4 Risk Management

Risk management is recognised as an integral part of good management practice. It is an iterative or continuous improvement process consisting of steps undertaken in sequence to enable continual improvement.

4.1 Advantages

The main advantages of risk management are:

- A consistent, auditable record of the reasons and rationale for decisions taken.
- A logical way to review the operation and assess which critical areas require further investigation.
- Critical risk factors can be monitored.
- A way to achieve sustained compliance with legislative requirements.

4.2 Methodology

The methodology used to develop this Guide considers:

- The **context** for cooling tower systems and *Legionella*.
- The **potential impact** of an outbreak of Legionnaires' disease.
- The **legal responsibilities** for site owners and those responsible for cooling tower systems.
- **Identification**, **analysis**, **evaluation** and **treatment** of **critical risks** for cooling tower systems.
- **Monitoring** and **reviewing** the RMP.
- The importance of **communication** in the event of problems with a cooling tower system.

The Guide culminates in a template RMP that will enable you to properly manage the risks associated with a cooling tower system.

Owners or operators of more complex sites should consider engaging specialist assistance to perform the risk assessment and develop a risk management plan.

4.3 Risk Management Standard

Australian and New Zealand Standard 4360: 1999 Risk Management (AS/NZ 4360) describes the main elements of a risk management process as:

- Establishing the context (strategic, organisational, risk management, risk evaluation criteria)
- Identifying risks
- Analysing risks
- Evaluating risks
- Treating risks
- Monitoring and review
- Communication and consultation.

This Guide follows the basic framework outlined in AS/NZS 4360.

4.4 Integration with Quality Assurance Programs

Many organisations follow formal quality assurance programs such as ISO 9000 series (Quality Management Systems), ISO 14000 series (Environment Management Systems), AS 4804 (Occupational Health and Safety Management Systems). The development of an RMP should ideally be integrated into these programs where appropriate. Businesses considering this approach should note that it may make the auditing of the plan more complex than if it were a separate document.

4.4.1 SafetyMAP

This is an audit tool designed to assist organisations of all sizes and functions improve their management of health and safety. The audit criteria within SafetyMAP enable an organisation to:

- Measure the performance of health and safety programs.
- Implement a cycle of continuous improvement.
- Benchmark its health and safety performance.
- Gain recognition for the standards achieved by its health and safety management system.

In the 'Self Assessment User Guide' for the Initial Level of SafetyMAP, cooling tower systems should be included in the risk assessment. Cooling tower systems are a potential hazard. They must be assessed and should have documented control measures.

Cooling towers on a rooftop: The tower in the foreground is of fibreglass construction and is often described as a bottle tower. The larger tower at rear is made of metal. Both are induced draught counter flow towers.

5 Identifying and Analysing *Legionella* Risks

During the normal operation of a cooling tower, aerosols are formed and then carried into the environment through the tower exhaust. If *Legionella* bacteria are present in the cooling tower system water, breathing these aerosols can result in infection.

Figure 3 Mechanism of Heat Exchange in a Cooling Tower

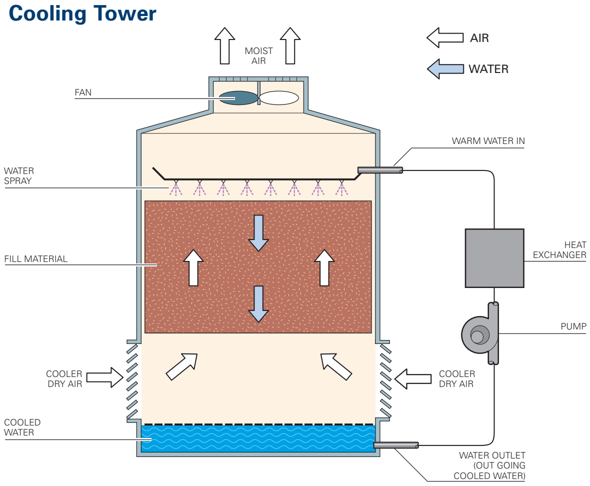
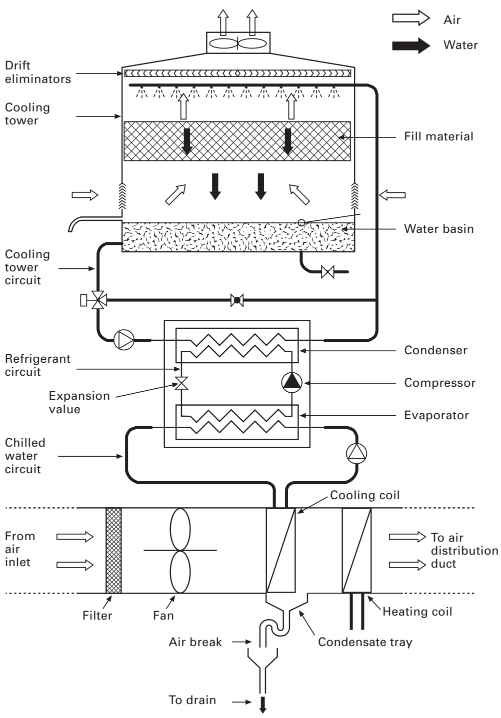


Figure 4 Typical Layout of Air Conditioning System



5.1 Problems with Cooling Tower Systems

Cooling tower systems can provide an ideal environment for the growth of *Legionella*. This can pose a health risk to employees, contractors, customers or members of the general public who have been in or near buildings with a cooling tower system.

In the past, owners of cooling tower systems have usually learned of cases of Legionnaires' disease when public health officers from the Department investigate possible sources of infection associated with their location.

5.2 Types of Cooling Towers

Cooling tower systems are normally associated with air conditioning systems, refrigeration systems and industrial processes. The basic function of the system is to remove heat. Figure 3 shows this process. Cooling tower systems temporarily store water in a basin, which is usually recirculated. The water is sprayed or dripped into a large chamber. Air is forced through this chamber by a thermostatically controlled fan. Discharges from cooling towers are normally warm and humid; sometimes steam can be observed as condensation.

The typical layout of air conditioning systems that use cooling towers is shown in Figure 4. These cooling towers contain fill material inside the tower. Usually made of plastic, it allows the falling water to spread over a greater area. This increases the surface area of the water to be cooled, allowing better and more effective cooling.

Industrial processes often have a device called an evaporative condenser to reject heat from the process. These units work in a similar manner to cooling towers. The cooled water is distributed over a series of pipes that contain circulating refrigerants or other fluids. Unlike cooling towers, evaporative condensers do not contain any fill material. These systems also present risks for Legionnaires' disease and fall within the definition of 'cooling towers' as described in the Building Act and related Regulations. The design of a typical evaporative condenser is shown in Figure 5.

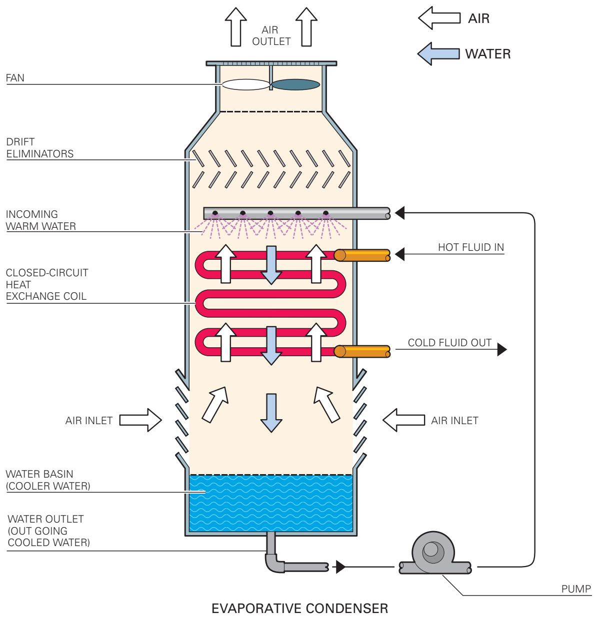
Cooling towers are often confused with evaporative coolers. An evaporative cooler uses the same general principle of recycling water. The main difference is that cooling towers use air to cool the water, whereas evaporative coolers use water to cool the air. There has been no evidence linking evaporative coolers or evaporative air conditioners to cases of Legionnaires' disease.

The definition of cooling tower within the Health (*Legionella*) Regulations 2001 clearly states that evaporative air coolers or evaporative air conditioners are not cooling towers.

Cooling towers may be found on rooftops, and in plant rooms, basements, mezzanines and at ground level. There are four types of cooling tower.

Evaporative Cooler: These units have not been linked to cases of Legionnaires' disease

Figure 5 Typical Layout of an Evaporative Condenser

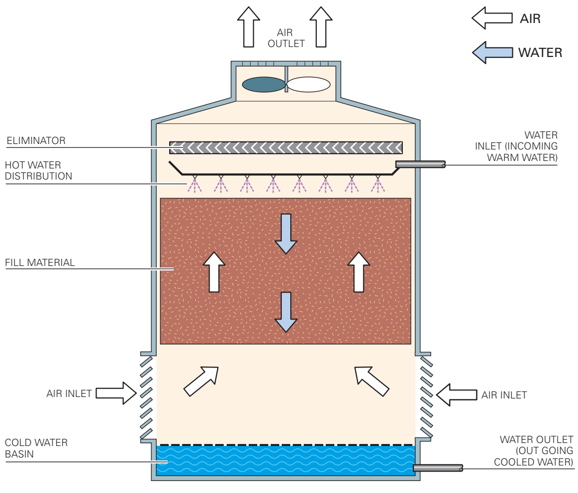


5 Identifying and Analysing the Risks of *Legionella*

5.2.1 Induced Draught Counter Flow

This type of tower is very common. It can be identified by the fan at the top of the tower. The fan pulls air up through the tower in the opposite direction to which the water is falling. The air usually enters the tower through inlet louvres on the sides of the tower. Water is usually delivered by means of fixed or rotating spray arms. Drift eliminators are usually placed above the sprays to prevent loss of water through drift. Figure 6 shows a schematic of these types of cooling towers.

Figure 6 Induced Draught Counter Flow Cooling Tower

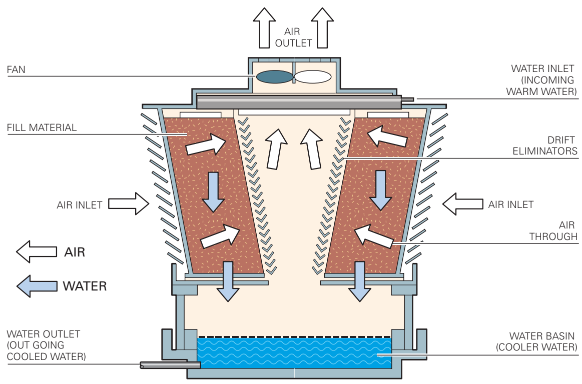


INDUCED DRAUGHT COUNTER FLOW COOLING TOWER

5.2.2 Induced Draught Cross Flow

The fan is also mounted on the top. However, in this type of tower the fan draws or induces the air across the water falling from the top of the tower to the basin. Figure 7 shows a schematic of these types of cooling towers.

Figure 7 Induced Draught Cross Flow Cooling Tower

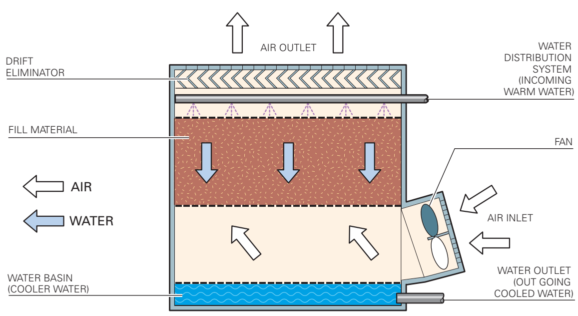


INDUCED DRAUGHT CROSS-FLOW COOLING TOWER

5.2.3 Forced Draught Counter Flow

The fan is located at the air inlet just above the basin. Air is forced vertically through the tower fill in the opposite direction to the water flow. The air is forced out through the top of the tower. Figure 8 shows a schematic of these types of cooling towers.

Figure 8 Forced Draught Counter Flow Cooling Tower

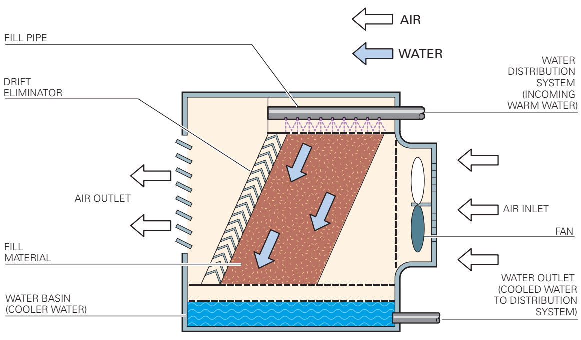


FORCED DRAUGHT COUNTER FLOW COOLING TOWER

5.2.4 Forced Draught Cross Flow

The fan is mounted on one side and pushes the air in a cross flow manner past the falling water. Figure 9 shows a schematic of these types of cooling towers.

Figure 9 Forced Draught Cross Flow Cooling Tower



FORCED DRAUGHT CROSS-FLOW COOLING TOWER

5.3 Why Outbreaks Happen

Cases of Legionnaires' disease associated with a cooling tower system usually occur as a result of one or more of the following scenarios:

- Failure to treat the water to an adequate standard, which can in turn be due either to a lack of or breakdown of:
  - a regular treatment schedule or system equipment
    or
  - human error.
- Environmental contamination of the cooling tower water, for example from nearby construction works.
- Poor cooling tower system design or location.
- Inadequate or non-existent maintenance (including plans for replacement of ageing cooling tower systems).

5.4 Incubation Period

Legionnaires' disease has an incubation period of between two and ten days. This means that symptoms do not appear until two to ten days after a person has been exposed to *Legionella* bacteria. More cases may continue to be diagnosed for up to ten days after the source of the infection has been successfully eliminated.

5.5 Risk Factors for Cooling Towers

Twenty risk factors associated with cooling towers are listed in the Australian/New Zealand Standard 3666.3:2000 Air-handling and water systems of buildings – Microbial control Part 3: Performance-based maintenance cooling water systems (AS/NZS 3666.3):

- Presence of water (especially if stagnant, for example, 'dead legs' or system not in use)
- Presence of *Legionella*
- *Legionella* concentration
- Presence of other heterotrophic bacteria
- Presence of protozoa and algae
- Presence of nutrients
- System size [(surface area available for biofilm development (compared with water volume)]
- Presence of biofilm
- Water quality:
  - cleanliness
  - pH
  - presence of corrosion products
  - presence of scale and fouling
  - conductivity/Total Dissolved Solids
  - control limits out of range
  - suspended solids
  - control of water treatment chemicals, bleed
- Water temperature
- Characteristics of make-up water
- Direct sunlight
- Physical condition of system
- Microbial control program
- Open system
- Aerosol generation
- Mode of operation
- Intermittent operation
- Seasonal usage
- Drift elimination
- Aerosol dispersion
- System location (distance to other cooling water systems, air intakes and passers by).

5 Identifying and Analysing the Risks of *Legionella*

5.6 Critical Risks for Cooling Towers

The development of an RMP which considers all these factors can be very complex, so we have identified the following five most critical risks associated with outbreaks of *Legionella* from cooling tower systems:

- Stagnant water
- Nutrient growth
- Poor water quality
- Deficiencies in the cooling tower system
- Location and access to cooling tower systems.

The Building *(Legionella)* Act 2000 and the Building (*Legionella* Risk Management) Regulations 2001 require each of these critical risks to be addressed in the Risk Management Plan. Failure to address these risks in the RMP will result in the independent accredited auditor being forced to fail the Plan and advise the Department of Human Services of the issue. Similarly, if the Plan does address the critical risks but is not implemented, the auditor will also have no choice but to fail the Plan and advise the Department. Addressing these risks will significantly reduce the likelihood of the cooling tower system contributing to an outbreak of Legionnaires' disease.

5.6.1 Stagnant Water

Stagnant water covers four risk factors outlined in AS/NZS 3666.3:

- Presence of water
- Mode of operation
- Seasonal usage
- Intermittent operation.

Stagnant water is a risk because:

- A lack of circulation will allow solids in the water system to settle out as sludge. This sludge is implicated in the growth of *Legionella* (as discussed in 5.6.2) and also causes corrosion.
- Any biocide delivered into the system will not reach all parts of the system in sufficient concentration to kill the bacteria. A reservoir of *Legionella* can develop in the biofilm (which is a combination of bacteria, algae, protozoa including amoebae and other micro-organisms). This can then reinfect the entire system, whenever the biocide levels drop.

Stagnant water often occurs if a cooling tower system is not used for periods of more than a month, where there are disused or superfluous pipes (also called 'dead legs') full of water, or where there are pipes full of water with little or no flow or turbulence.

The way that a cooling tower system is used is significant. The start-up time for a cooling tower is a critical point where potential problems can occur if it is not handled well. Well maintained cooling tower systems in use for most of the year are generally of lower risk than those that remain idle for more than one month. This is because the biofilm is not as readily disturbed with starting and stopping operations.

Where the system's circulation is shut down for a month or more, the water may become stagnant. The risk of problems when the system is next turned on increases significantly because *Legionella* may have grown in the stagnant conditions, where the biocide may not have reached all parts of the system.

'Dead legs': These pipe extensions are potential 'dead legs' that should be investigated, and if confirmed, either removed or activated

The lack of a recirculating pump controlled by a timer to circulate water through the system in times when the tower is not in use can be a key contributor to stagnant water.

Similarly if a tower system has 'dead legs', even with a high quality maintenance program it may not be possible to consistently meet the desired standards. The biocide may not reach all extremities of the system, allowing *Legionella* to grow and potentially regularly reinfect the system.

5.6.2 Nutrient Growth

Nutrient growth covers four risk factors outlined in AS/NZS 3666.3:

- Presence of nutrients
- Presence of biofilm
- Water temperature
- Direct sunlight.

The amount of nutrients in the water has a significant effect on the ability of bacteria to grow rapidly and so it needs to be controlled. The more nutrients there are in the water, the more 'food' there is for bacteria.

Environmental contamination can cause nutrients to enter into a cooling tower system. Dust generated on or off the site may enter the cooling tower system and provide a steady source of nutrients for bacteria and other organsims. Building demolition or construction, major roads, dirt roads or car parks may all generate dust. Other sources of nutrients include leaf litter from overhanging trees, bird droppings falling into the cooling tower or kitchen exhausts.

Algae, biofilm and corrosion all have the ability to conceal and protect *Legionella* from biocide in the water, increasing the risk posed by the cooling tower system.

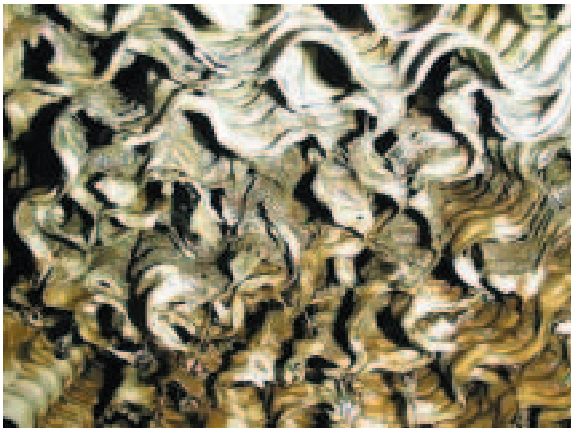
Algae can grow rapidly if the cooling tower water is exposed to sunlight. This most commonly happens when the tower basin or other wetted areas, such as the top wet deck of some types of cooling towers, are exposed to sunlight. Other types of cooling towers often have no sunlight protection for the tower basin. Inspection openings may be missing and also expose the fill to sunlight. Any algal growth will provide a food source for bacteria, including *Legionella*.

The control of biofilm is fundamental to minimising risks from *Legionella* in a cooling tower system. *Legionella* bacteria are relatively easily killed by moderate concentrations of many biocides, provided the bacteria are free-floating in the water and exposed to the biocide.

Hiding out: *Legionella* bacterium being engulfed by an amoeba

However, *Legionella* has adapted to survive in potentially adverse conditions with an ability to live and multiply within organisms called protozoa. These engulf the *Legionella* bacterium, but the bacterium continues to grow and multiply inside the larger organism. Protozoa can resist much higher concentrations of biocides. *Legionella* survives inside the protozoa, particularly when the larger organism has become part of the biofilm typically found on the inside of pipes and other wetted surfaces. The biofilm may peel away from the pipe surface for a range of reasons, including physical disturbance. The *Legionella* bacteria may then be released into the recirculating water and be discharged out of the tower inside water aerosols, before any biocide has had a chance to kill the bacteria. Biofilm can form on any of the wetted surfaces of the cooling tower system.

Biodispersants, which are low foaming detergents, are used to break down biofilm. Systems in which biodispersants are not present are at significantly higher risk of nutrient growth and biofilm formation.



Biofilm build-up: Fill inside a cooling tower with biofilm showing as visible slime, preventable with use of biodispersants and regular cleaning

Corrosion is also regarded as a risk factor, because any corrosion in the system may release iron as a product and iron is a growth factor for *Legionella*. Internal surfaces of a cooling tower system may also become heavily corroded, unless anti-corrosion chemicals are used and corrosion levels monitored carefully.

The temperature of the recirculating water can have an impact on the growth of nutrients. It is impossible to eliminate bacteria from a cooling tower system, so water temperature will be a factor in bacterial growth rates.

5.6.3 Poor Water Quality

Poor water quality covers seven risk factors outlined in AS/NZS 3666.3:

- Presence of *Legionella*
- *Legionella* concentration
- Presence of other heterotrophic bacteria
- Presence of protozoa and algae
- Water quality
- Characteristics of make-up water
- Microbial control program.

This is a risk because poor water quality has a direct effect on the likelihood of *Legionella* multiplying in a cooling tower system. Water quality is affected by things such as the:

- External contamination of the water with dust or soil.
- Accumulation of solids in the system.
- Choice and levels of biocides and anti-corrosives.
- Presence of high levels of bacteria and *Legionella*.
- Provision of nutrients supporting microbiological growth.

Systems which do not have a comprehensive water treatment program or are not monitored for bacterial levels are significantly more likely to have poor water quality.

5.6.4 Deficiencies in the Cooling Tower System

Deficiencies in a cooling tower system covers five of the risk factors outlined in AS/NZS 3666.3:

- System size
- Physical condition of system
- Open system
- Aerosol generation
- Drift elimination.

A cooling tower system that is poorly designed or maintained is a risk because:

- High water temperature allows rapid bacterial growth.
- Aerosols that may be contaminated with *Legionella* can more easily leave the tower.
- Unsafe conditions such as non-existent, unstable or rusted climbing ladders pose a risk to people who need to access the tower. Consider the method and condition of access to the towers and other parts of the system for authorised maintenance workers, to ensure a safe working environment.

The physical design, maintenance and operating performance of the tower and related system can have a significant impact on the potential risk of *Legionella* transmission. If the system is undersized and water temperature is too high, this increases the potential for rapid bacterial growth. The risk of aerosol distribution is much greater without design modifications such as fitting an effective drift eliminator.

System size is also important, because towers with low water volume will have a high water turnover and the biocide is less likely to be effective. In this case, the choice and concentration of biocide needs to be matched to the low water volume.

5.6.5 Location and Access to Cooling Towers

The location of and access to cooling towers covers two risk factors outlined in AS/NZS 3666.3:

- Aerosol dispersion
- System location.

The location of, and access to, cooling towers can be a risk because:

- A poorly located tower can be subject to environmental contamination, for example, from building sites. This can increase the level of nutrients and with it, the number of bacteria, including *Legionella*.
- A cooling tower system located in an area where large numbers of people have access can be a particular problem if the system becomes contaminated with *Legionella*. The number of people that will be potentially exposed to the tower is high. If the people exposed to the tower are from a susceptible group, the risk will be higher.

The extent to which people are exposed to aerosols is an important factor when assessing the risks associated with a cooling tower system.

First consider whether the tower is located in or near an acute health or aged residential care facility. This is important, because of the potential for highly susceptible people to be exposed to the tower aerosols. The residents of these types of facilities are most at risk of serious health consequences if an outbreak of Legionnaires' disease occurs.

Then estimate the number of people who come within close proximity of the tower in a day. The number of people who may be exposed to the tower aerosols will impact on the size of an outbreak. It is therefore a significant consideration in a risk assessment. Look closely around the immediate area of the cooling towers. They are sometimes located close to heavily trafficked areas, such as footpaths or roads. Some workplaces with a policy of not allowing smoking inside buildings have developed practices where smokers leave the building to smoke. Monitor the area around each cooling tower to ensure that it is not an area where smokers congregate. This is a high risk situation, given the potential for cooling towers to discharge *Legionella* contaminated aerosols and the evidence that smoking is a risk factor for Legionnaires' disease.

6 Evaluating the Critical Risks

The previous section identified and analysed the critical risks. In this section we evaluate these risks.

Cooling tower with basin exposed to sunlight: This cooling tower does not have sunlight protection to the side and basin of the tower

6.1 Risk Classification Criteria

The critical risks described in the previous section can, if worked through carefully, allow for an accurate judgement to be made about the quality of a cooling tower system. A further process is needed to turn that judgment into an estimate of the overall risk.

To simplify an otherwise complex task requiring significant knowledge of risk management, some **critical questions** are suggested that relate directly to the critical risks. These questions should be answered for every cooling tower system, to help evaluate the overall risks. This approach is particularly suitable for small installations, where access to risk management specialists is not readily available.

The end result of this risk evaluation is a recommendation on how to classify your cooling tower system. In section 7, this recommendation is used to help you treat these risks and develop your operational program.

• Stagnant Water

Is the cooling tower system (or part of the system) idle for more than a month?

Comment: The way that the tower system is used is important. Lack of water circulation is likely to result in solids in the system settling out as sludge. This may encourage the formation of biofilm. Similarly, lack of circulation will almost certainly mean that any biocides or other chemicals being added will not reach all parts of the system. Well maintained systems in use for most of the year are generally of lower risk than systems that are intermittently used. Cooling tower systems used in conjunction with air conditioning systems are commonly shut down over winter, creating potential 'dead legs'.

Where the system (or part of the system) is idle for more than a month, is a recirculating pump with a timer fitted to automatically circulate the water at regular intervals, to prevent it becoming stagnant?
Comment: Fitting a recirculation pump to move the water around all parts of the system is an effective risk reduction strategy in these situations.

Are there 'dead legs' present?
Comment: 'Dead legs' in a cooling tower system are characterised by pipes that are full of water, but with little or no flow through the pipes. Biocide added to one part of the system is unlikely to reach all parts of the system to control bacterial growth. Also, a lack of flow through the system will allow solids in the water to settle out in the pipe as sludge. A potential 'dead leg' is regarded as any pipe that branches off from another main pipe and has a length longer than the diameter of the main pipe. Other components of a cooling tower system such as off-line chillers or stand-by pumps may also become potential 'dead legs'.

'Dead legs' have been linked to consistent problems with maintaining water quality and the presence of *Legionella,* due to the difficulty in killing *Legionella* in such areas.

• Nutrient Growth

Are there factors in and around the site that may lead to environmental contamination and an increase in the level of nutrients in the cooling tower system?
Comment: Environmental contamination provides nutrients that can encourage more rapid bacterial growth. The introduction of high levels of solids will also reduce the effect of biocides. Inspect the site and identify potential nutrient sources.

Nutrients may be introduced through dust from building demolition or construction sites, heavy traffic, unmade roads or car parks, trees or other vegetation and birds or other animals. Once identified, this can be taken into consideration in developing the RMP.

Is there a corrosion control program?
Comment: Without adequate corrosion control, iron may be released as a product of corrosion, encouraging *Legionella* to grow.

A good corrosion control program will include both the continuous addition of anti-corrosion chemicals and close monitoring of the impact of the recirculating water on the metal surfaces of the tower system. This is generally done by regular inspection (at least quarterly) of test plates, called corrosion coupons. These are made of identical metals to those used in the system. Under some circumstances, chemical testing to measure the concentration of soluble copper and iron in solution is used as a supplement to the use of corrosion coupons. It is also important to regularly inspect components such as condensers for corrosion on an annual basis.

Are any of the wetted surfaces exposed to sunlight?
Comment: A physical check of the cooling tower should confirm whether any of the wetted surfaces, including the water in the basin, wet deck (if present) and fill, are exposed to sunlight.

Is a biodispersant used?
Comment: Biodspersants should be applied to continually break down biofilm as it forms. Biodispersants need to be compatible with the other chemicals that are to be used.

• Poor Water Quality

Has an automated biocide dosing device been fitted?
Comment: Siphon devices intended to deliver biocide into the cooling tower water are known to block up regularly and as a result, biocide may not be delivered to the cooling tower water. Similarly, manual dosing is totally reliant on operator reliability and quality. An automated biocide dosing device is a significant improvement over a siphon device or manual dosing, in that a pre-set amount of biocide (and other chemicals) can be injected into the recirculating water at regular intervals. There are various types of automated devices; the most sophisticated types monitor chemical parameters and add varying amounts of biocide, depending on the water quality.

Automated biocide dosing: This device has a timer which controls a pump to inject a pre-set volume of biocide into the water

As with any method of biocide dosing, a calculation of the total water volume of the system must be made, so that the correct amount of biocide is used to obtain the manufacturers' recommended concentration required to kill *Legionella*. This concentration will vary, depending on the particular biocide used. Automated biocide dosing devices with poorly calculated dosing will not be effective, so both aspects must be addressed.

Is a comprehensive water treatment program in place?
Comment: A comprehensive water treatment program usually includes the use of:

- Two or more biocides in combination, to reduce the likelihood of *Legionella* becoming resistant to a particular biocide. These must be used in the appropriate concentrations and at least one must be proven to be effective in controlling *Legionella*.
- A biodispersant compatible with the chemicals in use (including chlorine).
- Chemicals or other agents to effectively minimise scale formation, corrosion and fouling.
- Control measures relevant to the water treatment process involved, monitored very frequently, which collectively inspire confidence that the cooling tower system water chemistry is under effective control. These control measures may include parameters such as the concentration of

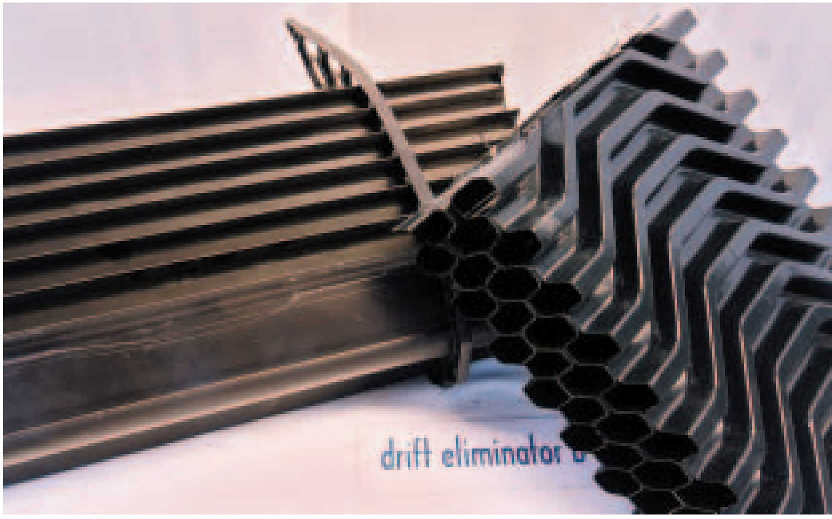
biocides, levels of solids/conductivity, pH and water clarity.
- Effective biocide dosing to maximise the impact of the biocides.

• Deficiencies in the Cooling Tower System

Is a modern, high efficiency drift eliminator fitted to all cooling towers in the system?
Comment: Cooling tower systems that have towers that are not fitted with an effective, modern drift eliminator present a higher risk of an outbreak of Legionnaires' disease in the event that the water treatment regime fails. A drift eliminator fitted and installed to Australian Standards can significantly reduce the amount of aerosols that would otherwise leave the tower. If the water treatment fails or is ineffective, these aerosols can contain *Legionella*. The Australian Standard (AS/NZS 3666) establishes a performance standard for drift eliminators. This is highly difficult to verify in practice, so check with the manufacturer. As a minimum, check the drift eliminator is of modern, high efficiency design. Where the drift eliminator **does** meet the Standard, its condition and position should be checked to ensure it has not been bypassed.

Has a review of system design been conducted?
Comment: A review of the system design may highlight issues that impact on overall system risk. For example, automated valves that shut off part of the system for lengthy periods of time may create stagnant water.

Detailed operational manuals will assist this process greatly, but where these are not available, the review ought to ensure that there is a detailed understanding of how the system works and of water flows. Mechanical services contractors may be required to assist with a review of more complex systems. Where a detailed understanding of the system design already exists, additional work may not be required.



Drift eliminator: This shows a typical modern drift eliminator

The review should also establish if the system complies with AS/NZS 3666.1. It is likely only relatively new towers will comply in all respects. The key features of this Standard include:

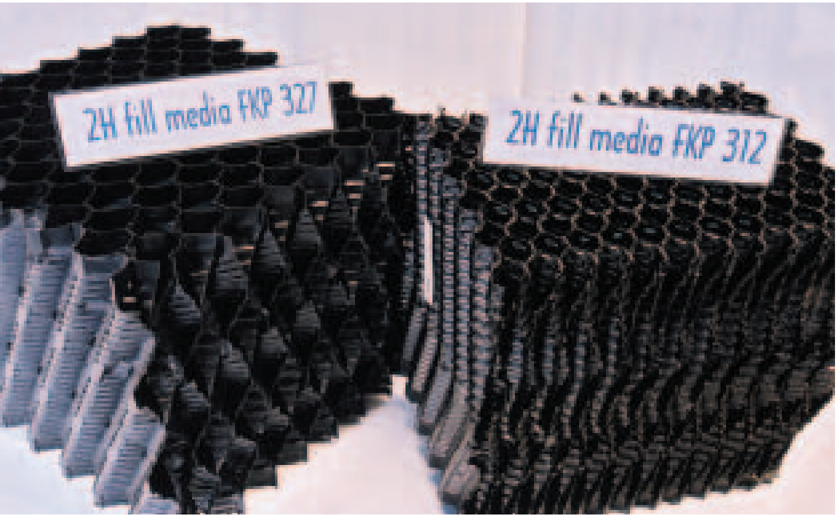
- Easy and safe access for maintenance
- Automatically controlled water treatment systems
- Materials used in construction
- Tower fill
- Ease of cleaning including drainage of basins
- Drift eliminators
- Splash prevention
- Location
- Bleed-off
- Sunlight protection.

As constructed plans may assist with this review.

To respond positively to this question in the risk assessment it is expected that as a minimum an assessment be made to check that:

- There is easy and safe access to the towers to allow for cleaning and maintenance. Without such access it may not be possible to adequately clean or maintain the system.

6 Evaluating the Critical Risks



Modern fill: Fill made of materials such as polypropylene is now available for retrofitting to most types of cooling towers.

- The tower fill and drift eliminator are installed correctly and in good condition.
- Wetted surfaces are protected from sunlight.
- The towers discharge exhaust away from occupied areas, pedestrian thoroughfares, air intakes, building openings, trafficable areas and avoids contamination by the exhaust discharges of air-handling systems such as kitchen exhausts or other cooling tower systems.

Has a review of system operation and performance been conducted?

Comment: A review of the operation of the system can detect practices or procedures that actually increase the risks of Legionella growing in the system. Such as review should confirm how the system is used including any manual or automated operation controlling water flow or water temperature.

• Location and Access

Is the tower system located in, or near an acute health or aged residential care facility?

Comment: There is potential for highly susceptible individuals to be exposed to the tower aerosols in these types of facilities. Typically, their occupants are at greater risk of infection than other members of the community. Cooling tower systems located in acute health or aged residential care facilities are always classified as the highest risk, regardless of the condition of the tower or operational program. A cooling tower system located near such a facility is regarded as high risk. Where an RMP is being developed for a cooling tower system located near an acute health or aged care residential facility, it is good practice to discuss the development of the plan with the facility's management.

• Location and Access

How many people come within close proximity to the tower within a day?

Comment: People who come into close proximity to the tower may become exposed in the event that the system becomes contaminated and allows *Legionella* to escape as aerosols. There is no exact or defined distance beyond which a tower is regarded as safe, so it is difficult to make this estimate[1]. Clearly anyone working, visiting or living on or near the site of the tower is at a higher level of risk than someone who does not pass anywhere near to the tower.

Later we will use the term 'very high', 'high', 'moderate' and 'low' to describe the potential numbers of people exposed to a tower system. Figure 10 describes examples of sites that fit these descriptions.

1 One study suggested that there is higher risk of contracting Legionnaires' disease where the cooling tower is located within 500 metres of the place of residence (Bhopal, Fallon, Buist, Black, Urquhart, 'Proximity of the home to a cooling tower and risk of non-outbreak Legionnaires' disease', BMJ 1991 Feb;302 (6773):378-83).

Figure 10

Potential numbers of people who may be exposed to a cooling tower system	Examples of sites which fit the description
Very High	All buildings within large business districts For example, Melbourne Central Business District, Southbank, Geelong Business District.
	Major place of assembly or entertainment.
	Large suburban and regional shopping complexes.
	Office towers.
High	Large strip shopping precincts.
	Workplaces including factories with significant staff numbers.
	High density residential areas.
	Apartment buildings in city fringe areas.
Moderate	Small strip shopping precinct.
	Smaller workplaces.
	Low density residential areas.
Low	Rural site. For example, dairy milking sheds.
	Tower located well away from public gathering places, or thoroughfares with few workers.

Of those exposed to the aerosols from a tower, not all may be susceptible to Legionnaires' disease, but generally it will be difficult to make an estimate of those numbers. For this reason, unless there are special circumstances where significant numbers of groups at risk come in close proximity to the tower, the overall number of people can be used as a guide.

Where you have special local circumstances, these need to be taken into consideration in your risk assessment. For example, if the cooling tower is located next to a senior citizens club, a higher risk classification should be used. Similarly, where the number fluctuates greatly to a much larger number, say once or twice a year with a special event, use the highest estimate for the purposes of categorising the system.

6.2 Evaluating the Risk Associated with a Cooling Tower System

The first step in evaluating the risk associated with a particular cooling tower system is to understand and describe the existing situation. Figure 11 lists the questions that should be considered for each critical risk, based on the earlier risk analysis.

6.2.1 Risk Classification

Responses to these questions will enable you to establish the overall risk associated with a cooling tower system using the Cooling Tower Risk Classification Table (Figure 12).

We have evaluated possible responses to these questions. For the various combinations, we have evaluated the combined risk and developed a logical

Figure 11 Risk Evaluation Table

Critical risk	Question
Stagnant water	Is the system (or part of the system) idle for more than a month?
	Where the system (or part of the system) is idle for more than a month, is a recirculating pump with a timer fitted to automatically circulate the water at regular intervals, to prevent it becoming stagnant?
	Are there 'dead legs'?
Nutrient growth	Are there factors in and around the site that may lead to environmental contamination and an increase in the level of nutrients in the cooling tower system?
	Is there a corrosion control program?
	Are any of the wetted surfaces exposed to sunlight?
	Is a biodispersant used?
Poor water quality	Has an automated biocide-dosing device been fitted?
	Is a comprehensive water treatment program in place?
Deficiencies in the cooling tower system	Is a modern, high efficiency drift eliminator fitted to all cooling towers in the system?
	Has a review of system design been conducted?
	Has a review of system operation and performance been conducted?
Location and access	Is the tower system located in or near an acute health or aged residential care facility?
	How many people come with close proximity to the tower within a day?

grouping within the table. Different cooling tower systems are grouped into a category with similar overall risks. There are four risk categories: A, B, C and D.

These risk categories are used in Section 7 to help you select an appropriate maintenance or operational program.

6.2.2 Using the Risk Classification Table

The table (Figure 12) lists each of the critical risks in the left hand column and for each risk, the possible combinations of responses to the questions in Figure 11 are listed to the right.

You should be able to find a response that matches the situation with your system for each question.

If your system matches any of the combinations of responses in a particular row (for example the row associated with the stagnant water critical risk), then the risk classification is to be found at the base of the column in which the combined response is located (A, B, C or D). A is the highest risk and D is the lowest risk.

The overall risk associated with a particular system is the highest classification obtained for **any** of the critical risks.

For example:

- If a system **does match** a response to any critical risk in column A then the overall risk classification is Risk Category A.
- If a system **does not match** a response to any critical risk in column A **but does match** a scenario in column B then the overall risk classification is Risk Category B.
- If a system **does not match** a response to any critical risk in column A or column B **but does match** a scenario in column C then the overall risk classification is Risk Category C.
- If a system **does not match** a response to any critical risk in column A, column B or column C **but does match** a response to any critical risk in column D then the overall risk classification is Risk Category D.

This process of categorising the cooling tower system should be:

- Completed prior to developing a maintenance or operational plan.
- Repeated for every cooling tower system on the site.
- Repeated whenever the cooling tower system or environmental conditions are changed (for example, by completion of a works program).

Section 7 discusses how to treat each of the critical risks and strategies for reducing your overall risk classification.

Figure 12 Cooling Tower System Risk Classification

Cooling Tower System Risk Classification				
Critical Risk	**Higher risk** →			**Lower risk**
Stagnant Water	System is idle more than one month **and** Recirculating pump with timer not fitted **and** 'Dead legs' exist	System is idle more than one month **and** Recirculating pump with timer fitted **and** 'Dead legs' exist	**Any ONE of the following:** System is idle for more than one month **or** 'Dead legs' exist	System operates continuously **and** No 'dead legs'
Nutrient Growth	**Any THREE of the following:** Environmental contamination **and** No corrosion control program **and** Wetted surfaces not protected from sunlight **and** No biodispersant used	**Any TWO of the following:** Environmental contamination **or** No corrosion control program **or** Wetted surfaces not protected from sunlight **or** No biodispersant used	**Any ONE of the following:** Environmental contamination **or** No corrosion control program **or** Wetted surfaces not protected from sunlight **or** No biodispersant used	No significant environmental contamination **and** Corrosion control program exists **and** Wetted surfaces protected from sunlight **and** Biodispersant used
Poor Water Quality	No automated biocide dosing device installed **and** No comprehensive water treatment program in place	No automated biocide dosing device installed **and** Comprehensive water treatment program in place	Automated biocide dosing device installed **and** No comprehensive water treatment program in place	Automated biocide dosing device installed **and** Comprehensive water treatment program in place
Deficiencies in the Cooling Tower System	Modern, high efficiency drift eliminator not fitted **and** No review of system design **and** No review of system operation and performance	Modern, high efficiency drift eliminator not fitted	Modern, high efficiency drift eliminator fitted **and at least ONE of the following:** No review of system design **or** No review of system operation and performance	Modern, high efficiency drift eliminator fitted **and** System design reviewed **and** System operation and performance reviewed
Location and Access	System is located in an acute health or aged residential care facility **or** Very high numbers of people are potentially exposed	System is located near an acute health or aged residential care facility **or** High numbers of people are potentially exposed	System is not located near an acute health or aged residential care facility **and** Moderate numbers of people are potentially exposed	System is not located near an acute health or aged residential care facility **and** Low numbers of people are potentially exposed
Risk Classification	If your system matches **any** of the above responses, the Risk Classification for the system is **A**[1]	If your system matches **any** of the above responses and does not match **any** of the responses in Risk Classification A, the Risk Classification for the system is **B**	If your system matches **any** of the above responses and does not match **any** of the responses in Risk Classification A or B, the Risk Classification for the system is **C**	If your system matches **any** of the above responses and does not match **any** of the responses in Risk Classification A, B or C, the Risk Classification for the system is **D**
	Higher risk →			**Lower risk**

1 The only exception to this table is with regard to Category A systems which would fall into this category only because of the **number** of people who are potentially exposed to the cooling tower system. In this case, an exception is provided to classify these systems within Category B provided that the system meets the prerequisites described in Section 6.2.2.1.

6.2.2.1 Exceptions to Cooling Tower System Risk Classification

It is important to strive for ongoing improvement and continual minimisation of risks associated with cooling tower systems. Capital improvements can assist in this objective. As an incentive for organisations to continue upgrading their cooling tower systems, the risk classification table makes an exception with regard to systems classed as Category A, only because of the **number** of people who are potentially exposed to the cooling tower system. In this case, an exception is provided to classify these systems within Category B, **provided that the system meets the prerequisites described below.**

These systems can be categorised in Category B where the system meets the following prerequisites:

- There are either no ‘dead legs', or where potential ‘dead legs’ exist, they have been activated.
- The system or part of the system is either not idle for more than a month, or where it is idle, a timer has been fitted to control a recirculating pump that circulates the water in the system at least once a day.
- There is a corrosion control program involving both anti-corrosive chemicals and corrosion monitoring, using corrosion coupons or an equivalent technique.
- The water in the system and the wetted surfaces of the system are protected from sunlight.
- Control measures are established and monitored.
- The system is fitted with a high degree of automation to monitor the water chemistry, incorporating:
  - Effective automated dosing systems to deliver all chemicals into the recirculating water. These are connected to alarms (and preferably building automation systems) to warn of pump failure or a failure in the supply system (to warn a human operator of the problem).
  - Chemicals or other agents to effectively minimise scale formation and fouling.
  - Biodispersant is applied which is compatible with chemicals in use (including chlorine).
  - At least two biocides, including at least one oxidising biocide, that have separate chemical stores and separate dosing mechanisms.
  - Automated bleed–off systems using conductivity probes with a locking device to prevent bleed at the time of chemical dosing. This should ideally be connected to the building automation system.
  - pH meters connected to the building automation system.
- After all of the above actions have been taken, six months of intense testing to demonstrate consistent chemical and bacterial test results that indicate that the system is under control.

Note that acute health or aged residential care facilities should *always* be classified as Category A, because of the population of vulnerable people.