MIDDLE EAST TURBOMACHINERY SYMPOSIUM

15-18 FEBRUARY, 2015, DOHA, QATAR

Oil-flooded Screw Compressor Failures, Causes, Rectifications

Quraisy Shatri (RE Specialist - RasGas)
Mansoor Saed (Head of Workshop & Support Services – RasGas)
Mohamed AbdelKhalek (RE Specialist – RasGas)

the power of the drop
THE ENERGY TO TRANSFORM

Abstract:

Qatar is second world largest producer of Helium after the US, and biggest exporter of this lightest gas. In Helium Plants operated by RasGas several flooded-type screw compressors are running. There have been some issues with the units which can be categorized in to three groups: installation, maintenance and operations.

Recent problems encountered were with HP Helium oil-flooded screw compressors in the first Helium Plant (Helium-1) commissioned in 2004. Two units running in parallel, when one is down then less than 50% production could be made. One to the other was failed with severe components damage: started with a sudden increased in rotor axial positions, operator run in to the site to see that oil was streaming out and noise was emitted to then immediately shut the unit down.

Each unit is driven by 6600 volt / 50 Hz / 2974 rpm / 198 amps at approximately 2 MW Asynchronous Electric Motor. Immediate action taken was to review and re-establish trip mechanism due to high vibration and high rotors axial positions, while dismantling was progressing to quickly return in to operation and an RCFA team was set up.

This case study is aimed to share with and get feed-back for improvements from the audience the operational aspects of this HP oil-flooded type screw compressors in the context of overall processes, fact findings, repair and rebuild aspects and RCFA process and outcome. Required control and protection systems vis-à-vis project specifications and International standards would also be covered.

Contents

Objective

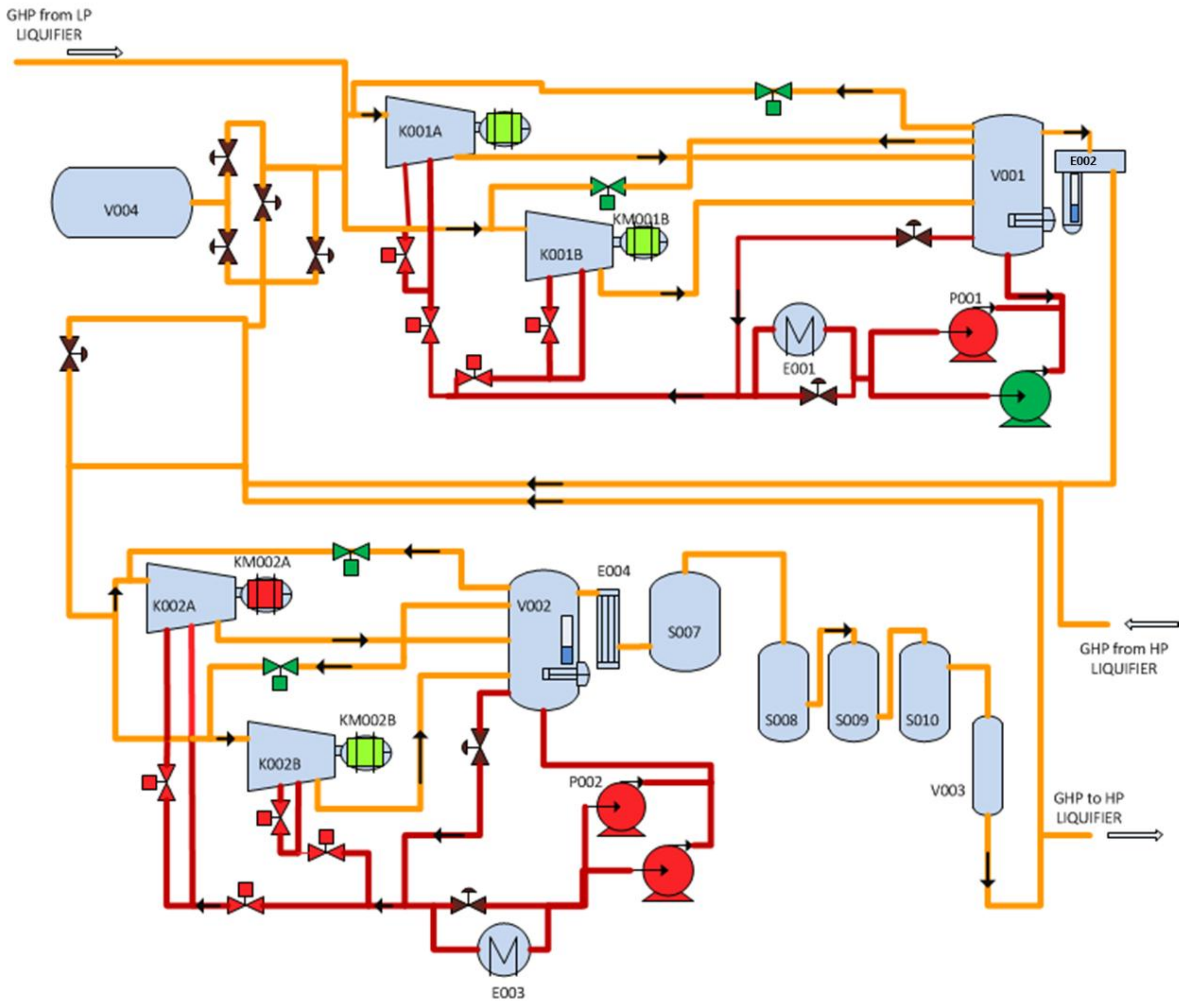
LL sharing from screw compressor failures @ Helium Recovery unit

- ✓ *Problems*
- ✓ *Inspection*
- ✓ *Failure Analyses*
- ✓ *Rectifications*
- ✓ *Best Practices*

Problem

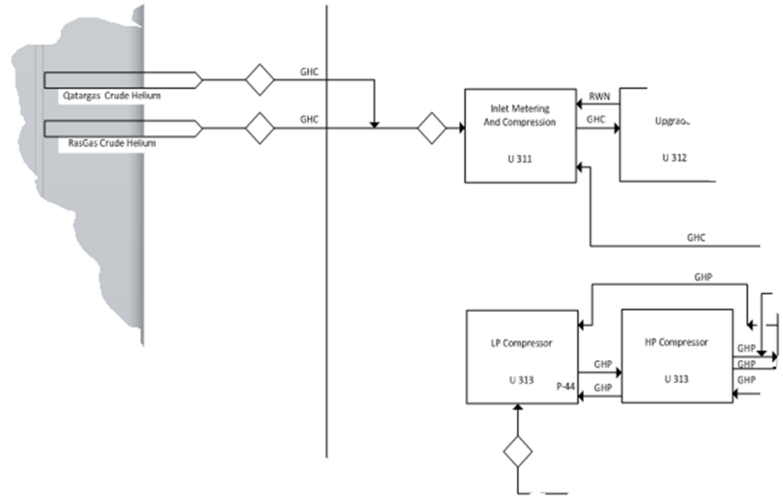
- Sudden increased (doubled, from approx. 0.5 to 1.05 mm) of rotors axial displacement – in 5 seconds -- prior to failure
- Oil leaking
- Motor amps increased by about 10% than normal
- Abnormal noise was emitted upon surveyed by operator
- The unit was shut down

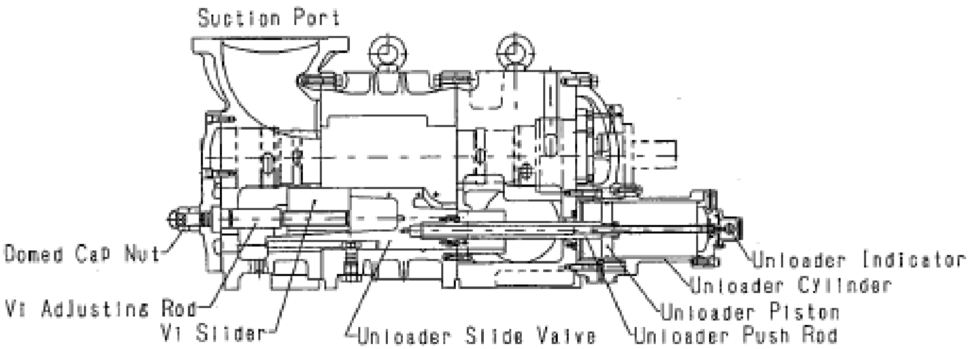
Process – *illustration*

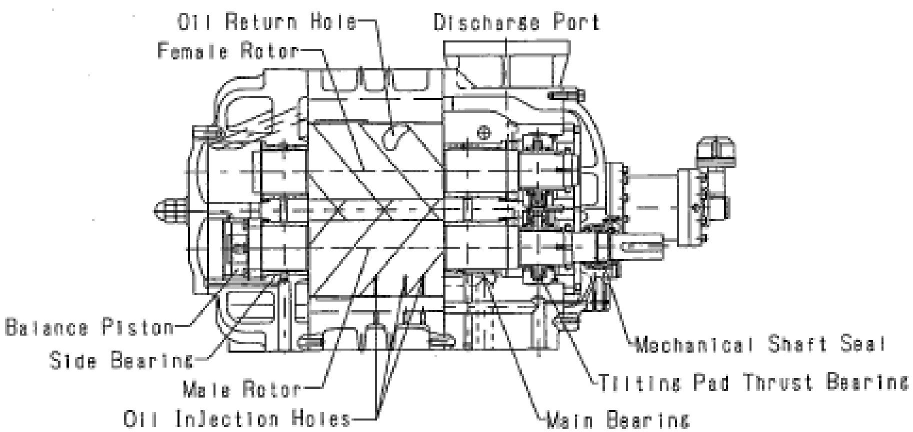


Arrangement & basic data

Inlet Compressor (1 unit)
LP Compressors (2 units)
HP Compressors (2 Units)





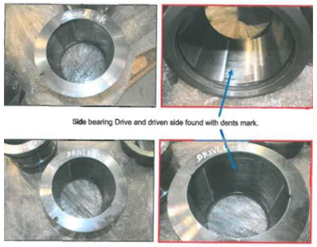


HP Compressors (HE-400SUD-L, tags 313-K002A/B)
6600 volts / 50 Hz / 2974 rpm / 198 amps
2 MW Asynchronous Motor
Max process flow-rate ~ 5200 m3/hr (6440 Nm3/hr)
Pressure Ratio: ~ 5.4
Inlet / Disch. Temp: ~ 45 / 80 deg-C
Oil Pump flow-rate 214 m3/hr. Breox B35 @ 86 deg-C.

Male rotor shaft connected to the driver has 4 convex lobes,
The female rotor has 6 concave lobes

Findings

- Male rotor was found with severe damage to the NDE side surface area.
- Suction cover severely damaged
- Scoring on male and female rotors
- Scratches at screw-blades of female rotor
- Scratch marks on male / main rotor casing
- Thrust bearings both active and inactive and the thrust runners were severely damaged, worse on active sides
- scratch marks and dents on radial bearings drive and driven, reusable

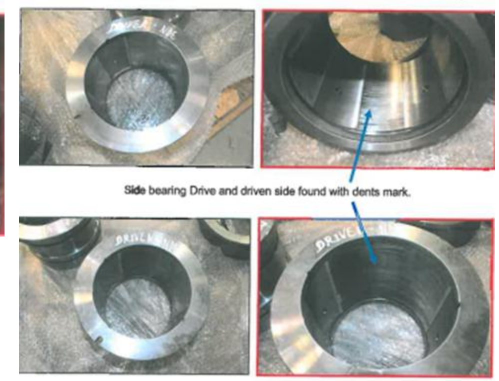


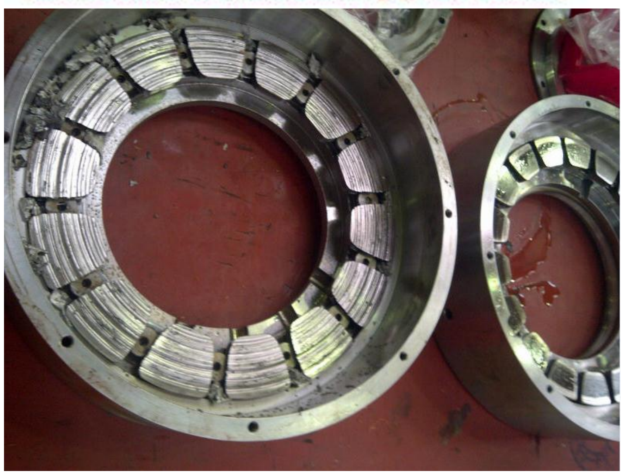
Damage casing (in conjunction to male rotor (see above pic)...

Male (left) and female rotors...

Findings

Thrust runner and thrust bearing of male rotor....





- Male rotor’s active & inactive thrust pads severely wiped-out; thrust runner ‘grinded-off.’
- Male-rotor shaft @ seal area worn-out
- Stuffing box – worn-out

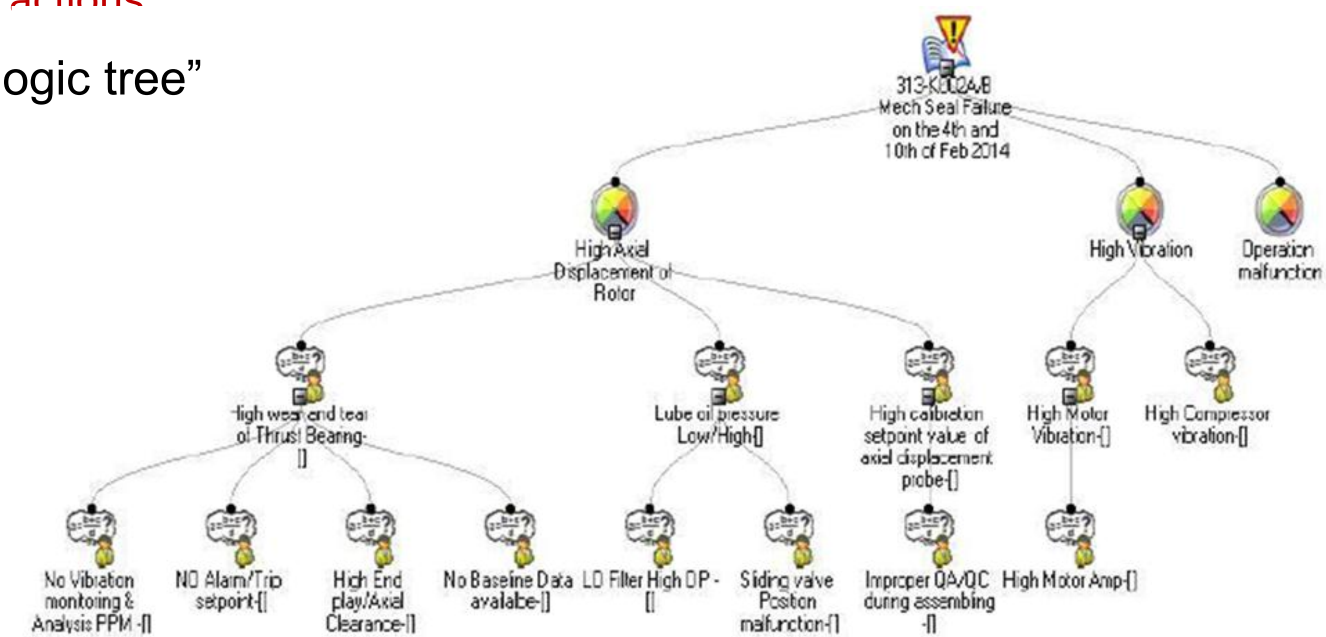
Failure analyses

Form an RCFA / FA Team - establish “team charter”
Prepare required historical data e.g.

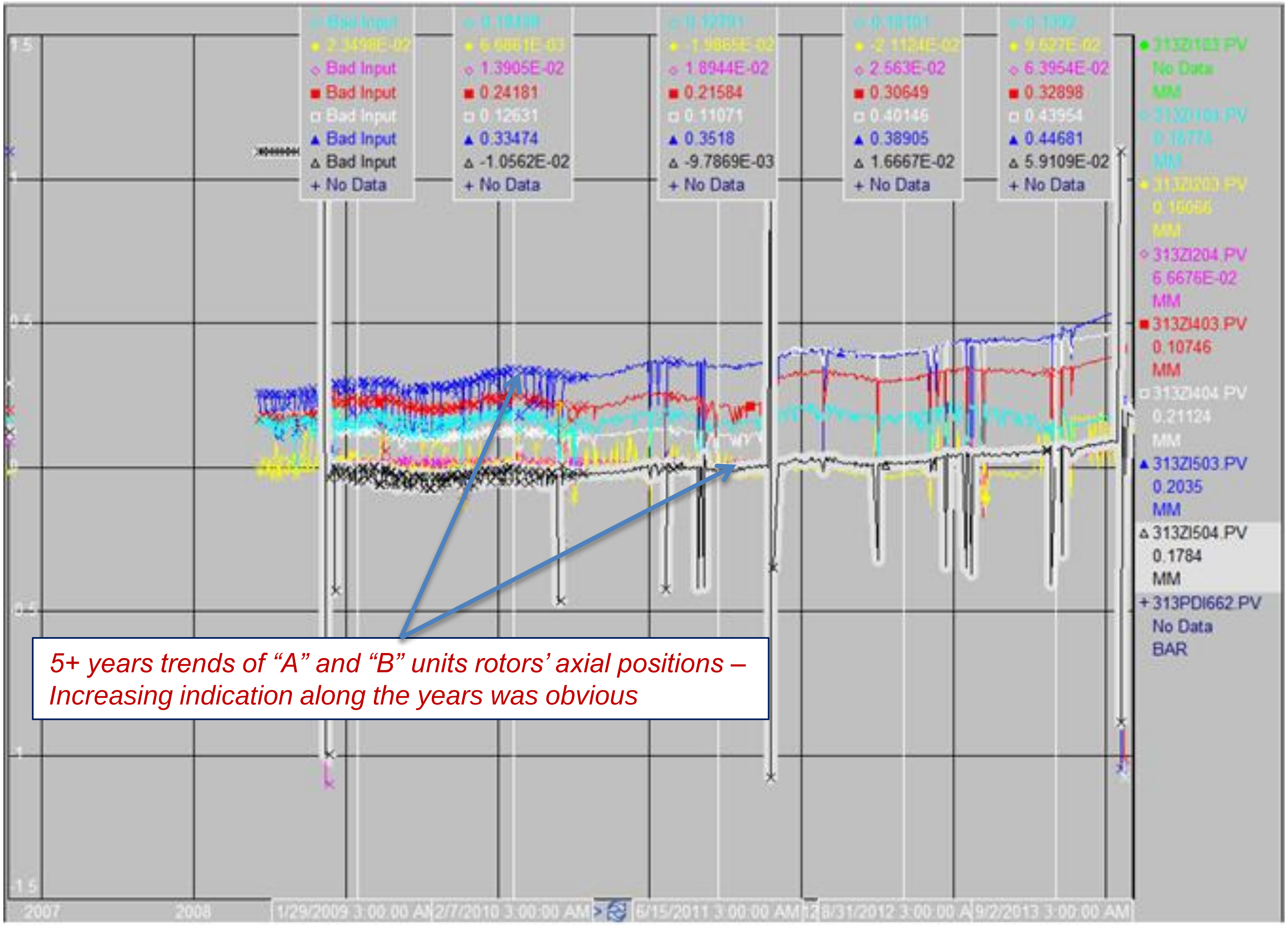
- vibrations, includes axial position setting, and protection
- loading and unloading mechanism
- lube oil system – quality, pumping system vis-à-vis compressor discharge condition
- units operating parameters include power

Develop / agree FTA
Verify / validate hypotheses
Recommend actions

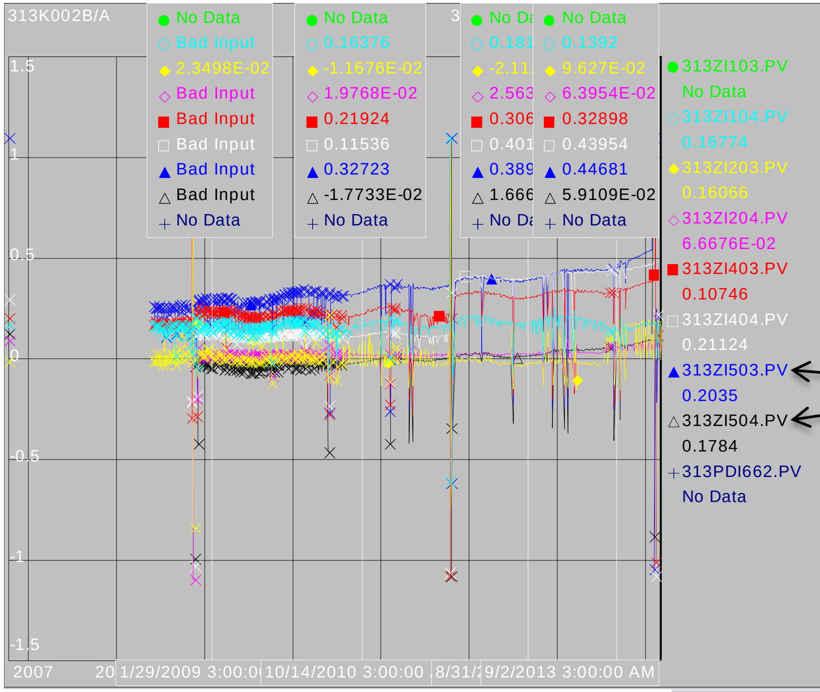
The FTA / “logic tree”



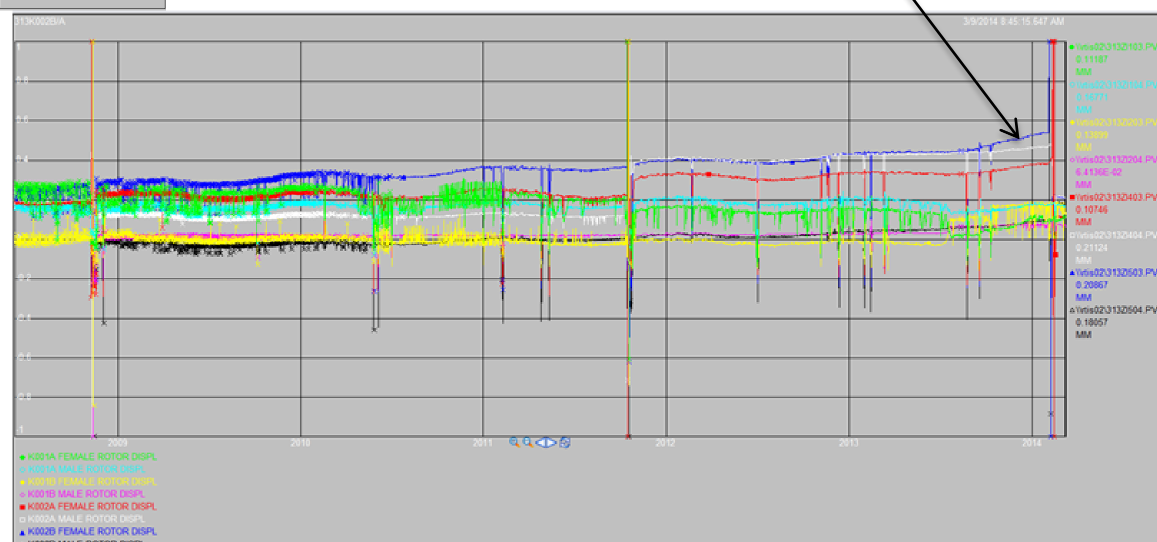
Failure analysis



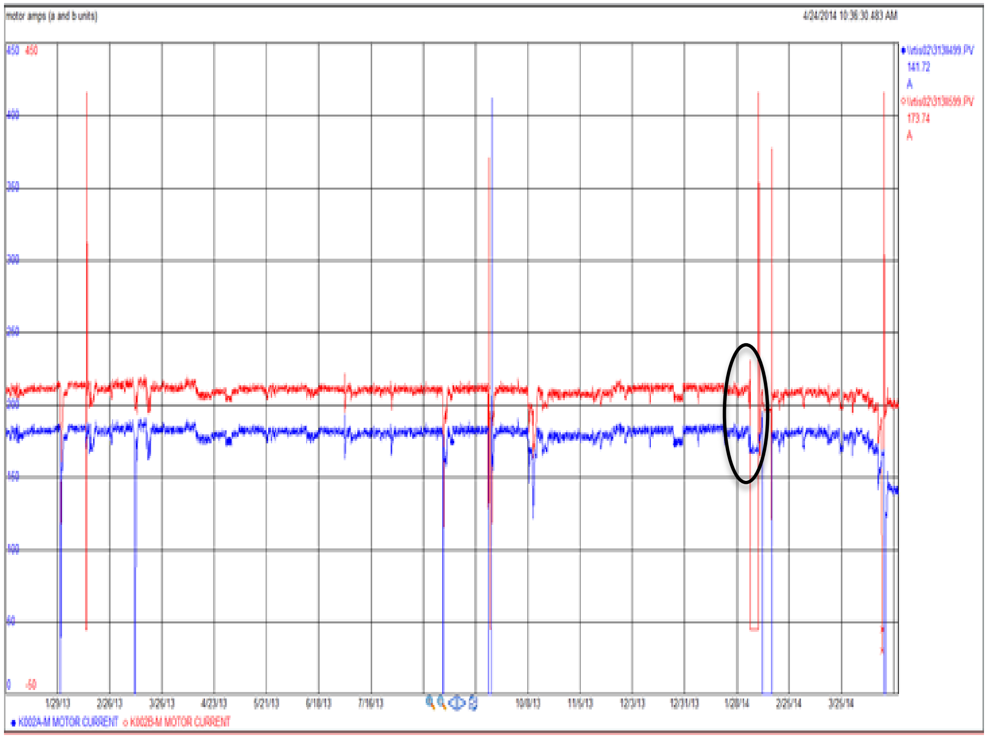
Failure analysis

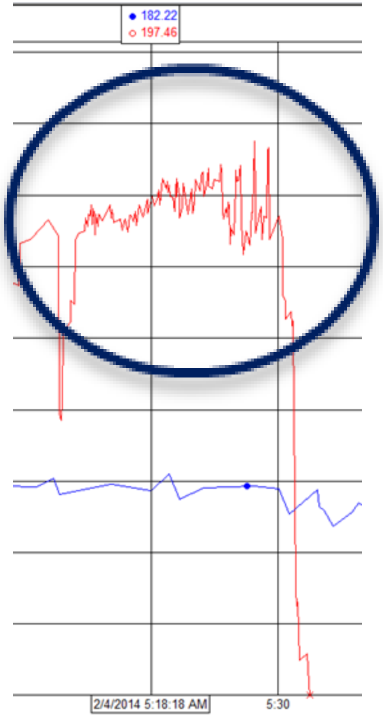


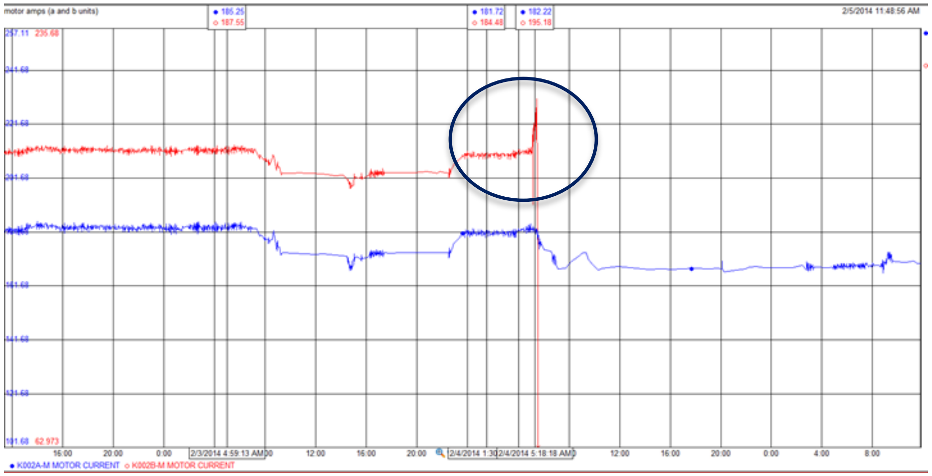
Increasing trends of both male and female rotors' axial position after ~ 6 years in service (2008 ~ 2014)



Failure analyses: motor amps







Motor amps decreased from normally ~ 182 by About 10 amps along ~ 15 hours, returned to normal Amps for about 5 hours prior to failure in which the “B” motor amps reached ~ 205.

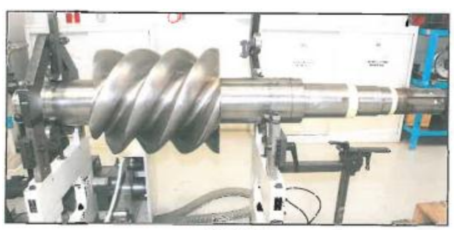
Failure analyses: thrust bearings – axial play & protection settings

- If thrust bearings have not been replaced with new ones for a period of 5 or more years, plan for a change.
- 0 ~ 5 years of operations…review operation records to determine time to replace
- OEM recommendation (L = Lmax * CF); Correction Factors are dependent on thrust-load (inlet pressure), service gas, oil properties, and change-out experience; with Lmax = 30,000 hours.
- This HP Screw Compressor experience indicated that approx. life-span of the thrust bearings was 25k hours.

Rebuild

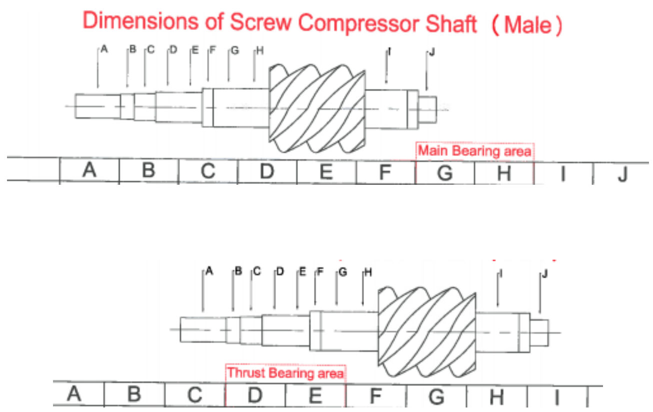
- Damaged area @ the casing NDE side was machined **)
- Damaged areas on both male and female rotors were grinded-off, polished
- Both the male and female rotors were balanced (G2.5)
- Unit was rebuilt with new bearings and seals – dimensions, clearances / tolerances strictly following the OEM / standard

**) ~ 1.5 mm; welding repairs were not recommended; performance is expected to be very slightly lower



Male rotor

Female rotor



Conclusions

- All operating data indicated no operational issues which may had brought about the failures
- Motor's bearing radial vibes and compressor's casing seismic indicated no problems.
- The latent root-cause of the unit failure was most likely thrust bearing (fatigue) failures shown through gradual increases of both rotors and failure findings
- Alert and Trips set points were established as employed in other screw compressors

Best practice: Equipment Strategy

- Calculate correct levels to alert and trip on axial positions (refer the OEM).
- Ensure rotor's axial position alert and trip values are correct and set up in the System. Refer to your specific units' experience and established standards e.g. API619, ISO (2372).
- Enhanced performance and mechanical integrity reviews should be carried out should a postponement from a planned inspection is to be made for some other reasons.
- Ensure all accessories and auxiliaries e.g. valves, filters, oil quality are working well and as per the design.
- Internal clearances and notably rotors axial position settings shall be done with an utmost care and well documented.
- Review and enhance 'equipment strategy' to carry out inspection of the internals notably at bearings, seals more on a "time-based" practice.

- END -