EFRC Training Workshop Lubrication and Wear

Monitoring Wear

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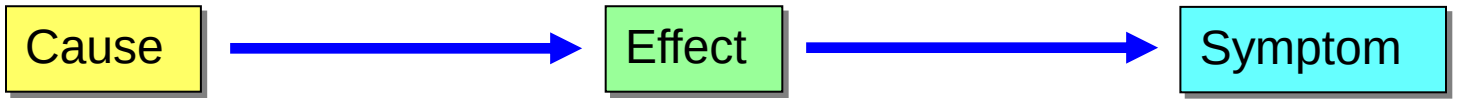
Malfunctions causes and effects

Causes

- Normal component wear
- Process gas contamination
- Abnormal component motion
- Support system problems

Effects

- Valve failures
- Pressure packing leaks
- Piston ring failures
- Rider band wear
- Crosshead and pin wear



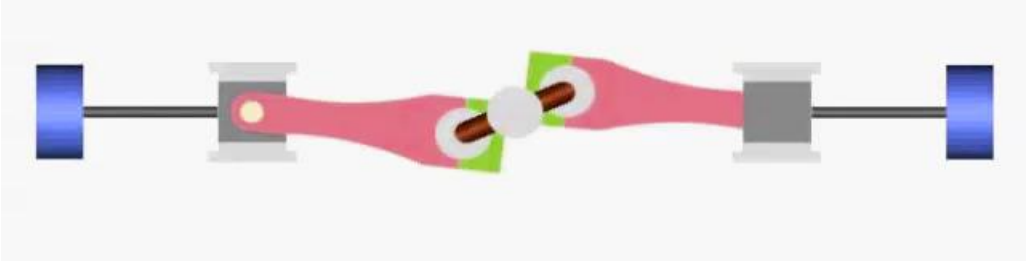
Normal component wear

Fatigue – from cyclic stresses caused by normal compressor operation

Erosion – from frictional contact between stationary and moving components

Both of these causes can be minimized, but never eliminated completely, since they occur as part of normal operation.

Excessive pulsations and/or mechanical induced vibration and lubrication issues may accelerate the wear process.



Process gas contamination

- Abrasive Particles
  - “Dirt”, corrosion products, debris from broken valves…
- Coke Deposits
  - Solid carbon particles from decomposed lubricating oil…
- Corrosive Substances
  - Acidic attack from sour gas (hydrogen sulfide) and others…
- Liquid Slugs
  - Condensation of process gas, problems with liquid separators…
- Process Gas Polymerization
  - Sticky long-chain molecules formed from some process gases…

Abnormal component motion

- Valves (fluttering, slamming, sticking)
- Piston Rings (misalignment, sticking, excessive shifting in piston groove)
- Pressure Packing (seizing, not floating)
- Crosshead (knocking due to excessive clearance)
- Frame (inadequate supporting, grouting or foundation design)

Normal component wear is a large contributor to excessive clearance, so abnormal component motion may be expected to become more severe over time.

Support system problems

Support systems strongly influence compressor operation:

- Control System
- Cooling System
- Gas Composition Monitor
- Instrument Air System
- Lubrication System
- Unloaders

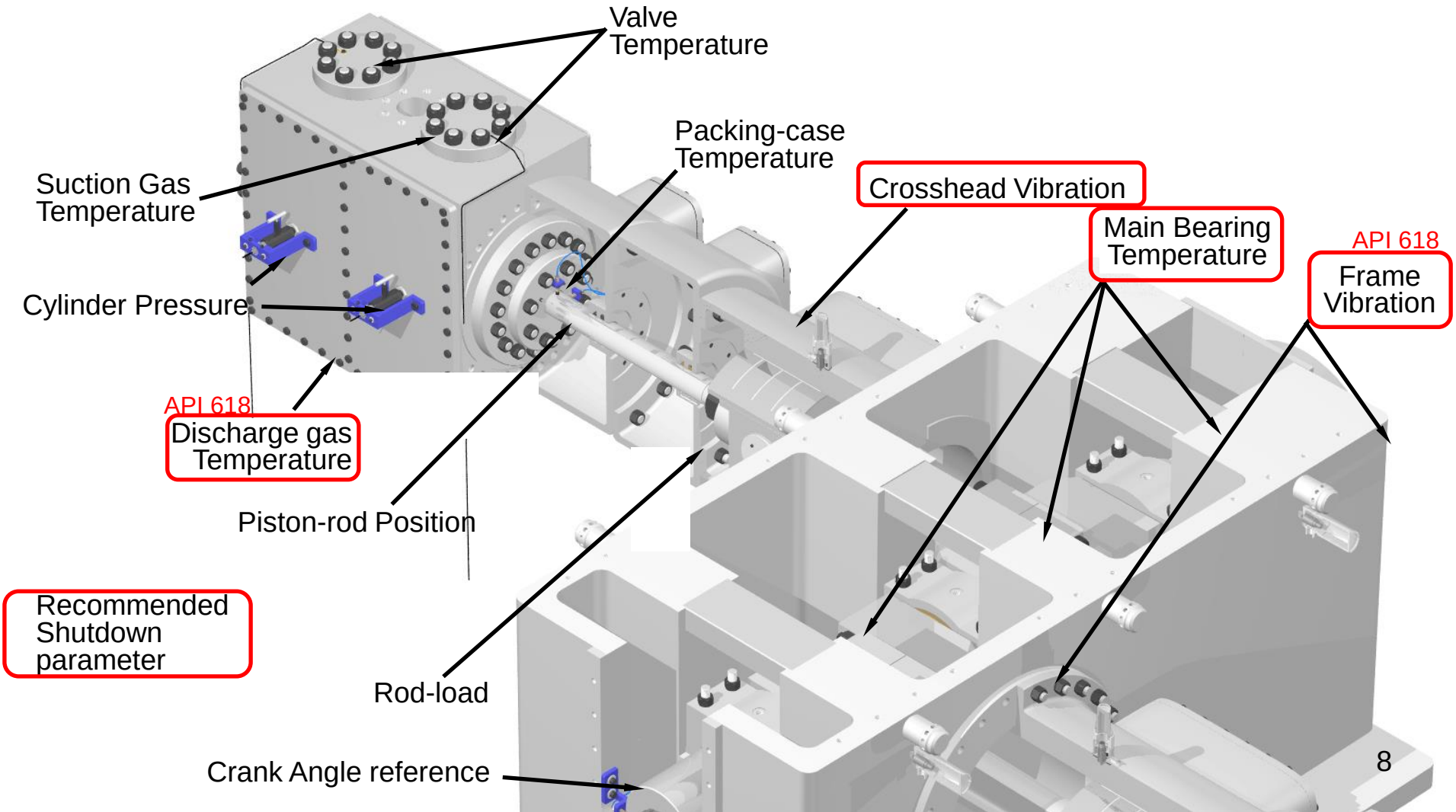
Equipment Status

Temperatures

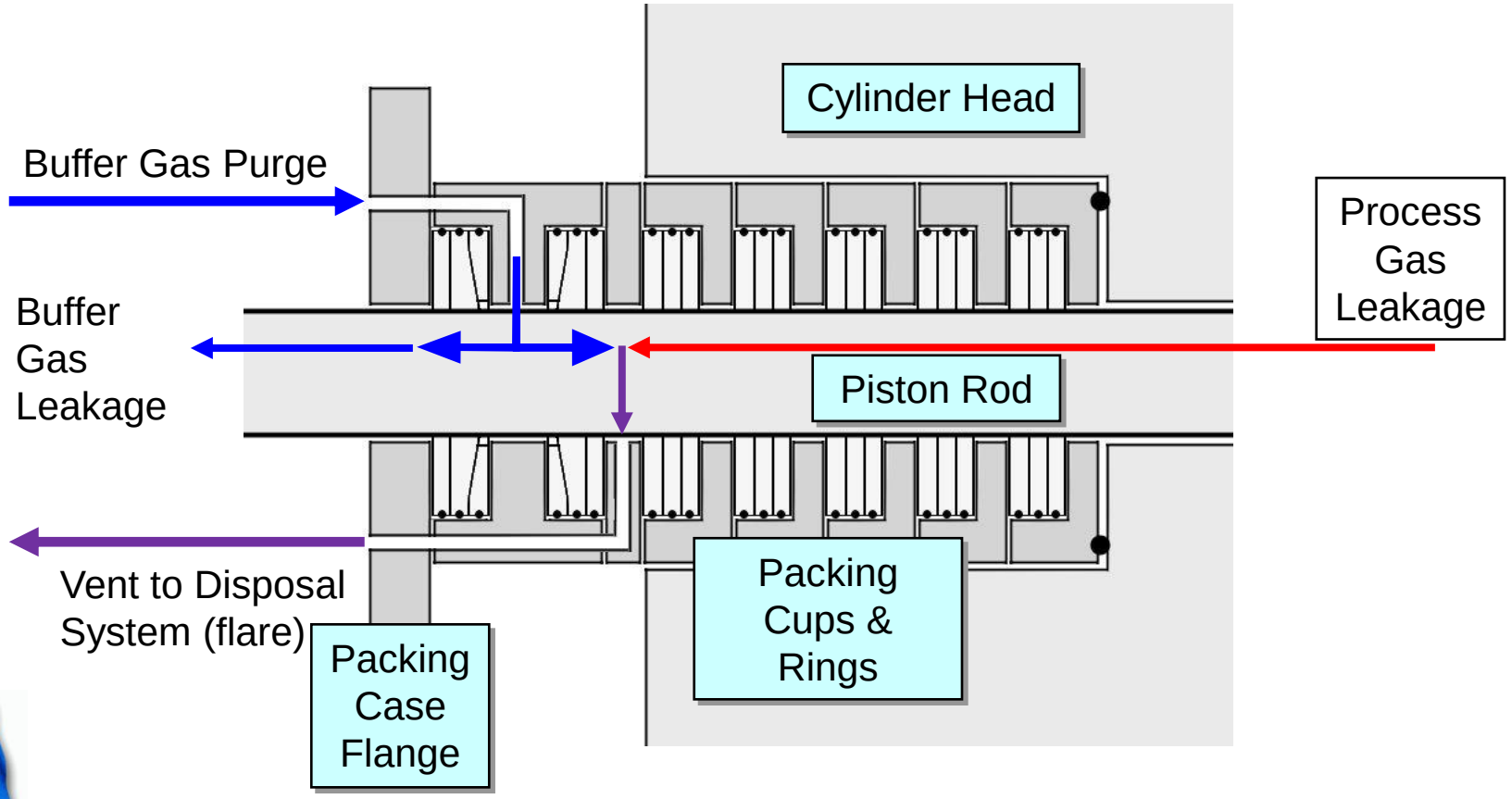
A few malfunction symptoms

- Abnormal temperatures or pressures
  - overheated bearings, leaky valves, piston rings or packing
- Unusual forces or impacts
  - Worn crosshead shoes, loose pins, excessive clearances
- Excessive vibration
  - Broken foundation bolts, piping hangars, structural resonances, improper unloader operation

Reciprocating Compressor Condition Monitoring

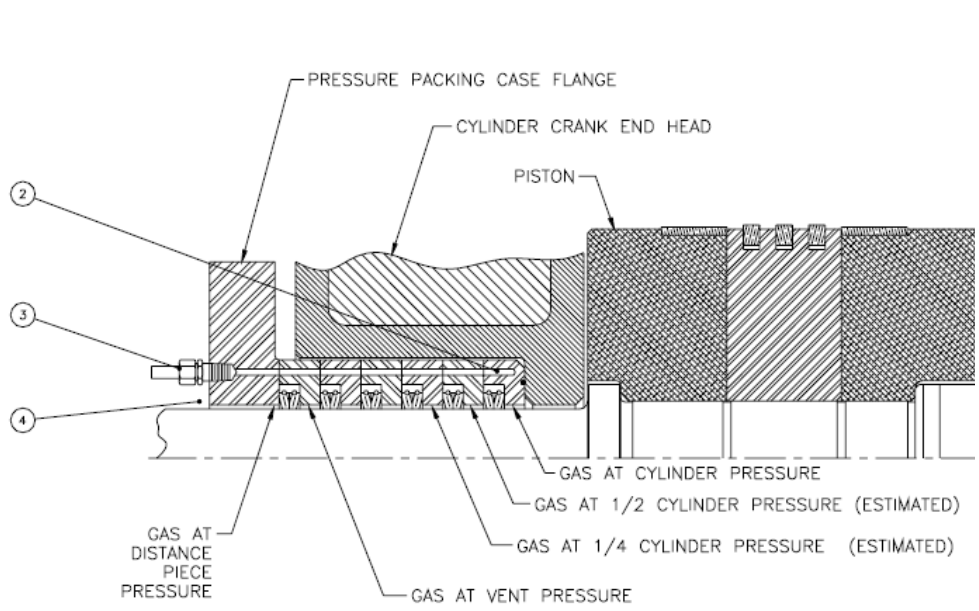


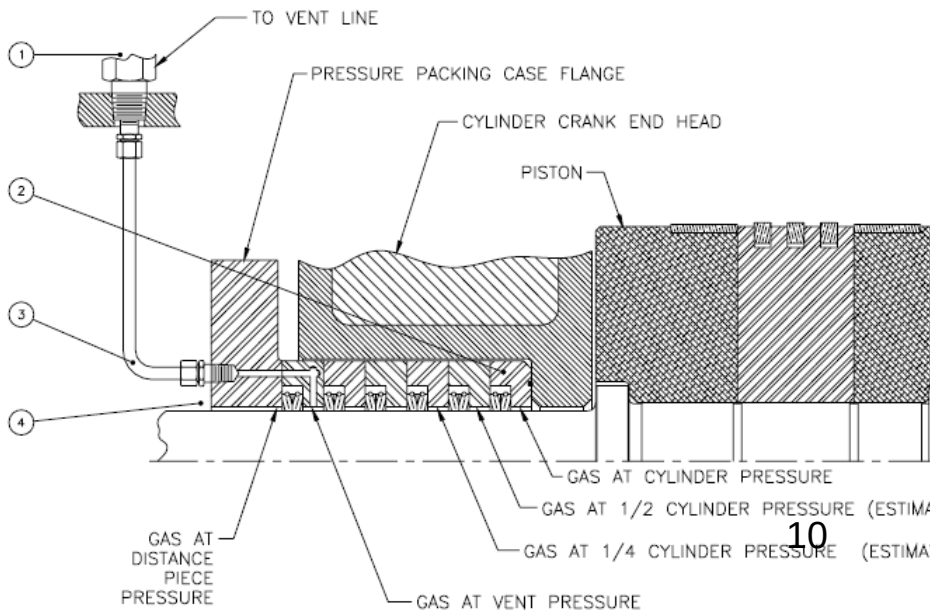
Temperature monitoring: packing case



Temperature monitoring: packing case

- Packing case (or vent) temperature may indicate poor lubrication or insufficient cooling
- Gas leakage indicates the condition of wear of the packing rings



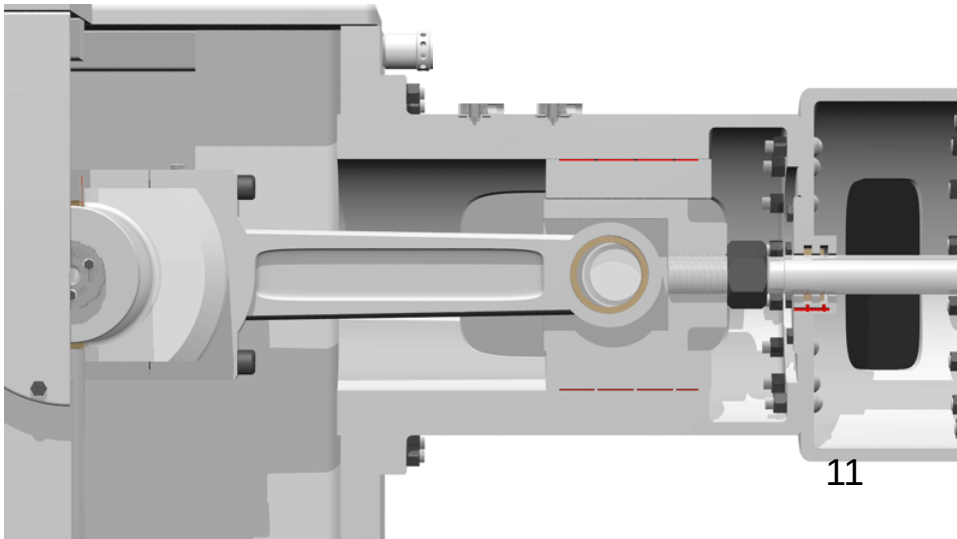


Temperature monitoring: connecting rod bearings

Reciprocating compressors may face abnormal operating conditions such as:

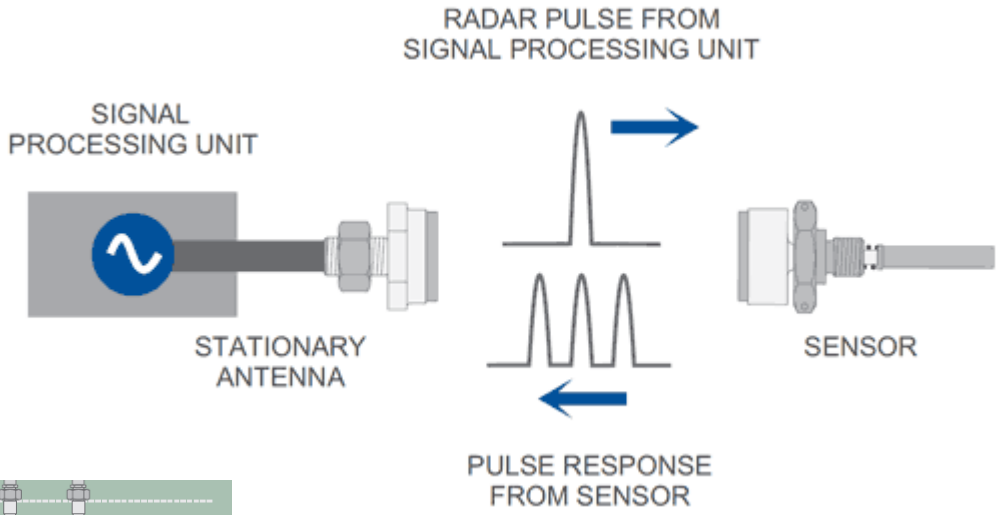
- Overloads of individual cylinder lines
- Loss of load reversal on small end bearing
- Lubrication failure

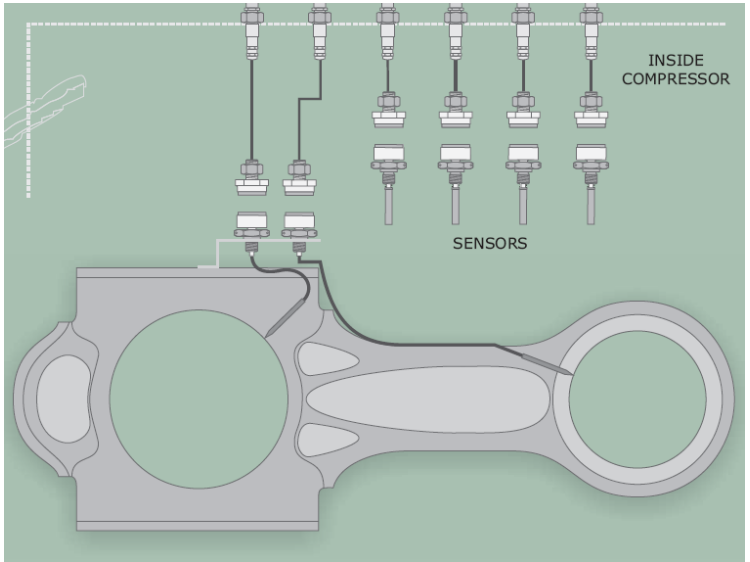
Bearings temperature increase is a symptom of such malfunctions



Temperature monitoring: connecting rod bearings

- Wireless Connecting Rod bearing and Crosshead Pin Temperature Monitoring
- Non-contact temperature sensing with passive elements.





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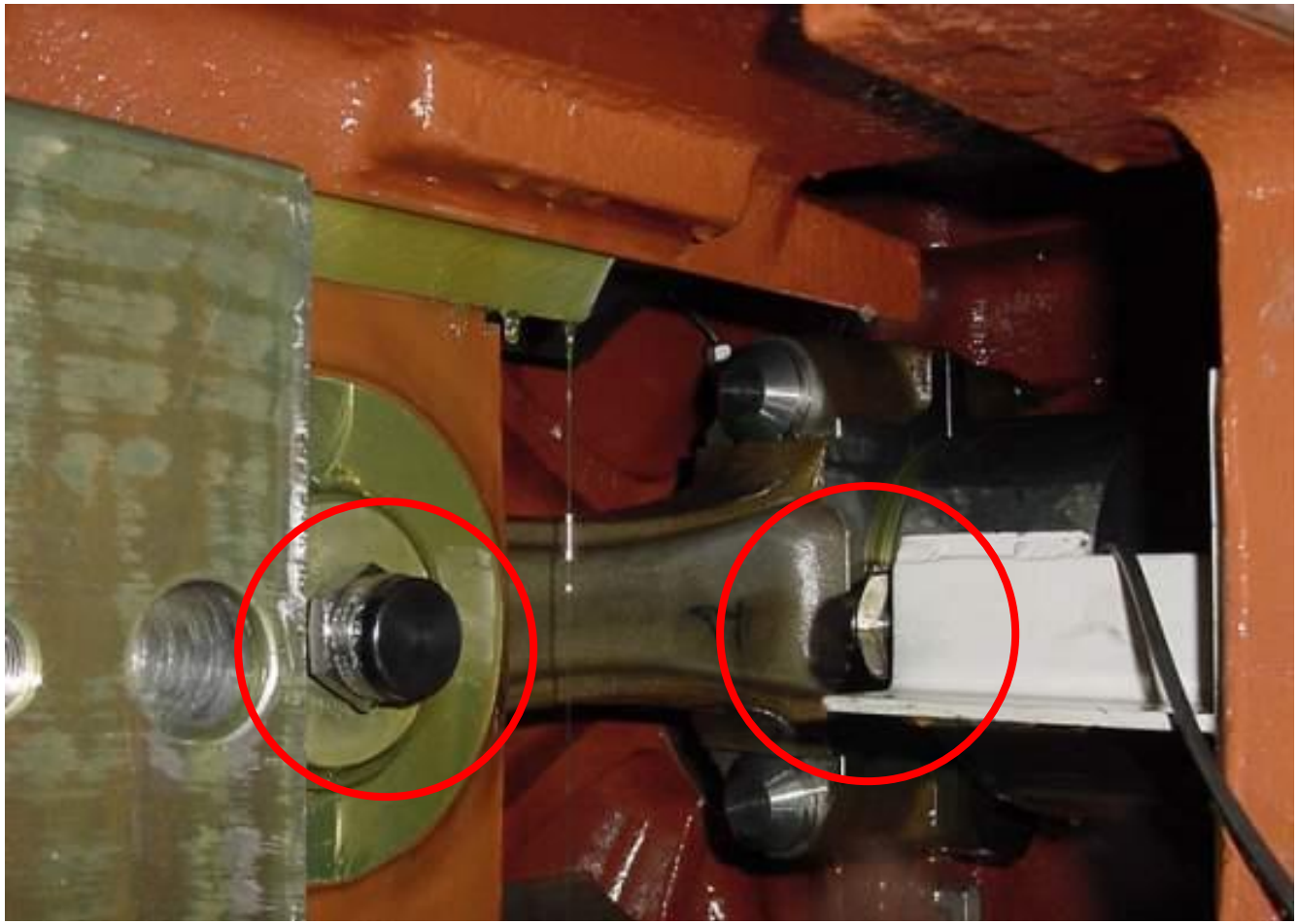
Temperature monitoring: connecting rod bearings



Crosshead Pin Small End Sensors Installation

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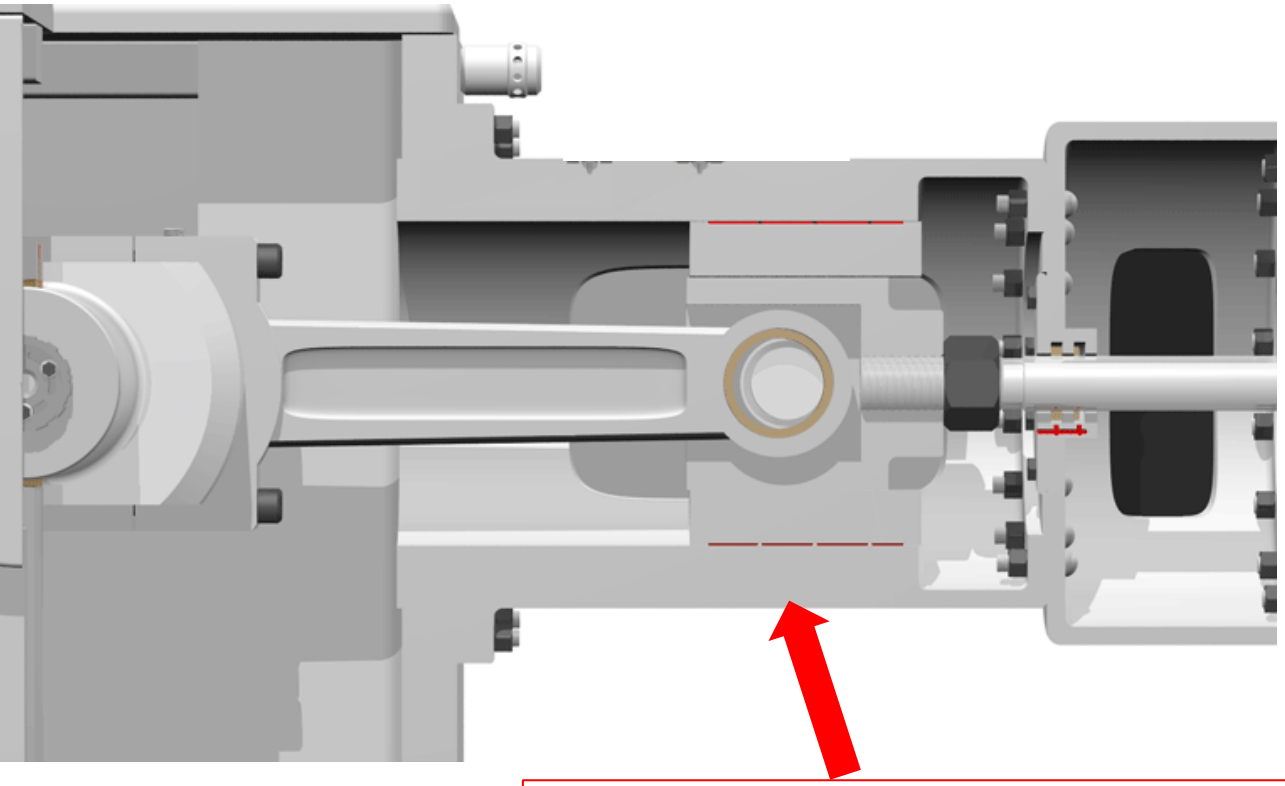
Rod load reversal



Rod load reversal is the periodic shifting of piston rod load from **tension** to **compression** during a crankshaft revolution.

A proper reversal time during revolution is critical for crosshead pin and bushing lubrication.

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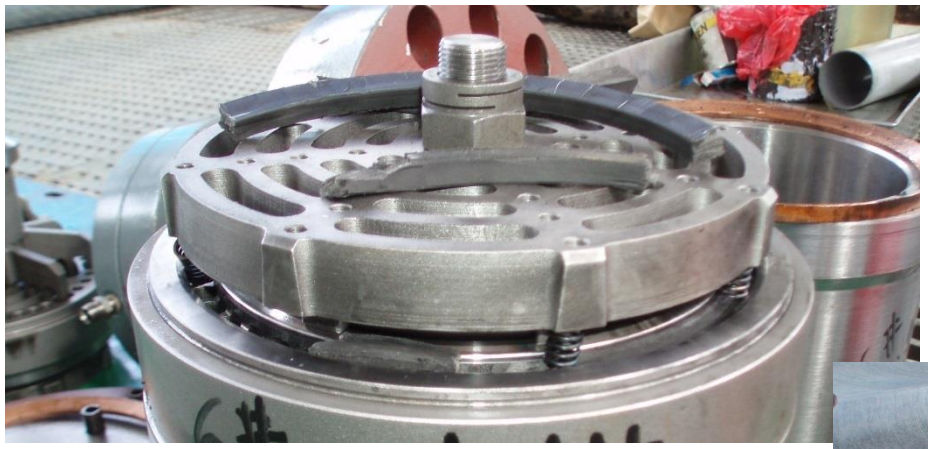
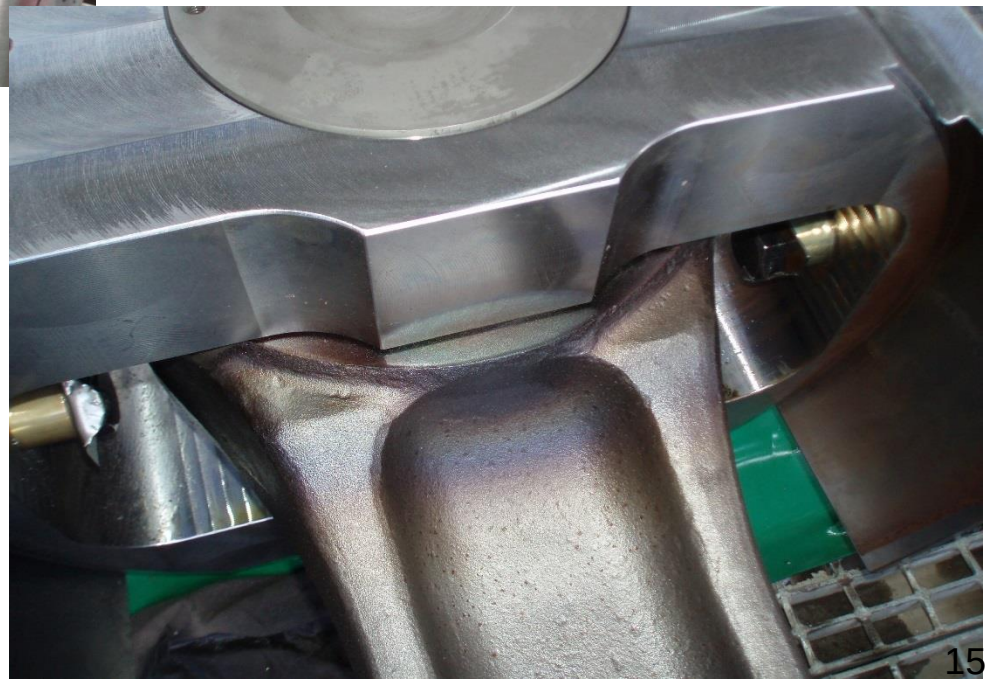
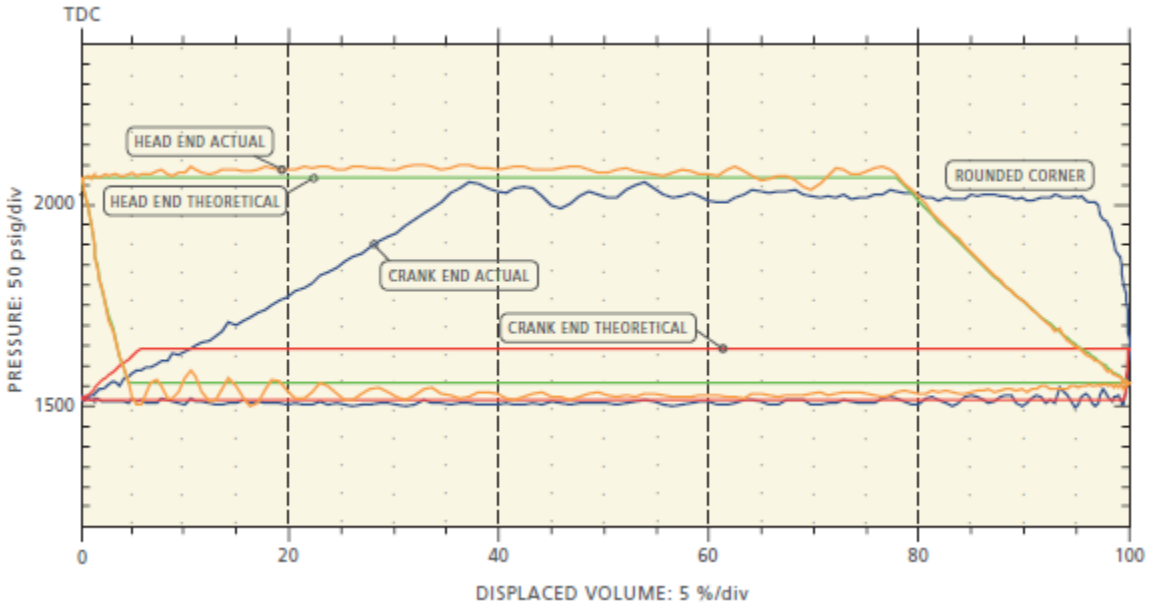
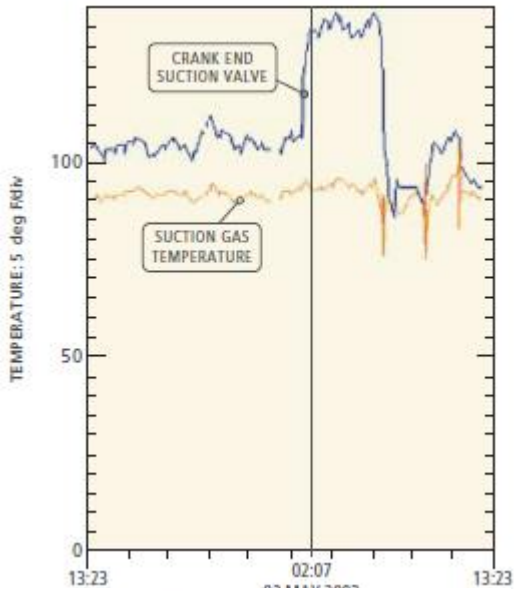
Secondary damage of valve failure: loss of reversal

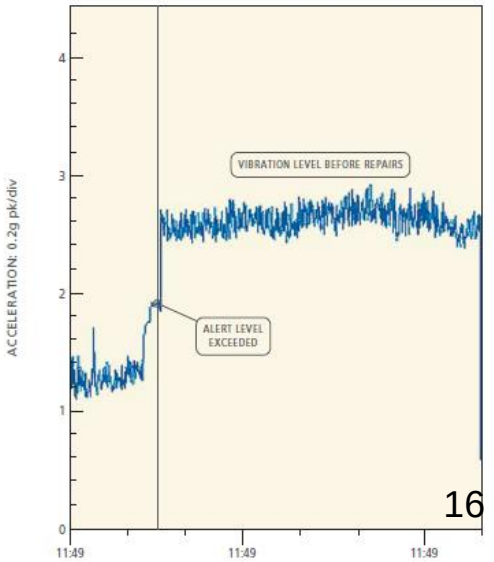




Reversal monitoring: Valve leakage







Suction valve leakage identified via cylinder pressure cycle, valve temperature, and crosshead vibration monitoring.

Increased vibration is s consequence of unbalanced rod load.

But how severe is the leakage?

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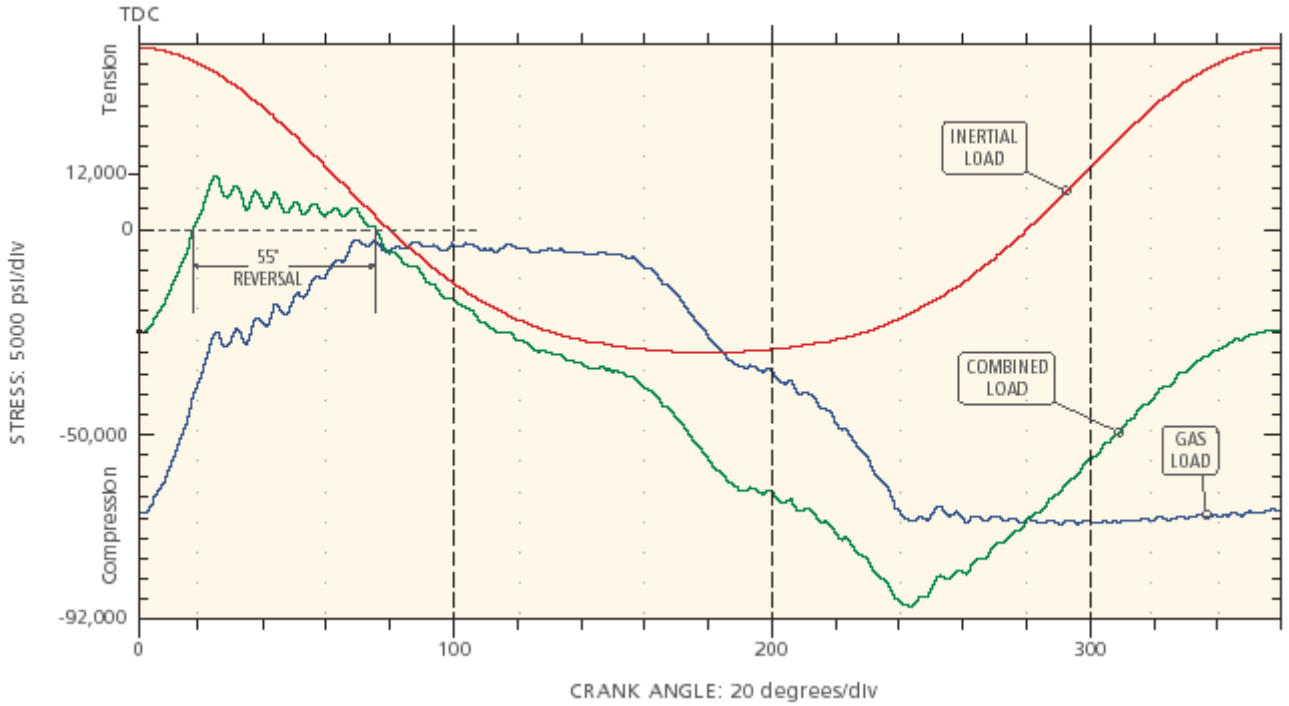
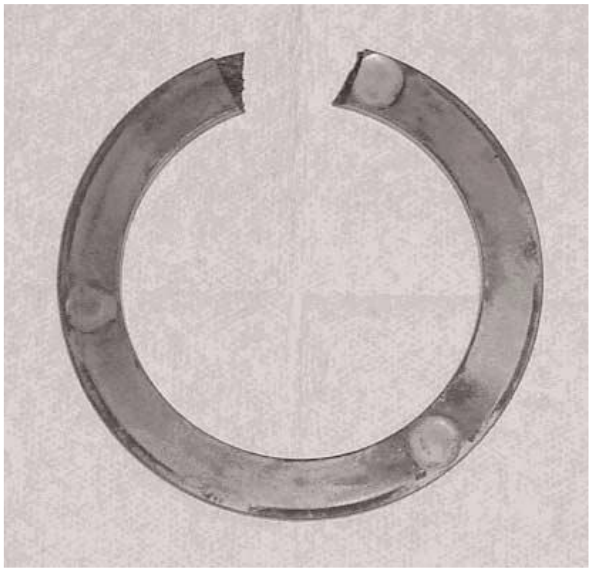
Reversal monitoring: Valve leakage

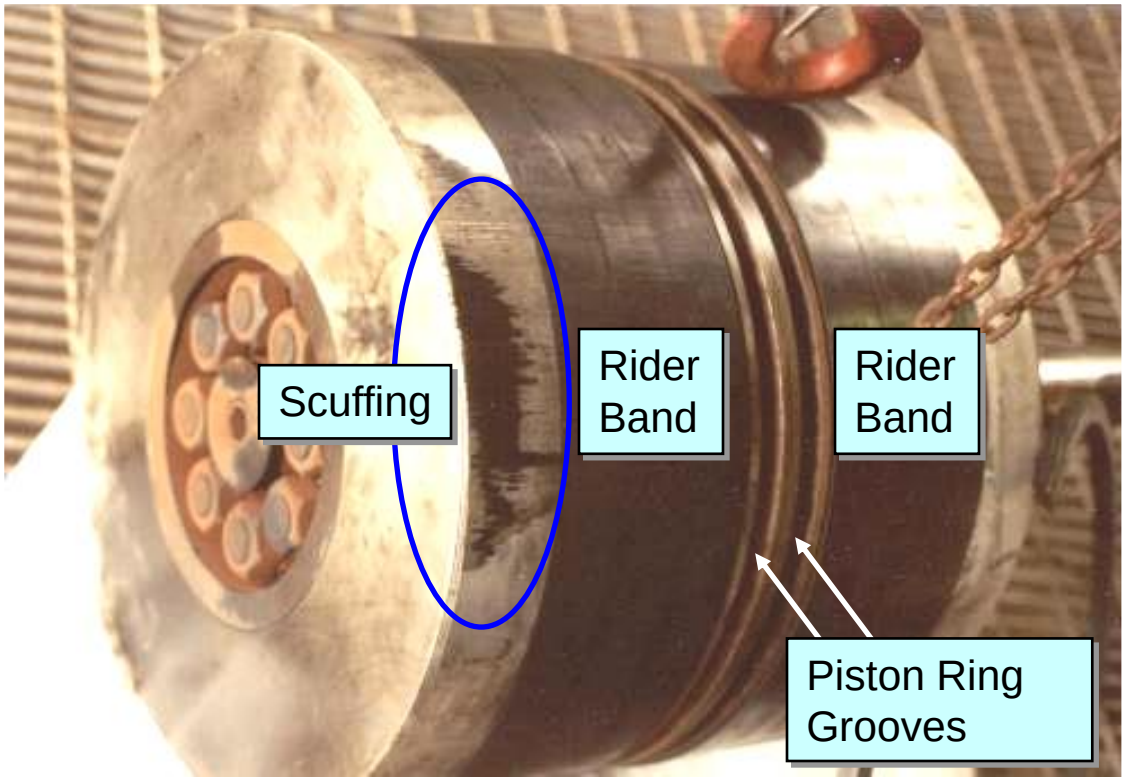




The load curve showed only 55 degrees of reversal, and there was a large difference between the magnitudes of the peak tension and the peak compression.

Monitoring allowed to assess the impact of valve leakage on rod loads and reversal, and consequentially on lifetime of crosshead pin bushing.

Rider band wear



Worn Piston & Rider Bands

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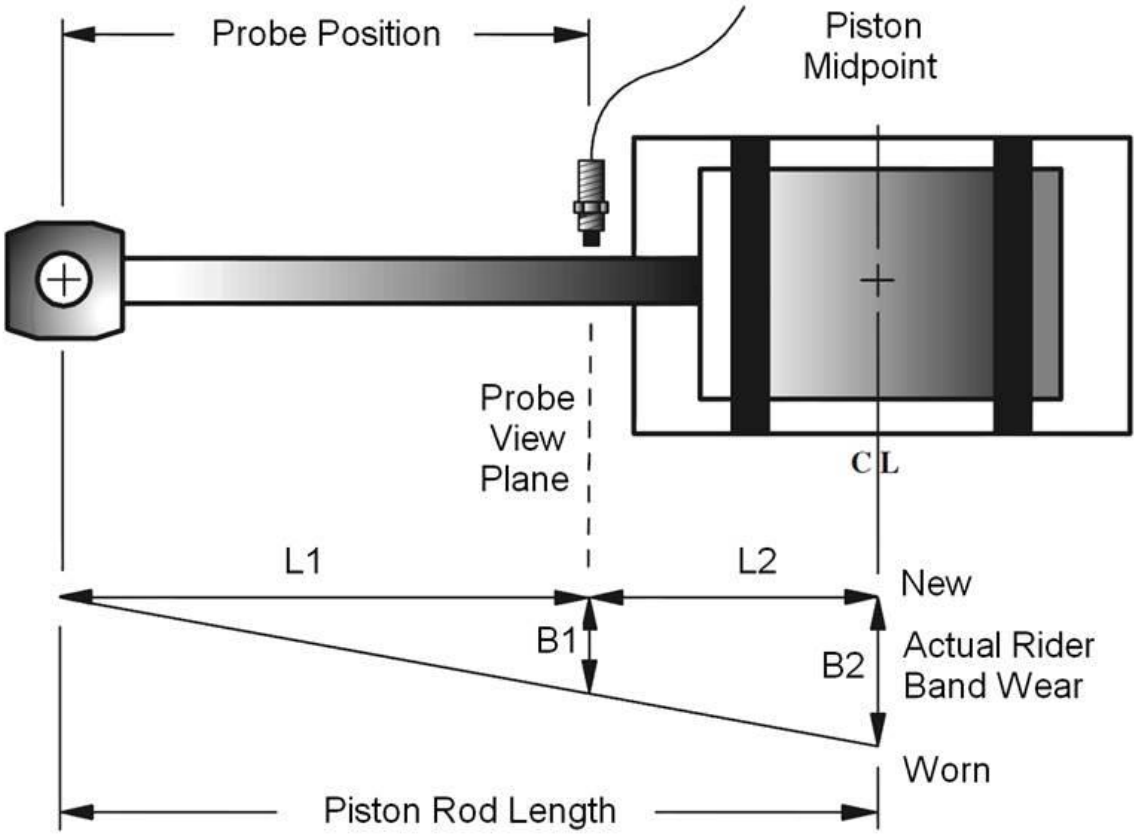
Rider band wear monitoring: "Rod drop"



Rod drop monitoring is accurate only if correctly applied to specific compressor designs and operating conditions

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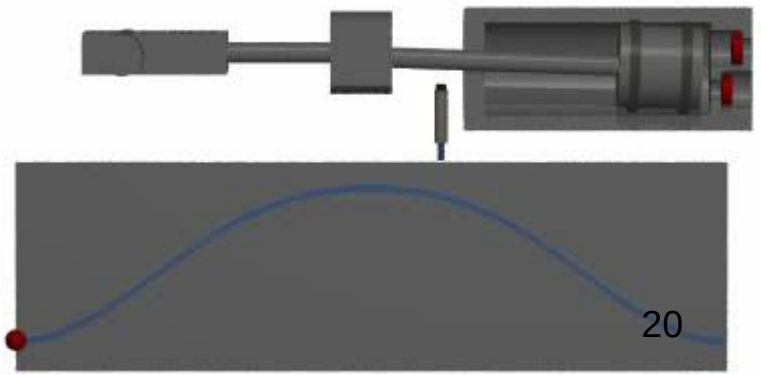
Rod drop estimate will be accurate if:

1. The distance measurement made at the pressure packing case changes in direct proportion to the change in rider band wear.
2. Gravity is the predominant vertical force acting on the piston and rod assembly.
3. Rod flex is negligible compared to the amount of rider band wear being measured.
4. Operating temperature of the piston is relatively constant.

Accuracy will be reduced as further we are from ideal conditions.

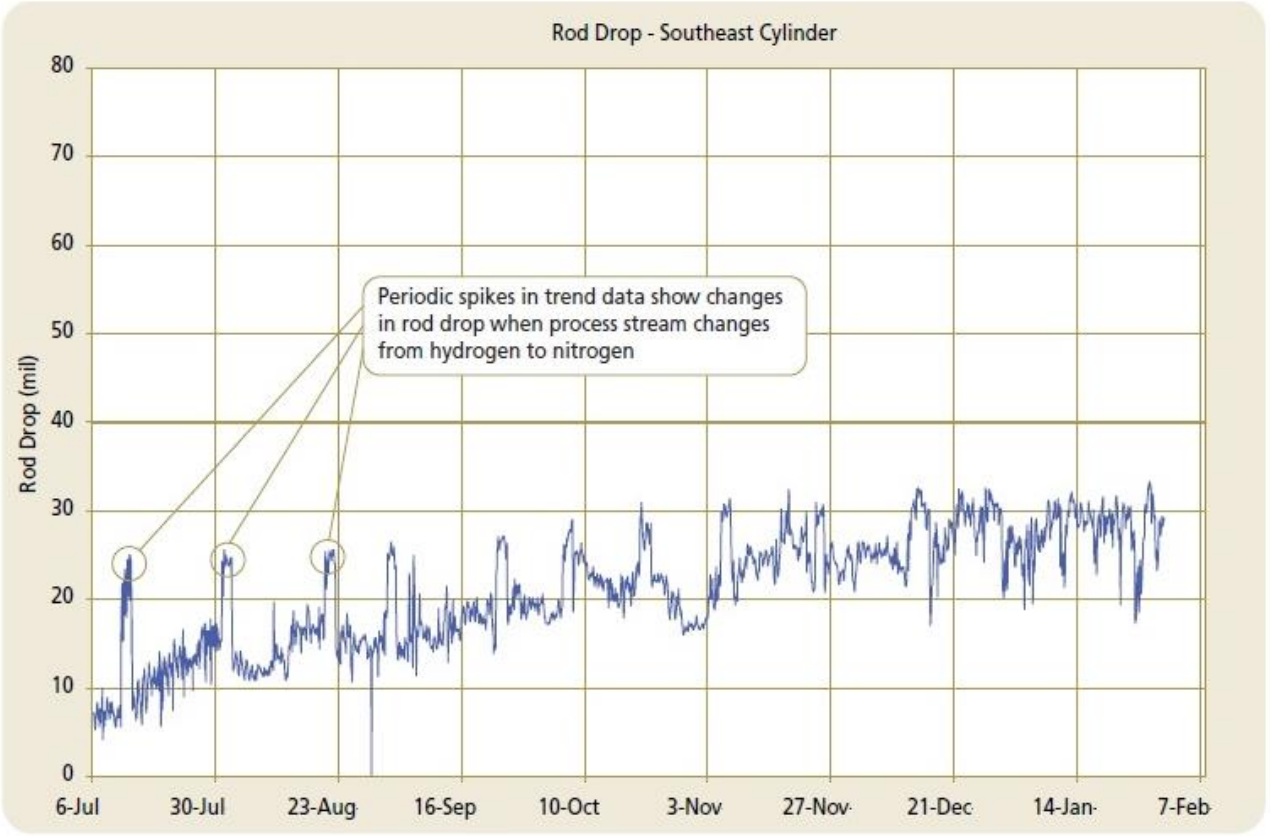


Rod drop monitoring: Getting it right

- System configuration may mitigate deviations from the assumptions
  - Instantaneous vs. average readings (select correct crank angle)
  - On-site probe calibration based on actual rod material
  - “Hot zero” adjustment

Rod drop fluctuations

Rod position fluctuations can be due to transient conditions (startup), changing operating conditions and may impact differently on different cylinders.



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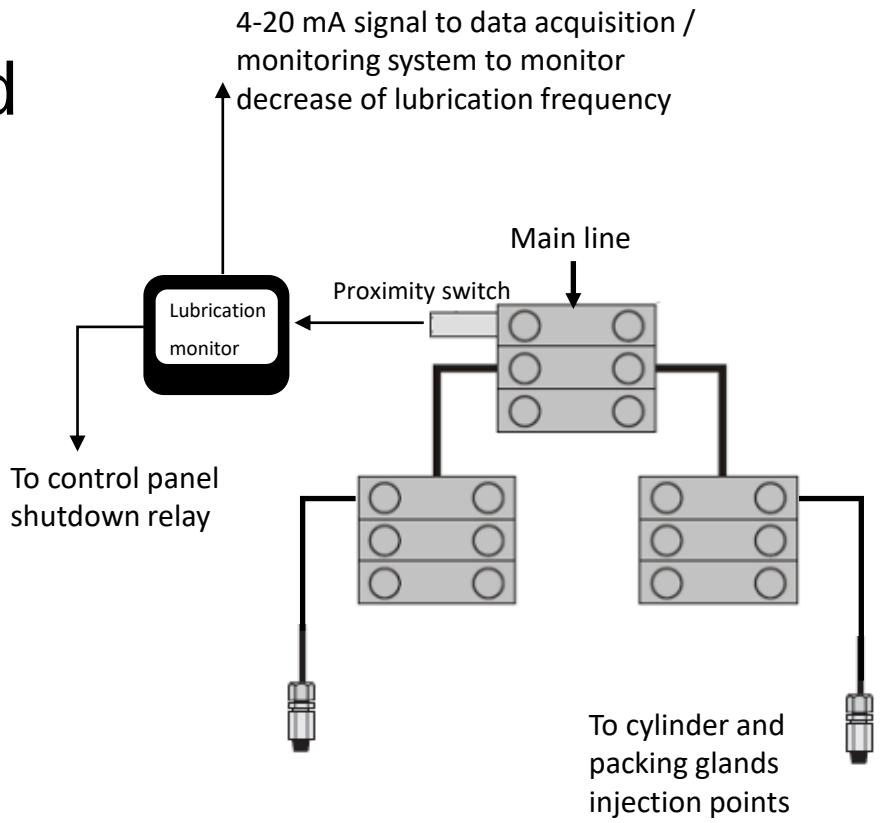
Lubrication monitoring

- Lubrication to cylinder/packing gland with a “divider block” system
- Flow monitor and shutdown devices to PLC or monitoring system



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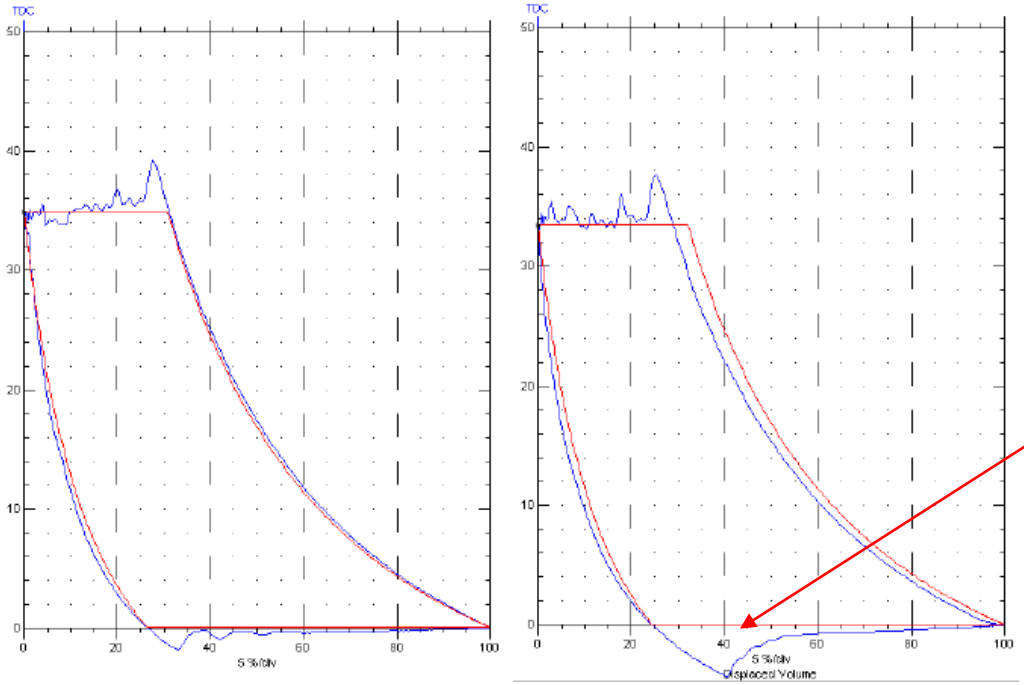
Lubrication monitoring

- Consequences of over-lubrication as valve sticking can be monitored with PV analysis

Ok condition



"Sticking" at suction valve after insertion of oil

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Oil contamination: effect of particles on a piston pump

- Oil contamination (particle, water, gas) is usually monitored offline

Conclusions

Many techniques can be employed to effectively monitor wear on recip compressors, to plan maintenance and minimize risks of secondary damages.

- Temperature
- Vibration
- Position
- Cylinder internal pressure
- Lube oil flow and quality

Questions