Brüel & Kjær Vibro

Application Note

Monitoring strategy – Protection and basic condition monitoring of reciprocating compressors

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ABSTRACT

Reciprocating compressors are subject to considerably more downtime and maintenance costs than a comparable centrifugal compressor, but often have less monitoring. A simple, reliable monitoring strategy for API 618 compressors is described in this Application Note. The technique is sufficient for early detection of most types of reciprocating compressor faults and protection to effectively reduce downtime and maintenance costs, while at the same time avoiding a catastrophic failure.

Application

The monitoring solution described in this Application Note has been developed especially for existing reciprocating compressor applications where there is only minimal downtime allowed to install sensors. This monitoring solution can be used in many piston and labyrinth seal type reciprocating compressor applications in the petrochemical industry, such as in refineries, gas treating facilities, polyolefin plants, etc. Many of these compressors operate in an explosive atmosphere, and therefore require an ATEX compliant protection system such as the one described in this Application Note. A hydrogen service compressor, for example, should not be operated without such a protective system.

Need for monitoring

In nearly all petrochemical applications, the reciprocating compressors are critical to the process but unspared, so downtime can be costly.

Figure 1. Reciprocating compressors play a significant role in the petrochemical industry.

Studies show that most of the downtime and subsequent maintenance associated with reciprocating compressors are caused by faults in the cylinders. This includes damage caused by liquid ingestion, rider band wear, worn crosshead pin, leaking seals, defective valves, broken piston rings, and broken piston rods. Valve problems are the most common cause for shutdown due to failure.

For applications where there are condensable hydrocarbons, this can cause fouling and valve problems. Corrosion can also occur due to the presence of a number of chemicals such as ammonia and hydrogen sulphide. If the knock-out drums, filters and strainers are damaged or are not functioning properly, liquids and solid material can enter the compressors and cause damage.

For hydrogen applications (e.g. a recycle hydrogen compressor used in a catalytic reformer or catalyst regeneration), liquid ingestion can lead to an explosive catastrophic failure.

Monitoring strategy

Reciprocating compressors are subject to more maintenance problems than rotating machinery but are some of the least monitored critical machines in the plant.

Some reciprocating compressors are monitored using old monitoring technology that is neither accurate nor reliable. Other systems may be obsolete and therefore spare parts may be difficult to find. In either case these systems should be replaced as soon as possible.

Many faults develop slowly in a reciprocating compressor due to the gradual wearing process of components (rider bands, cross-head shoe, valves, etc.). For this reason some users feel it is sufficient to collect data using portable instruments, but this is not an acceptable strategy for all applications. It isn't possible to detect fast developing faults in time to prevent a catastrophic failure, such as solid/liquid ingestion or component breakage.

For early, automatic fault detection monitoring and protection of most types of faults, a very basic monitoring strategy is all that is needed. Such a monitoring solution is very simple yet robust, with a minimal amount of sensors installed. Additional sensors can be installed for a more complete automatic monitoring strategy, as described in the section on extended monitoring, but this requirement – more the exception than the norm – is limited to special applications.

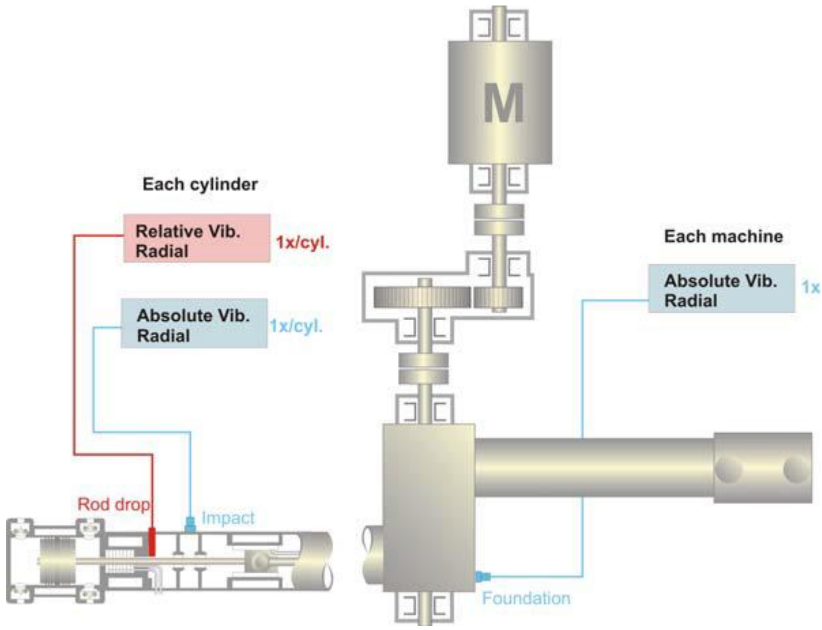

Figure 2. Protection and basic condition monitoring. Vibration measurements are indicated as relative vibration displacement transducers (red) and seismic absolute vibration sensors (blue).

Specialized diagnostic and analysis tools for post processing detected faults can also be added, but caution should be exercised in using these tools; they are for post-analysis only and do not reduce the time for automatically detecting faults. These tools require a lot of expertise to interpret. For this reason they are used infrequently by the end-user, or used improperly and thus can result in incorrect predictions.

Monitoring solution

The machine configuration shown in Figure 2 is primarily protection with basic condition monitoring capability for the reciprocating compressors, where a number of faults can be detected early (i.e. basic condition monitoring) and remotely displayed on a windows computer in the control room. This solution does not require a database for storing and trending data.

When an Alert alarm limit is exceeded, there normally is sufficient lead time to plan maintenance ahead of time. When a Danger alarm limit is exceeded, a relay is used to provide immediate warning of an imminent failure (i.e. in the case of a rod drop sensor) or to shut the machine down to avoid a catastrophic failure (i.e. in the case of a frame or impact sensor). Relays can be reset remotely.

The measurement techniques shown in Table 1 are for early, automatic detection of developing faults. The configuration shown in Figure 3 and 4 is for an explosive atmosphere.

Meas. point	Signal	Measurements	Faults that can be detected	Monitoring
Rod drop	Radial relative vibration	DS- 10[A]	Calculated radial displacement of rider rings using a geometric factor	Condition (no trip)
Impact	Radial absolute vibration	ASA-68/100/1	**Bandpass** (acceleration)	Protection
Frame	Radial absolute vibration	ASA-68/10/1	**Bandpass** (velocity)	Protection

Table 1. Protection system sensors and measurements. A: The rod drop sensor is mounted inside the stuffing box on a bracket connected to the cylinder head flange as shown in Figure 4. B: It is also possible to monitor rod drop with a triggered signal at 1 or 2 measurement points. This requires a phase/reference sensor.

Additional protection

The reciprocating compressor drive train (i.e. motor, gearbox, coupling and crankcase) can also be monitored for protection. This can optionally include X-Y relative vibration of the main bearings, PT-100 sensors for the main bearing temperatures (more time is needed to install these sensors), accelerometer for gearbox vibration, an X-Y foundation sensor configuration, and an axial sensor for thrust bearing axial position.

The monitoring strategy shown in Figure 2 can also be easily extended to monitor other protection functions on the cylinders themselves, such as the crosshead shoe temperature, leak flow and valve temperatures. A phase/reference sensor can also be added for gated rod drop measurements.

Condition monitoring extension to the protection system

The basic condition monitoring solution previously described is sufficient for detecting early faults in many reciprocating compressor applications. In certain applications, however, a more comprehensive condition monitoring strategy may be required, which includes early fault detection, trending and diagnostic and analysis capability.

The VIBROCONTROL 6000® monitoring system can be extended to a Compass 6000™ monitoring system by adding a remote computer server running the Type 3160 Analysis software for diagnostics, and a database for trending.

Figure 3. Typical accelerometer mounting for impact and frame vibration monitoring. Minimal downtime is required to install this.

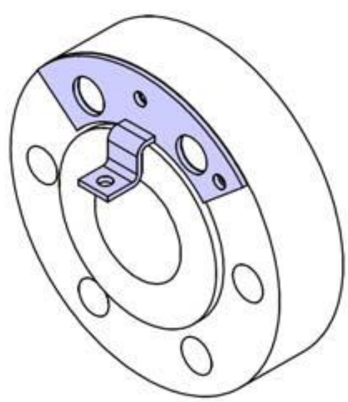

Figure 4. A typical rod drop sensor bracket that mounts on the stuffing box flange. Minimal downtime is required to install this.

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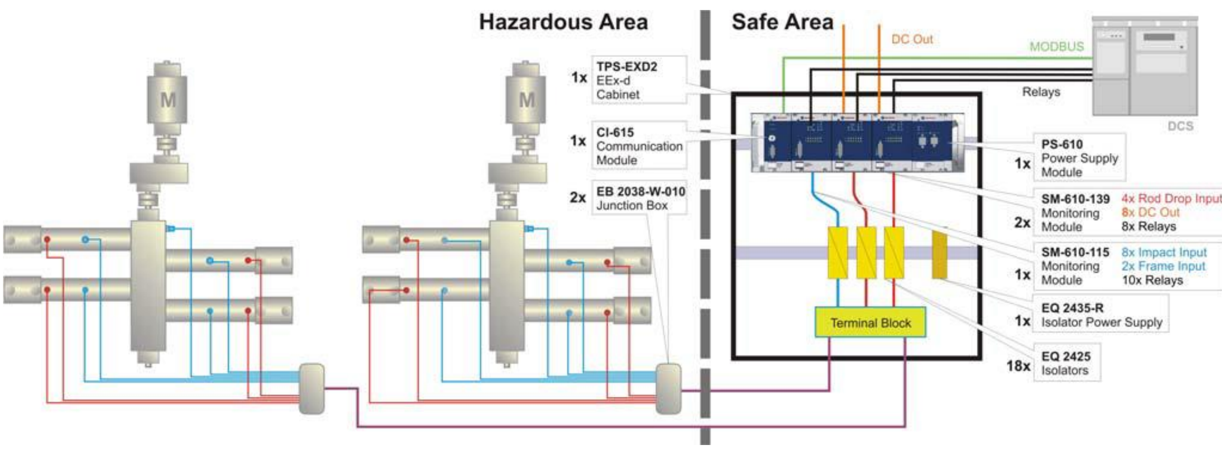

Figure 5. Typical reciprocating compressor monitoring system configuration. A local display can be optionally placed in the EEx-D cabinet.

The original VIBROCONTROL 6000® system configuration in Figure 2 does not need to be changed, unless more data needs to be monitored. The additional data can include:

- Discharge gas temperature
- Suction gas temperature
- Dynamic cylinder pressure
- Jacket water pressure, temperature
- Lube oil pressure, temperature
- Valves temperature
- Packing temperature
- Leak gas temperature
- Bearings temperature
- Mass flow
- Motor current
- Phase reference sensor (tacho)
- Rod reversal

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