Oxytech \textit{D50/500} against \textit{Legionella in Water Systems}
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1. What are Legionella?

Legionella are rod-shaped bacteria and a natural component of fresh water.

Beside legionella pneumophila, the epidemiologically most important species, more than 30 other species exist, at least 17 of them are human pathogenic. About 80% of all legionella infections are caused by legionella pneumophila.

Colloquially the legionellosis is also called legionnaires disease.

The „legionnaires disease“ acquired its name in 1976 (July 21 to 24) when an outbreak of pneumonia occurred at the Bellevue-Stratford Hotel in Philadelphia among people attending a veteran convention of the „US American Legion“. Of 4,400 participants ca. 149 persons got sick, and 34 of them died. The legionnaires disease is an acute and serious bacterial pneumonia. Anyone can get this disease, but people with a weak immune system (most often patients hospitalized, older people living in nursing homes, etc.), are particularly at risk.

Due to three reasons the legionella pneumophila remained undiscovered for a long time. On the one hand, this disease resembles the atypical, non-bacterial pneumonia. On the other hand, the legionella pneumophila makes unusual demands to the nutrient medium for its growth. The nutrient media usually used for the progeny of the pneumonia pathogens do not contain the ideal concentration of cysteine and iron.

At the end, it is not easy to stain the legionella pneumophila (gram staining), which makes the microscopical identification rather difficult.

Outbreaks of legionellosis are observed quite often in hospitals, nursing homes, homes for handicapped or rehabilitation centers. Root cause is the presence of people, who are highly susceptible for this kind of infections (immunodeficiency, older people) on the one side, and the kind of sanitary piping systems (big buildings, long pipes) on the other side. Therefore hotels are potentially at risk, too.
2. Infections

The infection with legionella happens in the respiratory tract, when inhaling aerosols (smallest droplets of water), containing the bacteria. Aerosols develop primarily when water is suspended in the air, thus in the shower, in ventilation systems, humidifiers, air conditioners, whirlpools, portable fountains, etc.

Legionella, migrating in the lungs, are identified by the macrophages (body innate immune cells). These cells phagocytose (“en-gulf”) the legionella, in order to eliminate them. But the legionella, protected by a special mucous layer, becomes a parasite, invades the macrophages and begins multiplying inside the macrophages (facultative intracellular parasites), which now become its host. This occurs until the macrophages burst and other legionella are spread.

2.1 Course of Disease

The legionellosis, caused by the bacterium Legionella pneumophila, begins usually two to ten days after infection. A general malaise is accompanied by myalgias (muscle aches) and a slight headache. The body temperature is rapidly rising which is followed by cough, chest pains and abdominal pains, diarrhea and shortness of breath. Mostly the fever has already achieved 39 to 40 degrees, when the doctor is consulted. Some of the patients show mental confusion and apathy, an indicator, that the central nervous system is affected. The speed of the erythrocyte sedimentation rate is increased, the leukocytes and the immature blood cells are augmented, protein (albumen) and red blood cells are detected in the urine, and malfunctions (dysfunctions) of the liver and the kidneys are observed. Chest X-rays of 90% of the patients indicate pneumonia-like symptoms. Most of the patients need to be admitted to hospital. In the first days after hospitalization their state of health tends to get worse. If the treatment is not performed adequately (e.g. with antibiotics like Erythromycin), 20% of the patients are dying due to preceding pneumonia (the red blood cells within the lung do not get enough oxygen) or due to a shock caused by flushing out the bacteria in the bloodstream.

Patients who survive will recover within about eight days. Some of them need temporary artificial respiration or need to be connected to the kidney machine due to acute renal failure. Also, after recovering, the patients may get symptoms such as tiredness and weakness, this may take several months, and a damage of the pulmonary tissue may remain.
3. Legionella in the Drinking Water System

Because the legionella are not killed with natural drinking water purification, they can enter into domestic piping systems via the drinking water supply in low and nonhazardous concentrations. Here they coexist with ameba, protozoa and ciliates (protozoa, which exist in drinking water, the most famous is the paramecium). The existence of these protozoa highly relies on the conditions of the inner walls of tubes, of fittings and the temperatures of the line system. Incrustations, sedimentations on the container base, dead water areas and low system temperatures support the growth. Macrophages Ameba, protozoa and ciliates, and macrophages (body innate immune cells) too, try to “feed” the legionella. But the legionella are not “digested”, they continue living in these protozoa, even multiplying, and, at some stage, the host cells burst.

This has the unpleasant side effect, that legionella within the cell aggregates (cell shells) are protected against the attack of UV-light, chlorine, ozone, etc., and, at a low effective period, also against the temperature.

4. Legionella and the Water Temperature

The temperature range promoting an intensified growth of legionella lies between 30 and 45°C. At about 55°C the multiplication is not possible anymore and slowly the legionella die. A safe and with increasing temperature a faster killing can be observed at temperatures slightly above 60°C.

<table>
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<th>Temperature Range</th>
<th>Description</th>
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<tbody>
<tr>
<td>Until 20°C</td>
<td>low risk for legionella</td>
</tr>
<tr>
<td>33 – 42°C</td>
<td>opportunity for multiplication</td>
</tr>
<tr>
<td>42 – 50°C</td>
<td>multiplication stopped</td>
</tr>
<tr>
<td>50 – 60°C</td>
<td>slow killing of legionella</td>
</tr>
<tr>
<td>60 – 70°C</td>
<td>legionella are killed within minutes</td>
</tr>
</tbody>
</table>

Therefore the “hot water – low temperature range”, as proclaimed with the Energy Saving Regulation, is counterproductive and dangerous due to the legionella growth.
5. Protection against Legionella

The easiest way of preventing legionella in hot water systems is to keep the temperature in the whole distribution system above 50°C.

But the responsible persons will be confronted with three problems:

1. To ensure a proper hot water temperature up to the most distant point of use, it might be necessary to keep the operating temperature of the hot water heating system (boiler, etc.) rather high. At the same time, the energy consumption (electrical power, gas, oil) and the related operating costs will increase dramatically. Furthermore (besides), elevated water temperatures support the corrosion of hot water heating systems.

2. Even if energy reduction measurements are disregarded, it is sometimes impossible to ensure that the water temperature remains consistently in the safe range. Long high-temperature water pipes with scarce discharge and deficient insulation support the drop of temperature to a risky level. If, in such pipes, the taps for hot and cold water are turned on at the same time (e.g. washing hands), cold water containing legionella may enter into the hot water pipe via dosing control unit, where legionella will be able to proliferate.

3. Another risk factor is the occlusion of air bubbles in the pipes. These bubbles suppress water, and, because air is a very bad heat conductor, the microorganisms in the bubbles may survive and thrive, unmolested of the hot water temperatures.

The sole alternative for a temperature-dependent minimization of the legionella hazard is a careful and continual disinfection of the hot water system with chemicals. The difficulty is to use a disinfectant that kills the bacteria, protozoa and viruses, that is not corrosive and not toxic for humans and animals.

The solution is the disinfectant Oxytech D50/500, which meets all these requirements mentioned above.
6. Oxytech Disinfectant – Product Description

Oxytech disinfectant products are highly efficient, and universally applicable broad-spectrum disinfectants.

The reliable effect against pathogenic bacteria, viruses, yeasts, fungi, protozoa, etc., without secondary effect was re-tested and confirmed at internationally well-known institutes repeatedly. Compared to many other products, the Oxytech disinfectants have an outstanding effect against biofilms, too – and this without any harmful side effects. Legionella pneumophila also use biofilms as a “safety shell”.

As the main active component, the environmentally friendly hydrogen peroxide is used, that was stabilized in an extensive procedure and enhanced in its effect against microorganisms, by the addition of silver. Thus, the antimicrobial effect compared to normal hydrogen peroxide is improved multiple times. The amount of silver, remaining at the surface, is neither visible nor toxic, but counters effectively against microbial re-contamination.

At direct contact molecular oxygen (O2), released in the decomposition reaction of hydrogen peroxide, attacks the cell walls of the microorganism. Due to the chemical reaction of oxygen with molecules of the cell walls, those are denatured and killed. This effect is potentiated by silver ions, which inactivate and precipitate the microorganisms while binding to sulfur bonds of certain proteins of these microorganisms.
6.1 Important Properties

Oxytech Disinfectants …

- prevent microbial re-contamination reliably, therefore they are best suitable for water disinfection.
- are also stable at high water temperatures, the effectiveness increases with increasing temperature.
- do not alter the odor or taste in treated water when dosed.
- do not cause irritations of skin, eyes and of the respiratory tract when dosed.
- are neither toxic, nor carcinogenic or mutagenic after dosing
- are environmentally friendly, the main component, hydrogen peroxide, does not pollute wastewater, because of its decomposition in water and oxygen (H2O and O2), which are non-polluting by products.

6.2 Product variations (Oxytech D50/500)

The Oxytech disinfectants are available for the destruction of legionella in two different concentrations. At the respective comparable concentration applied their effectiveness is identical.

<table>
<thead>
<tr>
<th>Product</th>
<th>- Concentration - Kind of product</th>
<th>- User requirements (Application)</th>
<th>- H2O2-content</th>
</tr>
</thead>
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<tr>
<td>Oxytech D50/500</td>
<td>100% solution</td>
<td>Application only by professional personnel</td>
<td>Contains 50% H2O2</td>
</tr>
<tr>
<td>Highly concen-</td>
<td>Concentrated product to be diluted</td>
<td></td>
<td>Dangerous good: UN 2014 C, O</td>
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<td>trated disinfe-</td>
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environmentally friendly

Oxytech®
The German Disinfectant Specialists
7. Application of Oxytech Disinfectant in Water Systems

7.1 Basic Disinfection

A water analysis may help to determine the right time for decontamination. Once the laboratory identifies critical values in the pipe the cold and the hot water system need to be disinfected. For disinfection works, a mixing unit (with bypass) is to be installed by a professional person directly into the main supply line, after the water meter and in front of the water boiler. Thus, the Oxytech disinfectant can be dosed directly into the system. The Oxytech LLC offers several dosing and mixing units.

In the next step the boiler is completely emptied. Subsequently, the Oxytech mixing unit is turned on and the water system is put into operation again. Now all hot water tapping points (hot and cold water separately) need to be opened one after another (alternately), until the disinfectant solution can be determined with Oxytech test strips measuring strips at the required concentration in each tap. Special attention needs to be paid to possible existing hot water circulating pipes, which normally have a single tap. These special tapping points need to be opened for ca. 5 minutes after the Oxytech test.

Generally, the water taps in a building should be opened from the bottom to the top (first in the basement, at last in the top floor). After the completion of these works the Oxytech Disinfectant needs to react.

During the disinfection phase the tap should be kept closed and no water should be removed or consumed. After the recommended reaction time (mostly over night) the mixing unit is turned off. The boiler is completely emptied again and flushed with water.

Afterwards all water tapping points need to be opened one after another (hot and cold water separately) to rinse the disinfectant from the pipes. The water taps should be opened from the bottom to the top (first in the basement, at last in the top floor).

The rinsing can be stopped as soon as the Oxytech measuring strips are not colored any longer. The water in the pipes might be slightly colored, due to strippings of pipe linings caused by the disinfection (rust, died protozoa and MO, mineral linings, etc.).

Upon completion of the disinfection and rinsing of the system, all pipes are sterile, but the sterility should be confirmed by a water analysis after all treatments. It is absolutely important to understand that, after a certain time, the water system (especially the hot water system) may contaminate again. To keep this contamination of the system as low as possible, the disinfection should be repeated at regular intervals.

Recommended Dosage* for the basic Disinfection with Oxytech D50/500**

<table>
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<tr>
<th>Concentration ppm***</th>
<th>1000 ppm</th>
<th>2000 ppm</th>
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<tbody>
<tr>
<td>Reaction time in hours</td>
<td>5-6 h</td>
<td>3-4 h</td>
</tr>
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</table>

* The recommended dosage is based on average empirical values, which, depending on the microbial contamination of the system, on the condition of the surface, etc may deviate and might be adapted to the requirements

** Recommended dosage for Oxytech D50/5000.

*** ppm = parts per million / mg per liter / ml per m³
7.2 Prevention of Post-Microbial Contamination by Continual Water Treatment

If country-specific regulations for the drinking water disinfection with Oxytech disinfectant coincide, a continual dosing of a low amount of Oxytech D50/500 is recommended after a successful basic disinfection (see 7.1).

The dosage is performed in front of the hot water heating system (e.g. boiler) by a proportional dosing device (water meter with contact signal control and dosing pump). A microbial re-contamination of the hot water network is prevented successfully, and another general disinfection is not necessary when applying this procedure.

Proportional Dosing Device

Recommended Dosage* for continual Disinfection with Oxytech D50/500**

For the continual disinfection we recommend a dosage of ca. 20 ppm*** (mg/l / mg/m3) Oxytech D50/500 to prevent the microbial re-contamination in the hot water heating system. The outcome of this is a residual value of about 5-10 ppm (mg/l / ml/m3) Oxytech D50/500 in the water taps.

* The recommended dosage is based on average empirical values, which, depending on the microbial contamination of the system, on the condition of the surface, etc., may deviate and might be adapted to the requirements.

** Recommended dosage for Oxytech D50/500

*** ppm = parts per million / mg per liter / ml per m³

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