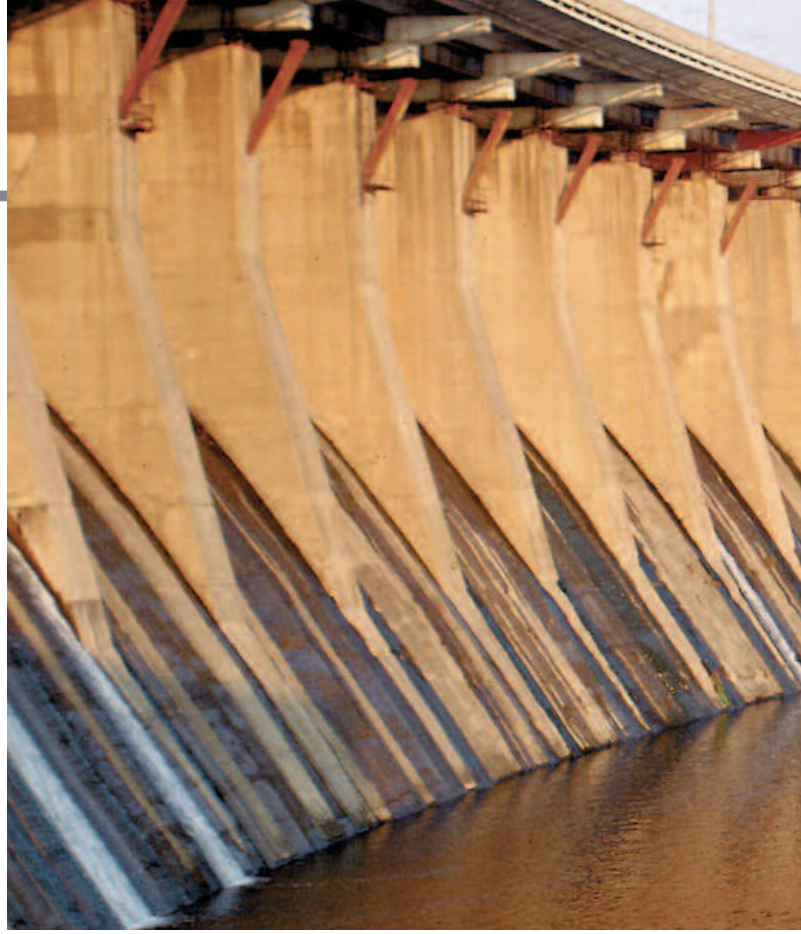
Online Hydro Machinery Monitoring

Protection, Prediction and Performance Monitoring Solutions

EMERSON.
Process Management



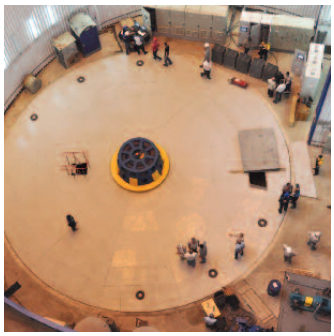
As hydro turbine health degrades, performance decreases, generation declines, and unplanned shutdowns are possible. Safely operating this machinery requires special load considerations and monitoring equipment designed for its unique needs.

ENSURE YOUR HYDRO MACHINERY ISN'T PUTTING YOUR OPERATIONAL GOALS AT RISK

Operating hydro turbine machinery at different loads can be challenging. At partial load, the unit is running far from its optimal efficiency and can experience a rough load zone and troublesome cavitations. At continuous load, possible mechanical stresses should be considered. With either load, stress on the machinery can cause fatigue that leads to further damage and degradation of the machine's health. Without feedback on hydro machinery health, production in rough load zones may be unnecessarily prolonged.

Because hydro electric turbines operate at low speeds, with faults appearing as low as 0.5 hz, analysing the health of the unit requires special monitoring hardware capable of detecting these extremely low frequencies.

Detecting underlying problems early and integrating machinery health data to process control allows you to correct issues before they affect your production. Emerson's best-in-class technologies and services allow proactive maintenance to prevent turbine damage and maintain safety and environmental standards.



Emerson addresses even the most complex hydro applications with a comprehensive portfolio of permanently installed and portable condition monitoring technology. With continuous online monitoring for protection, prediction, and performance indicators, portable analyzers and advanced asset management capabilities, Emerson will help you maintain and extend the life of your hydro turbine machinery.

Hydro Turbine / Generator failures that can be detected early with predictive diagnostics

- Imbalance
- Misalignment and coupling
- Cracked or chipped blades and shaft
- Inadequate lubrication of mechanical parts
- Cavitation erosion on the impellers
- Breakage of wicket gate linkage
- Rotor rub
- Rotor bow
- Hydraulically-induced vibration and imbalance
- Damaged stator isolation

TURN TO CONTINUOUS ONLINE PROTECTION, PREDICTION, AND PERFORMANCE MONITORING

Whether your challenge is detecting an underlying mechanical problem that could affect power generation, planning an effective maintenance strategy, or preventing an unplanned shutdown, Emerson provides the solution.

Any problem that interrupts power generation can be the difference between profit and loss. When the stakes are high, you need to be equipped to react to issues that relate to the heart of producing electricity — hydroelectric turbine machinery. You need to be confident that any mechanical issue will be detected early so you can monitor and plan accordingly.

Emerson makes your decision-making easier with the CSI 6500 Machinery Health™ Monitor, part of the PlantWeb® digital plant architecture. Including a wide range of specialized sensors, the CSI 6500 is designed for hydro turbine and generator units. Together with AMS Suite predictive maintenance software and backed by configuration, installation, and support services, Emerson provides the ideal solution for monitoring different designs of hydro turbines, including Kaplan, Pelton, Francis and Bulb.

Protection Monitoring

The CSI 6500 delivers protection monitoring vital to preventing a catastrophic failure. As a single protection-only configuration or incorporating prediction and performance monitoring, the CSI 6500 helps prevent trips by using module self-health checking and instrument health monitoring with easy integration to the Ovation™ expert control system.

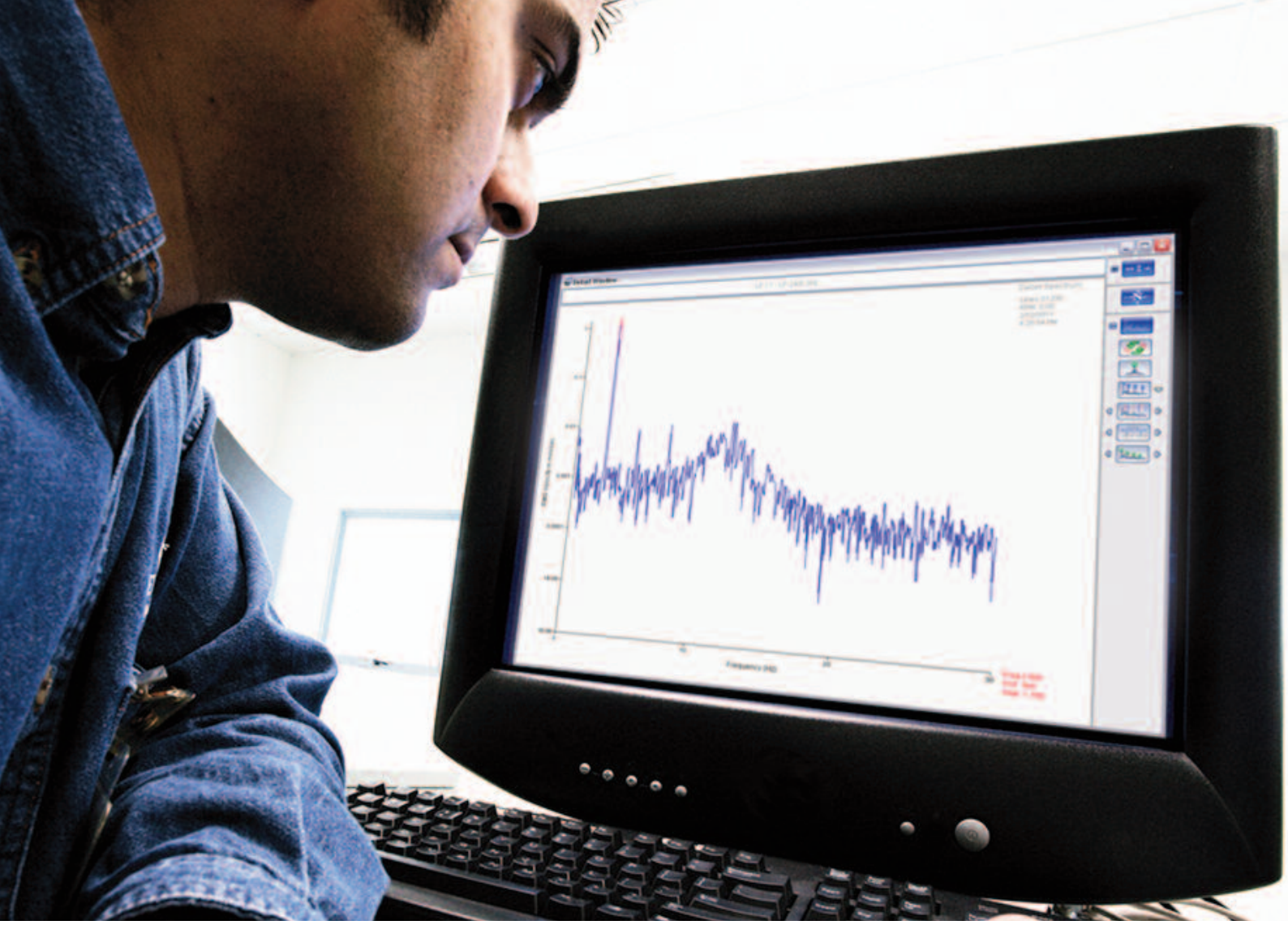
In addition, the CSI 6300 SIS Overspeed Protection System protects against severe overspeed events. The overspeed protection system is SIL 3 rated according to the IEC 61508 version 2010.

Predictive Monitoring

Incorporating predictive monitoring in the CSI 6500 ensures you will have visibility to deterioration in hydro machinery health before the protection component is needed. Enabling predictive monitoring provides real-time information to maintenance departments, ensuring you are forewarned of major issues. With predictive diagnostics, you can decide if the unit can continue to operate within acceptable parameters until the next scheduled outage or if you need to shut down to prevent further equipment damage.

Performance Monitoring

Inefficient operation of the hydro turbine is attributed to deteriorating performance. Performance monitoring provides the information necessary to help achieve and maintain optimum efficiency. Through thermodynamic performance analysis, you can track performance against original design, or target, and determine the root cause of inefficiencies, so maintenance can be planned.



Sensors

Specialised sensors include dynamic AC displacement, DC position, air gap, or partial discharge measurement capabilities based on machine size and rotating speed. Vibration measurements include low frequency sensors, with built-in signal filtering and conditioning that are important for monitoring low speed hydro machinery.

Sensors for online Hydro monitoring are connected to the CSI 6500 system, equipped with cards configured for protection and predictive monitoring.

The CSI 6300 SIS Overspeed Protection System and its connected sensors work as an independent system to ensure the highest level of protection and availability for the turbine.

Pressure and flow field devices are used for performance monitoring through the control system or data historian. Emerson's extensive portfolio of field instrumentation provides an excellent complement to the CSI 6500 monitoring solution.

Additional wireless measurement points can be easily implemented without costly installation or cabling challenges.

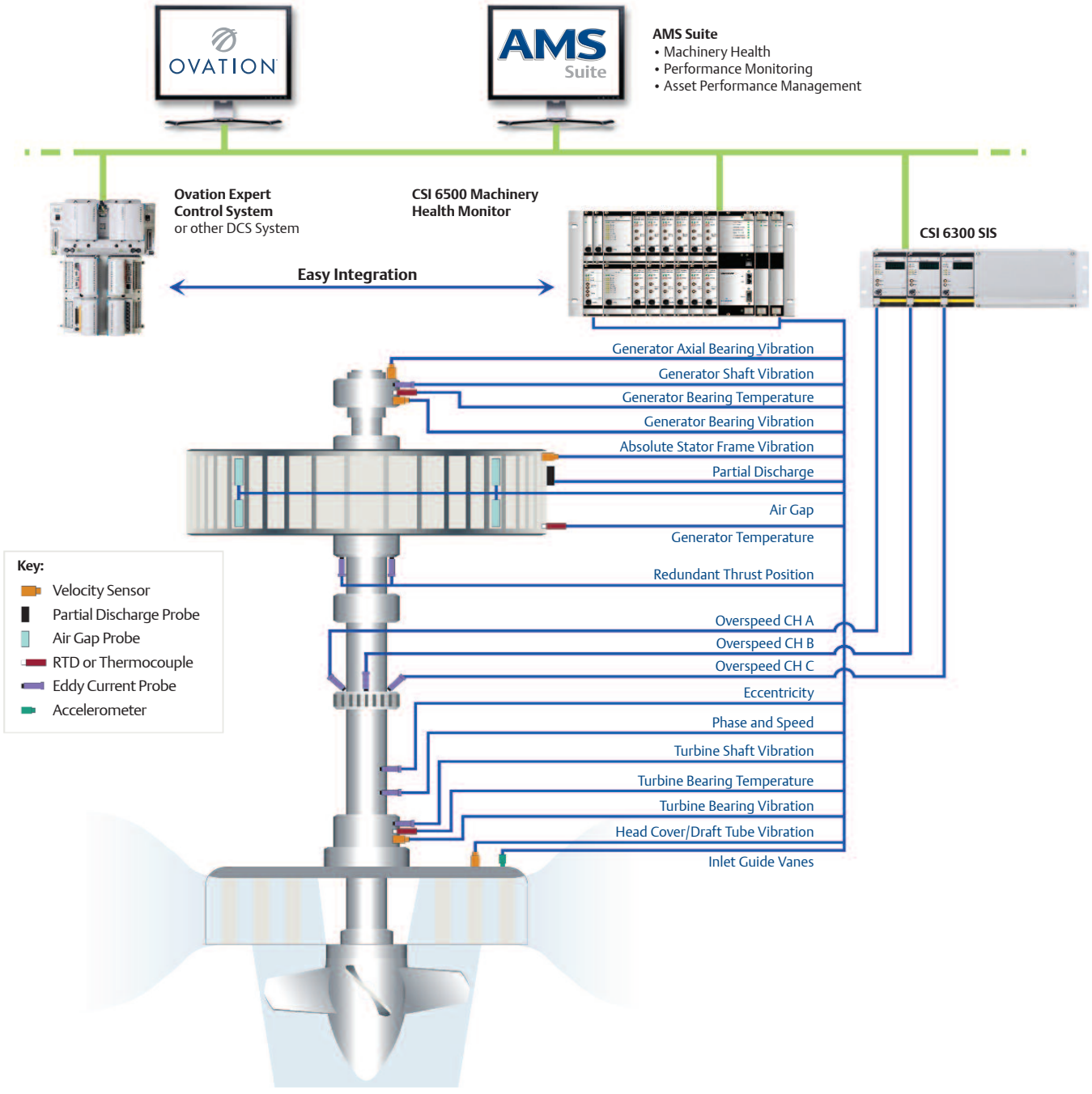
Process Control Integration

As a key element of plant operation, the CSI 6500 can be integrated with the hydro plant's control system. Integrating the CSI 6500 with systems like Emerson's Ovation™ expert control system gives operators visibility to real-time vibration information. Operators can make adjustments based on hydro machinery condition to reduce production disruption.

CONNECTING YOUR HYDRO TURBINE AND GENERATOR

Emerson's CSI 6500 is designed to work with a variety of sensors that are mounted on the stator, rotor, turbine section, and shaft.

Existing sensors can be used as well as those from Emerson and other third party vendors to provide flexibility in selecting those that meet your requirements. All diagnostic data is accessible in AMS Suite for analysis and troubleshooting.

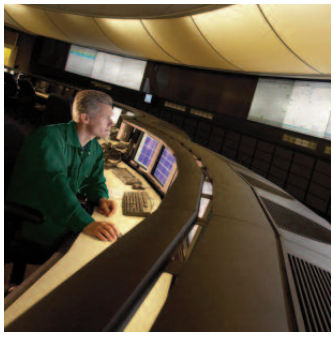


DIAGNOSTIC MEASUREMENT SENSORS GUIDE

Measurement	CSI 6500 Module Card	Sensor Type	Monitoring Benefit
Generator/Turbine Radial Bearing Vibration and Generator Axial Bearing Vibration	A6150 and/or A6510-T	Low Frequency Velocity Sensor	Generator and turbine bearings can experience high vibration related to bearing condition and machine load. In addition, issues with insufficient support stiffness or rotor imbalance can be detected.
Generator/Turbine Shaft Vibration	A6151 and/or A6510-T	Eddy Current Probes	Generator and turbine shaft vibration monitoring complements bearing vibration monitoring by detecting radial loads, imbalance (mechanical, hydraulic, etc.), and bearing fatigue.
Generator/Turbine Bearing Temperature	A6630 and/or A6510-T	Resistance Temperature Detector or Thermocouple	Bearing vibrations are frequently caused due to wear. In sleeve bearings where bearings can have metal to metal contact, temperature readings will help detect rotor rub vibration.
Absolute Stator Frame Vibration	A6150 and/or A6510-T	Low Frequency Velocity Sensor	Stator frame movement is usually caused by a loose stator segment. Stator vibration can also be caused by an uneven air gap. The movement of the stator frame relative to the windings can cause excessive wear and damage to the winding insulation.
Partial Discharge	A6620 and/or A6510-T	PD Probe	Small imperfections in the stator insulation cause small sparks (partial discharge). If the sparks become larger, serious equipment damage can occur.
Air Gap	A6620 and/or A6510-T	Flat Mounted Probe	Monitoring the air gap distance between the rotor and stator provides an indication of the rotor position and shape to detect problems such as vibration, magnetic imbalance, offset center, fretting, misalignment, and excessive wear.
Generator Temperature	A6630 and/or A6510-T	Resistance Temperature Detector or Thermocouple	Measuring the temperatures in the stator slots and the air cooler inlet/outlet identifies changes in stator condition due to plugged coolers, overheating coils, and blocked ventilation ducts.
Redundant Thrust Position	A6210 and/or A6510-T	Eddy Current Probes	Monitoring thrust position detects any significant overload or wear in the thrust bearing.
Eccentricity	A6220	Eddy Current Probes	Eccentricity probes detect any significant rotor bow or a change in position caused by bearing wear.
Phase and Speed	A6312 and/or A6510-T	Eddy Current Probes	Monitoring shaft rotation from a notch (key) provides a revolving speed and vibration phase measurement to enable analysis of phase differences between multiple bearings along the same shaft.
Head Cover / Draft Tube Vibration	A6150 and/or A6510-T	Low Frequency Velocity Sensor	Monitoring at the head of the turbine cover, or draft tube, provides readings of cover stiffness and/or flow energy changes so flow adjustments can be made to reduce vibration levels.
Inlet Guide Vanes	A6125 and/or A6510-T	Accelerometer	Cavitation damage caused by metal erosion impacts turbine impeller condition and efficiency. Monitoring high frequency vibration components allows for vanes position or flow parameter correction.
Overspeed Protection	CSI 6300 SIS	Eddy Current Probes	Protects generator and turbine against overspeed events. SIL 3 rated system according to IEC 61508:2010

AMS SUITE: POWERFUL PREDICTIVE DIAGNOSTIC PLATFORM

AMS Suite predictive maintenance software provides access to all the information necessary for online machinery monitoring of hydro turbines and generators.



Emerson's comprehensive hydro machinery monitoring offering ensures early detection through predictive diagnostics . AMS Suite provides a user-friendly graphical view of performance monitoring indicators, machinery protection parameters, and machinery health information. Using real-time information from the CSI 6500, AMS Suite can detect potential problems early so you can diagnose and quickly troubleshoot issues. Operators receive real-time machinery health information to make informed decisions to protect production, while maintenance personnel receive detailed vibration information for root cause analysis and critical decision making.

With AMS Suite you can integrate hydro machinery and other mechanical asset diagnostics with CMMS systems and documentation of work processes to improve reliability and overall performance. Use key performance indicators on the health of critical assets or the entire process to make fact-based decisions for equipment that impacts the bottom line.

- Accurately identify the cause and criticality of developing problems
- Obtain early warning of a pending failure to plan maintenance
- Accurately measure turbine efficiency relative to design and determine cost of degradation
- Easily interpret vibration and performance defects

DIAGNOSTIC TOOLS IN AMS SUITE

KPIs	An overview of real-time indicators pertinent to the complete hydro equipment, or per turbine and generator section, with parameters based on the severity of an alarm.
Graphical Displays	Graphical displays and analysis tools enable an accurate diagnosis of equipment health and performance. Advanced analysis functionality includes waterfall plots, shaft orbits, efficiency and deviation from design graphs, polar graphs, and waveform and spectrum graphs.
Transient Live Display	Data can be recorded simultaneously for each channel, allowing replay of a particular event or specific time period for further analysis.
PeakVue™	PeakVue technology captures vibration signals into a frequency-based spectral plot to provide advanced identification of element bearing problems that are undetectable with other solutions.

Diagnose hydro machinery health problems with complementary technology

In addition to online machinery monitoring, AMS Suite can be integrated with other machinery health technologies to diagnose equipment issues in your balance-of-plant equipment. AMS Suite will manage information from a range of portable condition monitoring capabilities.

- CSI 2140 Machinery Health Analyzer is a portable tool that identifies vibration problems including misalignment, balancing, looseness, and worn and chipped gears.
- Lubrication and oil analysis detect improper lubrication, corrosion, oil contaminants, and chemical changes in the oil that indicate degradation.
- Emerging faults can be accompanied by excessive heat or heat loss. Infared thermography can help identify machinery health.

LIFECYCLE CARE: REALIZE THE FULL VALUE FROM YOUR SOLUTION

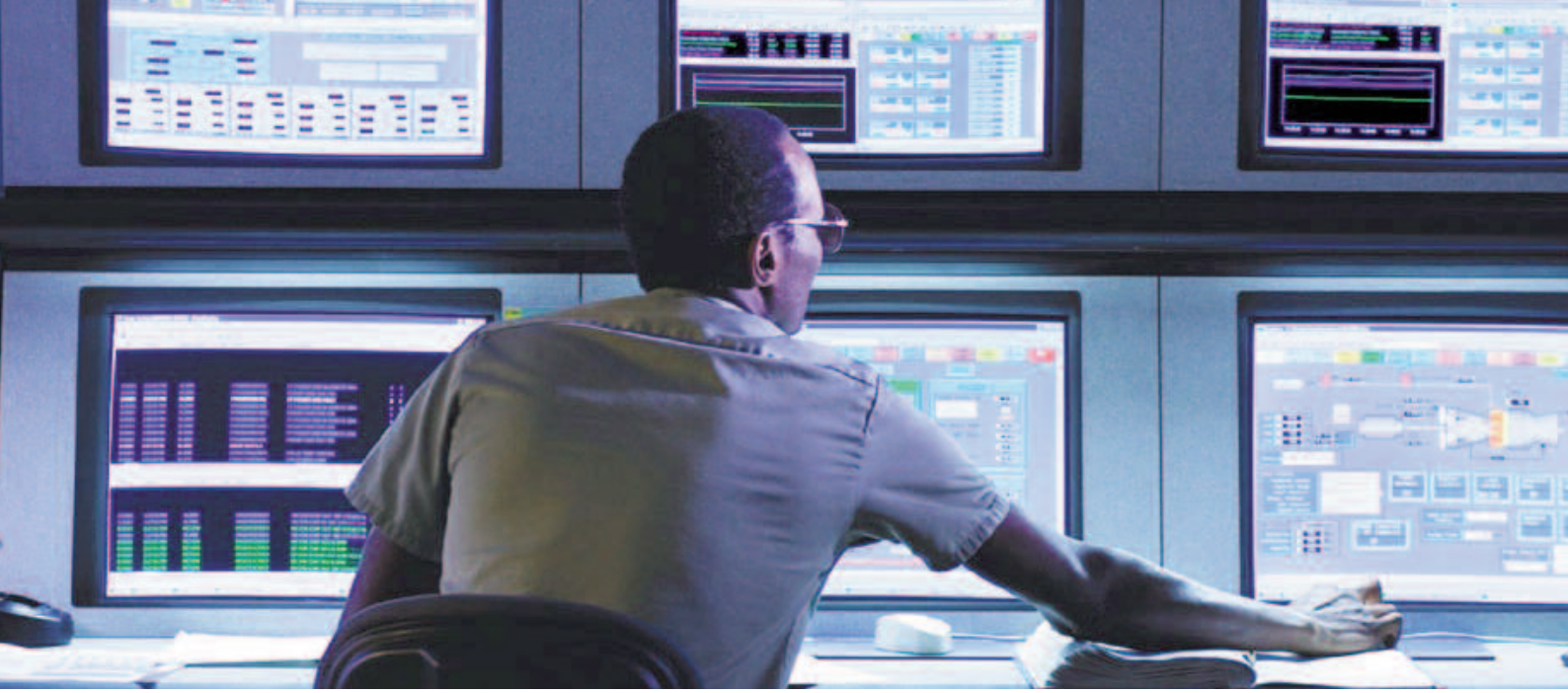
Whether you need a protection-only configuration or if prediction and performance monitoring of your hydro machinery system will be included, you cannot afford to overlook services.

Emerson experts ensure that you experience the full value of your investment so you will see improvements in your plant and can interpret the diagnostic information that is available. Our commitment is to support you through all steps of the project and to keep your system running smoothly and reliably.

In addition, our response centers offer troubleshooting, remote monitoring, diagnostic interpretation, and emergency site services to help keep your hydro machinery running smoothly. Partner with Emerson to make the most of your resources; our global network will be there when and where you need us.

You can rely on Emerson for:

- Assessment of your most critical assets to uncover gaps in your monitoring processes.
- Customisable design of your hydro machinery 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 and CSI 6300.
- Integration to the process automation system.
- A training program that covers operation and diagnostic capabilities.
- Full access to firmware and software updates, technical and product support.



TURN TO EMERSON FOR HYDRO ASSET MANAGEMENT

When you need a partner you can trust for your hydro machinery monitoring needs, turn to Emerson. For over 25 years, Emerson has led the market in the development of vibration and machinery health monitoring technologies, software and services to help users achieve operational and maintenance goals. Our technologies, leadership, and experience ensure plants are run safely and efficiently.

With Emerson, you have a partner for your hydro machinery asset management and control needs. Whether it's a broken wicket gate, a chipped blade, or a sleeve bearing problem, detection is made easier through Emerson's online machinery monitoring solution.

- Achieve optimal health and performance of your hydro turbine machinery
- Prevent catastrophic failures and unplanned shutdowns
- Meet operation and power production targets
- Shift from reactive and preventive to predictive and proactive maintenance
- Determine maintenance action and prioritize based on criticality
- Diagnose the root cause of performance degradation and reoccurring problems

Move from reacting to predicting mechanical problems so your hydro machinery will not put your operational and safety goals at risk.

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