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

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Contents

Summary of pages

This document comprises a front cover, and inside front cover, pages i to ii, pages 1 to 48, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 January 2019. 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 these committees can be obtained on request to their secretary.

Supersession

This British Standard supersedes BS 8580:2010, which is withdrawn.

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".

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

Where words have alternative spellings, the preferred spelling of the Shorter Oxford English Dictionary is used (e.g. "organization" rather than "organisation").

The word "should" is used to express recommendations of this standard. 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.

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 refers to illness caused by bacteria of the genus *Legionella* including Legionnaires' disease and Pontiac fever. The most serious form of disease caused by *Legionella* 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 61 species of *Legionella* have been described and over 28 have been associated with disease in humans, but the predominant cause of Legionnaires' disease is *L. pneumophila. Legionella* 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 contagious 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 (water going down the wrong way) containing *Legionella* can also cause infection, particularly in hospitalized individuals.

There is a chain of events leading to an individual contracting Legionnaires' disease:

- the water system needs to become contaminated (inoculated) with the bacteria;
- hazardous 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 individual;
- 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*, combined with their association with protozoa, means that all building water systems are susceptible to contamination with *Legionella* 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 *Legionella* 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 recommended to test for the presence of *Legionella* prior to the implementation of a water management programme.

The generation of aerosols can be observed in the operation of systems such as cooling towers, evaporative condensers, 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 an 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 can increase susceptibility. Host susceptibility is therefore an important factor influencing risk and needs to be considered in the assessment.

A site-specific analysis of hazardous conditions allows appropriate control measures to be identified and 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 [2], [3] and the Control of Substances Hazardous to Health Regulations [4], [5] 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*" [6], otherwise known as ACoP L8, and the associated Technical Guidance HSG274 Parts 1 to 3 [7] and HSG282, *The control of legionella and other infectious agents in spa-pool systems* [8].

Risk assessment is an ongoing process and the report of the risk assessment's findings is a live document. The risk assessment report needs to be reviewed regularly 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 recommended that a risk assessor is involved from the design stage onwards.

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*. The appointed competent person(s) (also known as 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 as the competent person. Further guidance for duty holders on how to put in place suitable arrangements for managing health and safety risk is provided in HSG65: *Managing for Health and Safety* [9].

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 *Legionella* risk assessment relevant to 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 there is potential for exposure to water or when water is used or stored in circumstances that could cause a reasonably foreseeable risk of infection by *Legionella* and contracting legionellosis.

This British Standard is applicable to risk assessments being undertaken on premises, plant and systems for the first time. It also covers reviews and reassessments where a previous assessment has been undertaken and where control measures might have been implemented.

While the principles of risk assessment presented in this British Standard can be applied to natural waters, including rivers, lakes, ponds, waterfalls, caves, dew ponds or natural recreational facilities, such as boating lakes, this British Standard does not give specific recommendations for these water sources. This British Standard does not give recommendations for 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. A list of equipment that might be used by a risk assessor is given in Annex F, and Annex G gives guidance on the production of schematic diagrams.

NOTE The guidance in the annexes is not intended to be exhaustive but 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 documents are referred to in the text in such a way that some or all of their content constitutes provisions 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*

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

NOTE In the context of this document, it is a suspension of particles which might contain Legionella with a typical droplet diameter size of <5 µm that can be inhaled deep into the lungs.

3.2 aspiration

liquid accidentally passing into the lungs when swallowing

NOTE This is commonly referred to as water "going down the wrong way".

3.3 asset register

list of all items relevant to the risk and control of legionellosis and pertinent information to allow them to be effectively used in the written scheme of control and in the risk assessment

NOTE Ideally, this will be made available to the risk assessor by the duty holder. This includes the physical components of the system and might also include other standalone items that could present a legionellosis risk. It also includes the schematic diagram, scheme of control and risk assessment.

3.4 biofilm

community of bacteria and other microorganisms and entrained debris, embedded in a protective layer at interfaces in water systems

3.5 calorifier

apparatus used for the transfer of heat to water in a vessel by indirect means and incorporating a source of heat

3.6 dead end

blind end

capped pipe

length of pipe closed at one end through which no water passes

[SOURCE: HSG274, Part 2, 2014 [7]]

3.7 dead leg

length of water system pipework leading to a fitting through which water only passes infrequently when there is draw off from the fitting, providing the potential for stagnation

[SOURCE: HSG274, Part 2, 2014 [7]]

3.8 doubling time

time taken for a population of an organism to double in number

3.9 guidance for control

findings from the risk assessment that can be used in producing a scheme of control

3.10 hazard

biological, chemical or physical agents or water conditions with potential to cause adverse health or safety-related effects

3.11 key roles

3.11.1 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 undertaking 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. 28.

*NOTE 2 In most cases there will only be one duty holder, but in cases of shared accommodation there could be a shared duty. There might be some cases where the duty holder is a group such as a corporate body, Trust, etc. The duty holder cannot delegate this duty, but can delegate managerial responsibility to the competent person, also known as the nominated responsible person (see **3.11.2**).*

3.11.2 competent 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". This role can be taken by more than one individual, for example, in a water safety group.

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

3.12 *Legionella*

genus of bacteria first described as a result of the outbreak of Legionnaires' disease in Philadelphia at the Bellevue-Stratford Hotel in 1976

NOTE It contains at least 61 species, according to www.bacterio.net. [Last viewed 12 December 2018.]

3.13 logbook

a) system activity logbook

b) operator activity logbook

record book (one or more) or its electronic equivalent where all relevant details of the system, the operation, its performance, its monitoring and its maintenance can be entered in a secure manner for subsequent retrieval

[SOURCE: BS EN ISO 16484-2:2004, **3.111** – order of bullets modified and monitoring added]

3.14 open evaporative cooling system

system in which a small proportion of a circulating body of water is caused to evaporate into the atmosphere, taking the latent heat of vaporization from the remainder of water and cooling it

3.15 risk

3.15.1 inherent risk

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

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

3.15.2 risk (general)

likelihood of a hazardous event occurring and its consequences

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

3.15.3 residual risk

risk remaining after the application of control measures

[SOURCE: BS EN ISO 27000:2017, **2.64**, Notes removed]

3.16 risk assessments

3.16.1 risk assessment (general)

overall process of risk identification, risk analysis and risk evaluation

NOTE Includes hazard identification.

[SOURCE: BS 31100:2011, **2.24**, Note added]

3.16.2 *Legionella* risk assessment

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

3.16.3 risk assessment review

process of determining if the current risk assessment and scheme of control are still valid and effective

NOTE This is completed by the competent person if systems are simple and/or they have an appropriate level of competence. Often the services of third party competent help is utilized for complex or high-risk systems such as evaporative cooling or hospital hot and cold water systems.

3.16.4 reassessment

process of reassessing a system after the need is determined by review

NOTE This entails all the steps needed in an initial risk assessment.

3.17 schematic diagram

simple but accurate illustration of the configuration of the water system, including parts that are out of use, to be effectively used in the written scheme of control and in the risk assessment

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

3.18 scheme of control

procedures and checks intended to control the risk of *Legionella*, including an up-to-date schematic diagram

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

3.19 water safety group (WSG)

multi-disciplinary group formed to undertake the commissioning and development and ongoing management of the risk assessment and the scheme of control

NOTE It also advises on the remedial action required when water systems for outlets are found to be contaminated.

3.20 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* which should be considered in any risk assessment process:

a) contamination;

b) amplification;

c) transmission;

d) exposure; and

e) susceptibility of individuals exposed.

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

5 Preparations for risk assessment

5.1 Competence of the risk assessor

NOTE 1 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.

The competence of the assessor is of paramount importance and should be matched to the complexity of the system and the risk being assessed. If the assessor is not competent then the assessment might not be suitable or sufficient. In each case, they should be able to demonstrate that they have sufficient experience, specialist knowledge and understanding of:

- the factors affecting the colonization by and growth of *Legionella*;

- the evaluation and assessment of risk from *Legionella* and the controls in place;
- the procedures necessary to complete surveys, measurements and sampling (see Clause 7);
- the corrective actions that can be applied to reduce or eliminate the risk;
- the relevant control measures that can be applied, e.g. water treatment, inspections, monitoring, etc.; and
- the type of water system(s) and associated equipment to be assessed.

Risk assessors should provide evidence that they have undertaken the necessary training appropriate to the type and complexity of the system and the risk assessment required and gained practical experience with a competent assessor. Individuals commissioning risk assessments should establish the relevant competence of an assessor prior to appointment.

Assessors should have their competence formally assessed and there are organizations that require employees of service providers to do this, such as LCA's A Code of Conduct for Service Providers and UKAS accreditation for *Legionella* risk assessment. These records should be easily available for inspection.

NOTE 2 There are increasing opportunities for individuals to engage in independently recognized Continuing Professional Development (CPD) activities. This may be, for example, a record of certificates of attendance at relevant training courses, seminars and conferences, or participation in online training courses for related activities from recognized training providers.

Proportional management of *Legionella* risk is founded on effective risk assessment and any shortcoming in this process is likely to have an impact throughout risk management. Complex systems or those with unfamiliar equipment require assessors with the highest levels of competence. Assessors should obtain competent help, which might be from designers, manufacturers, specialist suppliers or technical operatives, in order to attain the collective competence to assess the risk in these systems.

NOTE 3 Hot and cold water systems can be simple in domestic and small commercial premises, more complex in larger commercial and residential premises and highly complex in healthcare and other speciality premises, each requiring a greater skill, experience, and/or training which contribute to the overall competence of the assessor. Non-domestic water systems including cooling tower systems, spa pools, hydrotherapy pools and some industrial systems depend on water treatment to control the legionellosis risk and therefore require an understanding of the principles of water treatment to complete the risk assessment. Other water systems can also range from simple to highly complex and might require the risk assessor to apply first principles rather than use a prepared format, in which case, assessors need greater knowledge and understanding of these principles and the judgement to apply them in unfamiliar situations.

NOTE 4 There is an increasing requirement, particularly in healthcare premises, to undertake risk assessments for other waterborne pathogens such as Pseudomonas aeruginosa and non-tuberculous Mycobacterium species. As a consequence, there might be pressure to include these other organisms in a Legionella risk assessment or to carry out the risk assessments together. The risk factors and controls for other organisms are not necessarily the same as for Legionella. An individual who is competent to perform a Legionella risk assessment requires a different set of skills and competence to perform these other risk assessments. Competence may be demonstrated by, for example, a CV indicating the assessor's experience or a documented assessment of competence.

5.2 Agreeing the terms of reference

The risk assessor should, before conducting the risk assessment, agree the following with the competent person and/or 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, taking into account the asset register, any schematic diagrams (**3.17**) and documentation on operation and maintenance. This is important as certain aspects of the risk assessment could require specialist knowledge or equipment [including personal protective equipment (PPE)] to which the assessor would require access. The risk assessment should take into account all parts of the system, for example, a cooling tower should not be risk assessed in isolation from the rest of the cooling system, e.g. intermediate tanks, heat exchangers, pipework, pumps, etc.

b) Whether and how the risk assessment addresses additional hazards, including biological, chemical or physical.

NOTE 1 This British Standard only applies to Legionella risk assessments.

c) Whether the asset register and/or schematic diagrams have to be prepared or redrawn as part of the assessment and, if so, their form and their coverage.

d) The person to whom the risk assessment is communicated and reported and to whom the recommendations are addressed.

e) Time frames for key milestones and the completion of the risk assessment report.

f) 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).

NOTE 2 The assessor has a duty to not put themselves or others at risk during the visit.

g) 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.

h) Any "permit to work" or access clearance necessary for access to the site of the assessment.

i) The provision of unrestricted and safe access to all relevant parts of the system(s) to be assessed; how to record any unavoidable omissions; the effect any such omissions might have on the assessment; whether the required information can be obtained by other means and; what provisions should be made to provide access on a subsequent occasion. Wherever it is practicable to do so safely, all parts of the system(s) should be visited. Whenever reported information, such as records of previous inspections, is included, this should be recorded.

j) Where a large number of essentially identical units/premises are to be assessed and it would be impractical or unrealistic to assess each individual unit/premises straight away, what proportion of these would constitute a representative sample (see **7.2**). For example, where there are a significant number of similar units under the control of the landlord, such as housing associations or councils, a representative proportion of the premises for which they have responsibility should initially be assessed on a priority basis, taking into account the susceptibility of occupants, similar design, size, age and water supply, with the entire estate eventually assessed on a rolling programme of work.

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 **7.2**), the individual nature of each site should be taken into account.

5.3 Independence

The risk assessor should be able to demonstrate impartiality and independence when carrying out *Legionella* risk assessments. The risk assessor or assessing organization should not allow commercial, financial or other pressures to compromise impartiality and should be able to demonstrate valid reasons for any proposed course of action. It should be clear, for example, why a recommendation has been made to clean cold water storage tanks.

NOTE 1 This could be achieved by including photographic evidence and, if required, supplementary testing to support the recommendation within the risk assessment report.

Where an organization provides risk assessment services as well as other services, for example, water treatment or cleaning and disinfection, it should have safeguards in place to ensure adequate segregation of responsibilities and accountabilities through appropriate reporting structures.

NOTE 2 It is important that a risk assessment is unbiased and the judgement of the risk assessor is not compromised by the assessor or a colleague responsible for designing, providing or implementing the risk control measures.

In circumstances where risk assessments are conducted internally, for example, by health and safety professionals working within the organization for which the assessment is undertaken, the assessment and any resulting recommendations should not be influenced by factors such as the cost of remediation.

6 Desktop appraisal of documentation

6.1 Preparation

If an existing risk assessment report is available, it should be appraised by the risk assessor to determine if it is still valid and to identify any changes since the last assessment.

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 as demonstrated by their responsiveness to previous risk control recommendations made.

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 should be carried out to determine whether the system is under control and the risk is continuing to be adequately managed. If the current controls, etc., are found to be insufficient or not to have been fully implemented where there have been adverse monitoring results, or if there has been a change in process or management, then the risk assessor should request/obtain and appraise the following:

a) current risk assessment;

b) current logbooks, asset register 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 asset register or 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 report.

c) any recent *Legionella* control audits;

d) 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 and contractors;

   3) monitoring and inspection records;

   4) the scheme for the safe operation of the systems;

   5) timely and appropriate reactions to lapses of control;

   6) any substantive changes in the at-risk population; and

7) any substantive changes to relevant personnel.

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 showing implementation of the written scheme of control, ensuring that there is a dated 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; certificates raised by others after the event should be supported by signed contemporaneous worksheets or their electronic equivalent.

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

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 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 recognized national guidance documents 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 assessment report.

6.2.3 Appraisal of management responsibilities

The risk assessor should check that:

a) the duty holder, the competent person and any deputies are clearly identified in the written scheme of control and that the appointment of the competent person(s) is confirmed in writing by the duty holder;

b) where applicable, there is an appropriately comprised multi-disciplinary water safety group;

c) the roles of all competent 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;

d) lines of communication and the reporting structure are clearly stated in the scheme of control; and

e) the responsibility for 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, the assessor can look 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 can also be checked to verify, as far as reasonably practicable, that staff are competent to take measurements (see 7.3).

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 or 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 or 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 within the scope of the assessment which:

a) includes a description of the correct operation of the plant and any precautions to be taken;

b) details any start-up and shutdown procedures, and plant rotation and flushing requirements for little-used outlets;

c) includes details of any plant or equipment brought onto site by third parties;

d) includes, where appropriate, method statements, e.g. for major tasks such as cleaning operations;

e) outlines any tests that are to be completed on the systems, along with the required frequency of the tests and the acceptable control parameters;

f) details defects or out-of-parameter results; and

g) logs appropriate corrective actions.

6.2.6 Appraisal of the monitoring and inspection records

The assessor should appraise the records of monitoring and inspections for the systems being assessed.

NOTE 1 These might be found within the written scheme of control or separate documents, such as logbooks (hardcopy or electronic) or maintenance reports. It is reasonable to expect these records to be easily available for inspection.

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

NOTE 2 The assessor will not necessarily have sufficient knowledge of specialized chemical formulations or control equipment or experience to determine whether any specified control parameters are appropriate. It might be necessary for the assessor to seek verification from the service provider or product manufacturer for products used and elements of the control programme.

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

The results of inspections should be checked to see whether these indicate if the scheme of control 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 and when?

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

NOTE 3 Common faults found include:

a) no records in place;

b) records in place, but incomplete due to actions going unrecorded;

c) actions not completed, for example, due to continued lack of access without escalation;

d) inadequate or no escalation procedures;

e) records are kept, but corrective actions have not been performed (or recorded as having being performed) following results which are out of specification;

f) no preventative maintenance in place;

g) no, or inadequate, records of maintenance in place;

h) records not kept for appropriate periods, such as the five years required by COSHH [4], [5];

i) work not completed in a timely manner.

7 Site survey

7.1 General

As part of the risk assessment, the assessor should conduct a site survey, with reference to the asset register, schematic diagrams and logbooks [see 6.1b)]. The assessor should use the survey to check that the schematic 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, for example, deliveries of food ingredients causing organic dust to be sucked into a cooling tower and reacting with the biocides.

If the assessor identifies an imminent danger of exposure to *Legionella*, e.g. failure of a biocide dosing system, cold or hot water supplies to aerosol-generating outlets, such as showers which are significantly too warm or too cool respectively, they should report this immediately to the competent person or their site representative, and not keep this for the final written report.

NOTE Attention is drawn to Section 7 of the Health and Safety at Work etc. Act 1974 [1] regarding responsibilities of employees.

At the outset, the assessor should decide whether they have sufficient available information to assess the risk successfully. If they conclude that it is insufficient, for example because of the absence of schematic diagrams, or any other critical information, they should decline to issue the assessment, or decide to issue it in draft or otherwise qualified format, identifying any omissions and the effect they might have on the assessment.

Whether carrying out an assessment on a familiar site, or one previously unknown, the assessor should ensure their own personal safety from any health risks associated with the site. This includes operational hazards, for example, if plant is operating, history of positive *Legionella* testing results and associated hazards, such as those arising from working at height or in confined spaces [10], [11], [12], [13]. All hazards, their assessment and the precautions planned and taken, should be recorded.

The assessor should ensure that all necessary PPE is available, and prepare their own equipment list (see Annex F).

As part of the site survey the assessor should speak to management and staff to judge the effects of management culture and work practices of the organization in adding to (or reducing) the risk.

Where there is a current scheme of control, any sentinel/sampling points identified within it should be reviewed for their suitability.

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

The assessor should inspect the water system to confirm that the configuration is as illustrated in the schematic diagram (see Annex G 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*. Details of each system should be examined, including any discrete plant or component and existence/location of sentinel points.

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 units are not assessed in successive cycles (see **5.2**).

NOTE 1 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 practicable, the assessor should check that the materials of construction of the water system have been tested for their tendency to support microbial growth as indicated, for example their compliance with BS 6920 (all parts).

NOTE 2 Attention is drawn to the Water Supply (Water Fittings) Regulations [14], [15].

7.3 Measurements

Measurements routinely taken on site, for example, temperature, should be checked for accuracy and reliability, and validated. Measurements of various types (e.g. temperature, biocide, pH) therefore should usually be undertaken and evidenced by the assessor as part of the risk assessment. Where such measurements are undertaken, test meters should be regularly calibrated to ensure accuracy. Similarly, microbiological tests may be utilized, in which case the risk assessor should consider whether the test is suitable to provide the results required for the purposes of the assessment.

7.4 Testing for *Legionella*

It is not normally necessary to take samples for *Legionella* analysis as part of a risk assessment. However, if the assessor decides it will assist in determining risk, sampling should be carried out in accordance with BS 7592.

NOTE HSG274, Parts 1, 2 and 3 [7] give further information on when sampling might need to be performed.

Testing for *Legionella* should be considered if any of the following occur.

a) The risk assessor encounters a novel situation and/or piece of equipment perceived to be a potential risk to health.

b) There is a 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 the final assessment report.

8 Evaluation of the risk

8.1 General

Each risk should be analysed appropriately, considering its consequences and the likelihood of those consequences arising, to derive a measure of the severity and to set priorities for action.

Where there are common factors within the premises being assessed, while a proportion of these may be treated as a representative sample (see 5.2), the individual nature of each site should still be taken into account.

Where the risk assessor identifies a hazardous situation from the site survey, processes, visual inspection, measurements, records or sample analysis results, they should record each situation and assess the risk arising from it.

The resulting risk assessment should take into account the inherent risk, the controls in place and how well these mitigate the risk. This combination should be evaluated to determine if the residual risk is as low as reasonably practicable (ALARP) and, if not, what additional control measures are needed to achieve this. As control measures are introduced, residual risks can fall so low that additional measures to reduce them further are likely to be grossly disproportionate to the risk reduction achieved, and are therefore unjustified. However, measures should still be monitored in case the risks change over time.

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.

NOTE 2 See Annex A for factors that increase the level of risk.

NOTE 3 Although Legionella actively grows between 20 °C and 45 °C, if the system contains water at a temperature greater than 20 °C and less than 50 °C, and an aerosol can be generated under any foreseeable circumstance (operation or maintenance), then it is a system at risk of causing legionellosis. The risk of proliferation is highest between 32 °C and 42 °C.

8.2 Risk rating systems

Legionella risk assessments should contain a risk rating system.

When assigning a risk rating, individual water systems and individual levels of relative risk should be appropriately reflected within the final report. Where risks are common it is acceptable to summarize that within the risk rating.

Risks should not simply be defined by the highest element of risk or multiple risk factors added together to find an average. For example, different buildings within a single site might have a common water source that could be collectively described under a contamination risk but one building might have showers where another does not, and this should be reflected separately within a description of the transmission risk.

NOTE "Risk scoring systems" or "risk algorithms" have been used as an aid to understanding the relative risk of the systems assessed, but they require care in use as they can mask important issues.

Any rating system used by the risk assessor should be explained to the intended reader and cover the following.

a) *Contamination*. An assessment of the risk at source, including assessment of the quality, temperature and integrity of the water supply.

b) *Amplification*. An assessment of the conditions and whether they are likely to support *Legionella* growth, including temperature, water change rate, nutrients, materials of construction and areas where water is not replaced with fresh.

c) *Transmission*. An assessment of whether droplets or aerosols are likely to form and spread.

d) *Exposure*. An assessment of the risk that droplets or aerosols will be inhaled (or contaminated water aspirated).

e) *Susceptibility of individuals exposed*. An assessment of the nature of the exposed population, taking account of their vulnerability to *Legionella* infection.

For the implementation of a risk rating 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.

9 Risk assessment reporting

9.1 General

The findings of the risk assessment, prioritized recommended remedial works and ongoing actions should be presented as a formal document, in hard copy or electronic form as agreed in the scope. To achieve a concise report it may be appropriate to provide in an appendix any test documentation, photographs, measurements, and survey checks rather than including them directly in the main report.

The report should avoid the use of jargon or abbreviations that are not explained clearly, so that it can be readily understood by the people for whom it is intended. Most importantly, it should be clear and unambiguous in its findings and recommendations; the inclusion of these in an executive summary section in the report can help in this respect.

NOTE 1 Where a project includes risk assessments on a number of individual systems or buildings, e.g. on an industrial, academic or hospital site, it is useful to have an overall summary report detailing the overall findings, recommendations and priorities.

The report should be concise and unnecessary repetition and/or the inclusion of superfluous information should be avoided; examples of such inappropriate content include that which relates to risk systems other than those that are the subject of the assessment, risks other than those associated with *Legionella* (these may be identified, but detailed discussion should be elsewhere) and large extracts from guidance such as ACoP L8 [6]and HSG274 [7].

It should be remembered that the principal purpose of the report is to convey to the reader the findings of the assessment in an efficient and effective manner. It should be sufficiently detailed to allow owners of the risk an appropriate understanding of the key issues and actions required to control risks from exposure to *Legionella*.

The report should be issued to a nominated person, be dated and include verification that it has been checked and by whom.

The report should explain clearly the scope of the assessment and identify those water systems that have been assessed. Whilst there will inevitably be common factors associated with the many and varied types of premises being assessed (see **7.2** on representative samples) the individual nature of each site should be briefly described with particular attention to the evaluation of susceptibility of the persons likely to be present.

The report should include details of the training, experience and skill of the assessor(s) relevant to the water systems within the scope of the assessment so as to demonstrate their competence to the reader who might be different to the person who commissioned the assessment.

The report should record the key people responsible for, and conducting, tasks relating to *Legionella* risk management.

NOTE 2 These can include the duty holder, the competent person(s), or appointed responsible person(s), members of the water safety group, service providers, site operatives, competent help and deputies.

Where the appropriate roles are not being fulfilled, remedial action should be recommended as a high priority.

9.2 Identified risks

The report should clearly highlight the status of any key risks identified (e.g. low, medium, high risk, or ALARP risk, slight risk, moderate risk, serious risk, imminent danger to health) and indicate:

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

9.3 Control measures

Where there are shortcomings in the written scheme of control, the assessor should make practical prioritized recommendations for improvement to control any identified risk to ALARP. This should include items for urgent action and implications if no action is taken.

NOTE 1 For example, if the assessor concludes that the system being assessed has significant risk, 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 might 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 report should identify:

- the inherent risk and the residual risk (see **3.15.3**) after the written scheme of control measures are applied;
- the system-specific checks and inspections identified as required; and
- any limitations of the assessment.

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

The risk assessment should not involve the preparation of the written scheme of control, but rather provide information that is critical to its preparation, improvement and review.

NOTE 2 Ensuring that there is a written scheme of control is a legal requirement of the duty holder, though they might instruct the risk assessor to advise or prepare the scheme of control on their behalf as a separate commission. It is important that operation and maintenance individuals are consulted.

Photographs can provide an effective means of illustrating issues that are relevant to the assessor's findings, and when used, they should be cross-referenced clearly to those findings. It should be remembered that excessive use of photographs can confuse the reader and distract from important findings of the assessment.

NOTE 3 Survey results, including tests, measurements and visual observations can be extensive on large sites and these might be best presented as an appendix or supplementary report.

NOTE 4 In some cases where third parties undertake the assessment, it might be helpful to send the draft risk assessment report to the competent person in sufficient time to allow recipients to adequately review its content and comment as to whether specific details are accurate and the assessment is appropriate.

In the event that the assessment process identifies a significant risk that requires immediate attention, the assessor should urgently communicate to the competent person any areas of evident concern prior to receipt of the written assessment report.

Whilst a risk assessment report does not have a strict lifespan or expiry date, it should include a recommendation to indicate under what circumstances a review is required (see Clause **10** for further details).

10 Risk review and reassessment

10.1 Risk assessment is an ongoing process which should be continually reviewed and updated as and when there are changes.

NOTE 1 For simple assessments of inherently low risk water systems, the risk review could be performed by the competent person providing they have the appropriate level of competence to do so. However, for complex *water systems with inherently higher risks, such as cooling towers and for water systems in healthcare, or where additional expertise is required, it is helpful to have a periodic review process involving competent help, for example, regular formal review of the performance of the risk control measures with an appropriate specialist independent consultant or with a hospital authorizing engineer being present at water safety group (WSG) meetings. This would typically range from monthly to annually dependent upon the perceived risk. The output of this review process is a determination of the need for formal reassessment of the risk.*

The original risk assessment should be formally reassessed when there are significant changes to ensure that it remains valid, for example, when there are:

a) changes to the water system or its use;

b) changes to the use of the building or part of the building in which the system is installed;

c) changes to the availability of information about risks or control measures;

d) indications that control measures are no longer effective;

e) any of the factors in Clause **4**;

f) new construction works or system modifications planned; or

g) changes to the key personnel, contractors and service providers.

Where a reassessment has not been triggered by the above, there should be a policy of planned reassessment.

NOTE 2 Water systems with higher inherent risk or complex water services where changes are poorly documented may need to be reassessed frequently, e.g. annually, whereas for water systems with a lower inherent risk, or those where all changes are recorded and where systems are well managed, it may be sufficient for a formal reassessment to be performed every 2 to 5 years.

NOTE 3 It is unlikely that circumstances will be so stable that a risk assessment will not need reassessing within this period, in particular, due to staff and management changes. In reality, so many changes occur with time that it is difficult to keep track of them all, for example, general ageing and deterioration of the system and its equipment.

Any new risk assessment report should recommend a reassessment frequency based on the current and expected future risk.

10.2 When reviewing a current risk assessment report to determine whether it remains valid, the competent person(s) or the water safety group 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 HSG65 [9]);

NOTE 4 See also COSHH [4], [5] and ACoP L8 [6].

d) resources and how they are prioritized; and

e) escalation of risk management issues.

In particular, the assessor should consider:

1) the training and experience of the duty holder and competent person and those with any input into management and control, e.g. samplers, temperature monitors;

2) any known changes to supplier, owner and equipment, e.g. a change management process;

3) schematic diagrams to see if they show any known changes;

4) whether the audit trail of documents in the written scheme of control has been maintained;

5) the monitoring records for the cleanliness and condition of the system, including materials;

6) appropriate actions have been taken in a timely manner in response to monitoring;
7) the risk assessment and current scheme of control to ensure these can be read and that they make sense as standalone documents and are not just lists of cross-references; and
8) control measures and independently measure, for example, temperature and/or biocide concentration.

10.3 The reassessment should reflect the risk assessment process given in Clause **5** to Clause **8**.

The reassessed risk assessment should be issued as a new report.

Annex A (informative) Factors 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 *Legionella* and create a risk of legionellosis. Conditions supporting the growth of *Legionella* could occur frequently under normal operation or infrequently during exceptional but predictable circumstances, for example, during maintenance, breakdown, component failure 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.

A.2 Contamination

The chances of *Legionella* 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 *Legionella*. It may be assumed that the public mains could contain *Legionella* in low concentrations. It is not practicable to prevent *Legionella* from entering a building water system at some times and in cold mains water it is particularly difficult to detect their presence. They can be introduced from:

- the water supplied to the system;
- contaminated new components;
- dust or dirt from the air or surroundings entering during equipment failure, maintenance or normal operation;
- flooding; or
- process contamination.

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 *Legionella*. Splashes from colonized drains can contaminate outlets which could 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* to grow within it, either during normal operation, maintenance or some other predictable but less common circumstances, such as temporary shutdown.

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 or dead ends.

NOTE The detection of any Legionella species in a water system is considered to indicate that the system can also support the growth of L. pneumophila. Failure to detect L. pneumophila by culture when other Legionella species *are present could mean they are too small a proportion of the Legionella population to be readily detected or too few isolates have been selected for confirmation.*

A.3 Amplification

A.3.1 General

When *Legionella* multiply they require appropriate physico-chemical conditions and sufficient nutrients for them and their supporting organisms to grow. *Legionella* can grow in biofilms in association with water. The system might be apparently visibly clean but still contain these organisms.

NOTE Legionella are unable to grow without the support of other organisms, and can grow inside protozoa which normally utilize other bacteria as food. Protozoa, particularly their cysts, are often relatively resistant to chlorine, heat and UV. Since the nutrients for protozoa are primarily bacteria and microscopic organic debris they can be indirectly controlled by removing their nutrient sources, i.e. keeping the system clean, free of bacteria and excluding light to prevent the growth of photosynthetic microorganisms (algae and Cyanobacteria).

In rare instances a piece of equipment is a potential source of infection without amplification of *Legionella* occurring within it. For example, a nebulizer or other misting device filled with water that already contains high concentrations of *Legionella*. In this case the temperature of the water in the equipment needs only to be conducive to survival rather than growth. *Legionella* can survive below 20 °C and die slowly at 50 °C and are not affected by pressures likely in most water systems.

Legionella 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 *Legionella* 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 important. *Legionella* 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 *Legionella* can grow or survive in the range of pH likely to be found in most equipment and systems. Highly saline and similar environments are unlikely to support *Legionella*, but there is insufficient evidence published to define a safe concentration.

There are few estimates of the rate of growth of *Legionella* under natural conditions.

When grown under natural conditions in the laboratory (tap water with low nutrients, supportive complex microbial biofilm and no disinfectant), doubling times of 8 h to 14 h at 30 °C to 40 °C have been recorded. Within protozoa and human cells doubling times in the laboratory can be as fast as 2 h.

A.3.3 Nutrient sources

Nutrients for the growth of *Legionella* 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 used in potable water systems have to be tested for their ability to support microbial growth and conformity with BS 6920-2.4, and be WRAS-approved. In other artificial aquatic systems where the minimization of microbial growth is required, i.e. *Legionella* risk systems, materials used ought not to enhance microbial growth and conformity to BS 6920-2.4 and WRAS-approval are therefore appropriate in the absence of any other relevant standards.

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. Similarly, irregularities on the insides of piping and particularly at joints can provide areas for colonization. Recycling of water could lead to the concentration of dirt and nutrients. Inevitably, sediments, other deposits such as scale and corrosion products, dirt and possibly biological material 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 therefore has 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 need to be of known effectiveness including against *Legionella* (see **A.3.1** and **A.3.2**) and need to have been validated to be effective in the system/equipment and situation being assessed.

A.4 Transmission

Water containing *Legionella* 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. The survival of *Legionella* in an aerosol is dependent upon a variety of factors including humidity, temperature, light and certain toxic factors in the air. In general, survival indoors is better than outdoors. Dissemination outdoors could be up to many hundreds of metres or several kilometres. Under experimental conditions similar to common indoor conditions, 30% of a population of *Legionella pneumophila* remains viable after 30 min indoors [16].

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 breaks the surface of the water, even if there is little evident splashing, can produce droplets and thereby form aerosols. Dense sprays and large numbers of bubbles obviously generate aerosols, but running a tap, flushing a toilet, water striking a hard surface or the surface of a body of water (such as in a tank) 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 to be considered. Forcing water containing *Legionella* 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 proportion of the bacteria. In contrast, 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, meaning of those bacteria that survive aerosolization a higher proportion are 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 *Legionella* have to survive this drying process and subsequent transmission through the air before inhalation.

A.5 Exposure

The closer a person is to the source, the more likely they are to inhale the aerosol before it has become dispersed 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 metal working fluid (emulsion of small proportion of oil in water) 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 reduced by other means, such as ducting away the contaminated air or capturing a significant portion by a mechanism such as high efficiency drift eliminators in a cooling tower.

The nature and proximity of the population exposed to the system or equipment also needs to be considered. For example, if the equipment/system is sited in a hospital ward housing immunocompromised individuals, any chance of emission of an aerosol containing *Legionella* 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.

A.6 Susceptibility of individuals exposed

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.

Annex B (informative) Hot and cold water systems

B.1 Requirements of the assessor

There is extensive information on the control of *Legionella* in hot and cold water systems in ACoP L8 [6] and HSG274 Part 2 [7]. It is necessary that the assessor understands the guidance and how all the control measures work and are administered. The assessor also needs to have an understanding of the design aspects of these systems and how these affect the risk.

B.2 Domestic water systems

Wholesome hot and cold water systems (often referred to as "domestic") are the most common, usually the simplest and therefore most straightforward to understand for the less experienced assessor. Whilst small systems are generally similar and relatively simple, systems in larger buildings can include much more complex layouts and uses.

When compared to evaporative cooling systems, one major difference is that significant proportions of the pipework might be concealed and difficult, dangerous or impractical to inspect. Also, older buildings might have some components made from materials now considered unsuitable; they might be wrongly sized for present-day usage or have been modified in ways which make understanding the configuration or function more difficult.

B.3 Water supply

Where water is fed directly to the outlets from a public mains supply and is in regular use, the risk would be expected to be minimal. However, this risk could be increased if, for example, a pipe passes through a warm environment to a rarely or infrequently used outlet. Mains supply pipes that run close to the surface or above ground could be subject to significant heat gain, potentially raising the temperature above 20 °C. For this reason, almost all water systems require risk assessment.

Different water sources which might have poorer quality control than mains water supply, such as private boreholes, require additional data gathering to establish greater detail about them at the outset of the assessment so that any additional risk factors can be taken into account.

B.4 Storage of water

In the majority of systems there is some storage of cold water. This might be subject to changes in temperature, the potential for contamination and possible stagnation, all of which can increase the likelihood of *Legionella* growth. Hot and cold water systems have been identified as the cause of many sporadic cases of Legionnaires' disease. Cold water systems can become contaminated via supply water, by dirt entering uncovered or poorly covered tanks during maintenance and through back-contamination at the outlet or by splashback from taps.

For hot water, the inherent risk of water heaters incorporating storage is greater due to the potential for temperature stratification than that where there is no storage, such as plate heat exchangers or well-designed electrical instantaneous shower heaters.

There are other systems which might use heated water storage tanks within the growth range for *Legionella*, such as solar systems, heat recovery systems, ground/air source heat generation. Such systems require built-in designed control measures such as ensuring they are heated to 60 °C for at least one hour a day. For further information, see for example, **E.9.4**.

In a combination water heater where the integral cold water tank is directly over the hot water storage vessel there is a high probability of the cold water reaching temperatures permitting the growth of *Legionella*.

B.5 Control of *Legionella* growth in hot and cold water systems

The commonly accepted method to control *Legionella* in hot and cold water systems is by temperature, ensuring:

a) hot water is maintained at 60 °C at the outlet from calorifiers and at 50 °C or above throughout any circulating hot water system. Localized failure in circulation can increase risk and can often be identified by slow or delayed temperature increase when turning on a tap. Non-circulating systems are targeted to reach a minimum of 50 °C within one minute of turning on; and

b) cold water is stored in tanks at temperatures close to the supply and ideally below 20 °C. The whole distribution system will ideally achieve less than 20 °C within two minutes of turning on a tap.

NOTE In healthcare premises, hot water temperatures at outlets or the feed to mixer units are required to be at least 55 °C, at which there is a risk of scalding. HSG274 Part 2 [7] provides guidance on when to install thermostatic mixer valves to prevent scalding.

Spikes of higher temperatures during the initial two minutes after turning on a cold tap can provide useful indications of poor design. For example, cold pipes might be gaining temperature from close co-location with hot water or other sources of heat.

HSG274 Part 2 [7] gives guidance on developing programmes of regular routine checks to confirm that the above temperatures are being achieved. Records of these results will help assess any risk arising from inconsistency in control. In some cases, methods other than temperature, or in addition to temperature, are used, for example, biocides or other chemical or physical controls.

B.6 Testing for *Legionella* and other bacteria

Usually it is only necessary to test for *Legionella* in hot and cold water systems where validating a control regime other than temperature or where there is some question over the performance of any biocide or other chemical or physical control in use, or when controls (temperature or other) fail. In some circumstances, as determined by a risk assessment, monitoring might be appropriate, for example, in premises where there are people especially vulnerable to *Legionella* infection 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.

Systems are sometimes 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.

Risk assessors will also need to consider the upkeep of competency in the utilization of sampling techniques (see BS 7592) and data relative to other bacteria where this is used for routine monitoring and evaluation of risk. Competency relative to techniques set out in BS EN ISO 19458 will need to be evaluated.

B.7 Monitoring through visual inspection

Contamination might yield nutrients or provide a focus for bacterial colonization in *Legionella* control. Visual checks for evidence of contamination are therefore important and HSG274 Part 2 [7] advocates their use. It is recommended that the assessor conducts a visual inspection of the hot and cold water system as part of the risk assessment, as well as examining records of previous visual checks to see the history of findings and actions taken.

Examination of tanks is an essential part of the assessment, including their configuration and water flow pattern; their size in comparison to water consumption; materials from which they are constructed, insulation, their general condition; temperatures achieved; cleanliness or contamination and means of protection against contamination. Photographic records provide useful additional information, demonstrating both satisfactory and unsatisfactory conditions.

Examination of the interior condition of calorifiers and other hot water storage vessels can provide useful information for the risk assessment. However, the size, design and mode of action of some calorifiers can make internal inspections problematic and difficult to preform if an initial survey of the system is undertaken when it is in its normal working mode. Consequently an additional visit during system downtime, e.g. during maintenance, might be required to carry out the inspection. Records of recent previous assessments of the internal condition of the vessel can be used together with an assessment of the condition of the vessel drain water. Borescopes can also be used to undertake internal examination of vessels.

Borescopes can be a source of contamination to clean tanks and therefore need to be disinfected before use. See Annex F item 6) for details of a suitable chemical disinfection.

B.8 Elements of inspection

Surveys undertaken by the assessor involve 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 as well as for any potential sources of aerosol. This includes the following:

a) any points in the system where there can be no flow, e.g. dead ends (capped pipes), dead legs and little-used outlets;

b) any parts of the system with low water throughput, including little-used outlets such as in unoccupied areas or where oversized tanks are installed;

c) any parts of the system which are configured in parallel with others which could lead to an imbalance in water flow;

d) routes by which contamination can enter, including poorly fitting lids on tanks, unscreened overflow pipes, inappropriate cross connections, inadequate backflow prevention and emergency water supplies;

e) cool zones at the base of storage calorifiers;

f) installations where either the hot water is able to flow into the cold water system, or vice versa. This is mainly through faults occurring during local installation and failures in backflow prevention, including hot water flowing into the cold feed to a calorifier. This can rise by convection to the tank and might only happen when the shunt pump operates, which is typically at night and therefore not evident at the time when the system is being inspected. If this problem is found it needs to be pointed out to the system maintenance operator for rectification as soon as possible;

g) any parts of the system where incubating temperatures might prevail, including dead legs, little-used outlets, showers and thermostatic mixing valves (TMVs);

h) sources of heat transfer, including heating, hot and cold pipes running together such that cold water is heated or warm water is cooled, sharing a common duct, shared lagging materials and insufficient lagging;

i) materials of construction which could yield nutrient or otherwise support microbiological growth;

j) scale, sediment, corrosion or biofilm, including at the outlets; and

k) any changes to a system which might create stagnant areas, alter flow, or create dead legs, dead ends, etc.

B.9 Training and competence of maintenance and service provider staff

Service provider staff and site personnel are required to be competent to carry out their duties, therefore this is part of the assessor's report. 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 relevant 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 indicate poor management control which would need to be recorded as an additional risk factor.

Annex C (informative)
Open evaporative cooling systems

C.1 General

These systems can be complex and extensive, they almost all operate at incubating temperatures and *Legionella* growth is usually controlled by a chemical treatment regime. They also generate large volumes of dense aerosols which are expelled into the surrounding area by air streams usually mechanically generated. They require assessment by specialist assessors with the relevant competence.

These systems use water to remove heat and reject it to the atmosphere. In the process, water will typically get to a temperature suitable for *Legionella* growth. The range of designs for these types of devices is continually increasing and evolving. Many systems use evaporative cooling continuously but others, for example, adiabatic cooler/condensers normally operate in a dry mode but can sometimes operate in evaporative cooling mode as well. It is the responsibility of the assessor to determine the risk presented by any particular installation and although information from the manufacturer might prove useful, risks need to be independently assessed. Examples of common systems can be found in Part 1 of HSG274 [7].

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 ALARP risk.

Depending on the particular nature of the cooling system, factors that might need to be taken into account include the following:

a) non-potable make-up water;

b) aerosol generation, dissemination and its control;

c) seasonality and intermittent use;

d) proximity of susceptible populations, air intakes, etc.;

e) local sources of aerial contamination and process contamination;

f) accessibility for operation, cleaning, maintenance and inspection;

g) materials of construction;

h) physical condition;

i) dead legs, balance pipes, bypasses and cross connections;

j) intermediate collection chambers, "hot wells", "cold wells";

k) adequacy of water treatment;

l) adequacy of scheme of control, including monitoring activities; and

m) records of inspection, cleanliness and disinfection.

C.2 Open evaporative cooling systems

Open evaporative cooling systems are classed as very high inherent risk. The risk assessment of a cooling system will therefore concentrate on the controls to evaluate the residual risk.

It is essential to consider the whole cooling system, not just the cooling tower.

Annex D (informative) Spa pools

As spa pools are inherently high risk and potentially complex, the assessor needs to be competent in these types of system and understand spa pool treatment strategies, together with system design features which increase the risk of *Legionella* growth. See HSG282 [8].

Spa pools and hot tubs are warm water leisure pools designed for sitting or lying in up to the neck and not for swimming or total immersion. 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 near the users' faces. They are not cleaned or drained after each use as opposed to a whirlpool bath.

The choice of design is dependent upon the likely bather load, whether it is to be used intermittently by a small discrete number of the bathers as in a privately owned home or a business setting, such as a rented chalet, or whether it is to be used by a large number of bathers but possibly irregularly, for example, in a spa serving a number of apartments, or continuously, for example, in a busy commercial leisure centre.

Hot tubs are a type of spa pool designed for essentially private domestic use by a small number of bathers (see BS EN 17125). They are commonly self-contained factory-built units with a free board and skimmer system where the water level is below the top of the system to accommodate bather immersion and there is no balance tank (see Figure D.1). Hot tubs can be used in business situations where they require risk assessment, for example individual holiday chalets or hotel rooms might have their own hot tubs and hot tubs might be hired out for parties.

Those spa pools having a relatively high bather load, such as those in commercial leisure centres or a spa pool serving a hotel or block of apartments, as opposed to a single apartment are recommended to be of the deck level overflow design with a balance tank and continuous disinfection and filtration (see Figure D.2). In very large spa pools, balance tanks can be of similar construction and design to swimming pool systems with underground balance tanks. Smaller spa pools have balance tanks usually made of glass-reinforced plastic or polythene, with a firmly fitting lid, and are accessible for regular cleaning.

NOTE Safe access requirements for some balance tanks for cleaning purposes might be covered by the Confined Spaces Regulations [12], [13].

Depending on the particular nature of the spa pool, factors that might need to be taken into account include the following:

a) design appropriate for bather load and use;

b) materials of construction;

c) water supply, e.g. directly connected or via hose;

d) seasonality and intermittent use;

e) operation and maintenance;

f) spa pools on display (when chemical treatment might be less carefully applied or even not applied);

g) management and training;

h) susceptibility of users;

i) sources of environmental and user contamination;

j) frequency of cleaning and disinfection;

k) accessibility for operation, cleaning, maintenance and inspection, including air channels and all wetted parts (air channels are often not readily accessible for cleaning and balance tanks are often in locations which are difficult to access and where there is inadequate clearance for inspection and cleaning);

l) physical condition;

m) dead legs, bypasses and cross connections;

n) filters, including cleaning and backwashing;

o) balance tank, where fitted;

p) adequacy of water treatment and replacement of water;

q) adequacy of scheme of control, including microbiological monitoring activities; and

r) records of bather load, inspection, cleanliness and disinfection.

Figure D.1 — *Diagram of a typical hot tub*

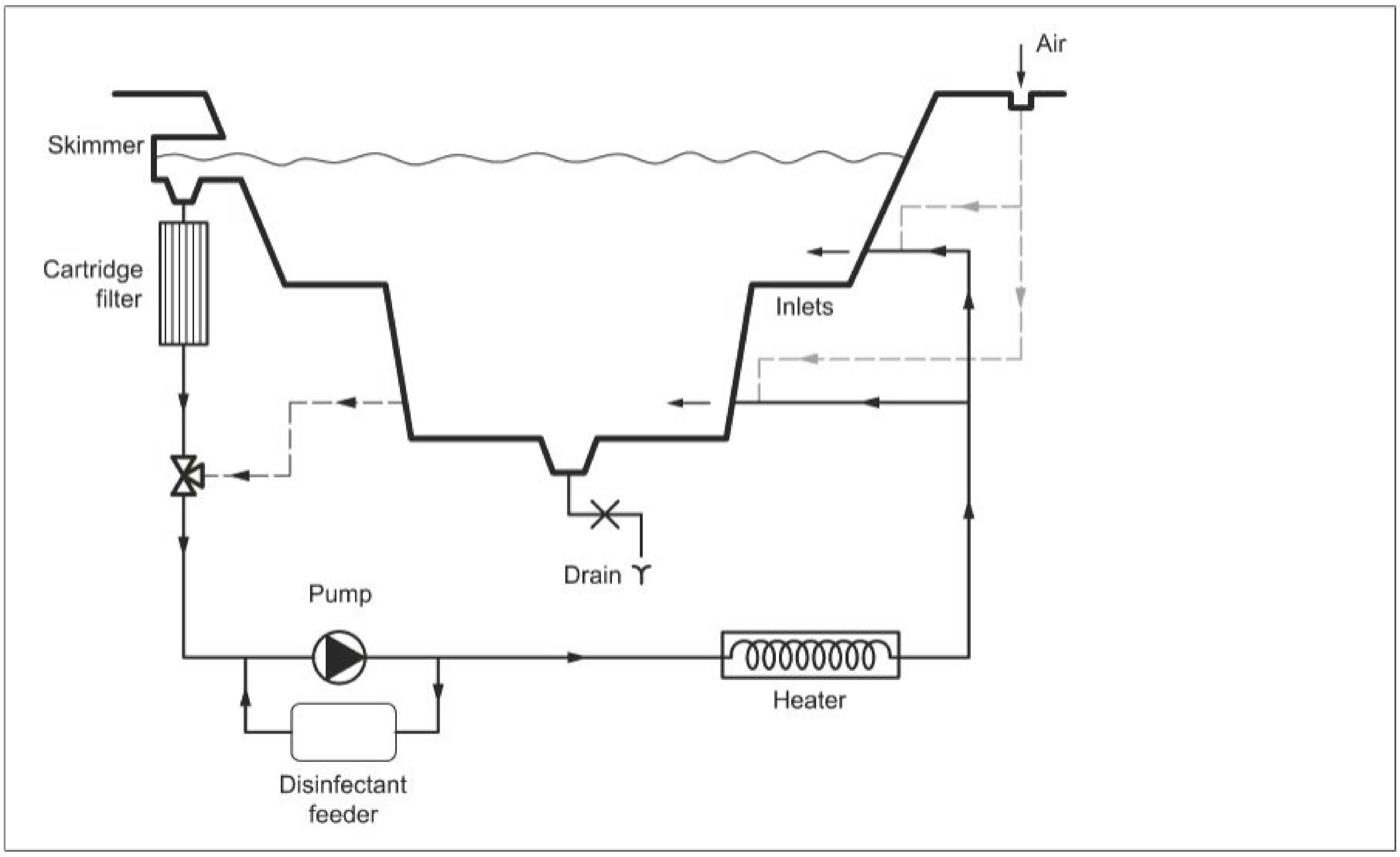
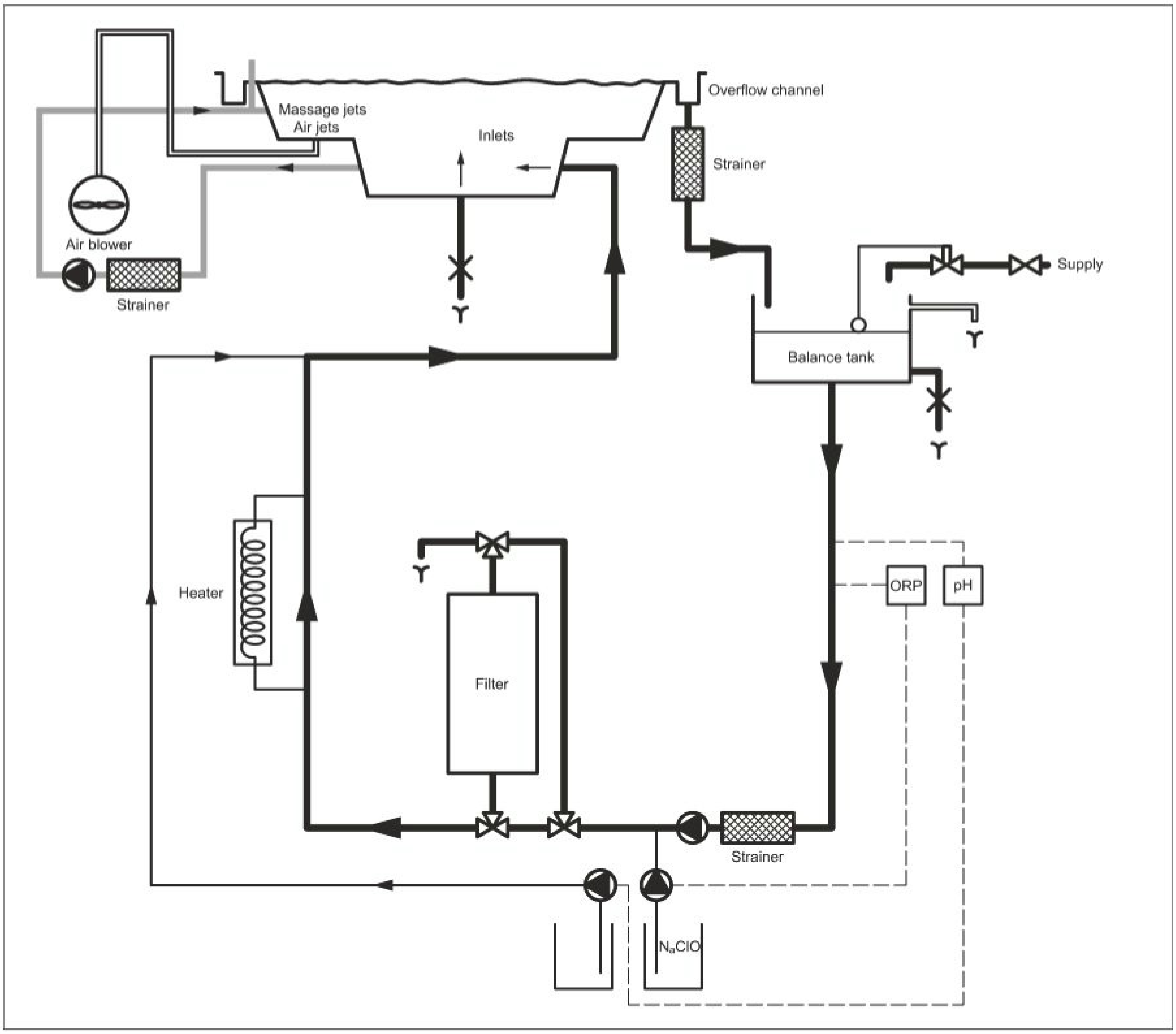


Figure D.2 — *Diagram of a typical commercial spa pool*



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 other potential sources will be confirmed and other pieces of new equipment identified as potential hazards. This annex discusses risk assessment issues 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 sprinkler and drench systems. Fire hose reel systems are used less frequently. Dry riser systems are inherently safer with regards to the risk of *Legionella* growth.

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.
- Backflow prevention might be needed to protect the mains supply and other water systems.
- 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, however, these systems are used to fight fires and the risk from fire outweighs the risk from Legionnaires' disease.

These systems are likely to be stagnant, might contain debris and be corroded to some extent. This is not of concern unless it threatens the operation of the system. The risk assessor needs to give consideration to the implications of emptying, cleaning or disinfecting fire suppression systems and what alternative fire control measures are in place.

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, *Legionella* can grow in them. The risk can be eliminated completely by removing the equipment. If fountains and interactive water features are to be retained, it is important that they are carefully designed and managed to control the risk.

NOTE More information can be found in the Swimming Pool Water Book by PWTAG [17].

Water features inside buildings have a greater inherent risk because they release aerosols into the building itself and have been responsible for outbreaks of legionellosis. Particularly where there is a small volume of water, the circulation pump and any decorative lighting can increase the temperature of the water to within the growth range of *Legionella* and supporting micro-organisms. There are many potential sources of nutrients 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. Humidifiers are typically described by the industry as adiabatic or isothermal.

- Steam humidifiers where water is boiled to produce steam (isothermal), typically either by electrode boiler, by gas fired heaters and other heat exchange methods. Steam is injected at low pressure often into an air handling unit.
- Cold water humidifiers (adiabatic) are cold water systems that increase moisture content by evaporating water either directly into a room, or into an air handling unit. Traditionally, direct room systems are spray type and in-duct systems are either spray or evaporative types.

Spray humidifiers atomize water directly into the air which then vaporizes. The systems sometimes use compressed air at low pressure, [less than 10 bar (1 000 kPa)] to atomize the water, or high pressure typically [from 16 bar to >70 bar (1 600 kPa to >70 000 kPa)].

Evaporative humidifiers are designed in order that the air passes through an evaporative media which is saturated with water and evaporated from the surface. These by design are not intended to create aerosols.

There are a number of other cold water systems including:

- ultrasonic humidifiers, which create a very fine mist;
- atomizing water directly by spraying it onto spinning discs; and
- older designs that simply circulate excess water from a pond to spray nozzles.

NOTE Humidifiers often have or require ancillary equipment including air compressors, water treatment devices, softeners and/or reverse osmosis (RO) systems (high pressure spraying systems or larger ultrasonic systems are normally operated on RO water).

The different units operate in fundamentally different ways and the level of risk needs to be judged individually. Very few recorded outbreaks of Legionnaires' disease have been associated with humidifiers, however humidifier systems are often seasonal and during periods of low use, bacteria can potentially accumulate in stagnant water and, without proper design and maintenance regimes such as cleaning and disinfection, might present a risk. Small ultrasonic humidifying units associated with food displays have caused outbreaks of Legionnaires' disease when incorrectly installed and maintained.

E.4.2 Steam humidifiers

Steam humidifiers are likely to present minimal risk due to the high temperatures involved in the production of steam.

E.4.3 Spray humidifiers

Spray humidifiers in which the water is recirculated are intrinsically more likely to present a risk of microbial growth and are now uncommon.

With spray humidifiers, the released aerosols could contain micro-organisms if control is not achieved, including *Legionella*, which could be inhaled by people. Because people are likely to breathe the humidified air, systems are rarely treated with chemicals to prevent the normal problems associated with using and evaporating water.

To prevent microbial growth, the systems concentrate on delivering good quality water to the humidifier, including careful attention to avoid stagnation by incorporating regularly induced operation and flushing processes.

E.4.4 Evaporative humidifiers

Evaporative humidifiers operate by applying relatively small amounts of water to a wetted media through which the air passes. They are often described as not producing aerosols, however, more accurately they can be described as having very low aerosol generation. Since evaporation occurs, the design is likely to include mechanisms for controlling increasingly dissolved solid concentrations within the water. Without careful control of water conditions and cleaning it is possible to scale (or foul) the evaporative media resulting in unintentional flow patterns and product failure.

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. It is recommended that humidifiers are therefore 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 include the following.

a) Feed water supply is not satisfactory – i.e. not clean, fresh wholesome water, at less than 20 °C.

b) The feed water supply pipework is not of approved materials or creates long dead legs from the flowing main.

c) Tank fed supplies are not closely monitored for water hygiene.

d) No water test points are installed.

e) System designed does not incorporate features to prevent water stagnation, such as:

   1) automatic flushing and purging cycles, in particular, confirm the system operates automatically during periods of low use;

   2) self-draining, with air gaps to prevent back siphonage from drains;

   3) automatic water drainage if the system stops operating.

f) Within air handling systems, limited air filtration is in place or badly maintained.

g) Condensation or water carry over is causing damp conditions.

h) No evidence of commissioning and preventative maintenance activities, including:
   1) limited access to the equipment;
   2) evidence of scaling or biofilms;
   3) build-up of dirt or debris, infestation;
   4) signs of damp, mouldy conditions, caused by condensation, water carry over or leaks;
   5) no replacement of consumables, such as water filters;
   6) limited water hygiene records.

i) Any ancillary equipment, such as air compressors or water treatment devices, are not maintained as part of the system.

j) Relative humidity conditions are incorrect and set points and air changes are not at desired levels in order not to over-humidify and create damp conditions.

E.5 Vehicle wash systems

E.5.1 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.5.2 Types of vehicle wash systems

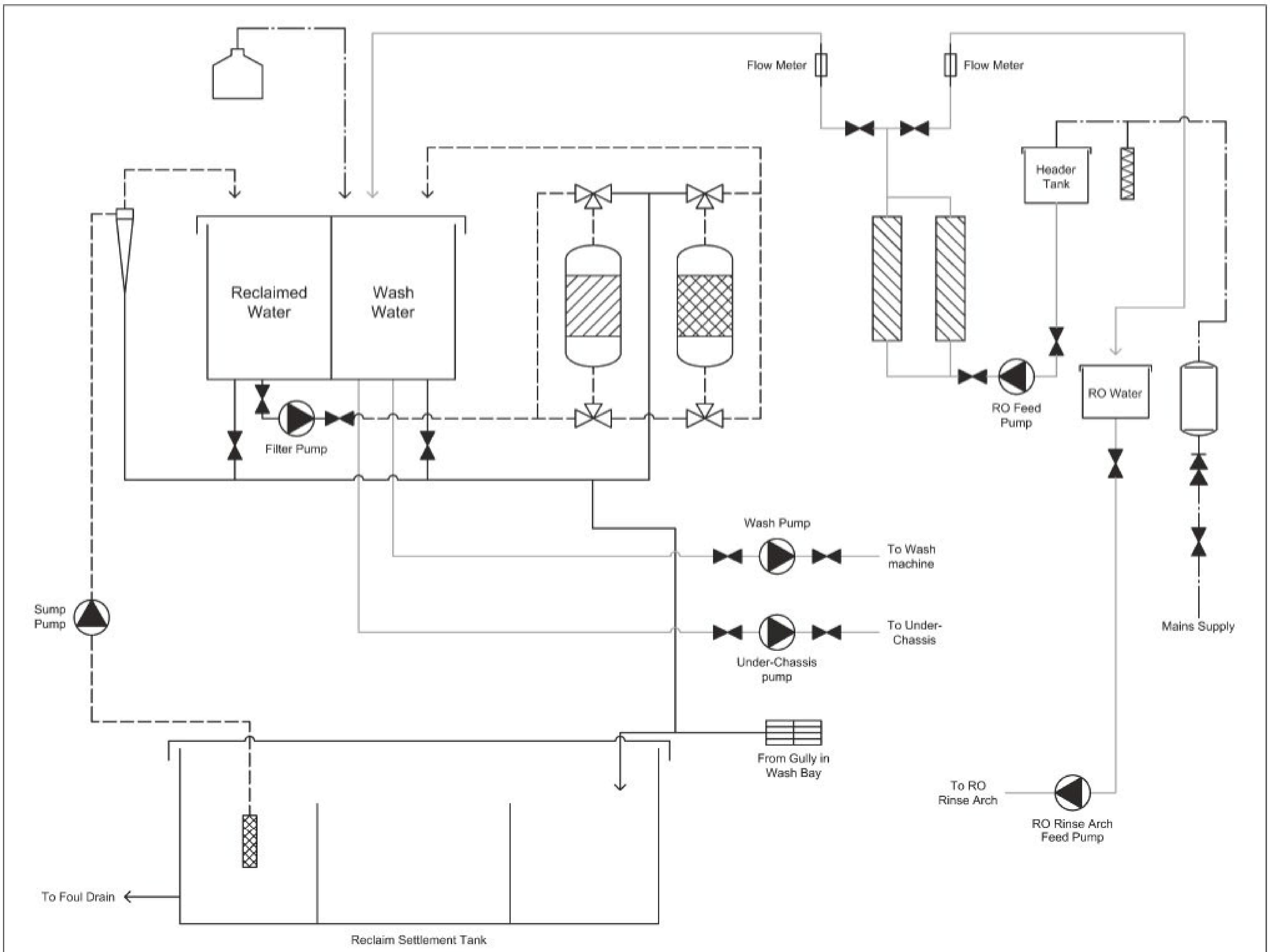
A car or lorry wash can be a manual jet wash, in which the jets or brushes are operated manually, or the automatic type, in which the washing is done by jets and brushes mounted on a moving frame that passes over the length of the car. In a train or bus washing system, the train is driven through the 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 pre-treatment need to be taken into consideration. An example of a car wash schematic diagram is given in Figure E.1.

Figure E.1 — *Example of a car wash schematic diagram*



Key

—·—	Mains water supply		Strainer
—	Tank-supplied washing water		Sand filter
– –	Reclaimed water system		Carbon filter
—	Drain/backwash line		Softener
	Water storage tank		Biocide dosing unit
	3-way valve		Hydrocyclone
	Flow meter		Isolation valve
	Cartridge filter		Double check valve
	Reverse osmosis (RO) unit		

E.5.3 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 *Legionella* as a result. It is important to establish the system conditions on shutdown 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 of water after filtration/separation 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.6 Thermal processing — Food industry (pasteurizers)

Food and drink products, including milk, juice, canned food, beers and others, are susceptible to spoilage by the growth of microbes. To reduce microbial activity, which is mainly bacterial but can be fungal in origin, a process called pasteurization is employed, where the food or drink product is subjected to elevated temperature which destroys the contaminant organisms without adversely affecting the taste and quality of the product.

There are several designs of pasteurizers available. Commonly, a pasteurizer consists of several zones (baths or tanks in which the product might be immersed or from which water might be pumped and sprayed over the product) which contain increasingly hotter water until pasteurization temperatures are achieved, followed by zones which reduce the temperature of the product. Such pasteurizers are called tunnel pasteurizers and typically contain a total of eight or more pre-heat and pre-cool zones. The actual number of pre-heat and pre-cool zones depends on the temperature profile the manufacturer needs for pasteurizing their product. Maximum temperatures in the hot zones can range from 60 °C up to >90 °C in certain food applications.

When considering the temperature profile in such pasteurizers, typically one pre-heat zone operates at a similar temperature as a pre-cool zone and so the zones are linked and "share" the water between those respective zones. Only the zones with water at the highest temperature are independent to allow pasteurization of the product. In certain pasteurizers the regenerative zones are linked to a cooling tower and so it is common to encounter pasteurizers that are dosed with water treatment products to maintain water quality similar to that required in a cooling system.

With water at varying temperatures, if hygiene procedures are not maintained, package failures and cross-contamination from package failures will likely provide a nutrient source to the warm water and encourage any microbiological contamination present in the water to grow. This increased microbiological contamination present in the water, including *Legionella*, will:

a) impact pasteurizer operation due to the disturbance of the thermal balance (fouled pump strainers upsetting the balance of the flows between the regenerating zones, fouled spraying nozzles or distribution decks causing reduced flows and hence interfering with the pasteurizing process); and

b) cause health and safety risks (e.g. contaminated aerosols increasing health risks for the people working in the vicinity of the pasteurizer (*Legionella*) plus microbiological slime causing floors to become slippery).

Since a pasteurizer uses or stores water which can create an aerosol, these systems require a *Legionella* risk assessment and control programme to be implemented. It is recommended that the assessor reviews all mechanical, operational and chemical aspects of control to include inspections, cleaning procedures, water quality (corrosion, scaling and biocide efficacy), periods of extended stagnation (typically at weekends or shutdown), results from monitoring, aerosol production and employee exposure.

E.7 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. Other similar devices are used to cool or quench the coating after its application. This might 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 identified 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 *Legionella* can assist risk assessment and might be required for monitoring of control.

E.8 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 *Legionella* and causing Legionnaires' disease. A large outbreak of Legionnaires' disease was caused by an air scrubber in Norway in 2005 [18]. In design and operation, air scrubbers using water might 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 the atmosphere possibly after passage through other devices to reduce the release of droplets to the 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 depends 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 *Legionella*. 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 *Legionella* 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 *Legionella* 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 *Legionella*.

As with any other system the risk assessor will have to consider the likelihood of *Legionella* 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 *Legionella* might be needed to assist the risk assessment process and might need to be incorporated into the ongoing monitoring of control.

E.9 "Green" technologies

E.9.1 General

Many technologies are being introduced into buildings, 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 *Legionella* could inform the risk assessment process and might be needed to confirm control is being achieved consistently.

Commonly these systems fall out of use due to lack of understanding or commitment and this will impact the risk.

E.9.2 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 is 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 are 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.9.3 Greywater reuse

Greywater is water generated from domestic activities, such as laundry, dishwashing and bathing, or from other sources such as air handling unit condensate or RO reject streams. It might be used for irrigation, toilet flushing or other non-potable purposes. Depending on the source, it frequently contains much higher levels of micro-organisms or has chemical characteristics different from the mains water supplies. It is also often warm and therefore a potential medium for the growth of *Legionella*. Depending upon what the greywater is used for, it might undergo different levels of treatment, often including chlorine treatment or other disinfection. The *Legionella* risk assessment has to include a careful consideration of how the water is 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. This is an example of where sampling for *Legionella* might help the assessment.

E.9.4 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 pre-heat 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 pre-heat store is in a separate cylinder.

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 pre-heat store, called the dedicated solar volume, is usually a minimum of 25 L/m^2 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. 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 *Legionella*. With many of these systems there is a conflict between maximizing energy conservation and minimizing the risk of *Legionella* growing. Energy conservation is maximized by distributing the hot water at 50 °C or less, but this increases the risk of *Legionella* growing. A common recommendation is to ensure that the stored hot water is heated to 60 °C for at least one continuous hour once a day. Currently, there is insufficient microbiological evidence available to confirm which designs and modes of operation are safe.

Consequently, sampling for *Legionella* 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.

E.9.5 Ground, air and water source heating

Other renewable energy heating systems or energy recovering 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 is likely 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 again, there might be a conflict between energy conservation and the risk of *Legionella* growth.

Annex F (informative)
List of equipment

The assessor's equipment list could include:

a) calibrated immersion and contact thermometers (immersion and surface probes);

b) mobile phone (with timer and calculator), if allowed on site;

c) torch and mirror;

d) sterile sample containers for microbiological sampling;

e) paper towels;

f) digital camera if allowed on site, or portable borescope camera;

g) recording device (clipboard, voice recorder, personal digital assistant or other);

h) respiratory protective device, overalls, eye protection, safety footwear, disposable powder-free 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 EN 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 (700 ml/l) ethanol and water, 70% v/v (700 ml/l) propan-2-ol and water, or a 1 in 100 dilution of a commercial grade sodium hypochlorite solution containing in the range 12% to 14%

available chlorine [0.1% available chlorine is equivalent to 1 000 mg of chlorine per litre of solution (1 000 ppm)]. 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, such as immersion probes.

NOTE 4 Attention is drawn to the COSHH Regulations [4], [5].

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) Containers and/or packaging materials for transportation of sample bottles, as applicable.

15) Bags for waste disposal.

Annex G (informative) Schematic diagrams

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 person 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 (see Figure G.1), which has the advantage of clarity and ease of editing, but hand-drawn diagrams are acceptable for simple systems (see Figure G.2).

Key components of a schematic diagram 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.

For parts of the system which are inaccessible for safety and practical reasons, it is recommended that these are indicated on the schematic diagram [see 5.2 i)].

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, one showing the configuration of the plant (tanks, pumps, softeners, etc.) and one showing 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-built 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 schematic diagrams 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 diagram.

Figure G.1 — *Example of a computer-drawn schematic diagram of an evaporative cooling system*

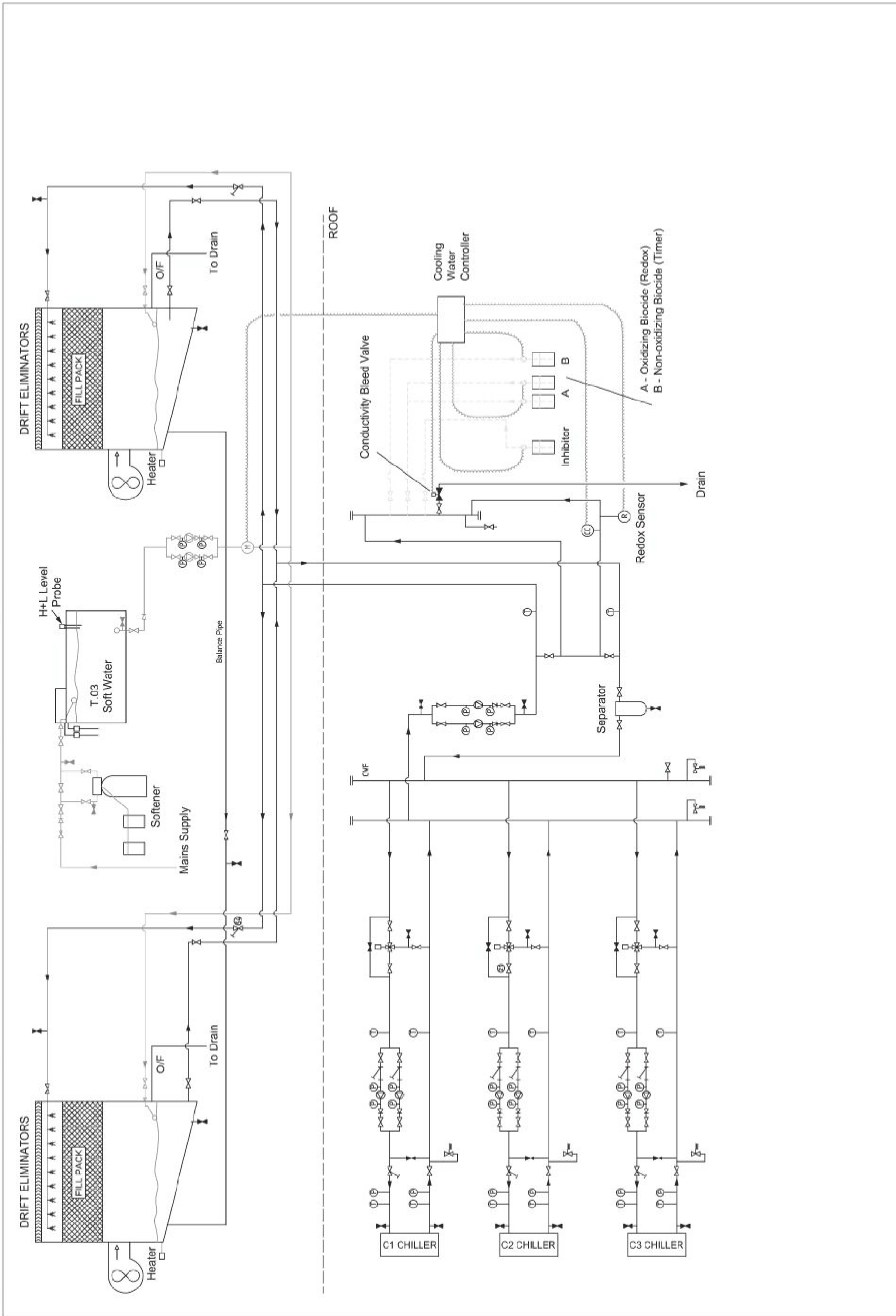
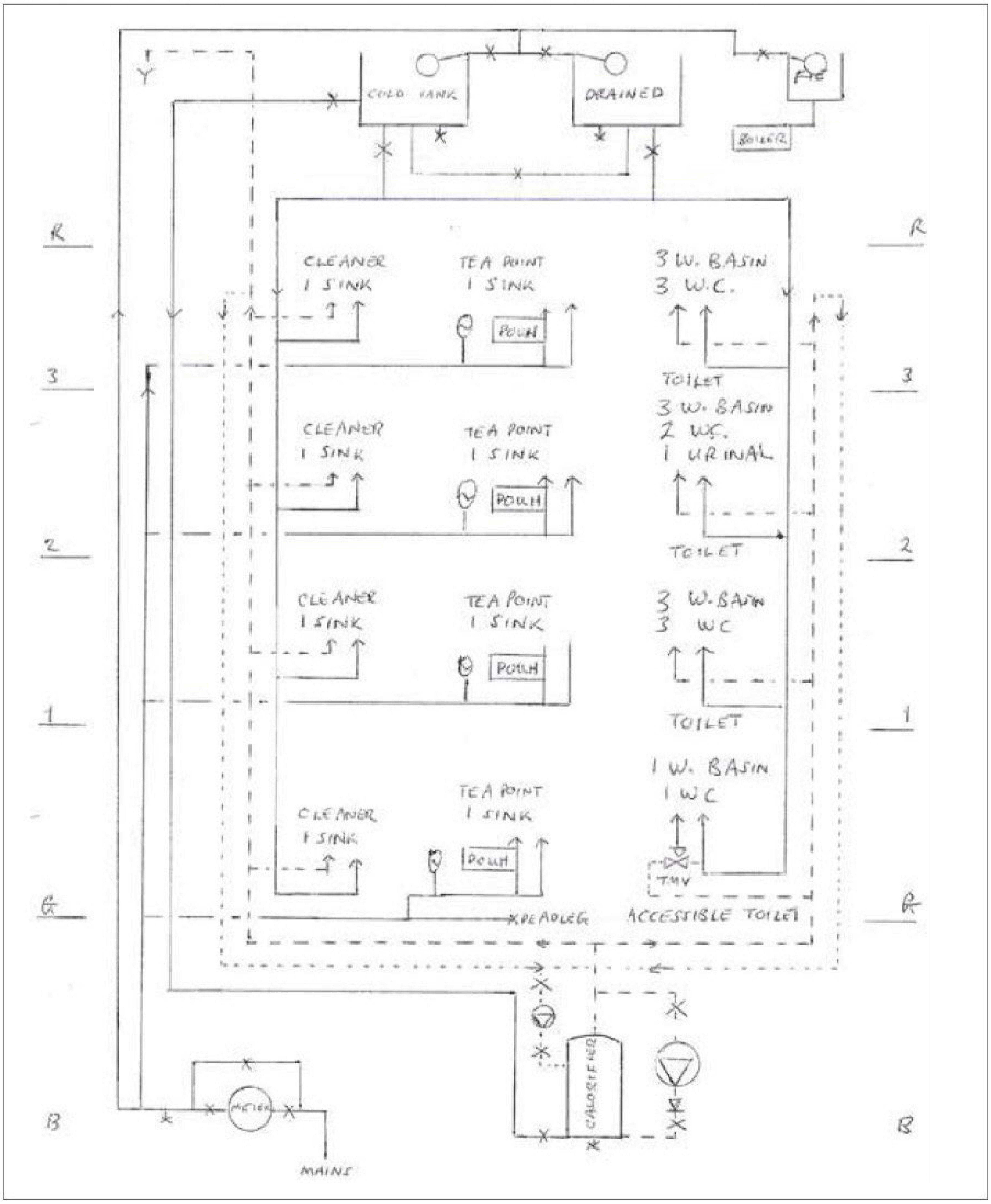


Figure G.2 — *Example of a hand-drawn elevation of a hot and cold water system in a commercial building*



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