

BS 8580:2010



BSI Standards Publication

Water quality – Risk assessments for *Legionella* control – Code of practice

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ISBN 978 0 580 67113 5

ICS 07.100.20, 13.060.70

The following BSI references relate to the work on this standard:

Committee reference EH/3

Draft for comment 10/30200234 DC

Publication history

First published, December 2010

Amendments issued since publication

| Date | Text affected |
|------|---------------|
|------|---------------|

Contents

Foreword *ii*

Introduction *1*

- 1 Scope *2*
- 2 Normative references *3*
- 3 Terms and definitions *3*
- 4 Factors to be considered in the risk assessment *5*
- 5 Preparations for risk assessment *5*
- 6 Desktop appraisal of documentation *7*
- 7 Site visit/survey *10*
- 8 Risk assessment reporting *14*
- 9 Risk review *16*

Annexes

- Annex A (informative) Issues to be considered during a risk assessment *18*
- Annex B (informative) Hot and cold water systems *21*
- Annex C (informative) Cooling towers and evaporative condenser systems *24*
- Annex D (informative) Spa pools *26*
- Annex E (informative) Other systems *28*
- Annex F (informative) Example checklist for a spa pool *36*
- Annex G (informative) Equipment *38*
- Annex H (informative) Schematic drawings *39*

Bibliography *42*

List of figures

- Figure 1 – Example of a computer-drawn schematic of an evaporative cooling system *12*
- Figure 2 – Example of a hand-drawn elevation of a hot and cold water system in a commercial building *13*
- Figure D.1 – Diagram of a typical commercial spa pool and associated water system *28*

List of tables

- Table H.1 – Relevance of the components of a cold water system *40*

Summary of pages

This document comprises a front cover, an inside front cover, pages i to ii, pages 1 to 44, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI and came into effect on 31 December 2010. It was prepared by Subcommittee EH/3/4, *Microbiological methods*, under the authority of Technical Committee EH/3, *Water quality*. A list of organizations represented on this committee can be obtained on request to its secretary.

Use of this document

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this British Standard is expected to be able to justify any course of action that deviates from its recommendations.

Presentational conventions

The provisions in this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is "should".

The word "may" is used in the text to express permissibility, e.g. as an alternative to the primary recommendation of the clause. The word "can" is used to express possibility, e.g. a consequence of an action or an event.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

Introduction

Legionellosis is an infection caused by bacteria of the genus *Legionella*. The most serious is legionnaires' disease, a severe pneumonia with a relatively high fatality rate, which was first recognized in 1976. Outbreaks and sporadic infections occur throughout the world. At least 50 species of *Legionella* have been described and twenty have been associated with disease in humans, but the predominant cause of legionnaires' disease is *L. pneumophila*. *Legionella spp.* are opportunistic pathogens of humans and normally inhabit warm moist or aquatic environments where they grow in association with other organisms. In particular, they are known to grow in a range of protozoa. Their predilection for warm water means that they are capable of colonizing artificial water systems and equipment containing water. Legionnaires' disease is not transmitted from person to person, but is of environmental origin and usually contracted by inhaling the organism in an aerosol produced from water contaminated with the organism. Aspiration of water containing *Legionella spp.* can also cause infection, particularly in hospitalized individuals.

There is a chain of events leading to an individual becoming infected with legionnaires' disease:

- the water system needs to become contaminated (inoculated) with the bacteria;
- conditions have to exist within the system for the amplification of the bacteria to sufficient concentrations to cause infection;
- the contaminated water usually needs to be dispersed into droplets fine enough to form an aerosol for transmission to the victim(s);
- inhalation of contaminated aerosols or, in rare cases, aspiration of contaminated drinking water; and
- the exposed individual has to be susceptible to succumb to infection.

The ubiquitous occurrence of *Legionella spp.*, combined with their association with protozoa, means that all water systems are susceptible to contamination with legionellae via the water supply or dust entering the system. It is therefore normal practice to assume that a system can become contaminated. Whether the amplification of legionellae is likely within the equipment or system can be inferred from the conditions of the water; the design, construction and operating conditions of the equipment or system at the time of assessment; and records of treatment and monitoring of the equipment or system in the past. It is not usually necessary to demonstrate the presence of legionellae by laboratory analysis of samples.

The generation of aerosols can be observed in the operation of systems such as cooling towers, evaporative condensers, many industrial processes, spa pools/hot tubs, showers and taps. Many of these can produce substantial aerosols. Some systems, such as cooling towers, evaporative condensers and some industrial processes, can transmit the aerosol widely, exposing a large population over a wide area, up to several kilometres. Spa pools and hot tubs can expose many users and anyone in the immediate vicinity, while showers and taps are most likely to lead only to the exposure of individual users.

Finally, for an individual to become infected following exposure they have to be susceptible, usually having predisposing conditions. Only a very small proportion of those exposed develop disease, but increasing

age, particularly 50 years and over, smoking, being male and being immunosuppressed through disease or treatment increases susceptibility.

Suitable and sufficient assessment of risks allows appropriate control measures to be put in place to protect the health and safety of employees and members of the public who could be affected by work activities. *Legionella* risk assessment is no different, and is a legal requirement under the Health and Safety at Work etc Act 1974 [1]. The Management of Health and Safety at Work Regulations 1999 [2] and the Control of Substances Hazardous to Health Regulations 2002, as amended) [3], make specific requirements for risk assessment. These regulations apply to the control of *Legionella* and are embodied in the Approved Code of Practice and guidance document, "*Legionnaires' disease: The control of Legionella bacteria in water systems*", otherwise known as ACoP L8.

A risk assessment is a live document, not a one-off exercise, and needs to be reviewed regularly, ideally in anticipation of, rather than in response to, changes. For example, the risk assessment for a new construction ought to be performed before commissioning, but then reviewed when the system has been operating normally for several weeks or months.

It is the responsibility of the duty holder to ensure that an assessment is carried out to identify and assess the risk of exposure to *Legionella* from work activities and water systems and to put in place any necessary precautions. The duty holder appoints a person to take day-to-day responsibility for controlling any identified risk from *Legionella* bacteria. The appointed "responsible person" needs to have:

- a) sufficient standing and authority within the organization (e.g. a manager or director) and competence and knowledge of the system to ensure that all operational procedures are carried out in a timely and effective manner; and
- b) a clear understanding of their duties and the overall health and safety management structure and policy in the organization.

If the duty holder is competent, they may appoint themselves responsible person. Further guidance is given in HSG65: *Successful health and safety management* [4].

A person is identified to carry out the risk assessment. This person can be an employee of the duty holder or an external contractor. This British Standard gives recommendations for how such a person conducts a risk assessment for *Legionella*, though the duty holder remains accountable for implementing the recommendations.

1 Scope

This British Standard gives recommendations and guidance on the assessment of the risk of legionellosis presented by artificial water systems. It is applicable to any undertaking involving a work activity or premises controlled in connection with a trade, business or other undertaking where water is used or stored in circumstances that could cause a reasonably foreseeable risk of exposure to legionellae and contracting legionellosis.

The standard is applicable to risk assessments being undertaken on premises, plant and systems for the first time, and to review and audit

where a previous assessment has been undertaken and where control measures might have been implemented.

This British Standard does not give recommendations for:

- a) the assessment of the risk presented by natural waters, including rivers, lakes, ponds, waterfalls, caves, dew ponds or natural recreational facilities, such as boating lakes; or
- b) the preparation of the scheme of control for the risk systems identified.

Annex A gives general guidance on the assessment of systems, while Annex B to Annex E give guidance on the assessment of specific types of system. Annex F gives an example checklist for the assessment of a particular system (spa pool). A list of equipment that might be used by a risk assessor is given in Annex G, and Annex H gives guidance on the production of schematics.

NOTE The guidance in Annex A to Annex E is not intended to be exhaustive; merely to highlight some of the more common issues associated with particular systems to be considered as part of a Legionella risk assessment. Where appropriate, these annexes contain references to publications that give more detailed information about these systems.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 7592, *Sampling for Legionella bacteria in water systems – Code of practice*

Approved Code of Practice (ACoP) and guidance L8, *Legionnaires' disease – The control of Legionella bacteria in water systems* (third edition), HSE: 2000

3 Terms and definitions

For the purposes of this British Standard, the following terms and definitions apply.

- 3.1 aerosol**
suspension in a gaseous medium of solid particles, liquid particles or solid and liquid particles having negligible falling velocity
- 3.2 calorifier**
apparatus used for the transfer of heat to water in a vessel by indirect means and incorporating a source of heat
- 3.3 guidance for control**
findings from the risk assessment that can be used in producing a scheme of control
- 3.4 hazard**
biological, chemical or physical agents or water conditions with potential to cause adverse health effects

3.5 key roles

3.5.1 duty holder

individual(s) with the legal responsibility to ensure that health and safety is managed effectively

NOTE 1 The duty holder is the employer where the risk is from their undertakings to their staff or others, the self-employed person where the risk is from their undertaking to themselves or others, or the person in control of the premises where the risk is from systems in the building (e.g. a landlord who remains responsible for the maintenance of the systems). See ACoP L8, para. 23.

NOTE 2 In most cases there will only be one duty holder, but in cases of shared accommodation there could be a shared responsibility. The duty holder cannot delegate this duty, but can delegate managerial responsibility to the responsible person (see 3.6).

3.5.2 responsible person

individual appointed with, and who has accepted, responsibility under the authority of the duty holder for ensuring that the organization's responsibilities for the control of *Legionella* are met and that all individuals and organizations assigned to carry out tasks in the scheme of *Legionella* control are competent to do so

NOTE 1 Also referred to as the "nominated responsible person".

NOTE 2 In a large undertaking there may be more than one responsible person, each responsible for a part of the undertaking, e.g. each block of a large teaching hospital.

3.6 risk

3.6.1 inherent risk

risk associated with the system before any action has been taken to control it

NOTE In the context of Legionella risk assessment (LRA) there is an assumption that the system is or will be inoculated at some point with Legionella.

3.6.2 risk (general)

likelihood of a hazardous event occurring and its consequences

NOTE In the context of this standard, amplification and dissemination of Legionella spp, and exposure to an aerosol of such, are hazards and legionellosis is a consequence.

3.7 risk appetite

amount and type of risk that an organization is prepared to seek, accept or tolerate

[PD ISO/IEC Guide 73, modified]

NOTE For the purposes of Legionella risk assessment, the appetite is for as low as reasonably practicable (ALARP).

3.8 risk assessments

3.8.1 risk assessment (general)

overall process of risk identification, risk analysis and risk evaluation

[BS 31100]

NOTE Includes hazard identification.

3.8.2 Legionella risk assessment (LRA)

process of identifying and assessing the risk of exposure to *Legionella* bacteria from work activities and from water systems or equipment

3.8.3 risk review

reassessment of both the current risk assessment and control scheme to ensure they are valid and up-to-date

3.9 schematic diagram

simple but accurate illustration of the configuration of the water system, including parts that are out of use

NOTE An example of a computer-drawn and a hand-drawn schematic are given in Figure 1 and Figure 2, respectively. These figures are monochrome, but colour might be useful for schematics of more complex systems.

3.10 scheme of control

procedures and checks intended to control the risk of legionellosis

NOTE The scheme can be in either hard copy or electronic formats.

3.11 WRAS

Water Regulations Advisory Scheme

4 Factors to be considered in the risk assessment

There is a chain of events leading to the infection of a human by *Legionella spp.* which should be considered in any risk assessment process:

- a) contamination;
- b) amplification;
- c) transmission;
- d) exposure;
- e) host susceptibility.

NOTE Further information on each of these is given in Annex A.

5 Preparations for risk assessment

5.1 Competence of the risk assessor

The person appointed to carry out the risk assessment may be the duty holder or an employee of the duty holder, but in many cases it is an external contractor. In each case, they should be able to demonstrate that they have specialist knowledge of *Legionella* bacteria, relevant water treatment and the water system(s) to be assessed, and are competent to carry out any necessary surveys, measurements and sampling (see Clause 7).

NOTE 1 Competence may be demonstrated by, for example, a CV indicating the assessor's experience.

NOTE 2 A complex site might require input from more than one assessor of different expertise.

5.2 Agreeing the terms of reference

The risk assessor should, before conducting the risk assessment, agree the following with the responsible person or/and duty holder.

- a) The scope of the risk assessment, including identifying the systems that are to be assessed and those that are not to be assessed. This is important as certain aspects of the risk assessment could require specialist knowledge or equipment (including PPE) to which the assessor would require access.
- b) Whether a schematic has to be prepared or redrawn as part of the assessment and, if so, its form and its coverage.
- c) The person to whom the risk assessment is communicated and reported.
- d) Time frames for key milestones and the completion of the risk assessment report.
- e) The necessary access to the site to be surveyed and the need for a competent escort, as necessary, who is familiar with the system(s) to be assessed and who will be responsible for the assessor's health and safety (see Clause 7). The assessor has a duty to not put themselves or others at risk during the visit.
- f) That the assessor will be made aware of any factors which could compromise the validity of the risk assessment process, such as planned treatment or maintenance.
- g) Any "permit to work" or access clearance necessary for access to the site of the assessment.
- h) Where a large number of essentially identical units/premises are to be assessed and it would be uneconomical to assess each individual unit/premise, what proportion of these would constitute a representative sample (see 7.3).

While there will inevitably be common factors associated with the many and varied types of premises being assessed such that a proportion of these may be treated as a representative sample (see 7.3), the individual nature of each site should be taken into account.

5.3 Independence

The risk assessor should be able to demonstrate impartiality and integrity when carrying out surveys of legionellae in premises. The risk assessor or assessing organization should also demonstrate valid reasons for any proposed course of action. It should be clear, for example, why a certain number of samples were taken for a premises survey or why a particular recommendation was made.

Where an organization provides risk assessment and other services, then it should have in place safeguards to ensure adequate segregation of responsibilities and accountabilities through appropriate reporting structures.

6 Desktop appraisal of documentation

6.1 Preparation

If a current risk assessment is available, it should be appraised by the risk assessor to determine if it is still valid and to identify any changes.

NOTE 1 Appraising the current risk assessment can give the assessor valuable information about the water systems being assessed and the attitude of the management on site.

NOTE 2 The appraisal of the validity of the existing risk assessment cannot be performed adequately without a site survey (see Clause 7).

An appraisal of the current risk assessment, together with the logbook or other records, e.g. monitoring records, should be carried out to determine whether the system is under control and is continuing to be adequately managed. However, recommendations should still be made in the report to keep these successful controls in place. If the current controls, etc., are found to be insufficient or not to have been fully implemented, or if there has been a change in process or management, then the risk assessor should request/obtain and appraise the following.

- a) Up-to-date logbooks and schematic diagram(s) of the water system(s). This will allow the assessor to determine inherent risk arising from design and construction.

NOTE 3 In the absence of an up-to-date schematic diagram, the risk assessor has to make a value judgement as to whether they have sufficient information to complete and issue a risk assessment.

- b) Any current audits.
- c) The current written scheme of control, including:
 - 1) the maintenance history of the water system(s) to be assessed;
 - 2) training records of, and records of competence checks on, site personnel;
 - 3) monitoring and inspection records; and
 - 4) the scheme for the safe operation of the systems.

6.2 Appraisal of the current scheme of control

6.2.1 General

Where a scheme of control is in place, the risk assessor should undertake a detailed appraisal and audit of the scheme and report on its adequacy. If there is no scheme of control in place, a high priority in the risk assessment recommendations should be that one needs to be produced, unless the risk assessor considers that there is no reasonably foreseeable risk, in which case they should document that this is their assessment.

6.2.2 Appraisal of the maintenance and testing records within the scheme of control

The risk assessor should appraise any records of the scheme of maintenance and control that have been implemented for the water systems, ensuring that there is a signature or electronic identification

against each record, depending on whether the records are stored in hard copy or electronically.

NOTE 1 Study of the maintenance records can help the assessor derive information about the continued success of any control measures that are already in place.

The risk assessor should note the relevance and success of the scheme which has been implemented. Evidence should be sought to confirm that work was completed competently and within a reasonable time, and the identity of those who carried out the work.

For actions taken after adverse results have been found in the past the following should be considered.

- a) Were the correct actions taken and the correct communication chain invoked?
- b) Were the actions taken within a reasonable time?
- c) Were the results rechecked (after the action) to confirm conditions were back under control?
- d) If the actions did not result in better control, was an escalation procedure invoked to help and ensure conditions were eventually controlled? If not, is there an escalation procedure in place?
- e) Were there lessons learned or a new procedure put in place to prevent recurrence?

NOTE 2 The answers to all these questions, and the review in general, might also help the assessor gain some insight into the overall management of the site.

The scope of tests can vary according to the plant on each site, but a check should be made to ensure that all the control items or tests outlined within the ACoP L8 for each type of system are being considered.

If these records are not being kept, or cannot be found, the assessor should recommend that a system is put in place as a matter of priority in the final report.

6.2.3 Appraisal of management responsibilities

The risk assessor should check that:

- a) the duty holder, the responsible person and any deputies are clearly identified in the written scheme;
- b) the roles of all responsible persons and parties (e.g. consultants, facilities management companies and water treatment companies) are clearly defined and contact details for these persons and parties are readily available;
- c) lines of communication and the reporting structure are clearly stated in the scheme; and
- d) the tasks to be undertaken by each individual or party are outlined clearly with the necessary frequency of the tasks.

6.2.4 Appraisal of training records and competence checks of site and service provider personnel

The assessor should review the training records of those personnel with an involvement in the scheme of control and make comments as to their relevance and validity. In addition to the formal training records,

the assessor should derive an indication of the level of competence of the staff by studying the site records.

NOTE 1 For example, looking at actions taken after adverse results have been found in the past to ensure that suitable corrective actions were taken in a timely manner.

Records may also be checked to verify, as far as reasonably practicable, that staff are competent to take measurements (see 7.4).

Similarly, the assessor might be concerned that the checks on competence are inadequate, in which case they should make recommendations to improve the procedure for confirming competence.

If the assessor considers the training and/or competence of one or more of the parties to be inadequate, they should state this as part of the report and include the need for training or refresher training as a priority in the recommendations of the final assessment report.

NOTE 2 Common faults or shortfalls might include the following.

- a) *No records of checks of competence in place.*
- b) *Records are in place, but there is no indication of how competence was assessed.*
- c) *Records in place, but refer to training rather than employees' ability to work safely and effectively.*
- d) *No checks on contractor, subcontractor and service provider competence.*
- e) *No review to confirm continued and up-to-date competence.*

6.2.5 Appraisal of the safe operation of the systems

The risk assessor should check that there is a scheme for the safe operation and maintenance of all risk systems which:

- a) includes a description of the correct operation of the plant and any precautions to be taken;
- b) details any start-up and shut-down procedures, and plant rotation and flushing requirements for little-used outlets;
- c) includes, where appropriate, method statements, e.g. for major tasks such as cleaning operations;
- d) outlines any tests that are to be completed on the systems, along with the required frequency of the tests and the acceptable control parameters;
- e) details defects or out-of-parameter results; and
- f) logs appropriate corrective actions.

6.2.6 Appraisal of the monitoring and inspection records

The assessor should appraise the records of monitoring and inspections that have been carried out on the systems being assessed, which may be found within the written scheme or a separate document (possibly cross-referenced with the maintenance history reports).

The assessor should identify the control parameters that have been set (both chemical and physical) and check whether these have been set correctly before deciding if the existing control measures are adequate.

NOTE 1 The assessor will not necessarily have the knowledge or experience to determine whether the control parameters are appropriate,

so it might be necessary for the assessor to check this with the system manufacturer or the representative of the water treatment company.

The assessor should note the relevance and success of the monitoring and inspection work that has been carried out as these will indicate whether the correct actions have been taken based on the monitoring results obtained.

The results of inspections should be checked to see whether these indicate whether the control scheme is sufficient.

To obtain an indication of what to expect during the survey, the assessor should consider the following.

- a) Has the work been completed competently and in a timely manner?
- b) Has the work been completed at the correct frequency?
- c) Do the records indicate who carried out the work?

If these records are not being kept, or cannot be found, the assessor should recommend in the final report that such a system be put in place as a matter of priority.

NOTE 2 Common faults found include:

- 1) *no records in place;*
- 2) *records in place, but incomplete due to all actions going unrecorded;*
- 3) *inadequate or no escalation procedures;*
- 4) *records are kept, but corrective actions have not been performed (or recorded as having being performed) following results which are out of specification;*
- 5) *no preventative maintenance in place;*
- 6) *no, or inadequate, records of maintenance in place;*
- 7) *records not kept for appropriate periods, such as the five years required by COSHH [3];*
- 8) *work not completed in a timely manner.*

7 Site visit/survey

7.1 General

As part of the risk assessment, the assessor should conduct a site survey, with reference to the schematic diagrams and logbooks [see 6.1a)]. The assessor should use the survey to check that the diagrams are still valid and up-to-date. They should also familiarize themselves with the processes taking place on site, including how these could place limitations upon measures to control *Legionella* risks. If sufficient information is not available, the assessor should determine whether, in the absence of the schematic diagrams (or any other critical information), they have enough information available to successfully assess the risk. If they conclude that there is not enough information, they may decline to issue the assessment or decide to issue it in draft format.

When carrying out an assessment, be it on a familiar or previously unknown site, the assessor should consider their own personal safety and ensure that they are safe from all other inter-related health risks while undertaking the risk assessment, including those arising from working at height or in confined spaces [6],[7]. The assessor should ensure that

all appropriate personal protective equipment (PPE) is available and suitable, and prepare their own equipment list (see Annex G).

Before commencing a site visit, the assessor should undertake an assessment of the risks of the site survey. All hazards, their assessment and the precautions planned and taken should be recorded (for example, if plant is operating, history of positive *Legionella* testing results).

7.2 Site inspection

While there will be common factors associated with the types of premises being assessed such that a proportion of these may be treated as a representative sample (see 7.3), the individual nature of each site should be taken into account.

If the assessor identifies an imminent danger of exposure to *Legionella*, e.g. failure of a biocide dosing system or a previously unidentified water system, or one which falls outside the scope of their brief, they should report this immediately to the responsible person or their site representative, and not keep this for the written report.

NOTE Attention is drawn to the Health and Safety at Work Act 1974 [1].

The site inspection should include speaking to management and staff to allow the assessor to judge the effects of the management culture and work practices of the organization in adding to (or reducing) the risk.

The suitability of sentinel/sampling points identified in the current control scheme should be reviewed as part of the survey.

The risk assessor should ensure that measurements of, for example, temperature, taken on site are accurate/reliable by checking the equipment and, as appropriate, taking their own measurements. Performance of equipment installed on site may be assessed by checking records.

7.3 Visual inspection of utilities/location for possible sources of contamination

The assessor should examine sentinel points and any discrete plant or component. The assessor should inspect the water systems to confirm that the configuration is as illustrated in the schematic diagram (see Figure 1 and Figure 2 for examples) and to determine the operation and condition of each system and its components to the extent that they could affect the proliferation and dissemination of *Legionella*.

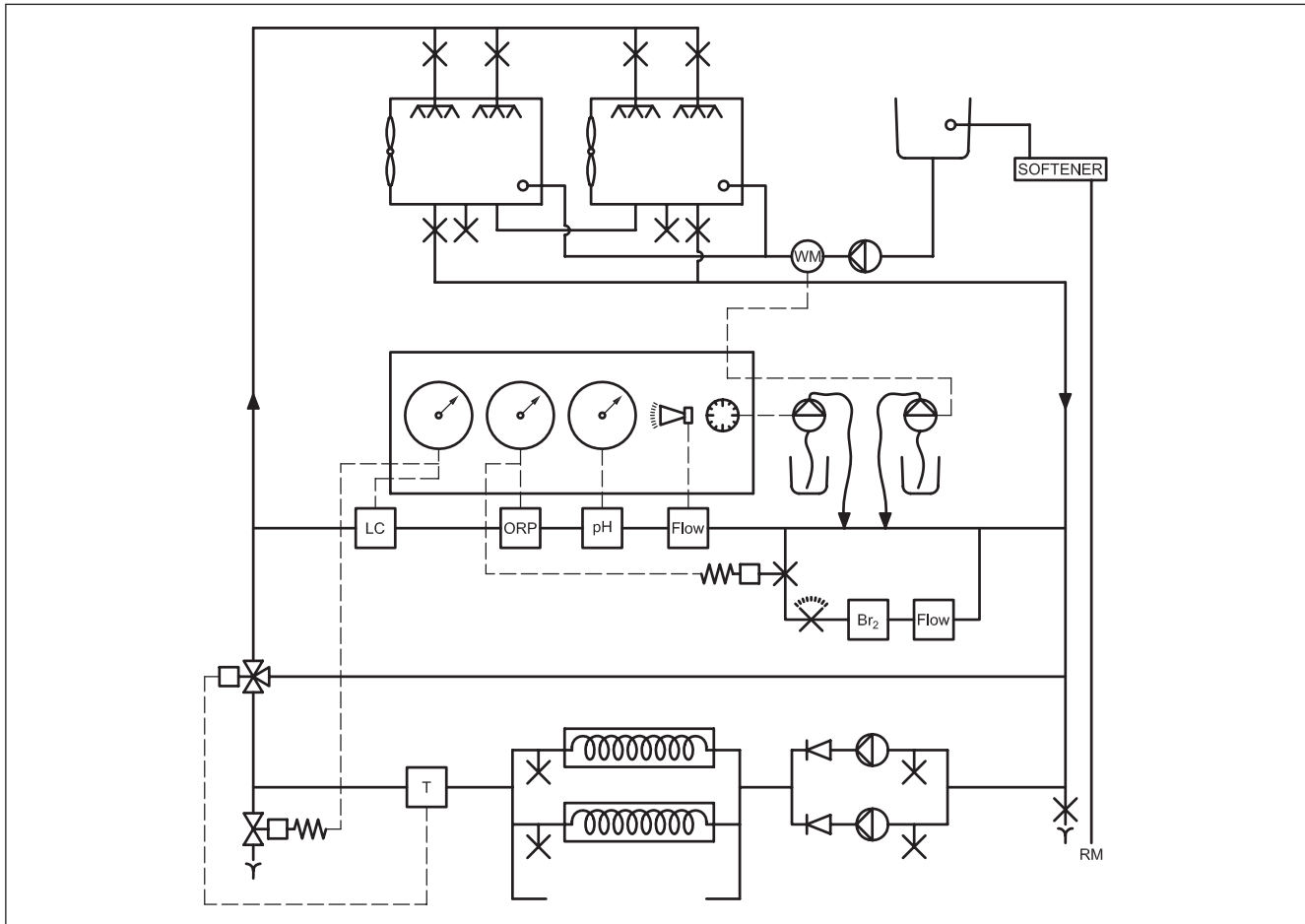
Where the system being assessed consists of several repeated units, such as multiple storeys or pods in a commercial building, the assessor should decide on representative examples to be inspected. A rolling programme should be employed to ensure that the same premises are not assessed in successive cycles. Where there are many individual self-contained units, such as flats or houses, the *Legionella* risk assessment may be scheduled to coincide with mandatory visits, such as those for gas safety checks. This type of approach may be appropriate in situations where access to housing units for *Legionella* risk assessment is problematic for whatever reason.

Where possible, the assessor should check that the materials are WRAS-approved and conform to the Water Fittings Regulations [5].

7.4 Measurements

Measurement of various types (e.g. temperature, pH) should usually be undertaken as a part of the risk assessment. Where such measurements are undertaken, precautions should be taken to ensure accuracy, such as the regular calibration of test meters. Other measurements, such as determination of levels of halogen, may be undertaken using chemical test kits. Similarly, microbiological tests may be utilized, in which case the risk assessor should ensure that the test is suitable to provide the results required for the purposes of the assessment.

Figure 1 Example of a computer-drawn schematic of an evaporative cooling system



7.5 Testing for *Legionella*

Samples for *Legionella* analysis do not normally need to be taken as part of a risk assessment, but where the assessor decides that sampling will assist in determining risk sampling should be carried out in accordance with BS 7592.

NOTE ACoP L8 gives further information on when sampling can be performed.

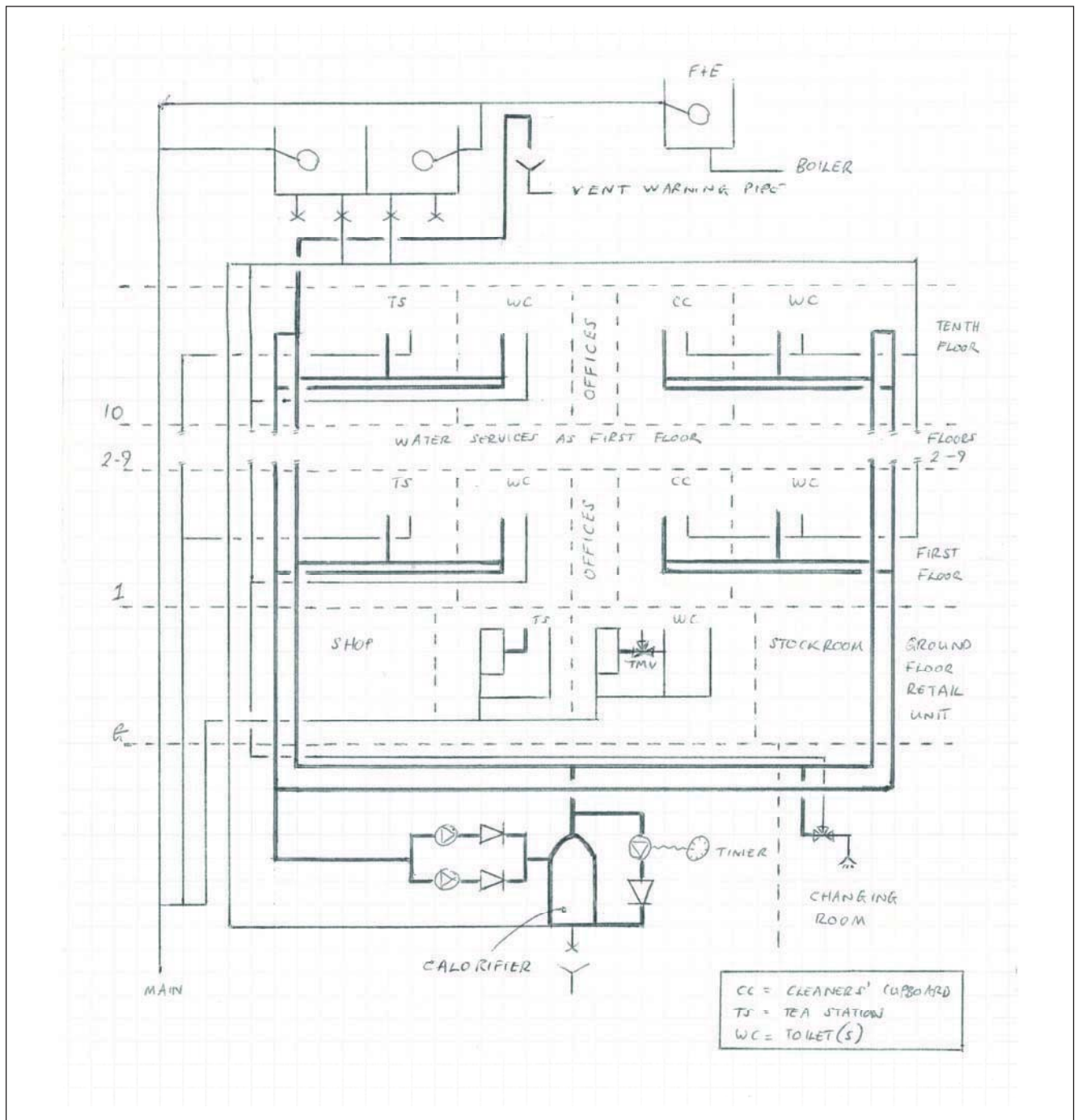
The assessor should consider testing for *Legionella* if any of the following occur.

- The risk assessor encounters a novel situation and/or piece of equipment perceived to be a potential risk to health.
- Failure of, or concerns about, control measures.

- c) It is necessary to verify the operation of a control regime, particularly if it has recently been changed or implemented and the system is known to have previously been colonized.
- d) The assessor has reason to doubt the validity of the results of routine tests or has identified areas of concern during the survey.

Recommendations for any further sampling should be included in any final risk assessment report.

Figure 2 Example of a hand-drawn elevation of a hot and cold water system in a commercial building



7.6 Risk assessment

The risk assessor should identify and record each hazard, and evaluate and assess the risk arising from these.

Each risk should be analyzed appropriately, considering its consequences and the likelihood of those consequences arising, using, for example, a risk matrix.

While there will inevitably be common factors associated with the many and varied types of premises being assessed such that a proportion of these may be treated as a representative sample (see 7.3), the individual nature of each site should be taken into account.

The risk assessment should take into account the inherent risk, the controls in place and how well these mitigate the risk.

NOTE 1 Resources in an organization are finite, so an understanding of inherent risk might help to ensure that the response is proportionate to the risk. It might also help the organization to understand what its full exposure could be if controls fail, and therefore recognize the contribution of certain controls to overall risk mitigation.

The risk assessor should evaluate risk by appropriately combining factors and comparing the levels of risk with the level acceptable (or risk appetite) for each circumstance (in this instance, as low as reasonably practicable [ALARP]). The risk factors should be prioritized according to how soon each might occur and their manageability.

NOTE 2 The level of risk increases with:

- a) the temperature of the water (>20 °C and < 50 °C);
- b) the rate of growth and the amount of microbial flora present, excluding legionellae;
- c) the rate of growth and the amount of *Legionella* present;
- d) the amount of aerosol produced and the time over which it is produced;
- e) the degree of dissemination of the aerosol into the atmosphere; and
- f) the number of people potentially breathing the aerosol, their length of exposure and their susceptibility.

NOTE 3 If the system contains water generally between 20 °C and 50 °C, but particularly between 32 °C and 42 °C, and an aerosol can be generated under any foreseeable circumstance (operation or maintenance), then it is a risk system.

8 Risk assessment reporting

8.1 General

The results of the risk assessment, including tests, measurements, checks and recommended remedial works, should be presented as a formal document, in hard copy or electronic form.

While there will inevitably be common factors associated with the many and varied types of premises being assessed such that a proportion of these may be treated as a representative sample (see 7.3), the individual nature of each site should be taken into account.

The report should be concise, clearly explain the scope of the assessment, identify the key people, including the duty holder and

the responsible person, and be sufficiently detailed to allow owners of the risk an appropriate understanding of the key issues and actions required to control the risk of legionellosis. The report should be readily understandable by the people for whom it is intended and, most importantly, be clear and unambiguous in its findings and recommendations.

NOTE 1 In some cases where third parties undertake the assessment, it might be helpful to send the draft risk assessment report to the responsible person in sufficient time to allow recipients to adequately review its content and allow comment as to whether specific details are accurate and the assessment is appropriate.

NOTE 2 In the event that the assessment process identifies a significant risk that requires immediate attention, a process is necessary to allow the assessor to urgently communicate to the responsible person any areas of evident concern prior to receipt of any written assessment report.

The risk assessment report should highlight the status of any key risks identified (e.g. low, medium, high risk) and indicate:

- a) the underlying cause/source of risk(s), e.g. a particular activity or process, or source of water;
- b) whether the risk can be eliminated, e.g. "Removal of the little-used shower in Room XX";
- c) if the risk cannot be eliminated, whether the risks are being managed effectively;
- d) evaluation of the various risk factors (e.g. mechanical, operational or chemical) and the prioritization of corrective/remedial actions; and
- e) when the assessment is to be reviewed.

Where the risk assessment identifies a reasonably foreseeable risk of exposure to *Legionella* bacteria a written scheme for controlling the risk should be recommended. The written scheme may form part of the risk assessment or can be provided under separate contract (see 8.3).

NOTE 3 It is important that the views of personnel involved in the operation and maintenance of the water system are taken into account in the preparation of the written control scheme.

8.2 Risk scoring systems

Legionella risk assessments may contain a "risk scoring system" or "risk algorithm" as an aid to understanding the relative risk of the systems assessed. However, any scoring system used by the risk assessor should be explained to the intended reader and cover the following.

- a) *Contamination.* An evaluation of the risk at source, including assessment of the quality, temperature and integrity of the water supply.
- b) *Amplification.* Determination of the cultivation conditions: assessment of the likelihood that *Legionella* will proliferate, including an assessment of conditions such as the temperature, water change rate, areas of static or slow water movement and how conducive the conditions are to microbial growth.
- c) *Transmission.* An assessment of whether droplets or aerosols are likely to form and spread.
- d) *Exposure.* Determination of the risk that droplets or aerosols will be inhaled (or contaminated water aspirated).

- e) *Host susceptibility.* An evaluation of the nature of the exposed population, taking account of their vulnerability when exposed to *legionellae*.

For the implementation of a risk scoring system to be of value, the repeatability of the system should be assured by clear guidance on the application of such a system to all risk assessors undertaking such evaluations.

8.3 Control measures

Having used their knowledge and experience to determine the degree of risk constituted by the system, the assessor should make practical recommendations to control any risk identified to ALARP. The recommendations should be prioritized, ideally with an indication of timescales. For example, if the assessor concludes that the system being assessed is a risk system, they may recommend that the risk(s) be eliminated/minimized or substituted with a lower risk(s). For site- and system-specific control measures (monitoring, inspection and treatment), including the identification of sentinel outlets or other relevant sample and inspection points, the assessor may also recommend:

- a) short-term control measures to be applied until completion of corrective actions; and
- b) long-term control measures to be applied following completion of corrective actions.

The assessor should also recommend that a management scheme is put in place to ensure that all the necessary controls are maintained, monitored and remain effective.

NOTE The risk assessment does not involve the preparation of the written scheme of control, but rather provides information that is critical to the preparation.

9 Risk review

NOTE A risk assessment is reviewed when there is a change in the following to ensure that it remains valid, or once every two years, as recommended by ACoP L8.

- a) The water system or its use.
- b) The use of the building in which the system is installed.
- c) The availability of information about risks or control measures.
- d) The management of control measures or water source/quality.
- e) Any of the factors in Clause 4.
- f) Where new construction work is expected to be carried out.

9.1 When reviewing a current risk assessment to determine whether it remains valid, the risk assessor should consider:

- a) the key risks identified and how these are changing over time;
- b) the monitoring data for the controls in place;
- c) whether key risks are being managed so far as is reasonably practicable (see HSG 65 [4]);

NOTE See COSHH [3] and ACoP L8.

- d) resources and how they are prioritized; and
- e) escalation of risk management issues.

In particular, the assessor should examine:

- 1) the training and experience of the duty holder and responsible person and those with any input into the management and control, e.g. samplers, temperature monitors;
- 2) supplier and owner changes;
- 3) schematic diagrams to see if these are present and up-to-date;
- 4) the audit trail of document changes;
- 5) the cleanliness and condition of the system, including materials;
- 6) the risk assessment and current control scheme to ensure these can be read and that they make sense as stand-alone documents and are not just lists of cross-references; and
- 7) some temperatures with an independent temperature monitoring device.

9.2 The review of a risk assessment should reflect the risk assessment process in Clause 5 to Clause 8.

The risk assessment should be revised as appropriate in response to the risk review.

Annex A (informative) **Issues to be considered during a risk assessment**

A.1 General

This annex gives guidance to enable an assessment to be made of the potential for a system or piece of equipment to support the growth of legionellae and create a risk of legionellosis. Conditions supporting the growth of legionellae could occur frequently under normal operation or infrequently during exceptional but predictable circumstances, for example, during maintenance or following a period of non-use. It might be perceived that there is a potential risk but that it is normally controlled by some feature of the design or operation of the equipment. However, if, for example, the design or application is new or novel, any control measures need to be validated, and this will normally involve testing.

A.2 Contamination

The chances of legionellae being introduced into the water or moist environment of the equipment/system are higher if the water entering is derived from a natural source, such as a river, lake or spring, or a private water supply, rather than a treated and disinfected mains water supply. Water from natural warm springs commonly contains high concentrations of legionellae. It may be assumed that the public mains could contain legionellae in low concentrations. Consequently, it is usually not practicable to prevent legionellae entering a water system at some time, either from the water supplied to it or from contamination entering as dust or dirt from the air or surroundings during maintenance or normal operation. The exception might be a completely closed system that is supplied with sterile water, but even then there is the possibility of contamination during temporary opening for maintenance or possibly back-colonization from an outlet. Drains can become colonized by micro-organisms, including legionellae, so that outlets could be contaminated by splashes from a drain and subsequently become colonized. Thus, any system/piece of equipment ought to be considered a potential source of infection by *Legionella* species if it contains or uses water and assessed for the potential for *Legionella spp.* to grow within it, either during normal operation, maintenance or some other predictable but less common circumstances, such as temporary shut-down.

The potential for nutrients to enter the system, for example by airborne contamination, can be influenced by the location and/or operating characteristics of the equipment.

Apparently clean systems can be rapidly re-contaminated by microbial growth (biofilms) within dead legs.

A.3 Amplification

A.3.1 General

When legionellae multiply they require appropriate physico-chemical conditions and sufficient nutrients for them and their supporting organisms to grow.

NOTE Legionellae are unable to grow without the support of other organisms, and can grow inside protozoa.

In rare instances a piece of equipment is a potential source of infection without amplification of legionellae occurring within it. For example, a nebulizer or other misting device filled with water that already contains high concentrations of legionellae. In this case the temperature of the water in the equipment needs only to be conducive to survival rather than growth. Legionellae can survive below 20 °C and die slowly at 50 °C.

Legionellae can grow in biofilms in association with water. Unless distilled, the water will normally be a weak complex solution of inorganic minerals and possibly organic compounds. Legionellae can also grow in biofilms in association with more semi-solid matrices, such as the sediments, moist soil and sludges in some effluent treatment systems. These more solid materials can be broken up, homogenized in the water and aerosolized in some manner, but they would also release legionellae into any water surrounding them, which could in turn become aerosolized.

A.3.2 Physico-chemical conditions

The physico-chemical conditions in the equipment/system have to be considered. Temperature is particularly critical. Legionellae are generally considered to be capable of growth between 20 °C and 45 °C, but most rapid growth occurs between 32 °C and 42 °C, so this is the temperature range associated with the highest risk. The pH appears to be less important as legionellae can grow or survive in the range of pHs likely to be found in most equipment and systems. Highly saline and similar environments are unlikely to support legionellae, but there is insufficient evidence published to define a safe concentration.

A.3.3 Nutrient sources

Nutrients for the growth of the legionellae and their supporting flora can be derived from the incoming water. There is a spectrum of nutrient levels in the incoming water, ranging from mains water derived from groundwater (lowest) through to untreated lowland river water, hypertrophic (nutrient rich) lake water or sewage contamination (highest). Nutrients can also be derived from dirt entering the system during construction, normal operation or maintenance. Some sites, such as food processing plants, can constitute a higher risk environment due to airborne powdered ingredients (e.g. flour, chocolate powder) in the atmosphere, both within and without the plant, which can be of an intermittent nature. The potential for system contamination with respect to the siting of factory exhausts and protection of the system(s) from airborne contamination have to be considered.

It is also important to consider the ability of the materials used to construct the equipment to supply nutrients and support microbial growth. Where components of equipment (e.g. piping, washers, seals and couplings) or systems are made of synthetic materials that could leach nutrients, e.g. plastics, the materials have to be tested for their ability to support microbial growth and conformity with BS 6920-2.4, and be WRAS-approved.

A.3.4 Design

The design of the system or equipment is important. Stagnant or slow-flowing water increases the risk of sedimentation of particulates out of the water, which can act as a focus for growth. Biofilms formed on surfaces at low flow rates are less firmly attached and prone to detaching. The presence of intermediate tanks and lengths of pipe with limited, intermittent or no flow could also be factors increasing risk. Recycling of water could lead to the concentration of dirt and nutrients. Inevitably, sediments, other deposits such as scale and corrosion, dirt and possibly growth can accumulate in the equipment or system over time and these could offer sites for growth and inhibit the effect of some control measures. The assessor has therefore to ascertain whether the equipment or system is readily and safely accessible and can be dismantled for thorough cleaning and maintenance.

A.3.5 Water treatment and maintenance

Any water treatment or other processes already in place to control or minimize the accumulation of deposits and growth need to be reviewed to evaluate their likely effectiveness. All biocidal treatments have to be of known effectiveness against legionellae and its supporting flora and have been validated to be effective in the system/equipment and situation being assessed.

A.4 Transmission

Water containing legionellae has to be transmitted to humans before it can be inhaled or aspirated. For inhalation to occur, the water has to be aerosolized, producing droplets small enough to be inhaled. Aspiration occurs when water is drunk but, instead of going down the throat into the stomach, goes down the wrong way into the lungs; this can also happen when ice cubes are sucked.

Systems and equipment ought to be examined for any mechanisms which can generate and release aerosols into the surrounding environment. Any process that causes the mechanical disruption of the air-water interface can produce droplets and thereby form aerosols. Dense sprays obviously generate aerosols, but running a tap, flushing a toilet, water trickling onto a hard surface and bubbles bursting at the surface of a liquid can all generate aerosols, albeit to a lesser degree. While high density aerosols, such as those generated from a cooling tower or high-pressure spray cleaner, have the potential to infect large numbers of people over a large area, smaller amounts of less dense aerosol might still present a significant risk to a susceptible individual in the immediate vicinity of the source.

The rate of the aerosol generation and the distance the aerosol has to travel before inhalation also needs consideration. Forcing water containing legionellae through a small orifice under high pressure might well be an efficient mechanism for aerosolizing the water, but the shearing forces could kill or injure a significant proportion of the bacteria, whereas, for example, dropping water onto a spinning disc, such as the cutting bit on a machine tool, could generate a less dense aerosol but only cause minimal injury to the bacteria, leaving a higher proportion that remains infective. Once in the air the water in small droplets rapidly evaporates, leaving a small particle or droplet nucleus containing any salts and particulate matter, including bacteria that

were in the original droplet. The legionellae have to survive this drying process and subsequent transmission through the air before inhalation.

A.5 Exposure

Obviously, the closer a person is to the source, the more likely they are to inhale the aerosol before it has become disseminated and the bacteria in it have died. One of the reasons spa pools (see Annex D) have a high inherent risk is that dense aerosols are generated relatively gently by bubbling at the surface, close to the bather's nose and mouth. Similarly, the aerosol from contaminated cutting oil which is used to lubricate the spinning cutting bit of a machine tool is generated very close to the operator.

It is important to consider the risk generated under all modes of operation and maintenance. For example, during normal operation some systems could be entirely enclosed so that no risk is generated, but this might not be true when the equipment is opened for cleaning and maintenance.

The danger of aerosols can be eliminated by a physical barrier between people and the source, or ameliorated by other means such as ducting away the contaminated air or capturing a significant portion by a mechanism such as the drift eliminators (reducers) in a cooling tower.

A.6 Host susceptibility

Some individuals are much more likely to become infected than others. Susceptibility increases with age, and males are more likely to become infected than females (ratio of 3:1). Smoking is a significant risk factor. Disease or therapy that reduces immunity, such as organ transplantation, cancer, blood disease and diabetes, also significantly increases the risk of infection.

The nature and proximity of the population exposed to the system or equipment also needs consideration. For example, if the equipment/system is sited in a hospital ward housing immunocompromised individuals, any chance of emission of an aerosol containing legionellae might be considered unacceptable. Consequently, more stringent precautions or complete replacement of the equipment/system by an alternative without an associated risk of aerosol generation might be required.

Annex B (informative) Hot and cold water systems

Hot and cold (often referred to as "domestic") water systems are very common and it is likely that they will be the first type to be assessed by most new assessors, as they are relatively familiar from similar systems in their homes. Although systems in large buildings might appear to be simple, they can be very complex, with substantial proportions of the pipework concealed and difficult (or even dangerous) to inspect. In addition, especially in older buildings, some components are made of unsuitable materials, wrongly sized for present-day usage, or have been modified in ways which make understanding the configuration or function difficult.

The water normally used as supply to these systems is public mains supply, which constitutes little direct risk, depending on the depth of

the supply pipework into the building (where the supply pipes are close to the surface or above the surface when entering the building system there can be significant heat gain in the summer, potentially raising the temperature above 20 °C). There could, though, be a different source, such as a private borehole, so the water source(s) needs to be established at the outset of the assessment and any additional risk taken into account. A system can become infected not only by supply water, but also by dirt entering uncovered or poorly covered tanks during maintenance and back-contamination from the outlet/splashback from taps.

Where mains water is fed directly to the outlets, the risk would be expected to be minimal, though a risk could still be present, for example, where a pipe passes through a warm environment to a rarely or seasonally used outlet. For this reason an assessment is still needed. In the majority of systems there is some storage of water, which can result in changes in temperature, contamination and possible stagnation, so the risk of legionellae growth is increased. Indeed, these systems appear to be the cause of many sporadic cases of legionnaires' disease.

There is extensive information on control of *Legionella* in hot and cold water systems in ACoP L8 and associated documents. It is necessary that the assessor understands the guidance and has a clear understanding of how all the control measures work and are administered. The assessor also requires knowledge of the design aspects of these systems and how these affect the risk.

The commonly accepted method of controlling *Legionella* in hot and cold water systems is by control of temperature:

- a) ensuring the hot water is maintained at 60 °C from the outlet of calorifiers and at or above 50 °C at the return to the calorifiers, and that it reaches a minimum of 50 °C within one minute of turning on a tap; and
- b) ensuring the cold water is stored below 20 °C in cisterns (and ideally throughout the whole distribution system) and that it does not exceed 20 °C within two minutes of turning on the sentinel taps.

The intrinsic risk of storage water heaters is greater (due to stratification) than that where there is no storage, such as plate heat exchangers or well-designed electrical instantaneous shower heaters. ACoP L8 specifies programmes of regular routine checks to confirm that these temperatures are being achieved. Records of the results will help the assessment of the risk arising from inconsistency in control.

It is appropriate to test for *Legionella* in systems where biocide or other chemical or physical control is in use; in premises where there are people especially vulnerable to *Legionella* infection; when controls (temperature or other) fail; or in the event of one or more cases or suspected cases of *Legionella* infection. Many commercial premises are also tested as a matter of routine, even though they do not fall into any of these risk categories. The results of any such monitoring need to be considered in the risk assessment.

Some systems are monitored for general background bacteria (heterotroph) levels, commonly termed "total viable count" (TVC). Whilst frequent, well-conducted monitoring of this type, together

with trend analysis, can yield information on the water condition, there is little or no correlation between heterotroph levels and the incidence of *Legionella*, so appropriate caution needs to be exercised in considering the results in a *Legionella* risk assessment.

Contamination with material which can yield nutrients or provide shelter is also a factor in *Legionella* control and ACoP L8 advocates that visual checks are carried out. It is recommended that the assessor examines these records to see the history of findings, but also inspects the plant during the assessment.

Examination of cisterns for configuration, flow pattern, protection against contamination, materials of construction, condition, temperature, size in comparison to water consumption and cleanliness or contamination is an essential part of the assessment. A photographic record will be a useful addition to the report, whether it shows satisfactory or unsatisfactory conditions. Examination of the interior condition of the calorifier can provide useful information for the risk assessment. However, the size, design and mode of action of some calorifiers make internal inspections problematic or impossible. However, where it is reasonably practicable to do so, such an inspection ought to be considered. This might be difficult to perform during the initial survey of the system when it is in its normal working mode, in which case an additional visit during a period of system down-time, e.g. during maintenance, might be required to carry out the inspection. Alternatively, records of recent previous assessments of the internal condition of the calorifier can be used, together with an assessment of the condition of the calorifier drain water.

Service provider staff and site personnel are required to be competent to carry out their duties, so the assessor needs to check and report on these aspects. For example, training is necessary to ensure people involved in temperature monitoring understand how to use their equipment correctly and why the work is important. In systems where methods of control other than temperature are used, service providers and staff need to be competent in the appropriate checks, chemical handling, dosing, sampling, testing and adjusting of dosage rates to allow the required parameters to be met. They also need to be aware of the communication channels to indicate when monitored parameters are out of specification.

Where maintenance has been carried out on systems, the assessor needs to inspect any records; if any of the expected records are not available, this might be an indication of poor management control and needs to be recorded and considered as it affects the risk.

The survey involves practical inspection of the whole system, not just the tanks and calorifiers. During the inspection the assessor is looking for any elements of the design, construction or operation which could lead to conditions under which *Legionella* would be expected to multiply and for any unnecessary sources of aerosol, for example the following.

- 1) Any points in the system where there can be no flow, e.g. blind ends, dead legs and little-used outlets.
- 2) Any parts of the system with low water throughput, including low-use fittings such as in unoccupied areas or oversized cisterns.
- 3) Any parts of the system which are configured in parallel with others and where the water flow could be unbalanced.

- 4) Routes by which contamination can enter, including poorly fitting lids on cisterns, unscreened overflow pipes, inappropriate cross connections, inadequate backflow prevention and emergency water supplies.
- 5) Cold zones at the base of storage calorifiers.
- 6) Installations where a fault causes either the hot water to flow into the cold water system, or vice versa. The causes of this can be many and varied and are related exclusively to the local installation. If this problem is found it needs to be pointed out to the system maintenance operator for rectification as soon as possible.
- 7) Any parts of the system where incubating temperatures might prevail, including dead legs, under-used outlets, showers and thermostatic mixing valves (TMVs).
- 8) Sources of heat transfer, including heating, hot and cold pipes running together such that cold water is heated, sharing a common duct, shared lagging materials and insufficient lagging.
- 9) Materials of construction which could yield nutrient or otherwise support microbiological growth.
- 10) Excessive scale, sediment or corrosion, including at the outlets.
- 11) Any changes to a system which might create stagnant areas, alter flow, or create dead legs, blind ends, etc.

Annex C (informative) **Cooling towers and evaporative condenser systems**

These systems either circulate water through a heat exchanger to remove heat from a process or system then pass it through a tower to cool ("open type") or they are configured with the heat exchanger within the cooling tower ("closed type"), usually comprising horizontal tubes known as coils. If the coils contain refrigerant, the cooling tower is known as an evaporative condenser.

Within the cooling tower the water flows down over the fill pack or coils and is either broken into droplets or formed into films causing some of the water to be evaporated. The remaining water continues to circulate through the system with make-up water being added to compensate for that lost through evaporation. This process produces large quantities of aerosols. Fans on mechanical draught coolers which force air across or against the flow of water to assist the evaporation (and hence cooling) process can blow the aerosols, known as "drift", into the atmosphere unless control measures are in place, i.e. drift reducers (eliminators). High-efficiency drift eliminators, when fitted correctly, significantly reduce the amount of aerosol released into the atmosphere.

Most such systems operate at temperatures and other conditions that would support the growth of legionellae if left unchecked. Without controls, the released aerosol could contain high levels of legionellae that could be inhaled by many people (depending on location and other prevailing conditions, such as wind direction), some of whom could be highly susceptible to legionellosis. In certain weather conditions aerosols could remain stable for several tens of minutes and travel a long distance, so it is necessary for the duty holder to consider the proximity of potentially susceptible populations.

The location of nearby hospitals, nursing homes and care homes can be identified using local knowledge and satellite imagery available on a number of websites. The closer such premises are to the systems, the greater the risk.

The continual addition of fresh make-up water into these systems (to replace that evaporated or lost through purging, leaks, etc.) provides an opportunity for inoculation with legionellae. Inoculation of the system might also occur via material (e.g. dust) entrained in the air that is drawn or pushed through the cooling system. The quality of the air passing through the tower has a bearing on the likelihood of growth of legionellae (soot, dust or dirt that could provide nutrients and the introduction of legionellae to the system from droplets of water from other nearby towers). Process contamination could be a further source of nutrients in cooling towers and has also to be considered in the assessment.

The source of make-up water needs to be ascertained as the water quality will likely affect the risk of inoculation of the system with legionellae and other contaminating material. Cooling water can come from a variety of sources, ranging from good quality towns mains through river or canal water and, more rarely, secondary treated sewage. Clearly, the more contaminated the water source, the greater the risk of contamination of the system and this will have a bearing on the overall risk.

If the growth of legionellae is uncontrolled, these systems are classed as very high risk. If the assessor were to find such a system in which no controls are in place, they would immediately give advice that the system presents a real danger to people and that immediate action be taken to prevent or control exposure.

It needs to be remembered that such a system includes not only the cooling tower and evaporative condenser units, but also associated plant such as the flow and return pipework, pumps, heat exchangers, any bypasses and cross connections, collection sumps, etc., and components in the feed system. These might include break tanks, booster pumps and pre-treatment plant, such as water softeners, in which case a note ought to be made of this. In addition to the checks in Clause 6, the water treatment programme needs to be checked to ensure it is effective and includes measures to prevent corrosion, fouling, biofouling and build-up of scale. If any of these adverse conditions are found, remarks would be made in the assessment.

It is normal for such adverse conditions in the assessment to be supported by photographic evidence (though some sites, particularly chemical and petrochemical plants, do not allow cameras due to security and safety considerations).

The survey will also include checking that the dosing equipment itself is in good working order. Consideration may also be given to other conventional health and safety or environmental hazards to ensure that the chemical use is not presenting additional unnecessary risk (e.g. COSHH, work at height and manual handling issues, pumps and lines are not leaking).

The risk assessor has to check that the samples for microbiological analyses are collected in accordance with BS 7592 to ensure the validity and relevance of the results, e.g. collected from appropriate points; taken at times when the biocide concentration is at its lowest; and

biocides where appropriate are neutralized, transported and analysed within an appropriate time frame. Non-oxidizing biocides are usually difficult to neutralize. Samples from systems treated with non-oxidizing biocides need to be processed as soon as possible after collection.

Components of the system have to be clean, undamaged and correctly fitted. This is especially true of drift reducers (eliminators), which ought to be inspected as part of the assessment.

The risk assessor will also check whether the materials of construction are likely to support the growth of micro-organisms and that components do not cause operational difficulty and have safe access.

The design of the system will be checked to ensure that water does not become stagnant in dead legs, blind ends, duty/stand-by equipment (including towers and pumps), or in parts of the systems switched off or isolated for periods of time, or which experience poor flow conditions in balance pipes on towers and by-pass systems, etc. If any design faults are identified, recommendations will be made that they are rectified.

An important consideration in the safe operation of evaporative cooling plant is that it is maintained in a clean condition and that the water circulating through the system is kept clean. An assessment of cleanliness is therefore a key measure in the control scheme, and the risk assessment has to include an appraisal of the ease with which this can be achieved. Consideration ought to be given to safe and effective access to key components in the system, such as packing material in cooling towers, heat exchangers, and other internal surfaces that could be prone to build up of biofilm and other contaminating material. ACoP L8 provides guidance on the frequency with which such cleanliness checks ought to be performed and there is additional practical guidance available, in particular relating to cooling tower packing material (<http://www.hse.gov.uk/legionnaires/coolingtowers.htm>). Consideration ought also to be given to the means by which dirty components might be cleaned and any difficulties highlighted in the risk assessment.

Only when sufficient controls are in place, and the system is maintained in a clean condition and a good state of repair, would such a system be classed as operating at minimal risk.

Annex D (informative) Spa pools

Spa pools and hot tubs are warm water leisure pools designed for sitting or lying in up to the neck for therapeutic effect (and not for swimming). They are aerated by water jets and often also by air jets which create a stream of bubbles that break at the surface, releasing aerosols in close proximity to users' faces.

"Spa pool" refers here to pools within commercial premises, such as health clubs and leisure complexes, which contain water and are not cleaned or drained after each use (as opposed to a whirlpool bath). These systems can be very complex (see Figure D.1). They are generally stand-alone overflow type pools with a balance tank to maintain the water level when users enter or leave the pools.

NOTE 1 A domestic spa pool installed in a hotel bedroom or holiday home ought to be assessed as a commercial spa pool. Similarly, spa pools rented out to domestic dwellings for parties, etc., have also to be considered commercial.

In very large spa pools balance tanks can be of similar construction and design to swimming pool systems with underground balance tanks.

NOTE 2 Access to underground balance tanks for cleaning purposes is covered by the Confined Spaces Regulations [7]

Smaller pools have balance tanks usually made of glass-reinforced plastic, with a firmly fitting lid, and are accessible for regular cleaning. Spa pools are treated by continuous filtration through a sand or diatomaceous earth filter, together with chemical treatment; usually oxidizing biocides such as chlorine and bromine. They can also have ozonators or UV light systems.

Hot tubs are stand-alone systems intended for domestic use only; they are not cleaned or drained between users. They usually have removable cartridge filters and are intermittently treated with chemicals by hand-dosing or with floating/slow release dispensers that rely on the user checking that they are kept topped-up. They might also have built-in ozonators or UV light systems. They are not normally of the overflow design and, therefore, do not usually have balance tanks.

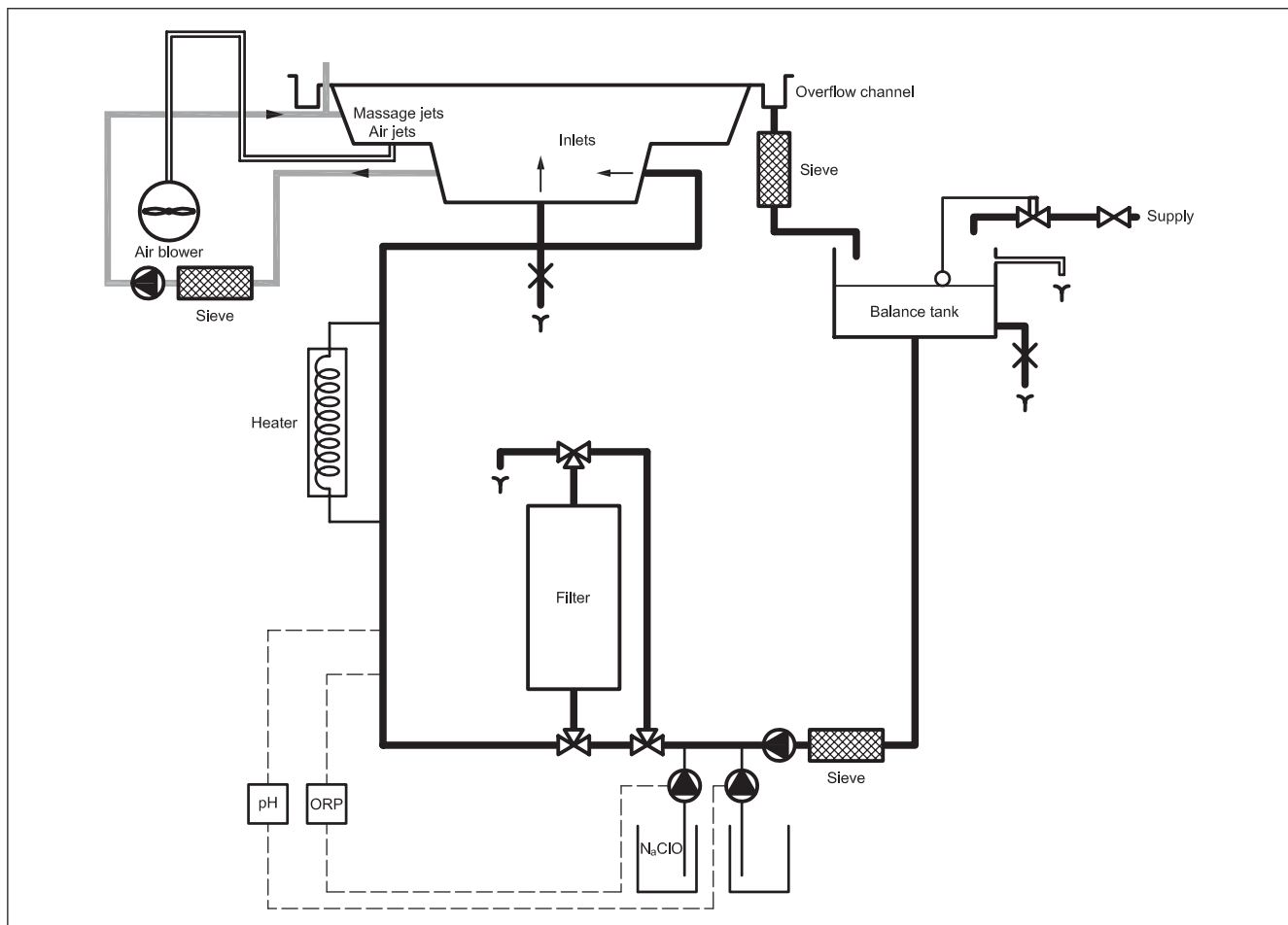
Spa pools and hot tubs fulfil the criteria for classification as a high-risk system for acquisition of legionellosis.

- a) *Innoculation.* Small spa pools in hotels and holiday lodges and hot tubs in private homes can be sited outdoors, which increases the potential for dust and dirt to enter the system and the need for more regular cleaning. Sometimes, these are filled by hosepipes which could themselves become colonized and introduce additional risk (ideally, pipes are plumbed in with appropriate back-flow protection).
- b) *Temperature.* The operating temperature, typically 32 °C to 40 °C, is within the range for legionella multiplication.
- c) *Nutrient availability.* In most spa pools and particularly hot tubs there is a low water volume-to-user ratio, so the scrubbing action of the water and/or air jets removes skin cells and other nutrients, such as cosmetics, tanning products, creams and lotions, from the skin of users, and these can then support microbial growth. These systems have a high surface area, often with many metres of pipework supplying the water and air jet systems. They are often difficult to clean, particularly the system pipework which is prone to biofilm build-up. The air jet system does not get disinfected by the passage of the treated water above the water level and is therefore subject to condensation and biofilm build-up. In domestic systems the air jet system is built into the fabric of the pool wall and base, terminating in small holes which are completely inaccessible for cleaning.
- d) *Dissemination.* The action of the water and air jets produces high velocity small bubbles which burst close to the user's face, with the result that aerosols are inhaled. When sited within buildings, the temperature and humidity in the proximity of the spa pools increases the survival time of legionellae suspended in aerosols, thereby increasing the potential for larger numbers of users and staff to be exposed.
- e) *Disinfection.* Maintaining an effective disinfection residual and optimum pH range for disinfectant action in spa pools is difficult because disinfectant can be lost to the atmosphere due to the

temperature of the system and the dissemination of the bubbles from the surface. This is exacerbated when the pool is sited outdoors.

As these systems are inherently high-risk and potentially complex, the assessor needs to be competent and experienced in these types of system and have an understanding of spa pool treatment strategies, together with system design features which increase the risk of legionellae growth. The HPA/HSE joint guidance "Management of Spa Pools: Controlling the risks of infection" [8] contains comprehensive information on design, hygiene, hazards, treatment and monitoring of spa pools.

Figure D.1 Diagram of a typical commercial spa pool and associated water system



Annex E (informative) Other systems

E.1 Introduction

There are many other types of water systems that have been shown to be the cause of outbreaks of legionnaires' disease, and others which are potential sources that have not yet been identified as a source in an outbreak. Many cases of legionnaires' disease remain unexplained and, in time, it is likely that some of these other potential sources will be confirmed as sources and other pieces of new equipment identified

as potential sources. This annex discusses risk assessment problems with some of the more commonly encountered systems and some potential problems with novel technologies.

E.2 Fire suppression systems

The most common types of fire suppression system are fire hose reel systems and sprinkler systems.

When assessing these systems, the following have to be considered.

- The water might be from a source which is contaminated, e.g. a river or canal.
- A large volume of water could be stored in a fire tank for very long periods without significant turnover.
- The lines from the tank to the fire hose reels could be filled with this water.
- The fire tank could have been constructed using unapproved materials, contain contamination or be in poor condition due to lack of maintenance.
- The temperature of the water in the system could be above 20 °C due to thermal gain from the building.
- When the system operates, large amounts of aerosol could be produced.

Ultimately, though, these systems are used to fight fires and the risk from fire outweighs the risk from legionnaires' disease.

The risk assessor ought not to make recommendations about emptying, cleaning or disinfecting fire suppression systems unless there are particularly good reasons for doing so.

The assessor needs to make clear that the systems are needed for safety reasons and highlight that, when testing this equipment, the work has to be completed with minimum exposure to aerosols, perhaps at times when there is a minimum number of people on site to be exposed to any aerosol produced.

E.3 Fountains and water features

Water fountains and water features, including interactive water features and zero-depth pools, release aerosol into the surrounding atmosphere. If conditions are favourable, legionellae can grow in them. Water features inside a building release the aerosols into the building itself, presenting a particular risk, and have been responsible for outbreaks of legionellosis. Particularly where there is a small volume of water, the circulation pump can increase the temperature of the water to within the growth range of legionellae and supporting micro-organisms. There are many potential sources of nutrient in these systems, especially those which are open to the public, as debris can enter and be captured by the water.

The risk assessor needs to inspect all parts of such a system during the survey, checking the temperature of the water in the system on the day of the survey and inspecting any records of temperature that have been taken in the past.

Common faults found with such features include:

- insufficient water treatment and testing in place;
- no preventative maintenance in place;
- no, or inadequate, records in place;
- no temperature monitoring; and
- records not kept for at least five years.

E.4 Humidifiers

E.4.1 General

There are many different types of humidifiers found in industry, commerce and catering, including devices that:

- atomize mains water directly by spraying it onto a spinning disc or passing it through a nozzle under pressure;
- use sonication to atomize mains water that has been purified, usually by reverse osmosis;
- inject steam directly into the airflow;
- spray water through nozzles, with the excess water being captured by the unit and recirculated; and
- humidify air by passage over a wet medium.

The different units present various levels of risk and need to be judged individually.

E.4.2 Ultrasonic humidifiers

Ultrasonic humidifying units associated with food displays have caused outbreaks of legionnaires' disease when incorrectly installed and maintained.

E.4.3 Spray humidifiers

Spray humidifiers in which the water is recirculated are intrinsically more likely to present a risk of microbial growth. Although in operation they usually contain very cold water due to the high levels of evaporation, they trap dirt and micro-organisms from the air and the stored water can stagnate and become warm, encouraging growth. They have been associated with the syndrome "humidifier fever". Legionellae have at times been found in spray humidifiers, so they are a potential risk. Because people can breathe the humidified air, these systems are rarely treated with chemicals to prevent the normal problems associated with using and evaporating water. If there is no control, the released aerosol could contain high levels of micro-organisms, including legionellae, which could be inhaled by people inside the building. To prevent microbial growth, the systems have to be cleaned and disinfected regularly, often as frequently as fortnightly. The humidifiers themselves are usually quite small, and it is easy to clean all wetted surfaces, including make-up tanks, sumps and lines. Disinfection can be by application of a chlorine release agent. If water treatment is used, its operation ought to be checked weekly. Because of the problems in maintaining these devices, they are increasingly replaced by other, more intrinsically safe methods of humidification.

E.4.4 Steam humidifiers

Steam humidifiers present minimal risk due to the high temperatures involved in the production of steam. Steam is usually generated by an electrical heating element similar to an electric kettle.

E.4.5 Risk assessment

Humidifiers using water without recirculation, e.g. spinning disc types and some spray humidifiers, normally present a low risk provided there is continued use and the water source is largely free from bacteria, such as towns mains supply. The risk assessment will concentrate on ascertaining if there is any way that bacteria could grow within the feed system.

Humidifiers are often used seasonally or intermittently, potentially resulting in water being left stagnant in the system and allowing growth that could result in a contaminated aerosol being disseminated when the system is put into use. Humidifiers ought therefore to be drained down when not in use.

Risk assessment ought to involve careful visual examination of the system, including the feed water supply, to ensure it is clean, and constructed and operated appropriately. Sumps and drip trays in the humidifier and other equipment in ventilation systems, such as heater and chiller batteries, ought to be self-draining with air gaps to prevent back-siphonage from the drains.

Where humidifiers are associated with air handling units in air conditioning systems, the assessor needs to be aware of the possibility of condensation in the ductwork, as this can result in a microbial growth and a theoretical increase in risk.

Common faults found

- Systems in poor condition due to contamination and inadequate cleaning regimes.
- No preventative maintenance in place.
- Intermittently used (e.g. seasonal) systems not drained when out of use.
- No records of maintenance in place.
- Records are in place, but are inadequate.
- Records not kept for five years.

E.4.6 Vehicle wash systems

E.4.6.1 General

Vehicle wash systems include car washes, lorry washes (often found at distribution depots and at manufacturing plants), bus washes and train wash systems.

There are two categories with regard to water usage:

- a) those that collect and recycle the wash water; and
- b) those that use once-through water and discharge it to drain.

Vehicle washes can be manually operated or have automatic spray systems. They are often in the open and, when enclosed, this only

reduces the nuisance of noise or spray. The degree of enclosure often has little effect on the reduction of aerosol released into the environment.

E.4.6.2 Types of vehicle wash systems

A car or lorry wash can be a manual jet wash, in which the jets or brushes are operated manually, or the automatic type, in which the washing is done by jets and brushes mounted on a moving frame that passes over the length of the car. In a train washing system, the train is driven through the jets and spinning brushes.

The wash process consists of an initial wash cycle with detergents, a rinse cycle and a warm air drying cycle. It is common for the system water to be recycled through an interceptor tank (usually below ground) which separates floating debris and allows silt and grit to settle. Oil pads and filters remove small quantities of oil before the water is returned to a collection tank, filtered and returned to the initial wash cycle water.

The rinse cycle water flows into an intermediate tank where fresh water is added and cycled through carbon filters which remove detergents, remaining solids and chlorine to produce rinse quality water.

Wash systems using once-through water from a mains supply still require a full assessment, with a survey of jet operation and design and the quality and temperature of the water. On industrial sites, a process water could be used, in which case the source and possible pretreatment need to be taken into consideration.

E.4.7 Factors affecting *Legionella* risk assessments

It is important that a full understanding of the design and operation of each wash system is known to the assessor. There will always be some exposure of the user and the public to aerosols, but the degree of exposure depends on the design of the unit.

It is important to assess the temperature of the system water and to consider seasonal variations, including exposure of storage and distribution systems to thermal gain by exposure to sunlight or extended periods of stagnation due to holidays, such as in factory lorry wash installations. During periods of drought wash systems are often the first to be shut down and there is the risk of increased proliferation of legionellae as a result. It is important to establish the system conditions on shut down and the procedures in place to restart the system.

In systems in which the wash water is recycled, the presence of soaps, oils, dirt and sediments provide nutrients for microbial growth, so assessment of water temperatures and cleanliness is important.

The significant sources of contamination to be considered in the risk assessment are:

- a) the suitability and efficiency of filtration and separation system used;
- b) management of filters, including carbon filters;
- c) the suitability of any chemicals and associated dosing equipment;
- d) the maintenance and servicing schedule of the equipment; and
- e) the frequency of dirt/silt removal from the system, e.g. by gully sucker.

E.5 Tunnel washers

Plants manufacturing large metal components, particularly in the motor industry, frequently have systems for degreasing and cleansing the components prior to painting them. This may involve passing the components on a conveyor through a tunnel, with successive spray washes of hot caustic or other solutions followed by one or more spray rinses with hot or cold water. There is dense production of sprays and considerable amounts of aerosol can be produced which might be released into the workspace. Often, the water is recycled and there is much opportunity for contamination of the water stored in collection tanks prior to reuse. In some of these tanks, the conditions could be ideal for microbial and legionella growth. Tunnel washers have some similarities to vehicle washers and have been incriminated as the source of an outbreak on at least one occasion in a plant producing heavy machinery.

The risk assessor has to consider each step in the process as not all stages will necessarily produce a legionella risk. The use of biocides might not be appropriate, so alternative means of minimizing the potential for growth have to be considered. Sampling for legionellae can assist risk assessment and might be required for monitoring of control.

E.6 Air scrubbers

There are many kinds of air scrubber and risk assessors are unlikely to be familiar with them all. Risk assessment will therefore require the input of the system designers. Some scrubbers incorporate the use of water which might be recycled, and this can present a risk of growing legionellae and causing legionnaires' disease. A large outbreak of legionnaires' disease was caused by an air scrubber in Norway in 2005 [9]. In design and operation air scrubbers using water may have several characteristics in common with cooling towers. In particular, the air to be scrubbed passes through a matrix like a cooling tower pack which is kept wet by water falling through it. Scrubbers can be multiple-stage, but ultimately the air is exhausted to atmosphere possibly after passage through other devices to reduce the release of droplets to atmosphere. The water could then be recycled after the materials captured from the air have been removed. The removal process depends upon the nature of the materials being scrubbed from the air. It might simply be a physical process to remove particulates or one or more chemical treatments to remove or render safe soluble substances.

The risk of legionella growth will depend upon the nature of the materials being removed from the air and the temperature attained in the water and pack. Organic particles such as wood dust or flours and some soluble organic compounds can provide nutrients for microbial growth and will therefore potentially support the growth of legionellae. As always the temperature achieved is a critical factor and some systems achieve temperatures in the high-risk range. There could be a risk of growth of legionellae within the pack and/or the recycled water circuit itself.

Some air scrubbers incorporate biological treatment stages to break down captured organics. These can operate at temperatures that permit the growth of legionellae depending upon the ecology of the system. The relative novelty of these systems incorporating biological treatment means that there is insufficient data to determine whether

a particular system is likely to pose a risk. They will therefore require monitoring for legionellae.

As with any other system the risk assessor will have to consider the likelihood of legionellae growing in the system, how this can be controlled, the likelihood of droplets being released into the exhaust air and the means of reducing the droplet release. In view of the variability in design of the systems and the processes they are applied to, some monitoring for legionellae might be needed to assist the risk assessment process and to be incorporated into the ongoing monitoring of control.

E.7 New technologies

E.7.1 General

Many new technologies are being introduced into the workplace and homes, particularly to reduce energy demands and water usage. These include rainwater harvesting, greywater reuse, sewage reuse, solar heating, air water and ground source heating using heat pumps and geothermal heating. There are many different designs of systems coming to the market and, although the risks from faecal contamination might be considered, the risks of microbial growth and the associated potential risk to public health are often overlooked. These need to be considered at the design stage so that the design requires the input of microbiologists as well as engineers, plumbers and chemists. Often, a *Legionella* risk assessment identifies factors that would be considered as creating a risk. However, as the technologies are relatively new, the risk assessor might have no prior experience of the equipment. There is also a lack of data from the microbiological sampling of such equipment. This is an instance where sampling for legionellae could inform the risk assessment process and might be needed to confirm control is being achieved consistently.

E.7.2 Rainwater collection

Rainwater harvesting systems are installed on a wide range of buildings and therefore can vary greatly in size. Rain itself contains dust and micro-organisms, but potentially the greatest source of contamination and nutrients is deposits of dirt and bird or other animal droppings from the roof or other surface from which the rain is captured. An important aspect of design, therefore, is to have mechanisms in place for trapping this or diverting the first rainfall washing off the roof after a dry period. Another key factor to be considered in the design are access to the holding tank for inspection and ease of cleaning. Sometimes, greywater recycling and rainwater capture are combined into one system and this can create difficulties for *Legionella* control as greywater is often warm and always more contaminated by micro-organisms and nutrients. Protection from thermal gain and the temperature during storage is important as large volumes could be stored for considerable times. The final use of the water and whether it is subjected to any filtration and/or biocide addition are also important factors.

E.7.3 Greywater reuse

Greywater is water generated from domestic activities, such as laundry, dishwashing and bathing. It can be used for irrigation and sometimes for toilet flushing. It will always contain micro-organism derived from

the household plumbing system, along with those of human or animal origin washed off during bathing or laundry. It is also often warm and therefore a potential medium for the growth of legionellae. Depending upon what the greywater is used for, it might undergo different levels of treatment, often including chlorine treatment or other disinfection. BS 8525-1 recommends microbiological (including legionellae) guideline values for monitoring greywater according to its use. The *Legionella* risk assessment has to include a careful consideration of how the water will be used, the likelihood of biofilm formation and legionella growth in the associated plumbing system, and the means of controlling this. If used for irrigation, the risk is related to the method of delivering the water. Sprinklers or sprays can produce significant amounts of aerosol, whereas drip irrigation produces very little, and soaking into the soil via water permeable hoses produces little or no aerosol.

E.7.4 Solar heating

In solar heating the sun's radiant energy is captured in a solar collector (solar panel), usually situated on a roof. There are two main methods of delivering the energy of the sun to generate hot water for either bathing or heating purposes. In the first, the "direct" heating method, water is passed through the solar panel to heat it and is then fed directly back into the hot water distribution system for end-use.

Secondly, there is the "indirect" method, which takes water, usually containing antifreeze, from the solar panels and passes this through a heat exchanger coil located inside the hot water storage cylinder. The area where this heat exchange coil is situated forms the preheat store, which is the principal location where energy is delivered from the primary system. In single-cylinder systems, the heat exchange coil is in the bottom of the water tank with a second heating coil in the upper half of the tank to provide supplementary heating. The supplementary heating can ensure the water is distributed into the hot water system at the appropriate temperature when there is insufficient solar energy.

There are also multi-cylinder systems in which the preheat store is in a separate cylinder. In addition, there are thermal store systems where solar energy heats the body of the store and heat is extracted by a mains cold water coil passing through the vessel or by an external heat exchanger. The volume of water in the preheat store, called the dedicated solar volume, is usually a minimum of 25 L/m² of solar collector, and is additional to the normal volume of water stored in an equivalent conventional system.

On sunny days the water in the solar collector can get very hot, possibly reaching boiling point, whereas on dull winter days there might be insufficient solar energy to heat the household's water to a usable temperature. In order for the solar water heating system to run safely and efficiently, a range of valves and sensors are installed to switch the system on or off according to the solar energy available.

Both direct and indirect systems can present risks, depending upon their design and operation. The risk factors and control measures for solar-heated systems are the same as other hot water systems. The main difference is that in many designs of solar-heated domestic hot water systems the volume of warm or hot water stored is greater than in normal domestic hot water systems. Depending on the amount of solar energy available and the design of the system a significant portion of this water can be at temperatures conducive to the rapid

growth of legionellae. With many of these systems there is a conflict between maximizing energy conservation and minimizing the risk of legionellae growing. Energy conservation is maximized by distributing the hot water at 50 °C or less, but this increases the risk of legionellae growing. A common recommendation is to ensure that the stored hot water is heated to 60 °C once a day. Currently, there is insufficient microbiological evidence available to confirm which designs and modes of operation are safe. Consequently, sampling for legionellae is likely to be an essential part of the monitoring of these systems until sufficient experience has been gained to validate the controls.

More detailed information on solar heating systems is given in BS 5918, which was being revised at the time of publication.

E.7.5 Ground, air and water source heating

Other renewable energy heating systems incorporating heat pumps and extracting heat from air, the ground or water (air/ground/water source heating) are becoming more widely available. They also often use heat stores. The heat extracted is most commonly used to provide space heating, often via underfloor heating. When used for space heating the legionella risk needs to be minimal as the system remains closed in normal operation. However, sometimes the systems might also be used to heat the domestic hot water, in which case there might again be a conflict between energy conservation and the risk of legionella growth.

Annex F (informative) Example checklist for a spa pool

A checklist can be helpful to experienced personnel in ensuring that obvious potential risks have been assessed, though it ought not to be considered exhaustive. The following is an example checklist for a spa pool. Similar checklists can be prepared for other systems.

Checklist

- **Spa pool design and manufacture**
 - Ascertain type of pool system, e.g. stand-alone overflow, part of swimming pool system, and make, model, year of manufacture, etc.
 - Do the materials support microbial growth; do they have corrosion resistance and WRAS approval?
 - Is the whole system drainable and accessible for cleaning, including the pipework and balance tank?
- **Operation and maintenance**
 - Is the spa pool used regularly?
 - Is there a written scheme in place to control the risk of legionellosis and foreseeable infections from other potential pathogens such as *Pseudomonas aeruginosa*?
 - Does the written scheme identify all the factors which are required under legislation, codes of practice and guidance to ensure the risks of infection from legionellae are successfully managed?
 - Is there evidence that bather loading is understood, monitored and managed?

- Is there an up-to-date schematic diagram/plan? Have there been any modifications since the schematic was drawn? If so, this has to be verified.
 - Does the schematic show all parts of the system?
 - Source water input.
 - System plant components, including strainers, pumps, filtration and chemical dosing system components, dosing and sampling points, pipework and flow direction, valves; storage/balance tanks, pressure vessels and any system components or equipment out of use or on standby.
 - A written procedure for safe handling and storage of chemicals, safety data sheets, dosing requirements and dealing with spillages.
- Are there clear health warning signs for potential spa users with a clear admissions policy.
- **Written scheme control measures**
 - Does the scheme describe control measures for *Legionella* under normal operation?
 - Is there a water treatment programme in place?
 - What checks should be carried out to ensure safe operating conditions?
 - Does it state who is responsible for monitoring the control measures?
 - Are chemical and microbiological monitoring parameters defined with appropriate target levels and frequencies of testing?
 - Are there clear acceptable limits for chemical treatment, i.e.:
 - 3 mg/L to 5 mg/L free chlorine and 4 mg/L to 6 mg/L active bromine (Are the calculations for the additions to achieve these concentrations correct?);
 - pH maintained between 7.0 to 7.6?
 - Who reviews the results of control measure monitoring?
 - Is there a logbook with records of daily, monthly and quarterly tests and checks and details of any cleaning, maintenance, operational issues and remedial actions recorded?
 - Daily chemical and pH tests.
 - Weekly cleaning, e.g. balance tanks.
 - Are chemicals dosed automatically? Are there details of pumps and associated equipment with operating schedules, calibration and maintenance records?
- **Abnormal operating conditions**
 - Is there a plan for managing the operation of the control measures when the system is not operating correctly, e.g. when monitoring parameters are outside the target range, such as low or no biocide in the system; vital equipment fails, e.g. a dosing pump; or legionellae are detected or there is a case(s) associated with the system?

- Is there a plan for actions leading to closure and for re-opening of the pool?
- Is there a plan of action if there is regular staff illness, e.g. with flu-like symptoms or a person with legionellosis associated with the pool?
- **Management and training**
 - Does the scheme have a clearly described management scheme, such as a diagram of management structure showing both lines of responsibility and communication?
 - Are deputies identified to cover for staff sickness/holidays, etc.?
- **Training**
 - Are there records of staff competence?
 - Are the staff well trained and do they understand the importance of cleaning and maintenance?
 - Are staff trained to understand the monitoring requirements, carry out monitoring and understand the risks and the consequences if they fail to react to parameters which are out of specification?

Annex G (informative) **Equipment**

The assessor's equipment list may include:

- a) calibrated immersion and contact thermometers;
- b) mobile phone (with timer and calculator), if allowed on site;
- c) torch and mirror;
- d) sterile sample containers for aerobic bacteria (TVC) and *Legionella* samples;
- e) paper towels;
- f) digital camera;
- g) recording device (clipboard, voice recorder, personal digital assistant or other);
- h) respiratory protective device, overalls, eye protection, safety footwear, gloves, hard hat and other suitable PPE; and
- i) sampling and test equipment.

The following apparatus and materials have been found useful, and might also be required for the collection of samples.

- 1) Sample bottles, usually 200 mL, 500 mL or 1 000 mL, but 5 L or 10 L bottles might also be required.
- 2) Appropriate biocide-neutralizing agents.
- 3) Sterile absorbent cotton wool swabs, and sterile tubes (typically 30 mL capacity) containing Pages' saline or dilute (1:40) Ringer's solution.

NOTE 1 BS 6068-4.12, ISO 11731 describes how to make both these diluents.

- 4) Wide-necked, screw-capped sterile containers (typically 50 mL capacity) for scrapings of biofilms and other materials.

- 5) Sterile spatulas or similar implements for scraping off or lifting out biofilm or other material samples.
- 6) Means for disinfection of sample points.

NOTE 2 Disinfectant: 70% v/v ethanol and water, 70% v/v propan-2-ol and water, or a 1 in 10 dilution of a commercial grade sodium hypochlorite solution (containing in the range 12% to 14% available chlorine (1% available chlorine is equivalent to 10000 mg•L-1 chlorine). Alternative disinfection methods, such as heating using a portable gas blowtorch, might also be used where safe to do so and where fittings are suitable (subject to site rules).
- 7) Commercially available alcohol-based wipes.

NOTE 3 These are only suitable for disinfecting external surfaces.

NOTE 4 Attention is drawn to the COSHH Regulations 2002, as amended [3].

NOTE 5 On some sites, use of certain disinfectant processes might be prohibited, for example use of ethanol on sites where there are fire or explosion risks, or hot work/blowtorches. It is essential that the specific site health and safety rules are followed.
- 8) Permanent marking or writing implements.
- 9) Recording forms, survey forms, labels. These might need to be waterproof or protected from water.
- 10) Sterile food grade silicone rubber tubing with appropriate clamps. The tubing ought to be in 2 m to 3 m lengths, of various internal diameters (15 mm to 30 mm) and packed in a manner that ensures it remains sterile prior to use.
- 11) New, food grade plastic bags not containing any antimicrobial agents, elastic bands and sterile scissors.
- 12) Hand-held vacuum pump and sterile 1 L flasks.
- 13) Sterile disposable or sterilized re-usable dip samplers.
- 14) Thermometer, preferably electronic, with immersion and surface probes (calibrated against a primary reference thermometer certified by a national accreditation body).
- 15) Disposable powder-free gloves.
- 16) Containers and/or packaging materials for transportation of sample bottles, as applicable.

Annex H (informative) Schematic drawings

Schematic diagrams are accurate but simplified illustrations of the configuration of water systems, which include all key components and relevant components and omit everything which is not relevant. They are not formal technical drawings and are intended to be easy to read without specialized training or experience. Like maps of underground railways in many cities, they allow the layperson unfamiliar with the layout of a system to understand quickly the relative positions and connections of the relevant components, whilst providing only an indication of the scale. It is common for schematic diagrams to be computer-generated, which has the advantages of clarity and ease of editing, but hand-drawn diagrams are acceptable for simple systems (see Figure 2).

Key components of a schematic are the parts of a system which constitute the system itself and could be considered its principal characteristics. Relevant components are those which could have some bearing on the *Legionella* risk, but are not essential to the routine operation of the system. Details which are not relevant are those which have no bearing on the *Legionella* risk and either have no function or whose presence and function could be reasonably assumed. Examples of each type of component of a building cold water system are illustrated in Table H.1.

Table H.1 Relevance of the components of a cold water system

| Key components | Relevant components | Not relevant details |
|--|--|---|
| Origin of the water, e.g. mains | Water meter and bypass Main stopcock Mains water sample valve | |
| Break tanks Pressure booster pumps Booster pump set manifolds Pressure accumulator vessels Storage tanks | Vibration insulating couplings Strainers Drain tails | Drain cocks without drain tails |
| Distribution pipework | Cross connections and valves for isolating tanks for servicing Mixing valves, thermostatic or non-thermostatic Showers | Individual fittings Servicing valves |

Simple systems, such as those providing drinking, washing and sanitary water in small buildings might require only very simple diagrams, but these ought to distinguish parts which are connected directly to the supply from those supplied via tanks and calorifiers (or other water heaters). More complex buildings could require more than one diagram, for example, one showing the overall layout, another showing the configuration of the plant (tanks, pumps, softeners, etc.) and another the details of the fittings at the point of use. For very complex systems, a balance might need to be struck between completeness and ease of reading, in which case omissions and approximations ought to be recorded on the diagram using statements such as "General configuration only. For detail refer to as-installed technical drawings or confirm by inspection".

Where control of the *Legionella* infection risk is by active devices, for example, the dosing and control equipment used on cooling tower systems, these ought to be included in the schematic diagram, showing the routes of signals from sensors (e.g. electrical conductivity) through any control units to actuators (e.g. bleed valve).

Water systems which are self-contained and separated from their supply, either for operational reasons or to protect the supply against back-contamination (e.g. cooling tower systems), ought to be illustrated showing the make-up water configuration, including the origin of the water, any pre-treatment (such as softening), and all break tanks (cisterns), pressure booster pumps, etc. These systems are likely to incorporate operational control and contingency components, such

as circulation pumps, three-way valves and multiple components on standby, alternating, or in lead and lag operation, and to have multiple drain points. They might also incorporate specialized devices for particle removal heat recovery and operation in “free cooling” mode, etc., and these ought to be included in the diagram.

It is important that all schematics drawings identify the date when they were last reviewed and updated. The name (initials) of the individual and their organization ought also to be recorded. Where required, a legend detailing any symbols or abbreviations ought to be included on the schematic.

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