EN8491WATER SUPPLY ENGINEERING

UNIT I SOURCES OF WATER

Public water supply system – Planning, Objectives, Design period, Population forecasting; Water demand – Sources of water and their characteristics, Surface and Groundwater – Impounding Reservoir – Development and selection of source – Source Water quality – Characterization – Significance – Drinking Water quality standards.

UNIT II CONVEYANCE FROM THE SOURCE

Water supply – intake structures – Functions; Pipes and conduits for water – Pipe materials – Hydraulics of flow in pipes – Transmission main design – Laying, jointing and testing of pipes – appurtenances – Types and capacity of pumps – Selection of pumps and pipe materials.

UNIT III WATER TREATMENT

Objectives – Unit operations and processes – Principles, functions, and design of water treatment plant units, aerators of flash mixers, Coagulation and flocculation – Clarifloccuator-Plate and tube settlers - Pulsator clarifier - sand filters - Disinfection - Residue Management –Construction, Operation and Maintenance aspects.

UNIT IV ADVANCED WATER TREATMENT

Water softening – Desalination- R.O. Plant – demineralization – Adsorption - Ion exchange– Membrane Systems – RO Reject Management - Iron and Manganese removal - Defluoridation - Construction and Operation & Maintenance aspects – Recent advances - MBR process

UNIT V WATER DISTRIBUTION AND SUPPLY

Requirements of water distribution – Components – Selection of pipe material – Service reservoirs – Functions – Network design – Economics – Analysis of distribution networks -Computer applications – Appurtenances – Leak detection. Principles of design of water supply in buildings – House service connection – Fixtures and fittings, systems of plumbing and types of plumbing.

TOTAL: 45 PERIODS

TEXTBOOKS:

1. Garg, S.K. Environmental Engineering, Vol.IKhanna Publishers, New Delhi, 2010.
2. Modi, P.N., Water Supply Engineering, Vol.I Standard Book House, New Delhi, 2010.
3. Punmia, B.C.,Ashok Jain and Arun Jain, Water Supply Engineering, Laxmi Publications (P) Ltd., New Delhi, 2014.

REFERENCES:

1. Manual on Water Supply and Treatment, CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 1999.
2. Syed R. Qasim and Edward M. Motley Guang Zhu, Water Works Engineering Planning, Design and Operation, Prentice Hall of India Learning Private Limited, New Delhi, 2009.

Department of Civil Engineering

SUBJECT CODE: EN8491

SUBJECT NAME: WATER SUPPLY ENGINEERING

Semester & Year: V & III

.

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ANNA UNIVERSITY, CHENNAI-25

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UNIT II CONVEYANCE SYSTEM 9

Water supply -intake structures -Functions and drawings -Pipes and conduits for water- Pipe materials - Hydraulics of flow in pipes -Transmission main design -Laying, jointing and testing of pipes - Drawings appurtenances - Types and capacity of pumps -Selection of pumps and pipe materials.

UNIT III WATER TREATMENT 9

Objectives - Unit operations and processes - Principles, functions design and drawing of Chemical feeding, Flash mixers, flocculators, sedimentation tanks and sand filters - Disinfection- Residue Management - Construction and Operation & Maintenance aspects of Water Treatment Plants.

UNIT IV ADVANCED WATER TREATMENT 9

Principles and functions of Aeration - Iron and manganese removal, Defluoridation and demineralization -Water softening - Desalination - Membrane Systems - Recent advances.

UNIT V WATER DISTRIBUTION AND SUPPLY TO BUILDINGS 9

Requirements of water distribution -Components -Service reservoirs -Functions and drawings -Network design -Economics -Computer applications -Analysis of distribution networks -Appurtenances -operation and maintenance -Leak detection, Methods. Principles of design of water supply in buildings -House service connection -Fixtures and fittings -Systems of plumbing and drawings of types of plumbing.

TOTAL:45 PERIODS

TEXTBOOK:

1. Garg, S.K., "Environmental Engineering", Vol.1 Khanna Publishers, New Delhi, 2005.
2. Modi, P.N. "Water Supply Engineering", Vol. I Standard Book House, New Delhi, 2005.
3. Punmia, B.C., Ashok K Jain and Arun K Jain, "Water Supply Engineering", Laxmi Publications Pvt. Ltd., New Delhi, 2005

REFERENCES:

1. Government of India, "Manual on Water Supply and Treatment", CPHEEO, Ministry of Urban Development, New Delhi, 2003
2. Syed R. Qasim and Edward M. Motley Guang Zhu, "Water Works Engineering Planning", Design and Operation, Prentice Hall of India Private Limited, New Delhi, 2006.

AIM AND OBJECTIVE OF THE SUBJECT

AIM:

To make the students conversant with principles of water supply, treatment and distribution.

OBJECTIVES:

The students learning the course will have an

- An insight into the structure of drinking water supply system, including water transports, treatment and distribution
- An Understanding of water quality criteria and standards, and their relation to public health.
- The ability to design and evaluate water supply project alternatives on basis of chosen selection criteria.

DETAILED LESSON PLAN

Code and title of the subject: EN8491 – WATER SUPPLY ENGINEERING

Text Book:

1. 1. Garg, S.K., "Environmental Engineering", Vol.1 Khanna Publishers, New Delhi, 2005.
2. 2. Modi, P.N. "Water Supply Engineering", Vol. I Standard Book House, New Delhi, 2005.
3. 3. Punmia, B.C., Ashok K Jain and Arun K Jain, "Water Supply Engineering", Laxmi Publications Pvt. Ltd., New Delhi, 2005

Reference Books*:*

1. Government of India, "Manual on Water Supply and Treatment", CPHEEO, Ministry of Urban Development, New Delhi, 2003

2. Syed R. Qasim and Edward M. Motley Guang Zhu, "Water Works Engineering
3. Planning", Design and Operation, Prentice Hall of India Private Limited, New Delhi, 2006.

Sl.no	Unit	Topic/Portions to be Covered	Hours Required/ Planned	Cummulative Hrs	Books Referred
UNIT – I PLANNING FOR WATER SUPPLY SYSTEM					
1	1	Public water supply system -Planning - Objectives	2	2	T1, T2, R2
2	1	Design period - Population forecasting	2	4	T1, T2, R2
3	1	Water demand -Sources of water and their characteristics	2	6	T1, T2, R2
4	1	Surface and Groundwater- Impounding Reservoir Well hydraulics	2	8	T1, T2, R2
5	1	Development and selection of source	2	10	T1, T2, R2
6	1	Water quality - Characterization and standards	2	12	T1, T2, R2
7	1	Impact of climate change.	2	14	T1, T2, R2
UNIT – II CONVEYANCE SYSTEM					
8	2	Water supply -intake structures	2	16	T1, T2, R2
9	2	Functions and drawings -Pipes and conduits for water	2	18	T1, T2, R2
10	2	Pipe materials - Hydraulics of flow in pipes	1	19	T1, T2, R2
11	2	Transmission main design -Laying, jointing and testing of pipes	2	21	T1, T2, R2
12	2	Drawings appurtenances	1	20	T1, T2, R2
13	2	Types and capacity of pumps	1	21	T1, T2, R2

14	2	Selection of pumps and pipe materials.	1	22	T1, T2, R2
UNIT – III WATER TREATMENT					
15	3	Objectives - Unit operations and processes	1	23	T1.T3,R1
16	3	Principles, functions design and drawing of Chemical feeding	1	24	T1.T3,R1
17	3	Flash mixers,	1	25	T1.T3,R1
18	3	Flocculators	1	26	T1.T3,R1
19	3	Sedimentation tanks	1	27	T1.T3,R1
20	3	Sand filters.	1	28	T1.T3,R1
21	3	Disinfection- Residue Management	1	29	T1.T3,R1
22	3	Construction and Operation & Maintenance aspects of Water Treatment Plants.	1	30	T1.T3,R1
UNIT - IV ADVANCED WATER TREATMENT					
23	4	Principles and functions of Aeration	1	31	T1, T2,T3
24	4	Iron removal	1	32	T1, T2,T3
25	4	Manganese removal	1	33	T1, T2,T3
26	4	Defluoridation	1	34	T1, T2,T3
27	4	Demineralization	1	35	T1, T2,T3
28	4	Water softening	1	36	T1, T2,T3
29	4	Desalination	1	37	T1, T2,T3
30	4	Membrane Systems - Recent advances.	1	38	T1, T2,T3
UNIT - V WATER DISTRIBUTION AND SUPPLY TO BUILDINGS					
31	5	Requirements of water distribution - Components -Service reservoirs	1	39	T1, T2,T3
32	5	Functions and drawings -Network design - Economics -Computer applications	2	40	T1, T2,T3
33	5	Analysis of distribution networks – Appurtenances	1	41	T1, T2,T3
34	5	Operation and maintenance -Leak detection, Methods.	1	42	T1, T2,T3
35	5	Principles of design of water supply in buildings	1	43	T1, T2,T3
36	5	House service connection -Fixtures and fittings	1	44	T1, T2,T3
37	5	Systems of plumbing and drawings of types of plumbing.	1	45	T1, T2,T3

Industrial / Practical Connectivity of the subject

The field of Environmental Engineering and Science has made incredible contributions to improving public health and quality of life over the past century, with particularly strong advances in drinking water treatment, wastewater treatment, air pollution control, and contaminant fate and transport. In recent years, however, this success has led environmental regulatory and funding agencies, to begin to reorient their focus toward addressing other environmental challenges, often in areas related to energy, climate change and broader questions of sustainability.

The Global Challenge for Water Supply: Seawater Desalination a Sustainable Solution

UNIT – I

PLANNING FOR WATER SUPPLY SYSTEM

PART-A

1. What are the objectives of water supply system? (Nov/Dec-2012) (Nov/Dec-2013)(Nov/Dec-2014)

- To provide wholesome water to the consumer for drinking purpose.
- To supply adequate quantity of water to meet the least minimum needs of the individuals.
- To make adequate provisions for emergencies like fire-fighting, festivals, meeting, etc.
- To make provisions for future demand due to increase in population, increase in standard of living, storage and conveyance.
- To prevent pollution of water at source, storage and conveyance.
- To maintain the treatment units and distribution system in good condition with adequate staff and material.
- To design and maintain the system that is economical and reliable.

2. Define design period?(Nov/Dec-2011) (Nov/Dec-2012) (Nov/Dec-2013) (Nov/Dec-2010)

- This time after completion of the project is called “design period”.
- It is expressed in years.
- During design period, the structures, equipment and components should be adequate to serve the requirements.
- As per normal procedure water works is designed for a period of 30 years.

Influencing factors:

- Useful life of pipes, equipment and structures.
- The anticipated rate of growth. If rate is more, design period will be less.
- The rate of inflation during the period of repayment of loans when inflation rate is high, a longer design period is adopted.
- Efficiency of the component units. The more the efficiency, the longer will be design period.

3. What is per capita water demand? (Nov/Dec-2012)

It is the annual average amount of daily water required by one person, and it includes the domestic use, industrial and commercial use, public use, wastes, thefts, etc.

$$\text{Per capita demand (Lit/head)} = \frac{\text{Total yearly water requirement of the city in liters (V)}}{365\times \text{ Design population}}$$

4. What are the population forecasting methods? (Apr/May-2012)

1. Arithmetic increase method.
2. Geometric increase method.
3. Incremental increase method.
4. Decreasing rate of growth method.
5. Simple graphical method.
6. Comparative graphical method.
7. Master plan method or Zoning method.
8. The Ratio method.
9. The Logistic curve method.

5. How to determine the storage capacity of impounding reservoir? (Apr/May-2014)

- Mass curve diagram method
- Analytical calculation method

6. List out the standards for water quality? (Apr/May-2013)

- Colour – 5 to 25 cobalt units
- pH – 6.5 to 8.5
- Chlorides – 200 to 1000 mg/l
- Sulphates – 200 to 400 mg/l
- Flourides – 1 mg/l

- Nitrates – 45 mg/l

7. What is an Artesian well? (Nov/Dec-2010)

- The Artesian well is a source of underground-water spring in which the water is stored under pressure
- Flow is through confined aquifer.
- It will yield a Uniform quantity of flow
- In artesian wells since the water oozes out in pressure, they are able to provide high yield.

8. What are the physical and chemical characteristics of water along with the standards? (Nov/Dec-2011) (Nov/Dec-2010)

As per Indian Standard Drinking Water Specifications (IS 10500:1991)

PHYSICAL CHARACTERISTICS	STANDARDS
Turbidity	5NTU
Colour	5 Hazen units
Taste	Agreeable
Odour	Unobjectionable
Temperature	10˚ C – 25 ˚C

CHEMICAL CHARACTERISTICS	STANDARDS
pH	6.5-8.5
Total hardness	300 mg/l
Iron content	0.3mg/l
Chloride content	250mg/l
Nitrogen content	0.15mg/l
Alkalinity	200mg/l

9. What are the different types of surface and under-ground water?

Surface sources:

a) Natural ponds and lakes.
b) Streams and rivers
c) Impounding reservoir.

Under-ground sources:

a) Infiltration galleries
b) Infiltration wells.
c) Springs.
d) Wells including tube wells.

10. Explain the impact of climate change?

High temperature

Increase variability in precipitation.

Emission of green house gases.

PART – B

1) Explain in detail about the water quality standards. (Nov/Dec 2012)

Water Quality Standards

The objective of water works management is to provide water free from pathogens, undesirable taste, odour, corrosion, scale forming and harmful minerals which is clear, palatable.

(a) Physical and Chemical quality of drinking water

RECOMMENDED GUIDELINES FOR PHYSICAL AND CHEMICAL PARAMETERS

Sl. No.	Characteristics	*Acceptable	**Cause for Rejection
1.	Turbidity (NTU)	1	10
2.	Colour (Units on Platinum Cobalt scale)	5	25
3.	Taste and Odour	Unobjectionable	Objectionable
4.	pH	7.0 to 8.5	<6.5 or > 9.2
5.	Total dissolved solids (mg/l)	500	2000
6.	Total hardness (as $CaCO_3$) (mg/l)	200	600
7.	Chlorides (as Cl) (mg/l)	200	1000
8.	Sulphates (as SO_4) (mg/l)	200	400
9.	Fluorides (as F) (mg/l)	1.0	1.5
10.	Nitrates (as NO_3) (mg/l)	45	45
11.	Calcium (as Ca) (mg/l)	75	200
12.	Magnesium (as Mg) (mg/l)	≤ 30	150

13.	Iron (as Fe) (mg/l)	0.1	1.0
14.	Manganese (as Mn) (mg/l)	0.05	0.5
15.	Copper (as Cu) (mg/l)	0.05	1.5
16.	Aluminium (as Al) (mg/l)	0.03	0.2
17.	Alkalinity (mg/l)	200	600
18.	Residual Chlorine (mg/l)	0.2	>1.0
19.	Zinc (as Zn) (mg/l)	5.0	15.0
20.	Phenolic compounds (as Phenol) (mg/l)	0.001	0.002
21.	Anionic detergents (mg/l) (as MBAS)	0.2	1.0
22.	Mineral Oil (mg/l)	0.01	0.03
	TOXIC MATERIALS		
23.	Arsenic (as As) (mg/l)	0.01	0.05
24.	Cadmium (as Cd) (mg/l)	0.01	0.01
25.	Chromium (as hexavalent Cr) (mg/l)	0.05	0.05
26.	Cyanides (as CN) (mg/l)	0.05	0.05
27.	Lead (as Pb) (mg/l)	0.05	0.05
28.	Selenium (as Se) (mg/l)	0.01	0.01
29.	Mercury (total as Hg) (mg/l)	0.001	0.001
30.	Polynuclear aromatic hydrocarbons (PAH) (µg/l)	0. 2	0. 2
31.	Pesticides (total, mg/l)	Absent	Refer to WHO guidelines for drinking water quality Vol 1. – 1993
	RADIO ACTIVITY+		
32.	Gross Alpha activity (Bq/l)	0.1	0.1
33.	Gross Beta activity (Bq/l)	1.0	1.0

Bacteriological Characteristics

BACTERIOLOGICAL QUALITY OF DRINKING WATER[a]

Organisms	Guideline value
All water intended for drinking	
E.coli or thermotolerant coliform bacteria[b,c]	Must not be detectable in any 100-ml sample
Treated water entering the distribution system	
E.coli or thermotolerant coliform bacteria[b]	Must not be detectable in any 100-ml sample
Total coliform bacteria	Must not be detectable in any 100-ml sample
Treated water in the distribution system	
E.coli or thermotolerant coliform bacteria[b]	Must not be detectable in any 100-ml sample
Total coliform bacteria	Must not be detectable in any 100-ml sample. In case of large supplies, where sufficient samples are examined, must not be present in 95% of samples taken throughout any 12 month period.

(c) Virological Quantity

Entero viruses should be removed which are due to faecal contamination. Water should be free from faecal contamination or it should be treated to reduce the risk of virus infections. From virological, Epidemological and risk analysis the treatment methods are recommedded to obtain virus free water for drinking.

RECOMMENDED TREATMENT FOR DIFFERENT WATER SOURCES TO PRODUCE WATER WITH NEGLIGIBLE VIRUS RISK[a]

Type of Source	Recommended Treatment
Ground water	
Protected, deep wells; essentially free of faecal contamination	Disinfection[b]
Unprotected, shallow wells; faecally contaminated	Filtration and disinfection
Surface water	
Protected, impounded upland water; essentially free of faecal contamination	Disinfection
Unprotected impounded water or upland river; faecal contamination	Filtration and disinfection

Type of Source	Recommended Treatment
Unprotected lowland rivers; faecal contamination	Pre-disinfection or storage, filtration, disinfection
Unprotected watershed; heavy faecal contamination	Pre-disinfection or storage, filtration, additional treatment and disinfection
Unprotected watershed; gross faecal contamination	Not recommended for drinking water supply

2) Explain laboratory procedure to find out physical, chemical, biological characteristics of water. (May/Jun 2012)

Characteristics of water are physical, chemical and bacteriological which defines water quality.

Physical Characteristics

- **Turbidity**
- **Colour**
- **Taste and Odour**
- **Temperature**

Turbidity

If a large amount of suspended solids are present in water, it will appear turbid in appearance. The turbidity depends upon fineness and concentration of particles present in water. Originally turbidity was determined by measuring the depth of column of liquid required to cause the image of a candle flame at the bottom to diffuse into a uniform glow. This was measured by Jackson candle turbidity meter. The calibration was done based on suspensions of silica from Fuller's earth. The depth of sample in the tube was read against the part per million (ppm) silica scales with one ppm of suspended silica called one Jackson Turbidity unit (JTU). Because standards were prepared from materials found in nature such as Fuller's earth, consistency in standard formulation was difficult to achieve. These days turbidity is measured by applying Nephelometry, a technique to measure level of light scattered by the particles at right angles to the incident light beam. The scattered light level is proportional to the particle concentration in the sample. The unit of expression is Nephelometric Turbidity Unit (NTU). The IS values for drinking water is **10 to 25 NTU**.

Colour

Dissolved organic matter from decaying vegetation or some inorganic materials may impart colour to the water. It can be measured by comparing the colour of water sample with other standard glass tubes containing solutions of different standard colour intensities. The standard unit of colour is that which is produced by one milligram of platinum cobalt dissolved in one litre of distilled water. The IS value for treated water is **5 to 25 cobalt units**.

Taste and Odour

Odour depends on the contact of a stimulating substance with the appropriate human receptor cell. Most organic and some inorganic chemicals, originating from municipal or industrial wastes, contribute taste and odour to the water. Taste and odour can be expressed in terms of odour intensity or threshold values.

A new method to estimate taste of water sample has been developed based on flavour known as 'Flavour Profile Analysis' (FPA). The character and intensity of taste and odour discloses the nature of pollution or the presence of microorganisms.

Temperature

The increase in temperature decreases palatability, because at elevated temperatures carbon dioxide and some other volatile gases are expelled. The ideal temperature of water for drinking purposes is **5 to 12 °C** - above 25 °C, water is not recommended for drinking.

Chemical Characteristics

- **pH** (Power or Percentage of Hydrogen)
- **Acidity**
- **Alkalinity**
- **Hardness**
- **Chlorides**
- **Sulphates**
- **Iron**
- **Solids**
- **Nitrates**

pH (Power or Percentage of Hydrogen)

pH value denotes the acidic or alkaline condition of water. It is expressed on a scale ranging from 0 to 14, which is the common logarithm of the reciprocal of the hydrogen ion concentration. The recommended pH range for treated drinking waters is **6.5 to 8.5**.

Acidity

The acidity of water is a measure of its capacity to neutralise bases. Acidity of water may be caused by the presence of un-combined carbon dioxide, mineral acids and salts of strong acids and weak bases. It is expressed as mg/L in terms of calcium carbonate. Acidity is nothing but representation of carbon dioxide or carbonic acids. Carbon dioxide causes corrosion in public water supply systems.

Alkalinity

The alkalinity of water is a measure of its capacity to neutralise acids. It is expressed as mg/L in terms of calcium carbonate. The various forms of alkalinity are (a) hydroxide alkalinity, (b) carbonate alkalinity, (c) hydroxide plus carbonate alkalinity, (d) carbonate plus bicarbonate alkalinity, and (e) bicarbonate alkalinity, which is useful mainly in water softening and boiler feed water processes. Alkalinity is an important parameter in evaluating the optimum coagulant dosage.

Hardness

If water consumes excessive soap to produce lather, it is said to be hard. Hardness is caused by divalent metallic cations. The principal hardness causing cations are calcium, magnesium, strontium, ferrous and manganese ions. The major anions associated with these cations are sulphates, carbonates, bicarbonates, chlorides and nitrates. The total hardness of water is defined as the sum of calcium and magnesium concentrations, both expressed as calcium carbonate, in mg/L. Hardness are of two types, temporary or carbonate hardness and permanent or non carbonate hardness. Temporary hardness is one in which bicarbonate and carbonate ion can be precipitated by prolonged boiling. Non- carbonate ions cannot be precipitated or removed by boiling, hence the term permanent hardness. IS value for drinking water is **300 mg/L as $CaCO_3$**.

Chlorides

Chloride ion may be present in combination with one or more of the cations of calcium, magnesium, iron and sodium. Chlorides of these minerals are present in water because of their high solubility in water. Each human being consumes about six to eight grams of sodium chloride per day, a part of which is discharged through urine and night soil. Thus, excessive presence of chloride in water indicates sewage pollution. IS value for drinking water is **250 to 1000 mg/L**.

Sulphates

Sulphates occur in water due to leaching from sulphate mineral and oxidation of sulphides. Sulphates are associated generally with calcium, magnesium and sodium ions. Sulphate in drinking water causes a laxative effect and leads to scale formation in boilers. It also causes odour and corrosion problems under aerobic conditions. Sulphate should be less than 50 mg/L, for some industries. Desirable limit for drinking water is **150 mg/L**. May be extended up to **400 mg/L**.

Iron

Iron is found on earth mainly as insoluble ferric oxide. When it comes in contact with water, it dissolves to form ferrous bicarbonate under favourable conditions. This ferrous bicarbonate is oxidised into ferric hydroxide, which is a precipitate. Under anaerobic conditions, ferric ion is reduced to soluble ferrous ion. Iron can impart bad taste to the water, causes discolouration in clothes and incrustations in water mains. IS value for drinking water is **0.3 to 1.0 mg/L**.

Solids

The sum total of foreign matter present in water is termed as 'total solids'. Total solids are the matter that remains as residue after evaporation of the sample and its subsequent drying at a defined temperature (103 to 105 °C). Total solids consist of volatile (organic) and non-volatile (inorganic or fixed) solids. Further, solids are divided into suspended and dissolved solids. Solids that can settle by gravity are settleable solids. The others are non-settleable solids. IS acceptable limit for total solids is **500 mg/L** and tolerable limit is **3000 mg/L** of dissolved limits.

Nitrates

Nitrates in surface waters occur by the leaching of fertilizers from soil during surface run-off and also nitrification of organic matter. Presence of high concentration of nitrates is an indication of pollution. Concentrations of nitrates above 45 mg/L cause a disease methemoglobinemia. IS value is **45 mg/L**.

Bacteriological Characteristics

BACTERIOLOGICAL QUALITY OF DRINKING WATER[a]

Organisms	Guideline value
All water intended for drinking	
E.coli or thermotolerant coliform bacteria[b,c]	Must not be detectable in any 100-ml sample
Treated water entering the distribution system	
E.coli or thermotolerant coliform bacteria[b]	Must not be detectable in any 100-ml sample
Total coliform bacteria	Must not be detectable in any 100-ml sample
Treated water in the distribution system	
E.coli or thermotolerant coliform bacteria[b]	Must not be detectable in any 100-ml sample
Total coliform bacteria	Must not be detectable in any 100-ml sample. In case of large supplies, where sufficient samples are examined, must not be present in 95% of samples taken throughout any 12 month period.

Tests to indentify bacteria

- **Standard plate count test**
- **Most probable number**
- **Membrane filter technique**

Standard plate count test

In this test, the bacteria are made to grow as colonies, by innoculating a known volume of sample into a solidifiable nutrient medium (Nutrient Agar), which is poured in a petridish. After incubating (35°C) for a specified period (24 hours), the colonies of bacteria (as spots) are counted. The bacterial density is expressed as number of colonies per 100 ml of sample.

Most probable number

Most probable number is a number which represents the bacterial density which is most likely to be present. E.Coli is used as indicator of pollution. E.Coli ferment lactose with gas formation with 48 hours incubation at 35°C. Based on this E.Coli density in a sample is estimated by multiple tube fermentation procedure, which consists of identification of E.Coli in different dilution combination. MPN value is calculated as follows:

Five 10 ml (five dilution combination) tubes of a sample are tested for E.Coli. If out of five only one gives positive test for E.Coli and all others negative. From the tables, MPN value for one positive and four negative results is read which are 2.2 in present case. The MPN value is expressed as 2.2 per 100 ml. These numbers are given by Maccardy based on the laws of statistics.

Membrane filter technique

In this test a known volume of water sample is filtered through a membrane with opening less than 0.5 microns. The bacteria present in the sample will be retained upon the filter paper. The filter paper is put in contact of a suitable nutrient medium and kept in an incubator for 24 hours at 35°C. The bacteria will grow upon the nutrient medium and visible colonies are counted. Each colony represents one bacterium of the original sample. The bacterial count is expressed as number of colonies per 100 ml of sample.

3. Enumerate and explain the characteristics of surface and ground water and state their environmental significance. (May/Jun 2014)

Surface and ground water types

Surface Sources

i) Natural ponds and lakes

ii) Streams and Rivers

iii) Impounding reservoirs

SURFACE SOURCES

Ponds and Lakes

A natural large sized depression formed within the surface of the earth, when gets filled up with water is known as pond or lake. Difference between pond and lake is only that of size.

Pond:

If the size of depression is comparatively small, it is termed as pond.

Lake:

When the depression is large, it is termed as lake.

Contributions to ponds and lakes

- Surface run off
- Underground water

Streams and Rivers

Streams

- Feed their waters to lakes
- Quantity of water available is small
- Sometimes go dry
- Not suitable for water supply schemes
- Large streams may be used as source of water by providing storage reservoirs, barrages etc.,

Rivers

Rivers are of two types. They are perennial and non-perennial rivers.

Perennial

- Water is available throughout the year
- Rivers are fed by rain during rainy season
- They can used as source of public supplies directly

Non – perennial

- Used as source of public water supply by providing storage on the upstream side of the intake water.
- Not reliable
- Contains large amount of silt

SUB SURFACE OR GROUND WATER SOURCES

(a) Springs

(b) Wells (i) Shallow (Dug, Sunk, built, bore or driven) (ii) Deep (Sunk, Bore and Drill)

(c) Galleries

Springs

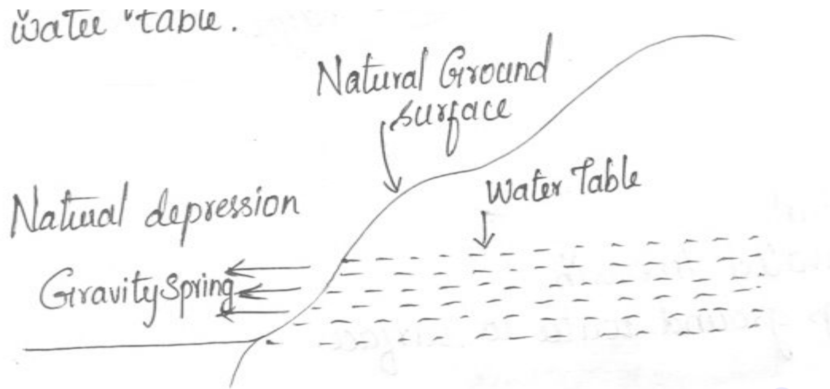
- Natural outflow of ground water at the earth's surface is said to form a spring
- Pervious layer sandwiched between two impervious layers give rise to natural spring
- Supply small amount of water

Types

- Gravity springs
- Surface springs
- Artesian springs

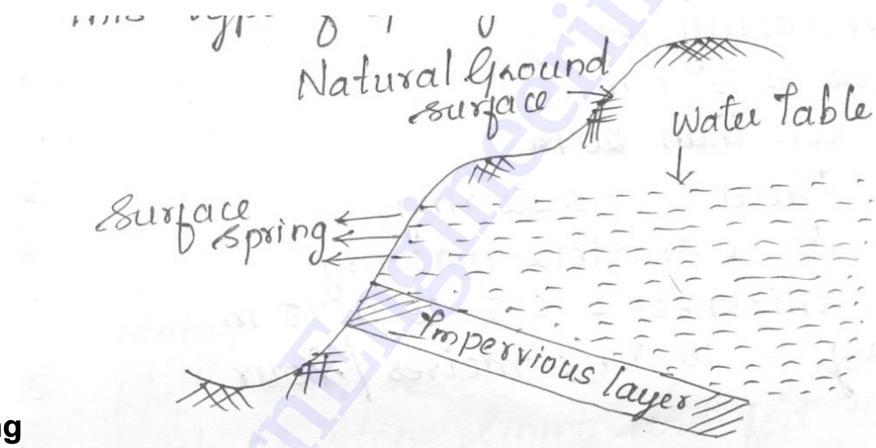
Gravity Springs

- High rise in water table and the water over flow through sides of the natural valley and forms a spring
- Flow from springs depends on the rise or fall of water table



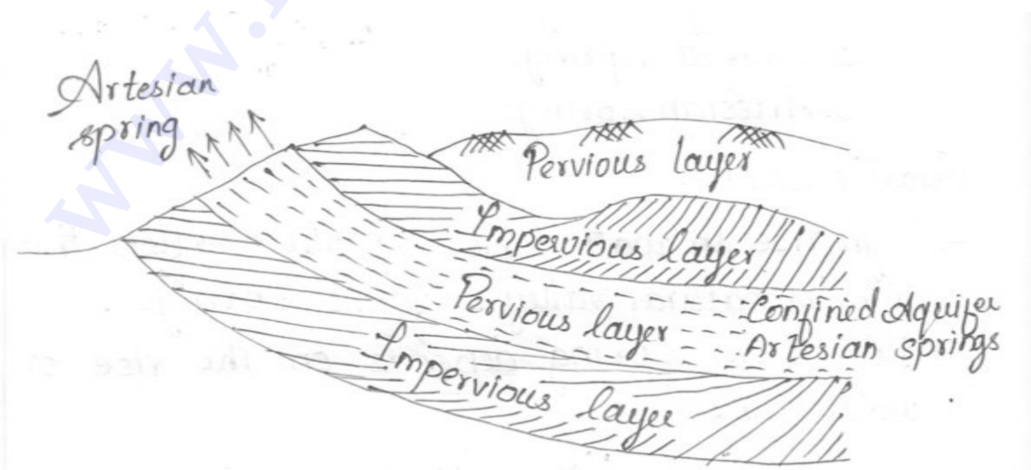
Surface Springs

- Impervious layer become inclined to keep water table rise to get exposed to ground surface



Artesian Spring

- Water stored under pressure, flow through the confined aquifer
- Uniform quantity of water is obtained here
- Since the water oozes out under pressure, they are able to provide high yield.



Classification of Wells

(a) Dug wells

(b) Sunk wells

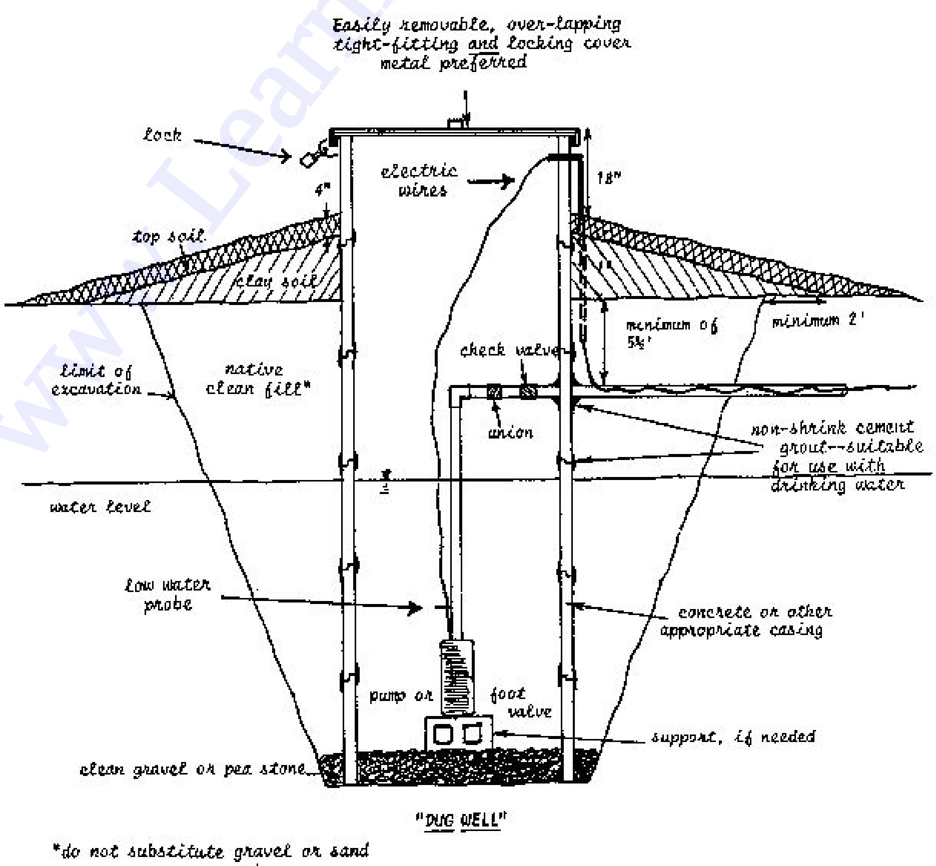
(c) Driven wells

(d) Bored wells

(a) Dug wells

- Semi permeable hard formations up to sufficient depth to provide optimum water yield at summer
- Depth, diameter are decided with reference to seepage area exposed for obtaining required yield
- No need for steining after 3 to 5 metres depth, steining extended above ground surface
or closed with steel or concrete manhole
- Water quality mat get affected due to poor maintenance
- Infiltrations into wells are through dry masonry or weep holes
- Cut pipe section in steining with wire gauze and gravels are provided for steining

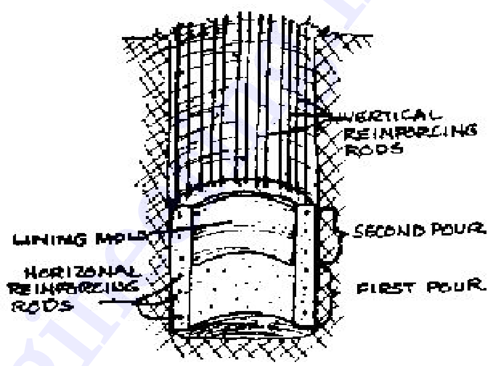
Construction of Dug Well for Drinking Water

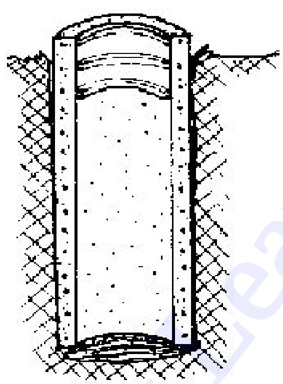


(b) Sunk wells (masonry barrels placed in soil to intercept large quantity of water)

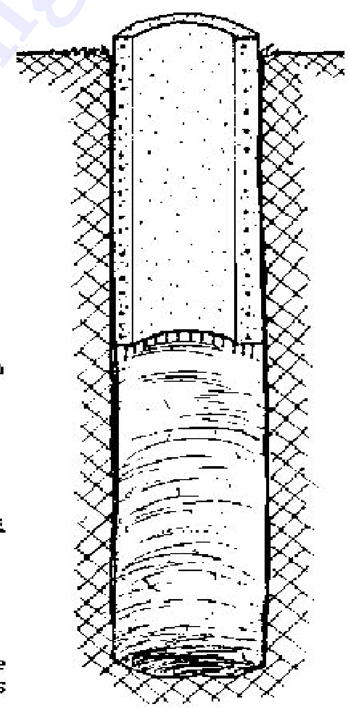
- Depends on water bearing formations with adequate extent and porosity
- Minimum depth is determined from optimum penetration in to water bearing stratum for providing required yield
- Weep holes are provided to increase yield
- Porous plugs are provided at bottom for sunken infiltration galleries
- Wells should be protected from floods by providing top level steining 0.5m to 1m above HFL or concrete or steel lids

a. The hole has been dug as deep as five meters and trimmed to the proper diameter. Vertical reinforcing has been put in place over the entire dug section. The second pour has just been completed on top of the first pour. Each successive poured lining section will be poured on top of the previously poured section until the hole is completely lined.





b. The final poured section has been completed for this short section of the well.



c. The hole is now extended as deep as five meters beneath the first short section. It will then be lined as in the previous short section and connected to it with the vertical re-rod that was left beneath the first pour of the first short section.

(c) Driven wells or Shallow tube wells

 It is also called as Shallow tube wells and it is sunk depending upon size, depth and soil stratum.

 Closed end of the well consists of pipe diameter of 40mm to 100mm and perforated there from to the top level of water table

 The perforations are covered with gauze with suitable size related to soil grain size

 The driving head will be larger than the pipe diameter

 Suitable for places where water is thinly distributed with soft ground or sand up to 25m depth

 Concrete platform is used to deflect the pollution above the well

(d) Bored wells

Bored wells are constructed by sinking pipes through various methods. They are

(i) Direct Rotary Method

(ii) Percussion or Cable tool method

(iii)Pneumatic rotary drilling (a) Top hammer and eccentric bit (b) Down the hole Hammer

(iv) Hydraulic jet method

(v) Reverse rotary method

(vi) Sludger Method

4. Explain how five demand is calculated. (Nov/Dec 2010)

While designing the water supply scheme its necessary to determine the total quantity of water required. there are so many factors involved in the demand of water, it is not possible to accurately determine the actual demand.

Types of water demand:

1. Domestic water demand.
2. Industrial demand.
3. Commercial demand.
4. Demand for public use.

5. Fire demand.
6. Losses, wastes and thefts.

DOMESTIC WATER DEMAND:

- The quantity of water required in the houses for drinking, bathing, cooking, washing, etc. is called domestic water demand
- It mainly depends upon the habits, social status, climatic conditions and customs of the people.
- As per IS 1172:1993 the domestic consumption of water in India is about 135 l/day/capita.The details of the domestic consumption are

  Drinking – 5 l/day

  Cooking – 5l/day

  Bathing – 55l/day

  Clothes washing – 20 l/day

  Utensils washing – 10 l/day

  House washing – 10 l/day

  Flushing of water closets - -20 l/day.

INDUSTRIAL DEMAND:

- It mainly depends on the type of industries existing in the city.
- The water required by factories, paper mills, cloth mills, cotton mills, etc. comes under industrial use.
- Th quantity of the water demand for the industrial purpose is around 20- 25% of the total demand of the city.

COMMERCIAL DEMAND:

Universities, institutions and commercial centers including office building, ware houses, hotels, health centers, etc. comes under this category

Water supply requirements for the buildings other than residences

S/No	Type of occupancy	Average water consumption in litres/head/day
1	Hospital (including laundry) (a) No of beds exceeding 100 (b) No of beds not exceeding 100	 450 340
2	Hotels	180
3	Hostels	135
4	Nurses homes and medical quarters	135
5	Boarding schools/ colleges	135
6	Restaurants	70 (per seat)
7	International and domestic airports	70 with bath facilities, 70 without bath facilities
8	Railways, bus stations and sea ports (a) Junction stations	70 with bath facilities, 45 without bath facilities
	(b) Intermediate stations	45 with bath facilities, 25 without bath facilities
	(c) Terminal stations	45 with bath facilities, 45 without bath facilities
9	Day schools/ colleges	45
10	offices	45
11	(a) Factories with bathroom (b) Factories without bathroom	45 30
12	Cinema, concert halls and theatres	15 (per seat)

DEMAND FOR PUBLIC USE:

- The quantity of water required for public utility purposes such as for washing and sprinkling on roads, cleaning of sewers, watering of public parks , etc. comes under public demand.
- It is 5% of the total consumption.

Requirements of water for public utility

S.No	Purpose	Requirements
1	Public Parks	1.4 Lit/M^2/Day
2	Street Washing	1 – 1.5 Lit/M^2/Day
3	Sewer Cleaning	4.5 Lit/Head/Day

FIRE DEMAND:

- This is the quantity of water required for fire-fighting purpose.
- Fire may take place due to faulty electric wires by short circuiting, fire catching materials, explosions, bad intention of criminal people, etc.
- During a fire breakdown large quantity of water is required to extinguish it. Therefore provision is made for the fire demand.
- In the cities fire hydrants are provided on the water mains at 100-150m apart for fire demand.

LOSSES AND WASTES.

- Losses due to defective pipe joints, cracked and broken pipes, faulty valves and fittings.
- Losses due to consumers keep open their taps off public taps even when they are not using the water.
- Losses due to unauthorized illegal connections while estimating the total quantity of water of a town
- An allowance of 15% of total quantity of water is made to compensate for losses, thefts and wastage of water.

5. Problem:-

The Population of 5 decades from 1930 to 1970 are given below in Table. Find out the Population after One, two and three decades beyond the last known decade, by using:

(i) Arithmetic Increase Method

(ii) Geometric Increase Method

(iii) Incremental Increase Method.

Table :-

Year	1930	1940	1950	1960	1970
Population	25,000	28,000	34,000	42,000	47,000

Solution :- (i) ARITHMETIC INCREASE METHOD

Increase in Population (x) for each decade, the total increase, and average increase Per decade ($\bar{x}$), are Computed below.

Year	Population	Increase in Population (x)
1930	25,000	
		3000
1940	28,000	
		6000
1950	34,000	
		8000
1960	42,000	
		5000
1970	47,000	

Total = 22,000

Average increase per decade ($\bar{x}$) $= \frac{22{,}000}{4}$

$= 5{,}500$.

The future populations are now computed by using, $\boxed{P_n = P_0 + n.\bar{x}}$

∴ (a) Population after 1 decade beyond 1970 (i.e., 1980).

$P_{1980} = P_1 = P_{1970} + 1.\bar{x}$

$= 47{,}000 + 1 \times 5500$

$= \underline{\underline{52{,}500}}$

(b) Population after 2 decades beyond 1970

(ie., 1990)

$= P_{1990} = P_2 = P_{1970} + 2.\bar{x}$

$= 47,000 + 2 \times 5,500$

$= \underline{\underline{58000}}$

(c) Population after 3 decades beyond 1970

(ie., 2000)

$= P_{2000} = P_3 = P_{1970} + 3.\bar{x}$

$= 47,000 + 3 \times 5,500$

$= \underline{\underline{63,500}}$

(ii) GEOMETRIC INCREASE METHOD.

Year (1)	Population (2)	Increase in Population in each decade (3)	Percentage increase in Population ie., Growth rate (r) = $\frac{col(3)}{col(2)} \times 100$ (4)
1930	25,000		
		3000	$\frac{3000}{25000} \times 100 = 12\%$.
1940	28,000		
		6000	$\frac{6000}{28000} \times 100 = 21.4\%$.
1950	34,000		
		8000	$\frac{8000}{34000} \times 100 = 23.5\%$.
1960	42,000		
		5000	$\frac{5000}{42000} \times 100 = 11.9\%$.
1970	47,000		

The Geometric mean of the Growth rates (r)

$$= \sqrt[4]{12 \times 21.4 \times 23.5 \times 11.9}$$

$$= 16.37\% \text{ Per decade.}$$

Now, assuming the future Population increase at this Constant rate (16.37%), We have,

$$P_n = P_0 \left(1 + \frac{r}{100}\right)^n$$

$$P_n = P_0 (1 + 0.1637)^n$$

$$= P_0 (1.1637)^n$$

Using $n = 1, 2, 3$ decades, We have,

The Population after 1 decade ie., for the year

$$1980 = P_{1980} = 47,000 (1.1637)$$

$$= \underline{\underline{54,694}} \text{ Ans.}$$

Similarly P_{1990} = Population after 2 decades

$$= 47000 (1.1637)^2$$

$$= \underline{\underline{63,647}} \text{ Ans}$$

Similarly P_{2000} = Population after 3 decades

$$= 47000 (1.1637)^3$$

$$= \underline{\underline{74,066}} \text{. Ans}$$

(iii) INCREMENTAL INCREASE METHOD:-

Year (1)	Population (2)	Increase in Population (3)	Increamental increase ie. increment on the increase (4)
1930	25,000		
		3000	
1940	28,000		(+) 3000
		6000	
1950	34,000		(+) 2000
		8000	
1960	42,000		(-) 3000
		5000	
1970	47,000		
Total		22,000	(+) 2000

Average per decade $\bar{x} = \frac{22,000}{4} = 5500$ $\bar{Y} = \frac{2000}{3}$

$= (+)\ 667$ (say)

The future population P_n is now given by

$$P_n = P_0 + n\bar{x} + n \cdot \frac{(n+1)}{2} \cdot \bar{Y}$$

Hence $P_{1980} = P_{1970} + 1 \cdot \bar{x} + \frac{1(1+1)}{2} \cdot \bar{Y}$

$$= 47,000 + 1 \times 5500 + \frac{1 \times 2}{2} \times 667$$

$P_{1980} = \underline{\underline{53,167}}$ Ans

$$P_{1990} = P_{1970} + 2.\bar{x} + \frac{2(2+1)}{2}.\bar{y}$$

$$= 47,000 + 2 \times 5500 + 3 \times 667$$

$$= \underline{60,001}. \quad \underline{\text{Ans}}$$

$$P_{2000} = P_{1970} + 3\bar{x} + \frac{3(3+1)}{2}.\bar{y}$$

$$= 47,000 + 3 \times 5500 + 6 \times 667$$

$$= \underline{67,502}. \quad \underline{\text{Ans}}$$

UNIT-II
CONVEYANCE SYSTEM
PART – A

1. What is an intake? Mentions its types. (MAY/JUN 2014)

The intake or intake works comprises of a structure placed in a surface water source to permit the withdrawal of water from the source and then to discharge into an intake conduit through which it will flow into the water works system.

Types of intake:

- Simple submerged Intakes
- Intake towers
- Reservoir Intake
- Canal Intake

2. What are the two important types of conduit depending upon characteristics of flow? (NOV/DEC 2010)

(i) Gravity conduits (ii) Pressure conduits

3. What are the different pipe materials which are used for water conveyance? (NOV/DEC 2010)

Cast iron, wrought iron, galvanized iron, steel, cement concrete, asbestos, plastic, lead, copper, wood

4. Define pipe joints. What are the various types of joints?

Pipe joints are the assemblies used to connect one pipe with other without any leakages or other losses.

Types of joints:

- Spigot and socket joints
- Expansion joints
- Flanged joints
- Flexible joints
- Screwed joints

5. Mention the advantages and disadvanatages of RCC pipes.

Advanatages:

- More suitable to resist external loads and load due to backfilling.
- Maintenance cost is low.
- Corrosion free

Disadvanatages:

- Difficult to repair.
- Pipes are heavy and difficult to transport them.
- Liable to tensile cracks, since unable to withstand high pressure.

6. **What are the advantages expected in using pressure conduits instead of gravity conduits? (NOV/DEC 2011)**
    - Pressure conduits may be constructed at any elevation of hydraulic gradient
    - Location, construction and maintenance are easy and costs low
    - Direct route connections are possible
    - Pipes for low and high pressure can be designed economically
    -

7. **Mention the factors governing location of an intake.**
    - ➢ It should be near the treatment plant.
    - ➢ It must be located in the purer zone to avail good quality of water.
    - ➢ It should not be located near navigation channels.
    - ➢ It should permit greater withdrawal of water.

8. **What is meant by pipe appurtenances and mention their role? (NOV/DEC 2011)**

Pipe appurtenances are components attached in pipe line which aid in proper functioning of pipe network. Role of appurtenances are ceasing, controlling, diversion and regulating flows through the pipe network. Appurtenances are valves, tees, bends, crosses etc.

9. **Enlist the external forces acting on water transmission main if the pipe is laid under heavy traffic? (NOV/DEC 2014)**

Internal pressure, vertical earth load, surface live loads, surface impact loads, thermal expansion and movement at pipe bends

10. **What is head loss in pipes?**

The available pressure head between the source and the city is just lost in overcoming the frictional resistance offered to the flow by the pipe interior, pipe size, bends, valves, etc. It is represented by H_L.

11. **Mention the situation in which pumps will be connected in (a) series (b) parallel (APR/MAY 2011)**

(a) Pumps in series
- o When high head is required for water supply
- o When the area of water supply is steep sloped or undulated
- o When the intake is located at low lying area

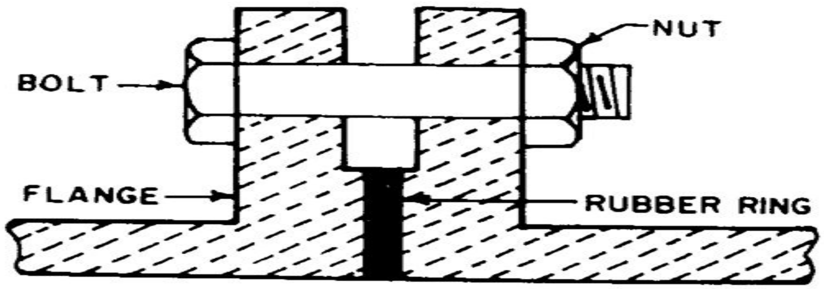
(b) Pumps in parallel
- o When more quantity of discharge is required
- o To have a spare pumping system when one pump is under repair
- o When water supply area is relatively flat

12. **What is meant by economic diameter of pumping main? (NOV/DEC 2014)**

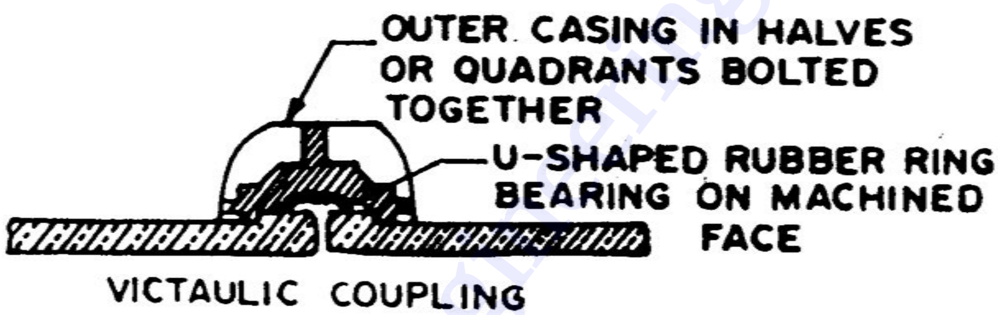
Large diameter of pumping main increases investment cost, smaller diameter increases operation, maintenance cost and head loss. For optimum conditions diameter of pipe selected and pumping cost should make total annual expenses minimum. Selection of such diameter of the pipe is called as economical diameter of the pumping main.

$D = 0.97$ to $1.22\sqrt{Q}$, D = Diameter, Q = Discharge

13. Any two line diagrams of joints in pipe lines? (NOV/DEC 2013)
Flanged joint



Mechanical joint or Victaulic joint



14. What is the difference between system curve and pump curve? (NOV/DEC 2013)

System Head Curve	Pump Head Curve
The system head curve is the sum of the static head and the friction losses that have to be overcome in order to pump liquid into the process.	The pump curve describes the relation between flow rate and head for the actual pump.
The static head does not vary with the flow rate and it is only function of elevation or back pressure against which the pump is operating	Increasing the impeller diameter or speed increases the head and flow rate capacity

Part - B

1. With neat sketch, explain river intake and canal intake towers. (May/Jun 2012)

Intake Structures: (development of surface sources)

- A device or structure placed in surface water source to permit the withdrawal of water from the source
- Used to draw water from lakes, reservoirs or rivers at the most desirable depth.

Conveyance

- The available fall from the source to the town and the ground profile should be feasible by a free flow conduit.
- Water is conveyed or transported from the source to the community through various types of conduits

(a) Types

a. Wet intakes
b. Dry intakes
c. Submerged intakes
d. Moveable & floating intakes

(b) Location (for locating the intake)

The location where the best quality of water is available.

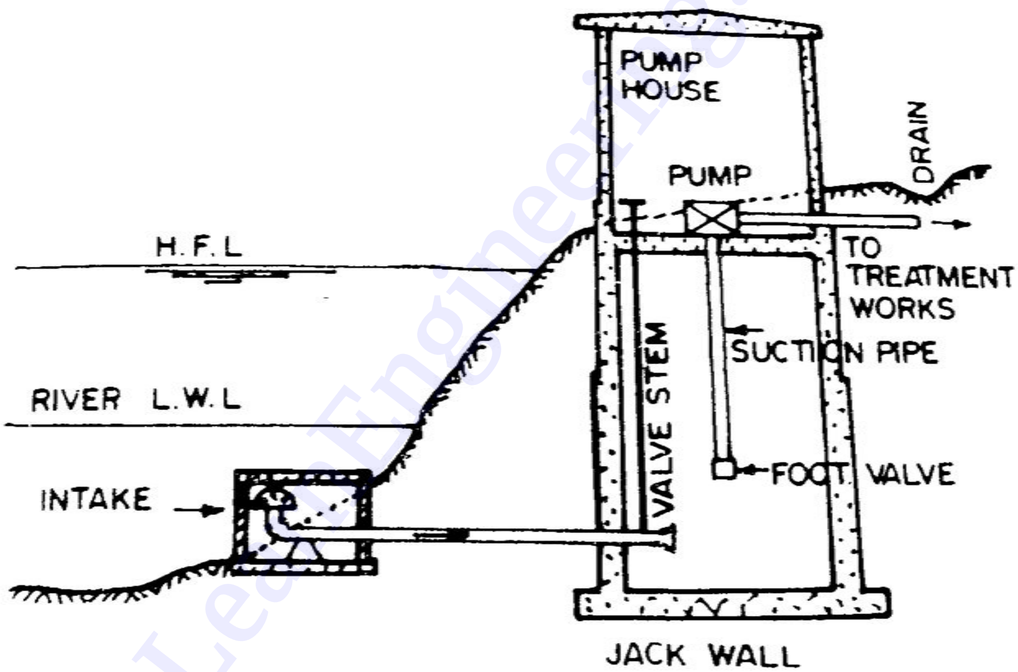
- Absence of currents that will threaten the safety of the intake.
- Absence of ice floats.
- Formation of shoal & bars should be avoided.
- Navigation channels should be avoided as far as possible.
- Distance from pumping station

River Intakes

A river intake is located to the upstream of the city so that pollution is minimized. They are either located sufficiently inside the river so that demands of water are met with in all the seasons of the year, or they may be located near the river bank where a sufficient depth of water is available. Sometimes, an approach channel is constructed and water is led to the intake tower.

The intake tower permits entry of water through several entry ports located at various levels to cope with the fluctuations in the water level during sufficient seasons. The entry points are called as penstocks and provided with screens to exclude debris and floating material. The entry ports contain valves which can be operated from the upper part of the well. The lowest entry is placed below the low water level of the river so that water is available in the jack well during summer season also when river carries minimum discharge.

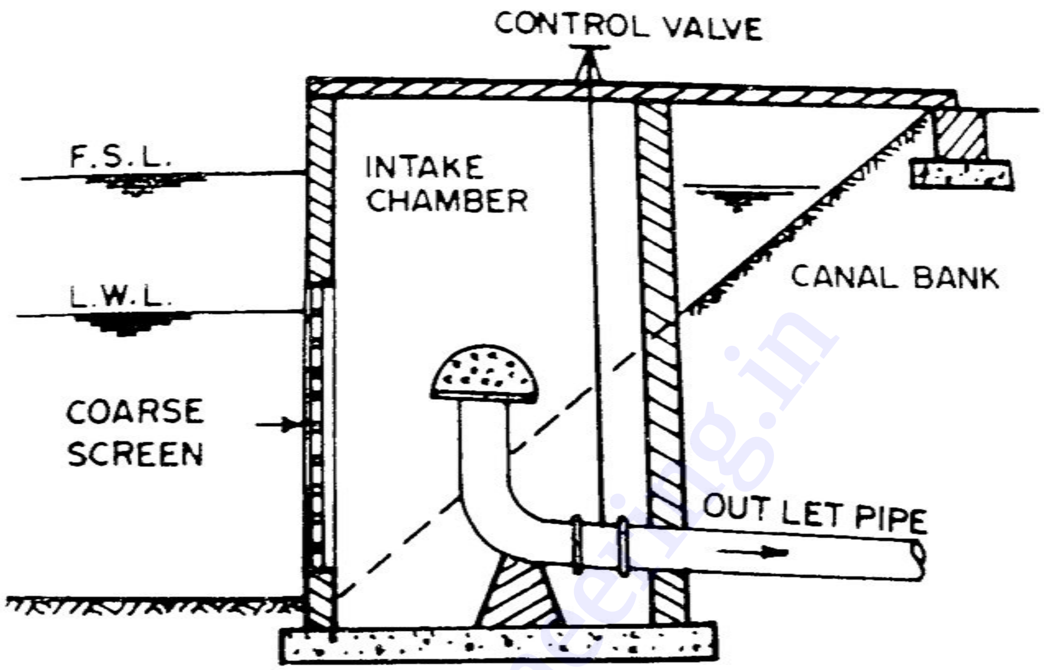
Where river bed is soft or unstable, the intake tower may be founded slightly away from the river bed. The intake is kept submerged under the low water level of the river. It essentially consists of a rectangular or circular entry chamber with a strong grill at its top. The pipe conveying water from the intake to the jack well has a bell mouth entry with a screen and is supported on a concrete support. While the entry of debris and floating material is checked by the top grill, the entry of mud or course sand is checked by the screen provided at the bell mouth entry. Water enters to the jack well through a valve which can be controlled from the pump house.



River Intake

Canal Intakes

Sometimes, the source of water supply to a small town may be an irrigation canal passing near the town. It essentially consists of concrete or masonry intake chamber of rectangular shape admitting water through a coarse screen. A Fine screen is provided over the bell mouth entry of the outlet pipe. The bell mouth entry is located below the expected low water level in the canal. Water may flow from outlet pipe under gravity if the filter house is situated at the lower elevation. Otherwise the outlet pipe may serve as suction pipe and the pump house may be located on or near the canal bank. The intake chamber is so constructed that it doesnot offer any appreciable resistance to normal flow in the canal. Otherwise the intake chamber is located inside the canal bank. Near the location of the intake work, the canal is lined.



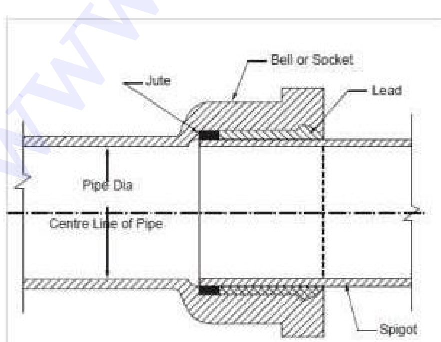
Canal Intake

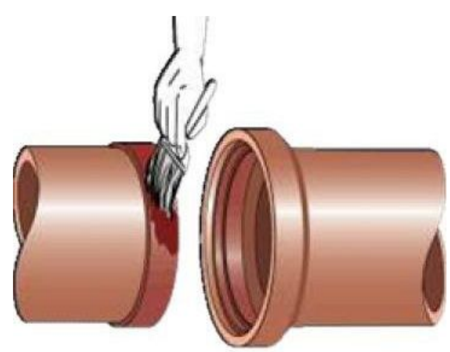
2. **What are the various joints used in pipeline construction? (Apr/May 2015)**

<u>Jointing of pipes</u>

1. Socket and spigot joint
2. Flanged joint
3. Mechanical joint called dresser coupling
4. Flexible joint
5. Expansion joint

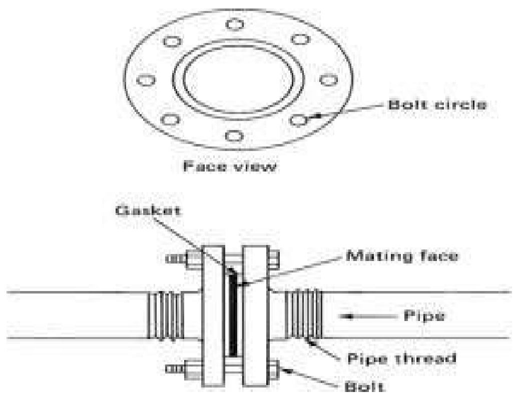
<u>Socket and Spigot joint</u>

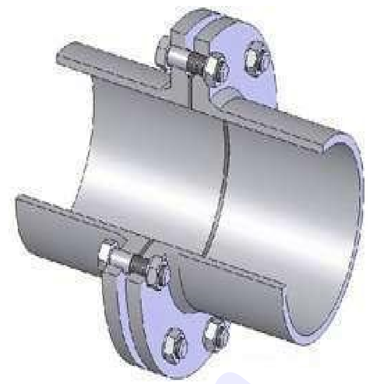




- Century old type – Used in large scale till date
- Molten lead : 3.5 to 4 kg – 15 cm dia, 45 to 50 kg – 1.2 m dia
- Skilled labours required

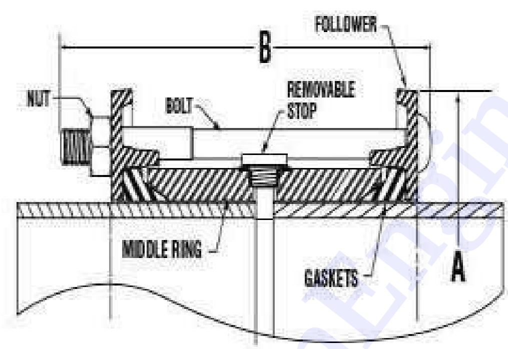
Flanged joint





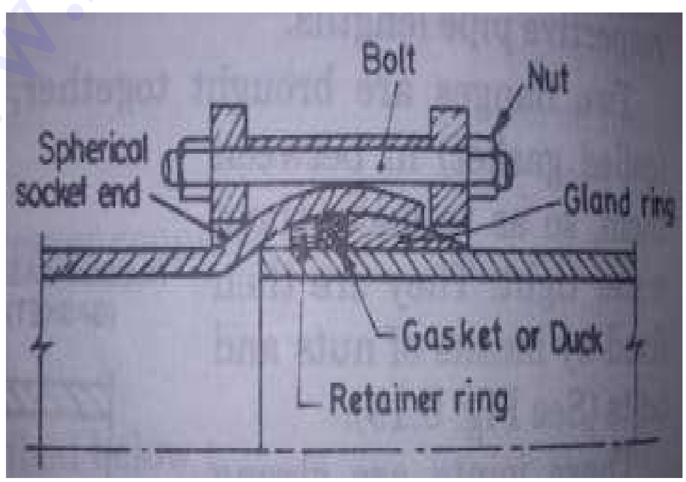
- Used in places where disjointing is done.
- Strong but rigid – cannot with stand vibrations.
- Expensive – used in indoor works

Mechanical joint / Dresser coupling



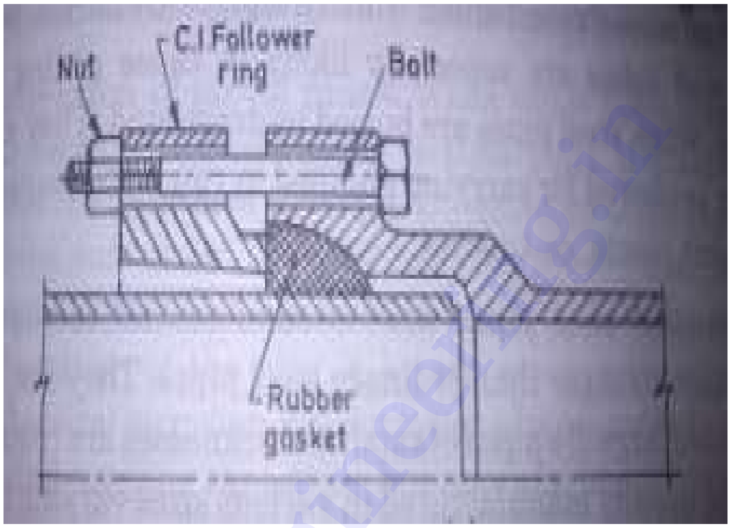
- Used in joining plain ends of the pipe
- Strong and rigid
- Withstand vibrations – carried over bridges or below bridges in hangers.

Flexible joint



• Used in places where large scale flexibility required
• Eg: Rivers and Sea – uneven beds
• Socket is spherical – Spigot is plain

Expansion joint



- Used to counteract the thermal stresses due to temperature variations
- Socket is cast flanged – Spigot is plain
- During expansion and contraction of pipes, socket ends counteract

3. What are the pipe materials used in water transmission? (May/June 2013)

Pipeline materials

- Cast iron
- Wrought iron
- Steel
- Galvanized iron
- Cement concrete
- Asbestos cement
- Plastic
- Lead
- Copper
- wood

Cast iron pipe

Cast iron pipes are used in great majority of water in distribution mains because of centuries of satisfactory experience with it. Cast –iron pipe is resistant to corrosion and accordingly is long lived –its life may be over 100 years.

Cast iron pipes are manufactured by two methods (i) ordinary sand moulding process (ii) centrifugal process.

Advantages of C.I pipes

1) C.I pipes are of moderate cost
2) Their jointing is easier
3) They are resistant to corrosion
4) They have long life.

Dis -advantages

1) They are subject to tuberculation in certain waters, due to which their carrying capacity is reduced to as much as 70%.
2) They are heavier and hence uneconomical when their diameter is more than 120 cm.
3) They can not be used for pressures greater than 7 Kg/cm^2
4) They are fragile.

Wrought iron and galvanized iron pipes

Wrought iron pipes are manufactured by rolling flat plates of the such pipes are much lighter than the C.I pipes and can be more easily cut ,threaded and worked .they look much neater ,but are much costlier.

Steel pipes

Steel pipes of small diameter can be made from the solid, but the larger sizes are made by riveting together the edges of suitably –curved plates, the sockets being formed later in a press. The joints may be either transverse or longitudinal or transverse and spiral.

Cement concrete pipes

Cement Concrete pipes may be either plain or reinforced and are best made by spinning process. they may be either pre-cast, or may be prepared at the site .The plain cement concrete pipes are used for heads up to 7 m while reinforced cement concrete pipes are normally used for heads 60 m.

Advantages

1) They are more suitable to resist the external loads due to backfilling.
2) They maintenance cost is low
3) The inside surface of pipes can be made smooth, thus reducing the frictional losses.
4) The problem of corrosion is not there.
5) Pipes can be cast at site, and hence the transportation problems are reduced.
6) Due to their heavy weight, the problem of floatation is not there when they are empty.

Disadvantages

1) Un-reinforced pipes are liable to tensile cracks ,and they cannot with stand high pressure
2) The tendency of leakage is not ruled out as a result of its porosity and shrinkage cracks.
3) It is very difficult to repair them.
4) Pre-cast pipes are very heavy, and it is difficult to transport them.

Asbestos cement pipes

Asbestos cement pipes are manufactured from asbestos fiber and Portland cement combined under pressure to form a dense homogenous structure having strong bond between cement and the fiber. Such a pipe is claimed to be completely impervious to passage of water through its walls.

Advantages

1) They have smooth internal surface, due to which the frictional losses are reduced.
2) They are light and can be easily transported.
3) They can be easily cut, fitted or jointed.
4) Service connections can be easily taken, sine they can be easily drilled and tapped
5) They are anti-corrosive.

Disadvantages

1) They are soft and brittle .they are very weak under impact loading due to moving traffic.
2) They are can not be laid in exposed places.
3) They are not durable.

They are costly.

4. a) Explain Laying, Joining & Testing of Pipes **(8 marks)**

Laying, Joining & Testing Of Pipes

Detailed requirements

- Materials for pipes (standards for material)
- Diameter of pipe
- Wall thickness / other dimensions of the pipe
- Class of pipe
- Laying length
- Pipe ends – flanged – socket / spigot / plain
- Special pipe lengths and special fittings
- Working pressures
- Pipe lining and coating both for buried & exposed pipes

Installation

- Time schedule
- Construction facilities – storage space
- Work & materials
- Concrete
- Excavation - safety to public

Laying & Joining

Before laying pipes detailed map of the area should be studied in relation with valves, fire hydrants, telephone & electric cables.

Pipe line may be laid on the side of the street where the population is dense.

Pipes are laid underground with a minimum cover of one meter on the top of the pipe.

Proper Laying of Pipes Depends on

- Excavation & preparation of trench
- Handling of pipes
- Detection of cracks in pipes
- Lowering of pipes & fittings
- Cleaning of pipes & fittings

Joints Types

- Rubber gasket joint known as Tyton joint
- Mechanical joint known as screw gland joint.
- Conventional joint known as lead joint.

Categories of joints

- Rigid joints
- Semi rigid joints
- Flexible joint

Asbestos cement pipes joint

- Cast iron detachable joint
- AC coupling joint

Concrete pipes joint

- Bandage joint
- Spigot & socket joint (rigid & semi flexible)
- Collar joint (rigid & semi flexible)
- Flush joint (internal & external)

Plastic pipes joint

- Solvent cement
- Rubber ring joint
- Flanged joint
- Threaded joint

Testing of Pipes

(1) Testing of pressure pipes

The field test pressure to be imposed should be not less than the maximum of the following

1. 1 ½ times the maximum sustained operating pressure
2. 1 ½ times the maximum pipeline static pressure
3. Sum of the maximum sustained operating pressure & the maximum surge pressure
4. Sum of the maximum pipeline static pressure and the maximum surge pressure, subject to a maximum equal to the work test pressure for any pipe fittings incorporated.

In case of gravity pipes, maximum working pressure shall be 2/3 work test pressure.

The allowable leakage during the maintenance stage of pipes carefully laid and well tested during construction, however should not exceed

$ql=(ND(P)^2 / 115)$

ql=Allowable leakage in cm^3/hour

N= No of joints in the length of pipeline

D= Diameter in mm

P=The average test pressure during the leakage test in kg/cm^2

(2) Testing of non-pressure conduits

- The pipeline shall be subject to a test for of 2.5 meters head of water at the highest point of the section under test for 10 minutes.
- The leakage or quantity of water to be supplied to maintain the test pressure during the period of 10 minutes shall not exceed 0.2 litres/mm diameter of pipes per kilometer length per day.

4. b) Discuss the factors influencing the selection of a pump. (Nov/Dec 2011) (8 mark)

In a water supply system, pumping machinery serves the following purposes

a. Lifting water from the source (surface or ground) to purification works or to the service reservoir.
b. Boosting water from source to low service areas and to the upper floors of multistoried buildings
c. Transporting water through treatment works, draining of settling tanks and of other treatment units, withdrawing sludge, supplying water especially water under pressure to operating equipment & pumping chemical solutions to treatments.

Types and construction of pumps (based on)

- The underlying operating principle.
- The type of energy input
- The method of coupling the drive
- The position of the pump axis
- The constructional features

Types of pumps & their choices

(1) Classification based on mechanical principle of operation

- Displacement pumps
- Centrifugal pumps
- Air lift pumps
- Miscellaneous pumps

(2) Classification based on type of power required

- Steam engine pumps
- Diesel engine pumps

- Electrically driven pumps.

(3) Classification based on the type of service

- Low lift pumps
- High lift pumps
- Deep well pumps
- Booster pumps

Selection of a particular type of pump depends on factors

1. Capacity of the pump
2. Number of pump units required
3. Suction conditions
4. Lift (total head)
5. Initial cost & running costs

Criteria for pump selection

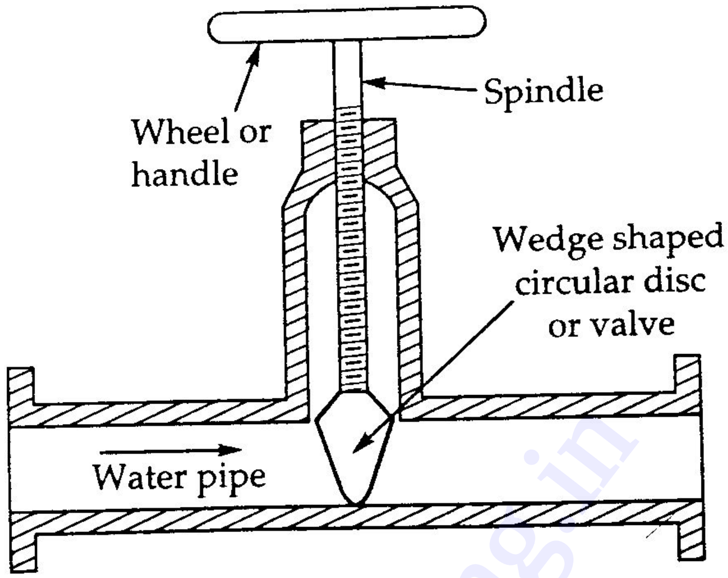
1. Nature of liquid, may be chemicals or if water, then whether raw or treated.
2. Type of duty required i.e. whether continuous, intermittent or cyclic.
3. Present projected demand & pattern of change in demand.
4. The details of head & flow rate required
5. Type & duration of the availability of the power supply.

5. Explain different types of Pipe appurtenances used in water supply project. (May/Jun 2012)

Sluice valve or gate valve

These are also known as shut off valves or stop valves. They are extensively used in the distribution system to shut off the supplies whenever desired .they are also helpful in dividing the water mains into suitable sections.

The spacing of such valves may between 150 to 300 meters. They are also placed at street corners or where two pipe lines intersect. they posses the advantage over most other types of valves ,of combining relatively low cost and offering almost no resistance to flow of water when the valve is wide open.

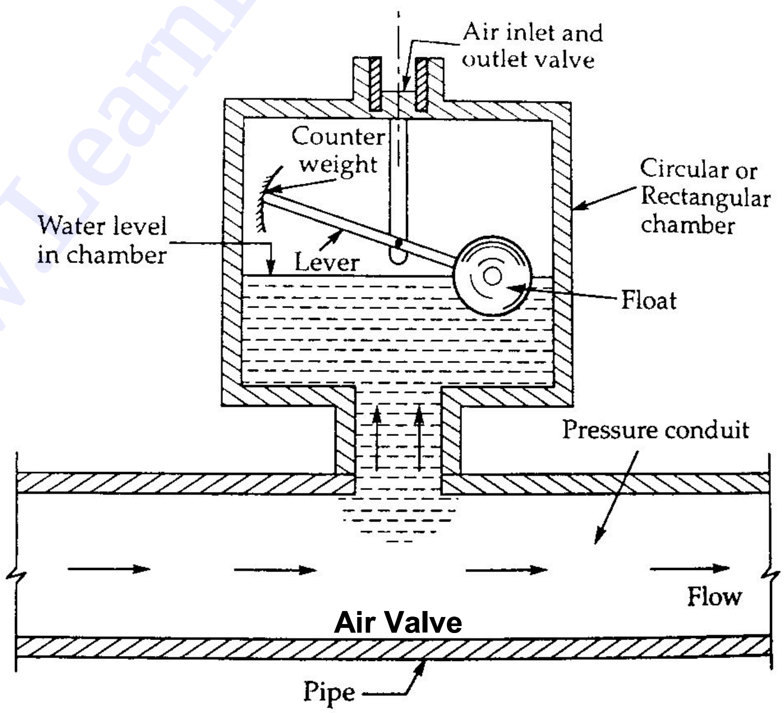


Sluice Valve

Air relief valves

The water flowing through the pipe lines always contain some air. This air tries to accumulate at high points, and may interfere with flow.

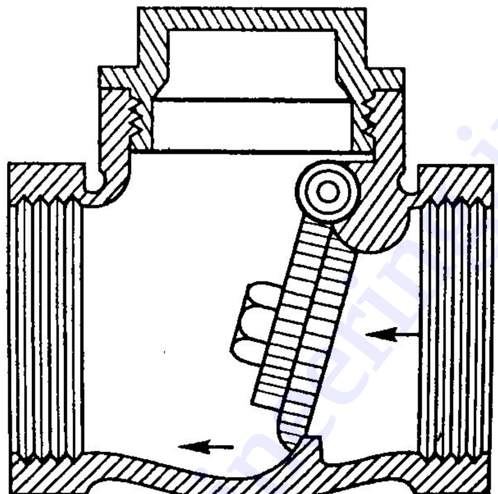
Air valves are also required to discharge air when a main is being filled and to admit air when it is being emptied .the admission of air on emptying the main is of great importance on steel mains, which may flatten if the pressure falls below that of the atmosphere.



Air Valve

Reflux valves

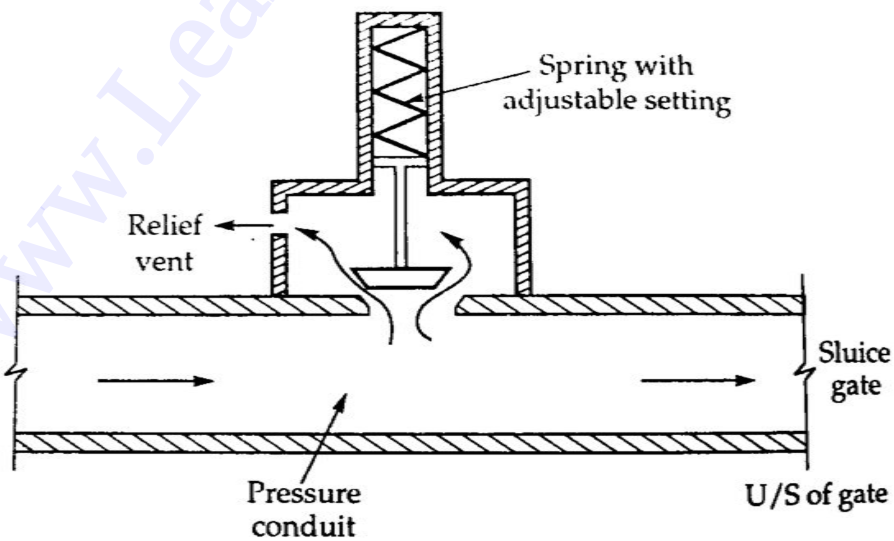
Reflux valves are also known as check valves or non-return valves. It is automatic device which allows water to flow water to flow in one direction only. They are placed in water pipes which obtain water directly from the pump. When the pump is stopped, the water in the pipeline does not rush back and damage the pump.



Reflux Valve

Pressure relief valves

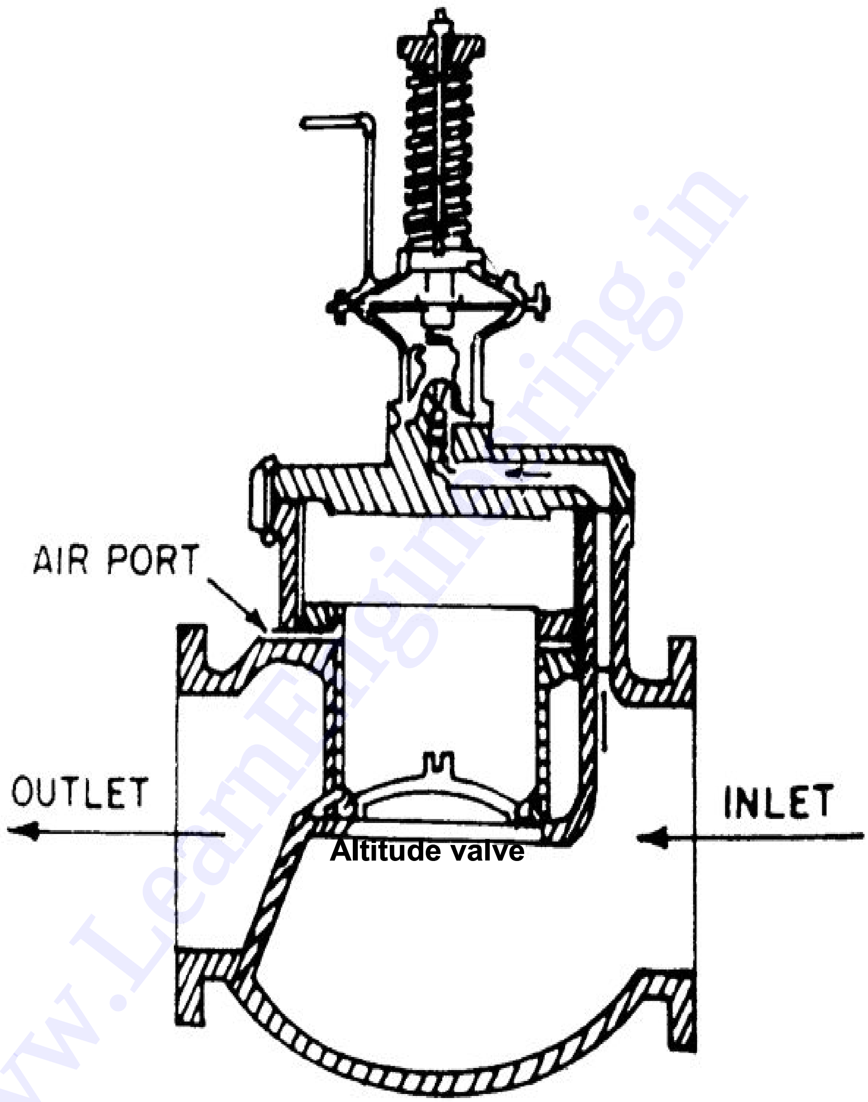
These are also known as automatic cutoff valves or safety valves. They are located at those points where pressure is likely to be maximum. When the line pressure increases above the pre-set valve operates automatically and the pressure is reduced.



Pressure – relief valves

Altitude valves

They are mainly used on those lines which supply water to elevated tanks or stand pipes. They close automatically when the tank is full and open when the pressure on the pump side is less than that on the tank side of the valve.



Altitude valve

Scour valves

Scour valves or blow off valves or washout valves are ordinary sluice valves that are located either at the dead ends or at lowest points in the mains. They are operated to blowoff or remove the sand and silt deposited in the pipe line. They are operated manually.

6. In a water supply scheme to be designed for serving a population of 12 lakhs, the storage reservoir is situated at 9 km away from the city and the loss of head from the source to city is 19.5 m. Calculate the size of the supply main by using Darcy-Weisbach formula as well as by using Hazen's formula assuming a maximum daily demand of 150 lpcd and 2/3 of the daily supply to be pumped in 10 hours. Assume friction factor (4f) for the pipe material as 0.005 in Weishbach formula and $C_H = 110$ in Hazen's formula.
[Nov./Dec, 2014]

Given:

Population = 12,00,000 nos.

Length, L = 9 km = 9000 m

Head Loss, H_L = 19.5 m

Maximum daily demand = 150 lpcd

f = 0.005

C_H = 110

To find:

Size of Supply main [Dia of pipe], d = ?

Solution :

1. To calculate maximum daily water demand (Q_{max})

Maximum water demand = Max. daily per capita demand × Population

$$= 150 \frac{l}{\text{Capita}}\cdot\text{day} \times 12{,}00{,}000 \text{ capita}$$

$$= 180{,}000000 \text{ litres/day}$$

$$= 180 \times 10^6 \; l/\text{day}$$

$$= 180 \text{ Million litres/day}$$

$$\boxed{Q_{max} = 180 \text{ Mld}}$$

2. To calculate maximum water demand for which the supply main is to be designed. (Q)

⇒ 2/3 of daily supply to pumped in 10 hours.

$$\therefore \frac{\frac{2}{3} \times 24 \text{ (hrs)}}{10 \text{ (hrs)}} \times 180 \text{ Mld}$$

$$= 288 \text{ Mld}$$

$$= 288 \times 10^6 \frac{l}{d} \times \frac{1 m^3}{1000 l} \times \frac{1 d}{24 \times 60 \times 60 \text{ sec}}$$

$$= 3.33 \; m^3/\text{sec}$$

$$\boxed{Q = 3.33 \; m^3/\text{sec}}$$

3. To calculate size of supply main (dia of pipe)

(i) By using Darcy-Weisbach formula:

$$H_L = \frac{f' L}{d} \cdot \frac{V^2}{2g}$$

Here,

$H_L = 19.5\ m$

$L = 9000\ m$

$f' = 0.005$

$V = Q/A = \left[\frac{Q}{\frac{\pi d^2}{4}}\right]$

$$\Rightarrow H_L = \frac{f' L}{d} \frac{\left[\frac{Q}{\frac{\pi}{4} d^2}\right]^2}{2g}$$

$$= \frac{f' L}{2 \cdot g \cdot d} \cdot \frac{16 Q^2}{\pi^2 d^4}$$

$$= \frac{8 f' L Q^2}{g \pi^2 d^5}$$

$$\Rightarrow 19.5 = \frac{8}{9.81 \times (3.14)^2} \frac{(0.005)(9000)(3.33)^2}{d^5}$$

$$= \frac{4012.19}{d^5}$$

$d^5 = 205.75 \Rightarrow \boxed{d = 2.90\ m}$

(ii) By Hazen - William's formula

$$V = 0.85\, C_H \cdot R^{0.63} \cdot S^{0.54}$$

Here,

$$C_H = 110$$

$$R = \frac{d}{4} \text{ (for circular pipe running full)}$$

$$\Rightarrow \quad V = \frac{Q}{A} = \frac{3.33}{\pi/4\, d^2}$$

$$\frac{3.33}{\pi/4\, d^2} = 0.85 \times 110 \times \left(\frac{d}{4}\right)^{0.63} \times \left(\frac{19.5}{9000}\right)^{0.54}$$

$$\frac{4.24}{d^2} = 0.85 \times 110 \times \frac{d^{0.63}}{(4)^{0.63}} \times \left(2.16 \times 10^{-3}\right)^{0.54}$$

$$\frac{4.24}{d^2} = 0.85 \times 110 \times \frac{d^{0.63}}{2.39} \times 0.036$$

$$\frac{4.24}{d^2} = 1.41 \times d^{0.63}$$

$$d^{2.63} = \frac{4.24}{1.41}$$

$$d = (3.01)^{\frac{1}{2.63}}$$

$$\boxed{d = 1.52 \text{ m}}$$

7. a) For water supply of a town, water is pumped from a river 3 km away from a reservoir. The maximum difference of levels of water in river and the reservoir is 20 m. The population of the town is 50,000 and per capita water demand is 120 litres per day. If the pumps are to operate for a total of 8 hours and the efficiency of pumps is 80%. Estimate the power requirement. Assume friction factor as 0.03, the water main being designed as economical diameter main and the maximum daily demand as 1.5 times the average daily demand. [Nov./Dec.2010]

Given :

Per capita water demand = 120 lpcd

Population = 50,000 persons

Peak factor = 1.5

friction factor, f = 0.03

Length, L = 3 km = 3000 m

Head difference = 20 m

To find :

Power requirement (Brake horse power), H.P = ?

Economical dia of pipe, d = ?

Solution:-

1. To calculate maximum daily water demand

Average daily water demand = Population × Per capita demand

$= 50000\,c \times 120 \frac{l}{c}\,d$

$= 6000000 \frac{l}{d}$

$= 6$ Mld.

Given that maximum demand to be 1.5 times the average annual demand.

Maximum water demand $= 1.5 \times 6$ Mld

$= 9$ Mld.

$= 9 \times 10^6 \frac{l}{d} \times \frac{1 m^3}{1000 l} \times \frac{1 d}{24 \times 60 \times 60 \text{ sec}}$

$\boxed{Q_{max} = 0.1042 \ m^3/sec}$

2. To calculate maximum water demand for which the supply main is to be designed

⇒ Pumps are working for 8 hours a day to supply full day demand.

$\therefore \frac{24}{8} \times 0.1042 \ m^3/sec$

$\boxed{Q = 0.3126 \ m^3/sec}$

3. To calculate economic diameter of main.

Assume flow velocity through the pressure pipe to be 1.5 m/sec

∴ Area of the pipe required.

$$A = \frac{Q}{V}$$

$$= \frac{0.3126}{1.5} \frac{m^3}{sec} \times \frac{sec}{m}$$

$$A = 0.2084 \ m^2$$

$$\Rightarrow \quad \frac{\pi}{4} d^2 = A$$

$$d^2 = 0.2084 \times \frac{4}{\pi}$$

$$d = \sqrt{0.2655}$$

$$d = 0.515 \, m \simeq 0.52 \, m$$

4. To calculate head loss, H_L

Using Darcy's formula.

$$H_L = \frac{f' L}{d} \frac{V^2}{2g}$$

$$= \frac{0.03 \times 3000 \times (1.5)^2}{0.52 \times 2 \times 9.81}$$

$$H_L = 19.85 \, m$$

Given that actual lift level, $L = 20 \, m$

∴ Total lift required, H = Actual lift level + Calculated head loss

$$= 20 + 19.85$$

$$\boxed{H = 39.85 \, m}$$

5. To calculate Brake horse power of pumps (H-P)

$$\text{Horse power of pump} = \frac{\gamma_w \cdot Q \cdot H}{0.735 \cdot \eta}$$

Here, γ_w = unit weight of water, $9.81 \ kN/m^3$

Q = discharge = $0.3126 \ m^3/sec$

H = Total head lift = $39.85 \ m$

η = Efficiency = 80%

$$\Rightarrow \quad = \frac{9.81 \times 0.3126 \times 39.85}{0.735 \times 0.80}$$

$$= 207.83$$

$$\simeq 208 \ HP$$

$$\boxed{\text{Horse power of pump} = 208 \ H \cdot P}$$

7. b) Quantity of water required by a town is 20,000 m^3/day. The pumps are working against a total head of 40 m for 8 hours. Total length of the main is 20 km. $f = 0.075$. Determine the size of the main using Darcy - Weisbach formula. Assume any other data required. [Apr/May, 2011]

Given:

$$Q = 20{,}000 \ m^3/day = 20{,}000 \ \frac{m^3}{day} \times \frac{1 \ day}{24 \times 60 \times 60 \ sec}$$

$$= 0.2315 \ m^3/sec$$

Length, L = 20 km = 20,000 m

Head loss, H_L = 40 m

$f' = 0.075$

To find:

Size of supply main [Dia of pipe], $d = ?$

Solution:

1. To calculate maximum water demand for which the supply main is to be designed (Q)

⇒ Pumps are working for 8 hours a day to supply full day demand,

$$= \frac{24}{8} \times 0.2315 \ m^3/sec$$

$$\boxed{Q = 0.6945 \ m^3/sec}$$

2. To calculate size of supply main (dia of pipe)

$$H_L = \frac{f' L}{d} \frac{V^2}{2g}$$

Here,

$H_L = 40$ m

$L = 20000$ m

$f' = 0.075$

$$V = \frac{Q}{A} = \frac{Q}{\frac{\pi d^2}{4}}$$

$$\Rightarrow 40 = \frac{0.075 \times 20000}{d} \times \frac{\left(\frac{Q}{\frac{\pi d^2}{4}}\right)^2}{2.g}$$

$$40 = \frac{0.075 \times 20000}{d} \times \frac{\left[\frac{0.6945}{\frac{\pi d^2}{4}}\right]^2}{2g}$$

$$40 = \frac{0.075 \times 20000}{d} \times \frac{0.6144}{d^4 2.}$$

$$= \frac{46.97}{d^5}$$

$$d^5 = \frac{46.97}{40}$$

$$d^5 = 1.17$$

$$\boxed{d = 1.03 \text{ m}}$$

UNIT – III
WATER TREATMENT

PART – A

1. **Differentiate between unit operations and unit process in context of water treatment? (NOVDEC 2010), (NOVDEC 2012)**

Unit operations	Unit process
Unit operations are primary treatment of water which uses physical forces to create the desirable changes during water treatment	Unit processes are secondary treatment of water which uses chemicals to get desirable changes during water treatment
Unit operations causes physical change to the water to be treated	Unit process causes chemical changes to the water Treated
Unit operations are mixing, agitating, aeration, absorption, membrane separation, distillation, sedimentation and filtration	Unit processes are oxidation, nitrification, coagulation, chlorination and disinfection

2. **What is the significance of velocity gradient in flash mixer? (NOVDEC 2010), (MAYJUN 2012), (MAYJUN 2014)**

- Velocity gradient determines how much the water is agitated in the flash mixer
- Velocity gradient determines how much energy is used to operate the flash mixer
- Velocity gradient defines rate of change of velocity per unit distance normal to a section

3. **State stokes equation for finding settling velocity of particles? (APRMAY 2011)**

$$v_s = \frac{g\,d^2}{18v}(G-1)$$

v_s = velocity of particle settling
g = acceleration due to gravity
d = diameter of the particle
G = specific gravity of the particle
v = kinematic viscosity of particle

4. **Give the design criteria for flash mixer and state its use in water supply scheme? (NOVDEC 2011)**

Design criteria:
Impeller speed is between 100 to 250 rpm
Detention time of 30 to 60 seconds is practised
Flash mixer units are circular or square tanks with height to diameter ratio of 1:1 to 3:1
Mean velocity gradient (G) is kept above 300 s^{-1} to 900 s^{-1}
Power requirements are from 1 to 3 watts per m^3/hr of flow
Ratio of impeller diameter to tank diameter is 0.2:1 to 0.4:1
Uses:
In Flash mixer coagulant is agitated vigorously by a paddle operated by a variable speed motor

5. What are the factors influencing the settling of a particle? (NOVDEC 2011), (MAYJUN 2015)

- The velocity of flow which carries the particle horizontally
- The viscosity of water in which the particle is travelling
- The size shape and specific gravity of the particle
- Temperature of water
- Short circuiting
- Scour velocity
- Flocculation of particles

6. Differentiate between sterilisation and disinfection? (MAYJUN 2012)

Sterilisation	Disinfection
Total destruction of disease-causing germs and other organisms.	Killing disease causing bacteria to obtain safe drinking water is known as disinfection
physical methods are used mostly to achieve sterilization	Chemical methods are mostly preferred to achieve disinfection
Types of sterilisations are Moist heat in autoclaves, Dry-heat in ovens, Gamma irradiation, Filtration, Plasma sterilization	Types of disinfections are treatment with chlorine, ozone, UV, and potassium permanganate

7. Define: Detention time and surface over flow rate for a sedimentation tank? (MAYJUN 2013)

Detention time is theoretical time taken by a particle of water to pass between entry and exit of the settling tank

$t_0 = \frac{\text{Volume of tank}}{\text{Rate of flow}}$

Rectangular tank $t_d = \frac{BLH}{Q}$

Circular tank $t_d = \frac{d^2(0.011d + 0.785H)}{Q}$ d = diameter of tank, H = depth at wall

Actual detention period should be twice as the theoretical detention period

Surface loading rate or surface over flow rate

The quantity of water passing per hour per unit horizontal area is known as the over flow rate or surface loading.

SOR or SLR $= \frac{Q}{A}$

8. What are the tests to be done to find the residual chlorine in water? (MAYJUN 2013)

Orthotolidine test
D.P.D test
Chlorotex test
Starch Iodide test

9. **How to manage the residue in water treatment plant? (NOVDEC 2013)**

Land filling, horticulture use, disposal to waste water treatment plant, deep well injection, regeneration of coagulants, incineration

10. **List out advantages of rapid sand filter? (NOVDEC 2013)**

- High filtration rate 3000 to 6000 litres/m^2/hr
- Occupies less area when compared to slow sand filter
- Less initial cost when compared to slow sand filter
- Flexible in operations to meet varying water demand

11. **What is break point chlorination? (MAYJUN 2014), (NOVDEC 2014)**

Chlorine when added to water reacts with ammonia to form chloramines. Addition of excess chlorine till all bacteria's are killed and organic matters are oxidised results in break point. Beyond break point chlorine appears as residual chlorine in water which is called as break point chlorination.
Residual chlorine limit is 0.2 to 0.3 mg/l

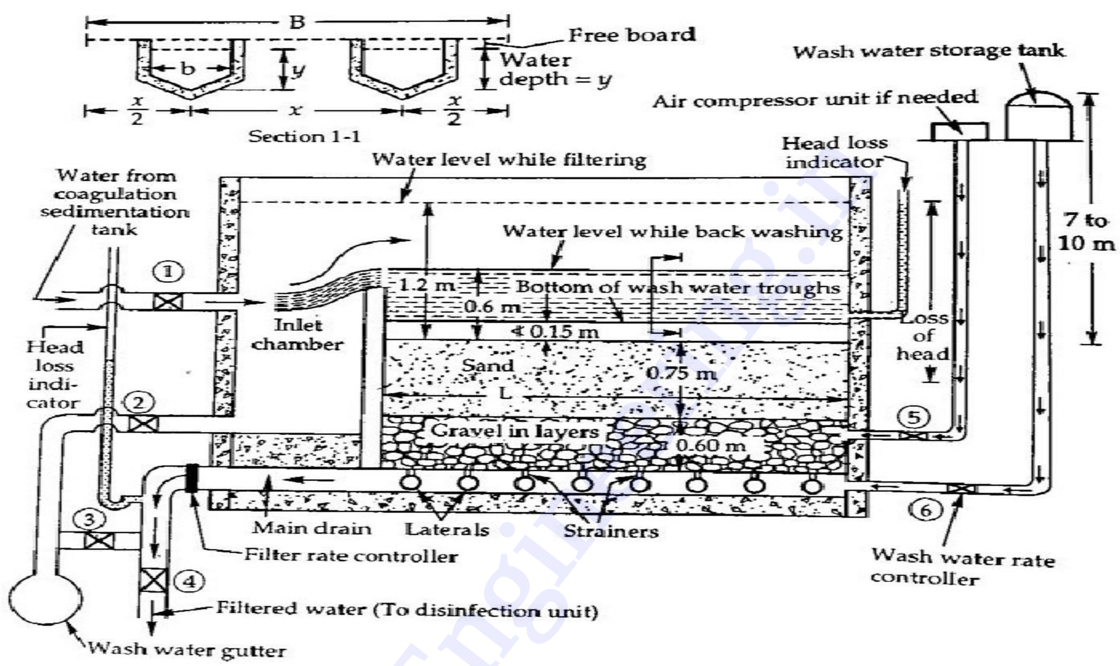
12. **What is the significance of velocity gradient in flocculator design? (NOVDEC 2014)**

- Velocity gradient determines how much the water is agitated in the flocculator
- Velocity gradient determines how much energy is used to operate the flocculator.
- Velocity gradient defines rate of change of velocity per unit distance normal to a section

PART – B

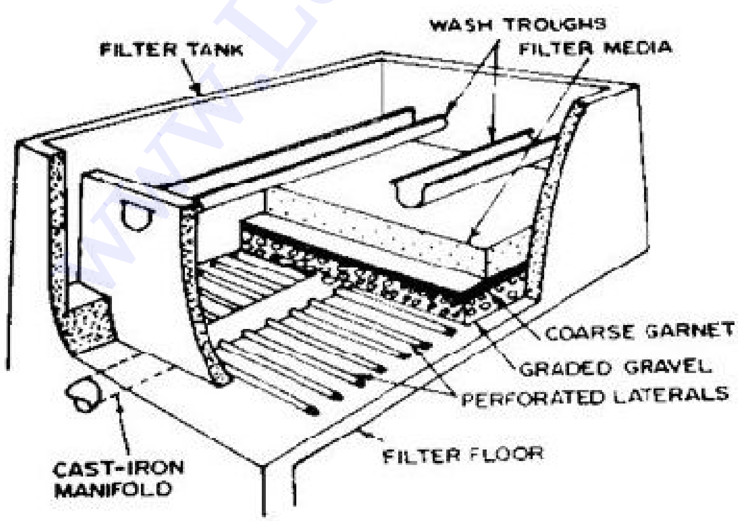
1. With neat sketch explain working principle of rapid sand filter. (May/Jun 2012, Nov/Dec 2012)

RAPID SAND FILTER (GRAVITY TYPE)
ESSENTIAL FEATURES



Rapid Sand Filter

Enclosure tank
• Smaller in size, therefore can be placed under roof.
• Rectangular in shape and constructed of concrete or masonry.
• Depth – 2.5 to 3.5



VIEW OF RAPID SAND FILTER WITH UNDERDRAINAGE SYSTEM

• Surface area – 20 to 50 m2

• L/B ratio – 1.25 to 1.35.

• Designed filtration rate are 3000 to 6000 lit/m2/hr

Filter media

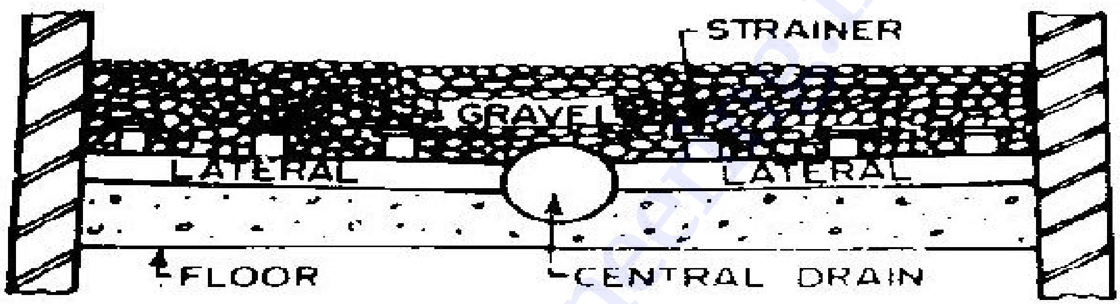
• Should be free from dirt, organic matter and other Slow Sand.

• It should be hard and resistant.

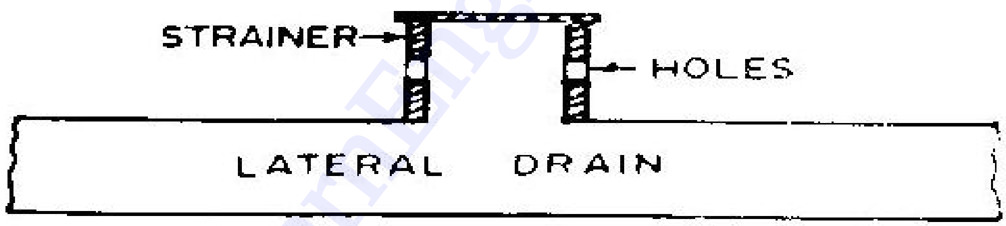
• Depth of sand media – 0.6 to 0.9 m

• Effective size – 0.35 to 0.6 mm (Common value 0.45)

• Uniformity coefficient – 1.2 to 1.7 (Common value -1.5)



(a) SECTION OF UNDERDRAINAGE SYSTEM



(b) LATERAL WITH STRAINER

Estimation of sand depth

• The depth of sand bed should be such that flocs should not break through the sand bed.

• Depth varies from 60 to 90 cm

• Min depth required is given by Hudson's formula

[(q . D3. H) / l] = Bi x 29323

Where,

• q = Filtration rate in m3/m2/hr

[Assumed filtration rate x Factor of safety (2)]

(Factor of safety 2 is taken to cater emergency situation)

• D = sand size in mm

• H = terminal head loss in m

• I = depth of sand bed in m

•Bi = Break through index= 4×10^{-4} to 6×10^{-3}

Base material

• Depth 45 to 60 cm

layer	**Depth (h)**	**size**
Topmost	15	3 to 6
Intermediate	15	6 to 12
intermediate	15	12 to 20
bottom	15	20 to 50

Estimation of gravel size gradation

• To start with, a size gradation of 2 mm at top and 50 mm at bottom is assumed.

• The required depth (I) in cm of a component of gravel layer of size d (mm) can be computed by following equation

I = 2.54. K. (log d)

K can be taken as 12 d = gravel size in mm

Under drainage system

• Objectives of under drainage system

1. To collect filtered water uniformly over the area of gravel bed

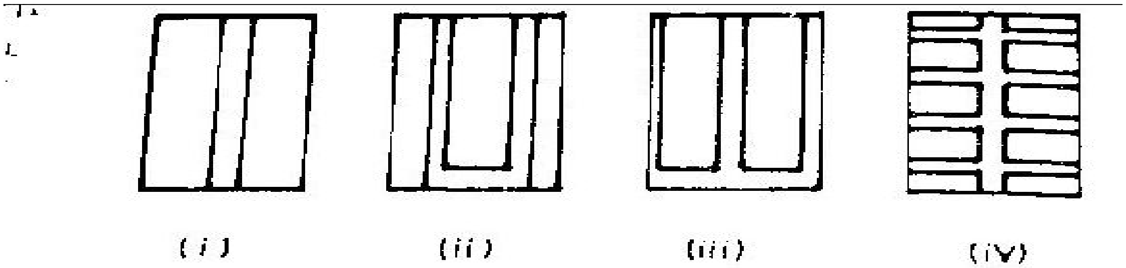
2. It provides uniform distribution of back wash water without disturbing or upsetting gravel layer and filter media

Appurtenances

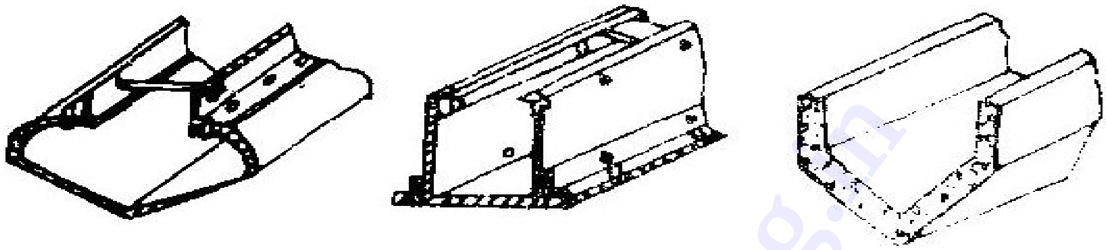
1. Wash water troughs

2. Air compressors

3. Rate control device

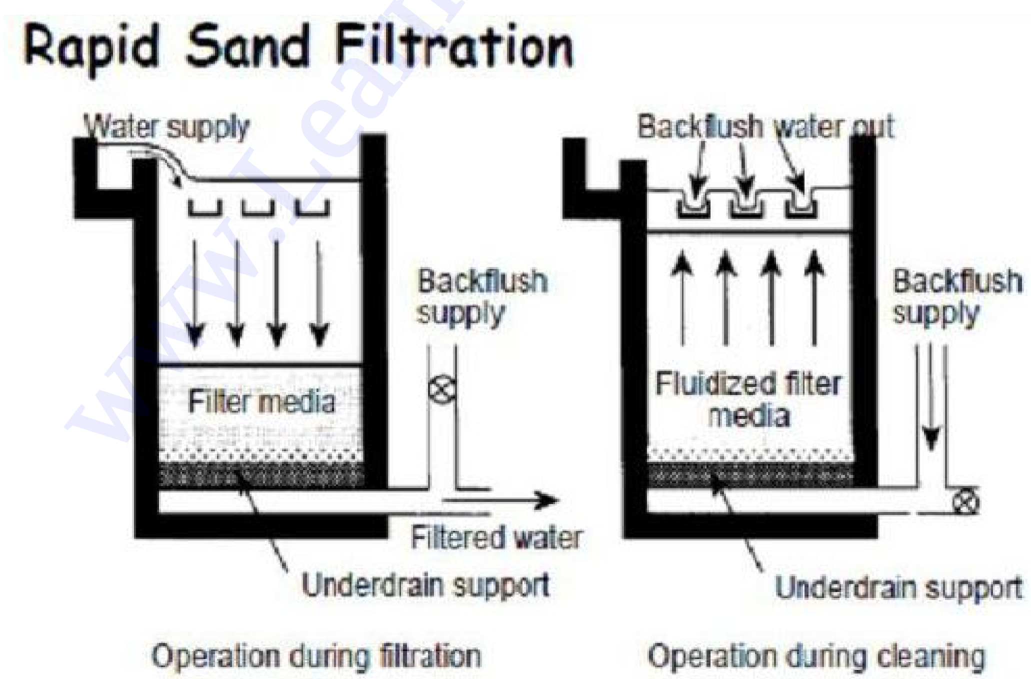


(a) ARRANGEMENT OF WASH-WATER TROUGHS



WORKING AND BACKWASHING of Rapid Sand Filter

• All valves are kept closed except valves A and B.
• Valve A is opened to permit water from clarifier
• Valve B is opened to carry filtered water to clear water sump
• Head of 2m over sand bed is maintained
• Designed filtration rate are 3000 to 6000 lit/m2/hr
• Filter run depends on quality of feed water
• Filter run may range between less than a day to several days
• Objective of backwash is to remove accumulated particles on the surface and within the filter medium
• Backwash is performed using wash water or air scouring.



Back washing

• Filter is back washed when head loss through it has reached the maximum permissible.

• RSF are washed by sending air and water upwards through the bed by reverse flow through the collector system.

• 2% - 4% filtered water is used for backwashing

Steps in back washing

1. Close influent valve A
2. Close effluent valve B
3. Open air valve F, so that air blows at rate of 1 to 1.5 m

3free air /min/m2of bed area for @ 2 to 3 min. this will break up the scum and loosen the dirt.

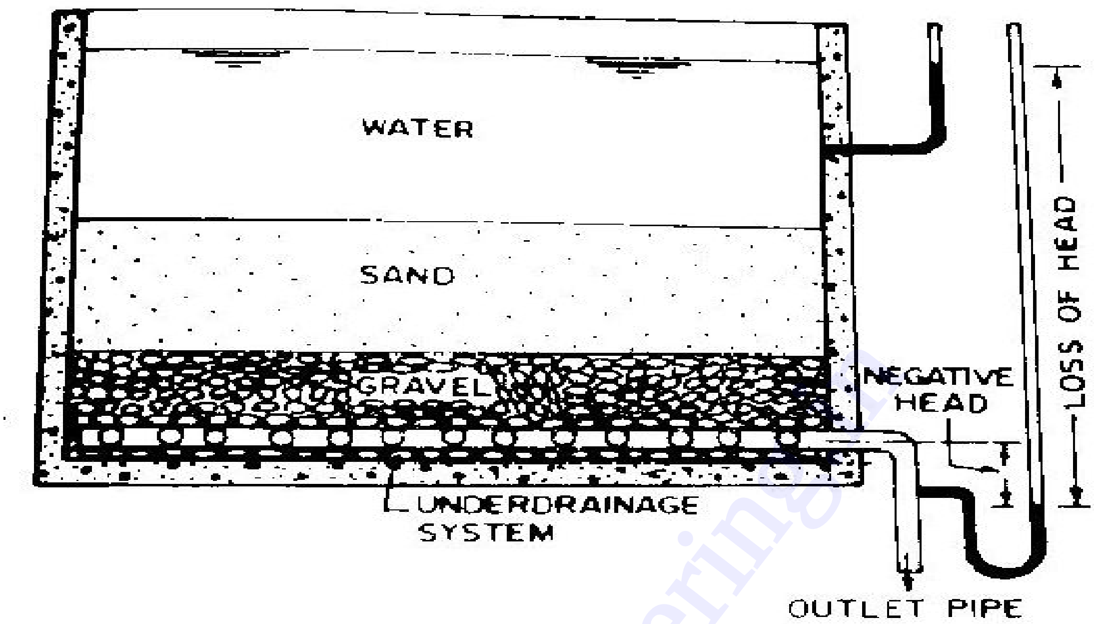
4. Close the air valve F and open the wash water valve E gradually to prevent the dislodgement of finer gravel.
5. Open the wastewater valve D to carry wash water to drain. Continue backwashing till wash water appears fairly clear.
6. Close the wash water valve E. Close the wastewater valve D. wait for some time till all matter in bed settles down.
7. Open valve A slightly, open valve C for carrying filtered water to drains for few minutes.
8. Close the valve C and open valve B. Open valve A completely to resume normal filtration

Negative head and filter troubles

• When clean bed is put into operation the loss of head will be small usually in order of 15 to 30 cm.

• During filtration impurities get arrested in the voids and head loss goes on increasing.

• Loss of head can be measured by using two piezometric tubes as shown in figure



• As thickness or depth of suspended matter on the sand bed increases, the head loss increased.

• A stage comes when frictional resistance exceeds the static head above the sand bed.

• At this stage, lower parts of sand bed and under drainage system are under partial vacuum or negative head.

• Because of negative head water is being sucked rather than being filtered.

• In Rapid Sand Filter head loss may be 2.5 to 3.5 m

• Permissible negative head may be 0.8 to 1.2 m.

• Filter run is terminated and filter is then backwashed when these values are reached.

• Frequency of backwashing is 2-4 days for Rapid Sand Filter in normal conditions

FILTER TROUBLES

Following filter troubles are commonly observed

1. Cracking and clogging of filter bed
2. Formation of mud balls
3. Air binding
4. Sand Incrustation
5. Jetting and Sand boils
6.Sandleakage

2. Explain conventional method used to disinfect water. (May/Jun 2012)

Disinfection

Partial destruction and inactivation of disease-causing organisms from exposure to chemical agents (e.g., chlorine) or physical processes (e.g.,UV irradiation). (or)
A process that eliminates a defined scope of microrganisms, except most spores, viruses and prions. The purpose of disinfection prevents transmission of certain microorganisms with objects, hands or skin and prevent spreading the infection

Principle of Disinfection

Decontamination- removal of microorganisms contaminating an object
Preservation- preventing methods of microbe caused spoilage of susceptible products (pharmaceuticals, foods)
Sanitisation - removal of microbes that pose a threat to the public health, food industry, water conditioning sanitizer - an agent, usually a detergent, that reduces the numbers of bacteria to a safe level
Aseptic techniques- prevent microbial contamination of materials or wounds
Antisepsis- disinfection of living tissues (e.g., in a wound), achieved through the use of antiseptics
Antiseptics are applied (do not kill spores) to reduce or eliminate the number of bacteria from the skin

Factors influencing Disinfection

Types of organisms
Number of organisms
Concentration of disinfecting agent
Presence of organic material (e.g., serum, blood)
Nature (composition) of surface to be disinfected
Contact time
Temperature
pH
Biofilms
Compatibility of disinfectants and sterilants

Sterilization

Total destruction of disease-causing germs and other organisms.

physical methods are used mainly to achieve sterilization

Sterilization methods

Physical method	**Chemical method**
Moist heat in autoclaves	Ethylene oxide
Dry-heat in ovens	Glutaraldehye (high concentration)
Gamma irradiation	
Filtration	
Plasma sterilization	

Methods of Disinfection

(a) Physical methods

(i) Boiling of water (ii) Solar Disinfection

(b) Chemical methods

(a) Physical methods

Boiling

This is the most effective method of killing bacteria but impracticable in large scale. Most of bacteria are destroyed when the water has attained of about 80˚C temperature. Prolonged boiling is unnecessary and wasteful

Solar Disinfection

Solar disinfection is a thermal process consisting of raising water temperature for a long enough period of time in containers that have been prepared to absorb the heat generated by solar radiation for disinfection of water

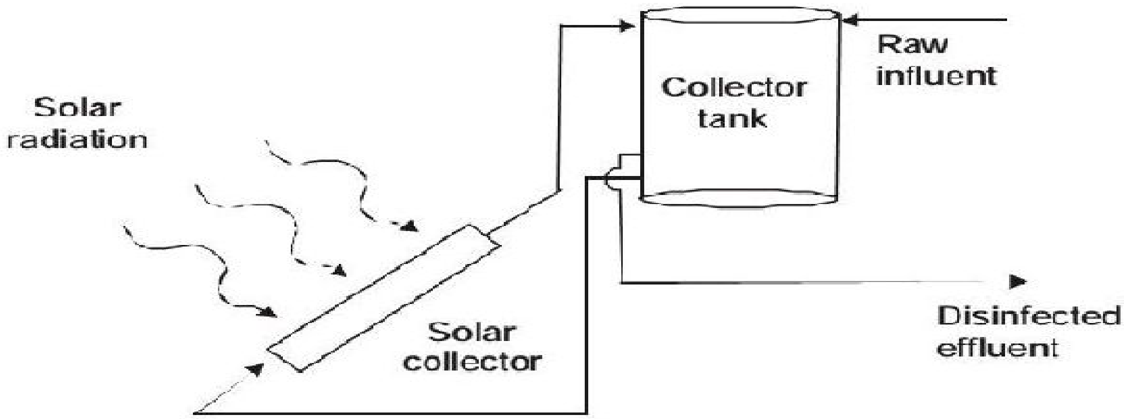


Diagram of a thermosiphon for water heating

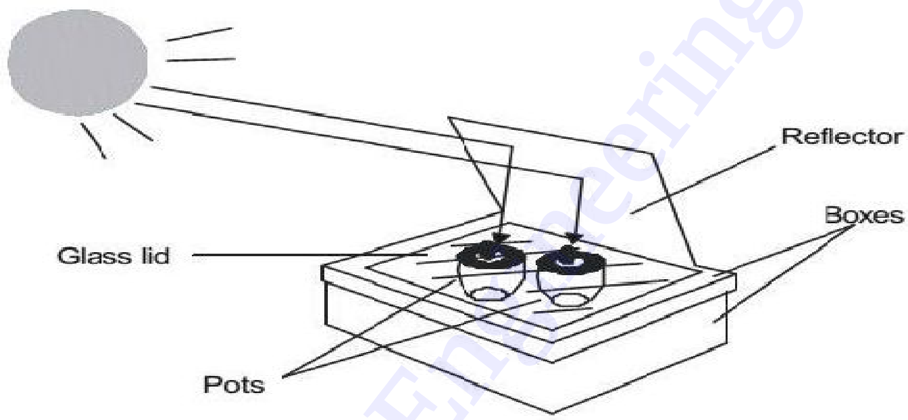
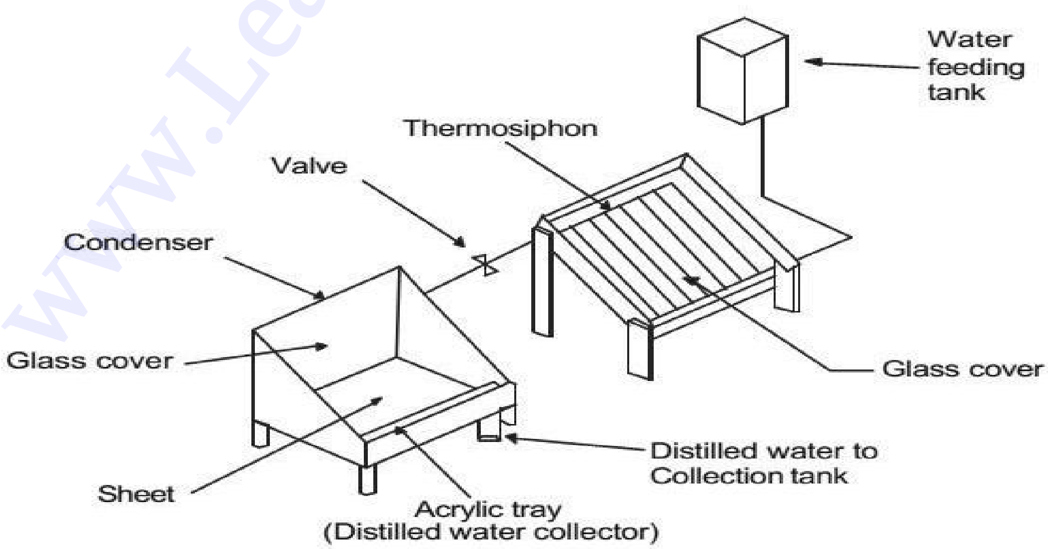


Diagram of a solar stove



Combined themosiphon and solar stills

Monitoring

At effluent temperatures of over 55 ºC, total coliform inactivation has been demonstrated in 99% of the cases. For safety reasons, however, the golden rule is to have a margin of safety and to set 65 ºC as the minimum temperature for disinfection. Monitoring of these systems should confirm that the water at the outlet of any of these systems or following treatment reached 65 ºC.

In as much as solar heaters were not designed for water disinfection, but merely to heat it, there is no way to check whether the temperature reached the pasteurization point. Therefore, it would be advisable to install a thermostat connected to a valve that would allow the water passage only at a temperature of over 65 ºC. A thermometer can be attached to the cover of solar stoves or bottles; in other cases, bottles can be fitted with small ampoules containing a substance that will melt at a temperature of above 65°C, ensuring that the required pasteurization temperature has beenattained.

(b) Chemical Methods

Use of Disinfectants as Chemical Oxidants

Oxidation is a chemical reaction where **electrons are transferred** from one species (the reducer) to another species (the oxidant)

Disinfectants are used for more than just disinfection in drinking water treatment. While **inactivation of pathogenic organisms is a primary function**, disinfectants are also **used oxidants** in drinking water treatment for several other functions:

1. Minimization of Disinfection Byproducts formation : Several strong oxidants, including potassium permanganate and ozone, may be used to control DBP

2. Prevention of re-growth in the distribution system and maintenance of biological stability;

– **Removing nutrients** from the water prior to distribution;
– **Maintaining a disinfectant residual** in the treated water;
– Combining nutrient removal and disinfectant residual maintenance

3. Removal of color: Free chlorine is used for color removal. A low pH is favored. Color is caused by humic compounds, which have a high potential for DBP formation

4. Improvement of coagulation and filtration efficiency;

a. Oxidation of organics into more polar forms;

b. Oxidation of metal ions to yield insoluble complexes such as ferric iron complexes;

c. Change in the structure and size of suspended particles.

5. Oxidation is commonly used to remove taste and odor causing compounds. Because many of these compounds are very resistant to oxidation, advanced oxidation processes (ozone/hydrogen peroxide, ozone/UV, etc.) and ozone by itself are often used to address taste and odor problems. The effectiveness of various chemicals to control taste and odors can be site-specific.

6. Removal of Iron and Manganese

Oxidant	Iron (II) (mg/mg Fe)	Manganese (II) (mg/mg Mn)
Chlorine Cl_2	0.62	0.77
Chlorine Dioxide, ClO_2	1.21	2.45
Ozone, O_3	0.43	0.88*
Oxygen, O_2	014	0.29
Potassium	0.94	1.92
Permanganate, $KMnO_4$		

7. Prevention of algal growth in sedimentation basins and filters: Prechlorination will prevent slime formation on filters, pipes, and tanks, and reduce potential taste and odor problems associated with such slimes.

Factors affecting disinfection effectiveness

• Time

• pH

• Temperature

• Concentration of the disinfectant

• Concentration of organisms

• Nature of the disinfectant

• Nature of the organisms to be inactivated

• Nature of the suspending medium

Chlorine

Chlorine has many attractive features that contribute to its wide use in the industry.

Four of the key attributes of chlorine are that it:

• Effectively **inactivates a wide range of pathogens** commonly found in water;

• **Leaves a residual** in the water that is easily measured and controlled;

• **Is economical**; and

• Has an extensive track **record of successful** use in improving water treatment operations

There are, however, some concerns regarding chlorine usage that may impact its uses such as:

• Chlorine **reacts** with many naturally occurring **organic and inorganic** compounds in water to produce undesirable **Disinfectant By Products**;

• **Hazards associated with using chlorine**, specifically chlorine gas, require special treatment and response programs; and

• High chlorine doses **can cause taste and odor problems**.

3. a) Explain the sedimentation process used in water treatment plant. (Apr/May 2011)

Sedimentation:

Sedimentation is the removal of suspended particles by gravitational settling. Sedimentation tanks are designed to reduce velocity of flow of water so as to permit suspended solids to settle out of the water by gravity

Plain sedimentation:

When impurities are separated from water due to action of gravity alone then it is called plain sedimentation.

Sedimentation with coagulation or clarification:

When chemicals or other substances are added to induce the suspended solids to aggregation to form flocs then it is called as sedimentation with coagulation or clarification

Chemical precipitation:

When chemicals are added to throw dissolved impurities out of solution it is called as chemical precipitation

Discrete particles:

A particle that does not alter its size, shape, and weight while settling in water is known as discrete particle

Types of settling:

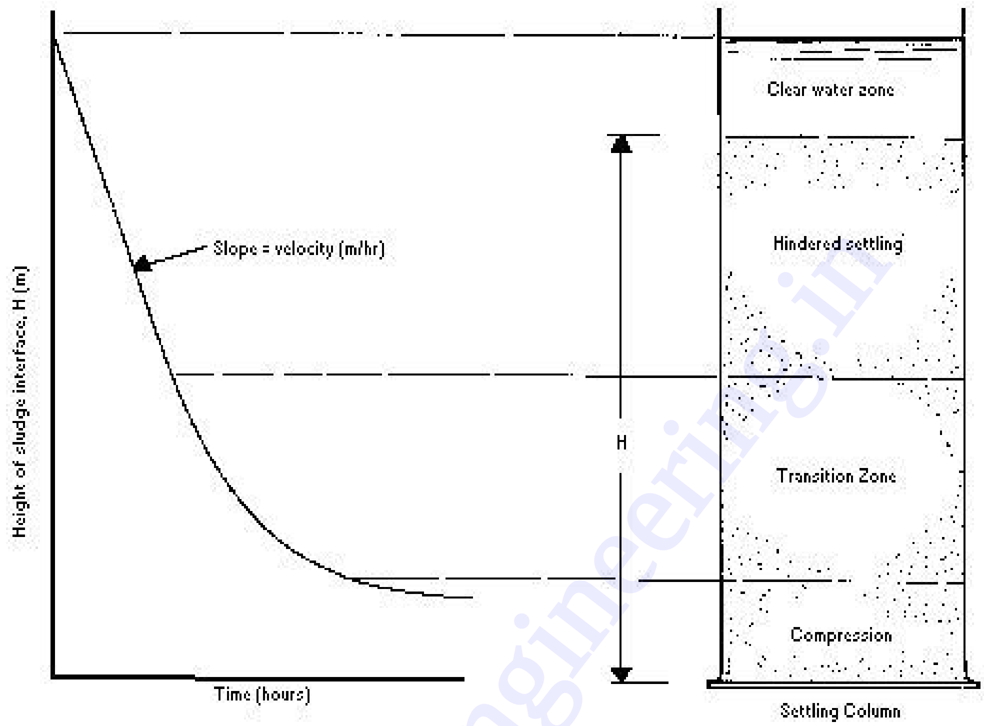
Type I: Discrete particle settling - Particles settle individually without interaction with neighbouring particles.

Type II: Flocculent Particles – Flocculation causes the particles to increase in mass and settle at a faster rate.

Type III: Hindered or Zone settling –The mass of particles tends to settle as a unit with individual particles remaining in fixed positions with respect to each other.

Type IV: Compression – The concentration of particles is so high that sedimentation can only occur through compaction of the structure.

In water treatment Type – I and Type – II settlements are encountered



Column test for a suspension exhibiting zone-settling behavior of all types of settling

Type I Settling

· Size, shape and specific gravity of the particles do not change with time.

· Settling velocity remains constant.

If a particle is suspended in water, it initially has two forces acting upon it:

(1) **force of gravity**: $F_g=\rho_p g V_p$

(2) **buoyant force** quantified by Archimedes as: $F_b=\rho g V_p$

If the density of the particle differs from that of the water, a net force is exerted and the particle is accelerated in the direction of the force:

$F_{net}=(\rho_p-\rho)gV_p$, This net force becomes the driving force

Once the motion has been initiated, a third force is created due to viscous friction. This force, called the **drag force**, is quantified by:

Fd=CDApρv2/2, CD

= drag coefficient, Ap = projected area of the particle

Because the drag force acts in the opposite direction to the driving force and increases as the square of the velocity, acceleration occurs at a decreasing rate until a steady velocity is reached at a point where the drag force equals the driving force:

(ρp-ρ)gVp=CDApρv2/2

For spherical particles,

Vp=πd3/6 and Ap=πd2/4

Thus, v2= 4g(ρp-ρ)d

3CDρ

Expressions for CD change with characteristics of different flow regimes. For laminar, transition, and turbulent flow, the values of CD are:

CD = 24 (laminar)

Re

CD= 24 + 3 + 0.34 (transition)

Re Re

1/2

CD= 0.4 (turbulent)

Where Re is the Reynolds number:

Re=rvd

m

Reynolds number less than 1.0 indicate laminar flow, while values greater than 10 indicate turbulent flow. Intermediate values indicate transitional flow.

Stokes Flow

For laminar flow, terminal settling velocity equation becomes:

v= (rp-r)gd2

18m

which is known as the **stokes equation.**

Transition Flow

Need to solve non-linear equations:

v2= 4g(rp-r)d /

3 CDr

CD= 24 + 3 +0.34 /

Re Re1/2

Re=rvd /

m

Types of Sedimentation tanks

Depending upon the types of operation there are two types

(i) The Quiescent or fill and draw type

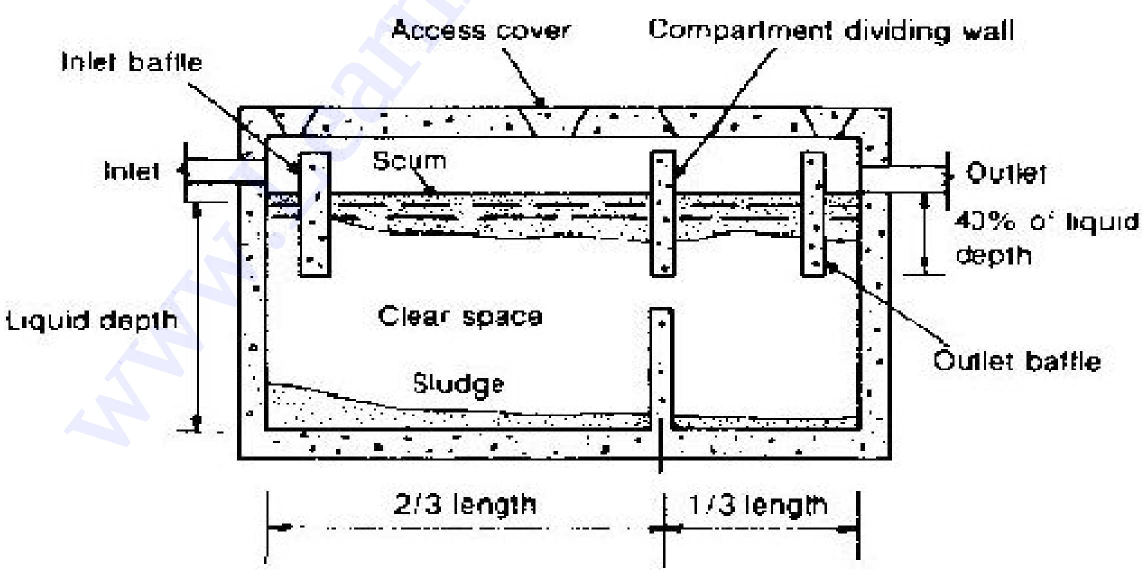
(ii) The continuous flow type

(i) Fill draw type

Sedimentation tank is filled with incoming water and is allowed to rest for a 24 hours. Suspended particles settle down at the bottom of the tank during rest the clear water is drawn out and the tank is cleaned which takes 6 to 12 hours

Cycle of operation takes 30 to 36 hours

Minimum of three units are required for constant supply



(ii) Continuous flow type tank

In factors controlling settling or sedimentation under gravity, velocity of flow can be controlled in continuous flow type tanks

In continuous flow type tanks water flows at constant velocity in the tank

The particles settle at bottom during flow of water before it reaches to tank outlet

(a) Horizontal flow tank

(b) Vertical flow tank

The horizontal flow type tank is generally rectangular in plan with length twice as width and water flows at velocity 0.3 m/sec

Vertical flow type tanks are deep circular or rectangular with hopper bottom

3. b) State and explain break point chlorination. (Apr/May 2011)

Chlorine

Chlorine has many attractive features that contribute to its wide use in the industry. Four of the key attributes of chlorine are that it:

• Effectively **inactivates a wide range of pathogens** commonly found in water;

• **Leaves a residual** in the water that is easily measured and controlled;

• **Is economical**; and

• Has an extensive track **record of successful** use in improving water treatment operations

There are, however, some concerns regarding chlorine usage that may impact its uses such as:

• Chlorine **reacts** with many naturally occurring **organic and inorganic** compounds in water to produce undesirable **Disinfectant By Products**;

• **Hazards associated with using chlorine**, specifically chlorine gas, require special treatment and response programs; and

• High chlorine doses **can cause taste and odor problems**.

Chlorine purposes in water treatment

• Taste and odor control;

• Prevention of algal growths;

• Maintenance of clear filter media;

• Removal of iron and manganese;

• Destruction of hydrogen sulfide;

• Bleaching of certain organic colors;

• Maintenance of distribution system water quality by controlling slime growth;

• Restoration and preservation of pipeline capacity;

• Restoration of well capacity, water main sterilization; and

• Improved coagulation by activated silica.

Chlorine Chemistry

• Chlorine gas **hydrolyzes** rapidly in water to form **hypochlorous acid**

Cl2+ H2O = H++ Cl- + HOCl (hypochlorous acid)

• **Hypochlorous acid is a weak acid** (pKa of about 7.5), meaning it **dissociates slightly** into hydrogen and hypochlorite ions

HOCl = H++ OCl-

• Between a **pH of 6.5 and 8.5 this dissociation is incomplete** and both HOCl and OCl- species are present to some extent (White, 1992). **Below a pH of 6.5, no dissociation of HOCl occurs**, while **above a pH of 8.5, complete dissociation to OCl- occurs**.

• As the germicidal effects of **HOCl is much higher than that of OCl-**, chlorination at a lower pH is preferred.

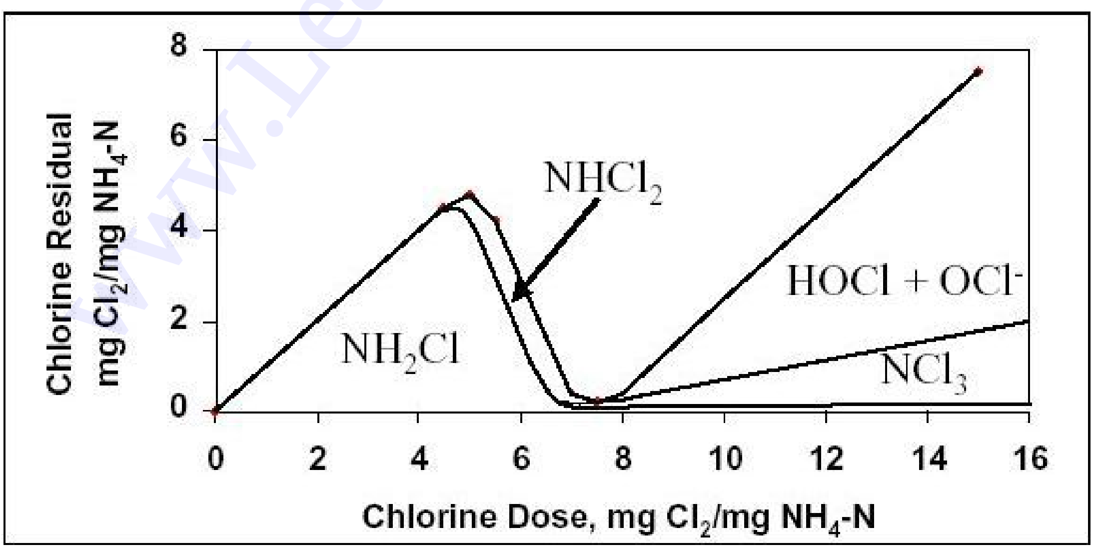
Breakpoint Chlorination

• The type of chlorine dosing normally applied to piped water supply systems is referred to as breakpoint chlorination. Sufficient chlorine is added to satisfy all of the chlorine demand and then sufficient extra chlorine is added for the purposes of disinfection.

• As the applied Cl2: N ratio increases from 5:1 to 7.6:1, breakpoint reaction occurs, reducing the residual chlorine level to a minimum.

• Breakpoint chlorination results in the formation of nitrogen gas, nitrate, and nitrogen chloride.

• At Cl2:N ratios above 7.6:1, free chlorine and nitrogen trichloride are present.



The importance of break-point chlorination lies in the control of taste and odour

Advantages

• Chloramines are not as reactive with organics as free chlorine in forming Disinfectant By Products.

• The monochloramine residual is more stable and longer lasting than free chlorine or chlorine dioxide, thereby providing better protection against bacterial regrowth in systems with large storage tanks and dead end water mains. However excess ammonia in the network may cause biofilming.

• Because chloramines do not tend to react with organic compounds, many systems will experience fewer incidences of taste and odor complaints when using chloramines.

• Chloramines are inexpensive.

• Chloramines are easy to make.

Disadvantages

• The disinfecting properties of chloramines are not as strong as other disinfectants, such as chlorine, ozone, and chlorine dioxide.

• Chloramines cannot oxidize iron, manganese, and sulfides.
• When using chloramine as the secondary disinfectant, it may be necessary to periodically convert to free chlorine for biofilm control in the water distribution system.
• Excess ammonia in the distribution system may lead to nitrification problems, especially in dead ends and other locations with low disinfectant residual.
• Monochloramines are less effective as disinfectants at high pH than at low pH.
• Dichloramines have treatment and operation problems.
• Chloramines must be made on-site.

The use of chlorine has become practically universal in the disinfection of water. It is cheap reliable, and presents no great difficulty in handling. According to AWWA, the earliest recorded use of chlorine directly for water disinfection was on an experimental basis, in 1896 at Louisville, and in 1897 at England. Its first continuous use was in Belgium, in 1902, for the dual objective of aiding coagulation and making water biologically safe.

Chlorine may be applied to water in one of the following forms

- Hypochlorite
- Chloramines
- Free chlorine gas
- Chlorine dioxide

Chlorine demand is the difference between the amount of chlorine added to water and the quantity of free available chlorine remaining at the end of a specified contact period.

4. A coagulation sedimentation plant clarifies 40 million litre of water every day. The quantity of filter alum required at the plant is 18 mg/L. If the raw water is having an alkalinity equivalent to 5 mg/L of $CaCO_3$, determine the quantity of filter alum and the quick lime (containing 85% of CaO) required per year by the Plant. Given the molecular weights as :

[Al = 27, S = 32, O = 16, H = 1, Ca = 40, C = 12] Apr/May-Nov/Dec-15

Solution:

Quantity of water to be treated = 40×10^6 litres/day

∴ Quantity of filter alum required per day @ 18 mg/L

$$= 18 \times 40 \times 10^6 \text{ mg} = \frac{18 \times 40 \times 10^6}{10^6} \text{ kg} = 720 \text{ kg}$$

∴ Quantity of filter alum required per year

$$= 720 \times 365 \text{ kg} = 262.8 \text{ Tonnes}$$

The chemical reactions that take place are

$$Al_2(SO_4)_3 \cdot 18\,H_2O + 3\,Ca(HCO_3)_2 \longrightarrow 2\,Al(OH)_3 \downarrow + 3\,CaSO_4 + 18\,H_2O + 6\,CO_2 \uparrow$$

$$CaCO_3 + H_2O + CO_2 \longrightarrow Ca(HCO_3)_2$$

$$CaCO_3 \longrightarrow CaO + CO_2$$

The molecular masses are worked out as below:

Mol. mass of $Al_2(SO_4)_3 \cdot 18\,H_2O = 2 \times 27 + 3(32+64) + 18(2+16)$
$= 54 + 288 + 324 = 666$

Mol. mass of $Ca(HCO_3)_2 = 40 + 2(1+12+48) = 162$

Mol. mass of $CaCO_3 = 40 + 12 + 48 = 100$

Mol. mass of $CaO = 40 + 16 = 56$

Now, from the above equations, it is clear that alum requires (3×162) parts of natural alkalinity as $Ca(HCO_3)_2$ for every 666 parts of alum. (3×162) parts of alkalinity as $Ca(HCO_3)_2$ is equivalent to (3×100) parts of alkalinity required as $CaCO_3$.

Hence, the alkalinity required as $CaCO_3$ for the water containing alum of 18 mg/l $= \frac{3 \times 100}{666} \times 18$ mg/l $= 8.108$ mg/l.

Natural alkalinity available as $CaCO_3 = 5$ mg/l.

∴ Additional alkalinity required to be added in the form of lime

$= 8.108 - 5 = 3.108$ mg/l as $CaCO_3$

Now, 100 parts of $CaCO_3$ is produced by 56 parts of CaO

Hence the quantity of CaO required

$$= \frac{3.108 \times 56}{100} \text{ mg/l}$$

$$= 1.74 \text{ mg/l}$$

Since quick lime contains 85% of CaO, the quick lime required

$$= \frac{1.74 \times 100}{85} \text{ mg/l}$$

$$= 2.05 \text{ mg/l}$$

∴ The quantity of lime required for treating 40×10^6 litres of water/day

$$= 2.05 \times 40 \times 10^6 \text{ mg/day}$$

$$= 2.05 \times 40 \text{ kg/day}$$

$$= 82 \text{ kg/day}$$

Hence, the yearly consumption of quick lime

$$= 82 \times 365 \text{ kg}$$

$$= 29,930 \text{ kg}$$

$$= 29.93 \text{ Tonnes}$$

Ans:

Estimation of Alum = 262.8 Tonnes / year

Estimation of Quick lime = 29.93 Tonnes / year.

5. Design a rapid sand filter to need for 4 million litres/day of supply with all its Principle components. (May June 2014, Nov/Dec 2014, 2015)

Solution :

Step 1: Water required per day = 4 ML

Assuming that 4% of filtered water is required for washing of the filter, every day.

we have, Total filtered water required per day

$$= \frac{4}{0.96} \text{ ML}$$

$$= 4.167 \text{ ML/day}$$

Now, assuming that 0.5 hr is lost every day in washing the filter water required per hour

$$\text{Filtered water required per hour} = \frac{4.167}{23.5} \text{ ML/day}$$

$$= 0.177 \text{ ML/hr}$$

Step 2: Now, assuming the rate of filtration to be 5000 lit/hr/sq m we have the area of filter required

$$\text{Area of filter required} = \frac{0.177 \times 10^6}{5000}$$

$$= 35.46 \text{ m}^2$$

Now, assuming the length of the filter bed (L) as 1.5 times the width of the filter bed (B) and 2 beds, the total area provided,

Assume L = 1.5 times (B)

$$\text{Total area required} = 2 \times (L \cdot B) = 35.46$$

$$2 \times (1.5B \times B) = 35.46$$

$$3B^2 = 35.46$$

$$B^2 = \frac{35.46}{3} = 11.82$$

$$B = 3.44 \text{ m}$$

$$L = 1.5 \times B$$
$$= 1.5 \times 3.44$$
$$L = 5.16 \text{ m}$$

$$\text{Filter Area} = L \times B$$
$$= 3.44 \times 5.16$$
$$= 17.75 \text{ m}^2$$

Design of under drainage system

Let a manifold at lateral system be provided below the filter bed, for receiving the filtered water and to allow back washing for cleaning the filter. this consists of the central manifold pipe with laterals having perforations at their bottom. To design the system, let us assume the total area of the perforations, all the laterals is 0.2 % of the total filtered area.

Step 3 : Assume 0.2 % at all

Total area of perforations = 0.2 % filter area

$$= \frac{0.2}{100} \times (5.2 \times 3.4)$$

$$= 0.035 \text{ m}^2$$

Step 4 : Now, assuming the area of each lateral

= 2 times the area of the perforations in (for 30 mm dia perforations)

we have,

Total area of laterals = 2 × total area of perforations

$$= 2 \times 0.035 \text{ m}^2$$

$$= 0.07 \text{ m}^2$$

Step 5 : Now, assuming the area of manifold to be above twice the area of laterals, we have

Area of manifold $= 2 \times 0.07 \text{ m}^2$

$$= 0.14 \text{ m}^2$$

Diameter of manifold (d) given by

$$\frac{\pi d^2}{4} = 0.14$$

$$d^2 = \frac{0.14 \times 4}{\pi} = 0.178$$

$$d = 0.42 \text{ m}$$

Hence, use 45 cm dia of manifold pipe laid length by along the centre of the filtered water bottom

laterals running Perpendicular to the manifold (width wise) the manifold may be laid at has the spacing of 16 cm (max 30 cm)

The no of lateral is given as $= \frac{5.2 \times 100}{15}$

$= 34.67$

$= 35$ numbers

on either side of the manifold.

Hence, use 70 laterals in all, in each unit.

Step 6 :

Now, Length of each lateral

$$= \frac{\text{width of filter}}{2} - \frac{\text{Dia of manifold}}{2}$$

$$= \frac{3.44}{2} - \frac{0.42}{2} = \frac{3.02}{2} = 1.51 \text{ m}$$

Now, adopt the 13 mm dia perforations in the laterals, we have

Total area of perforations $= 0.035 \text{ m}^2$

$$350 \text{ cm}^2 = x \cdot \frac{\pi}{4} (1.3)^2$$

where,

x = Total no of perforations in all 70 laterals

$$x = 350 \times \frac{4}{\pi} \times \frac{1}{(1.3)^2}$$

$x = 263.8$ ie. $x = 264$

$\therefore$ No of perforations in each lateral $= \frac{264}{70}$

$= 3.77 \Rightarrow 3.8$

Step 7 :

Area of perforation per lateral

$$= 4 \times \left[\frac{\pi}{4} \times (1.3)^2 \right] \text{cm}^2$$

$= 5.30 \text{ cm}^2$

Now, Area of each lateral = 2 × Area of perforation per lateral

$= 2 \times 5.30$

$= 10.6 \text{ cm}^2$

∴ Dia of each lateral $= \sqrt{10.6 \times \frac{4}{\pi}}$

$= 3.67$ cm ie: 3.7 cm

Hence, use 70 laterals each of 3.7 cm dia at 15 cm cross section each having 4 perforations of 13 mm size with 45 cm dia manifold

check :

$$\frac{\text{Length of each lateral}}{\text{Dia of lateral}} = \frac{1.475 \text{ m}}{3.7 \text{ m}}$$

$= 39.9$ ie: 40 [should be < 60]

Now, let us assume that the rate of washing of the filter be 60 cm per min or 0.60 m/min.

Step 8 :

$$\text{The wash water discharge} = \frac{0.60 \times (5.2 \times 3.4)}{60}$$

$= 0.177 \text{ m}^3/\text{sec}$

Step 9 :

$$\text{Velocity of flow in the laterals for wash water} = \frac{0.177}{70 \times \left[\frac{\pi}{4} \times \left(\frac{3.7}{100}\right)^2\right]} \text{ m/sec}$$

$= 2.36$ m/sec

$$\text{llly velocity of flow in manifold} = \frac{\text{Discharge}}{\text{Area}}$$

$$= \frac{0.177}{\frac{\pi}{4}(0.45)^2} \text{ m/sec}$$

$= 1.11$ m/sec [should be < 1.8 m/sec]

Design of wash water troughs

Wash water troughs as said earlier are generally kept at above 1.5 to 2 m apart. So in a width of 3.4 m of filter bed, let us provide 3 troughs.

Step 10 :

Assume 3 trough, 3.4 m filter bed

$$= \frac{3.4}{3} = 1.13 \text{ m apart}$$

Now, the total wash water discharge of $0.177\ m^3/sec$ enters these three troughs.

$$\therefore \text{Discharge in each troughs} = \frac{0.177}{3}\ m^3/sec$$

$$= 0.059\ m^3/sec$$

The dimensions of a concrete bottom trough are now designed by empirical formula

Empirical formula

$$Q = 1.376\ b \cdot y^{3/2}$$

Q = Discharge in m^3/sec

b = width of trough in m = y (assume)

y = water depth in trough m

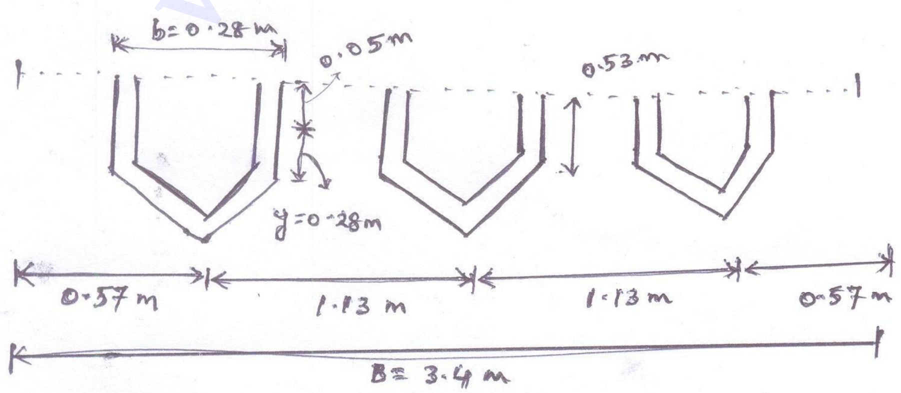
Let $0.059 = 1.376 \times y \times y^{3/2}$

$$y^{5/2} = \frac{0.059}{1.376} = 0.043$$

$$y = (0.043)^{2/5} \Rightarrow y = 0.28 \text{ m ie: } y = 28 \text{ cm}$$

keeping 5 cm free board, adopt depth of trough = 28 + 5 = 33 cm

Hence 3 no of wash water troughs of size 28 cm × 33 cm may be used



UNIT - IV
ADVANCED WATER TREATMENT
PART – A

1. How do you remove iron and manganese from water? [NovDec2010]

Iron and manganese from water can be removed by Physical process (Unit operations) and Chemical process (Unit Process)

Physical process (Unit Operation)

Aeration

Chemical process (Unit Process)

Chemical Oxidation using Chlorine dioxide, potassium permanganate and ozone

Manganese Zeolite Filters

2. Describe about the term water softening? [NovDec2010]

Reduction or removal of hardness from water is known as water softening.

Types of hardness are permanent and temporary hardness

3. State the objectives of aeration process in water treatment? [AprMay2011]

Objectives of aeration are to remove dissolved gases, such as carbon dioxide, hydrogen sulfide, and to oxidize dissolved metals iron and manganese. It can also be used to remove volatile organic chemicals (VOC).

4. Mention any four methods of desalination process? [AprMay2011]

(i) Desalination by evaporation and distillation
(ii) Electrodialysis
(iii) Reverse osmosis
(iv) Freezing process
(v) Solar distillation method

5. List the pollutants get removed in an aerator? [NovDec2011]

Carbon dioxide, Hydrogen sulfide (rotten-egg odour), Methane (flammable), Iron (will stain clothes and fixtures), Manganese (black stains), Volatile organic chemicals, Various chemicals causing taste and odour

6. Name the methods of deflouridation? [NovDec2011], [MayJun2014], [NovDec2014], [AprMay2015]

- Prashanthi technique using adsorption by activated alumina
- Ion exchange adsorption method
- Nalgonda technique
- Reverse osmosis process

7. List out the unit process applied to remove iron and manganese from water? [AprMay2012]

Chemical process (Unit Process)

Chemical Oxidation using Chlorine dioxide, potassium permanganate and ozone

Manganese Zeolite Filters

8. What is reverse osmosis? [AprMay2012]

The natural osmotic pressure is opposed by exerting an external pressure on the side containing the salt solution which forces pure water from the salt solution to move across the membrane towards the side containing water this process is called as reverse osmosis

9. What is the maximum permissible limit of fluoride in drinking water? [NovDec2012]

Acceptable limit of Flouride in drinking water is 1mg/l

10. How do you protect water treatment plant from corrosion? [NovDec2012]

- Cathodic protection by making pipe line as cathode and separate scrap iron as anode using DC power supply
- Sacrificial Anodic protection by attaching zinc, aluminum and magnesium no need for power supply
- Control of internal corrosion by protective coatings and water treatment

11. Mention the types of aerators used in water treatment? [MayJun2013]

(i) Gravity aerators (water into the air), (ii) Spray aerators (water into the air), (iii) Diffusers (air into the water), and (iv) Mechanical aerators (air into the water)

12. Any four effects of hardness in water? [MayJun2013]

Hardness in water,

- Causes more consumption of soap in laundry work
- Affects dyeing of textiles
- Causes difficulties in paper, canning, ice and rayon industry
- Causes choking and clogging of pipes
- Causes scaling in boilers and heaters
- Makes food tasteless, tough or rubbery

13. Write down the principle of desalination of water? [NovDec2013]

Desalination is the process of removing dissolved salts from water, thus producing fresh water from seawater or brackish water. Salts are present in water as hydrated Na^+ cation and Cl^- anion. Removing hydrated salt ions from water through physical or chemical process is the principle of desalination.

Distillation: $Na^+ (aq) + Cl^- (aq) + heat = NaCl(solid) + H_2O(gas)$

$H_2O(gas) + Condensation = H_2O(liquid)$

Freezing: $Na^+ (aq) + Cl^- (aq) + freezing = NaCl(concentrated\ solution) + H_2O(ice\ crystals)$

$H_2O(ice\ crystals) + Heat = H_2O(liquid)$

14. How do you regenerate softener? [NovDec2013], [MayJun2014]

Water softeners can be regenerated by treating with 5-10% solution of sodium chloride

$$CaZ + 2Nacl = Na_2Z + CaCl_2$$

$$Mg + 2NaCl = Na_2Z + MgCl_2$$

15. Distinguish between physical adsorption and chemical adsorption? [NovDec2014]

Physical Adsorption	Chemical Adsorption
The forces operating in these are weak vander Waal's forces	The forces operating in these cases are similar to those of a chemical bond.
Takes place at low temperature and decreases with increase in temperature	Takes place at high temperature
Heat of adsorption is low	Heat of adsorption is high
It forms multimolecular layer	It forms monomolecular layer

16. What is meant by adsorption isotherm? [AprMay2015]

The adsorption isotherm is an equation relating the amount of solute adsorbed onto the solid and the equilibrium concentration of the solute in solution at a given temperature.

$$q_e \,(mg/g) = \frac{C_o - C_e}{C_{solid}}$$

q_e = equilibrium concentration of a solute on the surface of an adsorbent

C_e = concentration of the solute in the liquid

PART – B

1. Enumerate and explain the various methods of removal of iron and manganese from groundwater.(Nov/Dec 2015),(Apr/May 2015)

Iron and manganese removal

Iron and manganese control is the most common type of municipal water treatment. Iron and manganese occur naturally in groundwater. These elements are, in fact, essential to the human diet. Water containing excessive amounts of iron and manganese can stain clothes, discolor plumbing fixtures, and sometimes add a "rusty" taste and look to the water. Surface water generally does not contain large amounts of iron or manganese, but iron and manganese are found frequently in water systems that use groundwater. Iron in drinking water is 0.3 parts per million (ppm) and 0.05 ppm for manganese.

Bacteria and Iron and Manganese

Iron and manganese in water also promote the growth of bacteria (including iron bacteria). These organisms obtain energy for growth from the chemical reaction that occurs when iron and manganese mix with dissolved oxygen. These bacteria form thick slime growths on the walls of the piping system and on well screens. The growth of iron bacteria can be controlled by chlorination. However, when water containing iron is chlorinated, the iron is converted from the ferrous state to the ferric state in other words, rust and manganese is converted into black manganese dioxide. These materials form a coating on the inside of the water main. Iron bacteria will use even small amounts of iron present in the ferrous state, oxidize it, and then use the energy. Manganese is also used by other bacteria to form organics, which contribute to the iron bacteria slime in the well and/or water system.

Methods to control iron and manganese

(i) Aeration

(ii) Chemical Oxidation

(iii) Manganese Zeolite Filters

(i) Aeration

(i) Gravity aerators (water into the air)

(ii) Diffusers (air into the water)

IRON AND MANGANESE REMOVAL BY AERATION

- Iron and manganese minerals are found in soil and rock.
- Iron and manganese can dissolve into groundwater as it percolates through the soil and rock.
- more than 0.3 mg/l of iron will cause yellow to reddish-brown stains of plumbing fixtures or almost anything that it contacts.
- Manganese even at levels as low as 0.1 mg/l, will cause blackish staining of fixtures and anything else it contacts.
- If the water contains both iron and manganese, staining could vary from dark brown to black.
- Iron and manganese in well waters occur as soluble ferrous and manganous bicarbonates.
- In the aeration process, the water is saturated with oxygen to promote the following reactions:

$$4Fe(HCO_3)_2 + O_2 + 2H_2O = 4Fe(OH)_3^- + 8CO_2$$

ferrous bicarbonate oxygen water ferric hydroxide carbon dioxide

$$2Mn(HCO_3)_2 + O_2 = 2MnO_2 + 4CO_2^- + 2H_2O$$

manganese bicarbonate oxygen manganese dioxide carbon dioxide water

- The oxidation products, ferric hydroxide and manganese dioxide, are insoluble.
- After aeration, they are removed by clarification or filtration.
- Occasionally, strong chemical oxidants such as chlorine (Cl_2 or potassium permanganate (KMnO4) may be used following aeration to ensure complete oxidation.

(ii) Chemical Oxidation

For oxidation following oxidants are used:

Oxygen O_2,

Chlorine dioxide ClO_2,

Potassium permanganate $KMnO_4$ and

Ozone O_3

Chlorine dioxide ClO_2:

Chlorine dioxide (ClO_2) is widely used for water purification due to the ability of disinfection, oxygenation and odor control. For water treatment aqueous solutions of 0.1-.05% ClO2 is commonly used, although some generators produce a continuous supply of diluted gas, allowing the usage of most of the diffusers mentioned above for admixture. Chlorine dioxide is explosive at higher concentrations than 10% per air volume and cannot be stored or transported in pressure tanks as other gases; therefore a ClO2 generator is needed on the location of water treatment

Chlorine Dioxide reaction:

$$5Fe^{2+} + ClO_2 + 4H^+ \rightarrow 5Fe^{3+} + Cl^- + 2H_2O$$

Ferrous iron oxidizes into ferric iron, which can be removed by filtration, chloride ion and water.

$$Mn^{2+} + 2ClO_2 + 2H_2O \rightarrow MnO_2 + 2ClO_2^- + 4H^+$$

Manganese reaction with chlorine dioxide creates manganese dioxide that can as well be removed by filtration leaving chlorite as a byproduct.

Use of chlorine dioxide leaves chlorite, chlorate and organic DBPs as byproducts. The concentration of chlorine dioxide leaving the water treatment system must be lower than 0.8 mg/l and the concentration of the chlorite should not exceed 1.0 mg/l in the distribution system

Disadvantages

- Chlorine dioxide causes skin and respiratory organ irritation, may cause headaches, bronchospasm, pulmonary edema and at long exposure chronic bronchitis. Exposures limit 0.3 mg/m3, short time exposure 0.9 mg/m3.
- In generators the ratio of sodium chlorite to hypochlorous acid is very important since insufficient chlorine feed leaves chlorite and excessive creates chlorate ions.
- Chlorine dioxide is explosive at higher concentrations than 10 % per air volume.

Ozone O_3:

Ozone (O3) is a more effective oxidant than oxygen due to less stable molecular structure and can be admixed through most of the diffusers mentioned above. Ozone has the ability of oxygenation, disinfection and odor control just like chlorine dioxide in addition it does not leave any byproducts. The disadvantage of ozone reactivity is that O3-molecules react with each other breaking down ozone to oxygen, which means that ozone cannot be stored and an ozone generator is needed on the location.

Ozone reactions:

$$2Fe^{2+} + O_3 + H_2O \rightarrow 2Fe^{3+} + O_2 + 2OH^-$$
$$2Fe^{3+} + 6H_2O \rightarrow 2Fe(OH)_3 + 6H^+$$

First the iron oxidizes from ferrous iron to ferric iron and then hydrolyses into ferric hydroxide which can be removed by filtration.

$$2Mn^{2+} + 2O_3 + 4H_2O \rightarrow 2MnO(OH)_2 + 2O_2 + 4H^+$$

Manganese reaction with ozone creates manganese oxydihydroxide that can as well be removed by filtration.

Disadvantages

- Ozone exposure may cause headache, eye-, throat-, nose- or skin irritation, respiratory problems, increased heart rate and low blood pressure. The exposure limit is 0.2 mg/m3, 1 mg/m3 is considered immediate danger.
- In choice of the construction material consider that ozone accelerates decomposition of elastomers.
- Over-ozonation may lead to creation of permanganate (MnO4) which, unlike manganese oxydihydroxide, is soluble in the water and gives it pink color.

Potassium Permanganate

Potassium permanganate is mainly used for oxidation of iron and manganese, taste and odor removal and control of organisms in the water, it is considered ineffective disinfectant due to long contact time requirement. Potassium permanganate is provided in powder form, which is usually diluted into 4 % solution on the location for facilitation of the admixture process, although it may be added into the treated water as powder.

Potassium permanganate reactions:

$$3Fe^{2+} + KMnO_4 + 7H_2O \rightarrow 3Fe(OH)_3 + MnO_2 + K^+ + 5H^+$$

Ferrous iron oxidizes into precipitants for ferric hydroxide and manganese dioxide.

$$3Mn^{2+} + 2KMnO_4 + 2H_2O \rightarrow 5MnO_2 + 2K^+ + 4H^+$$

Manganese oxidizes into precipitants for manganese dioxide.

Disadvantages

- Contact with potassium permanganate powder may lead to eye injuries, skin and respiratory organ irritation and can be fatal to swallow.
- Potassium permanganate should be used earlier in the purification process than active carbon, otherwise it will consume active carbon and less potassium permanganate will be available for the oxidation.
- Over-dosage of potassium permanganate results in residuals, which give water pink color.

MANGANESE ZEOLITE FILTERS

This system uses manganese zeolite as both the oxidizing source and filter medium. Manganese zeolite is made from processed green sand zeolite by alternate treatments with manganese sulfide and KMn04, as follows:

$NaZ + Mn^{++}$ ————> $MnZ + 2Na^+$

$MnZ + KMn0_4$ ————> $Z.Mn0_2 + K^+$

NaZ is green sand zeolite and Z.Mn02 is manganese zeolite.

This process produces higher oxides of manganese in and on the granules of green sand. The resultant manganese zeolite is a black granular material.

Although the original green sand is a natural softening material, no softening of the water takes place during treatment with manganese zeolite. The bed oxidizes soluble iron or manganese to insoluble oxides and simultaneously filters them out of the water. The oxidation reaction is as follows:

$$Z.MnO_2 + \begin{matrix} Fe^{++} \\ Mn^{++} \end{matrix} \longrightarrow Z.Mn_2O_3 + \begin{matrix} Fe^{+3} \\ Mn^{+3} \\ Mn^{+4} \end{matrix}$$

The complete exchange, generation, degeneration and regeneration process are given below.

Exchange:

$$NaZ + Mn^{2+} \rightarrow MnZ + 2Na^{+}$$

Generation:

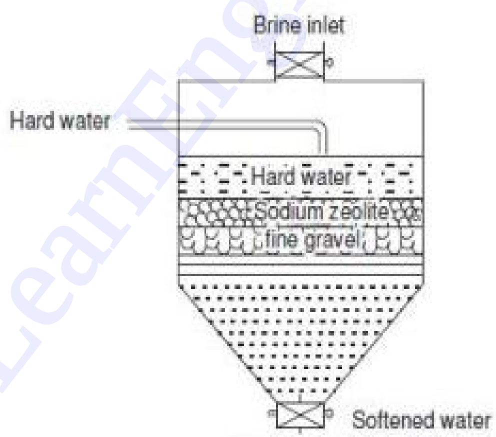
$$MnZ + KMnO_4 \rightarrow Z \cdot MnO_2 + K^{+}$$

Degeneration:

$$Z \cdot MnO_2 + \begin{matrix} Fe^{2+} \\ Mn^{2+} \end{matrix} \rightarrow Z \cdot MnO_3 + \begin{matrix} Fe^{3+} \\ Mn^{3+} \\ Mn^{4+} \end{matrix}$$

Regeneration:

$$Z \cdot MnO_3 + KMnO_4 \rightarrow Z \cdot MnO_2$$

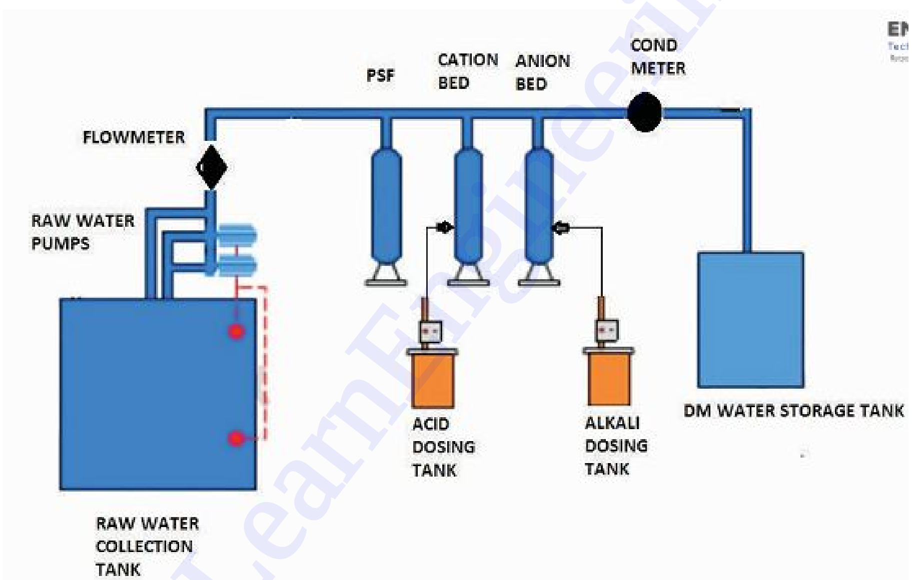


Zeolite softener

Once the oxidizing capacity of the bed is exhausted, soluble iron and manganese breakthrough occurs. To prevent this leakage or breakthrough of iron or manganese into the water supply, the bed is batch-regenerated (to restore its oxidizing capacity) at predetermined intervals. The manganese zeolite bed is regenerated by treating it with a 0.5% solution of $KMnO_4$. Besides regeneration, backwashing is carried out at intervals whenever accumulated deposits in the bed build up a pressure loss. Backwashing is best accomplished with treated filter water.

This manganese zeolite process can also be operated by dosing the continuously ahead of the filter bed. Instead of the bed being regenerated, the continuous feed of the permanganate oxidizes iron and manganese to an insoluble state before it reaches the manganese zeolite bed which acts as a buffer. It oxidizes any residual dissolved iron and manganese like the batch regenerated system if the permanganate dosage is slightly low and removes any excess unreacted permanganate when the dosage is high, by partial regeneration of the manganese zeolite bed.

2. Draw a schematic diagram of a DM plant and explain the mechanism of cations as well as anions removal. Also briefly outline the design procedure. (Apr/may 2014)



Design parameters

○Feed water analysis

○Production flow rate

○Cycle length

○Required treated quality of water

○Regeneration technology

○Dimensions of the vessels

○Selection of resin types

Some basic principles

Design parameters are:

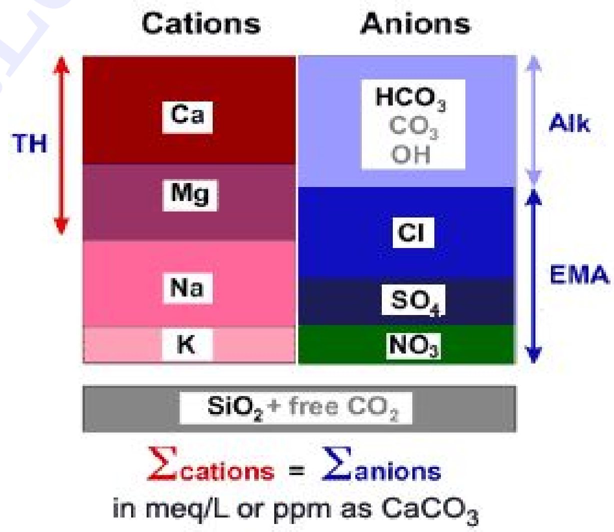
- Feed water analysis
- Production flow rate
- Cycle length
- Required quality of the treated water
- Regeneration technology
- Dimensions of the vessel

Analysis of the feed water

All ion exchange systems are designed for given feed water. Some variations of the feed water analysis are acceptable, and should be taken into account, but an ion exchange system cannot be designed efficiently for vastly different water types. For instance, a demineralisation system designed for the treatment of deep well water is completely different from a system designed to treat reverse osmosis permeate.

When the water analysis is not constant, e.g. due to seasonal variations, do not take an "average composition" as the basis of your design. Instead, use the "most probable" case, design with this water, and check as a second step what will happen with the "minimum" and "maximum'" waters. All water analyses must be perfectly balanced.

The water analysis will determine what resin combination is required, and if a degasifier should be considered.



Production flow rate

It is important to know whether the system will operate at constant or variable flow rate. Some system designs require a minimum flow rate. Obviously, the system should be able to operate at both limits.

In general, it is not advisable to operate intermittently, i.e. to stop production in the middle of the run and re-start it. Treated water quality may be affected after a stop not followed by regeneration.

Cycle length

A **short cycle length** is desirable in most cases. The practical limit is that the production run should be at least as long as the regeneration process. As most ion exchange systems are regenerated automatically, the duration of the production run does not have to be "at least one day" as was the rule at the time (many decades ago) when the morning shift would regenerate manually every day at 7 o'clock. Efficient systems have been designed with running times as short as 3 hours.

The limits of the running time are also related to resin kinetics. When reading ion exchange resin product data sheets, you will typically see that the specific flow rate in water treatment should be between 5 and 50 bed volumes per hour (m^3/h per m^3 of resin). At lower flow rates, hydraulic distribution in the resin bed may be poor, and at higher flow rates, kinetic effects may affect the speed of exchange, resulting in both cases in deterioration of the treated water quality.

So in practice the running time must be selected as a function of the following parameters:

- Specific flow rate between 5 and 50 bed volumes per hour (BV/h).
- Mixed bed units should be designed to operate at a minimum of 12 to 15 BV/h.
- Make the system as small as possible for economical reasons (lower investment in hardware and resins).
- For packed bed systems, ensure that bed compaction is good both in the production phase and during regeneration.

With low salinity waters, e.g. when the feed water is good RO permeate, the running time can be several days. Mixed bed polishers after a primary demineralisation will run for several weeks before regeneration is required.

Treated water quality

In ion exchange the quality of the treated water does not depend much on the feed water analysis. Factors affecting the treated water quality are essentially related to the regeneration process.

To a minor extend, temperature may affect the residual silica leakage in the treated water: at temperatures higher than about 50 °C, silica is hardly removed by strongly basic anion exchange resins (SBA).

Other than that, you can expect the treated water quality of a regeneration system regenerated in reverse flow to be:

- Conductivity: ~ 1 µS/cm
- Silica: 10 to 25 µg/L

For polishing MB units, conductivity is generally around 0.1 µS/cm, and silica less than 10 µg/L. Well designed and operated mixed bed polishers can achieve conductivity close to that of pure water (0.055 µS/cm) and silica in the single µg/L range, or below.

Regeneration technology

Details of the regeneration are given in a separate page. Another page shows the corresponding column designs.

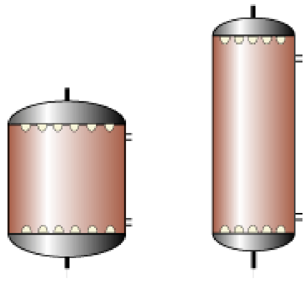
Except for very small ion exchange units (and for de-alkalisation with a WAC resin only), plants should always be designed using reverse flow regeneration. Packed bed columns are particularly useful, as they offer a compact and economical design, and very good treated water quality. They are normally sized for relatively short cycles.

Vessel sizing

For a given resin volume, it is generally cheaper to make a tall and narrow column rather than a wide and short unit: in the illustration, both columns contain the same resin volume. Column B is cheaper, because the major cost components of the column are the dished ends and nozzle plates.

There is no limit in height, except that the pressure drop at maximum flow rate should not exceed 100 to 150 kPa (1 to 1.5 bar) at maximum flow rate with clean resins.

When selecting the vessel diameter, the limits of the preceding section (regeneration technology) should also be considered.



Resin choice

- Macroporous resins are normally not required for demineralisation or softening
- An exception: all styrenic WBA resins are macroporous
- Special particle sizes are required depending on the design technology:
  - uniform or semi-uniform resins are necessary for packed beds
  - special grades are required for stratified beds (e.g. Stratabed™ or Stratapack™)
  - special grades are also required for mixed bed polishers
- When the feed water contains high organics, acrylic anion resins are a good choice

Selection of Resin Types:

Strong Acid Cation Resin
Weak Acid Cation Resin
Strong Base Anion Resin Type I
Strong Base Anion Resin Type II
Weak Base Anion Resin

3. Write short notes on

i) Membrane process

ii) Defluoridation (Nov/Dec 2013)

(i) Membrane process

Definition:

Membrane processes are those in which a membrane is used to filter through (i.e. permeate) high quality water while rejecting the passage of dissolved and suspended solids. A filtration membrane is a physical boundary over which a solute (TSS or TDS) can be separated from a solvent (water) by applying energy in the form of pressure or electric potential.

Membrane process types:

The main membrane processes used in water treatment are:

A. Microfiltation (MF)

B. Ultrafiltation (UF)

C. Nanofiltration (NF)

D. Reverse Osmosis (RO)

E. Electrodialysis (ED)

The classification and comparison between these processes is Based on many characteristics of each such as

1) The driving force [hydrostatic or electrical],

2) The separation mechanism,

3) The nominal size of the separation achieved.

General characteristics of Membrane process

Membrane process	Membrane driving force	Typical separation mechanism	Operating structure (pore size)	Typical operating range, μm	Permeate description	Typical constituents removed
Microfiltration	Hydrostatic pressure difference	Sieve	Macropores (>50 nm) (Note: nm=10^{-9} m)	0.08–2.0	Water + dissolved solutes	TSS, turbidity, protozoan oocysts and cysts, some bacteria and viruses
Ultrafiltration	Hydrostatic pressure difference	Sieve	Mesopores (2–50 nm)	0.005–0.2	Water + small molecules	Macromolecules, colloids, most bacteria, some viruses, proteins
Nanofiltration	Hydrostatic pressure difference	Sieve + solution/ diffusion + exclusion	Micropores (<2 nm)	0.001–0.01	Water + very small molecules, ionic solutes	Small molecules, some harness, viruses
Reverse osmosis	Hydrostatic pressure difference	Solution/ diffusion + exclusion	Dense (<2 nm)	0.0001–0.001	Water, very small molecules, ionic solutes	Very small molecules, color, hardness, sulfates, nitrate, sodium, other ions
Dialysis	Concentration difference	Diffusion	Mesopores (2–50 nm)	—	Water + small molecules	Macromolecules, colloids, most bacteria, some viruses, proteins
Electrodialysis	Electromotive force	Ion exchange with selective membranes	Micropores (<2 nm)	—	Water + ionic solutes	Ionized salt ions

MembraneConfigurations:

The principal types of membranes are:

1.Tubular Modules
2.Hollow Fiber Modules
3.Spiral Wound Modules

1. Tubular Modules

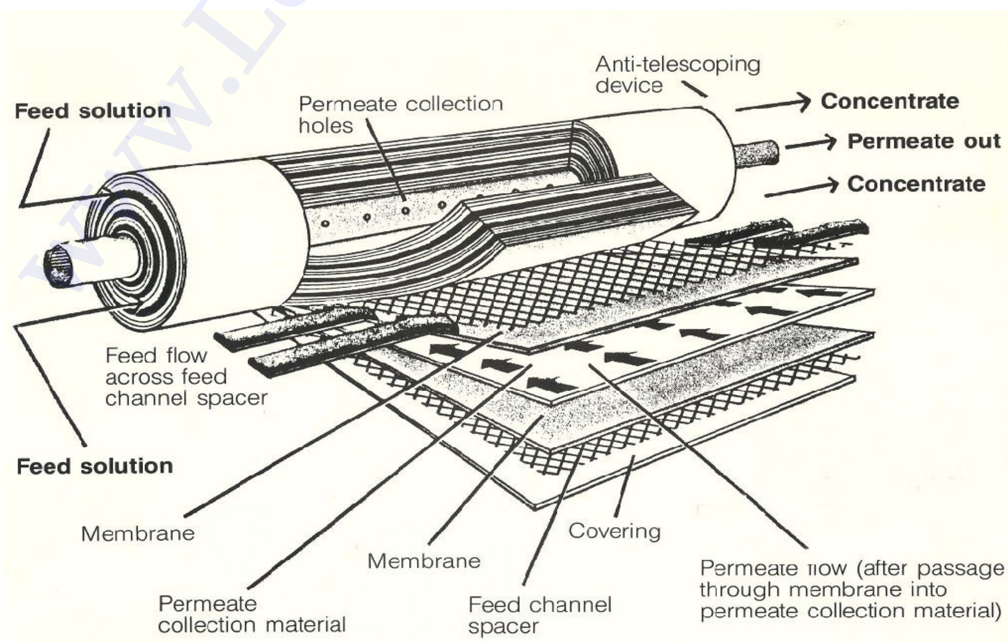
• In this type the membrane is cast on the inside of a support tube.
• A number of tubes are then placed in a pressure vessel.
• The feed water is pumped through the feed tube and the product water is collected on through the skin of the membrane.
• The concentrate continues to flow through the feed tube.
• This type is used for water with high suspended solids content since it is the easiest to clean. Cleaning can be accomplished by circulating chemicals and pumping a "foam ball" or "sponge ball".

2. Hollow Fiber Modules

- In hollow fiber modules hundreds to thousands of hollow fibers are bundled together to form a module.
- The entire assembly is inserted into a pressure vessel.
- The feed water can be applied to the inside of the fiber (inside out flow), or the outside of the fiber (outside-in flow).

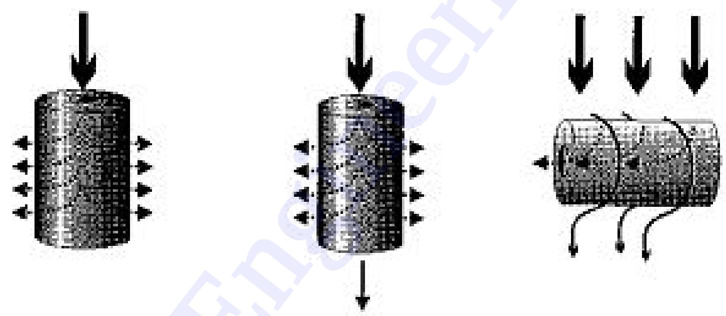
3. Spiral Wound Modules

- In hollow the spiral-Wound membrane, a flexible permeate spacer is placed between two flat membrane sheets.
- The membranes are sealed on three sides.
- The fourth open side is attached to a perforated pipe.
- A flexible feed spacer is added and the flat sheets are rolled into tight circular configuration.
- The term spiral is derived from the fact that the flow in the rolled up arrangement of membranes and support sheets follows a spiral flow pattern.
- The feed water can be applied to the inside of the fiber (inside out flow), or the outside of the fiber (outside-in flow).



Membrane Processes Terminology:
The following is a brief description of some of the terms used in the membrane processes:
Feed stream : The influent water to the membrane.
Concentrate or Retentate: the portion of the feed water that does not pass the membrane that contains higher TDS than the feed stream.
Permeate: the portion of the feed stream that passes through the membrane that contains lower TDS than the feed water.
Flux: mass or volume rate transfer the rough the membrane.
Solvent: Liquid containing dissolved matter, usually water.
Solute: Dissolved matter in raw, feed, permeate and concentrate water.
Recovery rate: the ratio between the product water to the feed water.
Rejection rate: percent removal of the solute from water.
Fouling: deposition of solids on the feed side of the membrane

Filtration Mode



Dead end flow: All water passes through the membrane, particles are trapped within the membrane structure.

Cross flow: Feed water passes parallel to the membrane surface, product water permeates through the membrane, the concentrated stream helps carry particles out of the system.

Transverse flow: Feed water meets the membrane surface at right angles, product water permeates through to the inside of the tube, concentrate washes over the outside of the tube removing particle build-up.

ig. 4.14

Membrane Operation:
Key factors that directly impact membrane operation in water treatment:
Flux
Fouling
Rejection rate
Recovery rate
Temperature - Viscosity of Water (Note: Change from 20°C to 4°C results in a ~50% decrease in production for similar membrane area and pressure)

Membrane fouling:
Definition:
• It is the deposition and accumulation of solid from the feed water on the membrane.
• It is an important design and operation membrane as it affects:

- Pretreatment needs
- Cleaning requirements
- Operating conditions
- Cost and performance

Forms of Fouling:

• Formation of chemical precipitates “Scaling”.
• Buildup of solids in the feed-water.
• Damage of the membrane due to the reaction between chemicals in the feed water and the membrane

Control of membrane fouling:

There are three approaches are used to control fouling:
1. Pretreatment of the feed water Buildup of solids in the feed-water.

The following are some examples on pretreatment:
- using conventional filtration, microfiltration or ultra filtration.
- disinfecting the feed water to limit the bacterial activity using either chlorine, ozone or UV.
- removal of iron and manganese to prevent scaling.
- adjusting the pH of the feed water in the range (4 to 7.5) using sulfuric acid to prevent the formation of calcium carbonate, and using hexametaphosphate to prevent the formation of calcium sulfate. Other chemicals called antiscallants are added instead of sulfuric acid.

2. Membrane back-flushing with water.
3. Chemical cleaning of membranes.

Disposal of concentrate waste stream “Brine”:

Disposal of the concentrated waste streams produced by membrane processes represents the major problem in membrane operations.
The principal methods used for the concentrate disposal:
1. Ocean discharge
2. Surface water discharge
3. Discharge to wastewater collection system.
4. Deep-well injection
5. Evaporation bonds
6. Controlled thermal evaporation

Working of membrane processes:

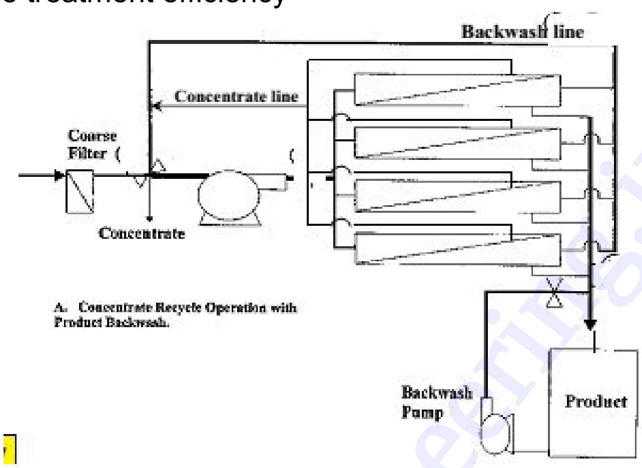
The operation of membrane processes is simple:

• A pump is used to pressurize the feed solution and to circulate it through the module.

• A valve is used to maintain the pressure of the concentrate (retentate).

• The permeate is withdrawn typically at atmospheric pressure.

• Units are arranged in parallel to meet the flow requirements, and arranged in series to increase the treatment efficiency



Membrane applications in water treatment:

○MF can remove suspended solids, turbidity, crypto and giardia. Not color, virus, or dissolved solids.

○UF can remove color and odor causing organics, virus, and other microbiological pests. Not dissolved salts.

○RO and NF systems should be used to remove only dissolved solids - they need very clear feed water.

○ED removes IONS from water - it does not remove crypto, giardia, uncharged molecules, suspended solids etc.

(ii) Defluoridation

When water containing 8 to 20ppm of fluoride is consumed over a long period of time, bone changes may occur, resulting in crippling fluorosis. Hence when the fluoride concentration is more than 1 to 1.5ppm.

The process of reducing the fluoride concentration of water is known as deflouridation

Principle Methods

i).Calcium Phosphates
ii).Bone charcoal
iii).Synthetic tri calcium phosphates
iv).Fluorex
v).Ion-Exchanger
vi).Lime
vii).Aluminium compounds

viii).Activated Carbons

i).Calcium Phosphates

Bone has great affinity for fluorides and can be used in the filter for removal of fluorides. The bone is calcinated at 400^0C to 600 C for 10 minutes followed by mineral acid treatment. It is then pulverised to pass 40 to 60 mesh and is used in the filter bed. The filter is regenerated with alkali and acid. 1 cubic meter of bone can treat one million litres of water containing 3.5ppm of fluoride.

ii).Bone charcoal

It is essentially tricalcium phosphate and carbon, and has been used successfully for the removal of fluorides.

iii).Synthetic tri calcium phosphates

It can be prepared from milk of lime and phosphoric acid when the reaction is carefully controlled. This material has been used in contact filters for removal of fluorides. The regeneration can be done by 1% caustic soda followed by a dilute HCl acid or Co_2 wash to new tralise the excess alkali.

iv).Fluorex

Fluorex is a special mixture of tricalcium phosphate and hydroxyapatite. It is used as filter medium Fluorex can be regenerated by washing with 1.5 % solution of caustic soda. It can be next rinsed with twice its volume of water and the excess soda can be neutralised with the solution of CO_2 at 0.15% strength.

v).Ion-Exchanger

There are a number of ion exchanger materials which can be used for removel of fluorides. Bensol reported that fluorides in water can be rempoved by successive passage through beds of cation exchanger of the sulphonate coal type and an amin resin “NALCITE B”. Alum treated cation exchange resin from Avaram bark can be used as an effective material for removing fluorides from warter.

vi).Lime

Lime can also be used for reducing the fluoride content of watrer. Fluoride is removed along with the magnesium in a direct relationship to the amount of magnesium taken out in the softening process.The water must br treated to a caustic alkalinity of 30ppm and a pH value of 10.5; hence recarbonation is necesssory. The process is suitable for hard waters containing less than 4ppm of fluorides.

vii).Aluminium compounds

The fluorides are removed by the formation of an aluminium fluoride complex, or by absorption on the floc. Another method utilising aluminium salts involves the use of contact beds of insoluble materials impregnated with aluminium compounds. Dehydrated aluminium oxide (calcium alumina) can be used in contact beds for removal of fluorides.

viii).Activated Carbons

Removal of fluoride from water has also been effected by treatment with activated carbon at pH 3 no removal takes place at pH 8 or above the carbon when used as a contact bed can be regenerate within the week acid and alkaline solution.

4. What are the functions of aerators? Explain the different types of aerators. (Nov/Dec 2013)

Aeration

Aeration is the process of bringing water and air into close contact. Aeration is the process to remove dissolved gases, such as carbon dioxide, hydrogen sulfide, and to oxidize dissolved metals such as iron. It can also be used to remove volatile organic chemicals (VOC).

Types of Aerators

- **water into the air**
- **air into the water**

Principle of Aeration

Oxygen uptake depends on the area and duration of contact between water and air. For porous air diffusers this means that the size of the bubbles should be relatively small, since surface area is bigger in proportion to their volume and they rise slower, which gives a longer contact duration. According to diagram, figure 5, the slowest rising bubbles are those with diameter around 6 mm, and same velocity can be reached at around 1 mm.

Types of Aerators: Four types of aerators are in common use: (i) Gravity aerators (water into the air), (ii) Spray aerators (water into the air), (iii) Diffusers (air into the water), and (iv) Mechanical aerators (air into the water) A major design consideration for all types of aerators is to provide maximum interface between air and water at a minimum expenditure of energy. A brief description of each type of aerator is provided here.

Gravity Aerator: Gravity Aerators utilize weirs, waterfalls, cascades, inclined planes with riffle plates, vertical towers with updraft air, perforated tray towers, or packed towers filled with contact media such as coke or stone. Various type of gravity aerators are shown in figures.

Cascade Aerators (water into the air)

- Consists of a series of steps that the water flows over.
- Aeration is accomplished in the splash zones.
- The aeration action is similar to a flowing stream.
- Splash areas are created by placing blocks across the incline.
- Cascade aerators used to oxidize iron and to partially reduce dissolved gases.
- The oldest and most common type of aerators.

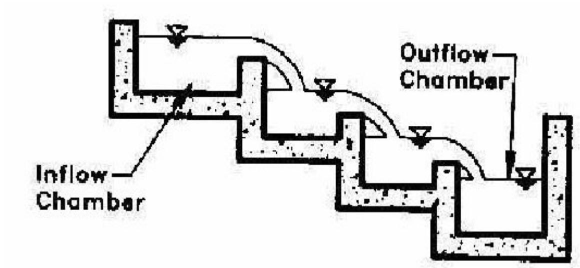
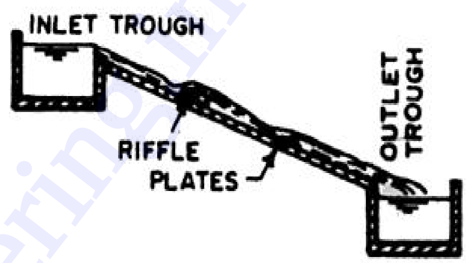


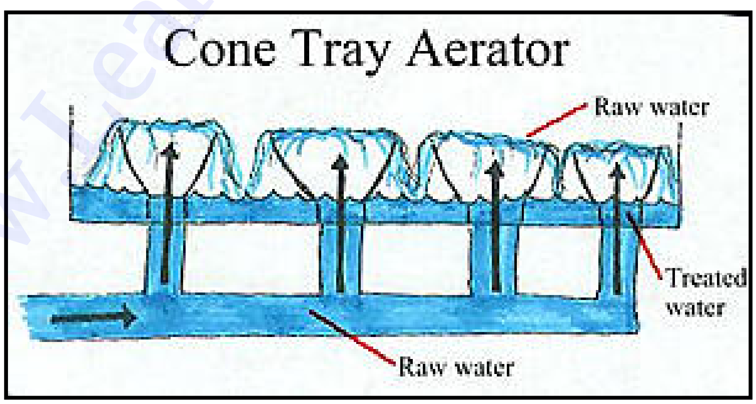
Fig 3.1 A: Cascade type Gravity Aerator



Inclined planes with riffle plates

Cone Aerators(water into the air)

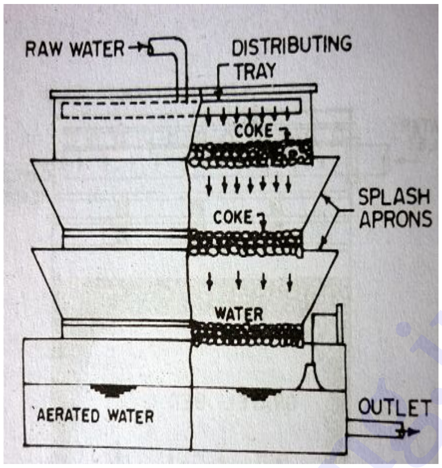
- are used primarily to oxidize iron and manganese prior to filtration.
- the water pumped to the top of the cones and then allowed to cascade down through the aerator.



Slat and Coke Aerators (water into the air)

- Similar to the cascade and cone types.
- They usually consist of three-to-five stacked trays, which have spaced wooden slats in them.
- The trays are filled with fist-sized pieces of coke, rock, ceramic balls, limestone, or other materials.

- The primary purpose of the materials is to provide additional surface contact area between the air and water.



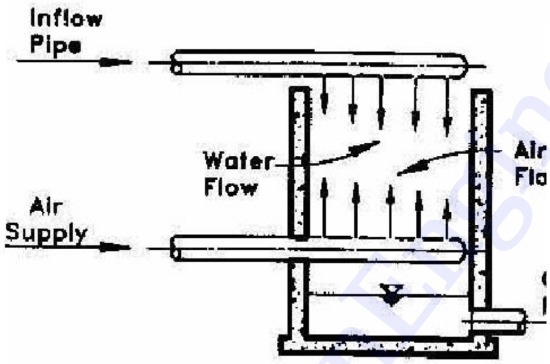


Fig. 3.1 C: Tower with counter current flow of air

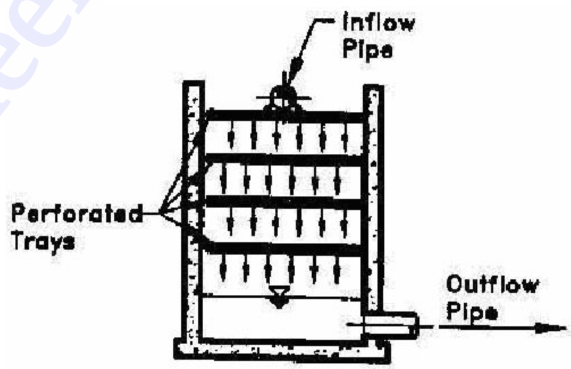


Fig. 3.1 D: Stack of perforated pans possibly contact media

Spray Aerator (water into the air)***:*** Spray aerator spray droplets of water into the air from moving or stationary orifice or nozzles. The water raises either vertically or at an angle and falls onto a collecting apron, a contact bed, or a collecting basin. Spray aerators are also designed as decorative fountains. To produce an atomizing jet, a large amount of power is required, and the water must be free of large solids. Losses from wind carryover and freezing in cold climates may cause serious problems. A typical spray aerator is shown in **Fig.3.2.**

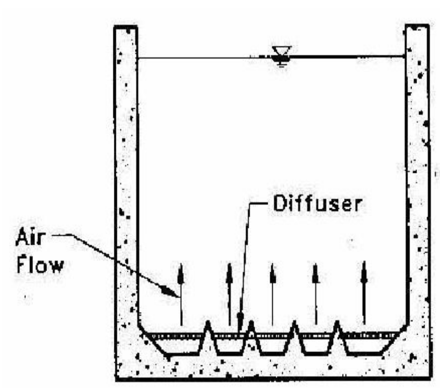


Fig. 3.3 A: Longitudinal Furrows

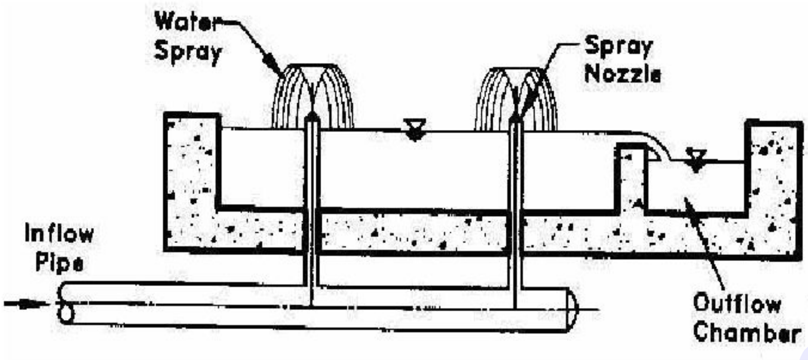
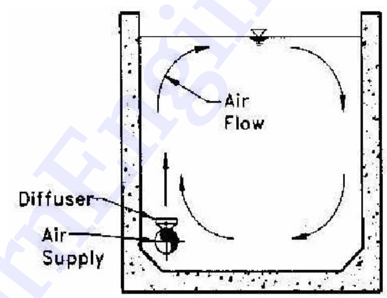


Fig. 3.2: Spray Aerator

Diffused-Air Aerators(air into the water)***:*** Water is aerated in large tanks. Compressed air is injected into the tank through porous diffuser plates, or tubes, or spargers. Ascending air bubbles cause turbulence and provide opportunity for exchange of volatile materials between air bubbles and water. Aeration periods vary from 10 to 30 min. Air supply is generally 0.1 to 1 m3 per min per m3 of the tank volume. Various type of diffused aeration systems are shown in **Fig. 3.3 (A to D).**



Spiral Flow with bottom diffusers

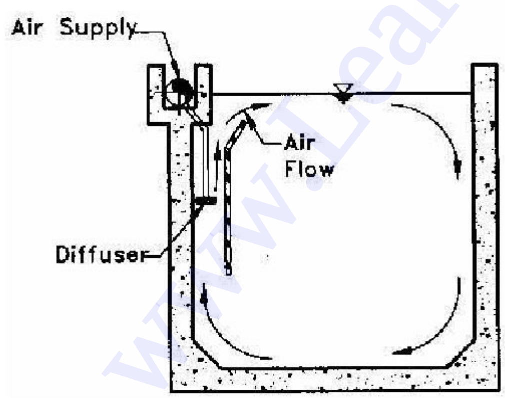


Fig. 3.3 C: Spiral flow with baffle and low depth diffusers

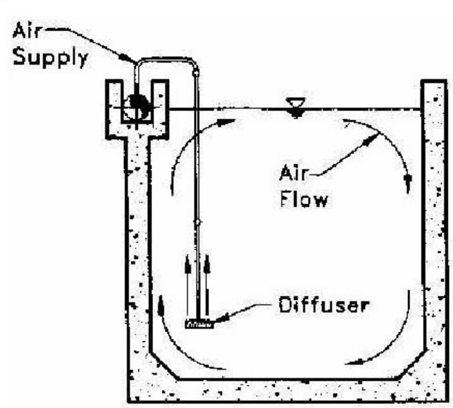
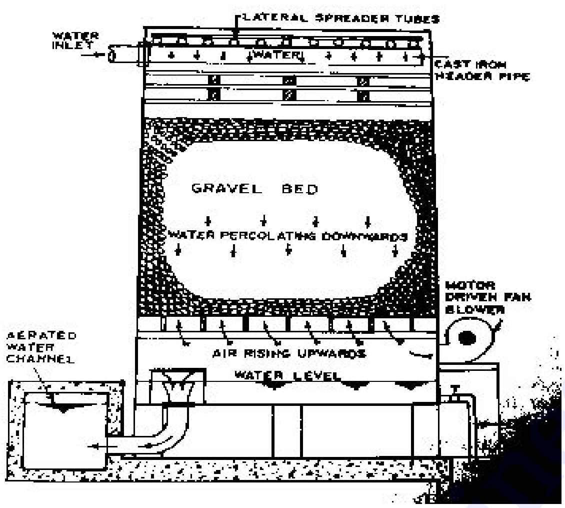
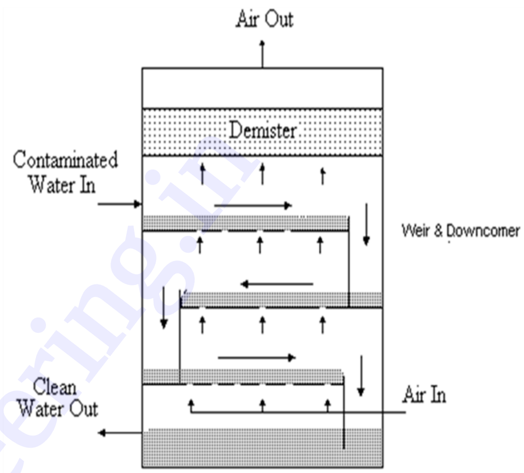


Fig. 3.3 D: Swing diffusers

Air stripping(air into the water):

- Can be quite effective in removing volatile organic chemicals (VOCs) from water.
- A major concern is that VOCs may be carcinogens.

- Air stripping capable of removing up to 90 percent of the most highly volatile VOCs.
- Water flow over cascade aerators or in specially designed air-stripping towers.
- Water is allowed to flow down over a support medium or packing contained in the tower, while air is being pumped into the bottom of the tower.
- 



Low profile sieve tray air stripper

Mechanical Aerator(air into the water)***:*** Mechanical aerators employ either motor driven impellers or a combination of impeller with air injection devices. Common types of devices are submerged paddles, surface paddles, propeller blades, turbine aerators, and draft-tube aerators. Various types of mechanical aerators are shown in **Fig 3.4 (A to C).**

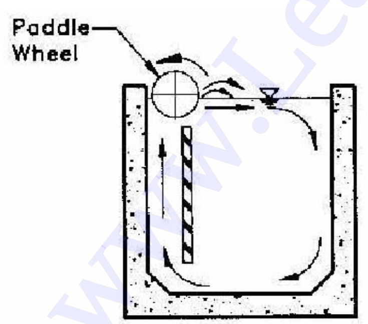


Fig. 3.4 A: Surface Paddles

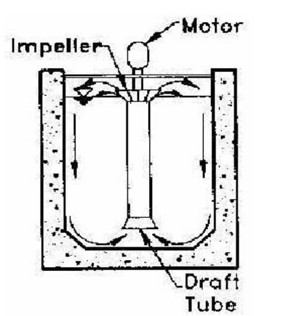


Fig. 3.4 B: Draft Tube Turbine Type

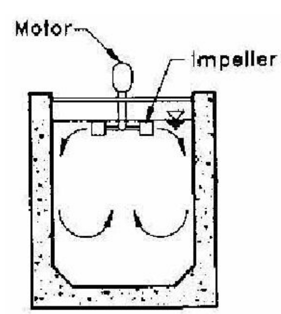


Fig. 3.4 C: Turbine Aerator

5.

Design a zeolite softener for an industrial concern, using the following data :

(i) Qty of soft water required per hour = 25,000 litres.

(ii) Hardness present in raw water as $CaCO_3$ = 400 ppm.

(iii) Hardness to be obtained in the treated supplies = 50 ppm

(iv) Ion exchange capacity of the zeolite = 10 kg of hardness per cu.m. of zeolite

(v) Salt required for regeneration of exhausted zeolite = 50 kg per cu.m of zeolite

Also assume that the industry works for 2 shifts of 8 hours each per day. Make suitable assumptions where needed, if not given

[Nov/Dec: 2014 & 2015]

Solution :

Qty of soft water reqd. per shift of 8 hrs

$= 25{,}000 \times 8$ litres $= 2{,}00{,}000$ litres.

$= 2 \times 10^5$ litres.

Now, the hardness reqd. to be removed is upto 50 ppm out of a total hardness of 400 ppm. This means that 350 ppm i.e. $\frac{350}{400} \times 100 = 87.5\%$ of hardness has to be removed. Now assuming that part of the total requirement will be softened to zero degree hardness, and then raw water will be added to get the water of the desired hardness (50 ppm), we can say that only 87.5% of the raw water needs to be softened to zero degree hardness, and the balance 12.5% can be added as raw water to obtain 50 ppm of hardness.

$\therefore$ the qty of water to be treated per shift

$= 2 \times 10^5 \times 0.875$ litres $= 1.75 \times 10^5$ litres.

Let us also assume that the regeneration of the zeolite shall be carried out once in 8 hours shift, and that the regeneration process will take one hour. Hence, the zeolite softener will remain out of service for one hour out of 8 hours ; thus giving a useful service of 7 hours per shift. A balancing tank of 1 hr. capacity will hence be provided to supply water during regeneration period.

Now, the amount of hardness to be removed per shift

$$= \left[\begin{array}{l}\text{Qty of water to be treated} \\ \text{Per shift in litres}\end{array}\right] \times \begin{array}{c}\text{Hardness} \\ \text{in mg/l}\end{array}$$

$= (1.75 \times 10^5) \times 400$ mg

$= 700 \times 10^5$ mg

$= 70 \times 10^6$ mg $= 70$ kg

$\therefore$ The qty of resin reqd. $= \dfrac{\text{Hardness to be removed in kg}}{\text{Iron exchange capacity of resin in kg/cu.m}}$

$= \dfrac{70}{10} = 7$ cu.m.

* Provide 6 units of 1.4 cu.m. each, thus giving one unit as stand by. Each unit of 1.4 cu.m may have 1 sq.m. Plan area and 1.4 m depth.

Regeneration

After the softener has remained in operation for 7 hours, its zeolite beds will be regenerated by passing 10% solution of sodium chloride (NaCl) through it. the storage in the balancing tank will provide water during this one hour interval. The stand by unit will help during any break downs etc.

Now, the qty of salt reqd. for regeneration

= 50 kg/cu.m of zeolite

$= 50 \times 7$ kg

= 350 kg (without additional unit)

using 10% brine solution, means that 10 kg salt will be dissolved in water to make up 100 kg of solution.

$\therefore$ 350 kg of salt will produce

$= \dfrac{350 \times 100}{10}$

= 3500 kg of water solution

$$= \frac{3500 \text{ kg}}{1000 \text{ kg/m}^3} = 3.5 \text{ cu.m.}$$

Hence, two tanks of 1.75 cu.m. capacity each can be provided. If 1.2 m is the dia. of such a tank, then the height required.

$$= \frac{1.75}{\frac{\pi}{4}(1.2)^2} = 1.53 \text{ m} \Rightarrow 1.55 \text{ m}$$

* using 0.15 m free board, the overall tank size will be 1.2 m dia x 1.7 m height.

check for the contact period

The flow rate over the softener beds = $\frac{\text{Volume of water to be treated/shift}}{\text{7 hrs working of the softener}}$

$$= \frac{1.75 \times 10^5}{7} \text{ litres/hr}$$

$$= 25{,}000 \text{ litres/hr}$$

Average flow velocity (or)
Rate of filtration = $\frac{\text{Rate of Volume of water to be passed}}{\text{Surface area}}$

$$= \frac{25{,}000}{5 \times 1.0} \text{ litres/m}^2\text{/hr} = 5000 \text{ l/m}^2\text{/hr}$$

$$= \frac{5000}{60} \text{ l/m}^2\text{/min} = 83.3 \text{ l/m}^2\text{/min}$$

$= 0.083$ m/minute (should be < 0.3 m/min)

Since each bed is 1.4 m deep, the average time of travel through the bed or the contact period

$$= \frac{1.4 \text{ m}}{0.083 \text{ m/min}} = 16^{\circ} \text{ minutes}$$

Since the contact time available for the ion exchange is sufficient (> 7.5 minutes or so), the Design is ok.

UNIT-V

WATER DISTRIBUTION AND SUPPLY TO BUILDINGS

PART-A

1. **What is Equivalent Pipe?**
   - An equivalent pipe is an imaginary pipe in which the head loss and discharge are equivalent to the head loss and discharge for real pipe system.
   - Equivalent pipe method is a method of reducing a combination of pipes into a simple pipe system for easier analysis of a pipe network such as Water Distribution System.

2. **What are the methods of distribution of water?**
   - Gravitational system
   - Pumping system
   - Combined Gravity and Pumping system

3. **What is the role of computer application in water supply system and list some software's?**

   Role of computer application in water supply system:
   - It helps you to successfully plan, design, and operate water distribution systems
   - It is essential for carrying out environmental impact assessments.
   - To access and identify where fire protection is inadequate.
   - To access Design improvements such as the sizing and location of pipes, pumps, and tanks in order to meet fire-flow and protection requirements.

   List of software's:
   1. WATSYS
   2. EPANET
   3. WaterCAD,

4. WaterGEMS,
5. HAMMER
6. SewerCAD
7. EPA SWMM 5

4. How to identify leakage in pipes?

The methods used to detect leakage in pipes are

- By Direct observation
- By using sounding Horns
- By plotting hydraulic gradient line
- By using waste detecting meters

5. What are the requirements of water distribution system draw the layout of WDS?

- It should be capable of supplying water to all places within the city with a reasonably pressure head
- It should be capable of supplying sufficient quantity of water for fire-fighting during such needs
- It should be cheap with least capital construction cost (it gobbles up , upto 70% of total cost of the scheme)
- It should be simple and easy to repair
- It should be safe against ant future pollution of water
- It should be safe as not to cause the failure of pipelines by bursting
- It should be fairly water-tight to keep the losses due to leakage to the minimum.

6. Name any five Appurtenances in WDS?

i. Fire hydrants
ii. Water meters
iii. Water taps
iv. Stop cocks
v. Pipe bends

7. What factor controls water supply to buildings?

- Storage of water in buildings
- Water piping system in buildings
- Water demand for a building
- Required flows for various water supply fixtures and probable simultaneous demand
- Principles of distribution and design methods

8. What do you mean by sanitary fitting?

The term "sanitary fittings" is generally taken to include all fittings intended for the reception of the foul liquids and water carried solids which are produced in and about our buildings, exclusive of trade processes. Sanitary fittings include all components used to connect sanitary tubes or piping. Generally, sanitary piping systems include all plumbing applications where cleanliness and sanitation are of primary concern.

9. List out the components of service connection pipes?

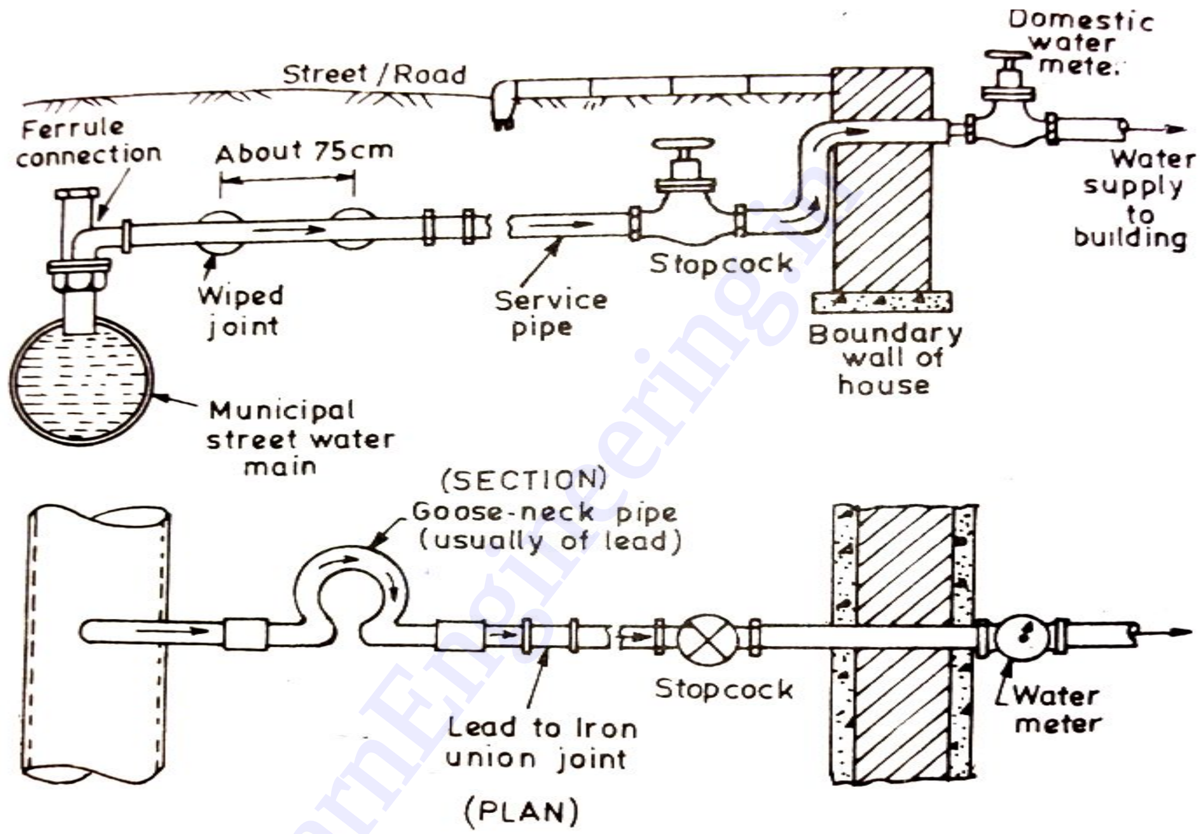
- Ferrule
- Goose neck
- Service pipe
- Stop cock
- Water meter

10. What are prime functions of service reservoir?

a) To absorb the hourly variations in demand
b) To allow the water treatment units and pumps to operate at a constant rate
c) To help in maintaining constant pressure in the distribution mains
d) The pumping of water by shifts is made possible by them without affecting the supply
e) The water stored in the reservoir can be supplied during emergencies such as break-down of pumps, heavy fire demand.

f) They lead to an overall economy by reducing the size of pumps, pipe lines and treatment units.

11. Draw house service connection?



PART-B

1) **Explain in detailed about the appurtenances in the distribution system**?

Appurtenances are fitted in the pipe network and distribution system for its efficient and controlled functioning.

The following are some appurtenances of distribution system:

1. Fire hydrants
2. Water meters
3. Water taps
4. Stop cocks
5. Pipe bends

FIRE HYDRANTS:

A Hydrant is an outlet provided in water distribution main or a sub-main for tapping water mainly during fires and sometimes used for withdrawing water for filling the municipal water tankers.

During fire breakout, a nearby hydrant is connected to the fire hose, and water obtained from the hydrant is used to extinguish the fire

Fire hydrants are used so as to obtain the water at high rates and also to make it reach several storeyed high buildings, such pressures are generally developed by attaching fire hydrants outlet to the fire engine.

The fire engine will

- Draw water from the hydrant
- Boost it pressure within the engine
- High pressure water will come out from the outlet of the engine
- The hose pipe is connected to the outlet of the engine
- The other end of the hose pipe carries water to the building with a pressure of at least 32m of water head.

PRESSURE AT FIRE HYDRANTS:

Case: 1 when water is pumped with motor pumps-7 to 14m head of water

Case: 2 when the direct flow from the hydrant is used-35-50m head of water

The fire hydrants are generally provided at all street crossings and turnings at 90 to 120m intervals.

REQUIRMENTS OF GOOD HYDRANTS:

i. It should be such as to connect the hose or the motor pump easily to it.
ii. It should be cheap.
iii. It should be easily detectable during the panicky atmosphere of fire.
iv. It should not get out of order during the operation.
v. On being fully opened it should allow undisturbed water flow.

TYPES OF FIRE HYDRANTS

1) Post Fire Hydrants
2) Flush Fire Hydrants

1) Post Fire Hydrants:

- The post fire hydrant remains standing above the ground like a post by about 0.9 to 1.2m
- It can be detected very easily as they project above the ground.
- They are liable to be damaged by children and mischief mongers.
- They are widely used in countries like America, because of the greater civic sense prevailing there.

Parts of Post Fire Hydrants

- Cast iron barrel of hydrants
- Valve stem- Leather valve at lower end, top end connected to the nut
- Valve seat
- Drain valve
- Outlet pipe-with nozzle cap at the periphery of the hydrant barrel

Working

- In closed position the leather valve rest at valve seat, for opening the hydrant the nut is operate so as to raise the leather valve up, thereby admitting the water into the hydrant barrel. The outlet at the periphery of the hydrant carries the water to the location through hose pipe.
- Outlet diameter:
- 63mm diameter outlet: when boosting of pressure is not required
- 100mm diameter outlet: when boosting of pressure is required for connecting it to fire engine or pumps

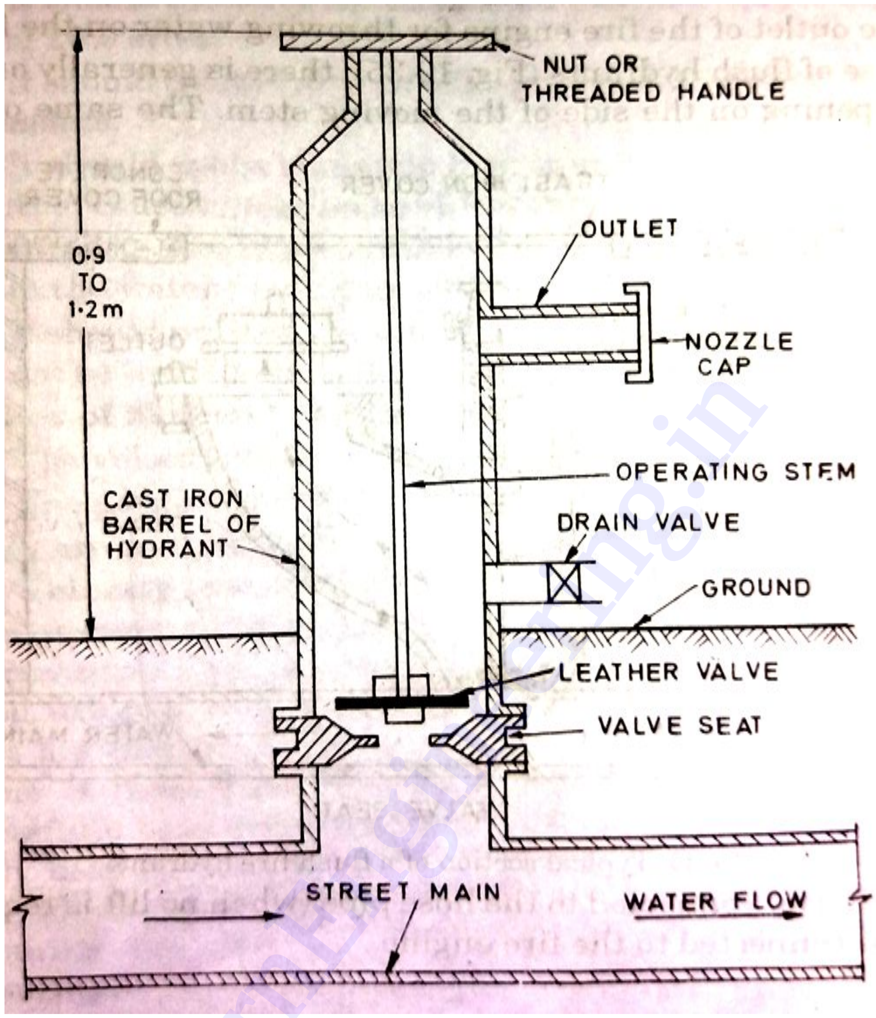


Figure: Post Fire Hydrant

2) Flush Fire Hydrants

- It is installed underground in a brick or cast iron chamber with its top cover slightly above the street level.
- Under the panicky circumstances during fire, it is difficult to search the flush fire hydrants.
- They are less prone to damage by mischievous people.

Parts of Flush Fire Hydrants

- Masonry wall
- Cast iron cover
- Concrete roof cover
- Valve stem
- Leather valve
- Outlet

Working

- There is only one outlet opening on the side of the moving stem.
- The same opening may be directly connected to the hose pipe or may be connected to the fire engine

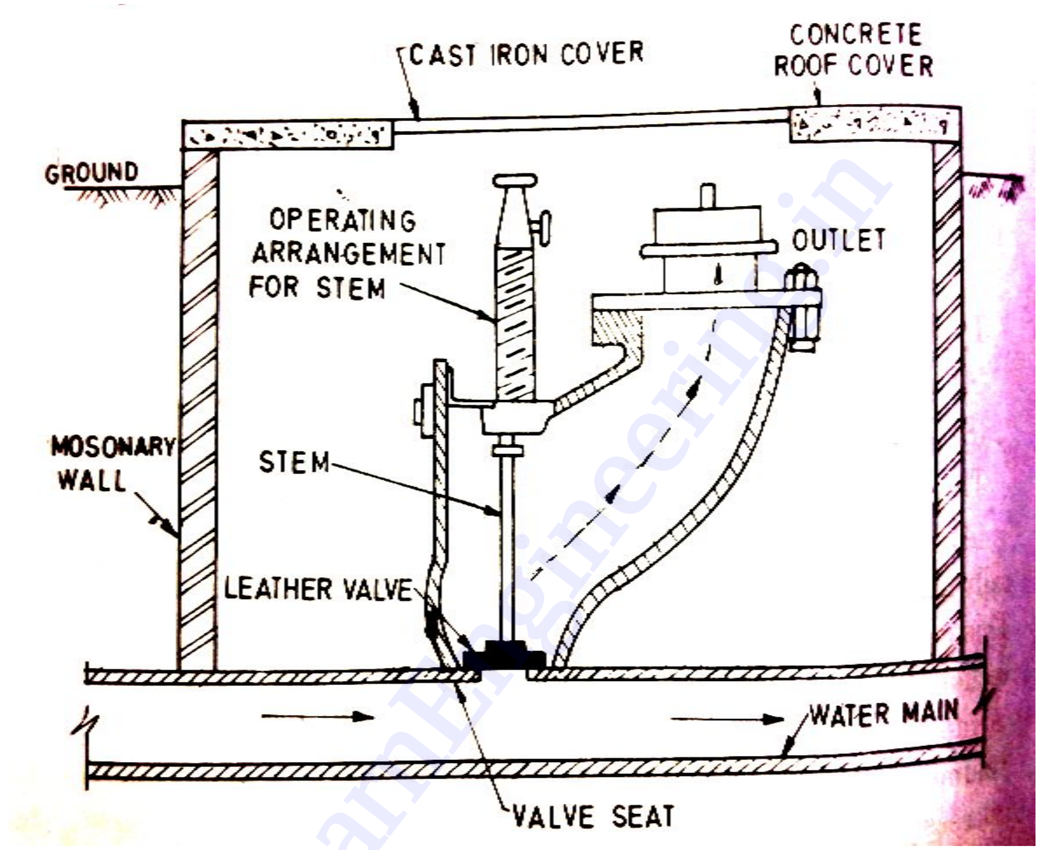


Figure: Flush Fire Hydrant

WATER METERS:

Water meters are the devices which are used for measuring the quantity of water flowing under pressure through a pressure conduit.

The measurement of quantity of water supplied to the general public is necessary, in order to charge the consumers according to the quantity of water supplied to them.

Requirements of good Water Meters

- It must record the entire water passing through it.
- Its maintenance and repair should be easy.
- It should measure the discharge within the maximum limit of 20% error.

- It should be able to work efficiently at all pressures in the mains.
- It should cause minimum hindrance to the flow and therefore cause minimum head loss in working.
- Its parts should not be easily affected by the chemicals present in the water passing through it.
- It should prevent the back flow passing through it and should not be liable to clogging.

Types of Meters

- Velocity meters or the inferential meters.
- Positive meters or the Displacement meters.

1) VELOCITY METERS OR THE INFERENTIAL METERS

- It measures the horizontal velocity of water flowing through them.
- It can be successfully used for measuring high flows.
- Generally used for measuring supplies to industries and trades
- They are available in smaller sizes up to 20 mm; therefore it is also used for measuring small domestic supplies.
- Their accuracy is less when compared to displacement meters

Examples of velocity meters;

- Rotary meters
- Turbine meters
- Venturimeter

Rotary meters:

- It consists of radial vanes attached to the shaft and enclosed in the casing.
- When water entering with certain velocity passes through the meter, the radial vanes are rotated in clockwise direction.
- The number of revolutions per unit time depends upon the velocity of flow.
- The greater the velocity the higher will be the speed of rotation.
- The discharge is proportional to the speed of the shaft.
  The meter can hence be calibrated to directly read the discharge.

Turbine meters:

- It is similar to rotary meter.
- It consists of turbine wheel which is rotated by moving water.
- The number of revolutions made by turbine wheel will give the discharge as in rotary meters.

Venturi-meter:

- It works based on the principle of Bernoulli's equation.
- It is preferably used to measure high flows in large pipes with nominal head loss.
- It is not suitable to measure small flows.
- The venturi-meter consists of gradually contracting the normal pipe to the throat section and then expanding to normal size.
- Piezometers are inserted at normal end and throat section.
- The discharge through pipe is proportional to the difference of heads between two piezometers
- It measures the head difference (H-h) and then integrates the discharge over any period of time.

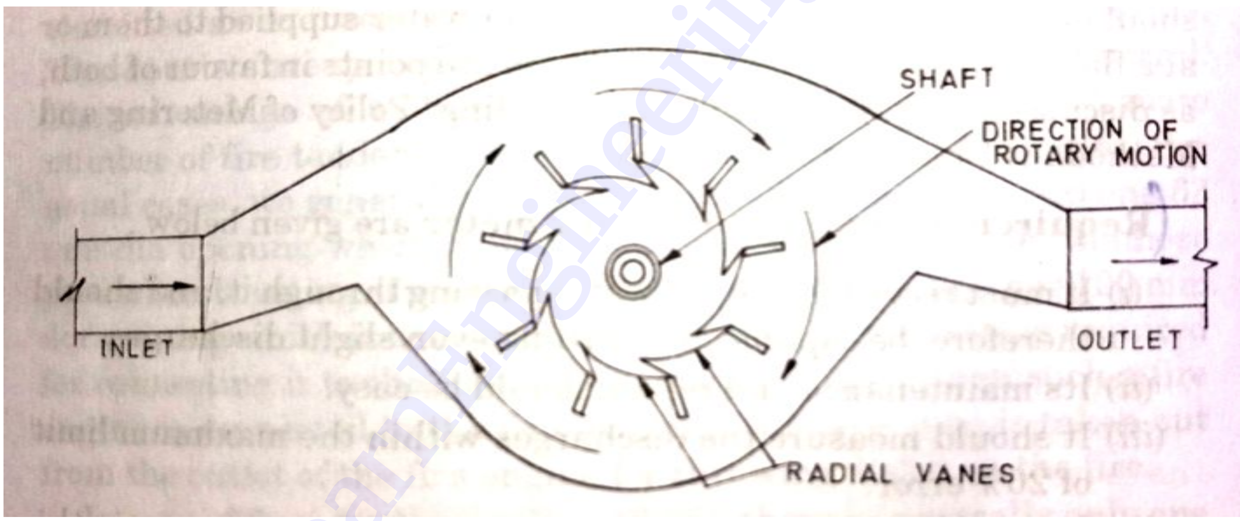


Figure: Rotary Meter

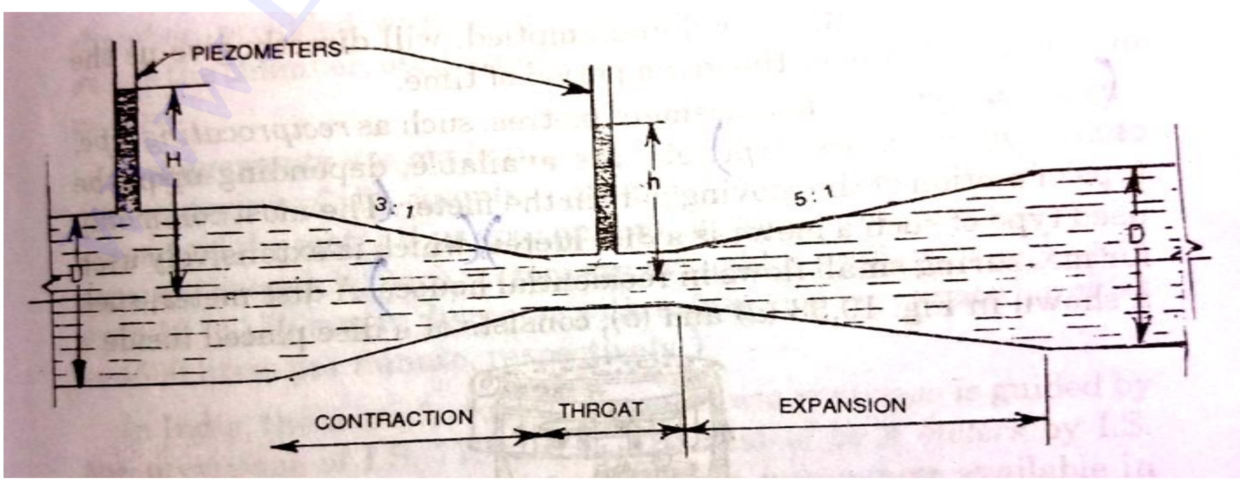


Figure: Venturi-meter

Advantages and Disadvantages of velocity meters:

- They are cheaper.
- They are light and require less head.
- They are less accurate.
- If anything stops the rotation of rotary or turbine meters, the water will continue to flow without being recorded.
- They can be installed on horizontal flows, vertical pipes need positive meters.

2) POSITIVE OR DISPLACEMENT METERS

These meters are more accurate because they measure the quantity of passing water by counting the number of times the meter chamber is filled and emptied.

Quantity of flow = Capacity of meter chamber × number of times it is filled and emptied.

Types of Displacement meters:

- Reciprocating type.
- Oscillating type.
- Disc type.

Disc meters:

- The most commonly used of meter is disc meters.
- It is used for measuring small flows in residential houses.
- It consists of a disc placed inside a chamber provided with inlet and outlet.
- The water when enters the chamber, oscillates the disc about its centre with a spiral motion.
- Arrangements are made in such a way that one complete filling and emptying of the chamber gives one revolution to train of gears, thus goes on recording the volume of the water passing through it.
- The meters are available in different sizes say 16 to 150mm in diameter with safe operating capacities of 90 to 4500 litres/minute.

STOP COCKS

- A stop cock is a screw down type of sluice valve which is used in smaller sized pipes in service connections for stopping and opening the supply.
- They are generally provided at the entrance of each building and also within the building.

- The water enters through the orifice when the valve stem is raised.
- When the valve is closed, the stem rest against the seat, and thereby closing the orifice.They are extensively used in pipes up to 50mm sizes.

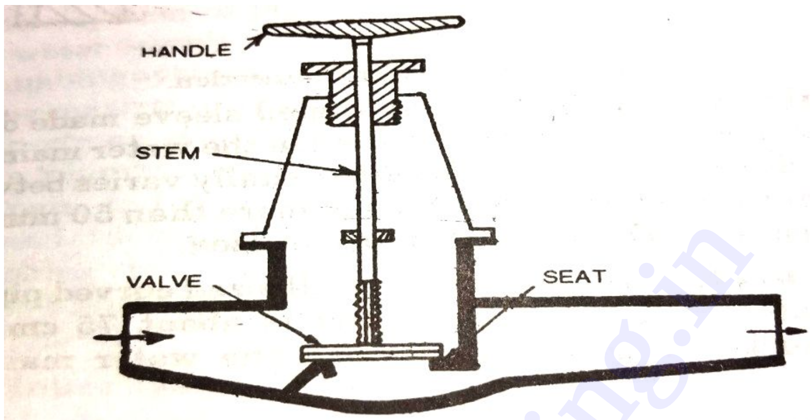


Figure: Stop cocks

WATER TAPS AND BIB COCK

- It is provided at the end of service pipes for withdrawing water at the consumer's house.
    - The most common type of water tap used is bib cocks.
- When the handle of the bib cock is rotated the orifice opens through which the water passes, can be increased or decreased, thereby controlling the out-flow through the spout.
- They are available in different pipe sizes from 10 to 50mm diameter.
- The bib cock should be water-tight and should not leak.

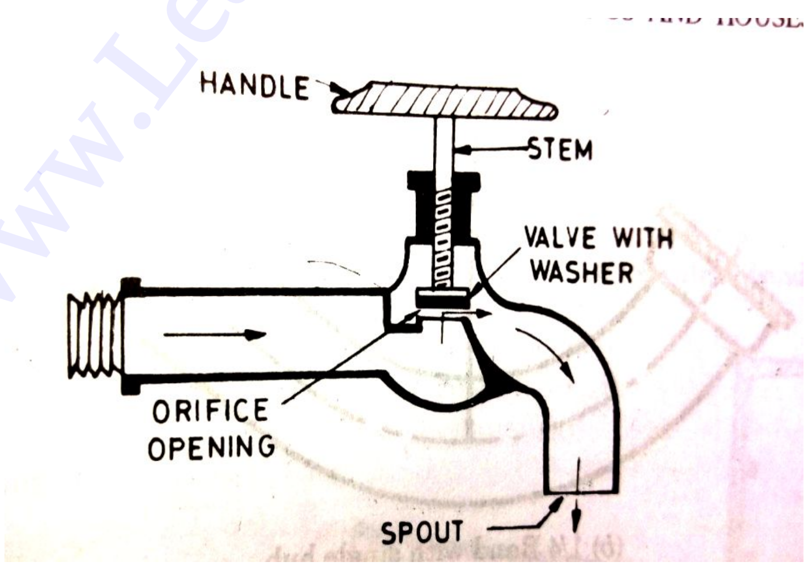


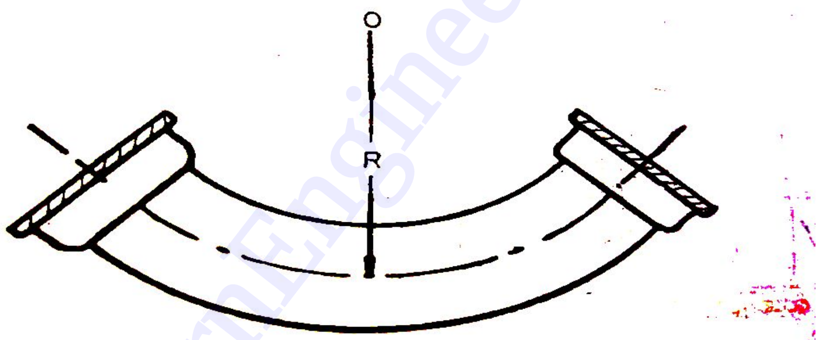
Figure: Bib cocks

PIPE FITTINGS

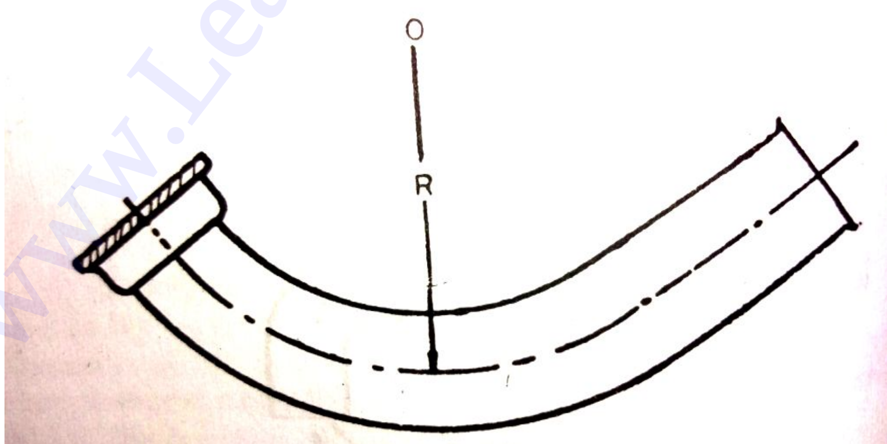
The following are the various pipe fittings

- Bends
- Crosses
- Tees
- Elbows
- Wye unions
- Caps
- Plugs
- Flanges
- Nipples

These are frequently used in making service connections and also in bigger size mains or sub-mains.

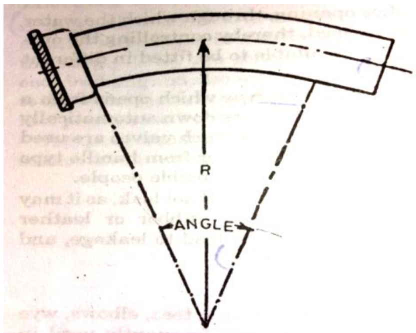


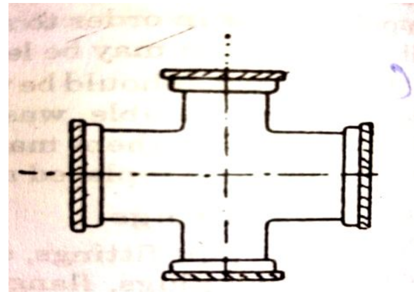
(*a*) 1/4 Bend with double hub.



(*b*) 1/4 Bend with single hub.

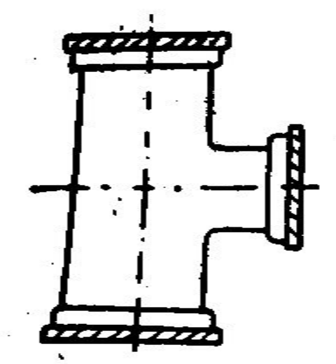
Figure: various pipe fittings



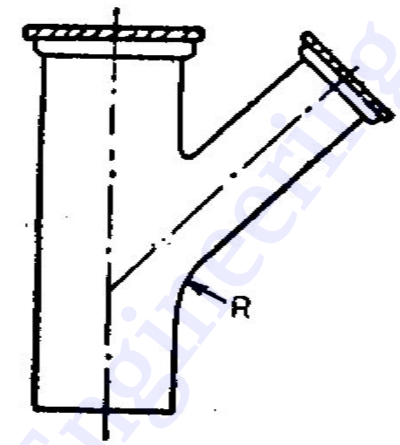


(d) Cross

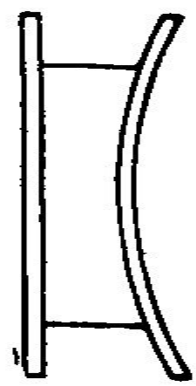
Figure: various pipe fittings



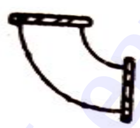
(e) Tee



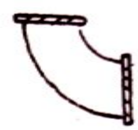
(f) Wye



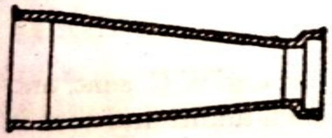
(g) Saddle flange



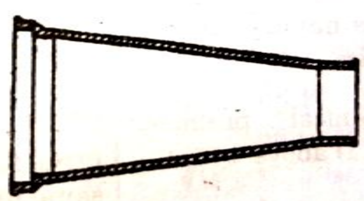
(h) Reducing elbow or bend



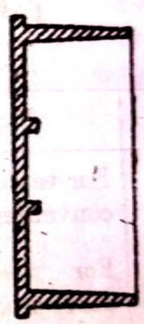
(i) Elbow or bend



(j) Increaser



(k) Reducer



(l) Ordinary plug

Figure: various pipe fitting

2. Explain different layouts of distribution network with sketches stating their merits and demerits. (Apr/May 2011, May/Jun 2014)

- Dead end system
- Grid iron system
- Ring system
- Radial system

DEAD END SYSTEM

- It is also called Tree system.
- It consists of one supply pipe, from which a number of sub-main pipes are originated.
- Each sub-mains, then divide into several branch pipes called Laterals.
- From laterals service connections are given to consumers.
- The water supply mains have then be taken along the main roads, and branches taken off wherever needed, thus resulting in the formation of several dead ends.

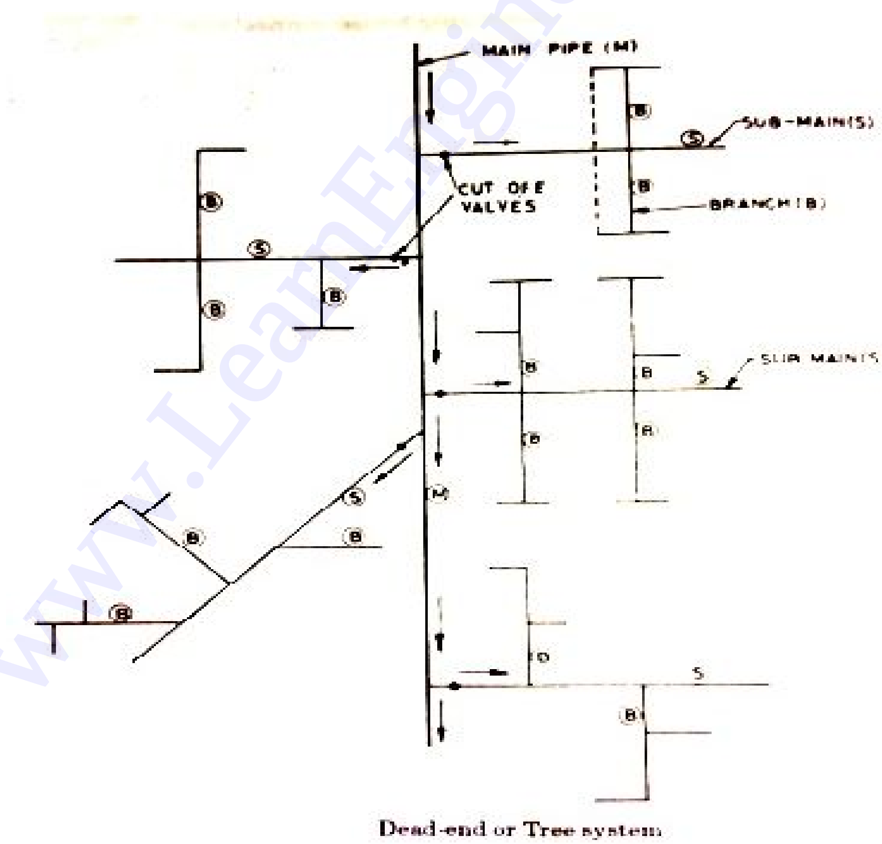


Figure: Dead end system

Advantages:

- The distribution net-work can be easily solved.
- It is possible to easily and accurately calculate the discharge and pressures at different points in the system.
- Lesser number of cut-off valves is required in the system.
- Shorter pipe lengths are required, laying of pipes is easy.
- It is cheap and simple, can be extended and expanded easily.

Disadvantages:

- Water can reach a particular point through a single route, if any damage or repair in pipe will stop the supplying the area being fed by that pipe.
- There are numerous dead ends in this system, which prevent the free circulation of water
- Only limited supplies are available, so that it cannot be used in emergencies of fire fighting.

GRID-IRON SYSTEM

- It is also known as interlaced system or Reticulation system.
- The mains, sub-mains and branches are all inter-connected with each other.
- In a well planned city or town, the roads are generally developed in a grid-iron pattern, and the pipe lines in such places can follow them easily.

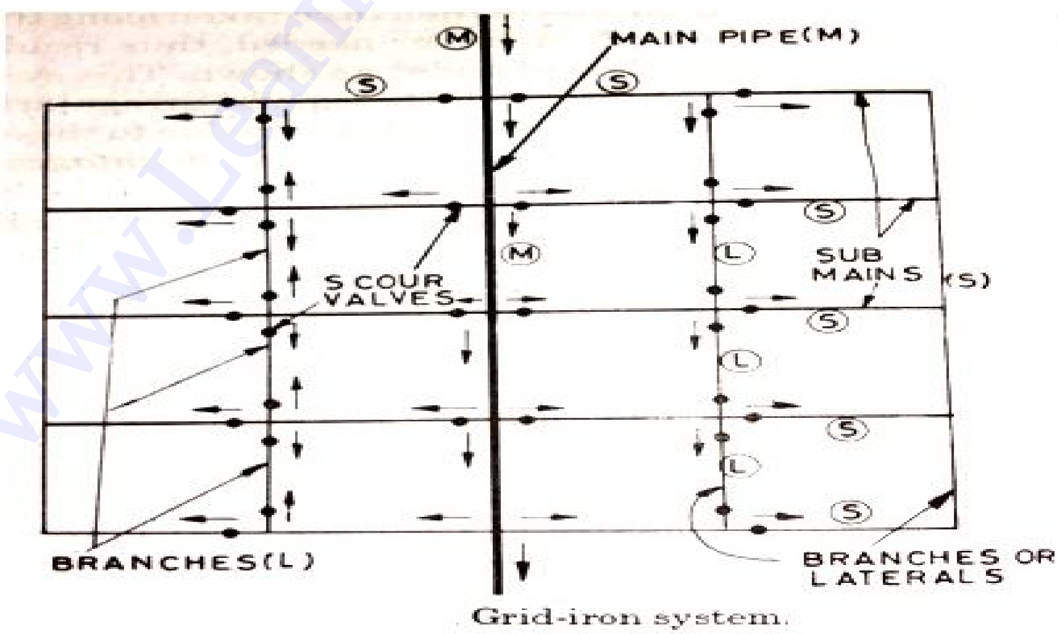


Figure: Grid-iron system

Advantages:

- Since the water reaches at different place through more than one route, the discharge can be carried out by each pipe, thereby reducing the friction losses and size of the pipe.
- In case of repairs the supply of water reaches through the alternate pipes.
- Water remains in continuous circulation due to the absence of dead ends, and hence not liable to pollution.
- During fire more water can be diverted by closing and manipulating various cut-off valves.

Disadvantages:

- The system requires more number of pipes and a larger number of sluice valves.
- Its construction is costlier.
- The design is difficult and costlier.

RING SYSTEM

- This system is also known as circular system
- A closed ring either circular or rectangular of the pipe mains is formed around the area to be served.
- The distribution area is divided into rectangular or circular blocks, and the main water pipes are laid on the periphery of these blocks, inside which the sub-mains are located.
- The ring system is suitable for towns and cities having well planned roads.
- This system is used as a looped feeder placed centrally around high demand area along with the grid-iron system.
- It enhances the capacity of grid-iron system and will improve the pressure at various points.

Advantages & Disadvantages:

It is same as that of grid-iron system.

RADIAL SYSTEM

- If the city or town are designed by radial road system, then the pipelines can be best laid by radial method.
- In this system the distribution reservoir are placed at the centre.
- The water is taken from mains and pumped to different distribution reservoir placed at different centres and then is distributed by radially laid distribution pipes.
- This method ensures high pressure and efficient water distribution.

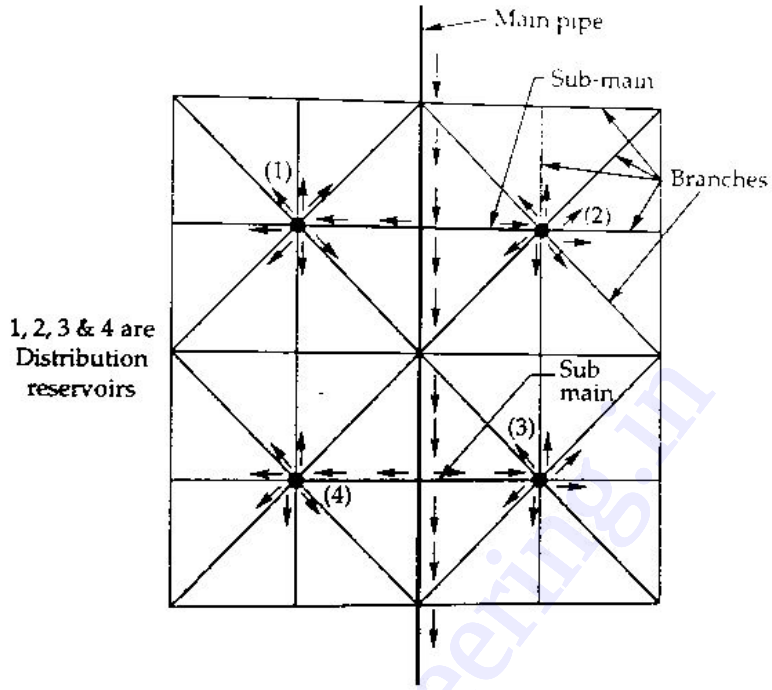


Figure: Radial system

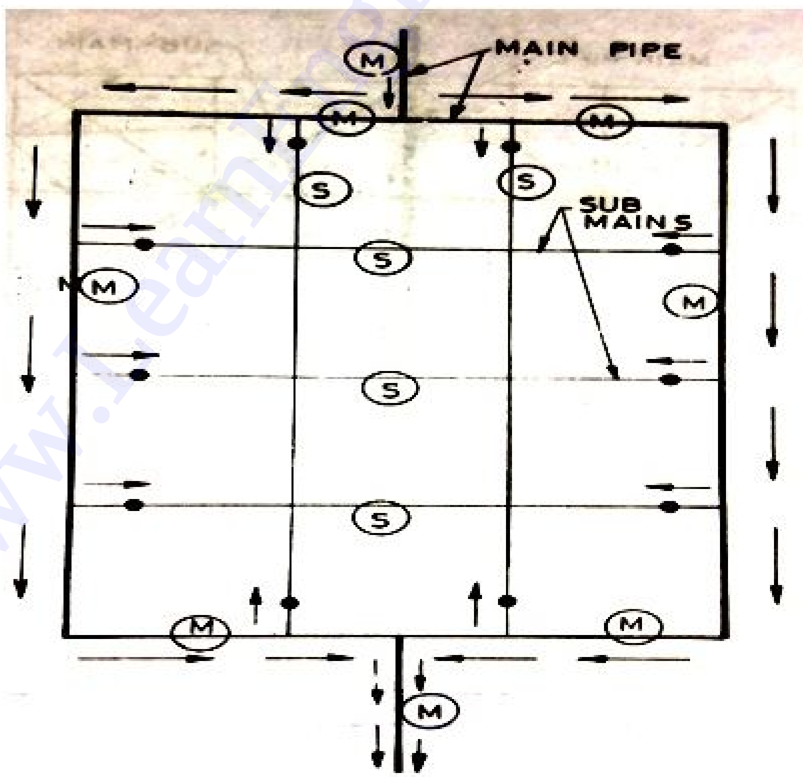


Figure: Ring system

3) How to distribute water for multi-storeyed building? Explain in detail. (Nov/Dec 2013)

(or)

Discuss the various possible water distribution arrangements in multistoraged buildings. (Nov/Dec 2012)

The system of piping's, fixtures, appliances etc. used in providing water supply and drainage to building is called plumbing system.

Water piping system:

- Piping system using direct supply.
- Piping system using overhead tank.
- Piping system using underground over head tank supply.
- Pumped system.
- Other systems:
  - Continuous running system.
  - Variable speed pumping system.
  - High pressure system.

Piping System Using Direct Supply:

- Water is supplied to all fixtures at all floor levels of a building directly from the city mains, through the house connection
- This system will be successful only when water supply is available at adequate pressure round the clock.
- This system is more convenient and economical to users as it avoids the necessity of storage tanks, pumping sets, etc.
- In case of accidental low pressure or breakdown in the city mains, a separate provision for supplying stored over head water to closets and urinals is made to ensure the supply to these fixtures.

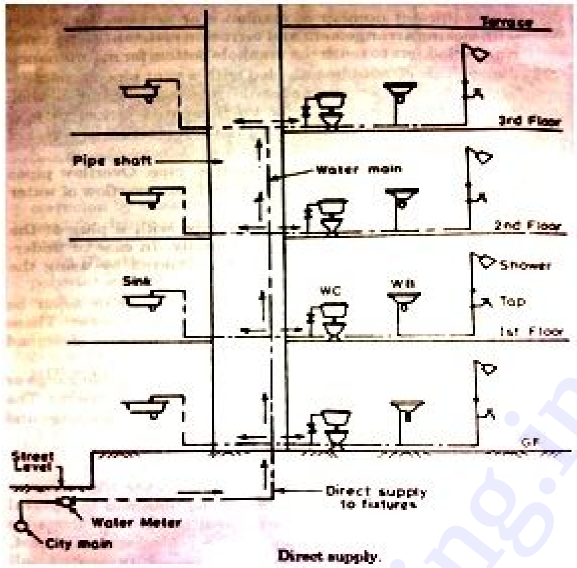


Figure: Piping System Using Direct Supply

Piping system using overhead tank:

- This system is commonly used in Indian cities.
- In many cities water is supplied with sufficiency pressure to 3-4 storeys or higher, but only for limited period in morning and evening.
- To meet the water requirement during non-supply hours, water is stored in over-head tanks placed on the terrace.
- Supply to kitchens is taken from the direct mains
- Supply to taps for bathing and flushing etc. is taken from over head tank.

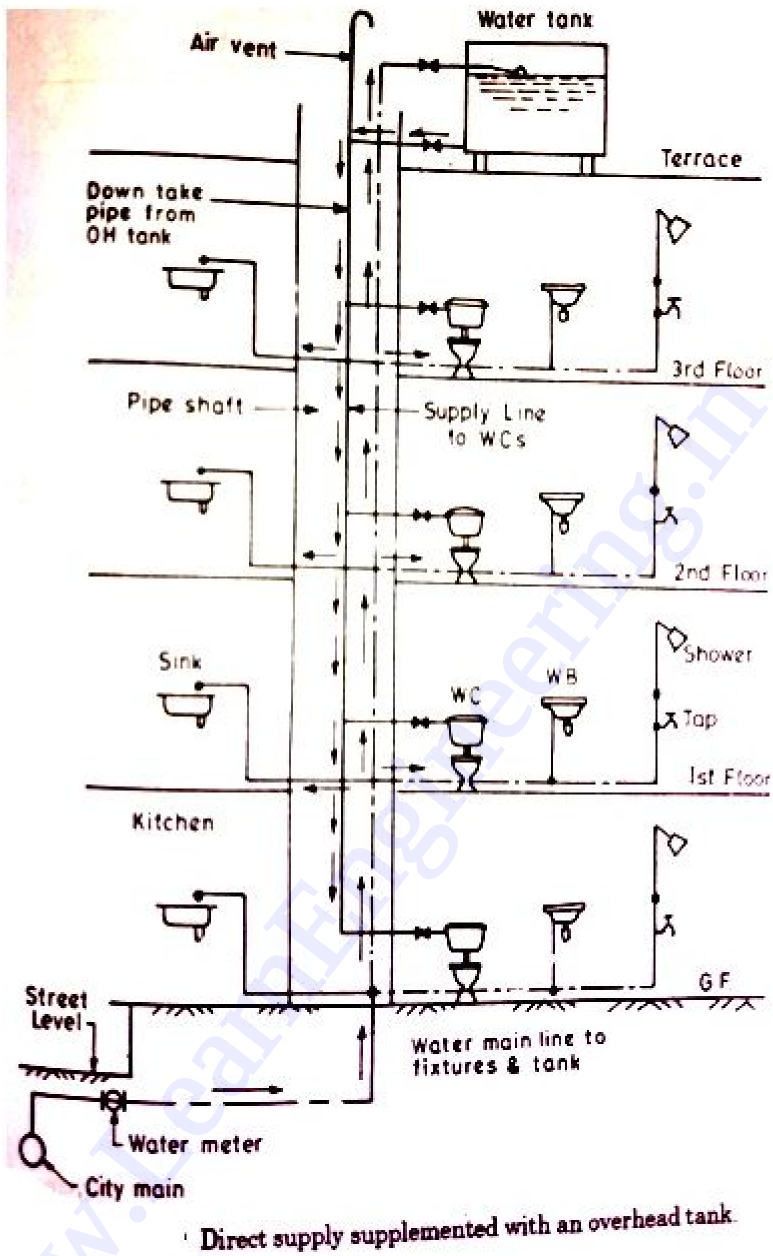


Figure: Piping System Using Over Head Tank

Piping system using under-ground over head tank supply:

- When the municipal water supplies are at low pressure, it becomes necessary to store water in underground tanks; the water collected in the underground tank is lifted to the overhead tank.
- The lower storeyed buildings use direct supply for drinking water.
- In Multi-storeyed buildings, the water have to be pumped for the entire requirement to the overhead tank by collecting it in the under-ground tank

- In such cases, use of domestic filters and Aqua guards are essential to obtain safe drinking water.

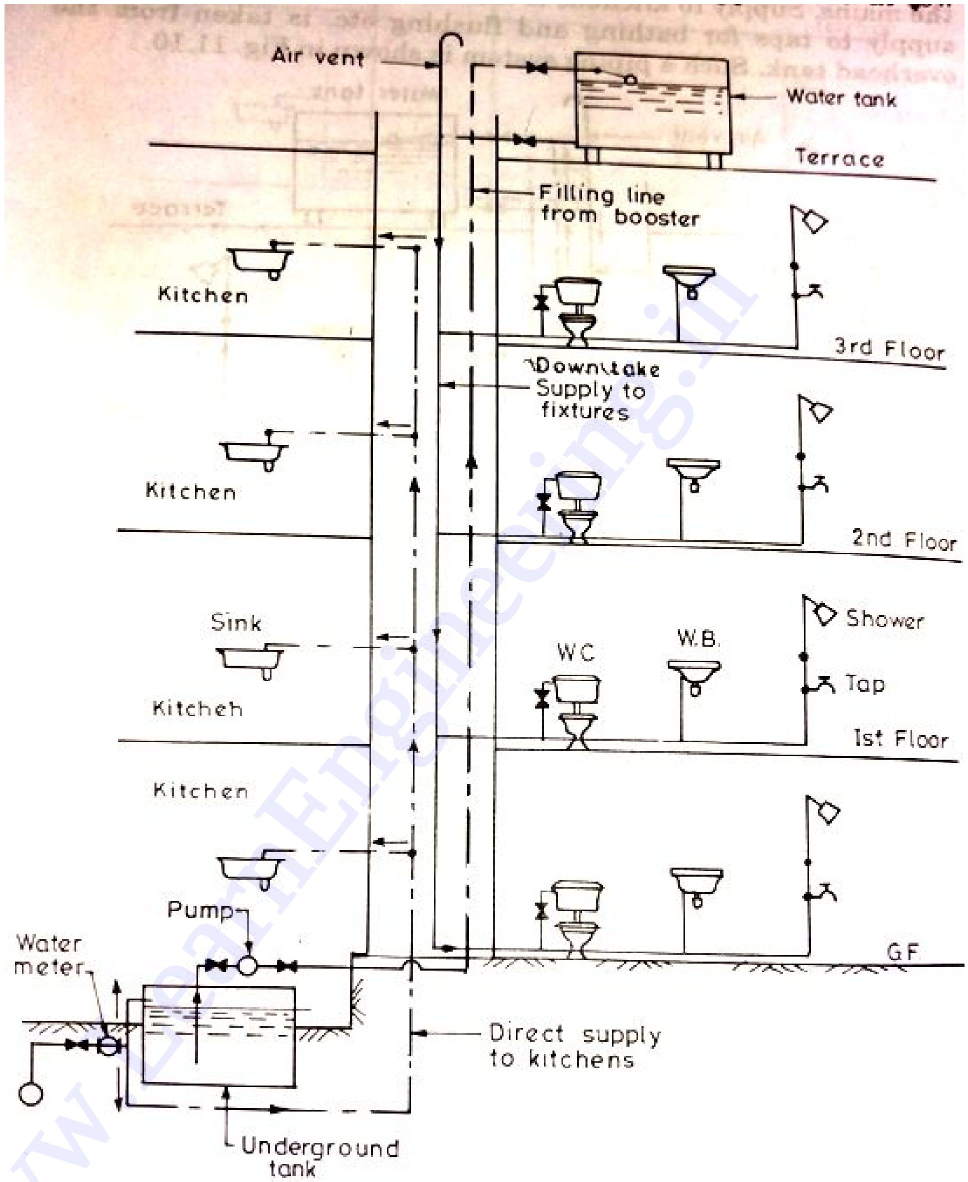
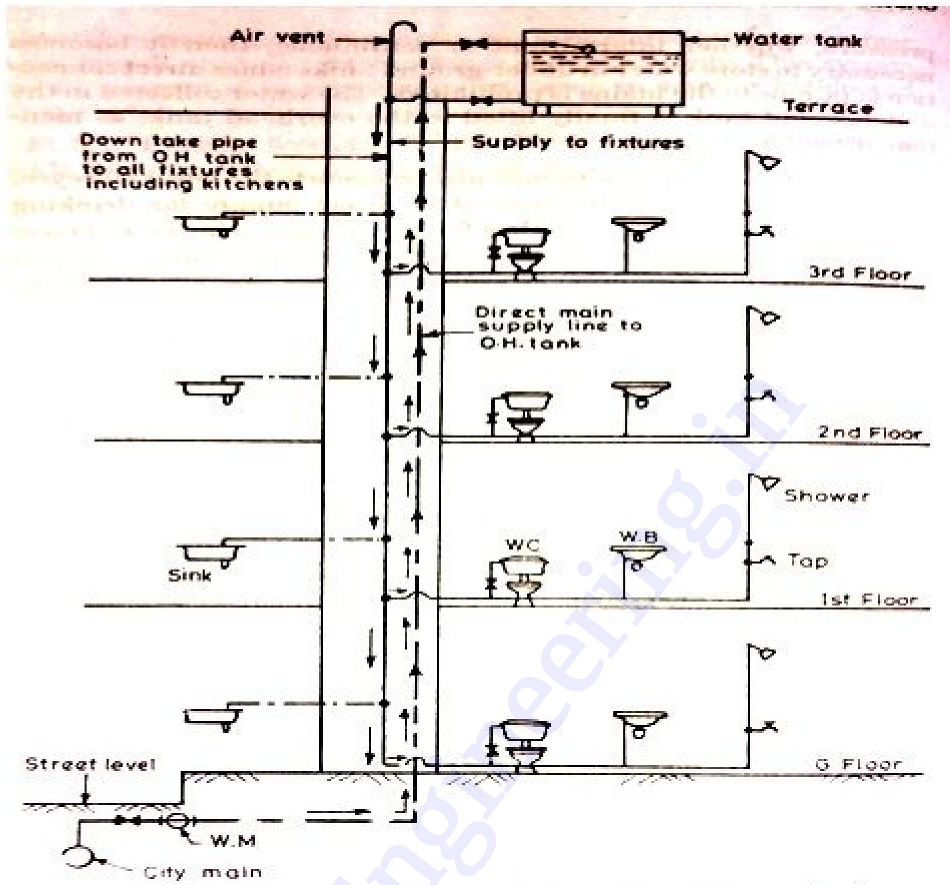


Figure: Piping system using Under0ground overhead tank supply



Total overhead tank supply through underground tank.

Figure: Total over head tank supply through underground tank

PUMPED SYSTEM

- Water can be distributed by automatic pumping system directly to the supply-point.
- The pressure in the system is boosted using pumping sets
- There is no need for overhead tanks.

OTHER SYSTEMS

Continuous Running System:

- Water is directly supplied to the point of use where the water is constant and matches with the pump capacity.

MODERN SYSTEMS

- Variable speed pumping systems.
- High-pressure systems.

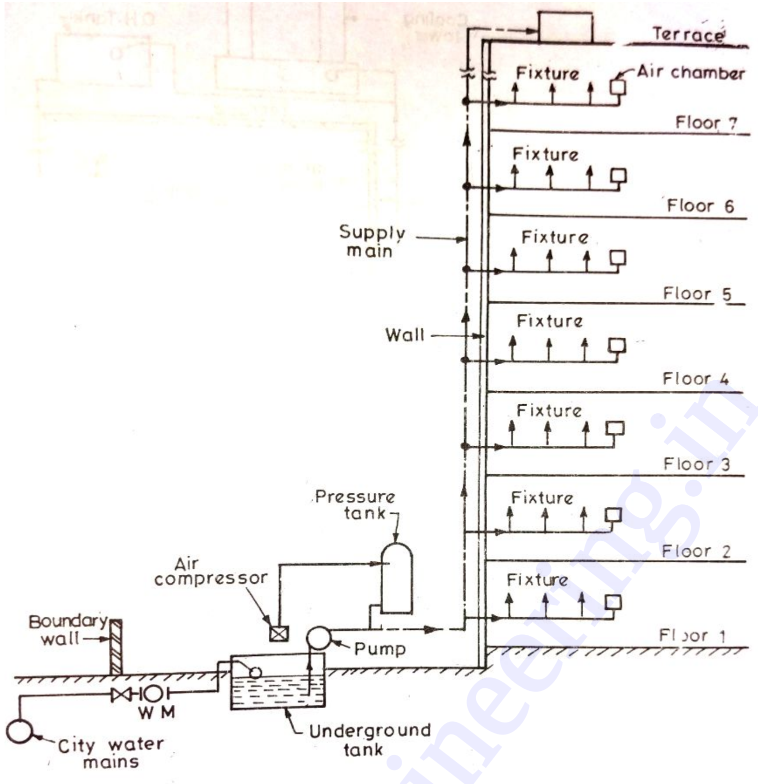


Figure: Hydro-pneumatic piping system

4) What are the functions of service reservoir? Briefly outline the design aspects of Service Reservoir? (Nov/Dec 2015, Apr/May 2015)

FUNCTIONS OF SERVICE RESERVOIR

- To absorb the hourly variations in demand, to allow the water treatment units and pumps to operate at a constant rate. This will reduce the RMO costs and improve efficiency.
- They help in maintaining constant pressure in distribution mains.
- The pumping of water in shifts is made available without affecting the supply.
- The water stored in this reservoir can be supplied during emergencies such as break-down of pumps, heavy fire demand.
- They lead to an overall economy by reducing the sizes of pumps, pipe lines and treatment units.

DESIGN ASPECTS OF SERVICE RESERVOIR

a) Storage capacity of Distribution Reservoir
b) Location and Height of Distribution Reservoir

STORAGE CAPACITY OF DISTRIBUTION RESERVOIR

Total storage capacity of Distribution reservoir = Balancing storage + Breakdown storage + Fire storage

1) Balancing storage or Equalising storage:

- The quantity of water required to be stored in the reservoir for equalising and balancing the variable demand against the constant supply is known as balancing storage.
- The balancing storage can be worked out by
  1. Mass-curve method.
  2. Analytical tubular method.

MASS CURVE METHOD

- A mass diagram is a plot of accumulated inflow and outflow versus time.
- The mass curve of supply is super imposed by the demand curve
- The amount of balancing storage can be determined by adding the maximum ordinates between the demand and supply lines

CONSTRUCTION OF MASS CURVE

a) From the past record, determine the hourly demand for 24 hours for typical days.
b) Calculate and plot the cumulative demand against time and thus plot the mass curve of demand
c) Draw the cumulative supply against time
d) Read the storage required, as a sum of the two maximum ordinate between demand and supply line
e) Repeat the procedure for all the typical days and determine the maximum storage required for the worst days

ANALATICAL SOLUTION

- The cumulative hourly demand and cumulative hourly supplies are tabulated for all 24 hours
- The hourly excess of demand as well as the hourly excess supply are then worked out
- The summation of maximum of excess of demand and the maximum of excess of supply will give us the required storage capacity

2) Break down storage

- It is the storage preserved in order to tide over the emergencies posed by the failure of pumps, electricity or any other mechanism driving the pumps
- The amount of provision to be made for this factor is very difficult to access because it depends upon frequency, extend of the failure and time required for carrying out the repairs
- A lump sum provision is made for the storage
- A value of about 25% of the total storage capacity of the reservoir or 1.5 to 2times of the average hourly supply may be considered as enough provision for accounting the storage.

3) Fire storage

- Water required for extinguishing fires.
- The water required for the fire fighting is generally small say 1to5 litres/day/person.
- The storage of fire-fighting is dependent upon the chances of fire break-outs in the considered city.
- Under normal conditions in India, we may store about 1 to 4 litres/person/day as the necessary fire storage, depending on the importance of the city.

LOCATION AND HEIGHT OF THE DISTRIBUTION RESERVOIRS

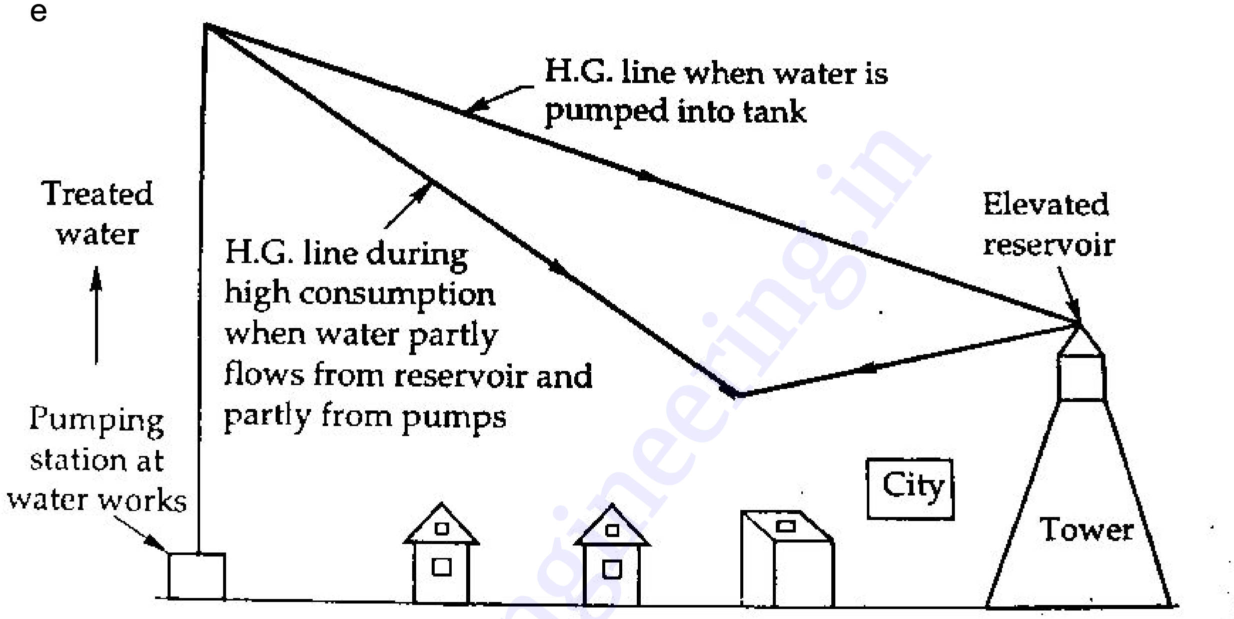
The following points are to be considered

1. They should be placed as close as possible to the points of heavier demand.
2. They should be located at high elevations, so that adequate pressure is maintained in the distribution system.
3. With respect to the position of the pumping stations and the distribution area, the reservoir may be located in two different ways:

    - They can be placed between the pumping stations and the distribution area.
        - The elevation of reservoir must be high.
        - The water to be supplied always passes through the reservoir
        - The length of the raising main will be less

- They can be placed at the farther end of the distribution area.
    - The elevation of reservoir must be low.
    - The supply can be made available directly from the pumps as well as reservoir.
    - The length of raising main will be large, more head loss

e



Functioning of the elevated reservoir located at the farthest end of the distribution area

Storage Capacity of Service Reservoir

METHODS:

1. Mass Curve Method.
2. Analytical Method.

5. A town with a Population of 1 million has a continuous water supply. Average supply in 270 lpcd, the water being supplied by direct pumping. The total supply of 270 lpcd is phased as follows:

Time	lpc
5 AM to 11 AM	90
11 AM to 3 PM	54
3 PM to 9 PM	81
9 PM to 12 midnight	27
12 midnight to 5 AM	18

water is supplied from the treatment plant at a uniform rate of 11.25 million litres per hour, for all the 24 hours. Find out the capacity of the reservoir required for distribution of water. Assume no loss or drawal from the trunk main.

To find: The Capacity of the Reservoir.

Method used: Mass Curve Method.

Solution:

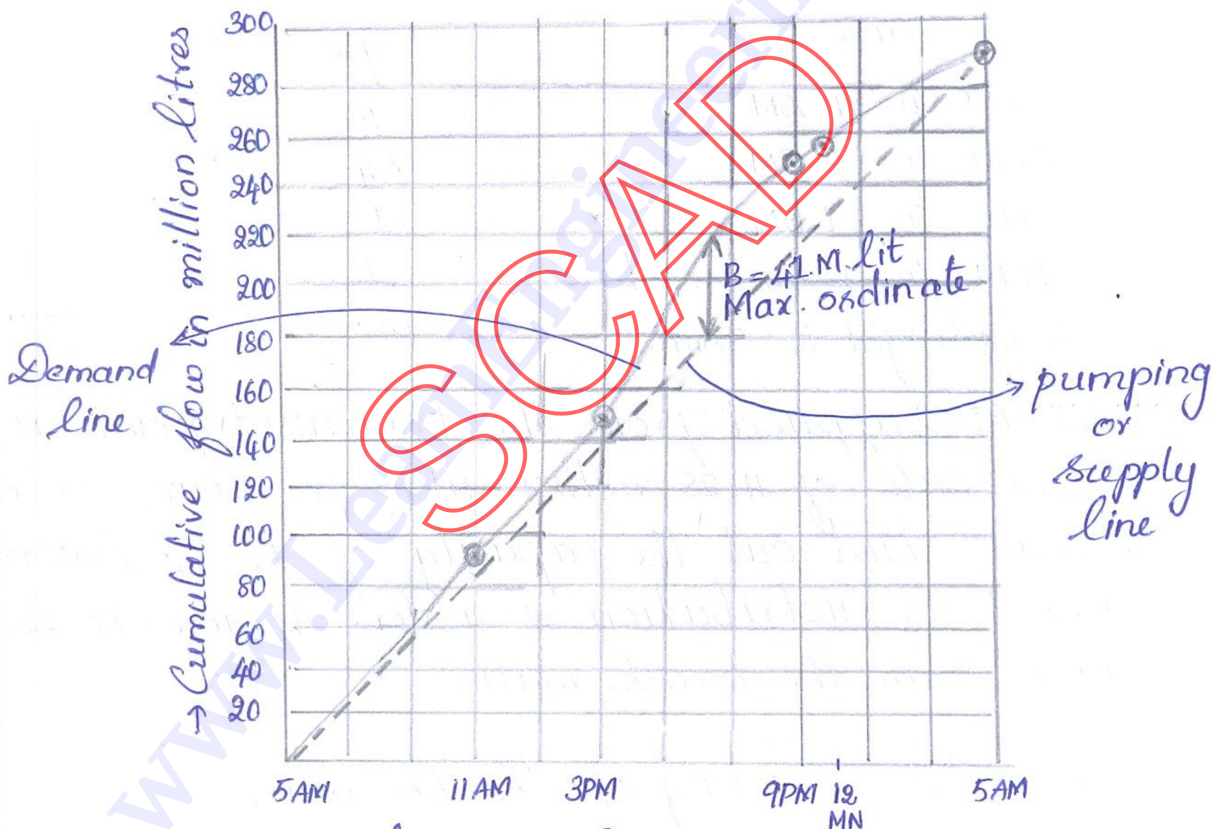
Total daily supply = Rate of supply × Population

$= 270 \times 10^6$

270 M litres

Time (1)	Per capita Consumption in lpc (2)	Consumption in M.litres for 1 million population (2) × 1 M.P (3)	Cumulative demand in M.litres (4)
5 AM to 11 AM	90	90	90
11 AM to 3 PM	54	54	144
3 PM to 9 PM	81	81	225
9 PM to 12 (M.N)	27	27	252
12 (M.N) to 5 AM	18	18	270

The mass curve of Demand Col (1) Vs Col (4)



The supply line on the mass curve will be straight line with the slope of 11.25 M.lit / hour.

The two max. ordinates are taken from the graph.

A = 0 million lit

B = 41 million lit

Total storage required = A + B

= 0 + 41

= 41. Million litres

6. Total storage capacity required = 41 Million litres

Calculate the storage required to supply the demand shown in the following table if the inflow of water to the reservoir is maintained at a uniform rate throughout 24 hours.

Time	00 - 04	04 - 08	08 - 12	12 - 16	16 - 20	20 - 24
Demand in M. litres	0.48	0.87	1.33	1.00	0.82	0.54

To find:

The storage required for supply

Method used:

Analytical Method

Time (hrs)	Demand in Million litres	Cumulative demand in million litres	Pumping in Million litres	Cumulative pumping in Million litres	Excess of demand (3) – (5) (only +ive values)	Excess of supply (5) – (3) (only (+ive) Values)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
0 – 4	0.48	0.48	0.84	0.84	–	0.36
4 – 8	0.87	1.35	0.84	1.68	–	0.33
8 – 12	1.33	2.68	0.84	2.52	0.16	–
12 – 16	1.00	3.68	0.84	3.36	0.32	–
16 – 20	0.82	4.50	0.84	4.40	0.10	–
20 – 24	0.54	5.04	0.84	5.04	–	–

From the above table

The maximum excess of demand = 0.32 M. litres

The maximum excess of supply = 0.36 M. litres

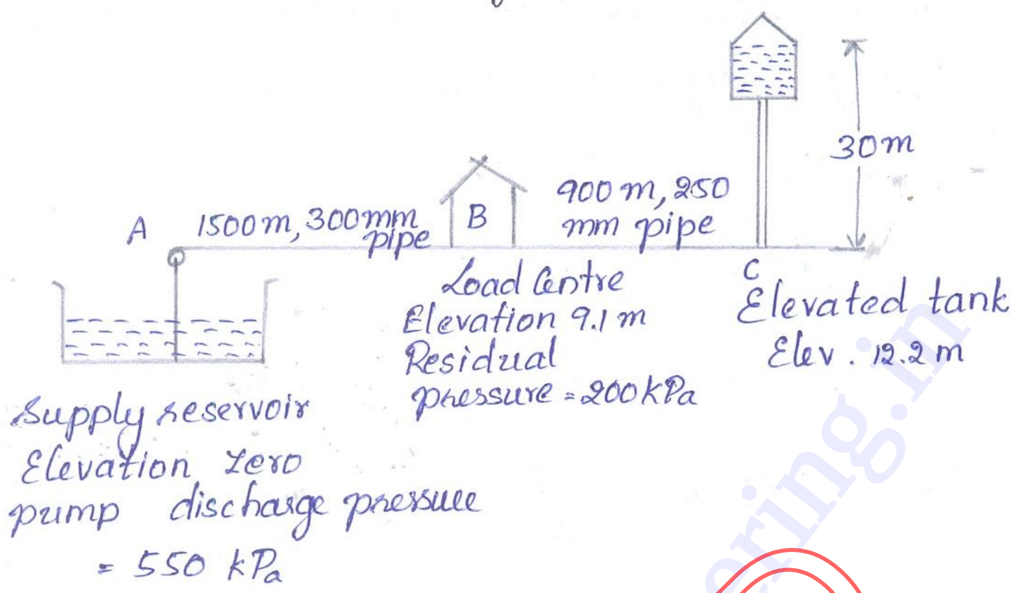
The total storage required = 0.32 + 0.36

= 0.68 Million litres

Answer:

The storage required to supply the demand is 0.68 million litres.

7. A water supply system consisting of a reservoir with lift pump, elevated storage tank, piping and withdrawal points is shown in diagram



(i) Based on the following data, sketch the hydraulic gradient for the system

$Z_A = 0$ m $Z_B = 9.1$ m $Z_C = 12.2$ m

$P_A = 500$ kPa $P_B = 200$ kPa $P_C = 30$ m

(ii) For these conditions, compute the flow available at point B for both the supply pumps and elevated storage. Use C = 100 and pipe sizes are shown in diagram. Hydraulic values are given below.

Table of Hydraulic Values for C = 100

d (mm)	h_L (m/1000)	Q (l/s)	V (m/s)
300	17.8	133	1.7
250	14.1	117	1.5
200	20.0	48	1.6
150	30.0	30	1.7
100	40.0	13	1.5

To find:

1. Sketch the hydraulic gradient line for the system
2. Compute the flow available at Point B for both the supply pumps and elevated storage.

Solution:

$$1\ kPa = 1\ kN/m^2$$

$$1m \text{ of water head} = 9.81\ kN/m^2$$

$$1\ kPa = 1\ kN/m^2 = \frac{1}{9.81}\ m \text{ of water head}$$

$$100\ kPa = \frac{100}{9.81}\ m \text{ of water head}$$

$$= 10.1937\ m \text{ of water head.}$$

Pressure @ A

$$P_A = 550\ kPa$$

$$= \frac{550}{100} \times 10.1937$$

$$= 56.065\ m$$

Pressure @ B

$$P_B = 200\ kPa$$

$$= \frac{200}{100} \times 10.1937$$

$$= 20.387\ m$$

Total head @ A $= Z_A + P_A$

$= 0 + 56.07$

$= 56.07$

Total head @ B $= Z_B + P_B$

$= 9.1 + 20.39$

$= 29.49$ m

Total head @ C $= Z_C + P_C$

$= 12.2 + 30$

$= 42.2$ m

(ii) For pipe AB of dia 300 mm,

S = gradient of hydraulic line

$$= \frac{\text{Total head @ A} - \text{Total head @ B}}{\text{Length of the Pipe}}$$

$$= \frac{56.07 - 29.49}{1500} \times 1000 \text{ m/1000 m length}$$

$$= 17.72 \text{ m/1000 m} \simeq 17.8 \text{ m/1000 m}$$

From the table given in Ques;

The Value of Discharge is 133 l/s with respect to the h_L (m/1000) = 17.8 m/1000 m.

$\therefore$ Discharge @ B due to pumps = 133 l/s

For Pipe CB of 250 mm ϕ,

$$S = \frac{42.2 - 29.47}{900} \times 1000 \text{ m}/1000 \text{ m length}$$

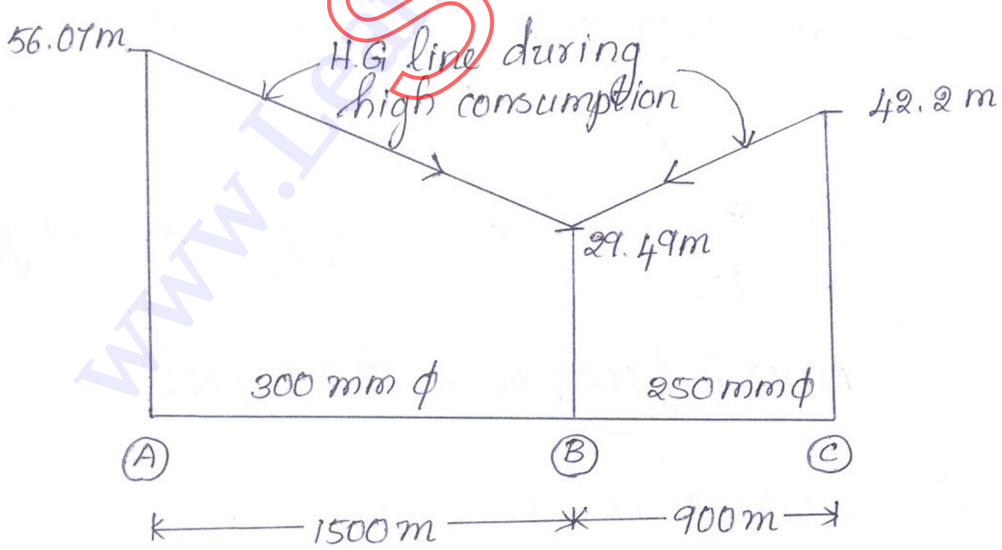
$$= 14.1 \text{ m}/1000 \text{ m}.$$

From the table, the discharge is 117 l/s with respect to the $h_L = 14.1$ m/1000 m

Discharge @ B by storage reservoir = 117 l/s

Answer:

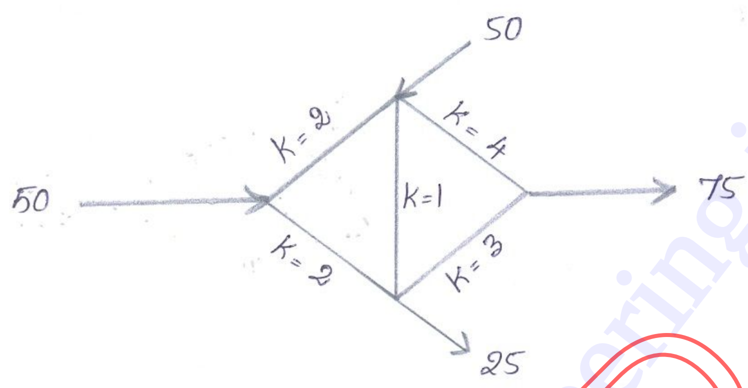
Discharge @ B by pumps = 133 l/s
Discharge @ B by storage Reservoir = 117 l/s



Hydraulic Gradient Line.

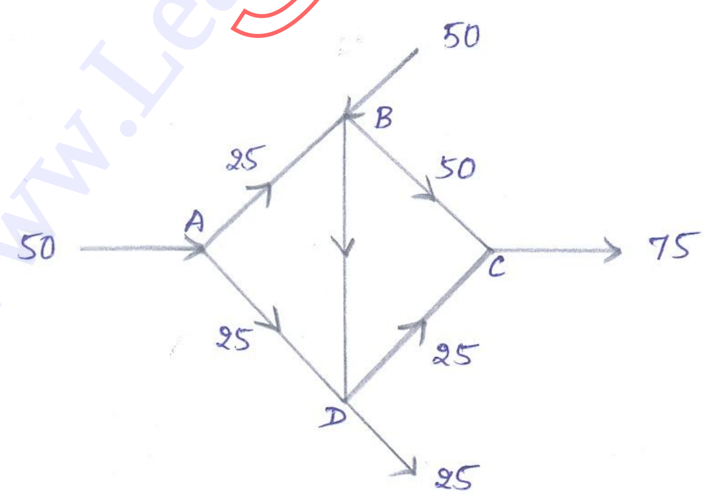
Hardy Cross Method:

8. Determine the Distribution of flow in the pipe network shown in Fig(1). The head loss h_L may be assumed as KQ^n. The flow is turbulent and pipes are rough. The value of k for each pipe is indicated in the figure. Use Hardy cross method.



Solution:

1. Considering the Law of Continuity (input equals the off-take at each junction) the magnitude as well as directions of possible flows in each are assumed.



2. Head Loss in each pipe $H_L = K \cdot Q^n$

Assume $n = 2$

FIRST CORRECTION

Pipe	Assumed flows Q_a (l/s)	K (given)	$H_L = K \cdot Q_a^2$	$\left\lvert \frac{H_L}{Q_a} \right\rvert$	Corrected Q after first correction $Q_{a_1} = Q_a + \Delta_1$ (l/s)
(1)	(2)	(3)	(4)	(5)	(6)
Loop (1) ABDA					
AB	25	2	1250	50	22.5
DB	25	1	625	25	35.0
DA	−25	2	−1250	50	−27.5
Σ			625	125	

$$\Delta_1 = \frac{-\Sigma H_L}{x \cdot \Sigma \left[\frac{H_L}{Q_a}\right]} = \frac{-625}{2 \times 125} = -2.5$$

Pipe	Assumed flows Q_a (l/s)	K (given)	$H_L = K \cdot Q_a^2$	$\left\lvert \frac{H_L}{Q_a} \right\rvert$	Corrected Q after first correction $Q_{a_1} = Q_a + \Delta_1$ (l/s)
Loop (2) BCDB					
BC	50	4	10,000	200	37.5
CD	−25	3	−1875	75	−37.5
DB	−25	1	−625	25	−35.0
Σ			7500	300	

$$\Delta_1' \text{ (2nd Loop)} = -\frac{7500}{2 \times 300} = 12.5$$

FLOWS AFTER 1st CORRECTION

Pipe	Corrected discharge after 1st correction
ABDA Loop	
AB	22.5
BD	35.0
DA	−27.5
BCDB Loop	
BC	37.5
CD	−37.5
DB	−35.0

Hardy Cross Procedure for Second Correction

Pipe	Assumed flows Q_{a_1} (l/s)	K	$H_L = K.Q_a^2$	$\left\lvert \frac{H_L}{Q_a} \right\rvert$	Corrected flows after 2nd correction $Q_{a_2} = Q_{a_1} + \Delta_2$
(1)	(2)	(3)	(4)	(5)	(6)
Loop ABDA					
AB	22.5	2	1012.5	50	19.8
BD	35.0	1	1225.0	25	32.6
DA	-27.5	2	-1512.5	50	-30.2
		Σ	725	135	

$$\Delta_2 = \frac{-725}{2 \times 135} = -2.7$$

Pipe	Assumed flows Q_{a_1} (l/s)	K	$H_L = K.Q_a^2$	$\left\lvert \frac{H_L}{Q_a} \right\rvert$	Corrected flows after 2nd correction $Q_{a_2} = Q_{a_1} + \Delta_2$
Loop BCDB					
BC	37.5	4	5625	150	37.2
CD	-37.5	3	-4218.75	112.5	-37.8
DB	-35.0	1	-1225	35	32.6
		Σ	181.25	297.5	

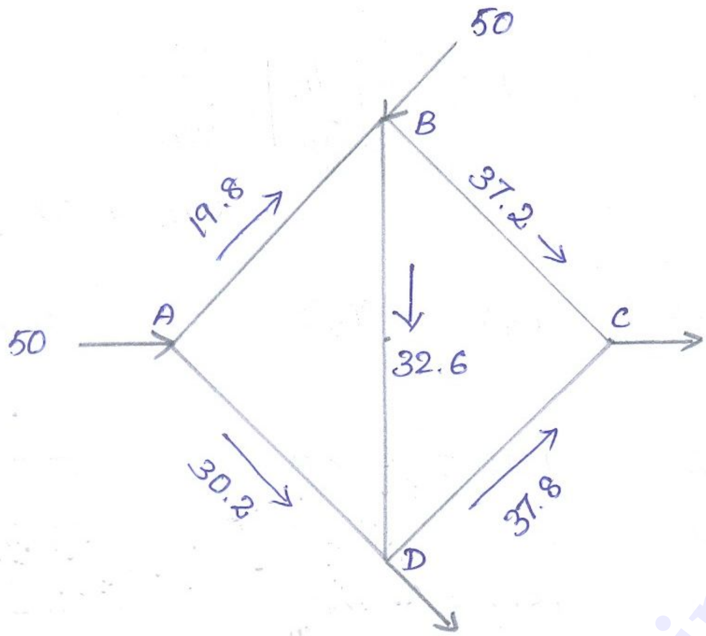
$$\Delta_2' = \frac{-181.25}{2 \times 297.5} = -0.3$$

Corrected flow in common pipe BD

$$= (25 + \Delta_1 + \Delta_1') - \Delta_2 - \Delta_2'$$

$$= 35 - 2.7 - (-0.3) = 35 - 2.7 + 0.3$$

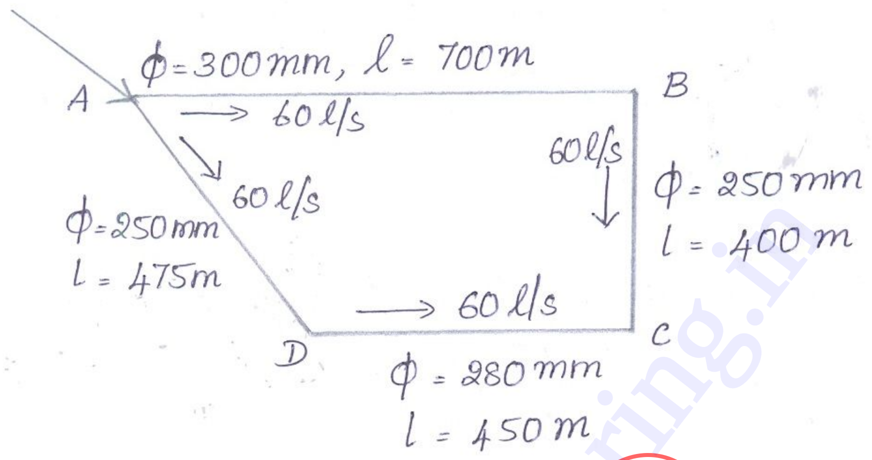
$$= 32.6 \text{ l/s}$$



Corrected flows.

EQUIVALENT PIPE METHOD:

1. Solve the large networks of pipe given in the figure using equivalent pipe Network.



Solution:

1) In the figure, the flow through the Pipes ABC and ADC are assumed to be 60 l/s

2) Compute the head losses in the two circuits using William-Hazen's nomogram

Circuit ABC $= \frac{4.5}{1000} \times 700 + \frac{12}{1000} \times 400 = 7.95m$

Note: In Hazen's William's Nomogram

Dia of pipe	h_L (m/1000 m)
300 mm	4.5
250 mm	12
280 mm	6

Circuit ADC

$$= \frac{12}{1000} \times 475 + \frac{6}{1000} \times 450 = 8.4\ m$$

2) If the pipes of the circuit ABC & ADC are replaced by 300 mm dia pipe, Length of the pipe required to replace the each pipe can be obtained.

For circuit ABC, 300 mm ϕ pipe $h_L = 4.5\ m/1000\ m$

$$\text{Length} = \frac{7.95}{4.5} \times 1000\ mm$$

$$L = 1767\ m$$

For circuit ADC, 300 mm ϕ pipe $h_L = 4.5\ m/1000\ m$

$$\text{Length of pipe} = \frac{8.4}{4.5} \times 1000$$

$$= 1865\ m$$

3) The loss of head in all the routes should be the same. If the route ADC, should have the head loss of 7.95 m,

$$\text{Rate of loss of head}/1000\,m = \frac{7.95}{1865} \times 1000$$

$$= 4.27\ m$$

This head loss of 4.27 m/1000 m can be achieved only when the discharge is 56 l/s

Reference : Hazen's William's Nomogram

The circuits ABC & ADC can be replaced by equivalent pipe carrying a total discharge of

$$= 60 + 56 = 116 \ l/s$$

Referring Hazen William's Nomogram, the Equivalent pipe of 300 mm ϕ & discharge of 116 l/s have a head loss of 15 m/1000 m.

In order to ensure 7.95 m head losses in equivalent pipe, the length of the pipe should be

$$= \frac{1000}{15} \times 7.95 \ m$$

$$= 530 \ m.$$

Answer:

The total loop ABCD can thus be replaced by a single equivalent pipe of 300 mm ϕ with a length of 530 m, irrespective of the flow discharges.

Reg. No. :

Question Paper Code : 11214

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2011

Fifth Semester

Civil Engineering

CE 2304 — ENVIRONMENTAL ENGINEERING — I

(Regulation 2008)

Time : Three hours Maximum : 100 marks

Answer ALL questions

PART A — (10 × 2 = 20 marks)

1. What are the main objectives of treating water?
2. Enumerate the components of a water supply scheme.
3. Enlist the factors controlling the choice of materials for water conducts.
4. Mention the situation in which pumps will be connected in (a) series (b) parallel.
5. State the Stokes equation for finding settling velocity of particles.
6. On what factors does the dose of coagulants depend?
7. State the objectives of aeration process in water treatment.
8. Mention any four methods of desalination process.
9. What factor control water supply to buildings?
10. What is an equivalent pipe?

PART B — (5 × 16 = 80 marks)

11. (a) (i) Explain the factors affecting the per capita demand of a town. (8)

(ii) The population of a town Panchayat as obtained from census report is as follows.

Census year :	1965	1975	1985	1995	2005
Population :	80000	90000	100000	114000	130000

Estimate the population of the town Panchayat in 2025 by Geometric Increase method. (8)

Or

(b) (i) Describe the Mass curve analysis for the determination of impounded storage requirement for water. (8)

(ii) Derive an expression for determining the discharge from an unconfined aquifer under steady flow conditions. (8)

12. (a) (i) Sketch and explain the various components of a reservoir intake. (8)

(ii) Quantity of water required by a town is 20,000 m^3/day. The pumps are working against a total head of 40 m, for 8 hours. Total length of the main is 20 km. f = 0.075. Determine the size of the main using Darcy-Weisbach formula. Assume any other data required. (8)

Page no. 55

Or

(b) (i) What are the various types of joints used for the water mains? Sketch and explain any two types of joints. (8)

(ii) What is meant by economical diameter of a rising main? On what factors does it depend?

13. (a) (i) Explain the sedimentation process used in water treatment plant.

Page no. 72 (8)

(ii) Sketch and explain break point chlorination. (8)

Or

Page no. 76

(b) Find the area of rapid sand filter required for a town having a population of 80,000 with an average rate of demand 180 lpcd. Assume suitable data for design. Draw the cross section of the designed filter. (16)

14. (a) Describe the need for removal of Iron and Manganese from water. Explain the methods of removal of Iron and Manganese from water when present without combination with organic matter and in combination with organic matter.

Or

(b) Sketch and explain Zeolite process for the removal of permanent hardness from water. (16)

15. (a) (i) Explain the Hardy-Cross method of distribution network analysis.

(8)

(ii) Write short notes on the detection and prevention of wastage of water. (8)

Or

(b) Explain different layouts of distribution network with sketches stating their merits and demerits.

Page no. 131

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Reg. No. :

Question Paper Code :

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2011.

Fifth Semester

Civil Engineering

CE 2304 — ENVIRONMENTAL ENGINEERING — I

(Regulation 2008)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What is design period? List any two factors influencing it.

2. State the purposes of carrying out water quality characterisation.

3. What are the advantages expected in using pressure conduits instead of gravity conduits?

4. What is meant by pipe appurtenances and mention their role.

5. Give the design criteria for a flash mixer and state is use in water supply scheme.

6. What are the factors influencing the settling of a particle?

7. List the pollutants get removed in an aerator.

8. Name the methods of defluoridation.

9. List out the components of a service connection pipe.

10. What do you mean by sanitary fitting?

PART B — (5 × 16 = 80 marks)

11. (a) (i) Discuss the factors that affect the rate of water demand. (8)

(ii) Explain about fire demand – its characteristics and the method of estimating it. (8)

Or

(b) (i) Present and past populations 20 years and 40 years back for a town are 292000, 172000 and 30000 respectively. Estimate the population expected after 40 years using logistic curve method. (8)

(ii) Discuss the physical characteristics of water and their influence on water quality. (8)

12. (a) What are the basic requirements of a pipe joint? Explain the various pipe joints with neat sketches.

Or

(b) (i) Explain the functioning of a jet pump with a neat sketch. (8)

(ii) Discuss the factors influencing the selection of a pump. (8)

Page no. 72

13. (a) (i) Discuss the sedimentation by coagulation process using alum and state the merits and demerits of using alum. (8)

(ii) What are the methods of disinfection and state the quality requirements of a good disinfectant? (8)

Or

(b) (i) Find the settling velocity of a particle of 0.06 mm diameter having specific gravity of 2.65 in water at a temperature of 20° C. Take kinematic viscosity $\gamma = 1.007 \times 10^{-6}\, m^2/sec$. (8)

(ii) Design a slow sand filter for a town of population 6000 persons, provided water supply at the rate of 160 litres/head/day. Take the filtration rate as 2.5 litres/minute/m^2, L/B ratio as 2, maximum demand as 1.8 times average demand. (8)

14. (a) (i) What are the effects and sources of Iron and Manganese present in water? Explain the methods of removing them. (8)

(ii) Explain the activated carbon treatments and the pollutants removed and advantages of the process. (8)

Or

(b) Explain the following water treatments.

(i) Softening by lime - soda process (8)

(ii) Reverse osmosis and the reject management. (8)

15. (a) A town having 1,00,000 population and need provide water supply at the rate of 200 lpcd. Following is the variation in demand.

6 am to 9 am = 40% of demand

9 am to 3 pm = 10% of demand

3 pm to 6 pm = 15% of demand

6 pm to 9 pm = 20% of demand

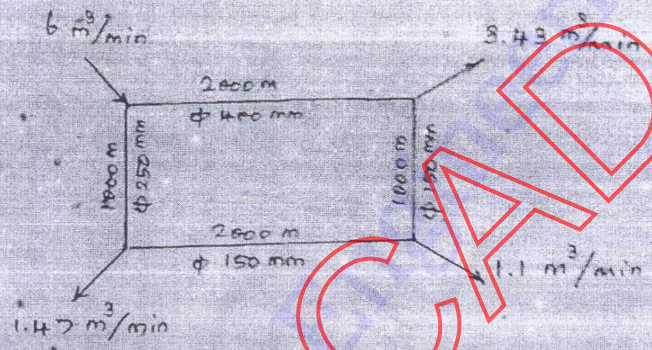
9 pm to 6 am = 5% of demand

Determine the capacity of service reservoir if the pumping of water to the reservoir is to be made during the hours of 6 am to 9 am and 3 pm to 9 pm at constant rate.

Or

(b) Analyse the pipe network shown below and tabulate the flow values in each of pipe.

Page no. 152



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Reg. No. :

Question Paper Code : 10227

B.E/B.Tech. DEGREE EXAMINATION, MAY/JUNE 2012.

Fifth Semester

Civil Engineering

CE 2304/CE 53/10111 CE 504 — ENVIRONMENTAL ENGINEERING — I

(Regulation 2008)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. List out the various water demand encountered in society.

2. What are the assumptions in an incremental increase method to forecast population?

3. Brief the function of intake structure.

4. Write down the formulae to find out head loss caused by pipe friction.

5. What is the significance of velocity gradient in flash mixer?

6. Differentiate between sterilization and disinfection.

7. List out the unit processes applied to remove Iron and manganese from water.

8. What is reverse osmosis?

9. What is the function of service reservoir?

10. Write down anyone of the empirical formulae to relate pressure to height in distribution system.

PART B — (5 × 16 = 80 marks)

11. (a) The population figures of a town as per census records are given below for the years 1911 to 1971. Find out the population after one, two and three decades beyond the last known decades by using incremental increase method.

Year	1911	1921	1931	1941	1951	1961	1971
Population	40185	44522	60395	75614	98886	124230	158800

Or

(b) Explain laboratory procedure to find out physical, chemical and biological characteristics of water. **Page no. 08**

12. (a) With neat sketch, explain river intake and canal intake towers.

Page no. 33

Or

(b) Explain different types of pipe appurtenances used in water supply project. **Page no. 43**

13. (a) With neat sketch explain working principle of rapid sand filer.

Page no. 60

Or

(b) Explain convent:~~nal~~ method used to disinfect water. **Page no. 66**

14. (a) Calculate amount of lime and soda ash required for softening. The concentration of hardness and alkalinity causing components are given below. The excess lime is 1.0meq/L.

Components	CO_2	Ca^{2+}	Mg^{2+}	HCO_3^-	CO_3^{2-}	OH^-
Concentration (mg/L)	10	70	40	250	2	0.02

Or

(b) Explain ion-exchange process to demineralize water.

15. (a) (i) What are the requirement of good distribution system? (8)

(ii) Discuss the method of distribution of water from source. (8)

Or

(b) Explain Hardy-Cross method and equivalent pipe method to analyze complex pipe network.

Reg. No. :

Question Paper Code : 11192

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2012.

Fifth Semester

Civil Engineering

CE 2304/CE 53/10111 CE 504 — ENVIRONMENTAL ENGINEERING — I

(Regulation 2008)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What is the objective of Water Supply Scheme?

2. Define design period.

3. How do you select pipe material for water supply scheme?

4. What is the loss of head in a CI transmission main of 300 mm in diameter and 2 km length with C-value 100, when it carries a flow of 10 m^3/min?

5. What are the differences between Unit Operations and Unit Process?

6. What are the advantages of chlorine as disinfectant?

7. What is the maximum permissible limit of fluoride in drinking water?

8. How do you protect water treatment plants from corrosion?

9. What is the role of computer applications in Water Supply Systems?

10. How do you identify leakage in pipelines?

PART B — (5 × 16 = 80 marks)

11. (a) The population of a town as per part census records are given below for the years 1951 to 2001. Forecast the population in the years 2026 and 2041 respectively using the following methods.

(i) Arithmetical increase method

(ii) Incremental increase method

(iii) Geometrical increase method. **Page no. 24** (16)

Census Year :	1951	1961	1971	1981	2001
Population :	44,487	62,356	78,538	98,861	1,33,58[illegible]

Or

(b) (i) List out 10 parameters of Water Quality Standards as per the Tamilnadu pollution Control Board Standards. **Page no. 05** (8)

(ii) Write a short notes on various characteristics of water. (8)

12. (a) Explain the different joints used in water supply distribution system. (16)

Or

(b) What is intake structure? Explain with neat sketches, the various type of intake structures based on sources. (16)

13. (a) Design a sedementation tank for water treatment plant to treat 8 MLD of water. Assume a surface loading rate of 30 $m^3/m^2/day$. Check the adequacy of detention time. Draw the plan of the water treatment plant. (16)

Or

(b) With the help of the diagram, explain the process of Rapid sand filter. (16)

14. (a) What is aerators? Explain different type of aerators with sketches.

Or

(b) Write notes on :

(i) Membrane process. (8)

(ii) Desalination process. (8)

15. (a) Discuss with neat sketches the various types of layout of distribution system. **Page no. 131** (16)

Or

(b) Discuss the various possible water distribution arrangements in multistoraged buildings. **Page no. 135** (16)

Reg. No. :

Question Paper Code : 21208

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2013.

Fifth Semester

Civil Engineering

CE 2304/CE 53/10111 CE 504 — ENVIRONMENTAL ENGINEERING — I

(Regulation 2008/2010)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What are the components of a water supply (scheme) system?

2. What are the acceptable quality standards as per BIS10500 : 1983 for Fluoride and Nitrates?

3. What are the two types of 'Intake' according to their position?

4. How will you calculate the total head in the design of pumbs for water supply schemes?

5. Define : Detention time and surface overflow rate for a sedimentation tank.

6. What are tests to be done to find the residual chlorine in water?

7. Mention the type of aerators used in the water treatment.

8. Write any two effects of hardness in water.

9. What are the layouts of water distribution system?

10. What is 'Ferrule' in house service connection?

PART B — (5 × 16 = 80 marks)

11. (a) Explain the different sources of water and their characteristics with respect to turbidity, Hardness, Chloride and microbiology. (16)

Or

(b) (i) Write a note on water demand. (6)

(ii) In two periods each of 20 years a city has grown from 50000 to 110000 and 160000 find the population expected in the next 20 years and also the saturation population. (10)

12. (a) (i) What are the classification of intakes based on source also explain with a sketch any one of the intakes? (10)

(ii) What are the different pipe materials used in the water transmission? **Page no. 37** (6)

Or

(b) (i) List the classification of pipe joints depending their ability to movement and briefly explain the factors that influence the decision on the type of joints. (10)

(ii) Write a note on pumps used in water supplier. (6)

13. (a) (i) Draw the longitudinal section of a rectangular sedimentation tank indicating the various zones. (8)

(ii) The following data are corresponding to a clariflocculator find the volume of the flocculation and its diameter.

Detention time : 30 min, Depth : 3 m, Outer diameter of the inlet shaft = 0.9 m, Water to be treated : 10 ML/d. (8)

Or

(b) (i) With a neat sketch (cross section) explain the working of a rapid sound filter. (12)

(ii) Write a note on 'Break Point Chlorination'. (4)

14. (a) (i) What are the effects of excess concentration of Fluoride in water and list the methods available for defluoridation and explain any one of them. (10)

(ii) Write a note on iron removal from water for small communities. (6)

Or

(b) (i) What are the types of hardness present in water? (4)

(ii) Explain the Ion exchange method of water softening with a sketch. (12)

15. (a) (i) What are the general design guidelines for a water distribution system? (8)

(ii) Briefly explain the house service connection with a sketch. (8)

Or

(b) Find the equivalent pipe AD for the network ABCD shown in Fig Q15(b) by equivalent pipe method. (16)

Page no. 156

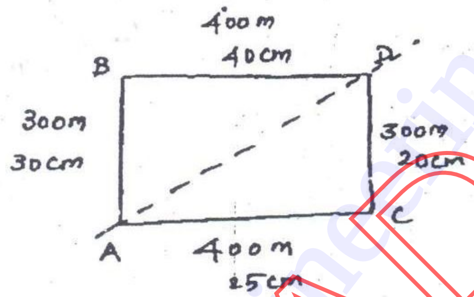


Fig. Q15(b)

8

Reg. No. :

Question Paper Code : 31208

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2013.

Fifth Semester

Civil Engineering

CE 2304/CE 53/10111 CE 504 — ENVIRONMENTAL ENGINEERING — I

(Regulation 2008/2010)

Time : Three hours　　　　Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What is the objective of water supply system?

2. Define design period.

3 Draw any two line diagram of joints in pipelines.

4. What is the difference between system curve and pump curve?

5. How to manage residue in water treatment plant?

6. List out the advantages of rapid sand filter.

7. Write down the principle of desalination process.

8. How do you regenerate softener?

9. How to detect leakages in pipelines?

10. What are the requirement of water distribution system?

PART B — (5 × 16 = 80 marks)

11. (a) The population of a town as per census records are given below. Forecast the population in the year 2020 and 2035 using arithmetical increase method and incremental increase method. Estimate the water demand at 135 lpcd for the year 2035. (16)

Year :	1961	1971	1981	1991	2001
Population :	39250	54390	68010	83630	99850

Or

(b) (i) Write the drinking water quality standards as per BIS. (10)

(ii) Explain the chemical characteristics of water. (6)

12. (a) With the help of schematic diagram, explain different type of water intake structures. (16)

Or

(b) How to select pumps and pipe materials for water supply systems? Explain in detail. (16)

13. (a) Design a rectangular sedimentation tank for 5 MLD flow. (16)

Or

(b) What is disinfection? What are the factors affecting disinfection? Explain the chlorination process. (16)

14. (a) Write short notes on :

(i) Membrane process (8)

(ii) Defluoridation. **Page no. 102** (8)

Or

(b) What are the functions of aerators? Explain the different types of aerators. **Page no. 109** (16)

15. (a) How to distribute water for multistoreyed building? Explain in detail. (16)

Page no. 135

Or

(b) (i) What is the role of computer applications in water distribution systems? (8)

(ii) How to maintain the drinking water pipeline system? (8)

Reg. No. :

Question Paper Code : 51238

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2014.

Fifth Semester

Civil Engineering

CE 2304/CE 53/10111 CE 504 — ENVIRONMENTAL ENGINEERING – I

(Regulation 2008/2010)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. How do you determine the storage needed for an impounding reservoir?
2. State the drinking quality standards for any four physico-chemical parameters.
3. What is an intake?
4. What are the properties of ductile iron pipe?
5. What is the significance of velocity gradient in flash mixer?
6. What is break point chlorination?
7. How will you do regeneration of softener?
8. Enumerate the methods of defluoridation.
9. What is the function of service reservoir in distribution system?
10. Name any two appurtenances used in water distribution system.

PART B — (5 × 16 = 80 marks)

11. (a) Enumerate and explain the characteristics of surface and ground water and state their environmental significance. **Page no. 15**

Or

(b) The population of a town as per past census records are furnished below. Forecast the population in the year 2031 and 2041 Using the following methods:

(i) Arithmetical increase method (5)

(ii) Geometrical increase method (5)

(iii) Incremental increase method. **Page no. 24** (6)

Census year	1941	1951	1961	1971	1981	1991	2001	2011
Population	44642	50487	56816	63859	71458	78543	88131	100290

12. (a) (i) What are the important considerations which govern the selection of site of an intake structure? (8)

(ii) Explain the salient features of river intake with the aid of a neat sketch. (8)

Or

(b) (i) Describe the various pipe materials used in conveyance of water. (10)

(ii) What factors are required to be considered in the selection of the type of a pump? (6)

13. (a) (i) Calculate the average chlorine required per day to treat 150 ML/d of water. Also calculate the storage required for 60 days. Assume an average chlorine dosage of 5mg/L. (4)

(ii) Explain the various unit operations and unit processes involved in water treatment. (12)

Or

(b) A new township is to have a population of 5,00,000 and 90 Lpcd of water supply. Design a rapid sand filter unit with details of under drainage and water washing including gutter arrangement. Limit the maximum spent backwash water as 3.5 %.

14. (a) Determine the volumes of cation and anion exchanger beds to demineralize 0.35ML/d water that has the following chemical quality :

Cations	Anions
Ca^{2+} = 30 mg/L	HCO_3^- = 50 mg/L
Mg^{2+} = 5 mg/L	SO_4^{2-} = 45 mg/L
Na^+ = 25 mg/L	Cl^- = 45 mg/L
K^+ = 10 mg/L	NO_3^- = 10 mg/L

The ion exchange capacities of cation and anion exchange resins are 70,000 and 40,000 g $CaCO_3/m^3$ /cycle, respectively. Also, calculate the required quantities of regeneration chemicals. The regeneration cycle is once per day.

Or

(b) Describe various methods of removing excess iron and manganese from ground water.

15. (a) Describe the various layouts of distribution network in a water supply system and state their advantages and disadvantages. **Page no. 131**

Or

(b) Draw a sketch of a water supply service connection from the Street main to a residential building and state the functions of each fitting.

Reg. No. :

Question Paper Code : 91239

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2014.

Fifth Semester

Civil Engineering

CE 2304/CE 53/10111 CE 504 — ENVIRONMENTAL ENGINEERING — I

(Regulation 2008/2010)

(Common to 10111 CE 504 – Environmental Engineering — I for B.E. (Part-Time) Fourth Semester Civil Engineering – Regulation 2010)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. State the objectives of public water supply scheme.
2. Distinguish between carbonate and non-carbonate hardness.
3. Enlist the external forces acting on water transmission main if the pipe is laid under heavy traffic.
4. What is meant by economic diameter of a pumping main?
5. What is the significance of velocity gradient in flocculator design?
6. What do you mean by break point chlorination?
7. List out any two methods of defluoridation of water.
8. Distinguish between physical adsorption and chemical adsorption.
9. Why are the requirements of water distribution system?
10. Enumerate the methods of leak detection in water distribution system.

PART B — ($5 \times 16 = 80$ marks)

11. (a) The population of a town panchayat as per past census records are furnished below. Forecast the population in the year 2031 and 2041 using the following methods :

    (i) Arithmetical increase method. (5)

    (ii) Geometrical increase method. (6)

    (iii) Incremental increase method. (5)

Census year	1941	1951	1961	1971	1981	1991	2001	2011
Population :	35642	39487	46816	57859	70458	83543	92131	116500

Or

(b) (i) Discuss the factors to be considered in fixing the design periods for water supply components. (8)

(ii) Explain the various sources of surface and groundwater. (8)

12. (a) In a water supply scheme to be designed for serving a population of 12 lakhs, the storage reservoir is situated at 9 km away from the city and the loss of head from the source to city is 19.5 m. Calculate the size of the supply main by using Darcy-Weisbach formula as well as by using Hazen's formula assuming a maximum daily demand of 150 Lpcd and 2/3 of the daily supply to be pumped in 10 hours. Assume friction factor (4f) for the pipe material as 0.005 in Weishbach formula and $C_H = 110$ in Hazen's formula.

Or

(b) (i) What are the important considerations, which govern the selection of site of an intake? (8)

(ii) Discuss the factors to be considered in the selection of pipe material for water transmission. (8)

13. (a) Design a clariflocculator for a proposed water treatment plant with a capacity of 80 ML/d and draw a neat sketch of the unit.

Or

(b) A new township is to have a population of 6,00,000 and 90 Lpcd of water supply. Design a rapid sand filter unit with details of under drainage and water washing including gutter arrangement. Limit the maximum spent backwash water as 3.5 %.

12

14. (a) Design a zeolite softener for an industrial establishment working for 2 shifts of 8 hours each for the following data and draw a neat sketch of the unit.

Soft water requirement	=	2.5 ML/d in 16 hours
Raw water hardness	=	800 mg/L as $CaCO_3$
Product water hardness	=	50 mg/L as $CaCO_3$
Exchange capacity of the resin	=	35 kg $(CaCO_3)/m^3$
Salt required for regeneration	=	50 kg $(NaCl)/m^3$ of resin

Page no. 114

Or

(b) Draw a schematic diagram of a DM plant and explain the mechanism of cations as well as anions removal- Also briefly outline the design procedure. **Page no. 97**

15. (a) Describe the various layouts of distribution network in a water supply system and state their advantages and disadvantages.

Or

(b) Draw a sketch of a water supply service connection from the street main to a residential building and state the functions of each fitting.

Reg. No. :

Question Paper Code : 71256

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2015.

Fifth Semester

Civil Engineering

CE 2304/CE 53/10111 CE 504 — ENVIRONMENTAL ENGINEERING – I

(Regulation 2008/2010)

(Common to 10111 CE 504 – Environmental Engineering – I for B.E. (Part-Time) Fourth Semester Civil Engineering – Regulation 2010)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What are the objectives of public water supply scheme?
2. Distinguish between shallow well and deep well.
3. What is the role of intake structure in water supply scheme?
4. List out any two appurtenances in water conveyance system.
5. Enumerate the mechanism of disinfection process.
6. What are the factors influencing settling of discrete particle?
7. What is meant by adsorption isotherm?
8. List the different methods of defluoridation.
9. What are the requirements of a good water distribution system?
10. List the major components of house service connection.

PART B — (5 × 16 = 80 marks)

11. (a) Explain the different methods used for prediction of future population of a city, with reference to the design of a water supply system.

Or

(b) Discuss the various sources of water and give a brief account of the characteristics of water.

12. (a) Mention the points which should be taken into consideration in deciding the location of an intake for the water supply of a large town, the source being a perennial river. Draw a neat sketch of a canal intake and explain the salient features.

Or

(b) (i) What are the factors to be considered in the selection of pipe material for water transmission? **Page no. 35** (8)

(ii) Describe the various joints used in the pipeline construction. (8)

13. (a) (i) Design a flash mixer for a proposed water treatment plant with a capacity of 25 ML/d and draw a neat sketch of the unit. (8)

(ii) Estimate the alum and quick lime requirements with reactions involved to treat 2 ML/d of water with raw water alkalinity of 9 mg/L as $CaCO_3$ if the alum dosage adopted was 40 mg/L. (purity of quicklime – 80%). **Page no. 80** (8)

Or

(b) Briefly explain the mechanism of sand filtration. Draw a neat sketch of rapid sand filter unit and explain the working principle.

14. (a) Determine the volumes of cation and anion exchanger beds to demineralize 0.35 ML/d water that has the following chemical quality.

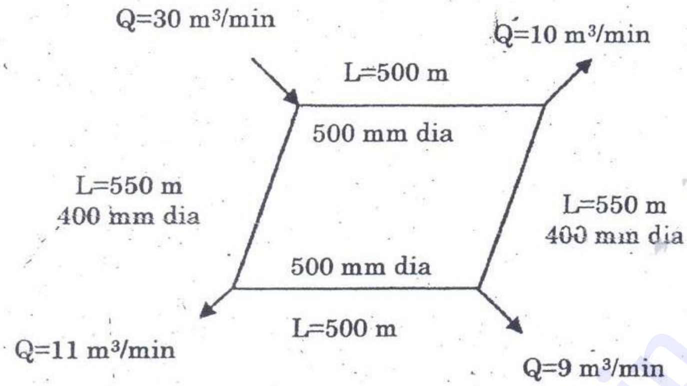
Cations	Anions
Ca^{2+} = 30 mg/L	HCO_3^- = 50 mg/L
Mg^{2+} = 5 mg/L	SO_4^{2-} = 45 mg/L
Na^+ = 25 mg/L	Cl^- = 45 mg/L
K^+ = 10 mg/L	NO_3^- = 10 mg/L

The ion exchange capacities of cation and anion exchange resins are 70,000 and 40,000 g $CaCO_3/m^3$ cycle, respectively. Also, calculate the required quantities of regeneration chemicals. The regeneration cycle is once per day. **Page no. 114**

Or

(b) Describe various methods of removing excess iron and manganese from groundwater. **Page no. 91**

15. (a) Find the flow in each pipe in the Loop shown in Fig.1 Use Hardy Cross method for analyzing the Loop. Consider C_H as 110 for all pipes.



Page no. 152

Fig.1

Or

(b) What are the functions of service reservoir? Briefly outline the design aspects of service reservoir. **Page no. 140**

15

Reg. No. :

Question Paper Code : 27124

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2015.

Fifth Semester

Civil Engineering

CE 6503 — ENVIRONMENTAL ENGINEERING — I

(Regulations 2013)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. List out the components of a public water supply system.
2. What do you mean by design period?
3. What are the advantages of DI pipe over CI pipe?
4. Distinguish between unit operation and unit process.
5. What is the significance of velocity gradient in flash mixer design?
6. Enumerate the mechanisms of disinfection process.
7. What do you mean by adsorption capacity?
8. Distinguish between ultrafiltration and nanofiltration.
9. List out the methods to reduce wastage of water in a distribution system.
10. List the requirements of good distribution system.

PART B — (5 × 16 = 80 marks)

11. (a) The population of a town as per census record is furnished below. Forecast the population in the year 2031 and 2041 using the following methods :

(i) Arithmetical increase method

(ii) Geometrical increase method

(iii) Incremental increase method.

Census year :	1931	1941	1951	1961	1971	1981	1991	2001	2011
Population :	22300	35642	49487	55816	65859	79458	95543	110131	129500

Estimate the water demand at 90 Lpcd for the year 2031 and 2041 by incremental increase method.

Or

(b) Enumerate and explain the characteristics of surface and ground water and state their environmental significance.

12. (a) (i) What are the important considerations, which govern the selection of site of an intake? (8)

(ii) Discuss the factors to be considered in the selection of pipe material for water transmission. (8)

Or

(b) A centrifugal pump with the following characteristics is installed in a system to raise water from one reservoir to another. The water surface elevation in the first reservoir is 150m and that in the second reservoir is 200m. The pipeline connecting the reservoir is 3 km of 300mm diameter. Determine the operating point in the system. Take $C_H = 110$. Also compute WHP and BHP of the pump assuming pump efficiency of 70%.

Pump discharge. Lpm :	0	650	1400	2150	3000	3650
Total dynamic head, *m* :	63.0	60.5	56.0	49.5	36.5	21.0

13. (a) (i) Estimate the alum and quick lime requirements with reactions involved to treat 100 MLD of water with raw water alkalinity of 9 mg/L as $CaCO_3$ if the alum dosage adopted was 40 mg/L. (12) **Page no. 80**

(ii) Briefly explain the role of sedimentation tank in water treatment. (4)

Or

(b) A new township is to have a population of 5,00,000 and 90 Lpcd of water supply. Design a rapid sand filter unit with details of under drainage and water washing including gutter arrangement. Limit the maximum spent backwash water as 3.5%. **Page no. 82**

16

14. (a) (i) Why and what pretreatment is required in the feed water to RO plant? (6)

(ii) Design a zeolite softener for an industrial establishment working for 2 shifts of 8 hours each for the following data and draw a neat sketch of the unit. (10)

Soft water requirement = 2×10^6 L/d in 16 hours

Raw water hardness = 400 mg/L as $CaCO_3$

Product water hardness = 50mg/L as $CaCO_3$

Exchange capacity of the resin = 30 kg ($CaCO_3$)/m^3

Salt required for regeneration = 50 kg (NaCl)/m^3 of resin.

Or

(b) Enumerate and explain the various methods of removal of iron and manganese from groundwater. **Page no. 91**

15. (a) Find the flow in each pipe in the Loop shown in Fig. 15 (a). Use Hardy Cross method for analyzing the Loop. Consider C_H as 110 for all pipes.

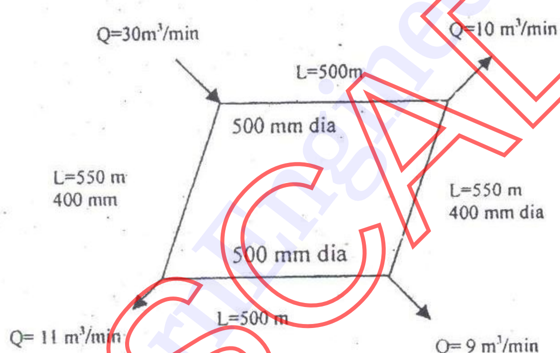


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Fig. 15 (a)

Or

(b) What are the functions of service reservoir? Briefly outline the design aspects of service reservoir. **Page no. 140**