DESIGN OF AIR CONDITIONING SYSTEM FOR AN AUDITORIUM

A project report submitted in partial fulfillment of the requirements for the Award of the Degree of

BACHELOR OF ENGINEERING

in

MECHANICAL ENGINEERING

by

M Vineetha (314126520094)

K Hemanth Kumar (314126520085)

N Bhargav Sai (314126520108)

A Meher Krishna Teja (314126520098)

under the guidance of

Sri. G.UMA MAHESHWARA RAO,

Assistant Professor

PRAGNANAM BRAHMA
ANITS

DEPARTMENT OF MECHANICAL ENGINEERING
ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES
(Affiliated to Andhra University)
SANGIVALASA–2013

2018

ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES

(Affiliated to Andhra University)

Sangivalasa, Bheemunipatnam (Mandal), Visakhapatnam (District)

PRAGNANAM BRAHMA
ANITS

CERTIFICATE

This is to certify that the Project Report entitled "**DESIGN OF AIR CONDITIONING SYSTEM FOR AN AUDITORIUM**" has been carried out by M Vineetha (314126520094), K Hemanth Kumar (314126520085), N Bhargav Sai (314126520108), A Meher Krishna Teja (314126520098) under my guidance, in partial fulfillment of the requirements of Degree of Bachelor of Mechanical Engineering of Andhra University, Visakhapatnam.

APPROVED BY

(Prof. B Naga Raju)
Head of the Department
Dept. of Mechanical Engineering
ANITS, Sangivalasa
Visakhapatnam.

PROFESSOR & HEAD
Department of Mechanical Engineering
ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCE
Sangivalasa 531 162 VISAKHAPATNAM Dist A.P.

PROJECT GUIDE

24/4/18

(Sri. G.Uma Maheshwara Rao)
Sr. Asst. Professor
Dept. of Mechanical Engineering
ANITS, Sangivalasa
Visakhapatnam.

THIS PROJECT IS APPROVED BY THE BOARD OF EXAMINERS

INTERNAL EXAMINER:

Dr. B. Naga Raju
M.Tech,M.E.,Ph.d
Professor & HOD
Dept of Mechanical Engineering
ANITS, Sangivalasa,
Visakhapatnam-531 162.

EXTERNAL EXAMINER:

ACKNOWLEDGEMENTS

We express immensely our deep sense of gratitude to **Sri. G. Uma Maheshwara Rao,** Assistant Professor, Department of Mechanical Engineering, Anil Neerukonda Institute of Technology & Sciences, Sangivalasa, Bheemunipatnam Mandal, Visakhapatnam district for his valuable guidance and encouragement at every stage of the work made it a successful fulfillment.

We were very thankful to **Prof.T.V.Hanumantha Rao**, Principal and **Prof.B.NagaRaju**, Head of the Department, Mechanical Engineering Department, Anil Neerukonda Institute of Technology & Sciences for their valuable suggestions.

We express our sincere thanks to the members of non-teaching staff of Mechanical Engineering for their kind cooperation and support to carry on work.

Last but not the least, we like to convey our thanks to all who have contributed either directly or indirectly for the completion of our work.

M Vineetha (314126520094)

K Hemanth Kumar (314126520085)

N Bhargav Sai (314126520108)

A Meher Krishna Teja (314126520098)

ABSTRACT

In recent years the term Air Conditioning has come into common use in every city and town. Due to global warming and increase in carbon dioxide limits the temperatures in summer is gradually increasing from day to day which cause discomfort to the human beings.

Especially in auditoriums there is a need for proper air conditioning system, to provide a comfortable environment for the occupants.

In this project the tons of refrigeration required for central air conditioning system. While calculating the load all aspects such as local atmosphere conditions, place to be conditioned etc., the best possible and economical design and equipment is suggested. Psychrometry is used for study of air and the humidity.

Also included the design of ducts for proper circulation of conditioned air. Finally the concept of green building approach in air condition system design is discussed.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

Introduction

In recent years the term Air Conditioning has come into common use in every city and town. At one time the familiar saying “Everybody talks about the weather, but nobody does anything about it” was certainly true. Today it is no longer true, for air conditioning engineers and technicians are modifying indoor weather in every part of the country. Our homes and business houses are warmed in a winter, cooled in summer and made comfortable the year round by the proper application of air conditioning principles and equipment.

First air conditioned theatres and then air-conditioned restaurants have become well known to the general public. Today when the members of a family are discussing what motion picture theatre to go to, they are likely to say, “Let us go to the Sarath, it is air conditioned.”

Theatres were among the earlier ventures in the air conditioning of public buildings, and it is unfortunately true that the effect is not always pleasant. There are many air conditioned theatres in which the temperature is held too low or in which the humidity is permitted to reach almost 100 percent. Such conditions are definitely unhealthy. Proper load calculations must be done and in supply air, temperature and specific humidity should be such as to remove the latent heat and sensible heat load from the space.

Looking towards the accelerated demand for air conditioning application we adopted “Air conditioning of auditorium” as our project work.

Due to global warming and increase in carbon-dioxide limits the temperatures in summer is gradually increasing from day to day which causes discomfort to human beings. As an auditorium is a venue for many important meetings and seminars, the people who attend them must be provided a pleasant atmosphere inside so that they can put in their best levels of

So Air conditioning of auditoria has become a necessity in present days. Considering all aspects e.g. local atmosphere conditions place to be conditioned etc.

The best possible and economical design and equipment is suggested psychrometry is used for study of air and humidity. In summer the outdoor air is very humid and in addition, occupants add humidity because of the evaporation of perspiration. This human humidity load is greater if persons are active then if they are relaxed.

This report contains essential literature, survey information, load calculations, to provide a comfortable environment for the occupants, and a detailed economical design for the management.

1.1 DEFINITION OF AIR CONDITIONING:

Air Conditioning is defined as a process, which heats, cools, cleans and circulates air and controls its moisture content.

Air Conditioning then makes it possible to change the condition of the air in an enclosed area.

1.2. APPLICATIONS OF AIR CONDITIONING:

1.2.1 EARLY APPLICATIONS:

As early as 1500 A.D Leonardo de Vinci built a water driven fan to ventilate a suit of rooms for the wife of his patron. This could possibly have been the first attempt to automatically change the condition of the air in an enclosed space. Another device, which originated in India many years ago, was the ‘PUNKA’.

1.2.2 PRESENT DAY APPLICATIONS:

- Over one-third of the rooms in major Hotels .fifty percent of all departmental stores, almost every major office buildings, half of the hospitals operating and delivery rooms and approximately six million homes are air-conditioned.

- Military centers, which treat and intersect hostile missiles are able to operate continuously only because air is maintained at suitable temperature without air conditioning the mechanical brains in these centers would cease to operate in a matter of minutes because of the intense self-generated heat.
- Atomic submarines can remain submerged almost indefinitely due, in part, to conditioning.
- Modern medicines such as Salk vaccine are prepared in scientifically controlled atmosphere.
- Man's exploitation of outer space will be greatly simplified by air conditioning.

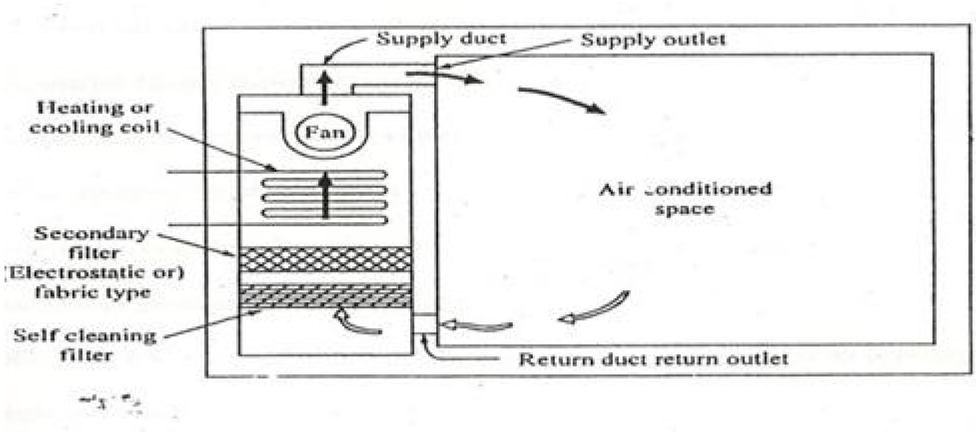


Fig. 1.1. Air Conditioning Cycle

1.3 CLASSIFICATION of AIR-CONDITIONG SYSTEMS:

1. 3.1According to the arrangement of equipment:

- Centralized system
- Unitary system
- Zoned system
- Unitary-Central system

1.3.2. According to purpose:

- Comfort air-conditioned system.
- Industrial air-conditioned system.

1.3.3. According to season of the year:

- Winter air-conditioning system.
- Summer air-conditioning system.
- Year-round air-conditioning system.

Another method of classification of air-conditioning system is as follows:

- Single-air systems.
- Dual-air systems.
- Primary-air systems.
- Unit systems.
- Panel systems.

CENTRALIZED SYSTEM:

This type of system is one in which various equipment components are selected

Depending on the load and erected on the job, usually in a central equipment room. The entire process of conditioning the air is done in the central station and the conditioned air is delivered to the various rooms of the building through sheet metal. Many large capacity systems, such as multi stored buildings, hotels use central station system.

Advantage:

The main advantage of a centralized system is:

- Lower cost as compared to total cost of separate units.
- Space occupied is unimportant as compared to room unit conditioner, which must be placed in the room.
- Better accessibility for maintenance.

UNITARY SYSTEM:

The system makes use of air conditioners which are completely factory assembled. A single air conditioner may serve if the building is a small one, or the building may be divided into several parts each being served by an air conditioner of moderate initial cost and also that of flexibility of operation. These do not have the “life expectancy” as central station system.

Advantage:

The initial cost of unitary system is moderate and has a flexibility of operation.

Disadvantage:

These do not have the life expectancy as the central station system.

ZONED SYSTEM:

When in a building several rooms or floors are to be served, it is necessary to consider means by which the varying heat gains in the different departments can be dealt with. Some rooms may have some and other not; some may be crowded and other empty; again some may contain heat producing equipment. Variations in requirements of this kind are the most common case with which Air Conditioning has to deal, and for this central system is unsuitable. Zoned system is one approach.

In zoned system the building is divided into zones such that as nearly as possible conditions may be expected to exist. Each zone is provided with its own local re-circulating fan and booster cooler or heater, and this unit receives fresh air supply conditioned to some average temperature and corrected for humidity by means of what is in effect a central plant. In this case the central plant is on the roof. The re circulating units are fixed overhead adjacent to the corridor, taking then return air there from, and distributing ducts are run above the corridor false ceiling delivering into the various rooms, floor by floor each floor, constituting a separate zone.

The return air from the room passes through grilles into the corridor which acts as the returning air collecting duct. The cooling or heating booster coils could be served from circulating water mains, each coils being controlled locally according to the requirements of the zone served.

UNITARY CENTRAL SYSTEM:

In a unitary central system each room is provided with a room unit which gets a supply of conditioned air from a central system. The main aim of such systems is to either decrease the size of the ducts or to eliminate them completely.

The following three unitary central systems are in common use:

- Induction units
- All Air velocity systems
- Fan coil units

Induction units

An induction unit uses the principle of induction as a means of recirculation. Each induction unit receives primary conditioned air under pressure from a central plant.

All air high velocities:

In these systems special control and acoustic equipment are employed since they use high static pressures and high velocities. The ducts used are round and are designed carefully in order to reduce friction and noise.

Fan coil units:

The fan coil units which are installed in individual room are supplied with primary air. The return room air mixes with the primary air and the mixture is then blown over coil by a fan located in the unit. The operation is just similar to induction coil units. The room thermostat is heating cooling type. It controls the quantity of hot water in Winter and chilled water is supplied to the room coil.

1.4 SELECTION OF SYSTEM:

The selection of a system is determined by a great variety of design requisites, and the choice may vary from a minimum cost, summer – relief cooling installation to a closely controlled, year round air-conditioning system.

The most important factors to be considered in the selection of a system may be classified as follows:

1.4.1 General:

- New or existing building.
- Nature of building occupancy
- Type and construction of building.
- Relative magnitude of cooling air heating loads, particularly including the
- Highly variable effect of solar loads.
- Ratio of interior to peripheral zones.

1.4.2. Functional:

- Independent control of temperature and humidity.
- Zone or individual room control.
- Simultaneous heating and cooling capacity for reversal of intermediate season
- Loads on exterior zones.
- Mixing of air between the spaces.
- Noise and vibration.
- Cleanliness of supply air.
- Adaptability to partial load operation.

1.4.3. Initial cost:

- Required refrigeration capacity.
- Apparatus and equipment requirements.
- Cost of duct work, piping and miscellaneous services.
- Possible use of exiting heating systems, ventilation ducts, piping etc.
- Cost of design engineering.

1.4.4. Operating and Owing cost:

- Relative costs of power, steam, fuel and water.
- Possible use of 100% outside air for cooling without refrigeration during
- Intermediate seasons.
- Amount of cancellation of cooling effect by heating for control purpose.
- Service and maintenance requirements.
- Rental value of space occupied by air-conditioning equipment, duct and pipes.
- Rate of depreciation and obsolescence of equipment.
- Insurance, taxes and financing costs.

1.4.5. Space requirements:

- Equipment and apparatus space size and locations.
- Duct and pipe sizes and locations.
- Possible use of marginal spaces, such as abandoned elevator shafts, closets etc.

1.4.6. Installation problems:

- Disturbance of occupants of existing building.
- Adaptability to progressive or partial installation
- Adaptability to installation of equipment in isolated or remote areas
- Skills required by installation mechanics

1.4.7. Miscellaneous:

- Flexibility for architectural and partition changes
- Simplicity of operation and maintenance
- Appearance

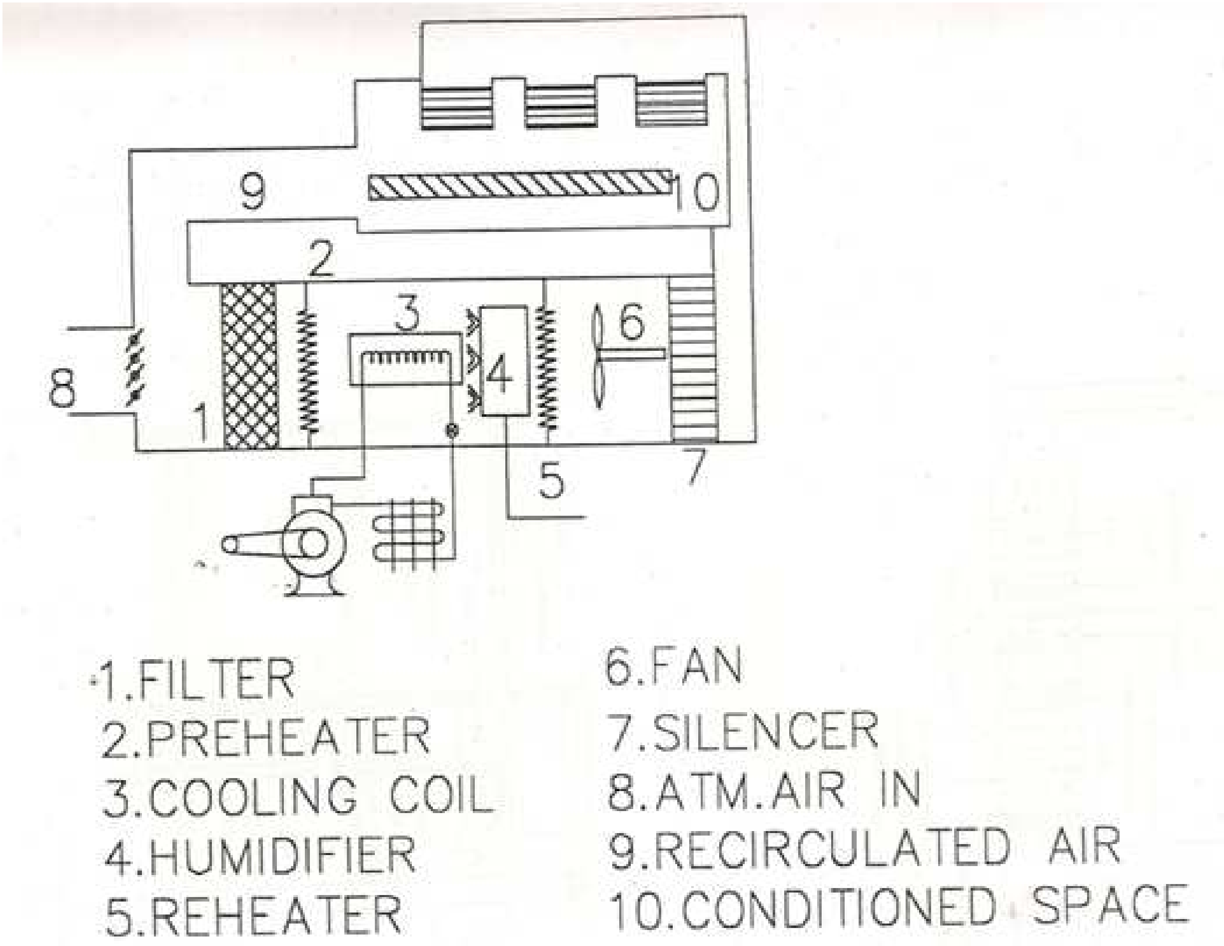


Fig.No:1.1.7. Air Conditioning System

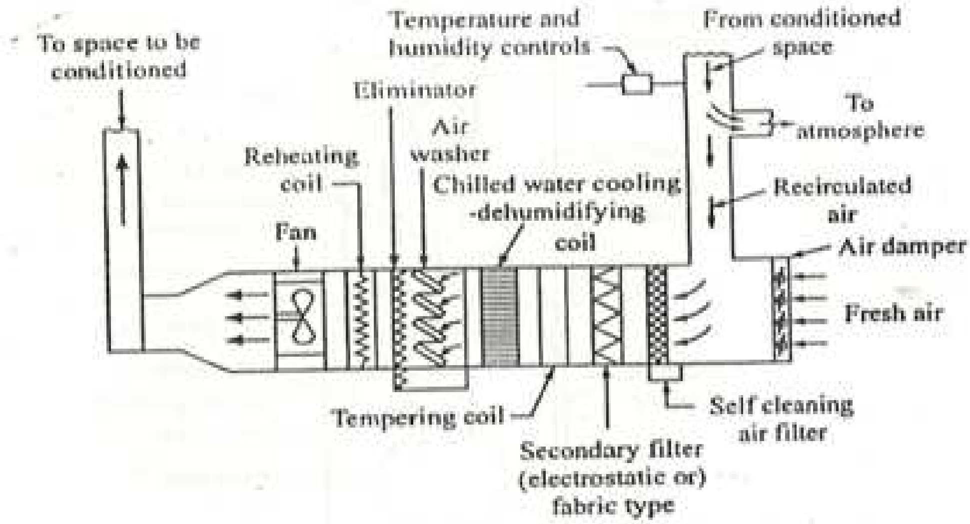


Fig. No 1.2 Central system

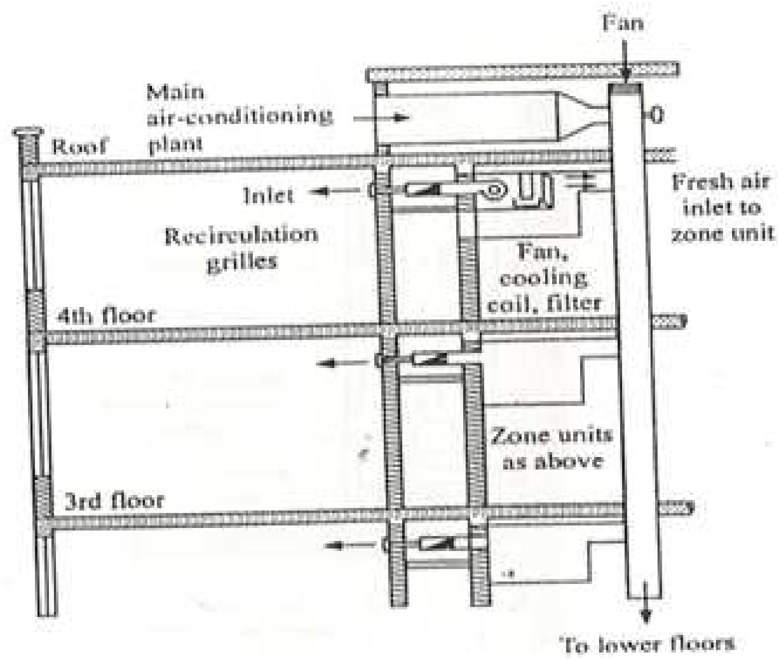


Fig. No 1.3. Zoned system

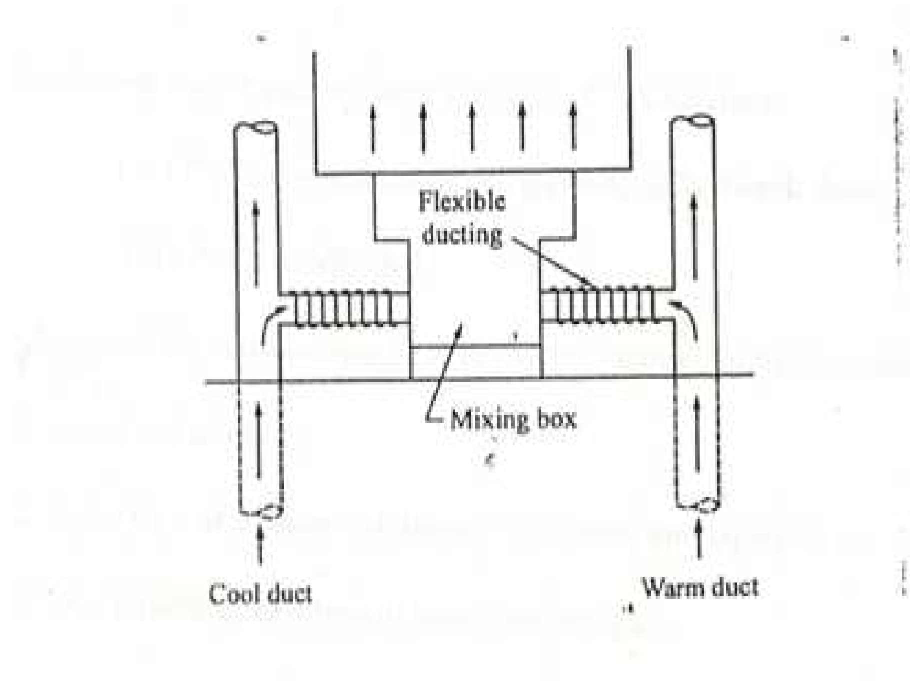


Fig.No. 1.4 Dual Duct system

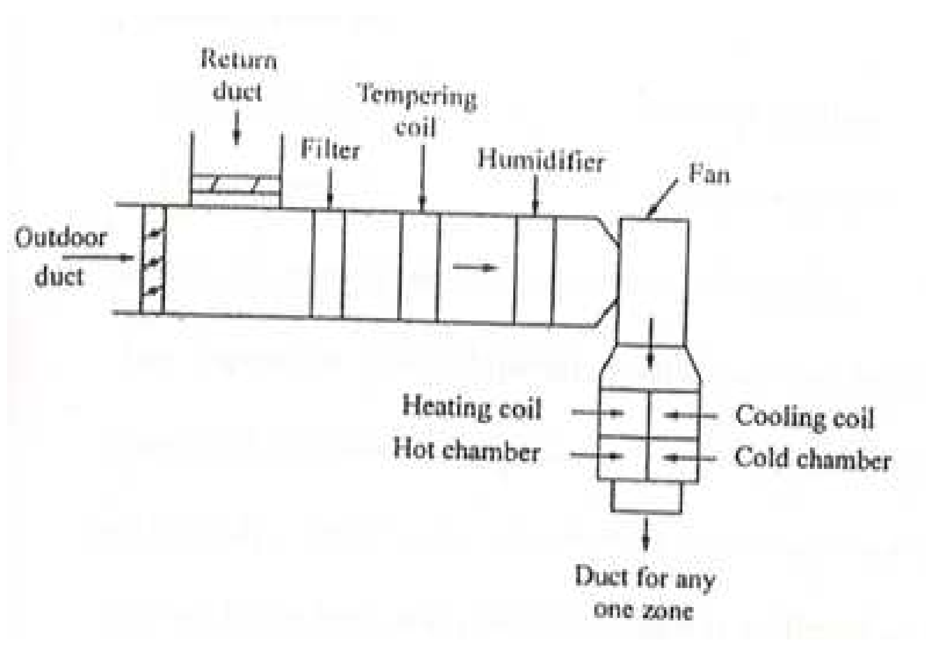


Fig No 1.5. Single Duct system

CHAPTER II

CONDITIONS FOR AIR CONDITIONING

2.1. Simple vapor compression system:

In the simple vapor compression system fundamental processes are completed in one cycle. These are:

1. Compression 2. Condensation

3. Expansion 4. Vaporizations

The flow diagram of such a cycle is shown in figure.

The vapor at low temperature and pressure enters the compressor where it is compressed isentropic ally and subsequently its temperature and pressure increases considerably. The vapor after leaving the compressor enters the condenser where it is condensed into high pressure liquid and is collected in a receiver tank. From receiver tank it passes through the expansion valve here it is throttled valve it finally passes on to evaporator where it extracts heat from the surroundings or circulating or fluid being refrigerated and vaporizes to low pressure vapor.

Work done by the compressor=W=Area of T-S diagram

C.O.P = Heat extracted or refrigerating effect/work done.

C.O.P= $(h2-h1)/ (h3-h2)$

The design of air conditioning system can be, mainly divided into three parts.

- Load calculations.
- Selection of proper refrigerating system and equipment.
- Air handling equipment and duct design.

The main idea of conducting a literature survey is to collect sufficient data to help in designing a particular project. It gives the proper theoretical background in completing the given project.

2.2. Selection of air conditioning system is based on the following factors:

- Comfort.
- Heat loss from human body.
- Factors determining comfort.
- Air movement.
- Psychometrics.
- Typical air cycle.
- Cycle description.
- Equipment in the air conditioning cycle.
- Ozone.
- Atmospheric pollution.
- Odors and Bacteria.
- Metabolism.

2.2.1Comfort:

The normal temperature of the human body is 98.6º F. This temperature is called “subsurface ” or “deep tissue ” temperature as opposed to skin or surface temperature. An understanding of the manner by which the body maintains this temperature will to understand the manner by which the air conditioning process helps to keep the body comfortable. Earlier investigations believed that the atmosphere of a crowded room caused discomfort through its effect on the lungs, and carbon dioxide, being the principal’s product of respiration, we looked upon as the harmful element. Air conditioning, or ventilation, as it was formally called, was therefore, considered for many years a problem of supplying sufficient fresh air to dilute the carbon dioxide content.

For body comfort certain combination of moisture and air temperature is more comfortable than other combinations. For example in winter 30 to 35% relative humidity at 72 to 75°F represents the indoor condition of moisture and temperature that is comfortable for most of the people. In summer the combination is 45% relative humidity and approximately 75 to 78 ºF.

COMFORT CHART

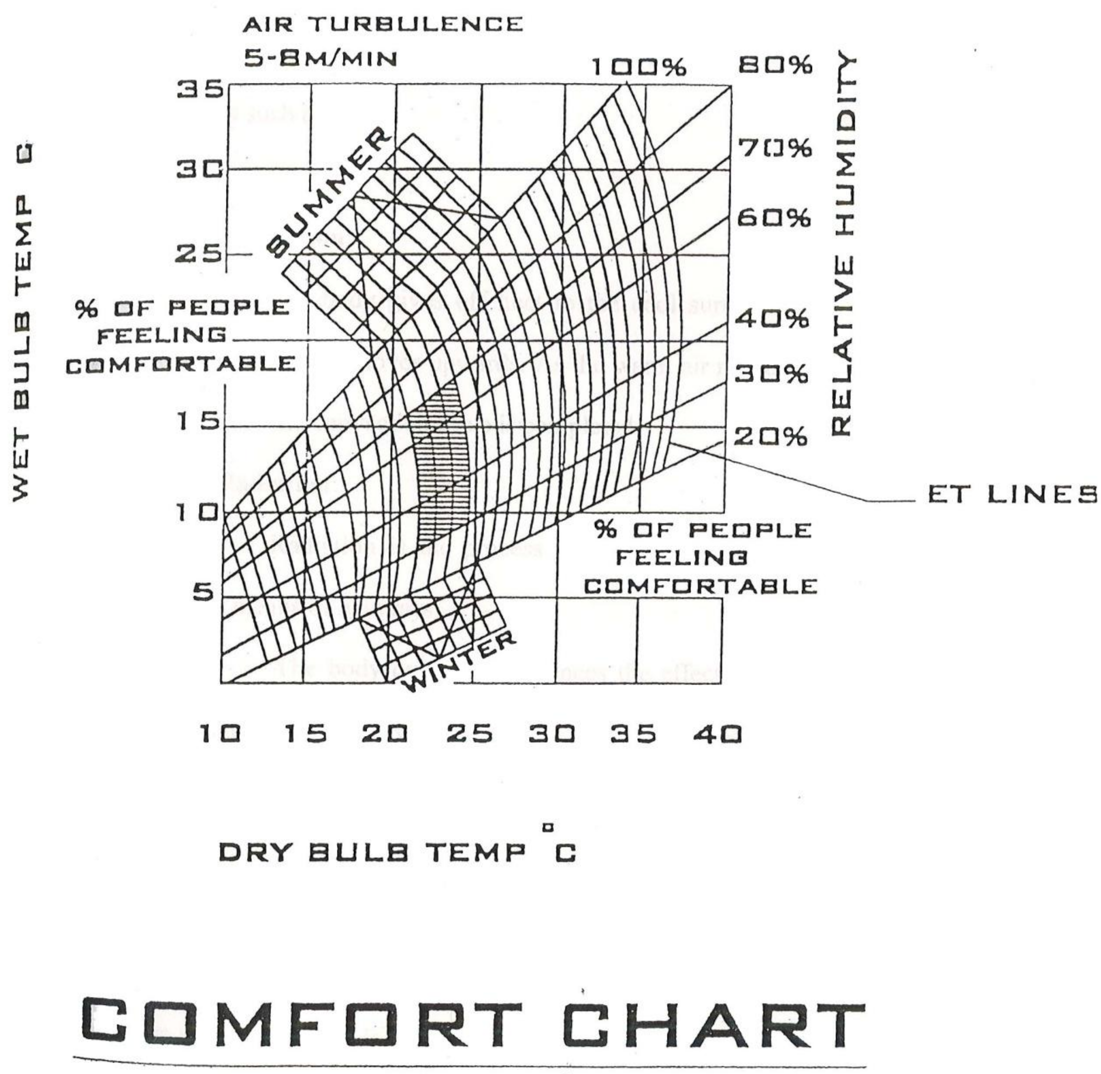


FIG.NO:2.1 Comfort Chart

Heat Loss from the Human Body

Human body is maintained at constant temperature by continually dissipating the heat developed from the chemical processes in the utilization of food, drink, the oxygen. The constant removal of body heat takes place mainly through three natural processes such as:

1. **Convection:**

The body gives off heat to the cool surrounding air. The surrounding air becomes warm and moves upwards. As the warm air moves upward, more cool air takes its place and the convection cycle is completed.

2. **Radiation:**

Radiation is the process by which heat moves from a heat source to an object by means of heat rays.

The body quickly experiences the effects of sun radiation when it moves from a shady to a sunny area. It again experiences modulation effects when the body surface is close to fire become warm while the opposite surface remains cool. Just as the heat from the sun, the heat from the body moves to a colder surface.

3. **Evaporation:**

Is the process in which moisture becomes vapor. As moisture evaporates from a warm surface, it moves heat and thus cools the surface. This process takes place constantly on the body surface.

The total heat omitted from the human body at rest varies but slightly under ordinary indoor conditions, average about 400 B.T.U per hour for adult men.

Under normal conditions, in heated rooms, radiation usually accounts for 46 to 60 percent of total heat loss, convection for 15 to 30 percent, and evaporation, for 20 to 30 percent. The proportions depend upon the amount of clothing and upon the wall temperature and other physical conditions of the environment.

2.3. FACTORS DETERMINING COMFORT:

There are three factors which their combined effect, determine the cooling power of the atmosphere upon the human body. They are temperature and humidity. The dry bulb temperature of the atmosphere has long been used along as an index of comfort, but it is obviously an incomplete index.

Temperature:

Cool air lowers the temperature of surrounding surfaces and increases the rate of radiation. Warm air raises the surrounding surface temperature and decreases the radiation rate.

We all know that when the indoor air is very dry, a higher temperature is necessary for comfort because of the greater cooling power of the dry air. The evaporation of the perspiration with which the body is always partially covered has a marked influence upon the rate of heat loss, and the rate of evaporation is dependent upon the humidity of the surrounding atmosphere.

Humidity:

Moisture in the air is measured in terms of humidity. 50% relative humidity means that the air contains one-half the amount of moisture that it is capable of holding. The unit of humidity is grain of water vapor.

Relative Humidity:

Relative humidity is the actual amount of moisture in the air as compared with the maximum amount of moisture the air can hold.

A Grain of Water vapor:

Is the unit of measurement used to determine the percentage of relative humidity. The relative humidity changes when the temperature changes. To increase relative humidity, increases the actual moisture content of the air or decreases the air or decreases the air temperature. To decrease relative humidity, decreases the actual moisture content of the air or increases the air temperature.

A lower humidity permits heat to be given off from the body by evaporation. This occurs because air at lower humidity is relatively dry and thus can readily absorb moisture. A high relative humidity has slows down the evaporation process and thus decreases the speed at which heat can be removed by evaporation. An acceptable comfort range for the human body is 72 to 80°F at 45 to 50% relative humidity.

Another factor which affects the ability of the body to give off heat is the movement of air around the body as the air movement increases:

- The evaporation process of removing body heat speeds up since moisture in the air near the body is carried a Way at a faster rate.
- The convection process increases since the layer of warm air surrounding the body is carried away more rapidly.
- The radiation process tends to accelerate because the heat on the surrounding surfaces is removed at a faster rate. As air movement decreases, the evaporation, convection and radiation process decreases.

Air Supply:

In a room occupied by many people the desired air conditions cannot be obtained without a reasonably generous air supply. On the other hand the permissible quantity is limited by the danger of creating an uncomfortably high rate of air movement. The figures usually specified for schools and auditorium and theater is 30 cu.fit.per minute per person.

Air Distribution:

Merely to supply enough air to a room is not sufficient for good ventilation. It must be distributed in a fairly uniform manner so that each occupant receive approximately the specified amount. To determine the uniformity of distribution , one method is to take measurements of carbon dioxide content in different parts of the room and this determine the variation of the quantity supplied per occupant at the different points from the average quantity . This variation should not exceed one part in which ozone is produced by an electrical discharge, are on the market 10,000 measured at a level 36 inch above the floor.

2.4. Types of Air-distribution systems:

Conditioned air from air-conditioning plant may be fed to a room through supply by any of the following air-distribution systems:

- Ejector system.
- Downward system.
- Upward system.

Ejector system:

The inlet grille ejects the air into the room and inducts sufficient velocity for circulation. Letter system is known as Pan-type arrangement.

Downward System:

In this system the air is introduced through openings located in the ceiling and removed through the openings made in the floor or in the walls near the floor. This system is costly because of the use of perforated ceiling. It may be employed in schools, offices, theaters and auditoriums.

Upward Systems:

The air outlets are located in walls near the ceiling or in the ceiling. This system is employed in the situations when the air in the room occupied by persons rises carrying with it foul smell, odors from their bodies.

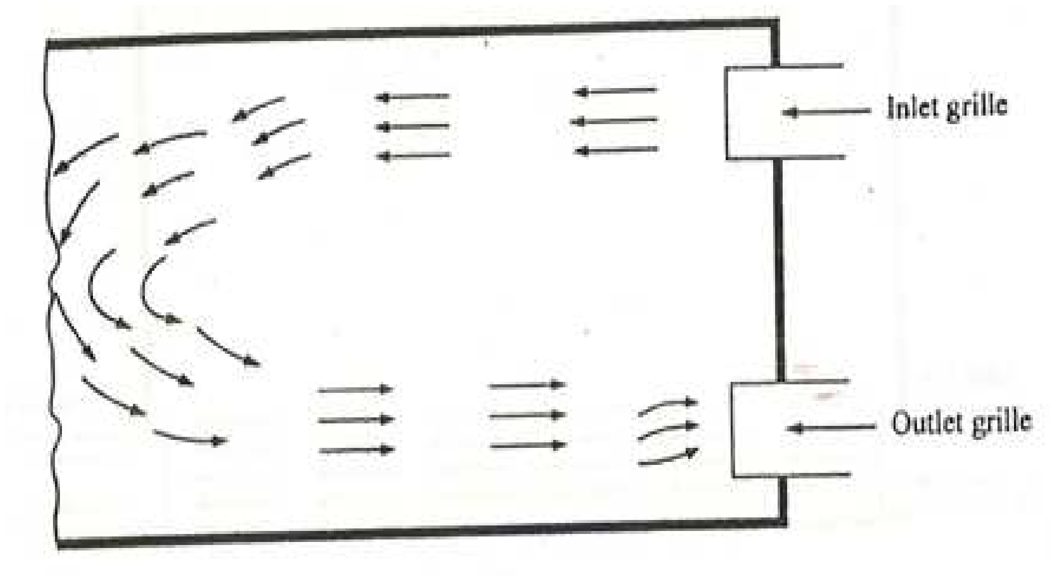


Fig.No:2.2 Ejector System

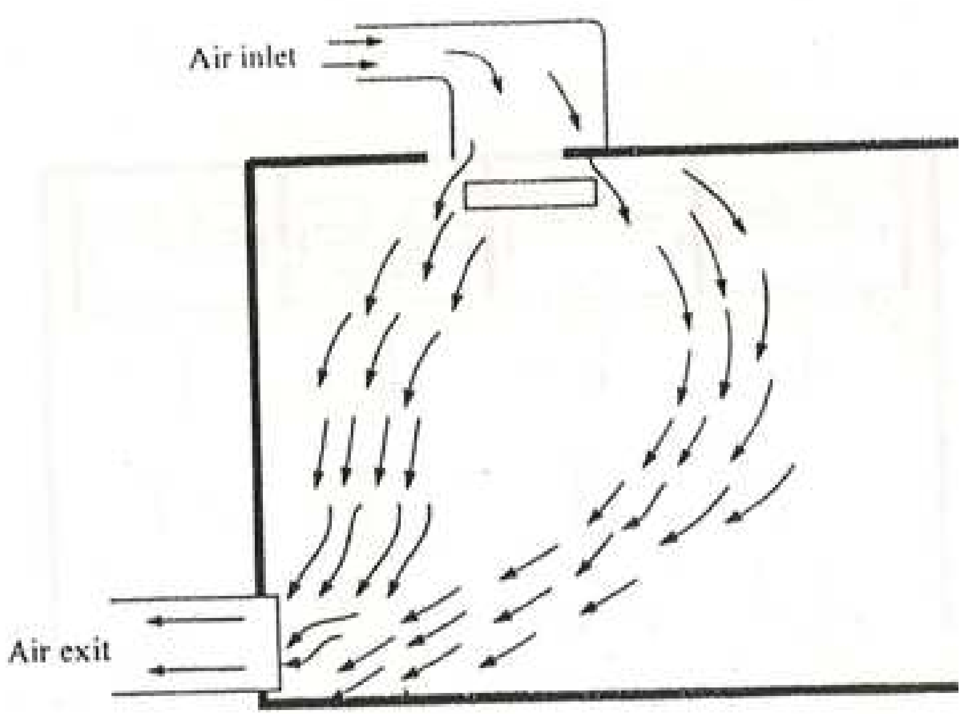


Fig. No. Ejector System (pan type)

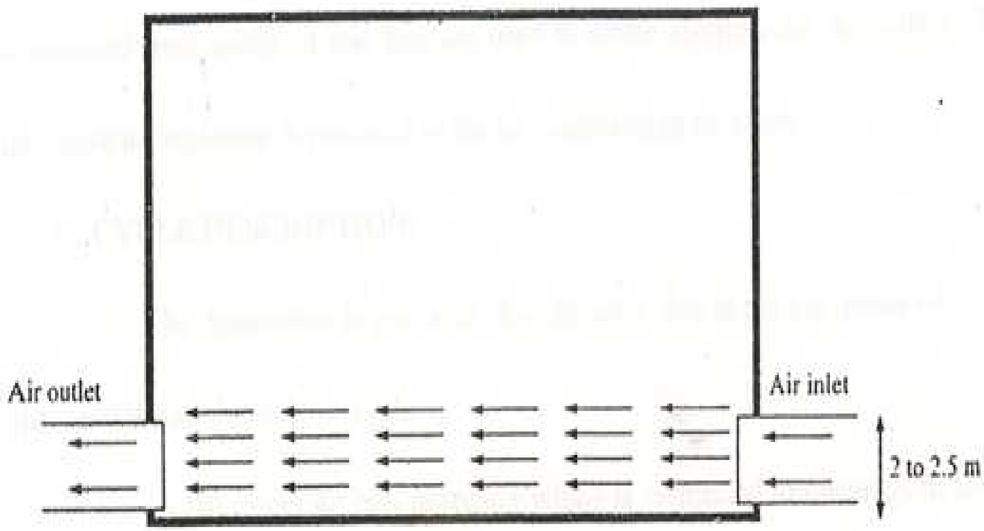


Fig.No:2.4 Uniform Air Distribution

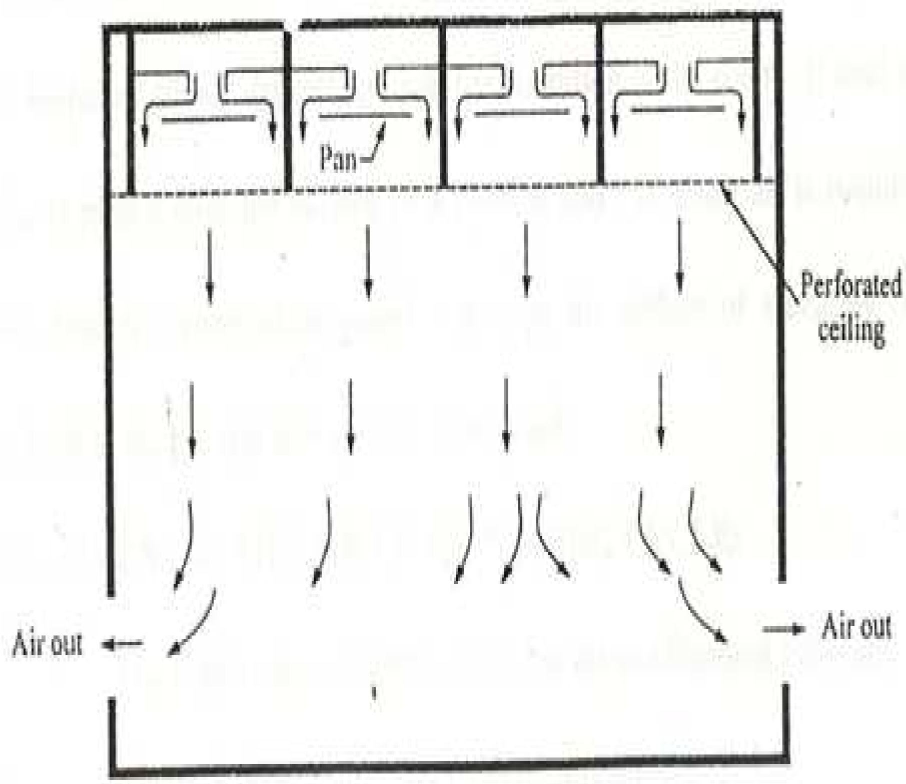


Fig No 2.5 Downward system

2.5. Typical Air Cycle:

Cold air is heated, hot air is cooled, moisture is added to dry air, moisture is removed from damp air and fans are used to create adequate air movement. Each of the above air treatment is provided in the air conditioning air cycle.

2.5.1. Cycle Description:

The description begins with the fan since this is the one piece of equipment that starts the air through the cycle.

A fan forces air into ductwork which is connected to openings in the room. These openings are commonly called outlets or terminals. The air enters the room and either heats or cools as required. Dust particles from the room enter the air stream and are carried along with it.

Air then flows from the room through a second outlet and enters the return duct work where dust particles are removed by air filter. After the air is cleaned, it is either heated or cooled depending upon the condition in the room. If cool air is required, the air is passed over the surface of a cooling coil. If warm air is required, the air is passed through a combustion chamber or over the surface of a heating coil. Finally it flows back to the fan and then cycle is completed.

2.5.2. EQUIPMENT IN THE AIR CONDITIONING CYCLE

The major parts of equipment in the air conditioning cycle are:

- Fan
- Supply ducts
- Supply outlets
- Space to be conditioned
- Return outlets
- Return ducts
- Filter
- Heating chamber or cooling coil.

Fan:

In an air conditioning system, the air that the fan moves is made up of:

1. All outdoor air 2. All indoor or room air 3. A combination of outdoor and indoor air.

The fan pulls air from outdoors or from the room but in most systems it pulls air from sources at the same time.

Since drafts in the room cause discomfort, and poor air movement slows the body heat rejection. Process, the amount of air supplied by the fan must be regulated. This is done by choosing a fan that can deliver the correct amount of air and by controlling the speed of the fan so that the air stream in the room provides good circulation but does not cause drafts.

Supply Ducts:

The supply duct directs the air from the fan to the room. It should be as short as possible and have a minimum number of turns so the air can flow freely.

Supply Outlets:

Supply outlets help to distribute the air evenly in a room.

Room Space:

The room is one of the most important parts of the air cycle description. A room is an enclosed space set apart by partitions. If this enclosed space did not exist it would be impossible to complete the air cycle since conditioned air from the supply outlets would flow into the atmosphere. The enclosed space therefore, is all important.

In fact material and the quality of workmanship used to enclose the space are also important since they help to control the loss of heat or cold that is confined in it.

Return Outlets:

Return outlets are openings in the room surface that are used to allow room air to enter the return duct. They are usually located at the opposite extreme of a wall or room from the supply outlet.

The main function of the return outlet is to allow air to pass from the room.

Filters:

The purpose of all filters is to clean the air by removing dust and dirt particles usually they are located at some point in the return air duct. They are made of many materials from spun glass to composition plastic. Other types operate on the electrostatic principle and actually attract and capture dust and dirt particles through the use of electricity.

Cooling coil and Heating coil or combustion chamber:

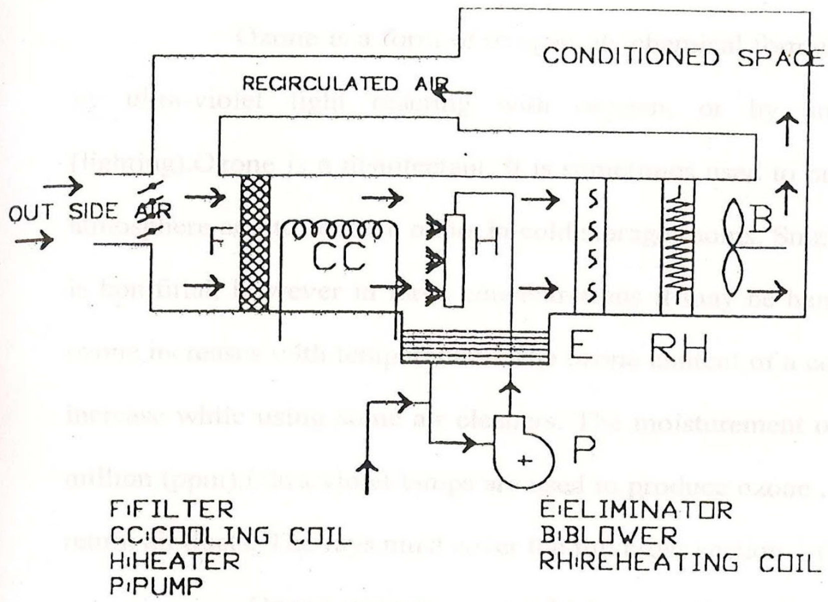
The coil can be located either shead of or after the fan, but should always be located after the filter. A filter shead of the coil is necessary to prevent excessive dirt, dust and dirt particles from covering the coil surface.

Winter Operation

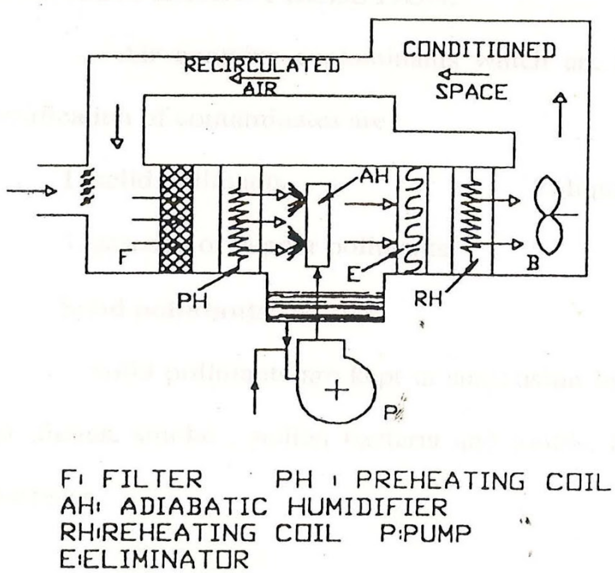
During winter operation, the air-conditioning cycle adds heat to the air. This is done by passing the return air from the room over the surface of a combustion chamber. This air is heated to the required (temperature and delivered to the room through the supply duct.

Summer operation:

During summer operation, the air conditioning cycle cools the air. Return air from the room passes over the surface of the cooling coil and the air is cooled to the required temperature. If there is too much moisture present it is removed automatically as the air is cooled by the coil.



SUMMER AC SYSTEM



WINTER AC SYSTEM

FIG.NO:2.6&FIG.NO:2.7

OZONE

Ozone is a form of oxygen, its chemical formula is 03.0zone is made either by ultra-violet light reacting with oxygen, or by an electric discharge in air (lighting).Ozone is a disinfectant. It is sometimes used to purify water, maintain a sterile atmosphere and to remove odors in cold storage rooms. Small amounts of ozone in the air is beneficial, however in large concentrations it may be harmful to health. The effect of ozone increases with temperature. The ozone content of a conditioned space may slightly increase while using some air cleaners. The measurement of ozone is made in parts per million (ppm).Ultra violet lamps are used to produce ozone. These lamps are installed in return air ducts. The rays must cover the full cross section of the duct to be effective.

Ozone generators, in which ozone is produced by electric discharge, or from the market and are designed to be used in connection with air- conditioning systems.

2.6. ATMOSPHERIC POLLUTION:

Air contains contaminants which are harmful to health. The three general classification of contaminates are:

- solid pollutants
- liquid pollutants
- gaseous or vapor pollutants

Solid Pollutants:

Solid pollutants are kept in suspension in the air by air currents. They may be dust fumes, smoke, pollen bacteria and molds. Pollen bacteria and molds are living substances.

Liquid Pollutants:

The liquid impurities are mist and fog.

Gaseous or Vapor Pollutants:

Gaseous and vapor contaminants may act like true gases. There is little difference between the two carbon monoxide, photochemical oxidants and nitrogen oxides.co is dangerous gas and is fatal if unhealed in large amounts. Nitrogen oxides which causes them to react to produce fog. Methane comes from the decomposition of vegetable matter. Organic vapors are a major source of pollution.

These vapors can be absorbed by active charcoal.

Odors and Bacteria:

Most odors are gases and even electrostatic filters will not remove them. Some odors can be removed by cooling the gases to their condensation or freezing temperature. Some can be removed by oxidation. Odors can be removed with active charcoal.

Bacteria are microorganisms that are responsible for the transfer of many diseases. In some cases the construction and condition of operation of some air conditioning equipment may increase rather than decrease bacteria, Ultra violet light is used to kill both bacteria and odors. Ultra violet lamps are placed in the return duct of the system where the air speed is the slowest.

Effective Temperature:

The areas under the comfort zone are sometimes defined as effective temperature Effective temperature is the combined effect of dry bulb temperature, wet bulb temperature and air movement, which provide an equal sensation of warmth or cold

Moisture and Heat Loss:

Water vapor flows easily through all porous substances. Water in vapor form will remain a vapor as long as its temperature is above the dew point .In modern housing water vapor is kept from passing through walls and towards surfaces where it might condense by the use of moisture proof material. Experiments show that the average person is most comfortable of the skin temperature is approximately 90°F (33 c). In hot weather, the temperature is maintained by the evaporation of the moisture (sweat) from the skin surface and from the air by the use of dehumidifiers.

Radiant (light) from the sun has high amount of heat energy. If glass in surface is exposed to the light sources, the energy will enter a space and become heat. Since glass is poor conductor of heat, the heat that comes in as a ray of light is trapped in the room as heat energy. The surface of buildings exposed to sun light gain heat. Thus heat source should be taken into account when designing cooling requirements of air conditioning systems. Odor has considerable effect on the amount of heat absorbed from the sun's rays. Dark colors absorb more heat and radiate more effectively than light colors.

Air Supply and Air Motion:

In an air conditioning system the air to be supplied must be conditioned before distribution. The air supply must be clean provide proper amount of ventilation and be able to absorb heat to cool the conditioned spaces. Air movement in a conditioned space is important. If the air moves to fact persons feel an annoying draft. If the air movement is too slow the air becomes to stale (contaminated) and lack of air movement. It is important to place thermostat and dehumidifiers at proper level in order to eliminate stratification.

Metabolism:

The human body is able to accustom itself to a certain amount of change in a given length of time. Hence it becomes necessary to regulate air conditioning equipment so that it will produce only a certain output while this will be less comfortable it will not subject a person to too great a shock on entering or leaving conditioned room. Air conditioned buildings are usually maintained at a temperature which is not over 10°F below the outside temperature.

Some people are quite sensible to thermal shock when entering or leaving an air conditioned space. Human illness due to thermal environment is sometimes called thermal disorders. High temperature may cause human illness, particularly when accompanied by high humidity. This is due to the increase in the rate of metabolism

Under long exposure to very hot conditions the human body attempts to adjust to the conditions by increasing sweating and the flow of blood finally leading to heat strokes. Under very cold conditions the body temperature drops few degrees below normal which causes an uncomfortable sensation, also physiologically the body attempts to correct this condition by showering.

Comfort Zone:

Most people are comfortable in atmosphere where the relative humidity is between 80% and 70% and the temperature is between 70 to 85° F. These points can be plotted on a psychrometric chat .The area in between these points represent the comfort zone which is over a considerable area.

2.7. VAPOUR COMPRESSION CYCLE

It is so needed because it is the compressor which changes the refrigerant vapor from low pressure to high pressure. This pumping machine causes the transfer of heat energy from one place to another. And it is also called as heat pump. A refrigeration system consists of principally of a high pressure side and a low pressure side. The speed of the compressor is usually less than the speed of the motor. This is done by using pulleys. The vapor compression cycle follows these steps. From liquid receiver G, liquid refrigerant at a high pressure flows through the thermostatic expansion valve 'A' (pressure reducer). It moves into the evaporator 'B'. The evaporator is under low pressure, hence the liquid refrigerant vaporizes (boils) and absorbs heat. The vapor then flows into the compressor through the intake valve 'C'

Back into the compressor cylinder .The piston 'D' on the compression stroke squeezes the vapor into small space with an increase in temperature. The compressed high temperature vapor is pushed through exhaust valve 'E' into the condenser 'F'. In the condenser heat from the refrigerant is passed on to the outside air. In giving up heat it returns to a liquid and is stored in the receiver. From here the cycle is repeated.

Work done by the compressor =W= Area of T-s diagram.
C.O.P= (Heat extracted or refrigerating effect)/Work done
C.O.P= $(h_2-h_1)/(h_3-h_2)$.

CHAPTER III

PSYCHROMETRICS

3.1. Definition:

Psychrometry is a branch of engineering science which deals with the study of the properties of moist air under various conditions. Psychometrics literally means "pertaining to the measurement of the cold" but in modern usage it refers to the state of the atmosphere with reference to moisture. In refrigeration application the atmosphere is considered as the mixture of dry air and water vapor.

3.2. Basic Concepts:

Is the study of the properties of air psychometrics involves measuring and determination of the properties of outside air and of air that is present in the conditioned form.

3.2.1 Dry air:

The mixture of nitrogen & oxygen neglecting the water vapor & other gases is known as dry air .Volumetric composition of dry air is 77% of nitrogen and 23% oxygen. The approximate composition of dry air is

S.No	Constituent	% By volume	% By mass
1.	N2	78.08%	75.46%
2.	02	20.99%	23.19%
3.	Ar	0.94%	1.29%
4.	Co2	0.03%	0.05%

5.	H_2	0.01%	0.01%

Molecular mass of dry air =28.966 TABLE NO: 1

Gas constant of air, Ra=0.287KJ/kg

Density of dry air at NTR=1.293kg/m^A3

Completely pure dry air does not exist in nature because water vapor in various amount diffuses into it. At low pressures both dry air and water vapor coexist in nature as perfect gases and all the perfect gases terms can be applied.

3.2.2 Moist Air:

It is a mixture of dry air & water vapor .The maximum quantity of water vapor that can be present in air depends upon the temperature of the air.

3.2.3 Saturated Air:

It is a mixture of dry air and water vapor .When the air as diffused the maximum amount of water vapor into it. The water vapor usually occurs in the form of super-heated steam as an invisible gas.

3.2.4 Degree of Saturation:

The ratio of the weight of the water vapor associated with a pound of dry air to the weight of water vapor associated with a pound of dry air saturated at the same temperature.

3.2.5 Moisture:

The water vapor in the air is known as the moisture and its quantity in air is an important factor in all air conditioning system.

3.2.6 Humidity:

Moisture in the air is measured in terms of humidity. 50% relative humidity means that the air contains one-half the amount of moisture that it is capable of holding. The unit of humidity is grain of water vapor.

3.2.7 Relative Humidity:

Relative humidity is the actual amount of moisture in the air as compared with the maximum amount of moisture the air can hold.

3.2.8 Absolute Humidity:

The weight of water vapor per unit volume, pounds per cubic foot or gms per cub. cm.

3.2.9 Dry Bulb Temperature:

The temperature of a gas or mixture of gases indicated by an accurate thermometer after correction for radiation. Is the temperature of the air as measured by an ordinary thermometer such as a household thermometer?

3.2.10 Wet Bulb Temperature:

It is the temperature at which liquid of solid water, by evaporating into air can bring the air to saturation adiabatically at the same temperature .Is the temperature of the air as measured by an ordinary thermometer

3.2.11 Wet Bulb Depression:

It is difference between DBT and WBT at any point .WBD indicates RH of air. WBD becomes zero when air is fully saturated.

3.2.12 Dew Point Temperature:

Is the temperature at which moisture condenses on a surface at a given state of humidity and pressure as the, temperature of the vapor is reduced. The temperature corresponds to saturation for a given absolute humidity at a constant pressure.

3.2.13 Dew Point Depression:

It is the difference between the DBT and DPT of the air.

3.2.14 Sensible Heat of Air:

The quantity of heat which can be measured by measuring the DBT of air is known as sensible heat.

3.2.15 Total Heat of Moist Air:

It is the sum of sensible heat of dry air and sensible & latent heat of water vapor associated with dry air.

3.2.16 Psychrometer:

The equipment used for measuring simultaneously DBT and WBT is known as Psychrometer

3.2.17Types of Psychrometer:

1. Laboratory Psychrometer 2.Sling Psychrometer
3. Aspirating Psychrometer 4. Continuous reading type

Laboratory Psychrometer:

It is the simplest type which is mounted on wall, and it always reads DBT & WBT of the surrounding air.

Sling Psychrometer:

It is widely, used to measure the DBT & WBT for calculating psychrometric properties of air it consists of two mercury thermometers. The wet bulb thermometer is covered with a cloth wetted by distilled water and exposed to air flow of 300mt/min. The

DBT of air is the temperature measured by an ordinary DBT the whirling round of unit rapidly is necessary to have air motion over wet bulb until wet bulb.

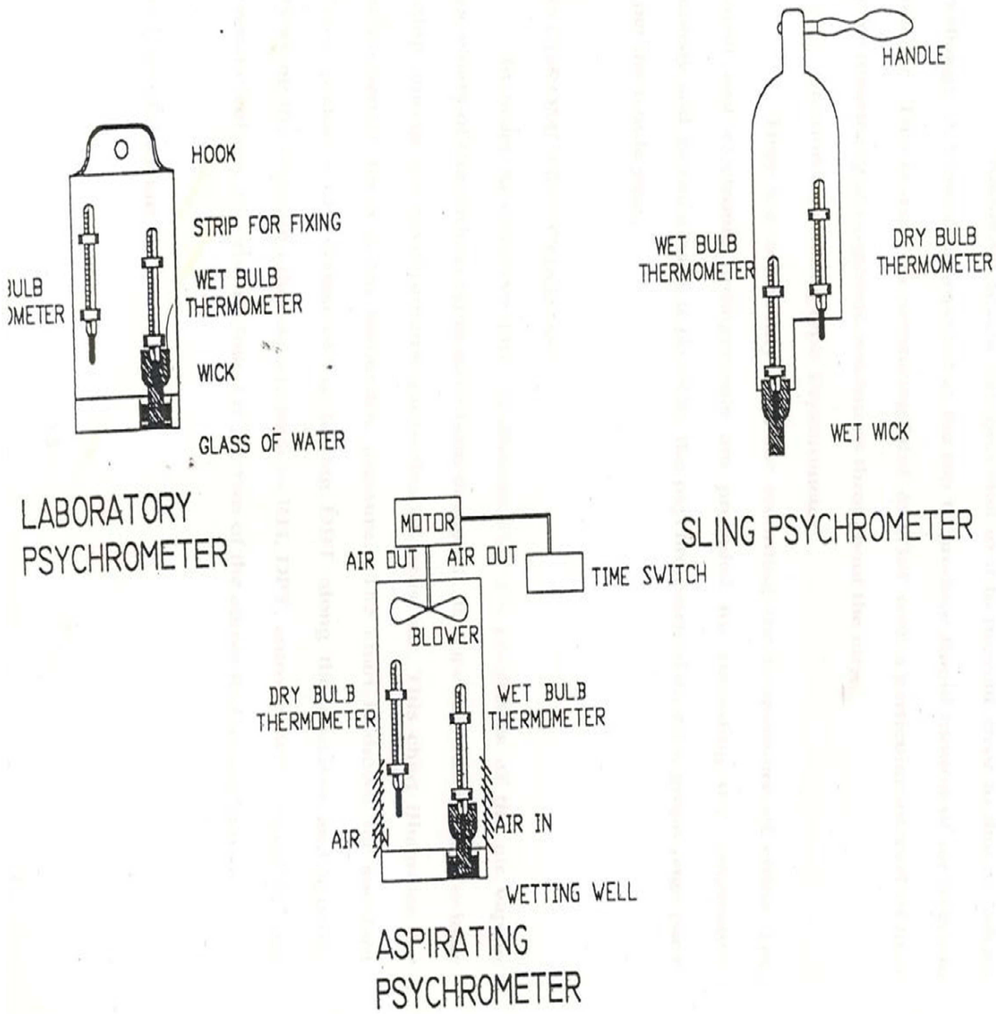


FIG.NO:3.1&FIG.NO:3.2&FIG.NO:3.3

becomes steady. A stagnant layer of air near the cloth will attain a temperature in between DBT & WBT, & thus will give a wrong reading of actual WBT.

Aspirating Psychrometer:

Radiation sheets are provided to it to prevent error to due to radiant heat exchange. A blower is provided at the top to produce Rapid motion of air over the thermometer. This is used for measuring DBT & WBT with a particular interval of time mostly for measuring atmospheric conditions throughout the air.

Continuous reading type Psychrometer:

They are commonly used for recording the temperature of cities. The mechanical and electronic arrangements are provided for recording the temperature continuously and automatically. It provides the psychrometric data on a graph page per a day or per the whole year.

3.3. PSYCHROMETRIC CHARTS:

In order to conserve time in determining the properties of the air vapor mixtures, charts of the various types have been designed. It is a chart that shows the inter relationship among the psychometric properties of moist air. This chart illustrates the different properties for a given barometric pressure. The chart is drawn for standard atmospheric pressure of 760mm of Hg having DBT along the abscissa and specific humidity along the ordinate other details such as RH, DPT, entropy, WBT, sensible heat factor, specific volume can also be found if any two of the above factors are known.

3.3.1 Analysis of the chart:

The DBT lines are vertical lines drawn parallel to ordinates, and are equispaced every 5°C. The ordinate represents the specific humidity lines. These are straight, horizontal, uniformly spaced lines ranging from 0- 0.03kg/dry air. The constant DPT lines drawn horizontally starting from the saturation curve on the left to the right side end. The WBT lines are inclined straight lines non uniformed spaced to the right hand side of the chart running diagonally downwards. At any point on the saturation curve

DBT, WBT and DPT are equal which contains 100%RH curve. The constant enthalpy lines are inclined straight lines uniformly spaced and indicates the total heat content. These lines are almost parallel to the WBT lines. The specific volume lines start from saturation curve and drop downwards with a straight angle to the vertical lines. These lines are more inclined to the horizontal than the WBT lines. Vapor pressure lines are straight, horizontal, parallel lines with non-uniform spacing between them to avoid clumsiness these values are shown on a scale in mm of Hg on extreme left of the chart. The relative humidity lines are curved lines starting from left and extending upwards, diverging to the right side of the chart. These lines are drawn with values 10%, 20%....so on up to 100% RH. These saturation curve itself presents 100%RH curve.

CHAPTER IV
REFRIGERANTS

Any substance capable of absorbing heat from another required substance can be used as refrigerant that is ice, water, air or brine. A mechanical refrigerant is a refrigerant which will absorb the heat from the source (which is at a low temperature) and dissipate the same to the sink (which is at a higher temperature) either in the form of sensible heat (as in the case of air -refrigeration) or in the form of latent heat (as in the case of vapor refrigeration).The refrigerants which carry the heat in the form of latent heat and also dissipate in the form of latent heat are more efficient than refrigerants which carry the heat in the form of sensible heat.

In selecting a refrigerant for a particular purpose, both thermodynamic, chemical and safety characteristics must be considered in addition to their physical characteristics. Air was used as refrigerants in many refrigerants systems in olden days considering safest refrigerant. Ammonia, Co2 & So2 were also used as refrigerants for different purposes. Methyl chloride was commonly used for domestic and commercial purpose until Freons were available.

4.1. CLASSIFICATION OF REFRIGERANTS:

These refrigerants are classified into two groups,

- Primary refrigerants
- Secondary refrigerants

Primary Refrigerants:

Primary refrigerants directly take .part in the refrigeration system where as secondary refrigerants are first cooled with the help of primary refrigerants and are further used for cooling purpose.

The classifications of the primary refrigerants are made in different groups as follows:

Halocarbon Compounds:

These groups of refrigerants was invented and develops by Charles Kettering and Dr. Thomas Medley in 1928. This group includes refrigerants, which contains one or more of the three Halogens, fluorine and bromine.

EX: Methyl-chloride, Ethyl-chloride etc.

Commonly used halocarbon refrigerants are

Refrigerant number	Chemical name	Chemical formula
R-11	Trichloro mono fluoro methane	CCbF
R-12	Dichlorodifluoromethane	CCI2F2
R-13	Monochlorotrifluoromethane	CCIF3
R-14	Carbotetrafluoride	CF4
R-21	Dichloromonofluoromethane	CHCI2F
R-22	Monochlorodifluoromethane	CHCIF2
R-30	Methylene chloride	CH2CI2
R-40	Methyl chloride	CHsCL
R-100	Ethyl chloride	C2H5CI
R-113	T richlorotrifluroethane	CCI2FCCIF2
R-114	Dichlorotetrafluoroethane	CCIF2CCIF2
R-115	Monochloropentafluroethane	CCIF2CF3

R-152	Difluroethane	C2F4CI2

TABLE NO: 2

Azeotropes:

The refrigerant under this group consists of mixtures of different refrigerants, which do not separate into their compounds with the change in pressure & temperature or both.

EX: R-500, which contains of 73.8% of F-12 & 26.2% of F-152.

Hydrocarbons:

These refrigerants under this group were universally used for all purposes before the introduction of halocarbon group. They are still used for different purposes due to their inherit thermodynamic and physical properties.

EX: Methane, Ethane, Propane etc.

Inorganic Compounds:

The refrigerants under this group was universally used for all purposes before the introduction of halocarbon group.

They are still used for different purposes due to their inherit thermodynamic and physical properties.

EX: NH3, H20, Co2, S02 etc.

Unsaturated Organic Compounds:

The refrigerants under this group are mainly hydrocarbon group with ethylene and propylene base.

Desirable properties of an ideal refrigerant are,

- Thermodynamic properties
- Safe working properties

Thermodynamic Properties:

The following table represents different thermodynamic properties of different refrigerants.

Refrigerants	NH3	F11	Fl2	F22	C02	S02	CARREN-1	CARREN-7
Boiling point(°C)	-33.3	23.3	-29.8	-41.3	-	-	40.5	-33.3
Freezing point(°C)	-77.8	-111	-157.8	-.160	-56.7	-75.6	-96.6	-159
Pressure in evaporator at - 15°C	2.34 ATA		1.8 ATA		23.7			
Pressure in condenser at 29°C	11.5 ATA	-	7.32		71.2	-	-	-
Pressure ratio Pc/PE	4.92	-	4.07		3.02	-	-	-
Critical Temp(°C)	132.8	197.5	112.1	95.4	30.5	157	216	105
Critical Pressure (kg/cm^2)	112	43.2	40.6%	48.7	72.8	77.5	43.5	42.9

TABLE NO: 4.1

4.2. Physical properties:

- Low specific volume of vapor Low specific heat
- High thermal conductivity
- Low viscosity
- High electrical insulation.
- Other properties:
- Ease of leakage location Availability and low cost Ease of handling
- High C.O.P.
- Low power consumption per ton of refrigeration Low pressure ratio and pressure difference.

Flammability:

The ideal refrigerant should not have any danger of explosive in presence of air or in association with lubricant oil.

Corrosive Property:

Refrigerant must be chemically inert with materials as well as they must also remain in the presence of water or air.

Viscosity:

This property of refrigerant in both states carries importance for calculating heat transfer coefficients in evaporators and condensers.

Dielectric strength:

The electric resistance of the refrigerant becomes an important factor when it is used in hermetically sealed unit where the motor is exposed to refrigerant.

Other Properties:

Besides these the following are the other refrigerant properties.

- Odor
- Leak-tendency
- Refrigerant and oil relationship
- C.O.P and H.P requirement
- The important refrigerants commonly used in R&A.C are as follows:
- Ammonia
- Carbon dioxide
- Sulphur dioxide
- Methyl chloride
- Methylene chloride '
- Freon- 11(CCbF) ;
- Freon-12(CChF2)
- Freon-22(CHCLF2)
- Refrigerant-500.

CHAPTER V

LOAD CALCULATIONS

The building to be conditioned is an Auditorium having an area of 440.27 mt^2

Specifications:

Capacity=400 persons at a peak load

Dimensions of the space to be conditioned:

Length of the auditorium: 30.28mt.

Width of the auditorium: 14.54mt

Height of the auditorium: 4.5mt.

Thickness of wall: 23cm.

Total number of doors: 5

Total number of windows: 14

Electrification:

40 florescent lamps of 40 W each

16 florescent lamps of 11 W each

28 florescent lamps of 20 W each

3 incandescent lamps of 500 W each

Construction: Heavy.

Volume of the Auditorium:

30.28×14.54×4.5=1981.22mt^3.

Auditorium Conditions:

Dry bulb temperature: 25ºC.

Relative humidity : 55%

Outside Conditions:

Outside temperature: 40ºC.

Outside relative humidity: 65%.

Design Factors:

1. Sensible heat factor for people: 50 kcal/mt^2/hrºC.
2. Sensible heat factor for door having thickness of 3.75cm: 2.55kcal/mt^2/hrºC
3. Sensible heat factor for windows of single thick glass: 5.50 kcal/mt^2/hrºC
4. Sensible heat factor for wall of thickness 20cm plastered on one side: 1.45kcal/mt^2/hrºC
5. Sensible heat factor for roof (plaster ceiling): 1.35 kcal/mt^2/hrºC
6. Sensible heat factor for floor: 1.6 kcal/mt^2/hrºC
7. Sensible heat factor for lighting: 6
8. Latent heat factor for people: 38kcal/min.
9. Infiltration air change=1 air change.
10. Infiltration for doors and windows: 4mt^3/min.

Exposed Area:

North Side:

Area of doors: (2.05×1.22) =2.5m^2

Area of north faced wall: (14.54×4.5) = 65.43m^2.

North side stone wall area: (65.43-2.5) =62.93m^2.

South Side:

Total stone wall area: (14.54×4.5) = 65.43m^2

There are no windows and doors in south side.

East Side:

Area of windows: 4(1.3×1.67) + (4×1.4) = 14.284m^2.

Area of doors: (1.95×1.13) + 2(1.95×1.45) + (2.1×1.5) = 11m^2.

Area of east faced wall: (30.28×4.5) =136.26m^2.

East side stone wall area: (136.26-14.28-11) = 110.98m^2

West Side:

Area of windows: 7(1.67×1.3) + (2.5×1.3) + (3.2×1.3) = 22.607m^2.

Area of east faced wall: (30.28×4.5) =136.26m^2

West side stone wall area: (136.26-22.60) = 113.65m^2.

Total stone area: (62.93+65.43+110.98+113.65) = 353m^2.

Total area of doors: (2.5+11) = 13.5m^2.

Total area of windows: (14.28+22.60) = 36.88m^2.

Number of lights:

Total wattage: (40×9) + (16×11) + (28×20) + (3×500) = 2.596kw.

SENSIBLE HEAT LOADS

Sensible heat load = A× U × (T_0-T_i)

Where A= area U= sensible heat factor

$T_{0=}$ outside temperature T_i = inside temperature

1. through walls:

353×1.45× (40-25) = 7,677.75 kcal/hr.

2. through doors:

13.5×2.55× (40-25) =516.73 kcal/hr.

3. through windows:

36.88×5.5× (40-25) = 3043.5 kcal/hr.

4. through roof:

440.27×1.35× (40-25) = 8915.5 kcal/hr.

5. through floor:

440.27×1.6× (40-25) = 10566.48 kcal/hr.

6. through people:

Number of people × sensible heat factor = 400×50=20000 kcal/hr.

7. through lights:

2.596 × 860 = 2232.56 kcal/hr

Total sensible heat = 52952.51 kcal/hr.

Latent heat load calculations:

Latent heat load= number of people × latent heat factor

Through people= 400×38 = 15200 kcal/hr.

Infiltration:

Volume= (30.28×14.54×4.5) =1981.22m^3

Total quantity of air is computed as follows: (volume×A_c)/60 m^3/min.

Where A_c=air change per hour= 1

Through room= (1981.22×1)=1981.22m^3/hr.

Through doors and windows= 50.392×4=201.568m^3/hr

Total infiltration= 2182.8m^3/hr

Psychometric calculations:

Enthalpy at A i.e inside auditorium at T_i =25ºC and Relative Humidity=55%.

H_a= 12.66 kcal/hr.

Enthalpy at B i.e outside at T_0 = 40ºC and Relative Humidity=65%

H_b= 25.35 kcal/hr.

We can find a point c from the psychometric chart i.e. where these two points are intersecting that point is C. H_c=16.5kcal/hr

At A: specific humidity w = $(0.622P_v)/(P_t-P_v)$.

Where P_v= partial pressure of vapour

P_t = barometric or total pressure= 1.0132 bar

Relative Humidity=P_v/P_{vs}

P_{vs}=0.0317

0.55= P_v/0.0317

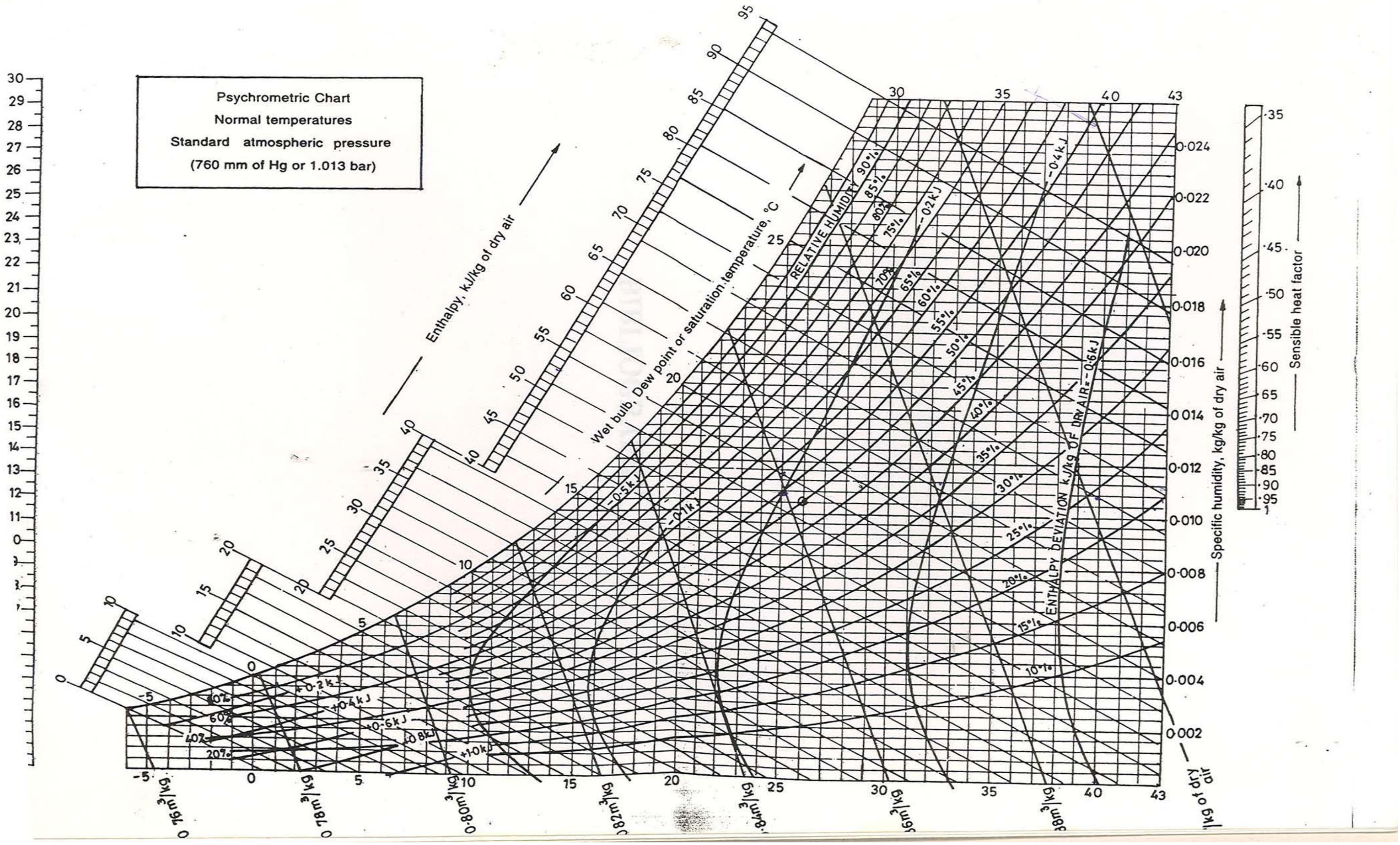
P_v=0.00175435 bar

Specific humidity=W_a=(0.622×0.017435)/(1.01325-0.017435

W_a=0.011kg/kg of dry air.

At B: P_{vs}=0.0813bar

0.65=P_v/0.0813



Psychrometric Chart
Normal temperatures
Standard atmospheric pressure
(760 mm of Hg or 1.013 bar)
Enthalpy, kJ/kg of dry air
Wet bulb, Dew point or saturation temperature, °C
RELATIVE HUMIDITY
ENTHALPY DEVIATION kJ/kg OF DRY AIR
Specific humidity, kg/kg of dry air
Sensible heat factor
0.76 m³/kg
0.78 m³/kg
0.80 m³/kg
0.82 m³/kg
0.84 m³/kg

P_v=0.052 bar

Specific humidity=W_b= (0.622×0.052)/(1.01325-0.052)

W_b =0.036 kg/kg of air

Plotting on the psychometric charts, we get the specific volume of the mixture

as x = 0.94m^3/kg.

Weight of in filtered air = Total infiltration/specific volume

= 2181.768/0.94

= 2322.09 kg/hr

Latent heat due to infiltration = 2322.09× (H_b-H_c)

= 2322.09× (25.35-16.5)

= 20550.5kcal/hr

Sensible heat due to infiltration = 2322.09× (H_c-H_a)

= 2322.09× (16.5-12.6)

= 8916.82kcal/hr

Total sensible heat = 61869.33 kcal/hr

Total latent heat = 35750.5 kcal/hr

Total load = Total sensible heat + Total latent heat

= (61869.33+35750.5) =97619.83 kcal/hr

Total load = 97619.83 kcal/hr

1 Ton of refrigeration=3020 kcal/hr

Number of tons=97619.83/3020

Number of tons=32.32.

CHAPTER VI

DUCT DESIGN

Function of Ducts:

The function of a duct is to convey the air between two points, such as between the air handling unit or air-washer and the room to be conditioned. It also carries the room air back to the air conditioning apparatus.

Air to be delivered to the conditioned space is to be carried by ducts. They are made up of non-combustible material. Ducts work on the principle of air pressure difference. The pressures in the duct are small. Ducts must be designed not only to circulate a certain amount of conditioned air, but must also over come objectionable noise and drafts. Noise overcomes by living the ducts with felt or soft insulation or by covering the ducts with thick cloth while a grill is used to reduce air drafts. Ducts commonly used are round, square or rectangular. Supply ducts carry conditioned air to the room and return duct carry away the heated air to the evaporator. Rooms opening to ducts have several devices such as dampers to control air flow in a forced air system, diffusers to deliver large volumes of air and registers to deliver concentrated air streams into a room.

Two methods to calculate the proper size plenum chambers, main ducts , branch ducts and grills are

- Unit pressure drop system.
- Total pressure drop system.

6.1. Air Transmission System:

Low velocity system:

Air velocity in the main supply -air duct is within 760m/min.

High velocity system:

Air velocities above 760m/min.

The successful operation of any air-conditioning system is dependent upon the sufficient circulation of air in the air-conditioning space.

The duct cost in air-conditioning system is above 20-30% of the total cost of the equipment required and power required by the fan contributes the substantial part of the running cost.

It is therefore necessary to design an air-duct system for least capital cost and lowest running cost of the fan.

Duct Sizes:

The duct has to be so sized that it is accommodated within the available space. Air while passing through a duct suffers a pressure drop due to friction. Larger the quantity of air passing through a given cross-sectional area of the duct greater will be the frictional loss and pressure drop. The initial cost depends on the size of the duct.

Ducts must be so designed such that each room being several receives the correct amount of air. The volume of air to be delivered to the room must be known before calculating the duct size. The volume depends on the amount of heat to be removed from the room. The amount of air delivered to a room must always equal or exceed the minimum fresh air ventilation requirements. Space in buildings is decreased by increasing the duct size but then pressure and velocity of delivered air are reduced which results in less power consumption and less noise.

Aspect Ratio:

Aspect ratio is the ratio of long side to the short side of the duct. Aspect ratio of square section is one, a square duct or duct very near a square section is best for minimizing the initial and operating cost.

Duct material:

The ducts and usually made from the following materials:

Galvanized iron sheet metal.

Aluminum sheet metal, or

Black steel.

In air-conditioning system, galvanized sheet metal is most commonly used duct material. Since the Zinc coating of this metal prevents rusting and avoids the painting cost. The gauge used is 26 to 16gauge (0.55 to 1.6mm)

The aluminum is used because of its lighter weight and resistance to moisture. The black sheet metal is always painted unless it withstands high temperature. Stainless steel is used in special applications for maximum resistance to moisture.

The “Resin bonded glass fiber “ducts are used because they are quite strong and easy to manufacture according to the desired shape and size.

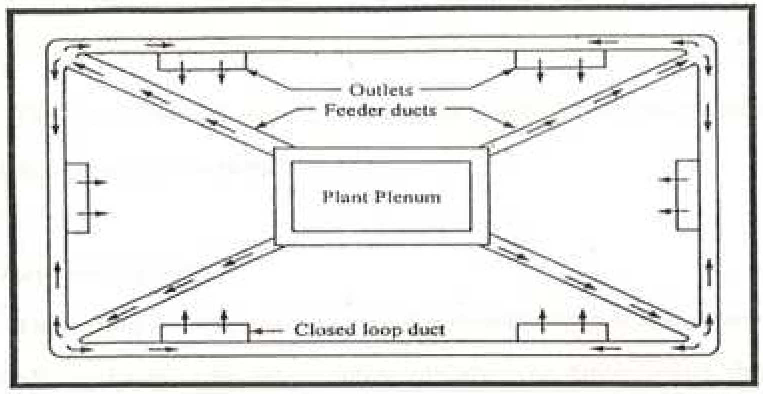


Fig.No.6.1 Loop Perimeter Duct system

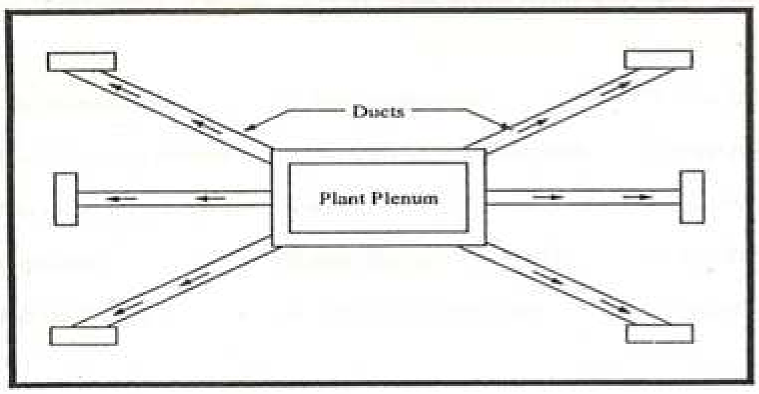


Fig.No:6.2 Radial perimeter Duct system

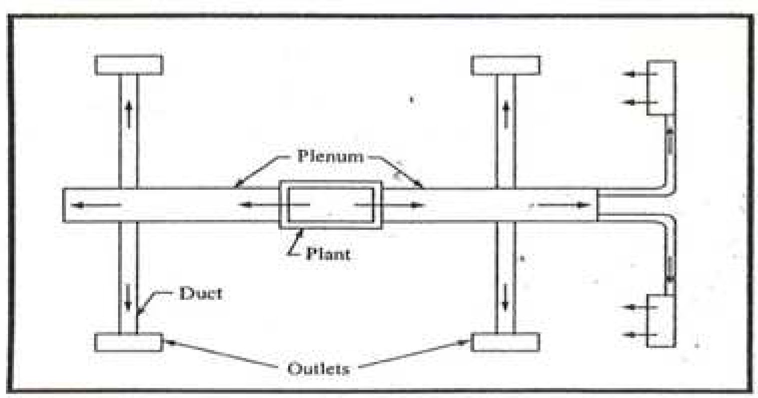


Fig.No.6.3 Extended plenum duct system

The “Cement asbestos “ducts may be employed for underground air distribution and exhausting corrosive materials.

Duct Construction:

Ducts made of sheet metal expand and contract when heated and cooled, The Movement is absorbed by fabric joints often. The fabric joints should also be used where ducts fasten to a furnace or an air-conditioner. But in fact most duct joints are made of sheet metal. Various types of sheet metal joints used in the construction of ducts are:

1. Grooved seam
2. Drive slip joint
3. Double seam corner
5. Standing seam (riveted)
6. Pittsburg hammered lock seam
7.cup joint.
8. Bar slip joint (riveted)
9. Pocket joint with bar slip
10. Riveted seams
11. Channel type seam
12. Reinforced duct.

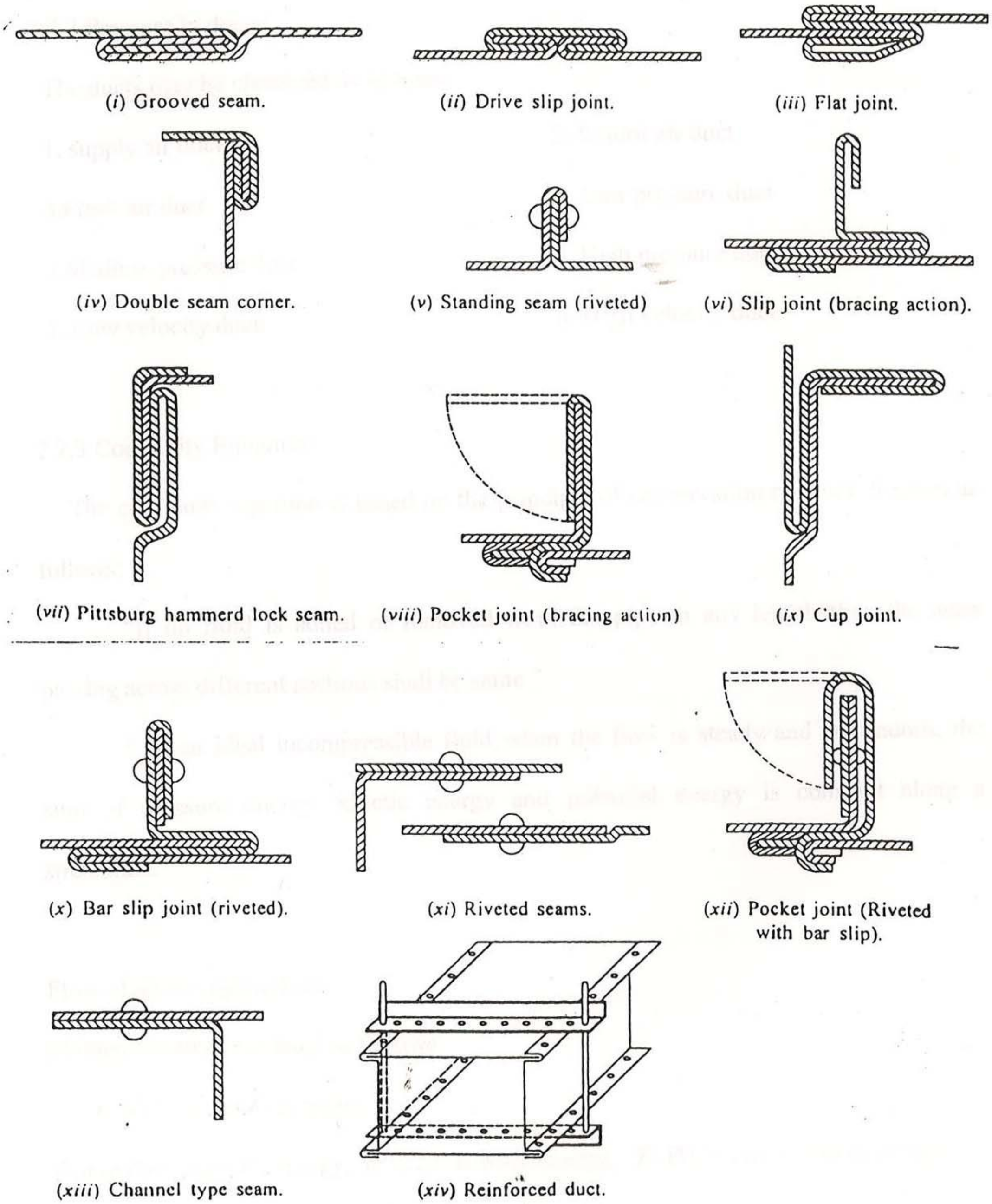


Fig. 16.1. Sheet metal duct joints.

Fig.No.6.4. Types of Joints used in Ducts

6.2. The ducts may be classified as follows:

1. Supply air duct.
2. Return air duct
3. Fresh air duct
4. Low pressure duct
5. Medium pressure duct
6. High pressure duct
7. High velocity duct.

Continuity Equation:

The continuity equation is based on the principle of conservation of mass. It states as follows:

"If no fluid is added or removed from the pipe in any length then the mass passing across different sections shall be same."

"In an ideal incompressible fluid when the flow is steady and continuous, the sum of pressure energy, kinetic energy and potential energy is constant along a streamline."

Flow of Air through a Duct:

Mathematically it is stated as follows:

$P/W+C^{A}2/2g+Z=constant$

Where P/w=pressure energy; $C^{A}2/2g$=Kinetic energy; Z=Datum or elevation energy. General Aspects in Duct design:

Low Velocity Duct:

- The major consideration in duct design is that ducts should carry the necessary volume of conditioned air space with minimum frictional and dynamic pressure losses and still be economical in size.
- The duct layout must be made so as to reach the outlet with least number of bends, obstructions and changes must be gradual where possible and limited to not more than 20° for diverging area and 60° for converging area.
- With rectangular ducts the aspect ratio of 4:1 and less is desirable but in no case be made greater than 8:1.
- The velocities in the ducts must be enough to reduce the size of the ducts but low enough to reduce the noise and the pressure losses, to economize power requirement.
- Ducts should be made of smooth materials such as galvanized iron or aluminium sheet metals. Whenever other materials are used, allowance should be made for the roughness of the material.
- Dampers should be provided in each branch outlet for balancing the system.
- Obstructions in the ducts should be avoided.

Determination of Duct Size:

After deciding the layout and calculating the requirements of air quantities at various outlets the size of the ducts may be determined by using one of the following three methods:

- Velocity reduction methods.
- Equal friction (or constant pressure loss) method.
- Static regain method.

6.3. Types of duct systems:

- Loop perimeter duct system
- Radial perimeter duct system
- Extended plenum duct system

Loop Perimeter Duct System:

The conditioned air is carried in several feeder ducts to a common continuous closed loop duct around the perimeter of the building. The outlets then supply air to the room.

Radial Perimeter Duct System:

Separate ducts supply conditioned air to the respective supply outlets from the planet Plenum. This system is recommended for crawl-space houses. It can also be used in slab floors, but will not be effective as the loop perimeter system in warming the perimeter of the floor.

Extended Plenum System:

The plenum is extended to one or both sides of the air-conditioning plant. Each supply outlet is fed with conditioned air from the separate duct. This system is recommended for houses with basement or crawl space.

Controls:

Buildings are kept comfortable and healthy with automatically controlled temperature, humidity, air movement and cleaning and air sterilization. The three basic groups of controls are

- Operating controls
- Primary controls
- Limit controls

Operating Controls:

These are usually the thermostats which signal the start or the stop of a cooling system

Primary Controls:

These insure a safety start and safe operation of the system.

Limits Control:

These are for safety; they will not permit a system to run unless all the safety conditions are in good order.

Operating controls start and stop a system through the primary controls when the

Limiting controls permit these actions. Several types of control systems in use are electric, pneumatic, electronic fluidic and combinations.

6.4. Calculations:

Total load=97,619.83kcal/hr

The volume of the air to be delivered to the room must be known before calculating the duct size.

The volume of the air to be delivered to the room is calculated by using this formula

Total load = Q_r ×A× (T_o-T_i)

Where Q_r = the total volume of the air to be delivered to the room

A = area of auditorium.

T_o = outside temperature of the auditorium

T_i = inside temperature of the auditorium.

97,619 = Q×440.27× (40-25)

Q_r =16.94m^3/sec

Total volume of the air required to conditioned the auditorium is 16.94m^3/sec.

Considering a square duct system with four main ducts and twelve branched ducts the design of duct can be done as follows.

Assuming the dimensions of main duct on west and east side as 0.75×0.75mt^2.

And on east and west side as 0.65×0.65mt^2

Assuming four branched ducts on east and west side each and two each on north and south side.

Consider velocity of air for main ducts 1&2 on east and west side as 9m/sec.

Consider velocity of air for main ducts 3&4 on north and south side as 8m/sec

Consider velocity of air for branched ducts as 7m/sec.

Area of main ducts 1&2=A_1=A_2=0.75×0.75=0.5625m^2.

Area of main ducts 3&4=A_3=A_4=0.65×0.65=0.4225m^2

Area of branched ducts=a_1=a_2=a_3=a_4=a_5=a_6=a_7=a_8=0.45×0.45=0.2025m^2.

Area of branched ducts=a_9=a_{10}=a_{11}=a_{12}=0.5×0.5=025m^2

Quantity of air passing through main ducts 1&2 is Q_1=Q_2=A_1×C_1=A_2×C_2

0.5625×9=5.06m^3/sec.

Quantity of air passing through main ducts 3&4 is Q_3=Q_4=A_3×C_3=A_4×C_4

0.4225×8=3.38m^3/sec

Total quantity of air passing through the duct Q_d = Q_1+Q_2+Q_3+Q_4

= 16.88m^3/sec.

Total quantity of air passing through the ducts Q_d=16.88m^3/sec.

Here $Q_r = Q_d$.

So assumed dimensions are correct.

Design of branched ducts

Quantity of air passing through branched ducts 1,2,3,4 is $Q_{b1}=Q_{b2}=Q_{b3}=Q_{b4}$

$$Q_{b1}=a_1\times c_1=0.2025\times 7=1.4175 m^3/sec.$$

$$Q_{b2}=a_2\times c_2=0.2025\times 7=1.4175 m^3/sec.$$

$$Q_{b3}=a_3\times c_3=0.2025\times 7=1.4175 m^3/sec.$$

$Q_{b4}=Q_1-(Q_{b1}+Q_{b2}+Q_{b3})$ =5.06-(1.4175+1.4175+1.4175) = 0.8075m^3/sec.

Similarly

Quantity of passing through branched ducts 5,6,7,8 is $Q_{b5}=Q_{b6}=Q_{b7}=Q_{b8}$

$$Q_{b5}=a_5\times c_5=0.2025\times 7=1.4175 m^3/sec$$

$$Q_{b6}=a_6\times c_6=0.2025\times 7=1.4175 m^3/sec$$

$$Q_{b7}=a_7\times c_7=0.2025\times 7=1.4175 m^3/sec$$

$Q_{b8}=Q_2-(Q_{b5}+Q_{b6}+Q_{b7})$ = 5.06-(1.4175+1.4175+1.4175) = 0.8075m^3/sec.

Quantity of air passing through branched ducts 9&10 is Q_{b9}&Q_{b10}

$$Q_{b9}=a_9\times c_9=0.25\times 7=1.75 m^3/sec$$

$$Q_{b10}=Q_3-Q_{b9}=3.38-1.75=1.63 m^/sec$$

Similarly

Quantity of air passing through branched ducts 11&12 is Q_{b11}&Q_{b12}

$$Q_{b11}=a_{11}\times c_{11}=0.25\times 7=1.75 m^3/sec$$

$$Q_{b12}=Q_4-Q_{b11}=3.38-1.75=1.63 m^/sec.$$

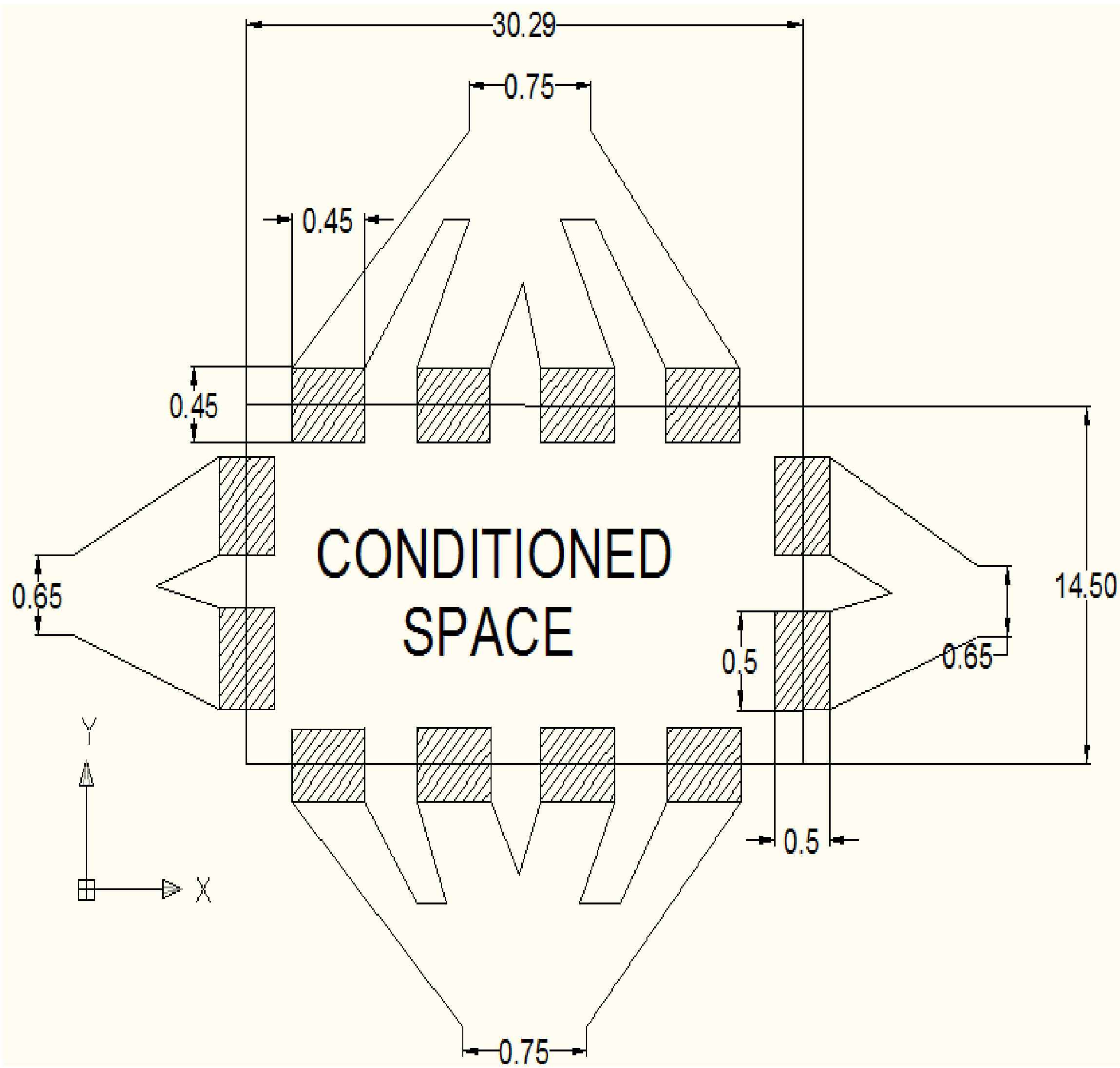


Fig.No.6.5. Proposed Duct for an Auditorium

CHAPTER VII

Green Building Approach in Air conditioning System Design

A green building is the one which uses less energy, water & natural resources, creates less waste and is healthier for the people living inside compared to a standard building. A green building design is not only dependent on Air conditioning system but also concentrating on the following areas

- Site selection in sustainable way
- Water efficiency (in Plumbing engineering service)
- Environmental Friendly ideas
- Energy efficient lighting / Day lighting
- Electrical services
- Material selections
- Effective optimizing the operations & maintenance

Building Engineering Services brings the buildings & its structures to life. The following are the three major categories of the building services

- Mechanical (Includes air conditioning & mechanical ventilation systems, commonly referred to as "HVAC" (Heating Ventilating & Air conditioning).
- Electrical systems & Equipment
- Plumbing & Firefighting system (commonly referred to as Public Health Engineering

Among the above engineering services, this report will only be concentrating on Air conditioning system due to the following reasons,

- Air conditioning is the major consumer of energy in building – around 57%
- It has a direct impact in the Occupant's health
- It has major contribution to Ozone depletion &
- Global warming
- It has major impact on occupant's productivity and contributing to "Absenteeism".

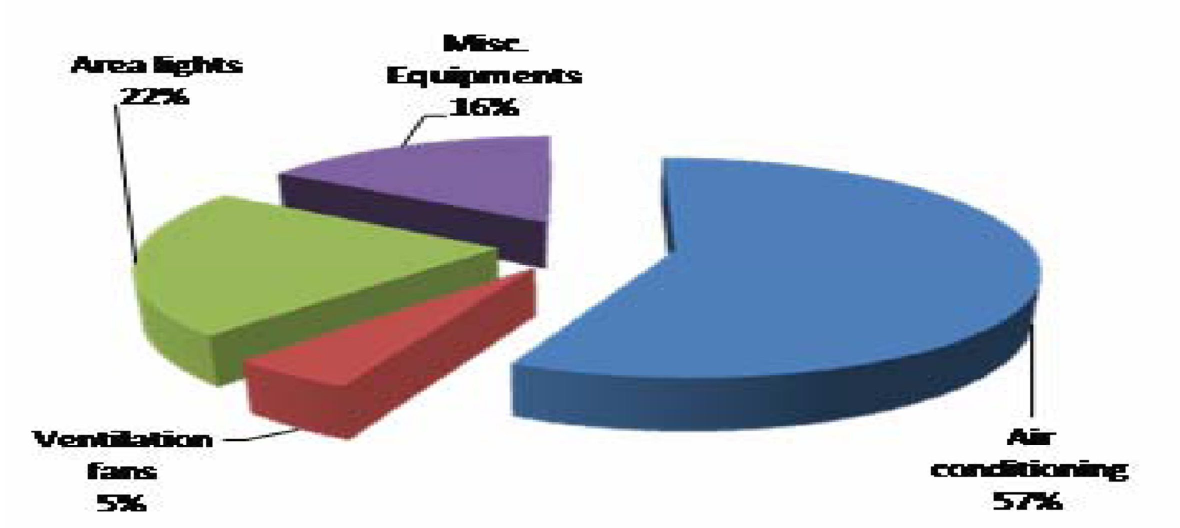


Fig. 7.1 Break-up of energy consumption in a typical building

The air conditioning itself is having several individual parameters contributes to that 57% energy consumption and those are expressed in the fig. 8. 2

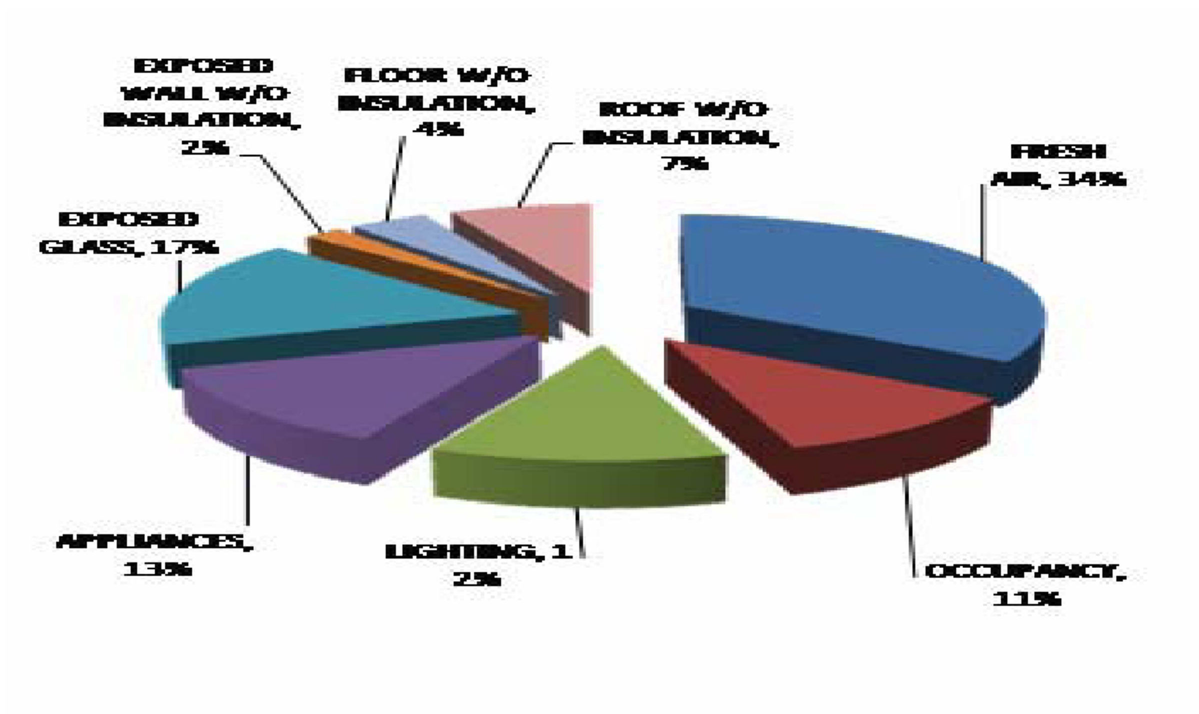


Fig. 7.2 Conventional Building air conditioning system load break

A Sample Building Analysis of an auditorium building is taken as a reference and the following analysis shall be made on it to prove the green design's output.

- Conventional system design
- Annual Energy consumption report for the conventional system
- Green design with minimum fresh air (Air cooled)
- Green design with minimum fresh air (Water cooled)
- Green design with Increased fresh air (Air cooled)
- Green design with Increased fresh air (Water cooled)
- Annual Energy consumption report for the Green building
- Comparative Energy savings of Green building over Conventional building

The perspective view of the auditorium building is expressed in Fig 8.3

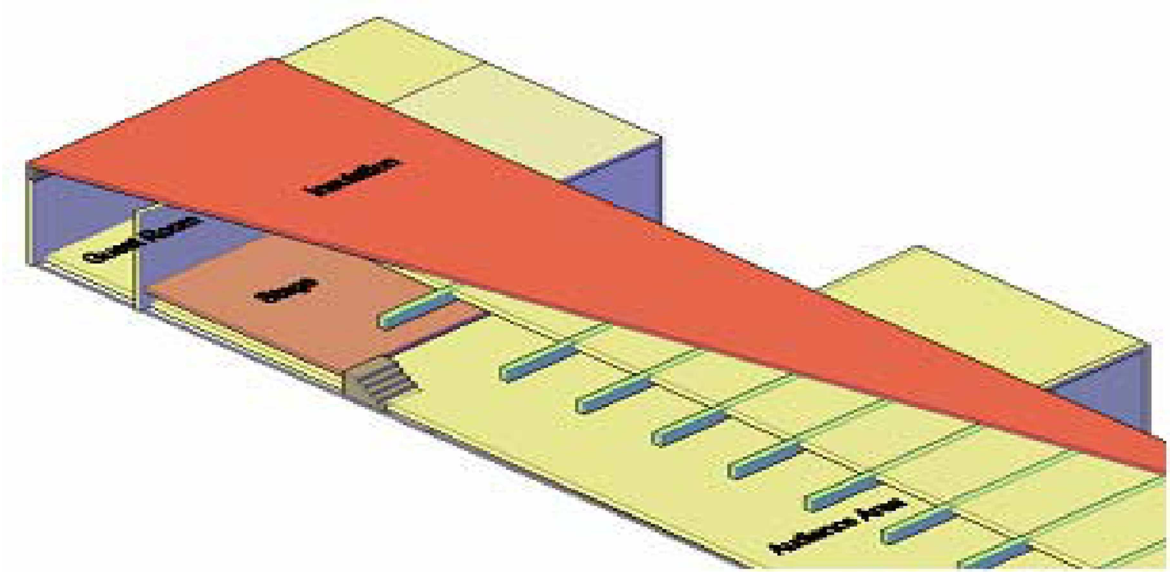


Fig. 7. 3   Perspective view of the auditorium building

It is very clear that there is proven energy saving in air conditioning system based on Green Design. The energy reduction of green design is expressed in KWH when compared to the conventional system with minimum fresh air. Further the graphical form of conventional and green design energy consumption is expressed in Fig. 8.4

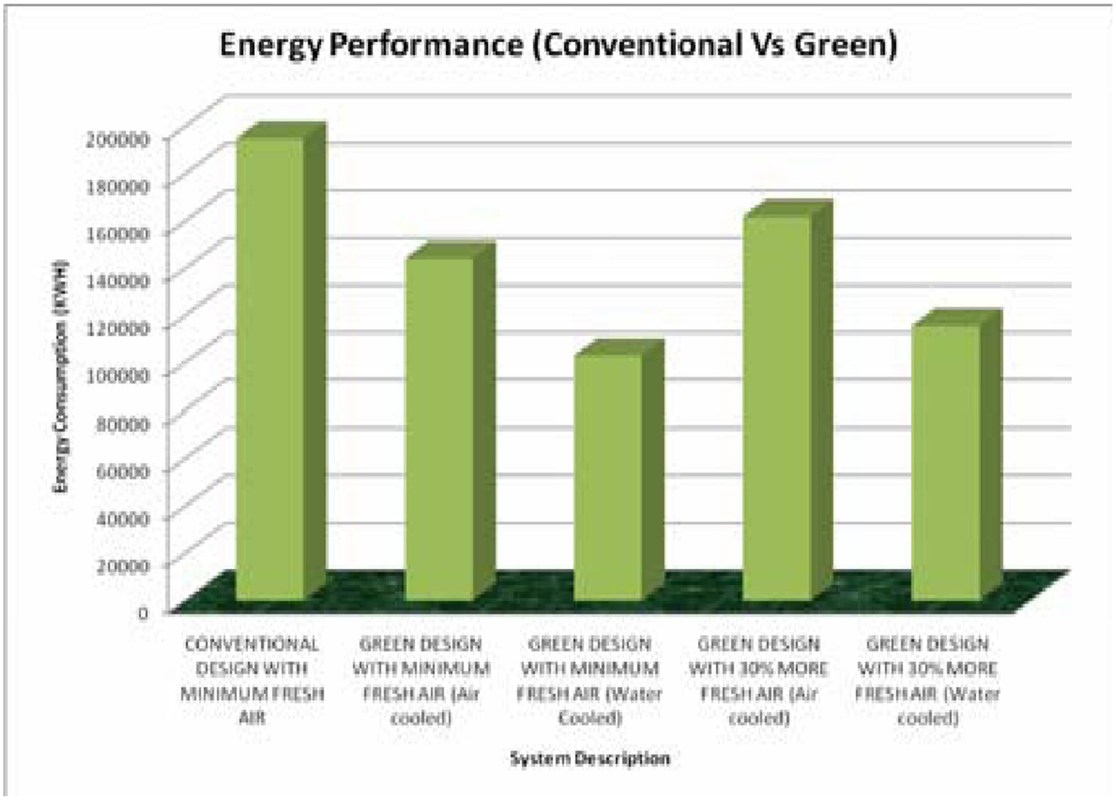


Fig. 7.4 Comparative Energy performance of Conventional & Green Design

CHAPTER VIII

CONCLUSION

Due to global warming and increase in carbon dioxide limits the temperature in summer is gradually increasing from day to day which causes discomfort to human beings. So air conditioning of auditorium has become a necessity in present days.

The main idea of undertaking this project was to design the basic of the central air conditioning plant for a proposed auditorium. The load calculations have been done keeping in view all the practical aspects of the design. Hence the infiltration of air through swinging doors and windows is large, thereby increasing the cooling load.

Infiltration can be reduced by providing proper insulation to all doors and windows if we were to consider the hall as an auditorium. The cooling load can be reduced by about 30 to 40% by sealing the hall, thereby reducing the cost of the project.

As the tonnage is very high, and the maximum tonnage that can be taken by unitary system is very low when compared with the total tonnage, it is propose to install a centralized air conditioning system, rather than so many unitary air conditioning systems. For air recirculation duct system is provided inside the auditorium which reduces the temperature of the indoor air.

Hence centralized air conditioning is more effective and economical when the space to be conditioned is very high.

Green Building approach in Air Conditioning system is used to reduce the energy consumption.

Appendix -I

U – Values for Different Types of Walls:

Material of the wall	**Thickness in cms**	**U in Kcal/m^2hr c**
Brick(plain)	20 30 40	2.45 1.75 1.35
Brick (plastered on one side)	20 30 40	1.45 1.15 1.00
Concrete(plain)	15 25 40	3.85 3.05 2.35
Concrete (plastered on one side)	20 30	2.55 2.25
Cylinder block (plastered inside)	20 30	1.90 1.80

Appendix-II

U- Values for floors and ceilings:

Type of floor or ceiling	U in kcal/m^2-hr c
Plain pine floor	2.25
Plaster ceiling	1.35 to 1.15
Ceiling plastered on wood lathe with rock wood insulation	0.385
10cm. base concrete floor	5.25
15cm. base concrete floor	4.40
10cm. concrete with pine floor	1.70
15cm. concrete with pine floor	1.60
10cm. concrete with 2.5cm insulation	1.1
20cm. concrete with 2.5cm insulation	1.0
Pebbles on wood (6cm) with plastered hung ceiling	1.15
Wood shingles laid on rafters'(roof)	2.25

Appendix -III

U - Values for Glass Windows and Door

Type of glass or wood	U in Kcal/m²-hr°c

Single thick glass	5.5
Double thick glass	2.20
Solid wood door 2.5cm, thick	3.35
Solid wood door 3.75cm, thick	2.55
Solid wood door 5cm, thick	2.25
Solid wood door 7.5cm, thick	1.60

Appendix -IV

Heat Loss from Human body at Different room DBT Conditions

	Person at Rest			Person doing light work		
21.1	40	60	100	27.5	137.5	165
22.2	45	55	100	37.5	37.5	165
23.3	50	50	100	45.0	120.0	165
24.4	55	45	100	52.5	112.5	165
25.5	60	40	100	60.0	105	165
26.6	35	100	67.5	97.5	165	165
27.7	70	30	100	75.0	90	165
28.8	72.5	27.5	100	82.5	82.5	165
29.9	75	25	100	87.5	77.5	165
31.0	80	30	100	90.0	76	165

REFERENCE

1. Tecumseh Technical Manual. - Sriram
2. Modern Air-Conditioning Practice. - Norman C. Harris
3. Air-Conditioning Elements of Refrigeration. - Samuel P. Brown
4. Refrigeration and Air-Conditioning. - Jorden & Priester
5. Principles of Refrigeration. - Roy J.Dossat
6. Heating and Air-Conditioning. - Allen & Walker
7. Official Air-Conditioning Manual. - L.K. Wright
8. "Ashare" Refrigeration data.
9. Refrigeration and Air-Conditioning. - R.K. Rajput