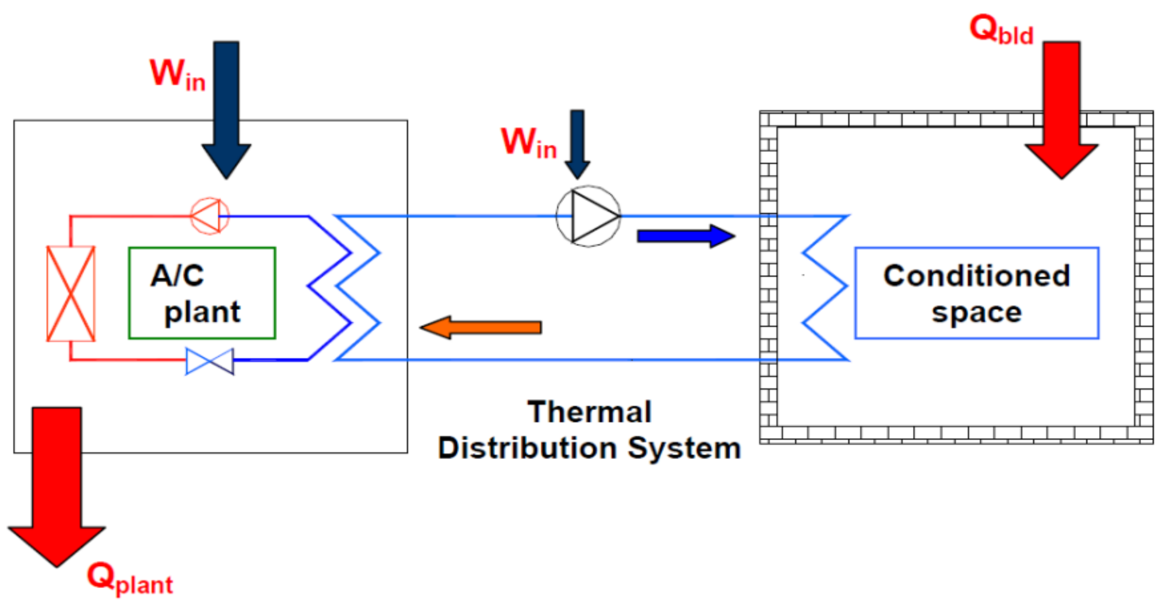
AIR CONDITIONING AND VENTILATION

INTRODUCTION:

In order to maintain required conditions inside the conditioned space, energy has to be either supplied or extracted from the conditioned space. The energy in the form of sensible as well as latent heat has to be supplied to the space in winter and extracted from the conditioned space in case of summer. An air conditioning system consists of an air conditioning plant and a thermal distribution system as shown in Fig below, the air conditioning (A/C) plant acts either as a heat source (in case of winter systems) or as a heat sink (in case of summer systems). Air, water or refrigerant are used as media for transferring energy from the air conditioning plant to the conditioned space. A thermal distribution system is required to circulate the media between the conditioned space and the A/C plant. Another important function of the thermal distribution system is to introduce the required amount of fresh air into the conditioned space so that the required Indoor Air Quality (IAQ) can be maintained.



Schematic of a summer air conditioning system with the thermal distribution system

SELECTION CRITERIA FOR AIR CONDITIONING SYSTEMS:

Selection of a suitable air conditioning system depends on:

1. Capacity, performance and spatial requirements
2. Initial and running costs
3. Required system reliability and flexibility
4. Maintainability
5. Architectural constraints

The relative importance of the above factors varies from building owner to owner and may vary from project to project. The typical space requirement for large air conditioning systems may vary from about 4 percent to about 9 percent of the gross building area, depending upon the type of the system. Normally based on the selection criteria, the choice is narrowed down to 2 to 3 systems, out of which one will be selected finally.

CLASSIFICATION OF AIR CONDITIONING SYSTEMS:

Based on the fluid media used in the thermal distribution system, air conditioning systems can be classified as:

1. All air systems
2. All water systems
3. Air- water systems
4. Unitary refrigerant based systems

All air systems:

As the name implies, in an all air system air is used as the media that transports energy from the conditioned space to the A/C plant. In these systems air is processed in the A/C plant and this processed air is then conveyed to the conditioned space through insulated ducts using blowers and fans. This air extracts (or supplies in case of winter) the required amount of sensible and latent heat from the conditioned space. The return air from the conditioned space is conveyed back to the plant, where it again undergoes the required processing thus completing the cycle. No additional processing of air is required in the conditioned space. All air systems can be further classified into:

1. Single duct systems, or
2. Dual duct systems

The single duct systems can provide either cooling or heating using the same duct, but not both heating and cooling simultaneously. These systems can be further classified into:

1. Constant volume, single zone systems
2. Constant volume, multiple zone systems
3. Variable volume systems

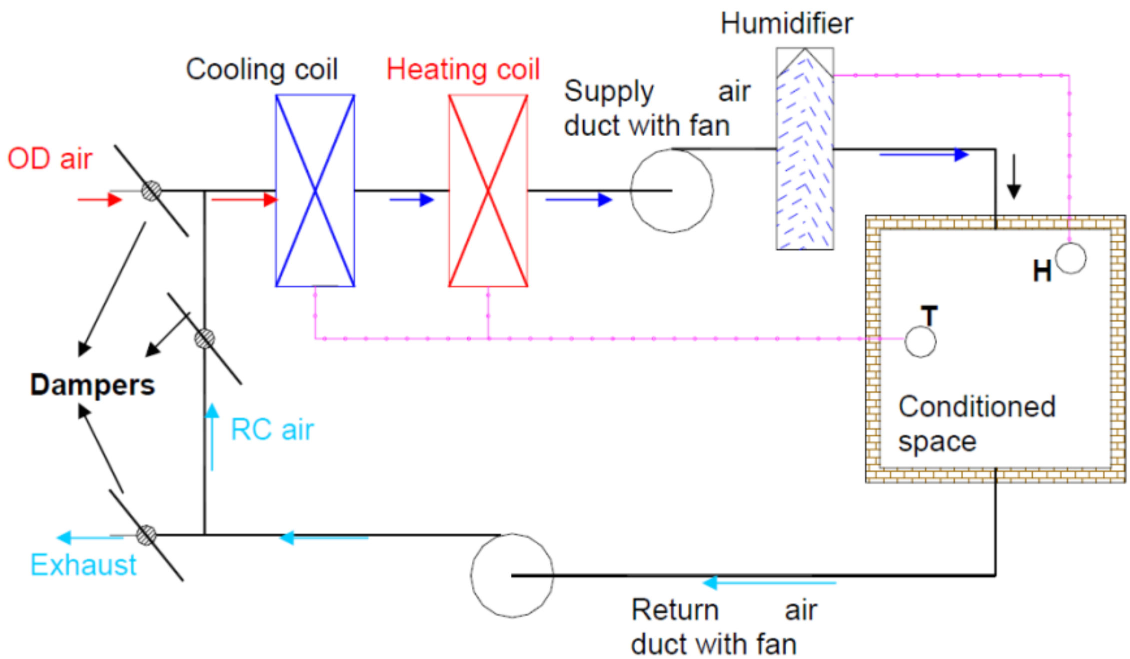
The dual duct systems can provide both cooling and heating simultaneously. These systems can be further classified into:

1. Dual duct, constant volume systems
2. Dual duct variable volume systems

Single duct, constant volume, single zone systems:

Figure shows the classic, single duct, single zone, constant volume systems. As shown in the figure, outdoor air (OD air) for ventilation and recirculated air (RC air) are mixed in the required proportions using the dampers and the mixed air is made to flow through a cooling and dehumidifying coil, a heating coil and a humidifier using a an insulated ducting and a supply fan. As the air flows through these coils the temperature and moisture content of the air are brought to the required values. Then this air is supplied to

the conditioned space, where it meets the building cooling or heating requirements. The return air leaves the conditioned space, a part of it is recirculated and the remaining part is vented to the atmosphere. A thermostat senses the temperature of air in the conditioned space and controls the amount of cooling or heating provided in the coils so that the supply air temperature can be controlled as per requirement. A humidistat measures the humidity ratio in the conditioned space and controls the amount of water vapour added in the humidifier and hence the supply air humidity ratio as per requirement.



This system is called as a single duct system as there is only one supply duct, through which either hot air or cold air flows, but not both simultaneously. It is called as a constant volume system as the volumetric flow rate of supply air is always maintained constant. It is a single zone system as the control is based on temperature and humidity ratio measured at a single point. Here a zone refers to a space controlled by one thermostat. However, the single zone may consist of a single room or one floor or whole of a building consisting of several rooms. The cooling/ heating capacity in the single zone, constant volume systems is regulated by regulating the supply air temperature and humidity ratio, while keeping the supply airflow rate constant. A separate sub-system controls the amount of OD air supplied by controlling the damper position.

Since a single zone system is controlled by a single thermostat and humidistat, it is **important to locate these sensors** in a proper location, so that they are indicative of zone conditions. The **supply air conditions** are controlled by either coil control or face-and-bypass control.

In coil control, supply air temperature is controlled by varying the **flow rate of cold and hot water** in the cooling and heating coils, respectively. As the cooling season gradually changes to heating season, the cooling coil valve is gradually closed and heating coil valve is opened. Though coil control is simpler, using this type of control it is **not possible to control the zone humidity** precisely as the dehumidification rate in the cooling coil decreases with cold water flow rate. Thus at low cold water flow rates, the humidity ratio of the conditioned space is likely to be higher than required.

In face-and-bypass control, the cold and hot water flow rates are maintained constant, but the amount of air flowing over the coils are decreased or increased by opening or closing the by-pass dampers, respectively. By this method it is possible to **control the zone humidity more precisely**, however, this type of control occupies more space physically and is also expensive compared to coil control.

Applications of single duct, single zone, constant volume systems:

1. Spaces with uniform loads, such as large open areas with small external loads e.g. theatres, auditoria, departmental stores.
2. Spaces requiring precision control such as laboratories

The Multiple, single zone systems can be used in large buildings such as factories, office buildings etc.

CHARACTERISTICS OF AIR WATER SYSTEMS

Dry-bulb temperature (DBT)

The dry-bulb temperature is the temperature indicated by a thermometer exposed to the air in a place sheltered from direct solar radiation. The term dry-bulb is customarily added to temperature to distinguish it from wet-bulb and dewpoint temperature. In meteorology and psychrometrics the word temperature by itself without a prefix usually means dry-bulb temperature. Technically, the temperature registered by the dry-bulb thermometer of a psychrometer. The name implies that the sensing bulb or element is in fact dry.

Wet-bulb temperature (WBT)

The thermodynamic wet-bulb temperature is a thermodynamic property of a mixture of air and water vapor. The value indicated by a wet-bulb thermometer often provides an adequate approximation of the thermodynamic wet-bulb temperature.

The accuracy of a simple wet-bulb thermometer depends on how fast air passes over the bulb and how well the thermometer is shielded from the radiant temperature of its surroundings. Speeds up to 5,000 ft/min (~60 mph) are best but it may be dangerous to move a thermometer at that speed. Errors up to 15% can occur if the air movement is too slow or if there is too much radiant heat present (from sunlight, for example). A wet bulb temperature taken with air moving at about 1–2 m/s is referred to as a **screen temperature**, whereas a temperature taken with air moving about 3.5 m/s or more is referred to as **sling temperature**.

A psychrometer is a device that includes both a dry-bulb and a wet-bulb thermometer. A **sling psychrometer** requires manual operation to create the airflow over the bulbs, but a **powered psychrometer** includes a fan for this function. Knowing both the dry-bulb temperature (DBT) and wet-bulb temperature (WBT), one can determine the relative humidity (RH) from the psychrometric chart appropriate to the air pressure.

Relative humidity

The ratio of the vapor pressure of moisture in the sample to the saturation pressure at the dry bulb temperature of the sample.

Dew point temperature

The saturation temperature of the moisture present in the sample of air, it can also be defined as the temperature at which the vapour changes into liquid (condensation). Usually the level at which water vapor changes into liquid marks the base of the cloud in the atmosphere hence called condensation level. So the temperature value that allows this process (condensation) to take place is called the 'dew point temperature'.

Humidity

Specific Humidity

Specific humidity is defined as the proportion of the mass of water vapor per unit mass of the moist air sample (dry air plus the water vapor); it is closely related to humidity ratio and always lower in value.

Absolute humidity

The mass of water vapor per unit volume of air containing the water vapor. This quantity is also known as the water vapor density.

Specific enthalpy

Analogous to the specific enthalpy of a pure substance. In psychrometrics, the term quantifies the total energy of both the dry air and water vapour per kilogram of dry air.

Specific volume

Analogous to the specific volume of a pure substance. In psychrometrics, the term quantifies the total volume of both the dry air and water vapour per kilogram of dry air.

Psychrometric ratio

The **psychrometric ratio** is the ratio of the heat transfer coefficient to the product of mass transfer coefficient and humid heat at a wetted surface.

The psychrometric ratio is an important property in the area of psychrometrics, as it relates the absolute humidity and saturation humidity to the difference between the dry bulb temperature and the adiabatic saturation temperature.

Mixtures of air and water vapor are the most common systems encountered in psychrometry. The psychrometric ratio of air-water vapor mixtures is approximately unity, which implies that the difference between the adiabatic saturation temperature and wet bulb temperature of air-water vapor mixtures is small. This property of air-water vapor systems simplifies drying and cooling calculations often performed using psychrometic relationships.

Humid heat

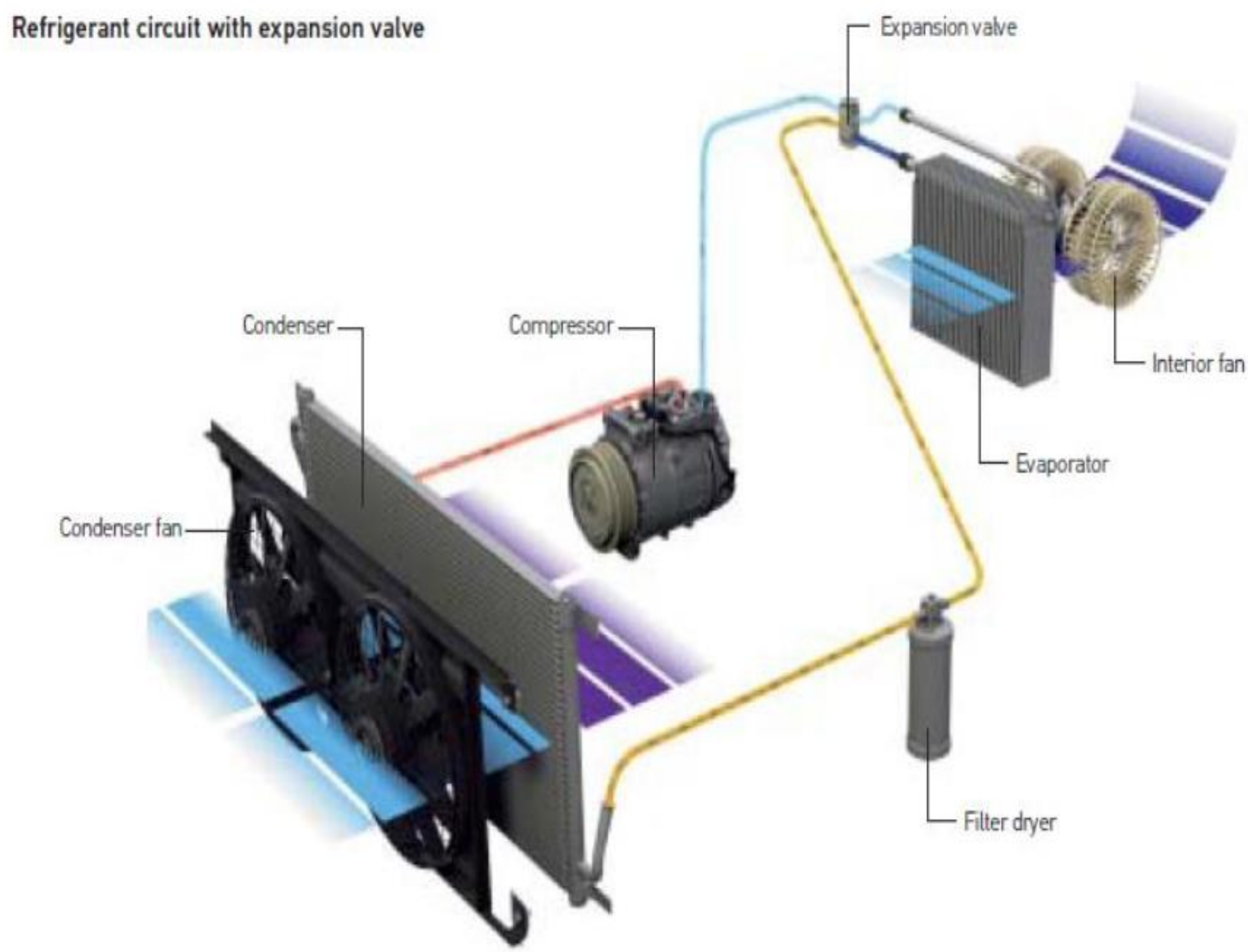
Humid heat is the constant-pressure specific heat of moist air, per unit mass of the dry air.[8]

Pressure

Many psychrometric properties are dependent on pressure concept:

- vapor pressure of water;
- atmospheric pressure at the location of the sample.

TRANSPORT AIR CONDITIONING



How the air conditioning system with expansion valve works For controlling the climate in the vehicle interior, refrigerant circuit as well as coolant circuit are required. A mixture of cold and warm air allows the generation of the desired climate conditions - completely independently from outer conditions. As a result, the air conditioning system becomes an important factor for safety and driving comfort. The individual components of the refrigerant circuit are connected by tubes and/or aluminium pipes and thus form a closed system. Refrigerant and refrigerant oil circulate in the system, driven by the compressor. The circuit has two sides:

_ The section between the compressor and the expansion valve is the high pressure side (yellow/red).

_ The section between the expansion valve and the compressor is the low pressure side (blue).

The gaseous refrigerant is compressed by the compressor (thereby significantly increasing its temperature) and pressed under high pressure through the condenser. This removes heat from refrigerant - it condensates and changes its state from gas to liquid. The filter dryer, the next unit, removes contaminants and air from the liquid refrigerant as well as humidity. This ensures system effectiveness and protects the components from damage caused by contaminants. Condenser fan Compressor Filter dryer Evaporator Expansion valve Interior fan Condenser