SUBJECT - PUBLIC HEALTH ENGINEERING
BRANCH - CIVIL ENGG.
SEMESTER- 4th

Unit -1. Introduction

What are objectives of water supply?
To supply safe and wholesome water to the consumers

To supplywater in adequate quantity.

To make water available within easy reach of the consumers.

What is the need for protected water supply schemes in the present day civil life:-

- It is necessary that the water which is supplied to the public, must be free from all types of impurities both suspended or dissolved in it, any kind of bacteria and any other contamination which may cause serious harm to the public health.
- It is therefore imperative to plan and built such a water supply scheme which would provide potable water free from any kind of contamination.
- In general the water obtained from wells or springs, i.e., ground water which is free from impurities and it may be supplied to the public without adopting any method of purification.
- This is so because in the course of its movement through porous substrata the water is completely relieved of its suspended impurities.
- However before supplying to public the water may have to be disinfected by chlorination.
- Water obtained from any of the surface sources of water need to be purified, before it can be supplied to the public.
- The most commonly adopted method of purification of water is filtration.

Define Water demand?

ans) water demand is the quantity of water that the treatment plant must produce in order to meet all water needs in the community.

Define purification of water

ans) Water purification is the process of removing undesirable chemicals, biological contaminants, suspended solids and gases from water

What is principal of coagulation

ans) Coagulation is a process used in the treatment of water, it facilitates the agglomeration of fine particles contained in the water.

Define pressure filter

ans) a filter in which the pressure on the feed side of the filter medium is greater than that of the atmosphere

Define Chlorination

ans) Water chlorination is the process of adding chlorine to water. This method is used to kill certain bacteria

and other microbes in tap water as chlorine is highly toxic. In particular, chlorination is used to prevent the spread of waterborne diseases such as cholera, dysentery, and typhoid.

What is water softening

ans) Water softening is the removal of calcium, magnesium, and certain other metal cations in hard water.

what are the general requirements of water softening

ans) It improves the taste of foods

It increases the life of textiles which are frequently sent to the laundries

It leads to overall cleanliness because of the fact that personal washing and domestic cleanings are much more efficient and less laborious with soft water than with hard water

It makes washing and cleanings easy

Define service connection

ans) The water service connection is a small water pipe connecting the distribution water main to residential, commercial or industrial buildings

Define hydrant

ans) a fitting in a street or other public place with a nozzle by which a fire hose may be attached to a water main.

- In the process of filtration water is allowed to passed through sand and gravel beds where by, suspended and dissolved particles are removed.

- The water which undergone through the process of filtration is still found to contain some harmful disease producing bacteria.

- As such, in order to ensure protected supply of water free from any health hazard, it is necessary to kill bacteria by disinfecting water.

- The most commonly adopted method of disinfection is chlorination.

- Thus it may be seen that a public water supply system should be such that it is able to provide an adequate and reliable supply of water to all the public needs and ensure that the supply is so made are not only potable but also fully protected against any infection which might pollute the water and cause epidemics resulting in human sufferings and loss.

- Factors affecting the per capita demand
  ans)

- For the purpose of estimating total requirement of water of a community, it is usual to calculate the consumption on an average basis and express it in litres percapita per day.

- If Q is the total quantity of water in litres, required by a community per year having 'P' as its population, then percapita consumption or rate of demand in litres percapita per day is given as = Q / (P X 365) (lpcd (litres percapita per day)

The various factors and the way they affect the percapita consumption are stated as follows:

1) Climate

2) Class of consumer

3) Industries and Commerce

4) Quantity of water

5) Pressure in the distribution system

6) Metering system

7) Sewage facilities

8) System of Supply Number of Inhabitants

9) Climate

- Hotter places require higher consumption, in domestic use there is more of bathing, in public use of more lawn and street sprinkling.

Hotter temperatures also lead to greater use of air conditioning.

- Class of consumer

For people having higher economic status and better standards of living requirements of water supply would be greater.

Industries and Commerce

Consumption is usually higher when water supply has to provide for larger industries and commercial uses.

Quantity of water

A water works system having a safe and wholesome water supply always be more popular with consumers who would, consequently, depend less for their requirements upon such sources of water supply as private wells

Pressure in the distribution system

- These would be of greater importance in the case of localities having a number of two or three stored building.

- Adequate pressure would mean an uninterrupted and constant supply of water. Metering

system

- Good quality and high pressure of water supply encourages more liberal use of water.

- Meters also help in cutting down waste or loss of water through leakages in the pipes.

- A metered supply ensures minimum of waste as the consumer then knows that he has to pay for the water used by him and consequently is more careful in use.

Sewage facilities

Where various facilities of a water borne sewerage system exists, residence and buildings require more water for flushing of sanitary appliances i.e., water closets, urinals etc and for efficient drainage through pipes and sewers.

System of supply

- When water is supplied for certain fixed hours of the day, results in some reduction in consumption.
- This may be due to decrease in losses and other wasteful use.

Number of Inhabitants

- This would affect the extent to which use is made of private water supply.
- Thus in large cities, the public water supply is almost a necessity while in small towns and villages, the private supplies may remain in use, even after the introduction of public water supply.
- Generally, the percapita consumption is found to increase with increase of population

Explain the suitability with regard to quality and quantity of surface source ans)

Surface water is just what the name implies; it is water found in a river, lake or other surface cavity.

This water is usually not very high in mineral content, and is often called “soft water” even though it is probably not.

Surface water is exposed to many different contaminants, such as animal wastes, pesticides, insecticides, industrial wastes, algae and many other organic materials.

Even surface water found in what seems like pristine mountain streams can be contaminated by wild animal waste, dead animals upstream or other decay.

Explain different types of materials used for pipes ans)

The general requirements of pipes of different materials are strength, resistant to corrosion, effective capacity, maintenance, economy, availability and easy transportation to the site .

With respect to the various pipe materials these are discussed as below: Cast

Iron pipes

- These pipes earlier cast vertically, but this type has been largely in the use by the past iron pipes, which are manufactured by the centrifugal action and now they are used universally.

- The cast iron pipes are lighter in weight, longer in length and have improved metal qualities.
- They are strong, durable, easy to join and most commonly used.
- Principal disadvantages are difficulty in transformation of large sizes, decrease in their carrying capacities with age and with quality of water transported

Wrought Iron and steel Pipes

- The wrought iron and steel pipes are stronger than cast iron and can withstand much higher pressure, but are of lighter section and hence easy to transport.
- They are however, less durable (life span upto 50 years) more liable to corrosion and there is also the difficulty of easy availability of pipe special i.e. joints, bends, etc

Concrete pipes

- Concrete pipes are very durable, heavier and can be hold in sizes upto 1800 mm in diameter
- Transportation costs are much reduced, if the pipes are cast at the construction site
- Concrete pipes have low maintenance cost and their resistance to corrosion is high. Hume

steel pipes

- These steel pipes are made from mild steel and shell lined and out coated with cement concrete or cement mortar through a centrifugal process
- They are available upto 1350 mm size and are used for trunks and distribution mains.
- They are heavy and difficult to handle.

Asbestos cement pipes

- These pipes are composed of asbestos fiber and Portland cement combined under pressure into dense homogeneous structure.
- These pipes are light in weight and can be easily cut, joined and handled and also they are smooth and resistance to corrosion.
- Lead pipes
- They do not find any place in conveying domestic water supply for fear of lead poisoning due to plumb solvency, where water is soft.

- They are however soft and flexible and as such used in house plumbing as overflow and flushing pipes.

Plastic pipes

- They are now finding increase in use for potable water supply in India
- These pipes have the characteristics of higher strength to weight ratio, greater environmental stability and better resistance to corrosion and bacterial contamination.
- These pipes are also resistant to a wide range of chemicals.

Mention the standards for drinking water as per BIS ans)

S.No	Parameters	Desirable limits mg/l	Permissible limits mg/l
Essential Characteristics			
1	Colour Hazen unit	5	25
2	Odour	Unobjectionable	-
3	taste	agreeable	-
4	Turbidity (NTU)	5	10
5	pH	6.5-8.5	No relaxation
6	Total Hardness, $CaCO_3$	300	600
7	Iron (Fe)	0.3	1.0
8	Chloride (Cl)	250	1000
9	Residual Free Chlorine	0.2	-
10	Fluoride (F)	1.0	1.5
Desirable Characteristics			
11	Dissolved Solids	500	2000
12	Calcium (Ca)	75	200
13	Magnesium (Mg)	30	100
14	Copper (Cu)	0.05	1.5
15	Manganese (Mn)	0.1	0.3
16	Sulphate (SO_4)	200	400
17	Nitrate (NO_3)	45	100
18	Phenolic compounds	0.001	0.002
19	Mercury (Hg)	0.001	No relaxation
20	Cadmium (Cd)	0.01	No relaxation
21	Selenium (Se)	0.01	No relaxation
22	Arsenic (As)	0.05	No relaxation
23	Cyanide (CN)	0.05	No relaxation
24	Lead (Pb)	0.05	No relaxation
25	Zinc (Zn)	5.0	15
26	Hexavelant Chromium	0.05	No relaxation
27	Alkalinity	200	600
28	Aluminum (Al)	0.03	0.2

Explain the different methods of purification of water

ans) Raw water may contain suspended, colloidal and dissolved

impurities.

The purpose of water treatment is to remove all those impurities which are unpleasant either from taste and odour point of view or public health point of view.

Following are the purposes of water treatment-

- To remove colour, dissolved gases and murkiness of water
- To remove the unpleasant taste and odour.
- To remove the disease producing micro organism, so that water is safe for drinking purposes.
- To remove hardness of water
- To make it suitable for a wide variety of industrial purposes such as stream generation, brewing, dyeing.

Following are the methods of purification of water

a) Screening

b) Aeration

c) Sedimentation

d) Filtration

e) Disinfection

f) Miscellaneous treatment

Screening

- This is adopted to remove all the floating matter from surface water.
- It is generally provided at the intake point of the treatment plant

Aeration

- This is adopted to remove unpleasant taste and odour and also to remove the dissolved gases such as carbon dioxide, hydrogen sulphide etc
- The iron and manganese present in water are also oxidized to some extent
- This process is option and is not provided in cases where water does not contain objectionable taste and odour.

Sedimentation with or without coagulants

- The process of sedimentation is to remove the suspended impurities
- With the help of plane sedimentation, silt and sand can be removed
- However with the help of sedimentation with coagulants, very fine suspended particles and bacteria can be removed

Filtration

- The process of filtration forms the important stage in the purification of water
- Filtration remove very fine suspended particles and colloidal impurities that may have escape the sedimentation tank
- In addition, the micro organisms present in water can be removed.

Disinfection

- It is carried out to reduce or eliminate the remaining microorganism to a safe minimum limit,
- And to prevent contamination of water during its transportation from treatment plant to the place of its consumption

Miscellaneous treatment

- These include water softening, desalination, removal of iron, manganese and any other type of harmful constituent

Explain the difference between slow sand filter and rapid sand filter ans)

S.No.	Characteristic	Rapid Sand Filter	Slow Sand Filter
1	Space	Occupies little space	Occupies large area
2	Rate of Filtration	200 million gallon per acre per day 100 times faster than SSF	2-3 million gallon per acre per day
3	Effective sand size	0.4 - 0.7mm	0.2 - 0.3mm
4	Preliminary treatment	Coagulation & Sedimentation	Plain Sedimentation
5	Washing	By back washing	By scraping the sand
6	Loss of head allowed	6-8 feet – higher than SSF	4 feet
7	Removal of turbidity	Good	Good

8	Removal of color	Good	Fair
9	Removal of bacteria	98 to 99 %	99.9 to 99.99 %
10	Operation	Requires expert supervision	Dose not require expert supervision
11	Cost of operation	Capital cost low Running cost high	Capital cost high Running cost low
12	Reliability for bacteria removal	Slightly less	High
13	Suitability for turbid water	Suitable	Not Suitable
14	Common applications	Small groundwater systems	Most commonly used filter for surface water treatment

Explain the different methods of disinfection

ans) Following are the methods of disinfection

1) Boiling method
2) Excess lime treatment
3) Iodine and Bromine treatment
4) Ozone treatment
5) Potassium permanganate
6) Silver treatment
7) Ultra- violet ray treatment

Ozone treatment

- The atmospheric oxygen is in molecular form containing two atoms of oxygen
- But when a high- tension electric current is passed through a stream of air in a closed chamber, triatomic molecules of oxygen are formed as shown by the following equation

$$O2 + O = O3$$

- Such oxygen is known as Ozone
- The third atom is very loosely bound and the ozone easily breaks down into oxygen and releases nascent oxygen which is very powerful in killing bacteria
- The advantage of ozone treatment is that ozone is unstable and it does not remain in the water when it reaches the consumer
- The dosage of Ozone is about 2 to 3 p.p.m to obtain residual ozone of 0.1 p.p.m and the contact period is about 10 minutes or so
- But the cost of ozone treatment is much more than that of chlorination
- However, it is adopted in France and Russia to disinfect water on a large scale
- Ozone as such is a powerful agent, bleaching agent and bactericide

Explain the different methods of removing temporary and permanent hardness ans)

Types of hardness

Following are the two types of hardness

  - Temporary hardness
  - Permanent hardness

- The temporary hardness is due to the presence of bicarbonates of calcium and magnesium and is also known as carbonate hardness
- The permanent hardness is mainly due to the presence of sulphates, chlorides and nitrates of calcium and magnesium and is also known as non- carbonate hardness

Removal of temporary hardness

- The temporary hardness of water can be removed either by boiling or by adding lime
- The reactions involved are as follow

$$Ca(HCO3)2 + Heat = CaCO3 + CO2 + H2O$$

$Ca(HCO3)2 + Ca(OH)2 = 2CaCO3 + 2H2O$

$Mg(HCO3)2 + Ca(OH)2 = CaCO3 + MgCO3 + 2H2O$

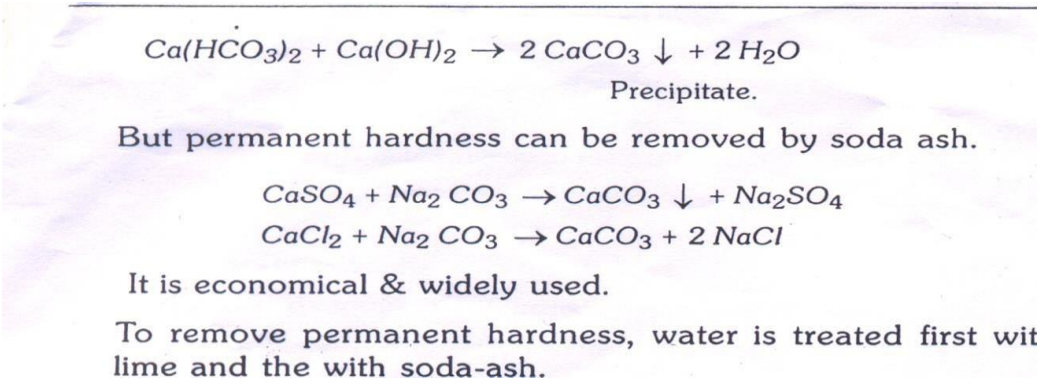
- The calcium carbonate CaCO3 and magnesium carbonate MgCO3 are insoluble in water
- They can, therefore be easily removed in the sedimentation tanks
- The boiling of water on a large scale is impracticable and uneconomical
- Hence, addition of lime is preferred, instead of boiling, for the removal of temporary hardness

Removal of Permanent hardness

- It is caused due to the presence of sulphates, chlorides and nitrates of Calcium and Magnesium
- This can be removed by
  - Lime- Soda process
  - Base- Exchange process
  - Demineralization

Lime- Soda process

- In this process the salts responsible for hardness are converted into insoluble form so that they can be precipitated out
- Temporary hardness can be removed by lime only



Base Exchange process

- This process is also known as Zeolite or Cation Exchange process
- The hard water is passed through a bed of zeolite sand (complex silicates of Aluminium and Sodium)

- While passing through it the Ca and Mg Cation get replaced by sodium from the exchanger and water becomes soft

(a) For softening the water

$$Na_2Z + \begin{Bmatrix} Ca(HCO_3)_2 \\ CaSO_4 \\ CaCl_2 \\ Mg(HCO_3)_2 \\ MgSO_4 \\ MgCl_2 \end{Bmatrix} \rightarrow \begin{Bmatrix} Ca \\ Ca \\ Ca \\ Mg \\ Mg \\ Mg \end{Bmatrix} Z + \begin{Bmatrix} 2\,NaHCO_3 \\ Na_2SO_4 \\ 2NaCl \\ 2NaHCO_3 \\ Na_2SO_4 \\ NaCl \end{Bmatrix}$$

(b) For charging the Zeolite

$$\begin{Bmatrix} Ca \\ Mg \end{Bmatrix} Z + 2\,NaCl \rightarrow Na_2Z + \begin{Bmatrix} Ca \\ Mg \end{Bmatrix} Cl_2.$$

Demineralization process

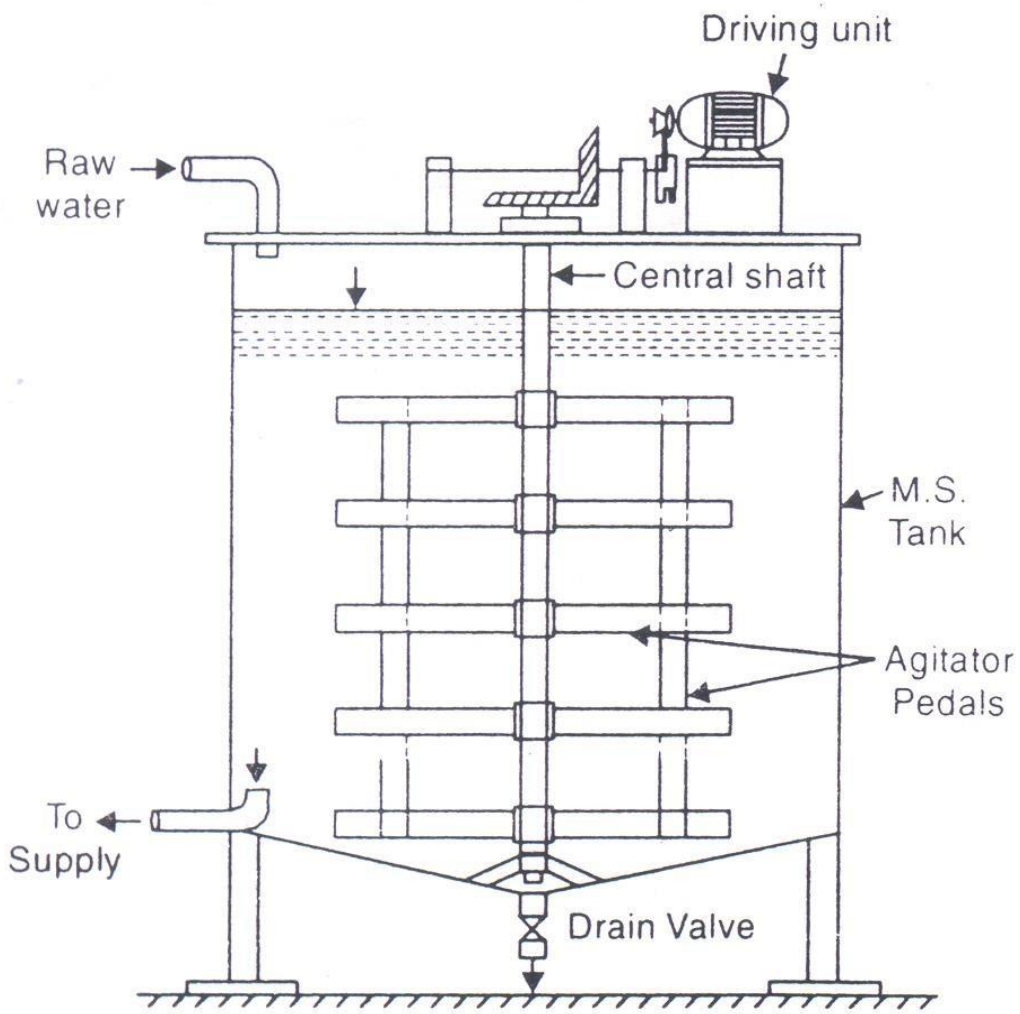
- Softening of water can be done by demineralization process which is also known as de- ionized water
- In this method, first the minerals are removed by passing the water through a bed of cation exchange resins and then passing through a bed of anion exchange resins
- The anion exchange resins are formed by the condensation of amines with formaldehyde
- When water is passed through these two stages, the mineral impurities are removed
- After sometime of working the cation exchange resins and anion exchange resins are exhausted and can be regenerated by treatment with sulphuric acid and sodium carbonate respectively

Explain the method of defluoridation? ans)

Deflouriodation of water

- When concentration of flourides in water is more than 1.5 mg/l, mottling of teeth or dental flourosis occurs
- These are highly prevalent among the people of states like Rajasthan, Punjab, Haryana, Andhra Pradesh, Bihar, Gujarat, and Tamil Nadu, where ground water containing high concentrations of flourides is used for household consumption

- A simple method of deflouriodation which has been popularly used for domestic as well as community water supply schemes is the Nalgonda Technique developed by NEERI



Deflouridation plant

Fig. 7.21. (Fill and Draw Type)

- This involves the addition of two readily available chemicals- lime and alum
- The process employees the sequence of precipitation, settling and filtration
- Raw water is pumped into the tank and the required amounts of lime, bleaching powder and alum are added
- The contents are stirred slowly for ten minutes and then allowed to settle down for 1-2 hours
- The supernatent deflouridated water is withdrawn for supply and the settled sludge is disposed of seperately

Explain the different classification of distribution system? ans)

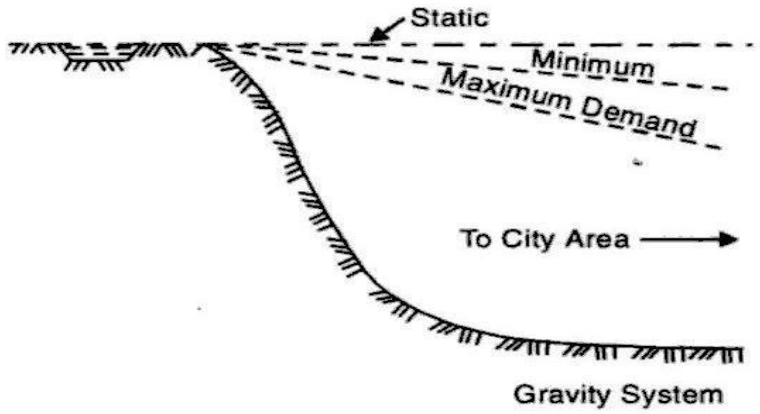
Classification of distribution system

Depending upon the methods of distribution, the system are classified as

- Gravity system
- System with direct pumping
- System with pumping and storage

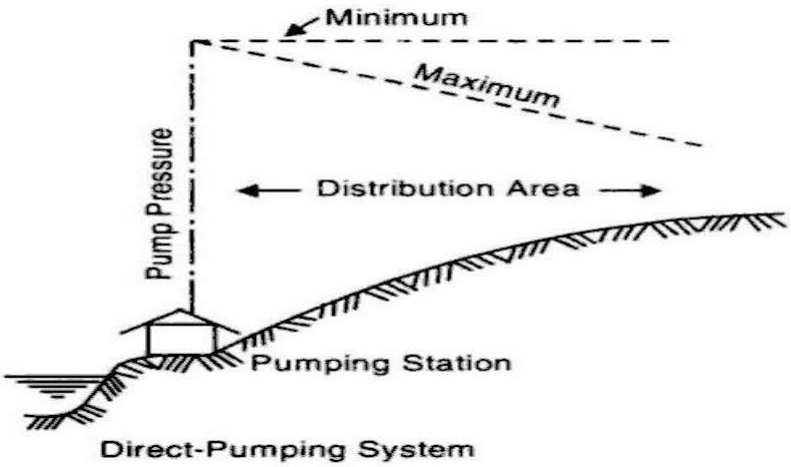
Gravity system

- A gravity system is adopted where the source of supply such as a lake or on impounding reservoir, is at a sufficient elevation with respect to the city in order to produce adequate pressures for fire and domestic service
- This method is the safest and most reliable



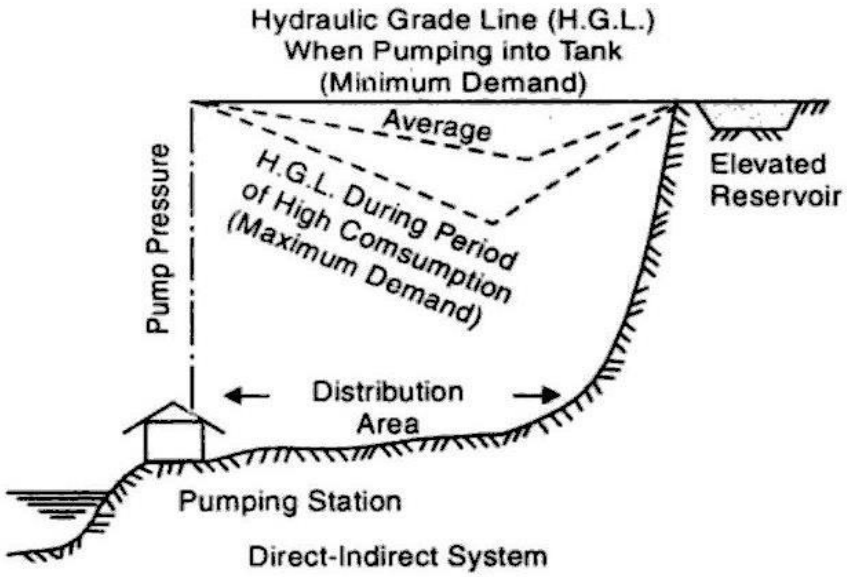
System with direct pumping

- In this, water is directly pumped into the mains
- Consumption is the only outlet
- This method is least desirable, a failure in the power- supply means breakdown of the system
- Also pressures in the mains vary with the consumption,
- So that under varying consumption, several pumps may be required to conform to the supply, adding to cost



System with pumping and storage

- This is also called the direct- indirect or dual system
- In this, when the demand- rate exceeds the rate of pumping, the flow into the distribution system is both from the pumping- station as well as the elevated reservoir
- When, however, the reverse condition exists i.e. pumping is more than the demand, the excess of water is stored in the reservoir
- This system obviously is the most economical and reliable
- The water stored serves as a reserve to take care of fire demands and pump break



9) Explain the different pipe appurtenances in the distribution system ans)

- The distribution pipes are provided with various pipe appurtenances or accessories so as to make the distribution of water easy and effective

- Following are some such appurtenances-
  - Sluice Valves
  - Check Valves or Reflux Valves
  - Air Valves
  - Drain valves or Blow-off Valves
  - Scour Valves
  - Fire Hydrants
  - Water Meters

Sluice Valves

- These are provided to control the flow of water in the distribution system, at street corners and where the pipe lines intersect

- These valves should be spaced at short intervals in order to cause minimum dislocation of the service, if a portion of pipes line is to be shut off

- These are also known as Gate Valves or Stop Valves

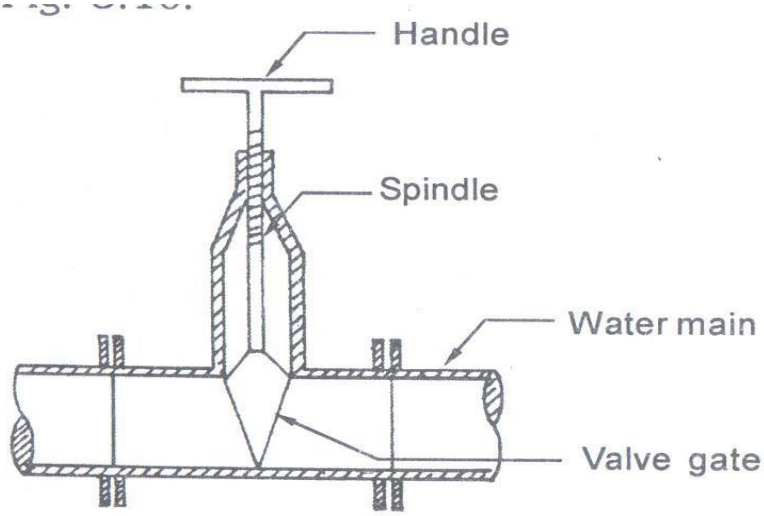


FIG 5.10 : Sluice Valve (or) Gate Valve

Check valves or Reflux valves

- These are also known as Non Return Valves
- A reflux valve is an automatic device which allows water to go in one direction only
- When water moves in the direction of flow, the valve swings or rotates around the pivot and it is kept in an open position due to the pressure of water
- When the water tries to move in the backward direction, the flow gets ceased by the valve itself.

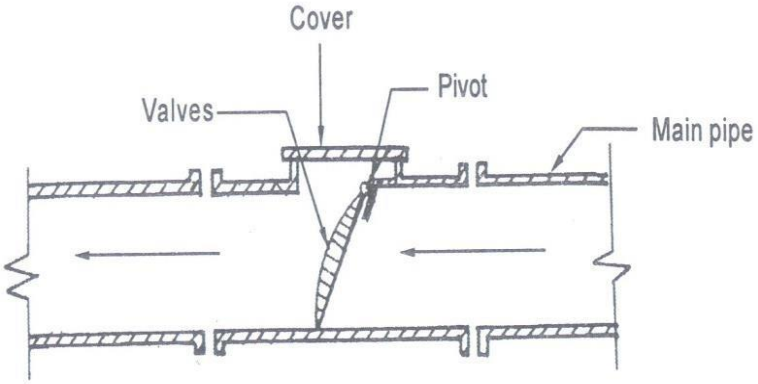


FIG 5.11 : Check Valve or Reflux Valve

3. **Air Valves :** These are automatic valves and are of two types namely
   (a) Air Inlet Valves.
   (b) Air relief Valves.

(a) Air Inlet Valves : Air inlet valves are those which open automatically and allow air to enter into the pipe line so that development of negative pressure can be avoided in the pipe lines. The vacuum pressures are created in the down stream side in pipe lines due to sudden closure of sluice valves.

(b) **Air Relief Valves** : Some times air is accumulated at the summits of pipe lines and blocks the flow of water due to air lock. In such cases the accumulated air has to be removed from the pipe lines. This is done automatically by means of ***"Air Relief Valves"***.

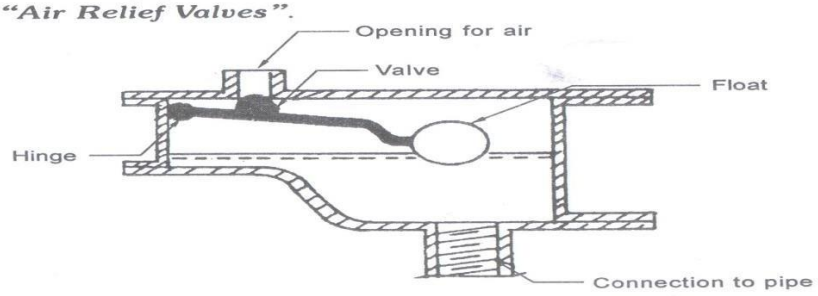


FIG 5.12 : Air Relief Valve

Drain Valves or Blow Off- Valves

- These are also called washout valves
- They are provided at all dead ends and depressions of pipe lines to drain out the waste water
- These are ordinary valves operated by hand

Scour Valves

- These are also ordinary valves operated by hand
- These are similar to Blow off Valves
- These are located at the depressions and dead ends to remove the accumulated silt and sand
- After the complete removal of silts, the valve is closed

Fire Hydrants

- Fire hydrants are the mountings on water mains and distribution pipes acting as outlets for drawing large quantities of water for fire fighting purposes
- The requirements of a good fire hydrants are
  - It should be of such a form that they may be connected at any point easily
  - It should allow the full undisturbed flow as opening the valve
  - It should be of moderate cost

The types of Fire hydrants are

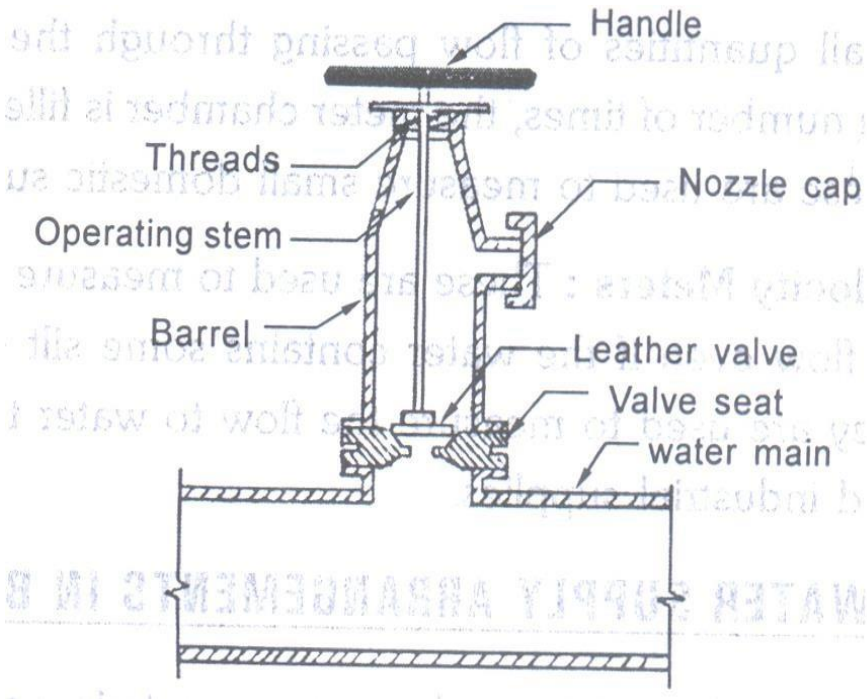
- Flush Hydrants
- Post hydrants

Flush hydrants

- A flush hydrant is provided below the foot path or street level and it is protected or covered by a cast-iron box or brick masonry chamber
- The flush hydrant is more safely attached to water pipe and can not be easily dislocated
- Usually, a plate with letter F.H is attached as some near by permanent structures Post

Hydrants

- The post hydrants remains projected 60 to 90 cm above ground level
- Then have a long stem with screw and nut to regulate the flow
- In case of fire accident, the fire fighting squad connect their hose to the hydrant and draw the water and spray it on fire
- A good fire hydrants should be able to draw large quantities of water



Water Meters

- The water meters are used for measuring water under pressure
- They are essential for controlling and regulating the supply and preventing the waste

The characteristics of water meter

- It should register all the water flowing through it
- It should be easy to maintain and repair
- It should be capable of working at all pressures efficiently
- It should absorb minimum head in working
- Its parts should not be affected by chemicals used for purification and the impurities in water
- It should prevent back-flow passing through it and should not be liable to clogging
- It should not register any flow when no water passes through it Types

of water meters

  - Displacement meters
  - Velocity meters

Displacement meters

- These are accurate and measure even small quantities of flow passing through them by counting the number of times, the meters chamber is filled and emptied
- These are used to measure small domestic supplies

Velocity meters

- These are used to measure large quantities of flow even if the water contains some silt content
- Hence they are used to measure the flow to water treatment plants and industrial supplies

SECTION –A

(Very Short Answer Type Question)

a) Supply system
b) Sedimentation
c)Coagulation
d) Filtration
e)pH value
f) disinfection
g)Back filling
h) Surface drains
i) grease and oil trap
j) inverted siphon
k) trickling filter
l) BOD

SECTION- B

(Short Answer Type Questions)

Q- I How will you determine turbidity of water sample
Q-II What are the methods of Population Forecasting
Q-III What are the variation in rate of demand.
Q-IV Draw Flow diagram of different water treatment units
Q-V Diff. b/w slow and rapid sand filters.
Q-VI What are the different types of pipes use in w. s.

Q-VII What are layout of distribution system.
Q- VIII What are different types of pipe joints
Q- IX Explain Testing of pipe lines.
Q-X Draw layout Connections to water main.

SECTION-C

(Long Answer Type Questions)

1. Q-3 Natural Methods of Sewerage Disposal
2. Q-4 Explain Location, function and construction features of Manholes with diagrams.
3. Q-5 Explain steps Sewage Treatment process with flow diagrams
4. Q-6 Physical, chemical and bacteriological analysis of sewage
5. Q-7 Explain Standard of potable water as per Indian Standard.