Part 1 – Cooling Tower Basics in MVAC System


By Mr. Anlam Tam, Ir Leo Lau

Air Conditioning Basics:

Life experience let us know human comfort depending on temperature and moisture content of air in the space. Humid air contains higher moisture content. Engineering/Scientific representation refers to higher humidity/relative humidity. Both temperature changes and moisture changes are caused by changing of energy both sensible and latent. Controlling both factors (temperature and humidity) can make Indoor environment controllable. Heat engine provides such control mechanism for heat exchanging. As climate in Hong Kong is hot and humid. Air conditioner is a common heat engine for cooling and dehumidifying so as to control room temperature below 25.5°C and maintain relative humidity around 55%~60%.

For large commercial complex or buildings, by using huge numbers of small refrigerant type air conditioner for cooling and dehumidifying is not efficiency and environment friendly. Therefore, air-conditioning system with secondary cooling circuit (chilled water) is commonly applied to the complex and buildings.

Water Systems in MVAC System:

Common heat engine used in central air conditioning plant for cooling (chilled water) is chiller. However, chiller could not be operated itself. It is necessary a complete chilled water circulation circuits, which also includes chilled water air side equipment and chilled water pumps. Researchers found that the effective way of heat rejection for the chiller is water cooled. As far as energy and carbon foot print are concerned recent years, water cooled system becomes popular. To complete the water-cooled circuits, the system, that is called condenser water system, comprises cooling tower and condenser water pumps.

The purpose of the chilled water system is to transport chilled water from the central plant to the air-handling units, fan-coil units, and chill beam. The purpose of the condenser water system is to transport the condenser water from the cooling tower to the condenser inside the central plant for heat rejection.

In Figure 1, the chilled water is cooled by chillers and then is distributed to the cooling coils of various air-handling units. The temperature of the chilled water leaving the coil of AHU increases after absorbing heat from the airstream flowing over the coil. Chilled water with higher temperature is then returned to the chillers for re-cooling through the chilled water pumps. For condensing water circuits, the condenser water has been cooled in the cooling tower, it flows back to the condenser of the centrifugal chillers. The temperature of the condenser water again rises owing to the absorption of the condensing heat from the refrigerant in the condenser. After that, the condenser water is pumped to the cooling towers by the condenser water pumps.

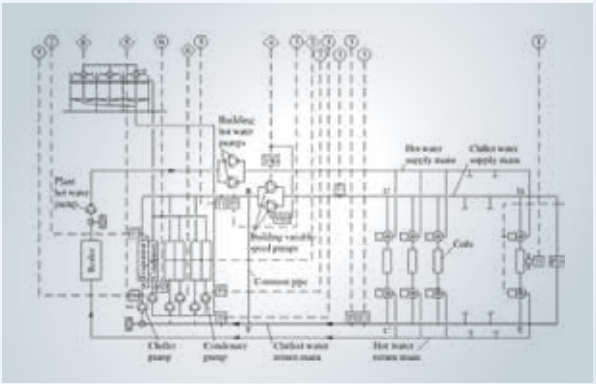


FIGURE 1 Schematic diagram of water system for the central air conditioning system.

Cooling Tower Basics:

Condensing water (approximate 32°C) leaving cooling tower is circulated through a piping system to carry away the heat rejected from chiller (condenser), then to a cooling tower outside the building again. The water droplet is sprayed into the fill interacting atmospheric air inside cooling tower. Water droplets are partially evaporated to liberate heat, then, recovered and returned at a lower water temperature for heat rejection in the condenser of the chiller. The evaporated process of dragged water droplet causes loss of water due to vaporization and fug. The rate of evaporation depends on ambient temperature and humidity, major in humidity factor.

The cooling tower is typically constructed with component a metal frame work, water basin, float valve, filler, sprinkler system, drift eliminator, duffusion deck, motor, gear/pully, fan and bearings completed with accessories such as pully cover, suction strainer, sump tank, discharge hood, etc.. Typical cooling tower has three kinds of configuration – (a) Counterflow induced-draft, (b) Crossflow induced-draft, (c) Counterflow forced-draft. (Figures 2 & 3)

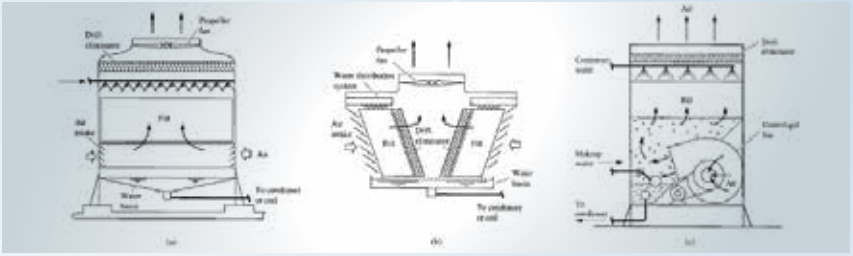


FIGURE 2 Type of Cooling Towers

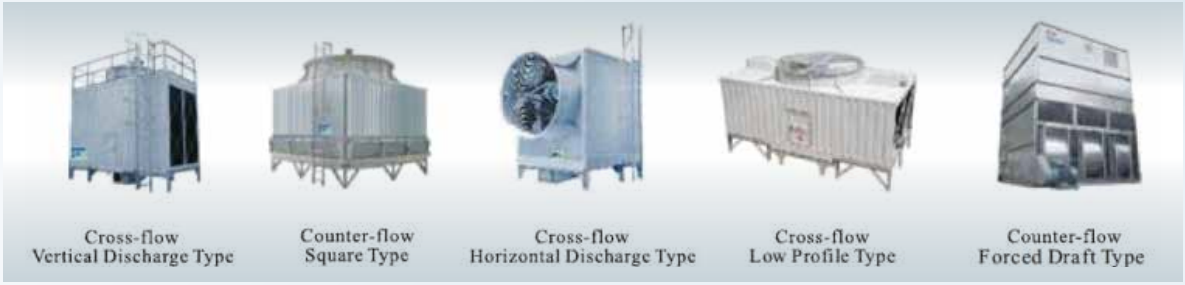


FIGURE 3 Cooling Towers

Condenser water is easy contaminated by the air surrounding the water droplet and returns to the water basin for recirculation. Air borne bacteria, microbes, dust, fungi will enter the water basin and will be accumulated. Microbes grow rapidly especially at the zone with stagnant water because of its operating warm water temperature. Legionnaires' disease is major concern for the cooling tower operation.

Generally, water consumption and water quality are concerned items of Water Services Department (WSD). Contractors shall comply their statutory requirements for cooling tower installation. The leading role for the statutory submissions for the cooling tower is the Electrical and Mechanical Services Department (EMSD). The following Part 2 is talking about the requirements leading to statutory compliance.

Part 2 – Statutory Requirements for Cooling Tower

Background:

Fresh water cooling tower (FWCT) scheme is monitored under Hong Kong SAR Electrical and Mechanical Services Department (EMSD). Under the FWCT Scheme, owners of existing or new nondomestic buildings and other buildings where fresh water for evaporative cooling is supplied for nondomestic usage in either the designated areas or nondesignated areas should submit an application to the EMSD and Water Supplies Department (WSD) for approval of using water from the waterworks for cooling under the Waterworks Ordinance, Cap 102 and Waterworks Regulations, Cap 102A

The application requirements, procedures and forms are revised after a recent review completed in December 2016 to streamline the application process and requirements. The revised requirements, forms and procedures within the administration of the Scheme are implemented with effect from 3 January 2017, with a grace period of 6 months for using the old version of Scheme documents. Such that, the actual implementation date of revised scheme will be 3 July 2017. FWCT scheme Brochure (2016 edition) and Code of Practice (COP) for Fresh Water Cooling Towers (2016 edition) are available and can be download from EMSD website.

Major changes for FWCT scheme Brochure & COP for FWCT (Part 1) (2016 edition):

A) FWCT scheme Brochure:

2010 Edition	2016 Edition	Major Changes in FWCT Scheme Brochure
Section 2.2	Section 2.2.1	To specify the buildings covered by the FWCT Scheme, including non-domestic buildings and other buildings, such as composite building, detached (or stand-alone) clubhouse building ancillary and hotel- like service apartment. Section 2.2.1 "This scheme applies to all buildings and other buildings where the use of fresh water for evaporative cooling is supplied for non-domestic usage within the designated areas....".
N/A	Section 6.5	To specify the validity of five (5) years for approval of each stage of submission by means of Forms CT1A or CT1B, counting from the approval date of each application.
Section 8.4	Section 6.8	To specify that consultation is required to be sought from the resident associations if a cooling tower is proposed to be installed at an existing composite building (residential & commercial) or existing domestic building. The resident associations to be consulted include Owners' Corporations or Incorporated Owners, Management Committees or Owners' Committees, Mutual Aid Committees or alike.
N/A	Section 7.3.3	To include the conditions of de-registration. "The owner of cooling tower(s) is required to notify EMSD and WSD in writing within 30 days after removing or permanently discontinuing use of cooling tower(s)." "Cooling tower(s) will be de-registered from the Scheme if the cooling tower(s) system is no longer found to be complied with the requirements under the Scheme."
N/A	Section 8.5	To include a new section on temporary water supply for testing and commissioning. If there is no appropriate water source available for testing and commissioning of the cooling tower, applicants may submit Form CT3 to EMSD within six (6) months after Form CT2B (or Form CT2A) is accepted by EMSD. The Water Authority will provide temporary water supply for carrying out the testing and commissioning within the specified period for the specific conditions.
Section 12	Section 11	To include the information required for application of a discharge licence."...For application of discharge licence, the prospective discharger (or the applicant) should submit a duly completed Form A to EPD..."
Section 15	Section 14	To include nuisances arises from cooling water of the cooling towers under PHMSO as part of nuisance control.
N/A	Section 16	To include a new section on requirement of Buildings Energy Efficiency relating to FWCT.

B) COP for FWCT (Part 1) (Design, Installation and Commissioning)

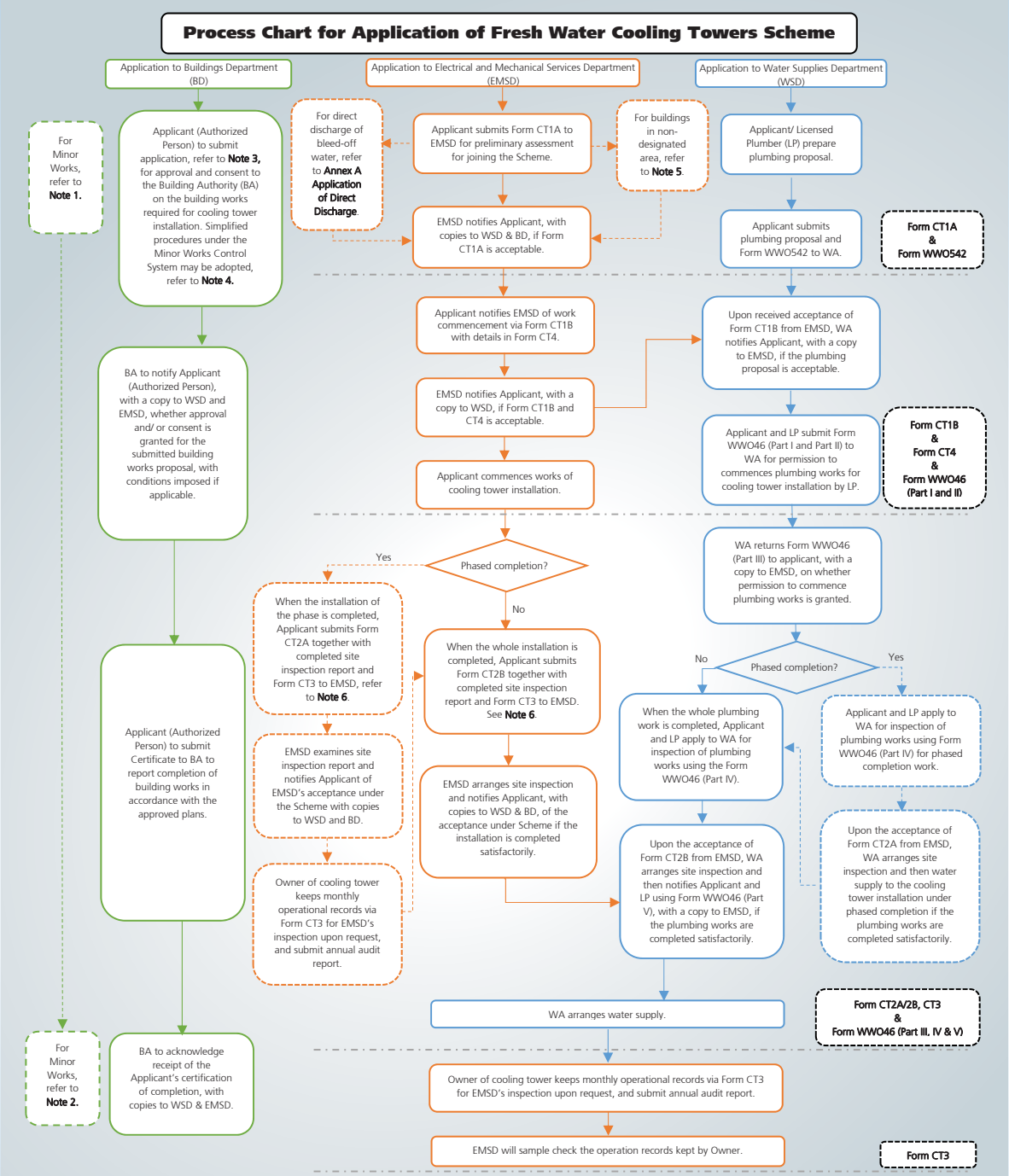
2010 Edition	2016 Edition	Major Changes in COP for FWCT (Part 1)
Section 2.2	Section 2.2.1	To replace the term "Pedestrian thoroughfares" by "Public accessible area", which includes other areas that are accessible by the public or building occupants.
Section 4.1.3 and Section 4.1.4	Section 4.1.4(a) and Section 4.1.5	To update the separation requirement between public accessible area and cooling tower. Public accessible area should be distant from cooling tower intake by minimum 5m, and cooling tower exhaust by minimum 7.5m. To include new requirements on vertical separation distance. The vertical separation distance To add the definitions of critical outdoor air intake and critical exhaust air outlet. "Critical outdoor air intake refers to fresh air intakes of the building air conditioning systems (e.g. primary air unit, air handling unit, lift vent) or any intake that draws fresh air into the occupied area." "Critical exhaust air outlet refers to kitchen exhaust, toilet exhaust, car park exhaust, food processing exhaust, laboratory exhaust or any exhaust that can contaminate the cooling water or pollute the cooling air."
N/A	Section 4.1.4(b)	To include new requirements on vertical separation distance. The vertical separation distance requirements are specified in Table 1.2 and Table 1.3. To update the requirements on vertical separation distance between cooling tower and public accessible area that an addition of 1.8m above ground is required for breathing zone for pedestrian.
N/A	Section 4.8	To include new requirements on cooling towers located at composite building (residential and commercial). Section 4.8.1: "...an applicant should also carry out a technical assessment..." Section 4.8.2: "The preferred installation location of cooling towers should be distant from the domestic block the farthest, and cause the least nuisance to the residents and nearby occupants." Section 4.8.3: "Cooling tower exhaust air should be discharged away from buildings' operable windows and outdoor air intakes..." Section 4.8.4: "...the exhaust of cooling tower should be facing upwards or appropriate direction to avoid direct facing to the nearby occupants." Section 4.8.5: "Plume abatement measure should be adopted..." Section 4.8.6: "Risk management plan for the cooling tower system should be prepared and submitted..." Please refer to Section 4.8 for more details.
N/A	Section 7.2.5	To specify the conditions for reviewing Risk Management Plan. "Risk management plan is required to be reviewed under the following circumstances: a) Results of checks indicate that mitigation measures are ineffective; or b) If a case of Legionnaires' disease is associated with a building"
Section 12	Appendix 1C	To include samples of notices and labels for cooling tower system.

Notes:

1) The above tables are mentioned the major changes on FWCT scheme brochure and COP for FWCT Part 1. Detail refer to the EMSD website.

Procedures for FWCT Submission:

Application Procedures (extracted from EMSD website):



Note 1: Applicant (Authorized Person / Prescribed Registered Contractor) to submit specified forms and documents for the building works under the simplified requirements of the Minor Works Control System

Note 2: Applicant (Authorized Person / Prescribed Registered Contractor) to provide to WSD and EMSD a copy of the acknowledgement letter issued by the BD for the certificate of completion of minor works.

Note 3: Including building plans, structural plans, alteration and addition plans or drainage plans, where appropriate.

Note 4: Building works designated as minor works may be carried out without obtaining prior approval and consent from the BA, but should comply with the simplified requirements of the Minor Works Control System, including the appointment of prescribed building professionals and/or prescribed registered contractors. For details of the Minor Works Control System, please refer to BD web site at www.bd.gov.hk and "General Guidelines on Minor Works Control System" and "Technical Guidelines on Minor Works Control System" published by the BD.

Note 5: For building in non-designated area, application will be considered on a case-by-case basis in consultation with WSD on adequacy of fresh water supply.

Note 6: If no appropriate water supply for T&C of cooling tower, applicant may apply to WSD for temporary water supply for T&C of cooling towers if required, and submit Form CT3 within 6 months after Form CT2B (or CT2A) is accepted by EMSD. Details can be referred to Section 8.5 of the FWCT Scheme Brochure.

Process Chart (12-2016)

Notes for Application for FWCT scheme on WSD submission:

1. During CT1A submission (Planning Stage) , a copy for the FWCT application will be sent to WSD for processing. The applicant should also submit the plumbing proposal and the Form WWO 542 to the Water Authority (WA).
2. After receiving acceptance of plumbing proposal from the WA, applicant should submit Form WWO46 (Part I and II) to the WA for approval for the plumbing works to be commenced for cooling towers installation.
3. The Applicant / licensed plumber should also apply to WSD for inspection or process for connection of water supply to the cooling towers installation Upon completion of the installation.

Procedures for building outside designated areas:

The designated areas for application for joining the Scheme are delineated in the latest location plans which can be downloaded at EMSD's website. Application to the Scheme are not limited to designated area and application in non-designated areas will be considered in consultation with WSD on a case-by-case basis with regard to the adequacy of water supply in the areas considered.

My previous successful experience on application for the building outside designated area is to demonstrate for water saving for cooling tower installation such as rainwater harvesting system and submit the proposal for WSD vetting.

Reference:
1. Shan K. Wang, Handbook of Air conditioning and refrigeration, Second Edition, McGraw-Hill 2000
2. EMSD - http://www.emsd.gov.hk/en/energy_efficiency/fwct_scheme/index.html 2017