

# How to improve boilers and steam efficiencies

This 5 Minute Guide examines boilers and their water usage. Boilers are a common major plant item, especially within manufacturing sectors. They use large quantities of energy and water to produce hot water and/or steam under pressure. Ensuring they are operating efficiently can deliver significant water, energy and money savings.

**There are a few basic steps that can be taken to optimise the efficiency of boilers.**

## Steps to reduce the water use of boilers

### Step 1: Stop Water Leaks

Check the boiler and pipe system for leaks as these are easily preventable losses. Significant water, energy and heat can be lost due to leaks in boiler and pipe systems. Checks should be done during shut down, maintenance activities and, where possible, on a monthly basis. Reviewing the company's water bills can also identify problems.

Check all valves and levels in the boiler and associated equipment to prevent overflow and overflow situations.

Monitor water flows in the boiler and pipe system as this is the easiest way to detect leaks. Armed with a baseline of the plant at peak performance (e.g. after shutdown maintenance) a mass balance will reveal any leaks immediately. This can be done by installing flow meters and or recording metered volumes on existing meters.

### Step 2: Fit Pipe Lagging (Pipe Insulation)

Consider insulating any surface (pipe, flanges, valves etc.) hotter than 50°C as heat losses contribute directly to carbon emissions, energy use and steam lost to condensation.

Lagging or pipe insulation, when correctly applied, can significantly reduce thermal losses resulting in less energy, carbon emissions and water use as there is less steam lost to condensation. It is recommended that any surfaces (pipes, flanges, valves etc.) hotter than 50°C be insulated. Heat losses also increase ambient temperature and impact upon other equipment, especially cooling

systems which have to work harder, and staff working conditions which become uncomfortable.

Lagging is relatively easy, low cost and has a reasonable return. Lagging is best done during shutdown. As an example, a typical uninsulated 100mm steam pipe will:

- lose approximately 21GJ/yr in natural gas (heating fuel)
- cost \$300 per meter to insulate
- have a payback period of approximately 3 years for the insulation.

### Step 3: Improve Feed Water Quality

Use high quality feed water (in this case low dissolved and undissolved solids). Clean water will mean less blowdown is required to prevent scale, fouling, corrosion and blockages. This means less wasted energy, less heat and less trade waste discharges. Low quality feed water can cause unreasonably quick build up of scale. Scale works as an insulator and reduces the effectiveness of the boiler's heat exchanger. This will be seen as an increase in flue gas temperature and will result in lower boiler efficiencies and therefore higher fuel usage, costs and carbon emissions.

Rainwater (which tends to be lower in salts), water softeners or appropriate chemical treatment can be used to improve water quality, reduce the rate at which scaling occurs and decrease blowdown losses. Demineralising and reverse osmosis plants are other options worth investigating.

## Step 4: Fix Steam Traps

Steam traps collect and vent the condensate from the piping system. When steam traps fail they will either stick open or shut, both of which degrade performance and increase fuel and water use.

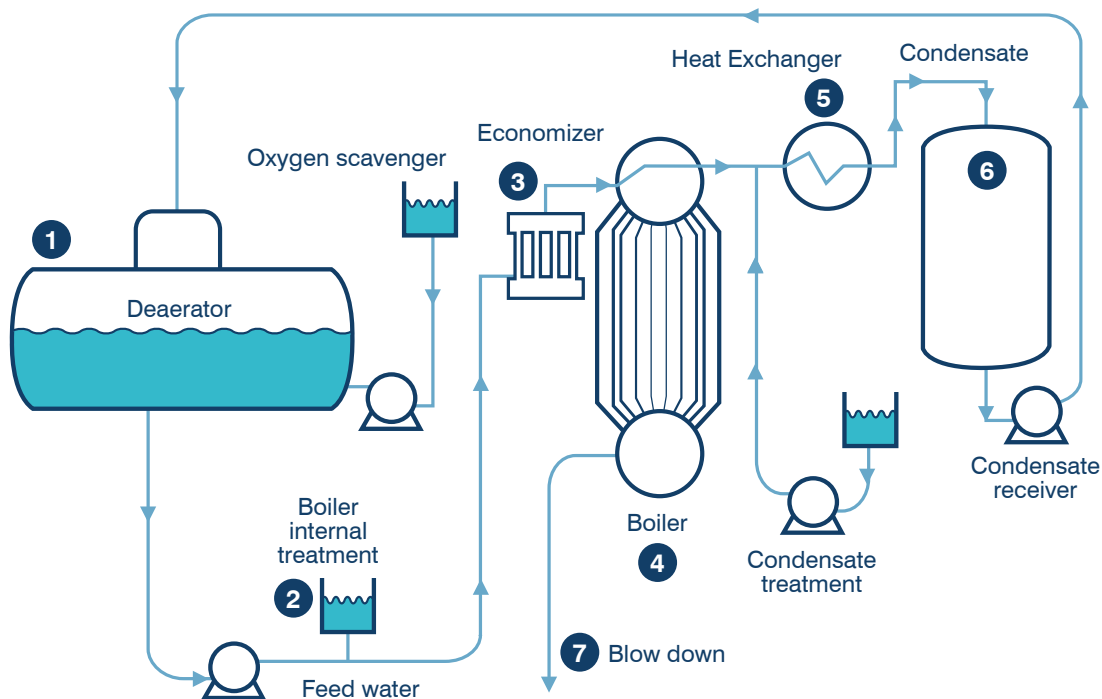
When a steam trap sticks open pressurised steam leaks out of the system and wastes a large amounts of water and energy, sometimes doubling consumption. When a steam trap sticks closed, the system can become water logged causing flow problems and degraded system performance.

Check and maintain steam traps to ensure correct function. Steam traps can be fitted with steam sensors to raise the alarm if stuck open or shut. An operational baseline is invaluable for monitoring plant performance.

As a rule of thumb there is:

- A 30-40% failure rate on systems that have never been maintained; and
- A system as such can cost thousands of dollars per year in water, chemical treatment, energy and trade waste costs.

**Fig.1 Boiler Schematic**



*Typical boiler layout (Source Queensland Government, Boiler Efficiency – M5, ISBN 978-0-9775169-8-8)*

Feed water is held in the **deaerator 1** tank to help remove dissolved air and is then **treated 2** before entering the **boiler 4**. There are two types of boilers – **water tube** and **fire tube**. **Water tube boilers** heat water in tubes and the hot combustion gasses fill the space around these tubes. **Fire tube boilers** on the other hand have hot combustion gasses inside the tubes and water circulating around them. An **economiser 3** pre-heats feedwater using the flue gasses from the boiler's chimney. The water is further heated in the **boiler 4** to produce hot water and/or steam that can be used directly or sent to a **heat-exchanger 5**. The **heat-exchanger** is used to heat air, oil, solvent or other products that must be kept dry. Any **condensate 6** (steam that has condensed) is captured and returned to the deaerator for reuse (since it's already clean). Because contaminants build up in the boiler water that can cause biological growth, corrosion and scale, a portion of the water is **blown down 7**.

### Step 5: Return and Reuse Condensate

Water condensate captured from steam traps should be routed back to the boiler. This water is already hot and demineralised and therefore requires less energy to boil than the feed water and requires no treatment, saving on fuel and chemical costs. This is generally an easy to install low cost pipe system. To retain as much heat as possible insulate condensate return lines.

### Step 6: Reduce and Reuse Blowdown

The process of producing steam leaves contaminants (dissolved solids) in the boiler which can cause corrosion and scale. To prevent this, water is rejected by blowdown. The blowdown takes with it both water and heat, thereby reducing overall energy and water efficiency. By improving feed water quality (e.g. shandy with rainwater), monitoring conductivity and blowing down the minimum water required to maintain the maximum allowable conductivity, total blowdown can be considerably reduced.

Reducing blowdown reduces energy, carbon emissions, heat losses, water treatment costs and water consumption. It may be possible to process and reuse the blowdown water to further reduce costs. Blowdown can be minimised by automating the boiler blowdown for finer regulation of dissolved solids and hence a higher average value resulting in less wasted hot water. Where possible, the heat in the blowdown water should be reused, e.g. to preheat feed water and the water could be used in other areas such as cleaning.

Further savings exist in passing blowdown water through a flash boiler and returning the steam/demineralised water to the deaerator tank.

### Step 7: Reuse Water

Blowdown water can be used for other purposes within the facility where the heat and pressure is useful and the application is not sensitive to the higher concentration of solids. For example, wash down, or certain stages of cleaning cycles may use this water (ensure chemical compatibility).



#### Checklist for improving boiler water efficiencies

- ✓ Conduct a baseline review of water and energy use for the boilers
- ✓ Monitor the flow of blowdown water and the conductivity to identify any anomalies
- ✓ Undertake a leak detection investigation for both steam and condensate. Fix leaks where possible
- ✓ Invest in lagging of steam pipes to reduce heat loss and condensation
- ✓ Increase condensate recovery where possible
- ✓ Look at reuse of boiler blowdown for preheating the intake, or reuse for things such as toilet flushing, 'wash down', Clean-in-Place (CIP) rinses or other purpose.
- ✓ Investigate capturing and reusing rainwater for use in boilers.

**It is recommended that any surfaces hotter than 50°C be insulated.**



# 5 MINUTE GUIDE SERIES

There are 9 titles in the 5 Minute Guide series. See also:

## 5 MINUTE GUIDE

### The new frontiers in water efficiency and conservation

This 5 minute guide provides an insight into the new frontiers in water efficiency and conservation. In the last decade drought and climate change impacts have created an increase in water harvesting and creative efficiencies with pumps, pipes, cooling systems, and sensibly, an improved competency in handling these opportunities.


The new frontier is beyond these well-efficiency and regeneration systems. It's beyond the plant gate. It is in the sharing of water across boundaries and in the supply chain of products. The current trend of examples are likely to grow and in another decade integrated water supply and treatment systems (local and continental), and integration within supply chains will become more widespread.

#### 1. Sharing water across boundaries

There are a small and growing number of instances where water is being shared across industrial, manufacturing, residential and recreational/regional boundaries in Australia. Water sharing can be complicated because water is generally a public good and private, and governments control the price of water at a minimum level irrespective of scarcity, demand and supply.

It is now possible to trade water between cities and parties, in a formal way as one trade company shares through a stock exchange or indirectly through banking. Water trading can be common in farming communities, for example the Murray Darling Basin. Currently, urban and industrial areas, trading water is not commonly a direct exchange of water or otherwise for a service. Trading can not be the water to a neighbour that does. Trading can also occur with waste water from a going to the toilet. It is a lot for purposes need, however, such instances are still rare.

An alternative and less complicated option can be community water gifting



## 5 MINUTE GUIDE

### Establishing a water baseline and measuring success

This 5 Minute Guide provides the tools needed to define and measure water saving success. It is an easy and cost-effective process to measure good, present and future performance. Water bills and equipment guidelines contain readily available information which will provide a baseline of past and present performance to plan and improve for the future.

#### Baseline Basics

A baseline is a bar or standard by which things can be measured, compared and changed. Baselines can be measured in a number of ways. With regard to water use, baselines can be measured in kilolitres per annum (KL/a), however it may be more accurate to measure baselines in terms of key performance indicators. For instance, this could be volume per tonne of product produced or litres per tonne of liquid chemical produced.

A few reasons for establishing a baseline include:

- Baselines are important because they allow the tracking of efficiency and progress over time.
- Baselines allow for target setting and are the first part of understanding water usage.
- Until a baseline is established it is impossible to measure progress towards any water saving goals and to understand which efficiency actions work.

Baselines can also be set for energy usage, carbon emissions, waste production and other environmental performance indicators. Some actions improve both water and energy efficiency, and some others have contrary impacts on other factors. Prioritisation of efficiency objectives is required in such instances.


#### Establishing a water use baseline

Establishing a water use baseline is simple. It requires the completion of the next 2 years of water bills and clearly note dates of production figures for key production output indicators. On-site water meter readings and sub-meter data for equipment provide more accurate data. Sub-meter data for equipment will show if an system is operating as designed and if equipment efficiency as per equipment guide.

The easiest way to establish a baseline is to repeat the water usage bill figures in a simple excel spreadsheet which can be set up with the following headings as shown in Fig 1.

Remember to input the water use volume figures and not the charge amount as water cost charge over time. Also, check with the accounts department as they may already be collating this type of data and can be prepared to add this water meter reading figures again. The accounts department may also be able to continue to input the data into the system as set up.

Water bills are not necessarily issued in precise cycles as they may depend on when the water authority was available to undertake a meter reading. It may also be possible to input production figures if they are recorded in monthly production. If they are



## 5 MINUTE GUIDE

### Matching water and purpose

This 5 minute guide discusses matching water and purpose. It can be difficult to know the impact of alternative water on operating equipment and the quality of water required, even the noise to staff, product quality and productivity. Risks can include infectious disease, contamination, reduced product quality, to name a few.

High quality drinking water may not always be required for industrial or other processing purposes. Sometimes water can be reused, again and again instead of single pass usage. It is important to know when and how to reuse water and to match it correctly and it is for its intended use.

The changes to most operations water saving actions are usually in the order of:

1. Reuse
2. Reduce
3. Recycle
4. Replenish

Many of the initiatives identified in this guide will fit into the water category and the costs involved will be in the range of water from around the plant.

#### 'Fit for purpose'

'Fit for purpose' in matching water of a certain quality to appropriate use. The examples required water from machines might be reduced and control regeneration salts which has low for use in one process, but not for use in another, e.g. the water may not require but not cooling towers.

The least suitable place for use of recycled water is EPA Victoria's Industrial Water Guidelines (Publication 16/04/2017 - June 2018) and the Australian Guidelines for Water Recycling: Managing Health and Environment Risk (ANZHC 2015).

#### Sources and potential end use of fit for purpose water

There are many sources and uses for fit for purpose water. The table below details these and includes links to water efficiency guide and a combination of what can be used where.

Sources of fit for purpose water can include:

- Rainwater
- Condensate
- Cooling tower blow down
- Boiler blow down
- Shower tap condensate
- Clean in Place (CIP) effluent
- Pump and water
- Accurate water (water that is used for insulation preparation)
- Fire water testing
- Grey water from washing
- Local recycled water schemes
- Cooling towers trade waste streams
- Product wastewater

Areas where fit for purpose water may be suitable include:

- Cooling towers
- Wash down
- Heat treating
- Irrigation
- Large process plant
- Fire water testing
- Clean in Place (CIP) effluent

Other opportunities exist off-site and these include:

- Shaving areas (off-site)
- Soil application
- Car washes
- Local park or sporting field irrigation



## 5 MINUTE GUIDE

### Top 10 Water Saving Actions

This 5 minute guide discusses the Top 10 actions to save water. While water is seen to be cheap, there can be many hidden costs in its use. The true cost of water can include sewage and trade waste, any water treatment chemicals required, and energy for heating, cooling and pumping.

An effective way to find out about water usage in the plant is to consult the staff and ask, "What? and How?". Sometimes this becomes truth and a process is done in particular way just because "That's the way I've always done it". Understanding and questioning "Why?" can reveal where improvements or changes can be made.

Plant and equipment operators and other staff members will also have ideas about how to save water, implement change and improve environmental outcomes. So use the operators, and all staff and have training people. In the process will provide a best perspective, create a sense of ownership, create champions for efficiency and company sustainability and ensure that new measures are successfully implemented.

#### 1. Check for leaks


Leaks can double water consumption and waste large amounts of high quality water, costing the company in water bills. Above ground leaks are usually water to find, however, below ground leaks in a building can be much harder.

A physical inspection of all pipes and water using equipment (such as boilers) should be carried out for leaks and problems rectified during routine maintenance.

The easiest way to detect leaks that are harder to find is to monitor water usage during shut down. Take a meter reading before shift start and end times. If there is a change in water usage, investigate the cause. If necessary, any changes should be made to find and repair.

#### 2. Ask operators why and how

Plant and equipment operators and other staff members will also have ideas about how to save water, implement change and improve environmental outcomes. So use the operators, and all staff and have training people. In the process will provide a best perspective, create a sense of ownership, create champions for efficiency and company sustainability and ensure that new measures are successfully implemented.



## 5 MINUTE GUIDE

### Rainwater Harvesting

This 5 Minute Guide provides the tools to evaluate how rainwater harvesting can save a company money and reduce their environmental impact.

#### What is rainwater harvesting?


Rainwater harvesting is widely recognised as a sustainable high quality water that can supplement mains water supplies. The quality depends on the roof and locality, and for most depends on the equipment. While it is often more expensive to install rainwater harvesting systems than people think, the cost may be offset by considerations such as:

- 1) It is not subject to water restrictions
- 2) There are no ongoing purchase costs for that water, and
- 3) It generally results in good engagement with staff and community.

Rainwater is often collected with rainwater harvesting in collection from roofs and is comparatively clean, whereas stormwater drains from roads, footpaths and parking areas so it may contain oil, dirt and debris.

#### Types of rainwater harvesting

Rainwater harvesting can either be 'roof' or 'dry'. 'Roof' systems use underground pipes and collect the water into a tank. They may require additional management and pumping as water can sit in storage in pipes. Dry systems divert water direct from the roof area under gravity. The water is pumped into the tank and the water is used for roof water will determine which system is the easiest to implement at the site.



## 5 MINUTE GUIDE

### Reduce trade waste impact

This 5 minute guide provides the tools for companies to review and reduce their trade waste impact. Companies are beginning to realise the potential value of their wastewater and the savings that can be made in avoiding, reusing and recycling water. Trade waste can often contain valuable materials, not to mention significant volumes of water which could potentially be reused.

Similarly, increasing costs and public pressure to improve efficiency is resulting in companies investigating cost effective ways of reusing, reusing or treating and recycling their wastewater. Business and society is increasingly recognising that 'water can be used more than once'.

#### What is trade waste?

'Trade waste' is any wastewater discharged from commercial, industrial or trade activities. It specifically excludes any wastewater discharged from domestic premises.

Discharge of trade waste requires a trade waste agreement, under which trade waste discharge is measured (in a factor applied based on trade water use) and the quality of the trade waste analysed for pricing.

Trade waste is a blend of many waste streams, including cooling tower and boiler blow down, process by-products, unreacted chemicals and Clean in Place (CIP) waste streams.

#### How is it charged and why?

Trade waste charges are based on volume and the concentration of contaminants. The primary contaminants upon which trade waste charges are calculated are:

- Biological Oxygen Demand (BOD)
- Total Suspended Solids (TSS)
- Total Nitrogen (TN) (or Total Kjeldahl Nitrogen (TKN))
- Total Phosphorus (TP) and
- Total Dissolved Solids (TDS)

Trade waste charges are calculated on the load of contaminants in kilograms per day, where load = volume of trade waste x concentration. (These charges vary between water authorities, as City West Water does not charge for Phosphorus). 

## 5 MINUTE GUIDE

### How to reduce the water use of Cooling Towers and Chillers

This 5 Minute Guide examines the water usage of cooling towers and chillers and provides the tools to reduce water usage.

Please note this is written with the assumption that current safe maintenance practices exist and this document is to be used to improve performance and efficiency.

Heat is a by-product of manufacturing and machine operation. That heat can be useful but must be removed. The heat is removed and mechanical goods to be cooled. Traditionally, machines are cooled by chiller or cooling towers, but with the growing concern around energy, carbon and water efficiency pressure and single water systems (e.g. air cooling tower and boiler blow down) are making a name for themselves.

Companies should always seek to reduce heat gain with insulation and a well laid out plant with intakes, exhausts, hot and cold plant isolation. For more information read 'Top 10 Water Saving Actions' and 'Top 10 Water Saving Actions' and 'Top 10 Water Saving Actions' and 'Top 10 Water Saving Actions'.

There are many sources and uses for fit for purpose water. The table below details these and includes links to water efficiency guide and a combination of what can be used where.

11% of systems are using 50% of the total volume of all recovered systems, and that after implementation of water saving recommendations, these inefficient systems of that water can be a minimum 50%. The information below discusses the techniques used to achieve these great savings.

#### Types of Cooling Towers and Chillers


Cooling towers and chillers are different systems. A chiller refrigerates water and a cooling tower cools hot water from a system. For example a chiller, machine, engine and a compressor. It differs because water, it is a cooling tower loss or heating gain where the chiller had in water.

Chillers can be either:

- 1) Refrigerative
- 2) Absorptive

Refrigerative chillers consist of a traditional compressor, refrigerant gas, condenser and evaporator tube loop.

Absorptive chillers are heat driven cooling systems and are often used in regeneration or regeneration equipment to provide chilled water. A good example is a gas fridge often used in camping or at remote sites.



## 5 MINUTE GUIDE

### Understanding water, sewage and trade waste bills

This 5 minute guide examines water, sewage and trade waste bills and discusses how this important information can be used to assist in developing water savings initiatives. By understanding water bills and making use of this information, improvements in water efficiency and reductions in the cost of water can be made across the company.

So often the water bill is sent straight to the Accounts Department where it is paid and then that is it. It is important that people in the company know how to read the water, sewage and trade waste bills as they indicate a company's environmental footprint. The information below discusses the techniques used to achieve these great savings.

#### Water supply

Historically, water, sewage and trade waste costs have been ignored or not fully understood by the people who supply and demand. However, with drought, climate change and community concern about water waste, many companies have become increasingly aware of the scarcity and value, going beyond the purchase price of water to implement water saving initiatives. As a result of this, a growing number of companies monitor water use on a daily basis to ensure that water is used as efficiently as possible.

#### Reviewing of water bills

Reviewing water bills can assist in identifying times where water is being wasted or where leaks may be present. Companies can use the information to identify areas for improvement and take action to reduce water usage. This is a key step in helping water bills to be more efficient.

