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EFFORTS TO REDUCE WATER LOSSES IN LARGE WATER COMPANIES

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ABSTRACT: The water losses are unavoidable and the amount of loss may vary depending on the type of mains material, structure and operational parameters. The evaluation of water loss is an individual issue and should be done in terms of length of mains. In accordance with IWA terms (International Water Associations) there's more often used economic level of leakages then percentage of water loss. The paper refers to the efforts to reduce the losses in one of the largest water companies in Poland – in Krakow. Those efforts should be conducted according to established strategy and aim to optimize the costs of operation in Water Company.

KEY WORDS: water losses, economic level , water meters

Introduction

Water losses are still one of the most important issues in water mains exploitation. Unfortunately, they are unavoidable in the water supply process. They can occur at every stage of the water supply process (intake, treatment, transmission, distribution, retention). If we take into consideration potential legal changes concerning water losses phenomenon, especially losses in the distribution to water companies, this issue becomes a hug challenge.

Most important causes of water losses in the mains are: leakages from untight conduits and the laying of mains, failures of the water supply conduits, stealing water. However, water losses are not only caused by leaky infrastructure or failures but also result from keeping the high quality of the supplied water e.g. through rinsing the water system. The risk of water losses occurrence may be magnified by many factors, e.g. excessive pressure in the water system.

Water losses in the mains are, by definition the difference between produced water volume (pumped into water system) and water volume sold to the end users, so defining them requires balancing water in the system based on measuring the water volume used by end users in a given area and water volume provided to the area (Kwietniewski, 2013; Rak, Sypień, 2013).

Water losses volume is mainly determined by real water losses, i.e. losses which are resulting from poor technical condition and failures of the water system. Latest years show a decrease in water losses which has been achieved mainly through active leakage control through state of the art technology as well as pressure optimisation.

Water losses cannot be eliminated and every water main, even new, has a defined, tolerated water loss threshold. In the beginning they are caused by filtration through pipe joints and later leakages start occurring more often. To overcome this challenge we should use the so called optimal level of water losses in the mains. We should define whether water losses in given exploitation conditions and at a given cost are regular (proper) or excessive so to what level we should reduce them to save water and minimize the supply costs. Thisis the so called economical approach to water losses which comes in accord with IWA (International Water Association) (Hotloś, 2010; Kwietniewski, 2013).

When analysing water losses, apart from financial benefits, ecological perspective as well as protection against serious failures should be taken into consideration.

The main component of economical level of leakages is the volume of the so called inevitable losses, which are proportional to the length of used water

system and the number of service pipes. Figure 1 shows water balance in accord with IWA (International Water Association).

Water input	Authorized consumption	Billed consumption	Billed metered consumption	Revenue Water
			Billed unmetered consumption (flat rate)	
		Unbilled consumption	Unbilled metered consumption (billing error)	Non Revenue Water
			Unbilled unmetered consumption (eg firefighting)	
	Water Loss	Apparent losses	Customer meter inaccuracies	
			Data handling errors	
			Unauthorized consumption (theft)	
		Real losses	Leakage on mains pipes	
			Leakage and overflow on tanks	
			Leakage on service connections	

Figure 1. Water balance by IWA

Source: (Kwietniewski, 2013).

Water losses indicators

Precise and objective measurement of water losses is hard and often impossible. One of the reasons for that are apparent losses, which are not real losses but they influence the value of the indicator, so the numeric result of balance between the water volume supplied to the system and volume sold to the end users. While measuring the losses it is best to use a group of indicators describing their magnitude and permitting for water losses monitoring. Its analysis is the base for starting renovations and repairs in the water distribution sub-system (Piechurski, 2014; Rak, Sypień, 2013; Studziński, Pietrucha-Urbanik, Mędrala, 2014).

Most important indicators are:
- PWS – percentage water loss indicator,
- RLB – real loss basic,
- NRWB – non revenue water basic,
- ILI – infrastructural leakage index.

PWS, which is determined by water balance, defines the share of water losses in comparison to water volume pumped into the system. Using PWS

only leads to inadequate results, because the indicator does not take into consideration important factors like: the length of water system or the number of service pipes. More precise indicators, which take additional factors into consideration are RLB, NRWB and ILI. They are recommended by International Water Association because they allow for reliable comparison of losses in accord with international norms. External water systems length or water meters' position can usually be easily obtained GIS numeric maps, if the water company has them.

RLB real water losses in reference to the length of the water system (when number of service pipes is lower than 20 pipes/km) or to the number of water pipes (when number of service pipes is greater than 20 pipes/km).

NRWB is based on the difference between water volume produces and water volume sold to the end users, (indicator of NOT sold water in %).

ILI allows to define the technical condition of the mains as well as the actions undertaken to reduce the water losses in the water system. It is a derivative of yearly RLB volume and yearly NRWB volume. Volume of inevitable losses consists of inevitable leakages in the external water systems(water mains, conduits) and service pipes. The volume of these losses is estimated as 18 dm^3/km/day/metre pressure for external water system conduits, as 0,8 dm^3/service pipe/day/metre pressure for service pipes to the border of the property and 25,0 dm^3/service pipe/day/metre pressure for service pipes from the border of the property to the main water meter.

Minimal night flow is nowadays used more frequently (flow between 1 AM and 5 AM). Knowledge of the characteristic features of the end user that could influence night consumption is essential for this indicator.

Experience of Cracow Water Company

Results of the research

Cracow water system is mainly built on ring plan (water conduits create close circuits) and its length with service pipes is around 2170 km – this will become bigger in time. The company enhances the infrastructure to allow access to the water system to all community citizens. The huge increase in the length of the water system (figure 2) occurred with the simultaneous sales decrease which has clearly caused the decrease of the indicator of the system overpower and increase of the economical level of leakages.

Despite the decrease of the indicator of the system overpower and its lengthening PWS in the last 10 years is systematically decreasing. It means that quantitative water losses are systematically decreasing with the increase of inevitable losses. It is obvious that water losses are proportional to the size
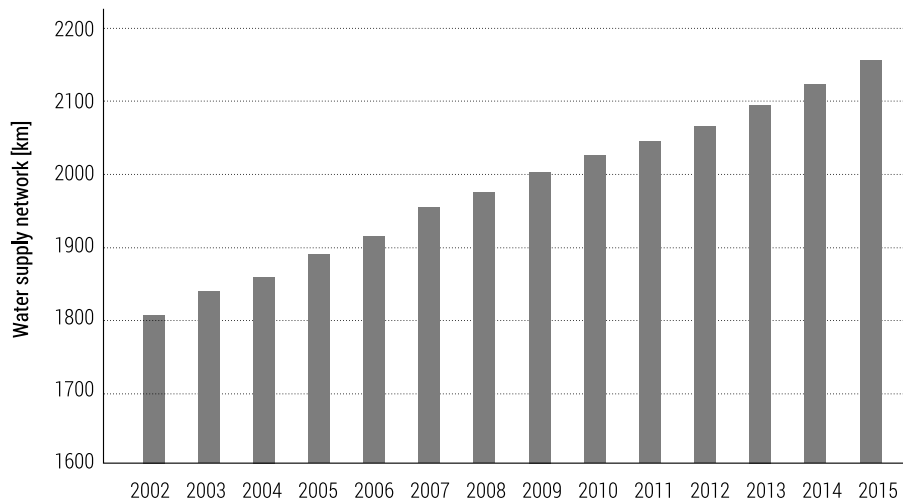
Figure 2. Chart showing the length of the water system with service pipes at the end
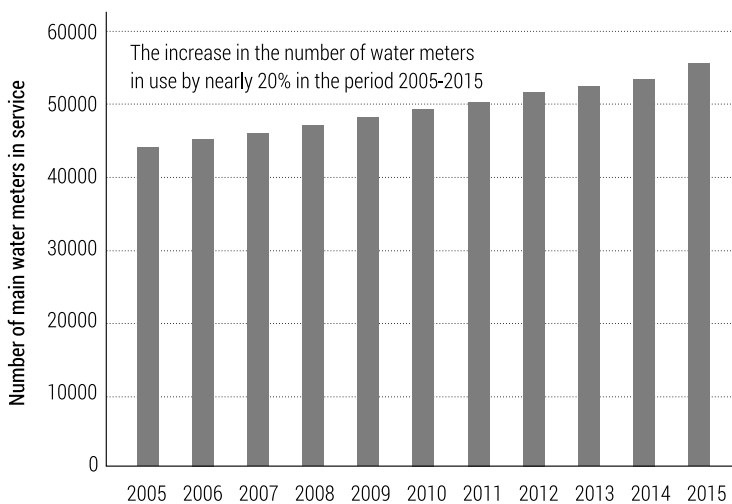of each year

Figure 3. Chart showing the number of main water meters used at the end of the year

of the infrastructure which causes that PWS in a growing water company
may naturally increase. Individual indicator is the volume of water losses per
km/per day. This indicator in Cracow Water company is decreasing through-
out the years which is a result of intensive, active water losses control and

monitoring. Number of water meters as well as the water systems' length (figure 3.) shows the scale of growth of the water supply system.

Infrastructure growth combined with sales decrease causes the change of indicator showing the sale per water meter what is depicted on figure 4.
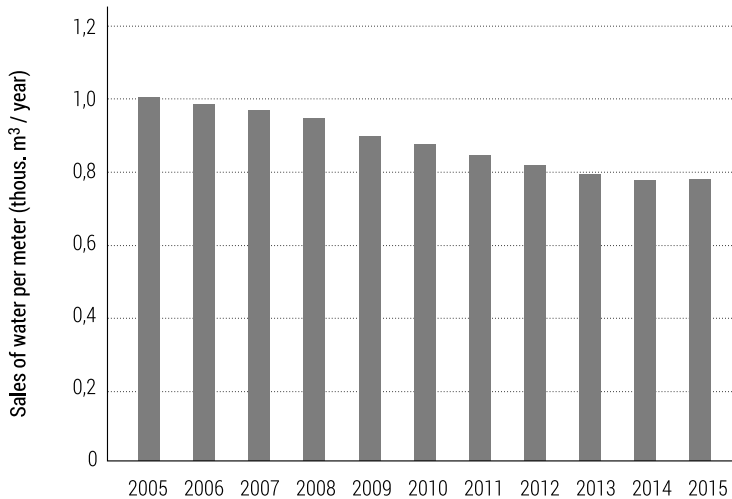

Figure 4. Indicator of sale per water meter

Company's efforts which reduced the total volumes of water losses are even greater when compared to the growth of infrastructure in time. Figure 5 shows RLB calculated on the basis of the data published by the company. RLB for 2002 till 2015 greatly decreased. The chart shows a steady decrease (over 30% in 13 years) of the water losses per km per day indicator with simultaneous decrease of the water system load.

Water losses per service point are similar, as the number of service points has increased by 10 000.

Water losses reduction on the Cracow Water company distribution sub-system is a priority task, successively realised during the last years.

Main action undertaken by MPWiK SA in Cracow are:
• monitoring water system tightness;
• active leakage control;
• fast reaction to failures and their swift removal;
• pressure optimisation;
• examination and changes of water meters;
• adjusting water meters' diameter to the flow rate in the system;
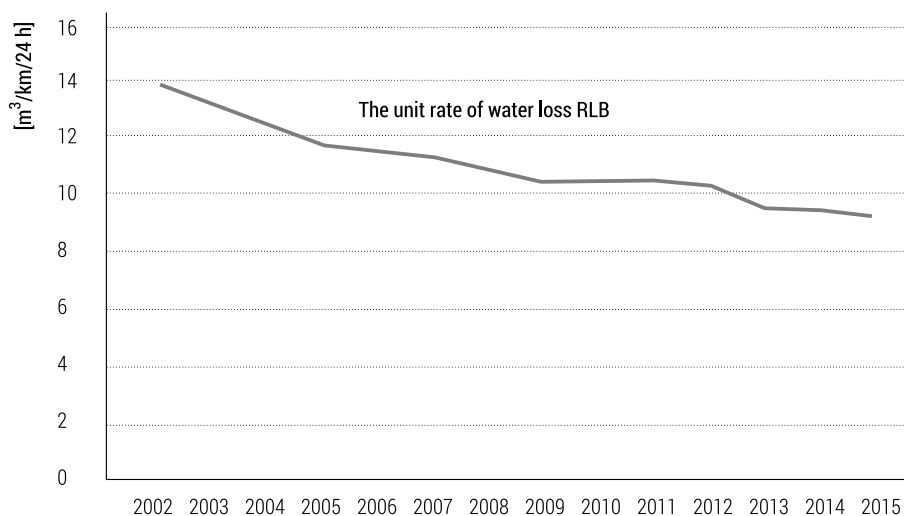• installing water meters in the areas of the system.

Figure 5. Water losses indicator 2002–2015

Apart from RLB reduction, the company devotes much time to reducing apparent water losses. The company uses volumetric water meters from the highest metrological classes, resistant to unauthorized interventions e.g. using neodymium magnets, pressing the abacus, equipped with overlay detecting potential alarming condition of the water meter e.g. reverse flows or blockade. Special attention is paid to legalisation terms, cyclic water meters exchange, proper installation as well as flow profile capturing to determine the best diameter and metrological class of the water meter in a given typical building.

Additional research concerning the metrological parameters of water meters throughout exploitation period and after it is being conducted. The research's main aim is to choose the best water meters, which keep proper metrological parameter throughout exploitation period and concern meters removed after reporting a failure or complain as well as meters after legalization period.

Well chosen water meters are necessary to ensure minimal apparent water losses. The danger of apparent water losses increases if meters are oversized at the end users point. Following actions aim to eliminate it:

• Observing current readings (average daily consumption) as parameters to optimise the diameter of water meters;
• Lowering water meters' diameters in the process of change to legalisation;
• Creating current norms of choosing water meters for new buildings.

Increase of water meters with lowest diameter is an effect of adjusting water meter diameter to flow rates in end users' installations. Increase in this water meters group is greater than the one coming from overall increase of exploited water meters shown in pic. 6.

The most effective action to reduce water losses is creation of metered areas in the water supply system which include a few thousands end users. Cracow water system has a few of such areas created naturally (e.g. hydrophore areas) as well as areas created by construction and installation of a few dozens of measuring units.

Currently, thank to integrating the billing system with GIS water meters installed in end users places are or can be assigned to junction supply points creating multi level structures. The billing system calculates average day usage of a given water meter from every reading. Basing on the values from average day usage it is possible to calculate the water balance for a given area through comparing the sum of all average day usage values from a given area with the average day usage reading measured at the junction supply points. Such a balance cannot be the tool used for fast failure detection, but it is used to chose the areas requiring further analysis to reduce water losses and optimise the system.

It concerns both RLB (mainly leakages) as well as apparent water losses caused by metrological features of the installed water meters.
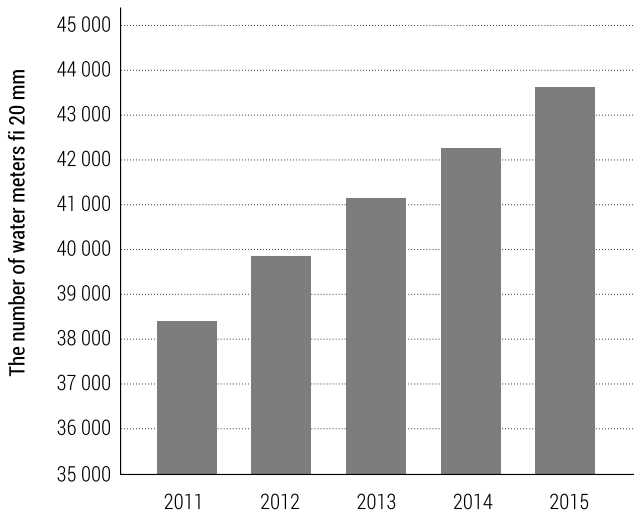

Figure 6. Chart showing the number of 20 mm diameter water meters
            at the end of the year

Another point in water losses reduction will be using water meters over-lays allowing for distant GSM readings. It will allow to collect water meter readings on daily basis and will become a tool used to conduct real time water system balancing in 24 hours periods. Thank to such a technology water supply companies will gain new quality in conducting research over the risk of water losses occurrence. Pilot works are being carried out to intro-duce such readings in chosen areas.

Such a system will provide a constant, successive control over water losses and maintaining them at the inevitable losses level.

Conclusions

Water losses in the system are, unfortunately, inevitable and their level in different systems may vary from a few to a dozen of per-cents, but they have to be evaluated individually paying special attention to the systems' size. Level of water losses in Cracow water company is acceptable when we take into consideration the fact that cost to avoid water losses should not be higher than the losses themselves. The real aim of water losses reduction is to reduce the financial losses of the company.

That is why currently, in accord with IWA (International Water Associa-tion) standards we more often use economical leakage level than PWS. The main element of economical leakage level is the volume of the so called inev-itable losses counted per kilometre of the system and per service pipe.

To serve the areas properly it is necessary to implement special software with its own data base which will include the data from all of the readings. Data from this software must constantly exchange with billing systems and GIS. The application must resemble the structure of supply trees in system's areas. The software should include an algorithm calculating the average daily usage from supplied readings. Every incoming reading should be compared with the predicted value. If deviation is greater than a given threshold, it is a signal to carry out additional analysis in the given area.

Apart of the actions resulting from water meter readings continuous analysis of minimal night flow and deviation from the given parameters are carried out. Data from such analyses are used for early warnings about leak-ages.

In the process of water meter readings carried out for invoicing purposes, additional analysis of every case of increase or decrease in water meter read-ings is done in every invoicing period. Such an observation relies on counting the predicted usage from average daily usage. If the next reading is different from the predicted by a value greater than the given threshold value than the

given end point is controlled. Those actions are aimed to eliminate damaged water meters as well as prevent unauthorised interventions into the devices.

The contribution of the authors

Tomasz Cichoń – 50% (conception, literature review, acquisition of data, analysis and interpretation of data)

Jadwiga Królikowska – 50% (conception, literature review, acquisition of data, analysis and interpretation of data)

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