SEWERIN
Technologies for leak detection.

Combining location techniques for water leak detection

The importance of drinking water as a vital commodity has been growing steadily for years, and both water suppliers and their customers are increasingly aware of the need to conserve this not inexhaustible resource. Just as consumers should continually ask themselves how they can do more to reduce water usage on a day-to-day basis, water supply companies too are constantly seeking out possible ways of saving water. Their focus is primarily on the water distribution network, which for various reasons is highly susceptible to leaks: by the time a leak is repaired, vast amounts of water may have been lost. For that reason water companies are keen to minimise the number of leaks and to ensure that once a leak is detected, it is repaired without delay.

In its simplest form, the process of repairing leaks has changed little over the decades: Passers-by or householders affected by flooding report a visible water leak to the water company; the water company pinpoints the damage and then repairs it (reactive process). Unfortunately, however, a leaking water pipe does not always result in visible evidence or a surface water leak. In addition, the still widely held assumption that leaks always come to the surface – it is often simply a matter of time – is actually true (with some exceptions), since depending on the soil type and the structure of the distribution network, much of the escaping water may well appear at the surface at some point. However, this disregards the fact that the length of time for which the leak has been in existence has a major impact on the total amount of water lost. When water appears at the surface, the length of time for which it has been leaking is not necessarily obvious. Reactive, visual methods can therefore only ever form one strand of the strategy for leak detection in the water pipe network, and they are never suitable as the sole method of permanently reducing water losses.

A fundamentally different approach from the simple response to visible pipe fractures is now much more widespread. Most water suppliers have systemised the search for water losses and are using proactive methods for the early detection of losses in the pipe network. In Germany, DVGW (Technical and Scientific Association for Gas and Water) Code of Practice W 392 underpins all measures aimed at reducing water losses. Chapter 6 recommends introducing a strategy for monitoring, reducing and keeping down water losses and defines three key steps: measuring leak tightness, determining water losses by measuring flow, and using leak detection methods.

Leak tightness measurement and the quantitative determination of water losses can be combined into a single step. The information obtained can be sufficient to identify even minor leaks and small leakage volumes. In order for losses to be detected as accurately and reliably as possible, it is essential to divide the pipe network into monitoring zones. These zones must be able to be isolated completely from the rest of the network by means of valves and be supplied by a defined infeed of a measurable volume. These pipe network zones could conceivably be fitted with a permanent meter. The process of determining all inflows and outflows in the zone is defined by Code of Practice W 392 as continuous flow measurement.

The measured values should be transmitted and evaluated promptly. Sections of the pipe network measuring from around 4 to 30 km in length are suitable as stationary zones. Measurements should be carried out overnight for a period of 1 to 2 hours. The overnight minimum consumption determined over the measurement period always includes a certain residual consumption volume, which must be used as a reference value in defined stationary zones. Overnight minimum consumption values do not change significantly provided that the operating conditions of the network section remain the same. So in normal conditions roughly the same minimum values are measured every night. If a leak occurs in the measuring area, the overnight values will rise appreciably and will remain high. Since continuous flow measurement allows the actual leakage amount to be measured directly, changes can be responded to immediately. The necessary actions to contain the problem, such as closing valves to reduce the size of the measuring area, can be taken without delay.

This type of continuous flow measurement is a costly exercise for the installation and the operation. It also requires a detailed knowledge of the pipe network hydraulics in order for suitable measuring points to be selected. A thorough and verified pipe network capacity calculation is usually essential.

Instantaneous flow measurement represents an alternative to continuous flow measurement with fixed measuring points. Here the network is inspected at regular intervals, depending on the water losses. The pipe network zones should generally be rather smaller than those used for continuous measurements. Sections of between 1 and 10 km are recommended, so that the influence on the measurements of the anticipated residual consumption volume and any continuous customers such as industrial plants is not too great. The designated section of the pipe network is shut off from the rest of the network for the inspection. The isolated network zone is supplied by means of a bridging hose via two hydrants, one inside and one outside the measuring area. A portable metering device (see Figure 1) connected to this bridging hose transmits pressure and flow data to a PC. The minimum flow can be calculated from these measurements. The residual consumption volume has to be estimated as accurately as possible. If only a few consumers are connected to the pipe network zone being measured or if the diversity factor of water with-

Figure 1: Instantaneous flow measurement – roadside setup

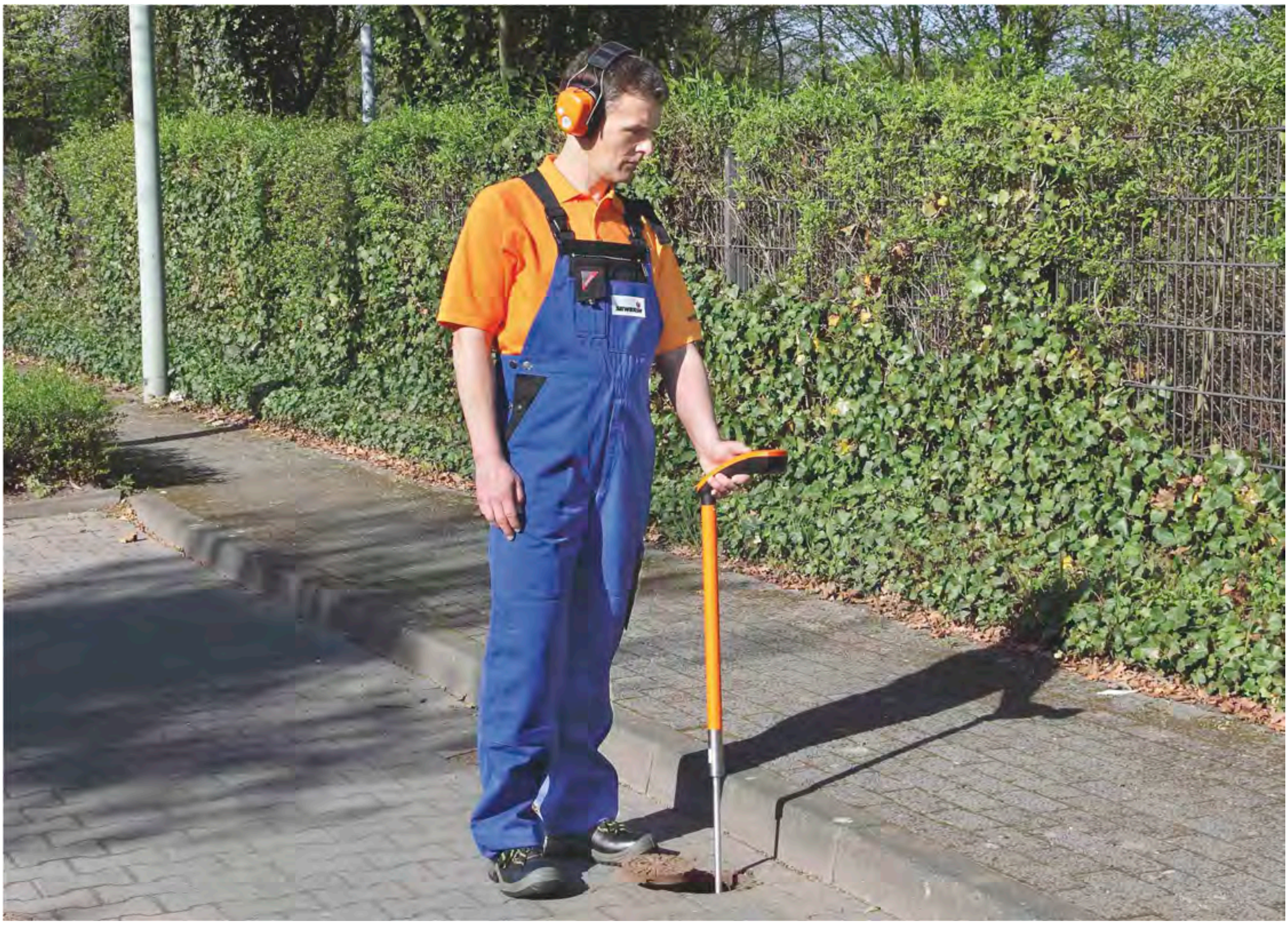

Figure 2: Using a test rod for prelocation

drawal is very low, in practice a zero-consumption measurement is frequently also recorded, where no water flows into the area in question.

If the result of the leak tightness inspection in a section of the pipe network suggests the presence of leaks, further steps are necessary to narrow down the detected leak and ultimately to pinpoint it as accurately as possible. One proven option for prelocating the leak site in a given pipe network section is the temporary use of noise loggers. They are installed in a hydrant in the network section for one or two nights, and the quietest moments during the measurement time are recorded. If the logger is close to a leak, the noise level at even the quietest moment during the night will be significantly greater than zero. By systematically moving the logger within the area in question, the hydrants at which loud noise can be measured can be identified quickly and reliably. Just 20 or so loggers are sufficient to narrow down the possible leak sites within the area to a few hundred metres after a few nights.

If, however, the leakage amount in the inspection area is very high and there is an imminent risk of the leaking water causing damage to buildings or roads or other structures due to subterranean erosion, faster methods of prelocating the site of the damage are required. This is where portable electroacoustic methods come into their own.

Here a leak detection specialist systematically surveys the network with a test rod. He or she opens all manhole covers and assesses the noise at all fittings, such asvalves, stop tapsor hydrants (see Figure 2). If audible leak noise can be heard at the fittings, these sites are marked. This concludes the prelocation process. As the effectiveness of all electroacoustic methods is very much dependent on ambient noise and on the experience of the operator, these inspections often take place at night. This is the quietest time, and traffic noise and water consumption are low. The biggest advantage of this prelocation technique is that it is suitable for all network structures.

The noise that is heard is influenced by the nature of the pipe, its material and diameter, so it is highly individual. One leak rarely sounds exactly the same as another. But in every case a leak has a distinctive noise that cannot be mistaken for normal flow noises in the water pipe network.

To enable a site to be excavated, however, the exact location of the leak has to be pinpointed, and that cannot be done simply by inspecting the fittings. One technique that has been used successfully for many years is the correlation method. This pinpointing method involves installing microphones at two measurement locations (fittings in the pipe network). The microphone signals are transmitted wirelessly to a receiver, where they are analysed mathematically (see Figure 3). The correlator then shows the position of the leak as the distance from one of the two measuring points. Correlation methods do not require an experienced operator, and the accuracy of the measurement is determined by objective factors: the length of pipe between the two fittings used as measuring points and the material and diameter of the correlation section.

In plastic pipes in particular, pinpointing a leak is often very difficult as the noise does not travel as far as it does in metal pipes. So it is often hard to correlate a leak in non-metallic pipe networks, especially if the distance between adjacent fittings is very long. In such a case the leak noise may not even reach the contact points. Successful correlation is still possible, however, using a different type of microphone: the hydrophone. This is installed directly in the water column. As noise propagation in

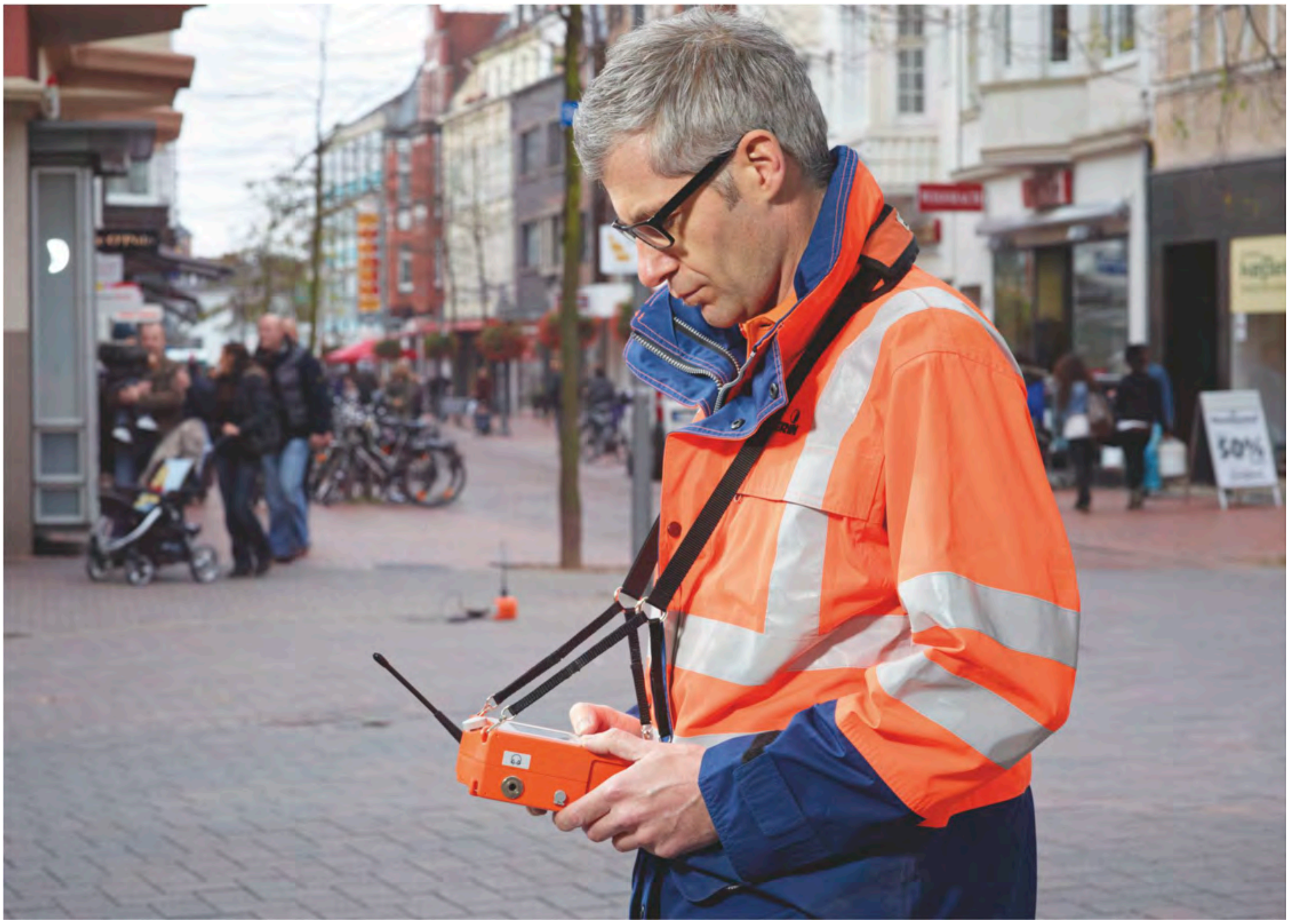

Figure 3: Pinpointing the leak with a correlator

water is much more effective than structure-borne noise in a pipe, successful correlation using hydrophones is possible even over long measuring sections.
In practice, the accuracy of leak detection depends on the quality of the available pipe data. Following a successful correlation it has proved beneficial to confirm the result and the location of the leak site using an electroacoustic method.

This is done by connecting a receiver to a ground microphone, which should be suitable for the surface at the site in question. The inspection is then carried out directly over the pipe at the correlated position. The noise transmitted through the ground to the surface is analysed by the leak detection specialist. A noise is generally loudest directly over the leak. If ambient noise such as rain, wind or traffic noise at the leak site makes it harder to pinpoint the leak or if the leak noise is not clearly audible, filter settings on the receiver can help to isolate the noise.

Once all the pinpointing steps have been completed and the result has been confirmed by acoustic methods, the position of the leak is marked on the ground surface and a report is produced. Work to repair the damage can then begin.

All of the aforementioned methods for prelocating and pinpointing a water leak – use of noise loggers, prelocation with a test rod, pinpointing with a correlator and electroacoustic confirmation of the leak with a ground microphone – depend upon a noise being generated by the water escaping from the site of the damage.

However, the leakage amount determined during inspection of the pipe network section may not necessarily come from a leak that is large enough to create an audible noise. Instead it may be made up of several small leaks, which on their own do not generate a measurable or audible noise.

The leak detection techniques mentioned so far can also encounter difficulties for other reasons. The absence of contact points (valves, hydrants, etc.), or too great a distance between them, makes it more difficult to use acoustic methods. A case that is typically encountered in practice is the inspection of long transport pipes. Instantaneous flow measurement is an effective way of checking for leaks in this type of section, but using acoustic methods to prelocate and pinpoint the damage is often unsuccessful. An alternative approach is the gas inspection method.

Here a volatile, odourless, tasteless and non-combustible gas is introduced into the pipe to be inspected. Hydrogen mixtures with nitrogen have proved effective for this purpose. Helium is also used, though only very rarely in the drinking water supply sector. Unlike helium, hydrogen in nitrogen has the advantage that hydrogen is readily detected at the ground surface even in trace amounts of a few ppm. These mixtures are known as tracer gas or forming gas. They are technical gases which are easily available and mostly contain 5% hydrogen in nitrogen. Mixtures containing 10% hydrogen are also used, though less commonly.

There are various ways of using tracer gas to pinpoint leaks in water pipes. Firstly the gas can be added to the pipe during operation. As both hydrogen and nitrogen have very restricted solubility in water, the gas flows along the pipe in the form of bubbles close to the top of the pipe, unless severe turbulence in the pipe causes the gas and water to mix. There are, however, a number of disadvantages associated with the presence of bubbles of an undefined size in the pipe. One is that sensitive fittings in the network, such as automatic bleeders in a transport pipe, continuously release the gas, causing a leak to be indicated at

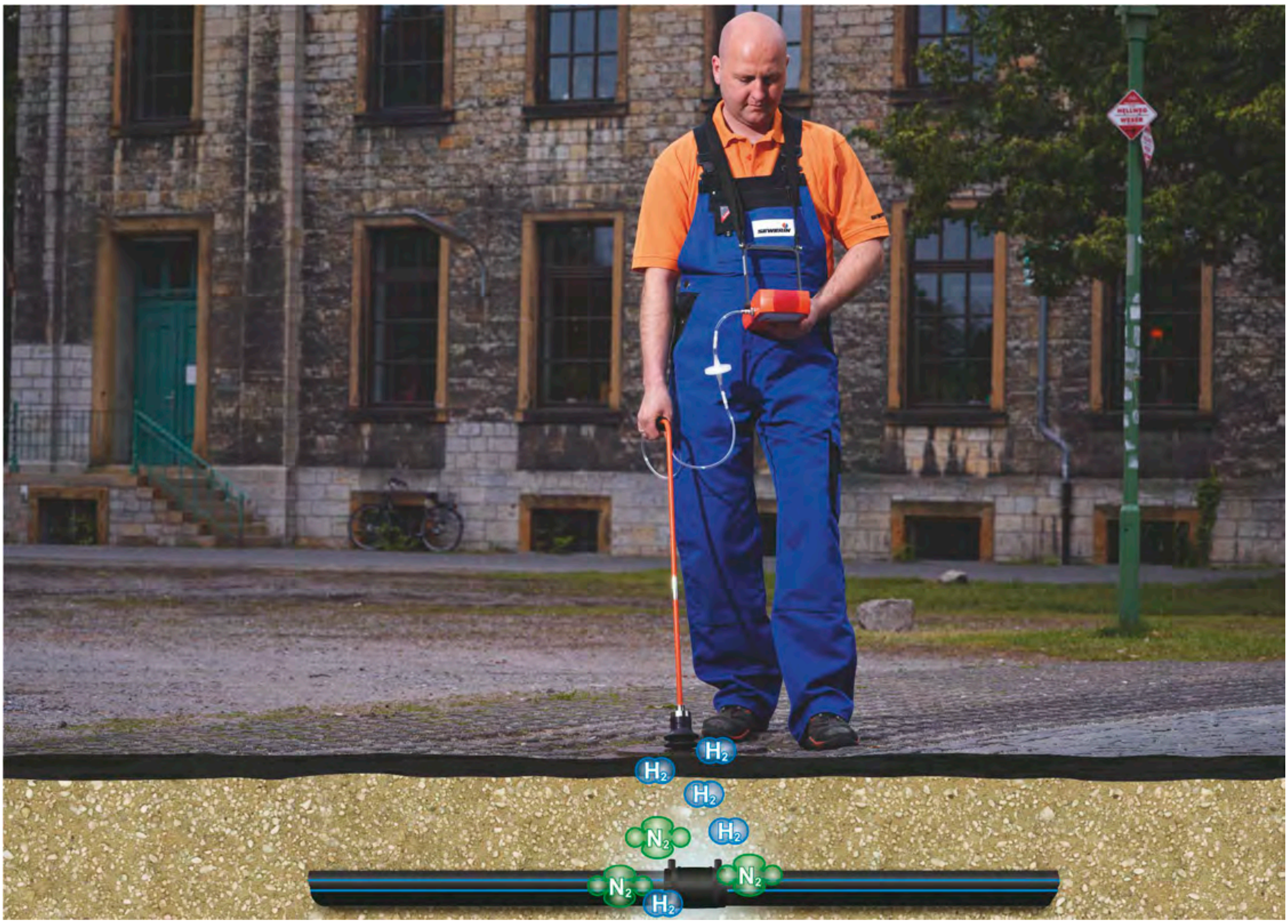

Figure 4: Tracer gas to pinpoint leaks in water pipes

the ground surface. Another is that bubbles are released with the water when the consumer turns on a tap. This can cause damage to domestic appliances in some cases. However, the biggest disadvantage of the incomplete dissolution of the gas in water and the resulting bubbles close to the top of the pipe is undoubtedly the fact that leaks at the bottom of the pipe are not detected because the leaking water contains no hydrogen.

So in practice the pipes in question have to be taken out of service and drained. The gas can then expand to fill the entire volume of the pipe. This ensures that the gas can escape from all possible leaks over the full extent of the pipe in the ground. The hydrogen, which is very light, then diffuses quickly to the surface, where it can be detected with a highly sensitive gas leak detector (see Figure 4).

DVGW Code of Practice W 392 recommends that the frequency of leak tightness inspections should be based on the level of water losses in the pipe network. It recommends annual inspections for high losses, three-yearly inspections for moderate losses and at least six-yearly inspections for low water losses. The key elements of any strategy are the division of the pipe network into monitoring zones for inspection, the quantitative determination of the leakage amount in the pipe network, and the choice and combination of techniques to allow a leak to be located with sufficient accuracy for confident excavation. The exact combination of the methods used depends as much on local conditions as on the available measuring technology. No one method or technique used in isolation will deliver success, however. The only sure way of achieving a long-term reduction of water losses in pipe networks is by combining location techniques for water leak detection.

Published by:

Hermann Sewerin GmbH | Robert-Bosch-Straße 3 | D-33334 Gütersloh
Phone +49 5241 934-0 | Fax +49 5241 934-444 | www.sewerin.com | info@sewerin.com

RLWA-BI 01023013 GB