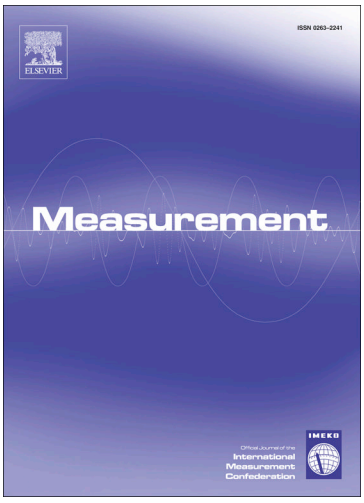

Leak detection of water distribution pipeline subject to failure of socket joint based on acoustic emission and pattern recognition

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Leak detection of water distribution pipeline subject to failure of socket joint based on acoustic emission and pattern recognition

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Abstract. Early leak detection is of great importance for life-cycle maintenance and management of municipal pipeline system. Due to economic and technical efficiency, ductile iron pipe segments and socket joints are widely used in practice to construct water distribution systems. The ductile configuration of the socket joint allowing for large deformation constitutes the most common cause for water leakage. Using acoustic emission (AE) techniques, this paper presents an experimental study on leak detection of a water distribution system subject to failure of socket joint. The acoustic characteristics of leak signals in the socket and spigot pipe segments are investigated. After feature extraction and selection, a classifier based on artificial neural network (ANN) is established. It has been validated that the dominant frequencies of the AE leak signals due to the failure of the socket joint concentrate on 0~10kHz. The proposed ANN-based method can achieve good estimation accuracy of 97.2% and 96.9% by using the feature set {Peak, Mean, Peak Frequency, Kurtosis} and {Mean, Peak Frequency}.

Keywords: water leak detection, socket joint, acoustic emission, pattern recognition, artificial neural network

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1. INTRODUCTION

As a major municipal infrastructure to deliver water with appropriate quality, quantity and pressure, water distribution pipeline plays an important role in modern society. A serious issue existing in the daily operation of the water supply system is leakage, which may cause considerable cost difference between production and sale of water and even pose a threat to public safety. Early detection and precise location of leakage is of great importance for life-cycle maintenance and management of widely-distributed pipeline system.

Many methods have been proposed for leak detection in water pipes, including visual inspection, electromagnetic methods, acoustic methods, ultrasound methods, radiographic methods, and thermography methods (Liu & Kleiner, 2013). In the past few years, acoustic emission (AE) techniques have demonstrated to be an excellent tool for on-line leak detection given the fact that the leakage can release elastic energy in form of transient stress waves and generate the signals representative of the abnormal AE events (Dipen, 2005; ASTM, 2011). Many efforts have been made to investigate acoustic features of leakage source, propagation characteristics of acoustic waves along pipelines, and the relation of AE signals with different parameters like leakage rate, propagating distance, material and geometric properties of pipelines, operating conditions etc. (Gao et al., 2004, 2006; Brunner and Barbezat, 2006; Yang et al., 2008; Tang et al., 2009; Khulief et al., 2012; Juliano et al., 2013). Compared with the leak detection methods using hydrophones or accelerometers for measurements of fluid-borne waves or vibrations (Puust et al., 2010; Yazdekhasti et al., 2016), AE techniques provides the signals which are very sensitive to the leakage (Gao et al., 2005). Some successful detections have been reported with considerable detecting distances (Anastasopoulos et al., 2009; Lim, 2015) and adaptability to various pipe materials (Hunaidi et al., 2000; Martini et al., 2016).

Leak detection using AE signals has gone through several stages of development. Parameter analysis is a common method for the early AE-based leak detection. Some characteristic indices are