the Rippleffect
Water efficiency for business

Reducing water use –
pressure, pipework and hoses

All businesses use water in some way, whether for domestic use, in the manufacturing process or for ancillary activities. Usually, water is delivered to the site and to the point of use under pressure through pipes. The water pressure and the pipework diameter will influence the rate of flow of water. Consequently, they will also influence the rate of use.

- The water pressure at the point of use has a significant effect on the flow rate – the greater the pressure, the greater the flow.

- The diameter and configuration of the pipework will also influence the rate of water use - the larger the diameter, the greater the flow at a given pressure.

In general, these factors can be easily optimised such that water use is reduced without compromising production. With few exceptions, once optimised, any savings achieved will be repeated year on year.

Pressure

Pressure is required in a water distribution system to push the water through the pipes to the point of use and to overcome pressure loss or 'head' loss. Pressure loss can be due to:

- friction losses against pipe walls, valves and bends (dynamic head); and

- pushing water uphill, for example to an elevated tank (static head).

While adequate pressure is necessary to overcome these pressure losses, too great a pressure will cause excessive flow at the point of use. This may not be important when filling a set-volume vessel (e.g. a tank) because it simply fills up more quickly. However, for other uses, such as taps, hoses or spray bars, excessive pressure can lead to a waste of water. Excessive pressure can also lead to greater wear and tear on the plumbing system and may cause or exacerbate leakage.

Water pressure is measured in a variety of units. Table 1 shows the most frequently used units of measure and how they relate to one another.

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Table 1: Units of pressure and conversion factors

Unit of measurement						
pascal (Pa)	**bar**	**kg/cm²**	**lb/sq in (psi)**	**millibar**	**H₂0 (at 4°C)**	**mH₂0 (at 4°C)**
1	0.00001	0.000010	0.000145	0.01	0.004015	0.000102
100,000	**1**	1.0197	14.5037	1000	401.4629	10.1972
98066.50	0.9807	**1**	14.2233	980.665	393.7006	10
6894.75	0.0689	0.0703	**1**	68.9476	27.6799	0.7031
100	0.001	0.0010	0.0145	**1**	0.4015	0.0102
249.09	0.0025	0.0025	0.0361	2.4909	**1**	0.0250
9806.65	0.0981	0.1	1.4223	98.0665	39.3701	**1**

To meet their 'service standard', water companies should maintain a minimum pressure of water in the communication pipe serving the premises supplied with water of 70 kPa (0.7 bar). There is a risk of low pressure if 100 kPa (1 bar) is not maintained at the external stop tap, at a flow of 9 litres per minute. This should be sufficient to fill a one-gallon (4.5 litre) container in 30 seconds (source: OFWAT).

High-rise buildings or extensive distribution systems often require booster pumping stations to ensure water is supplied at an adequate pressure to reach all points of use.
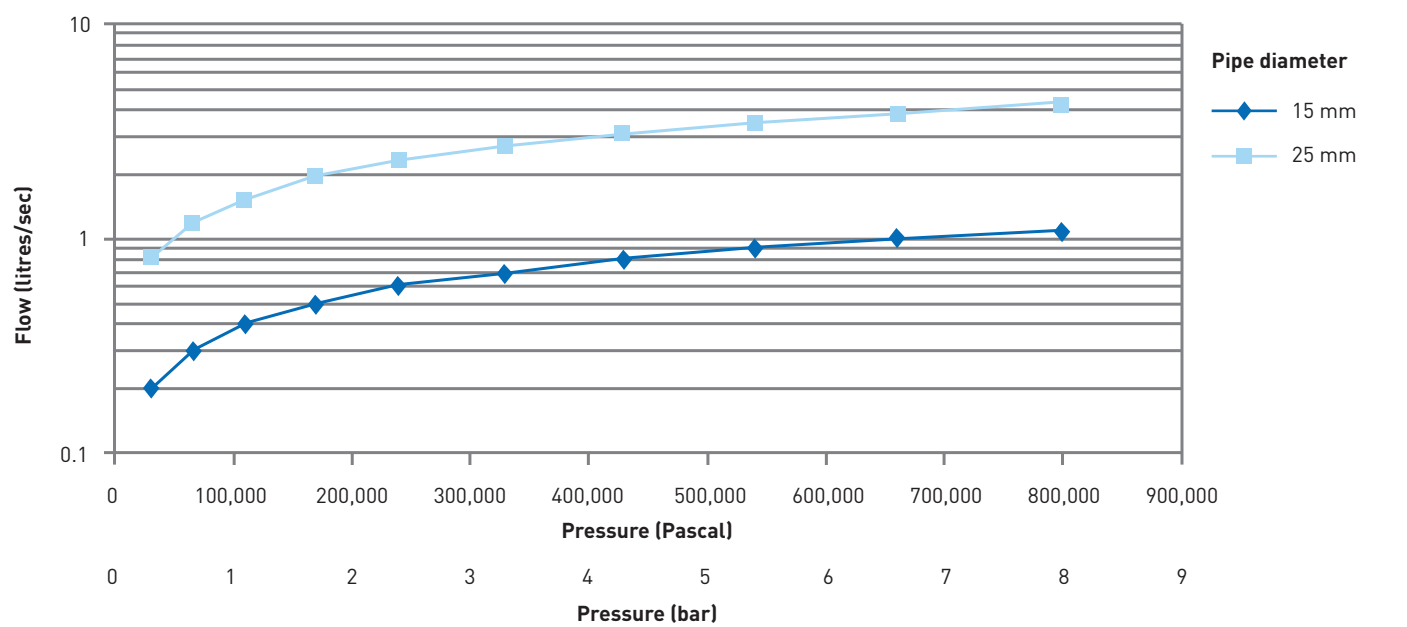
Typically, high pressures occur where:

- The site is supplied directly off the town's mains supply, where this is at a high pressure (e.g. near a pumping station or in a valley).

- High-pressure booster pumps have been installed to reach the top floor of a multi-storey building and there are off-takes from the supply at lower levels.

- The site is supplied under gravity from an elevated storage tank. For example, if the storage tank is located on the roof of a 16-storey tower block, pressure in the basement can be around 680 kPa (6.8 bar).

The majority of water fittings are designed to work at the minimum mains pressure 100 kPa (1 bar), usually making it unnecessary to supply water at a greater pressure. However, there are exceptions to this so it is always worth checking pressure requirements. Water pressure higher than the set operating range will simply use more water than needed, usually with little or no benefit. The importance of this is shown in Figure 1 where the flows through 15 mm and 25 mm pipes are shown at various pressures.

Figure 1: Approximate flow through 20 m of pipe at different pressures, for two pipe diameters

Apart from the unnecessary use of water, excessive pressure can also:

- subject the distribution system and fittings to additional (unnecessary) wear and tear; and

- cause or exacerbate leakage.

The pressure your water distribution system is operating at can be found from:

- your local water company, which may be able to inform you about supplies direct from the mains.

- looking at your booster pumps – these usually have a pressure indicator (delivery pressure) or set point; and

- pressure gauges in your system (if gauges are not fitted, it is worth installing them – they typically cost between £10 and £20, excluding fitting).

Actions

1. Establish the pressure(s) of the cold and hot water distribution system(s) on your site.

2. Install pressure gauges in appropriate locations if necessary.

HIDDEN COSTS OF EXCESSIVE PRESSURE

Controlling pressure can usually save more than the direct cost of the water alone. Often, the amount of hot water used (which has added value) can also be reduced and so can the energy costs for any on-site pumping. Understanding the true cost of water is important for calculating the savings that can be made by improving water efficiency.

Typical costs for water:

UK mains supply[1]	£0.59 – £1.75/m^3
Softened water	£1.00 - £2.16/m^3
Hot water (60°C) – gas heated[2]	£2.82 - £3.98/m^3
Hot water (60°C) – electrically heated[2]	£6.48 - £7.64/m^3

Remember that additional costs will also be incurred for disposal of any wastewater to sewer, typically between £0.54 and £2.67/m^3.

Pumping costs may also be incurred if a site has a booster pumping station. These costs can be estimated from the following equation:

Power (kW)

$$= \frac{\text{flow (m}^3\text{/minute)} \times \text{delivery head (m)}}{6.1 \times \text{pump efficiency}}$$

Where: 6.1 is the units conversion factor
Efficiency of a typical pump ≈ 60 – 70%[3]

Energy is wasted when booster pumps are set to deliver and maintain excessive pressures. The example below calculates the additional power required to pump 100 m^3/hour to the roof of a 7-storey building (i.e. 32 m high) at a head of 70 m (7 bar) rather than an adequate 50 m (5 bar):

Additional power (kW)

$$= \frac{1.66 \times 70}{6.1 \times 0.6} - \frac{1.66 \times 50}{6.1 \times 0.6}$$

$$= 31.75 - 22.68$$

$$= 9.07 \text{ kW}$$

With electricity costs of 9.5 p/kWh and an 8-hour day, 6-day week operation for 48 weeks, the annual cost for unnecessary pumping will be about £1,985. This excludes any costs for excessive water use if there are any take-off points at the unnecessarily high pressure.

Action

1. Work out how much 1 m^3 of water costs you. Do this for each type of water used (e.g. hot water, cold water, softened water).

[1] UK mains supply based on standard 2010/11 tariffs
[2] Energy costs at 3.6p/kWh for gas and 9.5p/kWh electricity, using a boiler with 90% efficiency
[3] Pump efficiency can be obtained from pump manufacturer

Saving water by reducing pressure

When considering reducing water pressure, it is important to:

- identify the minimum operating pressure required that will not compromise performance (i.e. that equipment will operate effectively at the lower pressure); and

- check that mixer taps or shower mixer units will not be adversely affected by the new pressures (i.e. the thermostatic control will still operate).

Although there may be items of equipment that require a higher pressure, it is unlikely that the whole water distribution system will need to be operated at that pressure.

Two easy methods of controlling the pressure in a water distribution system are:

- adjusting booster pump set-points; and

- fitting pressure reducing valves (PRVs).

BOOSTER PUMPS

Booster pump units often have a simple dial or preset in the control panel to set the desired delivery pressure. Adjusting the delivery pressure will reduce the pressure to the entire distribution system. Undertake this adjustment with care and seek further advice if necessary.

The cost of reducing the pressure in this way is low and reversible – the original pressure can be reinstated if necessary.

Figure 2: Typical booster pump unit (courtesy of Lyreco)

Actions

1. Identify the location of any booster pump units on your site.

2. Establish which areas of your site the booster pumps supply and what the current pressure settings are.

3. Check whether the set pressure could be reduced.

4. Reduce the set pressure if possible and check that the water supply is not adversely affected.

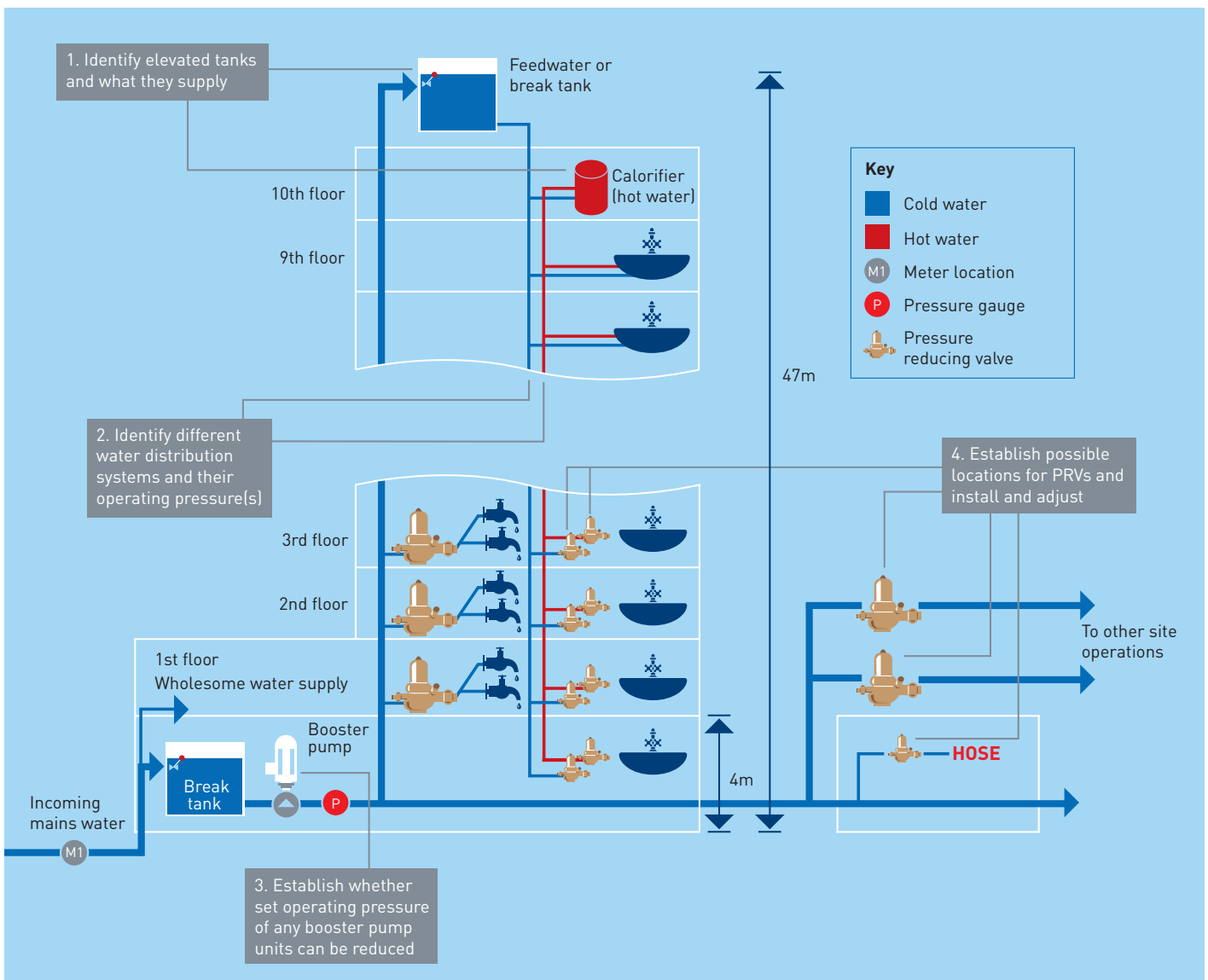### PRESSURE REDUCING VALVES

PRVs can be used to control the pressure of the incoming mains, the distribution system or specific points. For example, PRVs can be installed on:

- the supply to each floor;

- the down legs of a gravity-fed distribution system;

- the risers in a pumped system; and

- the supply to hoses.

PRVs can be preset or adjustable; the latter offers more flexibility in operation. Typically, they can accept delivery pressures of up to 2,500 kPa (25 bar) and deliver a pressure of between 150 kPa and 600 kPa (1.5 bar and 6 bar), under variable flow conditions. They are available in a number of sizes - an adjustable PRV will cost around £20 (15 mm) to £200 (50 mm), excluding installation. Pressure gauges are optional on some PRVs, but having one fitted is worthwhile in many situations. The use of PRVs in the water supply industry is commonplace.

Typical locations of PRVs are shown in Figure 3.

Figure 3: Potential areas for water efficiency improvements using pressure regulation

1. Identify elevated tanks and what they supply

Feedwater or break tank

Calorifier (hot water)

10th floor

9th floor

Key

- Cold water
- Hot water
- M1 Meter location
- P Pressure gauge
- Pressure reducing valve

47m

2. Identify different water distribution systems and their operating pressure(s)

3rd floor

2nd floor

1st floor
Wholesome water supply

Booster pump

Break tank

4. Establish possible locations for PRVs and install and adjust

To other site operations

HOSE

4m

Incoming mains water

M1

3. Establish whether set operating pressure of any booster pump units can be reduced

Actions

1. Identify any points of water use operating at excessive pressure.

2. Identify where PRVs could be fitted to reduce pressure.

3. Calculate the cost savings that could be achieved.

4. Install PRVs and monitor savings.

How reduced flow is assessed

It is always a good idea to measure the flow before pressure adjustments are made. This provides a baseline against which changes can be measured and assessed, and the benefits calculated. Flow rates can be measured simply using a bucket or other container of known volume and a stopwatch. Installed sub-meters can also be used.

The flow rate that would be obtained after a change of pressure can be estimated from:

$$\text{New flow rate} = \text{old flow rate} \times \sqrt{\frac{\text{new pressure}}{\text{old pressure}}}$$

To properly assess the benefits of reducing pressure, it is important to calculate total flow rates and water savings accurately, and take into account all cost savings. For example, if PRVs were fitted to the hot and cold supplies to the sinks in the ground floor washrooms shown in Figure 3 then, using the following information, the cost savings that could be achieved can be calculated:

- Number of handwashes per day – 350

- Duration of handwash (mainly hot water tap) – 20 s

- Pressure reduced from 470 kPa (4.7 bar) to 125 kPa (1.25 bar)

- Flow rate per tap before PRVs installed – 15 litres/minute

- Flow rate per tap after PRVs installed – 7 litres/minute

Amount of water saved

$$= \quad \frac{350 \ \times 20 \times \ (15 - 7)}{60} \quad \text{litres/day}$$

$$= \quad 933 \ \text{litres/day}$$

At a site working 6 days a week, for 50 weeks of the year, the annual saving is around 279,900 litres of water, or nearly 280 m^3/year.

As most of this water use is from the hot tap, with a cost of water supply and heating (gas) at £3.40/m^3 together with sewerage charges of £1.61/m^3, the cost saving by fitting two PRVs (one each for hot and cold supply) will be about £1,402/year (excluding the PRV purchase and fitting costs).

Pipework

Pipework in a water distribution system is usually sized to minimise the dynamic head loss.

This is achieved by using pipes with a large diameter to keep the velocity down – usually to less than 1.5 – 2 m/s at maximum flow. If this is exceeded, then turbulent flow in the pipe increases to a point where it may become noisy (the typical sound of water rushing through a pipe) or cavitation occurs, which is the formation of small bubbles. These will gradually erode pipework and/or fittings.

However, this is not necessarily the case at the point of use – and pipe sizing, particularly on hoses, can have a significant effect on water use.
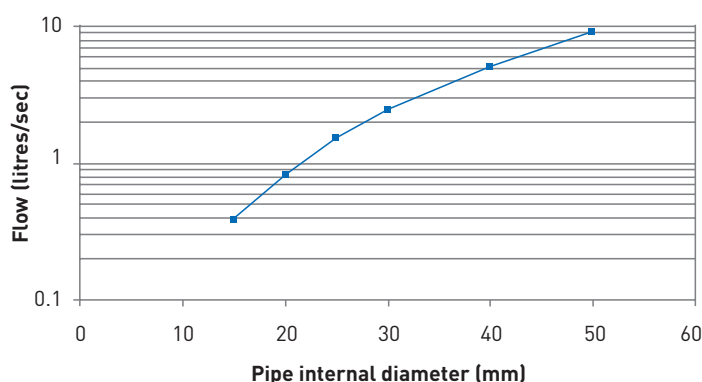

Actions

1. Measure flow rates at certain points of water use (e.g. sink, hose) before any pressure reduction is implemented.

2. Measure flow rates at the same points after pressure has been reduced and calculate savings.

3. If necessary, install meters to monitor water use.

SAVING WATER BY REDUCING PIPE SIZE

It is important to note that halving the diameter of a pipe reduces the flow of water by more than 50% if operated at the same pressure.

The effect of pipe diameter can be seen in Figure 4

Figure 4: Variation of flow due to pipe size at 100 kPa (1 bar) pressure

Actions

1. Identify any hoses or other open discharges of water (e.g. pipes into rinsing tanks).

2. Review opportunities for reducing the diameter of pipework.

3. Modify pipework, and assess water and cost savings achieved.

Greater pipe diameter can lead to significant overuse of water. For example, an open-ended 25 mm (1") diameter hose that is 45 m long and operated at 400 kPa (4 bar) will deliver around 36 litres/minute. If it is used for 2 hours/day, 260 days/year, the total annual water use will be about 1,123 m^3.

A 15 mm (1/2") diameter hose of the same length and operating at the same pressure, delivers only about 9 litres/minute (i.e. a quarter of the flow). Used for the same duration, this smaller hose would only use 281 m^3/year – saving a considerable 842 m^3/year.

It is important to note that this concept also applies to taps and any other open discharge – if the diameter can be reduced with no detrimental effect, then the water and cost savings can be significant. More detail on reducing flows through taps is given in EN664 'Reducing water use in washrooms: taps', available on the WRAP website.[4]

[4] http://envirowise.wrap.org.uk

www.wrap.org.uk/rippleffect