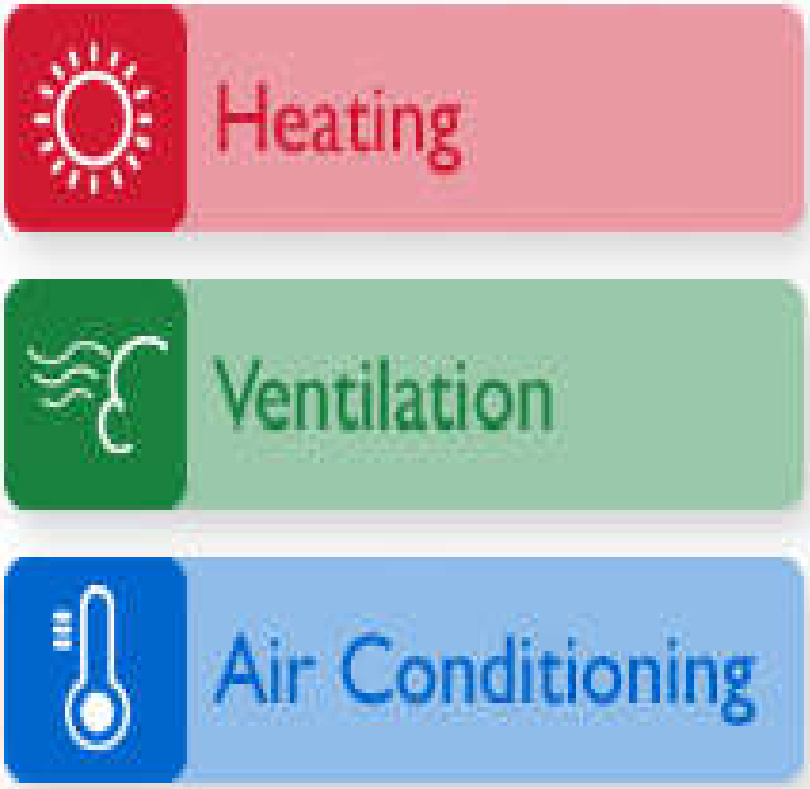
IN THE NAME OF ALLAH
THE MOST BENEFICENT
THE MOST MERCIFUL

(ME-225) HEATING, VENTILATION AND AIR-CONDITIONING SYSTEM



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MS POWER MECHANICAL

(MUST)

MBA (COL) EXECUTIVE

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BSC MECHANICAL ENGINEERING

(MUST)

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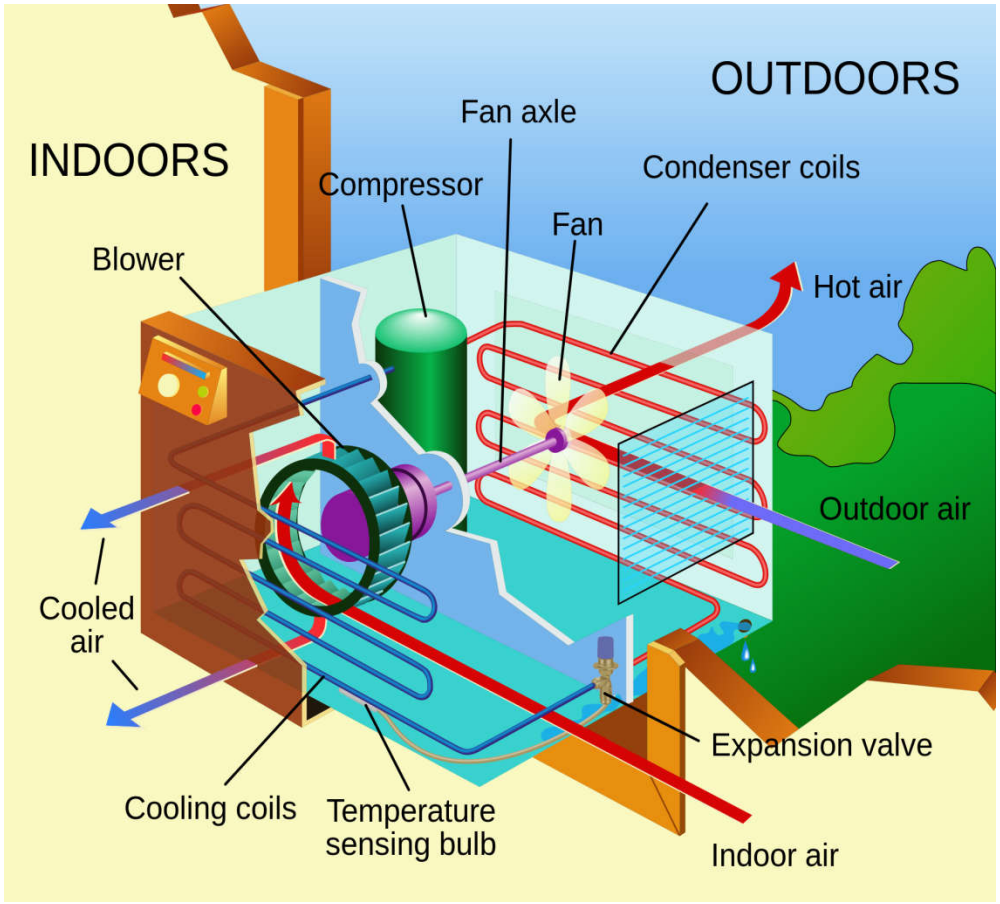
INTRODUCTION

LECTURE #1 & 2

Objective of HVAC

1. To understand refrigeration systems.
2. To develop basic ideas about cycle analysis and designing parameters pertaining to refrigeration and air conditioning systems
3. To deal with the problems related to architectural, building services, HVAC, equipment cycle refrigeration, multiple effect compression, multi-stage compression, heat pumps

   Air conditioning
4. Indoor and outdoor air conditions, comfort conditions and comfort zone, indoor air quality, psychometric



Course Outlines (HVAC)

- **Basic Concepts**
- **Refrigeration cycles**

  Reversed Carnot and Joule Cycles, vapour compression and vapour absorption systems, COP, pressure- enthalpy chart, types of refrigerants, air 56
- **Central air-conditioning system**

  Essential components of central air-conditioning plant, water chiller and water heater, air handling unit, chilled water and hot water recirculation system, return air supply system, fresh air supply system air mixture chamber, supply fan, air dust cleaning and bacteria removal, air supply and air return terminals, diffusers and grilles, CFM rating and tons of air-conditioning of a central air-conditioning plant.
- **Load calculation and system design**

  Cooling and heating load calculation procedures, duct sizing and piping design, pumps and fans selection, air ventilation: calculation of fresh air supply of a multi story building, air handling unit for untreated fresh air, forced convection based air ventilator design.

Recommended Books

1. Heating, Ventilating, and Air-Conditioning Analysis and Design**,** *By McQuiston, Parker and Spitler* John Wiley & Sons
2. Heating and Cooling of Buildings, *By Ed. Kreider, Curtiss & Rabl* McGraw-Hill
3. Principles of Refrigeration, By *Dossat, R. J., John Wiley*
4. HVAC Systems Design Handbook, *By Haines, Roger W. Wilson, Lewis* Mc-Graw-Hill Companies
5. ASHRAE Handbook
6. Refrigeration and Air Conditioning, *By C P Arora*
7. Refrigeration and Air Conditioning, 4th Edition By *GF Hundy, T.C Welch & A.R Trott*
8. Principles of Air Conditioning By *V. Paul Lang.*
9. Refrigeration and Air Conditioning By *R.S Khurmi*
10. Refrigeration and Air Conditioning By *Ahmadul Ameen*

Principles of Refrigeration

Fourth Edition

Roy J. Dossat

ALWAYS LEARNING

PEARSON

HANDBOOK OF AIR CONDITIONING AND REFRIGERATION

SECOND EDITION

SHAN K. WANG

The McGraw-Hill Companies

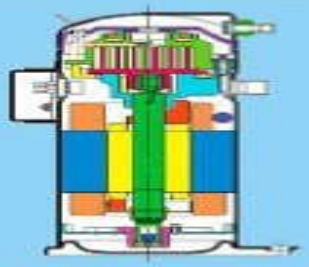
THIRD EDITION

REFRIGERATION AND AIR CONDITIONING

C P ARORA

Fourth Edition

Refrigeration and Air Conditioning



G. F. Hundy · A. R. Trott · T. C. Welch

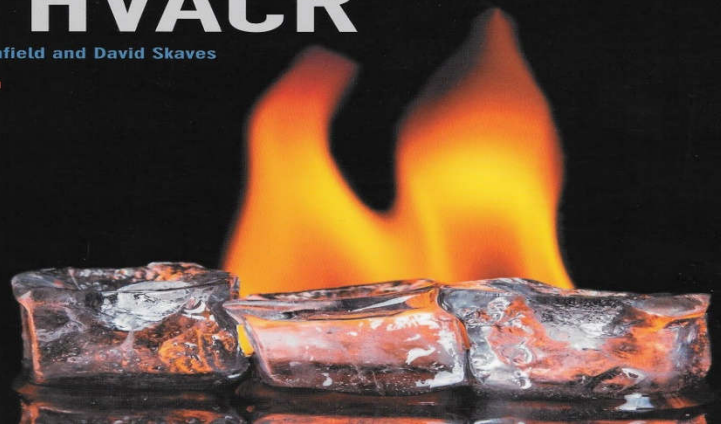
B H

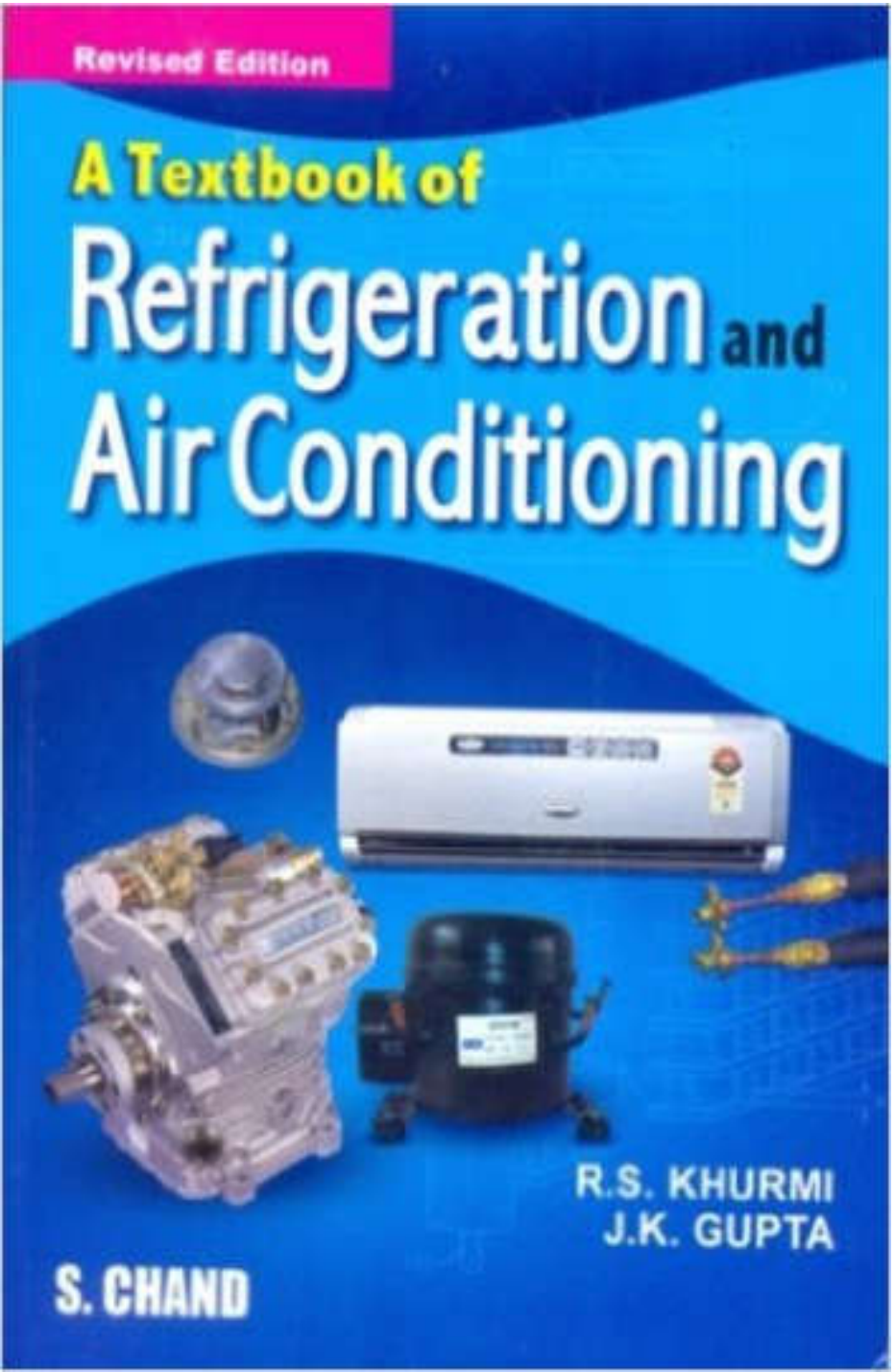
AHRI Air-Conditioning, Heating, and Refrigeration Institute

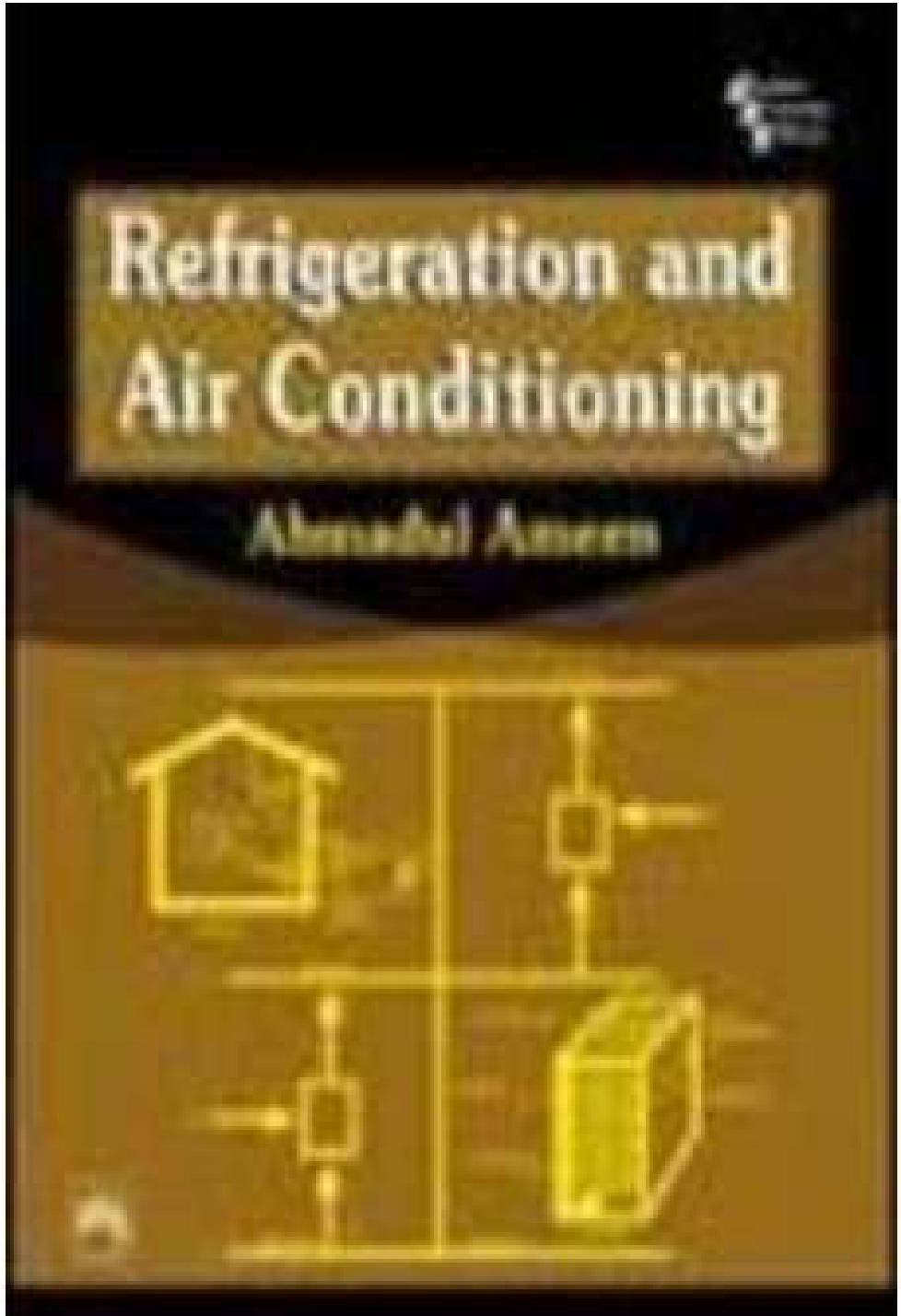
Fundamentals of HVACR

Carter Stanfield and David Skaves

Third Edition




Revised Edition
A Textbook of
Refrigeration and
Air Conditioning
R.S. KHURMI
J.K. GUPTA
S. CHAND


Refrigeration and
Air Conditioning

Weightage of Marks

COMPONENT OF EXAM	WEIGHTAGE %	TOTAL
Assignments	2 ×4.5% = 9%	75
Quizzes	2 ×5 %= 10%	
Midterm Exam	25%	
Semester Project	10%	
Final Exam	45%	
Practical + Viva	25%	100

(Basic Concepts)Air Conditioning

- Refrigeration is the action of cooling, and in practice this requires removal of heat and discarding it at a higher temperature. Refrigeration is therefore the science of moving heat from low temperature to high temperature.
- Process of treating air so as to control simultaneously its temperature, humidity, cleanliness, and distribution to meet the environmental requirements of the conditioned space.
- It deals with artificial tampering of the condition of air that may involve:
  a. Heating coupled with ventilation
  b. Filtration
  c. Air Circulation
- **ABSOLUTE HUMIDITY** - The weight of water vapor in a given amount of air.
- **ABSOLUTE PRESSURE** - Pressure measured with the base of zero.
- **ABSOLUTE TEMPERATURE** - A temperature scale expressed in degrees ^{o}F or ^{o}C using absolute zero as a base. Referred to as the Rankin or Kelvin scale.
- **ABSOLUTE ZERO** - The temperature at which molecular activity theoretically ceases. -273.16 ^{o}C
- **AMBIENT** - Refers to the temperature surrounding a body or unit under test.

Air Conditioning Processes

- **Absorption Refrigeration:** A system in which a secondary fluid absorbs the refrigerant, releasing heat, then releases the refrigerant and reabsorbs the heat. Ammonia or water is used as the vapor in commercial absorption cycle systems, and water or lithium bromide is the absorber.
- **Accumulator:** Storage tank which receives liquid refrigerant from the evaporator and prevents it from flowing into the suction line and entering the compressor.
- **Calorie:** Quantity of heat required to raise or lower the temperature of 1 gram of water 1 degree Celsius.
- **Check valve** - A valve designed to permit flow in one direction only.
- **Compression** - The reduction of volume of a vapor or gas by mechanical means.
- **COMPRESSION RATIO** - The ratio determined by dividing the discharge pressure, in PSI (Pa), by the suction pressure in PSI (Pa).
- **COMPRESSOR** - A mechanical device used to compress gases. Three main types - reciprocating, centrifugal and rotary.
- **CONDENSATION POINT** - The temperature at which the removal of any heat will begin a change of state from a vapor to a liquid.

Absorption Refrigeration

- Both absorption and compressor refrigerators use a refrigerant with a very low boiling point (less than 0 °F (−18 °C)). In both types, when this refrigerant evaporates (boils), it takes some heat away with it, providing the cooling effect. The main difference between the two systems is the way the refrigerant is changed from a gas back into a liquid so that the cycle can repeat. An absorption refrigerator changes the gas back into a liquid using a method that needs only heat, and has no moving parts other than the refrigerant itself.
- The absorption cooling cycle can be described in three phases:
- **Evaporation**: A liquid refrigerant evaporates in a low partial pressure environment, thus extracting heat from its surroundings.
- **Absorption**: The now gaseous refrigerant is absorbed by another liquid (e.g. a salt solution).
- **Regeneration**: The refrigerant-saturated liquid is heated, causing the refrigerant to evaporate out. The hot gaseous refrigerant passes through a heat exchanger, transferring its heat outside the system and condenses. The condensed (liquid) refrigerant supplies the evaporation phase.
- In comparison, a compressor refrigerator uses an electrically powered compressor to increase the pressure on the gas, and then condenses the hot high pressure gas back to a liquid by heat exchange with a coolant (usually air). Once the high pressure gas has cooled and condensed into a liquid, it passes through an orifice which creates a pressure drop, which causes the liquid to evaporate. The evaporation process absorbs heat, and the temperature of the refrigerant drops to its boiling point at the now low pressure.

- **CONDENSING MEDIUM** - The substance, usually air or water, to which the heat in a condenser is transferred
- **DRY BULB TEMPERATURE** - Temperature read with an ordinary thermometer.
- **Dehumidifying:** removal of water vapor from the air in the space.
- **EVAPORATOR** - A device in which a liquid refrigerant is vaporized. Some super-heating usually takes place
- **Heating:** transfer of energy to the air in a space.
- **Humidifying:** transfer of water vapor to the air in a space.
- **Saturation temperature:** Temperature at which vaporization takes place at a given pressure.
- **Saturation Pressure:** Pressure at saturation temperature is called saturation pressure.
- **Sub-cooled Liquid:** A substance is called sub-cooled liquid if it exist as liquid at saturation pressure but below saturation temperature.
- **Saturated Vapour**: A substance is called saturated vapour if it exist as vapour at saturation temperature.

Thermodynamic System

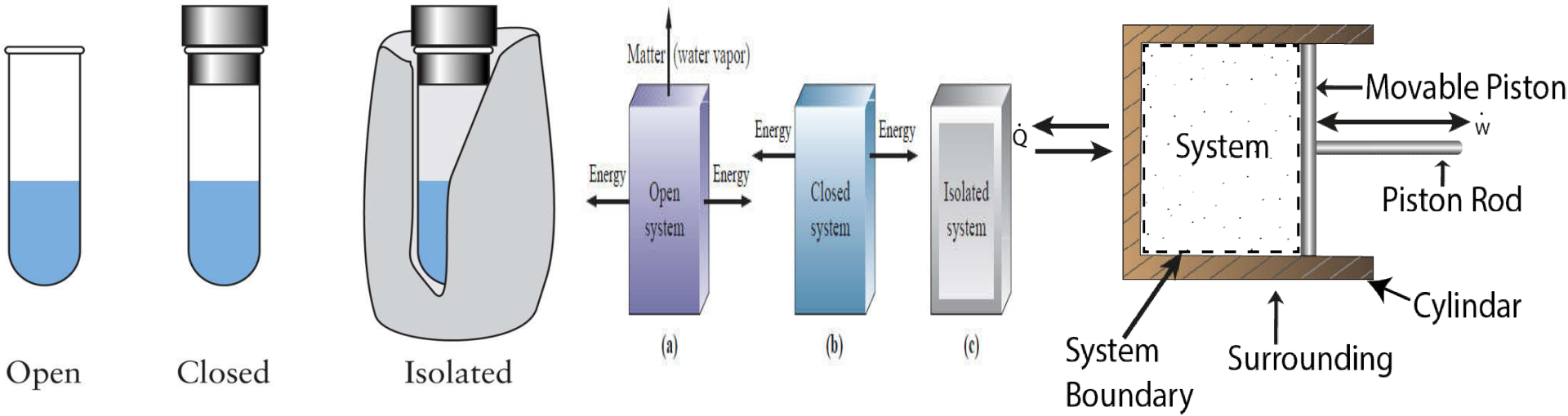
- **Thermodynamic system can be defined as definite area or space where some thermodynamic system take place.**
- Thermodynamic system is classified as

1. ***Open System:*** Mass and Energy crosses the boundary of the system e.g. water heater, nozzle, turbine, boiler and compressor.

2. ***Closed System:*** Does not permit any transfer of mass but permit transfer of energy across the boundary e.g. gas in sealed container, pressure cooker etc.

3. ***Isolated System:*** Completely uninfluenced by the surroundings.

   Fixed mass and no heat and work crosses the boundary e.g. Thermos flask and Universe.



Laws of Thermodynamics

1. **Zeroth Law of Thermodynamics:**

   When two systems are in thermal equilibrium with third system, than the two systems are also in thermal equilibrium.

2. **1st Law of Thermodynamics:**

   Heat and Mechanical work are mutually convertible. $\int Q = \int W$

   It is also known as law of conservation of energy.

3. **2nd Law of Thermodynamics:**

   According to Kelvin Plank: It is to is impossible to construct an engine working in a cyclic process whose sole purpose is to convert heat energy from a single thermal reservoir into an equivalent amount of work.

   According to Clausius Statement: It is impossible for a self acting machine working in a cyclic process to transfer heat from a body at a lower temperature to a body at a higher temperature without any aid of external agency.

4. **3rd Law of Thermodynamics:**

   The entropy of a system approaches a constant value as the temperature approaches absolute zero.

#	LAW [condensed form]
0th	The EQUILIBRIUM Principle
1st	The ENERGY Principle
2nd	The ENTROPY Principle
3rd	The TEMPERATURE Principle

Perfect Gas:

- It is defined as state of substance whose evaporation from its liquid state is complete and strictly obeys all gas laws.
- Real gases which are ordinarily difficult to liquefy such as N_2, O_2, H_2 and air within certain temperature and pressure limits may be regarded as perfect gas.

Enthalpy:

It is sum of internal energy and product of pressure and volume.

$$h = U + PV$$

Entropy:

- It means Transformation. It is a thermodynamic property that is used to determine the energy available for useful work done in thermodynamic process.

$$\Delta S = \Delta Q/T$$

- In a reversible process over a small range of temperature the increase or decrease of entropy when multiplied by the absolute temperature gives the heat absorbed or rejected by the working substance.
- Entropy remains constant in reversible process but increases in irreversible process.
- The change of entropy is positive when heat is absorbed and negative when heat is rejected.

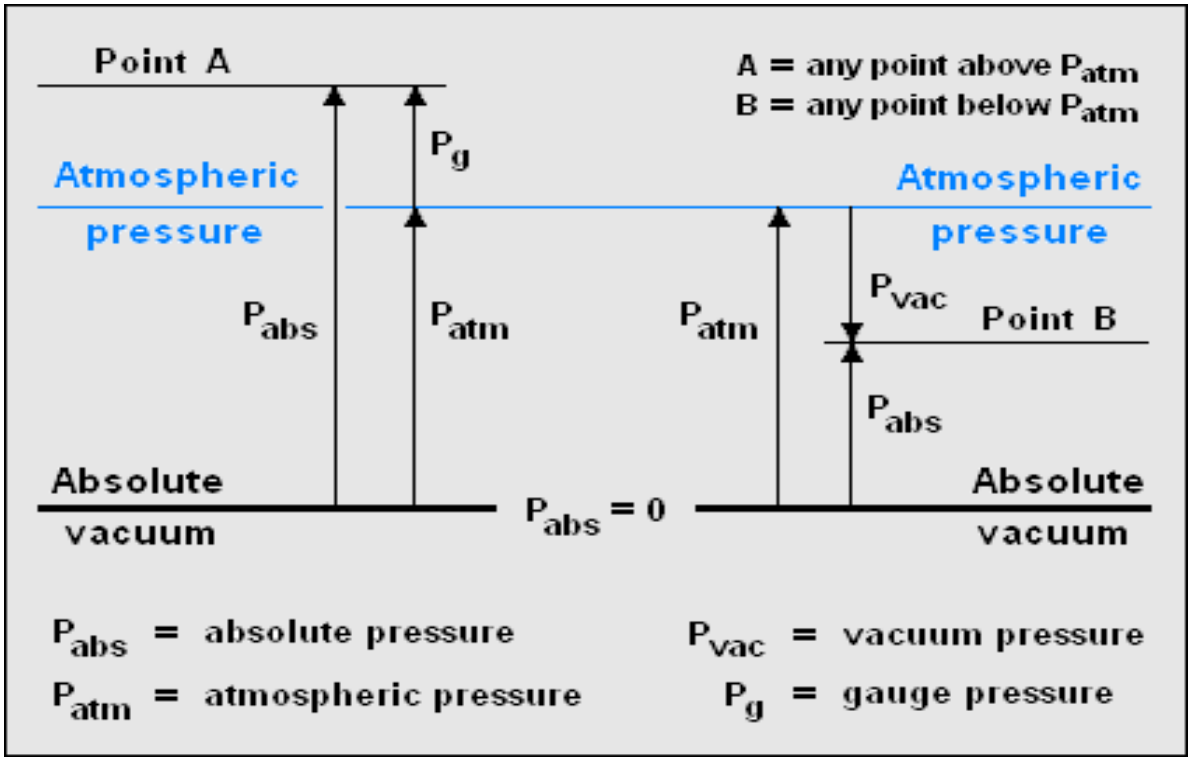
Pressure Gauges

- All the pressure gauges read the difference between the actual pressure and the atmospheric pressure.
- When the pressure is above the atmospheric pressure than the gauge pressure will be positive and relation becomes:

Absolute Pressure = Atmospheric Pressure + Gauge Pressure

- When pressure is below the atmospheric pressure than the gauge pressure will be negative and is known as Vacuum Pressure and relation becomes:

Absolute Pressure = Atmospheric Pressure - Vacuum Pressure



NORMAL TEMPERATURE & PRESSURE (N.T.P):

The temperature and pressure of any gas at 0^oC (273 K) and 760 mm of Hg is termed as NTP

STANDARD TEMPERATURE & PRESSURE (S.T.P):

The temperature and pressure of any gas under standard atmospheric condition is taken as 15^oC (288 K) and 760 mm of Hg.

Unit of Refrigeration:

- Tonne of Refrigeration (TR)
- TR is defined as the amount of refrigeration effect produced by the uniform melting of one tonne (1000 Kg) of ice from and 0^oC in 24 hours
- Latent heat of ice = 335 KJ/Kg

Coefficient of Performance of Refrigerator:

- It is the ratio of heat extracted in the refrigerator to the work done on the refrigerant.

Theoretical COP = Q/W

Relative COP = Actual COP / Theoretical COP

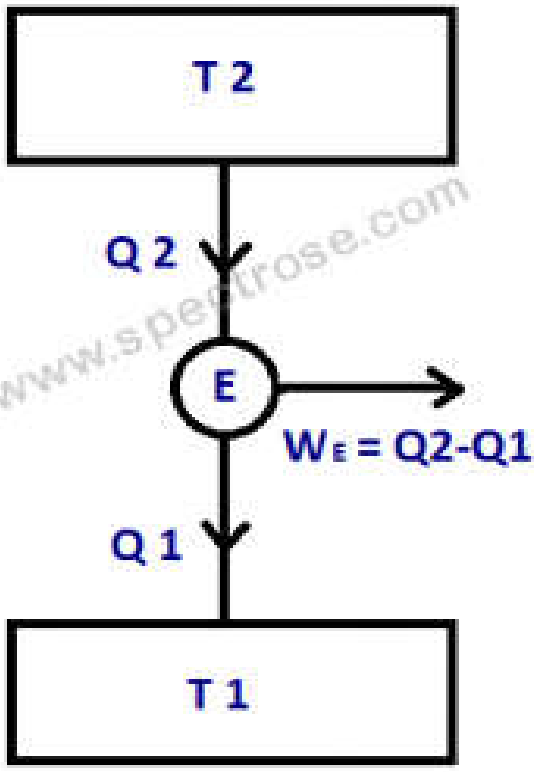
COP α 1/ ή heat engine

Difference Between Heat Engine, Refrigerator & Heat Pump

HEAT ENGINE

- In a heat engine, the energy is transferred from a higher temperature to a lower temperature level called sink. During the process, we get the output as work. The higher temperature is known as source and the lower temperature is known as sink.
- In the Diagram, the hot body is represented by letter T2 and Cold body is represented as T1. Q1 energy is taken from source and out of this energy, Q2 reaches the sink. The remaining energy (Q2-Q1) is obtained in the form of work.
- The Coefficient Of Performance (COP) value of a heat engine will be **always less than 1**.

DIAGAM



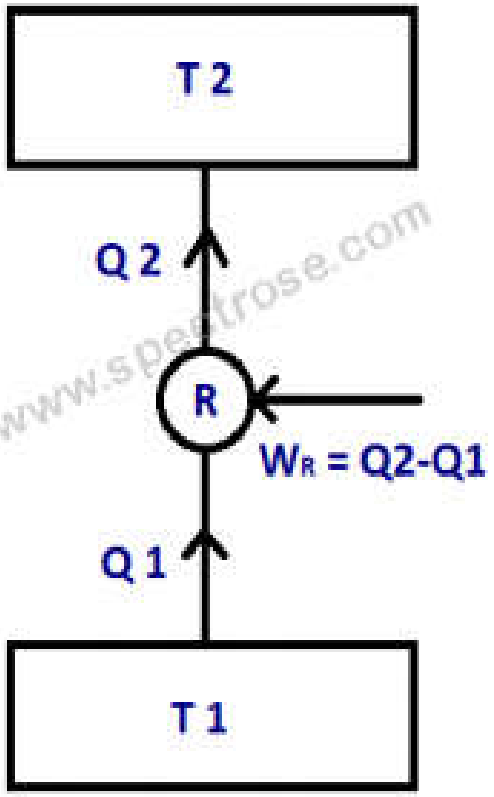
Difference Between Heat Engine, Refrigerator & Heat Pump (CONT.)

REFRIGERATOR

- A refrigerator is a reversed heat engine which cools and maintains the temperature of a body lower than the atmospheric temperature.
- This is done by the process of extracting heat from the cold body and then delivers it to a hot body.
- In the figure, Q1 is the energy taken from the cold body and Q2 is the energy given to T2. Since T2>T1, a work should be done to the system in order to make the process feasible

- T2 will be equal to the atmospheric temperature.
- **COP may be greater than, equal to or less than 1.**
- The product is cold volume.
- T1<Ta
- Where: Ta = Atmospheric Temperature.

DIAGAM



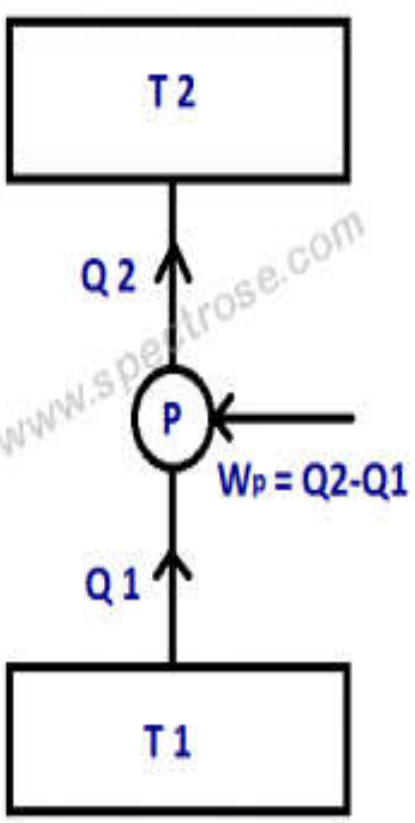
Difference Between Heat Engine, Refrigerator & Heat Pump (CONT.)

HEAT PUMP

- There is no difference between a heat pump and a refrigerator in the case of its cycle of operation. The main difference between the heat pump and refrigerator is its operating temperatures.
- The working temperatures of a refrigerator are cold temperature T1 and atmospheric temperature Ta. Where as in the case of a heat pump, the working temperatures are atmospheric temperature and hot body temperature T2.

- T1 = Ta
- **COP always greater than 1.**
- Hot volume is the product
- T2>Ta

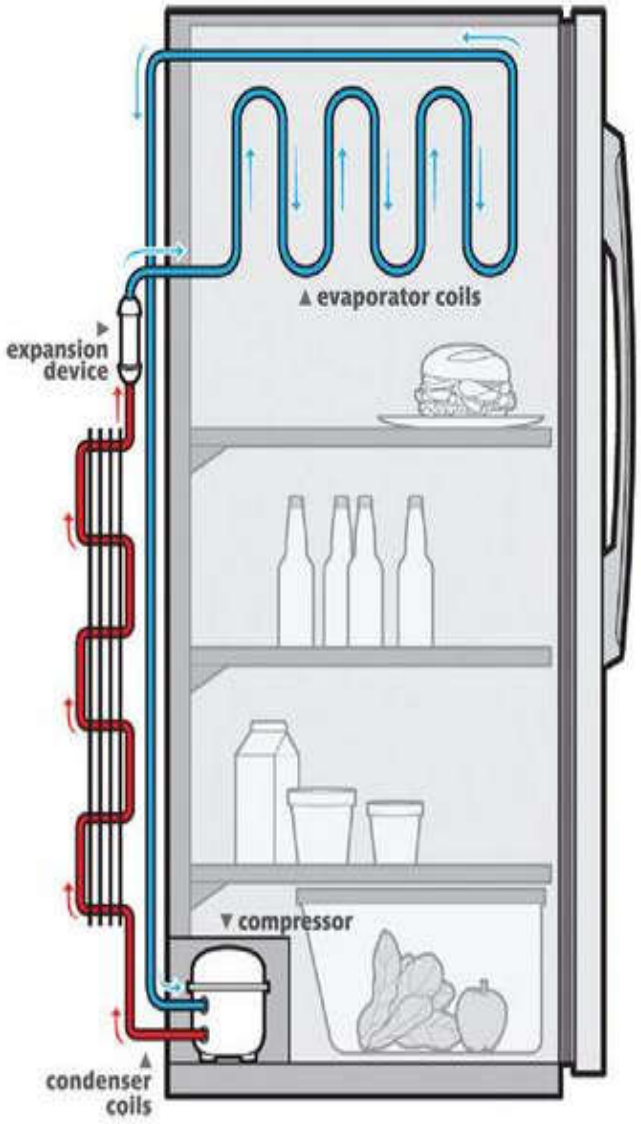
DIAGAM



Basic Refrigerator Working

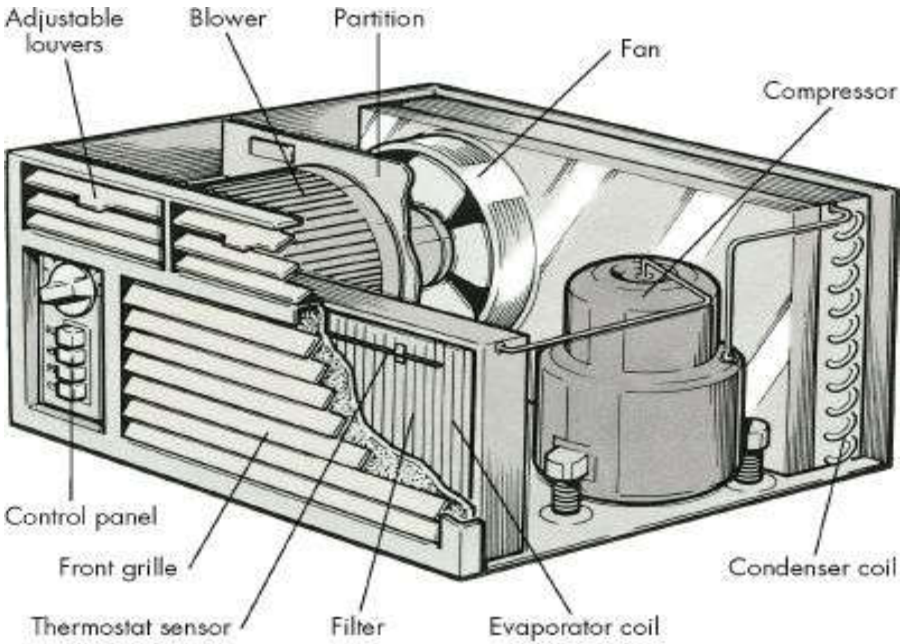
- In air refrigeration, the air is used as a refrigerant
- Since air does not change its phase i.e. remains gaseous throughout the cycle, therefore the heat carrying capacity per kg of air is very small as compared to vapour absorbing systems.
- Refrigeration essentially means continued abstraction of heat from a substance (perishable foods, drinks and medicines etc.) at low temperature level and then transfers this heat to another system at high potential of temperature.
- The basic elements of an air cycle refrigeration system are as follows:

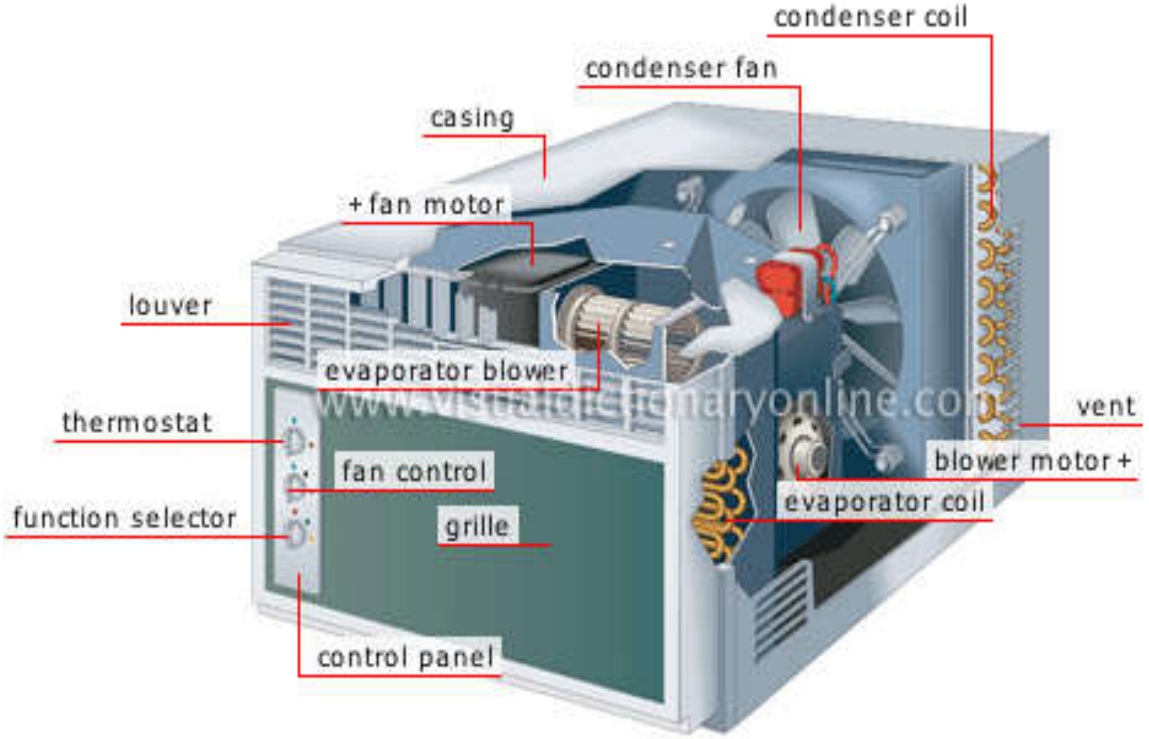
1) Fluid Refrigerant
2) Compressor
3) Condenser
4) Evaporator
5) Expansion device



Working of Refrigerator

1. Starting at the **compressor**;
2. Low pressure vapor refrigerant is compressed and discharged out of the compressor.
3. The refrigerant at this point is a high temperature, high pressure, superheated vapor.
4. The **high pressure refrigerant flows to the condenser** by way of the "Discharge Line".
5. The condenser changes the high pressure refrigerant from a high temperature vapor to **a low temperature liquid** and leaves through the "Liquid Line".
6. The high pressure refrigerant then flows through a filter dryer to the Thermal Expansion valve or **TXV**.
7. The TXV meters the correct amount of liquid refrigerant into the evaporator.
8. As the TXV meters the refrigerant, the high **pressure liquid changes to a low pressure, low temperature, saturated vapor.**
9. This saturated vapor enters the evaporator and is changed to a low pressure dry vapor.
10. The low pressure dry vapor is then **returned to the compressor** in the "Suction line".
11. The cycle then starts over.


Adjustable louvers
Blower
Partition
Fan
Compressor
Control panel
Front grille
Thermostat sensor
Filter
Evaporator coil
Condenser coil


condenser coil
condenser fan
casing
+ fan motor
louver
evaporator blower
thermostat
fan control
function selector
grille
control panel
vent
blower motor +
evaporator coil

WINDOW AIR CONDITIONER

Indoor Side Components

- **Cooling Coil** with a air filter mounted on it. The cooling coil is where the heat exchange happen between the refrigerant in the system and the air in the room.
- **Fan Blower** is a centrifugal evaporator blower to discharge the cool air to the room.
- **Capillary Tube** is used as an expansion device.
- **Operation Panel** is used to control the temperature and speed of the blower fan. A thermostat is used to sense the return air temperature and another one to monitor the temperature of the coil. Type of control can be mechanical or electronic type.
- **Filter Drier** is used to remove the moisture from the refrigerant.
- **Drain Pan** is used to contain the water that condensate from the cooling coil and is discharged out to the outdoor by gravity.

Outdoor Side Components

The outdoor side parts include:

- **Compressor** is used to compress the refrigerant.
- **Condenser Coil** is used to reject heat from the refrigeratn to the outside air.
- **Propeller Fan** is used in air-cooled condenser to help move the air molecules over the surface of the condensing coil.
- **Fan Motor** is located here. It has a double shaft where the indoor blower and outdoor propeller fan are connected together.

THANK YOU FOR YOUR INTEREST