EcoCooler Evaporative Cooler

Legionella Risk Assessment

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Summary

An EcoCooler presents a low risk of creating conditions that are conducive to the growth and dispersal of legionella bacteria when the following criteria are maintained.

- Quality of influx air
  - Wet bulb temperature below 25^{O}C
  - Low level of organic and microbial contamination
- Quality of water supplied to the cooler
  - Low level of microbiological contamination
  - Temperature below 20^{O}C
  - Low scaling potential
- Installation and operation should take place in accordance with the manufacturers specifications. In particular there should be no modifications to the cooler that may affect
    - Process controls
    - Air flow rate. The face velocity of the efflux air should not exceed 1.6m/sec in order to reduce the release of aerosols from the wetted media
    - Cooling media (CelDEK)
    - Materials of construction

EcoCooler should be installed and commissioned by an approved/competent person, and the maintenance regime should be carried out in accordance with the manufacturer's instructions.

It is important that a risk assessment is carried out after the unit has been installed in order to assess risks that may be generated by local conditions. The risk assessment should be reviewed in the event of any changes to the cooler or local conditions that may influence the growth and dispersal of legionella bacteria.

1.0 Background

EcoCooler is an evaporative cooler that is typically employed as part of a balanced ventilation system. A fan within the unit draws air through a cellulose based wetted media (CelDECK) which saturates and cools the air using the principle of adiabatic (evaporative) cooling.

With regards to reducing the risk of Legionnaires' disease, all wet cooling systems, including evaporative coolers, are subject to UK Health and Safety legislation, in particular the Health and Safety at Work etc Act 1974, and the Control of Substances Hazardous to Health. In addition, the Health and Safety Commission Approved Code of Practice and Guidance (ACoP) on ***Legionnaires' disease: The control of legionella bacteria in water systems (L8)*** provides further specific guidance on controlling the risk of legionellosis.

The ACoP requires that where there is a reasonably foreseeable risk of exposure to legionella bacteria, a risk assessment should be carried out. The risk of exposure to legionella bacteria exists wherever water is used or stored and where there is a means of creating and transmitting water droplets which may be inhaled. The risk of contracting Legionnaires' disease is determined by a number of factors:

- The presence of legionella bacteria in a water system
- Conditions that are suitable for the multiplication of legionella bacteria e.g.
  - temperatures between 20^{O}C and 45^{O}C,
  - sources of nutrients that support the growth of microorganisms e.g. organic matter and iron, the latter being an essential growth factor for legionella bacteria
  - stagnant water conditions which permit the accumulation of biofilm
  - scale deposits, which provide a habitat for biofilm and legionella, and protects them from biocides, raised temperatures and other harsh environmental conditions
- A means of disseminating breathable droplets or aerosols contaminated with legionella
- The presence of people who may be susceptible to legionella infection

With regard to the first and last of these factors, as legionella bacteria are present in all water supplies to buildings, albeit normally in small numbers, then water systems in all buildings are exposed to legionella contamination at source. Legionella bacteria may also enter exposed water systems as air borne particles discharged by other contaminated water systems.

A variable proportion of any group of people will be susceptible to legionella infection, notably smokers, the elderly, and those who are immuno-compromised or have underlying predisposing clinical conditions. Consequently, controlling the risk of legionella infection from water systems is normally achieved by preventing conditions in the water system that support the multiplication of legionella bacteria and/or by controlling the creation or discharge of contaminated aerosols.

This risk assessment is undertaken as a generic exercise appraising the design features of the EcoCooler that affect the risk of legionella proliferation and the potential for discharge of contaminated aerosols. This assessment cannot in isolation determine the overall risk of legionella exposure produced by the unit as this will also be influenced by other factors at the installation site, including the quality of the water supply to the evaporative cooler unit, the manner in which the unit is operated and maintained, and proximity to people.

Therefore, the overall risk of legionella infection from an evaporative cooler can only be determined after the unit is installed and operational. The risk assessment should be reviewed periodically (at least every 2 years) and particularly in the event of changes to the water system or its use, following changes in ambient conditions that may predispose the cooler to microbial contamination, and when results of analysis indicate that control measures are no longer effective.

The key principles to be considered in controlling the risk of legionella infection from an evaporative cooler are:

- Avoidance of stagnant water and the build up of biofilm
- Maintaining temperatures outside the growth range for legionella of 20^{O}C to 45^{O}C
- Avoidance of corrosion and scaling
- Controlling the formation and release of aerosols
- Use of a biocide

2.0 Controlling the risk of legionella contamination

2.1 Avoidance of stagnant water and the build-up of biofilm

Stagnant water supports the accumulation of biofilm and legionella bacteria as it facilitates heat gain in the water, and avoids the shearing forces created by moving water that can reduce the build up of layers of biofilm. When EcoCooler is in cooling mode the filter pads are kept wet using a water re-circulation system in which water, controlled by a solenoid valve and a level probe, is circulated over the pads by a centrifugal pump from a trough at the base of the unit. Continuous movement of the water through the system will help prevent

stagnation of water in the trough and other parts of the re-circulatory pipework. A good recirculating flow of water can also help reduce the accumulation of biofilm on the cellulose matrix.

As the units are installed externally they may become filled with rain water that can become stagnant when the unit is not operating. The cooler is fitted with low level sensors, and when it is first operated it should automatically purge any residual water to waste. The slope in the trough should further ensure that all retained water drains to waste. At the end of the cooling mode or whenever the cooler is stopped, a drain valve should open and empty the cooler of water. If the cooler is running continuously in cooling mode the drain valve will automatically operate periodically to prevent the build up of dissolved salts in the recirculating water. In addition there are a number of other failsafe mechanisms that should ensure water is not retained within the unit. These features are important to prevent stagnation of water in the system. In order to ensure that they function correctly it is important that the unit is maintained in accordance with the manufacturer's recommendations.

Biofilm can accumulate in stagnant water, but can also develop on wetted surfaces such as within the cellulose media in EcoCooler. Many microorganisms that comprise biofilm, including legionella bacteria, cannot survive in the absence of water, as they do not produce spores or cysts that protect the organism from desiccation and subsequent death. Complete drying of the media would reduce the number of viable microorganisms in the biofilm and should kill any exposed legionella bacteria.

EcoCooler has an optional programme that drains the water from the system and operates the fan to dry out the cellulose pads for 30 minutes every 24 hours. In order to reduce the opportunities for legionella bacteria to develop within the biofilm in the cellulose media, this programme should be operated at least twice weekly. In installations where increased amounts of biofilm develop, this programme should be made mandatory. Extension of the drying period beyond 30 minutes may be required in order to achieve complete drying and effective killing of susceptible bacteria in the media. Microbiological analysis of the re-circulating water by dipslide will provide some indication of the efficacy of the drying programme in reducing the microbial population attached to the cellulose media.

2.2 Maintaining temperatures outside the growth range for legionella bacteria

Legionella bacteria are able to multiply at temperatures between 20^{O}C and 45^{O}C, and their optimum growth temperature is around 37^{O}C. The propensity for legionella bacteria to cause infection also increases as the temperature approaches the optimum for growth.

Water requires energy in order to evaporate, and it can take energy in the form of heat from the ambient air thereby cooling the air. In the EcoCooler, water evaporating from the cellulose media cools the air as it passes through the honeycomb structure. The re-circulating water will accept some heat from the passing air, but as the wet bulb temperature in the UK is generally low, available data from EcoCooling© shows that the water temperature should rarely increase beyond 20^{O}C ($<20^{O}$C on 99% of occasions), and so would not actively support the growth of legionella bacteria. In order to reduce the risk of legionella growth, it is important to ensure that evaporative coolers are not supplied with water that exceeds 20^{O}C and water quality should also be high i.e. preferably potable quality water. Furthermore, the cooling units should not be in close proximity to heat generating plant that can raise the temperature of the air entering the unit, or raise the temperature of the re-circulating water.

At raised temperatures the rate of evaporation is high and the evaporative cooler is programmed to drain, flush and be replenished with fresh water approximately every two hours. This should reduce the temperature of the re-circulating water (providing the make-up water is $<20^{O}$C) and also prevent the over-concentration of dissolved salts in the water, which can lead to scaling. As part of the routine monitoring programme the temperature of the re-circulating water should be checked at least weekly.

2.3 Avoidance of corrosion and scaling

Iron, e.g. in the form of iron oxide (rust), is an essential factor required for the growth of legionella bacteria. It is important therefore to ensure that water systems do not accumulate significant quantities of iron corrosion

deposits. Scale deposits provide an environmental niche that can become readily colonised with biofilm and legionella bacteria. Scale has good insulating properties that can protect microorganisms from raised temperatures and it can also impede the full effect of water treatment biocides. Scale deposits will accumulate on surfaces within the water system when calcium and magnesium hardness salts become concentrated in water. In wet cooling systems evaporation of warm water increases the concentration of total dissolved solids including hardness salts. Over-concentration of these salts, plus other factors such as alkalinity, can lead to scaling. Microorganisms can colonise the many small fissures that develop in the scale.

Avoiding over-concentrating dissolved solids in water will prevent scale deposits from forming. The EcoCooler can monitor the number of occasions that make-up water is added to the unit to compensate for water lost through evaporation. This can provide an indication of how concentrated the dissolved solids are where the chemical composition of the water is known. At a pre-determined concentration factor of between 2.2 and 5.7, the cooler can be set to drain all water in the system to waste, and to replenish the system with fresh water. In addition to this safeguard, the cellulose media should be visibly inspected periodically to ensure that excess scale is not forming in the media. Analysis of the chemical composition of the make-up water is required in order to calculate the concentration factor at which scale will form in the system.

2.4 Controlling the formation and release of aerosols

Aerosols are readily generated within turbulent water systems, and where the water is contaminated with legionella the aerosols can facilitate the dispersal of the bacteria over large distances. Contaminated aerosols of 5 micron diameter can bypass host defence mechanisms and enter the deepest regions of the lung where legionella infection can commence.

With a 100mm media pad in place the face velocity of the air passing through the pad should be 1.6m/sec at max fan speed setting. Independent data from the University of Aachen (March 2002) indicate that test microorganisms deliberately added to the recirculating water were not detected by air sampling devices in the exhaust air from the unit. Aersosls are more readily discharged from evaporative coolers and other wet cooling systems when the fan speed generates high face velocities. Unsubstantiated data suggests that aerosols should not be discharged if face velocities remain below 3m/sec. The maximum face velocity generated by EcoCooler on maximum available fan speed is 1.6m/sec and so aerosol dispersal should be minimal. Face velocities may increase where sections of the media become damaged, and so it is important that the media is inspected periodically for any external damage.

2.5 Use of a biocide

Under normal circumstances treatment of the re-circulating water with a biocide should not be necessary in order to control legionella bacteria, as water temperatures in most cases should be below $20^{O}C$, and water is continuously circulated and regularly dumped to prevent stagnation. Operation of the drying mode (i.e. water drained with fan operating) can further control legionella and some of the microorganisms that comprise the biofilm.

However, biocide treatment may be required where water temperatures rise to a level that may support the growth of legionella bacteria, where there is a raised organic load in the ambient air which will accumulate in the water and provide nutrients for microbial growth, and where dipslide testing or visual inspection indicates the presence of excessive amounts of biofilm. The use of insect filters and appropriate positioning of the cooler can reduce the organic load in the air influx.

In these circumstances consideration should be given to continuous dosing or shot dosing of the re-circulating water with a suitable biocide to prevent build-up of biofilm and legionella. Non-oxidising biocides are generally preferred in evaporative coolers, as they are not lost due to evaporation from the re-circulating water, as can occur with oxidising biocides, and unlike oxidising biocides they will not encourage corrosion of the unit, and are less likely to denature the cellulose media. Where oxidising biocides are to be used they should not exceed 1ppm in the treated water. If treatment with a biocide is necessary, weekly dipslide testing should assess its efficacy.

Under normal circumstances and where the control measures discussed in this generic risk assessment are fully effective, it is unlikely that legionella bacteria would proliferate and be disseminated from an EcoCooler to the extent that they would present a risk of infection. It is important however that the control measures are inspected in accordance with the manufacturer's instructions, and that aspects of water quality are regularly monitored in order to ensure that opportunities for legionella bacteria to grow and colonise the system do not occur.

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