# MAINTENANCE

*Operations • Service & Repair • Inspection • Safety • Equipment • Condition Monitoring • Lubrication*

## Beyond the turbine: Understanding the collector system

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Once the wind has been converted to mechanical rotating energy and then to electrical energy, it leaves the turbine.

For some of us, our job is over. Some technicians don't work on anything beyond the turbine. For others, their responsibilities continue — or have just started — with still many components and miles of conductors to maintain. This part of the wind farm is called the "collector system," and without it, the wind farm doesn't work.

The collector system is comprised of many components. An important component of this system is the transformer. A transformer is an electrical component that has the ability to change high current, low voltage into high voltage, low current.

Transformers are used everywhere in the wind turbine and what is discussed here for the power transformers is applicable elsewhere. Transformers are electrical components that only work in alternating current (AC) systems.

The transformer takes the relatively low-voltage, high current power from wind turbines and "transforms" it to high-voltage, relatively low current for transmission over long distances. Or, when the turbine is not producing, the transformer takes the high-voltage low current and transforms it into low-voltage, relatively higher current for the turbine to operate its various systems.

In a transformer, the relationship between voltage and current are inversely proportionate. For example, if voltage is increased by a factor of 10, the current is reduced by a factor of 10. It is important to reduce the current for transmitting the energy for distance to reduce power or line loss. Line loss can happen just like when you try to use more than one long extension cord to run a power tool. There are voltage drops due to the friction of the electrical current in the conductor. On long distance power lines, if the voltage gets too low, then the voltage can be stepped up again by using another transformer.

Maintaining these transformers is fairly easy. For pad-mount transformers, keep your services trucks from running into them and if you are in areas of ice, build protective shelters to keep falling ice from damaging them. Keep the doors closed, seal the conductor entries to keep out the rats, and regularly inspect for bad connections — safely.

Checking for oil leaks and proper oil levels, as well as taking samples of the transformer oil can tell you if there are signs of internal problems. Hydrogen and acetylene are some of the gases found in the oil of transformers that are considered indicators of problems.

The concentration threshold of these gases is up to interpretation of an experienced transformer engineer. Some of today's transformers have high hydrogen gas counts, but when the transformer is inspected, there is no visible problem found. This is thought to be caused by certain manufacturing techniques beyond the scope of this article.

When transformers go bad, they can go quiet, or they can go out with a bang. A transformer explosion is extremely powerful and can cause significant damage. Transformer explosions can be so powerful that some wind farm substations utilize special concrete blast walls to separate transformers from other components in the substation for protection.

In the collector system, when the electrical current leaves the transformer, it continues to flow through high voltage conductors. Sometimes the conductors are underground and sometimes they are above ground, or a mix of the

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two. Both types have their advantages and disadvantages.

For underground systems, the advantage is that there are no cables to look at so a better visual view. A disadvantage is the cable is fairly expensive due to the insulation required to place the cable underground. Underground cable is connected together with specialty connectors. These connectors are typically called splices, and consist of conductor and insulator. It is just as important to properly treat the insulator as it is to connecting the conductor. High voltage electricity can destroy a high voltage electrical splice even if the conductor is well prepared but the insulation of the splice has not been prepared properly or treated well. Just a small nick in the insulation at the splice can cause a early failure.

With above ground or overhead conductors we typically don't have the same issue with insulation as air is used but issues with the power poles and animals can cause problems. Birds can build nest or cross conductors if the lines are not properly designed. The conductor lines can swing in the strong winds and short between another. In addition, in an effort to save money during construction, we sometimes have power poles that are not properly sized or not spaced properly and become overloaded with weight and line tension causing all kinds of havoc with leaning or bent poles and overloaded pole to line insulator connections.

These high voltage collector circuits, whether underground or overhead, feed power from the individual wind turbines and consolidate the power at a substation. At the substation the power is consolidated and usually transformed once again to a higher voltage and then sent out to the grid. In the substation, there are a variety of protection devices that use current, voltage, thermal and magnetic sensors to ensure things are safe. In addition, there is lightning protection and a substantial grounding system. There are circuit breakers and switches to control the power flow. Monitoring systems watch the power flow and the grid operator typically has control to operate or disengage the substation if something is awry.

Hopefully this article has served as an introduction to the collector system, and raises some curiosity and discussion with your team. It is beneficial that everyone understands the specifics of the collector system used by your facility.

As always work as safely as possible, and work to prevent surprises.

## PRODUCT

# Des-Case launches Extended Series desiccant filters


Des-Case Corporation has launched a new line of desiccant breathers called Extended Series — aptly named, as the breathers will help companies extend the life of their lubricants, the life of their equipment, the amount of time between maintenance intervals and, most importantly, maintenance budgets.

The series of four variously-sized breathers addresses a number of industrial needs, bringing greater protection and productivity to tank farms, wind turbines, large gearboxes, as well as applications in both high humidity environments and remote locations. The line features higher airflow, more moisture adsorbing desiccant, check-valve technology, and longer life.

Though simplistic in appearance, Des-Case desiccant breathers are highly sophisticated filters for industrial lubricants, removing dirt and water from the headspace of equipment.

"These breathers, as well as our other contamination control products and services have for years helped companies around the world detect, prevent and remove contamination from their equipment and plants," said Brian Gleason, CEO of Des-Case. "This new development continues our drive to help customers improve lubricant quality, maximize equipment reliability and achieve an entirely new level of performance."

Contaminants such as dirt and water in industrial lubricants can lead to equipment breakdown if not filtered out, bringing plants to a grinding halt and costing companies both time and money.

As wet, contaminated air is drawn through the breather, multiple 3-micron polyester filter elements remove solid particulate and the color-indicating silica gel extracts moisture. When air is expelled from the container, the top foam pad prevents oil mist from contacting silica gel or entering the atmosphere.

The breather is also outfitted with a nylon standpipe and polypropylene oil mist reducer to allow oil mist to coalesce and drain back into the reservoir, rather than compromising the desiccant. Six umbrella check-valves are located underneath the unit to isolate equipment from ambient conditions -- prolonging breather life and protecting system integrity.

Additionally, more desiccant in the Extended Series breathers provides more adsorption capacity and elongates breather life. The larger capacity accommodates higher airflow and female threaded mountings offer users greater durability, stability, and versatility with a number of adapters.

# Maintenance cost reduction achieved through comprehensive fleet monitoring

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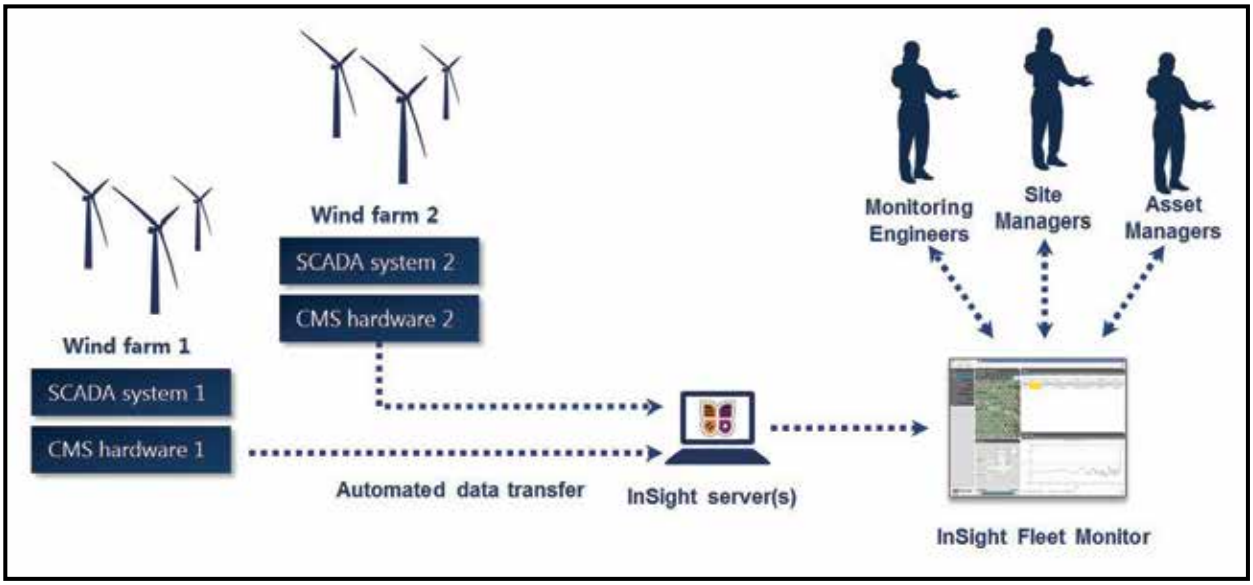


Figure 1: InSight software architecture

Major component repair costs are a real issue for wind farms over five years old. Taking as an example data set of six wind farms that Romax monitors, in the last 12 months there have been detections of nine failing planet bearings and 14 failing main bearings. In each case, the damage has been confirmed by inspection and repairs scheduled. These repairs are expensive and significant cost reduction can be achieved by optimizing the scheduling of repairs. Romax customers are using InSight Fleet Monitor to realize these cost reductions.

## Wind turbine Condition Monitoring

Effective signal processing techniques for condition monitoring of rotating machinery have existed for decades, but applying these techniques to the wind industry presents many challenges. A large fossil fired power station may have only four large machines that need to be monitored; these machines operate in a very predictable manner, in a carefully controlled environment, perhaps with the service engineer located just a walk away. A wind farm, by contrast, comprises many turbines, with highly variable operation, located at the top of tower, often in remote locations and often with extreme ambient conditions.

Many independent studies have shown that predictive condition-based maintenance can significantly reduce the cost of energy from wind but, in spite of the relative maturity of condition monitoring techniques, this value is often not realized. Most owners/operators face the challenge that they have a range of different condition monitoring systems (CMS) installed, with a variety of interfaces and software tools. This makes it difficult to monitor efficiently and to a consistently high quality. Moreover, there is a shortage of the valuable expertise required to interpret the data. Software tools designed with efficient workflow in mind are essential so that wind farm owners/operators can get the most value from scarce expertise; nobody wants their valuable experts to waste time waiting while switching between turbines, or different software systems.

Fleet Monitor is Romax's web-based, hardware-independent, software for wind turbine health monitoring. The software enables condition monitoring engineers to monitor an entire global fleet of turbines, whatever turbine type or CMS type, with one platform. This means that consistent alarm strategies can be applied so that lessons learned

on one farm can be quickly and efficiently implemented to improve the quality of monitoring on another, without the difficulties created by moving between disparate systems.

Using data from existing CMS and SCADA systems, along with lubrication and operations and maintenance data, the software is able to provide a complete picture of turbine health. Often, faults can be detected as much as 12 months in before failure. Once an incipient fault has been detected, various measures, such as main bearing life extension or turbine de-rating, may be taken to increase the component life. Multiple main bearing, or gearbox, change-outs may be scheduled together so that the crane cost is spread and the overall OPEX significantly reduced.

Designed with global access and collaboration in mind, Fleet Monitor enables site managers, asset management teams, and condition monitoring centers to communicate and collaborate more effectively.

### Fleet Monitor Features

- Hardware and software independent so that all turbines can be monitored efficiently and effectively through one platform.
- Proven analysis techniques including time domain trending, FFT, envelope, Cepstrum and time synchronous averaging enable faults to be detected early so that repair costs can be kept to a minimum.
- All data stored and backed up. Many CMS automatically decimate historical data, but with Fleet Monitor no historical data is discarded.
- Libraries of tried and tested alarm rules based on Romax's experience of monitoring over 3 GW of wind turbines mean more advanced warning and fewer false alarms.
- Remaining useful life models: these innovative prognostic techniques enable forecasts up to three years ahead, so that operations and maintenance budgets can be based on real data rather than guesswork.
- Automated alarm thresholding, which embeds best practice.
- Powerful alarm configuration enables alarms to be set against vibration, SCADA and lubrication data, resulting in confident diagnoses of the turbine condition.
- Automated reporting so that condition monitoring engineers can focus on what really matters rather than copying and pasting figures and formatting documents.

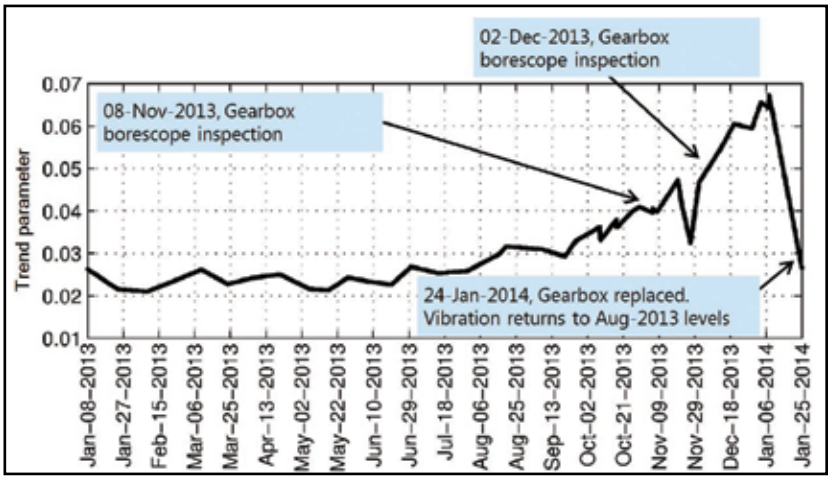


Figure 2: Example of Damaged Planet Bearing Detected by Fleet Monitor

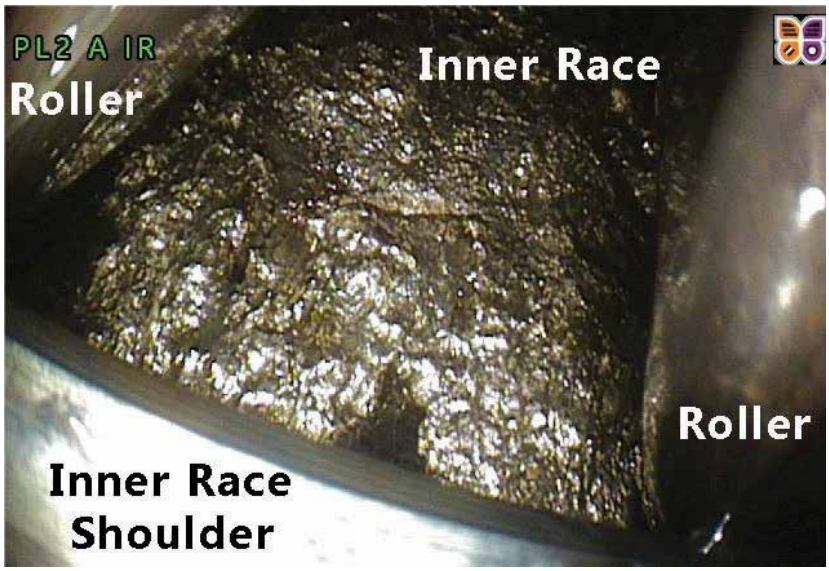


Figure 3: Romax Inspection Showing Failed Main Bearing

### Networking

To use Fleet Monitor, no hardware or software installation is required because Fleet Monitor is web-based Software as a Service (SaaS). All that is required is VPN access to the site server(s). This allows Romax to fetch the data and insert it into the InSight Health Management platform automatically, see Figure 1. Open an internet browser on any device, then go to the Fleet Monitor website and you'll be able to log-in and check the condition of your wind tur-

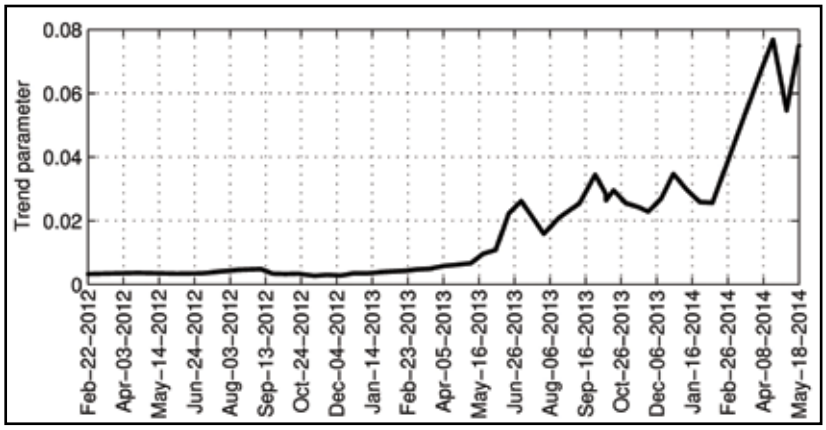


Figure 4: Example of Damaged Main Bearing Detected by Fleet Monitor

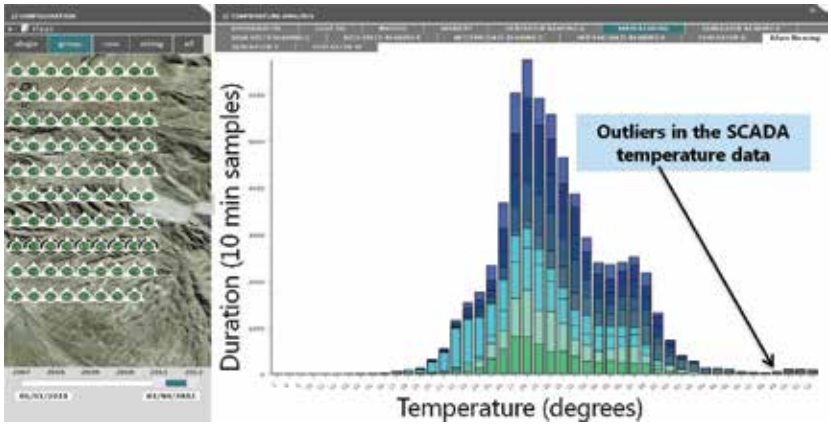


Figure 6: Using Fleet Monitor to Detecting Main Bearing Damage

bines, make rapid diagnoses and schedule inspections.

### Case Study 1: Planet Bearing Failure Detection

In this example the vibration health index started trending in September 2013, see Figure 2. The analyst using Fleet Monitor recommended inspection. The first inspection (November) showed significant surface distress on the planet gear teeth. The turbine could continue to operate and the trend was carefully monitored. A second borescope inspection was scheduled in December and severe damage confirmed on a planet bearing. The gearbox was replaced in January 2014. The site had four months warning to arrange the most cost effective repair and avoided a catastrophic failure and downtime (temperature trend or other turbine fault provided no indication). This is typical of Romax monitoring of planet bearing failures: 3-6 months warning as the wear out from bearing spalling is slow. Aging gearboxes that have survived infant mortality issues (e.g. from poor design, poor steel or heat treatment, grind temper and so on) are commonly failing in this mode.

### Case Study 2: Main Bearing Failure Detection

Main bearings failures (initiated from micropitting then progressing to surface initiated macro-pitting) also progress slowly. Figure 4 provides a typical example where the trend ran for 12 months. This is typical; Romax has not seen a case of less than three months warning and has


Figure 5: Romax Inspection Showing Failed Main Bearing

monitored failing main bearings for 18 months before a repair was made. At the end of useful life the condition shown in Figure 5 is typical. Romax's main bearing life extension technology can be applied to suspend or severely slow the failure, which offers a useful O&M strategy for sites with failing main bearings: Monitor and catch early, extend bearing life, optimize repair schedules.

Damaged main bearings can also be detected using SCADA data, however not nearly as early as by vibration monitoring. For sites that have no CMS this is valuable and Fleet Monitor provides flexibility to include vibration and/or SCADA monitoring. Figure 6 provides an example in which a damaged main bearing is the outliers in SCADA temperature data.

### Conclusion

Crane hire accounts for a large proportion of cost for a main bearing or planet stage repair; the benefits of carrying out multiple repairs with one crane mobilization are clear. Monitoring and scheduling all major component replacements in the low season reduces costs dramatically. Romax's proven monitoring technology is available to enable predictive maintenance with carefully optimized scheduling, worldwide, using a range of CMS hardware that is installed on the original equipment and incorporating SCADA and lubrication data.