Vocational Higher Secondary Education (VHSE)

SECOND YEAR

REFRIGERATION & AIRCONDITIONING (RAC)

Reference Book

Government of Kerala
Department of Education

State Council of Educational Research and Training (SCERT), KERALA
2016

List of Contributors

Participants

1. **Hashim PP**
   Vocational Teacher in R&AC, MMVHSS, Parappil, Kozhikode
2. **Premraj AR**
   Principal, NSV VHSS, Valacode, Punalur, Kollam
3. **Jyothish Chandran MR**
   Principal, Victory VHSS, Nemom, Trivandrum
4. **Ajayakumar GK**
   Vocational Teacher in R&AC,VHSS Arkanoor, Kollam
5. **Sainudheen A**
   Vocational Instructor in R&AC, GVHSS Chettiyankinar, Malappuram
6. **Subair K**
   Vocational Instructor in R&AC, MMVHSS, Parappil, Calicut

Experts

1. **Mohankumar**
   Managing Director, HEVACO Cooling Systems Pvt. Ltd, Trivandrum
2. **Saji K.Kuzhiyelil**
   Vocational Teacher in R&AC, St. Ignesius VHSS, Kanjiramattom

Academic Co-ordinator

Dr. Rekha R. Nair
Research Officer, SCERT

FOREWORD

Dear Learners,

This book is intended to serve as a ready reference for learners of vocational higher secondary schools. It offers suggested guidelines for the transaction of the concepts highlighted in the course content. It is expected that the learners achieve significant learning outcomes at the end of the course as envisaged in the curriculum if it is followed properly.

In the context of the Right- based approach, quality education has to be ensured for all learners. The learner community of Vocational Higher Secondary Education in Kerala should be empowered by providing them with the best education that strengthens their competences to become innovative entrepreneurs who contribute to the knowledge society. The change of course names, modular approach adopted for the organisation of course content, work-based pedagogy and the outcome focused assessment approach paved the way for achieving the vision of Vocational Higher Secondary Education in Kerala. The revised curriculum helps to equip the learners with multiple skills matching technological advancements and to produce skilled workforce for meeting the demands of the emerging industries and service sectors with national and global orientation. The revised curriculum attempts to enhance knowledge, skills and attitudes by giving higher priority and space for the learners to make discussions in small groups, and activities requiring hands-on experience.

The SCERT appreciates the hard work and sincere co-operation of the contributors of this book that includes subject experts, industrialists and the teachers of Vocational Higher Secondary Schools. The development of this reference book has been a joint venture of the State Council of Educational Research and Training (SCERT) and the Directorate of Vocational Higher Secondary Education.

The SCERT welcomes constructive criticism and creative suggestions for the improvement of the book.

With regards,

Dr. P. A. Fathima

Director, SCERT, Kerala

Contents

Refrigeration & Airconditioning (Rac) Module 3 & 4

PART - A

REFRIGERATION & AIRCONDITIONING (RAC)

ABOUT THE COURSE

The Vocational Higher Secondary course was envisaged as part of the National Policy on Education (NPE)-1986 with the noble idea of securing a job along with education. The relevance of vocational education is highly essential in this age of unemployment. Vocational Educational system, which ensures a job along with higher education, stands aloof from other systems of education. The twentieth century witnessed tremendous progress in commercial refrigeration and air conditioning particularly after DuPont introduced Freon refrigerants. The new century has emerged with the introduction of new alternatives. The vocational course in refrigeration and air conditioning intends to acquire refrigeration skills and update the knowledge of the present world.

Learning about refrigeration should be activity-based, process-oriented, learner-centered, environmental based and life-oriented. Refrigeration contributes to increase the raising of living standards of the people of all lands. The advances made in the field of refrigeration in recent years are the result of a team approach in which techniques, persons, engineers, scientists and others pool their skills and knowledge. The foundation on which new substances and materials are built is provided by science. This knowledge is applied to the refrigeration field by those who design, manufacture, install and maintain refrigeration equipment. It is then made useful through subsequent planned research, development and practical application.

The application of the refrigeration principle is limitless. The most common use, and that readily recognized, is the preservation of food. Almost all products in the home, on the farm, in the business, in industry or in the laboratories are in some way protected by refrigeration. Thus refrigeration has become an essential technology of modern living.

MODULE-3

MAJOR SKILLS

TROUBLE SHOOTING AND MAINTENANCE OF AIR CONDITIONING EQUIPMENTS

SUB SKILLS

- ENGINEERING GRAPHICS
- INSTALLATION OF WINDOW AC
- INSTALLATION OF SPLIT AC
- TROUBLE SHOOTING OF WINDOW AC
- SERVICING OF WINDOW AC
- TROUBLE SHOOTING OF SPLIT AC
- SERVICING OF SPLIT AC
- INSTALLATION OF DUCTABLE SPLIT AC
- TROUBLE SHOOTING OF DUCTABLE SPLIT AC
- SERVICING OF DUCTABLE SPLIT AC

MODULE - 4

MAJOR SKILLS

SERVICING OF AUTOMOBILE AC & CALCULATING CAPACITY REQUIREMENT

SUB SKILLS

- FIND CAPACITY OF EQUIPMENT REQUIRED
- MAINTENANCE OF AUTOMOBILE AC
- SERVICING AND REPLACEMENT OF AIR CONDITIONING CONTROLS
- FABRICATION OF DUCT

SYLLABUS

MODULE 3: SPLIT AND DUCTABLE AIR CONDITIONERS

Unit No.: 3.1 ENGINEERING GRAPHICS

Orthographic Projection - Orthographic views of simple objects - Pictorial Drawing - Isometric projection-Principle, isometric scale, isometric view. Auxiliary views – Principle – need - primary auxiliary views. Sectional views of objects. Free hands sketching of straight lines, rectangles, squares, circles - Sectional views of simple engineering components and devices. Development of surfaces - concept – applications - development of cylinder and pyramid.

Computer Aided Drafting

Introduction to CAD-compare conventional drawing and CAD –Starting to use CAD software –Application of CAD in engineering drawing-Opening of CAD-Setting of units and limits-Saving of drawing-Draw Commands (lines, circle, arc, ellipse, hatch, modify, erase, etc.).Dimensionig and text commands-Practice (different methods of drawing lines) Drafting of 2D figures creating a new drawing.

Unit No.: 3.2 PSYCHROMETRY

Air conditioning- comfort and industrial. Factors of comfort air conditioning. Psychometric properties of air. DBT, WBT and DPT, Vapour pressure, Specific and relative humidity, enthalpy. Psychometric charts- Sensible heating and cooling, Cooling by pass factor, Humidification and dehumidification processes. Classification- summer, winter, year round. Simple problems using psychometric chart.

Unit No.: 3.3 BASIC ELECTRICITY & ELECTRIC MOTORS

Basics of electricity. Single phase and three phase induction motor- working principle. Three phase motors- squirrel cage, slip ring. Single phase motors- split phase induction motors, capacitor start induction motors, capacitor start and capacitor run motors, permanent capacitor motor.

Unit No.: 3.4 AIRCONDITIONING EQUIPMENTS

Brief explanation about window, split, package, central, chilling plant & VRF air conditioning systems. Areas of application.

Unit No.: 3.5 WINDOW AC

Types-common, portable and precision-applications,working,care and maintenance-merits and demerits.

Unit No.: 3.6 SPLIT AC (Wall, Floor, Ceiling Mounted & Tower/Slim line)

Construction and working principle, types, trouble shooting-description of electrical components- study about the wiring circuit-Split AC (Tower/Slim line): Construction, working principle, types, trouble shooting. Description of electrical components used in split AC. Study about the wiring circuit.

Unit No.: 3.7 SPLIT AC (Duct, Multi/Dual Split)

Study of the ductable split AC, its construction and working principle.

MODULE 4: APPLICATION OF AIR CONDITIONING & CONTROLS

Unit No.: 4.1 INVERTER SPLIT AC

Construction and working principle-comparison between an AC with star rating (energy efficiency ratio) and inverter AC, Inverter AC-Normal compressor + variable speed compressor. Special features-motor, insulation, piping.

Unit No.: 4.2 HEAT LOAD CALCULATION

Importance of cooling load calculation. Different components contributing the total cooling load-heat load due to structural wall, infiltration, ventilation, occupants and power equipment of a building. Simple problems.

Unit No.: 4.3 SPECIAL AIRCONDITIONING APPLICATIONS

Elementary ideas of automobiles, railways, clean room, hospital and theatre air-conditioning. Elementary idea of Reefer air-conditioners, HVAC.

Unit No.: 4.4 REFRIGERATION & AIRCONDITIONING CONTROLS

Study of relays-amperage, voltage, PTC and hot wire relays. DOL Starter. OLP, thermostat, pressure controls and oil pressure failure controls. Variable speed drives.

Unit No.: 4.5 TRANSMISSION AND DISTRIBUTION OF AIR

Duct-classification of duct- supply, return and fresh air ducts, air outlets. Ducting components-fan, filter, duct openings. Introduction to different duct design methods, duct arrangement.

Unit No.: 4.6 SIMPLE PROJECT WORKS

One simple working model (skeletons) of refrigerator, water cooler, ice cream churner, car AC or any other relevant activity

PART - B

MODULE-3

SPLIT AND DUCTABLE AIR CONDITIONERS

This module is designed to develop both theoretical and practical skills of the learner in the field of all types of air-conditioning machines used now-a-days. An understanding of the psychrometric properties of air and their influence in comfort air-conditioning is imparted. Electrical wiring know-how is necessary for any basic trouble shooting of any machine. Installation, servicing and trouble shooting of widely used air-conditioning machines like window airconditioner, various direct and ductable split air-conditioners, cassette airconditioner will help the learner start his career directly as a grade "C" mechanic.

UNIT 3.1: ENGINEERING GRAPHICS

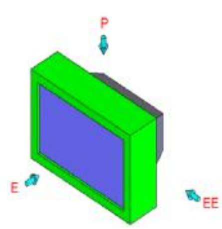
Engineering graphics is the language of Engineers.Drawing fundamentals and simple drawing up to the projection of points are detailed in Module 1. In this module Orthographic projection,Isometric view and Computer-Aided Drafting are included.

Learning outcome:

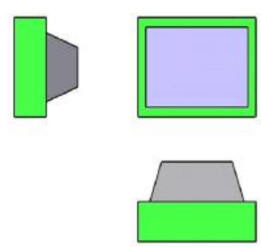
The learner :

- Understand orthographic projection
- Understand isometric projection
- Draw simple object using CAD

Orthographic projection: Orthographic projection is one method of projection used in engineering drawing in which the objects are projected on imaginary planes. This means the object becomes 2D. The difference between Orthographic Projection and any other drawing method is that, we use several 2D views of the object instead of a single view. In orthographic projection, the object is placed an infinite distance from the observer. The image, formed on the picture plane is orthographic projection. The word 'orthographic' means to draw at right angles**.**



P- Plan, E- Elevation,
EE- End Elevation



Side view (EE)
Front view(E)

Basics of Orthographic Projection: Orthographic Projection helps us see an object in 2D. To do this we need to look at 90 degrees to the face of an object. The planes of projection are extended beyond the line of intersection to form four quadrants. The position of objects in any one of these four quadrants are as follows:

1. First horizontal plane(HP) in front of vertical plane(VP)
2. Second quadrant-Above HP and behind VP
3. Third quadrant-Below HP and behind VP
4. Fourth quadrant; Below HP and in front of VP

Orthographic views: Orthographic views are obtained from orthographic projection. The front, top and side views are called as orthographic views. In orthographic projection, the picture planes are called as planes of projection and the perpendicular lines are called project lines or projectors. When we draw an orthographic view of the front of an object, it is called ELEVATION. When we draw an orthographic view of the top of an object, it is called PLAN. When we draw an orthographic view of one side of an object, it is called an END ELEVATION.

Types of orthographic projections:

Usually there are 4 types of orthographic projections

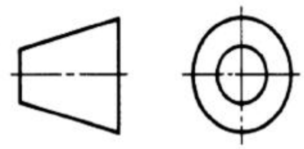
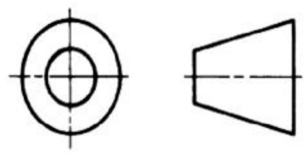
1) First angle projection
2) Second angle projection
3) Third angle projection
4) Fourth angle projection

In engineering drawing we prefer only the first angle projection.

DIFFERENCES BETWEEN FIRST ANGLE AND THIRD ANGLE PROJECTION

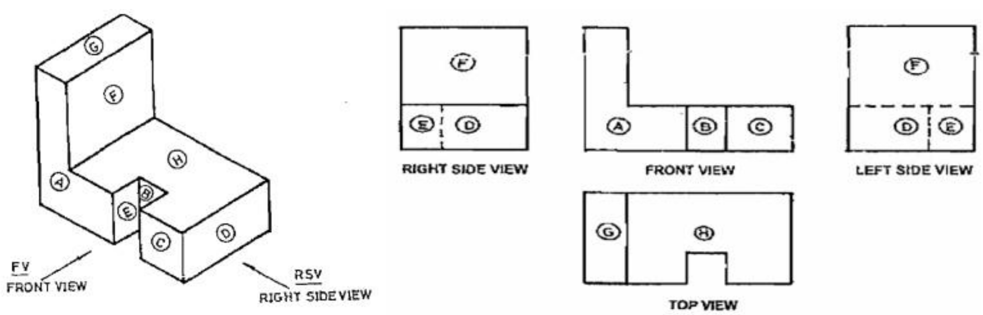
First angle projection	Third angle projection
The object is placed in the first quadrant	The object is placed in the third quadrant
The object lies between the observer and the plane of projection.	The plane of projection lies between the observer and the object
In this method, when the views are drawn in their relative position, the plan comes below the elevation. The left side view is drawn in the right side of elevation.	In this method, when the views are drawn in their relative position, the plan comes above the elevation. The left side view is drawn in the left side of elevation.

The plane of projection is assumed to be non transparent	The plane of projection is assumed to be transparent
Normally this projection is used in India and British countries	Normally this projection is used in USA

Projection	Symbol
First angle	
Third angle	

Example 1

Draw the elevation looking from the direction of arrow FV, plan, the right side view and left side view for the pictorial view as shown in figure.

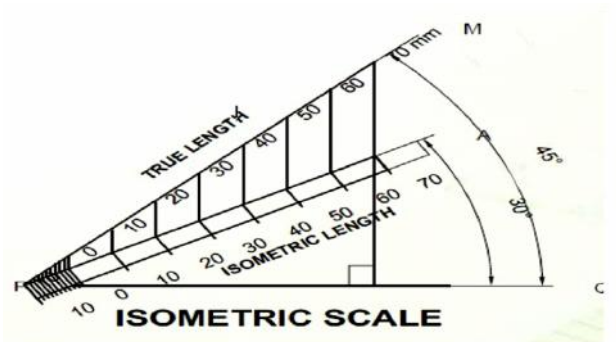


Isometric projection: The isometric projection of an object is a one plane view drawn with the object placed with respect to the plane of projection so that all the three principal axes appear to be inclined to each other at an equal angle of 120^0.

Isometric scale is used to measure the foreshortened length of dimensions of any object to draw the isometric projection. The steps of construction of isometric scale are given below :

(i) Draw a horizontal line PQ. (ii) Draw the true lengths on a line PM inclined at 45° to the horizontal line (say up to 70 mm) (iii) Draw another line PA at 30° to the horizontal line.

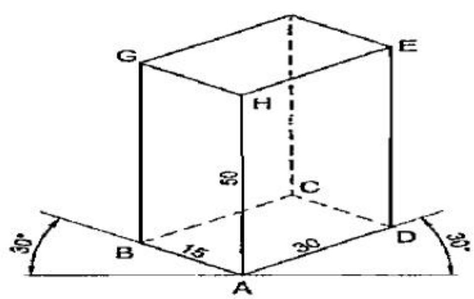
(iv)Draw the vertical projection of all the points of true length from PM to PA. (v) Complete the scale with the details as shown in the figure. The lengths shown at the line PA are the isometric lengths to be used to draw the isometric projection.



Isometric drawing:

Exercise: Draw the isometric drawing of a rectangular prism of base 30 mm x 15 mm and the height 50 mm

- Draw the isometric projection of a cube of side 50mm.



- Draw the three isometric axes through point 'A'.
- Mark AB = 15 mm, AD= 30 mm and AH =50 mm representing the three sides of prism.
- Draw two vertical lines parallel to the line AH through points B and D.
- Similarly draw two more lines parallel to AB and AD through point H.
- Mark G and E, the intersecting points.
- Draw lines parallel to GH and HE through points G and E intersecting at F.

- Draw lines parallel to AB & AD through points D and B respectively intersecting at C.
- Join CB & CD with dash lines.
- Join F and C also with dash lines.
- Rub off the construction lines and complete the prism.

T.E Questions

1. Draw a bisecting line for the given straight line AB of length 120 mm.
2. Draw a bisection line for the given straight line PQ of length 60 mm
3. Divide the given straight line AB of length 120 mm into seven equal parts.
4. Divide the given straight line PQ of length 70 mm into five equal parts.
5. Draw an arc of 40 mm radius touching the two given straight lines [AB = 80mm, AC = 70 mm] at right angles to each other.
6. Draw an equilateral triangle ABC for the given side. side AB=40 mm.
7. Draw an isosceles triangle ABC for the given data. AB = 70mm, AC = BC=55mm.
8. Draw a square for the given length of one side [side AB =60 mm].

Auxiliary view: If a surface of an object is inclined to any of the planes of projection, the view of the surface of that plane will not show its true shape and size. To overcome this difficulty, a view of the inclined surface is projected on to an imaginary plane parallel to this inclined surface. This imaginary plane is called Auxiliary plane and the view obtained on it is called Auxiliary view.

Sectional views: Interior details of an object cannot be shown on principal exterior views. In such cases an imaginary cutting (sectioning) plane may be used to cut through the object, so that the portion in front of the plane can be imagined to be removed so as to expose the inner details.

The sectional view shows and elaborates the internal construction of a machine, so that the drawing shows the components and parts of the machine. The view can be a section of either top view, front view or side view. Actually the sectional view is an “anatomy” of a machine. Designers use this view to analyse the constructional details and to modify the design of a machine. They are the projected views (either Auxiliary or Orthographic) which show a cross section of the source object along the specified cut plane. There are different types of sectional views such as:

(1) Full Sectional view

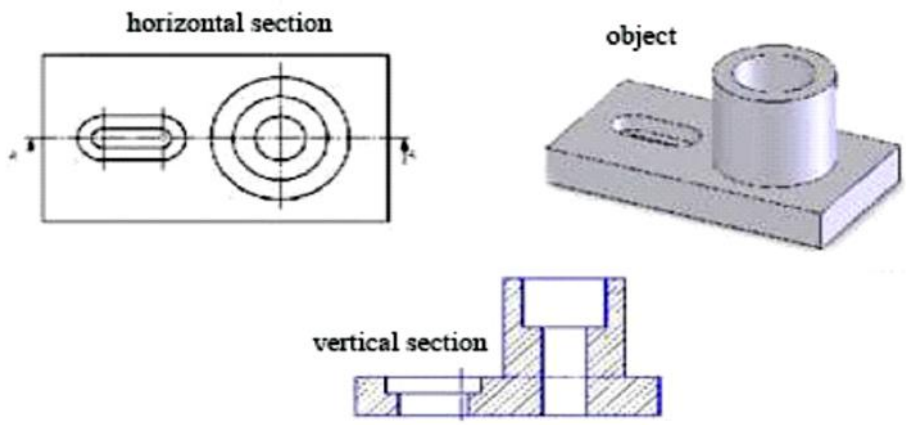
(2) Half Sectional view

(3) Partial/ Broken Sectional view

(4) Revolved Sectional view

(5) Offset sectional view

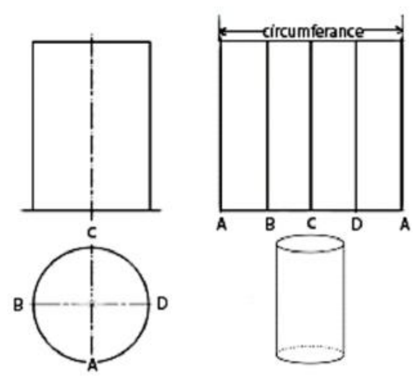
(6) Removed sectional view.



Development of surfaces: The knowledge of the development of surface is used in engineering applications such as sheet metal works, automobile body building, packing industry etc. The surface of an object which is opened out and laid on a flat plane is called the development of surface of that object.

Develpoment of cylinder: Cylinder is wrapped around a paper. When the paper is opened, it is rectangle in size. Length = circumference of cylinder, Breadth = Height of cylinder

Generally, parallel line method is used for the development of cubes, prisms, etc.



Development of hexagonal pyramid: Pyramid is developed as follows; Draw an arc of radius OA – o 'a'. Divide the arc into 6 equal sectors, so that each sector is equal to distance x.

Practical

1. Draw orthographic views
2. Draw isometric views
3. Draw sectional views
4. CAD practicals in computer lab

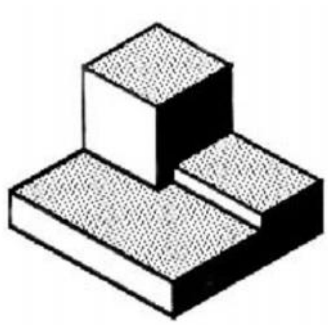
ASSESSMENT

Draw the orthographic view of parts of a dismantled compressor.

Draw schematic diagram of summer AC system using CAD.

TE Questions:

1. Draw the front view and top view of the object given below.



Computer-Aided Drafting (CAD)

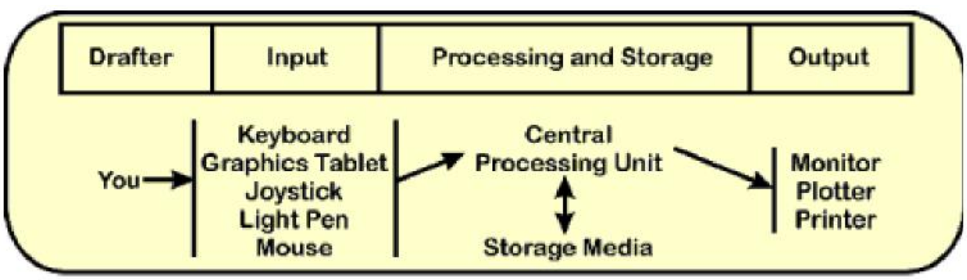
The last two decades brought about enormous changes in the physical appearance of the drafting industry. The tools, drafters and engineers have moved from **manual** (pencil and paper methods) to computer aided drafting techniques. These changes were brought about largely with the advent of computers.

The advantage of computer based drafting is its ability to automate the design process. Drawings done using a computer based drafting tool can easily be done in half the time compared to the manual drawing methods using pencil and paper. What makes a computerized design tool so effective is its ability to make revisions very quickly.

Components of a CAD System

Any computerized system, consists of four main components:

- **Hardware** - Hardware consists of equipment, or the parts of the computer that could be seen. Hardware is used to input the data into the computer system. Once inside the computer, the data is processed by the hardware into information. Output equipment is then used either to place the information on storage devices or to present the information in human readable form, such as on a display screen or printed onto paper.
- Software - Software programs are specific sequences of instructions needed to run computers. Without specific instructions provided by software, a computer-based system could not function. Software not only processes the information needed by users, but also provides the instructions needed just to get the computer running.
- **Data** - Data must be collected and changed into a form on which the computer can operate. Although collection methods vary widely, the most common data input methods are using a keyboard or mouse.
- **People** - People form an essential part of information system. They put together and coordinate all activities within the system.



CAD Software

Drafting is an art of communication. It has the ability to convey information to someone through the use of graphic media. Computer Aided Drafting (CAD) is simply the application of manual drafting technologies to a computer, the ability to draw a line, arc, or other object on a computer screen then get that information onto a piece of paper, so that it might be used by someone.

Advantages of using CAD

Some of the advantages of CAD over manual drafting are:

- **Drawing to scale.** In almost all instances, the CAD operator will produce a drawing that is drawn to actual size. There is no need of remembering which scale is which and no need for the continual mind set of , "I am drawing at 3/8" = 1'."
- **Drawing set up.** Being able to have a set of drawings which have already been set up with proper borders, title boxes, schedules, and any other pertinent information can save hours of layout and lettering time.
- **Drawing efficiency.** CAD programs often have built in tools which give the operator the capabilities of saving a great deal of time. For instance, if the operator is working on a drawing which has sixty detailed sprinkler heads distributed across a ceiling, it becomes very time consuming to draw every head one at a time. With a CAD package the operator can draw the head once and then "copy, array, mirror, or offset" as needed. This same drawing "block" could also be "inserted" into other drawings, so that it need never be drawn again.
- **Drawing modifications.** As it has been said, it is very rare that any drawing is completely correct the first time it is drawn. Modifying drawings is an integral part of any CAD package. (To be able to remake a drawing , change a line or two, and have it plotted in 10 to fifteen minutes, rather than manually re-dawn an entire drawing, or "smudge" up a drawing with erasures, as it has become more important since the need for fast and accurate results has increased.)

The CAD Interface

Virtually all modern CAD applications use a Graphic User Interface (GUI) to communicate with software users. A graphic user interface makes use of pictures, icons, pull-down or pop-up menus that allow the user to select from a predefined list of command choices. The combination of icons and menus gives users a complete picture of the items that can be used and the functions that can be performed. A graphic user interface normally makes use of a **mouse**. The mouse allows the user to point at and choose the items or commands that he or she would like to use. A user interface that combines icons, menus, and a mouse is easy to learn and natural to use.

UNIT 3.2
PSYCHROMETRY

Psychrometry is the study of atmospheric air and water vapour present in it.Atmospheric air is a mixture of a number of gases such as Nitrogen, Oxygen Hydrogen, Carbon dioxide etc.Knowledge of psychrometry is essential to understand the workingof air conditioning system.

Learning outcome

The learner :

- Understand the idea of air conditioning
- Learn factors of air conditioning and various psychrometric properties of air
- Explore psychrometric chart, classification and do simple problems

Psychrometry is the branch of science which deals with study of dry air and water vapour. The atmospheric air we breathe consists of a number of gases, water vapour and pollutant particles. The concentration of water vapour and pollutants decreases with altitude.

ATMOSPHERIC AIR

GASES $\mathbf{N_2, O_2, H_2, Ar, ...}$ **+** Moisture + Pollutants

Air conditioning means maintaining temperature,humidity,purity and circulation of air in accordance with human comfort or industrial needs. So psychrometry is very important in the field of airconditioning.

Dry Air: Dry air means a mixture of gases such as N_2, O_2, Ar, H_2......... or air without water vapour is called dry air. The percentage composition of air is given below.

GAS	FORMULA	%
Nitrogen	N_2	78.084
Oxygen	O_2	20.947
Argon	Ar	00.934
Carbon dioxide	CO_2	00.033

$N_2+O_2+Ar+CO_2$ =99.98% The rest is other gases.

Moist Air: Moist air is a number of gases and water vapour.The amount of water vapour depends on pressure and temperature of atmosphere.The amount of water vapour in the air is an important factor affecting human comfort.

Dry bulb temperature(DBT): Temperature measured with an ordinary thermometer is called Dry bulb temperature.

Wet bulb temperature (WBT): The temperature recorded by a thermometer when its bulb is covered with a wet cloth is called Wet Bulb temperature. Wet bulb temperature is always less than Dry bulb temperature. When relative humidity is 100%, wet bulb temperature and dry bulb temperature are equal.

Specific humidity: The mass of water vapour present in 1 Kg of air is called specific humidity. It is expressed in gms/Kg of air.It is also called humidity ratio.

Absolute humidity: The mass of water vapour present in $1m^3$ of air is called absolute humidity and expressed in $gm/m^3$of air.

Relative humidity (RH): It is the ratio of mass of water vapour present in humid air to the mass of water vapour that the air can hold at the same temperature. It is expressed in percentage.The moisture carrying capacity of air increases with increase in air temperature.

Dew point temperature (DPT): The temperature at which water vapour starts to condense is called DPT. When the temperature of air decreases, relative humidity increases and reach 100%.This air is called saturated air. At saturation point, water vapour begins to condense. So dew point is the saturation temperature for water in air.

Eg. When you buy cool drinks from a shop, you can see dewdrops outside the can. This is because when temperature of the air surrounding the can decreases, it gets saturated and water in the air condenses.

Specific volume: It is the number of cubic meters of moist air per kilogram of dry air. It is expressed as m^3/kg of dry air. In air conditioning process, the amount of dry air is always constant and the amount of water vapour may increase or decrease.

Enthalpy: Enthalpy of air is the total heat energy of dry air and water vapour.When air is heated enthalpy increases and when air is cooled enthalpy decreases. Its unit is kilo joule per kg.

Meaning of Air conditioning: Air conditioning refers to the treatment of air simultaneously controlling its temperature, moisture content, cleanliness, odour and circulation, as required by the occupants, process or products in the space. The subject of refrigeration and air conditioning has evolved out of the human need for food and comfort.

There are two basic types of air conditioning systems as far as their functions are concerned.

(a) Comfort air conditioning system : The purpose of this system is to create atmospheric conditions conducive for human health, comfort, and efficiency. Air conditioning systems at homes, offices, stores, restaurants, theaters, hospitals, schools, and churches are of this type.

(b) Industrial air conditioning system : The purpose of this system is to control atmospheric conditions primarily for the proper conduct of research and manufacturing operations.

The essential feature of comfort air conditioning system is to provide a comfortable environment for the occupants.

Factors Affecting Comfort Air Conditioning:

1. **Temperature of air:** In air conditioning, the control of temperature means maintenance of any desired temperature within an enclosed space, even though the temperature of the outside air is above or below the desired room temperature. This is accomplished either, by addition or removal of heat from the enclosed space as and when required. It may be noted that a human being feels comfortable when the air is at 21- 24 °C with 56% relative humidity.

2. **Humidity of air:** The control of humidity of air means decreasing or increasing the moisture content of air during summer or winter respectively in order to produce comfortable healthy conditions. The control of humidity is not only necessary for the human comfort but also increases the efficiency of the workers. In general, for summer air conditioning, the relative humidity should not be less than 60%, whereas for winter air conditioning it should not be less than 40%.

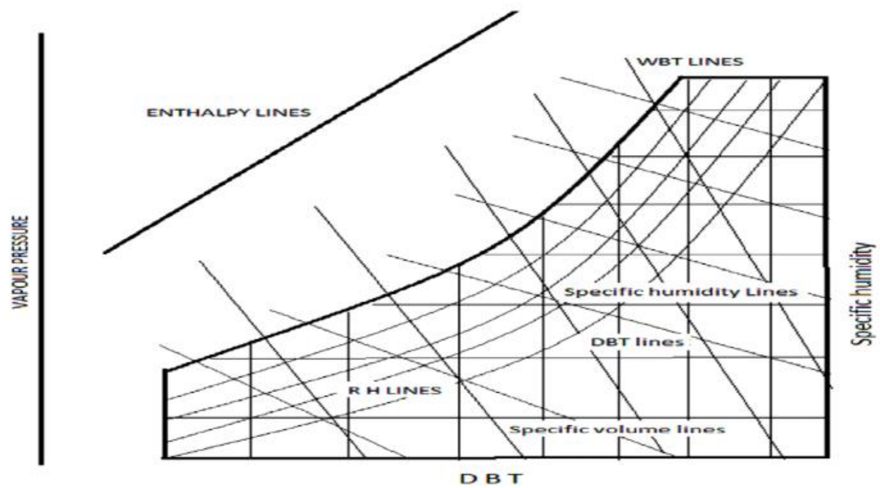
3. **Purity of air:** It is an important factor for the comfort of human body. It has been noticed that people do not feel comfortable on breathing contaminated air, even if it is within the acceptable temperature and humidity range. It is thus obvious that proper filtration, cleaning, and purification of air is essential to keep it free from dust and other impurities.

4. **Motion of air:** The motion or circulation of air should be controlled, in order to maintain constant temperature throughout the conditioned space. Hence, there should be equi-distribution of air throughout the space to be air conditioned.

The comfort air conditioning system is subdivided into three groups

1. Summer air conditioning system
2. Winter air conditioning system
3. Year round air conditioning system

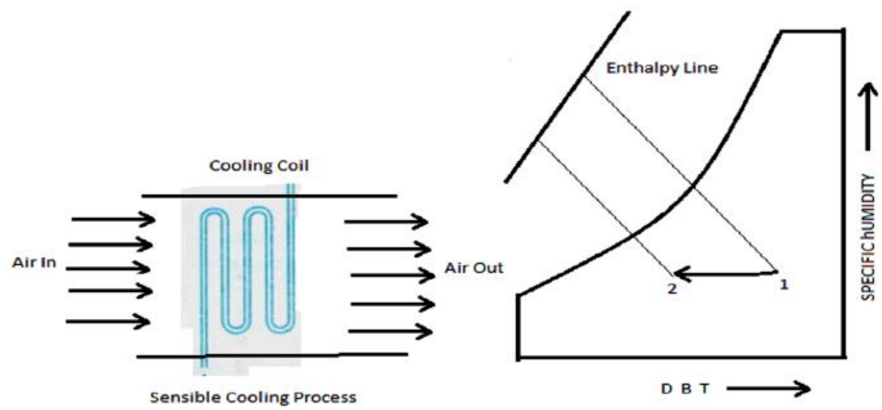
Psychrometric chart: It is the graphical representation of various psychrometric properties of moist air. These charts are very useful in cooling load calculations. Psychrometric chart is constructed by taking dry bulb temperature in X-axis and specific humidity in Y-axis. In psychrometric chart, the vertical lines are dry bulb temperature lines and horizontal lines are specific humidity lines. The curved lines are relative humidity lines. The left outer line is saturation curve ie. relative humidity is 100 percent. If you know any two psychrometric properties the rest you can find using a psychrometric chart.



Psychrometric Processes: In the design and analysis of air conditioning plants, the fundamental requirement is to identify various processes being performed on air. All these processes can be plotted easily on a psychrometric chart. This is very useful for quick visualization and also for identifying the changes that are taking place in the important properties such as temperature, humidity ratio, enthalpy etc. The various psychrometric processes involved in air conditioning that vary the psychrometric properties of air according to the requirement are as follows.

1. Sensible Cooling
2. Sensible Heating
3. Humidification
4. De-humidification

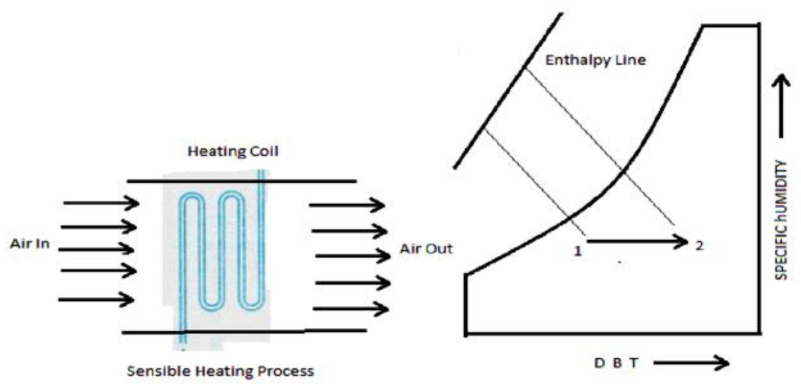
Sensible Cooling: The cooling of air without any change in its specific humidity is known as sensible cooling. Cooling of the air is one of the most common psychrometric processes in the air conditioning system. The basic function of the airconditioners is to cool the air absorbed from the room or the atmosphere, which is at higher temperature. The sensible cooling of air is the process in which only the sensible heat of the air is removed so as to reduce its temperature, and there is no change in the moisture content (kg/kg of dry air) of the air. During sensible cooling process the dry bulb (DB) temperature and wet bulb (WB) temperature of the air reduces, while the latent heat of the air, and the dew point (DP) temperature of the air remains constant. There is overall reduction in the enthalpy of the air.



During Sensible Cooling Process

Psychrometric properties of air	Change
DBT	Decreases
WBT	Constant
DPT	Constant
Specific humidity	Constant
Relative humidity	Increases
Partial pressure of water vapour	Constant
Enthalpy of moist air	Decreases

Sensible Heating of Air: The heating of air without change in its specific humidity, is known as sensible heating. Sensible heating process is opposite to sensible cooling process. In sensible heating process, the temperature of air is increased without changing its moisture content. During this process, the sensible heat, DB and WB temperature of the air increases while latent heat of air, and the DP point temperature of the air remains constant. Sensible heating of the air is important when the air conditioner is used as the heat pump to heat the air. In the heat pump, the air is heated by passing it over the condenser coil or the heating coil that carry high temperature refrigerant. In some cases, the heating of air is also done in different industrial and comfort air-conditioning applications, where large air conditioning systems are used. Like sensible cooling, the sensible heating process is also represented by a straight horizontal line on the psychrometric chart. The line starts from the initial DB temperature of air and ends at the final temperature extending towards the right (see the figure). The sensible heating line is also the constant DP temperature line.



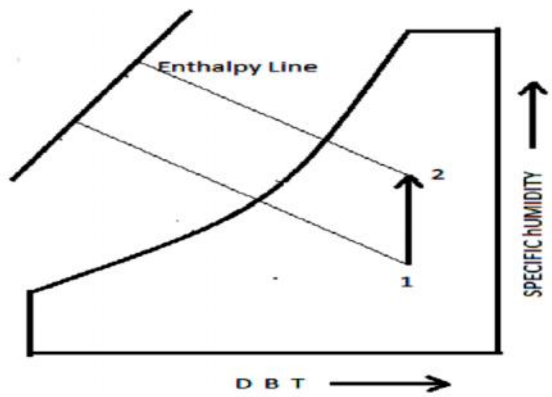
During Sensible Heating Process

Psychrometric properties of air	Change
DBT	Increases
WBT	Constant
DPT	Constant
Specific humidity	Constant
Relative humidity	Decreases
Partial pressure of water vapour	Constant
Enthalpy of moist air	Increases

Humidification of air: The addition of moisture to air, without change in its dry bulb temperature is known as humidification . The equipment used for humidification is known as humidifier.

Methods of humidification

1. Water is sprayed in highly atomized state in to the room to be air conditioned
2. Injecting steam
3. Evaporating water
4. By air washing



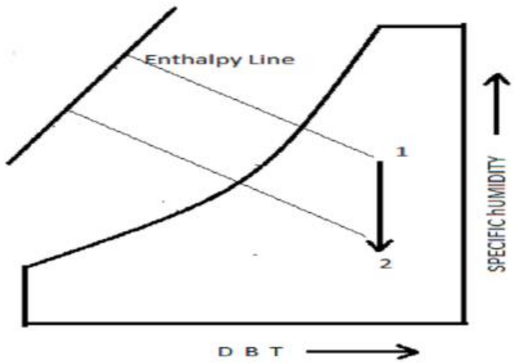
During Humidification Process

Psychrometric properties of air	Change
DBT	Constant
WBT	Increases
DPT	Increases
Specific humidity	Increases
Relative humidity	Increases
Partial pressure of water vapour	Increases
Enthalpy of moist air	Increases

De-humidification of air: The removal of moisture from air , without change in its dry bulb temperature is known as de-humidification. The equipment used for de-humidification is known as dehumidifier.

The methods used for de-humidification are given below

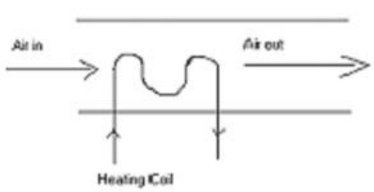
1. By reducing the temperature below DPT
2. By absorption of moisture from air
3. By adsorption of moisture from air

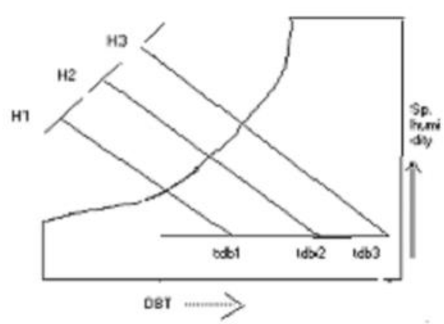


During Dehumidification Process:

Psychrometric properties of air	Change
DBT	constant
WBT	decreases
DPT	decreases
Specific humidity	decreases
Relative humidity	decreases
Partial pressure of water vapour	decreases
Enthalpy of moist air	decreases

BY PASS FACTOR (BPF):





The bypass factor for the process is defined as the ratio of the difference between the mean surface temperature of the coil leaving the air temperature and the difference between the mean surface and the entering air temperature.

The bypass factor is expressed as follows

BPF = $(tdb_3 – tdb_2)/(tdb_3 – tdb_1)$, where

tdb_3 →Average surface temperature

tdb_1 →Temperature of the air passes over heating coil

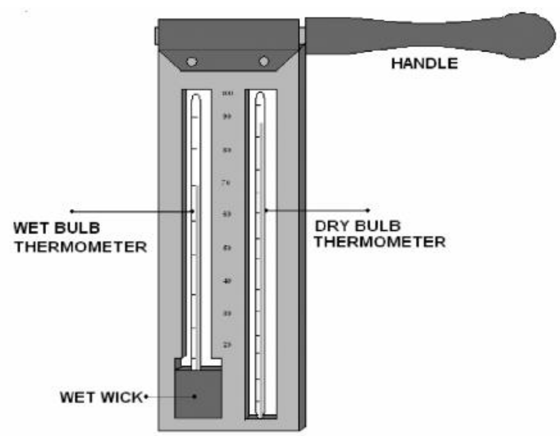
tdb_2 →Temperature of the air leaving the coil

The bypass factor is a function of the physical and operating characteristics of cooling or heating coil. It represents that portion of the air by passed when heating or cooling takes place. The performance of heating or cooling coil is measured in terms of BPF. A coil with low BPF has a better performance.

The parameters, which affect the BPF, are listed below.

1. No. of fins provided per unit length.
2. No. of rows in a coil in the direction of flow.
3. The velocity of the flow of the air

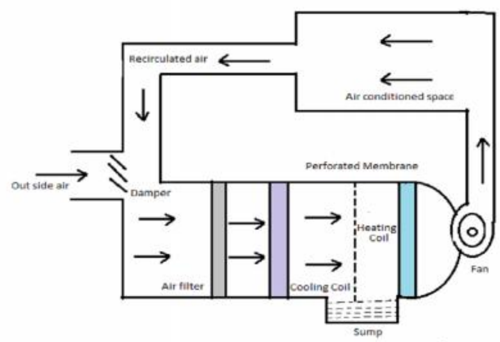
Psychrometer: It is also called wet-and-dry-bulb thermometer. It is a type of hygrometer consisting of two thermometers, one of which has a dry bulb and the other a bulb that is kept moist and ventilated. The sling psychrometer is rotated in the air for approximately one minute after which the readings from both thermometers are taken.This process is repeated several times so as to assure that the lowest possible wet bulb is recorded.



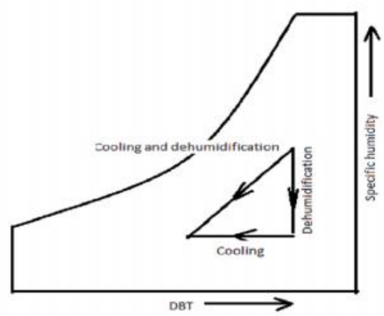
SLING PSYCHROMETER

Summer air conditioning system: It is the most important type of airconditioning, in which the air is cooled and dehumidified.The schematic arrangement of a typical summer air conditioning system shown in the figure. The outside air flows through the damper, and mixes up with re-circulated air (which is obtained from the conditioned space).The mixed air passes through a filter to remove the 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 loses 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 re-circulated air) is again conditioned.

The psychrometric process involved in summer air conditioning system is cooling and dehumidification and psychrometric chart represented by summer air-conditioning system is as follows.

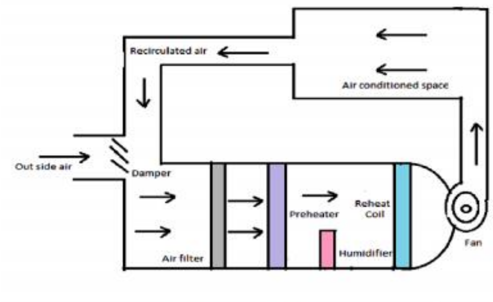


Summer Air conditioning System

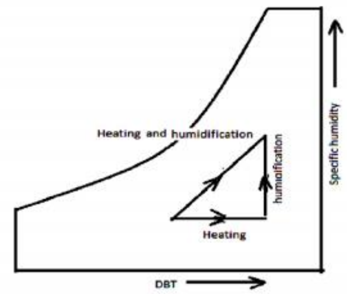


Summer a c system - psychrometric processes

Winter air conditioning system: It is the most important type of air conditioning , in which the air is heated and humidified. The schematic arrangement of a typical winter air conditioning system is as shown in the figure. The outside air flows through the damper, and mixes up with re-circulated air (which is obtained from the conditioned space).The mixed air passes through a filter to remove the dirt, dust and other impurities. The air now passes through a a pre-heat coil. The outside air flows through the damper, and mixes up with re-circulated air which is obtained from the conditioned space. 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 re-circulated air) is again conditioned. The psychrometric process involved in winter air conditioning system is heating and humidification and the psychrometric chart represented by winter air-conditioning system is as follows.

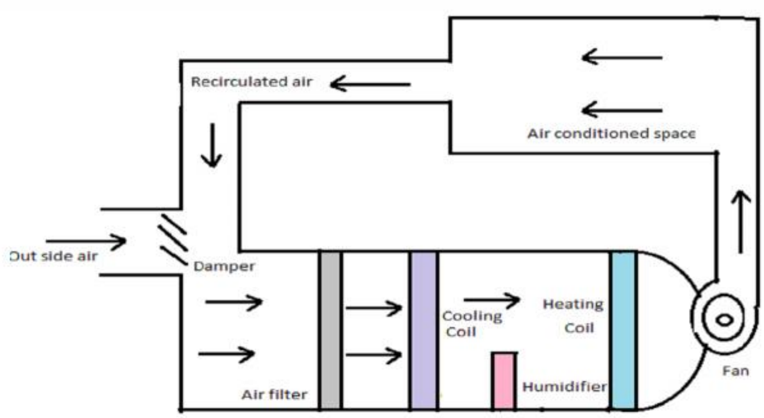


Winter Air Conditioning System



Winter a c system - psychrometric processes

Year round air conditioning system: The year-round air conditioning system should have equipment for both the summer and winter air conditioning .The schematic arrangement of a modern year round air conditioning system is shown in the figure. The outside air flows through the damper, and mixes up with re-circulated air (which is obtained from the conditioned space). The mixed air passes through a filter to remove the dirt, dust and other impurities. In summer air conditioning, the cooling coil operates to cool the air to the desired value. The dehumidification is obtained by operating the cooling coil at a temperature lower than the dew point temperature. In winter, the cooling coil is made inoperative and the heating coil operates to heat the air. The spray type humidifier is also made use of in the dry season to humidify the air.



Year Round Air Conditioning System

Practical

1. Study the use of a sling psychrometer.
2. Find out the various properties of air by using a psychrometric chart.

1. STUDY THE USE OF A SLING PSYCHROMETER AND FIND OUT VARIOUS PROPERTIES OF AIR BY USING A PSYCHROMETRIC CHART.

AIM:

To find out DBT and WBT of atmospheric air and air in an air-conditioned room, Also calculate various properties of air using sling psychrometer and psychrometric chart.

TOOLS AND MATERIALS REQUIRED

Sling psychrometer, psychrometric chart, steel rule, clean cloth and container of water.

PROCEDURE

1. Inspect both the thermometers of Sling psychrometer.
2. Dip the wick attached to the wet thermometer in water.
3. Whirl the sling psychrometer for 30 seconds.
4. Take the reading of Dry bulb and Wet bulb thermometers.
5. Repeat the steps and take two or more readings.
6. The lowest reading of Wet bulb thermometer is taken as WBT and corresponding reading on Dry bulb thermometer is taken as DBT.
7. The reading of DBT and WBT of atmospheric air and air in an air-conditioned room,is taken by conducting experiments in outside air and in the air-conditioned room.

USING PSYCHROMETRIC CHART

1. Locate measured DBT and WBT lines.
2. Note the intersecting point of DBT and WBT lines.
3. The horizontal line from this point meeting the right Y axis gives specific humidity value.
4. The horizontal line from this point meeting the left vapour pressure line gives partial pressure of water vapour value.
5. The relative humidity curve through this point gives the R H value.
6. The horizontal lines of this point meeting the saturation curve point is noted and the vertical line of this point meeting the DBT axis gives the Dew Point Temperature.
7. Draw a line parallel to WBT line. The intersecting point meeting the enthalpy scale line gives enthalpy value.
8. The specific volume line through this point gives the specific volume value.

OBSERVATION AND CALCULATIONS

ATMOSPHERIC AIR

SL NO	DBT	WBT

AIRCONDITIONED ROOM

SL NO	DBT	WBT

2. MEASURING THE VELOCITY OF AIR BY USING A VELOMETER/MANOMETER

AIM:-

To measure the velocity of air by using a velometer/manometer.

Tools and materials required

Velometer, clean cloth.

Procedure

1. Check the air flow in air conditioner name plate detail (1 ton = 400 CFM)
2. Switch on the air conditioner.
3. Select the switch in high cool (high speed)
4. Wait for 1 minute, till constant speed is attained by the in fan motor.
5. Hold the Digital anemometer in front of the grill.
6. Take the velocity of air directly,

Safety precautions: Take extra care about the sensor unit (highly sensitive).

Assessment

1. Take a piece of ice and put it in a closed steel vessel. Observe for a few minutes and write your observations and the reasons for the changes.
2. Sit in front of the table fan for five minutes. Then place a basin filled with cold water in front of the fan and sit for another five minutes. Write your inferences.

TE Questions:

1. According to purpose, air condition systems are classified in to .... and ....
2. Write short note on comfort and industrial air conditioning systems.
3. Presence of water vapour in the air is called.....................
4. Human comfortable temperature is................
5. What are the factors affecting human comfort?
6. Wet bulb temperature is

   (a) Greater than DBT (b) Equal to DBT

   (c) Less than DBT (d) Less than or equal to DBT
7. The temperature at which water vapour present in air begins to condense is called.....................
8. The amount of water vapour present in 1 kg of air is called..................
9. The amount of water vapour present in 1 M3 of air is called ....
10. What is relative humidity ?
11. Fill in the blanks

Psychrometric property	Sensible heating	Sensible cooling
Enthalpy	....	....
Specific humidity	Constant	....
DBT	....	....
Relative humidity	....	Increases
DPT	....	....

12. Suggest air conditioning system for the following places

    (a) Kerala (b) Shimla (c) Delhi
13. The temperature of a room is given DBT=34 C &WBT=31 C. Find?

    (a) Relative humidity (b) Specific humidity

    (c) Enthalpy (d) Dew point temperature
14. The curved lines in psychrometric chart are .... lines.
15. For saturated air

    (a) DBT is less than WBT (b) DBT is greater than WBT

    (c) DBT equals WBT (d) WBT is greater than DBT

UNIT 3.3
BASIC ELECTRICITY & ELECTRIC MOTORS

The unit deals with basics of electricity.It also explains different types of electric motors, working principle, constructional details and applications.This unit also handles different types of wiring practice.

Learning outcome

The learner :

Explain basics of electricity, working principle and type of single phase and three phase motors

Electricity is a form of energy that can come in positive and negative forms, that occur naturally (as in lightning), or is produced (as in a generator).It has lot of applications such as lighting, communication, heating, transportation, etc.Electric current is the flow of electric charge through a conductor. Flow of electric current is similar to that of flow of water in a pipe. SI unit of current is Ampere.

Potential difference

We know that water flows from higher level to lower level of its own. Greater the difference in the level, more will be the flow of water.

Similarly for the flow of electricity from one end of the conductor to other end ,the difference in electric pressure is necessary. This is called potential difference. Higher the potential difference, higher the flow of electricity.If there is no potential difference there will be no current flow. SI unit of potential difference is volt.

A current that changes its magnitude and direction periodically is called an alternating current (AC current), whereas direct current (DC current) is steady and uni-directional.

RESISTANCE: The property of a conductor which resists the flow of electric current is called resistance.

SINGLE PHASE SUPPLY AND THREE PHASE SUPPLY

In electrical engineering, single-phase electric power refers to the distribution of alternating electric power, using a system in which all the voltages of the supply vary in unison. Single-phase distribution is used when loads are mostly lighting and heating, with few large electric motors.

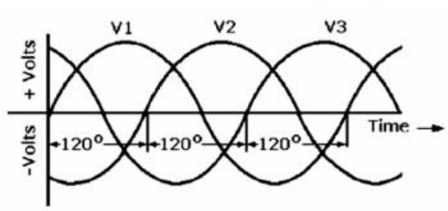
Voltage produced by single phase supply is not enough to meet all practical loads. Some loads need three phase power for its operation. A three phase supply can be generated using three winding. From these winding ,three separate phases are available having same magnitude and frequency.

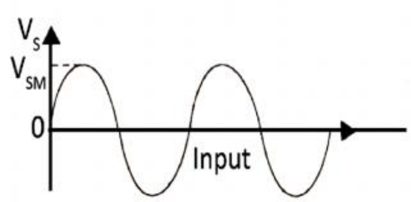
Both three-phase and single-phase devices can be powered from a three-phase supply. A three-phase circuit is a combination of three single-phase circuits. The current, voltage, and power relations of balanced three-phase AC circuits can be studied by applying the rules applicable for single-phase circuits.

The sine waves of three-phase voltage are separated by 120 electrical degree because they are generated by three separate sets of armature coils in an AC generator. These three sets of coils are mounted 120 electrical degrees apart on the generator's armature. The coil ends could all be brought out of the generator to form three separate single-phase circuits, but they are conventionally interconnected so that only three or four wires are actually brought out of the generator.

Single-phase AC voltage with zero power factor has both voltage and current sine waves in phase, so they cross the zero line together twice in each cycle. Similarly, a plot of three-phase voltage sine waves, also with zero power factors as shown in figure, has all three voltage and current waves crossing the zero line twice each cycle together. Each of its three phases, V1, V2, and V3, is separated by 120 electrical degrees. Power supplied to each of the three phases of a three-phase circuit also has a sinusoidal waveform, and the total three-phase power supplied to a balanced three-phase circuit remains constant.

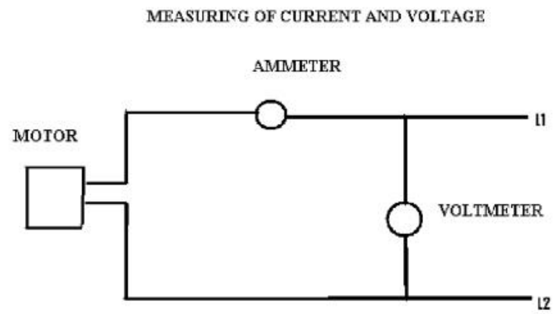
EARTHING: In electric supply systems, an earthing system or grounding system is circuitry which connects parts of the electric circuit with the ground, thus defining the electric potential of the conductors relative to the Earth's conductive surface. The choice of earthing system can affect the safety and electromagnetic compatibility of the power supply. In particular, it affects the magnitude and distribution of short circuit currents through the system, and the effects it creates on equipment and people in the proximity of the circuit. If a fault within an electrical device connects a live supply conductor to an exposed conductive surface, anyone touching it while





electrically connected to the earth will complete a circuit back to the earthed supply conductor and receive an electric shock.

MEASUREMENT OF CURRENT & VOLTAGE



AMMETER : It is used to measure current in a circuit.

VOLTMETER : It is used to measure voltage in a circuit

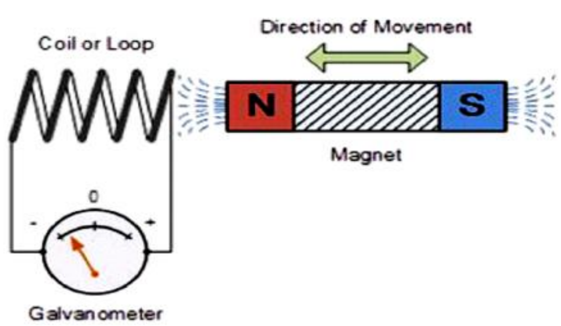
MULTIMETER : It is used to measure current, voltage and resistance.

TONG TESTER : It is used to measure current and voltage in a cable without cutting it.

FARADAYS LAW : In 1831, Michael Faraday, an English physicist gave one of the most basic laws of electro-magnetism called Faraday's law of electro-magnetic induction. This law explains the working principle of most of the electric motors, generators, electrical transformers and inductors. This law shows the relationship between electric circuit and magnetic field. Faraday performed an experiment with a magnet and coil. During this experiment, he found how emf is induced in the coil when flux linked with it changes.

RELATIONSHIP BETWEEN INDUCED EMF AND FLUX

(Faraday's Experiment):



In this experiment, Faraday takes a magnet and a coil and connects a galvanometer across the coil. At start, the magnet is at rest, so there is no deflection in the galvanometer ie, needle of galvanometer is at the center or zero position. When the magnet is moved towards the coil, the needle of galvanometer deflects in one direction. When the magnet is held stationary at that position, the needle of galvanometer returns back to zero position. Now when the magnet is moved away from the coil, there is some deflection in the needle but in the opposite direction and again when the magnet becomes stationary, at that point with respect to coil, the needle of the galvanometer returns back to the zero position. Similarly, if magnet is held stationary and the coil is moved away and towards the magnet, the galvanometer shows deflection in a similar manner. It is also seen that, faster the change in the magnetic field, the greater will be the induced emf or voltage in the coil.

ELECTRIC MOTORS: In refrigeration and air-condition, the electric motors are used to drive fans, compressors, and pumps. Electric motors are everywhere, in your house, almost every mechanical movement that you see around you is caused by an AC or DC electric motor. A motor uses magnets to create motion. If you have ever played with magnets you know the law of magnets: opposite poles attract and like poles repel each other. So if you have two bar magnets with their ends marked "north" and "south", then the north end of one magnet will attract the south end of the other. On the other hand, the north end of one magnet will repel the north end of the other. Inside an electric motor, these attracting and repelling forces create rotational motion.

PRINCIPLE & CONSTRUCTION OF SINGLE PHASE INDUCTION MOTOR: Like any other electrical motor single phase induction motor also has two main parts namely rotor and stator.

Stator: As its name indicates, stator is the stationary part of an induction motor. A single phase ac supply is given to the stator of a single phase induction motor. The stator of the single phase induction motor has laminated stamping to reduce eddy current losses on its periphery. The slots are provided on its stamping to carry stator or main winding. When the stator winding is given a single phase ac supply, the magnetic field is produced and the motor rotates. The single phase induction has two stator windings namely, the main winding and the auxiliary winding. These two windings are placed in space quadrature with respect to each other.

Rotor: The rotor is the rotating part of an induction motor. The rotor is connected to the mechanical load through the shaft. The rotor in the single phase induction motor is of squirrel cage type.

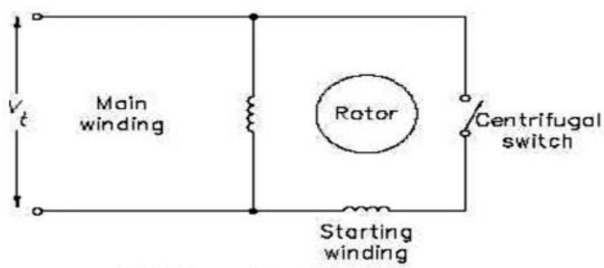
The construction of the rotor of the single phase induction motor is similar to that of the squirrel cage three phase induction motor. The rotor is cylindrical in shape and has slots all over its periphery. The slots are not made parallel to each other but a bit skewed as the skewing prevents magnetic locking of stator and rotor teeth and makes the working of induction motor smoother and quieter. The squirrel cage rotor consists of aluminium, brass or copper bars. These aluminium or copper bars are called rotor conductors and are placed in the slots at the periphery of the rotor. The rotor conductors are permanently shorted by the copper or aluminium rings called the end rings. In order to provide mechanical strength, these rotor conductor are braced to the end ring and form a complete closed circuit resembling like a cage and hence its name "squirrel cage induction motor". As the bars are permanently shorted by end rings, the rotor electrical resistance is very small and it is not possible to add external resistance as the bars are permanently shorted. The absence of slip ring and brushes make the construction of single phase induction motor very simple and robust.

Working Principle of Single Phase Induction Motor: When single phase AC supply is given to the stator winding of the single phase induction motor, the alternating current starts flowing through the stator or main winding. This alternating current produces an alternating flux called main flux. The main flux also links with the rotor conductors and hence cut the rotor conductors. According to the Faraday's law of electromagnetic induction, emf gets induced in the rotor. As the rotor circuit is once closed, the current starts flowing in the rotor. This current is called the rotor current. This rotor current produces its own flux called rotor flux. Since the flux produced is due to the induction principle, the motor working on this principle got its name as induction motor. Now there are two fluxes, one is main flux and the other is rotor flux. These two fluxes produce the desired torque which is required by the motor to rotate.

The Induction Motors are classified in to two groups

1. Single Phase Induction Motor
   a. Split Phase induction Motor
   b. Capacitor start & run Induction Motor
   c. Permanent split Capacitor Motor
2. Three Phase Induction Motor
   a. Squirrel Cage Induction Motor
   b. Slip Ring Induction Motor

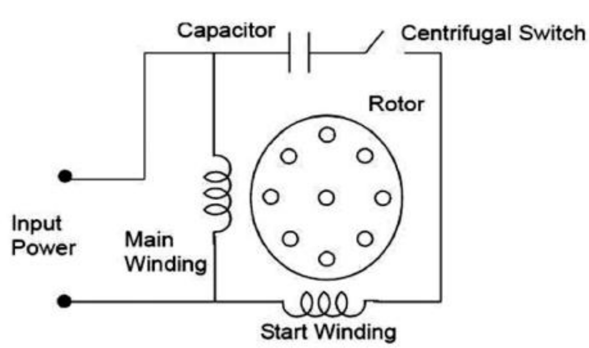
SPLIT PHASE INDUCTION MOTOR:



(a) Schematic diagram

Split phase induction motors have two windings, starting and main windings. The starting winding is made of thinner wire and fewer number of turns than the main winding. At the time of starting, due to phase difference, high starting torque is produced and the motor starts to rotate. When motor reaches 70 to 80 % of its speed the centrifugal switch disconnects the starting winding from the circuit. Application: Refrigerator

CAPACITOR START INDUCTION MOTOR

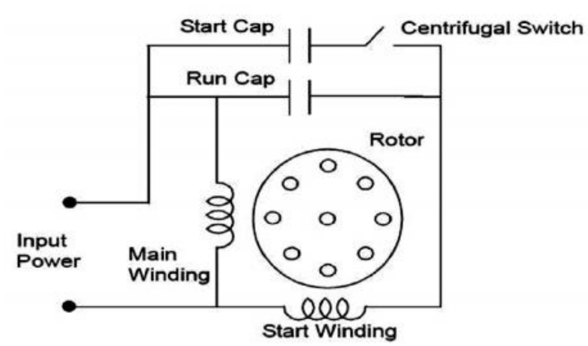


Capacitor start induction run motors are similar in construction to split phase motors. The major difference is the use of a capacitor connected in series to the starting windings to maximize starting torque. The purpose of the capacitor is to make the current enter the winding lead by approximately 90°. The capacitor is mounted either on the top or at the side of the motor. A normally closed centrifugal switch is located between the capacitor and the start winding. This switch opens when the motor reaches about 75 percent of its operating speed.

Capacitors in induction run motors enable them to handle heavier start loads by strengthening the magnetic field of the start windings. These loads might include refrigerators, compressors, elevators, and augers. The size of the capacitors used in these types of applications ranges from 1/6 hpto 10 hp . High starting torque designs also require high starting currents and high breakdown torques.

Capacitor start induction run motors typically deliver 250 to 350 percent of full load torque at the start. Motors of this design are used in compressors and other types of industrial, commercial and farm equipment. Application: Deep freezer

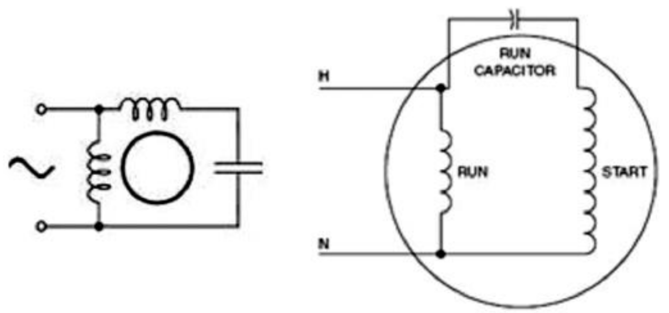
CAPACITOR START CAPACITOR RUN INDUCTION MOTOR



The working principle and construction of capacitor start induction motors and capacitor start capacitor run induction motors are almost the same. We already know that the single phase induction motor is not self starting because the magnetic field produced is not of the rotating type. In order to produce rotating magnetic field there must be some phase difference. Here we use capacitor for this purpose. A small value capacitor is connected permanently with running winding and high value capacitor is connected with starting winding .When motor picks up its rated speed, starting capacitor is disconnected from the circuit with the help of a starting switch and running capacitor remains in the circuit.

Application : These motors have high starting torque hence they are used in conveyors, grinder, air conditioners etc. They are available up to 6 KW.

PERMANENT SPLIT CAPACITOR MOTOR



The permanent-split capacitor motor has a greatly increased popularity for its use in the air conditioning field over the past years. This type of split-phase motor does not disconnect the start windings from the circuit when it is running. This eliminates the need for a centrifugal switch or starting relay to disconnect the start windings from the circuit when the motor reaches about 75% of its full speed. This motor has good starting torque and good running torque. Because the capacitor remains in the circuit during operation, it helps correct power factor of the motor. The stator winding of the permanent-split capacitor (PSC) motor is different from the stator windings of the resistance-start induction-run or capacitor-start induction-run motors. The PSC motor stator winding still contains a run and start winding, but the start winding generally has the same size wire and just as many turns as the run winding. The run winding is placed lower in the core material, which helps increase the inductance. Application: Fan, Pump etc.

THREE PHASE INDUCTION MOTOR: An electric motor is an electro-mechanical device which converts electrical energy into mechanical energy. In case of the three phase AC operation, most widely used motor is the three phase induction motor, as this type of motor does not require any starting device or we can say they are self-starting induction motors.

This motor consists of two major parts:

Stator: The stator of the three phase induction motor is made up of a number of slots to construct a three phase winding circuit which is connected to a three phase AC source. The three phase windings are arranged in such a manner in the slots that they produce a rotating magnetic field after AC is given to them.

Rotor: The rotor of the three phase induction motor consists of a cylindrical laminated core with parallel slots that can carry conductors. Conductors are heavy copper or aluminum bars, which fit in to each slot and are short circuited by the end rings. The slots are not exactly made parallel to the axis of the shaft but are slotted a little skewed because this arrangement reduces magnetic humming noise and can avoid stalling of the motor.

WORKING PRINCIPLE: The stator of a motor consists of an overlapping winding offset by an electrical angle of 120°. When the primary winding or the stator is connected to a three phase AC source, it establishes a rotating magnetic field which rotates at synchronous speed. The difference between the stator (synchronous speed) and rotor speeds is called slip. The rotation of the magnetic field in an induction motor has an advantage that no electrical connections an needed to be made to the rotor.

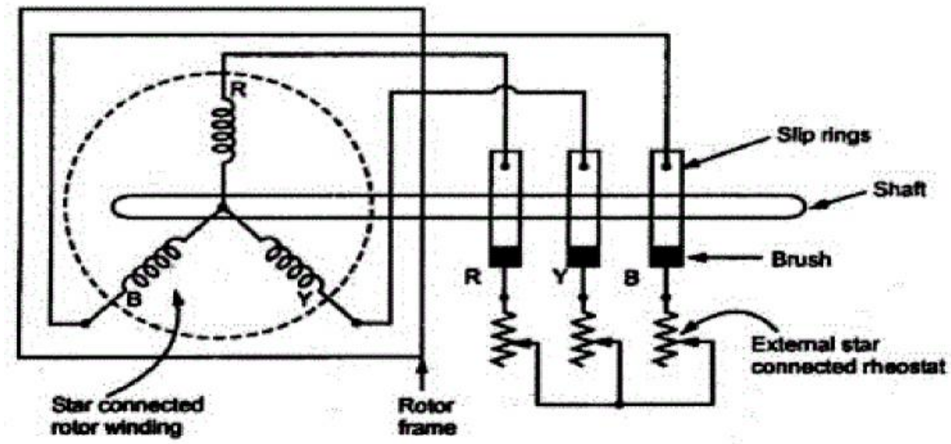
Thus the three phase induction motor is:

- self-starting.
- less armature reaction and brush sparking because of the absence of commutators and brushes that may cause sparks.
- robust in construction.
- economical.
- easier to maintain.

SQUIRREL CAGE MOTOR: In this motor, squirrel cage rotor is used. The rotor is assembled from circular silicon steel stamping. Rotor conductor bars are placed inside the rotor slots with their ends projecting out, so that the end rings are welded to them shorting all these conductor bars. The stator has a three phase winding, either star connected or delta connected .Squirrel cage motors are used, where low starting torque is required.

SLIP RING INDUCTION MOTOR:

The construction of a stator is the same for both the squirrel cage and slip ring induction motor. The main difference in a slip ring induction motor is of the rotor construction and usage. Some changes in stator may be encountered when a slip ring motor is used in a cascaded system, as the supply for the slave motor is controlled by the supply from the rotor of the other slip ring motor with external resistance mounted on its rotor. The slip ring induction motor usually has a “Phase-Wound” rotor. This type of rotor is provided with a 3-phase, double-layer distributed winding consisting of coils used in alternators.



The rotor core is made up of steel laminations which have slots to accommodate formed 3-single phase windings. These windings are placed 120 degrees electrically apart. The rotor is wound for as many poles as the number in the stator and is always 3-phase, even though the stator is wound for 2-phase. These three windings are “starred” internally and the other end of these three windings are brought out and connected to three insulated slip-rings mounted on the rotor shaft itself. The three terminal ends touch these three slip rings with the help of carbon brushes which are held against the rings with the help of a spring assembly. These three carbon brushes are further connected externally to a 3-phase start connected rheostat. The slip ring and the external rheostat make it possible to add external resistance to the rotor circuit, enabling them to have a higher resistance during the start and thus a higher starting torque.

When running under normal conditions, the slip rings are automatically short-circuited by means of a metal collar, which is pushed along the shaft, thus making the three rings touch each other. Also, the brushes are automatically lifted from the slip-rings to avoid frictional losses, wear and tear. Under normal running conditions, the wound rotor acts in the same way as the squirrel cage rotor.

In the case of a squirrel cage induction motor, the rotor resistance is very low, so that the current in the rotor is high, which makes its starting torque poor. But adding external resistance, as in the case of a slip ring induction motor, makes the rotor resistance high an starting, thus the rotor current is low and the starting torque is maximum. Also the slip necessary to generate maximum torque is directly proportional to the rotor resistance. In slip ring motors, the rotor resistance is increased by adding external resistance, so the slip is increased. Since the rotor resistance is high, the slip is more, thus it's possible to achieve "pull-out" torque even at low speeds. As the motor reaches its base speed (full rated speed), after the removal of external resistance and under normal running conditions, it behaves in the same way as a squirrel cage induction motor. Thus these motors are best suited for very high inertia loads, which require a pull-out torque at almost zero speed and acceleration to full speed with minimum current drawn at a very short time period.

Advantages of slip ring induction motors:

- The main advantage of a slip ring induction motor is that its speed can be controlled easily.
- "Pull-out torque" can be achieved even from zero RPM.
- It has a high starting torque when compared to squirrel cage induction motor. Approximately 200 - 250% of its full-load torque.
- A squirrel cage induction motor takes 600% to 700% of the full load current, but a slip ring induction motor takes a very low starting current approximately 250% to 350% of the full load current.

HERMETIC MOTORS: It is a motor used in hermetically sealed compressors used in refrigerators, water coolers, split airconditioner etc. A relay is used to disconnect the starting winding or starting capacitor of hermetic motor.

Special features:

1. These motors have special cooling provisions.
2. The windings of these motors are insulated with such insulations that are unaffected by oil, gas or moisture.
3. The alignment of stator, rotor and compressor is very accurate.
4. The electrical terminals of the hermetic motors are leak-proof.

Types & Application of Hermetic Motors:

Hermetic motor type	Application	Type of Compressor
Split phase single phase induction motor	Refrigerator, water cooler	Reciprocating, rotary, scroll
Capacitor start induction Motor	Deep freezer	Reciprocating, rotary, scroll
Capacitor start and Run Induction motor	Window AC	Reciprocating, rotary, scroll

Practical

1. STUDY THE CHECKING OF EARTHING.

AIM:- To study the checking of earthing of electrical circuits.

Tools and Materials required : Neon Tester, Multimeter, wire pieces.

Purpose of Earthing:

- Safety for human life/building/equipments
- Over voltage protection
- Voltage stabilization
- Prevent damages by electricity
- Prevent noise in the communication cable

PROCEDURE

- Set the multimeter knob to 750V AC and connect the red probe to phase and black probe to neutral. Keep the switch in the off position, and the reading shows zero.
- Turn on the switch and measure the voltage across Phase and Neutral. It reads 235V.
- Measure by inserting the black test probe into earth and red test probe into phase. Let the reading be "234"V.
- Next, measure by inserting the red probe into earth and black probe into neutral. Let the reading be "001"V.
- If the difference is zero, it means the earthing is perfect. As per the standard norms, the difference between earthing and neutral should not be more than 3 V (Up to 3V is an acceptable value).

2. Identifying Single phase and Three phase electrical circuits.
3. Identifying the neutral, phase, and earth lines of an electrical circuit.
4. Measure the voltage and current in a circuit.
5. Calculate power bill of a given set of values.

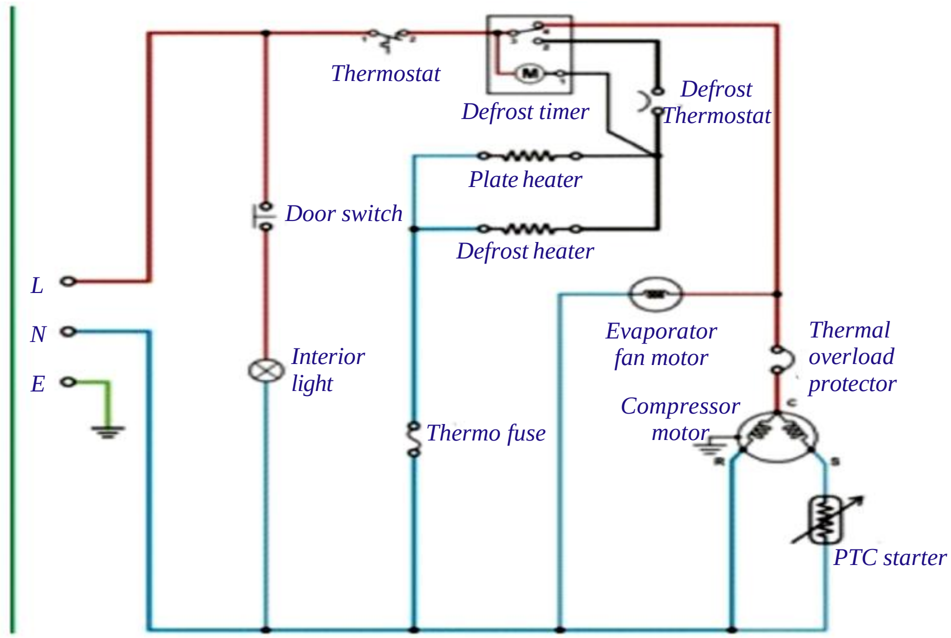
WIRING PRACTICE

1. Wiring of no frost double-door refrigerator

AIM:- To study the wiring of no frost double-door refrigerator.

Tools, Instruments & Materials Required :

Screw driver, Multimeter, Ammeter, Combination plier, Neon tester, Terminal clips, Insulation tape….



Procedure:-

1. Connect the phase line to the defrost timer terminal 3 through the thermostat.
2. Connect timer terminal 4 to the compressor terminal C through OLP
3. Connect the timer terminal 2 to the defrost heater through the defrost thermostat.
4. Connect the timer terminal 1 to the neutral through the plate heater.
5. Connect the evaporator fan to the timer terminal 4.
6. Connect the door switch and interior light between the phase and neutral lines as shown in the diagram.
7. Connect the neutral line to the compressor terminal R .
8. Connect the starting terminal of compressor to the neutral line through PTC relay and starting capacitor.

9. Link the neutral line between the terminals S and R through a running capacitor.
10. Check the circuit and finish the wiring.

2. STUDY THE WORKING OF SINGLE PHASE PREVENTERS.

In the three phase induction motors, if there is any fault in the single phase, the motor will draw more current from the other two phases and will supply less amount of load power, and so the efficiency of the system decreases. It is not economical to operate the load in this condition. So a system is designed called single phase preventer which will disconnect the load if there is fault in any of the phases.

In this system, we measure all the three phase voltages and the output is then given to the micro controller. The controller enables it as to observe whether the load should be connected or not. If not, it will give the display of faulty phase on the LCD so that the maintenance person could easily resolve the problem. To measure the current, we can use 230v/6-0-6 current transformer. This transformer gives the output in the form of voltage depending upon the load.

3. Wiring of one lamp controlled by one switch.
4. Wiring of two lamps controlled by one switch.
5. Wiring of two lamps controlled by two switches.
6. Parallel wiring.
7. Series wiring.
8. Staircase wiring
9. Godown wiring
10. Hospital wiring
11. Cinema hall wiring.
12. Tunnel wiring.
13. Identification of the terminals of a compressor
14. Direct starting of a compressor.
15. Testing of a capacitor.
16. Wiring of a single door refrigerator.
17. Wiring of a water cooler.
18. wiring of a deep freezer.

ASSESSMENT

Visit the nearest flour mill, and observe the motors and power supply being used. Compare it with the motor of your household appliances. Prepare a comparison chart.

TE Questions

1. Unit of current is

   a) Volt b) Watt c) Ampere d) Tesla

2. Motor is a device producing .... motion.
3. The rotating component of a motor is................ and the stationery element of a motor is ....
4. Motors are not ....started.
5. What are the two types of a three-phase motors?
6. What is the function of a capacitor in a motor?
7. Draw the name plate of a motor.
8. Which type of motor is used in refrigerators?
9. Which type of motor is used in central AC plants?
10. The single instrument that is used to measure voltage, current and resistance is called.......................

UNIT 3.4
AIRCONDITIONING EQUIPMENTS

The unit deals with the classification and general approach to various air-conditioning equipments.

Learning outcome:

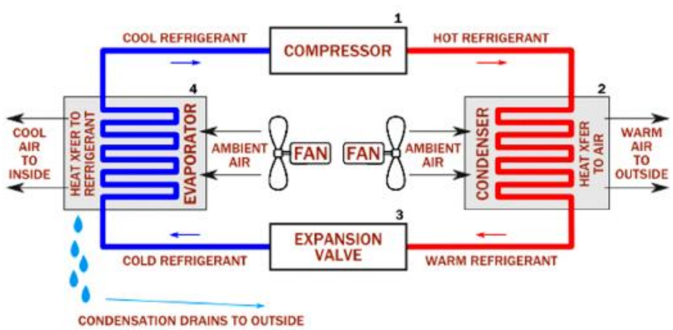
The learner :

Understand working and constructional details of different airconditioning equipments.

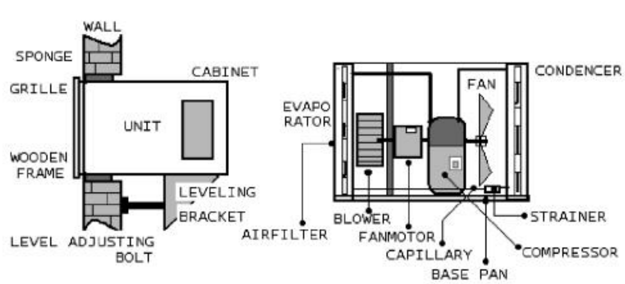
The following are the important air conditioning machines used now a days :

1. Window air conditioner
2. Split air conditioner
3. Package air conditioner
4. Central air conditioning plant – DX system
5. Central air conditioning plant – water chilling system
6. VAV systems
7. V R F systems

WINDOW AIR CONDITIONER: A window air conditioner unit encloses/ accomodates a complete air conditioner in a small space. The units are made small enough to fit into a standard window frame.



WINDOW TYPE AIRCONDITIONER

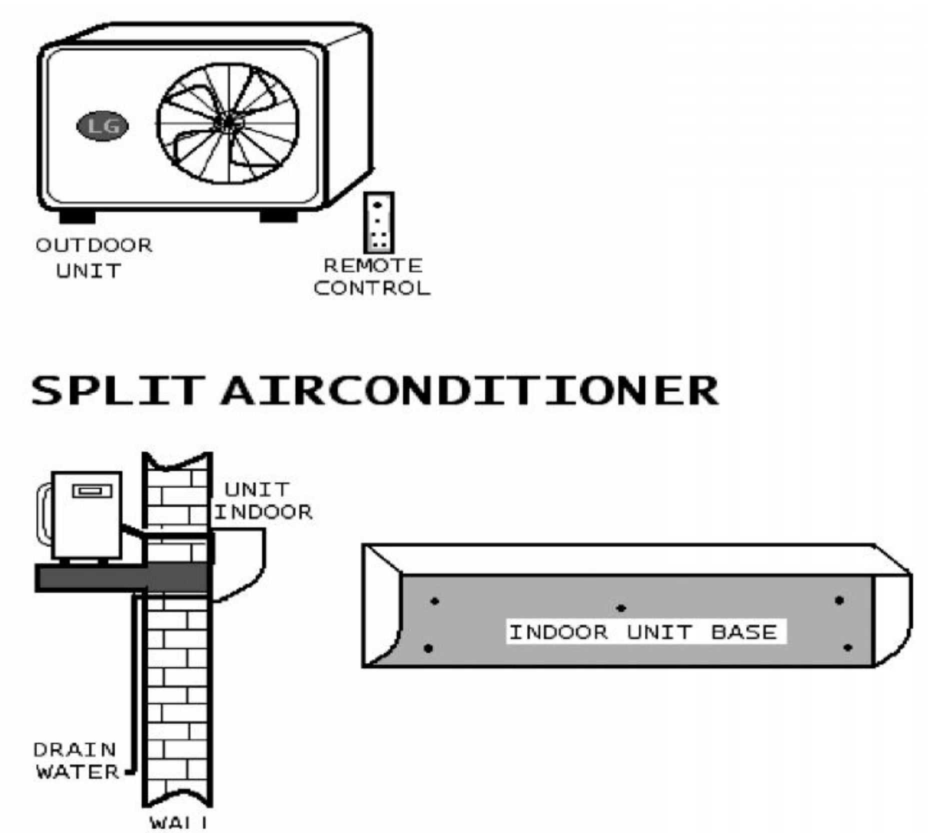


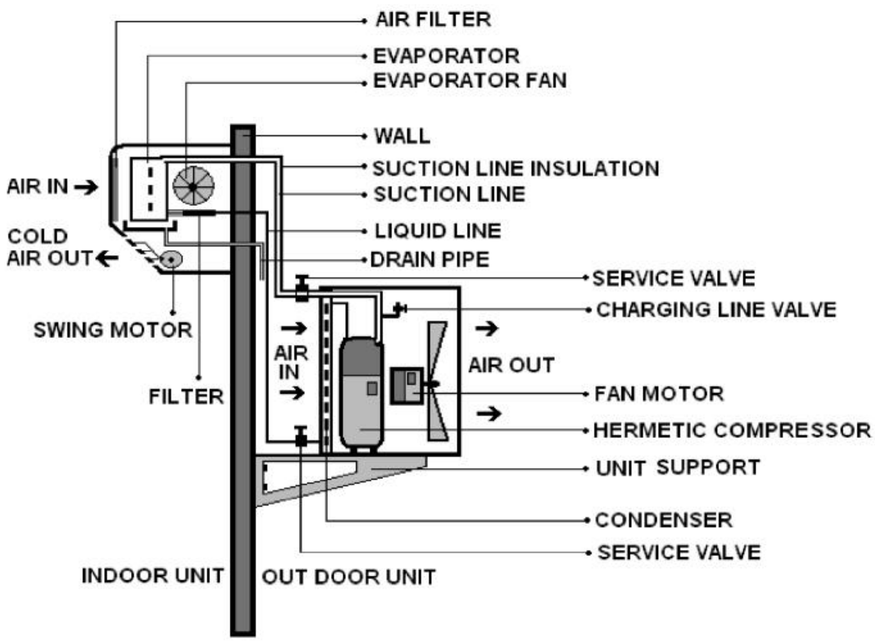
This type of AC is designed to fit into the window sills. A single unit of Window Air Conditioner houses all the necessary components, namely the compressor, condenser, expansion valve or coil, evaporator and cooling coil enclosed in a single box. Since the window AC is a single unit, it takes less effort to install as well as maintain.

Advantages

- Single unit air conditioner
- Less effort needed for installation
- Costs less compared to other varieties

SPLIT AC: This is a kit of 2 units, one internal and the other, external. The indoor unit installed inside the room intakes warm air and throws in cold air. The outdoor unit on the other hand, is installed out of the house. It contains the compressor, coneanser and is linked to the internal unit via pipes and electric cables.





Advantages

- Internal unit takes up less space for installation
- Usually more silent than window ACs
- Affect the home decor minimally.
- Can be installed in rooms with no windows

PACKAGE AC: The window and split air conditioners are usually used for small air conditioning capacities up to 5 tons. The central air conditioning systems are used where the cooling loads extend beyond 20 tons. Packaged air conditioners are used for cooling capacities in between these two extremes. The packaged air conditioners are available in the fixed rated capacities of 3, 5, 7, 10 and 15 tons. These units are commonly used in places like restaurants, telephone exchanges, homes, small halls, etc.

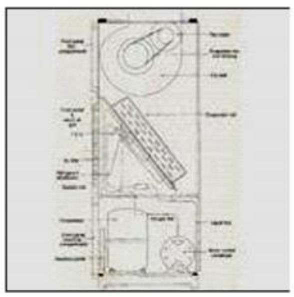
As the name implies, in the packaged air conditioners, all the important components of the air conditioners are enclosed in a single casing like the window AC. Thus the compressor, cooling coil, air handling unit and the air filter are all housed in a single casing and assembled at the factory location. Depending on the type of the cooling system used the packaged air conditioners are divided into two types: one with water cooled condenser and the other with air-cooled condensers. Both these systems are described below :

Packaged Air Conditioners with Water-Cooled Condenser

In these packaged air conditions, the condenser is cooled by water. The condenser is of shell and tube type, with refrigerant flowing along the tube side and the cooling water flowing along the shell side. The water has to be supplied continuously in these systems to maintain the functioning of the air-conditioning system.

The shell and tube type condenser is compact in shape and is enclosed in a single casing along with the compressor, expansion valve, and the air handling unit including the cooling coil or the evaporator. This whole packaged air-conditioning unit externally looks like a box with the control panel located externally.

In the packaged units with water-cooled condenser, the compressor is located at the bottom along with the condenser (refer the figure below). Above these components the evaporator or the cooling coil is located. The air handling unit comprising the centrifugal blower and the air filter is located above the cooling coil. The centrifugal blower has the capacity to handle large volume of air required for cooling a number of rooms. From the top of the package air conditioners, a duct comes out that extends to various rooms that are to be cooled.



Packaged Air Conditioners with Air-Cooled Condensers

In this packaged air conditioner, the condenser of the refrigeration system is cooled by the atmospheric air. There is an outdoor unit that comprises of important components like compressor, condenser and in some cases, the expansion valve (refer the figure below). The outdoor unit can be kept on the terrace or any other open place, where the free flow of the atmospheric air is available. The fan located inside this unit sucks the outside air and blows it over the condenser coil cooling it in the process. The condenser coil is made up of several turns of the copper tubing and is finned externally. The packaged ACs with the air-cooled condensers are more commonly used than that with water cooled condensers since air is freely available and it is difficult to maintain continuous flow of water.

The cooling unit comprising of the expansion valve, evaporator, air handling blower and the filter is located on the floor or hanged on to the ceiling. The ducts coming out from the cooling unit are connected to various rooms that are to be cooled.

Central Airconditioning Systems

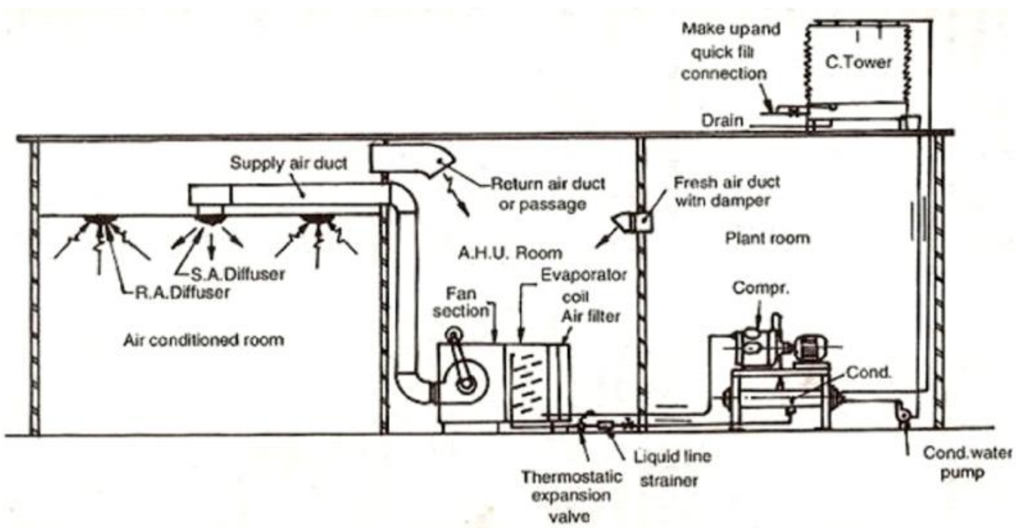
There are two types of central air conditioning system: Direct Expansion (DX) type and Chilled Water type. This article describes the DX central air conditioning system.

DIRECT EXPANSION (DX) TYPE OF CENTRAL AIR CONDITIONING PLANT

In DX system, the air used for cooling the room or space is directly passed over the cooling coil of the refrigeration plant. In the case of chilled water system, refrigeration system is used first to chill the water, which is then used to chill the air for cooling rooms or spaces.

In the direct expansion or DX type central airconditioning plant, the air used for cooling space is directly chilled by the refrigerant in the cooling coil of the air handling unit. Since the air is cooled directly by the refrigerant, the cooling efficiency of the DX plant is higher. However, it is not always feasible to carry the refrigerant piping to large distances hence, direct expansion or the DX type central air conditioning system is usually used for cooling small buildings or rooms a single floor.

There are three main compartments of the DX type of central conditioning system (please refer the fig below):



Central air conditioning—DX system

The plant room comprises of two important parts of the refrigeration system the compressor and the condenser. The compressor can either be of semi-hermetically sealed type or of open type. The semi-hermetically sealed compressor is cooled by air, which is blown by the fan, while the open type compressor is water-cooled. The open compressor can be driven directly by motor shaft by the coupling or by belt via pulley arrangement.

The condenser is of shell and tube type and is cooled by the water. The refrigerant flows along the tube side of the condenser and water along the shell side, which enables faster cooling of the refrigerant. The water used for cooling the compressor and the condenser is cooled in the cooling tower kept at the top of the plant room, though it can be kept at other convenient locations also.

The Air Handling Unit Room:

The refrigerant leaving the condenser in the plant room enters the thermostatic expansion valve and then the air handling unit, which is kept in a separate room. The air handling unit is a large box type of unit that comprises of an evaporator or the cooling coil, air filter and the large blower. After leaving the thermostatic expansion valve, the refrigerant enters the cooling coil where it cools the air that enters the room to be air conditioned. The evaporator in the air handling unit of the DX central air conditioning system is of coil type, covered with fins to increase the heat transfer efficiency of the refrigerant in to the air.

There are two types of ducts connected to the air handling unit: for absorbing the hot return air from the rooms and for sending the chilled air to the rooms to be air conditioned. The blower of the air handling unit helps absorb the hot return air that has absorbed the heat from the room via the ducts. This air is then passed through the filters and over the cooling coil. The blower then passes the chilled air through the ducts to the rooms that are to be air conditioned.

The DX expansion system runs more efficiently at higher loads. Even in case of breakdown of the plants, the other plants can be used for cooling purpose. The DX type of central air conditioner plant is less popular than the chilled water type of central airconditioning plants.

Air Conditioned Room:

This is the space that is to be actually cooled. It can be a residential room, room of the hotel, part of the office or any other suitable application. The ducts from the air handling room are passed to all the rooms that are to be cooled. The ducts are connected to the grills or diffusers that supply the chilled air to the room. The air absorbs the heat and gets heated and is passed through another set of grills and into the return air duct that ends up at the air handling unit room. This air is then re-circulated by the air handling unit.

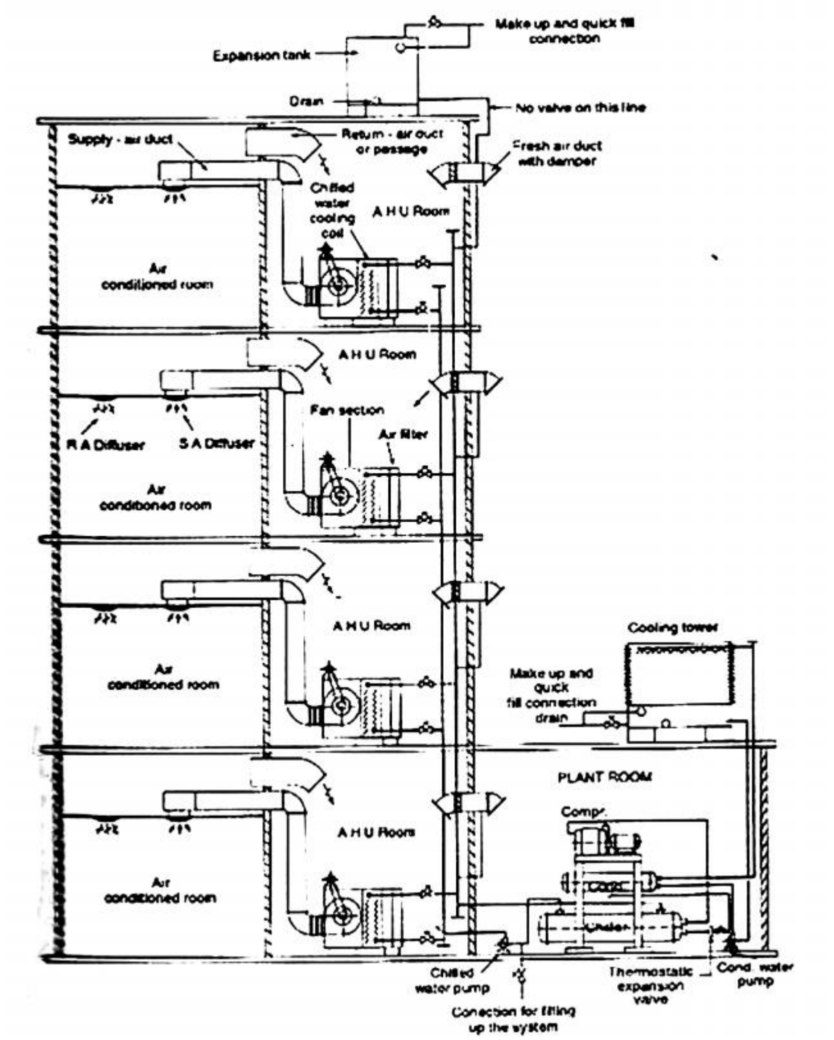
Though the efficiency of the DX plants is higher, the air handling unit and refrigerant piping cannot be kept at a very long distance since there will be a huge drop of pressure of the refrigerant along the way and there will also be cooling losses. Further, for long piping, large amount of refrigerant is needed which makes the system very expensive and prone to maintenance problems like the leakage of the refrigerant and soon.

Due to these reasons, DX type central air conditioning systems are used for small air conditioning systems of about 5 to 15 tons in small buildings or the number of rooms on a single floor. If there are large air conditioning loads, then multiple direct expansion systems can be installed. In such cases, it there is lesser heat load, one of the plants can be shut down and the other can be run at full load. The DX expansion system runs more efficiently at higher loads. Even in case of a breakdown of the plant, the other plants can be used for cooling purpose. The DX type central air conditioning plant is less popular than the chilled water type central airconditioning plant.

CENTRAL AIR CONDITIONING PLANT – CHILLED WATER PLANT

The chilled water type central air conditioning plant is installed in places like large buildings, shopping mall, airport, hotel, etc, having several floors to be air conditioned. While in the direct expansion type central air conditioning plant, the refrigerant is directly used to cool the room air; in the chilled water plant the refrigerant first chills the water, which in turn chills the room air.

In chilled water plants, the ordinary water or brine solution is chilled to a very low temperature of about 6 to 8 degree Celsius by the refrigeration plant. This chilled water is pumped to various floors of the building and its different parts. In each of these parts, an air handling unit is installed, comprising of a cooling coil, blower and the ducts. The chilled water flows through the cooling coil. The blower absorbs the return air from the air conditioned rooms that are to be cooled via ducts. This air passes over the cooling coil and gets cooled and in turn passes on to the air conditioned space.



VARIOUS PARTS OF THE CHILLED WATER AIR CONDITIONING PLANT

All the important parts of the chilled water ac plant are shown in the above figure and described in detail below:

Central Air Conditioning Plant Room:

The plant room has all the important components of the chilled water air conditioning plant. These include the compressor, condenser, thermostatic expansion valve and the evaporator or the chiller. The compressor is of open type and can be driven by the motor directly or by the belt via pulley arrangement connected to the motor. It is cooled by water just like automotive engine.

The condenser and the evaporator are of shell and tube type. The condenser is cooled by water, with water flowing along the shell side and refrigerant along the tube side. The thermostatic expansion valve is operated automatically by the solenoid valve.

The evaporator is also called chiller, because it chills water. If the water flows along the shell side and refrigerant on the tube side, it is called dry expansion type chiller. If the water flows along tube side and the refrigerant along the shell side, it is called flooded chiller. The water chilled in the chiller is pumped to various parts of the building that are to be air conditioned. It enters the air handling unit, cools the air in cooling coil, absorbs the heat and returns back to the plant room to get chilled again. The amount of water passing into the chiller is controlled by the flow switch.

In the central air conditioning plant room, all the components (the compressor, condenser, thermostatic expansion valve, and the chiller) are assembled in a structural steel framework making a complete compact refrigeration plant known as the chiller package. The piping required to connect these parts is also enclosed in this unit making a highly compact central air conditioning plant.

The air handling units are installed in various parts of the building that are to be air conditioned in places called air handling unit rooms. The air handling units comprise of cooling coil, air filter, blower and the supply and return air ducts. The chilled water flows through the cooling coil. The blower absorbs the return hot air from the air conditioned space and blows it over the cooling coil thus cooling the air. This cool air passes over the air filter and is passed by the supply air ducts into the space which is to be air conditioned. The air handling unit and the ducts passing through it are insulated to reduce the loss of cooling effect.

Air Handling Unit Rooms:

The air handling units are installed in various parts of the building that are to be air conditioned, in places called air handling unit rooms. The air handling units comprise of cooling coil, air filter, blower and the supply and return air ducts. The chilled water flows through the cooling coil. The blower absorbs the return hot air from the air conditioned space and blows it over the cooling coil thus cooling the air. This cooled air passes over the air filter and is passed by the supply air ducts into the space which is to be air conditioned. The air handling unit and the ducts passing through it are insulated to reduce the loss of cooling effect.

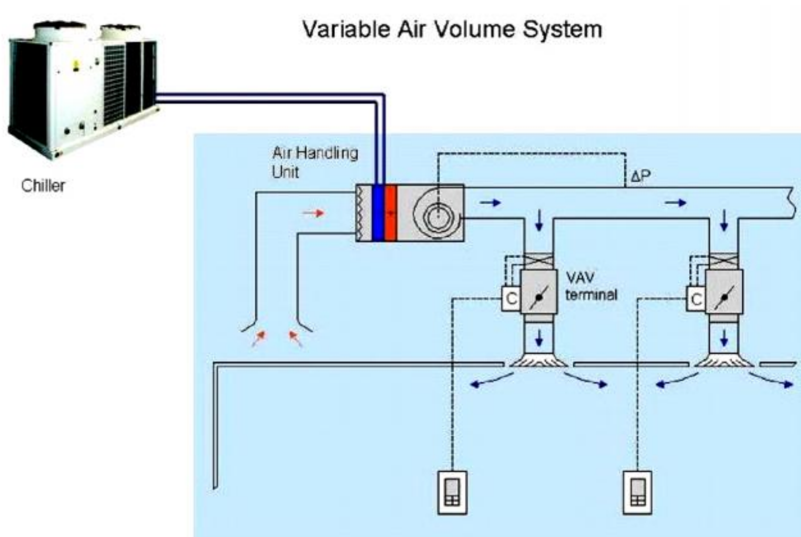
Air Conditioned Rooms:

These are rooms or spaces that are to be air-conditioned. These can be residential or hotel rooms, halls, shops, offices, complete theatre, various parts of the airport etc. At the top of these rooms the supply and the return air ducts are laid. The supply air ducts supply the cool air to the room via one set of the diffusers, while the return air duct absorbs the hot return air from the room by another set of the diffusers. The hot return air enters the air handling unit, gets cooled and again enters the room via supply duct to produce an air conditioning effect.

Cooling Tower:

The cooling tower is used to cool the water that absorbs heat from the compressor and the condenser. When water flows through these components some water gets evaporated, to make up this loss, water is also added to the cooling tower. The cooling tower is of evaporative type. Here, the water is cooled by atmospheric air and is re-circulated through the compressor and the condenser.

VARIABLE AIR VOLUME SYSTEMS



Variable Air Volume (VAV) is a type of heating, ventilating, and/or air-conditioning (HVAC) system. Unlike constant air volume (CAV) systems, which supply a constant airflow at a variable temperature, VAV systems vary the airflow at a constant temperature. The advantages of VAV systems over constant-volume systems include more precise temperature control, reduced compressor wear, lower energy consumption by system fans, less fan noise, and additional passive dehumidification.

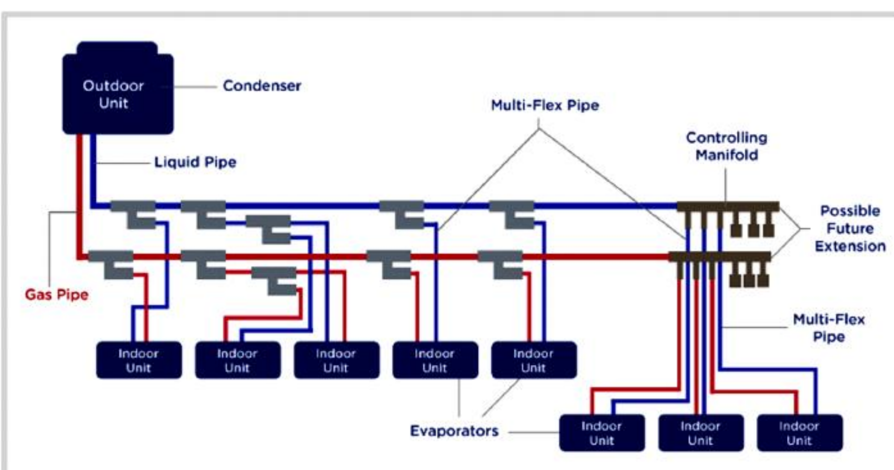
The simplest VAV system incorporates one supply duct that, when in cooling mode, distributes supply air at a constant temperature of approximately 55 °F (13 °C). Because the supply air temperature is constant, the air flow rate must vary to meet the rising and falling heat gains or losses within the thermal zone served.

Even a simple VAV system has several advantages over a CAV system. One has more precise temperature control. To meet a space cooling load, a CAV unit operates the fan and compressor at full capacity until the temperature drops to a specific limit, and then the compressor turns off. This on/off cycling causes the temperature to fluctuate above and below the temperature set-point. In a single-zone VAV unit, the fan speed varies depending on the actual space temperature and the temperature set-point, while the compressor modulates the refrigerant flow, to maintain a constant supply air temperature. The result is more precise space temperature control.

Another advantage is energy savings and reduced wear. VAV fan control, especially with modern electronic variable-speed drives, reduces the energy consumed by fans, which can be a substantial part of the total cooling energy requirements of a building. Modulating control of the compressor also reduces wear and delivers further energy savings.

A final advantage is increased dehumidification. Because VAV air flow is reduced under part-load conditions, air is exposed to cooling coils for a longer time. More moisture condenses on the coils, dehumidifying the air. Thus, although a constant-volume and a single-zone VAV unit maintain the same room temperature, the VAV unit provides more passive dehumidification and more comfortable space conditions.

VARIABLE REFRIGERANT FLOW SYSTEM



Fault	Cause	Remedy
Excess frost formation in the freezer compartment	Any of these component may be defective: Bimetal, Thermal fuse, Defrost heater	Check for the continuity as per the specification of various components, if not replace it.
Condensation on the inner cabinet of refrigerator	Air leakage	Check for the air leakage, if any in case of air leakage,kindly clear it for proper insulation
No proper cooling	There may be gas leakage in the system	Trace the joint leakage, repair it and refill with new refrigerant as per the process
Compressor tripping after some time	Condenser fan motor not working	Check for the condenser fan motor, if defective, replace it
Refrigerator unit humming and stops'	Too low voltage'	Check the voltage by voltmeter. It should be less or more than 10% of the standard voltage. If not, use a stabilizer
Refrigerator unit humming and it stops	Relay defective	Start the refrigerating unit directly without relay, if it runs properly replace the relay
Refrigerator running continuously	Thermostat	Disassemble the thermostat from the unit and check it using ice cube method, if thermostat is faulty, replace it.

Variable refrigerant flow (**VRF**) is an HVAC technology invented in Japan by Daikin company in 1982. Like ductless minisplits, VRFs use refrigerant as the cooling and heating medium. This refrigerant is conditioned by a single outdoor condensing unit, and is circulated within the building to multiple fan-coil units (FCUs).

VRFs are typically installed with an Air conditioner inverter which adds a DC inverter to the compressor in order to support variable motor speed and thus variable refrigerant flow is rather much more than simply on/off operation. By operating at varying speeds, VRF units work only at the needed rate allowing substantial energy savings at partial-load conditions. Heat recovery VRF technology allows individual indoor units to heat or cool as required, while the compressor load benefits from the internal heat recovery. Energy savings of up to 55% are predicted over comparable unitary equipment. This also results in the greater control of the building's interior temperature by the building's occupants.

VRFs come in two system formats, two pipe and three pipe systems. In a heat pump 2 pipe system, all the zones must either be in cooling or in heating. Heat Recovery (HR) systems have the ability to simultaneously heat certain zones while cooling others; this is usually done through a three pipe design, with the exception of Mitsubishi which is able to do this with a 2 pipe system using a BC controller to the individual indoor evaporator zones. In this case, the heat extracted from the zones requiring cooling is put to use in the zones requiring heating. This is made possible because the heating unit functions as a condenser, providing the sub-cooled liquid back into the line that is being used for cooling. While the heat recovery system has a greater initial cost, it allows for better zoned thermal control of building and overall greater efficiencies.

PRACTICAL

1. Leak testing of refrigeration system.
2. Evacuation.
3. Gas charging in a refrigeration system.
4. Trouble shooting of refrigerators.

ASSESSMENT

Collect different catalogues from air conditioner distributers and prepare a comparison chart showing application,capacity,power consumption and cost.

TE QUESTIONS

1. Which of the following AC is easy to install?

   a) Split AC   b) Window AC   c) Package AC   d) central AC

2. Which type of A/c is suitable for a mini conference hall

   a) Split AC   b) Window AC   c) Package AC   d) central AC

3. Air conditioning system suitable for cinema hall is ....
4. AHU means.....................
5. For purifying air, ... is used in AC systems.
6. Central AC plants are classified in to DX system and .... system.
7. For a 10x10 ft room what is the approximate capacity requirement of an air conditioner?
8. For a multi speciality hospital which AC system is suitable?
9. A cinema hall is to be air-conditioned using DX system.Draw the lay-out marking different components.Show the refrigerant and air flow directions.
10. A computer lab with 15mx8mx3m dimensions of a school is to be air-conditioned.Suggest a suitable air-conditioning system. Justify your answer.

A refrigerator is charged with excess refrigerant. How will you identify this from the working of the system?

UNIT 3.5
WINDOW AIRCONDITIONER

The unit deals with constructional details, working and trouble shooting of window airconditioners.

Learning outcome:

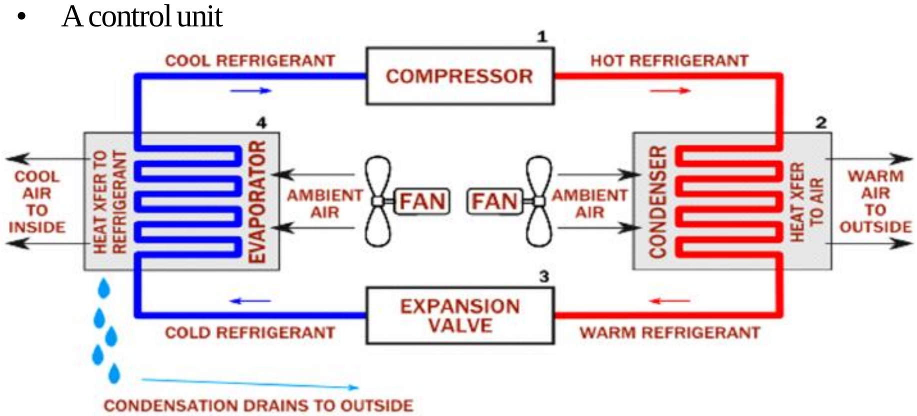
The learner :

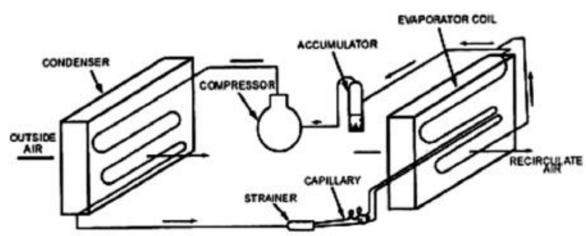
Understand working and trouble shooting of window airconditioner

Window AC Units

A window air conditioner unit encloses a complete air conditioner in a small space. The units are made small enough to fit into a standard window frame. A single unit of Window Air Conditioner houses all the necessary components, namely the compressor, condenser, expansion valve or coil, evaporator and cooling coil enclosed in a single box. If you take the cover off of an unplugged window unit, you'll find that it contains:

- A compressor
- An expansion valve
- A hot coil (at the outside)
- A chilled coil (inside)
- Two fans
- A control unit





This unit has a double shaft fan motor with fans mounted on either side of the motor. One at the evaporator side and the other at the condenser side. The evaporator side is located facing the room for cooling the space and the condenser side outdoor for heat rejection. There is an insulated partition separating the two sides within the same casing.

Front Panel

The front panel is the one that is seen by the user from inside the room where it is installed and has a user interface control be it electronically or mechanically. The older unit is usually of mechanical control type with rotary knobs to control the temperature and fan speed of the air conditioner.

The newer units come with electronic control system where the functions are controlled using remote control and touch panel with digital display.

The front panel has adjustable horizontal and vertical(some models) louvers where the direction of air flow are adjustable to suit the comfort of the users.

The fresh intake of air called VENT (ventilation) is provided at the panel in case user would like to have a certain amount of fresh air from the outside.

Components

- **Cooling coil** with an air filter mounted on it. The cooling coil is where the heat exchange happens 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. It can be noisy during operation if installed too near the evaporator.
- **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 of electronic type.
- **Filter drier** is used to remove the moisture from the refrigerant.
- **Drain plan** is used to contain the water that condensate an the cooling coil and is discharged outdoors by gravity.
- **Compressor** - used to compress the refrigerant.
- **Condenser Coil** - used to reject heat from the refrigerant to the outside air.
- **Propeller Fan** - 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.

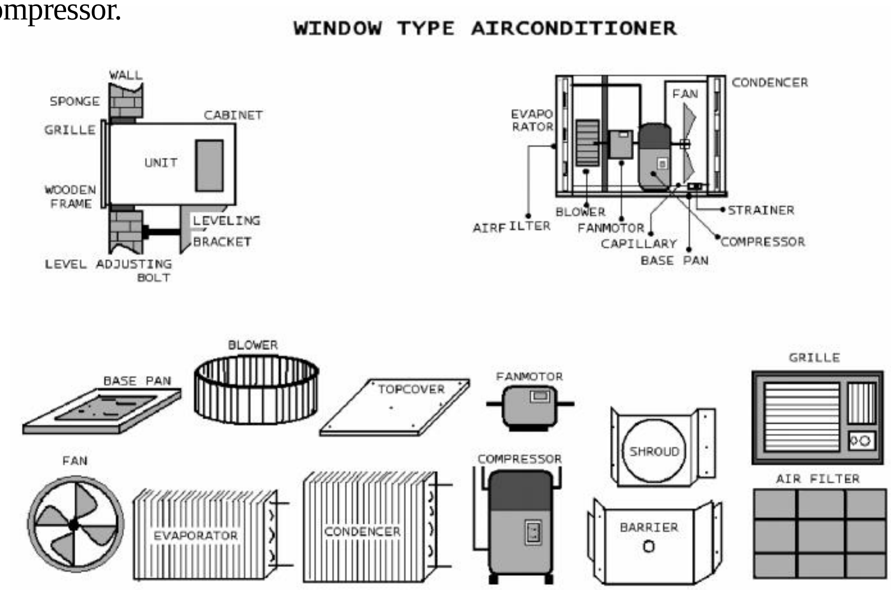
Operation

The evaporator blower fan will suck the air from the room to be conditioned through the air filter and the cooling coil. Air that has been conditioned is then discharged to deliver the cool and de-humidified air back to the room. This air mixes with the room air to bring down the temperature and humidity level of the room.

The introduction of fresh air from outside the room is done through the damper which is then mixed with the return air from the room before passing it over the air filter and the cooling coil. The air filter which is mounted in front of the evaporator acts as a filter to keep the cooling coil clean to obtain good heat-transfer from the coil. Hence, regular washing and cleaning of the air filter is a good practice to ensure efficient operation of the air conditioner.

During the operation, a thermostat is mounted on the return air of the unit. This temperature is used to control the on/off of the compressor. Once the room temperature is achieved, the compressor cuts off.

Usually, it has to be off for at least 3 minutes before turning on again to prevent it from being damaged. For mechanical control type, there is usually a caution to turn on the unit after the unit has been turned off for at least 3 minutes. For electronic control, there is usually a timer to automatically control the cut-in and cut-out of the compressor.



Advantages

- More popular, thus easier to find and economical.
- Often has relatively low noise output and high efficiency.
- Water drains from the unit to the exterior with no intervention.
- Even small units can adequately cool 100-300 square feet. Larger units can cool rooms up to 650 square feet.
- If carefully placed, can cool more than one room.
- Can be placed either in windows or wall holes.
- Single unit air conditioner.
- Less effort needed for installation.
- Costs less compared to other varieties.

Disadvantages

- The window where you install the air conditioner is blocked as long as the unit is there.
- Water dripping outside can end up where you do not want it to (pedestrians on a city street? creating rust on a metal roof?
- More of a hassle to remove and move to another room/location.
- Not all windows support air conditioners.
- Installation can get tricky if you do not have exterior support. It is not unheard of for window units to fall out of windows at inopportune times, even during installation.
- The panels that come with these units can let in a lot of hot air, making the air conditioner less efficient.
- Even the best installation can still leave your home or apartment at a security risk.
- Quite frankly, the appearance of many window units in a living area is not seen as the ultimate in decorating or class.

Name of Component	Type	Functions
Mechanical parts Compressor	Reciprocating, scroll, rotary hermetic type	To increase the pressure and temperature of refrigerant and driving force
Condenser	Air cooled- fin & tube type	Condense the vapour refrigerant to liquid form
Evaporator (cooling coil)	Fin & tube type - fan forced type	To produce cooling effect
Expansion valve	Capillary tube	Reduce pressure of refrigent
Fan blower Evaporator	Axial flow type	To draw air from the room
Condenser fan	Centrifugal fan	To force air on the condenser
Electrical parts Compressor motor	Capacitor start & capacitor run single phase induction motor	To run the compressor at a huge starting load
Double shaft motor	Permanent capacitor induction motor	To run evaporator blower and condenser fan
Relay	Potential type	To disconnect starting capacitor from connection after taking its rated speed
Selector switch	On,Off, Low / High speed switch	For on/off, speed regulation of the fan
Thermostat switch	High temperature switch	Temperature control inside the room
Starting & running capacitor	Starting capacitor -80-10 mfd Running capacitor -30-36mfd	For producing large starting current
Fresh air damper		For getting fresh air in room
Exhaust damper		To exhaust inside air
Air filter	Through away type	To remove dust & and impurities from the air

Electrical & Mechanical Parts of a Window Air Conditioner

CARE OF WINDOW AIR CONDITIONER

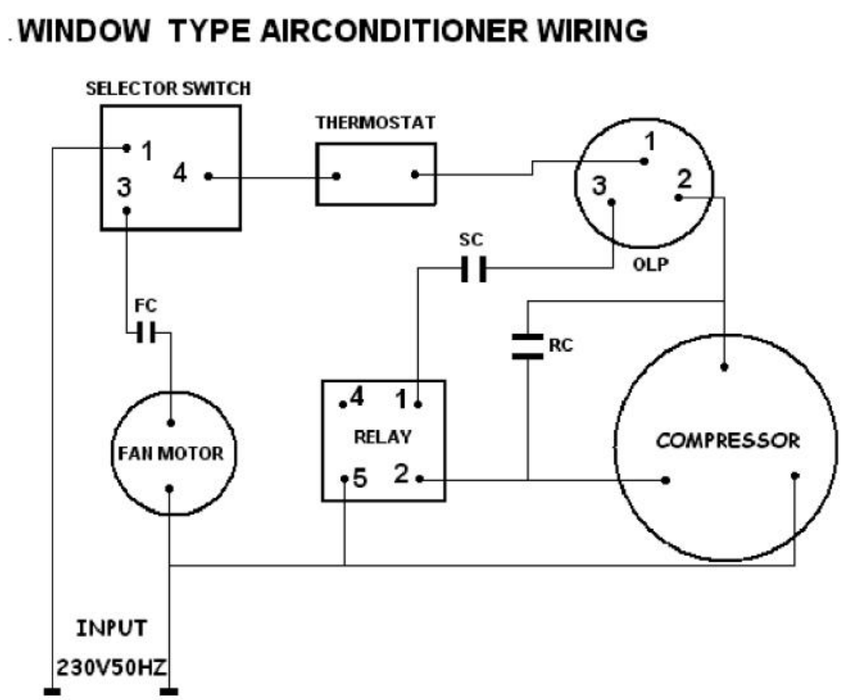
1. Clean the air filter monthly
2. Check for insect/animal nests
3. Clean the condenser coils once per season
4. Clean the water pan

5. Inspect cooling coils for frost or ice buildup
6. Check the remote control

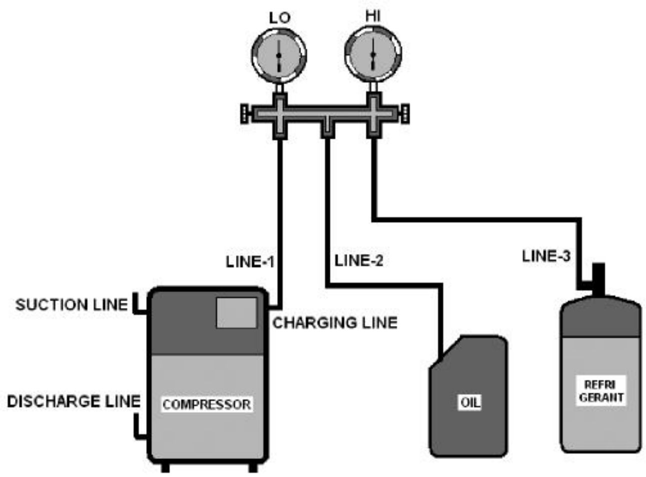
INSTALLATION OF WINDOW AIR CONDITIONER

Remove the unit from the cabinet and check the shipping damages. Run the unit and check the operation. Construct the wooden frame. Fix the wooden frame to the window or in the wall. Place the case in the frame with a slope for condensate drainage and drill the holes and fix the case to the frame using screws. Fix the support brackets to the cabinet and adjust the support brackets. Place a rubber gasket or sponge rubber or insulating material like thermocole between the case and frame to prevent hot air leakage. Place the AC unit in the cabinet and fill the space between the unit and cabinet with sponge rubber or thermocole. Fix the front grill on the unit. Check the line voltage. Start the unit and run for a few minutes and check the current drawn. Check the grill temperature and room temperature after a few hours of operation.

PRACTICAL



GAS CHARGING OF WINDOW AIR CONDITIONER



Testing of window Airconditioner

1. Identify the components of window airconditioner.
2. Test the selector switch of a window Airconditioner
3. Test the fan and blower motor of a window Airconditioner
4. Cleaning/replacing of air filter of a window Airconditioner.
5. Cleaning/servicing of evaporator of a window Airconditioner.
6. Cleaning and servicing of condenser of a window Airconditioner
7. Wiring of window airconditioner.
8. Fault finding of electrical components in window airconditioner.
9. Installation of window airconditioner.
10. Trouble shooting of a pre installed window airconditioner.

To install and inspect window air conditioner.

1. Unpack the window air conditioner carefully.
2. Use finished wooden frames to fix outer cover.
3. Fix wooden frames at required place, tighten the screws.
4. Fix the outer cover at wooden frame, Fix the screws.
5. Fix the outer cover on the rear side

6. Check the slanting with spirit level
7. Fix the window AC inside the frame
8. Fix MCB with suitable amperage.
9. Fix front panel to the window air-conditioner. Tighten the supporting screws.
10. Fix the main chord in the MCB.
11. Check the line voltage, and start the Airconditioner.
12. Start the fan motor.(Low)
13. Start the compressor; adjust the thermostat to the required level.
14. Check the air flow at the front grill
15. Check the temperature at the front grill
16. Record the temperature and voltage.

ASSESSMENT

Take a hand kerchief and hang it at different positions of a working window airconditioner and observe what happens. Write your findings.

TE QUESTIONS

1. What are the advantages and disadvantages of a window AC?
2. The condenser used in window AC is ....
3. What is the degree of inclination required for the installation of a window AC?
4. The airconditioner is working properly, but not geting adequate cooling. What are the possible reasons and how will you rectify them?
5. What is the power consumption of 1 TR air-conditioner for 24 hours
6. An office cabin is air-conditioned with window type air-conditioner.The system is working properly,but not achieving comfort condition.Suggest possible reasons.

UNIT 3.6

SPLIT AC (WALL, FLOOR , CEILING MOUNTED & TOWER/SLIM LINE)

Split airconditioner is widely using now-a-days so employability in this field is limitless. This unit details different types of split air-conditioner and their working, installation and trouble shooting.

Learning outcome

The learner :

- Understand, explain and classify different types of split air conditioning machines
- Explain working principle, types and trouble shooting of wall, floor, ceiling mounted & tower/slim type split airconditioner.

The split air conditioner comprises of two parts: the outdoor unit and the indoor unit. The outdoor unit, fitted outside the room, houses components like the compressor, condenser and the expansion valve. The indoor unit comprises the evaporator or cooling coil and the cooling fan. For this unit, you don't have to make any slot in the wall of the room. Further, present day split units have aesthetic appeal and do not take up as much space as the window unit. A split air conditioner can be used to cool one or two rooms.

PARTS OF SPLIT AIR-CONDITIONER: Wall Mounted Indoor Unit : It is the indoor unit that produces the cooling effect inside the room. The indoor unit of the split air conditioner is a box type housing in all the important parts of the air conditioner are enclosed. The most common type of the indoor unit is the wall mounted type though other types like ceiling mounted and floor mounted are also used.

These days the companies give utmost importance to the looks and aesthetics of the indoor unit. In the last couple of years, the purpose of the indoor unit has changed from being a mere cooling effect producing devise to a beautiful looking cooling devise adding to the overall aesthetics of the room. This is one of the major reasons that the popularity of the split units has increased tremendously in the last few years. Let us see the various parts enclosed inside the indoor unit of the split air conditioner

1) Evaporator Coil or the Cooling Coil:

The cooling coil is a copper coil made of a number of turns of the copper tubing with one or more rows depending on the capacity of the air conditioning system. The cooling coil is covered with aluminum fins, so that the maximum amount of heat can be transferred from the coil to the air inside the room.

The refrigerant from the tubing at a very low temperature and very low pressure enters the cooling coil. The blower draws the hot room air or the atmospheric air and in doing so the air passes over the cooling coil which leads to the cooling of the air. This air is then blown to the room where the cooling effect has to be produced. The air, after producing the cooling effect is again sucked by the blower and the process of cooling the room continues.

After absorbing the heat from the room air, the temperature of the refrigerant inside the cooling coil becomes high and it flows back through the return copper tubing to the compressor inside the outdoor unit. The refrigerant tubing supplying the refrigerant from the outdoor unit to the indoor unit and that supplying the refrigerant from indoor unit to the outdoor unit are both covered with insulation tape.

2) Air Filter:

The air filter is very important part of the indoor unit. It removes all the dirt particles from the room air and helps supply clean air to the room. The air filter in the wall mounted type of the indoor unit is placed just before the cooling coil. When the blower sucks the hot room air, it is first passed through the air filter and then though the cooling coil. Thus the clean air at low temperature is supplied into the room by the blower.

One of the most popular type of split air conditioners is the wall mounted type of split AC. In these ACs the indoor unit is mounted on the wall inside the room or the office.

3) Cooling Fan or Blower:

Inside the indoor unit there is also a long blower that sucks the room air or the atmospheric air. It is an induced type of blower and while it sucks the room air it is passed over the cooling coil and the filter due to which the temperature of the air reduces and all the dirt from it is removed. The blower sucks the hot and unclean air from the room and supplies cool and clean air back. The shaft of the blower rotates inside the bushes and it is connected to a small multiple speed motor, thus the speed of the blower can be changed. When the fan speed is changed with the remote it is the speed of the blower that changes.

4) Drain Pipe:

Due to the low temperature refrigerant inside the cooling coil, the temperature is very low, usually much below the dew point temperature of the room air. When the room air is passed over the cooling coil due the suction force of the blower, the temperature of the air becomes very low and reaches a level below its dew point temperature. Due to this the water vapour present in the air gets condensed and dew or water drops are formed on the surface of the cooling coil. These water drops fall off the cooling coil and are collected in a small space inside the indoor unit. To remove the water from this space the drain pipe is connected from this space extending to the some external place outside the room where water can be disposed. Thus the drain pipe helps remove dew water collected inside the indoor unit.

To remove the water efficiently the indoor unit has to be tilted by a very small angle of about 2 to 3 degrees, so that the water can be collected in the space easily and drained out. If this angle is in the opposite direction, all the water will get drained inside the room. Also, if the tilt angle is too high, the indoor unit will become shabby inside the room.

5) Louvers or Fins:

The cool air supplied by the blower is passed into the room through louvers. The louvers help changing the angle or direction in which the air needs to be supplied into the room as per the requirements. With louvers one can easily change the direction in which the maximum amount of the cool air has to be passed.

There are two types of louvers: horizontal and vertical. The horizontal louvers are connected to a small motor and the position can be set by the remote control. One can set a fixed position for the horizontal louvers, so that chilled air is passed in a particular direction only or one can keep it in a rotation mode, so that the fresh air is supplied throughout the room. The vertical louvers are operated manually and one can easily change their position as per the requirements. The horizontal louvers control the flow of air in the upper and lower directions of the room, while vertical louvers control movement of air in the left and right directions.

Outdoor Unit

As mentioned earlier the outdoor unit is installed outside the room to be air conditioned in the open space. In the outdoor unit lot of heat is generated inside the compressor and the condenser, hence there should be sufficient flow of air around it. The outdoor unit is usually installed at the height above the height of the indoor unit inside the room though in many cases the outdoor is also installed at a level below the indoor unit.

The outdoor unit contains the important parts of the split airconditioner like compressor, condenser, expansion valve etc. Let us see these parts in detail:

1) Compressor:

The compressor is the most important part of any air conditioner. It compresses the refrigerant and increases its pressure before sending it to the condenser. The size of the compressor varies depending on the desired air conditioning load. In most of the domestic split air conditioners, hermetically sealed type of compressor is used. In such compressors, the motor used for driving the shaft is located inside the sealed unit and it is not visible externally. External power has to be supplied to the compressor, which is utilized for compressing the refrigerant and during this process, lot of heat is generated in the compressor, which has to be removed by some means.

2) Condenser:

The condenser used in the outdoor unit of split air conditioners is the coiled copper tubing with one or more rows depending on the size of the air conditioning unit and the compressor. Greater the tonnage of the air conditioner and the compressor, more are the coil turns and rows. The high temperature and high pressure refrigerant from the compressor comes in the condenser where it has to give up the heat. The tubing is made up of copper since the rate of conduction of heat is high. The condenser is also covered with aluminum fins, so that the heat from the refrigerant can be removed at a more faster rate.

3) Condenser Cooling Fan:

The heat generated within the compressor has to be thrown out, else the compressor will get too hot in the long run and its motor coils will burn leading to complete breakdown of the compressor and the whole air conditioner. Further, the refrigerant within the condenser coil has to be cooled, so that after expansion its temperature become low enough to produce the cooling effect. The condenser cooling fan is an ordinary fan with three or four blades and is driven by a motor. The cooling fan is located in front of the compressor and the condenser coil. As the blades of the fan rotate it absorbs the surrounding air from the open space and blows it over the compressor and the condenser with the aluminum fins thus cooling them. The hot air is thrown back to the open space and the circulation of air continues unhindered.

4) Expansion Valve:

The expansion valve is usually a copper capillary tubing with several rounds of coils. In the split air conditioners of bigger capacities, thermostatic expansion valve is used which is operated electronically automatically. The high pressure and medium temperature refrigerant leaves the condenser and enters the expansion valve, where its temperature and pressure drops suddenly.

Refrigerant Piping or Tubing

The refrigerant piping is made up of copper tubing and it connects the indoor and the outdoor unit. The refrigerant at a low temperature and low pressure leaves the expansion valve and enters the copper tubing, which is connected to the evaporator or the cooling coil at the other end.

The distance between the indoor and the outdoor unit can be short or long depending on the distance at which the open space is available in the home or office building. The longer the distance, longer is the refrigerant piping between the two. When the refrigerant flows from the indoor unit to the outdoor unit in the tubing there is some loss of the cooling effect on the way, hence the distance between the indoor and the outdoor unit should be kept as minimum as possible. For the distance up to 15 meters there is not much appreciable loss of the cooling effect, however beyond that the losses become higher.

The refrigerant inside the tubing is at very low temperature and length of piping between and outdoor unit and indoor unit is quite long. Further, the tubing is exposed to the open atmosphere which is at very high temperature. Due to this, if the tubing is left uncovered, all the cooling effect will be lost to the open atmosphere and by the time the refrigerant enters the cooling coil its temperature will already be too high and the purpose of producing the cooling effect will not be served. To avoid this, the refrigerant tubing connecting the indoor and the outdoor unit is covered with the insulation. This prevents the loss of cooling effect to the atmosphere and low temperature refrigerant will produce the desired cooling effect inside the room.

After producing the cooling effect inside the room in the indoor unit, the refrigerant has to come back to the outdoor unit for getting compressed and re-circulated. There is another refrigerant tubing that connects the indoor and the outdoor unit, so that the refrigerant can travel from cooling coil back to the compressor. This tubing is also covered with insulation, so that the refrigerant enters the compressor at minimum possible temperature to increase the refrigeration efficiency of the air conditioner. Thus there are two tubing connecting the indoor and the outdoor unit and both are covered with the insulation tape.

The refrigerant tubing is made up of copper since it is a highly ductile and malleable element. The tubing can easily be manufactured from this material and as it is flexible enough it can be turned into angles and coiled easily. The copper tubing used for condenser and evaporator facilitates high rate of heat conduction.

TOWER/SLIM-LINE AIRCONDITIONER

These are also known as floor-standing air conditioners. Like split ACs, a tower AC set consists of 2 units- one internal and the other external. However, the indoor unit doesn't need wall installation. It rather occupies some space on the floor. Tower air conditioners usually have a high cooling capacity and are suitable for very large rooms. Floor Standing air conditioners are equipped with technologies to enable faster cooling and at the same time enhance the interiors of your home with their elegant look and design. They also save energy and cool your room faster.

Advantages

- Suitable for high capacity cooling
- Ideal for large rooms at home and offices
- Doesn't need windows or wall installation
- Ideally suited for commercial spaces

Slim-line air conditioner, also known as a tower AC or a floor-standing AC, is a nifty and slender device employed to dehumidify a particular zone and remove/provide heat to a particular area. The cooling is enabled by a refrigeration cycle identical to other air conditioners. Akin to split air conditioners, Slimline air conditioners boast of two separate units - the evaporative unit on the exterior and the condensing unit on the interior. Both the units are seamlessly connected a tube. While most households predominantly opt for a Window AC or a Split AC, Slim line Air Conditioners are ideal for industries, call centres, showrooms, offices, restaurants and other such sprawling and capacious areas, which do not require extensive cooling. These have gained immense popularity primarily because they function in the same way as a window unit air conditioner, without actually sitting in your window.

Get an extra edge with Slimline ACs

Slimline Air conditioners proffer a host of advantages over run-of-the-mill air conditioners. Some of them are given below:

- Slimline air conditioners do not require a permanent installation that essentially saves a lot of hassle and ensures fuss-free, quick installation.
- Slimline air conditioners do not require your premise to have any HVAC piping or plumbing in place. What this effectively means is that these air conditioners are ready for use right from the word go!
- With Slimline air conditioners, you are ensured a tranquil noiseless operating function, thanks to the inherent noise-suppression technology that smartly eliminates all the irksome noise.
- With Slimline air conditioners, you end up thwarting the risk of accidental leaking and spillage of water.
- Slimline air conditioners come in loads of vibrant hues and look really sleek and stylish. They are, thus, ideal cooling accessories for the most plush of interiors.
- Most of the current models of Slimline air conditioners sport a distinctive child lock switch, which allows the settings to be locked, thus making it absolutely child-proof and fail-safe.
- Most of the upscale Slimline air conditioner models come with a duplicate compressor comprising a unique internal overload protection device that protects the compressor from electrical and thermal overload.
- Slimline air conditioners are highly energy-efficient and, in addition to offering impressive cost savings, they remain your best bet in alleviating your carbon footprint.

Cooling capacity

Cooling capacity is defined as the air conditioner's ability to keep the requisite area cool. Slimline air conditioners come in a wide range of cooling capacities, viz., 1.5-ton, 2-ton, 3-ton, 4-ton etc. A good practice while choosing an appropriate capacity is to measure the area size in square feet. For an area with a dimension of 12×12 square feet (length x breadth), a single ton air conditioners should ideally fit the bill. This de-facto standard should help you customise your selection. A majority of the makers' websites offer detailed assistance to consumers to arrive at the appropriate tonnage as per individual requirements.

Energy Efficiency and Power Consumption

A slim line air conditioner's efficiency is measured using the energy efficiency ratio (EER). The EER is the ratio of the cooling capacity (in British thermal units per hour) to the power input (in watts). A higher EER rating ensures lesser power consumption and higher energy efficiency, and this is a boon for the environment too. In fact, National Appliance Standards mandatorily require all air conditioners to bear an energy efficiency ratio (EER) ranging from 8.0-9.8 or greater (depending on the type and capacity). Energy Star certified air conditioners enjoy even higher EER ratings.

Noise level

Noise level is another important selection criteria when buying an AC. Almost all Slimline air conditioners boast of the cutting-edge noise suppression technology that assures an absolutely noiseless operation.

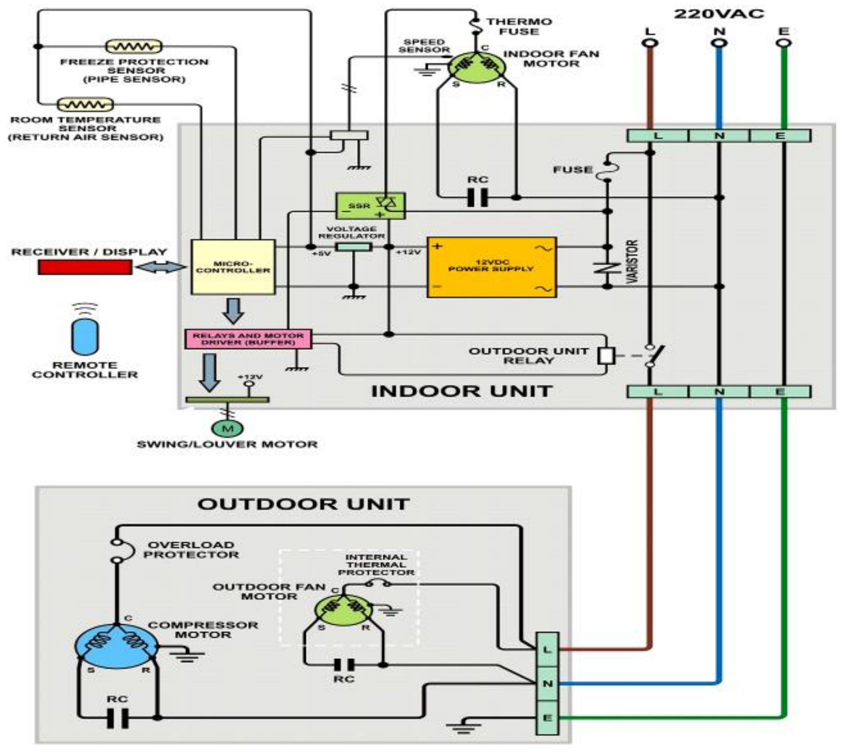
Practical

1. WIRING OF SPLIT AIR-CONDITIONER

AIM:- To carry out the wiring of a split air conditioner.

Tools, Instruments, Materials Required:- Screw driver, Spanner, Combination pier, Multimeter, clap meter, Neon tester, cotton waste.

Accessories:- Micro controller, Display unit, Voltage regulator, 12 volt DC supply transformer, Indoor fan motor, outdoor unit relay, freeze protection sensor, room temperature sensor, Remote control,etc…



Procedure

1. Connect the indoor unit and out door unit as shown in the diagram.
2. Connect the phase and neutral lines to the power supply.
3. Check the circuit and finish the wiring.

*Make sure that the phase and neutral lines are connected properly.

2. TROUBLESHOOTING OF SPLIT AC

Aim:- To study the trouble shooting methods of Split AC

*Fault: Remote not working

Remote not working/some button not working in the remote

Check remote

Step 1: Switch on the camera of mobile or infrared tester.

Step 2: Bring the remote in front of the lens.

Step 3: Press the button on the remote.

If light blinks on the screen of the mobile – remote is OK

*Fault: Machine not working

AC has no display/display not working

- Check socket & stabilizer output.
- Check fuse.
- Check Step down transformer.
- Check wiring connection.
- If all the above are OK, then replace PCB

*Fault: No Cooling, AC not cooled properly/only hot air comes/No cooling

- Check socket, stabilizer output & usage.
- Switch ON the AC. Wait till 3 – 4 minutes & observe the compressor working.

Observation: Compressor not working

Check supply on the outer terminal (Between Phase – Neutral)

If supply comes

- Check the Capacitor.
- Check Compressor. (If compressor is trips/hot, then wait for 2 hours for the internal overload to connect winding again)

If no supply comes

- Check the wiring.
- Replace power PCB.

*Fault: Water Leakage, Water is leaking from indoor

- Check installation. (Indoor should not tilt)
- Check ice on the Evaporator. (Check gas & fan speed)
- Check the dust in the drain pan & drain pipe should not get pinched.
- Check drain pipe should not be dipped in water.
- Check the weather condition. (High humidity)

3. Identify the components of split airconditioner.
4. Test the thermostat of a split airconditioner
5. Test the capacitor of a split airconditioner
6. Test the evaporator fan and motor of a split airconditioner
7. Cleaning/replacing of air filter of a split airconditioner.
8. Cleaning/servicing of evaporator coils of a split air conditioner.
9. Cleaning and servicing of condenser unit(ODU) of a split airconditioner
10. Fault finding of electrical components in split airconditioner.
11. Oil removal from the evaporator
12. U trap making in suction line.
13. Servicing of the swing motor of the split air conditioner

ASSESSMENT

Compare the split AC and Window AC fitted in your lab and find the differences in installation, design, safety and appearance. Prepare a note.

TE Questions

1. What are the two units of split AC?
2. What are the suitable positions to fit an indoor unit?
3. What should be the maximum distance between the indoor unit and the out door unit?
4. Write step by step procedure to install a split AC.
5. Split AC motor is dripping after few minutes working .What are the possible reasons ?
6. Is it possible to fit an outdoor unit above the indoor unit?
7. What are the accessories required to fit split AC?
8. While working, cooling is less what are the possible reasons?
9. What will be the power consumption for 1 tonne split AC for 24 hours?
10. What are the precautions taken while installing a split AC?
11. Compare split and window AC.
12. Name the important components of split AC system.
13. What should be the size of suction and discharge pipe of window?

UNIT 3.7
SPLIT AC (DUCT, MULTI/DUAL SPLIT)

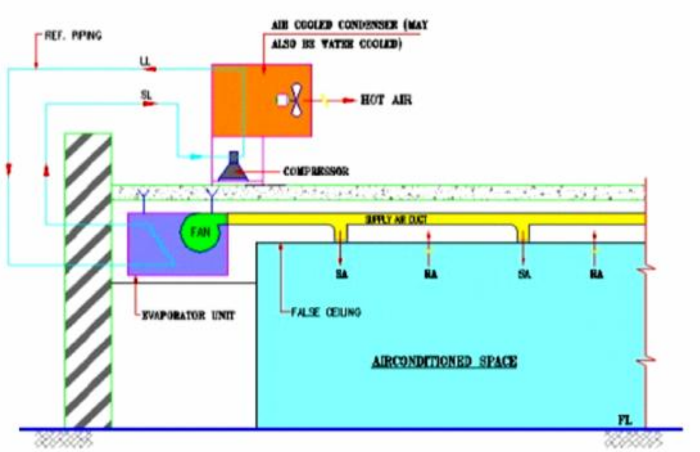
The unit deals with ductable and multi-split airconditioners, their construction,working and their installation details.

Learning outcome

Learn the use of multi/dual and duct type split ac

Ductable split air conditioner is designed for problem areas. This is because the components are installed separately.The sleek indoor cooling unit is installed within the room to be air conditioned and the condensing unit is located out side.Ideally suited for offices,conference rooms,apartments,etc, whereever a conventional air conditioner cannot be fitted or cool efficiently and economically.

Air conditioner maintains the humidity, temperature, pressure, sound, air velocity and dust control. If we have to maintain more than 2-4 rooms at a time with one air conditioner then we are using this type of air conditioner. In this system, one duct or line has to go through all the rooms to helps flow pure & cool air to the rooms and another duct or line has to bring all corrosive air outside the rooms and flow outwards. Ductable airconditioners are basically the indoor units of a centralized air-conditioning system. These are called ductable because they use ducts to connect to an air handling unit (AHU) which is located on a mechanical room adjacent to the office area. The refrigerant/chilled water cools and de-humidifies the air in the AHU. The cool air is then circulated throughout the building through the ductwork.



SECTIONAL DETAIL THRO'
A PACKAGE UNIT
(SPLIT A/C) - DUCTABLE TYPE

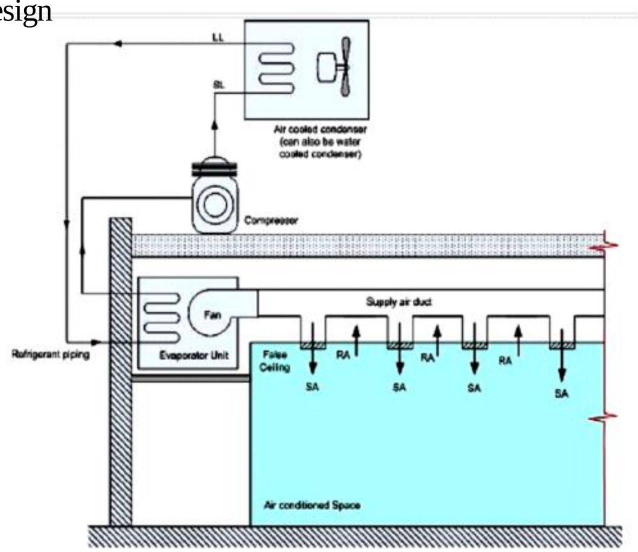
Packaged and Ductable Split Units are designed to be the most intelligent and compact systems, to cater to the total cooling requirements. Ideally suited for offices, conference rooms, apartments, hotels, restaurants, shops, basements, high security areas, bank vaults or wherever a conventional air conditioner cannot be fitted or cool efficiently and economically. Ductable Split System Air conditioner is designed for problem areas. This is true because the components are installed separately. The sleek indoor cooling unit is installed within the room to be air conditioned and the condensing unit is located outside. The external dimensions are kept to a minimum, enabling the transportation of the units economical, safe and simple. Flanges are provided for easy mounting to the ceiling of a room in a horizontal position. Pre drilled duct flanges are provided for supply air openings to minimize duct the connection work. These units are available in both air-cooled and water-cooled options.

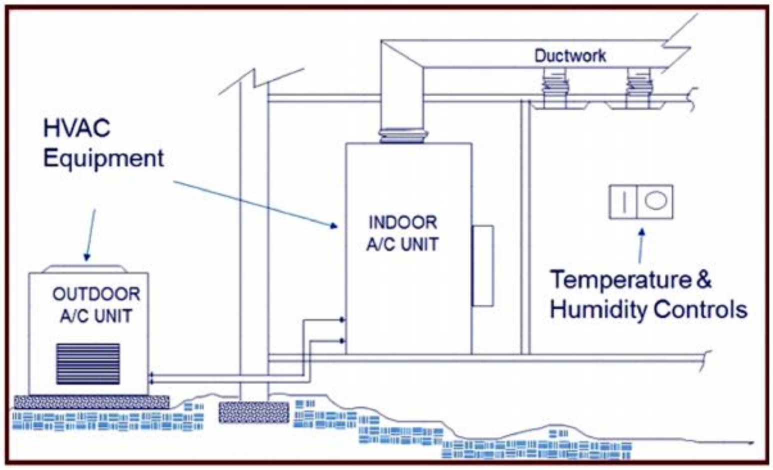
Cooling Capacity Range : 1.5TRto22TR

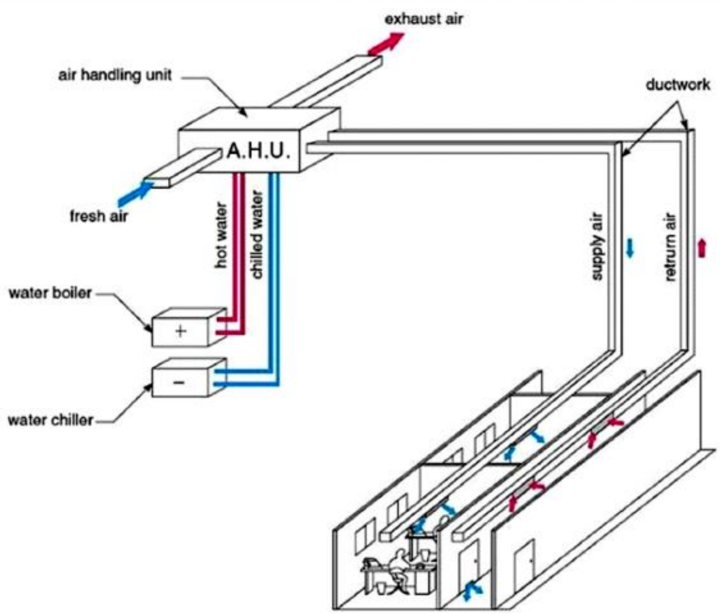
All models are also available in R 407C Refrigerant

MERITS

- Highly efficient units
- Designed to work effectively even in ambient temperatures as high as 50°C
- Compatible with eco-friendly R410A refrigerant
- Robust and reliable
- Aesthetically superior
- Service-friendly design







Ductwork is a branching network of round or rectangular tubes. It is generally constructed of sheet metal, fiberglass board, or a flexible plastic and wire composite material and is located within the walls, floors, and ceilings of the building.

Ductable airconditioners are of two types :- Air-cooled ductable airconditioners and Floor-mounted packaged airconditioners.

1. ***Air-cooled ductable air conditioners*** are generally located above the false ceiling of the conditioned area and are connected to the ducting. They are available in 3, 5, 7.5 and 8.3 tonne capacities. Ideally, the indoor units are to

be placed in the corridors or overhead lofts, where accessibility isn't a problem while servicing.

Advantages :-

- Distribute conditioned air over large area, uniformly through ducts.
- Prove advantageous for highly mechanized projects such as manufacturing plants, for example to maintain optimum temperatures.
- Maintain high static pressure in the premises.

2. ***Floor-mounted packaged air-conditioners*** are cupboard-shaped and are typically located adjacent to the conditioned area as small enclosures. Their capacity varies from 5 to 16.5 TR.

Advantages:-

- Efficiently handle large tonnages with less units of power.
- Easily serviceable due to accessibility.
- Better performance with longer ducts as powerful fans are installed.

Disadvantages:-

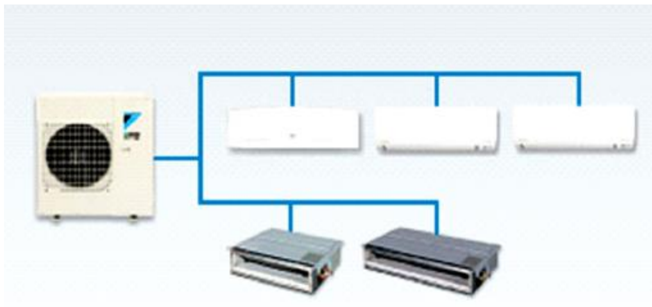
- Demand strong project management skills as it involves complex technology.
- Incur high installation cost, for duct work.
- Require additional equipments such as air handlers for working.

Application:-

They are commonly used in commercial complexes, showrooms, government/private institutions and also in industrial establishments.

DUAL/ MULTI-SPLIT A C SYSTEMS

If you want to keep a large floor as well as many rooms comfortable, it is recommended to use multi-split to build a simple system using one outdoor unit. Choose from a large line-up the air conditioner types that match your rooms. Multi Split Air Conditioning systems with inverter technology provide a good way to save space, buying cost and electricity cost in smaller offices. These air conditioners have multiple indoor units connected to a single outdoor unit as shown in the picture below. The temperature control is available at every indoor unit and the outdoor unit adjusts the compressor load, based on the heat load coming from various units.



Advantages:-

- Installs a complete air conditioning system to multiple zone interior spaces with no need for ductwork.
- Provides individual control of room temperature settings.
- Enables indoor units of different styles and capacities in one system for customized solutions unique to each residential setting.
- Multiple indoor units can be connected to one outdoor unit.
- Easy and flexible installation is possible by means of long piping connection and large height difference installation.
- Abundant indoor unit line-up matched to various customer needs

Compact and low noise outdoor unit design

Practical

1. Study the components of a ducted split unit.
2. Fault finding of components in the outdoor unit.
3. Fault finding of air supply unit.
4. Fault finding and replacing of Three-phase contactors.
5. Trouble shooting of Multi-split AC unit.

Ductable Air Handling Unit

Large Air Supply Unit (Ductable)

ASSESSMENT

Prepare and submit activity log regarding ductable split airconditioner.

TE Questions

1. What are the differences between a split airconditioner and ductable split air conditioner?
2. What are the applications of a ductable split air conditioner?
3. What are the ducting materials used for duct fabrication?

MODULE-4

APPLICATION OF AIR CONDITIONING & CONTROLS

This module is designed to get a clear idea about applications of airconditioning and cooling load estimation.Cooling load estimation is important to understand the capacity requirement of conditioning space. It gives an idea to reduce the heat load of conditioning space. Auto mobile industry require lot of air conditioning technicians. So much more importance given to automobile AC. .Railway air conditioning, clean room AC, hospital AC, Theatre AC,idea of reefer AC and HVAC are included.Various air conditioning controls,Transmission and distribution of air is detailing in this module.Simple project work included in this module helps the learner to go through fabrication and design aspects of Refrigeration and Air conditioning system.

UNIT 4.1
INVERTER SPLIT AC

Power saving is an important factor in designing. Inverter air conditioners are more powerful, offer great savings and are better at maintaining temperature.

Learning outcome

The learner :

Explain and compare the working of an inverter AC and other types of AC machines

INVERTER TECHNOLOGY

The inverter technology works like an accelerator in a car. When the compressor needs more power, it gives more power. When it needs less power, it gives less power. With this technology, the compressor is always on, but draws less or more power depending on the temperature of the incoming air and the level set in the thermostat. The speed and power of the compressor is adjusted appropriately. This technology was developed in Japan and is being used there successfully for air conditioners and refrigerators. This technology is currently available only in split air conditioners.

Air conditioner compressors are driven by motor, and the motor rotation speed depends on power supply frequency. An inverter modulates power supply frequency to control motor rotation speed. Inverters stabilize the temperature by adjusting compressor operation according to the load to eliminate waste and save energy. Even adopting an inverter to the fan motors of the indoor and outdoor units provides more precise control and contributes to energy savings.

What is the benefit of inverter technology?

Every air conditioner is designed for a maximum peak load. So a 1.5 TR airconditioner is designed for a certain size of room and 1 TR for a different size. But not all rooms are of same size. A regular air conditioner of 1.5 TR capacity will always run at peak power requirement when the compressor is running. An air conditioner with inverter technology will run continuously but will draw only that much power that is required to keep the temperature stable at the level desired. So it of automatically adjusts its capacity based on the requirement of the room it is cooling, thus drawing much less power and consuming lesser units of electricity.

Although air conditioner with inverter technology adjusts its capacity based on the room requirement, it is very important to install a right sized air conditioner in a room. Please make sure that you evaluate the room and air conditioner capacity before you make a purchase. Keep watching for this space as we are in the process of creating a comparator for electricity savings in various air conditioners.

INVERTER AC-ADVANTAGES & DISADVANTAGES

Inverter means the compressor uses DC power instead of AC power which is what is supplied to your house. It uses an internal power converter (inverter) to do so. This makes the equipment more complicated, and expensive. Troubleshooting can be difficult, and parts are expensive.

Since the unit uses DC power, the compressor can be modulated to meet the cooling demand of the room. AC powered compressors run at one speed and are either 100% on or 100% off. DC compressors can run anywhere from 30% to 100% .Since you don't need 100% most of the time, the compressor runs at the speed the room needs to maintain temperature, and in turn is much more efficient.

Energy Efficiency Ratio & Star Rating

Energy efficiency ratio (**EER**) is the **ratio** between the cooling capacity and the power input of the airconditioners. For example, if a 1 TR (3500 W) AC consumes 1000 watts, then the **EER** of the airconditioner is 3.5 W/W. ACs with high **EER** consume less power. The Energy Efficiency Ratio (EER) of a particular cooling device is the ratio of *output* cooling energy to *input* electrical energy at a given operating point. EER is generally calculated using a 95 °F outside temp and an inside (actually return air) temp of 80 °F and 50% relative humidity. Air conditioner EER ratings higher than 10 are considered most cost effective. The higher the ratio, lesser the unit will cost to operate.

Air conditioners that have been tested to have Energy Efficiency Ratios are certified by the Association of Appliance Manufacturers (AHAM). These units will generally list their EER ratios in their product features.

1 TR = 12000BTU = 3500 W

EER = TR in Watts/ Power consumed in watts

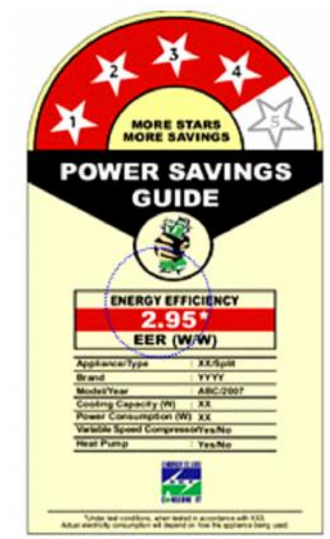
Meaning of star rating of an Air conditioner

At the time of Initial Purchase of airconditioner, customers want to know the electrical consumption of an airconditioner.

This star rating is provided for customer awareness by **BEE** (**Bureau of Energy Efficiency**.)

EER stands for **Energy Efficiency Ratio**.

This sticker is provided by **Bureau of Energy Efficiency** (BEE) Department of Energy Saving, Govt. of India.



EER is calculated by : Cooling Capacity (Watts) / Power Consumption (Watts)}

Example:

One 1.5 ton AC have 5275 Watts cooling capacity and 1650Watts power consumption, so EER of unit is 5275/1650=3.1 EER.

As per the below table, this unit is 4 star rated.

Star Rating Band Valid from 01 Jan 2008 to 31 December 2009.

EER (W/W)		
Star Rating	Maximum	Minimum
1 Star	2.50	2.69
2 Star	2.70	2.89
3 Star	2.90	3.09
4 Star	3.10	2.29
5 Star	3.30	

Difference between Inverter Technology AC and BEE 5 star AC:

1. Inverter technology air conditioners are variable speed/ variable tonnage air conditioners and thus operationally they are quite different from regular air conditioners that have single speed compressors and single tonnage.
2. Inverter technology air conditioners adjust their speed/tonnage depending on heat load of a room, whereas regular air conditioners do not.
3. Every room has a different heat load, even if they are of the same size. The heat load depends on various factors . To give you an analogy, every human being is different; even then the waist sizes of most trousers available in the market are fixed (leaving the ones with elastic). Inverter Technology AC is just like a trouser with an elastic waist that can adjust to the size. The other benefit is that even if the waist size increases or decreases, the trouser with elastic will adjust accordingly. Regular airconditioners are of fixed size.
4. Now as we can see that operationally inverter technology air conditioners are quite different from regular air conditioners, comparing them on efficiency with regular air conditioners is not easy. **Thus none of the inverter technology air conditioners have been rated by BEE star rating**. Only the regular air conditioners are rated by BEE star rating.
5. The heat load in a room does not remain constant and it varies from seasons, based on the number of people, varies between day and night, varies based on climate profiles of your location. To take the same analogy mentioned above, the waist size increases or decreases with the amount of food one eats or the amount of exercise one does. So as a trouser with elastic waist can work well, an air conditioner with inverter tech can work well.

Special features of inverter technology compressor motor

Using the latest advancements in inverter technology, air conditioners are quieter to run and more economical to operate than conventional AC units. Let's learn what this inverter technology is all about and the operating principle of this newer air conditioner.

An air conditioner described as using "inverter technology" or "inverter equipped" has the ability to continuously control its thermal transfer rate by modifying the compressor's speed in response to the demand for cooling. So, the basic operating principle of an inverter is pretty straight forward as it is comparable to the technology used in cars, where you need to press the accelerator harder to go faster. The same rule applies here, too!

What Does It Do?

The fixed speed compressor in a standard air conditioner runs at 100% capacity when it is started, but an inverter unit starts at a low level and then progressively enhances its capacity, depending on the requirement to heat up the room or cool it down. Fixed speed compressors start or stop automatically in order to sustain the desired temperature, but an inverter unit regulates the capacity of the compressor instead.

How Does It Work?

DC inverter air conditioners make use of a variable frequency drive to regulate the motor's speed, thereby controlling the speed of compressor too.

This variable frequency drive includes a rectifier that converts the incoming Alternating Current (AC) to Direct Current (DC). It then utilizes Pulse Width Modulation (PWM) of the DC in the inverter to generate AC of desired frequency. The alternating current is used to drive an induction motor or a brushless motor.

Since the frequency of the alternating current and the speed of the induction motor are directly proportional to each other, the compressors in an inverter window air conditioner unit operate at various speeds.

The current ambient air temperature is then sampled by using a microcontroller and then the compressor's speed is adjusted appropriately.

Insulation

In the modern propulsion applications of tractions drives, voltage source inverter-fed three phase AC machines are preferred due to their flexibility and high dynamic torque properties. However, the fast switching of the inverter (high dv/dt rates) causes increased stress for the motor windings and leads to insulation degradation. Thus, insulation condition monitoring is getting more and more important to ensure reliability. The proposed online insulation monitoring method is able to detect incipient insulation defects by evaluation of the motor current's transient response on voltage pulses injected by inverter switching. Experimental results are presented to prove the method's performance in the case of application of voltage source inverters with very high dv/dt rates for, e.g., inverters equipped by semi-conductors.

Practical

1. Comparison between split ac and inverter split air conditioner

Aim:-To compare non-inverter AC and Inverter AC

Item	Non-Inverter Ac	Inverter Ac
Time to reach pre-set temperature	Relatively long due to fixed capacity	Short because of increased capacity
Fluctuations after reaching pre-set temperature	Major fluctuations due to start/stop operations	Minor fluctuations due to load adaptable operations
Sudden current flow when the compressor started	5-6 times rated value	1.5 times rated value due to gradual increase at the start
Low temperature range during heating	Decrease in capacity	Decrease in capacity compensated by increased rotational speed
Defrosting time capacity	Relatively long due to fixed capacity	Short due to maximum operations
Unit composition	Relatively simple	Extra parts required

2. Servicing of condenser unit
3. Servicing of indoor unit
4. Cleaning of air filter.
5. Testing of thermostat.
6. Servicing of electronic expansion valve of an inverter split air conditioner.

ASSESSMENT

Distribute handouts of 1.5 ton Inverter AC and Split AC with star rating. Ask to prepare the constructional details and the comparison.

TE Questions

1. What is the working principle of an inverter air conditioner?
2. Arrange the air conditioners on the basis of power consumption (lower to higher)

   a) split air conditioner b)inverter air conditioner c)split air conditioner with 3* rating

   d) split air conditioner with 5* rating
3. Name the type of motor used in an inverter ac.

UNIT 4.2
HEAT LOAD CALCULATION

The unit details the factors to be considered in heat load calculations and the criteria in selecting an air-conditioning system.

Learning outcome

The learner :

Explain the importance of cooling load and the components contributing to the heating load.

HEAT LOAD CALCULATION: Importance of cooling load calculation. Different components contributing to the total cooling load-heat load due to structural wall, infiltration, ventilation, occupants and power equipment of a building. Simple problems Heat load estimation using softwares. Psychrometer and Calculation of air properties using psychrometer and psychrometric chart

COOLING LOAD

The design cooling load (or heat gain) is the amount of heat energy to be removed from a house by the HVAC equipment to maintain the house at indoor design temperature when worst case outdoor design temperature is being experienced. There are two types of cooling loads:

- sensible cooling load
- latent cooling load

The sensible cooling load refers to the dry bulb temperature of the building and the latent cooling load refers to the wet bulb temperature of the building. In the summer, humidity influences the selection of the HVAC equipment and the latent load as well as the sensible load must be calculated.

Factors that influence the sensible cooling load

- Glass windows or doors
- Sunlight striking windows, skylights, or glass doors and heating of the room
- Exterior walls
- Partitions (that separate spaces of different temperatures)
- Ceilings under an attic

- Roofs
- Floors over an open crawl space
- Air infiltration through cracks in the building, doors, and windows
- People in the building
- Equipment and appliances operated in the summer
- Lights

Factors that influence the latent cooling load

Moisture is introduced into the structure through:

- People
- Equipment and appliances
- Air infiltration through cracks in the building, doors, and windows

Other latent heat gain is taken care of by the HVAC equipment before the air reaches the rooms (system gain).

COOLING LOAD ESTIMATION

The total heat load to be removed from the space in order to bring it at the desired temperature by the air conditioning and refrigeration equipment is known as heat load. The purpose of heat load estimation is to determine the size of air conditioning and refrigeration equipment that is required to maintain inside design condition during the periods of maximum outside temperatures. The design load is based on the inside and outside design conditions and it is the air conditioning and refrigeration equipment capacity that produce satisfactory inside conditions.

STEPS FOR CALCULATING COOLING LOAD

SURVEY OF BUILDING

1. DBT and WBT of outside air -
2. DBT and WBT of inside air -
3. Size of building -
4. Structure of building -
5. Number of doors , windows , and ventilators -
6. Number of persons occupying the building -

7. Electrical appliances used in building -
8. Temperature maintained in the building -
9. Ventilation required in the building -
10. Purpose for which the building is to be used -
11. Locations where plant is to be installed -

1. HEAT LOAD THROUGH WALLS, WINDOWS, DOORS,ROOFS AND FLOORS

Heat load = U x A x $(T_2 - T_1)$

Where U is Overall heat transfer coefficient $W/m^2 K$

A is Area in m^2

T_2 is Outside temperature

T_1 is Inside temperature

U Values of common materials

Materials	**U value in W/m^2K**
Brick wall 30 cm	2.52
Brick wall 20 cm	2.82
Roof 20 cm concrete	3
Roof 15 cm concrete	3.5
Windows with glass	6
Doors	1.5
Floors	2

Heat load through walls = Total area of wall x U value x $(T_2 - T_1)$

Heat load through doors = Total area of door x U value x $(T_2 - T_1)$

Heat load through windows and doors = Total area x U value x $(T_2 - T_1)$

Heat load through roofs = Total area of wall x U value x $(T_2 - T_1)$

Heat load through floors = Total area of wall x U value x $(T_2 - T_1)$

2. HEAT LOAD DUE TO INFILTERATION AND VENTILATION

Heat enters by means of infiltration that is through the cracks , leakage around windows, doors and through ventilation etc. Ventilation is a source of heat entering in to the building.

Amount of infiltered air = v = (L x W x H x A) / 3600

Where L → Length in meters

W → Width in meters

H → Height in meters

A → No of air changes per hour

No of air changes value of rooms

Kind of room	No of air changes per hour - A
Room with no windows or outside doors	.5 to .75
Room with one wall exposed	1
Room with two wall exposed	1.5
Room with 2/3 wall exposed	2
Entrance Hall	2 to 3
Reception hall	2
Bath rooms	2

As from the psychometric chart note the following

Specific volume at point 1 $= v_s$

Enthalpy at point 1 $= H_1$

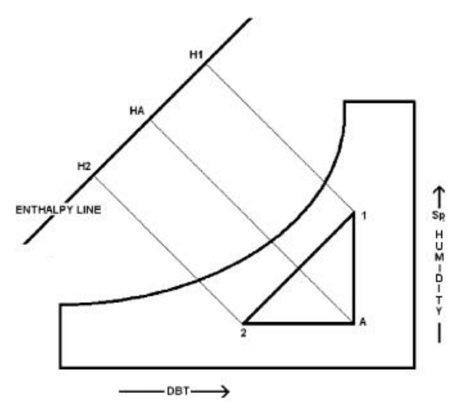
Enthalpy at point 2 $= H_2$

Enthalpy at point A $= H_A$

Specific humidity at point 1 $= w_1$

Specific humidity at point A $= w_A$

Mass of in filtered air = m $= v / v_s$



Sensible heat gain due to in filtered air $= m (H_A - H_2)$

Latent heat gain due to in filtered air $= m (H_1 - H_A)$

Ventilation required per person

Application	Outside air in m^3/min/person	
	Recommended	**minimum**
Apartment	0.6	0.45
Banking space	0.3	0.23
Hospital	0.9	0.75
Offices	0.45	0.3
Theatres	0.23	0.15

Volume of ventilation or outside air = outside air in m^3 x no of persons

Mass of in filtered air (m) = v / v_s

Sensible heat gain due to ventilated air = $m (H_A - H_2)$

Latent heat gain due to ventilated air = $m (H_1 - H_A)$

3. HEAT LOAD DUE TO ELECTRICAL LIGHTS AND EQUIPMENTS

Calculate the total wattage of = Total wattage / 1000

Electrical lights and equipments

4. HEAT LOAD DUE TO OCCUPANTS

The human body in a cooled space constitutes the cooling load of sensible heat and latent heat. The heat load from occupancies is based on the average number of people that are expected to be present in the conditioned space. The heat load produced by each person depends upon the activity of the person

Total sensible heat gain from occupants = Sensible heat per person x no of persons

Total latent heat gain from occupants = latent heat per person x no of persons

Total heat load = (1 + 2 + 3 + 4)

Capacity of air conditioning plant = (Total heat load/ 3.5) TR

Practical

1. Identify the sources of heat in a building.
2. Calculation of heat load in a given room.

COOLING LOAD ESTIMATION

AIM:- To estimate the cooling load of a given building

TOOLS, EQUIPMENTS AND MATERIALS REQUIRED: Sling psychrometer, 50 meter tape, Building plan.

The purpose of heat load estimation is to determine the size of air-conditioning and refrigeration equipment that is required to maintain inside design condition during the periods of maximum outside temperatures.

Steps for calculating cooling load

1. Survey of building
2. Heat load through walls, windows, doors, roofs and floors.
3. Heat load due to infiltration and ventilation.
4. Heat load due to electrical lights and equipments.
5. Heat load due to occupants.

Total heat load = Heat load through walls, windows, doors, roofs and floors + Heat load due to infiltration and ventilation + Heat load due to electrical lights and equipments + Heat load due to occupants.

ASSESSMENT

Enumerate the points for heat load calculation of your computer lab. Find the capacity of AC system required for your computer lab.

TE Questions

1. Which one of the following has the lowest heat transfer capacity?

   a. Brick wall 20 cm bare　　b. Brick wall 20 cm plaster one side.

   c. Brick wall 40 cm bare　　d. Brick wall 40 cm plaster one side.

2. Which one of the following liberates more heat?

   a) person sitting at rest　　b) person sitting at a matinee show

   c) person at light work　　d) person dancing

3. What do you mean by air change?

UNIT 4.3
SPECIAL AIR CONDITIOINING APPLICATIONS

The unit explains different areas of application of air-conditioning.

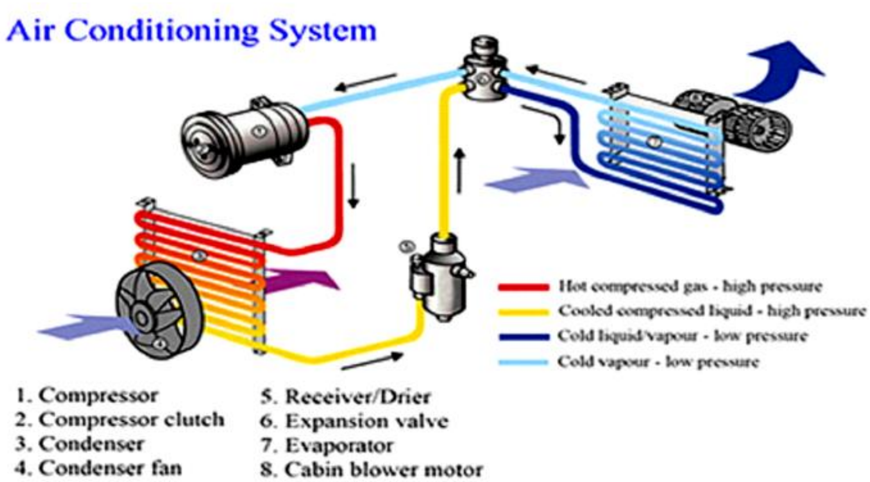
Learning outcome

The learner :

Understand various types of air conditioning applications

SPECIAL AIRCONDITIONING APPLICATIONS: Elementary ideas of automobiles, railways, clean room, hospital and theatre air-conditioning-Elementary idea of Reefer AC, HVAC -Trouble shooting and wiring of automobile a c systems

1. AUTOMOBILE AIR CONDITIONING SYSTEMS



Air Conditioning and Climate Control, both provide ways of controlling the air temperature inside your vehicle to deliver passenger and driver comfort. During the winter months, our vehicles use the waste heat from the engine to warm up the cabin air. However, during the summer, air conditioning is often needed to reduce the temperature of the cabin to a comfortable level. It also helps to de-humidify and de-mist the vehicle. Air conditioning just cools and dries the air, whereas climate control can provide both hot and cold air, allowing you to choose a specific temperature (usually between 15° and 26°). The use of air conditioning and climate control units can increase your fuel consumption by as much as 20% in cars and vans. This is because they take power from the engine and add to the weight of the vehicle.

When air conditioning is set to 'off', it should use no engine power. When it is turned on, it will use the maximum amount of fuel when set to high, and the minimum when set to low. If you need air conditioning, set it to its 'low' setting as soon as you can after starting your journey. To keep your vehicle cool, park in the shade or use underground car parks. Hybrid vehicles (A **hybrid vehicle** uses two or more distinct types of power, such as internal combustion engine+electric motor) also use their petrol or diesel engine to heat air for passenger comfort; this means these vehicles use significantly more fuel in cold conditions. During hot conditions, hybrid vehicles can use less fuel (relative to normal vehicles) as the air conditioning uses electricity from battery. Remember, air conditioning uses more fuel the cooler you wish to be. If you have climate control, set it to 20-22° or higher to reduce the load on air conditioning and your engine. Also – If you are driving a truck at high speeds for long periods, using air conditioning can be more fuel-efficient than driving with the windows open. This is because the increased drag caused by open windows uses more fuel than the air conditioning unit on a large engine. For coaches and buses, passenger comfort is part of the service, encourage drivers to: Use blowers only to cool the passenger compartment. Use air conditioning for just a few minutes before boarding. Set climate control to 20-22° and consider 'locking off' the setting in coaches. All automobile a c systems are used with R – 134a (HFC – 134a)

The main components of an automobile air conditioning system are compressor, condenser , thermostatic expansion valve (TEV) and evaporator.

2. RAILWAY AIR CONDITIONING

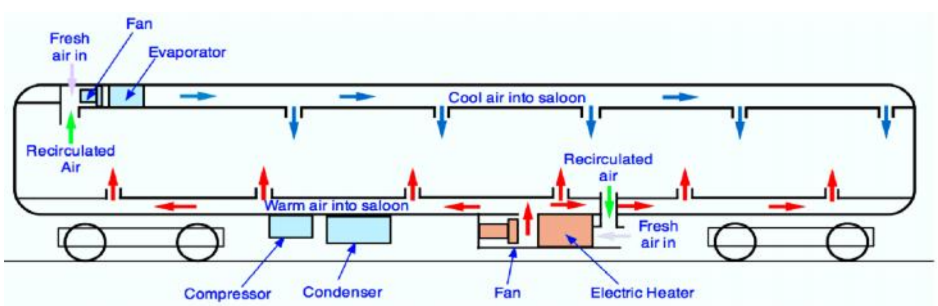


Diagram of typical passenger vehicle showing the layout of the air conditioning and heating equipment.

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 the 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. Airconditioning of railway coaches is, therefore, necessary for the maximum comfort and well being of passengers in railway travel. In keeping with modern trend, airconditioning of coaches for upper class travellers and lately even for lower class travellers has been introduced by the Indian Railways.

SPECIAL PROBLEMS FACED IN RAIL AIRCONDITIONING

As compared to the normal buildings, air conditioning of Railway coaches poses the following additional problems:

- Requirement of very high reliability standard.
- Equipment should be light in weight.
- Equipment should take minimum space.
- Available power, generally at 110V D.C. has to be utilised. 415 V, 50 Hz, 3 Ph, industrial power is available only on a few nominated trains like Rajdhani and Shatabdi Express. However, in such cases, the flexibility of attaching and detaching coaches is lost.
- Due to large number of passengers in small space, the space left for air circulation is limited.
- In the Railway coaches, where people move in and out at all hours of the day, sudden changes in temperature, which may cause chill or heat are to be avoided.
- 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.
- Safety of passengers and trains.
- Dirty environment for the maintenance staff.
- Restricted time available for maintenance. All these problems have to be solved, within a comparatively small outlay, so that air conditioned travel becomes more common.

REQUIREMENTS OF RAILWAY COACH AIRCONDITIONING SYSTEM

- 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 heating as well as cooling for a train that travels through areas of widely differing climate during its journey.
- Operation of the equipment from the power generated, stored and controlled on the train.

AC EQUIPMENT IN RAILWAY COACHES

This consists of the following:

- Evaporator Unit.
- Compressor.
- Condenser Unit.
- Gauge panel.
- AC control panel.
- Air Duct.
- Refrigerant piping & joints.

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 the quantity of high pressure liquid refrigerant and allows to expand to a lower pressure corresponding to the load demand. 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 settings 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.

*Gauge panel - Gauge panel consists of pressure gauges (HP, LP, and OP) and pressure cut-outs to protect the compressor against (i) High pressure, (ii) Low pressure and (in) low oil pressure. 5.7.5 High pressure cut-out. It is a safety device against build up of excessive delivery pressures and protects the compressor and piping system from damage. It is a pressure operated switch which switches off the compressor drive motor when the pressure exceeds a preset value (17.6 Kg/cm2). The plant cannot be restarted unless the cut-out is reset manually.

*Low pressure cut-out

It is also a pressure operated switch similar to the H.P. cut-out switch, but it shuts down the compressor if the suction pressure drops down below 0.7 Kg/cm2 . It protects the system against unduly low evaporator temperatures and formation of frost on the evaporator. No manual reset is provided on this and therefore the compressor starts automatically if the suction pressure rises above the pre-set value.

Low oil pressure cut-out - It ensures adequate lubrication of compressor to avoid piston seizure due to less lubricating oil or failure of oil pump. This cut-out is set at 2.5 Kg/cm2 . 5.7.8 AC control panel. The control of the air-conditioning system is achieved by means of air conditioning control panel. The design of the various elements in the control panel takes into account the system safety requirements.

*The safety requirements for the operation of the AC system are listed as under:

a. The working of blower fan of the evaporator and the blower fan of the condenser have to be ensured before the compressor starts functioning.

b. Suitable protection to ensure adequate lubrication of compressor to avoid piston seizure.

c. The excessive pressure on the discharge side of the compressor (High Head Pressure) should be avoided.

d. The suction pressure should not be lower than 0.7 Kg/cm2 to prevent frosting of the evaporator. ie. The compressor motor has to be soft started to limit the sudden in rush of starting current.

f. A suitable interlock has to be provided to ensure that heater is not on, when the compressor is working.

g. A low voltage protection for compressor motor to ensure that voltage does not go below 100 volts in order to avoid undue drain on battery.

h. The blower fan has to come ‘ON’ before the heater comes ‘ON’. Over load protection and short circuit protection for all electrical circuits. The AC control panel incorporates all the above safety requirements.

*CLEAN ROOM

A cleanroom is a controlled environment where products are manufactured. It is a room in which the concentration of airborne particles is controlled to specified limits. Eliminating sub-micron airborne contamination is really a process of control. These contaminants are generated by people, process, facilities and equipment. They must be continually removed from the air. The level to which these particles need to be removed depends upon the standards required. A **cleanroom** is an environment, typically used in manufacturing, including pharmaceutical products or scientific research, with a low level of environmental pollutants such as dust, airborne microbes, aerosol particles, and chemical vapours.

CLEAN ROOM APPLICATION AREAS

- Critical areas like operation theatres, post operative rooms ICU’ s etc, in hospitals
- Certain pharmaceutical processes like manufacture of antibiotics, injectibles etc
- Fabrication of microscopically small sub assemblies

- Electronic industry – manufacture of integrated circuits, electronic devices, instruments
- Space research, defence labs, scientific research are typical examples

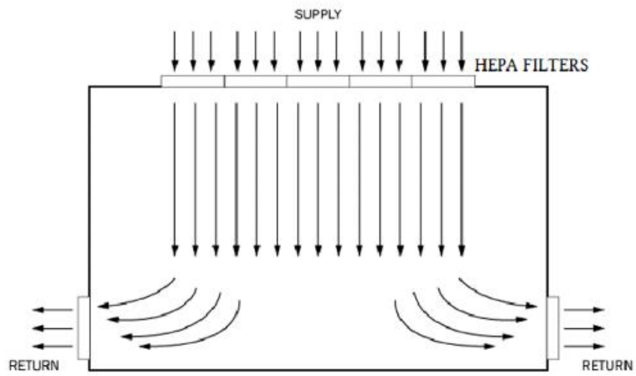
CLEAN ROOM CLASSIFICATIONS

Clean rooms are not dust/ particle free, and so are classified according to the numerical count of particles of specified dimensions in the unit volume of air. More accurately, a cleanroom has a controlled level of contamination that is specified by the number of particles per cubic meter at a specified particle size. To give perspective, the ambient air outside in a typical urban environment contains 35,000,000 particles per cubic meter in the size range 0.5 ìm and larger in diameter, corresponding to an ISO 9 cleanroom, while an ISO 1 cleanroom allows no particles in that size range and only 12 particles per cubic meter of 0.3 ìm and smaller.

Class	maximum particles/m³						FED STD 209E equivalent
	>=0.1 µm	>=0.2 µm	>=0.3 µm	>=0.5 µm	>=1 µm	>=5 µm	
ISO 1	10	2					
ISO 2	100	24	10	4			
ISO 3	1,000	237	102	35	8		Class 1
ISO 4	10,000	2,370	1,020	352	83		Class 10
ISO 5	100,000	23,700	10,200	3,520	832	29	Class 100
ISO 6	1,000,000	237,000	102,000	35,200	8,320	293	Class 1,000
ISO 7				352,000	83,200	2,930	Class 10,000
ISO 8				3,520,000	832,000	29,300	Class 100,000
ISO 9				35,200,000	8,320,000	293,000	Room Air

AIR FLOW PATTERN IN A CLEAN ROOM

Laminar air flow refers to the air that flows in a straight, unimpeded path. Unidirectional flow is maintained in clean rooms through the use of laminar air flow hoods that direct air jets downward in a straight path, as well as clean room architecture, that ensures lessened turbulence. Laminar air flow utilizes HEPA filters to filter and clean all air entering the environment. Laminar filters are often composed of stainless steel or other non-shed materials to ensure that the amount of particles entering the facility remains low. These filters usually compose roughly 80 percent of the ceiling space. Clean rooms employing laminar air flow are typically referred to as Unidirectional Airflow Clean rooms.



AIR FILTERATION METHODS

Pre-filters, fine filters and HEPA filters are used for filtering the supply air to the clean rooms.The pre-filters remove big particles and fabrics down to the size of 10 to 20 microns. The second stage of filteration is by fine filters (Electric filters) which arrest particulates up to three to five micron size. The fine filters are used to prolong the life of HEPA filters which do the final filtering to about 0.3 micron size. Clean rooms employ air filtration to limit the particles in the environment air. Typically, this is through the use of either a highly efficient particulate air (HEPA) or ultra low particulate air (ULPA) filter. These filters can remove roughly 99.9 percent of all micro-particles in room air by applying either laminar air flow or turbulent air flow techniques to the environment air.

Air conditioning requirements in hospitals

Proper air conditioning is helpful in the prevention and treatment of diseases. The factors determining the need for air conditioning in hospital facilities are:

(a) The need to restrict air movement within and between various departments.

(b) The specific requirements for ventilation and filtration to dilute and remove contaminants in the form of airborne microorganisms, viruses, odour, hazardous chemicals and radioactive substances.

(c) Different types of temperature and humidity requirements for various areas.

(d) Permit accurate control of environmental conditions.

(e) Control of air quality and air movement.

Indoor Air Quality in Hospitals

Indoor air quality in hospitals is a complex multi-faceted issue. Contaminants come with dust, air and visitors as well as originate inside the hospital complex and threaten the quality of environment. Most common contaminants are microbes and organic compounds. Ventilation and filtration provides means of combating contaminants by diluting their concentration.

Acceptable indoor air quality can be achieved by following the fundamental principles:

(a) Contaminant source control.

(b) Proper ventilation.

(c) Humidity management.

(d) Adequate filtration

The temperature and humidity conditions in a hospital environment can inhibit or promote the growth of bacteria and activate or deactivate viruses. Ventilation systems are used to provide air virtually free of dust, dirt, odour, chemicals and radioactive pollutants.

Contamination can be dispersed into the air of the hospital environment by one of the many routine activities of normal patient care. Because of the dispersal of bacteria resulting from such necessary activities, air-handling system should provide air movement patterns to minimise the spread of contamination.

The sense of thermal comfort results from an interaction between temperature, relative humidity, air movement, clothing, activity levels and individual physiology. The temperature and relative humidity measurements are indicators of thermal comfort. The medical need cares of patients require thermal comfort provided by air conditioning system.

Operating Room Air Conditioning Requirements

The primary task of the ventilation system in an operating room is to provide an acceptable indoor climate for personnel and patients, to remove odour, released anaesthetic gases and to reduce the risk of infection in the operating area. The greatest amount of bacteria found in operating rooms comes from the surgical team and is a result of their activity during surgery.

During an operation, most members of the surgical team are in the vicinity of the operating table, creating the undesirable situation of concentrating contaminants in this highly sensitive area. Studies of operating room air distribution systems and various air delivery systems indicate that these are the most effective methods for air movement pattern in operation theatres for limiting the concentration of contaminants to an acceptable level.

Theatre air conditioning

Same as that of DX system explained in Module 3

REEFER REFRIGERATED CONTAINERS

Refrigerated and insulated containers are mainly available as 20' and 40' containers.

1. Integral Unit (Integral Reefer Container,Integrated Unit)

This type of refrigerated container has an integral refrigeration unit for controlling the temperature inside the container. The refrigeration unit is arranged in such a way that the external dimensions of the container meet ISO standards and thus fit into the container ship cell guides. The presence of an integral refrigeration unit entails a loss of internal volume and payload.When being transported by ship, integral units have to be connected to the on-board power supply system. The number of refrigerated containers which may be connected depends on the capacity of the ship’s power supply system. If the aforesaid capacity is too low for the refrigerated containers to be transported, “power packs” may be used, which are equipped with relatively large diesel generators and satisfy ISO requirements with regard to the dimensions of a 20’container. When at the terminal, the containers are connected to the terminal’s power supply system. For transport by road and rail, most integral unit refrigeration units are operated by a generator set (genset). This may either be a component of the refrigeration unit or connected to the refrigeration unit.Air flows through the container from bottom to top. In general, the “warm” air is drawn off from the inside of the container, cooled in the refrigeration unit and then blown back in to the container as cold air.To ensure adequate circulation of the cold air, the floor is provided with gratings. Pallets form an additional space between the container floor and the cargo, thus forming a satisfactory air flow channel. In addition, the side walls of the container are “corrugated”, which ensure satisfactory air flow there too. In the upper area of the container, adequate space (at least 12 cm) must likewise be provided for air flow. For this purpose, during the packing of the container adequate free space must be left above the cargo. The maximum load height is marked on the side walls.To ensure vertical air flow from bottom to top, packaging must also be appropriately designed and the cargo must be sensibly stowed. In addition to temperature regulation, integral units also allow controlled fresh air exchange, for example, for the removal of metabolic products such as CO_2 and ethylene in the case of the transport of fruits.In the refrigeration units, both the supply and return air temperatures are measured and, depending on the operating mode, one of these values is used to control the cold air. Temperature measurement may be performed in various ways. The Partlow recorder generally records return air temperature, since this provides an indication of the state or temperature of the cargo. Data loggers are increasingly used, which detect temperature digitally and indicate it on a display. Once transferred to a PC, the data may then be evaluated. The temperature display is attached to the outside of the refrigeration unit, so that operation of the unit may be checked at any time.Digital or analog recorders may also be positioned directly in the cargo, so as to measure temperatures inside the container. The recorder should be accommodated in such a way that it records the temperatures at risk points in the container (inside the packaging, top layer at door end).Integral units may be stowed both above and below deck on a ship. Above deck stowage has the advantage that the heat from return air may be more readily dissipated. However, the containers are often exposed to strong solar radiation,leading to increased refrigeration capacity requirements.

HVAC (heating, ventilating, and air conditioning; also heating, ventilation, and air conditioning) is the technology of indoor and vehicular environmental comfort. Its goal is to provide thermal comfort and acceptable indoor air quality. HVAC system design is a sub discipline of mechanical engineering, based on the principles of thermodynamics, fluid mechanics, and heat transfer. Refrigeration is sometimes added to the field's abbreviation as HVAC&R or HVACR, (heating, ventilating and air-conditioning & Refrigeration) or ventilating is dropped as in HACR (such as the designation of HACR-rated circuit breakers).

HVAC is important in the design of medium to large industrial and office buildings such as skyscrapers, onboard vessels, and in marine environments such as aquariums, where safe and healthy building conditions are regulated with respect to temperature and humidity, using fresh air from outdoors. Ventilating or ventilation (the V in HVAC) is the process of "exchanging" or replacing air in any space to provide high indoor air quality which involves temperature control, oxygen replenishment, and removal of moisture, odours, smoke, heat, dust, airborne bacteria, and carbon dioxide. Ventilation removes unpleasant smells and excessive moisture, introduces outside air, keeps interior building air circulating, and prevents stagnation of the interior air. Ventilation includes both the exchange of air to the outside as well as circulation of air within the building. It is one of the most important factors for maintaining acceptable indoor air quality in buildings.

Practical

1. Identifying the components of an automobile airconditioner
2. Study of Railway air conditioning.(Field visit)

SERVICING OF AUTOMOBILE AIR CONDITIONER

AIM:- To study and service the components of an automobile air conditioner.

Tool, materials and equipments required

Screw driver, combination plier, spannerset, multimeter, clamp meter, cotton waste…etc…

Procedure

1. Take the Automobile AC system to a safe and convenient place.
2. Clean the outer surface of Auto AC system by a clean cloth.
3. Open the front cover carefully.

4. Observe the components thoroughly.
5. Identify the components and controls and record their names with the locations, functions and specifications.
6. Observe the details of all components.
7. Find out the faults of components, if any.
8. Service the faulty components or replace them.
9. Clean all the components.
10. Close the front cover with care.

ASSESSMENT

In a car AC, the compressor and evaporator blower are working, but do not get sufficient cooling. Find the trouble.

TE QUESTIONS

1. The expansion device used in an Automobile AC is :

   (a) Automatic expansion value (b) Thermostatic expansion

   (c) Capillary tube. (d) Low side float value.

2. In an automobile, to connect and disconnect the drive to the compressor __________ is used.
3. The refrigerant used in an Automobile AC is:

   a) R-134a b) R-22 c) R-500 d) Ammonia

4. What are the possible reasons for refrigerant leakage in a car AC?
5. What are the reasons for poor cooling in a vehicle ?
6. The filters used in a clean room AC are called _________ .
7. In a railway air conditioning system, power is generated from _________ .

UNIT 4.4

REFRIGERATION AND AIR CONDITIONING CONTROLS

The unit details about different controls used in refrigeration and air-conditioning like pressure controls and oil pressure failure controls, solenoid valves, Variable speed drives, Humidity controls, humidistat, and humidity sensors.

Learning outcome

The learner :

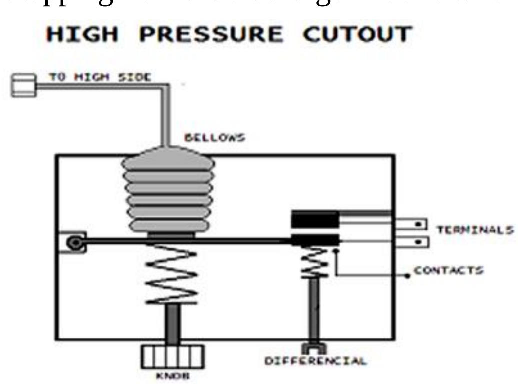
Study different types of relays, control components and variable speed drives

PRESSURE CONTROLS

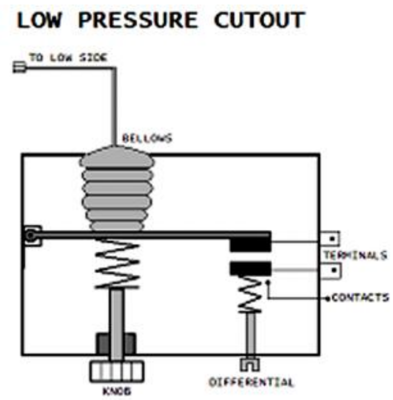
Pressure controls can also be used as protective devices. Low-pressure controls can protect compressors from excessive low pressure situations as the case of a coil freeze-up or lost refrigerant charge. Low-pressure controls can also protect water chillers from freeze-ups. High-pressure controls can protect compressors and system components from dangerously high-pressure situations by shutting the compressor off at certain elevated pressures.

High Pressure Cut-Out

High pressure can be caused in a refrigeration plant due to various reasons like over charge, loss of cooling water, high ambient temperature, air, or other incompressible gases in the system, and obstruction in the discharge line of the compressor. For protecting the compressor from high pressure and subsequent failure, a high pressure cut out is provided that take a pressure tapping from the discharge line and when it detects an over pressure, it stops the compressor. The HP cut-out is not resettable automatically but has to be reset manually by the operator. This is because the high pressure is a serious fault and the cause must be investigated and corrected before the plant gets started again.



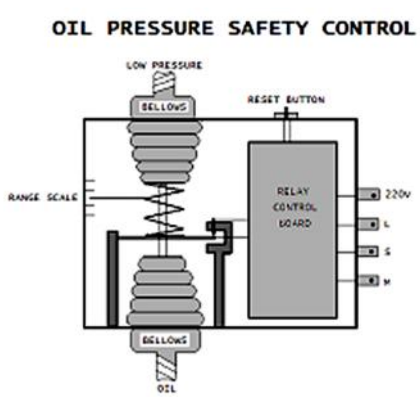
Low Pressure Cut-Out



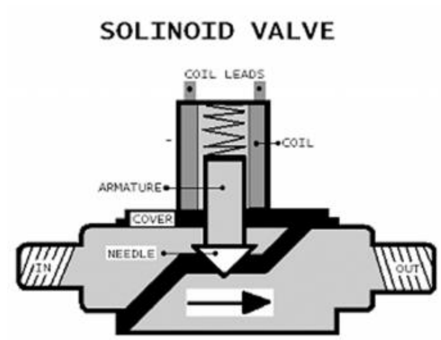
To protect the compressor against low pressure in the system and to avoid the ingress of air into the system if a vacuum is generated in the lines, a low pressure cut-out is provided. Also when the refrigerated compartments are cut off by the solenoids and there is no return gas, the low pressure cut-out is activated. When the solenoid of the refrigerated compartments open, the return gas comes in through the inlet of the compressor and the suction pressure rises, and then the low pressure switch cuts off the compressor. Unlike the high pressure cut out, the low pressure cut out is self-resettable and does not need to be reset manually.

OIL PRESSURE FAILURE CONTROL VALVES

The oil pressure safety control is a switch which disconnects the compressor motor if there is pressure difference between the two opposite bellows, one is connected to the low pressure side and the other connected to where the oil pressure build goes below the required oil pressure. There are several types of oil safety control devices the market today. The two basic controls most familiar with are the mechanical differential control and the pressure-sensing electronic control. The mechanical control uses tubing that senses the suction pressure of the compressor and the outlet oil pressure of the pump. The electronic control has a special pressure sensor that mounts the outlet of the pump and connects only with an electric cable. In the mechanical control, the total pressure from the pump (less the suction pressure) is the actual net oil pressure. The control requires a manual reset, once it is tripped. In the electronic control, the pressure sensor sends a signal to the control module whenever the pressure sensed falls below 7 from 9 psig. This signal causes the control module to open the safety contact points after a time delay. This control also requires manual reset, once it is tripped. In both controls, the opening of the safety contacts breaks the electric current in the system control circuit.



SOLENOID VALVES

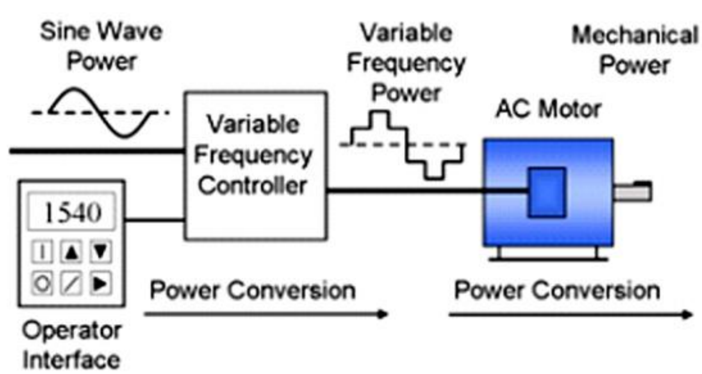


A solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current through a solenoid: in the case of a two-port valve the flow is switched on or off; in the case of a three-port valve, the outflow is switched between the two outlet ports. Solenoid valves are the most frequently used control elements in fluidics. Their tasks are to shut off, release, dose, distribute or mix fluids. They are found in many application areas. Solenoids offer fast and safe switching, high reliability, long service life, good medium compatibility of the materials used, low control power and compact design. Besides the plunger-type actuator which is used most frequently, pivoted-armature actuators and rocker actuators are also used.

VARIABLE SPEED DRIVES

The speed of standard induction motors can be controlled by variation of the frequency of the voltage applied to the motor. A variable-frequency drive (VFD) (also termed adjustable-frequency drive, variable-speed drive, AC drive, micro drive or inverter drive) is a type of adjustable-speed drive used in electro-mechanical drive systems to control AC motor speed and torque by varying motor input frequency and voltage.

Variable speed drives can have an integrated motor in a packaged configuration. The "packaged" drive consists of the adjustable speed section and an electric motor. The unit may also include a geared reducer. Choices for motor input include 115/ 120V 60Hz, 208-230 / 240V 60 Hz,460 / 480 V 60Hz, 575/600 V 60Hz, 50 Hz/ International Power, DC motor, and hydraulic motor. The phase for variable speed drives can be single or three phase. Special or extreme environments that variable speed drives can be configured for include clean room, cryogenic, explosion-proof, radiation hardened, vacuum use, and wash down duty.



HUMIDITY CONTROLS

Humidity control systems add or remove water vapour from the indoor air to stay within proper humidity ranges.

Humidity control is important for three reasons:

1. It is a large factor in people's thermal comfort.
2. Excess moisture in a building can lead to mould and mildew, causing problems indoor air quality.
3. It is a large energy user. De-humidification alone can be a quarter to a third of cooling energy in humid climates or seasons.

To keep humidity within comfort range, the building's thermostats should have humidity sensors in them. If they do not, you can specify separate hygrometer systems that can control humidifiers and de-humidifiers separately from the rest of the HVAC system.

The air inside a building can be very different from the air outside it. The enclosed nature of a building can cause pollution and allergens to build up inside a home. In addition, the use of air conditioning, heaters, stoves, baths, and similar items can dramatically change the humidity of the air. In order to keep the air inside buildings more comfortable, different methods of humidity control were developed. Some of these methods include humidifiers, de-humidifiers, vaporizers, and exhaust fans.

There can be physical consequences of having too little humidity inside a house. Like many natural processes, humidity travels from high concentration to low concentration. Thus, the lack of humidity in the air can result in the air stealing moisture from you, leading to chapped lips and dry noses. To counteract this, different humidity control methods are available to add humidity into the air. Some of these humidity control devices are humidifiers and vaporizers.

There are several types of humidifiers in the market. Some of them are evaporative, ultrasonic, impeller, and steam humidifiers. In some cases, such as impeller humidifiers, you may see the moisture rising from the product in the form of fog. Steam humidifiers are also known as vaporizers and add moisture to the air by boiling water. Medicine and herbs can also be added to a vaporizer, which can be of immense help it there is a sick person in the building.

HUMIDSTAT

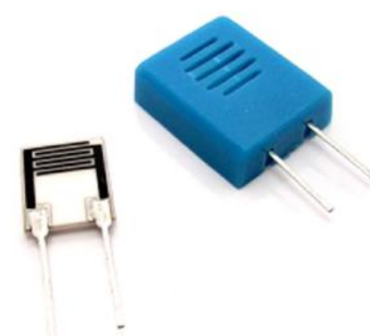
A machine or device which automatically regulates the humidity of the air in a room or building.

An electronic device analogous to a thermostat but responds to relative humidity, and not temperature. Humidistats are used in a number of devices including de-humidifiers, humidifiers, and microwave ovens. In humidifiers and de-humidifiers the humidistat is used, where constant relative humidity conditions need to be maintained such as in a refrigerator, greenhouse, or climate controlled warehouse. When adjusting the controls in these applications the humidistat would be with what is being set. In microwaves they are used in conjunction with “smart cooking” 1-button features such as those for microwave popcorn. Humidistats employ hygrometers, but are not the same as hygrometers. A humidistat has the functionality of a switch and is not just a measuring instrument like a hygrometer.

For Heating Ventilating and Air Conditioning (HVAC) of buildings, humidistats or humidity sensors are used to sense the air related humidity in the controlled space and thereby turn on and off the HVAC equipment. In fact, the work principal of a humidistat is very simple. If there are any variations in the relative moisture, an electrical resistance will be caused between the conductor sets that are mounted on the sensing element. The quantity of the electrical resistance can be precisely predicted by the alternate metal conductors according to the relative humidity. And the relay amplifier will measure the resistance, so that it can turn the humidifier on if the electrical resistance shows the humidity below the optimal level, or turn off the humidifier if the ideal level is achieved.

HUMIDITY SENSORS

Humidity is the presence of water in air. The amount of water vapour in air can affect human comfort as well as many manufacturing processes in industries. The presence of water vapour also influences various physical, chemical, and biological processes. Humidity measurement in industries is critical because it may affect the business cost of the product and the health and safety of the personnel. Hence, **humidity sensing** is very important, especially in the control systems for industrial processes and human comfort.



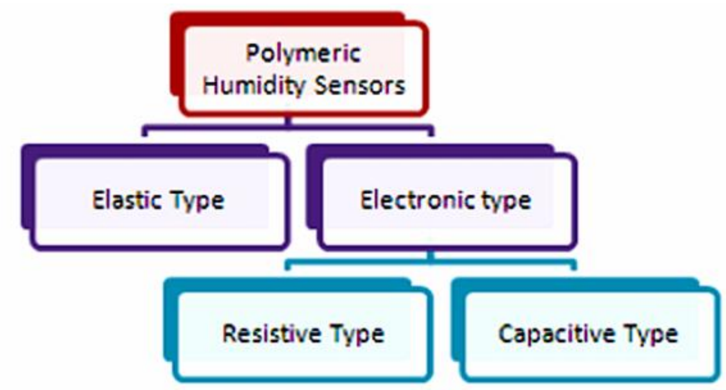
HUMIDITY SENSING – CLASSIFICATION & PRINCIPLES

According to the measurement units, humidity sensors are of two types: Relative humidity(RH)sensors and absolute humidity(moisture) sensors. Most humidity sensors are relative humidity sensors and use **different sensing principles**.

Sensing Principle

Humidity measurement can be done using dry and wet bulb hygrometers, dew point hygrometers, and electronic hygrometers. There has been a surge in the demand of electronic hygrometers, often called humidity sensors.

Electronic type hygrometers or humidity sensors can be broadly divided into two categories: one employs capacitive sensing principle, while the other uses resistive effects.



Sensors based on capacitive effect:

Humidity sensors relying on this principle consists of a hygroscopic dielectric material sandwiched between a pair of electrodes forming a small capacitor. Most capacitive sensors use a plastic or polymer as the dielectric material, with a typical dielectric constant ranging from 2 to 15. In the absence of moisture, the dielectric constant of hygroscopic dielectric material and the sensor geometry determines the value of capacitance.

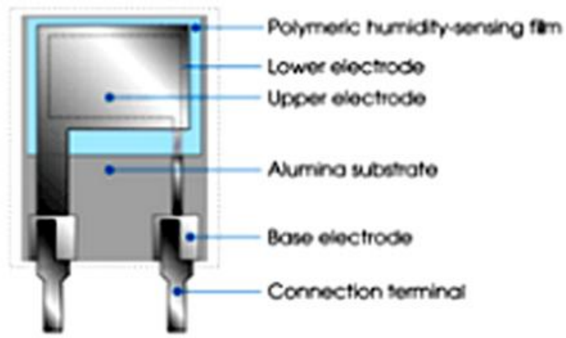
At normal room temperature, the dielectric constant of water vapour has a value of about 80, a value much larger than the constant of the sensor dielectric material. Therefore, absorption of water vapour by the sensor results in an increase in sensor capacitance.

At equilibrium conditions, the amount of moisture present in a hygroscopic material depends on both the ambient temperature and the ambient water vapour pressure.

This is true also of the hygroscopic dielectric material used on the sensor.

By definition, relative humidity is a function of both the ambient temperature and water vapour pressure. Therefore, there is a relationship between relative humidity, the amount of moisture present in the sensor, and sensor capacitance. This relationship governs the operation of a capacitive humidity instrument.

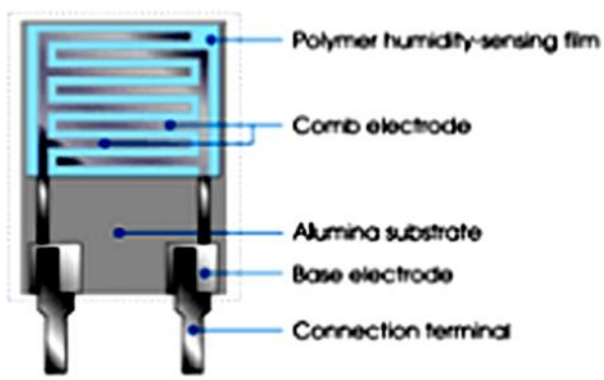
The basic structure of a capacitive type humidity sensor is shown below:



On an alumina substrate, lower electrode is formed using gold, platinum or other material. A polymer layer such as PVA is deposited on the electrode. This layer senses the humidity. On the top of this polymer film, a gold layer gets deposited which acts as a top electrode. The top electrode also allows water vapour to pass through it, into the sensing layer. The vapours enter or leave the hygroscopic sensing layer until the vapour content is in equilibrium with the ambient air or gas.Thus capacitive type sensor is basically a capacitor with humidity sensitive polymer film as the dielectric.

Sensors based on Resistive effect:

Resistive type humidity sensors pick up changes in the resistance value of the sensor element in response to the changes in the humidity. The basic structure of a resistive type humidity sensor from TDK is shown below :



A thick film conductor of precious metals like gold, ruthenium oxide is printed and calcinated in the shape of the comb to form an electrode. Then a polymeric film is applied on the electrode; the film acts as a humidity sensing film due to the existence of movable ions. A change in impedance occurs due to the change in the number of movable ions.

Practical

1. Study of thermostatic expansion valve

Aim:- To study the components of a TEV, and its common faults, causes and remedies.

Tools, Materials required:-

A thermostatic expansion valve.

A TEV keeps the evaporator supplied with enough refrigerant to satisfy all load conditions.

It is not a temperature control or suction pressure control, but a control to vary the compressors running time, or humidity control. Checking the superheat is the first step in a simple and systematic analysis of TEV performance.

The following are the typical valve complaints, causes and remedies.

1. Valve does not feed enough refrigerant.
2. Valve feeds too much refrigerant.
3. Valve feeds too much refrigerant at start up only.
4. Valve does not feed properly.
5. System hunts or cycles.

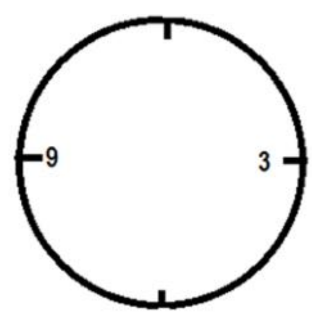


***Fig**: Element positioning of TEV*

2. TESTING AND ADJUSTING OF TEV

AIM:- To study the testing and adjusting of thermostatic expansion valve.

Tools, materials and equipments required.

High pressure gauge, Compound gauge, Shutoff valve, Adjustable wrench, Pressure regulator, Service cylinder, Flare nuts, Tee, Cracked ice, Copper tubes, Orifice, Thermostatic expansion valve.

Procedure:-

1. Connect the inlet of the TEV to the refrigerant cylinder with a hand shutoff valve and high pressure gauge.
2. Connect the outlet of the TEV to a pressure regulator to reduce pressure fluctuations.
3. Insert the feeler bulb in to the crushed ice.
4. Open the refrigerant cylinder valve and hand shutoff valve and build up a pressure of 70 Ps on the high pressure gauge.
5. Adjust the TEV.The Pressure at the outlet should be equal to the pressure of the refrigerant to be charged in the system at a temperature of 32 degree super heat temperature.

Testing of TEV

- Close the orifice and stop the leakage.
- If the pressure at the outlet increases a few pounds, and then either stops or build up slowly, the valve is not leaking.
- Take the thermal bulb from the ice and warm it by hand. If the pressure is increasing rapidly, power element is functioning properly.

3. Testing of a box type relay/ combination relay.
4. Testing of LMS relay.
5. Testing of PTC Relay.
6. Testing of a Voltage relay
7. Testing of Over load protector
8. Testing of a thermostat.

ASSESSMENT

Give ice, test lamp, and thermostat to students and ask to demonstrate the cut-out and cut-in temperature.

TE QUESTIONS

1. The temperature of a refrigerated space is controlled by ____________.
2. In a CSR motor, __________ relay is used.
3. State whether the statement is TRUE OR FALSE.
   a. The capacity of a starting capacitor is higher than a running capacitor.
   b. A selector switch is the ON-OFF control of an AC system.
   c. A relay coil is connected parallel to the motor running winding.
   d. In a window AC the refrigerant control is the capillary tube.
   e. In a window AC separate motors are used for condenser and evaporator.
4. A high pressure cut out is fitted in __________ pressure side of the refrigeration system.

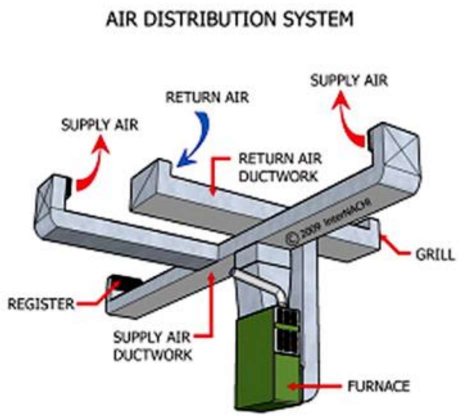
UNIT 4.5
TRANSMISSION AND DISTRIBUTION OF AIR

The unit explains different types of ducting systems used in air-conditioning.

Learning outcome

The learner :

Compare and explain various ducts, duct outlets and different duct arrangements.



In air conditioning systems the 'duct' is considered a static component of the installation through which air flows within the building, connecting all parts of the system and via used or exhaust air is discharged.

The a dvantages of Air Duct System

- Centralized filtration
- Humidity control
- Quiet operation – air handling equipment is centrally located allowing much simpler acoustic design
- Return air passing through the central treatment unit, is re-filtered and humidified, increasing air quality
- Fresh air replenishment from a external intake point, located to minimize the influence of wind turbulence and avoid contamination with discharging exhaust air
- Centralized maintenance and easy installation – filters, humidity systems, mobile heat exchangers and equipment all located in the same area
- Multi-area control options

Classification of ducts

Ducts are classified based on the load on duct due to air pressure and turbulence. The classification varies from application to application, such as for residences, commercial systems, industrial systems and so on. For example, one such classification is given below:

Low pressure systems: Velocity d" 10 m/s, static pressure d" 5 cm H2O

Medium pressure systems: Velocity d" 10 m/s, static pressure d" 15 cm H2O

High pressure systems: Velocity > 10 m/s, static pressure 15 < p < 25 cm H2o

High velocities in the ducts result in:

1. Smaller ducts and hence, less initial cost and less space requirement
2. Higher pressure drop and hence larger fan power consumption
3. Increased noise and hence need for noise attenuation. Recommended air velocities depend mainly on the application and the noise criteria.

Typical recommended velocities are:

Residences : 3 m/s to 5 m/s

Theatres : 4 to 6.5 m/s

Restaurants : 7.5 m/s to 10 m/s

If nothing is specified, then a velocity of 5 to 8 m/s is used for main ducts and a velocity of 4 to 6 m/s is used for the branches. The allowable air velocities can be as high as 30 m/s in ships and aircrafts to reduce the space requirement.

DUCT MATERIALS

Ducting may be categorized according to the materials of construction and are either metallic or non-metallic. The majority of ducts are constructed of metal and installed by tradesmen called sheet metal workers. In fact, sheet metal use in HVAC is greater than all the other materials combined together. The steel and aluminum used for ductwork is a "high achiever" in the 21st-century move toward sustainable buildings because of the high recycling rates and cleanliness.

Metallic Ducts

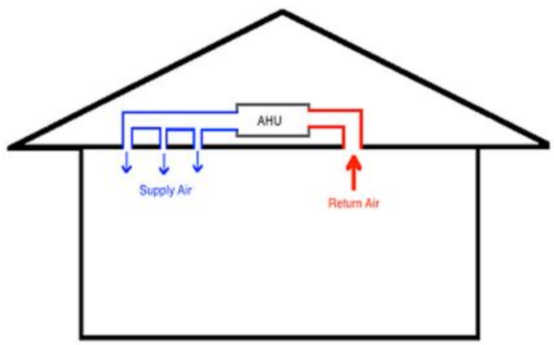
1. Galvanized Steel
2. Carbon Steel (Black Iron)
3. Aluminium

4. Stainless Steel
5. Copper

Non metallic ducts

1. Fibreglass Reinforced Plastic (FRP)
2. Polyvinyl Chloride (PVC)
3. Polyvinyl Steel (PVS)
4. Flexible Nonmetallic Duct
5. Concrete
6. Rigid Fibrous Glass

SUPPLY AIR DUCTS



SUPPLY DUCT CONFIGURATIONS The configuration of a duct system is often like a tree with branches connected to the terminal units and a fan located at the root. In reality, the ductwork forms a double tree because the fan is in the middle of the supply and return/outside air parts of the system. The two most common supply duct systems are the 'extended plenum' system and the 'radial' system because of their versatility, performance, and economy.

SUPPLY DUCT ARRANGEMENT SYSTEM

The duct systems carry the conditioned air from the air handling equipment to the air supply openings in the room . The different duct arrangement systems of the supply air duct system are given below

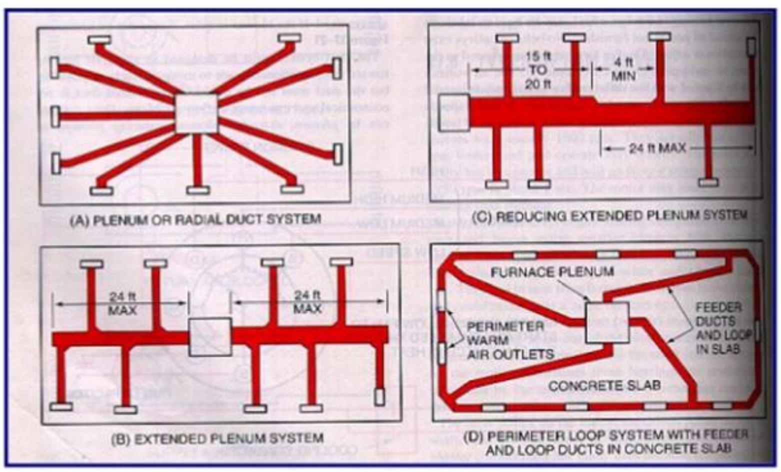
LOOP PERIMETER/ RADIAL PERIMETER SYSTEM

The perimeter system may be of loop type or radial type as shown in the figure. The conditioner is usually placed in the basement and is located near the geometric centre of all outlets. The supply outlets are placed close to the ceiling level. The ducts run through the basement, building, foundation lab, floor and connect with the air conditioner for supplying to the outlet grills.

EXTENDED PLENUM SYSTEM

The arrangement of this duct system is shown in the figure. The advantage of this system is that grills can be located at any point as per structural demands. The air conditioner unit may be located in the attic , in the basement or any other convenient place . This system can be used either for residential or commercial purposes.

SUPPLY AIR DUCT SYSTEM



(A) Plenum system. (B) Extended plenum system.

(C) Reducing extended plenum system. (D) Perimeter loop system.

RETURN AIR DUCTS

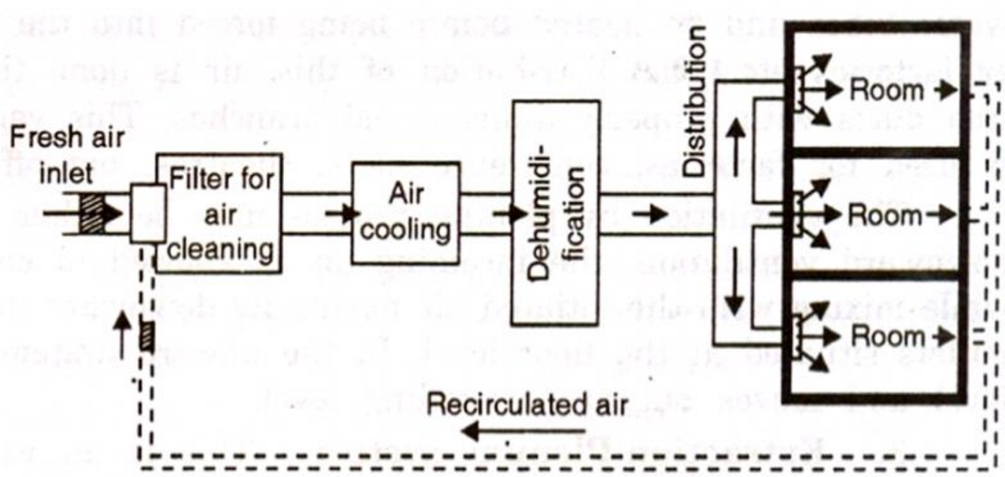
Return ducts are an integral part of nearly all heating, ventilating and air conditioning (HVAC) systems. Generally, HVAC systems use a forced air process that blows heat or air through ductwork. Return ducts are usually located either in a hallway or ceiling, and their purpose is to extract air from the room and recycle it through the system where it is further conditioned, either by heating or cooling. The main thing the duct does is to pull the air out of a room. In summer it will pull out air that is cold, whereas in winter it will pull out air that is hot and humid. In most cases, different ducts will re-circulate warm or cool air to bring the building to the optimum temperature.

FRESH AIR DUCTS

Adding fresh air to a heating or cooling system accomplishes two primary indoor air quality goals: It pressurizes a building, and increases indoor air quality by diluting polluted or stale indoor air. Adding a fresh air inlet to most systems is typically a simple and relatively inexpensive proposition. Fresh air ducts are used for carrying fresh air to mix with the re-circulated air.

PRESSURE LOSSES IN DUCTS

The schematic diagram of an air conditioning system is shown in the figure. The flow of air within the duct system is produced due to the pressure differences in different locations. The greater the pressure difference, the faster will be the air flow. The following are the three kinds of pressure evolved in a duct system.



1. Static pressure - The static pressure always exist in a duct system. Since it is not dependent upon the air movement, it is called static (stationary) pressure. This type of pressure pushes against the walls of the duct. It tends to burst a duct when it is greater than the atmospheric pressure and tends to collapse the confining envelope when its force is less than that of the atmosphere. The static pressure overcomes the friction and shock losses, when the air flows from the delivery of the fan to the outlet of the duct.

2. Dynamic or Velocity Pressure - The dynamic or velocity pressure is equal to the drop in the static pressure needed to produce a given velocity of flow. Conversely, it is equal to the possible increase in static pressure, when the velocity is reduced to zero.

3. Total Pressure - The total pressure is the algebraic sum of the static pressure and dynamic or velocity pressure.

   Mathematically total pressure of air $P_T = P_S + P_V$

   P_S = Static pressure of air

   P_V = Dynamic pressure or velocity pressure

Pressure is lost due to friction between the moving particles of the fluid and the interior surface of a duct. When the pressure loss occurs in a straight duct , it is usually termed as friction loss. The pressure is also lost dynamically at the changes of direction such as in bends, elbows etc and at the changes of cross section of the duct. This type of pressure loss is usually termed as dynamic loss.

DUCT DESIGN METHODS

The main goal of designing HVAC duct system is to use the lowest cost (read smallest) duct sizes without violating certain sizing constraints. First hand operating cost considerations dictate that duct systems should be designed to operate at the lowest possible static pressure. The most widely used method to size duct is equal friction loss method. The other methods are velocity reduction method and static regain method.

Equal friction Loss Method

A proper speed is selected in the main duct close to the fan. The pressure loss in the main duct is then used as a template for the rest of the system. The pressure (or friction) loss is kept at a constant level and automatic velocity reduction is maintained throughout the system. More duct cross-sectional changes can be added and the number of components increased in this system compared to other methods.

The equal friction method for sizing air ducts is often preferred to because it is quite easy to use. The method can be summarized as :

1. Compute the necessary air volume flow *(m^3/h, cfm)* in every room and branches of the system.
2. Use to compute the total air volume *(m^3/h, cfm)* in the main system.
3. Determine the maximum acceptable airflow velocity in the main duct.
4. Determine the major pressure drop in the main duct.
5. Use major pressure drop for the main duct as a constant to determine the duct sizes throughout the distribution system.

6. Determine the total resistance of the duct system by multiplying the static resistance with the equivalent length of the longest run.
7. Compute balancing dampers.

Advantages

1. If the duct layout is symmetrical giving the same length in each run , then no dampers are required to balance the system as this method gives equal pressure loss in various branches.

Disadvantages

1. If the runs are of different length , then the shortest run will have the minimum drop and air will come out with higher pressure compared the long run ducts
2. It makes it necessary to reduce the high pressure of the air coming out with the help of dampers or high velocity can be reduced in the shorter run but may create an objectionable noise, therefore noise absorbing outlets must be provided.
3. This method doesnot balance pressures at the outlets if the length of the runs are different, so that dampers are required for balancing the pressure drops in various runs.

VELOCITY REDUCTION METHOD

The various steps involved in this method are:

1. Select suitable velocities in the main and branch ducts.
2. Find the diameters of main and branch ducts from airflow rates and velocities for circular ducts. For rectangular ducts, find the cross-sectional area from flow rate and velocity, and then by fixing the aspect ratio, find the two sides of the rectangular duct.
3. From the velocities and duct dimensions obtained in the previous step, find the frictional pressure drop for main and branch ducts using friction chart or equation.
4. From the duct layout, dimensions and airflow rates, find the dynamic pressure losses for all the bends and fittings.
5. Select a fan that can provide sufficient FTP for the index run.
6. Balancing dampers have to be installed in each run. The damper in the index run is left completely open, while the other dampers are throttled to reduce the flow rate to the required design values.

The velocity method is one of the simplest ways of designing the duct system for both supply and return air. However, the application of this method requires selection of suitable velocities in different duct runs, which requires experience. Wrong selection of velocities can lead to very large ducts, which, occupy large building space and increases the cost, or very small ducts which lead to large pressure drop and hence necessitates the selection of a large fan leading to higher fan cost and running cost. In addition, the method is not very efficient as it requires partial closing of all the dampers except the one in the index run, so that the total pressure drop in each run will be same.

Advantages

1. This method is easiest among all methods in sizing the duct diameters.
2. The velocities can be adjusted to avoid noise.
3. This is adopted only for simple systems.

Dis advantages

1. The application of this method requires selection of suitable velocities in different duct runs, which requires experience for optimum economy and power.

STATIC REGAIN METHOD

The Static Regain method of duct sizing is based on Bernoulli's equation, which states that when reduction of velocities takes place, a conversion of dynamic pressure into static pressure occurs. This is used as the major principle for sizing the ducts, so that the increase in static pressure at each branch offsets the friction loss in the succeeding section of the duct. The static pressure should then be the same before each terminal and at each branch. This method provides a convenient means of designing a long duct run with several take offs, so that the same static pressure exists at the entrance to each branch, outlet, or terminal take off.

This method is commonly used for high velocity systems with long duct runs, especially in large systems. In this method the static pressure is maintained at each terminal or branch. The procedure followed is given below:

i. Velocity in the main duct leaving the fan is selected first.

ii. Velocities in each successive runs are reduced such that the gain in static pressure due to reduction in velocity pressure equals the frictional pressure drop in the next duct section.

Advantages

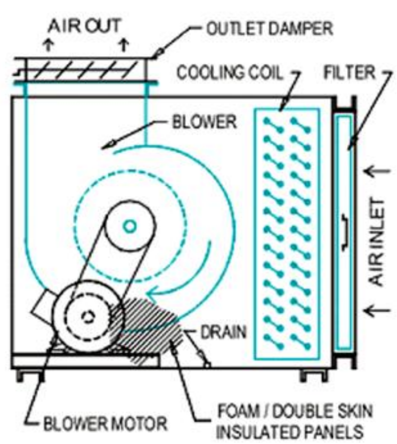
1. It is possible to design long runs as well as short runs for complete regain.
2. It is sufficient to design the main duct for complete regain and use of the same pressure at the outlets of branches.

AIR CONDITIONING SYSTEM COMPONENTS

Important air conditioning system components are:-

1. AHU
2. FCU
3. Chillers
4. Fans & blowers
5. Grills and registers
6. Diffuser
7. Dampers
8. Humidifiers & de-humidifiers
9. Air filters

1. AHU



An air handler, or air handling unit (often abbreviated to AHU), is a device used to regulate and circulate air as part of the heating, ventilating, and air-conditioning (HVAC) system.

The air handling unit is an integrated piece of equipment consisting of fans, heating and cooling coils, air-control dampers, filters and silencers. An air handling units is often called AHU. The purpose of this equipment is to collect and mix outdoor air with that returning from the building space. The air mixture is then cooled or heated, after which it is discharged into the building space through a duct system made up of five-feet diameter pipes.Air Handler is normally associated with heating/cooling (HVAC) systems in commercial buildings. These are normally very large systems moving from 2000 CFM to 10,000 CFM and higher. They may be mounted on the top of a roof or in large mechanical rooms located in the building. They often have an economizer or inlet damper that allows small amount of outside air or make-up air to be pulled in through the air handler. There are several types of Air Handling Units: Compact, Modular, Residential, DX integrated, Low Profile (ceiling), Packaged, Rooftop mounted (typically on the roofs of buildings, with special weather protection), etc.

To be considered as an air handling unit, a minimum of the following components are required : **at least 1 filtration section, 1 heat transfer component (cooling/heating coil or heat recovery system) and 1 fan.** Air Handling Units can have several components, depending on the complexity and requirements, such as the energy efficiency of each specific building and application.

Some of the most known components are:

Fans (Plug Fans, Double Inlet, Single Inlet, Axial, etc)- Filters (Plate Filters, Bag Filters, Compact Filters, EPA Filters, HEPA Filters, ULPA Filters, Carbon Filters)

Cooling/Heating Coils (water/steam/Direct Expansion DX/electric/gas fired) Heat recovery systems (cross flow plate heat exchangers, cross flow plate heat exchangers, heat wheel/rotating heat exchangers, run around coils and heat pipes, etc)

Humidifiers (Adiabatic/Evaporative Pad, non-pressurized Steam, pressurized steam) Dehumidifiers (DX coil, desiccant rotor)

Ultraviolet UV disinfection lamps

Photocatalytic oxidation (PCO) air cleaners

Sound attenuators

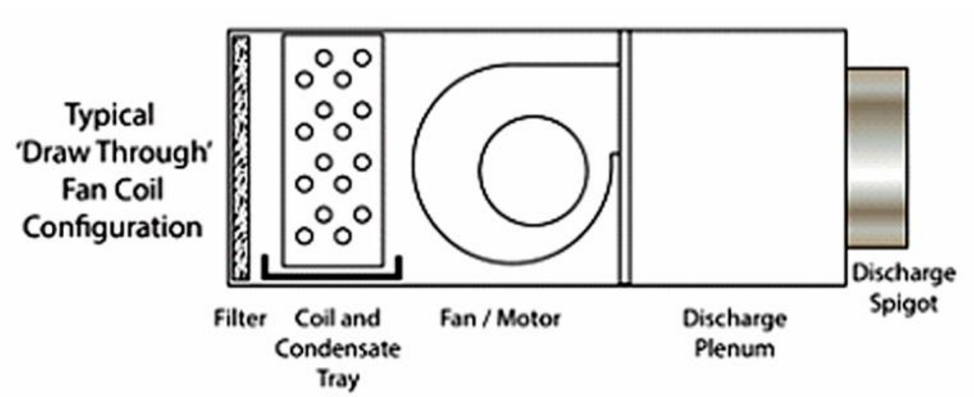
Mist/Droplet eliminators

Dampers

2. FCU

Fan coil units (FCU) consist of only a fan and a heating or cooling element, and are located within the space they are serving, and generally not connected to the ductwork. They may either just recirculate internal air, in which case a separate ventilation system is required, or may introduce proportion of 'fresh' air that is mixed with the re-circulated air.

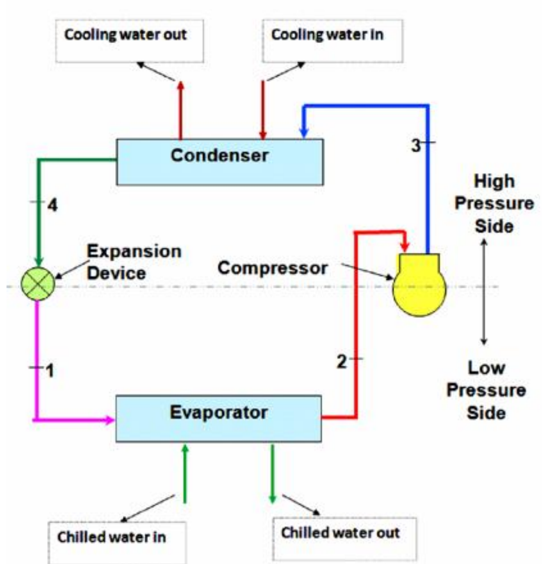
Fan coil units can be wall-mounted, freestanding or ceiling-mounted and may be concealed in ceiling voids. They may be controlled by local thermostats or by a building management system(BMS).Due to their simplicity, fan coil units are more economical to install than ducted air handling units. However, they can be noisy and can create vibrations because the fan is in the occupied space. Where fan coil units are supplied with chilled water and hot water from central boilers and chillers they are generally referred to as two pipe (either heating or cooling) or four pipe (both heating and cooling) units. Where the heating and cooling is provided locally, they may be referred to as variable refrigerant volume (VRV) or variable refrigerant flow (VRF) systems. Here, refrigerant is circulated between one or more fan coil units and is connected to an external heat exchanger. These systems may be more prone to refrigerant leakage than units that are connected to hermetically-sealed central chillers. Fan coin units are relatively compact and straightforward to install. However, they require regular maintenance to ensure continued efficient operation. When a fan coil unit cools air, it generally causes condensation which must be collected and drained or pumped away.



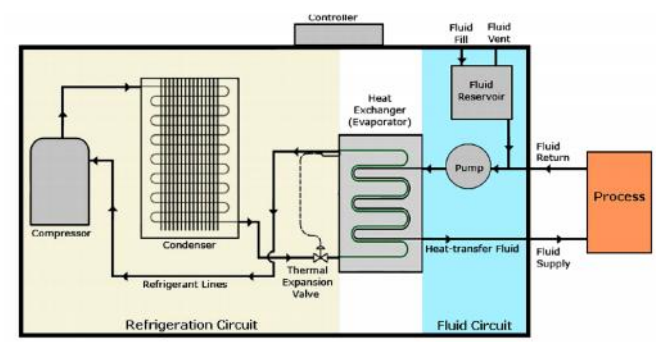
FCU is the abbreviation used for FAN COIL UNIT that are available for either DX or chilled water system that houses refrigerant or chilled water coil respectively. Beside the type of coil used, the other components are common such as the blower fan & filters. FCUs are usually available from0.75 to5 TR from various brands across the globe.

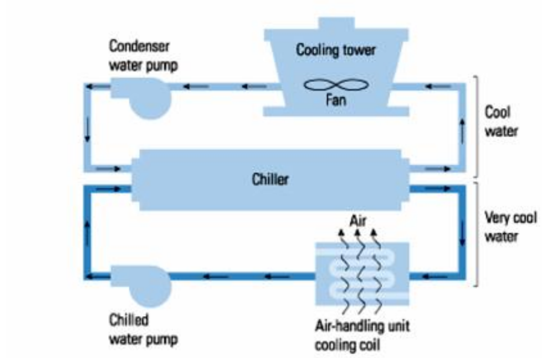
AHU is the abbreviation used for AIR HANDLING UNIT; is an adavnce type of FCU beyond5 TR capacity. They are either available in standard sizes or custom size & body construction. In addition to the standard components (blower fan & filter), it has advance filters, UV light, mixing chambers, etc. depending upon the requirement & construction.

3. CHILLERS



A *chiller* is a machine that removes heat from a liquid via vapour-compression or absorption refrigeration cycle. This liquid can then be circulated through a heat exchanger to cool air or equipment as required.





Courtesy: E source; adapted from EPA

When people first encounter the term “chiller” they usually think of something that **creates cold** or cools the surrounding air like an air conditioner or maybe even a refrigerator. This is a bit misleading.

A chiller consists of following six main components:

Evaporator - cools the water, water/glycol or air by transferring the heat to a refrigerant which is turned into a gas.

Compressor - takes this gas and increases its pressure, so that ambient air or water can remove the heat.

Condenser - rejects heat gained by the gas using ambient air or cooling tower water to condense the gas back to a liquid for reuse by the evaporator.

Holding Tank - holds the circulating coolant, usually water (can be water/glycol), tank is sized large enough to prevent a turbulent flow in the tank causing pump cavitation.

Pump - circulates the coolant from the holding tank to the evaporator and from the evaporator to the machine or process equipment after being cooled and back to the tank.

Control Panel - houses temperature controller, compressor contactor, pump starter, 3-phase fuses, control transformer, safety controls, run and fail lights.

While it is true that a chiller is a device that cools something else, i.e., in a plastic injection moulding machine, it does not cool, it removes heat. In short, it’s a **heat removal device**.

Using the six components listed above an “industrial” chiller removes heat from one element - water/glycol/air - and then circulates the cooler element through a heat exchanger to cool the surrounding air or process equipment.

A basic chiller has two circuits: the **water** circuit, and the**refrigeration** circuit.

In the **water** circuit, a pump circulates the water from the holding tank to the evaporator which cools it by transferring the heat to a refrigerant, the water then goes on to the process in a portable chiller or back to the tank in a packaged or central chiller. In the **refrigeration** circuit, the evaporator boils the liquid refrigerant into a gas, cooling the water. The compressor increases the pressure of the refrigerant gas to a pressure (200 to 220 psi for freon 22), so that the condenser can condense the gas back to a liquid (remove the heat gained) using ambient air at 95° F or cooling tower water at 85° F. In the case of an industrial chiller, the principle is the same. Water is pumped to the chiller normally at 60° F and cooled to 50° F, when using water/glycol, the solution can be cooled to 20° F. The heat is removed from the condenser either by means of a plant cooling tower water system, or outdoor air on the case of remote condenser and outdoor air cooled chillers, or by plant air for portable or indoor heat reclaim chillers. As one can imagine, chillers are extremely important in the industrial world where there are literally millions of machines that generate lots of heat. If these machines are to last any time at all, they need to be cooled. This is where chillers come in. A chiller can be used to cool any machine or process that operates at 60° F or lower. A cooling tower can be used to cool any machine or process that operates at 85° F or higher.

Applications

Plastics

In plastic industry, a chilling system cools the hot plastic that is injected, blown, extruded or stamped. A chilling system can also cool down the equipment that is used to create plastic products (hydraulics of the moulding machine, gear box and barrel of the extruder) that saves energy and wear and tear of the machine. itself.

Printing

In the printing industry, a chiller not only removes the heat generated by the friction of the printing rollers, but cools down the paper after it comes out of the ink drying oven in the process.

Laser

In the laser cutting industry, light projection industry, etc. a chilling system is used to cool down the lasers and power supplies.

Rubber

In the rubber industry, to cool the multizone water temperature control units of the rubber extruder barrel cool the rubber mill, calendars and bambury mixers.

Beverage

In the beverage industry, a chiller removes the heat gained from the process during mixing, cooking, or when pasteurizing the product.

Medical

If you use high tech equipment for magnetic resonance imaging, scanning, blood cooling and laboratory testing, you'll need a cooling system to remove all the heat thus generated.

AVAC

With cooling expenses accounting for 30% to 50% of your total energy costs rising fast, and the impending phase-out of chlorofluorocarbon (CFC) and hydro chloro fluorocarbon (HCFC) refrigerants, there is a rapidly growing need to replace large commercial air conditioning and refrigeration systems with a modular chilling system.

FANS & BLOWERS

Fans and blowers provide air for ventilation and industrial process requirements. Fans generate a pressure to move air (or gases) against a resistance caused by ducts, dampers, or other components in a fan system. The fan rotor receives energy from a rotating shaft and transmits it in to the air.

Difference between Fans, Blowers and Compressors

Equipment	Specific Ratio	Pressure rise (mmWg)
Fans	Up to 1.11	1136
Blowers	1.11 to 1.20	1136 – 2066
Compressors	more than 1.20 -	

Fans, blowers and compressors are differentiated by the method used to move the air, and by the system pressure they must operate against. As per the American Society of Mechanical Engineers (ASME) the specific ratio - the ratio of the discharge pressure over the suction pressure is used for defining the fans, blowers and compressors.

Fans fall into two general categories: centrifugal flow and axial flow.

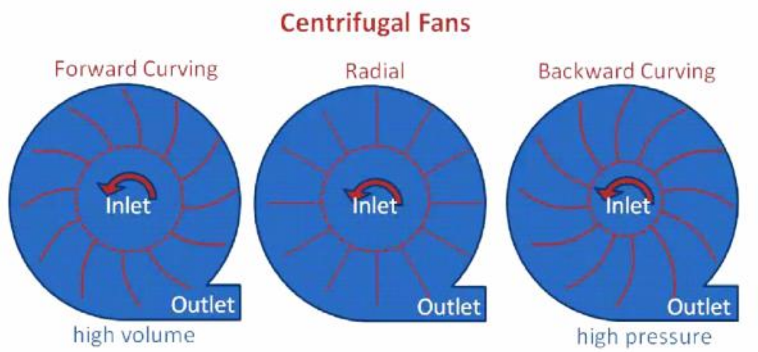
Centrifugal Fan : Types

The major types of centrifugal fan are *radial, forward curved and backward curved.*

Radial fans are industrial workhorses because of their high static pressures (upto 1400 mm WC) and ability to handle heavily contaminated airstreams. Because of their simple design, radial fans are well suited for high temperatures and medium blade tip speeds.

Forward-curved fans are used in clean environments and operate at lower temperatures. They are well suited for low tip speed and high-airflow work - they are best suited for moving large volumes of air against relatively low pressures.

Backward-inclined fans are more efficient than forward-curved fans. Backward-inclined fans reach their peak power consumption and then power demand drops off well within their useable airflow range.

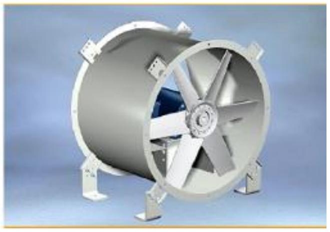


AXIAL FLOW FANS

An axial fan is a type of compressor that increases the pressure of air flowing through it. The blades of the axial flow fans force air to move parallel to the shaft around which the blades rotate.

The major types of axial flow fans are: *tube axial, vane axial and propeller*

Tubeaxial fans have a wheel inside a cylindrical housing, with close clearance between blade and housing to improve airflow efficiency. The wheel turn faster than propeller fans, enabling operation under high pressures upto 250 – 400 mm WC. The efficiency is up to 65%.



Vaneaxial fans are similar to tubeaxials, but with the addition of guide vanes that improve efficiency by directing and straightening the flow. As a result, they have a higher static pressure with less dependence on the duct static pressure. Such fans are used generally for pressures upto 500 mmWC. Vaneaxials are typically the most energy efficient fans available and should be used whenever possible.

Propeller fans usually run at low speeds and moderate temperatures. They experience a large change in airflow with small changes in static pressure. They handle large volumes of air at low pressure or free delivery. Propeller fans are often used indoors as exhaust fans. Outdoor applications include air-cooled condensers and cooling towers. Efficiency is low – approximately 50% or less.

GRILLS, REGISTERS, DIFFUSERS

Grill : A decorative covering element for an outlet or intake is known as grill. A fixed opening through which air passes.

Register : A grill equipped with a damper which supplies conditioned air. Typically used for supply air applications.

Diffuser : An air flow device designed to discharge conditioned air in a specific direction, path, or pattern. Used for supply air applications.

The proper supply to an air conditioned room is made through grills or registers. The grill or register can be located in the floor, high side of the wall or in the ceiling. The essential requirement of the supply point is that the air stream coming out should not strike the occupants before it looses its high velocity.

HUMIDIFIERS

A *humidifier* is a device that increases humidity (moisture) in a single room or an entire building. The humidification of air is one of the important phase of air conditioning system. The humidification is achieved by using any one of the four following methods :

1. **Injecting the steam**

   In this system , humidification of air is carried out by injecting the steam into the air just above atmospheric pressure. The steam condenses to a very fine mist as it is dispersed and evaporates almost instantly to the gaseous state raising the RH.

2. **Atomizing the water**

   An effective humidification can be achieved by using compressed air to draw water by aspiration from a supply tank and blow it in the form of fine mist into the duct carrying the air to the conditioned space.

3. **Evaporation of water**

   These type of equipments discharge pure water vapour into the air to be humidified. The process is endothermic and requires heat which is often provided by the equipment itself.

4. **Air washing**

   An air washer is a piece of equipment that is designed to improve air quality by scrubbing the air that moves through it and adjusting humidity levels to keep the environment consistent. Air washers are used as part of climate control and air quality systems. The air washer works by continuously moving a supply of air over chilled water and pushing the air out to cycle it through a room or building. Humidity is pulled out of the air as it reaches the dew point by passing over the cold water. In addition, impurities in the air such as pollen and dust precipitate out. The air exiting the machine is drier and cooler. It also contains fewer particulates, making it safer and more comfortable to breathe.

Application area – Air conditioning systems used in winter.

DE-HUMIDIFIERS

De-humidification is the process of removal of water from the air and the instrument used for de-humidification is called de-humidifier. De-humidifier is an instrument associated with summer air conditioning. There are three methods to accomplish dehumidification

1. By reducing the temperature of air below DPT. This is accomplished by passing the air over the cooling coil whose surface temperature is maintained below DPT of the air.
2. By absorption of moisture from the air: This is accomplished by passing the air through absorption bed. The moisture in the air does not enter into a chemical combination with the medium through which it is passed .It is simply removed from air.
3. By adsorption of moisture from air: This is accomplished by passing the air through a chemical .The moisture in the air enters into a chemical combination with the drying agent.

Application area

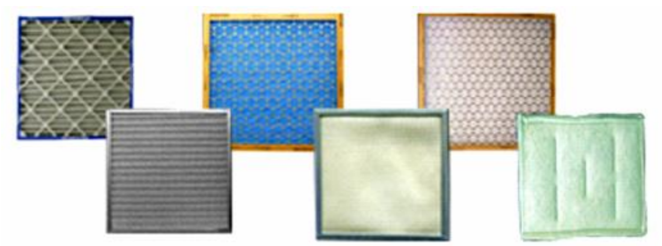
1. Food industry
2. Packaging industry
3. Production of english medicines
4. Storage area of iron products
5. Sugar industry

AIR FILTER

The air taken from atmosphere carries dust, bacteria and odours in the air conditioned system which are harmful for human health .The oxygen level in the air will be reduced when it goes out of air conditioning system as oxygen is used by the occupants. The removal of impurities from the outside air is most essential and important part of all air conditioning systems.

The different methods of air filtering are given below :

1. Dry Filter
2. Wet Filter
3. Electric Filters
4. HEPA filters
5. Centrifugal dust collectors



INSULATORS

A thermal insulator is something that prevents heat from moving from one place to another. There are 3 main ways that heat can travel: convection, conduction, and radiation. Typically the phrase 'thermal insulator' refers to a material that blocks conduction. A material or an object that does not easily allow heat, electricity, light, or sound to pass through it. Air, cloth and rubber are good electrical insulators; feathers and wool make good thermal insulators. (Compare it with conductor)

Insulations are defined as those materials or combinations of materials which retard the flow of heat energy by performing one or more of the following functions:

1. Conserve energy by reducing heat loss or gain.
2. Control surface temperatures for personnel protection and comfort.
3. Facilitate temperature control of process.
4. Prevent vapour flow and water condensation on cold surfaces.
5. Increase operating efficiency of heating/ventilating/cooling, plumbing, steam, process and power systems found in commercial and industrial installations.

6. Prevent or reduce damage to equipment from exposure to fire or corrosive atmospheres.
7. Assist mechanical systems in meeting the criteria of food and cosmetic plants. Reduce emissions of pollutants to the atmosphere.

PROPERTIES

1. Low thermal conductivity
2. Permanence
3. Strength
4. Light weight
5. Water repellent
6. Sanitary
7. Odourless
8. Fire proof
9. Low cost

Insulating materials

- Fiberglass. Fiberglass insulation. ...
- Mineral Wool. Mineral Wool. ...
- Cellulose. Cellulose insulation material. ...
- Polyurethane Foam. Polyurethane insulation. ...
- Polystyrene. Polystyrene (Styrofoam).

Air distribution systems

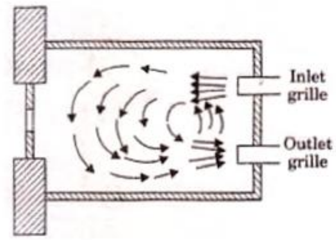
The object of air distribution in a warm air heating and air conditioning system is to create proper combination of temperature, humidity, and air motion in the occupied zone of the conditioned room.

The following points are preferred to in air distribution systems :

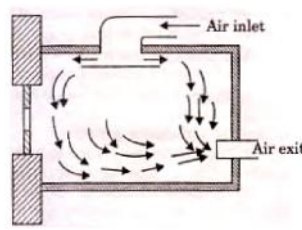
1. The temperature variation should not be more than two Degree Celsius in the occupied zone of the room.
2. The desirable air movement around the bodies of the people is 7.5 m/mt.
3. Flow direction of air towards the face of the people is preferred to instead of back or sides.
4. Downward flow is preferable to upward flow.

There are several methods of air distribution system which can be successfully used for different purposes.

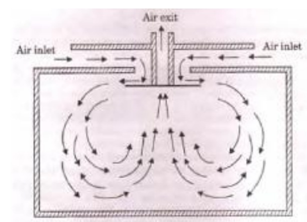
Excellent for cooling & heating (Year round air conditioning system)



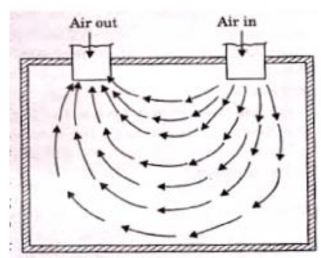
Excellent for cooling & heating (Year round air conditioning system)



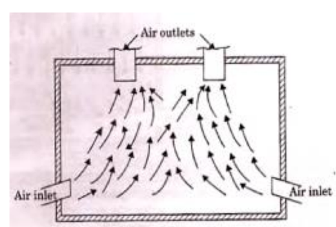
Excellent for cooling & heating (Year round air conditioning system)



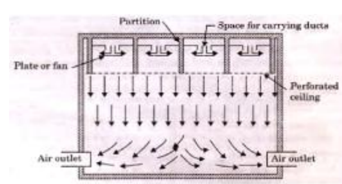
Excellent for heating (Winter air conditioning system)



Excellent for heating (Winter air conditioning system)



Excellent for cooling (Summer air conditioning system)



Practical

STUDY DIFFERENT TYPES OF FILTERS USED IN AIR DISTRIBUTION SYSTEM

AIM:-To study different types of filters used in air distribution system.

MATERIALS REQUIRED:-

Different types of filters used in air distribution system

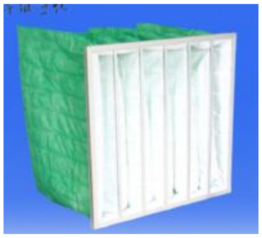
Air filters

Primary filters up to 20 microns

Secondary filters up to 10 microns

HEPA filters of 3 to 5 microns.

Bag Air filter for AHU (10 microns)

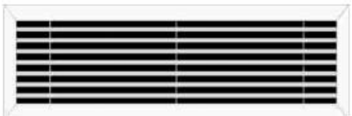


Heppa filter (3-5 microns)

Regular filter (20 microns)

Linear Slot Diffuser

Linear Bar Grills



Air Line Grills

Round Cieling Diffuser

Diffuser

Rubber insulation copper tube

Superloan pipe insulator

ASSESSMENT

Give a lay out of the structure of different types of buildings and ask to draw suitable ducting arrangements.

\

TE QUESTIONS

1. What are the factors to be considered for selecting a blower fan ?
2. The pressure inside the duct is measured using __________.
3. The velocity inside the duct is measured using _____________.
4. The duct used to intake outside air is called ____________.
5. The conditioned air is distributed to the rooms through ______________.
6. What are the factors to be considered while selecting a duct insulating material?

UNIT 4.6
PROJECT WORK

Construct a feasible working model or still model of relevant R & AC system and prepare a Project report.

REFERENCE :-

1. Heating and Cooling Essentials by Jerry Killinger. Good Heart – Will Cox Company (2005)
2. Refrigeration and Airconditioning Technology by William C Whitman, William M Johnson, John.A.Tom, Cengage Learning Custom Publishing (2012)
3. Technicians Guide to Refrigeration System by John.A.Corinchock. Mc Graw-Hill Education (1996)
4. Refrigeration and Airconditioning by R.S.Khurumi, S.Chand (2006)
5. Refrigeration and Airconditioning by C.P Arora, Tata Mc Graw-Hill (2006)
6. Refrigeration and Airconditioning by A.K. Anandharaman, Tata Mc Graw-Hill (2005)
7. Skill Development Handbook for Technicians by Indian Society of Heating, Refrigerating and Airconditioning Engineers (2015)
8. Work Shop Practice by Hajra Chaudhary
9. Basic Refrigeration - R Waxes Marsh
10. Refrigeration and Airconditioning by S. Domkundwar
11. *Refrigeration and Airconditioning* by N.Singh