



Module 1

BASICS OF WATER SUPPLY SYSTEM

Training Module for Local Water and Sanitation Management

Maharashtra Jeevan Pradhikaran (MJP)

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ABBREVIATIONS

CPHEEO	Central Public Health and Environmental Engineering Organisation
cu. m.	Cubic Meter
DN	Diameter Nominal
ESR	Elevated Surface Reservoir
FTS	Field Test Kit
GI	Galvanised Iron
GSR	Ground Service Reservoir
HDPE	High Density Poly Ethylene
HH	Household
ISI	Indian Standards Institute
MLD	Million Litres per Day
PHED	Public Health Engineering Department
PVC	Poly Vinyl Chloride
Mg/l	Milligram per litre
m	meter
MS	Mild Steel
MT	Metric Ton
NTU	Nephelometric Turbidity Unit
RCC	Reinforced Cement Concrete
r.mt.	Running Meter
TMT	Thermo Mechanically Treated

Conversion of basic units (with prefix)

1 meter (m)	100 centimeter (cm)
1 meter (m)	1000 millimeter (mm)
1 foot (ft')	12 inches (")
1 inch (")	25.4 millimeter (mm)
1 meter (m)	3.28 feet (ft')
1 cubic meter (cu.m)	35.31467 cubic foot (cu.ft.)
1 cubic meter (cu.m)	1000 litres
1 square meter (sq.m/ m ²)	10.76391 square foot (sq.ft.)
1 metric ton	1000 kilogram (Kg.)
1 kilogram (kg)	1000 grams (g)
1 gram (g)	1000 milligram (mg)

INTRODUCTION

Water Supply in India is now previewed as community based demand driven system, under which it is essential to enhance capacity of local community residing in villages and small towns to develop and manage their own water supply systems.

Role of community groups is to ensure effective and participatory implementation of water supply system in their village/town, water quality control, financial management and effective operation and maintenance of water supply system established.

Hence, it is evitable that such community groups are aware about the basics of water supply system, operation and maintenance of water assets and water supply system as well as basics of sanitation and waste management.

This training course series has been formulated in order to enhance capacity of community groups for enhanced operation and maintenance of water supply and sanitation systems in their village/town.

Module on Basics of Water Supply System provides insights on basics component of water supply system, installation and distribution of water supply systems, estimation and measurement of components of water supply system and drinking water quality control.

MODULE A: COMPONENTS OF WATER SUPPLY SYSTEM

Training Objectives

- a) To know basic components of village/town water supply
- b) To know various sources of water
- c) To understand water supply mechanism, storage facilities, distribution system.

Training tools: Slideshow and Quiz, powerpoint/on board presentation, question answer

Approximate time:

Presentation: 30 minutes

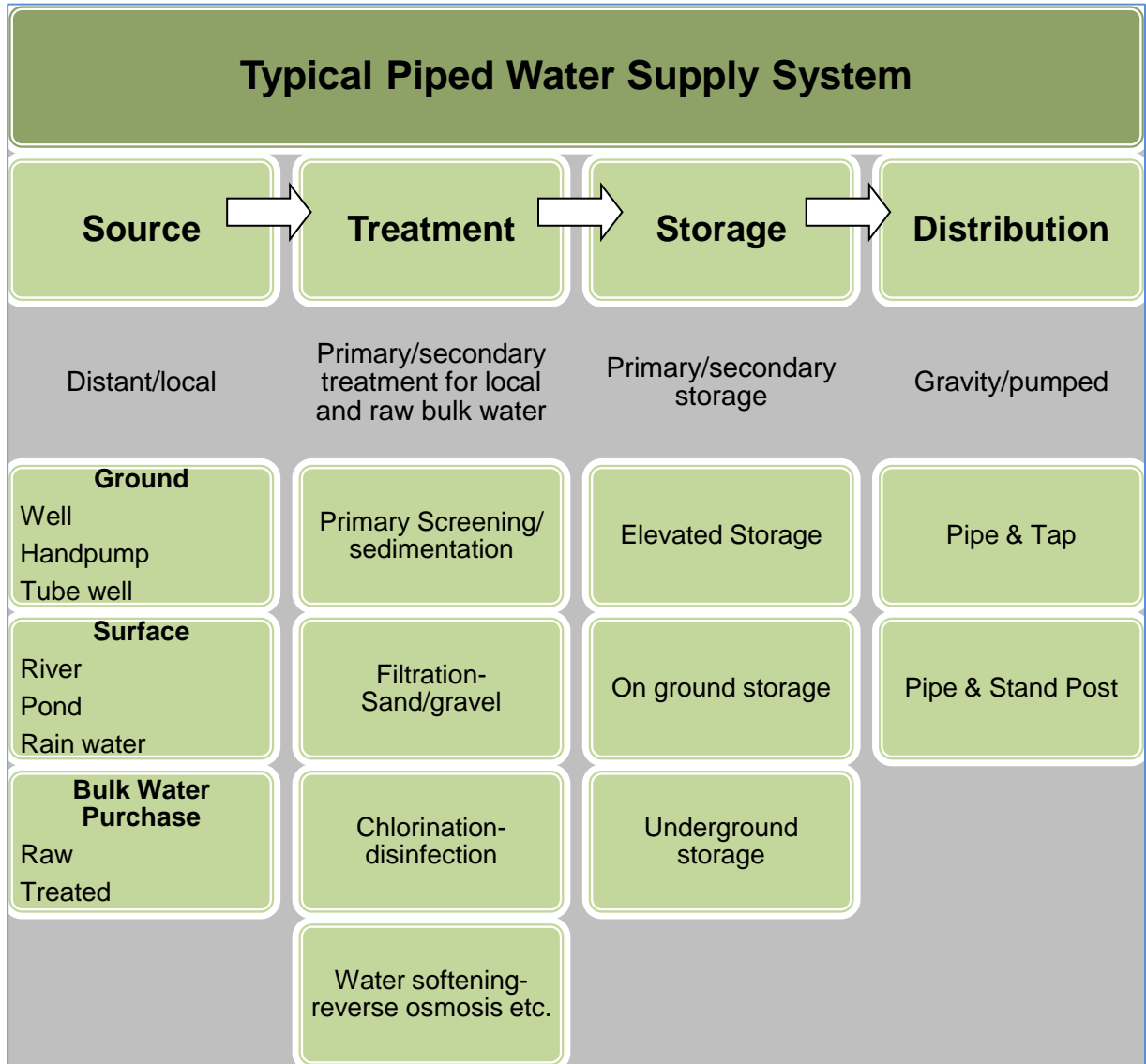
Slideshow and Quiz 15 minutes

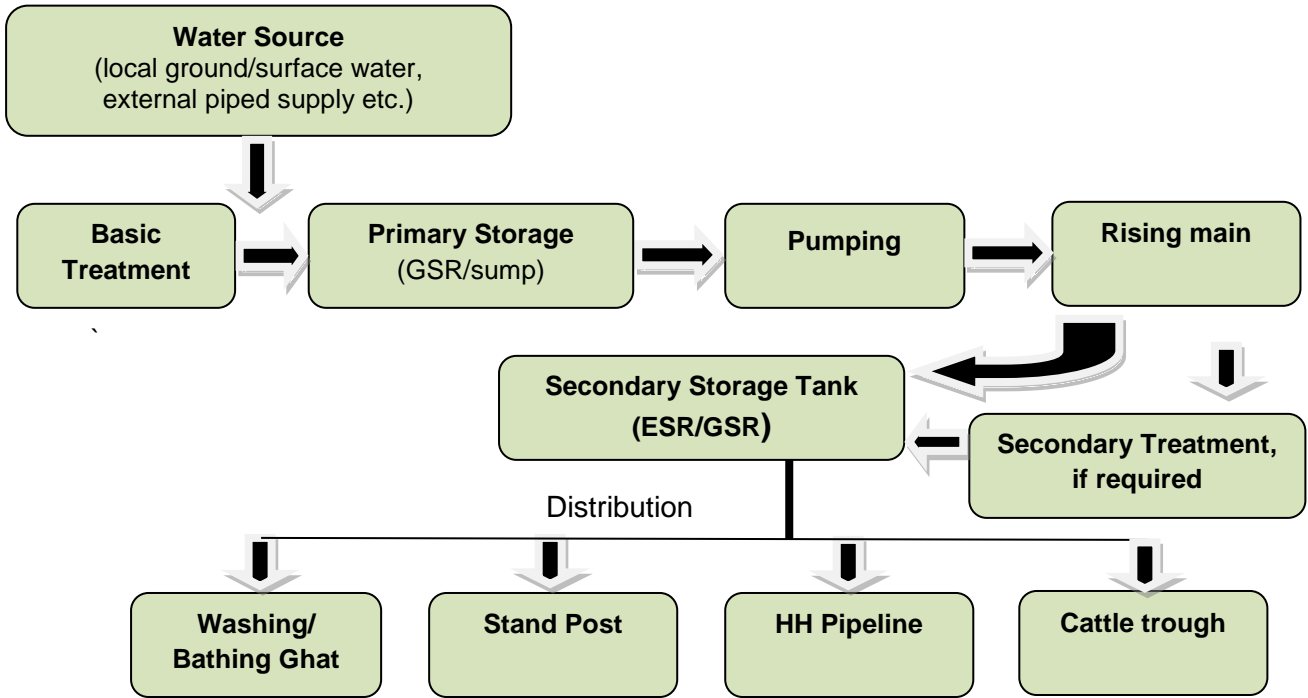
Question and answer: 15 minutes

TOTAL 1 hour

A1 Typical Water Supply System

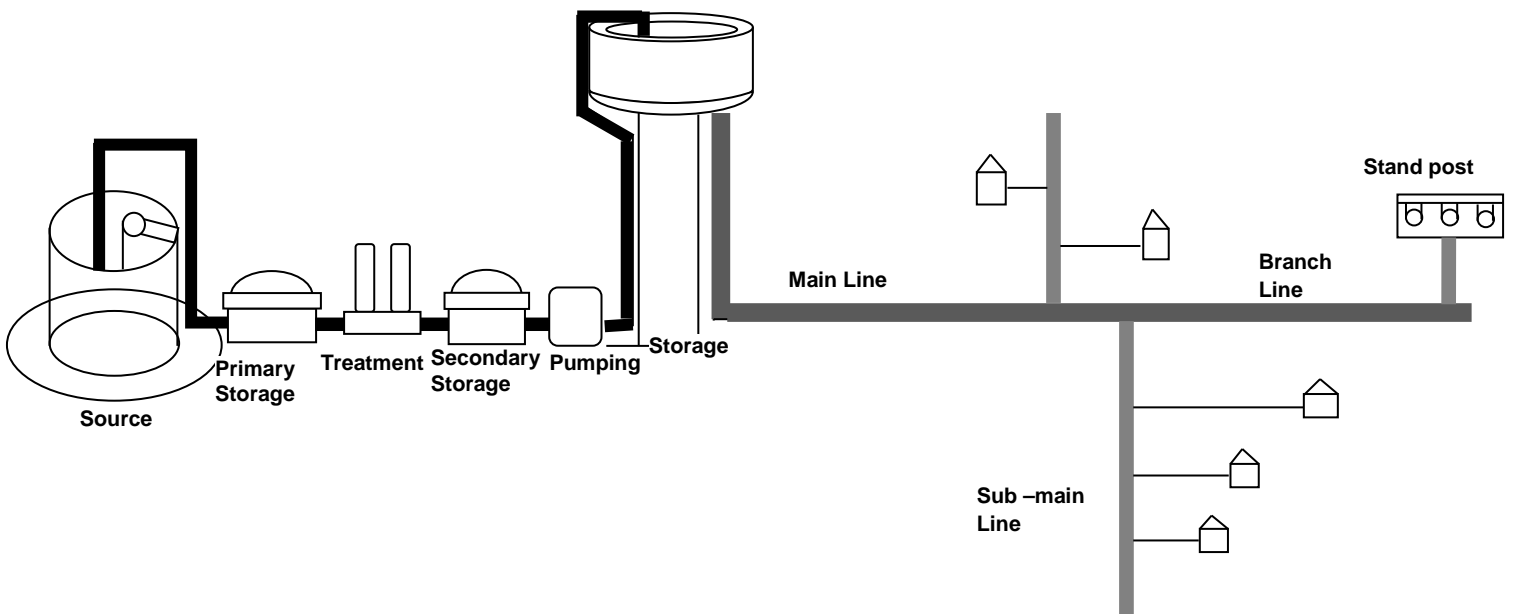
Typical Village/town water supply system constitutes of a gravity/pumping based transmission and distribution system from local/distant water source with needed water treatment system.





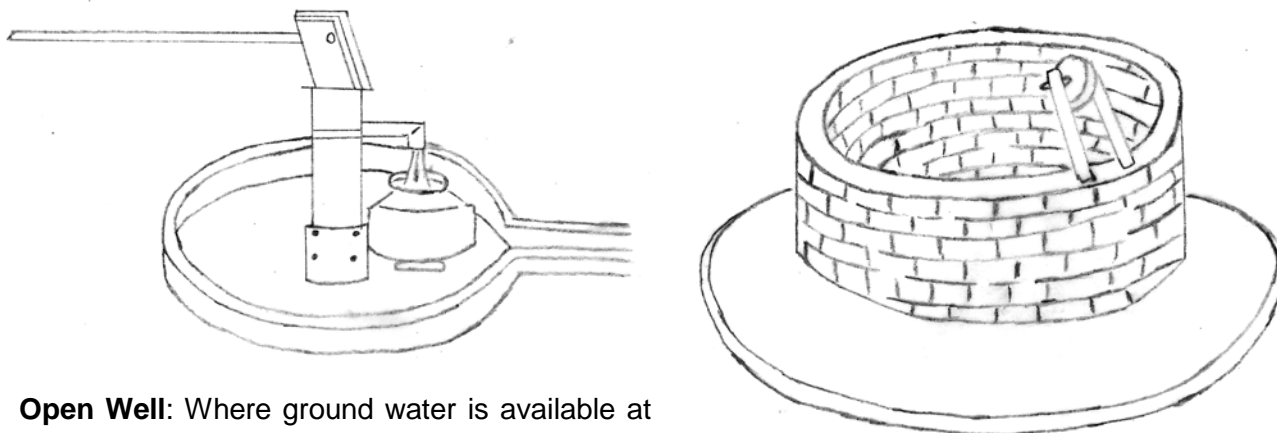
Standard Water supply System in village/town

Sources	Open Well, Tube Well, Hand pump, Pond, Dam Site, External Pipe Supply, Rain Water Harvesting System/Tank
Village/town level Treatment	Reverse Osmosis System (RO), Chlorination, Sedimentation, Sand Filter, etc.
Storage	Elevated Surface Reservoirs (ESR), Ground Service Reservoirs (GSR), Sump
Distribution	Main Line, Sub-Main Line, Branch Pipe Line, Household Level Tape, Stand Post, Washing Unit.



A2 Sources of Water

Ground water: Open well, tube well/bore well, hand pump are sources which make water available from ground.



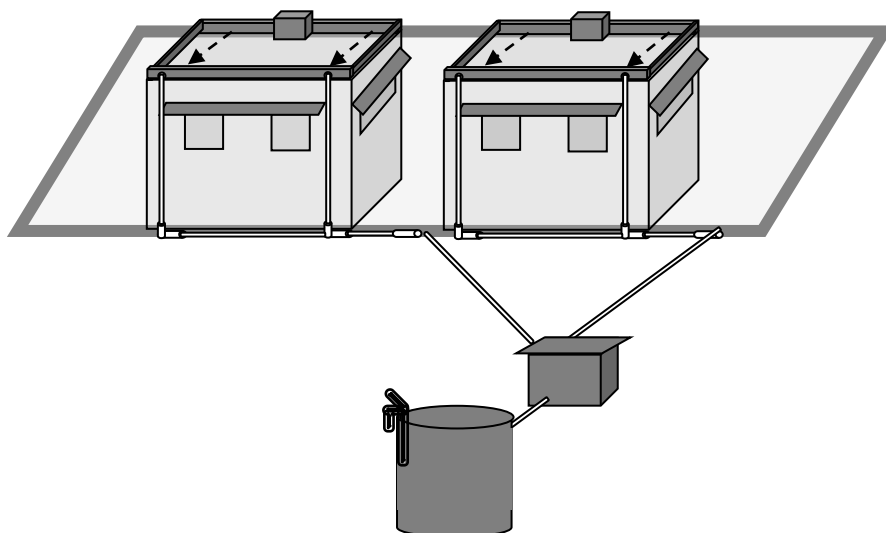
Open Well: Where ground water is available at low depth (less than 15 meters - and water is available all year round, open well is used.

Hand Pump: Where safe ground water is available upto 60 m depth, hand pump is ideal choice for a cluster or habitation.

Bore Well/Tube Well: Where ground water is at greater depth and open wells or hand pumps are not viable, bore well or tube well is installed.

Surface Water: River, pond, dam site are sources where surface water is available.

Moreover, rain water can be harvested and stored directly in storage tanks. This water is potable after first rain and can be used for drinking purpose also.



Rain Water Storage System

Classification of Water based on its Availability

A. Local Source: Sources which are available at village/town level like river, pond, open wells and bore wells.

B. Distant Source: When perennial reliable and safe source is not available, pipeline from distant sources can be laid. This bulk water is available from river, pond, dam, bore wells or storage tank itself, where water is available.

A3. Water Treatment

Water from source is treated at village level and even at household level, if needed. If bulk water available from the distant source is treated and potable, then further treatment may not be required at village level. There are various processes of treatment based on the source and quality of water in specific region.

- Village/town level water treatment systems are located mainly near head works. The treatment units are located in such a manner, where possible that flow of water from one unit to other can be done by gravity, so that additional pumping of water is not required. Sufficient area should be reserved near the treatment units for further expansion in future. Basic treatment system at village/town level involves removal of suspended solids through sedimentation, removal of micro-organisms and colloidal matter through sand/gravel filters, water softening through reverse osmosis (RO) system, disinfection through chlorination and any other chemical/specialised treatment for removal of fluoride, salinity etc.
- Treatment at household level is needed as there may be chances of water contamination while transmission of water. This mainly includes basic filtration for removal of any silt, etc.; boiling for removal of micro organisms or chlorination for disinfection.

It is very important to carry out water test in order to decide upon the type of treatment. It is also essential to carry regular water testing from various points starting from source to distribution points to maintain potable water quality. Details of water testing and treatment are discussed in detail in Module E.

A4 Water Supply Mechanism

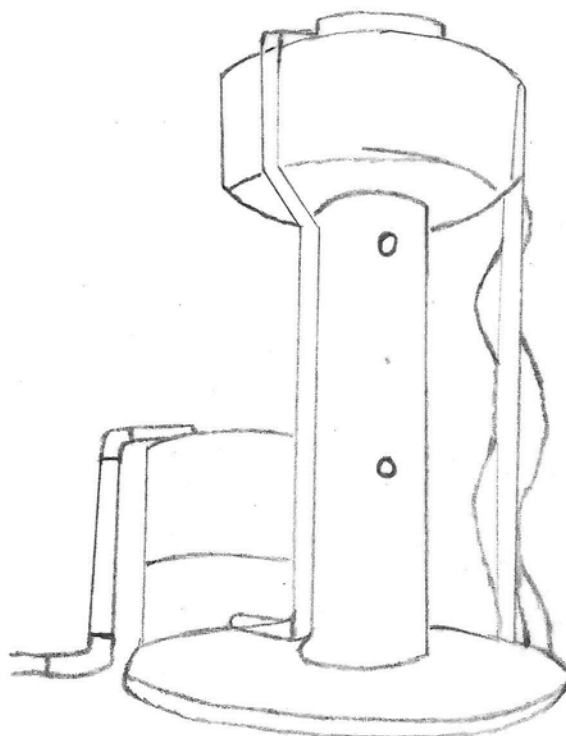
Pump House and Pumping Machinery: Pump is used to fetch water from source like bore well, open well, sump or ground water storage and supply it to pipelines or elevated storage. There are three main components: a) pump, b) electrical or oil engine, c) panel board. Pump house is constructed for security and safety of machineries.

Rising Main: The delivery line carrying water from pump to storage tank (elevated or ground) is called rising main.

A5 Storage Facilities

Elevated Surface Reservoir (ESR) or elevated storage tank: ESR is constructed, where water is to be supplied at elevated height (less than the level of ESR) or where the distance is large and topography is undulating. Generally, ESR is at height more than 15 m. Water can be distributed directly from this storage tank by gravity or pump.

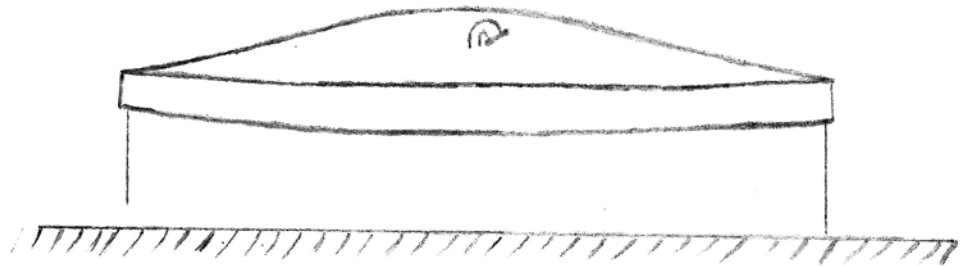
Ground Service Reservoir (GSR): GSR is ground level or plinth level storage tank. The plinth level is generally not more than 3 m.



GSR & ESR

Storage capacity of the service reservoirs is estimated based on pumping hours, demand and hours of supply, electricity available for pumping. Systems with higher pumping hours require less storage capacity. Normally, such reservoirs are calculated to store half to one day daily water requirement.

Sump: Sump is used as additional storage at village/town level or cluster level. It is not used for direct distribution of water. Rather, it is used as intermediate or



Sump

contingency storage, to store water before it is pumped to ESR/GSR. The underground

storage tank in circular shape with dome line covering is called sump. Generally, the capacity of sump is more (one and half to two times) than ESR or GSR or two to five days water requirement, so that if the supply is disturbed for that time, the water is available for the people.

A6 Water Distribution

For efficient distribution, it is required that water should reach end use with required flow rate with needed pressure in the piping system. There are three main types of distribution system that can be adopted in villages/towns:

a. Gravity Fed Distribution

When the ground level of water source/storage is sufficiently raised than the core village/town area, such system can be utilised for distribution. The water in the distribution pipeline flow due to gravity and no pumping is required. Such system is highly reliable and economical.

b. Pumping System

In such system, water is supplied by continuous pumping. Treated water is directly pumped into the distribution main with constant pressure without intermediate storing. Supply can be affected during power failure and breakdown of pumps. Hence, diesel pumps also in addition to electrical pumps as stand by to be maintained. Such system works only in condition where there is continuous power supply, reliable water source and where intermediate storage system cannot be installed.

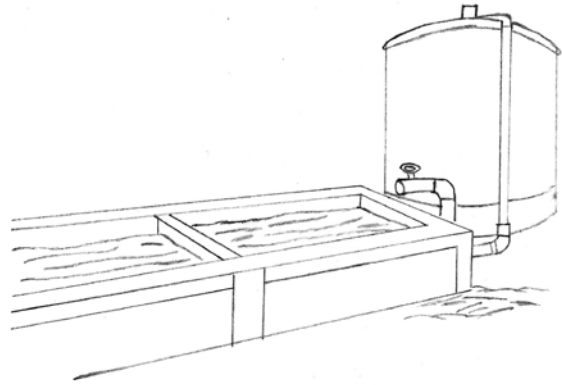
c. Dual/Combination

In such system, both gravity as well pumping systems are used. Such systems are used where there are variations in topography in town/village.

Minimum Residual Pressure in a distribution system should be 7 m for single storied, 12 m for two storied and 17 m for three storied building (Source: CPHEEO)

Distribution Lines: The lines carrying water from storage to its end use (stand post/ household tap etc.) are called distribution lines. Distribution pipelines consist of main pipeline connected from secondary storage; sub-main pipes connected from main pipeline and service/branch pipes connected from sub-main for distribution to households. Generally, Mild Steel (MS), Galvanised Iron (GI), High Density Polyethylene (HDPE)/ Poly Vinyl Chloride (PVC) pipes, Ductile Iron (DI) pipe with 15-200 mm diameter are used in distribution. These lines are generally underground (1-3 feet below ground). Valves are used to control the distribution.

Stand Post: Stand post with one or more taps are installed at cluster level or near the storage tank, in the villages/towns where household tap connection is not available or possible. Stand posts are constructed of masonry or concrete structures. Stand posts should have normal output of 12 litres/minute. One stand post is estimated for every 250 persons. In case of independent habitation, even if population is less than 250 and there is no potable water source, once stand post is provided. Moreover, stand posts should not be more than 500 m from any such targeted household.



Cattle Trough

Cattle Trough: These are masonry/RCC structures to provide water to cattle.

Bathing or Washing Cubicles: These masonry structures are generally constructed to facilitate washing clothes and bathing.

A7 Type of Water Supply

a. Continuous

In this system, there is continuous water supply (for 24 hours). This is possible where adequate quantity of water is available. The major advantage of such system is that due to continuous water supply, water remains fresh and rusting of pipes will be low. However, losses of water will be more in case of any leakage.

b. Intermittent

In such system, supply of water is either done in whole village/town for fixed hours or supply of water is divided into zones and each zone is supplied with water for fixed hours in a day or as per specified day. Such system is followed when there is low water availability, however, in certain cases, wastage of water is more due to tendency of community for storing higher amount of water than required. In such system, pipelines are likely to rust faster due to wetting and drying. However, maintenance can be easily done during no-supply hours.

Activity Sheet

Section A Components of Village/Town Water Supply System

1. List various components of water supply system
2. Mention various sources of water in village/town used for drinking/domestic purpose
3. Mention various storage facilities and its basic use for water supply system
4. Mention types of distribution system in water supply system

MODULE B: BASICS ON PLANNING AND ESTIMATING COMPONENTS OF WATER SUPPLY

Training Objectives

- a) To know principles of planning of water supply
- b) To estimate water demand and availability of water
- c) To estimate components of water supply

Training tools: Powerpoint/on board presentation, worksheets

Approximate time:

Power point presentation:

30 minutes

Activity Sheet: 1 hour

TOTAL 1 hour 30 minutes

B1 Basic Planning Principles of Water Supply System

- Rural water supply system should be designed to provide :
 - Atleast 70 liter per capita per day (lpcd) for piped water supply with household tap connections,
 - Atleast 55 lpcd for mix system with household (HH) tap supply + public taps/standpost + handpump
 - Atleast 40 lpcd where no other source except hand pump, open wells, protected ponds etc are available. Such areas can be augmented with alternative sources. (Source: Strategic Plan 2011-22, "Ensuring Drinking Water Security in Rural India", Department of Drinking Water and Sanitation, Ministry of Rural Development, Government of India)
- Stand posts/hand pumps should be provided where household water supply is not possible. They should have normal output of 12 litres/minute. Generally, one stand post/hand pump is estimated for every 250 persons. In case of independent habitation, even if population is less than 250 and there is no potable water source, once stand post/hand pump is provided. Moreover, stand posts/hand pump should not be more than 500 m from targetted household. (Source: Accelerated Rural Water Supply Programme (ARWSP), Ministry of Rural Development, Government of India)
- For towns, water supply is designed to provide atleast 40 litres/person/day where water is made available through standposts, 70 litres/person/day where piped supply is provided but sewerage system is not available. For urban areas with piped supply and sewerage system, water supply is designed for 135 litres/person/day (Source: Manual on Water Supply & Treatment, CPHEEO, 1999)
- The water supply system should be designed for at least 20-30 years.
- Population forecast needs to be done while designing of system. There are various methodologies for population forecast. However, population for 15 years can be considered 1.1 times current population and for 20 years can be considered 1.2 times current population for design.
- Public storage tanks are designed to store at least 50 percent of total daily requirement (or for atleast 12 hours supply) or requirement of peak period (Water Demand in peak period = average water demand * peak factor). Peak factor is about 3 for population upto 50,000 persons, 2.25 for population ranging from 50,000- 2,00,000 and 2 for population over 2,00,000. Such tanks can be installed at cluster/falia level or one single tank can be installed for a village/town.
- Thumb rule for distribution pipelines for rural areas.

Population	Length of total distribution pipeline
Upto 300	750 m
301- 750	1,500 m
751-1500	2,250 m
1501-3000	3000 m
>3000	3,750 m

- Design service life of various components (Source: CPHEEO):

Storage by dams	50 years
Infiltration works	30 years
Civil Works (pump house, water treatment civil work building etc)	30 years
Service reservoirs (overhead or underground)	15 years
Electric Pump and Motor	15 years
Pipeline	30 years

B2 Calculate Domestic Need of Water per Day in Your Village/Town

Government has laid standard of 40 -135 lpcd for villages and towns. The total per day consumption can be worked out by multiplying this demand to number of people residing in the village/town.

Table 1 (Yearly Water Demand of Village/town)			
Total population of village/town	Water requirement per person per day	Total water requirement per day at village/town level	Total water requirement in a year
(a)	(b)	$C = (a \times b)$	$C \times 365$
	40/70/135 lpcd		

B3 Assess Domestic/Drinking Water Availability:

Water availability for water supply system can be calculated based on water availability and usage from surface, ground source as well as rain water harvesting system.

Sources which can be utilised for domestic/drinking purpose should only be computed. Those source used for irrigation should not be computed. Moreover, sources with high contamination of water should not be considered unless the water is treated considerably. Consider only public water sources here.

Compute yearly water availability in Table 2 for each source type. Detailed method of computing water availability for source type is explained in Tables 2.1 to 2.5. (Details for Grey coloured boxes in each table can be put in Table 2).

Table 2 (Yearly Water Availability in Village)					
	No. of source	Total water availability in year	Season availability		
			(put tick if available)		
			summer	winter	monsoon
Surface water					
Pond/lake					
Ground water					
Hand pump					
Open well					
Bore/tube well					
Other					
External piped supply					
Any other					
	TOTAL				

Estimating water availability from ponds/lakes

	Name of source	Size/capacity		No. of filling per year*	Total capacity of storage (litres)
		(cu. m)	Litre (cu. m. *1000)		
			(a)	(b)	a*b
1					
2					
3					
TOTAL					

*partial (0.25-0.75), full (1), over flow (more than>1)

Estimating water availability from community hand pumps

No. of source	Average working hours per day*	Average discharge rate per hour**	Per day water availability	No. of functional days in year	Total water availability in year (litres)
(a)	(b)	(c)	d=(a*b*c)	e	d*e
TOTAL					

*Can be presumed to about 6 hours

**Can be assumed as 12 litres/minutes or 720 litres/hour if data not available

Estimating water availability from community bore/tube well

Water availability from bore well can be determined from discharge rate of pump placed for drafting water.

Bore well	Discharge rate of water (litres/hour)*	Average hours of pumping in a day**	Total water availability (litres/day)	Average no. of days of water availability in a year	Water availability in a year (litres/year)
	a	b	c=a*b	d	c*d
1					
2					
3					
Total					

*Discharge rate can be estimated from average volume of tank filling in an hour.

**Normally, pumping is done from 8-12 hours/day.

Estimating water availability from community open well

Water availability from open well can be calculated based on size of well (cu. m.) multiplied by number of times the well is filled in year. However, number of times well is filled needs to be calculated based on geo-hydrology of region with support of expert. Hence, easier way is to calculate based on average extraction of water per day by local community multiplied with number of day of water availability in well.

If the well is being pumped through motor, then calculation should be based on water discharge rate of pump and number of hours of operation of pump per day (as listed in section of bore/tubewells).

Open well	Average no. of people extracting water from well daily	Average water that a person extracts in a day (litres)	Total water extracted in day (litres)	Average no. of day of water availability in a year	Water availability in a year (litres/year)
	a	b	c=a*b	d	c*d
1					
2					
3					
				Total	

Estimating water availability from external piped supply

Various methods can be adopted for estimating water availability from external piped supply.

		Water availability Litres/day	Average days of water supply in year	Total yearly water availability
		a	b	a*b
Method 1	Through average volumetric measurement through water meters installed	_____ litres /day		
Method 2	Number of filling of head work/sump/main storage tank at village/town level in day	No. of fillings of tank per day * capacity of tank= _____ litres/day		

B4 Assess Domestic Water Gap

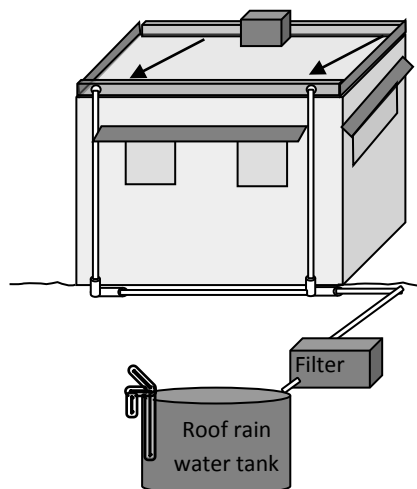
Table 3 (Water Gap)		
Yearly water demand as per table 1	Yearly water availability as per table 2	Yearly water gap
(a)	(b)	C= (a-b)

B5 Estimating Component of Water Supply System

Components required					Existing	Gap
No. of HH tap connections						
No. of Stand posts						
No. of Hand pump						
Village/town level storage tank (ESR/GSR/sump)	Type	No.	Capacity (litres)	Total capacity (litres)		
Filter/treatment unit	Type	No.	Capacity (litres)	Total capacity (litres)		
Pipeline (r. mt)						
Main						
Sub-main						
branch						
(HH/cluster level rain water harvesting system)	No.	Storage capacity (litres)		Total storage capacity (litres)		

B6 Basics on Calculating Roof Top Water Harvesting

- Roof top rain water harvesting is a simple method to collect and store rain water from roof top.
- Such system can be installed at household as well as community level like schools, panchayat building etc.
- Typical rain water harvesting unit consists of
 - a. Gutter pipes for conveying water from sloped roofs.
 - b. Conveyance pipes connected from gutter pipes (sloped roofs) or directly from roof outlet.
 - c. Valve prior to filter unit for flushing impure water, mainly first rain.
 - d. Filter unit consisting of sand-gravel bed for basic filtration.
 - e. Storage tank (normally 5,000-10,000 litres tank can be installed at HH level for family of five. At community level storage size can be decided on water that can be harvested and funds available). Storage tank normally should be underground.
 - f. Hand pump/motorised pump to withdraw water from the tank



- Normally, first rain water is not filled in tank as the roof top gets cleaned. Even for subsequent rains, allow rain water for first 5-10 minutes to flush away for getting rid of impurities from roof.
- Calculation for water that can be harvested from roof top in litres:

Area of roof in m^2 (a) X run-off coefficient (c) X annual rainfall in region in meter X 1000 (for converting m^3 into litres).

- Area of roof is measured as length in meter X breath in meter.
- Run off co-efficient caters to spillage, leakage, absorption by roof material. For smooth/pucca roof like sheet/tiled/RCC roof, run off co-efficient can be generally taken as 0.8. For kutcha roof, the co-efficient can be taken as 0.6
- Annual rainfall is normally available in millimeter. So convert it into meter by dividing it with 1,000.

- Sample calculation for small house with RCC slab roof =
 $36 m^2$ (area of roof) x 0.8 (run-off co-efficient) x 0.8 meter (annual rainfall) x 1000
 = 23,040 litres, day 20,000 litres.

This means that a standard house can harvest 15,000-20,000 litres of rain water in a year from roof top.

MODULE C: BASICS ON WATER PUMPING AND DISTRIBUTION

Training Objectives

- a) To know basics on pumping and types of pumps for water supply
- b) To know basics on pipelines distribution networks
- c) To know basics on types of pipe materials, pipe fitting, joining and laying of pipelines (with major focus on sub-mains/branch pipes)

Training tools: Powerpoint/on board presentation, question-answer, movies and pipe joining.

Approximate time:

Powerpoint presentation: 1 hour
Question-answer: 30 minutes Movies: 30 minutes

TOTAL: 2 hours

C 1 Basics on Water Pumping

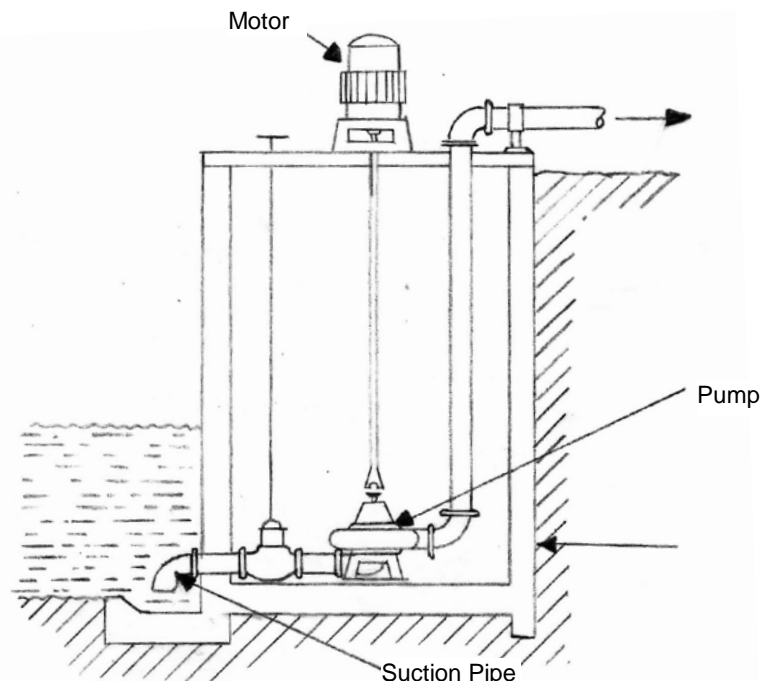
- Pumping Machinery is used for transfer of water from one place to another and pumping of water from water source. Pumping is required for
 - a) Lifting water from the source (surface or ground) to purification works or the service reservoir.
 - b) Transfer of water from source to distribution system.
 - c) Pumping water from sump to elevated/ground surface tanks.
- Pump house (civil works) is constructed for installation of pumping machinery.
- Pump House is designed for life of atleast 30 years, while pumping machinery is designed for atleast 15 years lifespan.
- Pumping Machinery consists of 3 major components:
 - a. Pump for lifting of water
The function of pump is to transfer water to higher elevation or at higher pressure. Pumps are driven by electricity or diesel or even solar power. They are helpful in pumping water from the sources, that is from intake to the treatment plant and from treatment plant to the distribution system or service reservoir.
 - b. Electric/diesel/solar powered motor
For pumping, 3 phase electric connection is required.
 - c. Panel board
Panel board consists of circuit breaker or switch and fuse, starter level controls etc for transmission of electric supply.

- For water supply system, three main types of pumps are used:
 - a. **Centrifugal Pump** which is used for pumping water from well/sump. It is a type of velocity pump where water is moved through continuous application of power. This type of pumps are used widely in water supply schemes containing sand, silt etc. Centrifugal force is made use of in lifting water. Electrical energy is converted to potential or pressure energy of water. The pump consist of following part:

The pump consist of following part:

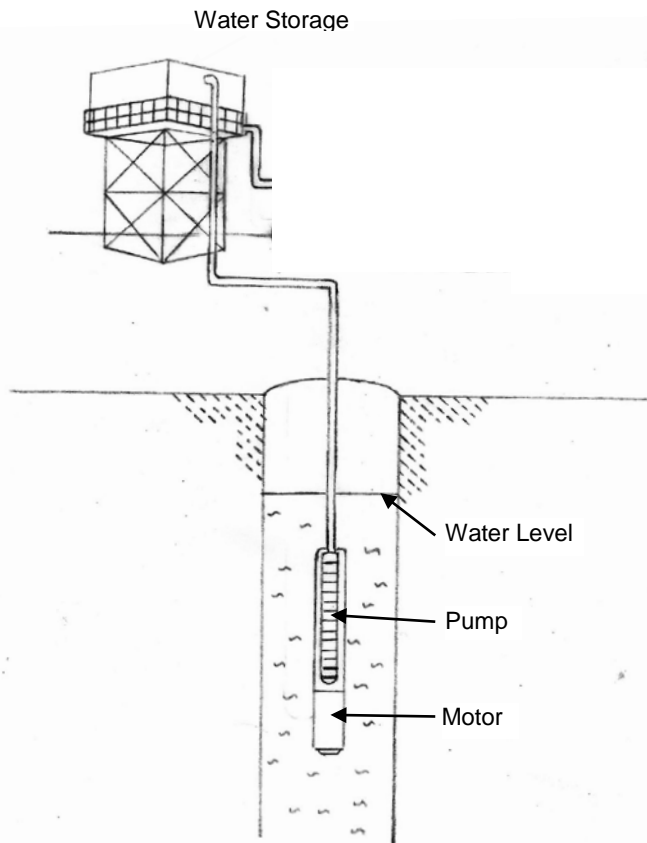
- Casing
- Delivery Pipe
- Delivery Valve
- Impeller
- Prime Mover
- Suction Pipe
- Strainer and Foot Valve

The pump consists of an Impeller which is enclosed in a water tight casing. Water at lower level is sucked into the impellor through a suction pipe. Suction pipe is air tight. A strainer foot valve is connected at the bottom of the suction pipe to prevent entry of foreign matter and to hold water during pumping. Suction pipe is kept larger in diameter than delivery pipe to reduce cavitations and losses due to friction.



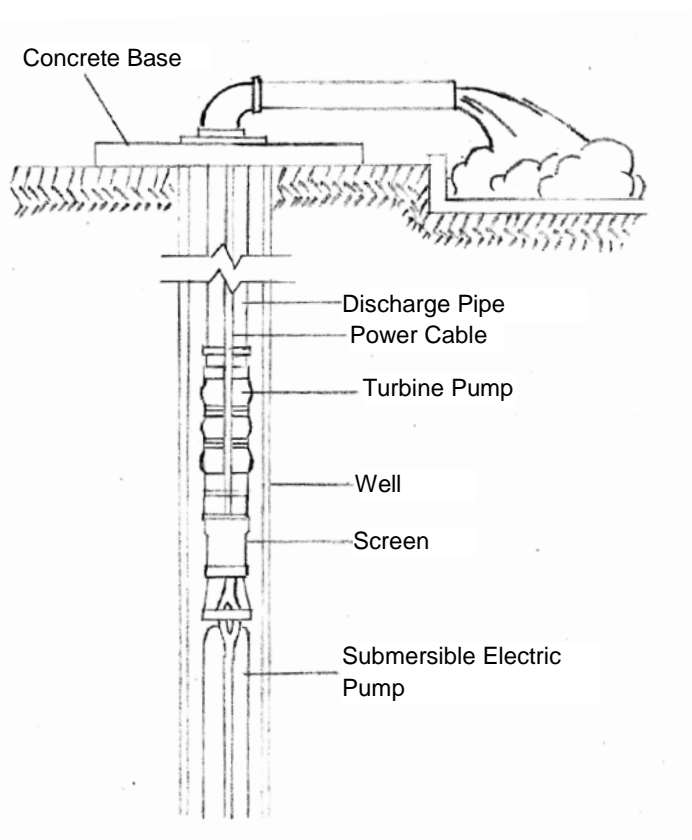
b. Turbine Pump

The principle of a pump used as turbine: When water flows back through a pump, the impeller will run in reverse and the pump will function as a turbine. The energy recovered from pressure differences, heads or flow can be fed back into the system or into the mains. Turbine pumps are mainly used in elevation of water from ground level storage to elevated areas/storage or pumping from deep wells/tube wells. If the water requirement is large and there is a large source of falling water (head and flow rate) nearby, turbine-pump sets can provide the best solution.



c. **Submersible pump** is designed such that it can be introduced into well casing and lowered to the bottom of the well. It is highly used for pumping from bore well and underground sumps. Such pumps are used for water yield of 100 litres per minute. It is driven by an electric motor, which is directly attached to the pumping element and therefore totally submerged. This pump type is mainly used where electric power is available or ideally in combination with a Solar Pumping System. The main parts of a submersible pump are:

- a) Electric motor



enclosed in a stainless steel sleeve.

b) Pump body with multiple impellers, foot valve and strainer.

c) Rising main of GI or stainless steel pipes connected with sockets or PVC-hose. If a hose is used, the motor with connected pump body has to be hung from the top of the well by a stainless steel cable.

d) Electrical cable for connecting the motor to the starting panel (power source).

e) Starting panel.

Various sizes of submersible pumps are available, which can be installed in casings of diameter 4", 6", 8", 10" and 12".

Submersible pump have high efficiency and durability, low operation cost and high resistance to sand content.

- Criteria for Pump Selection for water supply
 - a) Type of pumping required, i.e. whether continuous, intermittent or cyclic.
 - b) Present and projected demand and pattern of change in demand.
 - c) The details of head and flow rate required.
 - d) Type and duration of the availability of the power supply.
 - e) Selecting the operating speed of the pump and suitable drive/driving gear.
 - f) The efficiency of the pumps and consequent influence on power consumption and the running costs.
 - g) Ease in installation.

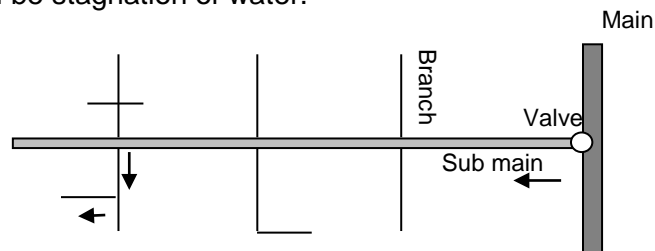
Guideline on pump selection	
Site Condition	Preferable Pump Type
Inside river	Submersible pump
Low lift raw water pumping, dry well built in the river/dam bank with suction head not to exceed 6 m	Centrifugal pump
Low lift raw water pumping, dry well built in the river/dam bank with suction head more than 6 m	Turbine pump
Ground level reservoir/sump	Centrifugal/Turbine
Line booster (small discharge < 1000 lpm)	Centrifugal pump
Open well with suction head less than 6 m in the lean period	Centrifugal pump/Submersible pump
Open well with the water level goes down and the discharge is less than 50 lpm	Submersible pump
Open well when water level is more than 15 m and discharge is more than 50 lpm	Turbine
Pumping from tube well	Submersible/Turbine

C 2 Pipeline Distribution Networks

Pipeline distribution networks are aimed at design of suitable routes for piping. It is very important for proper water pressure, capital cost and operation and maintenance cost. Different types of networks are adopted looking to the pressure requirement, operation and maintenance (O&M) strategy adopted, cost parameter and over all length of distribution system.

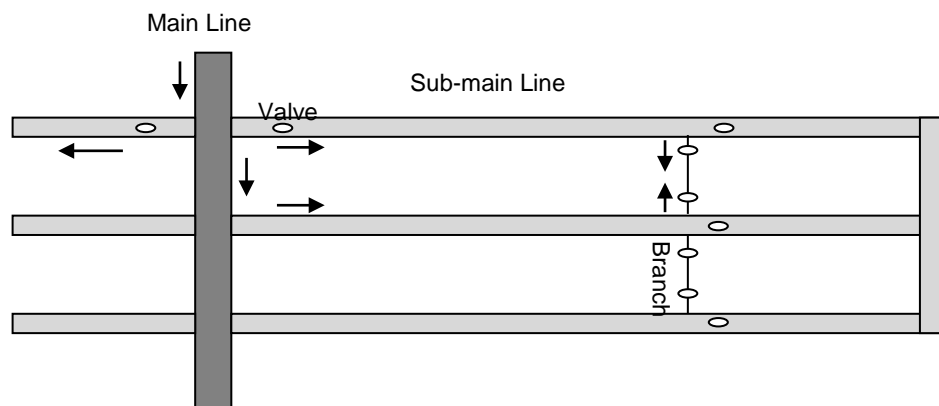
a. Dead end distribution system

In such system, sub main pipes are connected at right angles from main pipeline and branch pipes are connected to sub mains at right angles. This system is easy to lay. However, in case of failure in pipeline, it will be difficult to supply water to the area ahead of affected area. Also pressure at the tail end will be low compared to other area and there will be stagnation of water.



b. Grid Iron System

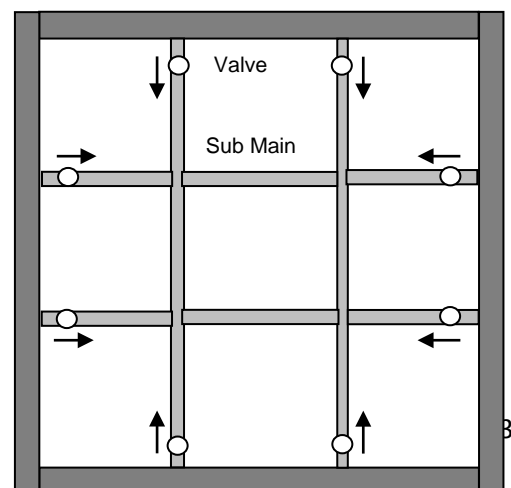
In such system; main, sub main and branch pipes are interconnected to each other. A grid

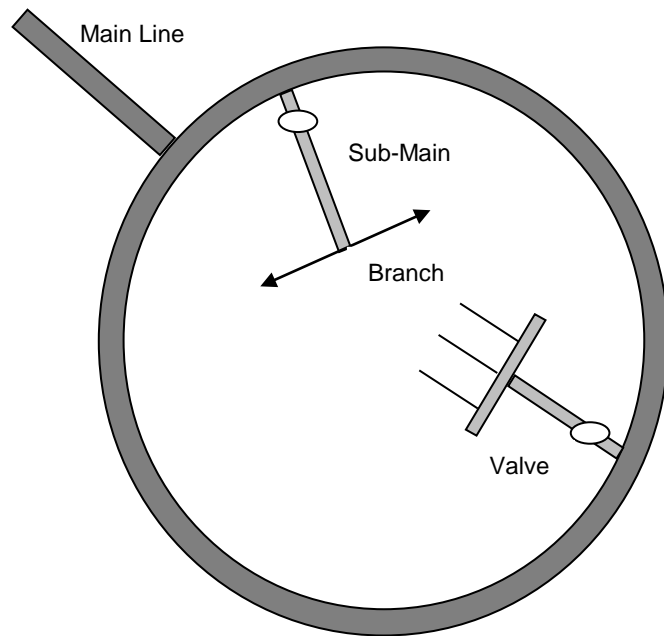


system is laid. Here, total length of pipeline required is high, but this helps in equitable water pressure. Also, blockage of pipes in one area does not affect the supply in the rest of area as there are multiple supply points to any area. This will also help in avoiding water stagnation. The system required higher number of valves.

Ring System

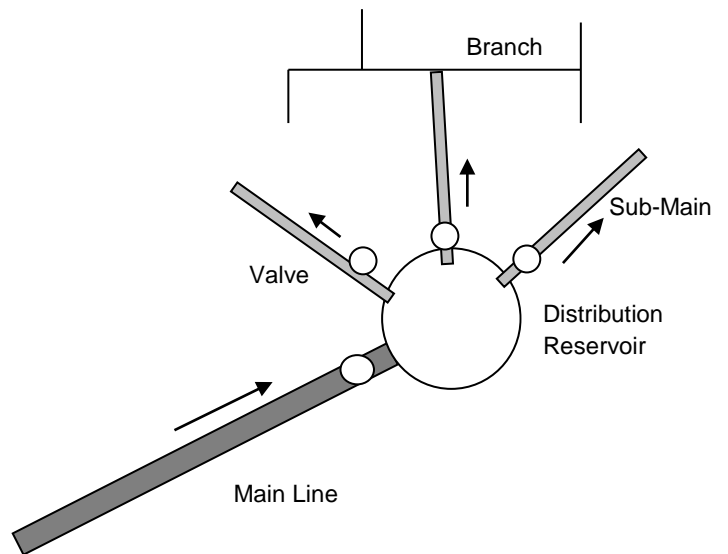
The whole system is enclosed by main pipeline in radial or rectangular shape. Smaller areas are enclosed by sub main pipeline. In case of failure of system, very small area will be affected. The area ahead of affected area can get water from other point. The system requires higher number





c. Radial System

The area is divided into different zones. The water is pumped into the distribution reservoir kept in the middle of each zone and the supply pipes are laid radially ending towards the periphery.



C3 Type of Pipe Material for Pipelines for Water Distribution

Various types of pipes are used for water supply system including metallic and non-metallic pipes. Most common types of pipes used for water supply system are:

- a. Galvanised Iron Pipes – metal pipe
- b. Mild Steel Pipes metal pipe
- c. Poly Vinyl Chloride pipes - non- metal pipe
- d. High Density Poly Ethylene Pipes - non metal pipe
- e. Ductile Iron Pipes

For water mains, mainly GI and MS pipes or even large HDPE pipes are used, while for branch/service pipes, most commonly used are galvanised iron and HDPE/PVC pipes. DI pipes are used for both purposes.

1. Mild Steel Pipes

- Number of joints are less as they are available in longer length.
- Pipes are durable and can resist high internal water pressure and highly suitable for long distance high pressure piping.
- Flexible to lay in certain curves.
- Light weight and easy to transport. Damage in transportation is minimal.
- Pipes are prone to rust and require higher maintenance.
- Require more time for repairs and not very suitable for distribution piping.
- Available in diameter of 150-250 mm for water supply and cut lengths of 4 - 7 m (2.6-4.5 mm wall thickness).
- Steel Pipes are joined with flanged joints or welding.



2. Galvanised Iron (GI) Pipes

- Cheap in cost and light in weight.
- Light in weight and easy to join.
- Affected by acidic or alkaline water.
- GI pipes are highly suitable for distribution system. They are available in light (yellow colour code), medium (blue colour code) and heavy grades (red colour code) depending on the thickness of pipe used. Normally, medium grade pipes (wall thickness 2.6-4.8 mm) are used for water supply system. Normally, 15-150 mm size pipes (nominal internal diameter) are used for distribution system. They are available in length of 3 m.
- GI pipes can be used in non-corrosive water with pH value greater than 6.5.
- GI pipes can be used for rising main as well as distribution.
- GI pipes are normally joined with lead putty on threaded end.



3. Poly Vinyl Chloride (PVC unplasticised) Pipes

- Cheap in cost and light in weight.
- Economical in laying and jointing.
- They are rigid pipes.
- Highly durable and suitable for distribution network.
- Free from corrosion and tough against chemical attack.
- Good electric insulation.
- Highly suitable for distribution piping and branch pipes.
- Less resistance to heat and direct exposure to sun. Hence, not very suitable for piping above the ground.
- PVC pipes weigh only 1/5th of steel pipes of same diameter.
- Certain types of low quality plastic impart taste to water.
- Available in size 20-315 mm (nominal internal diameter) for water supply with pressure class of 2.5, 4, 6, 8 & 10 kg/cm² for water supply. Ideally pipes with 6 kg/cm² should be used.
- Classification of pipes is done according to its pressure class.



Class	Working Pressure
Class 1	2.5 kg/cm ²
Class 2	4 kg/cm ²
Class 3	6 kg/cm ²
Class 4	8 kg/cm ²
Class 5	10 kg/cm ²
Class 6	12.5 kg/cm ²

- Available in lengths of 2, 3, 4, 6 m. For plain ended pipes, the overall length shall be measured from end to end. For socketed pipe for solvent cement jointing the effective length of pipe shall be determined by subtracting from the overall length, the socket length.
- Jointing of PVC can be made by solvent cement or rubber ring joint.

4. HDPE

- Light in weight.
- Flexible than PVC pipes.
- HDPE pipes are black in colour.
- Suitable for underground piping and can withstand movement of heavy traffic.
- Allows free flowing of water.
- Highly durable and suitable for distribution network.
- Free from corrosion
- Good electric insulation.
- Useful for water conveyance as they do not constitute toxic hazard and does not support microbial growth.



Normally, 20-315 mm diameter pipes are used for water supply and distribution system with pressure ranging from 6-

10 kg/cm². Available in coils in small diameters. Above 110 mm diameter, available in lengths starting from 6 m.

5. Ductile Iron Pipes

- Ductile Iron pipes are better version of cast iron pipes with better tensile strength.
- DI pipes are prepared using centrifugal cast process.
- DI pipes have high impact resistance, high wear and tear resistance, high tensile strength, ductility and good internal and external corrosion resistance.
- DI pipes are provided with cement mortar lining on inside surface which provides smooth surface and is suitable for providing chemical and physical barriers to water. Such pipes reduce water contamination.
- The outer coating of such pipes is done with bituminous or Zinc paint.
- DI pressure pipes are available in range from 80-1000 mm diameter in lengths from 5.5-6 m.
- Available in thickness class K7 and K9 with barrel wall thickness ranging from 5-13.5 mm. Also available in pressure class (Like C25, C30, C40 etc.).
- They are about 30 percent lighter than conventional cast iron pipes.
- DI pipes lower pumping cost due to lower frictional resistance.

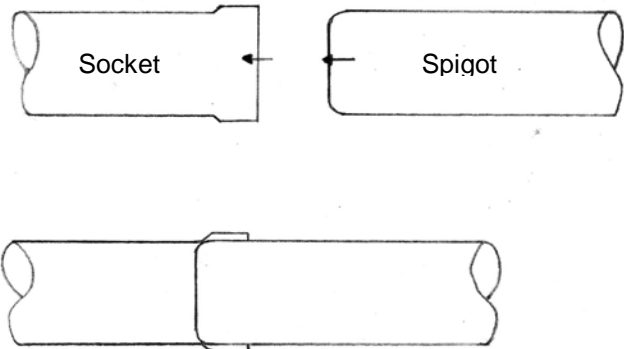


What is spigot and socket end in pipes?

Spigot and sockets are type of pipe ends.

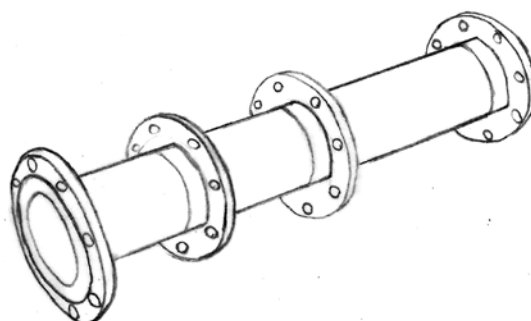
Spigot is the pipe end which is inserted into socket

Spigot and socket are joined with rubber seals, lubricants etc.



What is flanged end in pipes?

Pipes have flanged at their ends which are joined with nuts and bolts.

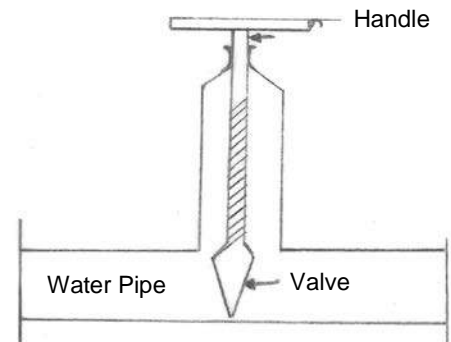


C4 Type of Valves for Water Flow Control and Estimation

Valves are used for control of water flow in pipeline and cleaning of pipes.

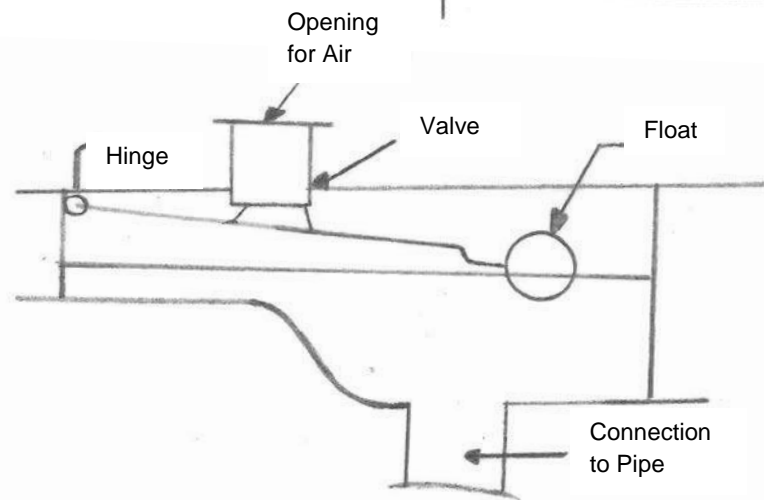
1. Sluice Valve

It is used for control on water flow in pipeline. It is fixed in main line and at start of branch line. It is also used as scour valve for cleaning of pipeline. They are provided in straight pipeline at 150-200 m intervals. When two pipes lines intersect, valves are fixed in both sides of intersection.



2. Air Valve

Air valve are fixed in order to allow air circulation in pipeline. It is placed in pumping main line and distribution line mainly which are at higher levels. Air valves may be placed at every 1000 m for pipe lines upto 600 mm dia.



3. Water Meters

- These are devices installed on pipes to measure quantity of water flowing in particular area. These are installed to keep control on water usage in case of metered water supply.
- Meters installed to measure household consumption are called domestic water meters. Water meters can also be installed for measuring quantity at stand posts.
- Water meters having sizes from 15 mm to 50 mm are considered for domestic water meters.
- Water meters are made normally of cast iron/brass/plastic body and plastic gears.
- Meters are classified according to the operating principle, type of end connections, the standard by which the same are covered, constructional features, method of coupling between the counter and primary sensor, the metrological characteristics etc.
- Automatic water meter reading system are used now in order to collect data from all the meters at central point through GSM/internet. This help in saving



time for collecting data from each individual place. This system helps in collection, displaying and processing of data at one single place. It also helps in monitoring of data daily.

- Sizing of water meter

Water meter has to be selected according to the flow to be measured and not necessarily to suit a certain size of water main. The maximum flow shall not exceed the maximum flow rating. The nominal flow should not be greater than the nominal flow rating.

- Installation guidelines and sizing recommendations for water meters are normally given by the supplier.

4. Flow Meters

- Flow meters are devices installed mainly to measure velocity/speed of water and also derive quantity of water.
- Flow meters are placed near water intake/head works, transfer mains, storage tanks/reservoirs, distribution network like branch/main/sublines etc.
- Various type of flow meters are available based on characteristic and performance line accuracy of measurement, range, resolution etc.

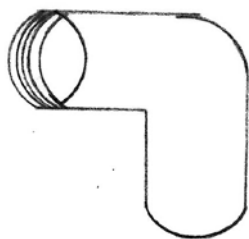
Difference of water meter against flow meter

- Water meter is a quantity meter and not a flow rate meter.
- Water meter is a mechanical device whereas flow meter is mechanical or an electronic device.
- Water meter is always specified in two accuracies i.e. lower range and upper range accuracies whereas a flow meter it is specified in a single range accuracy.
- The upper range and lower range accuracies are 2 percent and 5 percent of the actual quantity respectively for the water meter whereas it is variable for flow meter as per the customer's requirement.

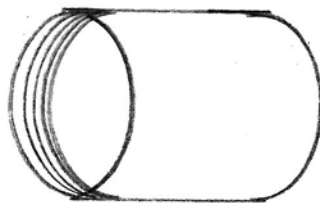
C5 Type of Pipe Fittings

Pipe fittings are important components of pipelines as they connect pipes and control pipe leakages. Various pipe fittings are used for distribution piping systems. Choose the diameter of the fitting based on the size of pipe. These fittings are available with threading, mainly for metallic pipes. For PVC pipes, non-threaded fittings are normally used for smaller diameter pipes. For HDPE pipe fittings, special flanged fittings are available for joining pipes.

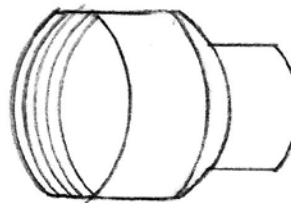
- a. Socket or coupling - It is used to connect two straight lengths of pipes. The outer diameter of pipe will be equal to inner diameter of socket after threading.
- b. Elbow - It connects two pipes of same diameter at an angle, normally 90 degrees.
- c. Tee - It will fit two straight pipes and will have an outlet at right angle.
- d. Union - It is used for joining the ends of two pipes which cannot be rotated. They are used in long stretches of straight pipes in the beginning of a pipe system and near all appliances along stop valves.
- e. Reducer - It is used to connect two pipes with different sizes (diameters) to reduce the size of pipe. Reducer can be a socket, elbow or a tee as per required distribution network requirement.
- f. Nipple - It is a tubular pipe fitting, mainly in 300 mm length. It is used for extending pipelines.
- g. Plug - It is used to plug the flow of water at dead ends.



Elbow



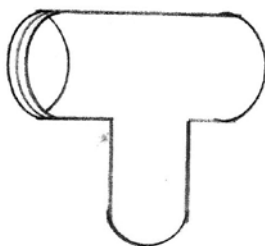
Coupling



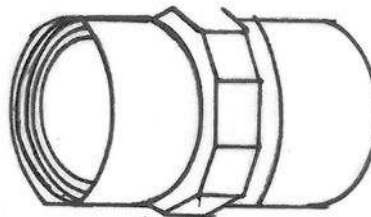
Reducer



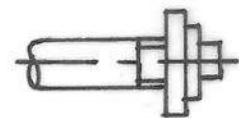
Bend



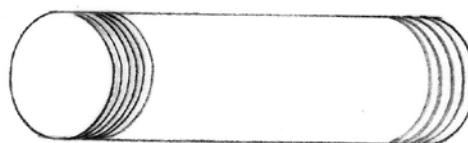
Tee



Union



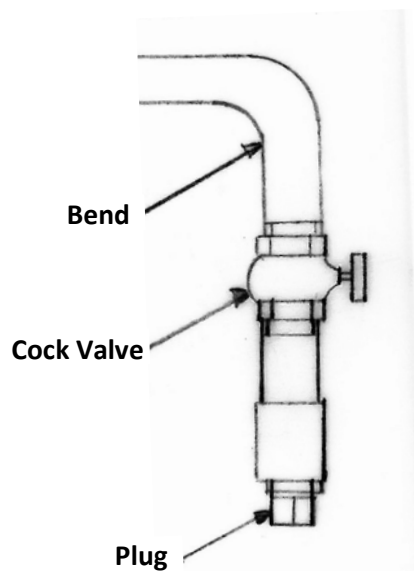
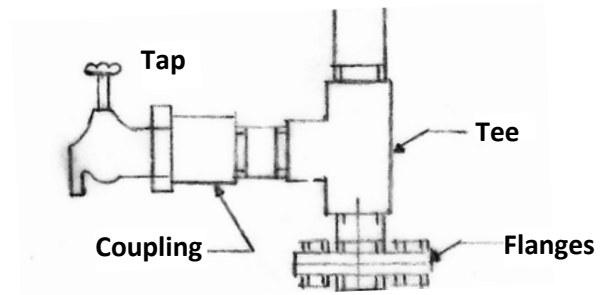
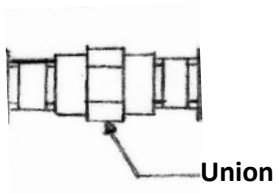
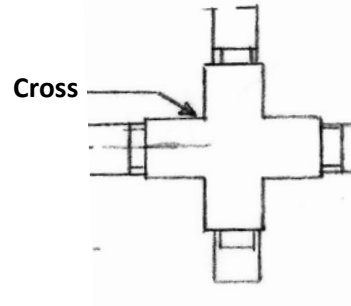
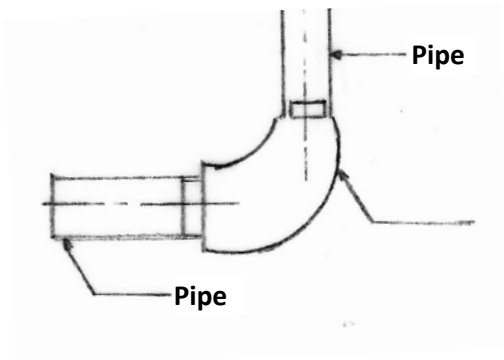
Plug



Nipple



Special Mechanical Fitting for HDPE pipes



Typical piping Layout with pipe fittings

C6 Types of Pipe Cutting and Assembling Tools

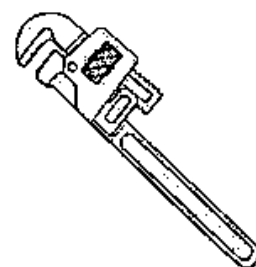
For pipe sizes greater than 25 mm, powered tools are used. And for pipe sizes below 25 mm following tools are used:

1. **Pipe Vice** - It is used for holding pipes in position rigidly for cutting and threading. Pipe vices are available in market in various sizes for holding pipes starting from 37 mm diameter.
2. **Pipe Wrench** - It is used for screwing and unscrewing small pipes. It is also used for tightening of nut and bolts, fixing of small taps, valves etc in pipelines. Pipe wrench size should be selected such that its opening exactly fits the pipe. Pipe wrench should not be used for bending, raising or lifting pipe.

3. **Chain Wrench** - It is used for turning and fixing large diameter threaded pipes. Chain wrenches are commonly available for holding pipes of 50 mm - 300 mm diameter.

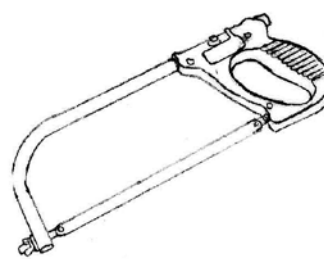


Chain Wrench

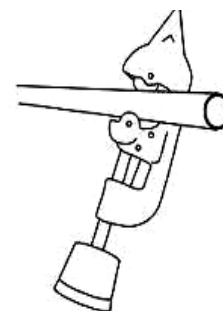


Pipe Wrench

4. **Pipe Cutter** - It is used for cutting of pipes. It is placed around pipes and tightens so that it holds the pipe tight. However, over tightening may damage pipe. The cutter is rotated around the pipe one to two times and then the pipe is tightened again. The process is repeated unless the pipe is cut. Pipe cutters are available for cutting of pipes from 25-150 mm.



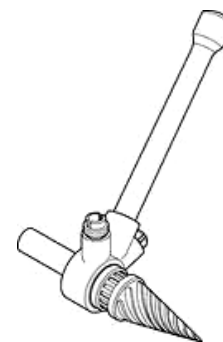
Hack Saw



Pipe Cutter

5. **Hack Saw with Blades** - It is used for cutting pipes of smaller diameters (15-25 mm). It consists of frame, handle, prongs, tightening screw and nut. The frame may be fixed type or adjustable type. Blade is fixed in position by means of tightening screw. The direction of the cutting teeth of the blade is to be in the forward direction.

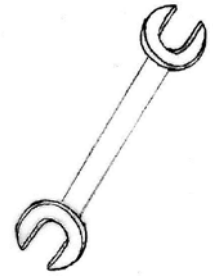
6. **Pipe Reamer** - It is used for chamfering on pipes. When the pipes are cut of threaded, burr or metal parts remain which are removed with pipe reamer. Various sizes are available in market. It should be selected based on the the pipe diameter.



Pipe Reamer

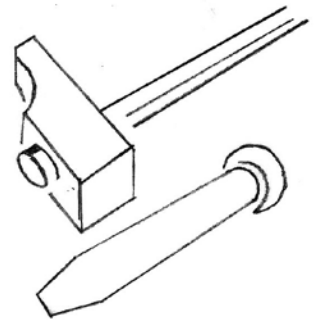
7. **Pipe Bending Machine** - It is used for bending pipes. Fix wooden stopper to one end of the pipe. Fill the pipe with sand completely. Fix wooden stopper from other side of pipe. Fix the pipe in the machine. Location of the the bend hould be in centre of pulley. Tight the screw. Bend the pipe with help of lever till required bend. Remove stopper and sand from pipe.

8. **Spanner** – Spanner is used for fixing and opening nuts and bolts. Different types of spanners and size are available as per requirement of pipe size.



Spanner

9. **Chisel and Hammer** - Chisel is meant for cutting metal pipes when very smooth surface is not required. Chisel is blown with hammer for cutting.



Chisel & Hammer

10. **Pipe Threading Die Set** - It is used for threading external taper threads of pipe. Pipe is fixed in the pipe vice and threading is done with help of the die set as per pipe size requirement.

Using instructions

- a) Take required size of pipe threading die.
- b) Fix the pipe in the pipe vice tightly.
- c) Cut the pipe to required size at right angle.
- d) Hold the die in right angle of the pipe and put some oil on pipe.
- e) Cut the thread on the pipe with die rotating in clockwise direction. Rotate the die in anti

clockwise direction so that the cut material will come out.

- f) Clean the chips or burr.



Pipe threading die set

C7 Types of Line and Levelling Instruments for Laying of Pipelines

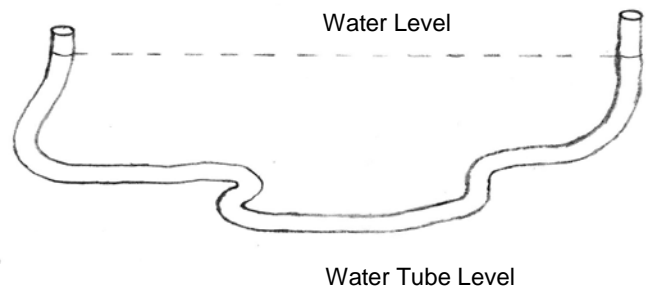
1. Plumb bob - It is used for determining straight vertical lines/plumb lines. It is most basic tool for measuring vertical lines while laying pipelines. It consists of string attached to pointed weight which swings and halts to give perfect vertical line.
2. Spirit level - It is used for leveling as it helps in maintaining horizontal lines. It helps in slope adjustment while laying pipes.
3. Water Tube Level - It is used for leveling while laying pipes. It consists of a plastic tube, where water is filled for levelling of tubes.



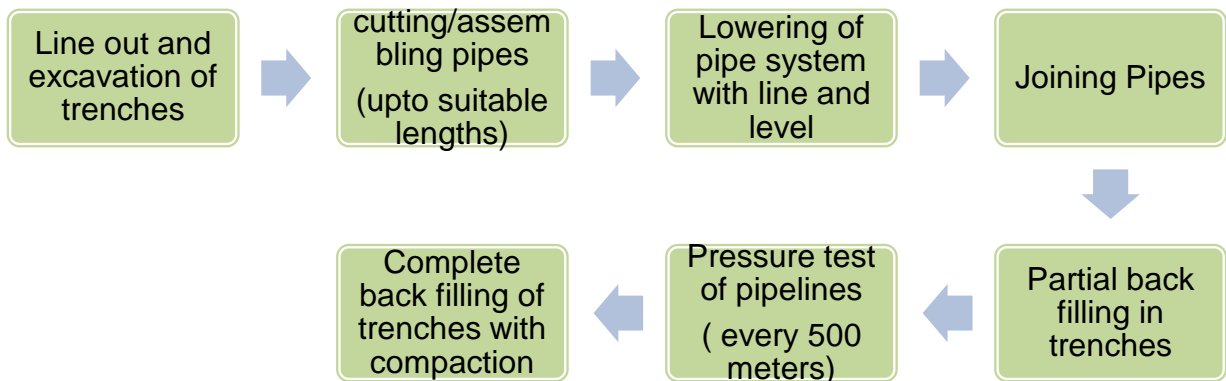
Plumb Bob

How to use water tube level

- a) Fill a jug with water for pouring water into tube.
- b) Attach one end of the tube to the jug, and place mouth on the other end. Begin sucking on the tube to get the water flowing. Suck from the tube hard enough to get the water moving. Once you get the water moving a little, it should flow freely.
- c) Pull out the tube from the water jug once it is nearly full.
- d) Hold both ends of the tube vertically so that no water can escape. Tap finger along the tubing to loosen any trapped air bubbles. Hold the ends of the tube even with one another, and verify that the water lines up equally. If it does not, you need to continue tapping the tube, as it is likely that air bubbles are still trapped.
- e) For leveling two persons are required. The person must hold the tube against the surface which requires leveling at a predetermined height. Hold the tubing at the desired height.
- f) Use chalk to mark the spot on the wall where the water line inside the tube falls.



C8 Basics About Laying of Distribution Pipelines

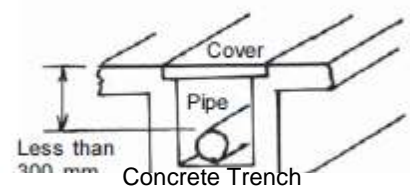


i. Preparation Prior to Laying of Pipes

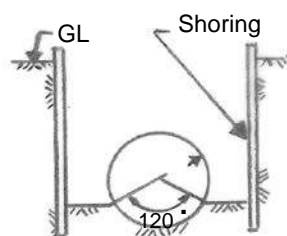
- Carry out line out as per need and plan with line out tools.
- Maintain exact stipulated levels and gradient for laying the pipelines with leveling tools. Difference in level may disrupt the flow of water or pressure at the end point.
- Excavate trenches for laying under ground pipelines. Trenches should be excavated with 600 mm width and 1000-1200 mm depth. Minimum clearance of about 150-200 mm is required on either sides of pipes in trenches.

Type of pipe	Minimum cover below road (mm)	Minimum clearance from either side of pipe in trenches (mm)
Steel (MS/GI/DI)	1200	200
Plastic (PVC/HDPE)	1000	200

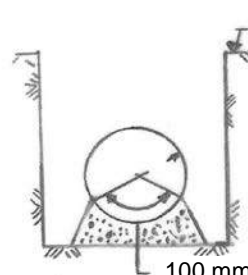
- Maintain levels after excavation. Place extra formworks and shuttering where needed in case the soil is soft to prevent collapse of soil. If excavation is done more than planned size, fill it with the soil and compact it. If the soil is hard or rocky the depth may be reduced. In hard rock, use blasting for excavation.
- If excavation is not possible, PVC pipes should be encased in masonry/concrete or steel pipes to prevent breakage and pressure of moving vehicles.



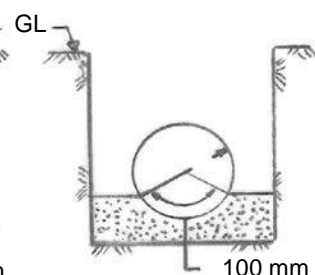
- In rocky surface, if necessary, the laying surface should be cushioned with a layer of sand or cement concrete bedding. This will prevent pipe from breakage due to point pressures.



Trench in Earth or Murrum



Trench in Hard Rock with Cement Concrete Bedding



Trench in Hard Rock with Sand Bedding

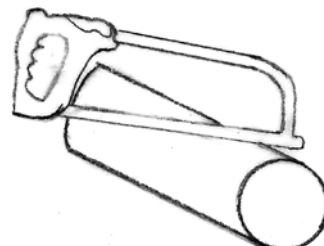
- All vegetation, shrubs, roots of the plant should be clean in and around of the laying line.

ii. **Joining, assembling and laying of various types of pipes**

Joining and Laying of PVC Pipeline

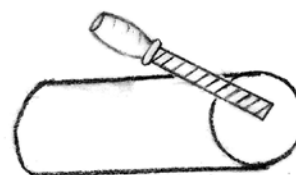
Preparatory

- All care should be taken to clean the inner surface of the pipe before laying. The residual adhesive/ cement mortar or any other obstructing objects should be cleaned.
- Mark each pipe with pencil or marker for required length.
- Cut the pipes as per required length with a fine tooth hand saw/hack saw or power saw. Chamfer the pipe ends at 15-20 degree and 3-5 mm for proper joining of pipes and adhesive. Clean the edge and surfaces with



clean cloth. Light sand paper or emery can be used lightly for cleaning if needed.

- Before joining pipes, mark the insertion depth of each pipe/fitting to be joined with marker/pen.

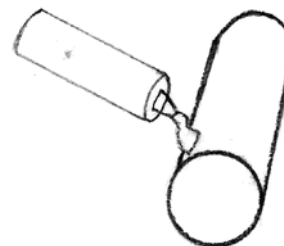


Jointing of pipes

- Pipes should be laid and joined with fittings on side of

trenches in suitable lengths and lowered after suitable lengths are prepared.

- PVC pipes are joined in following ways for distribution piping:



- Solvent welded joints - This system involves joining of pipes with solution made of polymer. This system is used for service pipes of water mains, branch pipes etc. For pipes upto 50 mm, regular viscosity solvent cement can be used, and for 50-150 mm diameter pipes, medium viscosity solvent cement should be used. Solvent is applied on end of pipe/fitting with brush. Within 20 seconds of last application of solvent cement, insert the pipe into fitting/socket and press it and hold it for a minute. Turn the pipes upto 1/4-1/2 turn. Clean the extra solvent. Following table enlist number of joint which can be made from 1 litre of solvent

Diameter of pipe in inches	2"	1.5"	1"	3/4"	1/2"
Approximate no. of joints which can done by 1 litre of solvent	70	100	130	150	200

Teflon tap can also be used for threaded connection for water seal.

- Rubber Ring joints - Rubber rings are joints are used for water tightness, but they cannot resist pull. Such joint are used where the soils in trenches are rough or aggressive. They are normally used for large sized pipes (> 63 mm dia). Insert the rings provided by manufacturer into the socket/groove and ensure that it is properly seated. Apply lubricant outside the spigot upto half the insertion depth. Insert the spigot end into the socket. Place a firm wooden block against the other end of pipe end. Using crow bar as level, push the spigot upto insertion depth mark. For larger pipes use jointing jack.



Rubber Seal

Lowering of pipes

Lower the cut pipes and fitting into trench manually. Care should be taken that they are not thrown in trenches. Mechanical device for lowering pipes can be done only in case large size pipes (>160 mm) are used. After laying, the open end of the pipes should be temporarily plugged to prevent access of water, soil or any other foreign matter

Joining and Laying of MS Pipeline

Preparatory

- All care should be taken to clean the inner surface of the pipe before laying.
- Cut the pipes as per required length and thread with threading die and filed for proper cleaning where needed Clean the edge and surfaces with clean cloth. Light sand paper or emery can be used lightly for cleaning if needed.

Jointing of pipes

MS pipes are joined in two ways:

- a) Threaded joint - Smaller pipes, below 200 mm are joined in such manner. Pipes have threaded ends with one socket. They are lowered down in trenches and laid to alignment and gradient. The pipes are joined with white lead and spun yarn. White lead is applied on the threaded end with spun yarn and inserted into socket of another pipe. The pipe is then turned and tightened.
- b) Welding - Large diameters pipes, normally above 200 m are joined by welding. Pipes are first lowered down manually or with chain pulley. Pipes are laid in level alignment before joining. Pipe ends are butted against each other. Plain ended pipes are joined by butt ends and sleeved pipes by fillet welds. For laying long straight pipeline, butt joint is preferred. Cement mortar is applied after welding.

Lowering of pipes

Lower the prepared pipes and fitting into trench manually or with chain pulley. Care should be taken that they are not thrown in trenches. The pipe laid on level ground shall be laid with socket facing the direction of flow of water. After laying, the open end of the pipes should be temporarily plugged to prevent access of water, soil or any other foreign matter.

Joining and Laying of GI Pipeline

Preparatory

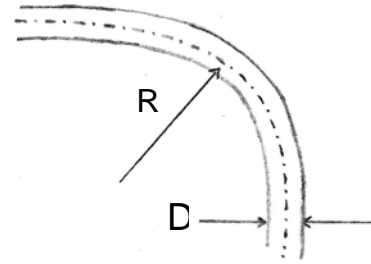
- All care should be taken to clean the inner surface of the pipe before laying.
- Cut the pipes as per required length and thread with threading die and filed for proper cleaning where needed Clean the edge and surfaces with clean cloth. Light sand paper or emery can be used lightly for cleaning if needed.

Jointing and laying of pipes

- Join inside of socket and the screwed end of the piped with white lead and put few turns of teflon tape or spun yarn around the screwed end of the pipe. Screw the end with socket, tee, etc. with a pipe wrench.
- After laying, the opens ends of the pipes should be temporarily plugged to prevent access of water, soil or any other foreign matter.
- Any threads exposed after jointing should be painted or coated with approved anti-corrosive paint to prevent corrosion.

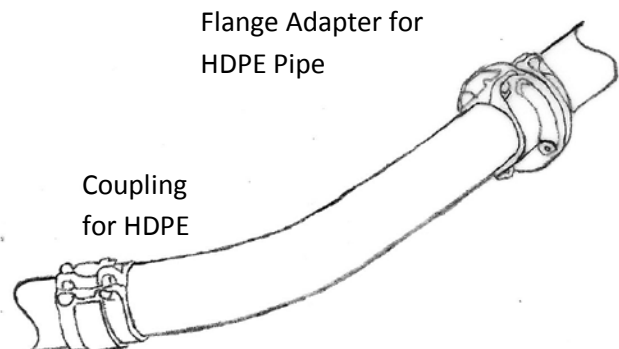
Joining and Laying HDPE Pipeline (Mainly for Service/Branch Connections)

- Small diameter pipes are flexible and available in coils and do not need special like bend, elbows etc. They can be cold bent easily. The radius (R) of the bend should be greater than 20 times the outside diameter of the pipe (D).



- Forming of small radius bend may easily be done by the application of heat. The pipe should be heated to a temperature of 130°C in an inert liquid, such as glycerol (or any oil in emergency). It should however be done by trained personnel.
- After the pipes are bent, they are joined with mechanical joints, and fixed with bolts. Use of synthetic rubber gasket can also be done with it to improve water tightness of pipes. For joining HDPE pipes to any other pipe, HDPE-to-metal transition couplings, outlets and fittings are used.

- The pipe line may be laid along side of the trench and jointed there. There after the jointed pipeline shall be lowered into the trench carefully without causing undue bending, manually or with chain pulley, sling etc. The pipeline shall be laid inside the trench with a slack/looseness of



about 1.0 m per 100 m of pipe line as they contract later on. For mechanical joints, thrust anchor are required in trenches for support it.

- As the pipe is laid, the front pipe in the trench should always be closed with a plug either of iron or wood and securely fastened. The plug should not be removed except, when pipe laying is resumed or for purposes of testing.

Joining and Laying of Ductile Iron (DI) Piping System

Preparatory

- Cut the pipes of needed length with hack saw, wheel cutter or pipe cutting machine.
- Where flexible joints are to be made, the cut ends must be trimmed with a file or grinder to remove the burr formed during cutting and a chamfer must be provided. When pipes are to be laid in aggressive soils, the pipes should be wrapped externally with protective coatings, such as bitumen or coal tar sheathing protective tapes.
- Lower all the pipes, pipe fitting etc. in the trench with ropes or suitable tools/equipments.
- Before joining, all the pipes must be cleaned of lumps, blisters, excess coating and must be clean from oil/grease etc.

Types of Joints for DI Piping System

- a. Socket and Spigot flexible joints
 1. Push on Joints
 2. Mechanical Joints

The spigot and socket flexible joints incorporate joining of pipes with gasket (rubber/elastomeric material) which permits angular deflection and compensates ground movement and thermal expansion/contraction. Such joints are used when pipeline is laid under ground. In push on joints, gasket is



Flexible Joints for laying under ground

inserted between socket and spigot and lubricant is applied on the gasket and spigot for effective joining. In mechanical joints, the joining is done by placing of gasket and tightening of follower gland and socket assembly with nut-bolt.



Push On Joints

- b. Flanged joints

Flanged joints are used when DI pipes are to be placed over ground or have exposed installations to overhead tanks etc. These joints act as self-restrained joints and reduce use of thrust blocks. Flanged joints are made on pipes having a machined flange at each end of the pipe. The pipes are joined by placing of gasket and is compressed



Mechanical Joint assembly

between two flanges by nut and bolts on flanges.



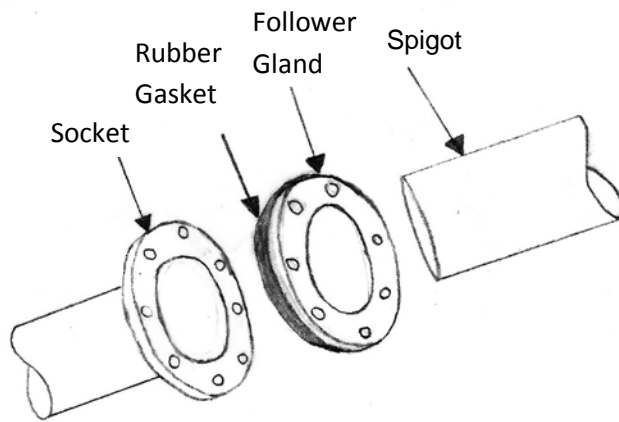
Flanged DI Joint Fitting

Joining of DI Pipes with Push on Joints

1. Clean the socket grooves and outside spigot end.
2. Place the gasket inside the socket.
3. Apply lubricant on the gasket and spigot as per manufacturer instruction. Do not use petroleum products for lubrication.
4. Properly align both the pipes. Gently push the spigot into the socket with suitable mechanical means like crow bar, etc.

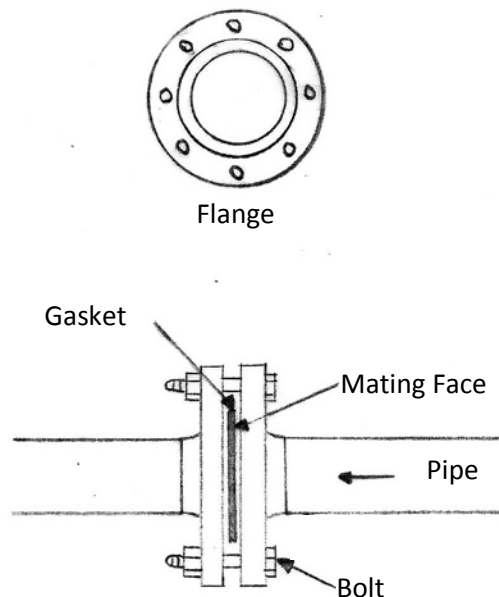
Joining of DI Pipes with Mechanical Joints

1. Clean the socket and spigot of the pipe.
2. Insert the follower gland and gasket on the spigot.
3. Put the spigot into the socket and align the pipes. Slide the glands and gasket in position. Insert nut bolts and tighten it.
4. Ensure that follower gland presses the rubber gasket properly.



Joining of DI Pipes with Flanged Joints

1. Align the pipes.
2. Clean flange faces.
3. Position gasket.
4. Lubricate bolt threads, mating surface and flange with automotive grade oil/grease.
5. Insert nut bolts one by one and tighten opposite bolts one by one.



iii. Filling Excavated Pit after Laying of Pipes and Testing of Piping System

- All backfill material should be free from cinders, ashes, slag, rubbish, vegetable or organic matter, boulders etc. Sand used for back fill should be natural sand, fine or coarse. Gravel used for back fill should be natural gravel with no boulders larger than 50 mm. Back fill can be done with excavated materials like clay, sand, gravel, etc.
- After laying of piping system, fill the trench upto 300 mm and compact by tamping.
- Carry out leakage testing of piping system after partial back filling.

The leakage can be detected in 2 ways:

1. Direct observation - spots of wet places in the pipeline indicates leakages.
2. Hydraulic test with pressure.

All the piping system laid should be tested for leakage. At village/town level, leakage test can be carried out after every 500-1000 m for such test and mainly for the mains. Pressure gauge should be fixed at lowest end of pipe. The water should be filled in from lowest point in network to be tested and air vents should be provided at higher points. During such filling of pipe line with water, air should be released from air vent pipes and care should be taken to close air vents only when complete air has been released from the pipe line and smooth flow of water starts. Calibrated tank can be installed for water supply and collection. For leakage test, 1.5 times the working test pressure of the pipes selected is done. There are specific formulas for testing the leakage amount at end of each test. It will vary with the pipe length, number of joints in pipeline and diameter of pipe. Consult the site engineer for its details.

Note: solvent joined pipes should not be tested before 24 hours of fixing.

- Fill the remaining pit in layer of 50mm with required compaction and watering.

iv. Disinfection of Pipeline

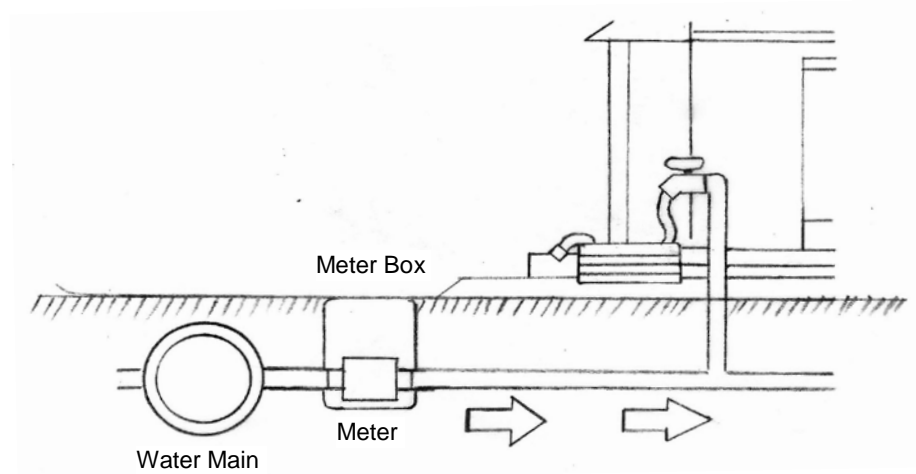
- The mains of water supply line should be disinfected before it is used.
- Flush the pipe with water of sufficient velocity to remove dirt and other foreign material.
- Later disinfection with chlorine water can also be done. Chlorine concentration of 20 mg/litre can be used for chlorination of mains. Chlorine water should remain for 24 hours in the main for proper disinfection. Hence, all the valve, etc. should be closed along mains before the procedure.
- The chlorine water can then be disposed off and pipeline be cleaned with fresh water.

C9 Installation of Water Meters

- Installation manual is normally given by the meter supplier.
- Domestic Water Meters can be fixed at household level in case there is 24 hours supply and water tariff is collected based on actual water consumption.
- A masonry pit is constructed around the meter to protect it. A lid should be placed on pit for taking readings. The protective lid should normally be kept closed and should be opened only for reading the dial.
- Technical parameters for fixing of water meters
 - a) Water meters must be fitted in the right direction of flow and positioned to allow easy visibility for manually reading the meter and for viewing the serial number.
 - b) The length of pipe that accommodates the water meter must be completely filled with water immediately upstream and downstream of the meter under all operating conditions.
 - c) Install meter such that top of the meter is below the level of the communication pipes so that meters always contain water.
 - d) Water meters are to be located to avoid damage (eg. vehicles, livestock, vandalism, flooding) a protective box/masonry pit may be necessary in some situations.
 - e) Water meters are to be installed as close as practicable to the extraction point and must be located upstream of any valves (except air valves), tees, takeoffs, diversions or branches.
 - f) Water meters are to be installed above ground if possible and located outside of wells to allow for safe and easy meter reading. If a water meter is required to be located below ground, or down a well then it should not be deeper than 500 mm below ground level.
 - g) Water meters fitted onto PVC, or HDPE pipeline must be adequately supported by a concrete block, or fabricated steel bracing to ensure stability.
 - h) Before connecting the meter to the water pipe, it should be thoroughly cleaned by installing in the place of the water meter a pipe of suitable length and diameter and letting the passage of a fair amount of water flow through the pipe work to avoid formation of air pockets. It is advisable that the level of the pipeline where the meter is proposed to be installed should be checked by a spirit level.
 - i) Before fitting the meter to the pipeline check the unions nuts in the tail pieces and then insert the washers. Thereafter screw the tail pieces on the pipes and install the meter in between the nuts by screwing. In order to avoid its rotation during the operation, the meter should be kept fixed with suitable non-metallic

clamps. Care should be taken that the washer does not obstruct the inlet and outlet flow of water.

- j) Where intermittent supply is likely to be encountered the meter may be provided with a suitable air valve before the meter in order to reduce inaccuracy and to protect the meter from being damaged.
- k) Test and calibrate the water meter before use and at regular intervals as per instructions given by manufacturer.



Typical Installation System for Domestic Water Meter

Activity Sheet

Section C

1. List components for water pumping
2. List types of pipes and mention any one advantage and disadvantage of each
3. List types of pipe fittings
4. Which tools are used for pipe cutting
5. List line and leveling tools for pipe laying
6. List sequence for pipe laying
7. How will you test any water leakage after pipeline laying
8. Which chemical is used for pipe disinfection
9. What is a water meter and what does it measure

MODULE D: BASICS ON WORK MEASUREMENT AND SPECIFICATIONS IN WATER SUPPLY SYSTEM

Training Objectives

- a) To know basics on material quality check and control on site
- b) To learn on basic specifications of various material and items for water supply system and in what units it can be measured.

Training tools: Powerpoint/on board presentation, question-answer

Approximate time:

Powerpoint presentation: 45 minutes
hour

Question-answer: 25 minutes

TOTAL 1 hour 10 minutes

D 1 Checklist for Quality Check of Basic Construction Materials for Water Supply System (at Site/Village/Town level)

This checklist is mainly for understanding specifications of materials to be ordered, its storage mechanism on site as well as quality check on site as per the order placed.

1. Cement

- Cement should be 53 grade ordinary Portland cement (OPC) with ISI mark.
- Cement should be used within three months from the date of manufacture. Date of manufacture is written on cement bags.
- Do not purchase cement bags which are damp.
- Store cement bags so that they do not catch dampness.

2. Sand

- River sand should be clean and sieved. It should not contain silt and dust.
- Use sand after washing it.

3. Gravel/Kaptchi/Aggregates

- Such aggregates come is 4-40 mm size.
- They should not be larger than 40 mm each.
- They must be hard, non-porous and free from excessive quantities of dust.
- They should not be rounded or with flakes.
- They should be angular, tough, and sharp and well graded stone metal, Basalt from approved source.

4. Stone

- Use stone from standard mines.
- Use stone which are hard and similar colour.
- Do not use stones which are round or very irregular in shape.
- Length of stone should not exceed three time its height. Height of stone can be upto 300 mm.
- Width/breadth of stone base shall not be greater than $\frac{3}{4}$ th of wall thickness. However, width of stone shall not be less than 150 mm.

5. Bricks

- Use bricks of even sizes from standard suppliers.
- Standard traditional size of bricks is 9" x 4.5" x 3".
- Use first class bricks.
- Bricks should not be over burnt or under baked.
- Bricks should be free from cracks, chips, flaws and stone.
- Compressive strength of bricks should be atleast 35 kg/cm².
- Use bricks with frog in it.
- Check few bricks on unloading for its size. The size (length/breadth/height) individually should not be more/less than 5 percent of size ordered.

6. Cement Concrete Blocks

- Compressive strength of blocks should be atleast 35 kg/cm².

7. Water

- Use clean water as far as possible.
- Do not use saline water.
- Water should be free from oils, acids, salts and other organic material/substances which may be harmful to concrete/pipes.

8. Steel Reinforcement Bars

- Use steel bars with ISI mark only.
- Store steel bars on site in such a manner that it does not catch corrosion and is not in contact with moisture/water.

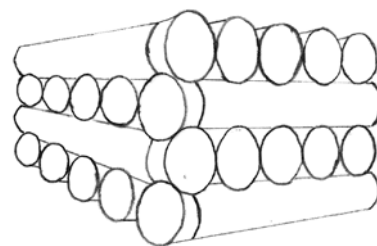
9. Pipes for water distribution

General

- Check manufacturer's trademark and name, ISI mark, outside diameter in mm, class of pipe and pressure rating, month and year of manufacture as well as length of pipe, once the pipes are unloaded on site. Check whether the pipes unloaded are as per specifications while ordering.

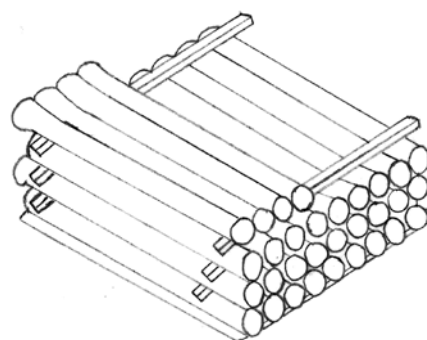
Metal pipes

- Pipes and fittings should not be thrown from trucks, nor dragged or rolled along hard surface. Pipes may be handled in slings of canvas or non-abrasive materials.
- Pipes can be stored in layer with each layer at right angle to another. Height of stack should not exceed 2 meter. Alternatively, parallel stacking can be done using timber.
- The pipes should be inspected while unloading



for defect like grooves, dents, notches. If large portion of such defect are found, material should be replaced.

- The pipes should be stored under cover on the site if it is to be used after long period.
- Pipes of different sizes should be stacked separately.



Plastic pipes

- Pipes should be stored undercover if it has to be used after longer period as it will get damaged due to direct sunlight.
- HDPE coils may be stored either on edge or stacked flat one on top to another. Straight lengths PVC/HDPE can be stored in horizontal racks with support. Pipes should not be stored in stacks more than 1.5 m in height. Pipes of different sizes should be stacked separately.

Pipe Fittings

- Check manufacturers' identification mark, ISI mark and size as well as working pressure when delivered.

D2. Basics on Material and Item Specification and Mode of Measurement.

Below listed are details for measuring of various material and activities. This checklist will help in placing orders and tendering for purchase of materials as well as for work estimation and cost estimation.

Specimen Specification and Unit of Measurement for Basic Construction Materials and Labour Work Mainly for Pipeline

Sr. No	Material/Item	Specification for inviting quotation	Quantity Measured in (unit)
1	Cement	Providing 53 grade OPC cement bags to the site specified with loading-unloading, taxes and transport to site (with ISI Mark).	Bags (50 kgs)
2	Sand	Provision of river sand to the site specified (with loading, unloading, taxes and transport to site).	cu. m
3	Stone	Provision of stone from quarry, with royalty, loading-unloading, taxes and transport to site	cu. m
4	Kaptchi	Provision of Kaptchi/grit from quarry, with royalty, loading- unloading, taxes and transport to site 6 mm-12 mm size 12 mm-20 mm size 20 mm-40 mm size	cu. m
5	Bricks	Providing first class burnt clay bricks of size 9"x4"x3" including loading-unloading, taxes and transport to site	1000
6	Cement Concrete Blocks	Providing cement concrete blocks 9"x4"x3" including loading-unloading, taxes and transport to site	1000
7	Excavation of pipeline trenches	Excavation for pipe line trenches including all safety provisions using site rails and stacking excavated stuff up to a lead of 90 m, cleaning the site etc. Complete for lifts and strata as specified for depth of 1.5 m. In all sorts of soil and soft murrum In hard murrum, boulders incl. macadam road. In soft rock and/or masonry in CM or L M or Lime Concrete. In hard rock and / or in C. C. 1:2:4 or RCC with blasting and chiselling or by chiselling only.	cu. m.
8	Extra for formwork	Shoring or timbering for trench with 50 mm thick planks and suitable size struts etc.	sq. m.

	during excavation	complete.	
9	Back fill of trenches	Refilling the pipeline trenches incl. ramming, watering, consolidating disposal of surplus stuff as directed within a radius of 3 km	cu. m.
10	PVC Pipe	Providing and supplying in standard lengths ISI mark rigid unplasticised PVC pipes (test pressure 6 kg/cm ² pressure) suitable for potable water with solvent cement joints including cost of couplers, as per IS specification no. 4985/1988 including all local and central taxes, transportation, freight charges, inspection charges, loading, unloading, conveyance to the site stacking including cost of jointing material i.e. solvent cement, etc. complete (as per specified diameter).	r. mt.
		Making available PVC fittings with all taxes, and carting, unloading etc. on site/store.	No.
		Lowering, laying and jointing PVC pipes and specials of specified class and diameter including cost of conveyance from stores to site of works including cost of labour, material, except cement solvent, giving satisfactory hydraulic testing as per ISI code.	r. mt.
11	Mild Steel Pipe	Supply and Delivery of M.S.Pipe, medium duty conforming to IS-3589 to the site including all taxes, insurance, transportation, freight charges, inspection charges, loading, unloading,, stacking etc. complete. (as per specified diameter).	r. mt.
		Lowering and laying in position to correct line and level M.S. Pipe with outer coating and inside lining/Epoxy painting on pedestal or chairs upon prepared formation or prepared bedding in trenches the rates include conveyance from store to site of work loading, unloading, joint plastering, hydro testing etc. complete. (as per specified diameter).	r. mt.
		Extra Welding in all positions with required number runs, for M.S. Pipes internally and/or externally including gauging wherever necessary, fixing appurtenances and other accessories in connection with pipe laying work as per specification. As per specified diameter.	r. mt.
12	GI pipes	Providing and supplying medium duty GI pipes in standard lengths as per specified diameter, ISI mark , with required coupling, suitable for potable water including all local and central taxes, transportation, freight charges, inspection charges, loading, unloading, conveyance to the site stacking including cost of jointing material i.e. solvent cement, etc. complete.	r. mt.
		Lowering & laying in position to correct line & level M.S. Pipe of specified diameter with	r. mt.

		required specials/fitting including conveyance from store to site of work loading, unloading, joint plastering, hydro testing etc. complete.	
13	HDPE pipes	Providing and supplying in standard length ISI mark high density Polyethylene HDPE Pipes of specified diameter suitable for potable water as per IS specification no. 4984/1995 including all local and central taxes, transportation, freight charges, inspection charges, loading, unloading, conveyance to the dept. stores etc. comp. (PE-100 or as specified).	r. mt.
		Lowering, laying and jointing HDPE pipes and specials of following class and diameter (By butt fusion welding method) including cost of conveyance from stores to site of works including cost of labour, material, giving satisfactory hydraulic testing.	r. mt.
14	Ductile Iron Pipes	Providing and supplying D. I. pipes for specified class and nominal bore diameter with internal cement mortar lining including all taxes, insurance, transportation, freight charges, octroi, inspection charges, loading, unloading, conveyance to departmental stores, stacking etc. complete. (IS 8329-2000).	r. mt.
		Supply and Delivery of Ductile Iron Flange socket spigot bends, tees, reducers or any other specials as per BS-EN-545/1995 Class-A series K12 suitable for use with D.I. Pipes manufactured as per IS:8329/1994 delivery of specials is to be made to store or site of works including all taxes, loading, unloading, carting, stacking, insurance, inspection charges, octroi etc. complete.	Kg
		Providing, laying and jointing sockets and spigot centrifugally cast (spun) ductile iron pressure pipes with inside cement mortar lining (class K 7/K 9) conforming to IS 8329/2000 with suitable rubber gasket joints as per IS 5382/85 for specified diameter.	r. mt.
15	Valves (PVC/CI/other)	Providing and supplying ISI mark D/F Sluice Valves , Butterfly Valves & Reflux/air Valves of specified class and diameter including all taxes, insurance, transportation, freight charges, octroi, inspection charges, loading, unloading, conveyance to departmental stores, stacking etc. complete.	No.
		Lowering, laying and jointing in position following specified valves, Butterfly valves, Sluice valves and air valves including cost of all labour, jointing material, including nut bolts and giving satisfactory hydraulic testing, etc. complete.	No.

IS Code for basic materials		
Sr. No	Type of Material	IS code
1	Ordinary Portland Cement (OPC)-43 grade	IS 8112
	Ordinary Portland Cement (OPC)-53 grade	Is 12269
2	Natural building stone	IS 1123
2	Coarse and fine aggregates	IS 383
3	Mild Steel	IS 432
4	Burnt Clay bricks	IS 1077
5	Fly Ash bricks	IS 13757
6	UPVC pipe	IS 4985
7	GI pipe	IS 1239
8	MS pipe	IS 1239 & IS 3589
9	HDPE pipe	IS 4984
10	DI pipe	IS 8329

Mode of measurement for specific work items		
Sr. No	Item **	Quantity Measured in (unit)
1	Water Storage tank	litres
1	Cement concrete	cu.m.
2	RCC	cu.m
2	Labour work for steel reinforcement	MT
3	Flooring	sq.m.
4	Colour works	sq.m.
5	Pumping Machinery	no.
6	Stand post installation	no.
7	Cattle trough installation	no.
8	Washing Ghat installation	no.
9	Water meter	no.
10	RO plant/filter units	no. / MLD
11	Electric panel board	no.
12	Water testing apparatus	no.

** These items include both, labour and material cost or can be taken up individually.

Worksheet Section D

1. In which units are following material and work measured

Cement	
Steel	
Bricks	
Pipes	
Cement concrete	
Excavation of trenches	
Back filling of trenches	

2. What will you check quality when following materials are unloaded on site

a. Cement

b. Steel

c. PVC pipes

d. GI pipes

3. How will you store and stack following materials on site

a. Cement

b. PVC Pipe

MODULE E: WATER TREATMENT AND QUALITY CONTROL

Training Objectives

- a) To know basic drinking water quality parameters
- b) To know type of tests and method of testing of selected parameters
- c) To know household and community treatment processes for drinking water

Training tools: Presentation/class room sessions, practical sessions (if testing kit available)

Approximate time: 2.5 hours

E.1 Water Quality and Testing

Water from ground or surface sources are not always potable for drinking and need some level of water treatment prior to supply for water supply system. Following are some of the quality issues that are normally seen in various types of water sources:

Water Source	Type of quality issues
Surface water	
Lakes and ponds	Development of algae on top, development of Micro organisms, high turbidity in bottom layers. May be affected by organic and chemical pollutants by disposal of wastewater.
River, irrigation canals	Organic debris, mineral salts May be affected by organic and chemical pollutants by disposal of wastewater.
Ground Water	
Well, tube wells, hand pump etc	Salinity, fluoride, alkalinity, hardness Chemical contaminations due to disposal of domestic waste/industrial chemical near by

There are certain parameters for potable drinking water, recommended by Government of India (IS 10500 -1991) which are enlisted below:

Parameter	Desirable Value	Maximum Permissible Value	Effects if not controlled
Colour	5 hazen unit	25 hazen unit	Unacceptable by people
Odour	odourless	Odourless	Unacceptable by people
Turbidity	5 NTU	10 NTU	Unacceptable by people
Soluble Salts/TDS	500 mg/l	2000 mg/l	Stomach ache
pH	6.5- 8.5	6.5- 8.5	Intestinal problems
Hardness	300 mg/l	600 mg/l	Not appropriate for cooking, washing clothes. flaking in pipes
Calcium	75 mg/l	200 mg/l	Not appropriate for cooking,
Chlorides	250 mg/l	1000 mg/l	Corrosion, taste differs
Sulphate	200 mg/l	400 mg/l	Indigestion, stomach problems
Magnesium	30 mg/l	100 mg/l	Stomach ache
Nitrates	45 mg/l	100 mg/l	Can lead to Blue baby (1-6 months child)
Fluorides	1.00 mg/l	1.50 mg/l	Fluorosis of teeth, bones and muscles
Alkalinity	200 mg/l	600 mg/l	Taste differs
E-coli	Count 0 in 100 ml		Infectious disease and intestinal problems
Coliform	<10 in 100 ml	Not detected in more than 50% sample in year	

For testing of water, services can be availed from Maharashtra Jeevan Pradhikaran, Public Health Engineering Department (PHED) and health department offices located at block/taluka level, or other water testing laboratories in the region.

Types of tests to be conducted

- Physical test including temperature, turbidity, colour, taste, and odour.
- Chemical tests including pH, alkalinity, acidity, hardness, calcium, magnesium, iron, manganese, copper, zinc, aluminum, sulphates, fluorides, chlorides, nitrates, total dissolved and suspended solids, tests for toxic chemicals (lead, mercury etc.), test for radio-activity.
- Bacteriological examination for presence of bacteria like coliform, E-coli

Sampling Frequency

Water from all the sources like wells/tubewell/hand pump or collection point like stand post or HH level/intermediate storage tank should be tested at regular intervals. Normally, one sample for every 5000 population should be tested in each month. Additional tests should be conducted during monsoon and epidemics as per need. Where there are issues of biological contaminations, samples should be taken every week from the specified water source.

Following chart enlists the minimum sampling frequency from distribution system as per CPHEEO guidelines:

Minimum Sampling Frequency and number from Distribution System		
Population	Maximum intervals between successive sampling	Minimum number of samples to be taken from entire distribution system
Upto 20,000	One month	1 sample per 5,000 population per month
20,000-50,000	Two weeks	
50,000-100,000	Four days	
>100,000	One day	1 sample per 10,000 of population per month

Sampling Methods

- a. Sampling for physical and chemical test
 - Samples should be collected in inert materials like glass or polythene.
 - Sample bottle must be cleaned prior to taking samples as directed by laboratories.
 - About 2.5 litres is required for testing from each sample.
 - Prior to filling, the sample bottle must be rinsed 2-3 times with water to be collected.
 - Sample should reach the testing place within 72 hours of collection.
 - Certain parameters like pH, temperature chlorine etc may change during transport and it is advisable if they are tested on spot by specific kits.
 - Samples collected from wells should be taken only after the well has been pumped for sufficient times so that the sample will represent ground water.
- b. Sampling for bacteriological test
 - Sterilised bottle, as directed by laboratory should be used for sample collection.
 - While collecting sample, hand should not touch the bottle neck or stopper. Bottle should be held from the base, filled without rinsing and stopper be closed immediately. Bottle should have some air space left and should not be filled completely. Finally, brown paper should be wrapped for avoiding further contamination of water.
 - Size of sample should be at least 250 ml (1/4th of litre).
 - The sample should preferably be analysed within one hour after collection. The test of the sample should be done maximum within 24 hours.

Note for collecting sample from various sources

- While taking sample from river, lake, etc. sample should be taken from middle of bank. Stagnant water should be avoided for sample.
- While taking sample from tap (HH or stand post), water should be allowed to flow for two to three minutes prior to taking sample. Tap from which sample is collected should be clean and free from grease etc.
- While taking sample from hand pump, water should be allowed to flow for four to five minutes prior to collection of sample.
- While collecting sample from well/bore well, sample be collected from discharge end through fitted mechanical pump.

Water Testing Kits

Several testing kits are available in market to test water quality at village/town level. Use of these kits need specialised training appropriate for tools and equipments of the kit.

Water Testing Kits in India

1. FTC (Field test kits)

- As per National Rural Drinking Water Quality Monitoring and Surveillance Programme, field testing kits are provided at Gram Panchayat level for testing of various parameters at village/town level. These Kits are meant for water quality monitoring and testing by PHED engineer, NGOs, Voluntary agencies, Women group etc. Such kits are used for primary detection of chemical and biological contamination of water sources in village/town. All the water sources should be tested twice a year for bacteriological contamination and once a year for chemical contamination.
- Such kits include testing of water for turbidity, pH, hardness, chloride, iron, nitrate, fluoride, residual chlorine, arsenic and bacteriological quality.

2. Jal Tara Water Testing Kits (Designed by Development Alternatives)

- Jal Tara Kits are developed by Development Alternatives, New Delhi
- The kit is available for testing various parameters. These kits are validated by UNICEF.
- A standard Jal Tara kit can test 14 parameters
Physical: pH, Temperature, turbidity, hardness
Chemical: chlorine, fluoride, iron, nitrate, residual chlorine, dissolved oxygen phosphorous, ammonia
Biological: Coliform bacteria



100 tests can be performed by this kit. However, 10 test for coliform can be done

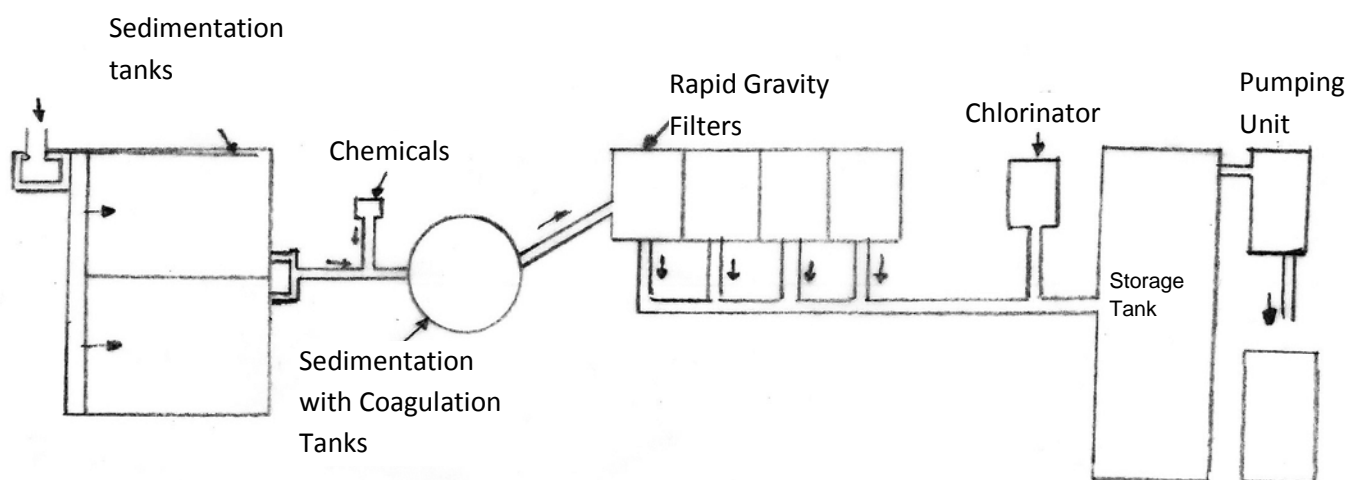
E.2 Water Treatment Systems

Normally, water supplied for drinking is treated at head works under the water supply system. However, water needs treatment even at household level as there may be chances of water contamination while transmission of water. Type of treatment depends on quality of raw water and source. Chart below enlists some of the common methods of water treatment used in water supply system:

Type of Filtration	Purpose	Type of unit
Sedimentation	Removal of suspended solids like sand, clay, silt etc.	Sedimentation tanks
Sedimentation with coagulation	Removal of suspended solids, colour, odour, taste, turbidity etc.	Sedimentation with chemical input
Filtration	Removal of micro organism and colloidal matter	Slow/rapid sand filter
Water softening plant	Removal of water hardness/salts	RO (reverse osmosis plant)
Disinfection	Removal of pathogenic bacteria	Chlorination
specialised water treatment plants	Removal of fluoride	De-fluoridation units, Nalgonda System
	Excessive salinity	De-salination plants

Village/Town Level Water Treatment Systems

- Village/town level water treatment systems are located mainly near head works, and should be located near to village/town if possible so as to avoid contamination in further water conveyance.
- The treatment units should be located in such a manner where possible that flow of water from one unit to other can be done by gravity, so that additional pumping of water is not required.
- Sufficient area should be reserved near the treatment units for further expansion in future.



Types of Water Treatment System at Village/Town Level

1. Primary Screening

- Screens are fixed in the intake works or at the entrance of treatment plant so as to remove the floating matters as leaves, dead animals etc.

2. Sedimentation

- In this process, suspended solids are made to settle by gravity under still water conditions. The sedimentation tanks may be rectangular or circular in shape.

Advantages

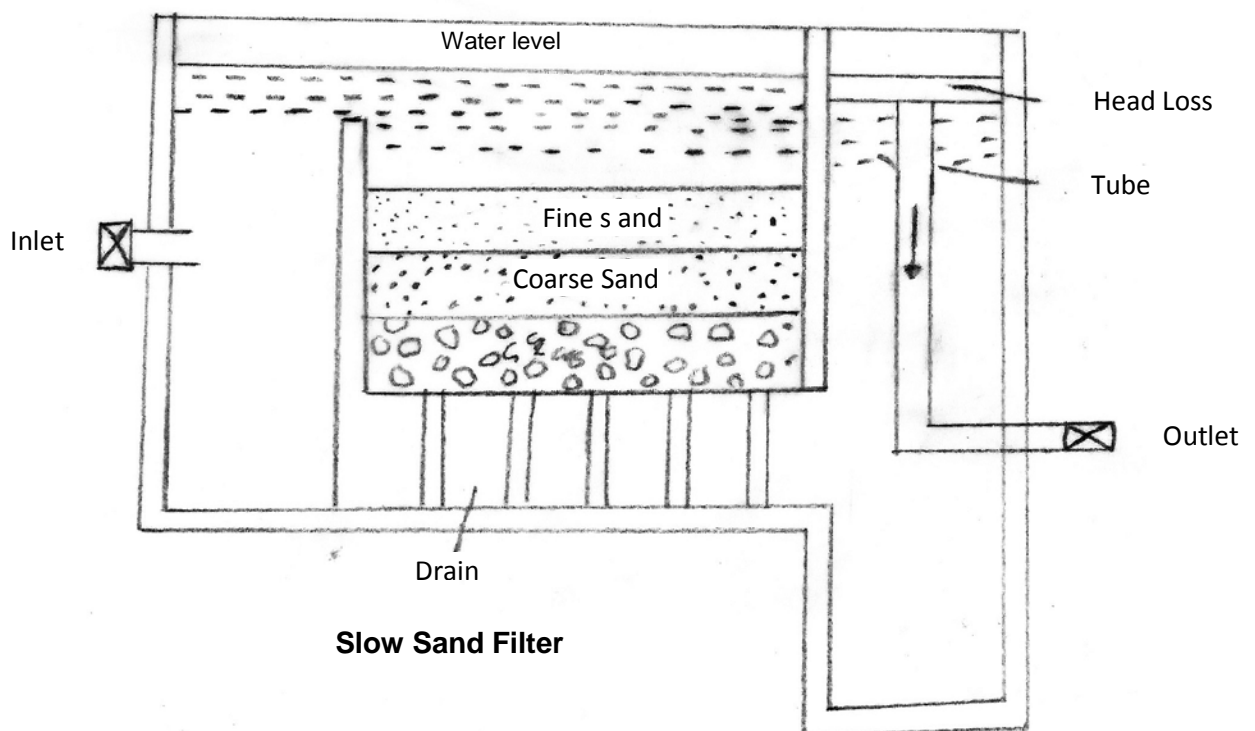
- Plain sedimentation lightens the load on the subsequent process.
 - The operation of subsequent purification process can be controlled in better way.
 - Less quantity of chemicals is required in the subsequent treatment processes.

3. Sedimentation with coagulation

- This process is used when raw water contains fine clay and colloidal impurities and needs extra chemical treatment for them to settle unlike plain sedimentation. In this process certain chemical/coagulant are added in the process along with sedimentation for impurities to settle down. This process is useful in removal of colour, odour and taste from water. Turbidity and bacteria can also be removed to certain extent.
- Coagulants are added based on pH of water. Alum or aluminium sulphate is common and cheaper coagulants added in the process. They are added in powder or solution form to raw water through some mechanical means.

4. Filtration

- This involves treatment of water by passing it through bed of sand, gravel and other granular materials. This system is useful in removal of bacteria, colour, odour, taste.
- This system is highly useful in removal of suspended impurities.



- The common type of filtration system is slow sand filter mainly used in rural/small urban areas. Such filter is made up of tank containing sand in top layer (size 0.2-0.3mm) upto thickness of 750-900 mm. Course sand layer is placed below fine sand layer upto 300 mm. The last layer is of graded gravel (2-45 mm) upto thickness of 200-300 mm. Water from sedimentation tank is passed through sand filter tank. Average flow of water from such filter is about 2400-3600 litres/m²/day. Hence, size of tank is decided upon daily requirement of water to be treated. The sand needs to be replaced every 6-8 weeks as it gets clogged with impurities. Gravel can be washed and cleaned and replaced again.

5. Water chlorination

- Chlorination is the cheapest form of water disinfection.
- Chlorination is done at head works/main storage tank in village/town prior to water distribution.
- Water test of the source needs to be done in laboratory in order to derive require amount of dosage of chlorination. Additional test should be done during monsoon and in case of epidemics.
- Bleaching powder or chlorine solutions are used for this purpose. If chlorine is used in powder form, it should be first diluted in form of solution and mixed in tank for proportionate mixing in the tank. Any form of chlorine should be of ISI mark. Normal dosages used for chlorination are listed below, however, prior test of water source needs to be done for deriving exact dosage:

Quantity of water to be used (litres)	Quantity of chlorine	
	Powder form chlorine/bleach (grams)	Chlorine solution (milliliter)
	25-35% powder	5% solution
1000	5	25
5000	15	125
1 lakh	500	1500
5 lakhs	2500	12500

- Chlorine gas is also used for water chlorination and it is available in cylinders. Such form is used for larger quantity of treatment in urban areas.
- Chlorine reaction time with water should be atleast half an hour. After this chlorine residue in water should be about 0.2 ppm. In monsoon/epidemics, this residue can be upto 1 ppm.
- Chlorine should not be stored in open area with direct sunlight as it will disintegrate. Chlorine containers should be closed immediately after its use.
- Chlorine should not be used in excessive amounts in drinking water as it may lead to health problems.
- Potential problems
 - Chlorination is less effective in alkaline water (pH above 8.0);
 - When the water contains excessive organic matter or suspended material, it will need to be pretreated;
 - Chlorination affects the taste of water.
- Despite these limitations, disinfecting drinking-water by chlorination is one of the most effective and least-expensive technologies available and should be encouraged.

Equipments for Chlorination at Cluster/Village/Town Level

Equipments for chlorination are selected based on type of source/storage to be chlorinated, availability of form of chlorine (powder, liquid or gas) and treatment capacity of the equipment. Following are some of the common types of equipments used for

chlorination.

a) Differential Pressure Type Chlorinator (with use of bleaching powder):

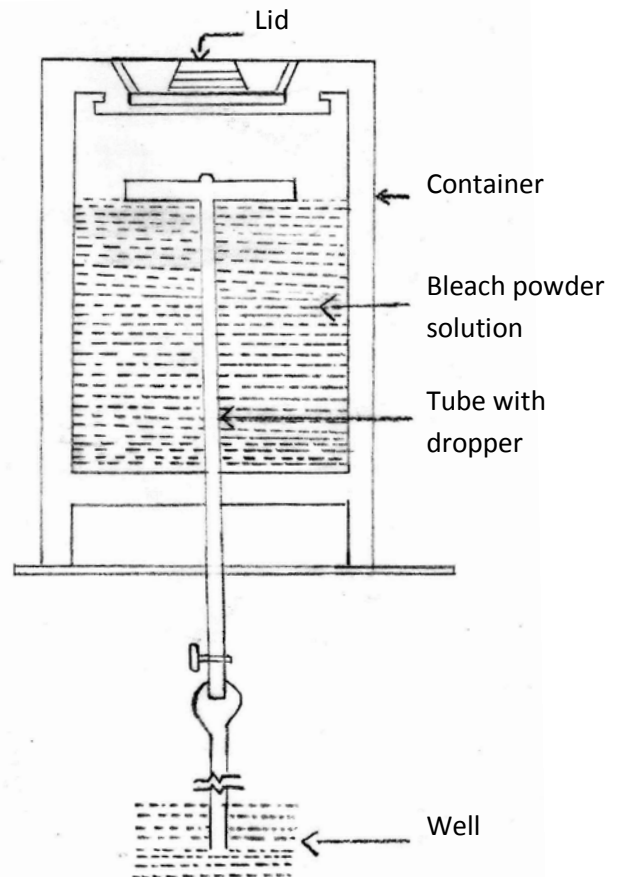
This equipment is widely used for piped water supply. The equipment consists of mild steel container with rubber bag inside it, which contains bleaching powder and soda ash in proportion of 5:1. This instrument is connected to water supply pipeline. Valve in the equipment helps in controlling application of bleaching powder as per required dosage. Such equipment is useful for small piped water supply with capacity of treating 3-20 lakh litres/day.

b) Drip type equipment:

Such equipment is used for chlorination of dug wells of flowing surface water. Such system consists of tank (may be made of RCC/masonry with glazed tiling or may be plastic tank), for containing chlorine solution, lid to filling tank and plastic drip pipe with stop cock. The drip pipe is placed in the well and chlorine solution is fed as per required dosage in the well.

Such system can also be used for chlorination of ground service reservoirs.

If the tube is placed directly into flow of water, then the rate of drops will slow down as level in the tank lowers. In that case, a constant head device is placed in the chlorinator system.



Drip Chlorinator

c) Gas Chlorinator:

Such system comprise of gas cylinder and gas absorption system which mixes the gas into raw water by dissolving chlorine gas in water. Various types of gas chlorinator system like gravity fed, pressure fed and vaccum fed are available in market.

6. Nalgonda System for Fluoride Removal

- Nalgonda Technique useful in treating of raw water with high amount of fluorides (1.5-20 mg/l). In this technique, besides fluoride, turbidity, colour, odour, pesticides and organic substances are removed. Bacterial contamination is also reduced.
- Nalgonda Technique involves additional of aluminium salts, lime and bleaching powder followed by rapid mixing, flocculation sedimentation, filtration and disinfection.

7. Reverse Osmosis System (RO)

- Treatment plants ranging from 10-6,000 litres/hour capacity are available.
- The system involves process that uses semi-permeable spiral wound membranes to separate and remove dissolved solids, colloidal matter and bacteria from water.
- Such plants are capable of removing upto 98 percent of TDS, upto 99 percent of organic matter, and upto 99 percent of bacteria. They are effective even with TDS concentration of 10000-20000 ppm. Hence, RO plants are highly useful in treating water with various impurities.
- Such system requires high investment cost as well as operation and maintenance.
- Community based RO plants are operated by private operators/water and sanitation committee.



Household Water Treatment Systems

- Basic filtration and boiling.
- Domestic chlorination.

1. Boiling at household level

- Water heating is effective in killing micro-organisms.
- Water should be heated in container for at least 10 minutes.
- Prior to boiling water should be filtered with sieve or clean cloth. Sieving will remove any particulate matter in water.
- Potential problems
 - The water becomes re-contaminated after boiling;
 - Fuel for boiling the water is scarce and, consequently, expensive;
 - Boiled water tastes flat – this may be corrected by adding herbs to the water during boiling and not drinking it for six hours after it has been boiled.

2. Water chlorination at household level

- Chlorination of water is a form of disinfection of water, mainly for removal of micro organisms causing water borne diseases like diarrhoea etc.
- This method is used mainly for drinking water to be consumed at household level.
- Chlorination at household level can be done through addition of chlorine pills. Such pills are available with PHED/Health Department/Asha worker. The chlorine pill should be allowed to dissolve in water and the mixture should be used only after half an hour.
- Based on the water quality, dosage of chlorine will vary. Instruction about the dosage can be sought from Asha worker/Health Department in your region.
- Chlorination should be done specially in monsoon.

Work Sheet

Section C

1. List basic parameters that need to be tested for water used for drinking purpose
2. Mention major drinking water quality issues from various sources in your village/town.
3. What type of treatment can be done for drinking water sources in your village/town
4. Mention various types of household level water treatment and its use.
5. Mention best way of drinking water-disinfection at village/town level
6. What type of treatment system is used when there is high amount of TDS.

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The Performance Assessment System (PAS) Project

The Performance Assessment System (PAS) Project aims to develop appropriate methods and tools to measure, monitor and improve delivery of water and sanitation in cities and towns in India. The PAS Project includes three major components of performance measurement, performance monitoring and performance improvement. It covers all the 400+ urban local governments in Gujarat and Maharashtra.

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PAS Project

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