Are there Alternatives to the DMA?

For many years water utility leakage engineers have been dividing large distribution zones into smaller areas (or DMAs) as a first step in localising potential areas of leakage. However, the DMA philosophy is not supported by all water company practitioners. With the recent surge in innovative monitoring technology, are DMAs still necessary? Let us look at the alternative technologies for monitoring networks without closing boundary valves, or, if large DMAs are already in place, some low-cost innovative flow metering technologies for sub-dividing them into smaller areas.

By Malcolm Farley

DMAs - The Benefits

The technique of night flow monitoring to identify areas of leakage is considered to be the major contributor to cost-effective and efficient leakage management. It is a methodology which can be applied to all networks. Even in systems with supply deficiencies, leakage monitoring zones can be introduced gradually. One zone at a time is created and leaks detected and repaired, before moving on to create the next zone. This systematic approach gradually improves the hydraulic characteristics of the network and improves supply. Leakage monitoring requires the installation of flow meters at strategic points throughout the distribution system, each meter recording flows into a discrete district which has a defined and permanent boundary. Such a district is called a District Metered Area (DMA).

Evolution of the DMA Methodology

While working for the UK Water Research Centre (WRc) in 1982, I was responsible for designing what were almost certainly the first two DMA systems to be introduced to the UK water industry, and certainly the first in the world. Known then as 'district metering systems' the first was in the City of Plymouth (now part of South West Water) and the second was a telemetered system for a small water company to the west of London, Rickmansworth Water Company (now part of Three Valleys Water).

The experience gained from designing and installing these systems, and later using them to guide leakage detection activities provided essential guidelines on DMA management for other leakage practitioners. Based on these practical experiences, from using the technology available at the time, I wrote two WRc reports in the mid 1980s: District Metering: Part1 - System Design and Installation' and 'District Metering: Part 2 – System Operation'. These formed the basis for a number of manuals and books that were produced in the years that followed.

DMAs have now been almost universally adopted in the UK water industry. The concept of DMA design and management was reviewed in 'Managing Leakage' in 1994, and was updated by UKWIR in 1999 with the report 'A Manual of DMA Practice'. Also, thanks to the promotion of the concept by the Water Loss Task Force (WLTF) - now the Water Loss Specialist Group - of the International Water Association (IWA), DMAs are being introduced into the distribution networks of many countries of the world, with practitioners following the detailed guidelines produced for them by members of the group. For most international water loss specialists, one of the first stages of developing a NRW reduction strategy is to carry out a water balance (to quantify components and prioritise subsequent actions), and then to introduce zoning where none exists, or dividing large zones into smaller ones, or DMAs. This stepwise concept was introduced in 'Losses in Water Distribution Networks – A Practitioner's Guide to Assessment, Monitoring and Control' and in a later Asian Water article by Liemberger and Farley in 2004.

The continuing success of DMAs is largely due to rapid developments in flow monitoring and data capture technologies since the early 1980s. When DMAs were first implemented only mechanical meters were available. These meters were (and still are) robust, reliable and accurate and were widely used.

However, electromagnetic meters and ultrasonic meters are now being increasingly used as DMA meters. They have a flow range which more than equals mechanical meters and their increasing use by utilities, allowing larger production volumes, have brought down the costs considerably. Coupled with their being non-intrusive, having the capability to be buried (saving on meter chamber costs) and having optional battery power supply, they are now the meter of choice for many new DMA systems.

Other contributing developments include better data logger technology and data capture and communication packages - using enhancements such as global system for mobile communication (GSM) and general packet radio service (GPRS) technologies. These enhancements allow more rapid data collection and analysis, shortening the time it takes for a suspected leak to be highlighted.

What's wrong with DMAs?

So if DMAs are so great - and so universally accepted - why are we looking at alternatives? There is nothing wrong with DMAs – the principle of breaking large areas into smaller ones, to have a better chance of understanding night flows into smaller areas - still stands. And the methodology for installing DMAs – and managing them - is well-defined with some excellent available technology and equipment. However, the DMA philosophy is not supported by all water company practitioners, and there are some clear disadvantages of dividing up zones into smaller areas. These need to be acknowledged.

Firstly, dividing large zones into smaller ones comes with a cost – the cost of a zone survey, installation design, flow meter and chamber installation etc., is substantial, particularly if small zones (say less than 1000 connections) are chosen. Also, creating DMAs requires the 'permanent' closure of many boundary valves – and, because of zone supply arrangements and network characteristics (such as topography and low system pressures) some networks are hydraulically difficult to divide into single-feed DMAs without disadvantaging customers. This means creating DMAs with fewer boundary valves and multiple flow meters, adding considerably to the cost, but also, particularly with 'cascading DMAs (flow between adjacent DMAs) making the analysis more cumbersome and flow errors more likely.

Secondly, DMAs can cause operational problems. Traditionally, there is often conflict between the leakage and the operations departments. By closing valves and creating DMAs, the leakage engineer's role is to better understand the areas where water is being lost to leakage. The operations engineer's job is to ensure that all customers are served with a supply of high quality water sufficient to meet their needs at all times. In times of water shortage this conflict can lead to boundary valves being opened to satisfy demand, resulting in meaningless flow data from the DMAs. Worse, when there is little or no communication between the two departments, boundary valves are frequently left open, resulting in spurious DMA night flow data, and in some cases, false alarms.

A lesser issue, but nevertheless an important one, is that closing in DMAs can lead to water quality problems and customer complaints, particularly where 'dead ends' are created at the end of a run of pipework. Dirty water complaints can usually be addressed by a regular flushing programme in the culprit areas, but this also adds to the DMA operating cost.

When these disadvantages are added up, it is not difficult to understand why there are some water company practitioners who feel that DMAs are redundant.

Figure 1: Logger deployment in Abu Dhabi by Gutermann

So what are the alternatives?

With the advance of correlating noise loggers, multi-parameter monitoring systems and hydraulic modelling techniques to predict areas of leakage, there are now several ways that the characteristics associated with leakage and bursts can be monitored and analysed – without installing meters or closing valves in the network.

Correlating noise loggers

The technique of noise logging has become increasingly popular and the technology has moved on apace (Figure 1). A cluster of sensors is deployed in an area to be surveyed. Logger data can be analysed in situ, either by downloading on site, or by driving past each logger with a van-mounted receiver to pick up anomalous noise signals. Noises which are suspected of being leaks can be confirmed, and the leak located. The latest generation of noise logger systems now incorporates a multi-point correlation facility to provide 'instant' location of the leak position - the correlating noise logger. Correlating loggers have been used successfully by Thames Water, the largest UK water utility. Following deployment of loggers, and finding and fixing the identified leaks, the nightline in one large zone was reduced from 96.3 Ml/day to 75.2Ml/day, a reduction of 22%. The utility claims that 90% of leaks detected were located within 2.5m of the point indicated.

Although the present cost of noise loggers precludes 'blanket' coverage of the entire network, such a system would be ideal for continuous and permanent noise monitoring. Perhaps, manufacturers need to ensure that future noise logger developments are focussed on low-cost sensor technology so that sensors can be permanently deployed on every fitting in the network.

The 'Alpha' system recently developed by Gutermann goes a long way to achieving this vision by creating a 'permanent unmanned leak monitoring system'. A set of correlating noise loggers is radio-linked by repeater modules to a communication link, which in turn communicates data to a PC or server via GPRS. The city of Abu Dhabi, UAE, is currently installing the system on its distribution network of 10,000 km. The system provides for leak alarming, automatic leak location and automatic reading of 'smart' meters – allowing the leak size to be calculated. Results and costs, and the pay-back time – is awaited with interest.

Multi-parameter monitoring

Multi-parameter monitoring is a technology comprising a sensor that can simultaneously measure, record and communicate bidirectional flow, pressure and noise. This system lends itself admirably to the concept of monitoring leakage throughout the entire network without creating zone boundaries. Instead, sensors are installed at key positions to create 'virtual zones'. The MWM system developed by Martinek Water Management is one such system designed to be used in the distribution network.

The three parameters are continuously monitored, measured and analysed during the night hours (between 0300 and 0400) and compared against a reference value. If a reference boundary value is breached - increased flow, changed flow direction, decreased pressure and/or higher noise (leak or flow) an alarm is raised (Figure 2). The interaction between the parameters and the automatically-calculated reference values gives an indication of where leakage is occurring. The system can be used in a DMA or in an open network creating 'virtual zones' (Figure 3).

HydroGuard, from Ashridge Engineering is a similar system. It has been developed, in conjunction with Thames Water, to measure, record and transmit flow, pressure and leak-noise data to provide a burst monitoring and warning system for trunk mains. The unit incorporates a 'pipeline activity signature' (PAS). The PAS takes flow, pressure and noise profiles at 15 minute intervals throughout the 24 hour period. A higher frequency logging rate can be initiated during the period of interest and alarms are sent directly to mobile phones via SMS.

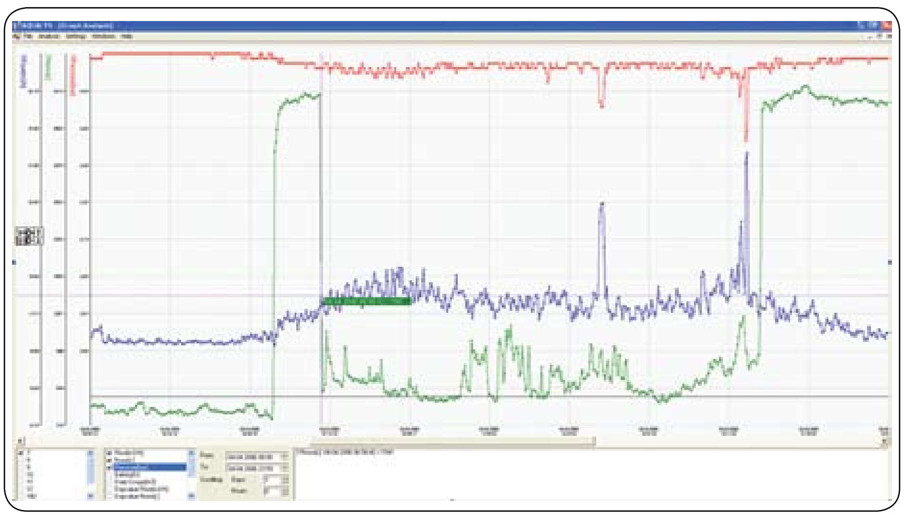

Figure 2: Pressure (top), flow (middle) and noise (bottom) recordings showing a leak occurring (MWM system)

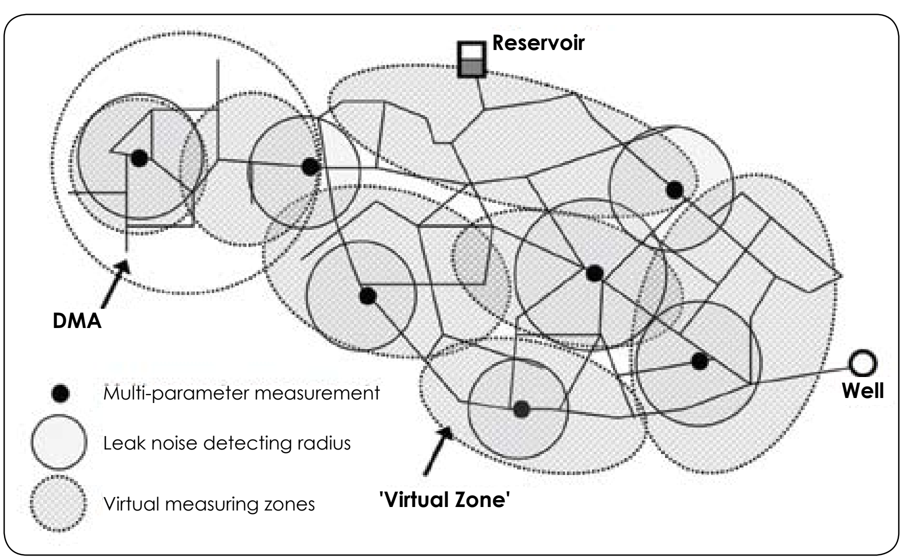

Figure 3: The MWM System, showing the radius of 'virtual zones'

Using network models to find areas of leakage

Using a hydraulic model to predict areas of leakage has long been a goal for the leakage practitioner. In recent years the technique has been further developed by at least two companies that specialise in software for hydraulic models

One of these is the Burstfinder developed by GL (formerly

Advantica). The technology utilises pressure data measured in the field to run an optimisation within a hydraulic model to locate leakage 'hotspots' for further investigation (Figure 4). Being pressure-based rather than noise-based, the technology operates equally well on all pipe materials and can localise anomalies to a street level, which enables improved effectiveness of leakage detection teams. Burstfinder prioritises attention on larger anomalies within a network and will direct leakage teams to mains breaks and customer supply leaks as well as network breaches. Additionally the technology is able to determine between leakage and other demands on the network so is capable of identifying other sources of non revenue water such as unknown or illegal demands.

Bentley Systems has developed a similar optimisation technology, incorporating its Darwin Calibrator module with leakage modeling capabilities into its WaterGEMS software. By 'leveraging' the conventional hydraulic model, leakage can be effectively simulated as pressure dependent demand - the greater the pressure the greater the leakage.

The leakage-detection feature of the module identifies the locations and sizes of the leakage holes, emulated as 'emitters' that allow water to spurt and seep out at different rates depending on prevailing pressure. The most likely leakage locations are identified, and, like BurstFinder, leakage engineers focus site investigations on the model-predicted leakage areas to test for leakage hotspots using conventional leak location instruments.

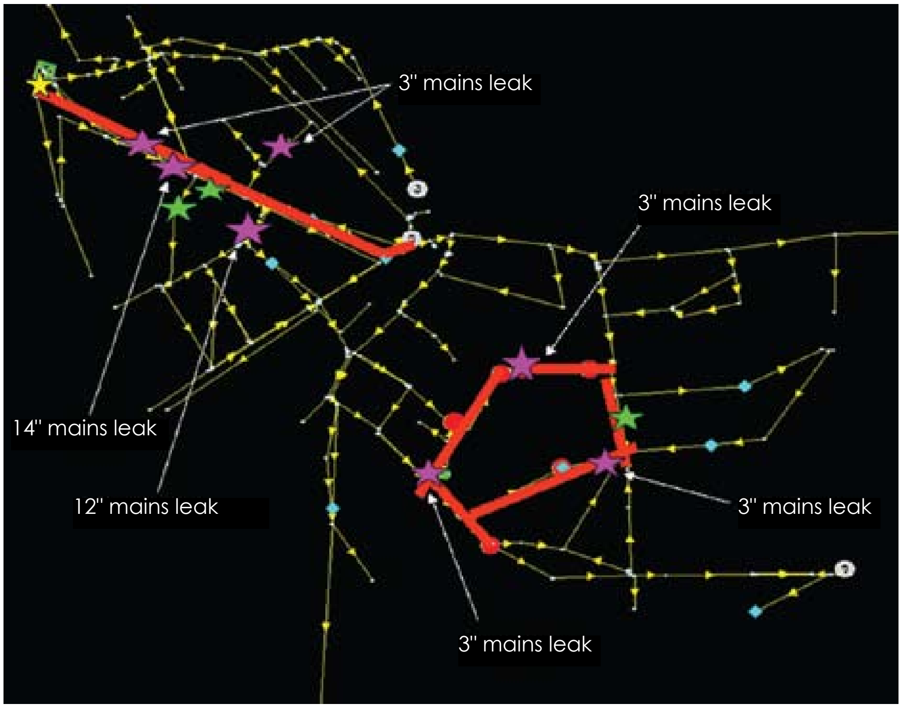

Figure 4: The Burstfinder developed by GL (formerly Advantica) shows areas of potential leakage.

What about reducing the cost of existing DMAs?

Other technologies, like the Incertameter developed by Yorkshire Water in partnership with Vernon Morris have been developed to identify leaks by measuring fluctuations in flow. The meter requires a small excavation and can be installed under pressure. This technology makes it easier to sub-divide DMAs without the use of permanent sub-meters, minimising disruption to supply. Data are communicated by wireless transmission. The benefits are clearly to considerably reduce the time it takes to become aware of the leak, and to make it easier to localise –or to narrow down the leak to a smaller sub-DMA.

Another contractor, Utilitec, (in partnership with RPS), has developed an innovative flow measuring system - an acoustic flow meter – the Accuflow (Figure 5).

The instrument is a valve key incorporating electronics and a colour display. The system uses a valve as a temporary flow meter and the software instructs the user to close then re-open the valve in a particular way. During this operation, the key is recording the noise of water passing under the valve - this information is used to determine the flow rate. The acoustic technique is able to provide a temporary measurement of flow in almost any pipe in the network, and is particularly useful at locations where no flow meters are available. The ability to measure the flow in any pipe in the network is clearly invaluable for quantifying leakage and may well replace the traditional step testing technique.

Some final thoughts

There is no doubt that DMAs are almost universally accepted as being a very successful tool in reducing leakage. Their use has also been expanded by water company practitioners by the providing of a convenient geographical area in which to manage water quality issues, capture asset data and measure asset performance.

However, there are now available alternative technologies for monitoring leakage and bursts, helping to meet the challenges of dividing hydraulically difficult networks. These are:

- Leak localising technology using large numbers of noise loggers
- Multi-parameter (noise, flow and pressure) monitoring
- Network models to predict leakage 'hotspots'

For established DMAs, there are low-cost flow meter options for sub-dividing them, reducing the time

Figure 5: Accuflow

required for leak localising and detection.

Closing the circle

It is indeed significant that, almost 30 years after introducing the first DMAs to the UK water industry, WRc has been asked by a group of UK water utilities to manage a collaborative project to investigate 'more open network scenarios' (WRc ENewsletter, November 2010).

The benefits of open network monitoring are listed as: *'improved flow regimes, more stable pressures and reduced potential for creation of water quality incidents from operation of boundary valves. It will be possible to increase network resilience, improve customer service, and reduce energy costs'.*

The benefits of traditional DMAs are challenged:

'With greater emphasis on customer service and cost reduction, as economic levels of leakage stagnate, and as flow and pressure measurement techniques improve, it is important to question whether DMAs will remain relevant'

However, WRc also advises that any such developments in monitoring in open networks must be accompanied by an equal or better approach to leak detection. Manufacturers of leakage monitoring and detection equipment will be well advised to anticipate the market demand for equipment to service and improve all these alternative technologies, and to find ways of producing high volume, low-cost sensors for permanent deployment on fittings throughout the network.

Then, we will be close to achieving what has been for many years the missing link in water loss management - a totally automated, integrated monitoring system that combines all network parameters - system input meters, DMA meters and customer meters - with 'blanket' sensor technology for leak location and pinpointing – all communicating with wireless communication links.

With the vision of a water utility control room managing the water network with high efficiency rapidly becoming a reality is the 'perfect' system within our grasp? **AW**

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