Brüel & Kjær Vibro

Application Note

Advanced Condition and Performance Monitoring of Reciprocating Compressors

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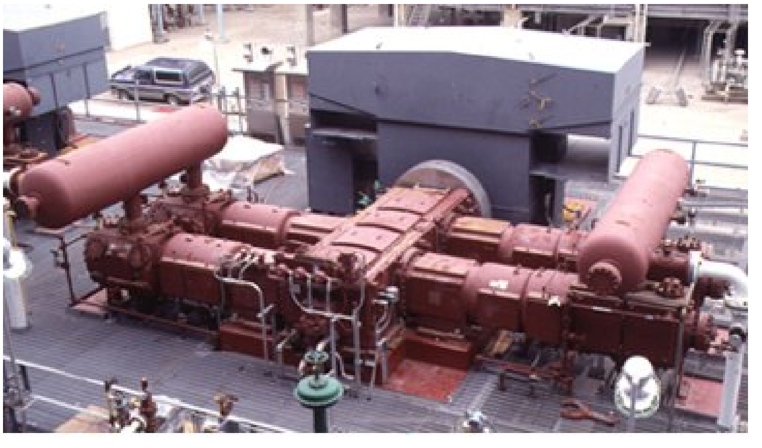

Scope

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 machines where unscheduled downtime is not tolerated, there are widely varying operating conditions, or maintenance has to be planned early

Monitoring Strategy

Machine protection and basic condition monitoring are considered as a minimal requirement for managing reciprocating compressors.

An **Advanced condition and performance monitoring** strategy, which is an extension to the basic condition monitoring strategy, is considered vital for critical machines where early detection of potential failure modes is imperative for maintenance planning. It focuses on the cylinders.

Monitoring Configuration and Techniques

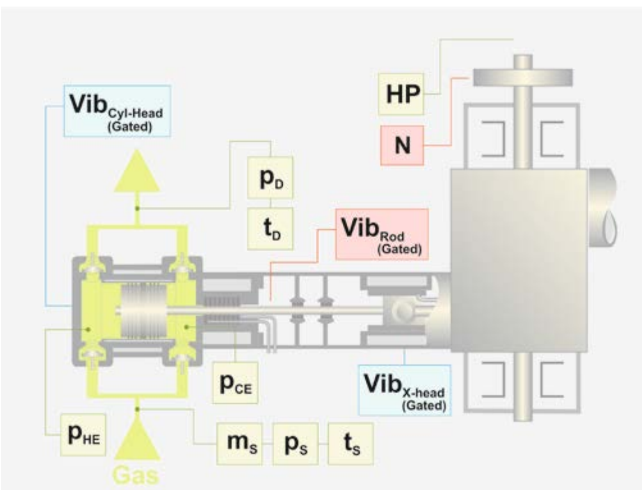

Figure 1. Monitoring inputs.

Symbol	**Signal** (from each cylinder)
p_{HE}	Dynamic cylinder pressures (HE)
p_{CE}	Dynamic cylinder pressures (CE)
p_S	Compressor static pressure at suction
p_D	Compressor static pressure at discharge
t_S	Suction temperature
t_D	Discharge temperature
m_S (or m_D)	Suction and discharge flow
P_{Sh}	Power
X	Fluid properties
N	Shaft speed, phase reference
$Vib_{Rod\ (Gated)}$	Gated rod position (DC vs. crank angle)
$Vib_{Cyl\text{-}head\ (Gated)}$, $Vib_{x\text{-}head\ (Gated)}$	Gated vibration (BP vs. crank angle, cylinder head and/or crosshead position)

Table 1. Input signal symbols.

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Monitoring Configuration and Techniques (cont.)

Measurements/Calculations	**Plots**	**Faults that can be detected and diagnosed**
Pressure-Volume function (PV plot)	Pressure vs. volume	Leaking valves, leaking seals, damaged valves, and unloaders, leaking piston rings
Polytropic exponent function	Scalar history	Leaking valves, leaking seals, leaking piston rings
Dynamic pressure in cylinder	Scalar vs. crank angle, scalar history (at 1 degree crank angles)	Cylinder leaks
Actual and theoretical power	Scalar history	Losses due to fouling, restrictions, slippage
Discharge temperature	Discharge temperature	Cylinder leaks, insufficient lubrication and/or cooling
Combined rod load, rod reversal	Scalar vs. crank angle	Excessive rod load, rod reversal
Suction and discharge valve losses	Scalar history	Defect valves
Leak flow/temperature, packing temperature	Scalar history	Packing leaks
Compression ratio, maximum cylinder pressure	Scalar history	Cylinder leaks, excessive loading
Median capacity, flow balance	Scalar history	Cylinder leaks
Volumetric efficiency	Scalar history	Cylinder leaks
Valve temperature spread	Scalar history	Valve leaking
Gated rod position	Scalar history, scalar vs. crank angle	Rider ring wear, crosshead wear/excessive clearance, rod condition, loose piston bolt, loose rod bolts or worn seal
Gated vibration (head-end and/or crank-end)	Scalar history, scalar vs. crank angle	Worn or damaged crosshead, valve, piston ring, piston bolt, seal, rod, rod bolts, liquid carryover

Table 2. Monitoring techniques.

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