APPROACHES ON METHODOLOGY OF LEGIONELLA CONTROL IN COOLING TOWERS

Marcel Sabin Popa[1] and Monica Popa[2]

[1] Technical University of Cluj-Napoca, Romania
Baia-Mare str., 25, 400171 Cluj-Napoca, Romania
E-mail: marcel.popa@tcm.utcluj.ro

[2] Univerity of Medicine and Pharmacy Cluj-Napoca, Romania
Dept. of Environmental Health
Pasteur str., 6, 400349 Cluj-Napoca, Romania
E-mail: dr_monica_popa@yahoo.com

ABSTRACT

Cooling towers have been refined to be highly efficient at heat rejection. They are widely used throughout the world from tropical to temperate climates wherever a source of water is available. Installations range in size from units at shops, restaurants and offices to large power generating stations. As with all mechanical devices, cooling towers require routine servicing of the moving parts, regular cleaning and close monitoring in order to operate properly.

Keywords: Cooling tower, *Legionella*, maintenance, risk management plan

LEGIONELLA AND THE EFFECT OF AEROSOLS ON HUMANS

Legionella bacteria are micro-organisms that can cause a serious infection in humans. It can cause infection called legionellosis, which can take two forms: Legionnaires' disease and Pontiac fever. Legionnaires' disease is an infection that presents as a type of pneumonia (lung infection) that can be severe and even life threatening. Pontiac fever is a milder form of respiratory illness.

Water contaminated with *Legionella,* particularly the bacterium of the *Legionella* species *Legionella pneumophila*, such as could occur in a cooling tower, presents a risk to health when the water from the tower is dispersed into the air as an aerosol and transported by natural and mechanical air currents. It may be inhaled by passers-by, or the aerosol may enter doors, windows, and air intake ducting of buildings where humans can then inhale it. The elderly, smokers, and those individuals with impaired immunity are more likely to develop infection from highly contaminated aerosol (Popa [1]).

RISK FACTORS AND RISK MANAGEMENT PLAN

Legionella bacteria occur naturally in the environment, in both water and soil. Artificial water systems may provide environments that allow *Legionella* bacteria to multiply in large numbers. Examples of relevant systems include evaporative coolers, closed circuit fluid coolers, evaporative condensers and cooling towers. Warm water systems (including showers), spa pools, fountains, warm water storage systems, and potting mixes and compost may also provide an environment that allows bacteria to multiply. Critical risk factors for *Legionella* growth in cooling water systems and resultant infection of people include: stagnant water, nutrient availability, poor water quality, deficiencies in the cooling tower and location of the cooling tower system near the public and/or close to other air handling services.

The main risk factors for an outbreak of the disease caused by cooling water systems are (Burge & Harriet [2]):

- The presence of *Legionella* bacteria;
- Conditions suitable for multiplication of the organisms: suitable temperature (20°C to 45°C) and a source of nutrients such as sludge, scale, rust, algae and other organic matter;
- A means of creating and spreading breathable droplets, such as the aerosol generated by a cooling tower;
- Exposure of susceptible people to these aerosols.

The risk management plan should outline:

- Procedures to manage the critical risk factors;
- Key performance indicators and targets for the maintenance of the cooling water system;
- Maintenance, service, inspection, and cleaning requirements;
- Procedures for reporting of maintenance, servicing, inspection, cleaning, disinfection, and required corrective actions to the cooling water system owner or person in control;
- Supply and means of providing makeup water of sufficiently high-quality so that biological contamination, corrosion, and scale deposits within the cooling water system are minimized;
- How the operation of the chiller/s impact upon the cooling tower risks (the number of hours of operation for each chiller/s).

WATER TREATMENT PROGRAM FOR THE COOLING WATER SYSTEM

The specific water treatment program requirements should be determined by a risk assessment process. As such the requirements may vary in different types of cooling water systems. A specific risk management plan should be documented for each system. Water treatment options can include both chemical and nonchemical. Careful consideration should be given before choosing any water treatment procedures to ensure that such procedures have been tried and proven to be effective. Evidence of the effectiveness of such water treatment procedures should be based on continuous trials operating under field conditions and should be validated by independent laboratory testing of the cooling system water in conjunction with various end users. These analytical tests need to be supported by physical examination and inspection of the cooling water system for evidence that critical risk factors such as stagnant water, nutrient availability and poor water quality are being controlled.

The water treatment program should include the following (Romanian Ministry of Environment [3]):

- A suitable, continuous water treatment program for effective management of corrosion, scaling, fouling and microbial growth, including *Legionella*. It is recommended that the water treatment be automated.
- Provision of an effective biocidal concentration/dose/action level in the system at all times as verified in part by test results of microbial samples taken from the system.
- Appropriate control of bleed-off rates suited to the system in use to prevent the build-up of solids. This is usually done by conductivity control (or Total Dissolved Solids) to ensure the correct cycles of concentration are obtained.
- Biocidal processes selected to avoid problems associated with particular bacterium developing a tolerance to a particular biocide process. Therefore dual or alternating biocidal processes are recommended. Multiple biocides that are rotated periodically to avoid the bacteria developing a particular biocidal tolerance.
- Continuous monitoring of corrosion, conductivity and pH.
- If the tower is exposed to significant environmental contamination, for example when construction activities are occurring in proximity to the cooling tower, the use of side stream filtration to reduce the level of solids and improve water quality may be considered.

The risk of stagnant water should be minimized by the installation of a timer to the recirculating pump. This ensures that water (and chemicals such as biocide) circulates through the system which reduces the likelihood of biofilm and bacterial growth. If a system has been shut down for more than 30 days without any significant water or biocide circulation the system should be cleaned, and water treatment reinstated before it is restarted. The tower basin must be protected from sunlight.

Inspection and servicing of the cooling tower and water treatment program should be carried out at least monthly. These include:

- The visual inspection of the cooling water system, including all wetted surfaces, drift eliminator, and tower basin for the presence of scale and particulate matter such as dirt, dust, insects, and leaves; slime and microbial growth such as algae and fungi; corrosion products;
- Checking the clarity of the water;
- Checking that the bleed-off system is functioning correctly and at the required rate;
- Measurement of the conductivity of the system to ensure that adequate cycles of concentration are used;

- Checking that the water treatment system is functioning correctly, including: all dosing and control equipment, timers, pumps and tubing; checks on flow rate of dosing equipment; adequacy of supply of any chemicals being dosed;
- Routine water analysis;
- The calibration and inspection of water monitoring and dosing equipment;
- Repair of obvious physical defects or damage, for example damage to drift eliminators;
- Checking for correct placement of the drift eliminator;
- Checking for changes in the local environment (local building demolition or construction that may cause increased entrainment of particulate matter into the cooling tower);
- Checking for leaks and unexplained water losses.

CLEANING PROCEDURE OF COOLING TOWER

Physical and chemical cleaning (to a visual state of cleanliness) should be performed on a routine basis, and when required as identified by inspection of the cooling tower. Such cleaning includes removal of corrosion products, rust, scale, slime, sludge, mould, algae, biofilm and fungi. These pollutants are known to provide nutrients for the growth of micro-organisms such as *Legionella* (Filermans [4]). The frequency of cooling tower cleaning maintenance programs should be determined by a risk management process. The need to clean a cooling tower will depend upon factors such as the clarity of the water, the cleanliness of the towers, abnormal contamination of the cooling water system with dirt and dust from activities such as nearby construction, and the results of water testing, including microbial testing. The cleaning process should include the cleaning of all wet surfaces in the system and all off-line equipment where practicable. Because the cleaning of cooling towers is a high risk activity that generates aerosols that are potentially contaminated with *Legionella* bacteria, it is imperative that a competent person carry out the cleaning process using a cleaning process that minimizes such exposure.

QUALITY OF THE MAKEUP WATER

The standard or quality of makeup water supplied to a cooling water system should be of sufficiently high quality to minimize biological contamination, corrosion, and scale deposits within the cooling water system.

Traditionally potable (drinking) water from the municipal water supply is used for makeup water. Increasingly non-potable water such as recycled water is being used for make-up water. Non-potable water can vary in constituents such as ammonia, phosphate, nitrates, conductivity, suspended solids, total organic carbon, biological and chemical oxygen demand, and microorganisms.

Examples of an adverse impact of potential constituents of nonpotable makeup water upon a cooling water system include: ammonia can impact the ability of certain biocides to adequately inactivate micro-organisms; phosphates and nitrates can enhance biological growth potential and elevated conductivity from higher chlorides or sulphates can increase corrosion rates.

HETEROTROPHIC COLONY COUNT TESTING AND LEGIONELLA TESTING

The primary means for the control of *Legionella* bacteria is good hygiene practice for the cooling water system. Monitoring of the cooling tower water for the presence of bacteria is an important tool in verifying if control strategies for the critical risk factors are effective. Such monitoring includes (Romanian Ministry of Environment [5]):

- Heterotrophic Colony Count (HCC) which is an estimate of the number of viable units (expressed as colony forming units) of bacteria per millilitre of water using the pour plate, spread plate or membrane filter test. Also known as total bacteria count, total plate count or viable bacteria count test;
- *Legionella* Count which is an estimate of the number of viable units (expressed as colony forming units) of *Legionella pneumophila* and a range of other *Legionella* species per millilitre of water using a test involving sample treatment followed by the spread plate technique.

Testing of bacterial levels in the recirculating water of a cooling tower system and appropriate corrective action should be a part of every cooling water system's regular service program. It is essential that decisions on the frequency of such testing be based upon a risk assessment for each cooling water system. This risk assessment needs to assess the potential for growth of *Legionella* combined with the potential for exposure of people to aerosols from the system (Popa & Popa [6]). For example, here it is impracticable to shut down a cooling water system for periodic cleaning, such as with large industrial cooling water systems serving power stations, co-generation plants and refining plants, a risk assessment may indicate the need for such testing to be more frequent.

The frequency of both HCC and *Legionella* testing may be influenced by factors such as:

- a change to the water treatment program which would necessitate an increased frequency of testing to verify the effectiveness of the new program;
- recent elevated HCC and/or *Legionella* results which would necessitate an increased frequency of testing to verify if resultant changes to the water treatment system are effective;
- alterations and changes to the water cooling system including replacement of equipment.

There is no direct correlation between HCC levels and *Legionella* concentration. For example, it is possible to have very low HCC levels and still detect *Legionella* up to significant levels of concern. Equally, it is possible to have very high HCC levels, but not detect *Legionella*. However, a high HCC level (greater than 100,000 CFU/mL) is an indicator that effective microbiological control is not being maintained and that the system may support *Legionella* growth unless action is taken to bring the system back under control. It is difficult to use data specific to *Legionella* bacteria alone to control the microbial characteristics of a cooling water system because laboratory testing requires 7 to 10 days to obtain an analysis. Monitoring the overall bacterial level (HCC) in addition to the *Legionella* levels is recommended as it only takes several days after sampling for the HCC analytical data to be available.

CONCLUSIONS

A clean system is of fundamental importance in *Legionella* control. The approach is aimed to monitorize the hygienic conditions (chemical and physical characteristics of the system water) and includes microbiological monitoring too. The *Legionella* control must be extended and applied in a cost effective and environmentally sensitive manner.

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