

# Chemical Treatment System for Legionnaires' Disease in Cooling Tower Application and Case Study adopted in a Project

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This article intends to compare some water treatment methods and their effectiveness to reduce the chance of Legionnaires' disease. It also reviews the kind of methods adopted on Hong Kong Science Park. Moreover, other reputable design guides are also mentioned as a reference.

## **Introduction**

The function of heat rejection system in air-conditioning installation is to reject heat to the environment. Cooling towers and evaporative condensers cool the warm water by allowing direct contact between atmospheric air and the water. Because of the large volume of air, organic material and other debris can be accumulated. These materials may serve as a nutrient source for Legionella growth. It is recommended that the system be maintained clean and a suitable water treatment program be used. The objective of it is to minimize Legionella counts in tower and prevent Legionella transmission from tower to people.

## **Legionella Pneumophila**

Legionella is a bacterium found primarily in warm water of natural environments and man-made systems. Legionella are present in the water along with other bacteria, protozoan and algae. Some protozoan even serves as host organisms for Legionella allowing amplification of Legionella to dangerous levels. Legionella can survive in man made water systems including cooling towers, domestic water systems, showers, whirlpool, spas, decorative fountains etc. The risk of infection depends on the existence of contaminated source, number of Legionella reaching to and inhaled by human body and resistance of individual.

The optimal temperature for the multiplication of Legionella is around 37°C. At 46°C, the multiplication ceases. Below 37°C, the multiplication rate decreases, and it can be considered insignificant below 20°C. Cooling tower is design to operate at temperatures that favor the growth of Legionella.

The operational method is a critical factor to control the outbreak of Legionella. Most professionals and governments do not recommend testing for Legionella bacteria on a routine basis. These may be due to the following aspects: There is no fixed "safe" infectious dose level that has been established. Legionella may not be detected in bulk water samples. Culture based techniques require 10 to 14 days turnaround for results. In spite of these, studies have shown that about 40 to 60% of cooling towers tested contained Legionella. So, Legionella need not to be totally eliminated in a system rather than keeping it at a low level.

## **A Case Study on Hong Kong Science Park Building**

### **Background information**

	<b>Close System</b>		<b>Open System</b>
	<b>Chiller water</b>	<b>Hot water</b>	<b>Cooling tower</b>
<b>No of System</b>	One	One	One
<b>System Capacity</b>	2 × 400 R.T. + 100R.T.	2 × 400 R.T.	3 × 500 R.T.
<b>Water Capacity</b>	30 m <sup>3</sup>	10 m <sup>3</sup>	20m <sup>3</sup>

<b>Water Source</b>	City water	City Water	Sea water/City water
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**Calculation**

1) Dosage of Biocides for Initial Treatment

For Close System e.g. Chilled water

- i) Recommended Dosage for Biocide 50mL/m<sup>3</sup> of total system water capacity  
= 0.05 L/m<sup>3</sup> × 30 m<sup>3</sup> = 1.5L

2) The application of Ozone

For Open System e.g. Cooling Tower

- ii) (a) The condensing water pump flow rate is 3 × 288 m<sup>3</sup>/hr = 864 m<sup>3</sup>/hr  
(b) The design dosage rate is 0.1ppm(mg/L)

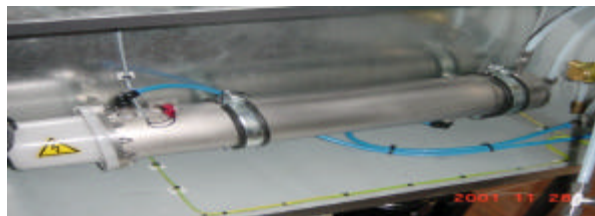
The capacity of ozonator requires would be:

$$864 \text{ m}^3/\text{hr} \times 0.1\text{mg/L} \times 1000\text{L/m}^3 \times 0.001 \text{ g/mg} = 86 \text{ g/hr}$$

The recommend ozonator is shown as follows:

Nominal rating (g/hr)	150
Ozone dose (mg/L)	0.174
Cooling water (L/hr)	230
Electrical rating (W)	1460
Overall dimension (mm)	Unit: 51×41×152 (W×D×H) Boxed: 66×165×58 (W×D×H) Crated: 64×165×61 (W×D×H)

**Photos of the Ozone generator:**



**Other Reputable Design Data**

**(I) Code of Practice of Legionnaires' Disease**

The Prevention of Legionnaires' Disease Committee has published a Code of Practice and information pamphlet which recommended the good practices to be followed in the design, operation and maintenance of cooling towers for the effective control and prevention of the Legionnaires' Disease. For cooling tower operation, it recommends to provide dosing points for chemical treatment for cooling tower. The following strategies maybe considered:

- (i) Use of two chemicals, by either continuous drip feed or manual slug dosing or automatic metered dosing.
- (ii) Use of a combination of 2 compatible chemicals to provide better control against a range of

- microorganisms.
- (iii) Carry out intermittent shock dosing with a high level of chlorine.

Besides, it also implemented the following preventive measures on the design, operation and maintenance of fresh water system.

- (i) The hot water storage device of the system shall be designed to reach 60°C for at least 5 minutes and water tap outlet temperature shall be at 50°C.
- (ii) Cold water storage tanks should be located and insulated to ensure that the bulk of water stored does not rise to temperatures where legionellae will proliferate.
- (iii) Cold water storage tank should be thoroughly cleaned and scrubbed with a solution of chlorine of lime or bleaching power containing not less than fifty parts of chlorine in one million parts of water.

### ***(II) Energy Efficiency Office***

Alternatively, the Energy Efficiency Office from EMSD suggests using Ozone for the chemical water treatment system. Ozone will oxidize many organic and inorganic substances. Under ambient conditions, ozone is very stable. It has potential for more water and energy savings and greater environmental benefits comparing with traditional chemical treatment processes. Moreover, ozone treatment contributes far less to the tower's dissolved solids. The main drawback of ozonation is its large plant size and expensive capacity cost.

### ***(III) Technical Memorandum of CIBSE***

CIBSE recommends that microbiological control can be done by continuous or intermittent chemical addition or by non-chemical means. Continuous chemical addition is usually the strategy adopted when using oxidizing biocides to maintain a low concentration at all times. Intermittent chemical addition is usually the strategy adopted when using non-oxidizing biocides. The dosing is carried out over a period at intervals of several days, and at least two chemically different formulations are used to guard against the development of resistant strains of bacteria.

Ultraviolet light gives non-chemical means of microbiological control but not recommended. The effect of UV is impaired by cloudiness of the water. Apart from this, it is also limited to the water passing through the light path, and there is no residual biocidal or biostatic action on the remainder of the water.

### ***(IV) Cooling Technology Institute Guideline for Legionellosis***

The following best practices for microbiological control are recommended to promote hyperhalogenation on open type cooling system. It is advised to feed a source of halogen (chlorine or bromine) by either continuous, intermittent use or routine on-line disinfection. The effectiveness of halogen decreases with increasing pH.

On-line disinfection system may be necessary for the system when Legionella test results show greater than 100CFU/ml. As practice is to maintain a minimum of 5ppm free halogen residual for at least 6 hours. Consequently periodic hyperhalogenation will discourage development of large populations of Legionella.

### ***Conclusion***

It is rarely interesting to see that all well-known institutions and governments suggested different kinds of water treatment system to kill Legionella in cooling tower. It may be concluded that each of these systems has their own advantages and disadvantages. To make it clearer, Table 1 shows a comparison between systems in several aspects. The best solution has not yet been found at this moment. The decision of using which system depends on the own specifications and requirements of the Engineers. Also, the available space and actual situation should be taken into account.

<b>Method</b>	<b>Hyperhalogenation</b>	<b>Chlorination</b>	<b>Chemical Biocides</b>	<b>Chlorine Dioxide</b>	<b>Ozonation</b>	<b>Ultra-Violet</b>
<i>Capital cost</i>	Low	Low	Lowest	Low	Highest	Medium
<i>Operating cost</i>	Low	Low	Low	Low	High	Lowest
<i>Ease of Installation</i>	Easy	Easy	Easy	Easy	Poor	Excellent
<i>Plant size</i>	Small	Small	Small	Small	Large equipment	Small
<i>Ease of Maintenance</i>	Good	Good	Good	Good	Poor	Excellent
<i>Cost of Maintenance</i>	Low	Low	Low	Low	High	Lowest
<i>Frequency of Maintenance</i>	Frequency	Frequency	Frequency	Frequency	Continues	Infrequency
<i>Control System</i>	Timer control	Timer control	Poor	Timer control	Good	Excellent
<i>Hazards</i>	Medium	Medium	Medium	Highest	High	Low
<i>Effect on Water</i>	Form Acid	Form Hypochlorous Acid	None	None	Decomposes quickly in hot water	None
<i>Contact Time</i>	0.5-5 seconds	0.5-5 seconds	0.5-5 seconds	0.5-5 seconds	10-20 minutes	0.5-5 seconds
<i>Maintain Residual</i>	Yes	Yes	No	Yes	No	No
<i>Disinfection Performance</i>	Only suppress Legionella (Bromine effective at pH8.5 to 9)	Only suppress Legionella	Leave some pathogens	Kills Legionellae at pH 4-9	Kill all microbes	Keep the bacteria level below a range
<i>Disinfection Capacity</i>	High	Medium	High	Medium to High	High	High
<i>By-product formation</i>	Carcinogenic THM / HAAs	Carcinogenic THM / HAAs	Unknown	Chlorite	Aldehyde / Bromate	Unknown
<i>Environmental friendly</i>	No	No	No	No	Yes	Yes

Table 1: Comparison of different kinds of water treatment system.

***List of references:***

1. Code of Practice for the Prevention of Legionnaires' Disease, *Prevention of Legionnaires' Disease Committee Hong Kong and Government of the Hong Kong Special Administration Region, 2000*
2. Pilot Scheme for Wider Use of Fresh Water in Evaporative Cooling Towers for Energy-efficiency Air Conditioning System, *Energy Efficiency Office EMSD, May 2000.*
3. Minimizing the Risk of Legionnaires' Disease, Technical Memorandum 13: 2000, *CIBSE*
4. Minimizing the Risk of Legionellosis Associated with Building Water Systems, *ASHRAE Guideline 12-2000*
5. Legionellosis Guideline: Best Practices for Control of Legionella, *Cooling Technology Institute (CTI), February 2000*