Brüel & Kjær Vibro

uptime magazine

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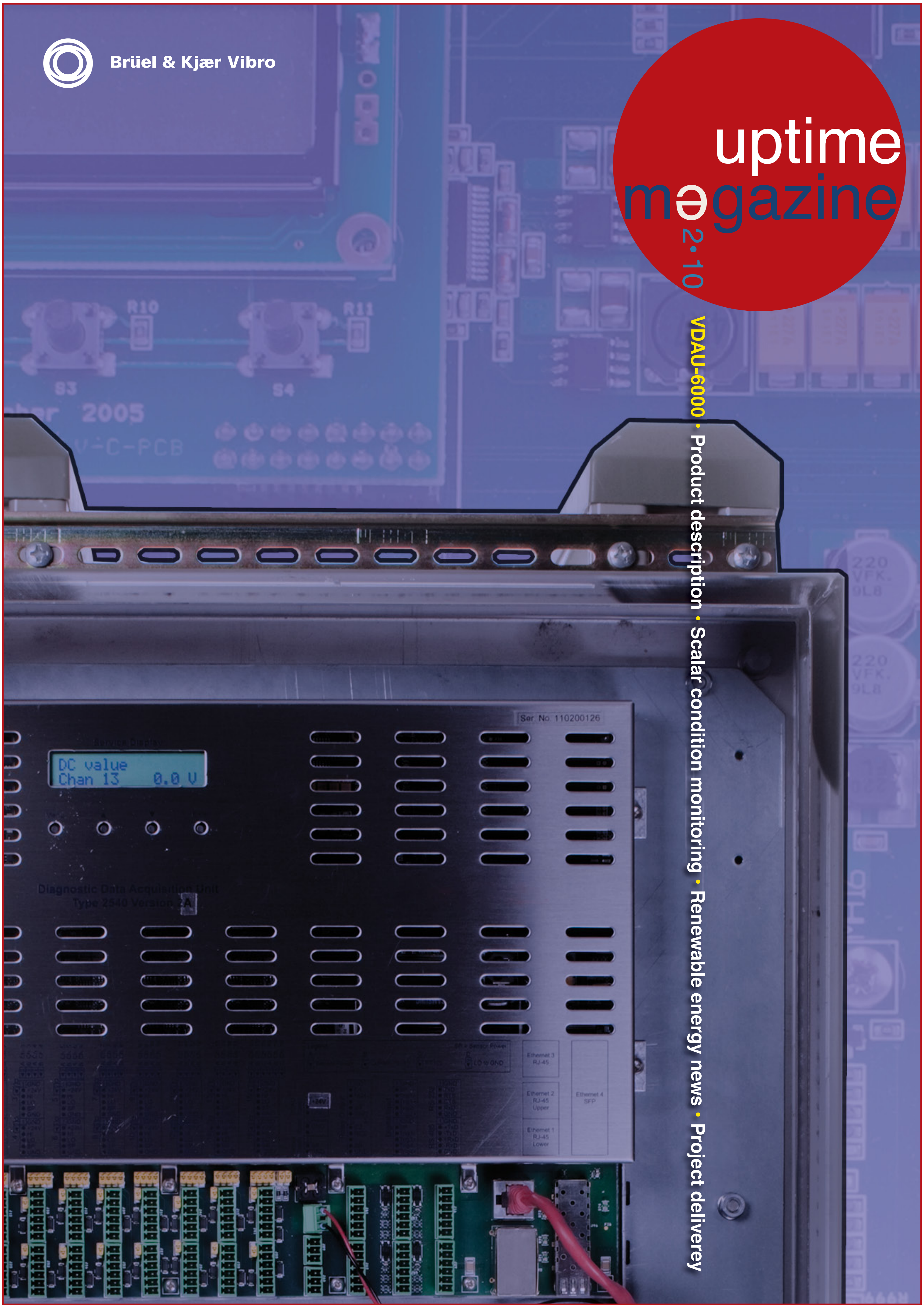
VDAU-6000 · Product description · Scalar condition monitoring · Renewable energy news · Project deliverey



uptime megazine 2•10

Brüel & Kjær Vibro

Uptime Megazine is a newsletter published by Brüel & Kjær Vibro to keep you up-to-date with new machine monitoring trends and technologies. This issue focuses on the VDAU-6000 Condition Monitoring System launch.

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VDAU-6000 Condition Monitoring System Launch!

It is my pleasure to launch the winter edition of Uptime, which is devoted to the release of the VDAU-6000 condition monitoring system.

This system offers a unique combination of early fault detection and a detailed analysis of the machine's behavior. VDAU-6000 can monitor auxiliary and balance-of-plant machinery as a field monitor mounted next to the machines, including those in ATEX certified areas, or as a condition monitoring extension to an existing safety systems for many types of machines.

The 16-channel VDAU-6000 enables up to 16 measurements to be taken from each channel for early fault detection, alarming and database storage. Controlled by **Monitoring Workstation**, the same monitoring software used in Compass, the fully automatic scalar condition monitoring functionality of VDAU-6000 frees the staff of complicated setups and interpretation, so they can focus their efforts on other maintenance issues (see Technical Focus in this issue of Uptime for more information on this functionality). Specialized narrow-band and tracking measurements have been pre-configured to detect faults such as unbalance, misalignment, bent shaft, eccentric rotors, looseness, rub, cavitation, oil whirl/whip, rolling element bearing faults, etc.

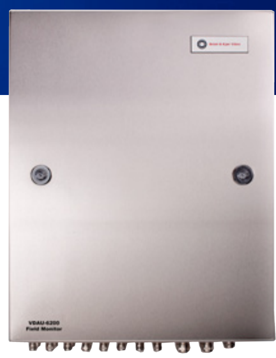
It is widely known that the machinery vibration signature is different for different running conditions, but not all condition monitoring systems take this into consideration. For this reason a unique **process class concept** has been employed in VDAU-6000 to ensure that only data from the same operating condition is monitored to the same alarm limits, in order to avoid false alarms.

Once a potential failure mode has been detected, **Diagnostic Workstation** can be used to provide in-depth analysis of the fault, which includes diagnostic measurements such as the raw time signal, FFTs, Envelope, Cepstrum, etc. All 16 channels are monitored simultaneously, so it is possible to correlate the scalar monitoring measurements, analysis spectra and time signals for every measurement point. Further information on Diagnostic Workstation will be available in the upcoming issue of Uptime.

Enjoy reading about VDAU- 6000 launch in this issue of Uptime!

Richard Jensen
Product Line Manager
for VDAU-6000

product update



VDAU-6000, Our New 16-Channel Scalar Condition Monitoring System

In October 2010 Brüel & Kjær Vibro launched an entirely new product concept in our condition monitoring product portfolio! The **VDAU-6000** is a family of condition monitoring and analysis systems based on the 16-channel VDAU-6000 vibration data acquisition unit. The VDAU 6000 product range provides a cost-effective condition monitoring solution for monitoring auxiliary machines as a field monitor, or for monitoring critical and auxiliary machines as an extension to any existing safety monitoring system. Optional online analyzer functionality is also available!

This 16-channel field monitor fills an important niche in our online condition monitoring product portfolio between our 1-3 channel compact monitors and Compass 6000 safety, condition and performance monitoring system. Utilising Monitoring Workstation, the same monitoring software used in Compass 6000, the VDAU-6000 database can be seamlessly integrated with existing Compass Classic and Compass 6000 installations.

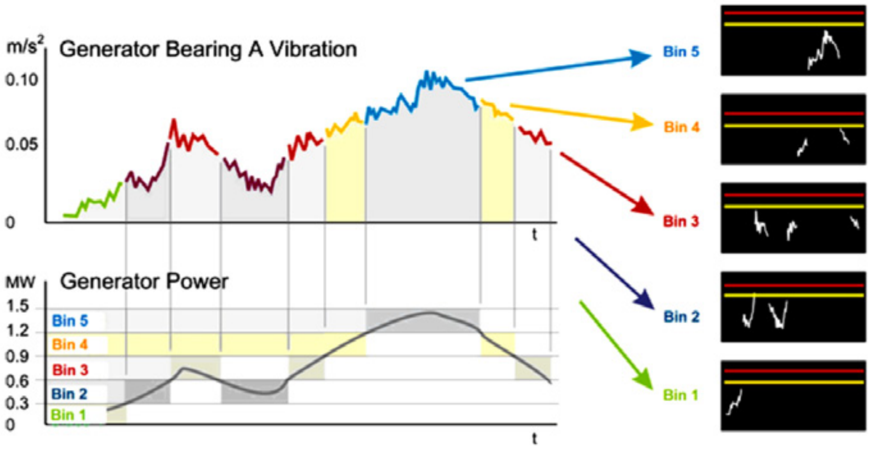


Figure 1. Adaptive monitoring concept.

VDAU-6000 System Applications

Many machines that play an important role in the productivity of industrial plants are monitored only for safety. These machines are adequately protected but no information on the present condition or insight into the development of incipient faults is provided. The VDAU-6000 can use the vibration signals from the buffered outputs of these safety systems to provide a comprehensive scalar condition monitoring strategy that rivals the costly rack-based systems.

Due to the high-channel density and scalar condition monitoring capability, the VDAU-6000 is also ideal for monitoring auxiliary machines, balance-of-plant machines – with or without an existing safety system, and applications involving numerous identical machines. The VDAU-6000 is well suited for both high-speed and low-speed applications, as well as fixed and variable speed machines.

Fault detection and Identification

VDAU-6000 is an automatic condition monitoring system that continuously acquires data at fixed user-defined intervals. The scalar measurements consist of broad-band and narrow-band measurements that are optimal for detecting incipient faults in machines supported by sleeve or rolling-element bearings. It can also be used for detecting flow disturbances in pumps and compressors, and machine-specific problems such as unbalance, misalignment, defective foundations, resonances, electric motor type problems, structural faults, etc. Refer to the technical focus article on Scalar Condition Monitoring in this issue of Uptime.

Adaptive Monitoring

The effectiveness of a monitoring system lies in the ability to detect developing faults at an early stage, without generating false alarms, despite speed and load changes. The VDAU-6000 uses the same proven adaptive monitoring concept that has been successfully used for years in the Compass family of condition monitoring systems.

VDAU-6000 System Configuration

The VDAU-6000 is a networked system consisting of the VDAU-6000 monitors, the condition monitoring server and database, and the client computers running **Monitoring Workstation** and **Diagnostic Workstation software** as shown in Figure 2. As a field monitor application, a number of the monitors can be connected together on-site by a LAN network, which is connected to a single condition monitoring server. One of the major benefits of VDAU-6000 is that it can be connected to an on-site condition monitoring server already being used by an existing Compass system for monitoring, for example, critical machines. Measurement data and alarm information can be easily accessed from any client computer on the network. VDAU-6000 can also be connected to an existing safety monitoring system, as shown in Figure 2, to add condition monitoring capability. Machines previously configured only with safety monitoring can be thus condition monitored for early fault detection with minimal effort, and without the need for installation of sensors or additonal wiring.

Measurements and Sensors

VDAU-6000 offers extensive monitoring capability. The 16 independent channels on a single unit provide

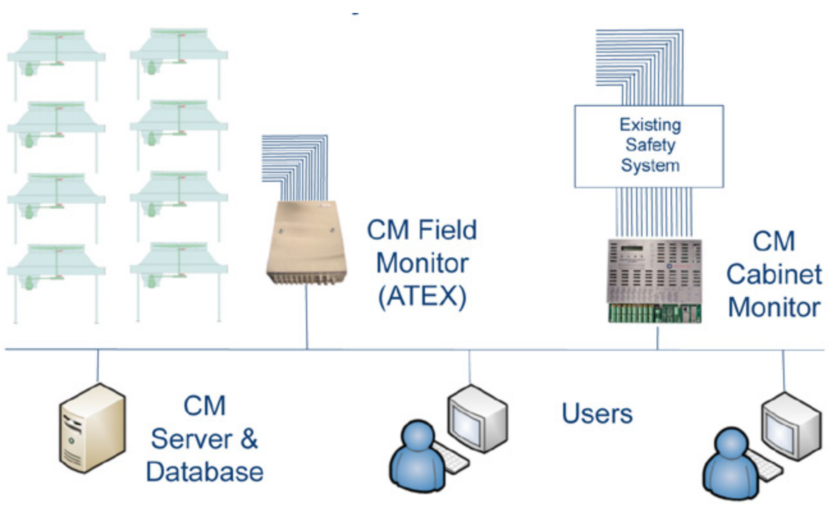


Figure 2. VDAU-6000 system configuration.

more than 200 individual measurements. This enables standardized setups for a broad range of applications that minimize the work on the operator.

The measurements are based on narrow-band and broad-band band pass measurements, i.e. scalar condition monitoring. They are pre-defined to detect the characteristic fault frequencies for the machine. This reduces diagnostic complexity while enabling early fault detection. The measurements used in VDAU-6000 include:

- DC – Displacement sensor gap voltage, process parameters
- Variable BP - Running speeds, harmonics, tooth/blade passing, etc.
- Vector - Magnitude and phase (0.5x, 1x, 2x, 3x, ...)
- Envelope - Bearing fault detection
- Tacho - Speed/Phase and Reference

A wide range of sensors can be used as inputs for the 16 input channels:

- Accelerometers
- Displacement sensors
- Process sensors

VDAU-6000 System Components

Data Acquisition Unit

The VDAU-6000 hardware is designed to the highest standards for use in the most demanding applications. The compact 16-channel unit simultaneously processes all channels in parallel, without scanning or multiplexing. This makes it is easy to correlate all the data, especially for complex machines.

The VDAU-6000 acquires scalar vibration data, processes parameters and raw time signals (waveforms), and exports these to a remote condition monitoring system server and database for storage, trending, early fault detection and alarming. The hardware can be installed in a robust enclosure close to the machines as a field monitor (including in ATEX Zone II areas), or it can import vibration signals from buffered outputs of an existing safety system located in an instrument cabinet. Data is exported via a LAN output at fixed, user-defined intervals.

Software

The VDAU-6000 Condition Monitoring and Analysis system has a powerful user interface and database. The standard **Monitoring Workstation** condition monitoring software is the same type of software used in our rack-based Compass 6000 safety and condition monitoring system. It is Windows based and displays all monitored data in easy-to-use plots, together with event and alarm information. It provides an at-a-glance overview of all the machines monitored and intuitive user friendly navigation through the tags, alarm lists and view screens to find a specific event. The optional **Diagnostic Workstation** provides advanced diagnostic measurement capabilities for performing in-depth online vibration analysis. The time signal can be simultaneously recorded and saved on all 16 channels for post-processing. A versatile analysis tool kit can be used to generate FFTs, envelope, cepstra, etc. from the raw time signal.

Conclusion

The high channel density of the VDAU-6000 makes it an economical option for providing condition monitoring functionality for non-critical auxiliary machines as a field monitor, or all types of machines as a condition monitoring extension to existing safety systems. With the online analyzer function, VDAU-6000 provides additional functionality for diagnosing potential failure modes from both simple and complex machines.

Contact your local Sales representative for more information or a live demonstration, or e-mail us at info@bkvibro.com ■

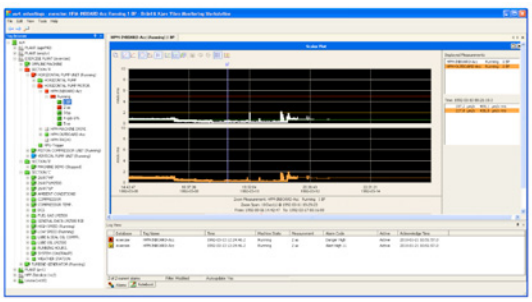


Figure 3. VDAU-6000 data acquisition unit shown in its field monitor enclosure (left), Monitoring Workstation software (centre), Diagnostic Workstation software (right).

technical focus

Scalar Condition Monitoring

VDAU-6000 uses scalar condition monitoring for detecting and identifying incipient machine faults. What are the benefits of SCM?

The primary purpose of a condition monitoring system is to provide measurement and alarming capability such that potential failure modes can be reliably and accurately detected, diagnosed and prognosed at an early stage. What information is needed for a developing machine fault to be detected reliably and early? As a generalization, the location of a fault is related to its vibration pattern, the type of fault is often related to its phase (in relation to another sensor, at the other end of the shaft for example), the severity of the fault is related to the vibration amplitude and the lead-time to maintenance by its trend. This fault information lies in the raw vibration time signature coming from the sensor but it is not readily evident. There are a various techniques for extracting this information, but two widely used techniques – both of which are based on isolating the individual frequency components - are:

- Frequency filtered narrowband band pass measurements (scalar values)
- Calculated Fourier transform function (FFT - spectral values)

The choice of technique depends on how early the fault should be detected and how much diagnostic specialist time the end-user is willing to use for this purpose.

FFT – Perfect for early fault detection and analysis

An FFT is a time signal that has been transformed into the frequency domain as a spectrum - see Figure 1. Each of the fault frequencies are separated from the other frequency components, thus making it easier to identify the symptoms of a developing fault. However an FFT provides a lot of information, not just the machine fault frequencies! Looking at Figure 2, in addition to the typical fault frequencies there are also frequencies related to the running speed of the machine (i.e. harmonics, blade passing frequencies, tooth meshing frequencies, etc.), frequency components not directly related to the running speed (i.e. asynchronous signals, as for example vibration coming from a nearby machine), and a host of other frequency components such as structural resonances, friction, flexing and even frequency components that result from the addition/subtraction of other signals.

Very early fault detection can be achieved with an FFT, but due to the complexity of the signal, the FFT is predominantly suited for diagnostic purposes where a specialist is needed. It is not well suited as an automatic monitoring function. It's possible of course to monitor an FFT to alarm limits and this is often done for special applications. The only drawback is that it requires some expertise to set it up and to diagnose the developing faults. If there are speed variations, the contoured alarm limits have to be wide enough to accommodate these changes but narrow enough to prevent nearby peaks of "invading" this contoured alarm space.

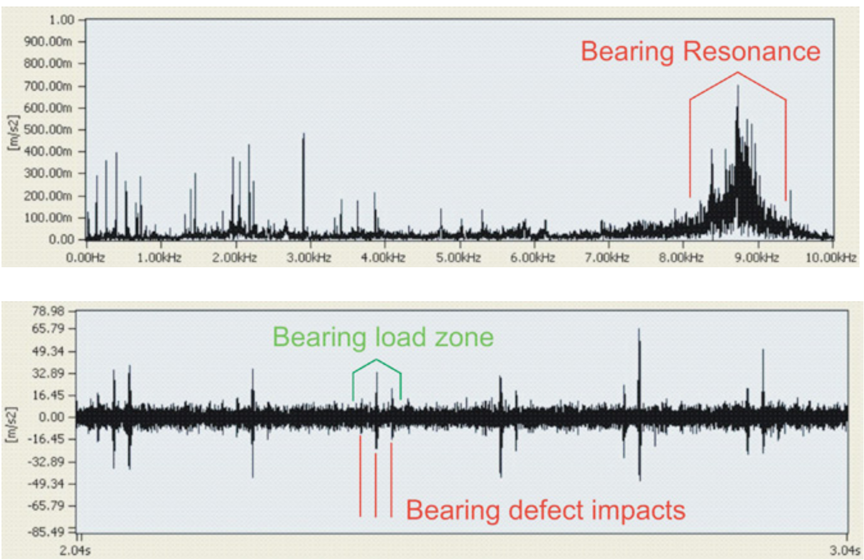


Figure 1. A time signal (bottom) and the FFT spectrum that it was generated from it (top). In this example an inner race bearing fault is visible in the time signal but not in the spectrum: The bearing fault impacts, however, excite the bearing components resonance, which is visible in the spectrum.

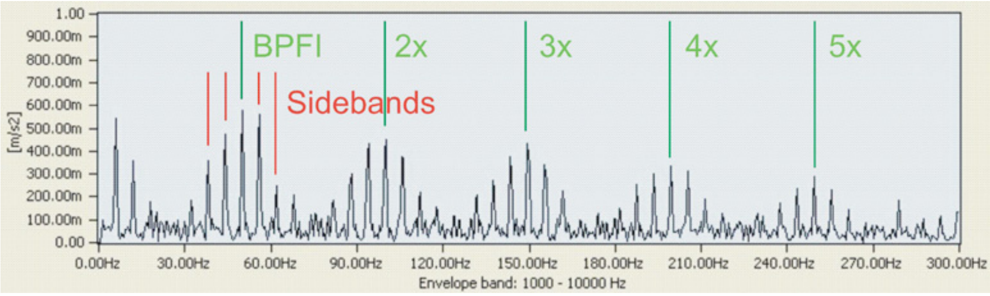


Figure 2. Frequencies of interest shown on an envelope plot. This spectrum was created from the time signal in Figure 1, and more clearly shows the bearing defect frequencies that are not visible in the FFT. VDAU-6000 offers a unique bearing fault detetion bandpass, called Envelope Condition Unit (ECU), that is the root mean square value (RMS) of all the values shown above. This scalar mearsurement is ideal for automatic early fault detection.

Scalar measurements – Perfect for automation

The simplest, fastest and most effective method for monitoring machine faults without the need for extensive expertise is by the use of scalar measurement techniques. These are narrow-band band pass measurements that are filtered to span the frequencies of interest and are proportional to the energy content of the vibration within the selected frequency range. These are defined to correspond to specific machine fault frequencies.

One of the primary differences between a narrow-band band pass measurement and an FFT is that the scalar value is a measured value, not a mathematical transformation. This means non-periodic impacts can also be monitored through such scalar measurements. In addition, scalar measurements are more reliable, repeatable and less vulnerable to small speed variations than an FFT and can be measured more often. An additional benefit is that the measurements are set up ahead of time, thereby lending themselves to fully automated operation without the need for specialist intervention to manually extract this information from an FFT. Scalar measurements are also easy to use with a tracking filter. If the machine speed changes, a tracking filter is used to “follow” the speed. Scalar measurements are typically set up to detect standard fault mechanisms such as unbalance, misalignment, bearing faults, gear faults, etc. and to provide a general warning for other machine condition changes. The scalar measurement is often used to simply detect and identify a developing fault, which can then be analyzed in more detail, if needed. If the scalar measurement is not set up for an unexpected developing fault, then this will not be detected. Here an FFT could be used.

Conclusion

VDAU-6000 allows machines to be automatically monitored with narrowband scalars, and the Diagnostic Workstation provides further in-depth analysis functionality, such as FFT, envelope, cepstrum, etc.

Narrow band scalar measurements provide early detection of incipient machine faults and as such are well suited to automatic condition monitoring of non-critical auxiliary machines. Spectral measurements (such as FFT, envelope, cepstrum, etc.), on the other hand, provide in-depth diagnostic information and fault detection capability but require specialist time for interpretation and require fine-tuning for automatic monitoring applications. The FFT is often used for critical machines as the extra costs associated with the specialist time is easier to justify, but it is less likely to be used continuously when monitoring auxiliary machines. ■

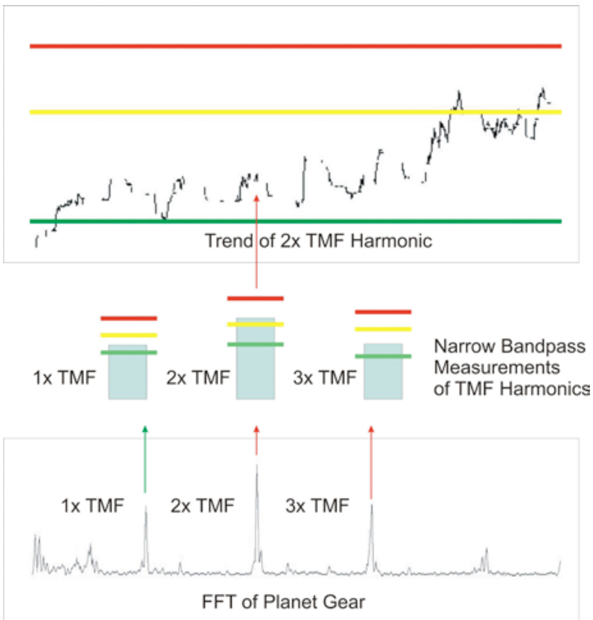


Figure 3. Another example of narrowband frequency bandpass measurements (middle) shown above the corresponding FFT frequency peaks (bottom). The narrowband trend (top) indicates a developing gearbox fault over a 2 month period.

Bearing fault detected during warranty

This is a reprint of a paper written by Walter Pilgerstorfer and Mike Hastings and presented by Alfred Schübl at the 16th International Seminar on Hydropower Plants, Vienna, Austria, 24-26 Nov., 2010

Summary

Unrealistically high shaft vibrations caused the end-user to question the validity of the vibration monitoring system. With the turbine still under warranty, the turbine manufacturer was asked to evaluate the situation, and they agreed with the end-user that the results from the monitoring system were dubious. The technician from Brüel & Kjær Vibro was called in and looked at the system and results and quickly determined that the monitoring system was actually functioning properly. How can he convince the end-user and machine manufacturer? A simple test with feeler gauges during start-up of the machine confirmed the validity of the results from the monitoring system. It was later determined that defective shaft bearings, which were eventually replaced under warranty, were the cause of the excessively high vibration levels detected by the monitoring system.

Introduction

A newly installed 140 MW vertical Pelton hydro-generating unit was installed and commissioned on-site and had been operating normally since start-up. It was operating with a 590 m head at 375 RPM, and configured with six jets and a Pelton wheel with 21 buckets. It was used primarily for peaking.

Abnormally High Vibrations Detected

While still under warranty, it was noticed that the running-state vibration of the turbine bearing increased from 29 μm to 70 μm. The vibration during run-up was at around 350 μm but this steadily increased to 1000 μm, causing the turbine to trip. Both the monitoring system manufacturer and the turbine manufacturer were contacted to assess the high vibration levels.

Turbine Manufacturer's Evaluation

The turbine manufacturer evaluated the generating unit on-site and agreed with the end-user that it was physically unlikely that such high vibrations could occur on the shaft. Their conclusion therefore was that it was a possible malfunction in the monitoring system or sensor.

Monitoring System Technician's Evaluation

A service engineer from the monitoring system manufacturer arrived on-site to evaluate the operation of the monitoring system. He determined after some initial tests that the monitoring system indeed was functioning normally, and that the high vibrations monitored were the result of a serious fault in the turbine bearing/shaft assembly. These readings were verified by an oscilloscope. As both the end-user and machine manufacturer doubted the readings of the monitoring system and the oscilloscope (where the signals were coming from the same sensors), it was necessary to find another solution to convince them of the accuracy of the monitoring system readings.

Simple Test to Evaluate the Shaft Vibrations

The service engineer chose to highlight the occurrence by using two feeler gauges that were available on site. Feeler gauge measurements were taken during start-up for about a minute. This was documented on video with the measurements of both feeler gauges indicating approximately 1000 μm shaft peak-peak vibration during the run-up.

Conclusion

The end-user and machine manufacturer accepted the results from the feeler gauges and decided to investigate the turbine bearings. The bearing housing was opened and there was evidence that the teflon coating on the bearings was damaged. This had increased the bearing clearance from 0.6 mm to approximately 2.0 mm. At the time of the writing of this paper, the cause for the premature failure of the teflon coating had not been confirmed, however the bearing was quickly replaced under warranty. This saved the end-user unplanned downtime, the expense of replacing the bearing outside of the warranty if it were allowed to run longer, or the costs associated with a catastrophic failure if the defective bearing was allowed to run without replacement. ■

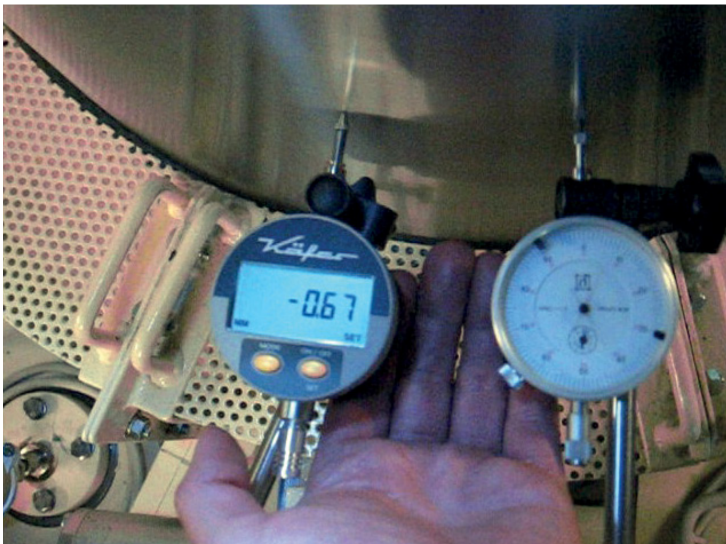
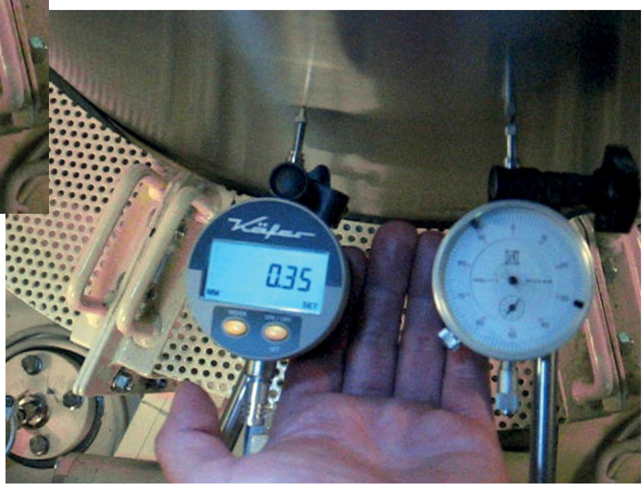


Figure 1. Feeler gauges indicating a zero-peak deflection of -0.67 mm at an instant of time during run-up.

Figure 2. A peak deflection of +0.35 mm is seen at this instant of time during the same run-up. This correlates to a total peak-peak vibration of 1020 µm.



business corner

Brüel & Kjær Vibro's **Project Delivery Group**

What ensures that a customised condition monitoring system is delivered and working for the customer from day one? A professional organization with a lot of experience, a comprehensive product range, highly trained staff, and a well organized project delivery department!

Machine safety and condition monitoring systems have come a long way in the past decade.
A modern plant-wide installation comprises various systems such as Compass 6000, VDAU 6000 and a host of other monitoring sub systems integrated into one comprehensive plant-wide monitoring system. Each system can comprise of thousands of measurements across numerous machines in refineries, offshore platforms, petrochemical plants, power plants and other process industries. The multitude of acquired signals are compared to alarm limits for safety, condition and performance monitoring purposes, and then stored in a robust database for trending and further analysis. From here the data is remotely accessed by various operators from client work stations all around the plant or the world. Additionally, much of the data is also transferred to process control systems, ERP, maintenance management systems and data historians for further processing.

For this to work, a range of hardware and software components have to be engineered, built and installed on-site for such a monitoring system, much of which is customised to the end-user's requirements. During all phases of the project a large volume of information, ranging from complex technical issues to handling logistic tasks, has to be exchanged in a precise and timely manner between several "stake-holders" in the project. Crucial to the success of this implementation, is an experienced, well functioning project delivery group.

The Brüel & Kjær Vibro Project Delivery Group is one of those business functions that could never be created overnight. It is based on vast experience and extensive knowledge of a number of different specialist disciplines. Where else in the organization can you find so many diverse expertises in one group? Here the project engineers have to be familiar with the monitoring strategies, the potential failure modes for machines, international standards on monitoring, safety and data security, IT system technology, documentation, project and contract management, product expertise and testing codes. OK, so not many business units have such concentrated expertise, but is this indeed of any use to the end-user? Absolutely! The Project Delivery Group is completely different from other business units that deliver

standard products. They offer an extensively customised value-added solution to each and every customer that enables the customer to seamlessly implement and integrate a monitoring system into their plant. This ultimately results in:

- Increased machine uptime
- Increased machine efficiency and reliability
- Reduced maintenance expenses

The nature of work necessitates a high level of flexibility within the Project Delivery Group. The projects can be very different across the petrochemical, power and other process industries, and the project services can range from delivering simple instruments to end-users and OEM customers, to providing complete turn-key projects with comprehensive plant-wide monitoring system installations. For this reason, depending on the project requirements, there are a number of Project Delivery services that can be offered either individually or as a combined offering.

Project management is one of the most important project delivery services offered, especially for large projects where a single point of contact is important for the complete condition monitoring solution. This streamlines the project execution and relieves the customer of stressful and potentially expensive coordination and management tasks. The project manager together with his or her team of specialists coordinates all aspects of a project, including resolution of technical issues, scheduling, manufacturing, testing, installation and training. Brüel & Kjær Vibro has developed effective solutions for coordinating numerous project tasks, much of them customised to meet the various customer requirements, and to enable coordination with the relevant stakeholders including end-users, contractors, OEM suppliers, distributed control systems (DCS) suppliers and other monitoring system suppliers. The Project Group also develops and maintains a broad network of sub-suppliers that are frequently evaluated within the scope of the ISO 9001 QA system.

Another added value for both the contractor and end-user is the factory acceptance test (FAT) services, where the functionality of the monitoring system is demonstrated in the factory in order to avoid costly on-site troubleshooting and re-engineering. You can get a glimpse of the FAT services provided by the Brüel & Kjær Vibro Project Delivery Group in the Spring-Summer 2008 issue of Uptime entitled “A visit to the Brüel & Kjær Vibro Project Group”.

The Project Delivery role ends after commissioning and the customer takes over the delivery, but that is not the end of the story! At this point the after-sales and support group takes over to ensure the system continues to run and deliver value to the customer, either as individual services or as a long-term service agreement. No matter what phase the monitoring system installation is in, whether it be sales, project delivery or after sales support, Brüel & Kjær Vibro’s mission is to ensure true value is delivered and realised! ■

events
2010-2

March 14-17 2011

EWEA 2011

Brussels, Belgium

The EWEA Annual Event is one of the most professional and informative wind energy events. The 2011 edition will be the biggest ever, bringing 10,000 key players together.

http://www.ewec2011.info

April 4-8 2011

Hannover Messe 2011

Hannover, Germany

With its line-up of 13 leading international trade shows, HANNOVER MESSE 2011 will underline its global importance as a showcase for tomorrow's technologies and ideas. Watch out for Brüel & Kjaer Vibro's booth in the Industrial Automation section, hall 15/G40!

www.hannovermesse.de

April 5-8 2011

CEPI 2011

Lyon, France

This newly established event, co-hosted with INDUSTRIE 2011, offers a platform for all those involved in process industries technologies. You will find Brüel & Kjaer Vibro France in hall 10/booth 16.2

www.cepi-expo.com

May 22-25 2011

Windpower 2011

Anaheim, USA

Organized by the American Wind Energy Association (AWEA), WINDPOWER Conference & Exhibition brings together thought leaders, industry experts, and investors combining education, exhibition, and networking to capture the energy of the rapidly expanding wind market

www.windpowerexpo.com

June 7-9 2011

Sensor + Test 2011

Nuremberg, Germany

From Sensors to evaluation: A comprehensive overview of system expertise for measuring, testing, and monitoring tasks.

www.sensor-test.com

June 14-17 2011

Brasil Offshore

Macaé, RJ, Brazil

Brasil Offshore is the biennial conference & exhibition for the Brazilian Offshore Oil & Gas Industry. Macaé is the base of operations for over 80% of Brazil's Offshore exploration. The organisers expect more than 49,000 visitors and over 600 exhibiting companies.

www.brasiloffshore.com

June 15-17, 2011

Offshore Wind China 2011

Shanghai, PRC

Offshore Wind China Conference and Exhibition brings together decision-makers, technical experts and industry professionals to learn about China's market, policy and projects, to present the latest technology and innovation

www.offshorewindchina.com