Cooling Tower Systems

Guidance for Energy Efficient Operation

by
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Contents

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Purpose

This guide is not intended to be comprehensive design manual or a text book; it is intended to provide a general overview of some of the main factors which influence energy efficient operation of cooling tower systems. The target audience for this guide could be developers and owners of cooling tower systems.

This guide will be distributed electronically free of charge.

About the Author

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Introduction

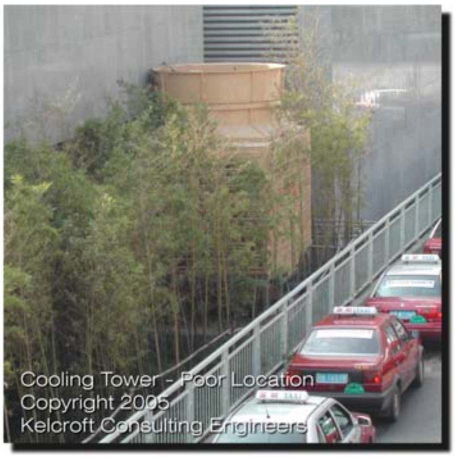
In 2000 the introduction of the pilot scheme for water cooled air conditioning in Hong Kong offered opportunities for building owners to lower their air conditioning operating costs through the application of cooling tower systems for commercial air conditioning systems. Cooling towers use less energy, lowering the operating cost they also benefit the environment; they create less noise, and the energy savings reducing emissions from power generators.

Fresh water cooling towers were prohibited in Hong Kong, and the knowledge and experience in the industry was lost. The result owners have reported new cooling tower systems have fail to meet their low energy expectations. To overcome this challenge this guide provides an overview of the primary factors that influence efficient operation of cooling towers systems.

Air Conditioning Basics

The air conditioning system for large commercial buildings, hospitals, etc. typically comprise central air conditioning system. A primary component, and energy user is the central chiller plant. Using chilled water it captures the heat energy from within the environment, transferring it to the condenser water system. In turn, the condenser water system rejects heat energy through cooling tower(s) to the atmosphere, returning cool water to the chiller for the cycle to be repeated.

To capitalise upon the inherent energy efficiency of cooling tower systems the condenser water, and cooling tower systems must be properly designed, operating correctly and regularly maintained. These systems need to incorporate the following features for effective energy



efficient operation.

There are several type of cooling towers, including open, closed circuit, and hybrid, each have different air flow options, for example natural, induced draft-type and counterflow.
Photo Above: An open type induced draught cooling tower very poorly located.

Cooling Tower Location

The positioning of every cooling tower is vital for efficient operation. The cooling tower must be installed in accordance with the manufacturer's recommended clearances, specifically to avoid short circuiting of the exhaust to the inlet, effectively lowering capacity. Ensure that the exhaust air cannot be re-entrained (short circuit) to the cooling tower intake.

Cooling tower intakes should not be installed near any source of pollution. For example gardens, shrubs, car parks, or the like. Furthermore the outlet must not discharge within thirty (30) metres of any fresh air intake.

It is important that the design includes safe lockable access, including fixed ladders, platforms, walkways and the like, to permit easy maintenance inspections.

Condenser Water System

A clean and properly maintained condenser water system is vital for energy efficient operation of cooling tower system.

Closed type cooling towers gained popularity because they have a separate the condenser water circuit thus preventing contamination of the condenser water circuit and heat exchanger.
Photo Above: Open type induced draught cooling tower, without filtration or blowdown is entirely blocked with mud Tower fill required complete replacement

Filtration

In operation cooling towers are efficient air cleaners; air passing through the cooling tower fill is not only cooled but also cleaned. The dirt and debris is entrained into the condenser water. Unchecked it accumulates in the cooling tower fill causing blockages, in the tower basin, and fouling heat exchanger surfaces and tubing.

Fine particulates easily pass through the standard HVAC strainer, and once the system is switched off, for example overnight, settle out forming sludge and mud. Additionally, the evaporation process decreases the water volume, increasing the concentration of sludge and mud collected to form solids, typically with the intricate pathways of the cooling tower fill.

Any contaminant, including sludge and mud, reduces the cooling tower effectiveness, impairing the capacity of the tower and the condenser heat exchanger. Once contaminated the heat exchanger must be dismantled for laborious cleaning.

Closed type cooling towers have a separate condenser water circuit thus preventing contamination of the condenser water system. If open type cooling towers are chosen then the system must be designed with an effective filtration system to remove this dirt and debris.

Pumps

Condenser water pumps connect to the chiller heat exchanger to the cooling tower basin. If the available static head (height of water) between the tower basin and pump inlet is limited no strainer shall be installed between the basin and pump.

Typically the condenser pump is rated as a constant speed pump, and typically sized at 3gpm/ton (0.0538 L/s per kW) the design condition. At non peak times of the year, the flow rate may be reduced, lowering pumping power consumed.

Water Treatment

Water treatment programs must be designed for three requirements:

1. Scale control
2. Protection of system components against corrosion; and
3. Control of biological contaminants, such as Legionella Pneumophila, the bacterium that causes Legionnaires' disease.

The first two help to ensure energy efficiency and longevity of the cooling system, while the third ensures safe operation. Cooling tower systems are a known source for the Legionella bacterium, the causative agent of Legionnaires Disease. As recognised by the EMSD pilot scheme, all cooling tower systems must be fitted with an effective chemical dosing system, to mitigate the risk of infection associated with this equipment. ASHRAE has published Guideline 12-2000, Minimizing the Risk of Legionellosis Associated with Building Water Systems.

In wet areas that are exposed to sunlight, algae and slime grow, unchecked they provide an excellent breeding ground for Legionella bacteria to grow and flourish; chemical water treatment solutions are required.

During the heat rejection process, some water is lost to the environment through evaporation; this is replaced with the make-up from the tank. To prevent wastage of water treatment chemicals the dosing and introduction of fresh water must be monitored and regulated.

Water contains various dissolved solids, and salts. Of particular importance for cooling tower installation is the calcium content, more commonly known as its hardness. As cooling towers operate evaporation occurs, this increases the concentration of any water constituent. Therefore the water treatment system needs to counter the increasing salt content to prevent formation of calcium deposits on the heat exchanger lowering efficiency.

Cycles of Concentration (CoC) is the technical term used to describe the maximum permitted concentration of a constituent permitted in the condenser water system before the concentrate is discharged to waste. To accomplish this, when the limit of concentration is reached a blowdown valve (also known as Bleed) is opened, discharging condenser water to drain and lowering the concentration.

Strainers

Typically Y-type HVAC strainers are always fitted to water circulation systems pump inlet, primarily to prevent damage to the pump seal. However, cooling tower / condenser water systems are different, strainers must be fitted after the pump because there is low static pump head, will leads to cavitation and early pump failure. Additionally, as a result of the towers air cleaning effect, the condenser circuit strainers require frequent access for inspection and cleaning. Bucket or basket type strainers with a quick release mechanism, provides easy access from above, encouraging regular maintenance.

Photo Above: Y-type HVAC strainer incorrectly located on the suction side of pump.

Control Logic

The control philosophy dictates how the combined chiller, condenser water, and cooling towers systems operate. It is often overlooked that how a system operates at the design condition (100% load) is not a sensible indication of the overall annual performance.

The control logic dictates how the systems operate together, and is used to optimize chiller, cooling tower and condenser pump system performance throughout the year.

Condenser Relief

It is expected that the chiller plant operates at full load and at design parameters only at design conditions.

During other periods (99% of the time), we expect the chiller plant to operate at less than design load, which provides an opportunity for condenser water relief strategy. Basically it means that the condenser water temperature can be lowered because the cooling tower is no longer at 100% capacity and the ambient wet bulb is not at design condition. Lowering the condenser water temperature can provide significant chiller energy savings.

Multiple Cooling Towers

The majority of the electrical power consumed by air conditioning systems is used in the chiller. Therefore even small improvements are beneficial, reducing running costs. The heart of the chiller is the compressor. Its workload is governed by the difference between evaporator refrigerant and condenser refrigerant pressure - reduce the differential pressure lowers power consumption and saves energy.

The condenser water system and the automatic control philosophy must be designed with energy efficiency in mind, operating multiple cooling towers simultaneously lowers the differential pressure, and that lowers the power consumed, saving energy.

Cooling towers have mechanical ventilation fans to move the air through the tower; these motors should be fitted with variable frequent drives, or alternately two speed motors.

Measurement and Verification (M&V)

Investors are often concerned that the promised energy savings are actually achieved. One tool to assist is independent Measurement and Verification (M&V). M&V is commonly employed on energy service contracts to verify that the promised savings have been achieved, and many be applied for cooling tower installations.

It is important to note that accurate M&V requires comprehensive energy metering instrumentation to be installed. However, it is often overlooked in the drive for lowest first cost bidding, moreover value engineered out in the drive to lower first costs. If you can't measure it - how can you manage it?

Conclusions

Cooling towers offer building owners opportunities to reduce energy consumption compared to air cooled chillers, lowering the energy cost and the associated power station emissions. This guide highlights some of the major opportunities to minimise energy consumption, without affecting the standard or quality of service.

For more information regarding cooling tower installations visit:

http://www.kelcroft.com.hk/cooling-towers.htm

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