Water Loss

IWA TASK FORCE

Leak detection practices and techniques: a practical approach

● In this fourth article in a special series for *Water21* by the IWA Water Loss Task Force, **RICHARD PILCHER**, leader of the Force's leak detection practices and technology team, describes advances in leak detection practices and techniques in reducing water loss from public water supply distribution networks.

Ken Brothers, chair of the IWA Water Loss Task Force, recently outlined the scope of this series of articles, 'A practical approach to water loss reduction' in *Water21*, June 2003. The overall aim of the Leak Detection Practices and Techniques Team is to report on available and emerging technology, and on research into the current best practices (and equipment 'packages') for water loss monitoring, assessment and reduction. This article outlines the importance of an active leakage control programme as part of a demand management strategy.

The four techniques of leakage management

The control of water losses has been an activity associated with water distribution since some of the earliest systems were built. The Romans were aware that a good proportion of the water put into supply did not reach its intended destination, and Sextus Julius Frontinus, Water Commissioner to Rome, used a crude measuring device to assess losses in the system.

The fight for the reduction and control of losses is never ending but, fortunately for today's water distribution engineers, a range of good equipment and techniques have been developed to assist him or her in tackling the four basic leakage management activities (see diagram). Julian Thornton very well described pressure management in the previous article in the series published in October 2003. This article deals with two of the other three activities – active leakage control and speed and quality of repairs.

The frequency at which new bursts and leaks occur depends upon the overall condition of the infrastructure and how well the pressure is managed. Dependent upon the specific ground type, there will always be some proportion of leaks and bursts that do not appear on the surface, i.e. non-visible leaks, and these need to be detected. Active Leakage Control (ALC) can best be described as a proactive strategy to reduce water loss by the detection of non-visible leaks using highly trained engineers and technicians using specialized equipment followed by the prompt repair of leaks.

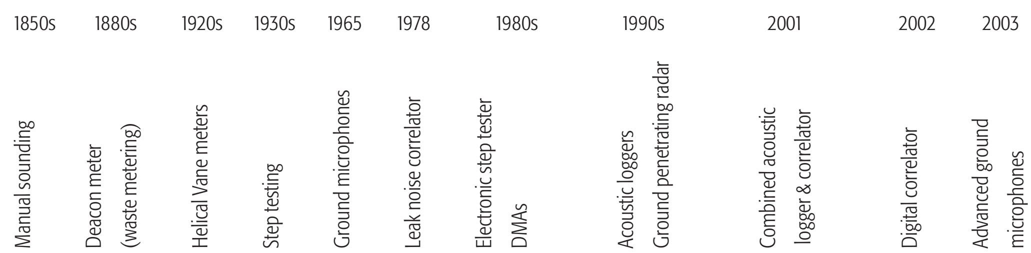
Leakage detection 100 years ago

For many years leakage engineers or technicians would carry out regular house-to-house surveys looking for the evidence of leaks from buried pipes or customer connections. The method relied upon a wooden listening stick which, when placed on the main or fittings such as valves and hydrants, allowed the inspector to listen for the sound of escaping water from a water distribution system. The leak noise was transmitted from the fitting to the engineer's ear via the listening stick, similar to a doctor listening to a heartbeat through a stetho-scope. Identifying the leak position using this traditional technique was a reasonably low cost operation; the success rate was moderate on metallic pipes, but with many "dry holes" or incorrectly sited excavations on non-metallic pipelines.

Leak localising

The above system of routine sounding was time consuming and not very efficient for the leak inspectors, who were often looking for leaks in areas where they did not exist. Leak detection gave way to two activities: leak localising and leak location. Leak localising is an activity that identifies and prioritises the areas of leakage to make pinpointing of leaks easier. The use of a small temporary zone was a traditional technique commonly used until the 1980s, where flows into a small area were measured using a single meter that had been temporarily set up to enable leakage to be identified. 'Step testing' was, and still is, carried out by some utilities in the small temporary zones. This is an activity whereby the area is subdivided by the systematic closing of valves during the period of minimum night flow. The flow data is analysed to determine the areas of suspected leakage. Leak location or the pinpointing of leaks is then carried out in the section of the zone that had high night flows.

A typical temporary zone covered a small area of a distribution system and has, in many utilities, been replaced by a District Meter Area (DMA). A DMA is an area of between 500 and 3000 connections into which water can be measured and analysed to determine the level of leakage. This is called leakage monitoring, and should be introduced in order for the activities of leak localising and leak location to be truly effective. The technique requires the installation of flowmeters at strategic points throughout the



Leakage Detection Technology Timeline

distribution system, each recording flows to a discrete district that has a defined and permanent boundary - the DMA. In many cases the small temporary zones for leak localising have become sub-districts of a DMA.

Leak localising by means of the step test was largely replaced by acoustic logging during the 1990s. This does not require night work and the shutting down of various parts of the distribution system. Acoustic loggers are used to define the general area (normally a DMA or part of a DMA) in which leaks are located and they can be used in any type of distribution network. They are installed on pipe fittings by way of a strong magnet and are programmed to listen for leak characteristics. By recording and analyzing the intensity and consistency of noise, each logger indicates the likely presence (or absence) of a leak. Acoustic loggers can either be permanently located in the network or they can be deployed at certain points for a short period, say two consecutive nights.

Leak location

Listening sticks moved into the electronic age in the mid1960s and were called ground microphones. This is a device placed on the ground that amplifies the sound produced by a leak to enable easier detection. These devices came in many shapes and sizes but one of the most popular was the 'elephant's foot', which was extremely sensitive and identified the strongest leak noise and the location of the leak

During the late 1970s the leak location activity dramatically improved with the development of the leak noise correlator. Similar to the traditional sonic equipment, the correlator relied upon the noise generated by a leak on a buried pipeline. The fundamental difference, however, is in how the leak noise is picked up. Sensors are deployed at two locations, e.g. two valves on the pipeline either side of a suspected leak position. The difference in the arrival time of the leak noise at each sensor, coupled with the knowledge of the pipe material, diameter and length, enables the leak to be pinpointed precisely. It is the usual practice after the prompt repair of the leak to recheck to ensure that no further leak noise is present in the leak zone. During the following 20 or so years the correlator developed from being the size of a large safe that took two men half a day to find a leak to a device that almost fitted into the palm of your hand and leaks were pinpointed in minutes rather than hours. In 2002 the digital correlator was developed offering the following advantages over its analogue predecessor:

- superior leak location performance on all pipe materials (especially plastic) and sizes
- quick and easier to use, especially for less experienced operators
- no interference or data loss in digital radio transmissions

In the first year of the 21st Century, a combined acoustic logger and leak noise correlator was developed. This system has the advantage of reducing the wait time between identification of a leak noise and pinpointing of the leak, thus reducing the run time for the leak and possibly the cost of repair.

Another development, ground radar, is a a device that has been developed in recent years and is primarily used for the location and surveying of pipes, cables and other buried objects. Water leaks can be found through the observation of disturbed ground or cavities around the pipe. It can locate leaks where leak noise correlation is difficult because of noise created by pumps or pressure reducing valves.

Leaks on house connections and other small diameter pipes, especially non-metallic pipes, can often be found by using gas injection and tracing techniques. The leak is located by filling the pipe with tracer gas (mainly industrial hydrogen) that escapes at the point of the leak and is detected accurately with a 'sniffing' probe on the surface. The tracer gas has the ability to rapidly penetrate all materials.

Emerging technology

An advanced form of leak localiser using a surface sensor array to detect and optimise leak sounds has recently been developed. The instrument sends a radio frequency carrier signal into the ground and detects the reflection. Flowing water from a leak causes phase and amplitude modulation of the reflected signal, which is detected by an interferometer. This should help the user to pinpoint or confirm a leak to a high degree of accuracy. Trials are continuing, but results so far show that it can be useful in the prevention of 'dry holes'.

There are also techniques being developed to improve leak location on non-metallic pipes and some existing techniques are being adapted to suit particular circumstances.

Repair of leaks

Leak location practices and techniques have advanced rapidly in the last few years, with the result that leakage awareness and detection times have been greatly reduced. It is vital that good quality repairs are carried out as quickly as possible in order to maximize the savings and also, of course, reduce the inconvenience to customers.

It is important to develop specific targets for the speed and quality for the repair work and these need to be reviewed regularly. ●

Leak localising logger for detecting areas of the network with leaks.

Next article in the series:

John Morrison, Leader of the District Meter Area Practices Team in the IWA Water Loss Task Force, will outline the practical approach to 'District Meter Area Design and Management'.

The Water Loss Task Force is interested in your participation. Please contact Ken Brothers, Chair of the WLTF for additional information and team selection at: kenb@hrwc.ns.ca

The four basic leakage management activities.