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PRESSURE MANAGEMENT FOR LEAKAGE REDUCTION IN WATER DISTRIBUTION SYSTEMS

BY

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Abstract. As a response for water losses in urban water supply networks, the pressure management has become now, one of the most effective method in order to reduce the leakage part of non-revenue water (NRW). The implementation of pressure management has as main objectives besides reducing leakage, reducing bursts frequency and extending the life of the infrastructure. Therefore, in order to improve the water distribution systems, this paper presents the advantages of pressure control and optimization for water distribution using pressure reducing valve (PRV). The main purpose of using PRV is to provide uniform distribution of the pressure and decreasing of the excessive pressure on the water system, reducing the water leakage and energy consumption accordingly. Reducing average and maximum excess pressure by only 10% produces a reduction in leakage, reduction in pipe bursts, deferred renewal and extension of residual asset life, as well as energy savings.

Keywords: water losses, pressure management, PRV.

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1. Introduction

The aim of the drinking water distribution network is to supply the consumer with water in the right quantity and pressure and it is not simple to accomplish because of the complexity of the network connections and the geometric complexity of the network.

To decrease water losses, pressure management techniques have been submitted as a qualified variable of the leakage indicator, for which the enforcement of elements that generate pressure losses, such as pressure reducing valves (PRV) has been indicated.

Pressure management can be realized through the performance of pressure reducing valves (PRV), which can be regarded as an streamlining problem with specific purpose functions and restrictions.

As a consequence, it is imperative to optimize the pressures in the distribution network to prevent damage to the pipelines that provide economic losses for the public municipal company of drinking water of the Iași city. The purpose of this study was to assess the leakages decreasing by optimizing the pressure through the introduction of pressure reducing valves (PRVs).

The overall aims of pressure management for leakage reduction are three-way (Fanner *et al*., 2007; Mutikanga, 2012):

1. Decrease environment leakage which is acoustically undetectable seeps at pipe joints and minor cracks. It cannot be cheaply remedied on an individual basis.
2. Decrease the frequency of new leaks and breaks which appear on mains and service connections, due to weakened stress on the pipes.
3. Decrease the flow frequency from any leaks and breaks.

The most usual procedures of pressure management contain developing zone boundaries, specified outlet pressure control valves, pump and level command, time modulated command valves and flow modulated command valves (Ferrarese and Malavasi, 2020). Nevertheless, one of the most common and successfull method is using pressure reducing valves (PRVs), (Fontana *et al*., 2020).

2. Case Study in Iaşi City

2.1. Study area

The study area is a district measured area (DMA) in Iași (Fig. 1). The drinking water distribution network is fed from a 500 m^3 capacity tank (located at elevation 201 m), which discharges by gravity through a Ø 110 mm conductive pipeline, after which it branches out into Ø 50 mm pipelines to the furthest reaches. The pipelines throughout the network are made of HDPE with a length of 8400 m. The nominal diameters of the existing pipelines are 50, 63, 75, 90 and

110 with lengths of 743 m, 1128 m, 235 m, 329 m and 5965 m respectively. There are currently 22 valves, among which are five pressure reducing valves (PRVs).

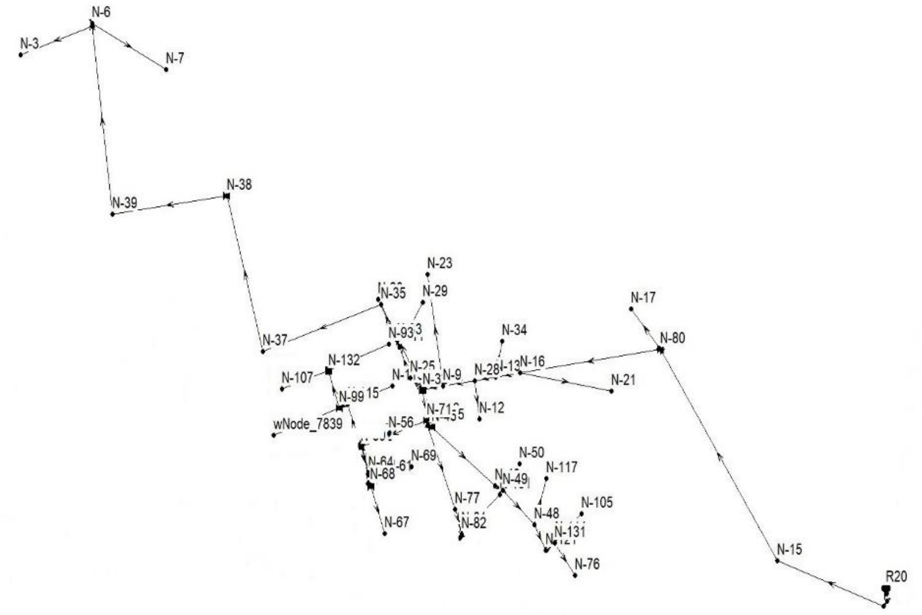

Fig. 1 – DMA existing piping system.

2.2. Hydraulic model

The hydraulic model of the network analysed was arranged following five consecutive phases directed at modeling a water distribution system: building of a network model, allocation of distribution network parameters, allocation of consumptions, calibration of the model and study and maintenance of the model (WRC).

The model was calibrated by fitting the value of the roughness coefficient, demand in the nodes, as good as in the minor loss coefficients of the valves, the stages were replicated until they had an closeness with the system reality.

2.3. Optimization of hydraulic network

Water losses in the network can be reduced by dint of distinct techniques, including the reduction of surplus pressures (Gupta *et al*., 2017).

The process of convenient pressures maximization seeks to check the pressure series determined by the irregular topography of the ground, locating the possible pipelines where it is practicable to install pressure regulating valves

(PRV), when taking into consideration the unit power, the most practicable pipeline can be identified where the PRV can be applied.

Consequently, the analysis centered on the optimization of energy decreasing in the system, through the installation of PRV, for which areas that had pressures higher than those laid down were identified.

The DMA was analyzed using WaterNetGen, an EPANET extension for automatic Water Distribution Network models generation.

The network simulation software need to fulfill three essential concepts to determine pressure and balance the flow within the model, energy and mass balance and at the same tine flow and head loss must be coherent with the suitable velocity-head loss equation.

PRVs are tools that are placed in strategic points in the network to reduce the number of leakage by decreasing pressure (Samir *et al*., 2017). PRVs keep up the pre-set downstream pressure disregarding of the upstream pressure. Valves are generally installed within a district metered area (DMA), they must be downstream of the flow meter in order that turbulence from the valve does not affect the precision of the meter.

Base scenario: the pressure reduction valves weren't used in this scenario. The pressure was monitored and the Figs. 2 and 3 show the pressure values in nodes (metres of water), at peak hours when water consumption is maximum (19:00 hours) and respectively at midnight when consumption is minimum (00:00 hours). The pressures calculated for network nodes, include values greater than 60 metres of water (the maximum pressure that is to be allowed in a water supply system), in a lot of nodes.

High pressures infleuence the pipeliness nearby to the nodes where the pressure is higher than permitted, with a high possibility for the appearance of leakages (unnatural operation). Pressure management can decrease pipeline leakages, at the same time as preventing potential bursts.

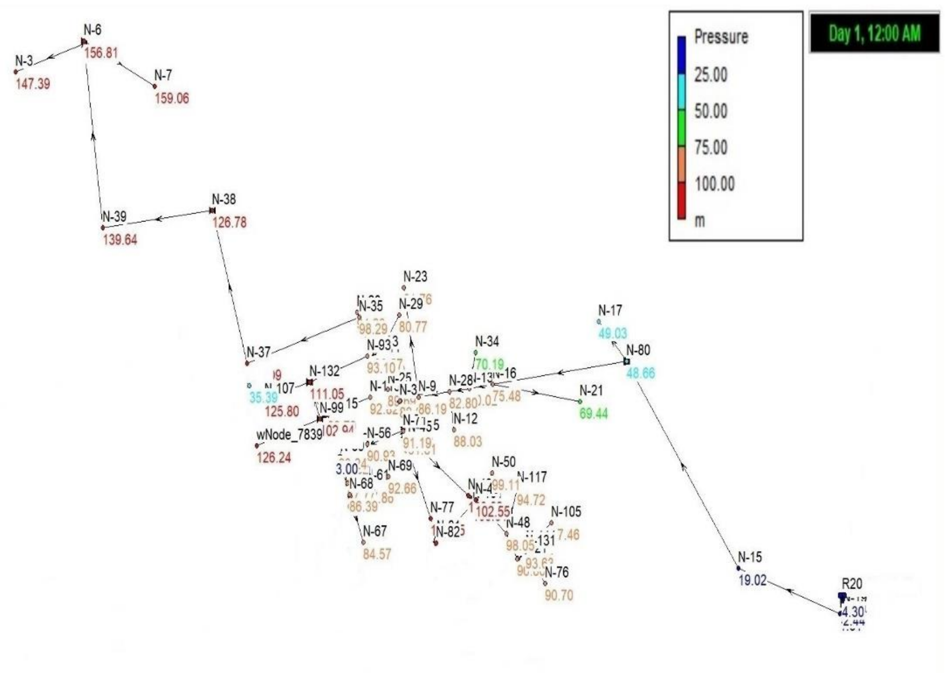

Fig. 2 – Pressure variation in network at midnight (00:00 hours).

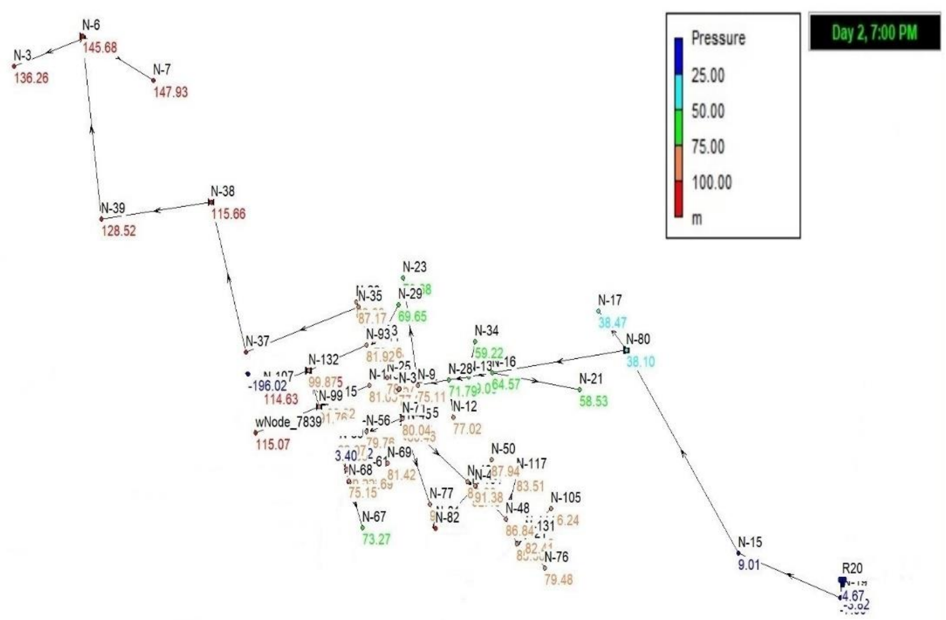

Fig. 3 – Pressure variation in network, at peak hours (19:00 hours).

In accordance with the results presented, the need to implement five PRVs was established, since the sector has independent zones in the lower part of the network, the installation of five pressure reducing valves (the PRV-1 is placed on the N8-N22 section, PRV-2 is placed on the N31-N2 section, PRV-3 is placed on the N27-N1 section, PRV-4 is placed on the N18-N38 section and PRV-5 is placed on the N70-N71 section). PRVs were set up to constant pressure 20 m and maintain preset downstream pressure regardless of upstream pressure.

Figs. 4 and 5 show the pressure variation (metres of water) in all nodes of the water supply network for the two time intervals, adopting the location of the five pressure relief valves.

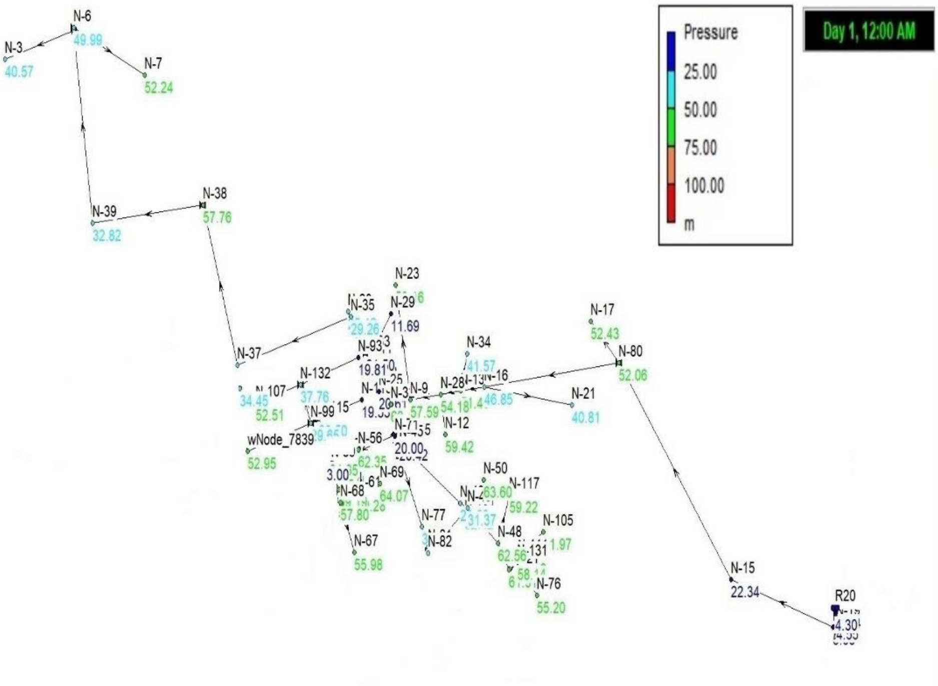

Fig. 4 – Pressure variation (metres of water) at midnight (00:00 hours), when pressure reducing valves are installed.

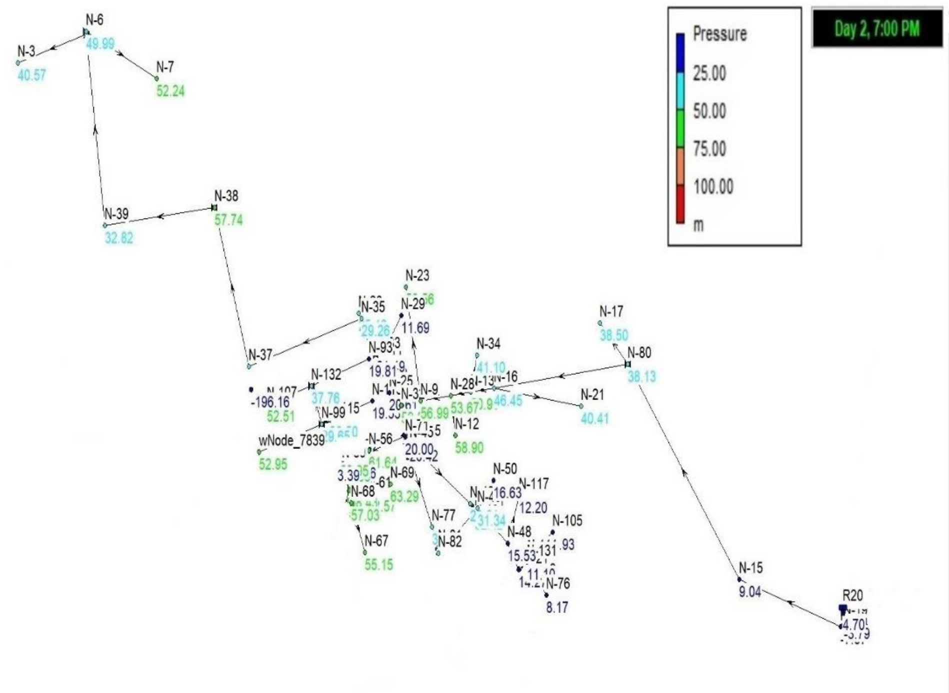

Fig. 5 – Pressure variation (metres of water) at peak hours (19:00 hours), when pressure reducing valves are installed.

3. Conclusions

For the distribution system analyzed, the efficiency and performance of this were simulated with EPANET. Excessive pressures were identified in the lower part of the network, indicating the need to install five PRVs in order to ensure adequate pressures.

Pressure management, using the pressure reduction valves is a succesfull method to control the number of leakage in water distribution system.

The water losses volume would reduce at the time of maximum pressure by 33% if the pressure will be optimized by installing five PRVs.

This approach offers improved system performance and can be extended to other DMA across Iași demonstrating successful results for water networks.

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MANAGEMENTUL PRESIUNII PENTRU REDUCEREA PIERDERILOR ÎN SISTEMELE DE DISTRIBUȚIE A APEI

(Rezumat)

Ca răspuns la pierderile de apă din rețelele urbane de alimentare cu apă, gestionarea presiunii a devenit acum, una dintre cele mai eficiente metode pentru a reduce partea de pierderi a apei fără venituri (NRW). Punerea în aplicare a managementului presiunii are ca obiective principale, pe lângă reducerea pierderilor, reducerea frecvenței acestora și prelungirea duratei de viață a infrastructurii. Prin urmare, pentru a îmbunătăți sistemele de distribuție a apei, această lucrare prezintă avantajele controlului și optimizării presiunii pentru distribuția apei folosind vanele de reducere a presiunii (PRV). Scopul principal al utilizării acestora este de a asigura distribuția uniformă a presiunii și scăderea presiunii excesive în sistemul de apă, reducând corespunzător pierderile de apă și consumul de energie. Reducerea presiunii excesive medii și maxime cu doar 10% determină reducerea pierderilor, reducerea avariilor la conducte, neînlocuirea acestora înainte de termen și extinderea vieții reziduale a activelor, precum și economii de energie.