Cooling Tower Application Study

By Peter Eitnier, Field Application Engineer, Wilcoxon Sensing Technologies
with input from Ron Peterson, Reliability Specialist, Aux Sable

Part I – Motor Madness

Cooling towers are a critical component in many process facilities and are made up of several different pieces of machinery that contribute to their operation. Motors, gearboxes, fans and shafts require vibration monitoring to provide technicians with early warning signs regarding impending failures that could lead to catastrophic breakdowns. Such failures can result in lowered production, safety hazards and expensive repairs that can set a site back for months.

Aux Sable, a natural gas processing facility located outside Chicago, Illinois, is one plant that has been using vibration monitoring on their critical machinery for years. As far back as 2001, Aux Sable has been using Wilcoxon accelerometers for monitoring their cooling tower components.

The Wilcoxon Model 797 is a standard 100 mV/g output sensor that was mounted on the drive-end (DE) of the motor directly coupled to an Aux Sable cooling tower fan. The motor operated at two different speeds, 1790 and 893 RPM. Over a three year period from 2004-2006, the sensor tracked an overall vibration signal that increased from 0.07 inches per second (ips) peak to 0.19 ips peak. While not exceeding their alarm value of 0.20 ips peak, the increase, combined with an audible noise coming from the motor, sparked Aux Sable's interest.

While investigating the issue on the motor DE, spectral analysis showed a bearing defect that was traced to the motor NDE bearing relating to the ball pass frequency inner race (BPFI).

Due to the information being collected, Aux Sable chose to pull the faulty motor in November of 2006 and replace it with a spare. The process was completed without issue during a planned shutdown and the motor was sent to a repair shop for inspection. The results of the inspection not only confirmed what Aux Sable had suspected on the motor NDE, but provided further root cause for the overall vibration increase.

As seen to the right, the motor NDE bearing inner race defect was confirmed (top right photo) and the outer race was showing rust and corrosion caused by an improper bearing to housing fit (bottom right photo).

The motor NDE bearing housing was also severely grooved at the bottom location which was caused by the bearing outer race turning in the bearing housing. Further inspection of the rotor assembly showed signs of contact with the stator on the NDE as evidenced by visible wear marks. The rotor bars were visible through the rotor laminations due to contact on the NDE.

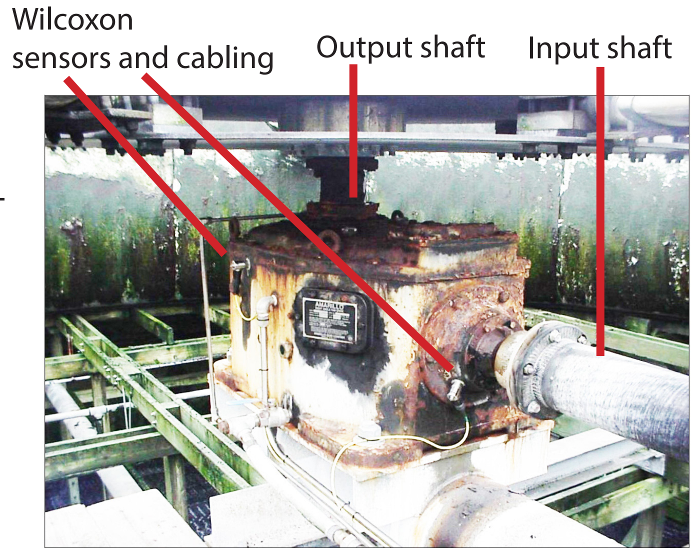
Cooling Tower Application Study

By Peter Eitnier, Field Application Engineer, Wilcoxon Sensing Technologies
with input from Ron Peterson, Reliability Specialist, Aux Sable

The machine shop was able to perform repairs on the motor for a total cost of just under $5,000, well below the nearly $20,000 quotation for a replacement motor. The replacement motor also would have had a 10 week lead time, whereas Aux Sable was returned the repaired motor in December of 2006, less than one full month after it was pulled from operation. The technician who performed the repairs noted that the motor would not have lasted much longer before entering catastrophic failure mode, a testament to the vibration monitoring that was being done.

Part II – The Gearbox Grind

After dealing with the motor bearing issue in November of 2006, Aux Sable resolved to immediately expand their vibration monitoring program to include the cooling tower fan gearboxes. They mounted Wilcoxon accelerometers to the gearbox input and output shaft bearing housings and ran cables from the sensors to a Wilcoxon enclosure mounted just outside of the fan housing. The gearbox, with input shaft speeds of 29.83 and 14.91 Hz and output shaft speeds of 2.13 and 1.06 Hz, and sensors can be seen to the right. A 797L with 500 mV/g sensitivity specifically designed for low frequencies was monitoring the output shaft due to the low rotating speeds.



Vibration data was then collected monthly from the enclosure and analyzed by the technicians. In October of 2008, the vibration trend showed a large increase and tripped a pre-programmed alert level. In addition to oil analysis from months earlier which indicated abnormal wear on the gearbox bearings, the vibration analysis showed a bearing defect on the gearbox bottom output shaft bearing. Upon replacement of the gearbox during a planned outage, inspection of the bearing confirmed what the sensors had been measuring. The image seen to the right shows just how bad the metal fatigue was, where nearly 60% of the outer raceway had been removed.

Furthermore, all 21 of the tapered rollers on the bottom output shaft bearing as well as the output shaft inner race exhibited heavy corrosion damage. Clearly, the vibration sensors and subsequent analysis had proved useful.

Wilcoxon Sensing Technologies
8435 Progress Drive
Frederick, MD 21701 USA

Tel: +1 301 330-8811
Tel: 1-800-WILCOXON
Fax: +1 301 330-8873

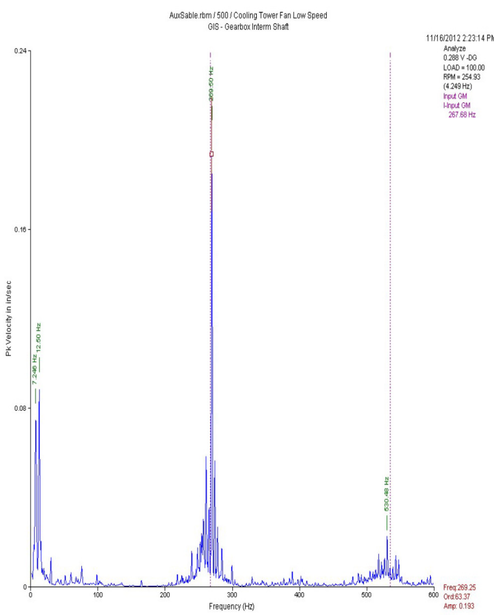
info@wilcoxon.com
www.wilcoxon.com
buy.wilcoxon.com

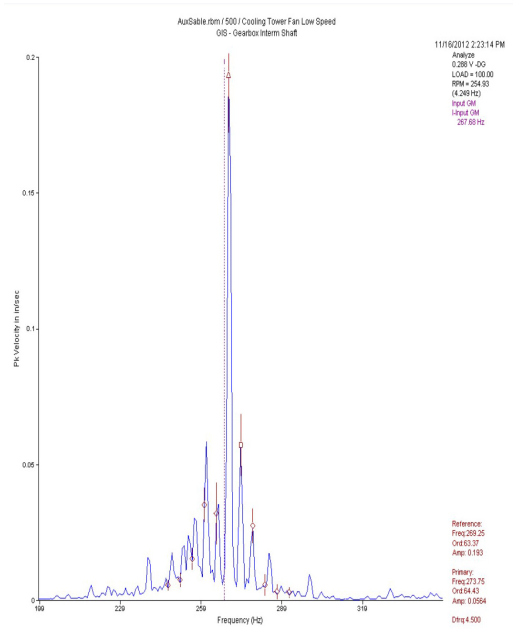
Somehow, only the gearbox bearings and seals needed replacing as all other major gearbox components, including the gear sets, were found to be in good condition. The repair costs totaled just under $2,700 while a rebuild would have cost over $13,000 more. This is without taking into account any losses in operations due to a reduction of cooling water had the fan not been in operation during peak demand.

Part III – New Gearbox, Continued Vibration Problems

After several years without issue, Aux Sable prospered once more from their vibration monitoring program. In 2012, trending from a Wilcoxon sensor showed an overall vibration increase from 0.10 ips peak to 0.24 ips peak between January and November. By digging into the data that had continued to be collected monthly they were able to determine a root cause. Oil analysis proved that the oil level was normal, so vibration was determined to be the sole issue.

Through analysis, it was determined that there was a spike in amplitude at the gear mesh frequency of 269 Hz. Shown below (left photo) is the troublesome spectrum. The expanded spectrum (right photo) detailed the issue further as numerous sideband frequencies at intervals of 4.5 Hz appeared. These correlated with gearbox intermediate shaft speed. That the amplitude was at approximately 30% the level relative to the fundamental frequency indicated a moderate level of severity.





Finally, a waterfall plot tracked throughout the year showed the continuous increase in amplitude of both the gear-mesh frequency and sidebands. The gearbox was replaced at the first opportunity and replaced with a spare while repairs were made.

Wilcoxon Sensing Technologies
8435 Progress Drive
Frederick, MD 21701 USA

Tel: +1 301 330-8811
Tel: 1-800-WILCOXON
Fax: +1 301 330-8873

info@wilcoxon.com
www.wilcoxon.com
buy.wilcoxon.com

By Peter Eitnier, Field Application Engineer, Wilcoxon Sensing Technologies
with input from Ron Peterson, Reliability Specialist, Aux Sable

Part IV – Testament To Excellence

After more than 10 years of operation in the cooling tower being subjected to sulfuric acid, water spray, dirt and grime, the sensors were pulled and replaced.

The image directly below shows the two sensors that came off the gearbox. The left sensor has been rubbed clean of most contaminants, while the sensor on the right appears just as it did when it was removed from operation. Both sensors still work exactly as they did when first commissioned, regardless of the chemicals they were subjected to, proof of the outstanding quality and durability put forward by Wilcoxon.

Paired with the R6Q(I) boot-style connector and Teflon-jacketed J9T2A cable, as seen in the image to the right, no contaminants made their way into the electrical wiring and the signal remained clear for the entirety of the sensor's lifetime.

Aux Sable was fortunate to employ their vibration monitoring program when they did and have benefitted immensely from the data collected. With their durable Wilcoxon sensors, cables and enclosures leading the way, Aux Sable has been able to avoid various catastrophic machine failures while keeping their cooling towers operational. Combined with their own vibration analysis expertise and the industry leading quality of Wilcoxon Sensing Technologies, Aux Sable has continued to grow as a business and extract liquid fuel from natural gas across Canada and the Northern United States.

Wilcoxon Sensing Technologies
8435 Progress Drive
Frederick, MD 21701 USA

Tel: +1 301 330-8811
Tel: 1-800-WILCOXON
Fax: +1 301 330-8873

info@wilcoxon.com
www.wilcoxon.com
buy.wilcoxon.com