Ethiopian TVET-System

Water Supply and Sanitation operation

Level-II

Module Title: **Operating water reticulation, distribution and bulk water transfer system**

TTLM Code: **EIS WSW2 TTLM 0920v1**

September,2020

This module includes the following Learning Guides

LG37: Establish system constraints and prepare work site.

LG Code: EIS WSO2 M09LO1-LG-37

LG38: Monitor system performance and usage

LG Code: EIS WSO2 M09LO2-LG-38

LG39: Regulate flow

LG Code: EIS WSO2 M09LO3-LG-39

LG40: Regulate pressure

LG Code: EIS WSO2 M09LO4-LG-40

Instruction Sheet	Learning Guide37: Establish system constraints and prepare work site

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Determining system layout and operational problem areas.
- Planning work required to operate and adjust water reticulation system
- Determining work requirements for operation and monitoring of bulk water transfer systems
- Performing site checks to prevent damage to other utilities and the environment,
- Selecting and checking equipment and personal protective equipment
- Identifying and locating isolation valves and hydrants and follow standard organizational procedures for their operation.
- Identifying pumping stations and following correct operating procedures

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- Determine system layout and operational problem areas.
- Plan work required to operate and adjust water reticulation system
- Determine work requirements for operation and monitoring of bulk water transfer systems
- Performing site checks to prevent damage to other utilities and the environment,
- Select and check equipment and personal protective equipment
- Identify and locate isolation valves and hydrants and follow standard organizational procedures for their operation.
- Identify pumping stations and following correct operating procedures

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- 7”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks" in each information sheets on pages 28, 39, 44, 55, 62, 65, & 79.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets 1- 5 on pages 81-88 and do the LAP Test on page 89”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result;
8. Then proceed to the next LG.

Information Sheet-1	Determining system layout and operational problem areas

1.1. Introduction to water reticulation, distribution and bulk water transfer system

1.1.1. Water reticulation

The water reticulation system includes the design, operation and maintenance of water distribution, storm water and wastewater collection systems. It comprises all the public pipe works in a town or city, including pumping systems, access chambers and their construction and maintenance.

Water reticulation system comprises from:

i. Pipes and fittings

The water reticulation pipes are available in various types and sizes. It is divided into three groups based on material used in their manufacturing:

Metallic pipes: The pipes such as Cast Iron pipes, Steel pipes and Galvanized Iron pipes Iron pipes are quite stable for high water pressure projects. Steel pipe are extensively used for long distance and large diameter projects.

Figure 1.1. Gate Valve

Cement pipes: The pipes such as Cement pipes, Asbestos cement (AC) pipes, Cement concrete pipes. Cemented pipes are expensive but noncorrosive and extremely strong and durable

Figure 1.2. cement pipe

Plastic Pipes: The pipes such as Unplasticized PVC (UPVC) pipes, Polythene pipes (HDPE)

Figure 1.3. plastic pipe

Pipe fittings

Pipe fitting are important component of pipelines as they connect pipes and control pipe leakages. Various pipe fitting are used for distribution piping system. Choose the diameter of the fitting based on the size of pipe. These fitting are available with threading, mainly for metallic pipes. For PVC pipes, non-threaded fittings are normally used for smaller diameter pipes. For HDPE pipe fitting 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 size (diameter) 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 tubular pipe fitting, mainly in 300 mm length. It is used for extending pipeline.

G. Plug - It is used to plug the flow of water at dead ends.

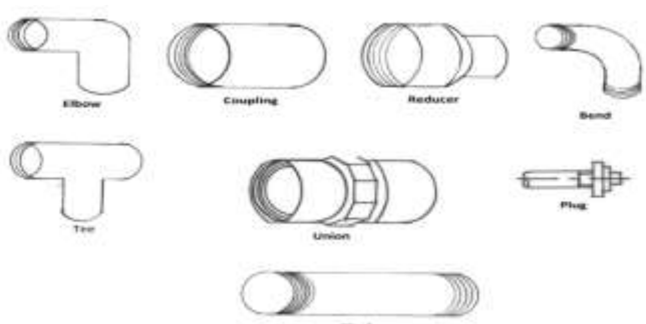


Figure 1.5. Pipe fitting

ii. **Chambers Access** may be provided by (non-man-entry) inspection chambers or (man-entry) manholes depending on the depth at which the pipe is laid. The guiding principle in the location of manholes or inspection chambers is that they should be so situated as to allow every length of pipe to be accessible for maintenance inspection and removal of debris.

Figure 1.6: manhole

A valve chamber is a room from which a gate or valve can be operated, or sometimes in which the valve is located.

Figure 1.7. valve chamber

iii. sluices

A **sluice** is a water channel controlled at its head by a gate. The terms sluice, sluice gate, knife gate, and slide gate are used interchangeably in the water and wastewater control industry. A sluice gate is traditionally a wood or metal barrier sliding in grooves that are set in the sides of the waterway. Sluice gates commonly control water levels and flow rates in rivers and canals.

iv. valves

The primary purpose of valves is to allow for isolation of mains or sections of main within the network. Another important function of valves is to control flow or pressure.

Isolation may be necessary when repairing main breaks or leaks or performing other distribution network maintenance activities. The most commonly used isolation valve is the gate valve. Gate valves should NOT be used to throttle flow.

Figure 1.8. Gate Valve

Control Valves are used to control flow or pressure in an area of the distribution network. Flow control valves can be used to throttle or limit flow, change flow direction, and prevent reverse flow (**check valves and backflow prevention valves**). An example of a flow control valve is a butterfly valve. It typically has several set positions and can be adjusted to allow various flows through piping.

Altitude valves are types of flow control valves that control flow in and out of storage facilities based on water level. When a tank reaches a maximum level the valve closes, preventing the tank from overflowing. When the water level in the tank drops due to system demands, the valve opens.

Pressure control valves control valves can be used to reduce pressure (pressure reducing valves), maintaining pressure (pressure sustaining valves), and protect against overpressure (pressure relief valves). Pressure reducing valves are used to create head loss and break pressure to keep system pressure less than the pressure ratings in pipes and to avoid other adverse impact of high pressure.

Figure 1.9 – Pressure Reducing Valve

Air Release Valves are used to eliminate air from a distribution network or to allow air into a distribution network. Air relief or air release valves relieve pockets of air which typically accumulate at high elevation points in a distribution network.

Vacuum relief valves allow air into the distribution network to protect the system against low pressures, including vacuum conditions. Vacuum relief valves are commonly used along transmission mains and at the discharge of pump stations to protect against low pressures that can occur as a result of sudden large changes to the flow velocity.

Figure 1.10 – Air Release Valve

Isolation valves should be located in a manner that will limit service interruptions during emergency repairs and general maintenance.

Check valves are used in distribution systems to prevent backflow. Check valves allow flow in only one direction.

v. Main taps

The water line tap is the valve that connects the homeowner's pipe to the city water main, all properties with running water must have a water main tap to receive water. When installing a water main, the tap allows the homeowner to connect a new water line service without affecting the surrounding neighbor's water.

When you're considering tapping a large diameter water main, it can be difficult to figure out how to go about the process. Though small taps are fairly common, those taps that are larger than 2" can create their own unique challenges.

Figure 1.11. Main taps

vi. meters

Meters measure, display, and record the amount of water that passes through a distribution system component.

Types of Meters

1. **Displacement Meters:** used as customer service meters having a diameter of 2-inches or less. It is used to measure low flow rates.

Figure 1.12. - Displacement Meter

2. Velocity Meters: Commonly used in pump stations, industrial facilities, and large diameter mains to measure high rates of flow. It do not accurately measure low flow rates. Include the Venturi, Turbine, and Propeller type meters

.

Figure 1.13. Velocity Meter

3. Compound Meters: used to measure flow at apartment, commonly complexes, schools, and that can typically have high rater use compared with daily of the displacement and velocity meters.

Figure 1.14 – Compound Meter

4. Electric Meters: measure flow magnetically (mag meter) or sonically. They are highly accurate if properly located.

Figure 1.15 – Electronic Meter

5. Proportional Meters: measure high flow rates at locations such as fire service lines.it do not measure low flows accurately.

Figure 1.16 – Proportional Meter

vii. Fire hydrant

The primary purpose of a fire hydrant is to provide water at high flow rates to aid in extinguishing fires. Fire hydrants can also be used for flushing pipelines in the event of taste and/or odor complaints. Fire hydrants can be used for supplying water to water trucks and construction equipment.

Types of Fire Hydrants

1. Dry-barrel hydrants

Include a shut-off valve and drain. The drain is open when the hydrants main valve is fully closed (otherwise the water left in the barrel once the main valve closes cannot escape and might freeze).

2. Wet-barrel hydrants

Will always be charged (have water in the hydrant). Have a shut- off valve at the outlet and can only be used in areas where freezing is not a concern.

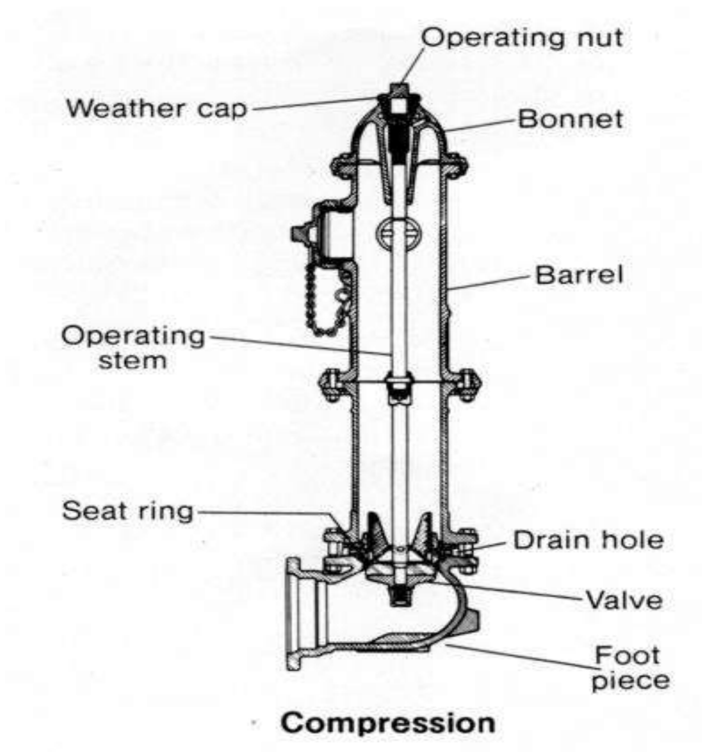


Figure 1.17. Dry Barrel Hydrant

Fire Hydrant Coding

Depending on the amount of water and water pressure each hydrant is paint its tops and caps using standardized color codes.

Table 1.1. Hydrant color and discharge

NFPA Top Colors		
Color	**GPM**	**Rating**
Blue	1500 or more	Very good flows
Green	1000-1499	Good flow for residential
Orange	500-999	Marginally adequate flow
Red	Below 500	Inadequate flow

viii. service reservoirs

A water reservoir or tank is normally a structure that allows a different inflow and outflow at any given time. When inflow is less than outflow, water is being drawn from storage.

1.1.2. Water distribution

Water distribution systems convey water drawn from the water source or treatment facility, to the point where it is delivered to the users.

Purposes of Distribution Networks

- The primary purpose of a distribution network is to deliver adequate volumes of safe drinking water to system customers at adequate pressures.
- Another important purpose of a distribution network is to provide adequate fire flows to areas of the system.

Components of Distribution Networks

The main elements of the distribution system are:

1. **Pipe systems**
2. **Pumping stations**
3. **Storage facilities**
4. **Fire hydrants**
5. **House service connections**
6. **Valves and Meters**
7. **Other appurtenances**

Storage facilities

Distribution storage tanks help offset system demand fluctuations.

Purpose

The three primary functions of distribution storage facilities are as follows:

Equalize Demands

One of the primary purposes for constructing a storage facility is equalization.

Water utilities like to operate treatment plants at a relatively constant rate however water use in most utilities varies significantly over the course of a day. Distribution storage facilities are typically designed to offset fluctuations in system demands, thus allowing a more constant rate of flow from the source of supply.

Minimize fluctuation in system pressure

Generally, the elevation of water stored in a tank determines the pressure in pipes which are directly connected to the tank. The larger the tank volume, the more stable the pressures in the distribution system despite fluctuations in demand or changes in pump operation. This type of design helps minimize capacity requirements of sources of supply, treatment facilities, and transmission and distribution mains, minimize fluctuations in system pressures, and increase distribution pumping efficiency.

Fire Protection

Distribution storage facilities are used to help meet fire flow needs in systems that provide fire protection.

Emergency Supply

Distribution storage facilities provide a volume of water that can be used to supply a system or parts of a system during an emergency event such as pump failures or main breaks.

System Storage Allocation

A combination of factors helps us determine the amount of water that must be stored.

Projected needs for fire, emergencies and equalization all contribute to the determination.

Useable Storage

The useable storage is the total volume of water in a storage facility that can provide minimum required pressures to the highest elevation customers who are served by the facility. The useable volume of water in a storage facility is generally allocated for the three primary distribution storage functions previously described in this Unit.

Equalization Storage

Equalization storage provides storage for the equalization of system demands and pressures. It is designed to handle the normal daily fluctuations in water level in a storage facility due to peaks in system demand.

Fire Storage

A reserve volume of water to help meet system fire flow needs. The volume of fire storage needed is dictated by the maximum fire flow needs in the system.

Emergency Storage

A reserve volume of water to help meet system supply needs during an emergency event. The volume of emergency storage needed is typically dictated by system demands.

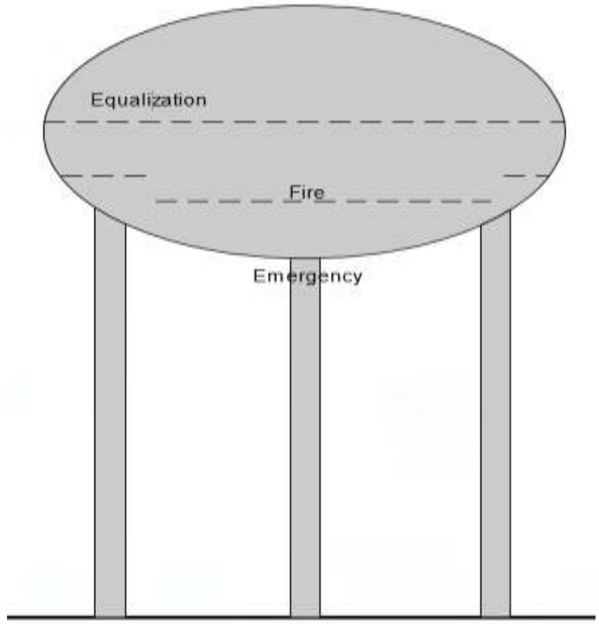


Figure 1.18. Schematic for System Storage Allocation

1.1.3. Bulk water transfer system

Bulk water supplies are used for both every day and emergency situations and include applications related to potable and non-potable water delivery systems and subsystems such as transmission and distribution pipelines, ship and aircraft transport, and water tankers/ wagons. Adequate water quality must be maintained in the bulk water filling, storage, transportation and distribution system/process so that safe water can be delivered to users.

Bulk water transmission systems typically have large diameter pipes and no direct connections to customers. The component of this system is the same as that of reticulation and distribution system except the larger size. A bulk water supply pipeline is used to transport large quantities of water across long distances at adequate pressure and flow.

Long distance projects uses the large diameter pipelines wherein more security and capacity is needed to transport the water and small diameter pipelines are being used for distribution to individual suppliers for short distances.

Three type of water transmission systems has been used, through which water is conveyed: Complete gravity flow, Direct pumping and Combined gravity & pumping. Pumping system are majorly used for water transmission for the vast plain areas, however in hilly regions gravity flow system is more economical to use.

In water supply system bulk water asset may include

Bulk water pipes, including:

Reinforced concrete, polyvinyl chloride (PVC), polyethylene, cast iron cement lined, ductile iron cement lined, glass reinforced piping, mild steel cement lined

Bulk water structures, including:

Meter pits, valve pits, regulators, person access chambers and pits, head walls, thrust blocks ,large mains, flow recorder **Pipes**

1. Cast Iron Pipe:

Cast Iron pipe is widely used for city water-distribution systems because of its high resistance to corrosion and consequent long life

Figure 1.19.cast iron pipe

2. Galvanized Iron Pipe (G.I).

G.I pipes are made of mild steel sheet.

Figure 1.20. galvanized steel pipe

3. Wrought Iron Pipe.

These types of pipes are like G. I. Pipes. They are also used to carry water, gas or certain other liquid from one place to another.

Figure 1.21. Wrought Iron Pipe.

4. Steel Pipe.

Steel pipes are used to carry water, gas or certain other liquid from one place to the other under pressure. These pipes are made from steel sheets

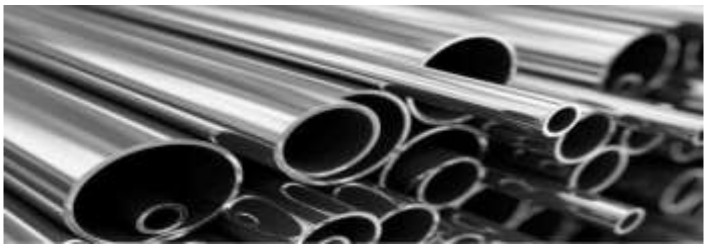


Figure 1.22. steel pipe

5. Copper Pipe.

Copper pipes are made of small diameter. Since copper does not admit rust, so these pipes are durable. However, as copper is costly, therefore, they are used in limited places.

Figure 1.23. copper pipe

6. Plastic Pipe.

These pipes – which include rubber and P. V. C. pipes – are used for the supply of water, acidic water, and alkaline water. Hot water should not be carried out.

Figure 1.24. plastic pipe

7. Asbestos Cement Pipe.

The asbestos pipe is made from asbestos, silica, and cement converted under pressure to a dense, homogeneous material possessing considerable strength.

Figure 1.25 asbestos cement pipe

8. Concrete Pipe.

The Pre-cast Concrete pipe is available in sizes up to 72 inches diameter, and sizes up to 180 inches have been made on special order.

Figure 1.26. Concrete pipe

9. **Vitrified Clay Pipe.**

Vitrified Clay Pipe is not often used as pressure pipe, but is widely used in sewerage and drainage for flow at partial depth.

Figure 1.27. vitrified clay pipe

10. Plastic pipe HDPE(highly dense polyethylene)

HDPE pipe is a type of flexible plastic pipe used for fluid and gas transfer and is often used to replace ageing concrete or steel mains pipelines.

Figure 1.28. HDPE pipe

Structures

Thrust blocks are used at these locations to prevent damage to the pipe caused by unsupported pipe movement. Tees, bends, plugs, hydrants, and other appurtenances and fittings require **thrust blocks** to restrain the pipe. ... **Thrust blocks** must bear against undisturbed soil.

Figure 1.29.thrust block

Valve chamber

A room from which a valve can be operated, or sometimes in which the valve is located.

Figure 1.30.valve chamber

Pumping stations, also called a **pump-house** in situations such as drilled wells and drinking water, are facilities including pumps and equipment for pumping fluids from one place to another.

Figure 1.31. pump station

person access chambers or pits

Inspection Chambers are a crucial part of any drainage system as they allow for testing, inspection and cleaning of the drainage system.

Manholes and Inspection Chambers are pit in place to serve the same purposes but Manholes are Large, build up with bricks that can even enable a person to physically climb down into the drainage system.

Figure 1.32. manhole

Erosion barriers

Erosion barriers are structure used to control runoff water and sediments flow to water pipes.

Headwalls

Precast concrete headwalls, wing walls, spillways and other precast pipe outfall structures help improve the flow of water into and out of connecting pipework and offer protection from erosion and scour caused by fast moving turbulent water.

A headwall also prevents the surrounding bank from eroding and sloughing into any adjacent watercourse, for example; attenuation ponds, detention basins, rivers, ditches and swales.

Figure 1.33. Head wall

1.2. Determining system layout

Before starting the operation of water reticulation, distribution and bulk water transfer system the operator is responsible for determining system lay out operational from drawings so that the operation is facilitated and operational problem areas can easily be determined and appropriate measures to be taken.

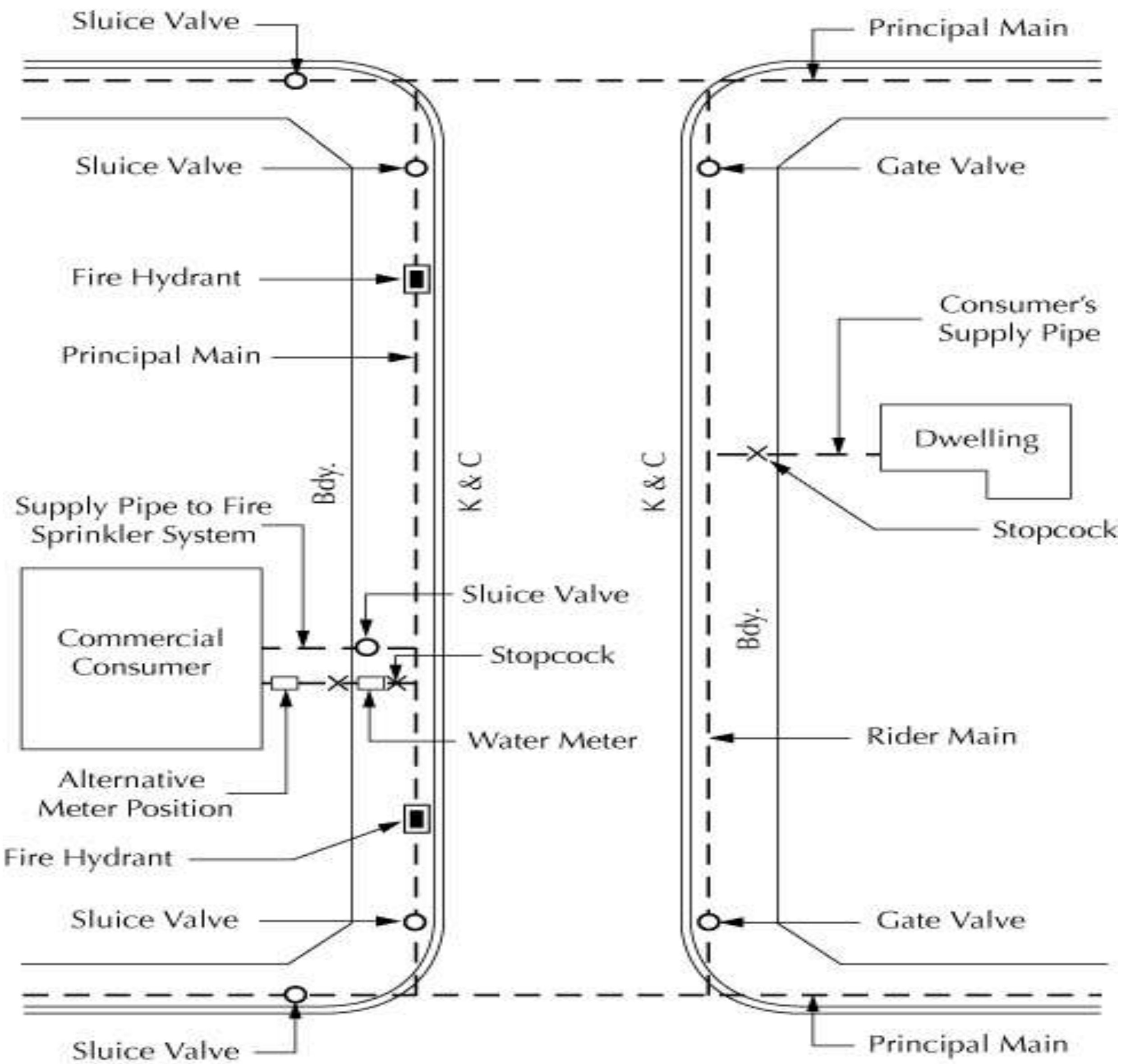


Figure 1.34.: Typical reticulation system

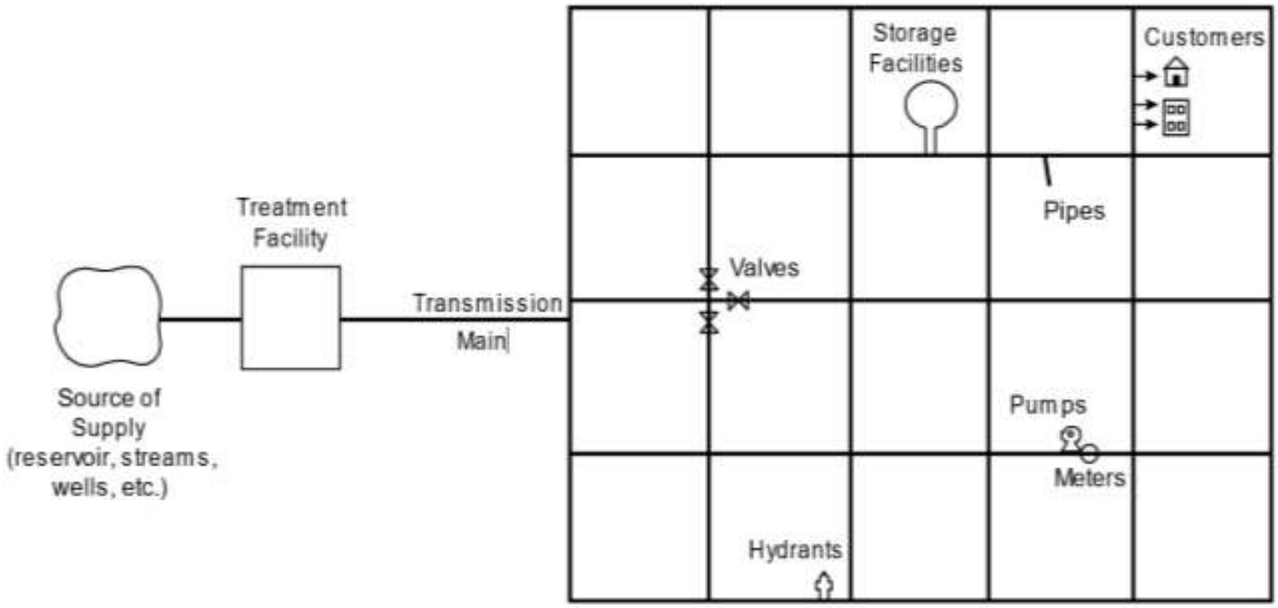


Figure 1.35. – Distribution System Layout

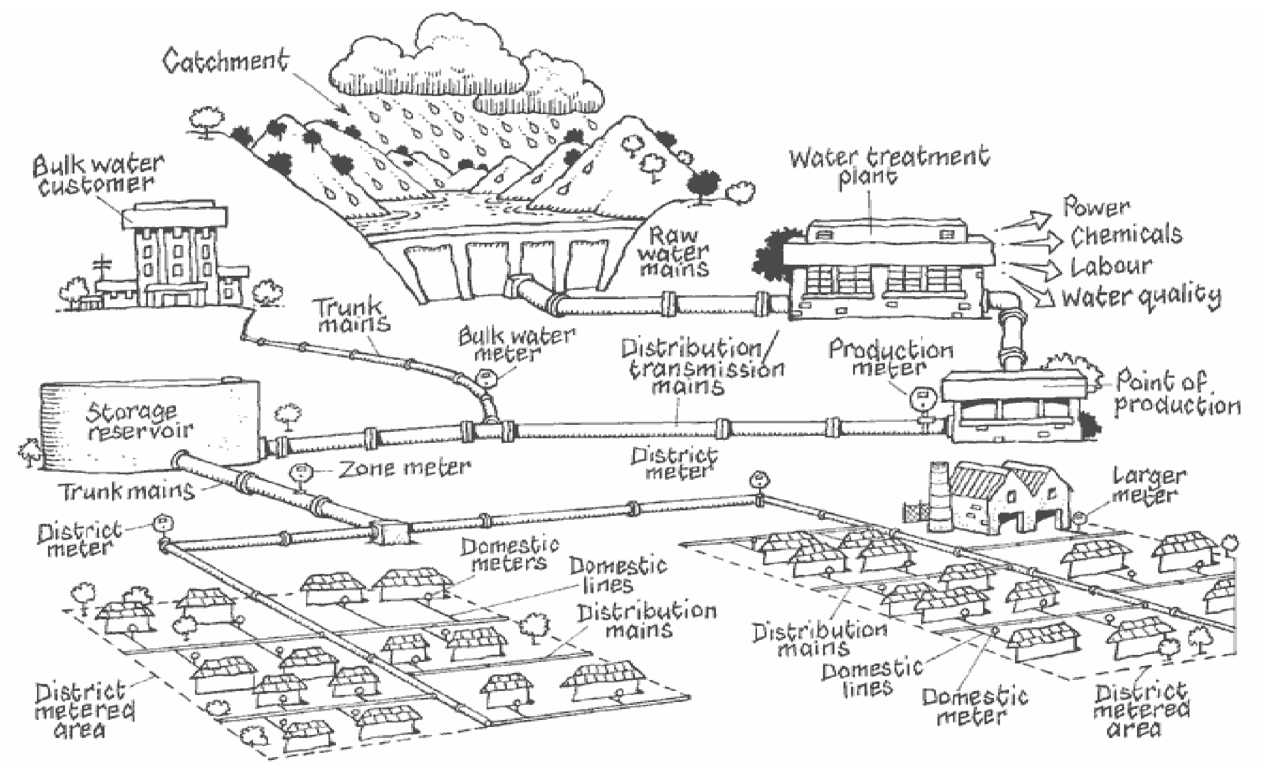


Figure 1.36. Water supply system layout

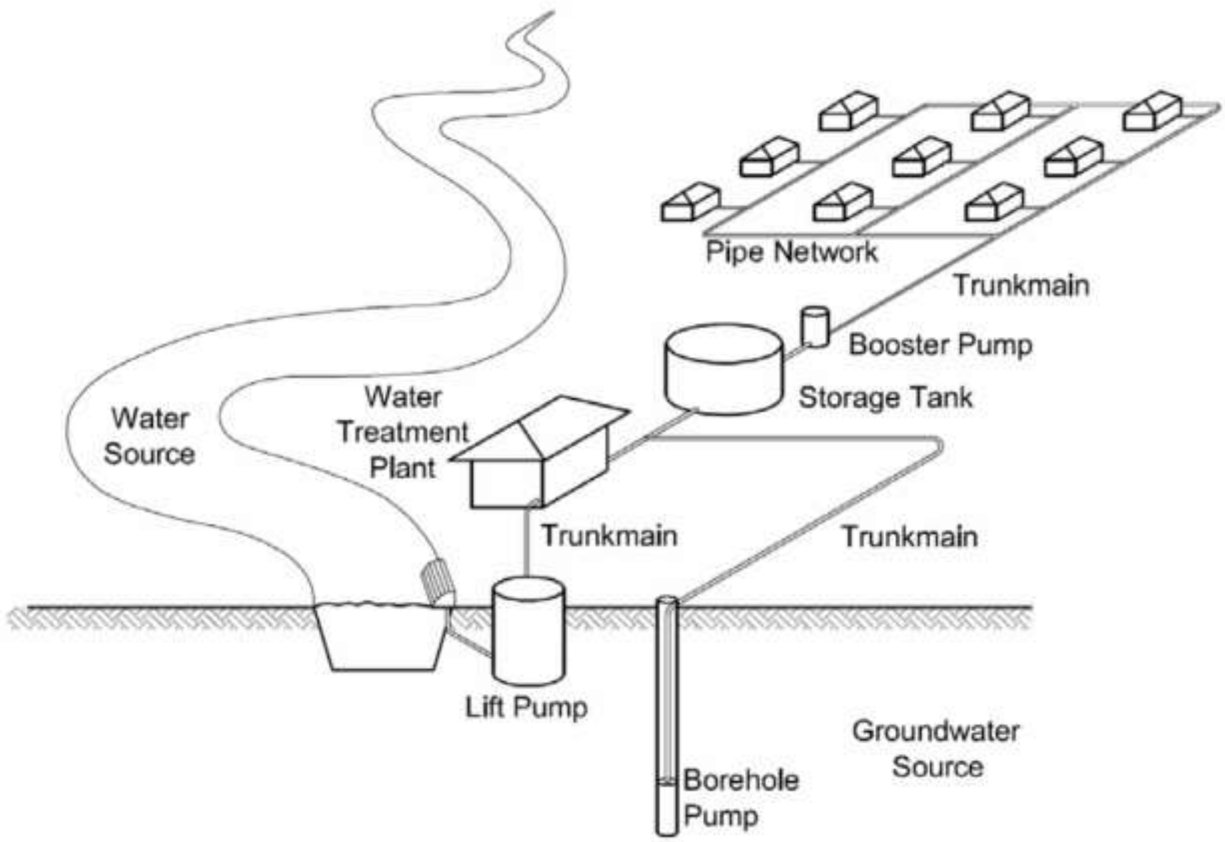


Figure 1.37. Bulk water transfer layout

1.3. Determining operational problem areas

Operation refers to the routine activities and procedures that are implemented to ensure that the water supply system is working efficiently. The purpose of reticulation and distribution system is to deliver water to consumer with appropriate quality, quantity and pressure. Distribution and reticulation system is used to describe collectively the facilities used to supply water from its source to the point of usage. But often times the system face different problems so the operator of the system is responsible for investigating/ determining those problems.

Requirements of good distribution and reticulation system

1. Water quality should not get deteriorated in the reticulation and distribution pipes.
2. It should be capable of supplying water at all the intended places with sufficient pressure head.
3. It should be capable of supplying the requisite amount of water during firefighting.
4. The layout should be such that no consumer would be without water supply, during the repair of any section of the system.
5. All the distribution pipes should be preferably laid one meter away or above the sewer lines.
6. It should be fairly water-tight as to keep losses due to leakage to the minimum.

Problems in Transmission/ distribution systems

(i) Leakage

Water is often wasted through leaking pipes, joints, valves and fittings of the transmission system either due to bad quality of materials used, poor workmanship, and corrosion, age of the installations or through vandalism. This leads to reduced supply and loss of pressure. Review of flow meter data will indicate possible leakages.

The leakages can be either visible or invisible. In the case of invisible leaks sections of pipeline can be isolated and search carried out for location of leaks. Most common leaks are through the glands of sluice valves. Leaks also occur through expansion joints where the bolts have become loose and gland packing is not in position.

(ii)Air Entrapment

Air in free form in rising main collects at the top of the pipeline and then goes up to higher points. Here, it either escapes through air valves or forms an air pocket which in turn, results into an increase or head loss. Other problems associated with air entrainment are:

surging, corrosion, reduced pump efficiency and malfunctioning of valves or vibration. In rare cases bursting of pipes also is likely to occur due to air entrainment. There should always be air valve chamber with cover slabs for the protection of the air valve and it should always be kept leakage free and dry. Frequent inspection should be conducted to check, whether Air valves are functioning properly and to ensure that there is no leakage through air valve

(iii) Water Hammer

The pressure rise due to water hammer may have sufficient magnitude to rupture the transmission pipe or damage the valves fixed on the pipeline. Water hammer in water supply systems occurs due to rapid closure of valves and sudden shut off or unexpected failure of power supply to the pumps. The care should be taken to open and close sluice valves gradually.

(iv) Lack of Records/ Maps etc.

Generally, maps showing the actual alignments of transmission mains and location of other pipes & the valves on the ground may not readily be available. The location of pipes and the valves on the ground becomes difficult in the absence of such updated maps and thus, need to be prepared and updated them from time to time. Some minimum information about the location and size of pipes and valves and the direction of opening of valves etc. is required to operate and maintain the system efficiently.

Self-Check -1	Written Test

Direction I: Fill in the Blanc space item (2 points each)

Instruction: fill in the blank space from the words bank provided on the top of the questions and write your answer on the answer sheet provided in the next page:

Butterfly valve **Altitude valve** **Gate valve** **Pressure**

Reducing valve **Air release valves** **Check valves**

1. ______________________Are used in distribution systems to prevent back flows.
2. __________________Are used to create head loss and "break" pressure to keep system pressures less than the pressure ratings in pipes and to avoid other adverse impacts of high pressure.
3. ___________________________ are the most commonly used isolation valve.
4. _____________________ are a flow control valve that can be adjusted to allow various flows through piping.
5. ______________________ are used to eliminate air from a distribution network or to allow air into a distribution network.
6. ________________ is a type of valve used to control flow in and out of storage facilities based on water level.

Direction II: Multiple choice item (2 points each)

Instruction: Choose the best answer of the following questions and write your answer on the answer sheet provided:

1. Select the component of water reticulation system
   A. Pumping system
   B. Storage facility
   C. Access chambers
   D. All
2. Identify metallic reticulation pipe
   A. Cast iron
   B. PVC
   C. HDPE
   D. Concrete pipe
3. Which pipe fitting is responsible for changing the direction of reticulation system?
   A. Union
   B. Reducer
   C. Elbow
   D. Nipple

4. A room from which a gate or valve can be operated, or sometimes in which the valve is located is?

   A. meter pit

   B. Personal access chamber

   C. Valve chamber

   D. Sluice

5. Which type of valve do you recommend if isolation of water reticulation system is required

   A. Gate valve

   B. Check valve

   C. Pressure reducing valve

   D. Back flow preventions

6. Flow control valves can be used to

   A. Throttle or limit flow,

   B. Change flow direction

   C. Prevent reverse flow

   D. All

7. Which type of water meters are used in customer service line

   A. Velocity Meters

   B. Displacement Meters

   C. Compound Meters

   D. Electric Meters

Direction III: Matching item (2 points each)

Instruction: Match column B with column A of the following questions and write your answer on the answer sheet provided in the next page:

	A		B
1.	A reserve volume of water to help meet system fire flow needs	A.	Dry-barrel hydrants
2.	Problem in transmission line	B.	Bulk water transmission systems
3.	Reducing water flow	C.	Measure of water consumption
4.	Water quality should not get deteriorated in the reticulation and distribution pipes.	D.	Pressure control valves
5.	Plastic pipe	E.	Leakage
6.	typically have large diameter pipes and no direct connections to customers	F.	Distribution storage tanks
7.	Water meter	G.	Requirement of distribution system
8.	The drain is open when the hydrants main valve is fully closed	H.	Reducer
9.	control valves can be used to reduce pressure	I.	PVC
10.	helps offset system demand fluctuations.	J.	Fire storage

Answer Sheet-1

Name: ___________________________ Date: ________________

Score = ___________
Rating: ____________

Fill in the Blanc space questions

1. ....
2. ....
3. ....
4. ....
5. ....
6. ....
7. ....

Multiple choice questions

1. ....
2. ....
3. ....
4. ....
5. ....
6. ....
7. ....
8. ....
9. ....

Matching questions

1. ....
2........................
3. ....
4. ....
5. ....
6........................
7. ....
8........................
9........................
10.......................

Note: **Satisfactory rating - 26 points and above Unsatisfactory - below 26 points**

You can ask you teacher for the copy of the correct answers.

Information Sheet-2	Planning work required to operate and adjust water Reticulation system

2.1. Planning basics

Planning is a process of forecasting future outcomes that may be uncertain or even unknown. It means assessing the future and making provision for it by gathering facts and opinions in order to formulate an appropriate course of action. Planning thus develops a strategy and defines expected outcomes (objectives) for undertaking a specific task before committing to such a task.

Planning-is thinking through an activity before performing or doing it/the actual work. If it is plane well; reduce or avoid mistake, reduce wastage of material, save time, energy and money and obtain a finished product of superior quality.

Planning, in its broader perspective, involves advance thinking as to what is to be done, what are the activities, how it is to be done, when it is to be done, where it is to be done, what is needed to do it, who is to do it and how to ensure that it is done; all of this is channelized to generate and evaluate options for evolving an action plan aimed at achieving the specified goals.

A plan prepared well before the commencement of construction in a project, can be instrumental in formulating directions, coordinating functions, setting targets, forcasting resources, budgeting costs, controlling performance and motivating people.

2.2. Organizational standard

The term standard refers specifically to a specification that has been approved by a standard setting organization. The standards most frequently encountered in construction work will now be described under two headings; 'general-purpose standards' and 'nuclear standards. Both standards specify systems which will maintain and assure quality; the difference is that whereas the first category is oriented to the requirements of the market place, the second is aimed more at satisfying the statutory requirements imposed by regulatory authorities particularly in respect of safety.

Federal democratic republic of Ethiopia, ministry of water resources formulates and adopt national standards and criteria for the design, installation, construction, operation, maintenance, inspection and other activities in all water resources management undertakings.

Any water work activities should be agreed with the standards and full fill with the following conditions.

- Adopt the water sector as the responsible authority for issuance of the necessary professional certification, professional permits and licenses for consultancy, contracting, as well as manufacturing and importing related to water resources development.
- Provide the necessary legal framework for penalties commensurate with the violation of legal provisions relating to water resources.

2.3. Legislative and organizational requirements

Legislative and organizational requirements are indicators of actual or potential risk of abuse, neglect or harm. You need to work within the parameters of accepted standards, such as:

- protocols defined in legislation
- Organizational procedures.

Legislative and organizational requirements may include:

- Relevant federal water legislation and regulations
- Local authority by-laws
- Organizational procedures
- Environmental
- Cultural heritage
- OHS procedures
- Dangerous goods and chemicals

2.3.1. Relevant federal water legislation and regulations

Relevant federal water legislation and regulations is legislative framework created for the implementation of the water proclamation and the operational of the Ethiopian Water Resources Management policy.

Development of the water policy, formulation of the national water sector strategy, the issuance of water resources management proclamation and the preparation of the 15-year Water Sector Development Programme (WSDP) beginning 2002 and in addition Ethiopia's effective involvement in the Nile Basin Initiative among others, are signs of effective governance by way of creating the ground for sustainable water resources development and management.

Focus will be given in this section for the Water Resources Management Proclamation issued in 2000(FDRE, 197/2000) and the Water Resources Management Regulations, which is due to be approved soon by the Council of Ministers before the end of 2004.

Water Resources Management Proclamation

The proclamation was issued with clear objectives and purpose to implement the, fundamental principles objectives, goal and the stipulated sectoral and cross cutting policy issues articulated in the water policy for Ethiopia.

- The proclamation has Nine Parts and 33 Articles and several sub- articles.
- The social, legal, environment, institutional and many more other related legislative provisions are treated here as appropriate and required.
- The proclamation declares, "All water resources of the country are the common property of the Ethiopian people and the state". (Federal Democratic Republic of Ethiopia (FDRE),197/2000 Article 5)
- Regarding water use priority, the proclamation states, “Domestic water use shall have priority over and above any other water uses". (FDRE, 197/2000 Article 7sub-article 1).

Relevant federal water Regulations

Relevant federal water regulations are those covered in the proclamation, but detailing the procedures as to how the various legal materials contained in the proclamation are to be achieved on the ground. The Regulation has TEN parts and 44 relevant Chapters (Articles).

2.3.2. Local authority by-laws

Planning and implementing of water resources development and management, which are within the legal competence of the Regional States are further transferring down to the local administrative units at Woreda levels known as water desk. These desks are responsible for planning, budgeting, implementing and monitoring and follow-up of water projects and programs, in their respective localities.

2.3.3. Organizational procedures

Procedure is the fundamentals of the policy, outlining what has to be done to implement the policy. A policy is a course of action or guidelines to be followed whereas a procedure is the 'nitty gritty' of the policy, outlining what has to be done to implement the policy. For example, a staff recruitment policy could involve the following procedures:

- All vacant paid positions will be advertised in local and state-wide papers.
- The advertisements will have details of duties, salary range, closing date and contact details.
- All interested people will be mailed job descriptions and information about the organization

The following strategies will support you to increase your knowledge and understanding of your responsibilities:

I. Current legislation

Obtain a copy of the legislation that informs your role and what some of your agency's policies are based on. Discuss how the legislation underpins the work of your agency with your supervisor.

II. Agency procedures

Read the Policies and Procedures Manual of your agency which details work practice guidelines in line with relevant legislation and regulations.

III. Consultation

Use all opportunities offered to you to consult with others (including involvement informal Supervision sessions with your supervisor and/or mentor) about your legal and workplace responsibilities and obligations.

2.3.4. Environmental requirements

Depending on the regulation, a violation can result in both civil and criminal penalties. Ethiopia has established 16 the fundamental general policy principles that guide the equitable, sustainable and efficient development, utilization, conservation and protection of water resources in Ethiopia as it is stated in the document of Ethiopian Water Resources Management Policy. Thus, any water resources development construction should obey federal water legislation and regulations.

2.3.5. Cultural heritage

Cultural heritage is the legacy of tangible and intangible attributes of a group or society that are inherited from past generations, maintained in the present and bestow for the benefit of future generations.

Tangible culture:-Tangible cultures are those of features such as buildings, monuments, landscapes, books, works of art, and artifacts.

Intangible culture: - Intangible cultures are those of attributes such as folklore, traditions, language, and knowledge, and natural heritage (including culturally significant landscapes, and biodiversity.

Ethiopia is rich in linguistic and cultural diversity. This diversity includes tangible and intangible heritage with both traditional and modern cultural expressions, languages, and centuries old know how in handicraft production. The intangible heritage of Ethiopia is also rich with an exceptional variety including ceremonies, festivals, celebrations, rituals, and other living expressions.

2.3.6. OHS procedures

Some kinds of accidents commonly caused by lack of Observing OHS policies and procedures are:

- Poor Interpretation of work instructions according to job requirements
- Well organized and selected tools are not available
- Substandard and unsafe installation
- Control devices remain unchecked

2.3.7. Dangerous goods and chemicals

Dangerous goods or **hazardous goods** are solids, liquids, or gases that can harm people, other living organisms, property, or the environment. Dangerous goods are substances, mixtures or articles that, because of their physical, chemical (physicochemical) or acute toxicity properties, present an immediate hazard to people, property or the environment. Hazardous chemicals are any substance, mixture or article that satisfies the criteria for a hazard class in the Globally Harmonized System of Classification and Labeling of Chemicals (GHS) that are used in the workplace. These can be classified according to their health and physicochemical hazards.

Regulatory Requirements

The World Harmonized System of Classification and Labeling of Chemicals (WHS) Regulation 2011 covers workplace hazardous chemicals and dangerous goods under a single framework for hazardous chemicals and introduces a new hazard classification and hazard communication system based on the United Nations' Globally Harmonized System of Classification and Labelling of Chemicals (GHS).

All hazardous chemicals and dangerous goods such as solvents, fuel, hydraulic fluid, oil and other potentially hazardous liquids (including batteries) must be stored in a secure, bunded facility as per the relevant standard to prevent spills and leaks escaping into the environment and reduce the risk of fire.

The following rules should be followed.

- All containers holding dangerous goods or hazardous chemicals used in the work place need to be appropriately labeled and labels must not be removed, defaced, modified or altered in any way.
- Employees must be trained in relation to the storage and use of dangerous chemicals and hazardous chemicals.

2.4. Reticulation system operation and adjustment Plan

The planning of operation and adjustment of water reticulation system includes the following points:

Table 2.1. Reticulation system operation and adjustment Plan

RN	Operation	Required materials tools, and equipment	Responsible person	Time	Budget
1.	Perform Routine Flushing				
2.	Perform Routine Valve Turning				
3.	Operate Well or Booster Pumps				
4.	Operate Fire Hydrants				
5.	Collect Routine Monthly Bacteriologic Samples				
6.	Operate or Control Water Storage				
7.	Perform Pressure Tests & Leakage Detection				

8.	Disinfect & Sample New Mains				
9.	Read Meters/Remotes Test Meters				
10.	Repair Meters/Remotes Install Meters/Remotes				
11.	Manipulate Services, Taps, Curb Stops				
12.	Perform Turn Ons & Shut Offs				
13.	Conduct Formal Cross Connection Inspections				
14.	Enforce Formal Cross Connection				
15.	Records Review Device Test Reports				
16.	Respond to Customer Complaints				
17.	Schedule Maintenance program				
18.	Maintain Distribution Appurtenance Records				
19.	Repair Water Mains				
20.	Repair Hydrants				
21.	Repair Well or Booster Pumps				
22.	Repair Control Valves				
23.	Repair Distribution Valves				

Self-Check -2	Written Test

Direction I: Multiple choice item (2 points each)

Instruction: Choose the best answer for the following questions and write the letter of your answer on the answer sheet provided.

1. What is a standard?

A. It is a specification that has been approved by a standards setting organization.

B. Is an indicator of actual or potential risk of abuse, neglect or harm?

C. Is a course of action or guidelines to be followed whereas a procedure is the 'nitty gritty' of the policy

D. All

2. Items to be included in contract specifications and drawings are:

A. Restrictions on the use of explosives, if any.

B. Restrictions on the burning of combustible materials as a disposal procedure

C. Required minimum depth of earth cover over buried materials, if applicable.

D. All

3. The national standard specifications are used to:

A. ensure adherence to laws and regulations, prevent conflicts within the

B. specifications and between the specifications and other contract requirements,

C. prevent omission of essential elements and inclusion of extraneous materials,

D. Provide a uniform basis for interpretation, and ensure uniform quality of a project works.

E. All

4. ---------is solids, liquids, or gases that can harm people, other living organisms, property, or the environment.

A. Dangerous goods

B. Inflammable goods

C. Poisonous goods

D. Harmless goods

5. One of the following is the operator's job of water reticulation system

A. Perform Routine Flushing

B. Perform Routine Valve Turning

C. Operate Well or Booster Pumps

D. All of the above

Answer Sheet-2

Score = ___________
Rating: ____________

Name: ____________________________ Date: _________________

Multiple choice questions

1. ....
2. ....
3. ....
4. ....
5. ....

Note: **Satisfactory rating - 12 points and above Unsatisfactory - below 12 points**

You can ask you teacher for the copy of the correct answers.

Information Sheet-3	Determining work requirements for operation and monitoring of bulk water transfer systems

3.1. Work requirement for operation and monitoring process

Work requirements for operation and monitoring of bulk water transfer systems are determined in line with specifications and instructions.

Determining work requirement is a process of identifying and arranging all necessary things by reading and interpreting the given design plans, drawings, specifications and instructions that can be used to accomplish the specific construction works.

In bulk water transfer system operation and monitoring the following work requirement should be determined

Example daily work requirements

- Check water meter readings and record water production.
- Check and record water levels in storage tanks and service reservoirs.
- Check chemical solution tanks and record amounts used.
- Inspect chemical feed pumps.
- Check and record residual chlorine at the chlorine contact tank and in the distribution system.
- Inspect inlet pumps, motors and controls.
- Record inlet pump running times and pump cycle starts.
- Complete a daily security check.

Example annual tasks

The schedule for these tasks is spread throughout the year with some allocated for September, some for October, etc. so that workload is managed sensibly. Some of these tasks may need to be completed three or four times a year.

- Overhaul chemical feed pumps.
- Inspect and clean chemical feed lines and solution tanks.

- Calibrate equipment's.
- Operate all valves inside the treatment plant and pump-house. Maintain log continuously throughout the year.
- Review emergency response plans.
- Inspect chemical safety equipment and repair or replace as needed.
- Inspect, clean and repair control panels in pump house and treatment plant.
- Inspect storage tanks for defects and deficiencies, and clean if necessary.
- Flush the distribution system and exercise/check all fire hydrant valves.
- Perform preventive maintenance on treatment plant and pump house buildings**.**

Statutory approvals and conditions

Operation of water reticulation, distribution system and bulk water transfer system arrangements should meet requirements of Environmental Assessment Procedures and Guidelines of Ethiopia according to environmental impact assessment (EIA) Guideline document (EPA 2002). This guideline follows the conventional pattern adopted in many other parts of the world, and makes provision for screening, scoping, identification and evaluation of impacts, the development of environmental management and monitoring plans, consideration of alternatives etc. At the project identification phase, based on EPA's guideline projects are categorized in one of the following three categories:

Schedule 1: Projects which may have adverse and significant environmental impacts, and may, therefore, require full EIA.

Schedule 2: Projects whose type, scale or other relevant characteristics have potential to cause some significant environmental impacts but not likely to warrant an environmental impact study.

Schedule 3: Projects which would have no impact and does not require environmental impact assessment.

Environmental aspects of operation

According to the guideline, all projects in environmentally sensitive areas are treated as equivalent to Schedule 1 activities irrespective of the nature of the project. Before operation of water system work implementation there should be environmental protection agency approval. The environmental impact of construction contributes to global warming. Water supply operational projects remove hazardous chemical wastes. Infrastructure developments cause pollution and produce waste.

3.2. Operation and monitoring of bulk water transfer systems

Monitoring to ensure an adequate level of residual disinfectant in the bulk water systems is important to control growth of microorganisms and inhibit biofilm formation. Monitoring should be conducted at least at the water filling or connection point, in the pipeline or bulk water transportation system during storage, transmission and at the point of delivery to the consumer. Residual disinfectant levels will diminish over time, depending on type of disinfectant, disinfectant demand of water, piping and tank container materials, water temperature, pH, venting, circulation of water or recontamination from external source.

In addition to operational monitoring, regular maintenance including scheduled inspection, cleaning, repair and asset replacement are key to ensure good water quality within the bulk water systems. Inspections should check for leaks, non-approved paint/coatings on surfaces, chips, damage and degraded gaskets. Repair and cleaning activities can pose contamination risks.

Self-Check -3	Written Test

Direction I: Multiple choice item (2 points each)

Instruction: Choose the best answer for the following questions and write the letter of your answer on the answer sheet provided.

1. ----------------is a process of identifying and arranging all necessary things by reading and interpreting the given design plans, drawings, specifications and instructions that can be used to accomplish the specific construction works.
   A. Work requirement
   B. Organizational procedure
   C. OHS procedure
   D. Dangerous goods
2. Operation of water reticulation, distribution system and bulk water transfer system arrangements should meet requirements of
   A. Environmental Assessment Procedures and Guidelines of Ethiopia
   B. Work requirement
   C. Dangerous goods
   D. Distribution network
3. Identify the false statement
   A. Before operation of water system work implementation there should be environmental protection agency approval.
   B. The environmental impact of construction contributes to global warming Nipple
   C. Water supply operational projects remove hazardous chemical wastes
   D. Infrastructure developments eliminate pollution and remove waste.

Answer Sheet-3

Score = ___________

Rating: ____________

Name: ____________________________ Date: ________________

Multiple choice questions

1. ....
2. ....
3. ....

Note: **Satisfactory rating - 3 points and above Unsatisfactory - below 3 points**

Information Sheet- 4	Performing site checks to prevent damage to other utilities And the environment

4.1. Hazard identification

4.1.1. Definition

A hazard is any biological, chemical, physical or radiological agent that has the potential to cause harm. A hazardous event is an incident or situation that can lead to the presence of a hazard (what can happen and how). Risk is the likelihood of identified hazards causing harm in exposed populations in a specified timeframe, including the magnitude of that harm and/or the consequences.

Hazards may occur or be introduced throughout the water system, from catchment to consumer. Effective risk management, therefore, requires identification of all potential hazards, their sources, possible hazardous events and an assessment of the risk presented by each. The hazard identification step, therefore, requires the water safety plan team to consider all potential biological, physical, chemical and radiological hazards that could be associated with the water supply.

4.1.2. Types of hazard in distribution system

While operating water distribution, reticulation and bulk water transfer system one can expose to various type of hazardous activity may be exposed:

1. Performing hot works in explosive atmospheres (i.e. solvent or dust laden atmospheres)
2. Tying into live piping systems
3. Working at heights, off ladders or scaffolds
4. Working in confined spaces, trenches or excavations
5. Construction plant and equipment moving around site
6. Working close by to suspended loads and lifting equipment
7. Being exposed to buried services and or electrical cables

8. Being exposed to hazardous wastes

4.1.3. Hazard identification process

Identify actions necessary to eliminate or control the risks associated with the hazard. After the hazard has been identified, reviewed and assigned a risk designation, it will be necessary determine what controls (measures) necessary to eliminate, reduce or minimize the risks associated with the hazard.

To control a hazard, review all available health and safety information about the hazard such as

- regulations,
- manufacturers literature,
- results of testing,
- MSDS,
- controls already in place,
- health policies and procedures,
- industry standards,
- Best practices, information from reputable organizations, etc.

4.1.4. Controlling hazard

Hazards should be controlled at their source (where the problem is created). The closer a control is to the source of the hazard, the better able to control potential exposures/risks. Hazards can be controlled:

- At the source
- Along the path to the worker (between the source and the worker)
- At the worker (always the last choice)

Hierarchy of hazard control

Hierarchy of hazard control is a system used in industry to minimize or eliminate exposure to hazards.

It is a widely accepted system promoted by numerous safety organizations. This concept is taught to managers in industry, to be promoted as standard practice in the workplace. Various illustrations are used to depict this system, most commonly a triangle.

The hazard controls in the hierarchy are, in order of decreasing effectiveness:

- Elimination
- Substitution
- Engineering
- Administration
- Personal protective equipment

Elimination

- eliminating the hazard
- physically removing it
- it is the most effective hazard control.
- for example, if employees must work high above the ground, the hazard can be eliminated by moving the piece they are working on to ground level to eliminate the need to work at heights.

Substitution

- Substitution is the second most effective hazard control
- involves replacing something that produces a hazard (similar to elimination) with something that does not produce a hazard
- for example, replacing lead-based paint with acrylic paint. To be an effective control, the new product must not produce another hazard.

Engineering *controls*

- it is the third most effective means of controlling hazards
- These do not eliminate hazards, but rather isolate people from hazards.
- Capital costs of engineered controls tend to be higher than less effective controls in the hierarchy; however they may reduce future costs.

For example, a crew might build a work platform rather than purchase, replace, and maintain fall arrest equipment. "Enclosure and isolation" creates a physical barrier between personnel and hazards, such as using remotely controlled equipment.

Administrative controls

- Administrative controls are changes to the way people work.
- Examples of administrative controls include procedure changes, employee training, and installation of signs and warning labels
- Administrative controls do not remove hazards, but limit or prevent people's exposure to the hazards.

Personal protective equipment

- Personal protective equipment (PPE) includes gloves, respirators, hard hats, safety glasses, high-visibility clothing, and safety footwear.
- PPE is the least effective means of controlling hazards because of the high potential for damage to render PPE ineffective.
- Additionally, some PPE, such as respirators, increase physiological effort to complete a task and, therefore, may require medical examinations to ensure workers can use the PPE without risking their health.

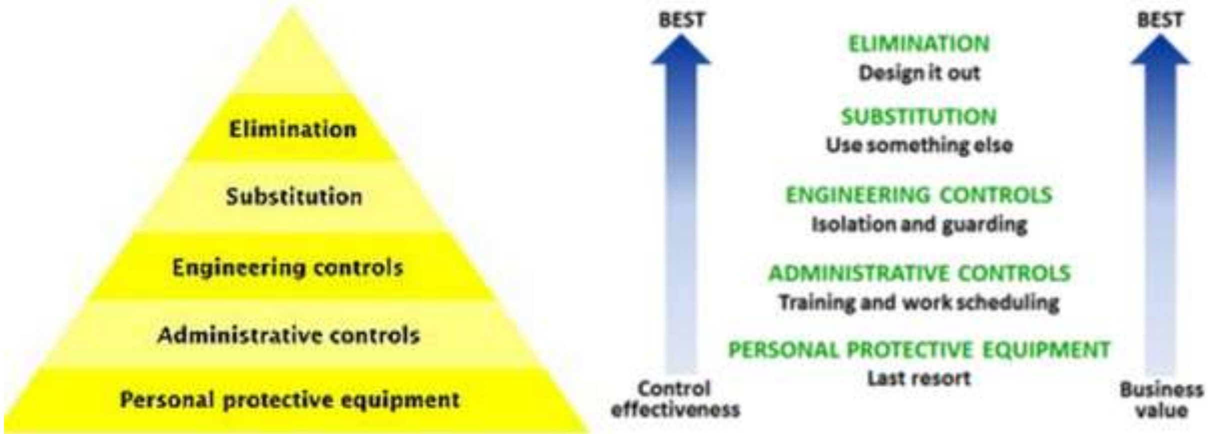


Figure 35. Hierarchy of hazard control.

On the left, illustrated as a triangle, on the right using arrows. In both images the most effective means is at the top, and the least effective at the bottom.

4.1.5.Hazardous materials handling

Hazardous material is any solid, liquid, or gas that can harm people, other living organisms, property, or the environment.

Rules for Safe Handling of Hazardous Materials

These 11 rules are presented in no particular order. They are all top priorities for chemical handlers. However, feel free to rearrange them in whatever order you think is best for your workplace, your workers, and your material hazards.

The followings are rules for handling hazardous materials:

1. Follow all established procedures and perform job duties as you have been trained.
2. Be cautious and plan ahead. Think about what could go wrong and pay close attention to what you're doing while you work.
3. Always use required personal protective equipment (PPE) and inspect it carefully before each use to make sure it's safe to use. Replace worn out or damage PPE; it won't provide adequate protection.

4. Make sure all containers are properly labeled and that the material is contained in an appropriate container. Don't use any material not contained or labeled properly. Report any damaged containers or illegible labels to your supervisor right away.
5. Read labels and the material safety data sheet (MSDS) before using any material to make sure you understand hazards and precautions.
6. Use all materials solely for their intended purpose. Don't, for example, use solvents to clean your hands, or gasoline to wipe down equipment.
7. Never eat or drink while handling any materials, and if your hands are contaminated, don't use cosmetics or handle contact lenses.
8. Read the labels and refer to MSDSs to identify properties and hazards of chemical products and materials.
9. Store all materials properly, separate incompatibles, and store in ventilated, dry, cool areas.
10. Keep you and your work area clean. After handling any material, wash thoroughly with soap and water. Clean work surfaces at least once a shift so that contamination risks are minimized.
11. Learn about emergency procedures and equipment. Understanding emergency procedures means knowing evacuation procedures, emergency reporting procedures, and procedures for dealing with fires and spills. It also means knowing what to do in a medical emergency if a co-worker is injured or overcome by chemicals.

4.1.6. Electrical safety for disconnecting and changing meters and fittings

Electrical hazards can be controlled by

Insulation

Insulation such as glass, mica, rubber and plastic is used on conductors to prevent shock, fire, and short circuits. Before you work with electrical equipment, especially power tools and extension cords always check the insulation before connecting to a power source to be sure that there are no exposed wires.

Grounding

This is a secondary means of protection in which an intentional conductive connection is made between an electrical circuit and the ground or ground plane. By grounding a tool or electrical system a low-resistant path to the earth is created to prevent the buildup of voltages that may cause a hazard. It is important that all electrical service and equipment be appropriately grounded.

Safe Work Practices

These must be employed by all plant personnel when working with or around electrical equipment. Work practices may include de-energizing electric equipment before inspecting or making repairs, using only tools that are in good repair, using good judgment when working near energized lines and using the right protective equipment.

4.2. Lock-out procedures for mechanical and electrical installations

Lockout/Tagout Program

Standard operating procedures should be established for all equipment that has the potential for accidental start-up or movement caused by an energy source such as electricity, hydraulics, pneumatic, rotating equipment, gravity, stored energy, pressure and water flow.

Purpose

these procedures usually are in the form of a lockout/tagout program. The purpose of a lockout/tagout program is to ensure that all personnel follow standardized shutdown and start-up procedures to prevent accidental equipment start up, energization or release of stored energy and personal injury or property damage.

A lockout/tagout program should include the following basic elements:

An energy control program that consists of energy control procedures for each piece of equipment, employee training and periodic inspections to ensure that the appropriate procedures and energy isolation is being performed.

Lockout/tagout must be used to provide full protection for workers when performing maintenance or repair on equipment. If the energy isolating device for a piece of equipment is capable of being locked out then the energy control procedure should use a standardized lockout device similar to those shown in the figures below. A lockout device uses a positive means such as a lock, chain, blank flange, wedge, block or slip blind to prevent the energizing of a machine or equipment

Figure 1.36. Typical lockout device

A standardized tagout system must be used if an energy-isolating device is not capable of being locked out.

A **tagout device** is a prominent warning, such as a tag, which can be securely fastened to an energy-isolating device to indicate that the energy isolating device and equipment are not to be operated until the tag is removed. The tags should have appropriate warning language such as: *Do Not Start, Do Not Open, Do Not Close, Do Not Energize, Do Not Operate.* The following two figures are examples of tagout devices

Figure 1.37. Warning tags

4.3. Identifying utility location

Before the operation of water reticulation, distribution and bulk water transfer system the operator should first identify different utility lines in the area. Utility location is the process of identifying and labelling public utility mains that are underground. These mains may include lines for telecommunication, electricity distribution, natural gas, cable television, fiber optics, traffic lights, street lights, storm drains, water mains, and wastewater pipes. In some locations, major oil and gas pipelines, national defence communication lines, mass transit, rail and road tunnels also compete for space underground. Be familiar with the uniform Temporary Markings for underground utilities as described below and are shown in the following figure

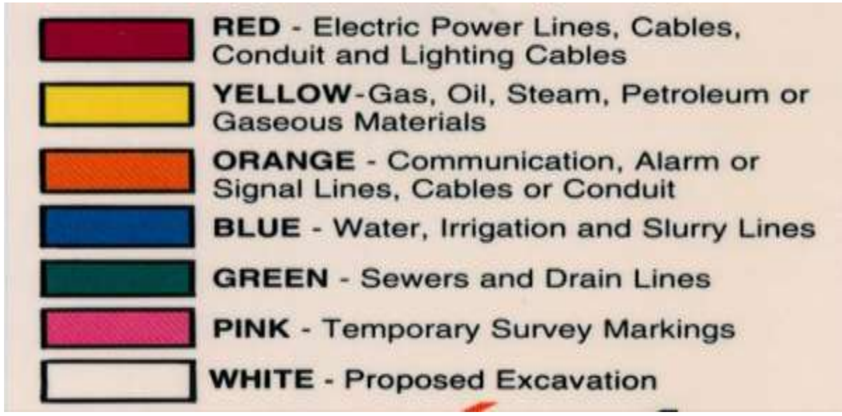


Figure 1.38. Utility color code

Information requirements

The following information relating to underground services must be obtained before any operation of the water system undertaken:

- Whether underground services exist in the area
- The type of services
- The exact location, depth and direction of the services
- Isolation points for the services (where required / available)
- Confirmation of whether services can be de-energised during the work
- Any specific restrictions to be followed during the work.

Self-Check -4	Written Test

Direction I: Matching item (2 points each)

Instruction: Match column B with column A of the questions and write your answer on the answer sheet provided:

	A		B
1.	Ensure that all personnel follow standardized shutdown and start-up procedures to prevent accidental equipment start up,	A.	Shown by red color
2.	prominent warning, such as a tag,	B.	Engineering control
3.	Sewer and drainage line	C.	insulation
4.	physically removing the hazard	D.	Risk
5.	Electric power lines, cables, conduit and lighting cables	E.	rules for handling hazardous materials
6	Isolate people from hazards.	F.	Substitution
7.	The exact location, depth and direction of the services	G.	hazard
8	The likelihood of identified hazards causing harm in exposed populations in a specified timeframe, including the magnitude of that harm and/or the consequences	H.	Utility information
9.	employee training, and installation of signs and warning labels	I.	Least effective hazard control
10.	Hazard type	J.	Lockout/tagout program
11.	glass, mica, rubber and plastic is used on conductors to prevent shock, fire, and short	K.	Elimination

circuits

12.	involves replacing something that produces a hazard (similar to elimination) with something that does not produce a hazard	L.	Being exposed to hazardous wastes
13.	Store all materials properly, separate incompatibles, and store in ventilated, dry, cool areas	M.	Tagout device
14.	PPE	N.	Administrative control
15.	Any biological, chemical, physical or radiological agent that has the potential to cause harm.	O.	Shown by green color

Answer Sheet-4

Score = ___________
Rating: ____________

Name: ___________________________ Date: ________________

Matching item

1. ....
2. ....
3. ....
4. ....
5. ....
6. ....
7. ....
8. ....
9. ....
10. ....
11. ....
12. ....
13. ....
14. ....
15. ....

Note: **Satisfactory rating - 15 points and above Unsatisfactory - below 15 points**

You can ask you teacher for the copy of the correct answers.

Information Sheet-5	Selecting and checking equipment and personal protective equipment

5.1. Selecting and checking equipment

The following tools and equipment are used for the operation of water reticulation, distribution and bulk water transfer system

Table 5.1 Tools and equipment are used for the operation of water reticulation, distribution and bulk water transfer system

Hand and power tools	Sluice	Portable pump	
Lifting equipment	Control device	Communicating equipment	Gas detection equipment
On and off road vehicle	Metering equipment	Disinfecting and sampling equipment	Rescue equipment

- **hand and power tools**

A hand tool is any tool that is powered by hand rather than a motor. A power tool is a tool that is actuated by an additional power source and mechanism other than the solely manual labour used with hand tools. The most common types of power tools use electric motors.

Example of hand and power tools

Hand tool: wrenches, pliers, cutters, striking tools, struck or hammered tools, screwdrivers, vises, clamps, snips, saws, drills and knives etc.

Power tool/equipment: cutting tool, treading tool, drilling tool, grinding tool, pumps, generators, air compressor etc.

- **lifting equipment**

Lifting and winching equipment is a general term for any equipment that can be used to lift loads. This includes jacks, rotating screws, gantries, A frames, gin poles, shear legs, sheer leg, windlasses, lifting harnesses, forklifts, hydraulic lifting pads, and cranes.

- **On- and off-road vehicles**

On and off-road vehicles are considered to be any type of vehicle which is capable of driving on and off paved or gravel surface. It is general characterized by having large tires with deep, open treads, a flexible suspension, or even caterpillar tracks.

Off-roading is the activity of driving or riding a vehicle on un surfaced roads or tracks, made of materials such as sand, gravel, riverbeds, mud, snow, rocks, and other natural terrain.

- **metering equipment**
- **sluices**
- **control devices**

These devices are used to control the distribution device. Examples: Valve key or valve box keys for all sizes (and extension kits if needed), Valve exerciser tool.

- **portable pumps**

Portable pumps are essential tools for modern firefighters. .Petrol engines are generally lighter than diesels and are preferred for portable fire pumps.

Figure 1.39. portable pump

- **communication equipment**

A communication device is a hardware device capable of transmitting an analog or digital signal over the telephone, other communication wire, or wirelessly.

- **disinfection and sampling equipment**

Water sampling equipment is used to collect water quality data to assess surface-water and groundwater resources. This is often done for site compliance and remedial performance monitoring.

Figure 1.40. Sampling bottles

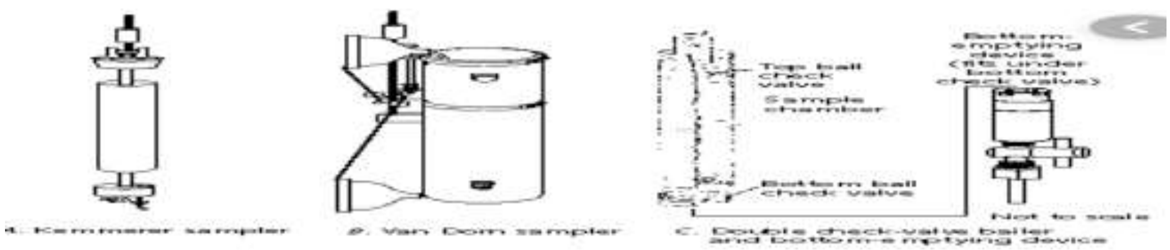


Figure 1.41. Sampling equipment

- **gas detection equipment**

A gas detector is a device that detects the presence of gases in an area, often as part of a safety system. This type of equipment is used to detect a gas leak or other emissions and can interface with a control system so a process can be automatically shut down.

- **rescue equipment**

In a high-hazard industry like construction, safety is an investment that provides real benefits for workplace illness and injury. Having measures in place to reduce risk and increase wellbeing are worthwhile investment because they will lower the number of days lost due to workplace illness/injury, increasing your overall productivity. Equipment's that are designed for purpose of safety in construction industries are called rescue equipment.

5.2. Selecting PPE

All PPE clothing and equipment should be of safe design and construction, and should be maintained in a clean and reliable fashion. Employers should take the fit and comfort of PPE into consideration when selecting appropriate items for their workplace. PPE that fits well and is comfortable to wear will encourage employee use of PPE.

Most protective devices are available in multiple sizes and care should be taken to select the proper size for each employee. If several different types of PPE are worn together, make sure they are compatible. If PPE does not fit properly, it can make the difference between being safely covered or dangerously exposed. It may not provide the level of protection desired and may discourage employee use.
The various types of PPE used for the operation of water reticulation, distribution and bulk water transfer system are:

- Safety Google: eye protection
- Gloves (rubber, leather, or leather palm): hand protection
- Dust Masks: breathing system protection
- Hard Hat: head protection
- Safety Shoes: foot protection
- Ear Plugs: ear protection
- Knee pads (as needed): knee protection

Other important safety equipment includes

- Water Buckets & Soap
- Fire Extinguisher
- Eye Wash Kit
- First Aid Kit

Self-Check -5	Written Test

Direction I: Multiple choice item (2 points each)

Instruction: Choose the best answer for the following questions and write the letter of your answer on the answer sheet provided in the next page.

1. One of the following is **NOT** construction equipment.

A. Hand and power tools

B. On and off-road vehicles

C. Air plane

D. Motorized equipment

2. Any type of vehicle which is capable of driving on and off paved or gravel surface

A. On and off-road vehicles

B. Space vehicles

C. Wing vehicles

D. Romantic vehicles

3. the most common types of power tools is: **[4 points]**

A. Electric motors

B. Shovels

C. Water

D. Solar energy

4. A tool that is actuated by an additional power source and mechanism other than the solely manual labour used with hand tools is:

A. Hand tool B. Power tool C. Communication tool D. Excavation tool

5. Protect head from any falling objects from high level during construction.

A. Helmet

B. Goggle

C. Face mask

D. Ear muff

Answer Sheet-5

Score = ___________
Rating: ____________

Name: ____________________________ Date: _________________

Multiple choice items

1. ....
2. ....
3. ....
4. ....
5. ....

Note: **Satisfactory rating - 5 points and above** **Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Information Sheet-6	Identifying, locating and operate isolation valves and Hydrants

6.1. Identifying and locating isolation valve

The most common use for valves in a distribution system is to isolate sections of pipe so that repairs can be made. Valves used for this purpose are often called ‘isolation valves’. As well as allowing repairs to be made, isolation valves also allow flushing to be carried out effectively and fire-fighting water to be accessed.

The location of hydrants can be identified from the drawing shown below

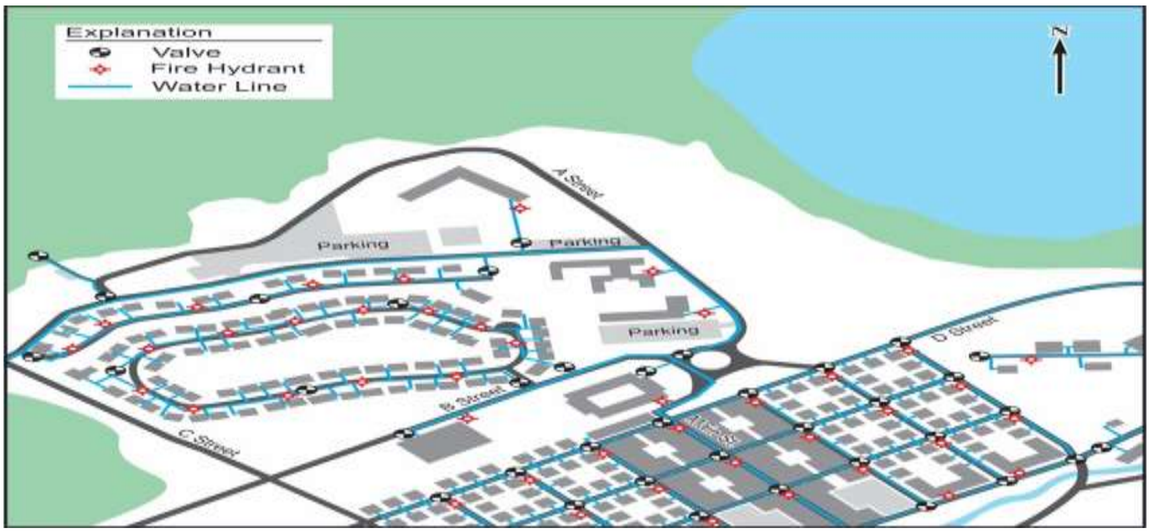


Figure 1.42. isolation valve and hydrant location

6.2. Common isolation valves

6.2.1. Gate valves and sluice valves

Gate valves are the most common valves in distribution systems operated by local authorities. Gate valves have a solid plate that slides down to block the flow of water. When the valve is opened (by raising the plate), there is no obstruction to the flow of water through the valve other important valves include fire hydrants, pressure-reducing valves and air valves

6.2.2. Globe valves

Globe valves work by pushing a hemispherical globe or circular plate against a hole. The edge of the hole where the globe contacts when closed is called the valve seat. Most household taps and stop cocks are globe valves.

6.2.3 Butterfly valves

A butterfly valve has a round, flat plate that is mounted on a shaft that passes directly through the middle of the valve body. By turning the shaft through 90º the plate is rotated to seal off the flow.

6.2.4. Fire hydrants

Fire hydrants are typically a globe valve in an epoxy-coated cast-iron body. A fire hydrant is designed to shut off completely for long periods of time, but when required they must reliably open and provide a high flow at a low pressure drop. Due to the flows and pressures required, fire hydrants are seldom installed on pipes of less than 100mm nominal bore.

6.3. Operation of isolation valves and hydrant

What is the use of isolation valve?

An **isolation valve** is a **valve** in a fluid handling system that stops the flow of process media to a given location, usually for maintenance or safety purposes. They can also be **used** to provide flow logic (selecting one flow path versus another), and to connect external equipment to a system

Valves on a distribution system are generally not used very often. As a result, problems with valves tend to stem from corrosion and disuse rather than wear. Regular inspection and 'exercising' of valves can help ensure the valves will work when they need to. This should be done at least once a year. The following procedure could be used.

Gate Valves. A gate valve functions by lifting a rectangular or circular gate out of the path of the fluid. When the valve is fully open, gate valves are full bore, meaning there is nothing to obstruct the flow because the gate and pipeline diameter have the same opening.

Which way do I turn my isolation valve off?

The way the valve is turned off or on is by using a slot head screwdriver to turn the screw in the center of the valve (only a quarter turn is required). If the slot of the screw is aligned with the pipe, then the valve is on and so water will be flowing through it.

How do you know if a valve is open or closed?

When the handle of a ball valve is parallel to the valve or pipe, it's open. When it's perpendicular, it's closed. This makes it easy know if a ball valve is open or closed, just by looking at it. The ball valve below is in the open position

Hydrant

They then open a valve that allows water to flow through the **hydrant** into the hoses. **Fire hydrants** can typically supply a large volume of water. This water is pumped through hoses to the **fire** truck, where it is pressurized and divided into several streams to supply water to multiple **fire** hoses at once.

How many turns does it take to turn on a fire hydrant?

A pressure activated rubber drain facing is de- signed to seal off at approximately 4 to 7 **turns** after opening of the **hydrant**. However, it is recommended that **hydrants** be operated to flow only in full open position.

How much pressure is on a fire hydrant?

NFPA and AWWA predicted flow of any **fire hydrant** is based on the rated capacity at 20 psi. All **hydrants** are assumed to provide at least 20 psi.

Fire Hydrant Operation Tips

- Always stand on the side of the hydrant without a cap when opening to prevent injury from the caps or barrel, which are under pressure and may become dislodged.
- Count the number of turns when operating a hydrant to ensure full opening or closing of the shut- off valve.
- Open and close the hydrant shut-off valve slowly to minimize potential pressure surges in the system.
- When possible, open the hydrant shut-off valve fully when operating to prevent excessive wear that can be caused by partially opening the valve. If the flow from a hydrant needs to be regulated, it can be accomplished through a portable valve which is attached to the hydrant nozzles.
- Hydrants should be exercised at least once per year. When exercising hydrants, hydrant maintenance should include operating valve, inspecting and greasing threads using a food grade lubricant, and insuring drainage in dry barrel hydrants.

Self-Check -6	Written Test

Direction I: Multiple choose item(2 points each)

Instruction: Choose the best answer and write your answer on the answer sheet provided in the next page:

1. All statement are correct. Except
   A. The most common use for valves in a distribution system is to isolate sections of pipe so that repairs can be made.
   B. Isolation valves allow flushing to be carried out effectively and fire-fighting water to be accessed.
   C. The location of hydrants can be identified from any drawing
   D. Gate valves are the most common valves in distribution systems

2. Which valve typically resembles fire hydrant in epoxy- coated cast iron body.
   A. Globe valve
   B. pressure-reducing valves
   C. air valves
   D. gate valve
3. A valve which has a round, flat plate that is mounted on a shaft that passes directly
   A. Butterfly valve
   B. Gate valve
   C. Globe valve
   D. fire hydrant

Answer Sheet-6

Score = ___________
Rating: ____________

Name: ___________________________ Date: ________________

Multiple choice questions

1. ....
2. ....
3. ....

Note: **Satisfactory rating - 12 points and above Unsatisfactory - below 12 points**

You can ask you teacher for the copy of the correct answers.

Information Sheet-7	Identifying pumping stations and following correct operating procedure

7.1. Definition of pumping terms

Pump: a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action. Pumps can be classified into three major groups according to the method they use to move the fluid.

Pump drives. Pump drives for water supply and distribution pumps will be electric motors. Diesel or other fuels will be considered as a power source only for emergency use.

Head: A term in fluid mechanics to represent the energy stored in a fluid due to the pressure exerted on its container. Measured as a length of fluid where a standard of 10m is equal to one atmosphere, or 14.7 psi.

Flow: The measurement of the liquid volume capacity of a pump. Often given in liters per minute (L/min), liters per second (L/sec) and metres3 an hour (m3/hr.).

Suction head: The head or height to which water can be raised on the suction side of the pump by atmospheric pressure.

Discharge head: the pressure at the discharge of a pump, measured as a height.

Total head: The sum of the head produced by the pump. It can be calculated by subtracting the suction head from the discharge head. Also referred to as Total Dynamic Head.

Friction head: the head lost by flowing water as a result of friction between the moving water and the walls of its conduit plus intermolecular disturbances

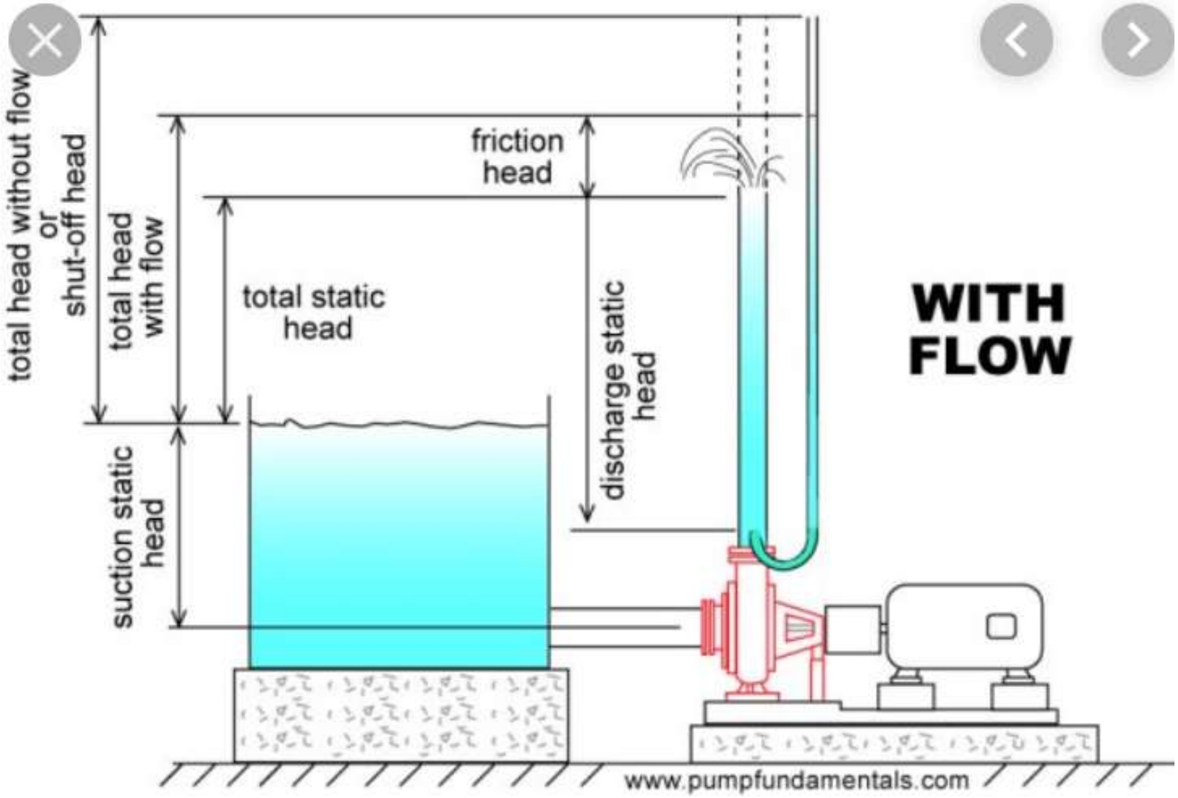


Figure 1.43. Discharge head

Pressure: Is the ratio of a force over an area over which the force is applied. Often measured in psi or kpa.

Pressure drop: The difference in pressure between two areas of a pump, or between the inside and outside of a container.

Efficiency: The measured power out of a piece of equipment divided by the power produced by the piece of equipment. Shown as a percentage.

Pump station: a place with pumps and equipment for pumping fluids from one place to another.

Impeller: A device that attaches to a rotating shaft and converts the energy of motion, into the fluid being pumped.

Priming: the operation in which the suction pipe, casing of the pump and portion of the delivery pipe up to the delivery valve are completely filled with the liquid which is to be pumped so that all the air from this portion of the sump is driven out and no air pocket is left.

7.2 Pump types

There are generally two types of pumps used for potable water pumping applications: the vertical turbine pump, line shaft and submersible types, and the centrifugal horizontal or vertical split case pump designed for water-works service. If the pump station and intake structure are to be located within a surface or underground reservoir, vertical turbine pumps with the column extending down into the reservoir or its suction well will be a logical choice. If the pump station is located at an above ground storage facility, split case centrifugal pumps will be the preferred selection. These pumps are normally horizontal but vertical split case pumps are common where there is limited space. Flexible couplings will connect pump and driver shafts. Split case pump design is used for ease of maintenance of the rotating elements, which can be removed without disconnecting the suction or discharge piping.

Centrifugal pump

Centrifugal pumps are used to transport fluids by the conversion of rotational kinetic energy to the hydrodynamic energy of the fluid flow. The rotational energy typically comes from an engine or electric motor.

A centrifugal pump is of a very simple design. The two main parts of the pump are the impeller and the diffuser. Impeller, which is the only moving part, is attached to a shaft and driven by a motor. Impellers are generally made of bronze, polycarbonate, cast iron, stainless steel as well as other materials. The diffuser (also called as volute) houses the impeller and captures and directs the water off the impeller.

Figure 1.44. Centrifugal pump

Submersible pump

The submersible pump is a centrifugal pump. Because all stages of the pump end (wet end) and the motor are joined and submerged in the water, it has a great advantage over other centrifugal pumps. There is no need to recirculate or generate drive water as with jet pumps, therefore, most of its energy goes toward "pushing" the water rather than fighting gravity and atmospheric pressure to draw water.

Virtually all submersibles are "multi-stage" pumps. All of the impellers of the multi-stage submersible pump are mounted on a single shaft, and all rotate at the same speed. Each impeller passes the water to the eye of the next impeller through a diffuser. The diffuser is shaped to slow down the flow of water and convert velocity to pressure. Each impeller and matching diffuser is called a stage. As many stages are used as necessary to push the water out of the well at the required system pressure and capacity. Each time water is pumped from one impeller to the next, its pressure is increased.

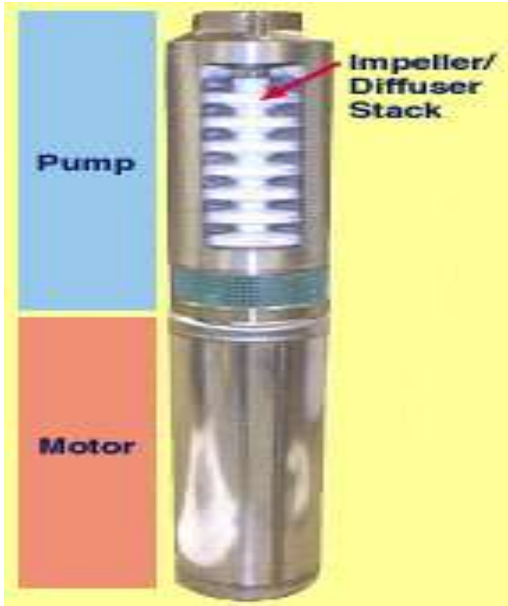


Figure 1.45. Submersible pump

Booster pumps

Booster pumps are additional pumps used to increase pressure locally or temporarily. A booster pump is used to increase the pressure in the mains, pump water from ground storage tanks into the water system or to supply water to an elevated or higher level storage tank. Booster pumps are centrifugal pumps and care should be used in their operation.

An operator should be concerned about three critical points: installation, alignment and protection for operators from moving parts. If the initial installation and the alignment are properly done, the pump should give few problems and require little maintenance other than routine checking of the packing and lubrication of bearings. Manufacturer's instructions must be followed for packing and lubrication requirements.

Protection from moving parts is critical as unprotected and rapidly rotating shafts can capture loose clothing and cause severe injury. As for all pumps, frequent inspection of the pump for heat, unusual vibration and noise are important parts of a maintenance program.

7.3 Pump supporting structures

Flow meters: pump station water is metered for several reasons: to calculate distribution system losses by subtracting the total of meter readings from total supply, to monitoring pump efficiency, and to determine gross billings for water supplied. High rate of accuracy and wide range criteria will be desirable in most pump station flow meter applications.

Valving: valves used in pump station piping system will include: gate valves, globe and angle valves, cone valves, butterfly valves, ball valves, check valves, and relief valves. Globe, ball, cone, and butterfly valves will be best suited as control valves for modulating the flow to provide desired pressure or flow rate. Check valves will not be used in vertical piping.

Suction piping valves: A gate valve will be installed in the suction piping so that the pump can be isolated from the line. The stem of this valve may be installed horizontal to avoid air pockets. Butterfly valves will not be installed in pump suction piping.

Discharge piping valves: a check valve and a gate or butterfly valve will be installed in the discharge piping with the check valve between the pump and the gate valve. The check valve will protect the pump from excessive back pressure and prevent liquid from running backwards through the pump in case of power failure. The gate valve will be used to isolate the pump and check valve for maintenance purposes.

In installations where an automatic surge control valve is needed the check valve will be eliminated, provided the drive will not be a wound rotor motor and pump design will allow some reverse rotation. Pressure relief valves, commonly diaphragm activated globe or angle type, will be installed in discharge piping system for flow control and/or pressure regulation, and to protect pump equipment and piping system from excessive surge pressures which could exceed the ratings of system components.

Air release and vacuum relief: air release and vacuum relief valves will be used on discharge piping for vertical turbine pumps.

Control system valving: Pump control systems range from single hand operated valves to highly advanced, automatic flow control or pump speed control systems. Particularly, in an unattended high head pump station the control valve may have a controller to close automatically when the pump is stopped and to open once the pump has reached specified speed after the pump is started. Control valves are installed to prevent surge pressures, which otherwise cause water hammer and high pressures.

A good surge control valve with low head loss will consist of a hydraulically operated valve on the pump discharge complete with speed control device to permit independent timing of both the valve opening and closing speeds. The controller will include hydraulic and safety equipment wired to function in sequence with the pump motor starting gear

7.3. Pump stations

Pumping stations in a water distribution system are necessary where water is pumped directly into the system (e.g. from a lake) or where pressure has to be increased because there is an insufficient difference in water levels in gravity flow distribution systems.

Pumping stations can be grouped as follows:

- for lifting water (high quantity, low pressure) from a well;
- for pumping water into a supply system, elevated water tank or water tower;
- to increase pressure.

Figure 1.46. Pump stations

7.4. Pump priming

Priming a pump is probably the first and one of the most important thing you should do before operating it. Not priming a pump or not doing it properly makes up 80 percent of centrifugal pump problems. While centrifugal pumps are relatively inexpensive, the downtime of your system due to a malfunctioning pump might be costly.

What is pump priming?

Priming simply means preparing or getting something ready for operation. For a centrifugal pump to work properly, you need to fill it up with water. When everything is right, a standard (non-self-priming) centrifugal pump looks like this. The pump will resume operation once the air is removed.

Most centrifugal pumps are incapable of pumping vapour or gases and continuously doing so will damage the pump impeller.

Self-priming pumps?

A self-priming centrifugal pump is able to overcome the problem of air binding by mixing air with water. After it gets rid of the air, the pump will continue to move water like a standard centrifugal pump.

7.5. Operational requirement

The following points should be observed while operating the pumps.

A. Dry running of the pumps should be avoided.

B. Centrifugal pumps if installed with negative suction should be primed before starting.

C. Pumps should be operated only within the recommended range of the head-discharge characteristics of the pump.

- If pump is operated at a point away from duty point, the pump efficiency normally reduces.
- Operation near the shut-off point should be avoided, as it causes substantial recirculation within the pump, resulting in overheating of sewage in the casing and consequently, overheating of the pump.

D. As far as possible positive suction is to be provided to avoid priming during design itself.

E. Voltage during operation of the pump-motor set should be within ±10 % of the rated voltage. Similarly, current should be below the rated current shown on the name plate of the motor.

F. When parallel pumps are to be operated, the pumps should be started and stopped with a time lag between two pumps to restrict change of flow velocity to minimum and to restrict the dip in voltage in the incoming feeder and should be adequate to allow the pump head to stabilize.

G. When the pumps are to be operated in series, they should be started and stopped sequentially, but with minimum time lag. Any pump next in sequence should be started immediately after the delivery valve of the previous pump is even partly opened. Due care should be taken to keep open the air vent of the pump next in sequence, before starting that pump.

H. The stuffing box should allow a drip of leakage to ensure that no air passes into the pump and that the packing gets adequate wetness for cooling and lubrication. When the stuffing box is sealed with grease, adequate refill of the grease should be maintained.

I. The running of duty pumps and standby pumps should be scheduled so that no pump remains idle for a long period and all pumps are in ready-to-run condition. Similarly, the running schedules should be ensured so that all pumps do not wear equally needing simultaneous overhaul.

J. If any undue vibration or noise is noticed, the pump should be stopped immediately and the cause for vibration or noise should be checked and rectified.

K. Generally, the number of starts per hour shall not exceed four. Frequent starting and stopping should be avoided as each start causes overloading of motor, starter, contactor and contacts. Although overloading lasts only for a few seconds, it reduces the life of the equipment.

L. Troubles in a sewage pumping station can be mostly traced to the design stage itself. This is all the more true when too much grit is likely to come into the sewage pumping stations from sewage at monsoon time, which is difficult to handle. Hence, sewers should not collect any storm water

7.6. Standard operating procedure of pumps

A standard operating procedure (SOP) is a set of step-by-step instructions compiled by an organization to help workers carry out complex routine operations. SOPs aim to achieve efficiency, quality output and uniformity of performance, while reducing miscommunication and failure to comply with industry regulations.

Pumping machinery is subjected to wear & tear, erosion and corrosion due to its nature of functioning, and therefore it is vulnerable to failures. Generally, failures or interruptions are mostly attributed to pumping machinery rather than any other component. Therefore, correct operation and timely maintenance and upkeep of pumping stations and pumping machinery are of vital importance. Sudden failures can be avoided by timely inspection, follow up actions on observations of inspection and planned periodical maintenance. Downtime can be reduced by maintaining inventory of fast moving spare parts. Obviously due attention needs to be paid to all such aspects for efficient and reliable functioning of pumping machinery.

Self-Check -7	Written Test

Direction I: Matching item(2 points each)

Instruction: Match column B with column A of the questions and write your answer on the answer sheet provided:

	A		B
1.	A device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action	A.	Flow meter
2.	Additional pumps used to increase pressure locally or temporarily	B.	Priming
3.	The pressure at the discharge of a pump, measured as a height.	C.	Head
4.	Is the ratio of a force over an area over which the force is applied	D.	Pressure
5.	Water supply pumps	E.	Pump station
6	The measurement of the liquid volume capacity of a pump	F.	Booster pumps
7.	A place with pumps and equipment for pumping fluids from one place to another	G.	Submersible pump, centrifugal pump
8	The head or height to which water can be raised on the suction side of the pump by atmospheric pressure	H.	Operational requirement of pumps
9.	The operation in which the suction pipe, casing of the pump and portion of the delivery pipe up to the delivery valve are completely filled with the liquid	I.	flow

10.	Used to calculate distribution system losses	J.	Standard operating procedure
11.	Dry running of the pumps should be avoided	K.	Suction head
12.	Set of step-by-step instructions compiled by an organization to help workers carry out complex routine operations	L.	Discharge head
13.	A term in fluid mechanics to represent the energy stored in a fluid due to the pressure exerted on its container	M.	Pump
		N.	Generator
		O.	Pressure gauge

Answer Sheet-7

Score = ___________
Rating: ____________

Name: ___________________________ Date: ________________

Matching item

1. ....
2. ....
3. ....
4. ....
5. ....
6. ....
7. ....
8. ....
9. ....
10. ....
11. ....
12. ....
13. ....

Note: **Satisfactory rating - 13 points and above Unsatisfactory - below 13 points**

You can ask you teacher for the copy of the correct answers.

Operation Sheet -1	Techniques of determining system layout and operational problem areas

Requirement: given the layout of a water reticulation, distribution and bulk water transfer system.

Steps

Step 1: Visit the site, having the system layout plan/map

Step 2: Make visual inspection of the system

Step 3: Determine operational problem

Step 4: Record and report the result

Operation Sheet -2	Procedure of Planning work required to operate and adjust water reticulation system

Steps

Step 1: Assess the water reticulation site

Step 2: Collect data necessary for planning activity

Step 3: Plan for work required to operate and adjust water reticulation system using the given template

Table 1.2. Reticulation system operation and adjustment Plan

RN	Operation	Required materials tools, and equipment	Responsible person	Time	Budget
1.					
2.					
3.					
4					
5					
6					
7					
8					

Step 4: Report your findings to the responsible person

Operation Sheet -3	**Procedure of performing site checks to prevent damage to other utilities and the environment,**

Activity 1: Risk assessment

Step 1: Identify hazards, i.e. anything that may cause harm. Employers have a duty to assess the health and safety risks faced by their workers. ...

Step 2: Decide who may be harmed, and how. ...

Step 3: Assess the risks and take action. ...

Step 4: Make a record of the findings. ...

Step 5: Review the risk assessment.

Activity 2: Lockout/Tagout

Step 1: Notify the that a lockout or tagout system is going to be used

Step 2: Operate the switch, valve or other energy-isolating device to ensure that the equipment is isolated from its energy source.

Step 3: Ensure that stored energy that may be in springs; elevated equipment parts (gravity); rotating flywheels; hydraulic systems; pneumatic systems; or gas, steam or water pressure is dissipated or controlled by venting, bleeding, blocking or repositioning.

Step 4: Apply the lockout or tagout device in accordance with your procedures. Perform a final energy isolation test by operating the start button or normal operating controls as a check to make sure that the energy source is isolated.

Step 5: After completing the test make sure that all operating controls are reset to the neutral or off position.

Step 6: Proceed with the necessary maintenance or repair work.

Step 7: Upon completion of the work, remove all tools, reinstall the guards, and clear the area of all personnel.

Step 8: Remove the lockout or tagout device and restore energy to the equipment

Operation Sheet -4	Procedure of Identifying, locating and operate isolation valves and hydrants

Activity 1: Identify, locate and operating fire hydrant

Steps

Step 1: Check that the hydrant location is correctly shown on a plan of the system.

Step 2: Open the hydrant by turning the operating nut a counter clockwise direction

Step 3: Open and close hydrants slowly.

- Opening a hydrant too quickly can cause a sudden decrease in pressure that could create vacuum in the distribution system; back-siphonage may occur
- Closing a hydrant too quickly can result in water hammer and may damage the distribution system

Step 4: Turns 18 to 22 of the hydrant valve will fully open or close the hydrant

Step 5: Close the **fire hydrant** slowly and completely. To close the **fire hydrant**, use the pentagon shaped socket and **turn** clockwise. Close the **fire hydrants** valve slowly and make sure that you close it completely

Activity 2: Identify, locate and operate gate valve

Steps

Step 1: Check that the valve location is correctly shown on a plan of the system.
Step 2: Remove any covers and inspect the top of the valve for damage or obvious leakage.

Step 3: Slowly close the valve fully and record the number of turns to the fully closed position.

Step 4: Reopen the valve to establish system flows. It is normal to avoid leaving a valve in a fully open or fully closed position to help avoid sticking, so back the valve off fully open by a turn or two.

Step 5:. Replace the cover

Operation Sheet -5	Identifying pumping stations and following correct operating procedures

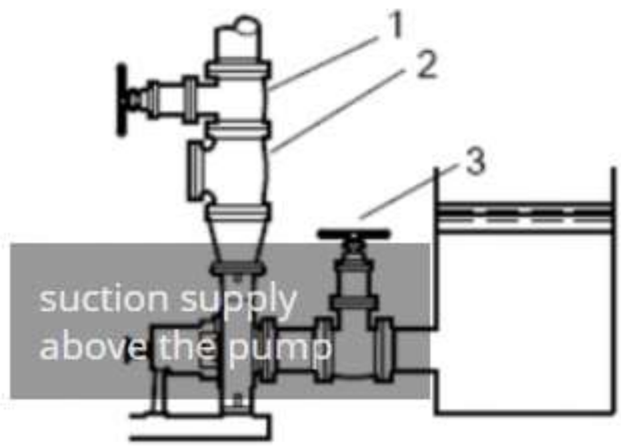
Activity 1: Steps for centrifugal pump priming

Condition 1: Prime the pump with the suction supply above the pump

Step 1: Slowly open the suction isolation valve.

Step 2:. Open the air vents on the suction and discharge piping until the pumped fluid flows out.

Step 3: Close the air vents.



Suction supply above the pump

1. Discharge isolation valve
2. Check valve
3. Suction isolation valve

Condition 2: Prime the pump with the suction supply below the pump

Steps

Step 1: Close the discharge isolation valve.

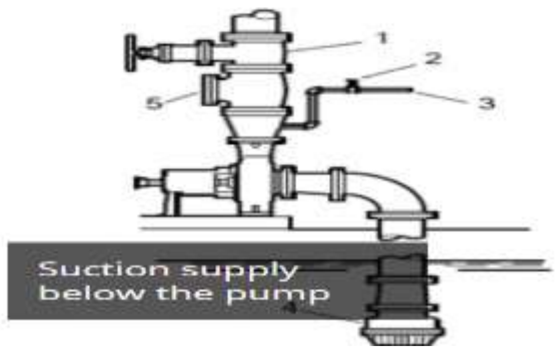
Step 2: Open the air vent valves in the casing.

Step 3: Open the valve in the outside supply line until only liquid escapes from the vent valves.

Step 4:.Close the vent valves.

Step 5:.Close the outside supply line.

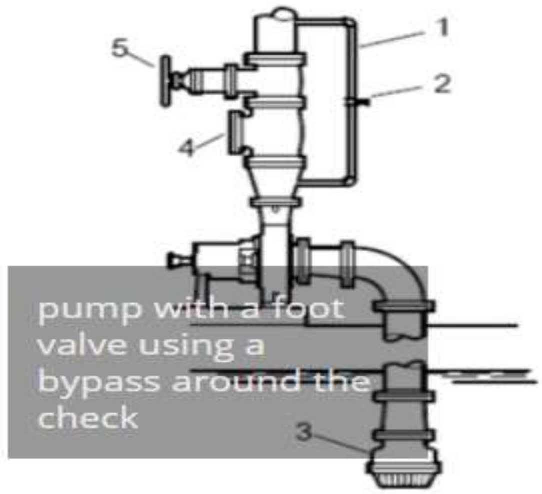
This illustration is an example of priming the pump with a foot valve and an outside supply:



Suction supply below the pump

1. Discharge isolation valve
2. Shutoff valve
3. from outside supply.
4. Foot valve
5. Check valve

This illustration is an example of priming the pump with a foot valve using a bypass around the check valve:



Pump with a foot valve using a bypass around the check

1. By-pass line
2. Shutoff valve
3. Foot valve
4. Check valve
5. Discharge isolation valve other

Activity 2: Pump Start-up Procedure

Step 1: Line up the pump valves.

Step 2: Ensure that the drain valve is closed.

Step 3: Open the suction valve.

Step 4: Open the vent valve to bleed off gases - when liquid comes from the vent valve - close it again. (This is called 'Priming the pump').

Step 5: Open the gland-seal valve (if fitted).

Step 6: Commission the bearing and oil cooling systems (if fitted).

Step 7: if an oil bottle or 'slinger-ring' reservoir is used for the bearings, ensure it is full and functioning properly.

Step 8: Check by hand that the pump shaft is freely rotating - (power is OFF at this point).

Step 9: Energize or, if the rule applies, have the electrician energize, the power supply.

Step 10: The discharge valve, at this point, should still be closed.

Step 11: Start the pump motor. Check that the pump is rotating in the correct direction.

Step 12: Check that the discharge pressure is steady - if not check at the vent and release any further trapped gas.

Step 13: Check for vibration, overheating and/or any undue noise from the pump, bearings or coupling.

Step 14: Re-check the lube and cooling systems and check for leaks at the pump glands. (With the 'packed' type gland seal, a slight leakage is desirable for lubrication and cooling of the gland). Open the discharge valve

Activity 3: Operate the centrifugal pump (standard operating procedure)

Step 1: The suction valve of the pump to be opened which cause the fluid flow to the impeller and fill the volute of the centrifugal pump.

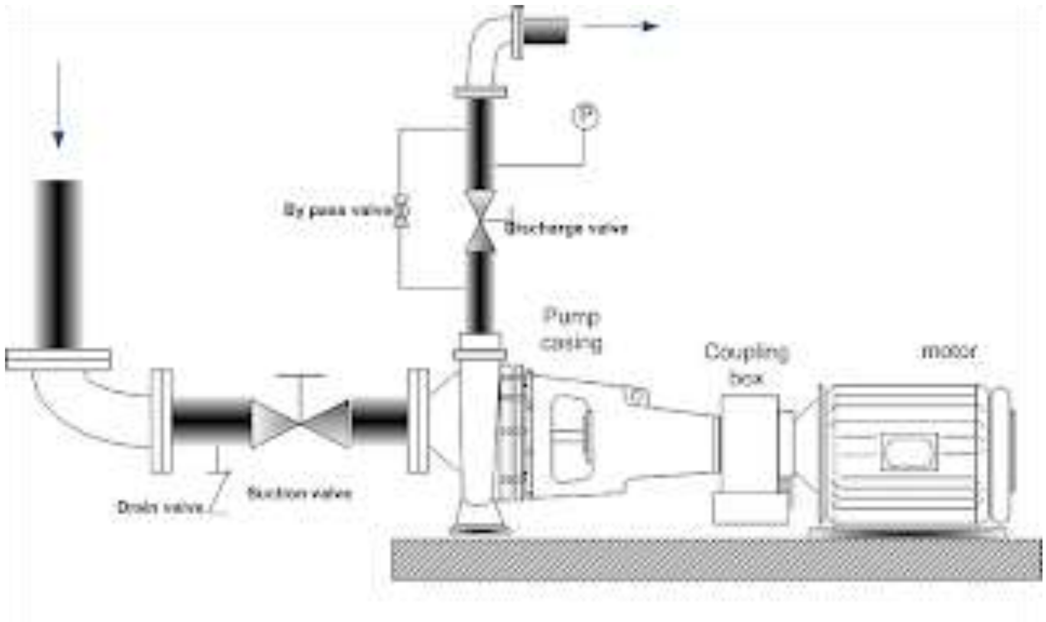
Step 2: Open the vent valve which is on the discharge line before the discharge valve of the centrifugal pump which causes all air to move out of the casing and filled with the pumping fluid only.

Step 3: When some quantity of the fluid comes out from the vent valve close the valve.

Step 4: Now open the bypass valve of the discharge valve which is near or side of the discharge valve on the discharge line.

Step 5: Now start the pump and let it attain its capacity in the pressure gauge on the discharge line.

Step 6: When the pressure gauge is stable it is time to open the discharge valve of the centrifugal pump.



Centrifugal pump system

Activity 4: stopping a pump of low and medium specific speed at normal Condition:

Step 1: Close the delivery valve gradually (sudden or fast closing should not be resorted to which can give rise to water hammer pressures).

Step 2: Switch off the motor.

Step 3: Open the air vent in case of V.T. and submersible pump.

Step 4: Stop lubricating oil or clear water supply in case of oil lubricated or clear water lubricated VT pump as applicable

LAP Test -1	Practical Demonstration

Name: _________________________ Date: ____________

Time started: ________________ Time finished: _______________

Instruction I: Given necessary templates, tools and materials you are required to perform the following tasks within ***40 hours.***

Monitoring and adjusting pressure at valves

Task 1: Determine system layout and operational problem areas.

Task 2: Plan work required to operate and adjust water reticulation system

Task 3: Perform site checks to prevent damage to other utilities and the environment,

Task 4: Identify and locating isolation valves and hydrants and follow standard organizational procedures for their operation.

Task 5: Identify pumping stations and following correct operating procedures

Instruction Sheet	Learning Guide #38 Monitor system performance and usage

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Conducting routine monitoring programs
- Identifying fluctuations in supply, system changes, community demands and water quality complaints.
- Collecting and reporting data on system performance and usage
- Collecting and recording water samples

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- Conduct routine monitoring programs
- Identify fluctuations in supply, system changes, community demands and water quality complaints.
- Collect and report data on system performance and usage
- Collect and record water samples

Learning Instructions:

9. Read the specific objectives of this Learning Guide.
10. Follow the instructions described below
11. Read the information written in the "Information Sheets 1- 4". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
12. Accomplish the "Self-checks" in each information sheets on pages 5, 14, 20 & 26.
13. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).

14. If you earned a satisfactory evaluation proceed to “Operation sheets 1- 4 on pages 28-35 and do the LAP Test on page”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back36 to Learning Activity.
15. After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result;
16. Then proceed to the next LG.

Information Sheet-1	Conducting routine monitoring programs

1.1. Introduction to routine monitoring

What is system performance?

In water distribution, reticulation and bulk water transfer system, system **performance** is the value of overall efficiency of the system.

A system performance monitor (SPM) is a type of application that identifies, collects, monitors and reports on the overall operational health of a system. It is a performance monitoring tool that enables end users, administrators and organizations to gauge and evaluate the performance of a given system.

Routine monitoring

The periodic tracking (for example daily, weekly, monthly, quarterly and annually) of any activity's progress by systematically routine gathering, analyzing and recording data and information is called routine monitoring.

Operational monitoring refers to collecting key system performance metrics at periodic intervals over time

Operational monitoring should be:

⇒ Simple – easy to perform

⇒ Rapid – quick to carry out, providing fast, reliable results

⇒ Routine – easy to incorporate into normal operational duties

Operational monitoring may be:

1) Visual (or observable) e.g.

⇒ Stock exclusion fence intact

⇒ Valve position closed/locked

⇒ Access hatch closed on intermediate storage tank closed

2) Measurable (water quality tests) e.g.

⇒ raw water turbidity

⇒ treated water residual chlorine concentration

⇒ Distribution system pressure

Operational Monitoring Operational monitoring may be:

⇒ Preventative – provide an early indication that a control measures is failing, or about to fail, such that corrective action may be taken before unsafe water is supplied or

⇒ Remedial – detects a problem after it has occurred, such that corrective action may be taken to fix the problem and minimize the extent of unsafe water supply

1.2. Monitoring parameters

The operators in the reticulation and distribution system is responsible for monitoring of key system parameters continuously to ensure that problems in the system are identified as quickly as possible. The following parameters should be monitored

1.2.1. System input flow rates from water reticulation, water treatment plants, bulk water supplies and other municipalities, as well as water distributed to the consumers. These flow rates are the largest in the system and thus accurate measurement is very important. Electromagnetic or ultrasonic flow meters are typically used and should be monitored continuously. The system input volume forms the basis for water loss estimation.

1.2.2. DMA meters should also be monitored continuously and the results analyzed for changes in consumption patterns and levels of leakage. Techniques are becoming available that can identify new bursts occurring in a DMA by analyzing its consumption patterns. DMA consumption patterns are important in determining accurate water demand patterns for distribution system calibration and modelling.

1.2.3. Consumption meters. Bulk consumers are the most important users of water in a municipality representing a high fraction of the total system demand. Their consumption monitoring should be given priority and should be done at least on a monthly basis, but more frequently if possible. Other consumer water meters should be read on a monthly basis. Metered consumption should be analyzed to identify patterns that may indicate defective meters, meter bypassing and on-site leakage.

1.2.4. System flow rates are important for monitoring the movement of water in the distribution system and maintaining adequate reservoir water levels while ensuring that pumps are operated in the most efficient cost periods.

1.2.5. Water quality should be monitored and corrective action taken immediately if problems are found.

Information should be gathered from **pipe repair reports** on the type and likely cause of failures, as well as the condition of the distribution system at the failure. This information should be analyzed annually to identify patterns and modify procedures if required.

1.2.6. Other aspects of the network that should be monitored include galvanic protection, user complaints of pressure problems or strange tastes (that might indicate permeation occurring), pipe failures and pipe roughness.

1.3. Water quality and monitoring

Water quality monitoring can evaluate the physical, chemical, and biological characteristics of a water body in relation to human health, ecological conditions, and designated water uses. Monitoring is a more comprehensive approach to data collection that incorporates water quality

Operational monitoring is a planned and routine set of activities used to provide timely indications of the performance of control measures and provide the opportunity for appropriate responses to non-compliance to maintain water quality. Such operational monitoring is usually based on **simple observations** and **tests** that can easily be measured and assessed, such as turbidity, chlorine residuals and infrastructure inspections that provide rapid feedback on how the system is working.

Why water quality monitoring is important?

Monitoring provides the objective evidence necessary to make sound decisions on managing water quality today and in the future. Water-quality monitoring is used to alert us to current, ongoing, and emerging problems; to determine compliance with drinking water standards, and to protect other beneficial uses of water.

How do you monitor water quality?

Water quality can be measured by collecting water samples for laboratory analysis or by using probes which can record data at a single point in time, or logged at regular intervals over an extended period.

Self-Check -1	Written Test

Direction I: Multiple choice item (2 points each)

Instruction: Choose the best answer for the following questions and write the letter of your answer on the answer sheet provided.

1. -------------- is the value of overall efficiency of the system.
   A. system performance
   B. Monitoring
   C. Routine monitoring
   D. Water system
2. A type of application that identifies, collects, monitors and reports on the overall operational health of a system is
   A. system performance monitoring
   B. system performance
   C. Routine maintenance
   D. Evaluation
3. ------------ refers to collecting key system performance metrics at periodic intervals over time
   A. Operational monitoring
   B. Operational evaluation
   C. Project management
   D. Project period
4. One of the following do not belongs to the characteristics of operational monitoring
   A. Simple
   B. Rapid
   C. Routine
   D. None

5. In which type of water supply system operation measurable operational monitoring is conducted by visual inspection
   A. raw water turbidity
   B. treated water residual chlorine concentration
   C. distribution system pressure
   D. valve position closed
6. Identify monitoring parameter
   A. System input
   B. Water quality
   C. System flow rate
   D. All
7. What parameter evaluate the physical, chemical, and biological characteristics of a water body in relation to human health, ecological conditions, and designated water uses
   A. System input
   B. Water quality
   C. System flow rate
   D. Consumption meter

Answer Sheet-1

Score = ___________

Rating: ____________

Name: ___________________________ Date: ________________

Multiple choice questions

6. ....
7. ....
8. ....
9. ....
10. ....
11. ....
12. ....

Note: **Satisfactory rating - 7 points and above Unsatisfactory - below 7 points**

You can ask you teacher for the copy of the correct answers.

Information Sheet-2	Identifying fluctuations in supply, system changes, community demands and water quality complaints

2.1. Basic terms and definitions

Water supply is the provision of water by public utilities, commercial organizations, community endeavors or by individuals, usually via a system of pumps and pipes. Irrigation is covered separately.

Water consumption (**Qwc**) is the quantity directly utilized by the consumers.

Water Demand is the measure of the total amount of water used by the customers within the water system

Water leakage Water leakage (Qwl) is the amount of water physically lost from the system. The generated flow rate is in this case more or less constant and depends on overall conditions in the system.

What is the peak hourly demand is the maximum flow rate delivered by the distribution system on any single hour during the year corresponds to the peak hour water demand. The peak hour demand (PHD) is the peak hour water demand divided by the average daily demand (ADD).

Water quality: refers to the chemical, physical, biological, and radiological characteristics of water.

Leakage: the amount of potable water lost from a supply source in transmission and distribution, other than by deliberate or controllable action.

2.2. Fluctuation in supply and demand

Adequate water supply is required by any individual, organization or other parties from water providers but due to different reasons municipal water providers cannot provide sufficient water to their customers to meet the maximum demand requirement. For the reason fluctuation of water supply is always expected

Possible major reasons for fluctuation in water supply and demand are:

- Climate change
- Expansion of cities

* Poor water distribution system
* Problem in distribution, reticulation and bulk water transfer system
* Increase population

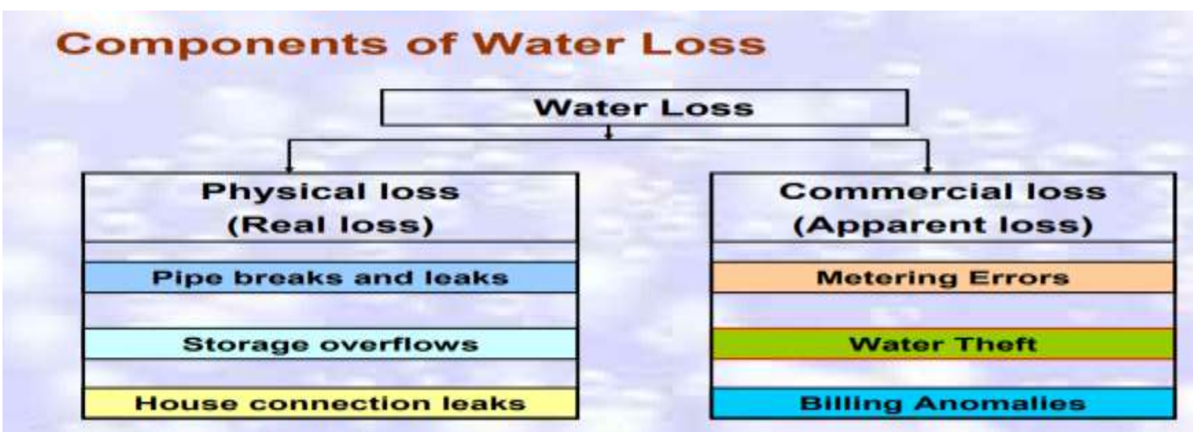
2.3. Water loss

Effective management of water supply systems consists in supplying adequate quantities of clean water to the population. To establish the feasibility of a water distribution system assessment, detection, and control of water losses from the system should be identified.

Loss of water from a distribution system can occur as a result of:

* leakage from reservoirs;
* leakage from water mains through faulty joints or corrosion;
* leakage in service pipes and fittings inside or outside the consumers' premises;
* Leakage through abandoned service pipes.

In addition to losses from the delivery system itself, consumers may waste water by failing to turn off taps when not needed, or using excessive amounts for washing vehicles, watering the garden, etc. It may be feasible to reduce such waste by education and by metering the consumers' premises. However, system losses must be assessed and controlled by systematic waste and leakage detection, followed by prompt corrective action.



Standard Terminologies *Source:* **IWA (2000)**

System Input Volume	Authorised Consumption	Billed Authorised Consumption	Billed Metered Consumption (including water exported)	Revenue Water
			Billed Unmetered consumption	
		Unbilled Authorised Consumptiion	Unbilled Metered Consumption	Non-Revenue Water
			Unbilled Unmetered Consumption	
	Water Losses	Apparent Losses	Unauthorised Consumption	
			Metering Inaccuracies	
		Real Losses	Leakage on Transmission and/or Distribution Mains	
			Leakage and Overflows at Utility's Storage Tank	
			Leakage on Service Connections up to point of Customer Metering	

All quantities in m^3/year

What is Unaccounted-For-Water?

Unaccounted-for water (UFW) represents the difference between "net production" (the volume of water delivered into a network) and "consumption" (the volume of water that can be accounted for by legitimate consumption, whether metered or not).

UFW = “net production” – “legitimate consumption”

Non-Revenue Water

Non-revenue water (NRW) represents the difference between the volumes of water delivered into a network and billed authorized consumption. NRW = “Net production” – “Revenue water” = UFW + water which is accounted for, but no revenue is collected (unbilled authorized consumption).

Calculating Water Loss

Water loss is expressed as

- A percentage of net water production (delivered to the distribution system)
- As m^3/day/km of water distribution pipe system network (specific water loss)

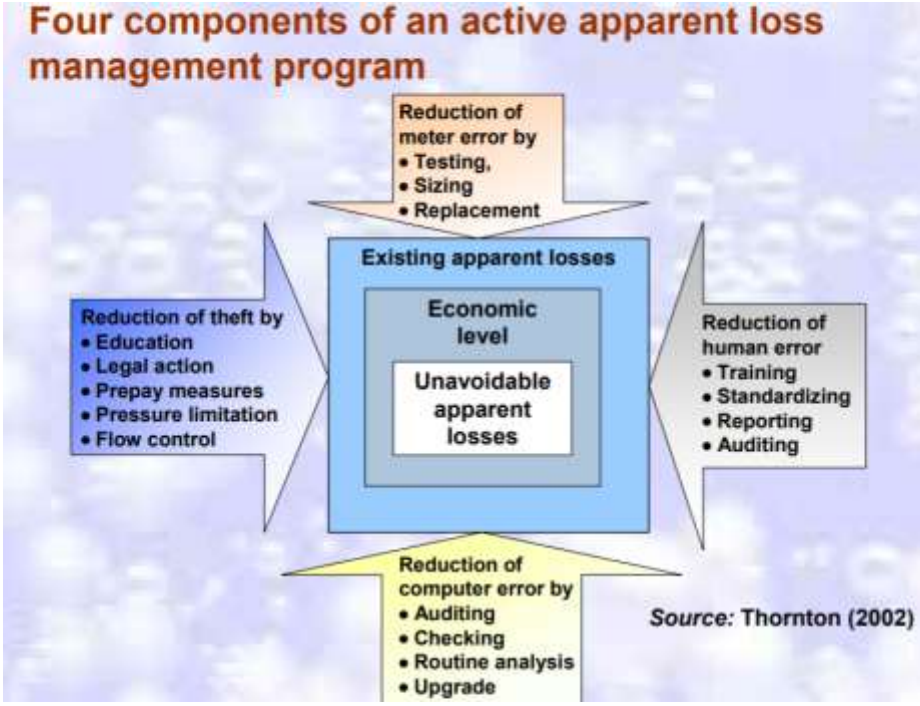
• Others - m^3/day/connection - m^3/day/connection/m pressure

Water loss as % of net water production is the most common. It could be misleading for systems with different net productions with same amount of real & apparent losses.

Controlling water loss

Water loss control includes:

- Water audit or Water balance
- Meter testing and repair/replacement, improving billing procedure
- Leak detection and control program - network evaluation - leak detection in the field and repair
- Rehabilitation and replacement program
- Corrosion control
- Pressure reduction
- Public education program; Legal provisions
- Water pricing policies encouraging conservation • Human resources development
- Information system development



2.3. Water quality

Absolutely pure water is never found in nature. Absolutely pure water is which contains only two parts Hydrogen and one part of Oxygen by volume. However, the water found in nature contains a number of impurities in varying amounts.

Conceptually water quality refers to the characteristics of water supply that will influence its suitability for specific use, i.e. how well the quality meets the needs of user. Quality is defined by certain physical, chemical and biological characteristics.

Water quality compliant

Private water suppliers will be aware that drinking water quality is very important to consumers. If something has gone wrong with the private water supply it could present a risk to consumers' health or affect the appearance, taste or odor of the supply. Therefore complaints about drinking water quality received from consumers should be investigated promptly by the private water supplier and the results of the investigation given quickly to the complainants.

Complaints may be received from consumers by telephone or in person. Customers can be the first to detect increased turbidity, color or off-tastes and off-odors or report illnesses linked to faults in distribution systems. SOPs should be established to receive and investigate customer inquiries and complaints. All information should be recorded and, where necessary, investigated. This is particularly important where clusters of complaints are received.

Customer complaint management is a system that allows customers to register their dissatisfaction with the organization. It allows organizations to obtain feedback on how to improve their services and to decrease the likelihood of problems with the customer base

An effective customer complaint mechanism can improve accountability, make sure that customers' expectations are met and ensure that the goods or services that the organization provides are continuously being improved.

Customers should be provided with various ways of filing complaints. Everyone should be enabled to file a complaint and no-one should to be discriminated against (e.g. illiterate customers, those without mobile phones etc.).

Water Quality Surveillance and Response System (SRS)

A Water Quality Surveillance and Response System (SRS) provides a systematic framework for enhancing distribution system monitoring activities to detect emerging water quality issues and respond before they become problems.

Self-Check -2	Written Test

Direction I: Matching item (2 points each)

Instruction: Match column B with column A of the following questions and write the letter of your answer on the answer sheet provided.

	A		B
1.	represents the difference between the volume of water delivered into a network and billed authorized consumption	A.	Water supply
2.	Water loss control	B.	Leakage
3.	The provision of water by public utilities, commercial organizations, community endeavors or by individuals, usually via a system of pumps and pipes. Irrigation is covered separately	C.	Water audit or Water balance
4.	The quantity directly utilized by the consumers.	D.	Customer complaint management is
5.	The measure of the total amount of water used by the customers within the water system	E.	Water consumption (Qwc)
6	Cause of water fluctuation	F.	Climate change
7.	The amount of potable water lost from a supply source in transmission and distribution, other than by deliberate or controllable action	G.	leakage from water mains through faulty joints or corrosion
8	Loss of water from a distribution system can occur as a result of	H.	Water quality
9.	A system that allows customers to register their	I.	Non-revenue water

	dissatisfaction with the organization.		(NRW)
10.	Refers to the chemical, physical, biological, and radiological characteristics of water	J.	Water Demand

Note: **Satisfactory rating - 10 points and above Unsatisfactory - below 10 points**

You can ask you teacher for the copy of the correct answers.

Score = ___________
Rating: ____________

Answer Sheet- 2

Name: ____________________________ Date: _________________

Matching questions

1. ....
2. ....
3. ....
4. ....
5. ....
6. ....
7. ....
8. ....

Information Sheet-3	Collecting and reporting data on system performance and usage

3.1. System performance monitoring

A system performance monitor (SPM) is a type of application that identifies, collects, monitors and reports on the overall operational health of a system. It is a performance monitoring tool that enables end users, administrators and organizations to gauge and evaluate the performance of a given system.

After the system has been monitored through visual inspection and testing methods data will be collected on system performance and usage of the reticulation, distribution and bulk water transfer system. Problems which are on the scope of the operator will be solved accordingly and those problems beyond the operator scope will be reported to the responsible personnel.

3.2. System performance parameter

A performance indicator or key performance indicator (KPI) is a type of performance measurement. KPIs evaluate the success of an organization or a particular activity (such as projects, programs, products and other initiatives) in which it engages.

Performance indicators tools which can be applied to the operation and maintenance of water reticulation, distribution and bulk water transfer systems are listed below. The purpose of this listing is to give the user a set of indicators from which those most appropriate to the local situation can be selected. It is not intended to be comprehensive, nor will it be appropriate for the user to try to calculate the value of all the indicators. Guided by the ideas and concepts from some of the indicators, the user should be able to develop alternative new indicators to suit the local circumstances.

Indicators are one approach to measure progress. The term "minimum indicators" is used in recognition that:

- It is better to start with a small set of indicators that are feasible to monitor and to improve over time.
- There are many other indicators that could be used to measure progress beyond this basic level.

Indicators provide an effective tool to measure progress and performance. An indicator is the representation of a trend tracking the measurable change in a system over time. Generally an indicator focuses on a small, manageable set of information that gives a sense of the bigger picture. Therefore it can be seen that there is no need to measure everything. Furthermore the choice of indicators is important as to whether it gives sufficient 'sense of the bigger picture'.

3.3. Use of Indicators

Indicators are useful to:

- Measure progress over time against various water and sanitation objectives providing information relevant to policy.
- Measure performance against a target to evaluate the effect of policy actions and plans.
- Present information to the public or stakeholders in a simplified way.
- Identify areas for increased attention by an organization.

3.4. Types of Indicators

The type of indicators for measuring the performance of water supply systems is

- **Functional indicators** (e.g. adaptability, durability, and reliability of the system)
- **Economic indicators** (e.g. capital costs, operation and maintenance costs and user costs)
- **Environmental indicators covering resource use** (e.g. nutrient reuse) and emissions (e.g. emission of carbon dioxide)
- **Social-cultural indicators** (e.g. public participation, acceptance, and stimulation of sustainable behavior)

Depending on the scope of the project area a water reticulation, distribution and bulk water transfer system operator can select the following performance indicators.

1. Existing condition of hydrants
2. Existing condition of valves
3. Water quality condition (physical, biological and chemical
4. Condition of water storage facilities
5. Pressure and flow condition of the system
6. Condition of pipe system (leakage free)
7. Water meter condition
8. Regular system record
9. Customer compliance report
10. Repair records
11. Schedule maintenance program
12. Appurtenant structure condition
13. Chlorine residual

3.5. Collecting and reported performance and usage data

By using user satisfaction surveys, visual observation and tasting methods the operation of water reticulation, distribution and bulk water transfer system data should be collected and reported as required.

Table 3.1. Monitoring performance report form

Monitoring performance report form

Place ------------------------ Operator ------------------------

Date--------------------------

RN	Operation	Yes	No	Comment
1.	Valves and hydrants			
2.	pumps are working properly			
3.	Water quality condition (physical, biological and chemical) is maintained			
4.	Water storage facilities are functional			
5.	Adequate pressure and flow is provided by the system			
6.	Pipe systems are free from damage and corrosion			
7.	Water meters are in fully operating condition			
8.	system records are maintained regularly			
9.	Customer compliance are managed and reported timely			
10.	Repair records are stored regularly			
11.	Maintenance program is schedule			
12.	Appurtenant structured are in good condition			
13.	Chlorine residual is maintained in the system			

Self-Check -3	Written Test

Direction I: Matching item (2 points each)

Instruction: Match column B with column A of the following questions and write the letter of your answer on the answer sheet provided.

	A		B
1.	a type of application that identifies, collects, monitors and reports on the overall operational health of a system.	A.	A system performance monitor (SPM)
2.	a type of performance measurement.	B.	Functional indicators
3.	measure progress over time against various water and sanitation objectives providing information relevant to policy	C.	performance indicator or key performance indicator (KPI)
4.	adaptability, durability, and reliability of the system)	D.	Indicators are useful to

Note: **Satisfactory rating – 4 points and above Unsatisfactory - below 4 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet- 3

Name: ___________________________ Date: ________________

Matching questions

1. ....
2. ....
3. ------------------
4. ....

Information Sheet-4	Collecting and recording water samples

4.1. Water sampling

Drinking water sampling, the process of taking a portion of water for analysis or other testing drinking water to check that it complies with relevant water quality standards.

4.1.1. Sampling point

Selecting sampling points, each locality should be considered individually; however, the following general criteria are usually applicable:

- Sampling points should be selected such that the samples taken are representative.
- These points should include those that yield samples representative of the conditions at the most unfavorable sources or places in the supply system, particularly points of possible contamination such as unprotected sources, loops, reservoirs, low-pressure zones, ends of the system, etc.
- Sampling points should be uniformly distributed throughout a piped distribution system, taking population distribution into account; the number of sampling points should be proportional to the number of links or branches.
- The points chosen should generally yield samples that are representative of the system as a whole and of its main components.
- Sampling points should be located in such a way that water can be sampled from reserve tanks and reservoirs, etc.
- In systems with more than one water source, the locations of the sampling points should take account of the number of inhabitants served by each source.
- There should be at least one sampling point directly after the clean-water outlet from each treatment plant.

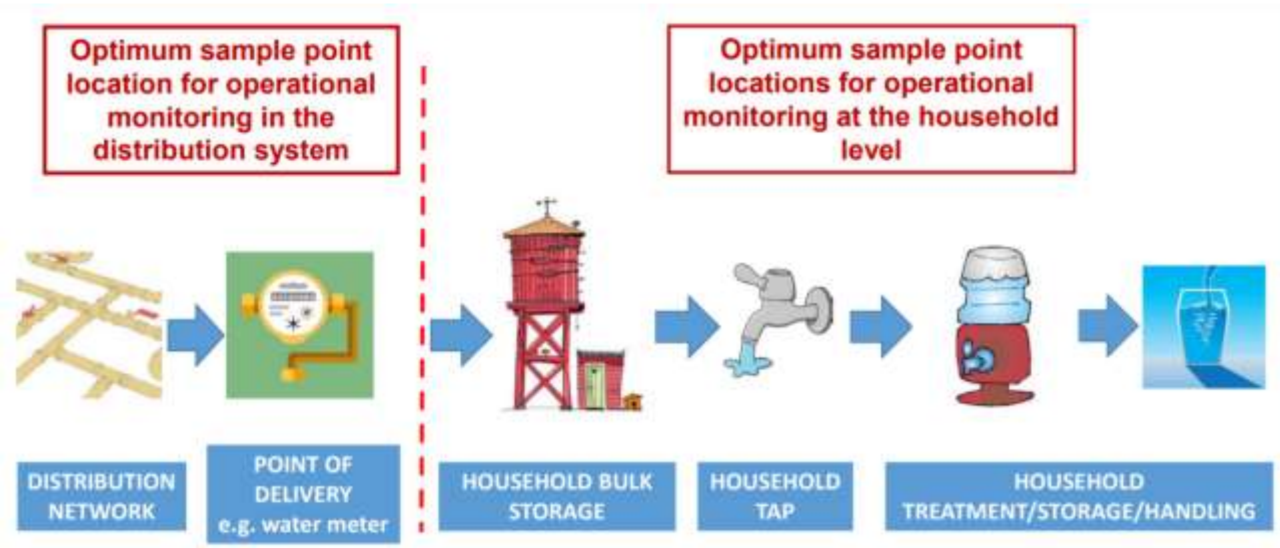


Figure 4.1. Sampling point

<u>Distribution system sampling</u>

- Samples should be collected at different locations in the distribution system including from the ends of the system.
- Samples can be collected from consumer's taps or designated sampling taps can be installed in parts of the system.
- When taking a microbiological sample, or sampling for chemical contaminants in the source water, the sample tap should be flushed for 2–3 minutes before the sample is taken.
- If taking a chemical sample to check if lead is leaching from the tap or plumbing fittings the tap should not be flushed, as it is necessary to collect the first flush of water from the tap after it has not been used for 12 hours.

Sampling sites in a piped distribution network may be classified as:

- Fixed and agreed with the supply agency;
- Fixed, but not agreed with the supply agency; or
- Random or variable.

Each type of sampling site has certain advantages and disadvantages. Fixed sites agreed with the supplier are essential when legal action is to be used as a means of ensuring improvement; otherwise, the supply agency may object to a sample result on the grounds that water quality may have deteriorated in the household, beyond the area of responsibility of the supplier. Nevertheless, fixed sample points are rare or unknown in some countries.

Fixed sites that are not necessarily recognized by the supply agency are used frequently in investigations, including surveillance. They are especially useful when results have to be compared over time, but they limit the possibility of identifying local problems such as cross-connections and contamination from leaking distribution networks.

Sampling regimes using variable or random sites have the advantage of being more likely to detect local problems but are less useful for analysing changes over time.

4.1.2. Sampling frequency

The most important tests used in water-quality surveillance or quality control in small communities are those for microbiological quality (by the measurement of indicator bacteria) turbidity, and for free chlorine residual and pH where chlorination is used. These tests should be carried out whenever a sample is taken, regardless of how many other physical or chemical variables are to be measured. The minimum sample numbers for piped drinking-water in the distribution system are shown below.

Table 4.1 Minimum sample numbers for piped drinking-water in the distribution system

Population served	No. of monthly samples
<5000	1
5000–100 000	1 per 5000 population
>100 000	1 per 10 000 population, plus 10 additional samples

4.2. Sample preservation

Sample preservation is the measure or measures taken to prevent reduction or loss of target analyses. Analyse loss can occur between sample collection and laboratory analysis because of physical, chemical, and biological.

Between the time that a sample is collected in the field and laboratory analysis, physical change and chemical reaction may take place. Therefore, it is necessary to preserve the samples before transporting to minimize these changes.

The most common sample preservation techniques are

- Acidification – addition of acid to the sample to preserve dissolved metals (nitric acid and sulfuric acid)
- Refrigeration – at 4^0C is common preservation technique, which is widely used in the field work.

4.2. Sampling methods for microbiological analysis

Although recommendations vary, the time between sample collection and analysis should, in general, not exceed 6 hours, and 24 hours is considered the absolute maximum. It is assumed that the samples are immediately placed in a lightproof insulated box containing melting ice or ice-packs with water to ensure rapid cooling. If ice is not available, the transportation time must not exceed 2 hours. Although recommendations vary, the time between sample collection and analysis should, in general, not exceed 6 hours, and 24 hours is considered the absolute maximum. It is assumed that the samples are immediately placed in a lightproof insulated box containing melting ice or ice-packs with water to ensure rapid cooling. If ice is not available, the transportation time must not exceed 2 hours.

4.3. Checking and recording Sample information

Immediately before or after collecting a sample, label the container clearly with information on:

Where – the sampling location, with sufficient detail to be able to repeat the sample from the same location, including the site code where possible.

Why – the reason for sampling (complaint, routine test, process control or compliance)

When – the time and date of collection

Who – the name of the person collecting the sample (for traceability)

How – the method of sample collection (ie, grab, first flush or full flush)

Other – weather conditions and any other useful observations.

Example 1: Information on a sampling, analytical and laboratory delivery form

Date and time	3 February 2010 at 2:30
Person undertaking sampling	Ato Alemu Asefa
Specific location	Kombolcha polytechnic college
Weather at time of sampling	Fine
Weather related observations	Heavy rain two days ago
Number of samples taken	One
Sampling location/place	Well
Sampling depth	10m
Actions taken to collect sample	Full flush
Type of sample	Grab
Any sample preservation?	Sterile bottle
FAC level	Zero (non-chlorinated)
Label on bottle	Yes
Field measurements	dissolved oxygen EC, pH, temperature, and

	turbidity
Unusual conditions and other observations	

4.4. Sample Disposal

All samples are disposed in an environmentally sound manner or returned to the client upon request. Samples may also be returned to the client if they contain hazardous wastes. Samples that contain solvents are evaporated in a fume hood unless the vapors create an environmental concern.

Self-Check -4	Written Test

Direction I: Multiple choices (2 points each)

Instruction: Choose the best answer from the given choices of the following questions and write the letter of your answer on the answer sheet provided.

1. The process of taking a portion of water for analysis or other testing drinking water to check that it complies with relevant water quality standards.
   A. Drinking water sampling
   B. Water testing
   C. Sampling frequency
   D. Collection of water sample
2. Identify the false statement about sampling point
   A. Sampling points should be selected such that the samples taken are representative
   B. The points chosen should generally yield samples that are representative of the system as a whole and of its main components.
   C. Samples should be collected at the same locations in the distribution system including from the ends of the system.
   D. Samples can be collected from consumer's taps or designated sampling taps can be installed in parts of the system.
3. Sampling sites in a piped distribution network may be classified as:
   A. Fixed and agreed with the supply agency;
   B. Fixed, but not agreed with the supply agency; or
   C. Random or variable.
   D. All

4. The most important tests used in water-quality surveillance or quality control in small communities are
   A. microbiological quality (by the measurement of indicator bacteria)
   B. turbidity
   C. free chlorine residual and pH
   D. All
5. The minimum number of sample numbers for piped drinking-water in the distribution system of population 110000 is
   A. 1
   B. 1per 5000 population
   C. 1 per 10 000 population plus 10 additional samples
   D. 20

6. Which sample preservation method is used for bacteriological test
   A. Refrigerator
   B. Nitric acid
   C. Sulfuric acid
   D. Ammonia

Note: **Satisfactory rating - 6 points and above** **Unsatisfactory - below 6 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet- 4

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Matching questions

1. ....
2. ....
3. ....
4. ....
5. ....
6. ....

Operation Sheet -1	Techniques of conducting routine monitoring programs

Activity 1: Monitor leakage

Steps

Step 1: Inspect the hole system walking through the system(using visual inspection method inspect if there is any flow come out of valves, water meters, fittings, pipes, pumps and other structures)

Step 2: Close the valve. Make sure no water is being used at the monitoring site

Step 3: Locate your water meter and check the leak indicator to see if it is moving.

Step 4: Look at a water meter and write down the meter reading. Don't run any water for a few hours. Re-read the meter. See if there is a difference

Step 5: Search for wet spot through the system.

Step 6: Correct the leaks if any (if possible, otherwise report to the responsible personnel)

Step 7: Record the result

Activity 2: Monitor valves

Steps

Step 1: Locate flow control valves

Step 2: Inspect the valve visually

Step 3: Inspect the valve mechanically (by opening and closing)

Step 4: Record the result

Activity 3: Flush fire hydrant

Steps

Step 1: Notify customers in particular:

Step 2: Isolate section to be flushed from the rest of the system: Close valves slowly to prevent water hammer.

Step 3: Open hydrant/blow off valves slowly until the desired flow is obtained.

Step 4: Maintain 20 psi minimum flushing pressure.

Step 5: Record data

Step 6: Close hydrant/blow off valve slowly, when water clears

Step 7: Reopen valves connecting flushed section to the larger system.

Step 8: Proceed to next section to be flushed.

Operation Sheet -2	Techniques of identifying and dealing with water quality customer compliant

Figure 1. Illustrates the Funnel/Filter/Focus surveillance approach.

Steps

Step 1: Review historical customer complaint data

Step 2: Funneled all complaints are into one location, such as a call management system, to ensure that complaints are not missed.

Step 4: Filter out water quality complaints from non-water quality complaints by Customer Service Representatives (CSR) or other water utility staff.

Step 5: Assess whether the complaints are related to a water quality incident or to system operations, such as main breaks water quality specialists.

Step 6: Track the time, number and location of complaints that are entered into call or work management systems, and alert utility personnel of unusually high call volumes or spatially-clustered complaints

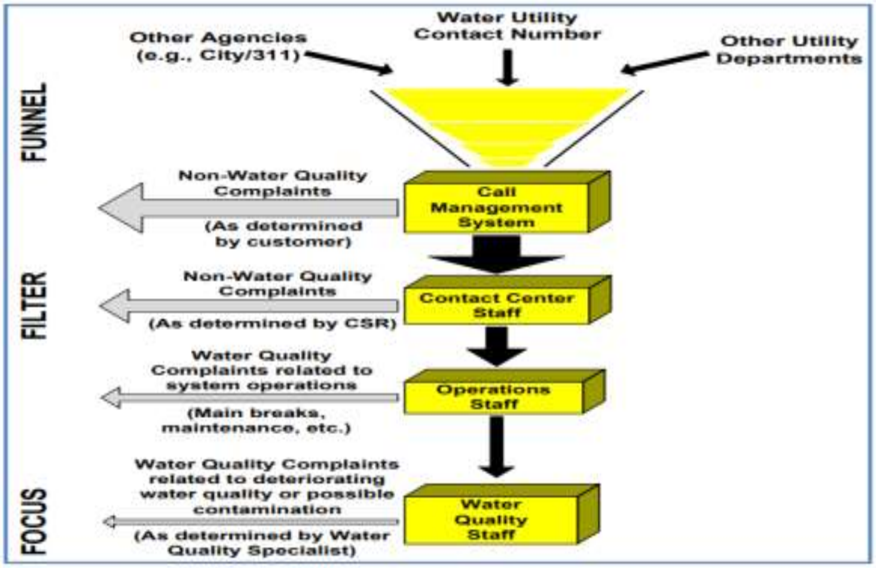


Figure 1. Recommended Funnel/Filter/Focus Approach for Utility-managed Customer Calls

Step 7: Inform the complainant if there is any delay

Step 8: Review the recent operation of the water treatment works, service reservoir/ water tower and the distribution network to determine whether any action may have contributed to the water quality problem

Step 9: Review the results of recent compliance and operational samples from relevant sampling locations;

Step 10: Take and analyze samples for appropriate parameters from appropriate locations including the complainant's premises.

Step 11: receive and assess the results of the investigation

Step 12: take any appropriate remedial action

Step 13: Give advice to the complainant on the actions he/she should take when the investigation has established that the cause is associated with the condition of his/her pipe work and fittings;

Step 14: Report the outcome to the complainant as quickly as possible in simple terms

Step 15: Review from time to time the procedures and modifying them if necessary

Operation Sheet -3	Techniques of collecting and reporting data on system performance and usage

Steps

Step 1: collect and report data on existing condition of valves and hydrants

Step 2: collect and report data on water quality compliments

Step 3: collect and report data on existing condition of water storage facilities

Step 4: collect and report data on existing Condition of pipe system (leakage free)

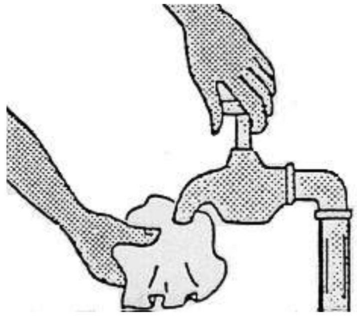
Step 5: collect and report data on water meter condition

Operation Sheet -4	Procedure of collecting and recording water samples

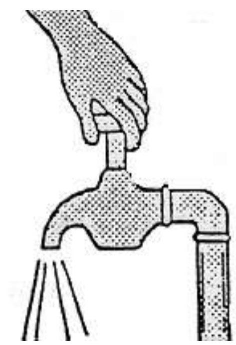
Activity 1: Collect sample for microbiological test from tap

Step

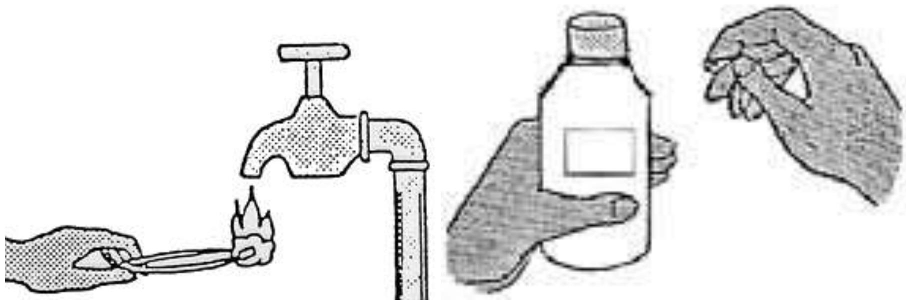
Step 1: Clean the tap*:* Use a clean cloth or paper to clean the outlet. Remove any dirt.



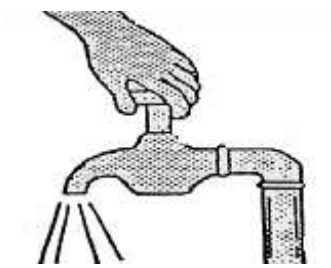
Step 2: ***Open the tap;*** full flush: Turn on the tap to maximum flow and allow water to run for 1-2 minutes. Sufficient water (at least 20 L) should have passed through the tap. Turn tap off.



Step 3: ***Sterilize the tap to kill any bacteria***: For a metal tap, sterilize the tap for about 15 seconds with the flame from an ignited cotton-wool swab that has been soaked in 70 percent alcohol; alternatively, a gas burner may be used on a gentle flame.

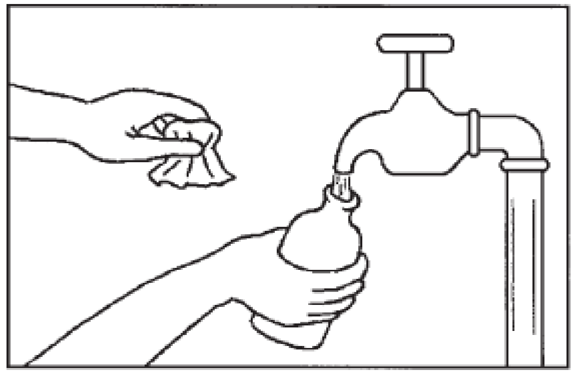


Step 4: ***Open the tap prior to sampling:*** Carefully turn on the tap to a medium flow rate and allow the water to flow. Then reduce the flow rate. Do not change the flow rate while filling the bottle, as deposits may be dislodged.

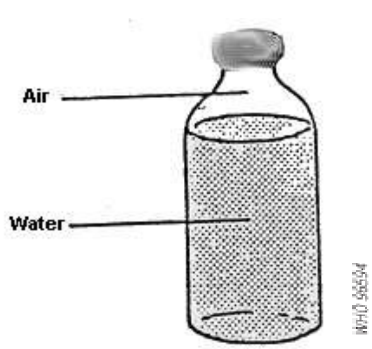


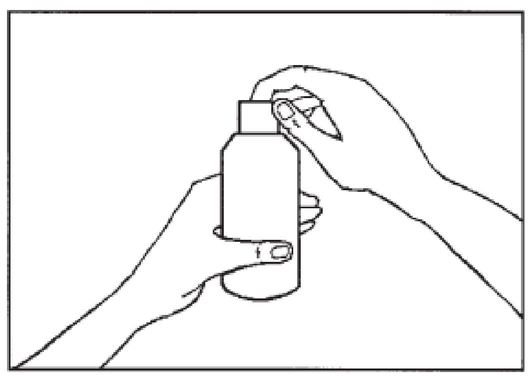
Step 5: Open sterilized bottle: The bottle will have been carefully prepared to be sterile until this moment so take great care in handling it. First, remove any protective cover and discard. Then open the container, with the bottle in one hand and the cap in the other. Do not place the cap on the ground or in your pocket, and do not touch the inside of the lid with your fingers. Hold the cap with the opening facing down. The inside of the cap can be easily contaminated which, in turn, can contaminate the water sample.

Step 6: Fill the bottle*:* After opening, immediately hold the container under the flowing water and fill it to the shoulder but leave an air space. Do not overflow the bottle. Hold the lid with its open end downwards (to prevent entry of dust that might carry microorganisms).



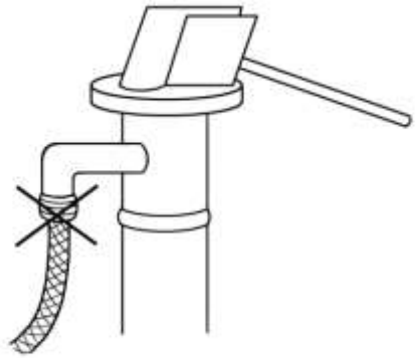
Step 7: Close bottles*:* Screw the lid firmly onto the container. Keep the container cool (less than 10^0C) and in the dark by placing it in a chilly bin complete with ice or chilled cooler pads. Send the sample to the laboratory promptly so that it arrives within 24 hours (preferably within six hours) from the time of sampling.





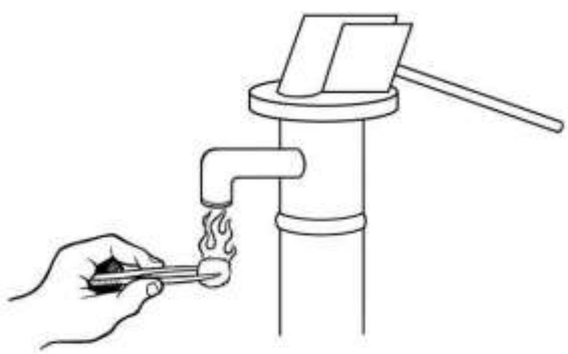
Activity 2: Collect sample for microbiological test from hand pump

Step 1: **Remove any attachments** (e.g., nozzles, pipes, screens) from the pump outlet. These attachments are a frequent source of contamination.



Step 2:. Optional - Use a clean cloth to wipe the pump outlet and to remove any dirt or grease.

Step 3: Sterilize the inside and outside of the pump outlet for 1 minute. Pour alcohol on the outlet and flame it with a lighter or use tweezers to hold an alcohol-soaked cotton swab that is burning. Sterilizing the pump outlet will tell you the actual water quality. Not sterilizing the outlet will tell you the water quality that people are drinking.



Step 4: Pump the water for four to five minutes (it depends on depth of the well, it may take up to 10 minutes) to remove standing water from the plumbing system or rising main of the pump. You can usually tell the standing water is removed when colder water comes through the pump. Take the water sample as soon

LAP Test -1	Practical Demonstration

Name: ___________________________ Date: ____________

Time started: ________________ Time finished: _______________

Instruction I: Given necessary templates, tools and materials you are required to perform the following tasks within ***40 hours.***

Task 1: Conduct routine monitoring programs

Task 2: Identify fluctuations in supply, system changes, community demands and water quality complaints.

Task 3: Collect and report data on system performance and usage

Task 4: Collect and record water samples

Instruction Sheet	Learning Guide #39 Regulate flow

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Monitoring and adjusting flow regulating systems to meet demand
- Regulating and diverting flows to facilitate repair or emergency activities
- Conducting Isolation and inspection of transfer systems

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- Monitor and adjust Flow regulating systems to meet demand
- Regulate and divert Flows to facilitate repair or emergency activities
- Conduct Isolation and inspection of transfer systems

Learning Instructions:

17. Read the specific objectives of this Learning Guide.
18. Follow the instructions described below
19. Read the information written in the "Information Sheets 1- 3". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
20. Accomplish the "Self-checks" in each information sheets on pages 12, 17, & 20.
21. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
22. If you earned a satisfactory evaluation proceed to "Operation sheets 1- 2 on pages 21 & 22 and do the LAP Test on page 23". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
23. After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result;
24. Then proceed to the next LG.

1.1. Impact of the principles of hydraulics on the operation of flows

To better understand what is happening to the water in a distribution system, it is helpful to review some of the fundamental principles of hydraulics. **Hydraulics** is the study of liquid in motion and under pressure.

The quantity of flow (Q) is the volume of water flowing in a pipeline passing a specific point in a specific unit of time. In water distribution the pipeline is under pressure and therefore fills the entire pipe. Flow can be expressed in several ways: cubic feet per second (cfs), cubic meters per second (m^3/sec), gallons per minute (gpm), or million gallons per day (mgd).

The basic flow equation is: **Q = A x V**

The "A" stands for the cross sectional area of the flowing stream of water in the pipeline. The cross sectional area is found by using a formula of the area of a circle.

The "V" in the formula stands for the velocity of flow (speed at which the water is moving) and is usually expressed in feet per second (fps).

The basic flow equation simply states the bigger the pipe through which water is flowing and the faster it is flowing and the more water that will be delivered per unit of time.

"Q" is the volume of water delivered over time and is expressed as cubic feet per second (ft^3 or cfs). One cubic foot per second (1 cfs) equals about 450 gallons per minute (gpm),

Measuring the Flow of Water

The flow of small diameter pipes can also be measured from a spigot or fire hydrant with just a bucket and a stop watch. For example, if a 5-gallon bucket is filled in 30 seconds the flow rate is 10 gpm as calculated below:

Convert 30 seconds to minutes so it can be used to compute gpm:

(30 sec)(1 min./60 sec) = 0.5 minutes

Calculate Q as gpm: Q = 5 gallons /0.5 minutes = 10 gpm

Frictional Loss in Pipelines

The water operator needs to have a good understanding of the relationship between head loss and pipe diameter. Simply stated, larger diameter pipes will create less head loss per foot of pipe than small diameter pipe. Pipe friction also increases as the velocity in a pipeline increases. Aging of metal pipes and subsequent corrosion cause the frictional losses to increase. After 20 years of age, iron pipes will have double the frictional value than new pipe.

Friction is also caused by bends, fittings and valves in pipeline systems. Each of these type of appurtenances reduce the energy available to move the water as it is dissipated by heat. Friction loss tables are provided by pipe manufactures for calculating these reductions. An example is provided below on how to use a head loss table:

Table 1.1. Head Loss for 100' of Service Pipeline at a Flow Rate of 15 gpm for new pipe

Pipe Size	¾ "	1"	1.5"	2"
Velocity fps	9.0	5.6	2.4	1.5
Head Loss ft.	80.0	25.0	3.0	1.1

Example

A customer is experiencing low water pressure. The distance to the house 300'.

The house is located about 10' higher than a fire hydrant with a static pressure of 40 psi.
The customer has a 1" service line.
Available Pressure is 40 psi X 2.31 = 92 ft.

For the 1" line shown in the table, a 300' run would consume 75 ft and another 10' of head would be needed to account for the elevation or 75' +10' = 85' of head! Under this condition the velocity of flow would be greatly reduced and the 1” line could not support the 15 gpm flow of water.

Using the 2” line, the frictional loss would be only be 3 X 1.1 = 3.3 feet of loss.
The additional 10 feet of head would mean a 10 + 3.3 = 13.3 or 6 psi drop in pressure. The pressure at the meter would be increased 31 psi with the larger pipe under this condition! Because the velocity of flow must also be considered, it is best to use the 1.5” size and give up a little head-loss for the additional velocity which would tend to prevent sediment from forming inside the pipe under these conditions. Use of head loss charts can be very helpful in determining the cause of service problems relating to low water pressure.

Pressure vs flow

Flow is the movement of fluid into continuous stream line by virtue of force and velocity. And as per the question **pressure** is nothing but the, resistance to **flow** of fluid. Hydraulic pump does not creates **pressure**, it creates **flow**. And the resistance offered to that **flow** is known as **pressure**.

1.2. Flow Testing Fire Hydrants

Fire flow tests are conducted to determine pressure and flow-producing capabilities at any location within the distribution system. The primary function of fire flow tests is to determine how much water is available for fighting fires, but the tests also serve as a means of determining the general condition of the distribution system.

A flow test is conducted in accordance with AWWA recommendations that identifies the capacity of individual fire hydrants under normal demand conditions. Flow is determined by using two fire hydrants and reading the flow from a pitot tube at the test hydrant and the residual pressure residual at a reference hydrant connected to the same main. The flow rating is then determined based on a reference pressure of 20 psi.

Tops of fire hydrants are often painted by to designate their capacity. These are shown below:

Standards for Identifying

Table 1.2. Flow Capacities of Fire Hydrants

Class	Color	GPM
AA	Blue	> 1500
A	Green	> 1000
B	Orange	> 500
C	Red	< 500

Fire hydrants must conform to the latest AWWA specifications C502. Typical fire hydrants will be the use a hydrant branch that is six inch in diameter and have a six-inch isolation gate valve on the branch as close as possible to the main.

Hydrants in traveled areas are usually furnished with a breakaway feature that will break cleanly upon impact. The valve stem will also break with impact in these types of hydrants.

In commercial/industrial areas hydrants must be installed on a minimum 8-inch main and hydrants in residential areas installed on a minimum 6 inch looped mains to provide adequate fire flow.

Each fire hydrant should be capable of delivering a flow of at least 500 gallons per minute with a residual pressure of not less than 20 psi.

Hydrant operation

Fire hydrants must be operated properly, so adequate fire protection can consistently be provided. Always use a hydrant wrench when operating a fire hydrant. Repeated use of a pipe wrench on the five-sided operating nut will round off the nut so a hydrant wrench will no longer work.

1.3. Valve Operation and Water Hammer

Valves of any size need to be operated slowly. Water hammer is caused by closing the valve too quickly. When water is suddenly stopped, shock waves are generated, which cause large pressure increases throughout the system.

These shock waves travel quickly and can cause extensive damage, sometimes splitting pipes or blowing fittings completely off the system. Frequently in the operation of valves, conditions cause a partial vacuum or void to occur on the downstream side of a valve. These voids will fill with low-pressure vapors from the water. When these pockets implode or collapse, they create a mechanical shock causing pockets of metal to break away from the valve surface.

Another problem in water distribution systems is noisy or vibrating valves. This is usually an indication that cavitation is occurring. Cavitation will eventually render the valve unsuitable for service. The most common cause of cavitation is that the valve is partially closed.

Valve Operation

Operation Mechanism Gate and Globe valve opening/closing is achieved using Hand wheel/Gear unit/Electrical/Hydraulic/Pneumatic Actuator.

Gear Unit Gear units are provided on valves for easier operation. Clockwise operation is for closing and counterclockwise for opening of the valve (Fig. 1.1). The position of the valve can be noted using the position indicator provided on the gear unit. The number of turns will depend on the gear unit used.

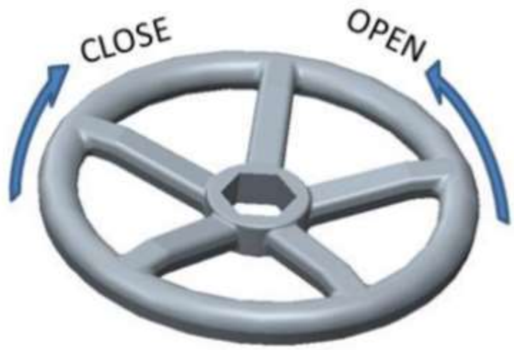


Figure 1.1. Valve opening and closing direction

Forcing the hand wheel, chain wheel against the stops will not provide tighter shutoff of the valve and may damage the seat faces, stem or gear unit.

Electric Actuator It gives multi-turn output and is either directly mounted on valve or on the gear unit. The actuator drives the gear unit shaft which in turn rotates the stem nut and because of this Gate / Globe valve stem travels linearly.

In Gate and Globe valves, electrically actuated valves shall be normally set as below:

Open : Position

Close : Torque

Pneumatic / Hydraulic Actuator Pneumatic/hydraulic actuators are fitted directly on the valve, without gear unit. It is recommended to adhere to the instructions as per actuator manual.

Do's and Don'ts

Do's	Don'ts
Before taking valve for erection, make sure that is cleaned properly from inside and outside and there are no foreign particles or metallic chips sticking on to sealing element.	DO NOT lift the valve by the hand wheel, gear box, actuator or bypass arrangement.
While installing the operator, make sure that the valve is in fully closed position.	DO NOT use the lifting points located on the Gear unit / actuator, if any, to lift the valve. These lifting points are for the Gear unit / actuator only.
Make sure to remove the entire rust preventive on the machined surface in the flow area before a valve is put in the pipe line.	DO NOT over-tighten packing gland nuts. Over-tightening will increase the torque required to operate the valve.
Carefully read the identification plate details and install the valve in the right place and for the correct duty conditions for which it is designed and manufactured. Gate with pressure relief arrangement, Globe and Check valves have preferred sealing direction marked by an arrow on the valve body beneath the identification plate.	DO NOT use impacting devices to tighten up the bolting on the body/bonnet (cover). Use suitable mechanical devices for tightening.
Make sure to supply rated voltage and frequency to the electrical actuator.	DO NOT tighten the body/bonnet nuts when the wedge/disc is in the fully closed position.
Swing check valves shall also be installed in vertical pipe line with flow in upwards direction.	DO NOT keep the Gate valves in partial open condition to regulate flow.

When operating a valve manually, the approximate number of turns required to fully open or close a valve can be calculated as follows:

# of turns = (Diameter of the valve (in inches) x 3) + 3

Table 1.3. Valve size and number of turns

Valve Size	Number of Turns
4 inch	14½
8 inch	27
12 inch	38½
16 inch	53

Sample Calculation

Approximately how many turns would it require to fully close a typical 6-inch valve that is initially fully opened?

Ans: # of turns = (6 x 3) + 3 = 21 turns

The direction (clockwise or counter clockwise) used to open or close a valve can vary from valve to valve. The proper direction to open the valve is usually indicated by an arrow on the valve bonnet. However, most systems typically standardize all valves in the system to operate the same.

When exercising a valve, the operator should make sure that a valve is properly returned to its original position. This is done by considering the number of valve turns required to fully open or close the valve. When exercising valves, be aware of water hammer.

How do you know if a ball valve is open or closed?

When the handle of a ball valve is parallel to the valve or pipe, it's open. When it's perpendicular, it's closed. This makes it easy know if a ball valve is open or closed, just by looking at it. The ball valve below is in the open position.

Water hammer

Water hammer is the momentary increase in pressure inside a pipe caused by a sudden Change of direction or velocity of the liquid in the pipe. Basically, water rushing through a pipe comes to an abrupt stop. The sudden stop creates a shock wave. Water hammer can cause pressure spikes 10 times higher than normal operating pressures. Water hammer can be particularly dangerous because the increase in pressure can be severe enough to rupture a pipe or cause damage to equipment. Therefore, to avoid water hammer, slowly open and close valves.

None return valve

What is the function of non-return valve?

The **function of non-return valve** is to limit the flow of fluid through it one direction. They may be manually operated or may be automatic operated. Automatic **valves** are designed for particular pressure, when pressure (of fluid) exceeds that limit, **valve** opens allowing the fluid to flow through it

1.4. Determining Water Level and System Pressure in an Elevated Tank

In a tank of water, the weight of water exerts a pressure on the bottom of the tank which we call pressure head. The deeper the water, the greater the pressure on the tank at that point. This pressure not only exerts itself downward, but also in equal amounts against the sides of the tank. The pressure is dependent only on the height of the water and not on the volume of the tank. Pressure head will commonly be expressed either as head (feet of water), or as pressure (pounds per square inch or psi).

A column of water 2.31 feet high provides a pressure of 1 psi at the bottom of the column. An example calculation is shown below:

What will be the height of the water in a tank with a pressure reading of 40 psi on a gauge connected to a water main at the bottom of the tank?

(40 psi) X (2.31 feet/psi) = 92.4 feet

Because pressure heads in water tanks can be easily calculated, tank levels are frequently used to start and stop high service pumps at treatment plants to meet changing water demand conditions.

Storage Volume and Water Level

Volume Calculations

The volume of water in a storage facility can be calculated for any given water level, if the dimensions of the tank are known. Tank volumes are typically provided in gallon units.

Volume Calculations for rectangular shapes: Volume (V) = Length (l) x Width (w) x Height (h) or it can also be written as Volume (V) = Area (A) x Height (h), and often written as:

V = A x H

Example

A rectangular ground level storage facility is 100 feet long by 50 feet wide. The water level in the tank (measured from the bottom of the tank) is 10 feet. What is the volume (in gallons) of water in the tank?

1.5. Operating procedures of storage facilities

1.5.1. Refilling of Storage

Routine Refill

The operation of distribution pumps is often controlled by the water level in a storage facility. When the water level in a storage facility reaches a set low level, the pumps are turned on until a set high level is reached. The operation of the distribution pumps and subsequent refilling of distribution storage can also be controlled by pressure, pump speed, flow rates, and time of day.

Emergency Refill

Secondary or lag pumps are typically operated to refill system storage following excessive peaks in demand or emergency conditions, such as a fire or a main break. Procedures should be developed and utilized to manually or automatically control system facilities to ensure proper refill of system storage for normal and emergency conditions.

1.5.2. Storage Level Controls

Level Recorders

In order to maintain proper operations, the water level in a storage facility should be monitored and recorded at all times.

Control Valves

Altitude valves are used to control flow in and out of storage facilities and prevent overflows. Altitude valves operate by sensing pressure. The pressure can be correlated to the water level in the tank using the formula provided in Unit 1.

Pressure, psi = 2.31 x Head, ft.

Self-Check -1	Written Test

Direction I: Multiple choice item (2 points each)

Instruction: Choose the best answer from the listed options of the following questions and write your answer on the answer sheet provided in the next page.

1. ------------------is the study of liquid in motion and under pressure.
   A. Hydraulics
   B. Hydrology
   C. Geology
   D. Water cycle
2. ---------------------is the volume of water flowing in a pipeline passing a specific point in a specific unit of time.
   A. The quantity of flow (Q)
   B. Pressure

C. Hydraulics

D. Water hammer

3. Determine the flow rate if water flow through a pipe of diameter 2cm and a velocity of 1Cm/s

   A. $4cm^3$

   B. $2cm^3$

   C. $3.14m^3$

   D. $0.5m^3$

4. Approximately how many turns would it require to fully close a typical 4-inch valve that is initially fully opened?

   A. 15

   B. 12

   C. 21

   D. 27

5. What will be the height of the water in a tank with a pressure reading of 100 psi on a gauge connected to a water main at the bottom of the tank?

   A. 92.4 feet

   B. 231 feet

   C. 124 feet

   D. 321.1 feet

Note: **Satisfactory rating - 5 points and above** **Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-1

Score = ___________

Rating: ____________

Name: ___________________________ Date: ________________

Multiple choice questions

1. ....
2. ....
3. ....
4. ....
5. ....

Information Sheet- 2	Regulating and diverting flows to facilitate repair or emergency activities

2.1. Repair or emergency activity

A **water emergency** is any event that disrupts the normal supply of clean **water** to your home. This may be due to repair of the reticulation, distribution and bulk water transfer system. At this stage the water authority should first notify the customer that there will be no water for the repair period so that the customers take precaution concerning water shortage. For repair or emergency activity the authority may totally shutdown the water supply system or partially by regulating and diverting water from the following components:

- pumping systems (centrifugal, submersible positive displacement)
- valving systems, including (sluice, gate, blade, non-return)
- electronic and manual controlling systems
- service reservoirs

2.2. Regulating and diverting flow

2.2.1. Pump flow control

There are several different methods to match the flow to the system requirements. The four most common flow control methods of pumps are throttling, bypassing, on-off control and variable speed drive (VSD) control. These are illustrated in Figure 1.2.

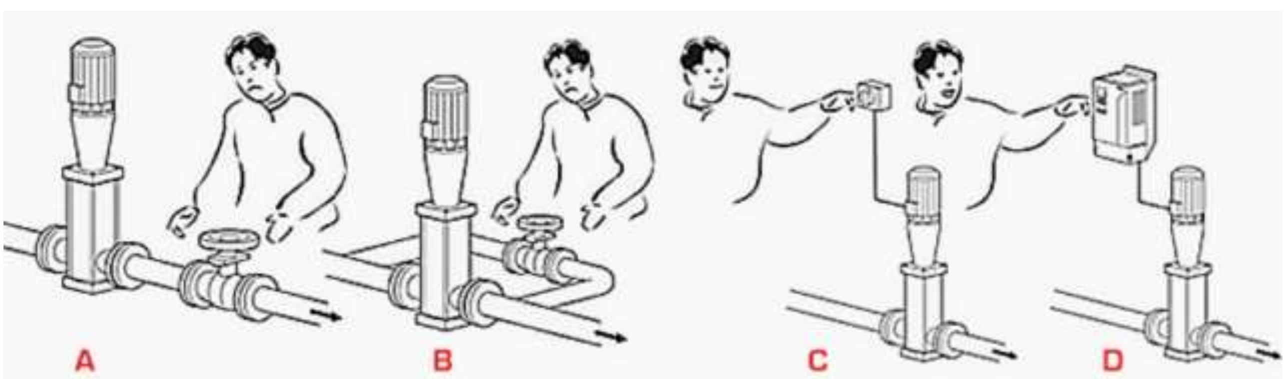


Figure 2.1. – Illustrations of pump flow control methods. A – Throttling, B – bypassing, C – on-off control and D – VSD control

Throttling

- Throttle control is **the most commonly used method**. The flow caused by the constant speed pump is reduced by increasing the losses in the system by closing the valve

Suction.

Bypassing

Although not commonly used, bypassing is applied mainly to circulation pumps. The flow output to the system is reduced by **bypassing part of the pump discharge flow** to the **pump suction**

On-off control is often used **where stepless control is not necessary**, such as keeping the pressure in a tank between preset limits. The pump is either running or stopped. The average flow is the relationship between the “on” time and the “total” time (on+off).

VSD control

A variable speed drive (VSD) changes equipment speed to provide the torque energy input needed to supply the hydraulic energy output to the process.

Centrifugal pump,

For every pressure, the pump will only deliver one specific flow rate. Therefore, to control the flow of a centrifugal pump, simply set the output pressure to the point on the P-V diagram that allows the pump to deliver the desired flow rate. The output pressure of the pump is set using a back pressure regulator.

Positive displacement pump

To control the flow from a pump is to throttle the discharge by opening and closing a valve at the exit of the pump. In the case of controlling the discharge of positive displacement pumps, this technique is used to prevent pump slip (also called pump runaway) and has the added benefit of pulsation dampening. The diagram to the right shows an Equilibar back pressure regulator in series with a flow transmitter controlling the discharge of a positive displacement feed pump.

Submersible pump flow regulation

Pressure Switch – senses pressure in the water line and signal the pump to start and stop with pre-set low- and high-pressure settings. Pressure switches can control well pumps and booster pumps. Proper high- and low-pressure settings allow multiple pumps to operate in lead and lag mode.

Ball Valve – has a lever to open and shut the ball-shaped valve and is more reliable than a gate valve. It is more likely to actually open and close after years of use.

Gate Valve – opens by lifting a round or rectangular plate out of the water flow. Gate valves are designed to operate fully opened or closed and are not well suited to regulate flow. When fully open, the typical gate valve has no obstruction in the flow path, resulting in very low friction loss.

Valve control

What is the difference between flow control valve and pressure control valve?

Basically, the pressure control valve is concerned with controlling the pressure that is upstream of its location by limiting the amount of liquid allowed to pass downstream. The flow control valve is concerned with controlling the amount of liquid that is flowing past it downstream.

How do valves reduce pressure?

One device which can help you to reduce the water pressure in water system is the water pressure reducing valve. These valves work by cutting down the amount of water which passes through a pipe. Water which is being forced through the pipes at high pressure before the valve will be slowed down after the valve.

Self-test - 2	Written test

Direction I: Matching item (2 points each)

Instruction: Match column B with column A of the following questions and write your answer on the answer sheet provided in the next page:

A		B	
1.	Regulating device	A.	water emergency
2.	To control the flow from a pump is to throttle the discharge by opening and closing a valve at the exit of the pump.	B.	Centrifugal pump
3.	is concerned with controlling the pressure that is upstream of its location by limiting the amount of liquid allowed to pass downstream	C.	flow control valve
4.	is concerned with controlling the amount of liquid that is flowing past it downstream.	D.	Positive displacement pump
5.	set the output pressure to the point on the P-V diagram that allows the pump to deliver the desired flow rate	E.	Valve
6.	Any event that disrupts the normal supply of clean **water** to your home.	F.	pressure control valve

Note: **Satisfactory rating - 6 points and above Unsatisfactory - below 6 points**

You can ask you teacher for the copy of the correct answers

Answer Sheet-3

Score = ___________

Rating: ____________

Name: ___________________________ Date: ________________

Multiple choice questions

4. ....
5. ....
6. ....
7. ....
8. ....
9. ....

3.1. Isolation and inspection of transfer system

Isolation valves are crucial components of water distribution systems for separating pipe segments from the network for repair or maintenance purpose. Portions of a water distribution network (segments) directly isolated by valve closure.

Planned (e.g. regular maintenance) and unplanned interruptions (e.g. pipe burst) occur regularly in water distribution networks, making it necessary to isolate pipes. To isolate a pipe in the network, it is necessary to close a subset of valves which directly separate a small portion of the network, causing minimum possible disruption. This is not always straightforward to achieve as the valve system is not normally designed to isolate each pipe separately (i.e. having two valves at the end of each pipe). Therefore, for management purposes, it is important to identify the association between each subset of valves and the segments directly isolated by closing them. Furthermore, it is also important to improve the design of the isolation valve system in order to increase network reliability.

What is the isolation procedure?

An **isolation procedure** is a set of predetermined steps that should be followed when workers are required to perform tasks such as inspection, maintenance, cleaning, repair and construction. Lock-out process is the most effective **isolation procedure**: shut down the machinery and equipment.

Inspection of transfer system

An inspection is, most generally, an organized examination or formal evaluation exercise. In engineering activities inspection involves the measurements, tests, and gauges applied to certain characteristics in regard to an object or activity. The results are usually compared to specified requirements and standards for determining whether the item or activity is in line with these targets, often with a Standard Inspection Procedure in place to ensure consistent checking. Inspections are usually non-destructive.

Inspections may be a visual inspection or involve sensing technologies such as ultrasonic testing, accomplished with a direct physical presence or remotely such as a remote visual inspection, and manually or automatically such as an automated optical inspection.

Self-Check -3	Written Test

Direction I: True false item (2 points each)

Instruction: Write true if the statement is correct false otherwise for the following questions and write your answer on the answer sheet provided in the next page.

1. Isolation valves are crucial components of water distribution systems for separating pipe segments from the network for repair or maintenance purpose.
2. Planned (e.g. regular maintenance) and unplanned interruptions (e.g. pipe burst) occur regularly in water distribution networks, making it necessary to isolate pipes.
3. Lock-out process is the most effective isolation procedure: shut down the machinery and equipment.

Note: **Satisfactory rating - 3 points and above Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Score = ___________
Rating: ____________

Answer Sheet-3

Name: ___________________________ Date: ________________

True false questions

1. ....
2. ....
3. ....

Operation Sheet -1	Techniques of monitoring and adjusting flow regulating systems

Activity 1: Flow control using 1'' GS gate valve

Steps

Step 1: locate the valve

Step 2: gently turn the handle counter-clockwise (to the left) without applying excessive force – do not 'jerk' the handle.

Step 3: Set the valve to the desired pressure by turning it to a specific setting, or by measuring with a pressure meter downstream.

Step 4: increase the turn up to 6 turns this is the final position, a typical 1″ main control valve for a water line will take about six full turns to fully open.

Step 5: Stop turning as soon as there is any resistance.

Step 6: Gently turn the handle clockwise (to the write) without applying excessive force

Step 7: Stop turning as soon as there is any resistance. At this point the valve is closed.

Activity 2: Hydrant flow control operation

Steps

Step 1: Open the highest port,

Step 2: Slowly open the hydrant valve a few turns until water has reached the open port.

Step 3: Flush any debris that may be in the fire hydrant barrel.

Step 4: When the water is clear, slowly open the hydrant fully. It is important to displace trapped air from the hydrant barrel. Compressed air could cause problems. Remember that air is compressible, and water is not compressible.

Step 5: attach an operating hand valve to the port from which water will flow if the internal hydrant valve may not function properly due to debris or mechanical problems. Whenever possible,

Step 6: using the operating nut close the hydrant.

If flow from the fire hydrant cannot be completely shut down using the operating nut, use the hand valve to stop flow, and then close the control valve on the hydrant lead to completely shut down the hydrant.

Operation Sheet -2	Techniques of conducting inspection of transfer systems

Steps

Step 1: Prepare for the inspection

Step 2: select an appropriate inspection method

Step 3: Gather relevant information relating the isolation and transfer system

Step 4: Communication the inspection results

LAP Test -1	Practical Demonstration

Name: _________________________ Date: ____________

Time started: ________________ Time finished: _______________

Instruction I: Given necessary templates, tools and materials you are required to perform the following tasks within ***30 hours.***

Task 1: Monitor and adjust flow regulating systems (valve and fire hydrant)

Task 2: Conduct inspection of transfer systems

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Monitoring and adjusting pressure to meet optimum delivery.
- Investigating and reporting pressure fluctuations
- Documenting and reporting reticulation and distribution information

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- Monitor and adjust pressure to meet optimum delivery.
- Investigate and report pressure fluctuations
- Document and report reticulation and distribution information

Learning Instructions:

25. Read the specific objectives of this Learning Guide.
26. Follow the instructions described below
27. Read the information written in the "Information Sheets 1- 3". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
28. Accomplish the "Self-checks" in each information sheets on pages 10, 17, & 36.
29. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
30. If you earned a satisfactory evaluation proceed to "Operation sheets 1- 3 on pages 37 & 40 and do the LAP Test on page 40". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
31. After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result;
32. Then proceed to the next LG.

Information Sheet-1	Monitoring and adjusting pressure to meet optimum delivery

1.1. Introduction to monitoring

Monitoring is the regular observation and recording of activities taking place in a project or programme. It is a process of routinely gathering information on all aspects of the project.

To monitor is to check on how project activities are progressing. It is observation; – systematic and purposeful observation.

Monitoring also involves giving feedback about the progress of the project to the donors, implementers and beneficiaries of the project.

Reporting enables the gathered information to be used in making decisions for improving project performance

Purpose of Monitoring

Monitoring provides information that will be useful in:

- Analyzing the situation in the community and its project;
- Determining whether the inputs in the project are well utilized;
- Identifying problems facing the community or project and finding solutions;
- Ensuring all activities are carried out properly by the right people and in time;
- Using lessons from one project experience on to another; and
- Determining whether the way the project was planned is the most appropriate way of solving the problem at hand

1.2 Water distribution system pressure

Pressure is defined as force per unit area and is a very important quantity in distribution system water flow. Mathematically pressure is expressed as P= F/A where, A refers cross-sectional area, F is the force excreted. Water pressure is a measure of the force that pushes water through our pipes and into your property.

There are three common units in which pressure is expressed.

1. Pascal (Pa) is the standard scientific unit in which pressure is measured. One Pascal is the pressure exerted by a force of 1 newton on an area of 1 m2.

2. Bar is another unit of pressure used for large pressures, with 1 bar = 100 kPa. One bar is approximately equal to atmospheric pressure.

3. Pressure head. Pressure head is measured in length units (typically metre) and is the height to which water will rise in a vertical tube placed on top of a pipe or pressure vessel. If, for instance, a thin and long vertical pipe is connected to a distribution mains that has a pressure head of 20m, the water rise in the vertical pipe to a height of 20 m above the pipe.

The amount of pressure at the delivery point can depend different factors such as: the pump capacity, the reservoir position, pipe type, the amount of water customers are using, elevation of dwellings and elevation of water assets.

For water utilities, understanding water pressure in the distribution system is a critical component of managing their community's water supply. Adequate positive pressure should be provided throughout a distribution network to ensure adequate water service and protect the system against backflow. The main purpose of elevated tanks in water distribution systems is to boost the pressure in the system.

Pressures should generally range from a minimum of approximately 35 psi to a maximum of approximately 100 psi. The minimum pressure allowed in a distribution system is 20 psi. When pressures drop below 20 psi, a system could experience backflow conditions which could impact water quality.

Often when a water system service area has a wide range of ground elevations within its boundaries, water distribution networks are comprised of several pressure zones to provide acceptable pressures to the varying ground elevation. Pressure zones are typically separated by pumps, pressure control valves, and isolation valves.

1.3. Understanding pressure gauges

System pressure: It is essential to maintain a continuous positive pressure in the main at the time of transmission of water in the pipeline. Low pressure locations have to be investigated if necessary, by measuring pressure with pressure gauge.

A pressure gauge is a device that helps monitor performance parameters. Our water systems and tanks function because the water or air that runs through them is pressurized. A pressure gauge measures the force of the pressure in the water or air so that you can determine whether you have any errors in your tanks or systems.

What is a pressure gauge's purpose?

Pressure gauges are used for a variety of things. We can use them to gauge distribution system pressure. We use them on a storage tank for a well system to make sure the pump is turning on and off properly. And, we use them on water treatment equipment or things like reverse osmosis where pressure is a key component to the operation of that system.

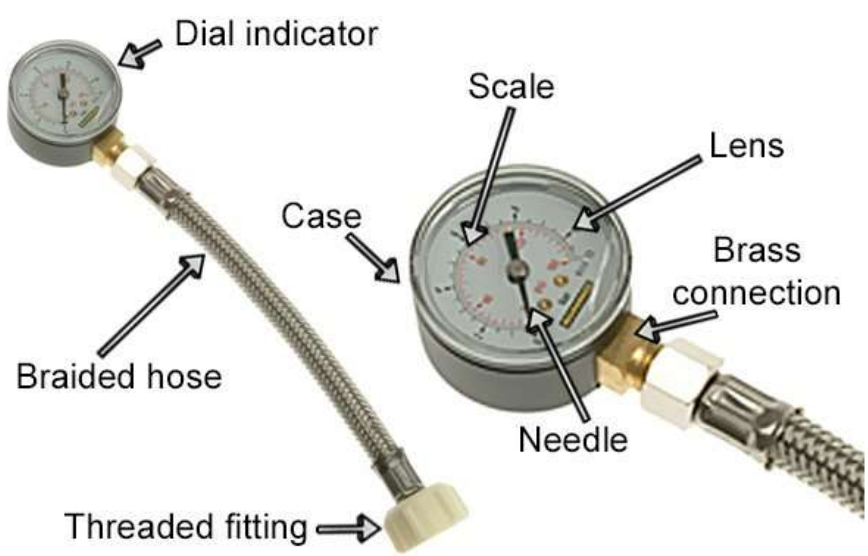
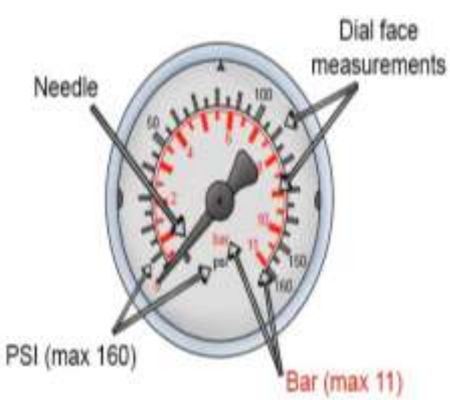


Figure 1.1. Pressure gauge components

	The dial indicator allows the user to easily read the pressure gauge. It consists of a face with a measurement scale on it (typically in bar or PSI, or both), a needle to indicate what pressure the water is at, a lens to protect the dial, a metal case, and a brass connection fitting.
	**What is PSI?** PSI stands for "Pounds per Square Inch" and is a unit of pressure measurement. In the UK we measure water pressure in bars, but in America they more commonly use PSI. Many water pressure gauges will have a scale including both measurements.
	Water pressure gauge scale and needle This scale and needle work together to provide an easily readable visual display that will indicate the pressure of water in a given system. On this dial indicator, bar measurements are indicated on the red scale and PSI measurements are indicated in black. The needle will move along the scale to indicate the pressure.

	What is the maximum measurement on the scale**?** There are many makes and models of water pressure gauge, with varying degrees of minimum and maximum measurements. This model has a maximum measurement of 11 bar which is typical for domestic use. The maximum measurement varies depending on the type of gauge you are using. Some industrial pressure gauges can measure in excess of 4000 bar!

There are two main types of pressure gauges

There are two basic types of pressure gauges: analogue (dial) and digital.

Analogue

Figure 1.2. Analogue pressure gauges

Check the benefits here:

- Extremely easy installation
- It is more affordable for companies
- It doesn`t require power

- Easier to read the results from a distance

The drawbacks are the following:

- Not as reliable and accurate as the digital gauges
- Pressure pulsation, over-pressure spikes and ambient temperature can cause premature wear
- It should be calibrated in the position where you will use it
- The glass of the gauge can break easily

Here you can find the major benefits and drawbacks of digital pressure gauges.

Figure 1.3. Digital pressure gauge components

List of advantages:

- Easy to install
- Suitable for a wide range of applications and industries as it is durable and robust
- They are as fast as they`re precise, as they have a large pressure range
- Small increments of pressure change can be detected
- Steady reading when the vibration is high
- Some equipment can hold the reading in memory
- There are some pressure gauges that will take international measurements, displaying results in units such as bar, psi, MPa
- Can withstand over-pressure, constant pressure pulsation

Disadvantages:

- They require a power supply, for example battery, loop or solar power

How do you calibrate a pressure gauge?

Calibrating a pressure gauge is fairly complex, depending upon the style of gauge or the accuracy that you are looking for. Sometimes, calibration on a periodic basis is necessary. For example, if you are treating water in an application where a very specific pressure has to be met, it is very important that your meter, or gauge, is calibrated correctly.

How do you read a pressure gauge?

You can read a pressure gauge by simply matching the needle to the number on the dial. Digital pressure gauges will read the exact PSI, and an air pressure gauge, like a tire gauge; will shoot out a little stick marked with measurements of PSI. The stick will line up with the end of the gauge so you can read the pressure.

What does it mean if the pressure gauge reads negative?

It is pretty obvious that a pressure gauge reading a negative number has a problem. Typically, pressure gauges range from zero up to any positive number. So, if your gauge is showing a negative number, either the gauge is malfunctioning, or it's working on a vacuum that is pulling the bourdon tube into a further curve, which would make the needle go down. It could be that the meter is calibrated poorly or needs calibration.

1.4. Pressure control

Rapid changes in flow velocity within a distribution network can result in a pressure surge or water hammer. If not properly controlled, the pressure surge can result in failure of distribution network components.

The Potential Problems of this effect includes:

- Pipe bursting,
- Pipe collapsing, or
- Failure of other distribution network components.

Possible Causes

- Opening or closing valves too quickly.
- Starting or stopping pumps, or
- Opening or closing fire hydrants too quickly.

Preventative Measures

- Proper operations, including slow opening and closing of valves and hydrants.
- Use of pressure surge control devices such as pressure and surge relief valves, vacuum relief valves, and surge tanks.

How is pressure managed?

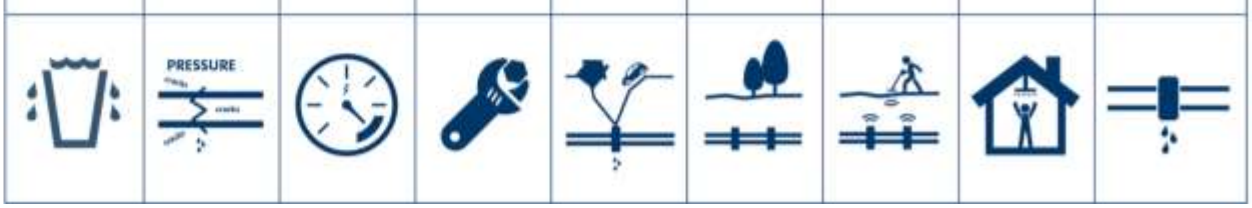
Excessive water pressure can lead to water main breaks and cause leaks in the water system. Water pressure management aims to adjust water pressure levels in the supply system to achieve more consistent pressure levels which will reduce the number of water main breaks, improve the reliability of the water supply system and conserve water, while maintaining adequate supply to customers.

Pressure and flow test

If low pressure is reported, to determine the cause of low pressure of the public or private side a pressure and flow test can be carried out at the stopcock outside the property.

Table 1.1. Pressure management: reduction of excess average and maximum pressure

Conservation benefits			Water utility benefits			Customer benefits		
Reduced flow rates			Reduced frequency of bursts and leakes					
Reduced excess or unwanted consumption	Reduced flow rates of leaks and bursts	Reduced and more efficient use of energy	Reduced repair and reinstatement costs, mains & services	Reduced liability costs and reduced bad publicity	Deferred renewals and extended asset life	Reduced cost of active leakage control	Fewer customer complaints	fewer problems on customer plumbing & appliances



1.5. Pressure management techniques

Pressure management started as an effective technique to reduce leakage rates in distribution systems due to the fact that leakage is often quite sensitive to changes in system pressure. However, it is now recognized that pressure management has many other benefits for distribution systems, including lower pipe failure rates, longer pipe service lives and improved water demand management.

In some cases pressures can be reduced at all times of the day and night, while in others pressures are only reduced during the night.

To implement pressure management, a section of the network with similar elevations is isolated from the rest of the system and supplied through a single point (or sometimes more points) equipped with a water meter and PRV. These areas are called pressure management zones (PMZs) or pressure management areas (PMAs). The PRV serving a pressure management zone can be controlled in four ways:

1.5.1. Fixed Outlet Pressure Control

Typically employs a pressure reducing valve (PRV) with no additional equipment; it is considered to be the most straightforward form of pressure management. PRVs are easy to install and require little with regard to operation and maintenance. However, most PRVs lack the flexibility to adjust water pressures at different times of day.

1.5.2. Time-Modulated Pressure Control: similar to fixed-outlet pressure control, includes an additional control which provide a further reduction in pressure during off-peak periods. This method is particularly useful in areas where water pressures build during off-peak, non-use periods. The controller provides greater flexibility by allowing for the reduction of pressures at specific times of day, resulting in greater savings. Additionally, the system's components are less expensive than those used in flow modulated pressure control.

1.5.3. Flow Modulated Pressure Control provides greater control and flexibility than time-modulated pressure control. This method uses an electronic controller which interacts with a properly-sized meter and PRV to ensure adequate water pressure in the event of needed fire flow. The increased flexibility of flow modulated pressure control offers more savings than fixed outlet and time-modulated control methods; these savings may be offset by the increased equipment expense associated with the electronic controller and properly-sized meter.

1.5.4. Closed-loop pressure control has historically been considered the best available form of pressure control, resulting in maximum savings to the water utility and consumer. This method is the most complicated form of pressure control, involving many integrated components; this presents a greater likelihood of equipment failure and requires a level of skill for maintenance and operation that is often too challenging for a water utility.

1.5.5. Remote Wireless Pressure Monitoring it is **t**he most advanced solution for every water distribution system is. As indicated by increasing numbers of reticulation system failures, real-time monitoring is critical to prevent costly and often unnecessary water system interruptions. Remote wireless pressure monitoring offers an end-to-end integrated hardware and software system for monitoring, analyzing and modeling a water distribution system in real-time.

Self-Check -1	Written Test

Direction I: Matching item (2 points each)

Instruction: Match column B with column A of the following questions and write your answer on the answer sheet provided in the next page:

	A		B
1.	The regular observation and recording of activities taking place in a project or program	A.	Pressure control
2.	Defined as force per unit area and is a very important quantity in distribution system water flow	B.	Fixed Outlet Pressure Control
3.	Rapid changes in flow velocity within a distribution network can result	C.	Flow modulated pressure control
4.	Proper operations, including slow opening and closing of valves and hydrants.	D.	Pressure
5.	Typically employs a pressure reducing valve (PRV) with no additional equipment	E.	Monitoring
6.	Method uses an electronic controller which interacts with a properly-sized meter and PRV to ensure adequate water pressure in the event of needed fire flow.	F.	pressure surge or water hammer

Answer Sheet-1

Score = ___________

Rating: ____________

Name: ___________________________ Date: ________________

Matching questions

10. ....
11. ....
12. ....
13. ....
14. ....
15. ....

***Note:* Satisfactory rating - 6 points and above Unsatisfactory - below 6 points**

You can ask you teacher for the copy of the correct answers.

Information Sheet-2	Investigating and reporting pressure fluctuations

2.1. Pressure fluctuation

Water pressure fluctuation is one of the most commonly reported troubles with fluid handling systems. When you have a system in place to deliver water. You should be able to rely on a consistent, measurable flow. Under normal conditions the static pressure in the reticulation network should be 250–300 kPa; 150 kPa at the consumer's tap is considered to be the minimum acceptable pressure.

If an event to do with system pressure occurs, ie, the pressure has not been maintained, the following could happen:

- If there have been fluctuations in the system pressure, sickness can come from germs or chemicals that have got into the water when the pressure was low.
- If pressure changes have stirred up debris within the mains, germs or chemicals in the debris can cause sickness.

2.2. Causes of pressure fluctuation

Distribution systems can lose pressure for various reasons that include water main breaks, equipment failures, losses of power, etc. Loss of pressure in a drinking water distribution system may cause a net movement of water from outside the pipe to the inside through cracks, breaks, or joints in the distribution system. Back siphonage is also a condition resulting from low or no pressure.

How do you know if pressure is too high or too low?

Pressure gauges come in a variety of calibrations. They can range 0 to 15 pounds per square inch (PSI), all the way up to a range of 0 to 1,000 PSI. So, the trick with a pressure gauge is to make sure the gauge that you are using is compatible with the scale of the application you are using it in. You can determine whether the pressure is too high or too low based on what parameters you are looking to operate under.

What does it mean if our pressure is too low?

Pressure gauges provide information that allows us to monitor equipment. If we see pressure going too high or low, it could be an indication that we need to fix something in our tank or pump system.

What does it mean if our pressure is too high?

If the pressure on your gauge reads too high, you may also have to take action. Extra-high pressure could result in a catastrophic failure. Fittings or tubing could burst, or housings could come apart. If this happens, you will begin to experience leaks that could result in flooding and be potentially dangerous for your home or office

If you are experiencing extreme fluctuations, one of the following issues might be the cause

2.2.1. Air in the Pipes

When air gets trapped in a piping system it acts as a valve and can "pinch off" or reduce the effective pipe size reducing flow and causing additional pressure loss due to friction. Air will usually accumulate at the highest point in the piping system. Symptoms include sputtering, a lack of flow, and then a sudden burst. Air in the pipes can be caused by a leaking suction line, damaged tank bladders, a faulty pump, gas build up in the well system, or one or more leaks in the pipe line.

2.2.2. Municipal Water Failure

From time to time, municipalities experience water failures that can impact entire neighborhoods. In addition, in areas experiencing severe drought, municipalities may redirect water for urgent use elsewhere.

2.2.3. Pressure Regulator Malfunction

Too much pressure can cause pipes to leak or burst, and of course leads to waste. If you are seeing signs of sudden pressure bursts, take a look at the pressure regulator.

2.2.4. Broken Pipe

If everything is going along smoothly and the water flow drops to a trickle, there may be a broken pipeline. Major leaks and breaks will cause a dramatic reduction in pressure and flow.

2.2.5. High usage of the same line

Even high water usage on the same main line as you, such as neighbors filling a pool or using water for landscaping can cause the pressure in your supply to go up and down. Stay up to date with your neighbors' water usage to understand how your supply might be affected.

2.2.6. Water hammer

When something is moving, and that something is large and heavy, it is not easily stopped. This is true of moving water. The energy of the moving water has to be contained by a pipe system when the flow stops. The more quickly the flow rate changes, and the greater the volume of moving water in a pipe, the greater the effect of the change.

The release of this energy is often experienced as a loud bang when shutting a household tap. In larger systems this 'water hammer' effect can seriously damage pipes and fittings. There are specific designs and methods of operation that prevent this form of damage. Where pipe velocities are likely to exceed 2 m/s, the design should be checked for the potential for water hammer, particularly in long sections of pipe.

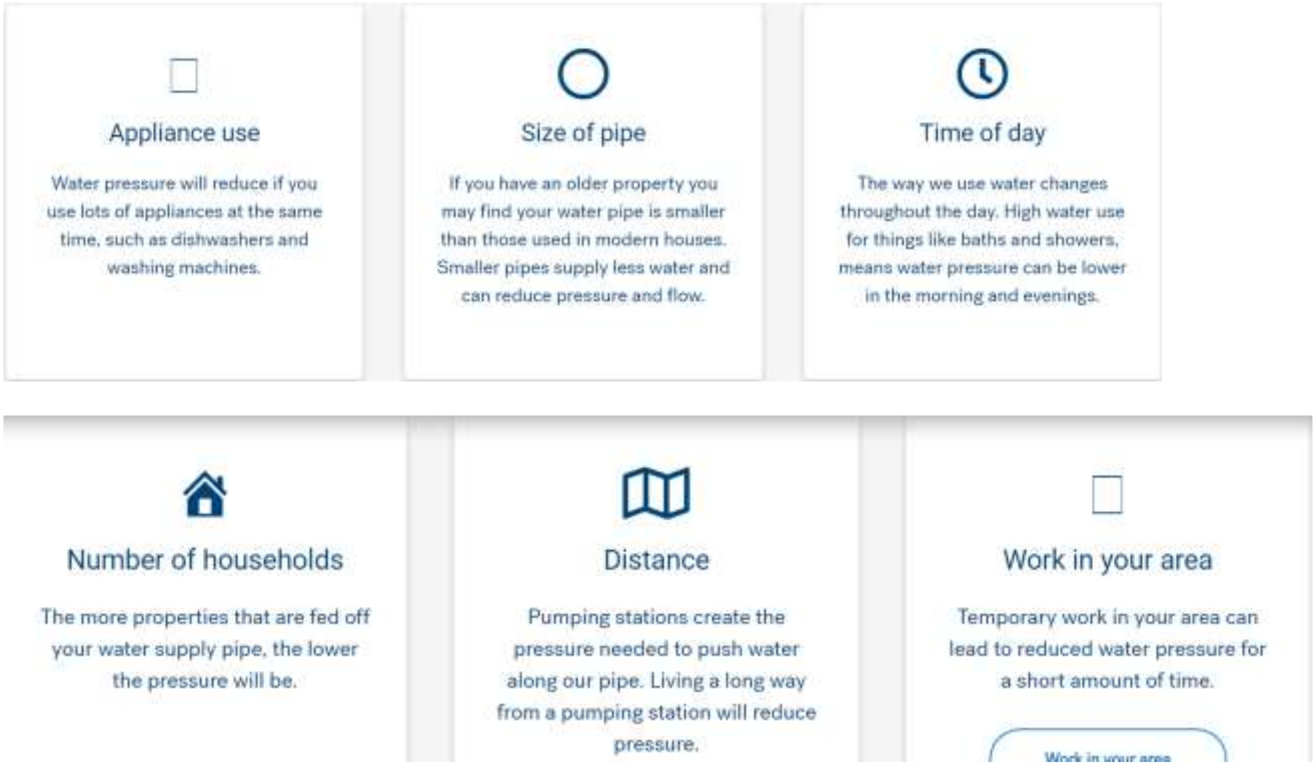
Low pressure causes

Low pressure can have a number of causes. For example, when demand for water is high (such as in the morning or early evenings) pressure can be lower than during the rest of the day. There can also be problems during dry spells due to high consumption.

Other causes of low pressure can include:

- inadequate pumping facilities
- water mains that are too small
- reduced pressure from the water main as a result of leakage, equipment failures or blocked service pipes

other causes which should be considered while determining the causes of lower pressure are



Higher pressure causes

Pressure that is too high can damage plumbing fixtures, which may cause flooding. The main causes of high water pressure are listed below.

- Trapped air in your water pipes, which can temporarily increase water pressure. Run your taps for a few minutes to release this air.
- Re-configuring the water supply network when water is moved round to wherever it is needed, sometimes changing the supply route. Normal supply will be returned very quickly in most cases.

2.3. Pressure fluctuation control

The event creating the greatest risk associated with system pressure is large fluctuations in pressure.

The most important preventive measures are:

Monitor changes in flows and pressure in the system take steps, including the development of backup sources of water, the use of pressure-reducing and pressure-sustaining valves, to allow better control of pressure .

Monitor the operation of network pumps and have preventive maintenance programmes for them (and bore pumps if part of the system)

Make sure properties where there are sources of possible contamination have backflow prevention– although not a preventive measure this action is important and therefore noted here).

Self-Check -2	Written Test

Direction I: Matching item (2 points each)

Instruction: Match column B with column A of the following questions and write your answer on the answer sheet provided in the next page:

	A		B
1.	Inadequate pumping facilities	A.	air gets trapped in a piping system
2.	acts as a valve and can “pinch off” or reduce the effective pipe size	B.	Air in the pipes
3.	The most important preventive measures are	C.	monitor changes in flows and pressure in the system
4.	Too high pressure	D.	Low pressure
5.	Monitor changes in flows and pressure in the system	E.	Pressure fluctuation control

Answer Sheet-2

Score = ____________

Rating: _____________

Name: ______________________________ Date: ________________

Matching Questions

1. ....
2. ....
3. ....
4. ....
5. ....

Note: **Satisfactory rating – 5 points and above Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Information Sheet-3	Documenting and reporting reticulation and distribution system information

3.1. System information documentation

An operator of water reticulation, distribution and bulk water transfer system is responsible for different tasks: monitoring the system i.e. maintaining pressure level, maintain water quality, regulate flow, managing customer compliance, and repair the system etc. The final step of his/her task should be documenting the result and reporting to the responsible person. In addition records should be kept of all operational actions, such as opening or closing isolation valves, changing control valve settings or amending pump operational schedules.

Routine record keeping is accomplished by utilizing the following reports:

- Monthly operating report
- Daily start-up checklist
- Weekly/Monthly inspection report
- Maintenance activity report
- Incident/Follow-up action report
- Annual consumers' confidence report

The Monthly Operating Report is used to maintain daily records of water pump age, chemical quantities, and routine test results.

A copy of the Daily Start-up Checklist should be kept. The form should be used to ensure that start-up activities are properly conducted, especially in the event of an emergency when the regular operator is not available. This report is not required to be submitted to the Bureau but should be kept on-site for review upon request.

The Weekly/Monthly Inspection Report can be used to document weekly and/or monthly inspections of mechanical equipment and appurtenances. Weekly/monthly inspections will ensure that the system is operating properly and in compliance with all applicable rules, regulations, and permit conditions. This report is not required to be submitted to the Bureau but should be kept on-site for review upon request.

The Maintenance Activity Report can be used to document preventative maintenance and testing activities, based on the manufacturer's recommendations and specifications for equipment. This report is not required to be submitted to the Bureau but should be kept on-site for review upon request.

The Incident/Follow-up Action Report can be used to record follow-up measures taken to correct any deficiencies noted during daily, weekly or monthly inspections. This report is not required to be submitted to the Bureau but should be kept on-site for review upon request.

The annual Consumers Confidence Report must be delivered to your customers with a copy to the Bureau.

Table 3.1.Weekly / Monthly Inspection Report

Inspection of:	**Observations/Initials**	**Date / Time**

Table 3.2. Maintenance Activity Report

Activity Performed:	Location	Initials / Date

Incident/Follow-up Action Report

This report documents all breaks, breakdowns, problems, bypasses, pump failures, occurrences, emergencies, complaints and/or intervening factors that result in or necessitate deviation from routine O&M procedures, and any situations that have the potential to affect public health, safety, welfare, or the environment or have the potential to violate any permits, regulations or laws relating to the water system. In addition, this report records the remedial or follow-up action taken to correct the circumstance.

Follow Up Action and/or Incident/complaint	Corrective Action Taken	Initials	Date/Time

3.2. Final documentation

The final documentation should include the following points

- Water quality complaint locations
- Reason of water quality compliant and respective solution

- Identified sours of leaks
- Repair and leak locations
- Record of Bulk meter/water meter reading
- Valve and hydrant locations and condition
- Coliform sample locations and sites of any unsatisfactory results
- Pressure reading of the transmission system.
- Identification of persistent low pressure location along the pipeline.
- Meter totalizer readings
- Water consumption
- Water level of reservoir
- Record of residual chlorine.
- Tank inspection dates and findings
- Pump operation maintenance and repair dates and details
- Water quality monitoring dates, locations and results
- Water treatment records and chlorine residuals maintained, if applicable
- Spare parts inventory
- Calibration records

Self-Check -3	Written Test

Direction I: True or False (2 points each)

Instruction: Write True if the statement is correct False otherwise of the following questions and write your answer on the answer sheet provided in the next page:

1. The final step of water distribution system operator is documenting the result and reporting to the responsible person.
2. Water quality complaint locations should be document and reported to the responsible person.
3. It impossible to record residual chlorine level

Answer Sheet-3

Score = ___________
Rating: ____________

Name: ____________________________ Date: _________________

Matching Questions

1. ....
2. ....
3. ....

***Note:* Satisfactory rating - 3 points and above** **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Operation Sheet -1	Procedure of monitoring and adjusting pressure

Adjust pressure at valve

Steps

Step 1: Locate the supply line

Step 2: Located the line you will be able to find the water meter.

Step 3: Find the valve

Make sure that your supply line has sufficient pressure before adjusting the pressure valve.

Step 4: Adjusting the Screw

Now that you have located the valve and the screw, you need to loosen the locknut all the way. The screw is your adjuster and it can be maneuvered only by loosening the locknut. The screw acts as a water pressure regulator. If you tighten the screw the water pressure will be more and if you loosen the screw the water pressure will be less. Turn the screw clockwise to tighten it and increase the pressure, or turn it counterclockwise to decrease the pressure.

Step 5: Tighten the Screw Slowly

Do not be too hasty. You need to tighten the screw little by little, in slow increments. Check the result each time you tighten the screw. If the water pressure is too high, it could result in leaks and the toilets to run all the time.

Step 6: Check the Pressure

Once you have adjusted the screw the water pressure should be regulated. Check the faucets in the house to see if there is a change in the pressure compared to before. If you find that after adjusting the pressure valve there is no significant improvement, your valve might be faulty and will need to be replaced.

Step 6: Test for leakage

Once you have successfully adjusted the pressure valve or replaced the valve make sure there is no leakage.

Operation Sheet -2	Techniques of investigating and reporting pressure fluctuation

Activity 1: Check pressure level at pumps

Steps

Step 1: Operate the pump and take readings on the flow meter as well as the two pressure gauges.

Step 2: Determine the pumping head by subtracting the suction pressure from the delivery pressure (if the suction pressure is a negative it will thus be added).

Step 3: Plot the flow rate and delivery pressure on the pump's head-flow curve that should be on record, or can be obtained from manufacturers.

Step 4: Record the result and match it with the standard. This point plots on or close to the original pump curve, the pump is still operating on its original curve otherwise it needs adjustment.

Step 5: Report the result to the responsible personnel.

Activity 2: Use a PSI pressure gauge to measure water tank levels

Steps

Step 1: Define the scale of your application. On non-pressurized tanks, every 27.71 inches of water height will impose 1 PSI on the pressure gauge. A pressure gauge that reads zero to 10 PSI is therefore capable of indicating up to 277.1 inches of level, or about 23 feet. In all cases, find the lowest reading PSI gauge you can that still fits your range, because trying to read a 1-foot water level on a zero to 50 PSI gauge would be beyond the gauge's capability to even move its needle.

Step 2: Select an available PSI pressure gauge range. Divide your highest level by 27.71. If your highest level is 6 feet, divide 72 inches by 27.71 and find an available gauge that is closest to 2.6 PSI. A zero to 5 PSI gauge would work better than a zero to 10 PSI gauge because of its greater mechanical resolution.

Step 3: Organize your materials. You will need the pressure gauge, tubing, connection fittings to connect to the bottom of the water tank, a Tee for the tubing and at least two shut-off valves. Use plastic if at all possible for the tubing and fittings, and snap-in fittings also make this project much easier.

Step 4: Install your level system. Locate one valve as close to the tank as possible. Run the tubing to your gauge. The gauge's height must be even or just slightly lower than the lowest level you want to indicate for the basic calibration to work. The tube from the tank, the other valve and the gauge should all be tied to the Tee. Mount the PSI gauge face side up so the sensing element will not trap sediment. The valve on the Tee allows flushing the gauge tube occasionally to remove sediment.

Step 5: Calibrate your level system and create a level-reading dial to indicate level directly. If your application is a 20-foot-high tank (240 inches), divide 240 by 27.71 to yield 8.66 PSI. Choose a zero to 10 PSI gauge. Cut out a concentric plastic dial that fits around the outside of the gauge. Mark a scale to align with the pressure readings on the gauge. At the 8.66 PSI point, mark "20 feet"; at the zero point, mark "0"; mark "5 feet" at 2.16 PSI; "10 feet" at 4.33 PSI; and "15 feet" at 6.5 PSI. Space out single-foot markings between these readings and your direct-reading level indicator using a PSI pressure gauge will be close enough.

Operation Sheet -3	Procedure of Investigate and report pressure fluctuation (low pressure)

Steps

Step 1: Observe any water loss from pipes system

Step 2: Observe reservoir levels

Step 3: Observe pressure valve conditions

Step 4: Observed problems with air valves.

Step 4: Record and report your result

Operation Sheet -4	Techniques of documenting and reporting reticulation and distribution information

Requirement: Inspection and monitoring of water reticulation and distribution system

Steps

Step 1: Document and report water quality issues

Step 2: Document and report customer compliant and management

Step 3: Document and report leaks and management techniques

Step 4: Document and report reservoirs/ pumps pipe/fittings and other structure condition

Step 5: Document and report pressure and flow condition

Step 6: Document and report calibration records

Step 7: Document and report problems faced in operating the system and respective solution to resolve the problem

Step 8: Document and report existing condition of water system

LAP Test -1	Practical Demonstration

Name: _________________________ Date: ____________

Time started: ________________ Time finished: _______________

Instruction I: Given necessary templates, tools and materials you are required to perform the following tasks within 40 hours.

Task 1: Monitor and adjust pressure at valves

Task 2: Investigate and report pressure fluctuation

Task3: Document and report reticulation and distribution information

List of reference

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