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WATER LOSS MANAGEMENT EXPERIENCE OF LITHUANIA

This article presents some general techniques for real water loss reduction and the results of tests on the ways for reduction of apparent water losses in Lithuanian water supply systems. It has been determined that the replacement of customer water meters (by Class C meters) can result in 10-15% reductions in apparent water losses. There is also presented a definition of night flow elements such as real water loss, night water consumption and background water loss. The article also defines minimum night-time water consumption for a single user which was determined as (0.9 l/h/flat).
Keywords: **water supply system, real water loss, apparent water loss, non-revenue water, active leakage control.**

Introduction. Water management is an important part of the urban infrastructure. Its condition and quality have a direct impact on population welfare and health as well as economic development. Lithuania has 58 water utilities which supply, by centralised networks, about 95% of the total water volume consumed in the country.

Only groundwater is used for centralised water supply in Lithuania. Not a single water utility uses surface water for drinking purposes. Over 80% of the country's population is connected to the water-supply network. In cities the degree of connection reaches 99%, while in rural areas in some cases it is below 50%. The country has enormous groundwater resources – 4 mln.m³/day, of which about 0,4 mln.m³/day is currently being exploited. Therefore, from water supply utility point of view, there is no such big motivation for saving water that is leaking from the water network. From scientific and humane point of view it is unacceptable do not take any measures for water loss reduction, because it causes unsustainable use of one of the main most lacking natural resource around the world. Seems only one driver could motive utilities is establishing the legal regulation for the maximum mandatory permissible losses in the network. As long as such regulation is absent, water utilities lack real motivation for applying active measures for water loss reduction.

The chart presented in Figure 1 shows water losses at Lithuanian water utilities. At the best utilities losses represents 12%, at the worst – exceed 54%.

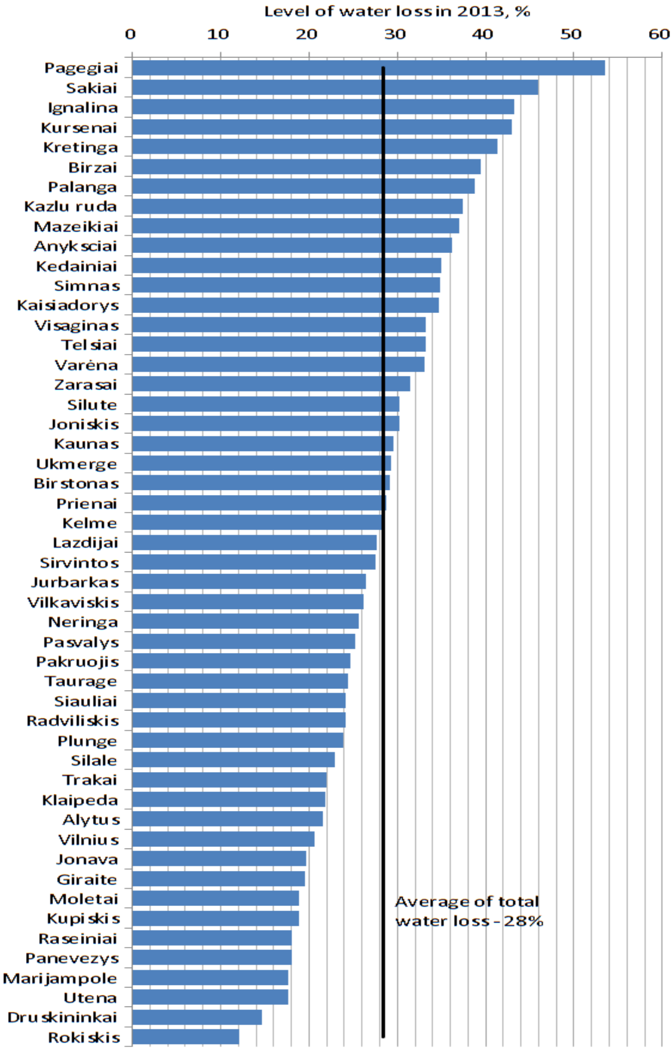

Fig. 1. Level of water losses at different cities in Lithuania (2013)

Water loss is described as difference between volumes of water supplied to the water network and sold to the consumers [1, 4, 6]. There are two types of water loss that can occur in water supply system: real water loss and apparent water loss. Sometimes they can also be called as physical and commercial water loss.

Water that is lost from the distribution system through leaking pipes, joints, and fittings, leakage from reservoirs, and improperly open drains is called real water loss. And water that is not physically lost but does not generate revenue because of inaccuracies related to customer metering, consumption data handling errors, or any form of illegal use is called apparent water loss. The sum of real and apparent losses plus unbilled authorized consumption is defined as total water loss or according to the standard water balance methodology – non–revenue water (NRW) [6, 7].

According to International Water Association (IWA) Guidance Notes for Leak Location and Repair there are passive and active water loss reduction measures [5]. When a Water Supplier only repairs leaks and bursts that are reported to them, that is known as Passive Leakage Control (PLC) [2, 3].

While Active Leakage Control (ALC) essentially solves the problems by creating a comprehensive water loss reduction strategy. ALC covers finding and fixing unreported leaks that usually would never reach the surface of the ground. Active Leakage Control includes: Water Balance and Performance Indicators calculation, zoning of water supply network for District Meter Area (DMA) installation, flow measurement, control of water meters, pressure management and permanent search of leaking pipes by using appropriate equipment. [1, 6].

Research methodology. The technique of real water leakage monitoring requires the installation of flow meters at strategic points throughout a distribution system, each meter recording flows (and often pressures) into a discrete sector or district which has a defined and permanent boundary. Such a district is termed a District Meter Area (DMA). In the United Kingdom DMA would cover between 500 and 3000 residential house connections [5]. In Lithuania one typical DMA in average city would cover between 50 and 500 residential house connections. Figure 2 represents typical DMA in one of Lithuanian cities during water loss reduction project. This DMA has 195 connections all of them are residential houses. Certain DMA is divided in to smaller sub zones for more specific information of night water consumption.

During the DMA investigation it is important to get proper information about: total length of water mains and underground pipes from the mains to the water meters, number of connections and water users, average pressure in water network during the night time. Pressure has significant impact on water leakage from the water network. The higher the pressure in the water network, the greater the water loss.

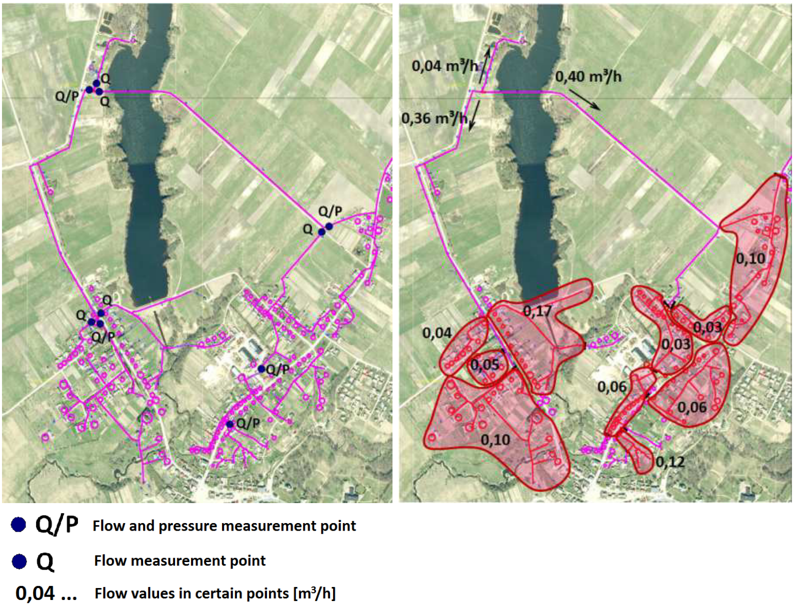

Fig. 2. Typical DMA in one Lithuanian city with night water flow measurement results

Night flow data from DMA`s provides the information that enables the prioritization of the leak location effort. This effort is divided into two separate activities, leak localizing and leak location. Leak localizing is the ‘narrowing down’ of a leak or leaks to a section of a pipe network. Leak localizing can be undertaken as a routine survey of the network or part of the network, e.g. every six months or annually, it can also be carried out in targeted areas e.g. DMA`s with high night flows. Leak location is the identification of the position of the leak and is often referred to as ‘pinpointing’ [5].

Night flow measurement data from 02:00 till 04:00 usually represents potential real water losses. During this time period there is no residential water consumption or if there is, it is at the minimum level. During the DMA research it has to be checked if there is no industrial objects connected to DMA that could increase night water consumption. Figure 3 shows typical water consumption and pressure pattern of one DMA.

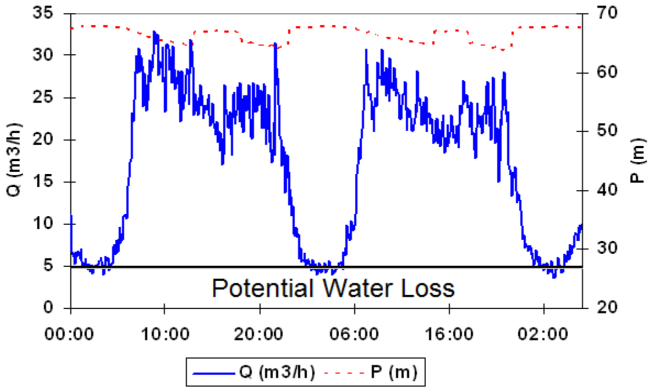

Fig. 3. Flow and pressure patterns in typical DMA

After receiving this kind of measurement data it is must be said that not 100% of all night flow is only water losses [8]. Water supply network has a lot of valves, joint, fittings, connectors that is described as high risk places for water leakage occurrence. Most often only small volume (less than 0,25 m³/h) of water is lost from these slowly leaking places so it is economically inefficient to search for this kind the so-called background leakage [5]. In order to define real water loss it is important to consider that measured night flow also covers background leakage and night water consumption. Figure 4 graphically shows the components of night water flow that is measured in water network.

Volume of background water loss is usually smallest component of total night flow. It depends on three indicators: length of water mains, number of connections and night water network pressure. Background water losses in DMA or entire city can be calculated according to the formula [2-4]:

$$(20 \cdot L_m + 1{,}25 \cdot N_s) \cdot \left(\frac{H}{50}\right)^{1{,}5}, \; l/h \qquad (1)$$

where L_m – length of water mains in kilometers; N_s – number of connections; H – average pressure of water network during the night time in meters of water column.

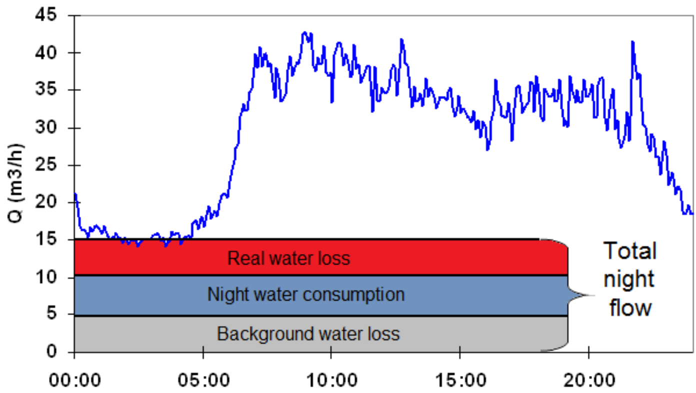

Fig. 4. Total night flow components in DMA

Night water consumption is relatively bigger and can vary with number of connections and water users in DMA and their water consumption habits. If there is any industrial companies it is necessary to take into account their water consumption, because they can vary from residential. Volume of real water loss depends on water network condition and size of DMA. Namely this part of total night flow is most interesting because it can be eliminated.

Apparent water loss usually cannot be seen in water flow measurement graphs. Inaccuracies related to customer metering and data handling errors do not increase water consumption it only counts incorrectly the volume of water that was consumed. However it is possible to track illegal water use (theft) by measuring the flow in DMA and comparing water volume that was supplied to the system with water volume that was billed.

Apparent losses also occur from unauthorized consumption which is caused by individual customers or others tampering with their metering or meter reading devices, and other causes. Direct water thefts are rarely committed. However, measurement errors and inaccuracies of water meters is a very actual problem. Because of apparent losses is particularly serious due to the fact that consumed water usually gets into the wastewater system. A water utility provides a double service – supplies water, and collects and treats wastewater, but nobody pays for that. Hence, water utilities should be especially interested in the minimization of apparent losses, since due to these losses they sustain financial losses in terms of a full price of water and wastewater, rather than a small amount as in the case of leak stopping.

For any types of apparent loss, it is incumbent on utility mangers and operators to realistically assess metering and billing inconsistencies, and then develop internal policies and establish programs to economically minimize these inefficiencies. It is also important to clearly communicate with customers, governing bodies of the utility and municipalities, financing agencies, and the media the problems of apparent losses and the need to control them.

Results. After the flow measurement and background water loss calculation sometime it can be hard to define correct night water consumption in the DMA. Usually every water utility can define number of connections and water users in DMA. But there is no legal document that reveals how much water is used in one statistical residential house or one flat in blockhouse. To fill this gap measurement was done in 16 blockhouses of 4 different cities of Lithuania. During the investigation water was metered with bulk water meter that counts volume of water that is supplied for all residents of blockhouse (see Figure 5).

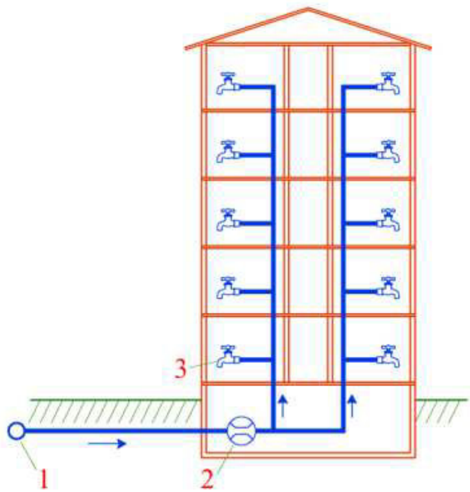

Fig. 5. Bulk water flow meters installed in series of blockhouses:
1 – water main pipe; 2 – bulk water meter; 3 – water user

Number of measurement days in different blockhouse varies from 11 to 38 days. Number of flats in the blockhouse varies from 12 to 96, but mostly these are typical blockhouses that can be found in each Lithuanian city. After the measurement it was defined average night water consumption for one flat – 0.9 l/h/flat. The determined night water volume was verified by identifying real water losses in the water supply network and by making calculations of the water system water balance.

Calculations included data of night flow between 02:00 and 04:00 o'clock. Figure 6 shows water consumption in one typical blockhouse during the night time. It is clear that even during the night time there is some casual water consumption.

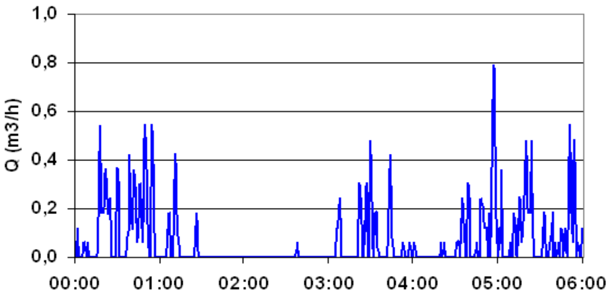

Fig. 6. Night water consumption in typical blockhouse

Defined average night water consumption can also be used for residential houses, because number of residents in one flat and in one individual house is mostly the same. The performed analysis of each blockhouse individually has shown that water consumption depends on dwellers' habits and it is difficult to see any relationships between consumed water volumes and the number of flats. On the basis of the average water consumption per flat determined during measurements it is possible to quantify the minimum night water consumption in the zone concerned. Night water metering is conducted in different districts where different consumers are present (in terms of water consumption) and therefore the determined average night water consumption indicator can be used for establishing the permissible level of night water consumption.

The reduction of apparent water losses is quite a different field then reduction of physical water losses as it does not require large additional investments and can produce quick and efficient results.

Apparent losses occur as a result of inefficiencies in the measurement, recording, archiving and accounting operations used to track water volumes in a water utility. These inefficiencies can be caused by inaccurate or oversized customer meters, poor meter reading, billing and accounting practice, or weak policies. This article presents the results of tests on the ways for reduction of apparent water losses in Lithuanian water supply systems. The aim of research is to show that apparent water losses consist of considerable share of water losses and to prove that inconsiderable efforts can significantly cut down water losses and improve the utilities' financial situation.

Single-flow water meters of Class B are normally used for water accounting in Lithuania. Such metrological definition of meters is inaccurate, as a new EU standard adopted in 2005 discontinued using such metrological classification of water meters. LST EN 14154–1:2005 standard defines metrological classes by Q_3/Q_1, ratio, which by analogy to the former Class B should exceed 50, while by analogy to Class C should be above 160.

In accordance with legislation, periodic verifications are conducted: every 4 to 6 years for customer water meters, and every 2 years for bulk metering instruments, industrial and public customers. Really, customer water meters are replaced every 8–12 years, while bulk water meters – only when they do not pass metrological verification. Tested meters of adequate quality are re–installed at industrial water inlet.

Reduction of apparent losses is important, because 99% of Lithuanian water consumers pay for water according to the readings of water meters. Customers invoiced according to the water consumption rate set by a utility account for less than 1% of the total customers. Therefore, a water meter of metrological Class B is mounted in each private house or flat.

The aim of the investigation was to evaluate water losses in single flats of a blockhouse. For this purpose meters were replaced in the flats of three blockhouses in Alytus city, Lithuania. The existing old customer water meters of Class B, 15 mm in diameter, were replaced by new meters of Class C. Parameters of the old and the new customer (DN15) meters are given in Table 1.

Table 1

Data of water meters

Model	Class	DN, mm	Start flow, l/h	Q_1, l/h	Q_2, l/h	Q_3, m^3/h	Q_4, m^3/h
Smart C+, PoWoGaz	C	15	5	10	16	1.6	2.0
Residia, Sensus	B	15	15	30	120	1.5	3.0

Three blockhouses were chosen for the test. The choice of these houses has been prompted by the fact that it was about time to replace their meters and the water losses in these houses corresponded to the average water losses in blockhouses. Meters in these blockhouses were replaced during March 2013. The last data were received in January 2014. At Figure 7 are presented measurement data obtained during 10 months.

Approximately 150 outdated water meters (DN15) were replaced in blockhouses. Average apparent water losses in three houses totalled 68 m^3 per month. After 10 months of measurement by Class C meters water losses in blockhouses dropped to 14 m^3 per month.

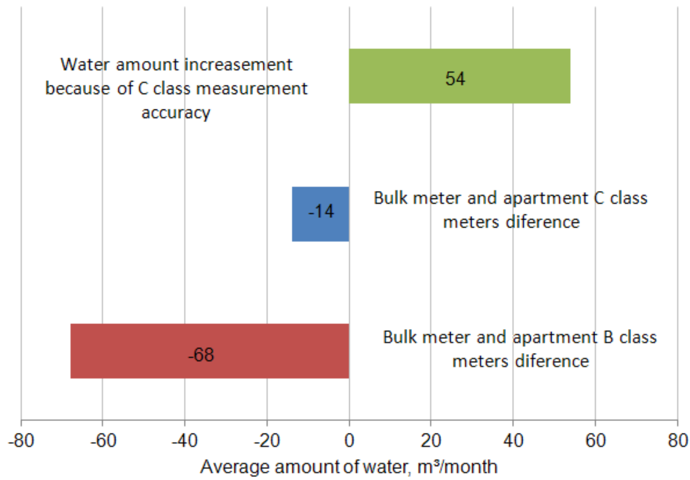

Fig. 7. B and C class customer water meter differences

After customer meters of Class B were replaced by Class C, it has been determined that average possible losses in flats are about to 12 litres /day or around 4 m^3/flat/year. Considering that the price difference between customer meters of Class B and Class C is about 10 USD, while the prices of installation and other works are the same, only the difference in meters prices can be used in economic calculations. Taking into account the difference in prices of water meters of Class B and Class C, investment in the replacement of meters will recoup quicker than in a year. According to the performed calculations, installation of Class C meters in flats would reduce apparent water losses in private houses and blockhouses by more than three times and at the same time would ensure higher revenue for a water utility.

Conclusions. In order to reduce water loss it is necessary to take Active Leakage Control (ALC) measures: divide water network in to zones or

District Meter Area`s (DMA), analyze measurement data and use specified equipment for identification of leakage position.

1. Night water flow measured in DMA present not only real water loss, but also covers background loss and night water consumption. During the analysis each component must be evaluated separately.
2. The determined average minimum night water consumption by one flat (house) was 0.9 l/h/flat. This indicator can be applied to both individual houses and apartment blocks when calculating the water balance and actual water losses.
3. One customer meter of Class C every day measures 12 litters of water more than one customer meters of Class B.
4. To reduce the apparent losses, it is necessary to use water meters of metrological Class C. For replacement of the meters, additional investments required only the price of the meter. The pay-back period of a Class C meter is no longer than one year. The use of Class C customer water meters can reduce apparent water losses in flats up to 10%.
5. The replacement of meters is a rapid and easy way of minimising apparent water losses.

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ДОСВІД УПРАВЛІННЯ ВТРАТАМИ ВОДИ В ЛИТВІ

У статті представлені результати зменшення реальних втрат води та результати випробувань відносних втрат води у водопровідних системах Литви. Було визначено, що заміна лічильників споживачів (на клас С) може призвести до зменшення відносних втрат води на 10-15%. Представлені результати нічних замірів води, які складаються з реальних втрат води, нічного споживання води та допустимих втрат води. Також у статті описано, що встановлено параметр мінімального нічного водоспоживання, він дорівнює 0,9 л/год на 1 квартиру.

Ключові слова: **водопостачання, реальні втрати води, відносні втрати води, невраховані витрати, активний контроль витоків води.**

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ОПЫТ УПРАВЛЕНИЯ ПОТЕРЯМИ ВОДЫ В ЛИТВЕ

В статье представлены результаты уменьшения реальных потерь воды и результаты испытаний относительных потерь воды в водопроводных системах Литвы. Было определено, что замена счетчиков потребителей (на класс С) может привести к уменьшению относительных потерь воды на 10-15%. Представлены результаты ночных измерений воды, состоящих из реальной потери воды, ночного потребления воды и допустимой потери воды. Также в статье описано, что установлен параметр минимального ночного водопотребления, он равен 0,9 л/час на 1 квартиру.

Ключевые слова: **водоснабжение, реальная потеря воды, относительная потеря воды, неучтенные расходы, активный контроль утечки воды.**
