BASICS OF AIR CONDITIONING

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AIR CONDITIONING & VENTILATION

- ***Air conditioning*** is the controlling of air temperature, its humidity, its purity, noise-free and its flow rate at a certain place to produce a comfort zone.

- ***Ventilation*** is refreshing the air in a crowded place by feeding the place with a mount of air at a certain time and draw the same a mount of air to obtain an healthy environment empty of dust, gases and bad smell.

- ***The human needs 16 kg. of air per day. The healthy requirements is:***
- One third of the feeding air must be fresh air and
- two third return air after purifying.
- Entire air in the air-conditioned areas must be moved at a velocity between 0.15 to 0.25 m/s . This velocity doesn't cause a noise.
- *Fresh air requirement in a railway coach – 0.35 m^3/min/passenger*

AIR CONDITIONING v/s REFRIGERATION

- Air-conditioning deals with Human comfort, while refrigeration deals with preservation of perishables.
- Air-conditioning involves both heating & cooling while refrigeration means only cooling.

WHY?

- Humans being warm blooded are comfortable in the TEMP.RANGE
  - 25-30 deg. C
- Excess Humidity is uncomfortable as sweat doesn’t dry and the body doesn’t cool down
- Extremely dry weather is also uncomfortable
  - Chaffing of skin and dryness
- In addition
  - Purity
  - Draft/Velocity
  - Noise
  - Power Consumption

WHY?

- Thermal comfort
  - Condition of mind that expresses satisfaction with the thermal environment
- High temperature & high relative humidity
  - Reduce thermal comfort and indoor air quality
- Depends on Various Factors
  - Metabolic rate- Varies from Individual to Individual
    - Level of transformation of chemical energy into heat & mechanical work by metabolic activities within an organism
    - Usually expressed in terms of unit area of the total body surface
    - 1 met = 58.2 W/m²-Surface area of an average person seated at rest
    - Surface area of an average person is 1.8 m²
    - 0.7 met for sleeping, 1.0 met for a seated and quiet position, 1.2-1.4 met for light activities
    - For activities above 2.0 Met, these values are not very reliable as there are multiple ways of conducting activities

    IMPLICATION
    - **AC design for a reservation counter & for an AC coach Chair car/ Sleeper would be different**

WHY?

- Mean Radiant Temperature
  - Amount of radiant heat transferred from a surface
  - For example, the area exposed to sunlight
  - IMPLICATION
    - DARK GLASSES and SILVER painted roofs are a better choice
- Air Speed
  - Moving Air feels cooler - FRESH AIR MASS moving in & easy evaporation
  - IMPLICATION
    - OPTION of Blower Speeds in CAR or Room AC & Vans in Each Compartment
- Relative Humidity
  - % of water vapor present to the max. amount that can be held at that temp. & pressure
  - Heat loss through sweating is reduced at HIGH RH & LOW RH has adverse impact on mucous membranes
  - IMPLICATION
    - Air cooler is not comfortable in coastal regions

Comfort means treatment of 5 properties of air

1. Dry bulb temperature(d.b.t) : cooling or heating
2. RH (%) : humidification or de-humidification.
3. Air purity : Free from dust & bacteria
4. Ventilation : Fresh air to provide the needed oxygen
5. Air movement : homogeneous flow rate and distribution

UNITS OF AIR CONDITIONING

- Kilo Calorie - It is defined as the amount of heat to be added/removed to raise /lower the temperature of one kg of water by one degree Celsius.
- BTU(British Thermal Unit)- It is defined as the amount of heat to be added (removed) to raise (lower) the temperature of one pound of water by one degree Fahrenheit.
- 1 Kilo Calorie = 3.97 BTU.
- TR -One ton of refrigeration is the heat required to melt 2000 lbs of ice at 0°C into water at the same temperature in 24 hrs
- 1 TR = 3024 Kcal/hr

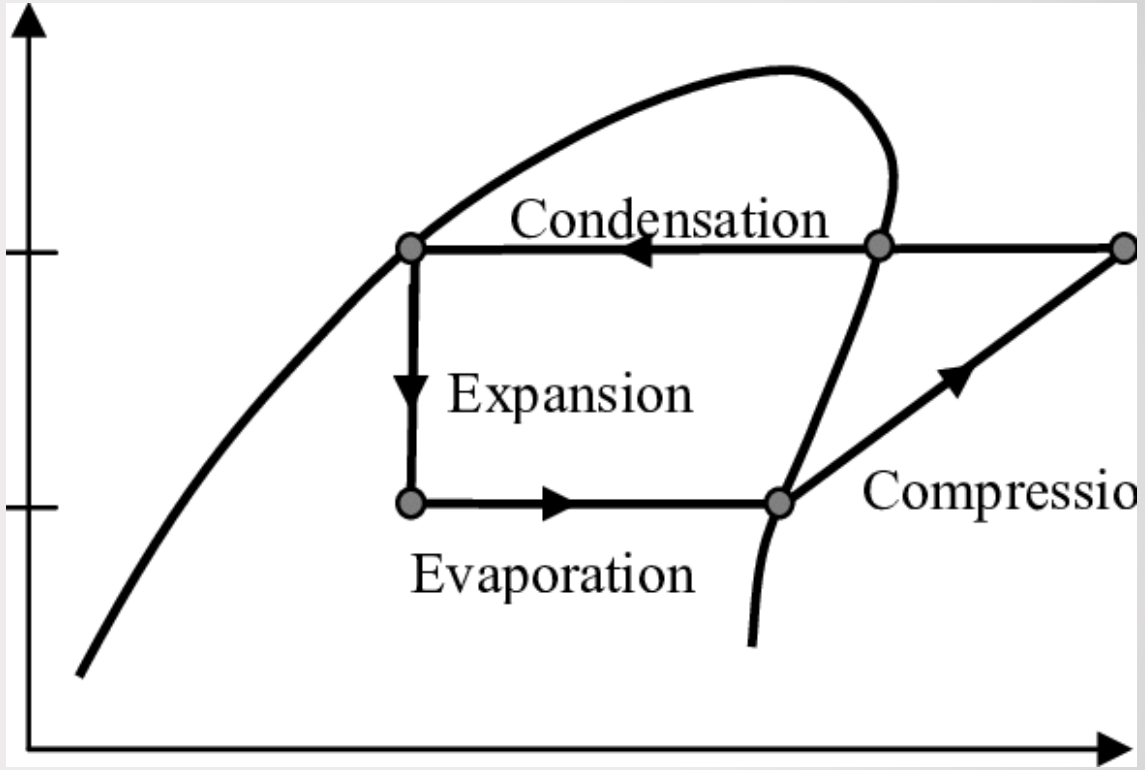
Refrigerant Properties

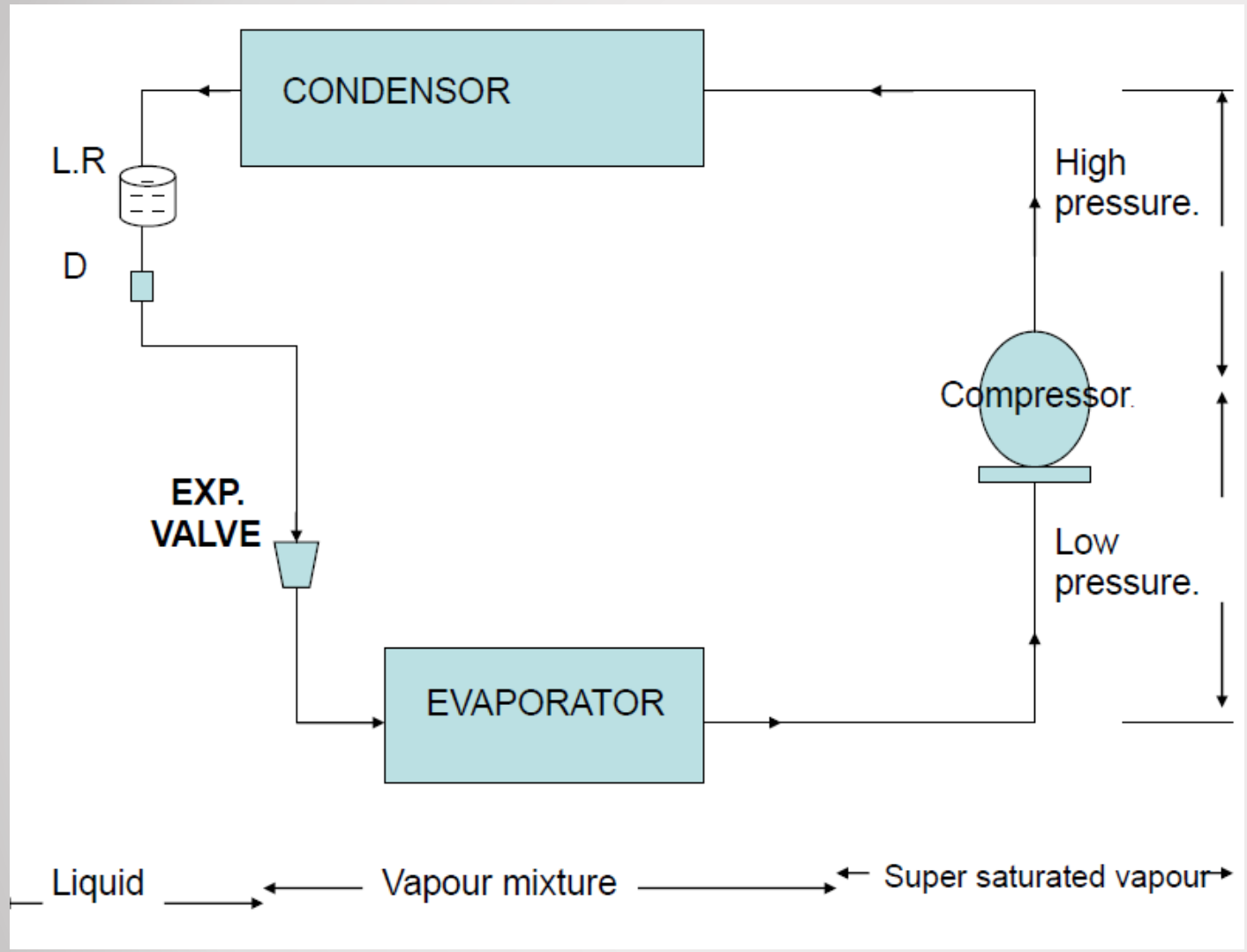
The refrigerant shall be:

- Non poisonous
- Non –inflammable.
- Non-corrosive.
- Non –irritating.
- Non – toxicity.
- No harmful effect on the taste.
- Cheap & readily available in the market.
- Eco Friendly.
- R-22 and R-407c refrigerants are used in railway coach air conditioning

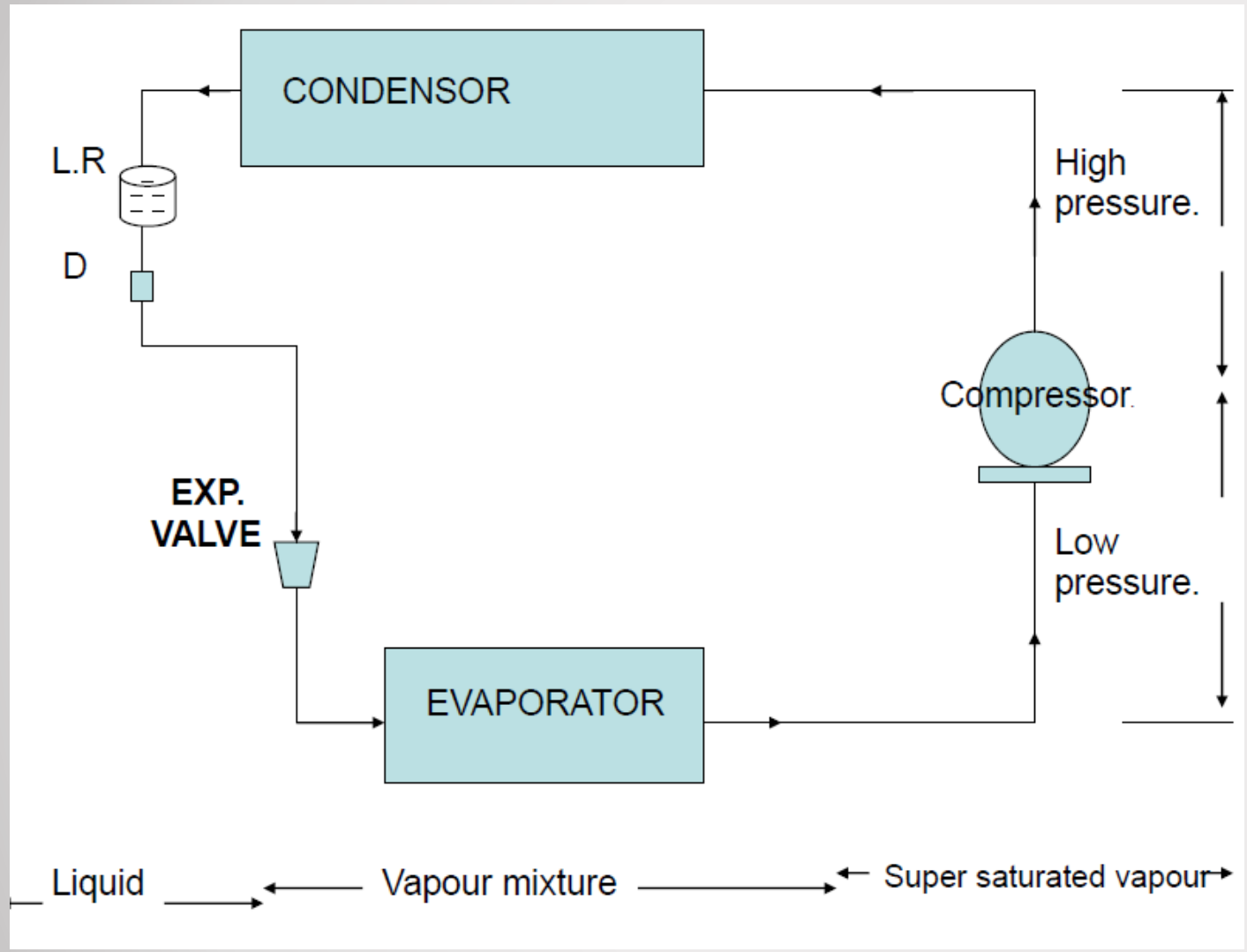
Vapour compression cycle

- ***Main component of Vapour compression cycle are :***
- i) Compressor
- ii) Condenser
- iii) Expansion valve
- iv) Evaporator unit.

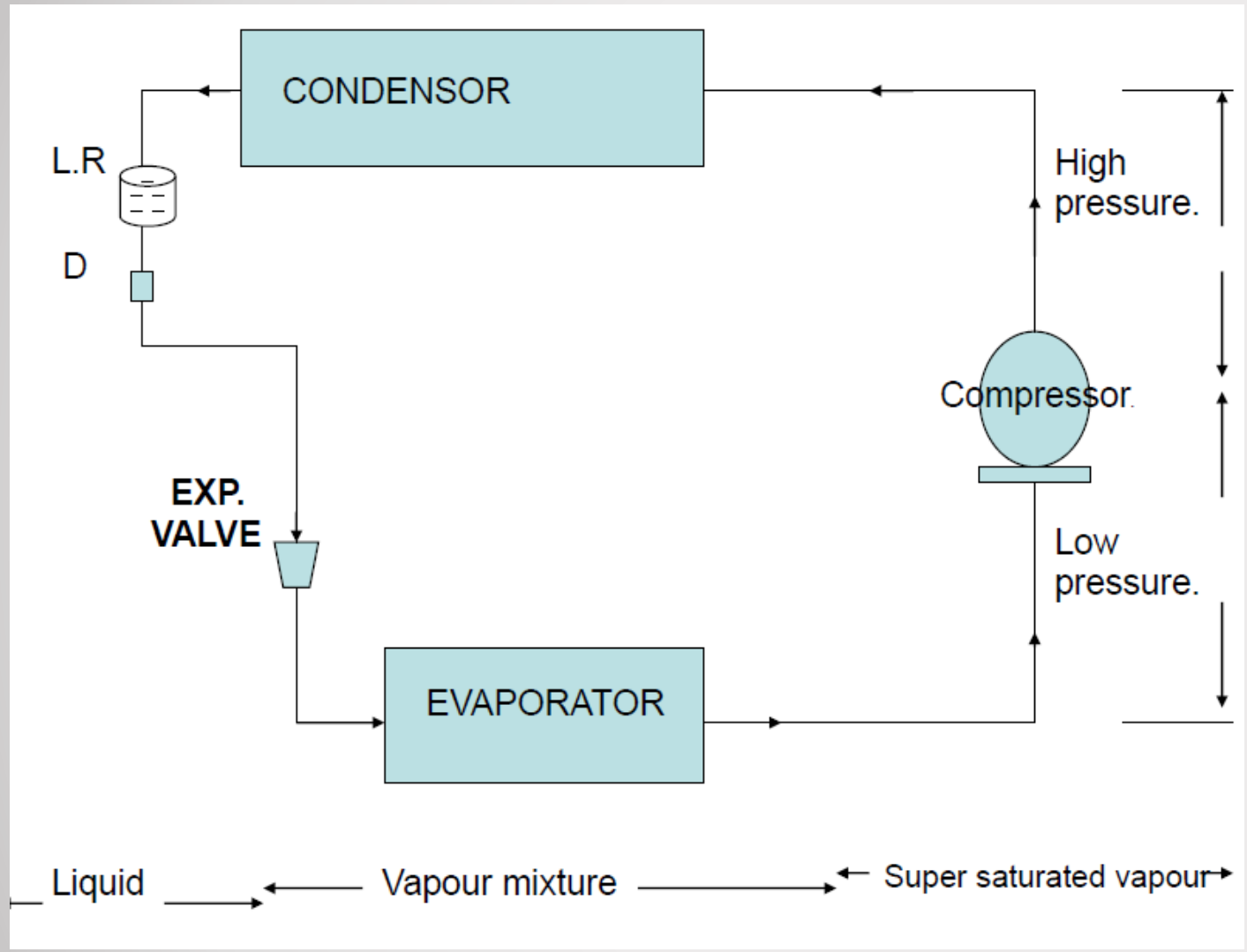




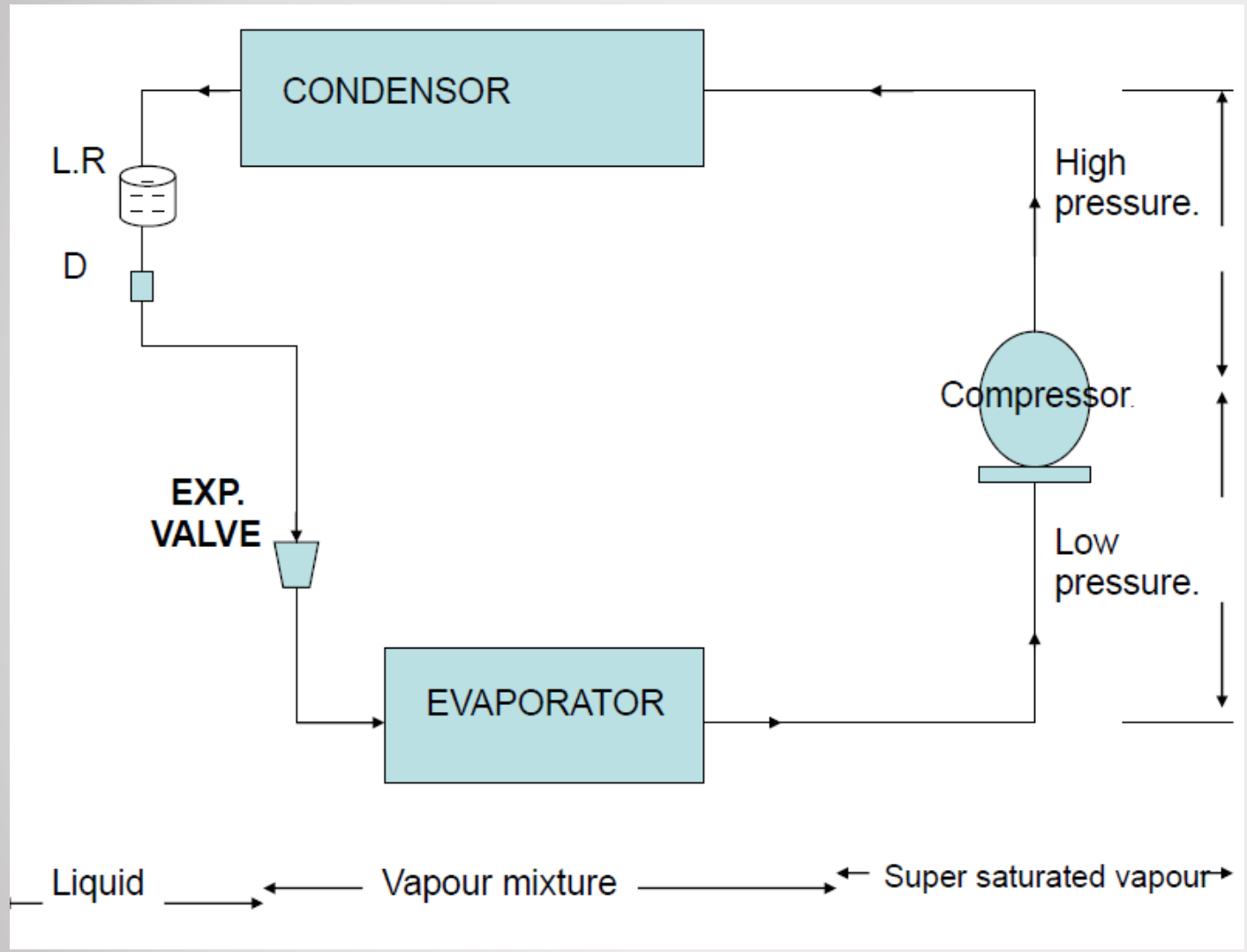
- Basic principle of air conditioning is that of a heat pump which collects heat from the control volume and dumps it outside the control volume.
- In practical applications, heat is collected from the room/coach and is dumped out into the atmosphere.



- The refrigerant circulates inside the system.
- High pressure refrigerant liquid at regular temperature passes through the drier unit. Drier absorbs moisture.
- High pressure liquid refrigerant expands in the expansion valve and gets converted to a vapour mixture at low pressure.

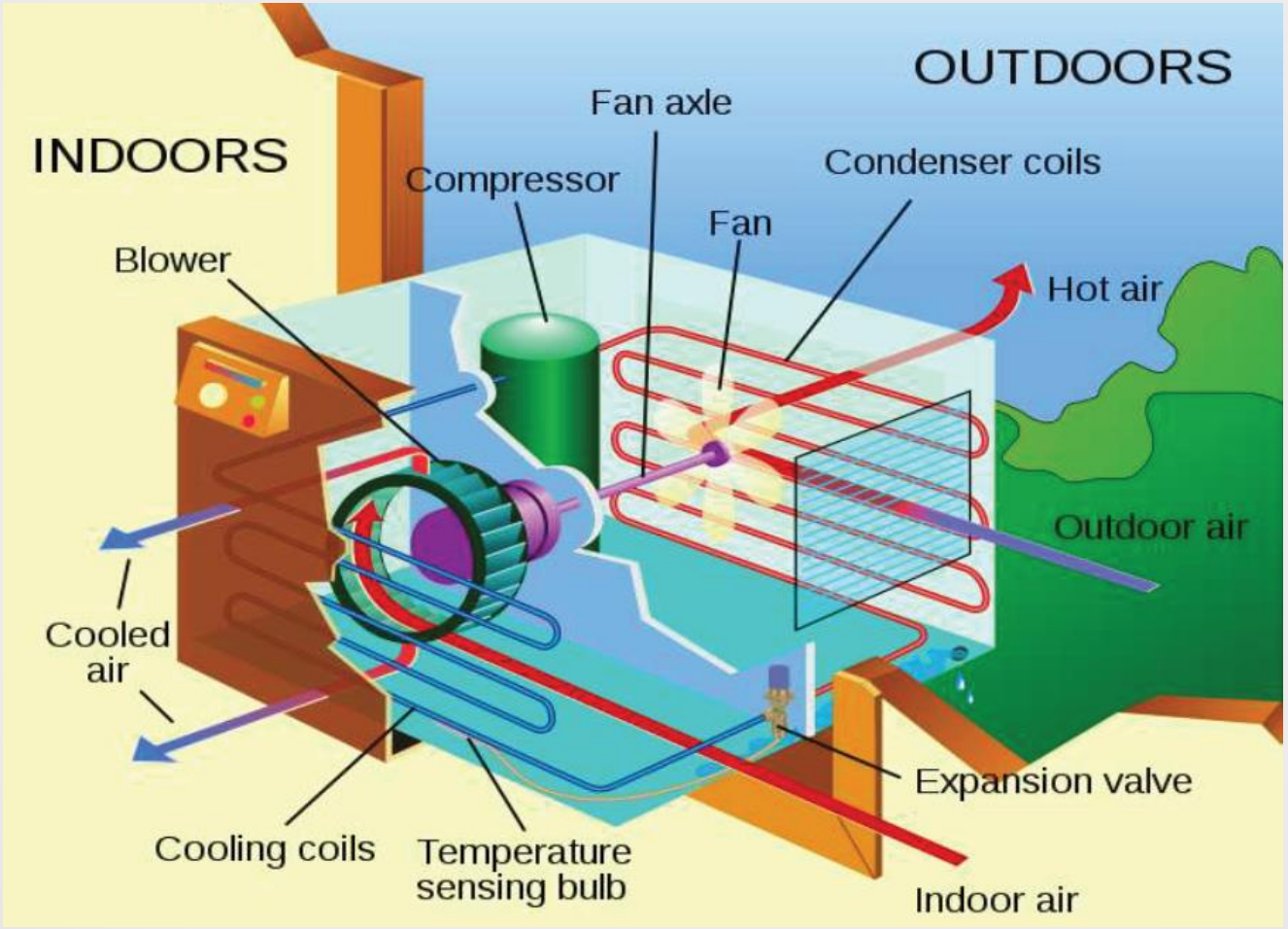


- The vapour mixture (liquid + vapour) passes through the evaporator, where it absorbs heat from the control volume and gets converted to saturated vapour.
- This low pressure saturated vapour refrigerant passes through the compressor yielding high pressure super saturated vapour.



- The super saturated vapour refrigerant is cooled down to liquid state in the condenser by loosing heat to the atmosphere, thus completing the cycle.
- Condensor may be air cooled or water cooled.

Room Air-conditioning



Air conditioning in Railway coaches

- Passengers in a railway travel are adversely affected by infiltration of air unpleasantly laden with dust due to open windows. This is more so in case of high-speed passenger carrying trains.
- Secondly for a tropical country like India, the temperature varies from 46 degree C during summer to 2 degree C during winter.
- Air conditioning of railway coaches is, therefore, necessary for the maximum comfort and well being of passengers in a railway travel.

Problems faced in Airconditioning of coaches

- Requirement of very high reliability standard.
- Equipment should be light in weight.
- Equipment should take minimum space.
- Due to large number of passengers in small space, the space left for air circulation is limited.
- Rapidly changing ambient conditions as the train moves from one part of the country to another.
- Excessive vibrations.
- Dusty atmosphere.
- Vandalism and abuse.
- Flying ballast hitting the equipment.
- Restricted time available for maintenance

Requirements for coach air-conditioning

- Supplying clean fresh air at a controlled uniform temperature.
- Catering, within the confines of the Railway carriages to the continuously changing number of passengers.
- Providing for heating as well as cooling on a train that travels through areas of widely differing climate during its journey.
- Operation of the equipment from power generated, stored and controlled on the train.
- Securing sufficient air movement.
- Energy efficient system

Heat load calculation for 2A coach

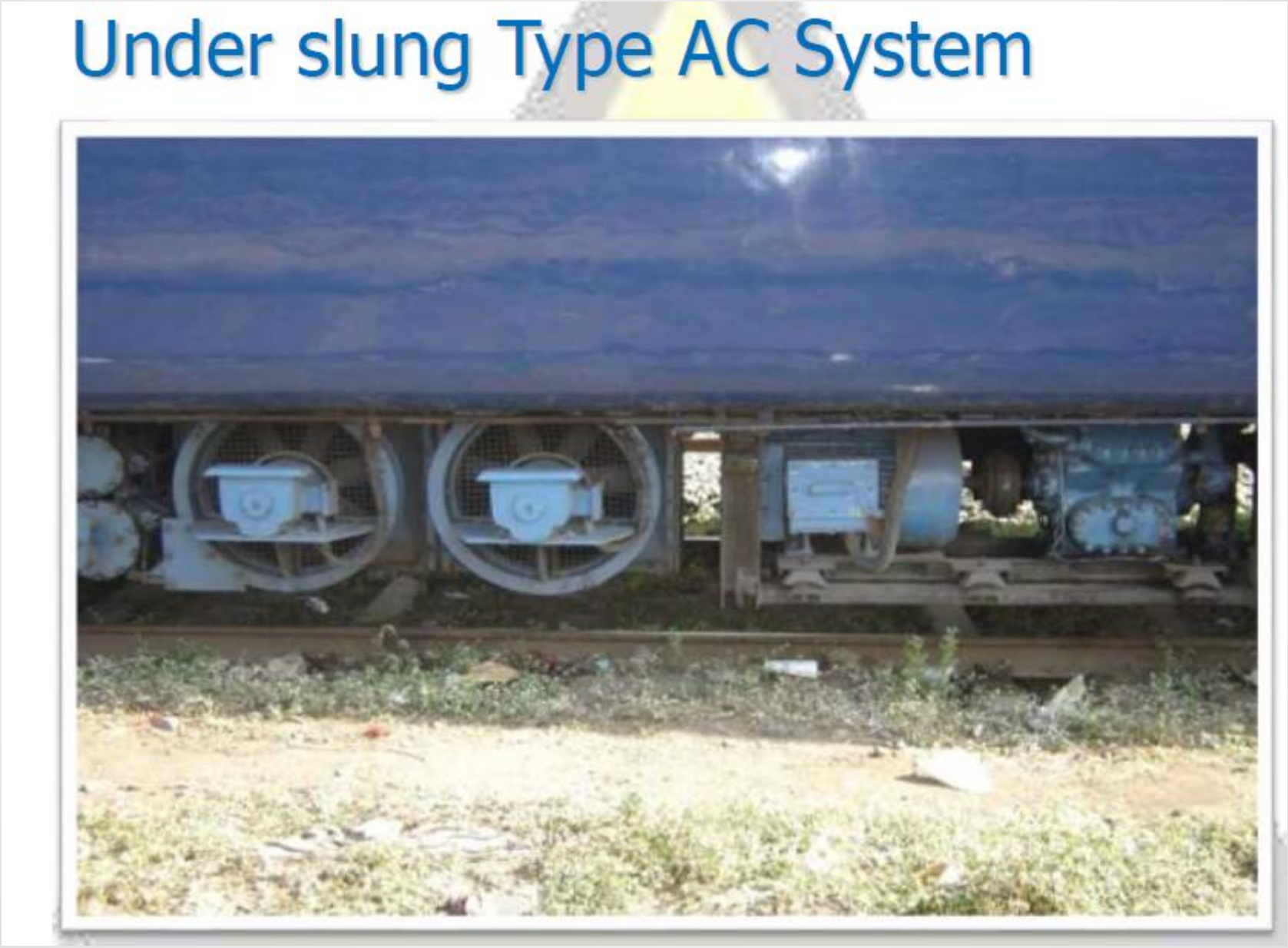
- AC coaches have to work under varying conditions of ambient temperatures and passenger loads.
- In deciding the capacity of plant certain assumptions and calculations have to be made in order to determine plant capacity.
- Coeffecient of heat transfer from side walls, roof, window etc are considered.
- Dimension of air conditioned space in the coach
- Heat generated from electrical loads inside coach
- Heat gain due to conduction
- Solar heat gain
- Heat gain due to ventilation
- Heat gain due to passengers
- Heat gain due to infiltration @ 10 %
- All these heat gain sources are added up and the gross heat gain value thus obtained is converted to BTU or TR.
- The value thus obtained shall be the required/desired TR for the AC plant to be installed.
- For e.g. Refrigeration capacity requirement for 2 AC coach is obtained as 7.4 TR

LOAD CAPACITY

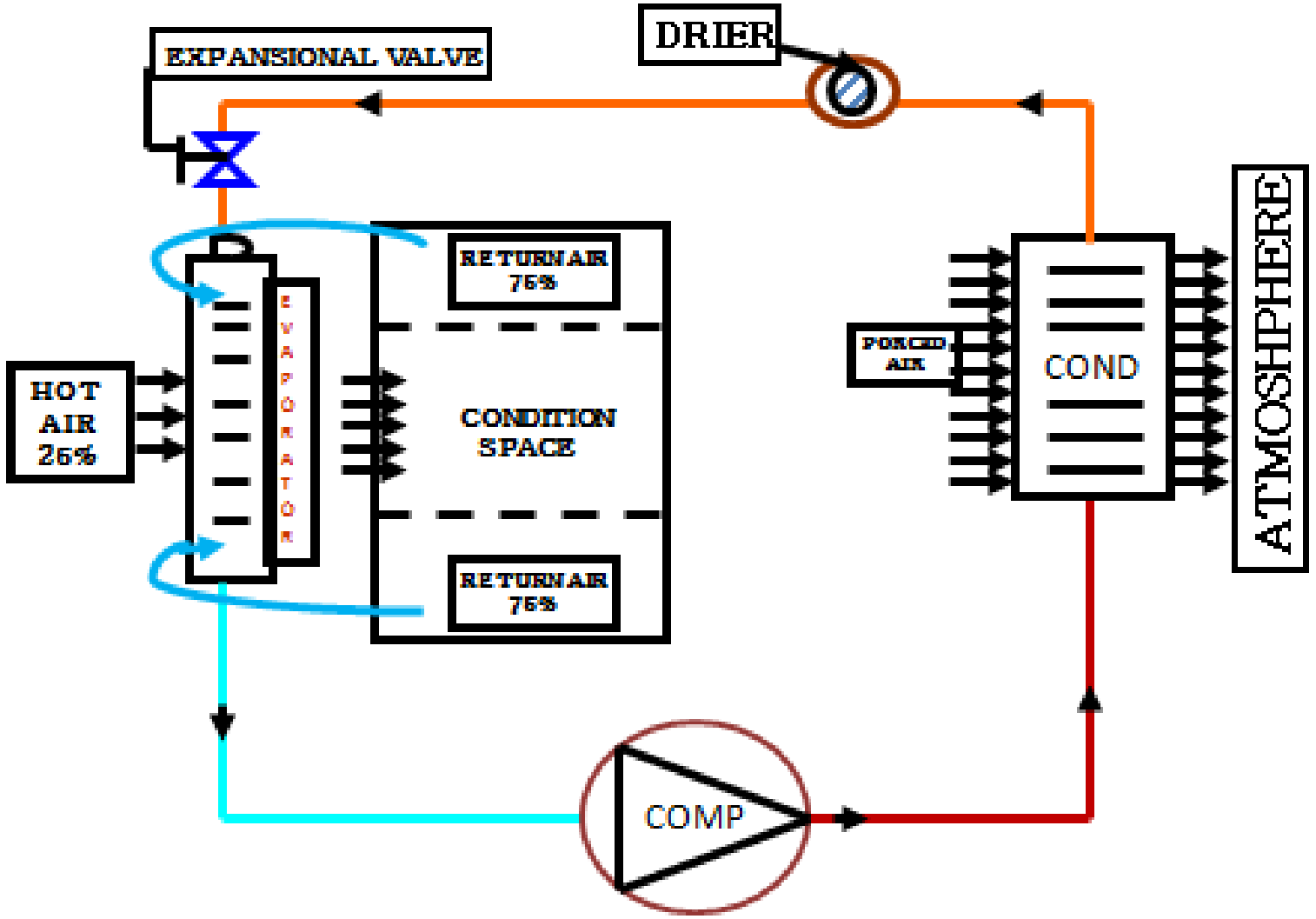
- As per heat load calculation, Load and Plant capacity of various Coaches

• AC II tier	8 TR	2 Plants x 5.3 TR
• AC Ist	5.3 TR	1 Plant x 6.7 TR
• AC Chair Car/III tier		2 Plants x 6.7 TR

CONVENTIONAL AC SYSTEM



CIRCUIT DIAGRAM OF REFRIGERATION CYCLE OF AC COACHES



Underslung AC system in SG ICF coach

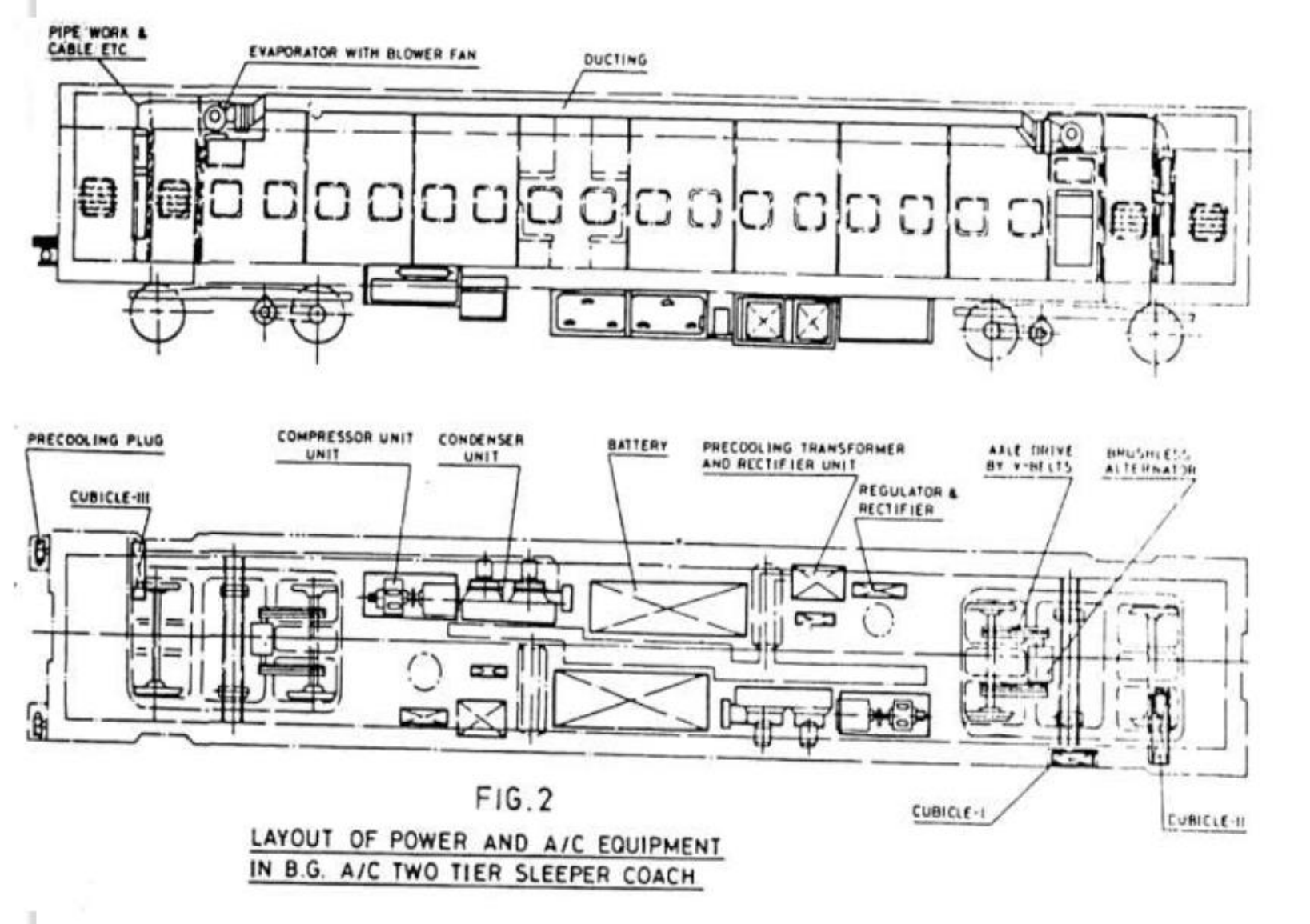
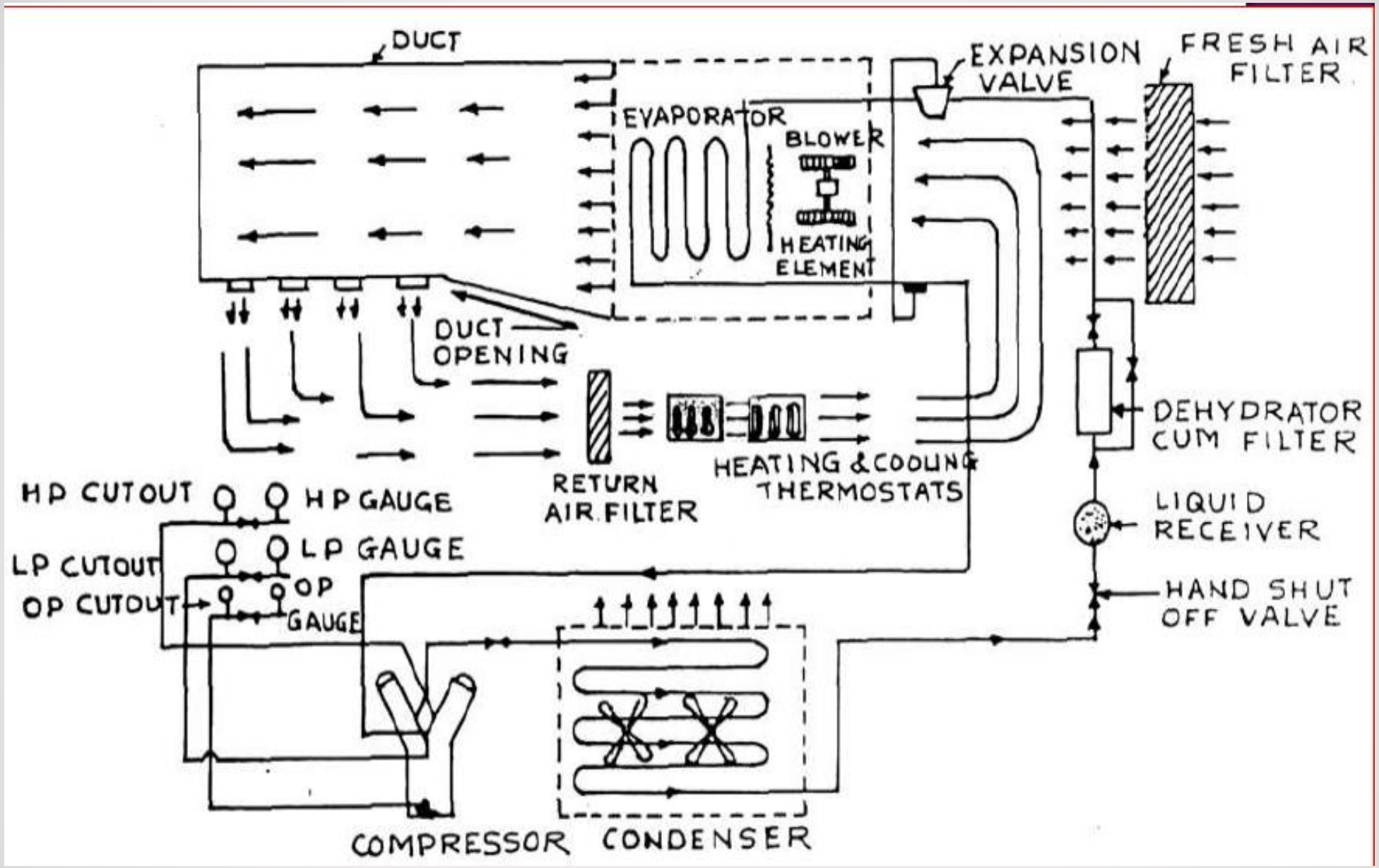


FIG. 2

LAYOUT OF POWER AND A/C EQUIPMENT IN B.G. A/C TWO TIER SLEEPER COACH


DUCT
EXPANSION VALVE
FRESH AIR FILTER
EVAPORATOR
BLOWER
HEATING ELEMENT
DUCT OPENING
DEHYDRATOR CUM FILTER
HP CUTOUT
HP GAUGE
RETURN AIR FILTER
HEATING & COOLING THERMOSTATS
LP CUTOUT
LP GAUGE
LIQUID RECEIVER
OP CUTOUT
OP GAUGE
HAND SHUT OFF VALVE
COMPRESSOR
CONDENSER

Evaporator Unit

- The evaporator unit consists of a thermostatic expansion valve, a heat exchanger, a resistance heating unit and centrifugal blower driven by a motor.
- The thermostatic expansion valve controls quantity of high-pressure liquid refrigerant and allow to expand to a lower pressure corresponding to the load demand (input from thermostat at return air duct).
- The expanded refrigerant passes through the distributor into the heat exchanger consisting of finned copper tubes.
- The return air from the air-conditioned compartment (75 %) is mixed with fresh air (25%) and this mixture is drawn/blown through the heat exchanger, where heat in the air is transferred to the cool refrigerant causing cooling of the air and the evaporation of the refrigerant inside the tubes.
- The cooled air is led through the ducting to the various compartments and diffused by means of air diffusers.
- Filters are provided in the fresh air and return air path to eliminate dust.
- When the outside ambient temperature is very low, heater is switched on according to the setting of the thermostats.

Compressor

- The refrigerant vapour drawn from the evaporator is compressed by means of a multi cylinder reciprocating compressor and compressed to a pressure ranging from 10 to 15 Kg/Cm2 according to the load demand.
- The work done due to compressor raises the temperature of the refrigerant vapour.

Condenser

- The condenser serves the function of extracting the heat absorbed by the refrigerant vapour in the evaporator and the heat absorbed during the compression process.
- The condenser consists of a heat exchanger, which is forced-air-cooled by means of two or three axial flow impeller fans.
- The refrigerant vapour is liquified when ambient cool air is passed through the heat exchanger. The refrigerant liquid leaving the condenser is led into the liquid receiver from where it proceeds to the expansion valve on the evaporator.
- The liquid receiver is a cylindrical container which contains a reserve of the refrigerant liquid. A dehydrator and filter are also provided to ensure that the refrigerant is free from moisture and dust particles.

Drawbacks of Conventional AC system

- Refrigerant gas leakage from pipes and joints
- Heavy weight - coach tare weight increases
- Large space occupation by the equipments
- Maintenance problems - Huge skilled manpower required
- Consumes more power - Less energy efficient
- Under-slung equipments get hit by ballast,CRO
- Accumulated dust affects heat transfer

WHAT NEXT???