Code of Practice for Water-cooled Air Conditioning Systems

Part 2: Operation and Maintenance of Cooling Towers

2006 Edition

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CODE OF PRACTICE

FOR

WATER-COOLED AIR CONDITIONING SYSTEM

PART 2: OPERATION AND MAINTENANCE

OF COOLING TOWERS

2006 EDITION

Electrical and Mechanical Services Department
The Government of the Hong Kong Special Administrative Region

Foreword

This Code of Practice was prepared to promote the proper use of water-cooled air conditioning systems with guidelines for cooling tower design, installation, testing, commissioning, operation and maintenance in order to meet the energy efficiency objective with due consideration of the environment and health issues. It was developed by the Task Force on Code of Practice for Water-cooled Air Conditioning Systems and Ove Arup & Partners Hong Kong Ltd.

The Part 2 of this series of Code of Practice for Water-cooled Air Conditioning Systems provides details on the operation and maintenance of cooling towers. It shall be read in conjunction and made cross-reference with the followings:
Part 1 – Design, Installation and Commissioning of Cooling Towers
Part 3 – Water Treatment Methods for Cooling Towers

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List of Abbreviation

AS	Australian Standard
AP	Authorized Person
AMP	Aminotris [methylene phosphonic acid]
APCO	Air Pollution Control Ordinance
APHA	American Public Health Association
ARI	Air Conditioning and Refrigeration Institute
BCYE	Buffered charcoal yeast extract
BCDMH	bromo-3-chloro-5, 5-dimethylhydantoin
BO	Buildings Ordinance
BOD_5	5 days Biochemical oxygen demand
BS	British Standard
BTA	Benzotriazole
CFD	Computational Fluid Dynamic
CFU	Colony forming Unit
COD	Chemical Oxygen Demand
CoP	Code of Practice
CTSC	Cooling Tower Specialist Contractor
DBNPA	2,2-dibromo-3-nitrilopropionamide
DFA	Direct fluorescence antibody
DNA	Deoxyribonucleic acid
DSD	Drainage Services Department, HKSAR Government
EMSD	Electrical and Mechanical Services Department, HKSAR Government
EPD	Environmental Protection Department, HKSAR Government
FRP	Fibreglass Reinforced Polyester
HCC	Heterotrophic colony count
HEDP	(1-hydroxyethylidene) diphosphonic acid
HKPLDC	Prevention of Legionnaire's Disease Committee, Hong Kong
HKSAR	Hong Kong Special Administrative Region of the People's Republic of China
HOKLAS	Hong Kong Laboratory Accreditation Scheme
ISO	International Organization for Standardization
MBT	Methylene-(bis)thiocyanate
MoO_4	Molybdate

MSDS	Material safety data sheet
NCO	Noise Control Ordinance
NZS	New Zealand Standard
O&M	Operation and Maintenance
ORP	Oxidation Reduction Potential
OSHO	Occupational Safety and Health Ordinance
PBTC	2-Phosophonobutane-1,2,4-tricarboxylic acid
PCR	Polymerase chain reaction
PO_4	Phosphosphate
ppm	Parts per million
PVC	Polyvinyl Chloride
Quats	Quaternary ammonium salts
RPE	Registered Professional Engineer
SSO	Sewage Services Ordinance
T&C	Testing and Commissioning
TBC	Total Bacteria Count
TCCA	Trichloroisocy anuric acid
TDS	Total Dissolved Solid
TTA	Tolytriazole
TTPC	Tributyl tetradecyl phosphonium chloride
WACS	Water-cooled Air Conditioning Systems
WPCO	Water Pollution Control Ordinance
WSD	Water Supplies Department, HKSAR Government
WWO	Waterworks Ordinance
Zn	Zinc

Definitions:

Aerosol	:	A suspension in a gaseous medium of solid particles, liquid particles or solid and liquid particles having negligible falling velocity.
Algae	:	Multicellular plants found in water or moist ground, that contain chlorophyll but lack true stems, roots and leaves.
Area of public access	:	Sitting-out area, playground or places where people would gather together for activities.
Bacteria	:	A microscopic, unicellular (or more rarely multicellular) organism (singular: bacterium).
Biocide	:	A physical or chemical agent that kills bacteria and other microorganisms.
Biodispersant	:	A chemical compound added to the water inside cooling tower system, to penetrate and break down any biofilm that may be present on the wetted surfaces of the cooling tower system.
Biofilm	:	A surface layer of microorganisms. It is usually combined with particulate matter, scale and products of corrosion.
Bleed off (blowdown)	:	The removal of water from a cooling tower system to maintain the concentration of total dissolved solids and suspended solids in an acceptable level.
Commissioning	:	A systematic and progressive process of putting the components of a system into operation, calibrating instruments and controls, and then making adjustments and checks to ensure that the total system is providing satisfactory operation and performance.
Cooling tower	:	A device for lowering the temperature of water by evaporative cooling in which ambient air is in contact with falling water, thereby exchanging heat. The term also includes those devices that incorporate a water-refrigerant or water-water heat exchanger (evaporative condenser or closed-circuit cooling tower).
Cooling tower system	:	A heat exchange system comprising a heat-generating plant (chiller condenser or heat exchanger), a heat-rejection plant (cooling tower or evaporative condenser) and interconnecting water recirculating pipework and associated pumps, valves and controls. Cooling tower systems is considered as a part of WACS.

Corrosion coupon	:	Small strip of metal, usually placed into water circuits so that they can easily be removed, to enable the corrosion characteristics of the water to be assessed.
Corrosion inhibitor	:	Chemical which protects metals by: (a) passivating the metal by the promotion of a thin metal oxide film (anodic inhibitors); or (b) physically forming a thin barrier film by controlled deposition (cathodic inhibitors).
Corrosion resistant	:	Material that is not inherently susceptible to rapid corrosion under the conditions normally prevailing in the system.
Cycle of concentration	:	The ratio between the concentration of dissolved solids in the cooling water and the concentration of dissolved solids in the make-up water as a result of the evaporation that takes place in the cooling tower.
Dead leg	:	Water pipe with length equal to or larger than one diameter of the pipe, ending at a fitting through which water flows only when the fitting is opened. These extra areas of the cooling tower system contain stagnant water, which can cause building up of bacteria and sludge in recirculating system, and can then contaminate the system.
Decontamination	:	A process used when a cooling tower system is found with a level of bacterial count which involves a series of actions to disinfect, clean and re-disinfect the cooling tower system.
Disinfection	:	Preventive maintenance action of applying a treatment to a system, in conjunction with system cleaning, in order to reduce the general concentration of infectious agents.
Dispersant	:	Reagent usually added with other treatment chemicals to prevent accumulation of sludge.
Drift eliminator	:	A grid or grill-like arrangement of physical barriers located before the cooling tower exhaust designed to minimize the drift emanating from a tower.
Drift	:	Water lost from the cooling tower as liquid droplets or aerosols entrained in the exhaust air, excluding condensation.
Evaporative condenser	:	A heat exchanger in which refrigerant is cooled by a combination of air movement and water spraying.
Exhaust air outlet	:	A termination of a mechanical or natural ventilation system that allows air removed from a space and discharged outside the building. The exhaust air outlets, which are crucial in the consideration of separation distance with the cooling tower, are exhausts from kitchens, toilets, emergency generator

		(combustion gas), carpark ventilation, fume cupboard and refuse collection room, and any exhaust that contains contaminants or nutrients for microbial growth in cooling water.
Fan	:	A rotary machine which propels air continuously. This is used for moving air in a mechanical draft tower. The fan may be of induced draft or forced draft application.
Fill (packing)	:	Material placed within cooling tower to increase heat and mass transfer between the circulating water and the air flowing through the tower.
Filtration	:	The process of separating solids from a liquid by means of a porous substance through which only the liquid passes.
Fouling	:	Organic growth or other deposits on heat transfer surfaces causing loss in efficiency.
Heterotrophic colony count (HCC)	:	The number of viable units of bacteria per millilitre of water sample. It is also known as Total Bacteria Count (TBC), Total Plate Count or Viable Bacteria Count.
Legionnaires' disease	:	An illness characterized by pneumonia and caused by infection with legionella bacteria species, commonly Legionella pneumophila.
Legionella count	:	The number of Legionella colony-forming units (CFU's) found in one millilitre of the water sample.
Maintenance	:	Regular routine activity aimed at preserving the operational standard and cleanliness of equipment, which includes inspection, repair, preventive service and cleaning.
Maintenance programme	:	Assembly of relevant data and the setting out of a formal strategy and recording system for the effective management of a series of maintenance procedures.
Maintenance report	:	Written communication, giving details of the physical and operational state of a piece of equipment when maintenance is carried out, which shall be kept by the building owner or agent.
May	:	Indicates that a course of action is permissible and the existence of an option.
Medical and health facilities	:	Hospitals, general clinics, specialist clinics; community support facilities for the elderly, such as residential elderly homes, social centre for the elderly; and establishments providing health care and services for the sick and infirm.

Non-oxidising biocide	:	A non-oxidising biocide is one that functions by mechanisms other than oxidation, including interference with cell metabolism and structure.
Operable window	:	An operable window is a window that has moving parts, such as hinges, and can be opened. If a window is permanently locked or required special tools to be opened, that window would not be considered as an operable window when examining the separation distance.
Outdoor air intake	:	A termination of a mechanical or natural ventilation system that allows ambient air entering a building. The outdoor air intakes, which are crucial in the consideration of separation distance with the cooling tower, are fresh air intake for the air conditioning system of a building, and any air intake that draws outdoor air into the building.
Oxidising biocide	:	Agents capable of oxidizing organic matter, e.g. cell material enzymes or proteins which are associated with microbiological populations resulting in death of the micro-organisms.
Passivation	:	The formation of a protective film, visible or invisible, which controls corrosion.
Pedestrian thoroughfares	:	A heavily travelled passage for the public from one place to another.
Plume	:	The visible discharge of air and moisture from a cooling tower due to condensation. It is usually most visible in cool and humid days when water vapour emanates from the cooling tower exhaust.
Podium Roof	:	Roof of the lower part of a building.
Scale	:	A crystalline deposit that can form on surfaces or pipework within the cooling tower system due to build up of minerals (usually calcium carbonate)
Scale inhibitor	:	Chemicals used to control scale. They function by holding up the precipitation process and / or distorting the crystal shape, thus preventing the build-up of a hard adherent scale.
Shall	:	Indicates that the statement is mandatory.
Sludge	:	A build up of sediment that can be found in the basin or pipework of a cooling tower system.

Slug dosing / Shock dosing	:	The process of adding in a single dose a much higher amount of chemical biocide than is normally applied, with the intention of rapidly raising the concentration of biocide in the water to a level expected to kill most of the organisms in the water.
Spray nozzle	:	A device used in an open distribution system to break up the flow of the circulating water into droplets, and effect uniform spreading of the water over the wetted area of the tower.
Stagnant water	:	Pockets of motionless water within the cooling tower system that can allow microorganisms to grow.
Temporary shut-down	:	Cooling tower temporarily shut-down is the entire / part of the system not in function and isolated from the main water-cooled condenser / heat exchanger to avoid contamination. Standby unit(s) with cooling water running once a week is not defined as temporary shut-down.

1. Introduction

1.1 Scope

This Part of the Code of Practice specifies the minimum requirements and good practices for the operation and maintenance of cooling tower systems. This outlines both prescriptive and performance requirements to minimize the risk of using cooling towers, and to optimize the system operating performance. Emphasis has been put on the followings;

a) Maintaining the system in a good and uncontaminated condition;
b) Monitoring and controlling cooling water quality, including the presence of Legionella and heterotrophic bacteria;
c) Annual independent audit on operation and maintenance.

1.2 Objectives

This Part of the Code of Practice aims to provide guidelines and technical reference to every party involved in the operation and maintenance of cooling tower so as to achieve the following objectives:

a) Assure public health and safety by preventing any potential risks associated with water-cooled air conditioning system;
b) Achieve better / maintain energy efficiency and operational performance of water-cooled air conditioning system;
c) Minimize nuisances caused by water-cooled air conditioning system to the public;
d) Prevent pollution and mis-use of water;
e) Assure occupational safety and health of the staff concerned.

1.3 Applications

1.3.1

This Code of Practice is intended for use by building owners, cooling tower system owner, cooling tower services designers, building and services contractors, cooling tower specialist contractors, operation and maintenance staff, manufacturers and suppliers, etc, responsible for operation and maintenance of water-cooled air conditioning systems. It shall be applied to both the newly installed and existing systems.

1.3.2 This Code of Practice shall be read in conjunction with any additional recommendations provided by suppliers / manufacturers of the cooling tower system equipment as well as relevant ordinances and regulations in Hong Kong.

1.3.3 EMSD reserves the right to interpret the contents of this Code of Practice.

1.3.4 In case of conflict between the requirements of this Code of Practice and any other requirements, the following order of priority shall apply:

a) All currently in force Legislation and other Subsidiary Legislation.
b) The relevant Codes of Practice and Technical Standards.
c) This Code of Practice.

2. Operation of Cooling Tower Systems

2.1 General

2.1.1 A comprehensive operation programme for cooling tower system that applicable throughout the lifetime of the entire cooling tower system shall be developed and implemented by the Cooling Tower Specialist Contractor (CTSC). The operation programme shall include, but not limited to, the following actions:

a) System operation & performance monitoring;
b) Water treatment programme;
c) Continuous / intermittent bleed-off;
d) Regular inspection and checking;
e) Periodic physical cleaning;
f) Periodic chemical disinfection;
g) Routine water sampling and bacteria tests (Heterotrophic Colony Count (HCC) and Legionella bacteria count);
h) Water quality monitoring;
i) Emergency decontamination; and
j) Record keeping.

2.1.2 Recommended checklists are shown in Appendix 2A – 2C for reference.

2.2 Periodic running of Standby Unit(s)

Cooling tower system shall be kept in regular use whenever possible. When a system is used intermittently or installed as standby unit, it shall be run at least one hour per week. Systems with standby unit(s) shall have the cooling towers in operation on a rotational basis to avoid a unit to be left idle for a long period. Water treatment and water quality monitoring is required to ensure effective levels of corrosion and scale inhibitor and biocide are maintained at all times. This shall also be applied to standby unit(s) filled with cooling water.

2.3 Temporary Shut-down

2.3.1 If the system is intended to be out of use for more than a week, the system shall either be:

a) kept full of treated water which shall be checked (for biocide levels and water quality) and circulated once a week; or
b) fully drain off the system water and dry the system by mechanical fan, and then cover and shut off the inlet and outlet pipes leading to the cooling tower(s) to prevent water from entering the system.

2.3.2 For both cases, cooling tower temporarily shut-down shall be isolated from the main system to avoid contamination. Drain valve shall be opened at all times to prevent accumulation of water in basin in rainy days. Full re-commissioning including cleaning and disinfection shall be carried out before the system is brought into service again.

2.4 Bleed-off Control

2.4.1 Bleed-off shall be performed automatically. Automatic bleed-off can be controlled by conductivity sensor or timer controlled drain valves. Bleed-off immediately after dosing chemicals shall be avoided.

2.4.2 The minimum cycle of concentration shall not be less than 6 for fresh water and 2 for seawater cooling tower system.

2.5 Cooling Water Quality Management

2.5.1 General

The water treatment programme shall aim at controlling the fouling of cooling tower system due to corrosion, scale and microbial growth in order to maintain efficient heat and mass transfer, to ensure free flow of cooling water throughout the system, and to control the proliferation of bacteria in the system. Details of water treatment methods shall refer to the Code of Practice for Water-cooled Air Conditioning Systems– Part 3: Water Treatment Methods for Cooling Towers.

2.5.2 Cooling water treatment

2.5.2.1 Water treatment shall be maintained throughout the whole life cycle of cooling tower system even when some parts of the system are being temporarily shut-down. The chemical and material used in water treatment shall be environmentally acceptable and complied with the EPD's requirements.

2.5.2.2 The following strategies may be considered in developing an effective water treatment programme:

a) Use two different chemicals alternatively at periodic intervals;
b) Use combination of two compatible chemicals to provide better control against a range of micro-organisms;
c) Carry out occasional slug dosing to maintain the biocide concentration at a higher level.
d) Install side-stream / in-line water filtration system and other physical sludge removal equipment to remove large solid contaminants.

2.5.3 Cooling water quality monitoring

2.5.3.1 Regular monitoring of specific water quality parameters can provide an early signal before abnormal condition is detected, which also indicates a potential problem within the system. Heterotrophic colony count and Legionella bacteria count shall be carried out regularly. Monitoring of other water quality parameters are also recommended in a regular basis. Indicative fresh water and sea water quality criteria are provided in Table 2.1 and Table 2.2 respectively for reference only.

Parameters	Cooling Water Quality Criteria
Heterotrophic colony count	Less than 100,000 cfu/mL
Legionella bacteria count	Less than 10 cfu/mL
Conductivity	Less than1500 μS/cm
Total dissolved solids	Less than 1500 ppm
Suspended solids	Less than 180 ppm
Calcium hardness	Less than 500 ppm
pH	8 – 10
Total alkalinity	80 – 500 ppm
Oxidising biocide	Follow manufacturers' specifications
Inhibitor level	Follow manufacturers' specifications
Temperature	Optimal temperature for the system design and current operating conditions
Chloride as mg/L Cl	Less than 200 mg/L
Sulphate as mg/L SO_4	Less than 200 mg/L
Total iron as mg/L Fe	Less than 1.0 mg/L
Residual Cl	Less than 0.3 ppm
BOD_5 COD Metal ions	Refer to EPD's Technical Memorandum on Standards for Effluent Discharged into Drainage and Sewerage Systems, Inland and Costal Waters

Note: prohibited substance listed in EPD's Technical Memorandum on Standards for Effluent Discharged into Drainage and Sewerage Systems, Inland and Costal Waters cannot be discharged in foul sewer.

Table 2.1: Indicative cooling water quality table for fresh water type cooling tower

Parameters	Cooling Water Quality Criteria
Heterotrophic colony count	Less than 100,000 cfu/mL
Legionella bacteria count	Less than 10 cfu/mL
Total dissolved solids	Less than 100,000 ppm
Suspended solids	Less than 180 ppm
pH	8 – 10
Total alkalinity	200 – 350 ppm
Oxidising biocide	Follow manufacturers' specifications
Inhibitor level	Follow manufacturers' specifications
Temperature	Optimal temperature for the system design and current operating conditions
Chloride as mg/L Cl	Less than 70,000 mg/L
Total iron as mg/L Fe	Less than 1.0 mg/L
BOD_5 COD Metal ions	Refer to EPD's Technical Memorandum on Standards for Effluent Discharged into Drainage and Sewerage Systems, Inland and Costal Waters

Note: prohibited substance listed in EPD's Technical Memorandum on Standards for Effluent Discharged into Drainage and Sewerage Systems, Inland and Costal Waters cannot be discharged in foul sewer.

Table 2.2: Indicative cooling water quality table for sea water type cooling tower

2.5.3.2 Information shown in the above tables is the indicative ranges which may vary with specific cooling tower location and configuration. Also, the use of metallic corrosion coupons in water circuit can provide an effective index of the corrosive nature of the water. Recommended minimum monitoring frequency of different parameters to determine the cooling water quality can be referred to Appendix 2A.

2.5.4 Cooling water discharge

2.5.4.1 Quality of cooling water (bleed-off water) discharged from cooling tower systems shall comply with the requirements stipulated in the EPD's Technical Memorandum on Standards for Effluent Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters. It should be noted that the effluent discharge requirement may vary with the discharge flowrate.

2.5.4.2 In case that the cooling water (bleed-off water) is reused for flushing, the quality of flushing water shall be checked and closely monitored. Some water quality objectives for flushing supply at distribution are shown in Table 2.3 for reference. The bleed-off water shall be treated to achieve the stated water quality objectives for flushing supply at distribution when necessary.

Parameters	Water Quality Objectives
Suspended Solids (mg/L)	< 10
Dissolved Oxygen (mg/L)	> 2
5-day Biochemical Oxygen Demand (mg/L)	< 10

Table 2.3: Some Water quality objectives for flushing supply at distribution

2.6 Control of Bacterial Growth

2.6.1 Control Measures for Legionella

If Legionella is detected in the water samples collected from the cooling towers, the control strategies and procedures shown in Table 2.4 shall be taken by the CTSC immediately.

Legionella count (cfu/mL)	Indication	Required control strategy
Not detected (<10 cfu/mL)	System under control	(1) (a) Maintain quarterly monitoring. (b) Maintain water treatment programme.
Detected as ≥10 and <1,000 cfu/mL	Review programme	(2) (a) Investigate problem (b) Review water treatment programme (c) Take necessary remedial action including immediate on-line disinfection as described in section 3.3 and undertake control strategy (3)
		(3) Collect and test a water sample within 3 to 7 days after on-line disinfection (a) If not detected, collect and test another water sample. If 2 consecutive samples have no Legionella detected, repeat control strategy (1) (b) If detected at ≥10 and <100 cfu/mL repeat control strategy (2) (c) If detected at ≥100 and <1000 cfu/mL investigate problem and review water treatment programme, immediately carry out cleaning and disinfection again as described in section 3.4 and repeat control strategy (3) (d) If detected at ≥1,000 cfu/mL, immediately carry out cleaning and disinfection as described in section 3.4 and undertake control strategy (5)
Detected as ≥ 1,000 cfu/mL	Implement corrective action	(4) (a) Investigate problem (b) Review water treatment programme (c) Take necessary remedial action including immediate emergency decontamination as described in section 3.6 and undertake control strategy (5)

Legionella count (cfu/mL)	Indication	Required control strategy
		(5) Collect and test a water sample within 3 days after emergency decontamination (a) If not detected, collect and test another water sample. If 2 consecutive samples have no Legionella detected, repeat control strategy (1) (b) If detected at ≥10 and <100 cfu/mL, repeat control strategy (2) (c) If detected at ≥100 and <1,000 cfu/mL investigate problem and review water treatment programme, immediately carry out cleaning and disinfection again as described in section 3.4 and repeat control strategy (5) (d) If detected at ≥1,000 cfu/mL investigate problem and review water treatment programme, immediately carry out system emergency decontamination as described in section 3.6 and repeat control strategy (5)

Table 2.4: Control strategies for the presence of Legionellae

2.6.2 Testing Methods for Legionella

Common testing methods for Legionella bacteria detection are described in the following paragraphs:

a) Cultured samples

Water samples are cultured on special buffered charcoal yeast extract (BCYE) culture media. Selective isolation processes to eliminate other microbial overgrowth can determine the number of cfu of Legionella pneumophila per millilitre of water. Cultured samples can also be analyzed to identify specific serogroups. Testing procedures shall comply with AS/NZS 3896: 1998 – Water – Examination for Legionellae including Legionella pneumophila, BS 6068-4.12: 1998 / ISO 11731: 1998 Section 4.12: Detection and enumeration of Legionella or equivalent international standards.

Testing of the presence of Legionella shall be carried out by the laboratories accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) [website: http://www.itc.gov.hk/en/quality/hkas/hoklas/laboratory_no.htm] to ensure the accuracy.

b) Direct fluorescence antibody (DFA)

The number of organisms in a water sample can also be determined via direct fluorescence antibody (DFA) conjugate tests that stain the organism with a

fluorescent dye. This is a rapid test to identify Legionella such that the results can be obtained within one working day. However, this test is unable to distinguish between live and dead bacteria and may also have some cross-reactivity with other bacteria. There is a higher potential to obtain unreliable results, therefore, attentions shall be paid to interpret the test results. Therefore, this method can only be used as a preliminary test if immediate cooling water quality monitoring result is required.

2.6.3 Control Measures for Heterotrophic Micro-organisms

If the Heterotrophic Colony Count (HCC) result is found greater than or equal to 100,000 cfu/mL in any water sample collected from the cooling towers, a control strategy shall be immediately initiated in accordance to Table 2.5.

HCC Test result (cfu/mL)	Indication	Required control strategy
<100,000	System under control	(1) (a) Maintain monthly monitoring (b) Maintain water treatment programme
Detected as ≥ 100,000 and < 5,000,000	Review programme operation	(2) (a) Investigate problem (b) Review water treatment programme (c) Take necessary remedial action including immediate on-line disinfection as described in section 3.3 and undertake control strategy (3)
		(3) Collect and test a water sample within 3 to 7 days after on-line disinfection (a) If test result is <100,000 cfu/mL repeat control strategy (1) (b) If test result is ≥ 100,000 cfu/mL and < 5,000,000 cfu/mL, immediately carry out cleaning and disinfection again as described in section 3.4 and undertake control strategy (2) (c) If test result is ≥ 5,000,000 cfu/mL, immediately carry out cleaning and disinfection as described in section 3.4 and undertake control strategy (5)
Detected as ≥ 5,000,000	Implement corrective action	(4) (a) Investigate problem (b) Review water treatment programme (c) Take necessary remedial action including immediate emergency decontamination as described in section 3.6 and undertake control strategy (5)

HCC Test result (cfu/mL)	Indication	Required control strategy
		(5) Collect and test a water sample within 3 to 7 days after emergency decontamination (a) If test result is <100,000 cfu/mL repeat control strategy (1) (b) If test result is ≥ 100,000 cfu/mL and < 5,000,000 cfu/mL immediately carry out cleaning and disinfection again as described in section 3.4 and undertake control strategy (4) (c) If test result is ≥ 5,000,000 cfu/mL investigate problem and review water treatment programme, immediately carry out emergency decontamination again as described in section 3.6 and repeat control strategy (5)

Table 2.5: Control strategies for the presence of heterotrophic microorganisms

2.6.4 Testing Methods of Heterotrophic Colony Count

Testing of Heterotrophic Colony Count shall be conducted by the laboratories accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS). This test method only measures a limited range of aerobic bacteria that can grow on a general purpose nutrient agar at the selected incubation temperature and shall be carried out in accordance with AS 4276.3.1: 1995 – Water microbiology Method 3.1: Heterotrophic colony count methods – Pour plate method using plate count agar (35°C/37°C method), the American Public Health Association (APHA) Standard Method 9215B: 1998 – pour plate method for water and wastewater, or other international standards.

2.7 Water Sampling

2.7.1 Sampling frequency

2.7.1.1 Regular water sampling, including testing for Legionella and heterotrophic colony count, is important to monitor the water treatment effectiveness and cooling tower system operating performance. Water sampling for Legionella bacteria count and heterotrophic colony count in fresh water cooling tower shall be carried out at least every three months and every one month, respectively. Monitoring of other parameters is recommended to provide a full picture on the water quality. Monitoring frequency of those parameters can be referred to Appendix 2A.

2.7.1.2 Cooling tower systems installed at premises of which Risk Management Plan is required to be submitted shall be monitored more closely. Water sampling for

cooling tower systems installed in these locations shall be carried out at least once a month for both Legionella test and heterotrophic colony count.

2.7.2 Sampling Point

Water sampling point shall be well away from the chemical dosing point, water inlet and bleed off position. It is preferable to collect water samples just before the warmed water enters the cooling towers, tower basin or water falling from the fill. Sampling tap and hose, if provided, shall be run for at least 30 seconds with cooling water discharged to the drainage system prior to sampling. Since the sampling tap and hose can create a potential dead leg, the tap shall be flushed at least once a month.

2.7.3 Water sample storage and delivery

Water sample shall be taken in containers as described in AS 2031 : 2001, BS 7592: 1992 or equivalent in terms of the selection of suitable sampling container and preservation of the sample for later testing. Water samples for laboratory tests shall be collected by trained personnel appointed by the laboratory or cooling tower specialist contractor in order to ensure no contamination throughout the process from water sample collection to laboratory test. The samples shall be stored at temperature between 2°C and 10°C and kept in dark environment prior to analysis. Samples shall not be frozen. Analysis shall be commenced within 24 hours of the sample taken.

3. Maintenance of Cooling Tower Systems

3.1 Routine Inspection

Cooling tower systems shall be inspected regularly. Inspection shall include all mechanical equipment, water tanks and water treatment facilities. Water in cooling tower basin shall be checked for clarity, odour, surface debris and temperature. Cleanliness of every component in cooling towers, including fan, fill, drift eliminator, water distribution and nozzle, basin, etc, shall be ensured. Recommended checklist and frequency for routine inspection of cooling tower system is shown in Appendix 2B for reference.

3.2 Routine and Preventive Maintenance

3.2.1 General

Routine maintenance is required to ensure cooling tower system operating in a good condition. Integrity and physical conditions of all components, including ladders, rails and platforms, etc. must be inspected as well as regularly maintained to prevent breakage or failure. Purging of dead leg shall be carried out regularly to prevent stagnant water and dirt accumulation. Recommended routine and preventive maintenance checklist is described in Appendix 2C for reference.

3.2.2 Drift eliminator and fill

Drift eliminator and fill require particular maintenance to avoid excessive drift loss and to maintain nominal thermal performance. Cleaning and maintenance for drift eliminator and fill are to ensure them free from biofouling, corrosion, scale and other deposits. Good workmanship and subsequent inspection are required to fix the drift eliminator and fill in the correct position without air bypass. Replacement is required if drift eliminator and fill are found to be deformed, which may result in adverse impact on drift loss control and thermal performance.

3.3 On-line Disinfection

3.3.1

On-line disinfection shall be carried out when:

a) Legionella count is detected as ≥ 10 cfu/mL and < 1,000 cfu/mL; or
b) HCC test result is ≥100,000 cfu/mL and < 5,000,000 cfu/mL.

3.3.2 On-line disinfection procedure for cooling tower systems are as follows:

a) Add biodispersant and circulate through the cooling tower system prior to on-line disinfection (dosage as recommended by the Cooling Tower Specialist Contractor).
b) Dose a biocide of different chemical composition, or similar composition at a higher concentration, to the cooling tower system in addition to that of the regular water treatment programme.
c) Circulate the biocide through the cooling tower systems for the time specified by the biocide manufacturer.
d) Return the system to normal operation.

3.4 Cleaning and Disinfection

3.4.1 Cooling tower systems shall be regularly cleaned, desludged and disinfected at least every 6 months.

3.4.2 Cleaning and disinfection shall be carried out immediately when:

a) Legionella count is still detected as ≥ 100 cfu/mL and < 1,000 cfu/mL after on-line disinfection;
b) HCC test result is still ≥ 500,000 cfu/mL and < 5,000,000 cfu/mL after on-line disinfection;
c) Cooling tower system is contaminated, which causes adverse influence to cooling water quality and cooling tower thermal performance;
d) Cooling tower system has been shut down for more than a week;
e) Cooling tower system has been mechanically altered or disrupted in a manner which may lead to contamination;
f) Cooling tower system has been infected or may have been infected by an adjacent cooling tower which has been suspected as a source of a case of Legionnaires' disease.

3.4.3 Cleaning and disinfection of cooling tower system shall be carried out by competent person with sufficient training. Water treatment programme shall be reinstated before the systems are brought into service again. The cleaning and disinfection procedures shall be as follows:

a) Circulate biodispersant throughout the system before disinfection (dosage as recommended by the Cooling Tower Specialist Contractor).

b) Chlorinate the water and circulate for 4 hours, maintaining a minimum level of free residual chlorine at 5 mg/L (ppm) through the entire water-cooled air conditioning system water circuit.

c) If pH value is greater than 8.0, higher free chlorine level of 15 – 20 mg/L (ppm) is required to achieve the disinfection performance.

d) Drain the entire water circuit, including the make-up tank.

e) Manually clean the cooling tower, sump, fill, drift eliminator, make-up tank and water recirculation circuit. Accessible areas of the cooling towers and its fill shall be adequately washed. If cleaning method involves high pressure water spraying, windows in the vicinity shall be closed, air inlets blanked off and the working area to be tented. The working area shall be isolated to avoid nuisance to the neighbourhood.

f) Refill with water, rechlorinate and recirculate for at least 6 hours, maintaining a minimum level of free residual chlorine at 5 mg/L (ppm).

g) Drain and flush the system. Refill with water and dose with the appropriate start-up level of treatment chemicals.

h) Re-commission the system.

3.5 Treatment of Cleaning Water

Before water containing high residual free chlorine is discharged to drain, it shall be de-chlorinated. The usual procedure is to add sodium thiosulphate, sodium sulphite or sodium bisulphate as a neutralizer. The level of residual free chlorine can be determined by testing and the quantity of sodium salt can then be calculated.

3.6 Emergency Decontamination

3.6.1

Under the following circumstances, emergency decontamination of water-cooled air conditioning system shall be carried out.

a) If Legionella bacteria is detected to be 1,000 cfu/mL or more; or

b) If heterotrophic colony count is detected to be 5,000,000 cfu/mL or more; or

c) If on-line disinfection, as well as, cleaning and disinfection are not effective in controlling legionella and heterotrophic colony count in cooling tower water.

3.6.2

The procedures for emergency decontamination of water-cooled air conditioning system are as follows:

a) Take water samples for laboratory investigation before any further action.
b) Prohibit entering the vicinity of cooling tower(s).
c) Circulate biodispersant throughout the system before disinfection (dosage as recommended by the cooling tower system services providers).
d) Add sodium hypochlorite to the system water to obtain a measured concentration of 50mg/L (ppm) of free chlorine at pH 7.0-7.6.
e) Circulate the system water with the fans off for a period of at least 6 hours.
f) Maintain the free chlorine level at an absolute minimum of 20 mg/L (ppm) at all times.
g) After 6 hours, de-chlorinate and drain the system.
h) Clean thoroughly the basin, fill, drift eliminator, fan and water distribution system.
i) Refill with fresh water and add sodium hypochlorite.
j) Recirculate without using the fan, at 20mg/L (ppm) of free available chlorine for 6 hours.
k) De-chlorinate and drain the system.
l) Refill, recirculate and take water samples for testing.
m) Re-commission system when Legionella and HCC levels are detected within acceptable range.

3.7 Occupational Safety and Health

3.7.1 Sufficient personal protective equipment shall be provided to the personnel responsible to carry out inspection and maintenance work of a cooling tower system. Recommended list of personal protective equipment required related to different job nature is shown in Appendix 2D.

3.7.2 Training in safe work procedure, including the use and maintenance of protective equipment shall be provided to the personnel carrying out cooling tower system commissioning.

3.7.3 Water treatment may involve the application of relatively aggressive and toxic chemicals in an environment, which is difficult to control. Safety of plant and personnel is the major concern. All personnel involved must be fully conversant with the safe handling of the products, which form part of the water treatment regime. Water treatment chemicals shall be handled with care according to the manufacturer's instructions.

3.7.4 Material safety data sheet (MSDS) and relevant recognized data sheet for the chemicals used in water treatment process shall be provided by water treatment services providers and included in the operation and maintenance manual. MSDS and relevant warning / safety label shall be provided on the surface of water treatment chemical bucket. The MSDS and labels shall be properly protected against water and chemical damage.

3.7.5 Workers shall practice with a high standard of personal hygiene. Adequate washing facilities shall be provided and made easily accessible.

3.7.6 Water treatment programme for a cooling tower system shall be established by a competent service provider and complied with the requirements specified in the CoP.

3.7.7 Eye wash bottles or washing basin with fresh water tap shall be provided adjacent to water treatment chemicals tanks or any appropriate location for emergency use. However, the water contained in the eye wash bottle shall be replaced periodically

3.7.8 Water treatment chemical shall be stored at an appropriate location to facilitate chemical handling. Mechanical / natural ventilation shall be provided to the room entirely / partially used for water treatment chemical storage.

3.7.9 Electrical fittings and luminaries serving water treatment chemical storage area shall be weather-proof and corrosion resistant type.

3.7.10 Warning signs shall be erected to alert for operation and maintenance personnel of the potential hazard caused by cooling tower; and to restrict the unauthorised access to cooling towers.

3.7.11 Workers exposed to hazardous substances and engaged in processes of cleaning and disinfection and water treatment shall undergo regular health surveillance with a medical practitioner. In the event that the worker develops respiratory, cutaneous and other symptoms when exposed to hazardous chemicals, immediate medical attention shall be sought.

4. Management of Cooling Tower Systems

4.1 Operation and Maintenance Manuals

The operation and maintenance (O&M) manual of the cooling tower system shall be prepared by the cooling tower specialist contractor and kept by the cooling tower system owner. The O&M manual shall at least consist of the followings:

a) Technical details of all equipment in a cooling tower system, including drawings of the plant, equipment and systems;
b) System schematic and layout plan showing the locations of cooling towers and the nearby openings in the building and the adjacent buildings;
c) Manufacturers' recommendations on operation and maintenance of all equipment in the cooling tower system;
d) A programme for routine chemical treatment, cleaning, desludging and disinfection of the cooling tower;
e) Details of chemicals used for water treatment;
f) Recommended cleaning methods and dismantling instructions;
g) Start-up, operating and shut-down procedures; and
h) Procedure for emergency operation.

4.2 Water Quality and O&M Records

4.2.1 Log books to record system operation, routine inspection, water sampling results and maintenance activities shall be kept properly by the operation personnel. Details of log books shall include at least the following information:

a) Date and result of visual inspection;
b) Date and result of water sampling;
c) Date of cleaning, desludging and disinfection;
d) Date of chemical treatment with details on the treatment carried out;
e) Method of bleed-off and details of the automatic bleed-off controls;
f) Date, item of plant, equipment or system and nature of service (routine, preventive and emergency maintenance) being performed;
g) Details of defects found and rectification procedure undertaken; and
h) The name of the person and company performing the service.

4.2.2 A sample operation and maintenance record form is enclosed in Appendix 2E for proper minimum records of routine operation, inspection, water sampling and

maintenance of water-cooled air conditioning systems.

4.2.3 Operation and maintenance manuals and records shall be kept by authorized personnel and readily available for inspection upon request. The operation and maintenance records shall be kept for at least 2 years. Defects identified in any reports shall notify the plant owner / occupier, manager or their nominated representative immediately.

4.2.4 Any information change related to the cooling tower installation, including the ownership and system components, shall be reported to EMSD. Records as listed in section 4.2 shall also be available for inspection by EMSD upon request.

4.3 Independent Operation and Maintenance Audits

4.3.1 Auditor's responsibilities

Annual independent audits of operation and maintenance records of cooling tower systems shall be carried out by an independent and competent auditor. The auditor can be employed by the building / water-cooled air conditioning system owner, or the property management companies; but shall not be employed by the Cooling Tower Specialist Contractor. Re-inspection and / or follow up action may sometimes be required if improvement work or remedial action is suggested to the system owner after the audit. Apart from document checking, auditors are responsible to carry out the following tasks:

a) Inspection on the validity of O&M manual, up-to-date water quality records, maintenance report and log book;
b) Visual inspection of cooling tower system operating conditions;
c) Risk and operational problem identification;
d) Recommendation on remedial actions required;
e) Preparation of audit report;
f) Report and explain the conditions of the system to the system owner; and
g) Submit annual audit report to EMSD.

4.3.2 Audit report

After the auditing process, auditor shall submit a signed formal annual audit report to the system owner and EMSD after the completion of the auditing process. Emphasis shall be put on whether the scheduled operation and maintenance work have been properly carried out in the past year and the appropriate actions have been taken in case of poor water quality. Improvement works and remedial

actions required shall also be highlighted in the report. Audit report shall consist of at least the following items (a sample audit report is attached as Appendix 2F for reference). Figure 2.1 illustrates the flow chart for audit process and shows the relationship between cooling tower specialist contractor and auditor in the audit process.

a) Details of the cooling tower (location, types, quantity);
b) Details of the Cooling Tower Specialist Contractor and the water treatment service provider (company's names, and contact details);
c) Availability of updated documents for the installation, completed inspection and maintenance checklists, records and logbook in the past 1 year;
d) Availability of proper record keeping of O&M manual, T&C records and drawing;
e) Risks and problems identified associated to the cooling tower system;
f) Recommended remedial actions required; and
g) Progress of the remedial works suggested in previous year.

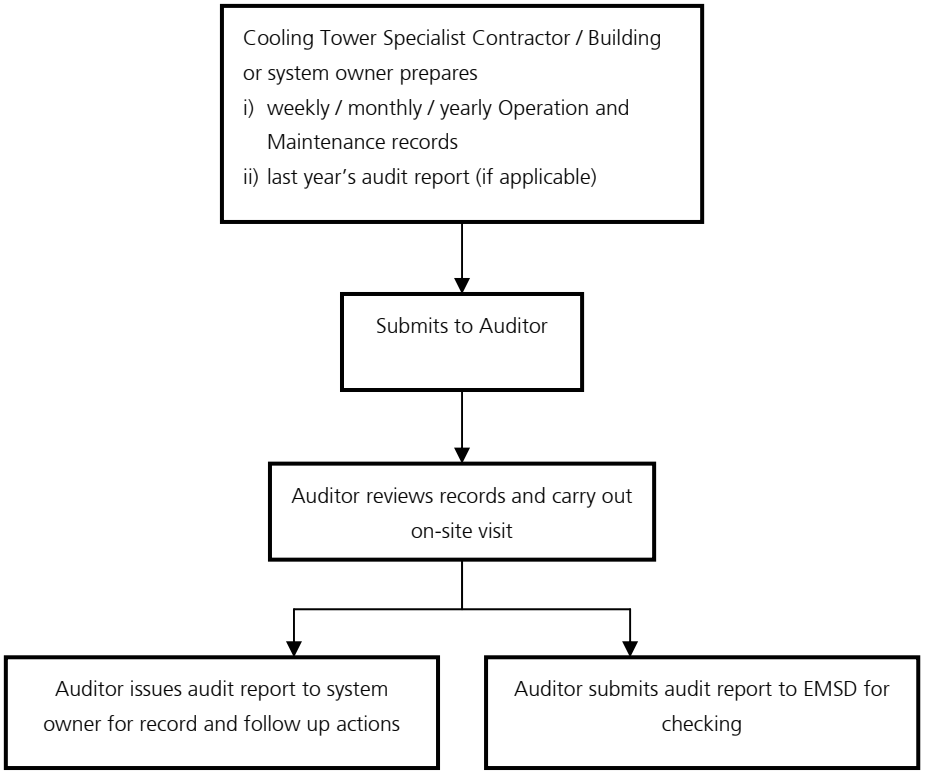

Figure 2.1: Flow chart for audit process

4.3.3 Qualification of Auditor

The Auditor should have relevant operation and maintenance experience on cooling tower systems and possess either one of the following qualifications:

a) Registered Professional Engineer in Building Services or Mechanical discipline, or

b) Higher Certificate or above in building services or mechanical engineering, plus at least five years of operation and maintenance experience on cooling tower systems.

4.3.4 Notification of Non-compliance

When the operation and maintenance audit reveals non-compliance results, the cooling tower specialist contractors and the building or system owners shall be informed immediately. Remedial action taken to improve cooling tower system water quality shall be recorded.

5. Decommissioning of Cooling Tower System

5.1 Where an existing cooling tower system is no longer required for operation, the following actions shall be taken to decommission the installation:

a) Drain the water of the cooling tower system to sewer, in accordance with any advice from the Environmental Protection Department, Drainage Services Department and Electrical and Mechanical Services Department;
b) Remove chemical dosing tanks;
c) Disconnect power supply to the systems;
d) Disconnect water supply to the systems;
e) Remove the tower and preferably the other components of the systems;
f) Deliver the dismantled components (if recyclable) to material recycling plant.

5.2 In case it is not practical to demolish the system immediately in the decommissioning period, the system shall be kept dry and signage shall be erected on the cooling tower indicating that the system must not be re-activated. The sump of the tower shall be dismantled in order not to allow rainwater accumulated in the tower. EMSD should be notified that the water-cooled air conditioning system has been decommissioned.

5.3 Building owner shall be responsible to demolish the abandoned cooling tower system if the owner of the cooling tower system cannot be contacted.

6. Reference Information

6.1 The following Ordinances, Technical Memorandum and Code of Practice shall be compiled with in the operation and maintenance of cooling towers:

- Waterworks Ordinance (WWO) (Cap. 102)
- Buildings Ordinance (BO) (Cap. 123)
- Sewage Services Ordinance (SSO) (Cap. 463)
- Water Pollution Control Ordinance (WPCO) (Cap. 358)
- Air Pollution Control Ordinance (APCO) (Cap. 311)
- Noise Control Ordinance (NCO) (Cap. 400)
- Occupational Safety and Health Ordinance (OSHO) (Cap. 509)
- Technical Memorandum on Standards for Effluent Discharged into Drainage and Sewerage System, Inland and Coastal Waters, EPD
- Technical Memorandum for the Assessment of Noise from Places other than Domestic Premises, Public Places or Construction Sites, EPD
- Pilot Scheme for Wider Use of Fresh Water in Evaporative Cooling Towers for Energy-efficient Air Conditioning Systems, EMSD
- Code of Practice for the Prevention of Legionnaires' Disease 2000, HKPLDC

Appendix 2A

Recommended Minimum Monitoring Frequency for Different Water Quality Parameters for Cooling Tower System

Parameters	Minimum Monitoring Frequency	
	Cooling water	Makeup water
Conductivity	Monthly	Quarterly
Suspended solids	Monthly	Quarterly
Calcium hardness	Monthly	Quarterly
pH	Monthly	Quarterly
Total alkalinity	Quarterly	Quarterly
Oxidising biocide	Monthly	N/A
Inhibitor level	Monthly	N/A
Temperature	Monthly	N/A
Chloride as mg/L Cl	Quarterly	Quarterly
Sulphate as mg/L SO_4	Quarterly	Quarterly
Total iron as mg/l Fe	Quarterly	Quarterly
Residual Cl / ORP	Monthly	N/A
BOD_5	Monthly	N/A
COD	Monthly	N/A
Heterotrophic colony count	Monthly	Quarterly
Legionella	Quarterly *	N/A*

* Remarks: Cooling tower systems installed at premises of which Risk Management Plan is required to be submitted shall be monitored more closely. Water sampling for cooling tower systems installed in these locations shall be carried out at least once a month for both Legionella test and heterotrophic colony count. Also, if Legionella or heterotrophic colony count is found to be greater than the specified requirement under routine sampling, more frequent samples is required to form part of the system operation programme.

Note: The above checklists are for reference only. The owners / operators of the cooling tower systems shall develop their own water quality monitoring schedules to suit their systems.

Appendix 2B

Recommended Routine Inspection Checklist for Cooling Tower System

	Procedures	Inspection Frequency
1.	Check condenser water pumps	Weekly
2.	Check cooling water quality	Monthly
3.	Check internal surfaces of cooling tower / evaporative condenser for scale, rust, sludge and biofilm accumulation	Monthly
4.	Check cooling water for clarity, odour, surface debris and temperature.	Weekly
5.	Check strainers	Weekly
6.	Check drains	Weekly
7.	Check float valves	Weekly
8.	Check water treatment dosing equipment, and conductivity sensors	Weekly
9.	Check water treatment chemicals for adequacy and safety	Weekly
10.	Check condition / cleanliness of fill pack / tubes	Monthly
11.	Check condition / cleanliness of drift eliminators	Monthly
12.	Check condition / cleanliness of distribution troughs / spray headers and nozzles	Monthly
13.	Check fans, drives and gearbox	Weekly
14.	Check water level of basin	Weekly
15.	Check bleed-off valve	Weekly
16.	Check for system leakage and overflow from cooling tower	Monthly
17.	Check air inlets and fan screens	Weekly

Note: The above checklists are for reference only. The owners / operators of the cooling tower systems shall develop their own inspection checklist to suit their systems.

Appendix 2C

Recommended Routine and Preventive Maintenance Checklist for Cooling Tower System

	Checklists	Maintenance Frequency
1.	Tighten all fasteners	Every 6 months
2.	Clean strainers	Monthly
3.	Clean water basin and all internal surfaces of cooling towers	Every 6 months
4.	Adjust and lubricate pumps and pump motors	Quarterly
5.	Adjust and lubricate fans and fan motors	Quarterly
6.	Remove drift eliminators and fills for cleaning	Every 6 months
7.	Adjust and lubricate valves	Quarterly
8.	Clean water distribution pipework, including nozzles	Quarterly
9.	Remove end cap in each header for cleaning	Every 6 months

Note: The above checklists are for reference only. The owners / operators of the cooling tower systems shall develop their own routine and preventive maintenance checklist for their systems.

Appendix 2D

Recommended List of Personal Protective Equipment

Job	Potential Hazard	Respirator and Clothing
Testing and commissioning	Aerosol	Half face piece, capable of filtering smaller than 5μm particulates, ordinary work clothing
Inspection	Aerosol	Half face piece, capable of filtering smaller than 5μm particulates, ordinary work clothing
Water Sampling	Aerosol	Half face piece, capable of filtering smaller than 5μm particulates, ordinary work clothing
High pressure spraying	Aerosol	Respirator as above, waterproof overalls, gloves, boots, goggles or face shield
Chemical treatment with sodium hypo-chlorite solution in ventilated space	Spray mist and very low concentration chlorine	Half face piece, acid gas and particulate respirator, goggles or face shield, overalls, gloves, and boots
As above, confined space	Unknown chlorine concentration, high mist, possible lack of oxygen	To comply with the requirement under The Factories and Industrial Undertakings (Confined Spaces) Regulation

Appendix 2E

Sample Operation and Maintenance Records for Cooling Tower System

For the period: _____

A. System Description

Record	Details
Building Name & Building Address	
Cooling tower type	
Number of cooling tower in system	
Heat rejection capacities of the cooling towers	
Building owner's name / contact details*	
Cooling tower owner's name and contact details*	
Cooling tower system operation team details*	
Water treatment services provider's name and contact details*	
Water sampling / laboratory contractor's name and contact details*	

* To include company name, contact person's business and after hours telephone numbers

B. *Weekly / Monthly Records for the month ( ) of year ( )*

	Procedures	Date of Action				
		Week 1	Week 2	Week 3	Week 4	Monthly
1.	Check cleanliness, organic fouling and physical debris					
2.	Inspect for slime and algal growth					
3.	Inspect for deterioration of materials, damage to components, blockages and corrosion					
4.	Inspect for correct operation of fans, motors and pumps					
5.	Inspect water leaks from seams					
6.	Inspect misshaped exterior or collapsed internal supports					
7.	Inspect supporting framework					
8.	Inspect fill and drift eliminator					
9.	Check condition and operation of ball valve					
10.	Check fan thermostat (if equipped)					
11.	Check sprays and distribution deck					
12.	Check bleed-off rate					

C. *Quarterly / 6-monthly / Yearly Records for the year ( )*

	Procedures	Date of Action			
		Quarter 1	Quarter 2	Quarter 3	Quarter 4
1.	Lubricate fan and pump bearings / gearbox				
2.	Drain basin and clean distribution deck, fill and drift eliminator				
3.	Check security of all bolts and fittings				
4.	Clean fan blades				
5.	Clean all components as required				
6.					

D. *Monthly Water Sample Bacterial Test Records for the year ( )*

Bacteria Test		Testing Laboratory	Date of Test	Test Results (cfu/mL)	Action
Heterotrophic colony count	Month 1				
	Month 2				
	Month 3				
	Month 4				
	Month 5				
	Month 6				
	Month 7				
	Month 8				
	Month 9				
	Month 10				
	Month 11				
	Month 12				
Legionella	Month 1				
	Month 2				
	Month 3				
	Month 4				
	Month 5				
	Month 6				
	Month 7				
	Month 8				
	Month 9				
	Month 10				
	Month 11				
	Month 12				

Note: The above formats are for reference only. The owners / operators of the cooling tower systems shall develop their own formats for their systems.

Appendix 2F

Sample Independent Audit Report for Cooling Tower System

A. System Description

Record	Details
Building Name and Building Address	
Cooling tower type	
Number of cooling tower in system	
Heat rejection capacities of the cooling towers	
Building owner's name / contact details	
WACS owner's name and contact details	
Cooling tower system designer's name and contact details	
Cooling tower system specialist contractor's name and contact details	
Water treatment services provider's name and contact details	

* To include company name, contact person's business and after hours telephone numbers

B. Documents Checking

Documents	Records available		Recommendation
	Yes	No	
Operation & maintenance manual			
Testing & commissioning records			
System schematic and layout drawings			
Routine inspection records			
Routine maintenance records			
Routine cleaning and disinfection records			
Monthly heterotrophic colony count (HCC) results			
Monthly / Quarterly* Legionella bacteria count results			
Routine water quality monitoring records (if available)			

* Delete as appropriate

C. Visual Inspection

Items	Acceptable		Recommendation
	Yes	No	
General cleanliness of cooling tower system			
Integrity of cooling tower			
Operation condition of cooling tower and pumps			
Operation condition of water treatment equipment			
Cleanliness of plant area			
Drift loss control			

D. Risk Identification

	Assessment of Cooling Tower System	Recommendation / remedial action required
System alternation	Any system addition, alternation and improvement work carried out in the previous year? ☐ Yes ☐ No	
	If yes, has operation and maintenance programme been reviewed? ☐ Yes ☐ No	
External environment	Is there any newly occupied building regarded as high risk designation located in vicinity to the system? ☐ Yes ☐ No	
	If yes, has operation and maintenance programme been reviewed? ☐ Yes ☐ No	
	Is there any construction site found nearby? ☐ Yes ☐ No	

	Assessment of Cooling Tower System	Recommendation / remedial action required
	If yes, has operation and maintenance programme been reviewed? ☐ Yes ☐ No	
	Is the separation between the designed cooling tower(s) and the nearest opening(s) maintained to be at least 5m (measured from cooling tower intake) and 7.5m (measured from cooling tower exhaust)? ☐ Yes ☐ No	
System performance	Has fouling of cooling tower system occurred in the previous year? ☐ Yes ☐ No	
	If yes, has appropriate rectify work been carried out? ☐ Yes ☐ No	
Water treatment programmed performance	Has HCC results exceed 100,000 cfu/mL during the previous year? ☐ Yes ☐ No	
	If yes, has appropriate rectify work, including cleaning and disinfection and water treatment programme review been carried out? ☐ Yes ☐ No	
	Has Legionella bacteria count results exceed 10 cfu/mL during the previous year? ☐ Yes ☐ No	

	Assessment of Cooling Tower System	Recommendation / remedial action required
	If yes, has appropriate rectify work, including cleaning and disinfection and water treatment programme review been carried out? ☐ Yes ☐ No	
Compliance of Code of Practice for Water-cooled Air conditioning Systems	Is the system complied with the CoP? ☐ Yes ☐ No	
Potential risk identified during walk-through inspection		

E. Progress of remedial works

	Assessment of Cooling Tower System	Recommendation / remedial action required
Remedial works	Are all the remedial works as recommended in the previous year being carried out? ☐ Yes ☐ No ☐ N/A	

F. Others recommendation

Signed by the Auditor : _____

Full name of Auditor : _____

Registration no.: _____

Date: _____

Note: The above formats are for reference only. The auditors of the cooling tower systems shall develop their own formats for their systems.

Energy Efficiency EMSD

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