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# Legionella Pneumophila on board ship's freshwater systems and technological and organizational measures of prevention and suppression

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## ABSTRACT

Contamination of freshwater piping on board ships could result in severe health problems, and hence, in lost of operating hours and profit. The paper aims at presenting the main reasons for the growth of bacteria and other parasites. Furthermore, technological and organizational measures for the prevention and suppression of legionella are pointed out.

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## 1 Introduction

There have been a number of accidents on board ships regarding legionella or other parasites during last decades. And yet, the prevailing opinion is that this is not a technological problem, a problem that the technical crew members should be dealing with, but that it is only a sanitation problem, while the truth is nothing but. The main reasons for the legionella growth are inadequate piping layout and its operation.

In respect to the above mentioned fact, the production of freshwater piping should take into consideration both the flow of the water through the piping and its temperature. Namely, the growth of legionella is stopped at low and high temperatures. The piping layout should avoid possible low flow parts where water would at the same time suffer certain temperatures fallings.

If contamination occurs, a careful system analysis should take place. The measurement of temperatures and flows in the water system is the first procedure. Corrosion and scale formation points should also be checked, corroded parts replaced and scale cleaned. A system has to be severely cleaned with chlorine solution and hot water. A possible system reconstruction could result as a necessary one.

## 2 Microbiological contaminants in freshwater system

Freshwater contains a certain quantity of bacteria. This quantity does not usually represent a treat. The water is treated with chemicals that consequently release free chlorine. Not all of the bacteria are killed instantaneously. In some cases hours and even days are necessary. Some of the contaminants could be: escherichia coli, hepatitis A virus, shigela, norvirus, giardia and cryptosporidium, and certainly legionella.

**Table 1** Bacteria, Viruses and Parasites Time of Inactivation [1]

Inactivation time		
Contaminant	Type	Time
Coliphorm	Bacteria	Less than 1 min
Hepatitis A	Virus	About 16 min
Giardia	Parasite	About 45 min
Cryptosporidium	Parasite	10.6 days

Freshwater for the needs of passengers and crew members is divided into the following subsystems:

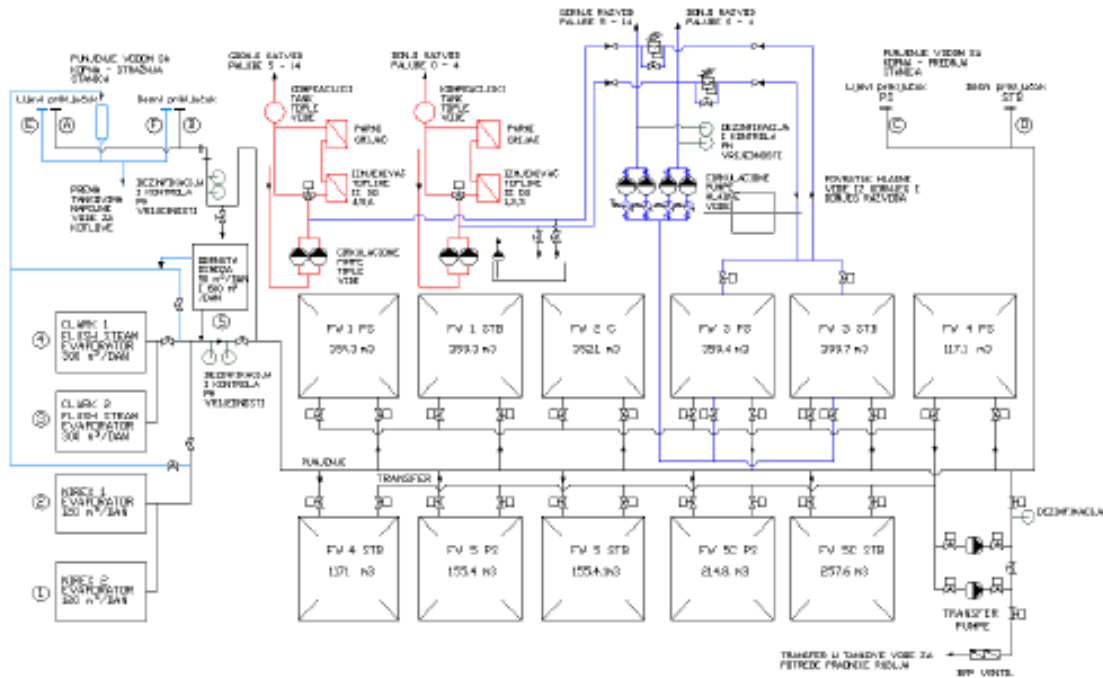


Figure 1 Bunker, Production and Distribution of Drinking water on board Passenger Ship [1]

1. potable water
2. water for decks and windows washing
3. technical water
4. water production
5. laundry
6. pool and spa

There could be even more subdivisions.

The technical water for the engine(s) propulsion is not disinfected, but the other ones should be. Since the consumption of water on board passenger ship is waste, the freshwater is bunkered occasionally (where the quality of water is in accordance with the regulations) or produced on board.

The system of bunker, production and distribution of freshwater on board passenger ships is given on Fig. 1. The freshwater production takes place in two Nirex type vacuum distillation plants (pos. 1 and 2), two Clark steam heated evaporation plants (pos. 3 and 4), and one additional RO plant 8 pos. 5). The bunker stations A, B, C and D are used for drinking water, while E and F for technical and laundry water. Connections are different so they could not be switched. There are eleven water tanks on board.

Transfer pumps are used to transfer water to the service tanks. The hot and cold water circulation pumps are also shown on Figure 1.

### 3 Legionella bacteria in water piping

The following factors are advantageous to the growth of the legionella bacteria in the system:

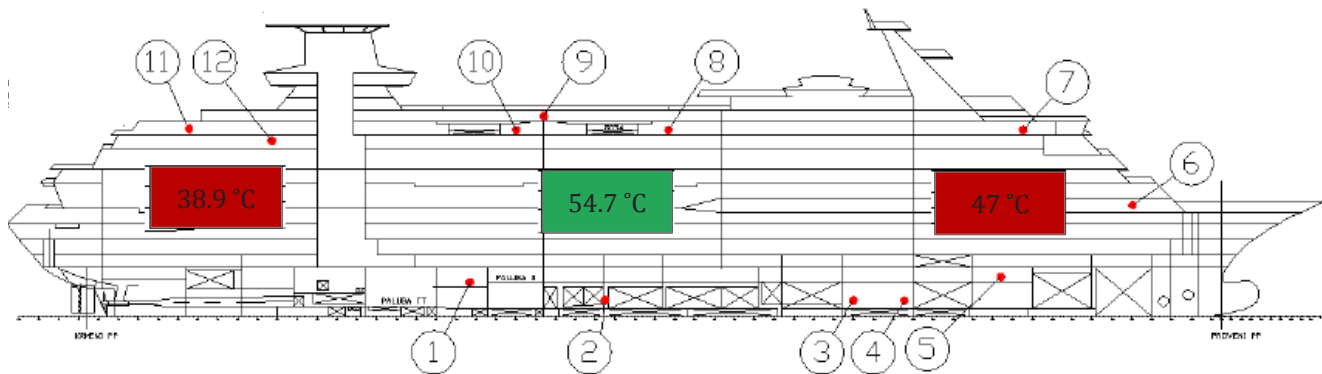
1. inadequate water temperature
2. poor water system project or its installation
3. inadequate disinfection after overhaul
4. scale and corrosion in the system

According to the WHO publication “Legionella and the Prevention of Legionellosis” from 2007, the dependence of the water temperature and the legionella bacteria growth is as follows:

1. temperature above 70 °C – the bacteria are killed instantaneously
2. temperature 65 °C – 90% of the bacteria are killed after two minutes
3. temperature 60 °C – 90% of bacteria are killed within 80 to 124 minutes
4. temperature between 48 °C and 50 °C – the bacteria could survive, but there is no reproduction
5. temperature between 32 °C and 42 °C – temperature ideal for growth and reproduction
6. temperature between 25 °C and 45 °C – growth of bacteria
7. below 20 °C – there is neither growth nor reproduction of the bacteria

It is quite clear what temperature should be avoided.

Obviously, the cool drinking water should be kept below 25 °C and the hot water should be kept above 50 °C. It seems an easy task to perform. An adequate thermal insulation around the tubes and that is it. But what about return pipes, or some not used or only occasionally used branches?



**Figure 2** Cross Section of a Typical Passenger Ship [1]

The marked positions having been contaminated by legionella are as follows: 1 – bunker station for freshwater in the main diesel generator room, 2 – all hot water circulation pumps, 3 – all cold water distribution pumps, 4 – technical hot water, 5 – ships hospital on deck 1, 6 – hot water piping in some passenger cabins, 7 – hot and cold water in some passenger cabins, 8 – hot and cold water booster pumps, 9 – spa tubs, 10 – circulation, heating and filtering system for spa tubs, 11 – hot and cold water on deck 9 astern, 12 – hot water for the bar on deck 8.

#### 4 Technological and operational measures

After legionella bacteria have been found in the ship's water piping by sampling, some measures could be done. In Figure 2, the ship's cross section, with points to be contaminated and average temperatures in the piping that have been measured, are shown.

Figure 2 also shows possible temperature differences in parts of the ship. Generally speaking, the parts of the system closer to the circulation pumps should not be a problem, while the parts further apart from those pumps could be.

Not only temperatures but flows should be analyzed as well, because low flow area, having a high enough temperature (one has to know that closed spaces on board ships are in general heated) is an ideal place for the growth of bacteria.

The complete piping has to be thoroughly checked. Every branch that is not used and has low flow has to be removed. Every cold and hot water pipe has to be thermally insulated and after installation temperatures have to be controlled. In contaminated pipes scale has to be removed and corroded pipes replaced. After installation the system has to be decontaminated with chlorine solutions and very hot water. Unfortunately, the bacteria would not be completely destroyed, because it has a certain self-protecting mechanism. When in danger, it protects itself inside of microorganisms that live in a biolayer in any water system.

#### 5 Conclusion

Legionella pneumophila bacteria could infect water systems on board within a relatively short period of time. There are several reasons that affect the fast growth of bacteria: inadequate temperatures, inadequate flows, scale formed in the system, corroded parts etc.

The technical measures that could be used on board ships are: hot water temperature, even in return lines, should not fall below 50 °C, cold water temperature should not exceed 25 °C, there should not be dead ends (not used branches of piping). The operational measures could be the following ones: a thorough study of planned modifications to determine the possible influence on the growth of bacteria, application of materials that have to be approved, water safety plan has to be made with procedures and control schedules to follow.

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