

THE MICROBIOLOGICAL RISK OF HOT WATER DISTRIBUTION SYSTEMS

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Abstract

The presence of the bacteria Legionella in water systems, especially in the hot water distribution system, represents in terms of health protection of inhabitants the crucial problem which can not be overlooked. The aim of the research is theoretical and experimental analysis of hot water distribution systems from the point of view of microbiological risk in conditions of the Slovak Republic. There are a lot of guidelines and regulations developed in many individual countries for the design, operation, and maintenance of tap water systems to avoid the growth of bacteria Legionella. The core of the article consists in investigation of Legionella contamination of hot water in a cross-sectional survey in Kosice, the Slovak Republic.

Key words: *Legionella pneumophila, contamination, hot water, distribution system, regulation, thermal disinfection*

1. INTRODUCTION

Legionellosis is a collection of infections that emerged in the second half of the 20th century, and that are caused by Legionella pneumophila and related Legionella bacteria. Water is the major natural reservoir for legionella, and the bacteria are found worldwide in many different natural and artificial aquatic environments, such as cooling towers; water systems in hotels, homes, ships and factories; respiratory therapy equipment; fountains; misting devices; and spa pools. About 20% of the cases of legionellosis detected in Europe are considered to be travel-related; these cases present a particular set of problems because of difficulties in identifying the source of infection.

Table 1 - Main characteristics of Legionnaires' disease and Pontiac fever (Woodhead & Macfarlane, 1987; Stout & Yu, 1997; Yu, 2000; Akbas & Yu, 2001; Mülazimoglu & Yu, 2001)

Characteristic	Legionnaires' disease	Pontiac fever
Incubation period	2–10 days, rarely up to 20 days	5 hrs–3 days (most
Duration	Weeks	2–5 days
Case–fatality rate	Variable depending on susceptibility; in hospital patients, can reach 40–80%	No deaths
Attack rate	Attack rate 0.1–5% of the general population 0.4–14% in hospitals	Up to 95%

The severity of legionellosis varies from mild febrile illness (Pontiac fever) to a potentially fatal form of pneumonia (Legionnaires' disease) that can affect anyone, but principally affects those who are susceptible due to age, illness, immunosuppression or other risk factors, such as smoking (see Table 1) [1].

The first evidence of the association between water for human consumption from shower and nosocomial legionellosis was reported more than 20 years ago [2], and the hot water system is thought to be most frequent source of case or outbreaks within a hospital [3], where patients may be at higher risk for a severe infection [4].

Relatively little is known about sporadically occurring cases of community-acquired legionellosis, which accounts for most infection [5], although correlation analyses suggest that a substantial proportion of these cases may be residentially acquired and associated with bacteria in hot water distribution system. Absolute exclusion of these particular bacteria from building water systems may not be possible, nor necessary. Outbreaks of disease have generally occurred when the concentrations in water systems have been high and aerosol has been produced. The aim therefore is to minimise the possibility for infectious doses to be produced as a result of operation of water systems. It is important that appropriate measures are taken to guard against conditions which may encourage *Legionella* multiplication.

2. LEGISLATION

In the last years particular parts of the 'STN EN 806 Specifications for installations inside buildings conveying water for human consumption' have been accepted by the Slovak Republic. Safety quality and suitability of procedures accepted for safeguarding of system performance according to EN 806 and EN 1717 should be regularly controlled. Conditions of installations operation have to be compared with conditions of design and assembly in order to insure their functionality.

Potable water is safeguarded by basic formula:

- Cold water must remain cold
- Hot water must remain hot
- Water must not stagnate in water pipes longer than it is necessary.



Figure 1 – *Legionella Pneumophila* [EWGLI].

3. RECOMMENDED REGULATIONS FOR INSTALLATIONS INSIDE BUILDINGS

Installations inside buildings conveying water for human consumption must involve EN 1487, EN 1488, EN 1489, EN 1490 and EN 1491.

The most important factor for the possible development of Legionella bacteria in hot water systems with circulation pipes could be the temperature difference between heater output and circulation pipe input to heater maximum 5 K see figure 2). These criteria are consistently reflected in guidelines and regulations developed in many individual countries for the design, operation and maintenance for tap water systems to avoid the growth of Legionella (the Slovak Republic does not have any guidelines or regulations related to Legionella bacteria).

STN EN 806 provides 30 seconds after fully opening a draw off fitting the cold water temperature should not be kept below or equal to 25 °C and hot water temperature should not be less than 60 °C. Hot water systems should have the facilities to enable the temperature at the extremities of the system to be raised to 70°C for disinfection proposes.

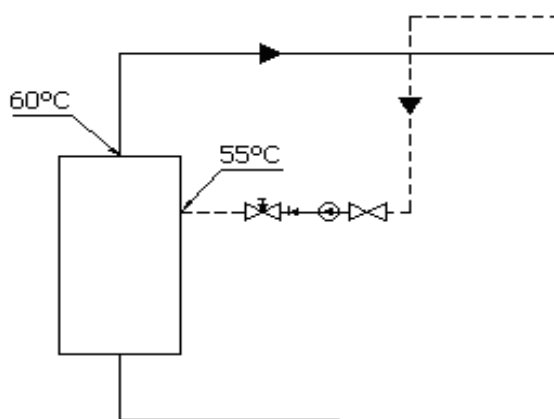


Figure 2 - Minimum temperatures in the heater outputs [6].

Technical commission TC 164, which creates European standards (as the EN 806), currently working on the final version of Technical report: Recommendations for prevention of Legionella growth for installations inside buildings conveying water for human consumption, which will complete the standard EN 806 [6].

The following conditions encourage the Legionella growth:

- water temperature between 25 °C and 50 °C;
- stagnation of the water;
- biofilm and sediment in the installation and water heater.

3.1 Temperature

To prevent the growth of Legionella bacteria the water temperature must be in a range that the bacteria will not grow or have minimum growth (>60°C). During normal use the hot water temperature in the

installation should be capable of reaching at minimum 55 °C at any point. For potable water installation with circulation of hot water the minimum temperature in the circulated parts should be 60 °C at any point (see figure 3).

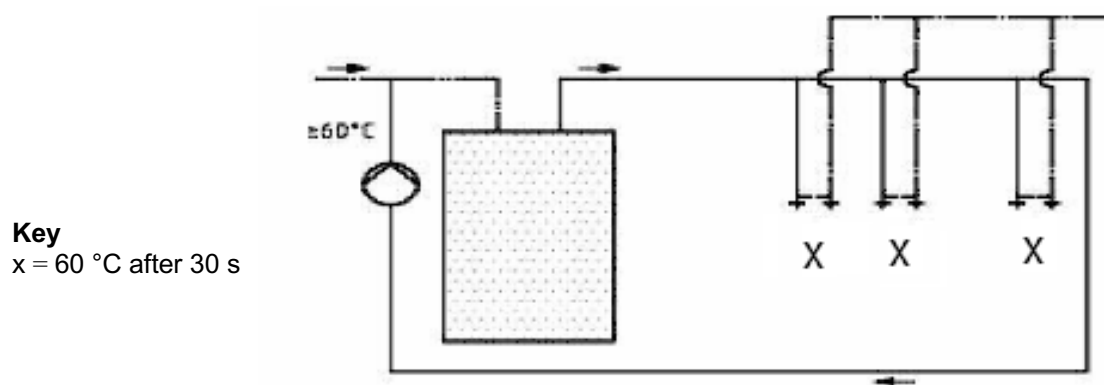


Figure 3 - Minimum hot water temperatures in a circulation system [6].

Following the recommendations made in this Technical Report the high hot water temperatures will increase the risk of scalding. Appropriate measures should be taken to reduce this risk e.g. notices by hot water draw-offs or mechanical devices (see table 2).

Table 2 - Guide values for the risk of scalding in relation to hot water temperature and time of exposure

Hot water temperature	70 °C	60 °C	50 °C
Children	< 1 s	3 s	2 min
Adults	1 s	7 s	8 min 30 s

3.2 Stagnation

In order to avoid long periods of stagnation the water in every part of the installation should be used or flushed weekly (see figure 4). The installation must be designed and installed in a way that stagnation of the water under normal use is avoided. Cut off ends should be as short as possible, but should not be longer than $l = 2 \times DN$.

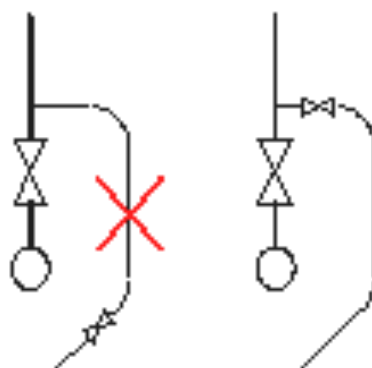


Figure 4 - Stagnant water [6].

Dead ends should be removed or disconnected, as close as possible to the connected installation. Infrequently operated pipes should be closed by a shut off device and drained or flushed regularly. It appears that during stagnation *Legionella* can grow in water volumes smaller than 3 liter. Therefore it is recommended to keep the volume of water contained in the pipe work between the circulation system and the tap as low as possible [3].

3.3 Biofilm and sediment

Biofilm may grow in any installation and can support the growth of *Legionella* [3]. At this point in time there is insufficient knowledge to define the extent of biofilm growth at which action is to be taken. Sediment can have a positive effect on the growth of *Legionella* bacteria and it should be removed from storage water heaters on a regular basis (e. g. once a year). Sediment in pipe work should be avoided by close attention to design parameters in EN 806-2 and EN 806-3 [3].

4. LEGIONELLA CONTAMINATION IN KOSICE, SLOVAK REPUBLIC.

4.1 Sample collection

From February to October 2006, a total of 46 water samples were collected from private homes, hospitals and boiler houses of Kosice, representative samples of Eastern Slovakia. The selection was made on the basis of the water distribution systems inside the town and buildings and heater types in each area. After we identified each building, we asked a random family, or a work collective to participate in the study, i.e. to complete our questionnaire and give informed consensus for water collection. Laboratory examinations and *Legionella* analysis were made by the Regional Health Office – referential centre for potable water in Kosice. The hot water samples were drawn from the bathroom outlets in the case of residential houses (shower heads or bathroom taps) in the sterile 1-L glass bottles after a short flow time (to eliminate cold water inside the tap or flexible shower pipe). To neutralize residual free chlorine, sodium thiosulphate was added into sterile bottles for bacteriological analysis, whereas acid-preserved glass bottles were used for chemical determinations.

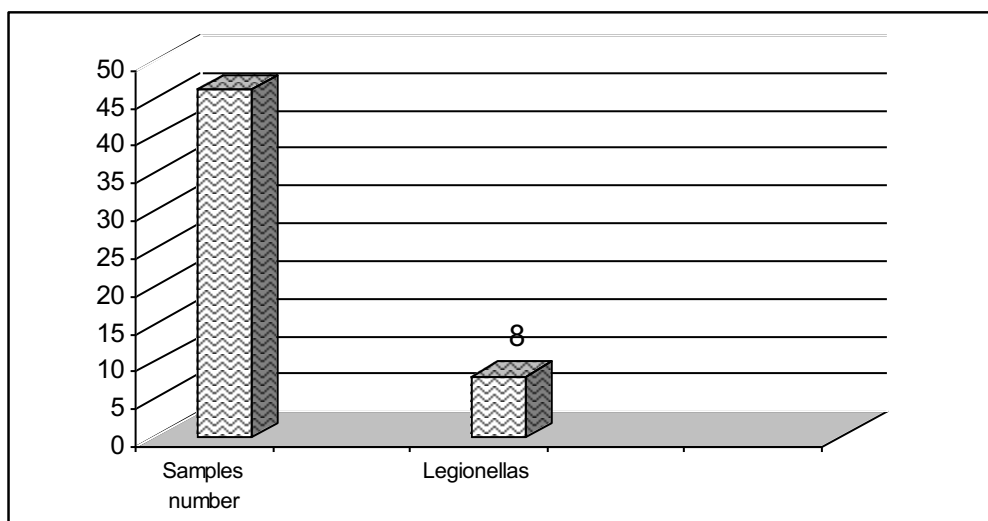


Figure 5 – Legionella results determination for potable water hot in Kosice.

The collection bottles were returned to the laboratory immediately after sampling for bacteriological examination by a Membrane filtration. Filters Millipore were used for 10 ml sample volumes. Adjusted samples were inoculated on the medium GVPC surface [7].

4.2 Positive samples

Legionellas presence was detected in 8 samples out of analysed drinking water samples (see figure 5). Positive findings were recorded in 8 samples of PWH (potable water hot) In waters for human consumption (potable water cold - PWC) volume of legionellas were detected, from sporadic colonies of 20 Colonies Formed Unites - CFU/100ml up to massive colonizations in the quantity 6700 CFU/100ml per a sample. In water for human consumption (PWH) volume of legionellas were detected, from sporadic colonies of 200CFU/100ml up to massive colonizations in the quantity 14600 CFU/100ml per a sample. Legionellas presence was detected in 8 samples of analysed PWH samples, i.e. in 17,4 %.

4.3 Results and Discussion

There was a necessity to react promptly due to positive findings in residential areas. The most reliable and available solution was thermal disinfection.

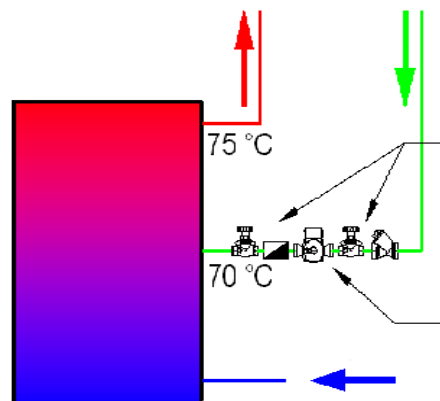


Figure 6 – Thermal Disinfection

Thermal disinfection (see figure 6) is periodic rising of temperature for specific time in the whole hot water distribution system including outlet points with a certain time of flushing these points at increased temperature. The temperature level and time of flushing are very important. (75 °C-with 10 minutes of outlet flushing). However, there are still areas not reached by disinfection which remain the contamination source. Non-adjustment of systems leads to fast spreading of Legionella in distribution systems (WHO 2007).

That is why our sampling in contaminated places was repeated immediately after thermal disinfection which was almost negative. After 12 days the level of Legionella colonies was almost the same as before this measure (Figure 7).

The measures have proved that the thermal disinfection is not a suitable system treatment.

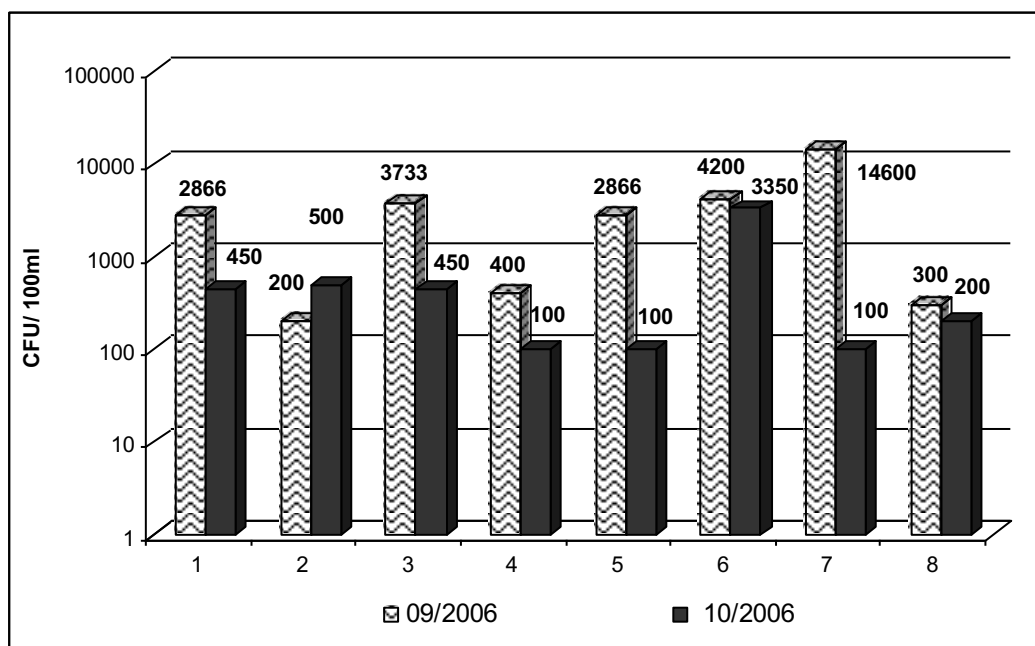


Figure 7 - Legionella results – positive samples

Much worse results were obtained in similar survey in Italy or Germany [7]. In this case 36 - 68 % of samples were positive. In case the thermal disinfection in contaminated places was not done the concentration of bacterias will have an exponential character. New strategies are tend to permanent disinfection due to the fact that spasmodic disinfection is not enough reliable to ensure the required standard.

5. CONCLUSIONS

Thermal disinfection was verified not to be the systematic solution and therefore it is inevitable to search for a new complex solution. Expenses on the elimination of Legionella from the water distribution systems are very high and the results are often not sufficient. Our control preventive measures have been in progress in order to search for an effective way to suppress the spread of the Legionella bacteria in water systems. Nevertheless, it should be the common goal of designers and operators to reduce the risk of Legionella bacteria in the installation inside buildings. To prevent tragic events it is necessary to monitor the issue in the world and pay attention to precautionary regulations.

ACKNOWLEDGEMENTS

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REFERENCES

1. Frade Jamie Bartram, Yves Chartier, John V Lee, Kathy Pond and Susanne Surman-Lee: Legionella and the prevention of legionellosis, 2007.
2. Tobin JO, Beare J, Dunnill MS, Fisher-Hoch S, French M, Mitchell RG, et al. *Legionnaires' disease in a transplant unit: isolation of the causative agent from shower baths*. Lancet 1980; 2: 118–21.
3. Sabria M, Yu VL. [Hospital-acquired legionellosis: solutions for a preventable infection](#). Lancet Infect Dis 2002; 2: 368–73.
4. Pedro-Botet ML, Sabria-Leal M, Sopena N, Manterola JM, Morera J, Blavia R, et al. *Role of immunosuppression in the evolution of Legionnaires' disease*. Clin Infect Dis 1998; 26:14–9.
5. Straus WL, Plouffe JF, File TM, Lipman HB, Hackman BH et al. [Risk factors for domestic acquisition of legionnaires disease](#). Arch Intern Med 1996; 156:1685–92.
6. Technical report TC 164 WI 164353: Recommendations for prevention of Legionella growth for installations inside buildings conveying water for human consumption.
7. Borella P, Montagna MT, Romano-Spica V, Stampi S, Stancanelli G, Triassi M, et al.: *Environmental diffusion of Legionella spp. and legionellosis frequency among patients with pneumonia: results of a multicentric Italian survey*. Ann Ig 2003; 15: 493–503.