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TEXAS A&M UNIVERSITY
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TEXAS A&M ENGINEERING EXPERIMENT STATION

LUBE OIL CARBONISATION

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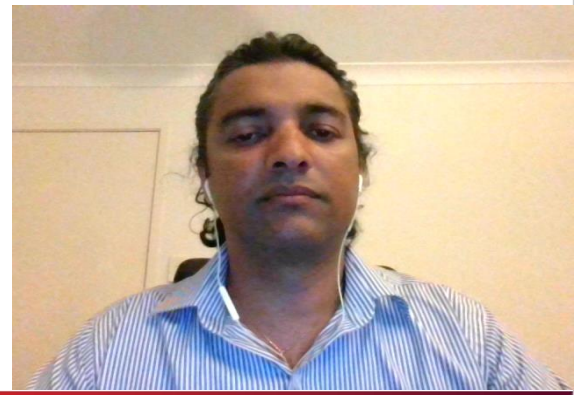

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ABSTRACT

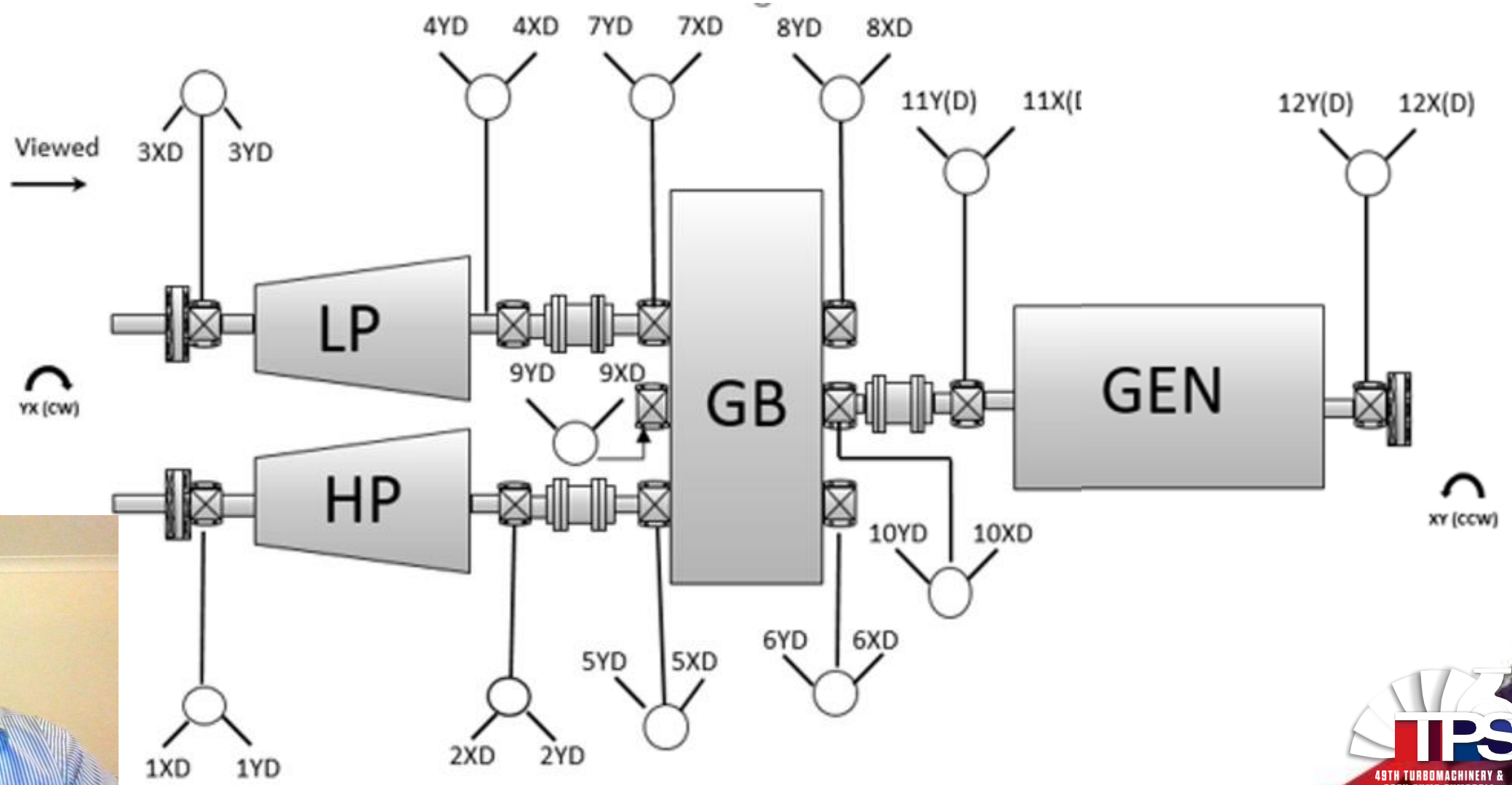
Carbonized particles can get deposited in housing oil seal clearances causing a partial rub like phenomenon. Friction caused due to reduced clearances because of accumulation of carbonized particles leads to shaft thermal bow inducing 1X vibration. When the accumulated particles are abraded due to increase in vibration, the clearance opens up which reduces the thermal bow causing the vibration levels to drop to normal levels and this cycle repeats.

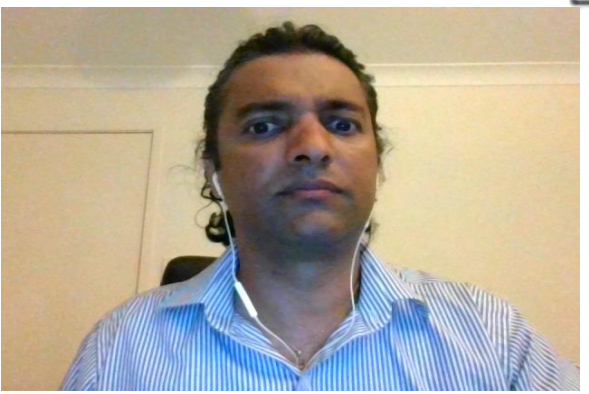
This presentation outlines a case where a similar phenomenon was observed causing the unit to trip after a few hours of operation. Successful diagnosis was carried out using vibration data which is presented in this case study.

Place of action- Mount ISA (Outback Australia)

- Combined cycle Steam Turbine Generator with power generating capacity of ~ 40 MW.
- Power plant consists of 6 units producing nearly 200 MW of electricity in the region.
- Multichannel data collector was used to capture higher resolution data and flexibility of doing analysis as there was no remote access to the diagnostic software.

STEAM TURBINE GENERATOR UNIT – MACHINE TRAIN



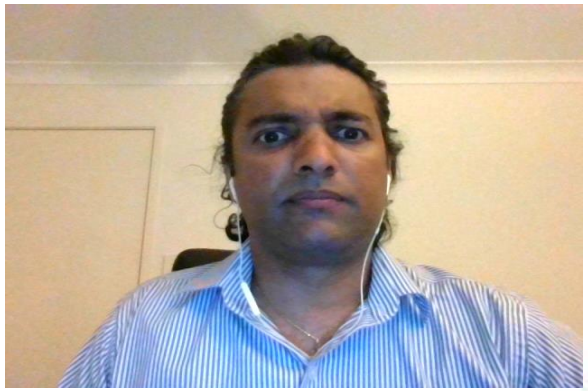


CONTINUED – MACHINE DETAILS

- There are only a few units of this configuration in the world.
- Since the location is remote, it is very critical the unit should be in good health to maintain power demand in the region.
- Constant tripping caused process upset and significant loss in revenue.
- Lead time to source critical parts would have taken few months as it had to be imported from France.
- HP Speed - ~ 13400 rpm.
- LP speed- ~6800 rpm.
- Generator speed- 1500 rpm.

HISTORY

Power station has a combined power generation capacity of around 230 MW.
This unit (~40 MW) was brought back into service after being in cold storage for 4 years.
Vibration excursions was noticed every few hours with levels coming back to normal operating levels, eventually the levels surpassed the trip limit causing the machine to shutdown.
The unit was restarted few times with similar outcome.
Lost revenue in production downtime –
could be in excess of $100K/day.



VIBRATION DATA

Since the online legacy system had no remote access and limitation of offsite reporting, multichannel data collector was used, which also provided the advantage of better resolution.

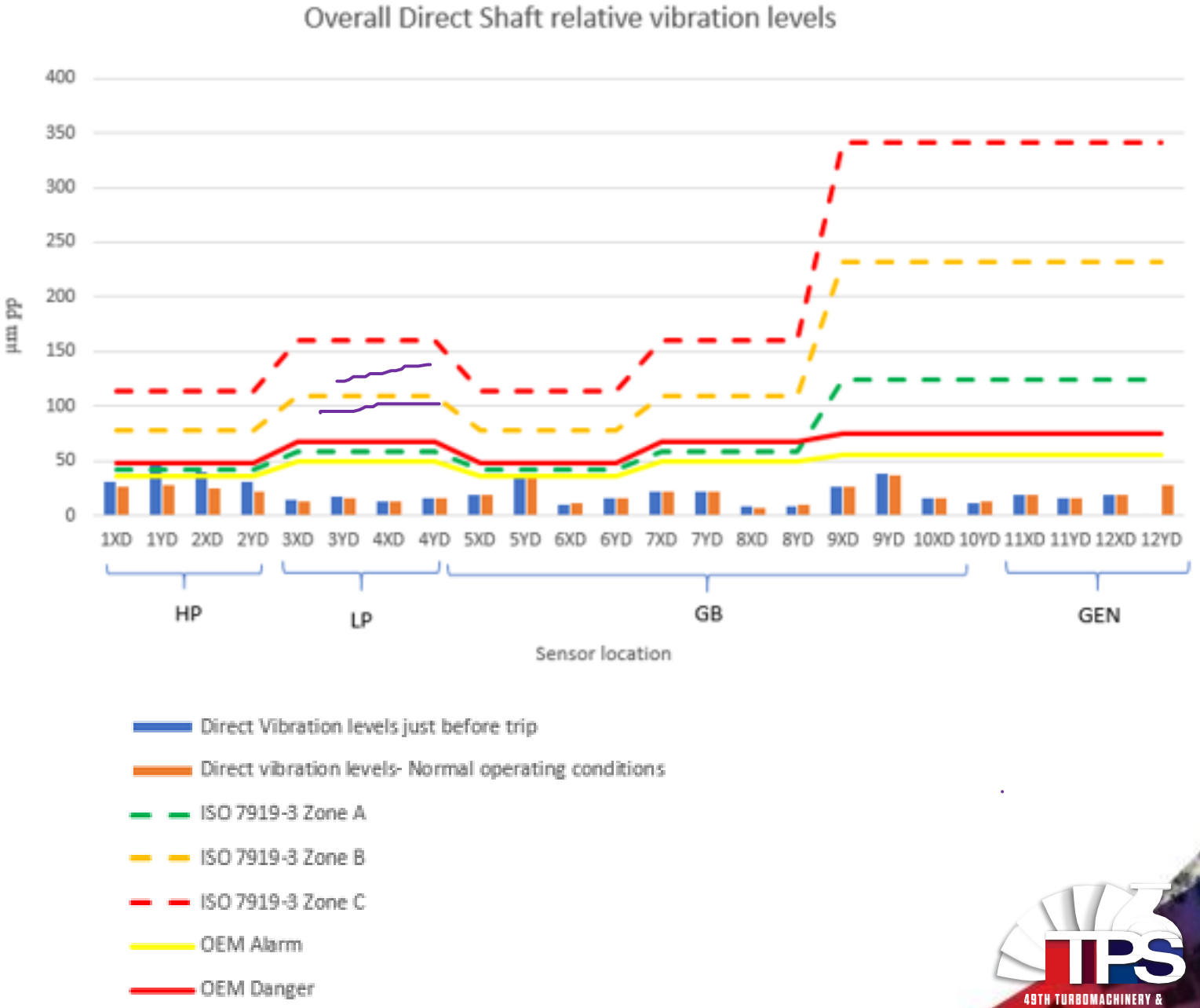
After initial discussion with site personnel it was decided to collect vibration data over a period of a few hours until the vibration excursions were observed.

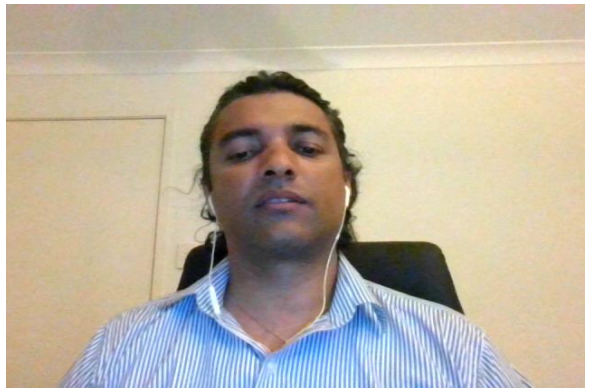
A few hours into operation the first vibration excursion was noticed and subsequently a couple of more vibration excursions eventually leading to the machine trip.

This phenomenon was predominantly noted at HP Turbine bearings.

VIBRATION DATA

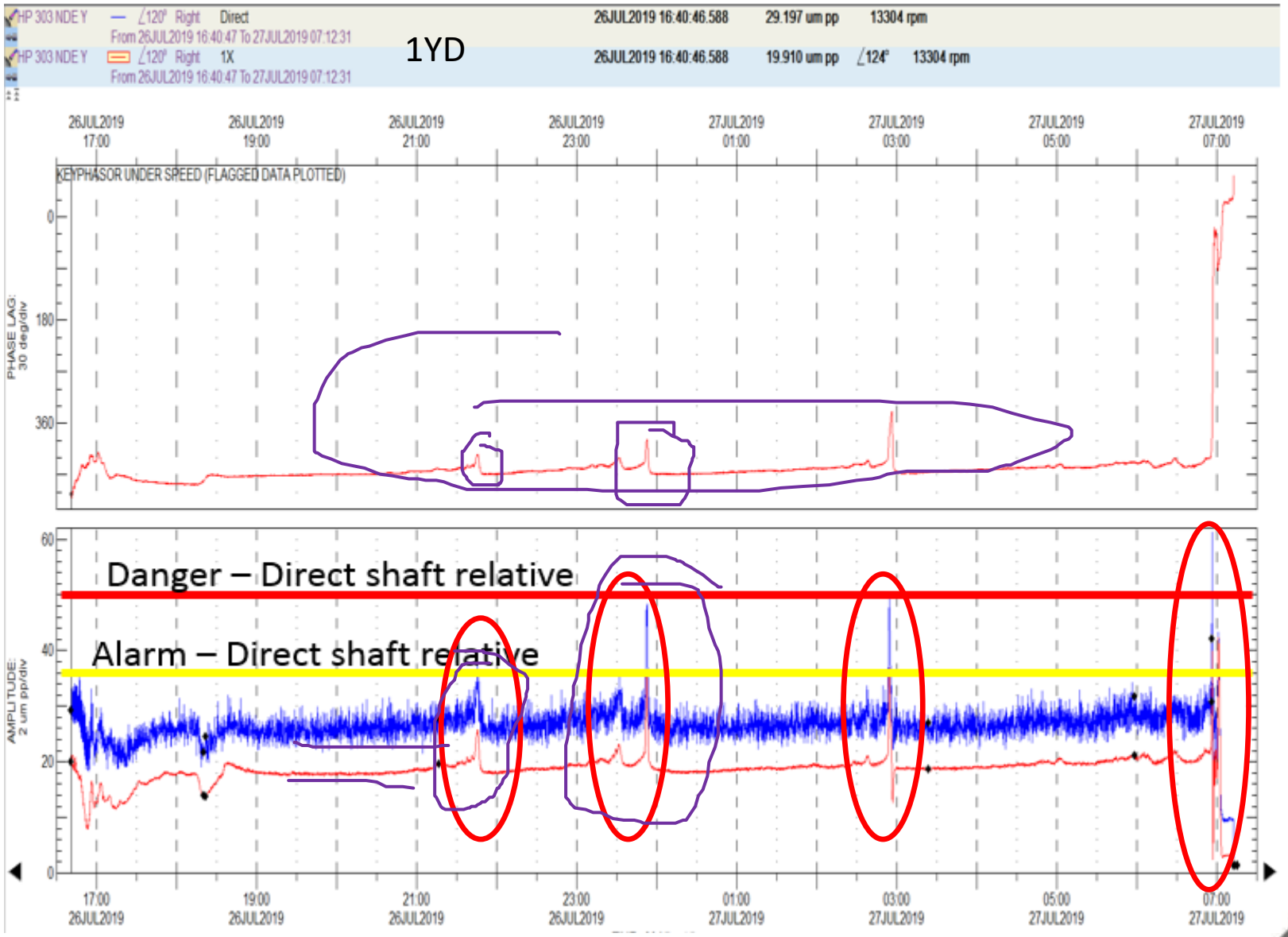
Overall levels were well below trip levels at normal operating condition however the levels exceeded alarm levels during one of the spiking event leading to a trip.

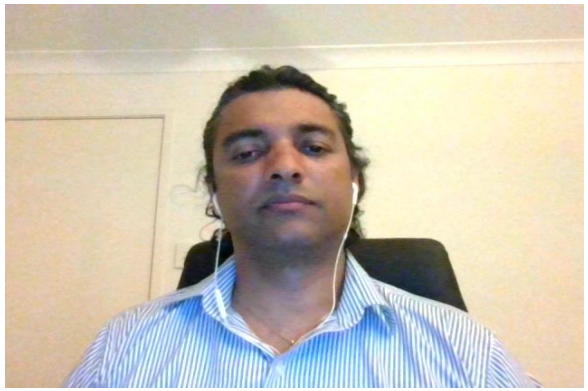




DATA REVIEW

Vibration excursions occurred every few hour intervals.
Change in phase is also noticed at the same time as vibration excursion.
Observed increase in 1X vibration (HP NDE Y).

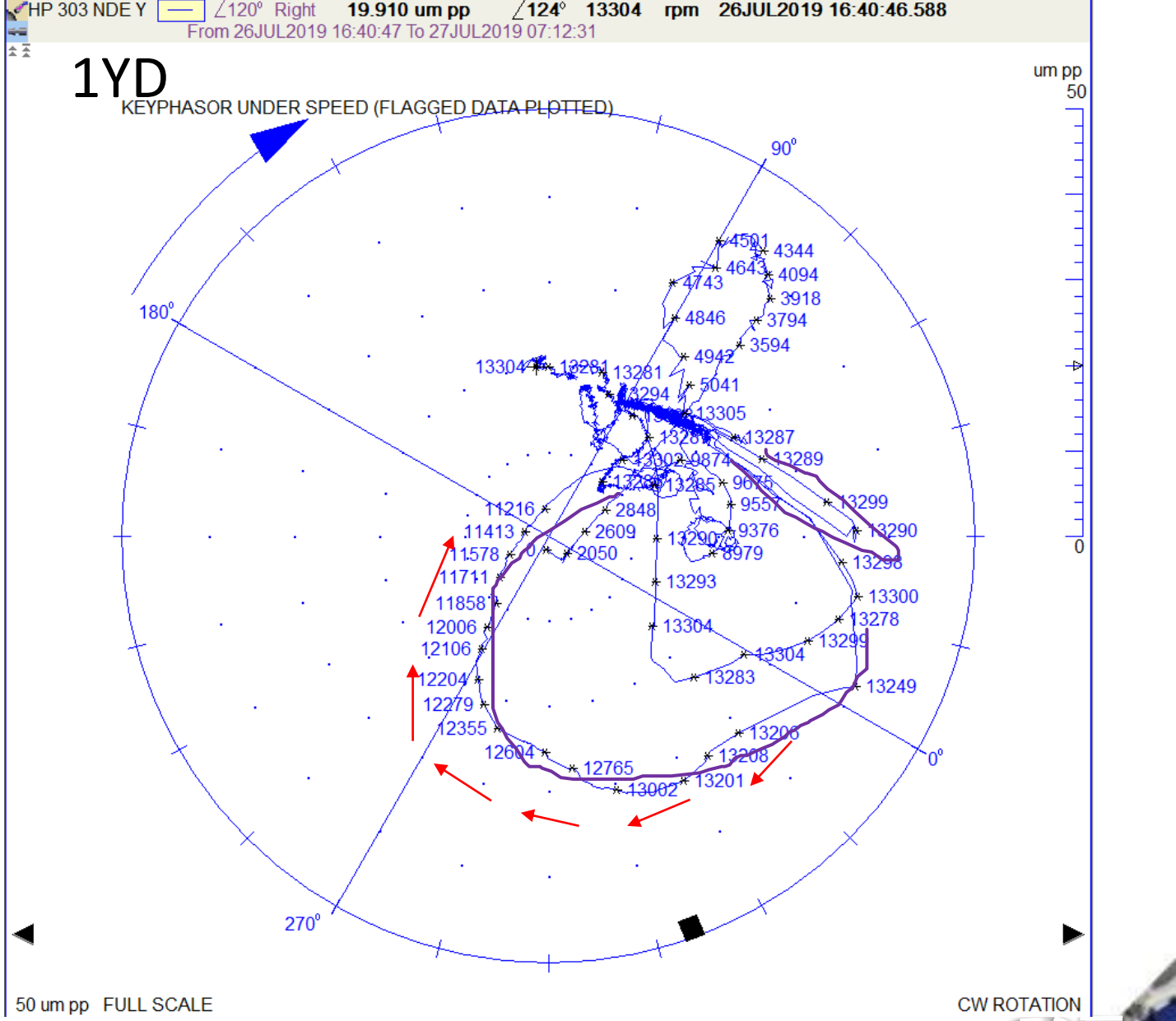




DATA REVIEW – POLAR PLOT

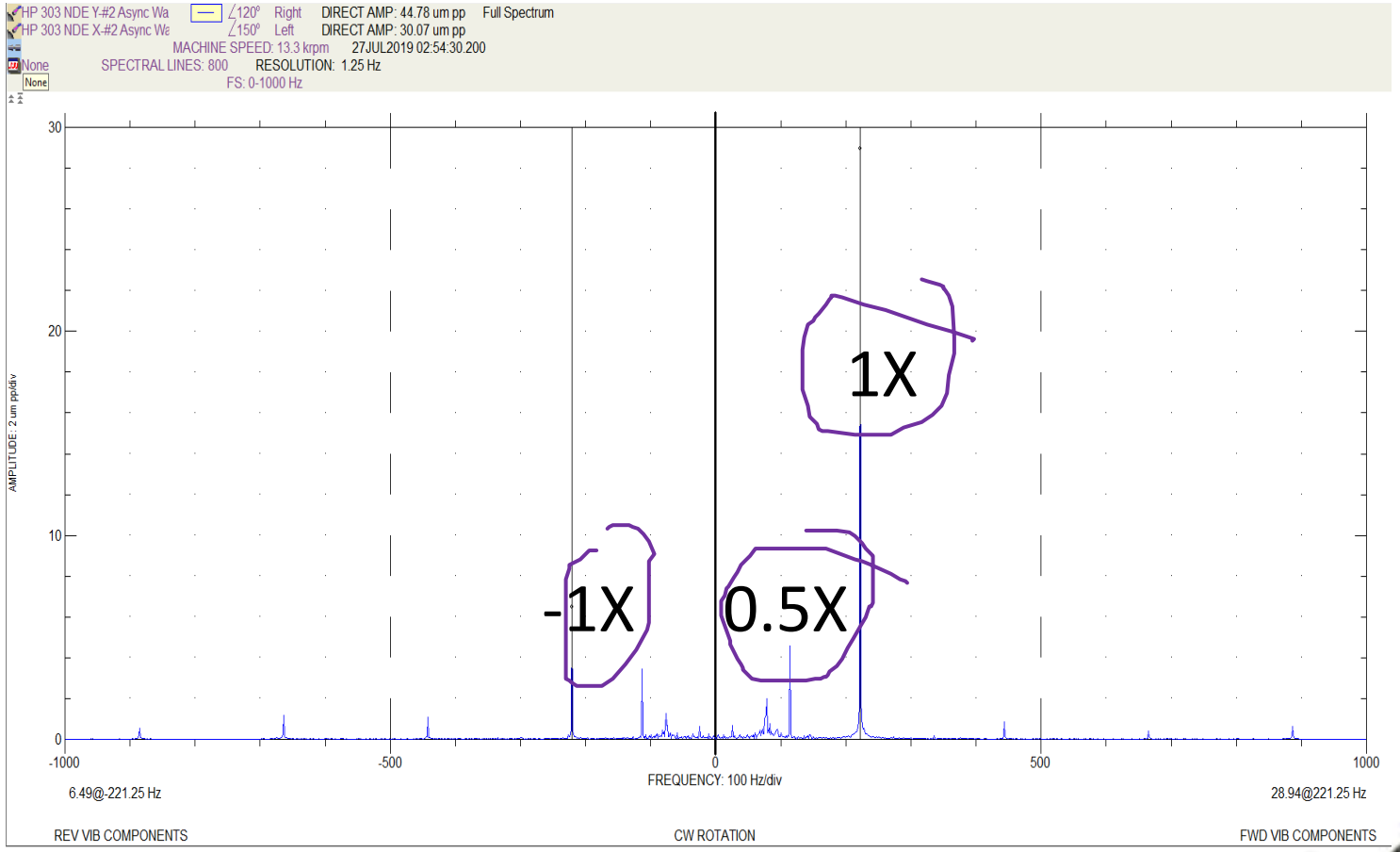
Polar plot showing rolling phase which happens at the same time as vibration excursions.

This is due to frictional forces when there is a partial rub phenomenon which induces a thermal bow and increase in 1X vibration.



DATA REVIEW

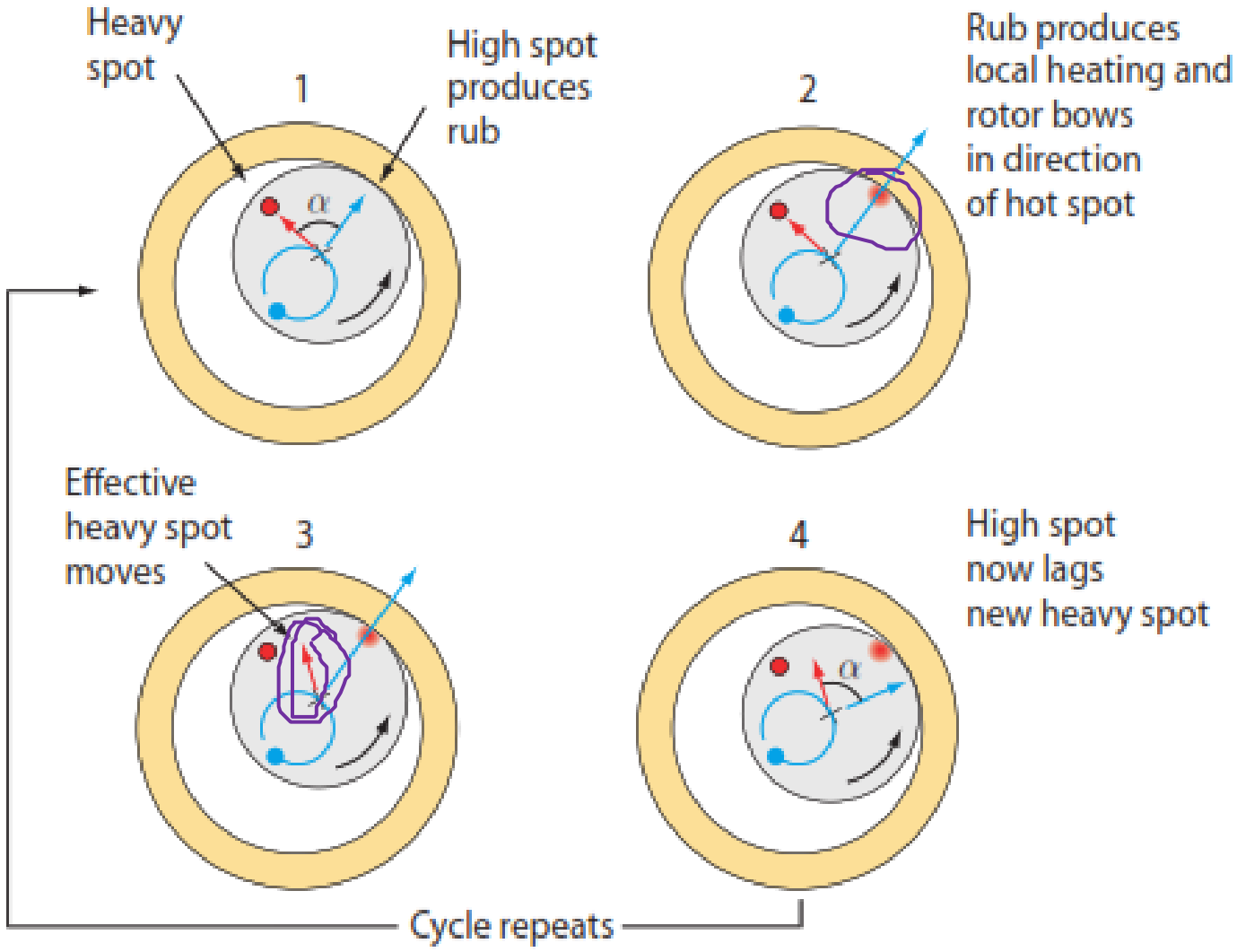
Sub synchronous vibration was evident with low levels of reverse precession amplitude.
However in case of severe rub, reverse precession will be more prominent.



DATA ANALYSIS – POLAR PLOT

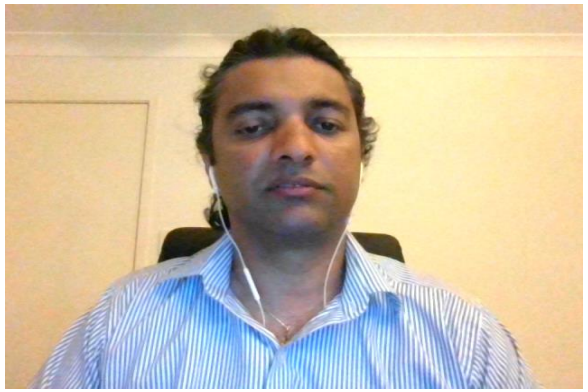
- Polar plot shows filtered vibration amplitude and phase lag for a single vibration channel.
- Plot shown in the previous slide indicates a change in phase with each vibration excursion.
- Also notice the phase change is getting bigger with each vibration excursion eventually leading to a trip.

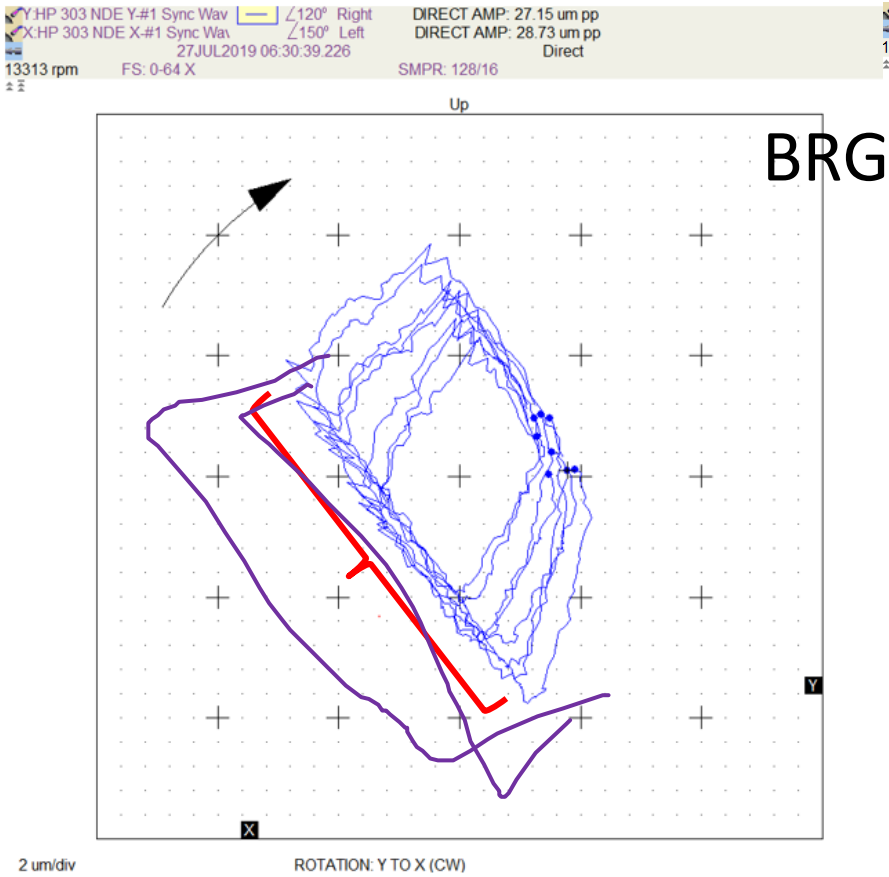
PRINCIPLE OF CHANGING PHASE DUE TO PARTIAL RUB



DATA REVIEW – ORBIT PLOT

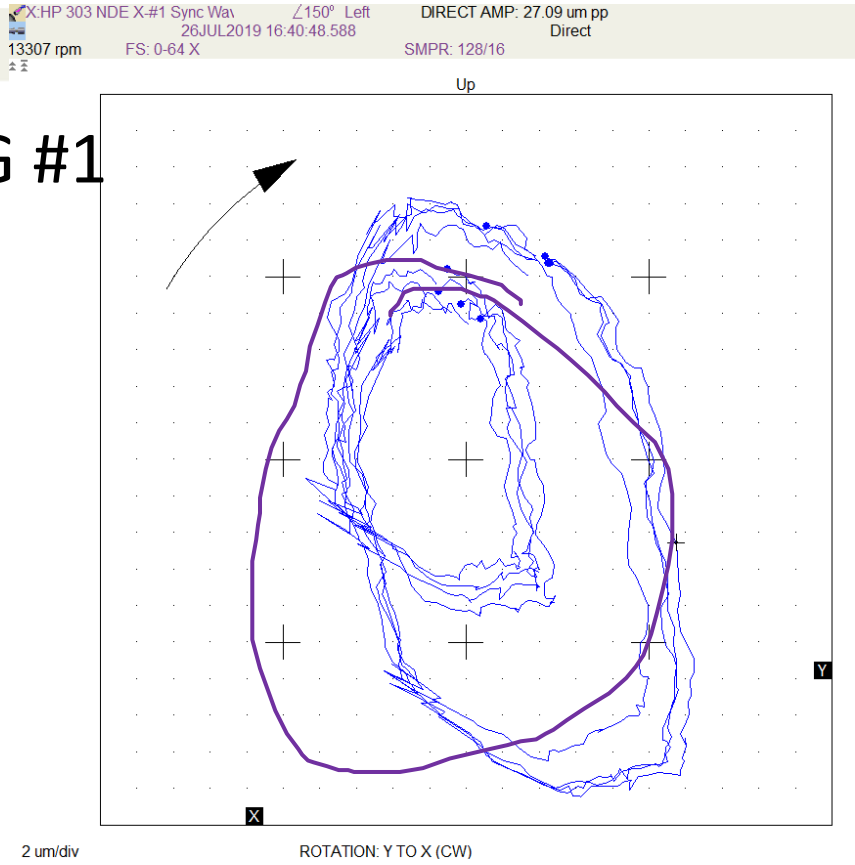
Orbit plot showing before and during vibration excursion. Flat side of the orbit is due to restricted movement.





Flat orbit showing partial rub

BRG #1



Before Rub – no flat side

PERIODICAL AMPLITUDE FLUCTUATION

- Friction caused due to rub increases temperature causing a bow resulting in imbalance, however we do not have temperature data to verify the change.
- When high vibration increases it abrades the deposited material resulting in normal operation.
- This cycle repeats itself.

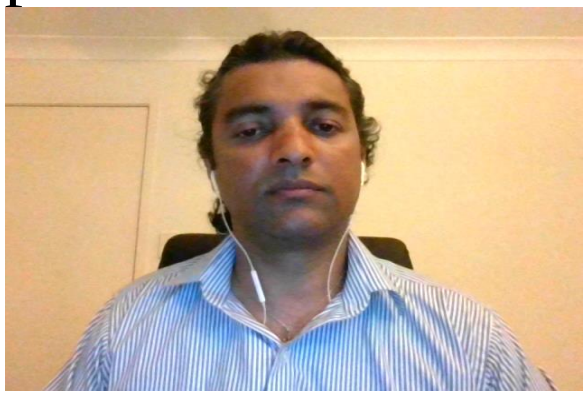
CONCLUSION AND RECOMMENDATION

From the evidence presented in previous slides it was concluded that Lube Oil Carbonization was the issue. Oil analysis was classified as Fair with water content at 207 ppm up from 45 ppm four months ago.

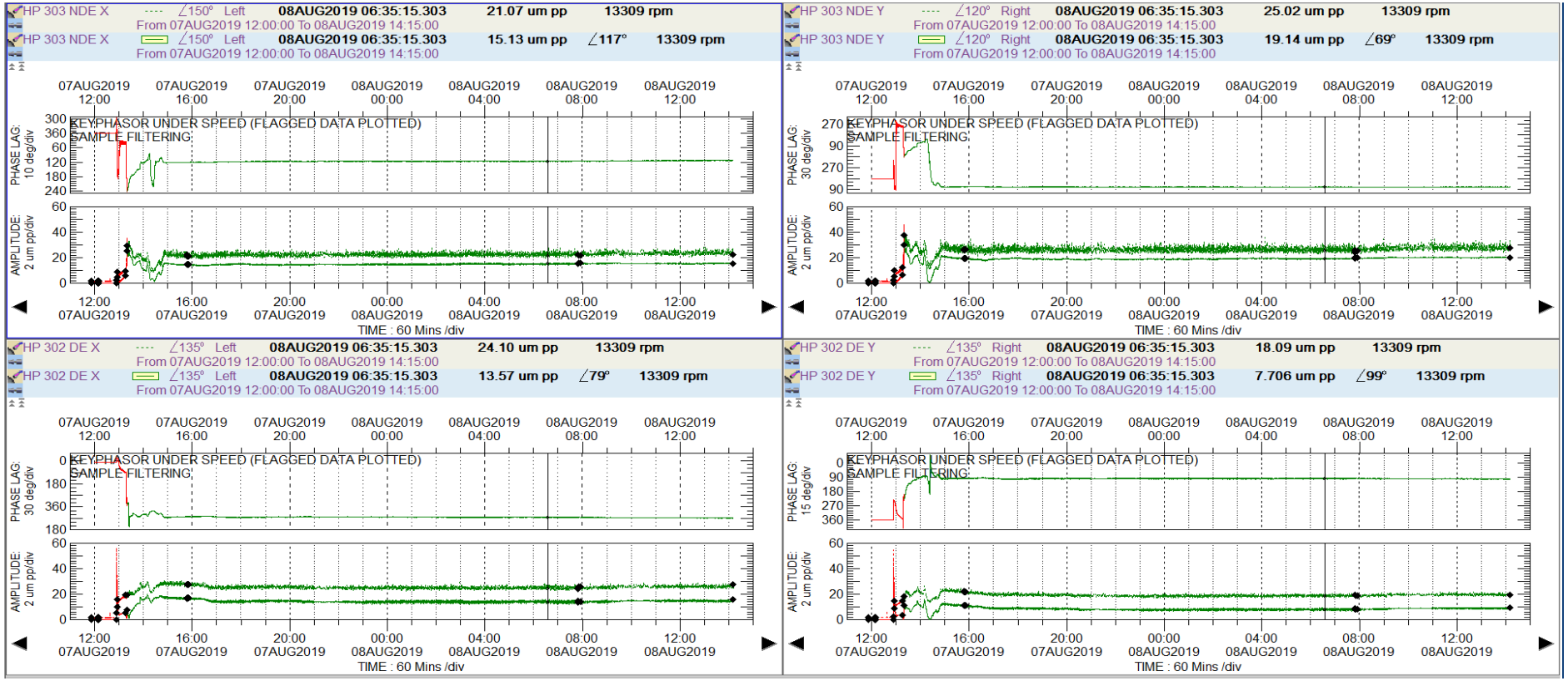
Gland steam pressure was very high at 60 Kpa way above normal operating range of 20 Kpa due to failure of pressure control valve. At low loads, the pressure inside the turbine will be low and gland steam is supplied to the seals to prevent ambient air from leaking into the system. If the pressure is too high the steam may leak past the seal system which could have happened in this case.

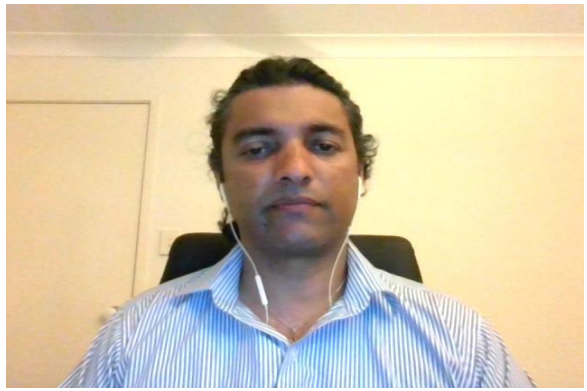
Recommended inspecting bearing/seals to check for carbonization.

Recommended to set gland steam pressure per OEM guidelines.

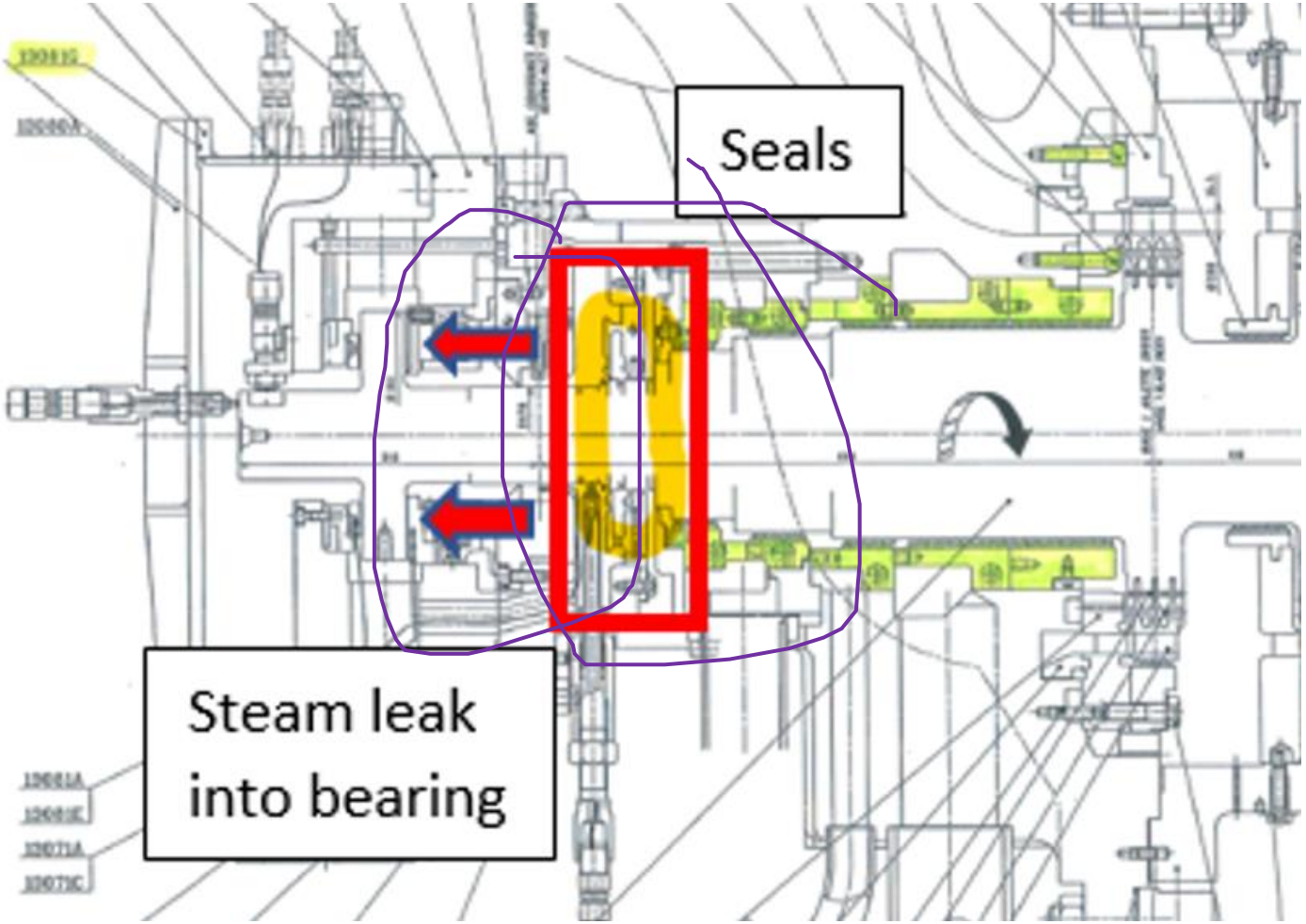


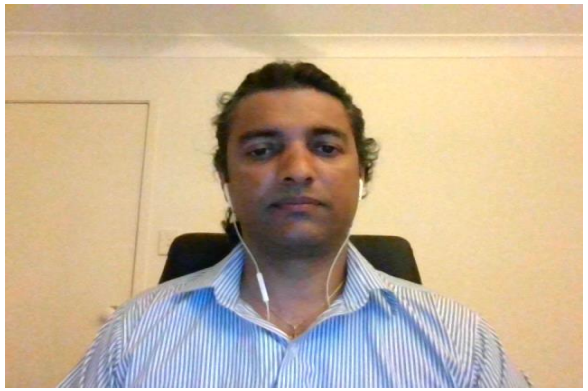
Vibration data post change in gland steam pressure





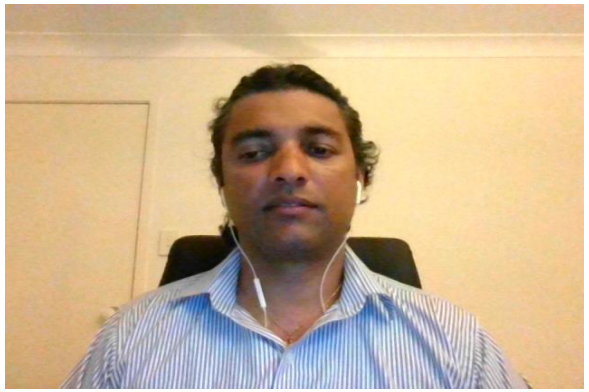
Schematic of turbine showing seal and steam path





INSPECTION RESULTS

- Upon inspection lube oil carbonization was evident.
- Lube oil filter was in poor condition.
- No locking tab on carbon seal.
- Pressure control was found to have failed increasing the gland steam pressure.



LESSONS LEARNED

During vibration investigation it is imperative to conduct a thorough review of all machine operation parameters and support systems. During field inspection of the unit oil leak, potentially from gearbox was also noticed.

Rubs are not primary malfunction; they are always a result of some other primary issue and in this case, it was lube oil carbonization.

High gland steam pressure was forcing the steam to leak past carbon seals causing carbonization.

Lube oil filter being not in good condition might have also played a role in carbonization by not filtering the contaminants.

An optimized online system with remote connection would be helpful for quick diagnosis of vibration problems, even more significant for remotely located plant.