

HyCon™ MD Monitoring, Analysis and Diagnosis



The Voith HyCon™ MD Monitoring, Analysis and Diagnosis system combines our engineering and manufacturing expertise with your operational experience and knowledge to design a powerful preventive maintenance tool tailored to your individual hydropower plant.

A power plant's one and only objective is to fully meet the electricity demands for a maximum of time at the lowest possible cost. Therefore, efficiency, reliability and availability are crucial and it is of highest importance that the machines are kept operating under optimum conditions. A key factor to meet these demands is to be able to support early fault detection and preventive maintenance techniques.

This is the focus of HyCon MD, which is designed to obtain early detection of incipient damages, reduction of inspection and repair work, and clear planning options for timely inspections.

Among series of monitoring and evaluation methods for probable root causes in machine behavior, vibration diagnosis and air gap analysis are examples of well-known and acknowledged machine monitoring methods in the hydropower industry.

Both – being essential elements of the HyCon MD diagnosis techniques – have gained importance and have become part of condition-based maintenance for hydroelectric equipment, and match today's needs with respect to measuring technology, data processing and evaluation procedures.

HyCon MD - Monitoring System

HyCon MD is an online monitoring, analysis and diagnosis system developed by Voith Hydro, combining the know-how and experience of international hydropower operation and Voith Hydro's deep knowledge and experience of hydropower layout and design.

To meet various demands for different types, sizes and operation modes of hydropower machines, we offer:

- Highly scalable systems
- Custom-tailored solutions regarding protection, monitoring, analysis and diagnosis
- Predefined standard configurations for sensors to assure reliable and safe measurement.

Our modules are designed as an integral part of our HyCon control system family making it more beneficial, because no interfaces have to be clarified or information already available in the control system does not have to be acquired twice.

To maximize the flexibility, the system is designed in three hierarchical levels:

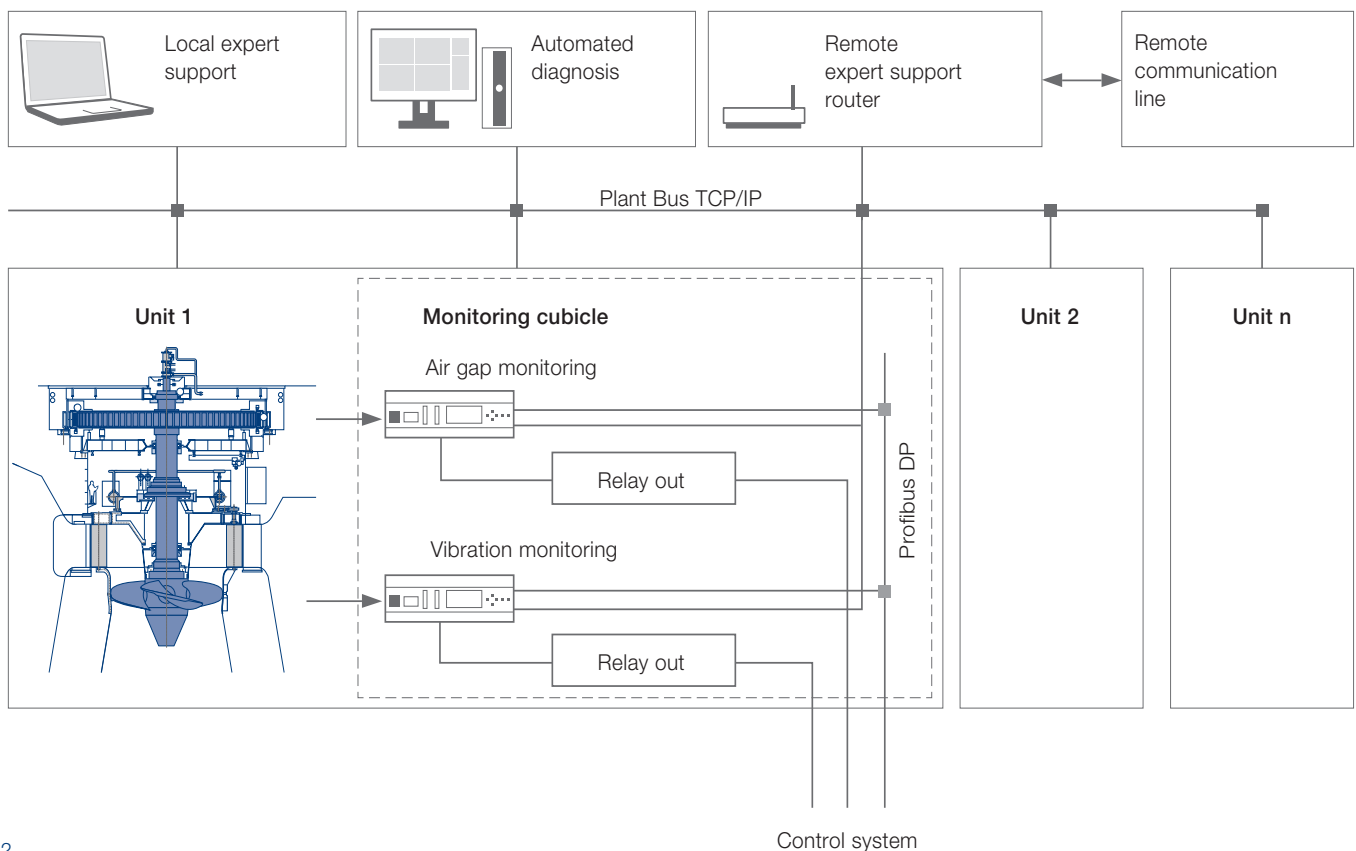
- Monitoring
- Analysis
- Diagnosis

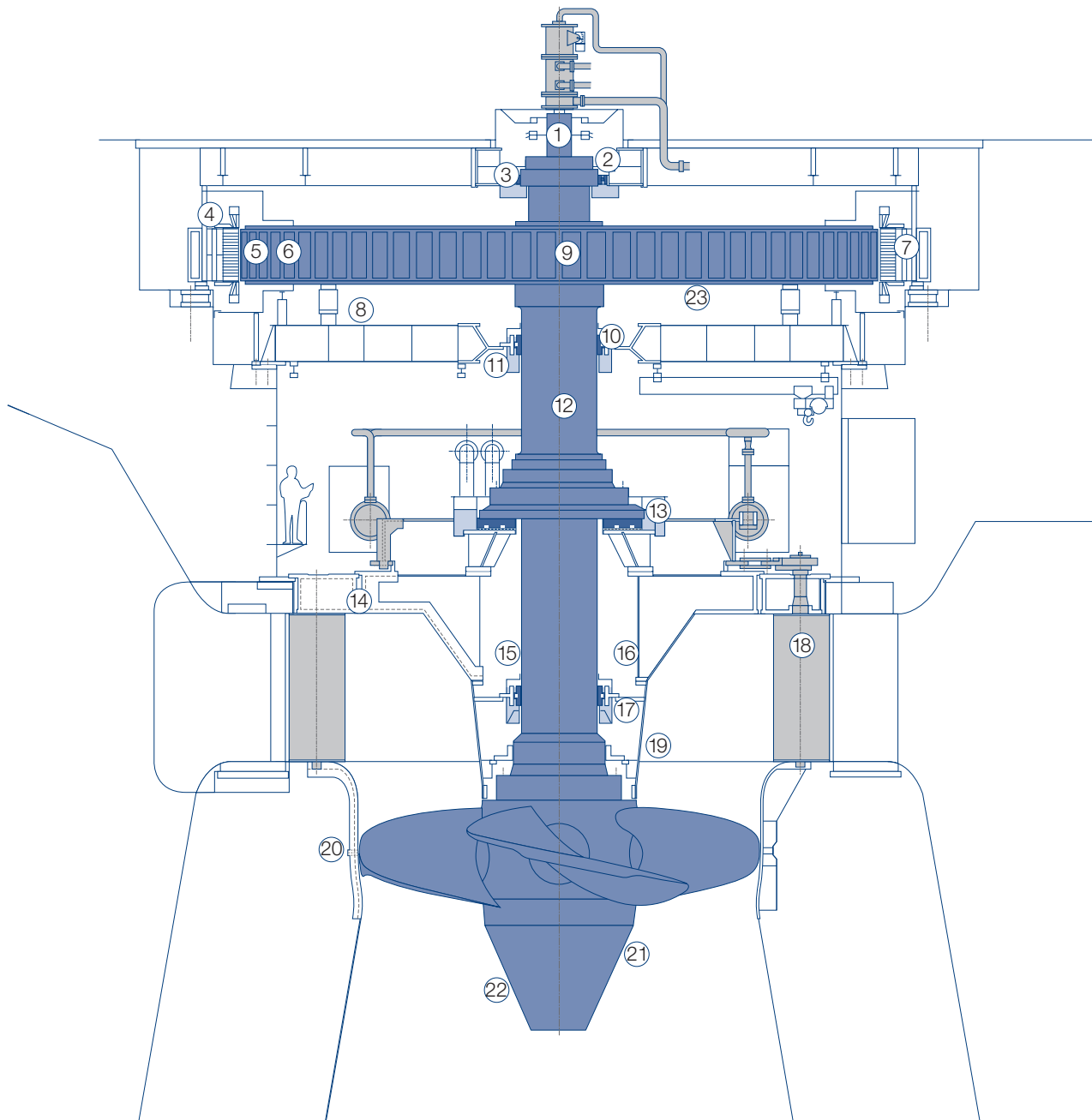
We also offer flexible solutions for hardware configuration and integration to be implemented into your existing plant control system.

Benefits using HyCon MD:

- Optimized total costs of ownerships
- Reduced costs
- Increased availability
- Voith Hydro know-how implementation

Hardware configuration





- | | | |
|------------------------------------|---|-------------------------------|
| 1 Keyphasor | 9 Partial discharge | 16 Shaft relative vibration |
| 2 Absolute bearing vibration | 10 Absolute bearing Vibration | 17 Absolute bearing Vibration |
| 3 Shaft relative vibration | 11 Shaft relative Vibration | 18 Wicket gate vibration |
| 4 Stator End Winding Vibration | 12 Shaft current monitoring | 19 Labyrinth gap (Francis) |
| 5 Air Gap | 13 Axial Thrust Vibration/
Movement and Oil Film Thickness | 20 Runner Gap (Kaplan/ Bulb) |
| 6 Magnetic flux | 14 Turbine headcover vibration | 21 Cavitation monitoring |
| 7 Stator Core Vibration | 15 Turbine temperature monitoring | 22 Pressure |
| 8 Generator temperature monitoring | | 23 Ozon monitoring |

Monitoring and protection interface

Reliable measurement and signal processing plus a well-engineered unit protection concept are considered to be of paramount importance for plant safety.

Monitoring

The highly sensitive measuring systems that are adapted to the requirements of hydropower machines ensure effective condition-based monitoring and maintenance, and thus increase the life cycle of rotating machines as well as increasing plant availability and reliability.

To provide plant safety, the primary tasks of monitoring are to:

- Identify the plant's individual optimum condition
- Recognize imminent damage early on
- Optimize modes of operation
- Allow for scheduled maintenance

For complex excitation mechanisms with high dependency on specific operation conditions of the unit, special monitoring techniques are applied. The HyCon MD monitoring module evaluates all measurements and characteristic values as a function of operation mode and operation point.

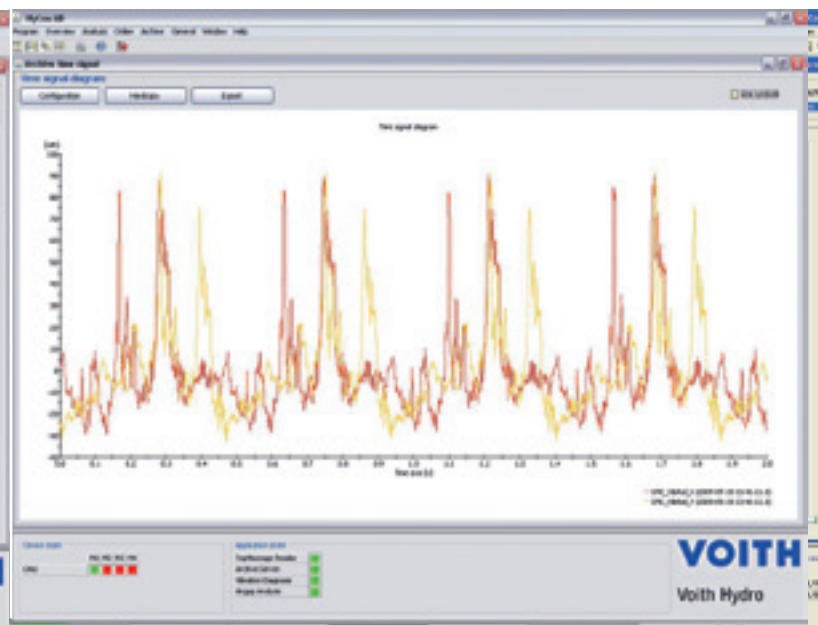
Protection interface

Our data acquisition devices include logical functions based on parameters that generate trip signals to be transferred to the mechanical protection of the unit. This requires simple and reliable solutions that, at the same time, need to be flexible to meet various machine characteristics that are highly dependent on operating conditions.

Monitoring



Time Signal Diagram



Intelligent measurement and analysis for additional benefits

In order to add on benefits for plant operators, our systems are designed to efficiently support predictive maintenance strategies.

More than monitoring

Most monitoring systems only measure values and create alarms based on limit values. In order to extend the benefit for the plant operator, the system must be able to efficiently support preventive maintenance strategies.

To fulfill this demand the following prerequisites must be met:

- Highly sensitive measurement technology with adapted analysis techniques
- Diagnostic intelligence for proper selection of specific parameters and comparison of the measured values with the expected behavior, depending on specific plant conditions and machine operation modes
- Tailor-made systems to meet specific conditions such as very low speed or various operating modes with highly volatile excitation requirements
- Precise machine monitoring through intelligent measuring and analysis systems covering analytic evaluation of pre-processed values from the measurement device, for example frequency analysis providing frequency-selective observation results, and the calculation of further hydro specific characteristic values.

Our modules are specifically designed to meet these advanced requirements.

Statistic module

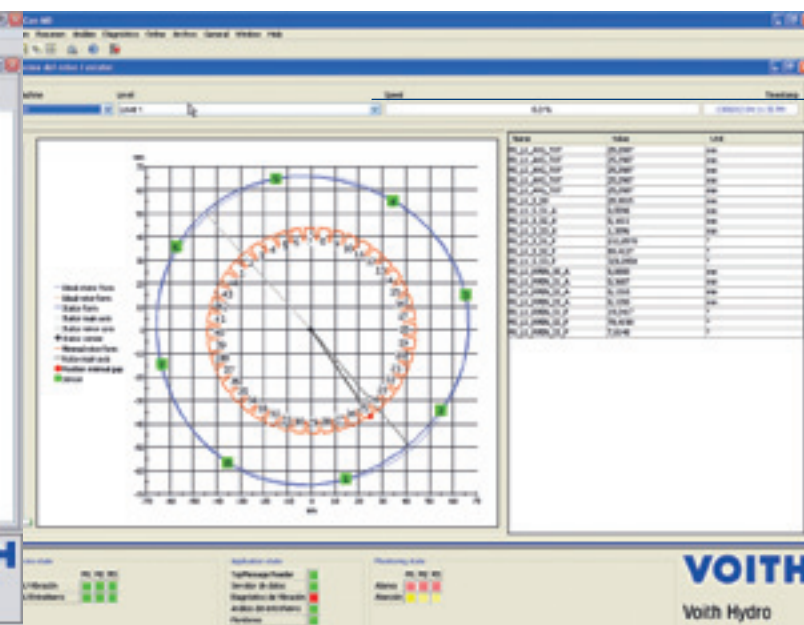
To increase the information content of for e.g. vibration signals, as well as to represent the great variety of vibration-related factors, our statistic module is flexible to provide measurement values from any desired process variable. Different measurement planes, signals and key parameters can thus be compared.

HyCon MD functions

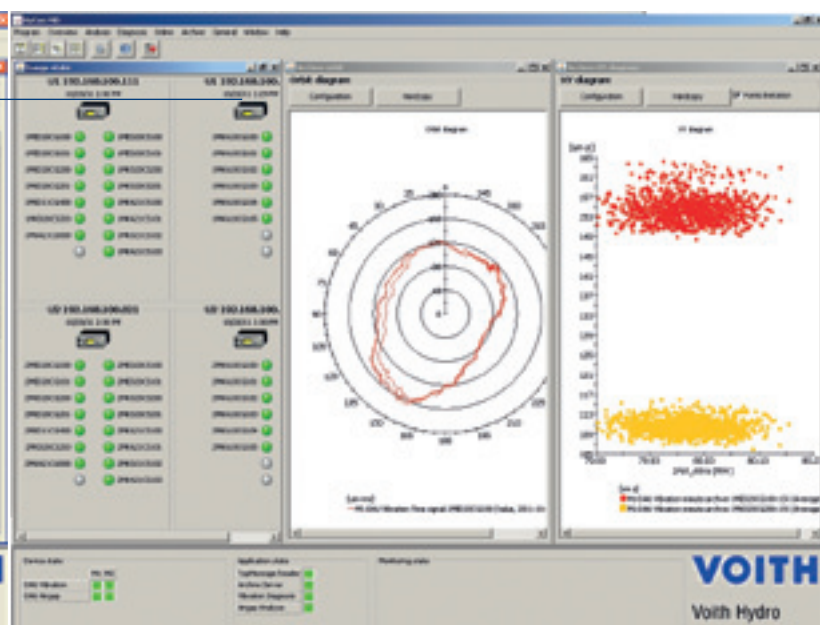
The HyCon MD system is a scalable system with several functions which will be adapted to the power plant requirements. The graphical user interfaces will also be configured according to the requirements.

- Vibration Diagnosis - VD
- Air Gap Module - AG
- Reporting Tool - RT
- Event Data - ED
- Internal Simulation

Rotor Profile



Shaft Orbit Diagram



Automated diagnosis: Value added for the operator

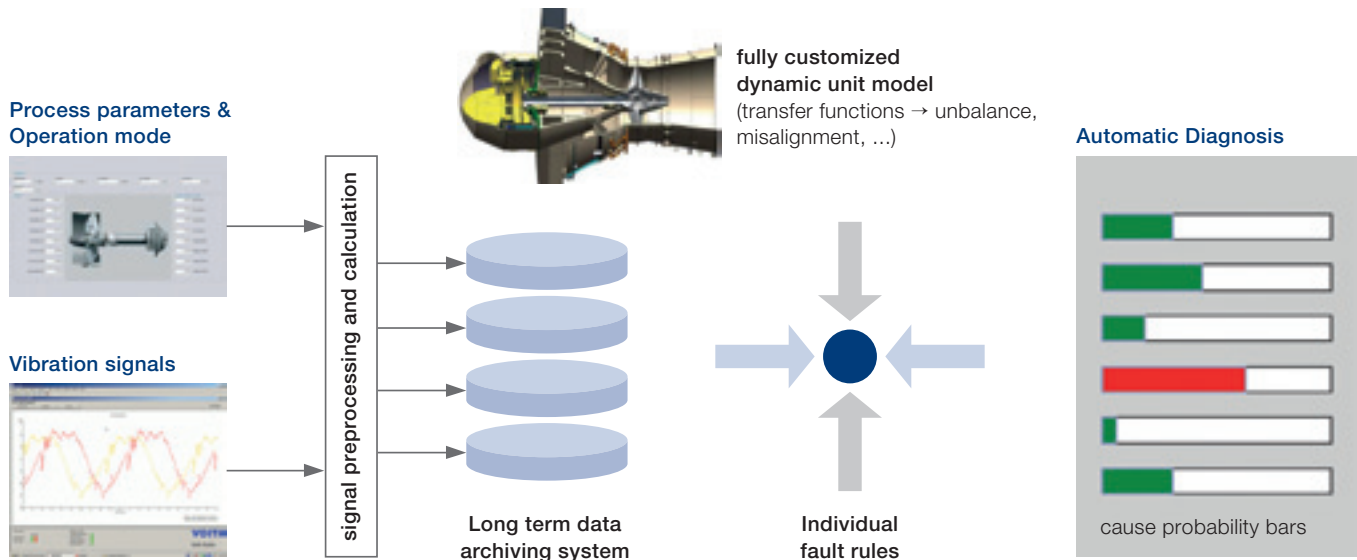
HyCon MD with its flexibility and adaptive modular configuration provides a powerful tool for you to do reliable diagnostics for safe operation all the time.

Many monitoring systems are available, which are able to measure and present the results using standard evaluation methods. In contrast, Voith, as an equipment manufacturer, understands the process and knows how to interpret these measurements. This knowledge is integrated in the HyCon MD system – a clear added value for the plant operator.

In order to automate diagnostic tasks, a knowledge database processes the results of the analysis. The database is adapted individually to each unit and is largely based on fully customized dynamic machine models.

A mathematical model of the unit ensures quantitative and qualitative evaluations since it incorporates the highest process know-how and all existing mechanical couplings as in the real machine. In addition, the owner's operational experience can be integrated into the knowledge database. The diagnostic module is structured with configurable sub-modules.

Diagnosis module process



Diagnosis user interface

Clear and basic information on the machine's condition is presented to the operator through user-friendly interfaces. Whenever information about a problem becomes evident, the results are passed to the user as a list of clearly identified failure causes including error probabilities.

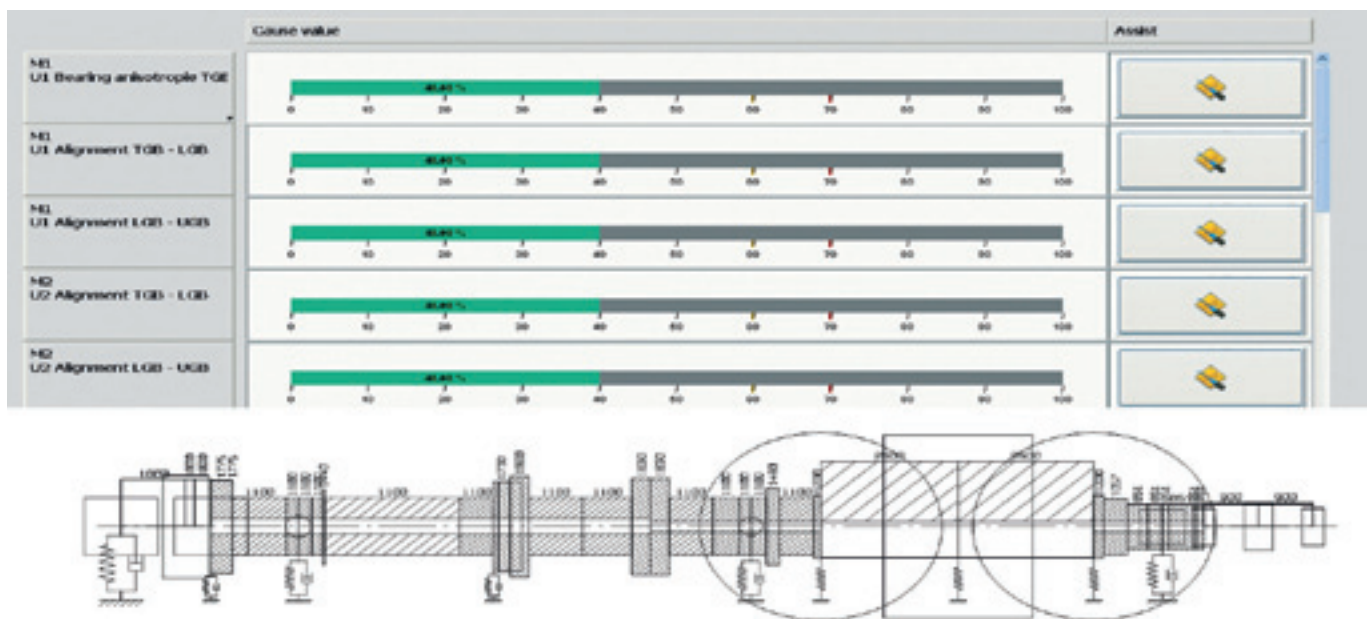
In addition, each failure is described in detail with recommendations on how the user should proceed. However, if the unit is in good condition, only condensed information is given to the user without the burden of too many details.

Evaluation module

The key to automated diagnosis is our knowledge-based evaluation module that is capable of recognizing a variety of error patterns. To monitor an actual machine condition at any point in time, all characteristic values are checked for limit violations. Trend analyses provide information on time sequences of characteristic values, and failure analysis is performed at regular intervals or in case of limit value violations.

As a result, abnormal behavior leads to processing of probabilities for various error patterns. The cause of the abnormality can thus be clearly identified. In case of the identification of an unidentified new fault pattern, our evaluation module is designed to constantly incorporate the new information into the knowledge base.

Diagnosis user interface



Model based diagnosis

Rotor dynamic analysis models play a crucial role during the design process of a hydropower unit. These analysis models are used to define complex transfer functions, which diagnoses special phenomena, for example those caused by different exciting forces. Moreover, the quality of this model is considerably improved through the correlation with readings from vibration measurements during the operation of the module.

Balance module

A balance module calculates current unbalance in various planes, using readings from vibration measurements and calculated information from a detailed dynamic shaft analysis. Changes in the balance can be clearly diagnosed this way, particularly through trend analysis. Furthermore, the hydraulic and electrical influences can be separated using this method.

Voith Hydro Remote Service: Just like sitting in front of the real PLC (Programmable Logic Control System)

Voith offers a safe remote access from a central server to your HyCon MD installation on site.

With this safe access possibility (only registered Voith specialists will have access to your HyCon MD), we can provide additional services and guarantee an even faster and better customer service.

This will help you to enhance the profitability of your plant by:

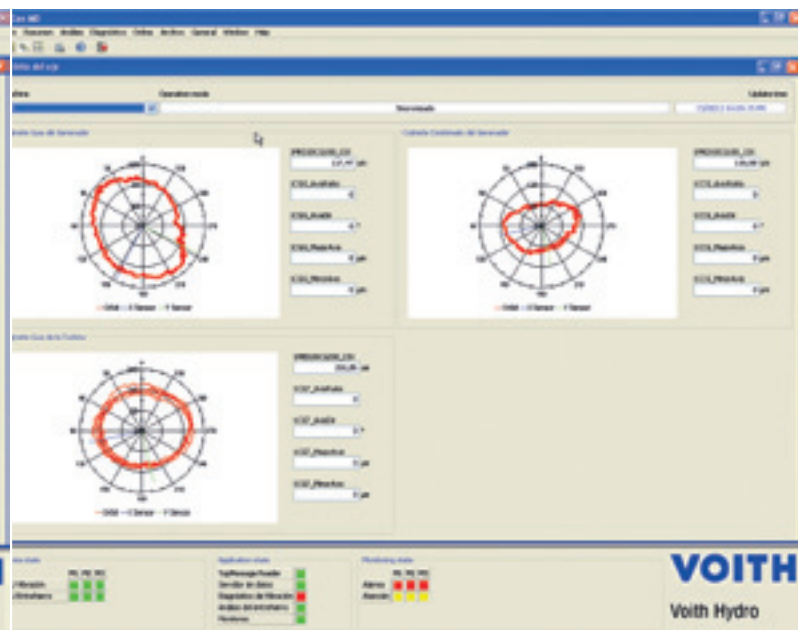
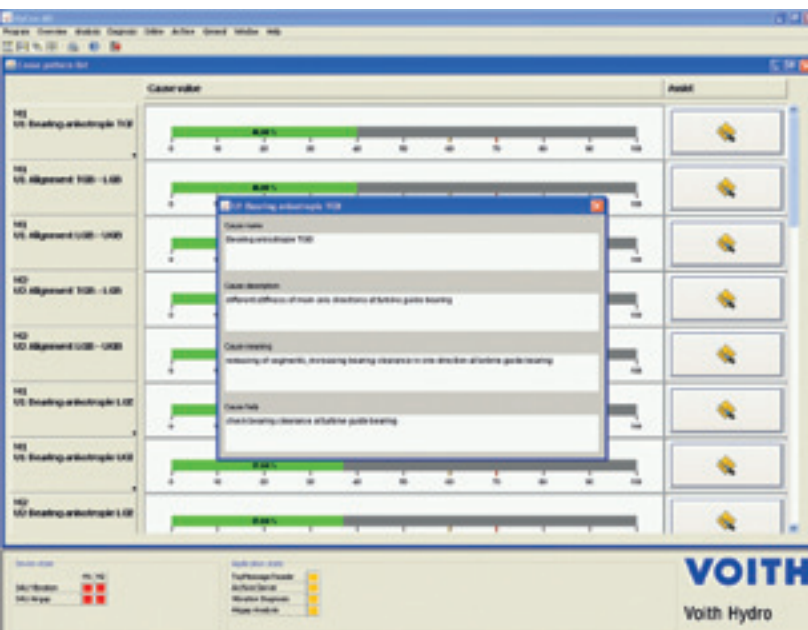
- Remote Updates of HyCon MD
- Remote support and quick analysis in case of unforeseen unit standstills w/o Voith specialists going to site
- Cyclic assessments
- Commissioning, troubleshooting and analysis can be centrally supported by specialists
- Remaining works via remote access (parameter settings and configuration)

Voith is also offering a wide range of service contracts which will help you to optimize the plant conditions. There are several options for these service contracts, such as:

- Evaluation of the machine condition
- Analysis of anomalies
- Recommendations for the correction of defects or advanced measurements to detect them
- Remote trouble-shooting and system update
- Check of monitoring and data archiving system
- Alert and trip optimization
- Predefined rates for additional services (e.g. on site)

Unbalance representation

Shaft orbits





1 Picote, Portugal

2 Omkareshwar, India

2004 Asswan High Dam, Egypt
HyCon MD for 12 x 175 MW (Francis units)

2006 Tai 'an, China
HyCon MD for 4 x 250 MW (Pump turbine)

2007 Omkareshwar, India
HyCon MD for 8 x 65 MW (Francis units)

2007 Lotru, Romania
HyCon MD for 3 x 170 MW (Pelton units)

2007 Baguari, Brazil
HyCon MD for 4 x 36 MW (Bulb units)

2007 Herdecke, Germany
HyCon MD for 1 x 150 MW (Pump turbine)

2010 Ferreira Gomes, Brazil
HyCon MD for 3 x 86 MW (Francis units)

2011 Picote, Portugal
HyCon MD for 1 x 248 MW (Francis unit)

2011 Amoya, Colombia
HyCon MD for 2 x 40 MW (Pelton units)

2013 Yacyreta, Argentina
HyCon MD for 20 x 145 MW (Kaplan units)

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