

# Legionella Prevention in Domestic Hot Water Heat Pump Systems: A Safe and Sustainable Approach

KEY WORDS: LEGIONELLA PNEUMOPHILA, SANITARY HOT WATER, HEAT PUMP, HYDRONIC THERMAL BALANCING, SMART BUILDINGS, SUSTAINABILITY



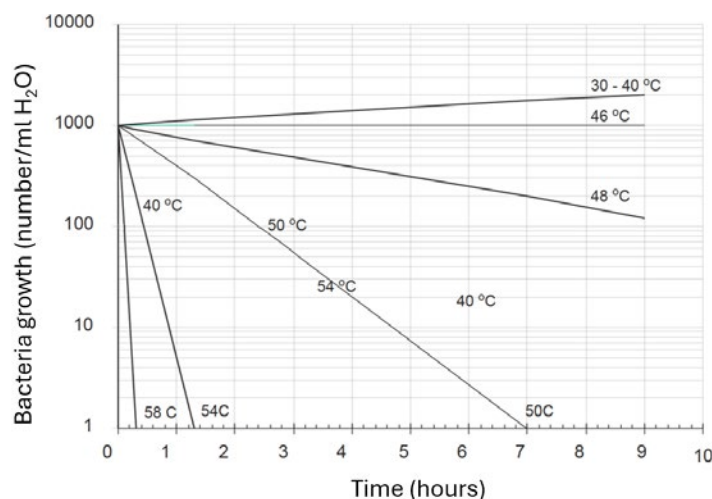
**PETER MEŽA**

Dr., College of Industrial Engineering,  
Kidričeva ulica 25, 3000 Celje, Slovenia

This article presents key measures for the safe and sustainable prevention of *Legionella pneumophila* in sanitary hot water systems using heat pumps. It focuses on adequate temperature control and the correct application of thermal disinfection, as well as essential preventive actions such as proper system sizing, regular maintenance, and appropriate operating regimes. The article also outlines practical strategies for managing thermal disinfection cycles adapted to heat pump operation, aiming to ensure microbiological safety while maintaining energy efficiency.

Domestic hot water heat pumps transfer low-temperature heat from air, ground, or waste sources into storage tanks, achieving high efficiency and reducing energy consumption. Typical operating temperatures range from 45°C to 60°C; higher temperatures are occasionally needed for thermal disinfection or specific user demands.

Although energy-efficient, these systems require careful management to prevent *Legionella* proliferation. *Legionella pneumophila* grows optimally around 37°C and is inhibited above 50°C, with inactivation occurring rapidly above 60°C (Brundrett, 1992). DHW systems must therefore balance energy efficiency with hygienic safety, ensuring adequate temperatures, circulation, and system maintenance.



**Figure 1.** Growth/dying model of *Legionella* – temperatures dependence. (Brundrett, 1992)

## Challenges and Risk Factors for Legionella Control in Domestic Hot Water Systems

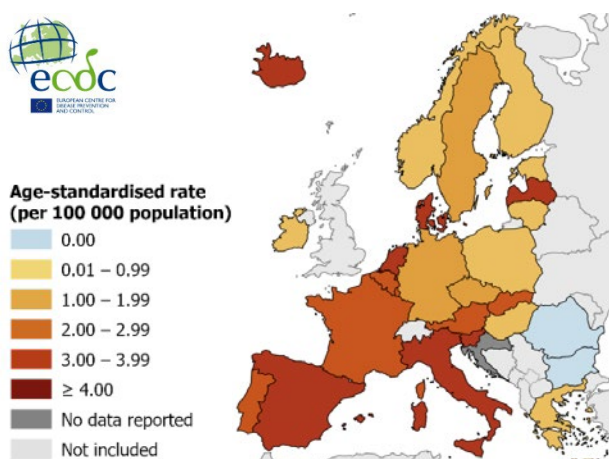
Domestic hot water systems provide favourable conditions for the growth of *Legionella pneumophila* if they are not properly designed, operated and maintained. Temperature ranges suitable for user comfort and energy efficiency often overlap with the temperature range that promotes bacterial growth. In addition, complex system layouts, variable usage patterns and ageing installations further increase the risk of *Legionella* proliferation.

Under natural conditions, *Legionella pneumophila* occurs in low concentrations; however, these levels are sufficient to contaminate man-made water systems where favourable conditions for growth exist. Domestic hot water systems often provide such conditions, enabling bacterial proliferation if preventive measures are not properly applied.

Studies show that a significant proportion of hotel facilities in Europe (Figure 2) and the United States are colonised with *Legionella*, in some regions affecting up to 50% of installations (ECDC, 2026). This highlights the widespread and global nature of the problem.

Key factors promoting the growth and spread of *Legionella* in building water systems include:

- Water stagnation or insufficient circulation.
- Inadequate water temperatures in storage tanks and distribution networks.
- The presence of organic matter, corrosion products, limescale deposits and sludge.
- Materials still found in older installations that favour microbial growth.
- High concentrations of microorganisms and the formation of biofilms on pipe surfaces.



**Figure 2.** Example of *Legionella* occurrence in hotels and public buildings. (ECDC, 2026).

Given these challenges and the widespread nature of *Legionella* in domestic hot water systems, effective preventive measures are essential to limit bacterial growth and ensure safe system operation.”

## Preventive Methods

Common *Legionella* control strategies include chemical treatment, UV disinfection, ionisation, filtration, and thermal disinfection. Among these, thermal disinfection is the primary method for high-risk facilities due to its reliability, chemical-free operation, and compatibility with heat pumps.

**Table 1.** Summary of *Legionella* Prevention Methods. (Meža, 2021)

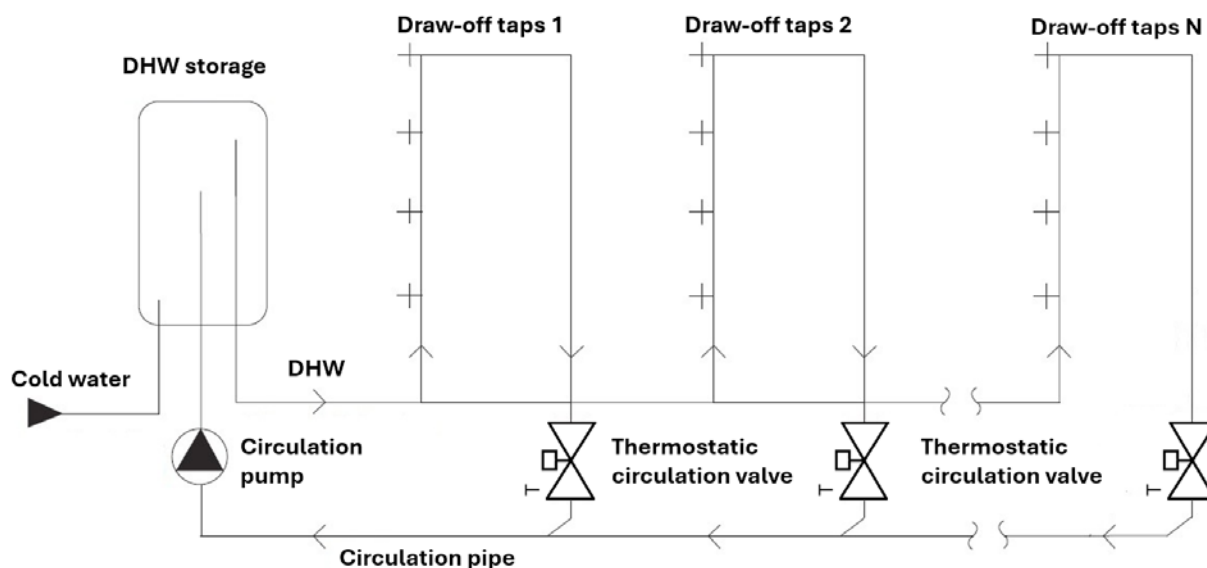
Method	Description / Key Points
Chlorination	Effective with precise control; may affect taste/corrosion; high monitoring required
Ozonation	Chemical-free; high cost; requires monitoring
Ag–Cu Ionisation	Controlled ion release; may influence water quality; high cost
UV Light	Local application; moderate cost; limited spectrum
Thermal Disinfection	Water $\geq 65^{\circ}\text{C}$ for defined period; primary method for hospitals and care homes
Chlorination	Effective with precise control; may affect taste/corrosion; high monitoring required

While these preventive methods can be highly effective when correctly implemented, their performance is often compromised by poor design, installation or maintenance practices, which are frequently observed in domestic hot water systems.

## Guidelines for DHW Heat Pump Installations

Safe DHW heat pump operation requires integrated measures (Meža, 2025); Gerhardy, 2012):

- System design: Ensure adequate flow, uniform temperature distribution, and accessibility for maintenance. Eliminate dead legs and zones with stagnant water ( $>3$  L).
- Circulation and control: Install balancing and thermostatic valves to maintain stable temperatures  $\geq 50^{\circ}\text{C}$  at all draw-off points.
- Material selection: Use potable-water-compliant materials (copper, stainless steel, low-lead brass, polypropylene, PVC) resistant to biofilm formation.



**Figure 3.** Thermostatic valve installation in a DHW circulation loop.

- System integrity and insulation: Prevent ingress of external water and insulate all hot pipes, separating them from cold lines.
- Thermal disinfection: Heat sources must reach  $\geq 70^{\circ}\text{C}$  for periodic disinfection.
- Pump sizing: Circulation pumps must maintain sufficient flow and temperature stability.
- Maintenance: Inspect, clean, and disinfect heaters, storage tanks, and piping regularly.
- Smart integration: Electronic monitoring and automated thermal disinfection cycles via BMS enhance safety, efficiency, and process control.
- Compliance with DHW regulations, legislation, and design guidelines (Drinking Water Directive EU 2020/2184, WHO, BS8580, ECDC, CEN/TR 16355:2012, REHVA Guidebook No. 30, etc.)

### Thermal Disinfection and Energy Efficiency

Thermal disinfection is reliable and compatible with energy-efficient DHW heat pump operation. Optimisation measures include:

- System segmentation: Divide networks into zones for targeted disinfection.
- Targeted heating: Maintain  $\geq 50^{\circ}\text{C}$  during normal operation,  $60\text{--}65^{\circ}\text{C}$  during disinfection.
- Heat pump selection: High-temperature models provide  $\geq 70^{\circ}\text{C}$  efficiently.
- Waste heat recovery: Reduce energy demand for disinfection.
- Smart scheduling: Perform disinfection during off-peak periods.

**Table 2.** Recommended Thermal Disinfection Times.

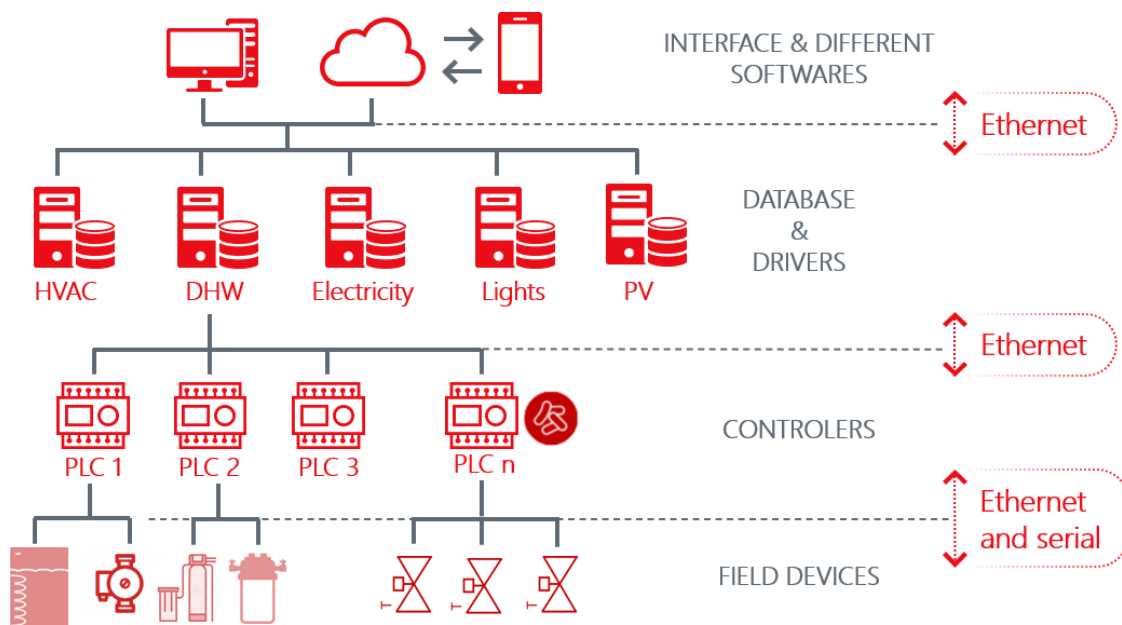
Disinfection temperature [°C]	Minimum time
50	6 hours 20 minutes
55	0 hours 50 minutes
60	0 hours 14 minutes
65	0 hours 11 minutes
70	0 hours 6 minutes
75	0 hours 3 minutes

### Monitoring and Performance Assessment

Monitoring is essential to ensure both safety and regulatory compliance:

- Temperature sensors at heaters and circulation loops.
- Automatic logging of temperatures and disinfection cycles.
- Alarm systems for failed cycles.
- Periodic microbiological sampling.
- Maintenance checks for valves, insulation, flow, and heaters.

High-risk buildings benefit from BMS integration, allowing real-time control, automatic logging, and digital reporting.



**Figure 4.** Schematic of monitoring and thermal disinfection control via BMS.

## Conclusion

Legionella control in DHW heat pump systems requires a holistic, integrated approach. Correct system design, material selection, stable temperatures, targeted thermal disinfection, regular maintenance, and smart monitoring combine to ensure hygienic safety without compromising energy efficiency.

Optimised heat pump operation, combined with smart thermal disinfection and BMS integration, enables sustainable and safe domestic hot water supply, regulatory compliance, and enhanced user comfort. Following REHVA guidelines ensures both microbiological safety and energy-efficient operation in modern buildings.

## Literature

- ASHRAE (2018). Standard 188. Legionellosis: Risk Management for Building Water Systems. ASHRAE.
- Brundrett, G. W. (1992). Legionella and Building Services. Jordan Hill, Oxford.
- BS 8580 (2019). Water quality. Risk assessments for Legionella control. Code of practice. British Standards Institution.

EU (2020). Directive (EU) 2020/2184 on the quality of water intended for human consumption (recast). Official Journal of the European Union.

ECDC (2026). Legionnaires' disease Annual Epidemiological Report for 2022. Stockholm: ECDC; 2026 ([https://www.ecdc.europa.eu/sites/default/files/documents/LEGI\\_AER\\_2022\\_Report.pdf](https://www.ecdc.europa.eu/sites/default/files/documents/LEGI_AER_2022_Report.pdf)).

Gerhardy K. (2012). Das DVGW-Arbeitsblatt W 551 und die 3-Liter-Regel. Energie wasser-praxis. Vol. 2: 42-45.

Meža (2025). Smanjenje rizika od infekcije legionelom u instalacijama potrošnje tople vode - učinkovita rješenja s dizalicama topline. Tehnologije dizalica topline. Vol. 6: 17-22.

Meža, P. (2021). Smart, energy efficient reduction of legionella risk in domestic hot water systems. In: International conference of SZE: Energy Supply and Use in Smart Buildings and Homes: Portoroz, 28.-29. June 2021: Conference proceedings. Ljubljana: Slovenian Energy Association. 50-51.

Persson T., Wollerstrand J. (2004). Temperature levels in domestic hot water systems and growth of Legionella. 9th International Symposium on District Heating and Cooling, Espoo, Finland Lund Institute of Technology, Department of Heat and Power Engineering. 283-294.

Polarczyk I., Fijewski M. (2017). Impact of the circulation system on domestic hot water consumption. E3S Web of Conferences 22, ASEE17.

REHVA (2019). Hygiene in potable water installations in buildings. REHVA Guidebook No. 30, Brussels. ■