Turn to the Experts.℠

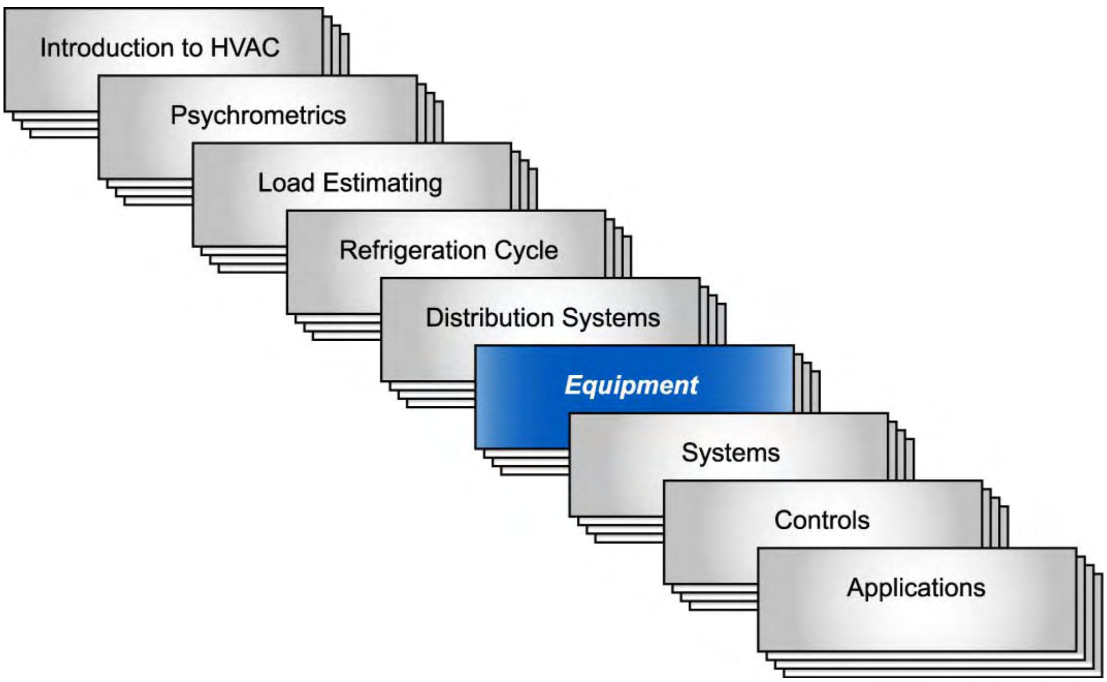
COMMERCIAL HVAC CHILLER EQUIPMENT

Air-Cooled Chillers

Technical Development Program

Technical Development Programs (TDP) are modules of technical training on HVAC theory, system design, equipment selection and application topics. They are targeted at engineers and designers who wish to develop their knowledge in this field to effectively design, specify, sell or apply HVAC equipment in commercial applications.

Although TDP topics have been developed as stand-alone modules, there are logical groupings of topics. The modules within each group begin at an introductory level and progress to advanced levels. The breadth of this offering allows for customization into a complete HVAC curriculum – from a complete HVAC design course at an introductory-level or to an advanced-level design course. Advanced-level modules assume prerequisite knowledge and do not review basic concepts.



Chillers are used in a variety of air-conditioning and process cooling applications. Air-cooled chillers can be used as a single piece unit or a split in various configurations. This flexibility has contributed to their overall popularity among designers of chilled-water systems. Air-cooled chillers range in size from small capacity models to several hundred-ton models that are utilized to cool large commercial buildings. This TDP module will cover both packaged single piece air-cooled chillers as well as split system types. This TDP module will also cover the available options and accessories, the applications, as well as criteria for selecting an air-cooled chiller.

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Introduction

Air-cooled chillers utilize the mechanical refrigeration cycle to produce chilled water or a chilled water and antifreeze mixture. They reject the building heat to the ambient with an air-cooled condensing coil. Chillers are the heart of the chilled-water air-conditioning system since they serve the pivotal function of creating the cooling effect required to maintain comfort conditions.

Chillers are used in a variety of comfort air-conditioning and process cooling applications. The chilled liquid is transported by pumps and pipes that can be connected to literally hundreds of room fan coils and terminals. This allows chillers to be applied on applications requiring many zones of control.

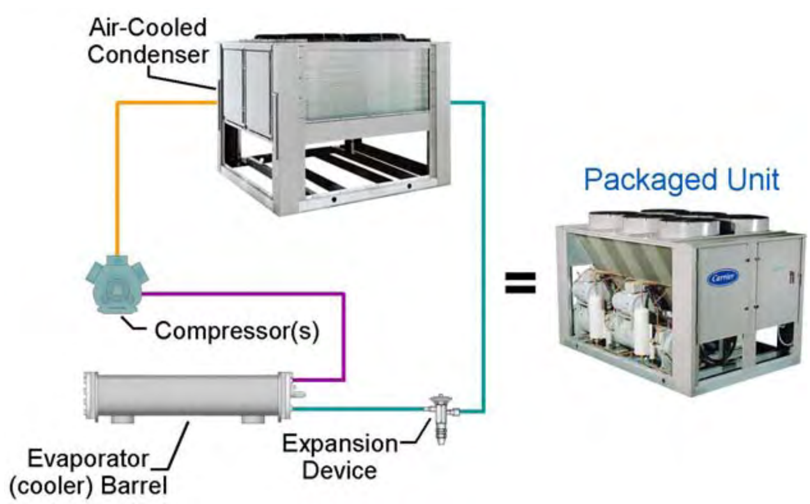

Figure 1

Air-Cooled Chiller Package

Air-cooled chillers are common in modern systems and have been growing in popularity since the 1980s, nearly doubling in the last ten years. Today, air-cooled chillers are applied on small to large commercial jobs and can be used in multiples to form systems reaching several thousand tons of installed capacity.

The popularity is primarily due to the all-inclusive nature of air-cooled chillers and the reduction of costs associated with eliminating cooling tower. On some models, even the hydronic accessories, such as the pump and expansion tank, may be included, assembled, and tested from the factory ready to begin operation.

Typical air-cooled chiller applications include schools, hospitals, retail environment, and offices. Additionally, air-cooled chillers are popular for cooling process or manufacturing operations.

This TDP will cover packaged single-piece, as well as split system air-cooled chillers. To learn more about water-cooled chillers, refer to TDP-623, Water-Cooled Chillers.

Air-Cooled versus Water-Cooled Chillers

A differentiating feature of the types of chillers is the method used to condense the refrigerant as it leaves the compressor. The two methods involve using either air-cooled or water-cooled condensers. Air-cooled condensers employ ambient air as the condensing medium and use a fan to move the air over the coil. For a given surface and airflow rate, the capacity of an air-cooled condenser varies with the refrigerant condensing temperature, which is a function of the entering dry-bulb temperature. Shown in Figure 2 is a typical air-cooled condensing temperature based on 95º F dry bulb ambient air.

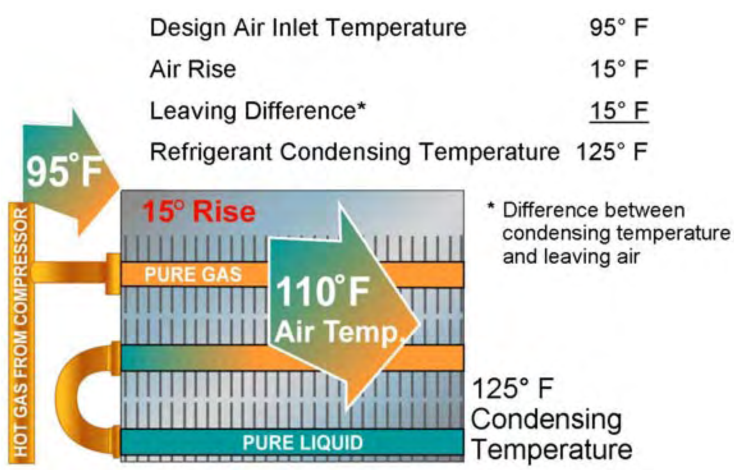

Figure 2

Air-Cooled Condensing Temperature

Water-cooled condensers employ water as the condensing medium and use a pump to circulate the water through the condenser and out to a cooling tower that rejects the heat to the atmosphere.

Operating cost is one of the primary factors when deciding between air-cooled or water-cooled chillers. Air-cooled chiller systems typically have a lower first and maintenance cost since they do not require a cooling tower, condenser water pumps, and associated condenser water chemical treatment. Operating costs, however, generally favor water-cooled chillers. This is because water-cooled chillers can take advantage of lower condensing temperatures than air-cooled chillers.

Air-cooled chillers have a full load kW/ton of approximately 1.25 while water-cooled chillers have a full load kW/ton of between 0.55 and 0.8 kW/ton. The kW draw of the cooling tower fans and condenser water pump should be added to the water-cooled chiller kW/ton for an even comparison. Even after accounting for this added auxiliary energy draw, water-cooled chilled-water systems normally have an efficiency advantage over air-cooled.

Figure 3

Air-Cooled vs. Water-Cooled Chiller Benefits

Air-cooled chillers

are typically available as a package ranging up to 500 tons, while packaged water-cooled chillers are typically available up to 3,000 tons. Some custom water-cooled chillers go even higher in capacity.

Air-cooled chillers eliminate the concerns and maintenance requirements associated with condenser water treatment, condenser-tube cleaning, cooling tower service, tower freeze protection, and the availability and quality of makeup water. This reduced maintenance requirement is particularly attractive to building owners because it can reduce overall costs. Water-cooled chillers must have a condenser water treatment program to eliminate contaminants such as bacteria and algae growth. Fouled condenser tubes, not uncommon with water-cooled chilled-water systems, can also reduce chiller efficiency.

Air-cooled chillers are often selected for use in systems that require year-round mechanical cooling requirements. Air-cooled condensers have the ability to operate in below-freezing weather, and can do so without the freeze protection issues associated with operating the cooling tower in these conditions. Cooling towers often require a basin heater, or even an indoor sump, for safe operation in freezing weather. For process applications, such as computer centers that require cooling year-round, air-cooled chillers have a distinct advantage over their water-cooled counterpart.

Note:

The primary convenience of an air-cooled chiller is that it does not require a cooling tower, condenser water pump, and the associated maintenance.

Figure 4

Condenser water systems are not required with air-cooled chillers.

Basic Refrigeration Cycle for Air-Cooled Chillers

The refrigeration cycle of an air-cooled chiller includes two important processes:

1. The evaporation of the liquid refrigerant in the evaporator, which absorbs heat and lowers the temperature of the chilled-water system
2. The condensation of the refrigerant vapor in the air-cooled condenser and rejection of heat to the atmosphere

In the air-cooled chiller refrigeration cycle, water enters the evaporator (also known as the cooler) and is cooled by the colder refrigerant flowing through the other circuit inside the evaporator. The chilled water is pumped from the chiller to the building coils to provide cooling. In the evaporator, the chilled water cools the building or process load and the cycle is completed when warmer water flows back to the evaporator. A mixture of cold liquid refrigerant and flash gas passes through the evaporator circuit opposite the water to be chilled.

The refrigerant in the evaporator absorbs heat from the warmer return water, evaporates to a vapor, and finally exits the evaporator as a superheated vapor. The superheated refrigerant vapor then enters the suction inlet of the compressor. In the compressor, the refrigerant is compressed, raising its pressure and temperature. High pressure and temperature refrigerant gas exits the compressor, passes through the discharge line and enters the condenser. While in the air-cooled condenser coil, the hot gas condenses to liquid inside the tubes as it gives up heat to the cooler outside air being drawn across the condenser coil by the condenser fans.

The refrigerant

is on the shell side of some evaporator designs and on the tube side of others. When the refrigerant is on the tube side, the evaporator is called a DX evaporator; when on the shell side, it is a flooded cooler.

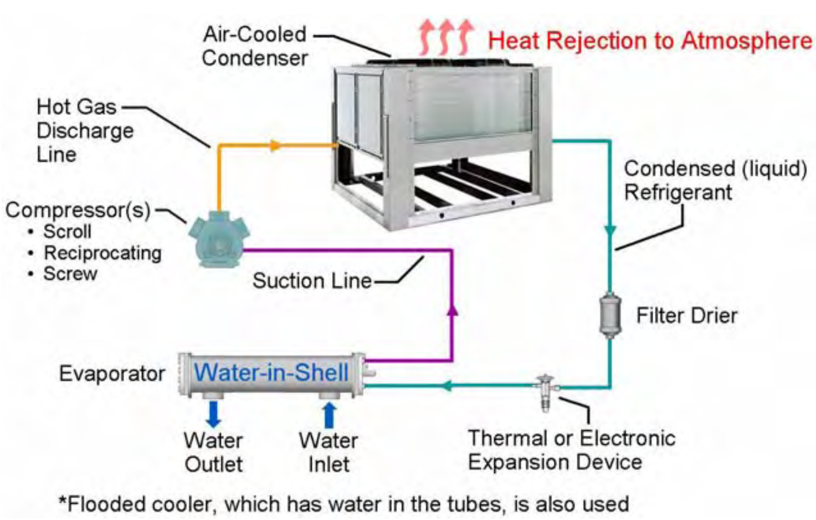

Figure 5

Refrigeration Cycle Components of an Air-Cooled Chiller

The condensed liquid refrigerant then leaves the condenser and enters the expansion device. As the refrigerant passes through the expansion device, its pressure and temperature is decreased to the point that some of the liquid flashes to vapor. The expansion device controls the amount of flashing in order to maintain a certain superheat to ensure no liquid droplets enter into the compressor suction. After leaving the expansion device, the refrigerant enters the evaporator and the cycle is repeated.