

## Cooling towers in Hong Kong Guidance for energy efficient operation

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The Capex (capital expense) in air-conditioning systems is insignificant compared to the TCO (Total Cost of Ownership). Experience from across Asia shows us that many cooling tower systems are designed, operated or installed incorrectly, have poor efficiency, and bad practice causes unnecessary energy losses. But before we delve in to more detail, why do we need cooling towers? Refrigeration systems effectively absorb heat energy from our buildings, and we need a method to reject this unwanted heat energy in to the outside. Basically there are two options, an air cooled or water rejection system, cooling towers fall into the latter category. Cooling towers offer building owners opportunities to lower there TCO (Total Cost of Ownership), compared to air-cooled, here in Hong Kong that equates to annual savings of upto seventeen percent.

So what is the secret behind efficient cooling tower operation? It must be cleanliness. The majority of towers deployed in Asia are the open (direct) type, so that is where we will focus this article. You are probably already asking yourself why all this enthusiasm for cooling towers? Well it is quite simple, water-cooled chillers used in conjunction with cooling towers have many advantages over there air-cooled, the not least of which are



Figure 1: Avoid primers for biological growth  
圖1：避免採用引致微生物滋生的底漆

## 冷卻塔－ 能源效益運作指引

－ John Herbert, Kelcroft E&M Ltd.

與整體擁有成本 (Total Cost of Ownership) 相比，空調系統的資本開支微不足道。亞洲各地的經驗顯示，很多冷卻塔系統的設計、運作和安裝都不正確，效率低落，並因採用不良的常規而導致不必要的能源損耗。然而，在我們深入探討之前，我們也許應該考慮，我們為甚麼需要冷卻塔呢？製冷系統能有效地吸收建築物的熱能，而我們需要將這些多餘的熱能排出。基本上，我們有兩個選擇，便是採用氣冷式或水冷式的冷卻系統，而冷卻塔屬於後者。與氣冷式系統相比，水冷式的冷卻塔可降低業主的整體擁有成本，在香港每年可節省達17%的成本。

冷卻塔要達致運作效益，有甚麼秘訣呢？關鍵在於清潔。亞洲採用的冷卻塔，大部分屬於開放（直接）型，這是本文集中討論的類型。你可能已經在問，為甚麼冷卻塔如此大行其道呢？答案其實很簡單，水冷式冷凍器與冷卻塔配合使用，其優點比氣冷式系統多，包括噪音較低、體積較小，以及營運開支較低。以一台標準規格的600TR冷卻塔為例，其用於推動風扇的能量只需15kw，比氣冷式系統低6倍，因而能大大節省成本。

### 五大貼士

- 清潔
- 位置
- 水處理計劃
- 自動控制
- 節約用水

### 清潔

水是強而有力的溶劑，也是冷卻塔的命脈，因此必須保持清潔，在設計上務求降低污染機會。保持冷卻塔清潔，有助防止水管和冷卻器受污染。所謂預防勝於治療，板對板式熱交換器是防止污染物入侵的有效策略。

lower noise levels, smaller size, and lower Opex (operating expense). For example, in standard configuration a 600TR cooling tower only requires 15kw to power the fan, six times less than an air-cooled system, that is a significant saving.

#### Top Five Tips

- Cleanliness
- Location
- Water Treatment Plan
- Automatic Controls
- Save Water

#### Cleanliness

Water is a power solvent, and the life blood of cooling towers, it needs to be clean, and kept clean, design to minimise contamination, keeping the tower clean prevents contamination of the piping and chiller. A plate-to-plate heat exchanger is an effective strategy to prevent the ingress of contaminants - prevention is always better than cure.

#### Location

Ease of access for maintenance is critical, out of sight is out of mind. Avoid locations that invite contamination, for example areas close to parking or garden areas. Avoid primers for biological growth (refer to photo Figure 1). Short-circuiting of vitiated air dramatically lowers the towers capacity.

#### Water Treatment Plan

Despite best practice, the condenser water contamination occurs, and we need a strategy to take care of that. Coupled with water lost through evaporation process that concentrates constituents, unattended particulates accumulate plugging the tower fill.

Cooling tower water has all the right ingredients for bacteria soup; it is warm, exposed to air and towers provide plenty of crevices to support growth.

A water treatment programme is essential to inhibit corrosion, the build-up of scale and fouling, and control microbial contamination.

Corrosion, scale and microbe development foul condenser tubes and the pipework distribution system resulting in poor system efficiency and premature failure. These factors can also provide a favourable environment for the growth of microbes such as Legionella. Although a thorough discussion of the complexities of water treatment management is beyond

#### 位置

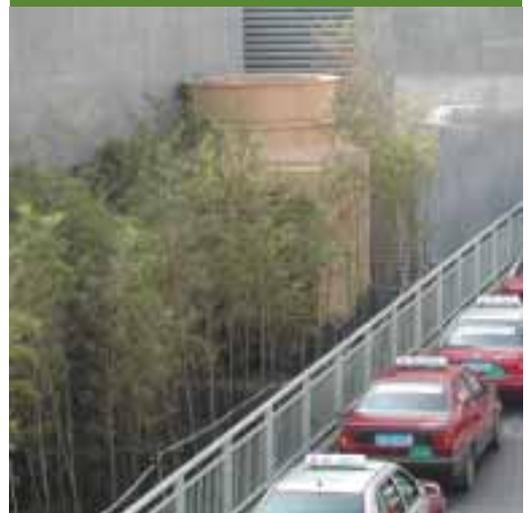
所謂「眼不見，心不煩」，我們往往忽略冷卻塔需要保持出入暢通以便進行維修。位置方面，我們應避免選擇停車場或花園附近等易受污染的地方。此外，我們應避免採用引致微生物滋生的底漆（請參考圖1）。空氣受污染，將大大降低冷卻塔的效能。

#### 水處理計劃

即使採取最佳常規，冷凝器內的水仍會受到污染，我們必須採取對策。此外，水份會因蒸發而流失，導致沉積物濃度增加，如果不加處理，供水管將會受到阻塞。

冷卻塔的水具有細菌滋生所需的一切條件：溫暖、外露於空氣中，塔身並有大量孔隙可供細菌生長。

因此，我們必須採取水處理計劃，以防止侵蝕、水垢和污物堆積，並控制微生物生長。侵蝕、水垢和微生物會影響冷卻管和輸水管，導致系統效率低落和提早出現故障。這些因素亦為退伍軍人症等病菌提供理想的生長環境。雖然受篇幅所限，本文未能充分討論水處理的複雜問題，但肯定的是，我們必須正確操作水塔和冷卻器。



Poor cooling tower location  
應注意擺放冷卻塔的地方

the scope of this article suffice to say that it is necessary to provide the proper operation of both the tower and the chiller.

#### Automatic Controls

The majority of the power consumed by air conditioning is used in the chiller. Therefore even small improvements are beneficial, reducing running costs. Its workload is governed by the difference between evaporator and condenser refrigerant pressure - in simple terms lower the differential pressure saves energy. We expect that the chiller plant will operate at full load and at design conditions, to suit the worse case scenario, a hot humid day in July. However 99% of the time the plant operates at a lower load, providing ample opportunities for energy conservation strategies.

For cooling towers, controlling the speed of the fan is an essential strategy, and ASHRAE 90 demands it. VFD (Variable Frequency Drive) speed control effectively lowers power needs saving money. The control philosophy must be designed from day one with energy efficiency in mind, operating multiple cooling towers simultaneously lowers chiller energy needs.

#### Save water

For retrofit projects, substituting electricity savings for water consumption is not sustainable solution. Since cooling towers don't demand potable water, harvesting rainwater is an effective method to provide make-up water and also lower your operating costs.

No article regarding cooling towers can overlook the Legionella. Cooling towers have been implicated in a number of high-profile outbreaks, and whilst the confines of this article preclude a detailed explanation of the risks, readers are reminded that compliance with relevant codes, including the HKCOP is recommended. In conclusion, cooling towers offer the best heat rejection solution for many larger applications, offering lower energy. Cooling tower problems can be avoided and or eliminated through rigours design, and operation protocols. Managing your towers effectively reduces your energy cost today and tomorrow.

#### 自動控制

在空調系統中，冷卻器是主要的耗電來源，所以即使是輕微改進，也有助減低營運成本。空調系統的荷載取決於蒸發器和冷卻器冷凍劑之間的壓力差，簡單來說，降低壓力差，便可節省能源。我們預期冷卻器將在設計狀況下滿載運作，以適應最惡劣的情況，即7月份炎熱潮濕的天氣。然而，冷卻器的荷載有99%的時間會低於峰值，因此我們有不少機會採取節省能源的策略。

對冷卻塔來說，控制風扇的速度是必要的策略，而ASHRAE 90更訂立這方面的規定。VFD（可變速驅動器）可有效減低電力需求，節省金錢。為能源效益著想，我們一開始便應落實控制速度的設計，多個冷卻塔同時操作，能降低冷卻器的能源需求。

#### 節約用水

對加裝項目來說，節省電力而非耗水量，並非長治久安之道。由於冷卻塔無需使用飲用水，故可收集雨水作為補給水，節省營運成本。

任何有關冷卻塔的文章，都不能不提退伍軍人症。多次備受矚目的退伍軍人症爆發，均涉及冷卻塔。雖然受篇幅所限，本文不能詳細解釋有關風險，但我們建議讀者遵守包括HKCOP在內的有關守則。總括而言，冷卻塔是大規模應用的最佳排熱方案，而且其能耗較低。我們可透過嚴格設計和營運規則，避免甚至消除冷卻塔的問題。有效地管理冷卻塔，將能減低今後的能源成本。