Simulation of *Legionella* Risk when Restarting a Sport Facility after a Period of Inactivity During COVID-19

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Abstract

During the COVID-19 lockdown the prolonged closure of sport facilities is causing *Legionella* growth in the system. Based on an in-house developed simulation tool, the *L. pneumophila* concentration is predicted dynamically throughout the system and restart guidelines are evaluated.

Key Innovations

- Coupled thermohydraulic and biological growth model confirms safety of current *Legionella* restart guidelines after a period of inactivity.
- The added value of the model lies in the possibility to evaluate dynamic methods for *Legionella* control.
- The model shows its potential in decontamination of systems contaminated with *Legionella*.

Research Implications

Follow the 5 steps of the LoWatter infographic to prevent *Legionella* risk when restarting a building system of e.g. a sport facility after a period of inactivity.

Introduction

During the COVID-19 lockdown, the media reported that the prolonged closure of buildings (e.g. hotels, sport facilities, student homes) is not without danger for *Legionella* growth as stagnant water is an important risk factor. LoWatter, a service of Ghent University, carries out scientific research and consultancy into *Legionella* in sanitary water systems (LoWatter, 2020). Based on an in-house developed simulation tool, the *L. pneumophila* concentrations can be predicted dynamically throughout the water circuit. More information concerning the models used in the simulation tool, such as the governing equation of *L. pneumophila* and model parameters can be found in (Van Kenhove et al., 2018; 2019).

Aim and Approach

The aim of the presented case study is to demonstrate the consequences of temporary shutting down a system with regard to the *L. pneumophila* contamination risk. To do so, a fictive, but representative case of a sport facility is modelled. Parameters, e.g. number of changing rooms and showers, are derived from a comparative study to represent the 'average' sport facility in Belgium (6 changing rooms with 8 showers with a 6 l/min flow rate).

The simulation tool applied for the described case study, is written in the Modelica language. This in-house developed tool is a parametric tool that allows to build up and size a simulation model of the hydraulic scheme quickly by defining primary building characteristics.

Results

The consecutive steps in the infographic (*Figure 1*), based on the official Flemish guidelines (Zorg en Gezondheid, 2020), are dynamically evaluated with the simulation tool.

Figure 1: Infographic with restart guidelines of sanitary installation during COVID-19 (LoWatter, 2020).

The case study distribution system consists of a circulation loop, located in the basement, with a vertical distribution to each changing room. Sizing of pipe diameters, insulation thickness, circulation pump and nominal power of the production unit is automatically done within the simulation tool according to DIN1988-300 (Kreps et al., 2017; DIN, 2012).

Figure 2 shows the case study model. The temperatures and corresponding *L. pneumophila* concentrations during the lockdown are shown in *Figure 3*. The results show

L. pneumophila concentrations in the boiler (‘C Boiler’), in the circulation circuit (‘C Circulation’), in the hot water distal pipes (‘C DHW CR#’) and in cold water distal pipes in each changing room (‘C DCW CR#’). Temperatures are shown in the boiler (‘T Boiler’), in the circulation circuit (‘T Circulation’), in the hot water distal pipes in each changing room (‘T DHW CR#’) and in cold water distal pipes in each changing room (‘T DCW CR#’).

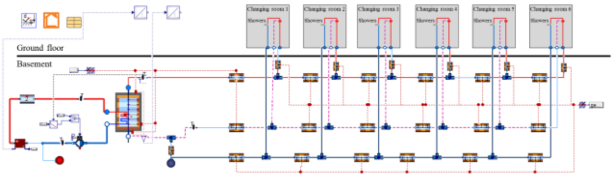

Figure 2: Simulation model of the sport facility.

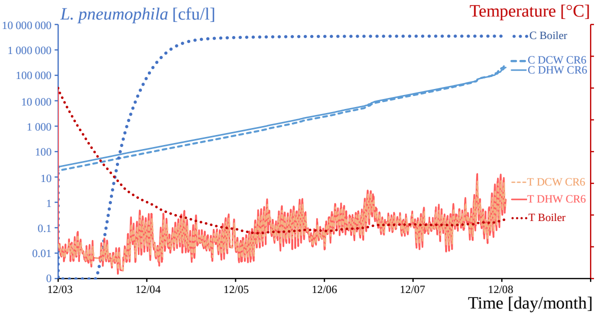

Figure 3: Temperature (in red) of boiler, domestic hot and cold water in distal pipes to changing room 6 with related predicted L. pneumophila concentrations (in blue) during lockdown March 12 2020 - August 10 2020.

Figure 4, *Figure 5* and *Figure 6* show the simulation results when ‘virtually’ implementing step 1, 2 and 3 of the infographic guidelines (*Figure 1*).

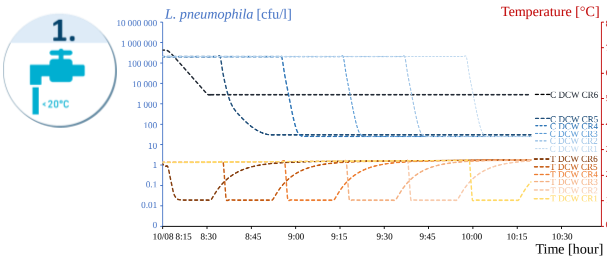

Figure 4: Effect of step 1 ‘flush cold water pipes’ (15 minute flush) on temperature (in red) and on L. pneumophila concentrations (in blue) in the changing rooms on August 10.

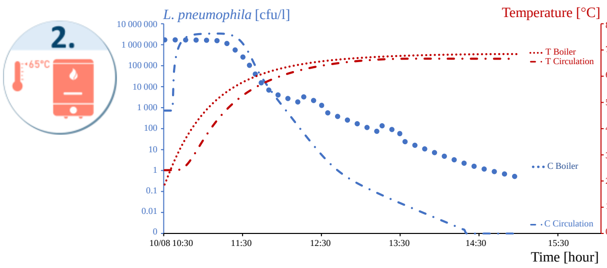

Figure 5: Effect of step 2 ‘restart hot water production and circulation’ on temperature (in red) and on L. pneumophila concentration (in blue) in boiler on August 10.

During step 3, in between each flush, it is checked that the boiler reheats to a temperature > 65 °C before flushing the next changing room (from CR6 to CR1). This results in a time shift for flushing the different changing rooms.

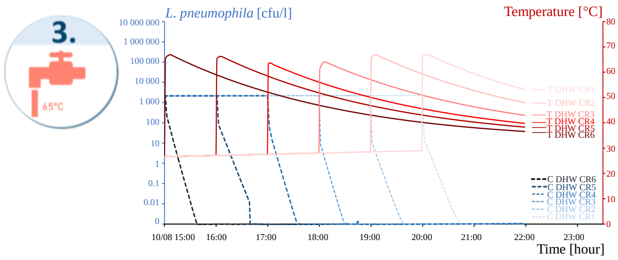

Figure 6: Effect of step 3 ‘flush hot water pipes’ for 3 minutes on temperatures (in red) and L. pneumophila concentrations (in blue) in the changing rooms on August 10.

Conclusion

The case study of the sports facility shows the effect of a prolonged stagnation of water in a sanitary cold and hot water system. As expected, the combination of stagnation and the relatively high ambient temperatures in March-August resulted in *L. pneumophila* growth. The model also shows the importance of the correct application of the proposed measures when restarting the system. Step 1: flushing cold water pipes until a stable temperature is reached, be aware that the distal pipes furthest away from the production unit need to be flushed longest (15 minutes is not long enough for CR6 in *Figure 4*). Step 2: restarting the hot water production and circulation at 65 °C for more than 1 hour, flushing the circulation circuit with 65 °C. Step 3: flushing the hot water pipes for more than 3 minutes at 65 °C. Be aware that the boiler needs to heat up between flushes to maintain 65 °C at the taps.

Furthermore, the case study also shows the potential of the developed tool in the design and decontamination of sanitary water systems. Although this tool was used in this paper to study the impact of temporary shutting down, the tool can also be used in other situations that may cause *Legionella* contamination (e.g. improper balancing of the system). This case-specific simulation model can then be used to first ‘virtually’ test the effectiveness of possible solutions on a contaminated system (modifications on the system design, decontamination techniques), before applying those in practice. Based on the results, it is possible to provide advice on which case-specific measure(s) are effective on the short and long term. Furthermore, it allows a building owner to get a better understanding of the system.

Acknowledgement

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