# ULTRASONICS:

## Industry's Multipurpose Maintenance Technology

Ultrasonic instruments are increasing production, reducing maintenance costs and energy consumption, and shortening downtime.

**Alan S. Bandes, UE Systems, Inc.**

Maintenance supervisors have for years relied on ultrasonic instruments for leak detection, but these devices can also be integrated into IR and vibration inspection equipment to handle a great many other jobs. Today, for example, these compact, portable instruments are commonly used to inspect high-voltage apparatus for arcing, tracking, and corona; to trend bearing failure; and to detect undesirable conditions such as lack of lubrication and the friction that results. Ultrasonic instruments are well suited to predictive maintenance, machinery reliability, energy conservation, and total productive maintenance programs in which a combination of technologies may be used by both maintenance and production personnel.

### Finding Source locations

All manufacturing and process equipment produces a broad range of sounds when operating. The high-frequency ultrasonic components of that noise are extremely short wave and tend to be fairly directional and localized. As a result, it is easy to isolate these signals from the background clamor and so pinpoint their physical source. Furthermore, as changes begin to occur in mechanical equipment, the subtle nature of ultrasound allows you to detect these potential warning signals early, before something fails.

Instruments designed to detect airborne and/or structure-borne soundwaves are often referred to as *ultrasonic translators*. They provide two types of information about what they sense: qualitative, by their ability to hear ultrasounds through noise-isolating headphones; and quantitative, from incremental readings on a meter/display panel. These instruments allow inspectors to make a diagnosis on the spot because they clearly discriminate among various equipment sounds. An electronic process called *heterodyning* accurately converts ultrasounds detected by the instrument into the audible range that, you can hear and recognize through headphones. You can even use conventional recording devices to capture the sound events.

Most of the sounds sensed by humans range in frequency from 20 Hz to 20 kHz; the average high-end human threshold is 16.5 kHz. Low-frequency sounds in the audible range have wavelengths of ~1.9 cm up to 17 m; those detected by ultrasonic translators are only 0.3-1.6 cm. Because the amplitude of a generated ultrasound falls off exponentially from the source, the emission is localized and can easily be isolated for detection and analysis.

**Figure 1. Ultrasound is a localized signal that makes detecting a leaking valve relatively easy. Sound levels are compared upstream vs. downstream. A louder downstream sound will indicate a leak.**

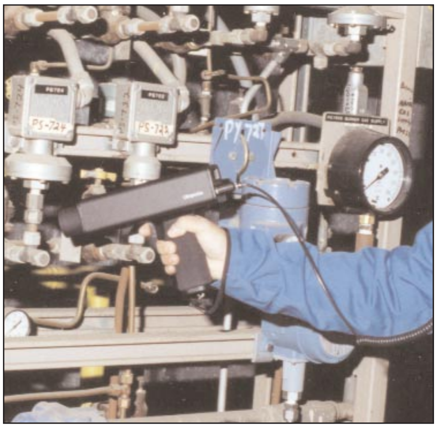

**Figure 2. According to the U.S. Department of Energy, compressed air is the most costly utility in plants today. The advantage of ultrasound is that it can quickly locate these leaks in noisy environments and in panels with multiple fittings.**

## Ultrasound Translators

Airborne ultrasound translators are hand-held units consisting of a meter and sensitivity adjustment, headphones and often interchangeable modules that are used in either a scanning or a contact mode. Some instruments can adjust the frequency response to between 20 and 100 kHz. An ultrasonic transmitter called a tone generator is often part of the unit.

Many of these features provide adaptability to specific inspection requirements. If the intensity of an ultrasound source makes it difficult to locate, you can adjust the sensitivity downward to focus in on the exact site.

Similarly, if a water or compressed gas leak is underground or behind a wall, you can tune the frequency to better hear the leak. Scanning mode detects ultrasound traveling in air from a pressure leak or corona discharge; contact mode senses sounds inside a housing, such as those made by a bearing, pump, valve (see Figure 1, page 24), or steam trap.

## Applications

Ultrasonic translator applications fall into three categories: leak detection, mechanical inspection, and electrical inspection.

**Leak Detection.** When a fluid, either liquid or gas, leaks, it moves from the high-pressure side of the leak site to the low-pressure side, where it quickly expands and produces a turbulent flow with strong ultrasonic components. Because the intensity of the signal falls off rapidly from the source, you can locate the exact spot of a leak, whether it's pressure from compressed air or other gas (see Figure 2), a vacuum leak, a condenser ing heat exchanger leak, or a leak that's under ground or behind a wall.

For faulty seals and gaskets, air infiltration, and leaks in systems that are hard to find with standard pressure or vacuum testing, you can use an ultrasonic tone test. You put an ultra-sonic transmitter either inside or on one side of the test subject and scan the opposite side with the translator, listening for the point of sonic penetration that indicates a leak.

**Mechanical Inspection.** According to NASA research, ultrasonic bearing monitoring (see Figure 3) can warn of wear and imminent failure before the conditions can be predicted from changes in vibration or temperature. The study indicated that a 12-50 x increase in amplitude over base-Iine of a monitored frequency signals the initial stages of bearing failure.

Bearing failure has three distinct phases. In pre-failure, lubrication levels diminish and levels of ultrasound increase without any dramatic change in the quality of the heterodyned signal. In the early stages of failure, the amplitude of the signal increases, accompanied by a recognizable shift in sound quality that can often be confirmed visually on a spectral or vibration analyzer. As the bearing deteriorates, the heat that begins to build can be detected with an IR instrument, but by this stage, failure can be catastrophic.

To determine whether a bearing is good or has failed, you touch a reference point on the bearing housing with the instrument's contact probe and adjust the sensitivity/volume to get a specific intensity reading. Next, using the same sensitivity setting, you compare it to a similar reference point on another bearing operating under the same conditions. The amplitude reading and sound quality should be similar. You can then use this second reading to trend each bearing over time to evaluate its status.

Overlubrication is a common cause of ball bearing failure. This practice can blow out the bearing's seals, introduce contamination, raise the pressure inside the cage, create excessive heat, and cause defects in the balls and race. With an ultrasonic detector, you can listen to the bearings and Iube them on an as-needed basis rather than according to a schedule that might not be appropriate for a particular bearing (see Figure 4).

**Figure 3. Some ultrasonic translators can log test results such as decibel and frequency readings. The heterodyned signal can be used to record sound samples or to connect directly to vibration analyzers for detailed spectral or time series analysis.**

**Electrical Inspection.** Electrical equipment is normally silent, although some transformers may produce a constant 60 cycle hum or steady mechanical noises. These should not be confused with the erratic, sizzling, uneven, and popping sounds of an electrical discharge. Some manufacturers of ultrasonic equipment offer sound samples either on their Web sites or on a disk to help you recognize problematical noises.

Changes in ultrasonic patterns produced by potentially damaging faults in electrical

**Figure 4. Overlubrication is one of the most common causes of bearing failure. To prevent this, when bearings are identified for lubrication, technicians can use ultrasonic translators to listen while the lubricant is applied and recognize when to stop lubricating.**


**Figure 5. Arcing, tracking, corona, and partial dis-charge produce ionization. Inspectors can identify the type of problem based on the sound patterns. Enclosed systems can be tested by scanning door seams and air vents. A contact probe can be used on totally enclosed systems.**

equipment such as switchgears (see Figure 5), transformers, insulators, or potheads and splices, are easily recognizable acoustically as arcing, tracking, or corona (corona does not occur at under 1000 V). Electrical disturbances ionize the air molecules around them, producing distinct. detectable changes in a component's acoustic signature High-frequency sounds tend not to penetrate solids, but will slip through the smallest openings Ultrasonic detectors are therefore an excellent way to safely troubleshoot electrical emissions through enclosed compartments by scanning door seals and air vents.

Technicians often use both IR and ultrasound for electrical inspections because ultrasonic devices detect acoustic events while IR instruments detect problems related to heat. There are times, however, when it may be difficult to access electrical equipment with IR, especially if the equipment is enclosed or if lighting conditions might affect results. In addition, there are high-voltage situations where for safety reasons you might not want to get too close. In such cases, you can use an ultrasonic detector with a parabolic microphone. These devices have a narrow field of view (10° or 5°) and can detect problems at more than double the distance of standard scanners.

## Summary

Airborne/structure-borne ultrasound instruments should be a key part of every company's predictive maintenance, leak detection, and energy conservation program. The advantages are many: They are directional and can quickly and easily pinpoint air leaks; they provide early warning of impending mechanical failure; they are ideal for use in loud, noisy environments; and they support and enhance other predictive maintenance technologies, such as infrared thermography and vibration analysis. ■

**Alan S. Bandes** is Vice President, UE Systems, Inc., Elmsford, NY; 800-223-1325, abandes@att.net, info@uesytems.com, www. uesystems.com.