The Prevention of Legionellosis in New Zealand
Guidelines for the Control of Legionella Bacteria

Revised October 2012
Disclaimer

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Foreword

Legionellosis refers to the disease caused by any species of *Legionella* bacteria, and includes Legionnaires’ disease. *Legionella* bacteria are widespread in the environment. They are found in various aquatic sources including lakes, rivers and hot springs, and in the air conditioning and water systems in buildings. Some species found in the garden environment – in soils, compost and potting mix – have also been linked to cases of legionellosis in New Zealand.

Legionellosis has been notifiable under the Health under the Health Act 1956 since June 1980. Health professionals and all medical laboratories (since December 2007) are required to inform their local Medical Officer of Health of any case of legionellosis (Graham et al 2012). Notified cases between 1980 and 2009 show an overall annual incidence rate of 1.4 per 100,000 per annum. However, in that same period, laboratory-proven legionellosis cases fitting the case definition were 2772 – an annual rate of 2.5 per 100,000 per annum. Of these, 1313 fitted the criteria for confirmation of a case and 1459 as probable (Graham et al 2012). It can be assumed, therefore, that the actual incidence of legionellosis is much higher than those notified.

In common with controlling most public health issues, the adoption of preventive measures is the most effective strategy for managing the risk of legionellosis. This includes careful attention to maintenance and cleaning schedules of air conditioning and water systems in buildings and devices that generate or release water or dust aerosols into the atmosphere. The purpose of these guidelines is to increase awareness about the hazards associated with *Legionella*, improve the management of potential sources of *Legionella*, and improve the reporting and investigation of cases of legionellosis.

The guidelines are intended to assist all those concerned with *Legionella* and health, including public health service providers, local authorities, building owners, air conditioning engineers, employers and others dealing with the maintenance and monitoring of air and water handling systems in buildings. They are also a general guide to other sources of *Legionella* such as garden soils, compost and potting mixes, and for the follow-up of cases of legionellosis.

Outbreaks of legionellosis can be associated with the cooling towers that are part of an air conditioning or industrial cooling system. Most cooling towers in New Zealand provide air conditioning to buildings, and are covered under the building warrant of fitness. Cooling towers outside of the building warrant of fitness, such as those associated with a manufacturing process, are covered under the Health and Safety in Employment Act 1992, administered by the Ministry of Business, Innovation and Employment. Advice to employers developed by the Ministry of Business, Innovation and Employment and the advice in this document are consistent.
This document builds on guidelines originally developed by the Public Health Commission in 1995, which were based on guidelines issued by the Victoria Health Department (Health Department, Victoria, 1989). As appropriate, more recent research on *Legionella* and legionellosis collected by the Institute of Environmental Science and Research (ESR) Ltd’s Legionella Reference Laboratory has been included. During the revision of the 1995 guidelines, the Ministry sought comments on an interim draft. Copies of the draft revised guidelines were distributed for comment and 19 submissions were received. As appropriate, the views expressed in submissions have been incorporated into these updated guidelines.

I would like to thank all those who have contributed to the revision of these guidelines.

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Clinical Leadership, Protection and Regulation Unit
**Ministry of Health**
Acknowledgements

These guidelines were originally adapted for use in New Zealand from the 1989 Guidelines for the Control of Legionnaires’ Disease of the Health Department, Victoria, Australia. They have been revised to include details of new technical developments and relevant standards.

The guidelines reference Standards published by Standards New Zealand, in particular provisions of Australian/New Zealand Standard (AS/NZS) 3666: Parts 1, 2, 3 and 4, Air-handling and water systems of buildings – Microbial control, with the permission of Standards New Zealand under Licence 000807, and compliance documents such as the New Zealand Building Code administered by the Ministry of Business, Innovation and Employment.

The latest versions of the Standards referred to in these guidelines may be purchased from:

- Standards New Zealand
  Private Bag 2439
  Wellington 6140
  Email: enquiries@standards.co.nz
  Phone: 0800 782 632
  Fax: (04) 498 5994

We also acknowledge the valuable contributions to the review of these guidelines by Associate Professor Richard Bentham, Flinders University, Australia, ESR’s Legionella Reference Laboratory and the individuals and organisations who submitted comments on an earlier draft of the revised guidelines.
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Part 1: Legionellosis, Sources of Legionellae and Control Measures

1 Introduction

This document updates the *Guidelines for the Control of Legionellosis* produced in 1995 and incorporates some of the provisions of Australian/New Zealand Standard (AS/NZS) 3666: Parts 1, 2 and 3, *Air-handling and water systems of buildings – Microbial control* and the *New Zealand Building Code*.

The document provides up-to-date information, advice and guidance for minimising the risk of significant contamination in waters of cooling towers, and cold and heated water distribution systems (Part 1). The procedures described for the decontamination and cleaning of such systems are based on current internationally accepted practices. Part 2 ‘Guidelines for the Follow-up of Cases of Legionellosis’ sets out the actions required following the identification of one or more cases of legionellosis.

1.1 Application

This document is intended for use by building owners and managers whose buildings incorporate the systems and specific items of equipment mentioned in these guidelines, as well as by health protection staff when advising or following up identified cases. The guidelines also recognise that *Legionella* bacteria have been isolated from composts, soil conditioners and mulches, soils for landscaping and garden use, and potting mixes, and provides a number of precautions that can be taken to minimise the risk of infection.

The application of principles and practices described in these guidelines should significantly reduce the risk of future outbreaks and sporadic cases.

2 Legionellosis

2.1 Historical aspects

In 1976, 201 people staying at a hotel in Philadelphia, USA, suffered from a respiratory illness that became known as Legionsnairs’ disease (a type of legionellosis). After a six-month investigation, researchers from the Centers for Disease Control in Atlanta, United States, isolated the causative agent – a previously unknown micro-organism, *Legionella pneumophila* serogroup 1 (Lpsg1). Since then many more *Legionella* species have been identified, and subdivision of some species into serogroups has occurred. Since 1976, outbreaks of Legionsnairs’ disease have occurred worldwide, and sporadic cases greatly outnumber cases related to outbreaks.
2.2 *Legionella* species causing disease

The number of species, subspecies and serogroups continues to increase. To date 56 different species of *Legionella* have been described; with 21 associated with human infection (Table 1). The predominant species responsible for cases of legionellosis in New Zealand are *L. pneumophila* and *L. longbeachae* (Graham et al 2012). This is contrary to most other developed countries where *Legionella pneumophila* causes 90% of illness; with Lpsg1 alone accounting for approximately 85% of cases (Doleans et al 2004). Other *Legionella* species frequently associated with disease in New Zealand are *L. bozemanae*, *L. dumoffii*, *L. gormanii*, and *L. micdadei*. Many of the more rare pathogenic species have not been seen in New Zealand and for some their pathogenicity has been reported following a single human case.

Table 1: *Legionella* species and serogroups

<table>
<thead>
<tr>
<th>Legionella species</th>
<th>Serogroups</th>
<th>Association with clinical cases</th>
<th>Isolated in New Zealand</th>
</tr>
</thead>
<tbody>
<tr>
<td>L. adlaidensis</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. anisa</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>L. bellardensis</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. birminghamensis</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>L. bozemanae</td>
<td>2</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>L. brunensis</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. busanensis</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. cherrii</td>
<td></td>
<td>Unknown</td>
<td>Yes</td>
</tr>
<tr>
<td>L. cincinnatiensis</td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>L. donaldsonii</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. drancourtii</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. dresdenensis</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. drozanski</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. dumoffii</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>L. erythra</td>
<td>2</td>
<td>Yes</td>
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</tr>
<tr>
<td>L. fairfieldensis</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. fallonii</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. feeleii</td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>L. geestiana</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. genomospecies 1</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. gormanii</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>L. gratiana</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. gresilensis</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. hackeliae</td>
<td>2</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>L. impletisoli</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. israelensis</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. jamestowniensis</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. jordanis</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Legionella species</td>
<td>Serogroups</td>
<td>Association with clinical cases</td>
<td>Isolated in New Zealand</td>
</tr>
<tr>
<td>-------------------</td>
<td>------------</td>
<td>--------------------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>L. lansingensis</td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>L. londiniensis</td>
<td>2</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. longbeachae</td>
<td>2</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>L. lytica</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. maceachernii</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>L. micdadei</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>L. moravica</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. nagasakiiensis</td>
<td>&gt;1</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>L. nautarum</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. oakridgensis</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>L. parisiensis</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>L. pneumophila</td>
<td>16</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>L. quateirensis</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. quinlivanii</td>
<td>2</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. rowbothamii</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. rubrilocens</td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>L. sainthelensi</td>
<td>2</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>L. santicrucis</td>
<td></td>
<td>Unknown</td>
<td>Yes</td>
</tr>
<tr>
<td>L. shakespearei</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. spiritensis</td>
<td>2</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. steigerwaltii</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. taurinensis</td>
<td></td>
<td>Unknown</td>
<td>Yes</td>
</tr>
<tr>
<td>L. tusconensis</td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>L. wadsworthii</td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>L. waltersii</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. worseleiensis</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>L. yabuuchiae</td>
<td></td>
<td>Unknown</td>
<td></td>
</tr>
</tbody>
</table>

Source: DSMZ (2012) and NCTC (2012)

### 2.3 The disease and symptoms

Legionellosis refers to infections caused by micro-organisms of the genus *Legionella*. *Legionella* infections can be classified into four categories: (i) subclinical infection (ie, infection with no disease), (ii) non-pneumonic disease (ie, Pontiac fever), (iii) pneumonia (ie, Legionnaires’ disease), and (iv) extrapulmonary disease. Subclinical infections are probably more common than clinical ones (Butler and Breiman 1998; WHO 2007). This may explain the detection of *Legionella* antibodies in a large population.

Extrapulmonary disease is a relatively rare manifestation following *Legionella* infection not involving the respiratory system especially in severely immunocompromised patients. The bacterium can move from the respiratory system to other sites or organs in the body including the heart, kidney, liver, spleen, digestive tract and bone tissue (WHO 2007).
percentage of the New Zealand healthy population. The two most common clinical manifestations of legionellosis are Legionnaires’ disease and Pontiac fever (WHO 2007). Table 2 lists their most common symptoms.

### Table 2: Main characteristics of Legionnaires’ disease and Pontiac fever

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Legionnaires’ disease</th>
<th>Pontiac fever</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incubation period</td>
<td>Usually 2–10 days, rarely up to 20 days</td>
<td>5 hours–3 days (most commonly 24–48 hours)</td>
</tr>
<tr>
<td>Duration</td>
<td>Weeks</td>
<td>2–5 days</td>
</tr>
<tr>
<td>Case-fatality rate</td>
<td>Variable depending on susceptibility; in hospital patients, can reach 40–80%</td>
<td>No deaths reported</td>
</tr>
<tr>
<td>Attack rate</td>
<td>0.1–5% of the general population</td>
<td>Up to 95%</td>
</tr>
<tr>
<td></td>
<td>0.4–14% in hospitals</td>
<td></td>
</tr>
<tr>
<td>Symptoms</td>
<td>• Often non-specific</td>
<td>• Influenza-like illness (moderate to severe influenza)</td>
</tr>
<tr>
<td></td>
<td>• Loss of strength (asthenia)</td>
<td>• Loss of strength (asthenis), tiredness</td>
</tr>
<tr>
<td></td>
<td>• High fever</td>
<td>• High fever and chills</td>
</tr>
<tr>
<td></td>
<td>• Headache</td>
<td>• Muscle pain (myalgia)</td>
</tr>
<tr>
<td></td>
<td>• Non-productive, dry cough</td>
<td>• Headache</td>
</tr>
<tr>
<td></td>
<td>• Sometimes blood-streaked expectoration</td>
<td>• Joint pain (arthralgia)</td>
</tr>
<tr>
<td></td>
<td>• Chills</td>
<td>• Diarrhoea</td>
</tr>
<tr>
<td></td>
<td>• Muscle pain</td>
<td>• Nausea, vomiting (in a small proportion of cases)</td>
</tr>
<tr>
<td></td>
<td>• Difficulty in breathing, chest pain</td>
<td>• Difficulty breathing (dyspnoea) and dry cough</td>
</tr>
<tr>
<td></td>
<td>• Diarrhoea (35–50% of cases)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Vomiting, nausea (10–30% of cases)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Central nervous system manifestations, such as confusion and delirium (50% of cases)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Renal failure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Hyponatraemia (serum sodium &lt;131 mmol/litre)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Lactate dehydrogenase levels &gt;700 units/mL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Failure to respond to beta-lactam antibiotics or aminoglycosides</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Gram stain of respiratory specimens with numerous neutrophils and no visible organisms</td>
<td></td>
</tr>
</tbody>
</table>


### 2.4 The micro-organism

Bacteria in the genus *Legionella* are widely distributed natural inhabitants of waters and soils (WHO 2007). They have been isolated from lakes, rivers, creeks and other bodies of water. Although they are rarely ‘free-living’ bacteria, *Legionella* have the ability to parasitise fresh water and soil amoebae (Rowbotham, 1980).
In the laboratory, *Legionella* has been found to grow over a wide temperature range (20–46°C), with an optimal temperature range for replication of 32–44°C. Although reported to survive at temperatures between 0°C and 63°C, *Legionella* cannot actively grow at either temperature extreme, and metabolic activity stops at around 50°C (Kusnetsov et al 1996; Schulze-Robbecke et al 1987). At 70°C the organism is killed almost instantaneously. Systems with waters in the 20–45°C temperature range facilitate proliferation of *Legionella* bacteria (Figure 1).

Table 3 shows a summary of the temperature effect on *Legionella pneumophila* growth. Under less-than-optimum temperatures *Legionella* can remain viable (actively respiring and cultivable on laboratory media) without replicating until conditions are more favourable. Under extreme environmental conditions *Legionella* can lose viability and become uncultivable on laboratory media, but can be revived by protozoan hosts (Dennis et al 1984).

The use of high holding temperatures for stored hot water (ie, 60°C) is encouraged because high temperatures kill *Legionella*. In order to comply with the *New Zealand Building Code* 1992 (currently under review), stored hot water in residential dwellings is required to be held at temperatures of 60°C or higher (irrespective of whether a mixing device is installed) and delivered at not more than 55°C, or 45°C for retirement homes and early childhood education centres, to prevent the likelihood of burns (scalding).

**Table 3:** The effect of water temperature on *Legionella pneumophila* growth

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Effect on <em>Legionella</em></th>
<th>Cell viability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 70°C</td>
<td>Disinfection temperatures</td>
<td>Instant death</td>
</tr>
<tr>
<td>66°C</td>
<td>Disinfection temperature</td>
<td><em>Legionella</em> will die in two minutes</td>
</tr>
<tr>
<td>60°C</td>
<td>No active growth</td>
<td><em>Legionella</em> will die in 32 minutes</td>
</tr>
<tr>
<td>55°C</td>
<td>No active growth</td>
<td><em>Legionella</em> will die in five to six hours</td>
</tr>
<tr>
<td>50 to 55°C</td>
<td>No active growth</td>
<td>Slow decline in viable cells</td>
</tr>
<tr>
<td>47 to 50°C</td>
<td>No active growth</td>
<td><em>Legionella</em> can survive but do not multiply</td>
</tr>
<tr>
<td>35 to 45°C</td>
<td>Optimum growth range</td>
<td>Rapid increase in viable cell counts</td>
</tr>
<tr>
<td>20 to 46°C</td>
<td>Active growth range</td>
<td>Viable cell count determined by nutrient level</td>
</tr>
<tr>
<td>Below 20°C</td>
<td>No active growth</td>
<td><em>Legionella</em> can survive but is dormant</td>
</tr>
</tbody>
</table>
The growth of *Legionella* is promoted by the presence of other micro-organisms such as algae, amoebae and other bacteria. Certain protozoa are able to support intracellular multiplication and act to amplify the *Legionella* bacteria in soil and aqueous environments. When growing in surface biofilm other bacteria and algae can provide nutrients for *Legionella*. In an aqueous environment scale and sediments can stimulate the growth of the environmental microflora which, in turn, stimulates the formation of biofilm and the growth of *Legionella*. A biofilm is defined as a ‘slimy matrix produced and inhabited by bacteria, which enables the bacteria to adhere to a surface and carry out certain essential biochemical processes’ (WHO 2007, p 209), as well as to protect them from adverse environmental conditions, including the biocidal action of water treatment chemicals.

Investigations of the relationship between the chemical environment in plumbing systems and the growth of *Legionella* have shown that low concentrations of certain metals such as iron, zinc and potassium enhance proliferation of the species. Hence, the metal components and corrosion products of plumbing systems (e.g., galvanized iron) may play a role in the formation of biofilm which promotes growth of *Legionella* bacteria (Berry et al 2006). The constituents of certain types of natural rubber compounds and hemp used in plumbing fittings can also support the multiplication of *Legionella* by promoting biofilm formation (Colbourne et al 1984).

Figure 1: Water temperature and increasing risk of *Legionella* proliferation

Source: South Australia Department of Health (2008)
In general, the proliferation of *Legionella* occurs in water systems as a result of the interrelationships between temperature, environmental microflora and sediments, and the chemical composition of water in engineered water systems. By controlling any or all of these factors reduces the proliferation of *Legionella* bacteria in these systems.

### 2.5 Exposure sources

The primary sources responsible for legionellosis cases in New Zealand are warm water or composted vegetative material, ie, water or soil. It is proposed that every legionellosis case has been exposed to a contaminated environmental source where the *Legionella* bacterium has been able to proliferate to a level where any eventual aerosolisation increases the likelihood of contact to a susceptible population.

Infections by *L. pneumophila* strains are commonly associated with exposure to a contaminated water source – either a domestic drinking water supply (usually un-chlorinated), or recreational water (eg, a spa or swimming pool, the sea or a river). As far as saline environments are concerned Gast et al 2011 showed that *L. pneumophila* was present being harboured in amoebae that can grow in salt water which could lead to the growth and persistence of this pathogen in the environment. A domestic water supply can be either reticulated from a territorial authority or from a private source, such as roof-collected rain water stored in a tank, or a ground water (well or bore) supply, or a terrestrial supply such as a stream or lake. Any water can potentially be a source, with the risk potential increasing as water temperature increases from 20 to 45 and biocide concentration decreases. In situations where aerosols of *Legionella*-contaminated water are generated, such as from cooling towers, humidifiers, spa pools or vehicle washes, the potential for outbreaks is increased because of the increased numbers of people potentially exposed to the contaminated source.

*Legionella longbeachae* has long been associated with composts and potting mixes, so infections caused by *L. longbeachae* are common amongst gardeners. The mechanism of infection from this material is not fully understood, but is likely to be caused by the inhalation of aerosolised dust particles created when handling the material. Another potential source for creating aerosols is the wind since gardening activities are usually undertaken outside. Many other *Legionella* species as well as *L. longbeachae* have been cultured from composted material. These include, but are not limited to *L. pneumophila* strains as well as *L. bozemanae*, *L. dumoffii*, *L. feeleii*, *L. gormanii*, *L. jordanis*, *L. micdadei*, and *L. sainthelensi* (Graham et al 2012).

*Legionella* has a worldwide distribution, and the reservoir for *Legionella* is primarily aqueous. Domestic hot water services in large buildings such as hotels and hospitals, have been shown to be a common source of infection. *Legionella* from natural sources can enter and colonise manufactured water systems including air conditioning cooling towers, decorative fountains, ultrasonic nebulisers, room humidifiers, hot whirlpool\(^2\) and spa baths, hot water from taps and showers, medical devices containing water (eg, respiratory care devices) (Butler and Breiman 1998), water coolers (Schousboe and

\(^2\) Studies have demonstrated respirable (5 micrometre and smaller) aerosols above whirlpool spas (Baron and Willeke 1986, Mangione et al 1985). These respirable aerosols are apparently generated largely by jet droplet and film collapse mechanisms (Baron and Willeke 1986).
Brieseman 2007) and ultrasonic mist machinery in grocery stores (Stout and Yu 1997). Lpsg1 has previously been found in the cold water storage tanks that receive water straight from Christchurch Hospital's 90m deep artesian well (Schousboe et al 2005). A Portuguese study found that over 100 groundwater samples collected from six different boreholes located in two geographical areas over a seven-year period had low numbers of *Legionella* isolates detected (Costa et al 2005).

In 2006 there was a reported outbreak of Legionnaires’ disease in Beachlands, Manukau, Auckland associated with contaminated rainwater storage tanks. It was concluded that aerosols from a nearby marina water blaster contaminated with the same strain of Lpsg1 were a likely source of spreading it onto nearby rooftops and rainwater tanks. It was also apparent from the index property at Beachlands that a filter on the cold water line to the kitchen tap was acting as an incubator – with higher *Legionella* counts downstream than upstream. Chlorination would have helped reduce the risk from the filter (Simmons et al 2008).

### 2.6 Mode of transmission

The route of human infection is considered to be through the inhalation of dust or water aerosols containing *Legionella*. Aerosols of five or fewer microns (micrometre, or one-millionth of a metre) in diameter are effective at reaching the alveoli of the lower respiratory tract.

Aerosol generating systems that have been linked to disease transmission include cooling towers and air scrubbers where *Legionella* can grow intracellularly in protozoa within biofilms. Aquatic biofilms are ecological niches in which *Legionella* survives and proliferates. Cooling towers and evaporative condensers of air conditioning systems produce aerosols that may be either inhaled directly or passed through an air intake system for a building and then inhaled. Transmission via cooling towers has been most often documented when cases have been in fairly close proximity (less than 500 m) from contaminated sources (Breiman 1993). Bhopal et al (1991) have suggested that cooling tower aerosols are responsible for a portion of sporadically occurring cases of legionellosis in Scotland.

A study in France showed that the transmission of *Legionella* bacteria from a cooling tower appears to have extended over a distance of at least 6 km from the source (Nguyen et al 2006). A spatial study that was carried out by the Ministry of Health, New Zealand in 2005, showed clusters of cases located in the southwest region of Christchurch, where a number of cooling towers were also concentrated. However, the report noted that the analysis did not specifically identify any single tower as the putative source of the outbreak (Ministry of Health 2005).

There is growing evidence that aspiration of drinking water contaminated with *Legionella* is an important mode of transmission, especially in cases occurring in hospitals. For example, contaminated potable water (with subsequent inhalation or aspiration of aerosols during drinking) has been suggested as a possible source of legionellosis (Stout and Yu 1997). In 1999, Loeb et al linked contaminated drinking water to two outbreaks of legionellosis in nursing homes. The research findings suggested that the most likely mode of infection was aspiration due to swallowing.
Cases of sporadic community-acquired Legionnaires’ disease have also been linked to drinking water in residential dwellings (Pedro-Bitet et al 2002).

There is also evidence that showers can produce aerosols containing *Legionella*. For example, *L. pneumophila* has been isolated from air samples collected in a shower room (Dennis et al 1984). Kool et al (1998) described taking air samples in a hospital and finding *L. pneumophila* serogroup 6 in the room after the showers had been turned on.

In Victoria in 2008, seven cases of Legionnaires’ disease were linked to a warm water system at a self-service car wash facility. Water was being stored at ~45°C before being supplied to a high-pressure hose that generated a fine mist. *Lpsg1* was detected in samples collected from the outlet at 80 cfu/mL and from the storage tank at ~39,000 cfu/mL (Department of Health 2010). More recently, car windscreen washing sprays without added wash detergent have been mentioned as a possible mode of transmission via inhalation (Wallensten et al 2010).

Globally (including New Zealand), all studies to date have shown that person-to-person spread of legionellosis does not occur.

### 2.7 Laboratory diagnosis

The diagnosis of legionellosis depends on specialised laboratory tests (see Table 4) (WHO 2007). Routine tests will not identify the *Legionella* bacteria. The clinical symptoms of the disease are not specific for legionellosis and may not contribute to establishing an accurate diagnosis.

Testing for Legionnaires’ disease should be routinely carried out on any patient admitted to hospital with severe pneumonia, whether or not they present with clinical features suggesting legionellosis. This is primarily because pneumonic illness due to a *Legionella* infection does not produce any characteristic symptom that typifies Legionnaires’ disease. The symptoms displayed are indistinguishable from those of other cases of atypical pneumonia.

Patients with pneumonia that do not respond to therapy with beta-lactam antibiotics or in combination with aminoglycosides, or with other severe chronic disease, or are immunocompromised, should also be tested for Legionnaires’ disease.

A number of methods are currently available for the diagnosis of legionellosis. These are *Legionella* culture, detection of *Legionella*-specific antibodies in serum, *Legionella* urinary antigen detection, and the detection of *Legionella* nucleic acid by nucleic acid amplification tests (Murdoch 2003; WHO 2007). The sensitivity of diagnostic tests for legionellosis ranges from 60% to 70% and does not exceed 90% for any one test used. None of the individual diagnostic tests fulfil all the requirements of clinicians, microbiologists and epidemiologists. For this reason, and to increase the positive predictive value of investigation, the examination of different specimen types with different tests in parallel is strongly recommended. The occurrence of false-positive *Legionella* testing results, particularly for serological and nucleic acid amplification tests (NAAT), demonstrates the value of routine confirmatory testing procedures. All clinical samples giving positive test results should be sent to the Legionella Reference
Laboratory (ESR Kenepuru Science Centre) for confirmatory testing and further characterisation for epidemiological purposes.

Culture is still considered the ‘gold standard’ method. *Legionella* does not colonise humans and cannot be isolated from healthy people. Culture should be encouraged as it also enables matching any isolates with available environmental samples. However, its relatively low sensitivity and the reliance on the availability of a lower respiratory tract sample make it inadequate as the sole diagnostic test (WHO 2007). In addition *Legionella* spp. other than *L. pneumophila* are not nearly as reliably culturable because standard methods have been developed specifically for Lpsg1. As a result standard methods may hinder the detection of non-pneumophila species. Culture methodology in outbreak investigations should take into consideration the source of the sample and associated species (WHO 2007).

Most cases of legionellosis in New Zealand are diagnosed serologically using indirect fluorescent antibody (IFA) testing methods to detect a rise in *Legionella*-specific antibodies in serum. Serological testing does not have an impact on patient management because seroconversion occurs relatively late (usually three to six weeks after the onset of symptoms, but occasionally longer and sometimes not at all) in the course of infection. Test sensitivity is increased using methods that detect both IgG and IgM antibody classes, since some studies have shown the immune response is primarily IgM. Serological testing is retrospective and serves as confirmation of suspected cases. Therefore, there is a need for additional tests to diagnose legionellosis in the early stage of disease.

Antibodies to all *Legionella* strains known to cause disease in New Zealand should be used when screening serum from suspected cases, as frequently this is the only clinical specimen taken. For effective surveillance all potential causative agents should be screened for.

The *Legionella* urinary antigen test (UAT) will only reliably detect antigens from Lpsg1 (Murdoch 2003). The sensitivity of the UAT is positively correlated with disease severity and the length of time since the onset of symptoms. The test can give a positive result many days before other laboratory methods. The antigen detected is a of the lipopolysaccharide component of the *Legionella* cell wall and is heat stable. Sensitivity is increased without loss of specificity by concentration of the urine. A positive *Legionella* UAT result, although proof of a *Legionella* infection, cannot be used as empirical evidence of infection by Lpsg1 because the test sometimes detect or cross-react with other serogroups of *L. pneumophila* and occasionally with other *Legionella* spp. (Murdoch 2003).

Several different immunochromatographic urinary antigen tests for the detection of Lpsg1 in urine are commercially available – each with differing performance characteristics, some of which should not be used as diagnostic assays. Supplemental testing using either culture or molecular and serological tests is encouraged, to increase the positive predictive value of the UAT (Murdoch 2003).

*Legionella* nucleic acid amplification tests (NAAT) enables specific amplification of minute amounts of *Legionella* DNA and can provide results within a short timeframe.
Unlike the UAT, it has the potential to detect infections caused by any *Legionella* species. However, data on performance characteristics for this test method are limited, making diagnosis of legionellosis based solely on a positive NAAT result risky. Since the issue of false-positive results is difficult to address, any suspected case giving a positive result by *Legionella* NAAT should be interpreted with caution. *Legionella* NAAT is only routinely available at a few specialised laboratories, including ESR.

### Table 4: Comparison of methods for laboratory diagnosis of Legionellosis

<table>
<thead>
<tr>
<th>Method</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Culture</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sputum</td>
<td>5–70</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>BAL or transtracheal aspirate</td>
<td>30–90</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Lung biopsy</td>
<td>90–99</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Blood</td>
<td>10–30</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td><strong>Serology</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paired sera</td>
<td>70–90</td>
<td>95–99</td>
<td>Seroconversion may require 3–9 weeks</td>
</tr>
<tr>
<td>Single serum</td>
<td>(unknown)</td>
<td>50–70</td>
<td>Valid test requires parallel testing of paired sera taken at least 14 days apart</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>May require follow-up testing</td>
</tr>
<tr>
<td><strong>Urinary antigen</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EIA</td>
<td>75–99</td>
<td>80-85</td>
<td>Very rapid (15 minutes–3 hours), frequently earliest positive finding, may remain positive for several weeks/months</td>
</tr>
<tr>
<td>ICT</td>
<td>50-90</td>
<td>65-99</td>
<td>Only for Lpsg1; limited data for other serogroups or species</td>
</tr>
<tr>
<td><strong>DFA testing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sputum or BAL</td>
<td>25–75</td>
<td>95–99</td>
<td>Very rapid (2–4 hours)</td>
</tr>
<tr>
<td>Lung biopsy</td>
<td>80–90</td>
<td>99</td>
<td>Limited sensitivity</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Experience needed</td>
</tr>
<tr>
<td><strong>PCR/NAAT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower respiratory tract specimen</td>
<td>85–92</td>
<td>94–99</td>
<td>Rapid</td>
</tr>
<tr>
<td>Urine, serum</td>
<td>33–70</td>
<td>98–98</td>
<td>Diagnostic validity of positive results without confirmation by other methods remains unclear</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Detects all <em>Legionella</em> spp.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Utility of urine as a specimen considered doubtful</td>
</tr>
</tbody>
</table>

BAL = bronchoalveolar lavage; DFA = direct immunofluorescence assay; Lpsg1 = *Legionella pneumophila* serogroup 1; PCR = polymerase chain reaction; NAAT = nucleic acid amplification test; EIA = enzyme; ICT = Immunochromatographic assay

Source: adapted from World Health Organization (2007)

### 2.8 Legionellosis in New Zealand

The first case of Legionnaires’ disease in New Zealand was reported in 1979. Legionellosis became a notifiable disease in June 1980.
The majority of New Zealand cases appear to be sporadic. The first reported outbreak of Legionnaires’ disease occurred in 1990, and since that time approximately 14 recorded outbreaks have been identified (Graham et al 2012). *L. pneumophila, L. longbeachae* and *L. dumoffii* were identified as the most likely causes of these outbreaks (Graham et al 2012). The largest outbreak to date occurred in 2005, involving 19 cases and causing three deaths. The source was thought to have been one or more cooling towers that returned a positive result after spatial analysis identified geographical clusters of cases (White et al 2012). It is possible, however, that common source outbreaks have happened without being recognised. The first suspected outbreak of Pontiac fever in New Zealand occurred in March 1998 (Maas et al 2000). In 2007, the first documented outbreak of Pontiac fever due to *L. longbeachae* serogroup 2 in potting mix was reported (Cramp et al 2010).

Between 1979 and 2009, of the 2772 legionellosis cases fitting the case definition, 1313 fitted the criteria for confirmation of a case and 1459 as probable (Graham et al 2012). Work carried out in Christchurch in over a 12-month period (July 1992 to July 1993) showed that *Legionella* spp. is a relatively common cause of pneumonia, accounting for approximately 11% of community-acquired cases (Neill et al 1996) and 13% of nosocomial cases (Everts et al 2000).

In New Zealand, unlike many other countries, *L. pneumophila* is not the most prominent *Legionella* species causing infection (see Figure 2). Each year approximately 30-50 % of all legionellosis cases are attributed to either *L. pneumophila* or *L. longbeachae* species, although these figures fluctuate from year to year. The remaining 10-20 % of cases are attributed to other *Legionella* species and these commonly consist of *L. bozemanae, L. dumoffii, L. feeleii, L. gormanii, L. jordanis, L. micdadei* and *L. sainthelensi*. In 2010, the most prevalent *Legionella* species identified by laboratory testing of clinical samples was *L. longbeachae* with 73 (41%) cases, followed by *L. pneumophila* with 51 (29%) cases (ESR 2011). In 2011 *L. longbeachae* accounted for 72 (45%) cases, followed by *L. pneumophila* with 48 (30%) cases (ESR 2012).

Figure 2: Clinical laboratory-proven (confirmed and probable cases) *Legionellae* by species, 1979–2011
2.9 Legionellosis and the role of agencies in New Zealand

This section outlines the role of different enforcement agencies and building owners in the control and prevention of *Legionella*.

### 2.9.1 Ministry of Business, Innovation and Employment

The Ministry of Business, Innovation and Employment came into existence on 1 July 2012. It integrated the functions of the former Department of Building and Housing (which was responsible for administering the Building Act 2004) and Department of Labour (which was responsible for administering the Health and Safety in Employment Act 1992).

The Building and Housing Group within the Ministry of Business, Innovation and Employment is responsible for administering the Building Act 2004. Under this Act, buildings must be safe, not endanger health and must have features that contribute to the health, physical independence and well-being of people who use them. The Building Act sets the framework to ensure this. For buildings with wet cooling systems provisions include:

- building warrant of fitness regime
- offence provisions
- territorial authorities setting policies on dangerous and insanitary buildings.

The New Zealand Building Code Handbook contains model compliance schedules that include mechanical ventilation and air conditioning systems. This involves complying with the AS/NZS 3666 *Air-handling and water systems of buildings – Microbial control* which specifies the design, maintenance and inspection regimes for cooling towers.

The role of the Labour Group (within the Ministry of Business, Innovation and Employment) is to assess a workplace’s ability to understand and manage hazards which may arise in their day-to-day work. The Labour Group works with businesses to promote compliance with health and safety legislation, establish health and safety controls around work processes, and educate on managing hazards. In the event of an outbreak of legionellosis, the lead agency in charge of the investigation is DHB’s public health unit.

If a workplace is identified as being a possible source of *Legionella* bacteria, the Labour Group within the Ministry of Business, Innovation and Employment will work with a DHB’s public health unit and other agencies such as territorial authorities to investigate specific risks in the workplace which may have contributed to the growth of the bacteria.

In serious cases, action may be taken under the Health and Safety in Employment Act 1992 to improve the health and safety of the workplace, prohibit dangerous activities or to prosecute (Department of Building and Housing et al 2005).

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3 Mechanical ventilation and air conditioning is a system specified under the Specified Systems, Change of Use, Earthquake Prone Buildings) Regulations 2005.
2.9.2 Ministry of Health and Public Health Units of District Health Boards

Legionellosis is a notifiable disease under the Health Act 1956. Health professionals and all medical laboratories (since December 2007) are required to inform their local Medical Officer of Health of the District Health Board (DHB) of any case of legionellosis either suspected on clinical grounds or established on both clinical grounds and positive laboratory tests.

The public health unit of each DHB will investigate each notified case using a standard risk assessment questionnaire aimed at identifying all potential exposure sources for the case. When there is more than one case in an area, the DHB’s public health unit will look for their exposures in common, such as visiting a building with cooling towers or visiting areas where there have been earthworks.

The Ministry of Health liaises with the Medical Officer of Health regarding the public health response and ESR regarding the laboratory testing and results.

The DHB’s public health unit will take environmental samples to test for *Legionella* bacteria from potential sources and may make recommendations if there are any health risks identified. The Ministry of Health will assist the public health unit by providing technical advice, if necessary.

In the event of a cluster of cases, the public health response involves using the characteristics of notified cases (place, time, personal attributes such as age, ethnicity and gender – this is known as descriptive epidemiology) to establish an hypothesis as to the source of the cluster. Environmental sampling is often helpful in supporting or refuting the hypothesis which in turn guides the appropriate response. Sampling can then be used after treatment of the source to assess whether it has been effective. The DHB’s public health unit may issue a media release and have direct communication with other members of the community who may have been exposed to a common source. This is to encourage prompt reporting of symptoms.

2.9.3 Territorial authorities (district, unitary and city councils)

Councils are required to follow the regulations established under the Building Act 2004 to ensure buildings are safe and healthy. They administer and enforce the building warrant of fitness regime under the Building Act 2004. This identifies safety systems and features present in a building (such as sprinkler systems, lifts or cooling towers), the performance standards for those systems, and how they will be monitored and maintained to ensure they continue to function safely (Department of Building and Housing et al 2005).

Compliance schedules made under section 22 of the Building Act 2004 specify inspection, maintenance and reporting procedures for mechanical ventilation and air conditioning systems, to ensure compliance with the *New Zealand Building Code*. For a building to comply with the Building Code, the territorial authority (or other building consent authority) will issue a ‘compliance schedule’ itemising all specified systems in the building, as found in the ‘Building (Specified Systems, Change of Use, Earthquake Prone Buildings) Regulations 2005’. Mechanical ventilation and air conditioning systems are specified under these regulations. The compliance schedule sets out the
inspection, testing and maintenance requirements for the specified systems. The building owner must maintain those systems in accordance with the compliance schedule, issuing each year a building warrant of fitness to the territorial authority confirming that this has been done. However there is no requirement to record this information as a minimum in the form of an electronic database. The Ministry of Health strongly advocates the provision by territorial authorities of a single register of both commercial and industrial cooling towers. This would ensure that situations such as in the 2005 Christchurch Legionella outbreak where there were significant delays in accessing the records showing the location of cooling tower for that city, would not eventuate. When the Medical Officer of Health approached the Christchurch City Council in 2005 and asked for a list of cooling towers in Christchurch the council conducted a search of the compliance schedules (Building Act 2004) on the file which contained mechanical ventilation or air conditioning systems and produced a list of cooling towers that were within the building warrant of fitness system. This took some time because cooling towers were not a separate specified system at that time. Industrial cooling towers did not come with the compliance schedule regime so council staff had to talk to people who provided services to treat towers or might have had the local knowledge of where there were industrial cooling towers. This was obviously a time consuming and not particularly reliable means of identifying all industrial cooling towers. In addition, resulting delay in identifying suspected cooling towers for immediate treatment may have increased the likelihood of more individuals contracting the disease.

2.9.4 Standards New Zealand

Standards New Zealand is an autonomous Crown entity responsible for managing the development and distribution of a variety of Standards across a range of sectors nationally. Standards are documents that define materials, methods, processes, practices, or outcomes and can be used to set requirements, provide better practice, and deliver guidance. The majority of Standards are developed in partnership with Standards Australia. Relevant standards for the control and prevention of Legionella in cooling systems include the Australian/New Zealand Standard (AS/NZS) 3666: Parts 1, 2, 3 and 4, Air-handling and water systems of buildings – Microbial control. It sets out evaporative cooling tower design and installation, water management practices and standards, equipment maintenance and sampling of evaporative cooling water for chemical and bacteriological testing. It also sets out disinfection and follow-up sampling procedures to follow in the event of Legionella positive test results.

To improve the control of Legionella bacteria, Legionnaires’ disease and general microbial control performance requirements at large installations, the Australian Standard AS 5059 entitled “Power station cooling tower water systems - Management of Legionnaires’ disease health risk” was developed, primarily for use by power station designers, constructors, owners, operators, and regulatory authorities. This Standard sets out an advanced risk management methodology that includes all procedures set out in AS/NZS 3666 Part 3.
2.9.5 Building owners/operators and employers

Building owners subject to a compliance schedule (as amended in April 2004) for their specified systems must demonstrate through robust records that the requirements for maintenance and testing for *Legionella* can be evidenced. Owners that comply with the compliance schedules are required to carry out monthly testing for the presence of total bacteria and *Legionella* bacteria provided they have an automatic dosing system. This is a requirement for the building’s annual warrant of fitness (BwoF) and must be made legally available for audit in the agreed format.

Building owners are responsible for ensuring their buildings are properly maintained to comply with the building warrant of fitness. A building warrant of fitness is a statement supplied by the building owner to the council confirming that safety systems have been maintained and checked in accordance with requirements issued by the territorial authority.

Building owners must provide their building warrant of fitness to the council on an annual basis along with copies of inspection forms and any recommendations made by the inspecting ‘IQP’ (an independent qualified person) approved by the territorial authority (Department of Building and Housing et al 2005).

If building owners do not comply with a notice from the territorial authority to comply with their building warrant of fitness, they could be fined up to $200,000 and in the case of a continuing offence, a further fine not exceeding $20,000 for day or part day during which the offence is continued (Department of Building and Housing et al 2005).

In circumstances relating to industrial cooling towers, or cooling towers for industrial process that are not part of a building as defined in section 8 of the Building Act 2004, testing for *Legionella* in these cooling towers is required to be carried out by employers to ensure safe working environment under the Health and Safety in Employment Act 1992. This can be achieved by seeking a copy of a monthly water quality report in accordance with AS/NZS 3666 or requiring the building to report by exception.

Operators of industrial cooling systems (including small transportable cooling equipment) need to satisfy themselves that the cooling equipment remains safe. Since there are a number of similarities between air conditioning units and cooling towers, monthly sampling and reporting of water quality in accordance with AS/NZS 3666 is highly recommended. Owners and operators of industrial cooling towers who choose voluntarily to comply with AS/NZS 3666 will be seen to have taken ‘all practicable steps’.

3 Water Cooling Systems

Water cooling systems such as cooling towers are an efficient and relatively inexpensive means of removing excess heat from industrial and refrigeration plants.

3.1 Cooling towers

Wet cooling towers are used in air conditioning systems to remove heat (through evaporation) collected from air conditioned spaces, and in industry to remove heat generated from many industrial processes. There are many different types and
configurations available, each of which has a common operational feature – the use of a water basin. Water is circulated from the basin at the bottom of the towers and returns to the top of the tower where it falls through a structure (fill) which is designed to create an extensive wet surface area through which air passes.

To date, large scale towers with natural updraughts, such as those used in power generation, have not been implicated in outbreaks of Legionnaires’ disease, and these guidelines are not applicable to towers of this type. However, it is recommended that organisations responsible for the operation of these towers develop and maintain proper control of water quality since \textit{Legionella} bacteria have been isolated from them.

Materials used in cooling tower construction should be corrosion resistant and non-porous, with easy-to-clean surfaces. Internal surfaces should be smooth, and edges and corners rounded to facilitate cleaning. The tower’s design should provide easy access to internal surfaces of the tower, including the fill. Towers should be designed so that components, particularly drift eliminators, can be easily cleaned, preferably in situ. There should be large access panels to allow easy removal of components when required. Basins and sumps should be graded to outlets with provision for rapid draining and filling.

In keeping with AS/NZS 3666.1, the following factors should be considered in the location of wet cooling systems that includes evaporative condensers and cooling towers:

- Locate as far as possible from fresh air intakes, including windows that can be opened.
- Do not locate in the immediate area of kitchen exhaust fans,\textsuperscript{4} plants, truck bays or other sources of organic matter which could assist in the growth of \textit{Legionella}.
- Consider the direction of prevailing winds and do not locate upwind of outdoor public areas.
- Consider future construction, including nearby sites, and the effects of reversal or air flow through some towers when the tower fan is idle. Relocation of cooling towers or air intakes should be considered in some circumstances, particularly if they are situated close to each other.

\subsection*{3.2 Types of cooling tower}

The usual arrangement of an air conditioning system is illustrated in Figure 3. The cooling tower water gains heat from refrigerant circulating through the condenser, and in the process of being distributed over the tower fill, loses heat to the rising air through evaporative cooling and convective and conductive heat exchange. The mode of air flow is either forced or induced draught. The more common types of cooling towers are detailed below.

\footnote{AS/NZS 3666.1: 2002 states that ‘kitchen exhaust should be discharged at a distance of not less than 8 m from any cooling tower intake or discharge opening’. Reproduced with the permission of Standards New Zealand under Licence 000807.}
3.2.1  **Induced draught**

This is the most commonly used type, where air is drawn through the tower fill by a fan located at the discharge of the cooling tower (Figure 4). Air enters the tower through inlet louvres located above the basin perimeter and is drawn horizontally through the tower at right angles to the tower water flow. This is a cross-flow configuration.

Figure 5 shows an induced draught tower (with a drift eliminator) in which the air is drawn vertically through the tower. This is a counter-flow configuration. This type of cooling tower can be fitted with drift eliminators and even retrofitted to older towers. Generally, towers which do not have eliminators that can reduce drift to below 0.002 percent of the circulating water flow, are not recommended.

3.2.2  **Forced draught**

This type of tower has the fan 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 (Figure 6).

3.2.3  **Single cell**

This type is not common and is used mainly for small applications. Most refrigeration engineers choose dry air cooled condensers for small applications as an economically viable alternative.

3.3  **Evaporative condensers and fluid coolers**

These units are similar in principle and in operation to cooling towers. Water is distributed directly over a bank of pipes which contain circulating refrigerant or other fluids, but there is no fill as in cooling towers (Figure 7). These systems have a smaller water volume but tend to operate at a higher temperature. They are commonly used as beer chillers, and have been implicated in outbreaks of Legionnaires' disease, for example, the 1989 outbreak (three people died) that was traced to a bowling club in western Sydney, Australia (Jalaludin et al 1995).
**Figure 3:** Schematic layout of an air conditioning system which uses a cooling tower for heat rejection

**Figure 4:** Induced draught cross-flow cooling tower

Source: Victorian Government Department of Human Services (2001a)
**Figure 5:** Induced draught counter-flow cooling tower

Source: Victorian Government Department of Human Services (2001a)

**Figure 6:** Forced draught cross-flow cooling tower

Source: Victorian Government Department of Human Services (2001b)
3.4 Drift eliminators

In the operation of all cooling towers, water is lost through evaporation, bleed-off and drift. Drift is the portion of the circulating water entrained in the cooling tower exhaust as very small droplets (aerosols). These droplets are produced within the tower by water impacting on the tower fill and also by the water distribution system. The air flow will carry the smaller droplets through the tower. To minimise drift loss, eliminators must be located before the tower exhaust. It is important to restrict the amount of drift emanating from the tower as it contains dissolved minerals, chemicals and micro-organisms, including bacteria. The risk of drift lies in the transport of bacteria and chemicals to nearby environs. Efficient eliminators, by presenting the discharge air and entrained water droplets with several changes of direction, should restrict the drift loss to less than 0.002 per cent of cooling tower re-circulating water.

The eliminator and fill material should be able to withstand the pressure of a water jet. Eliminators should preferably be able to be cleaned in-situ to avoid incorrect fitting when being replaced after removal for cleaning. Incorrect alignment of eliminators may result in unacceptable levels of drift.
Figure 8 illustrates three types of eliminators currently in use.

Figure 8: Types of drift eliminators

- Plastic drift eliminators
- Corrugated metal plate drift eliminators
- Wooden drift eliminators

Note: the use of wooden drift eliminators is discouraged as these are difficult to sanitise and encourage the growth of biofilm.

Source: Adapted from New South Wales Department of Health (2004)
4 Operation and maintenance of cooling towers

4.1 Water treatment

To optimise the heat transfer efficiency and maximise the effective life of the cooling tower and associated equipment, it has been standard practice for decades to chemically treat the circulating water.

Corrosion inhibitors are used to minimise the corrosion of metal surfaces, which may result in serious maintenance problems and premature failure of plant and equipment.

Surfactants, biocides and other chemicals are used to control fouling through scale, silt and microbial growths in order to maintain efficient heat transfer at metal surfaces. This ensures free flow of water throughout the system, and prevents the proliferation of certain micro-organisms which are responsible for surface corrosion and degradation.

These basic reasons for treating cooling tower water have not changed. However, with the discovery of *Legionella*, there is now an on-going re-evaluation of biocides used in these water systems. It is now recommended practice to incorporate biocides, preferably broad-spectrum types, which reduce the total microbial load.

In the dynamic environment of a cooling tower system, the performance of chemicals is different from that in a controlled laboratory trial. Cooling tower water is subjected to temperature changes and varying flow velocities at different locations within the system. Many other parameters, including pH, conductivity, total dissolved solids, suspended matter and the biological mass within the system, can vary over a period of time.

Biocides must come into contact with the micro-organisms to ensure adequate control. Particulate matter, scale, debris, slimes and the presence of other micro-organisms such as protozoa have the potential to shield *Legionella* from biocides, and this may result in their persistence and proliferation when biocide levels fall. For corrosion inhibitors to be effective, they must come into contact with the metal surfaces to be protected, which requires that the system be free of fouling. Chemicals may be absorbed by contaminants in a dirty system, further reducing the effectiveness of the treatment.

Most cooling tower fans are thermostatically controlled, resulting in variations in air flow rates and accompanying airborne debris. Thermostatically controlled water pumps and valves can be responsible for a wide range of waterflows through the system, including no flow during periods of low-heat rejection. Many air conditioning systems associated with office buildings are shut down at night and during weekends, resulting in stagnant conditions during these periods.

For any water treatment programme to be effective, it is important that the water and all wet surfaces of the cooling tower system are maintained in a high state of cleanliness.
The aim of combining physical cleanliness of the internal surfaces of a cooling tower system with the use of an appropriate water treatment programme, is to maximise heat transfer, minimise corrosion, and control microbial populations, including *Legionella*. As expected with any preventive maintenance programme, the cost will be offset by increased plant efficiency and increased operational life of the equipment.

If there is no on-site expertise, it is essential that specialists in the treatment of cooling tower water systems be brought in to provide and monitor appropriate water treatment.

### 4.2 Bleed-off

Water supplied to a cooling tower contains a wide and varying range of dissolved substances and the amount is dependent on the source water. During the normal operation of a cooling tower, evaporation occurs, resulting in an increase in the total dissolved solids in the cooling water over time.

Increasing levels of certain substances increase the potential for corrosion of metal surfaces. Eventually the water will become saturated and materials will start to deposit within the system. Because the solubility of certain compounds decreases with increasing temperature, deposits can occur at those heat transfer surfaces operating at the highest temperature. These inorganic materials cannot be removed by oxidising biocides such as chlorine and ozone.

To overcome these problems, a small percentage of the total water volume is regularly discharged to waste (bleed-off) and replaced with fresh water. This has the effect of limiting the concentration of total dissolved solids and is usually controlled in association with conductivity or chloride ion analysis of the water. Excessive bleed-off should be avoided as this will result in a loss of water treatment chemicals, which will reduce the effectiveness of the water treatment programme.

Bleed-off can be carried out by a continuous controlled flow to waste or by intermittent discharge. Intermittent bleed-off can be achieved by manual operation of drain valves or by automatic systems operating on a time frequency or controlled by a conductivity chloride meter. Back-washing of filters with cooling water is also a form of intermittent bleed-off.

Bleed-off also provides limited control of suspended matter in the cooling water. As the quantity of bleed-off in a cooling tower decreases, the cycles of concentration increase, the amount of make-up water needed decreases, and the quantity of treatment chemicals decreases. A bleed-off lockout timer should be used to prevent bleed-off for a set period following biocide dosage to prevent wastage of expensive biocide chemicals.

### 4.3 Biocides

#### 4.3.1 Ideal biocide

If biocides are to be cost-effective in cooling water systems, they should possess a range of properties.
The ideal biocide would be effective against a wide spectrum of bacteria, algae, protozoa and fungi. It would have a long activity time, no mammalian toxicity, and be environmentally acceptable in tower drift and water discharge. It must be quick acting and effective at a low concentration over the range of pH encountered in cooling tower water, be compatible with other chemicals used, and not cause deterioration of materials with which it comes into contact. Biocides should be capable of penetrating foam, sludge, slime and scale within the system without foaming.

Ideally, biocides should be low in cost, safe and easy to transport, handle and apply, and their effectiveness should not be reduced by contaminants within the cooling tower system or by substances present in the make-up water. The biocide should be able to be measured on-site over the range normally used in water treatment.

As the ideal biocide does not exist, the appropriate treatment for a particular tower is a compromise.

The discharge of cooling tower wastewater poses the following contamination risks:

- Sediment can cause turbidity problems in waterways and water bodies.
- Most biocides and anti-corrosion chemicals are toxic to humans and also to plants and animals in aquatic environments.
- Biocide and anti-corrosion chemical residues discharged to sewer may be toxic to the microbes used for sewage treatment.
- Heavy metals (additives or sourced from pipe-work) are toxic and can accumulate in aquatic organisms.

Currently within New Zealand there is no comprehensive or integrated statutory framework covering the management of liquid waste such as industrial cooling tower wastewater. The current management of industrial cooling tower wastewater in New Zealand is subject to a complex array of statutes, bylaws and regulations, including the Resource Management Act 1991 (RMA), Local Government Act (LGA) 2002 and the Hazardous Substances and New Organisms Act 1996 (HSNO).

The type, quality and quantity of industrial liquid waste such as cooling tower wastewater that may be released to a sewer, natural waterway or disposed of by some other means may be covered by legislation such as the Hazardous Substances (Disposal) Regulations 2001 made under the HSNO Act 1996 or by local trade waste bylaws pursuant to the LGA 2002. Alternatively the discharge of cooling tower wastewater to a natural waterway either with or without treatment, may be captured through the requirements of section 15(1)(d) of the RMA 1991 which provides for the regulation of the discharge of contaminants from industrial or trade processes. Under section 15 of the RMA no person may discharge cooling tower wastewater (captured under the definition of ‘contaminant’) unless the discharge is expressly allowed by a national environmental standard or a rule in a regional plan.
4.3.2 Types of biocide

Biocides used in cooling tower water are usually divided into two main groups: oxidising and non-oxidising compounds.

4.3.2.1 Oxidising biocides

Commonly used oxidising antimicrobials for cooling water include chlorine, bromine, stabilised bromine, combinations of bromine and chlorine, chlorine dioxide, peroxo compounds such as hydrogen peroxide and peracetic acid and ozone (WHO 2007). Oxidising antimicrobials are often effective when fed continuously using metering systems with small pumps and many towers are successfully treated with continuous dosing with chlorine or bromine (WHO 2007).

Chlorine in the form of ‘free chlorine’ is formed when chlorine gas, sodium hypochlorite or certain other chlorine-releasing compounds are added to water. Bromine in the form of hypobromous acid (‘free bromine’) has similar properties to free chlorine but its action is not as sensitive to pH variations. Also, certain bromine-ammonia by-products are more efficient biocides in contrast to the weaker effects of chlorine-ammonia compounds. A bromine-release compound bromo-chloro-dimethyl hydantoin (BCDMH) has shown acceptable control of *Legionella* spp. in field situations.

Ozone is a powerful oxidising biocide which has been used more recently in cooling towers. Ozone reacts with organic material, including micro-organisms within the cooling tower water. The oxidative products formed as a result of this further react with other micro-organisms, biofilm and scale. In addition ozone maintains very poor residual properties compared to halogens.

Other oxidising biocides have the potential for use in cooling tower systems but have been used to a very limited extent. One example is chlorine dioxide. The technical difficulties associated with its production and control on-site are factors which restrict its use.

One of the difficulties associated with oxidising biocides is the lack of penetration ability to control the biological growth within a biofilm, and it may be necessary to incorporate a dispersant to assist in the disinfection of cooling tower systems.

4.3.2.2 Non-oxidising biocides

The most common type of biocidal treatment of cooling tower water is by non-oxidising biocides. As an example, non-oxidising chlorinated phenolic thioether has shown acceptable control of *Legionella* spp. in field situations (when used correctly). Other broad-spectrum non-oxidising biocides are the quaternary ammonium derivatives and isothiazolinones. Halogenated hydantoins, isothiazolones and quaternary ammonium compounds have a high toxicity rating for aquatic flora and fauna so should not be used.

Both oxidising and non-oxidising biocides have a role to play, and it is often recommended that they be rotated.

Scale and corrosion inhibitors must be compatible with the biocides used.
4.3.3 Comparison of biocide types

The use of chlorine as a biocide for potable water and in swimming pools is well known, and bromine is now widely used in spa pools.

The advantages of these biocides are rapid kill of bacteria and easy measurement of the free chlorine or bromine residual on-site by means of a simple, robust and reliable test kit. Automatic electronic control systems, which can give accurate pH and low chlorine or bromine residual control in re-circulating water systems, have been available for many years. With either chlorine or bromine, this precise method of control should be used to overcome potential corrosion problems associated with high levels of oxidising biocide and low pH. Maintaining an active residual of between 0.5-1.0 mg/L [0.5-1.0 parts per million (ppm)] of free chlorine with appropriate pH and water quality in conjunction with maintaining good cleanliness of the system will usually result in good microbiological control.

A portion of any oxidising biocide added to a wet cooling system is consumed in reacting with organic and inorganic materials present in the make-up water. It is necessary to overcome this chlorine or bromine ‘demand’ of the system to provide a free biocide residual.

An increase or decrease in water pH reduces the effectiveness of halogenated biocides, chlorine much more so than bromine. Preferably, chlorine should be used in water where the pH is controlled between 6.8 and 7.8 and bromine in water where the pH is controlled between 7.4 and 9.0. Outside these narrow pH ranges the biocidal effect drops significantly.

Non-oxidising biocides usually have a much lower kill rate than oxidising biocides but, because they are less reactive, they may persist longer in the system (an advantage over oxidising biocides). Non-oxidising biocides are usually dosed at higher concentrations (15–20 ppm) than oxidising biocides (0.5-1.0 ppm) and may require longer contact times at these concentrations (4–10 hours) (World Health Organization 2007).

The major deficiency of the majority of non-oxidising biocides is the lack of a simple on-site test to determine their concentration in water. Consequently, initial biocidal concentration is determined by calculation based on the estimated water volume of the system and the weight of biocide added. A calculated figure may be determined for a limited period of time based on dilution with make-up water, bleed-off rates, drift loss, and other losses, if they can be quantified. However, it is almost impossible to directly determine the loss of biocide by absorption and breakdown under the varying conditions within the system.

4.4 Application of chemicals

4.4.1 Dosing points

Certain water treatment chemicals may have the potential to react with each other at the concentrations in which they are supplied. This should be established before use and if
problems are likely with the proposed chemicals, separate dosing points should be used to ensure dilution of one potentially reactive chemical prior to adding a second.

Water treatment chemicals should be added to turbulent zones within the water system to assist with rapid dilution and mixing.

4.4.2 Methods of dosing

A number of dosing systems are available for adding chemicals to cooling tower water.

Manual dosing is usually carried out on a regular basis (e.g., weekly) by broadcasting a diluted form of the biocide across the surface of the water in the tower basin. Another method is to add the chemical to a turbulent zone of the water system over a period of a few minutes. Safety is important when using this method, which should be used in conjunction with suitable automatic dosing equipment as required in AS/NZS 3666.1.

Metering systems are available which inject chemical solutions into the circulating water through a small pump. The metering devices may be controlled in a variety of ways, including:

- electrically linking the metering pump with the circulating water pump
- incorporating a timing device to produce pulse dosing of chemicals. Bleed-off should also be electronically delayed to allow biocides to circulate at maximum concentration before bleed-off.
- electronically linking a make-up water flow meter with a metering pump to inject chemicals in proportion to the volume of make-up water.

Automatic metering systems are the preferred method of dosing for most chemicals. It should be noted that AS/NZS 3666.1 (section 4.1.3) and AS/NZS 3666.3 (section 2.4) stipulate that all water cooling systems must have automatic dosing systems and should not be manually dosed. Drip-feed systems are not recommended.

4.4.3 Dosing frequency

Corrosion inhibitors, and scale and sludge dispersants should be maintained at appropriate levels at all times for optimum performance. Controlled dosing of the necessary chemicals by metering pump is the best way to achieve optimum concentrations.

Maintenance of a low concentration of biocide is used for microbiological control. It is common practice to alternate biocides periodically or use a combination of two different biocides to provide better control against a range of micro-organisms. Slug or shock dosing (single high-concentration injection of chemical) is not a recommended method for the addition of oxidising biocides, although this is acceptable for non-oxidizing biocides. However, metered automatic dosing linked to either blow-down or make-up is the most appropriate method of applying biocides to a wet cooling system. Frequency of dosing should be related to heterotrophic plate counts (HPC) (see section 4.9.2 and 4.9.4) and general cleanliness of the tower.
4.5 **Ozone**

Ozone is a powerful oxidising biocide which has been used overseas as an alternative for the chemical biocides in cooling tower water treatment. As ozone gas is an unstable chemical, it must be produced on-site by means of an ozone generator and used immediately in water treatment.

Ozone disinfection is a relatively new application for the control of bacterial levels in cooling tower waters. Care must be exercised to maintain the generators in accordance with the manufacturer’s recommendations to ensure peak efficiency. Ozone has had variable success in cooling tower water treatment, with some reports of accelerated corrosion.

4.6 **Ultraviolet light**

Ultraviolet (UV) light has been used to control bacterial levels in water and is preferably used with filtration to enhance water clarity and so penetration of the radiation. UV systems are now available which only require lamp replacement after about 300 days of continuous operation. Sensing devices may be located within the lamp mounting to measure UV intensity. The sensors will indicate loss of effectiveness and the need for maintenance such as lamp cleaning or replacement. For best results, it is essential to keep the UV units and the circulating water clean.

UV light as a biocide has several limitations in a cooling tower environment.

- Ultraviolet radiation has no effect on the pH, odour or chemical composition of the water. However, the colour, turbidity and chemical composition of the water can interfere with UV transmission, so it is advisable to determine the UV absorbance of the water to be treated before installing UV equipment. Bacteria may be protected by turbidity, clumping and the presence of slimes; therefore, appropriate water filtration (eg, sand filtration) is recommended to be used in conjunction with UV light.

- The UV damage can be significantly reversed in *Legionella* and other bacteria by enzyme repair mechanisms such as those which operate in the dark (dark repair) and on subsequent exposure to bright light, including sunlight (photoreactivation).

- Disinfection occurs only in water passing through the unit and, as no residual is produced, there is no anti-microbial action in other parts of the system.

- UV light has no effect on biofilm formation outside the immediate area of treatment.

4.7 **Proprietary devices**

A number of different devices for the conditioning of water in swimming pools, steam generators, potable water supplies and other water applications have been developed at various times over a number of decades. They are often claimed to control scale, bacteria, algae and other contaminants. These devices are said to rely on an effect produced by permanent magnets, electromagnets and electrostatic fields.
There is a lack of conclusive scientific evidence to demonstrate that these devices have any significant effect on water quality and the survival and growth of *Legionella* in controlled laboratory or field trials. Therefore they are not recommended for use in cooling towers.

### 4.8 Filters

Cleanliness of a system is of paramount importance in the control of microbes in cooling tower water.

One of the simplest methods available to control particulate matter in water is filtration. A full-flow filtration plant that will remove fine particles is impracticable in most systems because of space and weight restrictions, and such filtration units would have excessive installation and operating costs. However, side-stream filtration, incorporating an independent water pump and pipe work, is effective for all cooling towers.

The side-stream operation ensures that a proportion of the cooling tower water is continuously filtered, and the use of a sand filter of the domestic swimming pool type, with manual or automatic back-wash facility, should be considered. This system can circulate biocide-treated water through the tower basin when the cooling tower system is idle, and will provide a measure of microbial control within the basin water. Sand filters are capable of removing suspended debris from the circulating water and have the capacity to filter out larger micro-organisms, such as protozoa, which may protect *Legionella* from the effect of biocides. If filters are installed, they should be included in the routine inspection and maintenance programme.

Other methods of filtration with different retention capabilities are available. Coarse filters have the potential for full-flow filtration but allow a high percentage of suspended matter to pass through. Fine filters such as cartridge or membrane filters are able to produce water of very high quality but they may rapidly become fouled.

For larger systems, cyclonic separators are a good alternative because they require less maintenance than conventional methods of filtration. Poorly maintained or infrequently back-washed filters can become reservoirs for contamination rather than enhancing disinfection.

### 4.9 Water testing

#### 4.9.1 On-site testing

As noted in section 2.9.5 building owners that comply with the compliance schedules as amended in April 2004 are required to carry out monthly testing for the presence of total bacteria and *Legionella* bacteria provided they have an automatic dosing system. *Legionella* tests with results greater than or equal to 1000 cfu/mL should be notified within 48 hours to the local Medical Officer of Health at the Public Health Service of the District Health Board.
If a wet cooling system does not have an automatic dosing system in place for biocide addition, then the requirement is that a weekly dip slide\(^5\) test to monitor total microbiological activity is carried out. The result from this test should be consistently low, but if it suddenly increases or is shown to be elevated, then a full plate count should be undertaken. For more information refer to section 4.9, below.

The basis for the new compliance schedule is the AS/NZS 3666.3. This expands on what was a requirement of a monthly bacteriological testing of water in cooling towers, by also requiring a specific \textit{Legionella} bacteria test each month. This was previously required only six monthly. As far as situations for existing building prior to the revised compliance schedule coming into effect on 1 April 2004 (or if people choose not to adopt the new compliance schedule for existing buildings prior to 1 April 2004) the testing requirements are the procedures listed in section 309.3 of the previous NZS 4302: 1987 \textit{Code of Practice for the Control and Hygiene in Air and Water Systems in Buildings} and that is to ensure adequate chemical control is being achieved in cooling towers, bacteriological tests shall be performed for:

\textit{Legionella} culture – six-monthly

Heterotrophic plate count by dip slide methods – weekly, and by pour plate, spread plate or other approved method – monthly.

Territorial authorities are able to amend compliance schedules under the provision contained in the Building Act 2004 (section 107). For example, territorial authorities could now require all compliance schedules to include the current testing requirements for \textit{Legionella} contained in the Department of Building and Housing’s New Zealand Building Code Handbook.

Cooling towers outside of the building warrant of fitness, such as those associated with a manufacturing process, are covered under the Health and Safety in Employment Act 1992 administered by the Ministry of Business, Innovation and Employment and are expected to comply with AS/NZS 3666 Parts 1, 2, 3 and/or 4.

A number of tests on samples of cooling tower 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.

Monitoring of biocidal residual is generally restricted to halogenated biocides such as chlorine and bromine.

\textbf{4.9.2 Off-site testing}

When a decision has been made to carry out tests such as for suspended solids and total dissolved solids, water samples should be transported to a water testing laboratory for analysis. Turbidity may be determined either on-site with a portable turbidity meter or in the laboratory. The concentration of non-oxidising biocides can be determined in a well-equipped laboratory, although the methods used are usually time consuming and expensive.

\(^5\) While there is no established correlation between dip slide results and the presence of \textit{Legionella}, dip slides may provide some measure of assurance of the control of the overall microbial population.
Microbiological testing of cooling tower waters for the presence of both *Legionella* and heterotrophic bacteria should be carried out on a monthly basis using plate culture methods in accordance with appropriate standard methods and in a laboratory competent to do such work.

The presence of Legionella bacteria must be monitored on a monthly basis using the standard method AS/NZS 3896 *Waters-Examination for Legionella spp. including Legionella pneumophila*.

The presence of heterotrophic bacteria must be monitored on a monthly basis using the standard method AS/NZS 4276.3.2 *Water microbiology Method 3.2: Heterotrophic colony count methods – Plate count of water containing biocides*. An acceptable alternative method is AS/NZS 4276.3.1 *Water microbiology – Heterotrophic colony count methods – Pour plate method using yeast extract agar*.

Regular microbiological testing (ie, monthly) of cooling tower water is undertaken to assess the efficacy of the biocidal treatment and general cleanliness of the system, along with ascertaining the presence of *Legionella* bacteria. If either *Legionella* bacteria is detected or the acceptable HPC bacteria level is exceeded, then immediate remedial action is required and the frequency of testing should be increased to weekly until control has been re-established.

When weekly dip slides are used for monitoring the heterotrophic bacteria level, the incubation temperature for these is 30°C for a minimum of 48 hours. Counts must remain below 10⁴ to be acceptable. Although dip slides are convenient and inexpensive, their accuracy is limited. They are useful in detecting trends in bacterial levels and verifying that a water treatment programme is actually being implemented. When there is an increase in the dip slide result, the HPC test should be carried out to quantify the microbiological load and the appropriate remedial action undertaken. Many variables affect the dip slide results, and a two-log difference between counts obtained by the agar plate and dip slide methods is not an uncommon finding. Monthly testing by the agar plate method is a more accurate assessment of HPC, and is a useful check on the weekly dip slide results.

It should be noted that none of the above HPC methods will detect *Legionella* spp. because the media used will not support the growth of *Legionella*.

### 4.9.3 Collecting water samples

For routine water analysis, care must be taken that samples are representative of the bulk of water circulating through the cooling tower system. This requires careful selection of sampling sites. If there are open basins, samples should be taken below the surface of the water. When samples are obtained from taps, it is preferable to select those which connect directly into pipes containing the circulating water. If none is available, consideration should be given to installing sampling taps at appropriate locations. Sample taps should be clean, with no leaks and external fittings such as hoses, which may be responsible for sample contamination. In all cases of sampling
from taps, water should be run to waste to ensure the removal of stagnant water from the tap and associated fittings before taking a sample. Ensure that water samples are taken well away from the inlet make-up water and the metering point of any chemicals.

In special circumstances, samples may be taken from locations which are not representative of the bulk of the tower water. For example, information on water quality in locations of very low flow may be required to assess microbial levels and the potential for localised corrosion. In some instances, it may be of interest to include sediment in the sample to be analysed.

Advice regarding the type of sample container to be used and the method of taking samples should be obtained from the laboratory where the samples are to be processed. This is particularly important for microbiological analyses when sterile containers are used for sample collection.

It is essential that the samples are:

- collected as described in AS/NZS 3666.3 Part 3 ‘Performance-based maintenance of cooling water systems’
- stored as described in AS/NZS 2031: 2001 Selection of containers and preservation of water samples for microbiological analysis
- transported as described in AS/NZS 3896: 2008 Waters – Examination for Legionella spp. including Legionella pneumophila, for Legionella samples.

Rapid-acting oxidising biocides must be neutralised, otherwise the biocide will continue to kill micro-organisms while the sample is being transported and the results of bacteriological analysis will not be representative of the water quality of the cooling tower at the time of sampling. The sample container should be pre-sterilised and contain sodium thiosulphate to neutralise any chlorine or bromine which may be in the water. It is desirable to determine the level of residual disinfection at the sampling point at the time of collection.

The volume of the sample is usually determined by the analysing laboratory. A minimum of 100 mL is recommended by AS/NZS 3896. At least 2 cm of space must be left above the water to enable sample mixing to dissolve the neutraliser.

Samples must be clearly identified and be transported to the laboratory in containers that are securely sealed to avoid leakage and cross contamination. Water and biofilm swab samples must be packed into a container that protects the samples from exposure to light and temperature fluctuation.

Timing of sampling for bacteriological analysis is important, particularly when slug dosing of biocides is undertaken. It is recommended that sampling be undertaken just before slug dosing. This will demonstrate the worst case scenario in the dosing cycle and may indicate the need for corrective action in the water treatment or cleaning programme. In accordance with AS/NZS 3666.3, avoid sampling for at least 72 hours after online disinfection or system decontamination or cleaning. This is to allow conditions to stabilise before sampling. Where practicable, before sampling, the water should be circulated throughout the system for at least 30 minutes. Ideally, sampling
should occur while the system is in operation. The sample should be collected from the
directly from the water basin or a sampling point located in the cooling water return line
to the cooling tower. Take the sample for *Legionella* (or other microbiological
examination) before any sample required for chemical analysis to help prevent
contamination of the sampling point.

### 4.9.4 Relevance of heterotrophic plate count

Heterotrophic plate count (HPC) (also known as heterotrophic colony count, total colony
count, total viable count and total heterotrophic count) is used as a general indicator of
water quality in cooling tower systems. The test measures the total bacterial load in the
sample of water. It is reported as the number of colony-forming units per millilitre (cfu/mL).

Heterotrophic plate count is useful in assessing the effectiveness of biocidal treatment of
cooling tower water and general cleanliness of the system. AS/NZS 3666.3 specifies an
HPC of less than $10^5$ cfu/mL as a level showing microbiological growth in general is in
control. If the HPC result is greater than or equal to $10^5$ cfu/mL in any water sample
collected from the cooling tower, the appropriate control strategy should be immediately
initiated in accordance with Table 5 (see below), which is based on Table 3.2 from
AS/NZS 3666.3.

**Table 5:** Control strategies for the presence of heterotrophic micro-organisms

<table>
<thead>
<tr>
<th>Test result (cfu/mL)</th>
<th>Required control strategy</th>
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<tr>
<td>&lt; 100,000</td>
<td><strong>(1) Maintain monthly monitoring</strong>&lt;br&gt;Maintain water treatment programme.</td>
</tr>
<tr>
<td>≥ 100,000&lt;br&gt;&lt;5,000,000</td>
<td><strong>(2) Investigate problem</strong>&lt;br&gt;Review water treatment programme.&lt;br&gt;Take necessary remedial action (including immediate online disinfection) and undertake control strategy (3).&lt;br&gt;<strong>(3) Retest water within three to seven days of plant operation</strong>&lt;br&gt;a. If the test result is &lt; 100,000 cfu/mL, repeat control strategy (1).&lt;br&gt;b. If the test result is &gt; 100,000 cfu/mL but &lt; 5,000,000 cfu/mL, undertake control strategy (2).&lt;br&gt;c. If the test result is ≥ 5,000,000 cfu/mL, undertake control strategy (4).</td>
</tr>
<tr>
<td>≥ 5,000,000</td>
<td><strong>(4) Investigate problem</strong>&lt;br&gt;Review water treatment programme. Take necessary remedial action including immediate disinfection as described in these guidelines and undertake control strategy (5).&lt;br&gt;<strong>(5) Retest water within three to seven days of plant operation</strong>&lt;br&gt;a. If the test result on retesting is &lt; 100,000 cfu/mL, repeat control strategy (1).&lt;br&gt;b. If the test result on retesting is ≥ 100,000 cfu/mL but &lt; 5,000,000 cfu/mL, repeat control strategy (4).&lt;br&gt;c. If the test result on retesting is ≥ 5,000,000 cfu/mL, investigate the problem, review the water treatment programme, and carry out immediate decontamination and repeat control strategy (5).</td>
</tr>
</tbody>
</table>
HPC does not indicate *Legionella* levels, but a rise in HPC indicates that conditions have generally become more favourable to bacteria. More favourable conditions for the bacteria detected by the HPC test may indicate that conditions are also favourable for *Legionella* to flourish. A reduction in HPC may indicate harsher conditions that may be inhibitory to *Legionella* also. However, in some situations, low HPC could indicate a favourable environment, without competition, for *Legionella* to multiply.

When slug dosing is undertaken, the lowest HPC can be expected soon after application of the biocide, and the highest count just before the next addition. Because biocide is lost through various routes, including bleed-off, there may be periods between successive dosings when the biocide concentration is ineffective. When this occurs, microbial numbers can increase. The bacterial quality of the make-up water may also influence the HPC.

The trends in HPC are, therefore, the most useful indicator of microbial conditions. Careful logging and storage of HPC results are essential to gauge the effectiveness of any changes to the system or its operation.

The monitoring of HPC should be regarded as an integral part of a thorough maintenance programme which includes frequent inspections, routine cleaning and disinfection, assessment of all water testing results, and periodic review of all aspects of the water treatment programme.

### 4.9.5 Significance of *Legionella* testing

*Legionella* should not be detected in any wet cooling system at any time. Because this is realistically unavoidable, whenever *Legionella* is detected the appropriate remediation is required to ensure the system is brought back under control. Examination of water samples for the presence of *Legionella* bacteria collected from wet cooling systems is undertaken using methodology detailed in standard AS/NZS 3896. The lower limit of detection using this standard is 10 cfu/mL. Standard AS/NZS 3666: Part 3, Section 3.2 and Appendices B and C outline the control strategies to be initiated if *Legionella* are detected [26]. The required control strategy is dependent on the level of contamination, with more comprehensive action required as the level increases and if contamination persists:

- If any *Legionella* is detected but the level is less than 1,000 cfu/mL then immediate on-line biocide disinfection is carried out with retesting for *Legionella* repeated within three to seven days. Clear readings (<10 cfu/mL) from two consecutive samples must be obtained before the system is deemed ‘in control’. If on retesting, *Legionella* is still detected but at levels less than 100 cfu/mL, then the on-line disinfection and retesting cycle is repeated until two consecutive samples show undetectable (less than 10 cfu/mL) levels. If on retesting *Legionella* is still detected and at levels of 100 cfu/mL or higher, then shock-dosing of the system is required.
- If the level of *Legionella* detected is greater than or equal to 1,000 cfu/mL, then immediate shock dosing of the system is required with retesting for *Legionella* in...
three to seven days. Clear readings (<10 cfu/mL) from two consecutive samples must be obtained before the tower is deemed ‘in control’. If on retesting, *Legionella* is still detected but at levels less than 100 cfu/mL, then on-line disinfection is carried out and the system retested for *Legionella* within three to seven days. If on retesting *Legionella* is still detected and at levels of 100 cfu/mL or greater but less than 1,000 cfu/mL, then shock-dosing of the system is required. If on retesting *Legionella* is still detected but at levels greater than 1,000 cfu/mL, then the system must be shut down and completely cleaned to remove all biofilm and contaminated water from all wet surfaces and pipe work.

Appropriate disinfection and decontamination processes are detailed in sections 4.11 and 4.12 respectively.

There is no proven link between HPC levels and the presence of *Legionella* in cooling tower water. For example, it is possible to have very low HPC levels and still detect *Legionella* at significant levels. Because *Legionella* will not be detected by the HPC test, it is necessary to test specifically for *Legionella* on a monthly basis. This requires a specialist laboratory which uses test media specifically designed for the growth of *Legionella*, and has trained personnel and safety equipment in accordance with Appendix A ‘Guidelines for the use of personal protective equipment during inspection and maintenance of air-handling and water systems’ of AS/NZS 3666.2.

*Legionella* test results require careful interpretation because the concentration of bacteria present is not directly proportional to the risk of acquiring infection. Available data suggest that most outbreaks associated with cooling towers occur when the *Legionella* concentration reaches 100 cfu/mL (10^5 cfu/L or greater), although lower levels may be associated with sporadic cases. AS/NZS 3666.3 recommends immediate decontamination of cooling waters when levels of *Legionella* exceed 1000 cfu/mL. However, best practice dictates that wherever and whenever *Legionella* is detectable in a cooling tower water sample using test methods detailed in AS/NZS 3896, then immediate remediation of the tower is required. For any positive result the first response should be shock dosing and retesting since the minimum period between routine tests for *Legionella* is one month and in that time the *Legionella* count in the tower can become well above any ‘presumed acceptable’ level.

### 4.10 Maintenance

Well-maintained systems are less likely to be colonised with *Legionella* bacteria than systems that are poorly maintained. Continued vigilance in terms of preventive maintenance and a good water treatment programme are required to minimise the risk of *Legionella*. AS/NZS 3666.2 recommends a maintenance programme for cooling towers that aims to ensure optimum thermal performance through a combined strategy of mechanical maintenance and total tower cleanliness. These maintenance procedures provide for regular water treatment, inspections and cleaning, and should be put into practice immediately the cooling tower is put into service. Records should be kept when routine maintenance is carried out.
Cooling towers should also be cleaned and disinfected before commissioning in accordance with the routine cleaning and disinfection procedure.

4.10.1 Operation

Staff responsible for operating the relevant equipment should have clear instructions. These should describe the operating characteristics, including commissioning data, and installation drawings, together with any modification of the total air conditioning system, schematic wiring and automatic control diagrams, and manufacturer’s recommendations for servicing.

All operating staff must be trained to perform the required monitoring and maintenance tasks as described in section 2.6 of AS/NZS 3666.2. Authorisation of regular plant servicing and data collection by the building owner or nominated representative is essential. Details of all regular, planned maintenance should be recorded in a manual for performance trend identification and for prompt attention to faults reported by operational staff or building occupants.

4.10.2 Inspections

The Building Act 2004 requires that all buildings that contain a mechanical ventilation system (which can incorporate air conditioning cooling towers) have a compliance schedule. The New Zealand Building Code Handbook contains a model compliance schedule for mechanical ventilation systems. This requires monthly testing for the presence of bacteria and Legionella bacteria. Any test giving a positive Legionella result requires immediate remedial action to be carried out under the requirements of AS/NZS 3666.3 to ensure the Legionella control strategies are being met. The type of necessary remedial action escalates as the level of Legionella detected increases, from system disinfection (refer to Section 4.11 below) at levels <1000 cfu/mL to system decontamination (refer to Section 4.12 below) at levels ≥1000 cfu/mL. As noted in section 4.9.1, Legionella tests with results ≥1000 cfu/mL should be notified within 48 hours to the local Medical Officer of Health at the Public Health Service of the District Health Board.

In carrying out the inspection the tower should first be examined under normal working conditions, with appropriate safety equipment being worn to prevent the inhalation of aerosols. A number of items can be examined externally, including signs of microbial growths, algae, water leaks, splashing and blockages, or restrictions at air inlets. If chemical dosing equipment is installed, it should be examined for correct operation and for adequate stock of chemicals.

Internally, water flow through the tower should be viewed for normal unrestricted flow, and drift eliminators examined internally or externally for damage and excessive drift.

With the fan, water pump and any dosing and filtering equipment switched off, the internal structure of the tower should be examined to check the condition of plant and equipment. For example, note should be made of any deterioration of materials (timber, metal, etc) particularly the fill, drift eliminator, basin and water distribution system.
Internal surfaces should be examined for signs of corrosion, scale, microbial growths and general fouling, and the water checked for clarity.

More detailed inspections should be undertaken when the plant is completely shut down during the annual inspection. This provides an opportunity for examination of the interior of pumps, sections of pipework and heat exchange equipment. A water treatment specialist should assess the relevance of any signs of corrosion, biofilms or deposits.

4.10.3 Water treatment programme

A water treatment programme is necessary for cooling tower systems to control corrosion, the build-up of scale and biological fouling.

Records of the water treatment programme in accordance with section 2.6 of AS/NZS 3666.2 should be kept and co-ordinated with all other relevant activities such as draining and cleaning procedures. The programme should be regularly reviewed to assess its effectiveness.

Organisations supplying chemicals for particular applications should be able to provide scientific justification for their use and to advise on any necessary safety precautions, including material safety data sheets (MSDS).

On each inspection, the water treatment specialist should provide a detailed report, including advice necessary to ensure that proper water treatment chemistry is maintained, together with general assessment of the tower condition.

4.11 Routine cleaning and disinfection

Regular physical cleaning, the judicious use of chemicals, and appropriate bleed-off are effective procedures for maintaining a clean system. Chemicals should be added to the water at a rate sufficient only to maintain predetermined chemical concentrations and an HPC below the acceptable level. The bleed-off rate should be based on total dissolved solids, chloride or another appropriate parameter of the circulating water, and should be checked during regular maintenance inspections.

There are difficulties in prescribing a routine cleaning and disinfection frequency, as the operating conditions of cooling towers vary. As a guide, AS/NZS 3666.2 recommends the frequency of cleaning ‘shall not exceed six months’. More frequent cleaning may be required. When a cooling tower has been shut down for a prolonged period (for example longer than one month), the routine cleaning and disinfection procedure should be carried out just before restarting the equipment.

Storage tanks for drinking water which supply cold make-up water to the tower should be cleaned of rust, sludge and sediment whenever the tower is cleaned and disinfected. As an added precaution, these storage tanks can be disinfected by filling with water and chlorinating at 5 mg/L (5 ppm) free chlorine while maintaining the pH between 7.0 and 7.6. After one hour this disinfected water can then be added to the cooling tower as part of the routine cleaning and disinfection procedure shown below.
Relevant performance data determining the frequency of cleaning must be based on HPC levels and tower cleanliness.

A recommended procedure for routine cleaning and disinfection is as follows.

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Implement occupational safety and health procedures as described in section 8 ‘Occupational safety and health’.</td>
</tr>
<tr>
<td>2.</td>
<td>Cease any chemical treatment and isolate all electrical equipment except the water circulating pump.</td>
</tr>
<tr>
<td>3.</td>
<td>Add a low-foaming, chlorine-compatible biodispersant or low-foaming, bromine-compatible biodispersant to the re-circulating water before disinfection.</td>
</tr>
<tr>
<td>4.</td>
<td>Disinfect the system by dosing the water with a biocide, either:</td>
</tr>
<tr>
<td></td>
<td>• a chlorine-based compound (with detergent properties) equivalent to at least 10 mg/L of free chlorine for at least one hour, while maintaining the pH of the water between 7.0 and 7.5</td>
</tr>
<tr>
<td></td>
<td>• a bromine-based compound (with detergent properties), equivalent to at least 20 mg/L of free bromine for at least one hour, while maintaining the pH of the water between 7.0 and 8.5.</td>
</tr>
<tr>
<td>5.</td>
<td>Drain the entire water circuit, including the make-up tank.</td>
</tr>
<tr>
<td>6.</td>
<td>Manually clean the cooling tower, sump, fill, drift eliminator, make-up tank and water recirculation circuit. Accessible areas of the cooling towers and its fill must be adequately washed. If the cleaning method involves high-pressure water spraying, close all nearby windows, blank off all air inlets, and tent the working area. The working areas must be isolated to avoid nuisance to the neighbourhood.</td>
</tr>
<tr>
<td>7.</td>
<td>Refill with clean water, rechlorinate and recirculate for at least six hours, maintaining a minimum level of free residual chlorine at 5 mg/L (ppm) at pH of between 7.0 and 7.6.</td>
</tr>
<tr>
<td>8.</td>
<td>Drain cooling tower system to waste in a manner approved by the territorial authority. Refill with water and dose with the appropriate start-up level of treatment chemicals.</td>
</tr>
<tr>
<td>9.</td>
<td>Recommission the system and record all actions in appropriate written record. Refer to Appendix A for a sample service log sheet.</td>
</tr>
</tbody>
</table>

Source: Adapted from Department of Employment and Industrial Relations 2008
4.12 Decontamination of cooling towers

Decontamination is required as specified under AS/NZS 3666.3 (although sampling is considered to be a relevant monitoring activity by AS/NZS 3666.2) when *Legionella* is detected at levels at or above 1000 cfu/mL on initial testing and at or above 100 cfu/mL on any re-testing. Decontamination must also be undertaken when recommended by a Medical Officer of Health. Water samples should be taken prior to the addition of biocide and tests commenced immediately. It is prudent to immediately decontaminate any suspected system identified in source tracing rather than waiting for the results of the bacteriological tests. Storage tanks supplying cold make-up water to the tower should be decontaminated as described in section 6.9, ‘Decontamination of hot, warm and cold water systems’.

Cooling towers should be decontaminated in accordance with the following procedure.

1. Implement occupational safety and health procedures, including the use of personal protective equipment, as detailed in section 8 ‘Occupational safety and health’.
2. Cease any chemical treatment. Isolate all electrical equipment, such as cooling tower fans, except the water circulating pump.
3. Add a low-foaming, chlorine-compatible biodispersant or low-foaming, bromine-compatible biodispersant to the re-circulating water.
4. Dose the circulating cooling water system with a biocide, either:
   - a chlorine-based compound, equivalent to at least 10 mg/L of free chlorine for at least one hour, while maintaining the pH of the water between 7.0 and 7.6
   - a bromine-based compound (with detergent properties), equivalent to at least 20 mg/L of free bromine for at least one hour, while maintaining the pH of the water between 7.0 and 8.5
   - add the disinfectant slowly, over five to 10 minutes, to a turbulent zone of the tower basin to promote its rapid dispersion. Use an anti-foaming agent if excessive foaming occurs
   - circulate the system for one hour, measure the pH and free chlorine or bromine levels regularly (for example, every 15 minutes). Adjust as required and record levels and actions in appropriate written record
   - ensure that the water is circulated through all parts of the system, including the standby condenser pump and any chillers that may currently be offline.
5. Switch off the water reticulating pump and drain the cooling tower to waste in a manner approved by the territorial authority. A wet vacuum cleaner can make it easier to remove waste material from a basin floor.
6. Refill the tower with clean water and switch on the re-circulating pump.
7. Repeat step 4 then switch off the reticulating pump. Drain cooling tower system to waste in a manner approved by the territorial authority.

6 If this is impracticable, a very high bleed-off rate should be used during step 4 while still maintaining free disinfection concentration. This will facilitate removal of suspended particulate matter from the system and the partial replacement of cooling water with clean make-up water.
8. Thoroughly clean the basin, fill, drift eliminator, fan and water distribution system. If the eliminators are moved, ensure they are correctly re-installed after cleaning. Suitable precautions should be taken to minimise the release of aerosols during cleaning.

9. Refill the tower with clean water and switch on the reticulating pump.

10. Repeat step 4 then switch off the reticulating pump. Drain cooling tower system to waste in a manner approved by the territorial authority.

11. Refill with clean water, recirculate and take water samples for testing.

12. Recommission the system when *Legionella* and HPC levels are detected within acceptable range.

13. Enter details of all action in an appropriate written record (eg, maintenance log book).

Source: Adapted from Department of Employment and Industrial Relations 2008

### 4.12.1 System assessment after decontamination

Chemical treatment of the cooling tower water should be reviewed at this stage and the entire cooling tower installation examined for faults in design, operation and maintenance procedures. These faults should be corrected and a more reliable water treatment procedure instituted if necessary.

### 4.12.2 Bacteriological examination after decontamination

The water of a decontaminated cooling tower should be tested bacteriologically to assess the effectiveness of the procedure.

Avoid sampling for at least 72 hours after system operation following disinfection, slug dosing with biocide, decontamination or cleaning procedures to allow conditions to stabilise.

Water should be retested within three to seven days of plant operation (as described in Appendix A of AS/NZS 3666.3) after recommissioning, for the determination of HPC and the presence of *Legionella* spp.

The HPC should be less than 1000 cfu per mL, and *Legionella* spp. not detected. If this is the case, a further check on these parameters should be taken after one month and again a month later. If *Legionella* spp. are not detected, no further testing should be carried out for *Legionella* unless future events indicate the need for it.

If the testing of water samples still shows the presence of *Legionella* spp., the cooling tower should again be decontaminated, along with a critical review of all associated equipment and the water treatment protocol.
4.13 Future design considerations

When undertaking major modifications or maintenance tasks on an existing cooling tower, or when a new tower is to be purchased, consideration should be given to features which facilitate inspection, operation and maintenance procedures (without putting any persons or adjoining premises at risk). These include:

- smooth, graded basins which drain to an outlet of large bore at the lowest point for easy cleaning
- components and internal surfaces which are easily cleaned
- durable materials which resist corrosion, various chemical treatments and water jets used in cleaning
- exclusion of direct sunlight from wet surfaces
- high-efficiency drift eliminators
- large access panels for ease of inspection and removal of components
- minimal internal components such as structural brackets that can collect sediment
  - siting of cooling towers with attention to location of air inlets, localised wind patterns, height and design of adjacent structures.

4.14 Operation and maintenance records

The value of accurate records cannot be overstressed, because a lack of accurate and up-to-date records is a common feature of systems associated with disease outbreaks. Records should be kept on-site for inspection and should include information about:

- layout of the equipment and system, including safe access
- correct and safe operating (including shut-down) procedures
- maintenance, cleaning and disinfection procedures, and their frequency
- condition of the equipment
- regular water treatment procedures
- bleed-off rate
- testing requirements and results of previous testing:
  - pH
  - total dissolved solids or conductivity
  - bacterial counts
  - all other test results
- disinfectant levels
- safety precautions
- person or contracting agency responsible for:
  - overseeing and recording the work
  - ensuring that the plant operates normally.
5 Evaporative (air) coolers

There is a wide range of evaporative (air) coolers in use in industrial, commercial and domestic applications. A common feature of these coolers is that air is drawn from outside the building, through wet filter pads and discharged inside the building. Cooling is effected by evaporation of water in the filter pads. These pads are kept wet by water which is pumped from the basin of the cooler to a distribution system at the top of the unit where water gravity feeds through the filter pads back to the basin.

If water is allowed to stagnate in the basin of a dormant evaporative cooler, conditions may arise that facilitate the growth of micro-organisms, including *Legionella*.

Air drawn across the wet surfaces of an evaporative cooler may carry fine water droplets through very short lengths of unrestricted duct work into the building being serviced (see Figure 9). This precludes the use of biocides and other water treatment chemicals when the unit is in operation.

Figure 9: Evaporative (air) cooler
5.1 Cleaning and disinfection

When not in use, during the off season or any other prolonged break, the equipment should be cleaned and left dry. This involves turning off the inlet water, isolating the unit electrically and hosing down the wet surfaces with the drain valve in the open position. The cooler should be allowed to stand in this condition, preferably with a slip-on weatherproof cover.

The operation of any overflow, bleed-off or water replacement system should be checked regularly. Evaporative air coolers should be operated and maintained in accordance with AS/NZS 3666.2.

Water discharge from evaporative coolers should be drained to waste as approved by the territorial authority. This water should not be allowed to discharge into gutters that feed drinking water tanks.

Before bringing an evaporative (air) cooler back into service, remove the slip-on cover and thoroughly clean the equipment. Remove the filter pads and hose them with clean water. Clean all waterways, including the bleed-off system and sump, to ensure free flow of water when the unit is in use. Refit the cleaned filter pads, close the drain valve and open the water inlet valve to allow the unit to fill with fresh water.
With the fan isolated and the pump circulating water around the unit, add a small quantity of household bleach (10 mL of 4 percent available chlorine per 10 L of circulating water) and allow the disinfected water to circulate for 30 minutes. Run the water to waste and refill with fresh water, circulate for five minutes, and again run to waste. Repeat this fresh water rinse and dumping and then refill with water and place the unit into normal service. Check that the equipment is operating correctly.

5.2 Water replacement
5.2.1 Fixed water bleed-off
A continuous water bleed-off should be incorporated in the sump of the unit and adjusted to prevent the deposition of normally soluble substances and to limit the accumulation of suspended matter. Incoming water quality and airborne debris will have a major influence on the rate of bleed-off required.

5.2.2 Electrically operated water replacement systems
Electrically operated dump valves and the intermittent pumping to waste are two methods which are used to control water quality in evaporative coolers.

A recent innovation involves the solenoid operation of the inlet water and drain valves in conjunction with the water pump. Whenever the pump is switched on, the inlet water valve is opened and the drain valve closed. The reverse occurs when the pump is switched off, allowing the unit to be drained rapidly and to remain in a drying-out condition until the water pump is switched on again.

These electrically controlled systems can be particularly useful if sedimentation, biological fouling or other water quality problems become evident, and they may be fitted to existing systems.

5.3 Maintenance and cleaning frequency
The off season is an appropriate time to carry out preventive maintenance on evaporative coolers. For example, deteriorating filter pads should be replaced and the water filter, water pump and fan examined according to the manufacturer’s instructions. Corrosion should be appropriately treated and any badly corroded parts replaced.

Some evaporative (air) coolers are in continuous use and appropriate times must be selected to clean and maintain the equipment. It is recommended that this be carried out every three months for an initial period of two years. If the water system is free of biological fouling, sedimentation and other water quality problems, the interval between cleaning may be increased. This increase should be carried out gradually to a maximum of 12 months. In some locations, a dusty environment or water quality problems may indicate that more regular cleaning is required. Refer to Appendix A for a sample service log sheet.
Some types of evaporative (air) coolers incorporate a heating cycle. When the heating section is operating, the cooling section of the unit should be cleaned and left in a dry condition. In the heating mode, cold air is normally drawn through the dry filter pads, forced through the heating section and discharged into the building. It is important that airways are not restricted by covers when the units are in use.

6 Hot, warm and cold water systems

6.1 General

Piped hot and warm water systems have been associated with overseas outbreaks of legionellosis in institutional or hospital settings. However, there have been clusters of cases identified in people living in a single dwelling (Bates et al 2000). Hot water systems in households are a source of infection to which most people will be exposed in their everyday life. Lower hot water temperatures (< 48.8°C) have been shown to be significantly associated with the presence of *L. pneumophila* in residential water systems (Lee et al 1988). A New Zealand study found evidence of *Legionella* spp in electrically heated hot water systems of 100 houses in the order of 6 to 12 percent (Bates et al 2000). Hospital warm water systems are commonly contaminated with *Legionella*, with one study finding more than two-thirds of institutions affected (Alary and Joly 1992). One New Zealand study showed *Legionella* to be the main microbial cause of nosocomial pneumonia (Everts et al 2000).

Domestic dwellings supplied with raw water (untreated, rain water or spring water supply) are more likely to be contaminated with *Legionella* than a treated municipal supply containing an active chlorine residual above 1.0 ppm.

Routine water sampling for *Legionella* in hot and warm water systems is not a requirement of the *New Zealand Building Code*, and is generally not recommended in most other countries. However, regular water sampling and testing (about every six months) is recommended for hospitals and other high-risk health care establishments where immunocompromised people (ie, people with poor ability to fight infections due to reduced immunity) may be exposed to *Legionella*.

The risk of burns (scalding) from hot water has to be addressed in conjunction with *Legionella* control measures. Where heated water is stored, ideally it must be stored at temperatures at or above 60°C to prevent the proliferation of *Legionella*. Water heated to over 50°C can cause serious burns in less than a minute (Figure 10). At greatest risk are:

- children, because of their sensitive skin
- older people, because they have slower reaction times and thinner skin.

One way of achieving compliance with New Zealand Building Code clause G12.3.6 is the *Acceptable Solution for G12 Water Supplies G12/AS1*, which requires that the temperature of hot water delivered to sanitary fixtures (hand basins, baths, bidets and showers) not exceed:

- 45°C for early childhood education centres, schools, nursing homes, institutions and hospitals or similar facilities for young, sick, elderly and disabled people
• 55 °C for other buildings.

Section 6.14.2 of the Acceptable Solution for G12 Water Supplies G12/AS1 states that an acceptable method of limiting hot water temperature delivered from storage water heaters (holding the stored water at 60 °C) is to install a mixing device at the hot water outlet on the sanitary fixture.

Summary control of temperature

- The recommended temperature for storage and distribution of cold water, to prevent *Legionella* infection, is below 20°C.
- Store hot water above 60°C.
- Ensure hot water at the outlet of all sanitary fixtures used primarily for personal hygiene purposes is delivered at a temperature not exceeding:
  - 45°C for early childhood education centres, primary and secondary schools, nursing homes or similar facilities for young, sick, elderly and disabled people, institutions and hospitals
  - 55°C for other buildings.

![Figure 10: Full thickness burns – contact times with water](Image)

Source: South Australia Health 2008

People responsible for the operation and maintenance of water systems should have clear instructions describing the operational characteristics of each system.

Installation drawings with any modifications should be available on-site to facilitate maintenance procedures and the design of any future alterations to the system.

All piping systems and associated storage vessels should be flushed clean upon initial installation.

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The Prevention of Legionellosis in New Zealand
Chlorine is a cost effective chemical for use when potable water systems and tanks are cleaned. Other chemicals, including detergents, cleaning fluids and corrosion inhibitors, must not be used.

Copper-silver ionisation is gaining popularity worldwide, particularly in health care facilities, as a water disinfection method for the prevention and/or control of Legionella growth (Cachafeiro et al 2007). It is based on channelling the water through a device that applies low potential electricity to copper and silver electrodes. Ozone treatment and ultraviolet light are available but are of limited use as they are only effective at or close to the point of application (Health Protection Surveillance Centre 2009).

Deadlegs containing water which lies idle for more than one week should be flushed at full flow for a minimum period of fifteen seconds, after the water is delivered at its normal hot or cold temperature. Redundant pipe work containing water that lies idle should be removed. Tanks and pipe work should be positioned or insulated to prevent the cooling of hot water and the heating of cold water. Deadlegs need to be avoided in warm and hot water systems. Where possible, branch mains should be less than 6 m in length. Where thermostatic mixing valves or their equivalent are fitted, the length of the main after the valve should not exceed 2 m.

New systems should have provision for the draining and cleaning of storage cylinders. Existing storage cylinders should be retrofitted with drains if they are not already installed.

Appropriate occupational safety and health precautions as detailed in section 8 'Occupational Safety and Health' should be followed by personnel carrying out tasks on hot, warm and cold water systems. Appendix A of AS/NZS 3666.2 has further details relating to specific tasks and appropriate personal protective equipment.

### 6.2 Warm water storage systems (20–60°C)

These systems are commonly used in hospitals, retirement homes and early childhood centres. For the purposes of these guidelines, a warm (or tepid) water system is a piped water system, (including any modified systems as described in section 6.3), which is designed to supply water to a shower outlet at a temperature between 20°C and 60°C.

To inhibit the growth of Legionella bacteria, AS/NZS 3500.4 Plumbing and drainage – Heated water services and the New Zealand Building Code require hot water to be stored at a minimum of 60°C. The water is stored in thermostatically controlled tanks in order to prevent the growth of Legionella. As noted in section 2.4, Legionella is reported to survive at temperatures between 0°C and 63°C.

#### 6.2.1 Cleaning

Every 12 months, drain and clean the storage cylinder to remove sediment. This period may be extended if it can be demonstrated that the cylinder remains free of sedimentation.
6.2.2 High-risk categories

The procedures described below should be adopted in buildings and institutions where people are in a recognised high-risk category, for example:

- the immunocompromised
- older people
- smokers and those with alcohol problems
- people with chronic respiratory disorders.

**Routine heat disinfection**

1. Take precautions to adequately reduce the risk of burns (scalding) to building occupants during this procedure.

2. Raise the temperature of the cylinder water on a monthly basis to a minimum of 70°C for a minimum of one hour. Flush each outlet in turn for five minutes with water at a minimum temperature of 60°C. Note: This may not be achievable in some systems, particularly older premises, and prohibitively expensive in others.

3. Heat disinfect systems which lie idle for two weeks or more as above, before restarting.

4. Where there is high suspicion of the reticulation system being contaminated, regular testing of the water for *Legionella* must be undertaken to ensure the disinfection is effective in controlling the *Legionella* risk.

Refer to Appendix B for a sample service log sheet.

**Routine disinfection by chlorination**

An alternative method to heat disinfection is monthly chlorination of the tepid water system, which can be carried out as follows.

1. Turn off the water heater.

2. Drain any sludge from the bottom of the water storage tank.

3. Ensure that an air break is incorporated between the supply authority’s water main and the domestic warm water system to prevent contamination of the public water supply.

4. Add sodium hypochlorite solution to produce a free chlorine residual of approximately 10 mg/L (10 ppm) in the storage vessel as measured by a DPD test kit. Keep the pH between 7.0 and 7.6.

5. Ensure thorough mixing and circulation throughout the water storage tank and any ring main.

6. Flush each outlet in turn until there is a distinct smell of chlorine. If there is any doubt, check the free chlorine level with the test kit.
7. Check free chlorine residual in the water at one outlet, preferably at the furthest point downstream of the storage vessel – this should be not less than 7 mg/L.
8. Allow the water to stand for one hour.
9. Check the free chlorine residual at the same outlet – this should not be less than 2 mg/L.
10. Repeat the above procedure if the free chlorine residual is less than 2 mg/L.
11. Drain the storage tank if the free chlorine residual is 2 mg/L or greater, refill the storage tank with water and recommission the system.
12. Where there is high suspicion of the reticulation system being contaminated, regular testing of the water for *Legionella* must be undertaken to ensure the disinfection is effective in controlling the *Legionella* risk.

6.2.3 Low-risk categories

For warm water systems serving people in low-risk categories, any infrequently used shower heads, hand basin taps, bath taps and any other outlets should be flushed every week. Whether the outlet is for hot or cold water, flushing should be at full flow for a minimum of 15 seconds, after the water has reached its normal delivery temperature.

6.3 Modified warm water systems (20–60°C)

Existing warm water storage systems may be modified as illustrated in Figure 11 to reduce the risk associated with *Legionella*. Water is stored at a normal hot water temperature of 60°C, and warm water at approximately 42°C (or as required) is supplied to outlet fixtures by utilising an electrically operated three or four-way mixing valve. Mixing valves facilitate the warm water going back to the water heater and being heated before passing through the mixing valve to reduce the temperature again.

The advantage of this system is that all water passing through the storage vessel is heat disinfected. The warm water section has the potential to become colonised with *Legionella* if the bacterium is present in the incoming cold water. Depending on the risk category of persons using the facility, the following maintenance procedures should be implemented.

6.3.1 High-risk categories

The warm water section should be heat disinfected monthly as follows (Figure 11).

1. Take precautions to reduce the risk of burns (scalding) to building occupants during this procedure.
2. Close the cold water inlet valve No 1, open the hot water valve No 2, and close valve No 3. As valve No 4 is in the open position, hot water will circulate and heat disinfect the circulation loop and the pipes returning warm water to the storage vessel.
vessel. The thermometer at location T1 should record a minimum temperature of 65°C for at least two minutes.

3. Open valve No 3 and close valve No 4 to heat disinfect the remainder of the warm water circulation loop piping. The thermometer at location T2 should record a minimum temperature of 65°C for at least two minutes.

4. Flush all outlets with water at a minimum temperature of 60°C for two minutes.

5. Recommission the system by ensuring that valves No 3 and 4 are in the open position, valve No 2 is closed, and valve No 1 is opened.

6. Ensure that water discharging at all the warm water outlets is at 42°C to prevent burns (scalding).

6.3.2 Low-risk categories
Flush at full flow for a minimum period of 15 seconds after the water is delivered at its normal, hot or cold temperature, on a weekly basis. Refer to Appendix B for a sample service log sheet.

6.4 Indirect warm (tepid) water systems
With an indirect warm (tepid) water system (Figure 12), water supplied to the outlets is contained in a piping system rather than a large storage tank.
The heating coil part of the piping system is located in a warm water storage vessel. Heat is transferred through the walls of the heating coil to heat water which is supplied to the outlets.

Water is circulated through the pipework by means of a ring main water pump as illustrated in Figure 12. A thermostat located on the storage tank controls the heat source (gas burner and burner circuit pump), ensuring that the water is supplied to outlets at a temperature of approximately 42°C (or as required).

A relatively small volume of water is stored within this piped system compared to systems incorporating large capacity storage tanks, and, under normal usage, water is frequently replaced. Also, as the water is maintained in constant circulation, particulate matter present in the incoming water is prevented from depositing within the pipework. These two factors combine to reduce the risk of proliferation of Legionella.

**Figure 12:** Indirect warm (tepid) water system
6.4.1 High-risk categories
Take precautions to adequately reduce the risk of burns (scalding) to building occupants during this procedure.

Heat disinfect the warm water piped system monthly by raising the storage water temperature to enable all outlets to be flushed with water at a minimum temperature of 66°C for two minutes (Figure 1).

6.4.2 Low-risk categories
Flush at full flow for a minimum period of 15 seconds after the water is delivered at its normal, hot, or cold temperature, on a weekly basis.

6.4.3 Solar hot water heating system
There are two types of solar water heating systems available in New Zealand:

- Thermosyphon systems use the theory that hot water will rise through cold water, and thus rely on convection to circulate the water through the system. Therefore, the solar panels need to be located below the water storage cylinder to ensure that this convective circulation can occur.

- Pump circulated systems allow more freedom with regards to the positioning of the solar panels and the cylinder as there is a small electric pump in the system. This pump is used to generate water flow within the system.

Requirements for the installation and operation of solar hot water heating systems are described in section 3.5.1 of the New Zealand Building Code G12/AS2. To prevent the growth of *Legionella* bacteria, solar water heaters must either:

- **a)** have a continuously energised heating element fitted within 55% of the bottom of the water tank (by volume) and a thermostat set to 60°C or higher, or

- **b)** be controlled so that the water above the element is heated to 60°C once a day, and the element is in the bottom 20% of the water tank (by volume) and no more than 150 mm from the bottom of the tank, or

- **c)** be controlled so that all of the stored water is heated to 60°C or higher, once a week for not less than 1 hour. The temperature must be measured by a probe in the bottom 20% of the water tank (by volume) and no more than 150 mm from the bottom of the water tank. For open loop systems the stored water includes the water in the solar collector and water must be circulated through the collector during the heating period.’ (Department of Building and Housing 2007).
6.5 Thermostatic mixing valves

Warm water can be provided by the use of thermostatic mixing valves which mix hot and cold water to provide water at a predetermined temperature (Figure 13). These valves mean long-term storage of warm water is unnecessary and should be located close to the point of use.

Mixing valves must be fail-safe, and regular maintenance is necessary to ensure correct performance. There is a risk of burns (scalding) for people in institutions by malfunction of these valves. In addition, staff should check the temperature of the water from taps or showers serviced by mixing valves before use by occupants to ensure there is no risk of burning (scalding).

Figure 13: Basic layout of a thermostatic mixing valve

![Thermostatic Mixing Valve Diagram]


6.5.1 High-risk categories

Flush outlets weekly. Flush until all water in the pipe from the thermostatic mixing valve to outlets is replaced with fresh water. Remove shower heads monthly and heat disinfect, preferably in a dishwashing machine where the temperature of the hot water is at a minimum of 70°C, or by placing in water at approximately 70°C for five minutes. Alternatively, disinfectants containing chlorine can be used to disinfect shower heads. A solution of 1000 parts per million (ppm) of free available chlorine for 10–15 minutes should be used to disinfect shower heads (Health Protection Surveillance Centre 2009).

6.5.2 Low-risk categories

Outlets that are infrequently used should be flushed, on a weekly basis, until all water in the pipe from the thermostatic mixing valve to outlets is replaced with fresh water.
6.5.3 Maintenance procedures
If mixing valves are installed, the following maintenance procedures are recommended.

1. Check the outlet water temperature with an accurate thermometer at least fortnightly to detect the start of any drift in outlet temperature from the required setting.

2. Every 12 months carry out a comprehensive maintenance service involving complete dismantling of the valve for inspection and cleaning. Replace faulty parts and any other parts as recommended in the manufacturer’s service instructions. In areas with poor water quality, more regular comprehensive servicing may be required.

3. Perform a fail-safe test several times on each valve by shutting down the cold water supply to the valve. Water flow from the outlet should cease within four seconds of the cold water supply being isolated. Any leakage water should not exceed 46°C.

4. Fit a new thermostatic element at least every three years.

5. Record all service details and fortnightly operating checks on a log sheet for future reference in the event of valve failure.

Refer to Appendix C for sample service log sheets.

6.6 Warm water systems – alternative approaches (20–60°C)
Systems which aim to minimise the risk of burning (scalding) and at the same time reduce the Legionella risk associated with the storage of warm water are currently being assessed. These systems are explained in this section.

6.6.1 Heat exchange system
This involves passing all water through a hot water storage tank where the temperature is maintained at 60°C or higher and ensuring it stays in the tank long enough to inactivate any Legionella.

Water supplied to showers, wash basins and other facilities is cooled from 60°C in the hot water storage tank to around 42°C by passing it through a heat exchanger. Cooling is effected by means of cold water passing through the heat exchanger before it enters the hot water storage tank (Figure 14).

A heated, thermostatically controlled warm water storage tank located between the heat exchanger and the warm water outlets serves to maintain the water temperature at around 42°C. No cold water mixes with warm water at the taps in this system, as shown. Water is available at one temperature only. If it is required to mix cold water at the outlet fitting, this cold water may require separate disinfection.

Prior to commissioning, after maintenance, or at any time considered necessary, the entire system should be cleaned and disinfected with hot water at a minimum temperature of 60°C at the outlets. During this procedure, precautions should be taken to reduce the risk of burning (scalding) to building occupants.
6.6.2 Ultraviolet light systems

In these systems, an ultraviolet (UV) lamp is installed on the cold water inlet pipeline to the warm water storage cylinder. Alternatively, for warm water systems which include a re-circulating ring main, the UV lamp can be connected to the outlet pipe of the storage cylinder.

Retrofitting a UV disinfection device to a water reticulation system within a building will not remove *Legionella* downstream of the device. If cold water injection tempering (mixing hot water with cold water to cool it) is used, then the UV disinfection device must be fitted down-stream of the injection point because in-coming cold water risks introducing *Legionella* into the system.
The UV lamps used must be capable of disinfecting the range of water flows that pass through the system. Sensing devices may be located within the lamp mounting to measure UV intensity and to indicate loss of effectiveness and the need to undertake maintenance such as lamp cleaning or replacement. However, bacteria may be protected by particulate matter, and the need for water filtration should be determined.

Because the water in these systems is not subject to light, photoreactivation of *Legionella* is not a problem. However, dark-repair enzymes may operate.

Ultraviolet light is notably less effective if the water distribution system is already heavily colonised with *Legionella* (ie, static population of *Legionella*). This will persist in the biofilm throughout the water distribution system unless water is reticulated past the UV lamp to eliminate *Legionella* at the point of contact (Yu-sen et al 1998) Therefore, the system would need to be cleaned and heat disinfected prior to commissioning, after maintenance, and at other times when necessary.

### 6.6.3 Copper-silver ionisation

Disinfection using copper-silver (Cu/Ag) ionisation requires electrolytic generation of positively charged copper and silver ions, which are released into the water. *Legionella* growth is inhibited by the silver ions through interference with electron transport, binding to DNA and interaction with cell membranes. On the other hand, copper is required as a trace element for microbial growth, but in its free form is actually antimicrobial (Department of Health 2010).

The Cu/Ag ionisation system has been proven to be more effective in re-circulating ring main systems. Continuous monitoring of ion levels is required to ensure optimum concentrations are maintained. Deadlegs require frequent flushing to ensure an ion residual in the water.

Copper-silver ionisation is regarded as an effective means of treating warm water systems. However, if it is used, it is recommended that:

- 'it be placed on the hot or warm line rather than on the cold water line to minimise the volume of water ingested by patients, staff or residents
- copper concentrations of 0.2 to 0.4 mg/L and silver concentrations of 0.02 to 0.04 mg/L respectively be maintained and closely monitored.' (Department of Health 2010, p 44)

WHO suggests 20 µg/L of copper as a maximum level and considers that 0.1 mg/L of silver could be tolerated (WHO 2006a; WHO 2006b).

### 6.6.4 Chlorine dioxide

Chlorine dioxide is an oxidising biocide capable of reacting with a wide range of organic substances and is regarded as an effective means of treating warm water systems. It is a highly reactive gas that readily dissolves in water so, unlike chlorine, does not react to form hazardous by-products with naturally occurring organic compounds (Department of Health 2010).
Research has shown that chlorine dioxide levels of 0.5 mg/L can, if properly managed, be effective against *Legionella* in both hot and cold water systems (Health and Safety Commission 2000). This is provided that the application is properly assessed, designed and maintained as part of an overall water treatment programme.

### 6.6.5 Anti-scald safety valves

These devices consist of a spring-activated valve which senses temperature changes and shuts the water flow to a trickle at 43°C or higher.

The valves can be connected to shower heads and outlet fittings.

Hot water connected to these devices can be stored at a minimum temperature (60°C), which will kill *Legionella*.

Since the valves release a small amount of water in the shut-down mode, a burning (scalding) risk still exists, although greatly reduced from that at full flow.

Depending on the occupants of the building, these devices might be considered to adequately reduce the risk of burning (scalding). The anti-scald valve should be checked once a month to determine that it is functioning properly by turning the hot water on and ensuring that the water shuts down before reaching a burning (scalding) temperature. The anti-scald actuator cartridge should be replaced at least every three years.

### 6.6.6 Self-draining valves

Proprietary mixing and self-draining valves are available which automatically drain water from the shower head and pipe work when the water supply is turned off. Other self-draining valves can be retrofitted to existing mixing valves and pipe work. Although the need for these valves has not been demonstrated, they are designed to reduce residual warm water in the pipework, which could support the multiplication of micro-organisms. However, as with other systems, biofilm may still remain in the pipework.

### 6.7 Hot water storage systems

This section refers to the centralised reticulated hot water storage systems which are normally installed in non-residential buildings such as hotels, hospitals and offices.

It is important that systems be kept low in sediment and corrosion products and that the water is stored at a minimum temperature of 60°C.

Storage vessels and hot water pipework should be well insulated to prevent heat loss and cool spots where *Legionella* may survive.

Care should be taken to ensure that stratification within storage cylinders does not occur and appropriate pipework modifications or alterations to cylinders should be carried out if stratification is a problem. A make-up flow into the bottom of the cylinder
will cause stratification so it is preferable that make-up should enter towards the top of the cylinder. Cold water should not be able to short circuit through cylinders and the system should be designed to ensure that all water is adequately heat disinfected prior to leaving storage.

Hot water reticulation should avoid excessive deadlegs and, if necessary, pipework should be altered to reduce the length of deadlegs.

6.7.1 Maintenance

The temperature of the stored water should be checked every six months to ensure that it does not fall below 60°C.

Consideration should be given to removing hot water outlets and associated pipework that are infrequently used or that are situated at the end of excessive deadlegs. If these outlets cannot be removed, they should be flushed fortnightly with water at a minimum temperature of 60°C at the outlets for two minutes.

Hot water cylinders should be drained, cleaned and flushed once per year, or more frequently if sedimentation is a problem. With solar hot water systems, hot water cylinders should be maintained in a similar manner to normal electric hot water cylinders – hot and cold relief valves should be flushed every six months and the anode in a glass-lined water container should be changed every five years (or more frequently in hard water areas).

Care should be taken to minimise the generation of aerosols during routine cleaning operations.

6.8 Cold water supply and storage vessels

Outbreaks of legionellosis overseas have been associated with cold water storage tanks when the water storage temperature has risen above 20°C and dormant Legionella have multiplied (Hoebe et al 1998; Wagenvoort and Sijstermans 2004). For most of the population, domestic potable cold water in New Zealand is supplied by a territorial authority and is chlorinated. This reduces, but does not eliminate, the potential for Legionella bacteria to colonise the cold water system. If the water supply is not chlorinated and is from a bore, spring or roof catchment, the potential for Legionella bacteria to colonise the cold water system is significantly increased.

The following recommendations apply only to cold water systems serving cold water fixtures. They do not apply to storage tanks serving flushometer and fire service water systems.

Storage tanks should be designed to hold up to five days’ supply so that stagnation of water does not occur. If the storage tank is kept free of sediment and the storage temperature does not exceed 20°C, conditions favourable to the growth of Legionella should not occur, and any Legionella present in the incoming mains water will not be able to proliferate.
All cold water storage tanks should be fitted with a tight-fitting lid, and an appropriately sized drain valve and associated pipework to facilitate flushing, cleaning and decontamination. Overflow pipes should be fitted with a mesh to exclude mosquitoes, vermin, leaves and other extraneous material.

Tanks and associated pipework should be located and insulated, if necessary, to ensure that the storage temperature does not exceed 20°C. Sufficient space should be available to permit easy inspection and maintenance of these systems.

If multiple tanks are used to supply a common cold water system, they should be designed, installed and maintained to ensure that the flow rate through each tank is similar and that the water in all of the tanks does not become stagnant.

On commissioning, storage tanks should be cleaned to remove rust, sludge and sediment. It is recommended that the tanks be regularly inspected and cleaned, initially on an annual basis. The frequency of cleaning may be altered, depending on the levels of corrosion, sludge and sediment experienced.

Care should be taken to minimise the generation of aerosols during routine cleaning operations.

6.9 Decontamination of hot, warm and cold water systems

If a system is suspected or implicated as the source of legionellosis, then examination of fittings, the collection of appropriate water samples for biological and chemical testing and temperature measurements should be undertaken immediately and prior to any remedial action. It is also prudent to decontaminate any implicated system immediately after the completion of sampling rather than waiting for results of the bacteriological tests because these can take up to 10 days.

People taking these samples should follow the correct occupational safety and health procedures (see section 8).

Where appropriate a number of fittings, such as taps, shower heads, and associated washers and o-rings should be removed and investigated for the presence of *Legionella*. Swabs should be taken from the pipe work connected to the fittings and the swabs cultured for *Legionella*.

6.9.1 Water sampling

Water samples should be taken as follows and investigated for the presence of *Legionella*:

(a) at all outlets immediately the tap is open

(b) at all outlets after running the water for a few seconds to obtain samples representative of water in the delivery pipe work

(c) at one outlet after running sufficient water to obtain a sample representative of water contained in the storage vessel.
Samples should be kept at ambient temperature, in the dark, and transported to the laboratory immediately.

6.9.2 Temperature measurement

Water temperatures should be taken throughout the sampling with a thermometer accurate to within 0.5°C. Further measurements should be made to determine changes in water temperature at all outlets as water flows from the storage to the outlets.

Data concerning water temperatures and results of bacteriological analysis should be recorded and assessed in relation to water flow patterns throughout the water distribution system.

6.9.3 Decontamination procedures

(a) Hot and warm water systems

These systems can be heat disinfected. During this procedure, precautions should be taken to adequately reduce the risk of burning (scalding) to building occupants.

Raise the temperature of the water in the storage vessel to a minimum of 70°C and hold for one hour. Flush sludge from the bottom of the storage vessel using the drain valve. Flush each outlet in turn until the water temperature reaches a minimum of 70°C, then continue flushing for a further five minutes.

Heat disinfection should be carried out weekly, in conjunction with water analysis for Legionella, until the system is no longer considered to be a source or suspected source of infection. Corrective action may involve simple adjustment of thermostat settings, or may require complete or partial redesign and modification of the entire system.

If a water temperature of 70°C cannot be achieved at all outlets during heat disinfection, it may be necessary to fill the system with cold water and disinfect with chlorine as described below, until appropriate modifications can be made. Please note that thermal disinfection of piped water systems at temperatures below 70°C frequently fails and often has to be repeated.

(b) Cold water systems

Cold water systems can be disinfected by chlorination according to the following procedure.

1. Ensure that an air break is incorporated between the water supply authority main and the cold water storage system to prevent contamination of water within the supply authority’s distribution system.

2. Add 250 mL of 12.5 per cent sodium hypochlorite solution per 1000 litres of water contained in the storage vessel and any associated header tank. Mix thoroughly to provide a measure of disinfection of the system even though the initial free chlorine level is not maintained and the pH is not controlled during this operation.
3. Allow to stand for one hour, drain to waste in a manner approved by the territorial authority, and then thoroughly clean the inside of the storage tank.

4. Refill the storage tank with cold water, at the same time adding sodium hypochlorite solution to produce a free chlorine residual of 10 mg/L (10 ppm) as measured by a DPD test kit. Keep the pH between 7.0 and 7.6.

5. Flush all fittings with the chlorinated water until a minimum concentration of 5 mg/L (5 ppm) free chlorine residual is measured at each outlet.

6. Turn off each outlet and allow the chlorinated water to stand for one hour.

7. Recheck that at least 2 mg/L free chlorine residual is present at all outlets. If this cannot be achieved, it may be necessary to increase the free chlorine residual by further additions of sodium hypochlorite solution to the storage tank. In some circumstances, the storage tank may require further cleaning.

8. Drain the water contained in the storage vessel and associated pipework to waste.

9. Refill the system with cold water, and chlorinate to produce a free chlorine residual of between 1 and 2 mg/L.

Chlorination of a cold water system will control *Legionella* and other bacteria only as long as a free chlorine residual exists throughout the system. Chlorine levels of 1 to 2 mg/L should be maintained until it is considered that the system is no longer a source or suspected source of infection.

6.10 Plumbing fittings

Natural rubber used in plumbing fittings has been found both in New Zealand and overseas to provide nutrients and a favoured environment for the growth of *Legionella* (Colbourne et al 1984). All washers should therefore be of neoprene or other suitable synthetic material which does not support microbial growth. Similarly, teflon-type jointing tape should be used, not plumber’s hemp. Porous and organic washers (eg, leather) should not be used, and pipe fittings used for hot water must be suitable for the temperatures and pressures within that system. This is a requirement of the *New Zealand Building Code* G12/AS1.

6.11 Avoidance of cross-connections

Water supply should be designed and installed to comply with the *New Zealand Building Code* G12/AS1. Backflow or cross-connection of pipe work and drains is prohibited. Water traps and air breaks must be provided to prevent such occurrences. All pipework must be colour marked or coded in accordance with New Zealand Standard 5807: 1980 *Code of practice for industrial identification by colour, wording or other coding*, and comply with the Health Act 1956 as amended by the Health (Drinking Water) Amendment Act 2007.
7 Other sources of infection

7.1 Implicated sources

Investigations of outbreaks (more than two cases with an epidemiological link) of legionellosis, especially in the USA and UK, have identified several sources of infection. In New Zealand the first outbreak in 1990 was associated with a cooling tower, and the largest to date in 2005 was also associated with a cooling tower; both these outbreaks occurred in Christchurch (Cramp et al 2010). Since 1990, approximately 14 recorded outbreaks of legionellosis have been identified. Exposure to compost or potting mix, and cooling towers were suspected to be the source for 66% of these outbreaks (Graham et al 2012). Another common outbreak source is spa pools. Epidemics of Legionnaires’ disease and Pontiac fever have also been associated with other sources. This section gives more details on the potential *Legionella* sources besides cooling towers.

7.1.1 Spa pools (whirlpools, hydrotherapy pools)

These recreational baths or pools (both public and private), utilise warm water at temperatures between 30°C and 40°C, with air and water jets producing turbulence and creating aerosols. Such aerosols are in the breathing zone of spa users and therefore are likely to be inhaled. Excessive use of spas (including whirlpools, hydrotherapy pools) can lead to an accumulation of soluble matter in the water. Inadequately maintained public spa facilities have the potential to infect large numbers of people, as do natural hot-spring spa pools. The recommendations for the safe operations of spa pools include:

- testing the free available chlorine level daily before use and maintaining the water conditions with a pH of 7.2–7.8, and a free chlorine residual of 3–5 mg/L (ppm) or a free bromine level of 4–6 mg/L (ppm)
- operating the filter pump when dosing biocides, but not the air blower or venturi
- using a test kit to check water conditions and biocide levels
- filtering the water for at least two hours every day, even if the spa is not in use, and running the filter for at least one hour after use
- checking and cleaning the filter regularly
- removing at least 10 percent of the water weekly and replacing it with clean tap water – heavily used spas will need to have more water removed
- keeping spa surfaces clean, including the surrounds, tiles and cover
- not using the spa or operating the water jets if the water is not treated properly or the spa has not been maintained
- draining and cleaning the pool when not in use for any extended period of time.

Spa pools on display in a showroom environment can also become contaminated with *Legionella* and present a risk of infection. The risk of infection increases if the water jets of display spas are operated (ie, produce aerosols) when the water has not been properly treated. In 2002 a retail store in Auckland was the source of a Legionnaires’ disease outbreak causing death and again in 2003, display spa pools were considered...
to be the most likely source of *Legionella* infection in the three cases that had visited a retail outlet in Lower Hutt (Ruscoe et al 2006). Each year poorly maintained private spas are identified as the source for cases of sporadic community acquired legionellosis.

In 1999, an outbreak of Legionnaires’ disease affected a number of visitors to a flower show in the Netherlands. Of 77,061 visitors, 188 became ill (133 confirmed and 55 probable cases), for an attack rate of 0.23% for visitors and 0.61% for exhibitors. Two whirlpool spas in halls 3 and 4 of the exhibition and a sprinkler in hall 8 were culture positive for *L. pneumophila* (Der Boer et al 2002).

Natural hot springs (thermal spring waters) may also be a source of high numbers of *Legionella* spp. (Bornstein et al 1989; Martinelli et al 2001), and they have been implicated in cases of Legionnaires’ disease (Mashiba et al 1993).

### 7.1.2 Water-based metal-working fluids

Metal-working fluids are specially developed coolants and lubricating fluids used in the grinding, cutting and drilling of metals. These coolants support the growth of micro-organisms, including *Legionella*. Any equipment shutdown may lead to proliferation of micro-organisms, which can occur more rapidly when the coolant is not circulated and the oil-water emulsion separates.

The growth of micro-organisms can be controlled by regular cleaning, following the directions for use of the metal-working fluid. This includes the correct use of biocides and reduction of aerosol generation and exposure.

In equipment cooled using plumbed potable water systems where, for example, water is sprayed onto a grinding wheel, periodic inspection and disinfection of the equipment should be undertaken to avoid a build-up of biofilm and *Legionella* bacteria. The disinfection can be carried out using a 5% sodium hypochlorite solution (domestic bleach) for a minimum of one hour. This will help dislodge biofilm and kill any bacteria present. The disinfection should be undertaken every three to four months or more frequently if visible biofilm is present. The addition of a mild detergent to the disinfection solution can aid penetration of the disinfectant aiding both biofilm removal and the effectiveness of the disinfection.

During periods of shut down the equipment should be drained of water and left dry.

### 7.1.3 Respiratory therapy equipment

Portable room humidifiers and oxygen nebulisers (spray generators) are commonly used on patients with underlying lung disease, who will often have a weakened immunity against infection. There have been instances in which tap water, from which *Legionella* was subsequently isolated, was used in this type of equipment.

The World Health Organization (1990) and other jurisdictions recommend the following precautions for safe operation of this equipment.

- Use only sterile water.
• Use disposable parts in oxygen nebulisers. Alternatively, the nebulisers should be emptied after each use, the parts dismantled and washed with soapy water. The parts should then be washed and dried in a dishwashing machine where the temperature of the hot water is over 70°C. They should then be stored dry and never rinsed with tap water.

• If the equipment is used continuously by a long-term patient, disinfect, as above, at least weekly.

7.1.4 Potting mix, soil and compost

There are a significant number of sporadic cases of Legionnaires’ disease caused by the Legionella organism known as L. longbeachae, accounting for as many as 50% of cases in New Zealand (Cramp et al 2010). This organism has, in contrast to cooling towers and warm water systems, is frequently isolated from composts, soil conditioners and mulches, soils for landscaping and garden use, and potting mixes. Composted materials potentially contain other Legionella species other than L. longbeachae and these other species have also been implicated in Legionella infections from composted organic matter.

Although L. longbeachae has a clinical picture indistinguishable from other Legionella species there is less epidemiological evidence of risk factors and possible modes of transmission for L. longbeachae than for L. pneumophila. It is suspected that transmission from the compost material is via the inhalation of dust aerosols containing the Legionella bacterium. Results from an investigation into 22 cases of L. longbeachae infection in South Australia during 1988 and 1989, found that those affected were regular gardeners and a common feature of their gardens was the presence of ferneries with hanging baskets (Cameron et al 1991). L. longbeachae was subsequently isolated from potting mix (which consisted mainly of composted pine bark), providing a plausible natural habitat for this bacterium (Steele et al 1990a).

Further links between L. longbeachae infection and potting mixes and other composted vegetable matter have been made in Australia, Japan, Europe and the United States, through case-series and laboratory evidence (Steele et al 1990b; Gabbay et al 1996; Koide et al 2001). In a soil survey in Australia, 33 (73%) of 45 potting soil mix samples tested positive for Legionella; 26 (79%) of the 33 (79%) contained L. longbeachae (Steele et al 1990a). Nineteen (100%) soil samples in Europe and the United Kingdom were negative for L. longbeachae. A survey of 17 soil samples in Japan in 1998 yielded 31 different strains of Legionella; 8 of the 17 samples (47%) contained L. longbeachae. A soil survey of Legionella has not been conducted in the United States (Koide et al 1999).

While the link with materials like potting mix, pine bark and sawdust has been reported (Steele et al 1990b; Speers and Tribe 1994), facets of the transmission of infection are unclear, as are the full array of virulence factors that the bacterium must surely possess. Factors such as the processing of potting mix and the presence of other micro-organisms may also be important in the ecology of the Legionella bacterium in the natural terrestrial environment. Although L. longbeachae is predominantly terrestrial, this species has also been detected in water samples. One study utilised a polymerase chain reaction (PCR) technique, amplifying portions of the ‘mip’ gene that are specific
for both species and serogroup (Saint and Ho 1998). This method was able to show that water can sustain viable populations of \textit{L. longbeachae}.

7.1.4.1 Prevention
There is no statutory requirement in New Zealand for potting mixes and other compost materials to have warning labels attached. This is because most manufacturers have volunteered to use an industry-agreed warning label (Figure 15) as recommended by NZS 4454: 2005 \textit{Composts, soil conditioners and mulches}. To prevent \textit{Legionella} infection from potting mix and other compost materials, people should take precautionary steps, including the following.

- Wear a face mask when handling soil, mulches, compost or potting mix indoors or in windy conditions.
- Open the bag using a blade with care to avoid inhaling airborne potting mix, ie, slowly and away from the face.
- Moisten the contents of the bag on opening, by making a small opening and insert a garden hose to dampen the potting mix.
- Avoid potting-up plants in unventilated areas, such as enclosed greenhouses or sheds.
- Wear gloves.
- Avoid transferring potting mix from hand to mouth (eg, rubbing face with a soiled hand or glove).
- Always wash hands after handling potting mix, even if gloves have been worn, as \textit{Legionella} bacteria can remain on hands contaminated by potting mix
- Store potting mix in a cool place, away from the sun.
- Keep soils and potting mix damp.
- Avoid raising soil near evaporative coolers.
- Water gardens and composites gently, using a low-pressure hose.
- When handling bulk quantities of potting mixes or other soil products, follow procedures that minimise dust generation.

Face masks should be either P1 or P2 particulate masks, as specified in AS/NZS 1715: 2009: \textit{Selection, use and maintenance of respiratory protective equipment}, or AS/NZS 1716: 2003: \textit{Respiratory protective devices}. These must be tightly fitting over the mouth and nose with no air gaps between the mask edge and the skin. Surgical masks are not appropriate for this use. It is recommended good practice for retailers of potting mix and compost to also offer protective masks at point of sale. The Ministry of Health has developed a resource titled \textit{Safer and Healthier Gardening} to help reduce the risk for the home gardener, which could also be made available at point of sale. This resource is available free of charge and can be ordered from the following website: www.healthed.govt.nz/resources/saferandhealthiergardening.aspx.
7.1.4.2 Bulk handling

Regardless of the quantity of soil, potting mix or compost being handled, basic control procedures such as those outlined above should be implemented. However, when handling bulk products, remember to:

- keep the soil, potting mix or compost damp, to minimise the spread of particles
- avoid double handling of soil, potting mix or compost whenever possible
- if working in an enclosed vehicle, ensure that the cabin is sealed and air filters are cleaned regularly
- plan the work to minimise the need to move bulk soils, potting mix or compost, to reduce the risks of creating dust
- wear protective equipment, including both gloves and face masks.

If bulk compost, soil or un-bagged potting mix is being bulk stored at commercial sites such as retail outlets or nurseries, it is recommended that bins are designed to minimise wind disturbance of the contents and have barrier walls to reduce the risk of inhaling potentially contaminated dust or dust being blown off-site into neighbouring properties. Bulk bins should be located in full shade and the materials should be well-watered.

Figure 15: Recommended labelling of bagged products and bulk handling areas

Warning label 1 – Bags

<table>
<thead>
<tr>
<th>CAUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordinary garden soil and products like compost and potting mix may contain a variety of living microorganisms, some of which, on rare occasions, can cause illness in humans. Serious infection is rare. However, for older people or those with reduced immunity, infection can be life threatening. We recommend the following precautions:</td>
</tr>
<tr>
<td>• AVOID OPENING BAGS IN ENCLOSED AREAS (INCLUDING HOT-HOUSES AND FERNERIES)</td>
</tr>
<tr>
<td>• AVOID INHALING DUST OR AEROSOLISED PARTICLES FROM THE MIX</td>
</tr>
<tr>
<td>• ALWAYS WEAR GLOVES AND WASH HANDS AFTER USE.</td>
</tr>
<tr>
<td>See your doctor if you develop high fever, chill, breathlessness or cough.</td>
</tr>
</tbody>
</table>

Warning label 2 – Bulk handing areas

<table>
<thead>
<tr>
<th>CAUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordinary garden soil and products like compost and potting mix may contain a variety of living microorganisms, some of which, on rare occasions, can cause illness in humans. Serious infection is rare. However, for older people or those with reduced immunity, infection can be life threatening. We recommend the following precautions:</td>
</tr>
<tr>
<td>• AVOID INHALING DUST OR AEROSOLISED PARTICLES FROM THE MIX</td>
</tr>
<tr>
<td>• ALWAYS WEAR GLOVES AND WASH HANDS AFTER USE</td>
</tr>
<tr>
<td>• WHILE WORKING AROUND BULK STOCKPILES WEAR A MASK TO PREVENT INHALING THE WATER VAPOUR.</td>
</tr>
<tr>
<td>See your doctor if you develop high fever, chill, breathlessness or cough.</td>
</tr>
</tbody>
</table>
7.1.5 Indoor fountains and water features

Aerosols are created by splashing or spraying of water in a fountain. Fine droplets or mists present a greater risk than larger droplets. The re-circulating water in such systems may be inadvertently heated, such as through submerged lighting, direct sunlight or high ambient temperatures, producing conditions that may favour the growth of \textit{Legionella}. These factors should be considered during the design and installation phases, and when planning cleaning and maintenance schedules.

The majority of Legionnaires disease outbreaks linked to fountains have been associated with decorative fountains in enclosed areas or atria where aerosols are more likely to persist (Hlady et al 1993) and water temperatures are usually close the indoor ambient air temperature. The risk is considerably increased when water temperatures are increased and biocide control is absent or inadequate.

Maintenance schedules and water treatment plans for water features should include regular draining and physical cleaning of the entire system (including associated pipe work, pumps, filters sumps and drains). Microbiological control should also be undertaken using biocides commonly used in swimming pools and monitored in a similar way to ensure control is effective. Maintenance records should be kept showing frequency of system cleaning and biocide.

7.1.6 Grocery misting machines, humidifiers, and dental unit water lines

These devises have been proven sources of \textit{Legionella} infection overseas. Documented incidents are low; however some of these have been the source of outbreaks and show that any contaminated water-based system that generates an aerosol has a potential legionellosis risk. Again, this risk is considerably increased when water temperatures are increased and biocide control is absent or inadequate.

Humidification systems are used to humidify air that enters occupied spaces. There are many designs of humidifier, some of which operate on the principle of evaporation of cold water. These systems should be maintained in a thoroughly clean condition and stored dry when not in use. In some instances, it may be appropriate to replace water types with steam-generating humidifiers in which \textit{Legionella} will not survive.

Other water-based systems such as high pressure water blasters have the potential to disseminate \textit{Legionella} into the environment as an aerosol. These systems have in common a supply of water that at times is allowed to stagnate and may result in the water temperature and other factors becoming conducive to the proliferation of \textit{Legionella}. When such a system is activated after being idle, contaminated aerosols may be produced. These systems include high-pressure cleansing and cooling processes, and above-ground storage tanks which feed aerosol generating equipment.

Actions that should be taken if these systems are of concern may vary according to the circumstances. Periodic and regular flushing of the system to remove stagnant water (in a manner that does not produce aerosols) will suffice in some situations; the use of biocides may be appropriate in others. Storing water in a way to prevent temperatures rising above 20°C, such as in underground tanks, may be a solution. Each situation should be individually assessed and the appropriate action taken.
7.1.7 Washing systems using recycled water

Washing systems that use recycled water, particularly as a spray, have been identified as the source of *Legionella* infections. These types of systems may be found in crate washing systems, powder coating systems and include vehicle wash systems frequently found on service station forecourts.

Several risk factors have been identified that typically contribute to the growth of *Legionella* bacteria in any system using recycled water. They are:

- winding pipes and tanks that provide reservoirs for bacterial growth
- the presence of “deadlegs”
- water that can reach optimal temperature for bacterial growth
- high nutrient loading
- the build-up of biofilm, or the presence of lime scale or rust within tunnels and tanks
- the use of natural rubber seals and flexible rubber hosing
- infrequent usage
- the lack of appropriate biocide control.

‘Safety considerations for washing systems include:

- considering whether the water temperatures can be kept either below 20°C or above 60°C to discourage *Legionella* growth
- evaluating flow rates of water through tanks or pipework to eliminate stagnation and material build-up
- removing and replacing rubber hosing and seals used in the system as rubber encourages the growth of biofilm and *Legionella*
- implementing a regular regime of cleaning, giving attention to the removal of sludge
- implementing a regular disinfection and maintenance based on inspection and microbiological monitoring.’ (Commission for Occupational Safety and Health 2010, p 20).

7.2 Other potential (unproven) sources

Research has shown that professional drivers may be at increased risk of acquiring Legionnaires’ disease from windscreen wiper fluid. It is likely that *Legionella* bacteria could grow in the stagnant water of the windscreen wiper fluid reservoir which may be sprayed intermittently onto the windscreen, creating an aerosol (Wallensten et al 2010). A study carried out in 2008 and 2009 found that driving or being a passenger in a vehicle with windscreen wiper fluid not containing added screen wash had a very strong association with increased risk for legionellosis, although the confidence interval was wide. The authors estimated that around 20% of community-acquired sporadic cases under the age of 70 years could be attributed to this exposure. They noted that a simple recommendation to use screen wash could mitigate transmission of *Legionella* bacteria to drivers and passengers (Wallensten et al 2010).
8 Occupational safety and health

8.1 Introduction

Commissioning, maintenance, cleaning, decontamination and other procedures should be designed to minimise the risk to personnel working on or in the vicinity of cooling towers and other potential sources of Legionella.

Procedures that create aerosol sprays, such as high-pressure hosing, should be avoided whenever possible. If this is unavoidable, suitable respiratory protection should be worn to minimise the risk of inhaling water droplets contaminated with Legionella.

To reduce the risk to maintenance staff, decontamination and routine cleaning of cooling towers described in this document include chlorination of the tower water before any physical cleaning being undertaken.

Water treatment should be carried out by or under the direction of suitably qualified and experienced persons. Chemicals should be handled with care by personnel wearing appropriate protective clothing, including goggles and gloves, to prevent direct contact with these agents.

Personnel involved in the above procedures should be adequately trained in safety procedures, including the use and maintenance of protective equipment. Caution must be exercised so that occupants of the building and others in the vicinity are not put at risk by any procedures undertaken or by the handling of chemicals.

8.2 Safety standards

Appropriate respiratory, skin and eye protection should be selected by a qualified occupational safety and health professional. It is the employer’s responsibility (under the Health and Safety in Employment Act 1992) to provide protective equipment and to train staff in its correct use. The Ministry of Business, Innovation and Employment can provide further advice if required.

8.3 Safety practices and procedures

The following safety practices and procedures should be observed when working on or in close proximity to cooling towers.

8.3.1 General inspection and routine maintenance work

When inspecting or working in or on cooling towers where aerosols might be created and inhaled, cartridge respirators of the recommended type should be worn for the duration of the inspection or work. These respirators should contain a particulate filter of appropriate efficiency. Hands should be washed and thoroughly dried after inspection and maintenance work, and before eating, drinking or smoking.
If chlorine compounds or other biocides are handled in this type of work, appropriate precautions to prevent skin contact should be used. These precautions should comply with those outlined on the relevant material safety data sheet and may include wearing gloves, face shield and waterproof apron.

8.3.2 Decontamination and cleaning tasks

These tasks involve the generation of mists and the handling of a variety of chemical substances. The protective clothing outlined below should be considered the acceptable minimum. More stringent precautions may be necessary in some circumstances, for example, during work in a confined space.

Personnel carrying out decontamination and cleaning procedures should wear the following protective equipment:
- goggles or face shield
- hardhat and harness
- waterproof clothing or coverall
- protective gloves
- a suitable face mask with a particulate filter of at least Class P2, or powered air purifying respirators with a P2 filter that complies with AS/NZS 1716 which should be used in accordance with AS/NZS 1715 when inspecting a water cooling system which is in service. If there is also a risk of inhalation of low levels of chlorine, a combination acid gas and particulate respirator may be suitable. If aerosol sprays are created, personal protective equipment to protect the eyes should also be worn, such as goggles, face shield, waterproof clothing or coverall, protective gloves and a full-face respirator.

Table A1 of Appendix A of AS/NZS 3666.2 can be considered as the minimum requirement for personal protective equipment during any activity associated with water cooling systems, including maintenance.

8.3.3 Chemical handling

Chemicals such as biocides, cleaning agents, acids and alkalis may be used in cleaning and decontamination procedures. These materials may be corrosive to the skin and, if inhaled, may cause respiratory irritation. Material safety data sheets should be obtained for each chemical agent used and the recommended preventive measures and first aid procedures followed.

The handling and storage of chemicals used in cleaning and decontamination procedures need to conform to AS/NZS 3666.2 and AS/NZS 4452 – The storage and handling of toxic substances. In addition, water treatment chemicals used for cooling tower cleaning and decontamination are controlled by the Hazardous Substances and New Organisms (HSNO) Act 1996, which replaces previous laws such as the Dangerous Goods Act 1974 and the Toxic Substances Act 1979. HSNO regulations may require:
• a Location Test Certificate for the premises (previously a Dangerous Goods Licence)
• an Approved Handler Test Certificate for employees responsible for the handling of certain highly hazardous chemicals.

When handling chemicals of this nature, the following guidelines should be observed.

1. Comply with any instructions on the product label or container.
2. Avoid mixing the chemicals during storage or transport. Handle only one chemical at any time in one place.
4. Prevent the spread of chemicals by using sand or other suitable methods when cleaning up spills. Dispose of the contaminated sand in an appropriate manner. If possible, avoid washing spills into storm water drains.
5. If skin comes into contact with chemicals, wash immediately with copious quantities of clean water.
6. Wear goggles or a face shield, and impermeable gloves.
7. Wear respiratory protection if there is a risk of significant contamination of the air by a chemical substance in the form of vapour or powder. This may occur in a confined area where ventilation is limited.

If hazardous substances such as chlorine are used in a domestic setting they need to be stored so that any leak or spill is contained to avoid harm to people, property or the environment. Some hazardous substances can be highly poisonous to people. These chemicals must be kept secure under lock and key when unattended so that children and unauthorised people cannot get to them.

8.3.4 Working in confined spaces

More stringent safety procedures may be needed when work is carried out in a confined space, such as inside a cooling tower. The safety requirements are detailed in the Ministry of Business, Innovation and Employment’s publication Safe Working in a Confined Space.

8.3.5 Protective clothing and equipment

The safety equipment and procedures outlined above are specially aimed at the cleaning and decontamination of cooling towers but can reasonably be extended to cover maintenance tasks associated with other systems.
The following equipment should be used for specific tasks in addition to normal protective clothing such as overalls and dust coats:

- **respiratory protection** – Properly fitting protective devices conforming to the following New Zealand Standards:
  - AS/NZS 1715: 2009 *Selection, use and maintenance of respiratory protective equipment*
  - AS/NZS 1716: 2003 *Respiratory protective devices*
- **full-face masks** with a particulate filter of at least Class P2 that complies with AS/NZS 1716
- **skin protection** – the following waterproof clothing:
  - waterproof overalls (with hood) – either disposable or reusable rubber/vinyl suit
  - rubber or vinyl knee-length boots
  - rubber or vinyl gloves
- **eye protection** – goggles or face shields conforming to AS/NZS 1337.1: 2010, Part 1: *Eye and face protectors for occupational applications.*
Part 2: Guidelines for the Follow-up of Cases of Legionellosis

9 Introduction

This document has been revised to assist hospital staff and public health personnel in the investigation and control of potential or actual outbreaks of legionellosis in New Zealand. Guidelines for the public health management of Legionella are changing as more becomes known about this genus of organisms and its impact on human health. For this reason this document may be reviewed and updated from time to time.

9.1 Case definition

Clinicians should maintain a high index of suspicion for legionellosis in any patient with unexplained fever and pneumonia, especially when there is immune impairment, and they should treat such cases appropriately.

The current definition for a legionellosis case uses a combination of clinical and microbiological tests to distinguish legionellosis from other types of pneumonic illness with similar manifestations. Periodic updates are required to take into account development of new and improved diagnostic methods. The Legionella Reference Laboratory at the Institute of Environmental Science and Research (ESR) uses a two-tiered case definition for legionellosis cases: ‘probable’ and ‘confirmed’.

Probable case – clinically compatible illness with only one of the following:
- the detection of Legionella nucleic acid in either respiratory tract secretions, or tissue, or blood using validated nucleic acid amplification test (NAAT) methods and confirmed by DNA sequence analysis
- a single elevated (≥ 512) serum antibody titre to a specific Legionella species by the indirect immunofluorescence antibody test (IFAT) using species-specific antigen and validated reagents

Confirmed case – clinically compatible illness with or one or more of the following:
- the isolation by culture of Legionella species from clinical specimens (lung tissue, respiratory secretions, pleural fluid, blood or other tissue)
- demonstration of Legionella organisms in lung tissue or respiratory tract specimens or pleural fluid by direct fluorescent antibody staining using validated monoclonal reagents
- a fourfold or greater rise in serum antibody titre levels to ≥256 to a specific Legionella species by the indirect immunofluorescence antibody test (IFAT) using species-specific antigens and validated reagents
- two convalescent phase sera tested in parallel, showing elevated antibody titres ≥ 512 to a specific Legionella species by the indirect immunofluorescence antibody test (IFAT) using species-specific antigens and validated reagents
- demonstration of L. pneumophila serogroup 1 antigen in urine by using a validated enzyme immunoassay (EIA) or immunochromatographic test (ICT) method and reagents
• the detection of *Legionella* nucleic acid during the acute disease phase in either respiratory tract secretions, or tissue, or blood using validated nucleic acid amplification test (NAAT) methods and confirmed by DNA sequence analysis followed by an elevated (>256) serum antibody titre in the convalescent disease phase to a specific *Legionella* species by the indirect immunofluorescence antibody test (IFAT) using species-specific antigen and validated reagents (Ministry of Health 2012).

For further information refer to section 2.7 ‘Laboratory diagnosis’.

### 9.2 Notification

The criteria for notification of legionellosis in New Zealand are a clinically compatible illness and at least one positive *Legionella*-specific laboratory test.

Legionellosis has been a notifiable disease under section 74 of the Health Act 1956 in New Zealand since June 1980. Notification is on suspicion that is, not awaiting confirmation. General practitioners and hospital clinicians should notify the Medical Officer of Health serving the health district in which the patient resides. The introduction of direct laboratory notification to the Medical Officer of Health on confirmation or suspicion of legionellosis in December 2007 has added a new dimension for the detection of both sporadic cases and investigation of suspected outbreaks. A standard data set for each case is obtained and entered into EpiSurv, the database of notifiable diseases.

An enhanced *Legionella* data collection form to be used by investigating public health personnel is included in Appendix D.

Often public health authorities will, with index case approval (under the Privacy Act 1993), inform the appropriate occupational safety and health personnel if an industrial source is implicated.

### 9.3 Communication

After the identification of a case of legionellosis, these steps are followed.

1. The Medical Officer of Health should inform the appropriate health district staff, including the relevant local infection control committees, particularly if the cases may have been acquired in a hospital setting.

2. Epidemiological information on a single case should be forwarded to ESR’s Legionella Reference Laboratory so that it can be disseminated to other health districts and the Ministry of Health.

3. In the event of an outbreak, the Medical Officer of Health should consider contacting the Legionella Reference Laboratory at ESR immediately for advice.

### 9.4 Management of a single case

Isolation is not necessary. Erythromycin has been the drug of choice; however, macrolide and fluoroquinolone antibiotics are the most potent agents and have become
the first choice for the treatment of *Legionella* infections. The new macrolide antibiotics, such as clarithromycin and azithromycin, show more effective in-vitro activity and better intracellular and tissue penetration than erythromycin, as do the fluoroquinolones. Ciprofloxacin is a fluoroquinolone available in New Zealand and is known to be effective in treating legionellosis.

### 9.5 Management of contacts

Globally (including New Zealand) all studies to date have shown that person-to-person spread of legionellosis does not occur, so contacts of cases require only reassurance. If a common environmental source has been implicated, additional cases should be sought (eg, households, businesses). The incubation period for Legionnaires’ disease is 2–10 days; for Pontiac fever it is generally 1–2 days, but can be anywhere between five hours and three days.

### 9.6 Recognition and control of outbreaks

A summary of public health investigations for *Legionella* is shown in Figure 16. Investigations of single case reports are important because they may uncover other cases and may point to common exposures, such as contaminated soil, or air or water in commercial or institutional settings during the incubation period. Such settings include shopping centres, clubs, cinemas, hospitals, hotels and spa pools. If *L. longbeachae* infection is identified, then it is likely to have been caused by close or direct contact with potting mixes or soils (O’Connor et al 2007).

A single hospital-acquired case should prompt testing of the institution’s water system because of the potential risk to immunosuppressed and otherwise susceptible patients.

Suspected occupational sources such as a nursery or commercial composting operation should also be thoroughly investigated.

Other sporadic cases, however, may not warrant extensive investigation because of the frequent difficulty in identifying the specific source and the likelihood of detecting a variety of natural or human-made water distribution systems naturally colonised with other *Legionella* strains. Most such strains are rarely pathogenic and do not warrant interventions that are expensive, time consuming and have little impact on the risk of further cases.

For cases of *L. longbeachae*, the investigation should focus on gardening activities and the use of commercial potting mixes, or any activity where there may have been exposure to aerosolised soil or organic dust (eg, excavation and landfill operators). When two cases are not linked by a common exposure (which is very unusual), the investigation does not need to proceed further.

When common exposures can be identified for two or more cases, health protection officers should ideally conduct environmental investigations face-to-face based on the exposure histories obtained. A survey should be undertaken of all air handling systems, warm water systems and spa pools in the area where patients’ exposure may have occurred.
Ideally duplicate samples should be taken from all suspected sites, including aquatic (natural or human-made settings) and organic/soil environments. For cases of \textit{L. longbeachae}, when exposure to soil or potting mixes has been established, samples of suspected soils should be collected (as described in section 9.9 ‘Sampling procedures’). If laboratory tests demonstrate \textit{Legionella}, cleaning procedures should be undertaken, using appropriate precautions, upon informing the owners of the implicated facilities.

At all times when an outbreak is suspected, surveillance for past and new cases should be intensified, to establish the extent of the outbreak and determine if there is ongoing community exposure to \textit{Legionella}. Information sources could include local laboratories, GPs and hospital clinicians to report presumptive cases immediately. Releases to the news media may be helpful in increasing community awareness of the search for additional cases.

\textbf{Figure 16:} Public health action plan to investigate one or more cases of legionellosis

1. GP, hospital clinician or laboratory (clinical only) suspects initial diagnosis, on clinical and laboratory grounds.

2. Telephone the Medical Officer of Health and follow up with an email. Medical Officer of Health decides whether to initiate investigation or await further evidence of diagnosis.

3. Public health personnel interview patient and/or relatives or work colleagues.

4. Public health personnel assess information on other possible cases and the presence of any common exposures.

5. Common exposures?  
   - Yes
   - No
     - Seek a source and sample if indicated.

6. Survey the area concerned including all air handling systems, warm water systems, spa pools, suspected soils, compost, potting mix and other environmental samples, if indicated.

7. Take duplicate samples from all suspect areas (see section 9.9 ‘Sampling procedures’).

8. Ensure that cleaning procedures are instituted, using appropriate precautions.

9. Monitor for any new cases, and if appropriate recommence at interview stage of this plan.
9.7 Organising an outbreak investigation

When a potential outbreak has been detected, the Medical Officer of Health should be in charge of the field investigation, and should assess whether help will be required to handle news media queries and report updates. This person would act as a liaison person and spokesperson. Other staff that are likely to be involved include health protection personnel, laboratory personnel, clerical staff and personnel from ESR’s Legionella Reference Laboratory.

The following equipment has been found to be of value in conducting outbreak investigations:

- a supply of sterile 1L water/soil sampling bottles
- calibrated thermometers
- personal protective equipment in accordance with Appendix A of AS/NZS 3666.2, namely a minimum of a N95 face respirator, ordinary work clothing
- torches
- polystyrene six-pack container
- kits for measuring pH, chlorine and bromine.

9.8 Choosing the sample site

Sample sites should be chosen to be representative of all the identified risk areas where Legionellae can reside and grow. The approach taken for choosing sample sites is generally dependent on the nature of the site. For large sites this may necessitate taking multiple samples. To begin with, examine sites to establish all systems using water or compost, with careful consideration of the following:

- areas which contain water at temperatures likely to support the growth of Legionella
- cross-contamination between ‘dead’ (still or stagnant) and ‘live’ (flowing) water
- locations where water aerosols can be created and released into the atmosphere
- sites where organic matter is being composted that may release dust.

All water storage tanks, hot water cylinders, decorative fountains, spa baths, spa pools, thermal pools, misting machines, water spraying devices, water blasters, cooling towers, humidifiers, and any reticulated water system with either re-circulating water or water reservoirs where water can reach temperatures greater than 20°C but less than 60°C, must be considered potential sources for the growth of Legionella bacteria.

All of the systems or items listed above must be seriously considered for the taking of environmental samples for Legionella bacteria culture when investigating suspected and confirmed cases of legionellosis.

Reticulated water systems may become contaminated with Legionella from the deposition of wind-blown dirt into an exposed reservoir. Contamination of reticulated water systems can occur during construction activity or alterations to a building and where earthworks are carried out. Another common source of Legionella contamination of reticulated water systems is through soil contamination during plumbing work. When
investigating sources of exposure for legionellosis cases, determine if there has been recent plumbing work at the implicated building or construction work at or near the site.

Another major recognised source of *Legionella* infection is compost and material containing compost, such as potting mixes, seed-raising mixes and garden mulches, such as bark mulch. Use of these products in the 10-day incubation period before the onset of symptoms implicates them as a possible infection source.

When all risk sites have been identified, the appropriate samples can then be collected.

### 9.9 Sampling procedures

The laboratory should be contacted for advice prior to taking samples.

Everyone involved in taking samples from suspected equipment or soils during an outbreak should wear correct personal protective equipment in accordance with Appendix A of AS/NZS 3666.2, namely a minimum of a N95 face mask, ordinary work clothing.

Ideally duplicate samples of each sample type must be taken during an outbreak of legionellosis (a minimum 1 litre for water samples from raw or potable water sources, or 100 mL water samples from cooling towers, or 50 grams for soil or compost samples). The samples must be shipped immediately to the laboratory in a container at ambient temperature without ice packs to minimise temperature fluctuations and exposure to light.

When collecting samples for microbiological examination, scrupulous care is necessary to ensure that samples are representative of the water or soil being examined, and to avoid accidental contamination of water samples during collection. Sampling personnel should be properly trained, as the way in which samples are collected has an important bearing on the results.

If several samples are being collected on the same occasion from the same source, collect the sample for microbiological examination first. This is done to avoid contaminating the sampling point during the collection of the other samples.

Pre-sterilised disposable plastic sample containers to which sodium thiosulphate (which neutralises any active chlorine) has been added should be used if chlorinated water is being sampled. If samples of disinfected water are taken, it is desirable to determine the level of residual disinfectant present at the sampling point, at the time of sampling.

The sampling bottle should be kept unopened until it is required for filling. During sampling, the stopper or screw cap and neck of the bottle should not be allowed to touch anything which may contaminate the sample. The bottle should be held in one hand at the base while the screw cap is retained in the other hand to ensure the sodium thiosulphate does not fall out. The bottle should be filled, without rinsing, and the screw cap should be replaced immediately.
Changes occur in the bacterial content of water samples during storage. Therefore it is important that samples be examined as soon as possible after collection. Examination should ideally be started within six hours of collection of the sample, but the interval between collection and the beginning of examination should never exceed 24 hours.

Appendix D has additional information for notification via EpiSurv. Appendices D to H contain some specific instructions for various samples to be collected.

9.9.1 Air conditioning systems (use form in Appendix E)

Cooling towers: Duplicate samples should be taken from the sump water when the water cooling system has been turned off. If this is not practical, sample from the circulating water.

Evaporative coolers: Duplicate samples should be taken from the sump water when the evaporative cooling system has been turned off. If this is not practical, sample from the circulating water.

The “bleed rate” is the rate at which water is drained from the collection reservoir at the base of the cooling tower. The “pump cycle rate” is the rate at which water is pumped from the cooling tower reservoir back to the packing material.

9.9.2 Warm water storage systems (20–60°C) (use form in Appendix F)

Duplicate samples should be taken from three sites: One set should be taken from the closest outlet fixture, one set from the furthest outlet fixture, and one set from any storage tanks or vessels. Sludge samples should be avoided.

9.9.3 Spa pools (use form in Appendix G)

One set of duplicate samples should be taken from the water in the spa, and one set should be taken from the filter media or backwash water.

9.9.4 Potting mix, soil and compost (use form in Appendix H)

Check to see if health warnings are visible and explicit on the bag. Note the make or manufacturer of the material. Check condition of the material. If dry, ensure the sample is collected only from the ‘dampest’ material.

Thoroughly mix the suitable material to ensure a representative sample is obtained. If the material cannot be mixed, then take samples from a number of different points and combine to obtain a representative sample. The sample container should remain unopened until just prior to sampling. Using sterile sampling equipment, eg, scoop, spoon, etc, transfer approximately 100 grams into a sterile container. A freshly disinfected scoop, etc, must be used for each subsequent sample.

If a sterile scoop is unavailable, an alternative method to obtain a sample is as follows:

- put on fresh latex gloves and wash the outside of the gloves with an alcohol disinfectant
allow gloves to air-dry to remove excess alcohol then with gloved hands turn a zip-lock plastic bag inside out and place the bag over a gloved hand

Using ones hand inside the bag, take a handful of compost material and with one’s free hand pull the bag over the fist, capturing the material in the bag

seal the sample bag to prevent the material drying out. Clearly label the sample.

AS/NZS 5024 Potting mixes, composts and other matrices – Examination for Legionellae is based on the work on potting mixes and composts by Steele et al 1990a. The Standard sets out a qualitative test method for testing of potting mixes, composts and other solid matrices for Legionella spp. in particular L. longbeachae.

9.10 Submitting samples

Samples of water, soil, potting mix or compost should be submitted for examination, after consulting staff at ESR, to:

Street address: Legionella Reference Laboratory
Environmental Health
Institute of Environmental Science & Research Ltd
Kenepuru Science Centre
34 Kenepuru Drive
Porirua

Postal address: Legionella Reference Laboratory
Environmental Health
Institute of Environmental Science & Research Ltd
Kenepuru Science Centre
PO Box 50-348
Porirua

Send the completed relevant data sheet (Appendices E–H) with the sample.

The Legionella Reference Laboratory can be contacted via email at:
KSC.Legionella@esr.cri.nz

9.11 Decontamination of implicated sites

Cleaning and disinfection procedures for air conditioning and water systems in buildings are as described in earlier sections of this document.

9.12 Clinical specimens

Clinical specimens are usually tested in hospital laboratories but can also be referred to:
Legionella Reference Laboratory
Environmental Health
Institute of Environmental Science & Research Ltd
Kenepuru Science Centre
34 Kenepuru Drive
Porirua
The Legionella Reference Laboratory at ESR can culture *Legionella*, perform molecular tests including *Legionella* PCR and DNA sequencing and test for the presence of *Legionella* antibodies.

With each specimen, the sender should complete the ESR standard laboratory request form used by the Legionella Reference Laboratory that is testing the specimen. Seal the specimen in the sealable compartment of a plastic biohazard bag, with the form placed in the side pocket.

The following clinical specimens to be collected by medical staff are appropriate for the laboratory diagnosis of legionellosis.

**9.12.1 Specimens for culture, or PCR/NAAT testing**

**Legionella culture testing**

Any invasive lower respiratory tract specimen, including:
- bronchoalveolar lavage fluid
- endotracheal aspirates (any bronchial or tracheal aspirate or brushing)
- transtracheal aspirates (TTA)
- expectorated sputum (especially following TTA collection)
- deep throat swab – from trachea. Collect specimen with dry cotton bud swab and place in sealed container with sufficient sputa to prevent drying in transport. Alternatively, add 0.5 to 1.0 mL of sterile and 0.1μm-filtered water to the swab. (Do not add any other solutions, especially saline).

Where appropriate, biopsy and post-mortem specimens (freshly collected) especially in cases of:
- endocarditis with negative blood culture
- gram-negative bacilli infections that cannot be cultured by standard methods.

Notes:
- Avoid collecting lower respiratory tract samples with sodium salt-based buffers as these have been shown to be harmful for *Legionella* culture. Instead, use potassium salt-based buffers.
- Repeat sampling of any respiratory tract samples is useful to increase the chance of recovering *Legionella* since the organism may be initially absent in the sample or in very low numbers.
- Ideally, sampling should be taken prior to initiation of antibiotic treatment, although samples can still be culture positive after antibiotic treatment has begun.
- Pleural fluids rarely yield positive results. Upper respiratory tract samples rarely yield positive results.

**Legionella NAAT/PCR testing**

All samples listed for *Legionella* culture are acceptable for *Legionella* PCR.
Legionella DFA

All samples listed for *Legionella* culture are acceptable for *Legionella* DFA, as well as:

- paraffin-embedded biopsy and post-mortem tissues

Note: DFA testing has been superseded by NAAT/PCR testing in almost all cases due to the greater sensitivity and specificity of these tests compared to the DFA test.

9.12.2 Specimens for serological testing

Serological testing is currently the most sensitive diagnostic method, though it is generally of retrospective value only. Proper collection and testing of specimens from all suspect cases must be undertaken in order to assess the extent of an outbreak. A total of 0.5–1 mL of each serum is required for this test.

**Paired sera only (for retrospective diagnosis)**

An acute-phase serum is taken within the first week of onset and stored frozen. A convalescent-phase serum is taken three weeks later with both tested in parallel. A follow-up serum is taken at six weeks if seroconversion has not occurred or the first test is negative. If subsequent antibody testing is negative, a further sample should be provided at 90 days post-onset, as maximum sensitivity for seroconversion occurs at 90 days for some patients. Paired convalescent-phase sera should be collected at least 10 days apart.

**Single serum**

This is not considered a valid test sample unless done as an adjunct to *Legionella* culture or *Legionella* NAAT. A single acute-phase serum sample should be retained and tested in parallel with a convalescent-phase serum.
## Appendices

### Appendix A: Service log sheet for cooling towers and evaporative condensers

<table>
<thead>
<tr>
<th>Date</th>
<th>Water sampled</th>
<th>Chemicals added</th>
<th>Bleed-off rate okay</th>
<th>Unit cleaned</th>
<th>Unit inspected</th>
<th>Unit decontaminated</th>
<th>Name of contractor</th>
<th>Serviced by (signature)</th>
<th>Heterotrophic plate count (HPC)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes/No</td>
<td>Yes/No</td>
<td>Yes/No</td>
<td>Yes/No</td>
<td>Yes/No</td>
<td>Yes/No</td>
<td>Yes/No</td>
<td>Name of contractor</td>
<td>Serviced by (signature)</td>
<td>Heterotrophic plate count (HPC)</td>
<td>Remarks</td>
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<tr>
<td>Yes/No</td>
<td>Yes/No</td>
<td>Yes/No</td>
<td>Yes/No</td>
<td>Yes/No</td>
<td>Yes/No</td>
<td>Yes/No</td>
<td>Name of contractor</td>
<td>Serviced by (signature)</td>
<td>Heterotrophic plate count (HPC)</td>
<td>Remarks</td>
</tr>
<tr>
<td>Yes/No</td>
<td>Yes/No</td>
<td>Yes/No</td>
<td>Yes/No</td>
<td>Yes/No</td>
<td>Yes/No</td>
<td>Yes/No</td>
<td>Name of contractor</td>
<td>Serviced by (signature)</td>
<td>Heterotrophic plate count (HPC)</td>
<td>Remarks</td>
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<tr>
<td>Yes/No</td>
<td>Yes/No</td>
<td>Yes/No</td>
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<td>Yes/No</td>
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<td>Name of contractor</td>
<td>Serviced by (signature)</td>
<td>Heterotrophic plate count (HPC)</td>
<td>Remarks</td>
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<td>Yes/No</td>
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<td>Yes/No</td>
<td>Name of contractor</td>
<td>Serviced by (signature)</td>
<td>Heterotrophic plate count (HPC)</td>
<td>Remarks</td>
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<td>Yes/No</td>
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<td>Yes/No</td>
<td>Yes/No</td>
<td>Yes/No</td>
<td>Name of contractor</td>
<td>Serviced by (signature)</td>
<td>Heterotrophic plate count (HPC)</td>
<td>Remarks</td>
</tr>
</tbody>
</table>

Notes:
1. Recommended service periods
2. HPC to be entered by person responsible for site

- **Item**
  - Dip slide: Weekly
  - HPC plate count: Monthly
  - Legionella testing: Monthly or Six-monthly
  - Inspection: Monthly
  - Cleaning: Three to Six-monthly
  - Decontamination: When HPC > 100,000 cfu/mL or Legionella > 1000 cfu/mL
Appendix B: Service log sheet for warm water systems

Name of establishment: ............................................................ Contact: ............................................

Phone number: ..................................................................................................................................

Address of establishment: ..................................................................................................................

....................................................................................................................................................

Cylinder location: ..........................................................................................................................

Storage temperature setting: ............................................ Number of outlets: ............

<table>
<thead>
<tr>
<th>Date of service</th>
<th>Heat disinfection at 70°C</th>
<th>Cylinder drained</th>
<th>Remarks</th>
<th>Serviced by</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>
Appendix C(i):
Commissioning log sheet for thermostatic mixing valves
(Use a separate sheet for each valve.)

This work is to be carried out in strict accordance with the valve manufacturer’s or supplier’s published maintenance/service instructions.

Name of establishment: ...........................................  Contact: ....................................................
Phone number: ............................................................................................................................
Address of establishment: .............................................................................................................
....................................................................................................................................................
Make of valve:..........................................................  Model number: ..........................................
Valve location: .........................................................  Room designation: ....................................
Purchased from: ......................................................  Installation date: ........................................
Valve installed by: ..........................................................................................................................
Number of outlets served: Baths (............. )  Basins (............. )  Showers ( ............. )
Prescribed temperature range for associated water: .........................  to  ......................... °C
Total number of mixing valves at the site: .....................................................................................

i  Installation complies with the manufacturer’s or supplier’s published installation instructions:  ......................... (YES/NO)

ii Installation complies with the current requirements of the local water supply authority:  ......................... (YES/NO)

iii Temperature of hot water supply:  ............................. °C

iv Temperature of cold water supply:  ............................. °C

v Temperature of warm water delivered at outlet fitting:  ............................. °C

vi Dynamic pressure of hot water:  ............................. kPa

vii Dynamic pressure of cold water:  ............................. kPa

viii Check fail-safe operation: (hot water at least 20°C above warm water)  ............................. (PASSED/FAILED)

Commissioned by:  ...................................................................................................
Company name:  .............................................................................................................
Date:  .........................................................................................................................
Appendix C(ii): Routine service log sheet for thermostatic mixing valves

Name of establishment: ............................................  Contact: ....................................................

Phone number: ........................................................................................................................................

Address of establishment: ...........................................................................................................................

Make of valve: ..........................................................  Model number: ........................................

Valve location: ..........................................................  Room designation: ................................

<table>
<thead>
<tr>
<th>Date of service</th>
<th>Outlet water temperature</th>
<th>Outlets flushed for 15 seconds YES / NO</th>
<th>Shower heads disinfected YES / NO</th>
<th>Remarks</th>
<th>Serviced by</th>
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</thead>
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</table>

Recommended service periods:

<table>
<thead>
<tr>
<th>Item</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outlet water temperature</td>
<td>Fortnightly</td>
</tr>
<tr>
<td>Flushing of outlets</td>
<td>Weekly</td>
</tr>
<tr>
<td>Disinfect shower heads</td>
<td>Monthly</td>
</tr>
</tbody>
</table>
Appendix C(iii):
Twelve-monthly service log sheet for thermostatic mixing valves

Name of establishment: ...........................................  Contact: .................................................................

Phone number: ..............................................................................................................................................

Address of establishment: ...................................................................................................................................

Make of valve: ..........................................................  Model number: .........................................................

Valve location: ..........................................................  Room designation: ....................................................

<table>
<thead>
<tr>
<th>Date of service</th>
<th>Element OK / faulty</th>
<th>O-rings OK / U / S</th>
<th>Strainers OK / dirty</th>
<th>Non-return valves OK / faulty</th>
<th>Fail-safe test OK / faulty</th>
<th>Remarks</th>
<th>Serviced by</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

Note: A new thermostatic element should be fitted at least every three years.
Appendix D: Legionellosis case investigation questionnaire

Date of notification: ........................................ Notified by: ..............................................................

EpiSurv number: ........................................ Outbreak number: ...................................................

Status: Confirmed □ Date: ............................................................
        Probable □ Date: ............................................................
        Under investigation □ Date: ................................................

Case details
Work phone: ........................................... Ethnicity: ............................................................

Occupation (including part-time jobs): ..................................................................................................

Workplace/student institution (address and phone number): ...............................................................

Part A: History of illness
Clinical details
Symptoms
Anorexia       Y/N Date: ....................... Joint/Muscle pain       Y/N Date: .......................  
Malaise        Y/N Date: ....................... Cough – non-productive Y/N Date: .......................  
Headache       Y/N Date: ....................... Cough – productive Y/N Date: .......................  
Chills          Y/N Date: ....................... Abdominal pain Y/N Date: .......................  
Confusion       Y/N Date: ....................... Diarrhoea Y/N Date: .......................  
Fever           Y/N Date: ....................... Renal failure Y/N Date: .......................  
Other details Y/N Details: .......................................................................................................

EpiSurv number: ........................................ Outbreak number: ...................................................

Onset date: ........................................... Day of week: .........................................................

Lack of response to standard treatment Yes/ No ...........................................................................

Risk factors
Smoker Y/N Ex-smoker Y/N Number of cigarettes per day: ........................................
Chronic obstructive respiratory disease Y/N Immunosuppressed Y/N
Alcohol consumption: None / Light / Moderate / Heavy

Other medical conditions: ..............................................................................................................................................
..............................................................................................................................................
..............................................................................................................................................

Period of exposure (incubation period is 2–10 days)
Onset date: ............................................... Day of week: ..............................................................

Earliest date and day that the Legionellosis could have been contracted (10 days before onset)
Date: ......................................................... Day of week: ..............................................................

Latest dates and day (two days prior to onset)
Date: ......................................................... Day of week: ..............................................................

Name: ....................................................... Signature: ..............................................................
Designation: .............................................. Date: ................................ Time: ..............................

Part B: Persons with similar symptoms
Does the case know of anyone with similar symptoms: Y/N
If yes

<table>
<thead>
<tr>
<th>Name</th>
<th>Address and phone number</th>
<th>Relationship to case</th>
<th>Name of GP</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

Name: ....................................................... Signature: ..............................................................
Designation: .............................................. Date: ................................ Time: ..............................

Part C: Suspected source of exposure
Sections
1. Home environment
2. Gardening activities (include visits to landfill if composting occurs)
3. Workplace/occupation (include study institutions)
4. Commercial premises visited (include hospital visits, car wash facilities, dental surgery visits)

5. Travel

6. Other  Recreational activities (include spa pools, indoor swimming pools)

Environmental scan (description of potential dust and aerosol sources in the immediate environment)

Name: ......................................................  Signature: ..............................................................
Designation: .............................................  Date: ................................  Time: ..........................

Section 1: Home environment

Hot water system (tick the boxes that apply)

<table>
<thead>
<tr>
<th>Water supply origin</th>
<th>System type</th>
<th>Mixing valve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply: Town</td>
<td>Gas</td>
<td>Tempering device present? Y/N</td>
</tr>
<tr>
<td>Rural</td>
<td>Electric</td>
<td>Tempering water source</td>
</tr>
<tr>
<td>Private</td>
<td>Solar</td>
<td></td>
</tr>
<tr>
<td>Chlorinated?</td>
<td>Other (specify)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low pressure</td>
<td></td>
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<tr>
<td></td>
<td>Mains pressure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Header tank? Y/N</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Location/condition of header tank if applicable:</td>
<td></td>
</tr>
</tbody>
</table>

Comments (include details of hot water systems or if the cylinder is switched off; details of recent plumbing work in implicated building): ...........................................................................................................................................................................

Water temperature: .........................  °C thermostat  .........................  °C outlet pipe
.........................................  °C bathroom  .........................  °C kitchen

Temperature of the hot water cylinder if applicable:  .........................  °C

Does water stand undisturbed for long periods?  Yes / No

<table>
<thead>
<tr>
<th>Exposure Y/N</th>
<th>Comments</th>
<th>Sample number* (if applicable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot water system</td>
<td></td>
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<tr>
<td>Air conditioning system</td>
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<td></td>
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<tr>
<td>Spa/swimming pool</td>
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<td></td>
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<tr>
<td>Humidifier</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nebuliser</td>
<td></td>
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<tr>
<td>Other</td>
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</tbody>
</table>
* Use appropriate data sheets and sampling sheets.

Name: .......................................................  Signature: ...............................................................
Designation: ..............................................  Date:................................  Time: ...........................

**Section 2: Workplace/occupation**

Describe workplace activities undertaken by case (also consider other possible sources of exposure while at workplace).

.....................................................................................................................................................
.....................................................................................................................................................
.....................................................................................................................................................

Site visited Yes / No / Not applicable

<table>
<thead>
<tr>
<th>Exposure Y/N</th>
<th>Comments</th>
<th>Sample number* (if applicable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm water system</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hot water system</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air conditioning system</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spa/swimming pool</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humidifier</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil/potting mix/compost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Use appropriate data sheets and sampling sheets.

Name: .......................................................  Signature: ...............................................................
Designation: ..............................................  Date:................................  Time: ...........................

**Section 3: Gardening activities**

During the incubation period (2–10 days) was the case involved in any of the following activities?  Yes / No

<table>
<thead>
<tr>
<th>Y/N</th>
<th>Details of use (eg, ventilation, wetting)</th>
<th>Sample number* (if applicable)</th>
<th>Comments (eg, presence of ferneries with hanging baskets)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Composting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Landfill visits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Propagation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General gardening activities (describe)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
.............................................................. |                             |                                                       |
* Use appropriate data sheets and sampling sheets.

**Section 4: Commercial premises visited**

During the incubation period (2–10 days) did the case visit any commercial buildings (including hospitals)? Yes / No

<table>
<thead>
<tr>
<th>Premises visited</th>
<th>Date(s) visited</th>
<th>Time of visit</th>
<th>Length of visit (hours)</th>
<th>Location of premises</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

Do any of the above premises have air conditioning or misting systems? Yes / No

If YES provide details

.................................................................................................................................................................................................
.................................................................................................................................................................................................
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.................................................................................................................................................................................................

Name: ...................................................... Signature: ..............................................................
Designation: ............................................. Date: .................................... Time: .....................

**Section 5: Travel**

During the incubation period (2–10 days) did the case:

Return or arrive from an overseas country? Yes / No

If YES provide details

.................................................................................................................................................................................................
.................................................................................................................................................................................................
.................................................................................................................................................................................................
.................................................................................................................................................................................................

Travel in any air conditioned transport, either overseas or within New Zealand? Yes / No

If YES provide details

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.................................................................................................................................................................................................
.................................................................................................................................................................................................
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**Section 6: Other**

**Environmental scan**

Describe any potential sources of aerosol or dust in the immediate environment of the case’s home and/or workplace if applicable.

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.................................................................................................................................................................................................

Describe any recreational activities (eg, spa pools) that the case may have undertaken during the incubation period which may be a possible source of exposure to aerosols or dust.
Persons present: ..................................................................................................................................................

Interview location: ..................................................................................................................................................

Name: ............................................................  Signature: ...............................................................
Designation: .............................................  Date: ..................................  Time: ......................

Part D: Follow-up action

Did the investigation identify any suspected/confirmed sources of infection?  Yes / No
If YES provide details
..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................

Was sampling undertaken?  Yes / No
If YES did sampling confirm or suggest source of infection?  Yes / No
Comments:
..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................

What action has been taken?
..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................

Summary/outcomes:
..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................

Investigation completed

Name: ............................................................  Signature: ...............................................................
Designation: .............................................  Date: ..................................  Time: ......................
Appendix E: Wet cooling systems data sheet

Sample number: ..........................................................

Cooling system type: ........................................... Cooling tower: 1
                                                                 Evaporative condenser: 2

Bleed-off rate: ................................................. litres/hour

Pump cycle rate: ............................................... litres/hour

Unit condition: .................................................... Clean: 1, Fair: 2, Dirty: 3

Date last emptied: ............................................ Date last cleaned..........................

Biocide used: ............................................................................................................ (trade name)

Biocide dosage: ............................................... /units: ................................... (litres or kilograms)

Dose interval: ..................................................... days

Sump water temperature: ........................................ °C

pH: ........................................................................... pH units

Water turbidity: .................................................... Absent: 1, Present: 2, Extensive: 3

Wall slime: ............................................................ Absent: 1, Present: 2, Extensive: 3

Other comments: ..........................................................................................................
 ..........................................................................................................................................
 ..........................................................................................................................................
 ..........................................................................................................................................
 ..........................................................................................................................................
 ..........................................................................................................................................

Signature: ......................................................... Date: ..............................................
### Appendix F: Warm water systems data sheet

<table>
<thead>
<tr>
<th>Sample number:</th>
<th>Water supply origin?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>System type:</th>
<th>Gas: 1, Electric: 2, Solar: 3, Other: 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mixing valve present:</th>
<th>Yes / No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tempering device present:</th>
<th>Yes / No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tempering water source?</th>
<th>Yes / No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Estimated tank volume:</th>
<th>litres</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Water turbidity:</th>
<th>Absent: 1, Present: 2, Extensive: 3, Not tested: 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Date last chlorinated:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Date of other biocide:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No biocide used:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Water temperature:</th>
<th>°C thermostat setting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>°C at outlet sampled</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>pH:</th>
<th>pH units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other comments:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Signature:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>
Appendix G: Spa pool information sheet

Location: ......................................................................................................................................

Temperature of pool water: ...................................................... °C

pH of pool water: ...................................................... pH units

Total active chlorine: ...................................................... (optimum level 3-5 mg/L)
OR
Total active bromine: ...................................................... (optimum level 4-6 mg/L)

What biocide is used? .............................................

Frequency of biocide level checking: ......................

Type of filter used: ........................................................................................................................

Frequency of changing filter: ..........................................................
OR
Frequency of back-washing filter: ................................................................................................

Frequency of draining spa: ........................................... weeks

Date spa last cleaned: ..............................................

Date spa last emptied: ..............................................

Who maintains the spa? ..................................................

(surname) (first names)

Other comments: ..........................................................................................................................
....................................................................................................................................................
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Signature: ................................................................. Date: ....................................................
Appendix H: Potting mix, soil, compost data sheet

Location: ...........................................................................................................................................

Sample type: ............................................................ Potting mix: 1
Garden soil: 2
Compost: 3
Other (specify): 4

Date sample collected: ..........................................

Date material purchased: .....................................

Date first opened (if bagged): ..............................

Brand (if commercial product): ...................................

Manufacturer’s warning: Yes / No
If yes, give details: ..................................................

Water content of material: Dry / Moist / Wet

Other comments: ..........................................................................................................................
....................................................................................................................................................
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....................................................................................................................................................
....................................................................................................................................................

Signature: .......................................................... Date: .........................................................
Glossary

For the purposes of these Guidelines the following definitions apply.

**AS/NZS 3666**  
Australian/New Zealand Standard 3666: *Air-handling and water systems of buildings – Microbial control*. At present there are four parts to this standard:  
Part 1: Design, installation and commissioning  
Part 2: Operation and maintenance  
Part 3: Performance-based maintenance of cooling water systems  
Part 4: Performance-based maintenance of air-handling systems (ducts and components)

**Biocide**  
A physical or chemical agent that kills bacteria and other micro-organisms.

**Biofilm**  
A surface layer of micro-organisms.

**Clean**  
Visually free of sludge, sediment, slime, algae, fungi, rust and scale.

**Cleaning**  
Physical and/or chemical removal of scale, corrosion, biofilm, sludge, sediment and extraneous matter.

**Cold water**  
< 20°C (*Legionella* does not grow or multiply)

**Warm water**  
20–60°C (*Legionella* can grow and multiply)

**Hot water**  
> 60°C (*Legionella* will not survive).

**Colony forming unit (cfu)**  
A colony arising from a viable unit of one bacterium or more in a clump. For statistical significance, only those plates with 30 to 300 cfus are selected for counting.

**Conductivity**  
The ability of water to conduct electricity. Conductivity measurement is used for estimating the amount of total dissolved solids in water.

**Detergent**  
A cleansing agent capable of penetrating biological films, sludge and sediment, and having the ability to emulsify oil and hold materials in suspension. Water treatment specialists have developed detergent formulations which are capable of thoroughly cleaning components which are difficult to access and inspect, such as cooling tower fill.

**Dead-leg**  
A section of the system that does not permit the circulation of water.

**Dipslide**  
A glass or plastic slide coated with culture media on which micro-organisms can be grown and estimated. *Legionella* does not grow on these media.
DPD test kit
A kit for measuring free, combined and total chlorine residuals using the reagent DPD (N,N-diethyl-p-phenylene diamine). Many test kits available from swimming pool suppliers measure only total chlorine, not free chlorine, and consequently should not be used. Free chlorine residuals in excess of 10 mg/L (10 ppm) are capable of bleaching the indicator colour, rendering the test invalid. Samples of water may have to be diluted with distilled water, or other water which does not interfere with the test, to bring the sample within the range of the kit. Allowance must be made for the sample dilution factor when determining the free chlorine residual in the original sample.

Flushometer
A plumbing device that uses pressure from the water system itself, rather than a gravity-powered tank, to force water into the toilet bowl.

Free chlorine measurement
The measurement of hypochlorous acid (an efficient disinfectant) and hypochlorite ion (a poor disinfectant) in water. The ratio of these two materials in water is pH dependent. The pH range specified (7.0 to 7.6) ensures that sufficient hypochlorous acid is present to facilitate effective disinfection.

Immuno-compromised
When the body’s natural defences to infection are below normal.

Incubation period
The time interval between exposure to a infection source and development of first symptoms of the disease.

Make-up
Water feed needed to replace that which is lost by evaporation or leakage in a closed-circuit, recycle operation.

mg/L (ppm)
Milligrams per litre (parts per million). For practical purposes mg/L is assumed to be equal to ppm.

pH
A term used to describe the hydrogen ion activity of a water system. A solution of pH 0 to 7 is acidic, pH of 7 is neutral, pH 7 to 14 is alkaline.

Pneumonia
Typical symptoms include cough, chest pain, fever and difficulty breathing. Diagnostic tools include x-rays and examination of the sputum. Treatment depends on the cause of pneumonia; bacterial pneumonia such as legionellosis is treated with antibiotics.

Pulse dosing
The injection of small doses of water treatment chemicals at regular intervals, usually by some form of metering system.

Slug or shock dosing
The injection of a single, high concentration of water treatment chemicals.

Sodium hypochlorite
A chlorine-releasing material used for disinfection. The strength of sodium hypochlorite solution reduces on storage.

Surfactant
A soluble surface-acting agent that reduces surface tension between particulate matter and water.

Territorial authority
A city or district council named in Part 2 of Schedule 2 of the Local Government Act 2002.

Total dissolved solids
The total weight of dissolved substances in water, including those which are capable of conducting electricity and those which are not.
Turbidity  A cloudy appearance in water that is caused by a suspension of colloidal or particulate matter.

WHO  World Health Organization.
References


NCTC National Collection of Type Cultures, Health Protection Agency Culture Collections. Accessed 11 Sept 2012


