Chapter 10

Other techniques

Several other techniques have been developed as alternatives to the acoustic methods described above.

10.1 THERMAL IMAGING

Thermal infrared imagers are detector and lens combinations that give a visual representation of infrared energy emitted by all objects. In other words, thermal imagers let you "see" heat. Depending on the sophistication of your system, thermography is capable of providing very detailed images of situations invisible to the naked eye.

Thermal infrared pipeline surveys not only provide data on possible leakage points but also on the status of the wayleave (right-of-way), showing up any ground disturbance or building works over the pipeline. The surveys generally fall into two categories.

10.1.1 Low level surveys

These are surveys of the known course of a pipeline over open country. By carrying out a low level survey, extremely high resolution images may be produced which are invaluable to leakage engineers for defect identification and prioritization.

10.1.2 Higher level surveys

These are surveys of rural countryside where pipes lie but whose exact position is not known. These are usually flown at about 600 m (2000 feet), which gives a good balance between resolution and flying time (and therefore cost). The pipe or pipe bed is usually visible around 60% of the time depending on ground composition and cover.

Although infrared equipment is a valuable diagnostic tool, it merely provides a "map" of radiant energy. It cannot for example give a definitive answer to why a particular area is at a certain temperature or radiating at a certain emissivity. Consequently skilled interpretation can be a valuable source of advice in this

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area. High resolution thermal imaging has proven to be a versatile technique for identifying pipeline (or reservoir) anomalies in rural areas in addition to identifying environmental effects such as discharge into watercourses.

The pipeline is flown over in a series of tracks, the number of which depend on the pipeline route. Each of these is related by an on-screen time stamp to the real time video data. This map is then marked with any thermal anomalies noted and used as the basis for discussions with pipeline management staff that are familiar with possible valid causes for many of the anomalies (for example, pipe infrastructure, fitments, valves and so on). This is often provided in parallel with a tabulated list of anomalies, their track number, time/date stamp, classification of priority (high, medium, low) and appropriate comment. The technique does require considerable man hours in analyzing and tabulating the data.

10.2 PIPELINE INSPECTION WITH THERMAL DIAGNOSTICS

The idea of finding leaks over a pipeline has been investigated now for many years, however with the new products launched and open to use by the general public the use of drones has dramatically increased to become a standard approach in photography, filming and now inspection of underground assets.

In practice, a drone is flown over the route of the pipeline and using a drone-mounted thermal imaging camera ground temperature variations are recorded which can indicate if a leak is present or not. In hot regions where the ground is warm, if a leak is present the surrounding ground is less hot due to the cooling effect of the water escaping the pipe. Conversely, in regions of very cold ground temperatures the leaking water warms up the ground. It is important to note the time of day that these surveys are completed in order to relate to the ground temperature.

10.3 INSPECTION OF PIPELINES USING INFRA-RED OR THERMAL IMAGING CAMERAS

Pipelines should be regularly and carefully checked for leaks particularly those that are in remote and obscured locations which make surveying difficult. In most cases these pipeline systems are often located underground or run for a long distance in areas where access roads are restricted and, moreover, the actual location of the pipeline is difficult to identify. Due to these reasons it is not possible to walk

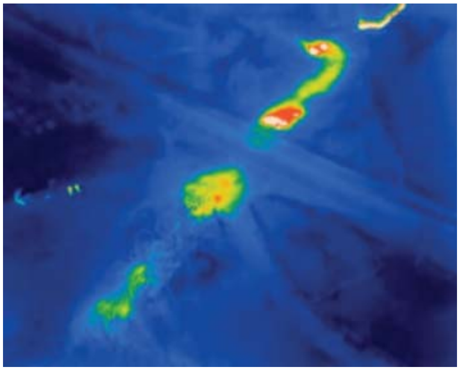

Figure 10.1 Water pipeline inspection using thermal imaging. (Source: Workswell Infra Red cameras and systems)

along these pipelines nor to be able to locate the valves or fittings to enable an acoustic survey to be undertaken.

To solve this issue the use of drones was identified (in the past a helicopter or airplane was used but at a significant cost). This simple, yet effective, approach can provide valuable information in leak identification by programming the drone to fly over the pipeline route taking live thermal images of the ground beneath along the pipeline (Figure 10.1).

The operator controlling the drone from a safe place has immediate knowledge of the found condition along the route of the pipeline and whether a leak may be present or not or indeed if there is a risk of damage to the pipe from other ground conditions.

Two cameras are located on a drone, one to take a general video and photographic images of the pipeline and the other for thermal imaging. The software that is controlled by the operator at the base station can easily switch between the cameras as necessary. The ability of the drone to stop and hover over a suspect location, zooming in where necessary while also surveying the surrounding region, has been a great advantage in the detailed investigation of leaks.

10.4 DRONES FOR LEAK DETECTION ACTIVITIES

Drones mounted with infrared or thermal cameras are used by water companies around the world to locate leaks and to reduce losses (Figure 10.3).

Many water companies have trained staff in the use of drones enabling the water company to very quickly find leaks in difficult locations not visible to the naked eye. The leak survey is normally carried out in the very early hours of the morning when the ground temperature is at its lowest, thus making it easier to identify underground leaks. The drone operators are licensed by the Civil Aviation Authority (Figure 10.2).

Normally the temperature of the water escaping from a leak is at a higher temperature than the temperature of the surrounding soil, which means that it will show up as a warm-coloured patch on the thermal imaging camera.

Figure 10.2 Use of a drone for leak location. (Source: Bath Echo)

Figure 10.3 A drone equipped with cameras for leak surveys. (Source: Bath Echo)

10.5 DOGS USED FOR LEAK LOCATION

10.5.1 A dog's nose

A dog's nose is composed of a nasal passage like a human's nose in which turbinates are located. Turbinates are the spongy tissues along the long shelves of bone in the breathing passage of the nose. It is these parts of the nose that are used to distinguish between smells. The internal construction of a dog's nose is such that it has ruffles or skin folds which means that there is an increased surface area so the number of turbinates is greatly increased. It should be noted that a human has 5 million turbinates and a dog over 300 million.

The long thin nose shape of a dog means that the complex network of its turbinates is such that can locate scents from the products that the dog has been trained for to identify. It is for this reason that not all dogs can be used for sniffing out drugs, money, people or in our case chemicals used in clean purified water.

Scientists during research have suggested that a scent sniffed by a dog passes through the turbinates and is then received at the olfactory bulb, which is a bulb of neural tissue within the dog's brain. A dog's olfactory bulb is many times larger than that of a human, about 44 times more. This gives a dog over 250 million more receptive smelling points than a human, hence the reason why dogs can distinguish so many more different scents than a human.

10.5.2 How does a dog complete leak detection?

Just as the human nose works when smelling goods, such as fresh cooked pizza or newly baked bread, and these smells are registered as a smell to remember, when a dog smells the same goods they can break down the smells to certain components of the product such as salt, pepper, yeast and so on.

If we apply this concept to the dog conducting leakage detection, then the dog is trained in the ability to smell a chemical that is added to the water such as chlorine. The dog is trained to find very small concentrations of the chemical therefore in some instances the dog can smell the chemical through many ground materials. The dog's ability to distinguish between smells and only react to the ones they are trained to locate, means that they will not be fooled by other sources of water, i.e. spring water. Properly trained pipeline leak detection dogs have been tested and proven to be accurate in the range 96%–99%.

In field trials, a dog that has been trained in locating a water leak has managed to find the leak being emitted from a small hole under pressure at a depth of up 4 m. It has to be noted that ground materials and backfill have an effect and the chlorine gas element has to be able to permeate to the surface although by a minor amount.

10.5.3 Dogs vs conventional methods

There are many types of methods of locating water leaks and all with a varied success in the field when being used. The idea of using dogs is a new concept recently started in around 2015 and this may be the process in the future. However, at this stage it is being tested to various degrees of success and should be considered as another idea to add to the process to find water leaks.

10.6 GROUND PENETRATING RADAR

GPR (ground penetrating radar) is so named because the radar is able to produce an image of what is below the ground by reflecting radar frequency waves emitted by the transmitter from any interface within the ground, this being earth/water, earth/rock, rock/air and so on back to the receiving antenna. Usually this antenna is part of the same unit as the transmitter which is drawn over the ground at a slow speed producing data which is processed and converted into vertical cross-sectional slices of the ground.

This image is shown on a screen for the engineer to interpret the results and decide whether a leak is present. This requires an experienced engineer to decipher. The depth of vision can be as much as 3–5 m but this is in perfect situations which are rarely seen (Figure 10.4).

There were several European Union co-funded research projects on technology – with varying results and successes. Two such projects are “Waterpipe” and “Leaking”. The projects have similar objectives – to provide a non-intrusive leak location technology:

“Waterpipe” is a system where the leak is located by Ground Penetrating Imaging Radar – GPIR. The objectives of the project were to investigate and develop a high-resolution imaging ground penetrating radar for the detection of pipes, leaks and damages to underground infrastructure – and to provide imaging ofthe damaged region. A further enhancement was to produce an integrated system that will contain both the GPIR equipment and a Decision-Support-System (DSS) for the rehabilitation management of the underground water pipelines. This would use input from the inspections to assess, probabilistically, the time-dependent leakage and structural reliability of the pipelines and a risk-based

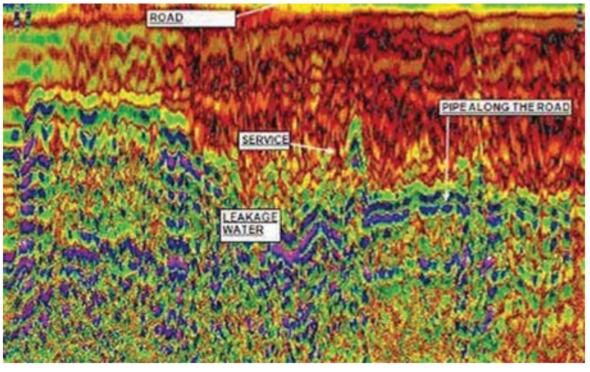

Figure 10.4 Data from ground penetrating radar. (Source: R Brier)

methodology for rehabilitation decisions that considers the overall risk, financial, social and environmental criteria.

"Leaking" had objectives to investigate and develop an innovative leak inspection equipment for water pipelines based on microwave technology (a Continuous Wave Doppler radar, a Frequency Modulated Continuous Wave radar and a radiometer), and a decision support system, that stores available data on the pipe network, and receives input from leak inspections. It should be able to perform condition assessment to determine residual lifetime of the pipeline in question.