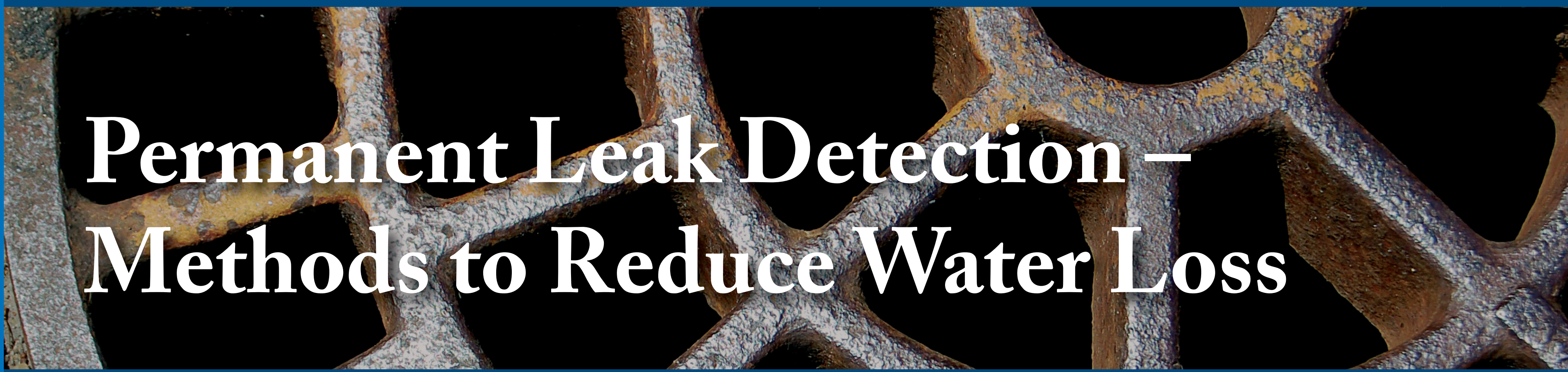

Permanent Leak Detection – Methods to Reduce Water Loss

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When it comes to permanent water pipe network monitoring, there are a number of established methods. Pressure or flow-based measuring techniques are the preferred methods of the day, even though there are various other methods based on alternative operating principles. The two conventional methods have one thing in common: it is time-consuming and therefore very costly to set up the measuring points. As a rule, it is necessary to build a shaft to install a water meter in a measuring area or a pressure measuring point in the pipe network. For this reason such measuring points are usually only found in select locations, and the zones monitored by them often comprise many kilometres of main pipeline.

If a leak occurs in the measuring zone, the pressure or flow data does indicate the existence of the leak, but the process of locating the leak for excavation and repair is, once again, very labour intensive as these methods only allow pinpointing to a limited extent. It is possible, however, to make the measuring areas smaller by briefly locking valve groups, potentially limiting the leak to one street of houses.
More precise pinpointing, however, is virtually impossible; even such a superficial investigation of the problem involves many hours of work, often extending into the night hours.

Another reason why pressure and flow measurements are only suited to a limited extent to detecting leaks is that pipe networks are often interconnected. The flow into a measuring area can only point precisely to a leak if it is a purely linear system. This is the case, for example, in the discharge from water towers or at defined transfer stations to adjacent systems. In closely interconnected structures, such as those often found in city centres, an altered flow pattern can also simply be an indication of a change in consumption patterns.
Pressure measuring methods are even more dependent on the degree of interconnectivity than flow methods; the size of a leak must be immense to be detected.

Owing to the weak points of the established methods, the search for a cost-effective and practicable alternative for early leak detection in water pipe networks began.

Stationary use of noise loggers

One possible solution for avoiding the problems described is the use of acoustic methods, in which microphones measure analyse the noises in the pipe network. This principle has been successfully used for many years in electro-acoustic water leak detection for prelocating leaks.

The acoustic methods are based on recording the noises in a pipe and evaluating the lowest level during measurement. When an operator is checking the fittings along a pipeline with an electro-acoustic locating device, he ignores passing vehicles and transient drops in his assessment of the noise in just the same way as data loggers do. The minimum level is evaluated independently of the precise manner in which the electro-acoustic method works. As with all mobile applications of such methods, it is, however, difficult to determine which is the "leak-free" base level. Stationary systems operate on a different basis.

The main difference with the use of stationary as opposed to mobile noise loggers is that it is not the absolute level that is analysed in a few measuring cycles but rather the relative change in the level over a defined observation period.
Every night, a logger records the noises at its measuring point and determines the minimum level. This and other information is automatically sent to a computer, where it is stored in a database. The software interprets the data and detects changes in the minimum level over several nights of measurement.

Figure 1: Options for installing the logger in the valve box

When using this method it is important to select the measuring points with care so that there is always at least one logger to detect the leak. This is mainly dependent on the sensitivity of the microphone. In practice, the measurement locations should not be more than 400 to 700 metres apart. In networks consisting of PE or PVC pipes, the distance should only be about 200 to 400 metres owing to the significantly poorer sound propagation in such materials. Data is transmitted from the loggers to the computer via SMS. For that reason the loggers have to be able to dial into the mobile phone network of a selected provider at the time of transmission. This is not always easy from a valve box, but by adapting the position of the antenna inside the valve box, reception can often be optimised (see Fig. 1).

Once the valve box cover has been closed, the measuring points are always ready for use.

Interpreting the measurement results

The measurement data sent via SMS can be received in various ways. The SMS messages are either received directly by a modem or the data is converted into an e-mail and the measurements are picked up by a server. The analysis can be carried out by device-specific software, or the task can be handed over to any network information system.

Figure 2 illustrates the graphic analysis of data from a measuring point showing differing effects when leaks occur.

In the example, the minimum levels were recorded every night from 16.04.2008 to 08.03.2009. After installing the logger at the measuring point, an only moderately fluctuating minimum level of a few measuring units was constantly recorded (1). This basic level was only interrupted by a one-time, transient event at the beginning of June 2008 (2). This peak in the curve was recorded during a night of heavy rain in the measuring area. At the beginning of September 2008 the logger recorded a leak located a few hundred metres from the measuring point. After a short time (3) and the subsequent repair of the leak, the nightly minimum levels returned to the usual initial values. At the beginning of December 2008 the logger recorded a sudden, very loud noise (4). However, after repairing the damage in the immediate vicinity of the measuring point, the values never

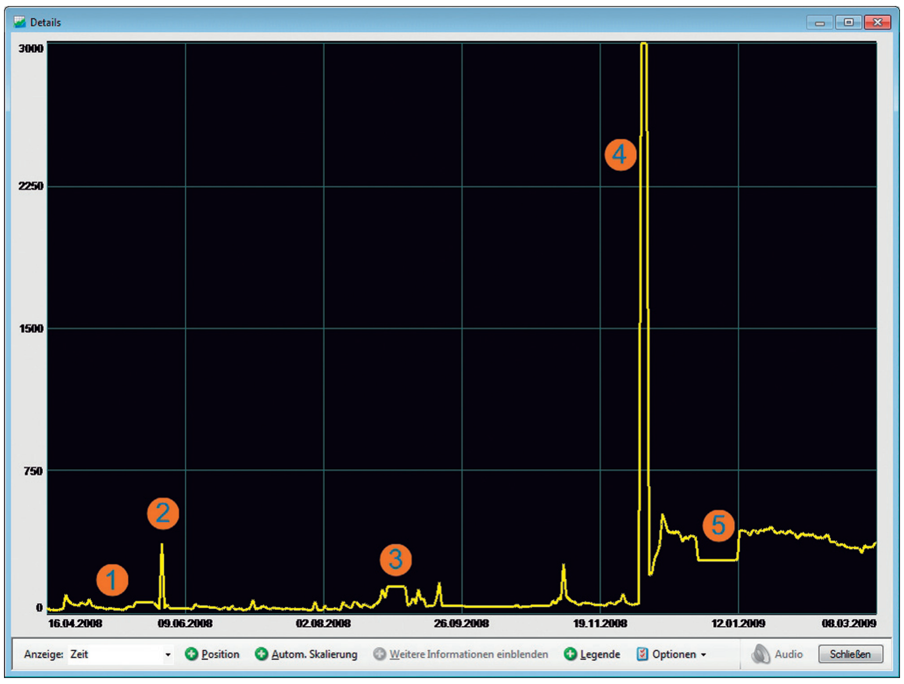

Figure 2: Example of a measuring point over time

Fig. 3: Continuous growth of a leak

returned to the previous minimum level. The significantly higher measurement values (5) suggest the presence of at least one further leak within a measurable distance of the logger.

The example in Figure 3 clearly illustrates that not only spontaneously occurring leaks can be detected but that growth patterns can also be positively identified.

Following the installation of the logger at the measuring point (16.04.2008), a minimum level that did not suggest the existence of a leak was established for only a very short time. Just a few days after installation, the measurement value during the quiet night hours increased steadily (1). From about the end of April until the end of June 2008, the measurement values fluctuated but remained approximately at a constant higher level (2). After that, measurement values increased further (3) and finally, around the beginning of October, investigations were carried out to pinpoint the leak. These investigations were successful and the damage was repaired (4).

Leaks are not only spontaneously occurring events in the pipe network. As can be seen in Figure 3, the growth of a leak can be tracked using stationary noise loggers. In practice, this pattern corresponds to damage caused by corrosion. This occurs when, following the initial escape of water from the pipeline, the constant friction at the edge of the new leak leads to an increase and intensification of the leak noise. From an imperceptible drip the damage grows steadily to a fine stream before finally the diameter of the leak is large enough to let through considerable amounts of water.

Advantages of stationary noise level measurement

In relation to the size of a measuring area, the volume of water initially escaping from a new leak is usually so low that it cannot be clearly distinguished from minimum night-time consumption when measuring the flow. In practice, many months often go by before the size of the damage is great enough to produce a flow volume that can clearly be identified as a leak. Noise loggers can report the leak after just a few days. In a pipe network, water loss caused by a number of smaller leaks added together is likely to be considerably higher than the loss caused by a few spectacular pipe bursts visible on the surface. Noise loggers are capable of reliably detecting both types of leak site - slowly growing and spontaneously occurring.

The cost of setting up a measurement location works out at a few hundred Euros, including the configuration and installation of the logger. This is compared to several tens of thousands of Euros to set up a flow measuring point with expensive shaft construction and a costly bulk water meter.

The running costs for operating and maintaining a stationary noise measuring point depend on the contracts with the selected mobile phone provider. To complete its measuring task, each logger typically sends eight SMS messages, which generally cost no more than 5 to 10 cents each. Since prepaid cards can be used to take advantage of the full range of functions of the logger, there are no other operating costs for this maintenance-free system. So with maintenance costs of less than one euro per month and per measuring point, this method is unrivalled in terms of its affordability.

Conclusion

Stationary noise loggers are a cost-effective addition to existing systems. They are particularly well suited to the monitoring of critical network areas in which quick, reliable leak detection is of great importance.

This applies in particular to highly interconnected structures in inner-city areas where flow measurement systems have reached their limits.

By systematically fitting new network sections with noise loggers at the time the pipes are laid or commissioned, these network sections can be reliably monitored from the first day of operation.
Leaks that occur in the pipe network no longer remain hidden.