INNOVATIVE NETWORK MONITORING TECHNOLOGIES

to support water loss management

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Every water supply network has specific loss dynamics and it is essential to take the appropriate measures for network monitoring, leakage location and damage repair in consideration of the basic technical and economic conditions. Modern technologies facilitate the recognition and discovery of leakages and provide essential information for network operation and the interpretation of the condition of the water mains. This article describes the challenges of water loss monitoring, covers developments in the fight against water loss, explains the challenges in a network monitoring system and describes the technology of multi-parameter measurement.

Das Management von Wasserverlusten in Wasserverteilnetzen stellt eine der größten Herausforderungen der zentralen Trinkwasserversorgung dar. Jedes Wasserversorgungsnetz weist eine bestimmte Schadensdynamik auf und es gilt in Abwägung der technischen und wirtschaftlichen Rahmenbedingungen geeignete Maßnahmen zur Netzüberwachung, Leckortung und Schadensbehebung zu ergreifen. Moderne Technologien, wie die Multi-Parameter-Messung, erleichtern das Erkennen und Auffinden von Leckagen und liefern essentielle Informationen für den Netzbetrieb und die Interpretation des Zustands des Rohrnetzes.

When considering the range of tasks of water supply companies in greater detail in regard to the monitoring of the distribution network and leakage location, one is inevitably reminded of the story of Sisyphus. In Greek mythology Sisyphus was compelled to repeatedly roll his boulder to the peak of the mountain only to watch it roll back down each time after having made such a great effort. The battle against water losses is similar: There will never be a complete elimination of the losses of a water supply system. Moreover, there will always be conditions and developments which represent setbacks for water supply companies in their battle against losses, such as the occurrence of individual pipe ruptures in the system or subtly increasing leakages of critical groups of lines which may occur as a result of corrosion. The use of modern measurement instrumentation makes it possible to not have to start over with this Sisyphean struggle each time.

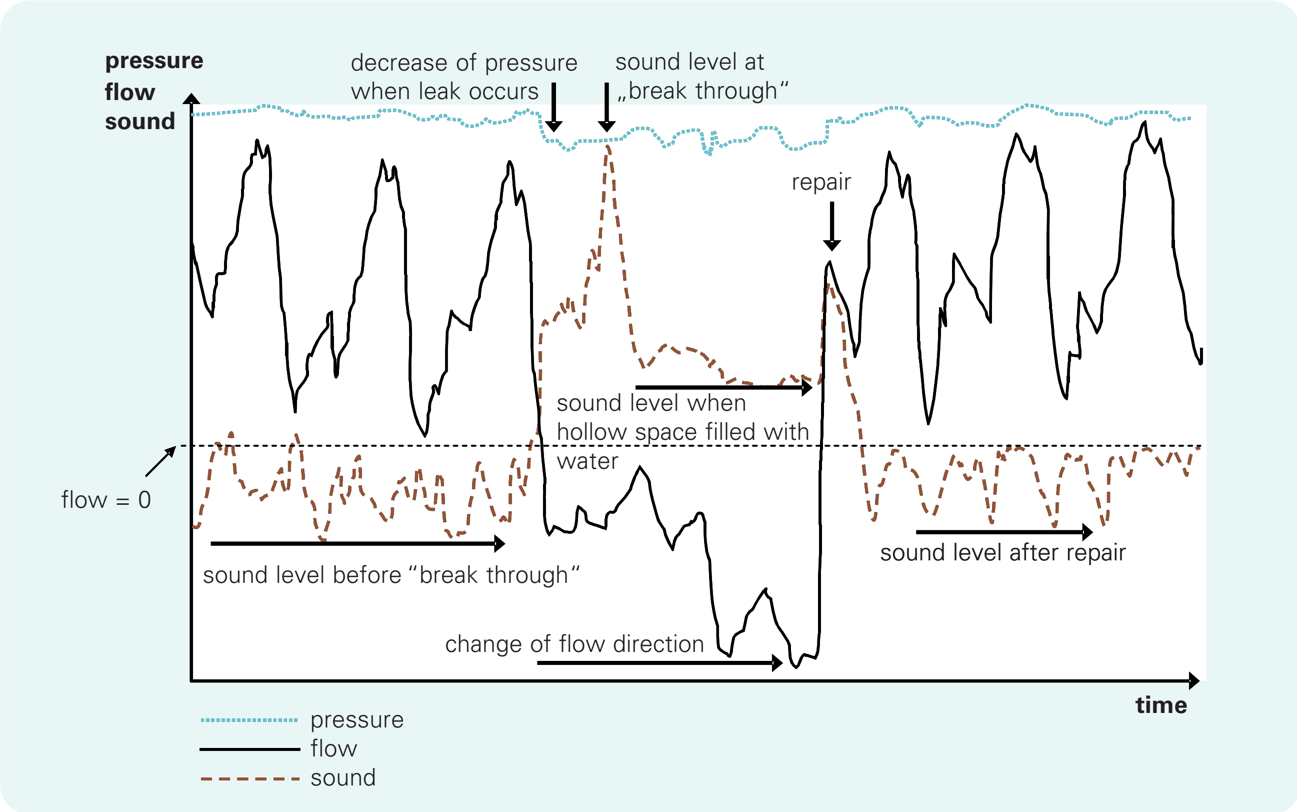
The expenditure for the water mains monitoring and the leakage location may not be underestimated. On a cursory examination this expenditure seems inefficient and, therefore, is usually unpopular. The media coverage of the opening of a new reservoir, a new well or a new desalination plant, in comparison with the battle against water loss, is usually a pompous act which decision-makers and politicians are all too happy to take advantage of for marketing purposes. The rectification of a leakage or the replacement of a line is far less glamorous. Moreover, negative reporting about spectacular pipe ruptures, closed roads or a would-be desolate pipeline network dominates the coverage of this topic.

However, the implementation of a new standard of technology for water loss management can entail enormous savings and potential yield, whereby the reduction of water losses achieved in this process equates to great quantities of "regained" drinking water. This can be advantageous for the actual intended purpose and thereby delay or even eliminate the need for investments in new resources.

Developments in the battle against water loss

Basically, it can be said that considerable efforts have been made in recent decades to reduce water losses, taking various approaches. In 1999 Edith Cresson – Member of the European Commission responsible for research and innovation – formulated the four most important measures in an European-wide brochure Water – a vital resource under threat in which measures were defined for the "prevention and discovery of leakages and technologies for the renewal of supply systems" (Cresson, 1999).

Shortly thereafter the German worksheet DVGW W 392 (2003) was published on the subject "Pipeline Monitoring and Water Losses". It describes tasks for water mains monitoring and leakage location, among other things. Another milestone is the newly reworked Austrian directive OVGW W 63 (2009) for Water Losses in



Drinking Water Supply Systems. This directive also includes recommendations from the International Water Association (IWA) for the calculation of a water balance sheet and of key figures as well as measures for the prevention of water losses in supply systems (Alegre et al. 2006, Lambert & Hirner 2000, Morrison et al. 2007 and Pilcher et al. 2007).

In some points, however, OVGW W 63 (2009) deviates from the recommendations of the IWA. This pertains primarily to the topics of pressure management and the monitoring of supply systems which are not subdivided into physical measurement zones (= DMA, District Metered Area), where innovative technologies are described.

While the IWA considers the theme of pressure management to be a key element to water loss management,

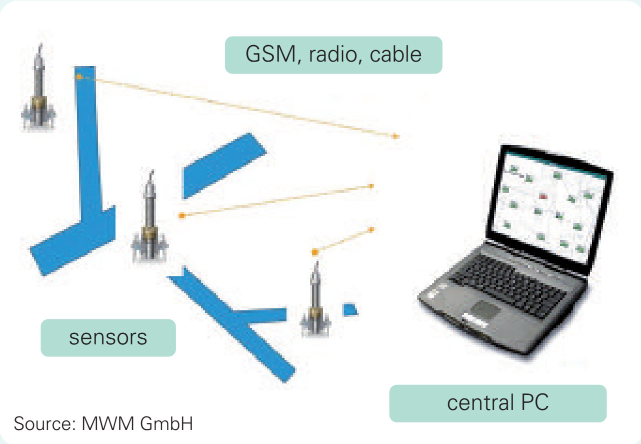
> Even with large investments, water losses can never be reduced to zero.

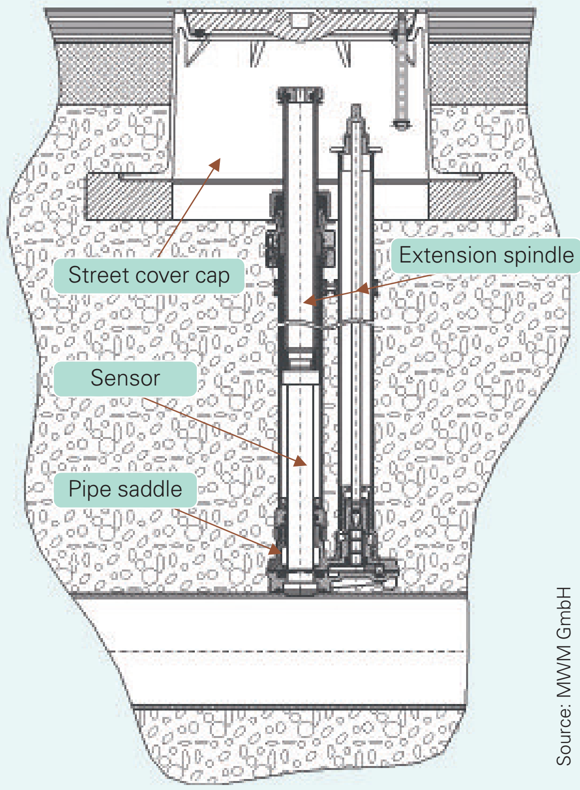
OVGW W 63 (2009) points out that in accordance with the valid legal and technical standards in Austria (e. g. Austrian Standard OeNorm B 2538 (2002)) a pressure management system must be rejected as a substitute for the necessary repair measures in the case of poor network condition. It also states that pressure management can help, however, in reducing the water losses in the time between recognition of a leakage and repair.

Pressure reduction is normally symptom control, but does not address the actual causes. Moreover, the reduction of the supply pressure complicates the discovery of leakages and thereby hinders sustainable repairs and renewal measures. The problem that water continually drains away into the ground through holes, ruptures and other leakages remains and without the implementation of additional monitoring measures like flow measurement, the lack of monitoring in the pipeline network continues.

Another important topic in water loss management is the assessment of the amount of water losses and the calculation of water loss key figures. A water balance sheet normally serves as the basis for this, comparing the quantities fed into the system with the various withdrawals (e. g. delivery to customers, nonpaid consumption). In recent years the IWA established a methodology for a water balance sheet and the IWA water balance sheet is also included in the directives DVGW W 392 (2003) and OVGW W 63 (2009).

Anyone who has already created such a balance sheet is aware of the difficulties involved in its creation. For example, some elements can only be estimated and there may be problems in defining time ranges, e. g. of consumption data. A balance sheet, as suggested by the term, is a time-based representation of a past period – normally one year. It also presents the extent to which the delivered water quantities correspond to the system input quantities and/or which share of the quantity of supplied water was delivered as a calculable water quantity.





◀ Fig. 1: Example of multi-parameter measurement

▲ Fig. 2: Principle of monitoring with the WLM SYSTEM

▶ Fig. 3: Installation of a WLM sensor using a special shaft (sketch)

Water balance sheets and the key figures calculated from them are elementary components of water loss management, however, this involves relatively inactive instruments which are normally based on past time periods. Therefore, they serve primarily for a long-term consideration of water loss development and can be a basis for strategic decisions about water loss management, among other things. However, water balance sheets and key figures provide very little or no information about the future loss dynamics of a water supply network and thus about the actual challenges of the running water works and the maintenance.

Sisyphus has already been mentioned in the introduction. Perhaps it is somewhat farfetched, but the battle against water losses is a continuous effort which never leads to a total achievement of goals in the form of the complete elimination of water losses. The continuously emerging leakages in the pipeline network are comparable to the failure of Sisyphus to roll the boulder to the peak. Depending on which efforts are made, the boulder can be brought closer to or further from its goal. When applied to a water supply network, that means the more effort which is made for network monitoring, leakage location, repair and rehabilitation, the greater the success in the reduction of water losses. However, even with large investments, water losses can never be reduced to zero. Therefore, it is essential to calculate the extent to which measures are cost-efficient and/or necessary.

Requirements on a network monitoring system

In order to be able to achieve long-term and sustainably low water losses, a water loss management correspon- ►

ding to state-of-the-art technology, including permanent monitoring of the supply network, is required at any rate. The type and extent of the network monitoring systems depend on a few factors, including:

- the supply structure,
- the network length and
- the production and distribution costs.

An effective and efficient monitoring system must fulfil the following criteria:

- Changes in flow rate and direction as well as changes in the supply pressure, which indicate leakages, must be reliably shown.
- The system must provide spatial details of the affected section of the supply network in order to be able to locate the leakage more quickly, efficiently and systematically.
- A quantitative estimate of the size of the leakage should be enabled in order to avoid costly repair measures for very small leakages.
- The installation should take place before commencing with extensive rehabilitation work. In doing so, the necessary information can be gathered for determining where, how and when the necessary maintenance measures should be taken. The more information a monitoring system can supply, the better and more reliably the network condition can be assessed and the better and more reliably the efficiency of different maintenance measures can be determined on the basis of substantiated facts.

> "Water balance sheets and the key figures calculated from them are elementary components of water loss management.

Fig. 4: Example of installation of a WLM sensor using a special shaft (street surface)

Source: MWM GmbH

- As a further consequence the monitoring system will show the improvements achieved through the ongoing maintenance work.
- The system should be cost-efficient and provide additional information for the daily network operation.
- The use of a modern network monitoring system must provide sustainability in the reduction of water loss.

Multi-parameter measurements

A technology which supports these criteria and has gained increased significance in recent years is multi-parameter measurement. In the process, several parameters, such as

- flow rate,
- pressure,
- sound

are simultaneously measured and recorded in the network. The measurements can also be combined with other parameters which are not relevant for leakage, such as the temperature of the water. With the common evaluation of the "leakage-relevant" parameters, significantly better interpretation possibilities arise than through measurements of only individual parameters (Koebl et al., 2009). **Figure 1** shows an example for the recognition of a pipe rupture and the associated development of the measured parameters – flow rate, pressure and sound.

Basically, the interpretation of the multi-parameter values should take place through the comparison of current data with earlier data under comparable consumption circumstances in the pipeline network, e. g. the respective values from calmer night times (night minimum). The OVGW directive W 63 (2009) recommends this technology especially for the permanent monitoring of non-limited hydraulic network areas, in other words large zones, which can only be insufficiently monitored through just a system input measurement.

In addition to individual solutions, there are already fully developed systems on the market whose sensors work with the currently available technical sensitivity (e. g. WLM SYSTEM, see **Fig. 2 to 4**). Integrated data storage functions with practicable connection to remote systems as well as suitable evaluation software with automatic limiting and a quasi artificial intelligence are also state-of-the-art. With the complexity of the monitoring, the decisive advantage of such a system is the fully-automatic monitoring function with simple representation of the individual sensors on a screen. This can, for example, take place with a traffic light function (red/green), where "red" shows that a limit value has been exceeded and "green" indicates the adherence to limit values. In the process, a fast and automated daily assessment of the network condition is enabled.

For significant measurements, a sufficient measurement point density depending on the measured parameters and

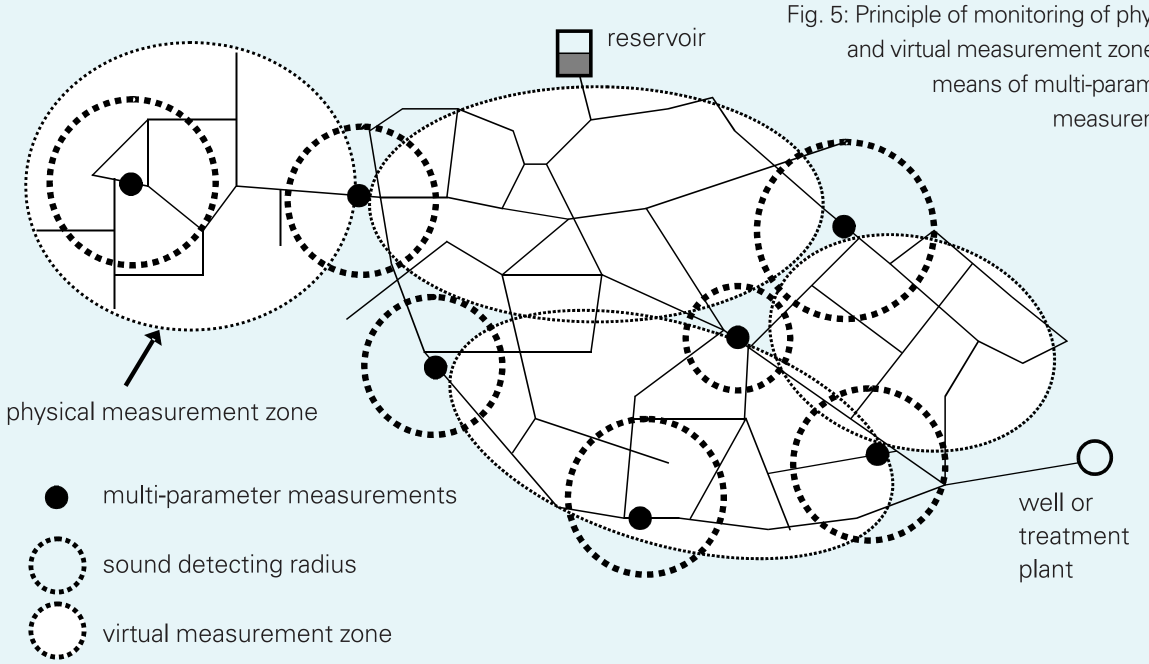


Fig. 5: Principle of monitoring of physical and virtual measurement zones by means of multi-parameter measurement

the permanent operation of the measuring devices are necessary. In the process, the detection radius of the measuring device for the sound level measurement, and especially the conditions of the sound development and sound distribution, must be taken into consideration (see the different circles in **Fig. 5**). In addition to use in large zones, where the monitoring of "virtual" zones is applied, that is to say any areas lying between the measurement points, multi-parameter systems are, of course, also suitable for the monitoring of physical measurement zones (Fig. 5).

In order to also be able to achieve the desired success in the battle against water loss, the quick rectification of damage spots is unavoidable. Through a risk assessment of the leakage (quantitative, spatial, damage potential), a prioritisation can be executed in advance of a repair and/or renewal, whereby a significant contribution to cost optimisation is made.

The trend reversal from inactive, static monitoring to the daily, dynamic and direct monitoring of a water supply network with immediate reaction capability opens up the possibility of a timely, cost-saving and reliable pipeline network management.

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