Legionella and warm water system management

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Introduction

Legionnaires' disease, an atypical pneumonia caused by the *Legionella* bacterium, is predominantly community acquired. In Australia the incidence of disease is approximately 2 in 100,000, and roughly half of these cases will be associated with exposure to a water system in the built environment.[1]

Legionnaires' disease was first associated with contamination of water cooling towers in 1977. Thirty years later reported cases of the disease are more prevalent than ever, due partly to improved surveillance and partly to increasingly more complex and varied water installations in the built environment. It is well established that a variety of water systems are potential sources of infection, and that water systems in buildings are one of the more commonly implicated of these sources.[2]

The simplest definition of a warm water system is one that delivers water to outlets at temperatures below 50 °C.[3] This includes all heated systems with thermostatic mixing valves and anti-scald devices, as well as cold water systems with supplies above 20 °C. By this definition, hotels, hospitals and residential care facilities are all warm water system operators. This is of concern because large building systems, if contaminated, will lead to exposure of larger sections of the population, including, in many settings, the more susceptible immuno-compromised.

This paper will outline key criteria that should be considered in a management strategy to control *Legionella* in a building water system. A more comprehensive document relating to this subject is the recently released World Health Organization book Legionella *and the prevention of Legionellosis*, available in printable form at the WHO website <http://www.who.int/water_sanitation_health/emerging/legionella.pdf>.[3]

Multiple barrier approach

A building water system may be an extremely complex arrangement, and in many cases exact plans of the system design may not be available. These complexities can be addressed by identifying component parts of the system. Interventions at each component point can then be used to construct a multi-barrier approach to the management of *Legionella* within the system. The management plan must be economically and logistically viable, otherwise implementation will never occur.[3]

Component parts and suggested interventions are detailed below in sequence from entry of the water supply into the building to the user outlet. The extent and practicality of the interventions at each point must be well considered and informed.

Storages

Large buildings may have storage tanks, often in the roof, in which supply water is kept. Location in the roof may result in warming of the water to temperatures conducive to *Legionella* growth (20–50 °C).[4] Storages should be enclosed to prevent ingress of vermin. A routine (annual) flushing and cleaning program should prevent the build-up of sediments. Continuous residual halogen disinfection of storages will minimise the introduction of microorganisms into the system. This can be automated via redox meters.[5]

Calorifier/heater

Boilers/calorifiers should supply heated water to the system at greater than 60 °C, preferably 65 °C. This is a thermal barrier to colonisation. Some systems are able to supply water at these temperatures during routine operation but may not meet these requirements during peak demand.[6] To maintain this temperature barrier against Legionella introduction into the system, the capacity of water heaters should be sufficient to more than cope with peak demand.

Circulating system

Ideally, water leaving the water heater should be maintained at a temperature high enough to inhibit *Legionella* survival until it reaches the outlet. In reality this may not occur due to poor flow or stagnation or because of use of devices that deliberately reduce temperatures to minimise scalding risks.[6] Stagnation and low flow rates within the system both influence *Legionella* multiplication. Stagnation permits the accumulation of deposits, which may in turn support biofilm growth. Low flow rates may contribute to stagnation but also permit greater heat loss from the system, thereby reducing water temperatures. Maintaining optimal flow rates is an effective barrier to *Legionella* colonisation of the circulating system. Low flow rates and stagnation may be remedied by upgrading the circulating pump, or by installing an auxiliary circulating pump on the return line to the water heater.[3,4]

Outlets

The outlet is the point of exposure for the resident population. Devices such as thermostatic mixing valves or tempering valves are often installed at this point in the system to reduce temperatures by mixing hot and cold water supplies to the mid-40 °C range (typically 43 °C). Because the system is suitable for *Legionella* growth and disinfection options are limited, it is essential that the length of pipe-work from this point on is minimised. Preferably one mixing valve should serve one outlet, as multiple outlets provide larger water volumes after the device, and greater

opportunities for stagnation. The action of cooling the water from the cold supply means that any disinfectant residual in the hot water system is diluted and will no longer be effective. Ingress of *Legionella* into the system may occur at this point, circumventing all the previous barriers.[6]

Shower fittings are the most frequently and heavily Legionella-colonised outlets as they have a length of hose, often lined with a polymer core, which is amenable to microbial colonisation and, at optimal temperatures, for *Legionella* growth.[3,4] Routine flushing of outlets is a proven strategy for control of Legionella colonisation. Shower fittings that 'self drain' will also reduce microbial contamination, but should not be confused with 'self-flushing' fittings, which may be less effective. Detachable shower hoses which can be alternately replaced and disinfected may be very useful in high-risk facilities.[7]

Disinfection
Disinfection of the system is always the last barrier for *Legionella* control. Ideally, if all the other barriers are effectively in place then disinfection should not be necessary,[3] especially as it is probably the most difficult barrier to put in place and requires the most attention in installation and maintenance.

As discussed, operational temperature control is a disinfectant measure, and heat flushing can be used to decontaminate systems. However, it should be noted that the effects of heat flushing are short lived and additional interventions will be necessary to maintain effective control.[4]

Chemical disinfection is a complex issue beyond the scope of this paper. Choice of disinfection must consider cost, maintenance, residual effects, solubility at operating temperatures, corrosion potentials, and loss of active concentration after mixing devices. Disinfection practices are doomed to failure unless other barriers and system design features are optimised first. [3,6]

Communication
The complexity and dynamic nature of building water systems means that a team approach is essential to understand what is required to maintain microbial control. At the core of the team approach is a clear chain of responsibility and reporting. Monitoring of the system may be conducted by various personnel but the review of the data should be the role of clearly designated individuals. Responsibilities for remedial action in instances where specific control limits have been exceeded should be identified and documented. An effective communication plan with clear lines of responsibility for actions will allow the system to be managed proactively rather than reactively. Proactive approaches will always be less costly in terms of both financial and health outcomes.[3]

Conclusion
The effective control of Legionella and Legionnaires' disease health risks in building water systems demands a good knowledge of the design and operational features of the system. This control is best achieved by an economically and logistically viable management plan, a multi-barrier team-based proactive approach and a commitment to implementation. A multi-barrier approach deconstructs the problem into individual identifiable issues that can be prioritised and addressed within the capability of, and according to the capacity of, the system operator.[2]

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