Brüel & Kjær Vibro

Application Note

Basic Condition Monitoring of Piston Reciprocating Compressors

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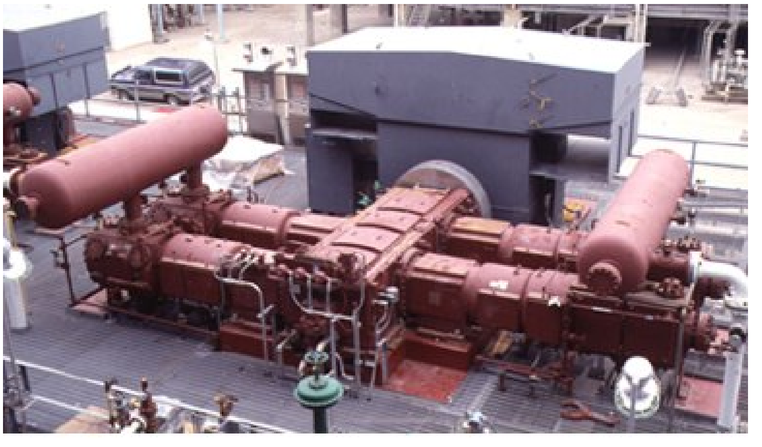
Scope

The machine monitoring strategy (Basic condition monitoring as well as the Advanced condition and performance monitoring) is applicable to all types of API 618 reciprocating compressors, lubricated and non-lubricated, piston ring sealing or labyrinth sealing, double acting or single acting. Hyper compressors (i.e. the secondary reciprocating compressor used in LDPE production) are covered by a separate application note.



Machine Operation and Maintenance Requirements

API 618 reciprocating compressors are used in a wide range of applications in the petrochemical industry. Regardless of the process, these machines are very maintenance intensive in relation to turbo-machinery, but are typically not monitored enough. If developing faults are unchecked, these can lead to component breakage, leaks or even complete machine failure.

This Application Note focuses on critical and non-critical machines that have only basic operation and maintenance requirements.

Monitoring Strategy

A **Basic condition monitoring** technique is intended to detect most developing faults at an early enough stage such that maintenance to be cost-effectively planned ahead of time without stopping the machine. The sensors used for protective monitoring are also used for condition monitoring, plus a rod drop and some extra process signals. Protective monitoring is vital for reciprocating compressors for monitoring failure modes of critical components which have little or no advance warning, such as liquid carryover, bolt/nut fracture, crosshead wrist pin seizing, loss of lubrication, etc.

The basic condition monitoring strategy can be extended with more **Advanced condition and performance monitoring** techniques for detecting a greater number of potential failure modes. The same faults detected by the Basic condition monitoring strategy can also be detected by the Advanced condition and performance monitoring strategy, but earlier, more reliably and with more specific information on the location of the fault. The Advanced monitoring strategy is more suitable for monitoring at different operating conditions.

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Monitoring Configuration and Techniques

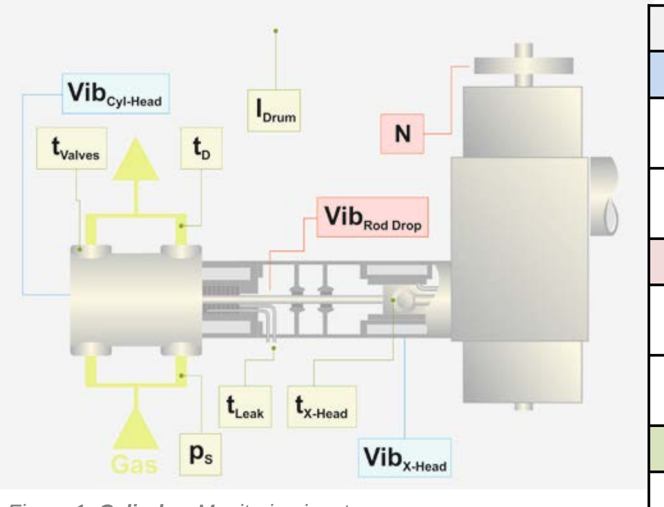

*Figure 1. **Cylinder:** Monitoring inputs.*

Symbol	Signal
Absolute Vibration Monitoring Sensors	
$Vib_{X\text{-}Head}$	Crosshead radial vibration (accelerometer)
$Vib_{Cyl\text{-}Head}$	Cylinder head radial vibration (accelerometer)
Relative Vibration Monitoring Sensors	
$Vib_{Rod\ Drop}$	Rider ring wear (displacement sensor)
N	Shaft speed, phase reference
Process Values (Imported or Sensors)	
l_{Drum}	Knock-out drum fluid level
$t_{X\text{-}head}$	Crosshead temperature
t_{Leak} (or m_{Leak})	Packing leak gas temperature (or flow)
Td	Discharge gas temperature
t_{Valves}	Suction and discharge valve temperature
Other process	Coolant and lube temp., pressure, differential pressure across filter, level, flow

Table 1. Input signal symbols..

Monitoring Configuration and Techniques (cont.)

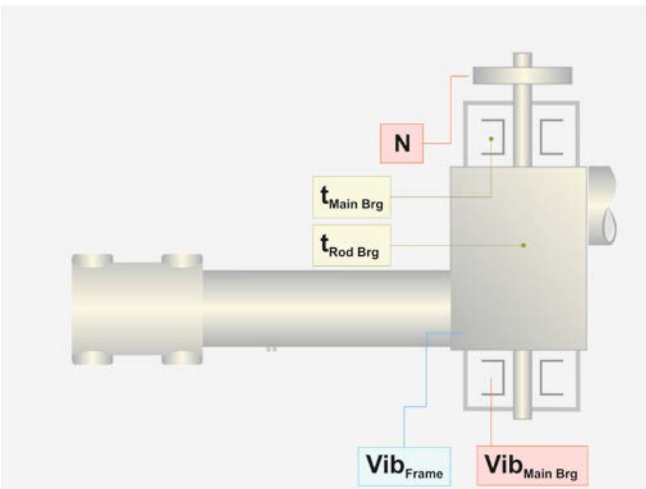

Figure 2. Frame: Monitoring inputs.

Symbol	Signal
Absolute Vibration Monitoring Sensors	
$\text{Vib}_{\text{Frame}}$	Frame radial vibration (velocimeter or accelerometer)
Relative Vibration Monitoring Sensors	
$\text{Vib}_{\text{Main-Brg}}$	X-Y radial vibration (displacement sensor)
N	Shaft speed, phase reference
Process Values (Imported or Sensors)	
$\text{t}_{\text{Main\_Brg,}}$ $\text{t}_{\text{Rod\_Brg}}$	Bearing temp. of main bearing and crank rod bearings
Other process	Coolant and lube temp., pressure, differential pressure across filter, level, flow

Table 2. Input signal symbols.

Sensor Location (type)	**Measurements**	**Plots**	**Faults that can be detected and diagnosed**
Crank shaft (Relative radial vibr.)	• **Overall** (ISO:1Hz/10Hz - 1kHz) • **DC** (bearing position) • **Autospectrum** (FFT) • **DC vs. RPM** • **1x, 2x, 3x**	• Trend vs. time/speed • Spectrum • Waterfall • Orbit • Shaft position • Transient (Bodé)	Bearing damage, lack of lubrication, overload, wear
Rod drop (Relative radial vibr.)	• **Cyclic DC** (wear ring displ.) • **CPB6%**	• Trend vs. time • Trend vs. crank angle	Wear ring wear and damage, rod condition, crosshead looseness
Shaft, flywheel (Tacho)	• **Speed, phase**	• Trend vs. time	Phase and triggering used in other measurements

Table 3. Monitoring techniques.

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Monitoring Configuration and Techniques (cont.)

Sensor Location (type)	**Measurements**	**Plots**	**Faults that can be detected and diagnosed**
Cylinder and/or crosshead (Absolute radial accel. vibr.)	• **Overall** (ISO:1Hz/10Hz - 1kHz) • **CPB6%** • **Autospectrum** (FFT)	• Trend vs. time • Trend vs. crank angle • Spectrum • Waterfall	• **Crosshead**: Pin looseness, shoe clearance, broken rod • **Head**: Liquid carryover, damaged rings, loose piston nut
Frame (Absolute radial velocity or accel. vibr.)	• **Overall** (ISO:1Hz/10Hz - 1kHz) • **CPB6%** • **Autospectrum** (FFT)	• Trend vs. time • Spectrum • Waterfall	Damaged crank, bearing, connecting rod, defective mounting supports
Cylinder (Process)	• **DC** (valve temp.) • **DC** (leak flow., temp., or pressure.) • **DC spread** (valve temp.) • **DC** (discharge temp.) • **DC** (suction pressure)	• Trend vs. time	• **Valves**: Damage, excessive gas leak • **Discharge/Suction**: High discharge gas temp. can damage seals. High discharge temp./pressure, or low suction pressure often due to improper process. • **Cylinder**: High D pressure could load rod/frame
Bearings (Process)	• **DC** (crosshead pin, shoe temp.) • **DC** (main bearing temp.) • **DC** (big end bearing temp.)	• Trend vs. time	Damaged and worn bearings, lack of lubrication, overload, wear
Aux. systems (Process)	• **DC** (KO drum liquid level) • **DC** (recycle gas flow)	• Trend vs. time	**KO drum**: Avoid liquid carryover that could damage piston, seal, rod and cylinder head.

Table 3. Monitoring techniques (cont.).

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