Practical experiences in applying advanced solutions for calculation of frequency of intervention with Active Leakage Control: results obtained

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Keywords: Flow Monitoring, Pressure Management, Active Leakage Control

Abstract

Due to the activities of the Water Loss Task Force, Utilities are becoming increasingly encouraged to measure inflows to small distribution systems, and to split larger systems into Zones with measured inflows. Sometimes, pressure measurements will also be taken in the Zones.

However, in the experience of the Authors, there are two common problems. Firstly, new potential users are often discouraged by the high initial cost of permanent metering and data transmission, and concerns that the water loss management opportunities may not justify the high initial costs. Secondly, new users are usually unaware that pressure measurements at a few carefully selected locations, taken together with the flow data, allows rapid quantification of water loss management opportunities without the need for setting up detailed network analysis models.

The paper explains, step by step, the type of broad conclusions that can be obtained from occasional reliable measurements of Zone inflows with portable equipment, over several days at carefully selected times of year, without any pressure measurements. Then, the additional conclusions and predictions that can be obtained from pressure measurements at a few selected specific locations (Inlet Point, Critical Point, Average Zone Point) are described, together with a simple test to assess the relationship between pressure and leak flow rate for the Zone. The paper also describes a low cost data transfer from the measurement sites by e-mail to any chosen recipient, and a software that allows users to quickly identify opportunities for water loss management by pressure control and/or active leakage control at an economic frequency of intervention.

Introduction

Non-revenue water (NRW) is a common problem to all utilities all over the world. In Italy NRW levels range from 15-60% of total system input volumes, the average being 42% (ISTAT 2003). Some European countries – notably the United Kingdom and Malta – have fully sectorised distribution networks, with continuous night flow measurements, and frequent interventions to locate unreported leaks. In Italy however, the majority of water utilities only repair 'reported' leaks, and do not practice any regular form of active leakage control or pressure management, except perhaps as an emergency response during droughts.

Minimisation of losses in the network is a key requirement, in particular in those countries where the water loss levels are very high.

The starting point

In an effort to better manage water loss from the networks, regulators are looking at new legislative measures to require water utilities to report their water loss. With these moves underway, there is an urgent need for water managers to gather information and to use tools for implementing such requirements.

Lack of information regarding the advantages and economic benefits, of a correct approach to water loss management using the most up to date concepts, technologies and software, often represents a barrier for the Utilities managers and delays necessary actions.

For this reason it is important to:

- Increase water utilities' awareness of the operational and economic benefits of improved pressure management to reduce new burst frequencies and leak flow rates;
- Disseminate the practical approach developed by the IWA Water Loss Task Force to a wide number of potential end-users, to encourage and motivate;
- Communicate and transfer available methodologies and innovative technologies for efficient water loss management, allowing end-users to make contact with each other and exchange ideas and experiences;
- Assist water utilities to identify both short and long term economic investment policies, using practical methodologies and accurate measuring instruments.

Economic Frequency of Active Leakage Control

A stated key objective of the present Water Loss Task Force (Liemberger and Farley, 2004) is 'to develop a quick and practical method for calculating economic intervention (for active leakage control to locate unreported leaks and bursts), and short-run economic leakage level (SRELL).

Clearly, there is little point in attempting to calculate, or to achieve, an economic level or real losses for a particular system, unless the Utility commits to undertaking (to an appropriate extend) all four components of real losses management (Speed and Quality Repairs, Pressure Management, Active Leakage Control and Rehabilitation). (Figure 1.1).

Pending the development of a method for calculating economic leakage levels, a practical approach successfully used by Utilities such as Malta Water Service Corporation and Halifax Regional Water Council (Canada) has been introduced to identify and implement a mixture of initiatives within the 4 components that individually have the highest benefit: cost ratio or shortest payback period. When no further economically viable initiatives can be identified, it can be reasonably assumed that an economic leakage level has been achieved – although it must be recognised that the economic leakage level will change with time.

Using assumption similar to economic stock control theory, Fantozzi and Lambert (2005) showed that, for a basic active leakage control policy based on regular survey, the economic frequency of intervention occurs when the cost of a 'full system' intervention (excluding repairs costs) equals the value of the unreported leakage volume. Thus the economic period between interventions (Te in days) and the necessary operational budget can be calculated accordingly.

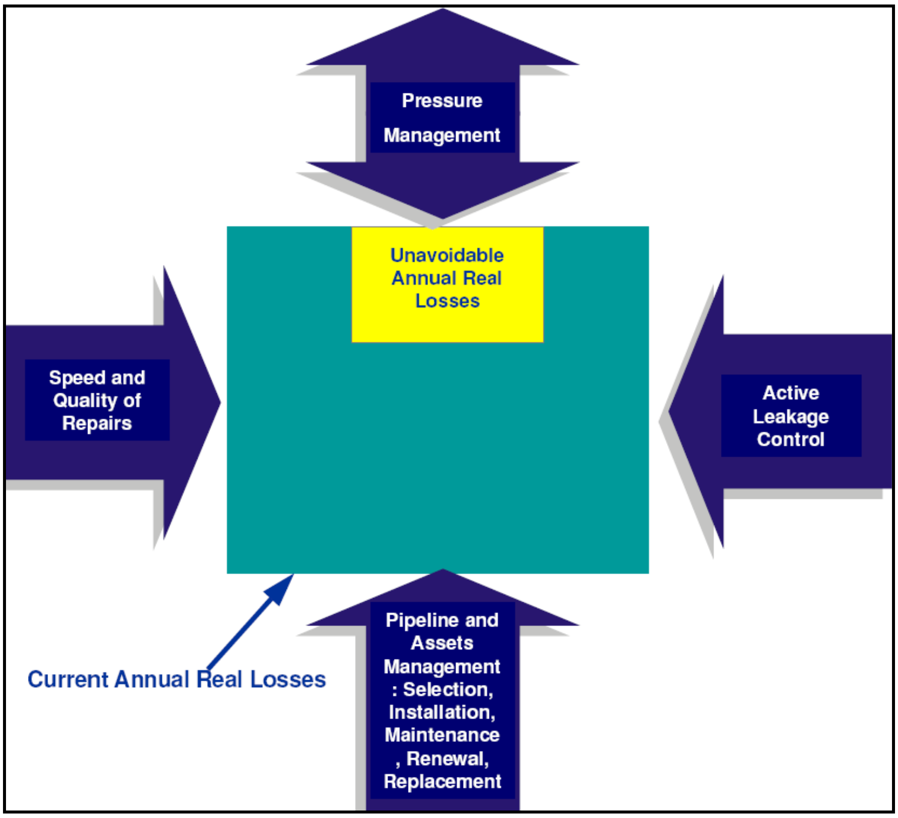

Figure 1.1 The Four Components Approach to Management of Real Losses.

A case study

This case study relates to a small system in Northern Italy with 1300 service connections, 23,2 Km of mains and with no permanent inflow metering (Fantozzi et Lambert 2006).

The following description clearly demonstrates that through the practical application of advanced methodologies and the use of the newest instrumentation for the acquisition and transmission of data from the field, 'hidden' leakage problems can be quickly identified and a significant improvement in the efficiency of this distribution system can be rapidly achieved. It is hoped that this case study will encourage Utilities in other countries to improve their performances using a similar quick, effective and low-cost approach.

Figure 2.1 shows the Montirone network and chosen specific monitoring points where temporary flow meters and pressure gauges were placed.

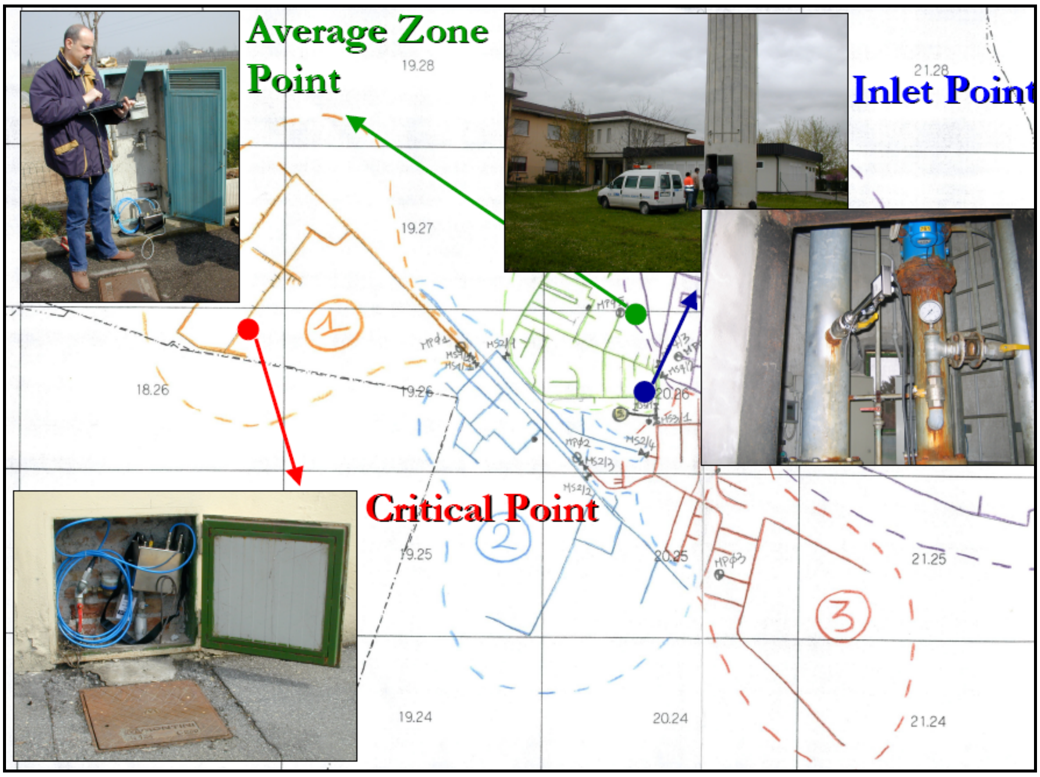

Figure 2.1 Montirone network and monitoring points.

Advantages of the technology used

In order to provide the user with a reliable analysis, data coming from the field must be of adequate accuracy for the purpose.

Different kind of flow-meters can be used, each of them characterised by different accuracy class and prices. The following are the components used:

- 1 battery powered electromagnetic flow-meter made of an insertion probe and a converter with an integrated Data logger for collecting data of flow and pressure and equipped with an internal GPRS module, which allow the sending of data wireless through e-mail directly to a remote personal computer. This mag-meter was installed at the Inlet Point (Figure 2.2);
- 2 battery powered electromagnetic converters coupled with 2 pressure transducers. Pressure data are sent by the converters through their internal GPRS modems. These 2 instruments must be installed at the Average Zone Point and Critical Point;
- the software Flowiz_Interface_Service able to extract the data excel files attached to the incoming e-mails and organise them into different folders identified by the instrument serial numbers;
- the Flowiz_Interface software, to present field data as tables and graphs, and identify the key parameters for the following economic intervention analysis (Figure 2.3);
- the WIZCalcs software, which uses occasional night flow measurements collected by the field instruments to decide when it is economic to perform a leak detection exercise. WIZCalcs uses the calculation methods described in Fantozzi & Lambert (2005) and Lambert & Lalonde (2005).

Figure 2.2 Electromagnetic flow-meter with GPRS modem and insertion probe.

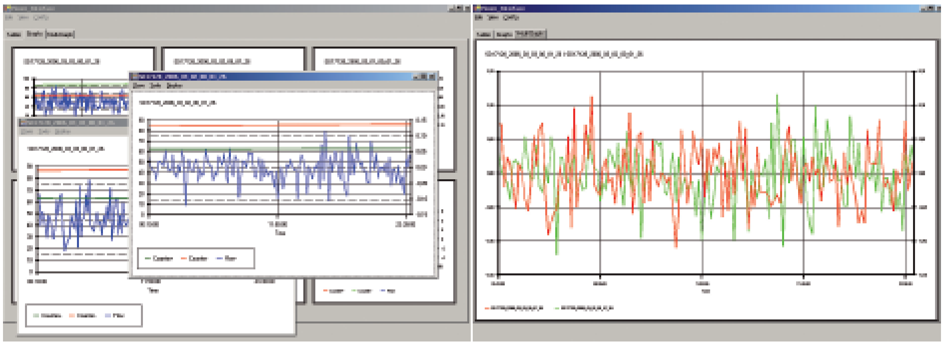

Figure 2.3 Example of graphs elaboration with the Flowiz_Interface.

The choice of using electromagnetic flow-meters reflects the high number of advantages provided by such equipment:

- High reliability granted by the absence of any mechanical moving part inside the instruments which avoids possible wear and tear;
- High accuracy also at low flow rates, essential for the reliable measurements of minimum flows.
- No significant pressure head losses, due to the absence of moving parts and absence of restriction within the pipe.

New features which have been integrated in these instruments have further increased their advantages:

- Pressure transducers with measurements driven, stored and elaborated directly by the instrument;
- Integrated Data Loggers collecting flow and pressure information at different selected sampling rates;
- GPRS Wireless communication protocol, enabling the transmission of data from remote sites directly to an e-mail account with no need of manual data collection by the users at sites where the instruments are installed.

Finally, also what was previously considered the highest limitations of the use of mag-meters in the water market has been overcome: battery power supply grants the independence of the instruments wherever it is installed.

But perhaps the real key factor in optimising this procedure in terms of savings of time and money is the way data are managed and analysed as an integrated part of the process.

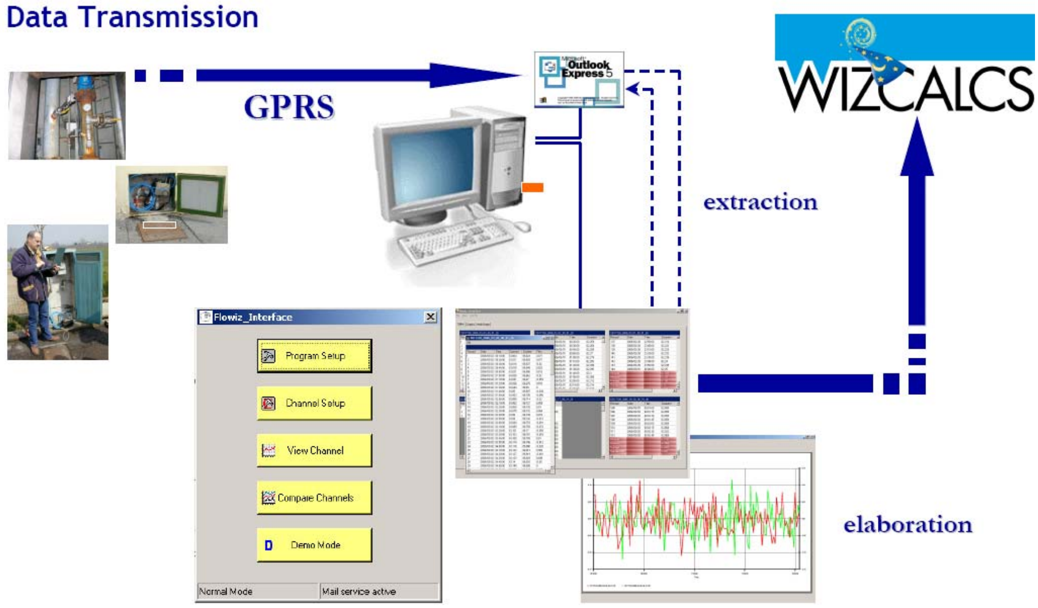

Figure 2.4 System data path.

Figure 2.4 shows the path followed by data from acquisition on site up to their loading in the final WIZCalcs software. The equipment is installed at the three specific locations (Inlet, Critical And Average Zone Points), collecting data of pressure (all three) and flow (only at the Inlet Point). Data are collected in the integrated Data Logger inside each instrument and finally sent to an e-mail address directly by the internal modem once a day.

The direct sending of data without any intermediate stage (i.e. pulses transmission to an external logger and subsequent flow rate derivation and transmission) guarantees the conservation of the flow-meter accuracy with no introduction of additional errors.

The GPRS (General Packet Radio System) protocol represents a very efficient way of transmitting data. Using a Packet commutation system, the GPRS collects data in packets made of sender address, information and receiver address. Once the packet has been sent through the net, there's no possibility of losing the information.

The e-mails contain a CSV format file (Comma Separated Value), which is automatically downloadable in any editing software, e.g. Excel). Each record represents a complete acquisition of data (Date, Time, Positive and Negative Totalizers, Flow rate, Velocity and Pressure).

Speed in sending data (Kb/sec.) is very high, thanks to the use of best available communication channels in the network and to the optimisation of the net itself (data being collected in packets with reference to sender and receiver, with the network free to organise according to the current traffic conditions)

Cost for the user are low, as they are based on the actual amount of sent data and not on the connection time.

The software implementation developed for this application starts with the extraction of the data files from the e-mail account. All files coming from the same instrument during the period of measurements (typically 3 to 4 days) are collected in the same folder, automatically created by the software inside a chosen directory. Once the data are in the folder, the software allows the visualisation and elaboration of the same through tables and graphs, for single instruments or by comparison of several, for one single measure (i.e. flow) or with both flow and pressure values in the same sheet.

It is also worth mentioning that the kit of instruments above described, consisting of converters, pressure transducers and insertion sensor, has the advantage of being completely portable and usable many times in different locations to monitor a number of DMAs or water networks.

The total cost of the intervention, which comprehends the whole equipment to perform the analysis, the installation and the software for the evaluation of the Economic Intervention Frequency, is typically lower than 10.000,00 Euros.

Data analysis

Figure 2.5 shows the best achieved Minimum Night Flow after an active leakage control intervention done in 2003 and recent Minimum Night Flow in April 2006. It is possible to see that, without any further active leakage control since 2003, the night flow in the distribution system gradually increased with time, because of ‘unreported’ leaks and bursts, even though all ‘reported’ leaks and bursts have been promptly repaired. The actual night flow is checked against estimates of customer night use and background leakage, to calculate potentially recoverable losses.

The average rate of rise that occurred is system-specific, being influenced by several local factors. And, for reliable results in WIZCalcs, the occasional night flow measurements must be taken at times of year when industrial and irrigation use at night is considered to be minimal (typically early spring and late autumn)

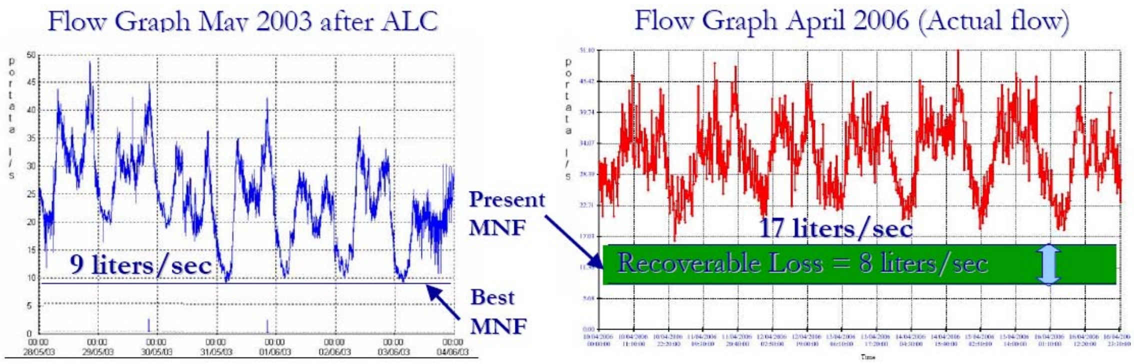

Figure 2.5 Comparison of night flows.

Figure 2.6 shows the results obtained from the WIZCalcs software. The applied method, presented in this paper, requires only three parameters:

- the average rate of rise of unreported leaks;
- the variable cost of water;
- the cost of intervention.

These are enough to determine the Economic Intervention Frequency with an Active Leakage Control, the Annual Budget for Intervention and the Economic Volume of Unreported Leaks.

In Montirone the calculated rate of rise of unreported leaks is very high and the previous intervention with active leakage control was 34 months before, WIZCalcs quickly shows that an intervention was overdue in April 2006. The annual budget for intervention and the economic volume of unreported leaks have also been calculated and reported in Figure 2.6.

Data entry	Calculated values	Data from another Worksheet		
Utility	Anytown	Country	Italy	Conf. limits+/-
System	Montirone	Currency	Euro	
Length of mains	23,2	km		1,0%
Number of service connections	1300			2,0%
Natural Rate of Rise of unreported leakage RR	232	m^3/day in a year		20,0%
	178,8	litres/conn/day per year		
	10,0	m^3/km mains/day/year		
This is categorised as being	Very High			
Variable cost of water CV	0,114	Euro/m3		10,0%
Full system intervention cost CI	5000	Euro		5,0%
Economic Intervention every	12	months		2
LAST INTERVENTION WAS	34,5	MONTHS AGO. AN INTERVENTION IS OVERDUE		
Annual Budget for Intervention	4,9	Thousand Euro		0,8
Economic Unreported Leakage	43	Thousand m^3/year		7
	91	litres/service conn./day		15
	5,09	m^3/km of mains/day		0,83

Figure 2.6 WIZCalcs software applied in Montirone.

Conclusions

Conclusions of this paper are the following:

- Starting a strategy in water loss control and in Active Leakage Control need not be expensive, or require permanent installations
- data collection from the field, to analysis and management decisions, can be completed in a matter of just a few days, and the equipment can then be moved to other sites
- the economical frequency of intervention, specific to each part of the network, can be quickly identified with little investment of time and instrumentation;
- flow and pressure values have to be considered together in order to reliably identify appropriate actions
- the data collected for economic intervention can be used off-line with another software (PreMOCalcs) to identify pressure management options , and predict benefits and payback periods for different types of pressure management
- the data transmission system explained in this paper is an optimum solution to manage network data: GPRS wireless transmission is safe, quick and low cost.

Acknowledgements

Grateful acknowledgements are made to Utilities that provided data for this article.

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