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PRELIMINARY FINDINGS ON PRV ANOMALIES IN A REAL DISCRICT METERED AREA

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ABSTRACT

Pressure Reducing Valves (PRVs) are vital components in water distribution networks (WDNs), ensuring effective pressure management to improve network efficiency and reduce water loss. This paper examines the behaviour of a PRV installed on a branch from a DN1300 transmission main serving the Villaggio del Pescatore Pressure Management Area (PMA), which has exhibited abnormal pressure fluctuations. Initial field tests revealed significant pressure variations exceeding 10 meters, with amplitudes reaching nearly 20 meters at both upstream and downstream points. These fluctuations were most prominent during periods of low flow, such as nighttime. The findings highlight the importance of careful PRV placement and response calibration to minimize risks of instability and enhance network reliability.

Keywords: Pressure Reducing Valve (PRV); transients; Water Distribution Network (WDN); pressure management; leakage reduction; District Metered Area (DMA).

1. Introduction

Pressure Reducing Valves (PRVs) play a critical role in the operation of water distribution networks (WDNs). These devices are commonly deployed to manage pressure levels, enhancing network efficiency and service quality, and significantly mitigating water loss due to leakage. Since leakage rates are directly influenced by pressure levels in pipelines, the use of PRVs for pressure management is an effective strategy for reducing water loss. A typical approach for pressure regulation involves segmenting the network into District Metered Areas (DMAs) where PRVs control the pressure at strategic entry points.

PRVs can exhibit significant instabilities under specific flow conditions, which can impact the overall performance and reliability of water distribution systems (Ulanicki and Skworcow, 2014; Marsili et al., 2020; Meniconi et al., 2016, 2017). These instabilities often manifest as pressure oscillations or fluctuations that can lead to adverse effects such as increased wear on infrastructure, compromised valve efficiency, and potential water loss. The behaviour and stability of PRVs are influenced by a range of factors, including flow velocity. Furthermore, improper or suboptimal settings of PRVs, such as overly reactive pilot responses or inadequate check valve adjustments, can exacerbate these issues, amplifying pressure surges and transient events (Ferrarese and Malavasi, 2022). Ensuring optimal PRV configuration and considering the specific flow conditions they operate under are critical for minimizing operational risks and maintaining network integrity.

This research investigates the performance of a PRV installed on a branch of the DN1300 transmission main that supplies the Villaggio del Pescatore district (Capponi et al, in press). This specific PRV has demonstrated unusual behaviour, resulting in significant pressure fluctuations, potentially compromising the integrity of the pipeline and service reliability for users.

2. Overview of Trieste's Water Supply System

Field tests were conducted in the water supply system managed by AcegasApsAmga S.p.A., part of the Hera Group. Trieste, located in northeastern Italy, faces unique water supply challenges due to its karst landscape, which lacks surface water resources and has significant altitude variations.

Trieste's water supply system relies on two main transmission mains: the DN900, built in 1929, and the DN1300, constructed in the 1970s with a submerged section under the Gulf of Trieste. These pipelines supply the city and nearby areas, including the Villaggio del Pescatore, a small town known for its marina. High pressures of up to 8 bar necessitated the installation of a pressure reducing valve (PRV) to safeguard the local distribution network.

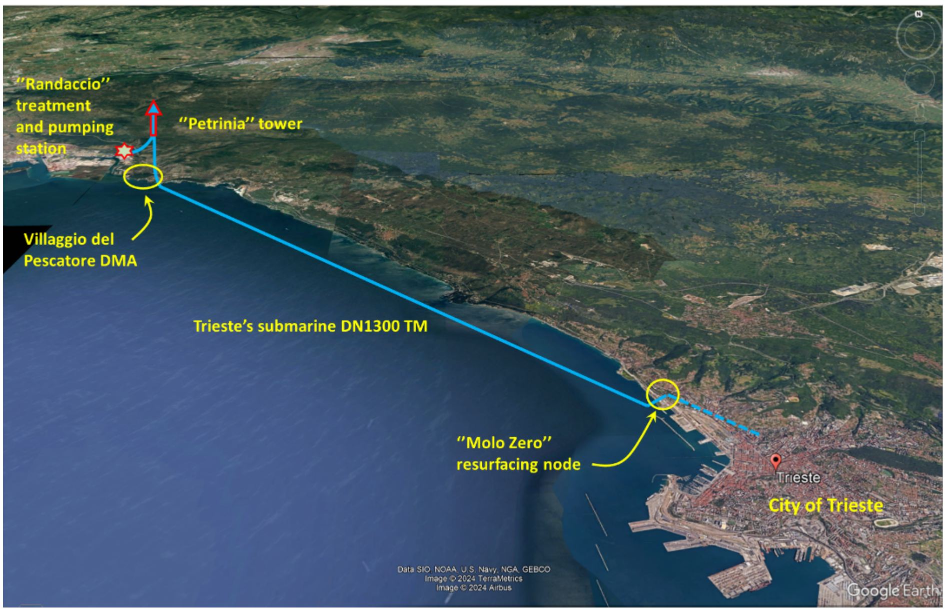

Fig. 1. Route of the DN1300 Transmission Main with the Indication of the Villaggio del Pescatore District

3. Preliminary field tests results and discussion

Preliminary field tests aimed to identify the source of increased leakage in the Villaggio del Pescatore district. High-frequency data loggers were positioned at key points upstream and downstream of the PRV, as well as at a user connection 448 meters downstream along the DN1300 TM. Results from the 24-hour monitoring period highlighted pronounced pressure oscillations, exceeding 10 meters from the PRV's pilot setting, with amplitudes approaching 20 meters at both the upstream and downstream measurement points. The oscillations were more pronounced during periods of low demand, particularly at night.

Subsequent frequency-domain analyses revealed high-frequency pressure spikes with harmonics indicating waves trapped within the short segment between the PRV and the DN1300 TM. The data suggested that the PRV's location, approximately 6.3 meters from the main junction, contributes to these oscillations. Adjustments to the PRV's check valve led to a reduction in the amplitude of pressure fluctuations, particularly during peak transient events.

Further monitoring and analyses confirmed that while these adjustments improved stability and reduced the intensity of pressure spikes, high-frequency oscillations persisted, indicating that the valve's rapid reactivity to pressure variations might still pose risks to network stability.

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