Brüel & Kjær Vibro

uptime
megazine

01|14

CASE: MIXER FAULT (PART 2)
CASE: WTG YAW BEARING FAULT
FIELD: NGHI SON REFINERY
FIELD: SUBSEA COMPRESSORS
PRODUCT: LTSA

uptime
megazine

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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 case stories where there is service.

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LONG-TERM SERVICE AGREEMENT – CUSTOMER DRIVEN

Stefan Burggraaf
Service Manager

I'm pleased to launch this issue of Uptime, which is dedicated to service. As demonstrated in the previous issue of Uptime, which was also geared to service, the importance service plays in our monitoring solution cannot be underestimated.

This particular issue focuses on the long-term service agreement (LTSA), which was only briefly mentioned in the previous Uptime. In this issue we go into more detail, but first I would like to mention the fact that the long-term service agreement is actually customer driven in many cases, not merely an invention of the machine or instrument supplier. There are several reasons for this:

1. There is increasingly fierce competition in the market place. This is pressuring customers to lower operating costs while simultaneously keeping their plants running at maximum production and efficiency. For this reason, customers often prefer to concentrate their efforts on their core business, while delegating the maintenance and in some cases even the operation of their machines and systems to suppliers. Even in the O&G industry where the companies have their own organizations for maintaining their plants, they are becoming more focused on the economic operation of their assets, and delegating the maintenance to the machine and instrument suppliers.

2. The customer appreciates the fact that the supplier has specialized knowledge, and therefore is an ideal partner in a LTSA. It is unlikely the customer could achieve the same level of expertise during normal operations.

3. More and more customers would like to operate together with the supplier, creating and strengthening a strong interconnection leading to a long lasting „partnership" through an LTSA, rather than just establishing a mere customer/supplier relationship with low added value for both.

With this in mind, you will have a better understanding when you read more about the LTSA's in this issue.

Oh yes, there is one more thing I would like to mention. I'm glad to introduce the new format of Uptime! This should indeed enhance the pleasure of reading the LTSA article as well as the other stories in this Uptime! Enjoy! ■

CASE STUDY

LDPE REACTOR MIXER BEARING FAULTS – PART 2

This case story from the Porvoo low density polyethylene plant demonstrates the importance of online condition monitoring of the LDPE reactor mixer. This article is the second part of a two-part series that graphically demonstrates three case stories. Part 1 which gave, background information on the monitoring system configuration, appeared in the previous issue of Uptime (www.bkvibro.com).

CASE STUDY OF BEARING FAULTS ON THE REACTOR MIXER

Some examples of bearing faults that have been detected in the reactor are shown in three different case stories.

Case 1: DE motor bearing fault

The driving end (DE) motor bearing, the most robust of all the bearings in the reactor (comprises of two sets of rolling element bearings) is the bearing that fails the most often. As seen in Figure 1, some of the bearings have a relatively short life cycle; there were 11 shutdowns to replace damaged/worn bearings during a five year period.

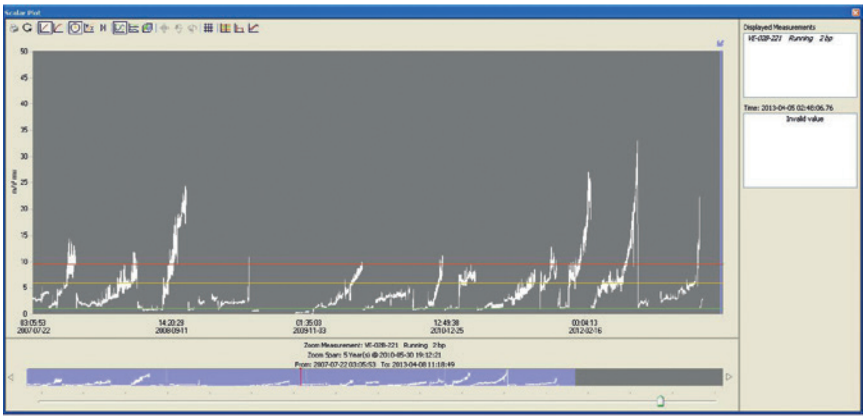


Figure 1. *Bearing vibration trend over a 5 years period showing primarily the DE motor bearing. (Acceleration band-pass measurement).*

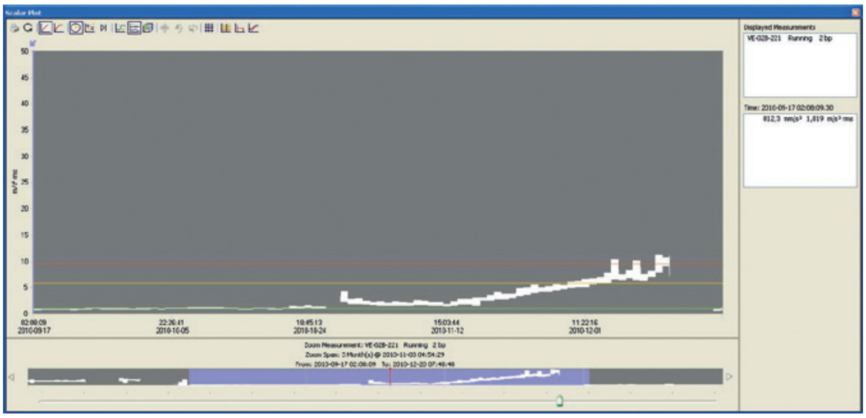


Figure 2. *An example of a DE motor bearing fault trend. (Acceleration band-pass measurement).*

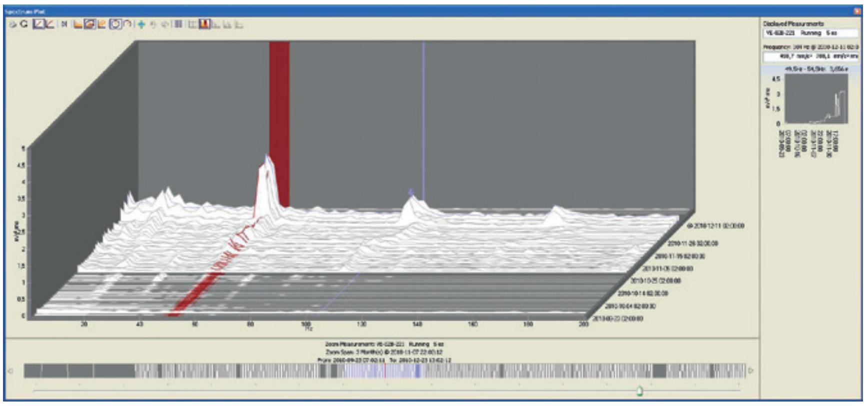


Figure 3. *Ball bearing fault frequency trend (49.5-54.5 Hz) over a period of five weeks. Mixer was changed afterwards. (Envelope spectrum for acceleration).*

Figure 4. *Condition of damaged DE motor bearings when reactor was dis-assembled after shutdown. Although the damage looks quite severe, only one set of the bearings was affected.*

Case 2: DE motor bearing fault – Delayed replacement

In certain situations, production requirements may delay when a bearing can be serviced. In such a case a bearing fault is carefully monitored to ensure that the risk of bearing failure is still minimal until, for example, the next scheduled shutdown. Five examples of this can be seen in Figure 6, where the bearing was allowed to operate after it exceeded the Danger alarm limits. A single example of this is shown in Figure 5.

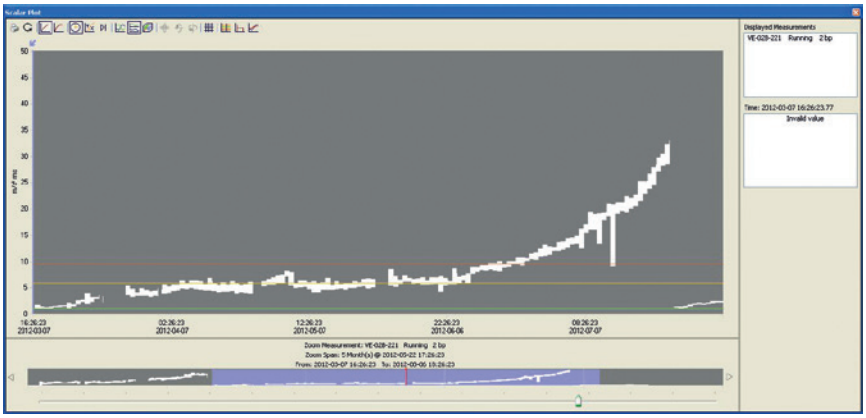


Figure 5. *An example of a DE motor bearing fault trend where repair was delayed due to production requirements. (Acceleration bandpass measurement.).*

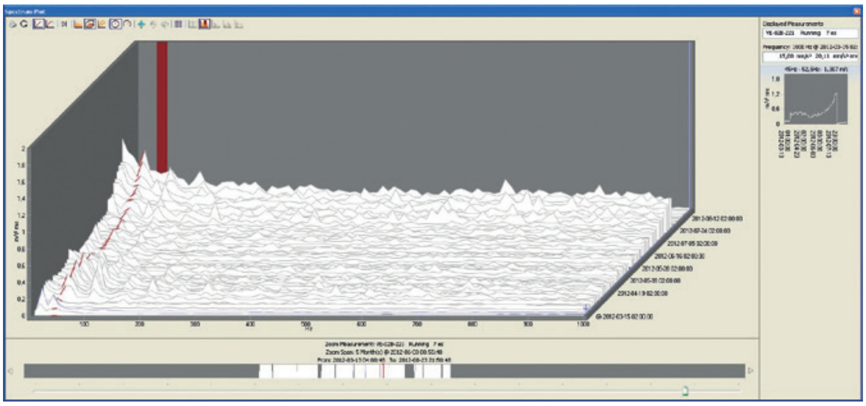


Figure 6. *Multiple bearing faults seen over broadband frequency trend over a period of five months. Mixer was changed afterwards. (Envelope spectrum for acceleration).*

Figure 7. *Condition of damaged DE motor bearings when reactor was disassembled after shutdown. Left: Outer race. Middle: Inner race. Right: Rolling elements. Both sets of the DE motor bearings were equally affected in this case (only one set shown), which is a much more severe situation than that shown in Case 1 (Figure 4).*

Case 3: Middle shaft bearing fault

Sometimes there are short shutdowns for process or other reasons not directly related to the reactor. Shutting down the reactor carries risks in itself. In this particular case, when the process was started up again, higher than normal vibrations were observed. In the course of just a few days the vibration amplitude doubled, as indicated in Figure 8. The mixer was changed the next day. Upon disassembly, it was seen that hardened polymer had found its way into the bearing and caused the bearing to fail prematurely.

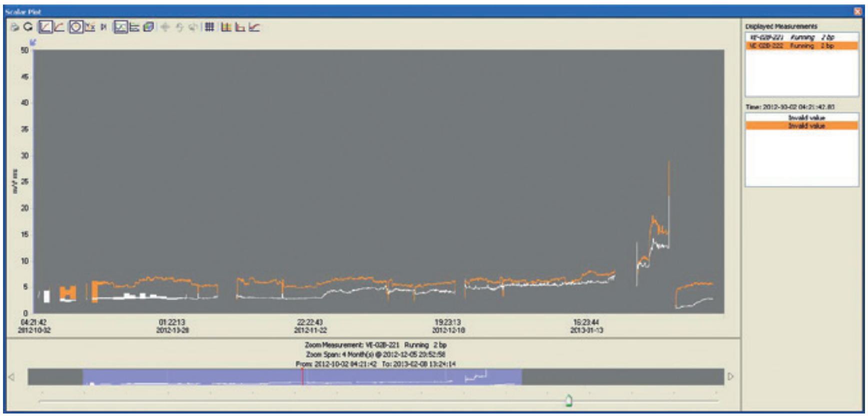


Figure 8. *Orange: Lower accelerometer measurement trend for the mixer shaft bearings. White: Upper accelerometer measurement trend for the motor bearings. The trend is normal up to the process shutdown but immediately after the reactor was put back into service, the vibration increased. Although the damage was limited to the middle mixer shaft bearing, this influenced the vibration on the upper accelerometer. (Acceleration bandpass measurement.).*

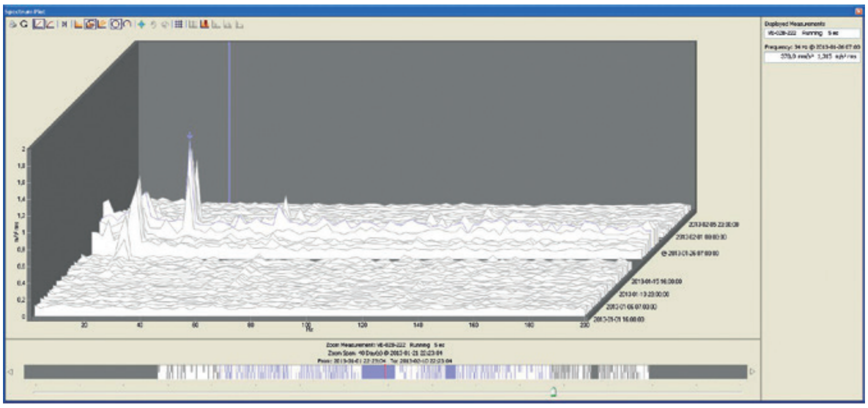


Figure 9. *Amplitude trend for running speed harmonics and bearing fault frequencies from the lower accelerometer. (Envelope spectrum for acceleration).*

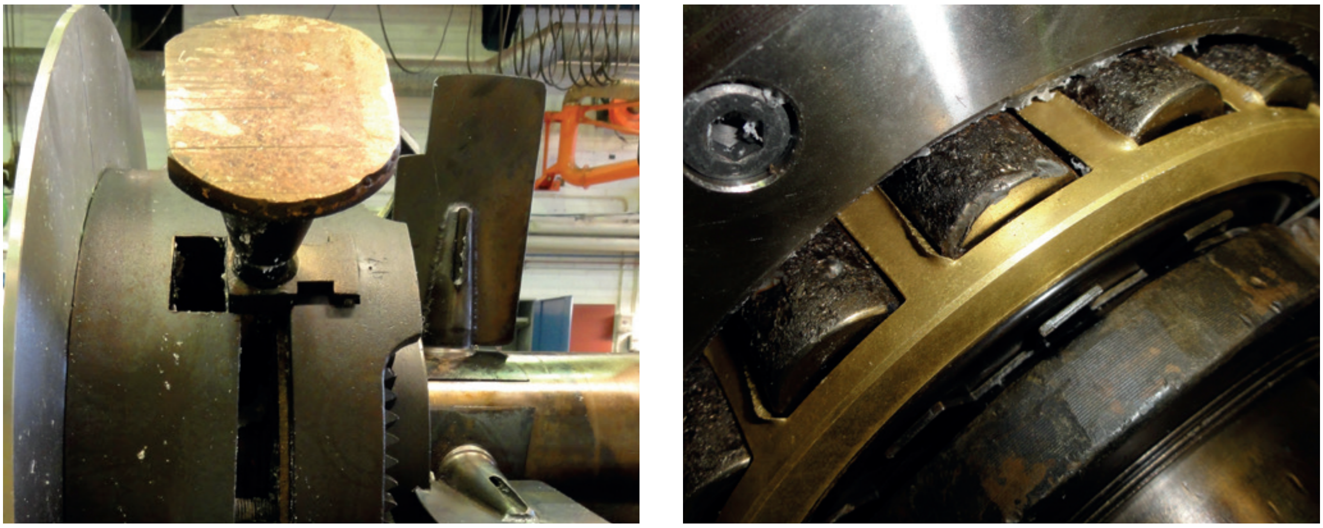


Figure 10. *Condition of the middle bearing when the reactor mixer was disassembled after shutdown. Damaged bearing (right) caused by polymer that entered the damaged bearing housing and hardened. The fractured bearing housing is shown on the left.*

CONCLUSION

As the reactor mixer is a critical machine in the LDPE process, the bearing fault detection cases in this article prove that online condition monitoring is an absolute imperative for this machine. Not only to avoid costly production losses due to downtime, but also to avoid consequential damages that occur as a result of decomp, possibly provoked by defective bearings.
As can be seen in some cases, the bearing fault can develop quickly as shown in Case 1, or even in a non-linear progression as seen in Case 3. This in itself precludes the use of offline monitoring using portable instrumentation. Moreover, premature bearing failures can be instigated by factors other than wear. This could be due to process conditions such as deposits on the mixer blades or even polymer that enters the bearing housing (Case 3) and can develop very quickly.

ACKNOWLEDGEMENT

Brüel & Kjær Vibro would like to thank Marko Heinonen from Borealis for his contribution in making this article. ■

Marko Heinonen
Condition Monitoring Engineer, Borealis Polymers Oy

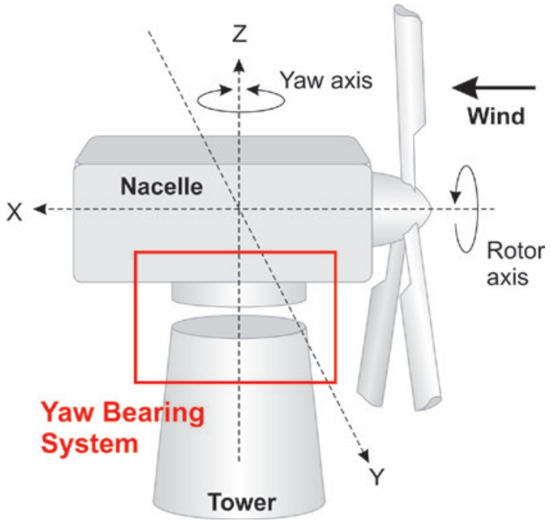
CASE STUDY

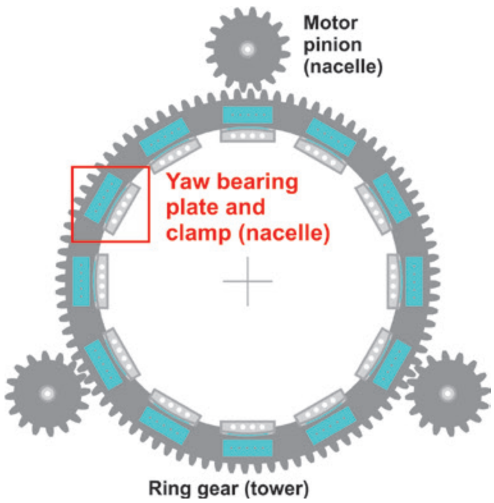
YAW BEARING SYSTEM FAULT DETECTED

Two case studies demonstrate how an effective remote condition monitoring strategy avoids uneconomical operation, costly downtime and consequential damage of wind turbines

After remotely monitoring several thousand wind turbines over the past 10 years, most of the wind turbine faults detected and diagnosed by the Brüel & Kjær Vibro Surveillance Centres have been related to the drive train. In this article, we give two case stories where the faults were detected and diagnosed in an entirely different but important component; the yaw bearing system. It is this system that bears the enormous static and dynamic loads of the nacelle and blades, and allows the nacelle to align itself into the wind.

The root cause in both case stories is the same but the fault manifested itself differently in each case, although the wind turbines were similar.





YAW BEARING SYSTEM

Located between the nacelle and tower (Figure 1, top), this system allows the nacelle to rotate on the tower to align the blades in the direction of the wind. If the blades are not perpendicular to the wind, the wind turbine will not be producing the maximum potential power and will be losing revenue. The yaw bearing system is also designed to bear the static weight of the nacelle, as well as resist the enormous dynamic loads that occur due the rotating drive train and blades.

The system consists of a toothed ring gear that is fixed to the tower (Figure 1, bottom). Yaw motors turn several pinion gears on the ring gear to rotate the nacelle. The load bearing components consist of axial and radial glide bearing pad segments that sit on the ring gear, as shown in Figure 1 (bottom). The bearing pad normally includes a pre-tensioning system, which consists of a spring and an adjustment screw, as shown in Figure 2. This ensures that there is no looseness between the glide bearing segments and the ring gear, and that there is even wear on all the guide bearings. If the glide bearings are not properly pre-tensioned, this can damage the glide bearings and adversely affect the ability of the nacelle to turn.

Figure 1. *The yaw bearing system on a wind turbine (top) aligns the blades to the wind. It consists of the ring gear, yaw motor and the yaw bearing clamp assemblies (bottom, looking down from the nacelle).*

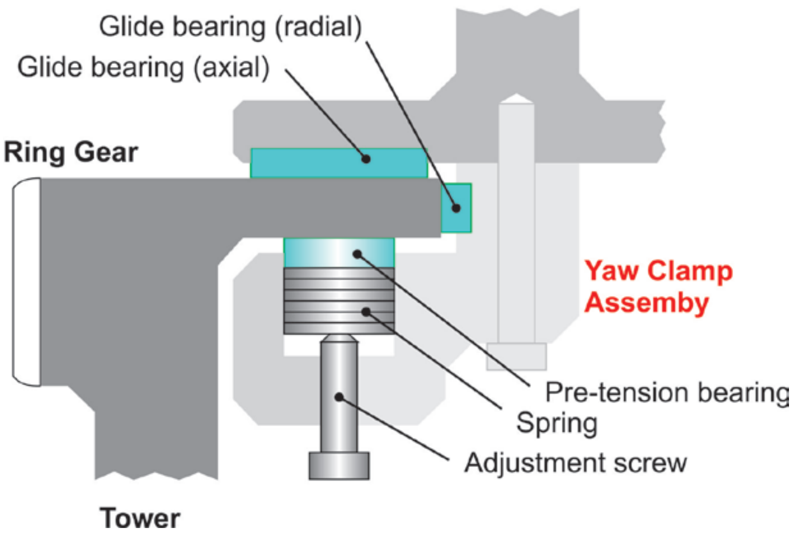


Figure 2. *Cross-section of the yaw clamp assembly on the ring gear.*

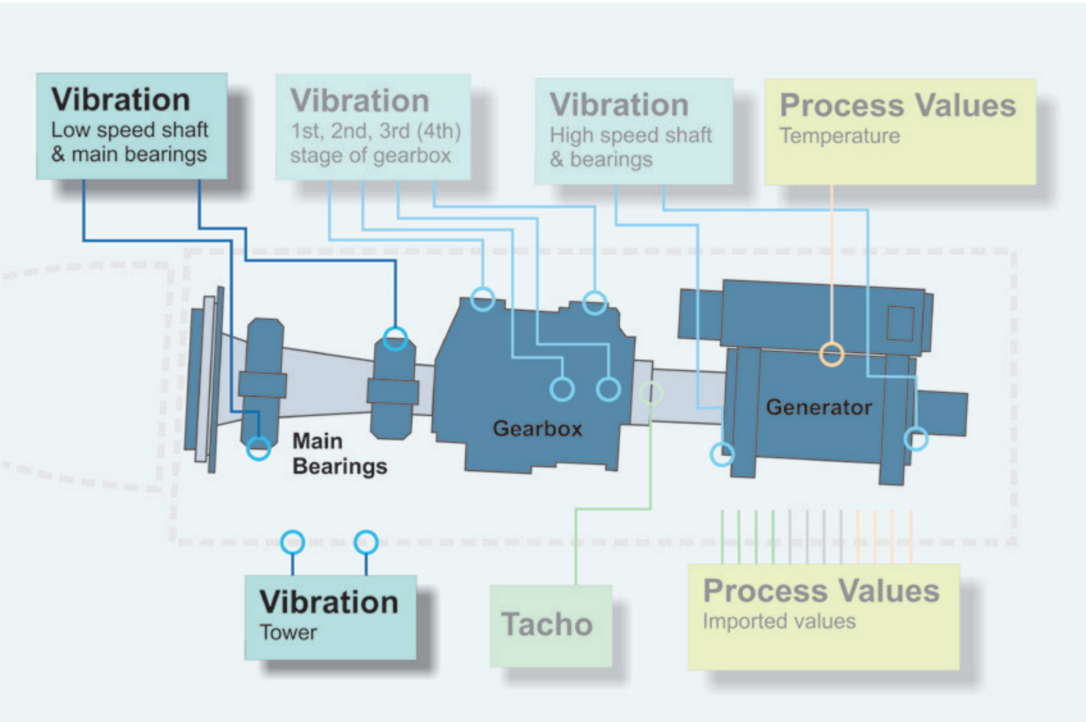
OBSERVATIONS

The Brüel & Kjær Vibro Surveillance Centres have been remotely monitoring many different kinds of faults, but these two cases were unique. The monitoring system configuration for detecting the faults is shown in Figure 3.

Case 1: The vibration descriptors of the signal from the accelerometers located on the main bearing (not shown) and on the tower (Figure 4, top) for a wind turbine exceeded the alert limits in February 2013. The overall RMS vibration signal, not shown, remained within acceptable limits. There were no faults found in the main bearing or blades, so the spring packs on the yaw clamp assemblies were replaced and the wind turbine put back into operation in May 2013, where the vibration levels returned to normal. The vibration increased again more dramatically in September 2013.

Case 2: The tower accelerometers for a wind turbine at another wind park showed an immediate and abrupt change as indicated on the bottom in Figure 4, exceeding the danger alarm limits. Monitoring focus was subsequently placed on the blade/main rotor assembly, the main bearing, and the yaw bearing system.

Figure 3. *Typical monitoring strategy for a wind turbine like the one in this case story. The accelerometers located on the tower and the main bearing detected the yaw bearing system fault.*



INTERPRETATION

The fault detected appeared to be unique. The time signals for both wind turbines proved to be ideal for the initial analysis.

Case 1: At both times, in February 2013 and September 2013, there appeared to be a random impact seen in the time signal from the accelerometers on the tower (Figure 5, top) and main bearing (not shown). Because of the randomness of the impacts, it was initially difficult to pinpoint the exact cause, as the problem could be related to the blades, main bearing or the yaw bearing system. No problems were found in either the blades or the main bearing, so the yaw bearing system was suspect. The spring packs for the yaw bearing clamp assemblies were replaced in May 2013 and the high vibrations disappeared. The high vibrations returned again in September 2013 unexpectedly. Again the yaw bearing system is suspect.

Case 2: The time signal shown in Figure 5 (bottom) indicated a periodic impact that corresponded to two times the main rotor running speed. This periodic impact was assumed to be related to the blades and/or the yaw bearing system.

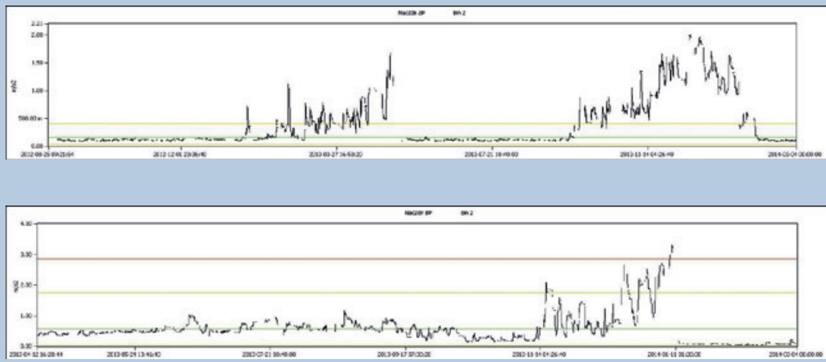


Figure 4. *Case 1 (top, before and after repair) and Case 2 (bottom, before and after repair): Bandpass acceleration vibration descriptors from the tower accelerometers.*

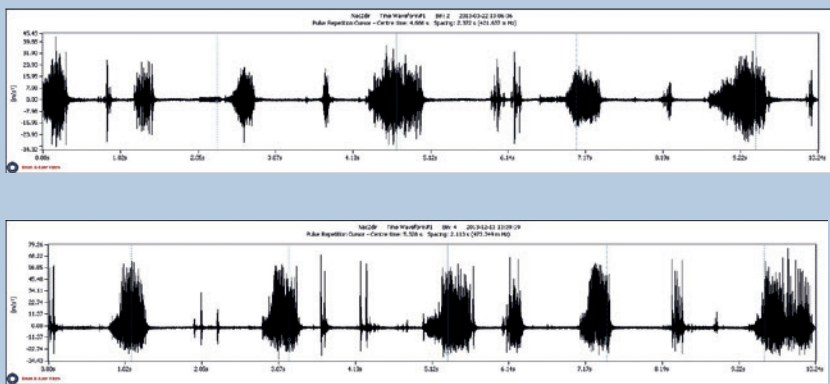


Figure 5. *Case 1 (top) and Case 2 (bottom): A vibration impact signal is visible in both plots. For Case 1 (top) it appears random while for Case 2 it occurs twice every rotation.*

ADVICE/ACTION

The severity level of the faults and the recommended service action time were different for the two wind turbines.

Case 1: Both faults were a unique occurrence for the wind park. A medium severity level was initially assigned to the first fault because it was present for some time and it never exceeded the danger limits. A higher severity was assigned to the second occurrence of the fault, partly because it was more dramatic, and because it was the second time the same fault symptoms occurred. In both cases the fault development was carefully followed.

Case 2: A high severity was assigned to this fault because of the very rapid vibration level increase combined with the fact that the danger alarm limits were violated. This was also partly based on the experience and feedback gained from Case 1. Recommended service time was 4 weeks.

FEEDBACK AFTER SERVICE

Case 1: When the wind turbine was shut down for the first time, the main bearing and blades were checked and found to be OK, so attention was given to the yaw bearing system. It was decided to change all the pre-tensioning spring packs in the system. When the wind turbine was re-started, the vibration levels returned to normal (Figure 4, top). However after only three and a half months operation, the same fault symptoms occurred again, but more dramatically. The yaw bearing system was disassembled again, and this time it was observed that many of the axial gliding bearing plates were damaged. These were re-machined, the spring packs changed a second time and the wind turbine was put back into normal operation. It is believed that the yaw plates were damaged due to a rocking motion of the nacelle on the tower, caused by the loose yaw bearings. The random motion of the rocking is believed to be due to the variable wind conditions and loading. There was no imbalance in the blades that would "tie in" the rocking motion of the nacelle to the rotation of the blades (as what occurred in Case 2). Over an extended period of time with loose bearings, the bearing plates were damaged by the continuous impacts to a point where the new pre-tensioning springs weren't capable of compensating for this.

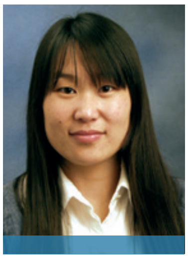
Case 2: Both the blades and the yaw bearing system were inspected. The blades were found to be out of balance, and around 60% of the yaw clamp assemblies had loose pre-tensioning screws. The combined effect of this resulted in a rocking motion of the nacelle on the yaw bearing system. This created the impact signature seen in the time signal (Figure 5, bottom), as one of the specific blades reached the 12 and 6 o'clock positions (2 vibration impacts for each rotation). After re-balancing the blades and tightening the pre-tensioning screws, the wind turbine vibration signature returned to normal. As a result of the unique occurrence of this yaw bearing system fault in Case 1, the detection and diagnosis techniques were quickly optimized by the time Case 2 occurred.

CONCLUSION

Both of these case stories demonstrate that there are critical components in the wind turbine other than the drive train that needs to be effectively monitored, like the yaw bearing system. Case 1 demonstrates that there can be more than one problem occurring at the same time. If the loose yaw plate bearings were not monitored and serviced in time, a catastrophic failure could occur that would render the yaw system non-functional, thus requiring a complete shutdown or operating at only partial power for a period of time.

ACKNOWLEDGEMENT

We would like to thank the diagnosticians Zhenyan Liu and Reynir Hilmisson from Brüel & Kjær Vibro Surveillance and Diagnostic Service Centre in Copenhagen for their contribution in making this article. ■




Zhenyan Liu
Reynir Hilmisson

FIELD NEWS

COMPASS 6000™ TO BE INSTALLED ON VIETNAM’S SECOND REFINERY

This is a photo showing the Dung Quat refinery, Vietnam’s first refinery, which is similar to the Nghi Son refinery (courtesy of Dung Quat refinery).

Brüel & Kjær Vibro have been chosen to deliver a comprehensive machine monitoring system to the Nghi Son crude oil refinery.

Compass 6000™ will be installed as a plant-wide safety, condition and performance monitoring solution for a number of machines in all the refining units of this medium sized, modern refinery. The Nghi Son refinery located in the Thanh Hoa province about 200 km south of Hanoi, is planned to produce 200,000 barrels per day when it is completed in 2017.

In addition to Compass, the **VDAU 6000** online system will also be used for specifically monitoring the large number of cooling towers in the refinery. The **VIBROPORT 80** handheld was selected for offline monitoring the balance-of-plant machines. All-in-all, over 3000 measurement points will be monitored in this plant-wide installation. Monitoring is considered to be critical for this plant as it is planned to reliably supply approximately 33% of the growing Vietnamese domestic market for oil and gas in the coming years.

Brüel & Kjær Vibro was selected for this project, partly based on the successful experience gained at Vietnam’s other refinery Dung Quat (described in the highlight box) and on the results achieved at the enormous Shell Pulau Bukom refinery (which produces 500,000 barrels per day).

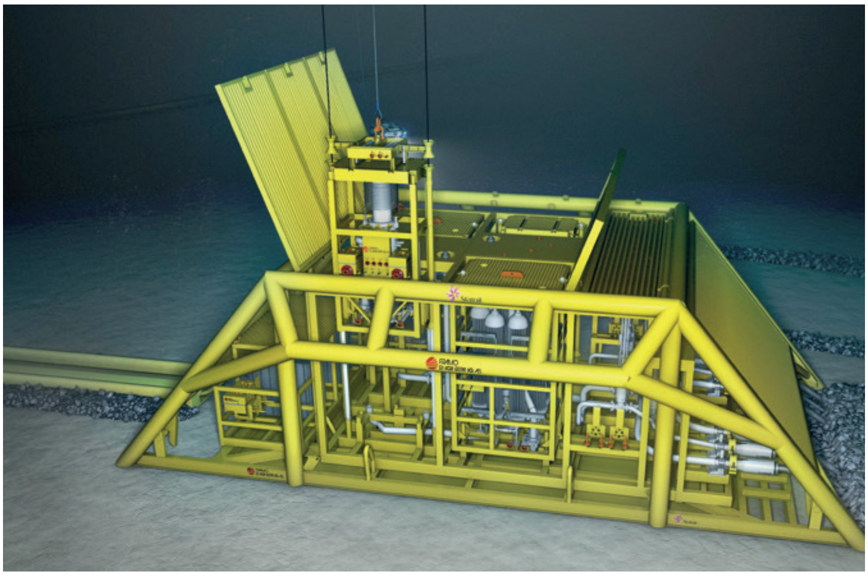
With this large order, the growing importance of Brüel & Kjær Vibro as a machine monitoring solution provider in the region is further confirmed. ■

COMPASS WILL BE MONITORING ALL OF VIETNAMS OIL & GAS PRODUCTION

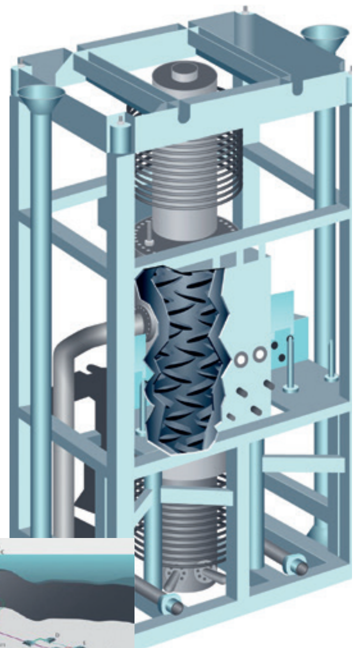
In addition to monitoring the Nghi Son refinery, Compass 6000™ has also been selected to monitor Dung Quat, Vietnam’s first refinery, which started operation in 2009. It is currently producing 140,000 barrels per day but this will increase to 200,000 by 2015. Nghi Son and Dung Quat combined will then supply 65% of the domestic needs - all under the watchful eyes of Compass 6000™! Vietnam is currently South East Asia’s 3rd largest oil & gas producer, after Indonesia and Malaysia.

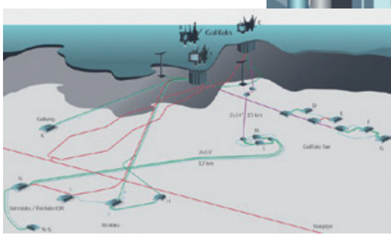
FIELD NEWS

COMPASS 6000™ SELECTED FOR SUBSEA COMPRESSOR FACILITY



Typical subsea compressor installation (courtesy of Statoil).





Brüel & Kjær Vibro was selected to deliver a condition monitoring solution to a North Sea subsea compression facility. The facility consists of two compressors for enhanced recovery, and a separation unit for separating the gas from the liquids.

Two subsea wet gas compressors (which compress a mixture of natural gas and liquid hydrocarbon condensates) will be monitored by four accelerometers that come with the compressor; a radial and axial accelerometer on the suction side of the compressor, and an X-Y radial configuration of two accelerometers on the discharge side. Our Compass 6000™ monitoring system stores the time signals and process values originating from another monitoring system into our database server. Our diagnostic monitoring software is then used to post-process the time signal into spectrum plots so diagnostic information on developing potential failure modes of the compressors can be detected early. Process values are used to correlate with the spectra in order to more accurately compare the data over time.

Monitoring is very critical for subsea compressors, since these machines will have to run several years between maintenance shutdowns. If one of the compressors were to shut down prematurely, a remotely operated underwater vehicle (ROV) will have to be dispatched to investigate and repair the machine, which can be costly. ■

SUBSEA COMPRESSION

Subsea compressor systems represent the newest technology to extract gas from depleting gas fields. As the natural gas pressure in the field formation reduces over time as it is produced, it is necessary to compress the remaining gas to improve recovery. This task was traditionally done by offshore platforms and onshore facilities, but these are expensive to construct, operate and maintain. A subsea compressor, however, is much less expensive because it is smaller and it requires much less power to perform the same task. The subsea compressor is typically installed close to the wellhead, so the suction pressure is less compared to that for a topside compressor. More gas can be recovered that way.

PRODUCT INFO

BRÜEL & KJÆR VIBRO LONG-TERM SERVICE AGREEMENTS

Uptime and Reliability for Industrial Machinery

The concept long-term service agreement conjures up different images for different people, and unfortunately sometimes negative. Some think of it as an indirect form of a forced partnership, others think of it as applicable only to large companies, and still others as a binding agreement to limit liability. In our case none of these are true! We consider it as an economical way of bundling several services in a single manageable, fixed-cost, low risk package over a prescribed time. Not only does this streamline the costs, but the services can be customized and delivered in a more efficient manner as well. It is tailored to the customer's requirements and budget, and can be used by small, medium and large size customers alike. It is a truly value-added function so the customer gets maximum advantage out of their investment, by improving the reliability and performance of their system (and their monitored machines), and optimizing the overall uptime of the system (and machines). These services are administered with priority with regards to delays, and all costs are transparent, and can be calculated in advance. The LTSA is available as a 1, 2 and 5-year contract, and encompasses everything from regular maintenance to emergency assistance.

Why bundle the services? Because running a condition monitoring strategy requires several areas of expertise that are not readily available to all companies. It is these areas of expertise where we offer many different services, and our long-term service agreement can combine these various services into a single service package customized to the specific customer. There are three specific areas where this expertise can be grouped:

- Diagnostic specialist knowledge
- High technology system expertise
- Installation and Commissioning

DIAGNOSTIC SPECIALIST KNOWLEDGE

Machine condition monitoring and performance monitoring are predictive maintenance techniques intended to maximize machine production and reliability while minimizing life cycle costs. This is achieved by detecting potential failure modes at an early stage of development so machines can still be operated at load until maintenance needs to be done, which is planned well ahead of time and is focused. A condition monitoring solution can range from simple 2-channel systems on a couple of machines to a plant-wide system consisting of safety, condition and performance monitoring functionality for many machines. What is common for both solutions is a need for expertise. Both systems can automatically detect a fault at an early stage, but specialist knowledge is needed to interpret the raw and conditioned signals, sometimes using specialized diagnostic tools, in order to identify the type of fault, location, severity, lead-time to maintenance and action to be taken. Specialist knowledge is also needed for understanding what are the potential failure modes to be monitored for a particular machine, and how. For many companies, this type of expertise is too expensive to keep in-house. Brüel & Kjær Vibro understand this need and therefore can provide this expertise in the form of a number of individual services and training.

HIGH TECHNOLOGY SYSTEM EXPERTISE

A plant-wide safety, condition and performance monitoring system can monitor hundreds of machines and share information with numerous systems, including operators, maintenance staff, administrators and even third-party machine manufacturers and consultants. The condition monitoring part of the system is intended to process sensor data so the user gets the necessary information in order that the operators and managers can take the appropriate operation and maintenance decisions in running the machinery. Within such a system, data is acquired, conditioned, stored, compared to alarm limits, displayed, and exported to other systems. Such a system can have an extensive frontend installation and include many servers. As with any IT system, if it is not properly configured, and not operated, maintained and updated as the need arises, the user will not get the maximum benefits from it. As in the case of diagnostic expertise, the expense and logistics for keeping system expertise in-house may be prohibitive. Brüel & Kjær Vibro, however, can also provide this expertise in the form of services and training.

INSTALLATION AND COMMISSIONING

Not only is there expertise required in running and maintaining a system as described previously, but there is also expertise required in installing and commissioning the system. In many ways this is one of the most crucial steps in implementing a monitoring system – if it is not done correctly from the start, it is possible the system will not be capable of achieving its expected performance when it is up and running. Installation is more than just running cables and making terminal connections. It could also involve engineering solutions to interface with the appropriate systems. Commissioning is important to ensure the system is fully functional to expectations before delivery. Both installation and commissioning is time critical, so expertise is needed to do it fast and efficiently.

THE SERVICE TEAM

The group consists of ISO18436 certified specialists from a vast world-wide network of sales and service offices. Each of these specialists is trained to perform many support functions, but each one also has an area of focus in one of

the three areas of expertise mentioned previously. What is remarkable about the group is that in addition to be able to perform on-site service calls when needed, even for extended periods of time, much of their work can be cost-effectively done remotely. This saves both money and time.

CONCLUSION

A condition monitoring based maintenance strategy requires expertise to implement and run it, in order to maximize the benefits the user gets out of it. This expertise is not limited to one specialist area but covers many areas within the system technology, installation and commissioning and signal analysis domains. For this reason Brüel & Kjær Vibro offer many individual services to meet the individual customer needs. The LTSA is a cost-effective and efficient method for combining these services into a single, manageable package.

If you are a customer currently using or considering using one of our condition monitoring systems, you should consider talking with your local sales representative to see how an LTSA can be customized to your needs to maximize your benefits. Or check our website **www.bkvibro.com** or read our service brochures. ■

EVENTS

EWEA 2014 ANNUAL EVENT

10-13 MARCH, BARCELONA, SPAIN

EWEA 2014 Annual Event, Europe's premier wind energy event, presents an international platform for the wind energy industry to showcase and demonstrate its latest products and services. As well as an extensive exhibition, the event features a broad conference programme and unrivalled networking opportunities.

Visit our stand D30 in hall 7 and see for yourself our flexible wind turbine monitoring solutions!
www.ewea.org/annual2014

AWEA WINDPOWER 2014

5-8 MAY, LAS VEGAS, USA

WINDPOWER is the annual conference and exhibition for the U.S. wind industry hosted by the American Wind Energy Association (AWEA). It's the nexus of wind energy professionals who converge to generate actionable ideas for expanding the wind energy economy through technology and collaboration. Visit our stand 2747 and meet our American sales team.
www.windpowerexpo.org

ASIA HYDRO

11-13 MARCH, COLOMBO, SRI LANKA

Fifth International Conference on Water Resources and Hydropower Development in Asia. Learn more about our dedicated monitoring solutions for the hydropower industry at our stand 111.
www.hydropower-dams.com/ASIA-2014.php?c_id=89

SMART AUTOMATION

6-8 MAY, VIENNA, AUSTRIA

The SMART Automation Austria is the commercial platform for the Austrian automation industry and takes place on an annual basis, alternating between Vienna and Linz. It attracts around 270 exhibitors from 14 countries; many of whom are market leaders and technological pioneers. Our Austrian sales team looks forward to meeting you!
www.smart-automation.at/de/wien

MAINTAIN

3-6 JUNE, MUNICH, GERMANY

The only international trade fair of its kind, MAINTAIN brings all maintenance and repair concepts together and depicts the value chain in its entirety. Welcome to our stand 324 in hall B6.
www.maintain-europe.com/en