A PRE-RELEASE PREVIEW OF AN EMERGING TECHNOLOGY: THE ACCUFLOW^{TM} KEY

Based on an Original paper by Arthur Arscott (UK);

Abstract

Accuflow^{TM} Key: A new innovation in step-testing using sluice valve metering

Industry advancements often arise out of new ways to apply well known principles rather than on the invention of new technologies. A recent case in point is the arrival in New Zealand of the computerised Accuflow^{TM} Key which uses a sluice valve to determine the flow rate in a pipeline.

Because of the close ties existing between Detection Services and the development company in the UK, New Zealand and Australia are privileged to have the first pre-production prototypes available for longer term trialling over a wide range of flow rates, pressures, valve types and pipe materials. Experience gained using an earlier version has led to a number of upgrades to the current model, thereby vastly enhancing results.

Expectations are that the new device will be a very useful, efficient and cost-effective alternative to flow testing under certain conditions. Although the Accuflow^{TM} Key is an important breakthrough in its own right, it is certainly not envisaged that the new device will be responsible for all existing technologies being consigned to the recycle bin.

This paper describes development work on a new portable sluice-valve flow meter that enables a conventional sluice-valve to be converted into a temporary metering point. The Accuflow^{TM} valve flow meter has opened up new concepts in step-testing techniques. With a sluice valve on nearly every corner, metering flows across the network has at last become a realistic option for demand management engineers.

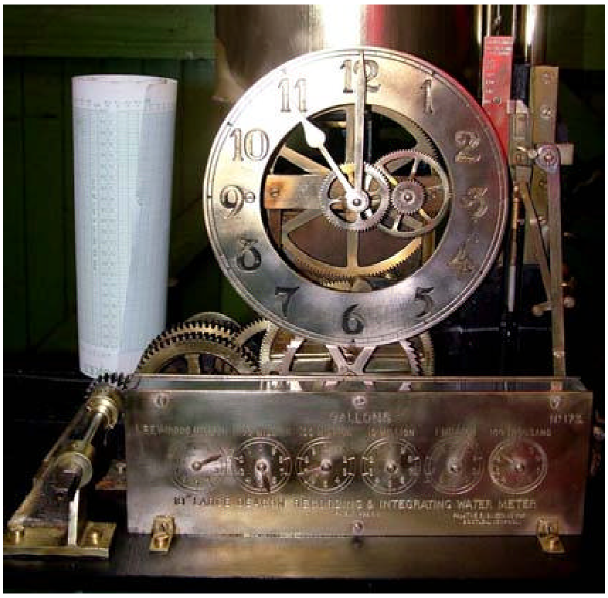
1. Background

Although New Zealand is, by world standards, well endowed with water, shortages still periodically occur due to insufficient storage capacity in the catchments, limited treatment capacity and pipes whose size has been overtaken by demand.

The question of whether to increase supply or manage demand has been with the water industry since urbanisation began and as each problem arose, a suite of solutions were forthcoming-until new problems started to raise their ugly head.

Mostly, however, the new devices were good and useful and form an integral part of the box of tools available to water engineers today.

Undoubtedly, the most outstanding fore-father of water supply management was George F Deacon, the then water engineer of Liverpool. The best known of his many inventions was the now famous Deacon waste-water meter, which he invented to try and measure water leakage by subtracting actual consumption from the total volume put into supply.



Alwen Dam

Clockwork Detail of Flow Meter

Today we would refer to such meters as District Meters. They would serve discrete zones of around 6 000 'water takers' and results showed that per capita consumption of around 25 – 28 gallons per person per day was reasonable. Some areas showed consumptions in excess of 95 gallons per person per day.

As technologies improved, meters became feasible at individual consumer installations, thereby reducing still further the consumption of metered consumers.

In 1896, in an address to the American Society of Civil Engineers, a certain Mr. Dexter Brackett postulated that, *"There is no doubt that the most efficient means of preventing waste of water on the premises of the water takers is the universal use of water meters,* *for if every water taker is obliged to pay for all the water entering his premises, whether used or wasted, the quantity wasted is very sure to be reduced to a minimum".*

New Zealand still has towns and cities where universal metering is resisted!

He went on to add that, *"next to the general use of meters, the most efficient method of preventing waste is by house to house inspection, aided by the Deacon waste-water meter".*

Not much has changed over the past century!

2. Moving forward

The domestic water meter has very effectively all but put an end to concerns about on-site water wastage, although there some exceptions.

As a consequence of universal domestic water metering, leakage from municipal distribution networks has dominated the attention of Demand Managers for the six decades since WW11. Questions involving water metering revolve around issues such as how frequently to read and bill; at which point do inaccuracies become an economic issue and automatic meter reading.

New technologies have appeared from time to time covering all aspects of water supply, all invariably driven by need, and one of the most recent developments in this regards is the Accuflow™ Key.

3. Overview

A prime challenge in leakage control is obtaining accurate information on the location of leaks across the distribution network. Performing step-tests has provided the best way to locate areas of high leakage and demonstrating the results following the repair of leaks. However, to date, this has required the setting up of monitoring areas and often the expensive installation of metering points across the distribution network.

This paper describes work that led to the development of the Accuflow™ Key, a new portable valve flow meter that enables a conventional sluice valve to be converted into a temporary metering point.

The Accuflow™ valve flow meter has opened up new step-testing techniques which provide a cheaper and more effective way to pinpoint leaks. With a sluice valve on nearly every corner, metering flows across the network has at last become a realistic option for the Leakage Engineer. These new techniques will be of particular benefit in countries where high set-up costs have previous prevented the use of conventional step-testing.

4. Evolution

In more recent history, the focus has evolved from the tried and trusted step-testing, to the creation of discrete isolated areas with the permanent installation of a District Meter.

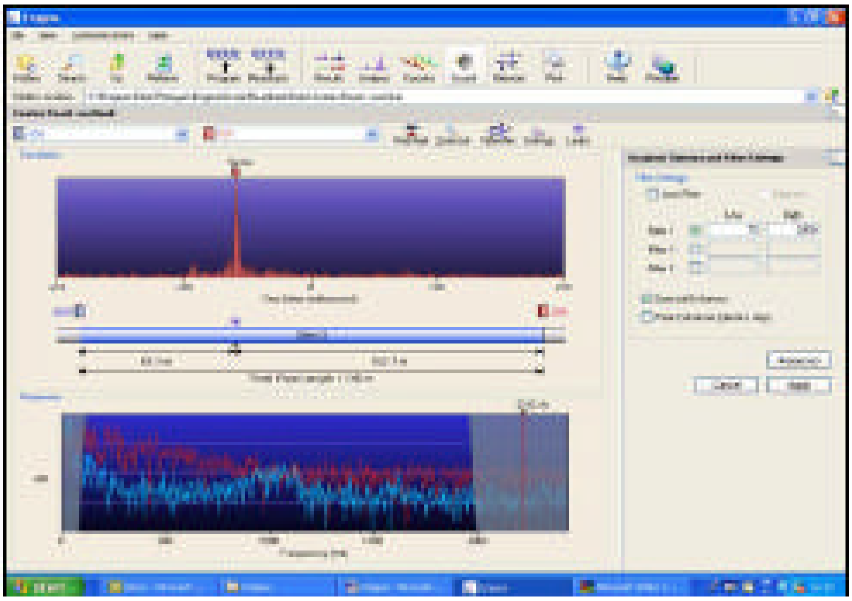
This has changed the design concepts from a ‘spider-web network’ allowing water to reach any consumer from any number of directions, to a single, metered, point of entry. As excess pressure in a pipe has been shown to greatly increase the occurrence of leaks and bursts forming, pressure control is very often also incorporated at the point of entry.

District metering (DMA) and Pressure Managed Areas (PMA) are, however, not without some notable disadvantages, such as cost and inflexibility once established; getting the size right (-too big and low-flow accuracy is compromised, too small and the system can become throttled); the creation of ‘dead-ends’ often resulting in red-water complaints; and the erection of hi-rise buildings within the zone.

In an attempt to avoid having to operate numerous valves in a particular entire zone, as is required for step-testing, an alternative approach was developed using acoustic flow loggers. These are essentially a stand-alone development of the leak noise correlator transducers.

Here, a number of noise loggers are deployed for a period across a defined area of the network. An analysis of the pattern of persistent noise generated by leaks provides an indication of the location of leakage.

Obvious advantages of this technique are that no permanent installations are required, they are cheaper to operate and can be quickly and easily moved from one application to the next. Results typically follow those of the leak noise correlator in that noise levels are not indicative of the size of a leak.



The need to develop the Accuflow™ Key was recognised from the convenience of merging the strengths of conventional step-testing with the cost and flexibility advantages of acoustic logging. Any such improvements would need to:

- Measure actual flows in the distribution network, rather than noise levels;
- Avoid expensive fixed installations;
- Eliminate the need for temporary shut off of customers' supplies, or at least reduce them to very short periods; and
- Provide metering as close as possible to each step, reducing the impact of customer usage on leakage measurements.

5. Developing new alternatives to conventional step-testing

As mentioned, neither conventional step-testing nor acoustic logging provides a completely satisfactory solution to leakage control, with each approach having its advantages and disadvantages.

It was recalled that from practical experience, skilled leakage inspectors could estimate the size of a leak by closing down a stop valve and listening to the volume of the noise. Generally, the sooner the noise started to increase and the louder the noise, the greater the volume of leakage that was found. This empirical observation lead to questions as to whether this principle could be enhanced by the use of electronic acoustic measurement and the identification of a relationship between the flow rate and the acoustic profile.

These ideas started an initial investigation into possible links between flow rate and the acoustic signature. A variety of existing metered sites with sluice valves provided ideal locations for testing the theory. By logging the meter readings, and carrying out acoustic measurements as the sluice valve was slowly closed, a positive correlation between the acoustic noise level and the full bore flow volume was established. The recognition of this principle justified further Research and Development.

6. Defining the basic principles of valve flow metering

The principles of valve flow metering are founded on traditional engineering hydraulics, generally based on Bernoulli's equation of fluid flow, as applied to orifice flow meters.

Here, there is a relationship between the flow rate, the size of the pipe, the size of the orifice, the upstream pressure and the downstream pressure immediately after the constriction. In summary, by measuring the upstream and downstream pressures for a given pipe and orifice, the equation can be used to calculate the flow rate. An orifice plate is a very simple device installed in a straight length of pipe, containing a hole smaller than the diameter of the pipe. The orifice in the plate can be Concentric, Eccentric or Segmental and it this latter option that is used in the sluice valve application. The closing gate of the valve provides the plate while the gap under the gate is the segmental orifice, the size of which is easily variable.

As the flow constricts, a pressure drop occurs and the differential pressure can be related to a flow using the Continuity Equation whereby flow upstream is equal to the flow downstream, A1V1 = A2 V2, as illustrated below:

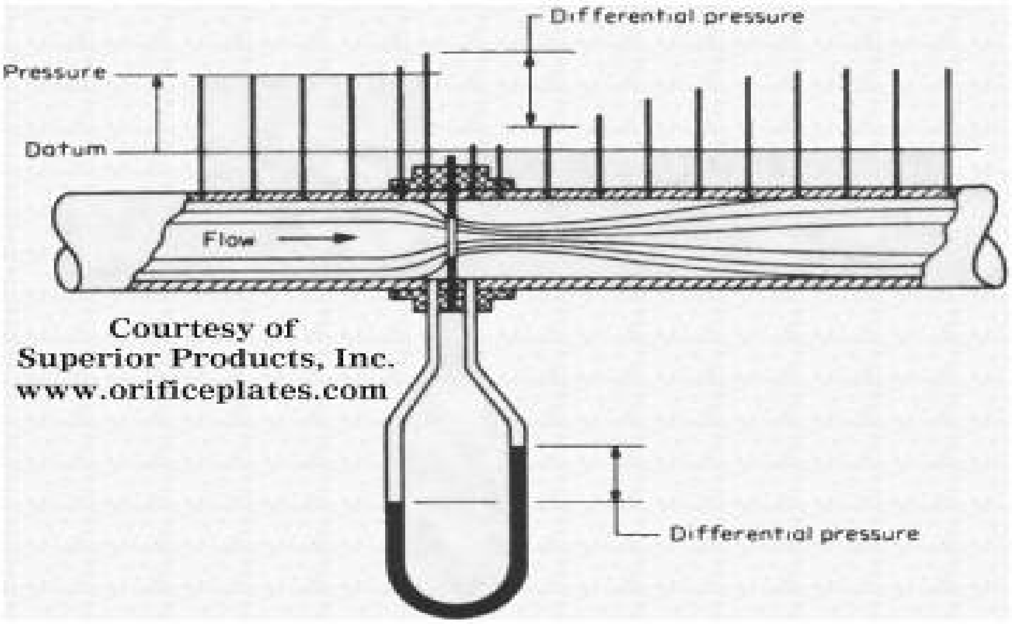


Figure 1: Orifice Plate Arrangement

The orifice being at the bottom of the pipe, rather than in the centre, introduces additional factors in the measuring process, including difficulties in measuring the pressure immediately downstream of the constriction.

However, as a sluice valve is closed, this also causes an increase in the noise level due to the acceleration generated as flow passes through the constriction. The greater the flow, for a given input pressure, pipe and valve combination, the larger the acoustic profile. This principle formed the basis for the development of the valve flow meter.

The initial research started in 2004 and was based on field tests rather than on laboratory based pipe configurations. Currently the valve flow meter has been calibrated for use on pipes of 200 mm and below, as this size range includes the majority of local distribution mains.

7. Developing the prototype valve flow meter

Once the principles, accuracy and algorithms had been established, the challenges were to provide a robust device which will fulfil the variety of functions required:

- operation as a conventional valve key;
- acoustic measurement;
- rotational measurement;
- input of data;
- output of operational instructions, together with processing, presentation and logging of results.

The development of the prototype device and field trials took place during 2005/06 and a number of prototypes were developed and extensively tested.

Development to date has involved over 1000 field tests which have has shown that the Accuflow™ delivers overall accuracy levels of +/- 10% at flow rates ranging from 0.3 litres/sec to 3 litres/sec. As to be expected for leakage control work, accuracy at low flows is an important characteristic of the Accuflow™.

The Accuflow™ as pictured below,

utilises leading edge technology for sensors, electronic control, graphical user interfaces and data logging and delivers a unique combination of technologies integrated into one device, providing, for the first time, a way to measure flow using existing sluice valves while incorporating the following functions:

- A traditional valve key, to open and close standard distribution sluice valves;
- A patented sensor system to log the rotation of the device when opening or closing a valve to take a flow measurement;
- An acoustic transducer, located in the bottom of the Accuflow, which rests on the valve head to accurately record changes in the acoustic profile;
- A LCD display unit and keypad for the user-input of key data which provides visual and audible signals giving step-by-step instructions on how to close the valve in a controlled fashion while taking the measurements;
- A microprocessor unit which records and processes the input and sensor-derived data to provide an estimate of flow.

Development to date has identified the following requirements for the Valve Flow Meter to operate effectively:

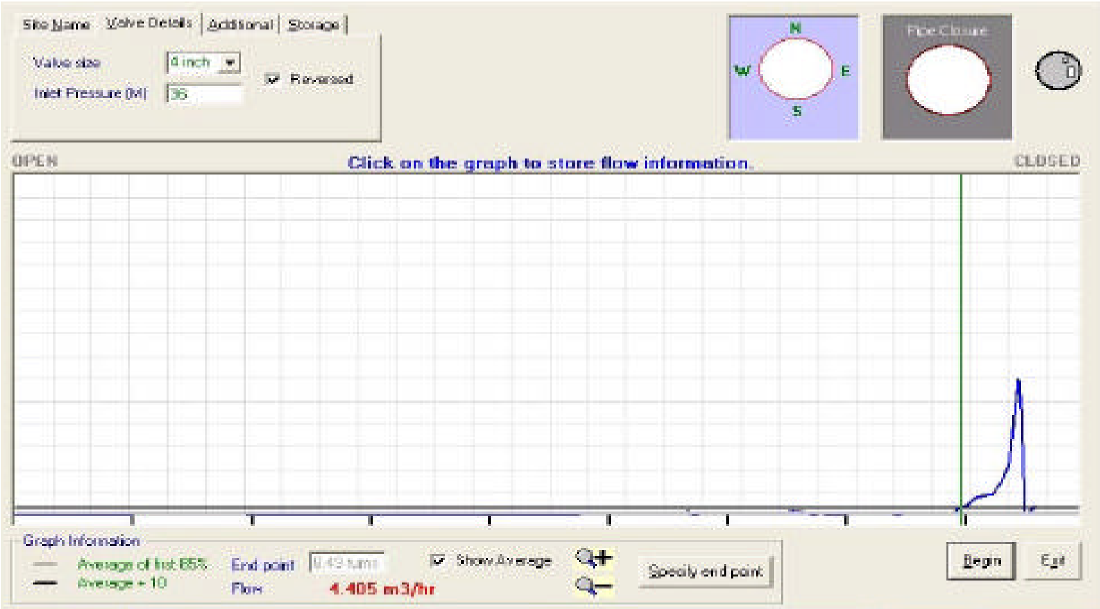
- a pipeline diameter of between 50mm and 200mm, with a sluice valve the same diameter as the pipe;
- a sluice valve in reasonably good condition, with leak proof closure;
- a clean valve head to provide a good contact with the acoustic sensor;
- the ability to take a pressure reading close to the valve (normally within 10 m);
- the ability to completely close the valve for a short period, although this is only normally required for 10 seconds or so;
- flow rate and inlet pressure during the measurement should be fairly constant.

8. Using the AccuflowTM

The Accuflow™ valve flow meter can be easily operated by one technician, having been designed for ease of use. However, in situations where it is likely to be of most use, such as measuring night flow across the distribution system, staff with a high standard of training and experience will be required to get the best results out of the device.

The basic steps in using the Accuflow™ valve flow meter assume that the valve has been exercised and checked prior to arrival on site, and does not leak. A leak on the valve stem will render that valve unsuitable for the purpose.

The time required for the flow measuring operation will depend on the valve size. The total operation will take about ten minutes for a 100mm pipe. If an incorrect valve pipe size has been input the device will identify this and will indicate whether a retest is necessary. Any major fluctuation in flow during the measuring operation will also trigger an unsuccessful test indication on the display. A typical display is shown below.

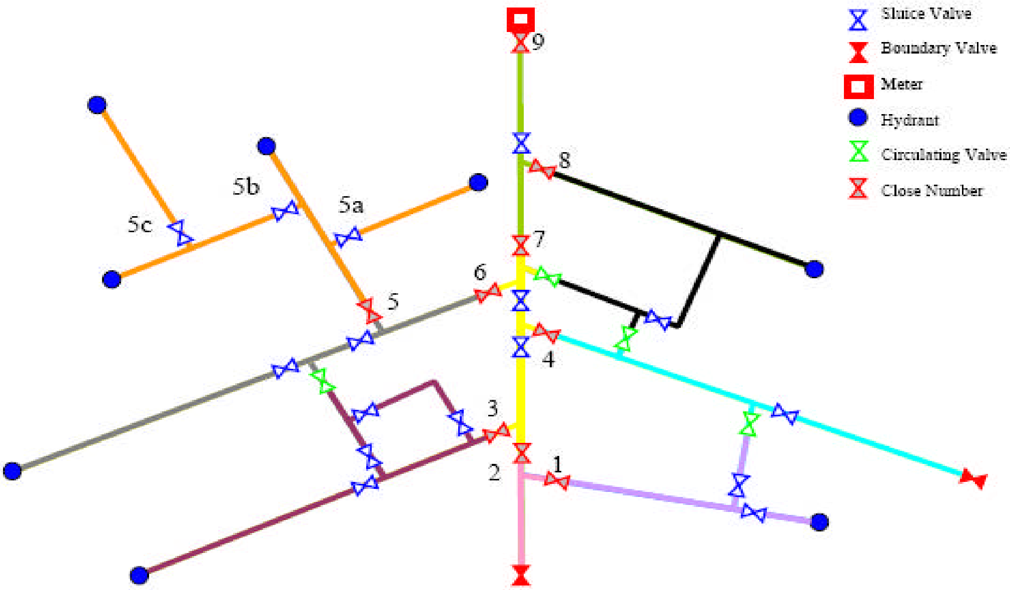


9. Developing new step-testing methods using the Accuflow

The step-testing procedure is normally carried out at night and is similar to that conventionally used for step-testing, but with some important differences. These can be explained by reference to the schematic diagram below.

The first step is to isolate the DMA by closing the boundary valves and to close all the light green coloured circulating valves to ensure that each step has a single feed. Testing is then carried out by using the Accuflow™ to measure the flow at point 1.

As soon as the Accuflow™ has calculated a flow value, the valve at point 1 can be reopened with a conventional valve key, while the Accuflow™ is moved to point 2 to start taking the next flow reading. The process continues at the remaining step points, 3 through to 9.



Once the all steps 1 through 9 have been metered using the Accuflow™, it is possible to review the results to see if any additional readings within the DMA are beneficial. For example, if an unexplained high flow at step 5 was obtained, it would help pinpoint the location of leakage if further Accuflow™ readings were taken at the three sluice valves downstream of step point 5 (shown as 5a, 5b and 5c).

10. Cost and performance comparison of conventional step-testing against the Accuflow™

The costs of carrying out step-testing using the Accuflow™ in an existing DMA is similar to conventional step-testing using radio linked equipment. Where a DMA is not already set-up, step-testing can be implemented using the Accuflow™ without incurring the capital set-up costs associated with a DMA.

In addition to cost advantages, the Accuflow™ step-testing procedure outlined above has major performance advantages over conventional step-testing. Firstly, the ability to use the sluice valve at each shut off step as the actual metering point, rather than the remote meter at the point of entry to the DMA. The effect of taking measurements at local street level eliminates the effect of any legitimate night use upstream of the step test point.

Secondly, the approach is far more flexible, as extra measurements can easily be taken at any sluice valve to help better pinpoint leakage for further investigation. This is of particular importance given the high cost of leak repairs.

11. Options for replacing DMAs with areas monitored using the Accuflow™ Key

The cost of setting-up, monitoring and maintaining a conventional DMA has a high ongoing cost and typical values are around £2 per year per property.

The Accuflow™ Key offers the possibility of carrying out area monitoring at far lower cost, which may prove to be a satisfactory and cost effective approach to leakage monitoring for many situations. The cost of using the Accuflow™ to valve in a discrete area at night four times a year to provide leakage monitoring information is around 43p per property.

12. Summary

The innovative technology of the Accuflow™ Key and valve flow metering, offers significant cost and performance benefits when compared with other established techniques such as acoustic logging, DMA monitoring and conventional step-testing. The use of enhanced step-testing using valve flow meters has been shown to improve identification of those leaks worth repairing and so significantly improve the efficiency of leakage detection and repair activities. The advantages include:

- it requires no fixed installations and so avoids capital costs;
- the flow into any zone can be seen as soon as the valve is closed, rather than relying on logging or additional staff at a remote input meter;
- it provides high quality quantitative data on the levels of leakage and enables better targeting of leaks worth repairing;

- unlike acoustic logging, it does not rely on noise to indicate the size of a leak, which can sometimes give misleading results leading to unnecessary repairs;
- the metering points can be close to the area being monitored, reducing the impact of customer usage on leakage measurements;
- the controlled nature of the valve operation reduces the likelihood of causing bursts on weak mains or of discoloured supplies;
- the short period for complete valve closure required, means minimal disruption to customers' supplies;
- it allows follow-up monitoring to determine the effect of leak repairs.

13. Our New Zealand Experience

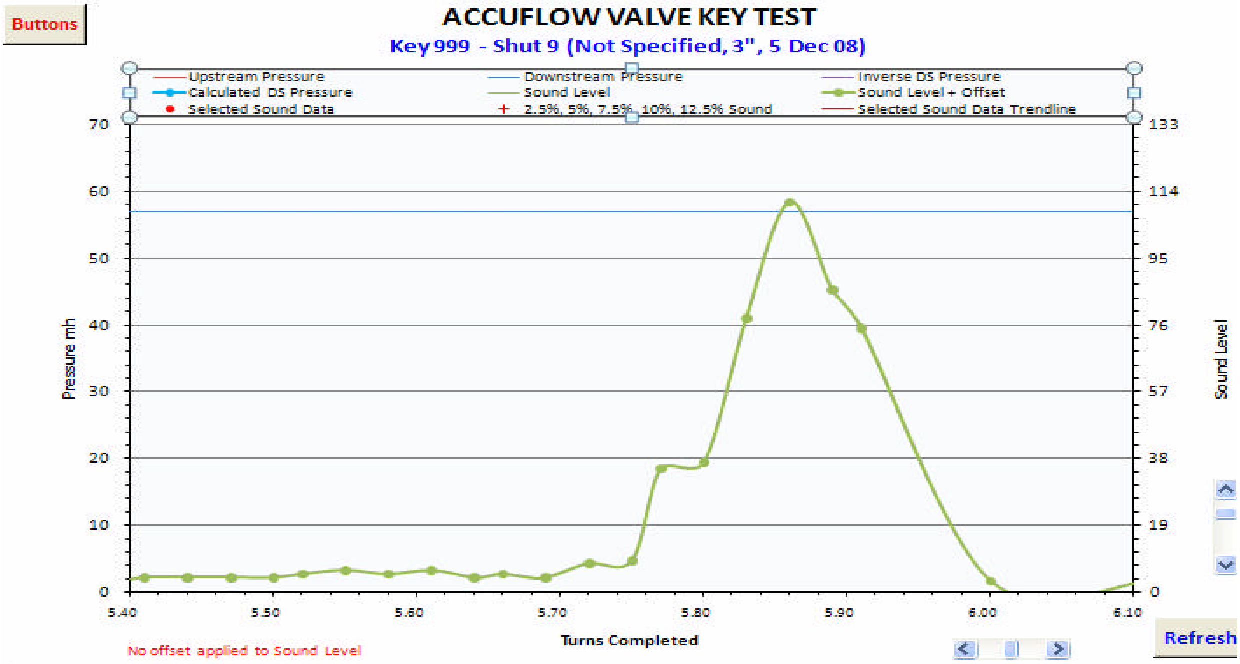
In September 2008, the Accuflow™ Key was made available to Detection Services here in New Zealand and Australia for trials.

One of the first issues to be encountered was the number of turns per inch (tpi) of local valves. In the UK valves are more or less standard at 2 tpi, while here we have very few of that gauge. Mostly the valves in use here have a tpi ranging from 3 to 6 tpi.

In addition, the pressures encountered in Australia and New Zealand are often considerably higher than those in the UK. We also experienced some interference to the magnetic compass as fitted to the prototype, which has subsequently been updated.

The first tests carried out in New Zealand were done by Vaughn Healey in Queenstown where universal metering is not applied and considerable on-site leakage is often encountered. By keeping test pipe lengths to a minimum, those lengths where significant flow is recorded can be investigated using the 'house to house' inspection technologies, so well known in leak detection circles today.

Because some of the anomalies mentioned above required further development input from the developers in the UK, direct flow measurement was not possible on the data collected by Vaughn. This data had to be e-mailed back to the UK for analysis. Reports are that the results were good and within the accuracy promised.



However, before any commercial work can be undertaken, the crucial upgrade to the software to enable direct reading of the flow rate will have to be completed. Previous upgrades have taken rather longer than anticipated but we are hopeful that the new revised software will be available rather sooner than later.

What we can say with full confidence is that the Accuflow™ Key itself and the computer operation and results, are all functioning perfectly. We are eagerly awaiting the upgraded software capability to automatically match the Key results to the flow rate and we're home and dry.

In conclusion we express our appreciation to Arthur Arscott and his development team in the UK and acknowledge their pioneering work in developing this exciting new technology.

Paper adapted and presented by Charles Chapman