Cooling Tower Guideline WG-2

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Glossary of Terms

- *Bleed*—- removal of water to reduce and maintain the concentration of total dissolved solids and suspended solids to an acceptable level. The level of bleed can be managed to minimise water wastage.
- *Cooling Tower*— an open recirculating cooling water system used to extract heat from processes or equipment on premises.
- *Conductivity* — measure of electrical conductivity (dissolved salt) in a sample of water. It is measured in micro siemens/cm (µS/cm), and has a close approximate relationship with TDS (multiply conductivity by 0.67 to get approximate TDS value). Make-up water typically has a conductivity in the range 100-550 whereas cooling water can range from 500 to 2,750 depending on the conductivity of the make-up water.
- *Cycles of Concentration (CoC* — also known as Concentration Ratio (CR), which is a very useful water performance index. CoC equals the tower system conductivity (or TDS) divided by the make-up water conductivity (or TDS):

  $$\boxed{CoC = C_s / C_m = TDS_s / TDS_m}$$

  As the concentration increases the amount of overflow decreases. This means less water is discarded and the tower is more water efficient.
- *Drift* — loss of water from the cooling tower in the form of mist or water droplets that are blown away from the cooling tower and regarded as leakage loss.
- *Evaporation* — water that is vaporised and expelled from the cooling tower.
- *Leaks* — these can occur at pipe flanges, joints, pump glands, tower sump, tower casing and heat exchangers.
- *Losses* — cooling water is mostly 'lost' by evaporation (typically 75-80 per cent of the water used). However, this is a legitimate part of the cooling system process which cannot be changed unless system demand can be reduced (eg increased heat transfer efficiency, reduced operating hours). Therefore evaporation cannot be considered a loss. Unnecessary and avoidable losses include leaks, drift, splash and overflow.
- *Make-up water* — water must be added (made up) to the cooling tower to replace the water lost through evaporation, overflow and drift.
- *Overflow* — loss of treated system water to the sump drain through the incorrect setting of level controls and/or back flow from high level cooling water piping when the tower is shut down.
- *Significant Proportion* — a significant proportion of water is defined as:
    - Greater than 15 per cent and less than 85 per cent of total water use for premises using greater than 50 ML per year
    - Greater than 30 per cent and less than 85 per cent of total water use for premises using less than 50ML per year
- *Scale* — a crystalline deposit that can form on surfaces or pipework within the cooling tower and equipment heat exchangers due to build up of minerals (usually calcium carbonate).
- *Splash* — water droplets that escape from the tower casing at the air intake openings as the cooling water falls back to the sump.
- *Total Dissolved Solids (TDS)* — are dissolved impurities that appear in make-up water and cooling tower water in the form of inorganic salts. They are measured in milligrams per Litre (mg/L) and correlate directly to conductivity readings (see above).

1. OVERVIEW

Cooling tower systems used to provide cooling water to air conditioning, plant, heat-generating, and industrial/manufacturing processes can account for a significant amount of water. Under QWC water restrictions, operators of cooling towers must submit a WEMP and any operational inefficiencies must be addressed to reduce water use.

In a cooling tower, a circulating stream of warm water comes in contact with air flow causing evaporation of a proportion of the water. When this water evaporates, the remaining water is cooled.

Figure 1 provides a representation of the evaporative cooling process and water balance in a typical cooling tower.

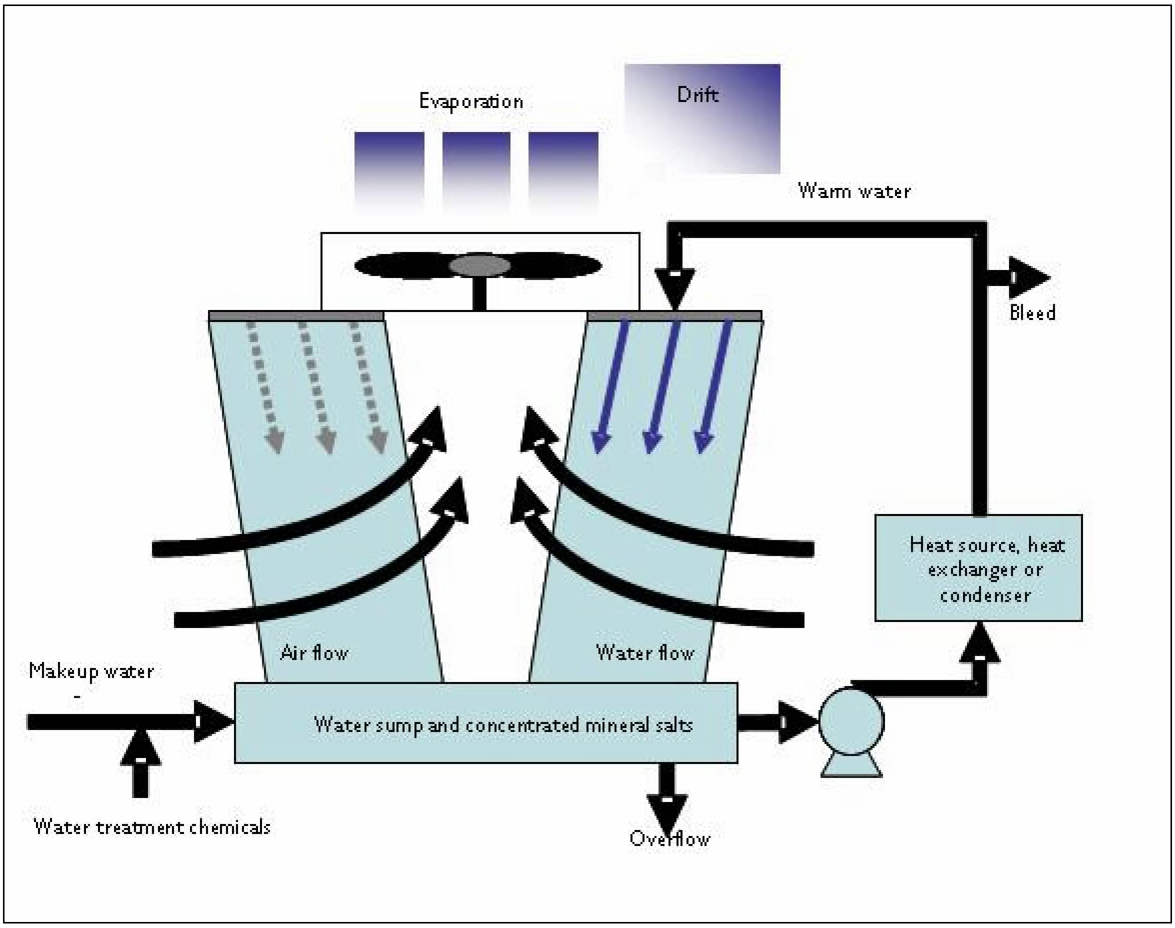

Figure 1: Cooling System Schematic

2. REGULATORY REQUIREMENT

All customers with operating cooling towers (regardless of their application) are required to prepare and submit a WEMP to their local WSP. The complexity of the WEMP to be submitted will depend on the volume of water that a site uses. If a site uses greater than 10 ML per year, the customer must complete a standard WEMP, which would be the same as any other user over the 10 ML threshold. If under the 10 ML per year threshold, the WEMP to be completed is smaller and simpler in scale, with the reporting requirements remaining the same.

Where the operation of a Cooling Tower consumes a **significant proportion** of the total water used on the premises, suitable sub-metering must be installed on the supply lines and bleed valves from each cooling tower (or group of cooling towers with shared supply and cooling water). Written records are required to be kept and reported annually.

A significant proportion can be defined as greater than 30 per cent and less than 85 per cent of total water use for premises using less than 50ML per year. For premises using greater than 50 ML per year, a significant proportion is defined as greater than 15 per cent and less than 85 per cent of total water use.

3. PERFORMANCE REQUIREMENTS

As a part of the requirements of a WEMP, losses should be kept to a minimum and the system should be operated in a manner that conserves water.

A cooling tower is considered “inefficient” if:

- System losses are greater than 8 per cent of the *make-up* water; and/or
- The system is operating at less than 5 Cycles of Concentration (CoC) **or** 1,850 mg/L TDS/2,750 micro siemens/cm (µS/cm) conductivity (allowed only in documented instances of high-TDS make-up water) .

The 8 per cent figure for losses will be kept under review. As further performance data is collected from customers’ reports and analysed, this figure may be revised to better reflect current best practice.

For sites where the operation of a cooling tower consumes a significant proportion of the total volume of water used on the premises, monitoring of the cooling tower is required. This is to determine the quantity of leakage and cycles of concentration at which the system operates. This requires monitoring both the usage and the conductivity of the make-up water and the bleed water.

Suitable sub-meters must be installed at:

- the inlet (make-up) line to the cooling tower system; and
- the outlet (bleed) line from the cooling tower system.

Conductivity measurements of the supply and bleed water should be recorded at least weekly. The bleed conductivity sensor should be cleaned at least monthly and recalibrated, if necessary, to achieve an efficient Cycles of Concentration, and the conductivity set point recorded. The conductivity setting on the conductivity controller should be checked weekly at the same time that the water meter readings are recorded. As per the *WEMP Guideline*, customers are required to read sub–meters and record readings on the *Meter Reading Log Sheet* at least weekly. Alternatively, install appropriate equipment that is tied into a building management system and has the capacity to automatically record and store a weekly reading, as well as issue an alert if necessary. This record forms part of the submission process for a WEMP and for routine reporting to the WSP.

Cooling Tower WEMPs must include:

Standard WEMP (customer usage 10 ML and greater per year)

- WEMP Template WG-9 – All modules

Simplified WEMP (customer usage less than 10 ML per year)

- Modules G1 through G6
- Module 5-2 showing all indpendent and groups of towers with shared make-up and cooling water.

All cooling towers must meet the following Australian Standards:

- AS/NZS 3666.1:2002 - Air-handling and water systems of buildings. Design, installation, and commissioning.
- AS/NZS3666.2:2002 - Air-handling and water systems of buildings. Microbial control, operation and maintenance.
- AS/NZS 3666.3:2002 - Air Handling and water systems of buildings - Microbial control. Performance-based maintenance of cooling water systems.

All work specified within a **WEMP** should be done in compliance with Workplace Health and Safety legislation, especially with respect to Legionella disease. Therefore, it is **strongly recommended** that an expert in cooling towers (such as a water treatment contractor) is consulted when assessing the cooling tower and developing the WEMP.

4. CYCLES OF CONCENTRATION

Water is recirculated within cooling towers. As the water is recirculated, total dissolved solids in the water (TDS) increase in concentration as a result of pure water being lost to evaporation. High TDS can cause scaling and corrosion within the system and therefore need to be managed. To reduce the concentrations of these salts, water is "bled" from the system.

Conductivity (µS/cm) is a measure of a water's ability to conduct electricity. The higher the level of TDS the higher the ability to conduct electricity and the higher the conductivity. The number of Cycles of Concentration is determined by dividing the TDS of the bleed water by the TDS of supply water, or the conductivity of the bleed divided by the conductivity of the supply water. The CoC of a cooling tower system is given by the following formula:

$$\text{CoC} = \frac{\text{TDS}_{\text{bleed}}}{\text{TDS}_{\text{make-up}}} \quad \text{or,} \quad \frac{C_{\text{bleed}}}{C_{\text{make-up}}}$$

A spreadsheet to perform the calculations appears in WG-9 WEMP template on Module 5-2.

Any changes made to the discharge (bleed) quality to the sewer or receiving environment should be done in consultation and with approval of the WSP.

Cooling towers that operate at a low CoC use more water and chemicals to operate. Best practice operation of cooling towers shows that cycles of concentration of 8 or 9 can be achieved depending on the make-up water quality.

The mimimum CoC target is 5, unless there is a documented case of unusually high-TDS make-up water. If 5 cycles of concentration are not acheivable, owners should modify cooling tower operation to bleed at 1,850 mg/L TDS OR 2,750 µS/cm. Customers will need to record the anomaly on the meter log, and submit a copy of the meter log with any anomalies with the annual report to the Water Service Provider.

In addition, if the cooling tower service provider records a make-up water TDS of 370 mg/L (550 µS/cm) or greater conductivity, the provider should notify the owner, who should then notify the Water Service Provider of the elevated TDS level.

TDS/conductivity bleed levels must be set and maintained in accordance with relevant trade waste regulations.

Conductivity readings are to be taken and recorded at least weekly (unless the readings are performed automatically as described above) to calculate and check the CoC.

5. SYSTEM LOSSES

The relationship between the TDS of the make-up and cooling tower system water allows another useful water performance indicator to be calculated – unnecessary system water losses. The losses can consist of splash, drift, leaks, and overflow.

Water lost to splash should be small in a well-designed tower. Once the tower is checked for splash and any necessary measures taken then splash can be ignored.

Similarly, in a modern cooling tower the amount of drift should be small. Under the previously mentioned Australian Standards, drift is not to exceed 0.002 per cent of the rate of flow of the cooling water. Drift can be ignored as an unavoidable system loss once the condition and position of drift eliminators are checked.

With splash and drift discounted, losses can primarily be attributed to leaks and/or overflow. They can be calculated from the following formula:

Losses = *(make-up water/CoC) – bleed water*

A spreadsheet to perform the calculations appears in WG-9 WEMP template on Module 5-2 Cooling Tower located in WG-9 WEMP template.

6. WATER SAVING MEASURES

The Annual Cooling Tower Report template provides a detailed checklist to help reduce cooling tower water use.

Some of the more common and effective measures include:

- Checking your cooling system controls to ensure that there is no non-required operation of the towers and temperature set-points are set at the maximum possible to minimise the tower heat load.
- Investigating the feasibility of fitting Variable Speed Drives (VSDs) to your cooling tower fan motors so the cooling system operation is better matched to the system heat load.
- If using conventional water treatment, working with your chemical vendor to increase the cooling system's CoC, thereby decreasing the amount of water being bled off.
- Ensuring all float valves are set within the correct operating range and no unnecessary overflow is occurring.
- Setting up performance-based specifications and requesting proposals from vendors for your facility's cooling tower water treatment. Requiring vendors to commit to a pre-determined minimum level of water efficiency, and providing projected annual water and chemical consumption costs.
- Using rainwater or recycled water wherever possible as a source of cooling tower make-up water. Be sure the water is of appropriate quality for use in your system.

- Re-using bleed water for lower grade non-potable uses such as toilet flushing.
- Collecting condensate from air handling units for reuse in as tower make-up water.
- Stopping all uses of water for once-through or “single-pass” cooling, unless you can reuse the water for another application. Connect to a re-circulating cooling water loop (such as the plant-chilled water system) instead of using once-through cooling.
- Consider replacing water-cooled equipment with air-cooled models. Note that energy consumption considerations also need to be considered.

It is recommended that building managers check for obvious leaks, correct make-up water ball valve and bleed control operation on a weekly basis. At this time, the building manager should do the following:

- Read water meters
- Take cooling water conductivity readings
- Analyse data to highlight problems.

The *Meter Reading Log Sheet* can be customised for this purpose to allow for conductivity readings and any relevant comments by the inpsector.

The cooling tower service provider should conduct some further basic checks (e.g. internals of the tower such as nozzles, position of fill material and drift eliminators) as part of their routine visit to check water treatment system operation and take water samples for testing for Legionella. Check regularly with Queensland Workplace Health and Safety Guidelines on cooling towers to ensure compliance.

Placing contractors on a performance contract with water use related incentives and penalties will ensure they share the owner and facility manger’s water efficiency objectives.

7. WATER EFFICIENCY ASSESSMENT

A water efficiency audit must be completed prior to the development of a WEMP.

As part of the audit, sub-metering locations must be identified. As a minimum, suitable sub-meters are to be installed on the make-up water line and the bleed line of each independent, or each group/bank of cooling towers at the premises.

The requirements shown in **Table 1** must be satisfied when auditing a cooling tower as part of preparing a WEMP:

Table 1: Auditing Requirements

Instruction	Description
Assess current performance	Outline the audit process completed to assess the current performance. Included is the system's first performance report, completed in line with the performance review guideline.
Identify possible water-saving measures	Water-saving measures identified during the water audit. Cooling tower reporting checklists include common water saving initiatives.
Calculate potential savings	As provided by a qualified cooling tower professional and/or in accordance with a valid industry methodology.
Performance reporting process	The performance assessment program outlined should be carried out. The implementation and responsibilities for this process are to be outlined within the WEMP. If a cooling tower is operating in an "inefficient" manner, then action must be described with responsibility assigned. Action needs to be taken by the date specified in the WEMP to the "inneficient" operation.

It is recommended that the cooling tower part of the WEMP template WG-9 (Module 5-2) be completed in conjunction with a WEA. This is to ensure that all requirements are being met when improving the cooling tower's water efficiency (i.e. health regulations, Workplace Health and Safety, and optimal chemical use).

8. COOLING TOWER TEMPLATE 5-2

The *Cooling Tower Module* (5-2) in the WEMP template provides the auditor with a standard form for recording cooling tower facts and operating parameters such as:

- conductivity (in µS/cm)
- water usage
- bleed quantity.

The template automatically calculates and displays the the CoC and the system losses and leakage loss percentage.

The conductivity of the make-up and bleed water are entered and used to calcluate the initial number of Cycles of Concentration (CoC_i). The proposed target or final number of Cycles of Concentration (CoC_f) value must be entered into the template, which automatically calculates any savings. The template also requires the user to enter the target percentage for system losses, which should be less than 8 per cent and closer to 4 per cent. If unnecessary system losses are not reduced to less than 8 per cent, the CoC_f target will prove difficult to achieve. The continual entry of make-up water to make up for such losses will dilute the cooling system water, keep the CoC_f low and the operation of the cooling tower will not be considered efficient.

9. REPORTING

Annual reporting is required in the form of WG-14 Cooling Tower Annual Report template for premises where a sub-meter is requried on the supply line and bleed valves of cooling towers.

Customers with cooling towers using over the 10 ML threshold will also need to submit the Annual Report template (WG-16) in addition to WG-14.

Customers are required to monitor and record sub-meter data, at minimum, on a quaterly basis to meet annual reporting requirements.

Prior to drafting an Annual Report, customers should check the QWC website for the most recent version of the template.