

*Guidance for the
control of Legionella*

National Environmental Health Forum Monographs

Water Series No. 1

Guidance for the Control of Legionella

Clive Broadbent

Reviewed by the South Australian Legionella Advisory Committee
(Scott Cameron, David Cunliffe, Richard Bentham, Trevor Steele, John Ingham, Martyn Kirk)

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Water Series No. 1

National Environmental Health Forum



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Preface

The National Environmental Health Forum has been established by the Directors of Environmental Health from each State and Territory with a secretariat provided by the Commonwealth Department of Health and Family Services.

The National Environmental Health Forum is publishing a range of monographs in three separate series dealing with soil, water and air to give advice and guidance on a variety of important environmental health matters. This publication is the first in the water series.

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Special acknowledgement

Special acknowledgement is made of the late Dr Gerry Murphy for the key role he played in the development of this document. Dr Gerry Murphy, as the Director of Public Health, Queensland Health Department, was a member of the NHMRC Public Health Committee and was Chairman of its Working Party which was established to review the 1989 NHMRC 'Australian Guidelines for the Control of Legionella and Legionnaires' Disease'. That review culminated in this publication.

Dr Gerry Murphy was a prominent and highly regarded figure who contributed greatly to public health in Australia. He was also a colleague and friend to many in public health in Australia, particularly those working in the environmental health area. All were saddened by his death in December 1995.

Disclaimer

This document has been prepared in good faith exercising due care and attention. However, no representation or warranty, expressed or implied, is made as to the relevance, accuracy, completeness or fitness for purpose of this document in respect of any particular user's circumstances. Users of this document should satisfy themselves concerning its application to, and where necessary seek expert advice about, their situation. The NEHF, its participants and the DHS shall not be liable to the purchaser or any other person or entity with respect to any liability, loss or damage caused or alleged to have been caused directly or indirectly by this publication.

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1. Introduction

1.1 Background

This booklet provides guidance on the control of *Legionella* in building water systems and other sources. It replaces the document entitled “Australian Guidelines for the control of Legionella and Legionnaires’ disease”. That document, published in 1989, foreshadowed a need for a revision as more information about *Legionella* came to light.

This guidance booklet therefore reflects this progress including laboratory and field research and the findings from recent outbreaks that have occurred. Even so, our knowledge of the bacterium, the routes of infection and the best means of preventing infection is incomplete and further revisions may be necessary.

1.2 Legionellosis

The outbreak of pneumonia amongst American ex-servicemen attending a bicentennial convention in a Philadelphia hotel in July 1976 resulted in the discovery of a bacterium later named *Legionella pneumophila* and the recognition and description of Legionnaires’ disease.

L. pneumophila was subsequently found to be only one species within the genus *Legionella*. To date some 39 species have been named and around half have been associated with infection in humans. Named species are listed in Table 1.

Illnesses attributed to *Legionella* have been both pneumonic and non-pneumonic. All infections caused by *Legionella* species are covered by the general term “legionellosis”. They are notifiable in all Australian states and territories, i.e. cases must be notified to the respective health authority. It is generally accepted that infection requires pathogenic legionellae (*Legionella* cells) to be dispersed in aerosols in such a way that they can be inhaled by susceptible humans. Methods for reducing the risk of infection are discussed in this booklet.

2. Natural habitats

The distribution of *Legionella* is world-wide and legionellae have been found in fresh or brackish water, coastal waters, mud, soil at the banks of water courses, and in potting mixes.

In its natural habitats, *Legionella* obtains its requirements for multiplication (i.e. cell division) through interactions with other microorganisms such as algae, protozoa and other bacteria, and by the utilisation of organic and inorganic material.

L. pneumophila and other species multiply in the temperature range of 20 to 45°C but most rapidly between 30 and 43°C. They survive freezing but die with increasing rapidity as temperatures rise above 45°C. At 70°C the organism is killed almost instantly.

Legionellae infect and multiply in free-living soil and freshwater amoebae. Persistence of legionellae in these amoebae may provide a means of dispersal and survival in ambient air conditions which would otherwise have resulted in their death from desiccation. When in water, amoebae may also protect parasitic legionellae from disinfection.

Table 1: Legionella species

L. adelaidensis (a)	L. londiniensis
L. anisa	L. maceachernii
L. birminghamensis	L. micdadei
L. bozemanii SG 1&2	L. moravica
L. brunensis	L. nautarum
L. cherrii	L. oakridgensis
L. cincinnatiensis	L. parisiensis
L. dumoffii	L. pneumophila SG 1-16
L. erythra	L. quateirensis
L. feeleii SG 1&2	L. quinlivanii SG 1&2 (a)
L. fairfieldensis (b)	L. rubrilucens
L. geestiana	L. sainthelensi SG 1&2
L. gormanii	L. santicrucis
L. gratiana	L. shakespearei
L. hackeliae SG 1&2	L. spiritensis
L. israelensis	L. steigerwaltii
L. jamestownensis (a)	L. tucsonensis
L. jordanis	L. wadsworthii
L. lansingensis	L. worsleiensis
L. longbeachae SG 1&2	

- (a) *first isolated in Adelaide*
(b) *first isolated in Melbourne*

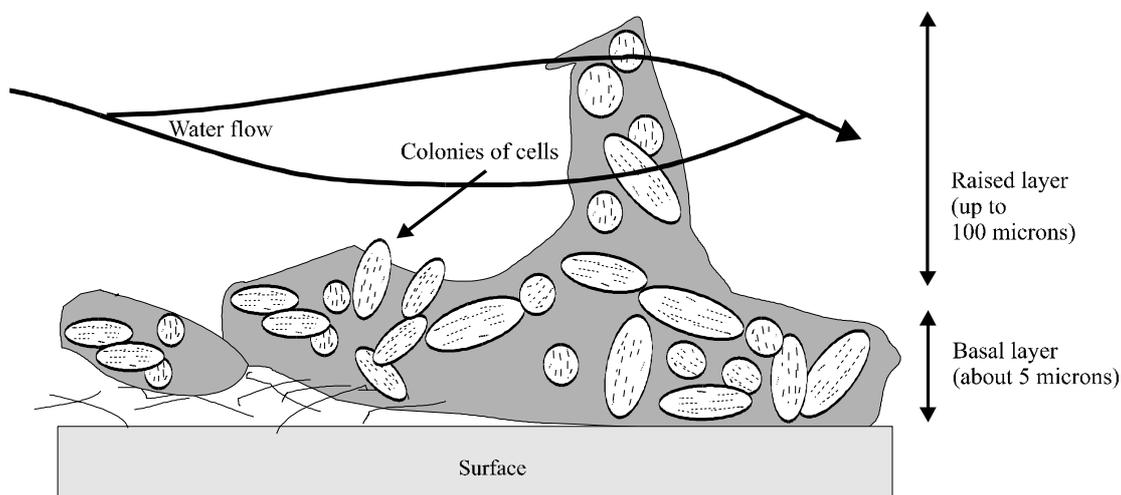
3. Presence in urban and industrial aquatic habitats

The modern urban environment provides a wide diversity of sites for *Legionella* to colonise and, should environmental conditions suit, to multiply to high concentrations. These sites predominantly comprise equipment such as cooling towers, hot and warm water systems and spa pools.

4. Multiplication in biofilm

Legionellae proliferate in biofilms which are slimy layers of bacteria, other microorganisms, and their byproducts as well as entrained matter as shown in Figure 1.

Figure 1: Biofilm



Adapted from Keevil et al (1993)

Multiplication is encouraged if nutrients are available, temperature is appropriate, and the water system is shutdown, used only occasionally (say, less often than weekly) or the pipework contains “dead-legs”. A dead-leg is a length of pipe that is capped at the end or provided with an end fitting through which water flows only rarely when the fitting is opened.

As biofilms develop, portions may peel away from the surface due to disturbance, turbulence, microbial competition or other causes and thus seed the circulating water with biofilm organisms.

This mechanism of seeding may account for apparent blooms of legionellae in water systems.

Intracellular multiplication of legionellae within larger microorganisms notably protozoa, that are also common in services with warm water such as cooling water systems, is considered to be a significant growth mechanism.

5. Airborne transmission of *Legionella*

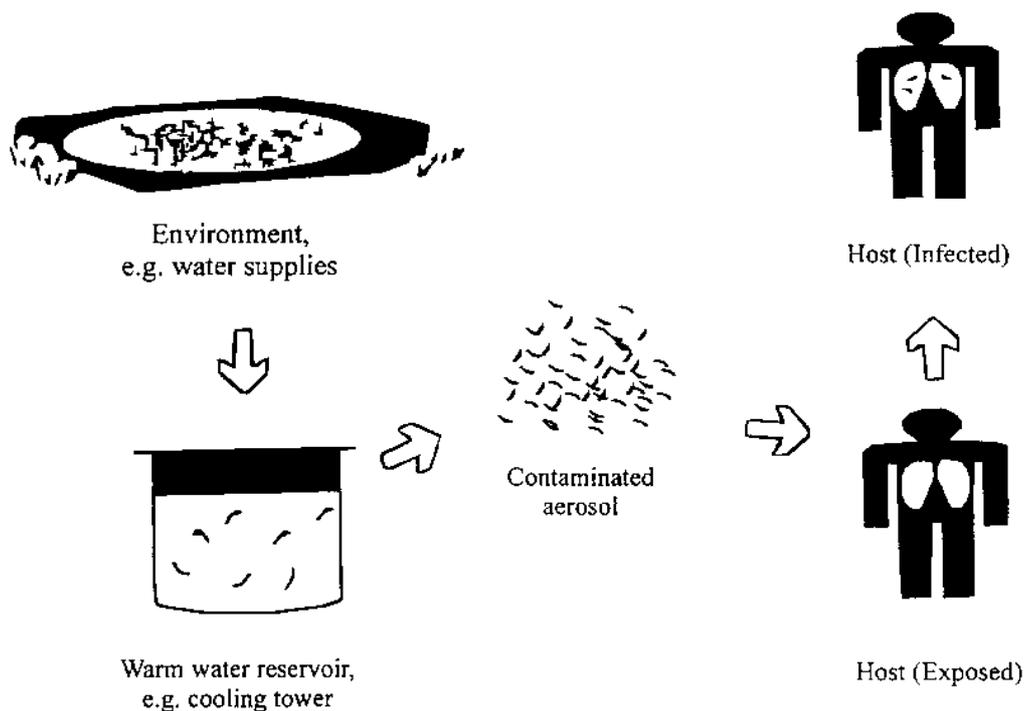
Legionellae may be dispersed from water systems if aerosols are discharged. This airborne phenomenon has been demonstrated by air sampling. While cooling towers can discharge aerosols in their exhaust air stream, they are not the only type water handling equipment able to do so. Spa pools, decorative fountains, humidifiers and domestic showers have also been implicated in causing infection.

Factors encouraging survival of aerosolised legionellae while carried on air currents include high humidity, absence of sunlight and lack of direct exposure to desiccation.

Wind velocity and climatic factors such as temperature inversions also influence survival and the distance over which the bacteria may travel.

The chain of transmission of legionellae from water sources is shown in Figure 2.

Figure 2: Chain of transmission of legionellae



Adapted from Barbaree, Breiman and Dufour (1993)

6. Infection and disease

Contact between humans and *Legionella* in both natural and urban environments would seem to be inevitable and is certainly very common. This rarely results in illness. Lung infection does not result from drinking or washing in water containing low numbers of legionellae, nor from contact with a person suffering from legionellosis. The inhalation of an aerosol containing bacteria may result in an infection which is not accompanied by any recognisable symptoms. Many adults possess antibodies that react with *Legionella*. It is not clear whether these antibodies result from contact with legionellae or are a response to antigens present in other common bacteria but closely related to those present in legionellae.

Illness resulting from infection with *Legionella* takes several forms:

- Respiratory illnesses which affect the lung and which may resolve without specific treatment. On the other hand, cases may be severe and pneumonia may be accompanied by involvement of multiple organs usually brain, kidneys, liver and bowel giving rise to symptoms of mental confusion, renal and liver failure and diarrhoea.

About 3 to 5 per cent of cases of pneumonia admitted to hospital in Australia suffer from legionellosis.

The incubation period of Legionnaires' disease ranges from 2-10 days or more. The current case fatality rate is, on average, around 15 per cent but the fatality rate may reach 50 per cent in severely affected or immunocompromised patients.

- Pontiac fever which is a non-invasive illness associated with respiratory exposure to legionellae or their antigens. It has been described with *L. pneumophila*, *L. anisa* and *L. feeleii* and also *L. micdadei* when it was called Lochgoilhead fever. Pontiac fever has an

incubation period ranging from 4-66 hours and presents as a short influenza-like illness with no pneumonia and with full recovery: a high percentage of those with significant exposure develop symptoms.

A number of factors influence the likelihood of illness being associated with infection:

- The virulence of the bacteria which varies between species and subtypes. Some appear to be more commonly associated with human disease. Though most isolates from patients with Legionnaires' disease belong to *L. pneumophila* serogroup 1, only some subtypes of that subgroup have been associated with epidemic disease.
- Sufficient bacteria must be present in an aerosol to cause an infection. The aerosol particle size needs to be small (2-5 µm) so that the microorganisms can reach sites deep in the lung where infection can occur.
- Legionnaires' disease tends to occur in people who:
 - are over 50 years old;
 - are male;
 - have a history of smoking;
 - have heavy alcohol intake; or
 - have medical conditions or treatments that impair the body's defence mechanisms.

7. Legionellosis in Australia

While there is evidence for earlier sporadic cases of Legionnaires' disease in Australia, the first outbreak, involving two proven and three possible cases, occurred in Melbourne in 1979. Two other cases were linked to a hospital in Ballarat in the same year. Since then there have been several large outbreaks or clusters of cases (Table 2). The majority of cases appear to be sporadic with the source of the infection not being established. It is possible that common source outbreaks have occurred without being recognised.

Table 2: Significant outbreaks of legionellosis in Australia

Year	Location	Outbreak area	Putative source
1979	Melbourne	light industrial building	medium sized evaporative condenser
1979	Ballarat	psychiatric hospital	shower water system
1985	Wollongong	social club building	small cooling tower
1986	Adelaide	community	small cooling tower at hospital
1987	Wollongong	shopping centre	small cooling tower at a shop
1988	Adelaide	community	potting mixes
1989	Sydney	bowling club	small cooling tower
1989	Burnie	community	small cooling tower at hospital
1992	Sydney	shopping centre	small cooling tower
1994	Sunshine Coast	holiday apartment unit	private spa pool
1995	Sydney	shopping centre	small cooling tower

The number of cases of legionellosis reported each year is around 180, a rate of 1.0 case per 100 000 population (Table 3). Based on overseas data, the true incidence of disease in Australia may be much higher because many infections may be sub-clinical or undiagnosed. Legionnaires' disease is a notifiable disease in each state.

Initially, all notified cases of legionellosis in Australia were due to *L. pneumophila* but by 1988 it became clear that several other species, including *L. micdadei*, *L. bozemanii* and *L. longbeachae*, could cause illness.

Table 3: Notified cases of legionellosis in Australia

Year	Cases	Male to Female ratio	Prevalent age group (males)
1992	185	2.4 to 1	70-74
1993	178	1.9 to 1	80-84
1994	179	2.2 to 1	65-69
1995	172	not yet available	not yet available

Source: Communicable Diseases Intelligence reports produced by the Communicable Diseases Branch, Federal Department of Human Services and Health, Canberra.

Peak seasons for onset of disease appear to be summer-autumn for cases due to *L. pneumophila* and spring for *L. longbeachae* cases. Geographical distribution is wide and generally reflects the size of metropolitan populations.

8. Sources of Legionellae causing outbreaks

In general the sources of legionellae implicated in outbreaks of legionellosis worldwide have been traced to air conditioning plants or to hot water distribution systems which have been incorrectly commissioned or have been poorly maintained. Aerosol drift from cooling tower exhausts may enter doors, windows, and ventilation air intakes of buildings.

Release of aerosols from water distribution systems may occur from shower heads or, to a lesser extent, from water splashing in hand basins or baths.

Spa pools are another significant potential hazard. Wherever water is disturbed there is the possibility that it will splash and introduce droplets and aerosols into the air.

In Australia major outbreaks have been traced to small cooling towers and to evaporative condensers associated with refrigeration systems. Small numbers of cases have been associated with warm water services and with spa pools.

Infections due to *L. longbeachae* serogroup 1 in Australia and New Zealand have been associated with gardening activities. Many of those infected had used potting mixes or composts shortly before illness commenced.

9. Brief description of common sources

9.1 Cooling water systems

Cooling towers are a type of heat rejection device used in many cooling water systems such as those serving refrigeration or air conditioning plant. (Refer Figure 3). To conserve water, the warm water from the process (e.g. refrigerant gas compression) is cooled in the cooling tower and recirculated.

In cooling towers, air currents pass over large wetted surfaces (fill) to maximise evaporative cooling of the falling water. They normally operate with water returning to the tower at up to 40° C under full load conditions which then cools to around 25 – 30°C in the tower, or lower in well-designed systems. The air is either blown through the fill (forced draft type) or drawn through it (induced draft type).

Figure 3: Typical cooling water system comprising cooling tower and condenser water circuit

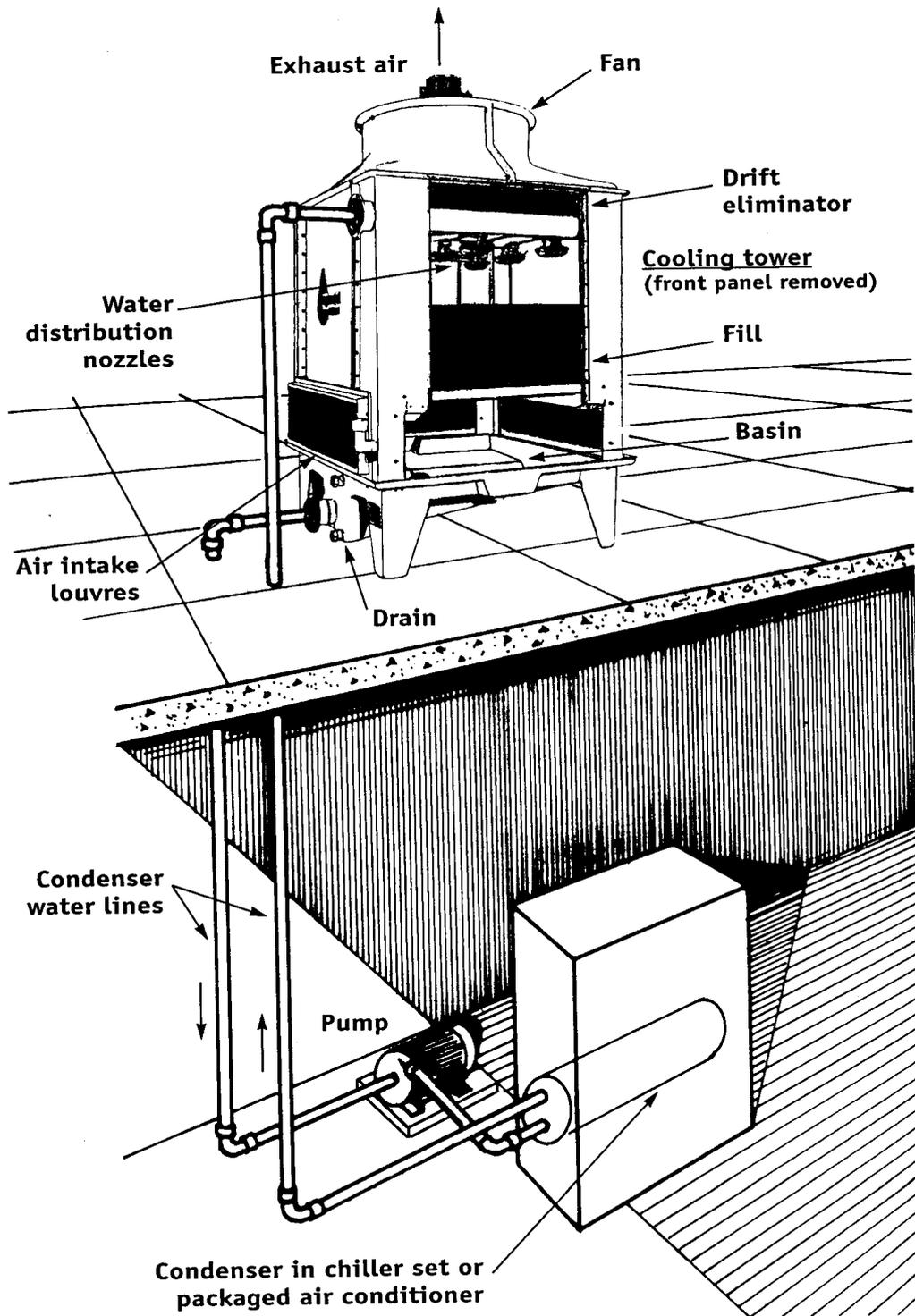


Figure 4: Evaporative condenser of the forced draft type

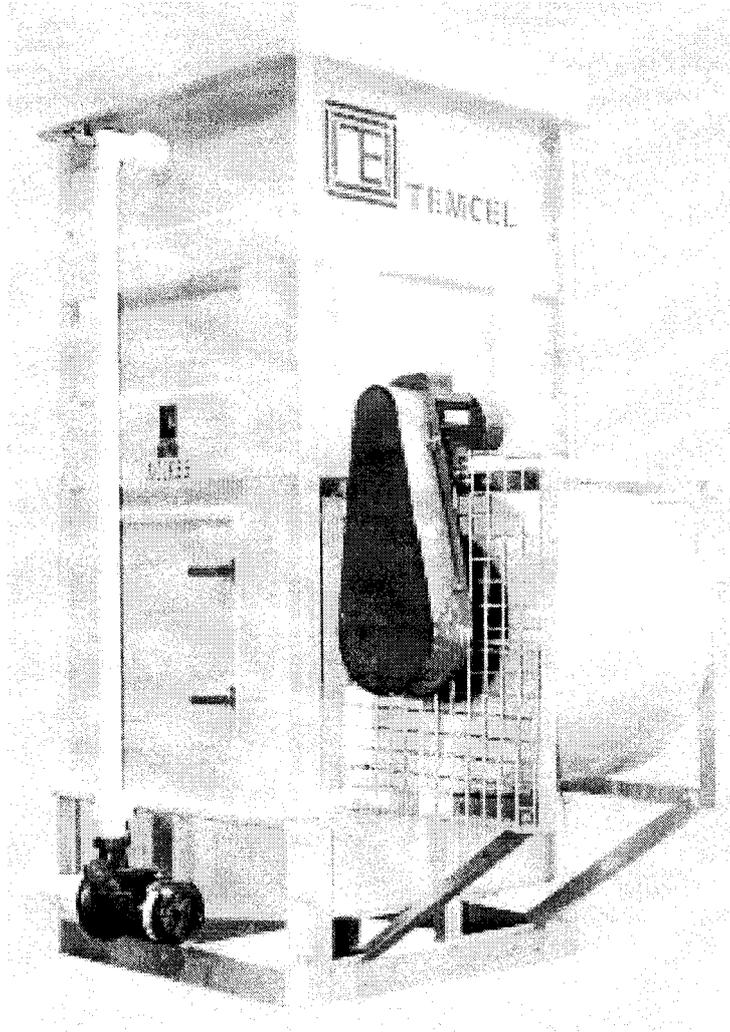
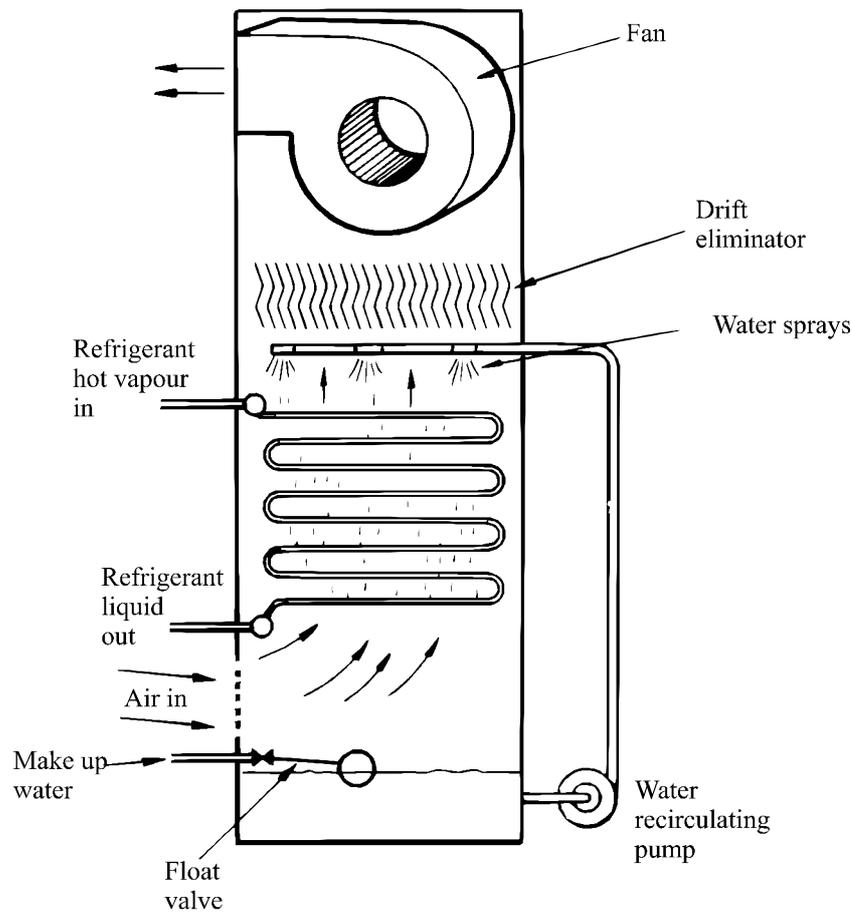


Figure 5: Typical evaporative condenser of the induced draft type



Evaporative condensers and industrial fluid coolers are heat rejection devices that are similar in principle and in operation to cooling towers. Refer Figures 4 and 5. The water system comprises a pump which draws cooled water from the basin and recirculates it directly back to the top of the unit from where it is distributed over a bank of heat exchange pipes. The pipes contain circulating refrigerant or another fluid in a closed system (i.e. not open to atmosphere). There is no heat exchanger fill as in cooling towers and system water volume is much less than for most systems incorporating a cooling tower.

Large quantities of organic material and other debris may accumulate in the water of such systems as a result of the air being scrubbed as it passes through the equipment. A typical cooling tower of 700 kW refrigeration capacity (such as may serve a 4-storey office building) may accumulate up to 1 kg of particulate matter every 3 hours of operation, drawn from the airborne dust and the mains water supply. This dust burden may increase rapidly if building site excavation work, for example, is being carried out nearby.

The elevated water temperatures and the moisture at air-water surfaces present ideal conditions for microbial growth. The extent of colonisation is variable and dependent also on other factors such as solar radiation, temperatures, pH, salinity, chemical additives and the presence of other organisms. These parameters can produce favourable conditions for microbial growth.

The large surface area of the tower, pipework and heat exchanger along with light and dark environments, variable oxygen tension and sites differing in temperature create a variety of sites suitable for colonisation by a range of microorganisms.

The microbial flora of cooling water systems include bacteria, protozoa, fungi and algae. Algae proliferate if the wet surfaces of the tower are in a sunlit position and their breakdown products may promote bacterial growth.

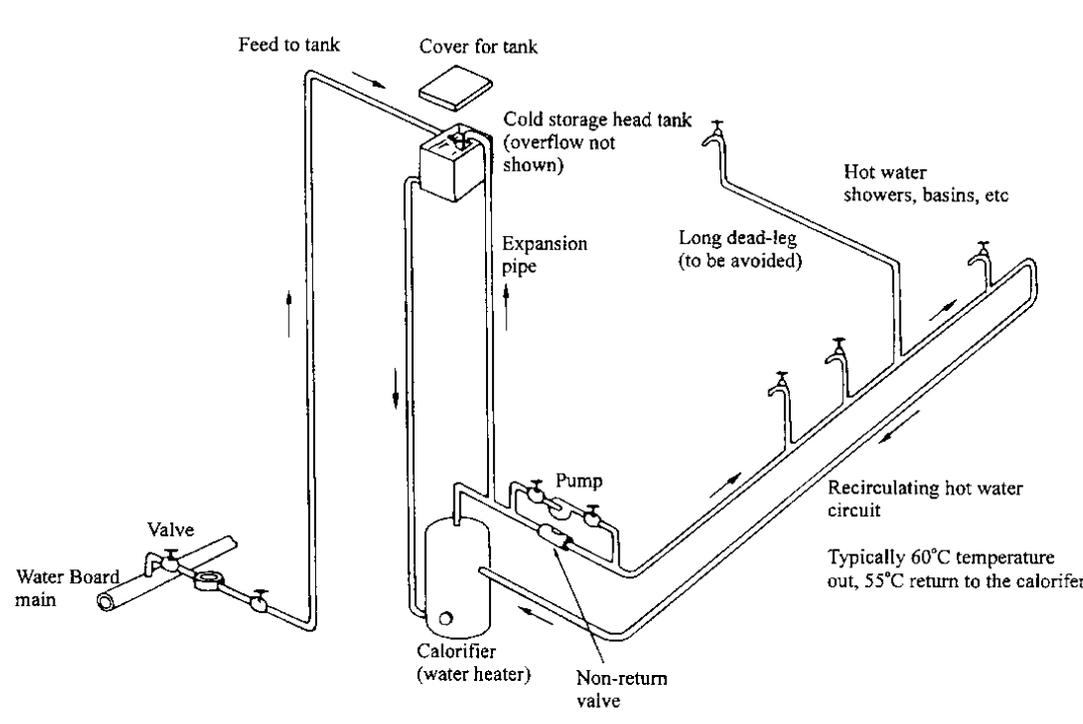
Planktonic organisms are those dispersed in water. They may attach to pipework, heat exchangers and to other surfaces forming biofilms incorporating various microorganisms. Biofilms provide an ecological niche for the growth of *Legionella* within the system. These biofilms normally make up the bulk of the microbial population. An aquatic ecosystem will contain more than 200 times more bacteria per cm² in biofilms than per cm³ of water. These biofilms 'seed' the circulating water creating an increase in the planktonic population and/or further biofilm formation.

Cooling system water is lost by carry over of droplets as drift in the exhaust air stream. In poorly designed cooling towers, drift can amount to 1 per cent of the water circulating rate, but efficient drift eliminators can now reduce this below 0.02 per cent as required by the Australian Standard, and often below 0.002 per cent. This drift contains visible droplets, as well as aerosols that can be inhaled. Drift will also contain water treatment chemicals and other contaminants found in the cooling system water.

9.2 Hot, warm and cold water supply services

Despite disinfection *Legionellae* may be present in reticulated water in very low numbers which are not a health problem. However, in many central hot and cold water services, conditions are conducive for multiplication of these bacteria especially when water remains at temperatures between 20° and 40°C. *Legionella* found in such services may multiply before the heater, within the heater (particularly near the base) or near hot water outlets such as on tap washers or in shower heads (Figure 6). Biofilms also develop in these water systems and may be dislodged by hydraulic shocks and vibration on the walls of pipes and vessels so markedly increasing the numbers of bacteria in the water.

Figure 6: Hot water supply in a commercial building (using head tank)



Adapted from Brundett (1992)

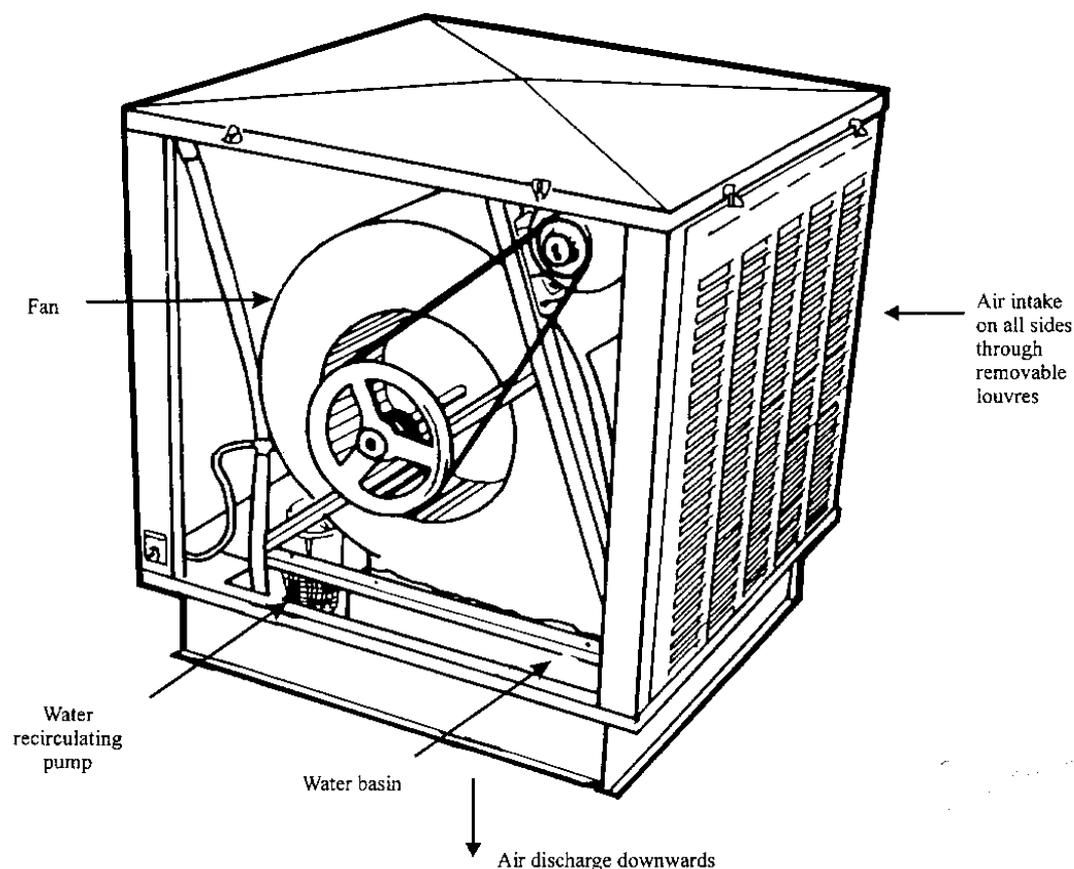
9.3 Spa pools

Spa pools and heated swimming pools operate at temperatures conducive to bacterial growth. The aeration of spa pools can result in formation of potentially contaminated aerosols. A range of pathogenic microorganisms, including *P. aeruginosa* and *L. pneumophila*, have been found in spa pools.

9.4 Other water systems

Less common sources of outbreaks overseas include decorative fountains, a supermarket vegetable misting machine, a machine shop cutting fluid system and ultrasonic nebulisers. Evaporative air coolers (Fig. 7) are a potential but, as yet, unconfirmed source of infection.

Figure 7: Evaporative water cooler



9.5 Composts and potting mixes

L. longbeachae serogroup 1 has been implicated in at least one outbreak and a significant number of sporadic infections in Australia. It has been isolated from composted animal manures, composted vegetable and plant material and from many potting mixes made in every state of Australia. Composted materials also contain other *Legionella* species capable of causing legionellosis but which have not been implicated in these infections.

10. Minimising hazards

To reduce contamination of systems such as cooling water systems, hot and cold water supply systems and spa pools, attention must be paid to equipment design, installation, operation and maintenance. The aim is to minimise microbial multiplication in these environments, to ensure treatment is adequate, and to minimise the production and release of aerosols.

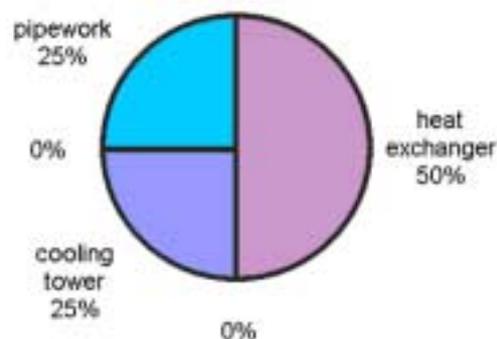
10.1 Cooling water systems

Wherever practicable, it is recommended that air-cooled plants rather than cooling water systems are used for small cooling duties. These do not become contaminated with *Legionella*. Air-cooled plants may be more cost-effective compared with cooling towers when all maintenance costs are considered.

10.1.1 Microbial Control

Effective control of bacterial multiplication and dispersion in drift from cooling towers and evaporative condensers involves attention to the *design* and *siting* of towers as well as attention to the *commissioning*, and *operation (including inspections) and maintenance* of the complete cooling water system. Refer AS/NZS 3666:1995 and SAA/NZ HB32:1995. Studies have shown that the multiplication of legionellae is preferentially at the surfaces of the warm piping and heat exchanger in the system rather than the cooling tower basin which contains the coldest water in the system. Average surface area proportions for small (under 300 kW refrigeration capacity) cooling water systems is shown in Figure 8.

Figure 8: Percentages of wet surface area contributed by components of typical cooling water system



Microbial control is not only important in preventing infection but is also necessary to ensure the continued effective and efficient operation of the cooling water system.

Design features that facilitate cleaning, control bacterial growth, and minimise drift include:

- convenient access openings;
- components which can be easily removed;
- basins that can be readily drained;
- materials compatible with the use of disinfectants and hosing with water jets;
- use of components that are corrosion resistant;
- efficient drift eliminators;
- minimal internal components such as structural brackets which can collect sediment;
- surfaces that can be readily cleaned;
- protection of wetted surfaces from direct sunlight;
- uniform flow of air through the tower;

- absence of dead-legs in the system;
- ability to drain the system;
- avoidance of unnecessarily long pipe runs (installation of plate heat exchangers to render a long run closed to atmosphere has been carried out at many sites in Australia); and
- absence of other opportunities for water to stagnate, e.g. at pipe connections to auxiliary cooling towers or water storage tanks.

Siting of cooling tower plant should include attention to:

- proximity and location of building air inlets, including openable windows;
- direction of prevailing winds and any localised wind patterns;
- height and design of adjacent structures;
- design of enclosures;
- proximity of other discharges such as kitchen exhausts; and
- likelihood of future developments for the system, the building and nearby sites.

Commissioning is a stage that is of vital importance and has been included in the requirements of AS/NZS 3666:1995. Commissioning includes taking precautions to control risk at start-up as well as ensuring the system operates correctly and meets the design parameters. The commissioning procedure should ensure that:

- air velocity is uniform through the fill and eliminators
- water distribution is even
- components are assembled correctly and are not blocked
- the system is clean and disinfected
- water treatment is established
- the system functions correctly
- performance is verified
- airflow around the tower is not restricted
- water overflowing does not occur.

It is a responsibility of the owner (in NSW, the occupier) to ensure that cooling towers are regularly inspected and that maintenance records are kept. Records should include maintenance details, cleaning and disinfection procedures and results of testing. Complete up-to-date drawings should be kept to ensure that all parts of the system are understood and receive ongoing attention.

Operation and maintenance records kept by the owner should include information about:

- layout of system;
- correct and safe operating procedures;
- maintenance, cleaning and disinfection procedures, and their frequency;
- regular water treatment regimes including judicious use of biocides; bleed rate;
- testing requirements e.g.:
 - pH;
 - total dissolved solids or conductivity; and
 - bacterial counts;
- disinfectant levels;

- safety precautions;
- material safety data sheets for chemicals to be used; and
- person or contracting agency responsible for:
 - overseeing and recording the work; and
 - ensuring that plant operates normally.

10.1.2 Biocides

Water treatment including the application of biocides is probably the most frequently used method of controlling legionellae in cooling water systems.

Ideally biocides should be effective against a wide range of microorganisms including *Legionella*, and be active against those organisms in slimes or other biofilms as well as those in the circulating water. Compatibility with dispersants, descalants and anticorrosion agents in tower water and stability at varied pH, temperature and water hardness is necessary. At required dose concentrations, biocides should be non-foaming and non-toxic in air and water. Though many of these chemicals biodegrade, their health and environmental effects must be considered. Safety for operators handling the chemicals and the general public exposed to any cooling tower drift requires careful attention.

Biocides can be separated into two groups: oxidising biocides, such as chlorine, bromine and ozone; and non-oxidising, such as isothiazolone mixtures. The active concentrations of many of these biocides in cooling water systems are not readily measurable. The desired working concentration of biocides is usually calculated on an estimation of the total water volume of the system and by adjusting for some rapid inactivation of the biocide, especially for oxidising biocides.

Biocides are generally pH dependent. Most cooling tower waters tend to have a high pH due to operating requirements. Some biocides require pH control for optimum performance.

Many biocides which have been shown to be effective against *Legionella* in laboratory trials may not be so in field situations. The presence of organic material, biofilms, microorganisms and chemical and physical conditions may increase the demand on the biocide or afford protection for *Legionella* from the biocide. Various operating conditions of cooling water systems may differ from the laboratory situation. Only field-proven biocides should be used.

Biocides are not likely to be effective unless used in conjunction with a regular cleaning program. Poorly maintained systems will create a greater demand on the biocide as the build-up of organic debris tends to neutralise the biocide and may prevent contact with bacterial cells necessitating higher dose concentrations or more frequent dosing to maintain control.

It is generally sound practice to regularly rotate the biocides chosen for a cooling water system to avoid the development of resistant strains of microorganisms.

10.1.3 Proprietary devices

Proprietary devices are now being marketed as alternatives to conventional water treatment. As with any form of water treatment, purchasers should ensure that suppliers' claims are substantiated with successful laboratory and field trial data. All water system treatments need to be able to control biofilm which may attach around the complete water circuit.

10.1.4 Cleaning and disinfection

Cleaning and disinfection of cooling water systems is required to remove accumulated sediment, corrosion products, fouling in the system and biofilm growth, all of which reduce system performance and support the multiplication of *Legionella* and other microorganisms.

Regular cleaning and disinfection is essential for efficient system functioning. This does not guarantee the absence of *Legionella* from the system but serves to reduce the risk of *Legionella* presence and multiplication particularly when a strong disinfectant such as chlorine is included in the cleaning protocol.

Frequency of cleaning and disinfection is largely dependent upon operating conditions and the effectiveness of the ongoing water treatment programme. AS/NZS 3666.2:1995 requires that the cleaning interval is not to exceed six months. More frequent attention may be justified in sensitive sites such as hospitals and health care premises or where there is evidence of heavy scale deposition, biofouling blocking equipment components, other mechanical considerations, or excessive solids entering the system, e.g. if the cooling tower is located near a source of extensive soil disturbance such as at construction sites.

Infrequent cleaning can be justified only where regular monitoring is pursued, the system is clean, and laboratory tests confirm low total bacterial counts. Systems should be cleaned and disinfected before commissioning and before each start-up after extended shut-down periods. Sodium hypochlorite solution is a useful disinfectant to use as part of the cleaning protocol. A minimum level of 5 mg/L (5 ppm) free chlorine residual maintained for a period of at least one hour at a pH 7.0-7.6 is suggested. With good pH control, corrosion of materials such as mild steel and copper is minimal. (The term free chlorine residual refers to the amount of chlorine freely available to act as a disinfectant in water. Disinfectant properties of chlorine decline rapidly when pH exceeds 8.0 and much more chlorine will need to be added).

10.1.5 Shut-down procedures

A number of outbreaks of Legionnaires' disease have been associated with the start-up of small cooling water systems after shut-down for periods as short as one week.

High *Legionella* concentrations can be expected in small systems as they generally have a relatively small water volume but high wetted surface area available for sediment deposition and biofilm development. Disturbance of sediments and biofilm can occur at start-up and can lead to seeding of high *Legionella* concentrations in the circulating water. Under conditions of poor water treatment, poor drift control and suitable weather conditions (warm and cloudy), dispersal of contaminated aerosol over a wide area may be possible.

The start-up procedure should involve: starting the system circulating pump; biocide dosage; and returning the system to service before starting the fan.

Draining of small cooling water systems at the time of shut-down will prevent them from becoming heavily contaminated with legionellae during periods of inoperation and stagnation of water.

It is particularly important that this occurs whenever such systems are to be shut-down for extended periods. Those systems for which the open water circuit is confined to the tower itself, e.g. evaporative condensers or industrial fluid coolers, can reasonably be drained via an automatic sump dump valve on a frequent basis, e.g. each weekend. There is generally a rapid turnover of water in such small-volume systems and they can readily be refilled when required at minimal cost.

If regular draining and drying of small systems is not practicable, greater attention must be directed towards water treatment.

This becomes a critical factor in *Legionella* control, particularly where water temperatures during the shut-down period cannot be maintained below 20°C.

Medium or large cooling water systems (over 300 kW refrigeration capacity) generally require much closer attention to the application and monitoring of water treatment and there is less need for draining and cleaning the system. Similar principles apply to those systems, such as large industrial cooling water systems, which are unable to be routinely shut-down.

10.1.6 Decontamination

Unlike the routine cleaning and disinfection procedures, decontamination of a cooling water system is a response to an emergency.

Where a cooling water system is implicated in an outbreak of legionellosis, the regulatory authority may direct that decontamination be carried out in accordance with local practices or with the following procedure which is a conventional approach based on the use of chlorine:

- dosing with sodium hypochlorite to maintain a free chlorine residual of 25-50 mg/L (25-50 ppm) for 30 minutes;
- circulation of a dispersant;
- draining followed by thorough scrubbing of all wetted surfaces of the cooling tower and other system components as practicable;
- refilling and redosing with sodium hypochlorite to maintain a free chlorine residual of 5 mg/L (5 ppm) at pH 7.0-7.6 for 1 hour, adding sufficient sodium thiosulphate (or other agent) to neutralise the chlorine then drain; and
- refilling followed by recommissioning, review and reinstatement of a full water treatment program.

10.1.7 Water testing

A number of tests on samples of cooling system water can be carried out on-site. Most analyses are for parameters related to control of corrosion, scale, and particulate matter and include measurement of temperature, pH, conductivity, chloride, and alkalinity. On-site monitoring of biocidal residual is generally restricted to oxidising biocides such as chlorine. Microbiological testing should be carried out in an accredited laboratory and with appropriate sample collection procedures.

Regular heterotrophic colony count (HCC) testing (e.g. monthly) on system water should be undertaken to assess the efficacy of the biocidal treatment and general cleanliness of the system. If the acceptable level of the HCC of bacteria is exceeded, the frequency of testing should be increased to weekly while control is re-established. An HCC of 10^5 colony forming units per millilitre (CFU/mL) of sample, as determined by an agar plate method such as that set out in AS 4276.3.1, is generally regarded as an acceptable upper limit. Concentrations above this level indicate that conditions in the system are favouring multiplication.

When dipslides are used, manufacturer's prescribed procedures must be closely followed.

Dipslides should be incubated in a purpose-made incubator and the incubation procedures should be similar to those used for agar plates. While dipslides are simple to use, convenient and inexpensive, their accuracy is very limited and many variables may affect the dipslide results.

They are useful in detecting major trends in bacterial levels and for verifying that the water treatment programme is actually operating; they should be used in conjunction with monthly agar plate testing.

The examination of water for the presence of legionellae on a routine basis is not usually warranted. This is because: *Legionella* is not the only microbial hazard likely to be present; the chances of this organism being present are very high; presence of the organism does not necessarily mean that infections will occur; laboratories may vary in the culturing techniques used; interpretation of results is largely subjective; and a negative result may lead to a false sense of security as any cooling water system can quickly become heavily colonised if it suffers neglect. Testing is not a substitute for sound maintenance practices and water treatment.

Nonetheless, culturing for *Legionella* may be appropriate if carried out for a specific purpose such as establishing an effective water treatment regime, to trace the source of an infection, or to establish that decontamination procedures have been properly carried out.

Where plant owners request testing, the test results require careful interpretation because the concentration of bacteria present is not directly proportional to the risk of acquiring infection. A level of 1 CFU/mL for action is not applicable because legionellae are endemic at low numbers even in most natural environments. Outbreaks of disease have generally occurred when the concentrations in water systems have been extremely high, e.g. more than 100 000 CFU/mL of water sample.

It needs to be appreciated that laboratory culturing for *Legionella* is influenced by many confounding factors such as overgrowth by other bacteria and the results may be misleading. All such quantification tests provide only rough estimates of specific bacteria, such as legionellae, present under the conditions of the test. No single method, culture medium or conditions of incubation can satisfy the growth requirements of each particular type of bacteria in a water sample.

A detectable population of legionellae in the system water indicates that there will be a larger population in sediments and biofilm within the system. Undetectable *Legionella* in the water sample does not indicate that the system is free of these organisms as they may still be attached to surfaces.

The primary tool for the control of *Legionella* is good system hygiene practices. Experience has shown that it is very difficult to manage the microbial characteristics of a cooling water system based only on *Legionella*-specific data, whereas monitoring the overall bacterial level by HCC testing is far more effective.

10.1.8 Occupational health

Maintenance workers for cooling water systems are at increased risk of inhaling infective aerosols. They may also be exposed to irritant chemicals used in disinfection, cleaning and water treatment through eye and skin contact as well as inhalation. Appropriate precautions are described in AS/NZS 3666:1995 and HB32:1995. State occupational health and safety legislation is also relevant. Maintenance activities should only be carried out by trained, competent persons.

10.2 Residential, warm and cold water supply services

To protect public health, mains water supplies are generally disinfected with chlorine which is usually added at the treatment works. Residual chlorine at the point of use may be low and legionellae may be present in very low, undetectable concentrations; they may multiply after the water enters the building in portions of the system used infrequently, in stagnant water, and in portions of the system with warm water. Multiplication may occur in dead-legs, attached hoses, shower nozzles, hot taps, and hot water storage vessels.

Water services at commercial, institutional and industrial buildings and grounds should be designed to avoid conditions likely to encourage *Legionella* multiplication. Control measures include:

- **Temperature control.** Incoming cold water should be protected against heat gains which may inadvertently increase water temperature from around 20°C initially, up to 30°C or more.

Hot water tanks or calorifiers should store water at 60°C or more from which it may be distributed to ablution outlets which can then mix water to attain 50°C or less if it is necessary to reduce the risk of scalds. (see AS 3500.4, and Wesley, 1995). Options available to effect this temperature reduction include:

- automatic shut-off devices in taps
- tempering valves
- thermostatic mixing valves
- restricted movement mixer taps
- child-proof taps.

Systems should be regularly inspected to ensure thermostats are not malfunctioning.

Where systems cannot be retrofitted with these devices, periodic (defined by each State's requirements) raising of temperatures to at least 70°C, or chlorination and flushing are recommended.

- **Storage time.** *Legionella* growth can occur in storage tanks and pipes containing warm water that is not in use for a prolonged period. Long dead-legs in hot water piping systems (Figure 6) should be avoided and recirculation loops incorporated as a design feature. New shower systems in large buildings, hospitals and nursing homes should be designed to ensure there is mixing of hot and cold water near the point of use such as the shower head.

Existing redundant pipe runs should be disconnected. Multiple storage calorifiers should be piped in parallel so that each can operate at 60°C or more and to ensure all are continually in use and that stagnation in one or other of the vessels does not occur. Heating elements in calorifiers should be located as near to the bottom of the vessel as practicable to reduce water temperature stratification below the elements. Water outlets at showers, handbasins and baths, which are not in use on a daily basis, should be operated each week for at least 30 seconds at full flow to remove stagnant water. Unused branch lines are best taken out of service.

- **Nutrients.** Dead and living microorganisms, biofilm, scale and sediment may provide nutrient sources for *Legionella* and amoebae and multiplication may occur if conditions are suitable.

Drainage facilities of adequate size at the lowest point of calorifiers will help remove accumulated sediment. Plumbing materials should not include natural rubber for gaskets and washers as there is evidence that *Legionella* multiplication is enhanced on this material. Relevant standards are AS 3500, AS 3855 and AS 4020.

Those hot water systems that incorporate a head tank (Figure 6) should be inspected, cleaned annually, and be checked to ensure that lids are close-fitting to exclude foreign matter.

- **Cleaning.** A regular cleaning and inspection schedule should be prepared for hot and cold water services and an up-to-date log maintained. Detailed current layout drawings for hot and cold water services should always be readily available.

Where decontamination of hot water systems is necessary (e.g. as a result of implication in an outbreak of Legionnaires' disease) this should be carried out by raising the water temperature to 70°C for one hour and progressively flushing the hot water outlets around the system. Appropriate safety procedures should be followed to prevent scalding. Where such thermal shock treatment is not possible, sodium hypochlorite may be added, preferably overnight, to maintain a free chlorine residual of at least 2 mg/L (2 ppm). This will normally necessitate chlorination of the head tank at 20 – 50 mg/L (20 – 50 ppm).

Although the storage of water at or above 60°C is adequate for the control of *Legionella* in most storage situations, peripheral colonisation of fittings such as taps and shower heads may still occur due to heat loss. A minimum return water temperature of 60°C is recommended according to AS 3500.4. Special maintenance and cleaning of fittings should be carried out where persons are at high risk of infection, such as at units housing renal transplant, tumour treatment and other immuno-compromised patients. Recommended procedures include:

- regular removal of shower heads to clean out sediment and scale;
 - regular removal and cleaning of aerators at taps;
 - replacement of natural rubber components with components which do not support growth of microorganisms in all taps and thermostatic mixing valves; and
 - weekly flushing of showers and taps if they are infrequently used.
- **Head tank design.** Bacterial cross-contamination has occurred where a single cold water head tank supplies water to both a potable water service and a stored water service such as fire sprinklers and fire hose reels. Bacteria may multiply in the latter, stagnant system and contaminate the former. Separate head tanks (providing an air gap between systems) should be used; check valves and backflow prevention devices have been shown to be ineffective against the cross-migration of biofilm bacteria in these circumstances. Refer also ASNZS 3666.1:1995.

10.3 Spa pools

Spa pools such as those installed in residences, hotel complexes and holiday resorts have been associated with cases of legionellosis. Spa pools require careful maintenance and disinfection and frequent cleaning of equipment such as filters, pool walls and floor.

These requirements are generally covered by government regulations and the NHMRC publication, “Australian guidelines for heated spa pools”.

10.4 Evaporative air coolers

Evaporative air coolers should not be confused with evaporative condensers.

Evaporative air coolers (Figure 7) are common in residences and larger buildings in arid and temperate zones of Australia where ambient humidity is not high during summer. They have not been implicated in outbreaks of legionellosis in Australia but involvement in one overseas outbreak has been speculated.

Evaporative air coolers operate by taking in the hot dry air from outdoors and passing it over wetted plastic pads, generally in a honeycomb configuration, to attain high evaporation and cooling of the air.

In this process the air humidity is increased and so air is not normally recirculated back to the unit as this may increase moisture content to an unacceptable level. Water is held in a small basin at the base of the unit. Evaporative air coolers should be operated and maintained in accordance with the requirements of the regulatory authority.

10.5 Humidifiers

An overseas outbreak of Legionnaires’ disease was traced to an ultrasonic misting machine used at a supermarket vegetable display case. The equipment had been inadvertently positioned above the lighting fixtures, which provided a heat source, and was poorly maintained. Such humidifiers incorporate ultrasonic transducers located in a small basin of water and generate aerosols. A programme of regular cleaning and disinfection with sodium hypochlorite is recommended for these devices.

10.6 Decorative fountains

Several outbreaks of legionellosis have been recorded overseas for which the sources were decorative fountains located in hotel foyers. If the recirculating water in such systems is heated, e.g. by submerged lighting, the conditions produced may favour *Legionella* multiplication. Aerosols will be created by the splashing spray water in the fountain. Regular cleaning and disinfection is recommended.

10.7 Other risk sources

Safety showers, eye wash stations, fire hydrant lines, room humidifiers, dental drilling systems and some industrial processes are examples of potential sources of *Legionella* and possible generation of aerosols. Commonsense principles of hygiene apply, i.e. keep them clean, in proper working order, and dry if out of service. Frequency of inspection, draining and cleaning for such equipment is covered in principle by AS/NZS 3666.2:1995.

Backflow of contaminated water from one source must be prevented from entering other systems by the use of air breaks.

10.8 Composts and potting mixes

Increasing numbers of cases of legionellosis in Australia are caused by infection with *L. longbeachae* serogroup 1, a species that is widespread in composted materials including potting mixtures but is not found in aquatic environments.

Although much remains unexplained, it is known that amoebae grazing on other microorganisms in composts are infected by various *Legionella* species including *L. longbeachae* which multiply within these amoebae to high numbers.

The major basic materials used in potting mixes are composted pine bark or sawdust whereas most home composts contain garden or household vegetable or plant wastes. The composting process requires moisture, and nitrogen which is usually added in the form of inorganic salts. Composting results in extremely active multiplication of bacteria, fungi and protozoa (including amoebae) and the generation of heat.

Although the centre of composting piles reaches sufficiently high temperatures to eradicate legionellae, the outer layers are maintained at temperatures ideal for the growth of amoebae and legionellae.

Many *Legionella* species but particularly *L. longbeachae*, *L. bozemanii*, *L. micdadei* and *L. pneumophila* flourish in this setting and several species have been detected in more than 50% of composted products. The majority of species found in composts have not been associated with human infections in Australia.

The source(s) of legionellae in composts has not been conclusively identified. Legionellae have been isolated from approximately 50% of fresh uncomposted sawdust and pine bark samples by researchers at the Institute of Medical and Veterinary Sciences in Adelaide. This suggests that legionellae could be intimately associated with trees and plants. At present, laboratory tests are relatively insensitive and will not reliably detect legionellae when there are less than 500 CFU per gram of compost.

It is not clear how people handling composts, potting mixes or working in gardens acquire their infection or if aerosol formation is essential for transmission. *L. longbeachae* persists on unwashed hands for at least 30 minutes but is readily removed by washing with soap and water. Persons who are gardening or using potting mixes and composts should wash their hands after handling these to prevent inadvertent ingestion or local skin infection. Potting mixes should be moist when used so as to prevent dissemination of bacteria and fungal spores. However storage of moistened potting mixes in warm conditions can result in multiplication of legionellae within the stored bags. Care should be taken when watering recently potted plants to avoid splashing, e.g. water leaching from pots should not be allowed to fall onto hard

surfaces. Splashing can result in aerosol formation and in confined and poorly ventilated areas may increase the risk of infection.

Bags containing potting mix manufactured in Australia presently are labelled to advise customers that potting mixes contain a variety of organisms capable of causing illness in humans. These products contain fungi and bacteria known to cause allergic lung disease, as well as legionellae, and free-living amoebae. The information provided on customer information labels is under review by Standards Australia.

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Appendix 1

Regulatory approaches by Australian States and Territories to the prevention of Legionellosis

The implementation of control measures to minimise or prevent the health hazards associated with air and water systems in buildings has legislative backing throughout Australia, although the means of enactment differs from State to State. The primary reference document used to facilitate this legislative process is the Australian Standard, AS/NZ 3666:1989, "Air-handling and water systems of buildings - microbial control". This standard was amended in 1995.

New South Wales

In NSW the legislation is enacted under the NSW Public Health Act (No.10, 1991, Part 4 - Microbial control) and associated regulation (Part 6, Microbial control) and came into effect in April 1991.

The legislation incorporates the requirement to comply with AS3666 - 1989. An amendment will be necessary for compliance with the 1995 revision of AS/NZ 3666.

The Public Health Act regulates the installation, operation and maintenance of certain systems in order to prevent or inhibit the growth in the systems of microorganisms that are liable to cause Legionnaires' disease and other diseases. These incorporate:

- air handling systems
- evaporative cooling systems
- hot-water systems
- humidifying systems
- warm-water systems
- water-cooling systems

Only licensed people are permitted to execute work on these systems.

Approved processes of disinfection are required for water cooling systems.

The Act requires the installation, operation and maintenance provisions to be met or otherwise the occupier of the regulated system is guilty of an offence. It also gives power to authorised officers to enter, inspect and investigate a regulated system on premises.

The Public Health Regulations also require the Local Authority to register certain systems such as:

- water-cooling systems
- evaporative cooling systems
- warm water systems

In addition to this legislation, NSW Health produced the “NSW Code of Practice for the control of Legionnaires’ disease” as a user manual for persons owning, operating and maintaining any of the systems under the legislation. Compliance with this Code constitutes a defence under the regulations.

In NSW enforcement of the *Legionella* legislation is by State Health or Local Council officers.

NSW is the only state or territory that has sought to approve treatment processes or biocides. A number of these processes, called “processes of disinfection”, have been given extended conditional approval. Submissions for approval must include acceptable results for bacteriological tests. An approval can be withdrawn should the relevant test standards not be met.

Victoria

Victorian *Legionella* legislation is covered by the Health Act 1958 and the Health (Infectious Disease) Regulations 1990. In addition the Victorian Health Department has produced a 1989 document called “Guidelines for the control of Legionnaires’ disease” which was the result of work by a task force that included industry representatives and is generally consistent with the requirements of AS/NZS 3666:1995. The Victorian legislation imposes a duty of care on the manager to maintain the system in accordance with the guidelines. Regulation is enforceable by Officers of the Victorian Health Department or Local Council Environmental Health Officers. The regulations have a requirement to provide information to inspecting officers and there are penalties for failing to comply with the requirements of the legislation. However, should a cooling tower be implicated in a case of Legionnaires’ disease, penalties under Occupational Health and Safety legislation and at common law (civil cases) may be far more severe.

The Guidelines document is presently under review and is likely to include additional requirements for health-care premises.

Queensland

Statutory requirements apply to individuals who are considered to have responsibilities in controlling the potential health risks associated with airconditioning units and cooling towers.

These requirements are administered, under the Workplace Health and Safety Act (1995), by the Division of Workplace Health and Safety, Department of Employment, Vocational Education, Training and Industrial Relations. This approach differs from other States which legislate under a Public Health Act.

Two key concepts in the Act are:

- specified high risk plant
- those who have obligation

“Specified high risk plant” is defined in the Act and includes an “airconditioning unit”, i.e. a unit of plant that provides airconditioning and that either

- (a) incorporates a cooling tower (or similar device); or
- (b) consists of one or more compressors and the power rating required for operation of the airconditioning unit is 50kW or more.

Such plant items are referenced in the obligations under the Act. Obligations apply to plant owners, erectors, installers, designers, manufacturers, importers and suppliers. Owners of specified high risk plant are required by the Act to maintain the plant in a condition that ensures it is safe and does not create a health risk when properly used.

The Act places other obligations upon the individuals who may deal with airconditioning units and cooling towers. Examples of others who could be considered as having some responsibility would be employers and other persons in control of workplaces.

Discharge of obligations for all these individuals requires, as a minimum, adherence to the requirements of AS/NZS 3666:1995. This Standard is regarded as a Compliance Standard (i.e. deemed to comply).

The Act requires owners of specified high risk plant to register the plant. Registration requirements apply also to cooling water systems used for industrial (non-air conditioning) purposes.

Western Australia

The Health (Air-handling and Water Systems) Regulations were introduced in 1994 under the WA Health Act of 1911. The Regulations incorporate AS3666 - 1989 and will be updated for the 1995 edition. The regulations apply to all buildings, other than domestic residences and non-habitable out-buildings, and cover the operation and maintenance of air handling systems, water systems and cooling towers whether installed before or after the gazettal date (24 September 1994). Provisions applying to the design and installation of such systems are not, however, retrospective.

The regulations, while adopting AS3666, contain a number of additional requirements relating to the enforcement roles and functions of local government authorities.

Local authorities have responsibilities for:

- processing applications for new or substantially modified installations,
- assessing applications for exemptions from AS3666 and making recommendations to the Executive Director Public Health (EDPH),
- advising the EDPH and issuing directives if construction materials are, or may be, unsafe (e.g. if they cannot be effectively maintained in a clean condition),
- issuing notices to close systems or cooling towers if a serious health risk does, or could exist, and advising the EDPH,
- taking necessary action to ensure compliance with the regulations and consequently with AS3666.

The provision for exemptions from compliance with AS3666 is intended to improve the flexibility of the regulations, particularly in regard to future technological changes in equipment or methods. In such cases applicants must demonstrate that the system is functional and does not pose a risk to health; evidence could include testing protocols, test results or other explanatory material.

An occupational health and safety code of practice entitled, "The Prevention and Control of Legionnaires' disease" was produced in November 1989 by the then Occupational Health, Safety and Welfare Commission of WA, now called WorkSafe WA.

However administration of the Health (Air-handling and Water Systems) Regulations is through the WA Health Department.

South Australia

State and Local Government Environmental Health Officers monitor cooling towers under the general “insanitary conditions” provisions of the Public and Environmental Health Act (1987) and subordinate regulations. Currently SA has not formally adopted AS/NZS 3666:1995 but is drafting regulations under the Public and Environmental Health Act referencing the Standard as well as preparing a Code of Practice. Some Councils register and conduct regular inspections of cooling towers. A survey of local government held data on water handling systems has been undertaken for the SA Health Commission.

Tasmania

In Tasmania the design and installation of new air handling/water systems is required by Building Regulations to comply with AS 3666. Municipal councils approve these installations as part of the building plans that are routinely submitted for assessment.

For new and existing air handling/water systems, commissioning, operation and maintenance requirements are required to be in accordance with AS 3666. The Public and Environmental Health (Legionnaires Disease) Regulations 1989 adopt AS 3666 by reference and are administered by the State Department of Community and Health Services, Public Health Branch. There are no specified Codes of Practice in addition to AS 3666. At present there is no requirement for registration of air handling/water systems. While there are penalties for failing to comply with the Act, a self regulatory approach is currently practised.

The Public Health Act is under review and measures are being considered for:

- specific requirements for registration of air handling/water systems and auditing of maintenance procedures by municipal councils
- specific training requirements for maintenance personnel.

Occupational health issues relating to cooling tower maintenance workers are covered by general provisions in the Workplace Health and Safety Act 1995 administered by the Workplace Standards Authority.

Australian Capital Territory

The ACT has the advantage of a single Territory/Municipal government structure. It has adopted a licensing procedure for:

- cooling towers
- evaporative condensers
- closed circuit industrial coolers
- warm water systems (including spa and hydrotherapy pools)

The legislation involved is the Building Act 1972 (Amendment 23, 1991) which requires licensing of the above systems and compliance with AS3666. This is an interim measure until this legislation is transferred into the ACT Health Act as it is the Act Public and Environmental Health Service that has actual responsibility for administering the Act.

A certificate from a mechanical ventilation engineer certifying compliance with AS3666 is required with each application to initially licence each system. Additionally a further certificate of compliance with AS 3666 is required for each replacement system.

Monitoring is by environmental health officers with annual inspections of low/medium risk systems and biannual or more frequent inspection of high risk systems.

The licensing requirements under the Act are designed to avoid an outbreak of Legionnaires’ disease by providing for:

- standards for design, location, operation and maintenance of mechanical ventilation and warm water systems,

- licences for the operation of such systems,
- regular approved maintenance, inspections and keeping of records to ensure that such systems meet the standards,
- powers to enable environmental health officers to check, take samples for testing and for the Chief Health Officer to require the shut down of mechanical ventilation or a warm water system and to require the evacuation of a building where a suspected or actual outbreak of Legionnaires' disease has occurred.

Because the legislation in the ACT is embodied in the Building Act, the Public and Environmental Health Service is unable to draw up a code of practice; it is anticipated this will be rectified with the passing of a new Public Health Act. In the meantime the guideline document in use is the NSW Code of Practice for the control of Legionnaires' disease.

Northern Territory

There is currently no specific legislation in the Northern Territory on this subject. The main legislative tools used are the Public Health Act, Nuisance Prevention Regulations, and the Work Health Act. The general provisions contained in the Public Health Act allows for delegated Environmental Health Officers to issue notices for the removal of any public health risks, or in the event of non-compliance, to authorise persons to remove the public health risks at the expense of the person to whom the notice was served. Under the Nuisance Prevention Regulations, Environmental Health Officers have enforcement powers to rectify matters on premises that are prejudicial or injurious to health. It is anticipated that future Environmental Health legislation will contain specific *Legionella* provisions.

Local regulatory approaches

In addition to the regulatory approaches of each State and Territory, direct action has been taken by local municipal authorities to whom Legionnaires' disease is a particularly sensitive issue. Councils such as Wollongong and Fairfield in NSW have adopted comprehensive *Legionella* monitoring programs. Generally, however, self-monitoring of *Legionella* has been the approach adopted throughout Australia within the broad framework of the relevant State legislation.