

EWGLI Technical Guidelines for the Investigation, Control and Prevention of Travel Associated Legionnaires' Disease

September 2011

Version 1.1

Produced by members of the European Working Group for Legionella Infections



These guidelines were produced with the assistance of funding from the European Commission prior to 2007, and the European Centre for Disease Prevention and Control (ECDC). Neither the ECDC nor the European Commission, nor any person acting on their behalf is liable for any use made of the information published here.

These guidelines were originally developed in 2001/02 by members of the European Surveillance Scheme for Travel Associated Legionnaires' Disease (EWGLINET) and the European Working Group for Legionella Infections (EWGLI). They were endorsed in 2003 by the Committee for the Epidemiological Surveillance and Control of Communicable Diseases in the Community, instituted by Decision No 2119/98/EC of the European Parliament and the Council.

The following members of the European Surveillance Scheme for Travel Associated Legionnaires' Disease and the European Working Group for Legionella Infections are responsible for this revised edition of the guidelines:

Dr Carol Joseph	UK
Dr John Lee	UK
Dr Susanne Surman-Lee	UK
Dr Vladimir Drasar	Czech Republic
Dr Sebastian Crespi	Spain
Dr Emmanuel Briand	France

The Working Group is grateful for all comments and contributions to these guidelines that have been received during the course of their revision.

The Working Group would like to acknowledge its consultation of the UK Health and Safety Executive's document L8 (Legionnaires' Disease, the Control of Legionella Bacteria in Water Systems. Approved Code of Practice and Guidance) (1) during the preparation of the first and revised editions of the European guidelines.

If you notice any mistakes in these guidelines or have suggestions for improving them please address them to johnvlee@leegionella.co.uk

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About these Guidelines

The first edition of this guidance document was produced in 2002 to describe the procedures for control and prevention of travel associated Legionnaires' disease for participants in the European Surveillance Scheme for Travel Associated Legionnaires' Disease (EWGLINET). It was produced by a small team from the surveillance scheme and the European Working Group for Legionella Infections and agreed by all collaborators in EWGLINET. The guidelines were submitted to the Network Committee for the Epidemiological Surveillance and Control of Communicable Diseases in the Community, that operated under Decisions 2119/98/EC (Anon 1998) and 2000/96/EC (Anon 2000). After some modifications the EU Network Committee officially endorsed the document in June 2003. In 2005 the European Centre for Disease Prevention and Control (ECDC) was established through the Parliament and Council Regulation 851/2004 (Anon 2004). As a disease specific network ECDC funded EWGLINET from January 2007 till April 2010 when ECDC took over completely and the scheme became known as the European Legionnaires' Disease Surveillance Network (ELDSNET).

In this new edition, revisions to the technical guidelines have been prepared that reflect developments in clinical and environmental microbiology for the detection, control and prevention of *Legionella* infections. This edition also updates advice on risk assessments and the management of newly recognised sources of infection.

The guidelines offer a standardised approach to procedures for preventing and investigating *Legionella* infections associated with travel and aim to further harmonise these procedures among Member States. However, national laws apply where advice on specific aspects of control and prevention differs between the European guidelines and regulations in force in Member States. The principles for investigation and control outlined in this document are not restricted to travel associated infections but can also be applied to the prevention of *Legionella* infections in other situations.

These guidelines are available on the ECDC website (<http://ecdc.europa.eu/en/activities/surveillance/ELDSNet/Pages/index.aspx>).

If you notice any mistakes in these guidelines or have suggestions for improving them please address them to johnvlee@leegionella.co.uk

Executive Summary

Legionnaires' disease is a serious pneumonic infection caused by inhaling the bacteria *Legionella pneumophila* or other *Legionella* species. This bacterium is frequently found in domestic, hotel and other water systems and in water used for air conditioning or air cooling systems. After the first recognition of the disease in people attending a hotel conference in the USA in 1976 (Anon 1997), national surveillance for the condition began in several countries. The European Working Group for Legionella Infections (EWGLI) was formed in 1986 and members of this group established a European surveillance scheme for travel associated infections in 1987 (Anon 1990). Twenty four years later, EWGLI remains a voluntary group of international scientists who share a common goal of furthering the microbiological and epidemiological understanding of *Legionella* infections. The surveillance scheme however, which was named EWGLINET in 2002, has grown in size and complexity since 1987, and now functions under an official EU Control of Communicable Disease programme (Anon 2000a).

Legionnaires' disease principally affects older adults. Those with risk factors such as smoking and immunosuppression are at increased risk from the disease. The case fatality rate is currently 10% to 15% and despite the availability of appropriate antibiotic treatment a certain number of deaths are recorded each year in otherwise healthy persons with no known underlying risk factors. Hence the main intervention against the condition is prevention, through control of the organism in water systems. For a number of reasons people travelling to holiday destinations are particularly at risk and such cases account for up to half of the cases reported from some European countries. Through extensive media coverage the public has become increasingly aware of Legionnaires' disease, the specific risks associated with travel and hotel stays and a view that early pan-European action should protect them against the risks of infection.

These guidelines should be read in conjunction with the ELDSNET Operational Procedures and provide technical guidance for those involved in the risk assessment of premises following the reporting of cases of legionnaires' disease, the investigation of outbreaks and the implementation of control measures.

Part 1: Procedures for the risk assessment, environmental investigation and control and prevention of *Legionella* in water systems

This part summarises the factors to be considered in the risk assessment which include: the responsibilities of the individuals concerned, measurement of competence, their training requirements; management structure; the factors promoting the growth of *Legionella* bacteria; the types of water systems to be considered and the documentation of the risk assessment; the systems for implementing and monitoring the control scheme. It details the items that should be included in the written scheme for the control of the risk and the need for regular review of the control measures, including the role of microbiological sampling. The responsibilities of manufacturers, importers, suppliers and installers are also detailed.

Part 2: Methods for the investigation and control of an outbreak of Legionnaires' disease in a hotel or other accommodation site

This part briefly outlines the procedures for investigating an outbreak, with an emphasis on sampling for *Legionella* and consideration of the emergency and long-term remedial measures for control.

Supplement 1: Technical guidelines for the control and prevention of Legionella in water systems

This section provides the technical background to the control measures commonly applied to hot and cold water systems and cooling systems, including features of the design and construction; management of the systems during commissioning and re-commissioning and normal operation. It is separate from the main European guidance document, because it is mainly based on technical recommendations contained in the revised UK guidelines published in December 2000. Supplement 1 should be regarded as one example of good practice, which may not be entirely consistent with guidance produced in some other European countries because of legal requirements or constraints within individual countries. It is however, a useful model to follow. National legislation should be adhered to where relevant but where legislation exists this can also be used to enhance investigations.

The supplement emphasises the use of temperature control for hot and cold water systems along with good maintenance with regular disinfection and cleaning. It also provides information on the use of alternatives such as chlorine, chlorine dioxide and copper/silver ionisation. The methods of monitoring the operation of the control measures are given. The design, construction operation and control of cooling systems with cooling towers or evaporative condensers is detailed, including the methods of cleaning and disinfection, biocidal regimes and the use of chemical and microbiological monitoring. The design, construction operation and control of spa pools are also detailed.

Supplement 2: Treatment methods for different water systems

This section provides brief information on the use of biocides for the regular control of cooling systems. It also describes the use of heat, chlorine, chlorine dioxide and copper/silver ionisation for the disinfection and control of growth of *Legionella* bacteria in hot water systems and considers some alternatives.

Supplement 3: References for National Guidelines for Control and Prevention of Legionnaires' disease and References for National Water Regulations

A list of the current range of technical guidelines produced by individual European countries is provided at the end of Supplement 3. Website addresses for national water regulations where the control of *Legionella* infections is included are also listed by country.

Part 1

Procedures for the Risk Assessment, Environmental Investigation and Control and Prevention of *Legionella* in Water Systems

Introduction

1. This part of the guidelines outline the general principals and procedures that should be followed in order to carry out a risk assessment of the control measures against the proliferation of legionellae in an establishment such as a hotel. It must be emphasised that, for the effective prevention of Legionnaires' disease, risk assessments and control measures must be implemented proactively and not merely in response to a case or cluster of cases of Legionnaires' disease. Consequently if a single case is associated with the establishment it should only be necessary to ensure that an adequate up-to-date risk assessment is in place and check that all the control measures are operating correctly and consistently. However following a cluster of cases it will be necessary to carry out a new thorough risk assessment.
2. This part should be read in conjunction with Supplement 1 that provides more technical information on the methods available to control the growth of *Legionella* in different kinds of water systems. Although this document deals primarily with travel associated Legionnaires' disease and is therefore concerned mostly with hotels; the risk assessment procedures and technical guidance can be applied to all kinds of premises and water systems.

Scope

3. These guidelines apply primarily to the control of *Legionella* in premises likely to be associated with travel associated cases of Legionnaires' disease, for example, hotels, holiday apartments, camp sites, cruise ships, leisure centres and trade shows. They may also be applicable to any undertaking involving a work activity and to premises controlled in connection with a trade, business or other undertaking where water is used or stored, e.g manufacturing premises and other commercial premises. These guidelines should be read in conjunction with the technical notes (Supplement 1).
4. A reasonably foreseeable risk of exposure to legionellae exists in:
 - Water systems incorporating a cooling tower
 - Water systems incorporating an evaporative condenser
 - Hot and cold water systems
 - Natural thermal springs and their distribution systems
 - Spa pools (also known as hot tubs, whirlpool spas and commonly as 'Jacuzzis' - the name of one particular brand)

- Humidifiers
 - Other plant and systems containing water that is likely to exceed 20°C and which may release a spray or aerosol (i.e. a cloud of droplets and/or droplet nuclei) during operation, demonstration or when being maintained, for example industrial water systems and horticultural sprinkler systems
5. **NOTE:** Although it is commonly accepted that legionellae can begin to grow at temperatures above 20°C, at temperatures below 25°C growth is still very slow. The rate of growth of *L. pneumophila* increases with increasing temperature to a maximum of about 37- 43°C. At temperatures above 40°C many heterotrophic bacteria found in water with legionellae start to die; however legionellae can grow relatively quickly inside amoebae. Thus the risk may be considered to appreciably increase the closer the water temperature comes to about 40°C.
 6. Not all of the systems listed above will require elaborate assessment and control measures. A simple risk assessment may show that the risks are low and that no further action will be necessary.
 7. A water system includes all plant/equipment and components associated with that system, e.g. all associated pipe-work, pumps, feed tanks, valves, showers, heat exchangers, quench tanks, expansion vessels, chillers etc. It is important that the functioning of the system and equipment associated with it is considered as a whole, and not, for example, the cooling tower in isolation. Dead-legs and parts of the system used intermittently, e.g. sections of hotels that are closed in the low season also need to be included as part of the system since they can create particular problems with microbial growth going unnoticed. Once brought back on-line they can release heavy contamination which might overload the water treatment regime and result in dissemination of legionellae throughout the system.
 8. It is particularly important that the hydraulics of circulating piped systems are fully investigated and understood. It is essential for control that adequate flow is maintained through all parts of systems, e.g. all return loops within hot water systems must be checked to confirm that they have flow within them and that they reach the appropriate temperatures.
 9. Other systems, such as humidifiers and air washers, spa baths and pools, car/bus washes, wet scrubbers, industrial water systems, fountains and water features, should also be considered where relevant.

Identification and assessment of the risk

10. A survey is required to identify and assess the risk of exposure to legionellae from water systems on the premises and what precautionary measures will be required to reduce the risk. The individual whose duty it is to have the assessment carried out is:
 - The employer, where the risk from their undertaking is to their employees or to others; or

- A self-employed person, where there is a risk from their undertaking to themselves or to others; or
 - The person who is in control of premises or systems in connection with work where the risk is present from systems in the building (e.g. where a building is let to tenants but the landlord retains responsibility for its maintenance); or
 - The person who is in control of premises used for overnight accommodation, such as hotels, holiday apartments, campsites and cruise ships, where the risk is present from water systems in the building.
11. The person conducting the assessment must be competent to assess the risks of exposure to legionellae in the water systems present in the premises, and the necessary control measures (e.g. a microbiologist, environmental health officer or water engineer with this specific expertise).
12. The assessment should include a full inspection to identify and evaluate potential sources of risk and
- the particular means by which exposure to legionellae is to be prevented (e.g. replacing a cooling tower with a dry system or the closure of a spa pool); or
 - If prevention is not reasonably practicable, the particular means by which the risk from exposure to legionellae is to be controlled.
13. Where the assessment demonstrates that there is no reasonably foreseeable risk or that risks are insignificant and unlikely to increase, no further assessment or measures are necessary but a written record of this conclusion should be kept. However, should the situation change, the assessment needs to be reviewed and any necessary changes implemented.

Carrying out a risk assessment

14. The risk of a person being infected with *Legionella* depends on a number of factors. These include:
- The presence of legionellae and the strain observed
 - Conditions being suitable for multiplication of the organisms for example a suitable temperature (20°C to 50°C but see paragraph 39 above), poor flow backflow and a source of nutrients such as sludge, scale, rust, algae and other organic matter
 - A means of creating and disseminating inhalable droplets such as the aerosol generated by operating a tap, shower, the jets in a spa pool or cooling tower
 - The presence (and numbers) of individuals who may be exposed
 - The vulnerability of these individuals.
15. While there will inevitably be common factors associated with the many and varied types of premises being assessed, the individual nature of each site should be taken into account. In complex systems or premises, a site survey of all the water systems should be carried out and should include an asset register of all associated plant and equipment, e.g. pumps, strainers and other relevant items. This should include an up-to-date drawing/diagram showing

the layout of the plant or system, including parts temporarily out of use. A schematic diagram would be sufficient. It should then be decided which parts of the water system, for example which specific equipment and services are likely to pose a risk to those at work or other persons. Where a site has several systems, for example a hotel with an air conditioning system cooled by a water tower; a leisure complex together with the domestic hot and cold water systems it may be necessary to assemble a team of assessors with appropriate expertise in each of these areas.

16. A fully documented record of the risk assessment should be kept and the record of the assessment should be linked to other relevant health and safety records.
17. Employers should consult employees or their representatives on the identified risks of exposure to legionellae and on the measures and actions taken to control the risks.
18. It is essential that the effectiveness of the control measures is monitored and decisions made on the frequency and manner of this monitoring.
19. The assessment should be reviewed regularly (at least every two years) and in any case whenever there is reason to suspect that it is no longer valid. This could occur due to changes to the water system, its use, if the results of checks indicate that control measures are no longer effective; or if there is a substantive change in personnel managing the system.
20. The following paragraphs provide an overview of the rationale behind the definition of risk factors for typical systems. These factors should be considered, as appropriate, when carrying out the technical risk assessment for typical systems. More detailed checklists of items to be considered for different systems is given in Appendix 4 and on the ECDC website. See also the inspection frequencies checklists for the different systems, in Supplement 1.

Managing the risk: management responsibilities, training and competence

21. Where the assessment has identified a risk and it is reasonably practicable to prevent exposure or control the risk from exposure, the person on whom the duty falls (see paragraph 10 above) should appoint a person or persons to take day to day managerial responsibility and to provide supervision for the implementation of precautions for controlling any identified risk from legionellae. The appointed 'responsible person' should be a manager, director, or have similar status and sufficient authority, competence and knowledge of the installation to ensure that all operational procedures are carried out in a timely and effective manner. If a duty-holder is self-employed or a member of a partnership, and is competent, they may appoint themselves. The responsible person should have a clear understanding of their duties and the overall health and safety management structure and policy in the organisation.

22. Inadequate management, lack of training and poor communication have all been identified as contributory factors in outbreaks of Legionnaires' disease. Persons who carry out the assessment and who draw up and implement precautionary measures should have such ability, experience, instruction, information, training and resources as to allow them to carry out their tasks competently and safely. In particular, they should know about:
- Potential sources and the risks they present;
 - Measures to be adopted, including precautions to be taken for the protection of people concerned, and the significance of the measures;
 - Measures to be taken to ensure that controls remain effective and the significance of the controls.
23. Where the above expertise is not possessed by the person or persons appointed under paragraph 42, it may be necessary to enlist help and support from outside the organisation. In such circumstances, the person or persons appointed under paragraph 42 should take all reasonable steps to ensure the competence of those carrying out work who are not under their direct control, and that responsibilities and lines of communication are properly established and clearly laid down.
24. Management and communication procedures should be periodically reviewed as appropriate.

Competence

25. Those who are appointed to carry out the risk assessments; control measures and strategies should be suitably informed, instructed and trained and their suitability assessed. They should be properly trained to a standard that ensures that tasks undertaken are carried out in a safe, technically competent manner. Regular refresher training should be undertaken and records of all initial and refresher training need to be maintained. Although training is an essential component of competence, it is not the only component - it is a product of sufficient training, experience, knowledge and other qualities that are required to undertake a job safely. Competence is dependent on the needs of the situation and the nature of the risks involved.

Implementation of the control scheme

26. The implementation of the water system control scheme should be regularly and frequently monitored and all persons involved in any related operational procedure should be properly supervised. Staff responsibilities and lines of communication should be properly defined and clearly documented. It is important that all levels of staff are aware of actions to be taken in the event of a monitoring parameter being out of specification, for example biocide levels below the minimum acceptable limit.
27. Arrangements should be made to ensure that appropriate staff levels are maintained during all hours when complex water systems are in operation. The precise requirements will depend on the nature and complexity of the water system. Appropriate provision should be made to ensure that the responsible person or an authorised deputy can be contacted at all times.

28. Call out arrangements for persons engaged in the management of water systems that operate automatically need to be similarly maintained. 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.
29. Communications and management procedures are particularly important where several people are responsible for different aspects of the operational procedures. For example, responsibility for applying precautions may change when shift work is involved, or the person who monitors efficacy of a water treatment regime may not be the person who applies it. In such circumstances responsibilities should be well defined in writing and understood by all concerned. Lines of communication should be clear, unambiguous and audited regularly to ensure they are effective. This also applies to outside companies and consultants who may be responsible for certain parts of the control regime.
30. The employment of contractors or consultants does not absolve the duty holder (as defined in paragraph 40 above) of responsibility for ensuring that control procedures are carried out to the standard required for prevention of the proliferation of legionellae. Organisations should make reasonable enquiries to satisfy themselves of the competence of contractors in the area of work before entering into contracts for the treatment, monitoring, and cleaning of the water system, and other aspects of water treatment and control.

Preventing or controlling the risk from exposure to *Legionella*

31. Once the risk has been identified and assessed, a written scheme should be prepared for preventing or controlling it. In particular, it should contain such information about the system as is necessary to control the risk from exposure.
32. The scheme should specify measures to be taken to ensure that it remains effective, together with remedial action required in the event that the scheme is shown not to be effective. The scheme should include:
 - The up-to-date plan showing layout of the plant or system, including key components and parts temporarily out of use (a schematic plan would suffice)
 - description of the correct and safe operation of the system
 - The precautions to be taken
 - The checks to be carried out to ensure efficacy of scheme and the frequency of such checks
33. The primary objective should be to avoid conditions that permit legionellae to proliferate and to avoid creating a spray or aerosol. If it is practicable to prevent a risk by replacing a piece of equipment that presents a risk with one that does not, this should be done.

34. In general, proliferation of legionellae may be avoided by:
- Avoiding water temperatures throughout the system of between 20°C and 50°C. Water temperature is a particularly important factor in controlling the risks and water should be either below 20°C or above 50°C
 - Avoiding water stagnation and low flow. Stagnation may encourage the growth of biofilm (slimes that form on surfaces in contact with water) which can harbour legionellae and provide local conditions that encourage its growth
 - Avoiding the use of materials in the system that can harbour or provide nutrients for bacteria and other organisms e.g. natural compounds such as rubber washers and hoses
 - Keeping the system clean to avoid the accumulation of sediments which may harbour bacteria (and also provide a nutrient source for them)
 - The use of a suitable water treatment programme where it is appropriate and safe to do so
 - Ensuring that the system operates safely and correctly and is well maintained
35. 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, for example 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 contact time required; and data verifying that these are effective in the system being considered
 - Health and safety information for storage, handling, use and disposal of chemicals
 - System control parameters (together with allowable tolerances); physical, chemical and biological, together with measurement methods and sampling locations, test frequencies and procedures for maintaining consistency, together with appropriate remedial measures to be taken if results are out of specified limits
 - Remedial measures to be taken in the event that the control limits are exceeded including lines of communication
 - Cleaning and disinfection procedures
36. There should also be a description of the correct operation of the water system plant including:
- Commissioning and re-commissioning procedures
 - Shutdown procedures, opening procedures following temporary shutdown e.g. during winter
 - Checks of warning systems and diagnostic systems in the event of system malfunction together with remedial measures to be implemented
 - Maintenance requirements and frequencies
 - Operating cycles - to include when the system plant is in use or idle
 - When a case of Legionnaires' disease is associated with the building

Review of control measures - monitoring and routine inspection

37. If precautions are to remain effective the condition and performance of the control measures and system will need to be monitored. This should be the responsibility of the responsible person or, where appropriate, an external contractor or an independent third party and should 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 the system to the required standard
38. The frequency and extent of routine monitoring will depend on the operating characteristics of the system, but some should be at least daily for example checking that there is sufficient biocide available and that the expected usage is within normal limits.
39. Testing of water quality is an essential part of the treatment regime, particularly in cooling towers. It may be carried out by a service provider e.g., a water treatment company or consultant, or else by the operator, provided they have been trained to do so and are properly supervised. The type of tests required will depend on the nature of the system.
40. The routine monitoring of general bacterial numbers (total viable count) is also appropriate as an indication of whether microbiological control is being achieved. This is generally only undertaken for cooling towers and spa pools rather than hot and cold water systems. Periodic sampling and testing for the presence of legionellae may also be appropriate as an indication that the control measures are effective.
41. ***NOTE: reliably detecting the presence of legionellae is technically difficult and requires specialist laboratory facilities. The interpretation of results is also difficult; a negative result is no guarantee that legionellae are absent. Conversely, a low local count may not indicate a failure of system controls.***
42. A suitably experienced and competent person should interpret the results of monitoring and testing. Where necessary, any remedial measures should be carried out promptly and verification obtained that they have been effective.

External audit

43. An external competent person should audit the risk assessment and operation of the control measures periodically (at least every two years) and when there has been a cluster of cases linked to the system.

Record keeping

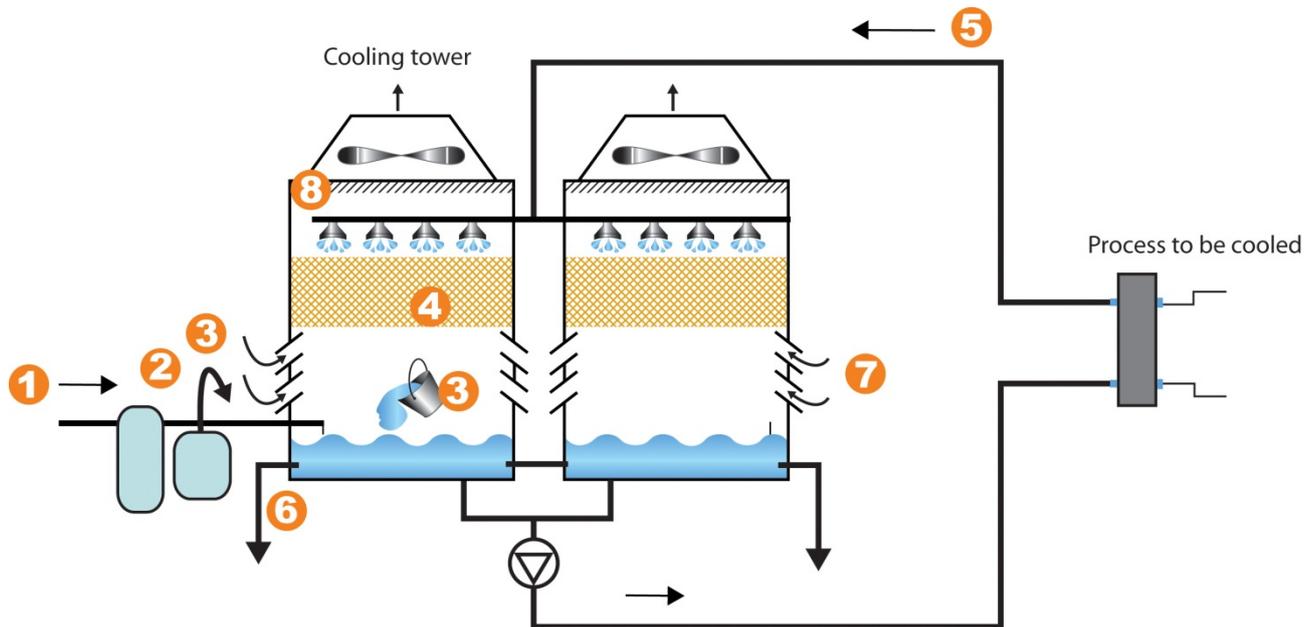
44. The person or persons appointed under paragraph 42 and 46 should ensure that appropriate records are kept, including details of:
- The person or persons responsible for conducting the risk assessment, managing, and implementing the written scheme;
 - The significant findings of the risk assessment;
 - The written scheme required under paragraph 45 and details of its implementation;
 - The results of any monitoring, inspection, test or check carried out, and the dates. These should include details of the state of operation of the system, i.e. in use / not in use;
 - All personnel concerned with the running and maintenance of the system and their training records.
45. Records kept in accordance with paragraph 47 should be retained throughout the period for which they remain current and for at least two years after that period. Records kept in accordance with paragraph 48 should be retained for at least five years.

Responsibilities of manufacturers, suppliers and installers

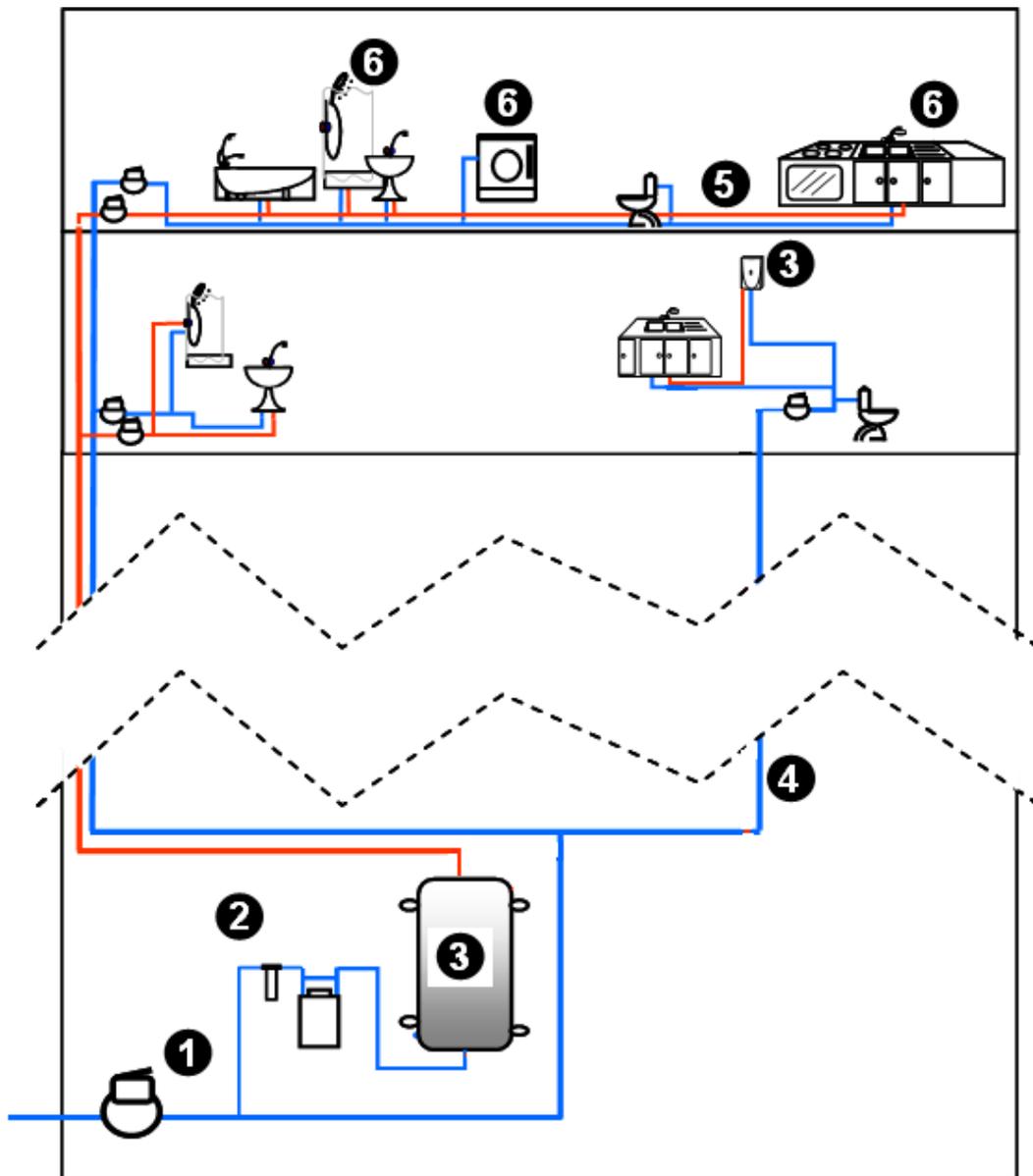
46. Outbreaks of Legionnaires' disease have been associated with faulty installation of equipment used in hotels (Anon 2000). Whoever designs, manufactures, imports or supplies water systems that may create a risk of exposure to *Legionella* should, so far as is reasonably practicable:
- Specify the usage and conditions under which the system has been designed and its intended use;
 - Ensure that the water system is so designed and constructed that it will be safe and without risks to health when used at work;
 - Provide adequate information for the user about the risk and measures necessary to ensure that the water systems will be safe and without risks to health when used at work. This should be updated in the light of any new information about significant risks to health and safety that becomes available.
 -
47. Suppliers of products and services, including consultancy and water treatment services, aimed at preventing or controlling the risk of exposure to legionellae, should, so far as is reasonably practicable:

- Ensure that measures intended to control the risk of exposure to legionellae are so designed and implemented that they will be effective, safe and without risks to health when used at work;
 - Provide adequate information on the correct and safe use of products, taking into account the circumstances and conditions of their use;
 - Ensure that any limitations on their expertise or on the products or services they offer are clearly defined and made known to the person upon whom the statutory duty falls or the person(s) appointed to take managerial responsibility;
 - Ensure that any deficiencies or limitations which they identify in the occupier's systems or in the written scheme to control the risk of exposure to *Legionella* bacteria are made known to the person upon whom the statutory duty falls or the person(s) appointed to take managerial responsibility;
 - Ensure that their staff have the necessary ability, experience, instruction, information, training and resources to carry out their tasks competently and safely.
48. All water systems should be properly installed, and commissioned as appropriate. New systems may contain high nutrient levels derived from the surfaces of some new materials and dirt entering the system while under construction. Consequently they should not be left with water in for prolonged periods before opening, but be filled as late as possible and disinfected and flushed with fresh water within two weeks of opening.

Figure 1: Schematic Example of installation with cooling towers and the key components to review during risk assessments

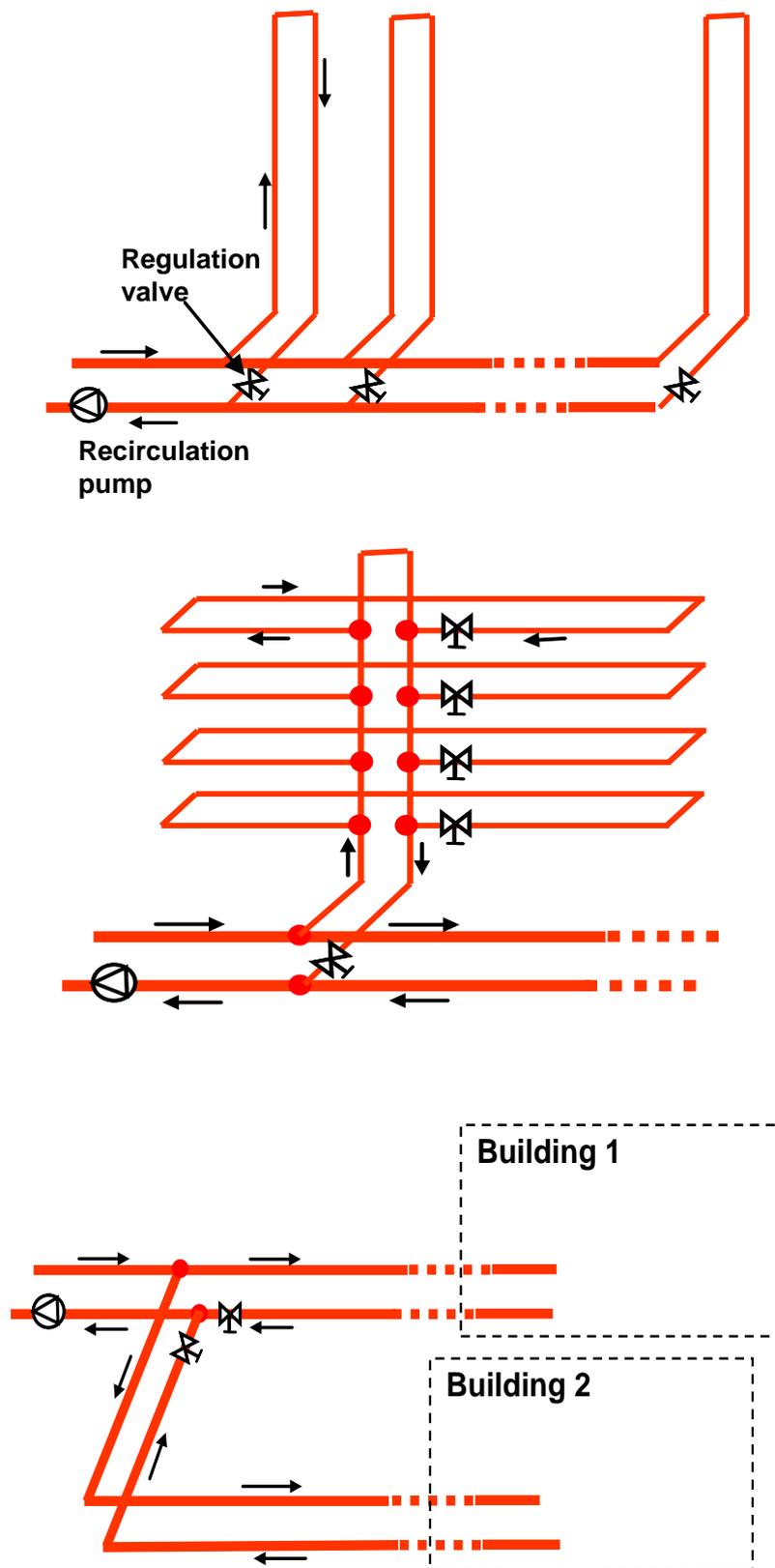


1. Supply water
2. Treatments against scaling and corrosion
3. Treatments against microbial growth (biocides and bio-dispersants)
4. Tower fill or pack
5. Circuit of water cooled by cooling towers (exposed to air within tower)
6. Blow-down / discharge network
7. Air inlet
8. Drift eliminator

Figure 2: Water system with centralised and local water heating**Key components requiring consideration during risk assessments:**

1. Incoming supply water and associated storage tanks
2. Treatment systems (can be collective or individual)
3. Water heater (can be combined serving several outlets or individual serving one outlet)
4. Distribution pipes (mains, including eventual recirculation pipes)
5. Distribution pipes (secondary spurs)
6. Point of use

Figure 3: Examples of hot water recirculation schemes



Appendix 1

Checklist to help with Conducting the Risk Assessment in Accordance with the European Guidelines

Objective: To provide a simplified guide for local public health authorities investigating clusters of travel associated cases of Legionnaires' disease to assist with the completion of the Form A.

Method: The checklist below is a simple working tool devised to help the health officers to conduct the pertinent risk assessment at a determined establishment. The checklist is mainly based on the 14 point programme for reducing the risk (see page 26). The final evaluation and relevant recommendations should be based on the results of the checklist, on other evidence gathered during the inspection of the premises, and in taking the European Guidelines and any relevant local regulations into consideration.

Facility identification data:

Address: _____

Item to check	Yes	No	Comment/Action required
1. Assessment of the ability of hotel personnel to control risk			
Is there a person appointed with responsibility for <i>Legionella</i> control			
Is this person, and other concerned relevant staff, properly trained in the control of <i>Legionella</i> ?			
If an external firm is providing help and advice, are they competent in this task?			

Item to check	Yes	No	Comment/Action required
2. Assessment of the domestic cold and hot water temperatures and biocide levels			
Are the hot water temperatures of the entire hot water system kept all times at 50°C-60°C?			
Are the cold water temperatures of the entire cold water system below 25°C?			
Are there other preventive methods in place (chlorine, chlorine dioxide, copper-silver ions, etc.)?			
Are biocide levels maintained in the entire circuits at adequate levels?			
3. Assessment of other factors that may promote <i>Legionella</i> growth (stagnancy, scale, sediments, corrosion, etc.)			
Are all taps, showers and any other points of water use in the hotel flushed for several minutes on a weekly basis?			
Are shower heads and tap filters cleaned, de-scaled and disinfected on a regular basis?			
Is there pipework with intermittent or no water flow (by-passes, dead legs, blind ends, etc) in any part of the water network?			
Is there any visible or significant sediment, biofilm/slime, dirt, corrosion or scale deposit in any part of the water network?			
4. Assessment of the cleaning and disinfecting practices			
Are the calorifiers cleaned and disinfected on an annual basis and always before the beginning of every season (in seasonal hotels) and after work in them?			
Are cold water tanks cleaned and disinfected on a yearly basis and always before every season (in seasonal hotels)?			
Is the entire water network disinfected before every season (in seasonal hotels)?			

Item to check	Yes	No	Comment/Action required
Are water filters (sand filters, multimedia filters and others) disinfected regularly, at least every three months?			
Are the procedures for cleaning and disinfecting the water systems adequate (e.g. 50 ppm x 1hour)?			
5. Assessment of the surveillance and monitoring practices and associated documents			
Is there a written <i>Legionella</i> preventive programme in place?			
Is this programme suitable and sufficient for the systems 'at risk' present at the hotel?			
Are pertinent records of the critical monitoring activities kept on site (e.g. temperatures, chlorine levels, etc.?)			
Is a Risk Assessment carried out regularly (at least every two years) at the premises?			
Are both the Risk Assessment and operation of the control measures periodically audited by a competent and independent person?			
6. Assessment of particular water systems (spa pools, wet cooling towers) present at the premises¹			
<p>If there is a spa pool (Jacuzzi©) ensure that:</p> <ul style="list-style-type: none"> • Continuous treatment with chlorine or bromine and pH adjustors (2-3 mg/l chlorine or bromine and pH at 7.0-7.6) • Chlorine/ bromine and pH monitored at least three times/day • Half water is replaced each day • Sand filters are back washed daily • The whole system, including the balance tank, is cleaned and disinfected once a week • Daily records are kept of all water treatment readings (Cl, 			

Item to check	Yes	No	Comment/Action required
pH) and ensure they are checked regularly by responsible persons.			
<p>If there is a cooling tower ensure that:</p> <ul style="list-style-type: none"> • An adequate water treatment regime is implemented (with effective biocides, corrosion inhibitors and adequate bleed-off rates as a minimum) • The entire cooling tower and associated pipes are cleaned and disinfected at least twice a year (and always before every season) • The system is inspected monthly for ensuring that drift eliminators are intact and firmly in place • A microbiological monitoring system (and a chemical one if pertinent, e.g. chlorine or bromine treatment) is in place. 			
<p>List of other 'at risk' water systems present at the hotel with indication of their hygienic status:</p> <ul style="list-style-type: none"> • Irrigation systems • Food display cabinets with ultrasonic misting devices • Ornamental fountains (indoor) • Ornamental fountains (outdoors) • Humidifiers (air conditioning) • Others: 			

¹ For certain basic systems, a simple risk assessment may show that the risks are low and that no further action will be necessary. Some other water systems may need more elaborate approaches for a correct assessment, depending of the different circumstances (size, type, location, number and connections, etc.). See the pertinent paragraphs of the Supplement 1 for more detailed information.

Part 2

Methods for the Investigation and Control of an Outbreak of Legionnaires' disease in a Hotel or other Accommodation Site

General – competence

49. The appropriate health authorities, in accordance with national arrangements for communicable disease control should investigate each outbreak. Sampling and microbiological analysis should be carried out by a laboratory that is accredited for the detection of *Legionella* species from environmental samples and capable of the recognition of *Legionella* species and serogroups and which performs satisfactorily in an external quality assurance scheme. It is recommended that samples are taken on a risk assessment basis with the engineer responsible for maintenance and operation of the water systems assisting in determining the appropriate sites to be sampled. The laboratory findings should be interpreted by a microbiologist experienced in the microbiology of water systems and the detection and ecology of *Legionella* species.

Temperature testing

50. Temperature testing of hot and cold water systems is an essential part of risk assessment and should always be undertaken in conjunction with sampling for legionellae. The measurement of temperatures in different parts of a system is also an essential aid to deciding where samples should be taken. It is important not only to determine the temperature of water coming out of outlets or entering a thermostatic mixing valve but also within the flow and return pipes in the different loops of the system (see Figure 3). This can be done by the use of an electronic thermometer with a contact probe placed on the surface of the pipe. For metal pipes the difference in temperature between the water within the pipe and the external surface temperature is small (<1 °C) but for plastic pipes it is larger, depending upon the type and thickness of the plastic. The difference should be checked near an outlet by determining the temperature of the water flowing from the outlet while measuring the pipe surface temperature.

Sampling: safety measures

51. Persons taking the samples should follow the recommendations given in paragraphs 187-190 of these guidelines.

Sampling the hotel's water systems

Aims

52. To establish if the hotel could be a source of infection and to ensure appropriate controls are in place to eliminate or control any risk

Objectives

It is not sufficient to simply collect samples. It is essential to carry out the following actions:-

- Risk assessment of the hotel water systems
 - Distinguish between local and systemic colonisation of the water systems
 - Identification of sites of highest risk
 - Checking the regulation of the temperature, pressure and flows in the plumbing system
 - Selection of the strategy for the immediate short term control of *Legionella*
 - Development of proposals for the long term control strategy for the whole facility.
53. Sample sites should be chosen to be representative of the whole water system. The water storage and piping plans should be consulted prior to selecting the sample points.

Distribution of sites to be sampled:

54. Systemic

- incoming cold water to the facility including any stored water cistern /tank
- hot water leaving the water heater
- circulating hot water returning to the heater

55. Basic

- the outlet nearest to the entry of the hot water into the facility
- the most distal sites within the hot and cold distribution systems
- the hotel room(s) where the infected guest(s) was accommodated
- the samples points in the leisure complex/ swimming/spa pool area

56. Supplementary

- guest rooms on different floors to be representative of the different loops of the distribution systems;
- temperature monitoring is an important factor in the risk assessment process to determine appropriate sampling points. For example, samples taken from the warmest point in a cold water system, or the coolest part of a hot water system, are likely to pose the greatest risk of legionellae growth, and survival of legionellae.
- areas where there has been stagnation; for example a closed floor of rooms

How to sample

57. Collect one litre samples in sterile containers containing sufficient sodium thiosulphate pentahydrate to neutralise any chlorine or other oxidising biocide (18mg in 1 litre will neutralise up to 5 mg/l chlorine). Measure the temperatures using a calibrated thermometer, placed in the middle of the water stream after the sample has been collected.

Systemic points

58. If possible, samples are collected from the water softener if fitted, in the boiler room from the discharge valves of the hot water flowing from the heater to the building, return water and cold water feed to the heater. If hot water storage heaters/ buffer vessels are installed, samples from the sludge drain valves should also be collected. If there are no suitably representative sample points of the water in the heater, i.e. the water flowing from the heater and the flow returning to the heater, this fact should be recorded. If expansion vessels are incorporated these should be sampled if possible.

Basic and supplementary points

Hot water

59. Collect the water discharging from the tap immediately after it is switched on. This "immediate" sample will be representative of the colonisation of the outlet and most representative of the risk to the user. Continue to run the tap until 60 seconds has passed and then measure the temperature.
60. If you wish to determine if the water feeding the outlet from the main cold water feed or circulating hot water system is colonised it is necessary to collect a sample from a tap after it has been flushed and disinfected. Run the tap for one minute, clean and disinfect the outside and inside of the tap spout with a 1% solution of sodium hypochlorite or 70% ethanol, leave it for at least one minute and then flush the outlet to remove residual disinfectant. Without adjusting the flow, collect the "post flush water sample" which represents the water feeding the outlet.
61. Swabs - sample the inner walls of showerheads and their handles with a sterile cotton swab using a rotating motion. Sample shower hoses at the point where it is attached to the fitting. Swabs should be transported in 0.5-1.0ml of the same residual water, sterile water or sterile Pages Saline.
62. ***Sieves on mixer valves - remove the sieves and swab and culture any deposit within them.***

Cold water

63. Collect an immediate sample as for the hot water, then leave the water running until it has flowed for two minutes in total and then measure the temperature of the flowing water. Finally, a post-flush sample may be collected if required in the manner described above. When the water temperature in the system is $\leq 20^{\circ}\text{C}$, the number of samples can be reduced.

Water closet cisterns

64. These should not be overlooked as potential sources of infection as they can become heavily colonised if the ambient temperature is high and the cold water feed is not directly off the town mains supply or the water closet is used infrequently e.g. disabled toilets often have restricted use. Collect water samples directly from the cistern using a clean sterile container. Swabs from the cistern at the waterline are also useful

Cooling towers

65. If suitable sample points are available collect a sample from the water returning to the cooling tower in addition to a sample from the cooling tower pond, as far away from the fresh water inlet as possible. Collect samples of 200ml to 1000ml. If the tower is implicated in an outbreak samples of sediment are also useful.

Spa pools

66. Collect water samples of one litre from the pool and, where fitted, the balance tank. In some investigations water from the pool has yielded few legionellae at the time of sampling although filter material and biofilm from inside the pipes contained large quantities of legionellae. This probably reflected the type and positioning of the biocide treatment and zones within the piping where the biocidal effect did not penetrate adequately. Therefore, it is also important to inspect the air and water circulation pipes and hoses for the presence of biofilm containing legionella. Biofilm samples should be collected with swabs from the inside of some sections of these pipes. It is sometimes possible to do this by removing a jet but quite often sections of pipe will have to be cut out to gain adequate access.

Air washers and humidifiers.

67. Collect samples of at least 200ml directly from the source.

Decorative fountains, water features and irrigation systems

68. Collect samples of at least one litre, if possible from the warmest part of the system.

Sample transport and laboratory processing

69. Samples must be kept at ambient temperature and protected from direct light. Water and swabs should be processed on the day of collection or within 24 hours of collection when stored at a refrigerator temperature (ISO 11731). Do not freeze samples.
70. During the sampling, all details that may help the implementation of possible remedial measures should be recorded. For example, obvious pressure and temperature drops or rises in the water circuits, the presence of iron sediment or sludge, the condition of aerator and taps, the occurrence of scale, and the presence of various rubber and plastic attachments. The presence of biocide

(time and date dosed) and type of biocide and other control factors dependent on the system e.g. pH levels, appearance of the water etc should be recorded.

71. Warning: it is important to follow the sampling procedure. Incorrectly collected samples make interpretation of the results difficult.

Use of PCR for detecting legionellae in water samples

72. In these guidelines the referred standard method for enumeration of *Legionella* in environmental samples is a culture technique which is performed in accordance with the ISO standard 11731 . *Legionella* can however be detected by other methods. One of the newer and now widely used techniques to detect and enumerate *Legionella* is polymerase chain reaction (PCR). It is possible to render the PCR technique quantitative by incorporation of standards with known amount of bacteria (genomes), and quantitative real-time variants of PCR (qPCR) are often used today. Several commercial kits are available, and several laboratories offer this analysis. Although qPCR can be useful in investigating potential sources of infection and in monitoring remedial actions, there is still no consensus on how and when qPCR should be used, and how the results should be interpreted. The results for qPCR are expressed as genome units (GU) per ml or litre, but it is clear from several studies that these qPCR results often have a very poor correlation with the results of culture (cfu/litre) and often are several times higher than the culture results. This is in part due to the fact that PCR also can detect viable but non-culturable and dead bacteria. The discrepant results are especially pronounced for *Legionella non-pneumophila*. The action levels given in Supplement 1 refer only to culture, and cannot be adapted for qPCR results. Studies are ongoing to establish the most appropriate interpretation of qPCR results.

Emergency action

73. Emergency control measures must be carried out as soon as possible after the outbreak has been recognised but not before samples have been collected. Non-essential equipment such as spa pools and cooling towers associated with air conditioning systems can be rendered safe by switching them off until samples can be collected and remedial measures implemented. A risk assessment should be carried out and emergency control measures implemented. The exact choice of measures will depend on the risk assessment and any available epidemiological evidence. The measures will usually involve disinfection of potential sources by high levels of chlorine or another oxidising biocide compatible with the current biocide regime, cleaning of tanks and water heaters and raising the circulating hot water temperature if this is below 60°C. The potential control measures are discussed more fully elsewhere in this document (see Supplements 1 and 2).

Long term remedial measures

74. The selection of the long-term remedial measures must be based on a thorough up to date review of the risk assessment combined with any monitoring and epidemiological information available. Effective long-term control depends on the rigorous adherence to the control measures. The

measures will probably be a combination of those described elsewhere in this document. They are likely to require engineering modifications to the existing water systems as well as improvements in monitoring controls, management and staff training.

75. **NOTE: Control measures in premises such as hotels that have been colonised with *L. pneumophila* and have caused outbreaks must be continued indefinitely. There are many examples of further cases resulting from the deliberate or accidental discontinuation or relaxation of control measures.**

Supplement 1

Technical Guidelines for the Control and Prevention of *Legionella* in Water Systems

Supplement 1 provides the technical background to the control measures commonly applied to hot and cold water systems and cooling systems, including features of the design and construction, management of the systems during commissioning and re-commissioning and normal operation. Supplement 1 is mainly based on technical recommendations contained in the UK Health and Safety Executive Legionella Guidelines published in December 2000 (HSE 2000). It should therefore be regarded as one example of good practice, and may not be entirely consistent with guidance produced in some other European countries because of legal requirements or constraints within individual countries. Although it is a supplement to the main EWGLI Guidelines, it is nevertheless a useful model to follow.

Hot and cold water systems

76. There are a variety of systems available to supply hot and cold water services:

Pressurised system

77. In cold water systems, the term pressurised system refers to systems in which the water is distributed by means of a pressure pump. There is not normally any tank.
78. The rising main is connected directly to the water heater. A double non-return valve on the cold feed to the water heater provides back-flow protection. There may also be a pressure reducing valve or, in large buildings, a pump and pressure vessel. Since the water in the system will expand with temperature, an expansion vessel and a safety temperature and pressure relief valve are required. Hot water distribution from pressurised systems can be used in both recirculation systems, which are normally fitted in large buildings, and non-recirculation systems, which are normally found in dwellings and some small buildings. In re-circulating systems there is a continuous circulation of hot water from the water heater around the distribution circuit and back to the heater. The purpose of this is to ensure that hot water is quickly available at any of the taps, independent of their distance from the storage water heater (see Figure 3).

Gravity system

79. Cold water enters the building from a rising main and is stored in an intermediate cold water tank located in the building from where it is distributed to the outlets by means of gravity. The cold water storage tank provides back-flow protection to the mains supply and a stable pressure in the system. Cold water from this storage tank is fed to the water heater where it is heated. The hot water system can be re-circulating or non-re-circulating.
80. Hot water systems present the greatest risk in environments that allow the proliferation of *Legionella*. For example:
- At the base of storage water heaters where the incoming cold water merges with the existing hot water;
 - Water held in pipes between a re-circulating hot water supply and an outlet (e.g. tap or shower) particularly when not in use as they may not be exposed to biocides and high temperatures.
81. Cold water systems may occasionally be contaminated with *Legionella* (usually in small numbers) which enter cold water storage systems from the main supply. This presents little risk under normal circumstances. *Legionella* will only grow in cold water systems and the distribution pipe-work when there are increased temperatures (e.g. due to heat gain), appropriate nutrients and stagnation.
82. Some of the features of gravity hot water systems, which are common in the British Isles, increase the risk of exposure to *Legionella*, such as having open header / feeder tanks and relatively large storage volumes can be eliminated by moving to mains pressure systems. Other problems, such as the maintenance of water temperatures throughout the distribution system and changes in demand, can be simplified by changing to point of use water heaters with minimal or no storage.

Design and construction

83. Hot and cold water storage systems in commercial buildings are often over sized relative to the actual usage, because of uncertainties in occupation at the design stage. This can lead to poor water movement and turnover and consequently an increased risk of *Legionella* growth. If the design needs to allow for future growth in hot or cold water demand then this should be organised by designing the system to be expanded in a modular fashion. This enables additional plant to be added at a later stage if required.
84. Hot and cold water systems should comply with the national regulations and be designed to aid safe operation by preventing or controlling conditions which permit the growth of *Legionella* and which allow easy cleaning and disinfection. In particular, the following should be considered:
- Materials such as natural rubber, hemp, linseed oil based jointing compounds and fibre washers should not be used in domestic water

- systems. Materials and fittings for use in water systems should have been shown not to support microbial growth;
- Cold water storage tanks should be fitted with covers which comply with the national water regulations and insect screens fitted to any pipework open to the atmosphere, e.g. the overflow pipe and vent. They should be insulated and sited to avoid heat gain from the surrounding environment;
 - Multiple linked cold water storage tanks should be avoided because of operational difficulties due to possible unequal flow rates and possible stagnation. Where they are present there should be cross-flow across the tanks to avoid areas of stagnation;
 - Accumulator / expansion vessels on pressure boosted hot and cold water services should be fitted with diaphragms which are accessible for draining and cleaning;
 - Point of use hot water generators, with minimal or no storage for remote low use outlets should be considered;
 - Thermostatic mixing valves (TMV) if any are fitted 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 distance to the outlet should be kept as short as possible, ideally less than two metres. Where a single TMV serves multiple outlets / showerheads, it is important to ensure that these are flushed frequently.

Hot water systems

85. The storage capacity and recovery rate of the water heater should be selected to meet the normal daily fluctuations in hot water use without any drop in the supply temperature. Where fitted, the vent pipe from the storage water heater, which allows for the increase in volume of the water should be of sufficient size and not discharge into a cold water tank but be directed to drain.
86. Where more than one storage water-heater is used, they should be connected in parallel. If temperature is used as a means of control, each storage water-heater should deliver water at a temperature of at least 60°C. All storage water-heaters should have a drain valve located in an accessible position at the lowest point of the vessel so that accumulated sludge can be drained easily and the vessel emptied in a reasonable time. A separate drain should be provided for the hot water system vent (particularly if the feed to the storage water heater incorporates a non-return valve).
87. It should be possible to balance the flow of water throughout the hot water circuit by adjusting regulating valves to ensure that the target temperature and adequate water pressure is achieved throughout the system under all levels of water consumption.
88. NOTE: The flow of water expected within the pipes must be within the design specification of the regulating valve to ensure that sufficiently sensitive control of the flow can be obtained. i.e. the flow that the design engineers intend to achieve within the pipework must be above the minimum which the valve is designed to work with.
89. If temperature is used as the means of controlling legionellae the hot water circulating loop should ideally be designed to give a return temperature to the

storage water heater of 55°C but certainly not less than 50°C. The pipe branches to the individual hot taps should also be of sufficient size to enable the water in each of the hot taps to reach 55°C, but certainly not less than 50°C, within one minute of turning on the tap. There should be adequate international signage warning of the risk of scalding. Where there are several return loops in a hot water system, on each floor of a building or several risers (see Figure 3), it is important to be able to measure the temperature of each return and not just the combined return to the heater. In addition to those required for control, thermometer/immersion pockets should be fitted on the flow and return to the storage water heater and in the base of the storage water heater.

90. In larger storage water heaters, the fitting of time controlled shunt pumps should be considered to overcome temperature stratification of stored water. These should not operate continuously but during periods of low draw off for a short period (typically 1-2 hours) and fitted so that they take hot water from the top of the vessel to the base.
91. Hot water distribution pipes should be sufficiently insulated so as not to affect cold water pipes, and where running alongside each other, cold pipes should be below the hot and the air gap between them sufficient to allow for insulation around both, in order to prevent heat radiation and conduction between them.

Thermostatic Mixer Valves (TMVs)

92. Downstream of TMVs it is not usually possible to retain control by means of heat and it is difficult to achieve control with biocides added to the hot and cold water. Some designs of TMVs include an over-ride mechanism enabling the downstream portions to be flushed with hot water. Where this is not possible colonisation will have to be limited through regular cleaning, descaling and disinfection of the TMV and its associated downstream attachments, such as the shower head and any associated hose.

Cold water systems

93. Access hatches should be provided on cold water tanks for inlet valve maintenance, inspection and cleaning (more than one hatch may be needed on large tanks).
94. The volume of cold water stored should be minimised and should not normally be greater than one day's water use. Multiple cold water storage tanks require care in the connecting piping to ensure that the water flows through each of the tanks, so avoiding stagnation in any one tank.
95. The cold water storage tank should be sited in a cool place and protected from extremes of temperature by thermal insulation. Piping should be insulated and kept away from hot ducting and other hot piping to prevent excessive temperature rises in the cold water supply; typically not more than a 2°C increase should be allowed. The pipe work should be easy to inspect so that the thermal insulation can be checked to see that it is in position and has remained undisturbed.

96. Screening should be provided to prevent the ingress of insects; birds and small animals.

Leak testing

97. New pipe-work has traditionally been filled with water to detect leaks. In large buildings such as hotels and hospitals this is often done many months before the building is occupied. Newly constructed systems may also contain nutrients for microbial growth from the surfaces of new components, fluxes or other compounds used in jointing, or from dirt entering during construction etc. This can lead to the system becoming heavily colonised with microorganisms including legionellae before the building is occupied, resulting in a risk to the new occupants. Leak testing can also be done by pressurising the system with air. This avoids the risk of leaving the system filled with water for prolonged periods before occupation and is the preferred option in healthcare premises.
98. If leak testing is done by filling with water, precautions need to be taken to limit colonisation by dosing the system with biocide for example while it remains unused and by ensuring some water flow in the system. Whatever precautions are taken following leak testing, within two weeks of the occupation of the building the water systems should be disinfected and flushed with fresh water in order to remove microbial growth and the build-up of nutrients.

Management of hot and cold water systems using the temperature control regime

Commissioning and re-commissioning

99. Following the commissioning of a new hot water system, the water temperature should be measured continuously over a typical day both at the bottom and at the outlet of the storage water heater. If the storage vessel is of sufficient capacity to deal with the demand, then the outlet temperature should not fall below 50°C for more than 20 minutes in a day. If the storage water heater is undersized then the outlet temperature will fall during use and remedial action may be required, particularly if temperature is used as a control method. If the system changes from the original specification, this procedure will need to be repeated.
100. Standby storage water heaters should be emptied of water and there should be specified procedures in place to be followed before they are brought back into use. If a storage water heater or any substantial part of a hot water system is on standby or has been taken out of service for longer than one week, then the water in the storage water-heater should be isolated from the system and brought up to at least 60°C for one hour before the isolation valves are opened to connect the heater to the system. If there are standby re-circulating pumps on the hot water circuits, then they should be used at least once per week. If the system is to be treated with biocides as a means of controlling *Legionella*, the biocide concentration in the system should be

monitored and reach normal operational levels throughout the system before being used.

Operation

Cold water

101. Cold water from the water utility is usually delivered to consumer buildings with a trace of active chlorine disinfectant and in a potable state to the customer but users should not rely on this to treat the hot water system. Where water comes from rivers, lakes, bore holes or other sources, it needs to be pre-treated so that it is of equivalent quality to the mains supply. Where the water is of high turbidity or has particulates this may require filtration prior to treatment.
102. The Council Directive 98/83/EC on 'The Quality Of Water Intended For Human Consumption' makes no specific recommendation about the temperature of the water supplied to premises. In practice the water temperature in winter is likely to be below 20°C in most parts of Europe. However, during summer, the incoming water temperature at some sites can become warm. If the incoming water is above 25°C, the water undertaker should be advised to see if the cause of the high temperature can be found and removed. If this is not possible, the risk assessment should reflect this increased risk and appropriate action taken if necessary.

Water softening

103. In hard water areas the water supply to the hot water system should be softened to reduce scale formation. Water softeners can occasionally become colonised with microorganisms including legionellae. For this reason it is advisable to have a sample point installed just downstream of the softener to enable water samples to be collected at least once a year and to be tested for the aerobic colony count and legionellae. The aerobic colony count should be compared with that of the incoming mains supply water. If there is evidence of colonisation as indicated by a rise in count relative to the incoming supply or the presence of legionellae, then the softener and its resin bed will need to be disinfected according to manufacturers' guidelines. If there is no colonisation there is no need to disinfect the softener as this may shorten the life of the resin bed.

Hot water

104. Hot water may be heated with or without storage in a number of ways.
105. In **storage water heaters** the water can be heated by hot water or steam from a boiler which is passed through a coiled heat exchanger sited inside the hot water storage vessel (indirect heating) The storage water heater can also be heated by means of an electric immersion heater within the vessel. Finally, some storage water heaters can be heated directly by gas or oil flame; these water heaters have been shown to have the lowest incidence of colonisation by *Legionella*.

106. In a storage water heater, cold water enters at the base of the vessel with hot water being drawn off from the top for distribution. A control thermostat to regulate the supply of heat to the storage water heater should be fitted near the top of the vessel and adjusted so that the outlet water temperature is constant. The water temperature at the base of the storage water heater (i.e. under the heating coil) will usually be much cooler than the water temperature at the top and potentially create a zone of water temperature conducive to the growth of legionellae. One method of preventing growth is to ensure that the whole water content of the storage water heater, including that at the base, is heated to a temperature of at least 60°C for at least one hour each day. A shunt pump to move hot water from the top of the storage water heater to the base is one way of achieving this. Ideally the storage water heater will have specific connections for the shunt pump return, as low down on the storage water heater as possible. The period of operation of this shunt pump needs to coincide with the operation of the heat source and a period of low demand, for example during the early hours of the morning. In all cases the operation of the pump should be controlled by a time clock.
107. Where more than one storage water heater is installed to supply one hot water system they may be connected in parallel or in series (see diagrams). If they are connected in series they should be designed and operated so that all of the water in all of the storage vessels is heated to at least 60°C for at least one hour each day and that there is sufficient storage capacity to ensure that the feed temperature to the system never drops below 60°C.
108. Hot water may also be heated by “instantaneous” water heaters such as Angeleri type heaters in which steam is used to directly heat the circulating water in a coil. Such systems and storage water heaters are increasingly being superseded by plate heat exchangers in which steam or hot water from a boiler passes on one side of thin metal plates and the water to be heated passes on the other. Plate heat exchangers are very efficient and may be used in conjunction with a hot water storage vessel, sometimes called a buffer vessel. The system should be operated to ensure that the circulating hot water remains at 60°C throughout the day and the whole volume of water within the storage vessel reaches at least 60°C for at least one hour each day.
109. In some instances water may be heated at the point of use by an instantaneous heater. Such systems are generally considered to be of low risk of growing legionellae provided the cold feed is cold enough to prevent growth.

Solar Heating

110. Solar energy is increasingly being utilised to heat domestic hot water. The principles of *Legionella* control must still be applied to these systems. The water may be heated directly by passage through the solar collector or via a heat exchanger. Systems should still be designed so that water is delivered to the hot water system at 60°C. This may require supplementary heating particularly during the cooler months. Solar heated systems are still relatively novel, particularly in the more temperate parts of Europe and systems may need testing for legionellae to confirm that control is being achieved.

Maintenance

111. Some form of scale control is desirable in hard water areas. This is because there is a risk of calcium being deposited at the base of the storage water heater at temperatures greater than 60°C. Control is normally achieved by softening the cold water feed (see Paragraph 56 above). An inspection port or hatch should be fitted in the side of the storage water heater so that the cleanliness of the base can be checked regularly and cleaned when needed.
112. Whenever hot taps are no longer required for use they should be removed and the pipe cut back to the re-circulating loop. Where standby units are provided, there should be procedures in place to enable incorporation of these units into routine use. Standby pumps should be changed over and used each week to avoid water stagnation. If storage water heaters are put on standby because they are not needed they should be isolated and emptied of water and there should be specified procedures in place to be followed before they are brought back into use.
113. Maintaining the cleanliness of water softeners and filters is important and best achieved by following the manufacturers' recommendations. Coarse filters and strainers should be checked and cleaned regularly to prevent the build-up of organic contaminants.

Regular flushing of showers and taps

114. Before the following procedures are carried out, consideration should be given to the removal of infrequently used showers and taps. If they are removed then the redundant supply pipe work should be cut back, as far as possible, to a common supply, for example to the re-circulating pipe work or the pipe work supplying a more frequently used upstream fitting.
115. The risk from *Legionella* growing in peripheral parts of the domestic water system such as dead-legs off the re-circulating hot water system may be minimised by regular use of these outlets. When outlets are not in regular use, weekly flushing of these devices for several minutes can significantly reduce the number of *Legionella* discharged from the outlet.
116. Where it is difficult to carry out weekly flushing, the stagnant and potentially contaminated water from within the showerhead and hose/tap and associated dead-leg 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.

Treatment and control programmes

117. It is essential that system cleanliness is achieved and maintained because the efficacy of the control method (both temperature and biocide activity) may be reduced substantially in systems that are fouled with organic matter such as slimes, or inorganic matter such as scale.

118. Different treatment methods are detailed in Supplement 2.

Monitoring the temperature regime

119. It is recommended that hot water should be stored at 60°C and distributed such that a temperature of at least 50°C and preferably 55°C is achieved within one minute at 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 persons but the risk increases rapidly with higher temperatures and for longer exposure times. The difference between the highest and lowest temperatures recorded at the taps after one minute should not be greater than 10°C. A wider difference may indicate inadequate flow, a poorly balanced system and a lack of insulation or backflow of cold water into the hot system.
120. Mixer taps and thermostatic mixer valves usually contain non-return valves within their hot and cold feeds in order to prevent backflow of hot water into the cold water or vice versa. Failure of the non-return valves can be detected by monitoring the temperatures of the cold water and the hot water supplies. If such a fault is found it can be overcome by installing extra non-return valves in the cold and hot water feeds.
121. In addition to the routine monitoring and inspection when using temperature as a control regime, the following checks should also be carried out and appropriate remedial action taken if necessary (Table 1).

Table 1: Monitoring the temperature control regime

Fre- quency	Check	Standard to meet		Notes
		Cold water	Hot water	
Monthly	Sentinel taps (see glossary)	The water temperature should be below 20°C or less after running the water 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 that the supply and return temperatures on each loop are unchanged i.e. the loop is functioning as required
	If fitted, input to thermostatic mixer valves (TMV) on a sentinel basis		The hot water supply to the TMV temperature 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 the water heater		Outgoing water should be at least 60°C, return at least 50°C	If fitted, the thermometer pocket at the top of the hot water storage heater 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. In complex systems the temperatures of individual returns and not just the combined returns should be monitored
Six monthly	Incoming cold water inlet (at least once in the winter and once in summer)	The water 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
	If fitted, cold input to thermostatic mixer valves (TMV)			
Six monthly	Representative number of taps on a rotational basis	The water temperature should be 20°C or less after running the water for two minutes	The water temperature should be at least 50°C within one minute of running the water. The difference between the highest and lowest temp recorded at the taps after one minute should not be greater than 10 °C	This check makes sure that the whole system is working properly

Biocide treatments

122. Where biocides are used to treat water systems they, like the temperature regime, will require meticulous control if they are to be equally effective. It is recommended that the control system be checked at least weekly to ensure that it is operating correctly and continuing to control *Legionella*. Biocides commonly used to control legionellae in hot and cold water systems include chlorine, chlorine dioxide, and copper silver ionisation.

Monitoring oxidising biocides (chlorine, chlorine dioxide)

123. For most systems routine inspection and maintenance will usually be sufficient to ensure control (see paragraph 58), if the following areas are checked at regular intervals and appropriate remedial action taken when necessary, with details of all actions being recorded. These include:
- The quantity of chemicals in the reservoir;
 - The rate of addition of the agent to the water supply;
 - On a monthly basis, the concentration of the agent should be measured at the sentinel taps;
 - On an annual basis, the concentration of the agent should be measured at a representative number of outlets.
124. If the levels are less than expected then appropriate investigations should be carried out to determine any remedial work needed and the frequency of monitoring increased until control is re-established to the predetermined levels.

Monitoring ionisation

125. For most systems routine inspection and maintenance will usually be sufficient to ensure control if the following parameters are also monitored at regular intervals and appropriate remedial action taken when necessary, with details of all actions being recorded. These include:
- The rate of release of ions into the water supply;
 - The silver ion concentrations at a small number of sentinel outlets should be checked at least quarterly;
 - The measurement of silver ion concentrations at representative taps selected on a rotational basis once each year;
 - The condition and cleanliness of the electrodes when fitted should be checked at least monthly unless an anti-scaling type of electrode cell is employed;
 - The measurement of the pH of the water supply, along with the other analyses.
126. Unless automatic controls are employed, fluctuations in concentrations of treatment may occur and therefore it is advisable to regularly check the concentrations of both silver and copper ions.

General monitoring

127. All water services should be routinely checked for temperature, water demand and inspected for cleanliness and use. Ideally, the key control parameters should be monitored by a building management system, if one is present. This will allow early detection of problems in maintaining the control regime.
128. The frequency of inspection and maintenance will depend on the system and the risks it presents. All the inspections and measurements should be recorded and should include:
- The name of the person undertaking the survey, their signature or other identifying code, and the date on which it was made. Computer records are acceptable;
 - A simple description and plan of the system, and its location within and around the building. This should identify piping routes, storage and header tanks, hot water storage heaters and relevant items of plant, especially water softeners, filters, strainers, pumps and all water outlets.
 - Records of any untoward incidents e.g. pump failure, monitoring results out of range etc and any remedial actions taken

Annual check

129. This should include:
- Visual inspection of the cold water storage tank in order to check the condition of the inside of the tank and the water within it. The lid should be in good condition and fit closely. The insect screen on the water overflow pipe should be intact and in good condition. The thermal insulation on the cold water storage tank should be in good condition so that it protects it from extremes of temperature. The water surface should be clean and shiny and the water should not contain any debris or contamination. The cold water storage tank and ball valves etc should be cleaned, disinfected and faults rectified, if considered necessary. If debris or traces of insects and / or vermin are found then the inspection should be carried out more frequently
 - Making a record of the total cold water consumption over a typical day to establish that there is reasonable flow through the tank and that water stagnation is not occurring. Whenever the outlet/ building-use pattern changes, this measurement should be repeated
 - Draining the hot water storage heater and checking for debris in the base of the vessel. The hot water storage heater should then be cleaned if considered necessary
 - Checking the plans for both the hot and cold water circuits to make sure they are correct and up to date
 - - this should be done by physical examination of the circuits, if possible. Plans should be updated if necessary
 - Ensuring that the operation and maintenance schedules of the hot and cold water systems are readily available and up to date with named and dated actions throughout the previous year
 - Checking the existence of all water connections to outside services, kitchens, fire hydrants and chemical wash-units should be noted. Any

insulation should be checked to ensure that it remains intact. Any water outlets that are no longer used should be removed

- Reviewing the lines of responsibility and competence of staff

Microbiological monitoring

130. The water used to supply hot and cold water systems should be of potable quality. There is not normally any requirement to test for the aerobic colony count although this may be useful as part of the checks following cleaning and disinfection of tanks or other parts of a system.

Monitoring for Legionella

131. It is recommended that this should be carried out:
- In hot water systems treated with biocides where storage and distribution temperatures are reduced from those recommended in the section on the use of temperature to control *Legionella*. This should be carried out on a monthly basis initially for 12 months and if satisfactory results are obtained, quarterly thereafter
 - In systems where control levels of the treatment regime (e.g. temperature, biocide levels) are not being consistently achieved. In addition to carrying out a thorough review of the system and treatment regime, frequent samples e.g. weekly, should be taken until the system is shown to be under control
 - When an outbreak is suspected or has been identified.
132. Samples should be taken as follows:
- Cold water system - from the cold water storage tank, the furthest outlet from the tank and the warmest part of the system
 - Hot water system - from the hot water storage heater outlet or the nearest tap to the hot water storage heater outlet plus the return supply to the hot water storage heater or nearest tap to that return supply. Samples should also be taken from any cool parts of the system identified by temperature monitoring and the base of the hot water storage heater where drain valves have been fitted. The furthest outlet from the hot water storage heater should also be sampled.
133. The complexity of the system will need to be taken into account in determining the appropriate number of samples to take, for example, if there is more than one ring main present in the building, taps on each ring (as described above) will need to be sampled. In order to be representative of the system as a whole, samples should be of circulated treated water and not be taken from temporarily stored water e.g. at TMV controlled taps and showers. These may require sampling but this should be determined by risk assessment e.g. where such fittings are used in areas where susceptible individuals may be exposed (see paragraph 56) for advice on flushing of such fittings).
134. Analysis of water samples for *Legionella* should be carried by an accredited laboratory, which takes part in an external quality assessment scheme for the isolation of *Legionella* from water. The interpretation of any results should be carried out by experienced microbiologists.

135. Table 2 (below) gives guidance on the actions to be taken in the event of finding *Legionella* in the water system.

Table 2: Action levels following *Legionella* sampling in hot and cold water systems

<i>Legionella</i> bacteria (cfu/litre)	Action required
More than 1,000 but up to 10,000	<p>Either:</p> <p>(i) If a small proportion of samples (10–20%) are positive, the system should be re-sampled. If a similar count is found again, then a review of the control measures and risk assessment should be carried out to identify any remedial actions;</p> <p>(ii) If the majority of samples are positive, the system may be colonised, albeit at a low level, with <i>Legionella</i>. Disinfection of the system should be considered but an immediate review of control measures and a risk assessment should be carried out to identify any other remedial action required.</p>
More than 10,000	<p>The system should be re-sampled and an immediate review of the control measures and risk assessment carried out to identify any remedial actions, including possible disinfection of the system.</p>

Cleaning and disinfection

136. Hot water services and exceptionally, cold water services, should be cleaned and disinfected in the following situations:
- If routine inspection shows it to be necessary;
 - If the system has been out of use for more than one month e.g. a hotel during the low season;
 - If the system or part of it has been substantially altered or entered for maintenance purposes in a manner which may lead to contamination;
 - During or following an outbreak or suspected outbreak of Legionnaires' disease.
137. Disinfection can be carried out by the use of chemical or thermal disinfection as described in Supplement 2. It is preferable to use chemical disinfection. It is essential that the system is clean prior to disinfection and that all parts of the system are treated, not just those that are readily accessible.

Cooling systems

138. There are a range of evaporative cooling systems available that vary considerably in size and type. These systems are designed to dissipate heat, using water as a heat exchange medium, from industrial processes and air conditioning.

Cooling towers

139. There are two main types of evaporative cooling towers: mechanical draught and natural draught. Mechanical draught towers use fans to move the air through the tower. The air can be either pushed (forced draft) or sucked (induced draft) through the tower. The forced draught tower, with the fan located in the side pushes the air through the tower and out at the top. Conversely the induced draught tower, with the fan located at the top, pulls air through the tower and out at the top. In natural draught towers the warm return water heats the internal air causing it to rise. Cooler air is drawn in at the tower base and passes through the falling water droplets causing evaporation.
140. Heat removal and dissipation is achieved primarily by the evaporation of a portion of the recirculating cooling water. To optimise the cooling process there needs to be a large area of contact between the water and the air stream flowing through the cooling tower. This is achieved either by distributing the water over a system of splash bars or filming the water over a large surface area of packing.
141. Different types of cooling towers and equipment are used because of the very wide range of cooling process applications. Open recirculating cooling systems are widely used in industry. Natural draught hyperbolic towers are commonly used in the power generation industry. Chemical, petro-chemical and steel industries may also use such towers but more often induced draught towers are used. Smaller industrial plants use forced or induced draught cooling towers. The cooling tower used will depend on the nature of the system's duty.

Evaporative condensers

142. Evaporative condensers are sometimes used for air-conditioning or industrial cooling applications. The evaporative condenser combines the function of both the cooling tower and the conventional condenser, as water is sprayed directly over the cooling coils. The volume of water in the evaporative condenser is usually less than in a cooling system. However, cases of Legionnaires' disease have been attributed to evaporative condensers and they should therefore be regarded as presenting a similar risk and requiring similar precautions.
143. In some circumstances it may be possible to use alternative methods of cooling. Dry cooling, for example using air blast coolers or air-cooled condensers, will avoid the risks presented by a wet cooling tower or evaporative condenser. Adiabatic cooling systems are increasingly used but if used intermittently, they may pose problems associated with poor source

water quality and / or water stagnation which may result in microbiological proliferation. In practice, each case should be considered on its individual merits.

Air conditioning systems

144. Air conditioning is a process of treating air to control its temperature, humidity and cleanliness and distributing this air to meet the needs of the conditioned space. Since temperature and relative humidity are interdependent, control is typically established by passing the air over chilled or heated coils and this may include humidification. The air is cleaned by filtration, and heat from the refrigeration cycle is removed by the condenser which is often cooled by water from a cooling tower. The cooling water is heated to around 30°C and with the potential for scale formation, corrosion and fouling this may provide an environment for the proliferation of legionellae.

Design and construction

145. Cooling systems should be designed and constructed so as to control the release of drift, to aid safe operation, cleaning and disinfection.

Management of cooling towers

146. The cooling system may consist of a cooling tower, evaporative condenser or other cooling element, the re-circulating pipe-work, the heat exchanger, pumps and ancillary items such as supply tanks and pre-treatment equipment. All of these items should be subject to the management and control system.

Commissioning

147. Systems should be properly commissioned to ensure that they operate correctly within the design parameters. It is essential that the commissioning process is carried out in a logical and defined manner. The responsibilities of the staff carrying out the commissioning process should be clearly defined with adequate time and resources allocated to allow the integrated parts of the installation to be commissioned correctly. The same precautions taken to prevent or control risk of exposure to *Legionella* during normal operation of cooling systems also apply to the commissioning process.

Operation

148. Cooling systems and towers should be kept in regular use wherever possible. Where a system is used intermittently or is required at short notice, it should be run once a week and, at the same time, be dosed with water treatment chemicals and the water quality monitored. The whole system should be run long enough to thoroughly distribute treated water. If the system is out of use for a week to one month, in addition to the above, the water should be treated with biocide immediately on reuse.

149. If the system is out of use for more than one month, and there are continued management/monitoring arrangements in place, it should be kept full of treated water which should be checked for biocide levels and water quality and circulated once a week (see Part 3 paragraphs 31-36). If it is not possible to ensure regular monitoring and circulation, for example if a building falls out of use, the system should be drained and sealed, with desiccant left in the system to reduce the effects of corrosion. Full re-commissioning will be required before the system can be brought back into reuse. Cooling systems that do not operate continuously such as cooling towers that cycle on and off automatically, or those on regular standby duty require particular attention with regard to the biocide programme in order to ensure that effective levels of biocide are maintained at all times.
150. Operation manuals should be available for each water system. These manuals should detail, in easily understood terms, operation and maintenance procedures which enable plant operators to carry out their duties safely and effectively.
151. Specific information on the water treatment programme in use should be included. Where automatic dosing equipment is used, there should be a means of confirming that the treatment is being applied. Irrespective of the dosing method, both the quantity and frequency of chemical application should be recorded, including:
- The results of the monitoring and any action required and carried out;
 - Normal control parameters;
 - Limits, with corrective actions, for out of specification situations, or where plant operating conditions or make-up water quality have changed;
 - Cleaning and disinfection procedures.
152. Where automatic controls are employed for chemical additions or to allow bleed-off, they should be checked over their full operating ranges. Where conductivity controls are used the conductivity cell should be regularly recalibrated.
153. In high nutrient environments additional controls such as side-stream filtration may be required to reduce the nutrient load on the system.

Maintenance

154. The operations manual should include a detailed maintenance schedule that should list the various time intervals when the system plant and water should be checked, inspected, overhauled or cleaned. Provision should be made for the completion of every task to be recorded by the relevant operatives.
155. Drift eliminators require particular attention with regard to maintenance so that aerosol release continues to be controlled. They should be of high efficiency rating and inspected, cleaned and maintained to ensure that they are free from biofouling, corrosion, scale and other deposits and are well seated and undamaged.

Treatment programmes

156. A complete water treatment programme based on the physical and operating parameters for the cooling system and a thorough analysis of the make-up water should be established. The components of the water treatment programme should be environmentally acceptable and comply with any local discharge requirements.
157. There are a number of factors which will influence the effectiveness of any treatment programme: corrosion, scale formation, fouling and microbiological activity (see further discussion below). In hard water areas the supply water will usually require softening.
158. All components of the treatment programme should preferably be dosed by pump or eductor (sometimes referred to as an ejector) systems or by a suitable halogen dosing system.

Microbiological activity

159. The operating conditions of a cooling system provide an environment in which micro-organisms can proliferate. The water temperatures, pH conditions, concentration of nutrients, presence of dissolved oxygen, carbon dioxide, sunlight, together with large surface areas all favour the growth of micro-organisms such as protozoa, algae, fungi and bacteria, including *Legionella*. Both surface adhering (sessile) and free flowing (planktonic) bacteria need to be controlled for a complete and effective treatment programme. Methods of treatment are detailed in Supplement 2.

Monitoring

General monitoring

160. The composition of the make-up and cooling water should be routinely monitored to ensure the continued effectiveness of the treatment programme. The frequency and extent will depend on the operating characteristics of the system, the minimum recommended frequency being once a week to ensure that dosage and bleed rates are correct (see Table 2).
161. Many routine monitoring tasks can be performed in-house provided that the individuals are trained and competent. Any laboratory tests, such as culturing for *Legionella* should be performed by laboratories that are accredited for the tests in question.
162. The identification of changes in the water chemistry such as pH, dissolved and suspended solids, hardness, chloride and alkalinity allows any necessary corrective actions to be taken to the treatment programme or system's operating conditions. In addition, chemical treatment reserves such as scale and corrosion inhibitors and oxidising biocides should be measured. Routine on-site determination of the concentration of non-oxidising biocides is not

practical. The amount of non-oxidising biocide required is therefore calculated from the volume and half-life of the system. Other aspects of the treatment programme such as corrosion rates and microbiological activity will also need to be monitored.

Table 3: Typical on-site monitoring checks recommended for good operating practice

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	-	Monthly
Oxidising biocide mg/l	-	Weekly
Temperature °C	-	Quarterly
pH	Quarterly	Weekly
Soluble Iron as mg/l Fe	Quarterly	Quarterly
Total iron as mg/l Fe	Quarterly	Quarterly
Concentration factor	-	Monthly
Microbiological activity	Quarterly	Weekly
<i>Legionella</i>	-	Quarterly

163. The monitoring programme should also include the routine sampling and testing for the presence of bacteria, both general (aerobic) bacterial species and *Legionella* bacteria. Since the detection of *Legionella* bacteria requires specialist laboratory techniques, routine monitoring for aerobic bacteria should be used as an indication of whether microbiological control is being achieved.
164. Where monitored parameters are out of specification, immediate remedial actions should be instigated to restore control and an investigation begun to determine the root cause. During this period increased monitoring should be implemented until the system is shown to be under long term control.
165. Table 4 lists microbiological counts and the appropriate action that should be taken in response to them. While the number of micro-organisms is itself important, it is also necessary to monitor any changes from week-to-week, particularly if there are any increases in the number of micro-organisms detected. This should always result in a review of the system and the control strategies. A graphical representation of these data will often assist in the monitoring of any trends.

Monitoring for legionellae

166. In addition to the routine sampling for aerobic bacteria, the routine monitoring scheme should also include periodic sampling for the presence of legionellae. This should be undertaken at least quarterly (Table 3), unless sampling is necessary for other reasons, such as to assist in identifying possible sources of the bacteria during outbreaks of Legionnaires' disease. If a *Legionella* positive sample is found as a result of routine sampling, more frequent samples may be required as part of the review of the system/risk assessment, to help establish when the system is back under control (Table 4). More frequent sampling should be carried out when commissioning a system and establishing a treatment programme. The method of sampling and analysis should be in accordance with ISO 11731 and the biocide neutralised where possible. Samples should be taken as near to the heat source as possible. They should be tested by a laboratory accredited by their national accreditation body and participate in an external quality assessment scheme for the isolation of *Legionella* from water. The laboratory should also apply a minimum theoretical mathematical detection limit of less than or equal to 100 legionellae per litre of sample.
167. Legionellae are commonly found in almost all natural water sources, so sampling of water systems and services will often yield positive results. Failure to detect legionellae should not lead to the relaxation of control measures and monitoring. Neither should monitoring for the presence of legionellae in a cooling system be used as a substitute in any way for vigilance with control strategies and those measures identified in the risk assessment. The interpretation of any results should be carried out by experienced microbiologists.

Table 4: Action levels following microbial monitoring for cooling towers

Aerobic count * cfu/ml at 30°C (minimum 48 hours incubation)	<i>Legionella</i> cfu/litre ♦	Action required
10, 000 or less	1,000 or less	System under control
more than 10,000 and up to 100,000	more than 1000 and up to 10,000	Review programme operation – The count should be confirmed by immediate resampling. If a similar count is found again, a review of the control measures and risk assessment should be carried out to identify any remedial actions
more than 100,000	more than 10,000	Implement corrective action – The system should immediately be 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

* Colony count determined by pour plate method according to ISO 6222 or by spread plate method on yeast extract agar

♦ Determined in accordance with ISO 11731.

Cleaning and disinfection

168. The maintenance of an effective biocide regime will provide a hostile environment for microbial life (including legionellae) and minimise biofouling. However, the use of biocides should not be considered in isolation but as part of the overall water treatment programme, including the manual and chemical cleaning and disinfection of open cooling systems, and in particular the cooling tower.
169. Disinfection, cleaning and manual de-sludging and de-scaling of cooling towers should be undertaken at least twice a year, but more frequent cleaning may be necessary dependent on local environmental conditions such as dirty atmospheres and the conclusions reached in the risk assessment. Cooling systems that have a short operating period may only need to be cleaned at the beginning and end of that period. If on inspection the system shows signs of a significant accumulation of deposits or slime, then disinfection and cleaning should be carried out. The use of chlorine, or other oxidising biocides, to disinfect the tower is an effective approach provided it is used correctly.
170. In addition to this regular disinfection, cooling towers should always be cleaned and disinfected before being put back into service:
- Immediately before the system is first commissioned
 - After any prolonged shutdown of a month or longer (a risk assessment may indicate the need for cleaning and disinfection after a period of less than one month, especially in summer)
 - If the tower or any part of the cooling system has been mechanically altered
 - If the cleanliness of the tower or system is in any doubt
 - If microbiological monitoring indicates that there is a problem.

Pre-cleaning disinfection

171. The system water should be disinfected using an oxidising biocide such as chlorine, bromine or chlorine dioxide to minimise health risks to the cleaning staff. This is undertaken by the addition of either sodium hypochlorite solution or chloro-isocyanurate compounds available as rapid release tablets to achieve a measured residual of 5mg/l free chlorine. Sodium hypochlorite solutions typically contain 10-12% available chlorine and rapid release tablets contain 50-55% available chlorine. Such products should be handled following a risk assessment and with care, according to instructions given by the supplier. A bio-dispersant should also be used to enhance the effectiveness of the chlorination.
172. The chlorinated water containing 5mg/l free chlorine should be circulated through the system for a period of five hours with the fan off, maintaining a minimum of 5mg/l free chlorine at all times. However, if the system pH value is greater than 8.0, the measured residual will need to be in the range 15-20mg/l free chlorine in order to achieve the required disinfection level. An alternative procedure to provide more effective use of chlorine is to introduce a heavy bleed-off for several hours to both reduce the pH of the system water and its chlorine demand, before carrying out disinfection. The system should then be dechlorinated and drained.

Cleaning

173. Manual cleaning operations can then be undertaken, with all accessible areas of the tower etc. being adequately cleaned. Where practicable, the packs should be removed at least once a year and preferably every six months. If this is not practicable, it may be necessary to apply supplementary strategies such as side-stream filtration, increased monitoring etc. Accessible areas of the tower and its pack should be adequately washed but cleaning methods that create excessive spray, for example, high pressure water jetting, should be avoided. If this is not possible, the operation should be carried out when the building is unoccupied or, in the case of permanently occupied buildings, windows in the vicinity should be closed, air inlets blanked off and the area that is being water jetted should be tented. The area should be isolated and consideration should also be given to other occupied premises in the immediate areas as well as to members of the public who may be in the vicinity during cleaning.
174. Cleaning staff that carry out water jetting should wear suitable respiratory protective equipment such as a positive pressure respirator with a full face piece or a hood and blouse. Staff that use this equipment should be adequately trained and the equipment properly maintained (see section on protection of personnel Paragraph 73).
175. Adherent scale or other deposits on the tower and distribution system that have not been removed by the above method can be dissolved using chemical descalents carefully chosen to avoid damage to the fabric of the system. If this is not possible, then routine inspection and testing of water quality should be particularly thorough.
176. Finally, the system should be sluiced out until the water going to drain is clear.

Post-cleaning disinfection

177. On completion of the cleaning operation, the system should be refilled and chlorinated to maintain a minimum level of 5mg/l of free chlorine for a period of five hours with the fan off. This needs to be checked hourly to ensure a concentration of 5mg/l is present for the total period. Again, the use of a biodispersant will enhance the effectiveness of this chlorination. If the system volume is greater than 5m³, the water should be dechlorinated, drained, flushed and refilled with fresh water and dosed with the appropriate start-up level of treatment chemicals, including the biocides.
178. Whilst the maintenance of a continuous minimum residual of 5mg/l of free chlorine for a minimum period of five hours is considered the best practice, where the downtime to conduct such a lengthy operation is not available, some compromise may be necessary. Under such circumstances it may be acceptable to shorten the pre- and post-chlorination times and to increase the free chlorine level, e.g. 50mg/l for one hour or 25mg/l for two hours. This should only be undertaken if the operators are trained in this process because at these levels, there is a greater risk of damaging the fabric of the system. The system should then be dechlorinated, drained, flushed and refilled with fresh water and dosed with the appropriate start-up level of treatment chemicals, including the biocides.

179. Before water containing high residual free chlorine is discharged to drain, it may need to be dechlorinated to comply with local environmental standards or to prevent damage to sewage works.

Spa pools

180. A spa pool (also known as a spa bath, hot tub, whirlpool spa and commonly known as a Jacuzzi - a trade name) is a bath or a small pool where warm water is constantly re-circulated, often through high velocity jets or with the injection of air to agitate the water. The water is not changed after each user; instead it is filtered and chemically treated. The water temperature is normally greater than 30°C and the deliberate agitation creates a spray or aerosol above the surface of the water. Spa pools are a recognised cause of Legionnaires' disease. Spa pools can be a risk even when not being used by bathers, for example when being run for display purposes. Careful attention to design, maintenance and cleaning of equipment such as filters, and regular water treatment to prevent/control the risk from *Legionella* is required. Whirlpool baths (baths fitted with high velocity water jets and/or air injection but without water recirculation) do not present the same risk as spa pools because the water is discharged after each use and only a limited number of people are exposed.
181. At least half the water in the spa pool should be replaced each day. The pools should be fitted with a sand filter of the type fitted to swimming pools and this should be backwashed each day. The turnover time (the time taken for the whole volume of the system to cycle through the filter and back to the pool) should be six minutes. Paper or polyester filters should not be used for commercial purposes, or in spas used in holiday accommodation. The pool should be treated automatically and continually with an oxidising biocide, preferably chlorine, ideally injected prior to the filter. Hand dosing must not be used except in an emergency. Where chlorinating disinfectants are used a free chlorine residual of 3-5 mg/l should be maintained in the spa water. The pH should be 7.0–7.6. The pumps and disinfection system should be left operating 24 hours per day. The residual disinfectant concentration and pH should be measured before use and every two hours during use. Pool waters should be tested microbiologically once a month for colony count, coliforms, *Escherichia coli* and *Pseudomonas aeruginosa*. The colony count at 37°C should be less than 100cfu/ml and preferably less than 10cfu/ml; there should be <10cfu *P. aeruginosa* per 100ml and there should be no coliforms or *E. coli* in 100ml. Spa pools should also be sampled quarterly for *Legionella*.
182. Pools on display in retail outlets should be treated in the same manner as if they were being used. Details on the maintenance of spa pools are given in the booklet Management of Spa Pools: Controlling the Risk of Infection. (HPA & HSE 2006) and in Surman-Lee *et al.* 2007.

Table 5: Action levels following *Legionella* sampling in spa pools

<i>Legionella</i> (cfu/litre)	Action required
More than 100 and up to 1,000	Resample and keep under review Advise to drain clean and disinfect Review control and risk assessment and carry out any remedial measures identified Refill and retest next day and 1-4 weeks later
More than 1,000	Close pool immediately and exclude the public from the area Shock dose the pool with 50mg/l chlorine for one hour circulating the water sufficiently to ensure all parts of the pipe-work are disinfected Drain clean and re-disinfect Review control and risk assessment and carry out any remedial measures identified Refill and retest next day and 1-4 weeks later Keep closed until legionellae are not detected and the risk assessment is satisfactory

Other risk systems

184. There are a number of other systems (which produce aerosols) which may pose a risk of exposure to *Legionella*. These include:

Humidifiers and air washers

185. Atomising humidifiers, ultrasonic misters/humidifiers and spray-type air washers may use water from reservoirs or tanks where the water temperature exceeds 20°C. Misters/humidifiers are increasingly used in food display cabinets in supermarkets and some hotels and have been associated with outbreaks. Unless they are installed correctly, regularly cleaned and maintained, they can become heavily contaminated, especially in industrial environments. The risk can be prevented by using humidifiers which do not create a spray, i.e. steam humidifiers.
186. The actions that need to be taken with regard to these and other risk systems are detailed in Checklist 3. In general, these systems should be maintained in a clean state, will often require regular disinfection and should be monitored on a regular basis where appropriate. There is also a duty to carry out a risk assessment and to maintain records of all maintenance that is carried out together with monitoring results. Great care needs to be taken during installation and commissioning to ensure that cross connections do not occur between different water systems e.g. fire mains and the cold water system.

Protection of personnel

187. Maintenance, cleaning, testing and operating procedures should all be designed to control the risks to staff and others that may be affected.
188. Cooling towers and evaporative condensers should be treated as described in the section on cleaning and disinfection and in particular, the requirement for pre-cleaning disinfection should be observed. This will only have a transient effect on *Legionella*, but it will reduce the chance of engineering staff being exposed while working on the tower. Where possible, cleaning methods that create spray, for example, high pressure water jetting should be avoided. If this is not possible, the operation should be carried out when nearby buildings are unoccupied or in the case of permanently occupied buildings, windows in the vicinity should be closed and air inlets temporarily blanked off, for example with tarpaulins.
189. As systems requiring cleaning may have been contaminated, the operator and others closely involved in the work should wear suitable respiratory protective equipment. This can be a powered filter and hood, European Class TH3 (assigned protection factor of 40) or a power assisted filter and close fitting full face mask, TM3 (assigned protection factor 40). It should be borne in mind that the filter on these systems is liable to get wet, and consequently resistance to air can increase with consequent discomfort to the operator.
190. Alternatively, a hood or full-face mask fed with breathing quality compressed air may be used. The preferred equipment is a full-face close fitting airline mask with a positive pressure demand valve, under a hood or helmet protecting the rest of the head. The air supply should come from an oil free compressor drawing air through a filter from a location well upwind of any jetting operation, or through cylinder supplies of compressed air. Further information on respiratory protective equipment can be obtained from Respiratory Protective Equipment at Work – a Practical Guide (HSE 2005)

Recommended inspection frequencies for risk systems

Checklist 1: Cooling water 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 observations of internal condition of pond, pack and water	See Table 3
	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. Check all valves, such as bypass valves are adjusted as intended.	Monthly to three monthly, according to risk (See Table 3)
	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	Six monthly

Checklist 2: Hot & cold water services

Service	Task	Frequency
Hot water services	Arrange for samples to be taken from hot water heaters, in order to note condition of drain water	Annually
	Check temperatures of flow and return of calorifiers	Monthly
	Check water temperature up to one minute to see if it has reached 50°C in the sentinel taps	Monthly
	Visual check on internal surfaces of water heaters for scale and sludge. Check representative taps for temperature as above on a rotational basis	Annually
Cold water services	Check tank water temperature remote from ball valve and mains temperature at ball valve. Note maximum temperatures recorded by fixed max/min thermometers where fitted	Six monthly
	Check that temperature is below 20°C after running the water for up to two minutes in the sentinel taps	Monthly
	Visually inspect cold water storage tanks, check temperature and carry out remedial work where necessary. Check representative taps for temperature as above on a rotational basis	Annually
Shower heads	Dismantle, clean and descale shower heads and hoses	Quarterly or more frequently if necessary
Thermostatic mixer valves	Check operation of TMV and dismantle and descale if necessary	Six monthly or more frequently if necessary
Little used outlets	Flush through and purge to drain	Weekly

Checklist 3: Spa pools

Task	Frequency
Check water clarity	Daily before first use
Check automatic dosing systems are operating (including ozone or UV lamp if fitted).	
Check that the amount of dosing chemicals in the reservoirs are adequate	
Determine pH value and residual disinfectant concentration	
Determine pH value and residual disinfectant concentration	Daily every two hours
Clean water-line, overflow channels and grills	At end of each day
Clean spa pool surround.	
Backwash sand filter (ensure water is completely changed at least every two days) - for diatomaceous earth filters comply with the manufacturer's instructions	
Inspect strainers, clean and remove all debris if needed	
Record the throughput of bathers	
Record any untoward incidents	
Clean and disinfect entire system including balance tank.	Weekly
Microbiological tests for indicator organisms.	Monthly
Full chemical test (optional).	
Clean input air filter when fitted.	
Inspect accessible pipe-work and jets for presence of biofilm; clean as necessary.	
Check residual current circuit breaker/earth leakage trip is operating correctly.	
Check all automatic systems are operating correctly e.g. safety cut-outs, automatic timers etc.	
Disinfectant/pH controller - clean electrode and check calibration (see manufacturer's instructions).	
Thoroughly check sand filter or diatomaceous earth filter membranes.	Quarterly
Where possible clean and disinfect airlines.	
<i>Legionella</i> test	
Check all written procedures are correct	Annually
Check sand filter efficiency.	

Checklist 4: Other risk systems

System/service	Task	Frequency
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
Emergency showers and eye wash sprays	Flush through and purge to drain	Six monthly or more frequently if recommended by manufacturers
Sprinkler and hose reel systems	When witnessing tests of sprinkler blow down and hose reels ensure that there is minimum risk of exposure to aerosols	As directed
Lathe and machine tool coolant systems	Clean and disinfect storage and distribution system	Six monthly
	Clean and disinfect entire system.	Weekly
Horticultural misting systems	Clean and disinfect distribution pipe-work, spray heads and make-up tanks including all wetted surfaces, descaling as necessary	Annually and more frequently where the public have access
Dental station cooling systems	Drain down and clean Flush	At the end of each working day At the beginning of each working day
Car/bus / train washes	Check filtration and treatment system, clean and disinfect system	See manufacturers instructions
Fountains and water features (particularly indoors)	Clean and disinfect ponds, spray heads and make-up tanks including all wetted surfaces, descaling as necessary	Interval depending on condition

Supplement 2

Treatment Methods

Cooling systems

Biocides

191. Biocides are used for the long-term control of microbiological activity in cooling systems, and can be oxidising or non-oxidising or a combination of both. The frequency and quantity of additions will depend on the microbiological activity of the system.
192. Biocides have been shown to be effective in preventing the proliferation of legionellae when applied and controlled as part of a comprehensive water treatment programme. Many factors will influence the selection of chemicals required for the treatment programme. However, the success of the treatment programme is dependent on:
 - Compatibility of all chemical components used;
 - Adherence at all times to the recommended application, monitoring and control procedures.
193. Biocides are routinely applied at the tower sump or the suction side of the re-circulating water pump but should be dosed so that the biocide will circulate throughout the cooling system. However, in air conditioning systems where the tower can be bypassed, the biocide needs to be added to the suction side of the re-circulating pump.
194. Specific surfactants (biodispersants) function by wetting biofilms and aiding penetration of the biocides into them. In microbiologically dirty systems that contain or readily grow biofilms, the use of biodispersants can improve the efficiency of oxidising biocides. Most non-oxidising biocide formulations already contain surfactants to improve performance. Then installation of sidestream filtration can significantly reduce suspended dirt in systems prone to process contamination or severe dust contamination from the incoming air.
195. Hazard data sheets should be available for all chemicals used in treatments applied to cooling towers and an assessment drawn up to ensure that those handling and applying them do so safely. Where a biocide has been selected specifically for control of *Legionella* the supplier should be able to present test data to demonstrate its efficacy.

Oxidising biocides

196. The halogens are dosed to give a free-chlorine or free-bromine reserve. This is a measure of the free-halogen, the hypochlorous/hypobromous acid (HOCl/HOBr) and the hypochlorite/hypobromite ion (OCl⁻ /OBr⁻). In all cases

the applied dosage should be sufficient to maintain a free reserve in the range of 1.0-2.0 mg/l chlorine/chlorine dioxide and 2.0–3.0 mg/l bromine in the return water. Reserves consistently above 3mg/l free chlorine/bromine should be avoided (except in exceptional circumstances) as this may cause system corrosion. The activity (in terms of time taken to have an effect) of chlorine is significantly reduced at alkaline pH and additions of this biocide need to be adjusted to take account of this. This can be overcome by continuous dosing. It is, in any case, preferable to apply oxidising biocides on a continuous basis but if they are applied as a shot dose, the effective concentration should be present for at least four out of every 24 hours. In large industrial systems, the dosage is based on water recirculation rate. This has to be sustained for a period of time, ranging from a few minutes to several hours, or even continuously, depending on the operating characteristics of the cooling system.

197. For small systems, such as air conditioning installations, halogen addition would normally be based on system volume. The system and its water chemistry will influence the choice of the best method of addition to obtain effective microbiological control. Once halogenation is stopped, the free halogen reserve is quickly lost, leaving the system open to re-infection and re-population by micro-organisms.
198. Oxidising biocides are also used for disinfection either in emergency or as part of the routine cleaning programme. For disinfection, much higher doses of up to 50 mg/l may be used.
199. Oxidising biocides have the advantage that they can be readily monitored by simple chemical tests that can be performed on site, are relatively cheap and are easy to neutralise for microbiological monitoring and disposal. Their major disadvantage is that they can be corrosive and their activity, particularly for chlorine, is pH dependent.

Non-oxidising biocides

200. Non-oxidising biocides are generally more stable and longer lasting than oxidising biocides. However, their concentration will reduce because of depletion via water losses from the system, and by degradation of the active material.
201. To achieve the right non-oxidising biocide concentration to kill micro-organisms, it should be added as a shot dose but may sometimes be added continuously. The frequency and volume of applications are dependent on system volume, system half-life and the biocide contact time, typically four hours. These need to be considered to ensure that the biocide concentration necessary to kill the micro-organisms is achieved. In systems with smaller water volumes and high evaporation rates it is particularly important that the above parameters are accurately determined. In the case of systems that have long retention times, the half-life of the biocide is the controlling factor.
202. A non-oxidising biocide programme should use two biocides on an alternating basis. Once the concentration of any biocide has been depleted to below its effective level, the system will be open to re-infection. The efficacy of non-

oxidising biocides may be influenced by the pH of the water in the system and this should be taken into account to ensure that the biocide programme is effective. The following points are important in selecting a non-oxidising biocide programme:

- Retention time and half-life of the system
- Microbiological populations
- System contaminants
- Handling precautions
- Effluent constraints

Hot water systems

203. National water regulations may prescribe a maximum value for the level of biocide being used in potable water supplies. It is important that installers of treatment systems are aware of the need to avoid any breach of these regulations and maintain biocide levels below the maximum allowable concentration.

Thermal shock

204. Thermal shock treatment at 70-80°C for relatively short periods has been used both for emergency disinfection, and as part of long-term control programmes. However recolonisation can frequently occur rapidly, even within a couple of weeks. This method carries an increased risk of scalding and must be carefully managed to avoid the risk. It is no longer recommended as part of a long-term control programme.
205. Thermal disinfection is carried out by raising the temperature of the whole of the contents of the hot water storage heater to 70-80°C then circulating this water throughout the system for up to three days. To be effective, the temperature at the hot water storage heater should be high enough to ensure that the temperatures at the taps and appliances do not fall below 65°C. Each tap and appliance should be run sequentially for at least five minutes at the full temperature, and this should be measured. For effective thermal disinfection the water system needs to be well insulated.
206. It is essential to check that during the procedure, the temperature of the water in distal points reaches or exceeds 65°C.
207. At the end of the procedure, samples of water and sediment should be collected at distal points of the installation and examined for *Legionella*. If the result is unsatisfactory, the procedure must be repeated until documented decontamination is achieved. Following decontamination, microbiological checks must be repeated periodically.
208. Thermal treatment has the advantages that no particular equipment is required so that the procedure can be carried out immediately, provided there is sufficient heat capacity in the system. However the procedure requires considerable energy and manpower and is not normally practical for large

buildings but may be suitable for small systems. It will not disinfect downstream of thermostatic mixer valves, unless the valves can be overridden, and so is of limited value where such valves are installed. There is a severe risk of scalding at these temperatures. Although the numbers of *Legionella* may be reduced, re-colonisation of the water system can occur from as little as a few weeks after treatment, particularly if it has not been accompanied by other remedial measures.

Constant maintenance of the temperature between 55-60°C

209. At 60°C it takes approximately two minutes to inactivate 90% of a population of *L. pneumophila*. The effectiveness of maintaining the circulating temperature at 60°C has been demonstrated both in hospitals and in hotels. Hot water installations maintained at temperatures above 50°C are less frequently colonised by legionellae. Circulating water at 60°C, such that the temperature at each outlet, or feed to a TMV, reaches at least 50°C and preferably 55°C within one minute of opening the outlet, is the method most commonly used to control legionellae in hot water distribution systems. Although raising the temperature to a constant 60°C has consistently been shown to control outbreaks it does not necessarily eliminate legionellae from the system but controls them at a level that prevents further cases. Provided there is sufficient heating capacity it is relatively easy to implement and is easy to monitor continuously. It is important that the temperatures of the returns on each loop of the system are monitored as well as the tap and flow temperatures. It has the possible disadvantage of increasing energy consumption and there is an increased risk of scalding. Where thermostatic mixer valves are installed to reduce scalding risk, they must be subjected to a programme of planned monitoring and maintenance.

Chlorination

210. Chlorine has also been used for the treatment of hot water systems. As the bactericidal action of the chlorine is pH sensitive and decreases rapidly at values above seven the pH of the water will have to be monitored and may need adjustment. In systems which are colonised the chlorine residual will be quickly used up; it is therefore essential that monitoring of distal points in all parts of the system is carried out to ensure there is an effective concentration of free chlorine available.

Shock hyperchlorination

211. This must be carried out in water at a temperature below 30°C, with a single addition of chlorine to the water to obtain concentrations of free residual chlorine of 20-50 mg/l throughout the installation, including distal points. After a contact period of at least two hours with 20 mg/l of chlorine or at least one hour with 50 mg/l of chlorine, the water is drained. Fresh water is then let into the installation until the level of chlorine returns to the concentration of 0.5-1 mg/l.

Continuous chlorination

212. This is achieved by the continuous addition of chlorine, usually in the form of calcium hypochlorite or sodium hypochlorite. Residual levels of chlorine can vary depending on the quality of the water, the flow, and the amount of the biofilm in the system. However the residual disinfectant must be between one and two mg/l. Where there are stagnant areas or circulation problems in the water distribution system, the chlorine will not inactivate *Legionella* in these areas.
213. Although continuous chlorination has been used as a means of control in hot water systems, it is difficult to maintain the required levels of chlorine as it volatilises off from hot water. In addition chlorine is corrosive and this effect is increased with raised temperatures.

Chlorine dioxide

214. Chlorine dioxide has been successfully used to control *Legionella* in some hot water systems and can be used in the same manner as chlorine. It has the advantage that it is not as volatile at high temperatures as chlorine and is said to be more active on biofilms.

Monochloramine

215. There is some evidence that hospitals receiving water that has been treated with monochloramine rather than chlorine are less likely to have outbreaks of Legionnaires' disease and are less colonised with *Legionella*. It is possible that treating hot water systems with monochloramine may prove more effective than chlorine. Appropriate dosing systems are becoming available for buildings. Monochloramine is more slow acting than chlorine but persists longer and is therefore said to be more effective against biofilms.

Ionisation

216. "Ionisation" is the term given to the electrolytic generation of copper and silver ions for use as a water treatment. Metals such as copper and silver are well known bactericidal agents. They act on the cell wall of the micro-organism that alters the cells permeability which, together with protein denaturation, lead to cell lysis and death.
217. Copper and silver ions are generated electrolytically and their concentration in the water depends on the power applied to the electrodes. Copper and silver ion concentrations maintained at 400 µg/l and 40 µg/l respectively can, if properly managed be effective against *Legionella* in the planktonic and biofilm phase in hot water systems. If however the water is softened then silver ion concentrations between 30 to 20 µg/l can also be effective, provided a minimum concentration of 20 µg/l is maintained. This level of silver still requires copper ions to complete the synergy.
218. The application of ionisation will need to be properly assessed, designed and maintained as part of an overall water treatment programme. It should be

noted that in hard water systems, silver ion concentrations can be difficult to maintain due to accumulation of scale on the electrodes in some systems, unless anti-scaling electrode cells are employed. High concentrations of dissolved solids may precipitate the silver ions out of solution. For both hard and soft water, the ionisation process is pH sensitive and it is difficult to maintain silver ion concentrations above pH 7.6. The accumulation of scale and concentration of dissolved solids therefore needs to be carefully controlled so that suitable ion levels are consistently maintained throughout the system. This may require additional water treatments.

219. The method is easy to apply and is not affected by the temperature of the water. However because the system is subject to fluctuations in concentration unless automatic controls are employed, it is necessary to check the concentration of the two metals regularly, as well as the pH of the water at 6-8. This technique is not suitable for systems that employ zinc cathodic protection for water systems because the metal deactivates silver ions. Furthermore, if the treatment is used continuously it is necessary to check that the maximum permissible concentration (CMA) laid down by current legislation for drinking water is not exceeded.

Hydrogen peroxide and silver

220. Treatment is carried out using a stable concentrated solution of hydrogen peroxide (oxygenated water) and silver, exploiting the bactericidal action of each of the two components and the synergy between them. The technique is relatively recent and requires further field trials to confirm its effectiveness.

Ultra violet (UV) radiation

221. Irradiation with ultraviolet light is an alternative method for the disinfection of drinking water. Ultraviolet light (254 nm) inactivates bacteria by producing thymine dimers in their DNA that inhibit replication. The application of ultraviolet light is a method of disinfection that has proven effective close to the point of use. The thermal shock and chlorination methods can be used prior to application of ultraviolet light to control *Legionella* present in the system. UV equipment is relatively easy to install and has no adverse effects on the taste or potability of the water and does not damage piping. The technique is not suitable as the only method for an entire building or water system because there is no residual effect, and legionellae remain in the biofilms, dead ends and stagnant areas of the system.

Terminal filtration

222. There are commercially available bacterial filters that can be fitted to taps and shower heads containing filters that can be fitted in place of the conventional shower head. These will prevent all legionellae and other bacteria from being released by the outlets to which they are fitted. They need to be replaced regularly which is an additional cost so they are commonly installed as a temporary measure, particularly in health care premises where they have been used very effectively to prevent infection.

Cold water systems

223. Oxidising biocides are the most widely used method of controlling *Legionella* in cold water systems. Chlorine, monochloramine and chlorine dioxide can all be used although chlorine has been most widely applied. If the water is to be used for drinking it is important to ensure that the national drinking water regulations are complied with. Where chlorine dioxide is used the concentration in water that is to be drunk should not exceed 0.5mg/l and this is often not enough to achieve control in colonised systems. Therefore it may be necessary to use it at a higher concentration say 1–2 mg/litre and to provide alternative sources of potable water until the legionellae are shown to be under control. This may take a considerable period of time.

Spa pools

224. It is imperative that spa pools are rigorously maintained. The water should be continuously filtered and treated continuously with chlorine or bromine to provide a residual concentration of 3-5 mg/l of chlorine. Public spa pools should be equipped with a sand filter of the type used for swimming pools and this should be back-washed each day. Alternatively diatomaceous earth filters may be used and backwashed according to the manufacturer's instructions. At least half the water should also be replaced each day. The water circulation and treatment system should be operated 24 hours a day. The residual concentration of chlorine should be measured several times a day. Spa pools on display should be treated in the same way as those used by bathers.

Supplement 3

References for National Guidelines for Control and Prevention of Legionnaires' disease and References for National Water Regulations

Country	Name of document	Year	Publication
Andorra	Water regulations http://www.bopa.ad/bopa.nsf/ad6c75eb167be7c7c1256afe003232ff/e1d45a591abb589cc125737e00217ded		
Austria	Kontrolle und Prävention der reiseassoziierten Legionärskrankheit http://www.ages.at/uploads/media/Leitlinie_Legionellen_07.pdf	2005	AGES Austrian Agency for Health and Food Safety and Ministry of Health
	ÖNORM B 5019 Hygienerelevante Planung, Betrieb, Wartung, Überwachung und Sanierung von zentralen Trinkwasser-Erwärmungsanlagen http://www.as-search.at	2007	Austrian Standard plus
	Bäderhygieneverordnung http://www.ris.bka.gv.at	1998	Bundeskanzleramt Rechtsinformationssystem
	Prävention der Legionellose, Checkliste zur Einschätzung des Risikos einer Exposition gegenüber Legionellen bei Kontakt mit zentralen Trinkwasser-Erwärmungsanlagen und anderen wasserführenden Systemen http://www.ages.at	2009	AGES Austrian Agency for Health and Food Safety and Ministry of Health
Belgium	Relatif aux dangers de et aux mesures préventives contre une contamination par <i>Legionella</i> en Belgique (CSH: 4870)	Sept 2000	Conseil Supérieur d'Hygiène Brussels
	Recommendations Pour La Prevention Des Infections A <i>Legionella</i> Dans Les Establishments De Soins (CSH : 7509)	Jan 2002	Conseil Supérieur d'Hygiène Brussels
Czech Republic	Metodicky navod k zajistení programu surveillance legioneloz	2000	Ministerstvo Zdravoknictvi Praha
	Water regulations http://aplikace.mvcr.cz/archiv2008/sbirka/2006/sb092-06 <i>Legionella</i> in indoor and outdoor	2006	

Country	Name of document	Year	Publication
	swimming pools http://aplikace.mvcr.cz/archiv2008/sbirka/2006/sb092-06 <i>Legionella</i> in drinking and hot water of health care and accommodation facilities	2006	
Denmark	Guidelines: <i>Legionella</i> En Vejledning: <i>Legionella</i> i varmt brugsvand. Overvågning, udbredelse og forebyggelse af legionærsygdom. ISBN 87-89148-25-8	1998 2000	Statens Serum Institut, Copenhagen As above
France	Arrêté du 13 décembre 2004 relatif aux installations de refroidissement par dispersion d'eau dans un flux d'air soumises à autorisation au titre de la rubrique n° 2921 Le risque lié aux legionelloses : guide d'investigation et d'aide à la gestion La prévention du risque lié aux légionelles dans les établissements sociaux et médico-sociaux d'hébergement pour personnes âgées Modalités d'organisation des services de l'Etat en cas de survenue de cas groupés de legionellose Référentiel d'inspection des mesures de prévention des risques liés aux légionelles dans les établissements de santé	December 2004 July 2005 October 2005 May 2006 June 2005	Minsitère de l'écologie et du développement durable Ministère de la santé et des solidarités , Direction générale de la santé As above As above As above
Germany	Drinking water heating systems and conduits; Technical measures to decrease <i>Legionella</i> growth Drinking water heating systems and conduits; Technical measures to decrease <i>Legionella</i> growth; rehabilitation and operation DIN 19643-1 Treatment of swimming pool water, general requirements VDI 6022 Hygienic requirements on room ventilation facilities www.beuth.de Protection of Infection Act (IfSG) Act on Prevention and Control of Infectious Diseases in Man	1993 1996 1997 1998 July 2000	W 551 DVGW, Bonn W 552 DVGW, Bonn Federal Ministry of Health

Country	Name of document	Year	Publication
	www.umweltbundesamt.de Water regulations http://www.umweltbundesamt.de/wasser-e/index.htm		
Hungary	Guideline on Legionnaires' disease and its prevention Water regulations http://net.jogtar.hu/ir/gen/hjegy_doc.cgi?docid=A0100201.KOR	2007	National Centre for Epidemiology and National Institute for Environmental Health
Ireland	National Guidelines for the Control of Legionellosis in Ireland, 2009 Water regulations http://www.irishstatutebook.ie/home.html	2009	Health Protection Surveillance Centre, Dublin.
Italy	Linee -guida per la prevenzione ed il controllo della legionellosi Linee guida recanti indicazioni sulla legionellosi per i gestori di strutture turistico-recettive e termali. Linee guida recanti indicazioni ai laboratori con attività di diagnosi microbiologica e controllo ambientale della legionellosi.	May 2000 2005 2005	Gazzetta Ufficiale della Repubblica Italiana, serie generale, n.103 Gazzetta Ufficiale della Repubblica Italiana n. 28 del 04/02/2005. Gazzetta Ufficiale della Repubblica Italiana n. 29 del 05/02/2005.
Latvia	Epidemiological surveillance of legionellosis	Oct 1998	Ministry of Welfare
Lithuania	Methodical recommendations for legionellosis diagnostics, treatment, epidemiological surveillance and control (www.ulpkc.lt) Recommendations for legionellosis prevention and control in procedures of legionellosis risk places (www.ulpkc.lt) Water regulations Requirements for quality and safety of drinking water" (Žin., 2003. Nr. 79-3603). Due confirmation Lithuanian Hygiene standard HN 24-2003	2004 2007 2003	Lithuanian Ministry of Health Lithuanian Ministry of Health Health Minister's of Republic of Lithuania order No V-455

Country	Name of document	Year	Publication
	Equipment and maintenance of safety to health requirements for swimming pools" (Žin., 2005, Nr. 87-3277). Due confirmation Lithuanian Hygiene standard HN 109-2005	2005	Health Minister's of Republic of Lithuania order No V-572
Malta	Code of Practice for the Prevention of Legionnaires' Disease in Hotels and Other Establishments Water Regulations https://ehealth.gov.mt/HealthPortal/public_health/environmental-health/health_inspectorate/env._hit._risk_management/legiionella_control.aspx	March 1999	Health Division, Malta
Netherlands	Drinking water decree: Waterleidingbesluit Hoofdstuk IIIC: <i>Legionellapreventie</i> . NEN1006, Algemene voorschriften voor leidingwaterinstallaties (AVWI – 2002), wijzigingsblad A1: 2005 Decree on Bathing locations: Besluit Hygiene en veiligheid badinrichtingen en zwemgelegenheden: Preventie van <i>Legionella</i> in leidingwater. Policy rule on working conditions: Arbowet beleidsregel 4.87a and 4.87b Guidance documents: ISSO publication 55.1 and 55.2 VEWIN werkbladen Guidance document (cooling towers): Arbo informatieblad AI32 Guidance documents: LCI protocol Legionellose Legionellapreventie bij publieksevenementen LCHV draaiboek melding van legionellabacterien in water	2004 2005 2004 2007 2007 2008 2007 2009 2009 2009	Staatsblad 2004, 576 ; www.wetten.nl/waterleidingsbesluit www.nen.nl www.wetten.nl/bsluit%20hygiene%20en%20veiligheid%20badinrichtingen%20en%20zwemgelegenheden Staatscourant 2007,244 www.wetten.overheid.nl/BWR0013042/Hoofdstuk2/Paragraaf4/Beleidsregel487a/ www.isso.nl www.uneto.vni.nl www.infomil.nl/onderwerpen/hinder-gezondheid/legionella/ www.rivm.nl/cib/infectieziekten-A-Z/infectieziekten/legionellose/ www.rivm.nl/cib/themas/hygiene_en_veiligheid/#index_12

Country	Name of document	Year	Publication
Norway	Smittevern 5. Smittevernhåndbok for kommune-helsetjenesten 2002-2003 ("Communicable Disease Control Handbook") (2001) ISBN 82-7364-177-5	2001	Statens institutt for folkehelse
	Forebygging av <i>Legionellasmitte</i> – en veiledning – 1 revisjon	January 2009	Folkehelseinstituttet
Portugal	Doença dos Legionários. Procedimentos de controlo nos empreendimentos turísticos	July 2001	Direcção Geral de Saúde e Direcção Geral de Turismo
	Circular Normativa n.º 06/DT de 22/04/2004 - "Programa de Vigilância Epidemiológica Integrada da Doença dos Legionários: Investigação Epidemiológica"	April 2004	Direcção Geral de Saúde
	Circular Normativa n.º 05/DEP de 22/04/2004 - "Programa de Vigilância Epidemiológica Integrada da Doença dos Legionários: Notificação Clínica e Laboratorial de Casos"	April 2004	Direcção Geral de Saúde
Russia	Determination of <i>Legionella pneumophila</i> in the environmental samples	MUK 4. 2217-07	
	Epidemiological surveillance for <i>Legionella</i> infection Water regulations www.rospotrebnadsor.ru	MU3.1.2. 2412-08.	
Spain	Recomendaciones para la prevención y control de la legionelosis	1999	Dirección General de Salud Pública. Ministerio de Sanidad y Consumo. ISBN 84-7670-507-7.
	Norma UNE 100030 IN/2005: Guía para la prevención y control de la proliferación y diseminación de la <i>Legionella</i> en las instalaciones. AENOR	2005	AENOR
	REAL DECRETO 865/2003, de 4 de julio, por el que se establecen los criterios higiénico-sanitarios para la prevención y control de la legionelosis. (B.O.E. nº 171 del 18 de julio de 2003)	2003	Ministero de Sanidad y Consumo.

Country	Name of document	Year	Publication
Sweden	<p>Water regulations</p> <p>Ordinance on Drinking water from the National Food Administration, SLV FS 1989:30, H318.</p>		
Switzerland	<p>Légionelles et légionellose. Particularités biologiques, épidémiologie, aspects cliniques, enquêtes environnementales, prévention et mesures de lutte</p> <p>Legionellen und Legionellose (in German) <i>Legionella</i> et légionellose (in French) <i>Legionella</i> e legionellosi (in Italian)</p>	<p>1999</p> <p>2009</p>	<p>Office Fédéral de la Santé Publique, Berne</p> <p>Federal Office of Public Health, Berne</p>
United Kingdom	<p>Legionnaires' disease The control of <i>Legionella</i> bacteria in water systems (L8)</p> <p>Management of Spa Pools - Controlling the Risks of Infection (ISBN 0 901144 80 0)</p> <p>Water regulations England and Wales www.opsi.gov.uk/SI/si2000/20003184.htm</p> <p>N Ireland http://www.drdni.gov.uk/index/water_policy.htm</p>	<p>2000</p> <p>2006</p>	<p>Health and Safety Executive</p> <p>Health Protection Agency</p>
WHO	<p><i>Legionella</i> and the Prevention of Legionellosis</p> <p>Guidelines For Safe Recreational-Water Environments. Vol. 2: Swimming pools, spas and similar recreational-water environments</p>	<p>2007</p> <p>August 2000</p>	<p>WHO Headquarters Geneva</p> <p>WHO Headquarters Geneva</p>

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HSE 2005 (as amended). Respiratory Protective Equipment at Work – a Practical Guide HSG 53. HSE Books, Sudbury, UK. ISBN 9780717629046.

Glossary

Adiabatic	Adiabatic cooling uses the latent heat of evaporation of water sprayed onto the incoming air stream to cool the air supplied to an otherwise dry chiller.
Aerosol	A suspension in a gaseous medium of solid particles, liquid particles or solid and liquid particles having negligible falling velocity. In the context of this document, a suspension of particles (droplet nuclei) derived from fine droplets from which the water has evaporated leaving small airborne particles typically <5µm containing legionellae which can be inhaled deep into the lungs.
Algae	Small, usually aquatic, plants which require light to grow, often found on exposed areas of cooling towers , tanks and walls of spa pools exposed to sunlight.
Air conditioning	A form of air treatment whereby temperature, humidity and air cleanliness are all controlled within limits determined by the requirements of the air conditioned enclosure.
Antibodies	Substances in the blood which destroy or neutralise various toxins or components of bacteria known generally as antigens. The antibodies are formed as a result of the introduction into the body of the antigen to which they are antagonistic as in all infectious diseases.
Bacteria	(singular bacterium) a microscopic, unicellular (or more rarely multicellular) organism.
Biocide	A substance which kills micro-organisms .
Biofilm	A community of bacteria and other micro-organisms , embedded in a protective layer with entrained debris, attached to a surface such as pipework within a water system.
Blow down/bleed off	Water discharged from the system to control the concentration of salts or other impurities in the circulating water; usually expressed as a percentage of recirculating water flow.
Calorifier	An apparatus used for the transfer of heat to water in a vessel by indirect means, the source of heat being contained within a pipe or coil immersed in the water.
Chlorine	An oxidising chemical element (halogen) used in disinfection .
Cold water system (CWS)	Installation of plant, pipes and fitting in which cold water is stored, distributed and subsequently discharged.

Cooling tower	An apparatus through which warm water is discharged against an air stream, where the latent heat of evaporation is used to cool the water. The cooler water is usually pumped to a heat exchanger to be reheated and recycled through the tower.
Concentration factor	Compares the level of dissolved solids in the cooling water with that dissolved in the make-up water (also known as cycle of concentration. Usually determined by comparison of either the chloride or magnesium hardness concentration.
Corrosion inhibitors	chemicals which protect metals by: (i) passivating the metal by the promotion of a thin metal oxide film (anodic inhibitors); or (ii) physically forming a thin barrier film by controlled deposition (cathodic inhibitors).
Dead end/blind end	A length of pipe closed at one end through which no water passes.
Deadleg	Pipes leading to a fitting through which water only passes when there is draw off from the fitting.
Dip slide(s)	A dip slide is a means of testing the microbial content of liquids. It consists of a plastic carrier bearing a sterile culture medium that can be dipped in the liquid to be sampled. It is then incubated to allow microbial growth. The microbial colonies resulting are estimated by reference to chart.
Disinfection	A process which destroys or irreversibly inactivates micro-organisms and reduces their number to a non hazardous level.
Distribution circuit	Pipework which distributes water from hot or cold water plant to one or more fittings/appliances.
Domestic water services	Hot and cold water intended for personal hygiene, culinary, drinking water or other domestic purposes.
Drift	Circulating water lost from the tower as liquid droplets entrained in the exhaust air stream: usually expressed as a percentage of circulating water flow but for more precise work it is parts of water per million by weight of air for a given liquid to gas ratio.
Drift eliminator	More correctly referred to as drift reducers or minimisers - equipment containing a complex system of baffles designed to remove water droplets from cooling tower air passing through it.
Evaporative condenser	A heat exchanger in which refrigerant held in coils is condensed by a combination of air movement and water sprays over its surface.
Evaporative cooling	A process by which a small portion of a circulating body of water is caused to evaporate thereby taking the required latent heat of vaporisation from the remainder of the water and cooling it.
Fill/Packing	That portion of a cooling tower which constitutes its primary heat transfer surface; sometimes called ' packing ' or ' pack '.
Fouling	Organic growth or other deposits on heat transfer

	surfaces or within pipework causing loss in efficiency.
Half life	Ratio of system volume to purge rate.
Hot water system (HWS)	Installation of plant, pipes and fittings in which water is heated, distributed and subsequently discharged (not including cold water feed tank or cistern).
Legionnaires' disease	a form of pneumonia caused by Legionella .
<i>Legionella</i>	A genus of aerobic bacteria that belongs to the family Legionellaceae which has over 50 species. These are ubiquitous in the environment and found in a wide spectrum of natural and artificial collections of predominantly warm water.
legionellae	Plural of legionella a single bacterium of the genus <i>Legionella</i> .
<i>Legionella pneumophila</i>	The species of <i>Legionella</i> that most commonly causes Legionnaires' disease.
Legionellosis	Any illness caused by exposure to Legionella .
Pontiac fever	An upper respiratory illness caused by Legionella , but less severe than Legionnaires' disease .
Make-up water	Fresh water which is added to a water system e.g. a cooling water system to compensate for wastage (e.g. via system leaks), evaporative loss and bleed.
Micro-organism	An organism of microscopic size including bacteria fungi, protozoa and viruses.
Non-oxidising biocide	A non-oxidising biocide is one that functions by mechanisms other than oxidation, including interference with cell metabolism and structure e.g. isothiazolone; glutaraldehyde.
Nutrient	A food source for micro-organisms .
Oxidising biocide	Agent capable of oxidising organic matter, e.g. cell material, enzymes or proteins that are associated with microbiological populations resulting in death of the microorganisms. The most commonly used oxidising biocides are based on chlorine or bromine (halogens) which liberate hypochlorous or hypobromous acids on hydrolysis in water. The exception is chlorine dioxide, a gas which does not hydrolyse but which functions in the same way. Other oxidising biocides are ozone and hydrogen peroxide.
Pasteurisation	Heat treatment to destroy pathogens usually at high temperature for a given period of time.
ppm	Parts per million a measure of dissolved substances given as the number of parts there are in a million parts of solvent. It is numerically equivalent to milligrams per litre mg/l with respect to water.
Pond retention time	Time a chemical is retained in the system.
Risk assessment	Identifying and assessing the risk of legionellosis from work activities and water sources on premises and determining any necessary precautionary measures.

Scale inhibitors	Chemicals used to control scale. They function by holding up the precipitation process and/or distorting the crystal shape, thus preventing the build-up of a hard adherent scale.
Sero-group	A sub-group of the main species
Sentinel taps	For hot water services –outlets selected for routine monitoring purposes usually the first and last taps on a recirculating system. For cold water systems (or non-recirculating hot water systems), the nearest and furthest taps from the storage tank or point at which the supply enters the building. The choice of sentinel taps may also include other taps which are considered to represent a particular risk.
Sessile sludge	A general term for soft mud-like deposits found on heat transfer surfaces or other important sections of a cooling system such as the base of the pond.
Shunt pump	A circulation pump fitted to hot water service/plant to overcome the temperature stratification of the stored water used during periods where there is little expected draw off of water from the system usually in the early hours of the morning to circulate the hot water from the top of the calorifier / buffer vessel to the cooler base.
Slime	A mucus-like exudate which covers a surface usually produced by some micro-organisms .
Stagnation	The condition where water ceases to flow within a system and is therefore liable to microbiological growth.
Strainers	A coarse filter usually positioned upstream of a sensitive component such as a pump control valve or heat exchanger to protect it from debris.
Thermal disinfection	Heat treatment to disinfect a system.
Thermostatic mixing valve	Mixing valve in which the temperature at the outlet is pre-selected and controlled automatically by the valve which usually delivers water at a temperature of between 42 - 44°C.
Total viable counts (TVC)	The total number of living micro-organisms (per volume or area) in a given sample remembering that it only includes those organisms detectable by the particular method used.