

Locating Low-Level Leaks In Heat Exchangers

Written by Alan S. Bandes, UE Systems, Inc.
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The versatility of this technology is providing value for more and more operations through more and more applications.

Ultrasonic leak detection has been enormously effective in applications ranging from energy reduction (by locating compressed air leaks) to quality-assurance inspections (such as locating wind noise and water leaks in automobiles). The secret to success, though, lies in knowing what type of leak produces a detectable ultrasound and what does not— *and knowledge of the techniques that can be used for effective leak identification*. Once this is understood, there are instances where the limits of detection can be enhanced to help locate a leak in difficult situations.

Typically, ultrasonic leak detection is used to locate leaks where the pressure differential is enough to produce a turbulent flow as the gas moves from the high-pressure to the low-pressure side of a leak. Most often, any leak with a rate below 1×10^{-3} std. cc/sec will not generate a detectable turbulent flow. For this reason, the majority of leak applications for ultrasound are limited to leaks above this threshold. One advantage of ultrasound is that leak detection is not limited to a specific fluid. The technology is open to identifying leaks in all types of gas and fluid systems. That's why its use paid off so well for Mason Manufacturing, a leading manufacturer of heat exchangers.

The problem

When confronted with a potentially difficult situation that involved locating low-level leaks in a particular shell-in-tube heat exchanger his company was fabricating, Mason's Dan Rennert made a point to investigate ultrasound. Having used the technology for a previous employer, he was aware of its potential for success—*and otherwise*.

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Rennert knew that ultrasound instruments detect turbulent flows and that to produce this turbulence, the flow rate would have to be in excess of some of the types of leaks he thought he'd need to find. He had performed a standard hydrostatic test on the exchanger and did locate several leaks. Still, he felt there might be some smaller leaks present.

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Mason Manufacturing fabricates a variety of pressure vessels and heat exchangers for chemical, food and grain processors. Some of its clients are very demanding in terms of the quality of products they order. They expect Mason to deliver a leak-free product and Mason in turn pursues all options to meet these demands.

Rennert had originally considered utilizing helium testing in his leak-detection efforts. Helium testing, he thought, should be able to find smaller leaks than ultrasound typically can sense. His concern was twofold: the proximity of the tubes and the time it would take to identify the leaks.

Generally, helium detection is a time-consuming process in that the sensor has to be carefully manipulated around the test area. In addition, there is a potential for confusion should the helium from one site drift to the sensor as it is scanning an adjacent site. In this instance, the tubes in the heat exchanger in question were in close proximity—*just a 3/8" distance between tubes*. That could make identification of a particular leaking tube difficult. Moreover, this was a large exchanger made up of more than 8000 tubes in a 15 to 16-foot-diameter tube sheet, with the tubes extending several inches from the tube sheet. The time it would take to manipulate a sensor around this configuration could be days!

The solution

Having decided to investigate ultrasound leak detection for his application, Rennert consulted with Mark Goodman, VP of Engineering at UE Systems. Since they were slow-forming and low-level, Goodman agreed that the leaks might not produce enough detectable ultrasound. He recommended employing the "Liquid Leak Amplification" method, which incorporates the use of a surfactant with low surface tension. The heat exchanger would be pressurized and the liquid applied to sections of the tube sheet. This approach is similar in nature to the typical "bubble test" with one exception. Since the fluid that is used has low surface tension, a low-flow leak forms a bubble that will burst almost immediately. This, in turn, will produce a detectable ultrasound. When used on low-level leaks (typically below 1×10^{-3} cc/sec), standard soap and commercially formulated bubble test solutions will take a much longer time to form bubbles and an even longer time for the bubble to burst. Furthermore, with unusual configurations (as was the case with the Mason heat exchanger, where the tubes extended beyond the tube sheet) the

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bubbles would not be seen—
and the leak would not be detected

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Rennert went ahead with the Liquid Leak Amplification method. He pressurized the heat exchanger to about 50 PSI and sprayed the Liquid Leak Amplifier on 4-foot-square sections of the exchanger tube sheet. With this procedure, it's normal for a number of bubbles to form upon contact with the tube sheet. Once those initial bubbles subsided, an ultrasonic sensor (part of a plug-in scanning module) was used to scan along the tube sheet.

Rennert repeated the process over and over, spraying the liquid on individual four-foot sections, one at a time, waiting and scanning. Doing so, he identified leaks by detecting what he describes as a slow "pop-pop" sound occurring about 1-2 seconds apart. Although he could not actually see the bubbles, he was able to confirm a leak by noting that the popping sounds did not occur around adjacent tubes. It took only eight hours to complete the entire scan of 8000 tubes. Three leaks were identified—*in addition to those previously detected with the hydrostatic test*

The payback

Confident that he had found and repaired all the leaks, Rennert was able to deliver the new heat exchanger to his customer. Had those leaks not been identified, they would have contaminated the customer's product. That would have been a very expensive proposition for everyone concerned.

Going forward, Rennert anticipates using ultrasound for large exchangers to be sure the gaskets are tight—*before conducting a hydro test on these exchangers*. As he explains it, "If you have an exchanger that's 10 to 11 feet in diameter and fill it up with water, that's a lot of water." With ultrasonic testing, he estimates that Mason Manufacturing can save many gallons of water. His planned procedure will be to add 5 psi of air after the gasket has been installed and to test with the Liquid Leak Amplifier method.

This was a large exchanger made up of more than 8000 tubes in a 15 to 16-foot-diameter tube sheet, with the tubes extending several inches from the tube sheet. Rennert also plans to use ultrasound in the company's shop to cut energy waste by locating air leaks. In fact, he recently walked one area in his plant near a wall and found leaks in the airline, a crack in the housing of an air dryer and another leak in an air hose.

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Last words

One word of caution: Any method established for leak detection has benefits and limitations. Leak detection is generally "hard work." It requires knowledge of the test subject and test conditions, and an understanding of the type of leak to be detected (i.e., is it a liquid or a gas; is it a slow-forming leak or a high-flow leak?). Once these issues are clarified, the inspector must decide on the technology and method best suited for the particular leak.

Effective leak detection also requires a strategy for preparation, safety, application, identification and confirmation of the leak. Some types of testing might need to conform to specific codes and standards. In addition, a method for leak management must be implemented so that the leaks are not only identified but also repaired and re-checked for quality assurance. **MT**

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