Managing pressures to reduce new breaks

JULIAN THORNTON and **ALLAN LAMBERT** report on recent research by the pressure management team of the IWA water loss task force into the beneficial effects of pressure management on new break frequencies in water distribution systems and raise some important issues for infrastructure and energy management.

A first outline of the issues being considered by the pressure management (PM) team of the IWA water loss task force can be found in the October 2003 issue of Water21[1]. An update, as of September 2005, was provided in papers to the Leakage 2005 conference in Halifax, Canada[2], while in the June 2006 issue of Water21[3], Ken Brothers outlined the ongoing work of the various teams within the task force.

The PM team seeks to improve the practical understanding of relationships between pressure and leak flow rates, pressure and consumption, and pressure and frequency of new leaks and breaks on mains and services.

This article concentrates on developments over the past 12 months relating to the third of these topics. Examples are provided from different countries of the immediate and often major influence that pressure management can have on the frequency of new breaks. The PM team's latest conceptual approach to analysis of pressure: break frequency data is shown, and the implications for the extension of the useful life of the network infrastructure and energy management are briefly discussed.

What do we mean by pressure management?

Pressure management can be defined as 'the practice of managing system pressures to an optimum level of service ensuring sufficient and efficient supply to legitimate uses and consumers, while eliminating or reducing pressure transients and variations, faulty level controls and reducing unnecessary or excess pressures, all of which cause the distribution system to leak and break unnecessarily.'

There are many different tools that can be used when implementing pressure management, including pump controls, altitude controls and installation of pressure reducing and sustaining valves (with or without sectorisation of distribution networks).

How pressure management can change new break frequency

The authors' interest in this topic was initially stimulated by working in many different countries with utilities that had introduced pressure management to a greater or lesser extent. In some cases, there was anecdotal evidence of noticeable reduction in new break frequencies. In a very few cases, repair records had been kept and analysed 'before' and 'after' pressure management, usually by an interested individual and often as part of a real loss component analysis. But in the great majority of cases, particularly in large utilities, no attempt had been made to analyse this type of data.

With some 21 members from 11 countries, the PM team is able to draw on a wide range of international experience, and to encourage members to contribute case studies and data on particular topics. The table shows summarised and simplified data for 110 pressure management schemes where PM team members have obtained data on breaks (or repairs) before and after pressure management.

It can be seen from the table that large reductions in new break frequency can be achieved over a wide range of pressures. Also, the percentage reduction in new breaks usually exceeds (and often greatly exceeds) the percentage reduction in maximum pressure and can differ significantly for mains and services in the same system.

In Brisbane, Colombia and Torino, Italy, ongoing monitoring shows that the reductions in break frequency have been sustained for over five years to date. By presenting the data as a monthly bar chart, as in Figure 1 for Gracanica (Bosnia and Herzegovina), the rapid reduction in new break frequency following pressure management is immediately evident.

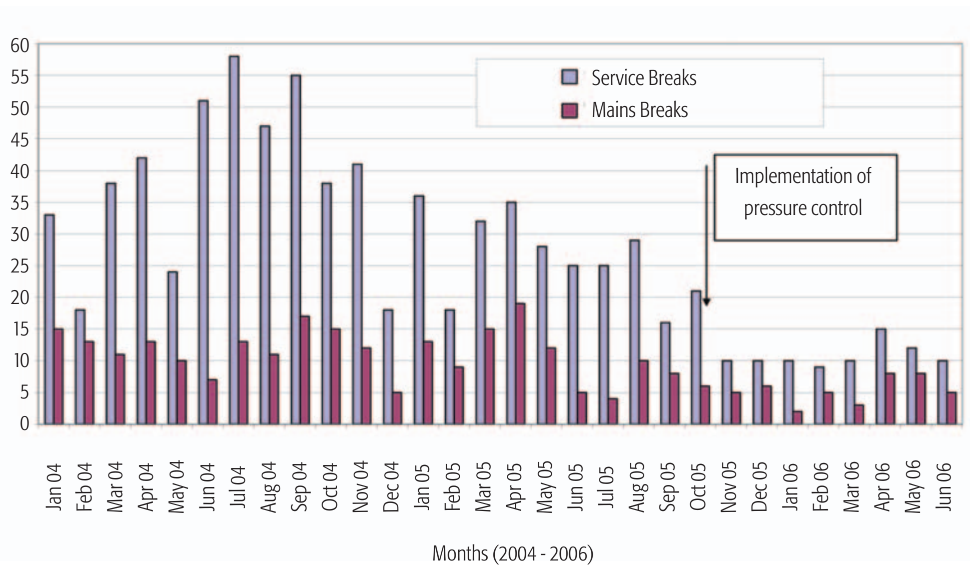

Figure 1
Breaks each month, before and after pressure management, Gracanica.

Implications for the management of operations, infrastructure and energy

Rapid, sustained reductions in break frequencies of the magnitudes experienced in the table have significant effects on several different aspects of utility operations and management. Some of the benefits reported by utilities to PM team members include:

- reduction in annual repair costs
- reduction of the repair backlog, shorter run-times for bursts
- fewer emergency repairs, more planned work
- reduced inconvenience to customers
- a reduction in insurance/compensation claims
- reduced real losses – fewer breaks, shorter run times, lower flow rates
- benefits arising from the transition from an intermittent to a continuous supply
- improvement in several performance indicators.

Calculations of the economic benefit of pressure management have, for some 25 years, been based on the predicted reduction in flow rates of existing leaks (indicated by changes in night flows) and the value of the water thus saved. If management of surges and excess pressures can also regularly achieve reductions in numbers of breaks of

Percentage reductions in new break numbers, before and after pressure management.

Country	Water Utility or System	Number of Pressure Managed Sectors in study	Assessed initial maximum pressure (metres)	Average % reduction in maximum pressure	Average % reduction in new breaks	Mains (M) or Services (S)
Australia	Brisbane	1	100	35%	28%	M,S
	Gold Coast	10	60-90	50%	60%	M
					70%	S
	Yarra Valley	4	100	30%	28%	M
Bahamas	New Providence	7	39	34%	40%	M,S
Bosnia Herzegovina	Gracanica	3	50	20%	59%	M
					72%	S
Brazil	Caesb	2	70	33%	58%	M
					24%	S
	Sabesp ROP	1	40	30%	38%	M
	Sabesp MO	1	58	65%	80%	M
					29%	S
	Sabesp MS	1	23	30%	64%	M
					64%	S
	SANASA	1	50	70%	50%	M
					50%	S
	Sanepar	7	45	30%	30%	M
					70%	S
Canada	Halifax	1	56	18%	23%	M
					23%	S
Colombia	Armenia	25	100	33%	50%	M
					50%	S
	Palmira	5	80	75%	94%	M,S
	Bogotá	2	55	30%	31%	S
Cyprus	Lemesos	7	52.5	32%	45%	M
					40%	S
England	Bristol Water	19	62	40%	40%	M
					55%	S
	United Utilities	10	47.6	32%	72%	M
					75%	S
Italy	Torino	1	69	10%	45%	M,S
	Umbra	1	130	39%	71%	M,S
USA	American Water	1	199	36%	50%	M
Total or Average		**110**		**37%**	**51%**	

between 28% and 80% per year, the annual savings in repairs costs (and the other benefits indicated above) will usually be far greater than the value of the water saved.

Accordingly, the basis for calculating the economic benefits of pressure management, and the short-term economic level of leakage, is in process of being transformed. But the implications of controlling break frequency by pressure management are much wider than simply improved leakage control.

Replacement of mains and services – the most expensive aspect of distribution system management – is normally initiated by break frequencies that are considered to be excessive. Most utilities consider break frequency to be a factor outside their control, and something that can only be remedied by expensive replacement of mains and services. However, if pressure management can reduce break frequencies and extend the working life of parts of the distribution infrastructure by even a few years, the economic benefits (in terms of net present value of deferred capital expenditure) would generally be even greater than the short-term reduction in repair costs.

Another aspect of distribution system management, where the link between pressure and break frequency has not yet (in the experience of the authors) been recognised or acknowledged, is the practice of increased pumping of water to storage during the night, when electricity is cheaper.

There are many distribution systems where the service reservoir is distant from the treatment works, and at night water is pumped through an over-pressurised distribution system to refill the service reservoir. In such cases, financial calculations currently assume (incorrectly) that this has no effect on leak flow rates, break frequency and repair costs or infrastructure life.

In such a situation in Torino, the installation of a booster pump at the end of the distribution system nearest the service reservoir permitted a 10% reduction in maximum night pressure over the rest of the system, and produced a 45% reduction in break frequency, which has now been sustained for almost 10 years.

Conceptual approach to analysis of pressure: break frequency data

Initially, the PM team's approach to analysis of case study data [2,4] was to try to relate break frequency (fb) to pressure (p) using an equation of the form: $fba/fbb = (pa/pb)^{n2}$. In this, subscripts a and b refer to 'after' and 'before', and n2 is an exponent.

However, it is now clear that the 'n2' exponent approach is not appropriate for this relationship. A PowerPoint presentation, outlining the latest conceptual approach, was recently circulated to all water loss task force members [5] and is available on request. This approach will be explained in more detail in a paper to be submitted to the Water Loss 2007 conference in Budapest next September.

If this conceptual approach proves to be valid, then it is likely that:

- if the existing break frequency is relatively high, significant reductions in new break frequencies could be produced by relatively small reductions in pressure
- the number of years for which low break frequencies can be sustained will be governed by the difference between the maximum operating pressure and the threshold pressure; and the rate at which the threshold pressure is reducing

The approach can be briefly summarised as follows (see Figure 2). When a distribution system is constructed with new mains and service connections, the pipes should be selected so that the range of operating pressures (A) is well below the 'threshold' pressure at which frequent failures would start to occur.

However, as the pipes deteriorate through age (and possibly corrosion), and other local and seasonal factors, the threshold pressure at which failure occurs gradually reduces until at some point in time the burst frequency starts to increase significantly.

By reducing any pressure surges (transients) and any excess and unnecessarily high pressures, the range of operating pressures is moved away from the threshold pressure to B, and the break frequency is immediately reduced.

Concluding comments

Distribution management is often called the 'Cinderella' or poor relation of water supply; leakage management is a speciality within distribution management, and pressure management a

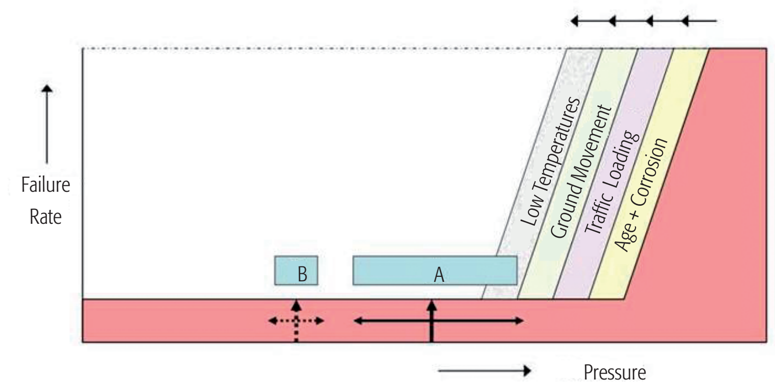

Figure 2 Conceptual approach to Pressure: Break frequency

speciality within leakage management. So it is perhaps unsurprising that the issues raised in this article are not yet part of the mainstream of distribution system management. The authors hope this article will encourage readers to seriously consider the important influences of pressure on the management of distribution systems, and to become proactive in managing pressures for the benefit of those systems.

The next article in this series will be written by Mary Ann Dickinson, who will discuss the needs for proper training and certification of operators in order to ensure sustainable loss control.

Grateful acknowledgements are made to all task force members and utilities that provided data for this article. ●

References

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2 Thornton J and Lambert A (2005). *Progress in practical predictions of pressure: leakage, pressure: burst frequency and pressure: consumption. IWA conference proceedings, Leakage 2005, Halifax, Nova Scotia September 2005*

3 Brothers, K (2006). *Gaining ground on water losses. Water21, June 2006*

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5 Thornton J and Lambert A. *Recent advances in understanding pressure: burst frequency relationships. Update note (PowerPoint) for water loss task force members, July 2006. Copies available from thornton@water-audit.com*

About the authors

Julian Thornton is team leader, pressure management for the task force. Allan Lambert chaired the task force from 1996-2000. Readers of this article with experiences or opinions on the topic of pressure: break frequency are cordially invited to contact the authors at thornton@water-audit.com.

Global Leakage Summit

London Business Conferences is holding its second Global Leakage Technology Summit in London on 25-26 January 2007, with a pre-conference workshop on 24th.

Conference sessions will include an international panel discussion, an industry and regulator panel discussion, and a ‘cutting edge’ technology session.

Alongside UK utilities, international speakers include: Bambos Charalambous, Head of Technical Services, Lemesos, and chair of the IWA Water Loss Task Force; Francisco Paracampos, Director of Operations, Sao Paulo; Hannes Buckle, Water Management Strategist, Rand Water; Francisco Cubillo, Director of Operations, Madrid, and chair of the IWA Specialist Group on Efficient Operations Management; and Bob Taylor, Deputy Managing Director, Abu Dhabi Distribution Company, ADWEA.

Full details at: **www.global-leakage-summit.com**

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