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Corona and tracking do not produce readably detectable infrared emissions but they do produce ultrasound that can be detected by scanning switchgear door seals and air vents. (Photo courtesy UE Systems.)

Why do infrared and ultrasound work so well together? One answer is to look at our own senses. The more senses we use, the better we are able to navigate through our world.

To expand on this concept, infrared inspection and ultrasonic inspection are expansions of the senses of sight and hearing. Infrared "sees" what we cannot see; ultrasound "hears" what we cannot hear.

By combining them we advance our ability to detect problems. In essence, infrared will detect changes in emissions related to heat characteristics of equipment it "looks" at, while ultrasound senses changes in sound patterns. Without getting into the basics of each technology, let's examine some of the common areas of application for these two inspection methods.

Steam systems

There are many opportunities to use both ultrasound and infrared in steam system inspections. A simple way to determine when to use a specific instrument is to look at the system from an objective perspective. Which components have more of a tendency to produce a change that is heat related and which are more sound related?

As an example, the loss of or weakening of insulation is measured best by determining heat-related changes. Pressure is calculated by checking temperature changes upstream and downstream of a valve or steam trap. Sound-related processes are best tested by using ultrasound. Valve leakage, steam trap inspection, and conditions such as cavitation in pumps are examples of sound-related inspection.

Heat or infrared alone cannot be used to validate steam trap operation. There are many subtle and not-so-subtle pressure changes that occur in and around the steam trap that can effect changes in temperature which can in turn lead to a false diagnosis.

Since a trap produces a distinct sonic signature, listening to the sound of the trap as it cycles can accurately determine the trap condition. Many steam trap manufacturers refer to this as a "positive" test. Infrared is useful in determining blockage conditions and whether a trap is on-line because the former will indicate a lower temperature than a working trap in the same area and the latter will be observed as producing heat. Using both infrared and ultrasound together will help make certain that the most common conditions of trap operations can be thoroughly inspected.

Using the two technologies in valve condition inspection also can provide useful information. In some cases, heat can be used to determine valve condition, while in other situations, the fact that a valve leak can be isolated and heard will help improve the accuracy of the diagnosis. By using an ultrasonic sensor's contact probe to touch a valve upstream and downstream, valve leakage or valve blockage can be identified. A leaking valve will be heard through the headphones as a gurgling or rushing sound while blockage will produce no sound. Valve blowby in steam systems will produce a higher temperature reading downstream. Ultrasound will tend to find smaller leaks, especially when the fluid does not have a higher temperature.

Loose connections and damaged conductors, electrical problems that produce increased resistance resulting in higher temperature of affected elements, are easily detected by inspection with infrared thermography. (Photo courtesy FLIR Systems, Inc.) **Heat exchangers**

The two technologies can be utilized quite effectively in the inspection of heat exchangers. An

infrared scan of a heat exchanger can indicate heat-related changes that can be diagnosed as anything from flow blockage of the cooling element to tube leakage. Once the condition is spotted with the scan, an ultrasonic detector can be incorporated to confirm a diagnosis and, in some instances, locate a leaking tube.

The ultrasonic inspection is performed while the exchanger is either on partial load or off line. By pressurizing, or by keeping a vacuum on the shell side, the headers of the exchanger can be removed and the tube sheet scanned to identify the leaking tube. A leaking tube produces a turbulent, rushing sound as air flows from the high-pressure to the low-pressure side of the tube leak.

The sound will be isolated to the leaking tube and will be heard as the scanning module passes over it. Combining infrared and ultrasound provides a fast, accurate way to keep on top of heat exchanger problems.

Underground leaks

Underground water leaks of any type are a very difficult proposition. Unless the leak is so gross as to produce an obvious wet pool or bubbling around the site, many days can be spent trying to locate the source. There are often situations in which inspectors have been called to locate a leak after most other methods have failed. This experience indicates that not one method works all the time. However, utilizing ultrasound and infrared together can produce effective results.

In an actual event, a condensate return line in a major airport was reported to be leaking. The area of investigation covered about 3 miles of piping located approximately 6 ft below the asphalt surface. Standard methods using listening devices that detected only the audible range were not successful. To find the leak quickly, a method incorporating ultrasound and infrared was devised.

Recognizing that condensate was heated water, it was determined that a late-night scan would be effective because the heated water would be easier to locate with the cooler ground around it. A scan of the piping system as determined by piping diagrams was performed. Every hot spot that could be suspected as a leak site was marked.

Metal wave-guides were then positioned in the ground over the marked hot spots. A contact

probe from the ultrasonic detector was placed directly on the wave-guide and an operator listened for a flow. The IR/UL inspection began shortly after midnight and continued until 4 a.m. Identified leaks were repaired before the end of that same day.

Motors and pumps

Here we have a combination of electrical, mechanical, and fluid flows that produce heat and sound. While the condition of most bearings can be diagnosed through changes in sound as determined by ultrasound, as well as by vibration analysis, there are also IR scans that detect heat-related problems.

According to NASA research, the earliest indicator of incipient bearing failure is a change in the amplitude of a monitored ultrasonic frequency. Ultrasonic inspection also can reveal lack of lubrication and prevent overlubrication.

Bad motor coils, windings, stators, or rotors can cause an increase in resistance and will produce heat that is readily detected with an infrared scan. In addition, overlubrication, misaligned belts, and bearings in advanced failure states can be quickly spotted due to the heat generated by friction and metal fatigue.

Pumps running dry, plugged feeds, and distorted vanes are all candidates for infrared detection. Cavitation, which is caused by air bubbles being trapped in fluid and then bursting under pressure, can destroy a pump or valve over time. Because these bursting bubbles produce a distinct sound, ultrasound inspection can trend the cavitation from onset. As it continues toward destructive levels, there is a combination of sound and heat.

Hydraulic valves and actuators

Heat is a good indicator of a leaking hydraulic valve. The forces of fluid moving through a leak can produce heat as a by-product. This has been a useful effect in aircraft inspection.

However, not every leaking hydraulic valve will produce heat, and the proximity of valves in certain configurations can lead to a potentially inaccurate diagnosis due to heat (and in some instances sound) transference. This inspection process can be aided by incorporating ultrasound with infrared. A valve, when leaking, will produce a louder sound downstream. By comparing infrared results and ultrasonic readings taken upstream with those from downstream,

an operator can quickly make a positive diagnosis.

Electrical equipment

This is the most common area of application. While infrared detects problems related to resistance and heat, the ultrasound detector can be used to locate sonic-related problems. Corona and tracking in its early stages do not produce readably detectable infrared emissions but they do produce ultrasound.

In addition, with enclosed switchgear and transformers where surface heat cannot be relied upon for diagnosis, scans can be aided by using ultrasound to listen. This can be accomplished by scanning switchgear door seals and air vents while listening to the sonic pattern. Corona produces a steady buzzing sound while tracking has a gradual build-up followed by a sudden drop off of signal. Arcing is heard as sudden starts and stops.

Inspection time can be greatly sped up by utilizing IR and UL scanning. Since switchgear can be inspected by scanning doors and air vents, there is no need to open each compartment.

In all types of mechanical function, changes in heat and sound are the most reliable indicators of potential problems. Fluid flow patterns, line blockage, and leaking valves and steam traps are best-diagnosed through IR/UL inspection. Hydraulic systems produce sound and heat that can be observed through an integrated approach, as does high voltage equipment.

Using IR/UL inspection will allow users to accurately determine the condition of operating equipment as well as identify the location of problems. These two technologies complement each other and advance the goals of condition monitoring programs. **MT**

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