LEGIONELLA IN COMBISYSTEMS TANKS

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1. Introduction

1.1. Characteristics of Legionella

The first epidemic outbreak documented was in 1976, where a convention of American ex-military legionaries took place in the Bellevue Stratford Hotel in Atlanta. 221 assistants became ill with pneumonia, and 34 died. A further investigation said that the infection was caused by Legionella Pneumophila, in pulmonary tissue. Once the cause was found, it could be correlated with other outbreaks happened before.

Legionellosis is an illness that affects mainly old people, smokers, people with pulmonary problems, and people with transplants. Legionellosis can be found in different forms. 10 to 15% of the infected people die.

Legionella are bacillus with a size from 0,3 to 0,9 µm width and 1,5 to 5 µm lenth. They are mobile organisms. Legionella can live in a wide range of ambient conditions: temperatures from 0 to 63ºC, pH from 5,0 to 8,5, and oxygen concentrations in water from 0,2 to 15 ppm. It can live long years in stored water between 2 and 8ºC.

Theoretically, the pneumonia can be prevented if the organism is removed from its reservoir. On top of the organisms usually living in the water system (algae, and other bacteria), it is considered that the presence of iron, sediments, sludge, calcium, and other systems, have an important impact in the living system of Legionella and give favourable conditions for its growth.

The optimum temperature for Legionella multiplication is 30 to 45ºC. In temperatures between 45 and 55ºC, its concentration can be higher than other bacteria usually found in drinking water. The bacteria does not multiply itself under 20ºC and does not live at over 70ºC, but can be in latent state in cold water and multiply itself when arrives at the adequate temperature.

Legionella can grow together with other aquatic bacteria, sharing nutrients and helping between them. The formation of these bacteria growths is promoted by:

- Quiet water
- Pipe parts of no frequent use
- Decrease of water flow
- Some pipe materials

- Water temperature (30-42ºC)

Legionella can multiply itself inside protozoa, microorganisms where it is protected from unfavourable ambient conditions. Under these conditions it can survive in habitats with a wide range of temperatures, is more resistant to water treatment with chlorine, biocides and other disinfectants, and it can even survive in dry conditions.

1.2. Infection of and symptoms in human beings

The only known infection route is the one by which people have inhaled aerosols with Legionella. People with a weakened defence system are most at risk. Other factors that increase the chance of infection are elderliness, smoking and drinking. Also, the chance of infection is greater for males than for females.

Infection can cause two separate diseases to develop:

- Pontiac Fever, an illness that is very similar to influenza and lasts for a couple of days. In many cases, the illness is not recognized as such.
- Legionnaires' disease, which has an incubation period of 2 to 10 days. The syndrome starts with flu-like symptoms, changing to a kind of pneumonia, followed by inflammation of various organs. Only 5% of the infected persons develop this disease; however, of those that do, some 10 to 30% die of it. Those who survive may suffer permanent damage to their lungs and other internal organs.

1.3. Installations with risk

Installations can be classified by their frequency in being colonized by Legionella and by their identification as source of epidemic outbreaks. They can be classified as follows [1]:

High risk:

- systems of distribution of domestic hot and cold water (network, tanks, boilers, heaters, and wells) from hospitals, and other installations of collective use with showers (hotels, sports installations, saunas, etc.)
- refrigeration towers and evaporative condensers and their water circuit
- humidifiers that generate aerosols, and similar equipment
- hydromassage baths
- thermal installations and their distribution systems

- other installations using water between 20 and 60ºC and that could produce aerosols during any operation, or maintenance

Low risk:

- ornamental fountains
- aspersion watering
- refrigeration by aerosols
- fire water systems
- any other apparatus that can produce aerosols

2. Control

Preferred methods for controlling Legionella in potable water systems are thermal prevention and disinfection. To prevent Legionelly from occurring, the temperature should remain below 20-25ºC (with only minor growth) or above 50ºC (no growth possible). Above 60ºC, Legionella will die, although a decimal reduction time of 2-3 minutes at 60ºC should be taken into account.

Under some circumstances, control measures are applied, such as pipe flushing or water reheating. In determining these target times, it is assumed that the concentration can have increased to 10^5 cfu/L, so that a reduction by a factor of 3 is required. Occasionally, higher temperatures are used.

Table 1. Flushing time and re-heating time as function of temperature [2].

Temperature	Flushing time in case of weekly flushing	Re-heating time
60ºC	20 min	10 min
65ºC	10 min	1 min
70ºC	5 min	10 s

In addition to thermal treatment, there are various chemical and/or physical disinfection and prevention methods available. A survey of these methods given in previous reports is given in Weiss (2001) [3]**¡Error! No se encuentra el origen de la referencia.**, including the substances released in these processes, as applicable to potable water.

These methods must also be supplemented with control measures, both to guarantee proper operation of the equipment, and ensure that the entire installation including all outlets is covered. Here too, dead pipes or pipes that have not been flushed may continue to be breeding grounds of Legionella.

Table 2. Survey of alternative disinfection methods to prevent and control Legionella [4].

Type of treatment	Description	Active substances
Thermal treatment	See previous paragraph	None
Pasteurization	Special execution of thermal treatment	None
Doses of sodium hypochloride	1. Short-term application (several hours) of high concentration 2. Continuous low concentration in the entire system	NaOCl 1. Minimally 20 mg/L 2. Up to 5 mg/L (max. 8 mg/L) This forms: HClO (pH<6,5) ClO^- (pH>8) High concentrations may cause significant corrosion of copper pipes
Doses of chlorodioxide	1. Short-term application (several hours) of high concentration 2. Continuous low concentration in the entire system	ClO_2 1. Up to 1,5 mg/L 2. Up to 0,2 mg/L Residue: chloride The above doses will have only a minor effect on pipe material
Doses of chloroamine	Continuous low concentration in the entire system is the most worthwhile application	$ClNH_2$ to 2 mg/L In this process, ammonia may be released, forming strong complexes with copper, thus possibly preventing the formation of a protective covering layer
Doses of hydrogen peroxide	Solely short, periodic treatment, applied for maximally 24 h. It kill bacteria in the entire system	H_2O_2 concentration of 200-500 mg/L At low concentrations, the effect on pipe material is minor
Anodic oxidation / electrolysis	By way of electrolysis, substances present in the water are converted into oxygen radicals, atomic oxygen, hydroxyl radicals, elementary chlorine and HClO. This kills bacteria in the entire system.	Concentrations: ?? Organic byproducts<5 μg/L
Cooper/silver ionization	Formation of copper and silver ions by way of ionization	Copper ions 100-400 μg/L Silver ions 10-40 μg/L
Membrane filtration	Microfiltration and ultrafiltration to keep out passing bacteria	None
UV disinfection	Local UV radiation kills passing bacteria	None
Electrical pulses	This affects the cell wall of the bacterium	Presumably none

3. Legislation. Overview per country

EU: EU-directives are very general, ’water should be safe’. In 1998 publishing of new Drinking Water Directive (98/83/EG). In EN 806-2 is stated ’The hot water temperature in the pipe work shall not drop below 50ºC’.

On a European scale, infections of legionella after travelling are being monitored in the EWGLINET program. Within this project, more than one incidence of Legionella in the same region within 6 months triggers measurements in suspected hotels [5,6].

There is also a Memorandum of the World Health Organisation concerning Legionella [7].

Netherlands: Since outbreak of Legionella on flora in Bovenkarspel (1999) with 32 dead, Legionella is a hot topic in the Netherlands. This resulted in Temporary Decree for Legionella Prevention in Tap Water, in which is stated that by 15 October 2001 all public or collective drinking water systems should have had a risk analysis. If there is a risk, a control plan must be implemented. Temperature at tap should be 60ºC at least. As soon as Legionella is detected, action must be undertaken to get rid of it.

- Legionella i varmt brugsvand. Overvagning, udredning ogforebyggelse af Legionaersygdom. Statens Serum Institut (2000).

Denmark: There is no specific legislation, normal regulations for hot water production are valid. All measures are recommendations. 50ºC at tap is enough. Proposed reaction limits: <1.000 cfu/L no action, >100.000 corrective measures should be taken [8].

France: There are draft new regulations with three main requirements (March 2005):

- In order to prevent burning risks, the temperature of DHW should never exceed at drawing point: 50ºC in bathrooms, 60ºC in other rooms. In kitchens and washrooms of collective buildings, and with particular warnings, 90ºC are allowed.
- Temperature of collective distribution networks must be permanently higher than 50ºC if the volume between the DHW heating system and the most distant drain up is greater than 3 litres
- If the total storage volume is higher than 400 litres, water in the tank/s must be:
    - Either always at a temperature higher than 55ºC
    - Or heated up once every 24 hours to a given temperature, with a given duration:

- 2 minutes if the water temperature is higher than 70ºC
- 4 minutes it he water temperature is higher than 65ºC
- 60 minutes it he water temperature is higher than 60ºC

There are also temperature requirements non mandatory for pre-heating tanks.

Germany: For several years now the codes of practice W551 (new buildings) and W552 (old buildings) are valid [8]. These codes of practice intend to reduce Legionella growth in drinking water heating systems and conduits. A distinction is made between small and large systems. Small systems are considered to have a very low risk so they need no special attention. Small systems are installations in one or two family houses, or installations with volume <400 litre and a volume <3 litre in pipe between heater outlet and draw off point. Large systems should be designed so that they can be heated up to 60ºC once a day.

Sweden: There is no specific legislation, normal regulations for hot water production are valid. Installations for hot water shall be designed so that the temperature at the hot water tap is not less than 50℃ and the temperature of circulating hot water shall not fall below 50℃. A recommendation is that the temperature of hot water in calorifiers or storage tanks should be not less than 60℃. 95% of thermal Solar panels systems are both for hot water and for water heating the building. Low risk of growth of Legionella because it is the heated water which is accumulated. There has not been any known case of Legionellosis in Thermal Solar panels systems. Boverket had produced a brochure on Legionella for house owners (in English) [8].

Belgium: Outbreak in November 1999 at whirlpool on exhibition. No specific regulation yet, but there is a proposal for regulations in region of Flanders concerning buildings open for the public. Requirements are cold water <20ºC and hot water >60ºC. All systems must have risk analysis, a Legionella managing plan and a logbook [8].

United Kingdom: Approved code of practice and guidance in place since 1991, revised in 2001. The Health and Safety at work etc act of 1974 gives health & safety inspectors the possibility to enter and inspect all sites, to issue enforcement's notices and eventually to prosecute. Temperature in storage >60ºC, cold water <20ºC. Separate action levels: <100 cfu/litre is under control, >1.000 cfu/litre means immediate action. There are thousands of companies that do inspections. For individual houses there are nearly no restrictions [8].

Switzerland: Laboratories are obliged to report any positive test results of Legionella infections to central and local health authorities. There is no mentioning of Legionella in the Swiss food or hygiene regulations [9].

Swiss Federal Office of Public Health states that the influence of energy saving measurements (reduction of boiler temperature) cannot be quantified. Never the less it recommends a minimum boiler temperature of 60℃ at least once a day and a minimum draw off temperature of 50℃ [5,9,10]. Although these measurements are recommended, it is also mentioned that the risk in private homes is extremely low, such that these temperatures do not have to be applied strictly if the installation is done correctly and in good condition [9].

The applicable norm of the Society of Swiss Engineers and Architects (SIA 385/3) only gives recommendations for tap water temperatures based on the type of use of the water (40...50 ℃ for body hygiene), and refers to the Swiss Federal Office of Public Health for recommendations concerning Legionella [11].

There are additional norms from SVGW (Schweizerischer Verein des Gas- und Wasserfaches) [12-14], but it could not be determined if they contain any regulations about Legionella or minimum boiler temperatures.

Spain: New legislation has come in the last years about the prevention of Legionellosis, all of it establishing criteria to prevent and control Legionellosis, general from the country and specifically from each Community [1]:

- Real Decreto 865/2003, de 4 de Julio: establishes higienico-sanitari criteria to prevent and control Legionellosis.
- Decret 152/2002, de 28 de maig: establishes higienico-sanitari criteria to prevent and control Legionellosis in Catalonia (DOGC núm. 3652 de 07/06/2002).
- Orden 1187/1998, de 11 de Junio: establishes higienico-sanitari criteria to prevent and control Legionellosis in Madrid (BOCM 144 de 19/06/98).
- Decret 173/2000, de 5 de desembre: establishes higienico-sanitari criteria to prevent and control Legionellosis in Valencia (DOGV 3893 de 07/12/00).
- Decreto 9/2001, de 11 de enero: establishes higienico-sanitari criteria to prevent and control Legionellosis in Galicia (DO Galicia núm. 10, de 15/01/01).
- Order de 11 de junio de 2001: establishes higienico-sanitari criteria to prevent and control Legionellosis in Extremadura (DOE 69 de 16/16/01).

4. Legionella in Solar Tanks – Research done

4.1. Denmark

It has been proposed that solar heating prepared tanks (solar heating tank with no solar collector connected yet) could cause increased nuisance with respect with bacterial growth than traditional tanks, because of larger volume and another form of operation.

This has been studied in Denmark [15]. This Danish report included the comparison between 8 solar heating prepared tanks, 8 solar heating tanks and 8 traditional tanks. Water samples were taken from the hot pipes after 2 minutes of draw off, in week 19 and week 28, 2000.

In this study, Legionella was not found in any of the solar heating prepared tanks. These tanks had volumes that were about 2 times as big as the volume of the traditional tanks. But Legionella was found in 1 of 8 of the traditional tanks and in 4 of the 8 solar heating tanks, but in low concentration.

The conclusion of this study was that Legionella can be found in hot water tanks in single family houses. Legionella was found in solar heating tanks, in traditional tanks, but not in solar heating prepared tanks. It was uncertain whether the large number of solar heating tanks with Legionella was due to statistical coincidence or other operation or installation conditions.

The results did not lead to any serious concern, but it was recommended to conduct further investigations to get a more precise picture of the presence of Legionella in hot water systems including solar heating systems. The reasons for presence of Legionella should be discovered.

These same authors presented a study, where bacterial growth included Legionella among others [16] were investigated. The objective of such investigation was to study the number of bacteria in smaller households in order to conclude whether solar heating prepared tanks gave rise to an increased number of bacteria in water compared to traditional tanks.

In this study it was not possible to spot a water quality deterioration, even though the solar heating prepared tanks on average had a volume 2.2 times as big as the traditional tanks, and the water had a longer residence time in the solar heating prepared tanks than in the traditional tanks. The microbiological water quality was measured on different water qualities on Zealand, which generally has hard water compared to many places in Jutland (Denmark). The scattering of the waterworks on Zealand does, however, not indicate significant geographical differences in the number of bacteria, and the results are expected to be national. The study included different manufacturers of solar heating prepared tanks and traditional tanks thus making the results representative of a broad segment of the types of tanks, which typically are marketed at the present time. *Legionella* was not determined in this investigation, but lately the problems concerning Legionnaires´ disease have been discussed and the next investigations will include measurements of *Legionella*.

In Denmark two more studies on domestic water heaters have been done. The first study was on the growth of bacteria in 12 solar prepared tanks and 12 traditional tanks. There were hardly any differences in bacterial counts. The bacterial counts were low compared to other investigations on larger systems in flats. In the second, following study, hot water samples were taken out of real domestic hot water systems and checked for Legionella. Five out of 24 boilers contained Legionella: none in the solar prepared tanks, one in traditional tanks and 4 out of 8 in the solar tanks. The level was considered low, and there was no time left to do thorough analysis of the systems conditions. The temperature level in the systems was rather low (40 – 50℃), which could stimulate the bacterial growth.

4.2. The Netherlands

More specific is the Dutch ISSO publication 55.1 [4] that describes a risk analysis. Part of it is a risk qualification of every part of the system. Total outcome should be neutral at least. It contains also lists of control measures and registration lists for logbook.

A study in this country [17] shows that:

- The fact that Legionella growth cannot be excluded between the temperatures 30-50ºC (in case of sufficient culture medium), in winter there is a possible risk for Legionella growth.
- Regularly during the year there will be a total thermal disinfection / eradication of Legionella in the entire solar store. After such a period of thermal disinfection, the solar domestic hot water systems will be “Legionella safe”.

- The possible Legionella risk will be mainly in the upper segment; in the lower segments of the store the duration of risky temperature levels is considerably shorter.

4.3. France

In France research was done with Legionella injected in a large hot water system (3 vessels of 1500 litres each) [18]. The Legionella was attacked with different control strategies. Main conclusions are that Legionella is reduced after a heating period of 8 hours at 65℃, after 2 days there was no Legionella detected at the outlet of systems (in any scenario), temperature of 70℃ is not sufficient to eradicate Legionella in all the systems (it is still present in piping without circulation).

4.4. Belgium

In Belgium a research project was running in 2000-2002 aiming to evaluate – in situ - anti Legionella treatments for sanitary hot water (physical and chemical) [19].

Preliminary results saw that it is difficult to achieve thermal disinfection. Also, immediately chemical treatment is only effective after a “good” thermal disinfection, otherwise a long waiting time is expected. When chemical treatment is used, corrosion care should be taken.

5. General conclusions

- Difference between large and small systems: is there a real problem in single family dwellings? There are no statistics, but Legionella has been found in some cases.
- There is a shift to higher risk factors by new building methods and regulations.
- What is large? Depends on volume/residence time/complexity/consumption rate/temperature.
- There is very little exact information, but risk analysis seems to be effective.
- All countries have specific situations, but the measures are quite similar.
- What is the right action level? There is not much science on this, only empirical data. Costs of sampling are a problem (in UK costs are relatively low because of high degree of automation).
- Engineers and biologists should work together.

From all the information gathered from many countries, reports, papers and legislation, the main conclusion of this report is that solar tanks are not more dangerous than other water tanks.

6. References

1. ”Curs de manteniment higienico-sanitari d’instal·lacions de risc davant la legionel·la”, Gremi d’Instal·ladors de Lleida, 2004.
2. Wolferen, H. “Legionella in hot tap water production”, “Proceedings IEA – Workshop Legionella”, Delft, The Netherlands, October 2001.
3. Weiss, W. “Industry Workshop”, Solar Combisystems IEA-SHC Task 26, Delft, The Netherlands, April 2001.
4. Wolferen, H. “Legionella in hot water preparation”, “Industry Workshop”, Solar Combisystems IEA-SHC Task 26, Delft, The Netherlands, April 2001.
5. Bundesamt für Gesundheit, „Legionellose in der Schweiz von 1999 bis 2001”, in Bulletin 7/03, S. 116 – 120, 3003 Bern (Schweiz), ISSN 1420-4266,
6. www.ewgli.org
7. World Health Organization. “Epidemiology, prevention and control of legionellosis: Memorandum from a WHO meeting”. Bulletin WHO 1990, 68: 155–64.
8. Warmerdam, J., Caris, R. “Proceedings IEA – Workshop Legionella”, Delft, The Netherlands, October 2001.
9. Bundesamt für Gesunheit, Abteilung Epidemiologie und Infektionskrankheiten, Sektion Bakterielle und parasitäre Erkrankungen, „Legionellen und Legionellose“.
10. Bundesamt für Gesundheit, „Legionellosemeldungen in der Schweiz 2002–2003“, in Bulletin 48/04, S. 900-903, 3003 Bern (Schweiz), ISSN 1420-4266,
11. Schweizerischer Ingenieur-und Architekten-Verein. „Warmwasserversorgungen für Trinkwasser in Gebäuden“. Norm SIA 385/3 (1991).
12. Schweizerischer Verein des Gas-und Wasserfaches. „Leitsätze für Erstellung von Wasserinstallationen“. Regelwerk SVGW – W3 (1992).
13. Schweizerischer Verein des Gas-und Wasserfaches. „Richtlinien für die Überwachung der Trinkwasserversorgungen in hygienischer Hinsicht“. Regelwerk SVGW – W1 (1997).
14. Schweizerischer Verein des Gas-und Wasserfaches. „Richtlinien für die Reinigung und Desinfektion von Trinkwasserleitungen“. Regelwerk SVGW – W1000 (1999, noch nicht veröffentlicht).
15. Bagh L. K., Ellehauge, K. “Undersogelse af Legionella I Solvarmebeholdere og I Traditionelle Beholdere”, Udfort af Teknologisk Institut, 2000.
16. Bagh L. K., Ellehauge, K. “Bacterial Growth in Solar Heating Prepared and Traditional Tanks”, presentation at Eurosun 2004, Freiburg, Germany, 2004.
17. Naron, D. “Legionella and domestic hot water systems”, “Industry Workshop”, Solar Combisystems IEA-SHC Task 26, Delft, The Netherlands, April 2001.

18. Ziegler, B. “Concentration of Legionella in hot water electrical storage systems”, “Proceedings IEA – Workshop Legionella”, Delft, The Netherlands, October 2001.
19. Cuyper, I. K., “In situ survey of Legionella in Belgium”, “Proceedings IEA – Workshop Legionella”, Delft, The Netherlands, October 2001.

Other references:

- Ditommaso, S., Guidetti, L., Giacomuzzi, M., Vallana, M., Ghia, C., Pepe, N., Maiello, A., Zotti, C., Vioglio, R., Ruggenini Moiraghi, A. “Contaminzione da Legionella degli impianti idrici degli ospedali piemontesi”, View & Review, 10(1), 11-15, 2000.
- Energie Plus, “Dossier. Légionellose”, 15 novembre 2004.
- Jarraud, S., Girardo, P., Reyrolle, M., Etienne, J. “Tours de Bectériologie Médicale – Legionella”, Université Claude Bernard, Lyon, 2004.
- Naron, D.J. “Microbiological safety of Solar Domestic Hot Water Systems”, Workshop Legionella, Leiden, October, 2001.
- Pagano, E., Raeber, P. A., Albert, J. P., Decludt, B., Francioli, P., Gaia, V., Gaille, P., Kamm, U., Gutzwiller, A., Hohl, P., Lang, T., Michel, P., Ruef, C., Studer, P. “Legionelle und Legionellose”, 1994.
- SVGW-SSIGE, “Legionella et eau potable: à quoi faut-il faire attention?”, 2001.