The Rippleffect: water efficiency for business

Cost-effective water saving devices and practices - for industrial sites
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Cost-effective water saving devices and practices - for industrial sites

Summary

All industrial sites use water. Most companies take water for granted and few know exactly how much water they are using. Water is an increasingly expensive resource with mains, sewerage and trade effluent charges all rising. Reducing your water consumption is one of the easiest and most inexpensive ways of achieving cost savings. Many companies can achieve a 20-50% decrease in the amount of water used through implementing water minimisation measures.

This Good Practice Guide describes a range of cost-effective water saving devices and practices - some with payback periods of only a few days. It highlights the typical water savings that can be achieved for industrial applications and explains how to identify the most appropriate devices and practices for specific equipment, processes or sites. The suggested actions are summarised in a series of comprehensive tables, which include an indication of the potential costs and payback period. The potential cost savings and other benefits of reducing water consumption are illustrated in industry examples.

This Guide is intended for all industrial or manufacturing operations. The water saving practices and devices described in this Guide are intended to be implemented as part of a systematic water saving campaign. Can your company afford to ignore the savings that could be achieved by following the advice given in this Guide? Other companies, including your competitors, may already have implemented water saving measures and could be paying less than you in water and effluent charges per unit of production or service.

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Contents

1 Introduction 1
1.1 How can this Guide help? 1
1.2 Carrying out a water use survey 2
1.3 Free services from WRAP 3
1.4 Water Technology List 3

2 Choosing water saving devices and practices 5
2.1 First considerations 5
2.2 Estimating potential savings 5
2.3 The impact of water savings on operating costs 8
2.4 Setting the project budget 8
2.5 Identifying appropriate water saving devices and practices 9
2.6 Identifying project costs 9
2.7 Worked example: evaluating possible water saving measures 10

3 Water saving devices and practices 13
3.1 General water use 13
3.2 Cleaning and rinsing 19
3.3 Process re-evaluation 29
3.4 Process plant 30

4 Action plan 39
4.1 Other sources of information 40

Appendices 41
Appendix 1 A typical water saving campaign 41
Appendix 2 The effect of pressure and heat load reduction on water use 42
Appendix 3 Estimating pumping, energy and treatment costs 43
Appendix 4 Converting between systems of units 47
1 - Introduction

Water is an increasingly expensive resource with mains, sewerage and trade effluent charges all rising. Reducing your water consumption is one of the easiest and most inexpensive ways of achieving cost savings. Many companies can save up to 30% of their water costs through implementing simple and inexpensive water minimisation measures.

1.1 How can this Guide help?
Water is used in many different ways by industry. Most companies think they know how much water costs and where their water goes. But do they really know?

Monitoring saves company from large water bill

Online water and effluent monitoring at a snack food manufacturer highlighted a process problem that was costing £720/day. It was fixed in three days. If the company had waited for the water bill, the fault might have gone undetected for four months. By then, it would have cost the company over £80,000. The problem was identified because the company monitors its consumption of water and other utilities carefully.

Mains water flow measurement, which included a connection into an existing online monitoring system for process control, cost less than £2,000 to install.

In addition, effluent billing used to be based on incoming metered water. This has been reduced by £24,000/year following a change to billing on the basis of effluent flow measurements. The equipment needed cost less than £3,000 to install.

Consider the following questions:

- How much water are we using?
- Are we using too much water?
- Are we paying too much in effluent charges?
- Have we tried saving water?
- Could we save any more water?
- Have our competitors implemented water-saving measures?

This Good Practice Guide describes a variety of cost-effective water saving projects for industry with payback periods from a few days to over one year. The Guide is intended to help companies identify the most appropriate water saving devices and practices for specific equipment, processes or sites. This Guide is intended for all industrial or manufacturing operations.

Inclusion of specific water saving devices and practices in this Guide is not a recommendation for their universal implementation. Cost-effective application is often site-specific. In particular, water saving devices and practices proposed for industrial processes should be evaluated before they are implemented by those who have a working knowledge of the processes.
It is sometimes useful to illustrate flow as detailed opposite, to give an indication of what water might be costing a company.

Before adopting any water saving device or practice, companies should:
- evaluate the technical issues;
- consider the health and safety implications, including carrying out a COSHH\(^1\) assessment (where appropriate);
- examine the financial considerations.

To help, this Guide highlights other benefits and possible disadvantages which should be taken into account when selecting a water saving device or implementing new practice.

The identification and evaluation of cost-effective water saving devices and practices should be part of a wider water saving campaign. The phases and steps involved in a typical water saving campaign are indicated in Appendix 1.

All publications mentioned in this Guide are available free of charge from WRAP’s website through the Rippleffect online water efficiency tool: (www.wrap.org.uk/rippleffect) and the Business Resource Efficiency Hub (www.wrap.org.uk/brehub).

1.2 Carrying out a water use survey
Before beginning a water saving campaign, you should review your water and effluent costs to make sure it is worth taking action.

As a rule of thumb, reductions of 30% in water and effluent bills are usually achievable at little or no cost for sites that have not previously tried to save water. As much as 50%, or more, might be achievable if projects with capital investment payback periods of up to two years are included.

Before being able to identify how and where water can be saved, it is necessary to understand how, where and why water is used at each particular site. This can be achieved by carrying out a water use survey and developing a water balance for a site as described in *Tracking water use to cut costs*.

A survey of water use and patterns of use typically reveals:
- excessive or unnecessary use;
- unknown use;
- unauthorised use.

A survey of effluent discharges and routes to sewer typically reveals:
- clean water discharges direct to effluent;
- unauthorised discharges to effluent;
- unnecessary surface water discharges to effluent;
- sources of a potential breach of effluent discharge consents.

*Tracking water use to cut costs* also contains details of how to measure water flow.

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\(^1\) Control of Substances Hazardous to Health (COSHH) Regulations 2002.
1.3 Free services from WRAP

Water minimisation is one of the easiest ways of achieving cost savings. WRAP provides a number of free guides and tools to help you reduce your water use and stop your profits from going down the drain.

For more information visit the Rippleffect: www.wrap.org.uk/rippleffect
1.4 Water Technology List

The Government's Water Technology List (WTL) promotes products that encourage sustainable water use and rewards businesses for investing in them. You can contact WRAP to find out about the Enhanced Capital Allowance (ECA) scheme for sustainable water technologies and the WTL.

ECAs allow businesses to write off 100% of investments in designated sustainable technologies and products (listed on the WTL) against tax in the first year of investment. All businesses that pay UK corporation or income tax are eligible for the tax allowance. Even if your organisation is not eligible for tax relief, the WTL provides a source of information about devices that help to minimise water use.

For more information see www.eca-water.gov.uk

Please note that the legislation mentioned within this publication was checked for accuracy in September 2005 before going to press. However, legislation is constantly changing and being updated. For information on current environmental legislation, please visit the Environment Agency website: www.environment-agency.gov.uk/business/default.aspx
Choosing water saving devices and practices

2.1 First considerations
Before starting to identify and evaluate water saving devices and practices, it is important to agree:

■ a target for net savings based on a preliminary water use survey (see section 1.2);
■ payback periods for any water saving projects

You also need to consider the following questions:

■ How are savings in water use estimated?
■ What impact will water savings have on overall operating costs?
■ How much can be spent on water saving measures?
■ How can appropriate water saving devices and practices be identified?
■ How much will it cost?

Appendix 1 contains a flow chart showing the steps involved in a typical water saving project. This chart will help you to implement a water reduction programme. The individual steps are simple but they must be carried out in the correct order to produce the most cost-effective water saving system.

2.2 Estimating potential savings
Once the water balance has been established and water use in each area of the site is understood, a water minimisation team can be assembled to start to identify water saving opportunities.

Table 1 overleaf shows the typical percentage reductions for industrial applications, which can be assumed when estimating potential savings. Although these are typical realistic reductions, they will vary between applications and sites, and should not be relied upon for design purposes at your own site. However, Table 1 will help to rule out projects that are non-starters.
Fig 1 opposite provides estimates of the significant annual losses from taps, joints on pipes, seals in pumps, hoses and valves. Although the figures are taken from real water surveys, they are intended for guidance only. The leaks and other losses of individual companies may be different and should be quantified on-site.

Table 1 Typical achievable reductions in water use

<table>
<thead>
<tr>
<th>Water saving initiative</th>
<th>Typical reduction per project (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed loop recycle</td>
<td>90</td>
</tr>
<tr>
<td>Closed loop recycle with treatment</td>
<td>60</td>
</tr>
<tr>
<td>Automatic shutoff</td>
<td>15</td>
</tr>
<tr>
<td>Countercurrent rinsing</td>
<td>40</td>
</tr>
<tr>
<td>Spray/jet upgrades</td>
<td>20</td>
</tr>
<tr>
<td>Re-use of wash water</td>
<td>50</td>
</tr>
<tr>
<td>Scrapers</td>
<td>30</td>
</tr>
<tr>
<td>Cleaning-in-place (CIP)</td>
<td>60</td>
</tr>
<tr>
<td>Pressure reduction</td>
<td>See Fig A2 (Appendix 2)</td>
</tr>
<tr>
<td>Cooling tower heat load reduction</td>
<td>See Fig A3 (Appendix 2)</td>
</tr>
</tbody>
</table>
The costs given in Fig 1 are intended for guidance only. They represent average water and trade effluent charges for the UK in 2004/05. Costs will vary depending on service provider, tariff, meter size, strength of effluent, etc and will be subject to annual review.

### Review highlights unnecessary water use

A manufacturer makes high-quality packaging at its site in Bradford where it employs over 350 people. As part of its waste minimisation campaign, the company reviewed water use and found that printers regularly left print cylinders to clean under running taps. Once identified, this habit was quickly corrected.

For more details, see *Measuring utility use boosts manufacturer’s profits (CS408)*.

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2 Assumed standard strength of trade effluent in terms of chemical oxygen demand (COD) and suspended solids.
2.3 The impact of water savings on operating costs

Cost savings can arise from reductions in:
- water use;
- on-site water pumping and associated maintenance;
- water treatment, eg lower chemical costs, column regeneration and filter backwash;
- water heating or cooling requirements;
- effluent pumping;
- effluent treatment;
- effluent cooling requirements;
- effluent discharge.

Savings can also arise from:
- a reduced requirement for additional capacity for water storage;
- increased production without having to upgrade the water supply system;
- less product discharged as effluent;
- lower capital investment in future effluent treatment plant;
- reduced corrosion and improved working conditions through the elimination of leaks.

2.4 Setting the project budget

Once you have estimated the potential impact of water savings on overall operating costs, it is useful to work out how much money could reasonably be spent on the project. This will eliminate obvious non-starters. One simple way of doing this is to work out the Maximum Project Budget (MPB).

\[ \text{Maximum Project Budget (£)} = \text{Calculated saving (£/year)} \times \text{Required payback period (years)} \]

To achieve the required payback period, the overall capital and operating costs of any water saving project must be less than the MPB. Operating costs should also be low enough to remain attractive in the long-term.

Your company may use other methods of financial appraisal to determine the viability of proposed projects. In such cases, it is best to seek advice from the finance department.
2.4.1 Worked example
This worked example from a fictitious factory illustrates the ‘project budget first’ approach. The factory is planning an increase in production. For the initial evaluation, it is assumed that implementing the water saving project would reduce water use on a particular item of plant by 50%. This would correspond to a 16% reduction in water use for that area of the factory.

Table 2 shows the effects of implementing the water saving project on the net cost of increased production. Using 13,290 m³/year less water would reduce annual operating costs by £21,735. However, this is not money saved, as the costs have not yet been taken into account. To achieve a one-year payback, the MPB will be £21,735, ie the combined capital and first-year operating costs of the new water saving devices and practices must be less than £21,735.

<table>
<thead>
<tr>
<th>Item</th>
<th>Without water saving</th>
<th>With water saving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production (including planned increase)</td>
<td>1,444,500 units/year</td>
<td>1,444,500 units/year</td>
</tr>
<tr>
<td>Specific water use</td>
<td>0.0575 m³/unit</td>
<td>0.0483 m³/unit</td>
</tr>
<tr>
<td>Total annual use</td>
<td>83,060 m³</td>
<td>69,770 m³</td>
</tr>
<tr>
<td>Water saving</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water and effluent charge*</td>
<td>£1.50/m³</td>
<td>£1.50/m³</td>
</tr>
<tr>
<td>Water and effluent bill</td>
<td>£124,590</td>
<td>£104,655</td>
</tr>
<tr>
<td>Cost saving</td>
<td>£19,935</td>
<td></td>
</tr>
<tr>
<td>Other reductions in operating costs (chemicals, pumping) associated with lower water use</td>
<td>0 (£1,800)</td>
<td></td>
</tr>
<tr>
<td>Net cost</td>
<td>£124,590</td>
<td>£102,855</td>
</tr>
<tr>
<td>Net cost saving</td>
<td></td>
<td>£21,735</td>
</tr>
</tbody>
</table>

* Average UK value 2004/05.

2.5 Identifying appropriate water saving devices and practices
Once the water minimisation team has identified potentially attractive opportunities for saving water, then appropriate water saving devices and practices can be investigated. Water saving devices and practices in industrial applications are considered in section 3 and summarised in Tables 8 - 10.

2.6 Identifying project costs
Given the Maximum Project Budget (see section 2.4), the next step is to evaluate the costs associated with the necessary equipment. In practice, this may be an on-going process as water savings and costs usually depend on the equipment selected.

For an accurate evaluation, it is best to obtain quotations for the equipment costs and estimated water savings from potential suppliers or installation contractors. You also need to allocate the costs of the initial water survey and management time.
Project costs occur in two stages:

- **Implementation:**
  - design and project management;
  - equipment purchase;
  - installation and commissioning of all equipment and instrumentation;
  - disruption of work during installation and commissioning.

- **Operation:**
  - employee training;
  - use and maintenance of utilities;
  - disposal of wastes from any treatment processes;
  - monitoring (including water quality);
  - reporting.

Appendix 3 gives some guidance on how to estimate:

- the effect of reduced water use on pumping costs;
- water heating and cooling costs;
- on-site water treatment costs.

### 2.7 Worked example: evaluating possible water saving measures

This example from a fictitious food manufacturer highlights the importance of evaluating possible water saving measures for their economic viability.

Following a water use survey and brainstorming session to discuss ideas, the environmental management team at a milk processing plant identified the following:

- The 2 bar (200 kPa) pressure at which water is supplied through a 1 inch (25 mm) pipe for operations lasting 4 hours per day (5 days a week) is unnecessarily high. A 1 bar (100 kPa) pressure would be adequate.
- There are five 1/2" (12.5 mm) hose pipes on site, each of which is used for about an hour a day at a flow rate of 1 m³/hr. On average, one hosepipe is left running to drain every day for a total of about 20 minutes.
- The site has two cleaning-in-place (CIP) sets that use water and chemicals on a once-through basis. On average, each set is used once a day (see Table 3).

Tables 4 and 5 opposite summarise the survey findings.
The team decided that it would consider only water saving measures that had a payback period of less than two years. Possible water saving devices included:

- fitting a pressure-reducing valve on the pipework that delivers water at 2 bar (200 kPa) pressure;
- installing trigger-operated spray guns to all five hose pipes;
- using the final rinse from the CIP sets as the following pre-rinse cycle. A redundant tank on site could be used to store the rinse water.
Table 6 shows the potential savings from these measures.

<table>
<thead>
<tr>
<th>Area</th>
<th>Future water use (litres/day) with water saving measure:</th>
<th>Water pressure</th>
<th>Hose pipe</th>
<th>CIP set</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery</td>
<td></td>
<td></td>
<td>2 000</td>
<td>-</td>
<td>2 000</td>
</tr>
<tr>
<td>Raw milk</td>
<td></td>
<td></td>
<td>-</td>
<td>18 600</td>
<td>18 600</td>
</tr>
<tr>
<td>Milk processing</td>
<td></td>
<td>102 400</td>
<td>2 000</td>
<td>-</td>
<td>104 400</td>
</tr>
<tr>
<td>Finished milk</td>
<td></td>
<td></td>
<td>-</td>
<td>18 600</td>
<td>18 600</td>
</tr>
<tr>
<td>Butter hall</td>
<td></td>
<td></td>
<td>1 000</td>
<td>-</td>
<td>1 000</td>
</tr>
<tr>
<td>Total water use (litres/day)</td>
<td></td>
<td>102 400</td>
<td>5 000</td>
<td>37 200</td>
<td>144 600</td>
</tr>
<tr>
<td>Total water use (m³/day)</td>
<td></td>
<td>102.4</td>
<td>5</td>
<td>37.2</td>
<td>144.6</td>
</tr>
<tr>
<td>Annual predicted cost (£)</td>
<td></td>
<td>£39 936</td>
<td>£1 950</td>
<td>£14 508</td>
<td>£56 394</td>
</tr>
<tr>
<td>Present annual cost (£)**</td>
<td></td>
<td>£56 160</td>
<td>£2 080</td>
<td>£16 068</td>
<td>£74 308</td>
</tr>
<tr>
<td>Annual reduction in water and effluent cost (£)</td>
<td></td>
<td>£16 224</td>
<td>£130</td>
<td>£1 560</td>
<td>£17 914</td>
</tr>
</tbody>
</table>

* Assuming factory operates 260 days/year.
** From Table 4.

When the project costs were compared with the expected savings, it was concluded that all three proposed water saving measures were cost-effective. The estimated project economics are summarised in Table 7. The total cost is £1 500. With predicted total savings of £17 914/year, the overall payback period is just over a month.

<table>
<thead>
<tr>
<th>Area of application</th>
<th>Water pressure</th>
<th>Hose pipe</th>
<th>CIP set</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of devices required</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Cost of each device</td>
<td>£100</td>
<td>£30</td>
<td>-</td>
<td>£130</td>
</tr>
<tr>
<td>Total cost (including installation)</td>
<td>£500</td>
<td>£250</td>
<td>£750*</td>
<td>£1 500</td>
</tr>
<tr>
<td>Expected annual saving**</td>
<td>£16 224</td>
<td>£130</td>
<td>£1 560</td>
<td>£17 914</td>
</tr>
<tr>
<td>Payback period</td>
<td>1.6 weeks</td>
<td>1.9 years</td>
<td>6 months</td>
<td>4.4 weeks</td>
</tr>
</tbody>
</table>

* Pipework installation (suitable tank already on site).
** From Table 6.
3 - Water saving devices and practices

This section suggests cost-effective devices and practices to reduce water use at industrial sites. The advice is summarised in Tables 8 - 10 and industry examples are used to illustrate the savings that can be achieved.

It is essential that someone with a working knowledge of the process evaluates proposed water saving devices and practices affecting an industrial process.

3.1 General water use
This section should be read in conjunction with Table 8 overleaf.

3.1.1 Taking meter readings

Consider the following questions:

- Do you know where your water meter is located?
- Do you have more than one incoming water meter?
- Are any of your areas sub-metered?

You can download a simple, practical tool from WRAP to enable you to record and monitor your water consumption. This series of Microsoft® Excel spreadsheets (monitoring_water_consumption.xls) is easy to use and allows you to record water consumption data and generate graphs automatically to illustrate trends. The data forms and graphs are designed for easy printing.

To download the spreadsheets, go to www.wrap.org.uk/content/water-monitoring-tool-0

Monitoring gives immediate savings

A family brewery achieved savings of over £32 500/year by monitoring water flows through the brewery and ensuring actual consumption was as close as possible to theoretical consumption. Payback was effectively instantaneous.

Electroplater saves with flow monitoring and good housekeeping

An electroplating company reduced its water consumption by nearly 60 000 m³/year, saving almost £45 000/year. Good housekeeping, use of flow monitors and some flow restrictors reduced water use significantly without any major modifications. The payback period was six months.
### Table 8: Cost-effective water saving devices and practices for industrial sites: general water use*

<table>
<thead>
<tr>
<th>Item/application</th>
<th>Description/purpose</th>
<th>Equipment/technique</th>
<th>Applicability</th>
<th>Other benefits</th>
<th>Other considerations</th>
<th>Potential cost</th>
<th>Potential payback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training</td>
<td>Increase staff awareness</td>
<td>Training, workshops and seminars</td>
<td>All areas of use</td>
<td></td>
<td></td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Water balance</td>
<td>Site-wide survey</td>
<td>Records, bills and flow measurements</td>
<td>All areas of use</td>
<td></td>
<td></td>
<td>M</td>
<td>S</td>
</tr>
<tr>
<td>Monitoring</td>
<td>Online water use</td>
<td>Flow meters, transmitters</td>
<td>All areas of use</td>
<td></td>
<td></td>
<td>M</td>
<td>S</td>
</tr>
<tr>
<td>Leakage identification and elimination</td>
<td>Inspection and repair of equipment</td>
<td>Regular inspection</td>
<td>Pipes, tanks, glands, gaskets, flanges</td>
<td>Reduced maintenance</td>
<td></td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Overflow identification and elimination</td>
<td>Avoiding overflows</td>
<td>Level controllers</td>
<td>Tanks</td>
<td>Reduced risk of flooding</td>
<td></td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Use of block valves for isolation, rather than preset control valves</td>
<td>Avoids the need to change preset positions</td>
<td>Block valves</td>
<td>Where preset or adjustable water flow</td>
<td>Consistent process efficiency</td>
<td></td>
<td>L</td>
<td>S</td>
</tr>
<tr>
<td>Tamper prevention</td>
<td>Preventing unauthorised adjustment</td>
<td>Straps/chains/locks</td>
<td>Widespread</td>
<td>Consistent process efficiency</td>
<td></td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>Maintaining water at required temperature</td>
<td>Preventing undesirable heat loss or gain</td>
<td>Insulation</td>
<td>Long distribution systems</td>
<td>Reduced energy costs</td>
<td></td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Trace heating</td>
<td>Heat/cool at point of use</td>
<td>High temperature</td>
<td>Acute sensitivity to water temperature</td>
<td></td>
<td>Equipment costs</td>
<td>M-H</td>
<td>M-L</td>
</tr>
</tbody>
</table>

Potential costs and paybacks are for guidance only. Actual costs and paybacks will vary due to project-specific details. * Risk assessment required

Potential cost: L = low (minor alterations) (£0 - a few £100s); M = medium (a few £100s - a few £1,000s); H = high (extensive alterations or new plant required) (many £1,000s)

Potential payback: S = short (months); M = medium (less than a year); L = long (over a year).
3.1.2 Leakage and overflows
If water use is limited to daytime operations, it should be nearly zero during the night. Does this apply to your company? To find out, carry out a night flow test - read the meter when everyone has left and then again the following day before work starts. The meter reading should be the same. If it is not, you may have a leak or an overflow and further investigation is required.

**TIP**
If you have a continual water demand (e.g., continual running cooling water or steam generation), the meter reading will change, indicating overall water use. To check there isn’t a leak, either take these readings into account or, if possible, switch off the water supply and carry out the night flow test again.

Leaks and overflows can arise from:
- damaged pipeline connections, flanges and fittings;
- worn and incorrectly set valves;
- corroded pipework and tanks;
- poorly set or flooded floats (balls) in tanks.

Overflows are usually due to poor control and most run to drain without being measured.

The following are usually sufficient to avoid overflows and identify leaks:
- implement a preventive maintenance programme;
- make regular checks on overflow outlets, pipework and valves;
- put a system in place for reporting leaks and faults;
- install simple level sensors and on/off control systems for pumps;
- install shut-off valves (easy to use).

**Review finds overflow from boiler tank**
In 2000, a processor of woven fabrics discovered that water was being used within non-production hours during a review of water at its dyeing and finishing works. Monitoring consumption identified the source - a faulty ball valve was causing the boiler hotwell tank to overflow to drain. A new ball valve (£30) was fitted, resulting in savings of £1 650/year.

3.1.3 Isolation of water supply
It is often hard to detect if an isolation valve (stopcock) (see Fig 2 overleaf) is open or closed and whether water is flowing through a pipe.
Looking at the wheel, it is hard to know whether the isolation valve (stopcock) is open or closed, i.e. is there flow in the pipeline or not? It is also impossible to judge the setting of such a valve when it is partially open.

The installation of a quarter twinball valve (as shown in Fig 3) provides a clear indication of whether the valve is open or closed.

- When the lever is at right angles to the pipe (as shown), supply is switched off.
- When the lever is in line with the pipe, supply is switched on.

This also enables quick and effective isolation of the water supply.

### 3.1.4 Water pressure

High water pressure can:

- result in excessive water consumption;
- cause or exacerbate leakage;
- put additional (unnecessary) wear and tear on the distribution system.

To meet minimum pressure and flow requirements, water mains are usually operated at a pressure of about 2 - 4 bar (200 - 400 kPa), though there is currently no stipulated maximum mains pressure limit.

In some cases, higher water pressures than necessary may be delivered to the lower floors of tall buildings. This can occur where the water is supplied under gravity from a break tank in the roof void or where distribution systems are equipped with booster pumps to ensure adequate pressure is delivered to the top floors of tall buildings. This is illustrated by the following example.

**Example of overuse due to high pressure**

At one company, water is stored in a bulk storage tank prior to use. A booster pump (consisting of two duty pumps and one standby pump) is used to supply water from the storage tank to the site via a distribution system at a preset pressure of 5 bar (500 kPa; 70 psi). The distribution system does not operate on a ring main principle but has distinct legs supplying water to the site.

The flow through a 1” (25 mm) pipe at the point of discharge furthest from the booster pump delivers water at around 7 litres/second and at a pressure of 2 bar (200 kPa; 30 psi). This was perfectly acceptable to the operator. However, the flow through a similar diameter pipe at the point of discharge closest to the booster pump was flowing with considerable force (4 bar; 400 kPa; 60 psi) at approximately 14 litres/second, which was much more than necessary. Over a period of an hour, this overuse equates to around 25 m³.

Assuming water is used for 1 hour/day (5 days a week), this represents an annual overuse of 6 550 m³. Taking average water and trade effluent charges of 79 pence/m³ and 71 pence/m³.

---

3 1 bar = 14.5 psi
4 Trade effluent charges vary depending on service provider, customer tariff and effluent strength, and are subject to annual review.
respectively, this represents a financial loss in water and effluent charges of around £9825/year for this overuse of water alone.

**Use of pressure-reducing valves**

Pressure-reducing valves or PRVs (see Fig 4) can be used to control the pressure in the incoming main or the distribution system. As well as being fitted on the incoming main, PRVs can be installed on:
- the supply to each floor;
- the down legs of a gravity-fed distribution system;
- risers in a pumped system.

The valve can be preset or adjustable. PRVs can typically accept delivery pressures of up to 25 bar (2500 kPa) and deliver a pressure of 1.5 - 6 bar (150 - 600 kPa) 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.

When considering the use of PRVs, it is important to identify the minimum required operating pressure that will not compromise performance, i.e., that equipment will operate effectively with the new pressures.

**Approximate determination of new flow rate, after a change in pressure:**

\[
\text{New flow rate} = \frac{\text{Old flow rate} \times \text{New pressure}}{\sqrt{\text{Old pressure}}}
\]

**3.1.5 Flow regulation**

Many systems require preset water flow rates. The flow rate in such systems is usually adjusted by careful setting of a control valve. However, the same valve is often used to isolate the water supply and is not reset to the same position when flow resumes.

A simple and cheap solution to this problem is to:
- fit a quarter-turn isolation valve, e.g., ball valve (see Fig 3);
- replace gate valves (see Fig 2) with quarter-turn isolation valves so that known flow rates can be reset easily;
- preset the existing flow control valve to the optimum flow rate;
- remove the handwheel from the flow control valve to prevent unauthorised changes to the flow rate.

If a precise or high flow is not crucial (e.g., for general washing purposes), simple pipe restrictions can be used to limit the instantaneous flow from a device. However, where steady flow is required, then pressure control devices may be more appropriate - especially on variable pressure supplies (see section 3.1.4).
Flow restrictors include:

- orifice plates;
- needle valves;
- isolator valves.

**Electroplater benefits from flow restrictors**

An electroplating company based in the West Midlands uses mains water to rinse components. Due to variations in water pressure, the inlets to the plating lines were set to maximum flow, giving a consumption of around 390 m³/day. Fitting flow restrictors to the inlet of each tank reduced water consumption to 226 m³/day. This represented a saving of over £36 000/year.

### 3.1.6 Reduce undesirable heat loss or gain

- Do not run hot and cold pipes closely together in situations where the temperature of the water is crucial to its suitability for use and water is used intermittently.

**Chiller solves drinking water problem**

At one site, the need to route the drinking water supply through hot areas made the water unpleasant to drink. The solution was to install a chiller at the point of use rather than running water to drain continuously. The cost of £400 was paid back in less than two months.

- Lag pipework (or trace it) to reduce heat losses or heat gain (see Fig 5). This avoids the practice of water being run to drain until it achieves the correct temperature. Lagging hot pipes will also reduce energy losses.\(^5\)

**Fig 5 Lag tanks and pipes**

Lagging tanks and pipes will reduce heat losses and help maintain water at the required temperature.

---

\(^5\) For free advice and publications on energy efficiency, visit www.thecarbontrust.co.uk/energy

\(^6\) ECAs are also available for the purchase of approved equipment on the Energy Technology List (www.eca.gov.uk).
3.2 Cleaning and rinsing
Cleaning and rinsing are usually the major uses of water on an industrial site and often offer significant opportunities for water use reduction.

See Table 9 overleaf for more details..
<table>
<thead>
<tr>
<th>Item/application</th>
<th>Description/purpose</th>
<th>Equipment/technique</th>
<th>Applicability</th>
<th>Other benefits</th>
<th>Other considerations</th>
<th>Potential cost</th>
<th>Potential payback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure control/flow restriction</td>
<td>Reducing instantaneous flow at point of use</td>
<td>Valves, orifices, pressure-reducing valves</td>
<td>Variable or intermittent supply, pressure or demand</td>
<td></td>
<td></td>
<td></td>
<td>L</td>
</tr>
<tr>
<td>Countercurrent rinsing Spray/jets</td>
<td>Re-use of rinse water</td>
<td>Tanks</td>
<td>Multi-stage unit processes</td>
<td>Water quality requirements</td>
<td></td>
<td></td>
<td>M</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Improved cleaning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Improved cleaning</td>
<td>Spray/mist drift</td>
<td></td>
<td>L-M</td>
</tr>
<tr>
<td>Automatic supply shut-off</td>
<td>Use of water only when needed</td>
<td>Solenoid valves in pipelines</td>
<td>Small bore pipes</td>
<td>Essential water requirement</td>
<td></td>
<td></td>
<td>M</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Actuated valves in pipelines</td>
<td>Large bore pipes</td>
<td>Essential water requirement</td>
<td></td>
<td></td>
<td>M</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jets/spray guns on hoses</td>
<td>Widespread</td>
<td>More efficient application</td>
<td>Theft of spray guns</td>
<td></td>
<td>L</td>
</tr>
<tr>
<td>Re-use of wash water</td>
<td>Re-use of wash water in other areas</td>
<td>Tanks/pumps</td>
<td>Widespread</td>
<td>Cross-contamination/water quality control</td>
<td></td>
<td></td>
<td>M</td>
</tr>
<tr>
<td>Scrapers/squeegees/brushes</td>
<td>Sweeping up of sludges</td>
<td>Dry cleaning methods</td>
<td>Large areas</td>
<td>Possible re-use of materials</td>
<td>Dry collection systems</td>
<td></td>
<td>L</td>
</tr>
<tr>
<td>Cleaning-in-place (CIP) technology</td>
<td>Countercurrent re-use of rinse water with multiple re-use of chemical cleaners</td>
<td>Proprietary plant</td>
<td>Processes with frequent cleaning</td>
<td>Hygienic plant/minimal downtime for cleaning</td>
<td>Water quality requirements</td>
<td></td>
<td>H</td>
</tr>
</tbody>
</table>

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</tr>
</thead>
<tbody>
<tr>
<td>Recycle after treatment</td>
<td>Treatment of wastewater to an acceptable standard for re-use</td>
<td>Filtration/sedimentation</td>
<td>Coarse solids removal/phase separation</td>
<td>Waste disposal and water quality</td>
<td>M</td>
<td>M-L</td>
<td></td>
</tr>
<tr>
<td>Centrifugation/flotation</td>
<td>High quality solids removal/phase separation</td>
<td></td>
<td></td>
<td>Waste disposal and water quality</td>
<td>H</td>
<td>M-L</td>
<td></td>
</tr>
<tr>
<td>Biological treatment</td>
<td>Removal of dissolved biodegradable solids</td>
<td></td>
<td></td>
<td>Waste disposal and water quality</td>
<td>H</td>
<td>M-L</td>
<td></td>
</tr>
<tr>
<td>Ion exchange</td>
<td>Removal of dissolved contaminants</td>
<td></td>
<td></td>
<td>Waste disposal and water quality</td>
<td>H</td>
<td>M-L</td>
<td></td>
</tr>
<tr>
<td>Distillation/striping</td>
<td>Solvent recovery</td>
<td></td>
<td>By-product</td>
<td>Waste disposal and water quality</td>
<td>H</td>
<td>M-L</td>
<td></td>
</tr>
<tr>
<td>Absorption/adsorption</td>
<td>High quality treatment, solvent recovery, removal of toxic substances, colour, etc</td>
<td></td>
<td></td>
<td>Disposal of spent absorbent</td>
<td>H</td>
<td>M-L</td>
<td></td>
</tr>
</tbody>
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Potential payback: S = short (months); M = medium (less than a year); L = long (over a year).
3.2.1 Countercurrent rinsing
Rinse water can often be more effectively used by moving a product through a series of tanks or stages. Instead of each of these stages being supplied with fresh ‘make-up’ water, countercurrent rinsing can be employed. In countercurrent rinsing, the product is rinsed first in dirty water and then in progressively cleaner water (see Fig 6). At the same time, the rinse water moves progressively from the last rinse towards the first rinse. Additional savings can be achieved if one or more rinsing stages uses hot or high quality (eg demineralised) water.

3.2.2 Sprays/jets
Sprays or jets can be used to direct or focus water for optimum effect while minimising water use.

Spray and jet technologies have improved in recent years. The latest designs are less susceptible to blockage and tolerate the re-use of dirtier water. New designs may be available which operate at much lower pressure and lower flow rate while maintaining cleaning and hygiene requirements.
Many sites with spray or jet washing systems could benefit from a review of the latest spray or jet technology.

**Improved cask washing plant makes large savings**

A brewery saved £86 900/year following the upgrading of its beer keg washing system with a more efficient spray nozzle (see Fig 7) and the re-use of final wash water for initial washing. The payback period was 13 months.

**Fig 7 Spray nozzles - redesigned (left) and original (right)**

**Project shortlisted for the Water Efficiency Awards 2001**

A food company produces around 3 000 tonnes of ham/year. Previously, showers were used to cool cooked hams for 4 hours at a flow rate of 3.8 litres/minute. Following a review of process requirements, nozzles were fitted to the showers to deliver water at a much reduced rate (1.08 litres/minute) and also intermittently, i.e. three minutes on, three minutes off. Water consumption was reduced by 64% - from 124 litres/ham to 45 litres/ham, while process efficiency increased allowing a greater production capacity. Total cost savings of £120 000/year have been achieved.

For more details, see www.ukceed.org/WaterEfficiencyAwards2001.pdf

### 3.2.3 Turbidity probes

Turbidity probes are simple and reliable devices that can be fitted in pipework to detect product-water interfaces during rinsing operations. This signal can then be used to control valves; Fig 8 shows the system installed at a creamery (see overleaf).

**Turbidity switch allows product recovery**

A creamery installed turbidity probes in the whey processing line at its North Devon site to reduce effluent strength when the evaporator was cleaned (see Fig 8). The probe requires little maintenance and is cleaned at the same time as the evaporator. Cost savings of £16 000/year were achieved, representing a payback period of eight months.

---

7 Measure cloudy liquids or turbidity caused by suspended solids in terms of turbidity units – FTU (formazine turbidity unit) or NTU (nephelometric turbidity unit).
Typically, when the probe detects product or product-water mix at a set point calibrated by the operator, flow is sent for processing or to a recovery system for re-use (A in Fig 8). When the turbidity reading drops to a level indicating predominantly water (again set by the operator), flow is diverted to drain (B in Fig 8), reducing effluent strength and maximising product recovery.

3.2.4 Conductivity probes
A conductivity probe\(^8\) can be fitted in a similar way to a turbidity probe (see section 3.2.3). The probe can be calibrated to determine the purity of water or how much acid or alkali is present in the effluent, and can thus be used to improve CIP operations (see section 3.2.7). However, it is a non-specific measurement, ie different types of ions cannot be distinguished.

3.2.5 Automatic supply shut-off
Items or areas of plant that do not require a constant supply of water can be isolated using a simple control system, thus avoiding water running continuously - often straight to drain. Successful switching methods include:
- limit switches;
- signals from existing process controls;
- signals from existing interlocks.

For example, automatic shut-off systems can be used:
- Where product is rinsed with water (eg through an overhead spray bar) while being transported along a conveyor. In this case, install an automatic shut-off device that links the motion of the conveyor belt with the spray water supply (see Fig 9 opposite). This is particularly important if the water has been chilled or chemically treated (eg softened, chlorinated) before use and is therefore a 'high value' commodity.
- For washing tins or bottles before they are filled. This often uses hot or high quality water, and water can sometimes be left on for long periods of time after the last bottle or tin has been rinsed.

---

\(^8\) Measures the ability of an aqueous solution to carry electrical current in terms of microsiemens per centimetre (µS/cm)
The water isolation system must be ‘fail safe’ where supplies are essential (e.g., for large gearbox cooling). For example, valves should remain open during power failures.

**Fish processing factory saves with water controls**

A company employs around 200 staff and processes 8,000 tonnes of fish a year at its factory in Hull. A solenoid valve was fitted to the water supply on the conveyor belt so that water was used on demand for fish washing rather than having a continuous supply. Trigger nozzles were fitted to hoses (see Fig 10) on the filleting line to reduce unnecessary water use.

These and other changes in practice reduced water use by around 40%, a cost saving of £31,840/year.
Because the flow stops when the trigger mechanism is released, trigger-operated spray guns on hoses (see Fig 11) can achieve significant reductions in water use.

**Cost benefits of trigger-operated spray guns**

A small washdown hose can use 1 m³ of water every hour. If it is hidden under a piece of equipment and forgotten (which does happen), this continual use will cost £36 per day or £252 per week at a combined water and effluent cost of £1.50 pence/m³.

A trigger-operated spray gun costs about £70 and fitting about £35; the payback period could thus be as low as three days.

### 3.2.6 Re-use of wash water

Used wash water is often flushed down the drain on the basis that it has been 'used'. Careful examination of the quality and availability of wash water, together with an understanding of water requirements elsewhere on-site, may reveal opportunities for re-use.

Typical final uses of wash water include:
- first washdown/rinse of floors and containers (inside or outside);
- making up raw material slurries (not applicable to the food or drink industries).

### 3.2.7 Cleaning-in-place (CIP) technology

CIP systems can be used to clean pipework, vessels and other equipment in situ and can result in water savings of about 50%. Since CIP is an automated process with no human contact, strong detergents and/or acid or alkaline solutions can be used for cleaning. The combination of longer contact time, temperature and chemical strength produces a method that is more effective than soaking or foam cleaning.

Further reductions in water, effluent and energy costs can be achieved through:
- internal recycling of water and chemicals (through re-use of final rinse water for first rinses);
- and re-use of concentrated cleaning chemicals);
- optimising CIP programmes (see box opposite);
- upgrading to more water-efficient spray devices, eg nozzles;
- removing product and gross soiling before cleaning;
- ensuring that equipment is designed correctly for CIP cleaning.
3.2.8 Scrapers/squeegees/brushes
During cleaning, large quantities of water from hoses are frequently used to wash slurry from floors and walls down the drain. Substituting water use with hand-held scrapers will still allow you to move most of the slurry across the floor efficiently.

The combined use of scrapers, brushes and hoses can reduce the time taken to clean an area. Removing slurries from surfaces before they start to dry or pre-wetting dry areas can reduce:
- the volume of water needed for washdown;
- the time taken.

In addition, damp floors can encourage microbial growth and be hazardous under foot. Reducing water use can thus improve working conditions and provide a more hygienic environment.

Pipelines can often be cleaned effectively using ‘pigging’ systems. A pig is typically an engineered plug or ball which fits inside the pipe and is pushed through mechanically or hydraulically to clear material ahead of the pig. This recovered material can often be re-used.

A company manufactures jam at its Merseyside site where it employs around 140 people. The washing of vessels, pipework and pumps between batches uses around 10 m³ of water daily. During cleaning, product is discharged to drain; this has a high chemical oxygen demand (COD), resulting in high trade effluent charges. Fitting a new pigging system to the pipework reduced effluent costs by £104 000/year and product loss by £134 780/year. These savings represent a payback period of around 4 weeks.
3.2.9 Drain covers
Fitting covers to drains on the factory floor will stop solids entering the drainage system. For example, fish waste is high in COD while fruit and vegetable waste can be acidic or high in starch. These factors contribute to the effluent load, resulting in high trade effluent charges.

In some cases, the solids retained by the drain cover can be collected and sold or disposed of as animal food.

Good management practices include colour-coding drains for ease of identification, eg:
- blue for surface water;
- red for foul water (domestic sewage);
- purple for trade effluent.

3.2.10 Minimising the need for rinsing
Chemicals are added to cleaning and process tanks for a number of reasons, including to:
- top up existing tanks;
- replace tank liquors;
- ensure that the chemical content is adequate and effective for the process.

However, chemical addition is not always monitored and an attitude of ‘better to add too much than too little’ can prevail. A higher chemical concentration produces a more viscous liquor, which in turn results in increased drag-out. As a result, subsequent tanks become more contaminated and less effective (through the formation of unreactive complexes), resulting in a need to replace their contents more often. Replacing tank liquors results in increased downtime, increased use of water for make-up and increased effluent volumes and strength.

For example, drag-out losses in the metal finishing industry can be reduced by up to 40% by implementing no-cost and low-cost measures such as the following:
- Extending drip time: in some cases, doubling the drip time from 15 to 30 seconds can increase the amount of electrolyte returned to the plating tank by 50%.
- Installing drip tanks and drip boards: these can be used to collect drag-out run-off as workpieces are transferred between process stages. The contents of the drip boards/tanks can then be emptied back into the appropriate tank for re-use.
- Spray and fog (finer spray) rinsing: mechanically wash drag-out solutions from workpieces by jetting water over the workpiece surface, returning the liquor back to the process tank. The spray replaces the evaporative loss from the tank. This technique is particularly useful when rinsing above hot liquor process tanks and can reduce drag-out losses by up to 50%.

3.2.11 Recycle after treatment
Re-use of water is often feasible (eg for cleaning) following suitable treatment to remove unacceptable impurities. Possible treatment technologies include:
- filtration;
- clarification/sedimentation;
centrifugation;
flotation;
ion exchange;
distillation/stripping;
absorption/adsorption.

However, it should be remembered that:
- a small flow to drain (purging) may be required to control impurities which are not removed by the treatment process(es);
- treatment processes give rise to sludges, dirty filters, etc which will require controlled disposal;
- closed loop flows may increase in temperature and thus require cooling.

The costs associated with on-site water treatment are outlined in Appendix 3.

**Water treatment allows re-use and cuts costs**

A lead acid battery manufacturer saved £110 000/year (payback period of 1 - 2 years) through a number of water minimisation measures including the following.
- Replacement of a wet filtration system with a membrane filter saved £12 000/year.
- Use of a crossflow filtration system allowed water recycling, saving £9 000/year.
- Re-use of treated effluent at various stages of the process saved £50 000/year.

**Treated effluent re-used by electroplater**

The use of ion exchange technology to treat effluent from a company’s electroplating shop allowed the water to be re-used in a closed loop system. The company saved £108 000 in the first year alone. Water consumption fell by 89% and the payback period was less than 16 months.

### 3.3 Process re-evaluation

Reviewing process requirements and production scheduling can lead to substantial savings.

These may include:
- reduced water costs;
- reduced effluent charges;
- eliminating the need for extensive effluent treatment prior to discharge;
- reduced disposal costs for wastes and sludges;
- product recovery.

NB changes in processing or production scheduling need not be capital intensive; a simple, low cost modification can lead to significant savings in water and effluent costs.

Reducing water use boosts copper recovery

A company employs over 220 staff in the manufacture of printed wiring boards at its site in Southampton. An increase in effluent charges following the imposition of a stricter discharge consent prompted a review of the process.

Reducing water consumption generated a more concentrated copper-laden wastewater, allowing cost-effective recovery of the copper. Water efficiency measures included:
- an improved nozzle design on spray heads;
- installing sensors on conveyors;
- recirculating rinse water.

Process review brings cost and environmental benefits

A company employs around 700 people at its two sanitaryware manufacturing sites in the West Midlands. Glaze is a high-cost material and optimising its application and recovery is important for process efficiency and profitability. Measures to improve glaze application and recovery led to substantial savings in raw material, water and energy consumption.

3.4 Process plant
The following section should be read in conjunction with Table 10 opposite.
<table>
<thead>
<tr>
<th>Item/application</th>
<th>Description/purpose</th>
<th>Equipment/technique</th>
<th>Applicability</th>
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<th>Potential cost</th>
<th>Potential payback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid ring vacuum pumps</td>
<td>Re-use of sealing water after treatment</td>
<td>Tanks/pumps/separators/cooling</td>
<td>Widespread</td>
<td>Energy savings from cooling seal water</td>
<td>Seal water: temperature and quality control</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>Eliminate water use</td>
<td>Mechanical vacuum pumps</td>
<td>Widespread</td>
<td>Liquid trap</td>
<td></td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>Cooling towers</td>
<td>Automatic blowdown - operation at maximum acceptable total dissolved solids (TDS) level</td>
<td>Conductivity-based control</td>
<td>Widespread</td>
<td>Reduced chemical use</td>
<td></td>
<td></td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>Cooling load reduction - minimise evaporation and blowdown</td>
<td></td>
<td>Widespread</td>
<td>Reduced chemical use</td>
<td></td>
<td></td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>Alternative cooling processes to avoid evaporation of water:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>(i) Air blast</td>
<td>High cooled water temperature (&gt;40°C)</td>
<td>Monitoring requirements</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td>(ii) Heat exchangers</td>
<td>Widespread</td>
<td>Waste heat could be used elsewhere</td>
<td></td>
<td></td>
<td></td>
<td>H</td>
</tr>
<tr>
<td>Heat exchangers</td>
<td>Water re-use through closed loop system</td>
<td>Tanks/pumps/heating source/cooling source</td>
<td>Widespread</td>
<td>Heat sink/cooling tower/water quality</td>
<td></td>
<td></td>
<td>H</td>
</tr>
<tr>
<td>Hydraulic power packs</td>
<td>Optimise water use by varying water flow depending on oil temperature</td>
<td>Bulb-and-capillary operated control valves</td>
<td>Widespread</td>
<td>Essential cooling requirement</td>
<td></td>
<td></td>
<td>L-M</td>
</tr>
<tr>
<td></td>
<td>Re-use after cooling - through closed loop system</td>
<td>Tanks/pumps/cooling source</td>
<td>Large installations</td>
<td>Cooling tower/water quality</td>
<td></td>
<td></td>
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3.4.1 Liquid ring vacuum pumps

Liquid ring vacuum pumps use a continuous supply of water to provide the seal. There may also be a requirement for some water to cool bearings or lubricate the shaft seal. Such pumps, which need a continuous supply of water to ensure a seal during operation, consume large volumes of water.

The seal water is typically heated by 15°C in the pump and, in some cases, is discharged directly to drain. This water can often be recovered for re-use. However, the possibility of directly recirculating it for re-use as seal water is limited by its temperature; the higher the water temperature, the lower the efficiency of the vacuum pump especially when drawing air saturated with water vapour. Seal water may require cooling and other treatment before re-use. Installing cyclone pre-separators on the vacuum side of the pump can help to minimise contamination of the seal water by particulates or solid matter.

Options for controlling the temperature of the seal water include:
- simple systems which bleed off warm water and top up with fresh cold water;
- cooling towers;
- refrigeration systems;
- integrated heat recovery systems.

Significant energy savings may be achieved by cooling seal water (even below ambient temperature), as this will increase vacuum pump efficiency and may enable the vacuum pump to be run at lower speeds.

For detailed information on the optimum use of water in liquid ring vacuum pumps and the reuse of seal water, see Good Practice Guide GPG083 *Energy efficient liquid ring vacuum pump installations in the paper industry*.

For some duties, the liquid ring vacuum pump can be replaced with a purely mechanical vacuum pump. This may have the added attraction of energy savings.

Cooling and re-using water reduces both water and energy costs

A Scottish paper mill saved £65 000/year by cooling and re-using water from the site’s liquid ring vacuum pumps. In addition, electricity costs fell by £173 000/year. The payback period was 14 weeks.

3.4.2 Boilerhouse

Significant quantities of water can be used in boilerhouse operations - for hot water supply, steam generation, heating, or a combination of these (see Fig 12 opposite).

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9 Available free of charge through the Carbon Trust website (www.thecarbontrust.co.uk/energy).
The ‘value’ of this water is often underestimated as it may have already undergone several steps; each step adds to the ‘value’ or cost of the water. For example, the water may have:

- been pre-treated (softening, demineralisation) before entering the boiler;
- had conditioning chemicals added to it;
- been heated.

Table 11 highlights the much higher cost of treated water, steam and condensate compared with that for potable water (ie water that is drinkable).

<table>
<thead>
<tr>
<th>Type</th>
<th>Typical cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potable mains water</td>
<td>£0.79 per m³</td>
</tr>
<tr>
<td>Demineralised or softened water</td>
<td>£2 - 3 per m³</td>
</tr>
<tr>
<td>Condensate</td>
<td>£3 - 4 per m³</td>
</tr>
<tr>
<td>Steam</td>
<td>£10 - 12 per tonne</td>
</tr>
</tbody>
</table>

* Costs do not include disposal of wastewater.

Not all water and steam is returned to the boiler for re-use. For example, losses occur through evaporation, use in the product, blowdown (see overleaf) and poor condensate recovery. To compensate for these losses, fresh make-up water is added to the system, usually via the hot well. Installing a sub-meter on the inlet to the hot well will allow you to monitor the volume of make-up water.

Measures to reduce water consumption in boilerhouse operations may also lead to significant energy savings.
Pre-treatment
Water is often pre-treated prior to its use in a boiler. Demineralisation or softening using ion exchange columns is common. These columns require regeneration (typically using hydrochloric acid/caustic soda for demineralisation plants and salt solution for softening plants), followed by a short period of operation to stabilise them. These processes use water and chemicals and generate effluent.

Regeneration of columns can be undertaken on one of the following bases:
- daily (either manually operated or via a timer): this can be wasteful and expensive because regeneration is not related to column use;
- volume of water treated: this can be wasteful and expensive if the quality of incoming water varies;
- conductivity measurement: this is the most cost-effective method because regeneration is related directly to the quality of the treated water, ie the column is regenerated only when the total dissolved solids (TDS) set limit is reached.

Ideally, you should optimise the frequency of regeneration of the columns to minimise costs and environmental impact.

TIP Can you optimise the regeneration of ion exchange columns used for boiler water pre-treatment?

Control of boiler blowdown
Blowdown from the boiler purges the system of impurities, preventing a build-up of TDS in the boiler water. Boiler blowdown can be controlled manually through use of timers or conductivity measurements (typically linked to TDS).
Automatic boiler blowdown control systems, based on conductivity measurements, are usually set to operate at a conductivity equivalent to a TDS of around 3 000 - 3 500 mg/litre. A typical treated water has a TDS concentration of 275 mg/litre.

\[
\text{Boiler blowdown} = \frac{275 \times 100}{3000} = 9.2\% \text{ boiler feed water}
\]

Typically, boiler blowdown should be discharged to sewer and not to the surface water drain.

**Condensate recovery**

The condensate (hot water) derived from steam cooling has a value in terms of water and its energy content. Condensate occurs in steam lines and often at the point of use of the steam.

Where possible, condensate should be collected and returned to the boiler hotwell, thus reducing the water and energy required to produce further steam and hot water.

Since condensate does not require pre-treatment and is typically low in dissolved solids, its recovery for re-use reduces ion exchange costs and reduces blowdown requirements. Condensate is typically at 60 - 80°C, so the energy lost if it is discharged to drain is also considerable.

**Benefits of steam condensate return**

A manufacturer of sausages, bacon and ready meals in North West England uses steam to heat the cooking vessels through a steam jacket, with condensate discharged directly to sewer. Operating costs were calculated to be around £25 500/year including water, effluent and energy charges. An investigation suggested that around 80% of the steam could be recovered and returned to the boiler (hotwell). Installing the necessary pipework cost £8 250 and resulted in savings of around £4 300/year, giving a payback period of 23 months.

**Steam losses and leaks**

The cost of generating and distributing steam is often underestimated. Steam contains a significant energy content. To produce steam (at 100°C) requires the energy equivalent of heating water to around 650°C, ie around 80% of the energy input to a steam boiler is for the latent heat of vaporisation.

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See ECG066 *Steam generation costs* and ECG092 *Steam distribution costs* published by the Carbon Trust.
Keep losses from leaks and poorly maintained steam vents to a minimum with regular checks, and prompt reporting and repair procedures.

### 3.4.3 Cooling systems

A number of systems can be used for cooling purposes, eg:
- cooling water used on a once-through basis;
- cooling water with closed loop cycle;
- cooling towers.

Equipment that requires cooling (eg cutting machines, cooling jackets on vessels, liquid ring pumps and gearboxes) is often switched off between shifts or during line changeovers. However, the cooling water system serving the equipment, which may be concealed, is often left running.

Where possible, switch off the cooling water at the same time as the equipment it serves. This can either be done manually by the machine operator or through the use of an automatic shutoff device (see section 3.2.5).

**Cooling water flow control**

In some cases, you can control the flow of cooling water. For example, a control valve linked to a thermostat in the oil can regulate the cooling water flow on large hydraulic power packs.\(^{11}\)

> **TIP**

If cooling is essential to avoid damage to equipment, set the valve to fail open rather than closed.

**Closed loop cooling water cycle**

Equipment that requires cooling water is often simply connected to the nearest available water supply and fresh cold water (mains supply) used for cooling on a ‘once-through’ basis ie discharged directly to drain. Fitting a closed loop system may allow this water to be re-used after cooling and provided it is not contaminated. A filter or a small flow to drain may be required to control the build-up of contaminants.

Air blast chillers, refrigeration units or evaporative towers can be used to cool the water circulating within the closed loop system. If the water has a significant heat content, it may be possible to recover the heat using a heat exchanger.

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\(^{11}\) These typically require a supply of cold water to cool the hydraulic oil.
3.4.4 Evaporative cooling towers

**Automatic blowdown control**

Evaporative cooling towers usually operate with a periodic or continuous discharge of water from the recirculated water circuit to drain (blowdown) see Fig 14 overleaf. This is intended to keep the level of dissolved solids below a set maximum. A build-up of solid deposits in the tower packing or plant cooling system will otherwise occur, reducing cooling efficiency.

Cooling towers are often operated either with a constant blowdown or a periodic discharge of a pre-set volume. This flow can be minimised by using automatic control systems that measure the TDS content of the cooling water.
**Cooling load reduction**

Cooling towers require fresh make-up water to replace evaporative losses and blowdown. The amount of make-up water depends directly on the cooling load. Minimising the cooling load will reduce the use of fresh water as make-up water. This can be achieved by:

- reducing waste heat generated;
- using the waste heat elsewhere in the factory.

For a 1 000 kW cooling duty, a typical cooling tower uses 2 m\(^3\)/hour of fresh water and produces 0.75 m\(^3\)/hour of blowdown to drain. These amounts will depend on the air temperature and relative humidity.

**Spray/mist recovery**

Cooling towers also lose water as spray/mist. This water loss depends on the effectiveness, or even the existence, of a mist eliminator.

In a cooling tower operating with optimised automatic blowdown control, losses of usable water are small as the spray loss is effectively blowdown. However, in a cooling tower operated with a fixed blowdown, spray loss represents a loss of usable water. It is likely to be more cost-effective to install automatic blowdown control than to upgrade the spray/mist eliminator.

**Use of alternative cooling processes**

Conventional cooling towers can be replaced by:

- air blast coolers, in situations where 'cooled' water temperatures of up to 40°C can be tolerated during the summer months;
- refrigerated closed loop systems.

In some cases, cooling systems can be designed such that the waste heat is used to pre-heat a cold feed to another process. A good use of waste low-grade heat is to pre-heat boiler feed water. Heat exchange with incoming cold water can often achieve lower temperatures in the cooling circuit than cooling towers.

NB all equipment attached to the mains water supply must be compliant with the Water Supply (Water Fittings) Regulations 1999.
4 - Action plan

- Find out how much your company is paying in water and wastewater charges.
- Use the guidance provided on the Rippleffect.
- Carry out a water use survey for your site - see Tracking water use to cut costs.
- Develop a water balance for your site.
- Identify and agree a target for water saving.
- Estimate potential savings from reducing water use and wastewater generation.
- Identify other benefits from saving water.
- Decide how much is worth spending on water saving projects.
- Identify and evaluate appropriate water saving devices and practices.
- Identify project costs.
- Consider the impact of the water saving measures on your particular activity.
- Implement cost-effective water saving devices and practices. Remember to check on the Water Technology List for information about products that encourage sustainable water use. See www.eca-water.gov.uk for details.

Identification and implementation of cost-effective water saving devices and practices should be carried out as part of a campaign to minimise water use and wastewater generation at your site. A systematic approach to waste minimisation is described in Saving Money Through Resource Efficiency: Reducing Water Use and the four phases of a typical water saving campaign are summarised in Appendix 1.

If necessary, obtain help. WRAP offers a range of free services including:

- free advice from WRAP experts through the helpline on a wide range of environmental issues, legislation and technology;
- a variety of publications and tools to help you reduce water use and wastewater generation;

To find out more, visit www.wrap.org.uk or contact the helpline 0808 100 2040
4.1 Other sources of information

4.1.1 WRAP publications
Use the Business Resource Efficiency Hub (www.wrap.org.uk/brehub) to identify the most relevant publications for your requirements. Particularly useful publications include:

- *Water Minimisation in the Food and Drink Industry*
- *Saving Money Through Resource Efficiency: Reducing Water Use*
- *Reducing Your Water Consumption*
- *Tracking Water Use to Cut Costs*

4.1.2 Other publications
Useful publications from the Environment Agency, Scottish Environment Protection Agency (SEPA) and the Northern Ireland Environment and Heritage Service (EHS) include:

- *Pollution Prevention Pays. Getting your site right: industrial and commercial pollution prevention,* 2004. 17
- A series of over 25 Pollution Prevention Guidance notes (PPGs). Each PPG is targeted at a particular industrial sector or activity and provides advice on statutory responsibilities and good environmental practice.

The various PPGs are available on request from local offices or can be downloaded from either [www.environment-agency.gov.uk/ppg/](http://www.environment-agency.gov.uk/ppg/) or [www.sepa.org.uk/guidance/ppg/](http://www.sepa.org.uk/guidance/ppg/)

The Environment Agency also publishes a range of free literature relating to water conservation and demand management, including *Waterwise: good for business and good for the environment,* 2002. To find out more, visit the Water Resources area of the Environment Agency website ([www.environment-agency.gov.uk](http://www.environment-agency.gov.uk)).

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17 Available to download as a pdf file from the Environment Agency website (www.environment-agency.gov.uk).
### Appendices

**A typical water saving campaign**

A typical water saving campaign involves four phases. These are summarised in Fig A1.

**Fig A1  Four phases of a typical water saving campaign**

<table>
<thead>
<tr>
<th>PHASE 1 - Initiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Involve staff and appoint the leader (‘champion’) of the water saving team.</td>
</tr>
<tr>
<td>- Find out about water saving devices and their application, e.g:</td>
</tr>
<tr>
<td>- read this Guide;</td>
</tr>
<tr>
<td>- visit <a href="http://www.envirowise.gov.uk/water">www.envirowise.gov.uk/water</a></td>
</tr>
<tr>
<td>- contact the Environment and Energy Helpline on 0800 585794 for advice.</td>
</tr>
<tr>
<td>- Talk to other interested people in your company.</td>
</tr>
<tr>
<td>- Develop a simple programme.</td>
</tr>
<tr>
<td>- Allocate sufficient resources.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PHASE 2 - Water use survey and development of the water balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Identify where, how and why water is used.</td>
</tr>
<tr>
<td>- Identify the water quantity and quality requirement at each point of use.</td>
</tr>
<tr>
<td>- Determine the water quality and availability at each point of discharge.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PHASE 3 - Evaluation of water saving options</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Evaluate current and future water costs by area or item of equipment.</td>
</tr>
<tr>
<td>- Identify and evaluate cost-effective water saving devices and practices.</td>
</tr>
<tr>
<td>- Carry out trials of likely options.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PHASE 4 - Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Train staff (if necessary).</td>
</tr>
<tr>
<td>- Implement cost-effective water saving devices and practices.</td>
</tr>
<tr>
<td>- Monitor the implemented devices and practices.</td>
</tr>
<tr>
<td>- Obtain feedback from staff.</td>
</tr>
<tr>
<td>- Communicate successes and savings to employees.</td>
</tr>
</tbody>
</table>
The effect of pressure and heat load reduction on water use

Fig A2 and Fig A3 show the potential water savings from reducing water pressure and reducing the heat load on cooling towers, respectively.
Estimating pumping, energy and treatment costs

This appendix outlines how to estimate:
- the effect of reduced water use on pumping costs;
- water heating costs;
- water cooling costs;
- on-site water treatment costs.

Estimating the effect of reduced water use on pumping costs

Pumping costs depend mainly on:
- mode of operation of the pumping system;
- flow being pumped;
- delivery pressure of the pump (often related to the head).

Fixed speed pumps

Pumping costs for a pumping station with fixed speed pumps that start and stop to meet demand can be estimated pro rata from the total flow and pump power consumption.

Variable speed pumps

Systems that use variable speed pumps to maintain either a constant liquid level (eg drainage sumps) or constant pressure (eg ring mains) require more thought.

Estimating the power consumption for variable speed systems is more complicated. For example, pumping at half the flow rate reduces the instantaneous power requirement to overcome the static head (pressure or gravity) to half. However, it reduces the instantaneous power requirement to overcome the dynamic head (friction) to approximately one eighth. The process also takes twice as long.

Potential reductions in pumping costs for variable speed pumping systems are best estimated (if the data are available) from hours-run meters, measured power consumption and total flow. Pump maintenance costs can be estimated pro rata from the hours run.

Estimating water heating costs

The power required to heat water is much easier to estimate. You need to know:
- required temperature difference (°C);
- flow rate (litres/second);
- density (kg/m³);
- heat capacity of the water (the heat capacity of clean water = 4.18 kJ/kg°C).
For clean water,

\[
\text{Power requirement (kW)} = \frac{\text{Flow rate (1 kg/second) \times Temperature difference (°C) \times Heat capacity (kJ/kg°C)}}{}
\]

Because the density of clean water is 1 000 kg/m³, a flow rate of 1 litre/second of clean water is equivalent to a flow rate of 1 kg/second. Dirty water may have a different density and heat capacity compared with clean water. If necessary, this should be taken into account.

\[
\text{Energy (kWh)} = \text{Power (kW)} \times \text{Time (hours)}
\]

\[
\text{Heating cost} = \text{Energy (kWh)} \times \text{Energy unit cost (pence/kWh)}
\]

The unit cost of a kWh of heating (pence/kWh) is given on your utility bill.

**Estimating water cooling costs**

The cost of cooling in a cooling tower can be estimated from the cost of the make-up water and blowdown to drain. For every 1 000 kW, this amounts to approximately 2 m³/hour make-up water and approximately 0.75 m³/hour of blowdown to effluent.

In most cases, the cooling tower fan power consumption can be ignored. This should remain constant unless controlled by the water temperature. The cost of cooling by refrigeration can be calculated directly from the refrigeration plant costs.

**Example calculation for a cooling tower**

A study in a fictitious factory has identified a process modification that would result in a reduction of 100 kW in the cooling load on an evaporative cooling tower.

Assume that 2 m³/hour of make-up water and 0.75 m³/hour of blowdown to effluent are saved per 1 000 kW.

The cooling tower operates for 330 days/year, water charges are 79 pence/m³ and effluent charges are 71 pence/m³.

The estimated reduction in water and effluent costs is estimated as follows.

**Step 1**

Calculate the reduction in water usage for evaporation and blowdown pro rata

\[
\text{Reduction in evaporation} = \frac{2 \text{ m}^3/\text{hour} \times 100 \text{ kW}}{1000 \text{ kW}} = 0.2 \text{ m}^3/\text{hour}
\]

\[
\text{Reduction in blowdown} = \frac{0.75 \text{ m}^3/\text{hour} \times 100 \text{ kW}}{1000 \text{ kW}} = 0.075 \text{ m}^3/\text{hour}
\]

**Step 2**

Reduction in water use = Reduction in evaporation + Reduction in blowdown

\[
= 0.2 \text{ m}^3/\text{hour} + 0.075 \text{ m}^3/\text{hour}
\]

\[
= 0.275 \text{ m}^3/\text{hour}
\]

Annual reduction in water use = 0.275 m³/hour \times 24 hours/day \times 330 days/year

\[
= 2.178 \text{ m}^3/\text{year}
\]
There will be small additional cost savings of a few pounds for water treatment chemicals.

The estimated cost reduction can be used in the calculation of the Maximum Project Budget (see section 2.4).

**Estimating on-site water treatment costs**

The costs associated with water treatment prior to use or re-use include:

- consumables;
- effluent and solid waste disposal;
- energy.

**Ion exchange system - worked example**

An ion exchange system (eg base exchange with salt solution regeneration) is used to reduce the total hardness of mains water from 375 mg/litre (as calcium carbonate) to less than 10 mg/litre (as calcium carbonate).

As shown in Fig A4, the system uses 1.05 m³ mains water to produce 1 m³ of usable treated water (0.05 m³ of regeneration solution and rinse water are produced). Regeneration requires 0.5 kg salt (typically costing £130/tonne). The process achieves 95% yield of treated water, with 5% waste as effluent to drain (incurring effluent charges).

The actual regeneration solution consumption depends on the quality of the mains water.
Membrane treatment
Reverse osmosis and membrane water treatment systems typically generate 0.25 m³ of effluent per m³ of usable treated water, ie the process achieves 80% yield of treated water.

If you need help on how to calculate the costs associated with water treatment, seek advice or contact the WRAP resource efficiency helpline on 0808 100 2040.
Converting between systems of units

<table>
<thead>
<tr>
<th>Volume</th>
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<th>Multiply by:</th>
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<tbody>
<tr>
<td>Litres</td>
<td>Cubic metres</td>
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<tr>
<td>Cubic metres</td>
<td>Litres</td>
<td>1.000</td>
</tr>
<tr>
<td>UK gallons</td>
<td>Cubic metres</td>
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<td>US gallons</td>
<td>UK gallons</td>
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<table>
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<td>UK gallons/minute</td>
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<td>Litres/second</td>
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