Chapter 7

Method G: Electronic amplified listening devices

When a pressurised water pipe develops a leak the water flows out into the surrounding ground at high speed, which causes the pipe and soil to vibrate at the exit point. This sound, or vibration, is transmitted by the pipe (structure borne), the surrounding material (ground borne) and through the water itself over a range of frequencies. Careful application of leak detection techniques will enable the operator to eliminate detected noises generated by poor pipeline design or consumer usage and to identify leakage due to pipe system damage.

In addition to being transmitted along the pipeline (both through the water and the pipe wall) the leak noise is transmitted into the ground around the pipe. The noise travels much better through "hard" materials so that the noise travels much further along metallic pipes than asbestos cement pipes which themselves are better than plastic pipes. Ground material generally provides a poorer travel path than the pipeline itself. However, usually some noise transmitted the short distance to the surface. Soft sandy ground provides a worse travel path than well compacted ground with a hard paved surface covering (Figure 7.1).

Factors producing good quality leak noise include high water pressure, hard backfill, a small rupture, clean pipes, metallic pipes and small diameter pipes. By contrast, factors producing poor quality leak noise include low water pressure, soft backfill, split mains, encrusted pipes, soft/lined pipes and large diameter pipes.

Since "leak detection" began, operators have been "listening" for this leak noise using mechanical devices. Traditional listening sticks for detecting water leaks rely on only one of the user's senses – hearing – the experience and skill of the operator is paramount and, at best, users are only ever able to detect leaks that produce loud noises.

However, it must be noted that not all leaks produce a noise audible to the human ear. Contrary to common perception it is not always the largest leaks which are the loudest; often a large split in a water pipe will produce a less clear noise than a small hole. This can be particularly true in P.V.C., P.E. and M.D.P.E. pipe materials. For this reason amplifying the noise with an electro acoustic microphone is

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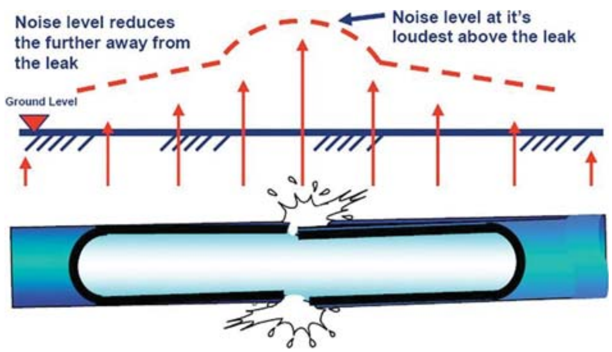

Figure 7.1 Schematic showing propagation of leak noise through ground. (Source: Halma Water Management)

becoming increasingly important to find leaks particularly in networks where these materials are increasingly used.

Modern electronics therefore provide the benefits of advanced sensor technology amplification and filtering to undertake this operation more effectively.

7.1 OPERATIONAL PRACTICE

The typical key components of a modern electronic amplified listening device are shown in Figure 7.2 below:

Pinpointing a leak position using an electronic amplified listening device involves a process of comparing a number of leak noises. To begin with, the operator must select the most suitable sensor device: the microphone foot for hard ground surfaces or the hand probe for soft ground.

To operate the ground microphone safely and effectively, the operator must adjust the headphone volume control to a comfortable listening level. Once the noise has been heard, the headphones should be muted before moving the microphone foot or hand probe to the next test position.

Figure 7.2 Components of electronic amplified listening device. (Source: Halma Water Management)

The operator should repeat the sequence to listen to each of the test locations as he moves along the pipe route in the direction where signal strength is increasing. If the leak noise level falls he has passed the leak and should go back and reduce the distance between each measurement. The loudest leak noise will then indicate the location of the leak bearing in mind the ground conditions already mentioned. These basic principles can be used in a number of operational modes.

7.2 SURVEY BY LISTENING AT FITTINGS – ELECTRONIC LISTENING "STICK" ACCESSORY

All listening devices give better response when in direct contact with the pipe, particularly on metal pipelines.

In this mode the unit is used for locating leaks by fixing it onto a contact point or fitting, such as a valve, meter, hydrant or stop tap. A hand-probe/extension rod can be used to listen at these points and these provide good sound pick-up particularly if the pipe is metallic.

This procedure was once commonly referred to as "bashing" when used with mechanical listening rods and is used to narrow down the location of the leak, a procedure known as localisation since the leak will be "localised" to some point between the fittings. It will then be located to an approximate position and then "pinpointed" for the exact position prior to excavation.

It is important to note that when listening on pipe-fittings the location of the point of maximum noise will probably not indicate the leak position, only the fitting closest to the leak (Figure 7.3).

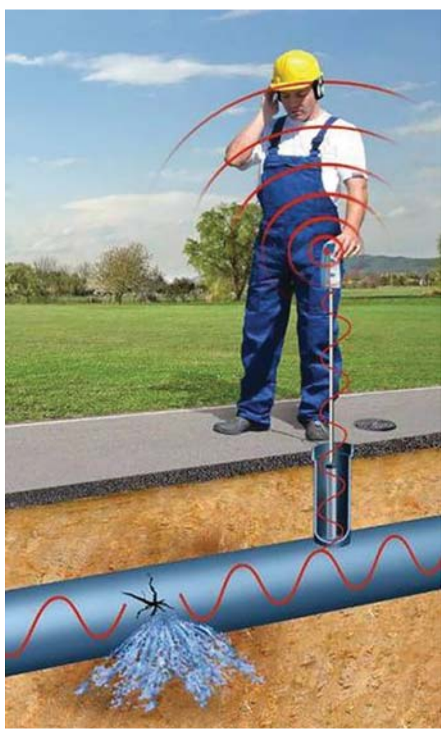

Figure 7.3 Leak position from sounding fittings. (Source: SEBA KMT)

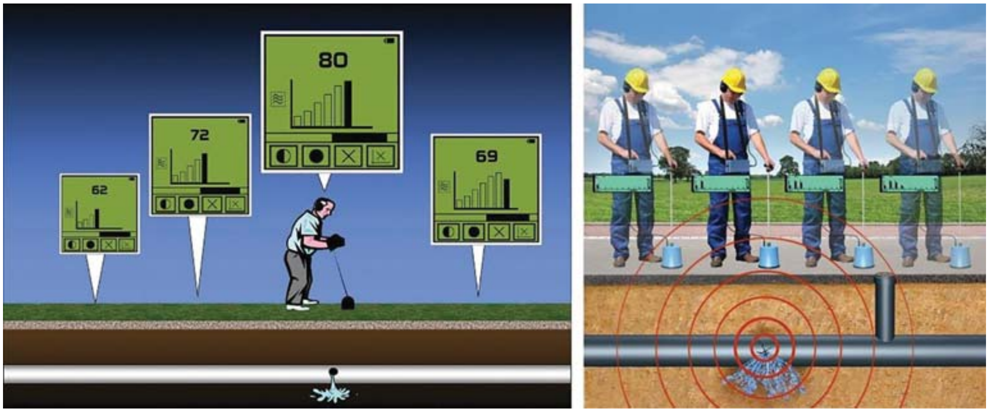

Figure 7.4 Surface sounding leak position. (Source: Halma Water Management and SEBA KMT)

7.3 SURVEY/PINPOINTING BY SURFACE SOUNDING "ELEPHANTS FOOT" – HARD GROUND

The ground microphone is used on the surface in the following circumstances: to pinpoint the leaks position after the "Localization" and "Locate" survey by listening at fittings; when no accessible contact points are available; when the pipe is of non-metallic material and no leak noise is being transmitted to available fittings.

The ground microphone is moved along the surface in regular positions following the path of the pipeline below ground with the operator noting the changes in sound amplification until the area of maximum noise level is identified (Figure 7.4).

To locate the position of an underground leak an acoustically shielded ground microphone foot (commonly known as an "elephant's foot") can be placed on the ground above the line of the suspect pipe and the readings observed. This is particularly useful on hard ground conditions and provides isolation from airborne noise interference which allows it to be used in noisy and windy conditions. On soft ground it is usual for a spike or tripod sensor to be used. A hand probe with a magnetic contact can also be used to provide excellent acoustic coupling to fittings, helping to ensure clearer, louder leak noise.

It is important to note that the noise level will also appear stronger where there is less thickness of ground or other material for it to pass through. The leak noise will always follow the path of least (acoustic) resistance.

7.4 OPERATIONAL EFFICIENCY – SURVEY VS. CONFIRMATION

Whilst it is recognised that the electronic ground microphone can be used for a complete leakage survey and pinpointing operation, using ground microphones in a survey operation is very labour intensive and involves operators covering (walking) large distances. Other modern technology is now available to survey large areas more quickly and efficiently.

Specifically, these methods include: (a) measuring flow into a self-contained District Metered Area and deducting known domestic and commercial usage in order to calculate the amount of real losses (leaks); (b) narrowing down the area by means of isolating parts of the distribution system (a procedure known as Step

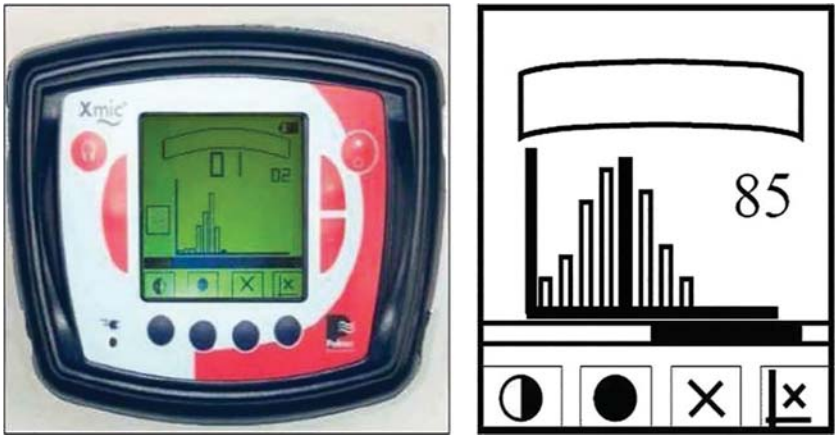

Figure 7.5 Images from electronic ground microphone. (Source: Halma Water Management)

Testing); and (c) deploying acoustic noise loggers along the pipeline within a District Metered Area to identify whether a leak may be present.

The above survey procedures are far more effective than using ground microphones to identify potential leak locations.

The modern Ground Microphone is therefore primarily used today as a confirmation of correlation results before excavation. This avoids errors due to unknown pipe characteristics, or operator error leading to dry holes or unnecessarily large excavations, and should be viewed as an essential final confirmation.

The illustrations (Figure 7.5) show how the electronic ground microphone is used effectively as a pinpointing tool prior to excavation, with the histogram of sample noises providing a clear visual depiction of the precise leak location.

In certain situations (nonmetallic pipes, poor pressure, holes in pipelines) leak noise may not travel over any distance along the pipelines and therefore pipe contact techniques may not be effective. In these circumstances the noise may still be sufficient at the surface above the leak to be identified by a Ground Microphone survey, and this may be the only practically effective acoustic technique.

7.5 ADVANCED FEATURES

7.5.1 Filters

Filters are required to selectively target and amplify leak noise and to suppress unwanted background noise and interference.

Metal pipes generally produce higher frequency leak noise as do small fractures, high pressures and hard compacted ground. Modern filtering allows the operator to set the instrument to focus on the leak noise and amplify it out of the background interference. Filter selection can be a great help, but it must be noted that unwanted noise may have a similar frequency to that of the leak, and not all ambient noise can be isolated out. For example, traffic and machinery noises often occur in the same frequency bands as leak noise and can travel for considerable distances through both air and ground material.

For this reason it is sometimes advisable to use acoustic leak detection techniques at night when interfering noises are less.

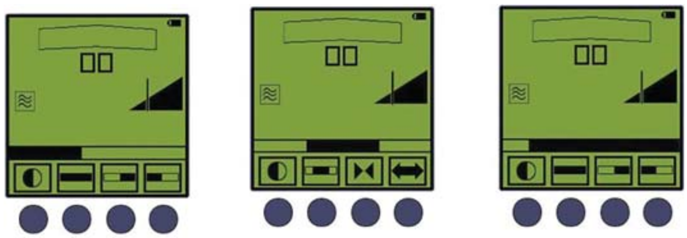

Figure 7.6 Filter settings for pipe materials. (Source: Halma Water Management)

The diagram below shows examples of approximate filter settings for sample pipe materials but please note that these are only given as a guide. The frequencies received will also depend on the ground conditions and type of leak and the filters may require further adjustment to remove unwanted background noise (Figure 7.6).

7.5.2 Memory comparison

Unlike its mechanical predecessor, the electronic amplified listening device enables automatic comparison of small noise differences to support the human ear.

Some advanced devices feature a minimum noise level memory to aid the operator to establish exactly the highest point of leak noise. This can greatly assist the operator to pinpoint the exact leak position, with comparison not possible by the human ear.

As the operator steps along the line of the suspect pipe listening to the sound levels, the device automatically records the base level of noise by checking and memorising the lowest noise level. This is the constant background (leak) noise. As the sensor is moved, a series of readings are taken. These are displayed digitally and graphically to show the difference between each reading clearly, for simple and precise pinpointing. The illustrations below (Figure 7.7) show that the memory comparison function clearly identifies that the leak is located at the highest point of the histogram.

In this example, eight consecutive readings have been taken by stepping the ground microphone along the length of the pipe and recording the leak noise at each position. This data is recorded and displayed as a

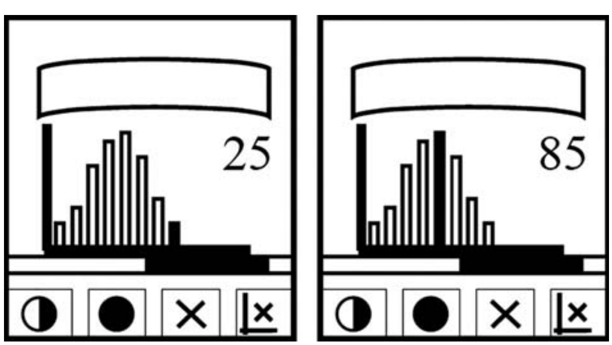

Figure 7.7 Ground microphone display. (Source: Halma Water Management)

vertical bar on a histogram. Each time a sample is taken, a relative number appears on the right of the screen. Each sample can be subsequently selected to check the relative number. This indicates the greatest leak noise acquired and the probable position of the leak.

7.6 AMPLIFICATION

Using the latest acoustic technology, modern electronic listening devices amplify signals which otherwise could not be heard by human ear, making them far more effective than mechanical listening sticks. The output of the amplifier is typically fed to high quality headphones to enable the operator to better detect subtle variations in frequency or pitch that enable the leak location to be positioned accurately.

The most effective portable amplifier modules have an integrated LCD display that enables noise levels and dynamic sensitivity (signal strength) received by the microphone to be displayed graphically as well as audibly.

7.7 REMOTE COMMUNICATION

The latest systems are available with a support app which uses smartphone technology to transmit results, and GPS stamped site reports to top end viewing software, or simply via e-mail to the supervising office. This prevents paper reports and the need to return to the office. Further developments include equipment that can also record the leak sound on site, and this also is transmitted through the app, for reporting, remote analysis or training purposes (Figure 7.8).

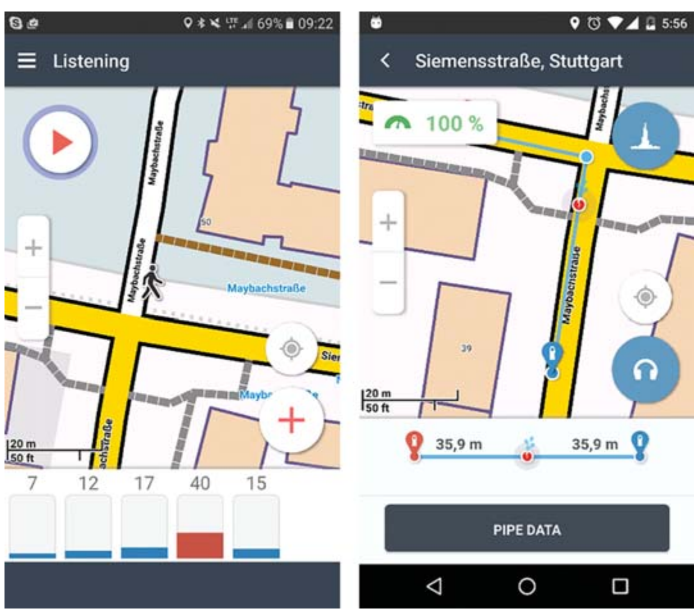

Figure 7.8 App interface for leak soundings and correlations including geospacial coordinates and mapping. (Source: Gutermann)

7.8 ADVANTAGES AND DISADVANTAGES

The operational advantages and disadvantages can be summarised as follows:

Advantages

- Low cost
- Easy to use
- Effective in some circumstances where techniques reliant on noise transmission through the pipe are not effective
- Provides effective leak confirmation following correlation.

Disadvantages

- Very labour intensive
- Inefficient when used as a surveying tool
- Difficult to operate effectively in high-noise conditions and busy urban environments which may require working at night
- Performance subject to soil conditions.

7.9 CONCLUSIONS

The electronic amplified listening device is an essential tool in the leak detection armoury. The most modern devices include advanced features to help the operator to survey, pinpoint and confirm leakage positions.

Whilst electronic devices with ground microphones are still used routinely in many parts of the world to survey areas of suspected leakage, its usage has evolved with the introduction of new areas of technology. Today, equipment exists that enables the leak detection operator to survey large areas much faster and utilizing significantly less manpower than that required by ground microphones alone.

However, the modern ground microphone is invaluable in general leakage work and particularly useful when used as a final confirmation of the leak position detected by a correlator prior to excavation, thereby greatly reducing the number of dry holes or unnecessarily large excavations (Figure 7.9).

Figure 7.9 Electronic amplified listening devices. (Source: Primayer)