

**Reduce outages and derates to improve your plant's availability.**

## **Deliver on Grid Demands**

Integrated monitoring technologies improve reliability to help deliver power on demand.





# Meeting Your Commitments in a Changing Environment

Your power generation facilities were designed to deliver consistent load profiles and handle routine peaks in demand. But the increased demand for renewable energy and the availability of inexpensive natural gas have forced a change in the way you operate. Ensuring a constant grid supply means increased cycling, which can lead to increased unit heat rates and unplanned shutdowns. Your equipment, budgets, and plant personnel are increasingly challenged to meet your commitment to deliver grid demand.

## Improve Equipment Availability

If your equipment isn't reliable, you cannot count on it to be available. And when equipment isn't available, the losses add up quickly.

Routine maintenance can help — but, it simply isn't good enough to ensure availability. Routine maintenance does not reveal the emerging health issues in your critical assets that can result in unit shutdowns or slowdowns. It does not take into account the operating history of the asset or the risk of introducing an issue while performing routine maintenance. To keep equipment available and producing revenue, you need solutions that identify the assets at risk of failure.

## Lower Operations & Maintenance (O&M) Costs

Stress on your equipment from cycling and meeting your demand loads means additional stress on your O&M costs.

Generally speaking, it costs more to repair a piece of equipment after failure than to repair or replace components prior to failure – assuming the equipment can be repaired at all. You simply cannot afford to operate that way.

## Supplement Resources & Expertise

Supplying power during peak demand often means providing O&M services in an efficient and timely manner. But workforce turnover diminishes the tribal knowledge your team has of the plant assets and processes. And their unseasoned replacements don't come with the years of experience necessary to make critical decisions. How do you maintain expertise under these conditions?

## Rely on Single Source Accountability

You need one place to turn to for the technology and expertise to resolve today's biggest challenges. Emerson offers solutions that integrate with your existing operations to help you meet today's power demands and achieve your business goals.



*Reliability, as defined by MIL-STD-721C, "Is the probability that an item will perform its intended function for a specific interval under stated conditions."*

- Military Standard: Definitions Of Terms For Reliability And Maintainability (12 Jun 1981)

**50% MORE REPAIR COSTS**  
It costs approximately 50% more to repair a failed asset than if the problem had been addressed prior to failure.

- U.S. National Response Center

**up to \$1M in costs**

One forced outage can cost up to \$1M in lost generation and increased maintenance costs.

- Reported in NERC Generating Availability Data System (GADS), 2007-2013

**O&M 60-80% of the total life cycle costs**

Operations and Maintenance costs are between 60-80% of the total life cycle costs for a given asset.

- Maintenance & Reliability Best Practices by Ramesh Gulati, 2012





## Predictive Maintenance Technologies Improve Reliability to Increase Availability

When you are constantly reacting to unexpected equipment failures, adding predictive technologies to your maintenance program is a game-changer. By uncovering developing faults well in advance of equipment failure, you'll begin scheduling the maintenance activities that lead to more reliable operations and minimize the risk of catastrophic events. Emerson offers solutions that deliver prediction and protection for all your assets – from turbines and boilers to feed pumps and fans.

### Vibration analysis — the cornerstone of predictive intelligence

Vibration analysis is accepted as an industry standard for gaining insight into potential equipment problems. Emerson's comprehensive line of vibration analysis solutions offers powerful predictive diagnostic capabilities best suited for the application:

- Online, continuous monitoring systems with both prediction and protection capabilities for 24/7 coverage of your most critical assets.
- Wireless transmitters for collecting and communicating data from hazardous or remote locations.
- Portable, route-based analyzers for monitoring the balance of plant assets and performing advanced testing as needed.

### A complete picture of asset health

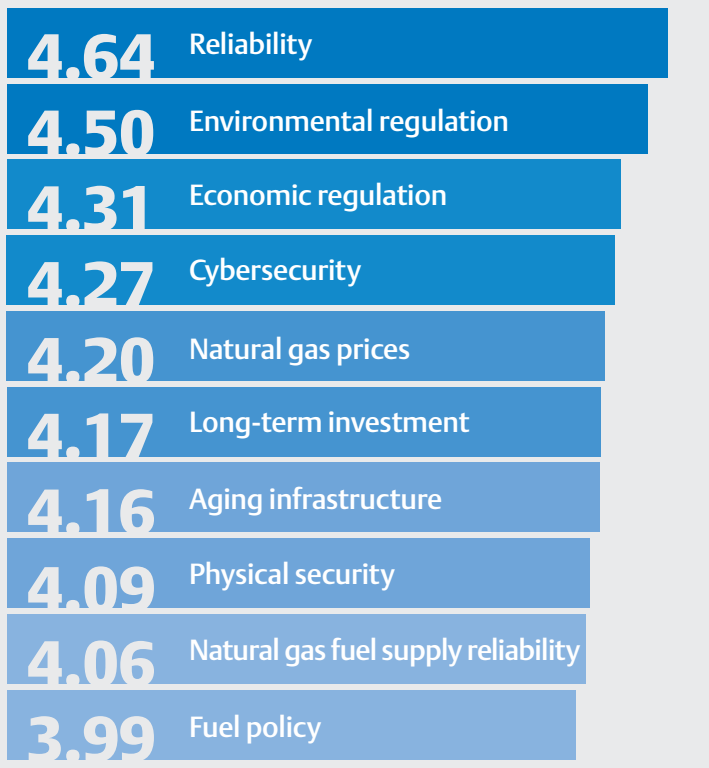
To truly understand what is going on with your machinery, you need a comprehensive view of asset health across your fleet. Emerson's AMS Suite software integrates data from all your monitored assets alongside other critical information, such as oil analysis and thermographic data, for the most comprehensive view of equipment health. Advanced tools in AMS Suite help you interpret data into machinery diagnostics that lead to addressing root-cause problems. Information is accessible to both operations and maintenance creating the best decision-making environment for operating your fleet.

### Early warnings for scheduled maintenance

To avoid unscheduled downtime or slowdowns, you need advanced warning of developing problems. Emerson uses a unique signal process methodology — PeakVue™ technology — that offers significantly earlier warning of issues in rolling element bearings and gearboxes over traditional vibration analysis. When monitoring gas, steam, or hydro turbines, Emerson's online and portable vibration technologies capture critical transient data during the startup and coast down events to identify developing faults and determine if the turbine is in a safe state to operate.

## Top 10 Industry Issues

Respondents were asked to rate on a scale of 1 to 5 (where 1 indicates "Very Unimportant" and 5 indicates "Very Important") the importance of a variety of issues to the electric industry. This chart represents the mean rating for each issue among utility respondents.



- Black & Veatch, 2014 Strategic Directions: U.S. Electric Industry.

**Operational Savings 5-10x**

A top reliability program delivers operational savings 5-10 times over maintenance savings.

- Reported by Emerson's Reliability Consulting based on multi-industry study of Best Practices

**80-90% vibration applied to important rotating machinery assets**

Top quartile companies in reliability excellence have vibration applied on 80-90% of their important rotating machinery assets.

- Reported by Emerson's Reliability Consulting based on multi-industry study of Best Practices

*With Emerson, you can implement a predictive maintenance strategy that opens a window to your equipment's performance. You'll make better operating decisions that deliver a more reliable operation.*



# Predictive Maintenance Lowers Your O&M Costs

Varying loads and unexpected peaks in demand takes its toll on your equipment. And fixing the same problems on the same machines time and again can put significant stress on your O&M budget.

Like other best-in-class facilities, you need to invest in proven technologies that focus your resources on the right equipment at the right time and fix the root cause of the problem. Emerson offers the services and solutions that curtail unnecessary costs and reduce your spares inventory.

## Planned Maintenance Reduces Costs

Improving reliability starts with a detailed plan for your overall program. Emerson's Reliability Consulting team works with you to review your existing program and identify areas for improvement, including:

- Master data quality
- Maintenance procedures
- Asset criticality
- Technology implementation
- Planning, scheduling, and work execution
- Supply chain management

With a detailed integrated reliability plan in place, you'll recognize cost savings you can implement with consistency across the fleet.

## Integrate Technologies for Better Decisions

When operators can see the impact of changing loads on equipment health, they can make informed decisions to avoid unplanned shutdowns. Emerson's CSI 6500 Machinery Health Monitor delivers online, continuous monitoring of the most critical power generation assets integrated with the existing digital control system (DCS).

Emerson's Ovation users can take advantage of a consolidated solution with the new Ovation Machinery Health Monitor by simply plugging the module directly into the I/O branch, users can take advantage of machinery health information within their existing system.

## When is it Safe to Ramp Up the Turbine?

Component problems in the turbine don't only occur over time – they can be introduced during routine maintenance or repairs. When the pressure is on to restart the turbine quickly, you need the right data in real-time to know it is safe to ramp up the turbine and avoid a turbine wreck. Emerson's advanced transient analysis capability captures critical information during routine startups and coastdowns to document a safe operating state. The data replay functionality allows you to compare recorded data during subsequent startups with real-time data to determine if it is safe to resume operations.

## Monitoring More Equipment Saves More Money

Many facilities understand the value of monitoring the critical equipment in the plant, but ignore those essential assets that can also impact production. When you introduce prediction to both the critical equipment and the balance of your plant, you create the best opportunity for O&M cost savings through scheduled maintenance and reduced on-hand inventories.



savings opportunities exceeding **30%-40%**

A properly functioning predictive maintenance program can provide a savings of 8% to 12% over a program utilizing preventive maintenance alone. Depending on a facility's reliance on reactive maintenance and material condition, it could easily recognize savings opportunities exceeding 30% to 40%.

Average savings for power generation facilities initiating a predictive maintenance program:




- Return on investment: **10x**
- Reduction in maintenance costs: **25%-30%**
- Elimination of breakdowns: **70%-75%**
- Reduction in downtime: **35%-45%**
- Increase in production: **20%-25%**

- U.S. Department of Energy's O&M Best Practice Guide, 2010.

*Working with Emerson, you can integrate proven advanced technologies into your operating practice to reduce O&M costs through scheduled, cost-effective maintenance activities.*



|                   | Assets & Components                                                                                                           | Root Causes                                                                                                                                           | Reliability Solutions                                               |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|
| Boiler (HRSG)     | Feedwater pump                                                                                                                | Bearing failures, misalignment, bowing, imbalance, rubs, oil availability or instabilities                                                            | Online Machinery Prediction & Protection                            |
|                   | Turbine Overspeed                                                                                                             | Grid failures and sudden load throwoff                                                                                                                | Digital OverSpeed Protection (SIL 3)                                |
| Turbine/Generator | Turbines                                                                                                                      | Bearing failures, misalignment, bowing, imbalance, rubs, oil availability or instabilities, transient events during startup/shutdowns/changes in load | Online Machinery Prediction & Protection                            |
|                   | Circulating Water System including: cooling tower fans, cooling tower water pumps, traveling screens, water circulating pumps | Bearing loads, abrasive conditions, lubrication contamination, misalignment, imbalance, cavitation, broken gear teeth                                 | Online Machinery Prediction: optional Wireless Machinery Prediction |
| Balance of Plant  | Compressed Air Systems including: compressors and drive motors                                                                | Bearing loads, corrosive conditions, lubrication contamination, misalignment, imbalance, broken gear                                                  |                                                                     |
|                   | Fuel Gas Compressors                                                                                                          | Bearing loads, corrosive conditions, lubrication contamination, misalignment, imbalance                                                               |                                                                     |
|                   | Fans                                                                                                                          | Bearing loads, abrasive conditions, lubrication contamination, misalignment, imbalance                                                                | Wireless or Portable Machinery Prediction                           |
|                   | Pumps                                                                                                                         | Bearing loads, abrasive conditions, lubrication contamination, misalignment, imbalance, cavitation                                                    |                                                                     |
|                   | Gearboxes                                                                                                                     | Bearing loads loads, abrasive conditions, lubrication contamination, misalignment, imbalance, broken gear teeth                                       |                                                                     |
|                   |                                                                                                                               |                                                                                                                                                       |                                                                     |

| Monitoring Technologies                                                             |                                   |
|-------------------------------------------------------------------------------------|-----------------------------------|
|  | PdM Prediction                    |
|  | API 670 Protection                |
|  | SIL3 Digital Overspeed Protection |

# Improving Reliability of the Most Important Rotating Assets in Your Plant

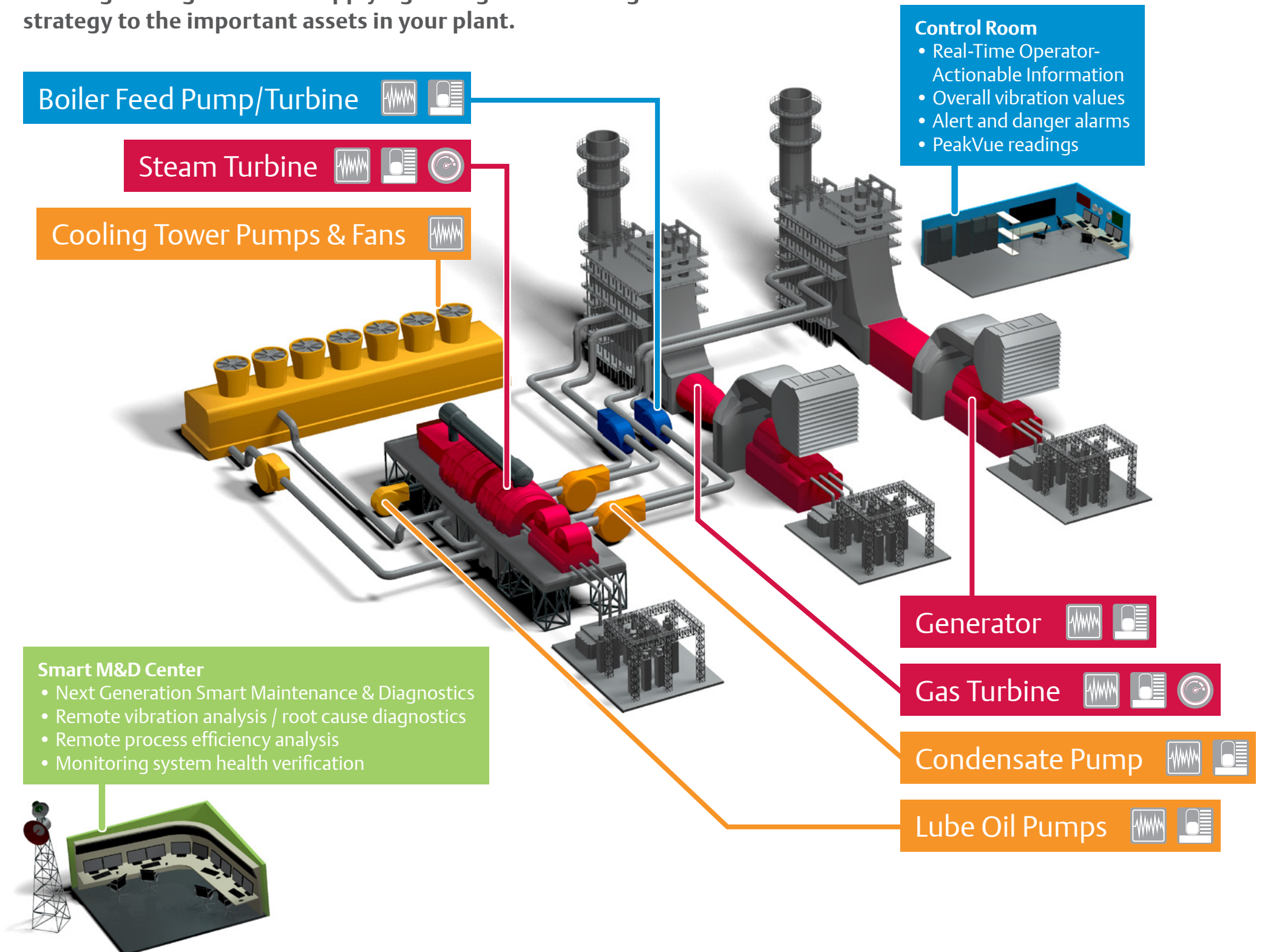
Achieving top-quartile reliability means:

>97% availability

<1% unplanned downtime

>95% of faults detected prior to failure

Meeting these goals means applying the right monitoring strategy to the important assets in your plant.







# Prediction and Protection for Your Turbines

*Emerson offers condition monitoring solutions that enable plant personnel to make informed decisions well ahead of a shutdown or slowdown.*

While the shutdown of many kinds of assets in your facility can halt plant output, few are as complex or as expensive as the turbine. Whether your operation centers on gas, steam, hydro, or combined-cycle, your maintenance priority and the asset you count on most for reliability is the turbine. For this critical asset, operations and maintenance personnel require a complete system – predictive intelligence plus protection capabilities that integrates with the distributed control system – to maximize reliability.

## Predictive Information Empowers Operating Decisions

With the predictive power of a CSI 6500 Machinery Health Monitor, you have real-time insight across the entire turbine train when performance deviates from expected, acceptable parameters. Advanced transient analysis capabilities allow you to record, view and replay data from startup, shutdown, and trip windows to ensure safe operations and avoid catastrophic failures.

## Protection You can Count On

The CSI 6500 delivers API 670- and API 618-compliant protection that is ideal for retrofit applications on existing cabinets. The CSI 6500 offers an easy integration process that links the system to the existing DCS. When the operator brings a machine online, machinery health information and PeakVue measurements are fed directly to operators so they can see the effects of their action on machines driving the process. Information is delivered across the enterprise via AMS Machinery Manager software.

Where overspeed is a concern, Emerson’s CSI 6300 SIS Digital Overspeed Protection System guards against conditions caused by unexpected changes or load losses. The CSI 6300 SIS is TUV-certified for SIL 3 and complies with the latest versions of industry safety standards.

## Machinery Health Information Now Native Within Ovation

Emerson’s new Ovation Machinery Health Monitor module plugs directly into the Ovation DCS, embedding the system with the same API 670- and API 618-compliant protection as offered in the CSI 6500 rack-mounted solution.



CSI 6500 Machinery Health Monitor



CSI 6300 SIS Digital Overspeed Protection System



Ovation Machinery Health Monitor



## Machinery Health Delivered by AMS Suite

|                                                  |                                                                                                                                                                                                                                   |
|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Key Performance Indicators (KPIs)                | Dashboard display with real-time indicators of condition, with parameters based on the severity of an alarm.                                                                                                                      |
| Advanced Analysis Displays                       | Advanced analysis functionality includes shaft centerline and orbit plots, cascade and waterfall plots, Bode/Nyquist plots, efficiency and deviation from design graphs, polar graphs, and waveform and full spectrum data plots. |
| Transient Live Display                           | Record data simultaneously for all channels, 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 early identification of gearboxes and rolling element bearing problems.                                                                                        |
| Integration of 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 machinery health.                                                  |





## Maintain Reliability Across the Balance of Your Plant (BOP)

There are a large number of assets in your facility that can impact capacity – fans, pumps, and motors to name a few. These BOP assets are essential to meeting your business goals and require the same field-proven monitoring technologies as your turbines. Emerson’s wireless and route-based solutions are the perfect balance of quality monitoring with cost-effective implementation for these applications.



Route-based monitoring covers the largest number of assets. Emerson’s CSI 2140 Machinery Health Analyzer features four-channels plus phase monitoring for advanced vibration analysis, cross-channel and transient analysis, dynamic balancing, and motor monitoring. The CSI 2140 delivers many of the same sophisticated diagnostic capabilities as the CSI 6500 without permanent, hard-wired mounting of sensors. Data is collected on a periodic basis, and advanced testing using embedded intelligence is performed to isolate and correct equipment problems.



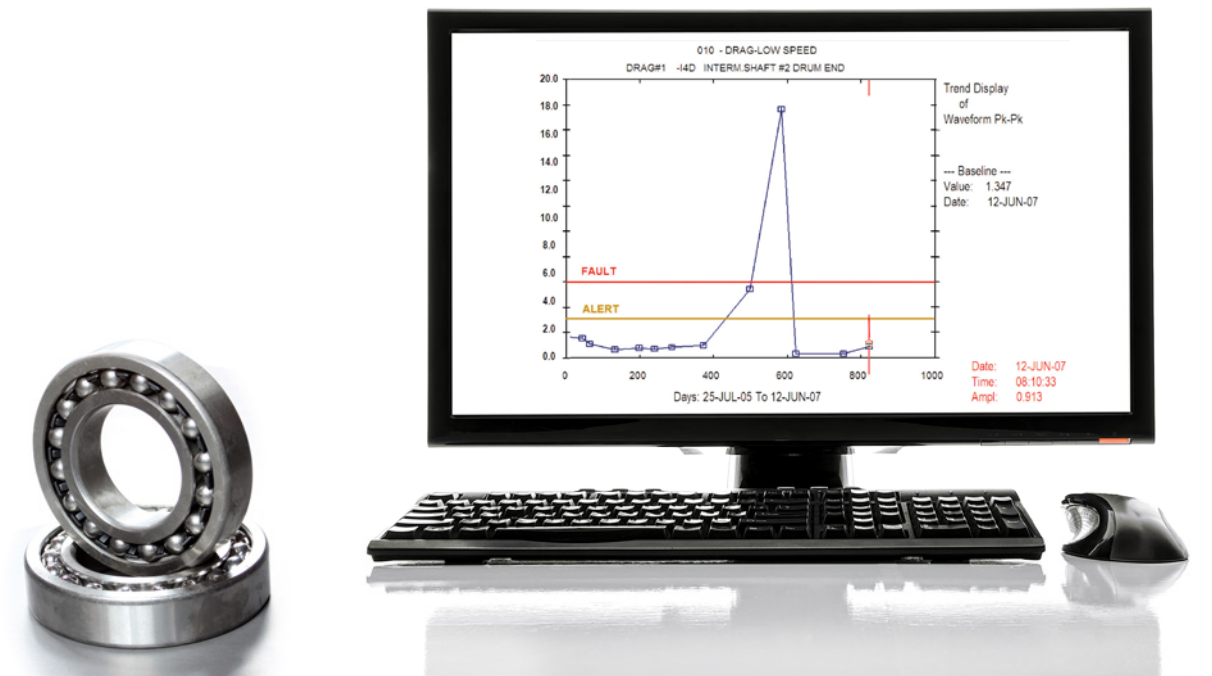
Wireless monitoring addresses both safety and cost concerns. The CSI 9420 Wireless Vibration Transmitter continually monitors vibration and delivers data and device alerts to extend your predictive intelligence to hazardous and remote locations. With fewer wires and reduced time/cost to install, the CSI 9420 is a cost-efficient means for data collection throughout the plant. The CSI 9420 is just one of many Emerson Smart Wireless solutions.



Emerson offers a scalable solution for expanding protection to your non-critical assets. Emerson’s CSI 3000 Machinery Health Monitor is a field-mounted, dual-channel solution for a variety of machines, including turbo compressors/pumps, centrifuges, blowers, generators and gearboxes.



Emerson’s sensor technologies support the entire measurement chain. With a comprehensive line of sensors for all your measurement needs, Emerson is your single source for collecting and communicating vibration data from critical and essential assets in the plant.



### PeakVue™ Technology: Focus on Impacting for Better Results

*Traditionally, vibration data has not been routed to the control room because it required specialized training – and frequently specialized tools – to extract any 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 gearbox or rolling element bearing machine.*

*PeakVue measurements are easy to interpret and are based on a concept called The Rule of 10’s. A properly installed and well lubricated machinery should not be impacting, therefore the measurement would be at or close to zero. As a problem develops, the PeakVue measurement will climb to 10g. A measurement of 20g indicates a serious problem in the bearing, even though overall vibration levels may not indicate the same. When the measurement exceeds 50g, failure is imminent.*

### More Insight Using One Software Application

Emerson’s AMS Machinery Manager predictive intelligence software delivers power diagnostics capabilities to help improve the availability and performance of your key production assets. Data integrated from a variety of collection technologies – including specialized third-party applications – creates an insightful, comprehensive view of machinery health. Alarm and reporting functionality delivers the right data to the right team – plant management, operations, or maintenance and reliability.

## Technology Alone Cannot Replace Experience

No one knows your production assets better than the team that works with them every day. When they retire or move to other positions, what happens to that tribal knowledge? By partnering with Emerson, you'll tap into resources experienced in building expertise within your team.

### Success through Training & Mentoring

Implementing technology is just part of improving availability in your facility. Your success depends on growing the expertise of your staff at an accelerated pace. Emerson's Reliability Consulting experts mentor your team while developing a detailed plan for your reliability program. Emerson's Educational Services addresses training gaps with offsite, onsite, and online courses, facilitated by certified subject matter experts and instructors.

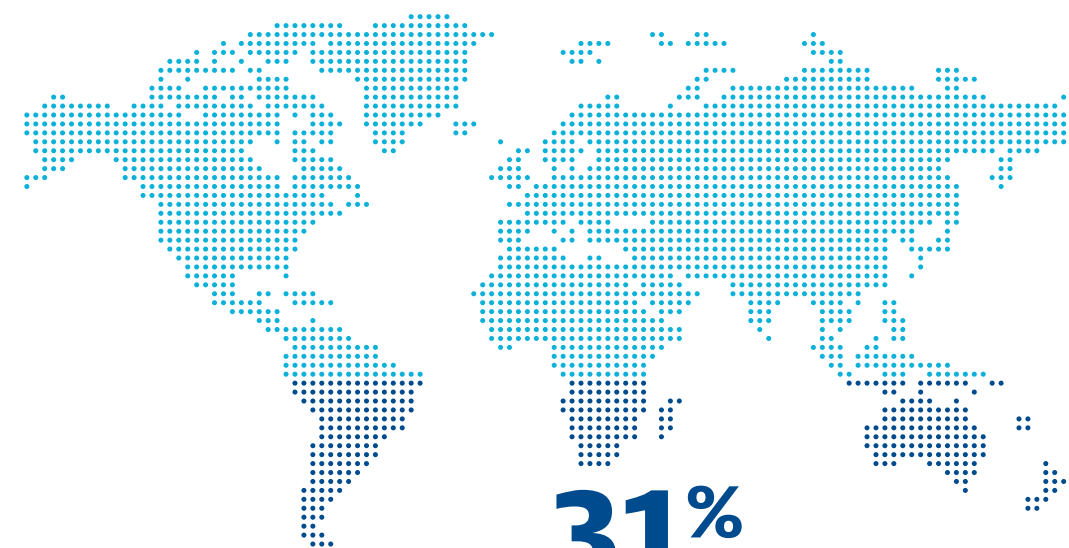
### Embedded Expertise Available 24/7

Automation and diagnostic technology built directly into monitoring equipment simplifies complex tasks and leads to faster, accurate analysis of developing problems. For example, embedded intelligence in the CSI 2140 allows even novice users to conduct sophisticated troubleshooting tests with the touch of a button. Advanced tests that are performed infrequently can be handled with the same ease and efficiency as often-repeated tasks.

### Remote Experts that Work for You

When there simply aren't enough man hours or expertise available, supplement your workforce with experienced consultants who perform a wide range of tasks, from standard data analysis and reporting to troubleshooting your most complex machinery problems. When you work with Emerson, you have the right people, technology, and expertise to fortify your team. You'll build expertise into your plant processes and operate more smoothly by utilizing specialized experts to augment your in-house staff. Emerson can help establish first-rate training programs for the up-and-coming members of your workforce to ensure qualified in-house resources.

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**31%** of employers cannot fill positions

An estimated 31% of employers worldwide find it difficult to fill positions because of talent shortages in their markets.

- Six Global Trends Shaping the World; Ernst & Young, <http://www.ey.com/GL/en/Issues/Business-environment/Six-global-trends-shaping-the-business-world---Demographic-shifts-transform-the-global-workforce>

### Reliability Consulting Starts And Keeps You On The Right Path

Emerson's Reliability Consulting team applies proven methodologies, tools, libraries and best practices from a wide range of industries to help launch or improve an existing reliability program that delivers on your business objectives. Working as both a business advisor and an implementation service, Reliability Consulting delivers performance improvement efficiently across your power generation assets.

### Lifecycle Services Keep You Successful

Emerson stands behind your investment in predictive technologies to ensure your reliability program is successful today and in the years ahead. Through technology support agreements, Emerson delivers on-going support such as software updates, repairs, and access to a wealth of technical information and expert support staff dedicated to assisting you in optimizing your technologies.





## Emerson – Your Partner for Reliability

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

Turn to Emerson to:

- Increase availability, decrease unplanned shutdowns and prevent catastrophic failures
- Reduce operating and maintenance costs, inventory and overtime
- Diagnose the root cause of performance degradation
- Enhance your workforce expertise

Emerson Process Management is the automation innovator to take on your toughest challenges and bring predictable success anytime, anywhere.

To view the entire Lifecycle service portfolio, visit:  
[emersonprocess.com/lifecycleservices\\_machineryhealth](http://emersonprocess.com/lifecycleservices_machineryhealth).

Learn more about Emerson's Educational Services offerings at  
[www.emersonprocess.com/education](http://www.emersonprocess.com/education).

### Emerson Process Management Reliability Solutions

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