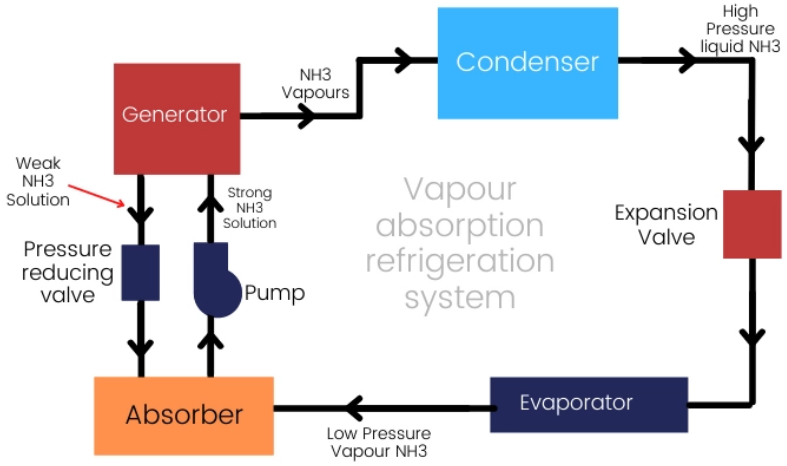
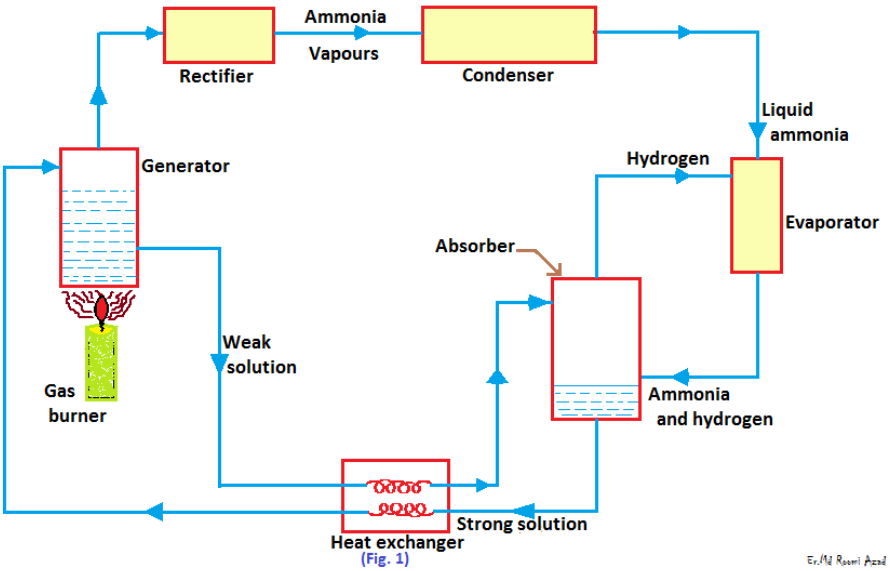
REFRIGERATION AND AIR CONDITIONING MODULE-II

VAPOUR ABSORPTION REFRIGERATION SYSTEM



- The compressor is replaced by a generator, a pump, and an absorber. So the basic components of a basic Vapor absorption refrigeration are-
- Generator,pump,absorber,condenser,evaporator and expander or throttling device.
- Here NH3 is the refrigerant and H2O is the absorbent.
- In VA refrigeration system the requirement of the compressor is fulfilled by using an arrangement consisting of an *absorber, a pump, and a generator.*
- The elements condenser, evaporator and expansion valve are all same for VC and VA cycles.
- First, evaporator passes the refrigerant vapor to the absorber (In this case ammonia vapor).
- NH3 has a property of mixing with the cool water promptly.
- So, in absorber ammonia mixed with water is known as strong NH3-Water solution.
- With the help of a pump, this strong solution moves towards the generator where the solution is heated and NH3 is liberated from the water and collected on the top of the generator with high pressure.
- In the VC system, the function of the compressor is to compress the refrigerant vapor and increase its pressure.
- Here in VARS, the generator is doing the same.Hence, the function of the compressor is already achieved.
- Likewise, the refrigerant vapor with high pressure goes to condenser and liberates heat and ultimately becomes liquid.
- The liquid is collected in a receiver tank and then moves through the expansion valve.
- Here it is expanded, moves towards the evaporator and collects heat and becomes vapor and the cycle continues.

ELECTROLUX REFRIGERATOR(THREE FLUID SYSTEM)



(Fig. 1)

- This type of refrigerator is also called *"Three- fluids absorption system".* The three fluids used in this system are ammonia, hydrogen and water
- The "ammonia" is used as a refrigerant because it possesses most of the desirable properties. Though it is toxic, and not otherwise preferred in domestic appliances, it is very safe in this system due to absence of any moving parts(no pump) in the system and , therefore, there is the least chance of any leakage.
- The "hydrogen" being the lightest gas, is used to increase the rate of evaporation (the lighter the gas, faster is the evaporation) of the liquid ammonia passing through the evaporator. The hydrogen is also non-corrosive and insoluble in water. This is used in the low-pressure side of the system.
- The "water" is used as a absorbent because it has the ability to absorb ammonia readily.
- The ammonia liquid leaving the condenser enters the evaporator and evaporates into the ammonia vapour at the low temperature corresponding to its low partial pressure.
- The mixture of ammonia and hydrogen passes to the absorber into which water is also admitted from the separator.
- The water absorbs the ammonia and the hydrogen returns to the evaporator.
- In the absorber the ammonia therefore passes from the ammonia circuit into water circuit as ammonia in water solution.
- This strong solution passes to the generator where it is heated and the vapor given off rises to the separator.
- The water with the vapor is separated out and a weak solution of ammonia is passed back to the absorber, thus completing the water circuit.
- The ammonia vapor rises from the separator to the condenser where it is condensed and then returned to the evaporator.

- Advantages:

1. No pump or compressor is required.
2. No mechanical troubles,maintenance cost is low.
3. No lubrication problem; no wear and tear.
4. Completely leak proof.
5. Noiseless.
6. Easy control, simply by controlling heat input.

- Disadvantages:

1.More complicated in construction and working.

2. C.O.P. very low.

3. The major disadvantages of this type of refrigerator are that if it is spoiled once, it cannot be repaired and has to be replaced fully

No	Vapour Absorption system	Vapour Compression System
1.	Uses low grade energy like heat. Therefore, may be worked on exhaust systems from I.C engines, etc.	Using high-grade energy like mechanical work.
2.	Moving parts are only in the pump, which is a small element of the system. Hence operation is smooth.	Moving parts are in the compressor. Therefore, more wear, tear and noise.
3.	The system can work on lower evaporator pressures also without affecting the COP.	The COP decreases considerably with decrease in evaporator pressure.
4.	No effect of reducing the load on performance.	Performance is adversely affected at partial loads.
5.	Liquid traces of refrigerant present in piping at the exit of evaporator	Liquid traces in suction line may damage the compressor
6.	Automatic operation for controlling the capacity is easy.	It is difficult.
7	Charging of refrigerant is simple	Charging of refrigerant is difficult
8	Part load performance is low	No effect of variation of load

COMPRESSORS

In vapour compression system the compressor is considered as *heart of the system*.

The function of the compressor is

- To draw the low pressure refrigerant from the evaporator
- To compress the refrigerant and to raise its pressure and temperature
- To deliver the high pressure refrigerant to the condenser
- To maintain continuous circulation of refrigerant through the refrigerating system

- **TYPES OF COMPRESSORS**

1)According to the method of compression

(a)Reciprocating compressors(b)Rotary compressors (c)Centrifugal compressors

2)According to the number of working strokes

(a)Single acting compressors (b)Double acting compressors

3) According to the number of stages

(a)Single stage (single cylinder)compressors (b)Multi-stage (Multi cylinder)compressors

4) According to the method of drive employed

(a)Direct drive compressors(b)Belt drive compressors

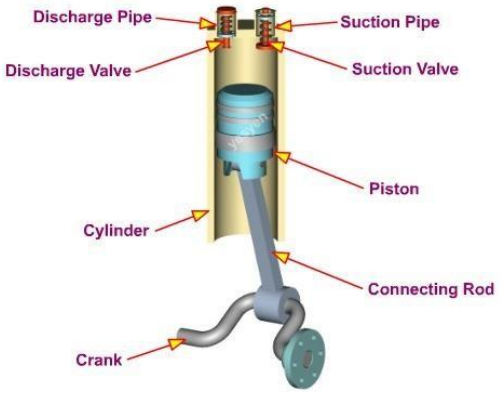
5)According to the location of the Prime mover

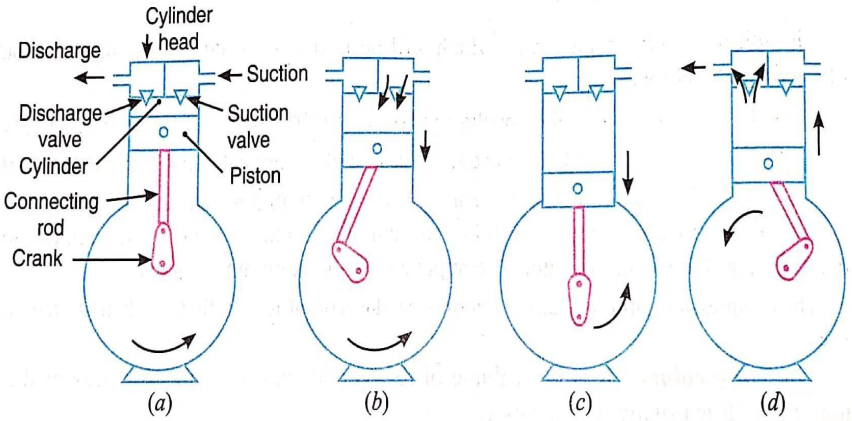
(a) Semi-hermetic compressors(Direct drive, motor and compressor in separate housings)

(b) Hermetic compressors compressors(Direct drive, motor and compressor in same housings)

RECIPROCATING COMPRESSORS

- The compressors in which refrigerant is compressed by the reciprocating motion of the piston are called reciprocating compressors.
- When piston starts moving downwards, the pressure inside the cylinder falls below atmospheric pressure& suction valve/inlet valve opens.
- The air is drawn into the cylinder through a suction filter element. This operation is known as suction stroke.
- When the piston moves upwards, compresses the air in cylinder & inlet valve closes when the pressure reaches atmospheric pressure.
- Further compression follows as the piston moves towards the top of its stroke.
- At the end of this stroke discharge/delivery valve opens & air is delivered to a receiver


Discharge Pipe
Suction Pipe
Discharge Valve
Suction Valve
Piston
Cylinder
Connecting Rod
Crank


Cylinder head
Discharge
Suction
Discharge valve
Suction valve
Cylinder
Piston
Connecting rod
Crank
(a)
(b)
(c)
(d)

- Reciprocating compressor classifications
- (i)Open Type
- An open type compressor is driven with electric motor with the help of pulley and belt system.
- The motor and compressor can be mounted on the same base. For this unit maintenance is very easy *as motor and compressor units are separate .*
- The refrigerant leakage problems are usual in this case in spite of providing refrigerant seals around the crank shaft.
- (ii)Semi Hermetic Type
- To avoid leakage of refrigerant the *motor and compressor are enclosed in the same housing.*
- In these compressors cylinder heads are removable type.
- As the top cover is bolted and removable the assemblies can be opened as and when required for servicing or repairs.
- (iii) Hermetic Type
- The compressor is directly mounted on the shaft of the motor and enclosed.
- The *compressor motor assembly are hermetically sealed in a welded steel shell*.
- The only connections to the compressor housing are suction and discharge fittings and terminals of the motor.
- These are employed in small domestic refrigerators ,home freezers and window air conditioners.

Open Type

Hermetic Type

Semi Hermetic Type

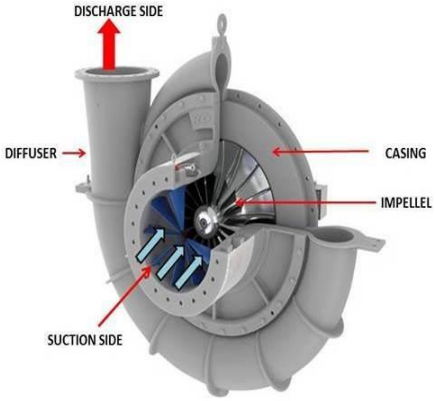
CENTRIFUGAL COMPRESSOR

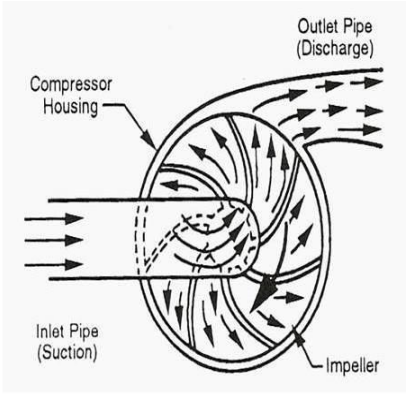
- The Principle of Centrifugal Compresser:

1. The air reaches the center of the impeller
2. Air is forced outward by centrifugal force.
3. Diffuser gradually reduces the air velocity.
4. Velocity energy is converted to higher pressure.

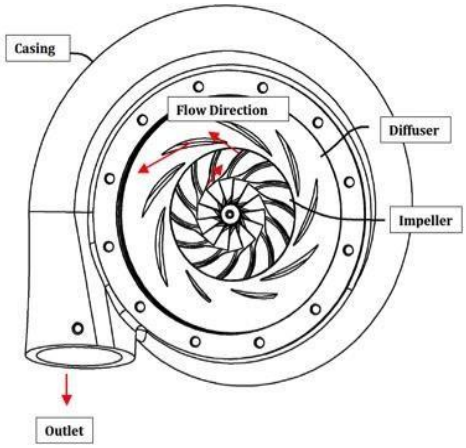
- Impeller contains a rotating set of vanes (or blades) that gradually raises the energy of the working gas.
- The diffuser's responsibility to convert the kinetic energy (high velocity) of the gas into pressure by gradually slowing (diffusing) the gas velocity.
- The refrigerant passes through the passage of the casing of increase area where in velocity of flow decreases and pressure increases.
- It consists of an impeller on which number of curved vanes are fitted symmetrically.
- The refrigerant vapour enters the rotating impeller through the intake port from the centre. The Impeller rotates in an air tight volute casing .
- When impeller rotates it pushes the vapour refrigerant from the centre of the impeller to its periphery by centrifugal force.
- The high speed of the impeller leaves the vapour refrigerant at a high velocity at the vane tips of the impeller.

- The refrigerant from the outer impeller passes over the diffuser.
- Diffuser converts its kinetic energy into static pressure energy .
- The refrigerant passes through the passage of the casing of increasing area where in velocity flow decreases and pressure increases .
- The volute casing is so designed that the kinetic energy of the refrigerant gets converted into pressure energy before leaving the casing.



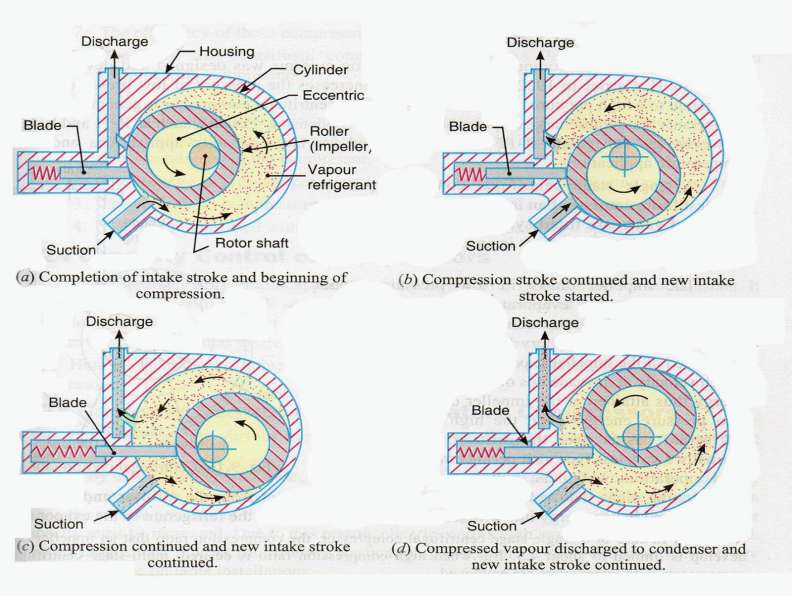


CENTRIFUGAL COMPRESSOR



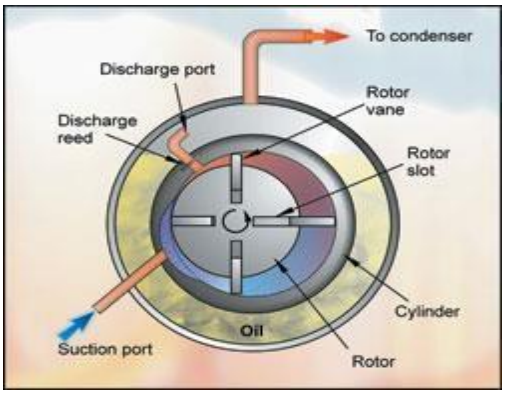
ROTORY COMPRESSORS

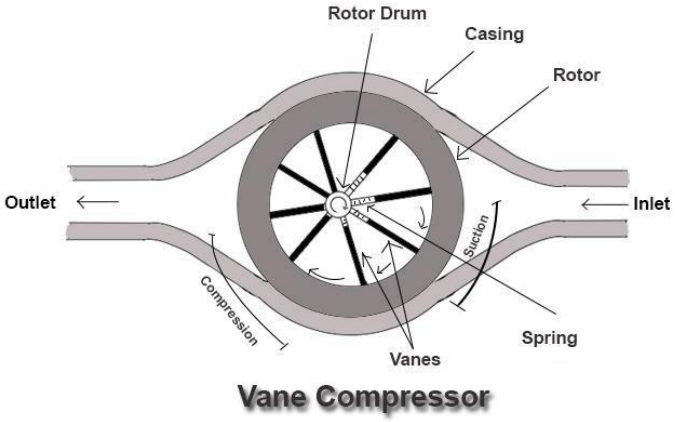
- Figure(a) shows completion of intake of refrigerant and the cylinder is full with low pressure and temperature refrigerant vapour.
- When the roller rotates the vapour refrigerant ahead of the roller is being compressed and new intake from the evaporator is drawn into the cylinder as shown in figure(b)
- When the roller turns towards mid position, the compressed refrigerant is discharged into the condenser from one side of the roller where as on the other side more vapour refrigerant is drawn into the cylinder as shown in figure(c)
- At the end of compression as shown in the figure (d)most of the compressed vapour refrigerant is pushed out in the condenser through the discharge port.



ROTATING BLADE (VANE)TYPE

- The low pressure and temperature vapour refrigerant is drawn from the evaporator through the suction port.
- As the rotor turns, the suction vapour is entrapped between the adjacent rotating blades as shown in the figure .
- The vapour is compressed as the blades rotate from the point of maximum rotor clearance to minimum rotor clearance.
- The compressed refrigerant at high pressure and temperature is discharged to the condenser.





Vane Compressor

https://www.youtube.com/watch?v=b93GSe-xgqI

CONDENSERS

- Condenser is an important equipment located on high pressure side of the refrigeration system.
- It is a heat exchanger where heat transfer takes place between the super heated refrigerant received from the compressor and the cooling medium of the condenser.
- The refrigerant is first cooled to saturation and then condensed to liquid state.
- The cooling medium may be air or water or a combination of the two

Types of condensers

The condensers are classified on the basis of cooling medium used in them.

- 1.Air cooled condensers

(a) Natural convection condenser.
(b) Forced convection condenser.

- 2.Water cooled condensers

(a)Shell and tube condenser (b) Shell and coil condenser (c)Double pipe condenser

- 3.Evaporative condensers

- 1.Air cooled condensers
- In air cooled condensers heat of the refrigerant is removed by air using either natural or forced circulation.
- The condensers usually made of steel ,copper or aluminium tubing provided with fins to increase the effective area of heat dissipation surface.
- The refrigerant flows inside the tubes and air circulates around the tubes.
- It is not used for large system because of high pressure drop, noise,high power consumption
- Heat transfer coefficient is very low hence fins are used.

NATURAL CONVECTION

- In natural convection type, heat transfer from the condenser is by buoyancy induced natural convection and radiation.
- Due to small air flow and low radiation heat transfer, the combined heat transfer coefficient in these condensers is small.
- As a result a relatively large condensing surface is required to reject a given amount of heat.
- Example - household refrigerators and freezers.

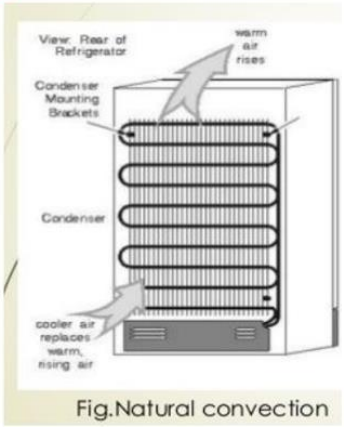


Fig.Natural convection

FORCED CONVECTION

- In forced convection type condensers, the circulation of air over the condenser surface is maintained by using a fan or a blower.
- These condensers normally use fins on air-side for good heat transfer.
- The fins can be either plate type or annular type.
- Forced convection type condensers are commonly used in window air conditioners, water coolers and packaged air conditioning plants.

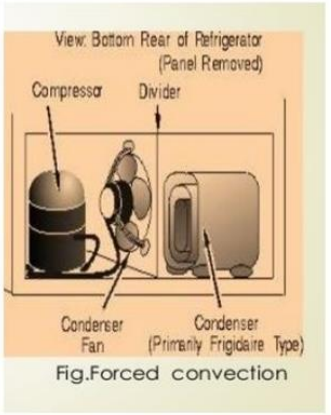
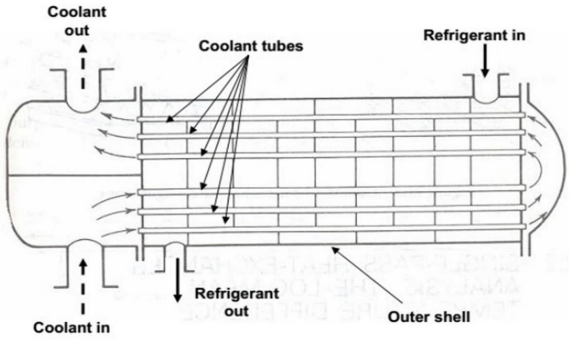


Fig.Forced convection

- Water cooled condensers
- The cooling medium used in these condensers is water
- These are all used for all sizes and types of refrigeration machines
- Classifications
- 1.shell and tube condensers
- 2.Shell and coil condensers
- 3.Double pipe condensers

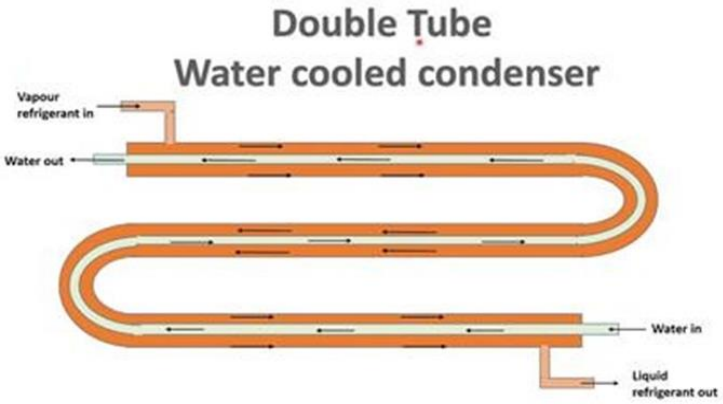


A two-pass, shell-and-tube type condenser

- a)Shell and tube condenser
- The shell and tube condenser consists of steel shell fitted with horizontal water tubes.
- This is universally used for all high capacity units and it gives satisfactory service among all types of condensers.
- The water tubes are connected to the headers which are provided at both ends of the condenser.
- These headers can be opened for periodic cleaning of the condenser tube.
- The cooling water enters at the bottom and flows through the lower set of the tubes till it reaches other end of the shell.
- It is then rises up and travels in the opposite direction through the upper set of the tubes and finally leaves the condenser through the outlet.
- Therefore the water travels in the tubes almost twice the length of the shell and absorbs heat from hot refrigerant and the temperature of water rises.
- Meanwhile the refrigerant vapours enter from the top and flows downwards coming in contact with surface of the cold water tubes.
- The refrigerant is cooled by the water and gets condensed .
- These condensers are available for units 2 to 1000 tons capacity

- b)Shell and coil condenser
- It can be used for units up to 50 tons capacity
- The cooling water enters the coil at the lower end and leaves it at the upper end.
- The refrigerant vapour enters at the top of the shell and flows downwards coming in contact with cold water outside surface of the coil.
- Thus the refrigerant is cooled and gets condensed.
- The liquid refrigerant collects at the bottom of the shell.

- c)Double tube condenser
- This condenser consists of two pipes in which one pipe is fitted inside the other .
- The cooling water enters in the inner pipe at the lower end and leaves it at the upper end.
- The refrigerant vapours enter the outer pipe at the upper end and liquid refrigerant leaves it at the lower end.
- This counter flow system is preferred in water cooled condensers because it gives high rate of heat transfer.
- Therefore maximum amount of heat transfer from the refrigerant to water takes place.
- In addition to this refrigerant vapour passing through the outer tube is further cooled by the out side atmospheric air.
- These condensers are efficient and effective.
- They are used up to 10 ton capacity plants.

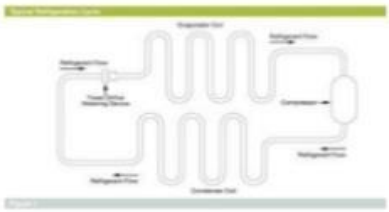


Sl.No.	Water cooled condenser	Air cooled condenser
1.	Initial cost and maintenance costs are high	It is simple in construction. It is cheap. Maintenance cost is also very low.
2.	Additional pipes are required to take water to and from the condenser.	No piping work is involved.
3.	If there is no water re-circulation system disposing of used water is difficult.	No problem in disposing of air.
4.	Corrosion occurs inside the water carrying surface and there are more fouling effects.	Corrosion and fouling effects are negligible.
5.	Heat transfer rate is high.	Heat transfer rate is low.
6.	Used for large capacity plants.	Its use is restricted to small capacity refrigeration units.
7.	It is silent in operation as there is no fan.	It produces noise in forced air circulation because of fan.
8.	Flexibility is low	High flexibility.
9.	Even distribution of water on the condensing surface area.	Un even distribution of air on the condenser surface area.
10.	Handling of equipment is difficult.	No handling problems.

EVAPORATORS

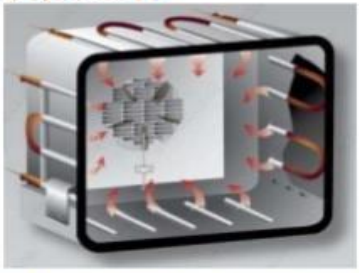
- The function of evaporator is to absorb heat from the refrigerated space and to produce required low temperature by means of a refrigerant.
- It is the most important part of the refrigeration system and it is located on the low pressure side of the system.
- Refrigeration effect or coldness is produced in the evaporator.
- The evaporator is known as cooler or freezers.
- Types of Evaporators
- 1.Natural Convection Evaporators (natural circulation)
- 2.Forced Convection Evaporators (Forced circulation)
- 3.Dry Expansion Evaporators
- 4.Flooded type Evaporators

Natural convection evaporators



- Low velocity and min. hydration is require
- Velocity of air depends upon temp. difference
- Circulation of air around coil depends upon its size shape and location
- The coil should occupy 2/3rd of width of the path & 3/4th the length of the box

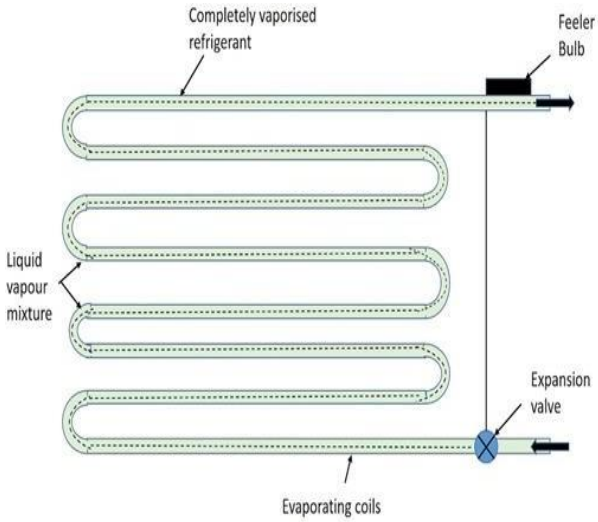
Forced convection evaporators



- Air is forced over refrigerant coils
- Fins are provided to increase heat transfer rate
- More efficient than natural convection evaporators
- Require less cooling surface and high evaporator pressure can be used which save power input to the compressor

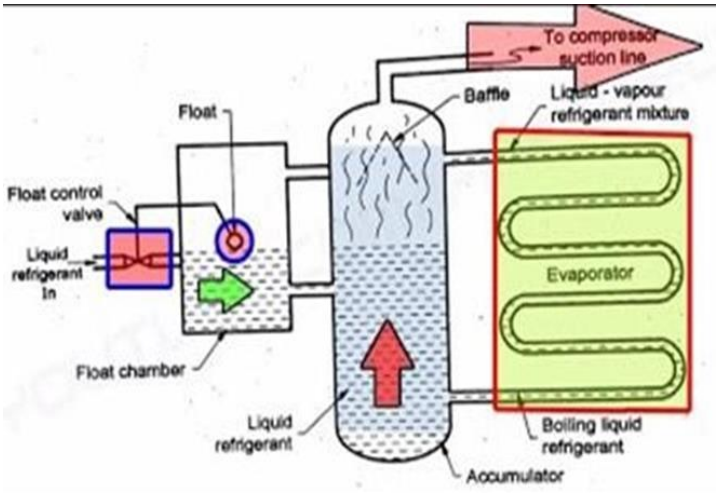
DRY EXPANSION EVAPORATOR

- Dry expansion type evaporators are used with smaller capacity refrigeration plants below 150 tons.The expansion valve feeds the liquid refrigerant to the evaporator
- The expansion device feeds the evaporator at such a rate that the whole of the refrigerant gets converted into vapour gradually by the time it reaches the end of the coil.
- The rate of feeding the liquid refrigerant depends on the refrigerating load.
- The feeler bulb of the expansion valve controls the rate of flow through the orifice of the control.
- This type of evaporator has the maximum efficiency when the system is fully loaded.



FLOODED TYPE EVAPORATORS

- The flooded type evaporators are always full of liquid refrigerant and its level is maintained constant by a float valve.
- A liquid refrigerant enters the evaporator through a float valve into the float chamber and flows down to the tubes.
- Due to the heat transfer the liquid refrigerant boils and the mixture of vapour and liquid refrigerant collects in flash chamber.
- The baffle plates provided in the tank prevents the liquid particles present in the vapour from entering into the suction line.
- In this chamber vapour and liquid are seperated .the vapour which is light in weight rises up and passes to the top of the flash chamber. The vapour is drawn by the compressor and the liquid remains in the evaporator.
- The flooded evaporators have many industrial applications, particularly in chemical and food processing industries



EXPANSION DEVICES

- An expansion device is an important component in vapour compression system and is located between receiver and evaporator.
- This device divides the high pressure side and low pressure side of a refrigerating system.
- It is also called as metering device or throttling device.
- Functions
- It reduces high pressure liquid refrigerant coming from condenser to low pressure liquid refrigerant before it is supplied to the evaporator.
- It regulates the flow of refrigerant according to the load on the evaporator. It supplies refrigerant at the rate at which it evaporates.
- Types of expansion valve

1.Capillary tube

2.Automatic expansion valve

3.Thermostatic expansion valve

1.CAPILLARY TUBE

- This device is used for small capacity units like domestic refrigerators, water coolers and small commercial freezers.
- It is a small diameter tube connected between condenser and evaporator.
- Typical tube diameters of refrigerant capillary tubes range from 0.5 mm to 3 mm and the length ranges from 1.0 m to 6 m.
- It is a constant restriction type device and is merely a tube with narrow area of flow.
- The required pressure drops is obtained due to heavy frictional resistance offered by a small diameter tube.
- The resistance offered is directly proportional to its length, and inversely proportional to its diameter.
- The liquid refrigerant enters the capillary tube. Because of frictional resistance offered by a small diameter tube, the pressure drops.
- The use of this capillary tube is limited to small capacity units up to 1 ton.

- Merits

1. It is simple in construction and no maintenance is required.
2. The cost of capillary tube is less compared to other expansion devices.

- Demerits

1.Can not be used with high fluctuating load conditions

2.The refrigerant must be free from moisture and dirt otherwise it will choke the tube and stop the flow of refrigerant.

- **Capillary tube**

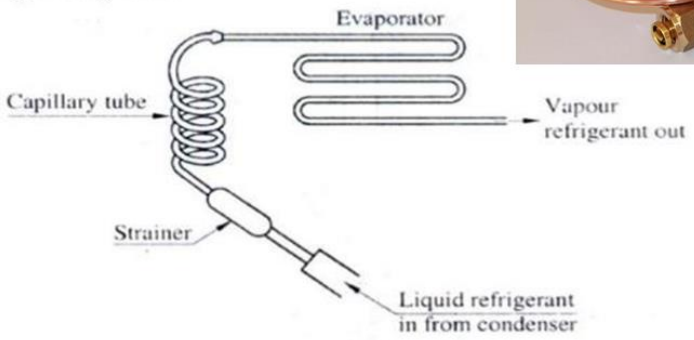


Fig. Capillary tube

AUTOMATIC EXPANSION VALVE

- The automatic expansion valve is also known as a constant pressure expansion valve. This valve maintains a constant evaporator pressure irrespective of the load on the evaporator.
- The automatic expansion valve consists of a needle valve, a valve seat ,a diaphragm. A spring and a strainer
- The spring exerts its force on the top of the diaphragm in the opening direction of the valve.
- Evaporator pressure acts below the diaphragm.
- Therefore the combined forces of evaporator pressure and the spring pressure act to counter balance each other.
- Working
- When the evaporator pressure drops below the valve setting due to change in heat load the spring pressure moves the valve in an opening direction which increase the refrigerant flow in an effort to raise the evaporator pressure.
- On the other hand, when the evaporator pressure rises, the diaphragm moves upwards to reduce the opening of the valve. This reduces the flow of liquid refrigerant to the evaporator ,thus lowers the evaporator pressure till the desired evaporator pressure is reached.
- Automatic expansion valve is suitable only for Constant load applications.
- The major disadvantages of this device is the poor efficiency of operation compared with other expansion devices .

- **Automatic Expansion Valve**

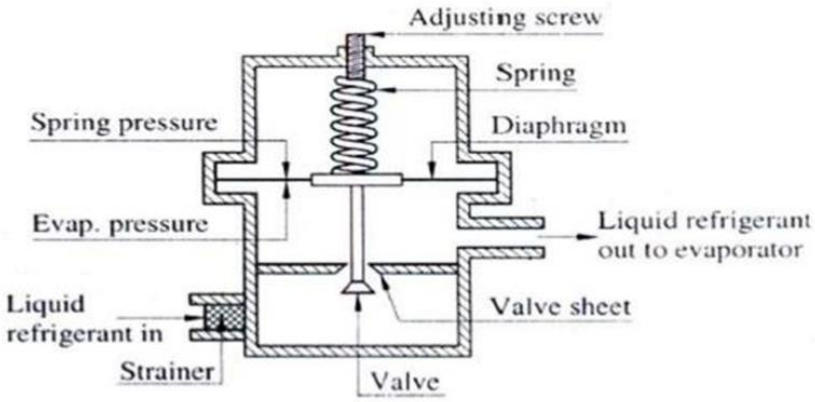


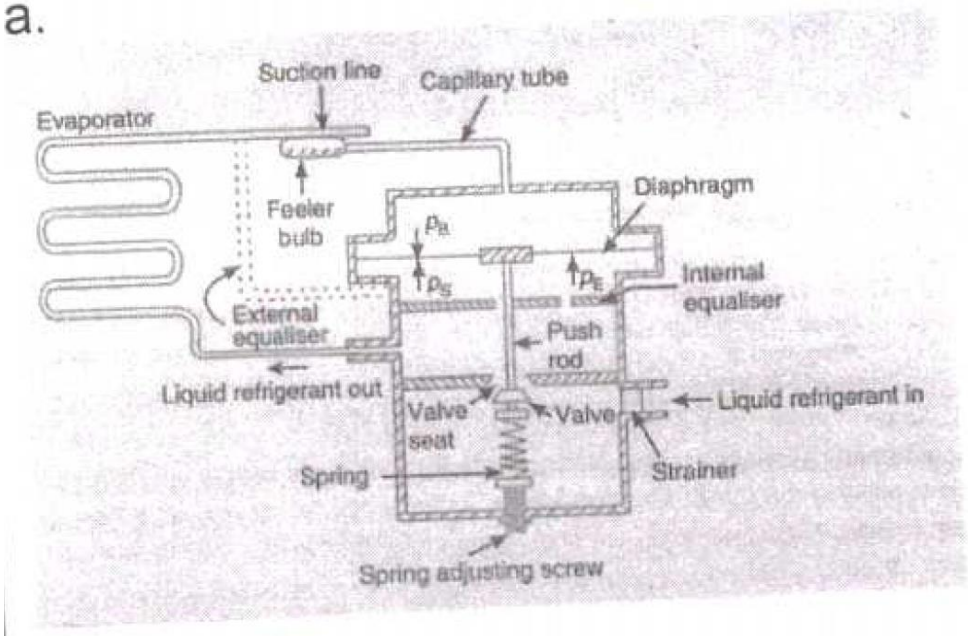
Fig. Automatic expansion valve

THERMOSTATIC EXPANSION VALVE

- This is the most popular type of expansion device commonly used for applications in refrigeration and air conditioning plants.
- This is the precision device used to regulate the flow of refrigerant into the evaporator in exact proportion to the rate of evaporation of the liquid refrigerant according to the load variations.
- This is also called constant super heat valve because at the exit of the evaporator it maintains constant super heat of the vapour refrigerant.
- The construction of a thermostatic expansion valve is shown in figure.
- It consists of a needle valve, valve seat, a diaphragm spring and adjusting screw.it has also a feeler or thermal bulb which is mounted on the suction line near outlet of the evaporator coil.
- The opening and closing of the valve depends upon three forces acting on the diaphragm. They are ..
- 1.The spring pressure P1 acting on the bottom of the diaphragm.
- 2.The Evaporator pressure P2 acting on the bottom of the diaphragm
- 3.The feeler bulb pressure P3 acting on the top of the diaphragm
- P3=P1+P2

- Working
- When the cooling load increases, the refrigerant evaporates at a faster rate in the evaporator.
- Then the degree of super heat and its pressure in the bulb increases ,it expands and transmits the pressure to the top of the diaphragm through capillary tube.
- This causes the valve to open more and admit more refrigerant into the evaporator.
- When the cooling load decreases the refrigerant evaporates at slower rate ,its pressure drops and its degree of super heat decreases .
- As the feeler bulb is cooled ,the refrigerant contracts and it transmits less pressure on to the diaphragm.
- This reduces the opening of the valve and thus flow of refrigerant into the evaporator.
- This continues till the spring pressure and evaporator pressure maintains equilibrium with feeler bulb pressure.
- Functions
- It reduces the pressure of the refrigerant before entering into the evaporator
- It feeds exact required amount of refrigerant into the evaporator according to the load variations.
- It controls the flow of refrigerant according the load variations

a.


Suction line
Capillary tube
Evaporator
Diaphragm
Feeler bulb
p_a
p_s
p_E
Internal equaliser
External equaliser
Push rod
Liquid refrigerant out
Valve seat
Valve
Liquid refrigerant in
Spring
Strainer
Spring adjusting screw

- Drier
- Drier is a device containing desiccant ,placed in the refrigerant circuit to remove moisture from refrigerant.
- It is usually placed in the liquid line.
- Driers are cylindrical shells in which drying materials provided.
- The drying material is called desiccant.
- The desiccant removes moisture from solid,liquid or vapour.
- It is charged with some moisture absorbing chemicals such as silicagel,activated alumina ,calcium sulphate ,calcium chloride.
- strainer
- Strainers are low cost filtration devices designed to protect refrigeration components, including valves, compressors and capillary tubes from system contaminants.
- It is made of copper construction to resist corrosion .
- Muffler
- Most refrigeration systems require mufflers to reduce noise due to gas pulsations in compressor suction and discharge lines.

- Defrosting
- The process of removing frost by melting is called defrosting the evaporators .
- Methods of Defrosting

1.Manual defrosting method

2.Pressure control defrosting method

3.Temperature control defrosting method

4.Water defrosting method

5.Simple hot gas defrosting method

6.Automatic hot gas defrosting method

7.Electric defrosting method

REFRIGERANTS

- It is the primary working fluid used for absorbing and transmitting heat in a refrigerating system
- Typically refrigerants undergo phase change during heat absorption (evaporation) ad heat releasing (condensation).
- Primary Refrigerants:
- When used in compression or absorption systems, these fluids provide refrigeration by undergoing a phase change process in the evaporator.
- Primary refrigerant directly take part in refrigeration, Eg Freon (R11, R22, R32, R407C, R134a etc), Ammonia, water. Theses refrigerants directly absorb heat from a system and take part of refrigerant cycle. In case of Primary refrigerant latent heat transfer takes place.
- secondary refrigerants
- secondary refrigerants are those liquids, which are used for transporting thermal energy from one location to other.
- Secondary refrigerant are cooled by primary refrigerant and then they are circulated, eg Chilled water, Chilled brine.(Methanol, Glycol, Cacl2 etc), In most cases secondary refrigerant usage sensible heat transfer.
- Avoidance of secondary refrigerant will improve energy efficiency in the system, while use of secondary refrigerant system provides freedom from design complication and can be managed easily.

Desirable properties of an ideal refrigerant

- Low boiling point
- High critical temperature
- High latent heat of vapourisation
- Low specific heat of liquid
- Low specific volume of vapour
- Non corrosive to metals
- Non flammable and non explosive
- Safe and non toxic
- Low cost
- Easy to detect leaks either by odour or indicator

APPLICATIONS OF REFRIGERATION

- Domestic refrigerator
- Ice plants
- Water coolers – pressure type and storage type
- Cold storage
- Dairy refrigeration system
- Freeze drying process
- Ice cream making process

DOMESTIC REFRIGERATOR

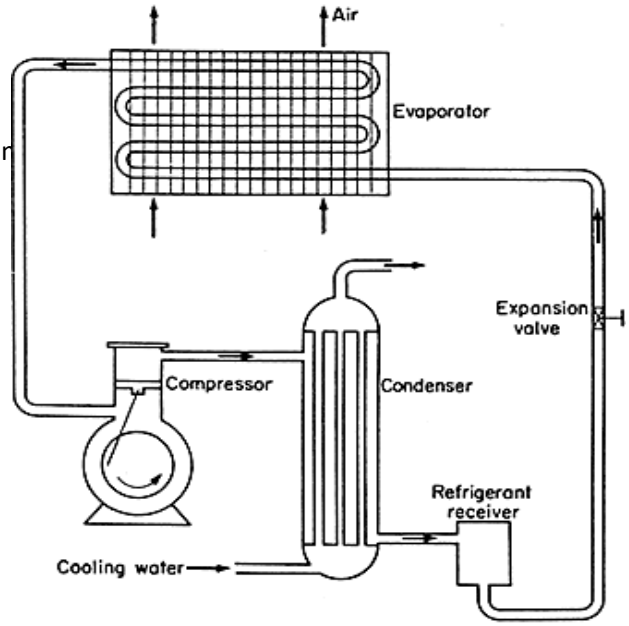
- It is used for domestic purpose ,vendors shop,hotels,officers,laboratories,hospitals,medical shops etc.
- The common sizes of refrigerators avilable are 80ls,165ls etc gross volur
- Refrigerators may be single door or double door type.
- The refrigerator works on vapour compression cycle.
- Each cycle of operation consists of the four fundamental changes in the state of the refrigerant:

(i) Expansion

(ii) Vaporization

(iii) Compression

(iv) Condensation.

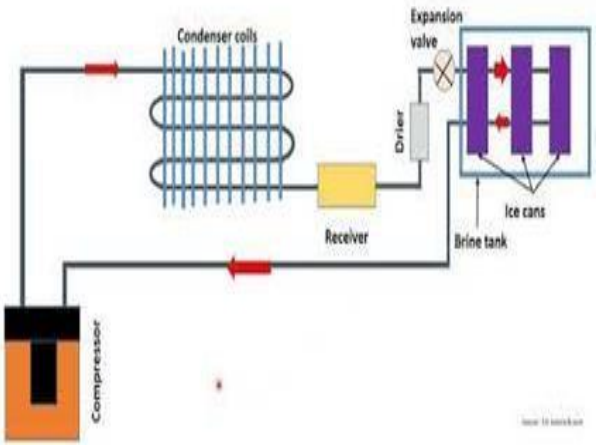


- **Compressor**:
- Hermitically sealed rotary compressor is placed in the cabinet case.
- The refrigerant widely used in the domestic refrigerator is R-12
- The compressor compresses the refrigerant vapour received from the evaporator through suction line.
- **Condenser**:
- The condenser is provided at the back side of the refrigerator.
- The condenser or cooler consists of coils of pipe in which the high pressure and temperature vapour refrigerant is cooled and condensed.
- The refrigerant, while passing through the condenser, rejects its latent heat to the external surrounding air.
- The hot refrigerant received from the compressor is converted into liquid form in the condenser.
- **Receiver**:
- The condensed liquid refrigerant from the condenser is stored in a vessel, known as a receiver
- **Expansion Valve or Throttle Valve**:
- The function of this valve is to allow the liquid refrigerant under high pressure and temperature to pass at a controlled rate after reducing its pressure and temperature.
- Some of the liquid refrigerant evaporates as it passes through the expansion valve, but the greater portion is vaporized in the evaporator at the low pressure and temperature.

- **Evaporator**:
- An evaporator consists of coils of pipe in which the liquid-vapor refrigerant at low pressure and temperature is evaporated and changed into vapor refrigerant at low pressure and temperature.
- The evaporator coil can produce low temperature upto -15C.The usual temperature in the refrigerator cabinet is around 7 to 10C.
- During the evaporation process, the liquid-vapor refrigerant absorbs its latent heat of vaporization from the medium which is to be cooled (i.e. items placed in the refrigerator).

ICE PLANT

- The function of an ice plant or ice factory is to make or form ice in large quantities and in large size.
- Ammonia: It is the secondary refrigerant which takes heat from brine. This ammonia changes phase while moving in the circuit
- Brine: It is the primary refrigerant which takes heat from the water and produces ice.
- Receiver: It is used to collect the liquid Ammonia from the condenser.
- Throttle Valve: It expands Ammonia coming out from receiver to low pressure.
- Evaporator: It vaporizes the liquid Ammonia from throttle valve by extracting heat from 'brine' and hence brine gets cooled and this brine solution is recirculate to water tank containing 'ice cans filled with water' to absorb the heat of water to freeze it and make ice.



- Components
- Compressor: Its function is to increase the temperature and pressure of Ammonia vapor coming out from evaporator.
- Condenser: It liquefies the high-pressure and high-temperature Ammonia to high-pressure and high-temperature Ammonia.. The heated water is pumped and again taken to the circuit after it has been cooled at natural cooling tower
- Working
- Low pressure and low-temperature Ammonia coming out from the throttle valve is vaporized by taking the latent heat from the brine. Hence brine gets cooled which is circulated in the brine circuit to freeze the water and forming ice from water.
- This cooled brine further absorbs the heat from water and converts water to ice.
- Vaporized Ammonia is compressed to high pressure and temperature and passes from condenser.
- In condenser Ammonia is condensed by water circulated in cooling water circuit having a natural cooling tower. The condenser condenses the Ammonia by water coming from natural cooling tower.

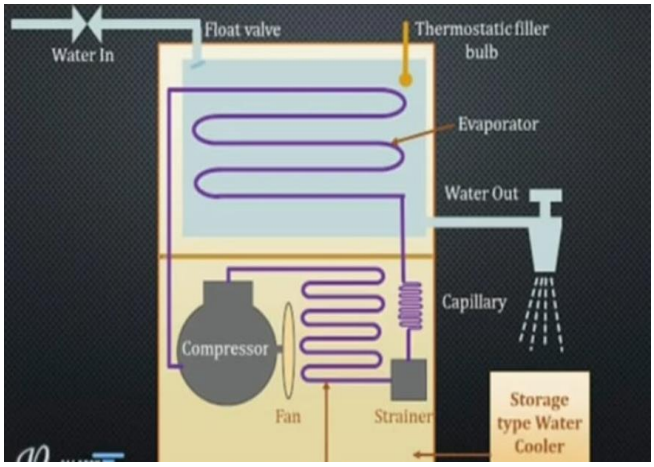
NH_3	CO_2	Trichlorofluoromethane(Freon 11)	Dichlorodifluoromethane (Freon 12)	Chlorotrifluoromethane (Freon 13)
requires smaller pipe diameters	Very good heat transfer coefficient	Colorless	It is normally odorless	non-flammable, non-corrosive
detected very quickly due to the odour	Very low viscosity	boils around room temperature	safe and nontoxic under normal conditions	high ozone depletion potential,
Energy efficiency	CO_2 has high energy content at higher temperatures,	Class 1 ozone-depleting substance	It is also used in aerosol spray propellants such as body sprays, hair sprays, etc.	high global warming potential
environmentally friendly refrigerant.	Eco friendly	refrigerant, aerosol propellant, and foam-blowing agent.	it damages the ozone layer.	
toxic refrigerant, and it is also flammable	CO_2 does not react with common metals	environmental contaminant.		

- Environmentally safe refrigerants
- R123
- R 123 refrigerant is a hydrochlorofluorocarbon (HCFC)
- Low ozone depletion and excellent environmental properties
- A Refrigerant for **Efficient Cooling in Large Buildings**
- The chilled water cools and dehumidifies air in commercial, industrial, and institutional facilities
- R-123 is **not flammable at ambient temperatures and atmospheric pressure**
- R134a
- R134a is also known as Tetrafluoroethane (CF3CH2F) from the family of HFC refrigerant
- Used in conditioning system in newer automotive vehicles.
- **high thermal stability, low boiling point, and chemical inertness** against the construction materials used; and is non-toxic and non-flammable.
- HFC-134A was developed to replace chlorofluorocarbon (CFC) refrigerants that contain chlorine, which damages the ozone layer.
- R125
- Pentafluoroethane
- **Volatile liquid with ethereal and faint sweetish odor**. Non-flammable material.
- **colourless HFC refrigerant gas**

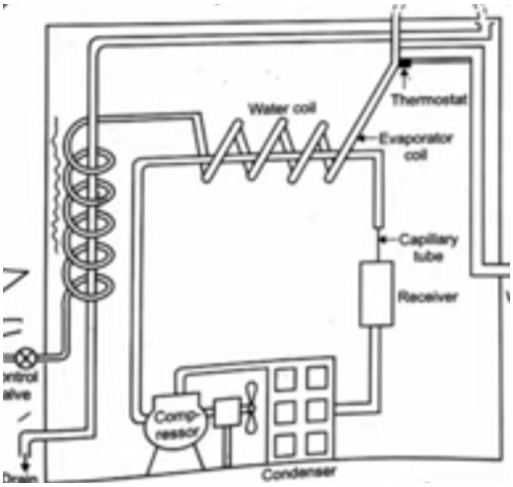
WATER COOLER

- A water cooler is **a machine that dispenses drinking water**
- **There are two types**
    - **Storage type**
    - **Pressure type**

  Storage type
- This type of cooler has all the parts that are used in a normal fridge that we use in our home
- In this type of cooler, the evaporator coils are soldered on to the outer surface of the walls of the storage tank.
- The water level of the storage tank may be maintained by a float valve. In this type of cooler, the disadvantage is that the time taken to bring the temperature down to the set value is more
- The thermostat senses the temperature of water and stops the machine when the set temperature has been achieved. When water is drawn from the cooler for drinking, an equal amount of water is being admitted in to the tank. When the temperature of the water increases more than the set point, the machine starts its cycle automatically.

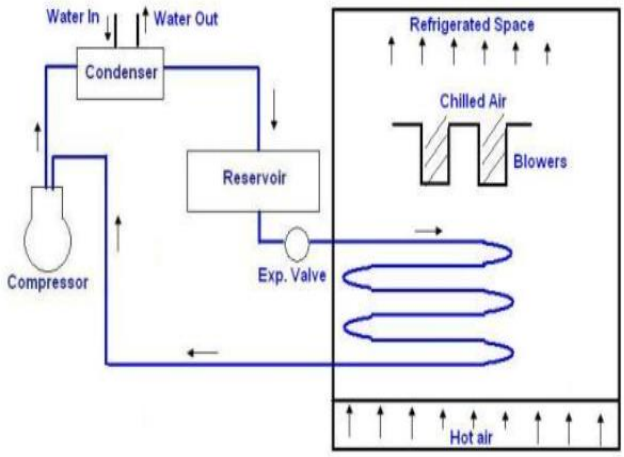


- Pressure type water cooler
- In this type of cooler, water is supplied under pressure. The city water enters the cooler at the rear of the cooler. It is cooled initially in a pre-cooler. The waste water passing through the drainage line is also cool; hence this drainage pipe is wrapped around the fresh water pipe for pre-cooling thus reducing the cooling load for the cooler. The pre-cooled water is then taken to the storage chamber, where the refrigerant gains heat from the water. The outlet for water is taken from the bottom of the storage tank which may be a bubbler or a self-closing valve. A thermostat is used to control the temperature of water in the pipe to maintain a particular set point.



WORKING OF COLD STORAGE

- The cold storage is specially designed and built of concrete, stone or brick in order to prevent leakage or cold leakage. Its floors and ceilings, walls and doors are properly insulated with special insulating materials with low thermal conductivity.
- Works on vapour compression refrigeration cycle



- The compressor compresses vaporized refrigerant(Ammonia) to high pressure and high temperature to raise the boiling point of refrigerant.
- The condenser then liquefies the vaporized refrigerant to high-pressure and high-temperature state. Thus, heat rejection takes place
- The condensate from the condenser is collected in a reservoir and allow to pass through an expansion valve where its pressure and temperature decrease from an earlier state.
- The the low-pressure liquid refrigerant then allows passing through refrigerated space whereby the heat of hot air of refrigerated space starts evaporating the liquid refrigerant hence, heat in the atmosphere decrease and cooling is produced.
- Blowers circulates the chilled air to stored fruits and vegetables.

FREEZE DRYING PROCESS

- Freeze Drying is a process in which a completely frozen sample is placed under a vacuum in order to remove water or other solvents from the sample, allowing the ice to change directly from a solid to a vapor without passing through a liquid phase. This process, called sublimation, along with the minimal heat input that is required, is ideal because of the long-term preservation properties it provides to the integrity of the sample's biological and chemical structure. Lyophilization can be achieved in various volumes, from small at-home freeze dryers all the way up to large, production-scale equipment.