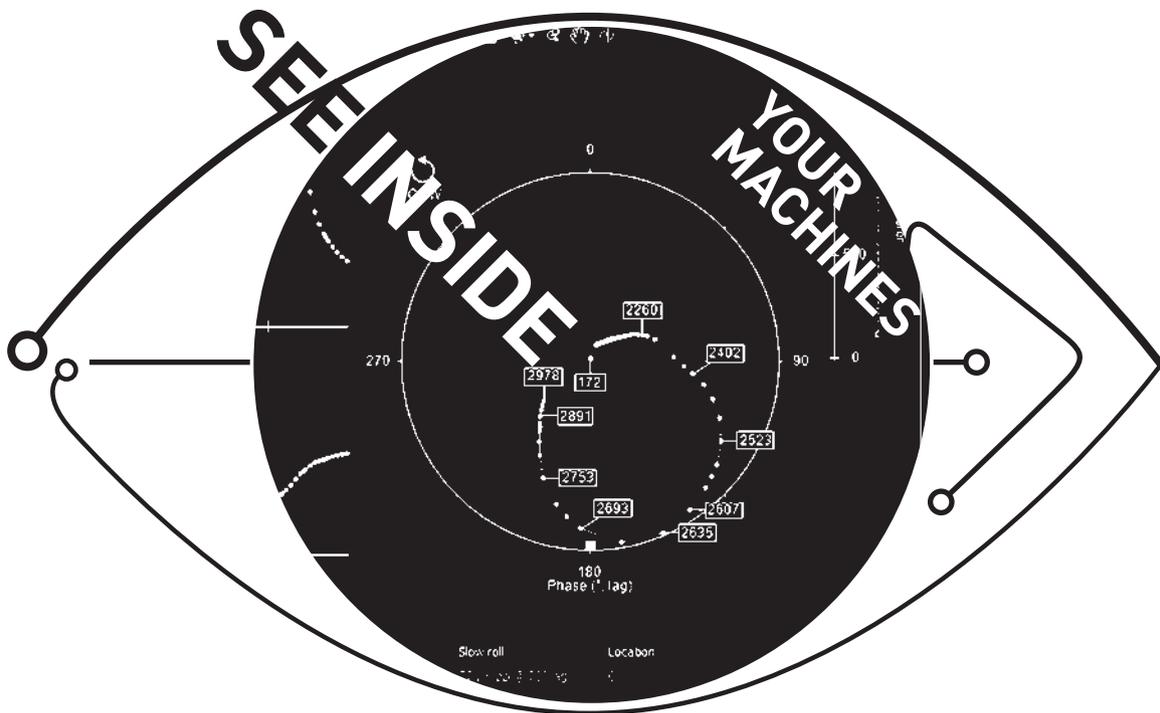

The power of observation



Condition monitoring opens a window on the inner working of hydropower plants, enabling operators to identify malfunctions early on and optimize efficiency. Without it, minor faults remain unseen and can escalate to a major failure, requiring unscheduled, lengthy and expensive repairs.



Repairing a large hydropower plant can take a turbine out of action for months because machinery must be accessed from the top. Condition monitoring lets a plant operator perform all maintenance actions during scheduled downtime, and minimizes the risk of taking the turbine offline unexpectedly.

Contents

- 1 **Avoid failures, schedule downtime and optimize efficiency**
- 2 **Extensive experience, exceptional quality and an all-in-one package**
- 4 **Sensors for vibration, position, air gap and partial discharge**
 - 4 Bearing and casing vibration
 - 4 Shaft vibration and position
 - 5 Partial discharge
 - 6 Air gap
- 8 **Complete intelligent monitoring solutions**
 - 9 Centralized intelligence | VM600
 - 10 Distributed intelligence | VibroSmart
 - 11 Visualized intelligence | VibroSight

Avoid failures, schedule downtime and optimize efficiency

Few drivers would run their cars without a dashboard to alert them to problems and avoid potential engine failures. So why would a hydropower plant manager 'operate blind' without sensors and software to visualize the workings of turbines?

Machinery protection, which shuts a unit down automatically in the case of a major failure, is now usually mandatory in hydropower plants. While this avoids disasters, it does not ensure against costly, unplanned downtime resulting from an unseen fault. Supplementing machinery protection with condition monitoring overcomes this blind spot by providing the power generation equivalent of the car dashboard. Any anomaly inside a turbine is flagged up early on to operators, so they can take action before an issue stops plant operation in its tracks.

With condition monitoring, the sensors are integrated with advanced diagnostic tools that help users turn data into explicit maintenance actions and monitoring into active management of system conditions. As well as highlighting potentially expensive technical problems, the system enables operators to optimize efficiency and extend the life of machinery, often by several years. Whether constructing new hydro plants or retrofitting aging ones, investing in condition monitoring is a small price to pay for the advantage of knowing what lies on the road ahead.

Extensive experience, exceptional quality and an all-in-one package

After decades working with turbine manufacturers and power-plant integrators, Meggitt has developed an array of sensors to monitor the performance of hydropower equipment. These are fully functional down to very low frequencies, in wet and corrosive environments and in the presence of electromagnetic and radio frequency interference.

Signals from these accelerometers, proximity probes, velocity sensors and air-gap sensors are relayed via VM600 or VibroSmart® hardware to Meggitt's VibroSight® condition-monitoring software package. These enable operators to detect issues, such as bearing failure and rough load zones, and take action to restore efficient operation. Any abnormalities show up long before they become critical.

Fully integrated turnkey solutions

Meggitt's machinery protection and condition monitoring systems can be configured to the customers' needs. Operators are assured of a fully integrated system, built from components designed to work together, and configured and tested by Meggitt experts before use.

Assured quality

Our heritage in the aerospace industry ensures our standards of quality meet those demanded by the power generation sector. As high as one million hours, our field-proven Mean Time Between Failures (MTBF) is among the highest in the industry.

On-site services

From system installation to configuration and commissioning, we ensure that operators benefit from the full value of our expertise for the life of our systems.

Project management for large installations

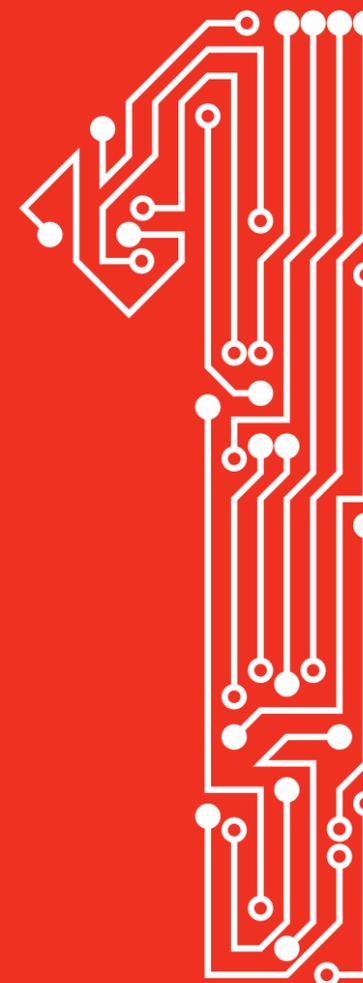
Project managing the installation of our bespoke systems, from design to site acceptance test, enables us to select application-specific sensors, protection criteria and data options for highly effective machinery monitoring.

Training

We offer comprehensive, hands-on, instructor-led training courses on all our products and systems, either at Meggitt's global training centers or customer sites.

Calibration and repair

Calibration certificates traceable to the National Institute of Standards and Technology can be issued after factory calibration. Meggitt can provide annual service checks, recommend corrective actions and resolve any equipment problems via the appropriate repair facility.



From the sensors, to the machinery protection system and the condition monitoring software—we provide it **all in one package.**

Sensors for vibration, position, partial discharge and air gap



Our watertight proximity probes are immune to contaminants.

NamPower, Namibia's national power utility provider, uses Meggitt's partial discharge solution to monitor the health of generators at units 1 and 3 of the Ruacana Power Station.

Bearing and casing vibration

Meggitt's velocity sensors and accelerometers measure absolute vibration of the casing and on the bearings of hydro turbines. Operators analyzing the signals can identify vibrations that forewarn of bearing failure.

Because they take measurements directly, Meggitt's velocity sensors provide excellent resolution and high-amplitude signals down to very low frequencies.

Accelerometers are effective at detecting cavitation, and any other high-frequency phenomenon. If cavitation is detected, operators can quickly alter control parameters to eliminate the effect.

- Absolute vibration measurements are taken horizontally or vertically on the bearings or stator frame
- Measurement frequencies down to 0.2 Hz
- Long-distance signal transmission
- Fully sealed transducer (IP68 rated)
- Embedded electronics

Shaft vibration and position

Proximity probes use eddy currents to monitor the relative vibration and axial displacement of the shaft and measure rotating speed (phase reference). Within hydro plants, these measurements sometimes need to be made underwater. Unlike capacitive sensors, Meggitt's watertight proximity probes are immune to any contaminant, including water, oils and dust. They are in service in thousands of power generation plants including the world's most powerful Pelton turbines at the Bieudron Cleuson-Dixence hydropower plant.

- 2 – 12 mm measurement range
- -40° to 180°C (-40° to 356°F)
- Voltage or current output
- Watertight applications for runner clearance measurements (IP68 rated)
- Inductive sensor immune to contaminants
- TQ probes with EA cables and IQS signal conditioner

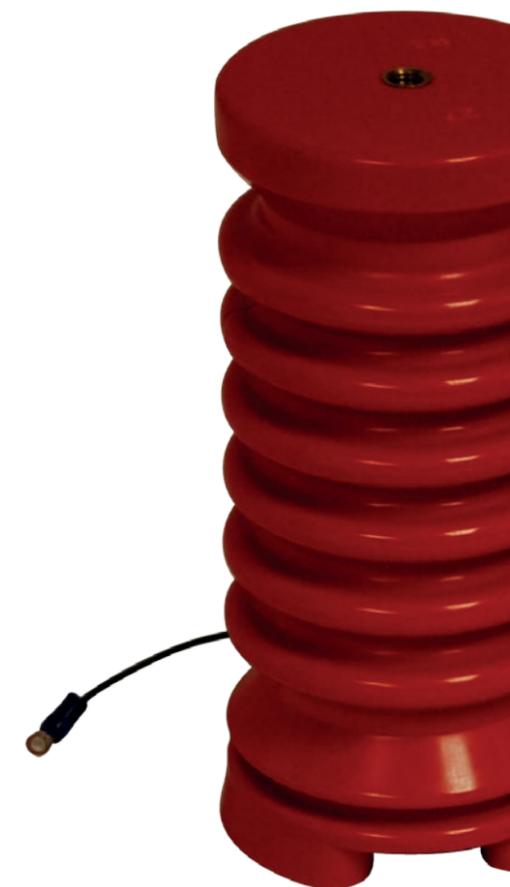
Partial discharge

Partial discharges signify that insulation is breaking down. If not addressed, this electrical arcing can destroy the generator. Meggitt's new partial discharge monitoring system provides additional protection for critical power-generating machinery. Early detection enables condition-based maintenance to take place at a convenient time, increasing reliability and minimizing repair costs.

Coupling capacitors are the hallmark of this leading-edge technology. Their robust design and safe, stable and reliable performance make it possible to install them extremely close to the windings, maximizing the sensors' sensitivity.

Most generators have embedded Resistance Temperature Detectors (RTDs). Meggitt's partial discharge monitoring system is also uniquely able to tap into the signals coming from these RTDs, and use them as additional partial-discharge sensors. This enables Meggitt to provide the best windings coverage in the industry.

- Excellent signal-to-noise ratio
- Calculates multiple partial discharge pulse parameters, including polarity, pulse count, magnitude, phase angle and intensity
- Provides more than 90% coverage of critical stator windings
- Coupling capacitors are available in 8 kV (CC 308), 16 kV (CC 316) and 28 kV (CC 328) voltage ratings



The partial discharge monitoring system provides an insight into the condition of windings.



Meggitt's velocity sensors measure vibration with a high sensitivity at ultra-low frequencies.

Meggitt's sensors monitor shaft and bearing vibration on more than 200 Hydro Quebec turbines

Air gap

Over time, heavy machinery can shift in its foundations and, if subjected to fluctuating temperatures, expand and contract. Such situations in hydro plants can bring moving and stationary parts of the generator closer together. Air-gap sensors measure the gap between the rotor poles and the stator walls.

- 2 – 33 mm measurement range
- Contactless measurement for alternators
- Capacitive sensor
- LS 120 transducer with integral cable and an ILS 730 signal conditioner

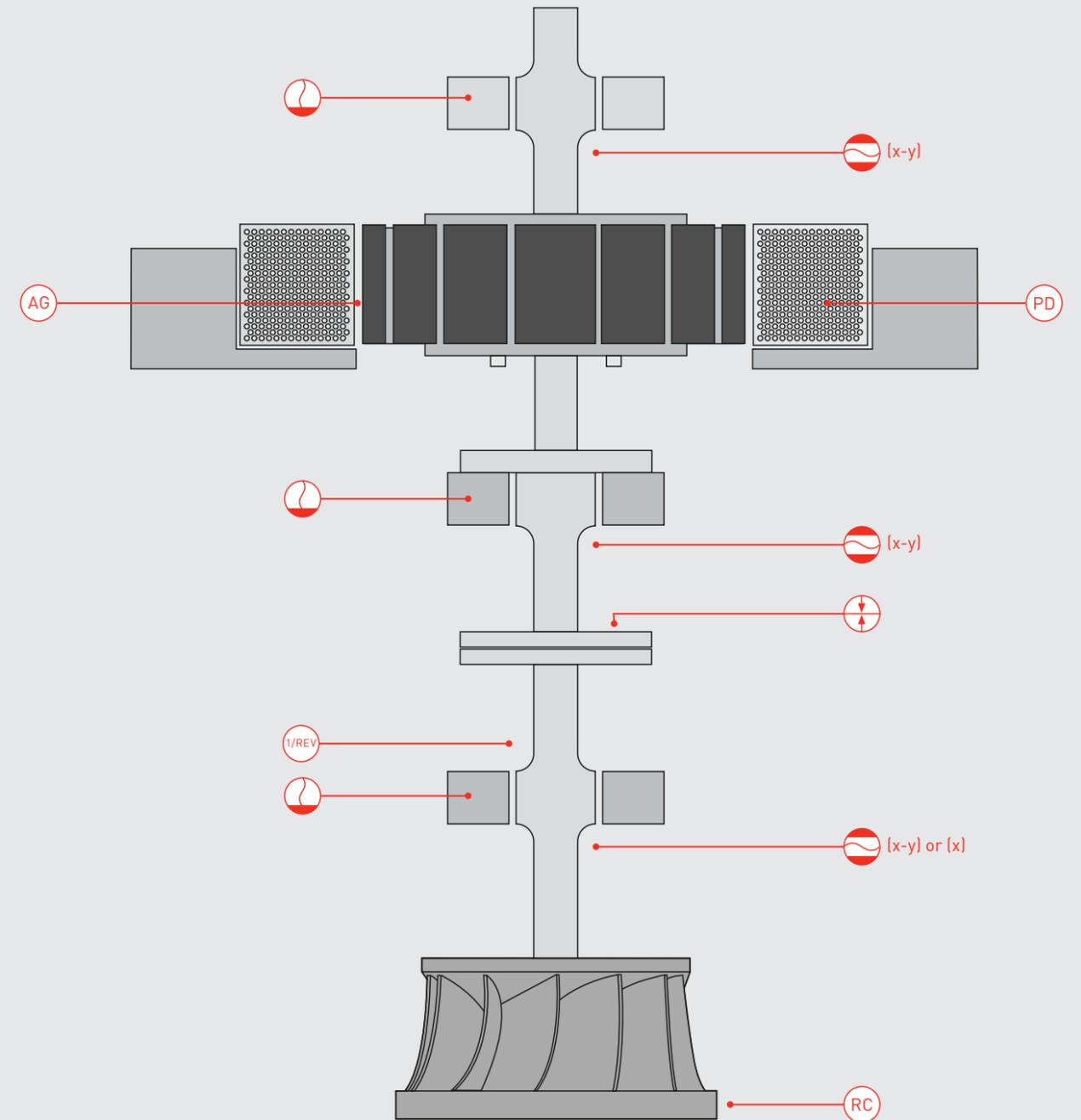
A small air gap is desirable to optimize efficiency. If the gap narrows too much, it can cause components to rub. The monitoring system sets off advance warning to prevent this from happening.

Some 160 Meggitt air gap sensors monitor 10 generators within Venezuela's 2160MW Tocoma hydropower project.



Measuring the air gap between rotor and stator avoids damage.

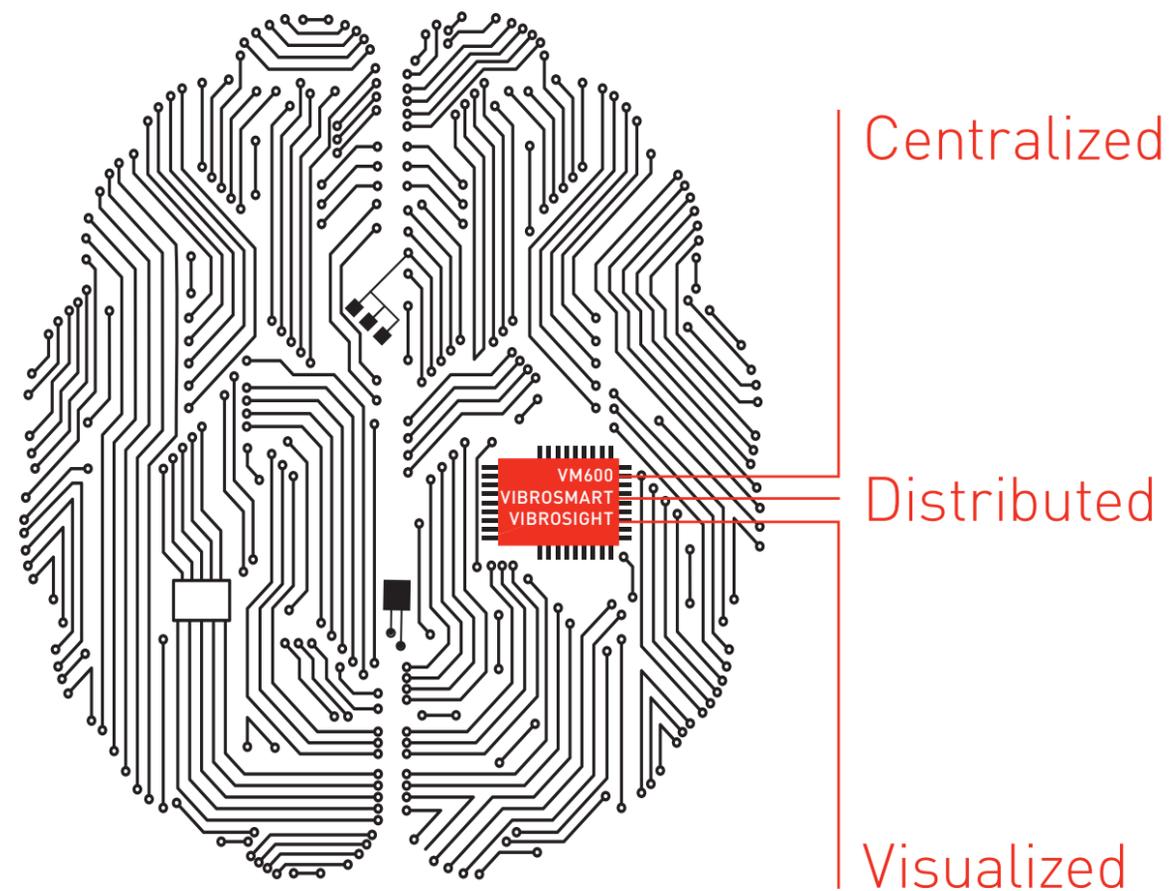
Sensors located on and around a hydro turbine communicate via Meggitt's machinery protection systems, VM600 or VibroSmart®, visualizing data through VibroSight® condition-monitoring software.



- | | | | |
|-------------------|------------------------------|---------------------|------------------------------|
| Partial discharge | Shaft vibration and position | Runner clearance | Bearing and casing vibration |
| Phase reference | Air gap | Thrust displacement | |

Complete intelligent monitoring solutions

Meggitt's advanced hardware and software monitoring tools enable plant operators to monitor and visualize the health of their machines, diagnose problems and take action to remedy issues before they become critical. Meggitt can provide the entire monitoring system, comprising accelerometers, proximity probes, velocity sensors and air-gap sensors, coupling capacitors, machinery protection systems, machinery management software, cabinets, factory acceptance tests, site acceptance tests, validation and trouble-shooting services.



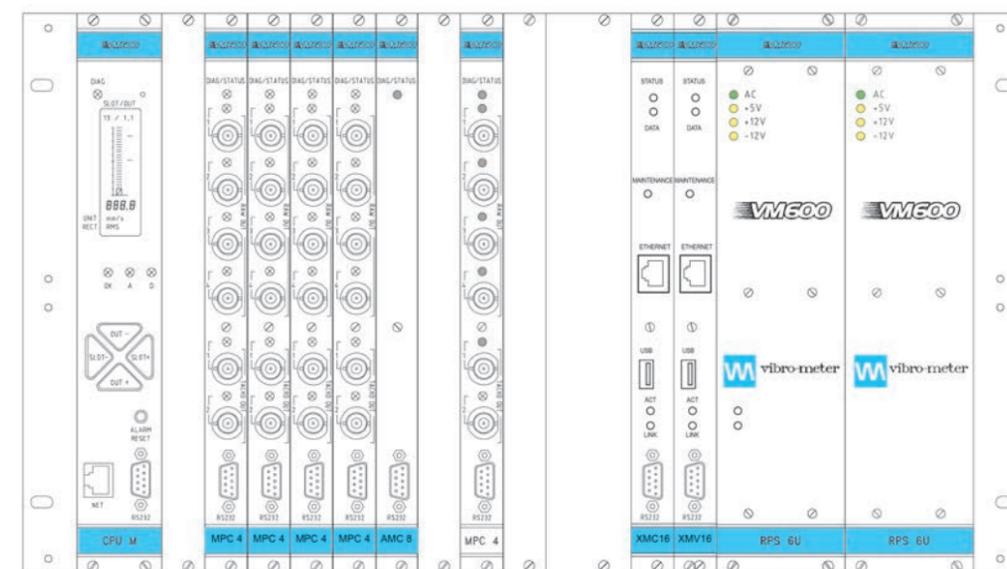
Meggitt's machinery protection and condition monitoring products enable solutions in accordance with ISO 10816-5 and ISO 7919-5 standards for hydropower applications.

Centralized intelligence | VM600

Meggitt's powerful rack-based machinery protection and condition-monitoring system is used by many of the world's largest hydro end users. Modular and scalable, each VM600 system is easily configured to meet the needs of individual applications. The system's high channel density makes it particularly suitable for complex hydro installations. Dynamic inputs from proximity probes, accelerometers, velocity sensors and air-gap sensors are fed into standard 19-inch, 6U racks. The distance between the sensors and the monitoring system can extend to 1,000 meters (3,000 feet).

It is possible to order Meggitt's VM600 fully configured for out-of-the-box installation. The system, which is highly configurable, does not require application-specific cards. A single signal input card (MPC4) for receiving condition monitoring data on vibration, position, air gap and phase reference/speed measurements will suffice.

Meggitt's turnkey solutions include **cabinets** based on your project's requirements.



VM600, our powerful, centralized, rack-based machinery protection and condition-monitoring system.

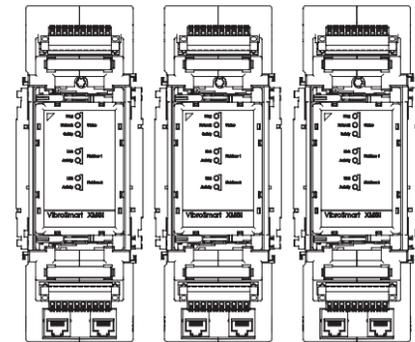
The VM600 is one of the industry's most reliable and respected monitoring systems; thousands are deployed around the world on many of the largest hydro installations in operation.

Distributed intelligence | VibroSmart

VibroSmart is Meggitt's distributed monitoring system for turbines, pumps and smaller critical assets requiring low-channel counts. Skid-mounting components near the turbine or running equipment calls for less wiring, cutting installation costs by 30% without compromising performance. Pricing the system by channel means more assets can be monitored for a lower capital investment.

VibroSmart's structure is highly flexible and can be easily extended. Ethernet-enabled, the system is designed for plants where a distributed architecture makes sense for the control system, such as where machinery is dispersed over a large area. Modules communicate in real time with each other and with VibroSight condition-monitoring software, via Ethernet or fieldbus.

Our modular VibroSmart system monitors turbines, pumps and smaller critical assets requiring low-channel counts.



VibroSmart is able to measure particularly low frequencies better than competing products. It is possible to add an additional high-pass filter that improves the cut-off frequency to 0.1Hz at -3dB.

Benefits shared by VM600 and VibroSmart

Machinery protection function safeguarded

With Meggitt's VM600 and VibroSmart systems, the machinery protection component is separate from the condition-monitoring software. This means that if a virus or other debilitating condition affects the condition-monitoring software, the machinery protection will continue to function independently, safeguarding the plant at all times.

Reduced spares required

The unique architecture of the VM600 and VibroSmart systems enables all machinery protection functions to be accomplished with a common processing module. This eliminates the need to stock multiple spare card types to process myriad inputs.

Shorter Mean Time To Repair

All configurations are stored in the memory of the dedicated interface module. If a component

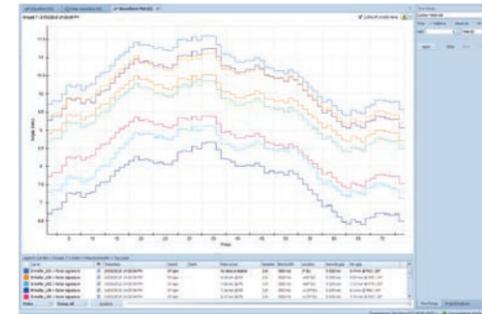
needs to be replaced in the field, the relevant data is automatically downloaded, without the need for configuration software. This significantly reduces the MTTR.

Built-in relays

The signal processing modules include alert and danger relays for machinery protection functions, so a separate relay card is not required.

Adaptive monitoring

Alarm and danger activation levels can be set according to operating speed, load and head. For example, VM600 and VibroSmart can detect whether a vibration condition is normal or abnormal for a given speed. This avoids false alarms while ensuring safety is not compromised. Trip multiply and danger bypass settings act as an override at times when acceptable sets of conditions might otherwise trigger an alarm.



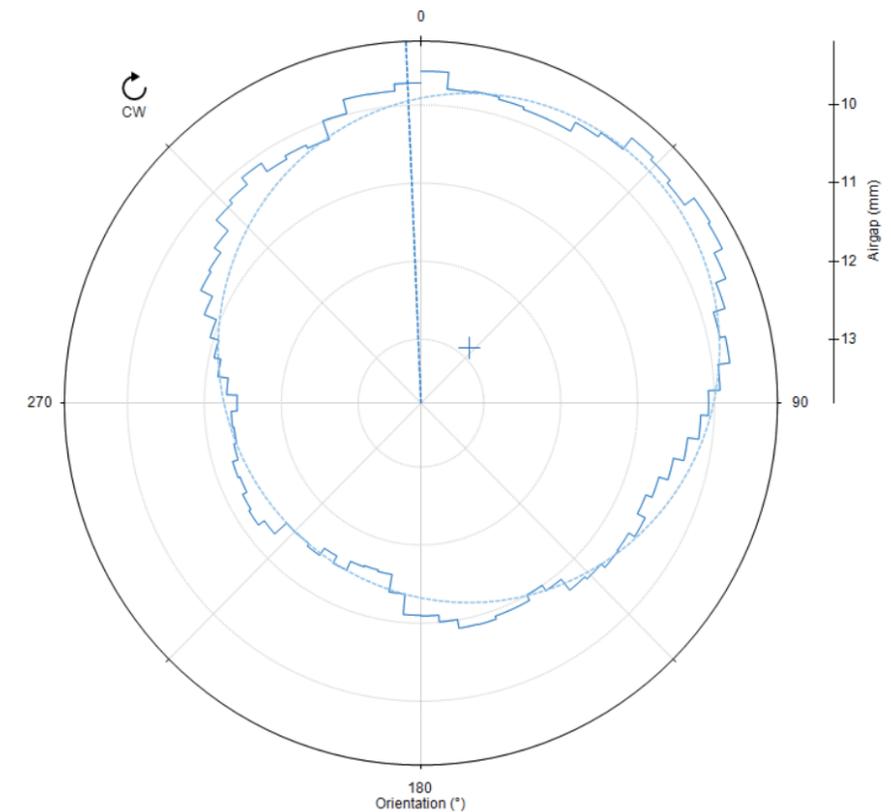
VibroSight visualizes live data and historical trends.

Visualized intelligence | VibroSight

VibroSight is the common software platform through which data from VM600 and VibroSmart is visualized. Operators can view live data and historical trends with graphical interfaces and plots from application-specific packages. The software's open architecture makes it easy to integrate and correlate additional system data, such as process parameters, with existing monitoring functions to help operators make informed decisions.

VibroSight visualizes data from all sensors for all applications. For air-gap monitoring, it provides true rotor and stator circularity and eccentricity measurements according to the industry standard set by the international Center for Energy Advancement through Technological Innovation (CEATI).

- Rotor and stator shape
- Rotor signature
- Average and minimum air gap
- Rotor and stator eccentricity, ellipticity and circularity



Meggitt Sensing Systems

We are a world-leading provider of high-performance sensing and monitoring systems for extreme environments.

After 65 years' experience, many turbine manufacturers frequently recommend us as their most-trusted supplier. Our systems monitor all types of hydro turbines (Kaplan, Pelton, Francis and variants) for OEMs and end-users.

Engineering Meggitt's technology in Switzerland, where hydroelectric dams generate more than half of domestic electricity, highlights our status within the hydro industry worldwide.

Our DNA

We pioneered high-performance sensing and condition monitoring solutions for extreme environments through our antecedents ECET, Endevco®, Ferroperm Piezoceramics, Piezo Technologies, Lodge Ignition, Sensorex®, Vibro-Meter® and Wilcoxon Research®. Today these operations are integrated within the Meggitt Sensing Systems division, providing complete systems from a single supply base.

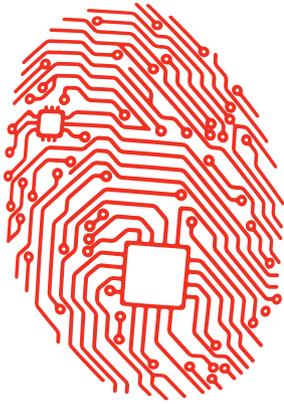
Working extensively with the world's turbine manufacturers has helped us master all aspects of condition monitoring; from high-performance sensing, data acquisition and management, to high-speed digital networking and the signal-processing algorithms that deliver insights for informing remedial action.

Our parent

Headquartered in the United Kingdom, Meggitt PLC is an international group operating in North and South America, Europe and Asia. Known for its specialized extreme environment engineering, Meggitt is a world leader in aerospace, energy and defense markets. An 11,000-strong workforce serves customers from around 40 manufacturing facilities and regional offices worldwide.



In service in thousands of power generation plants including the world's most powerful Pelton turbines at the Bieudron Cleuson-Dixence hydropower plant.



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