HVAC COOLING TOWER & CONDENSERS – ESSENTIAL TIPS & THUMB RULES

Struggling to choose the right heat rejection equipment for your HVAC system? Look no further! This course provides everything you need, from basics to best practices for cooling towers and air-cooled condensers.

In this 8-hour comprehensive course, you will gain a deep understanding of heat rejection principles, design tips, and operational strategies that will boost performance, cut energy costs, and enhance system reliability. You'll learn how to size and select cooling towers and condensers that align with industry standards and regulations. Additionally, you'll gain essential insights into water treatment, with techniques for managing corrosion, scaling, and microbial growth.

This course includes several metrics and easy-to-understand "Rules of Thumb" guidelines based on experience and commonly accepted practices in the HVAC industry.

You can find **Key Rules of Thumb in Annexure - 1** for quick and easy reference. These guidelines, metrics, and thumb rules are based on sound engineering practices and the author's experience, but they may vary depending on operating conditions and other factors. This document is a live resource that will be updated regularly as new information becomes available.

Read to explore heat rejection principles, design strategies, and options? Let's get started!

Important Note: We have covered the essentials of the chilled water system, focusing on refrigeration chillers (Module #8) and the hydronic distribution network (Module #9) in the HVAC Hacks series. Now, Module #10 will delve into the heat rejection system. By building on what you learned in Modules #8 and #9, you'll gain a comprehensive understanding of chilled water system design for large, centralized HVAC applications.

CHAPTER - 1: HEAT REJECTION OVERVIEW

In a chilled water system, the chiller acts as the heart, removing heat from water and lowering its temperature for building cooling. The figure below illustrates a typical chiller refrigeration cycle, which includes four main components: the compressor, condenser, metering device, and evaporator. The refrigerant serves as the working fluid within the chiller, absorbing heat from the chilled water loop and rejecting it to the heat rejection loop.

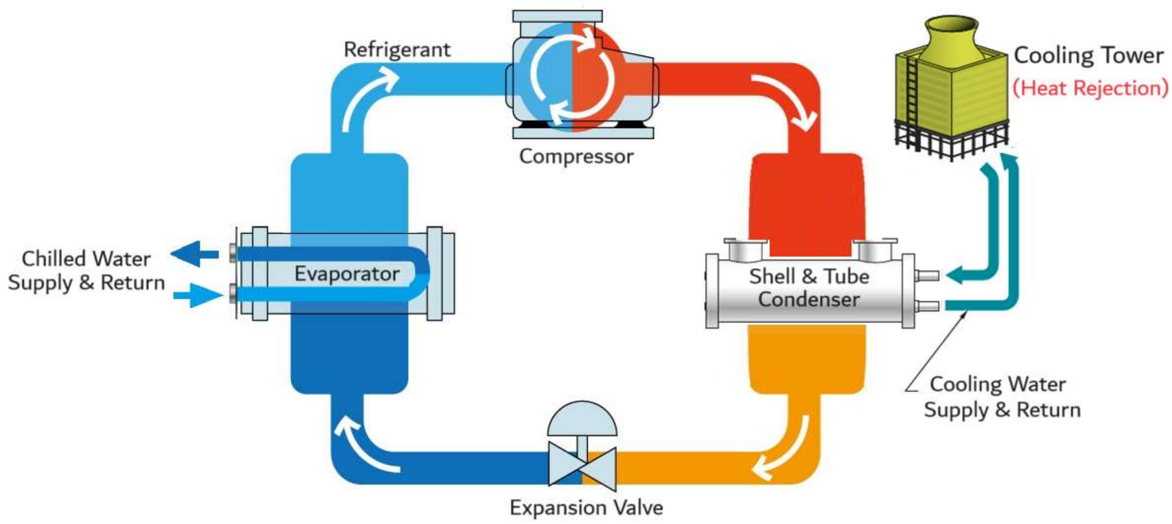

Figure 1. Water-Cooled Chiller Schematic

Let's revisit the fundamental principles of the refrigeration cycle to refresh our understanding.

1.1 Refrigeration Cycle Loop

The refrigeration cycle operates through four essential stages: evaporation, compression, condensation, and expansion. Each stage plays a critical role in facilitating heat transfer and maintaining the desired cooling effect. The following table provides a summary of these four stages, describing the processes involved and the changes in the refrigerant's state at each phase. Together, these stages form a continuous loop that drives the refrigeration process, ensuring efficient cooling in HVAC systems.

Table 1. Refrigeration Cycle Overview

	Stage	Process	State Change
	Evaporation	Absorbs heat from chilled water in the evaporator.	Liquid to Gas

	Stage	Process	State Change
👍	Compression	Compressor increases refrigerant pressure and temperature.	Gas
👍	Condensation	Refrigerant releases heat to surroundings in the condenser.	Gas to Liquid
👍	Expansion	Expansion valve reduces refrigerant pressure and temperature.	Liquid

Refer to the schematic below for a visual representation of the refrigeration cycle for an air-cooled chiller.

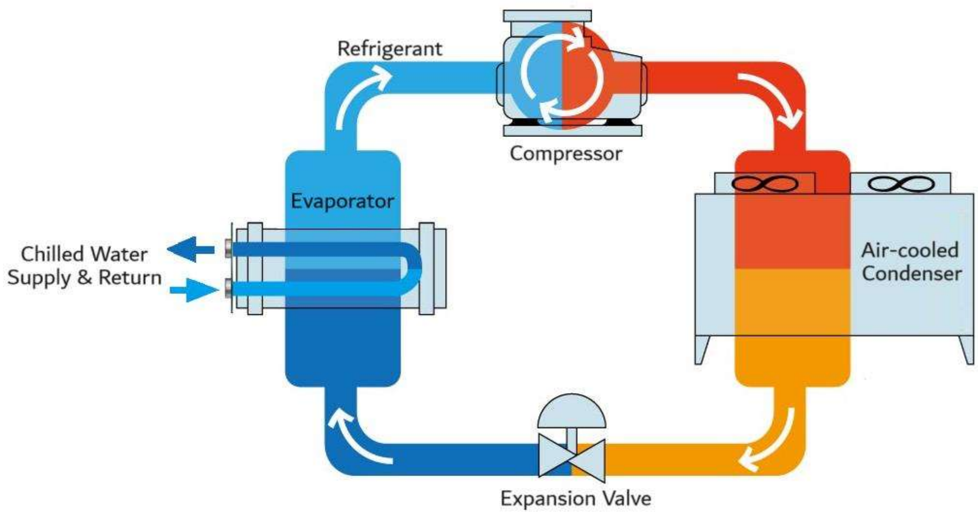

Figure 2. Air-Cooled Chiller Schematic

Efficient condenser heat rejection is crucial for refrigeration cycle performance. Inadequate cooling leads to higher energy use, reduced cooling, and equipment damage. The condenser dissipates heat absorbed by the refrigerant using air or water. We'll discuss both these methods in this course.

1.2 Water-Cooled Chillers

Water-cooled chillers use water as the cooling medium for heat rejection. These work by transferring heat from the refrigerant to the water in a shell & tube type condenser. A cooling tower is the unit in a water-cooled system that rejects the condenser water heat into the atmosphere. This type of chiller is commonly used in large-scale HVAC systems and industrial processes where a large amount of heat needs to be removed. The figure below illustrates a typical chiller operation, featuring four distinct heat transfer loops or subsystems along with their approximate design temperatures. While all four loops are essential, the heat rejection system is represented by the loop on the far right (red color).

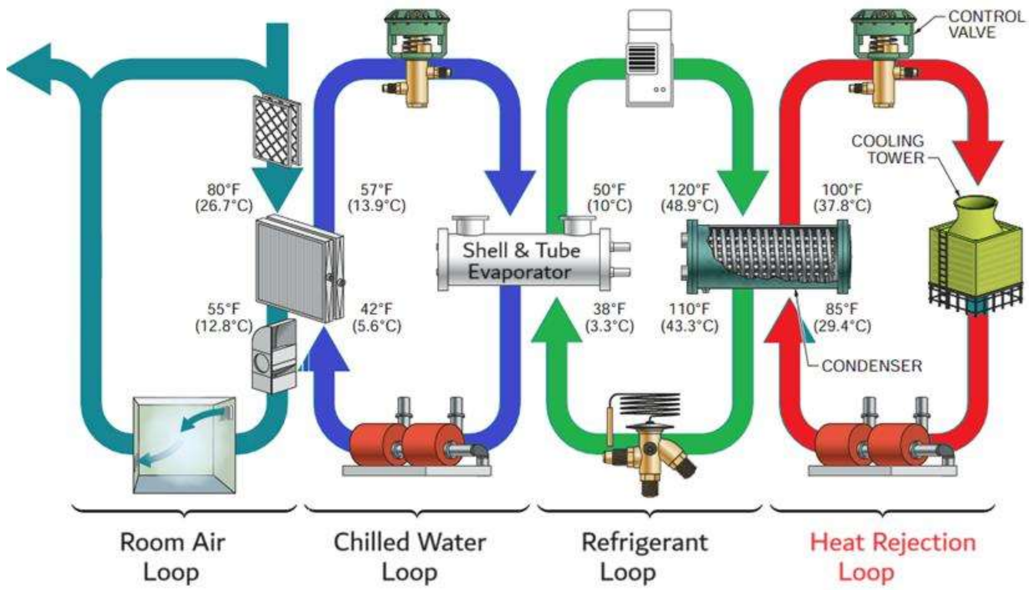

Figure 3. Typical Chiller System Heat Transfer Loops

Table 2. Heat Transfer Components of Water-Cooled Chiller

	Components	Function
	Condenser	Cools refrigerant by releasing heat to water, which is then sent to the cooling tower.
	Cooling Tower	Expels heat from the water to the atmosphere, cooling it before recirculation.
	Condenser Water Pump	Circulates water between condenser and cooling tower.
	Expansion Valve	Regulates refrigerant flow into evaporator.
	Evaporator	Cools water by absorbing heat from water that needs to be chilled.

Advantages

a. Higher Efficiency: Generally, more efficient than air-cooled systems, especially in larger installations.
b. Lower Operating Costs: Reduced energy consumption for heat rejection compared to air-cooled chillers.

Disadvantages

a. Higher Initial Cost: More complex and costly to install due to additional components like the cooling tower and associated piping.
b. Water Usage: Requires a consistent water supply and management of water treatment.
c. Maintenance: More maintenance is needed due to the additional equipment.

1.3 Air-Cooled Chillers

Air-cooled chillers work by transferring heat from the refrigerant to the surrounding air. They utilize fans to blow outside air over a finned-tube heat exchanger, with the refrigerant flowing through the tubes and the air passing over the fins. As the air moves over the fins, it absorbs the heat from the refrigerant, causing the refrigerant to condense and release heat to the surroundings. For air-cooled chillers, there is no need for cooling towers, condenser water pumps, blow down or make up water system, water treatment system and the likes. Refer to the schematic arrangement below:

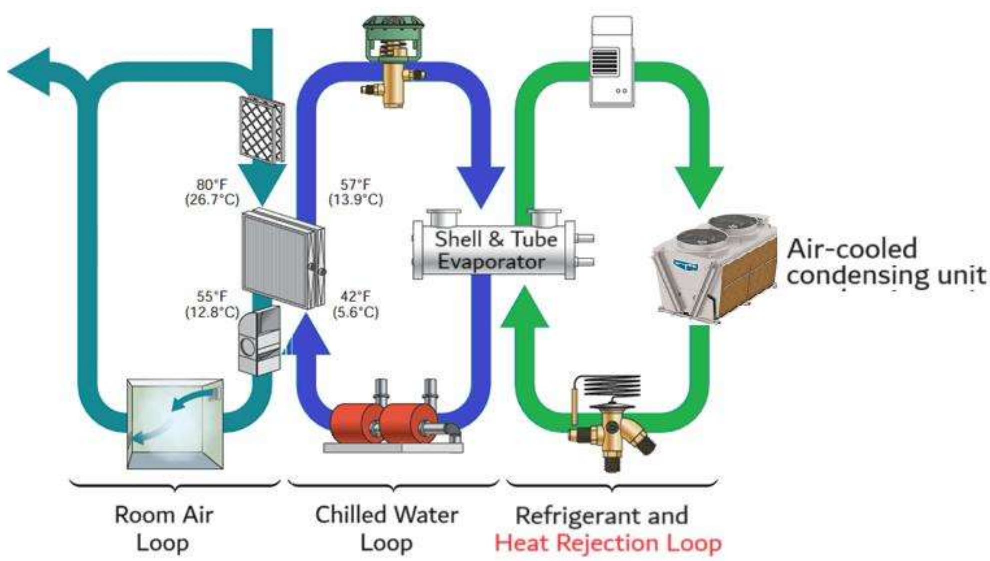

Figure 4. Typical Air-cooled Chiller System Heat Transfer Loops

Air-cooled chillers can be configured in two ways:

a. Split System: The compressor and condenser are separate units.
b. Packaged Unit: The compressor and condenser are housed together in a single casing. In this common arrangement, it is called condensing unit.

Air-cooled condensers are ideal for areas where water resources are limited or where water conservation is a priority. However, they require careful consideration of factors such as airflow, ambient temperature, and refrigerant type to achieve optimal performance.

Table 3. Heat Transfer Components of Air-Cooled Chiller

	Component	Function
	Condenser	Cools refrigerant by releasing heat to ambient air, expelled by fans.
	Fans	Circulate air over the condenser coils to remove heat from the refrigerant.
	Expansion Valve	Regulates refrigerant flow into evaporator.
	Evaporator	Cools water by absorbing heat from water that needs to be chilled.

Advantages

a. Lower Initial Cost: Simpler and cheaper to install as they do not require a cooling tower, extensive piping and associated water treatment equipment.
b. No Water: No need for a water supply or water treatment, making it suitable for locations with water scarcity.
c. Performance: Excellent in humid climates where evaporative cooling towers are not much effective.
d. Easier Maintenance: Generally easier to maintain due to the fewer components.

Disadvantages

a. Lower Efficiency: Air- cooled chillers tend to be less efficient, particularly in hot climates, as their performance relies heavily on cooler ambient air temperatures.
b. Higher Operating Costs: More energy is required for heat rejection due to ambient temperature fluctuations.
c. Performance Sensitivity: In hot climates, high ambient air temperature can affect heat removal and performance. Additional derating factor and chiller oversizing may be needed.

Key Takeaways….

Proper heat rejection is crucial for chiller efficiency. Water-cooled chillers with cooling towers are generally more efficient but require higher initial costs and maintenance. Air-cooled chillers offer simpler operation but are less efficient. The best choice depends on factors like climate, space, and water availability. We'll explore these systems in detail.

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