Customers report an excess of USD $300k for parts, labor, and lost production due to unplanned maintenance on their reciprocating compressors.

Critical reciprocating compressors that operate at high speeds, compress dirty gas and have no spares are target machines on maintenance improvement lists due to safety concerns and downtime risk.

Are your reciprocating compressors:

• at the top of your maintenance expense list?
• causing you to miss production goals?
• compressing dangerous gases?
• running greater than 500 rpm?
• unspared?
• changing gas frequently or compressing dirty/wet gas?

If you answered yes to any of these questions, and have documented losses associated with reciprocating compressors, you have identified an easy target for continuous improvement that can directly contribute to your company’s bottom line.

Many users don’t realize that online monitoring for their reciprocating compressors can simply be an extension of their rotating machinery program.

For 90% of the malfunctions, vibration, temperature and process measurements can be monitored to detect changing conditions early, so you can take action with process control or plan the maintenance activity at the most opportune time.

With a basic monitoring strategy focused on reciprocating compressors, you can reduce entire maintenance department spending by as much as 30% per year.

Emerson has created a targeted machinery condition monitoring solution for reciprocating compressors. By using the CSI 6500 with AMS Machinery Manager software, you can detect underlying problems and diagnose the root cause.

Emerson’s complete machinery health solution includes online monitoring, periodic portable analysis, wireless vibration monitoring, oil analysis, and infrared thermography.

Reciprocating compressors have been around for over 100 years but cost three and a half times more to maintain than other critical rotating assets in the plant. Reciprocating compressors are vital service machines often flowing dangerous process gases, sometimes at very high pressure. Many of these machines either have no monitoring at all — or they come with crude overall vibration switches and are plagued with false trips and instrumentation failures.
Combine protection and prediction data to effectively monitor reciprocating compressors.

With Emerson’s solution for reciprocating compressors, you have a comprehensive view from inside the machine, allowing you to detect and diagnose equipment issues before they affect your production goals.

- Minimize unplanned outages.
- Move from reactive to predictive maintenance.
- Facilitate timely decision making.
- Achieve optimal health and performance.
- Diagnose the root cause of performance degradation.
- Extend machinery life.

Focusing Maintenance

Basic API 618 protection monitoring starts with overall frame vibration. API 670 adds rod drop monitoring, which is applicable for certain types of compressors. After your reciprocating compressor is protected by equipment using API 618 and API 670 standards, the next goal is to monitor these machines and get machinery health information early enough so your protection system never has to shut the machine down.

Most failure modes provide plenty of early indication, provided the right tools are used for monitoring, operators are given actionable information, and maintenance has warning to effectively plan.

Probability of Failure

50% VALVE ISSUES
20% PACKING
7% PISTON RIDER BANDS
0.5% CYLINDER LINERS
2% PISTON RODS
0.5% BEARINGS
20% OTHER

Prediction Monitoring

Early visibility to a machinery component problem will ensure you can plan effective maintenance before a major problem occurs or causes a trip.

- Move from reactive to predictive maintenance.
- Real-time predictive alerts.

Your facility can lose millions of dollars in lost production if the control system malfunctions and causes an unscheduled shutdown. Protects your company’s investment by implementing the right processes to keep your facility running smoothly and productively.
Sensors
Emerson’s range of sensors includes velocity, thermocouple, eddy current probes, and accelerometers. Sensor measurements connect directly with the CSI 6500 so all your machinery health information is in a single database.

Valve Health Monitoring
Using accelerometers on each valve cover or cylinder head, the CSI 6500’s embedded PeakVue technology can measure ultrasonic vibration energy created by a leaky valve, a loose valve, or a stuck valve. An axially mounted accelerometer on the cylinder head not only detects valve leaks, but can also detect issues with the piston, piston rod, or crosshead in the axial direction. Combined with temperature measurements on the suction or discharge gives even more insight into valve performance and potential issues.

Protection Monitoring
The CSI 6500 meets API 670 protection monitoring requirements, vital to preventing possible catastrophic failures. If configured with protection inputs, the CSI 6500 helps to prevent trips by using module health checking and instrument health monitoring.  
• Protect against catastrophic failure.  
• Instant alert notification to control room.

API 618 and API 670 Compliant Shutdown Protection
The CSI 6500 is used to monitor high frame vibration, crosshead vibration, and rod drop. Frame vibration monitoring will detect imbalance in the running gear, loose counter weights, rod bearing looseness (big end), and main bearing health. Crosshead vibration monitoring detects crosshead shoe vibration, loose crosshead guide shims, piston rod nut looseness, or connecting rod bearing looseness (end). Rod drop monitoring provides early indication and trending of rider band wear on the piston before metal contacts the cylinder wall.

Machine Anomaly Detection
In addition to detecting valve health issues, PeakVue technology uses a unique signal processing technique to measure vibration signature caused by an impact. If loose parts or machine anomalies — such as crosshead vibration due to packing, loose shoe, or a wrist pin — cause machine parts to impact or rub, PeakVue technology can detect the subtle changes in vibration signature.

Piston Rod Monitoring
With the CSI 6500 transient analysis capability, you can monitor average rod position and the dynamic motion of the rod in real time across one revolution. Visualize rod flex, rod looseness, and rod vibration to determine if there is excess rod movement. With transient, you can pause, rewind, and replay the live rod dynamic motion. Too much rod motion and bending can be indicative of overloading, cracks in the rod, or a loose piston rod nut, and can damage pressure packing or cause leaks, leading to major compressor failures.

Easy Integration to Control Room
The CSI 6500 is part of a plantwide asset monitoring solution that integrates with the DeltaV™ or Ovation™ digital automation systems or third party process control systems. When integrated with a DeltaV or Ovation system, the CSI 6500 data can be integrated to the control system with a three-step process that requires about 10 minutes to complete.
Manage assets with predictive diagnostics.

AMS Suite delivers predictive diagnostics in a graphical user interface for real-time decision support. AMS Suite identifies the nature and criticality of developing problems so you can effectively plan your work. Whether you are in operations or maintenance, you have the information necessary to determine the root cause and make informed decisions.

With AMS Suite, you can consolidate machinery data from all other mechanical assets into a single application to analyze and measure overall performance. Use performance indicators on the health of the entire process to optimize maintenance costs and integrate with your CMMS system to create work notifications and track history.

Diagnostic tools in AMS Suite

| KPIs | Dashboard display with real-time indicators of overall reciprocating compressor condition, with parameters based on the severity of an alarm. |
| Waveform | Shown in XY Cartesian format or in polar format to better represent the cycle of a compressor. Waveforms can be normalized to 1 revolution to reduce clutter from a multi-revolution data sample. |
| Advanced Analysis Displays | Advanced analysis functionality includes waterfall plots, shaft or bits, stator thermal mapping, X-Y and Z plots, efficiency and deviation from design graphs, polar graphs, and waveform and spectrum data frequency graphs. |
| Transient Live Display | Record data simultaneously for each channel, allowing the replay of a particular event or specific time period for further analysis. |
| PeakVue™ Technology | Capture vibration signals into a frequency based spectral plot for advanced identification of sleeve and rolling element bearing problems. |
| Parameter Profile Status | Determine the parameter alarm status of the compressor and other mechanical machinery for easy fault identification. |
| Integration with other condition monitoring technologies | Combine data from infrared, oil and wear debris analysis, laser alignment and portable vibration analysis into a common database for a complete picture of the compressor health. |

Online monitoring of your reciprocating compressors enables you to view condition health information remotely, safely—instead of going to the field to determine issues.
Diagnosing Reciprocating compressor faults.

Sensors mounted on the compressor connect to the CSI 6500 to deliver vibration, position, and temperature measurements for machinery health monitoring. Data collected from these points is analyzed to determine reciprocating compressor failure modes at their earliest development to allow for process correction or planned maintenance activity.

- **Cylinder Head**
  - Piston vibration
  - Piston rod and nut vibration
  - Crosshead axial vibration
  - Valve monitoring

- **Cylinder Pressure**
  - Leaking

- **Inlet and exhaust Temp**

- **Crosshead Shoe Temperature**

- **Crosshead Vibration**
  - High frequency impacting
  - Lower frequency rubs
  - Loose shims
  - Loose piston lock nuts
  - Loose wrist pins

- **Speed**
  - Normalize waveform data to a single cycle to simplify analysis

- **Main Bearing Temperature**
  - Temperature
  - Rotor nut vibration
  - Wear

- **Frame Vibration**
  - Running gear imbalance
  - Loose counterweights
  - Bearing wear (main and big end)
  - Automatic trip measurement

- **Rod Drop/Rod Flex**
  - Excessive rod movement
  - Backlash
  - Excess Vibration
  - Rider band wear

- **Pressure Packing Temperature**
  - Leaking
Key performance indicators in AMS Suite.

AMS Suite provides trends and displays to help you analyze vibration data to diagnose the root cause of an impending problem. Typical performance indicators include:

Valve Leakage Plot
Since leaking valves emit very high vibration frequencies, PeakVue technology can detect them at an early stage. This plot shows early indications of a leaking valve with distinct peaks measuring 80 g’s. If the valves were performing normally, values would be 100x lower in energy.

Rod Position Plots
The rod position plot indicates rider band wear when the indicator is not tied to an automatic trip. The trend shows a decline in clearance over time so that outage planning can include the replacement of the rider bands.

Crosshead Vibration
In this trend, overall vibration is trending up. Further inspection revealed that bolts had snapped where the cylinder joins the distance piece. These types of trends can alert you to rapidly developing issues that happen between monthly route-based monitoring.

Cylinder Pressure
Typically cylinder pressure is measured with a portable analyzer, pressure sensor, and software. With online monitoring, valve leaks and ring leaks can be most easily monitored with temperature and vibration measurements.

Comprehensive services and support for your reciprocating compressor solution.

Emerson provides services to train you on monitoring capabilities and can even remotely diagnose—or help you diagnose—your machinery.

Emerson is committed to supporting you through all steps of the project—from system design to installation and lifecycle support—to keep your system running smoothly and reliably.

Our response centers offer troubleshooting, remote monitoring, diagnostics interpretation, and emergency site services to help keep your process running. Make the most of your resources with Emerson’s expertise when and where you need it.

You can rely on Emerson for:
• Assessment of your most critical assets to uncover monitoring gaps.
• Customizable design of your reciprocating compressor monitoring system.
• System staging and testing prior to installation and commissioning.
• Database design, alarm adjustments, network connectivity and system calibration.
• Installation and mounting of sensors including configuration of the CSI 6500.
• Patented Easy Integration to the process automation system.
• Delivery of a training program that covers operation and diagnostic capabilities.
• Full access to firmware updates, technical, and product support.
Three decades of leading the market in the development of advanced vibration monitoring technologies, software, and services has made Emerson renowned in machinery health monitoring for many blue chip organizations.

Throughout the lifespan of your compressor, our machinery diagnostics and performance monitoring will provide you with all the information necessary to identify, determine severity, and target the root cause of machine anomalies so you can minimize the risk of a failure.

The early detection of a piston ring leak, a faulty discharge valve, or excessive rod load will put you on the path to improved management of your reciprocating compressor.

With Emerson as your partner, you can:
• Achieve optimal health and performance of your reciprocating compressor.
• Reduce catastrophic failures and unplanned shutdowns.
• Meet operational and production targets.
• Shift from reactive and preventive, to predictive and proactive maintenance.
• Determine maintenance actions and prioritize based on criticality.
• Diagnose the root cause of performance degradation and reoccurring problem.

Move from reacting to detecting mechanical problems so your reciprocating compressor will sustain availability and throughput, reducing risk of meeting your operational goals.

A partnership with Emerson is one you can trust for your reciprocating compressor needs.

Complementary machinery health solutions.

Complementary to online machinery monitoring, Emerson provides additional condition monitoring technologies for a comprehensive view of the health of balance of plant equipment.

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<thead>
<tr>
<th>CSI Z140 Machinery Health Analyzer</th>
<th>CSI 9420 Wireless Vibration Transmitter</th>
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<tbody>
<tr>
<td>The CSI Z140 Machinery Health Analyzer is a portable analyzer that features four-channel monitoring for advanced vibration analysis, cross-channel and transient analysis, dynamic balancing, and motor monitoring.</td>
<td>The CSI 9420 delivers vibration monitoring over a wireless network and is ideal for hard-to-reach or cost prohibitive locations.</td>
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<th>CSI 9330 Vibration Transmitter</th>
<th>AMS Suite: Machinery Health Manager</th>
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<td>The CSI 9330 continuously transmit vibration data for non-critical machinery direct to the control system.</td>
<td>AMS Machinery Manager integrates data from multiple predictive technologies, including popular third-party providers such as Spectro Inc. (oil analysts data), Fluke, and FLIR (thermographic images and data).</td>
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