Evaporators

Introduction

- The evaporator is an important device used in the low pressure side of a refrigeration system.
- The liquid refrigerant from the expansion valve enters into the evaporator where it boils and changes into vapour.
- The function of a evaporator is to absorb heat from the surrounding location or medium so that the heat flows to the refrigerant.
- The evaporator becomes cold and remains cold due to the following two reasons:
  - The temperature of the evaporator coil is low due to the low temperature of the refrigerant inside the coil.
  - The low temperature of the refrigerant remains unchanged because any heat it absorbs is converted to latent heat as boiling proceeds.

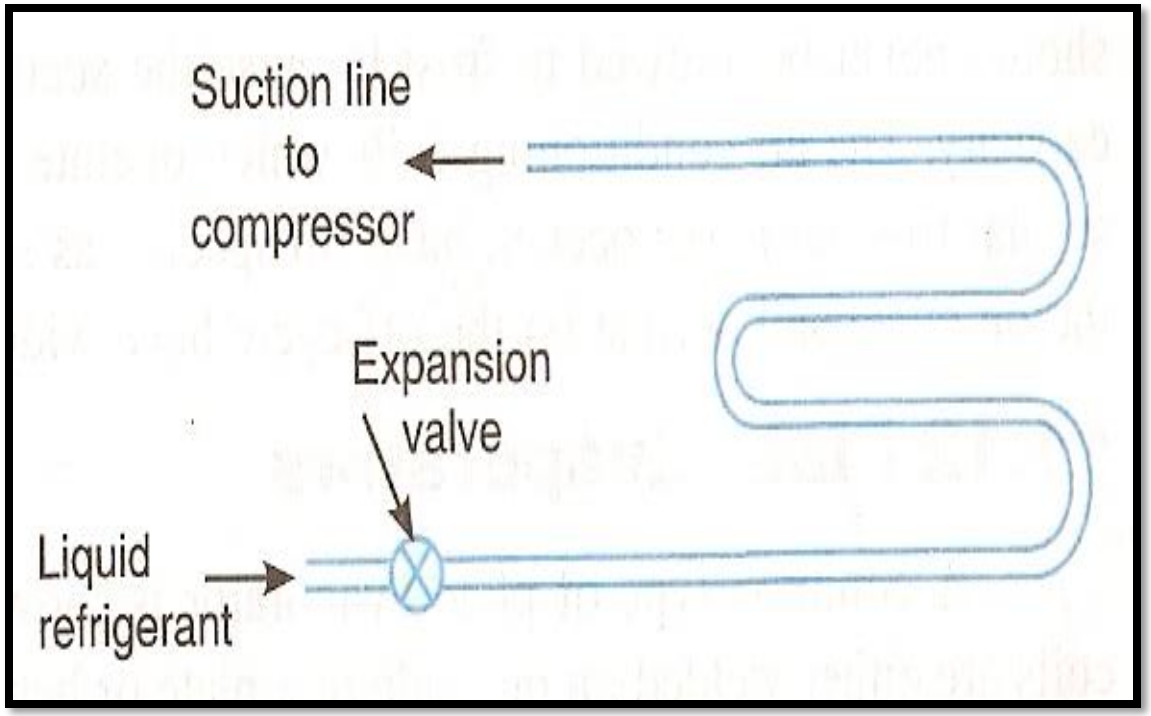
Factors Affecting the Heat Transfer Capacity of an Evaporator

- Material
- Temperature difference
- Velocity of refrigerant
- Thickness of the evaporator coil wall
- Contact surface area

Classification of evaporators

- **According to the type of construction**
  - Bare tube coil evaporator,
  - Finned tube evaporator,
  - Plate evaporator,
  - Shell and tube evaporator,
  - Shell and coil evaporator, and
  - Tube-in-tube evaporator,
- **According to the manner in which liquid refrigerant is fed**
  - Flooded evaporator, and
  - Dry expansion evaporator
- **According to the mode of heat transfer**
  - Natural convection evaporator, and
  - Forced convection evaporator
- **According to operating conditions**
  - Frosting evaporator,
  - Non-frosting evaporator, and
  - Defrosting evaporator

Bare tube coil evaporator



Finned evaporators

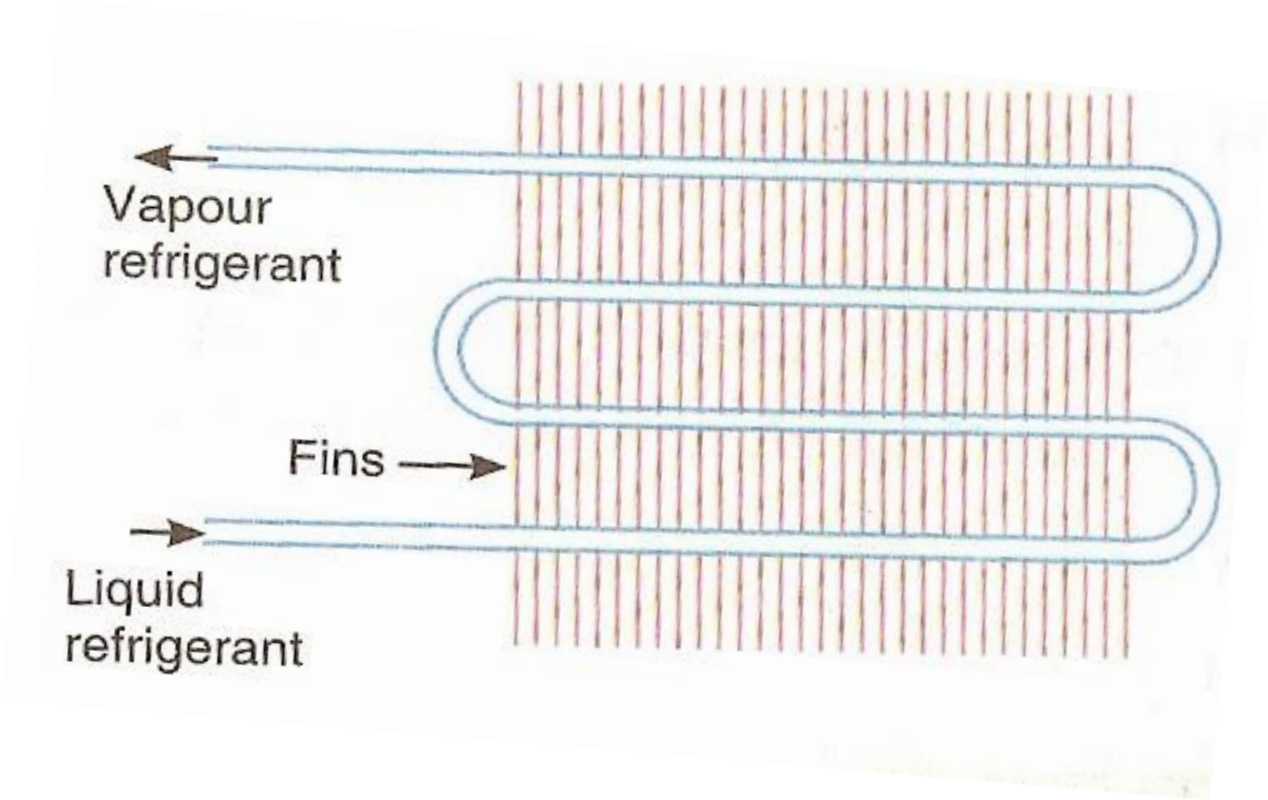
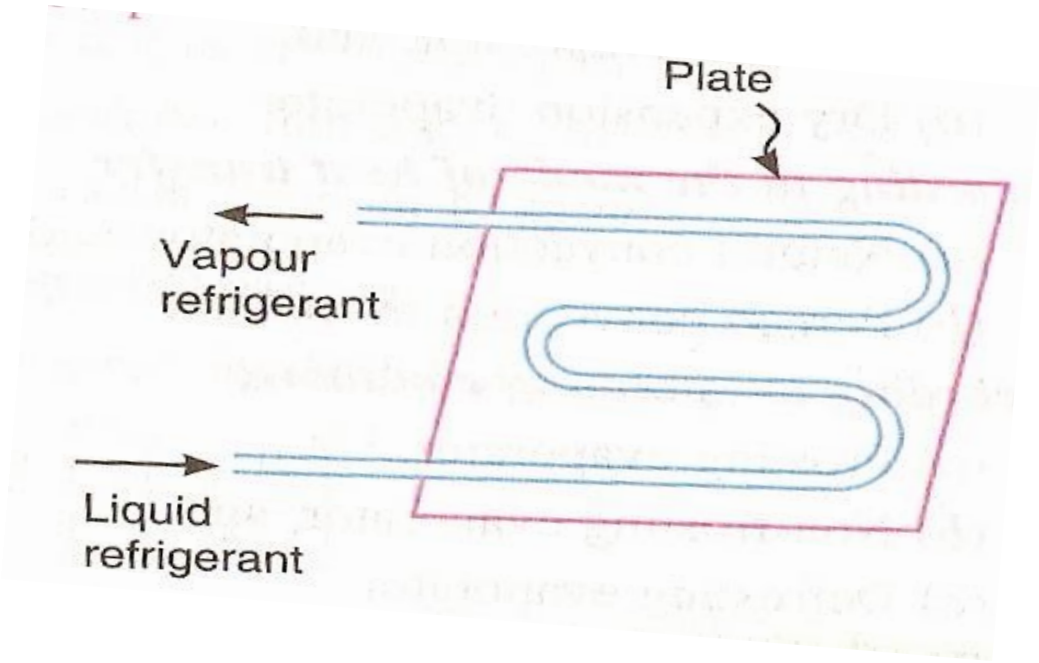
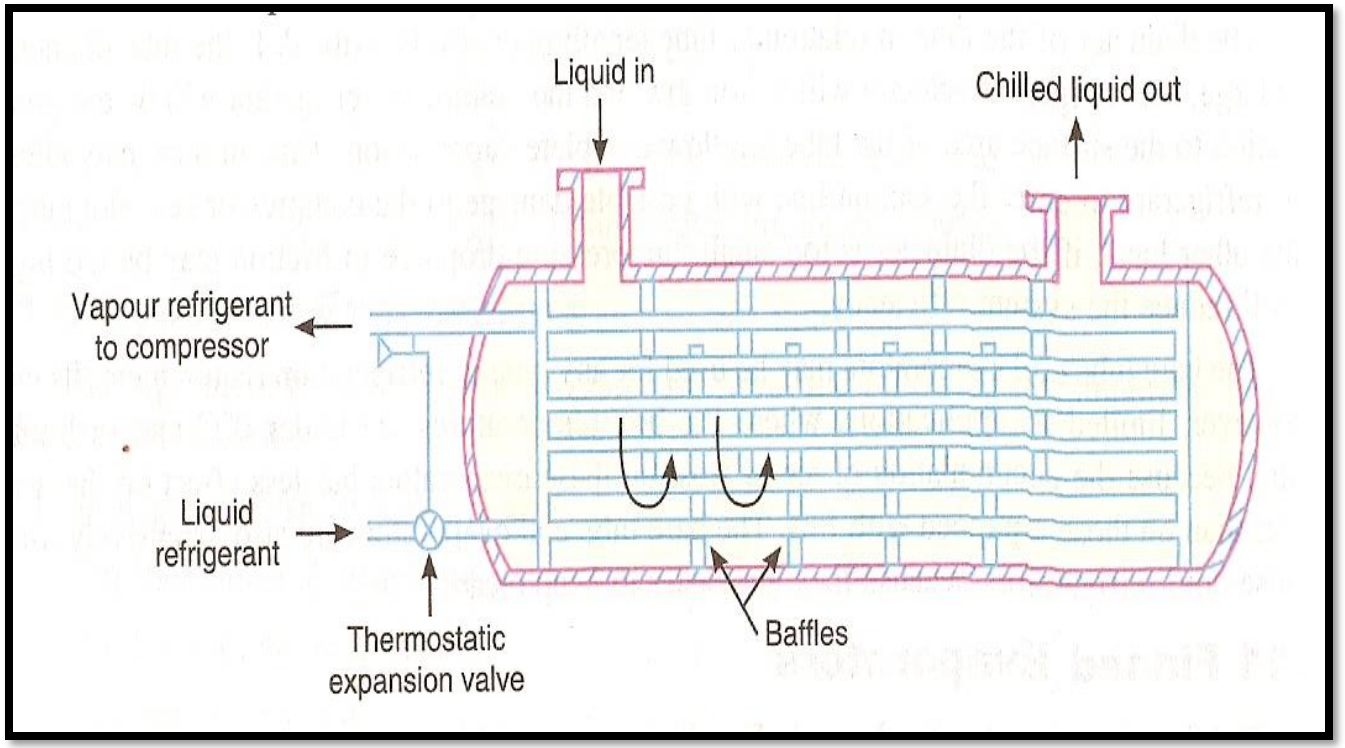


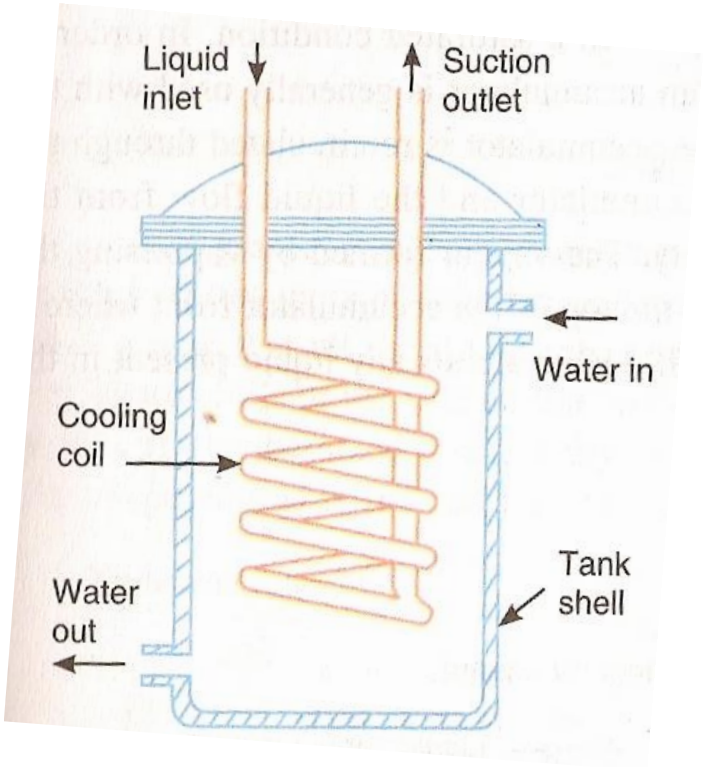
Plate evaporators

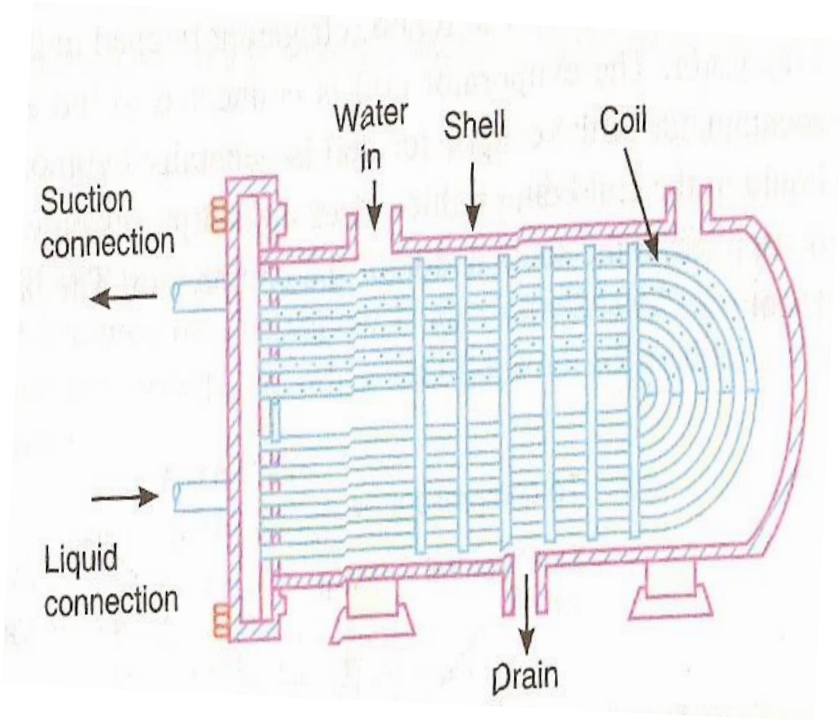


Shell and tube evaporators

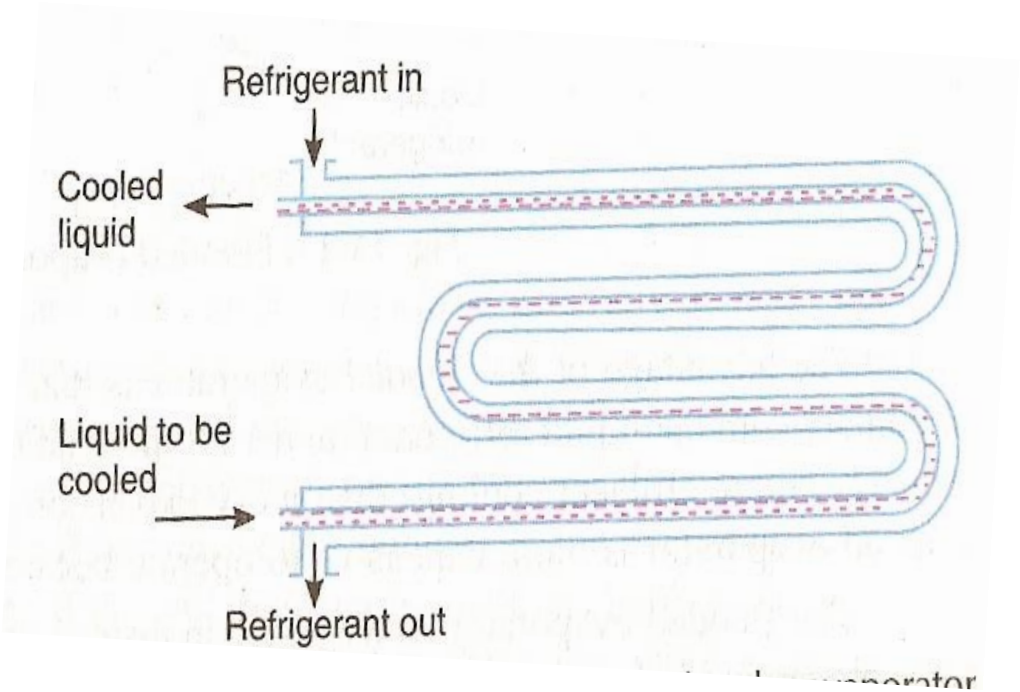


Shell and coil evaporators

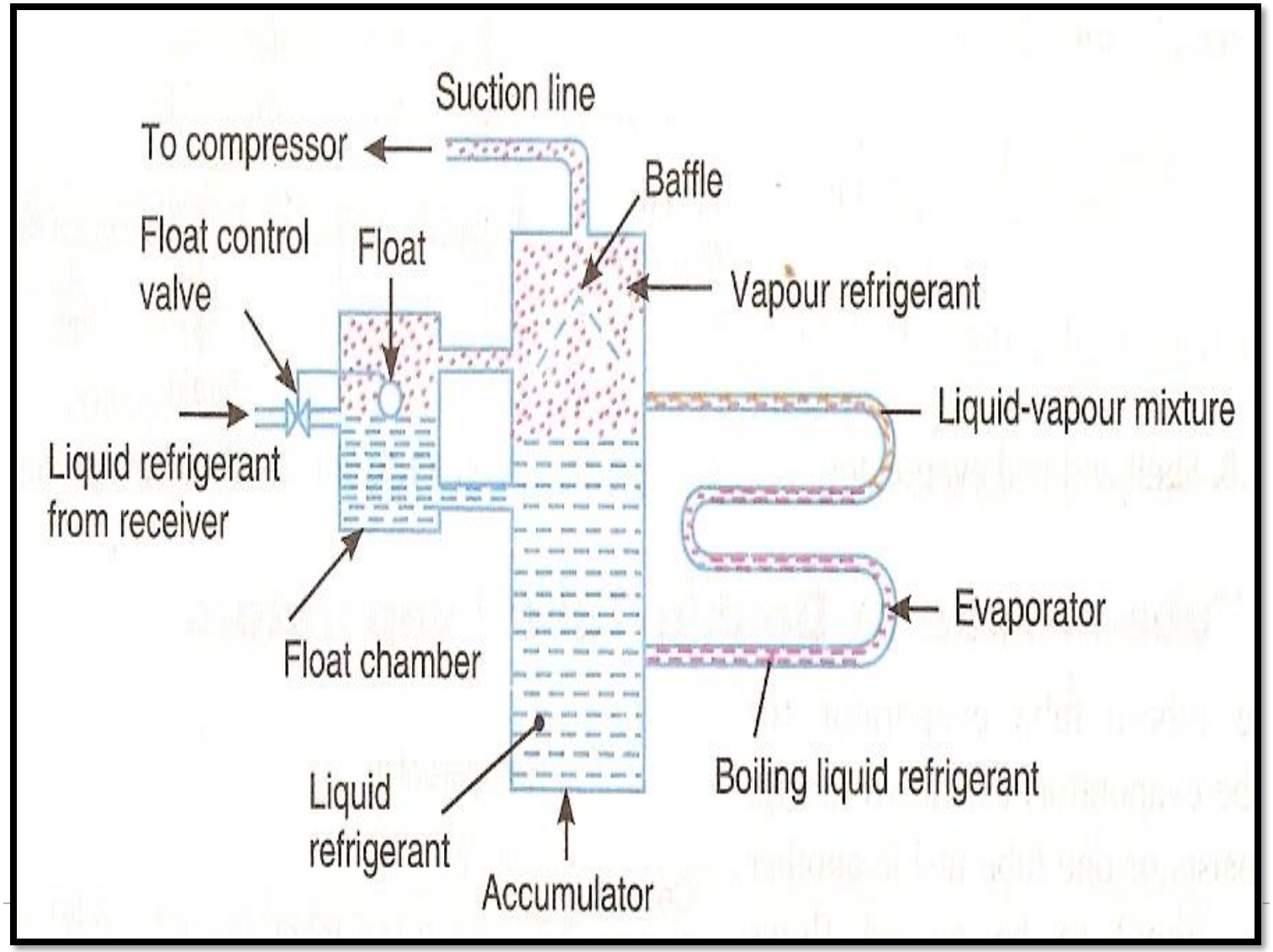




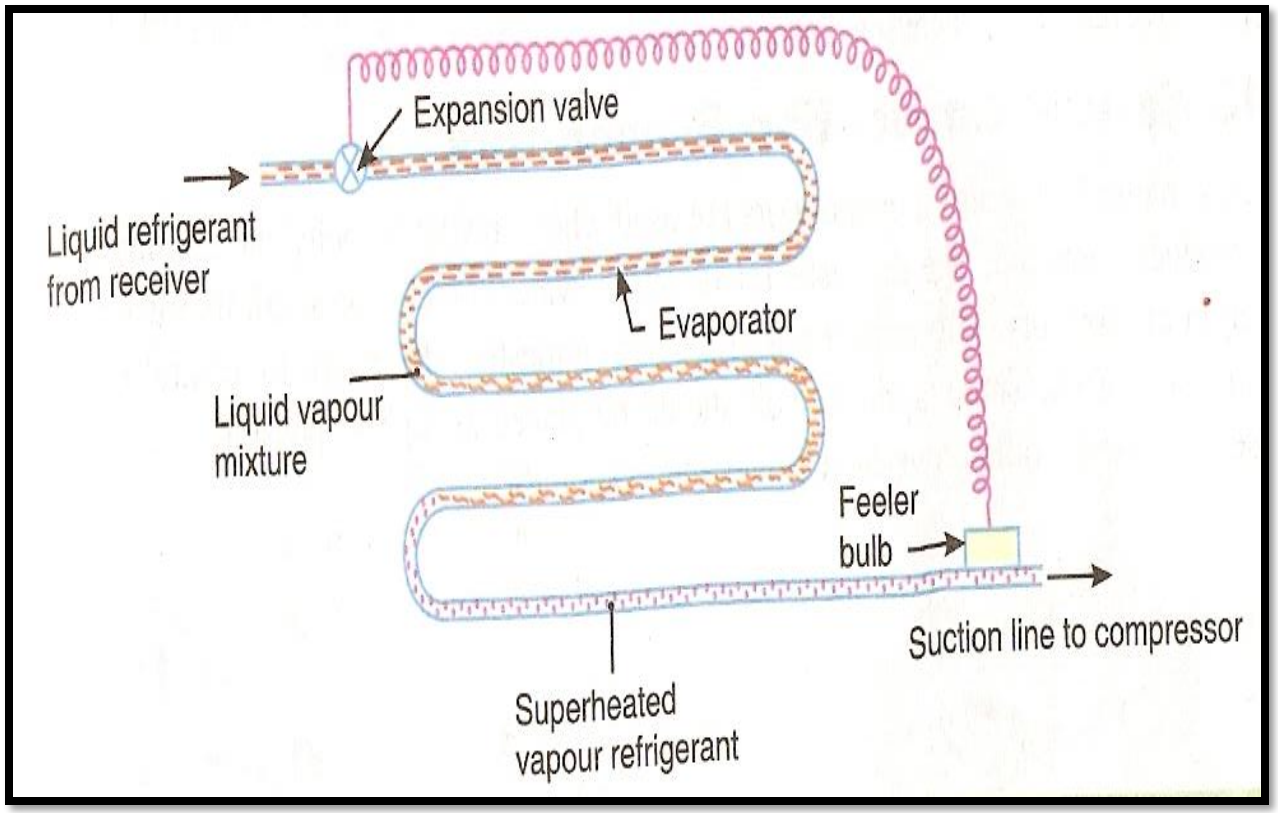
Tube in tube evaporator

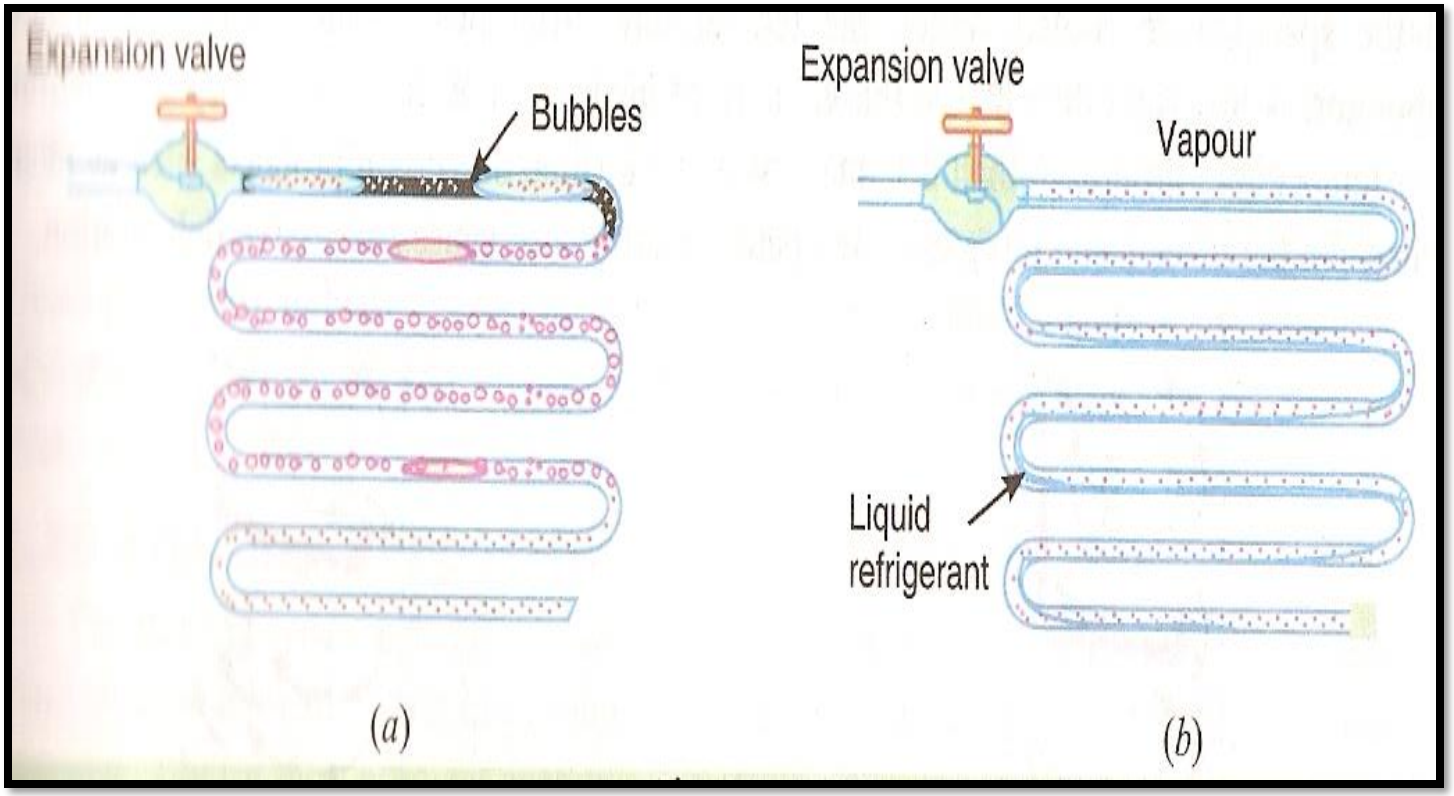


Flooded evaporators



Dry expansion evaporators




Expansion valve
Bubbles
(a)
Expansion valve
Vapour
Liquid
refrigerant
(b)

Natural convection evaporators

- The natural convection evaporators are used where low air velocity and minimum hydration of the product is desired.
- The circulation of air in a domestic refrigerator by natural convection.
- The evaporator coil should be placed as high as possible in the refrigerator because the cold air falls down as it leaves the evaporator.
- The velocity of air over the evaporator coil considerably affects the capacity.
- In natural convection, the velocity of air depends upon the temperature difference between the evaporator and the space to the cooled.
- When the temperature difference, using a natural convection evaporator, is low (less than 8^0 C), the velocity of air is too low for satisfactory circulation

Forced circulation evaporator

- In forced convection evaporators, the air is forced over the refrigerant cooled coils and fins.
- This is done by a fan driven by an electric motor.
- The fins are provided to increase the heat transfer rate.
- The forced convection evaporators are more efficient than natural convection evaporators because they require less cooling surface and high evaporator pressures can be used which save considerable power input to the compressor.
- These types of evaporators are suited for air cooling units as well as for refrigerator cabinets used to store bottled beverages or foods in sealed containers.

Frosting evaporators

- The frosting type evaporators always operate at temperatures below 0^0 C.
- This means that the coil frosts continually when in use and it must be removed at regular intervals either manually or automatically for most efficient operation.
- The frost which forms on the evaporator comes from the moisture in the air.
- Some evaporators run at extremely low temperature in order to keep the refrigeration fixture cool.
- This allows frost and ice to build up.
- It may be noted that as the frost grows in thickness, the coil or cooling efficiency decreases until the ice and frost is removed.
- The evaporators in household refrigerators, bare pipe coils in storage boxes and low temperature evaporators fall under the frosting evaporators.

Expansion Devices

Functions of expansion devices

- It reduces the high pressure liquid refrigerant to low pressure liquid refrigerant
- It maintains the desired pressure difference between the high and low pressure sides of the system
- It controls the flow of refrigerant according to the load on the evaporator

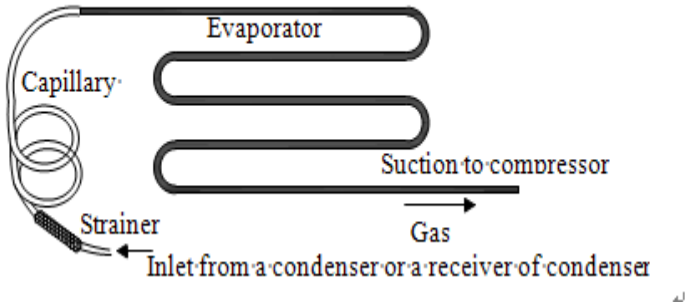
Types of expansion devices

- Capillary tube
- Hand operated expansion valve
- Automatic or constant pressure expansion valve
- Thermostatic expansion valve
- Float valves

Capillary tube

- Capillary tubes are widely used as expansion devices in small vapor compression refrigeration Systems, such as household refrigerators, room air conditioners, and small package air conditioning units.

- In these system, the capillary tube is wound into with coils for direct expansion.
- The tube connects the outlet of condenser to the inlet of the evaporator.

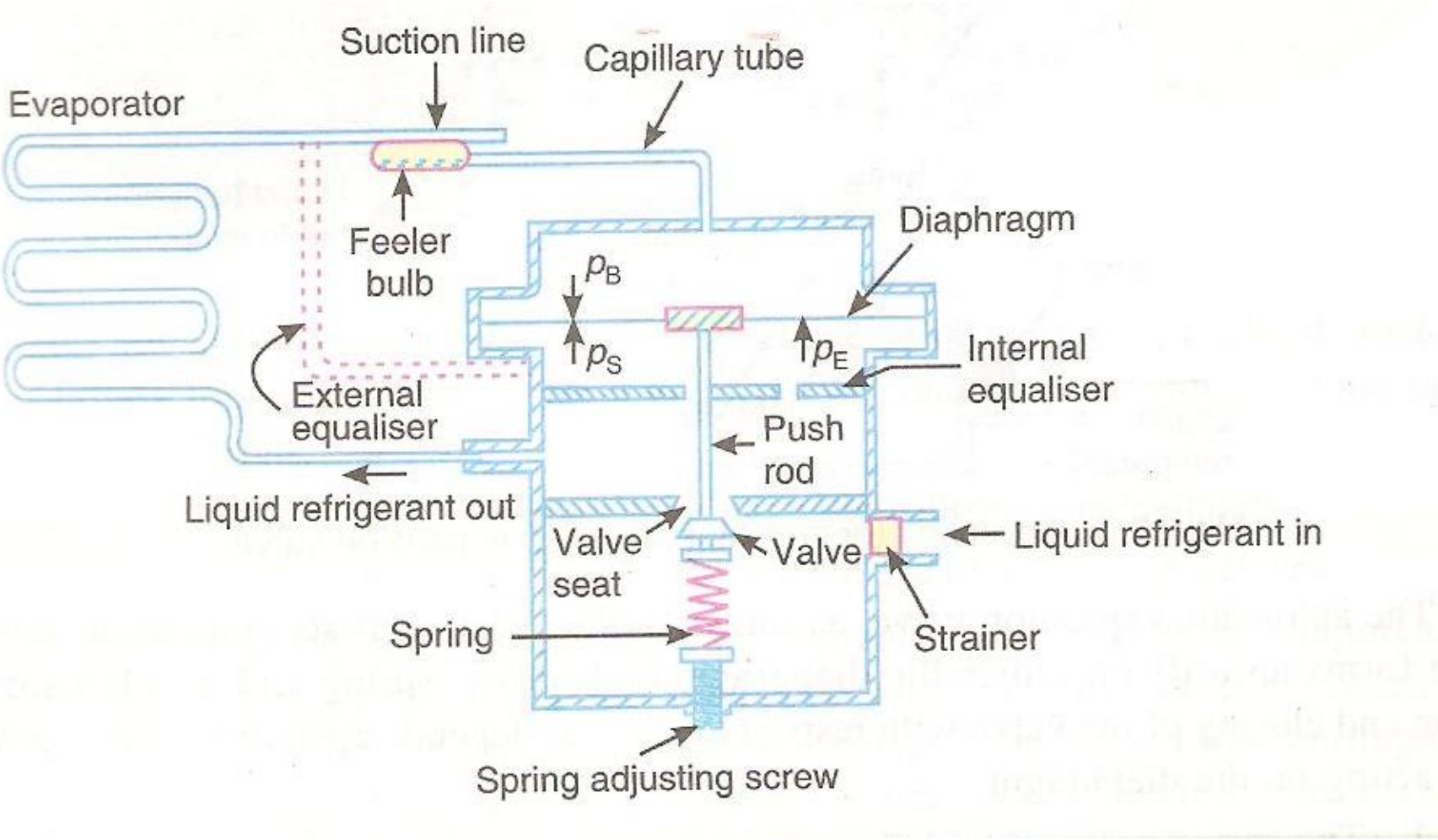


Physically the capillary tubes are hollow tubes made with drawn copper, with internal diameters ranging between 0.51and 2 mm

Thermostatic expansion Valves-Superheat Control

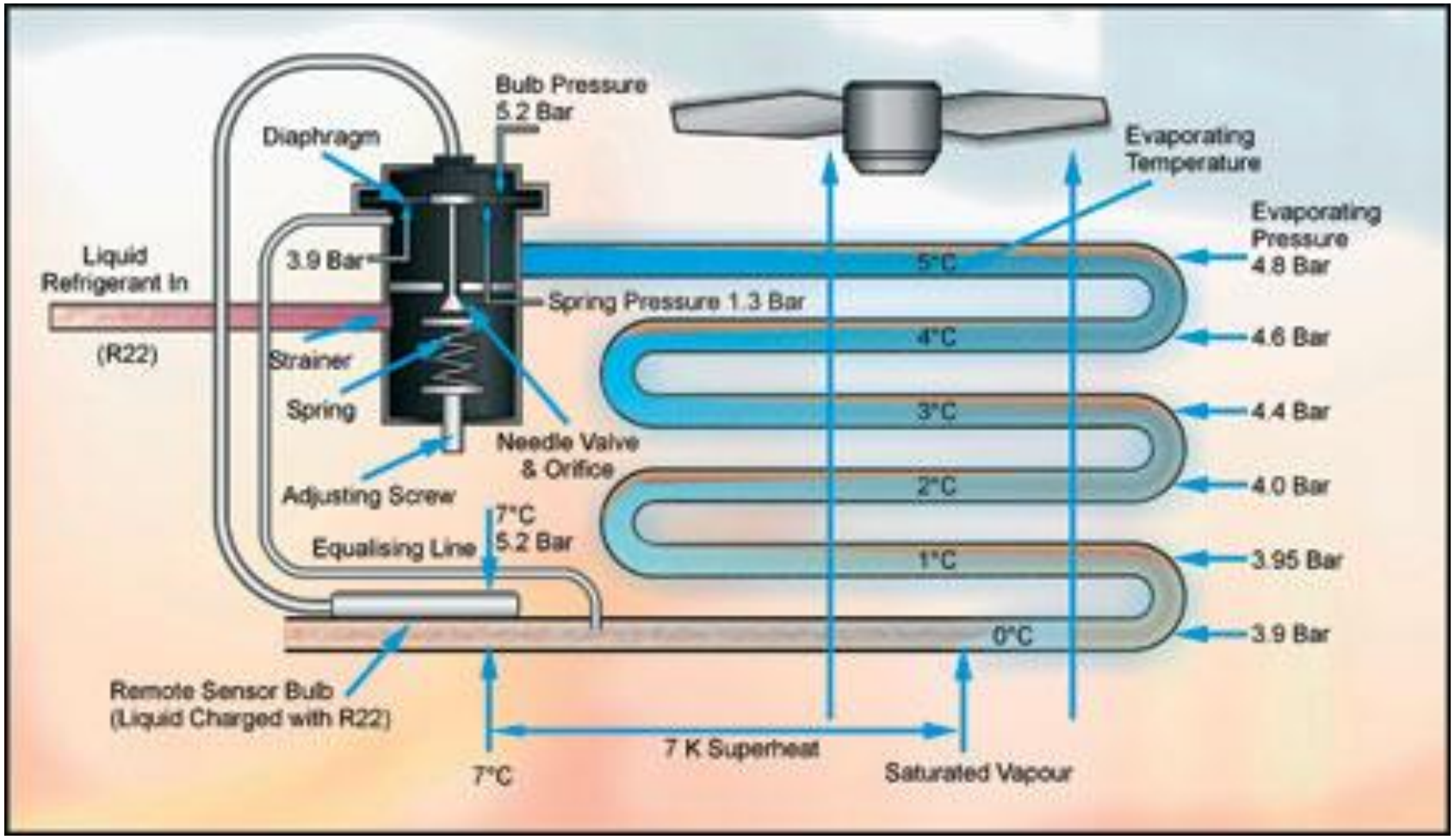
- At present, thermostatic expansion valve is probably the most widely used refrigerant flow control device because of its high efficiency and its ready adaptability to any type of refrigeration applications.
- The thermostatic expansion valve controls the mass flow rate of the refrigerant into the evaporator according to inspiration vapor degree of superheat, and at the same time throttles the liquid from condensing pressure to evaporation pressure.

Thermostatic expansion valve



- The bulb pressure p_b acts on the top of the diaphragm to open the valve.
- Besides the bulb pressure, there are two other pressures under the diaphragm to move the valve toward an open or closed position: the spring pressure p_s acts on the pin and the evaporator pressure p_e acts on the bottom of the diaphragm to close the valve.
- When the opening and closing pressures balance each other, the valve pin is in a stable fixed position.
- That is, when the valve is not opening or closing, the following balance of pressures exists:

$$p_b = p_s + p_e$$


Bulb Pressure
5.2 Bar
Diaphragm
Evaporating
Temperature
Evaporating
Pressure
4.8 Bar
Liquid
Refrigerant In
(R22)
3.9 Bar
Spring Pressure 1.3 Bar
5°C
4°C
4.6 Bar
3°C
4.4 Bar
Strainer
Spring
Needle Valve
& Orifice
2°C
4.0 Bar
Adjusting Screw
7°C
5.2 Bar
Equalising Line
1°C
3.95 Bar
0°C
3.9 Bar
Remote Sensor Bulb
(Liquid Charged with R22)
7 K Superheat
7°C
Saturated Vapour

Classification of air conditioning systems

1. According to the purpose
    a. Comfort air conditioning system
    b. Industrial air conditioning system
2. According to the season of the year
    a. Winter air conditioning system
    b. Summer air conditioning system
    c. Year-round air conditioning system
3. According to the arrangement of equipment
    a. Unitary air conditioning system
    b. Central air conditioning system

Comfort air conditioning system

In comfort air conditioning, the air is brought to the required dry bulb temperature and relative humidity for the human health, comfort and efficiency. If sufficient data of the required condition is not given, then it is assumed to be 21 ^{o}C dry bulb temperature and 50% relative humidity. The sensible heat factor is generally kept as following.

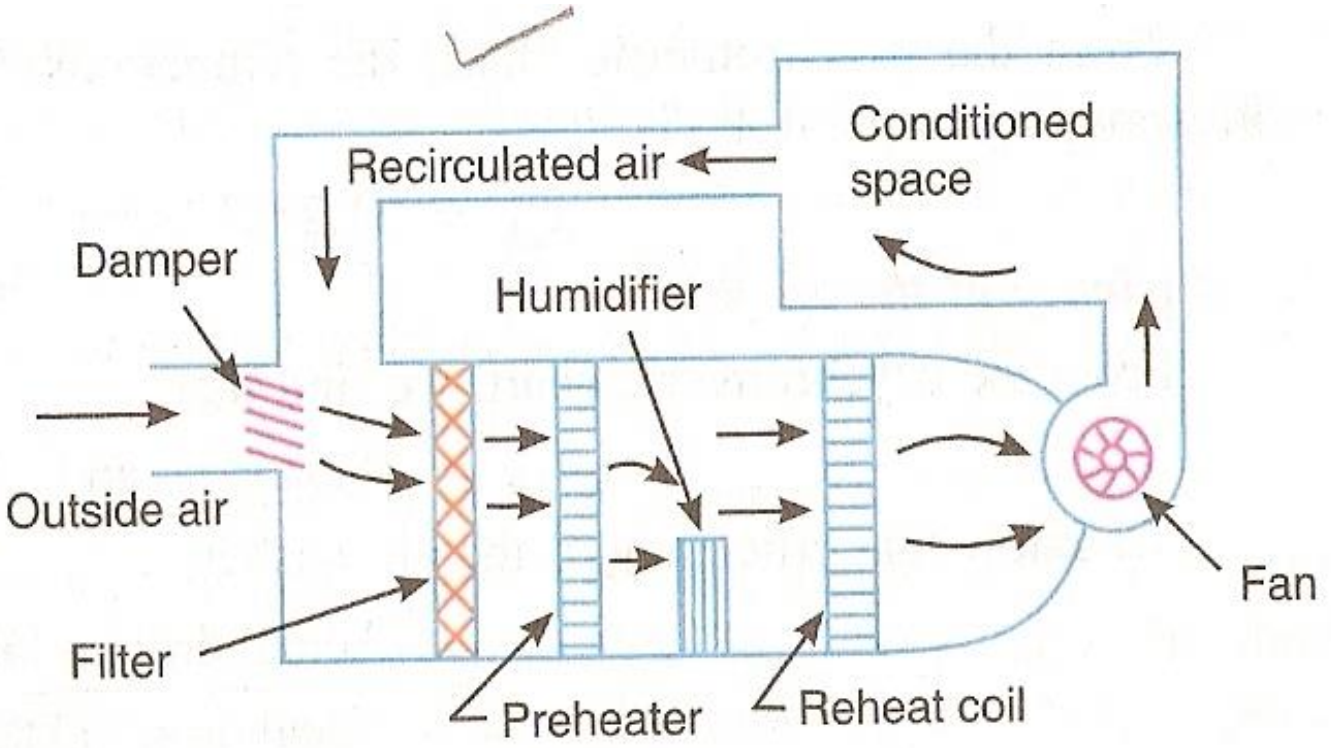
For residence or private office	=	0.9
For restaurant or busy office	=	0.8
Auditorium or cinema hall	=	0.7
Ball room dance hall etc	=	0.6

The comfort air conditioning may be adopted for homes, offices, shops, restaurants, theaters, hospitals, schools etc.

Industrial air conditioning system

It is an important system of air conditioning these days in which the inside dry bulb temperature and relative humidity of the air is kept constant for proper working of the machines and for the proper research and manufacturing processes. Some of the sophisticated electronic and other machines need a particular dry bulb temperature and relative humidity. Sometimes, these machines also require a particular method of psychrometric processes. This type of air conditioning system is used in textile mills, paper mills, machine parts manufacturing plants, tool rooms, photo processing plants etc.

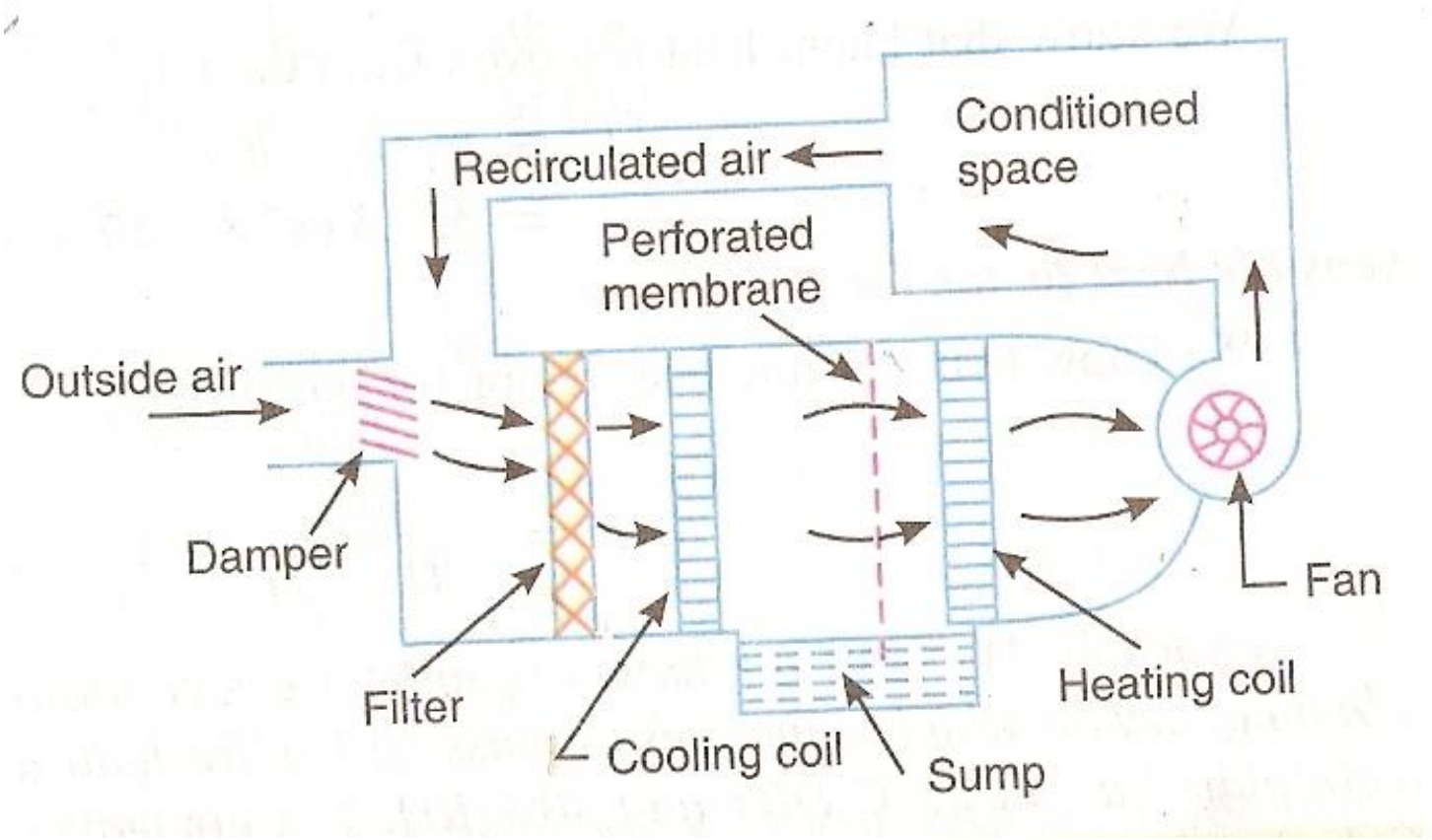
Winter air conditioning system



Winter air conditioning system

In winter air conditioning the air is heated, which is generally accomplished by humidification. The outside air flows through a dampers and mixes up with the recirculated air (which is obtained from the conditioned space). The mixed air passes through a filter to remove dirt, dust and other impurities. The air now passes through a preheat coil in order to prevent the possible freezing of water and to control the evaporation of water in the humidifier. After that, the air is made to pass through a reheat coil to bring the air to the designed dry bulb temperature. Now, the conditioned air is supplied to the conditioned space by a fan. From the conditioned space, a part of the used air is exhausted to the atmosphere by the exhaust fans or ventilators. The remaining part of the used air (known as recirculated air) is again conditioned. The outside air is sucked and made to mix with recirculated air, in order to make up for the loss of conditioned (or used) air through fans or ventilation from the conditioned space.

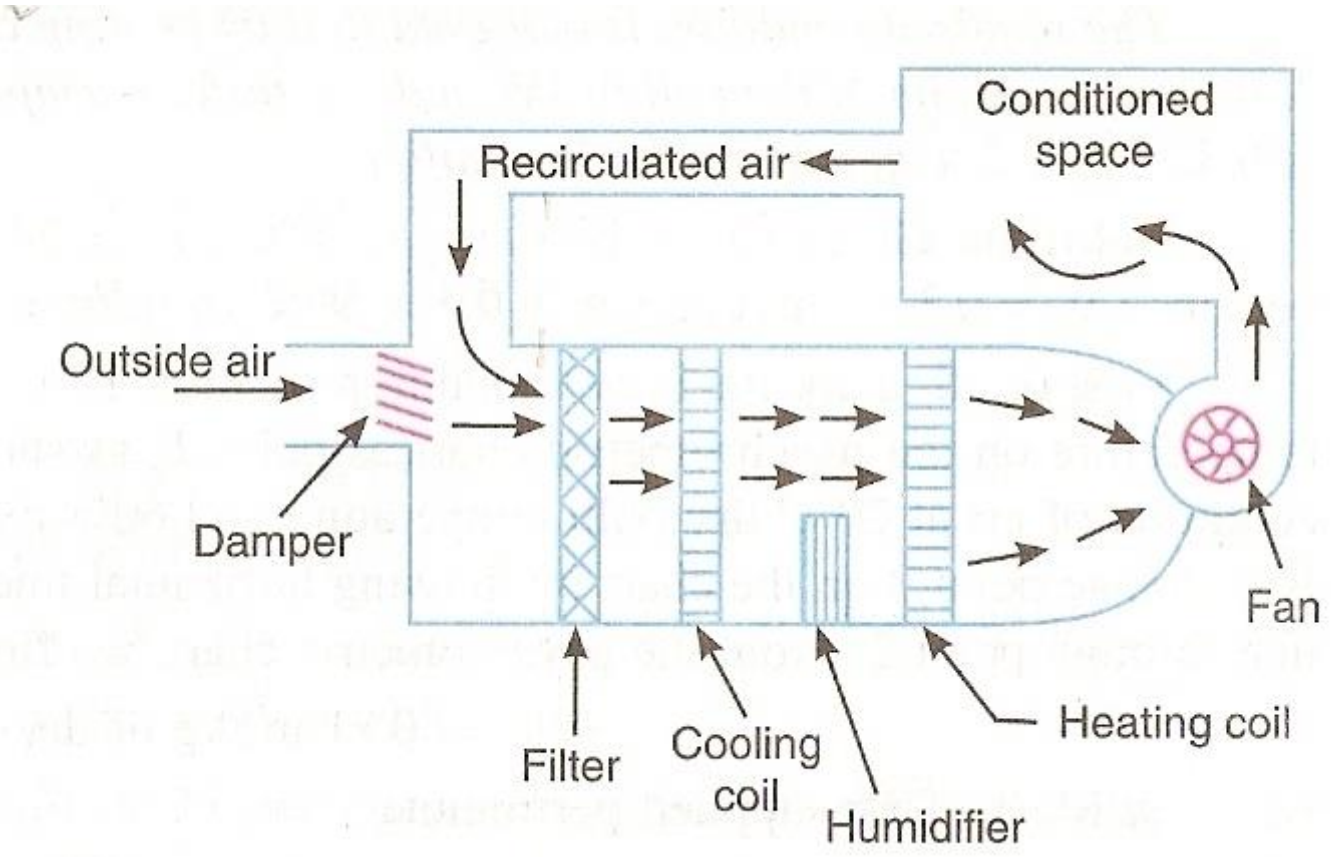
Summer air conditioning system



Summer air conditioning system

- It is the most important type of air conditioning, in which the air is cooled and generally dehumidified. The outside air flows through through the damper, and mixes up with recirculated air (which is obtained from the conditioned space). The mixed air passes through a filter to remove dirt, dust and other impurities. The air now passes through a cooling coil. The coil has a temperature much below the required dry bulb temperature of the air in the conditioned space. The cooled air passes through a perforated membrane and looses its moisture in the condensed form which is collected in a sump. After that, the air is made to pass through a heating coil which heats up the air slightly. This is done to bring the air to the designed dry bulb temperature and relative humidity.
- Now the conditioned air is supplied to the conditioned space by a fan. From the conditioned space, a part of the used air is exhausted to the atmosphere by the exhaust fans or ventilators. The remaining part of the used air (known as recirculated air) is again conditioned. The outside air is sucked and made to mix with the recirculated air in order to make up for the loss of conditioned (or used) air through exhaust fans or ventilation from the conditioned space.

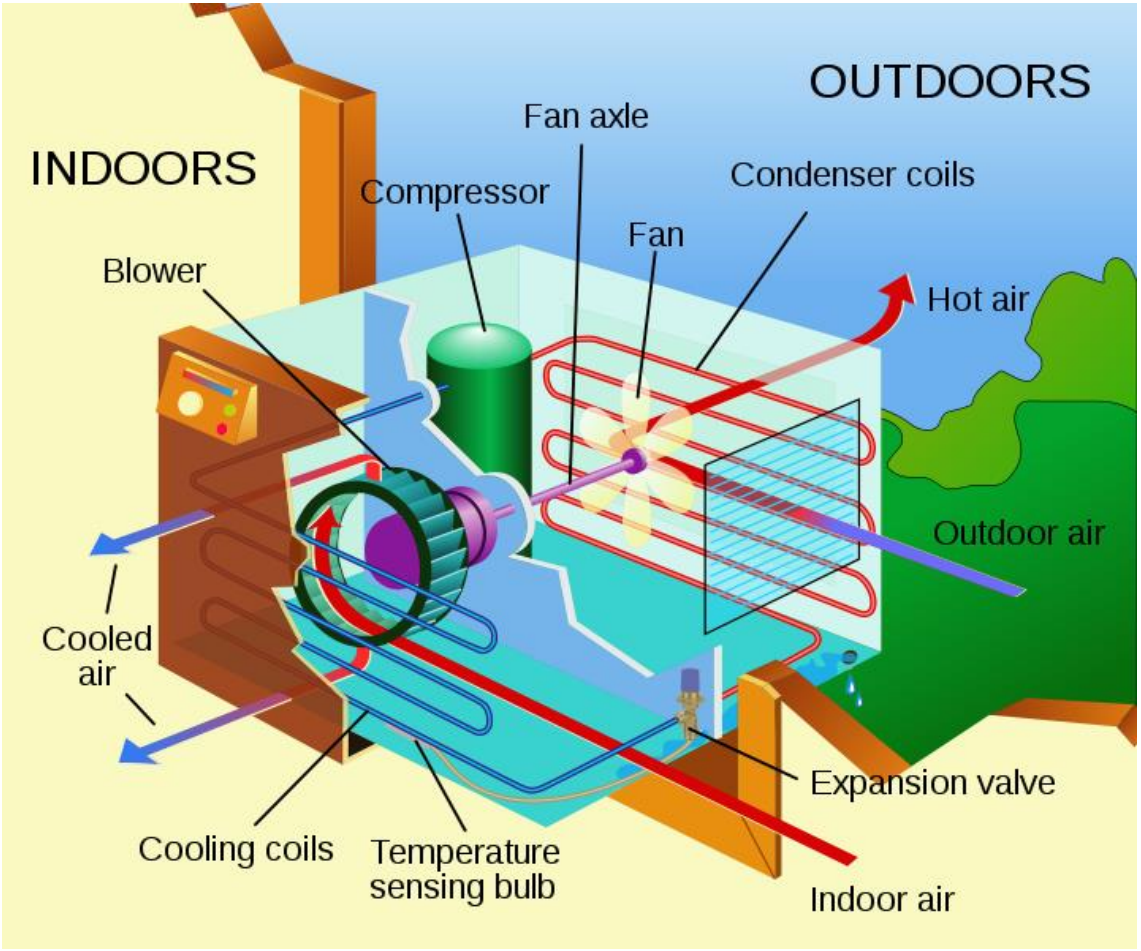
Year round air conditioning system



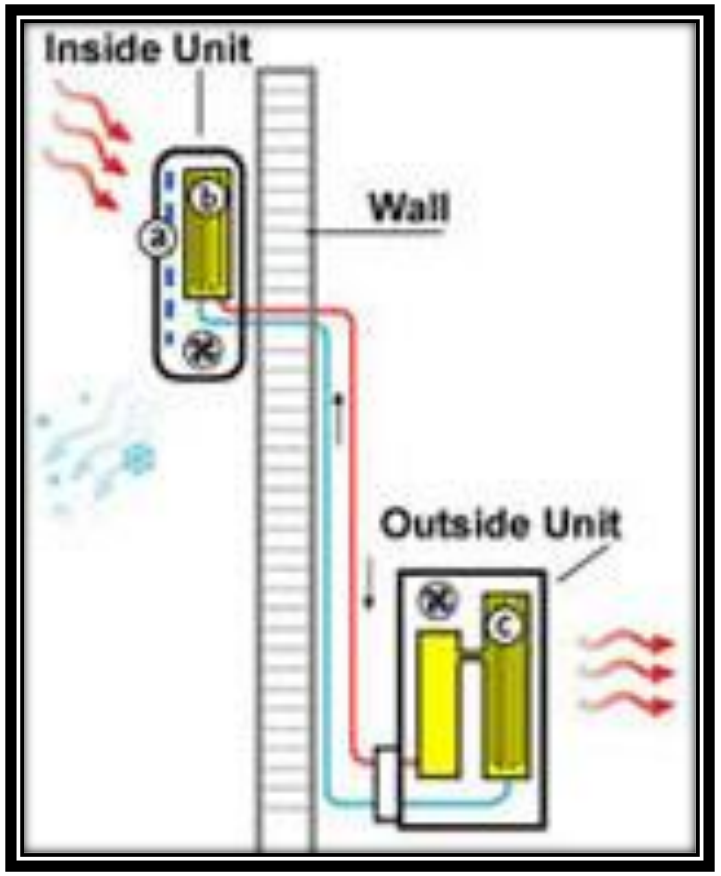
UNITARY AIR CONDITIONING SYSTEM

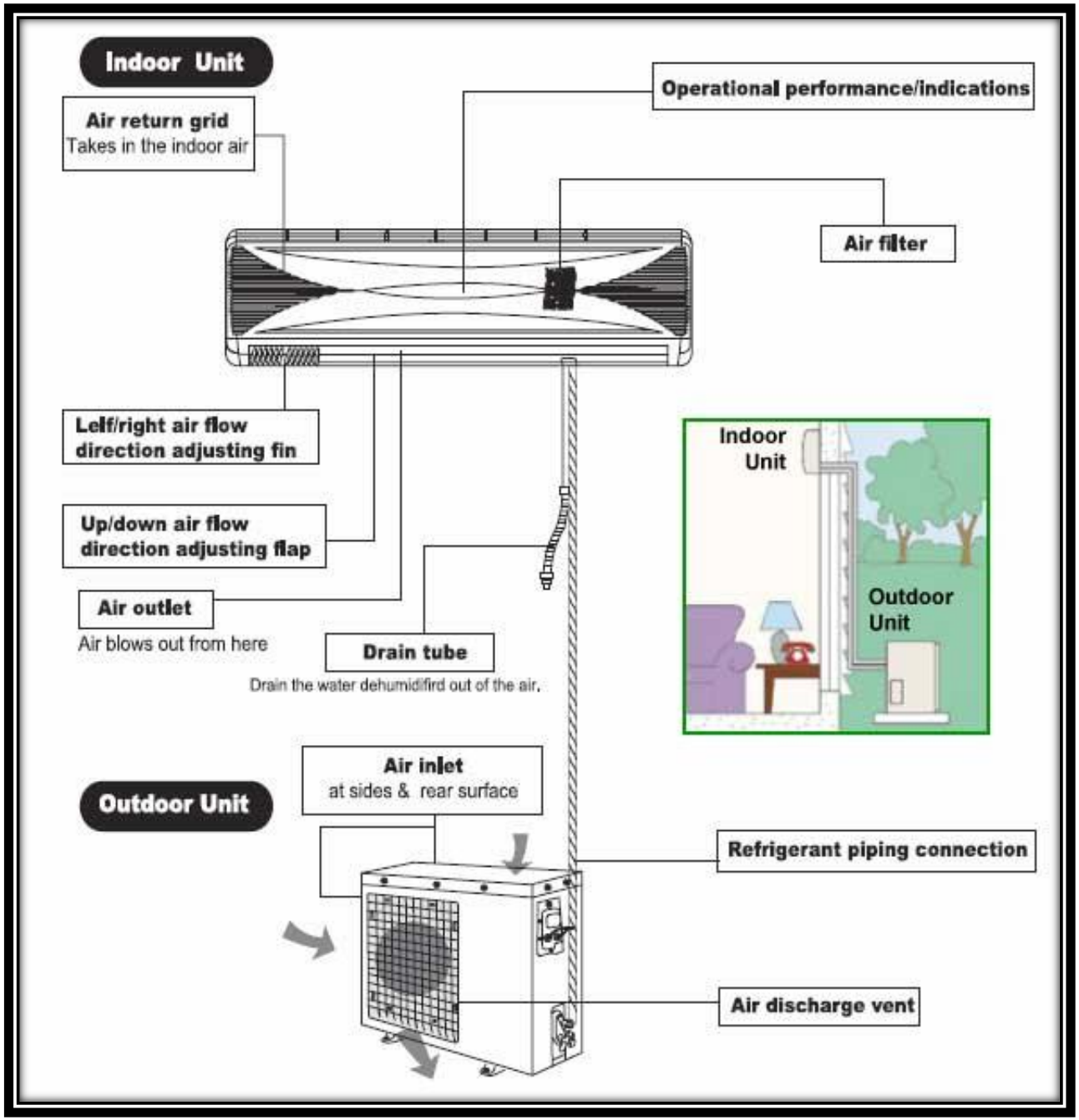
Window units

These are self-contained units of small capacity of **1 TR to 3 TR**, and are mounted in a window or through the wall. They are employed to condition the air of one room only. If the room is bigger in size, then two or more units are installed



Vertical packed units




Indoor Unit
Air return grid
Takes in the indoor air
Operational performance/indications
Air filter
Lelf/right air flow direction adjusting fin
Up/down air flow direction adjusting flap
Air outlet
Air blows out from here
Drain tube
Drain the water dehumidifird out of the air.
Indoor Unit
Outdoor Unit
Outdoor Unit
Air inlet
at sides & rear surface
Refrigerant piping connection
Air discharge vent

Central air conditioning system

- This is the most important type of air conditioning system, which is adopted, when the cooling capacity required is **25 TR or more**. The central air conditioning system is also adopted when the air flow is more than 300m^3/min or different zones in a building are to be air conditioning.

Central air conditioning system