Selection Tips for Air-Conditioning Systems

An Online Continuing Education Course for Engineers

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Selection Tips for Air Conditioning Systems

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Air conditioning is a combined process that performs many functions simultaneously. It conditions the air; provides heating and cooling; controls and maintains the temperature and humidity; and ensures air movement, air cleanliness, sound level, and pressure differential in a space within predetermined limits for the comfort and health of the occupants. A cooling system is a part of a heating, ventilation, and air-conditioning (HVAC) system that provides space cooling.

This course discusses the characteristics of an ideal cooling system for diverse applications.

The course is divided in three parts:

Part I Description of Cooling Systems
Part II Key Factors in Selection of Cooling Systems
Part III Key Factors Determining Heat Rejection Systems

PART I: DESCRIPTION OF COOLING SYSTEMS

There are literally hundreds of ways in which basic HVAC components may be assembled into systems, but there are **two** basic configurations in which the refrigerant cycle is applied. Both have to do with how the "cooling effect" is supplied to the desired location. Direct expansion type or DX type is the first configuration, where the air is directly cooled from the refrigerant; therefore, the cooling coil is filled with refrigerant. These cooling systems are widely used in small to medium sized buildings. For larger and more complex applications, a secondary cooling medium is used to deliver cooling to one or more locations. This is accomplished by utilizing the chiller to cool the water, which in turn is pumped to the cooling coil(s). The heat flow path is from the space to the chilled water to the refrigerant to the atmosphere.

Direct Expansion (DX) systems

In direct expansion (DX) systems, the air is cooled with direct exchange of heat, with refrigerant passing through the tubes of the finned cooling coil. A basic DX system is comprised of a hermetic sealed or open compressor/s, evaporator (cooling coil fabricated out of copper tubes and aluminum fins), a supply air blower, a filter, a condenser, and a heat rejection propeller fan. The term "expansion" refers to the method used to introduce the refrigerant into the cooling coil. The liquid refrigerant passes through an expansion device (usually a valve) just before entering the cooling coil (the evaporator). This expansion device reduces the pressure and temperature of the refrigerant to the point where it is colder than the air passing through the coil. Figure 1 shows the schematic of a typical DX air conditioning system.

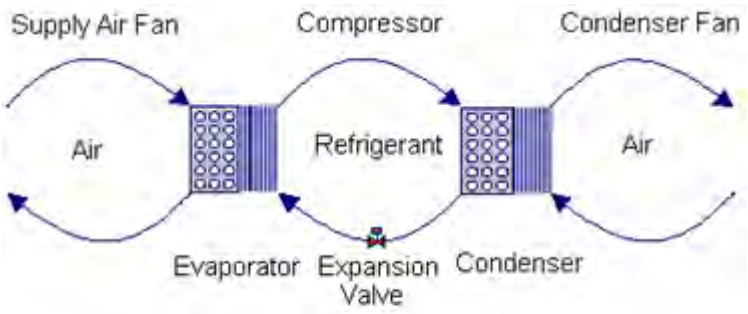

FIGURE - 1
DX SYSTEM

In this schematic, the heat is extracted from the space and expelled to the outdoors (left to right) through 3 loops of heat transfer.

- In the leftmost loop, a supply air fan drives the indoor air across the evaporator, where it transfers its heat to the liquid refrigerant. The resultant cooled air is thrown back to the indoor space. The liquid refrigerant is vaporized in the tubes of the evaporator.
- In the middle loop, a refrigeration compressor drives the vapor refrigerant from evaporator to the condenser back to the evaporator as a liquid refrigerant. The cycle continues in closed loop copper tubing.
- In the rightmost loop, a condenser air fan drives the ambient air across the condenser, where it transfers the heat of the refrigerant to the outdoors. The refrigerant is cooled and liquefied after expanding through an expansion valve located between the condenser and the evaporator.

The most common types of DX systems are also referred as “unitary” air conditioning systems. These are factory assembled, self-contained units commonly sold as "off the shelf" package units of varying capacities and types. Each package consists of refrigeration and/or heating units with fans, filters, and controls. Depending upon the requirement, these are available in the form of room air conditioners, split air conditioners, heat pumps, and ductable systems with air cooled or water cooled condensing options.

In the split system, the condensing unit comprised of the condenser, compressor, and condenser fan with motor are located outside, while the indoor unit consisting of the evaporator, evaporator fan with motor, expansion valve, and air filter is located inside the conditioned room. The indoor and outdoor units are connected by refrigerant piping. Flexibility is the overriding advantage of a split system. Because a split system is connected through a custom designed refrigerant piping system, the engineer has a large variety of possible solutions available to meet the architectural and physical requirements, particularly for buildings with indoor and/or outdoor space constraints.

DX systems operating in reverse cycle are called heat pumps. Through the addition of a special 4-way reversing valve, heat flow in a mechanical refrigeration loop can be reversed so that heat is extracted from outside air and rejected into the building. Heat pumps provide both heating and cooling from the same unit, and due to the added heat of compression, the efficiency of the heat pump in heating mode is **higher** when compared to the cooling cycle.

Types

Unitary DX systems come in two types:

1. Room air conditioners
2. Package type conditioners

Room air conditioners provide cooling to rooms rather than to the building. These provide cooling only when and where needed, and are less expensive to operate. These units are normally mounted either in the window sill or through the wall. For rooms that do not have external windows or walls, a split type room air conditioner can be used.

In the room air conditioners (both window mounted and split type), the cooling capacity is controlled by the on-and-off switching of the compressor. Sometimes, in addition to the on-and-off, the fan speed can also be regulated to have a modular control of capacity. It is also possible to switch off the refrigeration system completely and run only the blower for air circulation. Both the split type air conditioner and room air conditioners are equally reliable, but it is not possible to provide fresh air in split air conditioners. Room air conditioners generally have small dampers for letting in fresh air.

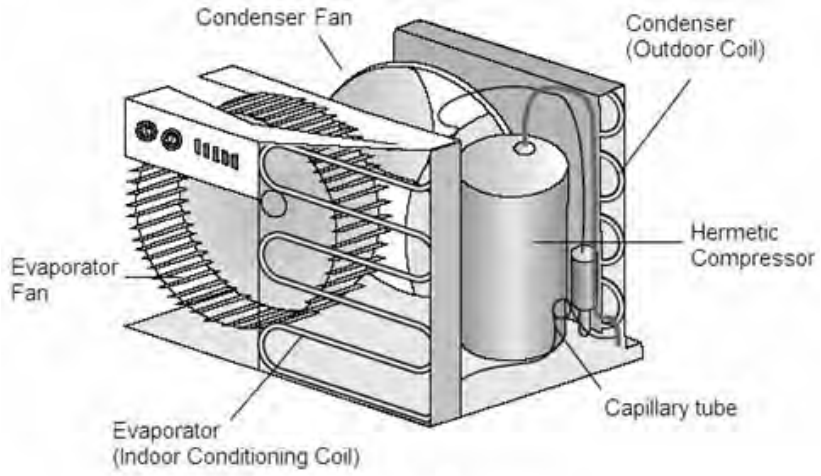

FIGURE - 2
TYPICAL ROOM AIR CONDITIONER

Room air conditioners are generally available in capacities varying from about 0.5 TR to 3 TR*.

Note: **TR*** stands for Ton of Refrigeration, and is defined as the ability of the air-conditioning equipment to extract heat. 1TR is equal to a heat extraction rate of 12000 Btu/h. Each building is different, and the design conditions differ greatly between region to region.

Packaged air conditioning systems are available in capacities ranging from about 5 TR to up to about 100 TR. This type of system can be used for providing air conditioning in a large room, or it can cater to several small rooms with suitable supply and return ducts. It is also possible to house the entire refrigeration in a single package, and may also include heating coils along with the evaporator. The condenser used in these systems could be either air cooled or water cooled. Figure 3 shows a packaged air-conditioning water cooled unit designed to operate with dual compressors.

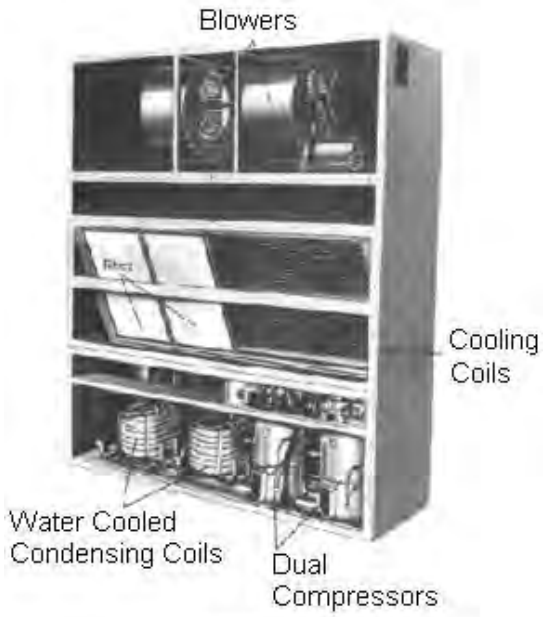

FIGURE - 3
PACKAGED AIR CONDITIONER UNITS

Smaller room air conditioners (i.e., those drawing less than 7.5 amps of electricity) can be plugged into any 15- or 20-amp, 115-volt household circuit that is not shared with any other major appliances. Larger room air conditioners (i.e., those drawing more than 7.5 amps) need a dedicated 230-volt circuit.

On hotter and humid regions the cooling requirement may be as high as 150 sq-ft/TR, and in cooler places it could be as low as 500 sq-ft/TR. For comfort applications, it is reasonable to assume a figure of 250 sq-ft/TR as a rough estimate in the absence of heat load calculations.

The overall cost for a packaged system can be as low as $10 per square foot (installed cost, including ductwork and controls.) The cost of the unit alone ranges from about $1,500 for a 2-ton unit to around $2,000 for a 5-ton unit. High efficiency package units (when available) cost about 10% more than standard efficiency models.

Ductless or Ducted Units

Small capacity individual room air conditioning systems are essentially ductless, while larger package units use ductwork for air distribution. Ductless systems are fundamentally different from ducted systems in that heat is transferred to the space directly by circulating refrigerant to evaporators located in the conditioned space. In contrast, ducted systems transfer heat to the conditioned space by circulating the air in ducted systems.

A standard DX system has a 400 cfm (cubic feet per minute) supply air flow rate per ton of cooling capacity. Therefore, larger tonnage units will need ductwork to carry the air.

Water Cooled

Refrigeration systems can be cooled by two methods. One method is air cooling, where the refrigerant is circulated through finned tube coils. The second method is water cooling, where the refrigerant is re-circulated through a cooling tower. The cooling tower is used to cool the condensers. Most DX systems use air-cooled condensers. Most larger packaged air conditioners may use water cooled condensers.

The economics of a water cooled system versus an air cooled system can be summarized as follows:

- At peak load conditions, air cooled machines consume over 30% more power than water cooled units.
- Compressor capacity drops by over 10% for air cooled machines compared to water cooled.
- The paucity of good quality soft water makes it imperative to opt for air cooled systems in most installations.
- The air cooled condenser have to be generally kept very close to the evaporator units. For smaller sized equipment, the length should be 30 to 40 feet, whereas for larger systems, it may go up to 3 to 4 times this figure. In the case of water cooled equipment, the cooling tower, which is the final heat rejection point, may virtually be placed at any distance from the cooling equipment.

Part III of this course addresses this topic in detail.