Brüel & Kjær Vibro

uptime magazine

2·09

Compass 6000 • Product description • Data security • Remote monitoring solutions

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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 Compass 6000.

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This autumn-winter edition of Uptime gives me great pleasure in announcing the successful release of the new Compass 6000 condition monitoring system. This innovative system, built on the successful 20 years service provided by our Type 3540 COMPASS Classic system, is the accumulation of several years of intensive development and testing. It also benefits from the cooperation and feedback from several global end-users and original equipment manufacturers. This ensures that the system we deliver fulfills the customer's application requirements today and into the future.

Is it just another new, untried product on the market? Not at all. Compass 6000 has already been put through its paces during a pre-release in June 2009. Not as a beta site test rig in sterile applications, but sold and delivered as a fully-functional system to a number of key customers. And these customers had the same high expectations for this system as for a standard, fully released product. The results? Very positive! We are proud to say that the Compass 6000 system we are delivering today has on-site operational experience under its belt (more than 10 site acceptance tests completed), and has already been optimized with improvements from this experience.

We are confident that Compass 6000 will be the leading benchmark player in condition monitoring system technology and solutions, not only today, but also in the future.

Condition monitoring has and always will play a critical role in the modern asset management strategy. During the current economic crisis capacity may be cut down in many industries, and even entire process lines may be completely shut down. But that doesn't mean the remaining machines should be operating unreliably, inefficiently or with expensive maintenance costs, high downtime or a high risk of a catastrophic failure. On the contrary! An investment is needed in a monitoring system such as Compass 6000 to reduce these costs and risks and increase uptime. The alternative, which is not recommended, is to do cost-cutting in the maintenance department now, but then pay for it dearly in later years as a result of machine failure.

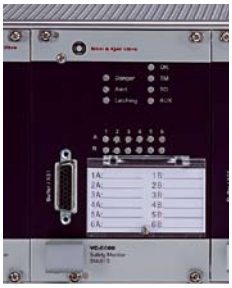
Machine monitoring remains our primary strategic business objective and Compass 6000 is our flagship condition monitoring system. I hope you enjoy reading more about the system and its unique features in this issue of Uptime.

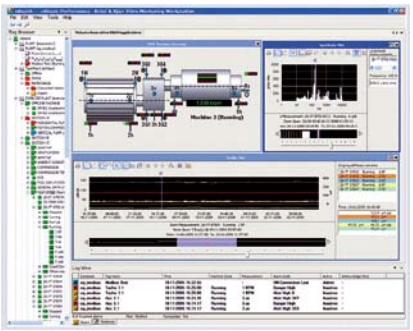
Torben Ekvall
Managing Director

product update

Compass 6000 – A significant step change in condition monitoring

The successful introduction of the new Compass 6000 platform confirms Brüel & Kjær Vibro's commitment to state of the art integrated machine protection and condition monitoring systems. In response to strong market demand for a transformation in the way condition monitoring is conducted, Brüel & Kjær Vibro have invested significant resources and technical expertise to develop the Compass 6000 platform. Not merely a modification or extension of existing functionality, the Compass 6000 platform represents a total bottom up transformation with one primary goal; to assist industry in maximizing machinery uptime, while optimising machine efficiency and reliability with reduced maintenance costs.





What distinguishes Compass 6000?

A plant-wide condition monitoring system is more than just a collection of diagnostic measurements; it is in fact an integral part of the plant's operation. Compass 6000 is connected to several plant systems including the machines, the plant network, DCS/SCADA systems, the emergency shutdown system and a variety of users. It is also indirectly connected to the machine asset management and maintenance systems, service, training and ultimately to the plant's production and its profitability. Choosing a monitoring system such as Compass 6000 therefore requires a far more holistic approach than a simple comparison of technical features.

The Compass 6000 platform has been designed with the following benefits in mind:

- Modular architecture that fits both independent safety and scalable condition monitoring applications
- Intuitive user-friendly interface
- Flexible and extensive alarm approach which enables adaptive alarm management functions
- Improved database management
- Powerful diagnostic and analysis capabilities
- Proven adaptive monitoring strategy implementation
- Extensive remote accessibility while maintaining the necessary security
- All encompassing services

Figure 1. A VC-6000 rack includes one communications module (left) and 1-4 monitoring modules. Power supply modules (optionally redundant) can also be in the same rack or placed in a special rack dedicated to power supply.

The modular structure lends itself to many applications

The Compass 6000 platform is a modular plant-wide monitoring system ideally suited for safety, condition and performance monitoring of machines in the oil & gas, petrochemical, power and heavy process industries.

It is based on a scalable, modular hardware and software platform. This allows Compass 6000 to be cost-effectively configured to fit the technical requirements of nearly any application – thus saving you time and money, and reducing the risk of improper monitoring. This same concept lends itself to extending the monitoring system with experience and plant expansion.

The data acquisition hardware used by the Compass 6000 platform is the **VIBROCONTROL 6000™ (VC-6000™)**. A reliable, robust system designed and built to the highest standards, it comprises a number of standard monitoring modules that can be used with specific machines including but not limited to gas turbines, steam turbines, compressors, hydro-generating units and pumps. This modular concept simplifies the process of building up and fine-tuning the system, while at the same time reducing the risk of incorrect setups. For machines requiring specialized monitoring strategies, there are a series of monitoring modules that are completely flexible and user-configurable. (See the 2008 Spring-Summer edition of Uptime issue for a more detailed description of the VC-6000 monitoring hardware).

The Compass 6000 platform is built up around the **Type 7123 Monitoring**

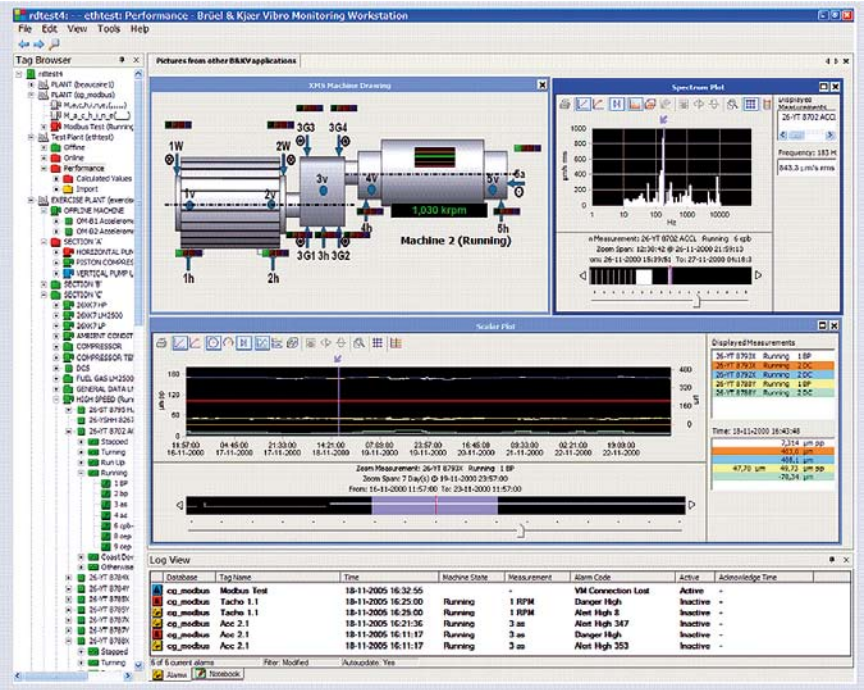


Figure 2. The Type 7123 Monitoring Workstation monitoring software.

Workstation software. This remarkably powerful software package is a modern, Windows-based platform that is highly customizable and easy to use. Most importantly the 7123 is completely independent of the safety monitoring portion of the system, hereby eliminating any risk of impacting the machine protection.

The Monitoring Workstation family of software, each with a common user-interface, is used in several different system configurations:

- **Type 7126 Monitoring Workstation** – Pure safety installations for display and setup without a database
- **Type 7123 Monitoring Workstation** – Safety and condition monitoring (including a database)
- **Type 7122 Monitoring Workstation** (and UPG-3540 upgrade series) – Software that is backwards compatible with the COMPASS classic monitoring system for data and alarm display

The Type 3160 Application modules, which are add-on programs to the 7123 Monitoring Workstation software, provide application module scalability for your condition monitoring requirements. Each module has a group of plots and measurements for a specific task:

- **3160-01 Fault detection and trending** – Basic condition monitoring
- **3160-02 Diagnosis** – Advanced diagnostic and analysis capability
- **3160-03 Performance monitoring** – Monitoring thermodynamic parameters such as efficiency and head for gas and liquid flow machines
- **3160-04 Advisory** – Expert diagnostic program that scans the database for developing fault symptoms

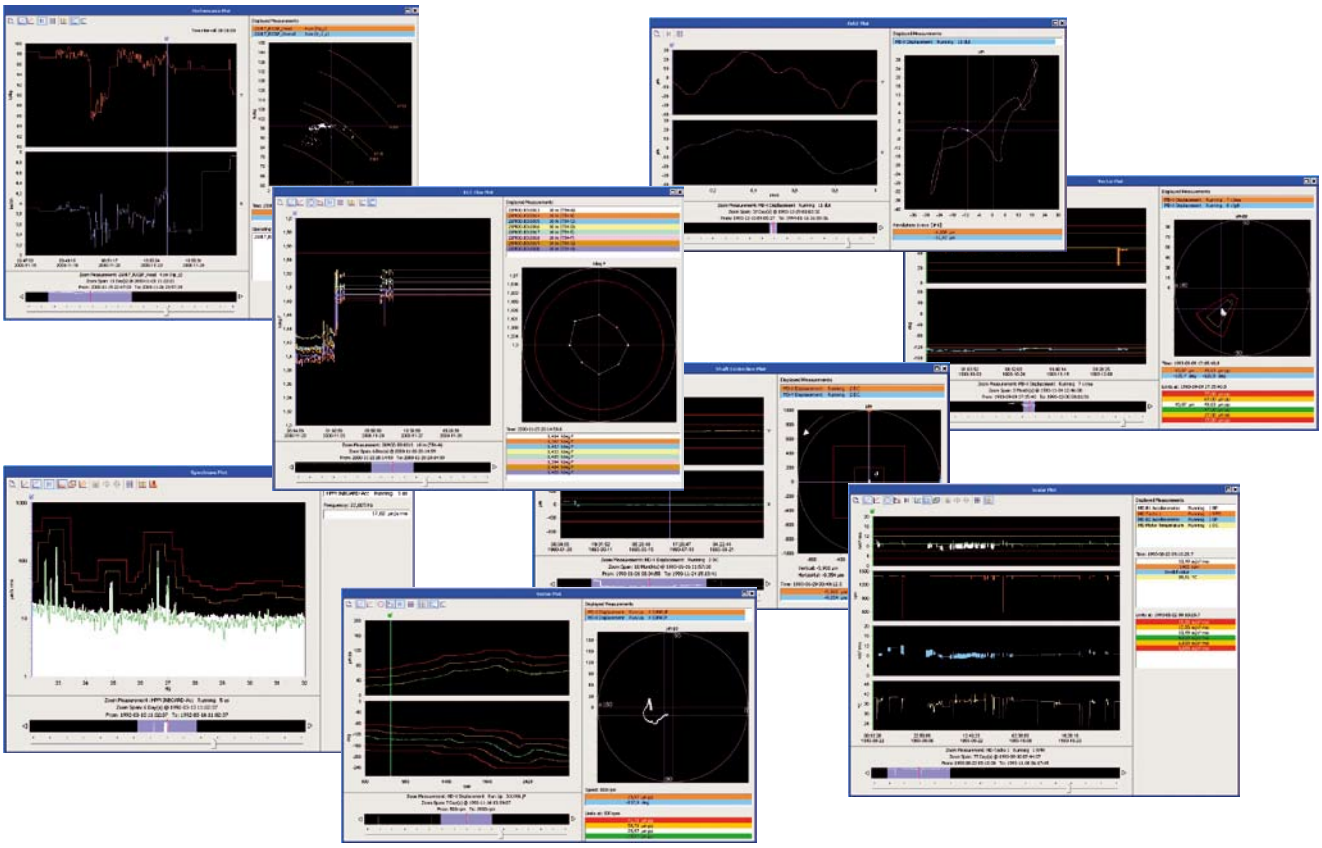


Figure 3. The plots and measurements that can be monitored in Compass 6000 depend on which Type 3160 Application module software is installed.

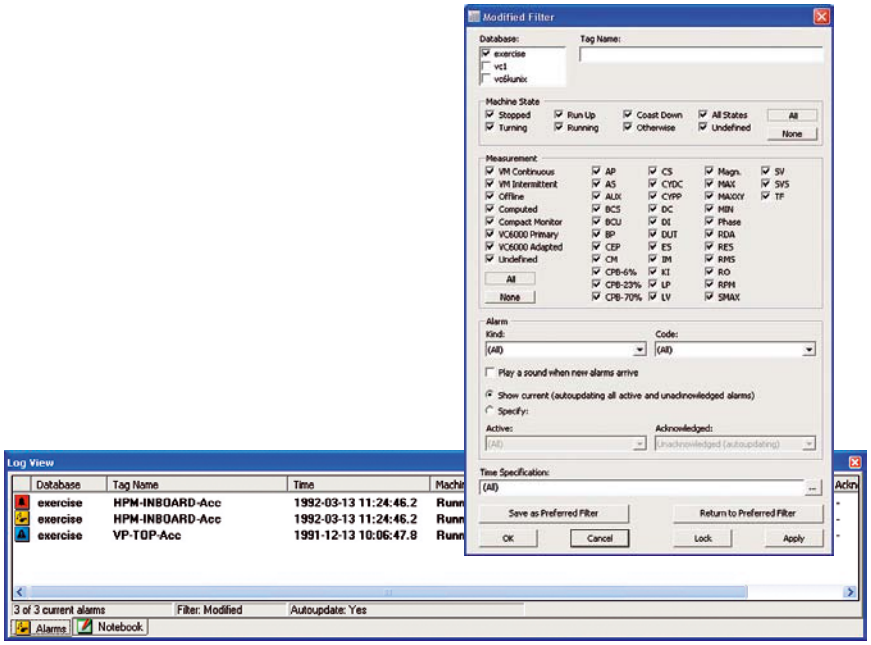


Figure 4. The alarm view log allows alarms to be filtered for different users.

Powerful user-interface

The versatile 7123 software package has been optimised to provide a high degree of operational simplicity and efficiency. Operators, maintenance personnel, condition monitoring experts and managers can all use the same platform for their information needs. The Windows-based functionality is very similar to Microsoft Outlook in look and feel, and therefore easy to learn and operate. It provides streamlined navigation through the machines and measurement points in all databases and displays the relevant alarm status and measurement data - all on the same screen. This provides you a quick overview of the condition of all machines in your plant, making the operation and maintenance decisions faster and easier.

Effective alarm management saves time and reduces risks

The alarm system concept used in the Compass family of monitoring systems has 20 years of experience of proven success. The 3-level alarm concept is used on all measurements - including spectra, transient speed measurements and scalar vs. scalar measurements. One of the new, unique features of the alarm management technology is the alarm log view. In plant-wide applications, where there are many machines, the operators can be overwhelmed by numerous alarms. The Compass 6000 system allows each operator to filter the alarms so they view only those alarms that are related to the particular machines of interest. Alarm filtering can be done not only on machines or machine groups, but also on measurement type, machine states, alarm type, time of alarm, acknowledgement status, or any combination of these. This relieves the operators of the workload of sorting through many alarms, making the job easier and less time consuming.

Effective database management is a core necessity of condition monitoring

Compass 6000 has zero tolerance for data loss, so the database itself has to be robust and secure. Compass 6000 constantly monitors the storage space and volume flow capacity limits in the Oracle® database to ensure optimal reliability. For proper database management there are several important requirements that have been designed into the system. Firstly data overkill is eliminated. The database uses a unique auto-compression technique that allows more data to be saved for a longer period of time compared to conventional databases, thus requiring fewer back-ups. There is high resolution in the most recent data and coarser resolution for the older data, giving 30 years of relevant data that can be accessed and trended. Secondly, it is possible to simultaneously display data from several databases. This is imperative for fast and effective correlation and diagnostic purposes. Thirdly, all data and alarm information is time synchronized and stamped for reliable correlation. Lastly, only significant data is stored. Compass 6000 uses a special dead-band method that does not trigger on noise, to enable relevant, detailed measurement information without unnecessarily occupying database space.

Early fault detection without the risk of false alarms

One of the hallmarks of Compass is the adaptive monitoring strategy. Measurements are monitored to alarm limits that are unique to each operational state of a machine (i.e. duty cycle) and stored separately in the database. This enables any vibra-

tion amplitude or frequency change to be related to the machine condition rather than a change in the operating speed, thus giving early fault detection without false alarms.

The diagnostic and analysis measurements offered by Compass 6000 are extensive, and match the added-cost expert systems of our competitors. Our FFT time-based and order-based spectra, orbit plots, constant percentage bandwidth measurements (CPB), vectors, user-defined bandpass measurements, rod drop, envelope spectra and all the other Compass 6000 measurements provide a complete condition monitoring solution for turbomachinery and reciprocating compressors sets and their auxiliaries. Spectra can be monitored at one second intervals with up to 6400 lines of resolution. Measurements can also be monitored to tight profile alarm limits for early detection and diagnosis of a number of machine faults for various machine states.

Remote Monitoring

As a plant-wide monitoring system, Compass 6000 is specifically designed for interoperability and connectability to customer process and operator systems. Ethernet LAN, OPC and Modbus communication interfaces allow data to be exported to a number of different customer systems, where different operators can access the data and alarm information according to their user privileges.

A web-enabled system has to be secure in a networked environment, where loss or corruption of customer data can cost millions. Brüel & Kjær Vibro has worked closely with customers on data security and Compass 6000 has been certified to some of the most stringent security requirements in the industry. You can read more information on this in the article on page 8.

Total solution delivery

Brüel & Kjær Vibro has an extensive global network of sales and support to help you get started and operating effectively. There are a wide range of services offered that complement the Compass 6000 system; including site surveys, installation, commissioning and after-sales support.

Need more information? The Compass 6000 condition monitoring system and service, well documented with Product Specifications, brochures, user documentation and training material, can be obtained via your Brüel & Kjær Vibro Sales Representative. ■

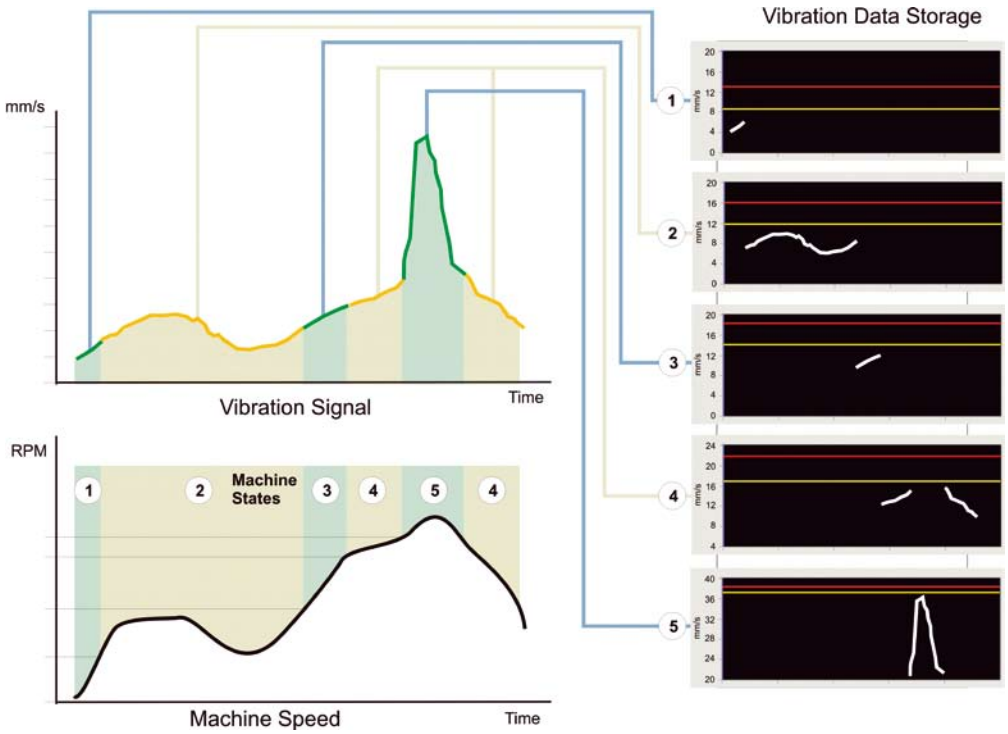
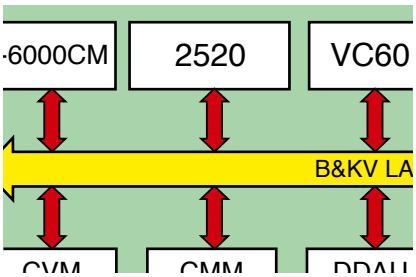


Figure 5. The principle behind adaptive monitoring strategy.

technical focus

Compass 6000 Secure System Architecture

Important or sensitive data is stored in computers and remotely accessed for information and control purposes. This is one of the fundamental concepts behind a distributed process control system, which is instrumental in providing an optimal corporate solution for maximizing production efficiency and throughput. On a daily basis, operators, IT staff, machine monitoring system specialists and automatic control processes all work with and use the information facilitated by the control system. Data security is the means of ensuring that data is not lost and kept safe from corruption. This is what forms the basis of a group of data security products specifically designed for the Compass 6000 system.



What can go wrong?

A large process company with a distributed control system that accesses a number of servers over the internet is potentially vulnerable to an unscheduled production stop, caused by a sudden loss of data or the data corrupting. This could have wide impacting affects in terms of lost revenue, and production interruption for the company itself and downstream operators. The worst case scenario, however, would be a process that handles dangerous chemicals. Viruses could render the control system unstable, or hackers could take control of the process. Consequently plant owners could be forced to pay millions or risk a severe process disturbance, such as a release of toxic gases or fluids to the environment or an explosion. This could ultimately have a catastrophic effect on the entire region, including loss of life and extensive clean up operations.

How big is the risk?

According to the annual Computer Crime and Security Survey (CCSS) conducted by the US based Computer Security Institute (CSI)* and the FBI, computer virus attacks continue to be the number one source of financial losses to companies and organizations. Furthermore, these attacks are increasing at an alarming rate. Symantec (maker of the Norton anti-virus and anti-spyware software), says there were 165% more mali-

** www.gocsi.com*

Figure 1. Data security is a paramount issue for many industries.

cious code signatures in 2008 - a total of 1656227 - than in 2007.

The computer virus is just one of the problems that can result in loss of data. The CCSS survey further claims unauthorized access (i.e. hacking) is the number two source of financial losses to companies and organizations. Who is doing the hacking? According to a major DCS manufacturer's own internet security investigation, 49% of the illicit intrusions actually come from within the corporate WAN and business network, 17% from the internet, 10% from trusted third party connections and 24% from other sources.

In addition to viruses and hacking, loss of data can also occur because of technical problems such as hard disk failure, software problems or even through operator error.

In summary, each vendor supplied server within the plant's entire distributed control system network poses a risk as a potential entry point for loss or corruption of data due to viruses, hacking, operator error or a server breakdown.

What is being done?

There is considerable effort directed at combating this problem on the corporate, national and international levels. The primary objective of these institutions and companies include the following:

- Create standards and guidelines for increasing security
- Certify vendors that comply with the standards
- Create methods for measuring, monitoring and managing security
- Establish an assurance process for auditing and reviewing security policy

While ISO 27001 Part 2 and other standards work hard to consolidate best practices, Brüel & Kjær Vibro, as a major plant-wide monitoring system supplier, has already taken an active role in defining an effective security concept, in collaboration with one of the major players in this field.

The specific data security requirements that resulted from this cooperation were put into a security concept that includes a suite of products collectively called the Compass 6000 Secure System Architecture (CSSA). It includes:

- Tight firewall between Compass 6000 and the customer's process network
- Time synchronization of all devices
- Centrally controlled automatic updates
- Centrally controlled virus protection
- Implementation of simple network management protocol system (SNMP) to monitor and alert the occurance of hardware errors (i.e. a hard disk near full capacity)
- Controlled and safe access for users to the Compass 6000 system through the DMZ
- Controlled and safe data import/export via a dedicated server in the DMZ

Brüel & Kjær Vibro is happy to report that Compass 6000 has been certified to comply with the strict data security requirements of a major oil & Gas company. You can find out more about the Compass 6000 data security solutions in the next issue of Uptime. There is also a Product Specification sheet on the CSSA concept and its products. ■

CPB measurements — Early fault detection with **minimal risk of false alarms**

Compass 6000 Condition monitoring system employs a number of monitoring and diagnostic techniques to help you to optimize the way you manage your machines. This Application Note reprint is one such technique.

An effective vibration measurement is available for automatic fault detection that is simple to set up and use, has good reproducibility, optimal resolution, and gives early, reliable warning for most machine faults. It is called the **Constant Percentage Bandwidth** measurement, or **CPB**, and has proven itself through the years to play an important role in condition monitoring for a wide range of machinery.

Early fault detection

Condition-based maintenance is the optimal solution for reducing the life-cycle costs of many industrial machines. One of the fundamental requirements for this strategy to be successful, however, is the ability to be able to detect faults reliably enough to minimize the costly risk of false alarms, and early enough so maintenance can be cost-effectively planned ahead of time with minimal interruption of production.

Vibration measurements remain one of the most effective techniques for fault detection and diagnosis of the most common machine faults. Different machine faults or *potential failure modes* are characterized by specific frequencies or frequency ranges, and these are detected (and trended) by monitoring minute *changes* in the vibration amplitude at those frequencies. There are many types of vibration measurements for different types of applications, but for automatic condition monitoring purposes, there is a big difference in how early or effectively you can detect changes.

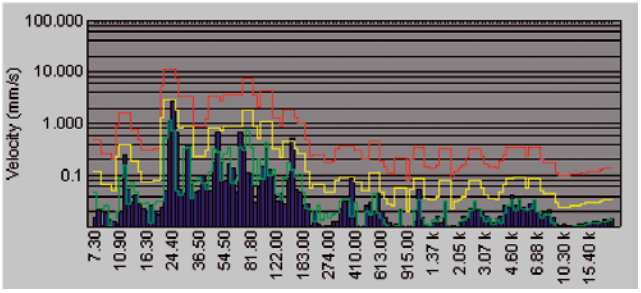


Figure 1. CPB23% spectrum measurement with alarm limits.

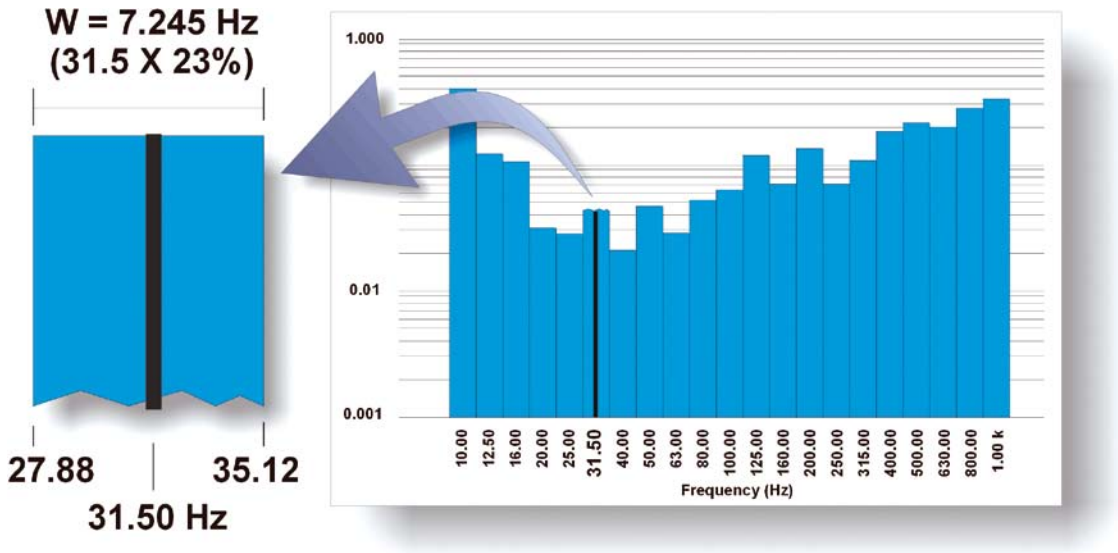


Figure 2. A CPB23% measurement from 10 to 1000 Hz has 21 frequency bars. In this example each bar has a bandwidth that is 23% of the center frequency.

CPB for automatic fault detection

The Constant Percentage Bandwidth or CPB measurement has been developed specifically to provide early fault detection for the most common machine faults with minimal risk of false alarms. This is made possible by an ingenious filtering algorithm that provides sufficient resolution for reliably detecting the most common types of faults.
The CPB is based on a constant *relative* bandwidth on a *logarithmic* scale - i.e. the bandwidth of each spectrum bar is a fixed percentage of the center frequency, as shown in Figure 2. This means the frequency resolution is relatively high at the lower frequencies and coarser at the higher frequencies, which is ideal for reliable, early fault detection.

At the lower frequencies much resolution is needed for detecting isolated, narrow *harmonic* signals such as that found in unbalance, rotor instability, misalignment and coupling problems.

In the high frequency end of the spectrum, less resolution is needed since this is where periodic impulse signals and distributed random noise are produced, for example, by rolling-element bearing faults, lubrication problems, local gear tooth problems, blade noise and gas-seal leaks.
The CPB has a frequency resolution that allows it to automatically detect all these faults, both in the low and high frequency ranges. The simplicity of the CPB spectrum plot display makes it also ideal for quick, at-a-glance diagnosis.

CPB offers minimal risk of false alarms

The CPB is built up on a number of relatively wide frequency lines or bars that allow small changes in frequency and speed to be “absorbed” without significantly changing the vibration signal. The number of frequency bars (and their consequential width) is user configurable, as shown in Figure 2 and 3. A greater number of bars provide earlier fault detection capability, whereas fewer bars provide faster access and analysis time

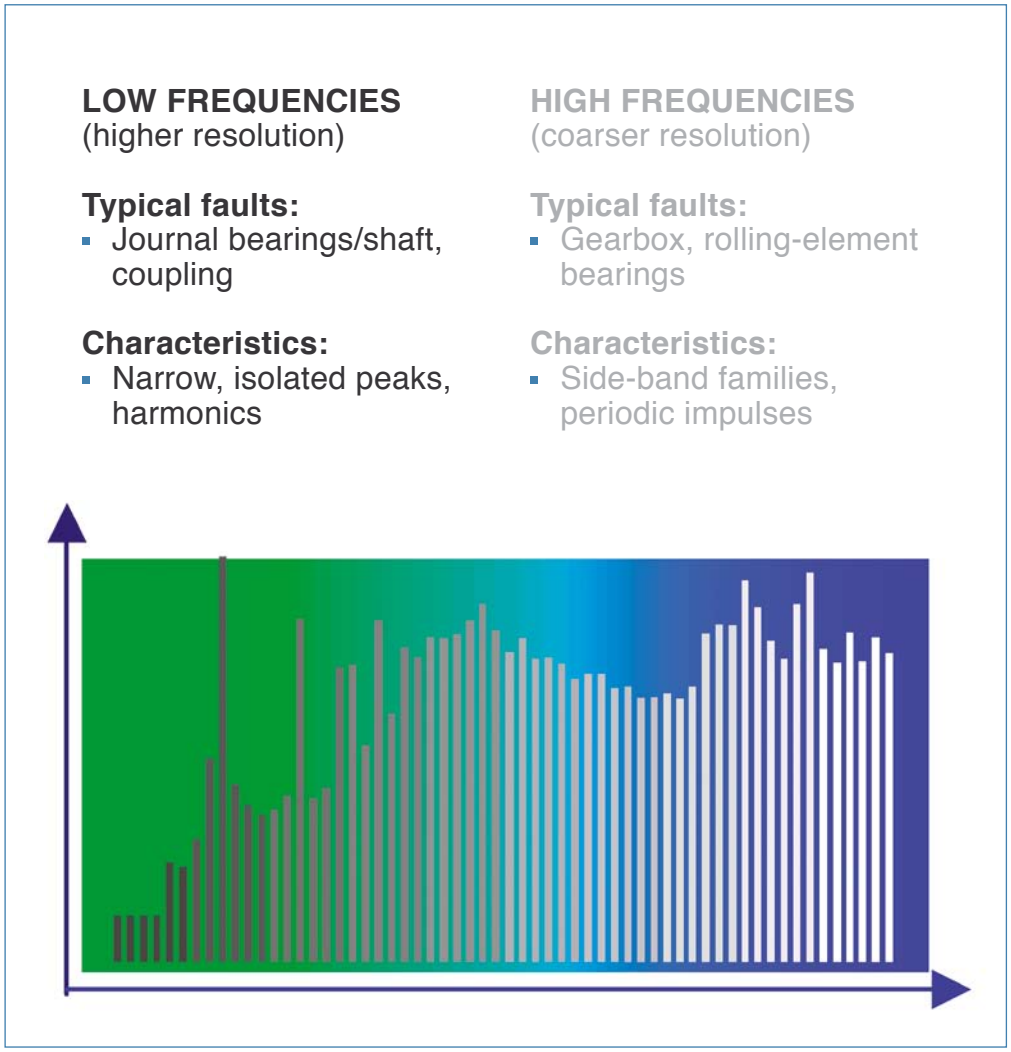


Figure 3. CPB has optimal resolution for detecting many kinds of faults.

and require less disk space. This makes the CPB flexible for many different types of applications.

For speed changes that are greater than the width of the frequency bars, it is a simple task to automatically shift the entire spectrum to its reference position so that all of the fundamental frequencies, harmonics and sidebands, etc. are re-aligned.

Other vibration measurements for other applications

The CPB is the ideal measurement for early fault detection for condition monitoring applications. It actually combines the benefits of other measurements that are used for entirely different purposes.

Like the CPB the *overall vibration* measurement is fast, reproducible, stable and is immune to small frequency variations. This is ideal for protective monitoring - but it lacks frequency information that is needed for early fault detection for condition monitoring purposes. The vibration signature of many faults manifest themselves as narrow spikes at specific frequencies, and the proportional energy contribution of such a fault signature in an overall measurement is very small in relation to the total broad-band energy content. This means a well-developed fault may increase the overall value only slightly. The result; less lead-time in detecting a fault and more monitoring rounds needed in off-line monitoring applications.

Unlike the overall value, the *FFT spectrum* measurement has a tremendous amount of diagnostic information. FFTs have many frequency components that are perfect for analyzing and diagnosing a wide variety of faults. But the FFT, however, is

also sensitive to process and speed changes. A slight speed change can shift a narrow peak away from its reference signature. For this reason it can be difficult to set up "tight" alarm limits on an FFT for automatic fault detection without getting false alarms. The FFT also requires more measurement time and more averages than for a CPB, which can be inconvenient in off-line monitoring applications.

In addition to the FFT, there are other measurements that are also better suited to diagnosis and analysis than to automatic early fault detection, such as:

- **Selective envelope detection (SED)** - Analyzes modulated high-frequency random noise and impacts in rolling-element bearings
- **Cepstrum** - Analyzes complex harmonics and side-band families generated by gearbox faults
- **Orbit** - Two perpendicular displacement sensors for analyzing journal bearing and shaft behavior

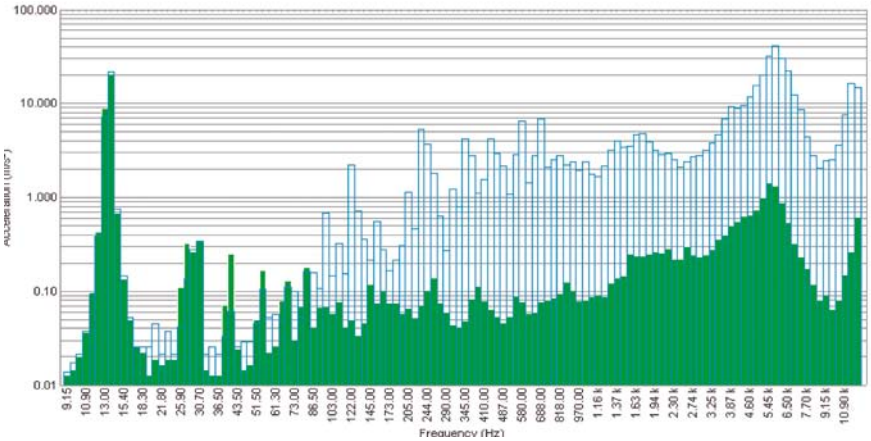


Figure 4. CPB6% plot showing increased medium and high frequency vibrations caused by excessive clearance in a rolling-element bearing (note that there is little change in the running speed frequency).

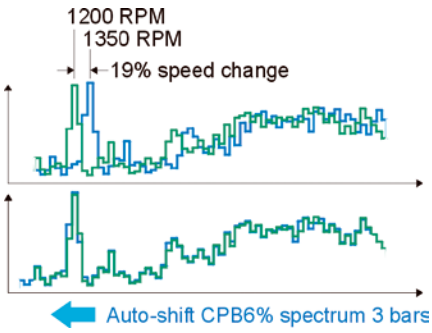


Figure 5 Example of an automatic speed compensation routine. In this example, each CPB bar is 6% wide, so a 19% speed change corresponds to moving the entire spectrum three lines.

Conclusion

The CPB is one of the most reliable, stable and economical methods for detecting the widest possible range of machine faults at an early stage of development. It is has good reproducibility with optimum resolution and thus a "standard" for early fault detection for condition monitoring applications. ■

renewable energy

User Homepage for WTG Condition Monitoring

Brüel & Kjær Vibro's internet-based service opens up an entirely new world in user-interactive condition monitoring of wind turbine generators (WTG). The secure website allows authorized users to get an overview on the condition of each and every wind turbine that is monitored in their park. All wind turbine alarm, vibration and process data can be quickly and easily accessed from the website. What is unique about the user homepage is that subscribers can download high resolution time waveforms directly from the wind turbines and do their own post-processing diagnosis and analysis. There are even demo files ready on the website with real data for training purposes.

Pioneering wind turbine monitoring solution

A large number of wind turbines world-wide are currently being remotely monitored by Brüel & Kjær Vibro using the versatile **Type 3652 Wind Turbine Analysis System**. This system is located within each turbine and comprises the Digital Data Acquisition Unit II (DDAUII) for data collection and a WEB Server for remote communications. You can read more on Brüel & Kjær Vibro's wind turbine monitoring solution in the 2007-2008 Autumn-Winter edition of Uptime.

The Brüel & Kjær Vibro Condition Monitoring Centre is an integral part of this solution. The centre provides a turn-key service that encompasses all monitoring activities for wind turbines, including monitoring, data storage, diagnostics and recommended action reports. This also includes the operation, maintenance and upgrading of all the installed monitoring equipment itself. This subsequently relieves the customers of the burden associated with the monitoring systems, IT maintenance and training of personnel, to undertake the service actions. With such a comprehensive service package, what more does the customer need?

"Black box" monitoring and proprietary diagnostics are things of the past

Our wind turbine customers are more than content with the Condition Monitoring Centre services they are receiving. Many also want to review the daily alarm status of the park and in some cases analyze the data themselves. For this reason the user homepage was introduced as a powerful extension of the Brüel & Kjær Vibro Condition Monitoring Centre service concept for these particular customers.

The user homepage is a transparent and effective way of both providing an instant status overview of all wind turbines in a park, as well as providing detailed data and trends on specific machines. Using the park trend

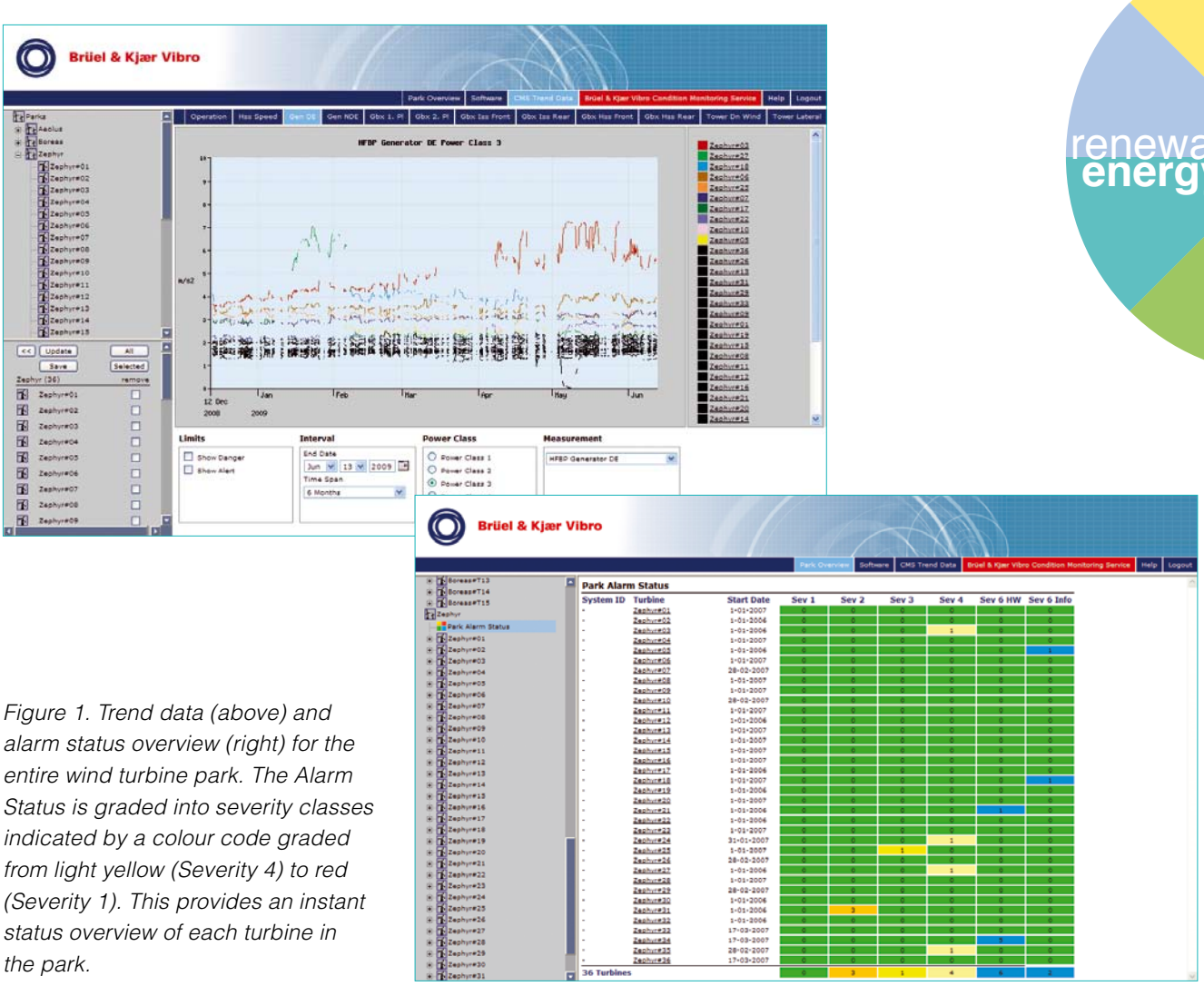


Figure 1. Trend data (above) and alarm status overview (right) for the entire wind turbine park. The Alarm Status is graded into severity classes indicated by a colour code graded from light yellow (Severity 4) to red (Severity 1). This provides an instant status overview of each turbine in the park.

facilities makes it very easy to review turbine data several months or years back and to find turbines with abnormal vibration patterns. Should the user decide to make further detailed analysis of the high resolution time waveforms, these can either be requested directly from the turbine, or the user can choose to download some of the files that are automatically recorded at regular intervals.

Useable data that can be downloaded

The user homepage is unique in the industry. The type of data that can be displayed and analyzed in the user homepage includes:

- **Alarm status overview of the wind turbine park** – The alarm status is graded into severity classes indicated by a colour code as shown in Fig. 1 and 2. Each severity class expresses an assessed lead time until an action has to be undertaken to remedy or investigate the reported potential damage.
- **Scalar vibration and process parameters** – These values are automatically recorded at short time intervals and stored in the Condition Monitoring Centre database. Values are grouped in the database according to the turbine operating conditions at the time of recording. These 100 or more different values are displayed as trends for each machine in the user homepage.
- **Time Waveform** – A time waveform is simultaneously recorded from all sensors, either by user-request, at pre-defined at intervals, or automatically by a trigger (e.g. power load). The time signals can also be post-processed using the WTG Analyzer program. Along with the time waveform a snapshot of the operating conditions of the turbine is stored for correlation purposes.
- **Kinematic data** - All bearing fault frequencies and gear meshing frequencies for each single wind turbine can be downloaded from the user homepage. These are displayed as cursors in the WTG Analyzer plots, to facilitate identifying rolling element bearing and gear faults.

Advanced post-processing capability

One of the most powerful features of the CMS User Homepage is the WTG Analyzer program. This power-

ful vibration analysis program,specifically designed for wind turbine analysis, can calculate and display a number of spectra with zoom, such as autospectra (FFT), envelope spectra and cepstra. These are ideal for analyzing and diagnosing rolling element bearing and gear faults. Scalar values (e.g. operating conditions), envelope and raw time signals and even an audio output are also available. Specialized plotting tools include harmonic cursors, several sideband cursors, delta cursors and pulse repetition rate cursors for time waveform analysis. In addition, multiple displays, zooming and panning, annotations, etc., are also standard (see Fig. 3).

Demo database

The user homepage also allows a set of demo time waveform files to be downloaded that includes actual wind turbine data for training and exercise purposes. Our diagnostic techniques and practices are open source to all.

Conclusion

Many wind turbine customers want to see the monitoring status of their machines, but without taking ownership of and managing the monitoring system, i.e. the responsibilities and tasks of operating, maintaining and upgrading the monitoring system, database, and the IT system and network. The user homepage provides an elegant solution, and has been a big hit since it was first introduced. If you would like more information on this service, visit our website (www.bkvibro.com) or contact your Brüel & Kjær Vibro sales representative. ■

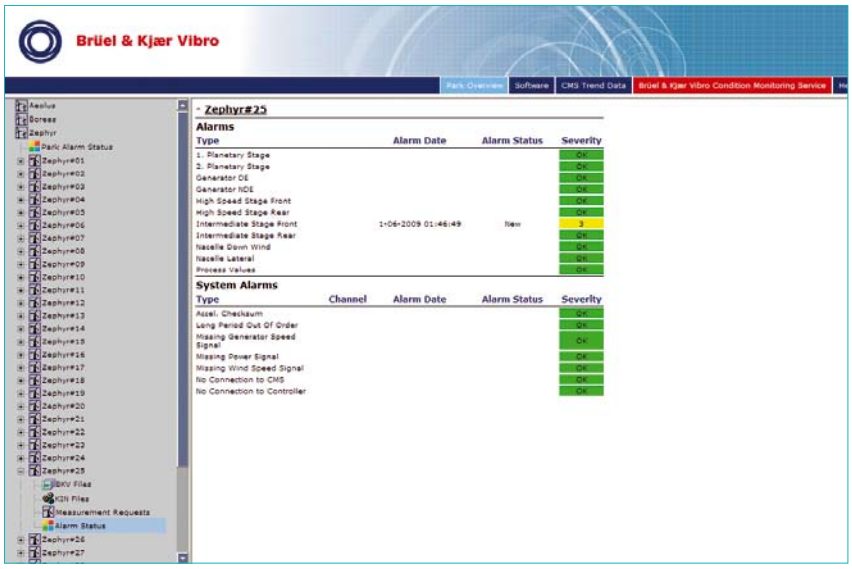


Figure 2. Alarm Status for a single wind turbine. The alarm state of each turbine component is shown on this page.

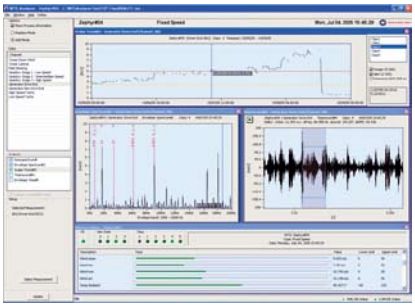


Figure 3. Full WTG Analyzer screen display with display of trend history, spectrum, time waveform and list of operating conditions.

What to do when the warranty runs out?

Wind turbine manufacturers provide a warranty to operating companies, during which they undertake extensive monitoring on the wind turbines. But what happens with the condition monitoring system after the warranty period ends? Is it possible to continue monitoring with the same installed system or is it necessary to find and install new hardware?

It's a lot easier than you think!

You don't have to buy a new monitoring system. All that is needed is to use a service that makes use of the existing monitoring hardware. Brüel & Kjær Vibro's **Remote monitoring service** is an all-inclusive, comprehensive service that takes care of everything, including maintenance of the IT system and the database,

Need more information on this service? Contact Steen Knudsen (steen.knudsen@bkvibro.com) at Brüel & Kjær Vibro's Remote Monitoring Group. ■

Courtesy of Vestas Wind Systems A/S

renewable energy

Wind Turbine Case Story – Shaft current bearing damage

This is another example of a wind turbine case story as seen in previous issues of Uptime. It is based on an actual report.

Observations

The generator drive end (DE) high frequency bandpass (HFBP) vibration level exceeded the danger limit in all power classes, as seen in the Figure 2. The HFBP vibration level for the non-drive end (NDE) approached the danger limit in all power classes but did not exceed it, while the DE overall vibration level exceeded the alert limit but was considered as acceptable at 2.4m/s^2. The NDE overall vibration level approached the alert limit but did not exceed it. The first and second vector magnitude levels remained unchanged for both DE and NDE bearings.

Interpretation

The elevated HFBP levels indicate a possible lack of lubrication or damaged bearings. The increasing overall vibration level indicates that the bearing damage is progressive. The low and unchanged first and second vector magnitude vibration levels negate the rotor as the source of the problem.

Detailed analysis by Brüel & Kjær Vibro has indicated the presence of outer race defects on both the DE and NDE bearings.

Advice/action

It was determined that the generator should be inspected as soon as possible for lubrication system problems and for damage to the bearings. Brüel & Kjær Vibro will closely monitor these bearings to identify any deterioration.

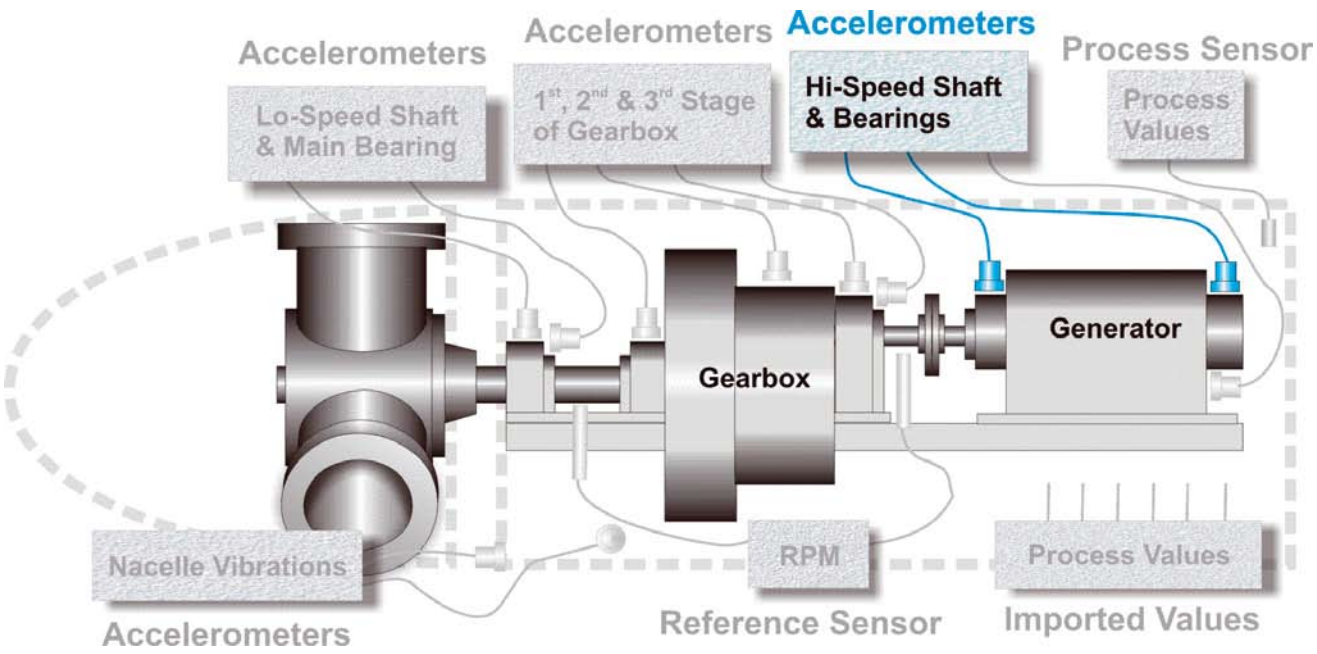


Figure 1. Location of the sensors (blue colour) with signals that exceeded the danger alarm limits or showed significant change (from left to right); generator driven-end and non-driven end accelerometers.

Figure 2. High frequency band-pass measurement from the generator DE bearing exceeds the danger alarm limit.

Feedback after service

When the generator bearings were removed, the outer and inner race of both showed signs of "fluting", which is very characteristic of bearing current discharge. Shaft current discharge through the bearings, if unchecked, can lead to premature bearing failure, which in turn can lead to generator failure.

The stray currents often originate from the power electronics converter of a wind turbine's double fed induction generator. The converter plays an important role in allowing the wind turbine to remain synchronized with the grid while the speed varies, and to maintain power system stability on the grid. The high-frequency switching, however, can cause capacitive coupling that induces rotor-shaft voltages. Without adequate generator shaft grounding, this will pass through the bearings and damage them. ■

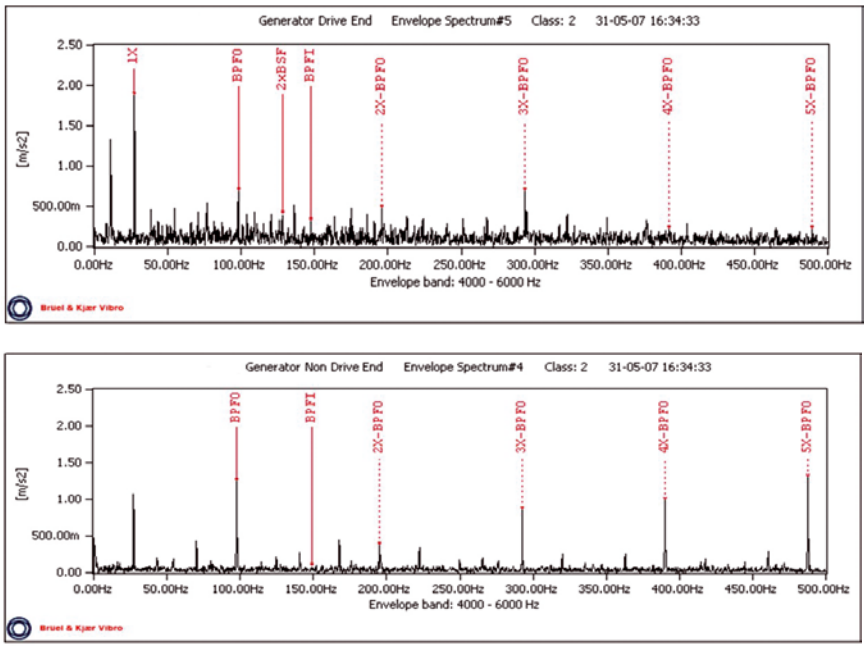


Figure 3. The envelope spectrum (4000-6000Hz) showing the DE (top) and NDE (bottom) bearing fault frequencies. BPFO (Ball Pass Frequency Outer Race) refers to the generator bearing fault frequency for outer race faults.

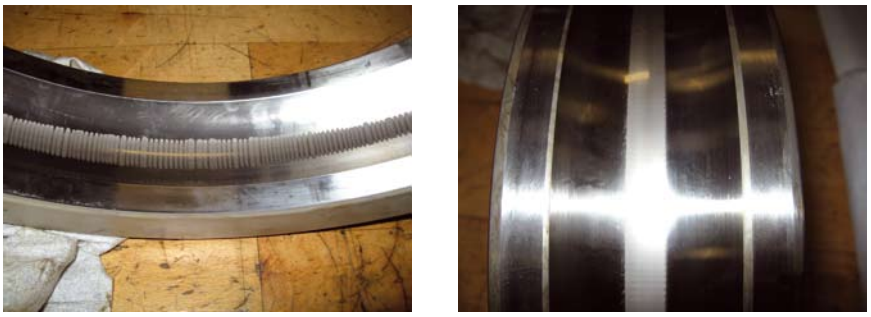


Figure 4. Bearing surface "fluting" caused by shaft current discharge on the outer race (left) and inner race (right).

Suzlon and Brüel & Kjær Vibro enter a condition monitoring frame agreement

Suzlon, one of the leading international wind turbine manufacturers, has entered into a long-term agreement with Brüel & Kjær Vibro for the supply of remote condition monitoring solutions for the Suzlon range of wind turbines. This frame agreement is based on the success of several installations and the mutual confidence in this dedicated condition monitoring solution enabling improved uptime of the turbines and thereby benefiting Suzlon and its global customer base. ■

Photo courtesy of Suzlon

events 2009-2

March 2 - 4 2010

MAINTEC 2010

Birmingham, UK

UK's biggest and most comprehensive event for maintenance and asset management.

http://www.easyfairs.com/EN/show-808/maintec-2010-birmingham-united-kingdom-industrial-technologies-2010-march/description.aspx

March 18 - 21 2010

New Energy Husum

Husum, Germany

Trade fair not just very popular with the small wind turbine sector, but also with the solar and biogas industries.

http://www.new-energy.de/startseite-new-energy.html?&L=1

April 21 - 23 2010

POWER-GEN India and Central Asia

Mumbai, India

Powering the future - Largest POWER-GEN conference and exhibition outside of Europe and North America.

http://www.power-genindia.com/index.html

April 18 - 21 2010

LNG 16

Oran, Algeria

16th International conference & exhibition on liquefied natural gas.

http://www.lng16.org/

April 20 - 23 2010

EWEC 2010

Warsaw, Poland

European wind energy conference and exhibition.

http://www.ewec2010.info/index.php?id=83

April 19 - 23 2010

Hannover Messe 2010

Hannover, Germany

2010 spotlight on industrial automation, energy, technology, technology, industrial subcontracting and cutting-edge technologies.

http://www.hannovermesse.de/homepage_e