PRESSURE MANAGEMENT WHITEPAPER

SAVE WATER, ENERGY AND COSTS USING PRESSURE MANAGEMENT

GRUNDFOS DEMAND DRIVEN DISTRIBUTION REDUCES LEAKAGE LOSSES, INCREASES ENERGY EFFICIENCY AND SAVES OPERATION AND MAINTENANCE COSTS.

AVERAGE FIGURES BASED ON DELIVERED PROJECTS SINCE 2014

15% LEAKAGE REDUCTION

25% ENERGY SAVINGS

35% PIPE BURST REDUCTION

GRUNDFOS iSOLUTIONS

PUMP · CLOUD · SERVICES

Prepared by Marco Fantozzi
(Studio Marco Fantozzi, Italy).

Contributors:
Allan Lambert (Water Loss Research & Analysis, UK),
Carsten Skovmose Kallesøe, Abdul-Sattar Hassan,
Danny Stærk, Sune Lieknins Neve,
Morten Riis (Grundfos Holding A/S, Denmark).

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INTRODUCTION

Pressure management has proven to be an effective tool for reducing the leakage part of Non-Revenue Water (NRW), improving energy efficiency and reducing operation and maintenance costs. This article looks at the benefits of tackling these three issues using pressure management, especially as the predicative models for burst frequency are now more precise. Extended asset life, based on latest research results, is expected to be the largest benefit with pressure management.

A major challenge facing many municipalities is how to deal with high levels of NRW. Although not all NRW is leakage, inefficient management of distribution system pressures is known to cause substantial excess leakage and bursts and other adverse consequences such as reduced infrastructure life.

Meanwhile, water scarcity and water quality are emerging as key issues of public concern and, more pressingly, as inhibitors of growth in cities and countries around the world. In addition, energy is the highest operating cost item after manpower for most water companies.

As a result, the water market that treats and transports water is expected to continue to grow rapidly as stakeholders look for new and efficient water solutions, technologies and approaches for improving water resource and distribution management.

However, many water utilities continue to struggle with forming a convincing business case to replace and upgrade aging and inefficient distribution networks, while many regulatory policies still fail to reward cost-conscious efforts to upgrade or improve the management of networks.

Pressure management has a great potential to help improve efficiency and alleviate water scarcity concerns. In fact, pressure management is now recognised as the foundation for optimal management of water supply and distribution systems. The proven benefits of pressure management in distribution systems now include not only the water conservation benefits of reducing leak flow rates, but also water utility and customer benefits arising from reduced numbers of bursts and leaks.

These are, for example, reduced repair and reinstatement costs, reduced public liability and adverse publicity, reduced costs of active leakage control, deferred infrastructure renewals and extended asset life of mains and service connections. Benefits also include fewer problems on customer service connections and plumbing systems, all leading to fewer customer complaints.

The **general purpose of this article** is to explain and demonstrate the benefits related to pressure management implementation based on the latest research, best practice methods developed by the Pressure Management Team of the IWA Water Loss Specialist Group, and the advanced tools and technologies available.

Three main areas of benefits related to pressure management implementation will be specifically addressed: **Non-Revenue Water, energy efficiency** and **operation and maintenance costs**. In addition, the latest research advances in assessing pressure management benefits and how water utilities can benefit from large scale pressure management implementation will be explained.

WHAT DO WE MEAN BY PRESSURE MANAGEMENT?

Pressure management can be defined as ***"the practice of managing system pressures to the optimum levels of service ensuring sufficient and efficient supply to legitimate uses and consumers, while reducing unnecessary or excess pressures, eliminating transients and faulty level controls, all of which cause the distribution system to leak unnecessarily"*** Definition by the Pressure Management Team of the Water Loss Specialist Group of the International Water Association (IWA)

RECENT HISTORICAL PERSPECTIVE

In recent years, focus on pressure management in potable water distribution systems has increased, as countries and water utilities begin to realise the many benefits that it can bring. What has caused this surge of interest?

Tests on Japanese and UK distribution systems from 1980 showed an approximate average relationship between pressure and leak flow rate that was stronger than the theoretical square root relationship between pressure and velocity of discharge through a fixed area orifice. This is because the area of some types of leaks also changes with pressure.

In 2003, the Pressure Management Team of the IWA Water Loss Task Force (now the water loss Specialist Group, WLSG) began to collate and publish their own research and recommendations, and encourage water utilities to present case studies at international water loss symposia. FAVAD (Fixed and Variable Area Discharges), recommended as the best practice concept for predicting pressure:leak flow relationships, is now widely used internationally.

Case studies showing a reduction of bursts following pressure management were not widely known, and it was not traditional practice within water utilities to relate burst frequency to pressure, even when collecting national burst statistics for different pipe materials. Accordingly, very few practitioners believed that pressure management could influence burst frequency, other than in the control of pressure transients. This perspective started to change when Thornton and Lambert (2006, 2007) published 112 sets of data from 10 countries, showing mostly significant reductions in burst frequencies after pressure management, together with:

- a general explanatory concept ('the straw that breaks the camel's back')
- quick practical methods for identifying zones with good potential for burst reduction on mains and/or service pipes

Fixed area orifice: Leakages in cast iron pipes are behaving as a fixed area orifice. With such a leak the leakage flow depends on the pressure according to q=K p^n where n=0.5

Pressure dependent area orifice: With pressure dependent orifice areas the orifice in the pipe opens with the pressure. This means that the leakage flow increases faster with pressure than in the case with a fixed area orifice. With such a leak the leakage flow depends on the pressure according to q=K p^n where n>0.5. In a network with different types of pipes an n value around 1 is typically a good choice (A. Lambert, 2000)

The prospect of a reduction in burst repair and associated costs, and the potential for improved asset management, created increased international interest in pressure management. Many hundreds of pressure management schemes have been implemented internationally since 2007, and whenever case studies are presented at conferences or published, the benefits of pressure management are now generally accepted as follows:

- reduction of leak flow rates
- possible reduction of burst frequency on mains and on services
- extension of residual asset life

Pressure management is now recognised as having an increasingly wide range of benefits

Water utilities wishing to justify the investment in pressure management need to be able to predict these benefits, which vary from one situation to another.

The conclusions of the most recent research on understanding and predicting pressure:bursts relationships are summarised in Lambert, Fantozzi and Thornton (2013). Some examples are shown here, and further details can be found in a series of papers available from www.leakssuite.com.

Other benefits of pressure management include reduced costs of active leakage control and improved service to customers from fewer interruptions to supply. Pressure management is now being used not only for leakage control, but also for demand management, water conservation and asset management.

Figure 1 below is the latest version of a format first used in a recent Australian research project (Water Services Association of Australia Asset Management Project PPS-3, 2008-11 2011) and most recently with an 'energy' component added (Fantozzi et al, 2013), which summarises the various benefits of pressure management.

The pressure management benefits shown in the table can be grouped in three main categories **(leakage, energy efficiency** and **operation and maintenance costs)**, and these three issues are now addressed below.

PRESSURE MANAGEMENT: REDUCTION OF EXCESS AVERAGE AND MAXIMUM PRESSURES								
CONSERVATION BENEFITS			WATER UTILITY BENEFITS			CUSTOMER BENEFITS		
REDUCED FLOW RATES			REDUCED FREQUENCY OF BURSTS AND LEAKES					
Reduced excess or unwanted consumption	Reduced flow rates of leaks and bursts	Reduced and more efficient use of energy	Reduced repair and reinstatement costs, mains & services	Reduced liability costs and reduced bad publicity	Deferred renewals and extended asset life	Reduced cost of active leakage control	Fewer customer complaints	fewer problems on customer plumbing & appliances

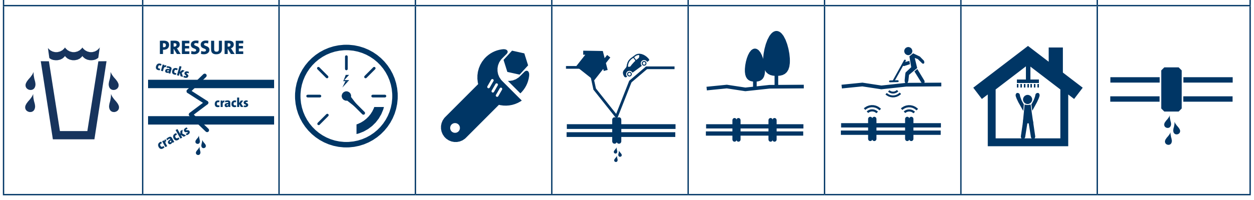

Figure 1: Multiple benefits of pressure management

ISSUE 1: LEAKAGE COMPONENT OF NON-REVENUE WATER

Non-Revenue Water (NRW) is the difference between the amount of water put into the distribution system and the amount of water billed to consumers. High levels of NRW seriously affect the financial viability of water utilities through lost revenues and increased operational costs.

The total cost to water utilities caused by NRW worldwide is conservatively estimated at USD 14 billion per year, with a third of it occurring in the developing world, according to the Energy and Water Department (EWD) of the World Bank Group (2006).

NRW includes unbilled authorised consumption (fire-fighting, flushing, and such like) and apparent losses (customer metering under-registration and unauthorised consumption), both of which represent water that is consumed but not paid for, and which are only marginally influenced by pressure management. The remaining component of NRW – leakage and overflows from water utility transmission and distribution systems – represents a wasted resource that can often be significantly reduced by pressure management.

The leakage component of NRW varies from 95 % down to 50 %, depending on apparent losses level due to the theft and customer meter under-registration, which is greatest in systems where customers have storage tanks.

On average, flow rates of individual leaks vary linearly with average zone pressure. By reducing both the frequency and flow rates of leaks, pressure management can reduce the amount of money spent on producing and/or purchasing water, and on the consumption of energy required to pump and treat water for distribution. Intelligent pumping solutions and the use of advanced pressure reducing valves can make a significant difference, but care is needed in identifying those parts of a distribution system that will benefit most from pressure management, and also the particular form of pressure management that is most appropriate.

The best long-term solution is to design systems to operate continuously at moderate pressures (Pearson and Lambert, 2013)

ISSUE 2: ENERGY EFFICIENCY

Water supply systems are massive consumers of energy along the multiple stages of water production and supply chain: water abstraction, treatment processes, and pumping stations within the supply system.

For most water companies, energy is the highest operating cost item after manpower. According to the Environmental Protection Agency (EPA), water and wastewater systems spend about USD 4 billion a year to pump, deliver, collect, treat and clean water. The EPA and other experts also predict that energy consumption at water and wastewater utilities will grow by more than 20 % in the next 15 years. Moreover, about 90 % of the energy used in water distribution is consumed by pumping systems.

Energy costs can represent, in water systems of large dimension, 80 % to 90 % of the total life cycle costs of pumping stations (DOE et al, 2001; Abelin et al, 2006; HI&PSM, 2008; Veness, 2007). Energy efficiency offers a major opportunity to achieve important cost reduction in the operation of water pumping systems, especially with regard to the expected rise of energy prices (EUROSTAT, 2009).

In view of the above it is clear that developing and implementing solutions that can significantly reduce the use and the cost of energy used is the right approach for efficient management of water distribution systems. Historically, and even now, the control functions in most of the water management systems used are targeted to successfully cope with operational constraints and demands without considering the drawbacks from too high pressure settings in the network. This is however mainly due to the lack of appropriate technologies that can address the cost function and lack of adequate knowledge about the consequences and related costs associated with unnecessary, excess pressure in the system.

Pressure management opens new options for reducing high energy costs if correctly embedded into optimal pumps scheduling and operation

PRESSURE MANAGEMENT HAS PRODUCED MEASURABLE BENEFITS

Grundfos has built up considerable experience with pressure management using the company's Demand Driven Distribution solution. In the following three cases the potential for energy savings using pressure management is demonstrated by using the Demand Driven Distribution solution, showing the benefit of the control approach. In addition, experience has shown that additional savings of up to 50 % can be harvested by replacing existing pumps with the latest pump solutions.

Case 1: Bucharest, Romania

APA-NOVA Bucharest has recently implemented new Grundfos solution for pressure management in one pumping station in Bucharest. The primary purpose of the controller is to optimise the pump delivery pressure into the city to reduce leakage and energy use – and at the same time maintaining good customer service. Changing the pumps from running at constant pressure to proportional pressure with Grundfos Demand Driven Distribution has had the following effect:

- Energy consumption reduced by around 15 %

Case 2: Talca, Chile

Essbio in Chile had a challenge in delivering good customer service, as well as improving the efficiency at the Tejas Verde plant. Grundfos implemented a pressure management Demand Driven Distribution controller at the start of 2013, achieving the following:

- Energy consumption reduced by around 28 %

Case 3: Skagen, Denmark

Frederikshavn Forsyning, the water utility serving Frederikshavn municipality in Denmark, has a proven track record in successful pressure management implementation. An example is the Skagen district, where the installation of the Demand Driven Distribution controller allowed better protection of the system, achieving:

- Energy consumption reduced by around 17 %

ISSUE 3: OPERATION AND MAINTENANCE COSTS

Europe alone has 3.5 million km of water distribution networks (EUREAU, 2009). Water utilities face a number of challenges related to these distribution networks. In the next 10 to 30 years large parts of water distribution networks will need to be rehabilitated. Based on experiences of major European water utilities and taking into account the state and performance of distribution networks, it is possible to estimate that EUR 20 billion per year will be needed in Europe to upgrade distribution networks.

Prioritisation and optimisation of these investments is urgently needed:

Strategic prioritisation and allocation of capital expenditures

Employing dynamic pressure management tools can result in a 10 % to 15 % savings on capital expenditures by strategically directing investment. Based on the estimate of the above-mentioned investments needed in Europe, such dynamic pressure management tools can save up to USD 2 billion annually.

Relationship between pressure and burst frequency

Until quite recently, calculations for the economic case for pressure management were traditionally based only on the predicted savings from the reduction of flow rates of existing leaks.

Thornton and Lambert (2006, 2007) demonstrated that reduction of excess pressure in zones with high burst frequencies could have a substantial influence on reducing bursts, and that separate predictions were needed for mains and for services. 112 case studies in 11 countries showed an average percentage reduction in burst frequency of 1.4 times the percentage reduction in average pressure for mains.

Using current and recent burst frequencies on mains (per 100 km/year) and on service connections (per 1000 services/year), it became possible to quickly predict if pressure management would reduce bursts on both mains and services, or one or the other, or neither. These simple qualitative and quantitative predictions proved to be effective for rapidly targeting zones which would give the fastest payback for pressure management.

Recent research has provided improved predictions for a whole range of burst frequencies and how pressure management provides benefits (Lambert, Thornton & Fantozzi 2013). It is important to point out that big savings can be achieved in many cases by a quite small reduction in pressure, as shown in Figure 2.

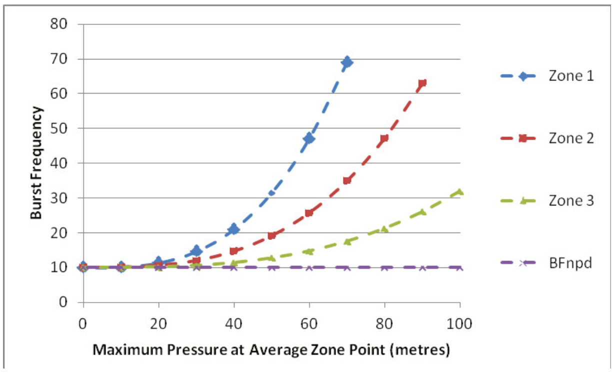

Figure 2: Characteristic relationship between AZPmax and burst frequency for individual zones (reproduced with the permission of WLRand Ltd)

Figure 3 shows actual and predicted changes in repair frequency on mains in the Durban Central Business District (CBD), South Africa, using both prediction methods, for mixed mains materials (AC, plastic, steel, cast iron). The seasonal variations in burst frequency were much reduced on both mains and services, with corresponding significant reductions in overall repair costs.

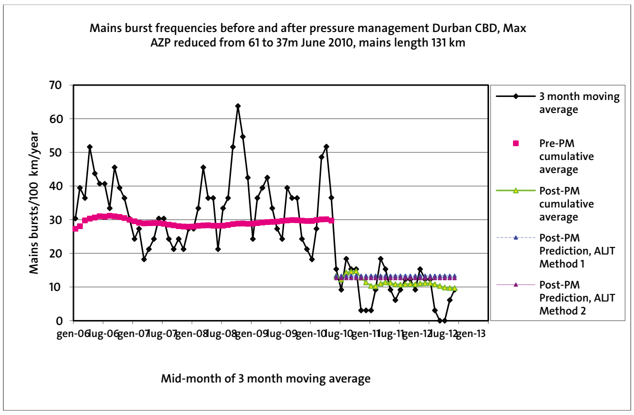

Figure 3: Mains repair frequencies pre- and post-pressure management, Durban CBD showing more than 50% drop in burst frequency, and therefore similar savings in maintenance costs (reproduced with the permission of Ethekwini Municipality)

The latest established relations between pressure and burst frequency (Shown in Figure 2 and 3) are now being used to make practical predictions of changes in burst frequency in an increasingly wide variety of countries and situations. However the largest financial benefits are likely to be deferred pipe renewals and extension of asset life, as explained below.

Deferred renewals and strategic prioritisation and allocation of capital expenditures
Significant reductions in burst frequencies on mains and services following large scale pressure management are beginning to have an influence on the numbers and choices of pipes that are renewed each year. Water utilities that have policies to replace their mains and services based on defined customer service criteria such as 'X bursts in Y km in Z years' are now retaining some mains and services that would otherwise have been replaced. Early indications from Australia are that financial savings arising from this can be several times the annual savings in burst repair costs.

A careful analysis is needed to identify those parts of a distribution system that will benefit most from pressure management and to assess the specific benefits.

Employing dynamic pressure management tools can result in great savings on capital expenditures by strategically directing investment

How pressure management may affect consumption
Some water utilities are concerned with potential losses in revenue after pressure reduction. When system pressure changes, some of the components of metered consumption may be affected, and pressure management may result in a change in the income received by the water utility from metered customers.

Based on prediction models recently developed in Australia, probable changes in consumption can be predicted based on assumed change in average system pressure, estimated percentage of annual residential consumption outside the property, presence of private storage tanks, and/or private booster pumps.

However, whether reductions in consumption from pressure management are considered to be a benefit or a cost, the volumes usually seem to be relatively small in relation to the reduction of leak flow rates, bursts frequency and extension of infrastructure life. Because consumption is charged at retail price, the financial implications should be calculated so that the implications on the revenue of the water utility are predicted and identified.

BENEFITS FOR RESOURCE MANAGEMENT, CUSTOMERS AND COMMUNITIES

Additional benefits from pressure management include:

Water resource management

Pressure management permits a water utility to vary pressure over both the seasonal and daily cycles of demand, providing the minimum required standard of service for pressure at the customers' premises.

During drought periods when water supply restrictions apply, pressures can be further reduced. The alternative of imposing intermittent supply is most likely to increase burst frequency and permanently damage the distribution system.

Some countries (such as Italy) now require water utilities to report their average pressure along with their water balance calculations and NRW performance indicators, and this should be regarded as best practice for others to follow.

Deliver improved customer service

Leading regulators are increasingly focused on customer service issues by introducing key performance indicators for interruption, continuity of supply, minimum pressure, and so on.
Pressure management schemes are normally designed to comply with such criteria in a cost-effective manner.

Minimise community disruptions

Water mains bursts and other major system failures lead to disruptions in daily life – thousands of hours of lost productivity on top of the costs of repair. Continuous pressure and flow monitoring, which is a normal part of pressure management, reduce the number, severity and duration of these disruptions.

Minimise damages to customers' plumbing

Increasingly, national plumbing standards are specifying and reducing the maximum permitted pressure that customers receive to avoid reducing the life of customers' appliances (taps and fittings) and for reducing excessive noise.

Reduced liability costs

Many water utilities suffer catastrophic water pipe failures every year. These failures, in addition to losing precious water and costing up to millions of dollars to repair, also cause interruption to the everyday life of the consumer and damage to the water utility. Because these failures are highly visible, the press all too often uses these failures to show the water utility in a bad light, causing deterioration in customer satisfaction. There are many variables that can contribute to a catastrophic failure; however excess pressure at night or pressure transients is often found to be 'the straw that breaks the camel's back'. Pressure monitoring and management can assist in reducing the frequency and effect of these failures thus saving money for the water utility and improving customer satisfaction.

OPPORTUNITIES AND SOLUTIONS

Consistent with the latest research results and with achievements by advanced water utilities, pressure management represents one of the biggest opportunities to improve water utility performance. Figure 4 summarises the various benefits of improved pressure management related to problems facing water utilities.

	PROBLEMS FACING WATER UTILITIES, AND BENEFITS WITH DIFFERENT MODES OF OPERATION		
	INTERMITTENT SUPPLY: (NOT "24/7" OPERATION)	CONTINUOUS SUPPLY: (EXCESS PRESSURE)	OPTIMAL PRESSURE MANAGEMENT: (DEMAND DRIVEN DISTRIBUTION)
NRW – HIGH LEAKAGE COMPONENT	Leakage flow rates reduction due to limited time of pressurisation. Very high burst frequencies on mains and services. Big risks of contamination when the pipes are not pressurised.	High burst frequencies due to higher than required maximum pressures for much of the time. High leak flow rates due to higher than required average pressures.	10 % reduction of average pressure produces 10 % to 20 % reduction in annual leakage (depends on pipe materials and type of leaks). Experience from delivered projects of DDD since 2014 show that leakage is reduced by 15% on average, and pipe burst frequency by 35%.
ENERGY EFFICIENCY	High energy costs for pumping as higher flow rates are imposed to move the same volume.	Excess energy costs due to excess pressurisation from pumping.	10 % reduction of excess average pressure produces around 10 % decrease in energy costs from pumping. Experience from real installations with DDD since 2014 show energy savings of 25% on average.
OPERATION AND MAINTENANCE	High manpower costs for valving operations. High repair costs.	High repair costs High liability costs	10 % reduction of average pressure decreases economic intervention costs of active leakage control by 10 %.
	Active leakage control is difficult due to insufficient pressure.	High active leakage control costs due to higher rate of rise of unreported leaks.	10 % reduction of average pressure decreases economic intervention costs of active leakage control by 10 %.
	Short asset life time due to poor operation and pressure transients.	Short asset life time due to excess pressure.	Deferred renewals, residual asset life extension. This benefit can be very substantial; prediction methodology for pressure reduction being developed.

Figure 4: Three different control approaches evaluated against their effect on water leakage, energy efficiency, and operation and maintenance costs

When considering pressure management, the first objective is to identify the presence of pressure transients and to minimise their adverse effects. The second objective is to move from intermittent supply to continuous supply (also known as 24/7 supply) at a lower pressure if necessary. Reduction of bursts through control of pressure transients and slow refilling of systems is one key aspect of this policy. The other key aspect is that lower continuous pressure reduces leak flow rates when the system is pressurised.

Reducing average and maximum excess pressure by only 10 % produces a reduction in leakage, reduction in pipe bursts, deferred renewal and extension of residual asset life, and energy savings. This can save water utilities a significant part of their budget and create a virtuous cycle leading to more effective investments and improved service. By reducing the amount of water leaked, pressure management can reduce the amount of money wasted on producing and/or purchasing water, consuming energy required to pump water and treating water for distribution.

Methodologies and concepts now exist to calculate payback periods and financial benefits for different pressure management options in different parts of the water utility's distribution system (Lambert A, Thornton J and Fantozzi M, 2013).

Pressure management is the right opportunity – right now

> ***In practice, pressure management benefits should be considered on a case-by-case basis against the actual cost of implementing a pressure management program***

Pressure management by means of smart pumping technologies and pressure-reducing valves (PRVs) can be leveraged to help address the water challenges discussed above. Awareness of the benefits of pressure management in distribution systems in combination with practical methods to make predictions of these benefits, which vary from one situation to another, and the capability to make a sound financial case for such investment make that possible today. In addition advancements in technology that deliver enhanced data allow the adjustment, control and monitoring of pressure, and then quantifying and certifying the results achieved.

It is important to understand the business case for using proper pressure management technologies as an alternative to investing heavily in capital expenditures, and to assess the potential annual savings related to pressure management implementation.

The path forward

Pressure management will begin to take hold when the potential value for water utilities becomes abundantly clear and the ability to capture that value is made easier. This article has aimed to bring to light the various barriers and opportunities that exist to help water utilities around the world make pressure management decisions based on a rigorous, analytically sound approach.

This shared understanding, while necessary, is not sufficient to drive widespread adoption of pressure management. Only with a concerted effort from all major stakeholders can the water industry as it stands today be redefined and overcome the looming challenges posed by water scarcity and water quality. Below are some initial thoughts on ways in which industry stakeholders can help catalyse the adoption of pressure management.

Water players must take action

Provided water players join forces, the following key challenges for implementing pressure management are not insurmountable:

- **Lack of awareness of achievable benefits**
  Most water utilities are still not fully aware of the benefits achievable with pressure management implementation. Design of new or extended systems to operate at low steady pressures (see page 6, Pearson & Lambert quote) would be very beneficial.

- **Lack of funding**
  Possible solutions to lower the barrier to entry include risk-sharing contracts to lower upfront investment required and third-party suppliers who implement technical solutions and analyse the data.

- **Lack of political and regulatory support**
  Regulatory support – as well as incentives – would be critical for kick-starting pressure management, beginning in water scarce areas where the need for water efficiency and conservation is greatest.

RESOLVING ISSUES WITH PRESSURE MANAGEMENT

As described above, pressure management is one of the key technologies to improve the operation of water distribution networks.

To obtain the best possible pressure management, the network pressures must be measured and the pumping station controlled according to these measurements. However, online communication between the network pressure sensors and the pumping station is expensive and hard to set into operation. This is solved with the Demand Driven Distribution solution from Grundfos, which is shown in figure 5.

Demand Driven Distribution measures the pressure in the network using a number of battery-driven data loggers that transmit the measured and logged values to the Demand Driven Distribution controller via the GSM network, using just one SMS text message pr. sensor a day. The measured data are then used in a smart adaptive control approach that controls the pumping station, keeping the pressure in the network at the desired value, without troublesome analysis and re-configurations of the system to obtain proper operation.

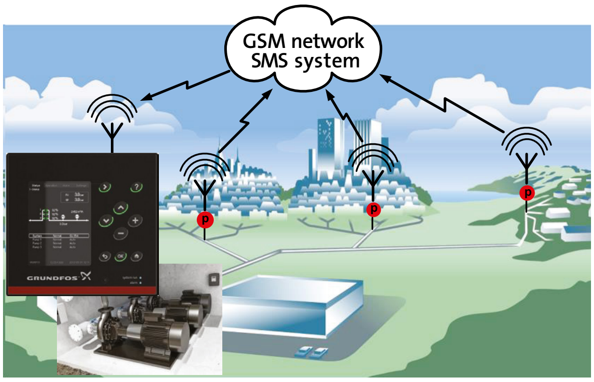

Figure 5: The Demand Driven Distribution controller connected to network pressure sensors via the GSM network allows control of the pumps in accordance with the logger data via a smart adaptive control algorithm

Pressure transients are one of the main reasons that cracks are created in piping. To avoid the pumping station creating such transients, pressure ramping is standard in the Demand Driven Distribution controller, using the soft pressure build up function.

With Demand Driven Distribution it is possible to control pressure according to the given operating conditions. For example:

- In a **continuous supply** situation, Demand Driven Distribution maintains the optimal level of service while generating savings from reductions in NRW, improved energy efficiency and reduced operation and maintenance costs.
- In areas affected by **periods of drought**, both leakage and water consumption can be lowered by lowering the network pressure without any risk of contamination.
- Where water shortages are managed by **intermittent supply**, advanced pressure management limits water consumption without the risk of contamination and reducing the burst frequency typically associated with intermittent supply.

New technical ideas and progress on pressure management

Pressure management is developing further and includes research into pressure management benefits as well as new technologies and modalities for pressure management implementation. Some of the areas being looked at include:

- Intelligent technologies to optimise distribution, pump pressure and PRV pressure
- Pressure:bursts relationships, and the influence of pipe materials
- Validation of scheme results, and implications of extended asset life
- Guidelines for transient analysis in water transmission and distribution systems
- Pressure management in very low pressure zones

Conclusion
Pressure management represents a great opportunity for water utilities to realise significant financial savings. The time is right for water utilities to seize this opportunity, as there is now enough knowledge about the relationship between pressure management and its related benefits, and enough water utilities have success stories that can be demonstrated.

With municipalities facing major challenges in water resource management in the near future, pressure management represents an effective way to reduce Non-Revenue Water, improve energy efficiency and reduce operation and maintenance costs.

Demand Driven Distribution from Grundfos is an effective way of applying pressure management for pump systems that resolves the issues outlined in this article, offering substantial benefits for resource management, customers and communities:

- **Water resource management**
  Vary pressure over both seasonal and daily cycles of demand, meeting the minimum standard of service for pressure at the customer.

- **Deliver improved customer service**
  Meet requirements for interruption, continuity of supply and minimum pressure in a cost-effective way.

- **Minimise community disruptions**
  Reduce the severity and duration of water main bursts and other major system failures.

- **Minimise damages to customers' plumbing**
  Meet national plumbing standards that limit the maximum pressure permitted in pipes.

- **Reduced liability costs**
  Help reduce the frequency and effect of water pipe failures, saving money for the water utility and improving customer satisfaction.

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