



ASIA **TURBOMACHINERY** & **PUMP** SYMPOSIUM
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Online Mitigation of Gearbox Bearing High Temperature due to Oil Varnishing

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Abstract

This case study presents an incident of sudden temperature increase of a bearing in a special purpose gearbox during normal operation. Details of the direct cause investigation, online mitigation and longer term improvements will be shared.

The compressor train (motor, gearbox and compressor) operates under higher than usual oil temperature because of the undersized cooling system. Over the years, oil varnishing was detected but did not cause major issues to the machines during operation.

In 2018, a sudden increase in bearing temperature of one bearing in the gearbox was detected. The increase was gradual over several weeks from ~80DegC to 105DegC. There was a corresponding decrease in vibration at the same bearing. Investigation concluded that the likely cause was varnish deposited on the bearing pads, causing the clearance to reduce which led to an increase in temperature and reduction in vibration.

An online de-varnisher was installed to the oil reservoir, and within a week of operation, the bearing temperature and the vibration started to reduce. The machine operation was sustained until the next shutdown. As part of the mitigation, a special cleaning additive was injected into the oil system prior to shutdown to clean the system. Detailed oil sampling tests (MPC, RULER) were introduced as part of the long term improvement strategy. A new type of oil was introduced with much better varnishing resistance.

This case study presents the problems encountered, analysis performed, recommendations (long and short term) implemented and results achieved.



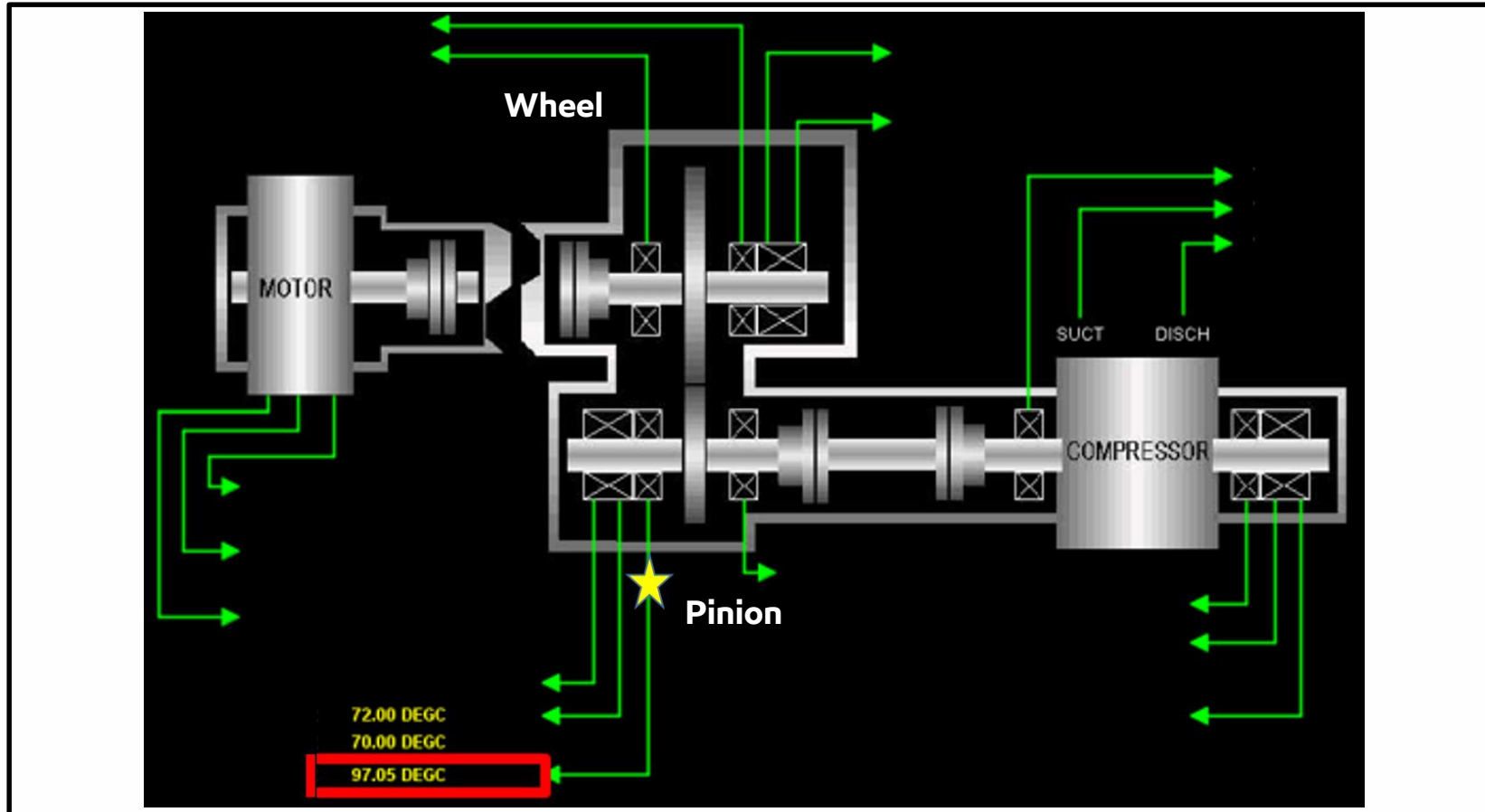
Agenda

- 1 Case Study Background
- 2 Problem Description
- 3 Analysis
- 4 Mitigation Implemented and Results
- 5 Key Learning



Background

Compressor Train Details



6-stage Centrifugal Compressor
Suction Pressure: 8,303 kPaA
Discharge Pressure: 10,309 kPaA
Discharge Temperature: 85°C

Motor power: 2,250 kW

Single Helical Gear
Gear rated power: 1,864 kW
Rated Input Speed: 1,490 rpm
Rated Output Speed: 11,500 rpm

Work Scope:

- Online lube oil replenishment
- Oil based solvent injection
- Gearbox overhaul
- New oil replacement

Background

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6-stage Centrifugal Compressor

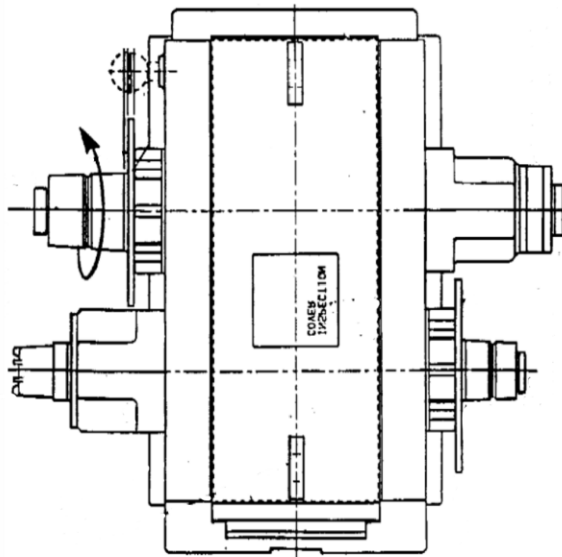
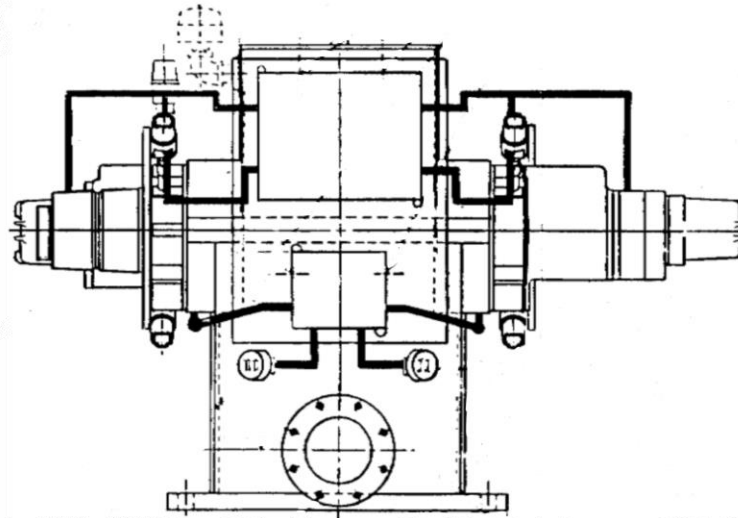
Suction Pressure: 8,303 kPaA

Discharge Pressure: 10,309 kPaA

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Work Scope:

- Online lube oil replenishment
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- Lube oil flushing
- New oil replacement

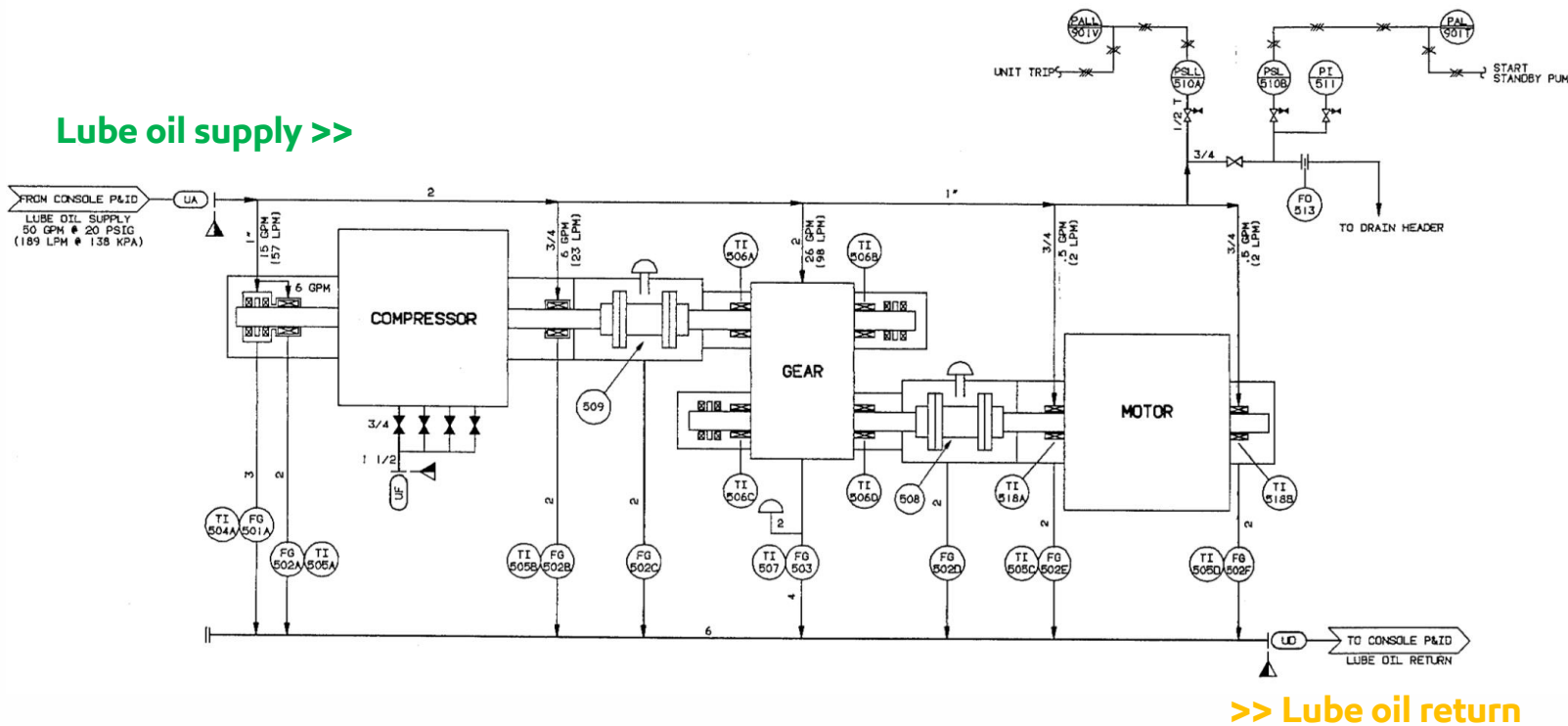


SP Gearbox Cross Section and Details



Background

Lube oil supply >>



>> Lube oil return

All bearings in the compressor train are lubricated by ISO 32 grade lube oil.

Common lube oil reservoir is used for supplying lubricating oil to all bearings and seal oil system.

Lube Oil System

Lube oil type: Light Turbine Oil

Supply pressure: 172 kPaG

Supply temperature: 40°C

Return temperature: 82°C



Problem Description

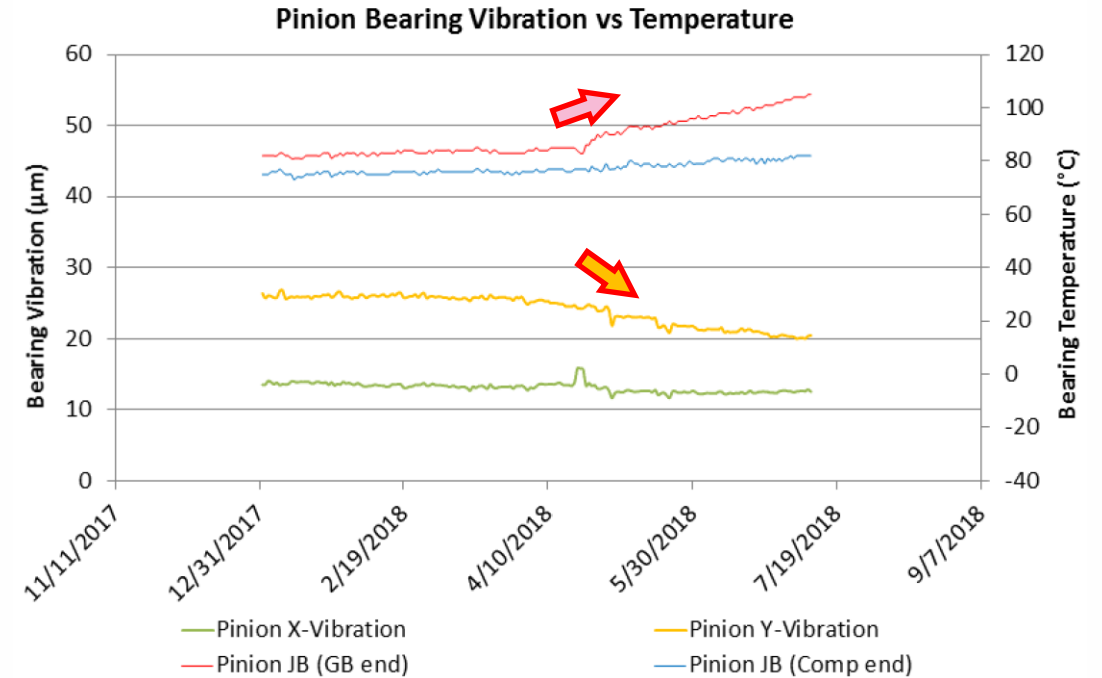
Two occasions of one pinion bearing temperature excursion beyond 100°C.

Pinion bearing temperature from 80°C to 105°C over 3 months.

However the vibration of the pinion bearing in X-direction decreased

Other bearing vibration and temperature in motor and compressor remain unchanged.

Presence of oil varnish in the past compressor overhaul report in 2007

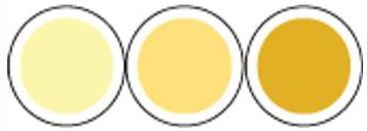


Analysis

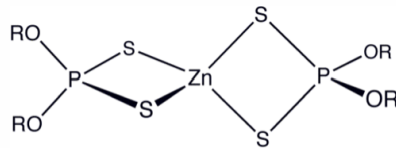
- No change in viscosity and flash point
- More samples for detailed laboratory test.



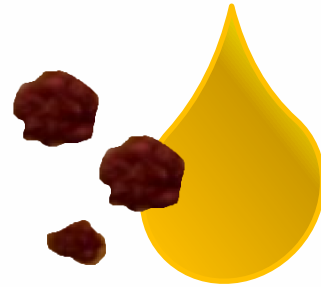
Results



High MPC >40
(Critical)



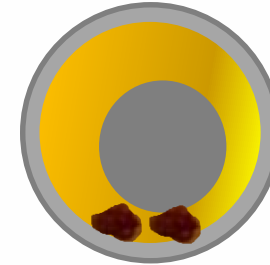
Deplete of
ZDDP & Phenols



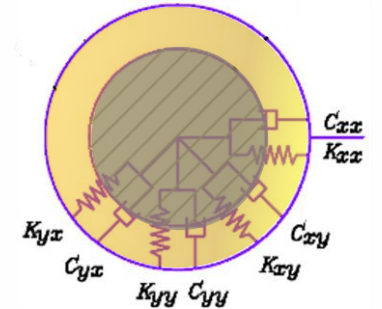
>290,000 particles
(5 to 15 μ m)



Soft contaminants
agglomeration
0.08 μ m

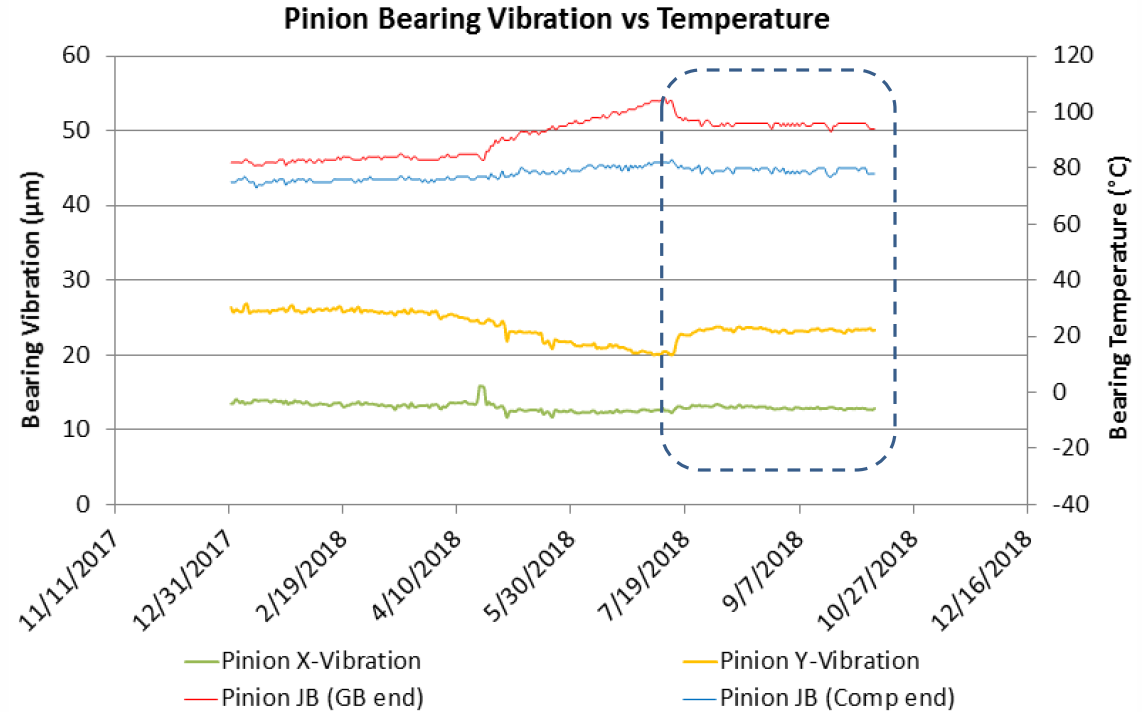
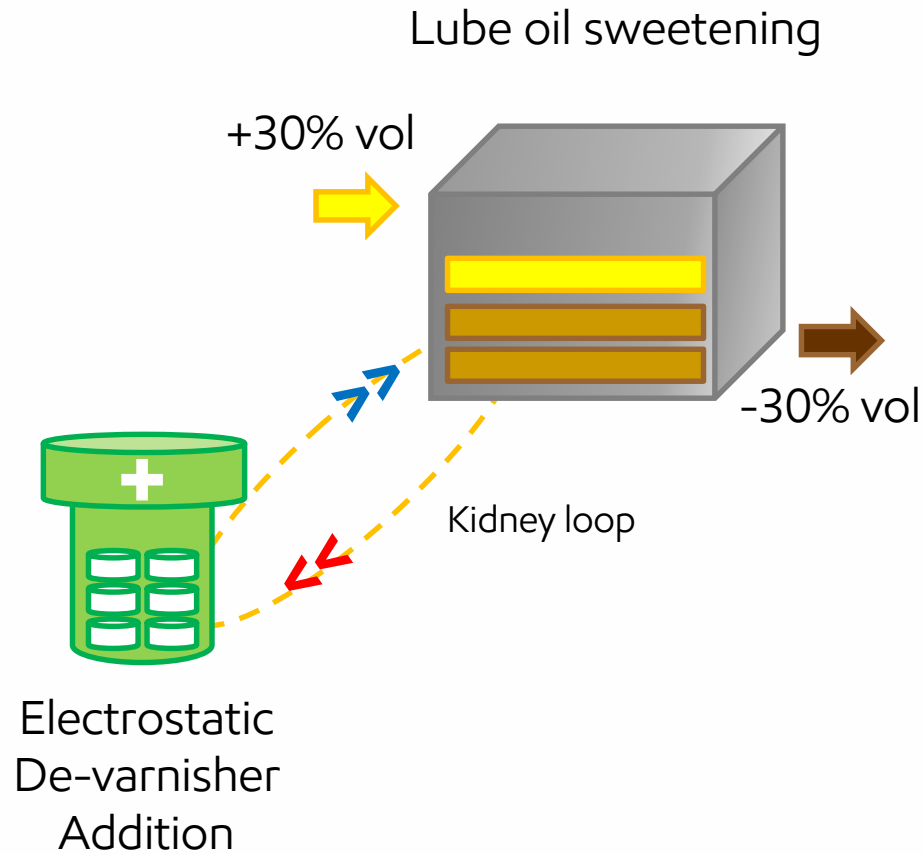


Reduce bearing
clearance



Increase
bearing stiffness

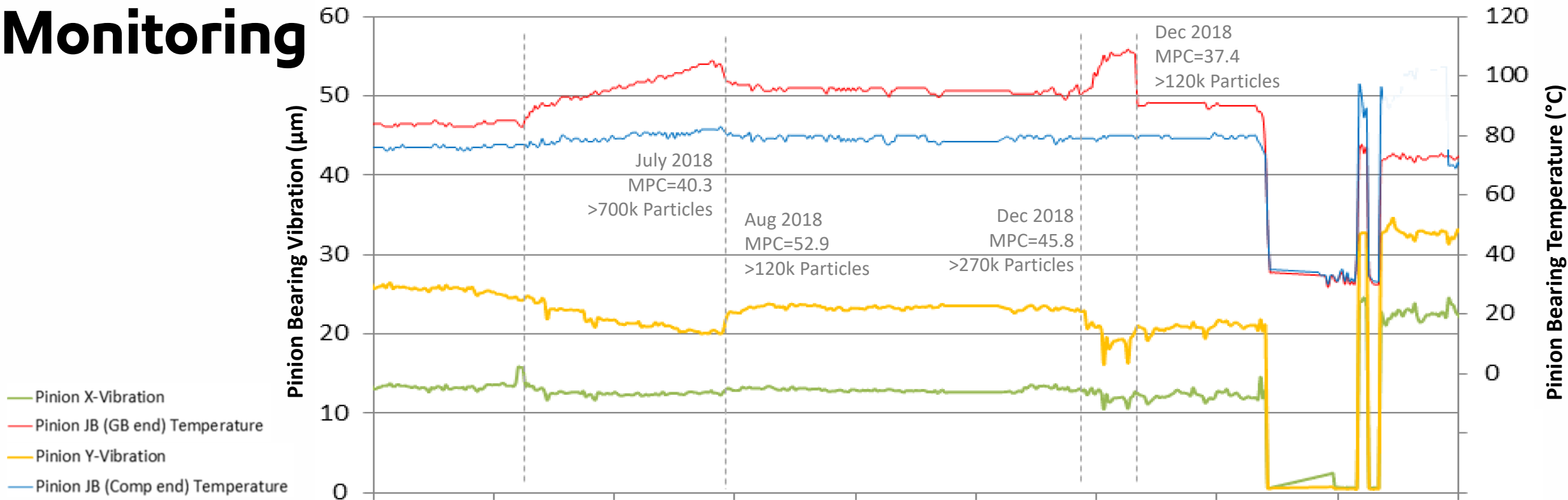
Temporary Mitigation



Effect of implementing temporary mitigation

- Recovering of pinion bearing vibration close to normal level
- Reduced in pinion bearing temperature to 92°C
- Particle counts (5 to $15\mu\text{m}$) reduced by $\sim 60\%$
- MPC remained high >40

Monitoring



Result

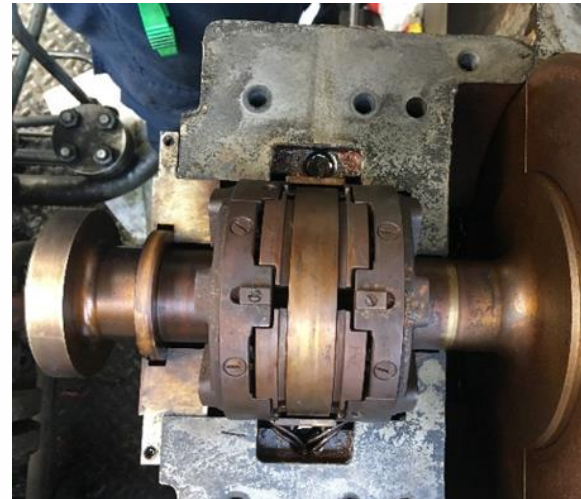
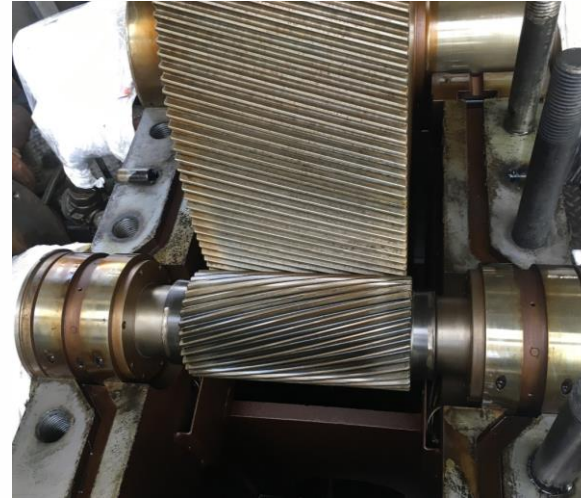
Overhaul was performed in early 2019.

Visually all the gear bearings were heavily coated with lube oil varnish and buttons on the tilting pad bearings were excessively worn out.

Bearings were found difficult to be removed during disassembly.

A thorough lube oil flushing plan was executed during the overhaul to flush the entire lube oil system before topping up with new lube oil.

The gearbox bearings have been running with stable vibration and temperature for five months after overhaul. Lube oil MPC index <10.



Key Learning

- Quarterly compressor mechanical performance monitoring is important to capture mechanical abnormality.
- The bearing failure pattern due to lube oil varnish can be very short (3 months) to cause a change in mechanical performance.
- Membrane Patch Colorimetry (MPC) test is essential to trace the content of antioxidant package in lube oil and the MPC index serves as a good indicator for action.
- Oil based solvent addition helps to dissolve lube oil varnish. However, it also poses potential consequence of agglomerating particles at area with small clearance.
- Electrostatic de-varnisher had not filtered the oil varnish effectively in one period of time. Understanding of the oil varnish properties has to be improved to select a suitable type of de-varnisher.
- Higher grade lube oil with antioxidant package is recommended for machinery known for oil varnish issue.



**End of Presentation
Questions?**

