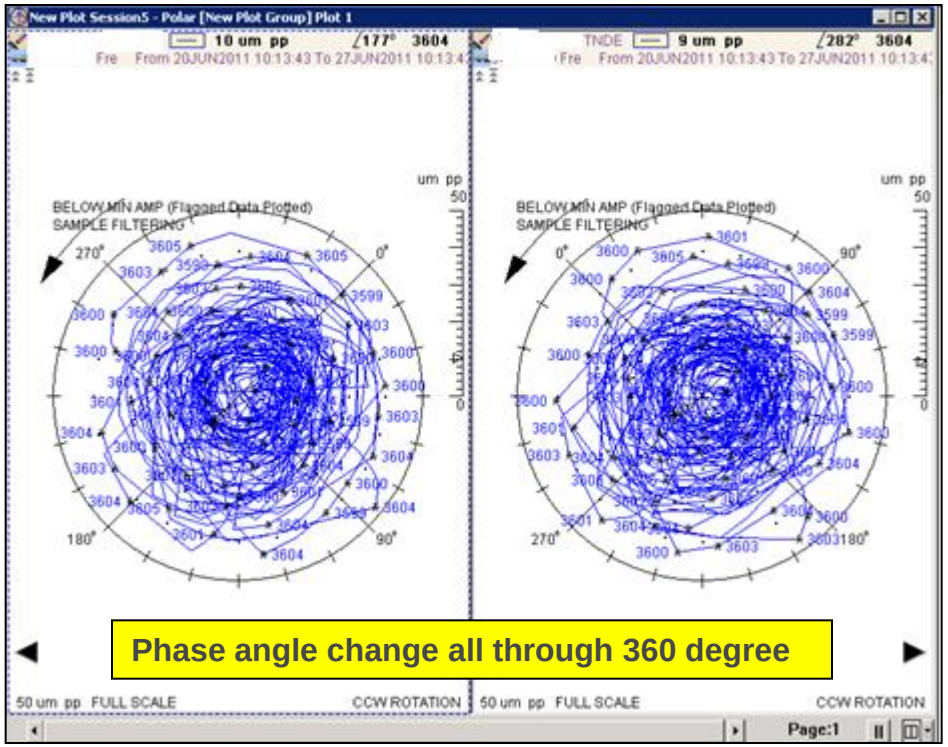
Thermal Bow Effect of Rub



Data Analysis Cont'd..

Vibration Trend and Polar Plot – Reviewed for 2nd Steam Turbine

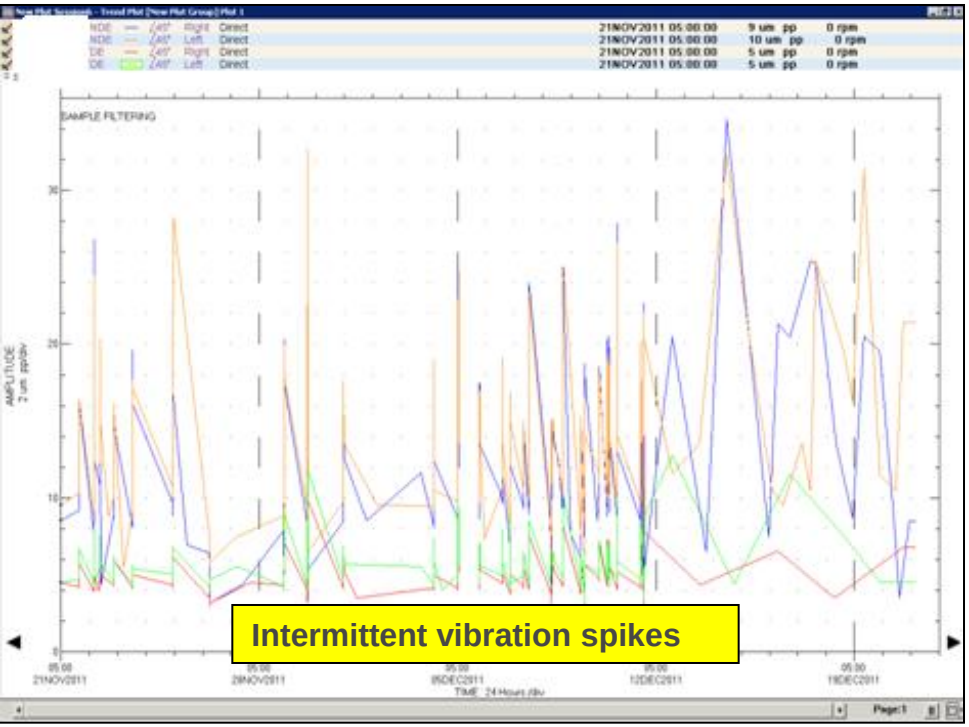


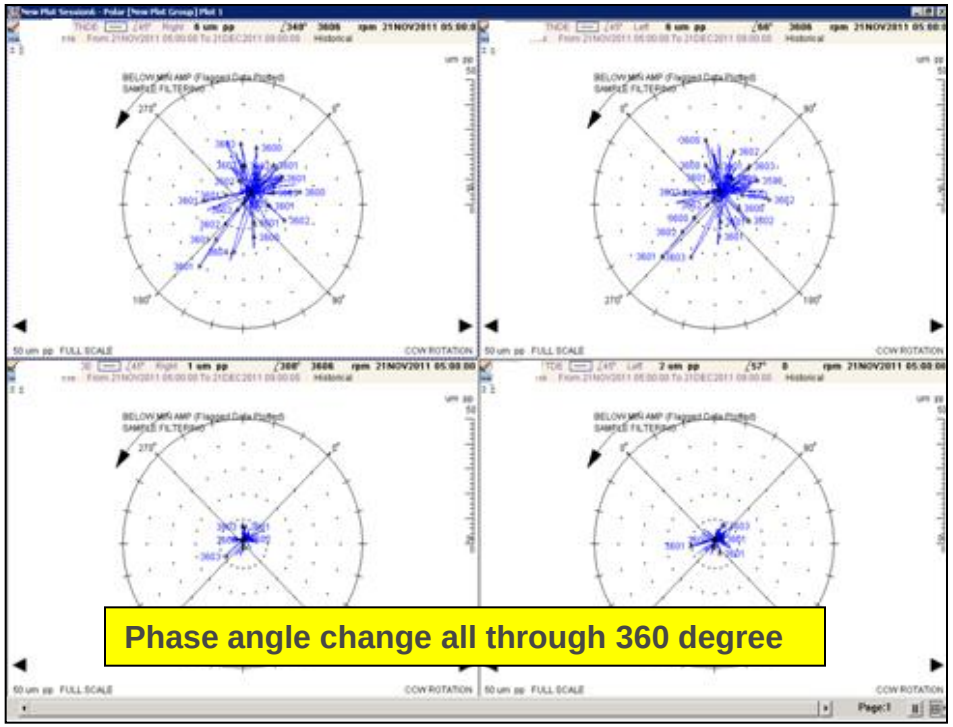


Similar Behavior - Intermittent vibration Amplitude & Change in Phase Angle

Data Analysis Cont'd..

Vibration Trend and Polar Plot – Reviewed for 3rd Steam Turbine





Similar Behavior But Less Severity - Intermittent vibration Amplitude & Change in Phase Angle

Initial Analysis & Recommendations:

Expert Analysts at site concluded the Rubbing Issue is most likely due to

- *Carbonized oil buildup in the oil deflector / seal area.*

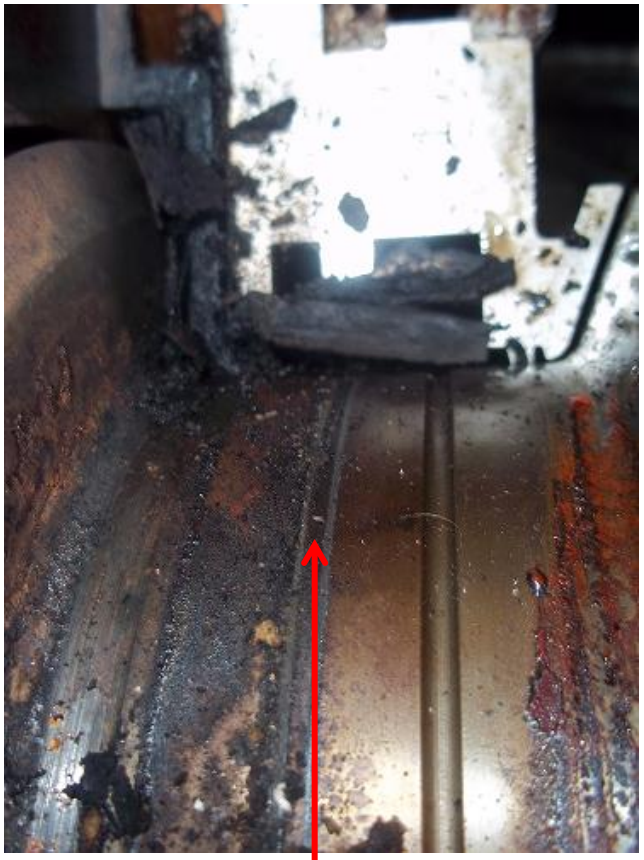
Recommended Action Items:

- ✓ *Inspect oil/steam seal areas for rubbing marks due to deposit built-up / carbonized oil.*

Machine Inspection Results

Oil Seal Area at Non Drive End Bearing of 1st Turbine

Carbonized deposits at NDE seal area



Rubbing Marks on the shaft

Rubbing Marks at the seal area due to oil carbonization is evidenced.

Machine Inspection Results Cont'd..

Rotor Internals of 1st Turbine

No abnormalities noticed on the Rotor internal components.

Machine Inspection Results Cont'd..

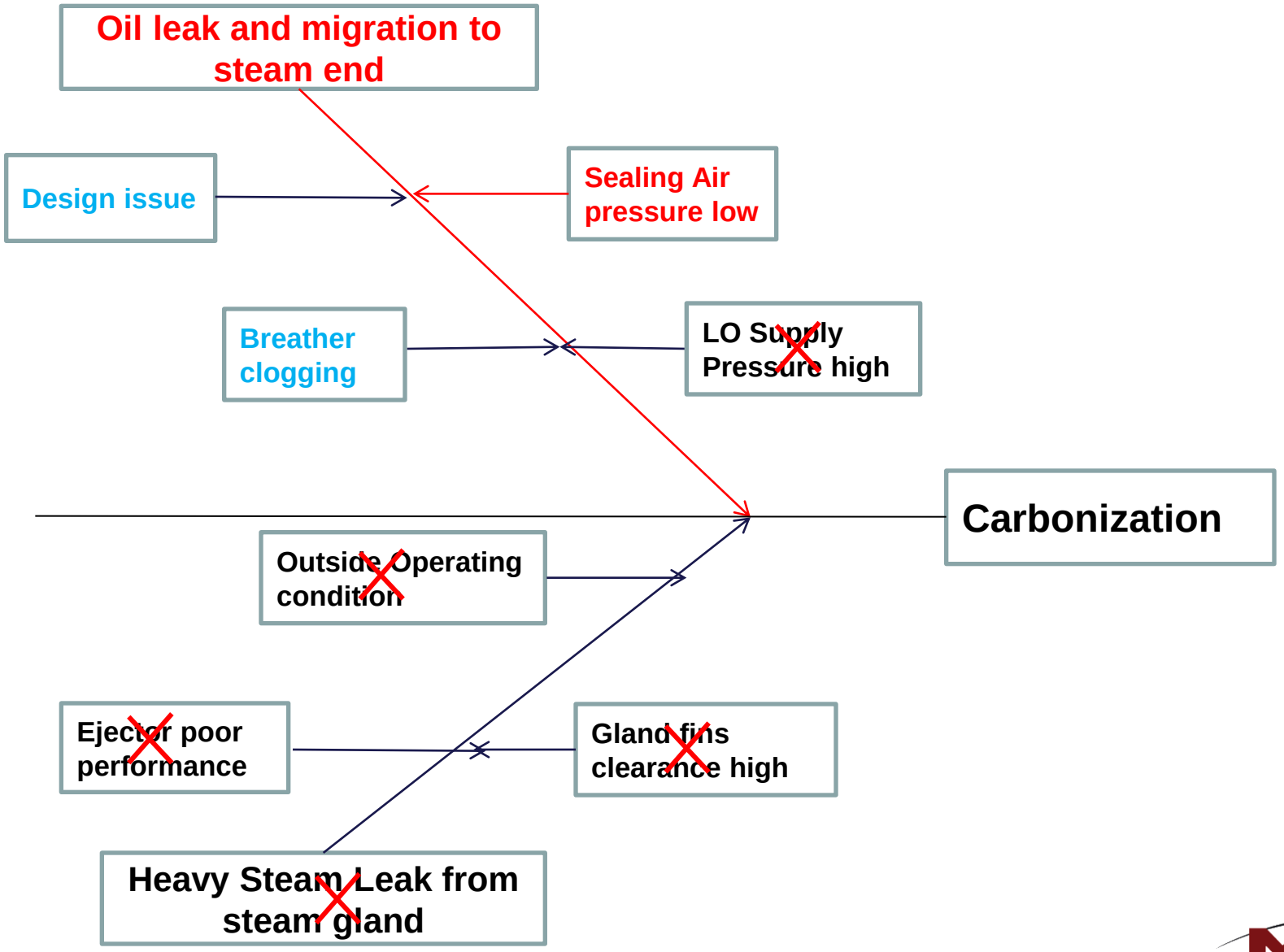
Oil Seal Area at Non Drive End Bearing of 2nd & 3rd Turbine

Seal Area of 2nd Turbine

Seal Area of 3rd Turbine

- Oil Carbonization deposits and Rubbing Marks at the seal area
- Based on the inspection results of 1st Turbine, no internal checks carried out for the 2nd & 3rd Machines

Subsequent Mechanical Failure Analysis



Conclusions

Primary Causes:

- Low seal air pressure - Oil leakage, migration at steam gland

Contributed Causes:

- Breather clogging - Oil leakage due to vapor accumulation and high lube oil pressure inside the bearing housing
- Design issues
  - Back pressure on the common return header - Wrong elevation of breather on the Gearbox drain line
  - Oil shelter in close vicinity to the steam gland

Action Items:

- Installed Pressure Gauge
- Included breather cleaning task on the Equipment Strategy.
- Modify the Breather elevation on the GB – being implemented.

Lessons Learned

- ✓ Reduced Maintenance Cost and Down Time
  - Prognostic approach on the issues and accurate analysis through experts helped early detection of machine malfunctions.
  - Findings on one steam turbine assisted to minimize the maintenance activities on other two steam turbines.
  - Presence of online diagnostic system helped to plan the machine shutdown for the maintenance without impact on the production.

- ✓ Design issues – A lesson for future projects.
  - Absence of seal air pressure monitoring
  - Close vicinity of oil seal and steam gland
  - Wrong elevation of breather location on the Gearbox