Innovative Sound Solutions™

## Ultrasonic Condition Monitoring

# MORE THAN JUST A LEAK DETECTOR

*Presented by*

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## Introduction

If you are using an ultrasonic sensor for leak detection and not achieving the expected results, there are better tools available. If your ultrasonic sensor is used for leak detection only, then you are not fully benefiting from the technology. Ultrasonic leak detection is recommended by many, such as the U.S. Department of Energy[1], as the best method for detecting the location of leaks in order to minimize energy waste and improve plant efficiency. Ultrasonic sensors designed with the right technology and software can be used for condition monitoring and predictive maintenance. This will minimize production downtime, improve quality control and safety, and decrease man-hours by improving troubleshooting capabilities.

Consider the following summary from a third party evaluation team for the integration of ultrasonic technology in a single organization with over 500 sites:

- More than 100 applications were identified in use for various equipment at each site such as boilers, heat exchangers, compressors, motors, pumps, valves, and steam traps
- The total savings for the organization would be approximately $3.7 million annually.
- The return on investment for the integration of ultrasound with this cost avoidance would be approximately 15:1.
- The annual man-year savings caused by the reduction of time spent diagnosing and troubleshooting would be approximately 45 man-years.

Proper integration for the proposed implementation of ultrasonic technology at this organization and other similar organizations realize the estimated benefits and more. Many companies, however, have good intentions of implementing predictive maintenance programs to decrease production and operation costs, but they lack the tools and time to develop an effective plan. This paper shall discuss ways to use ultrasonic technology for a fast and effective return on investment.

## Condition Monitoring

Condition monitoring and predictive maintenance has traditionally been performed through vibration analysis, infrared, and other technologies. Ultrasonic technology is often ignored but is an excellent option, especially for organizations with lower budgets. Ultrasonic detectors are capable of accurately interpreting the sounds created by under lubrication, over lubrication, and early signs of wear. The right ultrasonic technology is a fast and effective means of determining such conditions in moving, mechanical components such as bearings, gearboxes, motors, compressors, etc.

Ultrasound is produced by friction, impact, turbulence, and electrical discharge. Friction and impact are the by-products of mechanical equipment. For example, a roller bearing will produce friction as the shaft and balls roll around the center. If there is too much friction, however, problems begin to occur on the production line due to imbalance, or the bearing might seize, thereby shutting down production altogether.

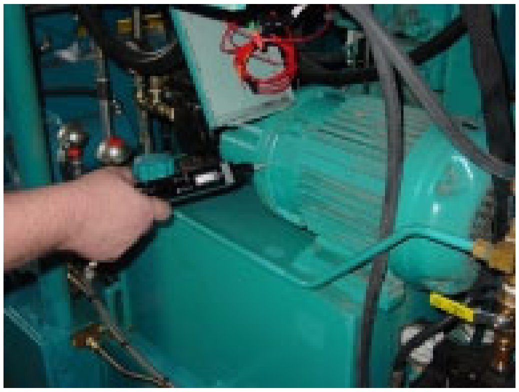

Figure 1

Proper lubrication of critical bearings is important at all times. A properly lubricated bearing will produce a smooth rolling ultrasound, detectable by an ultrasonic receiver whose microphone can be placed in contact with the housing (See Fig. 1).

[1] Office of Industrial Technology/U.S. Department of Energy: http://www1.eere.energy.gov/industry/bestpractices/pdfs/compressed_air3.pdf

If the bearing is over-lubricated, very little ultrasound can be heard through the headset. If the bearing is under-lubricated, the intensity of the bearing will increase dramatically and other sounds may be produced such as fluttering or scratchiness. Indications of an under-lubricated bearing will appear in ultrasound even before infrared can detect heat increases and well in advance of vibration analysis.

In addition, once a bearing begins to wear, the ultrasonic wave will produce large spikes in the signal caused by flat spots or scratches on the race. The spikes are heard as pops or crackles through the headset. Once the ultrasound produced by the bearing begins to indicate these characteristics, the replacement of the bearing can be planned during normal production shutdown. The detection of wear is instantaneous. It is not necessary to take readings of the bearing from several points of contact along different axes and send the readings away for analysis.

When using an ultrasonic sensor for condition monitoring, contact the solid probe at the same point each time. Adjusting the sensitivity will minimize ambient ultrasound caused by other components. Ultrasound attenuates, or loses energy, much more rapidly than audible sound that is detectable by vibration sensors, but ultrasonic vibrations in steel can still interfere with the component under test if the sensitivity is adjusted too high.

You may record the settings of the sensor and component operating conditions such as speed, load, etc. Each time you monitor that component, try to maintain the same operating conditions so that changes in the ultrasound can be attributed to component wear or lubrication rather than increased speed, for example.

There is no single ultrasonic characteristic that will, when considered alone, help determine the condition of a component under test. Digital indicators of relative measurements such as decibels or root mean squared (RMS) should not be solely used for trending. A decibel reading, for example, is a logarithmic unit used to describe a ratio that could include power, sound pressure, voltage, intensity, or several other factors.

The use of ultrasound technology for condition monitoring does not need to be complex, however. Software may be used to record the output of the ultrasonic sensor. Once a baseline or benchmark signal of a component is recorded (see Fig. 2), future recordings may be compared to it in order to determine the wear or proper lubrication of the component over time.

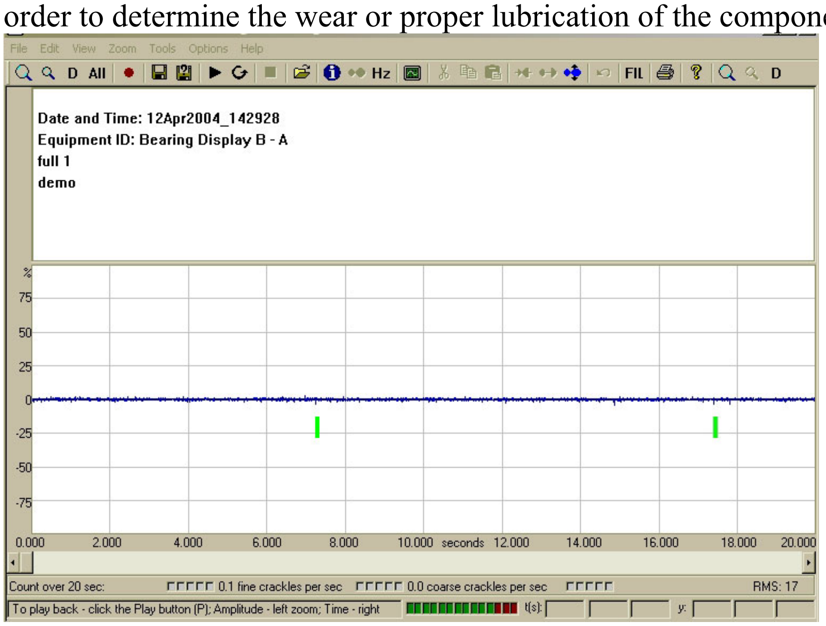


**Figure 2**

Again, signal analysis software should be easy to use and reflect the ultrasonic sensor's ease of use. If the sensitivity of the sensor is adjusted properly each time a recording is taken, then spikes and crackles should be easily identifiable as the bearing begins to wear (See Fig. 3).

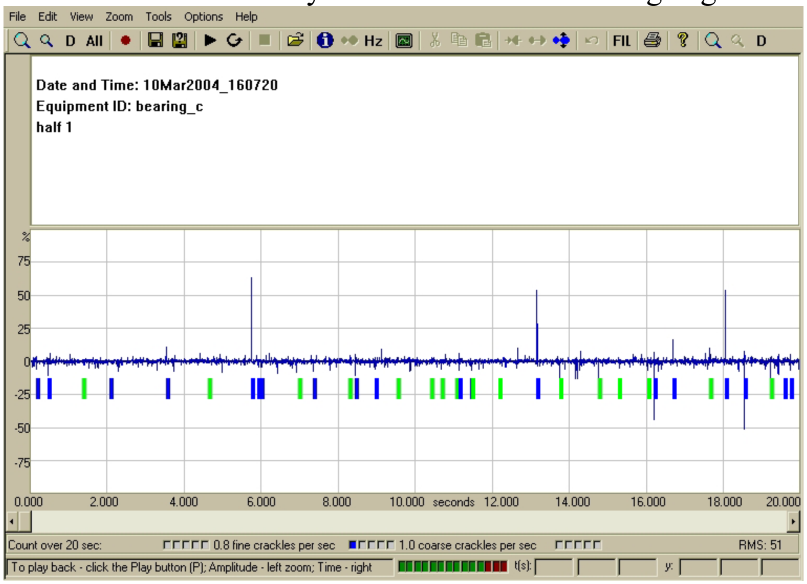


**Figure 3**

If the sensor is set to the same setting each time, you may compare the overall amplitude or RMS value of the component with its baseline RMS value (See Fig. 4). Verify that the increase in the amplitude is not attributed to other factors such as change in speed, load, or pressure of the contact point by recording the signal after additional lubrication has been applied and noting the decrease in overall amplitude of the signal.

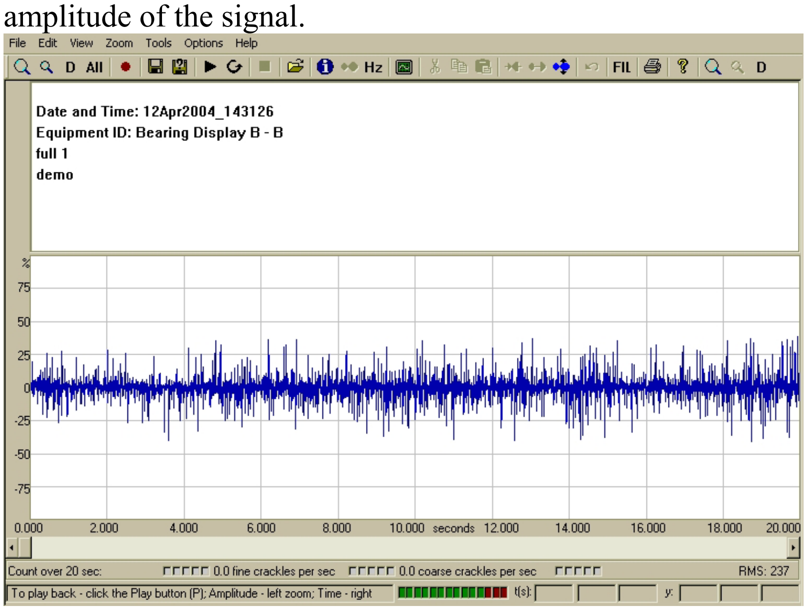


**Figure 4**

## Leak Detection

Ultrasonic sensors detect ultrasound transmitted by turbulent flow produced by gas molecules escaping through a crack, hole, or seam from a high-pressure system to a low-pressure system. A piezoelectric microphone is used to receive sound pressure waves at a specific ultrasonic frequency. Most airborne piezoelectric microphones have a characteristic center of frequency at 40 kHz. The human ear can only detect sound pressure at frequencies up to 20 kHz. Once ultrasound is detected by the receiver's microphone, the receiver will convert the incoming signal into a frequency range that can be heard by the human ear. The new signal is output to headphones.

When a leak occurs, the turbulent flow produces sound pressure waves all along the spectrum from 0 Hz to100 kHz and beyond. Lower frequency sounds travel greater distances and interfere with ambient noise such as running machinery. Also, these sounds have greater energy and can easily reflect off surfaces, minimizing the ability of a low frequency microphone to accurately locate the leak. High frequency waves (those far above 40 kHz) do not have sufficient energy to be detectable from reasonable distances. An ultrasonic sensor that is used for the detection and location of leaks should:

- Have a narrow bandwidth with center of frequency 40 kHz
- Have a narrow directional pattern of reception
- Have controls for adjusting the sensitivity of the receiver in order to pinpoint location
- Have an analog meter, that rapidly displays small changes in the input signal
- Have a good signal-to-noise ratio as noise will minimize the sensor's ability to detect a leak
- Have a long battery life

A good ultrasonic leak detector is important for the detection and location of leaks throughout a manufacturing facility, but no ultrasonic leak detector will be able to determine how much money you are saving or how much air you are losing. Ultrasonic sensors are incapable of determining leakage flow rate or CFM loss. There are many factors that change the intensity of the turbulent flow through an orifice such as thickness, size, and shape of the opening; roughness of edges; directional pattern; distance from receiver; humidity; temperature; atmospheric pressure; etc.

Consider the fact that under the same pressure differential inside and outside a system, the same leakage flow rate through a crack with rough sharp edges will produce ultrasound that is dozens and even hundreds of times as intense as the same flow rate through an opening with round, smooth edges. Therefore, in order to accurately determine cost savings, it is necessary to monitor electrical consumption and production output through other means. It is possible, using complex and expensive equipment to make such an accurate measurement, but it is not necessary. Routine air and steam audits will save money, though, even if you are unsure of how much. If you are not using ultrasonic technology, you are missing out on the fastest and easiest means of leak detection.

## Technology Integration Through Turnkey Implementation

Once a decision is made to implement a new technology, many organizations fail to achieve the desired benefits. There are several reasons including initial lack of understanding of the technology, improper training, improper devotion of time and resources, improper identification of critical areas of implementation, etc. Too many organizations are busy putting out fires, rather than taking the time to develop a plan for fire prevention, suppression, and containment.

Dedication to implementation is required in order to achieve the expected benefits from any new technology or program. When using ultrasound technology, the first step to fast return on investment is to ensure that the right people have the right technology in their hands. Many ultrasonic sensors, for example, are incapable of accurate condition monitoring and fail to detect a high percentage of the leaks. In addition, a turnkey program should be developed for implementation that considers all aspects of integration. Consider the following turnkey implementation program for ultrasonic technology integration:

1. Identify critical components and systems for testing
2. Identify the right products such as sensors, software, and accessories
3. Identify test points and take initial readings for benchmarking
4. Document test points, readings, components, and products
5. Train personnel to properly operate ultrasonic sensors and software in accordance to the documentation
6. Establish attainable milestones for integration
7. Maintain flexibility, expand product integration, and continue to evaluate key areas of integration including condition monitoring and leak detection

## Conclusion

If properly implemented and used on a regular basis, ultrasound technology can be a fast, cost-effective means of monitoring critical components at your facility. The approach to implementation should include the right product, training of personnel, identification of critical components, benchmarking, and the determination to follow through on good intentions. A lack of training and understanding, irregular monitoring, and a lack of commitment to the predictive maintenance program will lead to poor results. However, proper implementation of ultrasonic technology will increase production, decrease troubleshooting time, and decrease time spent putting out fires by your production and facility maintenance staffs. The right ultrasonic technology truly can be more than just a leak detector.