Reliability Solutions for Mechanical Equipment
Understanding Machinery Health for Increased Availability and Maximum Performance
Is Your Machinery’s Health Putting Your Operational Goals at Risk?

In an increasingly competitive market, organizations are challenged to run their plants more profitably and with greater efficiency. Yet mechanical equipment deteriorates causing a decrease in performance, a reduction in throughput and a rise in operating costs. Or an unplanned shutdown grinds production to a halt, resulting in a large loss in revenue.

Deterioration in machinery health and performance is usually associated with misalignment or imbalance, corrosion and wear, fouling, sediment build-up or poorly lubricated parts. Detecting these underlying problems early allows you to correct issues before they affect your process, optimizing the performance of your plant.

Emerson’s combination of best-in-class technologies and services helps increase equipment effectiveness, reliability and performance by allowing you to be proactive in your maintenance.

With Emerson’s approach to improving asset reliability, you have a comprehensive view of every machine, allowing you to diagnose problems early – before they even become an issue.
Turn to Emerson to ensure optimal health and performance of your mechanical equipment.

Knowing and understanding your machinery’s health can help you to:

- Increase throughput, availability and reliability
- Improve operating performance
- Reduce maintenance expenditures
- Avoid unplanned shutdowns
- Reduce energy consumption and costs
- Extend equipment lifespan
In an environment that relies on critical mechanical equipment, any failure can have a dramatic effect. A prolonged process interruption can be the difference between profit and loss. With this much at stake, having the correct protection, prediction, and performance monitoring system in place is essential. With Emerson’s online machinery monitoring technologies, you can monitor mechanical assets and analyze temperature, vibration, efficiency, and deviation data for changing conditions that could result in a shutdown.

Delivering reliability to your critical assets

- Combining protection, prediction, and performance capabilities makes the difference in knowing your mechanical equipment is truly reliable.
- Protect against catastrophic failures
- Reduce process disruption
- Improve maintenance effectiveness
- Start-up safely
- Increase plant profitability
- Reduce operating costs

Ensure protection from catastrophic failures. Protect people, facilities, and the environment.
Emerson’s machinery health and asset reliability solutions have been deployed in a variety of sites and processes around the world.

Here are some of the quantifiable results that our customers report:

- **Dolphin Energy** uses Emerson’s PeakVue™ technology extensively to reveal underlubrication and prevent unexpected breakdowns due to defective bearings.
- **Egypt Basic Industries Corp.** attributed additional uptime of five to seven days annually at a value of $4.1 to $5.8 million to predictive maintenance with AMS Suite.
- **Flint Hills Resources** achieved an 18 percent improvement in mean time between repairs (MTBR) on rotating assets in their Pine Bend Refinery and is “definitely saving maintenance dollars”.
- **Lyondell Chemical Company** saved $125,000 through predictive maintenance, while eliminating or reducing preventive maintenance.
- **Braskem** identified excessive vibration on a key reactor pump and avoided an emergency shutdown that could have cost more than $6 million in lost revenue.
- **Cemex** used vibration measurements to identify a severe bearing fault on a cement mill, avoiding unplanned downtime that could have cost as much as $510,000.
- **International Power Australia** integrates real-time prediction monitoring with turbine controls for powerful and flexible protection.

[www.EmersonProcess.com/Asset_Reliability_Results](http://www.EmersonProcess.com/Asset_Reliability_Results)
Best-In-Class Diagnostics Promote Operational Excellence

From API 670 and API 618 machinery protection to real-time analysis of critical machines, Emerson is the single source for improving reliability of your mechanical assets and ensuring high availability.
With a proven track record of implementing plant-wide predictive diagnostic solutions, you can count on Emerson to unlock the maximum potential in your machinery. Emerson’s AMS Suite predictive diagnostic software integrates information from robust diagnostic technologies. This powerful combination of software with online, wireless, and portable technologies builds a predictive diagnostic foundation leading to improved productivity.

Software
- **Machinery Health Diagnostics**—multi-technology integration, analysis and reporting tools allowing enterprise-wide predictive maintenance planning.
- **Performance Monitoring**—analyze and obtain peak performance of critical mechanical and process equipment in real time.
- **Third-Party Technologies**—integration of data from expert providers of complimentary technologies such as oil analysis and infrared thermography.

Online Technologies
- **Online Machinery Monitoring**—includes complete protection, prediction and performance monitoring capabilities integrated with process automation, as well as options for portable monitoring and digital overspeed protection.

Portable Technologies
- **Vibration Analysis**—conclusive condition information about bearings, gears and other rotating components; implement on a periodic basis.

- **Alignment and Balancing**—ensure precise alignment and balance of rotating machinery.
- **Lubrication Analysis**—determine that lubricants and fluids are clean and moisture-free; detect particles in oil after onset of wear.
- **Infrared Thermography**—thermal imaging detects mechanical and electrical anomalies.

Transmitters
- **Wireless Vibration Transmitter**—interface with existing plant monitoring systems to deliver vibration levels on critical equipment.

Expertise
- **Asset Reliability Services**—launch a new predictive maintenance program or implement new technologies within an existing program.
The Software Tools for Asset Management and Predictive Diagnostics

The performance and health of mechanical equipment will deteriorate over time. Early detection is vital.

Ensure gradual deterioration doesn’t strip away performance or your peace of mind. Knowing the health and performance of your mechanical equipment allows you to be proactive with your maintenance planning instead of reacting to unexpected events. When your maintenance and operations staff are alerted to degrading asset health, critical production decisions can be made to eliminate outages and improve the bottom line.

Predictive Intelligence

AMS Suite distributes predictive intelligence to the right people at the right time so accurate, timely decisions can be made. The integrated family of AMS Suite predictive maintenance applications brings together information from critical production assets, including mechanical equipment, process equipment, instruments and valves.

Machinery Health Diagnostics

AMS Suite integrates data from Emerson’s protection and prediction technologies, including online, wireless, and route-based monitoring. You gain a comprehensive view of each machine so you can accurately diagnose developing problems. Unsurpassed analytical capabilities through automated diagnostics, plotting, and reporting help determine machinery health. Through AMS Suite, you can document, trend and communicate all details of machinery health.

Performance Monitoring

AMS Suite provides real-time performance calculations, allowing you to improve the efficiency of your critical machinery – turbines, compressors, boilers and other assets. By analyzing machinery performance, you can run your process more efficiently, track operating performance against targets, schedule maintenance activities, and determine the root cause of equipment inefficiencies. Equipped with health and performance diagnostics information and backed by a team of Emerson engineers, you can move from reactive to targeted predictive and proactive maintenance programs. AMS Suite helps you focus on the assets that impact your bottom line, bringing improved performance and restoring your peace of mind.
Extensive Equipment Damage and Production Shutdown Avoided

- Saved about $28,000 USD by avoiding a production shutdown
- Prevented bearing failure, avoiding further damage to plant equipment
- Reduced maintenance costs through Predictive Maintenance

“AMS Machinery Manager is an important tool in providing information about the condition of rotating equipment throughout this plant, enabling us to effectively reduce costs through predictive maintenance.”

-Ahmed M. Ibrahim
Predictive Maintenance Engineer, Arabian Cement Co.

www.EmersonProcess.com/Asset_Reliability_Results
Continuous Online Monitoring: Delivering Integrated Protection and Prediction on Critical Assets

Critical machinery problems can bring production to a halt. A combination of shutdown protection and prediction capabilities ensure your machinery will continue to perform within acceptable parameters.

Machinery Protection
Today’s plants require machinery protection systems for the most critical rotating machinery. The CSI 6500 Machinery Health™ Monitor meets API 670 and API 618 requirements and provides protection integrated with process automation systems. The modularity of design gives the CSI 6500 flexibility in retrofit applications for existing cabinets.

The CSI 6500 protection system provides vital shutdown protection to prevent catastrophic failure.
- Continuous online monitoring for machinery prediction and protection
- Compliant with API 670 and API 618 standard
- Easy integration with Emerson’s distributed control systems.

Prediction Monitoring
Visibility to machinery health before the protection system engages is considered the critical missing component of today’s machinery protection solutions. Operations and maintenance personnel are no longer looking for just a protection capability when replacing an outdated protection system. They are requiring a complete protection, prediction, and performance monitoring capability integrated with process automation.

By inserting prediction modules, the CSI 6500 Machinery Health Monitor provides machinery prediction and protection in a single integrated rack. The modular architecture easily facilitates integration to an existing protection system, AMS Suite, and process automation. The CSI 6500 delivers real-time feedback to both maintenance and operations, so plant personnel can make informed decisions well ahead of a shutdown.

With prediction, a machine can continue performing as long as it is within acceptable parameters. Repairs can be made when they are economically convenient.
- Automated, continuous, predictive machinery health monitoring
- PeakVue technology provides bearing fault detection
- Record, view and replay transient data during startup, shutdown and trips

Empowering Decisions
When real-time machinery health information moves throughout the enterprise through the Ovation® or DeltaV™ Distributed Control System (DCS) and AMS Suite predictive maintenance software, both operations and maintenance are empowered to make the right decisions based on valuable predictive intelligence.

Digital Overspeed Protection
For rotating equipment operating in overspeed conditions, protection is a critical issue for maintaining a safe operating environment. The CSI 6300 SIS Digital Overspeed Protection system complies with the latest version of industry safety standard DIN EN 61508:2010, in addition to European Machine Directive 2006/42/EG and the API 670 standard. The CSI 6300 SIS provides rotation direction detection as an additional SIL 2-rated safety function.
Costly Unplanned Pump Events At Flint Hills Refinery

- No significant unplanned environmental, health, and safety (EHS) events in route-monitored machinery in three years
- 18% increase in mean time between repairs (MTBR) on pumps
- 100% completion of vibration data collection on 1500 pumps
- Shorter response time when potential failures are identified

“We are definitely saving maintenance dollars as a result of the extended MTBR on rotating assets.”

- Michael Popelka, Reliability Engineer, Pine Bend Refinery, Flint Hills Resources

www.EmersonProcess.com/Asset_Reliability_Results
Vibration Analysis
In an environment where you cannot afford to constantly chase the next breakdown, you need to quickly and accurately identify developing faults and, ultimately, the underlying root cause of the machinery problem. Vibration analysis offers the most information about the condition of rotating machinery.

The CSI 2140 Machinery Health Analyzer simplifies the task of vibration analysis by monitoring virtually every machine in the plant. Onboard analysis for advanced troubleshooting is available at the push of a button, providing an instantaneous machinery health assessment.

- Unmatched data collection speed using simultaneous four-channel analysis
- Powerful in-field alerts and analysis for guided, machine-side testing and troubleshooting
- PeakVue technology for advanced bearing and gear fault detection

Alignment and Balancing
Alignment and balancing can extend the life of your rotating machinery. The CSI 8225 works as a dedicated tool for conducting laser alignment on machine trains before returning them to service.

The CSI 2140 balances machines in up to 4 planes and at multiple speeds, and can automatically detect and alert you to secondary structural faults that might complicate the balancing job. Unique laser heads include dual high-speed angle sensors that measure the exact rotational position of laser heads, reducing sweep time and providing an accurate alignment solution.

- User-friendly display for faster balance and alignment jobs
- Balance four planes and multiple speeds
- Alignment within one quarter turn of shaft rotation

Electric Motor Diagnostics
After bearing problems, the most common motor problem is electrical failure. Heat and fatigue, associated with excessive motor starts or overloading, can lead to broken rotor bars in electric motors.

The CSI 2140 non-intrusively collects current, flux, and temperature data while the motors remain online. This motor analysis technology can diagnose electrical problems, providing information on rotor-related electrical faults such as broken rotor bars, high-resistance joints and cracked rotor end rings.

- Early detection of rotor and stator faults
- Collect motor analysis data while the motor is online
- Trend motor condition over time to plan and prioritize maintenance action

Unattended, 24-Channel Portable Analysis
Some critical plant assets require more than the data collected as part of a route-based vibration analysis program. Turbomachinery and other complex machines may require temporary, but continuous monitoring across a machine or multiple machines.

The CSI 2600 Machinery Health Expert is a temporary continuous monitoring and analysis system. It records data for hours or weeks at a time, and makes use of the advanced PeakVue technology for rolling element bearings and gearboxes. Real-time transient events can be viewed and replayed for further analysis with animated machine and structure views for advanced diagnosis of the most difficult reoccurring machinery problems.

- Monitoring and troubleshooting for turbomachinery startup, coast down, and production state
- Record 100 hours of simultaneous, continuous time waveform across 24 channels
- Live oscilloscope and FFT analyzer
Turbine-driven pumps plagued by sudden thrust bearing failures leading to additional damage and substantial production losses.

Route-based vibration program quickly and accurately identifies developing faults.

PeakVue measurements identify impacting faults days before they are evident in overall vibration levels.

"Using the PeakVue technology, we saved a critical machine and avoided production downtime."

- Ali Al Siyabi, Inspection Manager, Oman India Fertilizer Company (OMIFCO)

Experience savings by employing predictive and proactive maintenance strategies.

www.EmersonProcess.com/Asset_Reliability_Results
Transmitters: Keeping You Connected to the Health of Your Machinery

*Careful monitoring of critical assets prevents lost profit from unplanned downtime.*

**Wired Vibration Transmitters**
To gain continuous access to vibration levels on your critical machinery, the CSI 9330 Vibration Transmitter interfaces with existing plant monitoring systems while automatically detecting vibration levels.

The CSI 9360 Vibration/Position Transmitter is a highly versatile, field-configurable device that delivers information necessary for the basic protection of compressor, pump and fan assets.

- Continuous monitoring of machinery
- Convert vibration data into a 4-20 mA signal
- Measure overall vibration and PeakVue or temperature with CSI 9330
- Configure CSI 9360 for any of three vibration ranges or a position measurement with selectable polarity

**Wireless Vibration Transmitter**
As part of Emerson’s Smart Wireless solution, the rugged CSI 9420 Wireless Vibration Transmitter connects quickly, easily, and economically to any machine. It delivers vibration information over a highly-reliable, self-organizing WirelessHART™ network for use by both operations and maintenance personnel.

- Measure vibration, temperature, and bearing wear with PeakVue
- Ideal for hard-to-reach and cost-prohibitive locations
- Measure vibration on any plant asset
- Rated intrinsically safe for use in virtually all plant areas

Oil and lubrication analysis often provide the earliest indication of machine degradation, while infrared thermography and ultrasonic testing provide critical pieces of the information puzzle. Each test complements the others, confirming potential diagnosis or eliminating suspected causes of failure. Integrating this information into a single database allows the user to make the most accurate and reliable decisions regarding the health of production assets.
Additional Solutions for Complete Machinery Health Management

Vibration analysis is the core technology for predictive maintenance, but additional technologies complete the picture of machinery health.

Lubrication Analysis
Oil and lubrication analysis are widely-accepted tools for determining the health of machinery. Testing all machinery lubricants in an offsite lab can be an untimely, inefficient, and potentially costly means for recognizing the benefits of oil and lubrication analysis. The ideal lubrication analysis program balances the benefits of onsite testing with follow-up by an sophisticated offsite lab for questionable samples.

- Accurate onsite analysis of oil health information
- Early indication of machine wear and fatigue
- Verifies correct oil usage by screening oil supplies

Infrared Thermography
Emerging faults are frequently accompanied by excessive heat or heat loss. Capturing the thermal images of these potential problems and analyzing them along side data from vibration and oil analysis allows users to move from a single IR image to a detailed report of machinery health.

- Diagnose anomalies in electrical systems
- Scan mechanical equipment for heat-related problems
- Detect hot spots
Emerson Technology Simplifies Machinery Analysis

Vibration data that is understood by both operations and maintenance leads to accurate decision making.

Impact Detection
Traditionally, vibration data has not been routed to the control room because it required specialized training—and frequently specialized tools—to extract information from the data. Emerson’s unique PeakVue technology cuts through the complexity of machinery analysis to provide a simple, reliable indication of equipment health via a single trend. PeakVue filters out traditional vibration signals to focus exclusively on impacting, a much better indicator of overall asset health on pumps, fans, motors or any other type of rolling element bearing machine.

Simple Interpretation
PeakVue readings are much easier to interpret. A healthy machine that is properly installed and well lubricated should not show signs of impacting. This establishes the zero principle: The PeakVue measurement on a healthy machine should be at or close to zero.

As common faults begin to appear on rotating equipment, the PeakVue reading typically can be evaluated using the Rule of 10’s:

<table>
<thead>
<tr>
<th>PeakVue Reading (g’s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
</tr>
<tr>
<td>30</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td>10</td>
</tr>
</tbody>
</table>

- Critical abnormal situation (Implement action plan)
- Serious abnormal situation (Develop action plan)
- Abnormal situation developing (Monitor more closely)

Bringing Reliability to the Control Room
Operators with no special training in machinery diagnostics can use PeakVue measurements quickly and easily to determine both when a piece of rotating equipment is healthy and when an abnormal situation is present. Once an abnormal situation has been identified, detailed diagnostic information can be extracted from the PeakVue waveform or spectrum to determine the exact nature of the defect. PeakVue can visualize distress signals on a machine that are simply not visible with other vibration measurements.

Emerson’s vibration analysis offerings – from continuous online to wireless to route-based monitoring – utilize PeakVue technology for the earliest indication of developing problems and minimize their potential impact on production.
Manual, periodic monitoring of olefins cracker pumps missed fast-developing faults.

Wireless vibration transmitters with PeakVue technology were installed to broadcast Machinery Health alerts to the distributed control system.

Since installation, PeakVue has identified faults in gearbox and rolling element bearings that could have resulted in equipment failure.

“Wireless monitoring has shown itself to be a valuable tool in our condition monitoring armory. Predicting failures in gearboxes of this type can make considerable savings on any subsequent turnaround and help to keep equipment available.”

- David Hambling, Instrument Electrical Technical Engineer
People make the Difference in a Successful Reliability Program

Expertise can have a huge impact on your technology investment.

Implementing a world class machinery health program is no easy matter. Whether you are adding to an existing program or building from the ground up, you need confidence in your partner and confidence in your team’s ability to work with and maintain the program. That’s where Emerson’s experts can ensure a strong start and the training and support required to sustain success.

Customer Support
Emerson’s team of experts is committed to helping you do YOUR job, day or night, wherever you are in the world. Whether you need calibration of your analyzer, help with software functionality, or hardware repair Emerson provides the expertise and assistance you need at the time you need it most! Customer support allows you to:

- Review technical notes and application papers via online database
- Download software and firmware from the web
- Access global call centers 24/5 for personal assistance

Training
Training can be critical at every stage of a machinery health program. New programs and new staff require basic skills, but even experienced personnel benefit from expanding their knowledge of more advanced monitoring and analysis concepts. Every year more than 1500 individuals participate in Emerson’s Education Services on machinery health topics.

- Classes are offered in Emerson training facilities, regional locations, or customized for on-site instruction
- Most courses offer hands-on opportunity in a lab environment to increase retention
- Certification testing ensures your people have the skills needed to comply with all requirements

Services
Emerson understands the requirements deliver start-up success and ensure long-term support. We are fully committed to supporting you through all of the installation steps and to keep your system running smoothly and reliably.

- Implement a structured approach to technology implementation, based on proven experience, to ensure your reliability program starts right and endures over the years.
- Assess the skill sets of your workforce and deliver training programs with an emphasis on implementing maintenance practices that take full advantage of new technologies.
Emerson’s Reliability Solutions include comprehensive protection, plant-wide prediction, and complete performance monitoring systems for your rotating equipment.

When you partner with Emerson, you achieve optimal health and performance while experiencing the value of a predictive environment:

- Prevent catastrophic failures and unplanned shutdowns
- Meet production targets
- Diagnose the root cause of performance degradation
- Reduce maintenance and repair costs
- Reduce inventory and overtime
- Achieve predictive or proactive maintenance

Emerson is your single source for reliability technologies and services. Since the introduction of our first portable vibration analyzer in 1986, Emerson has led the market in the development of advanced vibration technologies. With an annual investment in machinery health research and development that exceeds the sales revenue of many reliability suppliers, Emerson continues to lead the industry in the release of new products for monitoring the health and performance of your mechanical equipment.

With Emerson, you have the complete portfolio of machinery health management technologies, software and services ensuring your mechanical equipment is maintained correctly for optimal health and performance.

**Realize the true potential of your plant.**
**Emerson Process Management – Reliability Solutions**

<table>
<thead>
<tr>
<th>North America</th>
<th>South America</th>
<th>Europe</th>
<th>Asia/Australia</th>
<th>Middle East/Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>835 Innovation Drive</td>
<td>Av. del Valle</td>
<td>Blegistrasse 21</td>
<td>1 Pandan Crescent</td>
<td>PO Box 17033</td>
</tr>
<tr>
<td>Knoxville, TN 37932</td>
<td>601, 4to piso,</td>
<td>6341 Baar,</td>
<td>Singapore 128461</td>
<td>Dubai - United Arab</td>
</tr>
<tr>
<td>USA</td>
<td>Ciudad</td>
<td>Switzerland</td>
<td>65 6777 8211</td>
<td>Emirates</td>
</tr>
<tr>
<td>T 1(865) 675-2400</td>
<td>Empresarial,</td>
<td>T 41 41 768 61 11</td>
<td>T 65 6777 0947</td>
<td>T 971 4 883 5235</td>
</tr>
<tr>
<td></td>
<td>Santiago</td>
<td></td>
<td></td>
<td>F 971 4 883 5312</td>
</tr>
<tr>
<td></td>
<td>Chile</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>T +56 (2) 4310-7432</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

www.emersonprocess.com/csi


The contents of this publication are presented for informational purposes only, and while every effort has been made to ensure their accuracy, they are not to be construed as warranties or guarantees, express or implied, regarding the products or services described herein or their use or applicability. All sales are governed by our terms and conditions, which are available on request. We reserve the right to modify or improve the designs or specifications of our products at any time without notice.

All rights reserved. AMS, PlantWeb, DeltaV, Ovation, Machinery Health, and PeakVue are marks of one of the Emerson Process Management group of companies. The Emerson logo is a trademark and service mark of Emerson Electric Co. All other marks are the property of their respective owners.

Turn to Emerson as your asset reliability partner to achieve your operational goals through increased availability and maximized performance of your mechanical equipment.