BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Volumul 63 (67), Numărul 3-4, 2017
Secția
HIDROTEHNICĂ

# THE ANALYSIS OF "WATER LOSS" PHENOMENON FROM PIPE NETWORKS

BY

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Received: August 25, 2017
Accepted for publication: September 28, 2017

**Abstract.** In recent years, the issue of water losses has become a priority for the water supply systems' management . Water losses occur on the system's ensemble: distribution network, adductions, tanks etc. They have reached values amounting to 50%,...,60% of the water entered into the supply system. The phenomenon is found both globally and nationally, where it is analysed and interpreted by laws, regulations and standards. Losses from water supply systems occur under physical or apparent form and influence the cost price. The control of the water loss phenomenon from pipe networks is a complex and lengthy process**.**

**Keywords:** physical and apparent water losses; pipe degradation; metering.

## 1. Introduction

The water loss phenomenon is a national and international priority. The concerns of International Water Association (IWA) and Romanian Water Association (ARA) in the last years demonstrates the necessity to adopt proper

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measures to address this issue. The control agencies examine the current state of the water supply systems and outline directions which the water-sewerage agencies must follow.

The water supply system performances can be improved through a series of actions implemented by each operator. Mainly, they concern the establishment of water loss detection departments, equiped with leak detection and measuring devices. Major investments in network rehabilitation and replacement also have a significant impact on the system's performance. Another aspect which must be developed is the metering of the water supply system's components.

## 2. Research Material and Methods

The material used for the documentary study and field research is composed of the water supply system ensemble: source, adduction, tanks, treatment plant etc. The highest water loss values are registered from the adductions, storage tanks and distribution networks. Considering this, the documentary study focused on highlighting the water loss from these components.

The study analysed pipe materials, particularly steel, cast iron, HDPE, reinforced concrete and composite materials such as GRP (PAFSIN) and HOBAS. The analysis took into consideration the site's geotechnical conditions, conveyed water quality, embedding environment groundwater quality, operational process parameters and some consumer water distribution management specific features.

The research methodology aims to highlight and analyse the water loss occurring in a settlement's complex water supply system ensemble. The research methodology consists of the following components:

a) documentary study regarding the types of water loss which can occur in the water supply system's structural components;

b) characteristic parameters of the "water loss" phenomenon occurring in the water supply system's various structural components (adductions, distribution pipes, tanks, water treatment plants etc.);

c) pipe material parameters and characteristics, which influence the water loss;

d) pipe embedding environment parameters and characteristics;

e) water loss field experimental study using bursts occurring on the pipe networks, operational activity accidents etc.;

f) laboratory experimental study using physical models, numerical models etc.

The research methodology uses a series of computing software, graphics and mathematical processing programs. Thus, water loss analysis uses statistical computer software, water loss mathematical models, graphical representations, digital data processing etc.

## 3. Results on Iaşi Distribution Network Water Losses Analysis

### 3.1. Analysis Elements

The water balance is one of the methods used to express the percentage of non revenue water (NRW). Water supply companies can evaluate the system's performances by identifying the water balance components and therefore establishing proper solutions to their needs. This methodology was developed by IWA and is based on the following tabulated form:

**Table 1**
*Water Balance Components* (Lambert & Hirner, 2000)

<table>
<tr><td rowspan="8">System input volume</td><td rowspan="2">Authorised consuption</td><td rowspan="2">Billed authorised consumption</td><td>Billed metered consumption</td><td rowspan="2">Revenue water</td></tr>
<tr><td>Billed unmetered consumption</td></tr>
<tr><td rowspan="2">Unbilled authorised consumption</td><td>Unbilled metered consumption</td><td rowspan="6">Non revenue water (NRW)</td></tr>
<tr><td>Unbilled unmetered consumption</td></tr>
<tr><td rowspan="4">Water losses</td><td rowspan="2">Apparent losses</td><td>Unauthorised consumption</td></tr>
<tr><td>Customer metering inaccuracies</td></tr>
<tr><td rowspan="3">Real losses</td><td>Leakage on transmission and distribution mains</td></tr>
<tr><td>Leakage and overflows at storage tanks</td></tr>
<tr><td>Leakage on service connections up to the point of customer meter</td></tr>
</table>

Measurement errors of the equipments used have a major impact on the recorded data. The operators rely mostly on flow metering data to determine the conveyed and delivered water volumes. The measurement accuracy of flow meters is limited by the equipment's technical characteristics and it varies widely depending on the type of flow meter used. The equipment stops recording real values under its sensitivity thresholds, indicating a flow rate of 0 $m^3/s$. Therefore, it is up to the operator's ability and experience to recognise the existence of water loss in the pipe network.

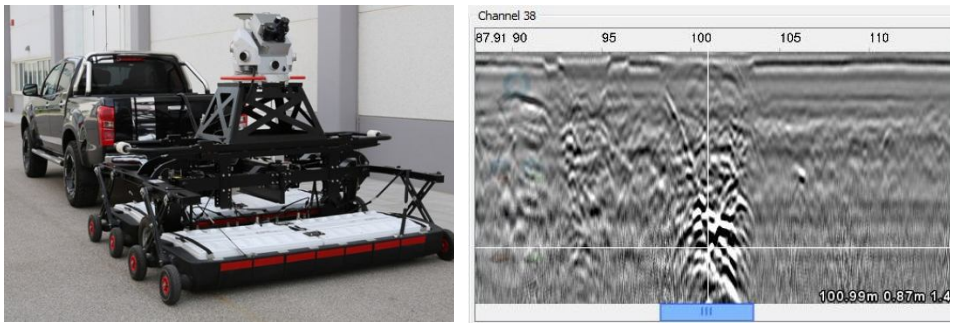
### 3.2. The International Context

Potable water supply services are regulated at international level in various forms. The issue of increasingly severe shrinkage and pollution of water sources and the need to protect them led to laws and water loss mitigation measures implementation. In the United States of America, Georgia state Senate passed a law which encourages efficient water usage. In Tennessee, the state has regulated the water loss aspect and Texas state Senate decided that all public water companies must establish network audits and report the results.

The IBNET report (Danilenko *et al*., 2014), reflecting the performances of water supply systems from 102 countries, revealed that NRW ranges from minimum values of 11% in Australia and maximum values around 65% in Albania. The large gap between these values shows the need for investments in infrastructure, equipment and personnel training to reduce this difference.

### 3.3. The National Context

In recent years, Romanian water supply companies have started to increase their water loss reduction actions. Operators have gone from the water balance to the implementation of IWA methodology. Regional operators have diversified their methods of water loss detection. In addition to night flow and pressure measurements and the use of acoustic equipments, companies have started to use hydraulic modelling software, genetic algorithms, satellite detection or equipments such as ground penetrating radars (Fig. 1).




*a* *b*

Fig. 1 – Water loss detection using ground penetrating radars: *a* – detection equipment; *b* – ground surface scanning results diagram.

During 2012, the European Bank for Reconstruction and Development (EBRD) ran a benchmarking program for Romanian water supply companies. According to the results, the average NRW percentage is 48.3%, ranging between 21.0% in Buzău county and 68.0% in Botoşani (Racoviţeanu G. et al., 2015). The elevated national average shows the need and urgency of investments into water supply systems supervision.

### 3.4. Case Study in Iaşi County

S.C. APAVITAL S.A. regional water supply company operated at the end of 2016 over 2293 km of distribution networks and 871 km of adductions. The water supply system serves 435570 people in the operational area, as shown in Fig. 2 (S.C. APAVITAL S.A., 2017b).

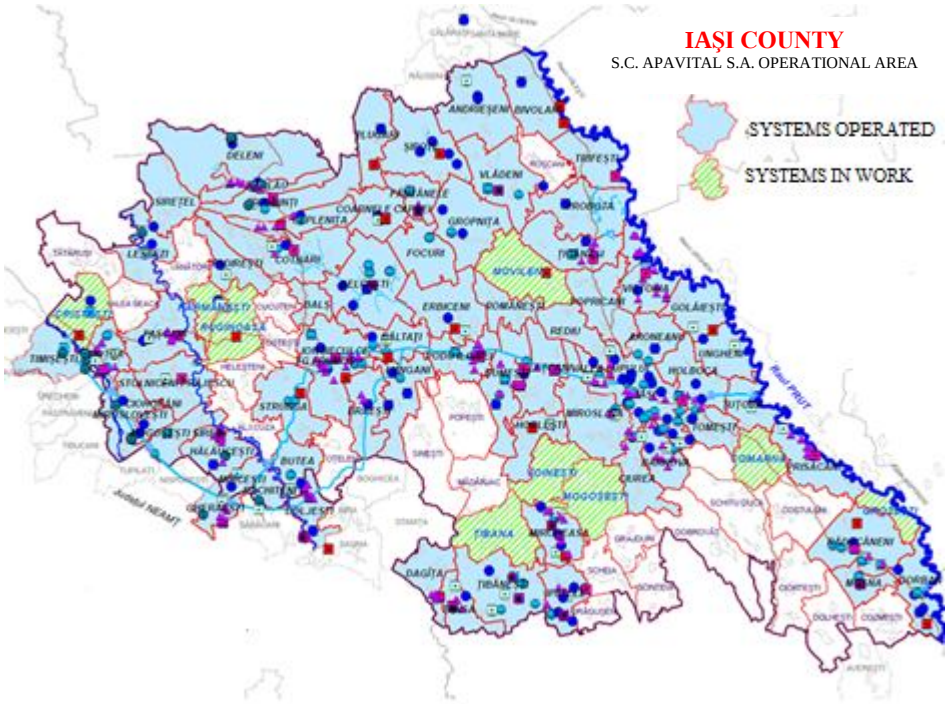



Fig. 2 – S.C. APAVITAL S.A. operational area (S.C. APAVITAL S.A., 2017b).

The company's 2016 performance report (S.C. APAVITAL S.A., 2017a) indicates a number of 7451 bursts, including 2660 in the metropolitan area and 4791 in the county area. The percentage of physical water loss on the entire operational area varies from very low values in regions with small distribution networks (0.10% in Brăeşti commune), up to very high values (Sirețel commune: 71.17%). Iasi municipality recorded losses of 30.93%, the average value in the operational area being 30.41%. The metering level achieved in 2016 amounts to 99.74%.

In recent years, several projects have been launched, many of which contributed to the system's water loss reduction. The implementation of "Extension and rehabilitation of water and wastewater in Iaşi county" project has led to a reduction on water loss from 59% to 47.87%. A complementary investment program further decreased the loss percentage to 30%.

S.C. APAVITAL S.A. Iaşi regional operator has taken a series of actions to decrease water losses (Doruş M. et al., 2015). These include GIS and SCADA systems implementation, networks hydraulic modelling, establishing district areas for consumption and night flow monitoring and the creation of a network analysis compartment.

Fig. 3 – Electromagnetic flowmeter fitted to a 400 mm diameter steel pipe inside Cerna pumping station, Iaşi.

The water volume introduced in Iaşi metropolitan area has decreased by 23% during 2013 – 2015 (from 3,981,750 $m^3$/month to 3,049,256 $m^3$/month) due to the strategies and investments carried out. Finally, the volume of water losses have decreased, from 27,720,520 $m^3$ during 2013 to 18,379,731 $m^3$ in 2014. These values prove the effectiveness of the measures established.

Fig. 4 – The replacement of a 600 mm diameter GRP (PAFSIN) pipe section in Mirosloveşti locality, Iaşi county.

The paper of Luca et al. (Luca *et al.*, 2015) highlights the extent of water losses from Iaşi county's operated adduction pipes. For Timişeşti – Iaşi adduction pipes, the following data are presented:

a) adduction pipe I was put into service in 1911, has a length of 105 km, diameters varying between 600,...,800 mm and is made of cast iron, steel and reinforced concrete;

b) adduction pipe II was put into service in 1973, has a length of 104 km and is made of steel and prestressed concrete tubes with 1000 mm diameter;

c) adduction pipe III was put into service in 2001, has a length of 37 km and is made of 800 mm diameter steel tubes.

The research revealed important issues regarding the adductions' performance at Moldova River undercrossing area in Soci locality. The adduction pipe I was affected by the riverbed's morphological alteration and by the materials' physical decay due to the extended operating period. The inlet and outlet valve chambers of adduction pipe II have been exposed to external factors and the hydraulic system revealed evidence of advanced degradation. Studies conducted in the last 15 years have shown the continuous degradation of the undercrossing's hydraulic structures, which have led to water losses from the three adduction pipes.

The rehabilitation works proposed for the adductions's undercrossings are difficult to carry out, given the hydrological regime and riverbed instability. The hydrotechnical structures' sizes and pipe diameters require special execution technologies. In order to reduce the water loss volumes, extensive rehabilitation works are recommended, because the proper performance of adduction pipes leads to a more effective water supply system. The rehabilitation project for Moldova River undercrossing constructions was completed in 2013 and in 2015 the works on the three adduction pipe sections were executed (Luca *et al*., 2012). This has contributed to the limitation of water losses from the three adduction pipes.

## 4. Conclusions

1. Water losses are present in all of the water supply system's structural components (adduction, distribution network, tanks, treatment plant etc.) and their value must be limited so that they do not influence the cost price.

2. Water losses must be limited through the rehabilitation of old pipes, tanks, valve homes' hydraulic systems and by using efficient materials for the water supply system components.

3. Water losses should be limited by using effective metering for the water volumes conveyed through networks and the ones provided to costumers.

4. The limitation of water losses from distribution networks must be carried out from design and execution phases through the use of methods, materials and technologies adapted to the site.

5. Water loss limitation contributes to an effective water supply system management, reduces the cost price and protects the water sources.

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## ANALIZA FENOMENULUI „PIERDERI DE APĂ" DIN REȚELELE DE CONDUCTE

(Rezumat)

Problematica pierderilor de apă din sistemele de alimentare cu apă a devenit o preocupare prioritară a companiilor de distribuție a apei în ultimii ani. Pierderile de apă se manifestă pe ansamblul sistemului: rețele de distribuție, aducțiuni, rezervoare etc. Acestea au ajuns la valori reprezentând 50,...,60% din volumele de apă intrate în sistemele de alimentare. Fenomenul se regăseşte atât pe plan mondial, cât şi pe plan național, iar acest aspect este analizat şi interpretat prin intermediul legilor, normativelor şi standardelor. Pierderile de apă din rețelele de conducte se manifestă sub formă fizică sau aparentă. Combaterea fenomenului de pierderi de apă din rețelele de conducte este un proces complex şi de durată.