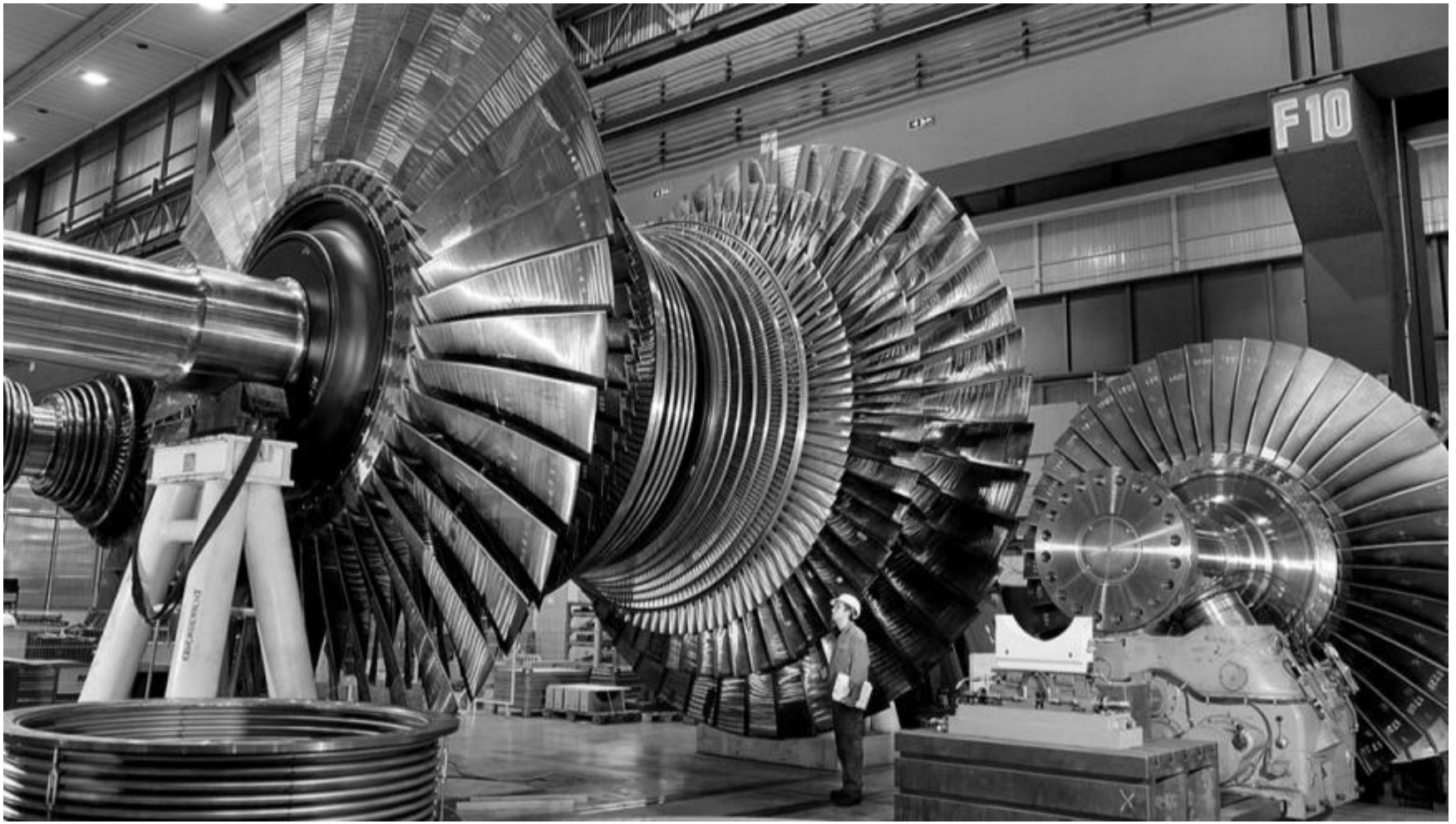

Sensor systems for turbomachinery

February 2015

MEGGiTT

Outline

- Key applications
- Overview
- Complete monitoring solution
- All new galvanic separation unit
- Application examples
- Meggitt's expertise

Key applications

- Integrated systems monitor thousands of machines worldwide
  - heavy duty gas turbines
  - industrial and aero-derivative gas turbines
  - steam turbines (nuclear and conventional)
  - hydro turbines
  - wind turbines
  - large generators
  - large pumps, compressors and fans
  - large electric motors
- Installations on the world's three largest hydropower plant installations, largest steam turbine (1800 MW) and most powerful gas turbine (at 530 MW)

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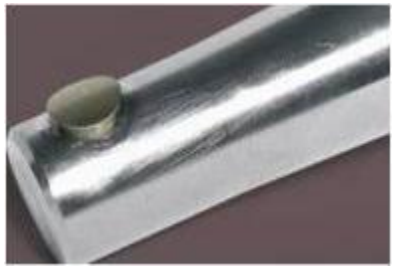
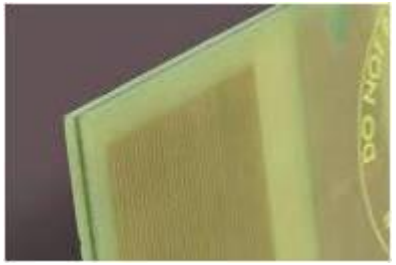
Overview

- CA and CE accelerometers
  - provide vibration measurements in harsh industrial conditions
  - sensitivities from 10 to 100 pC/g
  - temperature up to 700°C
- CP dynamic pressure sensors
  - key to optimizing low NO_X emissions
  - sensitivities up to 750 pC/bar
  - temperature up to 777°C
  - high frequency response up to 20 kHz
  - overload up to 350 bar
- TQ proximity probes
  - eddy current transducers for contactless measurements of relative vibration or axial displacement
  - API 670 compliant
  - available for high pressure and watertight applications
  - measuring ranges up to 12 mm

Overview

- CV and VE velocity sensors
  - for all types of low-speed turbomachinery
  - measure absolute vibration down to very low frequencies
- EW ice detection system
  - detects initiation of ice on gas turbine inlets
  - discriminates between ice and water
- LS air gap monitoring system
  - measures the air gap between rotor and stator
  - uses a capacitive technology

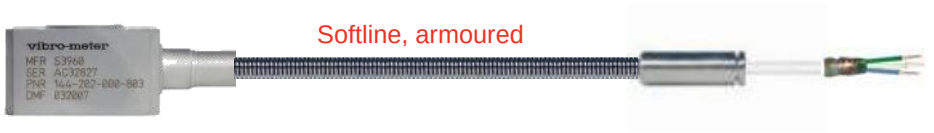




External charge amplifiers

CA 202

- 100 pC/g (400 g)
- -55 to 260°C
- 0.5 to 5,000 Hz



For heavy duty gas and steam turbines.
Piezoelectric accelerometer for use over an extended temperature range.

CA 280

- 100 pC/g (500 g)
- -55 to 260°C
- 0.5 to 10,000 Hz

For heavy duty and aero-derivative gas turbines, gearboxes, compressors and marine applications.
Multi-purpose, compact piezoelectric accelerometer for use over an extended temperature range.

CA 306

- 50 pC/g (100 g)
- -55 to 500°C
- 5 to 3,000 Hz

For aero-derivative and industrial gas turbines.
Piezoelectric accelerometer for use over a wide temperature range.

External charge amplifiers

CA 134

- 10 pC/g (500 g)
- -196 to 500°C
- 0.5 to 6,000 Hz

For cryogenic applications and gas turbines.
Piezoelectric accelerometer for use over a very wide temperature range.

CA 901

- 10 pC/g (500 g)
- -196 to 700°C
- 3 to 3,700 Hz

For heavy duty gas turbines.
Piezoelectric accelerometer for use at extreme temperatures.

Measurement chain

Meggitt manufactures the complete measurement chain with the sensor, extension cable, signal conditioner and galvanic separation barrier

IPC 704 conditioner

- Signal conditioner for CA and CP sensors
- Configurable high- pass and low-pass filters
- Frequency range 0.5 Hz to 20 kHz
- Optional integrator for a velocity signal output
- Optional 2-wire current or 3-wire voltage transmission
- Ex certified versions

GSI 127 galvanic separation unit

- Power supply for 2-wire transmission systems installed in potentially explosive environments
- µa to mV conversion for long distance (2-wire) signal transmission, up to 1000 m
- Galvanic separation, 4 kV $_{RMS}$
- High rejection of frame voltage
- DIN-rail mounting
- Ex certified versions

Built-in or attached electronics

CE 134

- 5 µA/g (400 g)
- -55 to 350°C
- 5 to 10,000 Hz

For heavy duty gas turbines, aero-derivative gas turbines and compressors.
Piezoelectric accelerometer with attached electronics, for use over an extended temperature range.

CE 281

- 10 µA/g (200 g)
- -55 to 260°C
- 3 to 10,000 Hz

For gearboxes, compressors, pumps and fans.
Compact piezoelectric accelerometer with attached electronics, for use over an extended temperature range.

CE 311

- 50 µA/g (40 g)
- -55 to 125°C
- 2 to 8,000 Hz

For heavy duty gas and steam turbines.
Piezoelectric accelerometer with built-in electronics, for use in industrial environments.

Built-in or attached electronics

CE 680

- 100 mV/g (80 g)
- -55 to 120°C
- 0.5 to 9,000 Hz

EC 319 - softline

For auxiliary machines.
Multi-purpose, compact piezoelectric accelerometer with built-in electronics, for use in industrial environments.

SE 120

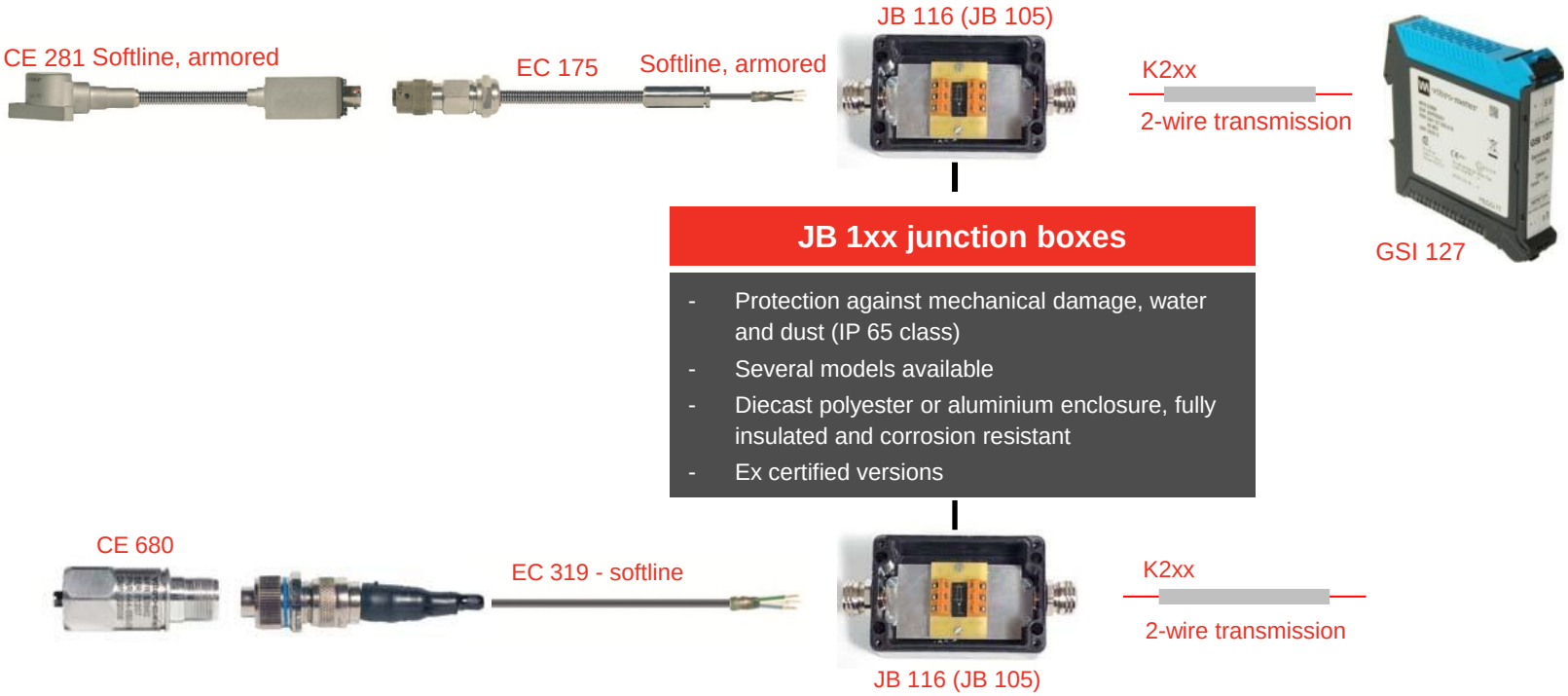
- 2 mA/g (4g)
- 0 to 75°C
- 0.2 to 750 Hz

Softline

For slow speed rotating machines, hydro turbines and fans.
High-sensitivity piezoresistive accelerometer.

Measurement chains

Complete measurement chain with CE 281 and CE 680 compact piezoelectric accelerometers, extension cable and junction box



Dynamic pressure sensors

Combustion monitoring

CP 103

- 232 pC/bar (20 bar)
- Overload up to 250 bar
- -196 to 700°C
- 2 to 10,000 Hz

Very high temperature.

CP 235

- 750 pC/bar (20 bar)
- Overload up to 100 bar
- -55 to 520°C
- 2 to 10,000 Hz

High temperature, very high sensitivity.

CP 211

- 25 pC/bar (250 bar)
- Overload up to 350 bar
- -196 to 777°C
- 2 to 15,000 Hz

Very high temperature, compact.
Primarily used for laboratory measurements in extreme environments.

Dynamic pressure sensors

Combustion monitoring

CP 216

- 200 pC/bar (250 bar)
- Overload up to 350 bar
- -70 to 520°C
- 2 to 15,000 Hz

High temperature, compact.

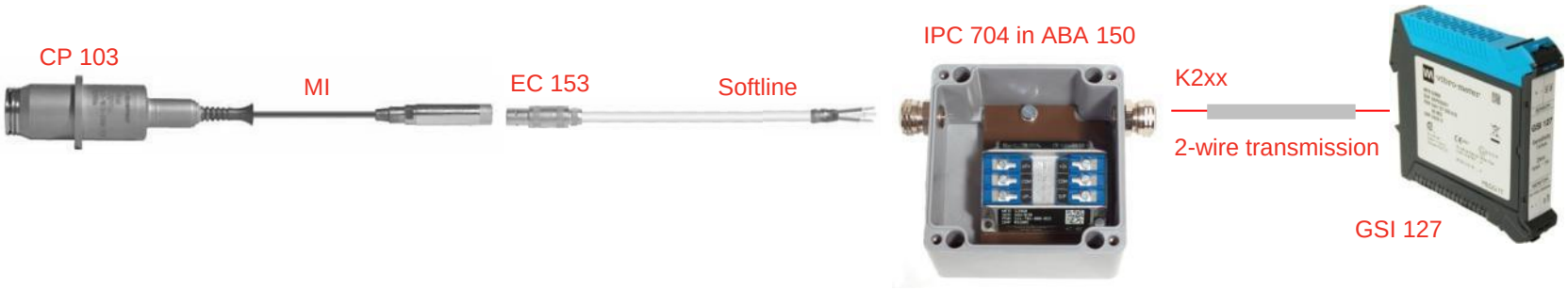
CP 50x

- 90 pC/bar
- Overload up to 100 bar
- -70 to 560°C
- 0.5 to 20,000 Hz

High temperature.
Outstanding thermal behaviour from piezoelectric material (no pyroelectricity) and virtually constant sensitivity.

Complete measurement chain

Complete measurement chain with CP 103 dynamic pressure sensor, extension cable, signal conditioner and galvanic separation barrier



Proximity probes

Displacement measurements

TQ 402

- 8 mV/µm or 2.5 µA/µm (2 mm range)
- 4 mV/µm or 1.25 µA/µm (4 mm range)
- -40 to 180°C
- 8.2 mm Ø tip

TQ 422

- 4 mV/µm or 1.25 µA/µm (4 mm range)
- -25 to 140°C
- 12.7 mm Ø tip
- Pressure proof, 100 bar (tip)

TQ 432

- 4 mV/µm or 1.25 µA/µm (4 mm range)
- -25 to 140°C
- 12.7 mm Ø tip
- Pressure proof, 100 bar (tip)
- Reverse mount

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Proximity probes

Displacement measurements

TQ 412

- 8 mV/µm or 2.5 µA/µm (2 mm range)
- 4 mV/µm or 1.25 µA/µm (4 mm range)
- -40 to 180°C
- 8.2 mm Ø tip
- Reverse mount

TQ 442

- 8 mV/µm or 2.5 µA/µm (2 mm range)
- 4 mV/µm or 1.25 µA/µm (4 mm range)
- -40 to 180°C
- 8 mm Ø tip
- 90° mount

Proximity probes

Displacement measurements

TQ 401

- 8 mV/µm or 2.5 µA/µm (2 mm range)
- -40 to 180°C
- 5 mm Ø tip

TQ 403

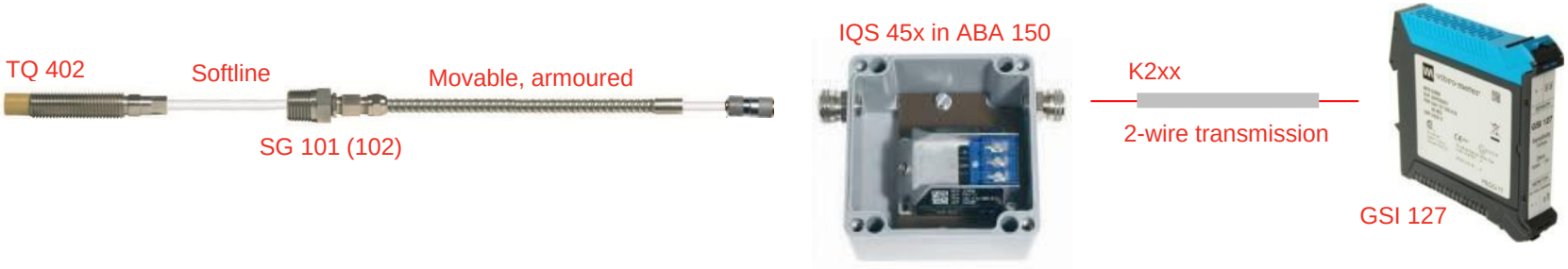
- 1.33 mV/µm or 0.417 µA/µm (12 mm range)
- -40 to 180°C
- 18 mm Ø tip

TQ 423

- 1.33 mV/µm or 0.417 µA/µm (12 mm range)
- -25 to 140°C
- 25 mm Ø tip
- Pressure proof, 100 bar (tip)

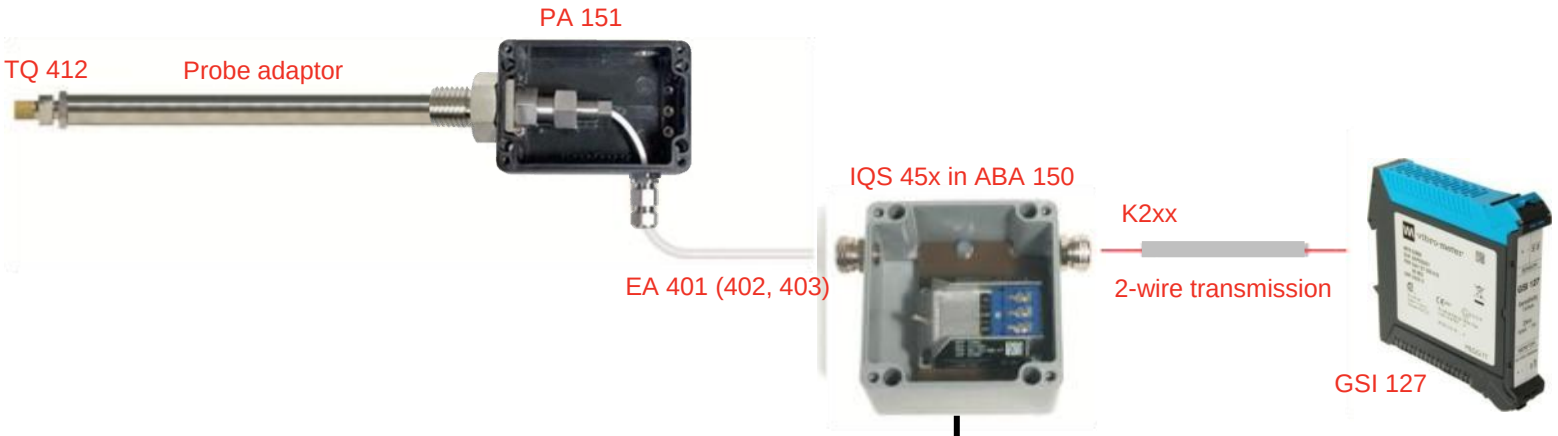
Measurement chain

Complete measurement chain with TQ 402 proximity probes, extension cable, conditioner and galvanic separation



Measurement chain

Complete measurement chain with TQ 412 proximity probes, extension cable, signal conditioner and galvanic separation barrier



IQS 45x conditioners

- Signal conditioner for TQ4xx probes
- Optional 2-wire current or 3-wire voltage transmission
- Diecast aluminium enclosure
- Ex certified versions

Velocity sensors

VE 210

- 50 mV/ mm/s or
  50 µA/ mm/s (100 mm/s)
- -25 to 80°C
- 0.5 to 400 Hz

EC 439 – 2-wire (current transmission)
EC 440 – 3 wire (voltage transmission)

For low-speed machines, such as hydroelectric turbomachinery.
Low-speed velocity transducer with stainless steel body and a protection rating of IP 68, ideal for moist or corrosive environments.

CV 213

- 20 mV/mm/s (1000 mm/s)
- -29 to 204°C
- 10 to 1,000 Hz

ED 120 - softline

For hydro and steam turbines.
Low-speed velocity transducers, resistant to dust and moisture (IP64 rated).

CV 214

- 20 mV/mm/s (1,000 mm/s)
- -29 to 121°C
- 10 to 1,000 Hz

ED 121 - softline

Ice detection and air gap monitoring systems

Ice detection system

EW 140

- 0.2 to 2 mm ice
- -55 to 120°C

EC 119 – softline, armored

For all gas turbines.
Detects initiation of ice on gas turbine inlets.
Used by turbine de-icing systems to optimise the use of bleed air.

Air gap monitoring system

LS 120

- 2 to 33 mm
- -15 to 125°C

For large hydroelectric generators.
Monitors the air gap between the rotor and stator.

Galvanic separation unit

The ultimate signal quality

- Years of experience in harsh environments
  - Vibro-Meter SA, now Meggitt, designed and patented the first galvanic separation unit (GSI) in the 1980s
  - More that 25,000 GSIs sold globally
- Current modulation: putting signal quality first
  - Selected for and adopted in the original design
  - Enables interference-free transmission over long distances, **up to 1000 m**
  - Two-wire current transmission

GSI 127

- All in one
  - galvanic separation
  - power supply
  - current-to-voltage converter
  - safety barrier
- Meets the requirements of Safety Integrity Level 2
- Ex nA [ia Ga] certification
  - can be used as intrinsically safe associated electrical apparatus outside Ex zone
  - can be installed in Ex zone 2 (nA) or Division 2 when powering measuring chains installed in Ex environments up to zone 0 ([ia]) or Division 1
- Fully compatible with installed Meggitt measurement chains
  - simplified replacement of competitors' chains due to floating outputs

Compatibility with measurement chains

Sensors and signal conditioners

- Compatible with existing Meggitt measurement chains
  - CE accelerometers
  - CA accelerometers and IPC signal conditioners
  - CP dynamic pressure sensors and IPC signal conditioners
  - TQ proximity probes and IQS signal conditioners
  - CV velocity sensors and IQS signal conditioners
- Simplified replacement of competitors' measurement chains
  - floating output allows connections to monitoring systems with single-ended inputs without an additional isolator

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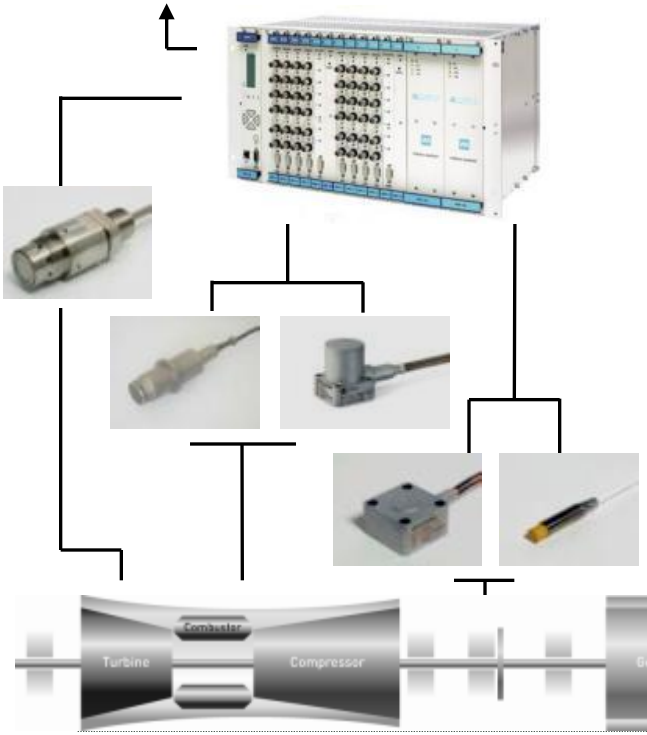
Complete monitoring solution

Gas turbine



Total condition monitoring
- » critical machinery
- » balance-of-plant assets

VM600
- » protection, condition and performance monitoring

Sensors
- » dynamic pressure
- » piezoelectric accelerometers

- » piezoelectric accelerometers
- » proximity probes

Plant asset management
Reduces the risk of failures and downtimes, enables maintenance to be planned, increases global plant effectiveness

Turbine health management
Safety, return on assets and environment impact

Blade tip clearance
Efficiency optimisation

Structural damages
Combustion humming, outer segments

Bearing
Defect detection

Turbomachinery operation
Safety, maintenance optimisation, lower spare parts inventory, improved efficiency, reduced emissions

Application examples

- The world's most powerful gas turbine (Irsching 4 - Siemens)
- Hydro turbine generator (Shipshaw – Rio Tinto Alcan)
- Combined cycle (Nhon Trach - Alstom)

Application examples

The world's most powerful gas turbine

Irsching 4 (Siemens)
Combined cycle

- The world's most powerful gas turbine at 578 MW
- Objective to reach the highest efficiency possible with the lowest emissions
  - efficiency of 60%, a new world record
  - 40,000 tons/year less CO_2 than comparable existing plants

Meggitt's solution

- Condition monitoring package
  - VM600 system
  - pressure, acceleration and proximity sensors
- On-line diagnostics and remote balancing
  - data collected and continuously transferred to Siemens' intranet
  - Siemens' diagnostic centers can remotely calculate balancing for turbines located in plants all over the world
  - local staff can balance a turbine without the need for a visit by experts

Application examples

Hydro turbine generator

Shipshaw (Rio Tinto Alcan)
Hydro power plant

- 12 hydro turbine generators with a combined output of 896 MW
- Objective to ensure permanent remote monitoring and analysis by their experts
  - main control center is 60 km from the plant

Meggitt's solution

- Remote monitoring package
  - 12 VM600 systems, one per turbine generator
  - accelerometers and air gap sensors
  - networked for remote monitoring from main control center

Application examples
Combined cycle

Nhon Trach (Alstom)
Combined cycle

- Heavy duty Alstom gas turbine, 460 MW
- Objective to combine high efficiency with extremely low NO_X emissions

Meggitt's solution

- Combustion monitoring package
  - VM600 system
  - accelerometers, dynamic pressure sensors and proximity probes
- Meggitt's dynamic combustion monitoring allows Alstom to control combustion parameters, such as fuel injection, which leads to
  - very low emissions
  - reduced fuel consumption
  - optimised timing of major inspections

Meggitt's expertise

- One source
  - design, manufacture and supply solutions for all monitoring and sensing needs
  - Our products are held to the highest quality standards
- Support and quality at your fingertips
  - Meggitt products meet your highest standards, and those set by regulatory authorities – guaranteed
- Decades of experience
  - over 65 years' supplying monitoring solutions to customers and thousands of systems currently deployed in the field

Meggitt Sensing Systems
Email: energy@ch.meggitt.com
Tel: +41 26 407 11 11