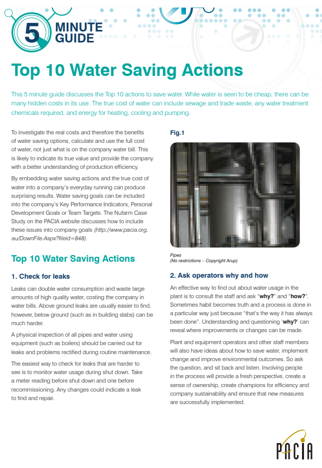
How to reduce the water use of Cooling Towers and Chillers

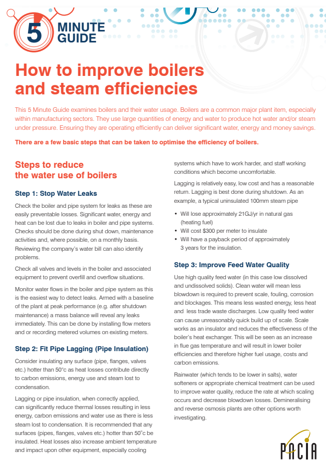
This 5 Minute Guide examines the water usage of cooling towers and chillers and provides the tools to reduce water usage.

***Please note:** this is written with the assumption that current safe maintenance practices exist and this document is to serve the operator hoping to improve performance and efficiency.*

Heat is a by-product of manufacturing and machine operation. Heat can be useful but most processes require the hot machines and manufactured goods to be cooled. Traditionally, machines are cooled by chillers or cooling towers, but with the growing concern around energy, carbon and water efficiency, passive and simple cooling systems (e.g. air cooling fins and below ground heat exchangers) are making a come back.

Companies should always seek to reduce heat gain with insulation and a well laid out plant with intakes, exhausts, hot and cold plant locations. For more information read *"Top 10 Water Saving Actions" and "How to Improve Boilers and steam efficiencies" 5 Minute Guides for helping reduce water use.*


5 MINUTE GUIDE
Top 10 Water Saving Actions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Cooling towers and chillers can be responsible for as much as 90% of site water use. Sometimes a single system may be using more than 50% of required water. Saving water saves money. Not only savings on bills for potable water but trade waste, chemical treatment and energy (fuels, electricity and carbon emissions). A recent review of cooling towers in Victoria *(AIRAH, 2010)* found 11% of systems were using 30% of the total volume of all reviewed systems, and that after implementation of water saving recommendations, these inefficient systems cut their water use by a phenomenal 51%. 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 line, for example a moulding machine, engine and a compressor. If chillers consume water, it is via a cooling tower line or leaking pipes where the circulated fluid is water.

Chillers can be either:

1) Refrigerative

Refrigerative chillers consist of a traditional compressor, refrigerant gas, condenser and evaporator type setup.

or

2) Adsorptive

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

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Cooling Towers can be:

1) Open Loop

Open loop cooling towers spray the hot water into air inside the tower to cool as it falls. Some of the water evaporates and the remainder falls to the bottom where it is collected and used again. Contact with the ambient air and evaporation cool the water (see Fig.1 below). Understanding the ways water is used can help in achieving significant savings.

2) Closed Loop

Closed loop cooling towers use a heat exchanger within the cooling tower to keep coolant flow and evaporative water flow separate, thereby reducing the risk of coolant contamination. These systems are almost as effective as open loop, are more expensive and safer. They can be run dry or with reduced evaporative water flow on cooler days or when the heat load is low. (see Fig.2 below)

3) Once Through Systems

Once through systems generally use water in a single pass to cool the plant before disposal to trade waste. Water usage can be minimised by stopping leaks, reducing heat load and minimising cooling water flow.

The best savings are made by replacing once through systems with cooling circuits, by plumbing into existing cooling circuits and closed loop systems. At a minimum, the outflow should be reused in other processes.

4) Hybrid

Hybrid systems use a closed circuit with a dry heat exchange followed by a closed loop cooling tower. These offer the best of both dry heat exchange systems and cooling towers with minimal water usage for the same heat rejection. The downside, however, is higher energy usage and higher system cost. (See Fig.3 opposite)

Fig.1 Open Loop Cooling Tower

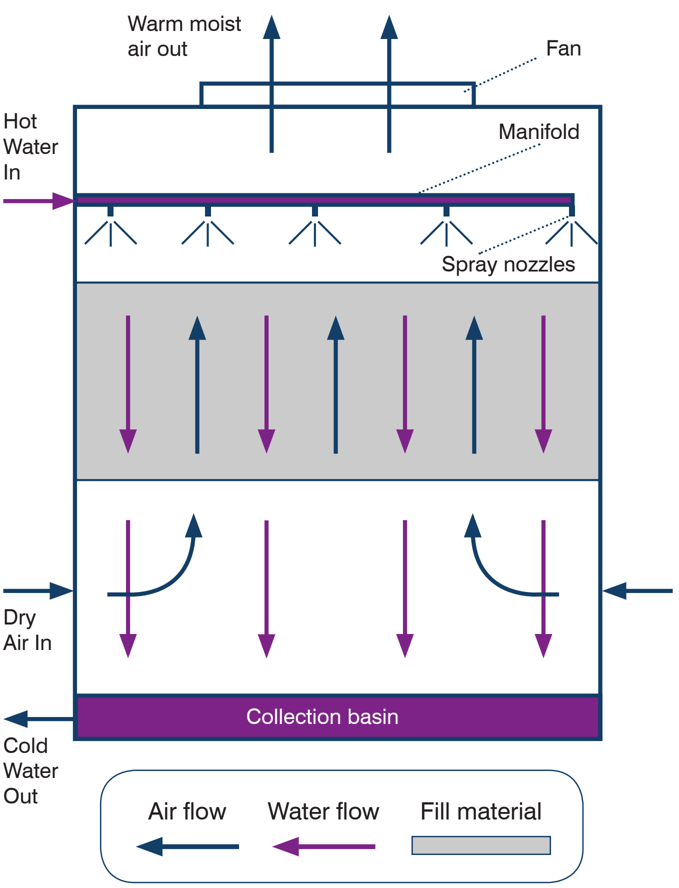


Fig.2 Closed Loop Cooling Tower

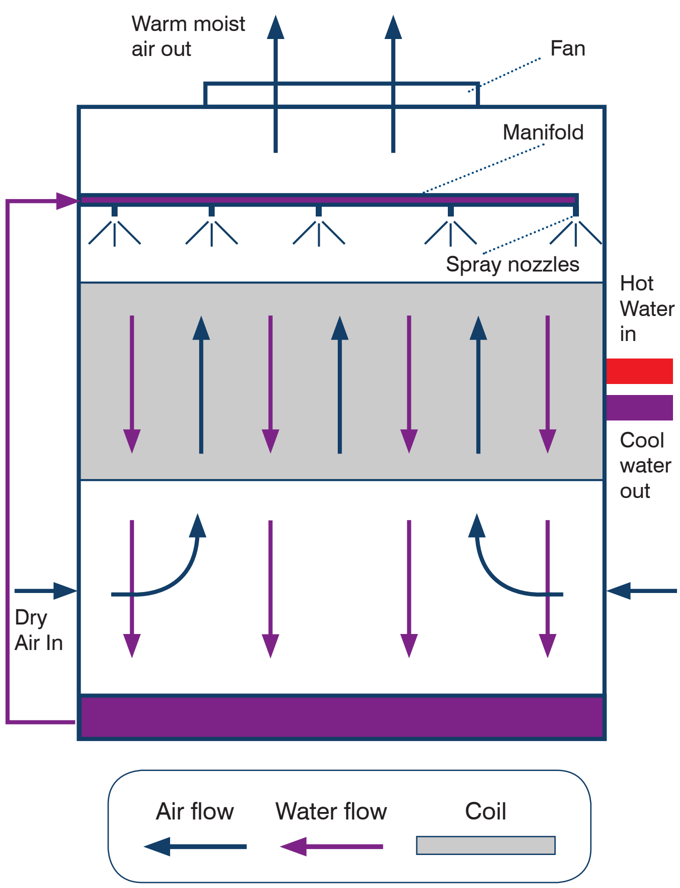
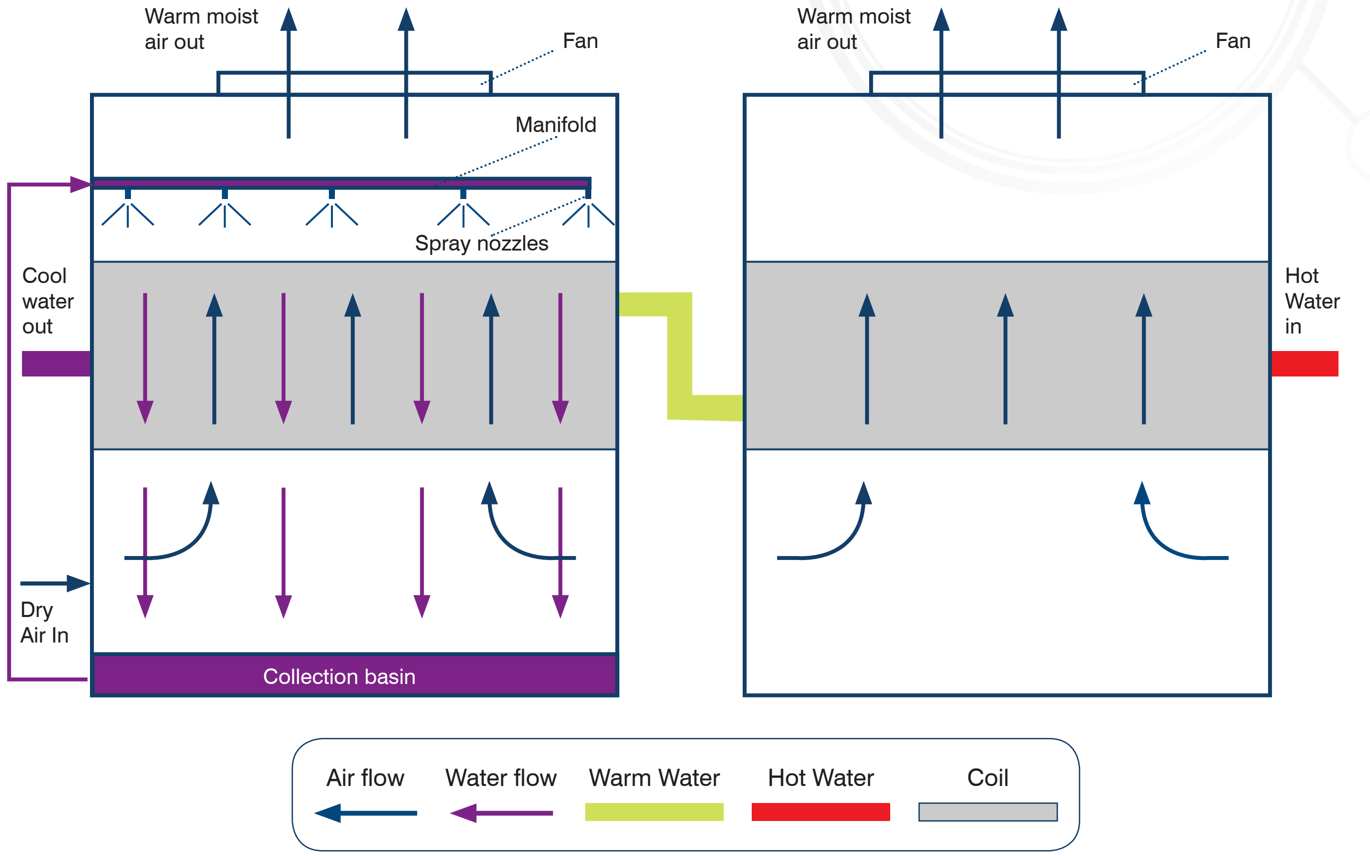


Fig.3 Hybrid Cooling Tower



Ways to improve water efficiency

There are four areas where cooling tower water consumption can be reduced:

1) Evaporation

Evaporative cooling is integral to open loop cooling towers, accounting for around 86% of cooling tower water consumption *(AIRAH, 2010)* and cannot be significantly reduced without degrading the cooling tower's performance. However, locating the system in a hot and windy position will increase water waste. By reducing the heat load on the cooling tower using a dry or closed loop system, the evaporative cooling work can be reduced.

2) Blowdown

Blowdown water is a vital process to preserve long life and efficiency of equipment as it reduces the build up of solids (salts, dirt, calcium, rust) in the system. The frequency of blowdown discharge is typically monitored by measuring cooling water conductivity.

Water consumption can be reduced by:

- Improving the quality of feed water
- Optimising the cooling tower process, and
- Removing solids from blowdown water before recirculating this water into the system.

It is possible to reduce blowdown volume without compromising plant longevity and efficiency by automating blowdown based on the conductivity of the circulating water to maintain the maximum allowable solids/conductivity (while staying within system requirements).

3) Reuse of Blowdown

A growing number of companies are now collecting blowdown water for reuse onsite instead of using potable water.

Blowdown water is typically higher in dissolved solids but can be (provided there are no harmful chemical treatments or risks of biological contamination) used for:

- wash down
- cleaning, and
- toilet flushing. ➲

Depending on the types of plants and grasses in the gardens blowdown water can be used to offset or replace irrigation water. [It is wise to test this water on a small section of the gardens to see if there are any negative effects.]

Blowdown can also be deionised and reused in the cooling circuit [provided there is chemical compatibility].

4) Drift, Splash-out, overflow and other losses

Cooling tower efficiency can be improved by locating the tower in areas not exposed to high winds or excessive heat. Winds can cause spray drift and splash out from air inlets. Design features such as drift eliminators or internal walls will reduce water loss in open loop cooling towers. In some cases, drift from the cooling towers may pose a public health issue.

Overflow can happen when a poorly adjusted float valve (or bad design) lets the tower overfill until water flows straight out the overflow and into the sewer. This problem can be avoided by checking during routine maintenance and by monitoring water consumption.

Overflow water can also be diverted to storage for reintroduction either with or without processing for use in the make-up water. Make-up water is the water added to compensate for all the water losses through the system. The more efficient the system the less make up water required.

Leaks can be detected either by inspection, performing a mass balance or direct metering of flows. Leaks, however small in appearance, can be significant, in some cases 30% of a company's water usage.

Checklist of Water Efficiency Improvements

- ✓ Calculate cooling tower water efficiency using the AIRAH cooling tower water efficiency calculator (*http://www.ctwec.com/ [mycoolingtower.com.au from July 2011]*)
- ✓ Determine a baseline and compare with industry benchmarks. This will also help assess the success of each water saving action. (For industry benchmarks see *http://www.citywestwater.com.au/business/3052.aspx*)
- ✓ Ensure make up water valves and overflow valves are correctly set
- ✓ Eliminate all leaks and monitor consumption
- ✓ Check if make-up water can be replaced with recycled, rain or storm water feeds
- ✓ Improve plant design, location and environment to optimise efficiency
- ✓ Pre-cool water with a dry heat exchanger to reduce heat load on cooling tower (hybrid systems)
- ✓ Improve plant design to eliminate overflow, splash-out, and drift
- ✓ Continuously monitor blowdown water to maintain a higher average conductivity, thus reducing total blowdown
- ✓ Investigate and implement recycling blowdown for reuse.

References: AIRAH, Dec 2010, Cooling system water efficiency study project report.

5 MINUTE GUIDE SERIES

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

- How to improve boilers and steam efficiencies
- The new frontiers in water efficiency and conservation
- Establishing a water baseline and measuring success
- Matching water and purpose
- Top 10 water saving actions
- Rainwater Harvesting
- Reducing your trade waste impact
- Understanding water, sewage and trade waste bills

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