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Sampling for Legionella bacteria in water systems – Code of practice

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Foreword

Publishing information

This British Standard is published by BSI and came into effect on 30 November 2008. It was prepared by Subcommittee EH/3/4, *Microbiological methods*, under the authority of Technical Committee EH/3, *Water quality*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This British Standard supersedes BS 7592:1992, which is withdrawn.

Information about this document

This is a full revision of the standard, and introduces the following principal changes:

This document makes a clearer distinction between routine and incident sampling.

It provides a clearer rationale for routine sampling, including newly-recognised sources, risk assessment, surveying and sample points.

It revises acceptable transport times to account for more quantitative results and sampling/transport subcontracting.

It takes account of new standards documents for water sampling and analysis.

Hazard warnings

WARNING. This British Standard calls for the use of substances and/or procedures that can be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage

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.

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

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.

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.

In particular attention is drawn to the following statutory regulations:

The Health and Safety at Work etc. Act 1974 [1].

The Management of Health and Safety at Work Regulations 1999 [2].

The Control of Substances Hazardous to Health Regulations 2002 (as amended) [3].

Introduction

Legionnaires' disease was first recognised in July 1976 and the bacterium later isolated and named *Legionella pneumophila*. Since then, over 50 other species of *Legionella* have been described of which at least 20 have been associated with disease in humans. These organisms are widespread in the natural aquatic environment and in artificial water systems. The organism is an opportunistic human pathogen and infection is more often associated with artificial water systems. The disease is not known to be transmissible via person-to-person contact. As a result, the way to prevent or control outbreaks of Legionnaires' disease is to inhibit or limit the growth of these organisms in water. In the UK, the control of legionellae (bacteria of the genus *Legionella*) falls within the general requirements of the Health and Safety at Work etc. Act [1] and the Control of Substances Hazardous to Health Regulations 2002 (as amended) [3].

Legionellae are only able to grow in water in the presence of other micro-organisms. In vitro they have been shown to be capable of growth within a number of protozoa, particularly amoebae and to be supported by some bacteria such as flavobacteria. In addition, legionellae have been shown to be associated with biofilm on surfaces in water systems where they can grow in the protozoa grazing the biofilm and there is also evidence suggesting they can grow outside protozoa alongside and supported by other organisms within the biofilm. Growth within protozoa, particularly with the potential for incorporation within protozoal cysts, can protect legionellae from biocides, heat and drying. This enables the legionellae to survive under conditions that would otherwise be fatal to them and to be transported within both protozoa and cysts to more favourable environments where they might subsequently grow. The association with biofilms, as with other aquatic bacteria, offers legionellae a nutritional advantage and also provides them with some protection against adverse environmental conditions, particularly biocides, that would otherwise kill them if they were simply suspended within the water column. Thus control of biofilm formation within water systems is of paramount importance for the control of legionellae.

The numbers of reports of Legionnaires' disease continues to rise, probably due to an increased recognition of the disease using improved diagnostic methods but possibly also resulting from a greater exposure to potential sources. To demonstrate that measures to control legionellae are effective there is an increasing need to sample potential sources for the presence of legionellae. Sampling is also required when investigating the sources of infection in cases of Legionnaires' disease. It is, therefore, the aim of this document to bring together information on likely sources of Legionnaires' disease, the selection of sampling sites and the methods of sampling for the purposes of routine monitoring, investigating a problem, or an outbreak investigation. Although it is necessary to cover some aspects of risk assessment in order to facilitate the selection of sampling sites, it is not the intention to give extensive explanations of how to carry out a risk assessment, as this is covered elsewhere, for example, in the Water Management Society guide [4].

To ensure personnel safety, a risk assessment of the system to be sampled should be conducted before sampling.

In the UK, outbreaks of Legionnaires' disease have been commonly associated with evaporative cooling towers and condensers, hot and

cold water systems in large buildings, such as hospitals and hotels, and spa pools. The use of nebulizers, or other medical respiratory equipment, contaminated with legionellae (usually by filling or washing such items with tap water containing the bacteria) has also been reported to cause infection. Other sources that have been implicated in outbreaks globally include cutting fluids (containing oil-in-water emulsions of about 95% water, and used for lubricating machine tools), natural warm spas or hot springs, indoor fountains, potting composts and ultrasonic misting devices used to humidify food display areas in shops and restaurants, pressure washers, air scrubbers and effluent treatment plants.

Household plumbing systems have also been implicated as sources of Legionnaires' disease. In one UK study [5], legionellae were isolated from approximately 15% of the homes of patients compared with approximately 5% of homes used for control purposes.

Section 1: General

1 Scope

This British Standard gives recommendations and guidance on the sampling of water and related materials for determination of the presence of organisms of the genus *Legionella*. It is applicable to sampling artificial water systems and also gives methods for sampling of biofilms and sediments that might be present in water systems. Some of the same sampling principles can be applied to natural water systems.

The standard is applicable to both sampling for routine monitoring and in outbreak investigations. For the latter, recommendations and guidance on the selection of sampling points are given. The rationale for the selection of sampling points for particular situations is also discussed.

This British Standard is intended for use by all those involved in water sampling for legionellae including the persons taking samples on site and their employers.

2 Normative references

BS EN ISO 19458, *Water quality – Sampling for microbiological analysis*

3 Terms and definitions

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

3.1 aerosol

suspension in a gaseous medium of solid particles, liquid particles or solid and liquid particles having negligible falling velocity

3.2 artificial water system

water system that has been constructed and does not occur naturally, e.g. a hot water system

3.3 biocide

substance which kills micro-organisms

3.4 biofilm

community of bacteria and other micro-organisms, embedded in a protective layer with entrained debris, attached to a surface

3.5 blind-end

length of pipe closed at one end through which no water can pass

3.6 calorifier

apparatus used for the transfer of heat to water in a vessel by indirect means, the source of heat being contained within a pipe or coil immersed in the water

NOTE 1 see also plate heat exchanger (3.21).

NOTE 2 A 'storage calorifier' also stores some of the heated water in the same vessel.

- 3.7 cold water system**
installation of plant, pipes and fittings in which cold water is stored, distributed and subsequently discharged
- 3.8 cooling tower**
device for cooling water that, in turn, is used for cooling in a process
NOTE The water is passed over the tower against an air stream. Water evaporates which causes the water to be cooled. The cooler water is then usually pumped to a heat exchanger to be reheated and recycled through the tower.
- 3.9 cistern**
tank for storage of water
NOTE This includes all cisterns, not just WC cisterns.
- 3.10 dead-leg**
length of pipe leading (to a fitting) through which water only passes when the fitting is operated
- 3.11 distribution system**
pipework which distributes water from hot/cold/cooling water plant to one or more fittings/appliances/processes
- 3.12 domestic water supply**
hot and cold water intended for personal hygiene, culinary, drinking water or other domestic purposes
NOTE This applies to all such systems and not just those in dwellings.
- 3.13 evaporative condenser**
device similar to a cooling tower, water is passed through the tower against an air stream but, as the water falls, it also passes over a heat exchanger within the body of the tower; the heat exchanger contains a refrigerant gas that is condensed by the cooling effect of the water passing over it
- 3.14 evaporative cooling**
process by which a small portion of circulating water is caused to evaporate, thereby taking the required latent heat of vaporization from the remainder of the water and causing it to cool
- 3.15 hot water system**
installation of plant, pipes and fittings in which water is heated, distributed and subsequently discharged (not including cold water feed cistern or cistern)
- 3.16 legionellosis**
any illness caused by exposure to legionellae
- 3.17 Legionnaires' disease**
form of pneumonia caused by legionellae

- 3.18 pontiac fever**
upper respiratory illness caused by legionellae, but less severe than Legionnaires' disease
- 3.19 non-oxidizing biocide**
biocide that functions by mechanisms other than oxidation, including interference with cell metabolism and structure
- 3.20 oxidizing biocide**
substance capable of oxidizing organic matter, for example cell material, enzymes or proteins that are associated with microbiological populations resulting in death of the micro-organisms
NOTE The most commonly used oxidizing biocides are based on chlorine or bromine (halogens) that liberate hypochlorous or hypobromous acids respectively on hydrolysis in water. The exception is chlorine dioxide, which does not hydrolyse but exists as a solution. However, chlorine dioxide functions in the same way as other oxidizing biocides.
- 3.21 plate heat exchanger**
type of heat exchanger that uses metal plates to indirectly transfer heat between hot and cold water
NOTE Often used in conjunction with a hot water storage vessel.
- 3.22 legionella risk assessment**
identifying and assessing the risk from legionellosis from work activities and water sources on premises, and determining any necessary precautionary measures
- 3.23 sentinel taps**
hot water services – the first and last taps on a re-circulating system; cold water systems (or non-re-circulating hot water system) – the nearest and furthest taps from the storage cistern (water heater)
NOTE The choice of sentinel taps might include other taps which are considered to represent a particular risk, for example, the coolest part of a hot water system or the warmest part of a cold water system.
- 3.24 spa pool**
self-contained body of warm water designed for sitting in (not whole body immersion), intended for a small number of people to use at one time; the water is re-circulated and kept between 30 – 40°C and is usually not drained between use and is continually filtered and cleaned; hydro-jet circulation, with or without an air induction bubble system, is also used to agitate the water
NOTE Spa pools are known under a range of names – spa bath, hot spa, hot tub, portable spa, whirlpool spa, swim spa and often Jacuzzi™. All systems usually work in the same way.
- 3.25 stagnation**
condition where water ceases to flow, and is therefore more liable to suffer microbiological growth

3.26 strainer

coarse filter usually composed of a metal strainer or mesh, and positioned upstream of a sensitive component such as a pump control valve or heat exchanger to protect the component from damage caused by debris

3.27 thermostatic mixing valve (TMV)

valve for mixing hot and cold water, the temperature at the outlet is pre-selected and then controlled automatically by the valve

4 Risk assessments

4.1 General

Where sampling is required, a risk assessment of all the water systems should be performed to determine the risks to human health from infectious agents, including legionellae, and the implementation of measures to control the risk, including management and monitoring of these risk control measures.

NOTE 1 Users are reminded of The Health and Safety at Work etc. Act 1974 [1] as implemented through the Management of Health and Safety at Work Regulations 1999 [2] and the Control of Substances Hazardous to Health Regulations 2002, (as amended) [3].

In addition, a risk assessment should be performed to ensure the safety of employees associated with the sampling process (e.g. working at height or in confined spaces, or the handling of chemicals) and measures put in place to control risks before employees go on site to take samples.

As part of these risk assessments a detailed survey of each water system is necessary, together with preparation of an up-to-date schematic diagram of each system: the results of this survey should be used to identify the sampling points. Samplers should be aware of risk factors for the growth of legionellae, such as temperatures between 20 °C – 50 °C, aerosol production, infrequent use etc.

NOTE 2 Practical advice on how to comply with the regulations is given in the HSE Approved Code of Practice and Guidance L8 [6].

4.2 Summary of the components of risk assessment

The risk associated with a water system or piece of equipment utilizing water is a reflection of its design, operation and maintenance, the greater the complexity of the system the greater the risk of colonisation – an estimate of the potential risk from each component of the system should be made based on a variety of factors including the following:

- the opportunity for legionellae to enter or inoculate the system;
- the suitability of physico-chemical conditions to sustain growth of legionellae;
- mechanisms whereby aerosols might be produced and released into the environment (where they might be inhaled by staff or members of the public);
- the susceptibility of the population exposed.

When undertaking a risk assessment, mechanical, chemical and operational parameters of the control programme, management procedures and training should be reviewed.

5 Safety of sampling personnel

COMMENTARY ON 5

Information on aerosols. *To cause infection, legionellae normally need to be inhaled. The inhaled particles of between one and three micrometres (1-3 μm) are small enough to penetrate down to, and be retained in, the deepest part of the lungs (alveoli) but large enough to contain at least one bacterial cell. These particles are too small to be seen by eye and can remain suspended in air for prolonged periods of time. A suspension of such particles in air is termed an aerosol, and might not necessarily be visible or even wet.*

It is a common misconception that a water spray is an aerosol and that legionellae have to be contained within a wet droplet. A mist of water droplets might constitute an aerosol if the droplets are small enough. Water evaporates from small droplets very rapidly. For particles of less than four micrometres (4 μm), the evaporative process will usually take place in less than one second, although the exact rate of evaporation will depend on the prevailing temperature, relative humidity and airflow.

If a water droplet contains a single bacterial cell, the droplet will rapidly evaporate to a particle size diameter or droplet nucleus of about one micrometre (1 μm). A particle of this size can remain suspended in air for prolonged periods of time and travel over considerable distances. These particles are dry and contain no free moisture. Only bound water is present which represents a small percentage of the total mass. When air is inhaled into lungs, about 50% of the particles, which are those of approximately one micrometre (1 μm), will be retained in the lungs.

Any mechanical action that causes the surface of a liquid (which contains bacteria) to be broken up might cause the production of small droplets containing bacteria suspended in them. If these droplets are small enough, the water might rapidly evaporate leaving the dry droplet nuclei containing the bacteria, so forming an aerosol. Natural aerosols can be generated by rainfall, waterfalls, bubbles rising through water or via wave formation. In artificial water systems or environments, it might be that running taps, showers, fountains, humidifiers, spa pools, whirlpool baths and evaporative cooling towers and certain industrial processes generate aerosols. Infection is also thought to have resulted from the aspiration in certain nosocomial cases either from drinking contaminated water, or ingesting liquid feeds or ice made with contaminated water, or using contaminated water for purposes such as irrigation or washing wounds.

When samples are collected for routine monitoring purposes the systems should already have been subjected to a risk assessment and suitable control and monitoring procedures should already be in place (see Clause 4). The risk to sampling personnel during sampling should, therefore, be minimized.

Appropriate precautions should be taken during sampling operations to minimize the production of, and exposure to, aerosols, for example:

- taps should be turned on and water run gently to reduce the amount of splashing;
- samples should be taken from cooling systems at sample point locations situated on the return service to the cooling water to the tower, and as near as possible to any heat source rather than

by removing an inspection hatch and collecting samples from within the tower itself.

Employers should be aware of possible increased risks to individual staff who might be particularly prone to an increased risk of legionellosis during sampling operations, due to underlying conditions or immuno-suppression.

WARNING. Users are reminded of the WHO report of Bartram *et al* [7] on legionellosis, mentioning that the risk of legionellosis increases with age, as well as to people who are smokers, have a weak immune system or those who have a chronic lung disease (such as emphysema).

6 Survey and sampling

6.1 General principles

Employers should ensure that persons selecting sample points and taking samples have appropriate training to understand the rationale for selecting sampling points, factors which might pose a risk for the growth and dissemination of legionellae, the effect of good sampling procedure on the final result and its implications (for example, a false negative result might mean a contaminated system does not get appropriately treated).

Certain principles apply to all samples collected for microbiological analyses, i.e. – the sample should be as representative as possible of the water at the location of the sample point and time of collection. In addition, the population of legionellae in the sample should undergo as little change as possible before the analysis begins (thus sample transportation and storage need to be correctly controlled) (see Clause 9). Other relevant factors include:

- choice of sampling point;
- possible presence of biocides;
- the need for disinfection of the sample point;
- the location and timing of the sample in relation to the normal operating conditions and control measures of the system, including the timing and levels of biocide dosing;
- the type and quantity of sample to be collected.

6.2 Survey of water systems

COMMENTARY ON 6.2

The choice of sampling point location requires a detailed knowledge of the lay-out of the water system to be examined, and an appreciation of the ecology of the organism. In outbreak investigations, there might be no reliable information available on either the lay-out of the system or conclusions of previous risk assessments, or indeed, knowledge of whether any risk assessments have been carried out. Guidance on sampling for outbreak investigations is given in Section 3.