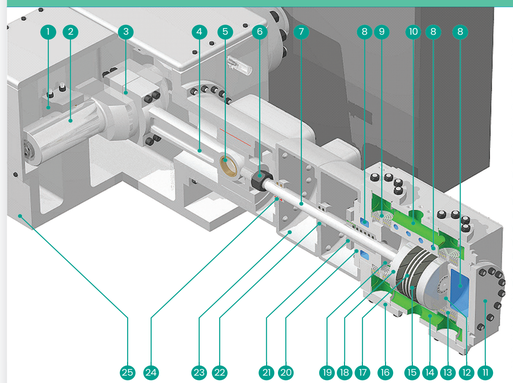
# Reciprocating Compressor Instrumentation and Condition Monitoring

Bently Nevada
a Baker Hughes business

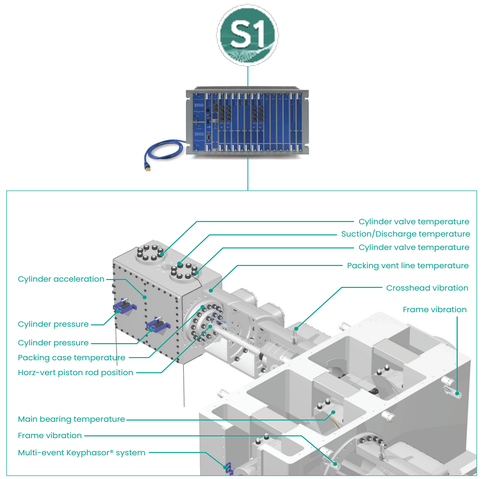
## COMPONENTS AND NOMENCLATURE



1. Main bearings
2. Crankshaft
3. Crankpin bearings
4. Connecting rod
5. Crosshead pin
6. Piston rod locknut
7. Piston rod
8. Cooling water
9. Suction valve
10. Suction plenum
11. Cylinder head (outer end or head end)
12. Chamber (outer end or head end)
13. Discharge valve
14. Discharge plenum
15. Wear bands (rider rings)
16. Valve cover
17. Piston rings
18. Piston
19. Chamber (frame end or crank end)
20. Cylinder head (frame end or crank end)
21. Pressure packing case
22. Intermediate partition packing
23. Distance piece
24. Oil wiper packing
25. Frame

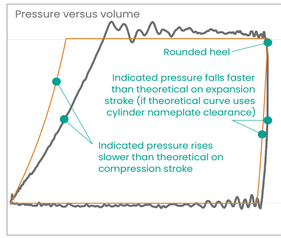

**Crosshead assembly nomenclature**

## INSTRUMENTATION LAYOUT




## LEAK

### Leak to low pressure side (suction valves or pressure packing leak, if CE chamber)

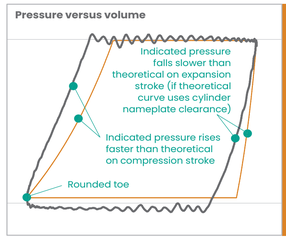



**Leak to low pressure reservoir**
(crank end shown, head end similar)

Supporting evidence
- Is flow balance greater than 1.05?
- Does the trend of a particular suction valve temperature indicate a rise compared to the other suction valve covers?
- Does valve cover acceleration/ultrasonic show high amplitude when suction valves are closed?
- If CE chamber: does the trend of the pressure packing temperature (or flow) increase?

Theoretical pressure curve
Indicated pressure curve

### Leak to high pressure side (discharge valves)

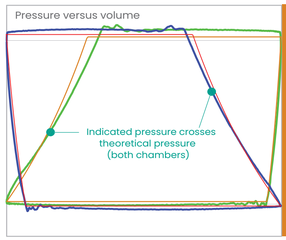



**Leak from high pressure reservoir**
(crank end shown, head end similar)

Supporting evidence
- Is flow balance less than 0.95?
- Does the trend of a discharge valve temperature indicate a rise compared to the other discharge valve covers?
- Does valve cover acceleration/ultrasonic show high amplitude when discharge valves are closed?

Theoretical pressure curve
Indicated pressure curve

### Inter-chamber leak (usually piston rings)




**Inter-chamber leak**

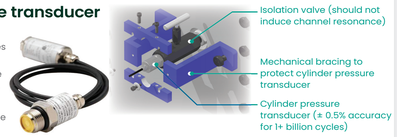
Supporting evidence
- Is flow balance on both chambers greater than 1.05?
- Is discharge temperature elevated compared to adiabatic discharge temperature?
- Does acceleration/ultrasonic show high amplitudes when chamber pressures different and low amplitudes when chamber pressures are equal?

Head-end theoretical pressure curve
Head-end indicated pressure curve
Crank-end theoretical pressure curve
Crank-end indicated pressure curve

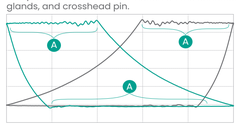
## CYLINDER PRESSURE INSTALLATION DETAILS

### Cylinder pressure transducer

Design features
- Tested to over 2 billion cycles
- Evacuated transducer for absolute pressure reference
- Gold-plated diaphragm for corrosion resistance
- Separate electronics module for high temperature resistance

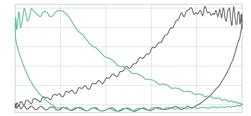



The single most effective way of determining the overall health of a reciprocating gas compressor is by examining the cylinder chamber pressure profile. Online access to the internal pressure for each compressor chamber enables continuous monitoring of chamber pressures, compression ratios, peak rod loads, and rod reversal. This provides valuable information on the condition of suctionvalves, discharge valves, piston rings, packing glands, and crosshead pin.




Typical pressure versus displaced volume

A typical indicated cylinder pressure curve will have some pressure fluctuation when the suction and discharge valves are opened. The areas labelled "A" and indicated by braces show these pressure fluctuations. When the valves are closed, the pressure shows a smooth line.

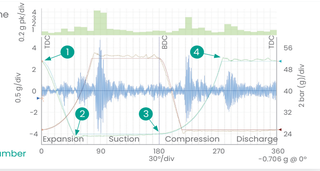


Channel resonance on pressure versus displaced volume curve

A pressure transducer installation suffering from channel resonance will show pressure fluctuations when the suction and discharge valves are closed as well as whenthe valves are opened. The frequency of this resonanceremains nominally constant throughout the cycle.

### CYLINDER ACCELERATION OVERLAID WITH DYNAMIC PRESSURES

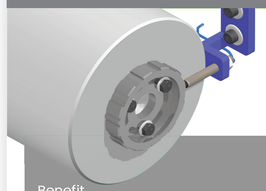
For each 10° CA, the 0-pk value of the acceleration signal is calculated




1. HE discharge valve closes
2. HE suction valve opens
3. HE suction valve closes
4. HE discharge valve opens

The process stages are for the HE chamber

## MULTI-EVENT WHEEL



**Benefit**

The torsional vibration of the crankshaft changes from revolution to revolution for each load step on the machine. Having multiple events per revolution improves the ability of the system to capture data with respect to crank position, regardless of the shape or change in shape of the torsional vibration.

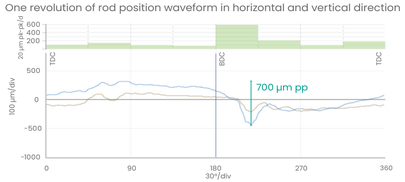
Sensing multiple events per revolution is the technique used with the Bently Recip Multi-Event Wheel.

Recip Mulit-Event wheel kit
(Part No. 146973-01)

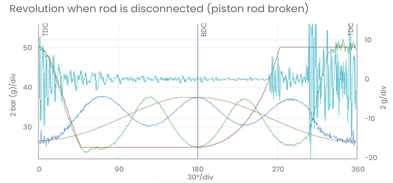
Custom Recip Multi-Event band
(Part No. 105M5964-xx)

## PISTON ROD BREAK

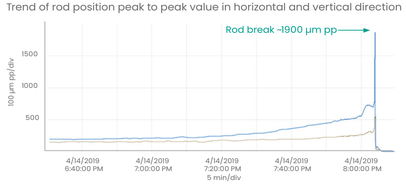
One revolution of rod position waveform in horizontal and vertical direction

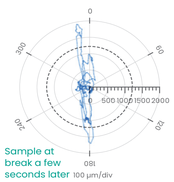



Revolution when rod is disconnected (piston rod broken)

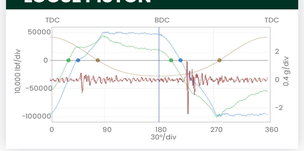



Trend of rod position peak to peak value in horizontal and vertical direction




### LOOSE PISTON




## ROD LOAD MONITORING

Combined (inertia and gas) rod loads calculated at the crosshead provide information about the lubrication condition of the crosshead pin. Insufficient reversal or excessive rod load can be identified and corrected before costly running gear damage occurs.

**Maximum allowable continuous combined rod load (MACCRL)**

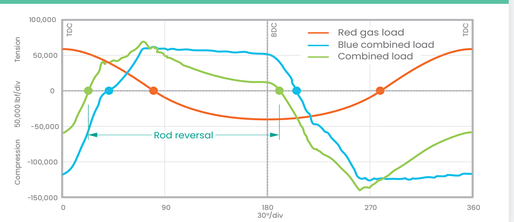
A value determined by the original equipment manufacturer (OEM) based on design limits of the various components in the compressor frame and the running gear ( bearings, crankshaft, connecting rod, crosshead assembly, piston rod, piston assembly).

**Maximum allowable continuous gas load (MACGL)**

A value determined by the OEM based on the design limits of the static components (frame, distance piece, cylinder, and bolting).

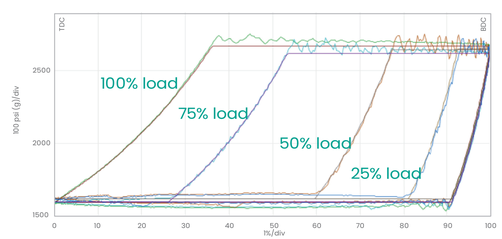
**Rod reversal**

The shortest distance, measured in degrees of crank revolution, between each change in sign of force in the combined rod-loading curve.




## CAPACITY CONTROL STEPLESS UNLOADER

Even during different load steps, the comparison between theoretical and measured pressures is available, due to a patented algorithm to determine suction valve closure with no input required from dynamic valve unloader controller.

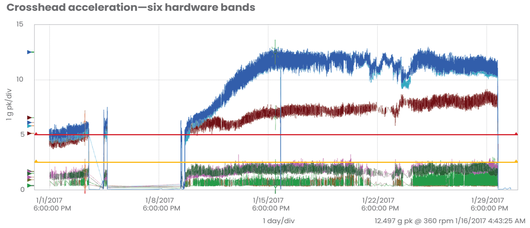



## CONDITION MONITORING

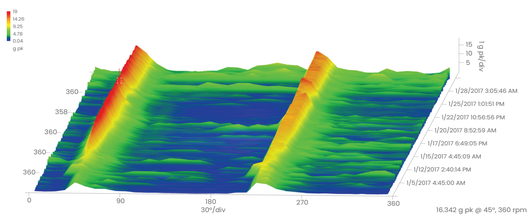
### Waveform types

Crosshead-mounted accelerometers can detect machinery problems due to impact-type events such as loose running gear components, liquid ingestion into the cylinder, or excessive clearance in the wrist pin bushing.

**Crosshead acceleration—six hardware bands**




**Crosshead acceleration—band waterfall with 36 software bands**

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