WATER LOSS DETECTIVES

Included :

Water detectives

Water detectives diary wants to be a dedicated profile publication for all those interested in water loss detection. Each water loss team detection has a diary to register defects that has been found, identified noises and the most important the problems they faced.

Water loss detection activity was compare with an Indian listening the earth, with a doctor listening the water network pulse but also with a detective investigating water loss out of network---in antique Rome they were known as water commissaries .

All persons involved in systematic water loss detection must be well trained so the team can reach maximum efficiency in water loss detection.

This publication wants to offer to all are interested in the topic information related to water loss detection processes, news, studies, theories, equipment presentation, field experience and other articles dedicated to this topic.

This project is a follow up of the project launched in 2010 when the forum

http://pierderiapa.forumactual.com/f10-english-water-detection

This forum was created to present problems and solutions that are met in water loss detection activity and also to become a way of experience change between water operators .

As much as we share from our experience the best for the ones that cares! This way I would like to keep a vivid dialog, to be informed all the time and be open when listening other points of view. Learn others and from others instead of being in competition ! Each debate is a winning – SO BE A WINNER !

Thank you to all that sent articles for this edition and I invite you to make improvement proposals for the next editions.
I accept your critics and your suggestions and I hope you will find at least one useful article.
Enjoy your reading .

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WWW.PIERDERIAPA.FORUMACTUAL.COM

INTRODUCTION

Historical aspects

Water loss in distribution systems was important since antiquity.

An American science man opinion was that the Queen of Sheba could stop the fall of her empire if she would accorded more attention and invested more money in the existing water distribution and irrigation system. In antic Rome, as part of water culture, a great attention was accorded to water system maintenance. Aqueduct administrator surveyed water springs, basins and conduits with 700 people designated for this activity. As described most of the time they detected hidden leaks using hard would steaks to detect noise of the water loss.

Sextus Julius Frontinus (ca. 40–103 AD) was one of the most distinguished Roman aristocrats of the late 1st century AD, but is best known as an author of technical treatises, especially one dealing with the aqueducts of Rome- *De Aquis Urbis Romae* or *De Aqueductibus* In 95 he was appointed Water Commissioner of the aqueducts (*curator aquarum*) at Rome by the emperor Nerva, his work presents a history and description of the water-supply of Rome, including the laws relating to its use and maintenance, the first official report of an investigation about engineering works ever to have been published. In this report explains how he prepared maps of the system so that he could assess their condition before undertaking their maintenance. He says that many had been neglected and were not working at their full capacity. He was especially concerned by diversion of the supply by unscrupulous farmers and tradesmen using illegal connections. He therefore made a meticulous survey of the intake and the supply of each line, and then investigated the discrepancies. He made a meticulous overview of water supply and than studied the apparent anomalies. His evaluation was based on conduit or tub section and did not considered water velocity.

In UK Margaret Thatcher - Iron Lady in the 90`s privatised the water companies and the company that won the distribution had the main objective to decrees the water loss, established by OFWAT regulating authority. District meetings were organised to inform the people about the importance of useless water consumption and water loss. That was the time when water detectors or so called `loss inspectors` appeared, they made regular inspections at consumers connections and taps listening with a metal rod the noise of a water damage. This operation is based on the fact that any water loss make a noise that indicates a damage.

To locate the water loss it is used the noise produced by the water that bursts with pressure throw the break. The water generate acoustic waves and are cared away by water and pipes wall in both directions. The essential condition for water loss detection is the water pipe material to be able to transmit vibration. For metal pipes in normal conditions there are no problems. Contrary non metallic pipes are inert to sounds and very week sound transmitters. The sound are weaker farther we go from the source.At a moment it reaches the point that the sound waves in the water did not touch the material and practically the water loss noise is undetectable. Other factors with influence or interfere with the noise produced by the water flow are soil quality and density, the depth and and material of the pipe, water pressure, traffic, wind or water usage noise. This are the reasons for not be possible to predict the distance of the detectable noise of a leak.

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World Water Day

On 22 March 2011 we celebrate "World Water Day", which, this year, has chosen the motto "Water responding to the challenge of urban cities." On this occasion, as at other times, are scheduled a series of actions designed to inform and educate the general public, youth in particular, on water issues. The official website is www.worldwaterday2011.org.

This year's theme "Water for Cities: Responding to the Urban Challenge" aims to bring public attention and encourage governments, organizations and local communities to become actively involved in finding solutions for efficient water management in urban areas.

World Water Day is celebrated worldwide since 1992. The United Nations Conference on environment in Rio de Janeiro, was adopted on 22 December 1992 decision by March 22 World Water Day grew. It proved to be a good opportunity to remind everyone how important are efforts to provide concrete for pure drinking water and identifying problems and finding solutions to these problems.

"More people die from unsafe water than from the root of all forms of violence, including war. These deaths are an affront to our humanity and undermines. The efforts of many countries to achieve its development potential "is the message of the General-Secretary of the World Water Day this year, with the theme: "Clean water for a healthy world".

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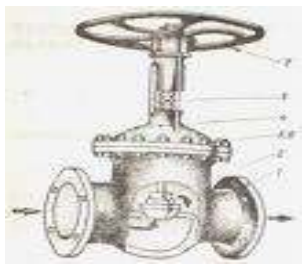
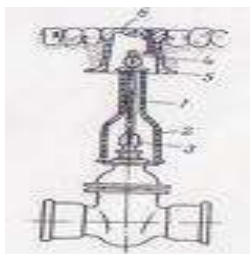
The importance of valve operation

The main condition for a proper functioning of the network is valves functioning (gate valves, hydrants, main valves, emptied valves).



In case of failure on the network if a faulty valve closing, more consumers are affected, increase uptime, so the amount of water is lost and the damage increase itself.
If the valves separating areas of complete closure pressure is very important because leaks can cause serious problems in the operation system and lead to energy losses. In the areas with low pressure may cause problems due to increased pressure on internal and external network.
To make measurements in both the loss detection when measured night flows and fault location using acoustic correlator or any other method is necessary that the operating state of the valves to be perfect.
If increased flow is constant means a failure occurs. The evaluation results should be taken into account the possibility of a new consumer of such a new plant or irrigation system. The location of the leaks involves a series of new measurements. Results can be checked after a fault correction.
If the area is too large, the system will not signal the emergence smallest leaks.
Correlator will indicate where the leak is or locate the damaged valve. The sound produced by the damaged valve is usually stronger than the fragment.



Flow measurements can not be performed if the valve does not close perfectly measuring point and valve defects involves dividing the measured sections. The valve malfunction makes it impossible to conduct zoning measurement.
Analysis of water losses is based on detection of "zero consumption" - or minimum consumption. The flow of water that flows through that portion of consumption in network provides real information only if the valves are fully closed.

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Utilizarea aparatelor pentru depistarea pierderilor de apă la temperaturi scăzute

Este binecunoscut faptul că perioada de iarnă este de departe cea mai grea perioadă din an atat pentru cei care se ocupă cu detectarea pierderilor ascunse, dar mai ales pentru cei care se ocupă cu repararea lor, atat din cauza condițiilor foarte grele de lucru, cat şi pentru faptul că în această perioadă se produc foarte multe defecțiuni.
Diferențele mari de temperatură dintre conducta, care este influențată direct de solul înghețat si apa care circulă, a cărei temperatură este întotdeauna pozitivă, fac ca iarna materialul îmbătranit al conductei să nu reziste la contracțiile generate în aceste situații şi să se fisureze atat transversal cat şi longitudinal. În perioadele de ger, cand solul este înghețat, uneori chiar la peste la 1 m adancime, apa provenită din defecțiuni nu iese în locul în care s-a fisurat conducta şi de foarte multe ori iese la suprafață la o oarecare distanță, sau se infiltrează în canalizații telefonice, termice, canalizări pluviale sau menajere ori în subsolul unor clădiri.
În toate aceste cazuri stabilirea locului unde se afla pierderea intra în sarcina echipelor de detectare pierderi ascunse.
În marea lor majoritate aparatele specifice (corelatoare şi detectoare acustice) au trecute în specificațiile tehnice la capitolul temperaturi de depozitare valori între –40 si +60oC, iar la temperaturi de lucru valori cuprinse, în general între –20 si +40oC.
Referitor la acest aspect este binecunoscut faptul că iarna, alături de valoarea intrinsecă a temperaturii, care este masurată în stațiile meteo în anumite condiții, se adaugă şi alți factori care poate influența uneori substanțial valorile reale la care aceasta este resimțită în mediul ambiant. Nu de puține ori citim în buletinele meteo informatii de genul ‘’temp. exterioara –6oC resimțită ca –10oC’’ din cauza vantului, a curenților de aer, etc. Iată deci că temperatura reală la locul de lucru poate fi mult mai coborată decat cea comunicată de stațiile meteo. Toate echipamentele au în general informațiile afişate pe un display cu cristale lichide, cristale care nu mai lucrează la temperaturi sub o anumita valoare, în general –25oC, sau uneori chiar la valori ceva mai ridicate decata aceasta. Sigur că în aceste situații cei de la intervenție au mare nevoie de ajutorul celor de la detectări pierderi ascunse si trebuie găsite soluții pentru a putea folosi aparatele din dotare chiar în aceste condiții.
În ce priveşte corelatorul, pentru ca acesta să fie funcțional pe timp de iarnă este bine ca pe timpul nopții să nu îl lăsăm în maşină, cu excepția situației în care maşina stă într-un garaj încălzit, de fapt lucru valabil pentru toate aparatele electronice care au display cu cristale lichide. Astfel, echipamentele vor putea fi folosite catva timp pana cand vor ajunge la aceeaşi temperatură cu mediul ambiant. La locul de lucru vom căuta să protejăm cumva aparatele ținandu-le în incinta încalzită a maşinii pană la momentul utilizării lor. Emițătorii pot funcționa fără probleme la temperaturi scăzute; dacă este totuşi foarte frig ei se pot lăsa chiar în căminul de armătură, aproape de locul unde este amplasat senzorul piezo, unde temperatura este oricum mai ridicată decat afară, ştiind că emisia radio, cel putin la produsele Seba KMT, este digitală şi semnalul se (autolaboratorului), semnalul radio receptionandu-se în condiții foarte bune cu condiția ca maşina să fie amplasată undeva între cei doi senzori-emițători.
S-a pus problema rezistenței cablurilor la temperaturi scăzute. Este adevărat că la modelele vechi, fabricate pană în anii 1999 -2002 materialele plastice folosite la izolarea cablurilor de la senzori deveneau

rigide la temperaturi foarte scăzute (asta era tehnologia la vreme aceea), dar în momentul actual nu ne mai confruntăm cu astfel de probleme deoarece tehnica mondială în domeniul materialelor izolatoare a progresat enorm, noile cabluri dintre senzor şi emițător fiind mult mai fiabile atat la capitolul rezistență fizică dar şi în ceea ce priveşte comportamentul la temperaturi extreme.
Cablurile dintre senzoruI piezo şi emițători, cel putin la noul model de corelator produs de Seba KMT, Corelux P2 sunt de o calitate deosebita şi nu au nici un fel de problemă la exploatarea pe timp de iarnă pastrandu-şi atat maleabilitatea cat şi rezistența la tracțiune.

Este cunoscut de asemenea faptul că în anotimpul rece acumulatorii se consumă mai repede şi trebuie avut grijă ca încarcarea acestora să fie făcută corect, iar în cazul în care lucrăm cu baterii, acestea să fie alcaline, de cea mai bună calitate.

În ce priveşte locatorul acustic vă pot spune din proprie experiență că am lucrat de multe ori cu detectoarele Hydrolux HL 4000 sau HL 5000 şi cristalele lichide ale displaylui nu au avut problele chiar la –20oC, aşa cum recomandă şi caseta tehnică a manualului.

Apropo de manual şi de specificațiile tehnice inserate în acesta, imi permit să fac cateva referiri pentru a evita anumite neajunsuri semnalate de-a lungul timpului.
Înainte de a utiliza orice echipament este bine să citim şi să ne însuşim temeinic manualul de utilizare, să respectăm condițiile de lucru, să cunoaştem performanțele din specificațiile tehnice, să luăm din surse autorizate toate informațiile despre teoria şi practica utilizării lui, realizand în permanență că rezultatele lucrului cu oricare produs de acest timp depind nu numai de performantele aparatului ci şi de experiența utilizatorului. Determinările făcute pot fi de asemenea influențate de factori aleatorii, de condiții particulare care fac uneori dificil, alteori chiar imposibil de folosit echipamentele respective.
În mod particular, pentru aparatele SebaKMT vă stau oricand la dispoziție pentru a lămuri eventualele probleme apărute în exploatarea acestora.

SEBA KMT •
Internet: www.sebakmt.com

First romanian competition on water loss detection organized on Mr. Vasile Ciomos's proposal on September 28-30, 2008

Satu Mare had the honor to be first romanian city that hosted water loss detection competition. How did it happed?

I was in Sibiu, attending a water loss detection workshop held by Andy Bowden, England, when together with the President of ARA, Ciomos Vasile, we started this project that seems to have had a great success, being probably the only project in Europe on this topic.

Mr. Ciomos, always receptive to new ideas, proposed the organization of this contest in Satu Mare under his direct sponsoring, attending every edition.

Mr. Andy Bowded was excited by this proposal, honoring us with his presence in the jury together with:

dl. Prof. MĂNESCU ALEXANDRU preşedinte CPPDA
ANDY BOWDEN consultat FOPIP I din England -UK
RICHARD NOAKES consultant FOPIP II din England- UK

Considering that no one has dealt with such a competition before, we were afraid of not getting fit in time to travel to the three proposed defects, reason for which the first edition had a small number of crews: 6 crews at the beginning and finally other three crews joined, the winner team from Timisoara was part of this last wave.

Important companies have participated like:

S.C. Compania Aquaserv Mureş
S.C. Compania de apă Someş S.A. Cluj
S.C Apa Nova S.A. Bucureşti
S.C. Apa-Canal Sibiu
S.C. Aquatim S.A. Timişoara
S.C. Apa-Canal 2000 S.A. Argeş
Apa Vital Iaşi
Compania de apă Braşov
Apa Buzău

The contest was developed in two workshops:

1. - practical test for detecting three burglaries
2. - presenting the strategies for loss reduction

The last day of the competition was focused on discussions with the manufacturer of the detection equipment and the presentation of technologies and equipments in this field.

There was a real burglary and a nonexistent one (in order to test the vigilance of the competitors) and an error due to a thermal channel.

The presentations of the strategies were special, each member team having the possibility to learn something one from the other.

As observers at this competition have participated some representatives of companies that wanted to acquire auto-laboratory and to make their own strategies.

We are sure that all the participants were winners both literally and figuratively leaving the competition with some gained experience, with the cup and a bottle of "Water from Satu Mare (Pălincă).

Finally I would like to wish this competition a long life and to have an increasing number of participants on the following editions.

ing. Sava Gheorghe

S.C. Apaserv Satu Mare
Director Tehnic
România

2008 AQUATIM TIMIŞOARA

2009 SECOM DR.TR.SEVERIN

2010 ACVARIM RM.VÂLCEA

Detecting atypical water losses methods

Infrared measuring method

Soil moisture is at fault and the surface temperature will be different from the ambient soil temperature.

Measurement method with infrared is a modern technique version of what was once only achieved through practical experience observing masters in water. A part of working is a regular monitoring network places after melting snow and unpaved areas on dense vegetation in May.

With high sensitivity a thermal camera can determine the lowest surface temperature variations occurring. Area showing the greatest difference in temperature location for failure.

Infrared measurement method is better to make the night as the sun heated surfaces, those remaining in the shadows can influence the evaluation.

The method can be applied successfully in central heating, but also for drinking water, primarily for transmission pipelines.

Air pressure method

In fact this method falls among acoustic methods, but rare due to their application are discussed in other ways.

The air that escapes from damaged pipe damage has higher pressure than water, producing a characteristic sound, and therefore, when other solutions are insufficient to fill the pipeline with compressed air, and then use interception method.

This method is most often combined with others.

Compressed air is introduced into the pipe and is detected using acoustic devices by tapping out the sound of the air-water mixture.

Tracer gas method

This method is applied by complete emptying and filling the pipeline with a gas tracking the pressure pipe section, where the fault is isolated and non-parties seeking to penetrate the soil gas using appliances, so instead of looking for fault.

Gas sensors are very sensitive: they are useful to demonstrate even a uniform distribution of a quantity of 3-5 cm of gas in one m3 of air. The gas used does not enter into the composition of the atmosphere, and is consistent in terms of taste, smell and health requirements. Such gases are helium-air mixtures, methane, argon, etc..

Gas tracking technology is used in critical cases, serious and very useful for determining small losses, such as when the previous method failed.

The method is applied successfully for years without a pavement surface with an efficiency of 100%.

The disadvantage of this method is the expense, and that its implementation should be decommissioned, this section should be emptied and sometimes dry. The large diameter gas costs are very high.

Isotope method

In this case the radioactive isotope is inserted in the pipe, which can be detected in the water that comes out of the damaged areas. It is a method rarely applied.

Ground Radar

This method is used primarily for detecting structures, pipes, pipe damage determination is possible,only if due to deterioration in soil cavities were formed.

Piston air press method

This method is applied by selling the two ends of the damaged section of pipe is placed in inflatable pistons, which are pressed on the pipe wall so as not to allow water passage.

Perform a pressure between the two fixed piston, which is repeated on all portions shorter pistons pushing until the smallest distance is obtained to repair the fault.

The method can use up to 150 m within the duct, where the bar is used with glass or pipe cleaning aid channels.

This is the only method that can be applied in case of pipe sections where it is impossible to locate the pipe and the defect (for example due to the laying depth of several meters).

The disadvantage is a high cost, complexity method and time consuming that the pipeline should be decommissioned, and the results are questionable. In the case of deposits on the inner walls of the pipe, it can not be achieved on the inner surface of the pipe.

Observing Sound

It belongs to the category of acoustic methods, a method is still not often used, but in distribution.

The apparatus is a high sensitivity hydrophones usually mounted on hydrants, registrar with the sounds, the section of pipeline located in the nodes examined. Measurement period is programmable, it's best to measure the sound level during night minimum consumption and leak location is determined by statistical analysis of sounds.

Monitoring the network methods, based on quantitative measurements

The method, which relies on quantitative measurements of the water passing through the meter is applied to smaller networks with a single point of supply. Measure night minimum, and changes its growth shows that the minimum consumption value has changed due to certain causes. If this change is permanent, it means the emergence of a new failure, but may be a new consumer (a new plant or irrigation system, etc..).

The method of monitoring network based on quantitative measurements - for networks with multiple supply points (due to higher costs for training and operation of measurement points, and because of the complexity) will be applicable for a long time, most economic methods and being the most effective analysis of water losses and related acoustic methods.

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Some aspects concerning water supply system's water balance

It was accepted the IWA concept about water balance for the water supply systems; in this concept the water from the supply system is divided in two parts: water producing benefits and water producing no benefits also called - Non Revenue Water (NRW). Theoretically the problem is correctly formulated.

Looking into more detail at the water included in the NRW we could make a short discussion about it. It is possible to divide this quantity of water into four parts:

- Water physically lost, a real leakage,
- Water non-metered due to the meter accuracy or difficulties during the calculation operations etc;
- Water used but unmetered due to different reasons (accepted or not); realy is not a leakage,
- Water needed for the technological process (to clean some parts of the water treatment plant, to clean reservoirs or the network, etc).

Water is a good sold on the market to obtain money in order to ensure the process continuity. Each cubic meter is sold at a certain tariff. This tariff includes all costs needed to produce this water as well as investment and operation costs. The operations costs include the entire quantity of water needed to produce a final cubic meter of clean water to be sold on the market, which in more details it means:

- Water lost during transportation between intake and consumers,
- Water needed to clean the treatment plant parts,
- Extra water used (non repaired plumbing, water for gardens irrigation, for car washes etc); this extra water is forcing the supply system to manage extra quantities of water, hence to buy a extra quantities of water,
- More water that needs to be bought in order to cover the existing leakages in the system.

So finally we can ask, which is a real quantity of water who produce benefits?

The problem, is similar with the bread preparation process. To sell one kg of bread you need ingredients such as flour, water, salt etc. During the preparation process, a part of the flour remains on the vessels walls, on the baker's hands or is burn in the furnace. To produce exactly one kg of bread you need some extra flour. So the question becomes, is this lost flour producing a profit or not? If we would save this flour it would be a good thing, but we will not be able to produce more bread with it. Therefore, in the total cost of producing one kg of bread there will be some extra grams of flour that need to be accounted for. Hence, in the baking process benefits the lost flour is included. In the case of bread it is possible to change the store. The difference between water process and baking process is that if the bread is to expensive you could try to buy it from another store, while in the case of water you cannot since there is only one water supply network.

Water tariff is controlled by National Agency ANRSC (National Agency for Public Services Regulations) and local authorities (in charge of the quality and quantities of water delivered to population).

In conclusion, the consumers have to pay all expenses needed to produce something ,including drinking water.
The real problem is *which is the low limit of the leakage*?

To solve this problem it is possible to involve all people implicated in the water production, in the specific way:

- Inadequate quality of water on the source means an extra quantity of water to be treated; National Water Agency is in charge of controlling this quality,
- A wrong technological process in the treatment plant means more quantity of water will be needed to clean all objects (if a part of this water is not re-circulated; but recirculation means a complication of the treatment process),
- Poor pipe quality (old, poorly realized and managed, working at high pressure etc) will result in an important water leakage,
- Water that is used for unusual purposes force the distribution systems to deliver an extra quantity of water (who must be bought from the source, treated, transported using energy etc).

A lot of measures can be adopted to control the general factors who influence water balance. For us it is important to develop a general leakage control management and to quantify the measures needed to fix the discovered damages.

Each water supply system is an unique engineering construction, hence, it is normal to develop a different way to control the water leakage. To disseminate the results of this management is a good opportunity especially concerning the minimum values of NRW; formula adopted by IWA (function of length of branch and mean values of pressure) really is particular for each network. It is important to particularize specific values to estimate the real values of NRW.

The second aspect of the problem is connected with the evaluation cost of repairing the construction where the water is lost. A comparison between cost of water lost and repairing cost ensure a correct possibility to decide on a suitable solution: pay lost water or seal the leakage.

Another important aspect can be calculated with maximum attention; which is a more suitable solution: to measure very accurately the delivered water (using a lot of money to buy an expensive meter) or to repair the distribution system, who has in this moment an estimated leakage percentage between 25-60%? The same problem can be discussed concerning interior building installation.

Specific education measures must be adopted to convince population (people who are the beneficiary of the water services and in the same time people who pay for all the water costs - including leakage) to use water in a responsible way. The population plays a double role: consumer and producer of water (wastewater), therefore it is important to consider both their roles.

Finally we have a very simple responsibility which is to save natural water that will ensure a good water for us for longer time.

Professor Alexandru Manescu
Technical University of Civil Engineering, Bucharest.

Leak localization using the Cross Correlation method. General presentation.

In time, detection and localization methods for noise sources within pipe systems have evolved, becoming more accurate.

Acoustic localization devices are the most popular. Whether we talk about noise and vibrations correlators or listening devices, acoustic detection methods are extremely widespread. For many companies which provide water services, these methods are the main tool for preventive maintenance. The leak detection procedures may include a "listening" stage using specialized microphones or aqua-phones. This type of localization depends on the knowledge of the user. The next stage is often called "precise localization" and involves the use of noise and vibrations correlators.

Along different acoustic localization procedures, one can find in the specialized literature detection methods which are based on: the use of colored gases, vapors monitoring, radars and sonars, pipe pressure monitoring, the use of fiber optics, the use of HTV closed circuit systems or thermographs.

For a better understanding of acoustic devices functionality we will shortly present the principle of acoustic leak detection in water pipes systems.

The flow of liquid out of the pipe, trough a leak point, causes specific sounds. These sounds travel in the pipe material, in the surrounding environment and in the liquid which is inside the pipe. The characteristics of these noises are affected by many factors. Their spectral components modify as the sound moves further from the leak point. Such sounds are called "leak noises".

When using noise correlators, piezo-electrical sensors which come in contact with the pipe material acquire the generated leak noises. These noises are transmitted to a correlator. Because the leak noise wave travels with the same velocity in the entire pipe material, the sensor which is closest to the leak will be the first to acquire signal. Basically, the leak noise will first reach the closest sensor. The propagation velocity depends on the pipe material. If the speed value is known, either from literature or can be experimentally determined, the time difference of arrival (TDOA) from the noise source to the sensors indicates the position. Modern equipments include filters and amplifiers which help emphasize the leak signals characteristics and reduce the unwanted interferences.

The correlator operation principle is presented in Fig. 1. Transmission of recorded signals from the sensors to the correlator is implemented using radio waves. Mathematical relations are presented as a principle.

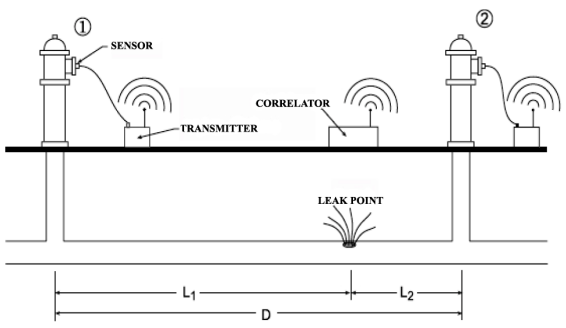

Fig. 1. The principle of noise source localization trough Cross-Correlation.

The Cross-Correlation is a fundamental method when we deal with signal processing algorithms for noise sources position identification (leak detection, in a particular case). The Cross-Correlation Function (CCF) indicates the degree with which two data sets are similar. It represents an important means of statistical analysis.

The CCF method refers to the relation between a recorded signal and a delayed version of the same signal. Trough the index of its maximum value, the CCF allows the calculation of the TDOA.

If we consider that *x(n)* and *y(n)* are two signals which travel from the noise source towards two piezo-electrical sensors (these signals contain *N* samples are considered stationary with zero mean values), we define the CCF as:

$$\hat{r}_{xy} = \frac{1}{N} \cdot \sum_{n=-\infty}^{\infty} x(n) \cdot y(n+l) \quad l = 0, \pm 1, \pm 2 \ldots, N-1 \tag{1}$$

The index l is considered the time shift (time lag). The order of the estimator indices shows that the *x(n)* signal is not modified, while *y(n)* is shifted with l time units. Considering relation (1), a positive time lag indicates that the sensor which provides *y(n)* is further from the noise source. The sensor which provides *x(n)* is closer to the noise source. Basically, *y(n)* is a l time units delayed version of *x(n)*. In order to obtain the normalized CCF (with values in the -1:1 interval) we can use relation (2). The scaling will not change the shape of the CCF.

$$\hat{\rho}_{xy}(l) = \frac{\hat{r}_{xy}(l)}{\sqrt{r_{xx}(0) \cdot r_{yy}(0)}} \tag{2}$$

For the special case when the leak is located exactly in the middle of the distance between the sensors, the CCF maximum value index is 0.

If the index of the CCF maximum value is r samples, one can calculate the TDOA value expressed in time units. It is $D_{time} = r \cdot T_e$, where T_e is the sampling frequency value.

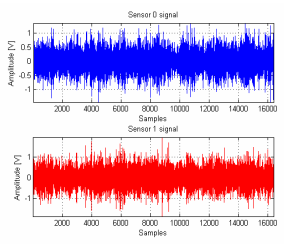

Fig. 2. Recorded leak signals.

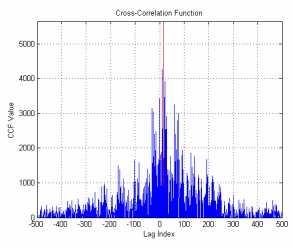

Fig. 3. Calculated CCF.

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Locating pipes

The main materials that can run outside for water distribution networks are:

- Tubes and related parts-iron pressure;
- Cement pipes (are forbidden);
- Reinforced concrete pipes;
- Steel-pipes;
- Rigid PVC-type pipes G (pressure resistant)
- Polyethylene HDPE Pipes

Materials had presented numerous failures in service (ex. steel), materials that have been banned (asbestos cement) or material more difficult to mount were replaced with modern materials like ductile iron and polyethylene.

The importance of determine branching ducts line (route pipelines and branching) is very high in this activity and helps the localization more accurate and pre-location of a fault.

Activity to detect water loss is based on the following aspects:

- Knowledge-branching and pipeline route
- Knowledge of the material and pipe diameter and branching

These data are entered in the noise correlator input calculated based on distance and indicate where is the leak. Then with the microphone (electronic ear) can be listen over the pipeline in place indicated by the noise correlator.

The device pipe is used to locate buried metal piping and cable trays, appliance-based generator-receiver system. The principle of localization is based on the fact that are around of cable or metal pipe, wich are crossed by an electric current, that generates an electromagnetic field. The extent and intensity of this field is determined through a search coil and a receiver. Evaluation of localized field serves to determine the route of the wire.

Connection Method:

- Direct galvanic induced electromagnetic field generator locates
- Clamp-inductively
- Internal antenna inductively

AC cord provides a transmitter module that generates an electric field around it. The receiver has a coil that is placed in close proximity to the electric lines of flux passing through the coil directly into the receiver. The coil produces a small voltage measured by the receiver and displayed on the display.

To make a detection of a pipeline must know his route, length, material, etc..

The new HDPE pipe, PVC, ductile iron are or should be provided with detection wire (wire reinforced in metal tracer). The importance of non-metallic wire for locating pipes is very high.

Going to receive new pipe work and connections I noticed that in most cases these pipes can not be detected (wireless off, very thin existing wired, wireless extended by another thread through direct binding without stripping, etc.). Wire taps have no limit.

For longer employs detection thread and if you want to locate an extension pipe, valve fitting, branch new rendition of the site for various companies to dig.

CONCLUSIONS:

Each non-metallic and metal-pipe (ductile iron is combined with the detection signal leaving rubber rings) must be provided with tracer wire

- Tracer wire must have a minimum thickness of 0.3 mm
- Connections between pieces of wire must be made dezizolând cords and tying them together

The tracer wire is recommended to have contact with the ground (to be stripped and connect to the hydrants, to introduce a metal nail from about 200m to 200m and make the connection thread, the thread of connections must to be linked with wire stripper joint pipeline)

- Wire should be positioned on the pipe (connected trough) to use the method of rendering pipeline depth
- There are situations in which the detection wire can be achieved even if the above conditions are met (for example an area where there are no underground household (cables, pipes, etc.)
- Each new work should be checked if the thread is inserted properly and may be useful to track the location of pipeline
- Project supervisor, builders, etc.. must know the importance of the yarn and how it works

I did the following experiment:

- I lay a 50m long wire, 0.3 mm thick copper
- I did the wired connection galvanically, the other end being kept in air
- I generated a frequency on the line and tried to find receiver
- As long as the wire was not grounding wire could not be detected even at a distance of 1cm
- When I did touch the ground wire could be located with no problems

There are effective devices capable of locating non-metallic pipes?

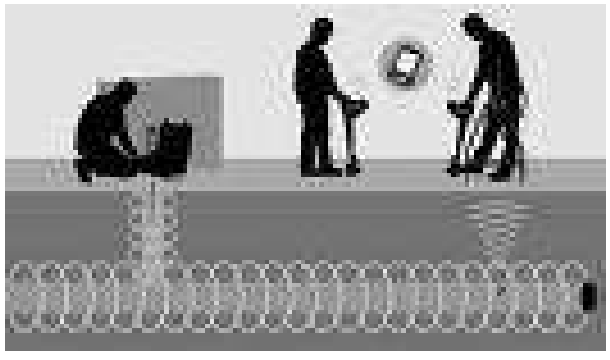
There are alternatives to wire detection, but some are more expensive and more vague:

- Electronic markers for marking and locating underground utilities routes
- Ground Penetration Radar
- Infrared
- Old method but useful in some cases, when using two electrodes that can determine if there is a buried pipeline

Unquestionably, the work of detection is necessary for utility networks and prevent major problems in yards, especially in cases where the network plans do not correspond with reality, no longer exist or have not been updated.

Technique for locating underground utilities is highly developed in the United States where each state has a so-called Call Before You Dig service, that provides updated information about the utility location. In this way these accidents can be avoided during excavation work.

I hope that in future we can establish an association in Romania to provide such information in each county, because it would reduce the cost of repairing damage caused, and also there would be work-related accidents that cause disability or even death, that can be avoided by using this method.



The normal would be to introduce a law whereby any excavation operation is not done without a preliminary determination process and without providing a site plan.

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WATER LOSSES

One of the major challenges facing water companies in Romania is the high level of water losses, which are either due to real losses (leakage from pipelines transporting or distribution of reservoirs, etc.) or apparent losses (errors of measurement of quantity of water supplied to customers, theft of water, etc..).

Factors Affecting Leakage

- Pressure
- Soil movement
- Pipe deterioration
- Poor quality of materials and workmanship
- Soil characteristics
- Traffic loading
- Stray electrical currents

A good management of water losses depends not only on identifying rehabilitation and improvement priorities for the distribution network , but equally on the introduction of effective methods and practices for assessing, monitoring and controlling of the main elements of non revenue water (NRW): real losses, apparent losses and unbilled consumption.

For a performant management of water losses it is proposed to include in current practices modern methods and tools for monitoring analysis, such as Water Balance and Infrastructure Leakage Indexes.

- Water Balance
- Losses in the infrastructure indices
- Evaluation of water distribution network
- Analysis, diagnosis of water and sewerage system

The reduction of real losses by:

- speed and quality of repairs;
- infrastructure management, pressure management
- establishing an annual program to check the network using special equipment to detect leaks and establishing a proactive maintenance program
- optimization of water supply system by using automation and dispatcher systems
- flow monitoring (district metering areas, flow analysis on each area
- identify potential pressure reduction areas (initial for Craiova and explore pressure reduction opportunities in other branches)
- identify DMA pilot for pressure reduction
- reduce water losses from reservoirs
- reducing water losses on transportation and distribution system(counting the source and the entrance to treatment stations, etc.)..

Reduce the apparent losses by:

- Identification of unauthorized consumers
- Meter installation programme
- replacement of old meters (correlation of consumption with the type of meter used)

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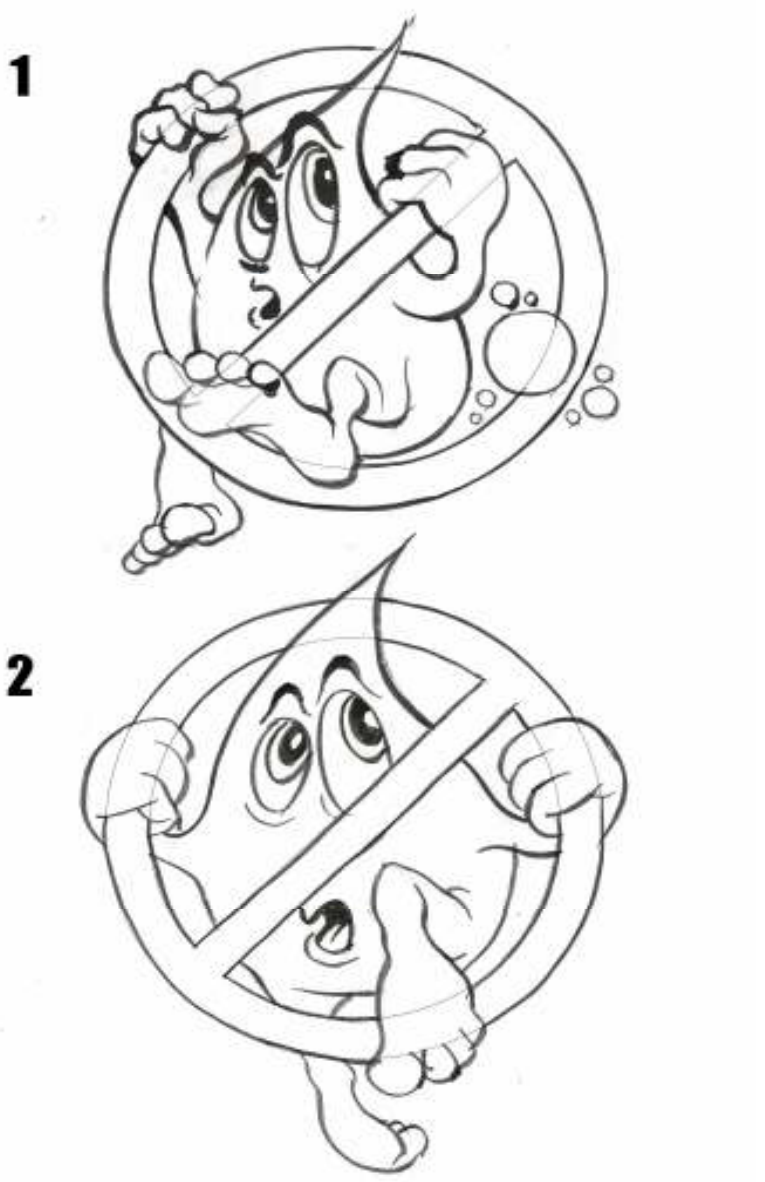
Did you know that...

-only 1% of the Earth's drinking water can be consumed? The rest is "stored" in the ice sheet and in glaciers?
- 141 million urban dwellers don't have access to safe drinking water resources?
- Romania's water requirement from 2010 has decreseased with 12 billion m³ since 1990, from 20.5 billion m³ water (reported value for 1990), to 8.45 billion m³ water (as recorded in 2010)
and with 1 billion m³ water - 27% of the urban dwellers from around the world don't have access to piped water at home and they live at at least 1 km distance away from the nearest fresh water resource?
- some 250 to 500 million m³ of drinking water gets lost in many mega cities each year?
- in Romania, the coverage of the waste water collection services is of 54,28%,
- water is the only chemical element capable of existing in a solid, liquid, and gaseous state of aggregation?
- the human body contains 75% water?
- in 2008, in Barcelona, because of the drought, drinking water has been brought with heavy-duty ships?
- Ireland and Great Britain – in 2010, the city of Dublin has been left without water because of the water-leaks?
- Thames Water Company is building a huge desalination plant (900.000 people) in order to ensure water requirements? The company doesn't allow anymore the usage of rubber pipes and spends £190 million every year to detect and to mend the water-leaks.



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NRW Guidelines - FOPIP, ISPA measure 2000/RO/16/P/PE/002-05
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WATER LOSSES IN THE DISTRIBUTION NETWORKS

Water distribution network is the most expensive in the drinking water supply system of populated centers (60-80% of the total cost of installation), due both to its large length (2-10 m / capital); and the fact that is a very applied hydrodynamic and static system (it works under pressure and is placed under roadways), and most of the problems concern the relationship between water quality, which is made of materials, their age, operating pressure and water losses. Aging materials increases the water losses. Today, water losses in the distribution networks, lies on average between 40% and 60%.

Water quality is becoming more expensive and less apparent need for an appropriate strategy for achieving optimal system operation so that the overall water and financial resources to be used as rational as possible.

Water losses are defined as the difference between the amount of water entered into the distribution system and authorized consumption, component which includes both the apparent and real losses.

Volume of water entered into the distribution system is the annual volume of water entered into the distribution system, consisting of authorized consumption and water losses.

Authorized consumption is the amount of water used by registered customers, consisting of authorized billed consumption (measured and unmeasured), bringing the income and authorized consumption invoiced (measured and unmeasured), but without revenue.

Actual losses of water are given annual volume of water lost through all types of leaks (pipeline damage and loss, cleaning tanks and branching) to capture and to the point of metering of consumers.

Apparent losses include actual volume of water used by unauthorized consumers (including the use / misuse connection) and measuring equipment data errors.

It is recommended that all components of real losses of water to be measured by the best means available. It is important to assess correctly invoiced water because its cost is reflected in the water price. Actual water losses should not exceed 15% for November networks (under 5 years) and 35% for existing networks undergoing rehabilitation and / or extension. Percentages greater than 35% of water losses are considered anormal and require the adoption of appropriate measures.

The amount of water losses in the distribution networks under pressure, given the size of holes and cracks in pipes and fittings, holes due to excessive chlorine corrosion, faulty joints, the mechanical stress from poor execution of the works adjacent ruptures or burglary pipeline caused by water hammer, leaking hydrants, etc…

The optimal operation of distribution networks should I place between pmin and pmax = 0.7 bar = 6 bar. Under these conditions may be obtained: the life extension of distribution network infrastructure, reducing the frequency of failures in pipes and connections, reducing the flow at all existing leaks and breakdowns in the system at any time, reducing consumption to users connected directly to network, reducing wastage of water to consumers in the network, waste water, even counted, is also a loss of water. Frequency of water losses is heavily influenced by the maximum pressure.

From this point of view, low pressure networks in towns, is a measure beneficial to minimize the loss of water pressure in the network with minimum value.

Water leak detection can be done by: passive control (determination of water losses by viewing production consequences), active control (systematic monitoring of the network) and regular audit.

Departments that have acted to control water losses, have regard to: maintaining a quasi-constant pressure in the system, close to the technological needs (the pressure at the branch), upgrading and replacement of damaged pipes, ensuring the quality of execution in parallel with Periodic cleaning of the sections of the network, setting a limit to economic losses can be reasonably low (cca.20%), active control of technological parameters of the water network operation, including the loss of water, computerized system (SCADA, GIS) .

Water quality in the distribution networks is determined by: the influence of the network constituent materials (iron, steel, concrete, cement, PE-ID, PVC, ceramics), residence /

stagnation in the network, forming deposits, accidental contamination (through interventions network and the reservoir, or when pressure drops below atmospheric pressure in the network), poor quality of treated water, training and developing a video / biological treatment system by advanced methods captured biological stability (water Biostable).

Water losses in the distribution networks can be regarded as beneficial for combating biological processes , then fall stagnation / residential water pipes, lasts more than 7 days, and residual chlorine becomes imperceptible. Flow of water losses through leaks joints, holes and cracks in pipes / fittings can ensure minimum flow rates to combat biological film on surfaces inside pipes carrying water for human consumption.

Reducing water losses became in the last 10 years the principal concern of all drinking water suppliers in our country.

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THE NECESSITY OF A STRATEGY TO CONTROL WATER LOSSES

ABOUT THE AUTHOR

Andy Bowden is an International Water Utility Consultant who provides institutional support to water utilities worldwide. He has been associated with the Romanian water sector since 1994 providing technical assistance to a large number of water and wastewater utilities in the field of operational management. This has included the important area of non-revenue water (NRW) where he has worked closely with utilities, government departments, international financing Institutions and the Romanian Water Association in developing strategy and supporting implementation of water loss reduction programmes throughout the country.

INTRODUCTION

It is a great pleasure for me to be asked to make a contribution to this magazine as I see it as being a forum for consolidating and building on the good work that has been done so far in Romania in addressing the issue of non-revenue water (NRW).

NRW constitutes a significant component of operating expenditure, particularly in Romania where water networks are, to a large extent, aging, are of poor quality materials and installed without an appropriate level of care or protection for long system life. This article highlights the benefits of having a proactive approach to reducing leakage and educating customers as part of an overall strategy that contributes to an overall reduction in NRW.

In Romania significant progress has been made in reducing levels of NRW but significant challenges still remain, particularly with the challenging targets that have been set for reducing NRW levels associated with Cohesion Fund investments.

PROACTIVE APPROACH TO LEAKAGE

The intention of introducing a proactive approach to leakage is to strike a balance between the cost of reducing leakage and the value of the water saved. The level of leakage at which it would cost more to make further reductions than to produce the water from another source is known as the economic level of leakage (EEL). Operating at economic levels of leakage means that the total cost of supplying water is minimised and companies are operating at optimum efficiency.

EEL is not fixed for all time as it depends on a wide range of factors. For example the cost of detecting and repairing leaks will reduce as new technology is introduced causing the ELL to fall. Conversely if water demand falls to a level such that there is a large surplus of water it may not become economic to reduce leakage.

An integral part of adopting a pro-active approach reducing levels of NRW is to know the starting point and to continually monitor performance. For this reason accuracy of the data used is of prime importance and an area where significant investment needs to be made in the field of metering to assure reliability. There are several components to the water balance that account for the total volume of water put into supply. These are, measured and un-measured domestic consumption, measured and un-measured non-domestic consumption, water taken billed or un-billed, either legally or illegally, water used for operational purposes and finally, distribution losses.

Unfortunately, leakage location still remains a far from exact science. Distribution systems can now be seemless, through the use of welded polyethylene (PE) pipe systems. Although the networks are now more robust than those of the past, it has made the pinpointing of leakages more difficult as those charged with locating water losses will tell you.

Reasons for repairing leaks

There are numerous reasons and benefits that can be realised for identifying and repairing leaks speedily as part of the proactive approach to leakage. These can be summarised as follows:

- leaks get bigger with age
- repairing leaks reduces water losses
- repairing leaks that are pre-identified can be approached in a planned way and reduce overtime rates
- repaired leaks ensure that more water is available to be sold to customers
- leak detection and repair reduce energy and chemical costs associated with the production of water
- leaks can cause damage to roads and buildings and have a negative effect on the environment
- active leakage detection and repair projects a good image to the general public
- a water company gains credibility by being seen as putting its own house in order before asking customers to conserve water

Methodology

The prime requirement for implementing a proactive approach to leakage reduction is the establishment of district meter areas (DMA's) supported by the use of new technology and a number of key initiatives. Such initiatives include the use of pressure reduction, computer modeling of water networks, priority response timing for identified leakage repairs.

The establishment of DMA's is essential for good management of any water distribution network and readily aligns itself to a proactive leakage strategy. DMA's are discrete areas of a distribution network comprising typically between 2000 and 5000 properties into which inflow, and where necessary, outflow is measured. Complete distribution networks are covered in such a way. Through flow monitoring of DMA's, total demand and night flows can be recorded and interrogated either locally or remotely depending on the sophistication of logging and telemetry provided. With time, experience will enable target levels to be set to trigger activity for leakage detection or investigation of unusual flow patterns. This facility enables leakage control to be monitored using both minimum night flows and total integrated flow linked into the flow balance.

The DMA approach better targets the leakage detection effort and maximises the benefit that can be provided from specially trained detection crews using location equipment. By linking to computerised data bases, leakage and DMA performance information can be used to drive forward network rehabilitation programmes in a truly objective manner ensuring that priorities are suitably addressed.

Pressure reduction is perhaps the simplest way of reducing leakage and should always be considered as part of a proactive leakage strategy. It can be provided by simple step pressure reduction through to full variable flow where minimum network pressures can be sustained whilst meeting diurnal demand.

The use of hydraulic computer models plays an important role in leakage strategies through providing engineers with a good understanding of network performance under dynamic conditions. It has proved particularly useful in verifying DMA's, selecting targets and identifying areas for potential pressure reduction.

To support the improved leakage identification that has results from the establishment of DMA's and the use of advanced location equipment it is important that this is linked to speed of response in carrying out repairs. In this respect targets need to be set for repair times following leakage identification.

Consideration should also be given to introducing incentives to encourage customers to have supply pipes repaired more speedily. Historically this had proved a difficult area to work in, with most water utilities having to rely on statutory powers in legislation to enter onto private property to effect repairs to defective apparatus. This in itself was a lengthy process and fraught with difficulties, particularly where 'shared' services were involved.

Water utilities need to project a high profile towards leakage as part of their strategies through media campaigns and improving customer access. This latter point has been achieved by a number of utilities in Romania through the introduction of customer 'leaklines' whereby customers can report leakages by telephone.

PROMOTING WATER EFFICIENCY

Water utilities have had a duty to promote the efficient use of water by their customers. This has results in all utilities producing water efficiency plans in consultation with interested parties involved in conservation.

Communicating with customers

Customers awareness of the need to conserve water is monitored by market research programmes that are carried out by the water utilities. Encouragingly the research is showing an increasing awareness of the need to use water efficiently and that customers are taking increasing actions to do so. Information on ways that customers can save on the use of water are provided in many ways and through a variety of methods, these can be summarised as follows:

- Details of available information sent out with water bills
- Providing specific responses to customers' postal or telephone phone requests
- Booklets/newsletters/ informative literature
- Visitors centres, usually located on operational sites
- Mobile visitor centres
- Television, radio and newspaper features
- Magazines
- Internet website
- Posters
- DIY/garden centre promotions
- Competitions
- Seminars
- Visits
- Information packs
- Competitions
- Talks
- Open days
- Sponsorship

Water in the home

Efforts have focused on encouraging customers to apply water efficiency where it has a minimum impact on lifestyle.

In addition to targeted literature water utilities also make use of promotional offers on water saving devices such as showers, watering cans, water butts, rainwater diverters, water efficient washing machines and dishwashers.

Bookmarks, stickers and cards are widely used to publicise water saving tips and campaigns are used to provide specific customer advise on issues such as frost protection.

Education and schools

Education plays an integral part in any promotional campaign. Therefore an important element of water efficiency strategies is targeted towards schools and schoolchildren.

Education packs can been developed which link into the schools educational programmes. Some water utilities establish classrooms on operational sites to support the learning process for schoolchildren and teachers.

A wide selection of information is available that is geared towards schools and educational liaison between the water utilities and educational establishments are well defined.

Business customers

Water utilities need to provide information for their business customers on how to use water wisely. Additionally seminars can be held to discuss ways of conserving or recycling water, these can be both general and sector specific.

Links need to be established with regional development agencies to encourage the fitting of water saving appliances in new developments. The use of new technology options such as grey water recycling units, low flush toilets and water efficient spray taps are viewed as being more likely to be accepted by customers if they are incorporated in buildings at the design stage.

CONCLUSIONS

As a result of the implementation of proactive water loss reduction strategies, leakage levels will reduce but it is an effort that needs to be sustained and supported if it is going to contribute to ongoing operational cost reductions.

Strategies need to be based on true facts rather than fictional information that could distort priorities for investment needs. In terms of performance reporting, this is always a challenge as there is always a need to demonstrate continuing performance against a wide spectrum of reporting indicators. Unfortunately these are not always compatible in financial terms and this can act adversely to the detriment of some activities such as leakage reduction.

There have been numerous benefits associated with targeting NRW reductions in the Romanian water sector, the main advantages of which are:

- Improved availability of water supplies
- Enhanced ability of customer affordability due to reduction in per capita consumption when tariff levels are increased
- Deferment of capital expenditure
- A better understanding of water demand profiles
- Cost effective performance of operational expenditure.

In addition to the training made available to enhance the knowledge of NRW and leakage reduction practices through the technical assistance programmes in Romania, is the ability for Water Utilities to network through nationally generated initiatives. The launch of the Leakage Challenge in 2008, under the umbrella of the Romanian Water Association, was one such initiative. It provided the opportunity for practitioners to present their strategies and practical expertise at a national level. In 2010, this was expanded to an international level. From this initiative an enthusiastic network of experts has been brought together to enable experiences and problems to be shared and discussed through vehicles such as this magazine.

My wish is for the good work to continue, as I am sure it will, due to the commitment that has been demonstrated to date. Good luck for the future.

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Do you want to promote your business, products, or to bring a contribution in the field of water losses?
We offer the opportunity to make known your business, products and innovations in the field of water losses. Send an article related to water losses.
People with experience in this field are invited to share their experience in some aspects like: monitoring, control, detection, tracking or any topic related to water losses.
The proposed article must be written in Word (Office) with a font size: 12 Times New Roman.
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