REDUCING WATER AND EFFLUENT COSTS IN BREWERIES

GOOD PRACTICE: Proven technology and techniques for profitable environmental improvement
REDUCING WATER AND EFFLUENT COSTS IN BREWERIES

This Good Practice Guide was produced by the Environmental Technology Best Practice Programme

Produced with assistance from:
Ashact Dames & Moore Ltd
and
Allied Brewery Traders’ Association (ABTA)
Brewers and Licensed Retailers Association (BLRA)
Society of Independent Brewers (SIBA)
The UK brewing industry uses large amounts of water, of which over 70% ends up as trade effluent. Unit costs for water supply and trade effluent discharge are expected to continue to rise as water companies invest in the new plant needed to comply with EC and UK legislation.

Water and effluent costs are controllable. A water management programme can produce savings of over 20% through good housekeeping and low-cost measures. Projects with a payback period of less than two years will allow you to achieve savings of at least a further 20%.

This Good Practice Guide indicates the potential savings from different types of water saving measures, and presents actions to reduce water and effluent costs in the brewing process, packaging, ancillary processes and general areas. Although the measures are aimed particularly at smaller breweries, many are cost-effective for all sizes of brewery. Industry Examples illustrate the savings that can be achieved by measuring water use and taking action to reduce waste.

Reducing the amount of water used not only reduces supply costs, but also the volume of trade effluent produced. However, reducing the strength of your brewery's trade effluent is equally important. Taking action to minimise the discharge of wastes with a high COD, eg residual wort and ullage, will dramatically reduce your trade effluent charges. Optimising your cleaning procedures, identifying leaks and stopping overflows are other areas where significant savings can be achieved.

Installing meters and carrying out a survey of water use will help you to decide your priorities for action.
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The UK brewing industry uses an estimated 34 million m³/year of water - enough water to supply everyone living in the city of Edinburgh for a year. However, the cost of supplying water to a brewery is only the beginning. Most breweries discharge over 70% of supplied water as trade effluent and, in many cases, trade effluent costs are higher than water supply costs. In most breweries, the total cost of water supply and trade effluent disposal is about the same as the site’s energy bill. If you add pumping, water treatment and effluent treatment costs, the bill is even higher. Wasting cold liquor, for example, also wastes the time and cost of treating the water.

Like energy costs, you can take action to control and reduce your water and effluent costs. A typical water saving programme can produce savings of over 20% for little or no cost. Further savings of at least 20% can be achieved by projects with a payback period of less than two years.

Breweries need to ask themselves the following questions:

- Has your brewery implemented a water management programme? If not, you could save 20% of your costs through good housekeeping and low-cost measures.
- Check your most recent water bill. Is the volume of water used more than 3.4 times the volume of beer brewed over the same period? If it is, you could do better - other breweries have (see Fig 1).
- Check your trade effluent bill. Is the average chemical oxygen demand (COD) of your effluent more than 2 000 mg/litre? If it is, you could do better.

This Good Practice Guide describes a range of cost-effective measures to reduce water use and effluent generation in breweries. Although the Guide is aimed mainly at small breweries (defined as producing less than 500 000 hectolitres/year), many of the measures - particularly the no-cost options - are applicable to all sizes of brewery.

### 1.1 WATER USE BY UK BREWERIES

Despite water use falling by a third over the last 20 years,¹ there is still significant scope for further cost savings through reducing water use and effluent generation.

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¹ See annual surveys of utility use carried out by the Brewers and Licensed Retailers Association (BLRA).
REDUCING WATER AND EFFLUENT COSTS IN BREWERIES

GOOD PRACTICE: Proven technology and techniques for profitable environmental improvement
2.1 CARRYING OUT A WATER USE SURVEY

A useful step towards identifying opportunities to reduce water and effluent costs is to understand how, where and why water is used by the brewery. This can be achieved by carrying out a water use survey and developing a water balance for your site. This preliminary work will also help you to decide if further metering would be useful.

- Map the brewery’s water distribution network and mark the routes of major pipes and drains on site plans. Find out:
  - How many projects, modifications and additions have there been since the last water survey?
  - Who performed the last survey and how thorough was it?
  - Are the drawings up to date?

- Identify the major points at which water is used.

- Quantify the amount of water used at each major point.

- Identify the water quality requirement and availability at each point.

- Produce water use diagrams (see Fig 2) for your hot liquor, cold liquor and drainage systems.

- Check water use in different areas of the brewery when production has ceased. If you find liquid flowing through pipes or to drain, either you have a leak or equipment has been left switched on.

You will find it extremely useful later on if, during the water use survey, you also:

- produce schematic diagrams of the water and effluent systems;
- label pipework, valves and manhole covers.

The task of mapping the brewery’s water network is a project that might suit a new employee or a graduate on a work experience programme.

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**Work experience student helps brewery make immediate savings**

A graduate trainee employed by J W Lees & Co on a work experience scheme:

- successfully mapped the water network in the family-owned brewery;
- helped to locate the best position for 16 new water meters;
- set up procedures for taking weekly meter readings and entering the data on a computer spreadsheet.

Meter readings showed that more water was being used for cleaning in the Brewery’s tank room than expected. By improving procedures, immediate water savings of 300 m$^3$/week were achieved, worth £18 000/year in reduced water and effluent costs.$^3$
Regular surveys, eg annual, will help to keep your water and effluent systems in good order. Surveys typically reveal:

- unidentified connections;
- cross connections;
- broken valves;
- incorrectly set valves;
- leaks;
- excessive or unnecessary use;
- unknown use;
- unauthorised use;
- clean water discharges directly to effluent, eg cooling water;
- unauthorised discharges to effluent;
unnecessary surface water discharges to effluent;

- surface water drainage from potentially contaminated areas;

- sources of potential failure of effluent discharge consents.

### 2.2 MEASURING WATER USE

All breweries should have a meter on their incoming water supply. In many cases, this meter reading is also used as the basis for calculating trade effluent volumes.

However, the supply meter only provides an indication of water use in the brewery as a whole. To target water and effluent saving measures effectively, a comprehensive system of meters will help you to:

- identify processes that use a lot of water;
- identify leaks in particular process areas;
- determine current water use;
- set targets to reduce water use;
- calculate potential savings and thus justify expenditure on water saving devices;
- compare actual water use with your targets;
- take action to manage water use.

The amount of water used in a brewery is linked to the volume of production. To make it easier to compare water use at different times of the year, it is best to relate water use over a specified period to a production indicator, eg the quantity of beer brewed or the quantity packaged.

**Leak detection is cost-effective**

The Eagle Brewery operated by Charles Wells Ltd has a comprehensive utility monitoring system that covers the water supply to the main process areas. Since it was installed, the system has paid for itself many times through rapid identification of leaks. As well as identifying major leaks, continuous metering allows the Brewery to identify changes in normal water use due to leakage from a single component, eg a valve.

Example faults and the estimated potential hourly cost are listed below.

<table>
<thead>
<tr>
<th>Fault</th>
<th>Estimated potential cost (£/hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hose left on</td>
<td>12.00</td>
</tr>
<tr>
<td>Bottle pasteuriser rinse jets left switched on</td>
<td>12.00</td>
</tr>
<tr>
<td>Bottle rinser left switched on</td>
<td>5.20</td>
</tr>
<tr>
<td>Leaking float valve on the cooling tower</td>
<td>3.50</td>
</tr>
<tr>
<td>Leaking ball valve in the bottle pasteuriser</td>
<td>1.70</td>
</tr>
<tr>
<td>Leaking ball valve in the keg plant</td>
<td>1.60</td>
</tr>
<tr>
<td>Pasteuriser header tank top-up valve jammed</td>
<td>1.40</td>
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</table>

**2.2.1 Where to meter water**

Many breweries have a water supply pipework which is old and has been extended or adapted over the years to meet the brewery's changing demands.

If your water supply network is a tangle of interconnections and dead-ends, you need to map the network before investing in new meters. This will ensure that meters are installed in the most appropriate places.
If your water supply network is particularly confused or so old that leaks occur frequently, rationalising the system to make it more logical will help to make management simpler and supplies are likely to be more reliable.

Some areas where individual metering could be particularly effective include the following locations:

- hot liquor tank top-up;
- wort heat exchanger;
- brew-house hoses;
- copper condenser;
- fermenter cooling;
- gland cooling;
- tank area hoses;
- bottle washer;
- cask washer;
- keg washer;
- bottle pasteuriser and filler;
- racking area hoses.

For processes with hot and cold water feeds, you should consider metering both feeds. This will tell you whether cold liquor is being heated for use when hot liquor is available.

### 2.2.2 Types of water meter

Mechanical meters are the most suitable type of water meters for most brewery applications. Pulsed-output mechanical meters allow data to be collected automatically, thus eliminating the need for manual reading and the risk of reading errors.


Do not assume that a piece of equipment actually uses the volume it is designed to use.

### 2.2.3 Other methods of measuring water use

If it is too expensive or not practical to install a meter, you may be able to estimate water use using other methods:

- Where water is pumped using a pump of relatively constant output, you can determine the volume of water pumped by multiplying the output of the pump by the hours run.
- Where a tank is filled on demand in response to low-level and high-level switches, you can fit a counter to count the number of filling cycles.

### 2.3 MOST WATER BECOMES EFFLUENT

Most breweries discharge over 70% of the water supplied to their site as trade effluent. Fig 3 shows the major sources of effluent from brewery processes. The main inputs and other wastes are also indicated.
Fig 3  Major inputs and outputs from the brewing process
2.3.1 Key effluent parameters

Trade effluent charges (see Appendix 2) are based on both the volume of effluent discharged and its strength. Water companies use two main parameters to measure the strength of trade effluent, ie:

- chemical oxygen demand (COD);
- total settleable solids (TSS or Ss).

Brewery effluent tends to have a high COD content due to the presence of soluble sugars, starches, alcohol and proteins in the wort, beer and yeast. The COD of these products is typically over 100 000 mg/litre, whereas domestic wastewater has a COD of only about 500 mg/litre.

The suspended solids content makes up a smaller part of the overall trade effluent charge. The main sources of undissolved solids in brewery effluent are grains washed from the floor, trub, yeast and ullage. With the exception of grains, these sources also have a high COD.

2.4 MONITORING TRADE EFFLUENT

2.4.1 Flow

Domestic wastewater from industrial premises and uncontaminated surface water, eg roof water, may be discharged to surface water drains. Hard standing areas that may become contaminated, eg oil storage areas and cask washing areas, must be discharged to the foul sewer (with the consent of the sewerage undertaker) or site treatment facilities. ‘Clean’ water discharges are charged at the lower domestic sewage rate whilst a higher charge is levied for contaminated waters. To minimise costs, ‘clean’ and ‘dirty’ discharges should be kept separate so that the higher charge is paid only for ‘dirty’ effluent.

Any process effluent must be discharged to the foul sewer or site treatment facilities. The only exception is cooling water which can be discharged to surface water with the consent of the Environment Agency. However, such water is generally re-usable and should not need to be discharged.

Keep domestic sewerage and surface water drainage separate from trade effluent.

One way is to label or colour-code all drains. For easy identification, foul water drains can be coloured red and surface water drains blue. Make sure staff are aware of the difference.

Ideally, the volume on which trade effluent charges are based should be obtained by direct measurement in the trade effluent sewer. However, flow measurement in gravity pipes tends to be inaccurate, particularly when settleable solids are present. The most reliable method is a flume, but the conditions required for accuracy are not readily achieved in many breweries. Consequently, the trade effluent volume is generally calculated from the water metered onto the site (with allowances for domestic use); water leaving site in the product; and evaporation. This method requires assumptions on the amount of water used to flush toilets, in washbasins, in staff canteens, etc.

Many older breweries are unable to segregate surface water and domestic wastewater from trade effluent. Determining the volume of trade effluent for charging purposes is therefore complicated. In such cases, the water company may agree to make allowance for domestic and/or surface water inputs into the trade effluent.

Remember to tell the water company about major changes in staff numbers or modifications to staff facilities that may affect water consumption and thus the allowance for domestic use in your trade effluent charges.

2.4.2 Strength

Regular sampling of trade effluent is required to:
confirm compliance with your discharge consent;

determine the average COD and suspended solids content for charging purposes.

Samples taken for the purposes of trade effluent charging can be taken either by the water company or by the brewery. They may be either spot samples or 24-hour composite samples. The choice will depend on the policy of the individual water company and the size of the brewery.

If an effluent flow meter is installed, a flow-weighted composite sample can be taken. This type of sample is the most accurate as it compensates for the variation in effluent flow rate during the day.

Because brewery effluent is highly degradable, samples need to be kept cool and analysed as soon as possible. Some characteristics - particularly pH - should be measured immediately, as a delay of only a few hours can alter the result significantly.

2.5 MEASURING TO MANAGE

2.5.1 Prepare a water balance

The amount of water entering the brewery equals the amount of water leaving it. Drawing up a water balance is a powerful technique for identifying waste. It can be applied to both the whole brewery and individual processes. When considering your inputs and outputs, remember to include:

- water contained in the product;
- water discharged as vapour directly to atmosphere;
- the route taken by rainwater.

Good Practice Guide (GG26) Saving Money Through Waste Minimisation: Reducing Water Use describes a systematic approach to reducing the costs associated with water use and effluent disposal. This includes the identification of all water inputs and outputs and how to draw up a water balance.

2.5.2 Read meters regularly

Measuring water consumption, effluent discharge and the associated costs are crucial to effective water management. Once you have completed your water use survey and installed more meters, you should establish a regime of regular reading and recording of water use throughout the brewery. Measuring water use and effluent generation will also allow you to work out how much money the brewery is saving.

If your meters are read manually, the frequency of readings depends on the balance between the effort involved and the ability to identify problems and leaks quickly. Weekly readings may be appropriate if your brewery only suffers from occasional leaks. Meters connected to computer-based automatic monitoring systems can take meter readings at intervals of 15 minutes and thus alert operators to faults much sooner.

Arrange for meters to be read regularly.
Take action immediately to repair leaks or investigate possible problems.
Remember that a major water leak can cost several thousand pounds in extra water and effluent charges in just a few days.
Tell staff about the savings the brewery achieves. Feedback will make them feel involved and encourage them to make an effort to save water.

Remember:
If you don’t measure it, you can’t manage it.
This Section will help you to work out how much money your brewery could save by adopting good practice and implementing cost-effective water saving measures. Start by finding out how much your brewery pays for water supply and effluent discharge.

3.1 WATER AND EFFLUENT COSTS

Water supply and trade effluent charges have increased significantly in recent years. This trend is expected to continue as UK water companies seek to recoup the substantial amounts of money invested in the new plant and treatment methods needed to meet stricter environmental legislation. Unit costs for trade effluent discharge are already significantly higher than those for water supply.

3.1.1 Water supply costs

Mains water typically costs 50 - 80 pence/m³ (1997 - 1998 prices), depending on the area of the country. Some breweries may benefit from a discount negotiated under a high-use charging scheme.

Water drawn from a borehole owned by the brewery is covered by an abstraction licence granted by the Environment Agency. For a fixed annual charge, this licence allows water to be abstracted from the borehole up to a specified annual volume. Borehole water typically costs less than 10 pence/m³, on top of the licence fee.

Low quality borehole water may only be suitable for general cleaning, cask washing, etc. As borehole water is not sterilised, it may require chlorination or ultraviolet (UV) treatment prior to some uses. Even though borehole water is much cheaper than mains water, reducing its use saves the cost and effort involved in treating it.

3.1.2 Trade effluent costs

Companies receiving trade effluents levy an appropriate charge based on the Mogden Formula (see Appendix 2). Brewery effluent typically costs £1.00 - £2.00/m³ to discharge to sewer, depending on the area of the country.

If your brewery pays less than this, either you may be diluting the effluent through excessive water use or the water company may not be treating the effluent fully. Trade effluent charges for primary treatment only are typically 40 - 50 pence/m³. For example, breweries in many coastal areas currently pay historically low trade effluent charges as the effluent receives little or no treatment prior to its discharge to the sea. Charges for trade effluent discharged untreated from a sea outfall are typically less than 35 pence/m³.

However, recent legislation sets out a timetable for the introduction of secondary (ie biological) treatment at most UK sewage treatment works. As brewery effluents have a high COD, the statutory requirement for biological treatment will have a major impact on trade effluent charges - an additional £0.5 - £1.50/m³ is anticipated.

Beware!

If you are paying less than 50 pence/m³ to discharge untreated trade effluent, your trade effluent charges are likely to increase significantly in the near future.

3.2 DECIDING YOUR PRIORITY ACTIONS

The information obtained from your water use survey will help you to identify areas and processes for priority action. The next step is to estimate the potential savings for each area of the brewery. This will allow you to concentrate on projects with the greatest potential cost savings.

Sections 4 - 7 describe a range of no-cost, low-cost and higher cost measures to reduce water and effluent costs. All of these actions will help to reduce your water:product ratio to nearer a best practice target of 3.4:1.

Most breweries will achieve the greatest savings through reducing trade effluent charges. As well as minimising effluent volumes, it is also important to take action to reduce the strength of the effluent. Effluent pre-treatment at the brewery and other measures to reduce effluent strength prior to discharge will reduce trade effluent costs considerably.

Discharging uncontaminated water to drain dilutes your effluent, but increases the volume element of the trade effluent charge. Reducing the volume of uncontaminated water running to drain may cut your bill by 30 - 50 pence/m³ of effluent saved. However, if you avoid discharging a concentrated waste with a high COD, eg yeast slurry or beer, you could save £30 - £50/m³ of effluent saved.

**COD reduction saves £10 000/year**

A brewery which uses 29 500 m³ of water/year to produce 30 000 barrels/year has a water:product ratio of 6:1. The brewery discharges an estimated 25 000 m³/year of effluent. However, when the COD was reduced from 3 000 mg/litre to 2 000 mg/litre, trade effluent charges fell from £35 000/year to £25 000/year.

You will save much more money by avoiding the discharge of concentrated waste than by reducing the amount of uncontaminated water running to drain.

3.3 ESTIMATING POTENTIAL SAVINGS

When calculating the potential savings from a particular water saving measure, there may be savings in the cost of:

- water use;
- on-site water pumping and associated maintenance;
- water treatment, eg chemicals and filter backwash;
- water heating or cooling;
- effluent pumping;
- effluent treatment;
- effluent discharge.

You may also achieve cost savings as a result of:

- increased beer production or recovery in process modifications;
- greater recovery of materials suitable for sale as animal feedstuffs;
- a delayed requirement for additional water storage capacity;
- increased production without having to upgrade the water supply system;
- lower capital expenditure on a planned effluent treatment plant.

6 The COD of beer is about 180 000 mg/litre.
You need to consider all of the potential savings and project costs before deciding whether a particular water saving measure is cost-effective for your brewery.

Good Practice Guide (GG67) Cost-effective Water Saving Devices and Practices\(^7\) gives the estimated cost of water losses from open taps and leaking valves, joints, pipes, pump seals and hoses, and discusses the effects of reduced water use on pumping, energy and on-site water treatment costs. GG67 also gives advice on how to identify project costs and set the project budget for water saving activities. These costs will help you to calculate potential savings from good housekeeping measures at your site.

### 3.3.1 Example savings

Table 1 shows typical percentage reductions in the amount of water used, achievable by selected measures in selected applications. You can use these values to estimate potential cost savings in your brewery, but you should not rely on them when preparing a detailed budget.

<table>
<thead>
<tr>
<th>Water saving measure</th>
<th>Possible application</th>
<th>Typical reduction in process use (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed loop recycle</td>
<td>Fermenter cooling</td>
<td>&gt;90</td>
</tr>
<tr>
<td>Cleaning-in-place (CIP)</td>
<td>New CIP set</td>
<td>60</td>
</tr>
<tr>
<td>Re-use of wash water</td>
<td>Cask washer</td>
<td>50</td>
</tr>
<tr>
<td>Countercurrent rinsing</td>
<td>CIP set</td>
<td>40</td>
</tr>
<tr>
<td>Good housekeeping</td>
<td>Hose pipes</td>
<td>30</td>
</tr>
<tr>
<td>Cleaning-in-place (CIP)</td>
<td>Optimisation of CIP set</td>
<td>30</td>
</tr>
<tr>
<td>Spray/jet upgrades</td>
<td>Cask washer</td>
<td>20</td>
</tr>
<tr>
<td>Brushes/squeegees</td>
<td>Fermenter cleaning</td>
<td>20</td>
</tr>
<tr>
<td>Automatic shut-off</td>
<td>Pump cooling water</td>
<td>15</td>
</tr>
</tbody>
</table>

\(^7\) This Guide is available free of charge through the Environmental Helpline on freephone 0800 585794.
This Section describes practical measures to reduce water use and effluent generation in different parts of the brewing process. These measures are summarised at the end of the Section in Table 2.

Throughout this Section, opportunities are identified for using brewery waste, such as grain, wort and yeast, as animal feed rather than adding to effluent concentration if sent to drain. Advice should be obtained before undertaking the handling of such feedstuffs.

4.1 MASH TUN AND LAUTER TUN

4.1.1 Accurate filling
Sufficient liquor needs to be added to the mash tun to produce the correct specific gravity, but too much liquor in the mash means that there is too much wort to transfer to the copper and subsequently to the fermenting vessel. Solving this problem by diverting part of the wort or the final runnings from the mash tun to drain not only wastes grain, but adds material with a high COD (commonly over 100 000 mg/litre) to your effluent. Since wort is rich in sugars and vitamins, excess wort can be sold for animal feed. Every 1% of wort discharged to drain adds approximately 5% to the COD of the brewery’s trade effluent.

Do not fill the mash tun too full. Train staff to add the correct amount of liquor and install a meter to measure the volume of liquor added to the mash tun.
If brews are fairly frequent, store your surplus wort and add it to the next brew.
Store residual wort with spoilt beer or trub for sale to farmers as an animal feed supplement.
Do not mix residual wort with surplus yeast - the mixture will start fermenting and the value of both wastes will be reduced. Fermentable matter needs to be kept separate to maintain its value as an animal feed, and yeast needs to be kept separate to maintain its value to food manufacturers.

4.1.2 Emptying the grain from the mash tun
After drawing off the wort, the grain should be reasonably dry and easy to transfer to a silo or another storage vessel prior to collection by a farmer as animal feed. Liquid draining from stored grain has a high COD; this can lead to problems if the grain is stored on, or above, a yard. Any grain that goes down the drain increases the effluent strength. It also tends to cause blockages or to accumulate in manholes.

Use dry methods to remove grain from the mash tun, eg a brush or rake. There is no need to use water jets to flush grain from the mash tun.
If you have large mash tuns, install a rotating rake to remove grain.
Make sure liquid draining from brewers’ grains goes down a foul sewer and not a surface water drain.
Fit fine mesh baskets in the floor drains in the mash tun area to reduce the amount of grain entering the drainage system.

8 For guidance on the supply of co-products as animal feed, contact the Brewers and Licensed Retailers Association (BLRA) (see Appendix 1).
4.1.3 Cleaning the mash tun

Cleaning-in-place (CIP) is generally more efficient than manual cleaning. The correct nozzle design and pathway for the cleaning head will let you ‘cut’ off dirt from the surface of the mash tun rather than blast it off with the sheer mass of cleaning water from a hose.

It may be possible to re-use water and detergents from other washing operations to clean the mash tun. For example, detergent used to clean the fermenter could be stored and subsequently transferred to the mash tun. After cleaning the mash tun, the same detergent could be re-used to clean the copper. However, hygiene standards must not be affected.

CIP uses much less water than a hose for cleaning. If CIP is not available, a high pressure hose will use much less water than a standard hose.

If appropriate and hygienically acceptable, use wash water and detergents from other cleaning operations to clean the mash tun.

4.2 COPPER AND WHIRLPOOL

4.2.1 Disposal of trub and spent hops

Trub is nutritious, but bitter in taste. For use as an animal feed, it may, subject to certain conditions, be mixed with other liquid wastes - eg wort, spoilt beer and ullage - and stored in a dedicated tank prior to collection. Removing the trub from the copper as a thick slurry minimises wort losses and reduces trade effluent charges.

If pelletised hops are used, these can be removed in the whirlpool. Whole hops can be removed in the hop-back. Trub and spent hops can be used as a garden mulch or soil conditioner, but demand is limited and therefore unlikely to raise much money.

Spreading of trub or other brewery by-products on land is covered by the Waste Management Licensing Regulations 1994. Further information on the rules governing the disposal of brewery by-products to land can be obtained from the Environment Agency on 0645 333111.

Remove trub from the copper in as thick a slurry as possible to reduce wort losses and trade effluent charges.

If possible, return any liquor removed with the trub and spent hops to the brew.

Store the trub in a tank with other wastes suitable for use as an animal feed.9

Find a suitable outlet for your trub and spent hops, but consult your local Environment Agency office before arranging to spread wastes onto land.

4.2.2 Cleaning the copper and the whirlpool

The advice given for mash tuns (see Section 4.1.3) also applies to cleaning the copper and the whirlpool.

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9 For guidance on the supply of co-products as animal feed, contact the Brewers and Licensed Retailers Association (BLRA) (see Appendix 1).
Compact tubular heat exchangers are used by almost all breweries to recover heat from the hot wort and cool the wort to the fermentation temperature. The recovered heat is used mainly to provide hot liquor for the subsequent mash, but when brews are infrequent, eg weekly, the hot liquor is often used for washing.

More information on waste heat recovery and energy efficiency in breweries is available through the Energy Efficiency Enquiries Bureau on 01235 436747. For specific energy-related queries, small and medium-sized companies can phone the Energy Helpline on 0541 542541.

The following provides guidance on how to reduce water, energy and effluent costs wherever heat exchangers are used.

**4.3.1 Temperature differentials**

Heat exchangers used in ale fermentation often have a single water-cooled section. To provide the colder fermentation temperature needed for lager, a second chilled section is required with glycol as the refrigerant. Both fermentation temperature and the temperature of the cold liquor vary widely. A typical ale heat exchanger cools the wort from 85 - 100°C to around 15°C and heats cold liquor from around 12°C to give hot liquor at 75 - 85°C.

Modern heat exchangers optimise hot liquor recovery.
An automatic temperature control loop allows you to optimise the flow of wort and cold liquor through the heat exchanger. This system adjusts the flow through the heat exchanger to maintain a pre-set wort outlet temperature with the minimum water use and thus maximise the hot liquor temperature. Automating the heat exchanger also tends to increase wort throughput as manual settings are often conservative.

If the cold liquor is allowed to warm up during storage or if the water supply is warm, the heat exchanger will need more cold liquor to cool the wort. You may end up with more hot liquor than usual and the wort may need further chilling to make it cool enough for fermentation. If you can’t find a use for the additional hot water, you will have to store it or dispose of it.

To make use of gravity, cold liquor tanks are traditionally located at the top of the brewery. Hot liquor tanks are often located immediately below the cold liquor tanks. However, the combination of convective heat from below and radiant heat from the sun can cause the cold liquor temperature to rise by several degrees - particularly after water has been standing over a weekend. Cold liquor also tends to warm up if left to stand for long periods in large tanks installed when brewery water consumption was higher.

Revised procedures help brewery to reduce hot liquor waste

The Brewery operated by Hardys & Hansons had a single, cold liquor tank, situated outside the Brewery on the south side. A second tank, twice the size of the first, was subsequently installed to meet water authority storage requirements. Flow into and out of the tanks is controlled from the brew-house using actuated valves.

During hot weather, the temperature of the cold liquor rose from 12°C to 20°C. This, combined with an outdated heat exchanger, produced an excess of low quality hot liquor which had to be diverted to drain. The wort also required further cooling in the fermenters before a brew could begin.

Installing water meters helped to identify these problems. Procedures have been revised to allow the brewer to bypass one of the cold liquor tanks, depending on demand and the ambient temperature. Cold liquor storage time is now minimised and temperature gain reduced. A further reduction in hot liquor waste has been achieved by automating flow through the heat exchanger and adding a chilled water section. In addition, the hot liquor retained is of a higher quality and processing has been speeded up.
4.3.2 Flow through the heat exchanger

The volume of hot liquor recovered in an ale heat exchanger is only slightly larger than the volume of wort. Some liquid is lost through evaporation, so there should be sufficient hot liquor for the next mash with little or no surplus. However, many ale breweries claim to produce sufficient hot liquor for other operations, e.g., cask washing. Hot liquor is still considered by some breweries to be a plentiful resource and overflows from the hot liquor tank are common.

In large breweries performing several brews a day, the production of hot liquor is more complicated. At the beginning of the week, several batches of hot liquor may be needed for mashing before any hot wort has been produced. An alternative method of producing hot water is therefore needed. At the end of the week, the situation is reversed; no more hot liquor is needed for mashing, but several brews may still be passing through the heat exchanger. The hot liquor tank should therefore have adequate capacity to receive these inputs.

Modify the heat exchanger or increase capacity to prevent overflows from the hot liquor tank.

When you calculate the capacity of the hot liquor tank, check the level at which the tank is automatically topped up with cold liquor.

If the setting on the hot liquor top-up valve is too high, the tank will be topped up with cold water unnecessarily so that, when hot liquor is available, it overflows to drain.

4.4 FERMENTATION VESSELS

4.4.1 Fermenter cooling

Single-pass cooling of fermenters uses vast amounts of water. It is generally found only at sites with a cheap source of water (e.g., borehole or river abstraction) and permission to discharge the cooling water to a river or estuary, rather than to the sewer.

In closed loop cooling circuits, chilled water stored at high level flows under gravity through the fermenter cooling system to a reception tank. The water is then pumped from the reception tank back to the chilled water tank. Automatic control systems installed to regulate the flow of cooling water will reduce energy use.

When replacing fermenter vessels, consider installing jacketed fermenters. Choose panel coolers rather than cooling coils as they are easier to clean.

Make sure the pump size is adequate to cope with the maximum flow of cooling water when all of the fermenters are in use.

Prevent overflows by setting the top-up level in the chilled water tank such that it is not topped-up until the reception tank is full.

Put in place procedures to ensure the cooling water supply to fermenters stops when the vessel is not in use.

10 From Good Practice Case Study (GC41) Family Brewery Makes Big Water Savings, available free of charge through the Environmental Helpline on freephone 0800 585794.
4.4.2 Fermenter cleaning

Jacketed fermenters provide sufficient surface area for cooling and do not need internal obstructions. However, they are expensive and existing vessels cannot be fitted easily with jacket cooling. The cooling coils of traditional fermenters are generally efficient, but awkward to clean. Cleaning therefore takes longer and uses more water. Panel coolers are much easier to clean and do not obstruct the walls of the vessel.

Fermenter vessels are the source of almost half of the COD/BOD$^{11}$ content and almost 70% of the suspended solids content of a typical brewery effluent.

Optimised cleaning-in-place (CIP) systems generally clean better and use less water than other methods. However, open fermenters are not suitable for CIP and have to be cleaned manually.

Proprietary products are available to make manual cleaning of fermenters easier, thus reducing cleaning times and producing significant water savings. For example, a clay-based product has been developed that stops yeast and tannins sticking to tank walls. The clay, which is used as a slurry and contains a food-grade preservative, is painted on the vessel walls above the liquor level and allowed to dry before the wort is added. Before the fermenter is used, a disinfectant is added to ensure aseptic conditions. Materials that would normally stick to the vessel walls bind to the clay instead and are removed more easily.

Detergent foam sprays are also effective in removing deposits on fermenter walls. After an initial rinse, the foam is used to soften deposits of yeast or scale with a minimum amount of water. A small volume of water is used to rinse off the foam before the walls are scrubbed. As well as reducing water use, manual cleaning takes less time. Foam canisters are available from most major detergent suppliers.

Peracetic acid is useful to sterilise tools, as a final rinse in the cleaning cycle and as a sanitising agent. Because it is food-grade, tools and equipment do not need to be rinsed after sterilisation. However, when diluted for use, peracetic acid solutions have a COD of approximately 1 000 mg/litre. Their acidity means that your trade consent may prevent you from disposing of large volumes to drain.

Tools kept under aseptic conditions in a bath of dilute propionic acid$^{12}$ can be used straight from the bath, without the need for rinsing - thus saving water.

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$^{11}$ Biochemical oxygen demand.
$^{12}$ The IUPAC name is propanoic acid.
For closed fermenters, install and optimise CIP.
Consider using a clay-based paint to stop yeast and tannins sticking to vessel walls.
Make manual cleaning easier by using a detergent foam spray to remove deposits from fermenter walls.
Use scrapers and brushes to reduce the time taken to clean the vessel with a hose.
Avoid disposing of large amounts of peracetic acid (used to sterilise tools) to drain.
Eliminate the need for rinsing by storing sterilised tools in dilute propionic acid.
4.4.3 **Dealing with yeasty bottoms**

After the beer is drawn off, you are left with a yeasty slurry - known as ‘yeasty bottoms’ - and yeast stuck to the fermenter walls. For safety reasons, yeast must be removed before an operator enters the fermenting vessel.

Avoid disposing of yeasty bottoms and first washings to drain as they have a high COD and suspended solids content. The best alternative is to pass the yeasty bottoms through a filter press or centrifuge to recover residual beer for return to the process. You can then send the yeast for sale or disposal (see Section 4.4.5). The next best option is to sell or give the yeasty bottoms and/or first washings to a farmer for use as an animal feed.\(^\text{13}\) The final option is to pass the first washings through a filter press or centrifuge, recover the yeast for sale or disposal and dispose of the liquid waste to drain.

The type of beer and yeast are important factors in determining the shape of a fermenting vessel. Most traditional ‘squares’ have flat bottoms and are particularly difficult to clean. Conical fermenters can be cleaned more efficiently because the bottoms drain from the tank without using large volumes of wash water. The bottoms are also more concentrated and easier to handle.

### When rinsing yeast off the walls of the fermenter

- Adjust the hose so that you get maximum pressure but not too much spray.
- Do not use mains-powered pressure washers to rinse yeast off walls as they cause too much spray.
- Find an alternative use for yeasty bottoms and first washings, do not dispose of to drain.

4.4.4 **Yeast pressing**

The filtrate from yeast pressing has a high COD, so return the filtrate to the product (provided it does not affect quality).

If this is not feasible, store the filtrate with spoilt beer and other waste liquids for separate disposal or collection by a farmer.\(^\text{13}\)

4.4.5 **Yeast disposal**

Disposal of yeast to drain will cause you problems because:

- Yeast has a very high COD;
- Large quantities of yeast lead to the formation of organic acids that will make the effluent acidic, if it is allowed to stand.

Large breweries generate enough surplus yeast to enable them to sell it to food manufacturers (provided hygiene criteria are met). Small breweries do not have this option as yeast cannot be stored for long periods. However, farmers - particularly pig farmers - are keen to use yeast as an animal feed supplement because it contains over 40% protein.\(^\text{13}\) To make it easier to handle, most farmers and animal feed merchants prefer the yeast to be pressed to at least 20% dry matter. You may still be able to find a market for yeast slurries.

Yeast can be given to ruminant animals, such as cows, without treatment. However, other animals, eg pigs, cannot tolerate high levels of live yeast and so the yeast must be killed. The most common method is to dose propionic acid into the yeast slurry. This acid is an effective anti-fungal agent, but degrades rapidly and, if used correctly, will not affect the taste.

\(^{13}\) For guidance on the supply of co-products as animal feed, contact the Brewers and Licensed Retailers Association (BLRA) (see Appendix 1).
4.5 BEER PROCESSING

4.5.1 Conditioning tanks
Using dual-purpose vessels (DPVs) reduces water consumption significantly because only one vessel needs cleaning per batch of beer.

Follow the advice on cleaning fermenters (see Section 4.4.2).
If planning new plant, consider installing DPVs to reduce water use for cleaning.

4.5.2 Beer filtration
Kieselguhr or rotary filters have traditionally been used to filter beer prior to packaging. However, water consumption is high as the filters have to be primed and large volumes of chase water are required. Although efficient interface detection systems can minimise losses (see Section 6.2), some beer loss and effluent generation are inevitable.

A recently developed alternative technology is cross-flow filtration. This process, which is increasingly competitive with traditional beer filtration methods, can achieve significant reductions in water use, beer losses, chemical use and labour. Beer haze is also less.

Cross-flow filtration involves circulating the beer through a microfiltration cartridge containing a ceramic membrane. Yeast, bacteria and other solids are retained on the membrane, producing a thick yeast slurry of typically 20% dry solids. This is suitable for direct sale as an animal feed without further processing. Since all the yeast and bacteria are removed from the beer, you do not need to add finings or pasteurise the beer prior to packaging.

Cross-flow filtration technology is developing rapidly and costs are falling. While early spiral filter designs required annual replacement, modern ceramic filters can last for 5 - 10 years. Until now, the high cost of membrane replacement has tended to limit the technology’s application to larger breweries.

For more information about cross-flow filtration, see Good Practice Guide (GG54) Cost-effective Membrane Technologies for Minimising Wastes and Effluents. This Guide is available free of charge through the Environmental Helpline on freephone 0800 585794.

Consider using cross-flow filtration to reduce water use and beer losses.

Avoid disposing of yeast as trade effluent.
Find a market for your surplus yeast.
Keep yeast separate from other wastes - if fermentation starts, the yeast will lose its value to food manufacturers.

Farmers save brewery money by taking away surplus yeast and other wastes
Ringwood Brewery stores surplus yeast in a former fermenter vessel. Weak wort, trub, ullage and spoilt beer are stored together in another vessel. The 4 900-litre (30 barrel) tanks cost £400 each and another £500 to install them both on steel supports. The tanks are emptied free of charge by local farmers. The savings in trade effluent charges to the Brewery are worth approximately £3 000/year, giving a payback period of just over five months.

14 For guidance on the supply of co-products as animal feed, contact the Brewers and Licensed Retailers Association (BLRA) (see Appendix 1).
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Potential costs and paybacks are for guidance only. Actual costs and paybacks will depend on the particular site.

Potential costs: Low = Minor alterations to practices or existing plant (£0 - a few £100s); Med = Some alterations to existing plant or minor new plant (£100 - £1 000); High = Extensive alterations or new plant (several £1 000s).

Potential payback: Short = Months; Med = Less than a year; Long = Over a year.

Table 2 Water and effluent saving opportunities in the brew-house
This Section describes practical measures to reduce water use and effluent generation in beer packaging. These measures are summarised at the end of the Section in Table 3.

5.1 CASK AND KEG WASHING

The amount of ullage in casks returned to the brewery from licensed premises depends on the sedimentation characteristics of the beer. However, it always represents a significant COD load.

If quality standards allow, pasteurise returned beer and blend it into another brew. Otherwise, store spoilt beer with trub, ullage and other high strength liquids for separate disposal or collection by a farmer. Disposal to drain should be avoided due to beer’s high COD (around 180 000 mg/litre).

5.1.1 General measures

The design of spray nozzles is important. High efficiency spray nozzles are now available. They use water at a lower pressure and the improved spraying action ensures better water contact with the cask. However, some modern nozzle designs are more easily damaged during placement of the cask in the cask washer.

Replace spray nozzles with more effective designs. These reduce the amount of water needed and also make the wash shorter.

To reduce the risk of nozzle damage for:

- moving-beam washers, make cask positioning as reliable as possible;
- manually-handled casks, simplify placement procedures.

Check damaged nozzles for efficiency. Repair or replace them immediately to avoid inadequate cask cleaning or unnecessarily long washing cycles.

Use of water to remove labels is unnecessary as many labels can be scraped off manually. This is easier if left until the casks have left the cask washer and the adhesive has been softened by the steam.
5.1.2 Moving-beam cask washers

Ullage drains from the cask as it is lifted onto the cask washer or rotated in the bung-finder. The ullage is often mixed with wastewater from the cask washer and passed through a large screen to collect fragments of keystone and other debris, before being discharged as trade effluent. However, ullage is a useful source of nutrients. Selling or giving your ullage to local farmers as an animal feed will reduce the COD of your trade effluent and thus reduce charges.\(^\text{15}\)

Most washers have a dedicated tank and pump serving each wash stage and there is considerable scope for re-using water within the cask washer. For example, water collected from the final rinse stage can be piped into the feed tank for the pre-rinse or external wash stage.

Many older designs of cask washer have undersized collection troughs. If you can see water falling on the ground under the collection troughs, they are too small. Larger troughs not only enable more water to be recovered for re-use, they reduce the risk of someone slipping on a wet floor. Another potential cause of overflows is leakage from float-operated top-up valves.

The throughput of a moving-beam cask washer is determined by the longest wash. For cask washers that use caustic detergents, the longest stage is often the final rinse as all traces of the washing chemicals have to be removed. Without chemicals, this stage can be significantly shorter. However, the hot washing stage may need to be longer.

The time taken to clean a cask also depends on its size. Computer-controlled cask washers can be set either for automatic cask size recognition or manual entry of the cask size. For cask washers with mechanical timers, automation may be difficult. However, the timing for individual cask sizes can be set before starting the cask washer.

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\(^{15}\) For guidance on the supply of co-products as animal feed, contact the Brewers and Licensed Retailers Association (BLRA) (see Appendix 1).
Collect ullage separately. Store in a tank with spoilt beer and other high strength liquids for use as an animal feed.\textsuperscript{16}

Re-use water in the cask washer wherever possible, e.g., pipe final rinse water back to the pre-rinse stage. Also re-use detergent.

Look for water escaping from the collection troughs. If the cask washer collection troughs are too small, make them bigger or make the gradient steeper to improve drainage.

Make the overflow pipes from the various stages of the cask washer clearly visible to enable you to identify leaks rapidly. Alternatively, fit level switches within the tanks to raise the alarm before the overflow level is reached.

Recirculate chemicals using either a continuous top-up and bleed system, or a batch system where the chemical tank is drained and refilled periodically. Minimise chemical use by optimising the recirculation process.

Omit chemicals from the final rinse. This will make this stage shorter and thus reduce water use and increase the throughput of the cask washer. It will also eliminate the need to spend money on buying, storing and disposing of the chemicals.

Modify your procedures to optimise cask cleaning relative to cask size.

Meter water use at the cask washer. This will help you to check that no water is used while the cask washer is not in use.

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**Omitting caustic allowed brewery to double washer throughput and save money**

The procedure used for cask washing in a moving-beam cask washer at Ringwood Brewery produced a throughput of 70 casks/hour. Omitting caustic from the hot washing stage reduced the rinse time considerably and allowed the brewery to increase washer throughput to 120 casks/hour. The Brewery was able to almost double capacity, while achieving significant savings in water, chemical and trade effluent costs for minimal cost. Cask cleanliness was not affected by the change.

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5.1.3 **Small cask washers**

The various designs of static cask washers vary in complexity. Owing to water retained in the pipework, use of a single spray nozzle for each cask means greater mixing between the water used in different washing stages. This can lead to contamination of the final rinse water with residual chemicals, thus making rinse water changes more frequent.

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\textsuperscript{16} For guidance contact the Brewers and Licensed Retailers Association (BLRA) (see Appendix 1).
5.2 CASK AND KEG RACKING

Beer lost at the racking stage is expensive in terms of lost product, wasted effort and trade effluent charges.

Most casks are slightly oversized to allow for any loss of volume due to dents during use. Using meters to measure the volume of beer entering the cask ensures that casks are filled to the correct volume and do not overflow. This reduces the need to rely on the fob return system. For detailed guidance on the control of volume in casks, see the Code of Practice on the Contents of Kegs and Casks (Large Pack Code) from the BLRA (see Appendix 1).

Meter the volume of beer used to fill the casks rather than capacity fill.
Fit fob return systems to filling heads to avoid the loss of fob or beer due to foaming or over-filling of the casks.

Modern cask racker eliminates beer losses

J W Lees & Co used pressurised hoses to fill casks manually to the brim by eye. The Brewery bought a modern, semi-automated cask racker with a backflow system and meter for £28 000. Eliminating lost beer saved £12 000/year, with further savings in reduced trade effluent charges and increased productivity.17

5.3 GLASS BOTTLE WASHING AND PASTEURISING

There is considerable scope for reducing the vast amounts of water used during the washing and pasteurisation of glass bottles.

Much of the waste from bottle washers and pasteurisers is due to overfilling of the feed tanks at the base of the units. This may be due to leaking or faulty valves, or simply an excessive top-up rate. In many bottle washers and pasteurisers, the overflow points cannot be seen by operators and overfilling of the feed tanks goes undetected for long periods.

In pasteurisers, water usually circulates around the first pre-heat stage and the pre-cool stage. Other stages have a high rate of internal recycle.

Make sure that overflow points are visible, eg extend the pipe to a position where operators can see it.
Meter water use to ensure that no water is used while the machine is not operating.

Optimise water use by bottle washers by:

- re-using final rinsewater for the pre-rinse or other stages;
- reducing caustic dosing to maintain a slightly lower caustic concentration;
- reducing the bleed rate from the caustic tank (provided bottle cleanliness is not affected).

Optimise water use by pasteurisers by minimising the bleed rate of water to the closed loops feeding the hot and cold stages of the pasteuriser unit. Microbial contamination of the water must still be prevented.

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17 From Good Practice Case Study (GC41) Family Brewery Makes Big Water Savings, available free of charge through the Environmental Helpline on freephone 0800 585794.
5.4 GLASS BOTTLE FILLING

The water used to rinse single use bottles before filling can be re-used for many purposes. However, as it may contain glass fragments, it should not be re-used if there is a risk of contaminating the product.

Large amounts of water are wasted if the water sprays carry on working when the bottle conveyor stops. Fitting a solenoid valve to isolate the flow when the conveyor is switched off is a low-cost measure that can produce large savings in water and effluent costs.

Liquid ring vacuum pumps, which require a continuous supply of water to maintain the seal in the pump, are often used in the filling process. The seal water reaches about 15°C in the pump and is thus suitable for re-use, eg as bottle rinsewater. Product is the most likely contaminant. More information about liquid ring vacuum pumps is given in Good Practice Guide (GG67) Cost-effective Water Saving Devices and Practices and Good Practice Guide (GG101) Reducing Vacuum Costs. Both Guides are available free of charge through the Environmental Helpline on freephone 0800 585794.

Collect rinse water in a dedicated tank and re-use it directly for rinsing or recycle it for other purposes, eg floor washing, cooling water and liquid ring vacuum pump seal water.

Connect a solenoid valve to the starter of the conveyor drive motor to stop the flow from the water sprays when the bottle conveyor is switched off.

Re-use seal water from liquid ring vacuum pumps as bottle rinsewater.

Install cyclone pre-separators on the vacuum side of the pump to minimise seal water contamination.

5.5 OTHER BOTTLING AND CANNING

The advice given in Sections 5.3 and 5.4 on reducing water use in glass bottling and pasteurisation also applies to polyethylene terephthalate (PET) bottles and cans.

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18 From Good Practice Case Study (GC41) Family Brewery Makes Big Water Savings, available free of charge through the Environmental Helpline on freephone 0800 585794
<table>
<thead>
<tr>
<th>Measure</th>
<th>Method</th>
<th>Description/ purpose</th>
<th>Equipment/ technique</th>
<th>Major benefits</th>
<th>Other benefits</th>
<th>Potential cost</th>
<th>Potential payback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ullage recovery</td>
<td>Collection and disposal</td>
<td>Reduce effluent strength</td>
<td>Collection trough, storage tank</td>
<td>Effluent savings</td>
<td>Potential income from disposal</td>
<td>Low</td>
<td>Med</td>
</tr>
<tr>
<td>Cask washer optimisation</td>
<td>Various</td>
<td>Reduce water consumption</td>
<td>High efficiency nozzles Rinsewater and detergent recovery</td>
<td>Water and effluent savings</td>
<td>Improved cask cleanliness</td>
<td>Med</td>
<td>Short</td>
</tr>
<tr>
<td>Omitting detergent from cask washers</td>
<td>Omit detergent and adjust rinse</td>
<td>Less need for extended rinsing to remove chemicals</td>
<td>Programming</td>
<td>Water and effluent savings</td>
<td>Increased throughput</td>
<td>Low</td>
<td>Med/Short</td>
</tr>
<tr>
<td>Overflow pipes</td>
<td>Extend to visible positions</td>
<td>Enable leaks to be seen</td>
<td>Pipework modification</td>
<td>Water and effluent savings</td>
<td></td>
<td>Med</td>
<td>Med/Short</td>
</tr>
<tr>
<td>Adjust cleaning cycles</td>
<td>Optimise for pipe length, cask size, etc</td>
<td>Reduce cross-contamination and optimise water use</td>
<td>Programming</td>
<td>Water and effluent savings</td>
<td>Increased throughput</td>
<td>Low</td>
<td>Med/Short</td>
</tr>
<tr>
<td>Cask racking</td>
<td>Metered fill or fob return</td>
<td>Reduce beer spillage</td>
<td>Proprietary equipment</td>
<td>Effluent savings</td>
<td>Accurate filling</td>
<td>High</td>
<td>Med</td>
</tr>
<tr>
<td>Bottle rinse</td>
<td>Re-use water</td>
<td>Collect and pump rinewater</td>
<td>Tank and pump</td>
<td>Water and effluent savings</td>
<td></td>
<td>Med</td>
<td>Long</td>
</tr>
<tr>
<td>Water sprays</td>
<td>Automatic switching</td>
<td>Isolate flow when conveyor is switched off</td>
<td>Solenoid valve</td>
<td>Water and effluent savings</td>
<td></td>
<td>Low</td>
<td>Short</td>
</tr>
<tr>
<td>Liquid ring vacuum pumps</td>
<td>Recycle seal water</td>
<td>Re-use of sealing water after treatment</td>
<td>Tanks/pumps/separators/cooling</td>
<td>Water and effluent savings</td>
<td>Energy savings</td>
<td>High</td>
<td>Med</td>
</tr>
</tbody>
</table>

Potential costs and paybacks are for guidance only. Actual costs and paybacks will depend on the particular site.

Potential cost: Low = Minor alterations to practices or existing plant (£0 - a few £100s); Med = Some alterations to existing plant or minor new plant (£100 - £1 000); High = Extensive alterations or new plant (several £1 000s).

Potential payback: Short = Months; Med = Less than a year; Long = Over a year.

Table 3 Water and effluent saving opportunities in beer packaging
6 WATER AND EFFLUENT MINIMISATION IN ANCILLARY PROCESSES

This Section describes practical measures to reduce water use and effluent generation in ancillary processes in the brewery. These measures are summarised at the end of the Section in Table 4.

6.1 REFRIGERATION PLANT

6.1.1 Compressors

Refrigeration compressors often need cooling water. However, because they are noisy, compressors tend to be hidden away and inspected only when necessary.

Compressor cooling water should not be contaminated and only slightly warm. It can thus be re-used within the brewery for various washing purposes.

Changing from once-through water use to a closed loop will greatly reduce water consumption. This can be achieved by using a cooling tower or integrating compressor cooling with another chilled water loop such as the fermenter cooling water circuit. A small bleed will be needed for hygiene reasons. Biocide dosing may also be necessary if the circuit is closed.

Connect a solenoid valve to the cooling water supply to cut off the supply when the compressor stops operating.

Set the cooling water flow rate to the rate specified by the compressor supplier. Then remove the handle of the control valve to prevent unauthorised tampering.

Where possible, pipe the cooling water outlet to a location where it can be seen and faults detected immediately.

Re-use the compressor cooling water as feed to a hot water washing system, a CIP set or a cask washer.

If the brewery has several water-cooled units, consider installing a cooling tower to close the coolant loop. Alternatively, consider including the compressors in the fermenter cooling water loop.

When replacing a water-cooled compressor, consider installing an air-cooled unit instead, to save water.

Replacing faulty valves stops expensive leak

Faulty control valves on the emergency cooling supply to the refrigeration plant at J W Lees & Co allowed 250 m$^3$ of water to be wasted each week. Checks on meter readings highlighted the fault and the valve was replaced at a one-off cost of £350. If the leak had continued undetected, it would have cost the Brewery £15 600/year in water supply and trade effluent charges.$^{19}$

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$^{19}$ From Good Practice Case Study (GC41) Family Brewery Makes Big Water Savings, available free of charge through the Environmental Helpline on freephone 0800 585794.
6.1.2 Cold radiators

Cold radiators in tank rooms tend to accumulate ice due to the humidity in the area. Using water sprays to thaw the ice uses excessive amounts of water and increases humidity levels.

Use off-peak electricity to defrost cold radiators in tank rooms. Do not use water sprays.

Using off-peak electricity for defrosting saves thousands of pounds a year

Greene King’s brewery has several cold rooms where conditioning tanks are chilled. The radiators were defrosted using water sprays at a cost of almost £70/day (£18 000/year). The high humidity was also damaging the fabric of the building.

A new defrost system was designed and installed by Brewery staff. This system uses cheap, off-peak electricity to heat the coolant via heat exchangers. Defrosting now costs the Brewery only £100/year.

6.2 CHASE WATER AND INTERFACE DETECTION

When beer is transferred in pipelines, the pipes have to be cleaned and rinsed - often between each use. Pipes are either left filled with rinsewater or purged with carbon dioxide.

If pipes are filled with water, the operator needs to decide when to stop running water to waste and when to begin filling the vessel with beer. Interface detection systems based on parameters such as colour, conductivity or specific gravity tend be unreliable, so breweries often rely on the operator watching to judge the point at which to switch over.

Purging lines with carbon dioxide avoids the problems associated with interface detection. However, the pressures involved mean it is not always suitable and there is a risk of carbon dioxide leaking if valves are inadvertently left open.

With high gravity brewing, it is possible to incorporate a controlled amount of chase water in the product as part of the dilution process. Flow is monitored and switched over according to the specific gravity of the liquid passing a sensor. The specific gravity is monitored continuously.

Pipelines can often be cleaned or purged 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. However, pigging can only be used where bends have a long radius and valves have full bore openings.

Install an interface detection system to minimise the quantity of beer going to drain and water addition to the product.

Consider purging pipes with carbon dioxide instead of leaving them filled with rinsewater.

For high gravity brewing, incorporate a controlled amount of chase water in the product as part of the dilution process.

When replacing sections of pipework, consider using pigging to clean/purge pipelines.
6.3 CLEANING-IN-PLACE

Cleaning-in-place (CIP) systems, which are used to clean process plant in-situ, have significant advantages over manual cleaning methods. These include:

- increased vessel cleanliness due to the chemicals and high temperatures employed;
- high levels of automation;
- reduced water and chemical consumption;
- the opportunity to recover and re-use water within the CIP system.

Correct nozzle design and the pathway followed by the cleaning head, ‘cuts’ off dirt rather than blasting it off with the force of water from a hose. However, CIP sets are often not set up properly in terms of water and chemical use. In most cases, optimising the process will allow you to achieve significant savings without affecting vessel cleanliness.

6.3.1 Internal water recycling

Install a recovered water tank so that final rinsewater can be recycled to the pre-rinse stage. To prevent overflows from the recovered water tank, make sure the volume of water used in the final and pre-rinse stages roughly balances.

Recover and re-use detergent or caustic several times. Make sure the solutions are strong enough and that they are not too contaminated, e.g., with yeast. In some cases, pH can be used to measure the strength of a chemical solution; conductivity measurements are unreliable if yeast is present. A programmed CIP set (see Section 6.3.2) allows the number and type of uses for a batch of chemicals to be determined automatically. An alarm may also alert you when the detergent or caustic needs to be inspected or discharged.

Re-use exhausted detergent or caustic solutions for general floor cleaning or other low-grade purposes.

When recovering water or chemicals, allow for the volume of pipework when determining the switch-over time between CIP tanks. Incorrect settings can, for example, allow first rinsewater into the final rinse recovered water tank.

6.3.2 Programming CIP sets

CIP sets often have only a limited number of cleaning cycle programmes. This may mean, for example, that a 120-barrel bright beer tank is cleaned with the same volume of water as a 600-barrel rough beer tank.

Adjust the CIP programme to take account of:

- vessel size and shape;
- potential content of the vessels;
- distance of the vessels from the CIP set (this determines the volume of the pipework).

When distances between the vessels are large, consider installing a second CIP set or buying a mobile CIP unit.
Some breweries remove most of the pollutants from their effluent before discharging it to sewer. A few breweries - mainly in isolated areas - treat their effluent fully prior to discharge to a river or estuary under an Environment Agency permit.

Effluent pre-treatment at a brewery usually consists of:

- a screening stage to remove grain and other solid debris;
- a balance tank to even out variations in flow, pH and strength;
- biological treatment, eg high rate biofiltration or activated sludge treatment, to remove most of the COD;
- a gravity settlement tank (with possibly a storage tank to retain the sludge for separate disposal).

If your effluent treatment plant is not operated at optimum efficiency, you will pay more than you need to in trade effluent charges.

A common problem is too long a retention time. Brewery effluent is highly biodegradable and contains active micro-organisms. If the effluent is left standing for too long in the balancing tank, microbial action uses up all of the available dissolved oxygen and the effluent becomes anaerobic, leading to the effluent becoming increasingly acidic. Acidic conditions cause damage to concrete structures and inhibit subsequent biological treatment processes. The overall result is difficulties meeting your consent limits for pH and COD. Odour also becomes a major problem.

Optimise your effluent treatment process.

- Avoid excessive retention times in the balancing tank due to reduced effluent flow.
- Adjust the level in the balancing tank, taking care to keep sufficient balancing volume to cope with peaks in effluent flow or strength.
- Where possible, agitate balancing tanks to prevent sludge accumulating at the bottom.
- When specifying a mixer for a covered balancing tank, take account of the potential build-up of methane.
For breweries without an effluent treatment plant or for those considering upgrading an existing system, Good Practice Guide (GG109) Choosing Cost-effective Pollution Control describes how to select the most appropriate treatment methods for your site. This Guide is available free of charge through the Environmental Helpline on freephone 0800 585794.

6.5 BOILER FEED WATER

Boiler feed water is generally treated using an ion exchange resin to remove hardness. The amount of water used during regeneration of exhausted resin can be reduced by using conductivity measurements to trigger regeneration only when necessary.

Returning condensate from steam heating systems for re-use as boiler feed water has the advantages of saving heat and water, and reducing the need for boiler water treatment. Contaminated condensate should not be returned to the boiler, as it will cause fouling of the heat transfer surfaces. In this case, its heat content can often be recovered by passing it through a heat exchanger. Significant energy savings can be obtained from condensate recovery and good water treatment. For more information and a list of free publications on boiler system efficiency, phone the Energy Efficiency Enquiries Bureau on 01235 436747.

Reducing the retention time in the balancing tank reduces trade effluent charges

The effluent treatment plant at George Bateman & Son’s brewery consists of a large effluent pumping station, an unmixed balancing tank, a biotower and a settlement tank. The Brewery had experienced problems with a low pH in the final effluent and poor COD removal.

Measurements of pH at the inlet and outlet of the balancing tank revealed that the pH was falling from 7.0 to less than 5.0 during balancing. Although degradation of organic acids in the biofilter allowed the pH to rise slightly, the brewery was not reliably achieving compliance with the consent minimum of pH 6.0.

The Brewery plans to overcome these problems by using low-cost methods to reduce the retention time in the balancing tank. As well as improved compliance with consent limits, savings in trade effluent charges of around £3 000/year are anticipated.

Talk to your water treatment contractor about ways of optimising the regeneration cycle for your boiler water softening system with the aim of reducing the quantity of backwash water.

You may be able to re-use uncontaminated cooling water such as compressor cooling water, gland sealing water and liquid ring vacuum pump seal water as boiler feed water. Pipe this water directly to the boiler house (rather than into the condensate recovery system) as it will probably require treatment before being used in the boiler.

Return as much condensate to the boiler as is economic for your site. Assess the cost-effectiveness of extending your condensate recovery system regularly, as rising costs may increase its viability.
<table>
<thead>
<tr>
<th>Measure</th>
<th>Method</th>
<th>Description/purpose</th>
<th>Equipment/technique</th>
<th>Major benefits</th>
<th>Other benefits</th>
<th>Potential cost</th>
<th>Potential payback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressor cooling</td>
<td>Replace compressor</td>
<td>Eliminate cooling water</td>
<td>Proprietary equipment</td>
<td>Water and effluent savings</td>
<td></td>
<td>High</td>
<td>Long</td>
</tr>
<tr>
<td>Compressor cooling</td>
<td>Close coolant circuit</td>
<td>Reduce cooling water use</td>
<td>Chiller and pump</td>
<td>Water and effluent savings</td>
<td></td>
<td>Med</td>
<td>Long</td>
</tr>
<tr>
<td>Cold radiators</td>
<td>Heating using off-peak electricity</td>
<td>Reduce water use for defrosting</td>
<td>Automatic electrical heating</td>
<td>Water and effluent savings</td>
<td></td>
<td>Med</td>
<td>Short</td>
</tr>
<tr>
<td>Interface detection</td>
<td>Detect beer/water interface</td>
<td>Optimise switch-over</td>
<td>Proprietary equipment</td>
<td>Water and effluent savings</td>
<td></td>
<td>High</td>
<td>Long</td>
</tr>
<tr>
<td>CIP optimisation</td>
<td>Recovery of rinsewater</td>
<td>Re-use final rinsewater as pre-rinse</td>
<td>Tank and pump</td>
<td>Water and effluent savings</td>
<td></td>
<td>Med</td>
<td>Short</td>
</tr>
<tr>
<td>CIP optimisation</td>
<td>Optimise programming</td>
<td>Adjust for different vessel sizes, cleaning cycles, etc</td>
<td>Programming</td>
<td>Water and effluent savings</td>
<td>Improved vessel cleaning</td>
<td>Low</td>
<td>Short</td>
</tr>
<tr>
<td>CIP optimisation</td>
<td>Re-use of detergent solution</td>
<td>Re-use detergent for low-grade uses</td>
<td>Procedural change</td>
<td>Effluent savings</td>
<td></td>
<td>Low</td>
<td>Med</td>
</tr>
<tr>
<td>Effluent treatment</td>
<td>Biological treatment</td>
<td>Reduce strength of trade effluent</td>
<td>Proprietary equipment</td>
<td>Effluent cost savings</td>
<td></td>
<td>High</td>
<td>Long</td>
</tr>
<tr>
<td>Effluent treatment</td>
<td>Optmise balancing tank conditions</td>
<td>Reduce odour and pH problems</td>
<td>Redesign</td>
<td>Effluent cost savings</td>
<td></td>
<td>Med</td>
<td>Long</td>
</tr>
<tr>
<td>Boiler feed water supply</td>
<td>Re-use cooling water</td>
<td>Reduce water consumption</td>
<td>Pipework modifications</td>
<td>Water and effluent savings</td>
<td>Energy savings</td>
<td>Med</td>
<td>Med</td>
</tr>
<tr>
<td>Condensate recovery</td>
<td>Route from steam system</td>
<td>Re-use for boiler feed water</td>
<td>Pipework modifications</td>
<td>Water and energy savings</td>
<td>Reduced need for boiler water treatment</td>
<td>Med</td>
<td>Med</td>
</tr>
</tbody>
</table>

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*Table 4 Water and effluent saving opportunities in ancillary processes in the brewery*
This Section describes simple and effective water saving measures that can be employed throughout the brewery. The most efficient measures are summarised at the end of the Section in Table 5.

A range of general water saving ideas is described in Good Practice Guide (GG67) *Cost-effective Water Saving Devices and Practices*. This Guide highlights the typical water savings that can be achieved for different industrial and commercial applications and explains how to identify the most appropriate devices and practices for specific equipment, processes or sites. Many of the water saving tips in this Guide are applicable to general operations in a brewery and its offices, and particularly to public houses. The Guide is available free of charge through the Environmental Helpline on freephone 0800 585794.

### 7.1 HAND-HELD WATER SPRAYS

Hoses are used widely in breweries to fill tanks and clean surfaces. However, there are a number of ways in which water consumption and effluent generation can be reduced.

#### Typical savings with a half inch hose compared to a one inch hose

A 2.5 cm (1") diameter hose operated at 60 psig typically delivers 36 litres/minute. If it is used for 2 hours/day, 260 days/year, water and effluent costs for that hose will amount to about £2 200/year.

A 1.25 cm (1/2") diameter hose operating at the same pressure delivers only about 12 litres/minute, ie a third of the flow of the 1" hose.

For most applications, a 1/2" hose is sufficient and could save around £1 400/year.

#### 7.1.1 Dry clean-up

Floors can often be cleaned more easily and effectively using a brush, mop or squeegee than with a hose pipe. Dry clean-up methods have the following advantages:

- increased abrasion to help remove tenacious dirt;
- staff can see the amount of dirt removed from the floor and thus know whether it is being cleaned often enough;
- little or no water needed or effluent produced;
- minimal effect on the room’s humidity and thus less risk of bacterial or fungal growth, rust, condensation, etc.

However, hoses can be useful when there is too much sticky material on the floor for a mop to cope with, eg dried beer. Hoses are also useful for rinsing open vessels.

#### 7.1.2 Use of triggers and other controls

Spring-loaded hose triggers are used extensively in breweries to control water use. However, problems can arise if:

- the trigger gun is heavy and awkward to manoeuvre;
- filling a tank with water means someone standing with a hand constantly on the trigger;
- the spray is not powerful enough.
If this is the case, you may find hose triggers have been cut off or otherwise removed. As each trigger-operated spray gun costs about £70 (1997 - 1998 prices), the cost of replacing damaged or lost hose triggers can mount up and you may find it worthwhile to find an alternative.

For some duties, an ordinary garden hose trigger may be adequate. These are much lighter and more manoeuvrable than standard industrial triggers. They are also about one-third of the price. Alternatively, you could modify the hose so that the valve is some distance from the nozzle, but near the operator. Where hoses can be left unattended safely, the end of the hose could be fitted with a standard ball valve with an attached nozzle. However, this design is not suitable for tasks where the hose could be accidentally left running.

Most hose triggers deliver a spray pattern use at a pressure of about 3 - 5 barg (45 - 75 psig). The cleaning potential will be affected if the mains pressure is too low. If this is the case, the nozzle should be replaced with a unit designed to operate at lower pressure.

Use brushes, mops, scrapers and squeegees instead of hoses for cleaning floors and tanks.
Use a narrower diameter hose wherever possible.
When rinsing open vessels, ‘burst’ rinsing, ie a short, intensive spray of water, is more effective.
Use trigger-operated spray guns on hoses to stop the flow when the hose is put down.
Make sure your operators are happy with the hose triggers provided. If they are not, seek an alternative solution.
Make sure that mains pressure is high enough for the spray nozzle.

Table 5 summarises the most efficient methods of cleaning different areas and surfaces.

<table>
<thead>
<tr>
<th>Area/surface</th>
<th>Cleaning equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floors in dry areas contaminated with dry matter</td>
<td>Brush, vacuum cleaner or mop</td>
</tr>
<tr>
<td>Floors contaminated with a wet or slightly sticky substance</td>
<td>Mop, wet vacuum cleaner or squeegee</td>
</tr>
<tr>
<td>Floors contaminated with a large sticky spillage</td>
<td>Wet vacuum cleaner or hose</td>
</tr>
<tr>
<td>Vessels containing dry residues</td>
<td>Brush or scraper</td>
</tr>
<tr>
<td>Vessels containing beer residues</td>
<td>Squeegee or mop</td>
</tr>
</tbody>
</table>

Table 5 Efficient cleaning methods
How to reduce your water and effluent costs

- Find out how much water your brewery is using and calculate your water:product ratio. Is it less than 3.4:1?
- Find out how much your brewery is paying in water and effluent charges.
- Map your water system.
- Install water meters at appropriate points and carry out a water use survey.
- Agree realistic targets and timescales for water saving in each process area.
- Estimate potential savings from reducing water use and effluent generation.
- Implement no-cost water saving measures, e.g., good housekeeping.
- Decide how much it is worth spending on water saving projects.
- Identify other benefits from saving water, e.g., lower pumping costs, energy savings and reduced treatment costs.
- Prioritise and implement other water saving measures. Measures that reduce the strength of your trade effluent generally produce the greatest savings.
- Regularly measure the amount of water used by different processes.
- Keep staff informed about progress and invite their suggestions.
- Revise your water saving targets to reflect changes and maintain progress.

If necessary, obtain help.
The Environmental Helpline (0800 585 794) can:

- Send you copies of relevant Environmental Technology Best Practice Programme publications, including those referred to in this Guide.
- Suggest other sources of information.
- Provide free up-to-date information on a wide range of environmental issues, legislation, technology and equipment suppliers.
- Arrange for a specialist to visit your company if you employ fewer than 250 people.
USEFUL PUBLICATIONS

The following Environmental Technology Best Practice Programme publications are available free of charge through the Environmental Helpline on freephone 0800 585794.

Good Practice Guide (GG26)  Saving Money Through Waste Minimisation: Reducing Water Use
Good Practice Guide (GG27)  Saving Money Through Waste Minimisation: Teams and Champions
Good Practice Guide (GG67)  Cost-effective Water Saving Devices and Practices
Good Practice Guide (GG109) Choosing Cost-effective Pollution Control
Good Practice Case Study (GC21)  Improved Cask Washing Plant Makes Large Savings
Good Practice Case Study (GC41)  Family Brewery Makes Big Water Savings

USEFUL CONTACTS

Allied Brewery Traders’ Association (ABTA)
85 Tettenhall Road, Wolverhampton, West Midlands WV3 9NE
Tel: 01902 422303
Fax: 01902 712006

Brewers Association of Scotland
6 St Colme Street, Edinburgh EH3 6AD
Tel: 0131 225 4681
Fax: 0131 220 1132

Brewers and Licensed Retailers Association (BLRA)
42 Portman Square, London W1H 0BB
Tel: 0171 486 4831
Fax: 0171 935 3991
e-mail: mailbox@blra.co.uk

Brewing Research International
Lytell Hall, Coopers Hill Road, Nutfield, Redhill, Surrey RH1 4HY
Tel: 01737 822272
Fax: 01737 822747
Energy Efficiency Enquiries Bureau
Energy Efficiency Best Practice Programme, Harwell, Didcot, Oxon OX11 0RA
Tel: 01235 436747
Fax: 01235 433066

For specific energy-related queries, small and medium-sized companies can phone the Energy Helpline on 0541 542541.

Further information on the rules governing the disposal of brewery by-products to land can be obtained from the Environment Agency on 0645 333111.

Institute of Brewing
33 Clarges Street, London W1Y 8EE
Tel: 0171 499 1144
Fax: 0171 499 1156

Society of Independent Brewers (SIBA)
Ballard’s Brewery Ltd, The Old Saw Mill, Nyewood, Petersfield GU31 5HA
Tel: 01730 821301
Fax: 01730 821742
Water company charges for trade effluent discharged to sewer are based on the Mogden Formula. This formula attempts to link charges for a particular customer to the cost of treating the effluent, i.e., customers pay according to the volume and strength of their effluent.

The Mogden Formula is expressed as follows:

\[ C = R + M + V + Bv + OtB + StS \]

where:

- \( C \) = Total charge (pence/m³)
- \( R \) = Charge for reception and conveyance (pence/m³)
- \( M \) = Charge for treatment and disposal where effluent goes to a sea outfall (M for marine) (pence/m³)
- \( V \) = Charge for primary treatment (V for volumetric) (pence/m³)
- \( Bv \) = Additional volume charge if biological treatment is required (pence/m³)
- \( Ot \) = Chemical oxygen demand (COD) of effluent after one hour quiescent settlement at pH 7 (mg/litre)
- \( B \) = Biochemical oxygen demand of settled sewage (mg/litre)
- \( Os \) = COD of crude sewage after one hour quiescent settlement (mg/litre)
- \( St \) = Total suspended solids (mg/litre) of trade effluent at pH 7
- \( S \) = Charge for treatment and disposal of primary sludge (pence/m³)
- \( Ss \) = Settleable solids (mg/litre), suspended solid after one hour quiescent settlement

The extent to which the Mogden Formula is applied by a particular water company depends on the degree of treatment provided.

- Discharge directly to a watercourse: site pays only the R component
- Discharge via an effective sea outfall: site pays only \( R + M \)
- Discharge receiving primary treatment only: site pays \( R + V + S \)
- Discharge receiving full treatment: site pays \( R + V + S + B \)

For further information about water supply and trade effluent charges in your area, contact your local water company (water authority in Scotland).
Appendix 3
CONVERSION FACTORS

VOLUME

\[
\begin{align*}
1 \text{ m}^3 & = 1\,000 \text{ litres} = 10 \text{ hectolitres} = 6.11 \text{ barrels} \\
1 \text{ barrel} & = 163.6 \text{ litres} = 1.636 \text{ hectolitres} = 0.1636 \text{ m}^3 \\
& \quad \text{1 US gallon} = 0.8327 \text{ UK gallons} \\
& \quad \text{1 UK gallon} = 0.0045 \text{ m}^3
\end{align*}
\]

FLOW

\[
\begin{align*}
1 \text{ m}^3/\text{hour} & = 0.278 \text{ litres/second} = 146.6 \text{ barrels/day} \\
1 \text{ litre/second} & = 3.6 \text{ m}^3/\text{hour} = 527.9 \text{ barrels/day}
\end{align*}
\]
The Environmental Technology Best Practice Programme is a joint Department of Trade and Industry and Department of the Environment, Transport and the Regions programme. It is managed by AEA Technology plc through ETSU and the National Environmental Technology Centre.

The Programme offers free advice and information for UK businesses and promotes environmental practices that:

- increase profits for UK industry and commerce;
- reduce waste and pollution at source.

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