Good Operation and Maintenance Practice of Fresh Water Cooling Towers

淡水冷卻塔操作及維修的良好作業

2023 Edition

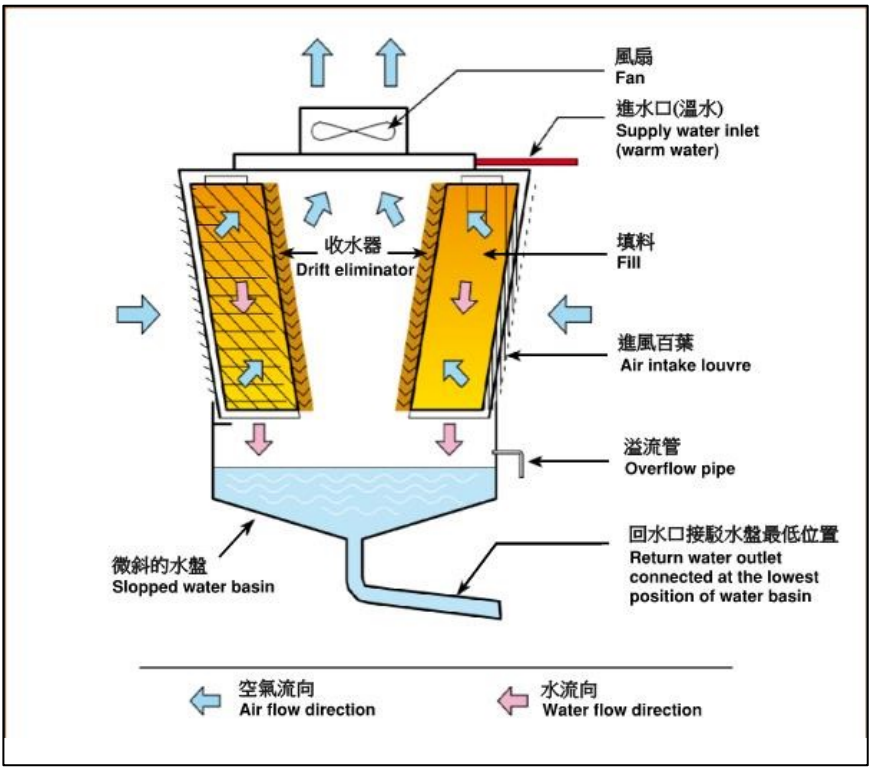
機電工程署
EMSD

1. General

1.1 A cooling tower is a heat rejection device that generally used in a cooling system for lowering the temperature of water by evaporative cooling in which the ambient air is drawn in to contact with the falling water to absorb heat before discharged into the atmosphere. A typical configuration of cooling tower with major components of fan, fill and drift eliminator etc is shown in Figure 1.

1. 引言

1.1 冷卻塔是透過蒸發式的冷卻作用，以降低水溫的一種散熱裝置，通常應用於冷卻系統。在該裝置內，由抽進的外間空氣與流水接觸以吸收熱量， 再排出大氣中。圖 1 展示典型冷卻塔的構造及其主要配置如風扇、填料及收水器等。

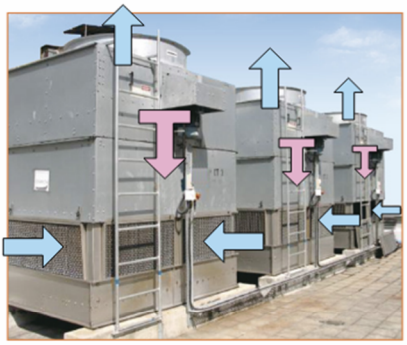


圖一：典型冷卻塔的構造

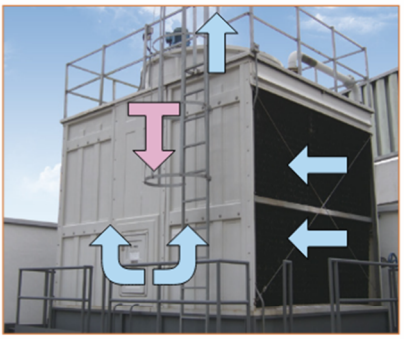
Figure : A typical cooling tower configuration

1.2 In general, cooling towers are classified based on their construction and air movement through the cooling tower in relation to the falling water droplets. Various types of cooling towers are shown below.

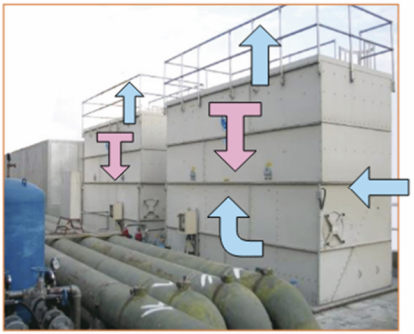
1.2 一般而言，冷卻塔可根據其構造及冷卻塔內水滴和空氣流動的關係進行分類。不同種類的冷卻塔如下圖所示。



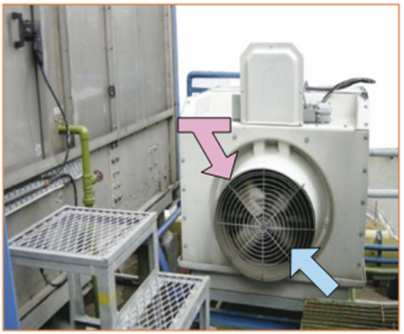
引風逆流式
Induced draft counter flow type



引風橫流式
Induced draft cross flow type



鼓風逆流式
Forced draft counter flow type



鼓風橫流式
Forced draft cross flow type

空氣流向
Air flow direction

水流向
Water flow direction

1.3 Operation and maintenance (O&M) work mainly comprise routine checking and the upkeep of conditions of components of cooling towers (e.g. water basin and drift eliminator) and associated equipment of the installation (e.g. pumps and valves), water treatment, and cleaning, desludging and disinfection of cooling towers

1.3 操作及維修工作主要包括例行檢查及妥善保養冷卻的器件(例如:水盤及收水器)和冷卻塔裝置的相關設備(例如:水泵及閥門)、冷卻塔的水處理、清洗、除淤及消毒。

1.4 This pamphlet provides concise guidelines on good operation and maintenance practice of fresh water cooling towers, making reference to the EMSD's Code of Practice for Fresh Water Cooling Towers (CoP (FWCT)), which is available on EMSD's website :

1.4 此小冊子參考了《淡水冷卻塔實務守則》 (實務守則)，就淡水冷卻塔操作及維修的良好作業，提供簡要的指引。

該實務守則可從機電工程署網站查閱:

https://www.emsd.gov.hk/

2. Why operation and maintenance of fresh water cooling towers are important?

2.1 With proper operation and maintenance, fresh water cooling towers can:

(i) achieve better energy efficiency and operational performance;

(ii) assure public health and safety; and

(iii) minimize nuisance to the public.

2.2 As revealed in some overseas cases that fresh water cooling towers could be sources of spreading legionella, which will pose risk to the public's health if the fresh water cooling towers are not properly designed, installed, operated and maintained. For more information on operation and maintenance of man-made water systems (including cooling towers) for prevention of Legionnaires' disease (LD), please refer to the Code of Practice for Prevention of Legionnaires' Disease published by the Prevention of Legionnaires' Disease Committee (available on website : https://www.emsd.gov.hk/).

2. 為何淡水冷卻塔的操作 及維修工作顯得重要?

2.1 在妥善的操作及維修下，淡水冷卻塔可以:

(i) 達致較佳的能源效益及運作性能;

(ii) 確保公共衞生及安全; 及

(iii) 減低對公眾造成的滋擾。

2.2 部分海外個案顯示，淡水冷卻塔可以是傳播退伍軍人桿菌的源頭，因此，使用不妥善設計、安裝、操作和維修的淡水冷卻塔將對公眾的健康構成風險。如欲獲得更多用水系統(包括冷卻塔)的操作及維修以預防退伍軍人病，可參考預防退伍軍人病委員會出版的《預防退伍軍人病工作守則》(可於網址

https://www.emsd .gov.hk/ 查閱)

3. Operation

3.1 Cooling towers and water treatment facilities should be regularly maintained by an O&M contractor of cooling tower.

3.2 Cooling water should be continuously or intermittently filtered and treated with chemicals, or other proven physical water treatment methods, to control corrosion, scaling and microbial growth.

3.3 Water treatment chemicals should be added by automatic dosing devices which may either be of metered dosing or proportional dosing type to suit the application.

Manual slug dosing on a routine basis may be adopted in small-sized cooling towers, but it is not preferred due to difficulty in controlling chemical concentration.

3.4 For chemical treatment, it is recommended to use two different biocide chemicals alternatively at periodic intervals, use combination of two compatible chemicals for better control, or conduct occasional slug dosing to maintain higher biocide concentration.

3. 操作方面

3.1 冷卻塔及水處理設施應定期由冷卻塔操作和維修的承建商定期維修。

3.2 冷卻水應持續不斷或間歇過濾及經化學處理，或其它經驗證的物理水處理方法來控制腐蝕、積垢和微生物的生長。

3.3 水處理化學劑應以自動投藥裝置投入，該裝置可以視乎應用的需要而選用計量器式或連續比例式的投藥裝置。

小型冷卻塔系統可採用化學劑定時作人手投放。但這種方法難以控制化學劑的濃度，故並不建議採用此方法。

3.4 化學劑處理方面，建議於定期時間交替使用兩種不同的化學殺菌劑、混合使用兩種相容的化學劑，以達致更有效的控制、或間中大量投藥以保持較高殺菌劑的濃度。

3.5 Cooling water should be regularly bled off and replaced with make-up water to limit the concentration of dissolved solids left behind in the cooling water. Bleed-off is preferred to be performed automatically by a conductivity sensor. Timer control or manual bleed-off is not preferred unless automatic bleed-off by a conductivity sensor is not practicable.

3.6 It is recommended to integrate to IoT Water treatment controller with cloud-based water treatment management software and/or Central Control and Monitoring System (CCMS) or Building Management System (BMS) of the building. The integrated control and monitoring system can allow the system operator and water treatment service provider to real-time remotely control and monitor the water treatment system. Attention should be paid to assure cyber security of cloud-based control system.

4. Routine Inspection and Preventive Maintenance

4.1 Cooling tower installations should be regularly inspected and properly maintained. Inspection should include cooling towers and their associated mechanical equipment, water treatment facilities and water tanks.

3.5 冷卻水應定期泄放及以補給水替換，以限制冷卻水中的溶解物濃度。泄放應優先採用電傳導數計控制的自動泄放方法。除非以電傳導數計控制的自動泄放的方法並不可行，否則不建議採用計時器控制或手動控制的泄放方法。

3.6 建議把水處理系統整合至結合雲端水處理管理軟件連接的物聯網(IoT)水處理控制器和/或中央控制及監察系統（CCMS）/樓宇管理系統（BMS）。系統操作員和水處理公司可以透過綜合控制及監察系統實時遙距控制和監察水處理系統。使用時須注意雲端管理軟件的網絡安全。

Two different biocide chemicals
兩種不同的殺菌化學劑

4. 例行檢查及預防性維修

4.1 冷卻塔裝置應定期檢查及妥善維修，檢查應包括冷卻塔、相關機械設備、水處理設施及水箱。

4.2 Weekly routines

(i) Check cooling water for clarity, odour, surface debris, algae and temperature

(ii) Check water level of basin and the foaming condition of the cooling tower

(iii) Check bleed-off valves, strainers, drains and float valves for proper operation

(iv) Check operation condition of water treatment system, including water treatment dosing equipment, controller, conductivity sensors, and other sensors, etc., and check water treatment chemicals or materials for adequacy and safety

(v) Check operation conditions of the cooling tower fan and drive, water treatment dosing facilities, and water pumps

(vi) Drain stagnant water in dead-legs if any by manual purging for at least 15 minutes each

(vii) Run all standby condensing water-side equipment at least one hour.

4.2 每週例行檢查

(i) 檢查冷卻塔冷卻水的清晰度、氣味、水面雜物、水藻及溫度

(ii) 檢查水盤水面高度及冷卻塔泡沫情況

(iii) 檢查泄放閥、隔濾器、去水位及浮球閥確保妥善操作

(iv) 檢查水處理系統的運作狀況，包括水處理投藥設備、控制器、電傳導感應器和其它感應器等，及檢查水處理化學劑或物料確保足夠存量和安全

(v) 檢查冷卻塔風扇及電動機水處理投藥設備及水泵運行情況

(vi) 每個死角用人手閥放以沖洗死角（如有）滯水最少 15 分鐘

(vii) 運行所有備用冷凝水設備， 至少運作一個小時

Check algae in water basin
檢查水盤內水藻

Check conditions of water treatment facilities
檢查水處理投藥設備的狀況

Drain off the dead leg
排走死角滯水

4.3 Monthly routines

(i) General

- Check cooling water for clarity, odour, surface debris, algae and temperature and ensure that the cooling water be properly dosed with biocides or alike by chemical treatment devices (or disinfected by physical treatment devices if adopted instead) to prevent microbial growth.
- Check internal surface condition of cooling towers for scale, rust, sludge, and biofilm accumulation, in particular the water basin. They should be removed by scrubbing and cleaning.
- Check sprays and distribution deck for proper water distribution.
- Check for proper operation of bleed-off valves and other valves of the installation.

(ii) Water Basin

- Check basin sides and corners of cooling towers for any leakage or overflow
- Inspect suction screen and clean away any accumulated debris.
- Assure float valves and make up water controls operating freely and maintain proper water level.

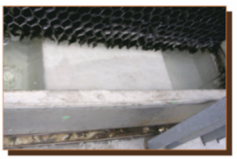
4.3 每月例行檢查

(i) 一般檢查

- 檢查冷卻塔冷卻水的清晰度、氣味、水面雜物、水藻及溫度及確保化學處理裝置妥善投放殺菌劑於冷卻水中 (或透過物理處理裝置（如採用的話）消毒)，以防止微生物生長。
- 檢查冷卻塔內部表面，特別是水盤的情況，是否積有水垢、銹蝕、淤泥及生物薄膜，並進行擦洗及清潔把它們除去。
- 檢查噴灑及配水板， 以作妥善配水功能
- 檢查泄放閥門及其他閥門裝置操作正常。

(ii) 水盤

- 檢查水盤周邊和冷卻塔角位有否漏水或溢流
- 檢查吸風口隔網及清走任何積聚的雜物
- 確保浮球閥及補給水控制操作自如及維持正常的水位



Water basin
水盤

(iii) Tower Framework

- Inspect visually for any deterioration and test members for soft spots with a screw driver or other pointed tool.
- Check and clean all air inlet corrugated GRP louvers
- Grease vibration isolation springs.
- Remove corrosion and rust and carry out touch-up painting
- Inspect the general condition and check tightness of framework bolts for safe use.

(iv) Fills and Drift Eliminators

- Check condition/ cleanliness of fills and drift eliminators, and remove any accumulated dirt.
- Check fills are intact and in place with no sagging or gaps in packs.

(iii) 冷卻塔結構

- 目視檢查任何退化和用螺絲批或其他尖頭工具敲打構築組件以測試弱位
- 檢查及清洗所有進風玻璃纖維百葉
- 潤滑避振器彈簧
- 清除腐蝕和鏽跡及補上油漆
- 檢查冷卻塔總體狀況及塔架螺栓的鬆緊，以確保安全使用

(iv) 填料及收水器

- 檢查填料和收水器狀況及清潔程度，及清除積聚的雜物
- 檢查填料完整無缺及處於適當位置，而沒有彎曲或隙罅

Deformed drift eliminator
已變形的收水器

Water showering from drift eliminator
水點由收水器大量瀉出

4.4 Quarterly routines

(i) Adjust and lubricate fans, pumps and motors bearings

(ii) Adjust and lubricate all moving parts of valves

(iii) Clean the water distribution pipework including nozzles

4.4 每季例行檢查

(i) 調校和潤滑風扇、水泵、電動機的軸承

(ii) 調校和潤滑閥門可移動的部件

(iii) 清洗配水管道包括噴嘴

Lubricate fan
潤滑風扇

4.5 Half yearly routines

(i) Water basin and internal surfaces of cooling towers should be cleaned, desludged and disinfected at least every 6 months:

(a) circulate first biodispersant in the system;

(b) circulate chlorinated water of 5 ppm for 6 hours and then drain;

(c) manually clean and desludge internal surfaces

(d) refill and recirculate chlorinated water for 6 hours and then drain.

The water in (b) and (d) should be dechlorinated by a neutralizer (e.g. sodium thiosulphate) before draining.

4.5 每半年例行檢查

(i) 水盤和冷卻塔內部表面應至少每六個月清洗、除去淤泥及消毒一次：

(a) 先投入生物分散劑於冷卻塔系統中循環；

(b) 再加入氯水(每公升 5 毫克)，循環 6 小時，然後排走；

(c) 用人手清潔和除去內部表面淤泥；

(d) 重新注氯水，並再次循環至少六小時，然後及排走。

以上(b) 及 (d) 項含有殘餘氯的水需作除氯後才可排放。一般步驟為添加中和劑如硫代硫酸鈉。

Clean internal surface
清潔內部表面

Clean water basin
清洗水盤

(ii) Fills and drift eliminators should be removed for cleaning.

(iii) End cap in each header should be removed for cleaning.

5. Monitoring of Water Quality

5.1 To monitor water treatment effectiveness, regular water sampling and testing of cooling water should be carried out and tested by laboratories accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS):-

(a) monthly testing of heterotrophic colony count

(b) quarterly testing of total legionella count

5.2 The owners or property management agencies may engage the O&M contractor of cooling tower to arrange water sampling for testing by an accredited laboratory and keep proper records in Form EMSD EE CT3.

(ii) 拆除及清洗收水器和填料

(iii) 拆除及清洗各水管末端端蓋

5. 冷卻水水質監察

5.1 為監察水處理效能，必須定期安排於冷卻塔抽取冷卻水水樣本及交由香港實驗所認可計劃認可的實驗室作化驗：-

(a) 每個月進行一次異養菌含菌量測試

(b) 每季進行一次退伍軍人桿菌總濃度測試

5.2 冷卻塔系統擁有人或物業管理公司可要求冷卻塔承建商安排抽取水樣本交予認可實驗室化驗和使用表格 EMSD EE CT3 保存適當的紀錄。

6. How to manage a fresh water cooling tower system?

6.1 The owners or property management agencies should keep a copy of operation and maintenance (O&M) manual prepared by the O&M contractor of cooling tower for management of maintenance of the fresh water cooling tower system. Medical and health facilities such as hospitals, clinics, elderly homes and social centre for the elderly should also follow the operational programme and measures as stated in the risk management plan (as per Section 7 of CoP(FWCT) Part 1).

6.2 The operator should keep records of system operation, routine inspection, water sampling results and maintenance work. Sample log sheet (as per Appendix 2E of CoP(FWCT) Part 2) is attached at Annex for use in keeping records. The O&M manual and records should be kept by authorized personnel and readily available for inspection and for reproduction when authorized public officers demand for them.

6. 如何管理淡水冷卻塔系統?

6.1 冷卻塔系統擁有人或物業管理公司應保存由冷卻塔操作及維修承建商制備的冷卻塔操作及維修手冊，以管理淡水冷卻塔系統的保養事宜。醫療及衞生設施醫院、診所、長者之家及長者社區中心，應該跟進循風險管理計劃內所制定的運作計劃及措施(如《淡水冷卻塔實務守則》第一部第 7 段)。

6.2 冷卻塔系統操作人員應保存系統運行、例行檢查、水樣本結果及維修工作的記錄。記錄樣本可參考本附本小冊子的附錄中(如《淡水冷卻塔實務守則》第二部附錄 2E)，以用作保存記錄之用。操作和維修手冊及記錄應由授權人員保存， 並在授權公職人員要求時，提供作檢查及複製。

6.3 The owners or property management agencies should engage an independent auditor to conduct an` annual audit of the system to check O&M manual and records, conduct visual and records, conduct visual inspection, and identify risks and problems with recommendation on remedial actions if any. The audit report should be submitted to EMSD each year.

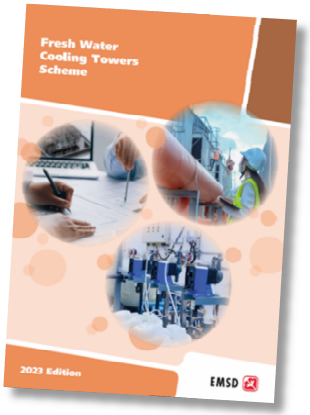
6.3 冷卻塔系統擁有人或物業管理公司需雇用獨立的審核人員，每年為系統進行操作及維修的審核，以檢查操作及維修手冊和記錄、進行目視檢查及辨出風險和問題，並建議補救措施 (如有)。審核報告應每年向機電工程署提交。

6.4 The owners of cooling towers for non-domestic usage are encouraged to apply for participation in the EMSD's Fresh Water Cooling Towers Scheme ("Scheme") Relevant information and application procedure of the Scheme can be downloaded from the EMSD's website:

https://www.emsd.gov.hk/

6.4 機電工程署鼓勵非住用途冷卻塔系統擁有人申請參加機電工程署的「 淡水冷卻塔計劃 」 ("計劃")。有關資料和申請計劃詳情可在機電工程署網址下載:

https://www.emsd.gov.hk/



7. Responsibilities of Cooling Towers Owners

7.1 The owners should ensure proper O&M of cooling tower system, including water treatment of their cooling towers so as to prevent contamination and nuisances to the public.

7.2 If fresh water cooling towers are found being so foul, or in such a state, as to be a nuisance or injurious or dangerous to health under the Public Health and Municipal Services Ordinance (PHMSO) (Cap 132), it can be dealt with summarily under the ordinance. EMSD can enter premises and take water samples for conducting testing and, by issuing a nuisance notice, instruct the owners/occupiers to carry out emergency decontamination with water re- testing to rectify unsatisfactory conditions of the fresh water cooling towers within a prescribed period.

7.3 Failure to comply with the requirements of the nuisance notice is an offence under the PHMSO.

7. 冷卻塔擁有人應有的責任

7.1 冷卻塔擁有人應確保冷卻塔系統妥善地操作和維修，包括冷卻塔的水處理方法，避免對公眾構成污染和滋擾。

7.2 如發現淡水冷卻塔的污穢程度或其狀況足以構成《公眾衞生及市政條例》(香港法例第 132 章)所指的妨擾、或足以損害或危害健康，有關妨擾事故可根據循簡易程序處理。機電工程署可進入處所、抽取水樣本、進行測試，並可發出《妨擾事故通知》，要求擁有人或佔用人進行緊急消毒和水質重新測試，在規定時限內，糾正淡水冷卻塔的欠妥情況。

7.3 在該條例下，如未能遵從《妨擾事故通知》的規定，即屬違法

8. Enquiries

For more information on the guidelines, please contact EMSD:

Electrical & Mechanical Services Department

Energy Efficiency Office

7/F EMSD Headquarters

3 Kai Shing Street, Kowloon Bay,

Kowloon, Hong Kong.

Website : https://www.emsd.gov.hk

Email : info@emsd.gov.hk

Tel : 3912 0642

Fax : 2890 6081

8. 查詢

如索取更多有關指引的資料，請聯絡機電工程署：

機電工程署

能源效益事務處

香港九龍啟成街 3 號

機電工程署總部大樓 7 樓

網址 : https://www.emsd.gov.hk

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Annex
附錄

Sample Operation and Maintenance Records for Cooling Tower System
冷卻塔系統操作及維修記錄樣本

(Extracted from Appendix 2E of CoP(FWCT) Part 2)
(取自淡水冷卻塔實務守則第二部附錄 2E)

For the period 記錄期間： _____

A. System Description
系統描述

Record 記錄	Details 詳細說明
Building Name & Building Address 樓宇名稱及樓宇地址	
Cooling tower type 冷卻塔類型	
Number of cooling tower in system 系統內冷卻塔數目	
Heat rejection capacities of the cooling towers 冷卻塔散熱量	
Building owner's name / contact details* 樓宇業主名稱/詳細聯繫方式*	
Owner of cooling tower's contact details* 冷卻塔擁有者名稱及詳細聯繫方式*	
O&M contractor of cooling tower's name and details* 操作及維修冷卻塔系統的承建商詳細資料*	
Water treatment services provider's name and contact details* 水處理服務供應商名稱及詳細聯繫方式*	
Water sampling / laboratory contractor's name and contact details* 取水樣本/試驗室承辦商及詳細聯繫方式*	

* To include company name, contact person's business and after office hours telephone numbers
包括公司名稱、聯繫人職務及非辦工時間聯繫電話

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

每週／每月檢查記錄 ( ) 年 ( ) 月

Procedures 步驟		Date of Action 檢查日期				
		Week 1 第 1 週	Week 2 第 2 週	Week 3 第 3 週	Week 4 第 4 週	Week 5 第 5 週
1.	Check cleanliness, organic fouling and physical debris 檢查清潔度、有機結垢及雜質					
2.	Inspect for slime and algal growth 檢查粘泥及水藻生長情況					
3.	Inspect for deterioration of materials, damage to components, blockages and corrosion. 檢查物料退化、部件損壞、礙塞及腐蝕					
4.	Inspect for correct operation of fans, motors and pumps 檢查風扇、電動機及水泵的正常運作情況					
5.	Inspect water leaks from seams 檢查接合口的漏水情況					
6.	Inspect misshaped exterior or collapsed internal supports 檢查外殼變形或內部結構倒塌情況					
7.	Inspect supporting framework 檢查支撐架					
8.	Inspect fill and drift eliminator 檢查填料及收水器					
9.	Check condition and operation of ball valve 檢查浮球閥的狀況及運作情況					
10.	Check fan thermostat (if equipped) 檢查恒溫器 (如有配置)					
11.	Check sprays and distribution deck 檢查噴灑及配水板					
12.	Check bleed-off rate 檢查泄放量					

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

每季度 / 每 6 個月 / 每年檢查記錄 ( ) 年

Procedures 步驟		Date of Action 檢查日期				
		Week 1 第 1 週	Week 2 第 2 週	Week 3 第 3 週	Week 4 第 4 週	Week 5 第 5 週
1.	Lubricate fan and pump bearings / gearbox 潤滑風扇和水泵軸及齒輪箱					
2.	Drain basin and clean distribution deck, fill and drift eliminator 水盤排水及清潔配水板、填料和收水器					
3.	Check security of all bolts and fittings 檢查所有門栓及配件的安全性					
4.	Clean fan blades 清潔風扇葉					
5.	Clean all components as required 清潔所需部件					

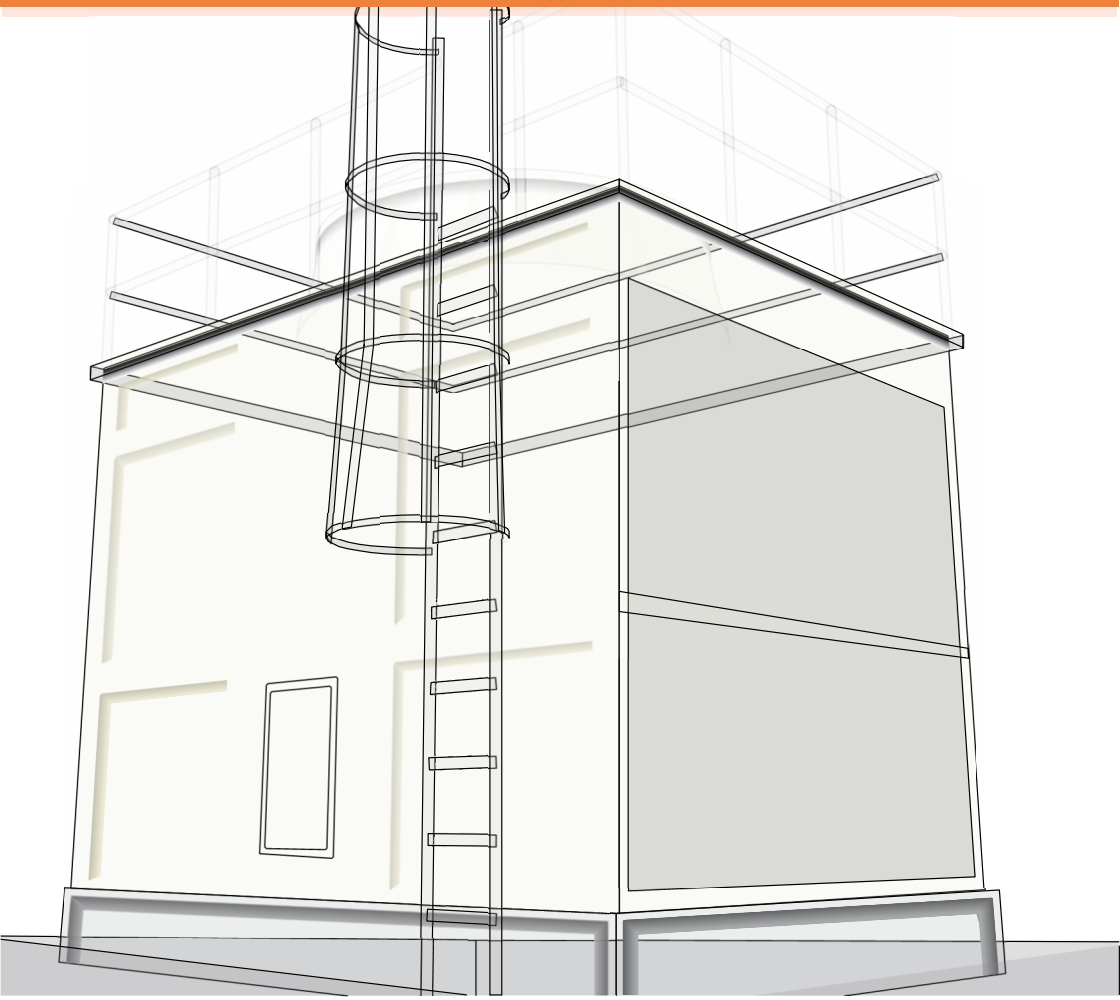
D. Monthly Water Sample Bacterial Test Records for the year ( )
每月水樣本細菌測試報告 ( ) 年

Bacteria Test 細菌測試		Testing Laboratory 測驗實驗室	Date of Test 測試日期	Test Results 測試結果 (cfu/mL)	Action 措施
Heterotrophic colony count 異養菌濃度	Month 1 第1個月				
	Month 2 第2個月				
	Month 3 第3個月				
	Month 4 第4個月				
	Month 5 第5個月				
	Month 6 第6個月				
	Month 7 第7個月				
	Month 8 第8個月				
	Month 9 第9個月				
	Month 10 第10個月				
	Month 11 第11個月				
	Month 12 第12個月				

Bacteria Test 細菌測試		Testing Laboratory 測驗實驗室	Date of Test 測試日期	Test Results 測試結果 (cfu/mL)	Action 措施
Total legionella count 退伍軍人桿菌總濃度	Month 1 第1個月				
	Month 2 第2個月				
	Month 3 第3個月				
	Month 4 第4個月				
	Month 5 第5個月				
	Month 6 第6個月				
	Month 7 第7個月				
	Month 8 第8個月				
	Month 9 第9個月				
	Month 10 第10個月				
	Month 11 第11個月				
	Month 12 第12個月				

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

註： 上述格式僅作為參考。冷卻塔系統擁有者必須為其系統制訂適合的格式。



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