Dr Christina Baxter, of EmergencyResponseTIPS.com and Hazard3.com, offers helpful advice for first responders

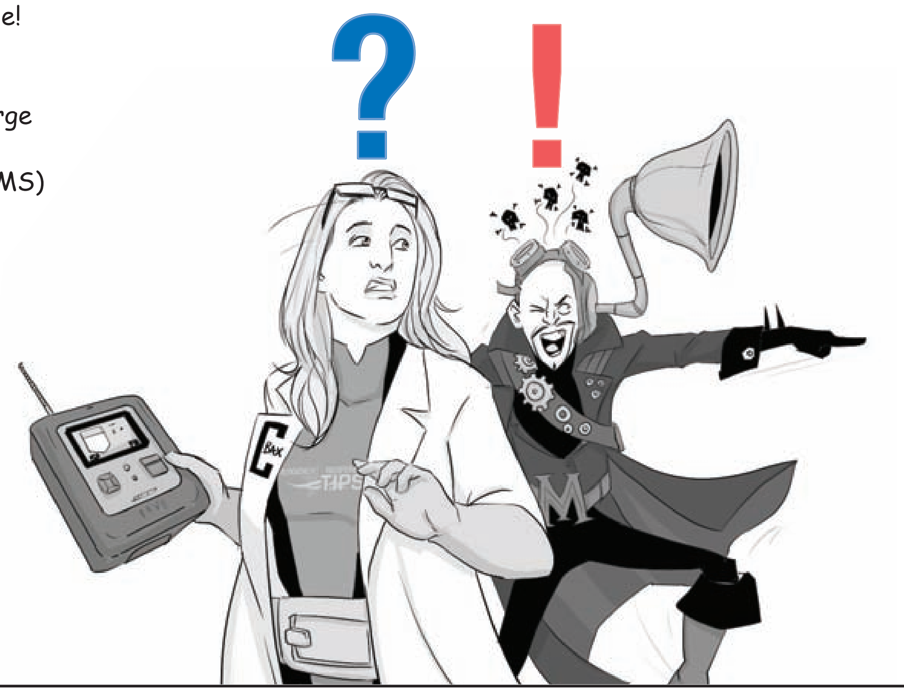
Keeping you safe!

This column aims to provide operational guidance to the hazmat/CBRNE community on the selection and performance of equipment and tactics. In this issue, we focus on the use of acoustic cameras to detect compressed gas leaks, partial electrical discharges, and mechanical faults.

The potential for applications in CBRN response is immense. Imagine identifying a leak and pinpointing its location before your chemical sensors can detect it or identifying a functioning, or even partially functioning, dispersal device from a safe distance!

How do they work?

Acoustic detectors incorporate a large array of highly sensitive microelectromechanical system (MEMS) microphones arranged in a specific pattern to capture sound waves across a wide frequency range, typically from audible up to 100 kHz (ultrasound). Leaks in compressed air or vacuum systems produce high frequency, turbulent noise that falls within this range. The systems detect sound energy density, acoustic pressure distribution, and sound wave direction, and extend our exploitation of the electromagnetic spectrum.



Sound is made “visible” using a process called acoustic beamforming. The internal processor analyses the minute time differences when a single sound (like a leak) reaches each of the microphones. The precise direction from which the sound came is determined by calculating these tiny differences. The process is named beamforming as it virtually focuses on a narrow beam of listening in a specific direction. Loud, distracting background noises common in industrial environments are filtered out.

The processed sound data is then merged with a visual image to create an acoustic image. A digital camera captures a visual image of the scene. The sound intensity is superimposed over the digital image as a sound spot or coloured area - rather like a thermal camera displaying heat. The louder the sound, the brighter and more focused is the spot. This combined image is displayed in real time on the camera's screen, allowing the user to instantly and accurately pinpoint the exact location of the leak or electrical fault from a safe distance of up to 130 metres (427ft).

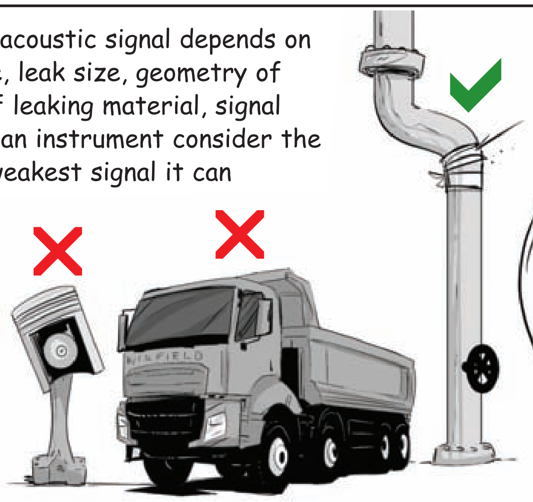
Many of the newer systems use cameras with built-in artificial intelligence to analyse the sound data for maintenance prioritisation. The AI can quantify the leak rate (eg litres/minute). For electrical systems, the camera classifies the type of partial discharge (eg surface discharge, corona) and assesses its severity. All these tools extend its application at CBRNE incidents.

Technical considerations

The sensitivity of a system is its ability to detect very small leaks or leaks under lower pressure conditions. High sensitivity models can also pick fainter acoustic signals at longer distances.

Systems incorporate AI or digital signal processing techniques to distinguish the acoustic leak signature from ambient noises like traffic, machinery, etc. This is crucial when responding to an industrial incident.

The accuracy or precision of an acoustic signal depends on many factors, including pressure, leak size, geometry of leak orifice, density/viscosity of leaking material, signal processing, etc. When selecting an instrument consider the microphone quality (what's the weakest signal it can capture) and array density (a higher density and more microphones allows for finer beamforming resolution). Some acoustic cameras can estimate the leak rate.



The acoustic camera's reliability and repeatability is another important factor to consider as it affects user confidence.

While acoustic cameras are expensive, and prices vary, of course, they generally do not require much maintenance. With proper care, they can last a long time, but as with any camera-based system, avoid vibrations, drops, and strong magnetic fields to minimise damage to the sensor array and other electronic components.

Operational considerations

These instruments are not generally certified as intrinsically safe so avoid potential flammable environments. Sound is easily reflected from flat, shiny surfaces such as stainless steel benches. Be sure to move the camera around and use a variety of camera angles. If the source stays in the same place, then it is likely a true reading.

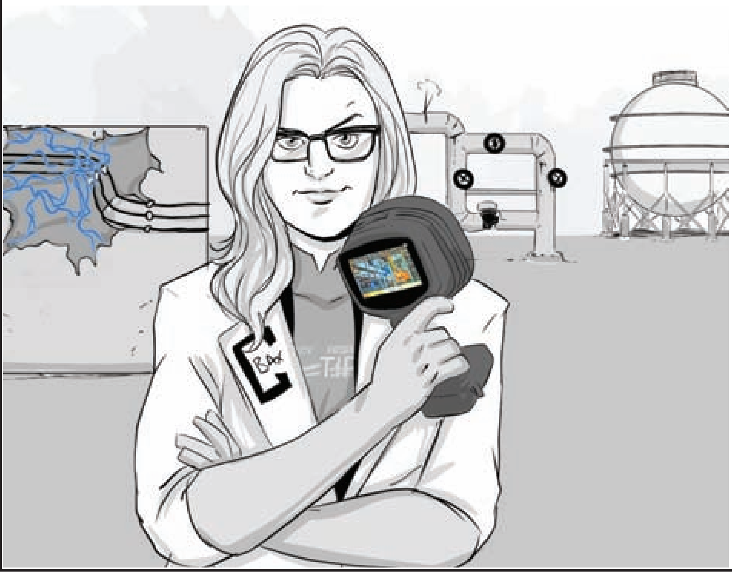
While each instrument is different, there are generally operational modes which can be selected to suit the operational environment. For example, if there is only a single source of sound in an area, a single source mode will focus on the most intense sound. When there are possibly multiple sources, a multi-source mode will identify the sound source and its reflections.

Sources can easily be overwhelmed by background noise as well as environmental factors like humidity and temperature. To overcome these issues, try changing the frequency measurement range, filter selection, or move closer to the source(s). For weak sound sources within a loud background, as often happens in industrial facilities, rotate the camera so that the strong sources are outside the camera's field of view, while the weak source remains within the field of view.

Tactical applications

In hazmat/CBRNE operations acoustic sensors are primarily used for gas leak and release detection. Unlike traditional chemical detectors, which require the hazardous material to accumulate to a level above the instrument's limit of detection and must be in the vicinity of the chemical, acoustic detectors "hear" the leak almost instantaneously from a distance. These systems are ideal for monitoring outdoor areas, storage tanks, and high pressure pipelines as they are less affected by environmental conditions, wind direction or gas dilution.

Acoustic sensors can also be used to monitor the integrity of containers, potential dispersal devices, or pipelines that may be subject to internal stress from hazardous materials. When a material undergoes stress or damage such as cracking, deformation or corrosion, it releases a transient elastic energy known as an acoustic emission. By monitoring this emission, active defects can be detected and located before a catastrophic failure occurs, hence they have a role at CBRN incidents assessing damaged or improvised containers.



Finally, acoustic sensors are used to identify the partial discharge, or localised electrical breakdown, of a small portion of a solid or fluid electrical insulation system. When partial discharge occurs, the rapid expansion and collapse of gas and plasma at the discharge site creates a pressure wave that travels through the surrounding medium. These waves are detected and localised by acoustic sensors.

Remember, use all the tools in your toolbox to characterise the scene. Stay safe out there!

Images are courtesy of Phil Buckenham *https://philbuckenhamart.wixsite.com/philbuckenham*