GUDLAVALLERU ENGINEERING COLLEGE

(An Autonomous Institute with Permanent Affiliation to JNTUK, Kakinada)
Seshadri Rao Knowledge Village, Gudlavalleru – 521 356.

Department of Civil Engineering

HANDOUT

on

BUILDING SERVICES

(2020-2021)

Vision

To provide quality education embedded with knowledge, ethics and advanced skills and preparing students globally competitive to enrich the Civil Engineering research and practice.

Mission

- Aim at imparting integrated knowledge in basic and applied areas of Civil Engineering to cater to the needs of industry, profession and the society at large.
- To develop faculty and infrastructure making the department a centre of excellence providing knowledge base with ethical values and transforming innovative extension services to the community and nation.
- To make the department a collaborative hub with leading industries and organisations, promote research and development and combat the challenging problems in Civil Engineering which leads for sustenance of its excellence.

Program Educational Objectives

- Exhibit their competence in solving Civil Engineering problems in practice using the knowledge in mathematics, physical sciences and engineering concepts.
- Adapt to changing technologies with societal relevance for sustainable development in the field of their profession.
- Develop multi disciplinary team work with ethical attitude and social responsibility and engage in lifelong learning to promote research and development in the profession.

HANDOUT ON BUILDING SERVICES

Class & Semester: II B.Tech. – II Semester Year: 2020-21

Branches:All Credits: 3

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1. Scope of the Subject

Amongst other things, Civil Engineers erect buildings for various functions. The 'core' and 'shell' of a building is what a team of Civil Engineers and an Architect realise together. For this skeleton and skin to come to life, the building has to be fitted with various services that provide suitable living and working environment in the buildings. This is accomplished by employing other trades such as mechanical, electrical, plumbing, communications and computer engineers in fitting the necessary services and integrating them into a manageable system for the smooth functioning of the building. The open elective building services exposes the 'non-civil' engineer to the scope of their services in the AEC (Architecture, Engineering and Construction' Industry which is on the biggest employment generation sector in the world. A young and growing country like India will have many opportunities for engineers to work in the building sector. Hence the importance of building services.

2. Course Objectives:

1. To introduce the concept of basic services and their applications.
2. To equip students with the required information and technologies of building services.
3. Evolving understanding in students to choose appropriate systems and integrate the same in their design projects.

3. Course Outcomes:

CO1: Specify the water requirement and propose suitable design for water supply.

CO2: Indentify wastewater generation and suggest treatment methods and disposal options

CO3: quantify sound pollution and suggest insulation materials for reducing sound.

CO4: Layout the electrical wiring for a proposed building

CO5: identify the ventilation and air conditioning needs of built spaces

CO 6: explain the causes and method of fire accidents and suggest preventive measures

4. Program Outcomes:

Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

5. Mapping of Course Outcomes with Programme Outcomes:

PO's	1	2	3	4	5	6	7	8	9	10	11	12
CO1	X		X				X					X
CO2	X	X				X	X					X
CO3	X	X				X						X
CO4	X		X				X					X
CO5	X			X								X
CO6	X											X

7. Prescribed Text Books:

1. S.C.Rangwala, Water Supply and Sanitary engineering, Charotar publishing house.

2. A. Kamala & DL Kanth Rao, Environmental Engineering, McGraw – Hill publishing company Limited

8. Reference Text Books:

1. Water Supply and Sanitary Engineering, Charanjit Shah, Galgotia Publishers.

2. V.K.Jain, Fire Safety in Building, New Age Publishers

3. M.David Egan, Concepts in Building Fire Safety.

4. E.G.Butcher, Smoke control in Fire-safety Design.

5. Handbook for building engineers in metric systems, National Building Code, India

6. Water Supply and Sanitary Engineering: G. S. Birdie and J. S. Birdie, DhanpatRai Publishing Company, New Delhi.

9. URLs and Other E-Learning Resources

1. https://ia601003.us.archive.org/4/items/gov.in.is.sp.7.5.2005/is.sp.7.5.2005.pdf

10. Lecture Schedule / Lesson Plan

Topic	No. of Periods
	Theory
UNIT –1: Water Quality, Treatments and Distribution (10)	
Sources of water supply, Water quality, Water requirements	2
Water treatment methods, Screening, Aeration, Sedimentation,	4
Filtration, Disinfection, Softening, Conveyance, Distribution	2
Plumbing Systems, Fixtures, Fittings, Pipe Materials	2
UNIT – 2: Wastewater, Treatments and Disposal (10)	
Disposal of Sewage, need for treatment, Characterisation of	2

sewage	
Primary and Secondary treatment of sewage, Biological treatment	4
Sewage Treatment Plant layout and functioning	2
Traps, Sewer appurtenances, Types, uses.	2
UNIT – 3: Room Acoustics (9)	
Key terms & Concepts, Introduction, Acoustic principles, Sound power and pressure levels, Sound pressure level.	3
Absorption of sound, Reverberation time, Transmission of sound. Sound pressure level in a plant room, Outdoor sound pressure level in a plant room, Sound pressure level in intermediate space.	3
Noise rating, Data requirement, output data	3
UNIT – 4: Electrical Services (9)	
Basics of electricity, single/three phase supply, protective devices in electrical installation, earthing, types, ISI specs.	3
Electrical Installations and Wiring in buildings, Types of wires, Wiring Systems and their choice Main and Distribution Boards	4
Illumination: Natural Light, Electrical light, glare, lumen method for designing the lighting layout.	2
UNIT – 5: Heat Ventilation and Air Conditioning (9)	
Behaviour of Heat propogation, Thermal Insulation materials and their coefficient of thermal conductivity general methods of thermal insulation:Thermal insulation of roofs, exposure wall.	4
Ventilation definition and necessity, ventilation systems	1
Principles of air-conditioning, air cooling, different methods of ducting, distribution, essentials of air conditioning,	4
UNIT – 6: Fire Fighting Services (9)	
Fire, Causes of fire and spread of fire, Classification of Fire,	1
Fire safety and fire fighting methods, systems,	4
Fire detectors, heat detectors, smoke detectors, Fire dampers, fire extinguishers.	4
Total No. of Periods:	**56**

BUILDING SERVICES

UNIT-I

Water quality, Treatments and Distribution

Assignment-Cum-Tutorial Questions

Part-A

1. A new water supply system should be designed for the present population.
   a) Agree
   b) Disagree

2. What option best describes an infiltration gallery?

   a) Tube well
   b) Artesian well
   c) Vertical well with arms
   d) Horizontal well

3. In our country, as per IS 1175-1963,water consumption per capita per day for domestic purposes is

   a) 135 litres
   b) 115 litres
   c) 100 litres
   d) 95 litres

4. The design period for water supply project is generally taken as
   a) 10 years
   b) 10 to 15 years
   c) 15 to 20 years
   d) 20 to 30 years
5. The geometric method of forecasting population is adopted for

   a) old and very large town
   b) Young and rapidly growing town
   c) Young but slowly growing town
   d) Old and slowly growing town
6. The most commonly used coagulant is
   a) Magnesium Sulphate
   b) Bleaching powder
   c) Alum
   d) Chlorine
7. Rate of filtration in slow sand filter in $l/hr/m^2$ _____
8. If the source of water supply is located at a sufficiently higher level than the city, the type of distribution system adopted is

a) Direct pumping system
b) Gravity system
c) Direct-indirect system
d) None of the above

9. The most reliable method of distribution system is _____
10. The valves which are used to remove the sediment in the pipelines are called
    a) Direct valve
    b) Scour valve
    c) Air valve
    d) Check valve
11. Slow sand filters requires_____area as compared to rapid sand filters.

12. The valve provided on the suction pipe in a tube well is

    a) Sluice valve
    b) Air valve
    c) Pressure relief valve
    d) Reflux valve

Part-B

1. State the classification of various surface and sub surface sources of raw water.
2. What is rate of demand? What are the factors affecting the rate of demand?
3. Sketch and explain the process of sedimentation in a rectangular tank.
4. Explain construction and working of slow sand filters with the help of a neat sketch.
5. Explain the construction, working and cleaning process of Rapid Sand Filter with a neat sketch.
6. List different methods of disinfection. Explain any three methods in detail.
7. Explain with sketches the different layouts of distribution system?
8. State the general precautions to be taken in plumbing work for building.
9. List various pipe materials used in plumbing and explain their merits and limitations.

UNIT 2

Wastewater, Treatments and disposal

Assignment-Cum-Tutorial Questions

Part-A

1) The sullage does not contain wastewater from
   a) Bath rooms
   b) Kitchen sinks
   c) Toilets
   d) Wash basins
2) Define BOD _____

3) Define COD _____

4) The sewer pipes
   a) Carry sewage as gravity conduits
   b) Are designed for generating self-cleansing velocities at varying values of discharge
   c) Should resist the wear and tear caused due to abrasion
   d) All the above
5) Anti-siphonage pipe is connected to _____
   a) top of P trap W.C.
   b) main soil pipe
   c) bottom of P trap W.C.
   d) side of water closet
6) A sewer which receives storm water, surface run-off and sewage is called a
   a) Common sewer
   b) Combined sewer
   c) Branch sewer
   d) Outfall sewer
7) If the cross-section of the sewer is small, then the velocity of flow will be high
   a) Yes

b) No

8) Manholes are generally located
   a) At all changes of direction
   b) At all changes of gradients
   c) At all junctions of main and branch sewers
   d) All of the above

9) The minimum diameter of a man-hole cover should be
   a) 25 cm
   b) 50 cm
   c) 75 cm
   d) 100 cm

10) The equipment used for checking the levels of the sewer inverts is _____.

11) A good trap should
   a) Not have self cleaning property
   b) Restrict the flow of water
   c) Provide an adequate water seal at all times
   d) All of those

12) Air vent pipe is not essentially required in septic tank.
   a) True
   b) False

PART-B

1. Draw the schematic diagram of typical sewage treatment plant.
2. Explain the methods of disposal of sewage in detail.
3. Explain the working of trickling filters.
4. Explain the method of removal of grit in grit chamber with the help of neat sketch.
5. Draw the flow chart of an activated sludge process.
6. Write short note on a) Aerobic lagoons b) Anaerobic lagoons.
7. Explain different types of water closets with sketches.
8. What is a trap in building drainage? What are the different types of traps and where are they used?
9. What is a manhole? Explain ordinary manhole with help of a sketch?

10. Sketch and explain the construction and working of a septic tank.

UNIT 3

Room Acoustics

Assignment-Cum-Tutorial Questions

Part-A

1. Sound travels through metals easily due to _____
2. What do you call the speed of sound in the study of acoustics?
   a. Rhythm
   b. Tempo
   c. Pitch
   d. Frequency
3. What is the unit of measuring sound?
   a. Sone
   b. Phon
   c. decibel
   d. Mel
4. Required time for any sound to decay to 60 dB.
   a. Echo time
   b. Delay time
   c. Reverberation time
   d. Transient time
5. Speed that is faster than speed of sound is termed as _____.
   a. Ultrasonic
   b. Supersonic
   c. Subsonic
   d. Transonic
6. For computation of ideal reverberation time, which formula is applicable?
   a. Sabine

b. Stephen and Bate

c. Norris-Eyring

d. Notch

7. Speaker is a device that

a. Converts current variations into sound waves

b. Converts electrical energy to mechanical energy

c. Converts sound waves into current and voltage

d. None of these

8. For the propagation of acoustical waves, the medium must be :

(a) plastic

(b) either elastic or plastic

(c) elastic

9. During rainy season, we see lightning first and hear thundering of clouds a little later because :

(a) Due to moisture

(b) Velocity of sound is greater than the velocity of light

(c) Velocity of light is greater than the velocity of sound

(d) None of these

10. The term defined as the sound energy per unit area at right angles to the propagation direction per unit time is

a. Loudness

b. Coherence

c. Sound pressure

d. Sound intensity

11. Sound wave has two main characteristics which are

a. Highness and loudness

b. Tone and loudness

c. Pitch and loudness

d. Rarefraction and compression

PART -B

1) What are basic principles of room acoustics?
2) Define the terms sound power level and Pressure level.
3) What is relation between sound power level and sound intensity?
4) Explain how sound energy is dissipated into the environment.
5) What is sound absorption and list out sound absorbing materials that can be used to insulate buildings from external noise.
6) Give expression to quantify sound absorption.
7) Define reverberation time. What is desirable reverberation time in a room or in an auditorium?
8) Explain noise rating.

UNIT 4

Electrical Services

Assignment-Cum-Tutorial Questions

Part-A

Multiple choice questions

1.Resistance is measured in

a) henries

b) ohms

c) hertz

d) watts

2.In a three-phase system, the voltages are separated by

a) 45°

b) 90°

c) 120°

d) 180°

3.The flow of electrons is called _____.

4._____ is the unit for measuring flow of current.

5. In plate earthing system, the plate is made up of

a)copper or galvanized iron (GI)

b)silver

c)bronze

d)metal

6.single-phase connection has----------wires

7.three-phase connection has----------wires

8.---------- is a measurement of light emitted by an electric lamp.

PART -B

1. The alternating electric current that supplies your home can be provided via different types of connection? What are they? Write their applications?

2. What are the different types of the protective device that are commonly used in electrical circuits?

3. In electricity supply systems, an earthing system or grounding system is included in the circuitry. Explain its significance and how it works.

4. How do you plan concealed electrical wiring for a new building?

5. Write the advantages of conduit wiring systems.

6. Explain Advantages of batten Wiring

7. What is the excessive brightness from a direct light source that makes it difficult to see called as? How is it restricted?

8. There is a high risk of fire in casing & capping wiring system How to avoid this type of risk?

UNIT –V

HEATING, VENTILATION & AIR CONDITIONING

Assignment-Cum-Tutorial Questions
Part - A

I) Objective Questions

1. In a refrigerating machine, heat rejected is _____ heat absorbed.

A. equal to

B. less than

C. greater than

2. In a refrigeration system, the expansion device is connected between the

A. Compressor and condenser
B. Condenser and receiver
C. Receiver and evaporator
D. Evaporator and compressor

3. Heat is measured in

A. Joule
B. Calorie
C. Both A & B
D. Joule/second

4. Which of the following are the processes of heat transfer

A. Conduction'
B. Convection
C. Radiation
D. All the above

5. _____ is an instrument used to measure relative humidity

A. Manometer
B. Barometer
C. Pressure guage
D. Psychrometer

6. **The process in winter air conditioning is**

(A) Dehumidification

(B) Heating and humidification

(C) Humidification

(D) Cooling and dehumidification

7. A good refrigerant should have

A. High latent heat of vaporisation and low freezing point

B. High operating pressure and low freezing point

C. High specific volume and high latent heat of vapourisation

D. Low C.O.P and low freezing point

8. **Insufficient moisture in a home can cause**

A: Dry, itchy skin
B: Clogged sinuses
C: Aggravated asthma and allergy symptoms
D: Increased risk of bacterial infection
E: All of the above

9. In conventional refrigerants what is the element responsible for ozone depletion?

A. Chlorine

B. Fluorine

C. Nitrogen

D. Carbon

10. The wall materials in buildings should be chosen based on ____ value to insulate the interior space from heat gains.

Part - B

1. Explain about heat propagation from environment into built spaces.
2. Define different thermal insulating materials with their importance and uses.
3. What are the different methods of ventilation systems and explain each.
4. Explain about principles of air conditioning.
5. What are the various essentials of air conditioning?
6. What are the types of air conditioning systems?
7. How does a condenser in a refrigerator work?
8. What is a duct system in air conditioner?

UNIT –VI

Fire Fighting Services
Assignment-Cum-Tutorial Questions

Part-A

1. Which one is a Class A fire?

A. Electrical
B. Cloth
C. Metal
D. Flammable liquid

2. What is not a combustible material?

A. Iron
B. Paper
C. Propane gas
D. Oil

3. The correct way to extinguish a fire is to aim.

A. At the center
B. At the base
C. At the top
D. At the side

4. What is oxygen's role in a fire?
A. It sustains combustion
B. It cools it down
C. It spreads it

5. A carbon dioxide extinguisher is rated for _____ fires.
a. Class A & D
b. Class B & C
c. Class C
d. Class D

6. The extinguishing method by which a pressurized water extinguisher works is
a. cooling.
b. oxygen exclusion.
c. fuel removal.
d. breaking the chemical chain reaction.

7. What does PASS stand for?
a. Pull Arm Shout Squeeze
b. Push Arm Shoot Sweep
c. Pull Aim Squeeze Sweep
d. Push Aim Shoot Shout

8. To be effective a fire extinguisher must be _____.
a. in working order
b. readily accessible and suitable for the hazard
c. large enough to control the size fire
d. all of the above

9. The three elements of the fire triangle are

A. Oxygen, water and fuel.
B. Oxygen, fuel and a heat or ignition source.
C. Fuel, a catalyzer, and oxygen.
D. None of the above

Part-B

1. Explain about classification of fire.
2. What are the different types of detectors? Explain them.
3. Explain about fire extinguishers.
4. What are the different causes of fire?
5. What are the different methods of fire fighting?
6. How can you tell the difference between a heat detector and smoke detector?
7. What is a Fire Damper and How Does it Work?

Unit-I

Water Quality, Treatment and Distribution

Sources of water supply:

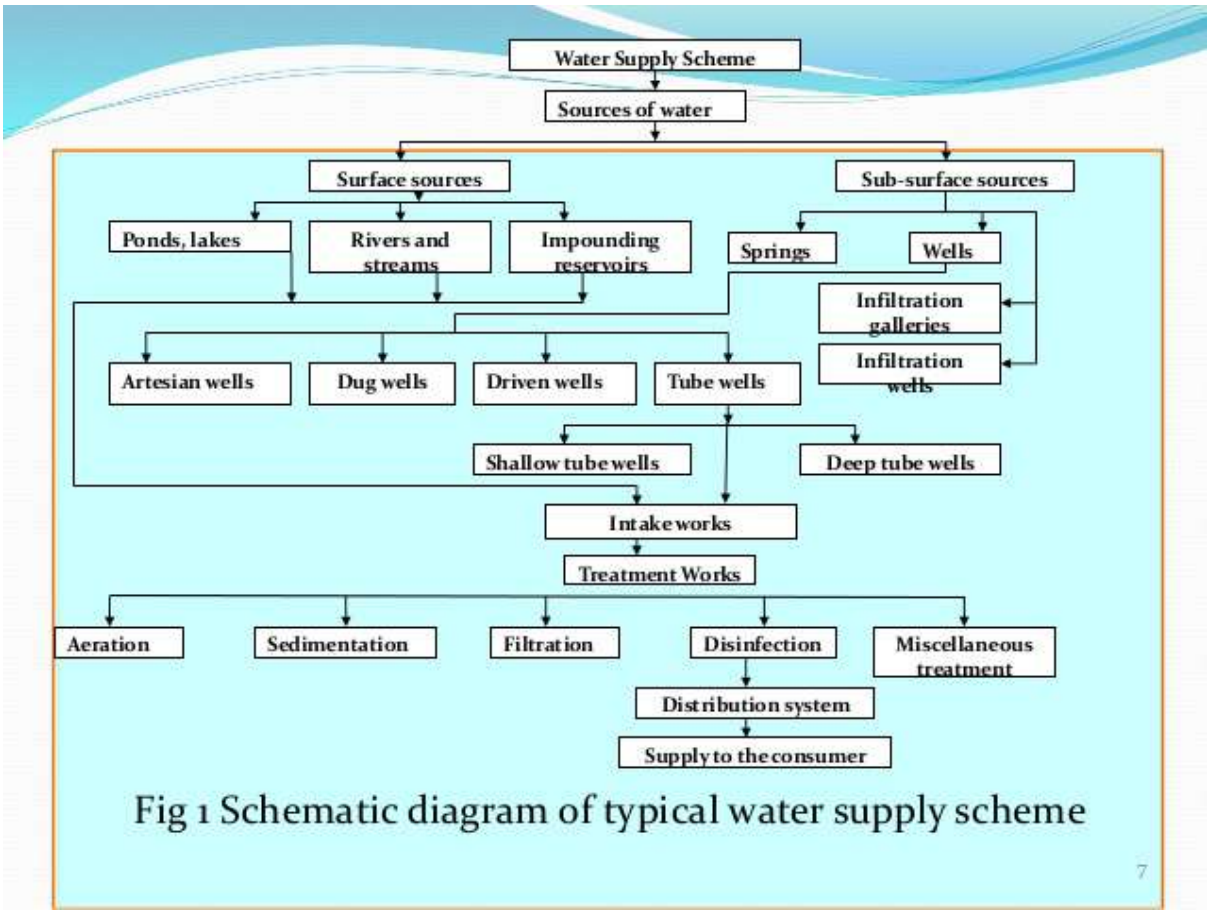

Fig 1 Schematic diagram of typical water supply scheme

Surface Sources:

In this type of source, the surface runoff is available for water supply schemes. Usual forms of surface sources are as follows:

1. Lakes and streams
2. Ponds
3. Rivers
4. Storage reservoirs

Lakes and streams:

A natural lake represents a large body of water within land with impervious bed. Hence, it may be used as source of water supply scheme for nearby localities. The quantity of runoff that goes to the lake should be accurately determined and it should be seen that it is at least equal to the expected demand of locality. Similar is the case with streams which are formed by the surface runoff. It is found that the flow of water in streams is quite ample in rainy season. But it becomes less and less in hot season and sometimes the stream may even become absolutely dry.

The catchment area of lakes and streams is very small and hence, the quantity of water available from them is also very low. Hence, lakes and streams are not considered as principal sources of water supply schemes for the large cities. But they can be adopted as sources of water supply schemes for hilly areas and small towns.

The water which is available from lakes and streams is generally free from undesirable impurities and can therefore be safely used for drinking purposes.

Ponds

A pond is a man- made body of standing water smaller than a lake. Thus ponds are formed due to excessive digging of ground for the construction of roads, houses, etc and they are filled up with water in rainy season. The quantity of water in pond is very small and it contains many impurities.

A pond cannot be adopted as a source of water supply and its water can only be used for washing of clothes or animals only.

Rivers

Since the dawn of civilization, the ancient man settled on the banks of river, drank river water and ate fish caught from river water and sailed down rivers to find out unknown lands.

Large rivers constitute the principal source of water supply schemes for many cities. Some rivers are perennial while others are non-perennial. The former rivers are snow fed and hence, water flows in such rivers for all the seasons. The latter type of rivers dries in summer either wholly or partly and in monsoon, heavy flood visits them. For

such types of rivers, it is desirable to store the excess water of flood in monsoons by constructing dams across such rivers. This stored water may then be used in summer.

In order to ascertain the quantity of water available from the river, the discharges at various periods of the year are taken and recorded. The observations over a number of years serve as a good guide for estimating the quantity of water available from the river in any particular period of the year.

Generally, the quantity of water available from non-perennial rivers is variable throughout the year and it is likely to fall down in hot season when demand of water is maximum. It becomes therefore essential to augment such source of water supply by some other sources so as to make the water supply scheme successful.

The quality of surface water obtained from rivers is not reliable. It contains silt and suspended impurities. When completely or partly treated sewage is being discharged into the river at some upstream point, the river water is to be suspected for high contamination. The river water requires to be properly analyzed as regards to the contents of disease bacteria, harmful impurities, etc. The presence of all such undesirable elements in river water requires an exhaustive treatment of water before it can be make fit for drinking purposes. It should however be noted that the quality of river water is subject to the widest variations because it depends on various uncertain factors such as character of the catchment area, the discharges of sewage and industrial wastes, climatic conditions, season of the year, etc. The character of the water differs not only with each individual river, but also at many points along the course of the same river. It is usually found that the quality of river water at its head is good, but it goes on deteriorating as the river proceeds along its course.

The chief use points to be considered in investigating a river supply of water are as follows:

- Adequacy of storage of purified water so as not to disturb the distribution system during periods of fold when the river water is turbid
- Efficiency of the subsequent stages of purification system adopted
- General nature of river, the rate of flow and the distance between the sources of pollution and the intake of the water and
- Relative proportions of the polluting matter and the flow of river when at

its minimum.

Storage reservoirs

An artificial lake formed by the construction of dam across a valley is termed as a storage reservoir. It essentially consists of the following three parts

- A dam to hold water
- A spillway to allow the excess water to flow and
- A gate chamber containing necessary valves for regulating the flow of water

At present, this is rather the chief source of water supply schemes for very big cities. The multipurpose reservoirs also make provisions for other uses in addit ion to water supply such as irrigation and power generation.

Forms of underground sources

Following are the four forms in which underground sources are found

1. Infiltration galleries
2. Infiltration wells
3. Springs
4. Wells

Each of the above form will now be separately discussed in briefly.

Infiltration galleries

An infiltration gallery is a horizontal or nearly horizontal tunnel which is constructed through water bearing strata. It is sometimes referred to as horizontal well

The gallery is usually constructed of brick walls with slab roof as shown in the figure. The gallery obtains its water from water bearing strata by various porous drain pipes. These pipes are covered with gravel, pebble, etc. so as to prevent the entry of very

fine material into the pipe.

The gallery is laid at a slope and the water collected in the gallery is led to a sump from where it is pumped and supplied to consumers after proper treatment. The manholes are provided along the infiltration gallery for the purposes of cleaning and inspection.

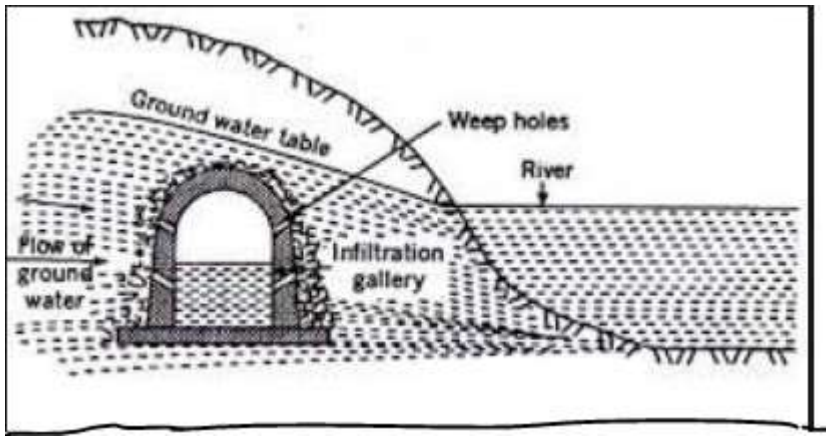

Fig.1

The infiltration galleries are useful as sources of water supply when ground water is available in sufficient quantity just below ground level or so. The galleries are usually constructed at depth of about 5 to 10 meters from the ground level.

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Infiltration wells

In order to collect large quantities of water, infiltration wells are sunk in series in the banks of river. The wells are closed at top and open at bottom. They are constructed of brick masonry with open joints as shown in figure

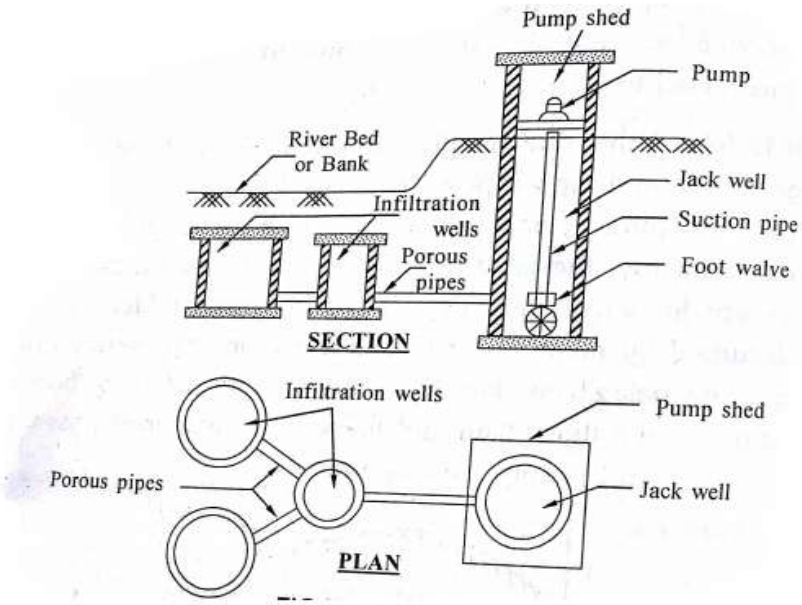


Fig.2

For the purpose of inspection of well, manholes are provided in the top cover. The water infiltrates through the bottom of such wells and as it has to pass through a sand bed, it gets purified to some extent.

The infiltration wells in turn are connected by porous pipes to a collecting sump, known as jack well as shown in figure and the water thus collected through the infiltration wells then flows by gravity into the jack well. The water from jack well is pumped to purification plant for treatment.

Springs

When ground water appears at the surface for any reason, springs are formed. They serve as source of water supply for small towns, especially near hills or bases of hills. Some springs discharge hot water due to presence of sulphur and other minerals in their formations. These hot springs cannot be used to supply water for domestic purposes. But hot water is found to cure some of the human disorders.

A good spring proves to be a sure source of water. But it is difficult to find a good spring for the purpose of water supply scheme. However, when a spring is to be

developed as a source of water supply, the following factors should be carefully ascertained:

- It should be easier, cheaper and surer enough to develop the spring for the locality than to adopt any other source of water supply.
- The flow of water should be adequate, even in dry weather
- The spring should be adequately protected from the water pollution sources
- The spring should be so located as to have natural gravity flow
- The water should be of good quality Following are the three types of springs
  1. Artesian springs
  2. Gravity springs
  3. Surface springs

Artesian springs

In this type of spring, the ground water comes to the surface under pressure as shown in the figure

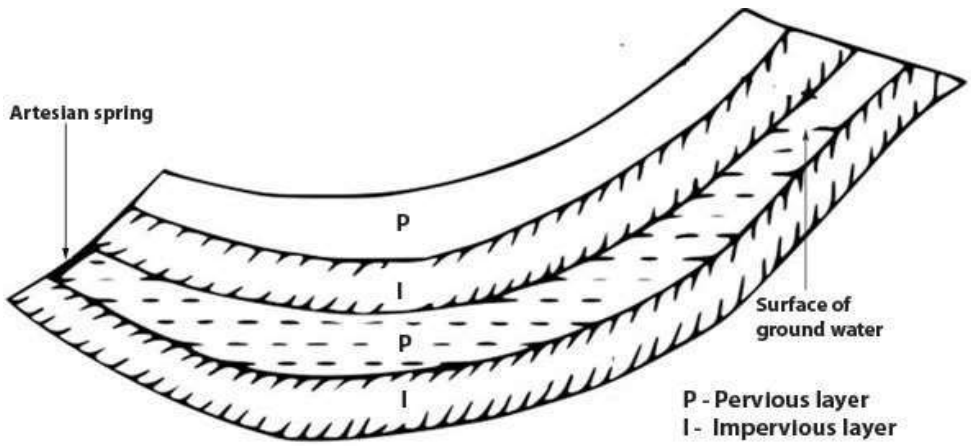


Fig-3

The artesian spring may also be formed due to presence of fissure or crack in impervious layer as shown in the figure. The fissure or crack should be continued up to the ground surface. The artesian springs give practically uniform quantity of water throughout the year.

Gravity springs

This type of spring develops due to overflowing of the water table as shown in the figure. The flow from a gravity spring is variable with the rise or fall of water table. In order to meet with such fluctuations, a trench may be constructed near such a spring as shown in the figure. The trench acts as a storage reservoir.

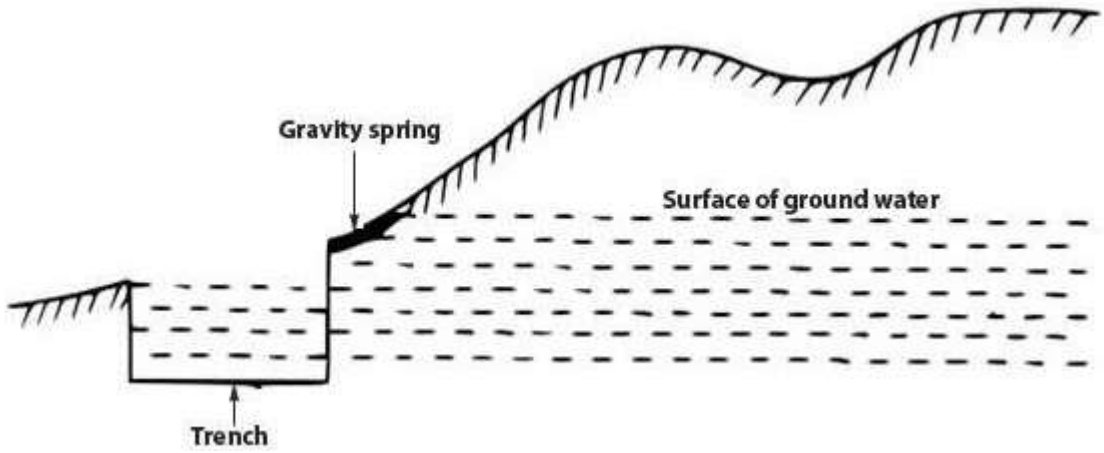


Fig.4

Surface springs

This type of spring is formed when subsoil water is exposed to the ground surface by the obstruction of an impervious layer as shown in the figure

The quantity of water available from surface springs is quite uncertain and cut-off walls, as shown in the figure, may be constructed to develop such springs.

It is found that the quality of spring water depends on geological and topographical conditions and it may be hard or soft, pure or polluted or sometimes saline, etc. Similarly, the yield from springs is mostly inadequate, except for small supplies. The spring water which is not disturbed by rainfall is usually attractive in appearance and

of good palatability.

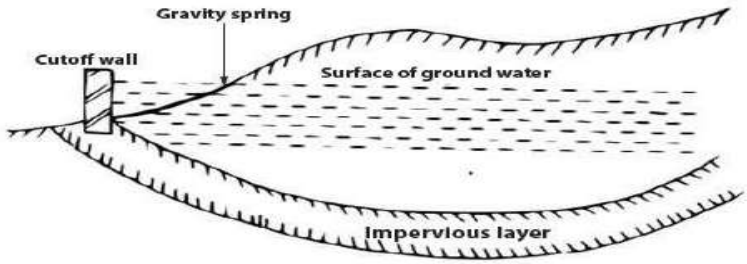


Fig-5

Wells

A well is defined as an artificial hole or pit made in the ground for the purpose of tapping water. The holes made for tapping oil are also known as wells. But in the general sense, a well indicates a source of water. In India, the chief source of water supply for most of its population is wells and it is estimated that 75 to 85% of Indian population has to depend on wells for its water supply.

The three factors which form the basis of theory of wells are as follows:

- Geological conditions of earth's surface,
- Porosity of various layers and
- Quantity of water which is absorbed and stored in different layers.

The geological conditions of earth's surface indicate the slope of water bearing strata. If the slope of water bearing layers is towards the well, there will be some quantity of water in the well even during the severe hot season. On the other hand, if the slope of water bearing layers is away from the well, such well will soon get dry and it will only give some quantity of water only in monsoon.

The porosity of aquifers will also play a great role in determining the quantity of water in the well. If the porosity of aquifers is more, the well will easily collect more quantity of water in less time. The capacity of aquifers to absorb and store water will determine the supply rate of water to the well. If the aquifers are capable of storing more water, the well will get more quantity of water and practically at a constant rate.

Water Requirements

Water requirement may be divided into following categories:

a) Domestic,

b) Institutional,

c) Industrial

d) Public,

e) Agricultural, and

f) Compensation of losses.

Domestic Water Requirements

Domestic water requirement may be divided as:

i) In-house requirement

ii) Sprinkling requirement

In-house requirement includes drinking, cooking, sanitation, house cleaning, clothes washing etc. Sprinkling requirement includes water requirement for garden watering, lawn sprinkling, car washing etc. Domestic consumption under normal condition in an Indian city as per National Building Code has been taken as 135 liters per head per day (in short designated as l/h/d) or liters per capita per day (lpcd).

Amount of domestic requirement may vary depending on size and location of a city or town. Depending upon location of a place living habits and condition vary. In a more civilized country per capita requirement of water is more. Similarly, for a big city per capita water requirement will be more than a small town. Per capita demand for a place may be as low as 75 lpcd to as high as 500 to 600 lcpd. Factors, which affect per capita requirement, are summarized below:-

a) Climatic Condition : In dried regions more water is required than colder places because of frequent bathing, more cleaning and more requirement of water for gardening etc. In hot and dry climate more consumption of drinking water is also there.

b) **Status and Habits of Residents:** For affluent class of people, more water is required because of their present habits and more sophisticated living style. For example, a house of rich people may have bathing tubs for their bath where excessive amount of water may be required per capita. In some of the Asian countries, toilets are cleaned after using it by pouring buckets of water. In addition, for their personal cleaning people use water. They do not use toilet papers and in such practice more water is consumed. In some religion people, wash themselves before every prayer and due to such habits also consumption of water varies.

c) **Size and type of the City:** for large city per capita, water requirement is more than a small town. For bigger city where population density is high, special arrangement has to be done for firefighting also. Although this type of demand may be taken up separately, it enhances per capita water demand. Large city have sewer system for waste water disposal and for this case water requirement may go as high as three times as open drain system. A town may be a smaller one but if it is an industrial town then per capita demand may be composed with a big city because of indirect use of water. Although an average value of 135 lcpd is taken for an Indian town but the total demand may go as high as 240 to 260 lcpd for a big or an industrial city. The value varies from 75 lcpd to 260 lcpd depending upon size and location of a town or city.

a) **Availability of Sewer:** It sewage system has been provided in the locality, consumption of water will be more and per capita demand may go high. Because for flow of sewage in closed conduits sufficient water should be available. Table 1.2 suggests tentative for various water supply schemes.

Table 1.2: Recommended Per Capita Water Supply Levels for Designing Schemes

S. No.	Classification of towns / cities	Recommended Maximum Water Supply Levels (lpcd)
1.	Town provided with piped water supply but without sewerage system	70
2.	Cities provided with piped water	135

	supply where sewerage system is existing/ contemplated	
3.	Metropolitan and mega cities provided with piped water supply where sewerage system is existing / contemplated	150

Source: Manual on Water Supply and Treatment: III Edition (1999)

b) Mode of Water Supply: Mode of water supply may be continuous of intermittent. In continuous system water is supplied continuously for 24 hours, whereas in intermittent system, water is supplied at peak demand hours. In morning and evening, sometimes when sufficient storage of water is available at the source, water is also supplied around noon hours. In both the systems, some advantage and disadvantage are there. In continuous supply, wastage of water is there through open and cracked joints. Whereas in intermittent supply, people leave taps open and when water supply is continued, water is wasted through these open taps. Generally, out of fear people store more amount of water than required. And when water supply is started, these collected water in pots and small tanks are thrown and again refilling is done. Of course, after getting confidence in the water supply system, this practice of water storage goes away.

d) Policy for Water Tax Collection: Water tax may be collected by knowing amount of water consumed. This information is obtained by providing water meters at the entrance of premises of the consumers. In that case, controlled water is consumed by consumers. But provision of water meters cause head loss and pump capacity has to be enhanced which may cause additional expenditure. Water meters may go defective and in such case accurate measurement of consumption may not be there or frequent replacement of meters, may be required which may cause annoyance to consumers. To overcome this difficult, water tax is levied on consumers as per assessment. Municipal or water supply agency assess the size and quality of house and based on some basic consumption, principle water tax is assessed. In some cases, water tax is levied on flat rate. And in such case more

consumption and wastage of water is there.

Table 1.3: Recommended Water Requirement for Various Institutions

S. No.	Institutions	Liters per head per day
1.	Hospital (including laundry)	
	(a) No. of beds exceeding 100	450 (per bed)
	(b) No. of beds not exceeding 100	340 (per bed
2.	Hotels	180 (per bed)
3.	Hostels	135
4.	Nurses homes and medical quarters	135
5.	Boarding schools / colleges	135
6.	Restaurants	70 (per seat)
7.	Air ports and sea ports	10
8.	Junction Stations and intermedi stations where mail or expr stoppage (both railways and bus stations) is provide	70
9.	Terminal station	45
10.	Intermediate stations (excluding m and express stops)	45 (could be reduced to 25 wh bathing facilities are provided)
11.	Day schools/ colleges	45
12.	Offices	45
13.	Factories	45 (could be reduced to 25 wh

		bathing facilities are provided)
14.	Cinema, concert halls and theatres	15

Source: Manual on Water Supply and Treatment: III Edition (1999)

Institutional Water Requirements

In addition to domestic demand water requirement for different institutions, is also assessed for a town or city. A well developed city or town has hospitals, schools, restaurants, hotels, railway stations, bus terminus and offices of different departments. To cater to need for water of these establishments, consideration has to be given for water requirements of these units while planning for water supply system of a town or city. Bigger the town or city larger requirements will be there. On an average additional per capita demand for these units may be taken as 25 liters/head/day to 60 liters/head/day depending on the town or city. Approximate water requirements for these units may be taken as given in table 1.3 for proper assessment of water needs while planning for a water supply scheme.

Industrial Water Requirements

Factors governing industrial water requirement depends on several factors. Such, as type of industry size of industry and number of industries for a particular water supply scheme. A water supply scheme may be planned for a residential town and amount of water requirement, may be taken care of for existing industry in the town or city likely to come up. Sometimes, a water supply scheme is planned for an industrial area where different types of industry of different sizes are located or likely to come. A case may be there, in which size of the industry is of such a giant one, that water supply scheme has to be planned for that particular industry in addition to housing and other amenities associated with the industry. Water requirement for a few industries located in a town may be taken around 60 liters/head/day but the demand may go as high as 500 liters/head/day depending on type of industry. Table 1.4 gives an idea of water consumption for different kinds of manufacturing industrial units.

Table 1.4: Industrial Needs of Water

Industry	Unit of Production	Water Requirement Kilolitres per unit
Automobile	Vehicle	40
Distillery	(Kilolitre Alcohol)	122-170
Fertilizer	Tonne	80-200
Leather	100 Kg(tanned)	4
Paper	Tonne	200-400
Special quality Paper	Tonne	400-1000
Straw Board	Tonne	75-100
Petroleum Refinery	Tonne(crude)	1-2
Steel	Tonne	200-500
Sugar	Tonne(Cane crushed)	1-2
Textile	100 Kg (goods)	8-14

Source: Manual on Water Supply and Treatment: III Edition (1999)

Requirement for Public Use

This includes requirement for Traffic Terminals, Fire, and Public Gardens etc.

Requirement of Traffic Terminals and Stations

The water requirements for traffic terminals, such as railway stations, but stations, harbours, airport etc. include provisions for waiting rooms and waiting halls. For retiring rooms, additional provisions are to be done. As per National Building Code, requirement for water supply for traffic terminals and stations may be taken as given in Table 1.5

Table 1.5: Water Supply Requirements for Traffic Terminal and Stations

Nature of Station/Terminal	With Bathing Facilities	Without Bathing Facilities
	Liters/Capita/Day	
Intermediate Stations (excluding mail and expr stops)	45	23
Junction Stations and intermediate Stations wh mail or express stoppage is provided	70	45
Terminal stations	45	45
International and Domestic airports	70	70

Estimation of number of persons is done by the average number of passengers handled by the station daily. Consideration should also be given for staff and vendors likely to use the facilities.

Water Treatment Methods:

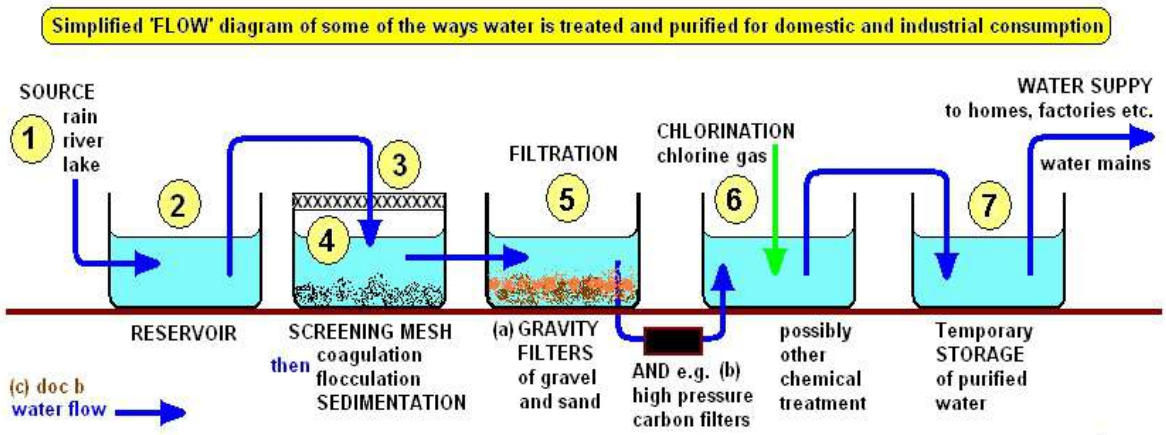


Fig-6

Conveyance and distribution of water within the premises

Basic Principles

Wholesome water supply provided for drinking and culinary purposes shall not be liable to contamination from any less satisfactory water. There shall, therefore, be no cross-connection whatsoever between the distribution system for wholesome water and any pipe or fitting containing unwholesome water, or water liable to contamination, or of uncertain quality, or water which has been used for any other purpose. The provision of reflux or non-return valves or closed and sealed stop valves shall not be construed as a permissible substitute for complete absence of cross connection.

The design of the pipe work shall be such that there is no possibility of backflow towards the source of supply from any cistern or appliance, whether by siphonage or otherwise. Reflux non-return valves shall not be relied upon to prevent such backflow.

Where a supply of less satisfactory water than wholesome water becomes inevitable as an alternative or is required to be mixed with the latter, it shall be delivered only into a cistern and by a pipe or fitting discharging into the air gap at a height above the top edge of the cistern equal to twice its nominal bore and in no case less than 150 mm. It is necessary to maintain a definite air gap in all appliances or taps used in water closets.

All pipe work shall be so designed, laid or fixed and maintained as to remain completely water-tight, thereby avoiding wastage, damage to property and the risk of contamination.

No water supply line shall be laid or fixed so as to pass into or through any sewer, scour outlet or drain or any manhole connected therewith nor through any ash pit or manure pit or any material of such nature that is likely to cause undue deterioration of the pipe, except where it is unavoidable.

Where the laying of any pipe through corrosive soil or previous material is unavoidable, the piping shall be properly protected from contact with such soil or material by being carried through an exterior cast iron tube or by some other suitable means as approved by the Authority. Any existing piping or fitting laid or fixed which does not comply with the above requirements, shall be removed immediately by the consumer and re-laid by him in conformity with the above requirements and to the satisfaction of the Authority.

Where lines have to be laid in close proximity to electric cables or in corrosive soils, adequate precautions/protection should be taken to avoid corrosion.

Underground piping shall be laid at such a depth that it is unlikely to be damaged by frost or traffic loads and vibrations. It shall not be laid in ground liable to subsidence, but where such ground cannot be avoided; special precautions shall be taken to avoid damage to the piping. Where piping has to be laid across recently disturbed ground, the ground shall be thoroughly consolidated so as to provide a continuous and even support.

In designing and planning the layout of the pipe work, due attention shall be given to the maximum rate of discharge required, economy in labour and materials, protection against damage and corrosion, water hammer, protection from frost, if required, and to avoidance of airlocks, noise transmission and unsightly arrangement.

To reduce frictional losses, piping shall be as smooth as possible inside. Methods of jointing shall be such as to avoid internal roughness and projection at the joints, whether of the jointing materials or otherwise.

Change in diameter and in direction shall preferably be gradual rather than abrupt to avoid undue loss of head. No bend or curve in piping shall be made which is likely to materially diminish or alter the cross-section.

No boilers for generating steam or closed boilers of any description or any machinery shall be supplied direct from a service or supply pipe. Every such boiler or machinery shall be supplied from a feed cistern.

Design of Distribution Systems:

Rate of Flow

One of the important items that need to be determined before the sizes of pipes and fittings for any part of the water piping system may be decided upon is the rate of flow in the service pipe which, in turn depends upon the number of hours for which the supply is available at sufficiently high pressure. If the number of hours for which the supply is available is less, there will be large number of fittings in use simultaneously and the rate of flow will be correspondingly large. The data required for determining the size of the communication and service pipes are:

a) The maximum rate of discharge required;

b) The length of the pipe; and

c) The head loss by friction in pipes, fittings and meters.

Design of consumer's pipes based on fixture units

The design of the consumers' pipes or the supply pipe to the fixtures is based on:

a) The number and kind of fixtures installed

b) The fixture unit flow rate

c) The probable simultaneous use of these fixtures.

The rates at which water is desirably drawn into different types of fixtures are known. These rates become whole numbers of small size when they are expressed in fixture unit.

Pipe Size Computation

Commercially available standard sizes of pipes are only to be used against the sizes arrived at by actual design. Therefore, several empirical formulae are used, even though they give less accurate results. The Hazen and William's formula and the charts based on the same may be used without any risk of inaccuracy in view of the fact that the pipes normally to be used for water supply are of smaller sizes. Nomogram of Hazen and William's equation has been provided in Annex F.

Distribution Systems in Multi-Storeyed Buildings

There are four basic methods of distribution of water to a multi-storeyed building.

a) Direct supply from mains to ablutionary taps and kitchen with WCs and urinals supplied

By overhead tanks.

b) Direct Pumping Systems

C) Hydro-Pneumatic Systems

d) Overhead Tanks Distribution

Direct Supply System

This system is adopted when adequate pressure is available round the clock at the topmost floor. With limited pressure available in most city mains, water from direct supply is normally not available above two or three floors. For details of this system, reference may be made to good practice may be referred.

Direct Pumping

Water is pumped directly into the distribution system without the aid of any overhead tank, except for flushing purposes. The pumps are controlled by a pressure switch installed on the line. Normally a jockey pump of smaller capacity installed which meets the demand of water during low consumption and the main pump starts when the demand is greater. The start and stop operations are accomplished by a set if pressure switches are installed directly on the line. In some installation, a timer switch is installed to restrict the

Operating cycle of the pump.

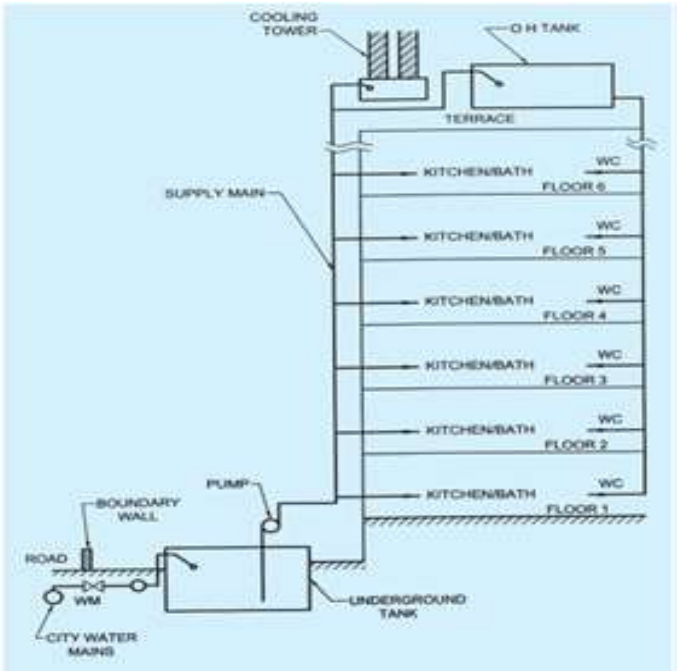


Fig-7

Hydro-Pneumatic Systems

Hydro-pneumatic system is a variation of direct pumping system. An air-tight pressure vessel is installed on the line to regulate the operation of the pumps. The vessel capacity shall be based on the cut-in and cut-out pressure of the pumping

system depending upon allowable start/stops of the pumping system. As pumps operate, the incoming water is the vessel, compresses the air on top. When a predetermined pressure is reached in the vessel, a pressure switch installed on the vessel switches off the pumps. As water is drawn into the system, pressure falls into the vessel starting the pump at preset pressure. The air in the pressure tank slowly reduces the volume due to dissolution in water and leakages from pipe lines. An air compressor is also necessary to feed air into the vessel so as to maintain the required air-water ratio. The system shall have reliable power supply to avoid breakdown in the water supply. Hydro-pneumatic system generally eliminates the need for an over head tank and may supply water at a much higher pressure than available from overhead tanks particularly on the upper floors; resulting in even distribution of water at all floors (see Fig. 8).

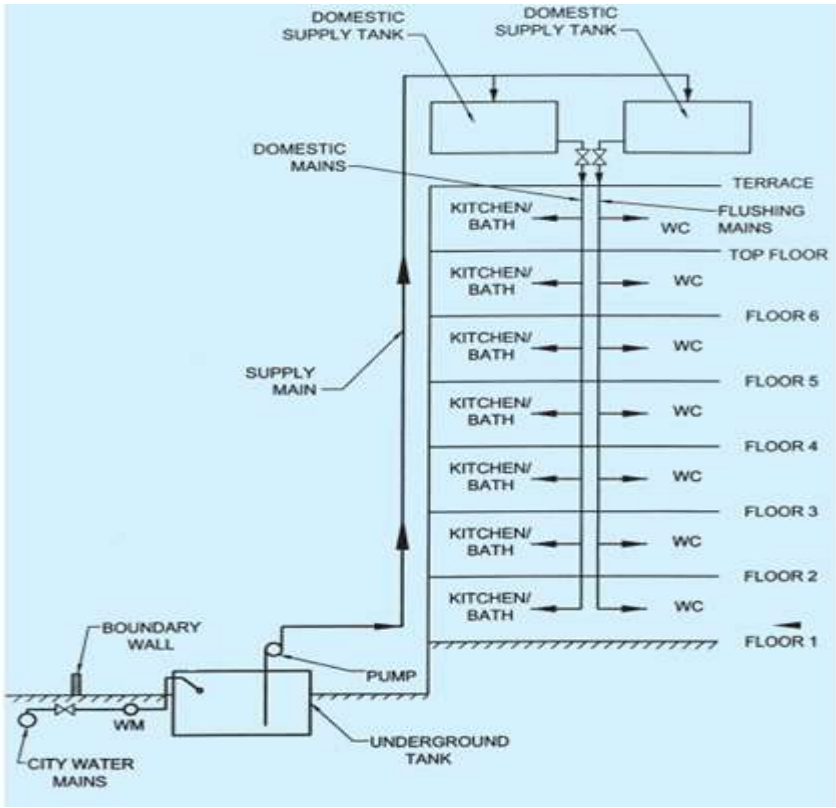


Fig-8

Overhead Tank Distribution:

This is the most common of the distribution systems adopted by various types of buildings. The system comprises pumping water to one or more overhead tanks

placed at the top most location of the hydraulic zone. Water collected in the overhead tank is distributed to the various parts of the building by a set of pipes located generally on the terrace. Distribution is accomplished by providing down takes to various fixtures (see Fig. 8).

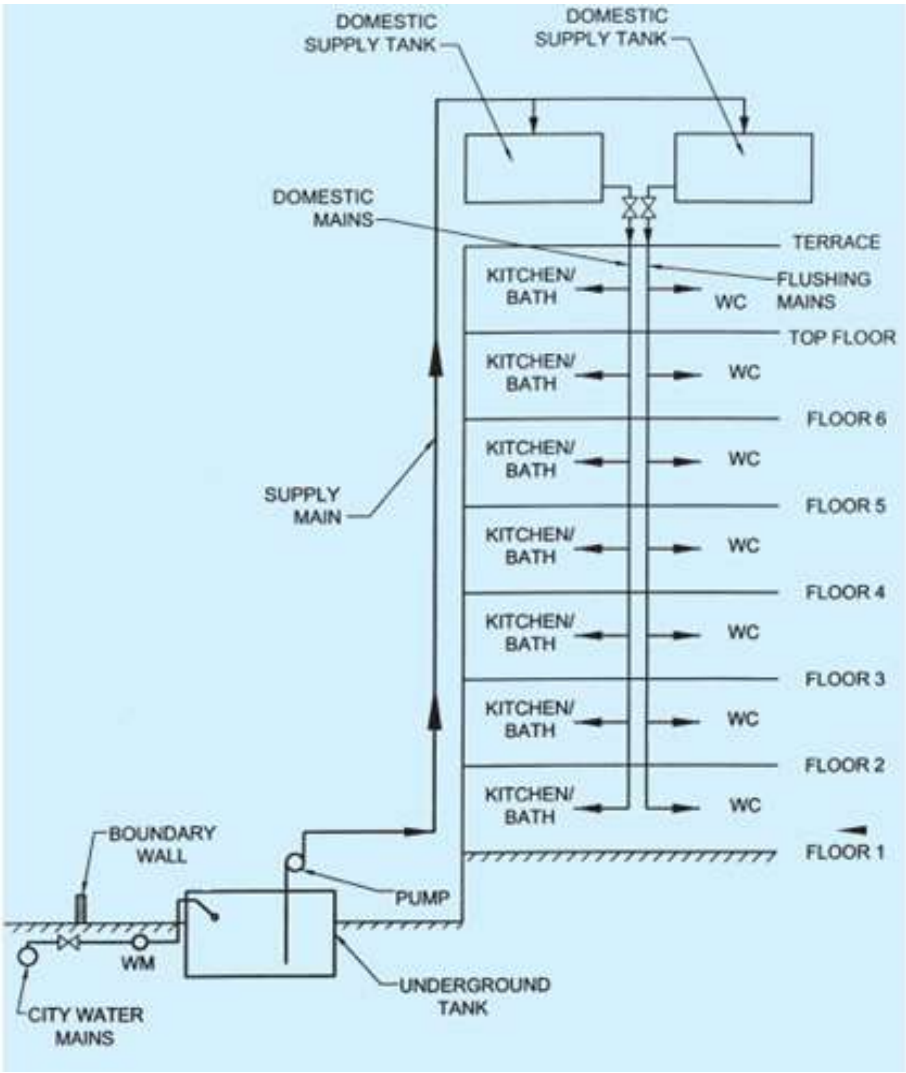


Fig-9

Pipes:

General Requirements for Pipe Work:

Mains

The following principles shall apply for the mains:

a) Service mains shall be of adequate size to give the required rate of flow.

b) The mains shall be divided into sections by the provisions of sluice valves and

other valves so that water may be shut off for repairs.
c) To avoid dead ends, the mains shall be arranged in a grid formation or in a network.
d) Where dead ends are unavoidable, a hydrant shall be provided to act as a wash-out.
e) The wash-out valve shall not discharge directly into a drain or sewer, or into a manhole or chamber directly connected to it; an effectively trapped chamber shall be interposed, into which the wash-out shall discharge.
f) Air valves shall be provided at all summits, and wash-out at low points between summits.
g) Mains need not be laid at unvarying gradients, but may follow the general contour of the ground. They shall, however, fall continuously towards the wash-out and rise towards the air valves. The gradient shall be such that there shall always be a positive pressure at every point under working conditions.
h) The cover for the mains shall be at least 900 mm under roadways and 750 mm in the case of footpaths. This cover shall be measured from the top of the pipe to the surface of the ground.
j) The mains shall be located sufficiently away from other service lines like electric and telegraph cables to ensure safety and where the mains cannot be located away from such lines, suitable protective measures shall be accorded to the mains.

Communication Pipes

a) Every premise that is supplied with water by the Authority shall have its own separate communication pipe. In the case of a group or block of premises belonging to the same owner the same communication pipe may supply water to more than one premise with the prior permission of the Authority.
b) The communication pipe between the water main and the stop-cock at the boundary of the premises shall be laid by the Authority.
c) Connections up to 50 mm diameter may be made on the water main by means of screwed ferrules, provided the size of the connections does not exceed one-third the size of the water main. In all other cases, the connection shall be made by a T-branch off the water main.
D) As far as practicable, the communication pipe and the underground service pipe shall be laid at right angles to the main and in approximately straight lines to facilitate location for repairs. It is also recommended that the communication pipe be laid in a pipe in pipe sleeve of larger dia. Made of non-corrosive material to protect the communication pipe.
e) Every communication pipe shall have a stopcock and meter inserted in it. The waterway of each such fitting shall not be less than the internal sectional area of the communication pipe and the fittings shall be located within the premises at a conspicuous place accessible to the Authority which shall have exclusive control over it.

Consumer Pipes

a) No consumer pipe shall be laid in the premises to connect the communication pipe without the approval of the Authority.
b) The consumer pipe within the premises shall be laid underground with a suitable cover to safeguard against damage from traffic and extremes of weather.
c) To control the branch pipe to each separately occupied part of a building supplied by a common service pipe, a stop tap shall be fixed to minimize the interruption of the supply during repairs. All such stop valves shall be fixed in accessible positions and properly protected. To supply water for drinking or for culinary purposes, direct taps shall be provided on the branch pipes connected directly to the consumer pipe. In the case of multi-storeyed buildings, down take taps shall be supplied from overhead tanks.
d) Pumps shall not be allowed on the service pipe, as they cause a drop in pressure on the suction side, thereby affecting the supply to the adjoining properties. In cases where pumping is required, a properly protected storage tank of adequate capacity shall be provided to feed the pump.
e) No direct boosting (by booster pumps) shall be allowed from the service pipes (communication and consumer pipes).
f) Consumer pipes shall be so designed and constructed as to avoid air-locks. Draining taps shall be provided at the lowest points from which the piping shall rise continuously to draw-off taps.
g) Consumer pipes shall be so designed as to reduce the production and transmission of noise as much as possible.
h) Consumer pipes in roof spaces and unventilated air spaces under floors or in basements shall be protected against corrosion.
j) Consumer pipes shall be so located that they are not unduly exposed to accidental damage and shall be fixed in such positions as to facilitate cleaning and avoid accumulations of dirt.

Prohibited Connections

a) A service pipe shall not be connected into any distribution pipe; such connection may permit the backflow of water from a cistern into the service pipe, in certain circumstances, with consequent danger of contamination and depletion of storage capacity. It might also result in pipes and fittings being subjected to a pressure higher than that for which they are designed, and in flooding from overflowing cisterns.
b) No pipe for conveyance or in connection with water supplied by the Authority shall communicate with any other receptacle used or capable of being used for conveyance other than water supplied by the Authority.
c) Where storage tanks are provided, no person shall connect or be permitted to connect any service pipe with any distributing pipe.
d) No service or supply pipe shall be connected directly to any water-closet or a urinal. All such supplies shall be from flushing cisterns which shall be supplied from storage tank.

e) No service or supply pipe shall be connected directly to any hot water system or to any other apparatus used for heating other than through a feed cistern thereof.

Pipe materials

The material chosen shall be resistant to corrosion, both inside and outside or shall be suitably protected against corrosion. Polyethylene and unplasticised PVC pipes shall not be installed near hot water pipes or near any other heat sources. For temperature limitations in the use of polyethylene and unplasticised PVC pipes to convey water, reference may be made to good practice

Materials for Pipes:

Pipes may be of any of the following materials:

a) Cast iron, vertically cast or centrifugally (spun) cast,
b) Steel (internally lined or coated with bitumen or a bituminous composition, and out-coated with cement concrete or mortar, where necessary),
c) Reinforced concrete,
d) pre-stressed concrete,
e) galvanised mild steel tubes,
f) Copper,
g) Brass,
h) wrought iron,
i) Asbestos cement,
j) Polyethylene,
k) Unplasticised PVC,
l) Chlorinated PVC, or
m) Stainless steel.

Cast Iron Pipes

Jointing may be done by any of the following methods:

a) Spigot and socket joints, or
b) Flanged joints in accordance with good practice the lead shall conform to the accepted standards.

Steel Pipes

Plain-ended steel pipes may be joined by welding. Electrically welded steel pipes shall be jointed in accordance with good practice [9-1(8)].

Wrought Iron and Steel Screwed Pipes

Screwed wrought iron or steel piping may be jointed with screwed and socketed joints. Care shall be taken to remove any burr from the end of the pipes after screwing. A jointing compound approved by the Authority and containing no red lead composition shall be used. Screwed wrought iron or steel piping may also be jointed with screwed flanges.

Asbestos Cement Pipes

Asbestos cement pipes may be jointed in accordance with good practice

Copper Pipes

Copper pipes shall be joined by internal solder ring joint, end-brazing joint or by use of compression fitting. The flux used shall be non-toxic and the solder used shall be lead free. The use of dezincification fittings shall be made in case of jointing of copper pipe and steel pipe.

Concrete Pipes

Concrete pipes shall be jointed in accordance with good practice

Polyethylene and Unplasticized PVC Pipes

Polyethylene and unplasticised PVC pipes shall be jointed in accordance with good practice.

Pipe specials:

1. Elbow
2. Coupling
3. Union
4. Reducer
5. Olets
6. Tee
7. Cross
8. Cap
9. Plug
10. Nipple
11. Barb

Elbow:

- An elbow is a pipe fitting installed between two lengths of pipe or tubing to allow a change of direction, usually a 90° or 45° angle, though 22.5° elbows are also made.
- The ends may be machined for butt welding, threaded (usually female), or socketed, etc.
- When the two ends differ in size, the fitting is called a reducing elbow or reducer elbow.

- A 90 degree elbow is also called a "90 bend" or "90 ell". It is a fitting which is bent in such a way to produce 90 degree change in the direction of flow in the pipe.
- It is used to change the direction in piping and is also sometimes called a "quarter bend“

- The main application of an elbow (90 degree) is to connect hoses to valves, water pressure pumps, and deck drains. These elbows can be made from tough nylon material or NPT thread.

Coupling:

- A coupling connects two pipes to each other.
- If the size of the pipe is not the same, the fitting may be called a reducing coupling or reducer, or an adapter.
- By convention, the term "expander" is not generally used for a couple that increases pipe size; instead the term "reducer" is used. There are two different types of couplings: slip and regular couplings.

Union:

- A union is similar to a coupling, except it is designed to allow quick and convenient disconnection of pipes for maintenance or fixture replacement.
- While a coupling would require either solvent welding, soldering or being able to rotate with all the pipes adjacent as with a threaded coupling, a union provides a simple transition, allowing easy connection or disconnection at any future time.

- A standard union pipe is made in three parts consisting of a nut, a female end, and a male end.

- When the ends are joined, the nut then provides the necessary pressure to seal the joint. Since the mating ends of the union are interchangeable, changing of a valve or other device can be achieved with a minimum loss of time.
- Pipe unions are essentially a type of flange connector
- In addition to standard, simple unions, other types of union exist:
  - Dielectric unions
  - Rotary unions

Reducer:

- A reducer allows for a change in pipe size to meet hydraulic flow requirements of the system, or to adapt to existing piping of a different size.
- Reducers are usually concentric but eccentric reducers are used when required to maintain the same top- or bottom-of-pipe level

Olets:

- Whenever branch connections are required in size where reducing tees are not available and/or when the branch connections are of smaller size as compared to header size, olets are generally used.

Tee:

- A tee is the most common pipe fitting. It is available with all female thread sockets, all solvent weld sockets, or with opposed solvent weld sockets and a side outlet with female threads.
- It is used to either combine or split a fluid flow. It is a type of pipe fitting which is T-shaped having two outlets, at 90° to the connection to the main line.
- It is a short piece of pipe with a lateral outlet.
- A tee is used for connecting pipes of different diameters or for changing the direction of pipe runs.
- They are made of various materials and available in various sizes and finishes. They are extensively used in pipeline networks to transport two -phase fluid mixtures
- They are categorized as:
    - Equal
    - Unequal

Cross:

- A cross has one inlet and three outlets, or vice versa. They often have solvent welded socket ends or female threaded ends.
- Cross fittings can generate a huge amount of stress on pipe as temperature changes, because they are at the center of four connection points.
- A tee is more steady than a cross, as a tee behaves like a three-legged stool, while a cross behaves like a four-legged stool.
- Crosses are common in fire sprinkler systems.

Cap:

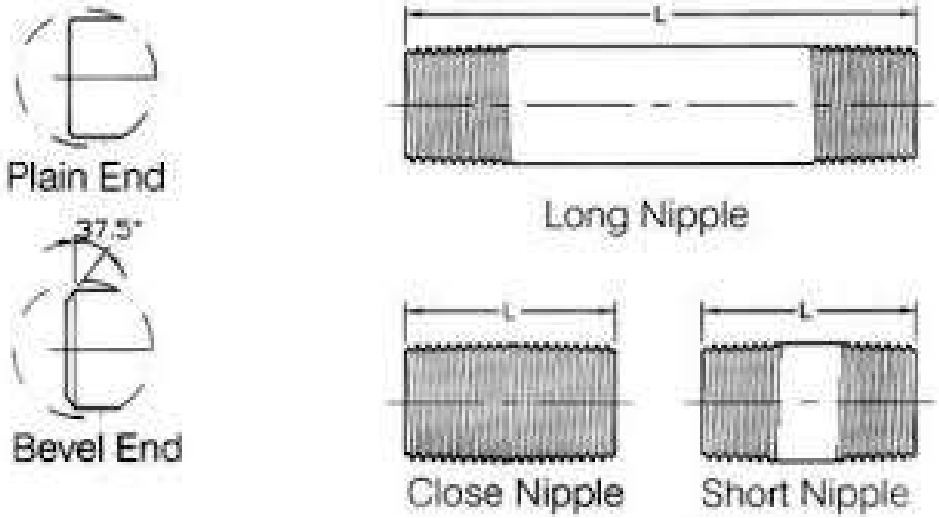
- A type of pipe fitting, usually liquid or gas tight, which covers the end of a pipe.
- A cap is used like plug, except that the pipes cap screws or attaches on the male thread of a pipe.
- A cap may have a solvent weld socket end or a female threaded end and the other end closed off. In plumbing systems that use threads, the cap has female threads.
- Industrial caps can be round, square, rectangular, U-shaped, and I-shaped and may have a round hand grip or a flat hand grip.

Plug:

- A plug closes off the end of a pipe. It is similar to a cap but it fits inside the fitting it is mated to. In a threaded iron pipe plumbing system, plugs have male threads.
- Some of the popular types of plugs are:
  - Mechanical pipe plug
  - Pneumatic disk pipe plug
  - Single size pneumatic all rubber pipe plug
  - Multi-size pneumatic pipe plug
  - Multi-size flow-through pipe plug
  - High pressure pipe plug

Nipple:

- A short stub of pipe usually threaded steel, brass, chlorinated polyvinyl chloride (CPVC) or copper; occasionally just bare copper.
- A nipple is defined as being a short stub of pipe which has external male pipe threads at each end, for connecting two other fittings.
- Nipples are commonly used for plumbing and hoses, and second as valves for funnels and pipes.



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Barb:

- A "barb" or "hose barb" fitting is used to connect flexible hose or tubing to pipes.
- A barb fitting typically has a male-threaded end used to mate with female threads.
- The other end of the fitting has either a single- or multiple-barbed tube having a tapered stub with ridges, which is inserted into a flexible hose to secure it.

VALVESAND CONTROLS:

FUNCTION OF VALVES

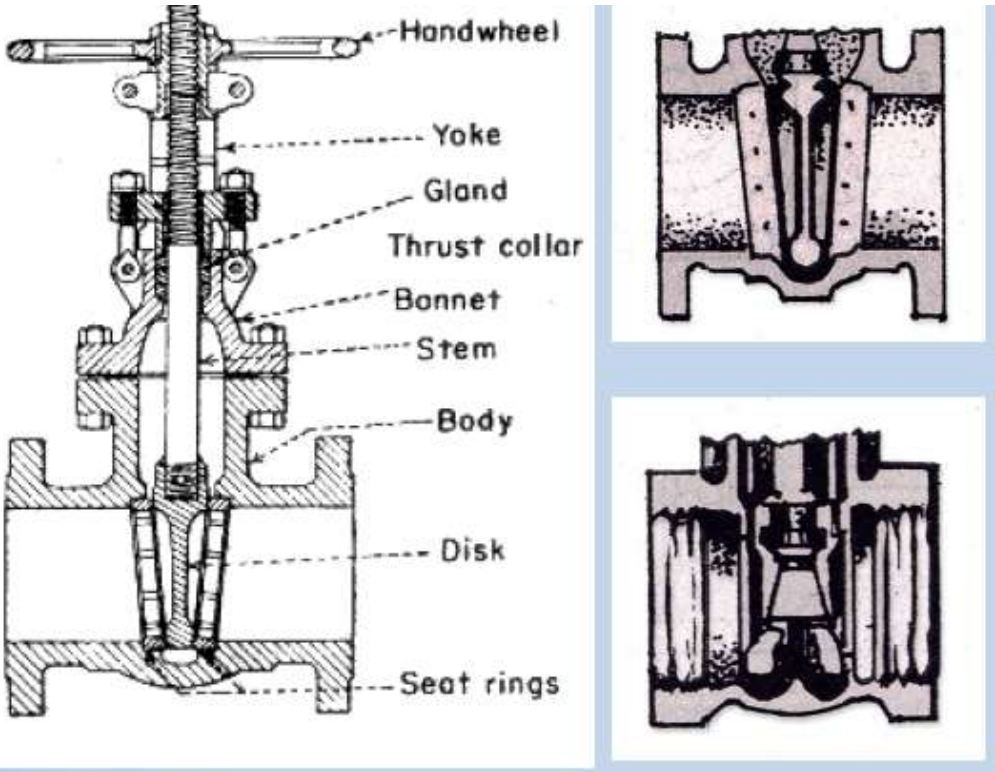
- Control of the water flow
- Start or shut down a system
- Regulate pressure
- Check backflow
- Control the direction of water flow

TYPES OF VALVES

GATE VALVE(Full-way Valve):

Used mainly to completely close or completely open the water line (does not control flow of water). Wedge Shape or Tapered Disc Valve

Double Disc Valve



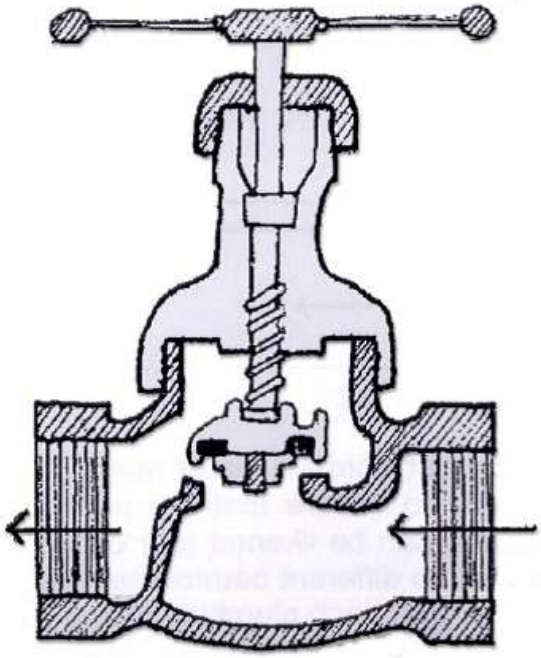
GLOBE VALVE:

Controls the flow of water with movable spindle. Can reduce water pressure.

Plug Type Disc Valve

Conventional Disc Valve

Composition Disc Valve



CHECK VALVE:

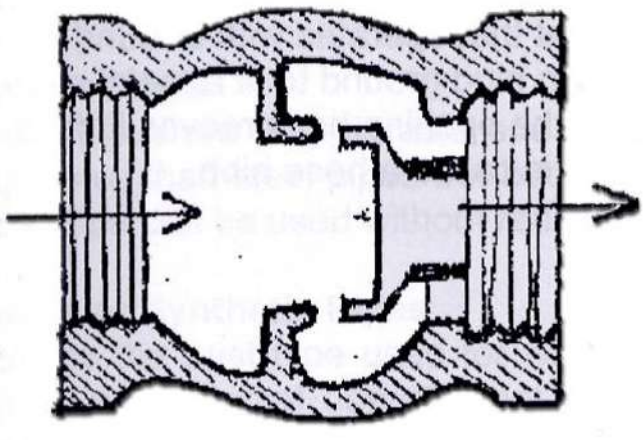
Main function is to prevent reversal of flow (backflow) in the line.

Types:

Swing Check Valve

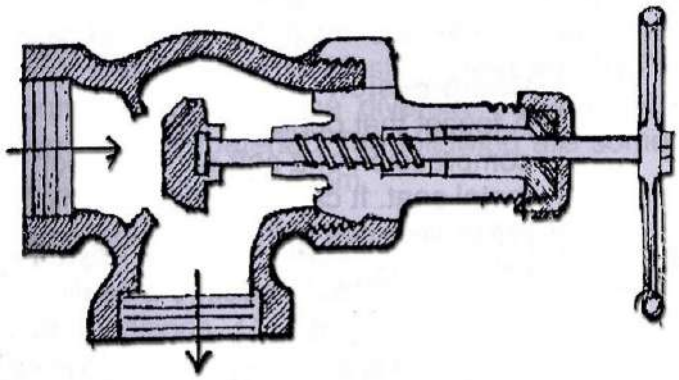
Lift Check Valve

Horizontal Check valve



ANGLE VALVE

Used to make a 90°turn in a line.

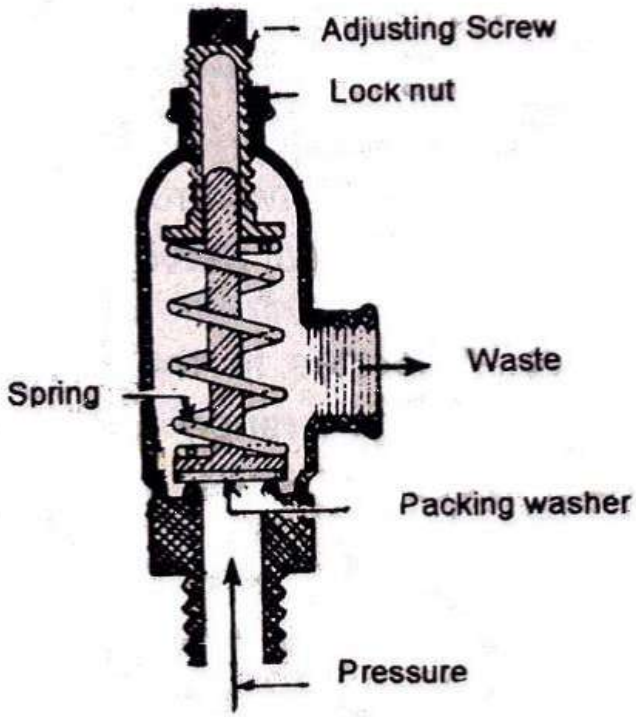


FOOT VALVE

Locatedatthelowerendofthepump.Usedmainlytopreventlossofprimingofthepumps.

SAFETY VALVE

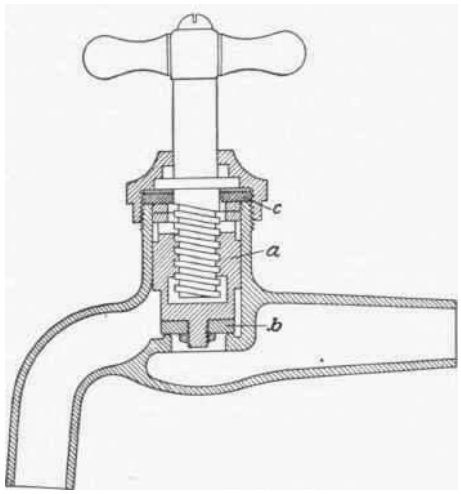
Used on water systems, heating systems, compressed air lines & other pipe lines with excessive pressure.



TYPES OF FAUCETS:

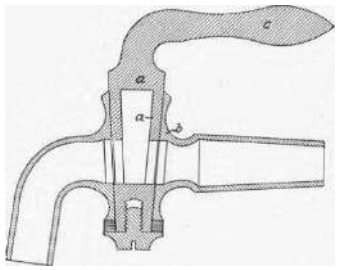
COMPRESSION COCK

Operates by the compression of a soft packing upon a metal sheet.



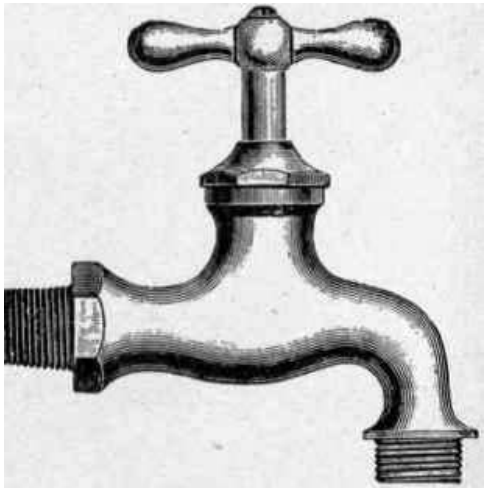
KEY COCK

Operateswitharoundtaperingpluggroundtofitametalsheet.



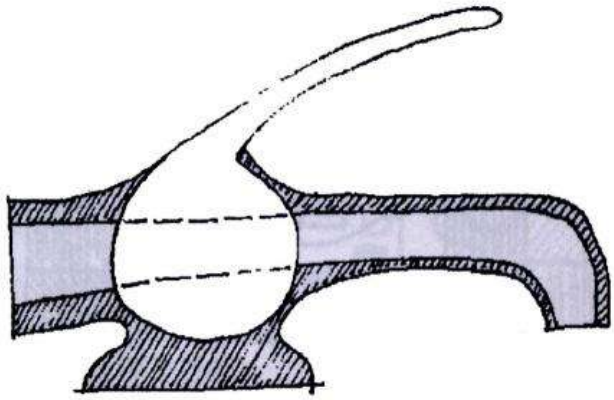
HOSE BIBB

A waterfaucetmade for the threaded attachment of a hose.



BALL FAUCET

Constructedwithaballconnectedtothehandle



Part-A

Assignment-Cum-Tutorial Questions

1. In India as per Indian standards, water consumptions per capita per day for domestic purpose is
   a) 85 liters
   b) 100 liters
   c) 115 liters
   d) 135 liters
2. The water supply system should be designed for the present population only
   a) Agree
   b) Disagree
3. An infiltration gallery is a?

a) Tube well

b) Artesian well

c) Vertical well with arms

d) Horizontal well

4. In our country, as per IS 1175-1963,water consumption per capita per day for domestic purposes is

   a) 135 litres

   b) 115 litres

   c) 100 litres

   d) 95 litres

5. The design period for any water supply project is taken as

   a) 10 years

   b) 10 to 15 years

   c) 15 to 20 years

   d) 20 to 30 years

6. The geometric method of forecasting population is appilied for

   a) old and very large town

   b) Young and rapidly growing town

   c) Young but slowly growing town

   d) Old and slowly growing town

7. The most common coagulant is

   a) Magnesium Sulphate

   b) Bleaching powder

   c) Alum

   d) Chlorine

8. .Rate of filtration in slow sand filter in $1/hr/m^2$

9. .If the source of water supply is located at a sufficiently higher level than the city, the type of distribution system adopted is

a) Direct pumping system

b) Gravity system

c) Direct-indirect system

d) None of the above

10. The most reliable method of distribution system is

11. The valves which are used to remove the sediment in the pipelines are called

a) Direct valve

b) Scour valve

c) Air valve

d) Check valve

12. The instrument used for measuring the quantity of water consumed by people is

13. Slow sand filters requires area as compared to rapid sand filters.

14. The valve provided on the suction pipe in a tube well is

a) Sluice valve

b) Air valve

c) Pressure relief valve

d) Reflux valve

Part-B

1. State the classification of various surface and sub surface sources ?
2. What is rate of demand? What are the factors affecting on the rate of demand?
3. Sketch and Explain the process of sedimentation in a rectangular tank?
4. Explain construction and working of slow sand filters with the help of neat sketch.
5. Explain the construction, working and cleaning process of **"Rapid Sand Filter** "Give the sketch?
6. List different methods of disinfection? Explain any three methods in detail?
7. List any six requirements of an efficient distribution system?
8. Explain with sketches the different layouts of distribution system?
9. State the general precaution to be taken in plumbing work for building?
10. Explain types of valves and their functions in plumbing with neat sketch.

UNIT-II

WASTE WATER, TREATMENTS AND DISPOSAL

Types of collection system

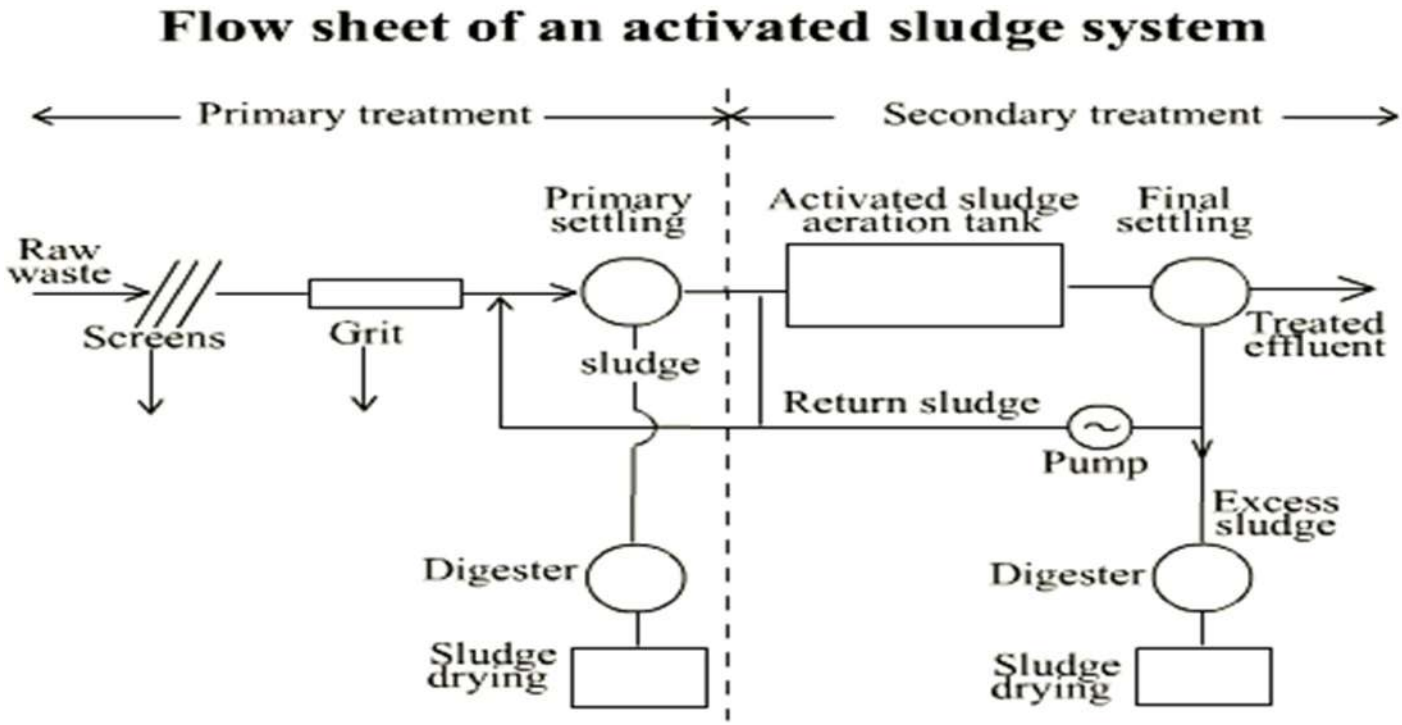
- Sanitary sewers

- Storm water sewers
- Combined sewers

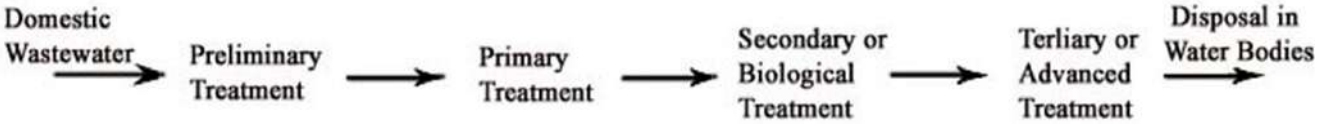
Types of sewers:

- Building sewer/Building connections: Connected to the building and used for conveyance of wastewater from building to lateral/branch sewer.
- Lateral or branch: Usually laid out on streets and used to collect the wastewater from one or more buildings.
- Main: Convey wastewater from one of more lateral sewers to trunk sewers or to intercepting sewer.
- Trunk: Large sewers used to convey wastewater from main sewer to treatment or other disposal facilities or to large intercepting sewers
- Intercepting: Large sewers that are used to intercept a number of main or trunk sewer and convey wastewater to treatment or other disposal facilities

Sewage Treatment Plant (STP)



Wastewater treatment: Unit Operations/Processes, Their Functions and Units Used for Domestic Wastewater Treatment



Phase of treatment	**Unit Operations/Processes**	**Functions**	**Treatment Devices**
Preliminary treatment	Screening	Removal of large floating, suspended and settleable solids	Bar racks and screens of various description
Primary treatment	Grit Removal	Removal of inorganic suspended solids	Grit chamber
	Primary Sedimentation	Removal of organic/inorganic settleable solids	Primary sedimentation tank
Secondary/Biological treatment	Aerobic Biological Suspended Growth Process	Conversion of colloidal, dissolved and residual suspended organic matter into settleable biofloc and stable in organics	Activated sludge process units and its modifications, Waste stabilisation ponds, Aerated lagoons
	Aerobic Biological Attached Growth Process	same as above	Trickling filter, Rotating biological contactor

	Anaerobic biological growth processes	Conversion of organic matter into CH_4 & CO_2 and relatively stable organic residue	Anaerobic filter, Fluid bed submerged media anaerobic reactor, Upflow anaerobic sludge blanket reactor, Anaerobic rotating biological contactor
	Anaerobic Stabilization of Organic Sludges	same as above	Anaerobic digestor
Advanced treatment	Nitrification-denitrification		

Preliminary wastewater treatment

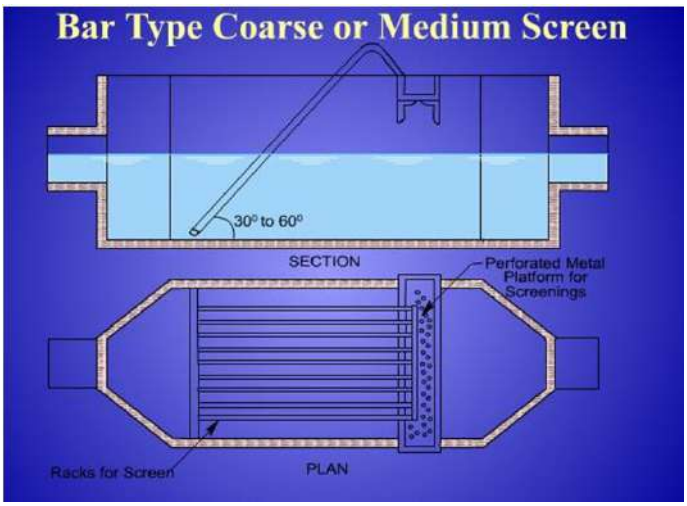
1. A screen is a device with openings for removing bigger suspended or floating matter in sewage which would otherwise damage equipment or interfere with satisfactory operation of treatment units.

1. Coarse Screens: Coarse screens also called racks, are usually bar screens, composed of vertical or inclined bars spaced at equal intervals across a channel through which sewage flows. Bar screens with relatively large openings of 75 to 150 mm are provided ahead of pumps, while those ahead of sedimentation tanks have smaller openings of 50 mm. Bar screens are usually hand cleaned and sometimes provided with mechanical devices. These cleaning devices are rakes which periodically sweep the entire screen removing the solids for further processing or

Hand cleaned racks are set usually at an angle of 45° to the horizontal to increase the effective cleaning surface and also facilitate the raking operations. Mechanical cleaned racks are generally erected almost vertically. Such bar screens have openings 25% in excess of the cross section of the sewage channel.

Medium Screens: Medium screens have clear openings of 20 to 50 mm. Bar are usually 10 mm thick on the upstream side and taper slightly to the downstream side. The bars used for screens are rectangular in cross section usually about 10 x 50 mm, placed with larger dimension parallel to the flow.

Fine Screens: Fine screens are mechanically cleaned devices using perforated plates, woven wire cloth or very closely spaced bars with clear openings of less than 20 mm. Fine screens are not normally suitable for sewage because of clogging possibilities.



Grit Chamber

- Grit Chambers

- Grit chambers are basin to remove the inorganic particles to prevent damage to the pumps, and to prevent their accumulation in sludge digestors.

- Types of Grit Chambers

Grit chambers are of two types: mechanically cleaned and manually cleaned. In mechanically cleaned grit chamber, scraper blades collect the grit settled on the floor of the grit chamber. The grit so collected is elevated to the ground level by several mechanisms such as bucket elevators, jet pump and air lift. The grit washing mechanisms are also of several designs most of which are agitation devices using either water or air to produce washing action. Manually cleaned grit chambers should be cleaned atleast once a week. The simplest method of cleaning is by means of shovel.

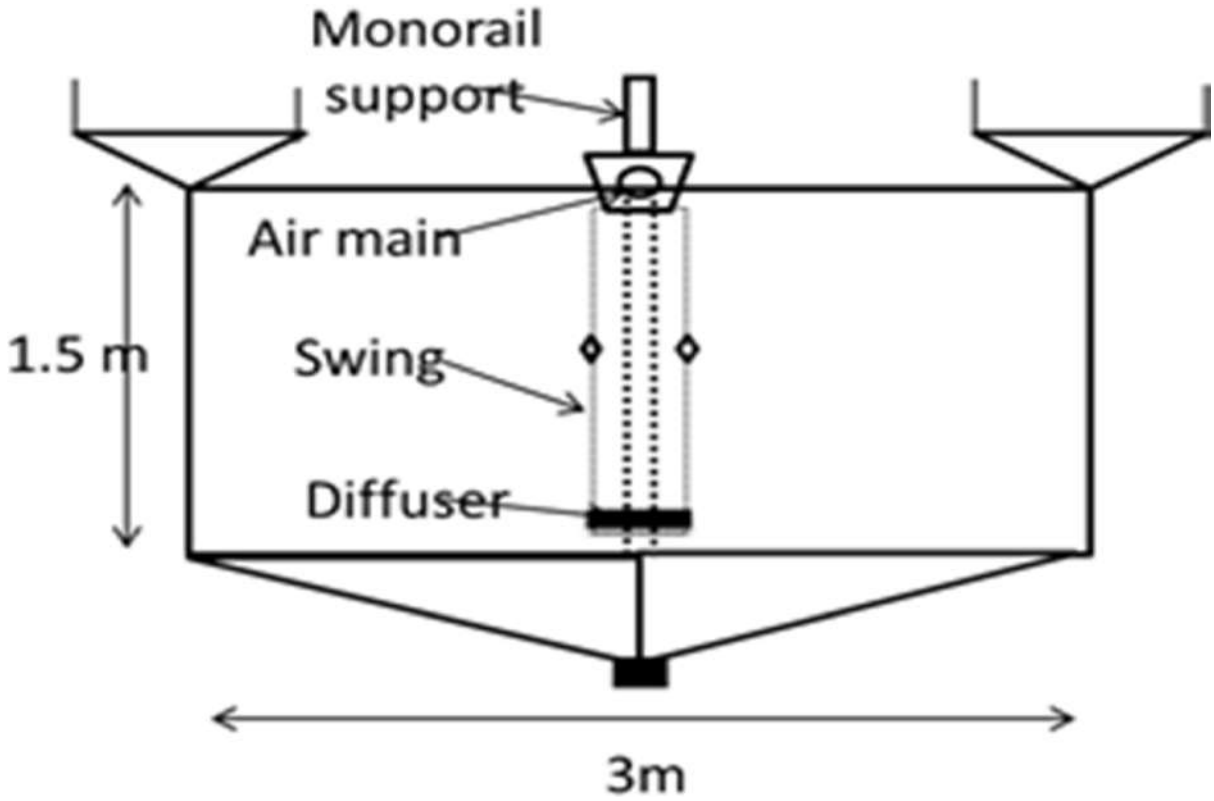
- Aerated Grit Chamber

- An aerated grit chamber consists of a standard spiral flow aeration tank provided with air diffusion tubes placed on one side of the tank. The grit particles tend to settle down to the bottom of the tank at rates dependant upon the particle size and the bottom velocity of roll of the spiral flow, which in turn depends on the rate of air diffusion through diffuser tubes and shape of aeration tank. The heavier particles settle down whereas the lighter organic particles are carried with roll of the spiral motion.

Primary Sedimentation

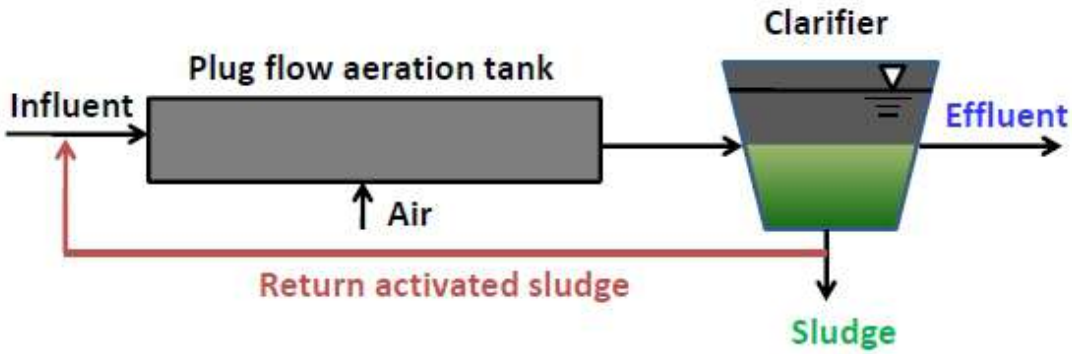
- Primary Sedimentation
- Primary sedimentation in a municipal wastewater treatment plant is generally plain sedimentation without the use of chemicals. In treating certain industrial wastes chemically aided sedimentation may be involved. In either case, it constitutes flocculent settling, and the particles do not remain discrete as in the case of grit, but tend to agglomerate or coagulate during settling. Thus, their diameter keeps increasing and settlement proceeds at an over increasing velocity.
- The settling tank design in such cases depends on both surface loading and detention time.
- Industrial wastewater: Long tube settling tests can be performed in order to estimate specific value of surface loading and detention time for desired efficiency of clarification for a given industrial wastewater using recommended methods of testing. Scale-up factors used in this case range from 1.25 to 1.75 for the overflow rate, and from 1.5 to 2.0 for detention time when converting laboratory results to the prototype design.
- Municipal or domestic sewage: For primary settling tanks treating municipal or domestic sewage, laboratory tests are generally not necessary, and recommended design values given in table may be used. Using an appropriate value of surface loading from table, the required tank area is computed. Knowing the average depth, the detention time is then computed. Excessively high detention time (longer than 2.5 h) must be avoided especially in warm climates where anaerobicity can be quickly induced.

Primary Settling Tank (Clarifier)



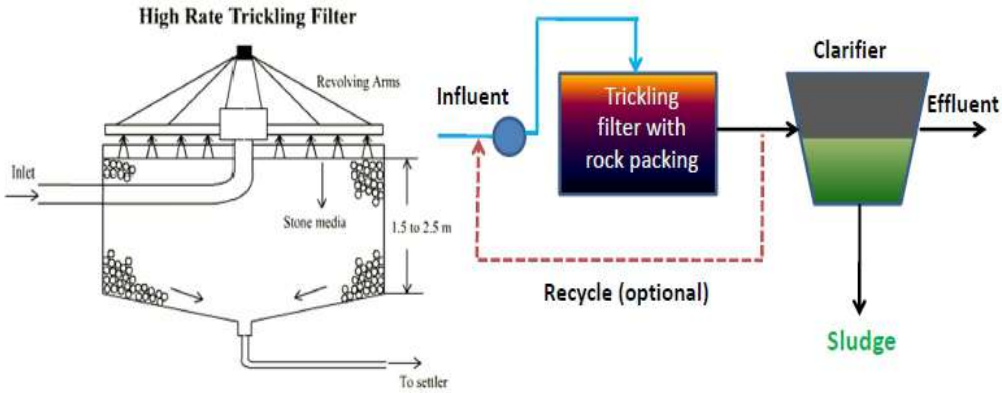
Biological processes for waste water treatment-II

Activated Sludge Process



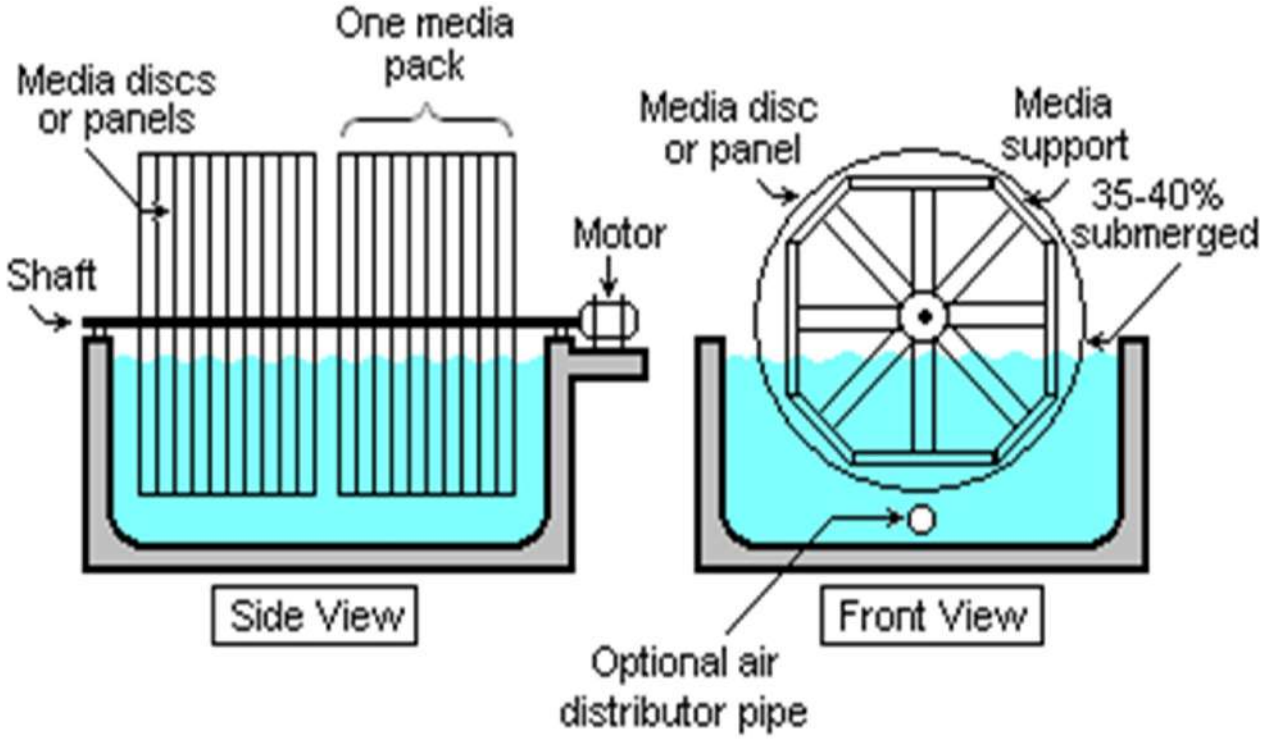
Biological processes for waste water treatment-II

- Attached growth process (AGP): The microorganisms responsible for the conversion of organic matter or nutrients are attached to an inert packing material (i.e. rock, gravel, slag, sand, redwood and wide range of plastic and other synthetic materials). The wastewater is passed through the attached growth also known as biofilm. The AGP could be aerobic or anaerobic. The packing material can be submerged or not submerged, with an air or gas space above the biofilm.
- Most common attached growth process used is the trickling filter.


High Rate Trickling Filter
Revolving Arms
Inlet
Stone media
1.5 to 2.5 m
To settler
Influent
Trickling filter with rock packing
Clarifier
Effluent
Recycle (optional)
Sludge

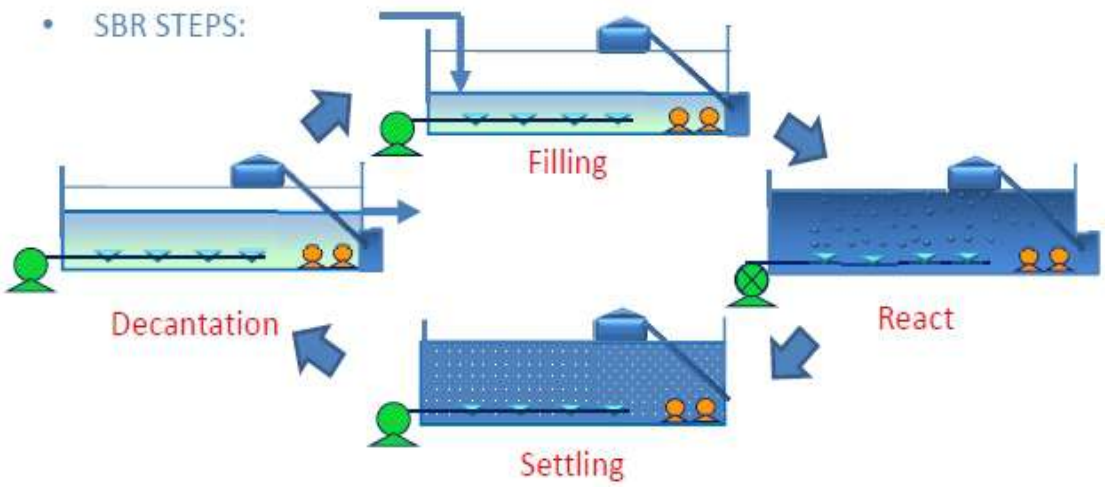
Rotating Biological Contactor

Conventional RBC Schematic



SEQUENCING BATCH REACTOR (SBR)

- SBR is a reactor that combines all treatment steps and processes into a single basin, or tank compared to conventional facilities which use multiple basins.



Biological treatment and role of microorganism

- Objective of biological treatment:
  - Oxidize dissolved and particulate biodegradable constituents into acceptable end product (CO2, H2O,)
  - Capture and incorporate suspended and nonsettlable colloidal solids into a biological floc or biofilm
  - Transform and remove nutrients such as N2 and P
  - In some cases remove specific trace organic constituents and compounds
- Role of microorganisms:
  - The removal of dissolved and particulate carbonaceous BOD and the stabilization of organic matter found in wastewater is accomplished biologically using variety of microorganisms (bacteria, protozoa fungi, rotifers, algae).
  - Microorganisms are used to oxidize the dissolved and particulate organic matter into simple end products and additional biomass.

- Example Aerobic biological oxidation
- ν (organic material) + ν_2O_2 + ν_3NH_3+$\nu 4PO_4^{3-}$ —Microorganisms→ ν_5 (new cell/biomass) +ν_6CO_2+ν_7H_2O

Nutrients

Biological processes for waste water treatment-I

- Biomass has specific gravity slightly higher than water and can be removed by gravitational settling.

- How does bacteria remove Nitrogen and phosphorus?
  - Ammonia: nitrite and nitrate
  - Oxidized nitrogen to gaseous nitrogen
  - Encouraging the growth of bacteria with the ability to take up and store large amount of inorganic phosphorous
- Type of biological processes for wastewater treatment
  - Suspended growth process: Microorganisms responsible for treatment are maintained in liquid suspension by appropriate mixing method. Many SG processes are aerobic (presence of O2) some are anaerobic (absence of O2). Most common SG process is activated sludge process.

➢ Activated sludge process (ASP): It involve the production of an activated mass of microorganisms capable of stabilizing the waste under aerobic condition. In aeration tank contact time is provided form mixing and aerating influent wastewater with microbial suspension, generally referred to as mixed liquor suspended solid (MLSS) or mixed liquor volatile suspended solids (MLVSS). Important feature of ASP is floc formation (50-200 □m) which can be removed by gravity settling. Greater than 99% of suspended solids can be removed in the clarification step.

Sewer Line Fixtures:

The following sanitary fitting are commonly used in buildings, for efficient collection and removal to the house drain:

1. Wash basins
2. Sinks

3. Bath tubs

4. Water closets

5. Urinals

6. Flashing cisterns

1. Wash basins:

- A wash basin is usually made of pottery or white glazed earth ware or enamelled iron, etc. Sometimes, they are also made of pressed steel or plastic.
- There are two types of wash basins - the flat back and the angle back.
- An ordinary wash basin is mounted on brackets fixed on wall. While a pedestal type basin is mounted on pedestal rising from wall. They are available in different shapes and sizes.
- Standard sizes for flat back wash basins are

  630 x 450 mm

  550 x 400 mm

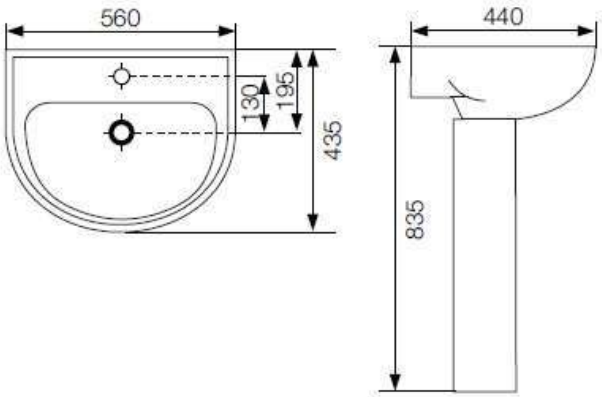
  450 x 300 mm

- Standard sizes for angle back wash basins are

  600 x 480 mm

  400 x 400 mm

- It has oval shaped bowl. With overflow slot at the top, the waste pipe with a metallic strainer is provided at the bottom of the bowl.



Sinks

- A sink is a rectangular basin used in kitchen or laboratory for cleaning utensils, and glass wares.
- These may be made of glazed earth ware, stainless steel or enamelled pressed steel.

- The sink has an outlet usually of about 40 mm diameter.
- The outlet pipe discharges water over a floor trap or nahni trap.

The mouth of outlet pipe is provided with grating of bras or nickel so that the entry of coarse solid substances is prevented.

Commonsizes of kitchen sinks:

600 x 400 x 150 mm

600 x 450 x 250 mm

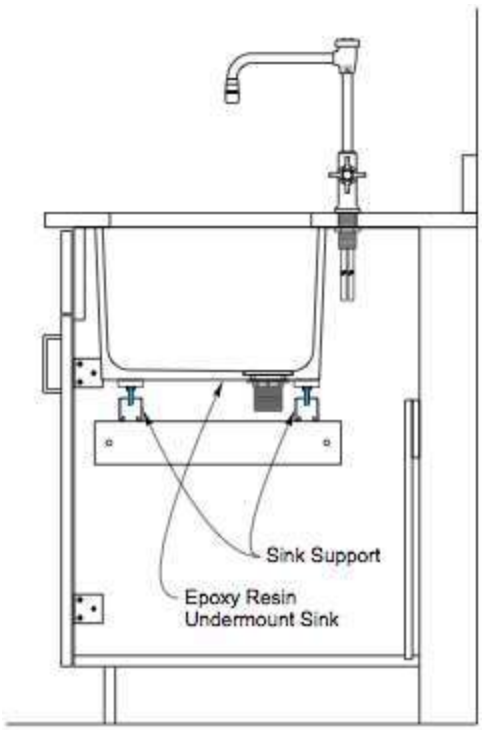
750 x 450 x 250 mm

Commonsizes for laboratory sinks:

400 x 250 x 150 mm

450 x 300 x 150 mm

600 x 400 x 200 mm



SINK BASE CABINET - SECTION

Bath tubs

• Bath tubs are usually made of iron or steel coated with enamel, enamelled porcelain or of plastic. They may be parallel sides or with tapering sides.

• The usual dimensions of both tubs are:

Length: 1.7 to 1.85 m

Width: 0.70 to 0.75 m

Depth: 0.6 m

Water closets (W/C)

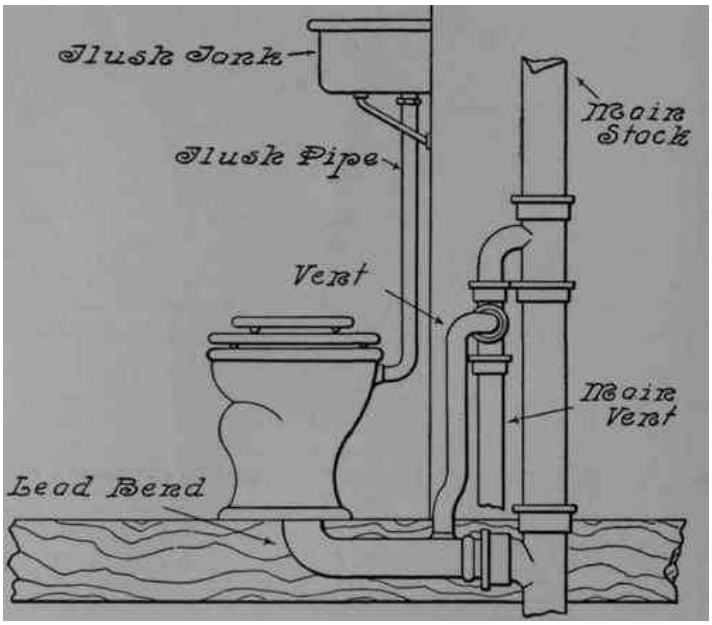
- A water closet is a sanitary fitting which is designed to receive human excreta directly and convey to the septic tank or underground sewer through a trap.
- It is usually connected to a flushing cistern to flush the closet and discharge the human excrete to the soil pipe.

The water closets are of three types:

1) Indian type

2) European type

3) Anglo- Indian type



Materials and functions:

1. **Salt glazed stoneware pipe**

For all sewers and drains in all soils, except where supports are required as in made-up ground, glazed stoneware pipe shall be used as far as possible in preference to other types of pipes. These pipes are particularly suitable where acid effluents or acid subsoil conditions are likely to be encountered.

2. **Cement concrete pipes**

When properly ventilated, cement concrete pipes with spigot and socket or collar joints present an alternative to glazed stoneware sewers of over 150 mm diameter. These shall not be used to carry acid effluents or sewage under conditions favourable for the production of hydrogen sulphide and shall not be laid in those sub soils that are likely to affect adversely the quality or strength of concrete. Where these pipes are employed for conveying liquid containing sulphates, the pipes used shall be manufactured using sulphate resisting Portland cement. Owing to the longer lengths of pipes available, the joints would be lesser in the case of cements concrete pipes. These

pipes may be used for surface water drains in all diameters. Cement concrete pipes shall conform to accepted standards.

3. Cast iron pipes

These pipes shall be used in the following situation:

a) In bed or unstable ground where soil movement is expected;

b) In made-up or tipped ground;

c) To provide for increased strength where a sewer is laid at insufficient depth, where it is exposed or where it has to be carried on piers or above ground;

d) Under buildings and where pipes are suspended in basements and like situations;

e) In reaches where the velocity is more than 2.4 m/s; and

f) For crossings of watercourses.

4. Asbestos cement pipes

Asbestos cement pipes are commonly used for house drainage systems and they shall conform to accepted standards. They are not recommended for underground situations. However, asbestos cement pressure pipes conforming to accepted standards may be used in underground situations also, provided they are not subject to heavy superimposed loads. These shall not be used to carry acid effluents or sewage under conditions favourable for the production of hydrogen sulphide and shall not be laid in those sub soils which are likely to affect adversely the quality or strength of asbestos cement pipes. Where so desired, the life of asbestos cement pipes may be increased by lining inside of the pipe with suitable coatings like epoxy/polyester resins, etc.

5. PVC pipes

Unplasticized PVC pipes may be used for drainage purposes; however, where hot water discharge is anticipated, the wall thickness shall be minimum 3 mm irrespective

of the size and flow load. PVC and HDPE pipes shall conform to accepted standards.

6. Corrugated pipes

These pipes (externally corrugated) are used for sewerage and drainage applications. They are light weight and have long life. The leakage and infiltration at joints are less. The operational cost is low and can easily withstand natural settlements without suffering cracks or leakages. They consume fewer raw materials and have less carbon dioxide emission.

7. Low noise pipes

Waste water systems encompass the system of drainage and pressure relief pipes within a building and terminate 0.5 m outside the external wall. Waste water systems are based on the primary pressure-relief system in which water and air-flow occurs in the same pipe. The waste water system shall be separated from the roof drainage system. Noise is a variance in air pressure that spreads like a wave. If quick changes in pressure occur between 20 and 20 000 times a second (frequency 20 Hz and 20 kHz), they are audible to humans. The loudness of noise is determined by the amplitude of the wave, which is measured in decibels (dB). The main cause of noise in indoor drainage systems (primarily focused on the downpipe) are the choice of the pipe system, the bracket type and the design of drainage system. Optimizing these factors will therefore have the best influence on noise reduction.

PIPES

Material	Application	Jointing
Cast iron	50 mm and above vent and discharge stacks	Lead caulking with molten or fibrous lead; cold compound caulking
Galvanised steel	Waste pipe	Screwed
Copper	Waste pipes and traps	Compression, capillary, silver solder, bronze weld or push-fit rings seal
Lead	Waste pipes and discharge stacks	Soldered or lead welded
ABS (acrylonitrile butadiene styrene)	Up to 50 mm waste and vent pipes	Solvent cement and push-fit ring seal
High-density polyethylene	Up to 50 mm waste and ventilating pipes and traps	Push-fit ring seal and compression fittings
Polypropylene	Up to 50 mm waste and ventilating pipes and traps	Push-fit ring seal and compression couplings
Modified PVC	Up to 50 mm waste and vent pipes	Solvent cement and push-fit ring seal
Unplasticized PVC	Over 50 mm soil and vent stacks; vent pipes under 50 mm	Solvent cement and push-fit ring seal
Pitch fibre	Over 50 mm discharge and vent stacks	Driven taper or polypropylene fitting with a push-fit ring seal

TRAPS

A trap is depressed or bent fitting that, when provided in a drainage system, always remains full of water, thus maintaining water seal. It prevents the passage of foul air or gas through it, though it allows the sewage or waste water to flow through it. The depth of water seal is the vertical distance between the crown and dip of a trap. The depth of water seal represents its strength or effectiveness. Greater the depth of water seal more effective is the trap. The depth of water seal varies from 25mm to 75mm.

TYPES OF TRAPS

ACCORDING TO SHAPE:

1. ‘P’ TRAP

2. ‘Q’ TRAP

3. ‘S’ TRAP

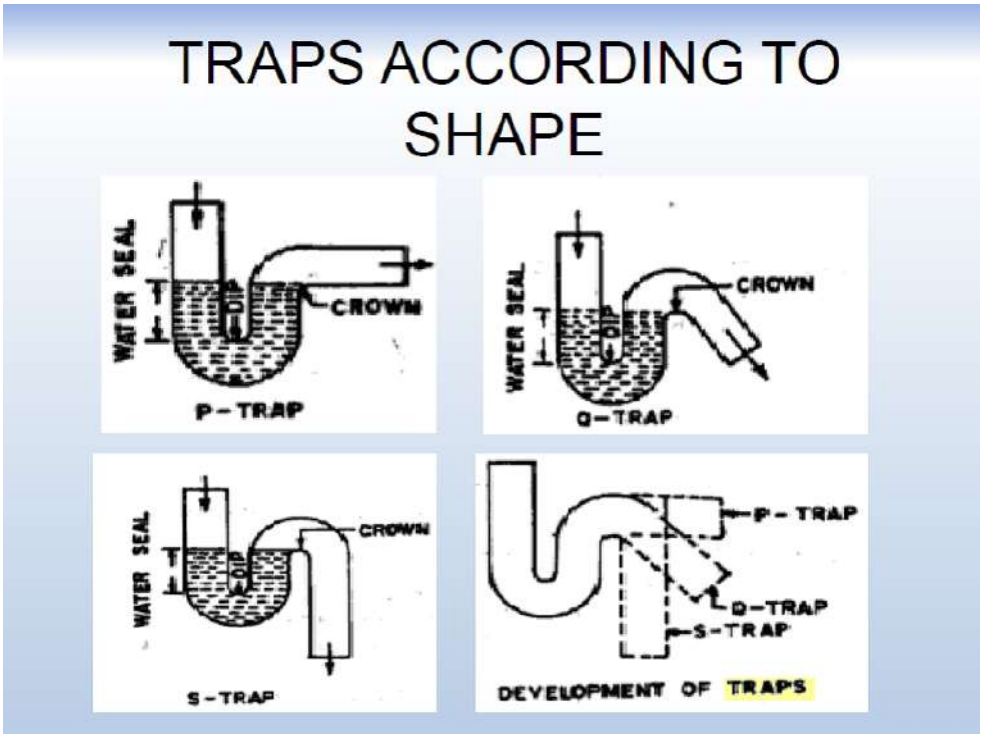
ACCORDING TO USE:

1. FLOOR TRAP

2. GULLY TRAP

3. INTERCEPTING TRAPS

4. GREASE TRAPS



Manholes

The structures, which are constructed at suitable intervals along the sewerage system to help its efficient operation and maintenance, are called as sewer appurtenances. These include:

(1) Manholes, (2) Drop manholes, (3) Lamp holes,

(4) Clean-outs, (5) Street inlets called Gullies, (6) Catch basins,

(7) Flushing Tanks, (8) Grease & Oil traps, (9) Inverted Siphons, and

(10) Storm Regulators.

Manholes

The manhole is masonry or R.C.C. chamber constructed at suitable intervals along the sewer lines, for providing access into them. Thus, the manhole helps in inspection, cleaning and maintenance of sewer. These are provided at every

bend, junction, change of gradient or change of diameter of the sewer. The sewer line between the two manholes is laid straight with even gradient. For straight sewer line manholes are provided at regular interval depending upon the diameter of the sewer. The spacing of manhole is recommended in IS 1742-1960. For sewer up to 0.3 m diameter or sewers which cannot be entered for cleaning or inspection the maximum spacing between the manholes recommended is 30 m, and 300 m spacing for pipe greater than 2.0 m diameter (Table 8.1). A spacing allowance of 100 m per 1 m diameter of sewer is a general rule in case of very large sewers (CPHEEO, 1993). The internal dimensions required for the manholes are provided in Table 8.2 (CPHEEO, 1993). The minimum width of the manhole should not be less than internal diameter of the sewer pipe plus 150 mm benching on both the sides.

Table 8.1 Spacing of Manholes

Pipe Diameter	Spacing
Small sewers	45 m
0.9 to 1.5 m	90 to 150 m
1.5 to 2.0 m	150 to 200 m
Greater than 2.0 m	300 m

Table 8.2 The minimum internal dimensions for manhole chambers

Depth of sewer	Internal dimensions

0.9 m or less depth	0.90 m x 0.80 m
For depth between 0.9 m and 2.5 m	1.20 m x 0.90 m, 1.2 m dia. for circular
For depth above 2.5 m and up to 9.0 m	For circular chamber 1.5 m dia.
For depth above 9.0 m and up to 14.0 m	For circular chamber 1.8 m dia.

Classification of Manholes

Depending upon the depth the manholes can be classified as:

(a) Shallow Manholes, (b) Normal Manholes, and (c) Deep Manholes

Shallow Manholes: These are 0.7 to 0.9 m depth, constructed at the start of the branch sewer or at a place not subjected to heavy traffic conditions (Figure 8.1). These are provided with light cover at top and called inspection chamber.

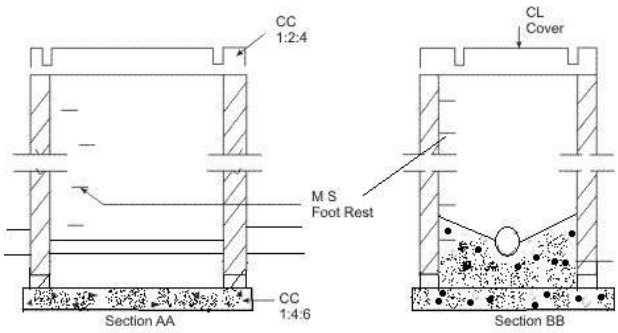


Figure 8.1 Shallow manhole

Normal Manholes: These manholes are 1.5 m deep with dimensions 1.0 m x 1.0 m square or rectangular with 1.2 m x 0.9 m (Figure 8.2). These are provided with heavy cover at its top to support the anticipated traffic load.

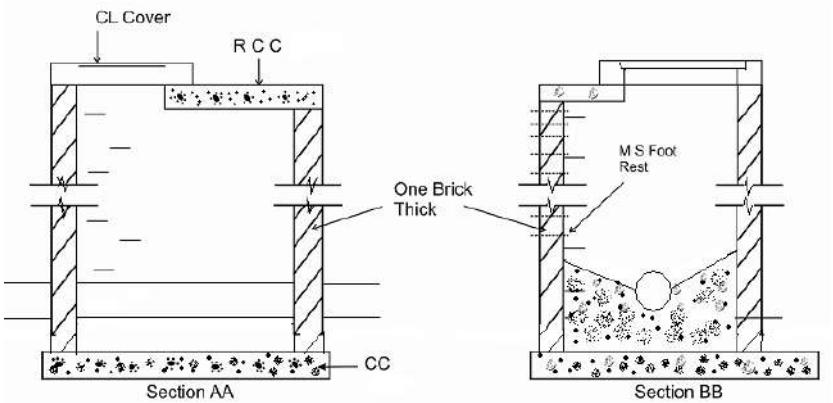


Figure 8.2 Rectangular manhole for depth 0.9 m to 2.5 m

Septic tanks:

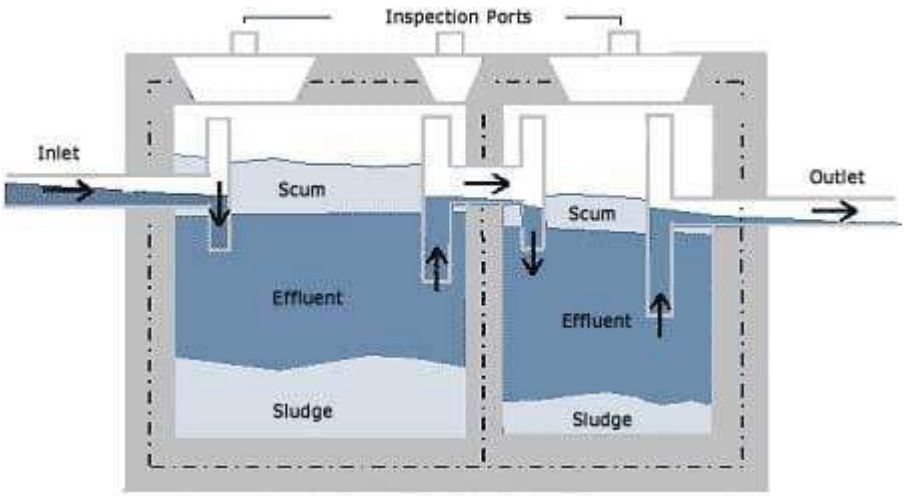
Any home or building that is not connected to a municipal or city sewage system needs a method for getting rid of human waste (feces and urine). All buildings not serviced by a municipal (centralized) treatment plant need to have an onsite sewage disposal system that is properly designed and filed with the local public health authority.

A typical sewage disposal system has 2 basic parts:

- Septic tank – which may also be accompanied by a treatment plant.
- Dispersal area - usually a series of underground pipes or chambers that evenly distribute the partially treated liquid into the ground for final treatment.

Septic tanks can function only when it can be ensured that the contents inside these do not freeze at low temperature. For this purpose, the septic tanks shall be located well below the frost line. The location of manhole openings shall be marked by staves. Fencing around the septic tanks shall be provided for discouraging traffic over them. As the rate of biological activity is reduced by 50 percent for every 10°C fall in temperature, the capacity of septic tanks shall be increased by 100 percent for operation at 10°C over that for operation at 20°C.

The construction of septic tanks is preferred in rural and fringe areas of suburban and isolated buildings where underground system may neither be feasible nor economical. Septic tanks are only recommended for small communities and institutions whose contributory population does not exceed 300.



Schematic design of a septic tank

Part-A

Assignment-Cum-Tutorial Questions

1) The sullage does not contain wastewater from
   a) Bath rooms
   b) Kitchen sinks
   c) Toilets
   d) Wash basins
2) What is BOD

3) What is COD

4) The sewer pipes
   a) Carry sewage as gravity conduits
   b) Are designed for generating self-cleansing velocities at varying values of discharge
   c) Should resist the wear and tear caused due to abrasion
   d) All the above

5) Anti-siphon age pipe is connected to _____
   a) top of P trap W.C.
   b) main soil pipe
   c) bottom of P trap W.C.
   d) side of water closet
6) Garbage is a
7) A sewer which receives storm water,surface run-off and sewage is called a
   a) Common sewer
   b) Combined sewer
   c) Branch sewer
   d) Outfall sewer
8) If the size of the sewer is small,then the velocity of flow will be high
   a) Yes
   b) No
9) Manholes are generally located
   a) At all changes of direction
   b) At all changes of gradients
   c) At all junctions of main and branch sewers
   d) All of those

10) The minimum diameter of a manhole cover should be
    a) 25 cm
    b) 50 cm
    c) 75 cm
    d) 100 cm

11)The equipment used for checking the levels of the sewer inverts is

12) A good trap should
    a) Not have self cleaning property
    b) Restrict the flow of water
    c) Provide an adequate water seal at all times
    d) All of those

13) Air vent pipe is not essentially required in septic tank.
    a) True
    b) False

PART-B

1. Draw the schematic diagram of typical sewage treatment plant?
2. Explain the methods of disposal of disposal of sewage in detail?
3. Explain the working of trickling filters?
4. Explain the method of removal of grit in grit chamber with the help of neat sketch?
5. Draw the floe chart of an activated sludge process?
6. Write short notes on a) Aerobic lagoons b) Anaerobic lagoons?
7. Explain with sketches different types of water closets?
8. What is a trap in building drainage? What are the different types of traps and where are they used?

9. What is a manhole? Explain ordinary manhole with help of a sketch?
10. Sketch and explain the construction and working of septic tank?;

UNIT – 3

ROOM ACOUSTICS

Syllabus:

Key terms & Concepts, Introduction, Acoustic principles, Sound power and pressure levels, absorption of sound, Reverberation time, Transmission of sound. Sound pressure level in a plant room, outdoor sound pressure level, Sound pressure level in intermediate space, noise rating, Data requirement, output data.

Introduction:

The concept of room acoustics shall include all aspects of the behaviour of sound in a room, covering both the physical aspects as well as the subjective effects. In other words, room acoustics deals with measurement and prediction of the sound field resulting from a given distribution of sources as well as how a listener experiences this sound field, i.e. will the listener characterize the room as having "good acoustics"? When designing for a good acoustic environment, which could be everything from introducing some absorbers into an office space to the complete design of a concert hall, one must bear in mind both the physical and the psychological aspects. This implies having knowledge on how the shape of the room, the dimensions and the material properties of the construction influences the sound field. Just as important, however, is a sound knowledge of the relationship between the physical measurable parameters of this field and the subjective impression for a listener. The reverberation time in a room is an important parameter in any judgement of quality.

Sound can be described as a disturbance or turbulence which passes through a physical medium in the form of longitudinal waves from a source to a receiver causing a sensation of hearing. This medium could be solid, fluid or gas. The speed of sound through these different media differs due to their molecular composition.

Wavelength of sound – This the distance between two pressure peaks or valleys, measured in metres (m) and represented with the Greek alphabet λ (lambda).

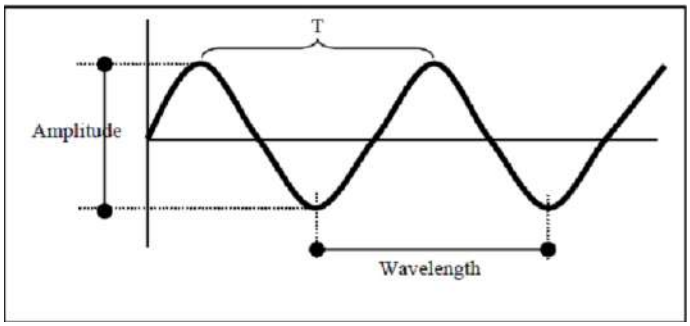
Period – This is the time taken for on complete oscillation. This is measured in seconds(s) and represented with the letter 'T'.

Frequency – This is the number of oscillations per second. This is represented with 'f' and measured in Hertz (Hz).

Velocity of sound – This is the rate at which a sound wave travels from a source through a medium to the receiver. The unit is m/s.

Amplitude – This is the distance between a crest (the highest point) and a valley (the lowest point)

Pitch – it is the highness or lowness of a tone determined by the rapidity of the oscillations producing it.



Decibels:

The basic unit of level in acoustics is the “decibel” (abbreviated dB). In acoustics, the term “level” is used to designate that the quantity is referred to some reference value, which is either stated or implied.

The decibel (dB), as used in acoustics, is a unit expressing the ratio of two quantities that are proportional to power. The decibel level is equal to 10 times the common logarithm of the power ratio; or

Acoustic principles:

Basic principles of room acoustics:

The main difference between indoor and outdoor sound propagation is in the level of reflected sound. Indoor environments naturally create more reflected sound than do outdoor environments. Reflected sound can be divided into three distinct categories: early and middle-reflected sound, reverberation (late-reflected sound) and standing waves.

Early reflections contribute more to the subjective perception of reverberance, or "liveness" of a space. Early and middle reflections occur within the first quarter of a second after arrival of the direct sound. Early sound is considered to be 40 ms after arrival of the direct sound for speech while for music 80 ms is more appropriate. Once sound reflections have built up to a point where they are not discernible as discrete events, the late reverberation process takes over. In most well-designed spaces, reverberation is a statistical phenomenon, no longer relying on specific room shape and sound propagation paths. For this reason, the statistical study of room acoustics, which ignores the path of specific reflections but considers reflected sound as an aggregate probability, is employed with respect to reverberation. Statistical analysis methods are applicable to rooms with relatively uniform sound absorbing material distribution and reasonable aspect ratios.

In spaces having a diffuse sound field where sound is uniformly distributed throughout the space, reverberation decays logarithmically, although the decay sounds even and consistent to the human listener. The reverberation time is defined as the time for reflected sound to decay 60 dB. Generally, it is necessary to avoid assessing early sound reflections as part of reverberation since the reflections contribute to sound build-up, rather than to sound decay. The first 5 to 10 dB of decaying sound reflections are generally not used to determine the reverberation time, which is

determined from the remaining decay.

Sound power and pressure levels:

Sound pressure, sound power, and sound intensity are acoustic quantities that can be expressed in decibels. They describe different aspects of sound, and the decibels for each represent different measurement quantities.

- Sound Pressure – Indicates the amplitude level of sound at a specific location in space, and is a scalar quantity. The level is *dependent* on the location and distance the sound is observed relative to a sound source. Sound pressure is measured in Pascal.
- Sound Power – The rate at which sound is emitted from an object, *independent* of location or distance that the sound is observed. Sound power measurements are often specified in the noise regulations of many different kinds of products, from construction equipment to computer printers. Sound power is measured in Watts.
- Sound Intensity – Sound intensity is sound power per unit of area. It indicates the flow of sound through a specific area. Sound intensity is measured in Watts/m^2.

Sound Pressure Level

The sound pressure is the force *(N)* of a sound on a surface area (m^2) perpendicular to the direction of the sound. The SI-unit for the Sound Pressure is N/m^2 *or Pa*.

The Sound Pressure Level in decibel can be expressed as

$$L_p = 10 \log (p^2 / p_{ref}^2)$$

$$= 10 \log (p / p_{ref})^2$$

$$= 20 \log (p / p_{ref})$$

where

L_p = *sound pressure level (dB)*

p = *sound pressure (Pa)*

$p_{ref} = 2\ 10^{-5}$ - *reference sound pressure (Pa)*

If the pressure is doubled the sound pressure level is increased with *6 dB (20 log (2))*

Sound Power Level:

Sound power is the acoustical energy emitted by the sound source, and is an absolute value. It

is not affected by the environment.

Motor *Lw* ratings are obtained from the determination of sound power levels generated by a motor when it is operated at no load. What is heard is a sound pressure level that is determined, for any particular location, by many factors, including size of the room, nature of its walls, ceilings, furnishings, etc. The pressure level at the point of hearing is also related to the distance from the sound source. The motor is the starting point, and when proper and accurate consideration is given to the other components of the system, sound power level ratings in octave bands will allow calculation of the resulting sound pressure levels in the space.

Sound power levels are connected to the sound source and independent of distance. Sound powers are indicated in decibel.

$L_w = 10 \log (W / W_0)$

where:

W_0 = *reference power* (W)

The normal reference level is 10^{-12} W, which is the lowest sound persons of excellent hearing can discern. Sound power is measured as the total sound power emitted by a source in all directions in watts (joules / second).

Sound Absorption:

An enclosed space is a room or area bounded on every of its sides. The materials for enclosure may be classified into two:

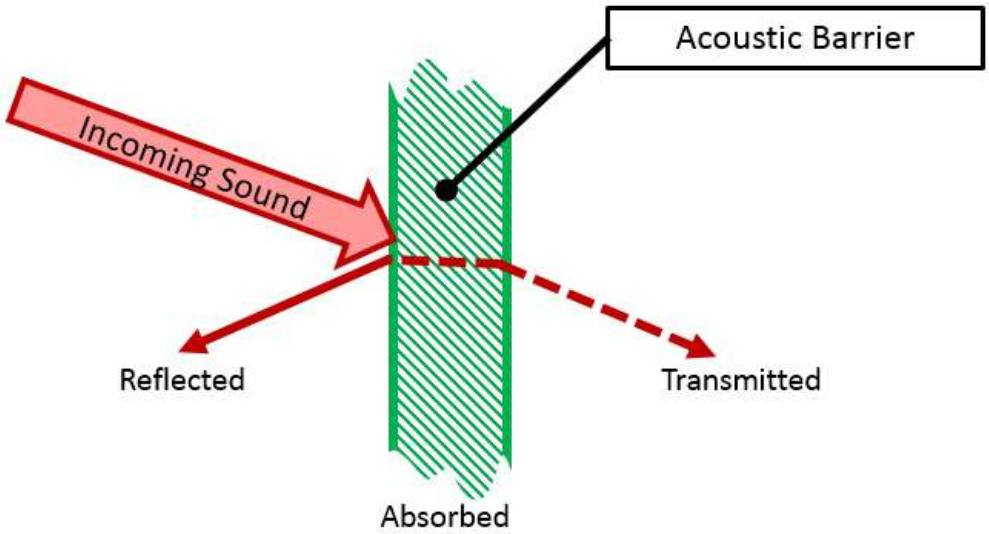
- Those that allow sound waves to pass through and
- Those that do not allow sound waves to pass through.

On encountering barriers posed by the enclosure, sound waves are likely to behave in the following ways:

- Reflection
- Absorption
- Refraction
- Diffusion
- Diffraction
- Transmission

Absorption:

When sound waves hit the surface of an obstacle, some of its energy is reflected while some are lost through its transfer to the molecules of the barrier. The lost sound energy is said to have been absorbed by the barrier. The thickness and nature of the material as regards its softness and hardness influences the amount of sound energy absorbed.



The amount of absorption, reflection, and transmission of the sound is different for every frequency.

For example, a high frequency sound with a short wavelength can be absorbed by a thinner piece of material, while lower frequency sounds are not absorbed, due to their longer wavelength.

Absorption Quantification

Absorption is can be expressed via the "absorption coefficient" which can have a value between 0 and 1.

$$\alpha = \frac{Absorbed\ Acoustic\ Energy}{Incident\ Acoustic\ Energy}$$

Alpha (α) represents the absorption coefficient.

- When the absorption coefficient equals one, all the sound is absorbed
- When the absorption coefficient equals zero, no sound is absorbed

Sound Absorbing materials:

1) Porous materials

2) Non-perforated panel or Membrane absorbers

3) Cavity (or Helmholtz) resonators

1) Porous materials:

- Basic acoustical characteristic of all porous materials is a cellular network of minute interlocking pores.
- They convert the incident sound energy into heat energy by the frictional and viscous resistance within these pores and by vibration of their small fibres.
- Their sound absorption is more efficient at the high than at the low frequencies.
- Their acoustical efficiency improves in the low frequency region with increased thickness and if spaced away from their solid backing

Example: **Rock wool and Glass wool**

2) Non-perforated panel or Membrane absorbers:

- Any impervious material, installed on a solid backing but separated from it by an air space, will be set to vibration when struck by sound waves.
- The flexural vibration of the panel absorber will then absorb a certain amount of the incident sound energy by converting it into heat energy.
- The theory of absorption provided by a vibrating panel is rather complicated but it is a fair approximation to assume that maximum absorption will occur in the region of the resonance frequency of the panel.
- The resonance frequency is normally at the lower end of the audio frequency range, therefore panel absorbers are efficient as low frequency absorbers.
- **Wood and hardboard panelling, gypsum boards, suspended plaster ceilings, furred out plasters, rigid plastic boards, windows, glazing, doors, wood floors and plat-forms, etc.**

3) Cavity (or Helmholtz) resonators:

- They consist of an enclosed body of air confined within rigid walls and connected by a narrow opening (called the neck) with the surrounding space in which the sound waves travel.
- A cavity resonator of this type will absorb maximum sound energy in the region of its resonance frequency.
- An empty jar or bottle, also acts as a cavity resonator; however, its maximum absorption is confined to a very narrow frequency band.

- **Individual cavity resonators** were used a very long time ago in Scandinavian Churches. These resonators were made of empty clay vessels, in different sizes, so that their effective absorption (at resonance frequencies) was spread between 100 and 400 cps (low

frequencies).

- In contemporary room acoustical practice their application is restricted to particular cases when individual low frequency peaks within an exceptionally long R.T. of a room have to be reduced drastically, without affecting the R.T. at medium and high frequencies.
- **Perforated panels,** spaced away from a solid backing, provide a widely used practical application of the cavity resonator principle.
- They contain a large number of necks, constituting the perforation of the panel, thus functioning as an array of cavity resonators.
- The perforations are usually circular, seldom slotted.
- The air space behind the perforation forms the undivided body of the resonator, separated into bays by horizontal and vertical elements of the framing system.

Reverberation Time

The reverberant sound in an auditorium dies away with time as the sound energy is absorbed by multiple interactions with the surfaces of the room. In a more reflective room, it will take longer for the sound to die away and the room is said to be 'live'. In a very absorbent room, the sound will die away quickly and the room will be described as acoustically 'dead'. But the time for reverberation to completely die away will depend upon how loud the sound was to begin with, and will also depend upon the acuity of the hearing of the observer. In order to provide a reproducible parameter, a standard reverberation time has been defined as the time for the sound to die away to a level 60 decibels below its original level. The reverberation time can be modelled to permit an approximate calculation.

$$\text{Reverberation Time} = RT_{60} = \text{time to drop 60 dB below original level}$$

Desirable reverberation time: The optimum reverberation time for an auditorium or room of course depends upon its intended use. Around 2 seconds is desirable for a medium-sized, general purpose auditorium that is to be used for both speech and music. A classroom should be much shorter, less than a second. And a recording studio should minimize reverberation time in most cases for clarity of recording.

The reverberation time is strongly influenced by the absorption coefficients of the surfaces as suggested in the illustration, but it also depends upon the volume of the room as shown in the Sabine formula. You won't get a long reverberation time with a small room.

Transmission of Sound:

Acoustic transmission in building design refers to a number of processes by which sound can be transferred from one part of a building to another. Typically these are:

1. **Airborne transmission -** a noise source in one room sends air pressure waves which induce vibration to one side of a wall or element of structure setting it to move such that the other face of the wall vibrates in an adjacent room. Structural isolation therefore becomes an important consideration in the acoustic design of buildings. Highly sensitive areas of buildings, for example recording studios, may be almost entirely isolated from the rest of a structure by constructing the studios as effective boxes supported by springs. Air tightness also becomes an important control technique. A tightly sealed door might have reasonable sound reduction properties, but if it is left open only a few millimetres its effectiveness is reduced to practically nothing. The most important acoustic control method is adding mass into the structure, such as a heavy dividing wall, which will usually reduce airborne sound transmission better than a light one.

2. **Impact transmission -** a noise source in one room results from an impact of an object onto a separating surface, such as a floor and transmits the sound to an adjacent room. A typical example would be the sound of footsteps in a room being heard in a room below. Acoustic control measures usually include attempts to isolate the source of the impact, or cushioning it. For example carpets will perform significantly better than hard floors.

3. **Flanking transmission -** a more complex form of noise transmission, where the resultant vibrations from a noise source are transmitted to other rooms of the building usually by elements of structure within the building. For example, in a steel framed building, once the frame itself is set into motion the effective transmission can be pronounced.

Permissible noise levels as given in NBC 2005:

Location	Noise level dB (A)
Auditoria and concert hall	20-25
Radio and television studios	20-25
Music rooms	25-30
Hospitals and cinema theatres	35-40
Apartments, hotels and homes	35-40
Conference rooms, small offices and libraries	35-40
Court rooms and class rooms	40-45
Large public offices, banks and stores restaurants	50-55

Outdoor Noise Level Standards:

Noise (ambient standards)			
Area Codes	Area category	Limit in dB (A) Leq	
		Day time	Night time
A	Industrial area	75	70
B	Commercial area	65	55
C	Residential area	55	45
D	Silence zone	50	40

Indoor Noise Level Standards:

Location	**Noise level dB (A)**
Auditoria and concert hall	20-25
Radio and television studios	20-25
Music rooms	25-30
Hospitals and cinema theatres	35-40
Apartments, hotels and homes	35-40
Conference rooms, small offices and libraries	35-40
Court rooms and class rooms	40-45
Large public offices, banks and stores restaurants	50-55

Noise Rating:

Noise rating (NR) is a graphical method for assigning a single number rating to a noise spectrum. It can be used to specify the maximum acceptable level in each octave band of a frequency spectrum, or to assess the acceptability of a noise spectrum for a particular application. The method was originally proposed for use in assessing environmental noise, but was later also found suitable for describing noise from mechanical ventilation systems in buildings.

Noise Rating Systems

PSIL

The first system used is Preferred Speech Interference Level. The PSIL is determined as the arithmetic average of the sound pressure level in the three octave bands with centre frequencies of 500, 1000 and 2000 Hz. This rating is a good guide to the effect of noise on spoken communications.

dBA

A second rating system is the "A" weighted sound pressure level (dBA) often used by government agencies in determining compliance with such regulations as the Occupational Safety and Health Act (OSHA). The dBA rating is determined directly by a sound level meter equipped with a filtering system which de-emphasizes both the low and high frequency portions of the audible spectrum. This measurement is recorded at a distance of 3 feet from the source.

NPEL

A third rating system is the "A" weighted sound power level reference to a 1 picowatt and expressed in Bels. This is also referred to as the Noise Power Emission Level (NEPL). NEPL was adopted by the Institute of Noise Control Engineering (INCE) as the preferred unit of measure. The INCE "Recommended Practice for Measurement of Noise Emitted by Air Moving Devices (AMDs) for Computer and Business Equipment" is a guideline for the description and control of noise emitted by components. ANSI S12.11 now includes the procedures called for in the INCE Practice. This is the latest and most technically thorough acoustic test procedure available. Comair Rotron does all acoustical testing per INCE and ANSI S12.11-1987.

Freely Suspended

The fourth rating system used is a method known as Freely Suspended. In this method a fan is suspended from springs in the middle of a Calibrated Reverberate Room. The fan is run at nominal voltage, free delivery, and at a distance of 1 meter. The sound pressure level (dBA) is recorded. (For comparison dBA @ 1 meter + .7778 = dBA @ 3 feet).

Noise rating data required and output:

To make a rating, the noise spectrum is superposed on a family of NR contours; the NR of the spectrum corresponds to the value of the first NR contour that is entirely above the spectrum. The data for drawing NR contours (from NR 0 to NR 75) is given in Table 12 for the frequency range 31.5 Hz to 8 kHz.

Table 12 Noise Rating Values

(*Clause* C-1)

Sl No.	Noise Rating	Octave Band Centre Frequency, Hz Sound Pressure Levels dB_{re} 20 µPa								
		31.5	63	125	250	500	1 000	2 000	4 000	8 000
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
i)	NR75	106	95	87	82	78	75	73	71	69
ii)	NR70	103	91	83	77	73	70	68	66	64
iii)	NR65	100	87	79	72	68	65	62	61	59
iv)	NR60	96	83	74	68	63	60	57	55	54
v)	NR55	93	79	70	63	58	55	52	50	49
vi)	NR50	89	75	66	59	53	50	47	45	43
vii)	NR45	86	71	61	54	48	45	42	40	38
viii)	NR40	83	67	57	49	44	40	37	35	33
ix)	NR35	79	63	52	45	39	35	32	30	28
x)	NR30	76	59	48	40	34	30	27	25	23
xi)	NR25	72	55	44	35	29	25	22	20	18
xii)	NR20	69	51	39	31	24	20	17	14	13
xiii)	NR15	66	47	35	26	19	15	12	9	7
xiv)	NR10	62	43	31	21	15	10	7	4	2
xv)	NR5	59	39	26	17	10	5	2	–1	–3
xvi)	NR0	55	35	22	12	5	0	–4	–6	–8

For computational methods the curves are defined by the equation:

$$L = a + bN$$

Where

L = octave band sound pressure level corresponding to NR level N; and

a and b = constants for each frequency band, as given in Table 13.

Although the NR system is currently the preferred method for rating noise from mechanical ventilation system, other methods which are more sensitive to noise at low frequencies are available, but they are not yet widely accepted. Low frequency noise may be disturbing or fatiguing to occupants, but may not have much effect on the dBA or NR value.

Table 13 Values of *a* and *b*

(*Clause* C-2)

Sl No.	Octave Band Centre Frequency Hz	*a*	*b*
(1)	(2)	(3)	(4)
i)	31.5	55.4	0.681
ii)	63	35.4	0.790
iii)	125	22.0	0.870
iv)	250	12.0	0.930
v)	500	4.2	0.980
vi)	1 000	0.0	1.000
vii)	2 000	–3.5	1.015
viii)	4 000	–6.1	1.025
ix)	8 000	–8.0	1.030

UNIT –IV

ELECTRIFICATION

ELECTRICAL SYSTEMS-basic of electricity-single/three phase supply-protective devices in electrical installation-earthing for safety-types of earthing- ISI specifications, electrical installations in buildings-types of wires, wiring systems and their choice-planning electrical wiring for building-main and distribution boards-principles of illumination.

Basic electricity:

Electricity is the flow of electrons from one place to another. Electrons can flow through any material, but does so more easily in some than in others. How easily it flows is called resistance. The resistance of a material is measured in Ohms.

Matter can be broken down into:

- Conductors: electrons flow easily. Low resistance.
- Semi-conductors: electron can be made to flow under certain circumstances. Variable resistance according to formulation and circuit conditions.
- Insulator: electrons flow with great difficulty. High resistance.

Since electrons are very small, as a practical matter they are usually measured in very large numbers. A Coulomb is 6.24 x 1018 electrons. However, electricians are mostly interested in electrons in motion. The flow of electrons is called current, and is measured in AMPS. One amp is equal to a flow of one coulomb per second through a wire.

Making electrons flow through a resistance requires an attractive force to pull them. This force, called Electro-Motive Force or EMF, is measured in volts. A Volt is the force required to push 1 Amp through 1 Ohm of resistance.

As electrons flow through a resistance, it performs a certain amount of work. It may be in the form of heat or a magnetic field or motion, but it does something. This work is called Power, and is measured in Watts. One Watt is equal to the work performed by 1 Amp pushed by 1 Volt through a resistance.

NOTE:

AMPS is amount of electricity.
VOLTS is the Push, not the amount.
OHMS slows the flow.
WATTS is how much gets done.
There are 2 standard formulae that describe these relationships.

Ohm's Law: Where

R = Resistance (ohms)

E = Electro-motive Force (volts)

I = Intensity of Current (amps)

$R = E / I$

To express work done: Power formula (PIE Law):

Where:

P = Power (watts)

I = Intensity of Current (amps)

E = Electro-motive Force (volts)

$P = IE$

This law is often restated in the units of measure as the West Virginia Law:

W = VA
for
Watts = Volts x Amps

All this is important because all electrical equipment has a limit to how much electricity it can handle safely, and you must keep track of load and capacities to prevent failure, damage, or a fire.

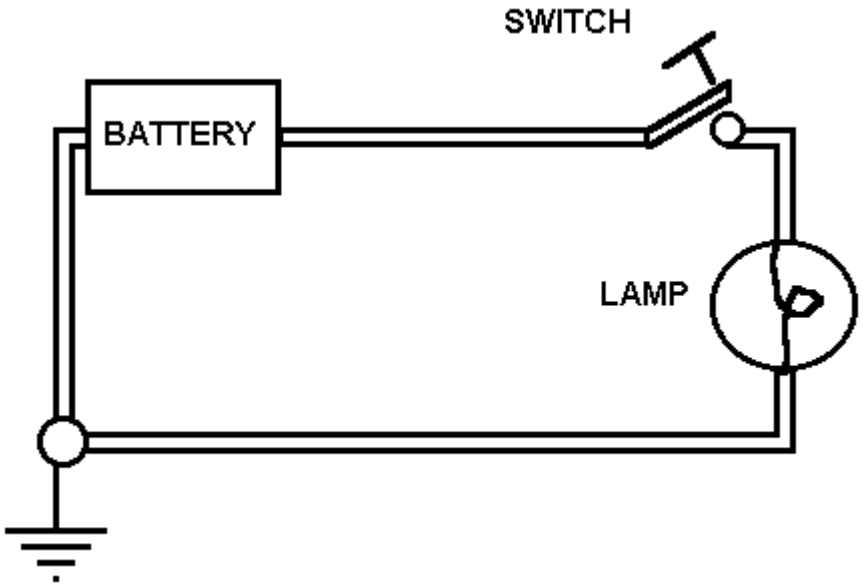
For example, a lamp is rated at 1000 w. @ 120 v. That means that at 120 volts it will use:

1000 w. / 120 v. = 8.33 a.

A common shortcut is to use 100 v. instead of 120. This makes calculating easier and builds in some headspace. So:

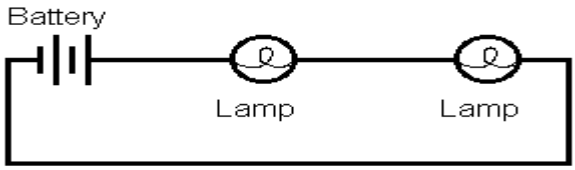
1000 w./ 100 v. = approx. 10 a.

A Simple Circuit:

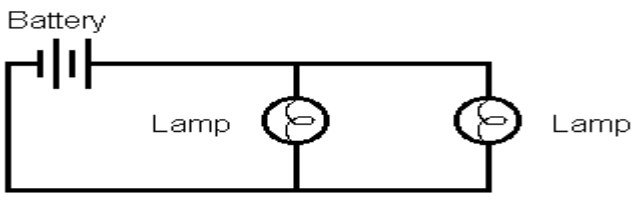


The simplest circuit has a power source, like a battery or outlet, a wire running from the "hot" side to a "load", then a wire from the load back to the power source. There is also usually a switch to "open" or "close" the circuit. The load will function only when the circuit is closed or complete.In more complex circuits where more than one load is connected, they may be either in series or in parallel. In a series circuit, current must pass trough one to get to the next. Voltage is divided between them. If one goes out, they all go out.

SERIES



PARALLEL



In a parallel circuit, each load is electrically connected to the source at the same point, each gets the full voltage simultaneously. If one goes out, the rest stay lit.

Most circuits are combinations of the two types. Circuit breakers and fuses are in series with the load, but multiple loads on a circuit are paralleled.

Circuit breakers and fuses can be placed in the supply circuit before the plug, as in lighting circuits, or between the plug and the load internally, as in most sound equipment, or both.

Cable, connectors, and circuits are all rated in amps according to size.

Cable

There are many types of cable, but the electrical code allows only certain types to be used. Stage use is very hard on equipment. Cable may be walked on, runover by scenery or vehicles, pulled and dragged, and pinched. The emphasis is therefore on flexibility and durability.

For single circuit used, ONLY type S or SO cables are permitted. Type S is a heavy-duty rubber covered cable. Type SO is a heavy duty Neoprene (synthetic rubber, oil resistant) covered cable. It must be a three wire cable, with black, white and green conductors. Type SJ, with a lighter weight rubber covering, is specifically NOT permitted. For single conductor feeder cable use, welding cable was once common but is specifically NOT permitted. It must be Types SC, SCE, PPE or similar Entertainment and Stage Cable, which has an extra-heavy duty cover and very flexible wire inside.

Connectors

Connectors allow temporary connections to be made and broken quickly and safely. Male connectors have exposed contacts. Female connectors have internal contacts inside an insulating shell with holes for plugging the two together. Think biology.

The male is always on the load side of a connection, the female on the line side; "the female has the power!"

Parallel Blade (Edison): the standard household plug, this is found on much equipment but is not durable enough for stage lights. The standard configuration, two parallel blades and a U-ground, is rated at 15 a. only. Usually the"hot" terminal is copper colored and the "neutral" is silver colored, and the "ground" is green.

Stage Pin (a.k.a. NEMA designation, 5T-20): has round 1/4" pins, and is very durable. Most common dedicated stage connector. Rated at 20 a.

The center pin is "ground", the outside pin nearest the ground is the "neutral", and the other is the "hot".

3-pin Twist Lock (a.k.a. NEMA L5-20): has three curved blades which are locked into the receptacle by rotating it 1/8 turn after insertion. Rated at 20 a. One blade has a tab bent towards center; that is the ground. The slightly larger blade with silver screw is "neutral", and the small blade with the copper screw is "hot".

Cam-locks: single wire connector for large wire, 2/0 or 4/0. Locked in place by rotating 1/2 turn after insertion. Comes in colors to indicate which leg is which. Rated at over 400 a. In most common size on stage. Also available in a mini-cam size for #1 cable, rated at 100 a.

Cable Accessories:

Two-fers: Y-cord with one male and two female connectors, for plugging two devices into one outlet.

Three-fers: same thing, 3 females.

Adaptors: a male connector on one end and a female of a different type on the other. Used to plug a device into a different type of outlet.

Single/three phase supply

The alternating electric current that supplies your home can be provided via different types of connection:

- 2-wires: single-phase connection
- 3- or 4-wires: three-phase connection

Each type of connection has its advantages. With a single-phase system it is easier to balance the electrical loads of the network. A three-phase connection on the other hand, is more suited to the consumption of a building that includes powerful machines (the premises of a self-employed contractor, for example) or an elevator for which a three-fase system is needed. It can, in fact, carry three times as much power.

2-wires: single-phase connection

If it is single-phase connection, two wires come into your electrical service panel:

- a black or red 'live' wire
- a blue 'neutral' wire

A voltage difference of 230 V separates these two wires.

3- or 4-wires: three-phase connection

If it is three-phase connection, 3 or 4 wires come into your electrical service panel, according to what your electrician was able to install with the available utillity network.

- three 'live' wires: black, red, brown or grey
- a blue 'neutral' wire

This will allow him to properly allocate your home's power cables depending on the type of connection to maintain the balance of the electrical network.

Most of the time, a voltage difference of **230 V** separates each live wire from the neutral, while there is a voltage difference of **400 V** between two live wires. This makes it possible to supply both the domestic cables with 230 V and machines requiring 400 V (a car charger for example).

Note that some homes are supplied with **three-phase 3 x 230 V**. A voltage of 230 V separates each live wire and there is no neutral wire.

protective devices in electrical installation

Electrical Protective Device

A device used to protect equipment, machinery, components and devices, in electrical and electronic circuit, against short circuit, over current and earth fault, is called as protective devices.

Necessity of Protective Devices

Protective devices are necessary to protect electrical appliance or equipment against

a)Short Circuit
b)Abnormal variations in the supply voltage
c)Overloading of equipment
d)To protect operator against accidental contact with the faulty equipment,falling which the operator may get a severe shock.

Types of Protective Device

Different types of the protective device that are commonly used in electrical and electronic circuit

1.Fuse Wire or Fuse
2.MCB – Miniature circuit breaker
3.ELCB – Earth Leakage Circuit Breaker
4.ELCB & MCB
5.Earthing or Grounding

EARTHING:

In electricity 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. Regulations for earthing system vary considerably among countries and among different parts of electric systems. Most low voltage systems connect one supply conductor to the earth (ground).

People use an earthing system mainly for these applications:

- To protect a structure from lightning strike, directing the lightning through the earthing system and into the ground rod rather than passing through the structure.

- Part of the safety system of mains electricity, preventing problems associated with floating ground and sky voltage.
- The most common ground plane for large monopole antenna and some other kinds of radio antenna.

Types of earthing

1)Plate Earthing:

- In plate earthing system, a plate made up of either copper with dimensions 60cm x 60cm x 3.18mm (i.e. 2ft x 2ft x 1/8 in) or galvanized iron (GI) of dimensions 60cm x 60cm x 6.35 mm (2ft x 2ft x ¼ in) is buried vertical in the earth (earth pit) which should not be less than 3m (10ft) from the ground level.
- For proper earthing system, follow the above mentioned steps in the (Earth Plate introduction) to maintain the moisture condition around the earth electrode or earth plate.

2). Pipe Earthing:

- A galvanized steel and a perforated pipe of approved length and diameter is placed vertically in a wet soil in this kind of system of earthing. It is the most common system of earthing.
- The size of pipe to use depends on the magnitude of current and the type of soil. The dimension of the pipe is usually 40mm (1.5in) in diameter and 2.75m (9ft) in length for ordinary soil or greater for dry and rocky soil. The moisture of the soil will determine the length of the pipe to be buried but usually it should be 4.75m (15.5ft).

3). Rod Earthing

- it is the same method as pipe earthing. A copper rod of 12.5mm (1/2 inch) diameter or 16mm (0.6in) diameter of galvanized steel or hollow section 25mm (1inch) of GI pipe of length above 2.5m (8.2 ft) are buried upright in the earth manually or with the help of a pneumatic hammer. The length of embedded electrodes in the soil reduces earth resistance to a desired value.

Copper Rod Electrode Earthing System

4). Earthing through the Waterman

- In this method of earthing, the waterman (Galvanized GI) pipes are used for earthing purpose. Make sure to check the resistance of GI pipes and use earthing clamps to minimize the resistance for proper earthing connection.
- If stranded conductor is used as earth wire, then clean the end of the strands of the wire and make sure it is in the straight and parallel position which is possible then to connect tightly to the waterman pipe.

Electrical system installations in a Building:

Electrical systems in these buildings begin at a step-down transformer provided by the utility company and located within or very close to the building. The transformer reduces the standard line potential to two dual voltage systems, which then pass through master switches and electric meters to record the subscriber's usage. Each of the voltages provided serves a separate category of use; different levels are required for incandescent lights and small appliances, large appliances, ceiling-mounted non-incandescent lighting, and heavy machinery. Each voltage pair has a separate distribution system of wiring leading from the meters and master switches to circuit breaker panels, where it is further broken down into circuits similar to residential uses. Because high-voltage wiring is considered hazardous, the switches controlling overhead lighting use lower voltages, and each heavy machine has its own fused switch. From the circuit breaker panel, low-voltage power conduit and wiring is typically distributed through partitions and ceiling sandwich spaces, but, in large open areas of commercial buildings, there may be wire ways embedded in the floor slab. These wire ways can be either rectangular metal tube inserted into the concrete slab before pouring or closed cells of formed steel deck; the wire ways are tapped where desired to provide convenience outlets at floor level.

ELECTRIC WIRING, CONTROL & PROTECTION:

Methods of Electrical Wiring Systems w.r.t Taking Connection

Wiring (a process of connecting various accessories for distribution of electrical energy from supplier's meter board to home appliances such as lamps, fans and other domestic appliances is known as Electrical Wiring) can be done using two methods which are

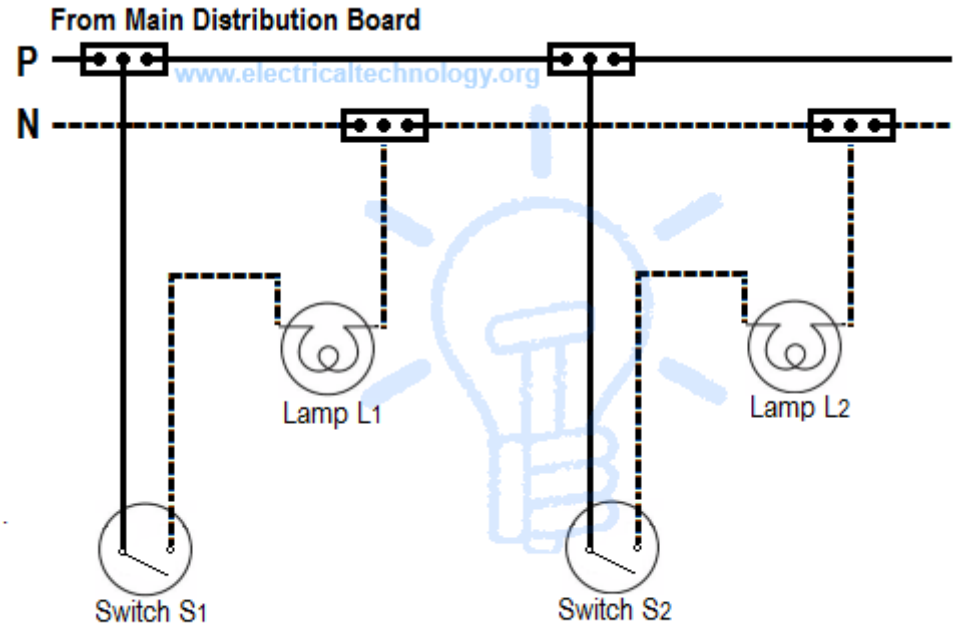
- Joint box system or Tee system
- Loop – in system

They are discussed as follows:

Joint Box or Tee or Jointing System

In this method of wiring, connections to appliances are made through joints. These joints are made in joint boxes by means of suitable connectors or joints cut-outs. This method of wiring doesn't consume too much cables size.

You might think because this method of wiring doesn't require too much cable it is therefore cheaper. It is of course but the money you saved from buying cables will be used in buying joint boxes, thus equation is balanced. This method is suitable for temporary installations and it is cheap.



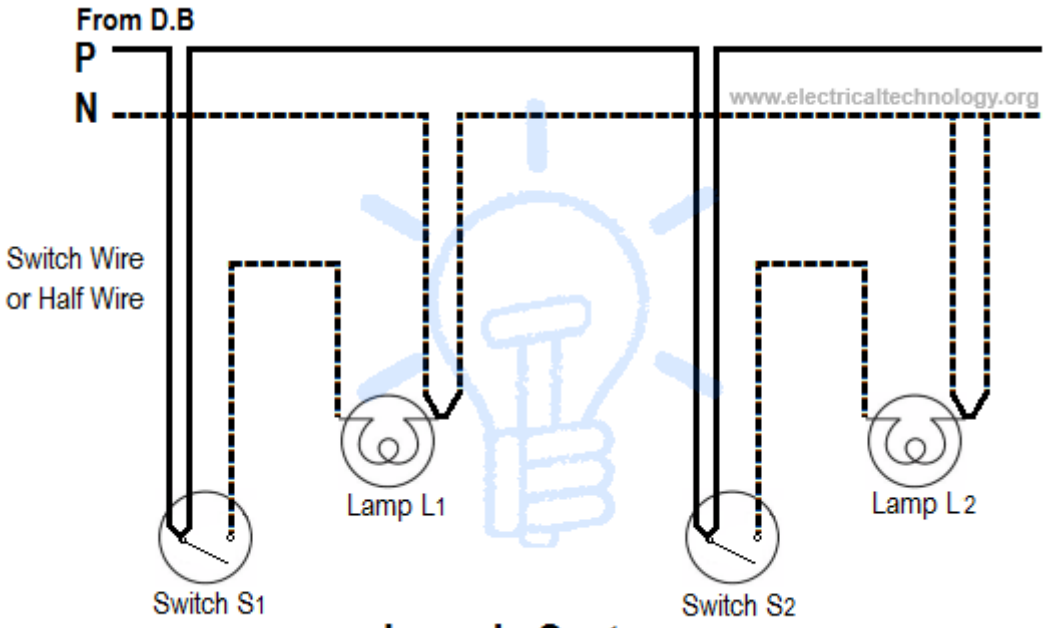
Joint Box System

Loop-in or Looping System

This method of wiring is universally used in wiring. Lamps and other appliances are connected in parallel so that each of the appliances can be controlled individually. When a connection is required at a light or switch, the feed conductor is looped in by bringing it directly to the terminal and then carrying it forward again to the next point to be fed.

The switch and light feeds are carried round the circuit in a series of loops from one point to another until the last on the circuit is reached. The phase or line conductors are looped either in switchboard or box and neutrals are looped either

in switchboard or from light or fan.



Loop-In System

Advantages of Loop-In Method of Wiring

- It doesn't require joint boxes and so money is saved
- In loop – in systems, no joint is concealed beneath floors or in roof spaces.
- Fault location is made easy as the points are made only at outlets so that they are accessible.

Disadvantages of Loop-In Method of Wiring

- Length of wire or cables required is more and voltage drop and copper losses are therefore more
- Looping – in switches and lamp holders is usually difficult.

Different Types of Electrical Wiring Systems:

The types of internal wiring usually used are

- Cleat wiring
- Wooden casing and capping wiring
- CTS or TRS or PVC sheath wiring
- Lead sheathed or metal sheathed wiring
- Conduit wiring-

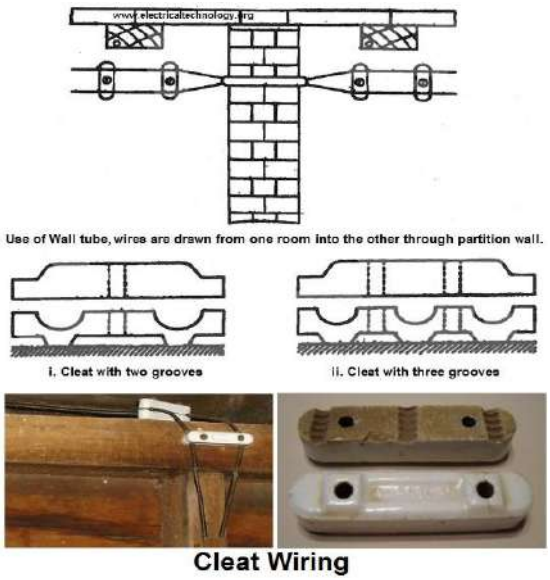
There are additional types of conduit wiring according to Pipes installation (Where steel and PVC pipes are used for wiring connection and installation).

- Surface or open Conduit type
- Recessed or concealed or underground type Conduit

1. Cleat Wiring

This system of wiring comprises of ordinary VIR or PVC insulated wires (occasionally, sheathed and weather proof cable) braided and compounded held on walls or ceilings by means of porcelain cleats, Plastic or wood.

Cleat wiring system is a temporary wiring system therefore it is not suitable for domestic premises. The use of cleat wiring system is over nowadays.



Cleat Wiring

Advantages of Cleat Wiring:

- It is simple and cheap wiring system
- Most suitable for temporary use i.e. under construction building or army camping
- As the cables and wires of cleat wiring system is in open air, Therefore fault in cablescan be seen and repair easily.
- Cleat wiring system installation is easy and simple.

- Customization can be easily done in this wiring system e.g. alteration and addition.
- Inspection is easy and simple.

Disadvantages of Cleat Wiring:

- Appearance is not so good.
- Cleat wiring can't be use for permanent use because; Sag may be occurring after sometime of the usage.
- In this wiring system, the cables and wiring is in open air, therefore, oil, Steam, humidity, smoke, rain, chemical and acidic effect may damage the cables and wires.
- it is not lasting wire system because of the weather effect , risk of fire and wear & tear.
- it can be only used on 250/440 Volts on low temperature.
- There is always a risk of fire and electric shock.
- it can't be used in important and sensitive location and places.
- It is not lasting, reliable and sustainable wiring system.

2. Casing and capping wiring

Casing and Capping wiring system was famous wiring system in the past but, it is considered obsolete this days because of Conduit and sheathed wiring system. The cables used in this kind of wiring were either VIR or PVC or any other approved insulated cables.

The cables were carried through the wooden casing enclosures. The casing is made up of a strip of wood with parallel grooves cut length wise so as to accommodate VIR cables. The grooves were made to separate opposite polarity. The capping (also made of wood) used to cover the wires and cables installed and fitted in the casing.

Advantages of Casing Capping Wiring:

- It is cheap wiring system as compared to sheathed and conduit wiring systems.
- It is strong and long-lasting wiring system.
- Customization can be easily done in this wiring system.
- If Phase and Neutral wire is installed in separate slots, then repairing is easy.
- Stay for long time in the field due to strong insulation of capping and casing..
- It stays safe from oil, Steam, smoke and rain.
- No risk of electric shock due to covered wires and cables in casing & capping.

Disadvantages Casing Capping Wiring:

- There is a high risk of fire in casing & capping wiring system.

- Not suitable in the acidic, alkalies and humidity conditions
- Costly repairing and need more material.
- Material can’t be found easily in the contemporary
- White ants may damage the casing & capping of wood.

3. Batten Wiring (CTS or TRS)

Single core or double core or three core TRS cables with a circular oval shape cables are used in this kind of wiring. Mostly, single core cables are preferred. TRS cables are chemical proof, water proof, steam proof, but are slightly affected by lubricating oil. The TRS cables are run on well seasoned and straight teak wood batten with at least a thickness of 10mm.The cables are held on the wooden batten by means of tinned brass link clips (buckle clip) already fixed on the batten with brass pins and spaced at an interval of 10cm for horizontal runs and 15cm for vertical runs.

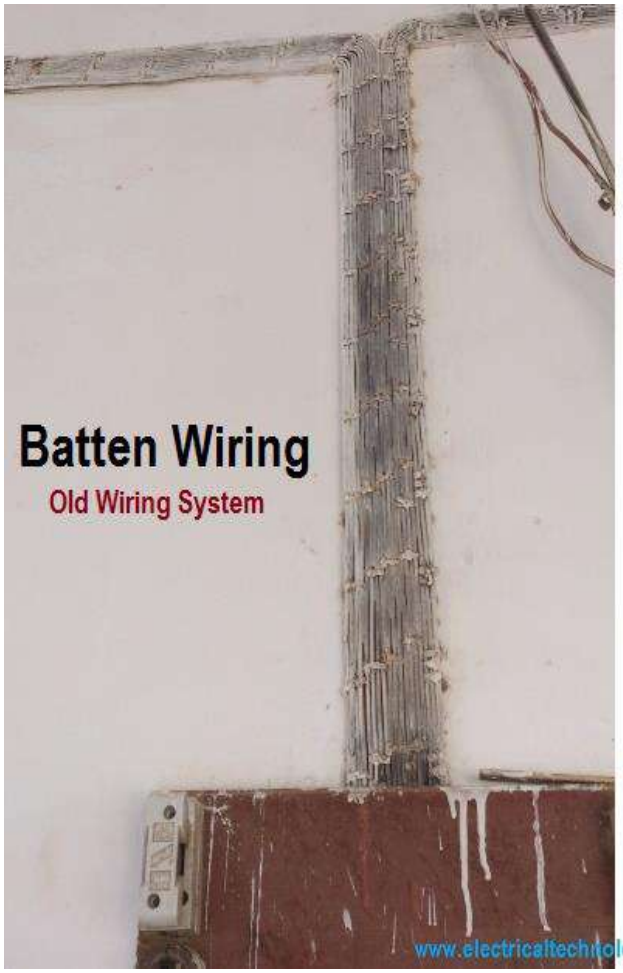
Advantages of Batten Wiring

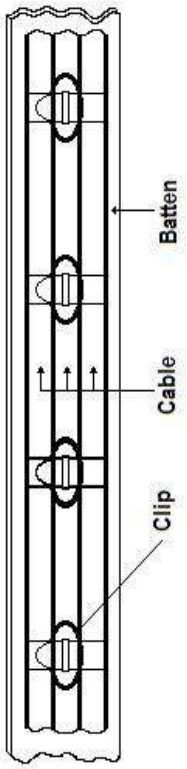
- Wiring installation is simple and easy
- cheap as compared to other electrical wiring systems
- Paraphrase is good and beautiful
- Repairing is easy
- strong and long-lasting
- Customization can be easily done in this wiring system.
- less chance of leakage current in batten wiring system

Disadvantages of Batten Wiring

- Can’t be installing in the humidity, Chemical effects, open and outdoor areas.
- High risk of firs

- Not safe from external wear & tear and weather effects (because, the wires are openly visible to heat, dust, steam and smoke.
- Heavy wires can't be used in batten wiring system.
- Only suitable below then 250V.
- Need more cables and wires.





4. Lead Sheathed Wiring

The type of wiring employs conductors that are insulated with VIR (Vulcanized Insulation Rubber) and covered with an outer sheath of lead aluminium alloy containing about 95% of lead. The metal sheath given protection to cables from mechanical damage, moisture and atmospheric corrosion.

The whole lead covering is made electrically continuous and is connected to earth at the point of entry to protect against electrolytic action due to leaking current and

to provide safety in case the sheath becomes alive. The cables are run on wooden batten and fixed by means of link clips just as in TRS wiring

5. Conduit Wiring

There are two additional types of conduit wiring according to pipe installation

1. Surface Conduit Wiring
2. Concealed Conduit Wiring

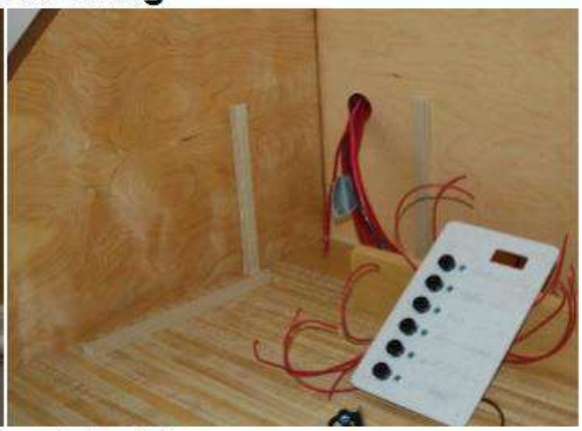
5.1 Surface Conduit Wiring

If conduits installed on roof or wall, It is known as surface conduit wiring. in this wiring method, they make holes on the surface of wall on equal distances and conduit is installed then with the help of rawal plugs.

5.2 Concealed Conduit wiring

If the conduit is hidden inside the wall slots with the help of plastering, it is called concealed conduit wiring. In other words, the electrical wiring system inside wall, roof or floor with the help of plastic or metallic piping is called concealed conduit wiring. Obliviously, It is the most popular, beautiful, stronger and common electrical wiring system nowadays.

Surface Conduit Wiring



Concealed Conduit wiring

In conduit wiring, steel tubes known as conduits are installed on the surface of walls by means of pipe hooks (surface conduit wiring) or buried in walls under plaster and VIR or PVC cables are afterwards drawn by means of a GI wire of size if about 18SWG.

In Conduit wiring system, the conduits should be electrically continuous and connected to earth at some suitable points in case of steel conduit. Conduit wiring is a professional way of wiring a building. Mostly PVC conduits are used in domestic wiring.

The conduit protects the cables from being damaged by rodents (when rodents bites the cables it will cause short circuit) that is why circuit breakers are in place though but hey! Prevention is better than cure. Lead conduits are used in factories or when the building is prone to fire accident. Trunking is more of like surface conduit wiring. It’s gaining popularity too.

It is done by screwing a PVC trunking pipe to a wall then passing the cables through the pipe. The cables in conduit should not be too tight. Space factor have to be put into consideration.

Types of Conduit

Following conduits are used in the conduit wiring systems (both concealed and surface conduit wiring) which are shown in the above image.

- Metallic Conduit
- Non-metallic conduit

Metallic Conduit:

Metallic conduits are made of steel which are very strong but costly as well.

There are two types of metallic conduits.

- Class A Conduit: Low gauge conduit (Thin layer steel sheet conduit)
- Class B Conduit: High gauge conduit (Thick sheet of steel conduit)

Non-metallic Conduit:

A solid PVC conduit is used as non-metallic conduit now days, which is flexible and easy to bend.

Size of Conduit:

The common conduit pipes are available in different sizes genially, 13, 16.2, 18.75, 20, 25, 37, 50, and 63 mm (diameter) or 1/2, 5/8, 3/4, 1, 1.25, 1.5, and 2 inch in diameter.

Advantage of Conduit Wiring Systems

- It is the safest wiring system (Concealed conduit wring)
- Appearance is very beautiful (in case of concealed conduit wiring)
- No risk of mechanical wear & tear and fire in case of metallic pipes.
- Customization can be easily done according to the future needs.
- Repairing and maintenance is easy.

- There is no risk of damage the cables insulation.
- it is safe from corrosion (in case of PVC conduit) and risk of fire.
- It can be used even in humidity, chemical effect and smoky areas.
- No risk of electric shock (In case of proper earthing and grounding of metallic pipes).
- It is reliable and popular wiring system.
- Sustainable and long-lasting wiring system.

Disadvantages of Conduit Wiring Systems

- It is expensive wiring system (Due to PVC and Metallic pipes, Additional earthing for metallic pipes Tee(s) and elbows etc.
- Very hard to find the defects in the wiring.
- Installation is not easy and simple.
- Risk of Electric shock (In case of metallic pipes without proper earthing system)
- Very complicated to manage additional connection in the future.

Comparison between Different Wiring Systems

Below is the table which shows the comparison between all the above mentioned wiring systems.

S.No	Particulars	Cleat Wiring	Casing Capping Wiring	Batten Wiring	Conduit Wiring
1	Life	Short	Fairly long	Long	Very long
2	Cost	Low	Medium	Medium	Highest
3	Mechanical Protection	None	Fair	None	Very good
4	Possibility of fire	Nil	Good	Good	Nil
5	Protection from dampness	None	Slight / a little	None	Good
6	Type of labor required	Semi-Skilled	Highly Skilled	Semi-skilled	Highly Skilled
7	Installation	Very Easy	Difficult	Easy	Difficult
8	Inspection	Easy	Easy	Easy	Difficult
9	Repair	Easy	Little bit difficult	Easy	Difficult
10	Popularity	Nil	Fair	Nil	Very High

Comparison of Different Wiring Systems

Use a ground plan to effectively plan electrical installations

The planning is carried out on the basis of a construction plan or floor plan of the house or apartment that is as accurate as possible – either in the original or on the computer with corresponding group plan software.

Pay particular attention to doors and their opening direction, windows and stairs, and steps and fireplaces.

Planning your kitchen

The first room that is planned is usually the kitchen, due to the long delivery times for many of its features.

Cooking islands, for example with an open plan kitchen adjacent to the living room, place very specific requirements on lighting planning, and connections for ovens, microwave, extractor fans or freezer and refrigerator. Electrical planning is often carried out in a dimensioned plan when ordering a new kitchen, in order to ensure the correct implementation.

Remember to consider your numerous other electric kitchen utensils, such as toasters, coffee machines, steamers, blenders etc. Depending on the size of the kitchen, 6 to 15 sockets can easily be installed.

You may also want to take a telephone connection or, for example, a flush-mounted radio, into account in the electrical plan of the kitchen.

Example of an electrical installation plan for the kitchen and adjoining rooms.

It is also ideal to place the most important furnishings in the floor plan as they will be placed in the rooms. Once all this information has been obtained, the respective connections in the rooms can be drawn in as required.

Planning bedrooms and children's rooms

In the bedroom, the first thing to consider is the lighting around the bed. If you want to save space, you can also design luminaires as wall lights.

You'll also be likely to need further sockets next to and around the bed, such as for a telephone or charging cable.

Planning is particularly important for children's rooms: children grow up fast, and you need to think about their needs as they grow older as well as right now.

For babies, for example, a heat lamp might be required, whereas when the little ones start school they may need a desk with appropriate connections for a desk lamp and computer.

And for teenagers, a telephone and internet connection, hi-fi system and television will need their place in the room.

Living room planning

In the living room, particular attention needs paying to electrical installations. Be flexible and generous with sockets, firstly factoring in electrical connections for TV and telephone.

If you know where your devices are to be placed, you can also plan for loudspeaker, Internet and antenna connections, avoiding loosely laid cables further down the line.

Bathroom planning

Bathrooms are increasingly becoming areas for rest, relaxation and wellness, as well as a practicality; therefore, the requirements for electrical installations have also changed.

Before, you only had to plan the ceiling lamp and sockets for shavers and hair dryers.

Today there are a lot of appliances in the bathroom to be considered in the electrical installation as well as the number and arrangement of sockets: electric toothbrushes, steam dryers, shower radios, jacuzzis or heated toilet seats.

Importantly, due to the high humidity in bathrooms, special installation regulations exist, so be sure to check this while planning.

Smart Home functionalities

Many features, such as electric blinds, control of individual lights and dimmers, motion detectors with cameras, multi-room audio systems, door-to-door communications, heating control or even kitchen appliances, can often be centrally managed from the smartphone via Smart Home systems (such as Homematic IP).

Systems like this have the advantage that they can be installed not only hardwired in houses and flats, but can also be flexibly integrated as an intermediate plug solution and taken with you during a house move.

It is important for all Smart Home installations to be intuitive and easy to use, both from your smartphone and on the individual switching components.

It is also an advantage if it is an open and therefore expandable system; who knows which electrical functionalities will come into our homes in the coming years?

Photo credits: Fotolia Marcus Hofmann – Illustrations Heike Schubert

to choose the best energy-efficient lighting options for your home, you should understand basic lighting principles and terms.

principles of illumination

Light Quantity

Illumination
The distribution of light on a horizontal surface. The purpose of all lighting is to produce illumination.

Lumen
A measurement of light emitted by a lamp. As reference, a 100-watt incandescent lamp emits about 1600 lumens.

Footcandle
A measurement of the intensity of illumination. A footcandle is the illumination produced by one lumen distributed over a 1-square-foot area. For most home and office work, 30–50 footcandles of illumination is sufficient. For detailed work, 200 footcandles of illumination or more allows more accuracy and less eyestrain. For simply finding one's way around at night, 5–20 footcandles may be sufficient.

Energy Consumption

Efficacy
The ratio of light produced to energy consumed. It's measured as the number of lumens produced divided by the rate of electricity consumption (lumens per watt).

Light Quality

Color temperature
The color of the light source. By convention, yellow-red colors (like the flames of a fire) are considered warm, and blue-green colors (like light from an overcast sky) are considered cool. Color temperature is measured in Kelvin (K) temperature. Confusingly, higher Kelvin temperatures (3600–5500 K) are what we consider cool and lower color temperatures (2700–3000 K) are considered warm. Cool light is preferred for visual tasks because it produces higher contrast than warm light. Warm light is preferred for living spaces because it is more flattering to skin tones and clothing. A color temperature of 2700–3600 K is generally recommended for most indoor general and task lighting applications.

Color rendition
How colors appear when illuminated by a light source. Color rendition is generally considered to be a more important lighting quality than color temperature. Most objects are not a single color, but a combination of many colors. Light sources that

are deficient in certain colors may change the apparent color of an object. The Color Rendition Index (CRI) is a 1–100 scale that measures a light source's ability to render colors the same way sunlight does. The top value of the CRI scale (100) is based on illumination by a 100-watt incandescent lightbulb. A light source with a CRI of 80 or higher is considered acceptable for most indoor residential applications.

Glare
The excessive brightness from a direct light source that makes it difficult to see what one wishes to see. A bright object in front of a dark background usually will cause glare. Bright lights reflecting off a television or computer screen or even a printed page produces glare. Intense light sources -- such as bright incandescent lamps -- are likely to produce more direct glare than large fluorescent lamps. However, glare is primarily the result of relative placement of light sources and the objects being viewed.

Lighting Uses

Ambient lighting
Provides general illumination indoors for daily activities, and outdoors for safety and security.

Task lighting
Facilitates particular tasks that require more light than is needed for general illumination, such as under-counter kitchen lights, table lamps, or bathroom mirror lights.

Accent lighting
Draws attention to special features or enhances the aesthetic qualities of an indoor or outdoor environment.

Multiple choice questions

1.The formula to find I when the values of V and R are known is

a) $I = VR$

b) $I = R/V$

c) $V = IR$

d) $I = V/R$

2.Resistance is measured in

a) henries

b) ohms

c) hertz

d) watts

3.In a three-phase system, the voltages are separated by

a) 45°

b) 90°

c) 120°

d) 180°

4.The flow of electrons is called current

5.Insulator have electrons flow with great difficulty and have High resistance.

6.AMPS is amount of electricity.

7.In plate earthing system, a plate made up of

a)copper or galvanized iron (GI)

b)silver

c)bronze

d)metal

8.single-phase connection has----------wires

9.three-phase connection has----------wires

10.conduits are used in the conduit wiring systems which is made up of

a)Metallic Conduit &non-metallic conduit

b)copper and bronze

c)both a&b

d)none of the above

11. ---------- is a measurement of light emitted by a lamp.

Descriptive questions

1. The alternating electric current that supplies your home can be provided via different types of connection? what are they? write their applications?

2. What are the different types of the protective device that are commonly used in electrical and electronic circuit?

3. In electricity supply systems, an earthing system or grounding system is circuitry? explain how it is work.

4. How to planning electrical wiring for building?

5. Write advantages of conduit wiring systems.

6. Explain Advantages of Batten Wiring

7. The excessive brightness from a direct light source that makes it difficult to see. how to it restricted.

8. There is a high risk of fire in casing & capping wiring system how to avoid this type of risk.

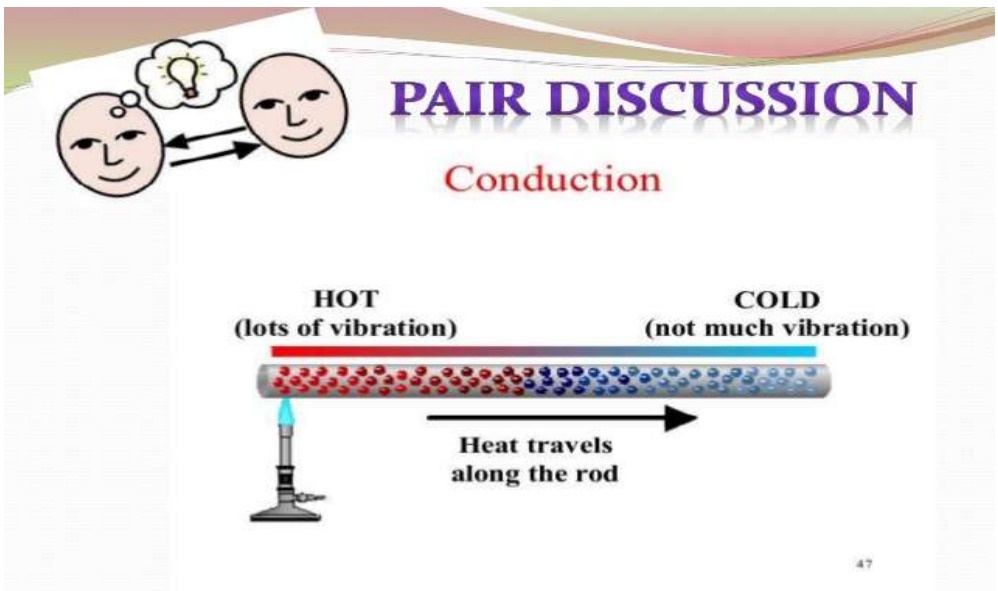
Unit-5

Heat ventilation and air conditioning

Introduction of behaviour of heat transfer:

Heat transfer is defined as energy-in-transit due to temperature difference. Heat transfer takes place whenever there is a temperature gradient within a system or whenever two systems at different temperatures are brought into thermal contact. Heat, which is energy-in-transit cannot be measured or observed directly, but the effects produced by it can be observed and measured. Since heat transfer involves transfer and/or conversion of energy, all heat transfer processes must obey the first and second laws of thermodynamics. However unlike thermodynamics, heat transfer deals with systems not in thermal equilibrium and using the heat transfer laws it is possible to find the rate at which energy is transferred due to heat transfer. From the engineer's point of view, estimating the rate of heat transfer is a key requirement. Refrigeration and air conditioning involves heat transfer, hence a good understanding of the fundamentals of heat transfer is a must for a student of refrigeration and air conditioning. This section deals with a brief review of heat transfer relevant to refrigeration and air conditioning.

Generally heat transfer takes place in three different modes: conduction, convection and radiation. In most of the engineering problems heat transfer takes place by more than one mode simultaneously, i.e., these heat transfer problems are of multi-mode type.
conduction:

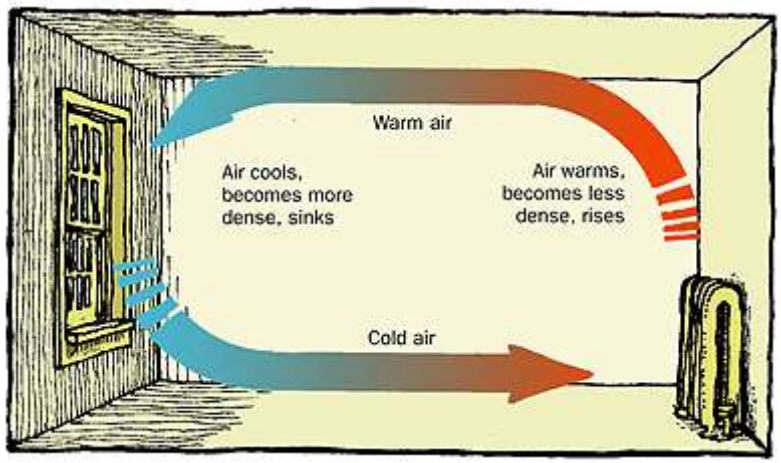


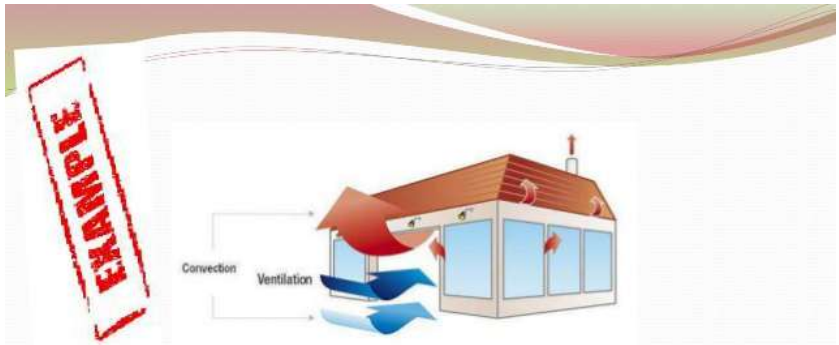
it is a mode of transfer of heat that requires a medium. it takes place in all the three states of matter. but it is much dominant in solids only. heat energy transfers from one p[lace to another place through molecular

vibrations in solids. these vibrations travel in the form of heat waves of very high frequency.

convection: Convection is the flow of currents in a liquid or gas. A current is created when the warmer (less dense) material rises forcing the cooler (more dense) material to sink

example:

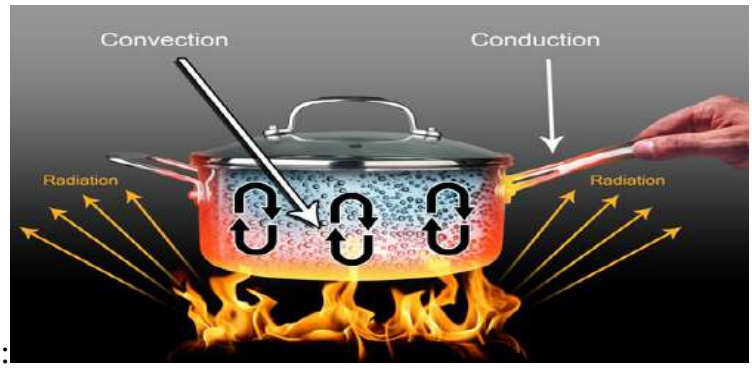


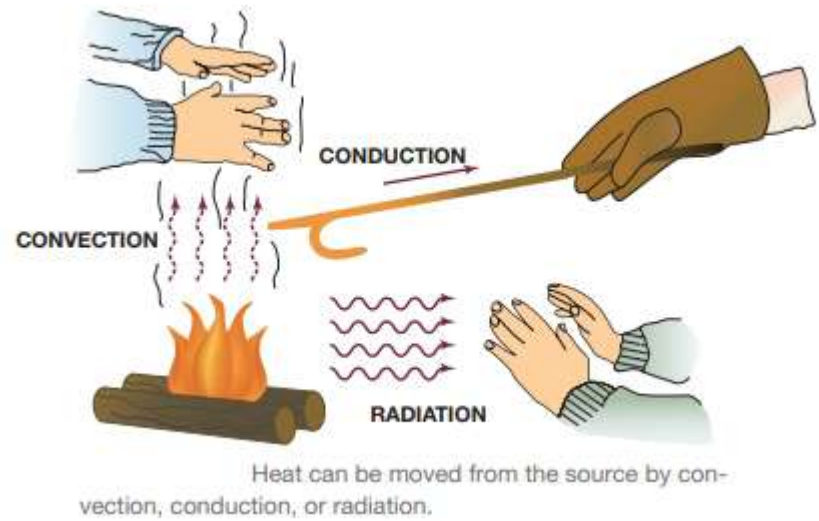


•**VENTILATORS**: Ventilators are provided in the walls of a room near the ceiling, which help to keep the room temperature moderate by continuous circulation of air. The air inside the room gets impure and heated due to our breathing. This hot air rises up and passes out through ventilators, thus allowing space for currents of fresh air from outside windows or doors.

Radiation: Radiation is heat transfer through space by electromagnetic waves. Unlike Conduction and Convection, Radiation can occur in empty space, as well as in solids, liquids, and gases. Waves such as visible light, infrared, and ultraviolet light are examples of radiation

example for complete three modes of heat transfer:





Heat can be moved from the source by convection, conduction, or radiation.

Thermal insulating materials:

The thermal conductivity is an important property of the medium as it is equal to the conduction heat transfer per unit cross-sectional area per unit temperature gradient. Thermal conductivity of materials varies significantly. Generally it is very high for pure metals and low for non-metals. Thermal conductivity of solids is generally greater than that of fluids. Table typical thermal conductivity values at 300 K. Thermal conductivity of solids and liquids vary mainly with temperature, while thermal conductivity of gases depend on both temperature and pressure. For isotropic materials the value of thermal conductivity is same in all directions, while for anisotropic materials such as wood and graphite the value of thermal conductivity is different in different directions. In refrigeration and air conditioning high thermal conductivity materials are used in the construction of heat exchangers, while low thermal conductivity materials are required for insulating refrigerant pipelines, refrigerated cabinets, building walls etc.

1. Fiberglass

Fiberglass is the most common insulation used in modern times. Because of how it is made, by effectively weaving fine strands of glass into an insulation material, fiberglass is able to minimize heat transfer. The main downside of fiberglass is the danger of handling it. Since fiberglass is made out of finely woven silicon, glass powder and tiny shards of glass are formed. These can cause damage to the eyes, lungs, and even skin if the proper safety equipment isn't worn. Nevertheless, when the proper safety equipment is used, fiberglass installation can be performed without incident.

Fiberglass Insulation.

Wood fiber: **Wood fibres** are usually cellulosic elements that are extracted from trees and used to make materials including paper.

Thermal conductivity/ λ (lambda) W/ m.K = 0.038

Cellulose (blown/sprayed)

Cellulose insulation is a material made from recycled newspaper. The paper is shredded and inorganic salts, such as boric acid, are added for resistance to fire, mould, insects and vermin. The insulation is installed either blown or damp-sprayed depending on application.

Some recent studies on cellulose have shown that it might be an excellent product for use in minimizing fire damage. Because of the compactness of the material, cellulose contains next to no oxygen within it. Without oxygen within the material, this helps to minimize the amount of damage that a fire can cause.

Thermal conductivity/ λ (lambda) W/ m.K = 0.035

Wool

Wool insulation is made from sheep wool fibres that are either mechanically held together or bonded using between 5% and 15% recycled polyester adhesive to form insulating batts and rolls. Sheep are no longer farmed primarily for their wool; however, they need to be clipped annually to protect the health of the animal. The wool used to manufacture insulation is the wool discarded as waste by other industries due to its colour or grade.

Thermal conductivity/ λ (lambda) W/ m.K = 0.038

Hemp

emp fibres are produced from hemp straw of the hemp plant. Most hemp is imported, but an increasing amount of home-grown crop is becoming available. Hemp grows up to a height of nearly 4 metres within a period of 100-120 days. Because the plants shade the soil, no chemical protection or toxic additives are required for hemp cultivation. The product is composed of, usually, 85% hemp fibre with the ballance made up of polyester binding and 3-5% soda added for fire proofing.

Thermal conductivity/ λ (lambda) W/ m.K = 0.039 - 0.040

Straw

Straw is an agricultural by-product, the dry stalks of cereal plants, after the grain and chaff have been removed. Straw makes up about half of the yield of cereal crops such asbarley, oats, rice, rye and wheat.

thermal conductivity/ λ (lambda) W/ m.K = 0.08 (for load bearing construction)

Phenolic foam

Phenolic foam insulation is made from a resole resin in the presence of an acid catalyst, blowing agents (such as pentane) and surfactants.

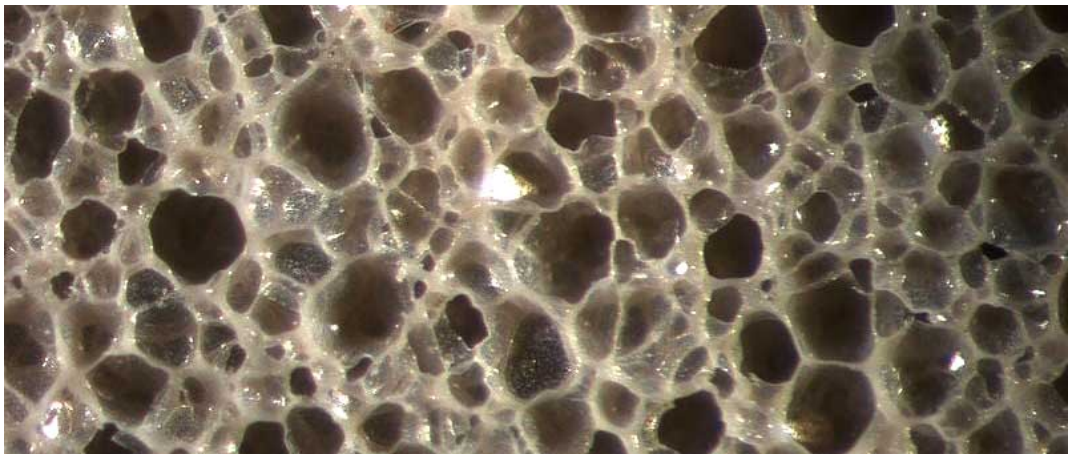
hermal conductivity/ λ (lambda) W/ m.K = 0.020

Polyisocyanurate/ Polyurethane foam (PIR/PUR)

Polyurethane (PUR and PU) is a polymer composed of organic units joined by carbamate (urethane) links. Polyurethane can be made in a variety of densities and hardnesses by varying the isocyanate, polyol or additives. Polyisocyanurate, also referred to as PIR, is a thermoset plastic typically produced as a foam and used as rigid thermal insulation. Its chemistry is similar to polyurethane (PUR) except that the proportion of methylene diphenyl diisocyanate (MDI) is higher and a polyester-derived polyol is used in the reaction instead of a polyether polyol. Catalysts and additives used in PIR formulations also differ from those used in PUR. Prefabricated PIR sandwich panels are manufactured with corrosion-protected, corrugated steel facings bonded to a core of PIR foam and used extensively as roofing insulation and vertical walls (e.g. for warehousing, factories, office buildings

etc.)

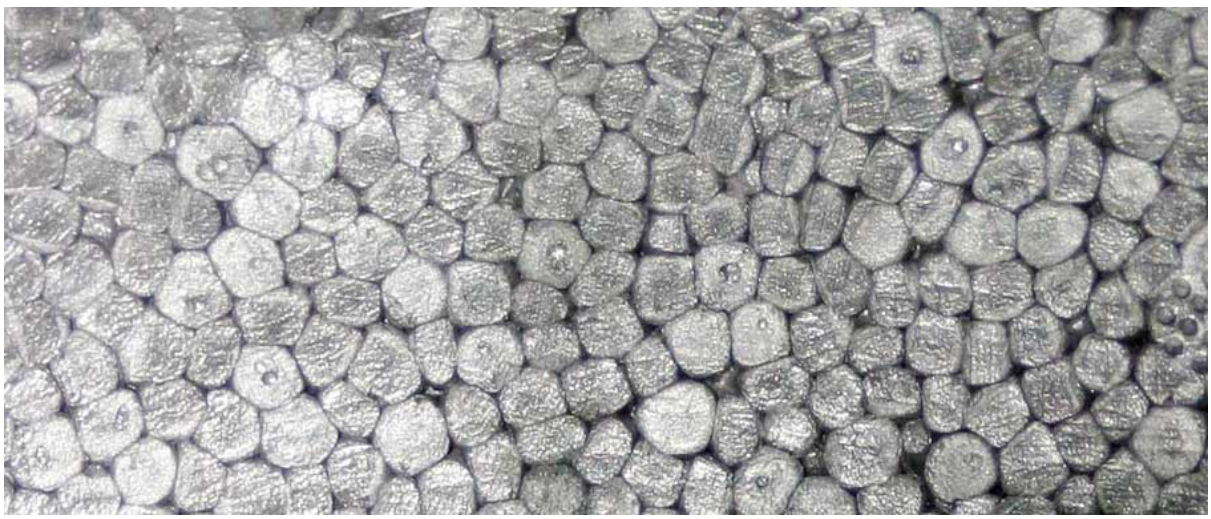
Thermal conductivity/ λ (lambda) W/ m.K = 0.023–0.026



Expanded polystyrene (EPS)

Polystyrene is a synthetic aromatic polymer made from the monomer styrene. Polystyrene can be solid or foamed. Expanded polystyrene (EPS) is a rigid and tough, closed-cell foam. It is usually white and made of pre-expanded polystyrene beads. Polystyrene is one of the most widely used plastics, the scale of its production being several billion kilograms per year. Polystyrene foams are produced using blowing agents that form bubbles and expand the foam. In expanded polystyrene, these are usually hydrocarbons such as pentane
Although it is a closed-cell foam, both expanded and extruded polystyrene are not entirely waterproof or vapour proof.
Discarded polystyrene does not biodegrade for hundreds of years and is resistant to photolysis.

Thermal conductivity/ λ (lambda) W/ m.K = 0.034–0.038



Insulating Material	**Thermal conductivity/ λ (lambda) W/ m.K**
Wood fibre	0.038
Cellulose	0.035
Wool	0.038
Hemp	0.039 - 0.040
Hempcrete	0.06
Cellular glass	0.041
Straw	0.08
Glass mineral wool	0.035
Rock mineral wool	0.032–0.044
Phenolic foam	0.020
Polyisocyanurate/ Polyurethane foam (PIR/PUR)	0.023–0.026
Expanded polystyrene	0.034–0.038
Extruded polystyrene (XPS)	0.033–0.035
Aerogel	0.014

METHODS OF HEAT INSULATION OR THERMAL INSULATION:

In general, people living in hot regions wants to make their inside atmosphere very cool similarly people living in cold regions, wants warmer atmosphere inside. But, we know that the heat transfer takes place from hotter to colder areas. As a result, heat loss happens. To overcome this loss

in buildings thermal insulation is provided to maintain required temperature inside the building. The aim of thermal insulation is to minimize the heat transfer between outside and inside of building.

The heat in a building structure is mainly transmitted through the roofs, exposed walls and exposed wall openings, such as windows, doors, ventilators, etc. and accordingly the methods of heat insulation usually adopted are as follows:

1. Methods of heat insulation of roofs
2. Methods of heat insulation of exposed walls

1. METHODS OF HEAT INSULATION OF ROOFS

It is desirable from comfort considerations that thermal transmittance '***U***' of exposed roofs should not exceed 2k.cal. per m^2 h^0C. Hence, methods are adopted to bring down the excess of '***U***' value by treating the roofs. The following methods of thermal or heat insulation for treating the internal and external surfaces are generally employed.

1. Heat insulating materials described are applied externally to the roofs. In case of external application, heat insulating materials may be installed over the roof but below a waterproof course. In case of internal application, heat insulating materials may be fixed by adhesives or otherwise, on the underside of roofs from within the rooms.
2. The false ceiling of insulating materials may be provided below the roof with air gaps in between.
3. Shining and reflective insulation materials may be installed or laid on the top of the roof.
4. An air space may be created on top of flat roofs by arranging sheets of asbestos cement or corrugated galvanized iron over the bricks.
5. Flat roofs may be kept cool by flooded water either by storing or by spraying regularly. This helps in reducing the outside temperature considerably. Water loss due to evaporation in such cases can be compensated by installing make up arrangements.
6. White washing of the roof before onset of each summer also helps in heat insulation.
7. Suitable shading of roof on the exposed surfaces also reduces the surface temperature.

2. METHODS OF HEAT INSULATION OF EXPOSED WALLS

For walls, also in view of comfort consideration, it is desirable to have the thermal transmittance (***U***) of exposed walls not greater than 2 k.cl per m^2 h^0C. To achieve this objective the following methods are adopted for thermal insulation of exposed walls:

1. The thickness of the walls may be increased, depending upon the extent of insulation derived.

2. Hollow wall or cavity wall construction may be adopted.
3. The walls may be constructed out of suitable heat insulating materials provided structural requirements are met.
4. The heat insulating materials of different types can be installed or fixed on the inside and outside of the exposed wall in order to reduce the thermal transmittance to the desired limits. In case external application, overall water proofing should be done.
5. For partition walls, an air space may be created by fixing the sheathing of hard boards or battens on either side of the walls.
6. Light colour white-wash or distemper may be applied on the exposed surface of the wall to increase thermal insulation value.

VENTILATION:

the process of supplying fresh air and removing contaminated air and heat by natural or mechanical means from a room is termed as ventilation

NECESSITY OF VENTILATION:

1. Control impurities
You may think that the air quality where you live isn't great, but it is often the case that the air inside is more polluted than the air outside. A good ventilation system will help expel a build up of pollutants, bacteria, moisture and nasty whiffs such as body odour.

2. Air regulation
Unless you have a ventilation system in place, you have no control of the air flow in a building. Too much fresh air can mean costly energy bills, which is why good ventilation makes perfect sense in so many ways.

3. Stop condensation
Condensation can lead to mould and rotten surfaces - something you want to avoid. Damp conditions and condensation can cause health issues such as allergic reactions and respiratory problems for many people. Good ventilation will help reduce these risks.

4. Reduce temperatures
When lots of people are in confined space, the environment can become hot and stuffy. A ventilated room will instantly be more comfortable - making for a more productive workplace.

5. Health benefits
Indoor air pollution coupled with bad ventilation can lead to a number of health problems including headaches, allergies, asthma, rashes and sinusitis. All of which can be avoided with the installation of a good ventilation system.

VENTILATION SYSTEM:

Ventilation moves outdoor air into a building or a room, and distributes the air within the building or room. The general purpose of ventilation in

buildings is to provide healthy air for breathing by both diluting the pollutants originating in the building and removing the pollutants from it. Building ventilation has three basic elements:

- *ventilation rate* — the amount of outdoor air that is provided into the space, and the quality of the outdoor air
- *airflow direction* — the overall airflow direction in a building, which should be from clean zones to dirty zones
- *air distribution or airflow pattern* — the external air should be delivered to each part of the space in an efficient manner and the airborne pollutants generated in each part of the space should also be removed in an efficient manner.

TYPES OF VENTILATION:

There are three methods that may be used to ventilate a building: natural, mechanical and hybrid (mixed-mode) ventilation.

1. Natural ventilation:

Natural forces (e.g. winds and thermal buoyancy force due to indoor and outdoor air density differences) drive outdoor air through purpose-built, building envelope openings. Purpose-built openings include windows, doors, solar chimneys, wind towers and trickle ventilators. This natural ventilation of buildings depends on climate, building design and human behaviour.

2. Mechanical ventilation:

Mechanical fans drive mechanical ventilation. Fans can either be installed directly in windows or walls, or installed in air ducts for supplying air into, or exhausting air from, a room.

The type of mechanical ventilation used depends on climate. For example, in warm and humid climates, infiltration may need to be minimized or prevented to reduce interstitial condensation (which occurs when warm, moist air from inside a building penetrates a wall, roof or floor and meets a cold surface). In these cases, a positive pressure mechanical ventilation system is often used. Conversely, in cold climates, exfiltration needs to be prevented to reduce interstitial condensation, and negative pressure ventilation is used. For a room with locally generated pollutants, such as a bathroom, toilet or kitchen, the negative pressure system is often used.

In a positive pressure system, the room is in positive pressure and the room air is leaked out through envelope leakages or other openings. In a negative pressure system, the room is in negative pressure, and the room air is compensated by “sucking” air from outside. A balanced mechanical ventilation system refers to the system where air supplies and exhausts have been tested and adjusted to meet design specifications. The room pressure may be maintained at either slightly positive or negative pressure, which is achieved by using slightly unequal supply or exhaust ventilation rates.

3. hybrid ventilation:

Hybrid (mixed-mode) ventilation relies on natural driving forces to provide the desired (design) flow rate. It uses mechanical ventilation when the natural ventilation flow rate is too low .When natural ventilation alone is not suitable, exhaust fans (with adequate pre-testing and planning) can be installed to increase ventilation rates in rooms housing patients with airborne infection. However, this simple type of hybrid (mixed-mode) ventilation needs to be used with care.

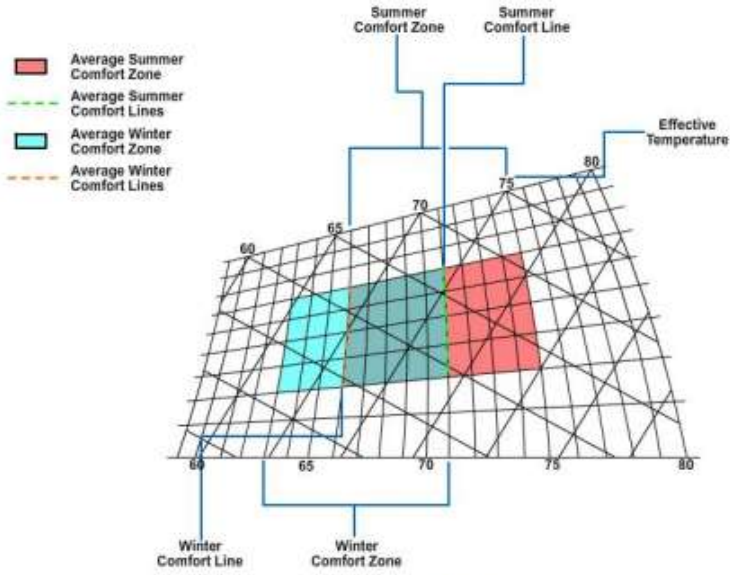
AIR CONDITIONING:

A method of filtering air and keeping its humidity and temperature at desired levels, as in buildings especially so as to cool the air and lower its humidity in warm weather.

PRINCIPLES of AIR CONDITIONING:

Air conditioning is the process of conditioning the air in a space to maintain a predetermined temperature-humidity relationship to meet comfort or technical requirements. This warming and cooling of the air is usually referred to as winter and summer air conditioning.

Temperature: Temperature, humidity, and air motion are interrelated in their effects on health and comfort. The term given to the net effects of these factors is effective temperature. This effective temperature cannot be measured with a single instrument; therefore, a psychrometric chart aids in calculating the effective temperature when given sufficient known conditions relating to air temperatures and velocity. Research has shown that most persons are comfortable in air where the effective temperature lies within a narrow range. The range of effective temperatures that most people feel comfortable in is called the COMFORT ZONE. Since winter and summer weather conditions are markedly different, the summer zone varies from the winter zone. The specific effective temperature within the zone at which most people feel comfortable is called the COMFORT LINE



Comfort zones and lines.

Humidity: When air is at a high temperature and saturated with moisture, it makes people feel uncomfortable. However, people usually feel quite comfortable at the same temperature with fairly dry air. As dry air passes over the surface of the skin, it evaporates the moisture sooner than damp air, producing a greater cooling effect. However, if the air is too dry it causes discomfort. When air is too dry, it causes the surface of the skin to become dry and irritated. Humidity is the amount of water vapor in a given volume of air. Relative humidity is the amount of water vapor in a given amount of air in comparison to the amount of water vapor the air would hold at a temperature if it were saturated. Relative humidity may be remembered as a fraction or percentage of water vapor in the air; that is, DOES HOLD divided by CAN HOLD.

Dew-Point Temperature: The dew point depends on the amount of water vapor in the air. If the air at a certain temperature is not saturated (maximum water vapor at that temperature) and the air temperature falls, a point is finally reached saturating the air for the new and lower temperature, and moisture condensation begins. This is the dew-point temperature of the air for the quantity of water vapor present.

Purity of Air: The air should be free from all foreign materials, such as ordinary dust, rust, animal and vegetable matter, and pollen. It should also be free of carbon (soot) from poor combustion, fumes, smoke, and gases. These types of pollution alone are harmful to the human body but they also carry bacteria and harmful germs, which can cause additional dangers. During air conditioning, the outside air brought into a space or the re-circulating air within a space should be filtered.

Circulation of Air: The velocity of the air is the primary factor that determines what temperature and humidity are required to produce comfort. (The chart in Figure 13-3 is based on an air movement of 15 to 25 feet per minute.) We know from experience that a high velocity of air produces a cooling effect on human beings. However, air velocity does not produce a

cooling effect on a surface that does not have exposed moisture. A fan does not cool the air, but merely increases its velocity. The increased velocity of air passing over the skin surfaces evaporates moisture at a greater rate thereby cooling the individual. For this reason, circulation of air has a decided influence on comfort conditions. Air can be circulated by gravity or mechanical means. When air is circulated by gravity, the heavier cold tends to settle to the floor, forcing the warm and lighter air to the ceiling. When the air at the ceiling is cooled by some sort of refrigeration, it will settle to the floor and cause the warm air to rise. The circulation of the air by this method will eventually stop when the temperature of the air at the ceiling is the same as the temperature on the floor. Axial or radial fans can also be used to circulate the air. When axial or radial fans are mounted in an enclosure, they are often called blowers.

Classification of air conditioning systems:

Based on the fluid media used in the thermal distribution system, air conditioning systems can be classified as:

1. All air systems
2. All water systems
3. Air- water systems
4. Unitary refrigerant based systems

All air systems:

As the name implies, in an all air system air is used as the media that transports energy from the conditioned space to the A/C plant. In these systems air is processed in the A/C plant and this processed air is then conveyed to the conditioned space through insulated ducts using blowers and fans. This air extracts (or supplies in case of winter) the required amount of sensible and latent heat from the conditioned space. The return air from the conditioned space is conveyed back to the plant, where it again undergoes the required processing thus completing the cycle. No additional processing of air is required in the conditioned space. All air systems can be further classified into:

1. **Single duct systems, or**
2. **Dual duct systems**

The single duct systems can provide either cooling or heating using the same duct, but not both heating and cooling simultaneously. These systems can be further classified into:

i. Constant volume, single zone systems
ii. Constant volume, multiple zone systems
iii. Variable volume systems

i. Single duct, constant volume, single zone systems:

Figure 1. shows the classic, single duct, single zone, constant volume systems. As shown in the figure, outdoor air (OD air) for ventilation and recirculated air (RC air) are mixed in the required proportions using the dampers and the mixed air is made to flow through a cooling and dehumidifying coil, a heating coil and a humidifier using a an insulated ducting and a supply fan. As the air flows through these coils the temperature and moisture content of the air are brought to the required values. Then this air is supplied to the conditioned space, where it meets the building cooling or heating requirements. The return air leaves the conditioned space, a part of it is recirculated and the remaining part is vented to the atmosphere. A thermostat senses the temperature of air in the conditioned space and controls the amount of cooling or heating provided in the coils so that the supply air temperature can be controlled as per requirement. A humidistat measures the humidity ratio in the conditioned space and controls the amount of water vapour added in the humidifier and hence the supply air humidity ratio as per requirement.

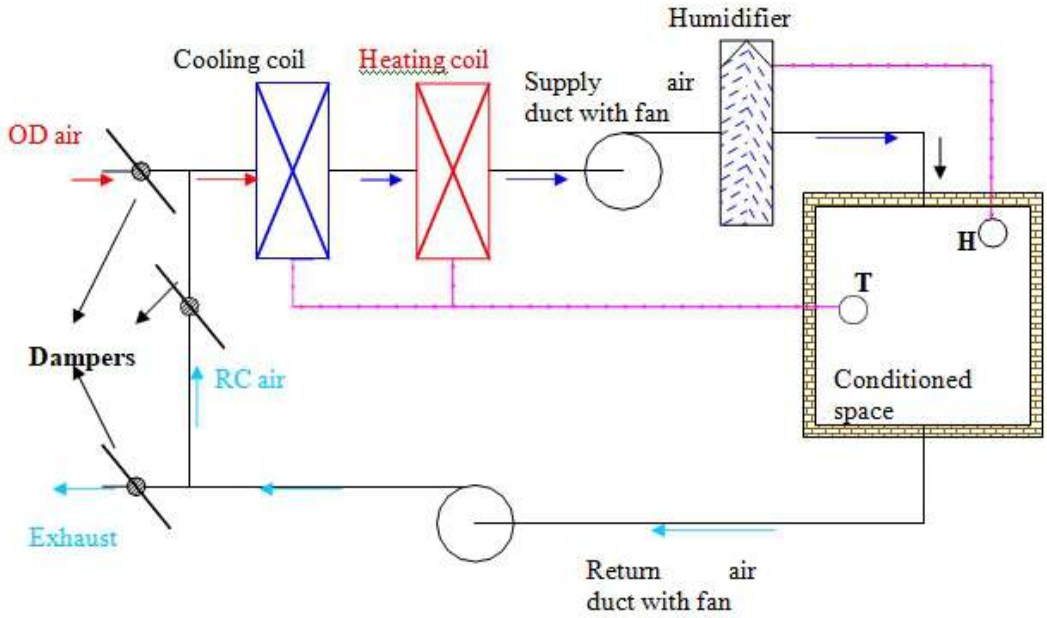


Fig.1. A constant volume, single zone system

This system is called as a single duct system as there is only one supply duct, through which either hot air or cold air flows, but not both simultaneously. It is called as a constant volume system as the volumetric flow rate of supply air is always m**aintained** constant. It is a single zone system as the control is based on

Temperature and humidity ratio measured at a single point. Here a zone refers to a space controlled by one thermostat. However, the single zone may consist of a single room or one floor or whole of a building consisting of several rooms. The cooling/ heating capacity in the single zone, constant volume systems is regulated by regulating the supply air temperature and humidity ratio, while keeping the supply airflow rate constant. A separate sub-system controls the amount of OD air supplied by controlling the damper position.

Applications of single duct, single zone, constant volume systems:

- Spaces with uniform loads, such as large open areas with small external loads e.g. theatres, auditoria, departmental stores.
- Spaces requiring precision control such as laboratories.

The Multiple, single zone systems can be used in large buildings such as factories, office buildings etc.

2.Dual duct, constant volume systems:

Figure 2.shows the schematic of a dual duct, constant volume system. As shown in the figure, in a dual duct system the supply air fan splits the flow into two streams. One stream flow through the cooling coil and gets cooled and dehumidified to about 13°C, while the other stream flows the heating coil and is heated to about 35–45°C. The cold and hot streams flow through separate ducts. Before each conditioned space or zone, the cold and hot air streams are mixed in required proportions using a mixing box arrangement, which is controlled by the zone thermostat. The total volume of air supplied to each zone remains constant, however, the supply air temperature varies depending upon load.

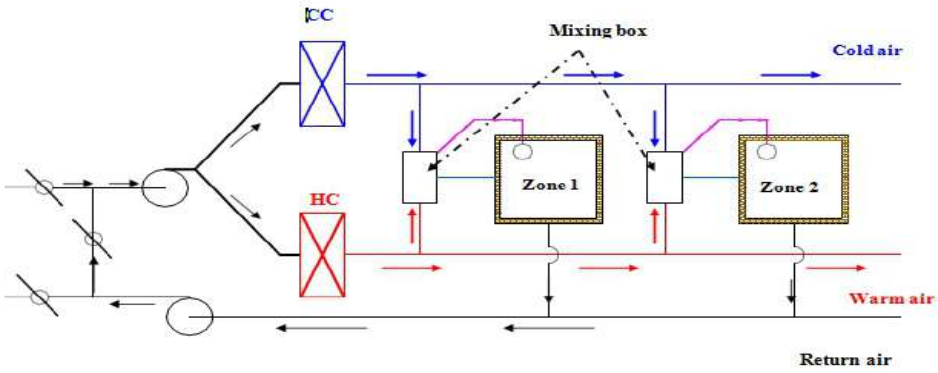


Fig.2: Dual duct, constant volume system

Advantages of dual duct systems:

1. Since total airflow rate to each zone is constant, it is possible to maintain proper IAQ and room air distribution.
2. Cooling in some zones and heating in other zones can be achieved simultaneously
3. System is very responsive to variations in the zone load, thus it is possible to maintain required conditions precisely.

Disadvantages of dual duct systems:

1. Occupies more space as both cold air and hot air ducts have to be sized to handle all the air flow rate, if required.
2. Not very energy efficient due to the need for simultaneous cooling and heating of the air streams. However, the energy efficiency can be improved by completely shutting down the cooling coil when the outside temperature is low and mixing supply air from fan with hot air in the mixing box. Similarly, when the outside weather is hot, the heating coil can be completely shut down, and the

cold air from the cooling coil can be mixed with supply air from the fan in the mixing box.

ESSENTIALS OF AIR CONDITIONING:

1. filteration

2. heating

3.cooloing

4. humidity

5. dehumidification

6. air circulation or distribution

Filtering: It should be capable of removing dust, smoke, bacteria. it should afford easy cleaning manually or mechanically

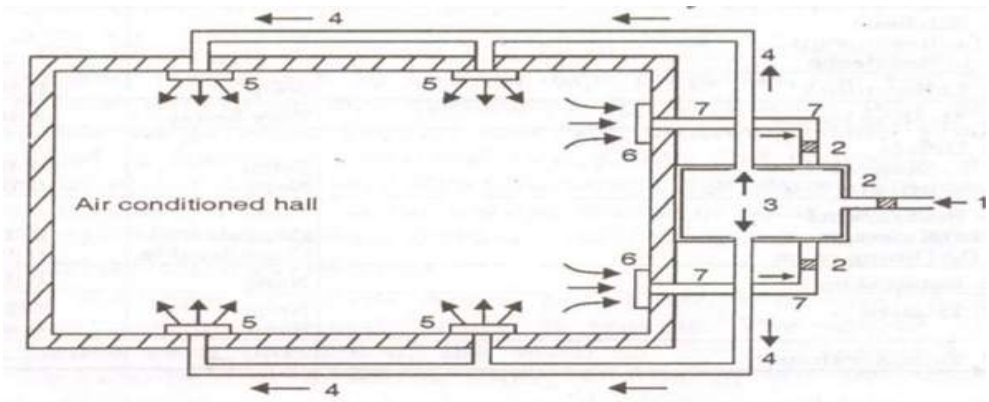
Heating: pre heating of incoming air may be done by passing over air furnaces.

Cooling: principle of mechanical refrigeration is used

Humidification: addition of water is necessary in winter when air because of low temperature has less humidity.

Dehumidification: certain amount of water is extracted from air. Adsorbents can be used to adsorb excess moisture from air.

Air circulation:



LAYOUT OF AIR-CONDITIONED HALL, SHOWING AIR CIRCULATION

1. INCOMING VENTILATION AIR 2. DAMPERS.
3. AIR CONDITIONER 4. SUPPLY DUCT. 5. OUTLET GRILLS.
6. RETURN AIR INLET. 7. RETURN AIR DUCT. 8. EXHAUST.

Unit- VI

Fire Fighting Services

Syllabus: Fire, causes of fire and spread of fire, Classification of fire, fire safety and firefighting method, fire detectors, heat detector, smoke detectors, fire dampers, fire extinguishers.

Fire is the rapid oxidation of a material in the exothermic chemical process of combustion, releasing heat, light, and various reaction products.

What is Fire?

Fire is a chemical process requiring three things to occur: oxygen, fuel and an ignition source. Without one of these factors, a fire can't start or will burn itself out.

In all chemical processes, molecules rearrange themselves and energy is either absorbed or expelled. When a fire burns, a process called oxidation occurs, the same process that causes metal to rust. Oxidation is when oxygen atoms combine with carbon and hydrogen to form carbon dioxide and water. When metal rusts, the process happens very slowly, but when a fire burns, heat and energy is released very quickly.

The rate of oxidation is especially fast with fuel sources such as paper and wood. When heat can't release faster than it's created, combustion occurs. This is what creates the flame and heat we call fire. Smoke comprised of unburnt particles, evaporated water and carbon dioxide is also produced, though the cleaner the burning process, the less smoke you see.

How does Fire Spread?

Once started, a building fire is likely to spread until all fuel has been used up. This could have devastating consequences for your home or business. By understanding how fire spreads, you may be better equipped to extinguish it.

- **Chemicals and combustibles:** When fire comes in contact with lab chemicals, household cleaners, paint and other chemicals, the fire burns hotter and more aggressively, encouraging it to spread. Other combustibles commonly found in the home include mattresses, sofa cushions, magazines, newspapers and various textiles.

- **Open space:** A building with limited interior structure burns much faster than one with hallways and closed doors. Walls and doors trap the fire and prevent the flames and smoke from spreading. While the fire will eventually burn through the structure and continue to spread if left to its own devices, a fire fighting team has a much easier time dousing the flames in a building with more walls and doors, especially if those structures are built to withstand the heat and damage of a fire.
- **Construction materials:** While a fire can burn through just about any modern building, fire resistive buildings made of concrete and steel curb the spread of fire better than wood frame homes.
- **Ventilation:** Buildings with central heating or air conditioning have ductwork, which provides a way for flames and smoke to spread between floors of a building, even when the structure is comprised primarily of concrete and steel.
- **Water:** In some cases, water is not the best fire extinguisher. Grease fires, for example, can actually spread faster when doused with water. A special fire extinguisher or baking soda should be used to suffocate and stop the spread of grease fires in the kitchen.

Common causes of fire in residential buildings:

1. Kitchen stoves

Never leave the stove unattended, these are the main cause of fire in residential areas.

2. Heating

Keep portable heaters at least one metre away from anything that could easily catch fire such as furniture, curtains, laundry, clothes and even yourself.

3. Smoking in bedrooms

Bedrooms are best to be kept off limits for smoking. A cigarette that is not put out properly can cause a flame, as the butt may stay alit for a few hours. It could burst into flames if it came into contact with flammable materials, such as furniture.

4. Electrical equipment

An electrical appliance, such as a toaster can start a fire if it is faulty or has a frayed cord. A power point that is overloaded with double adapter plugs

can cause a fire from an overuse of electricity. A power point extension cord can also be a fire hazard if not used appropriately.

5. Candles

Candles look and smell pretty, but if left unattended they can cause a room to easily burst into flames. Keep candles away from any obviously flammable items such as books and tissue boxes. Always blow a candle out before leaving a room.

6. Curious children

Kids can cause a fire out of curiosity, to see what would happen if they set fire to an object. Keep any matches or lighters out of reach of children, to avoid any curiosity turned disaster. Install a smoke alarm in your child's room and practice a home escape plan with your children and family in case there was a fire.

7. Faulty wiring

Homes with inadequate wiring can cause fires from electrical hazards. Some signs to see if you've bad wiring are:

- Lights dim if you use another appliance;
- For an appliance to work, you have to disconnect another;
- Fuses blow or trip the circuit frequently.
- Have a licensed electrician come and inspect you house, or contact your landlord if you have any of the above occurrences.

Classes of Fire - A, B, C, D, and K

Fires are classified by the types of fuel they burn.

Class A

Class A Fires consist of ordinary combustibles such as wood, paper, trash or anything else that leaves an ash. Water works best to extinguish a Class A fire.

Class B

Class B Fires are fueled by flammable or combustible liquids, which include oil, gasoline, and other similar materials. Smothering effects which deplete the oxygen supply work best to extinguish Class B fires.

Class C

Class C Fires Energized Electrical Fires are known as Class C fires. Always de-energize the circuit then use a non-conductive extinguishing agent. Such as Carbon dioxide.

Class D

Class D Fires are combustible metal fires. Magnesium and Titanium are the most common types of metal fires. Once a metal ignites do not use water in an attempt to extinguish it. Only use a Dry Powder extinguishing agent. Dry powder agents work by smothering and heat absorption.

Class K

Class K Fires are fires that involve cooking oils, grease or animal fat and can be extinguished using Purple K, the typical agent found in kitchen or galley extinguishers.

Fire safety:

- **Fire safety** is the set of practices intended to reduce the destruction caused by fire. Fire safety measures include those that are intended to prevent ignition of an uncontrolled fire, and those that are used to limit the development and effects of a fire after it starts.
- Fire safety measures include those that are planned during the construction of a building or implemented in structures that are already standing, and those that are taught to occupants of the building.
- Threats to fire safety are commonly referred to as fire hazards. A fire hazard may include a situation that increases the likelihood of a fire or may impede escape in the event a fire occurs.
- Fire safety is often a component of building safety. Those who inspect buildings for violations of the Fire Code and go into schools to educate children on Fire Safety topics are fire department members known as Fire Prevention Officers

The Chief Fire Prevention Officer or Chief of Fire Prevention will normally train newcomers to the Fire Prevention Division and may also conduct inspections or make presentations.

Fire Fighting Methods:

COMBUSTIBLE INVOLVED	TYPE FIRE	USEFUL EXTINGUISHING AGENTS
Woodwork, bedding, clothing, combustible	A	1.Fixed water sprinkling stores 2. High-velocity fog 3.Solid water stream 4.Foam/AFFF 5. Dry Chemical 6. CO_2 Extinguisher
Explosive Propellants	A	1.Magazine sprinkling Propellants 2. Solid water stream or high-velocity fog 3. Foam/AFFF
Paint, spiritsB1. CO2(Fixed System)Flammable liquid stores	B	1. CO2(Fixed System) 2. Foam/AFFF 3. Installed sprinklers 4. High-velocity fog 5. P-K-P Dry Chemical 6. CO_2 Portable
Gasoline	B	1. Foam/AFFF, handline or sprinkler systems 2. CO2(Fixed System) 3. Water sprinkling system 4. P-K-P Dry Chemical
Fuel oil, JP-5	B	1. Foam/AFFF, hand line or sprinkler systems 2. P-K-P Dry Chemical 3. Water sprinkling system 4. High-velocity fog 5. CO_2 (Fixed System)
Electrical and radio	C	1. (De-energize affected circuits) 2. Portable CO2or CO2hose reel system 3. High-velocity fog 4. Fog—Foam or Dry

		Chemical (if CO2not available)
Magnesium Alloys	D	1. Jettison into the sea 2. High-velocity fog—cool 3.Dry Sand—Talc—Smother
Grenades, Napalm	D	1. Dry sodium Chloride 2. Stow in kerosene or similar Hydrocarbon

Fire Detectors:

- Smoke and fire detection equipment is an integral part of any building's safety. When working properly, they alert the occupants in a building of a fire before it spreads, giving them enough time to evacuate.
- The most effective fire protection plans include detection, suppression and containment requiring both active and passive fire protection.

1. **Active fire protection**: it includes all systems designed to suppress or extinguish fire once it has started, as well as aid in the evacuation of occupants. These include smoke detectors, building pressurization, fire alarms, sprinklers, exit signs, and evacuation plans. However, active fire protection systems do not prevent the spread of smoke and toxic gases, the leading cause of death from fire.
2. **Passive fire protection:** it is designed to prevent smoke, toxic gases, and fire from spreading. These include fire dampers, smoke dampers, or combination fire/smoke dampers. These three damper types perform different functions and are installed and maintained differently as well.

1. Active fire protection:

A **heat detector** is a fire alarm device designed to respond when the converted thermal energy of a fire increases the temperature of a heat sensitive element. The thermal mass and conductivity of the element regulate the rate flow of heat into the element.

1. Fixed temperature heat detectors

2. Rate-of-rise heat detectors

1. Fixed temperature heat detectors

This is the most common type of heat detector. Thermal lag delays the accumulation of heat at the sensitive element so that a fixed-temperature device will reach its operating temperature sometime after the surrounding air temperature exceeds that temperature. The most common fixed temperature point for electrically connected heat detectors is 58°C (136.4°F).

2. Rate-of-Rise (ROR) heat detectors operate on a rapid rise in element temperature of 6.7° to 8.3°C (12° to 15°F) increase per minute, irrespective of the starting temperature. This type of heat detector can operate at a lower temperature fire condition than would be possible if the threshold were fixed

Flame detectors:

- A flame detector is a sensor designed to detect and respond to the presence of a flame or fire, allowing flame detection. Responses to a detected flame depend on the installation, but can include sounding an alarm, deactivating a fuel line.

1. Optical flame detectors; the most commonly used, these feature optical sensors for detecting flames.

2. UV detectors*:* These work very quickly. They can detect open flames, explosions, and fires within four milliseconds, due to the UV radiation emitted at the instant of ignition. However, to prevent accidental triggers, some UV detectors are designed to integrate a three second time delay**.**

IR detectors: Infrared detectors monitor the head radiation that is generated by open flames and fire. They have a response time of three to five seconds. Accidental triggers can be caused by nearby hot surfaces and background thermal radiation. False alarms can be decreased with the use of special programming algorithms, which are designed to recognize the frequency of flame flickering.

Near IR array: Near infrared (IR) array flame detectors (0.7 to 1.1 μm), also known as visual flame detectors, employ flame recognition technology to confirm fire by analyzing near IR radiation using a charge-coupled device (CCD). A near infrared (IR) sensor is especially able to monitor flame phenomena, without too much hindrance from water and water vapor.

Smoke alarms:

- Smoke alarms are designed to detect fires quickly. Like flame detectors, this fire detection equipment is divided into three subcategories.
- *Photoelectric alarms*: These operate with the use of a light source, photoelectric sensor, and beam collimating system. When smoke begins to enter the optical chamber, it crosses the light beam path. This results in light being scattered by the particles in the smoke. The scattered light is then directed to the sensor, after which the alarm is activated and sounded**.**
- *Ionization alarms*: A small amount of radioactive material, which passes through the ionization chamber, is contained inside of these alarms. There are two electrodes inside the chamber, with empty space in between. The radiation permits a small current between the two electrodes. If smoke enters the chamber, it absorbs the alpha particles, which results in an interrupted current and ionization reduction. When this occurs, the alarm is set off.
- *Combination alarms:* These have the features of both ionization and photoelectric alarm technologies. The photoelectric function responds to low energy smoldering fires, and the ionization function responds to rapid, high-energy fires.

2. Passive fire protection:

1. Fire dampers: A fire damper can be defined as “a device installed in ducts and air transfer opening of an air distribution or smoke control

system designed to close automatically upon detection of heat. It also serves to interrupt migratory airflow, resist the passage of flame, and maintain the integrity of the fire rated separation." Its primary function is to prevent the passage of flame from one side of a fire-rated separation to the other.
Location: Fire dampers are installed in or near the wall or floor, at the point of duct penetration

2. Smoke Dampers: Smoke dampers are defined as "a device installed in ducts and air transfer opening of an air distribution or smoke control system designed resist the passage of air and smoke. The device operates automatically and is controlled by a smoke detection system. They can be opened or closed from a remote fire command station if required." Their primary function is to prevent the passage of smoke through the heating, ventilation, and air conditioning system, or from one side of a fire-rated separation to the other.
Location: Smoke dampers are for use in or adjacent to smoke barriers.

3. Combination Fire/Smoke Dampers: They are used in HVAC penetrations where a wall, floor, or ceiling is required to have both a fire damper and smoke damper. They close upon the detection of heat (via duct temperature) or smoke (via a smoke detector) and "seal" the opening. Unlike regular fire dampers, however, fire/smoke dampers are available with electric heat release devices instead of fusible links. The electric release devices are resettable and allow the damper to close in a controlled manner rather than slamming closed and causing pressure problems in the HVAC system.

Fire Extinguishers:

- Is a portable device that discharges a jet of water, foam, gas, or other material to extinguish afire.

Types of fire extinguishers

1. Dry chemical

2. Carbon Dioxide
3. Water/Foam
4. Dry Powder
5. Wet Chemical
6. Clean Agent

Fire Triangle

- The triangle illustrates the three elements a fire needs to ignite: heat, fuel, and an oxidizing agent (usually oxygen). A fire naturally occurs when the elements are present and combined in the right mixture, meaning that fire is actually an event rather than a thing.

1. Dry chemical

- Dry Chemical is the most widely used type of fire extinguisher and is also recognized as a multi-purpose ABC fire extinguisher.
- The agent works by interrupting the chemical chain reaction. Also, on a class A fire it creates a barrier between the fuel and the oxygen.
- Dry chemical extinguishers put out fire by coating the fuel with a thin layer of dust, separating the fuel from the oxygen in the air. The powder also works to interrupt the chemical reaction of fire, so these extinguishers are extremely effective at putting out fire.
- These extinguishers will be found in a variety of locations. New buildings will have them located in public hallways. They may also be found in laboratories, mechanical rooms, break rooms, chemical storage areas, offices, university vehicles, etc.
- Dry chemical extinguishers with powder designed for Class B and C fires may be located in places such as commercial kitchens or areas with flammable liquids.

2.Carbon Dioxide

- Carbon Dioxide extinguishers are filled with non-flammable carbon

dioxide gas under extreme pressure. You can recognize a CO2 extinguisher by its hard horn and lack of pressure gauge. The pressure in the cylinder is so great that when you use one of these extinguishers, bits of dry ice may shoot out the horn.

- Carbon dioxide extinguishes work by displacing oxygen, or taking away the oxygen element of the fire triangle. The carbon dioxide is also very cold as it comes out of the extinguisher, so it cools the fuel as well. CO2 may be ineffective at extinguishing Class A fires because they may not be able to displace enough oxygen to successfully put the fire out. Class A materials may also smoulder and re-ignite.
- CO2s will frequently be found in laboratories, mechanical rooms, kitchens, and flammable liquid storage areas.

3. Water/Foam

- Water and Foam fire extinguishers extinguish the fire by taking away the heat element of the fire triangle. Foam agents also separate the oxygen element from the other elements.
- Water extinguishers are for Class A fires only - they should not be used on Class B or C fires. The discharge stream could spread the flammable liquid in a Class B fire or could create a shock hazard on a Class C fire.
- Never use water to extinguish flammable liquid fires. Water is extremely ineffective at extinguishing this type of fire, and you may, in fact, spread the fire if you try to use water on it.
- Never use water to extinguish an electrical fire. Water is a good conductor, and there is some concern for electrocution if you were to use water to extinguish an electrical fire. Electrical equipment, including computers, must be unplugged and/or de-energized before using a water extinguisher on it.

4.Dry Powder

- **Dry Powder** extinguishers are similar to dry chemical except that they extinguish the fire by separating the **fuel** from the **oxygen** element or by removing the **heat** element of the fire triangle.
- However, dry powder extinguishers are for Class D or combustible metal fires, only. They are ineffective on all other classes of fires.

5. Wet chemical

- Wet Chemical is a new agent that extinguishes the fire by removing the heat of the fire triangle and prevents re-ignition by creating a barrier between the oxygen and fuel elements.
- Wet chemical of Class K extinguishers were developed for modern, high efficiency deep fat fryers in commercial cooking operations. Some may also be used on Class A fires in commercial kitchens.

6.Clean Agent:

- Halogenated or Clean Agent extinguishers include the halon agents as well as the newer and less ozone depleting halocarbon agents. They extinguish the fire by interrupting the chemical reaction and/or removing heat from the fire triangle.
- Clean agent extinguishers are effective on Class A, B and C fires. Smaller sized handheld extinguishers are not large enough to obtain a 1A rating and may carry only a Class B and C rating.