UNIT-VII

REFRIGERATION

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RANGE

- By the end of this unit you will be able to understand:
- LAWS OF THERMODYNAMICS
- VAPOUR COMPRESSION CYCLE
- ABSORPTION CYCLE
- SOLAR REFRIGERATORS
- WALK IN CHILLERS
- COMPONENTS IN A REFRIGERATOR
- ENERGY MANAGEMENT SYSTEM

PRINCIPLES OF THERMODYNAMICS

- ZEROTH LAW
- FIRST LAW
- SECOND LAW
- THIRD LAW

VAPOUR COMPRESSION REFRIGERATION CYCLE

- It consists of following:

  1.Refrigerant 2.Reciever 3. Thermostatic expansion valve (TXV) 4. Evaporator 5. Compressor 6. Condenser.

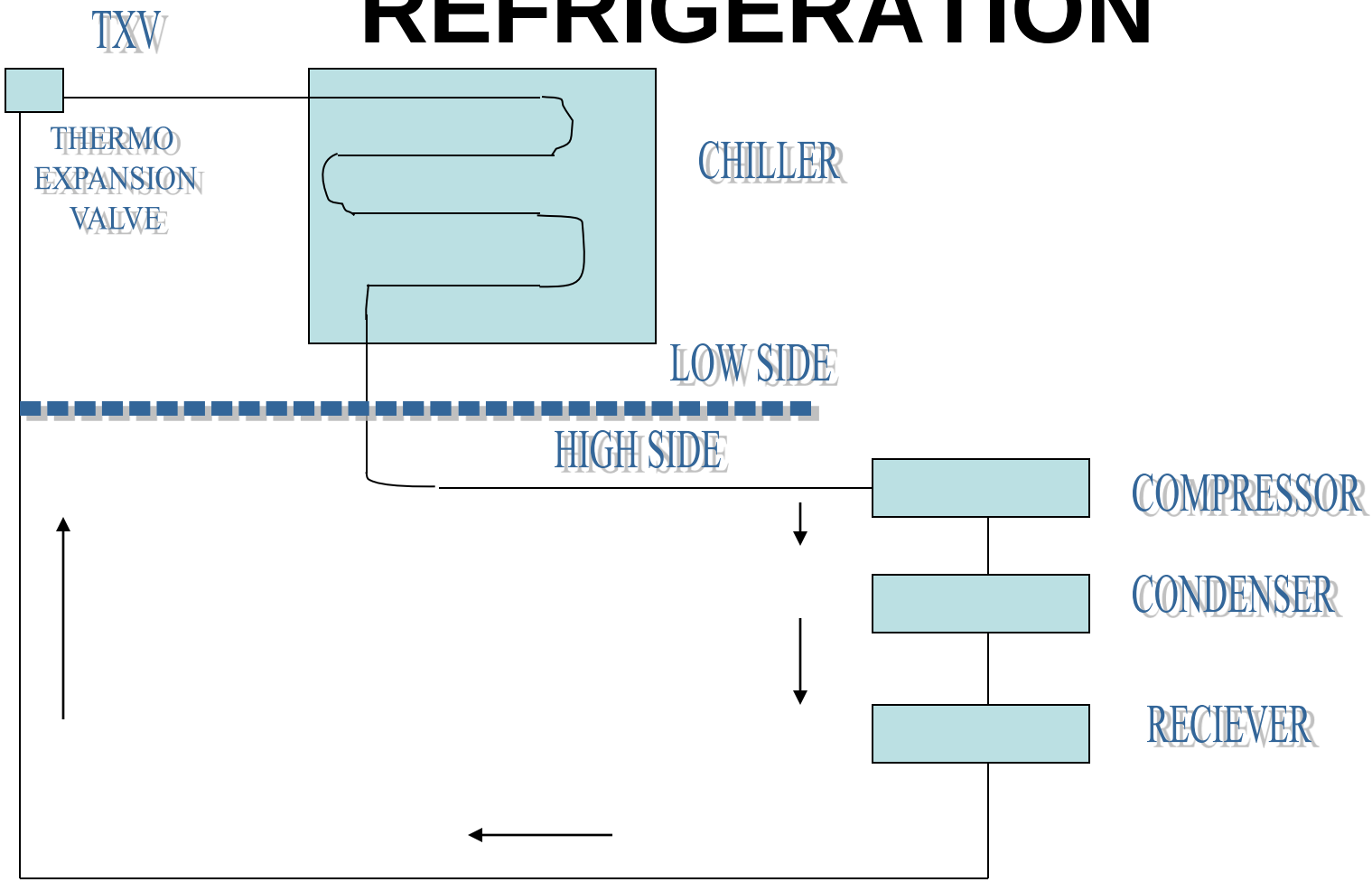
- **REFRIGERANT**: It should have a low boiling point.
- Boiling point of the refrigerant increases with increase in pressure. Decrease of pressure reduces the boiling point.

QUALITIES OF A REFRIGERANT

- The refrigerant should have following properties:

1. It should have a high latent heat of vaporization i.e. maximum cooling.
2. It should be non-toxic i.e. should not cause any health hazard.
3. It should have a desirable saturation temperature – for operating pressures.
4. It should be stable i.e. it should be non-flammable & non-explosive.
5. Leaks should be easily detected
6. It should have low cost.
7. It should be readily available.

VAPOUR COMPRESSION REFRIGERATION



EXPANSION

- The refrigerant which is in the liquid form enters the expansion valve at high pressure.
- TXV reduces the pressure & the refrigerant enters the evaporator (chiller).
- The TXV also regulates the flow of refrigerant to the evaporator.
- The expansion valves controls the compressor. When the valve is closed, the compressor also stops.
- Some appliances have thermostat connected to compressor & TXV.

EVAPORATION

- The refrigerant absorbs latent heat of vaporization
- The temperature can be maintained as low as the boiling point of the refrigerant.
- The heat gained by the refrigerant is equal to the heat loss from the surroundings.
- After this heat exchange process, the refrigerant is slightly superheated to 5°F.

COMPRESSION

- The compressor has two important functions;

  A. pump the refrigerant gas out of the evaporator.

  B. increase the refrigerant pressure.

- The compressor compresses low-pressure vapour to high pressure vapour.
- High pressure increases the boiling point hence the refrigerant condenses.
- Electricity is required to operate a motor which in turn drives the compressor.

CONDENSATION

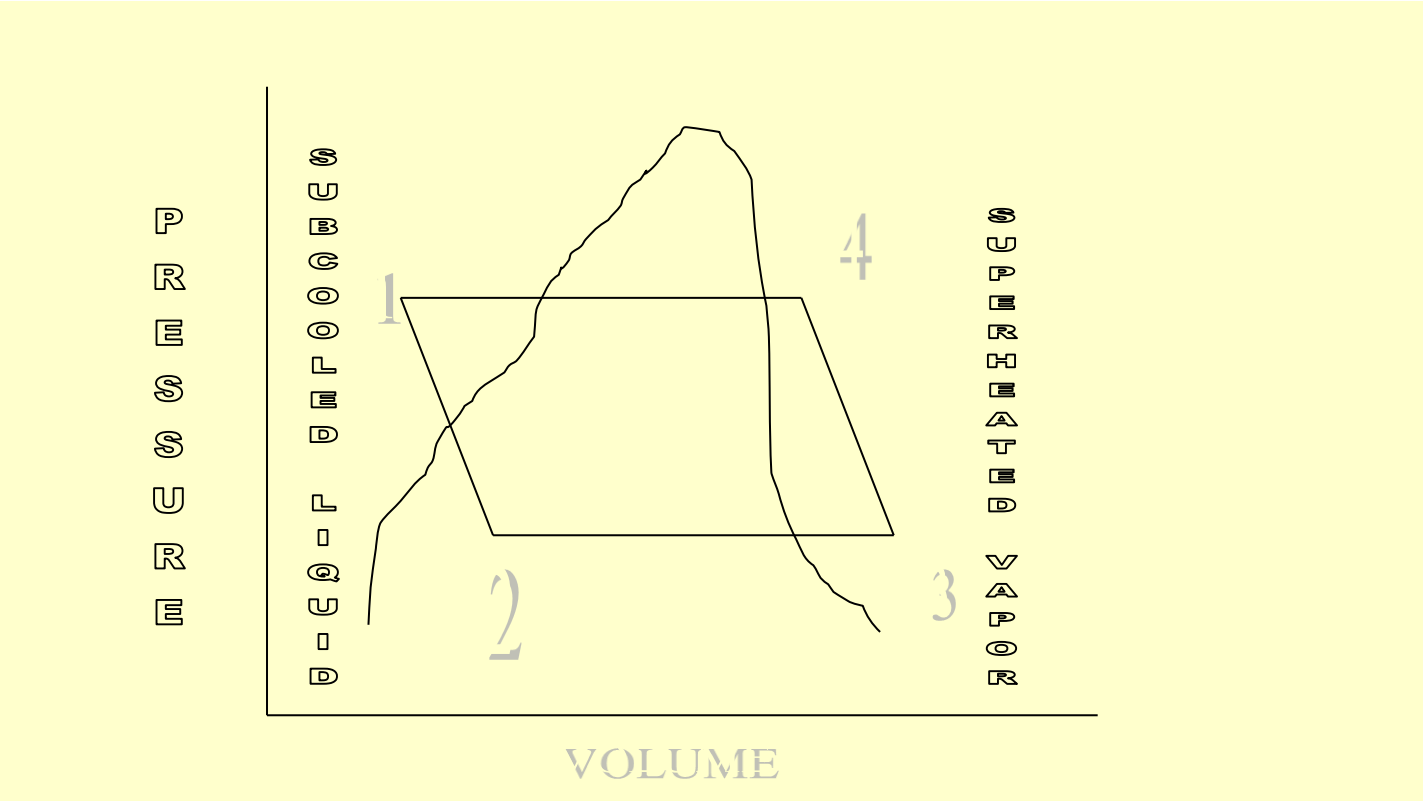
- The main function of condenser is to release the refrigerant heat which was absorbed in the evaporator & during compression.
- The refrigerant loses its latent heat of condensation, so that the refrigerant returns to a liquid state.
- Compression becomes more efficient when cool water is used to absorb heat at the condenser.

RECEIVER

- It is a temporary storage for the sub-cooler refrigerant. It also serves as a vapor seal to prevent vapor from entering the expansion valve.

- ENTHALPY: In thermodynamics, it is equal to the sum of the internal energy of the system plus the product of its volume multiplied by the pressure exerted on it by its surroundings.

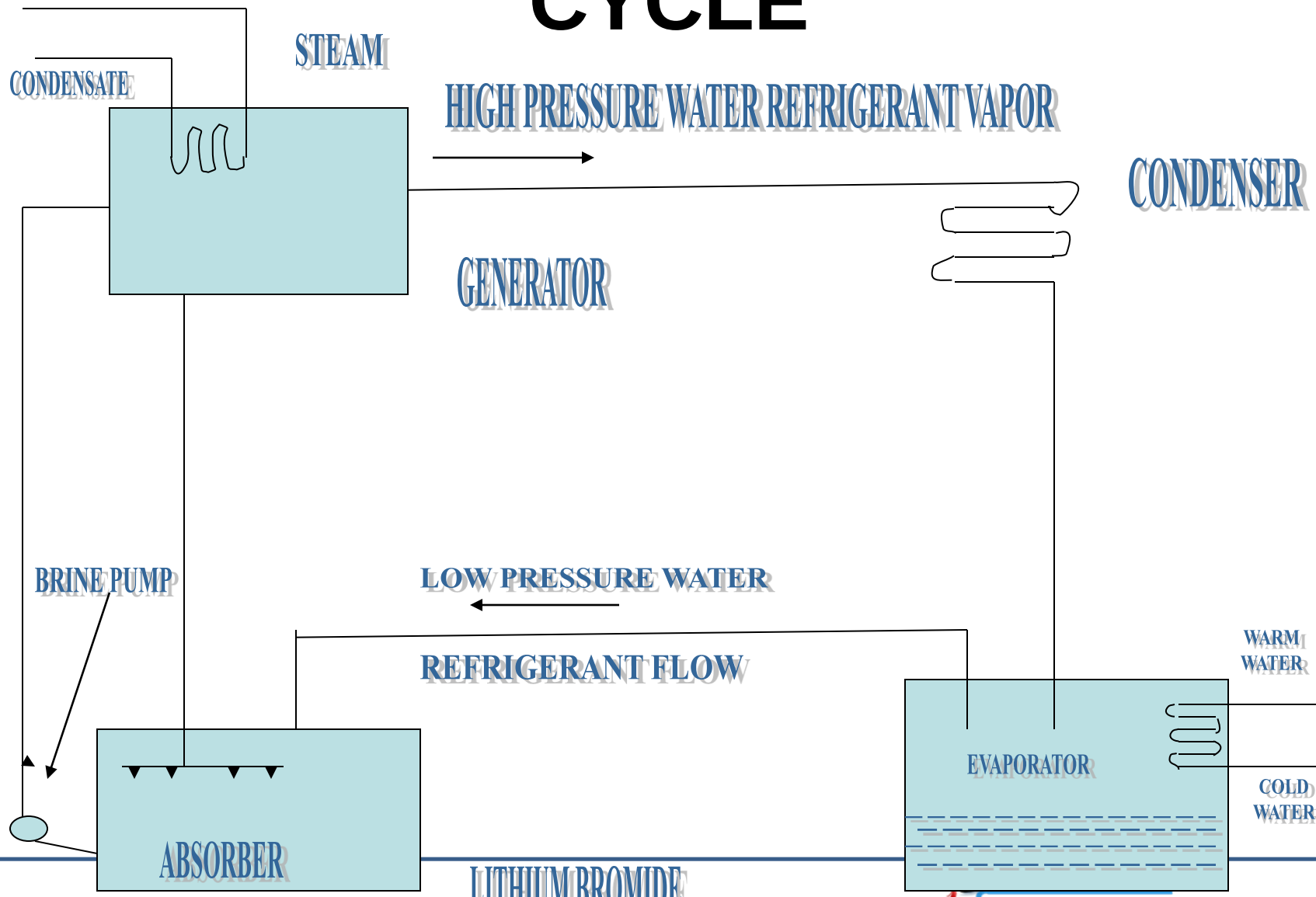
VAPOUR COMPRESSION CYCLE



VAPOR COMPRESSION CYCLE

- POINT 1-2(EVAPORATION)
- POINT 2-3(COMPRESSION)
- POINT 3-4(CONDENSATION)
- POINT 4-1(EXPANSION)

ABSORPTION REFRIGERATION CYCLE



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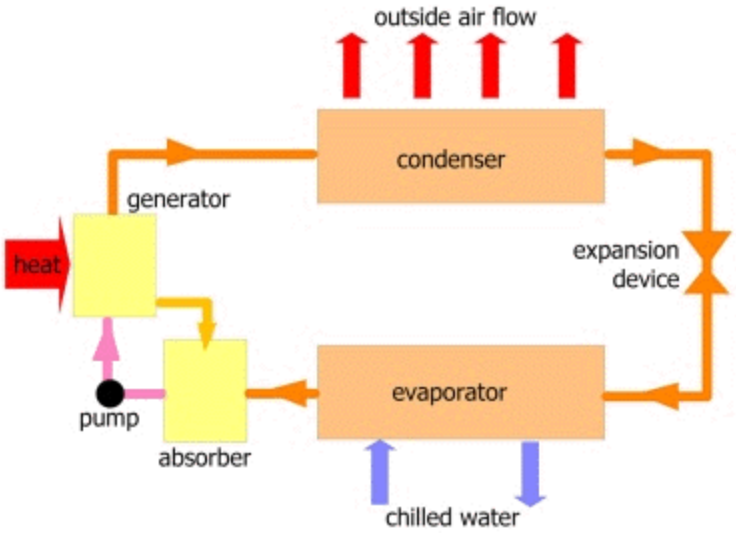
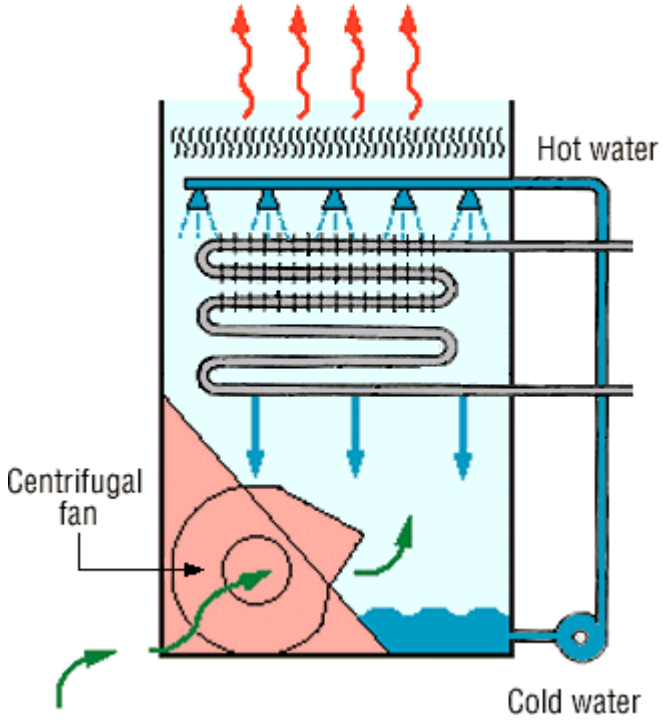
ABSORPTION REFRIGERATION

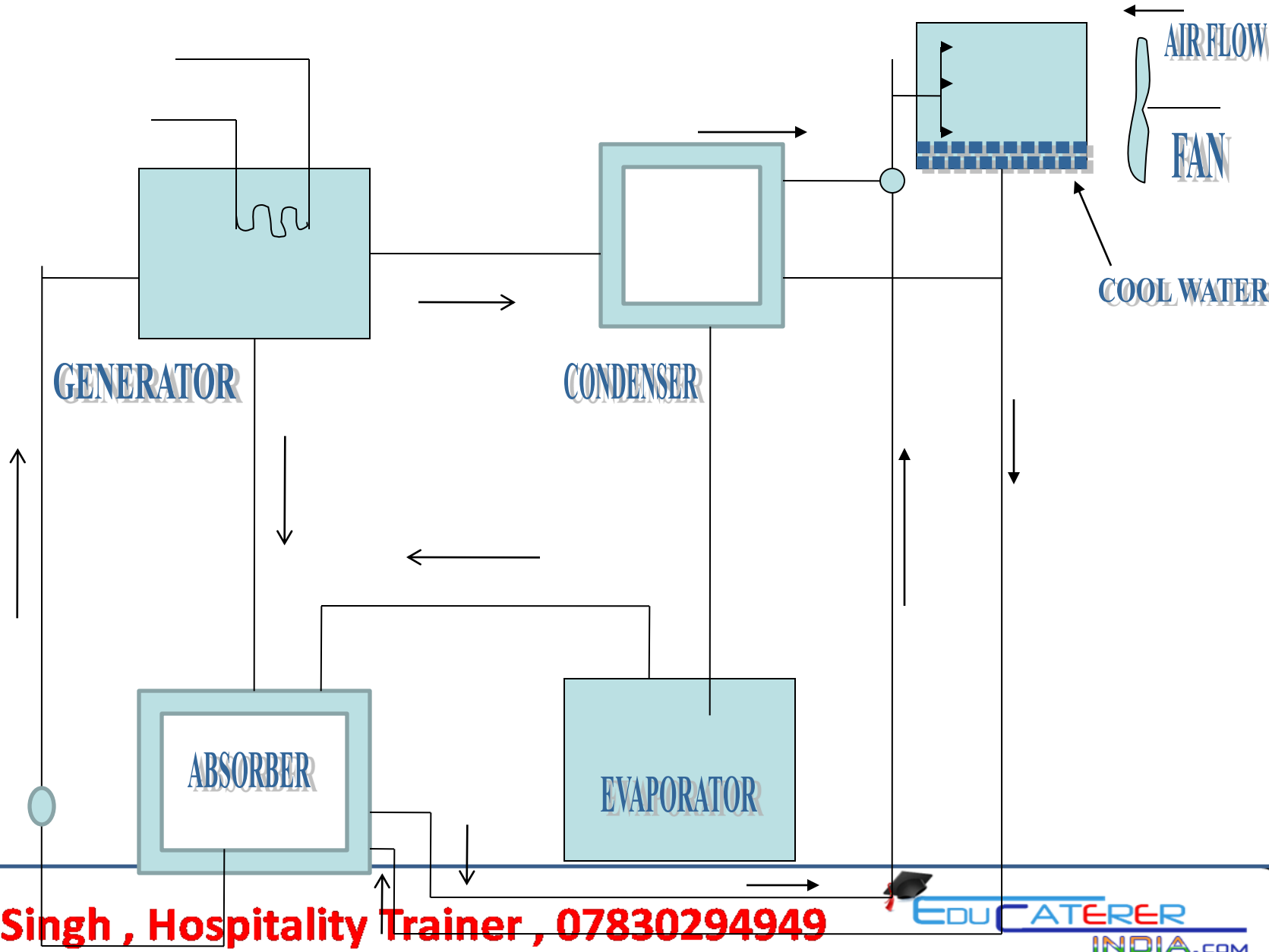
- It is also called as LITHIUM BROMIDE cycle.
  1. EVAPORATOR
  2. ABSORBER
  3. GENERATOR
  4. CONDENSER

ABSORPTION REFRIGERATION





WATER COOLING TOWERS



WATER COOLING TOWERS(CONTD)

- The absorption refrigeration cycle is connected to the cooling towers.
- The parts which are connected are CONDENSER & ABSORBER.
- Spraying water absorbs latent heat of vaporization.
- MAKE-UP WATER

SOLAR COOLING

- Three systems can be used for solar cooling of a building:
  1. RADIATIVE COOLING
  2. SOLAR VAPOR COMPRESSION
  3. ABSORPTION REFRIGERATORS
- **RADIATIVE COOLING**: During daytime water is circulated through pipes to the entire building & then allowed to radiate heat at night outside the building.
- **SOLAR VAPOUR COMPRESSION COOLING**: In this, the solar energy system drives a compressor.

SOLAR COOLING

- **SOLAR ABSORPTION COOLING**: This is similar to LITHIUM BROMIDE ABSORPTION CYCLE.
- **EVAPORATOR-**The refrigerant absorbs its latent heat of vaporization & converts into vapor.
- **ABSORBER**-Vapor refrigerant is absorbed by lithium bromide & the refrigerant loses its latent heat of condensation.
- **GENERATOR**-The chemical solution flows back to the absorber.
- **CONDENSER-**The refrigerant in vapor form moves to the condenser.

REFRIGERATION

- ABSORPTION REFRIGERATORS: LPG is used.
- SWAMP OR EVAPORATIVE COOLERS: They are similar to cooling towers.
- WALK-IN CHILLERS:

REFRIGERANTS

- They generally belong to the halocarbon family. Vapor compression refrigerants are of two types:

  1) PRIMARY REFRIGERANT TYPES: R-11, R-12, R-502

  2)SECONDARY REFRIGERANT TYPES: R-13, R-503.

- Food chillers & food freezers use chloro - fluoro carbons (CFCs).
- Blends of halocarbon refrigerants: R-22, R-152a, R-124, R-125, R-218, R-290.

HEAT LOAD FACTOR

- HEAT LOAD FACTOR. It consists of following:

1. TRANSMISSION LOAD

   RESIDUAL HEAT LOAD

2. INFILTRATION HEAT LOAD:
3. APPLIANCE HEAT LOAD:
4. PRODUCT HEAT LOAD:.

WALK-IN CHILLERS

- Size may be from 20 square feet of floor area to large rooms such as refrigerated warehouses used in institutional complexes.
- PLASTIC STRIP DOOR COVERINGS:

  These strips hang from top to bottom of the door frame hence reducing convection heat gain to walk-in.
- DESIGN FACTORS: The second door of the chiller should lead to the freezer.
- They are custom designed.

FOOD CHILLER SPECIFICATIONS

- RATING FOR CHILLERS: cubic feet (litres) or pounds (kilograms). Relationship: 30 pounds = I cubic foot(0.48 Kg. per litre).

- CHILLER TEMPERATURE: 40°F TO 45°F (4.4 – 7.2°C)

- CONDENSER ENVIRONMENT TEMPERATURE: 80 – 90°F(26.7 TO 32.2°C).

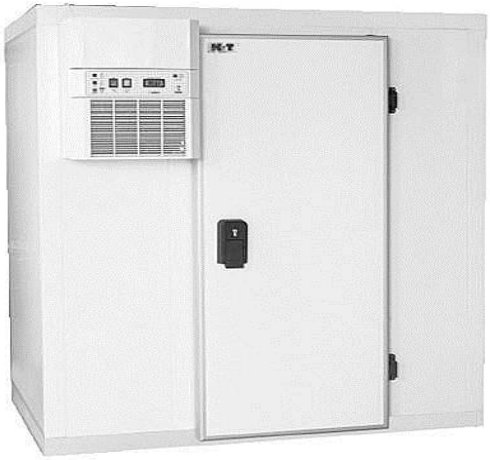
COMPONENT SELECTION FACTORS

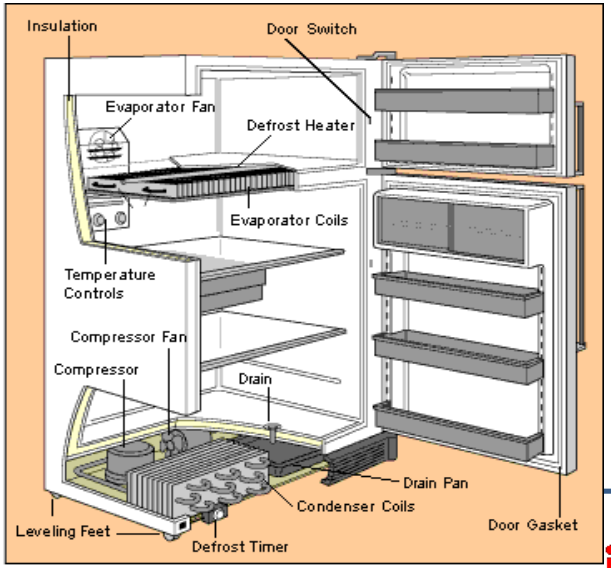
- AUTOMATIC DEFROST:
- The most common system used is HOT GAS DEFROST SYSTEM wherein a pipe connects compressor directly to the evaporator. Hot gas is passed through the pipe which melts ice formed on the evaporator.
- The evaporator has a outside covering of high resistance wires

EVAPORATOR SELECTION

- Due to the temperature difference between the evaporator & chiller, a convection current is formed inside the chiller.
- These can be either natural convection evaporators or forced convection evaporator.
- Food items must be packed to prevent dehydration.

1,2- WALK IN COOLER 3AUTOMATIC DEFROST
4. PLASTIC STRIPS





CHILLER MAINTENANCE

- Following points should be taken into mind:
  1. The temperature to be measured should be accurately measured by a thermometer.
  2. The condenser should be cleaned & free of dust.
  3. The refrigerator should not be placed near a source of heat.
  4. Sunrays should not fall directly on refrigerator.

REACH IN FREEZERS

- They utilize vapour compression cycle
- Rated in cubic feet (litres) or pounds(kilograms).
- Latent heat of fusion is removed.
- FREEZING RATE: Freezing rate is 2 to 3 pounds per hour.

TEMPERATURE CONTROL

- The shelf life & quality of a product depends on the temperature control in freezers.
- In natural convection evaporator, the temperature of the evaporator must be -20°F(-28.9°C) to achieve the temperature of 0°F(-17.8°C) in the chiller.
- Much lower temperatures increases the operating costs & greater food dehydration.

PRECAUTIONS

- Disconnect from mains before performing any repairs.
- Proper training should be given to engineers.
- The equipment should meet manufacturer's specifications.
- Phosgene gas is formed when refrigerant is exposed to high temperatures.
- Wear goggles & gloves to avoid frost bite.
- Asphyxiation hazards in the absence of ventilation.

ENERGY MANAGEMENT SYSTEM

- The computer controlled energy management system keeps a close control on the chiller temperature, evaporator temperature, temperature in condenser & temperature of environment surrounding condenser.
- The computer system can also control the operating timings of compressor as well as thermo expansion valve.
- The cooling tower for condenser can also be controlled by computer.

REVIEW

- Laws of thermodynamics
- Vapour compression cycle
- Absorption refrigeration cycle
- Cooling towers
- Solar cooling
- Types of refrigerants
- Heat load factors & walk – in chillers
- Component selection factors

ASSIGNMENT

- Explain laws of thermodynamics
- Explain vapour compression cycle
- What are the different types of refrigerants?
- What are the factors which influence the efficiency of a COOLING TOWER?
- Explain a) Automatic de-frost b) natural convection evaporators c) forced natural convection evaporators d) TXV e) walk-in-coolers e) solar vapor compression f) solar absorption refrigerators.

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