WATER LOSSES DETECTION IN NETWORK DISTRIBUTION USING NOISE LOGGERS

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ABSTRACT: *Water losses in distribution networks represent a significant challenge for utilities worldwide, resulting in wasted resources, increased operational costs and infrastructure damage. These losses are classified into real losses (physical leaks in pipes, joints and fittings) and apparent losses (caused by measurement errors or unauthorized consumption). Real losses, in particular, require effective detection and mitigation strategies to improve network efficiency and sustainability. This pilot project in Piatra Neam aims to increase the efficiency of leak detection using advanced technology for recording and transmitting noise from distribution networks. The project involves installing noise loggers at strategic points, such as in valve chambers, within the distribution system. These devices continuously monitor/correlate noise from pipes, identifying potential leaks based on characteristic sound patterns. Data from the loggers is transmitted to a central platform, where algorithms filter out background noise and identify anomalies that indicate leaks. This real-time monitoring allows for early detection of leaks, reducing water losses and minimizing repair costs. Key objectives include evaluating the effectiveness of the noise loggers in a real-world setting, optimizing their placement for maximum coverage, and integrating the system with existing SCADA network management tools. Field tests involve correlation techniques to confirm leak locations and evaluate detection accuracy. Preliminary results suggest that the noise logger tools significantly improve detection time compared to traditional methods, especially in areas with pressure variations. This short paper demonstrates the potential of noise loggers as a scalable and cost-effective solution for proactive leak detection. The findings will contribute to more sustainable water management practices in Piatra Neamt and beyond.*

Keywords: *water losses; noise loggers; water network; loss detection*;

1. Introduction

It is a common misconception that most water losses in distribution systems stem from large, visible mainline failures, due to their high pressure and high flow characteristics. However, detailed component analyses from well-managed utilities show that such events typically account for less than 10% of the total annual volume of actual losses. In reality, the largest contributors to actual water losses are background leaks or failures, long-standing unreported losses, and neglected failures that go unrepaired due to cost or logistical challenges. These invisible or hidden leaks pose a significant challenge because they continuously waste water, remaining undetected for long periods.[1] The primary difficulty lies in accurately locating these hidden leaks.

Traditional leak detection is based on the fundamental principle that most leaks produce a distinctive acoustic noise as water escapes under pressure through pipe defects. Early leak detection methods involved technicians manually probing pipes using rudimentary tools such as wooden sticks. By placing the stick against exposed fittings such as valves or hydrants, technicians could listen to the sounds of leaks transmitted through the pipes, similar to a stethoscope amplifying a heartbeat. While this method was inexpensive and moderately successful for metal pipes, it was much less effective for non-metallic materials such as asbestos cement and often resulted in inaccurate or "dry holes". The limitations of these conventional techniques, including their time-consuming nature and high labor requirements, prompted a shift in the 1980s to more systematic approaches - specifically, leak monitoring and leak control. Leak monitoring involves strategically deploying flowmeters throughout the distribution network, dividing the system into distinct sectors or district metering areas (DMAs). Each DMA is a hydraulically discrete area where flow and pressure can be monitored continuously, especially during low-demand nighttime periods. High nighttime flows in a DMA often indicate the presence of unreported leaks or bursts.[2]

The primary goal of this monitoring system is to optimize the number of DMAs while minimizing the number of flowmeters required. By analyzing nighttime flow data, utilities can prioritize their leak detection efforts, narrowing down suspect areas before conducting targeted acoustic surveys. This two-step process—DMA-wide monitoring followed by focused leak identification—forms the foundation of modern leak management strategies. Ultimately, it enables more efficient resource allocation and improves the detection and repair of invisible leaks, supporting a more sustainable and cost-effective approach to reducing water loss.[2]

Advances in leak detection technologies have introduced acoustic noise loggers as a promising tool to improve the efficiency and reliability of leak identification. These devices, when strategically deployed at key points in the distribution system, such as valve chambers, enable continuous acoustic monitoring of water pipes. By capturing and analyzing the characteristic sound patterns generated by leaks, noise loggers help utilities detect anomalies that might otherwise go unnoticed. Data from these loggers is transmitted wirelessly to a centralized platform, where sophisticated algorithms filter out background noise and highlight signals that indicate potential leaks.

Integrating noise loggers into water distribution networks supports real-time monitoring and early intervention, which are crucial for minimizing water losses, reducing repair costs, and extending the life of the infrastructure. This study focuses on evaluating the performance of noise recording technology in a real-world environment. Key objectives include optimizing logger placement to ensure comprehensive network coverage, improving detection accuracy through correlation techniques, and integrating findings into existing network management frameworks.

Preliminary field results indicate that loggers significantly reduce detection time compared to conventional leak detection methods, especially in areas characterized by low pressure fluctuations. This pilot project highlights the potential of loggers as a scalable and cost-effective solution for improving water network efficiency and promoting sustainable water resource management.[3]

2. Experimental

2.1. Sensors deployment in the field and results

On December 19, 2024, the Petrouzinex team proceeded to install 10 ORTOMAT noise loggers from VonROLL.

The area chosen to install the loggers was in the Maratei District of Piatra Neamt, an area with water distribution networks between DN 100 mm steel and DN 160 mm HDPE and mainline networks with DN 300 mm steel pipe.

The installation involves placing the sensor in valve or branch chambers (Fig. 1), and the antenna on the cover of this chamber to have a signal to transmit the GSM data collected during the night. The devices have a robust housing with IP68 protection and are therefore designed for the most unfavorable operating conditions.

Fig. 1 ORTOMAT logger

It is important that they are installed on the same type of network and as close as possible to each other to achieve optimal auto-correlation, also respecting installation techniques (cleaning the pipe so that the propagation frequencies remain consistent).[4]

In Fig. 2 we have a map with the location of the sensors, from the application called Infraport, an online application that manages noise loggers as well as other devices sold by VonROLL such as hydrants, presence sensors, etc.

Fig. 2. Overview of the area

After a period of 3 days in which the noise loggers “read” the noise data from the pipeline, they started to generate reports on the measurement results.

Thus, loggers 1 and 2 (Fig. 3 and Fig 4), which were placed on MarateiStreet in two valve chambers, recorded high noise levels.

The suggestion of the VonROLL team was to check the area of these two loggers, with the detection equipment, which was immediately

Fig. 3. Data from Pos. 1 logger

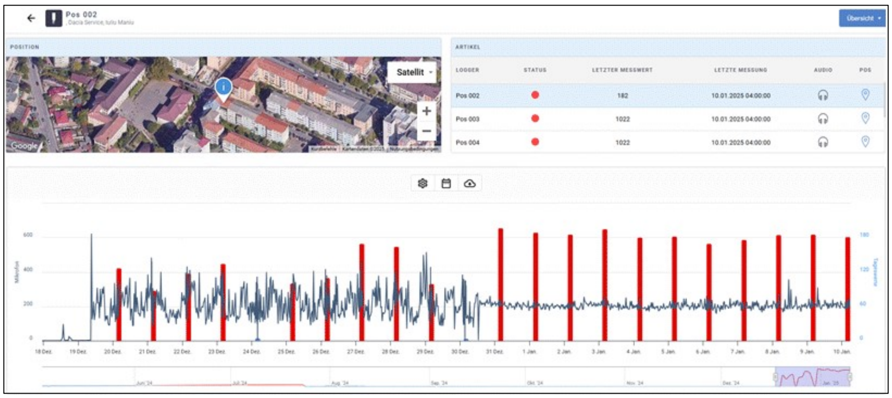

Fig. 4. Data from Pos. 2 logger

done in the following days, identifying the two valves in the two chambers where the sensors were mounted, they were in the half-open position. For the positions of the loggers 3, 4 and 9 there is also a high noise level and the suggestion was also to also check these 2 locations, the sensors being mounted on Strada Lamaitei in Piatra Neamt (Fig. 5, 6, 7).

As a result of field checks, a damage was discovered (Fig.8) in the valve chamber where the logger in position 3 was mounted (Fig. 8).

The next problems identified were at logger positions five and ten (Fig. 9 and 10), located in the valve chambers on Biruintei Street.

By querying the Infraport application and the autocorrelation report, another large-scale damage was approximately identified and confirmed in the field (Fig. 11).

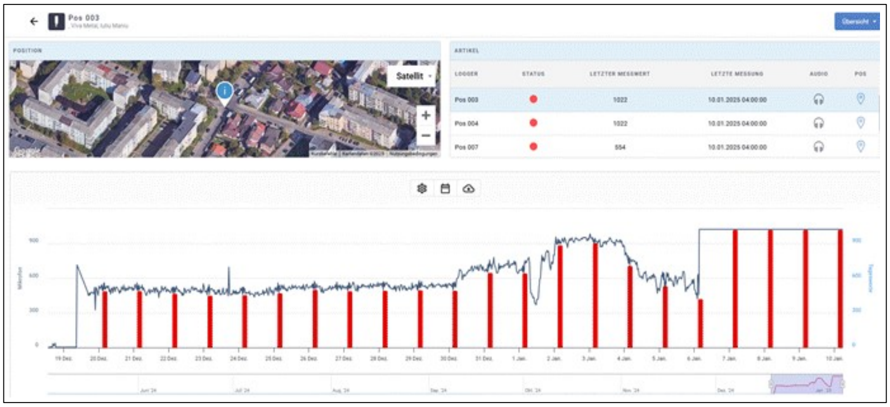

Fig. 5. Data from Pos. 3

Fig. 6. Data from Pos 4

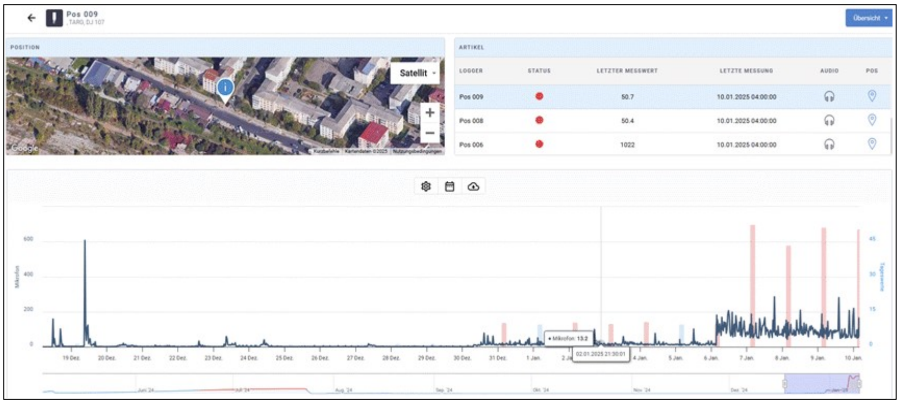

Fig. 7. Data from Pos. 9

Fig. 8. Water loss in Pos. 3

Fig. 9. Data from Pos. 5

Fig.10. Data from Pos. 10

Fig. 11. Correlation data of the water loss

The data from positions 6 and 7 (Fig. 12 and Fig. 13) where the loggers were installed on Dimitrie Leonida Street, revealed the presence of another damage on the water pipe, confirmed both in the field, using equipment (such as GPR, to scan for possible underground anomalies) [5] and through the correlation report issued by the platform (Fig. 14)

In the last two positions where the noise loggers were mounted, namely position 8 and position 9, no concrete data was provided, the noise level not being stable, meaning that no damage was identified (Fig. 15 and Fig. 16).

2.2. Analysis of the advantages and disadvantages of using VonRoll ORTOMAT logger noise sensors

Advantages

1. Ergonomic and optimized software interface for network management

The digital platform associated with VonRoll ORTOMAT equipment presents a high degree of intuitiveness in use, significantly facilitating the operations of positioning sensors on the digital map and tracing pipe networks, providing a virtual environment in which users can access a wide range of sensors.[6] Compared to other similar solutions available on the market, the application offers an improved user experience, reducing the complexity of the initial configuration process and contributing to increasing the accuracy in mapping the water supply system.

2. Increased operational reliability and efficiency in field data collection

VonRoll ORTOMAT sensors are designed to ensure reliable operation in various environmental conditions, offering significantly reduced data collection and transfer times.

Their placement directly on fittings or in inspection chambers allows for the rapid and accurate acquisition of acoustic data necessary for the identification of water losses. This feature effectively supports continuous monitoring and predictive maintenance activities of distribution networks.

Disadvantages

1. Limitations regarding the ergonomics of the installation process

The constructive configuration of the sensors, characterized by the physical separation of the microphone from the transmission unit and the antenna, interconnected by cables, generates additional impediments during the field installation stage.

This architecture requires additional time for assembly and requires increased attention in adapting to the specific geometry of each manhole or application point.

Optimizing the design by integrating the microphone and the transmission unit in a single housing would have simplified the assembly process and increased the ergonomics of use in the field.

Fig. 12. Data from Pos. 6

Fig. 13. Data from Pos. 7

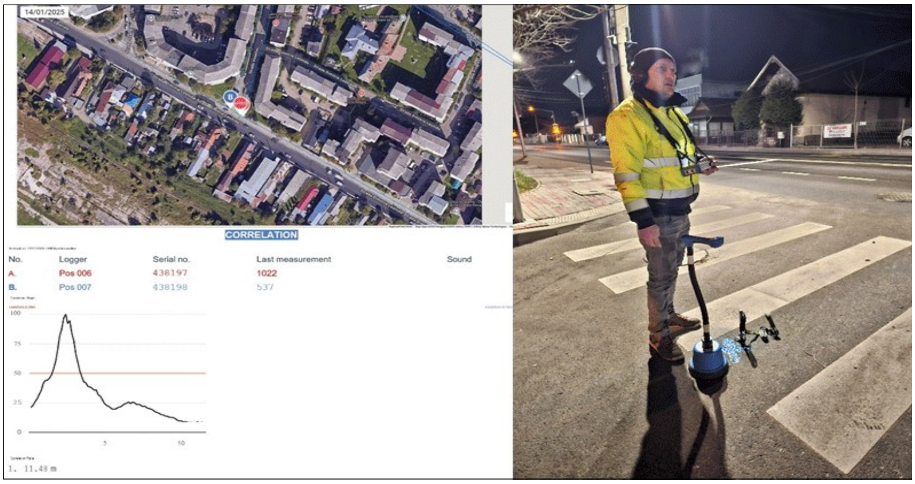

Fig. 14. Correlation data for pos. 6 and 7 and the confirmation

2. The need to manually reconfigure the communication frequency

In the context of relocating sensors to other geographical areas (e.g. between localities or regions with specific radio frequencies), manual adjustment of the FM transmission frequency is required to ensure compatibility with the local communications infrastructure.

Fig. 15. Data from the Pos. 8

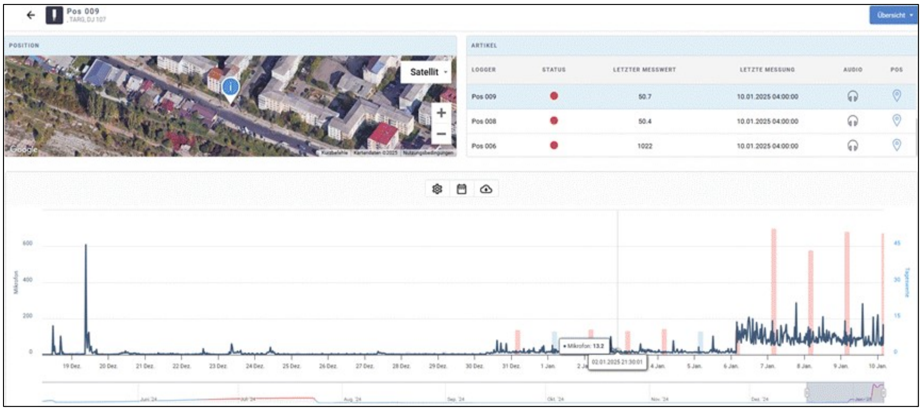

Fig. 16. Data from the Pos. 9

This additional requirement can extend the duration of reconfiguration operations. Implementing an automatic frequency adjustment solution, depending on the geographical location, could considerably improve the flexibility and operability of the system in the field.

Technical conclusion

VonRoll ORTOMAT logger noise sensors represent an efficient and reliable solution for monitoring water losses in distribution networks. They are distinguished by a powerful, robust software system and superior acoustic data collection capabilities in the field, contributing to increased operational efficiency and reduced leak detection time.

However, certain limitations related to installation ergonomics and the need to manually configure the communication frequency can negatively influence implementation times and the degree of operational flexibility.

3. Recommendations for optimization

1. Hardware design optimization.

It is recommended to develop an improved version of the sensors that integrates the microphone and the transmission unit into a single compact, sealed and ergonomic housing, to reduce assembly complexity and minimize field installation time.

2. Automating the frequency adjustment process

It is suggested to implement an automatic FM transmission frequency adjustment system, based on automatic identification of the geographical area or through a software self-configuration function. This functionality would help eliminate the risk of incorrect configuration and increase the mobility of sensors between different locations.

3. Field staff training

It is recommended to organize technical training sessions for personnel involved in the operation and installation of sensors, with an emphasis on the correct management of the constructive and operational particularities of VonRoll ORTOMAT equipment.

4. Conclusions

The study conducted in the Maratei District of Piatra Neam by installing 10 ORTOMAT noise loggers from VonROLL demonstrated the efficiency of modern technology in the early detection of water losses in distribution networks. The strategic placement of the loggers in valve chambers and branches, corroborated with the use of the Infraport platform for monitoring the collected data, allowed the rapid identification of acoustic anomalies specific to water leaks.

The data obtained after only three days of monitoring revealed several critical points where high noise levels were recorded, signaling possible malfunctions or losses.

Field checks confirmed these suspicions, with significant water damage being identified in the areas related to the loggers in positions 3, 5, 6, 7 and 10.

Cases were also observed in which the correlation of acoustic signals between several loggers allowed the localization of the sources of losses with greater precision.

Another important aspect is the confirmation of the reliability of the autocorrelation process performed by the Infraport platform, which provided consistent reports and considerably reduced the time required for the detection and localization of network failures. It is also worth mentioning that in some positions (8 and 9) no significant noise variations were recorded, indicating the absence of active faults.

In conclusion, the use of ORTOMAT noise loggers, together with advanced data analysis and subsequent field verifications, proved to be a valuable tool for optimizing the water loss management process.

The implementation of this technology contributed to the prompt identification of failures, preventing continued water waste and reducing operating costs associated with uncontrolled losses in the distribution network. The results obtained validate the applicability of the system in urban environments, representing a model of good practice for other similar areas.

References

1. Tugba Akdeniz, Cem Cakmak & I. Ethem Karadirek, 16 November 2024, *"A Case Study on Controlling Real Losses in Large-Scale Water Distribution Systems*";
2. B. Charalambous, D. Foufeas, N. Petroulias,Water Utility Journal 8: 25-30, 2014, *"Leak detection and water loss management*";
3. Crăciun I., Giurma I., Giurma-Handley C.-R., Boboc V., publicată în 2011 în Environmental Engineering and Management Journal "Evaluating the Climatic Changes in the Hydrological Flow Regime of the Moldavian Areas";
4. David A. Corelli, 2019 "How Sensor Mounting Significantly Affects Vibration Measurements";
5. Paper "Case studies on water leak detection using GPR" published in the Lost Water Detectives magazine November 2016 and presented at the International Water Association Regional Conference 2015;
6. Raluca-Georgiana Ion (Popa), Georgian Andrei, Stefania-Maria Armaselu, Decembrie 2023 International Cenference of Managemen and Industrial Engineering, "Study On The Use Of Digital Platforms".