Chapter 5: *Legionella* Prevention and Control

5.1 Implementing a control scheme

If the risk assessment identifies that there is a potential risk and it is practicable to prevent exposure or to control the risk from exposure, the person on whom the corporate/statutory obligation falls e.g. CEO, employer, should appoint a responsible person to take managerial responsibility and provide supervision for the implementation of the precautions and for ensuring that:

- All persons involved in the implementation of the control scheme are properly trained and supervised
- Staff roles, responsibilities and lines of communication are properly defined, clearly documented in writing and understood by all involved
- Management arrangements and communication procedures are audited regularly to ensure that they are effective.

The above also applies to outside companies and consultants who may be responsible for certain parts of the treatment regime. Their contract should clearly state what work they are contracted to do and to whom they are reporting. Also if they become aware, whilst on site, of something that would impact on *Legionella* control that they would transmit this information to the appropriate person even if the piece of equipment, etc. is outside the scope of their contract. The employment of contractors or consultants does not absolve the duty of the holder of responsibility for ensuring that control measures are in place to the highest standard to prevent the proliferation of *Legionella* bacteria.

The responsible person will have day-to-day responsibility for the prevention and control of *Legionella* bacteria in the organisation and is accountable to the manager/CEO who has corporate responsibility for the organisation. The responsible person should be a manager or director, or have similar status with sufficient authority, degree of competence and knowledge of the installation and resources to ensure control measures and systems operations are carried out in a timely, safe and effective manner. The competence required of the responsible person will depend upon the risks they have to manage, i.e. the nature, size, age, use and complexity of the water systems for which they are responsible. For locations with medium- to high-risk water systems the responsible person should have attended specific training courses given by a qualified training provider on the management and control of risks of exposure to *Legionella* bacteria. They should also attend regular refresher courses and attendance at all courses should be recorded. They should have a clear understanding of their duties and of the overall health and safety management structure and policy of the organisation.

Arrangements should be made to ensure appropriate staffing levels are maintained during all hours that water systems are in operation. Appropriate arrangements should be made to ensure that the responsible person or an authorised deputy can be contacted at all times. Details of the contact arrangements for emergency call out personnel should be clearly displayed at access points to all automatically or remotely controlled water systems.

A written scheme detailing measures to prevent or control risks should be implemented and properly managed, including:

- An up-to-date schematic of the plant, building or system, including parts temporarily out of use
- A description of correct and safe operation
- Precautions to be taken and checks to be conducted to ensure the efficacy of the scheme and frequency of such checks
- Remedial action to be taken if the scheme is shown not to be effective.

Based on the above scheme, a programme should be developed for implementation of control measures taking account of risk ratings, site requirements, resources and short-, medium- and long-term options for preventing and reducing risks as far as is reasonably practicable. This will require communication between the risk assessor, service provider and the responsible person.

The risk from exposure will normally be controlled by measures which do not allow the proliferation of *Legionella* bacteria in the system and reduce exposure to water droplets and aerosol. These include

engineering controls, cleaning protocols and other control strategies such as:

- Controlling the release of water sprays
- Avoidance of water temperatures and conditions which favour the proliferation of *Legionella* bacteria and other microorganisms i.e. avoiding water temperatures between 20°C and 50°C. Water temperature is a particularly important factor in controlling the risks and should be either below 20°C or above 50°C
- Avoidance of water stagnation that can encourage the growth of biofilm (slimes that form on surfaces in contact with water) which can harbour *Legionella* bacteria and provide local conditions that encourage growth
- Avoidance of the use of materials which harbour bacteria and other micro-organisms or provide nutrients for microbial growth e.g. natural rubber washers and hoses
- Maintenance of the cleanliness of the system and the water in it in order to avoid the build up of sediments which may harbour bacteria (and also provide a nutrient source for them)
- Use of water treatment regimes/techniques where it is appropriate and safe to do so
- Action to ensure the correct and safe operation and maintenance of the water system.

Decisions should be made about the maintenance procedures and intervals and where relevant on equipment used for carrying out the control measures. *Legionella* bacteria may be present in low numbers in many water systems but careful control will prevent them from multiplying. The scheme should give details on how to use and carry out the various control measures and water treatment regimes including:

- The physical treatment programme e.g. the use of temperature control for hot and cold water systems
- The chemical treatment programme including a description of the manufacturer's data on effectiveness, the concentrations and the contact time required. All disinfectants used must be validated for the purpose for which they are being used and the information available in peer-reviewed literature that has been independently assessed
- Health and safety information for storage, handling, use and disposal of chemicals
- System control parameters (together with allowable tolerables); physical, chemical and biological parameters, together with measurement methods and sampling locations, test frequencies and procedures for maintaining consistency
- Remedial measures to be taken in case the control limits are exceeded including lines of communication
- Cleaning and disinfection procedures.

There should also be a description of the correct operation of the water system plant including:

- Commissioning and recommissioning procedures
- Shutdown procedures
- Checks of warning systems and diagnostic systems in case of system malfunctions
- Maintenance requirements and frequencies
- Operating cycles – including when the system plant is in use or idle.

5.1.2 Monitoring the control scheme

Many outbreaks of legionnaires' disease are caused by poor maintenance and control procedures. The implementation of a control scheme should be regularly monitored and decisions should be made on the frequency and manner of the monitoring procedures. The effectiveness of the programme should also be monitored including the impact of short-term or interim measures. Regular review and updating of risk ratings is crucial to the success of the control scheme and the implementation programme should be updated to take account of any changes in priorities and timescales. This should be the responsibility of the responsible person or where appropriate an external contractor or an independent third party should be involved.

This will involve:

- Checking the performance of the system and its component parts
- Inspecting the accessible parts of the system for damage and signs of contamination
- Monitoring to ensure that the treatment regime continues to control to the required standard.

The operating characteristics of the water distribution network e.g. pumps **should be monitored at least once weekly**. The results of monitoring and testing should be interpreted by a suitably experienced and competent person and any remedial measures where necessary should be carried out promptly.

Testing of water quality is an essential part of monitoring of the treatment regime, particularly in cooling towers. A service provider e.g. a water treatment company or consultant may undertake it provided that they are trained to do so and properly supervised (see Chapter 7, Section 7.3). The type of tests required will depend on the nature of the system.

The routine monitoring of the general aerobic heterotrophic bacterial count (total viable count) is a very important indicator of whether microbiological control is being achieved. This should be routinely undertaken for cooling towers (see Section 5.2.2 and Chapter 6, Section 6.9.2) and spa pools (see Chapter 8, Section 8.5.9).

In relation to hot and cold water systems, there is no need for routine microbiological monitoring as systems should be supplied with water that is fit to drink and the system should be totally enclosed and not open to significant external contamination. However, if maintenance or control measures have been inadequate and there is a risk of microorganisms proliferating in the system then microbiological investigations should be undertaken.[64] Sampling and testing for the presence of *Legionella* bacteria may also be appropriate as an indication that adequate control is being achieved. More details on sampling for *Legionella* in the various systems are outlined in Sections 5.2.2 and 5.2.3, and Chapter 6, Section 6.9.

In order to ensure effective implementation of the control programme, a compliance checklist should be compiled which includes:

- Responsibilities allocated
- Risk assessments up-to-date
- Written control scheme implemented
- Written control scheme working
- Satisfactory closure of non-compliances
- Emergency action procedures
- Process of management review
- Records complete and up-to-date.

5.1.3 Record keeping

The responsible person(s) appointed must ensure that appropriate up-to-date records relating to the control scheme are kept. These records should include the following details:

- Names and positions of person(s) responsible for carrying out the various tasks under the written scheme i.e. responsible for risk assessment, managing and implementation of the control scheme
- Plans and schematic drawings of the systems
- Details showing the current state of operation of the system e.g. when the system or plant is in use and if not in use whether it was drained down or not
- The significant findings of the risk assessment
- The written scheme of actions and control measures required and details of their implementation
- The results of any monitoring, inspection, test or check carried out, and the dates
- A log detailing visits by contractors, consultants, and other personnel. The remedial work required and carried out and the date of completion
- The signature of the person carrying out the work or other form of authentication where appropriate i.e. contract specification
- Copies of contractor's method statements

- Cleaning and disinfection procedures and associated reports and certificates
- Results of the chemical and microbiological analysis of the water
- Information on other hazards e.g. treatment chemicals
- Personnel training records
- Review meeting notes and actions
- Product information and chemical/biocide safety data sheets.

Records kept in accordance with the above should be retained throughout the period for which they remain current. All test and inspection records must be kept for five years from the date of the test or inspection. All records should be signed by those persons performing the various tasks assigned to them.

5.1.4 Audit

A competent person should audit the implementation and performance of the risk management programme periodically (at least every two years). This person should be completely independent of the personnel responsible for the implementation of the risk control regime and should have no interest in the provision of such services.

5.1.5 Responsibilities of suppliers and service providers

Outbreaks of legionnaires' disease have been associated with faulty installation of equipment[65] and inadequate application of water treatment and risk control regimes. As outlined in Chapter 3 on legislation, suppliers and service providers have duties and responsibilities under occupational health and safety legislation and must ensure that:

- Equipment is designed and constructed to be safe and without risks to health when used at work
- Adequate information is provided to the user about risk and measures necessary to ensure that water systems will be safe and without risk to health when used. This should be updated in the light of any new information about significant health and safety risks that becomes available
- Products and services are fit for purpose and that any limitations are clearly defined and made known to responsible persons
- Staff have the necessary ability, experience, instruction, training and resources to carry out tasks competently and safely
- A written risk assessment is undertaken and a plan of work/method statement for their work activities is prepared so that such activities are planned, organised and controlled.

5.1.6 Reducing *Legionella* risks in new and refurbished buildings

Water systems should be designed, installed and commissioned to ensure risks from *Legionella* bacteria are eliminated wherever possible, or reduced as far as is reasonably practicable. Designs should also ensure that adequate provisions are made to facilitate safe system operation and maintenance since a poorly designed system can be both difficult and expensive to operate and maintain.

The 'designing out' of features that will increase the potential for seeding, growth and aerosolisation of *Legionella* should be regarded as an integral component of an effective risk control strategy, e.g. cold and hot water systems should be designed to preserve supply water quality, prevent microbial growth, eliminate or reduce formation of aerosols, minimise corrosion and maintain internal surfaces in a clean condition. This can be achieved by, for example:

- Using cold water storage tanks that optimise the maintenance of potable water quality with a storage capacity of no more than 24 hours average water demand
- Utilising unvented direct mains supplied hot water systems
- Avoiding water storage tanks supplying calorifiers
- Using point of use water heaters rather than centralised hot water systems
- Designing hot water storage vessels, direct fired hot water service boilers and calorifiers to ensure adequate control of water temperatures in storage and distribution, and with sufficient heating capacity to enable periodic pasteurisation of their contents
- Minimising the distance between the source of the water supply and point of use. Zoning should be

used where appropriate in more complex systems

- Designing distribution systems to ensure regular throughput of water by eliminating 'dead legs' and long pipework runs
- Hot and cold water distribution pipework should be installed to minimise the transfer of heat between both. Appropriate insulation of pipes is essential
- Ensuring that fittings, materials and components are corrosion-resistant and are constructed of approved materials which do not release nutrients into the water to support microbiological growth
- Avoiding use of equipment such as spray taps which generate aerosols where suitable alternatives are available. Where it is essential (e.g. showers) then equipment should be selected to facilitate routine cleaning and disinfection
- Thermostatic mixing valves, when used, should be sited as close as possible to the point of use. Ideally, a single TMV should not serve multiple tap outlets but if they are used the mixed pipework should be kept as short as possible.[64] Self-disinfecting TMVs are now available but their effectiveness may be compromised by the presence of extensive sludge, scale and biofilm in the water distribution network
- Sources of aerosols or droplets should be sited away from direct intake sites such as air vents and open windows.

It is important that the total requirements for water supply and quality are assessed in the planning stages and water systems appropriate to areas of accommodation are allocated. Where a building project is completed and commissioned in phases or it is anticipated that areas of the building are likely to have different levels of occupancy and usage then careful consideration should be given to **zoning** of the water services to enable floors and areas of the building to be isolated and operated independently.

Installation and commissioning also require careful planning and execution to ensure designs are properly implemented and the necessary pre-commissioning cleaning and disinfection are carried out in accordance with industry standards and completed in time for hand-over. Long delays between completing the system disinfection and operating the water system will result in a deterioration in water quality and should be avoided. It is essential to minimise the development of biofilms. This can be done by emptying water limbs that are not in service and by preventing water stagnation in the distribution system. Disinfection systems should be in place from the first moment the water flows through the system. Once established, biofilms are extremely difficult to eliminate. In new hot and cold water systems, if more than seven days has elapsed before the system is put into regular use, every outlet should be flushed until the water temperature stabilises.[66]

Only competent service providers should be appointed to design, install or modify water systems. For those installations or modifications which could significantly affect the risk of legionellosis from the system, the appointed service provider should submit the following to the appropriate responsible person:

- A detailed description of the proposed new system, including a schematic drawing showing the layout of all component parts and identifying changes to existing systems
- Confirmation that its design and construction complies with relevant legislation, guidance and standards
- A risk assessment which considers the risk of legionellosis arising during the installation, including from any changes to existing systems, and identifies the precautions required to mitigate against these risks.

This information should be submitted to the responsible person at a reasonable period in advance of commencement of the work. The work should not proceed until it has been approved by the responsible person or by a nominated deputy in their absence.

On receipt of the information specified in the section above, the responsible person, or their nominated deputy should review the submission within 20 working days to consider whether:

- The system design allows it to be subsequently adequately maintained
- The assessment of risk is suitable and sufficient, with precautions adequate to minimise the risks, for example, from creation of dead legs and blind ends, from possible contamination of the system, etc.
- Arrangements are in place to monitor the work and ensure adequate commissioning of the system

- Necessary contingency measures will be put in place to minimise potential disruption to business operations and welfare facilities, for example, by provision of alternative water supplies, communicating changes, etc.
- The site can be cleared of other work and properly prepared
- Adequate and appropriate records will be provided, including sufficiently detailed 'as-fitted' plan or schematic drawings, operations and maintenance manuals, etc.

Once satisfied that all necessary safety arrangements are in place, the responsible person should approve the work and notify the designer/installer. Larger and more complex projects will often benefit from a multidisciplinary approach involving, for example, designers, architects, manufacturers, installers, risk assessors, water quality specialists, microbiologists, operatives and users.

5.1.7 Materials for construction of water distribution networks

As *Legionella* bacteria are usually associated with bacterial biofilms and biofouling in water systems, consideration should be given to the materials used in the construction of water distribution networks. Previous studies with a range of materials commonly used in the construction of water systems showed that some materials were very good at limiting colonisation and biofilm formation by a wide range of bacterial species, whereas other materials were very poor. Copper was the best at limiting colonisation and biofilm formation, followed by polybutylene and stainless steel, whereas biofilm formed more readily on polyethylene, chlorinated polyvinyl chloride (PVCc), unplasticised polyvinyl chloride (PVCu), steel and ethylene-propylene.[67;68] Distributing hot and cold water using copper pipes may significantly improve the microbial quality of water in water distribution networks as copper has been shown to possess significant antimicrobial advantages over water pipework of other composition.

5.2 Technical guidelines for prevention and control

An effective water treatment regime is essential for *Legionella* control. In addition to controlling legionellae, water treatment must also address the control of general microbial activity, biofilm development, corrosion, scale deposition and the retention of particulate solids. A cooling tower for example, with an inadequate or poorly controlled water treatment programme will be more vulnerable to contamination with legionellae and, therefore, present a much higher risk of exposure. Similarly, a distribution system which is fed with water containing sediment, minerals, organic matter and biofilm seed will always present a high risk. Removal or control of these elements does much to reduce the risk and also reduces the requirements for residual disinfection.

In assessing the adequacy of water treatment, cleaning, disinfection and maintenance regimes particular attention should be paid to:

- Biocide type, dosage rate and frequency, and half-life
- Efficacy of corrosion/scale control
- Operation and calibration of dosing/control equipment
- Maintenance of pre-treatment and ancillary plant
- Adequacy of cleaning and disinfection.

5.2.1 Hot and cold water systems

Temperature control

Temperature control is the preferred strategy for reducing the risk of *Legionella* in water systems. Cold water systems should be maintained at a temperature <20°C, while hot water should be stored at 60°C and distributed so that it reaches a temperature of 50°C within one minute at the outlets. Care is needed to avoid much higher temperatures because of the risk of scalding. At 50°C the risk of scalding is small for most people. However, the risk particularly to young children, people who are disabled or elderly and to those with sensory loss will be greater. The risk of scalding also increases rapidly with higher temperatures and for longer exposure times. Where a significant scalding risk has been identified the use of TMVs on baths and showers should be considered to reduce temperature. These need to be placed as close to the point of use as possible.[64] Where buildings cannot be retrofitted with TMVs, periodically increasing the temperature to at least 66°C at the point of use or chlorination followed by flushing should be considered.[69]

Thermal disinfection of hot water systems in emergency situations is detailed in Chapter 9, Section 9.4.1.

Monitoring the temperature control regime

Table 4 outlines the recommended inspection frequency for the temperature control regime.

Table 4. Monitoring the temperature control regime in hot and cold water systems

Frequency	Check	Standard to meet		Notes
		Cold water	Hot water	
Monthly	Sentinel taps[1]	The water temperature should be below 20°C after running the tap for up to two minutes	The water temperature should be at least 50°C within one minute of running the water	This check makes sure that the supply and return temperatures on each loop are unchanged i.e. the loop is functioning as required
	If fitted, input to TMVs on a sentinel basis		The water supply to the TMV should be at least 50°C within one minute of running the water	One way of measuring this is to use a surface temperature probe
	Water leaving and returning to calorifier		Outgoing water should be at least 60°C and return water at least 50°C	If fitted, the thermometer pocket at the top of the calorifier and on the return leg are useful points for accurate temperature measurement. If installed these measurements could be carried out and logged by a building management system
Six monthly	Incoming cold water inlet (at least once in the winter and once in the summer)	The water temperature should preferably be below 20°C at all times		The most convenient place to measure is usually at the ball valve outlet to the cold water storage tank
Annually	Representative number of taps on a rotational basis	The water temperature should be below 20°C after running the water for two minutes	The water temperature should be at least 50°C within one minute of running the water	This check makes sure that the whole system is reaching satisfactory temperatures for *Legionella* control

Source: HSC UK – Legionnaires' disease: the control of Legionella bacteria in water systems: approved code of practice and guidance[64]

Chemical control

Although temperature control is the recommended strategy for reducing risks from *Legionella* bacteria in water systems, in some buildings, such as large healthcare facilities, chemical control (e.g. chlorine dioxide

[1] Sentinel taps: For a hot water system: the first and last taps on the recirculating system. For cold water systems (or non-recirculating hot water systems), the nearest and furthest tap from the storage tank. The choice of sentinel taps may also include other taps which are considered to represent a particular risk.

or silver/copper ionisation treatment) is often used as an additional means of control.

It is important to note that chlorine dioxide and its breakdown products chlorite and chlorate can be deleterious to certain high-risk groups, e.g. renal dialysis patients, and should be removed from the water supply to units where these patients are being treated. They are also a potential problem for neonates if ingested. It is important to ensure that the water used to make up feeds in neonatal units is from the potable water supply (drinking water) and not from the chlorine dioxide treated water. Where chlorine dioxide and other potentially hazardous chemicals (e.g. hydrogen peroxide) are used, water disinfection procedures should be reviewed and liaison should take place with units treating at-risk patients. For further information please consult the UK DoH documents HTM 04-01[6] and Estates and Facilities Alert, DH 2008/08, Gateway ref.10618.[70]

Backflow prevention is required if chemicals are injected into a pipe connected to the mains supply.[6] **Chloramines are increasingly being used to disinfect drinking water supplies but can also present problems for dialysis water systems.**[6]

In hot water systems, chlorine is rapidly lost and maintaining temperature control of the system is essential. Ionisation is pH-sensitive and there have been reports of a reaction between silver and dissolved calcium minerals in water, resulting in staining of sanitary ware. Ultraviolet light and ozone treatment are available but are of limited use as they are only effective at or close to the point of application.

Monitoring of chemical regime
Routine inspection and maintenance will usually be sufficient to ensure control in most systems provided the following parameters are monitored at regular intervals and remedial action taken when necessary:[64]

Chlorine dioxide regime

- The quantity of chemicals in the reservoir
- The rate of addition of chlorine dioxide to the water supply
- The concentration of chlorine dioxide at sentinel taps should be measured monthly and should be at least 0.1mg/l
- The concentration of chlorine dioxide at a representative number of outlets should be measured annually and should be at least 0.1mg/l.

Ionisation

- The rate of release of copper and silver ions into the water supply
- The concentration of silver ions at sentinel outlets should be measured monthly and should be at least 20µg/l
- The concentration of silver ions at representative taps selected on a rotational basis should be measured annually and should be at least 20µg/l
- The condition and cleanliness of the electrodes
- The pH of the water supply.

Additional monitoring of hot and cold water systems
Checklist 1 outlines additional monitoring that is required in hot and cold water systems. Monitoring in relation to *Legionella* is dealt with in Chapter 6, Section 6.9.

Checklist 1. Hot and cold water systems

Service	Task	Frequency
Hot water services	Visual check on internal surfaces of calorifiers for scale and sludge.	**Annually**
Cold water services	Visually inspect the cold water storage tanks and carry out remedial work where necessary	**Annually**

Source: Adapted from Checklist 2 in HSC UK – Legionnaires' disease: the control of Legionella bacteria in water systems: approved code of practice and guidance[64]

Flushing
The extent of water use is one of the most important factors affecting water quality.[6] Where stagnation occurs or water use is low, cold water temperatures can increase significantly and there is the potential for *Legionella* growth. Showers are very important in this regard because of their capacity to generate aerosols and their potential to be under-utilised. Management needs to ensure that water services are sufficiently used. All unnecessary showers should be removed and the supply pipework should be cut back as far as the mains connection.

The risk of legionellosis attributed to the colonisation of hot and cold water systems by *Legionella* bacteria is well established. In a study of ten hospitals that were colonised by *Legionella* and ten that were not colonised, legionnaires' disease was found significantly more often in colonised than non-colonised hospitals ($p = 0.054$).[71] In a study of 20 Spanish hospitals, nosocomial legionnaires' disease was found in 64.7% of the hospitals with water cultures positive for *Legionella*, whereas no nosocomial cases were found in hospitals with *Legionella*-negative water cultures.[72]

Exner *et al* in their review of the literature on nosocomial infections cite a German study which investigated hospitals and residential units and other buildings that could be affected by the colonisation of the water system with *Legionella* bacteria.[73] In the study, local colonisation of the water system was defined as colonisation of isolated parts of the plumbing system (taps or showerheads). Systemic colonisation was defined as colonisation of the whole system, including the central parts of the water supply. In the case of local colonisation it was possible to flush out *Legionella* bacteria from the distal water sites e.g. taps, showers. However, with systemic colonisation even intensive system flushing had no effect on the reduction of *Legionella* bacteria in the system. If regular flushing is having no effect on the levels of *Legionella* then all of the existing control procedures need to be reviewed and amended if necessary.

Hot and cold water systems should be designed to aid safe operation by preventing or controlling conditions which permit the growth of *Legionella*. Flushing procedures should be based on a risk assessment of the water systems in the building/institution concerned. A flushing protocol is only effective where the water system is adequate and the water supply is not contaminated. This particularly applies where there are water storage tanks.

The following are risk factors that should be considered in the risk assessment:

Institutional risk factors

- *Age and condition of the pipes*
  Older pipes are more prone to the growth of *Legionella* because of corrosion, scaling, biofilms and sediment. *Legionella* bacteria require a supply of nutrients to multiply. Sources of these nutrients include commonly encountered organisms within the water system such as algae, amoebae and other bacteria. The presence of sediment, sludge, scale and other material within the system, together with biofilms, facilitate the growth of *Legionella* and may provide protection for the *Legionella* bacteria from temperatures and disinfectants that might otherwise kill or inhibit the growth of these organisms.[64]
- *Redundant pipework and fittings*
  Hospitals are frequently constructed over a long period of time and as a result often contain a considerable amount of redundant pipework/deadlegs in which water can stagnate which also facilitates the growth of *Legionella*.[74] Studies have shown that flushing of outlets whilst reducing stagnation has little effect on biofilm, particularly when applied to outlets supplied from extensive pipework distribution systems. Therefore, before the procedures are carried out, consideration should be given to the removal of infrequently used sanitary fixtures such as showers and taps, etc. If they are removed then the redundant supply pipework should be cut back as far as the main connection.[64] Showers (excluding safety showers used for decontamination purposes) should not be fitted where they are likely to be used less than once per week.
- *Complexity of the system*
  Complex, lengthy pipe systems are more at risk than simpler, short systems.

Population at risk
In the hospital setting, patients with predisposing risk factors are not only at higher risk of infection but also have a higher mortality rate when infected with *Legionella*. Consequently, hospitals and residential institutions must pay particular attention to the prevention of legionellosis.[74] Those at higher risk include:

- Immunocompromised organ transplant patients, patients with HIV/AIDS, and those receiving systemic steroids
- Patients with underlying chronic disease such as diabetes mellitus, congestive heart failure, chronic obstructive pulmonary disease, and chronic renal disease
- People over 40 years of age
- Smokers
- Those with excessive alcohol intake.

Prior history of building

- History of legionellosis associated with the building
- History of positive water cultures from the potable water system and outlets or cooling towers.

Flushing procedure

The risk from *Legionella* bacteria growing in peripheral parts of the water system such as deadlegs off the recirculating hot water system may be minimised by regular use of these outlets. Water within the system may stagnate because a particular outlet is not used for more than a week.[74] In most hospitals, there are areas which may have water outlets such as showers that are not used for significant periods of time. These areas may change from time to time, as wards or patient bathroom areas are disused and reopened. Showers in such areas are more likely to harbour *Legionella* than those in areas where outlets are in regular use. Hotel accommodation may present the same problem with bedrooms unused during the off-peak periods.[74]

Showers and water outlets that are in daily use do not require flushing.

How to flush

The frequency and duration of flushing procedures should be based on a risk assessment. Only run showers that are intermittently used. All outlets should be flushed at least once per week at full flow (the water flow should be increased gradually to minimise the production of aerosols). However, risk assessment may indicate the need for more frequent flushing where there is a more susceptible population present, e.g. in hospitals, nursing homes, etc.[64] High-risk areas in hospitals e.g. wards with immunocompromised patients, renal transplant units, may require flushing on a daily basis and this should become part of the daily cleaning process. The local multidisciplinary infection prevention and control team should make these decisions.

Healthcare facilities

The duration of flushing should be based on a risk assessment but at a minimum the procedure below should be followed:

Showers

Run showers for six minutes weekly as follows:

- Run cold for three minutes
- Run hot for three minutes once water is hot.

Taps

Run individual hot and cold taps weekly as follows:

- Run cold for three minutes
- Run hot for three minutes once water is hot.

Mixer taps

- Run with the lever in the coldest position for three minutes weekly
- Run with the lever in the hottest position for three minutes weekly
- Ensure that hot water comes out hot when in the hot position and cold when in the cold position.

Cold water should be used to flush the cold water system and hot water to flush the hot water system. The period of flushing must be sufficient to remove all stagnant water leading to the outlet. The number of outlets that can be flushed simultaneously will depend on the capacity of the water heater and the flow capability of the system.[75]

Where it is difficult to carry out weekly flushing, the stagnant and potentially contaminated water from within the shower/tap and associated deadlegs needs to be purged to drain before the appliance is used. It is important that this procedure is carried out with minimum production of aerosols, e.g. additional piping may be used to purge contaminated water to drain. Automatic drain valves fitted to showers to drain the mixer valve and shower hose after use can produce conditions within the shower that support the growth of *Legionella* and are not recommended as a method for controlling the risk of exposure to *Legionella*.[64]

Where a single TMV serves several multiple showerheads, it is important to ensure that these showers are flushed frequently. Where an outlet is not used for more than a week it must be flushed until the temperature of the water at the outlet has reached the pre-determined temperature set by the thermostatic mixing valve. A surface probe can be used to measure the temperature of the water going into the TMV. Every thermostatic mixing valve must be cleaned and maintained at least once in every calendar year.[74]

The flushing procedures for hot and cold water services are shown in Table 5.

Table 5. Flushing procedures for hot and cold water services

Service	Task	Frequency
Intermittently used outlets	Flush for several minutes Where there is difficulty with weekly flushing, flush through and purge to drain immediately before use. Avoid the production of aerosols.	Weekly Before use
Hotels/accommodation	Run all taps and showers in every bedroom whether occupied or unoccupied for several minutes Flush cisterns once	Weekly Weekly
Emergency showers and eye wash sprays. Eye wash sprays should be on an independent water reservoir	Flush through and purge to drain	Quarterly or more frequently if recommended by manufacturers
Dental unit waterlines. Dental handpieces, ultrasonic scalers and air/water syringes	Flush for a minimum of 2-3 minutes Flush for a minimum of 20-30 seconds Flush for a minimum of 30 seconds	At the beginning of each working day After each patient After each patient

Source: Adapted from Checklists 2 and 3 in HSC UK – Legionnaires' disease: the control of Legionella bacteria in water systems: approved code of practice and guidance[64]

Monitoring

Once started, the flushing procedure has to be sustained and logged as lapses can result in a critical increase in *Legionella* bacteria density at the outlet. A flushing protocol should be introduced in each

institution. The protocol should be incorporated into the institution's regular cleaning contract. A monitoring system must be put in place to monitor compliance with the flushing protocol. Records of compliance should be maintained and a nominated person should be accountable for implementing the protocol and for maintaining records.

Audit
A regular audit of control and monitoring procedures should take place.

Precautions
Maintenance, cleaning, and operating procedures should be designed to control the risks to staff and others who may be affected. Personnel involved in flushing procedures should be adequately trained in safety procedures including the use and maintenance of PPE.

Cleaning and disinfection of showerheads
Consider replacing showerheads and hoses as an alternative to cleaning and disinfection.

Dismantle, clean and descale showerheads and hoses quarterly or more frequently as required based on a risk assessment. In high-risk areas this should be done on a monthly basis.[75] Disinfectants containing chlorine can be used to disinfect showerheads.[76] However, chlorine concentrations vary in different products.[77] Proprietary bleach can lose some of the chlorine over time so newly manufactured bleach should be used if possible. Thick bleach solutions should never be used for disinfection purposes as they contain potentially poisonous additives.

A solution of **1,000 parts per million (ppm)** of free available chlorine (Table 6) for 10-15 minutes should be used to disinfect showerheads.

Table 6. Preparation of chlorine disinfectants used for disinfecting showerheads

Proprietary bleach (4% free available chlorine)	
Volume of water to which chlorine is added	**1,000 ppm**
5 litres water	Add 125 ml bleach
10 litres water	Add 250 ml bleach
50 litres water	Add 1,250 ml bleach
Liquid pool chlorine (with 12.5% free available chlorine – concentrations are based on 10% free available chlorine)	
5 litres water	Add 50 ml bleach
10 litres water	Add 100 ml bleach
50 litres water	Add 500 ml bleach
Granular chlorine (with 65% free available chlorine)	
5 litres water	Add 8 g bleach
10 litres water	Add 15 g bleach
50 litres water	Add 77 g bleach

Source: Adapted from Victorian Government Department of Human Services[78]
***Note:** It is safer to add chlorine to water – do not add water to chlorine. Always use cold water to make up chlorine solutions.*

Procedure

a. Set up hazard warning signs at access points to the washroom area if the work site is open to the public or general staff. If possible showerheads should be removed from the area for cleaning at a designated point

b. The following PPE is required: standard overalls, gloves and goggles/face shield. In areas where there is a significant risk, PPE and respiratory filter masks should be worn
c. Transfer only small quantities of the required treatment chemicals to the area
d. Routine

- Remove the showerheads to be cleaned. If flexible hoses are used they should be included in the cleaning routine
- Dismantle the heads as far as possible
- Place the fittings into the cleaning product*, physically clean as required to remove scale and any other deposits
- Rinse seals and fittings thoroughly with fresh water (this is important to avoid potentially dangerous fumes from reactions with the disinfecting solution)
- Place the fittings in a disinfecting solution* (hypochlorite at 1,000 ppm for 10-15 minutes)
- Rinse seals and fittings thoroughly with fresh water
- Reassemble the showerhead
- Re-fit the showerhead
- Flush the whole showerhead assembly

e. Complete the showerhead cleaning record.

** Some showerhead materials require specific cleaning and disinfecting chemicals to avoid damage of the fitting, examples include gold plated and thin chrome plated fittings (see manufacturer's advice).*

5.2.2 Cooling towers and evaporative condensers

Evaporative cooling is a physical phenomenon by which evaporation of a liquid into the surrounding air cools the remaining liquid. In the case of water this phase change can be used as part of a cooling system.[75] Evaporative cooling is an energy efficient means to reject unwanted heat from an air conditioning, refrigeration or process cooling system using an open or closed circuit cooling tower. Evaporative condensers (Figure 7) which directly condense refrigerant use the same principle.

To optimise the evaporation process in evaporative cooling equipment there needs to be a large area of contact between the water and the airstream flowing through the unit. In an open circuit cooling tower this is achieved by filming the water to be cooled over a fill pack that has a large surface area to maximise the air and water interface. In a closed circuit cooling tower or evaporative condenser the fluid to be cooled or refrigerant to be condensed is in a closed loop heat exchanger within the unit. The evaporative cooling effect is achieved by a secondary re-circulating system which distributes water continuously over the heat exchanger.

Evaporative cooling equipment operates at temperatures which can provide an environment for the growth of microorganisms in the water, including *Legionella*. If the water is allowed to become heavily contaminated and to escape from the unit in aerosol form and then inhaled by susceptible persons in the vicinity, cases of legionellosis may result. However, this can be avoided completely by close attention to the design of the equipment, by using water treatment to maintain good water quality control, and by system cleanliness. An important element of the design is the need for high efficiency drift eliminators to minimise the water droplets and aerosols discharged into the atmosphere.

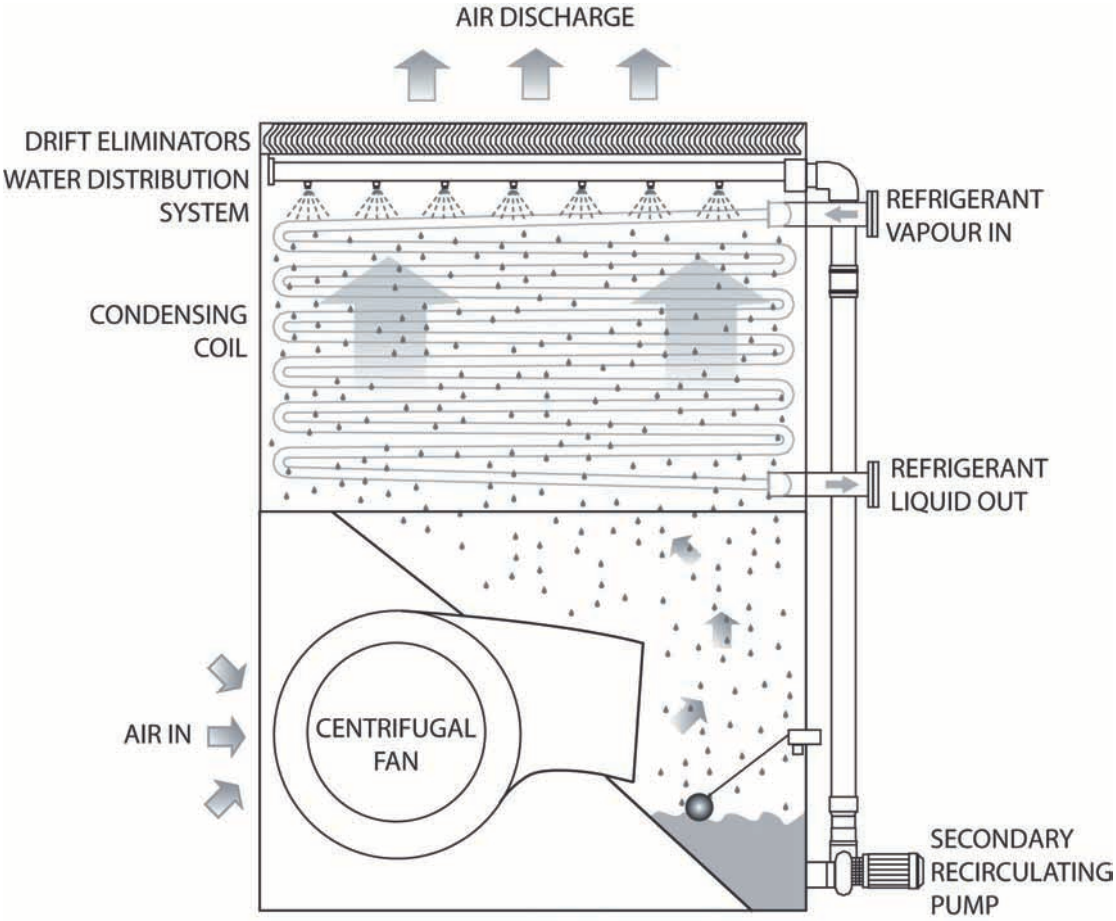

Figure 7. Evaporative condenser

Monitoring of cooling towers
Checklist 2 and Table 7 outline the inspection frequency for cooling towers and evaporative condensers.

Checklist 2. Cooling tower installations

System/service	Task	Frequency
Cooling towers and evaporative condensers	Monitor water quality, water use and biocide/ chemical use to assess and ensure effectiveness of water treatment regime, including key chemical and microbiological parameters, and observation of internal conditions of pond, pack and water	**See table 7 and 8**
	Central control function, conductivity sensor calibration, blowdown function, uniformity of water distribution, condition of sprays/troughs, eliminators, pack, pond, immersion heater, fans and sound attenuators	**Monthly to three monthly, according to risk (table 7)**
	Clean and disinfect cooling towers/evaporative condensers, make-up tanks and associated systems, including all wetted surfaces, descaling as necessary. Packs should be removed and cleaned where practicable (see the Health and Safety Executive guidelines on the removal of pack from cooling towers at www.hse.gov.uk/legionnaires/coolingtowers.htm)[79]	**Six monthly**

Source: HSC UK – Legionnaires' disease: the control of Legionella bacteria in water systems: approved code of practice and guidance[64]

Table 7. Typical on-site monitoring checks recommended for good operating practice of cooling towers

Parameter	Timing	
	Make-up water	Cooling water
Calcium hardness as mg/l $CaCO_3$	**Monthly**	**Monthly**
Magnesium hardness as mg/l $CaCO_3$	**Monthly**	**Monthly**
Total hardness as mg/l $CaCO_3$	**Monthly**	**Monthly**
Total alkalinity as mg/l $CaCO_3$	**Quarterly**	**Quarterly**
Chloride as mg/l Cl	**Monthly**	**Monthly**
Sulphate as mg/l SO_4	**Quarterly**	**Quarterly**
Conductivity µs (Total dissolved solids)	**Monthly**	**Weekly**
Suspended solids mg/l	**Quarterly**	**Quarterly**
Inhibitor(s) level mg/l	**Not applicable**	**Monthly**
Oxidising biocide mg/l	**Not applicable**	**Weekly**
Temperature °C	**Not applicable**	**Quarterly**
pH	**Quarterly**	**Weekly**
Soluble iron as mg/l Fe	**Quarterly**	**Quarterly**
Total iron as mg/l Fe	**Quarterly**	**Quarterly**
Concentration factor	**Not applicable**	**Monthly**
Microbiological activity	**Quarterly**	**Weekly**
Legionella	**Not applicable**	**Quarterly**

Source: HSC UK – Legionnaires' disease: the control of Legionella bacteria in water systems: approved code of practice and guidance[64]

Table 8. Outlines the action levels following microbial monitoring of cooling towers.

Table 8. Action levels following microbial monitoring of cooling towers

Aerobic count cfu/ml at 30°C (minimum 48 hours incubation)	*Legionella* bacteria cfu/litre	Action required
10,000 or less	100 or less	**System under control**
More than 10,000 and up to 100,000	More than 100 and up to 1,000	**Review programme operation** A review of the control measures and risk assessment should be carried out to identify any remedial actions and the count should be confirmed by immediate re-sampling
More than 100,000	More than 1,000	**Implement corrective action** The system should be immediately re-sampled. It should then be 'shot dosed' with an appropriate biocide as a precaution. The risk assessment and control measures should be reviewed to identify remedial actions

Source: HSC UK – Legionnaires' disease: the control of Legionella bacteria in water systems: approved code of practice and guidance[64]

5.2.3 Other risk systems

The monitoring frequency for various tasks in other risk systems is detailed in Checklist 3.

Checklist 3. Other risk systems

System/service	Task	Frequency
Ultrasonic humidifiers/foggers and water misting systems	If equipment fitted with UV lights, check to ensure effectiveness of lamp (check to see if within working life) and clean filters	**Six monthly or according to manufacturer's instructions**
	Ensure automatic purge of residual water is functioning	**As part of machinery shut down**
	Clean and disinfect all wetted parts	**As indicated by risk assessment**
	Sampling for *Legionella*	**As indicated by risk assessment**
Spray humidifiers, air washers and wet scrubbers	Clean and disinfect spray humidifiers/air washers and make-up tanks including all wetted surfaces, descaling as necessary	**Six monthly**
	Confirm the operation of non-chemical water treatment (if present)	**Weekly**
Water softeners	Clean and disinfect resin and brine tank - check with manufacturer what chemicals can be used to disinfect resin bed	**As recommended by manufacturer**

Lathe and machine tool coolant systems	Clean and disinfect storage and distribution system	**Six monthly**
Spa baths	***See Chapter 8, Section 8.5***	
Horticultural misting systems	Clean and disinfect distribution pipework, spray heads and make-up tanks including all wetted surfaces, descaling as necessary	**Annually**
Dental chair unit waterlines	***See Chapter 8, Section 8.3***	
Car/bus washes	Check filtration and treatment system, clean and disinfect system	**See manufacturer's instructions**
Indoor fountains and water features	***See Chapter 8, Section 8.4***	

Source: Adapted from Checklist 3 in HSC UK – Legionnaires' disease: the control of Legionella bacteria in water systems: approved code of practice and guidance[64]