Ultrasonic Air-Leak Detectors: A No-Brainer for Energy Savings

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Compressed air (CA) systems are a vital component of many industrial and commercial facilities. From traditional uses in manufacturing settings to commercial applications such as powering air brakes on amusement park rides, cleaning movie projector screens, and providing pressure for golf course sprinkler systems as well as powering the seeding and fertilizing functions, business operations can be shut down if a CA system fails.

Considering the critical nature of CA system reliability, it's surprising that these systems often go overlooked by maintenance personnel until something goes seriously wrong. The U.S. Department of Energy (DOE) estimates that unmaintained CA systems can develop leaks that waste 20 to 30 percent of a compressor's total energy usage—a staggering number considering that CA systems are typically the largest electricity user in many industrial facilities. In fact, many facility managers refer to the CA system as the "fourth utility" after

electricity, gas, and water.

Ultrasonic air-leak detectors can play an important role in a predictive maintenance plan for CA systems. These detectors are tools designed to identify and locate leaks in CA systems, but they also have other applications such as identifying leaks in steam traps and monitoring ball bearings in motor drive shafts prior to failure. Whatever the application, leak detectors offer facility managers the ability to observe and monitor equipment in a convenient and consistent fashion, ultimately helping them catch problems before they become too costly.

Leak detectors may not blow you away with stunning design or user ergonomics, but they're easy to use and provide quick and accurate results. Depending on the specific bells and whistles included in a given design, the price of a leak detector can range from as little as $1,000 to over $15,000, although most detectors will likely fall into the lower end of that spectrum. Even still, the capital cost for leak detectors is somewhat trivial because, for most CA systems that have been largely unmaintained, an ultrasonic leak detector will often pay for itself the first time it's used. Also, one detector may be purchased and shared by multiple facilities, making up-front equipment cost increasingly immaterial relative to the overall business case.

How Do They Work?

When leaks develop in CA systems, compressed air moves from a high-pressure environment into ambient air. The flow of this compressed air is turbulent and produces a wide spectrum of sounds, including ultrasonic frequencies. Ultrasonic leak detectors use acoustic sensors to detect sounds in the ultrasonic frequency range, which occur above normal human hearing capabilities, that is greater than 20 kilohertz (kHz). The detectors then convert the ultrasonic frequency to an audible level within the typical range of human hearing, which is then delivered to the operator via headphones, signaling that a leak is present. Because CA leaks emit a sound that is both directional and loudest at the source of the leak, it's fairly easy for operators to home in on the source using one of these handheld devices.

Leak detectors are designed to identify leaks of all sizes, from golf ball–sized holes to pinpricks. In fact, one manufacturer states that its products can detect leaks as small as 0.005 inches in diameter at 5 pounds per square inch (psi) of pressure from 50 feet away under laboratory test conditions. Obviously, lab conditions don't exist in industrial settings, but you can take comfort in knowing that most CA systems run much higher than 5 psi, making leaks easier to detect. Furthermore, most CA systems will need a fair amount of repair and maintenance before 0.005-inch leaks become a system's biggest problem. Operators should focus on the biggest leaks first and work their way down to the smallest leaks over time.

Operators can be quickly trained on how to use leak detectors. Leak detector vendors and customers are both quick to point out that training is simple and fast. One vendor likened leak detector training to using a screwdriver. The first time a person holds a screwdriver, he has no idea what to do with it; but once he's been shown how it works, he'll know how to use that tool for the rest of his life. The same principle applies to leak

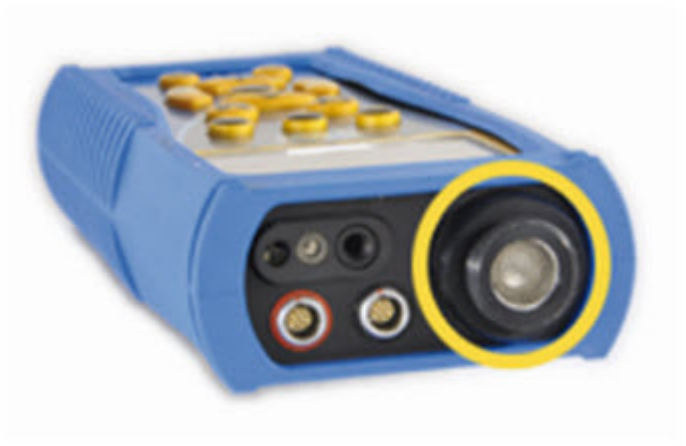
detectors: After 15 minutes of training, an operator should be able to start searching for leaks.

Accessories to Soup Up Your Handheld Unit

There are a variety of options when it comes to selecting a leak detector, but the products can be broken down into two basic categories: base units and accessories. Customers start by selecting a base unit (**Figure 1**). These are typically handheld devices that can detect leaks from several feet away. The unit could include integrated accessories like a laser pointer to help the operator pinpoint leak sources or connections that allow for the addition of attachments.

FIGURE 1: Basic ultrasonic air-leak detector handheld unit

SDT Inc.'s handheld leak detector design is typical for this technology. The primary ultrasonic sensor, circled in yellow in the image, is built into one end of the unit.

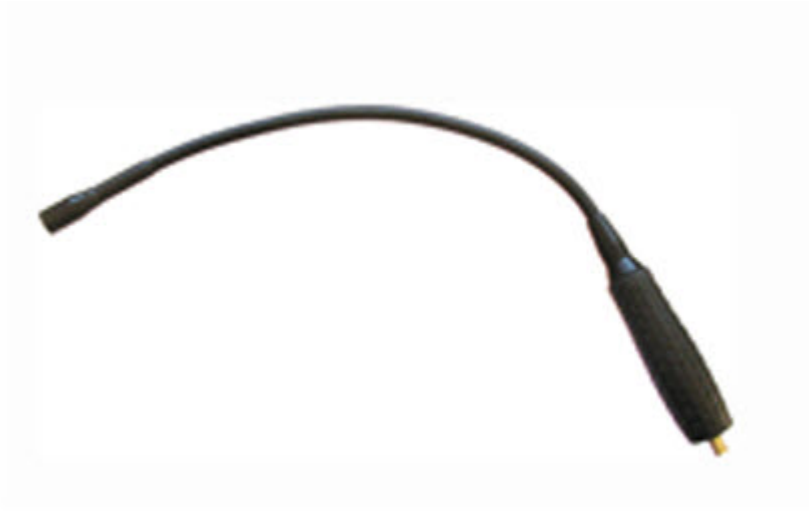


Courtesy: SDT Inc.

The handheld unit is useful for easily accessible leaks, but not every leak will spring in a convenient location. There are a variety of attachments available for handheld units, with each providing operators the ability to detect leaks in areas where standard units might fall short. For example, there's a flexible probe that's designed to detect leaks in hard-to-reach places like the back of a clustered pipe chase (**Figure 2**). There are also touch probes that can help detect leaks in valve bodies (**Figure 3**). If the operator touches the probe to the pipe downstream of a leaky valve, he'll hear a rushing sound. Other useful accessories include a cone attachment that increases the range of the handheld unit by approximately 30 feet (**Figure 4**) and a parabolic dish that can detect leaks from more than 100 feet away (**Figure 5**). For range extension, the cone is a less expensive alternative to the dish, albeit with a smaller detection range. The dish is a helpful tool for facilities with CA lines that travel along the ceiling or where direct access to CA pipes is blocked by other equipment.

FIGURE 2: Flexible sensor attachment

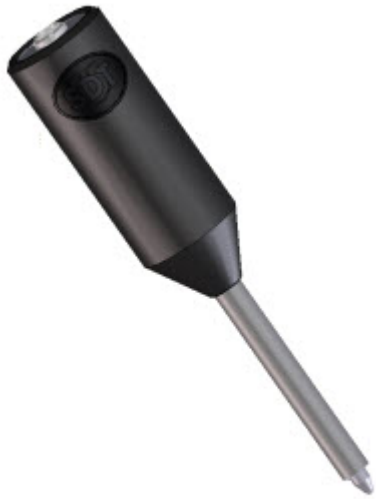
The flexible sensor attachment is a touch probe used to access hard-to-reach spaces that aren’t easily accessible with the basic unit.



Courtesy: SDT Inc.

FIGURE 3: Needle contact sensor

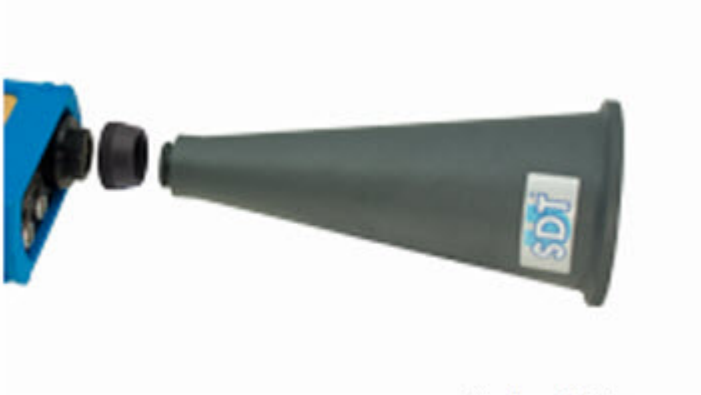
The needle attachment is an example of a touch probe, used to detect structure-bound leaks within pipes and valve bodies.



Courtsey: SDT Inc.

FIGURE 4: Extended distance module

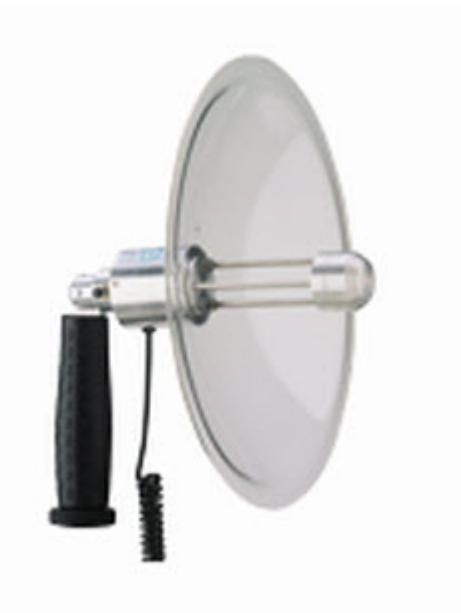
The extended distance module is a cone that attaches to the end of the handheld leak detector on top of the built-in ultrasonic sensor. It increases the detection range by approximately 30 feet.



Courtesy: SDT Inc.

FIGURE 5: Parabolic dish accessory

The parabolic dish is a handheld unit attachment that allows the operator to detect leaks from more than 100 feet away. This dish, manufactured by SDT Inc., is rated up to 164 feet. Ranges will vary by vendor.



Courtesy: SDT Inc.

Multitasking with Your Leak Detector

Though CA systems are the obvious first choice for applying the benefits of ultrasonic leak detectors, there are

many other systems and applications in which a leak detector can help you save energy. Steam and carbon-dioxide (CO_2) systems are also ripe for inspection by leak detectors because they present the same basic conditions: a gas or liquid under high pressure that will create a turbulent flow if leaking uncontrollably into ambient air. To detect leaks in pressurized steam or CO_2 systems, operators can use leak detectors in the exact same manner as they do for CA systems.

Leak detectors can also alert operators to leaks within valves, otherwise known as “structure-bound” leaks. Operators will need a surface or contact probe, like the needle contact sensor shown in Figure 3, to detect structure-bound leaks, but identifying them is relatively easy. In this case, the turbulent flow will be inside the valve body. For example, if hydraulic fluid under pressure is slipping past a valve, there will be turbulent flow at the source of the leak. An operator can use the contact probe downstream of the leaky valve and will hear a rushing sound, alerting him to a leak within the valve body. This same methodology can also be used for steam traps.

Another possible application for ultrasonic leak detectors is the monitoring of bearings prior to failure. This process starts with operators creating a decibel (dB)-level baseline for rotating parts using the leak detector. Once a baseline is established, operators can monitor this dB level, looking for increases over time. According to researchers at NASA, the earliest warning sign of bearing failure can be found through ultrasound: A 12 dB increase above the established baseline indicates that the bearings are beginning to fail.

The same comparative monitoring process can also be used to predict the failure of rotating equipment and to detect under-lubrication. Again, a dB-level baseline is needed for comparison purposes. Higher dBs are indicative of increased friction within the equipment, likely due to insufficient lubrication. One manufacturer we spoke with advises customers that an 8 dB increase for spinning equipment means that it’s time to relubricate. In this way, ultrasonic leak detectors can play an important role in any predictive maintenance plan.

Show Me the Money

Unmaintained CA systems are ripe for energy-saving opportunities. The DOE has conducted a number of CA system audits as part of its Advanced Manufacturing Office (formerly known as the Industrial Technologies Program). Finding and repairing CA system leaks were part of these audits, and the results from four of those audits are included in **Table 1**. In each case, an ultrasonic leak detector was used to find leaks throughout each facility’s CA system. As the table shows, the audits estimated annual energy savings from 155,000 kilowatt-hours (kWh) to 308,000 kWh, leading to annual dollar savings of $7,700 to almost $23,000, across the four facilities. Furthermore, the simple payback period was less than one year for each facility.

TABLE 1: Leak detector savings

The U.S. Department of Energy's Advanced Manufacturing Office measured the energy savings, dollar savings, and simple paybacks of finding and repairing compressed air system leaks in four industrial facilities.

Facility	Annual energy savings (kilowatt-hours)	Annual dollar savings ($)	Simple payback (years)
Rochelle Foods	308,602	22,951	0.40
Chrysler Transmission Plant	227,483	17,737	0.60
Southern Clay Products	170,745	11,952	0.80
Superior Graphite	155,804	7,728	0.97

The case study results alone would signal an effective technology, and they may even be conservative numbers. When this table was presented at a recent conference, two different energy managers for Fortune 500 companies said the measured savings values were too low. In fact, Richard Crowther, energy-efficiency manager for the Coca-Cola Co., had this to say about leak detectors: "We're finding that leak detectors pay for themselves the first time they get pulled out of the box; it's really a no-brainer."

Resources

Improving Compressed Air System Performance: A Sourcebook for Industry (PDF), U.S. Department of Energy (2003)

Paul Klimuc, Sales Manager, SDT Ultrasound Solutions (2012)

Minimize Compressed Air Leaks (PDF), U.S. Department of Energy (2004)

Analyzing Your Compressed Air System, U.S. Department of Energy (2004)

Optimizing Compressed Air Systems, E Source Business Energy Advisor

A System for Early Warning of Bearing Failure (PDF), NASA (1972)