Chapter 16

Method Z – Customer-side leakage using temperature and vibration

16.1 INTRODUCTION

Over the past 20 years, the cost and size of sensor technology has decreased dramatically. This has paved the way for the water industry to synthesise low cost, reliable sensors and leak detection. High-level leakage targeting is often based on principles developed in the 1990s using the BABE (Breaks and Background Estimate) methods that were based on UK water industry. These are the basis of the ILI (Infrastructure Leakage Index) that is in widespread use nowadays.

As our leakage management has improved over the years, we have reached a limit of detectability, known as background leakage. Background leakage refers to the "undetectable" level of leakage in the distribution network, large numbers of tiny leaks in the mains and service connection infrastructure. The Unavoidable Annual Real Losses (UARL) formula used in the ILI calculation is weighted towards service pipe leakage.

In a recent study from the "UK leaky loos" project it was found that 10% of toilet leaks had leaks averaging 400 l/day. Another study from Winnipeg, Canada found that 9% of toilets were identified as having a leak. In Hervey Bay, Australia, a study showed that the average leakage rate of a leaking residential property was 30.8 l/h. A Californian water-use study indicated that 7% of properties had a water loss in the property >350 l/day.

Typical leakage values assigned to night flow (in the UK at least) are approximately 0.5 l/prop/h for leakage inside the property, in case there are no customer meters (dripping taps, leaky shower heads, leaky toilet cisterns, etc.). The UK Managing Leakage reports suggest a default average value for Night use of 1.7 l/prop/h in the absence of any actual data.

Traditional customer-side leak detection is carried out using an acoustic method, where a leakage technician deploys a 'listening stick' to a stop tap and will identify a distinct sound corresponding to the

Editor(s): Stuart Hamilton and Bambos Charalambous
doi: 10.2166/9781789060850_0085

sound of the leak. This method has its advantages and disadvantages, with the main advantage being the speed of deployment and leak identification.

16.2 CUSTOMER-SIDE LEAK DETECTION FROM TEMPERATURE MEASUREMENTS

A method developed in the UK is to use temperature as a means of leak detection in customer pipes, while also assessing customer use. If a tap is turned on during a warm summer day, it is noticed that the water coming out of the tap is quite a bit colder than the ambient temperature. Water is generally kept within a temperature range of around 5 to 15°C (where 19°C is considered the 'limit' at which customers begin to complain) to prevent microbial growth in the water and to balance the chemical and mineral deposits. The temperature in the mains is generally different to the local air/ground temperature. When cooler water flows through a mains pipe, it is typically travelling quite fast, 0.1 to 0.3 m/s in typical ranges. At this speed the water in the mains does not get a chance to collect the energy (heat) from the soil around it, and so it remains cold by the time it gets to the tap. In the winter months, the opposite occurs, where the ground temperature is cooler than the water in the mains. At speed, the water does not lose its heat into the surrounding soil.

Figure 16.1 demonstrates the temperature effect on the stop tap when water flows through it. When there is no water flowing, the sensor will register the same temperature as the ground around it. When a water use event occurs, the temperature of the stop tap will rapidly decrease (or increase if the ground is colder). Once the use event has ended, the stop tap will return to its stable ground temperature again. Therefore, if there is a continuous leak in the house, the temperature difference between the ground and stop tap shall be significantly different (Figure 16.2).

The technique has been applied widely in the UK since early 2015, and data collected has been used from thousands of properties to develop automatic algorithms to process the results. The system comprises a sensor attached to the stop tap, a data logger, a cloud hosted database, and software to process the raw data and produce the results. The algorithms estimate the continuous flow due to leaks, as low as 1 l/h, and the intermittent flows due to use events. These are combined into a 15-minute average flow rate for each property surveyed. Loggers are left in place for between 24 hours for leak detection, and 7 to 14 days for consumption monitoring.

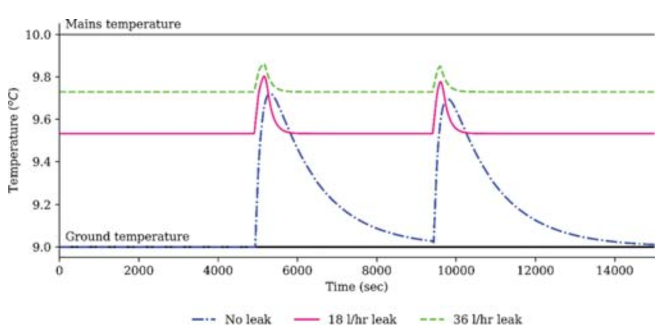

Figure 16.1 Simulated temperature data from stop tap with various continuous flow rates. (Source: Stuart Trow)

Figure 16.2 Device used for temperature measurements. (Source: Invenio Systems)

16.3 VIBRATION MEASUREMENTS FOR FLOW DETECTION

In order to speed up the rate of undertaking customer-side leakage surveys across whole areas, a vibration-monitoring device has also been developed (Figure 16.3). The device comprises two vibration sensors: one placed on the external stop tap; and a second used to take a background measurement. The hand-held unit takes simultaneous 30 second measurements from each device and stores them in its memory which can store up to 256 sets of readings, each of which is date and time stamped and GPS referenced. This enables productivity of the operations to be monitored and for the results to be displayed geographically.

Figure 16.3 Vibration recorder. (Source: Invenio Systems)

At the end of each day, or at intervals during the day the data is downloaded from the device and uploaded to a database where algorithms analyse the data and give each stop tap a result as follows:

(1) Definite flow at the time of measurement
(2) Probable flow
(3) Possible flow
(4) Definite no flow
(5) Problematic recording

This technology detects the low frequency vibration of the water flowing through the stop tap and can detect small leaks that make little or no noise detectable by traditional methods and leaks that are remote from the stop tap where the leak noise does not travel to the stop tap. The technology does not rely on the human ear or the experience of the operative, it is simple to use and therefore training needs are low. It tracks the progress of the survey in time and space and it keeps the recordings in the database for retrospective checking and to improve the data analysis through machine learning.