Sydney WATER

Water conservation

Best practice guidelines for cooling towers in commercial buildings

Acknowledgments

We wish to thank the following for assisting Sydney Water in the development of these best practice guidelines for cooling towers in commercial buildings:

- Steve Hennessy & Stan Wesley, AHA Management Pty Ltd
- Phil Bullock, Absolute Water Treatment Pty Ltd

and the following for their critical review of the document:

- Michael Bellstedt, Minus 40 Pty Ltd
- Clive Broadbent, Clive Broadbent and Associates Pty Ltd
- Stephen Buck, CSIRO Telecommunications and Industrial Physics, Lindfield
- Kevin Gehan, Ondeo Nalco Pty Ltd
- Jason Wagg & John Rule, Balticare Pty Ltd
- Stephen D'Alessandro, AMP Capital Investors Ltd
- NSW Sustainable Energy Development Authority (SEDA)

We would also like to thank the following companies for providing diagrams and photos:

- Carrier Air Conditioning Pty Ltd
- Muller Industries Australia Pty Ltd
- Thermal Energy Storage Technologies (Australia)
- Climatemaster's Australian agent – Air Solutions International Pty Ltd
- Daikin Australia Pty Ltd
- Microsoft Pty Ltd
- Royal & Sun Alliance Insurance Australia Ltd

Proudly supported by:

AIRAH CIBSE SBSE

PROPERTY COUNCIL of Australia

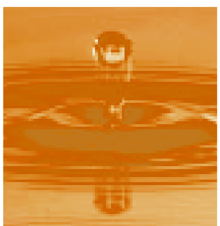
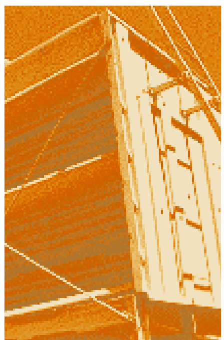
Solutions for the future SEDA

green building council australia

Contents

Disclaimer

This guide is sponsored by Sydney Water unless precluded from doing so by statute. Sydney Water disclaims any liability for any inaccuracy or incompleteness in the guide. Sydney Water makes no representation and does not warrant that any product process or procedure referred to in this guide is suitable for any purpose. Persons using this guide are not relieved from the responsibility of relying on their own enquiries as to suitability of any information, product, process or procedure for any envisaged purpose.


Introduction to best practice guidelines

Steps to reduce water use in the cooling of commercial buildings

Understand how a cooling tower works

▼

Minimise or eliminate water use through design

▼

Minimise water use through good operation and maintenance of cooling systems

▼

Minimise water use through effective contractor management

Objective

Sydney Water's every drop counts business program has prepared these Guidelines to help you minimise your water usage, particularly within your cooling towers.

More specifically it will help you to:

- Identify areas to reduce water use or minimise wastage in cooling towers.
- Identify alternatives to cooling towers.
- Identify opportunities for using alternative water supplies.
- Raise the sustainability rating of your building.

These Guidelines are intended for the use of building owners/managers, architects, system designers and services personnel. In implementing these Guidelines it would be advisable to consult with your maintenance personnel and water treatment specialist to help ensure a co-ordinated approach to achieving optimum savings in the water used in your cooling towers.

Benefits to the user

Cooling towers are critical components in the efficient operation of chiller systems. Towers that are in good condition, operated properly and well maintained allow chillers to operate at peak efficiency. Even the slightest decrease in performance in cooling tower operation will have a major impact on chiller efficiency.

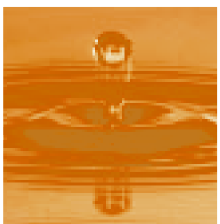
In spite of the important role that cooling towers play in chiller operation, they are often overlooked. Typically located on a building's roof, cooling towers all too often suffer from being out of sight and out of mind. Optimising the operation of the cooling tower not only could save you water but also help you operate and maintain your chiller at peak efficiency.

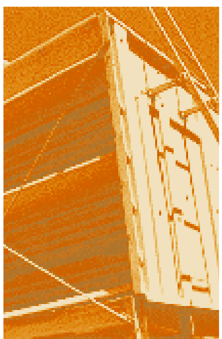
Why is Sydney Water interested in cooling towers?

Sydney Water is committed to reducing water consumption to ensure a safe and reliable water supply for the future.

Since 1990, water consumption has reduced by 18%. With your help, we are aiming to reduce water use by a further 17% over the next ten years.

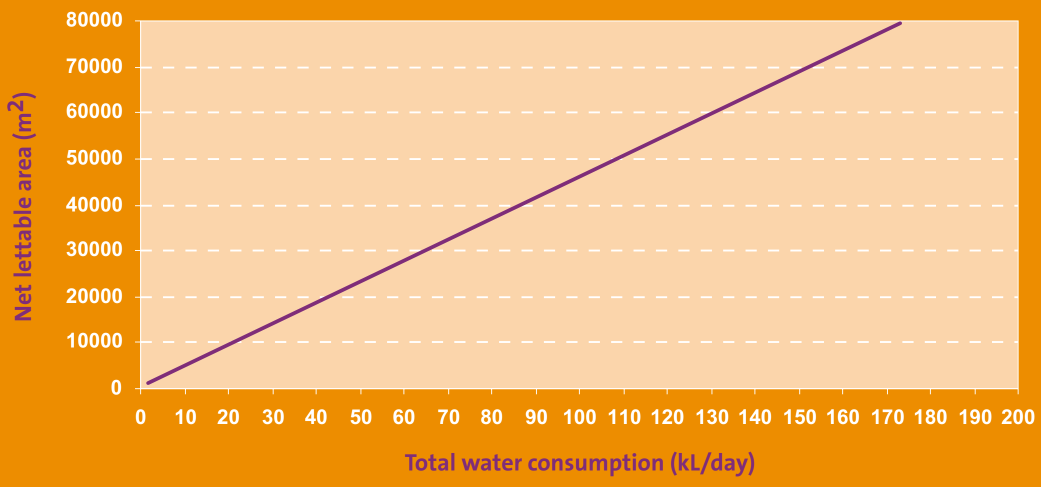
The commercial building sector in Sydney Water's area of operations currently uses approximately 100 million litres of water per day. Water audits to date have shown that on average 30% of this water is used in cooling towers. With approximately 6,500 cooling towers registered in NSW, the majority of these in Sydney Water's area of operations, this represents a significant water saving opportunity.





Water usage in commercial buildings with cooling towers

Best practice total water consumption guide for commercial buildings with water cooled air conditioning systems



Benchmark for water use

Sydney Water conducted audits in a number of commercial buildings in Sydney. It was found that some well managed buildings consume considerably less water than others. How building owners managed their cooling water systems played a significant role in determining overall water efficiency.

Current best practice in Sydney is 0.8 kilolitres (kL) per square meter per annum. That is 22kL per day for a 10,000m2 office. Use this graph to see if your office building is water efficient.

Estimating your savings

Using the graph above you can determine your "best practice" consumption. You can then estimate the potential water and financial savings possible by comparing the "best practice" consumption to your current consumption.

When you reduce your overall water consumption, you not only save the cost of the water coming in but you also save on water going out through the sewerage system. Sewer usage charges apply to businesses discharging greater than 1.37kL/day. They are calculated based on your sewer usage discharge factor (SUDF), a measure of the ratio of water going out to water coming in.

In 2003, water costs were set at $0.98/kL and sewer costs at $1.12/kL based on a SUDF of 100%. If your SUDF is 95%, your sewer cost becomes: 0.95 x $1.12/kL = $1.064 kL for every kL of water used above 1.37/kL/day.

These Guidelines have has plenty of ideas to help you reduce the water consumed by your air conditioning systems. The checklists in the back of the operation and maintenance of cooling towers section and the design of buildings and services to save water section serve as a summary. Feel free to photocopy and use them in your building.

Cooling towers

How do cooling towers work?

In simple terms, an air conditioning system operating in cooling mode, extracts heat from the air being supplied to a space, and discharges it to the atmosphere.

A cooling coil removes the heat from the air stream. The chilled water or refrigerant in the coil then transfers the heat to a chiller or compressor, where, through a refrigeration cycle, the heat is transferred to the condenser water system.

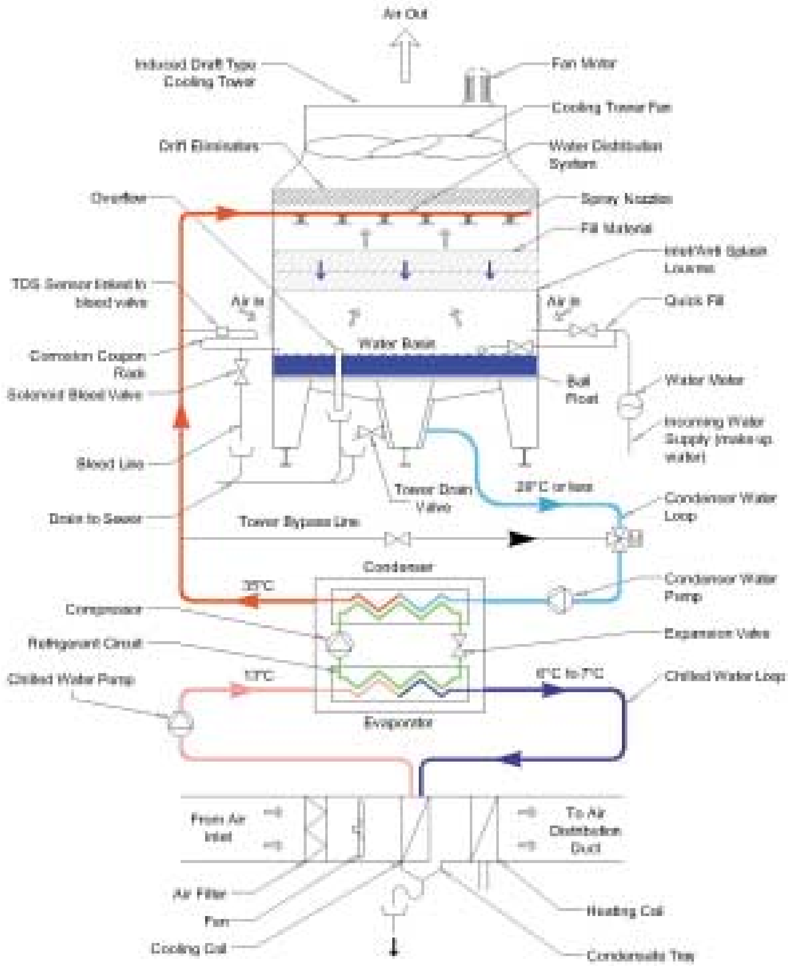
The condensed water is pumped to the cooling tower where it is sprayed over the fill material. Outside air is passed over the water, removing the heat. In removing the heat from the condenser water, significant evaporation occurs. Such evaporation is necessary for the system to work.

The cooled water that collects in the cooling tower basin, then returns to the chiller or compressor to complete the cycle.

The efficiency of the tower is dependant upon a number of factors including the wet bulb temperature of the air, the temperature of the inlet condenser water, the volume of fill material and the flow rates of air and water.

Cooling tower efficiency can affect chiller efficiency. For example, with a high efficiency chiller each one degree increase in condenser water temperature entering the chiller, could decrease chiller efficiency by 3.5%

Typically 0.1% of the recirculated water is evaporated. The evaporative cooling process is able to reduce the temperature of the condenser water by 5-15°C across the tower. A cooling tower, however, cannot reduce the temperature of the water below the wet bulb temperature of the outside air.

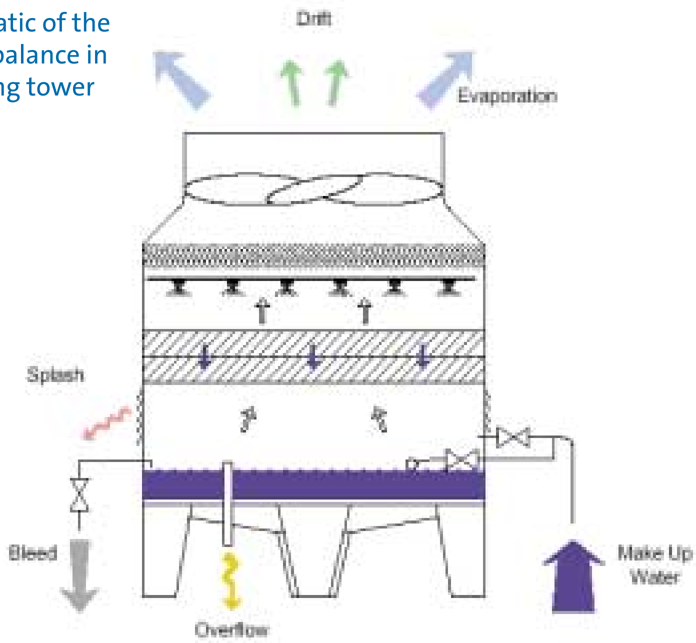


Schematic of a typical cooling water system.

There are approximately 6,500 cooling towers registered in NSW. About 5,000 of these towers are in Sydney Water's area of operations.

Water usage in cooling towers

Schematic of the water balance in a cooling tower



To establish how much water your cooling tower is using consider installing a sub-meter on the make up line. This will also assist with identifying excessive water use or wastage.

Make up water is added to the cooling tower basin to replace condenser water lost from the cooling tower through evaporation, bleed, drift, splash and overflow. It is regulated using a float valve. Studies carried out to date on cooling towers in Sydney's commercial buildings show that on average evaporation accounted for 88%, bleed accounted for 5%, and drift and splash together accounted for 7% of water make up to a cooling tower.

Evaporation

The amount of water consumed through evaporation is dictated by the temperature difference between the condenser water inlet and outlet of the cooling tower. As explained in "How do cooling towers work", evaporation is a normal part of the water cooling process in cooling towers.

Bleed

To prevent the build up of dissolved and suspended solids in the water left behind after evaporation, some water is bled off. The bleed is normally automatic and controlled via a sensor that measures the conductivity (i.e. TDS) in the water. When the conductivity reaches a predetermined setting, the bleed valve opens and allows water to flow to sewer.

Drift

Drift is the water lost from the cooling tower as liquid droplets are entrained in the exhaust air, excluding condensation. Current standards limit drift to 0.002% of the recirculated condenser water.

Splash

Splash is the water that may be accidentally emitted by a cooling tower due to the splashing action of falling water within the tower or the effect of a strong wind blowing through the tower when exposed to the elements.

Overflow

Overflow occurs when the level of water within a cooling tower basin rises above a predetermined design level. Normally this water flows down an overflow pipe to the sewer.

Studies have shown that overflow is a common area of water wastage in cooling towers. In some cases it can account for up to 40% of daily make up water. This wastage is often due to operational problems or inadequate maintenance.

Operation and maintenance of cooling towers

Steps to improve operation and maintenance of cooling towers

Reducing uncontrolled water losses

▼

Reducing controlled water losses

▼

Other ways to reduce water consumption through better operation and management

The following information can be used to help minimise water usage and to also eliminate any water wastage associated with the operation and maintenance of cooling towers used for air-conditioning and process cooling purposes. A check sheet has been provided at the end of this section to take on-site when examining the operation and maintenance of your cooling towers.

Reducing uncontrolled water losses (first priority)

Minimising water wastage through uncontrolled water loss is the first priority. Some common sources of water wastage include overflowing basins, leaking seals, splash, excessive drift and back-flooding. Such losses, referred to as 'uncontrolled water losses', can be reduced through proper maintenance and installation.

Fixing water overflows – incorrectly set ball float valves

If water is seen to be flowing out of the drain pipe when the pump stops, this is an overflow problem. The most common cause is an incorrectly set ball float valve.

All ball float valves need to be checked periodically, as the water movement in the tower affects their setting.

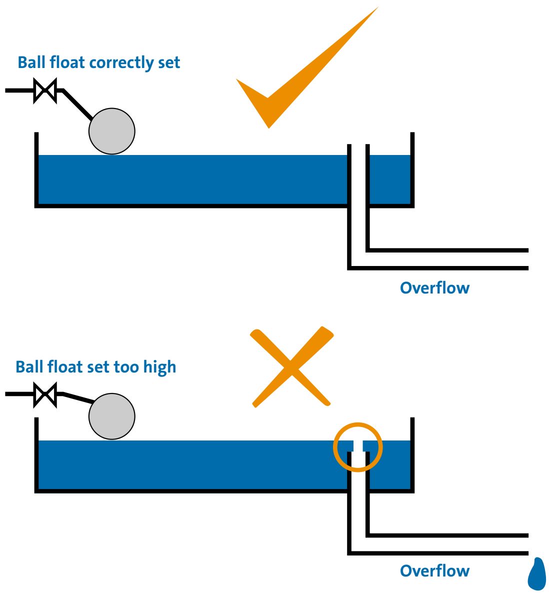


Diagram of correctly and incorrectly set ball float valve

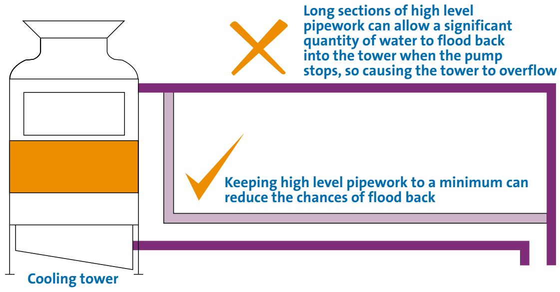
In towers with low water volume, such as those with a V shaped basin, getting the water level right can be difficult. Too high and you have an overflow problem, too low and you run the risk of emptying the basin on pump start-up. In such instances consideration should be given to using a break tank (to increase the effective volume), or replacing the ball float valve with a solenoid valve linked to electronic level detectors.

Sometimes the overflow pipe in the tower may be incorrectly positioned, or even leaking, and it is worth checking that the drain valve is properly closed and sealed.

Fixing water overflows – incorrect piping configuration

Another common cause of overflow relates to the pipework configuration. If condenser water pipes run above the height of the tower spray heads, when the pump shuts down, water could flood back into the tower. This is easy to observe. Just check the tower overflow when the pump stops. To rectify the problem it is usually necessary to reconfigure the pipework. The use of non-return valves is not recommended, as with time dirt lodges in the seals and renders them ineffective. Sometimes, when the tower is located below the equipment it serves, it may be necessary to incorporate a 'trap'. Either way, you should consult a hydraulics engineer before making changes.

Diagram of correct and incorrect piping configuration



Fixing water overflows – incorrect water balance

Where there are two or more towers that are interconnected, incorrect water balance can also be an issue. This can be as simple as ball float valves set at different heights, in which case the floats need to be adjusted, or as complex as a pipework design fault or inconsistent tower basin heights, in which case an engineering review will be required.

A leak of just 250ml per second can cost you more than $15,000 every year!

Severe overflow problems

Water should never flow over the edge of a tower basin. If it does, this suggests that there is both an overflow problem, and a problem with the overflow pipe (it could be blocked or incorrectly positioned). If the overflow pipe is clear and properly positioned, then the overflow problem is a severe one, as it is obviously overwhelming the capacity of the overflow pipe.

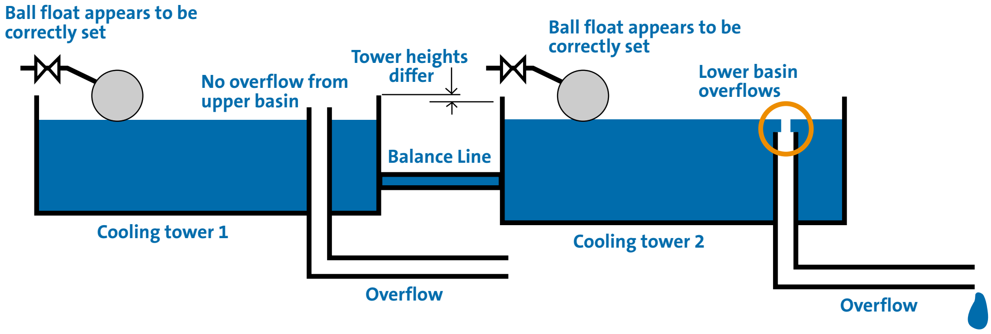
Reducing water splashing

If the area around the tower is regularly wet, water is splashing out of the tower. This may be a design issue with the tower or it could be due to high winds. Either way, steps should be taken to eliminate the water loss. Often this can be achieved through the use of anti-splash louvres or splash mats. Anti-splash louvres have the added advantage of reducing the incidence of sunlight hitting the tower basin, which in turn reduces algae growth. If wind is an issue, suitable wind breaks may also be required.

Leakage from pipes, joints and pump glands

If there is any leakage of water from the tower casing, basin or any air intake or exhaust ducts or flexible connections, then the joints may need to be adjusted or sealed. It is not just at the tower that uncontrolled water losses occur. Packed gland pump seals can often be problematic.

Diagram of incorrect water balance in connected cooling towers



1. Conductivity controller
2. Reading water meter on make up to the cooling tower

They should drip slowly, but if water is flowing from any pump gland, it indicates the need for attention. Ideally, packed gland pump seals should be replaced with mechanical seals to help prevent any wastage of water. At the very least they should be inspected on a monthly basis, and adjusted or repacked as necessary.

Minimising drift losses

Use and placement of the correct drift eliminator (arrestor) to help minimise the amount of water and chemical lost to the atmosphere as drift, is very important. The Standard AS/NZS 3666 Part 1 requires that all new cooling towers are designed to have a drift rate of not more than 0.002% water loss from the condenser water system due to drift.

Reducing controlled water losses

Controlling bleed

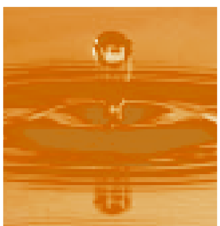
The evaporative cooling process causes dissolved solids present in the make up water to concentrate in the condenser water. Unless water is bled to manage the concentration of dissolved solids, two problems can occur – corrosion and scaling. Scale formation occurs when dissolved solids reach their saturation point. They precipitate as scale at the point of highest heat transfer (i.e. condenser tubes), reducing heat transfer and increasing the refrigerant head pressure. Higher refrigerant head pressures decrease chiller efficiency and reduce the chiller life expectancy. Dissolved solids can also contribute towards corrosion. It is, therefore, necessary to bleed some water.

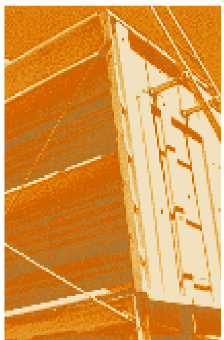
AS/NZS 3666 Part 1 dictates that conductivity controllers be installed to automatically control bleed. Automatic bleeds sense when the conductivity is too high by comparing the conductivity of the water to the set point. If the conductivity is higher than the set point it will open a solenoid bleed valve.

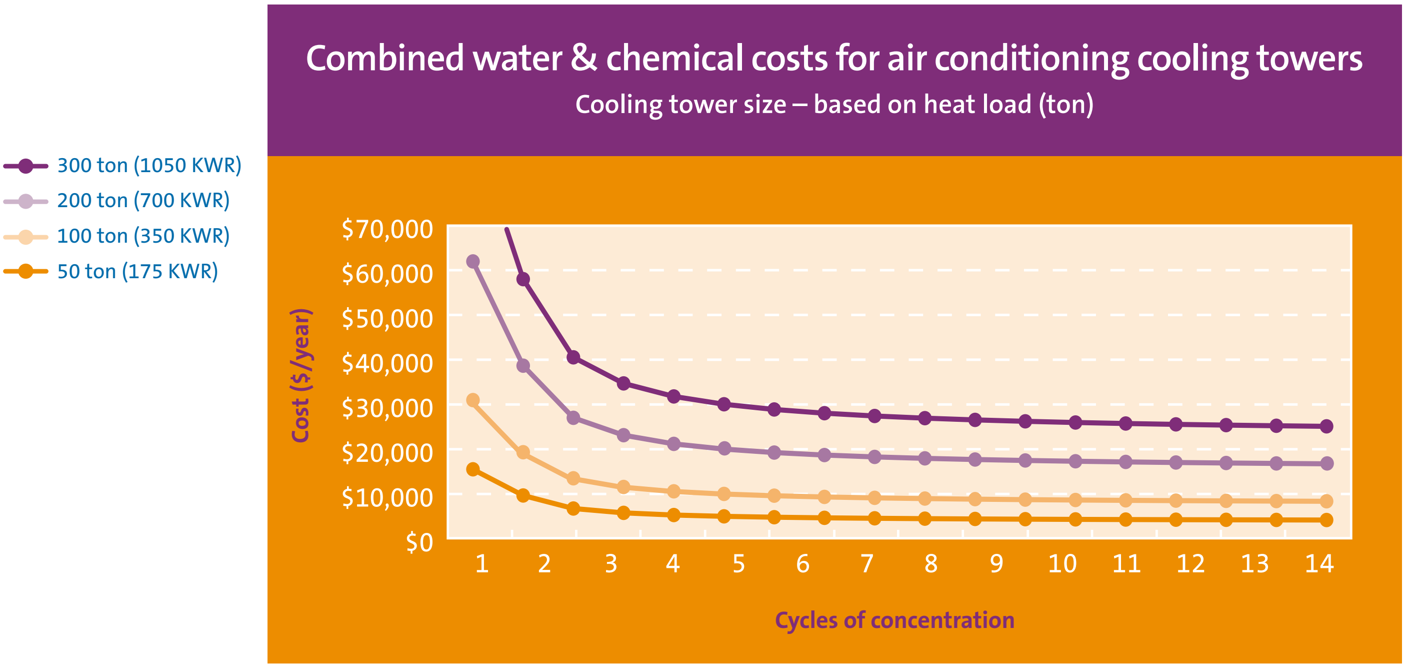
It is possible to get a rough idea of the cycles of concentration from the conductivity of the water (assuming the make up water conductivity is 148mS) :

740µS ≈ 5 cycles
1550µS ≈ 10 cycles
2200µS ≈ 15 cycles
3000µS ≈ 20 cycles
3600µS ≈ 25 cycles

The true value is dependant upon a number of factors, including the concentration of various chemicals, and the pH of the water







Controlling bleed continued

Many sensors are prone to fouling. A poorly maintained conductivity controller could keep the bleed valve open for longer than necessary. It is good practice to clean the conductivity sensor monthly and re-calibrate it at least every 6 months. Some systems require more frequent re-calibration. You should check with your water treatment contractor that this is being done, and that they note this in their service reports.

You should also check with your water treatment contractor that you have an automatic bleed lockout. This stops the bleed drain discharging treated water to waste while the biocide injection is in progress.

Managing cycles of concentration

Cycles of concentration is the ratio of concentration of the dissolved solids in the condenser water to that of the make up water.

In consultation with your water treatment contractor, it may be possible to increase the 'cycles of concentration' of the dissolved solids in the condenser water to the stage where the bleed rate starts to decrease. Increasing the cycles of concentration from say 3 to 9, can provide 25% saving in the bleed water going to sewer. Even higher ratios have been applied at some sites due to the good quality of water in Sydney.

Care should be taken to ensure that a reduction in bleed rate does not adversely impact the water treatment program.

Other ways to reduce water consumption through cooling towers

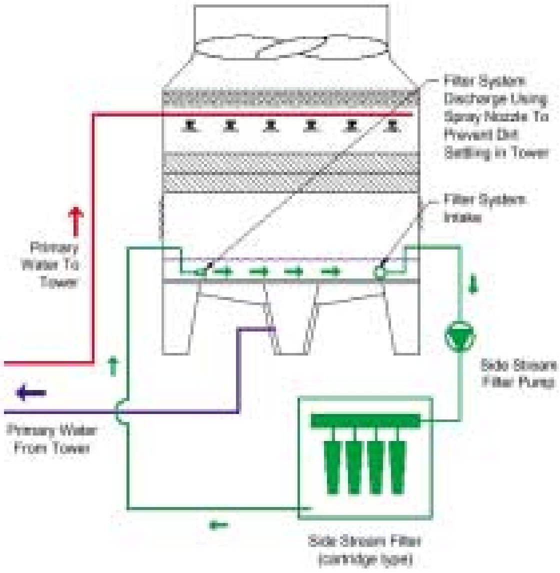
Monitoring water use

Consideration should be given to installing water meters on the make up to the cooling tower, and monitoring the water consumption regularly (perhaps by linking the meter to a building management system that reports consumption on a daily basis). By establishing a normal usage pattern, you will pick up abnormalities quickly.

Use of by-pass valves

If the condenser water system has a low heat load, the flow of condenser water through the cooling tower can be reduced via a tower by-pass valve. This valve enables the condenser water from the chiller to by-pass the cooling tower and return directly to the chiller, thus heating up to a point where maximum cooling can occur across the cooling tower. By minimising the number of times the condenser water flows through the cooling tower, water losses through evaporation, splash and drift can be minimised.

1



2

1. Cooling tower being cleaned
2. Schematic of cooling tower with side stream filter

Minimising cooling tower cleans through performance based maintenance

Building owners can elect to adopt a performance based approach to maintenance using AS/NZS 3666 Part 3. This Standard provides an allowable alternative to the routine six monthly minimum cleaning process for condenser water systems specified in AS/NZS 3666 Part 2. Tower cleans can be suspended indefinitely if a competent assessment of microbial control is made and an appropriate treatment program is implemented in accordance with a risk assessment conducted on site.

Monthly maintenance activities

The prescribed routine, monthly preventive maintenance activities conducted by your maintenance personnel, should identify and troubleshoot any problems which might occur with water losses in the cooling tower. See AS/NZS 3666 Parts 2 and 3.

At the very least you should ensure that your water treatment contractor inspects the cooling towers at each service visit, and reports back to you any water leaks or overflow problems. Often they will pick up excessive water consumption through low chemical levels in the water.

Side stream filters

Side stream filtration is typically employed in systems that are prone to fouling from air borne contaminants like dust. The filters reduce build up of suspended solids in the water helping keep the water cleaner.

Some systems, however, use a lot of water to ‘back wash’ the filter media. If you have such a filter give consideration to capturing bleed-off in a backwash holding tank. You can then use it to backwash these side-stream filters. Using a bag or cartridge filter would save even more water since it does not entail a backwash cycle.

Water loss means water treatment chemicals will be lost, which in turn compromises the effectiveness of the water treatment program and increases the cost of treatment.

Check sheet

Question	Answer	Action
When the pump is stopped, is there water flowing from the overflow drain pipe?	Yes ☐ No ☐	If yes, check that the drain valve is correctly set and if there are any leaks. Also check if the valve is closed and adequately sealed?
When the pump is stopped, does the water flow out of the overflow drain pipe whilst the water is coming in through the make up water line?	Yes ☐ No ☐	If yes, this indicates that the ball float valve is incorrectly set. The ball float valve needs to be reset.
If you have a V-shaped basin, when the pump stops does the cooling tower overflow?	Yes ☐ No ☐	If yes, consider installing a 'break tank' or a more precise make up control.
If there is a reasonable length of condenser water pipework running at high level, does the tower overflow when the pump stops?	Yes ☐ No ☐	If yes, consider reconfiguring the pipework.
If you have two or more cooling towers interconnected, when the pump stops does water flow from the drain pipe?	Yes ☐ No ☐	If yes, check the ball float valve settings and the height of the tower basins (if one basin is higher than the other some attention may be required).
Is the water overflowing the edge of the tower basin?	Yes ☐ No ☐	If yes, check that the overflow pipe is set correctly or not blocked.
Is the area around the tower regularly or constantly wet?	Yes ☐ No ☐	If yes, water is splashing out of the tower. Install anti-splash louvres.
Have you looked at dry, evaporative or evaporatively pre-cooled liquid coolers as an option?	Yes ☐ No ☐	If yes, look at installing a suitable wind breaks.
Is there any leakage present in the tower casing, basin, or any air intakes or exhaust ducts or flexible connections?	Yes ☐ No ☐	If yes, the joints need to be adjusted and sealed.
Is the cooling tower not equipped with drift eliminators or does the tower have old or ineffective eliminators?	Yes ☐ No ☐	If yes, a drift eliminator which provides a drift loss of 0.002% should be installed.
Are there any pumps with packed gland pump seals?	Yes ☐ No ☐	If yes, ensure pumps are inspected monthly and the seals tightened as needed. Also consider replacing the seals with a mechanical seals.
Does the water treatment contractor clean the conductivity sensor every month?	Yes ☐ No ☐	If no, organise to have them clean the conductivity sensor monthly and re-calibrate it at least every 6 months.
Is the water treatment system equipped with a bleed lockout.	Yes ☐ No ☐	If no, consider installing a bleed lockout.
Does the cooling water system have a side stream filter that uses water for back flushing purposes?	Yes ☐ No ☐	If yes, consider capturing the bleed off in a backwash holding tank and then using it to backwash the side stream filter.
Is there a water meter on the make up water pipe?	Yes ☐ No ☐	If no, consider installing a sub-meter, and monitoring the water consumption regularly.
Is your water treatment contractor able to increase the 'cycles of concentration' in the cooling water to the stage where the bleed rate starts to decrease?	Yes ☐ No ☐	If yes, ask him to do so. If no, discuss the opportunity of changing to a treatment system that can function effectively at higher cycles of concentrations.
Does your water treatment contract require the contractor to report back on all water leaks after each service?	Yes ☐ No ☐	If no, modify the contract to do so.
Is a certificate in place stating that an effective process of disinfection is installed and operating?	Yes ☐ No ☐	If no, ensure a certificate is acquired and in place as this is a mandatory requirement in NSW.

Design of buildings and services to save water

Options to reduce water use through design

Minimise cooling load

- **Improve design of cooling towers**
- **Alternative heat rejection systems**
- **Alternative water sources**

The following information can be used to help minimise or eliminate water usage associated with the provision of cooling in office type buildings. A check sheet has been provided on page 22 to be used as a prompt when examining design options for your cooling systems.

Minimise cooling load

It cannot be overstressed that one of the principal objectives of any building owner or manager should be to minimise the cooling load in a new or existing building. This is fundamental to having an energy efficient building. In addition, if the cooling system utilises a cooling tower, it follows that when the heat load is reduced, so water consumption at the cooling tower is also reduced, because less heat is rejected during the evaporative cooling process.

Minimising the cooling load in your building will require a co-ordinated approach by each discipline, i.e. design architect, air-conditioning system designer, services personnel and building management personnel.

Transmission, solar radiation, occupancy, heat infiltration and office equipment are some of the heat sources that need to be examined.

There are many useful references available on the subject of minimising the cooling load in a building, whether proposed or existing. A good starting point is the NSW Sustainable Energy Development Authority (SEDA) website www.energysmart.com.au which has tips, links to useful sites and a number of publications for download.

Saving energy makes good business sense. An energy analysis should be conducted on proposed buildings and an energy management plan or audit should be prepared for all existing buildings. The Property Council of Australia, in their publication "Energy Guidelines", details steps needed to identify and cost effectively reduce energy consumption.

Minimising energy wastage

= Reduced heat load

= Less cooling needed

= Less water used in the cooling tower

Some energy reducing initiatives might include:

- Obtaining 100% water saving by using an economy air cycle whenever the outside air conditions are favourable and thus the tower does not need to operate.
- Use of a hybrid type air-conditioning system which utilises natural ventilation via openable windows whenever the outside air conditions are favourable and thus the tower does not need to operate.
- Using heat recovery systems to help minimise the amount of heat to be rejected through a cooling tower. The heat saved, can be used for applications such as preheating domestic hot water used in the building, or even providing hot water to re-heat coils.
- Reducing the lighting load. In many buildings it is possible to cost effectively reduce the power consumed by the lighting systems by at least 30% without any discernable loss of amenity. When the lighting consumes less power, it produces less heat, which in turn reduces the air conditioning load.
- Retaining expert hydraulic or design consultants to provide you with up to date water efficient initiatives at the design stage.

Benchmarking your building from an energy perspective, will help you understand the energy savings potential. This can be done simply by using a free online rating tool, available at www.abgr.com.au. The lower the rating, the greater the energy saving potential. Having completed a rating, by following the ABGR Star Performer links, you will also find tools to help you improve the energy efficiency of your building.

Remember, by saving energy in buildings, you will be cutting energy costs. By saving energy in buildings with evaporative cooling water systems, you will be saving on both water and energy costs.

Design of cooling towers

Some simple design tips for reducing water wastage through cooling tower operation, discussed in these Guidelines, include installing drift eliminators and anti-splash louvres or splash mats. Another tip is to include a water meter on the make up line to the cooling tower to allow for monitoring of water consumption during operation. Further design considerations to minimise water wastage through cooling towers are given below.

Dual tower pipework design issues

When two cooling towers are linked together in a common system, it is not unusual to encounter pipework problems that contribute to water wastage. The most common problem relates to the way the water is distributed to the top of the towers. If the towers are of equal size and the pipework distribution to the two towers is not equal in length, it is not uncommon for one tower to receive more water than the other. The water level in the tower with the least flow, tends to be lower than in the other tower, so causing the ball float to call for more make up water. With time the water volume in the system increases such that an overflow occurs in the other tower.

Some designers believe that this problem can be solved with a ‘balance line’. Unfortunately, balance lines are often undersized and/or incorrectly positioned, so they fail to live up to the designers expectations.

Designers also tend to favour the use of balancing valves. If the flow rates are constant then these can be quite effective. If, however, the water flow rate is variable, then the valve settings may not always be appropriate. Ideally the pipework should be designed to negate the need for balancing valves.

Side stream filters

When the condenser water is clean, you can reduce energy wastage associated with fouled heat exchangers and you can reduce the microbial infection risks. A common way of keeping the system clean is to use a side stream water filter. These come in many forms, and some of them use a lot of water when they are in ' backwash' mode (not all filters require backwashing).

To reduce the water wastage associated with backwashing filters, one of two simple control strategies should be considered. Where possible, any bleed off from the system should be captured in a storage vessel. This can then be used as required, for the purpose of backwashing the filter. This not only saves water, but it also helps ensure that the system volume does not drop too low during operation.

If this procedure is not feasible, then consideration should be given to back washing the filter in response to a build up of solids in the condenser water system (i.e. using the backwash cycle as a de facto bleed).

Alternative heat rejections systems

There are various alternative, heat rejections systems available that can eliminate or dramatically reduce the water consumption associated with cooling systems. The best time to consider these alternatives is during the design of new systems or the retrofitting of existing chillers or towers.

Air cooled chiller

Air cooled chillers versus water cooled chillers

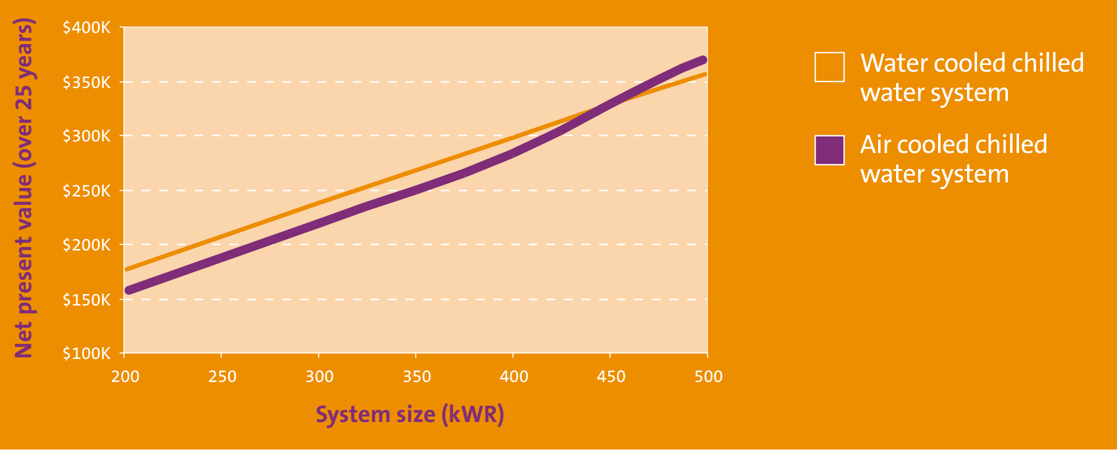
Air-cooled chillers do not use cooling towers, thus eliminating the condenser water loop. Not only is water saved, air-cooled chillers carry almost no Legionnaires' disease risks (regardless of cost, some companies are now installing air cooled chillers purely to minimise their exposure to this risk).

Other than ensuring that the chilled water corrosion control chemicals are periodically checked, there is little need for water treatment, and no harmful chemicals are discharged into the sewer, as there is no need for a bleed system. Air cooled chillers are also easier and cheaper to maintain, as they do not require an annual condenser water box clean.

Unfortunately, air-cooled chillers are not always a viable alternative to their water cooled counterparts. Air-cooled chillers are comparatively more expensive to purchase, they occupy greater floor space, and they can be significantly less energy efficient.

Positives of air-cooled	Negatives of air-cooled
Does not consume water during operation.	Higher energy consumption.
Does not regularly discharge chemicals and water to the sewerage system.	Larger electrical infrastructure requirements.
Lower maintenance requirements – only cleaning of fins.	Lower heat transfer efficiency. On very hot days the performance may be compromised.
Very low environmental health risks.	Higher purchase costs for equivalent heat loads.
Small (<500kWR) chillers may have lower operating costs.	Noisier.
	Greater floor space requirements.

Life cycle cost analysis of water cooled verses air cooled chillers



The graph above was prepared in conjunction with Carrier Air Conditioning. Carrier looked at all of the costs associated with running chillers of both types and despite the higher initial costs, the graph shows that air-cooled chillers of 450kWR (kilowatts of refrigeration) or lower, can be more cost-effective than their water cooled counterparts.

A number of assumptions have been made in determining these results. These include:

- No monetary value, such as reduced insurance costs, has been placed on eliminating the health risks associated with a cooling tower, so for some building owners even very large air-cooled chillers could be economically more viable.
- Electricity was assumed to cost 10c per kWh.
- The life of the equipment was taken as 25 years.
- Replacement of the coils on the air-cooled chiller was allowed for after 15 years.
- The equipment was assumed to run 60 hours per week.

These assumptions are general, and not applicable to all situations, so the most appropriate choice of chiller should be determined on a case by case basis.

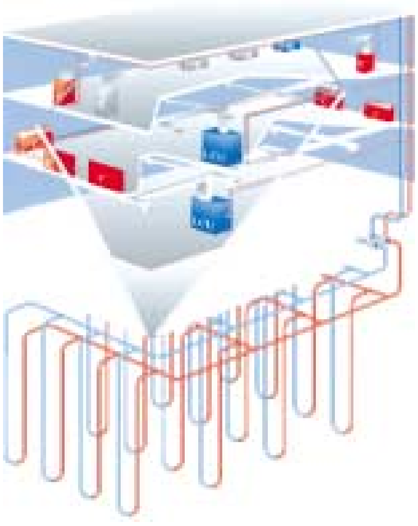
Ground source geothermal systems

When we cool a building we effectively reject the unwanted heat. To remove the heat we need a temperature gradient. Geothermal systems make use of the fairly constant temperature of the ground. Instead of rejecting the heat via a cooling tower, cooling water is passed through a series of long loops (bores) buried deep in the ground. The unwanted heat is passed to the soil and rocks, where it is dissipated. Since this is a closed loop system, there is little or no water usage.

Over one hundred such systems have been installed, including one at Macquarie University and one at the NSW Department of Environment and Conservation Lidcombe site (where heat rejection is 6kW/bore, with 56 bores delivering 336kW of heat rejection).

Geothermal systems are initially more expensive than conventional cooling systems. Due to drilling costs such a system would typically be 40% more expensive to install than a conventional water cooled system. However, because the ground temperature is fairly constant and relatively low, it is possible to achieve very high efficiencies. They also require land to drill the bores. Therefore, in built up areas this can be a problem.

The advantages of geothermal systems, apart from saving water and money, are low noise, almost no Legionella risk and reduced maintenance.



Picture courtesy of Air Solutions International Pty Ltd

Schematic of ground source geothermal system

Water source geothermal systems

Similar to the ground source geothermal systems, these systems either directly or indirectly make use of underground aquifers. Direct use systems draw water up from the ground, pass it through a heat exchanger, and return it to its source. Indirect systems utilise closed pipework loops that pass through the aquifer. The indirect systems can be cost comparable to a conventional water cooled system.

Ice storage and chilled water storage systems

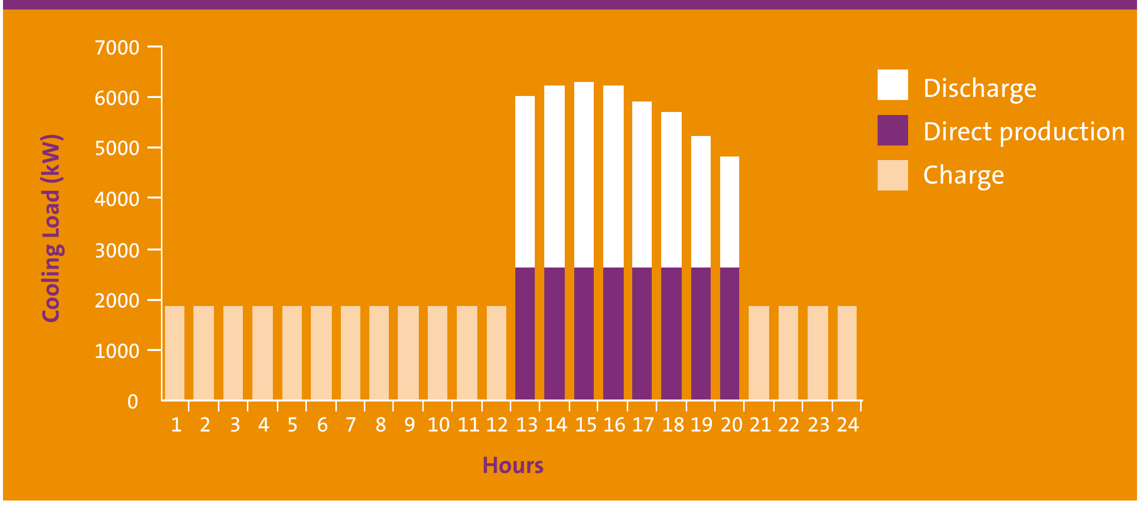
If the cooling system can be operated at night when the ambient air is generally cooler than during the day, the equipment will operate more efficiently, and there will be less evaporation loss.

Unfortunately maximum cooling is usually required during the hottest parts of the day. A solution which is gaining popularity, is to use a chilled water or ice storage system.

Generating ice or chilled water overnight can not only save water, but can dramatically cut operating costs, not least because such systems can use electricity at off peak rates. In addition, capital costs can also be reduced as it is no longer necessary to install large chillers etc to deal specifically with peak loads that occur on maybe 10 days of the year. For example, if the peak cooling load were 750kW, with a properly designed ice or chilled water storage system that could offset part of the peak load, you might only require a 620kW chiller (or two 320kW air cooled chillers). These systems could potentially save 15% in electrical energy.

Ice storage systems take up less space than chilled water systems. Their installation is dependent upon skilled engineering design and manufacture. For this reason they are generally contemplated for large installations. Advice of qualified professionals should be sought at the design stage.

Profile of cooling load in a commercial building over a typical day



Graph Courtesy of Thermal Energy Storage Technologies (Australia)

Sydney Opera House uses sea water for cooling

Sea or lake water cooling

When a building is located close to a large water source such as the sea, a river or a lake, there may be an opportunity to take advantage of the natural heat sink. A number of buildings in Sydney make use of the Harbour for cooling purposes, including the Sydney Opera House. There are a number of design issues that must be considered, such as the choice of metallurgy, especially when heat exchangers come into contact with highly corrosive sea water, as well as environmental issues. For example, the NSW Department of Environment and Conservation may place limits on the temperature of water discharged to the sea. Also macro-organisms such as Zebra mussels or Asiatic clams may cause fouling of heat transfer equipment and there are concentration limits placed on chemicals such as chlorine and other biocides that can be injected for control purposes and ultimately discharged to the sea.

Initial costs would normally be higher than a conventional water cooled system. However, the overall benefits may outweigh the initial costs.

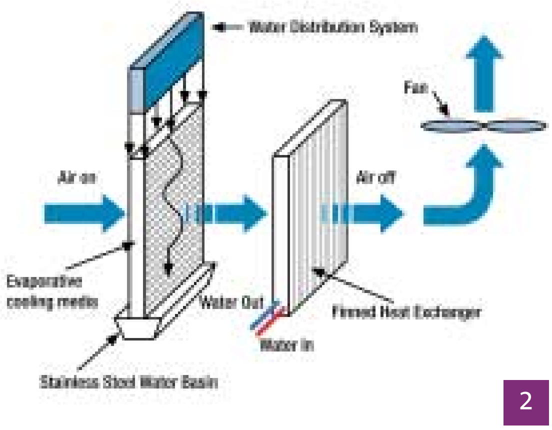
Liquid coolers (dry and evaporative)

Similar in concept to a radiator found in cars, the cooling tower is replaced with a heat exchanger and fan. This is the most basic form of liquid cooler, called a dry cooler. The cooling water is pumped through the heat exchanger (usually a finned coil type) and a fan forces air over it. The air picks up the heat and removes it. Because this is a closed loop system, there is little or no water usage.

The main disadvantage of dry coolers is that the lowest possible water temperature that can be achieved is the ambient dry-bulb or sensible temperature, which is normally (and especially so on hot summer days) much higher than the wet-bulb temperature. Therefore, dry cooler systems suffer from reduced efficiency at higher ambient temperatures due to increased cooling water temperatures.

This disadvantage can be overcome in several ways. The simplest way is to apply some form of evaporative pre-cooling to the air before it enters the dry-cooler.

Evaporative pre-cooling can, in its simplest form, consist of a system of water sprays at the cooler inlet. These sprays are activated when ambient temperatures become high and the air is pre-cooled by the evaporating effect of the fine water mist. A disadvantage of spray coolers is that they must be installed and operated with care to prevent the formation of scale on the surface of the dry-cooler, as a result of residues from the water.



Picture courtesy of Muller Industries Australia Pty Ltd

1. Dry cooler with evaporative pre-cooling
2. Schematic of a dry cooler evaporative pre-cooling

As an alternative to spray-coolers, commercially available pre-cooling pads can be installed. The advantage of such pads is that, although fan power increases somewhat due to the higher air-side pressure drop, no water droplets settle on the dry-cooler surface. Provided the cooling pad systems are properly installed and operated, by virtue of their operating temperature, they present a very low Legionella risk.

Some manufacturers now provide complete evaporative pre-cool liquid cooler units to replace cooling towers. The total running costs of such systems are often lower than with conventional cooling towers.

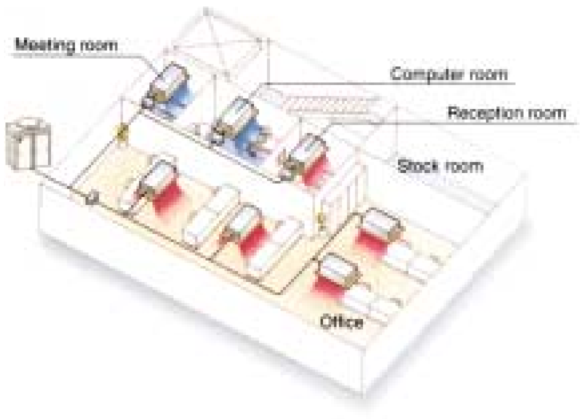
Another energy and water efficient way to overcome the disadvantages of a dry-cooler, is to use a hybrid cooler. This is similar in principle to the wet/dry cooling towers (see the next section), except that the condenser water circuit remains closed at all times. A section of the cooling coil surface is wet with water recirculated from a sump at times of high ambient temperature, but at other times the cooler acts as a normal dry-cooler. By draining the sump at night (when load on the cooling system is generally low, especially for air-conditioning applications) and running the cooler dry for a few hours, such hybrid systems can be Legionella free without the need for microbial water treatment. The significant advantage of such hybrid systems over a conventional cooling tower is lower annual average water consumption figures.

Wet/dry cooling towers

Wet/dry cooling towers utilise the positive aspects of both systems leading to overall lower water consumption. Water to be cooled is passed through the dry air cooled section then through the wet section of the cooling tower. During the cooler periods only the dry cooling tower section is used, reducing water consumption. In dry/wet mode both sensible and evaporative heat transfer takes place.

Variable volume refrigerant systems

Schematic of variable volume refrigerant system



Picture courtesy of Daikin Australia Pty Ltd

Thanks to improvements in refrigerant and control technologies, it is now possible to connect a number of individual air conditioning devices to a common refrigerant circuit, which in turn connects to common air-cooled condenser. The technology allows for split operation, i.e. to run one indoor unit in cooling mode whilst another runs in heating mode.

Such systems, commonly referred to as variable refrigerant volume systems (or variable refrigerant flow systems) have a number of advantages over conventional air conditioning systems. These include ease of installation, the ability to offer precise local temperature control in an energy efficient manner, low space requirements, and high reliability. It is particularly appropriate for buildings where occupancy is variable, as the air conditioning in unoccupied spaces can be turned off.

Because such systems are air-cooled, they do not use cooling towers, eliminating the consumption of potable water in the cooling process. Not only is water saved, but legionnaires' disease risk is also negated.

There are, however, a number of factors that should be taken into consideration when deciding on such a system as it is not always the most appropriate choice. For instance, the opportunity to incorporate economy air cycles for free cooling is to some extent excluded and the proliferation of individual fan coil units may increase maintenance costs (and complexity) when compared to a conventional central system. Such systems generally cost more than a conventional water cooled system to install (a 20% plus premium, depending upon the type of configuration) and they often use large quantities of chemical refrigerant in an extensive piped network, which, if not properly installed and protected, could present significant refrigerant leakage risks.

Alternative water sources

It is not always necessary to use potable water in the cooling water system. The use of lake water and sea water has been discussed, but there may also be an opportunity in some instances, to use bore water, reclaimed water or recycled water.

Bore water

If bore water is available, it may be suitable for use in a condenser water system. However, it is essential that the water quality be carefully assessed with particular emphasis placed on dissolved iron, pH, manganese, H_2S and corrosivity/scaling tendency of the water. For example, bore water samples taken in Sydney Region have shown iron concentrations vary from less than 0.05mg/L to in excess of 50mg/L. An experienced water treatment contractor is capable of assessing the water quality. Bore water use in cooling towers has been successfully trialled at the University of New South Wales.

Condensate

Traditionally designers of air conditioning systems have piped condensate drains from cooling coils, straight to waste. This is unfortunate, as the condensate is usually clean and cold. If the water could be piped to the cooling tower, not only would you save water, but you may marginally improve system efficiency. Whilst condensate is not sufficient to replace all potable water, it can make a significant difference to your water bill. Especially on hot and humid days when air conditioning systems extract a lot of moisture out of the air (as much as 170L/hr in a 10,000m^2 office building).

Rainwater

In some instances it may be possible to harvest rainwater, especially on industrial sites where buildings may be covered by large roofs. Given the significant amounts of water consumed by a cooling tower, it is unlikely that rainwater could substitute 100% potable water.

Recycled water

Recycled water is sewage effluent that has undergone some form of treatment such as secondary/tertiary treatment, microfiltration ozonation or chlorination. The use of recycled water in NSW is regulated by the NSW Department of Environment and Conservation and NSW Health. You will need to obtain permission from NSW Health prior to use in cooling towers. The suitability of recycled water as condenser water make up will be dependant upon the recycled water quality. Ammonia, phosphate, biological oxygen demand (BOD) levels, as well as dissolved solids, will increase microbial growth, scaling potential, and corrosion of mild steel, copper alloys and stainless steel metallurgy.

There is a great body of technical literature on ammonia causing stress corrosion cracking in certain copper alloys, specifically admiralty brass. Even at relatively low ammonia concentrations of 2.0 mg/L it can cause catastrophic failure. Control of copper corrosion other than stress corrosion cracking is possible with copper corrosion inhibitors.

The potential for calcium phosphate scaling increases with increasing calcium, phosphate, pH and temperature. Phosphate can also combine with iron to form a deposit of iron phosphate. In addition phosphate provides a nutrient for algae growth.

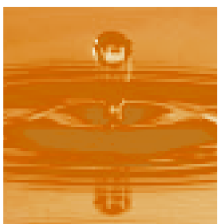
Total dissolved solids affect the corrosion reactions by increasing the electrical conductivity of the water: the higher the conductivity, the greater the corrosion potential.

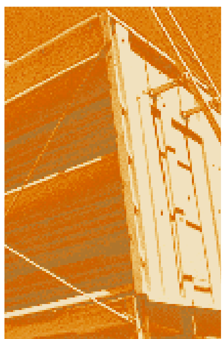
Chlorides has a particularly strong influence on the corrosion of most metals especially mild steel, but also for copper and stainless steel alloys. Chloride will increase the general corrosion, any galvanic effects and possibly the propensity for localised pitting corrosion. Chlorides in excess of 200 mg/L can cause stress corrosion cracking of some stainless steels.

Due to these reasons, plus the need for dual reticulation in the plumbing system, perceived and real health risks, the use of recycled water in cooling towers in commercial buildings needs to be carefully assessed.

Process water reuse

Whilst process water is typically not available in a commercial office complex, if there are installations such as reverse osmosis membrane units then the reject water could be a suitable substitute for potable water.





Design of buildings and services to save water

Designing a heat rejection system

Other options to water cooled systems

If the cooling load is under 500kWR have you considered air cooled?	Yes ☐ No ☐
Have you looked at either a water source or ground source geothermal system?	Yes ☐ No ☐
If the building is located close to the sea or lake have you looked at sea or lake cooling water systems?	Yes ☐ No ☐
Have you considered hybrid coolers or condensers as an option, especially for large scale heat rejection?	Yes ☐ No ☐
Have you looked at evaporatively pre-cooled air cooled condensers, either with spray or pad cooling?	Yes ☐ No ☐
Have you looked at dry, evaporative or evaporatively pre-cooled liquid coolers as an option?	Yes ☐ No ☐
Have you looked at a variable refrigerant volume system?	Yes ☐ No ☐

Design of water cooled systems

Have you looked at reducing the heat load on the building through:

Energy efficient lighting	Yes ☐ No ☐
Building insulation	Yes ☐ No ☐
External shading devices	Yes ☐ No ☐
High performance glazing	Yes ☐ No ☐
Improving the building envelopes thermal performance	Yes ☐ No ☐
Integrating economy cycle mode into the A/C system	Yes ☐ No ☐
Have you looked at incorporating a side stream filter into the system?	Yes ☐ No ☐
Have you ensured correct design of any dual tower system?	Yes ☐ No ☐
Have you looked at ice and chilled water storage systems?	Yes ☐ No ☐
Have you incorporated in your design a system which pipes back the condensate to the cooling tower?	Yes ☐ No ☐

Have you looked at incorporating alternative water sources into the cooling water system, such as:-

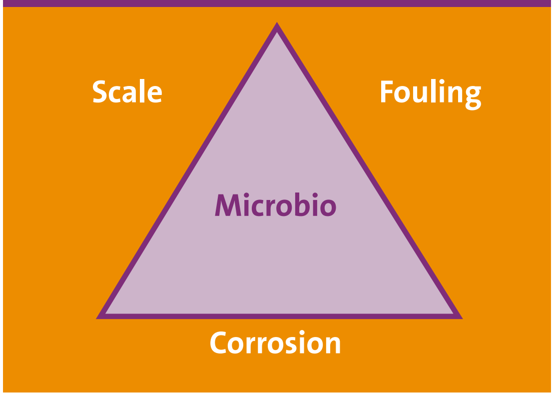
Lake water	Yes ☐ No ☐
Sea water	Yes ☐ No ☐
Bore water	Yes ☐ No ☐
Reclaimed water	Yes ☐ No ☐
Recycled water	Yes ☐ No ☐
Rainwater	Yes ☐ No ☐

Water treatment contracts

Contractor management

Whilst the current trend is to outsource the condenser water treatment works to water treatment suppliers, it is important to have a well written contract with key performance indicators (KPIs) to derive the maximum benefit from the program.

The water treatment triangle – a question of balance



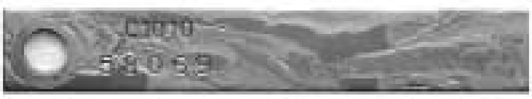
The major outbreaks of Legionellosis have been associated with ineffective cooling water treatment practices. Deposits and corrosion products increase the potential for microbial growth. Therefore, the control of corrosion and scaling is also very important. If corrosion is not properly dealt with, you may find yourself with substantial repair bills. Scaling can significantly affect the efficiency of your cooling systems and if left unchecked, will lead to loss of comfort and increased energy bills.

It often pays to sit down with water treatment contractor and discuss aspects of their service. You should satisfy yourself that they are using the right chemicals for the metals in your systems (this should be verified through a process of corrosion monitoring using either corrosion coupons or a corrater) that the biocide programme is effective and that the dosing equipment is appropriate. Your maintenance engineer or air conditioning contractor should be able to tell you what metals are used in your condenser system.

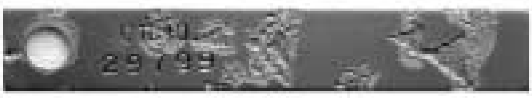
Examples of mild steel coupon corrosion

New coupon

General corrosion – low (0.223 mpy)



General corrosion – high (8.73 mpy)



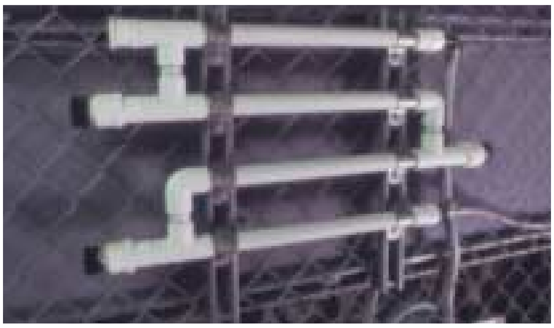
Pitting corrosion (5.99 mpy)

Typical KPIs for cooling water systems

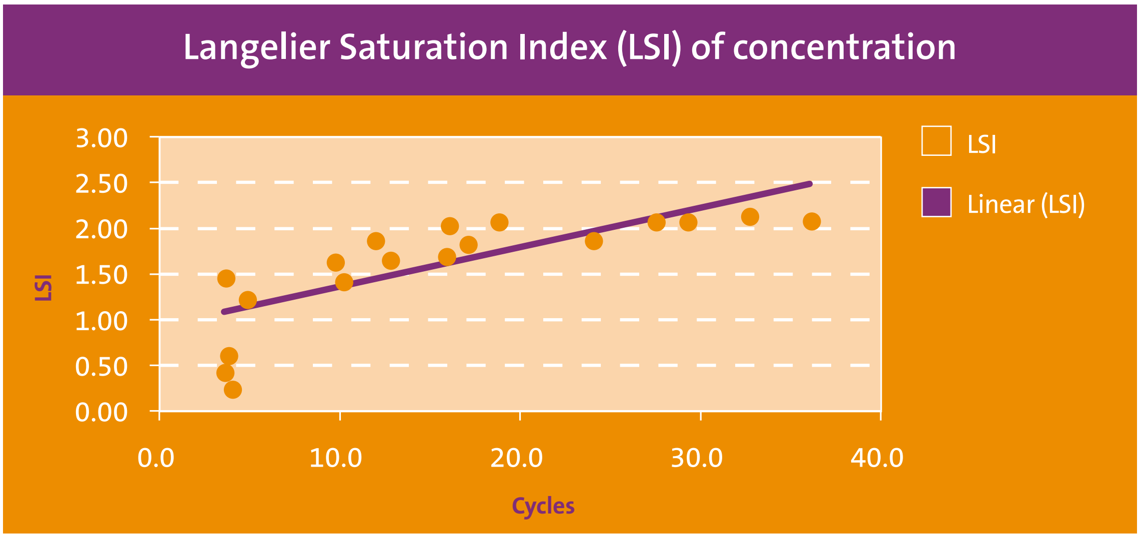
Corrosion	Corrosion rate <1MPY* (stainless steel)
	Corrosion rate <3MPY (mild steel)
	Corrosion rate <0.2MPY (copper alloys)
Microbio	Total plate count <100,000cfu/ml**
	Legionella <10cfu/ml**

* 1MPY = 25 microns per year

** Colony forming units per millilitre



Coupon rack



It is good practice to spell out the outcomes desired from a water treatment program, perhaps by determining suitable KPIs, and including them within a contract with the water treatment contractor.

The every drop counts business program carried out trials to assess the impact of high cycles of concentration on corrosion, scaling and microbial growth in cooling systems in office complexes. The trials confirmed that the above KPIs could be maintained even at conductivities of 5000 microS/cm corresponding to 37 cycles of concentration. The trials also showed that scaling tendencies become prevalent at conductivities in excess of 2400 microS/cm corresponding to Langelier Saturation Index (LSI) of 2 as shown in the chart. Therefore when operating at high cycles, it is important that the condenser water contain a calcium carbonate scale inhibitor. Before operating at high cycles seek advise from a qualified water treatment consultant.

Some tips to consider:

- Work closely with your water treatment contractor to reduce bleed off. Reducing bleed off will also reduce your chemical purchasing requirements.
- Require water treatment contractors to commit to a predetermined minimum level of water usage and make this a KPI (have them provide an estimate of projected water and chemical consumption and costs).
- When purchasing chemicals for treating cooling tower water, have the supplier explain the purpose and action of each chemical.
- Include in the service schedule a requirement that the contractor cleans the conductivity probe on a monthly basis and recalibrates the bleed controller at least once every six months.
- When commissioning new cooling towers, ensure that the condenser water system is pre-treated as per the water treatment contractors recommendations.
- Get the water treatment contractor to report or attend to water wastage problems in a timely manner.

Site manager with water treatment contractor inspecting a cooling tower

Examining monthly maintenance reports

Examine the NSW Health prescribed, monthly routine maintenance reports provided by the respective maintenance contractors, paying particular attention to minimising water usage and eliminating any water wastage. An analysis of cooling tower make up water meter readings should form part of the prescribed monthly maintenance report. The water treatment report should indicate the routine maintenance work carried out on the water treatment equipment including monthly cleaning and six monthly calibration check of the sensor for the conductivity controller. See AS/NZS 3666 Parts 2 and 3.

Co-ordination of monthly reports

Ensure that reports by the water treatment contractors are passed on to the mechanical services maintenance contractor for prompt attention in regards to any reported "uncontrolled water losses" e.g. pump leakage, tower overflowing etc. Then follow-up to ensure that any necessary action has been taken and documented in the maintenance records.

Periodic inspection by site manager/owner

Carry out or arrange a periodic visual inspection of the water cooling system to see if there are any obvious signs of water wastage occurring e.g. water flowing or leaking out of the tower drainline, tower basin overflowing onto surrounds, splash-out from the tower onto surrounds. Such problems need to be recorded and reported to the maintenance contractor for prompt attention.

Risk management plans

A good risk management plan can help ensure that your condenser water systems operate effectively and efficiently. They are mandatory in New South Wales should a building owner elect to use the performance based approach to cooling water system maintenance. Even if you are not following the performance-based approach, risk management plans make good sense.

Better understanding your risks is the first step to risk mitigation. When the plan has been completed, you should liaise with the water treatment contractor and other service providers to ensure the findings are properly implemented.

A good starting point for information on developing a risk management plan is the Victorian Department of Human Services "A Guide to Developing Risk Management Plans for Cooling Tower Systems". This can be downloaded from www.legionella.vic.gov.au

Regulations relevant to water cooling systems

Public health maintenance requirements

All buildings owners and facilities managers have an obligation to ensure that their condenser water systems do not compromise the health and well-being of the building occupants, the general public and anyone working in or around the systems. Condenser water systems have been associated with outbreaks of Legionnaires' disease, a potentially fatal form of pneumonia, so proper and effective water treatment programs are mandatory.

The condenser water system is an ideal environment for Legionella bacteria to proliferate. Cooling tower drift loss creates the mist that can be inhaled. A cooling tower provides many opportunities for increase in microbial population density. The long residence time in the condenser water provides time for reproduction of the organism.

In NSW all condenser water systems must be fitted with "a process designed to control microbial growth, and that process must be sufficiently effective so that no sample taken from the system subject to a test for total Legionella numbers has a level of Legionella of more than 10cfu/mL or a heterotrophic plate count of more than 100,000cfu/mL" (NSW Public Health Act 1991 and Public Health (Microbial Control) Regulation 2000). In addition, a competent person must certify the process annually.

Compliance with statutory requirements

One of the first steps to take in regards to following best practice, is to check for compliance with local legislative requirements, standards and codes. The relevant personnel need to keep up-to-date with the substance and intent of the requirements.

In the area administered by Sydney Water, the following legislation and licensing applies to condenser systems:

Legislation

The main legislation:-

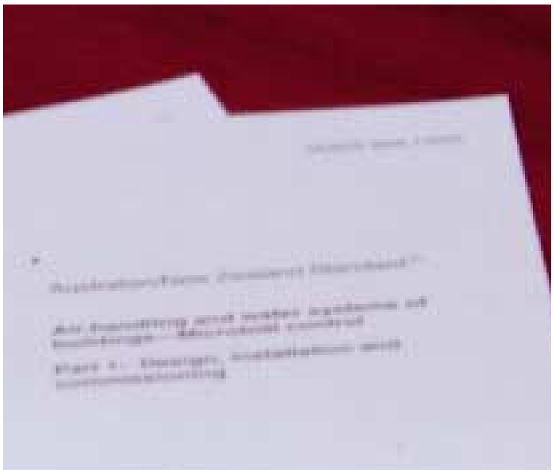
(a) Sydney Water Act 1994 and the Sydney Water Regulation 2000. This legislation has relevance to the plumbing and drainage requirements for condenser water systems.

(b) Public Health Act 1991 and the Public Health (Microbial Control) Regulation 2000. This legislation has relevance to the microbial control of condenser water systems including their construction, installation, commissioning, operation and maintenance.

(c) Occupational Health and Safety Act 2000 and the Occupational Health and Safety Regulation 2001. This legislation has relevance to the OH&S measures covering plant such as cooling towers.

Copies of the above legislation can be downloaded from www.austlii.edu

(d) Sydney Water Customer Contract. You have an obligation under the Customer contract with Sydney Water to ensure your "Water System" is properly maintained. Your water cooled air conditioning system when supplied with mains water from part of your water system.



Codes

The main code:-

The New South Wales Code of Practice – Plumbing and Drainage (1999) is relevant as it is referenced in Clause 6(1) of Sydney Water Regulation 2000. The Code is available from NSW Government Information Bookshops in Sydney.

Standards

The main standards:-

Standards AS/NZS 2845.3, AS/NZS 3500.1.2 and AS/NZS 3666 Parts 1, 2 and 3, are particularly relevant to water cooling systems as they are referenced in legislation. These Standards are available from Standards Australia on www.standards.com.au

Glossary of terms

For the purposes of these Guidelines, the following terms are used:-

Ball float valve

A valve which is actuated by a ball float and used to monitor the level of the water in a cooling tower basin and to regulate the flow of the make up water to maintain the preset level.

Bleed

The removal of water from a condenser water system to limit the concentration of the total dissolved solids and suspended solids.

cfu

Colony forming unit. Measure of bacterial population per mL.

Chiller

A device which cycles a refrigerant which is used to transfer heat from an evaporator to a condenser which is either air-cooled or water cooled.

Controlled water losses

Water losses in a condenser water system during the evaporative cooling process, bleed or blowdown, condensation of water vapour and also the drift in the exhaust air.

Cooling tower

A device for lowering the temperature of water by evaporative cooling in which atmospheric air is in contact with falling water, thereby exchanging heat.

Cycles of concentration

The ratio between the chlorides in the condenser water to the chlorides in the make up water, or any other ion such as magnesium.

Drift

Water lost from the cooling tower as liquid droplets entrained in the exhaust air, excluding condensation.

Drift eliminator

A device which is installed to help limit the rate of drift from a cooling tower.

Evaporation

The vaporisation of the condenser water during the water to air heat transfer process which occurs on the wetted surface of the heat exchange fill in the cooling tower.

kL

Kilolitres of water. 1kL = 1000 litres.

kWR

Kilowatts of refrigeration. 3.517kWR = 1 refrigeration ton.

Legionnaires' disease

A potentially fatal illness characterised by pneumonia and caused by infection with Legionella bacteria species, commonly Legionella pneumophila.

Licensed

Authorised by the Department of Fair Trading to perform the particular work e.g. water treatment, plumbing, drainage or electrical work or maintenance of air conditioning plant.

Life cycle
The process of examining the costs associated with the complete or whole life of a product.

Maintenance
That regular activity aimed at preserving the operational standard and cleanliness of equipment, which includes inspection, repair, preventive service and cleaning.

Make up
Water supplied to a cooling tower to replenish water lost through evaporation, bleed, drift and wastage.

mL
Millilitre. 1mL = litres.

MPY
Mils per year. Measure of corrosion rate. 1MPY = 25 microns/year.

Overflow
The water which may accidentally flow over the basin of a cooling tower, or through the tower overflow pipe, due to a deficiency in the condenser water system

Refrigerant
A medium which is used to transfer heat usually from an evaporator to a condenser as part of an air-conditioning or process cooling system.

Risk management
The process for identifying, assessing, monitoring and controlling the key factors that could affect the desired outcome of a maintenance procedure.

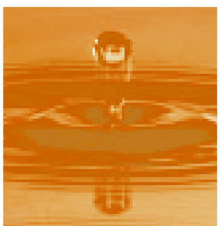
Splash-out
The water that may be accidentally emitted by a cooling tower due to the splashing action of falling water within the tower or the effect of a strong wind blowing through the tower when exposed to the elements.

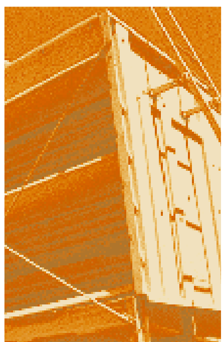
TDS
Total dissolved solids. A measure of the salinity of water. Expressed in mg/L. Typically conductivity is used as a proxy.

Uncontrolled water losses
Water losses in a condenser water system due to causes such as any leakage in pipe joints pump glands, tower casing or due to tower overflow or splash-out.

Water treatment
The process of treating the condenser water for effective control of corrosion, scaling, fouling and microbial growth.

Wet bulb temperature
The lowest temperature that can be obtained by evaporating water into the air at constant pressure. The average yearly wet bulb temperature for Sydney is 14.9°C.





For more information on Sydney Water call 1800 661 161 or visit www.sydneywater.com.au

CSD 264
Printed on recycled paper