

**CODE OF PRACTICE FOR THE  
CONTROL OF LEGIONELLA BACTERIA  
IN COOLING TOWERS**

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## **FOREWORD**

Legionnaires' disease is an acute bacterial infection of the lower respiratory tract. Among the elderly and persons whose body resistance is weakened by other concurrent illnesses, the infection can be fatal. The disease is caused by the inhalation of tiny water droplets containing the legionella bacteria which thrive in poorly maintained cooling towers. Proper maintenance of cooling towers with regular mechanical cleaning, and routine treatment with biocides is therefore important and necessary.

To minimise the risk of outbreaks of legionnaires' disease in Singapore, the Institute of Environmental Epidemiology, Ministry of the Environment, in consultation with other government departments and professional bodies, formulated this Code of Practice for the control of legionella bacteria in cooling towers. It is intended for building owners/management corporations of centrally air-conditioned offices and factories, contractors involved in the servicing and maintenance of cooling towers, and others responsible for the design, operation and maintenance of air-conditioned buildings.

This document specifies the design, construction and location of cooling towers. It also provides guidelines on servicing and maintenance of cooling towers. It includes a checklist for assessment of health risk of cooling towers and emergency remedial measures in the event of an outbreak.

Building owners/management corporations are reminded that based on the Environmental Public Health (Cooling Towers and Water Fountains) Regulations 2001, it is an offence to operate cooling towers that are grossly contaminated and pose a health hazard.

WANG NAN CHEE  
COMMISSIONER OF PUBLIC HEALTH  
MINISTRY OF THE ENVIRONMENT  
SINGAPORE

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Sewerage Department, Ministry of the Environment

Pollution Control Department, Ministry of the Environment

Building Engineering Division, Building and Construction Authority

Department of Industrial Health, Ministry of Manpower

Medical Laboratory Board, Ministry of Health

Pathology Department, Singapore General Hospital

Singapore Association of ASHRAE Members

Singapore Institute of Architects

Institution of Engineers Singapore

Singapore Contractors Association

# **PART I**

## **PRELIMINARY**

### **1 Purpose**

- 1.1 The purpose of this Code of Practice is to provide guidelines for the prevention and control of legionella bacteria in cooling towers in order to minimise the occurrence and risk of outbreaks of legionnaires' disease.

### **2 Scope and application**

- 2.1 This document applies to all cooling towers in new and existing premises which are used as shops, offices, trade, business, industry or for any other purposes in Singapore.
- 2.2 It is applicable for use at various stages during the inception, design, upgrading, refurbishment, extension and maintenance of the building.
- 2.3 In this document, references to specific requirements under the relevant legislations are made. Failure to comply with these requirements shall constitute an offence under the respective regulations, and appropriate enforcement action shall be taken.

### **3 Responsibility**

- 3.1 It shall be the responsibility of the owner/management corporation of the premises with cooling towers to:
  - (a) assess the risk of occurrence of legionnaires' disease arising from cooling towers;
  - (b) set up and manage a programme to minimise the risk of an outbreak of legionnaires' disease and monitor the effectiveness of the programme;
  - (c) keep records of all activities implemented; and
  - (d) ensure the safety of operation and maintenance personnel and that they are adequately trained.

- 3.2 The owner/management corporation shall ensure that persons designated to carry out the responsibilities specified above are competent, adequately qualified and experienced. Where the owner/management corporation lacks the expertise, it shall be delegated or contracted to consultants with the relevant experience and expertise.
- 3.3 The owner/management corporation shall ensure that every water cooling system in the premises is registered with the Ministry of the Environment, using the form in Appendix A.
- 3.4 The owner/management corporation shall ensure that there is an instruction manual for every air-conditioning system incorporating:
- (a) a schematic plan of the air-conditioning system;
  - (b) its operation;
  - (c) the necessary precautions to be taken specifying checks and their frequency, and steps to be taken to remedy defects and deficiencies; and
  - (d) equipment supplier's particulars/contact numbers.



## PART II

### COOLING TOWERS OF BUILDINGS

#### 4 Cooling tower design and construction

- 4.1 At the stage of the construction of the building and the installation of cooling system, inspection shall be made by competent persons so that the cooling towers pose minimal health risk to occupants of the building and members of the public.
- 4.2 Cooling systems shall be designed and constructed so as to minimise the release of drift and to aid safe operation, and regular cleaning and disinfection.
- 4.3 The design of the cooling system:
  - (a) shall be simple and practical (deadlegs, loops and bends should be avoided and redundant pipework removed); and
  - (b) shall allow for easy access to all parts of the system for inspection, sampling, cleaning and disinfection.
- 4.4 A new or refitted cooling tower shall have features that minimise the formation and release of drift, in particular:
  - (a) a water distribution system within the cooling tower designed to create as little spray as possible;
  - (b) an effective high efficiency drift eliminator; and
  - (c) an enclosure of the area above the cooling tower pond. This will reduce the effects of windage that cause the drift to escape through the sides. It should not be transparent or translucent as sunlight can promote the growth of algae which is conducive for the growth of legionella bacteria.
- 4.5 Construction materials shall be non-corrosive, resistant to chemicals (e.g. fibre glass, stainless steel), smooth, non-porous, opaque to sunlight and readily disinfected. Materials used shall not support the growth and proliferation of microorganisms.

- 4.6 A drain shall be located at the lowest point of the pond with a drain-down valve so that the entire system can be conveniently and completely drained.

## **5 Location of cooling tower**

- 5.1 The cooling tower shall be located at least 5 metres away (measured from the base of the cooling tower) from air circulating and ventilating inlets, open windows and occupied areas, pedestrian thoroughfares, trafficable areas, areas of public access, exhaust discharges from kitchens, air handling system or other areas where nutrients conveyed from these systems could assist in the growth of legionella.
- 5.2 When locating a cooling tower, the influence of adjacent buildings and of prevailing wind direction and the wind distribution over these buildings shall be taken into account. It shall be located away from the downwind of air intakes for the building.

## **6 Source of water**

- 6.1 The source of make-up water shall be supplied by the Public Utilities Board water mains or any source as may be approved by the Commissioner.

## **7 Discharge of water**

- 7.1 Discharge of effluent water from cooling towers shall be into the public sewers in accordance to the Sewerage and Drainage Act Cap. 293A. Approval for connection to sewers shall be obtained from the Central Building Plan Unit, Pollution Control Department, Ministry of the Environment.
- 7.2 The concentration of chemicals in the effluent shall be within the allowable limits of the Sewerage and Drainage (Trade Effluent) Regulations 1999 administered by the Pollution Control Department, Ministry of the Environment (Appendix B).
- 7.3 Water from supply or condensation or other sources in the ventilation or air-conditioning system shall be discharged into a pipe or drain incorporating a U-bend and an air break between the condensate drain pipe

and the floor trap so that potentially contaminated water is prevented from being drawn back into the ventilation or air-conditioning system.

## **8 Commissioning and operation**

- 8.1 The specifications and operations of the air-conditioning system shall be in accordance to all the provisions of the Singapore Standard Code of Practice for Mechanical Ventilation and Air-Conditioning in Buildings (SS CP13: 1999 or any revision thereafter).
- 8.2 Cooling towers shall be properly commissioned before use to ensure that they operate correctly and safely.
- 8.3 The entire air-conditioning system shall be clear of any construction debris and dirt, and cleaned before operation starts.
- 8.4 Precautions shall be taken to control the risks during commissioning, start up and during the normal operation of the system.
- 8.5 In existing buildings:
  - (a) Where a cooling tower is out of use for more than five days, it shall be drained, thoroughly cleaned and disinfected before re-use.
  - (b) Where a cooling tower is not in use, it shall be drained and kept dry.

## **PART III**

### **SERVICING, MAINTENANCE AND MONITORING OF COOLING SYSTEM**

#### **9 Maintenance**

- 9.1 Cooling towers shall be maintained in a clean working condition and in a good state of repair. A “good state of repair” would mean that there is no defect in the operation, and the cooling towers should be free from physical damage or deterioration which may arise from defects, such as, rusty pipes.
- 9.2 Every system shall have a comprehensive maintenance manual that incorporates:
  - (a) complete building plans of cooling and ventilation systems;
  - (b) cleaning methods, decontamination procedures and dismantling instructions;
  - (c) procedures for water treatment; and
  - (d) shutdown and start-up procedures.
- 9.3 The regular maintenance of the cooling system shall be carried out by competent persons, familiar with the prevention of any hazard arising from the work.
- 9.4 Cooling towers shall be visually inspected at least once a week for any physical defect, general cleanliness, organic fouling and presence of physical debris.
- 9.5 A comprehensive maintenance programme including cleaning, disinfecting and water treatment for every cooling tower shall be carried out to prevent legionella bacteria from multiplying and to allow water treatment chemicals to work more effectively.
- 9.6 Physical devices incorporating use of copper-silver ionisation, filtration, ultraviolet light or ozone may be incorporated to complement maintenance, but they shall not replace a proper and regular maintenance programme.

## **10 Cleaning and disinfection**

- 10.1 Thorough cleaning, disinfection and manual desludging of cooling towers shall be carried out at least once in six months.
- 10.2 Cleaning and disinfection shall also be carried out in cooling towers:
- (a) that have been contaminated during construction, or by dusts or organic matter;
  - (b) that have been shut down for more than five days;
  - (c) that have been mechanically altered or disrupted in a manner which may lead to contamination;
  - (d) at regular intervals where the surrounding environment is dusty or where the water quality is out of control; and
  - (e) where the adjacent cooling tower has been implicated as a source of an outbreak of legionnaires' disease.
- 10.3 By-pass systems or alternating re-circulating pump systems where water is stagnated shall be regularly cleaned and disinfected or brought into use.
- 10.4 The procedures for cleaning and disinfection shall be as follows:
- (a) The system water shall be pre-chlorinated to achieve a measured residual of 5 mg/litre free chlorine, to minimise health risk to cleaning staff. Circulate water together with a biodegradable dispersant, to enhance the effectiveness of chlorination, for 6 hours, maintaining a minimum of 5 mg/litre free chlorine at all times. If the circuit pH value is greater than 8, the measured residual will need to be in the range of 15-20 mg/litre free chlorine in order to achieve the required disinfection level. An alternative procedure to provide a more effective use of chlorine is to introduce a heavy bleed-off for several hours to reduce the pH of the system and its chlorine content;
  - (b) The circuit shall be drained and the tower, sump, and distribution system manually cleaned. Accessible areas of the towers and its pack shall be adequately washed. Scale and other deposits that have not been removed shall be dissolved using chemical descalants, carefully chosen to avoid damage to the circuit/cooling tower. Cleaning methods which create excessive spray such as high pressure water jetting shall be avoided. If this is not possible, the cleaning shall be carried out when the building is unoccupied or in the case of permanently occupied buildings, windows and air inlets in the vicinity closed. Staff involved in water jetting shall be

adequately trained and wear suitable respiratory protective equipment set out in section 18.2;

- (c) The system shall be refilled with fresh water, and re-chlorinated to maintain a minimum level of 5 mg/litre free chlorine throughout the period of 6 hours. A biocidal dispersant shall be used to enhance the effectiveness of chlorination; and
- (d) The system shall be drained and flushed, refilled with fresh water and dosed with the appropriate start-up level of treatment chemicals, including biocides.

During the procedure, the cooling tower fans should be switched off.

## **11 Water treatment**

- 11.1 To control legionella bacteria, the water treatment regime shall prevent or adequately reduce the amounts of:
  - (a) scale and corrosion products which might protect legionella bacteria in the system;
  - (b) sediments which might prevent water treatment processes from working effectively; and
  - (c) other bacteria and microorganisms.
- 11.2 A complete automatic water treatment shall be installed for accurate dosing comprising:
  - (a) a metering pump; and
  - (b) a chemical dosage pot for feeding the chemicals.
- 11.3 Slime and algae growth shall be controlled with biocides. If there is a sudden bloom of slime and algae, an alkaline cleaner to remove and disperse the growth shall be applied, the system flushed, cleaned, and biocide redosed.
- 11.4 The control of silt deposit shall be achieved by a chemical treatment programme using dispersants or formulated chemicals.

- 11.5 The chemical used in the water treatment programme shall have no detrimental effect on non-metallic materials such as rubber or epoxy anti-corrosive lining which may be used in the piping system. It shall be compatible and neutral to the pipework materials.
- 11.6 No system shall be treated with any chemical or compound for which there is no test procedure.
- 11.7 All packaging, storage and handling of chemicals shall be in accordance to the manufacturer's recommendation.

A checklist for assessment of health risk of cooling towers is shown in Appendix C.

## **12 Biocide**

- 12.1 At least two (2) types of biocides shall be used alternately on a weekly basis to prevent emergence of resistant strains of microorganisms.
- 12.2 Before setting up a biocidal water treatment programme, it shall be ensured that the system is clean.
- 12.3 The 'shot/slug dose' method shall be implemented to prevent microbiological acclimatisation. This involves the addition of the biocides, alternating them at suitable intervals, directly into the cooling tower basin using an automatic control system.
- 12.4 The biocide used to eliminate and control the growth of legionella bacteria shall comply with the following:
  - (a) It shall not be a prohibited chemical in the Poisons Act Cap. 234 for trade effluent discharge to a public sewer;
  - (b) It shall be effective against a wide range of micro-organisms (including all legionella bacteria) at the recommended dilutions, and its effectiveness supported by official independent reports;
  - (c) It shall be manufactured by the supplier to an independent specification such as the British Standard 5750 or other approved equivalent standards;
  - (d) It shall already have been in widespread use for similar field application in the country of manufacture for no less than 3 years;

- (e) It shall be proven to be effective when dosed in accordance to the manufacturer's recommendations (frequency, dose strength, preparation);
- (f) It shall have documentation available covering the safety and effectiveness of the product in recirculating systems;
- (g) It shall not interfere with the method used for identification of legionella bacteria;
- (h) It shall be chemically and physically compatible with processed water and neutral to piping materials.

12.5 The chemicals used and the subsequent end-products of the treatment programme shall be degradable with minimal hazards to the environment in the event of accidental spillage or through draining into effluent treatment plants, meeting all the necessary requirements of the Ministry of the Environment under the Sewerage and Drainage (Trade Effluent) Regulations 1999.

### **13 Record keeping**

13.1 A formal record book for every cooling tower with accurate and adequate information shall be kept and be made available for inspections by officials from the Ministry of the Environment.

13.2 The record shall include:

- (a) a description of the cooling tower such as location, model and capacity;
- (b) the name of the person who ensures that proper records are kept;
- (c) the person or company who is responsible for the assessment of risk and implementing and managing precautionary measures;
- (d) the person or company carrying out the water treatment;
- (e) details of maintenance such as:
  - (i) date and result of visual inspection
  - (ii) date of cleaning and disinfection



- (iii) date of chemical treatment
- (iv) date of biocidal treatment
- (v) monitoring for
  - standard plate count (date sampled and result)
  - legionella bacteria count (date sampled and result)
- (vi) remedial work (if required) and date executed.

Each activity (i)-(vi) shall be authenticated by signature of the person who carried out the task.

13.3 Record books shall be kept for at least two (2) years after their last entry.

#### **14 Action plan for an outbreak**

14.1 If an outbreak of legionnaire's disease has occurred or is suspected to have occurred, it shall immediately be notified to:

Commissioner of Public Health  
c/o Quarantine & Epidemiology Department  
Ministry of the Environment  
40 Scotts Road  
Singapore 228231

14.2 In the event or on the suspicion of an outbreak of legionnaires' disease implicating a cooling tower, an investigating team from the Ministry of the Environment shall require the following under the Infectious Diseases Act Cap. 137:

- (a) a building plan showing the details of all the floors, and location of the cooling towers and fresh air inlets to the building;
- (b) the cooling tower circuit in a diagram form;
- (c) the cooling tower maintenance records; and
- (d) any other information required for the epidemiological investigation.

- 14.3 The implicated cooling tower shall not be drained or disinfected before water samples are taken by the team.
- 14.4 The following emergency procedure shall take place urgently:
- (a) cordon off the cooling tower;
  - (b) switch off fan of the cooling tower immediately;
  - (c) switch off circulation pump as soon as practical;
  - (d) discontinue the regular chemical treatment programme (corrosion inhibitor, scale inhibitor) and shut off the chemical feeders; and
  - (e) keep all personnel clear of the tower.
- 14.5 The investigating team shall require the immediate cleaning and disinfection of the implicated cooling tower, under the Environmental Public Health (Cooling Towers and Water Fountains) Regulations 2001, as follows:
- (a) add sodium hypochlorite to the system water to obtain a measured concentration of 50 mg/litre of free chlorine. Add a suitable biodispersant immediately or at the same time as sodium hypochlorite;
  - (b) circulate the system water with the fans off for a period of at least 6 hours, maintaining the free chlorine level at an absolute minimum of 20 mg/litre at all times;
  - (c) after 6 hours, dechlorinate and drain the system;
  - (d) undertake manual cleaning of the tower, sump and distribution system with cleaning staff wearing suitable protective equipment as set out in section 18.2;
  - (e) refill with fresh water, add sodium hypochlorite;
  - (f) recirculate without using fan, at 20 mg/litre of free chlorine for 6 hours;
  - (g) dechlorinate and drain the system;
  - (h) refill, recirculate, and take samples for testing; and

- (i) re-commission the system when test results show absence of legionella bacteria.

## **15 Water sampling and bacteriological monitoring**

15.1 A regular testing programme for legionella bacteria (including total bacteria count) shall be carried out to check the efficacy of the water treatment regime at the following intervals:

Standard plate count - At least once a month.

Legionella bacteria count - At least once in every three months.

15.2 The water sample shall be taken before the dosing of biocide. If disinfection is carried out, the water sample shall be taken no less than 3 days after disinfection to ensure effectiveness of the treatment.

15.3 The water sample shall be taken from the cooling tower pond. The systems must be operating, and water circulated through the system for at least one hour prior to collection of the sample.

15.4 The water sample shall not be collected:

(a) near a make-up water inlet; or

(b) with sediments that have been deliberately stirred up.

15.5 The samples shall be transported to the laboratory in a cooler with ice packs to maintain sample temperature of 6 to 18°C within the same working day.

15.6 The government laboratory or any laboratory conducting the tests shall have official approval from the Commissioner/accreditation from the Ministry of Health.

15.7 One water sample shall be taken from each cooling tower. A laboratory report shall be supplied for each cooling circuit.

15.8 The laboratory reports shall be submitted to:

Commissioner of Public Health  
c/o Environmental Health Department

Ministry of the Environment  
40 Scotts Road  
Singapore 228231

at the stipulated intervals set out in section 15.1. Each report shall be submitted together with information on the maintenance of the system set out in Appendix D for each cooling system.

- 15.9 The routine microbiological monitoring of cooling systems for legionella bacteria shall not be used to replace sound engineering practices combined with a regular maintenance and cleaning programme.

## **16 Enforcement action for legionella bacteria and standard plate count contamination**

- 16.1 The interpretation for various levels of legionella bacteria and standard plate count contamination and the action to be taken by the Ministry of the Environment under the Environmental Public Health (Cooling Towers and Water Fountains) Regulations 2001 against the building owner/management corporation shall be as follows:

**Table 1**

<b>Legionella bacteria count (cfu/millilitre)</b>	<b>Interpretation</b>	<b>Action</b>
(a) $\leq 10$	Maintenance practices may not be satisfactory	Advisory letter to rectify maintenance programme, monitor and follow-up.
(b) $>10 - <1000$	Potentially hazardous situation	Enforcement action will be taken under the Environmental Public Health (Cooling Towers and Water Fountains) Regulations 2001.
(c) $\geq 1000$	Serious condition	Order under Environmental Public Health (Cooling Towers and Water

Fountains) Regulations 2001 to shut down the system immediately, decontaminate, clean and disinfect, monitor and follow-up.

---

cfu = colony forming unit

**Table 2**

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<b>Standard plate count (cfu/millilitre)</b>	<b>Interpretation</b>	<b>Action</b>
(a) >100,000	Potentially hazardous situation	Enforcement action will be taken under the Environmental Public Health (Cooling Towers and Water Fountains) Regulations 2001.

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cfu = colony forming unit

- 16.2 The remedial measures for Table 1 (a) & (b) and Table 2 (a) above shall be carried out not later than 24 hours after receiving the information. If legionella bacteria are again detected, the procedures shall be repeated until the system is free from contamination.
- 16.3 In the event that the advisory or warning is not heeded and subsequent testing by the Ministry of the Environment shows that the legionella bacteria contamination has not improved or worsened, the system shall be shut down under the Environmental Public Health (Cooling Towers and Water Fountains) Regulations 2001.

**PART IV**  
**WORKER SAFETY**

**17 Training**

17.1 Persons carrying out maintenance and water treatment shall undergo in-house training to achieve an appropriate level of knowledge.

17.2 Training shall include:

- (a) operations of cooling systems;
- (b) principles of water treatment;
- (c) maintenance of records;
- (d) safety precautions; and
- (e) legislations.

## **18 Personal protection of workers**

- 18.1 All workers carrying out maintenance of cooling towers shall be informed of the risk of legionnaires' disease, and instructed on the proper use of personal protective equipment.
- 18.2 The minimum equipment needed to protect the worker from exposure to potential hazards according to the type of job shall be:

<b>Job</b>	<b>Potential hazard</b>	<b>Personal protective equipment</b>
Inspection	Aerosol	Half face respirator, capable of filtering smaller than 5µm particulates, ordinary work clothing.
Water treatment	Aerosol, chemical mist	Half face respirator as above, rubber or vinyl gloves, boots, goggles.
High pressure spraying	Aerosol	Half face respirator, waterproof overalls, rubber or vinyl gloves, boots, goggles or face shield.
Cleaning and chemical treatment with sodium hypochlorite solution 12%	Chemical mist	Full face respirator with canister, waterproof overalls, rubber or vinyl gloves and boots.

- 18.3 When chemical accidentally come in contact with skin, the affected area shall be immediately flushed with plenty of clean water.
- 18.4 Workers shall practise a high standard of personal hygiene. Adequate washing facilities shall be provided and made easily accessible.
- 18.5 Eating, drinking and smoking shall be prohibited during maintenance work.
- 18.6 Hands shall be washed and dried before eating, drinking or smoking.
- 18.7 Workers exposed to hazardous substances and engaged in processes listed in sections 10 and 11 shall undergo regular health surveillance with a medical practitioner.
- 18.8 In the event that the worker develops respiratory, cutaneous and other symptoms when exposed to hazardous chemicals, immediate medical attention shall be sought.



**APPENDIX A**

**REGISTRATION OF COOLING TOWERS**

1. Address of premises where cooling towers are installed: \_\_\_\_\_  
\_\_\_\_\_

2. Particulars of owner of premises/management corporation of the premises:  
Name: \_\_\_\_\_  
Residential/Business address: \_\_\_\_\_  
Telephone No.: (O) \_\_\_\_\_ (H) \_\_\_\_\_

3. Number of cooling towers at the premises: 

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4. Particulars of each cooling tower:	<u>Ref No.</u>	<u>Location</u>
	1	_____
	2	_____
	3	_____
	4	_____
	5	_____
	6	_____
	7	_____
	8	_____
	9	_____
	10	_____

(attach a separate sheet if more than 10 cooling towers)

Submitted by: Name: \_\_\_\_\_  
Address: \_\_\_\_\_  
Tel No.: \_\_\_\_\_ Date: \_\_\_\_\_

(an original copy shall be sent to: Commissioner of Public Health  
c/o Environmental Health Department  
Ministry of the Environment  
40 Scotts Road  
Singapore 228231)

**APPENDIX B**

**ALLOWABLE LIMITS FOR TRADE EFFLUENT DISCHARGE  
TO A PUBLIC SEWER**

(Sewerage and Drainage (Trade Effluent) Regulations 1999)

	<b>Allowable limits</b>
Temperature of discharge	45 <sup>o</sup> C
pH value	6-9
BOD (5 days at 20 <sup>o</sup> C)	400
COD	600
Total suspended solids	400 mg/L
Total dissolved solids	3,000 mg/L
Chloride (as chloride ion)	1,000 mg/L
Sulphate (as SO <sub>4</sub> )	1,000 mg/L
Sulphide (as sulphur)	1 mg/L
Cyanide (as CN)	2 mg/L
Detergents (linear alkylate sulphonate as methylene blue active substances)	30 mg/L
Grease and oil	60 mg/L
Arsenic	5 mg/L
Barium	10 mg/L
Tin	10 mg/L
Iron (as Fe)	50 mg/L
Beryllium	5 mg/L
Boron	5 mg/L
Manganese	10 mg/L
Phenolic compounds (expressed as phenols)	0.5 mg/L
*Cadmium	1 mg/L
*Chromium (trivalent and hexavalent)	5 mg/L
*Copper	5 mg/L
*Lead	5 mg/L
*Mercury	0.5 mg/L
*Nickel	10 mg/L
*Selenium	10 mg/L
*Silver	5 mg/L
*Zinc	10 mg/L
*Total metal	10 mg/L

*\* where two or more of the metals are present, the concentration in the trade effluent shall not exceed 10 mg/L.*

**APPENDIX C**

## CHECKLIST FOR ASSESSMENT OF HEALTH RISK OF COOLING TOWERS

(A separate form shall be used for each cooling tower)

Site address: .....

Reference number of cooling tower: .....

### **1 Registration**

1.1 Is the cooling tower registered with Ministry of the Environment? (YES)

### **2 Water supply and discharge**

2.1 Is the water supply from PUB or approved by Commissioner? (YES)

2.2 Is the effluent discharged into a public sewer? (YES)

### **3 Location**

3.1 Is the cooling tower located in a position:  
(a) that is near a fresh-air intake to an air-conditioning or ventilating system? (NO)

(b) that it is possible for wind to carry the sprays/aerosols into the windows of an adjacent building? (NO)

### **4 Record keeping**

4.1 Is there a record/logbook for inspection by Ministry of the Environment? (YES)

### **5 Cooling tower**

5.1 Are all parts of the cooling tower accessible for maintenance? (YES)

5.2 Is there an accessible sampling point at:  
(a) cooling tower pond? (YES)  
(b) bleeding point? (YES)

5.3 Is the pack:  
(a) made from natural materials e.g. wood? (NO)  
(b) clean/scale free/no slime? (YES)  
(c) easily cleaned and disinfected? (YES)

5.4 Are natural rubbers used as seals or caskets? (NO)

5.5 Is the aerosol creation low? (YES)

- 5.6 When the system is operating at full load, is there excessive drift from the cooling tower discharge? (NO)
- 5.7 Are there drift eliminators? (YES)  
Are they securely and firmly fitted? (YES)
- 6 Maintenance**
- 6.1 Is there a regular maintenance programme in operation? (YES)
- 6.2 Is the cooling tower and the entire distribution system cleaned and disinfected at least once every six months. (YES)
- 7 Water treatment**
- 7.1 Is there a water treatment programme to control:  
(a) scale? (YES)  
(b) slime? (YES)  
(c) corrosion? (YES)  
(d) sludge/algae? (YES)  
(e) microorganisms (including legionella bacteria)? (YES)
- 7.2 Are the following apparent within the cooling tower:  
(a) corrosion? (NO)  
(b) fouling? (NO)  
(c) debris, foam, sludge or slime? (NO)
- 7.3 Is the cooling water clear/clean, without silt/scum/foam? (YES)
- 8 Monitoring**
- 8.1 Is there a regular water treatment for monitoring? (YES)
- 8.2 Are standard plate counts high (>100,000 cfu/ml)? (NO)
- 8.3 Are legionella bacteria detected in the system (>10 cfu/ml)? (NO)
- 8.4 Are the results of bacteriological monitoring routinely conveyed to Ministry of the Environment? (YES)

( ) correct answer in bracket

Assessed by: Name: \_\_\_\_\_  
Address: \_\_\_\_\_  
Tel. No.: \_\_\_\_\_ Date: \_\_\_\_\_

## APPENDIX D

### A RECORD OF RESPONSIBILITIES AND ACTIVITIES TO CONTROL LEGIONELLA BACTERIA IN A SPECIFIED COOLING SYSTEM

1. Building: Name: \_\_\_\_\_  
Address: \_\_\_\_\_  
Ownership: Government/Statutory Board/Private\*

2. Building owner/manager: Name: \_\_\_\_\_  
Address: \_\_\_\_\_

3. Location/Ref. No. of cooling tower: \_\_\_\_\_

4. Maintenance contractor: Name: \_\_\_\_\_  
Address: \_\_\_\_\_

5. Water treatment specialist: Name: \_\_\_\_\_  
Address: \_\_\_\_\_

6. Previous cleaning and disinfection: Date: \_\_\_\_\_

7. Biocidal treatment for legionella:  
(a) Name of biocides: 1. \_\_\_\_\_  
2. \_\_\_\_\_  
(b) Schedule of treatment: Continuous/slug or shot\* dose method  
(c) If slug/shot dose method is used,  
date of previous treatment: Date: \_\_\_\_\_

8. Water sampling for legionella bacteria test: Date: \_\_\_\_\_

9. Laboratory report submitted by: Name: \_\_\_\_\_  
Company: \_\_\_\_\_  
Tel No.: \_\_\_\_\_ Date: \_\_\_\_\_

*\* delete where necessary*

## APPENDIX E

### REFERENCES

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## APPENDIX F

### GLOSSARY OF TERMS

Aerosol	A suspension in gaseous medium of solid particles, liquid particles or solid and liquid particles having negligible falling velocity.
Air-conditioning	A form of air treatment whereby temperature, humidity, ventilation and air cleanliness are all controlled within limits determined by the requirements of the air-conditioned enclosure.
Air intake	Any opening through which air is admitted to an air-handling system in a building.
Algae	Small, usually aquatic plants which require light to grow.
Biocide	A chemical capable of killing living microorganisms.
Bleed	Water deliberately removed from a cooling system to control the concentration factor of dissolved solids.
Clean	Visually free of sludge, slime, algae, fungi, rust, scale, dust, dirt and any foreign material.
Competent person	One who is adequately qualified and experienced to provide supervision for the operation and maintenance of cooling towers.
Cooling tower	Any device in which atmospheric air is passed through sprayed water in order to lower the temperature of the water by evaporative cooling.
Corrosion inhibitors	Chemicals designed to prevent or slow down the waterside corrosion of metals.
Deadleg	A length of pipe, normally closed at one end, or ending at a fitting.
Disinfection	Reduction of population of micro-organisms using chemical or physical means.
Dispersant	A chemical usually added with other treatment chemicals to loosen organic material adhering to surfaces and prevent accumulation of sludges.
Drift	The water aerosol which emerges from the airflow outlet of a cooling tower.



Drift eliminator	Equipment containing a complex system of baffles designed to remove water droplets from cooling tower air passing through it.
Filtration	The process of separating solids from a liquid by means of a filter media through which only the liquid passes.
Fouling	Organic growth or other deposits on heat transfer surfaces causing loss of efficiency.
Legionella	A genus of bacterium which is ubiquitous in aqueous environments and found in water systems in the built environment, including cooling systems that are not properly or regularly maintained. It comprises numerous species. <i>Legionella pneumophila</i> is the most common causative organism of legionnaires' disease.
Legionnaires' disease	A rare form of severe pneumonia caused by <i>Legionella pneumophila</i> . It affects principally older men, especially smokers or persons whose defences are already impaired by serious disease.
Make-up water	Fresh water added to circulating water to compensate for losses, by evaporation, bleed, drift or leakage.
Outbreak	Two or more cases of legionnaires' disease linked by time and place.
Premises	All non-domestic premises used for or in connection with trade, business or other undertaking.
Scale inhibitor	Chemical added to water to inhibit formation of scale.
Slime	A mucous-like material which is produced as part of an organism's metabolism and allows adherence of protective layer to surfaces.
Sludge	A general term for soft mud-like deposits on heat-transfer surfaces or other important sections of a cooling system.
Windage	Physical loss of water from the base of a cooling tower caused by wind of unusual pattern passing through it.