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TRENDS IN FOOD SCIENCE &TECHNOLOGY

EHEDG Update

The prevention and control of *Legionella* spp. (including Legionnaires' disease) in food factories

This article is an extended summary of the report prepared by the Process Water Subgroup of the European Hygienic Engineering & Design Group (EHEDG). It is the 23rd in the series of EHEDG summaries published in TIFS. Copies of the full report (EHEDG Doc. 24, August 2002) prepared by A.M. van Buren (Chairman), J.A. Milligan, H.M.J. van Eijk, J. O'Brien, S.D. Pannell, D. Lawrence, R. Hopman, W.G.J.M. van Tongeren, are available from CCFRA at pubs@camden.co.uk Information about EHEDG can be found on the website at www.ehedg.org It is strongly recommended that for application in the field, operators in the food industry should read the guidelines in its entirety, to ensure a holistic approach to legionella control.

Introduction

Legionella spp. occurs naturally in water but becomes a hazard to humans if conditions allow it to proliferate in factory or domestic water systems. Unlike enteric organisms that infect humans via the gastro-intestinal tract, *Legionella* spp. needs to be inhaled via contaminated aerosols. The organism can cause severe respiratory illness, especially in immune suppressed persons and the elderly. The disease is indicated as legionellosis or as Legionnaires' disease.

There are many locations on food industry sites where the potential for the proliferation of *Legionella* spp. in water systems exists. It is of particular concern in cooling towers, evaporative condensers and hot and cold water systems where water temperatures are in the range 20–45°C. These guidelines highlight control measures for *Legionella* spp., which are of particular importance for the food industry. They are complementary to any existing national or local legislation or guidelines.

Scope of the guidelines

These Guidelines set out the main elements necessary to implement and maintain an effective management programme for the Prevention and Control of *Legionella* spp. in any water system in the Food Factory. Implementation of the guidelines will prevent any employee, visitor or neighbour (anyone within 1 km radius of plant location) from contracting Legionnaires' disease or any associated diseases.

A reasonably foreseeable risk of exposure to *Legionella* spp. may occur in:

- water systems incorporating a cooling tower
- water systems incorporating an evaporative condenser
- hot and cold water systems
- other plant and systems containing water which is likely to exceed 20°C and which may release a spray or aerosol (i.e. a cloud of droplets and/or droplet nuclei) during operation or when being maintained (see Box 1).

Assessment of risk

A number of factors are required to create a risk of acquiring legionellosis. These include:

- The presence of *Legionella* spp.
- Conditions suitable for multiplication of the organism e.g. suitable temperature (20–45°C) and a source of nutrients, e.g. sludge, scale, rust, algae and other organic matter;
- A means of creating and disseminating breathable droplets e.g. the aerosol generated by a cooling tower or shower;

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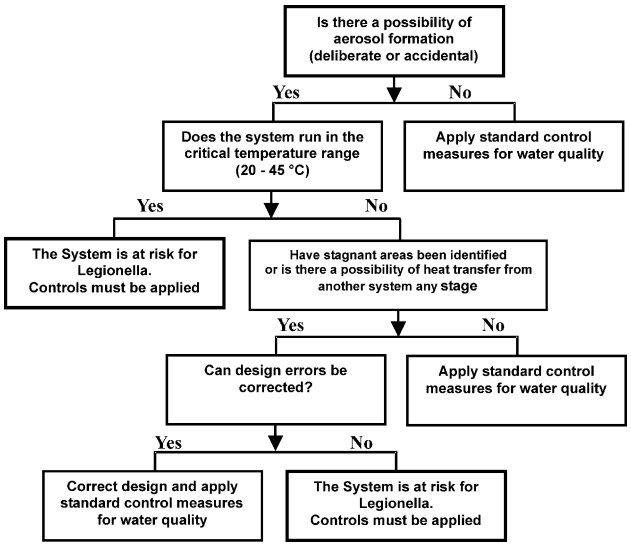
Box 1. Typical risk installations in food factories:

- Pressure jetting systems
- Can/bottle washing
- Vegetable washing
- Conveyor lubrication
- Tunnel pasteurizers and coolers
- Showers (including emergency)
- Non potable water storage for emergency use, e.g. fire fighting
- Garden hoses and sprinklers
- Spray humidifiers and air washers
- Machine tool cooling units
- Vehicle washing plants
- Ornamental fountains
- Waste water treatment plant

- The presence (and numbers) of people who may be exposed, especially in premises where occupants are particularly vulnerable, e.g. healthcare. Special attention should be paid to people treated with immune suppressive medicines.

Not all water systems pose a risk. The following decision tree helps to identify the systems at risk so that control measures can be applied:



Apart from the identification of potential sources of risk, the assessment should include the means by which exposure to *Legionella* spp. is to be prevented or how the risk of exposure to *Legionella* spp. is to be controlled. The assessment should be reviewed whenever there is reason to believe that the original assessment may no longer be valid.

Expertise required

The people who carry out the risk assessment and who draw up and implement any precautionary measures should have the experience, training and resources to enable them to carry out their tasks competently and safely. In particular, they should know:

- potential sources of *Legionella* spp. and the risk they present
- measures to be adopted, including precautions to be taken for the protection of people concerned and their significance
- how to ensure controls remain effective

Where a company has to use outside contractors all reasonable steps should be taken to ensure the competence of those contracted. Lines of communication with management should be clearly established.

Control measures

Water systems that show there is a reasonable risk of exposure to *Legionella* spp. should be avoided as far as is reasonably practicable. Where this is not possible there should be a written scheme for controlling the risk from exposure and this should be implemented and properly managed.

The risk from exposure will normally be controlled by measures that do not allow the proliferation of *Legionella* spp. in the system and reduce exposure to water droplets and aerosol. Precautions should, where appropriate, include the following:

- controlling the release of water spray
- avoidance of water temperatures and conditions that favour the proliferation of *Legionella* spp. and other micro-organisms
- avoidance of water stagnation
- avoidance of the use of materials of construction that harbour bacteria and other micro-organisms, or provide nutrients for microbial growth
- maintenance of the cleanliness of the system and the water in it
- use of water treatment techniques
- action to ensure the correct and safe operation and maintenance of the water system.

Air conditioning and cooling systems

Cooling towers

Cooling towers readily generate fine water droplets by distributing water over a packing material through which there is a counter-current flow of air. Cooling towers serving air conditioning systems have caused a number of outbreaks of legionnaires disease. Cooling towers are also used for many industrial cooling

applications and these have been identified as the cause of the majority of outbreaks. Most industrial cooling systems operate at water temperatures that are ideal for *Legionella* spp.

Evaporative condensers

Evaporative condensers are sometimes used for air conditioning or industrial cooling applications. The evaporative condenser combines the functions of both the cooling tower and the conventional condenser as water is sprayed directly over cooling coils. The volume of water in the evaporative condenser is less than in a cooling tower system and the control of water quality may be more difficult. Cases of legionellosis have been attributed to evaporative condensers.

Water standing in ductwork and condensate trays may represent a potential source of infection. Water can enter the duct from leaking equipment and pipes, from humidifiers or as condensation from duct mounted cooling coils. It may become contaminated; either directly by particles drawn through the air inlet, or indirectly from the drain if there is no air break between the condensate discharge and the drain. Condensed water is initially below 20°C but will warm to the ambient temperature if allowed to stand in the duct or tray. Such water will be scoured by the air flow in the duct. While air velocities are generally low and water droplets are unlikely to be picked up in normal circumstances, aerosols may sometimes be created.

Note that *Legionella* spp. will proliferate throughout the water cooling system and not just in the cooling tower, so preventive measures should apply to the whole system.

Design and construction

Cooling systems should be designed and constructed to control the release of drift and to aid safe operation, cleaning and disinfection. Fitting a short exhaust stack on the cooling tower will ensure that the hot humid air is discharged well away from the tower inlet. This will reduce the risk of recirculating contaminated exhaust air back into the tower and improve overall performance.

Drift eliminators should be fitted to all cooling towers. Drift eliminators, even those described as 'high efficiency', will not remove all droplets, particularly the smaller ones (<10 μm), which are significant constituents of aerosols. It is therefore essential that a full management regime is implemented in order to minimise the proliferation of *Legionella* spp.

Cooling towers should be positioned as far away as possible from air conditioning and ventilation inlets, opening windows and occupied areas. Note should be taken of the prevailing wind direction.

Management of cooling systems

Systems should be properly commissioned before use to ensure that they operate correctly and within the design parameters. This will apply both to new installations and to existing installations that have been substantially altered or following a period out of use. It is essential that precautions are taken to control the risk during commissioning and start up, as well as during normal operation of the system.

Cooling systems and towers should be kept in regular use where possible as occasional or intermittent operation creates a significantly higher potential risk than continuous operation. Where a system is used intermittently or it may be needed at short notice, one option is to ensure that it is run once each week. It should at the same time be dosed with water treatment chemicals and the water quality should be monitored. The whole system should be run for long enough to thoroughly distribute treated water. If a system is out of use for a week or longer the water should be treated with biocide immediately on reuse. If the system is out of use for a month or longer it should be drained, cleaned and disinfected immediately before reuse. This applies both to normal operation and commissioning periods.

Detailed maintenance schedules should be prepared for each water system. The schedule should include time scales for inspections and cleaning. Drift eliminators require particular attention with regard to maintenance in order to minimize aerosol release. They should be inspected, cleaned and maintained to ensure they are free from fouling, corrosion, scale and other deposits.

Water treatment programmes

A complete water treatment programme based on the physical and operating parameters for the cooling system and analysis of the make-up water must be established. Ideally this should be automated.

A number of interrelated factors influence the success of any treatment programme, including corrosion, scale formation, fouling and microbiological activity. Failure to control any one of these can lead to an environment that encourages the growth of micro-organisms. Inhibitors to control these factors can be applied as appropriate.

Cooling systems need to be cleaned and disinfected at appropriate intervals in order to prevent conditions which permit growth of micro-organisms including *Legionella* spp. to multiply, and to allow water treatment programmes to work effectively. It cannot be stressed too strongly that effective cleaning is an important precursor to disinfection. Failure to clean properly will almost certainly ensure that disinfection will be unsuccessful. Cooling towers should always be cleaned and disinfected in the following circumstances:

- immediately before the system is first taken into use (before first commissioning) to remove contamination which may have occurred during construction.
- if the system, or part of it, has been out of use for 5 days or longer.
- if the system, or part of it, has been altered, entered for maintenance or otherwise disturbed in a manner which may lead to contamination.
- if the cleanliness of the tower or system is in any doubt.

Hot and cold water systems

Legionella spp. may colonise water storage tanks, calorifiers, pipe work and associated plant such as water softeners and filters, and outlets including taps, showers and other appliances by biofilm formation. The optimum growth temperature is 42 °C. Proliferation can occur whenever there is a build up of nutrients particularly in the temperature range 20–45°C.

Legionella spp. is likely to proliferate in water storage tanks if the tanks and associated plant and pipe work become warm, if they are poorly insulated and if use is intermittent. The risk from this source will be small if water is subsequently stored and distributed outside the range 20–45°C.

Calorifiers are a major source of proliferation if parts of it contain water at 20–45°C. Water in storage calorifiers often stratifies so that although temperatures in the bulk of the calorifier may be high, there will be a cooler zone below the heating coils where *Legionella* spp. can multiply.

Dead legs, where lukewarm water can stand undisturbed for long periods, provide ideal conditions for the proliferation of *Legionella* spp. and other organisms.

Design and construction

Hot and cold water systems should be designed and constructed to aid safe operation by avoiding conditions permitting the proliferation of *Legionella* spp. It is most important that the system is easy to clean.

Hot water systems

Calorifiers should be capable of heating their contents to at least 60°C which should be sufficient to achieve a minimal temperature of 50°C at the most distant outlet and the hot water return. The installation should also be capable to raise the temperature in the system to >60°C if a periodic decontamination should be necessary. The water temperature at the base of the calorifier will usually be much cooler than the water temperature at the top. Arrangements should therefore be made to heat the whole of the water content of the calorifier, including that at the base, to a temperature of 60°C for 1 h each day. A shunt pump to move the hot water from the top of the calorifier to the base is one way of achieving this (Fig. 1). The pump should be

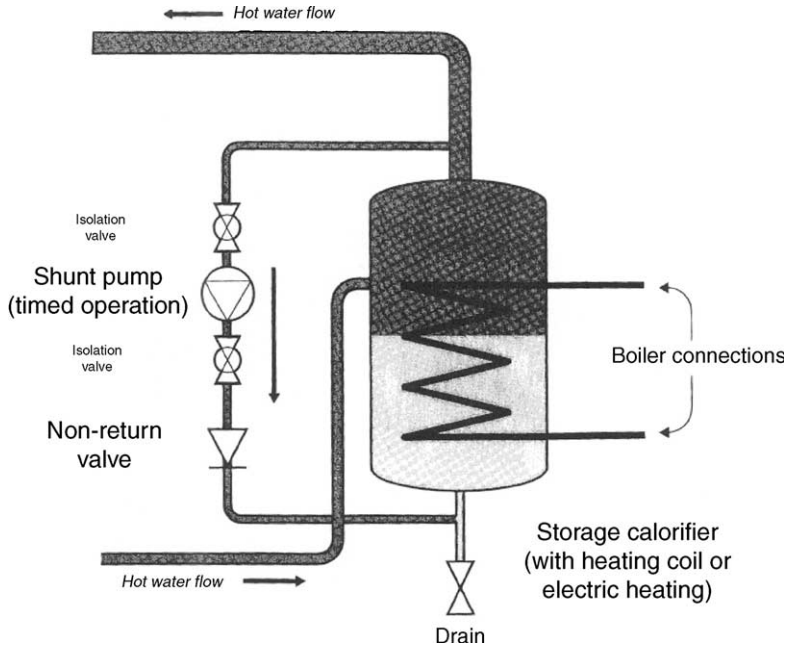


Fig. 1. Calorifier with shunt pump.

controlled by a time clock. All calorifiers should have a drain valve located in an accessible position at the lowest point of the vessel so that accumulated sludge can be drained easily and the vessel emptied in a reasonable time.

Hot water that is prepared on the spot by mixing steam and cold (potable) water from a controlled source does not present a legionella risk.

Cold water systems

The volume of cold water stored should be minimized, it should not normally be greater than 1 day's water use. Multiple cold water storage tanks require care in the connecting piping to ensure that water flows through each of the tanks and to avoid stagnation in any one tank.

Access ports should be provided on cold water tanks for maintenance, inspection and cleaning. Low use outlets should be installed upstream of higher use outlets to maintain frequent flow, e.g., a safety shower can be installed upstream of a WC to minimize stagnant water. Pipe work should be as short and direct as possible, especially where it serves intermittently used taps and appliances. The need for intermittently or infrequently used taps and appliances should be reviewed; if they are not necessary the supply should be cut off as far back as possible and removed. Hot and cold water pipes should be sufficiently separated and/or insulated to avoid the exchange of heat between them.

Management of hot and cold water systems

On commissioning a new hot water system, the water temperature should be measured continuously at the bottom of the outlet of the calorifier over a typical day. If the storage vessel is of sufficient capacity to deal with the demand then the outlet temperature will be a constant 60°C throughout the day. If the calorifier is undersized then the outlet temperature will fall during use and remedial action would be necessary. If the system changes from the original specification, this procedure would need to be repeated.

If a calorifier or any substantial part of a hot water system is on standby use or has been out of service for longer than 1 week, then the water should be brought up to the operating temperature of 60°C for at least 1 minute before being brought back into use.

Operation of hot and cold water systems

The table below shows the water temperatures required in hot and cold water systems in order to prevent the growth of *Legionella* spp.

Water system	Safe operating temperature
Hot water storage (calorifier)	At least 60°C
Hot water distribution	At least 50°C
Cold water storage and distribution	20°C or below[a]

[a]Impossible in the tropics and very difficult elsewhere in the summer months. The first objective must be to keep the system clean and to avoid water stagnation.

Treatment programmes for hot and cold water systems

The single most important part of preventing or controlling the risk from *Legionella* spp. is maintaining the cleanliness of the system and the water in it. Hot water services and, exceptionally, cold water services should be cleaned and disinfected in the following situations:

- if a routine inspection shows it to be necessary
- if the system or part of it has been substantially altered or entered for maintenance purposes in a manner which may lead to contamination
- during or following an outbreak or suspected outbreak of legionellosis.

Hot and cold water systems can be disinfected using chemical or thermal means. Prior to chemical disinfection it is vital that the system is clean. Thermal disinfection can be carried out by raising the temperature of the contents of the calorifier then circulating this water through the system for at least 1 h. To be effective the temperature should be high enough to ensure that the temperature at the taps and appliances does not fall below 60°C. The system also needs to be well insulated and free from stagnant areas.

Monitoring

For all systems the precautions taken to prevent or control the risk of exposure to *Legionella* spp. should be monitored weekly to ensure that they remain effective and all water services should be checked routinely for temperature and demand and inspected for cleanliness and use. The frequency of inspection and maintenance will depend on the system and the risks it presents. All inspections and measurements should be recorded.

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