CHAPTER 5: WATER STORAGE SYSTEMS

Unit of learning code: **CON/CU/PL/CR/05/5/A**

Related unit of competency in occupational standard: Install water storage systems and auxiliary fittings

4.1 Introduction to the unit of learning

This Unit describes the competencies required to install water storage systems and auxiliary fittings. It involves preparing water storage drawing, quantifying and costing storage and auxiliary fittings supplies, install storage systems and auxiliary fittings and testing and commissioning storage and auxiliary fitting. It applies in the construction industry.

4.2 Summary of Learning Outcomes

1. Prepare water storage drawings
2. Quantify and cost materials
3. Install storage systems and auxiliary fittings
4. Test and commission storage and auxiliary fittings

5.2.1 Learning outcome 1: Prepare water storage drawings

5.2.1.1 Introduction to the learning outcome

This learning outcome specifies the content of competencies required to prepare water storage drawings. It includes definition of terms and concepts, symbols, design and construction of water storage facilities, storage fittings and storage capacity.

5.2.1.2 Performance Standard

1. Drawings are identified and selected based on the job.
2. Scale of the drawing is determined based on the specifications.

3. Measurements are converted based on scale.
4. Symbols are identified based on best standard practices.
5. Simple working drawings are Prepared based on specifications
6. Isometric working drawings are drawn based on best practices

5.2.1.3 Information Sheet

Terms and Concepts

Piping: It is a system of pipes used to convey fluids (liquids and gases) from one location to another.

Valves: is a type of fitting that allows for regulation, control, and direction of fluids passing through a pipe.

Adapter: An adapter has male and female ends, the male having threads on the outside and the female on the inside.

They're used to connect different sized pipes, or even turn a male pipe into a female, and vice versa.

Nipple: It connects pipes to appliances such as water heaters, and connects two straight pipe runs.

Union: Union fittings are made up of three parts: a nut, a female end, and a male end. They're designed to connect two pipes with the possibility of being detached without damage or deformation to the pipes. They're conveniently used in maintenance or cases of planned replacements in the future.

Couplings: can be used to connect two pipes of the same size and diameter. They're also commonly used to change pipe sizes; a bell reducer is a common coupling used to do this since it connects a big pipe to a smaller one.

Cross: crosses are four-way fittings, a combination of two tees (see below). They consist of one inlet and three outlets, and these often have a solvent-welded socket or female-threaded ends.

Tees: They look like a coupling with an outlet in the middle. They're short pipes with a 90-degree "branch" at the center.

Wyes: They look like the letter "Y." They're generally used in drainage fittings and have a 45-degree branch.

Elbow: They are curved and are mainly used to change flow directions. These are mostly produced in 45 and 90-degree angles and can be sweated or threaded.

Bushing: It looks like small screws. They're mainly used to connect pipes of different sizes, reducing a large fitting to a small pipe. These can be threaded on the inside and outside; however, this is not always the case.

Bushing fittings are smaller than unions and couplings, and are, therefore, often used in the same situations.

Reducer: It is designed to reduce flow.

SYMBOLS

Piping **Valves**

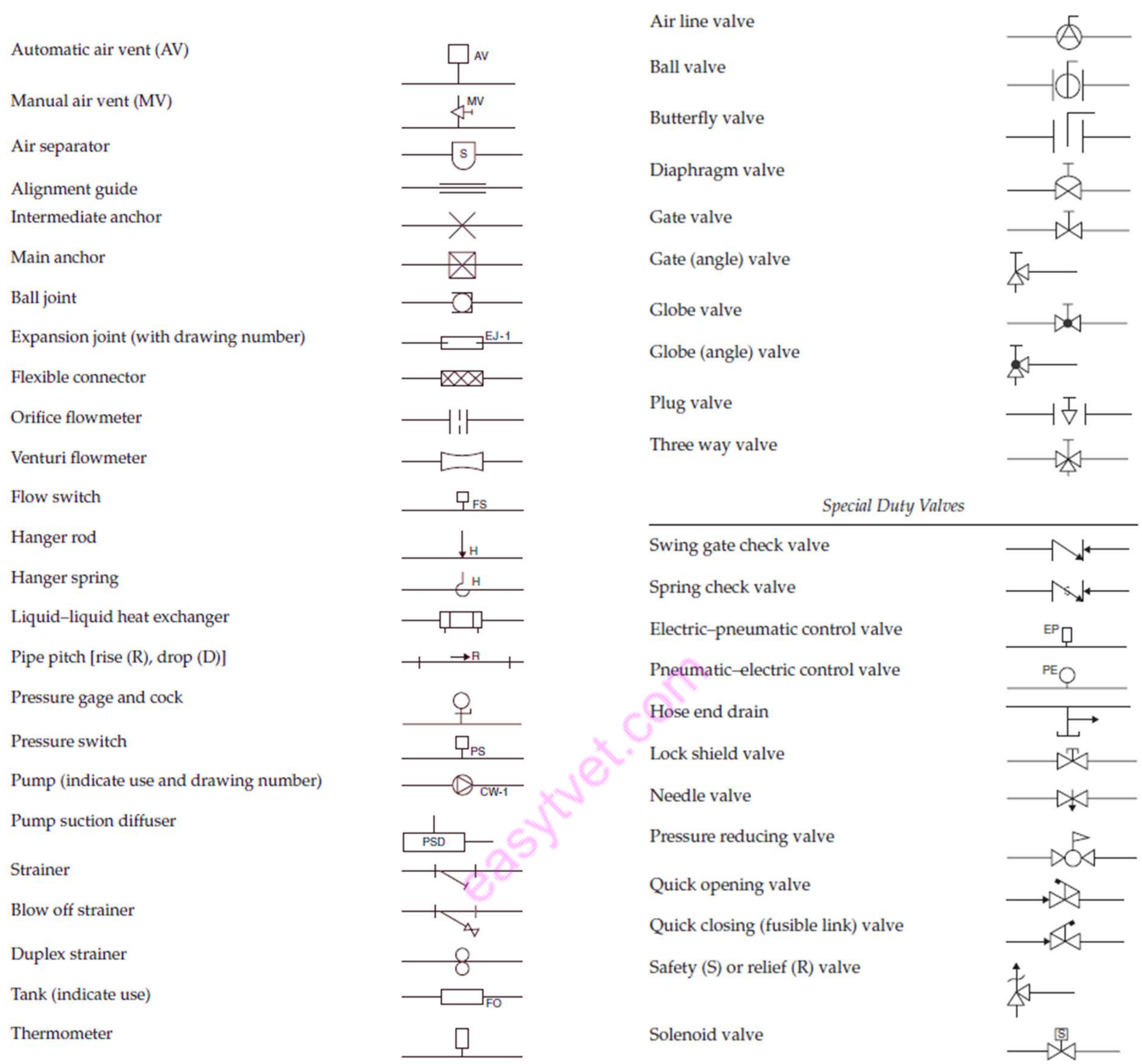
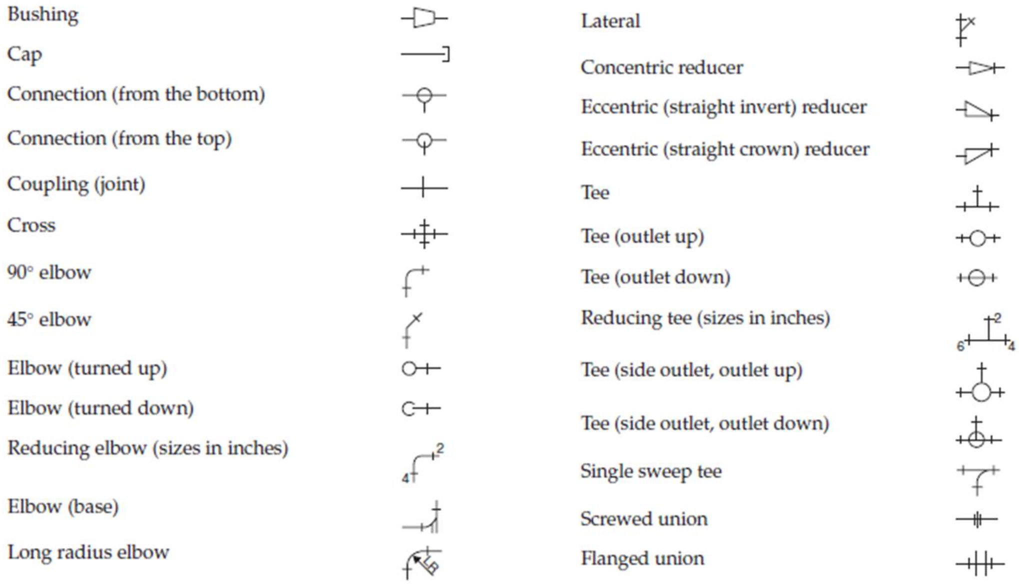


Figure 181: piping and valve symbols

Fittings



Fittings

DESIGN AND CONSTRUCTION OF WATER STORAGE FACILITIES

1. Capacity:

As a rule of thumb, the storage tank volume should be at least equal to one-fourth (25%) of average day demand of the community. The formula is:

$$Cr = \frac{1}{4}(ADD)$$

Where:

Cr	=	reservoir capacity in litres
ADD	=	average day demand in liters per day

2. Site of the Storage Tank

In the selection of the site for storage tanks, first priority should be given to natural elevated places. If the elevated storage tank is to be constructed in a flat area, it may be built central to the distribution system or opposite the source. This is to avoid long and consequently large-diameter service mains.

3. Structural Design

The structural design of reservoirs must meet the standards set by the National Structural Code of the Country. The reservoirs must be strong enough to withstand all loads, such as hydrostatic pressure, earth pressure, wind loads, seismic loads and other dead or live loads. The reservoir should be covered to avoid pollution and growth of algae.

RESERVOIR APPURTENANCES

1. Inlet Line

The size of the inlet line is determined by the supply and demand requirements. The inlet line on all reservoirs must have a shut-off valve located adjacent to the reservoir.

2. Outlet or Discharge Line

Like the inlet line, the size of the outlet line is determined by the supply and demand requirements. The upstream-end of the outlet pipe is usually installed at least 5 cm, above the floor of the reservoir to create a dead volume of water. This dead volume of water at the bottom of the reservoir acts as settling zone, where particles are allowed to settle and kept from entering the water distribution line.

These dead volumes of water are drained via a drainage pipe. The outlet line must also have a shut-off valve located adjacent to the reservoir.

In floating-on-the-line reservoirs, there is only one inlet and outlet line.

3. Drain Line

This is provided for draining and cleaning the reservoir. Draining could be done through the inlet–outlet line by shutting off the valve controlling the flow in the main line and opening the drain valve. To facilitate cleaning, the floor of the reservoir is sloped towards the drain.

4. Ventilation facilities

These are provided in reservoirs to allow the air to escape fast enough to prevent pressure from building up inside the reservoir during filling, and to prevent a vacuum from forming when water is being drawn out. The ventilation facilities should be designed to keep rain and surface water from entering, and they should be screened to keep out insects. Overflow and drainage pipes should be designed with a valve chamber to prevent rodents from entering the reservoir.

5. Overflow Line

Reservoirs should be provided with an overflow line large enough to allow the maximum anticipated overflow (pump or spring capacity) and should be properly screened and covered like an air vent.

6. Water Level Indicators

These are used to indicate the water level inside the reservoir. Depth gauges using a float and wires are usually used.

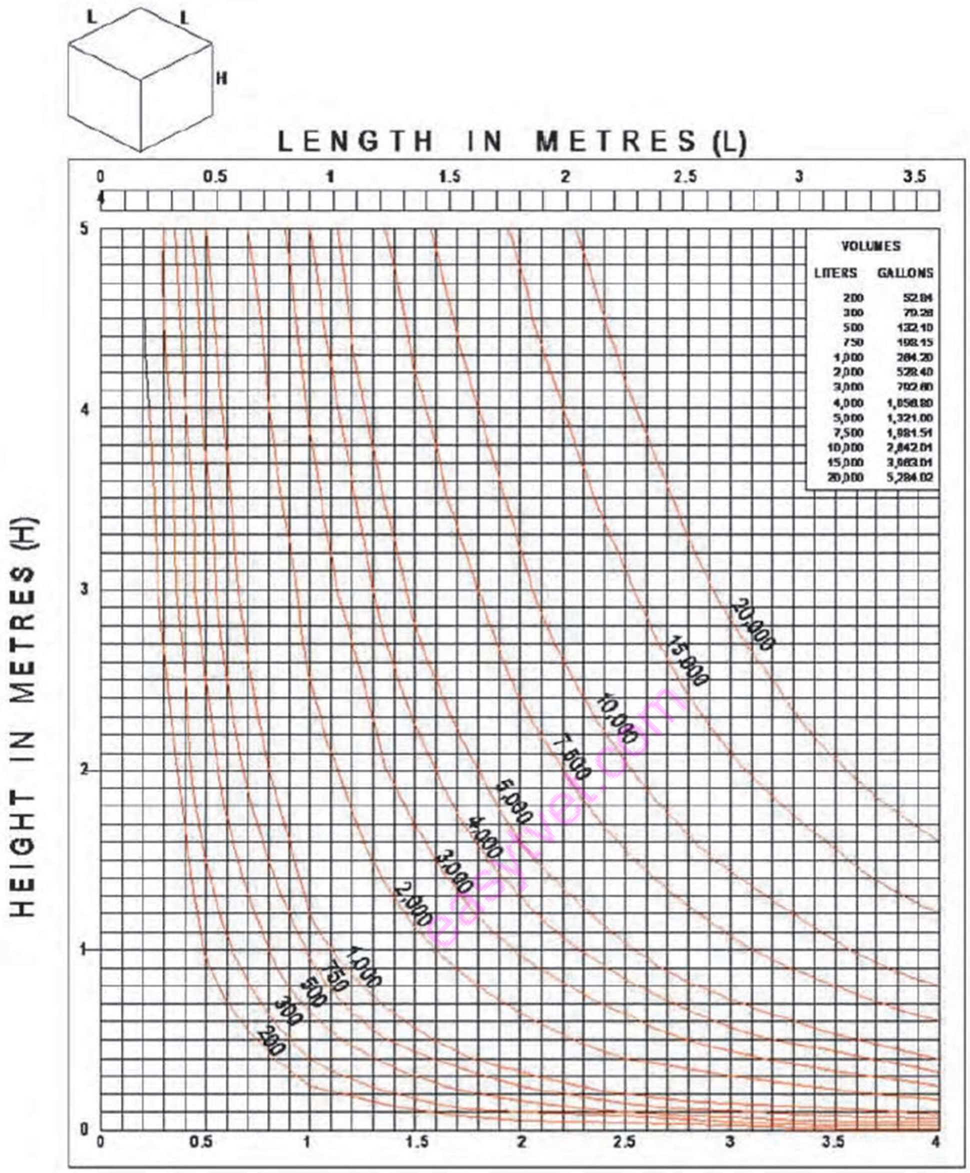
7. Control Valves:

The use of reservoir control valves will depend on the type of controls and means of operation to be employed for the system. The flow into the reservoir may be stopped manually or automatically by a float valve, pressure switch or equivalent device.

SAMPLES OF RESERVOIR DESIGN

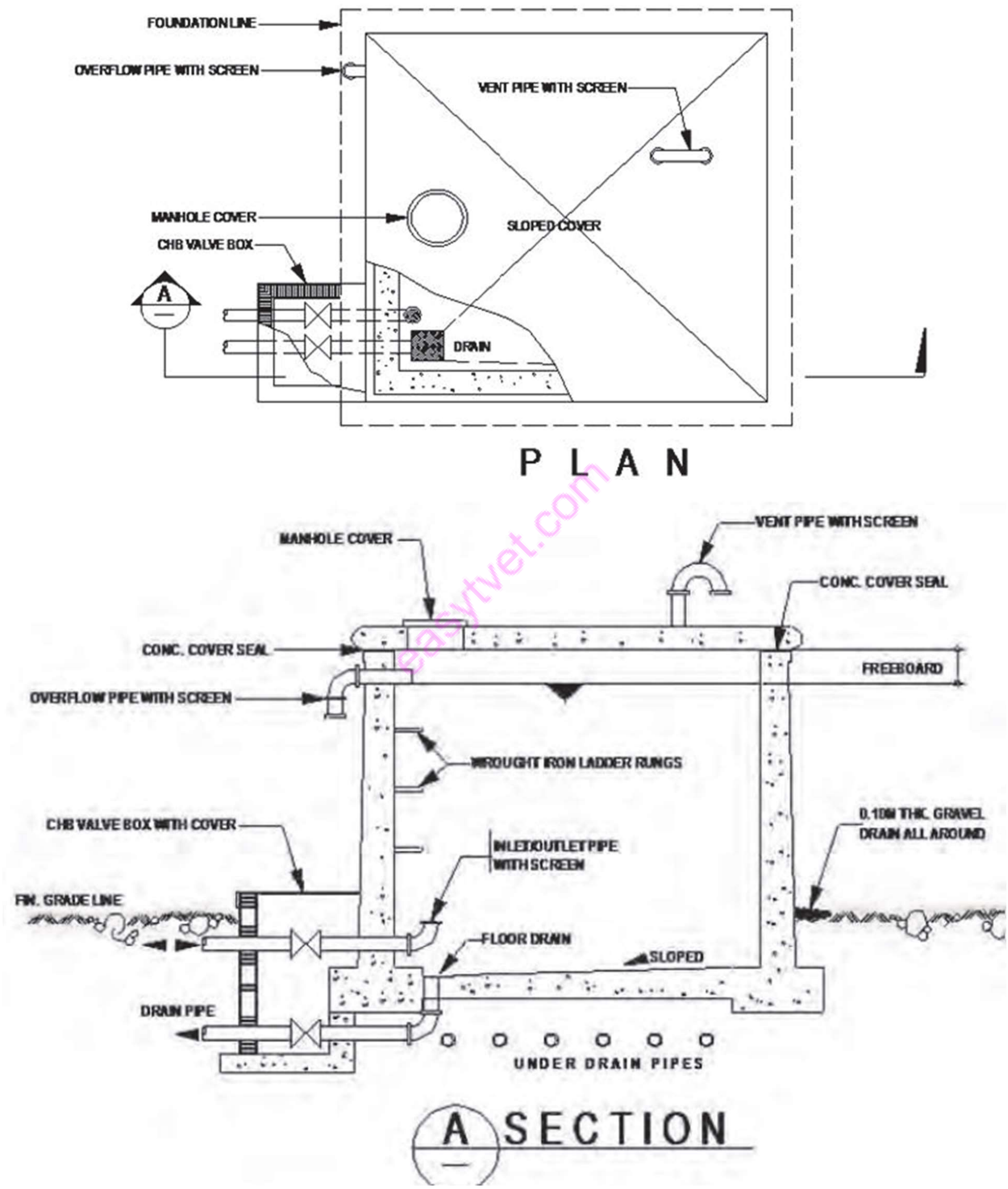
The figure below provides a quick method of determining prismatic tank dimensions.

Prismatic Tank Volume.



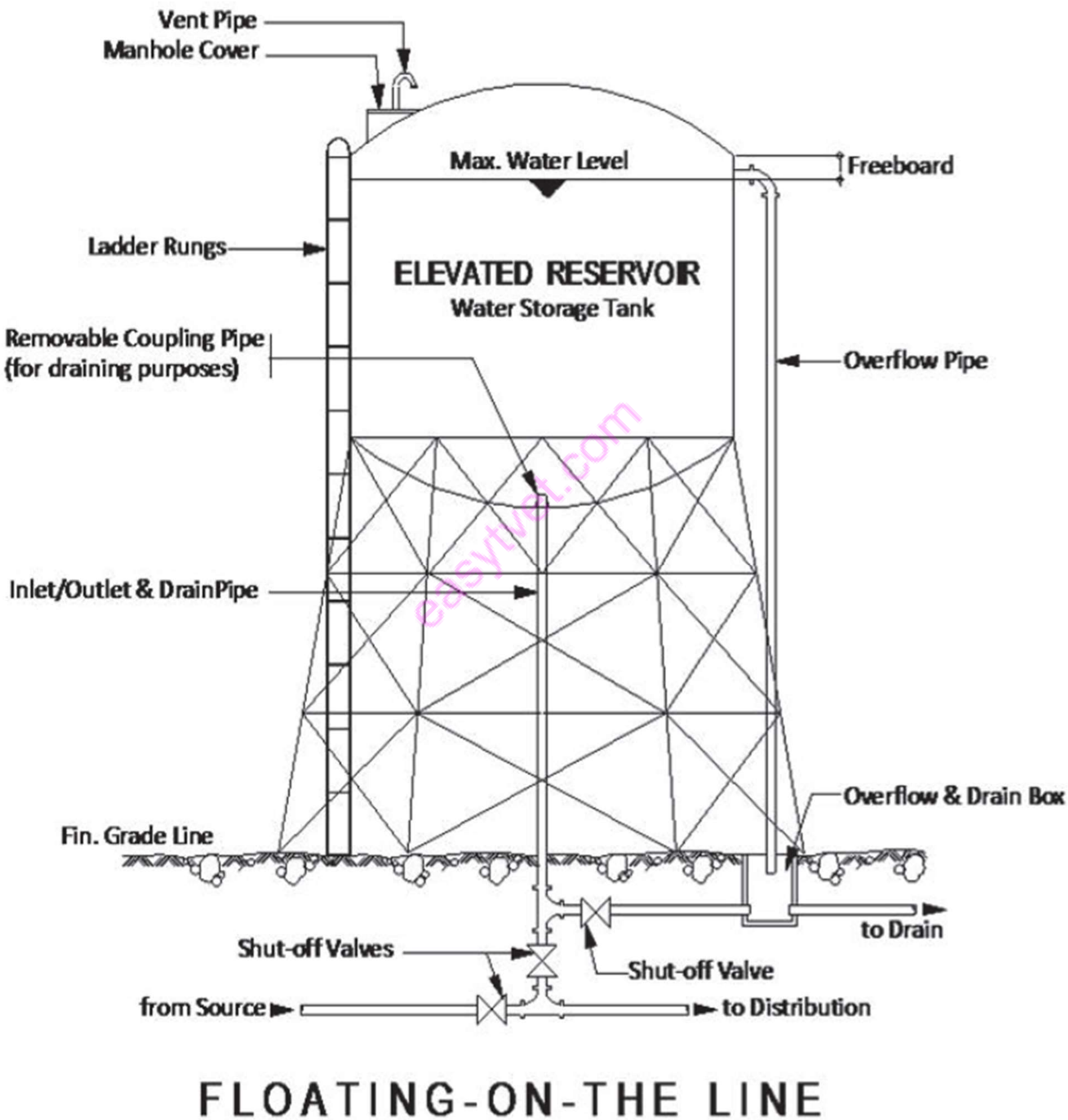
Tank Volume prismatic tank volume

Design of ground level reservoirs



Ground Level Concrete Reservoir

An elevated Reservoir



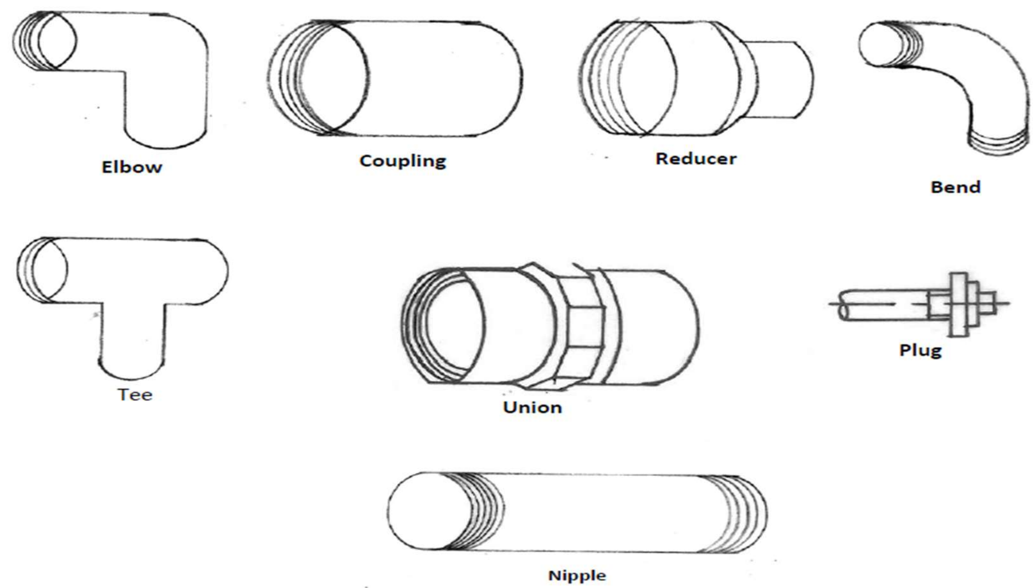
An elevated Reservoir

Storage fittings

Type of 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.



STORAGE CAPACITY

Determination of storage capacity required

Water Demand

Water demand is the volume of water requested by users to satisfy their needs. A simplistic interpretation considers that water demand equals water consumption. However, conceptually, the two terms cannot be equated because, in some cases, especially in rural parts of Africa, the theoretical water demand considerably exceeds actual consumptive water use.

Calculating Demand

Calculating the water needs of the user is relatively easy and involves a simple formula which includes the average daily consumption of water from the tank per person (or livestock), the number of days in the dry season, and the numbers of people using the tank.

Studies have shown that rural people with tanks next to their houses often use about 20 to 40 litres of water per person per day. This is high compared to people who must walk long distances for water who may use less than 10 litres per family per day. As an average, assume that each person will take 20 litres per day if it is a household tank, and 5 litres per day if it is a school or health centre tank.

The formula is;

Demand (litres) = Total dry days x water required per person x total number of consumers

It is good to note that if the consumption is higher than estimated, the tank will run dry before the next rainy season.

Volume of storage structure

This is calculated differently depending on the shape of the tank. The general formula adopted for all shapes is the prismoidal formula expressed as follows:

$$\mathbf{V = (A + 4M + B)^{d/6}}$$

where:

V = volume

A = top area of excavation (area of water surface when full)

B = bottom area of excavation (area of floor)

M = area at ½ depth

d = depth

For convenient calculating, the following derivations of the prismoidal formula can be used for each particular excavation shape:

Circular:

$$\mathbf{V = \pi\, [R^2 + (R \times r) + r^2]^{d/3}}$$

Rectangular:

$$V = [(L \times W) + (lf \times wf) + [(L \times lf) + (W \times wf)]]^{d/6}$$

Square shaped tank:

The design volume is calculated with the following equation:

$$V = [L^2 + (L \times lf) + lf^2]^{d/3}$$

where in all formulae:

V = volume (m^3)

R = radius of water surface (m)

r = radius of floor (m)

d = depth (m)

π = *Pi* or 22÷7 or 3.14159

L = length of water surface (m)

W = width of water surface (m)

lf = length of floor (m)

wf = width of floor (m)

d = depth of water from surface to floor (m).

Cold water storage data is provided to allow for up to 24-hour interruption of mains water supply.

Building purpose	Storage/person/24 hrs
Boarding school	90 litres
Day school	30
Department store with canteen	45 (3)

Department store without canteen	40 (3)
Dwellings	90 (1)
Factory with canteen	45
Factory without canteen	40
Hostel	90
Hotel	135 (2) (3)
Medical accommodation	115
Office with canteen	45
Office without canteen	40
Public toilets	15
Restaurant	7 per meal

1. 115 or 230 litres min.
2. Variable depending on classification.
3. Allow for additional storage for public toilets and restaurants.

At the design stage the occupancy of a building may be unknown.
Therefore, the following can be used as a guide:

Building Purpose	Occupancy
Dept. store	1 person per 30 m^2 net floor area
Factory	30 persons per WC
Office	1 person per 10 m^2 net floor area
School	40 persons per classroom
Shop	1 person per 10 m^2 net floor area

E.g., A 1000 m^2 (net floor area) office occupied only during the day therefore allow 10 hours emergency supply.

1000/10 = 100 persons x 40 liters = 4000 liters (24 hrs.)

= 1667 liters (10 hrs.)

5.2.1.4 Learning Activities

Design a Reservoir

Data:

Design Population: 600

Average Day Demand: 600 × 80 *lpcd* (level II/III) = 48,000 LPD

PF1, found at the remotest of the system

Friction Head Loss in Pipeline: F1 = 4m

Elevation of PF: E1 = 2m

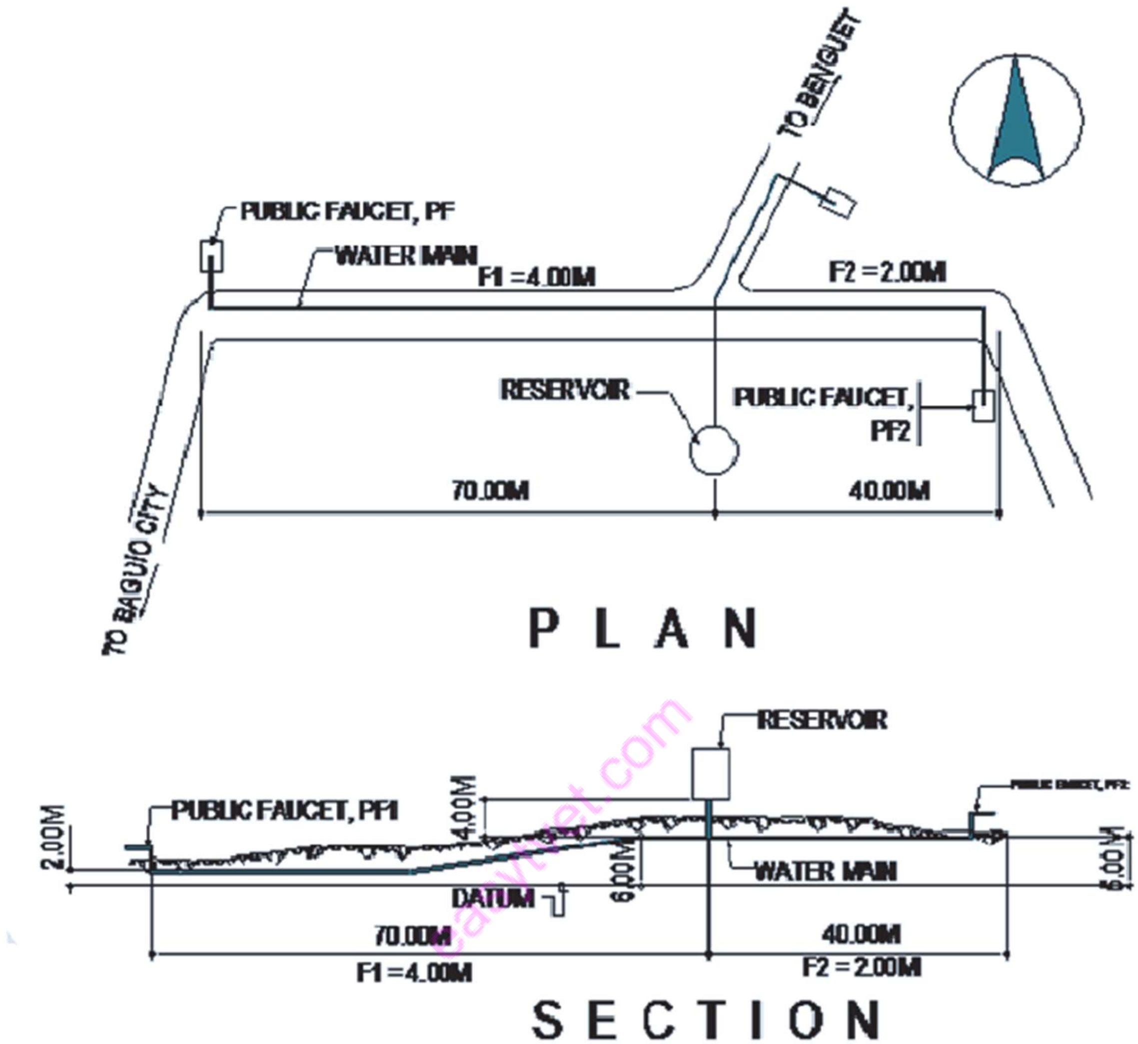
PF2, found 40 m from the storage tank

Friction Head Loss in Pipeline: F2 = 2 m

Elevation of PF: E2 = 5 m

Elevation of the location of Storage Tank: E3 = 6 m

Using an elevated tank, calculate tank capacity and height of the minimum water level.



5.2.1.5 Self-Assessment

1. While planning a water supply reservoir the design yield should be kept ___________________
    a. Higher
    b. Lower
    c. Equal
    d. Lower or higher as per designer's discretion

2. Yield of a water tank represents ____________________
    a. The inflow into the tank
    b. The capacity of the tank
    c. The outflow demand on the tank
    d. The optimum value of catchment yield

3. As the reservoir elevation increases, the outflow discharge increases.
    a. True
    b. False

4. What do you understand by the following terms?
    a. Valves
    b. Union
    c. Tees
    d. Valve

5. Draw the symbols of the following items:
    a. Cross
    b. 90^0 Elbow
    c. 45^0 Elbow
    d. Coupling

6. What is the function of the following pipe fittings?
    a. Socket or coupling
    b. Elbow
    c. Reducer
    d. Nipple
    e. Plug

7. Using an elevated tank, calculate the capacity and height of the required minimum water level given the data below:

5.2.1.6 Tools, Equipment, Supplies and Materials

Functional Plumbing Workshop with the following:

Tools and Equipment

- Pipe wrench
- Pipe cutter
- Hacksaw
- Pipe Threading Equipment
- Vice - Bench
- Pliers
- Tap and Punch
- Files
- Screwdrivers
- Drill with various sizes of bits
- Mallet
- Ball hammer
- PPR machine / Heat Fusion equipment
- Pipe bender
- Sealant gun

Supplies and Materials

- Fittings
- Back nuts
- Cisterns
- Valves
- Sealant
- Water proofing agents

5.2.1.7 References

Fred Hall & Roger Greeno., 2009., Building services handbook incorporating current building & Construction regulations., 5th Edidition

David V. Chadderton., 2007., Building Services Engineering., 5th Edition

Nissen Peterson., 2007., Water storage

Julie fryer., 2011., The complete guide to water storage

5.2.1.8 Model Answers

1. While planning a water supply reservoir the design yield should be kept ____________________

e. Higher

f. Lower

g. Equal

h. Lower or higher as per designer's discretion

2. Yield of a water tank represents ___________________

e. The inflow into the tank

f. The capacity of the tank

g. The outflow demand on the tank

h. The optimum value of catchment yield

3. As the reservoir elevation increases, the outflow discharge increases.

c. True

d. False

4. What do you understand by the following terms?

- **Valves:** is a type of fitting that allows for regulation, control, and direction of fluids passing through a pipe.
- **Union:** Union fittings are made up of three parts: a nut, a female end, and a male end. They're designed to connect two pipes with the possibility of being detached without damage or deformation to the pipes. They're conveniently used in maintenance or cases of planned replacements in the future.
- **Tees:** They look like a coupling with an outlet in the middle. They're short pipes with a 90-degree "branch" at the center.
- **Valve:** It is used to regulate or stop the flow of gas or liquid. Valves are generally categorized by application.

5. Draw the symbols of the following items:

- Cross
- 90^0 Elbow

- 45^0 Elbow
- Coupling

6. What is the function of the following pipe fittings?
    - 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.
    - Elbow – It connects two pipes of same diameter at an angle, normally 90 degrees.
    - 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.
    - Nipple - it is tubular pipe fitting, mainly in 300 mm length. It is used for extending pipeline.
    - Plug - It is used to plug the flow of water at dead ends.

7. Using an elevated tank, calculate the capacity and height of the required minimum water level given the data below:

    Minimum Pressure at the remotest public faucet (PF) = 3 m

    Average Day Demand (ADD) = 43,440 lpd

    Friction head loss from tank to remotest PF = 3 m

    Solution:

    Using Elevated Tank,

    Calculate the Reservoir Capacity

    Capacity = ¼ × 43,440 = 10,860 liters, say 11,000 liters

If Shape of Reservoir = Cylindrical

Assumed Height = 3 m

From Figure 13.4, Diameter = 2 m*

The diameter was determined using Figure 13.4. Locate the height =3 m in the figure and move horizontally to intersect V = 11,000 and then move down on the abscissa to find the diameter, D = 2.09 m.

Use D = 2.0 m

Calculate the Height of Minimum Water Level, H

H =Minimum Pressure at the remotest PF + Friction Head Loss in pipeline from tank to remotest PF,

H = 3 + 3 = 6 m

5.2.2 Learning Outcome 2: Quantify and cost materials

5.2.2.1 Introduction to the learning outcome

This learning outcome specifies the content of competencies required to Quantify and cost materials. It includes, definition of terms and concepts, types of storage, types of auxiliary fittings, quantify materials and supplies and estimation of quantities and costs.

5.2.2.2 Performance Standard

1. Materials required for installing storage and auxiliary fittings are identified based on requirements of the job.
2. Supplies required for installation of storage and auxiliary fittings are identified based on requirements of the job.
3. Types of storage and types of pumps required are enumerated based on the drawing.

4. Materials and supplies required are measured and counted based on working drawings and specifications
5. schedules of storage and pumps are prepared based on working drawings

5.2.2.3 Information Sheet

Choice of building materials for tanks

The choice of building materials can be decided by considering the following:

1. Where coarse river sand is expensive, tanks should be built of either burnt bricks or soil compressed bricks to reduce cost.
2. Where coarse sand is cheap, tanks should be built of ferro-cement if trained builders are available.
3. Where coarse river sand, pebbles, stones and hardcore (larger stones) are in plenty, it is most economical to use concrete in formwork (in situ) or concrete blocks.
4. The cost of making concrete blocks can be reduced by compacting rubble stones into the concrete in the steel mould. Such blocks, as seen in the photo are called rubble stone blocks.

TYPES OF TANKS

Plastic tanks (PE)

Spherical ground tanks are manufactured of seamless polyethylene. Spherical tanks are placed on a 2000 mm concrete slab in the bottom of a cylindrical excavation.

The space around the tank is back-filled with pea gravel or sand, while the tank is filled with water to the same level to avoid localized stress concentrations.

Cylindrical tanks are also made of two seamless layers of polyethene; the inner layer being white and the outer being black.

A cylindrical tank

Cylindrical tanks are also made of two seamless layers of polyethene; the inner layer being white and the outer being black. The tanks are UV stabilized and will not break down under harsh outdoor weather conditions.

A cylindrical tank

Steel tanks

Storage tanks come in a wide variety of types, shapes and materials. Every steel storage tank design must be specific to its task, be it underground or on-surface storage tasks. Steel tanks are among the most commonly preferred storage tanks due to their effectiveness and durability. Because of these traits they have found wide use in residential, commercial and industrial establishments.

Factors Considered During the Designing and Building of Steel Storage Tanks

There are number of important factors to consider when designing and building these storage tanks. They mainly involve the specific application and the intended method of usage for which the tank is being built.

Some of the main factors are;

- **Materials**: This mainly relates to the tank's application, simplicity and installation, regulations and codes, and the tank's cost.
- **Size and Shape**: Depends on the application, regulations and standards.
- **Strength**: Here designers and engineers decide on the thickness of the tank walls, and the vertical, horizontal and cross ribs depending on its application and usage.
- **Location**: Whether the tank will be aboveground, underground or partially buried also influences the design and the construction of the steel storage tank.
- **Accessibility**: Considering the accessibility during the initial designing of the tank helps facilitate the needed tank's and installed components internal inspection and maintenance.
- **Mobility**: Whether the tank will be fixed or mobile helps in deciding its size and weight, and the suitable way to assemble and disassemble for moving from one point to another.
- **Others**: There are a number of other design calculations that may be factored in such as on seismic load, snow load and wind load among others.

Types of Steel Tanks

Steel tanks come in many different types, with each fabricated to standards that will be effective to a specific type of application.

Some of the most common types of these tanks include:

- **Steel portable water tanks** – They can be used in schools, hospitals, rural developments and for emergency water.
- **Corrugated steel tanks** – These can be used for rainwater collection, storing irrigation water, freshwater, and fire suppression.

- **Steel rainwater collection tanks** – They are used for rainwater collection and water storage. They can also be used in fire sprinklers applications.
- **Double walled steel storage tanks** – For storing heating fuel, residual fuel oils, and for fuel storage and containment.
- **Mobile steel tanks** – For construction sites, agricultural sites, pipelines, and power utilities.
- **Steel fire protection tanks** – Used for fire sprinklers, storing water, and in commercial and industrial applications.
- **Above ground lube tanks** – They are designed to store lube oil, motor oil, class III B liquids, and emergency fuel
- **Underground steel tanks** – These can be used to store livestock liquid waste, wastewater, greywater, or for landfill collection among other applications.
- **Underground steel fuel tanks** – Storage of petroleum, chemical, and flammable liquid.
- **Diesel fuel tanks** – Used for fuel storage and in industrial locations

Advantages of steel storage tanks

i. Longevity

The resistance of steel to a number of environmental factors makes steel tanks withstand the test of time. Stainless steel tanks are rust-resistant, fire-resistant, U.V rays resistant and long lasting even without painting.

ii. Cost effectiveness

Steel storage tanks are more cost effective as compared to tanks made from other materials considering the low amount of maintenance they require.

iii. Versatility

Steel is a versatile material. Its resistance to corrosion and durability allows it to be used in a number of different storage applications when used to make steel tanks. This guarantees strength, resistance to corrosion, and durability.

Concrete tanks

Any water that is stationary will eventually become stagnant and undrinkable. How water is stored and its temperature will determine how long the water stays healthy and drinkable. Spring water is often considered as the best water you can drink and storing your water in an underground concrete tank maintains its value.

Why is concrete the best material to store water in

The very nature of water itself is that it wants to balance out to a neutral ph. and a concrete tank is the only man-made storage system that will allow this to happen. To neutralize itself, water will absorb some of the minerals out of the concrete and will generally settle in a slightly alkaline state.

An in-ground concrete water tank will keep the water at the temperature that it fell out of the sky at and if the area gets mostly winter rain, that cold water will remain cold all summer.

Even above ground, light cannot penetrate through the concrete walls of a concrete and into the water.

All of this become very important, because roof harvested rain water picks up all sorts of dust, bacteria, and bugs and even after being pre-filtered some always gets through.

Water that is alkaline, cold and removed from light will not support the growth of any bacteria that makes its way into your tank, thus allowing this water to stay clean and drinkable for years.

Masonry tanks

Masonry tanks are a low-cost option for storing water gained through water harvesting. They are cheaper than ferro-cement tanks and easier to build.

In clay areas, be sure to build the tank robustly enough to resist cracking. Ground tanks should always be designed as either hemispherical (half ball shape) or cylindrical because those shapes equalize the pressure of water and soil whether the tanks are full or empty (square or rectangular tanks will always crack).

Suitable conditions:

- The area should be suitable for **rooftop rainwater harvesting**. Volumes can be 0.5 to 30 m^3.
- Tanks should not be located near a pit latrine/toilet or rubbish or on an ant hill.
- Avoid building the tank next to a tree as the roots may undermine the foundation and dry leaves will block gutters.
- The height of the gutters should be higher than the proposed tank height.
- Do not site tanks where heavy vehicles will pass close to tank foundations.

Rubber tanks

Various materials are used for the construction of tanks.The majority of such vessels are, however, made of mild steel or cast iron, particularly the former, and it has become almost standard practice to line them with rubber or ebonite, materials which give protection in respect of a wide range of corrosive chemicals.

Fibre Reinforced Plastics (FRP)

FRP storage tanks are made with resins, but they are manufactured using resins that match the specific liquid material. So, when storing drinking water, your tank is made with resin suited and approved for potable (drinking water)

GRP, or glass-reinforced plastic, is composed of strands of glass. The glass fibres are very fine, and they are woven to form a flexible fabric. When layered with resin and catalyst and allowed to cure, the resulting material is extremely strong and lightweight.

Insulated tanks

Tank base insulation system has the following benefits:

- Reducing energy loss

- Protect the structural concrete base material against high temperatures. This means that the reinforced concrete foundation can be installed more cost efficiently.
- Helps protect against chemical attacks from the content of the tank in the event of a major spill or leakage which can put workers in danger.
- Provide adequate compressive strength suited for the tank's design. Insufficient compressive strength in high load bearing situations can lead to settlement and loss of thermal performance, which may result in viscosity increase or product solidification.
- Resist corrosion and mitigate deterioration of the vessel. Throughout its lifespan, a typical storage tank may be used for different purposes, or operate under cyclic temperatures, creating an environment where corrosion under insulation (CUI) becomes an issue if the tank is not properly insulated.

A tank base insulation system should always be included in the initial design when new multi-purpose tanks are being built.

Using non-flammable insulation will limit potential fire and smoke hazards inherent in storage tanks.

Moreover, it is critical for the insulation materials to be available in high load bearing grades that have been specially designed for tank base applications and can deliver a compressive strength up to 240 t/sqm without any compression.

In the case of high temperature tanks, insufficient insulation compressive strength can lead to settlement, loss of thermal performance, destabilisation of the processing environment, reduced viscosity control and possible solidification of the contents.

QUANTIFY MATERIALS AND SUPPLIES

Supplies

Various types of taps

1. Pillar Taps

They are mounted on a basin or a bath, with separate taps for hot and cold water. Pillar taps usually have a lever or a mechanism that enables you to turn the water supply on and off. These types of taps are available in a wide range of styles and designs.

pillar tap

2. Mixer Taps

Mixer taps are a traditional style of tap and they comprise two pillar taps joined, sharing one spout for the hot and cold water to come out together instead of separately. The improved water control can help you achieve the perfect, consistent temperature mix.

You can also get single-lever mixer taps besides the two pillar taps. With a single lever, you can turn the hot and cold water on and off, and mix them in the same way as the independent tap models. You can mostly find those in kitchen sinks and baths, and we recommend replacing your taps with mixer ones for your peace of mind.

mixer tap

3. Wall Mounted Taps

As the name implies, wall-mounted taps are fitted to the wall, protruding from it over the basin or bath. In essence, they are easier to clean, but there is a downside, and this relates to plumbing. Since the pipes are inside the walls, repairs are more difficult and costly.

wall mounted taps

4. Monobloc Taps

Monobloc taps are a type of tap that has a single spout for both hot and cold water. You can operate it with a lever that's adjustable. It allows choosing the temperature of the water with a single shift of the lever to the right or to the left. These are a more modern alternative to the taps discussed above and can be a beautiful choice for your bathroom or kitchen.

5. Washer Taps

Well-suited for DIY work, washer taps, otherwise known as compression washer taps, have a pillar tap that operates with a twisting handle. As the name suggests, the washer inside controls the amount of water released.

6. Ball Type Taps

A common problem with ball taps is that they are prone to leaks more easily. Apart from this downside, they are very easy to control because of the ball that sits inside the tap mechanism. It allows you to switch between hot and cold water easily, and control the amount of water that comes out of the tap.

7. Cartridge Taps

This is a combination type, and it comes with a tap lever. Moving it left-to-right controls the temperature of the water, while moving it from top to bottom enables you to control the water flow. You can choose from heavy flowing to completely off

8. Disk Type Taps

Similar to a monobloc tap type, this tap gets its name from the ceramic disks inside the tap mechanism. The disks control the amount of water that is released and flowing out of the tap. The disks have small holes and are fit in aligned order, which allows the water to pass through. Sometimes, however, dirt and grime can get captured in between. So, this type of tap may need replacement or repairs regularly.

Various type of Valves

A valve is a device that regulates, controls, or directs the flow of a fluid by opening, closing, or partially obstructing fluid flow.

Gate valve

A gate valve is the most common type of valve in any process plant. It is a linear motion valve used to start or stop fluid flow. In service, these valves are either in a fully open or fully closed position. Gate valves are used in almost all fluid services such as air, fuel gas, feedwater, steam, lube oil, hydrocarbon, and all most any services. The gate valve provides a good shutoff.

Globe Valve

Globe valve is used to stop, start, and regulate the fluid flow. Globe Valves are used in the systems where flow control is required and leak tightness is also necessary. Globe valve provides better shut off as compared to the gate valve and it is costlier than a gate valve.

Check Valve

The check valve prevents backflow in the piping system. The pressure of the fluid passing through a pipeline opens the valve, while any reversal of flow will close the valve.

Plug valve

Plug valve is a Quarter-turn rotary motion Valve that uses a tapered or cylindrical plug to stop or start the flow. The disk is in plug shape, which has a passage to pass the flow. Plug valve used as on-off stop valves and capable of providing bubble-tight shutoff. Plug valve can be used in a vacuum to high-pressure & temperature applications.

Ball Valve

A Ball valve is a quarter-turn rotary motion valve that uses a ball-shaped disk to stop or start the flow. Most ball valves are of the quick-acting type, which requires a 90° turn of the valve handle to operate the valve. The ball valve is Smaller and lighter than a gate valve of the same size and rating

Butterfly Valve

A Butterfly valve is a quarter-turn rotary motion valve, that is used to stop, regulate, and start the flow. The butterfly valve has a short circular body. Butterfly Valve is suitable for large valve applications due to Compact, lightweight design that requires considerably less space, as compared to other valves.

Needle Valve

Needle valves are similar to a globe valve in design with the biggest difference is the sharp needle-like disk. Needle valves are designed to give very accurate control of flow in small diameter piping systems. They get their name from their sharp-pointed conical disc and matching seat.

Pressure Relief Valve

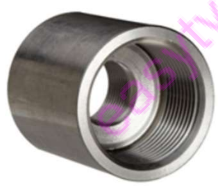
A pressure Relief valve or pressure safety valve are used to protect equipment or piping system during an overpressure event or in the event of vacuum. This valve releases the pressure or vacuum at a pre-defined set pressure.

Fittings

Elbows: Such pipe fittings are used to change the direction of the flow. They are majorly available in two standard types - 90- and 45-degree angles owing to their high demand in plumbing. The 90-degree elbow is primarily used to connect hoses to water pumps, valves, and deck drains, while the 45 degree elbow is mostly used in water supply facilities, electronic and chemical industrial pipeline networks, food, air-conditioning pipelines, garden production, agriculture, and solar-energy facility.

Fitting

Couplings: A coupling is a pipe fitting used to stop leakages in broken or damaged pipes. The pipes to be connected should be of the same diameter. The two kinds of couplings used in plumbing are regular coupling and slip coupling. The regular coupling is arranged between the two pipes to prevent further leakages with the help of rubber seals or gaskets on the both sides. The slip coupling itself contains two pipes to repair the damaged lengthy pipes.



Coupling

Union: This type of pipe fitting is almost similar to coupling in terms of functions, but just with a difference, i.e. a union can be removed easily any time while the coupling cannot. A variety of dielectric unions are used to join pipes made of different materials to avoid any kind of galvanic corrosion between them. These pipe fittings comprise of a nut, female and male ended threads.

Union

Adapters: Adapters are connected to pipes to either increase their lengths or if pipes do not have appropriate ends. These pipe fittings make the ends of the pipe either male or female threaded as per the need. This permits unlike pipes to be connected without any need of extensive setup. They are mostly used for PVC and copper pipes.

Adapter

Nipple: This is a short butt of a pipe that works as a connection between two other fittings having male threads. A close nipple is a type of pipe fitting having continuous threading on them. They are mostly used in hoses and plumbing.

Nipple

Reducer: This pipe setting is used to reduce the flow size of the pipe from the bigger to smaller one. There are two kinds of reducers- concentric reducer and eccentric reducer. Reducer the former one is in the shape of a cone used for gradual reducing of the size of the pipe. The latter one has its one edge facing the mouth of the connecting pipe reducing the chances of air accumulation.

Reducer

Tee: This T-shaped pipe fitting used in the plumbing system has one inlet and two outlets arranged at an angle of 90 degrees to the main pipe. This kind of fitting is used to connect the two pipes and make their flow direction as one. If all the three sides of this fitting are same in size, it is called equal tee, otherwise unequal tee.

Tee

Cross: This type of pipe fitting contains four openings in all thefour major directions. This fitting is adjoined to four pipes meeting at common point. There is either one inlet and three outlets or vice-versa to flow water or any other liquid in four different directions. These kinds of pipe fittings are commonly used in fire sprinkler systems.

Cross

Flanges: A flange is another pipe fitting used to connect pipes, pumps, valves, and other components to form a full-fledged piping system. They come with a flexibility of easily cleaning or inspecting the whole system from within. They are fixed to the pipes using welding, threading or screwing techniques and then finally sealed with the help of bolts. They are used in residential pump systems and majorly for industrial purposes.

Flanges

Caps & Plugs: Both these pipe fittings are used to close the ends of the pipe either temporarily or permanently. The plugs are fitted inside the pipe and threaded to keep the pipe for future use. There are a good number of ways a cap can be applied to the pipe like soldering, glue, or threading depending on the material of the pipe.

Caps and Plugs

Bushings: These pipe fittings are used to combine pipes of different sizes together by decreasing the size of the larger fitting to the size of the smaller pipe. Bushings are not always threaded inside out and occupy very little space in comparison to a union or coupling used for the same purpose.

Bushings

Wyes: Such type of pipe fittings are used in drainage systems and have a branch line at 45 degrees to keep the flow of water smooth. When the sanitary tees fail to work in a horizontal connection, such cases needs a wye.

Wyes

Valves: Valves are used in the plumbing system to stop the flow of gases or liquids. There are of three types – throttling, isolation, and non-return. The isolation valves are used to disconnect a part of the piping system temporarily for maintenance or repair. The throttling valves are used to regulate the amount of pressure of a liquid in a pipe; they can also withstand the stress caused by this process.

Valves

Barb: A barb is another useful pipe fitting used in the plumbing system that connects flexible tubing to pipes. It has a male-threaded end on one side that connects with the female threads, and the other end has a single or a multi-barbed tube that is inserted in the flexible tubing.

Barb

Diverter tee: This kind of a tee-shaped pipe fitting is commonly used in the pressurized hydronic heating systems to redirect a part of the flow from the main line to the side branch connected to a heat exchanger.

Fig 1.28: diverter tee

Gaskets and O-rings

Gaskets

A gasket is a flat piece of material that sits between to flat surfaces. The gasket's material whether neoprene, rubber, silicone or another flexible substance prevents liquid or air (or sometimes both) from leaking in or out of an area.

O-Rings

O-rings are circular, ring-shaped pieces that sit in a groove between two (usually cylindrical) parts. The compression of the two parts creates the airtight and liquid-tight seal.

O-rings can be made from many flexible materials, like rubber, neoprene, or polyurethane. While the ring-shape is a staple characteristic of o-rings, the height and thickness of the ring can vary based on your design.

Difference between a Gasket and O-Ring

Both perform the same basic function of stopping liquids or gasses from ingressing or egressing.

1. The shape of the seal is one key criteria where the difference between an O ring and a gasket becomes very clear. In some applications, only a gasket will work because the shape of the joint makes it difficult or impossible to design a good seal using an O ring, which requires a groove to sit in.
1. The other key factors are temperature and pressure. The material used to make the seal is a critical factor with regards to operating temperature. While both O rings and gaskets can perform well in a wide temperature range, gaskets have the edge in extreme temperatures. O rings, however, are the superior choice in applications with extreme pressure. Under pressure, an O ring's performance will improve while a gasket's effectiveness will decrease

Caulking agents

It is a sealant but differs from plumbers' putty. A big difference in both is that a silicone caulk cannot be replaced.

It is a sticky material and is an adhesive one. It is hard enough that you can use it everywhere. It also has a rubbery touch to it that keeps it elastic for quite some time. It can be so tight after applying, you would need a scrapping tool to remove this sealant.

Sealant and glue

Silicone sealants are a form of liquid adhesive commonly used in building, bonding, and repairing many materials, including finishing joints and filling seams or other gaps. Since they are waterproof and offer durable elasticity and stability in both high and low temperatures, silicone sealants work particularly well as plumbing sealants.

Water proofing agents

Concrete is the main building material used in all civil constructions and it is prone to shrinking. Concrete hence requires protection due to porosity, cracks & potential to reaction with atmospheric gases such as CO_2. Apart from that, the structures have various joints & connections which need to be considered & given extra protection.

Estimation of quantities and costs

Bill of Quantities and cost for a 5 cu.m. tank of concrete in situ

Description	**Unit**	**Quantity/ Days**	**Unit cost Ksh**	**Total cost Ksh**
Labour cost	Artisans	1 x 8 days	400/day	3,200
Artisan	Labourers	2 x 8 days	200/day	3,200
Labourers				**6,400**
Cost of labour				
Materials				
Cement	50 kg bags	12	600	7,200
River sand	Tonnes	3	200	600
Crushed stones	Tonnes	3	600	1,800

Burnt bricks 4” x 6” x 10”	Units	50	5	250
Water	Oil-drums	8	100	800
Weld mesh 2.4 x 1.2 m	Sheets	4	370	1,480
Barbed wire 20 kg rolls, g	Kg	1	3,000	3,000
12.5	Rolls	2	3,000	6,000
Chicken mesh, 3’ x 90’ x 1”	Kg	5	100	500
Nails, 2”	25kg	1	400	400
Lime	Lengths	1	400	400
uPVC, 2” sewage pipe	Metres	0.5	420	210
G.I pipe, 1½”	Metres	0.9	200	180
G.I pipe, ¾”	Units	4	500	2,000
G.I fittings, ¾” tap, elbow	Sq.m.	1	200	200
etc	6 mm x 25 mm	6	20	120
Galvanized coffee mesh	Centimetres	200 x 20	Free	Free
Circular bolts	Metres	30	75	2,250
Circular metal ring	Kg	5	80	400
Timber, 6” x 1”				**27,790**
Nails, 3”				
Cost of materials				
Transport of materials				
Hardware lorries	3 tonnes	1 load	3,000	3,000
Tractor trailer loads	3 tonnes	5 loads	900	4,500
Cost of transport				**7,500**
Total cost of a 5 cu.m. tank built of concrete in situ				**41,690**

Bill of Quantities and cost of a 90 cu.m. ground tank

Description	Unit	Quantity	Unit cost Ksh	Total cost Ksh
Labour cost				
Artisan	Artisans	3 x 14 days	400/day	16,800
Labourers	Labourers	4 x 20days	200/day	16,000
Cost of labour				**32,800**
Materials				
Cement	50 kg	73	600	43,800
Lime	bags	2	400	800
River sand	25 kg	17	200	3,400
Crushed stones	bags	1	600	600
Burnt bricks, 4” x 6” x 10”	Tonnes	1000	5	5,000
Water	Tonnes	45	100	4,500
Weld mesh, 2.4 x 1.2 g.8	Units	25	370	9,250
Chicken mesh 25mm, 0.9m	Oil-drums	100	110	11,000
Twisted bars, Y12	Sheets	5	60	300
Barbed wire g12.5	Metres	100	150	15,000
G.I pipe, 1½”	Metres	4	420	1,680
G.I elbow, 1½”	Kg	1	80	80
G.I pipe, ¾”	Metres	9	200	1,800
G.I tap, elbow, socket, nipple,	Unit	1	700	700
¾”	Metres	5	133⅓	670
uPVC, 4” sewage pipe	Tap unit	1	200	200
Galvanized coffee mesh	Metres	0.5	100	50
Mosquito mesh	Sq.m.	60	75	4,500
Timber, 6” x 1”	Sq.m.	60	75	4,500
Timber, 2” x 3”	Metres	12	40	480
Poles	Metres	12	50	600

Bolt 6 x 120mm	Units	48	Free	Free
Oil-drums, discharged	Units	50	30	1,500
Plastic bag	Units	16	120	1,920
Angle iron 25 x25mm	Units	1	100	100
Plastic basin	Units	3	70	210
Sisal twine	Units	3	80	240
Nails 3"	Kg			**112,880**
Cost of materials	Kg			
Transport of materials				
Hardware lorries	7 tonnes	1 loads	5,000	5,000
Tractor trailer loads	3 tonnes	14 loads	900	12,600
Cost of transport				**17,600**
Total cost a 90 cu.m. ground tank built of ferro-cement				**163,280**

5.2.2.4 Learning Activities

With the help of your trainer, Quantify and cost for materials and supply for the water storage system given

5.2.2.5 Self-Assessment

1. What factors are considered during the designing and building of steel storage tanks?

2. Which of the following is not a type of steel tanks?
    a. Steel portable water tanks
    b. Corrugated steel tanks
    c. Steel fire protection tanks
    d. Above ground tank

3. What are some of the signs that a septic tank is not working properly?

4. Of the following, which one is not a tank base insulation system benefit?
   a. Increases energy loss
   b. Protect the structural concrete base material against high temperatures.
   c. Helps protect against chemical attacks from the content of the tank.
   d. Resist corrosion and mitigate deterioration of the vessel.

5. How does a septic tank work?

6. Which of the following are suitable conditions for the construction of a masonry storage tanks?
   a. Tanks should not be located near a pit latrine/toilet or rubbish or on an ant hill.
   b. Avoid building the tank next to a tree as the roots may undermine the foundation
   c. The height of the gutters should be lower than the proposed tank height.
   d. Do not site tanks where heavy vehicles will pass close to tank foundations.

7. What factors are considered in the choosing of building materials for tanks.

5.2.2.6 Tools, Equipment, Supplies and Materials

Functional Plumbing Workshop with the following:

Tools and Equipment

- Pipe wrench
- Pipe cutter
- Hacksaw
- Pipe Threading Equipment
- Vice - Bench
- Pliers

- Tap and Punch
- Files
- Screwdrivers
- Drill with various sizes of bits
- Mallet
- Ball hammer
- PPR machine / Heat Fusion equipment
- Pipe bender
- Sealant gun

Supplies and Materials

- Fittings
- Back nuts
- Cisterns
- Valves
- Sealant
- Water proofing agents

5.2.2.7 References

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5.2.2.8 Model Answers

1. What factors are Considered During the Designing and Building of Steel Storage Tanks
    - **Materials**: This mainly relates to the tank's application, simplicity and installation, regulations and codes, and the tank's cost.
    - **Size and Shape**: Depends on the application, regulations and standards.
    - **Strength**: Here designers and engineers decide on the thickness of the tank walls, and the vertical, horizontal and cross ribs depending on its application and usage.
    - **Location**: Whether the tank will be aboveground, underground or partially buried also influences the design and the construction of the steel storage tank.
    - **Accessibility**: Considering the accessibility during the initial designing of the tank helps facilitate the needed tank's and installed components internal inspection and maintenance.
    - **Mobility**: Whether the tank will be fixed or mobile helps in deciding its size and weight, and the suitable way to assemble and disassemble for moving from one point to another.
    - **Others**: There are a number of other design calculations that may be factored in such as on seismic load, snow load and wind load among others.

a. Which of the following is not a type of steel tanks?
   Steel portable water tanks
b. Corrugated steel tanks
c. Steel fire protection tanks
d. Above ground tank

- What are some of the signs that a septic tank is not working properly? The sewage in the toilet or the liquid waste from other fixtures flows away very slowly
- Liquid waste overflows from the disconnector trap
- Wet areas are seen at the top of the septic tank
- There is a strong unpleasant smell near the septic tank
- The grass around the tank is very green and growing well

2. Of the following, which one is not a tank base insulation system benefit?
   a. **Increases energy loss**
   b. Protect the structural concrete base material against high temperatures.
   c. Helps protect against chemical attacks from the content of the tank.
   d. Resist corrosion and mitigate deterioration of the vessel.

3. How does a septic tank work?
   A septic tank must be filled with water before it is used. The water helps start the treatment of the sewage by the bacteria.
   The sewage treatment by the bacteria turns the waste matter into **effluent** (wastewater) and a solid substance called **sludge**. The effluent gets carried to the leach drain, French drain or lagoon.

   The material in the septic tank gets covered by a hard crust known as a **scum blanket.** This blanket acts as an **air seal** keeping air away from the sewage. The lack of air helps in the breakdown of the sewage by the bacteria.

The sludge gathers at the bottom of the tanks. Eventually there will be too much sludge in the tank and it must be pumped out and the sludge disposed of correctly.

By having two tanks or a rectangular tank divided into two sections, most of the sludge stays in the first tank or section. In the second tank or section, the sewage undergoes further treatment to remove solid matter.

The effluent is then piped to the effluent disposal system, such as the lagoon.

4. Which of the following are suitable conditions for the construction of a masonry storage tanks?
    a. Tanks should not be located near a pit latrine/toilet or rubbish or on an ant hill.
    b. Avoid building the tank next to a tree as the roots may undermine the foundation
    c. The height of the gutters should be lower than the proposed tank height.
    d. Do not site tanks where heavy vehicles will pass close to tank foundations.

5. What factors are considered in the choosing of building materials for tanks.
    - Where coarse river sand is expensive, tanks should be built of either burnt bricks or soil compressed bricks to reduce cost.
    - Where coarse sand is cheap, tanks should be built of ferro-cement if trained builders are available.
    - Where coarse river sand, pebbles, stones and hardcore (larger stones) are in plenty, it is most economical to use concrete in formwork (in situ) or concrete blocks.

- The cost of making concrete blocks can be reduced by compacting rubble stones into the concrete in the steel mould. Such blocks, as seen in the photo are called rubble stone blocks.

5.2.3 Learning Outcome 3: Install storage systems and auxiliary fittings

5.2.3.1.Introduction to the learning outcome

This learning outcome specifies the content of competencies required to Install storage systems and auxiliary fittings. It includes, terms and concepts, tools and equipment, PPEs, types of storages systems, pumping systems, types of pumps, their installation and supports, positioning, housekeeping and occupational safety and legal requirements

5.2.3.2.Performance Standard

1. Tools and equipment needed for fixing storage and ancillary fittings are identified based on the job requirements.
2. Tools and equipment are used based manufacturer's manuals.
3. Location of Storage and auxiliary fitting is determined based on drawings.
4. Support for Storage and auxiliary fitting are put in place based manufacturers' manual.
5. Storage and ancillary fittings are mounted based job requirements and manufacturer's installation manual.
6. Personal Protective Equipment is used in line with occupational safety and health regulations.
7. Housekeeping is conducted on work area based on work place procedure
8. Safety and health practices are observed based on OSHA.

5.2.3.3.Information Sheet

INSTALL STORAGE SYSTEMS AND AUXILIARY FITTINGS

Tools and Equipment

- Pipe wrench

Pipe wrench size should be selected such that its opening exactly pits the pipe and should not be used for bending, raising or lifting pipe.

It is used for:

- screwing and unscrewing small pipes.
- tightening of nut and bolts, fixing of small taps, valves etc in pipelines.

Pipe Wrench

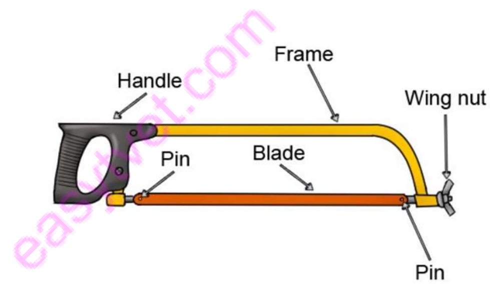
- Pipe cutter

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

Pipe Cutter

- Hacksaw

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



Hack Saw

- Pipe Threading Equipment

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

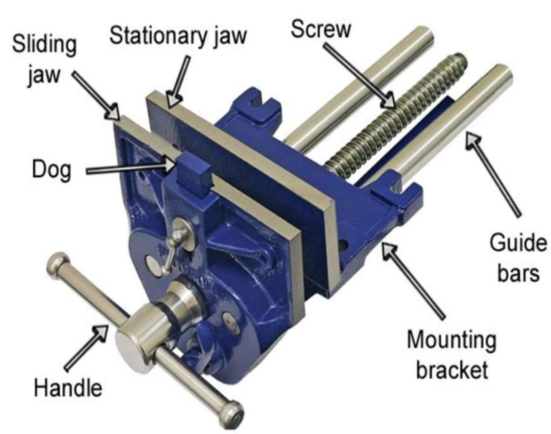
Pipe Threading Equipment

Using instructions:

a. Take required size of pipe threading die.
b. Fix the pipe in the pipe vice tightly.
c. Cut the pipe to required size at right angle.
d. Hold the die in right angle of the pipe and put some oil on pie.
e. Cut the thread on the pie with die rotating in clockwise direction. Rotate the die in anti clockwise direction so that the cut material will come out.
f. Clean the chips or burr.

- Bench vice

It is used for holding pipes in position rigidly for cutting and threading. Pipe vices are available in market in various sizes for holding pipes starting from 37 mm diameter.



Bench Vice

1. The Base

The base of the vise is the part that holds everything together. It is truly the life of the party. The base of the vise is fastened to the bench and it comes in different designs. Some can be clamped in place; the others can be bolted. There are also swivel and vacuum bases available for different purposes.

2. The Jaw

This is where everything stays. The jaw is jaw-like and clamps everything in place. It comes in two different parts. Considering the nature of the job, the jaws can take the form of wood, plastic, or metal.

The sliding jaw: this part of the jaw moves when the handle is turned. It also applies pressure on the object being clamped. If you are new to clamping, it's pretty easy to spot out which part of the clamp is the sliding jaw, since it's the part that allows motions and has a handle sticking through.

The static jaw: this part is fixed. This is the vise that enforces solidity. The sliding jaw backdrops in this component applying pressure for its immovability. You can identify the static jaw by its size.

3. The Slide

This part moves when the handle is turned, applying pressure to the object. It is attached to the sliding jaw.

4. Main Screw

The force applied to the handle is transformed into the movement of the sliding jaw, which moves towards the static jaw. This jaw is conspicuously attached to the handle and extends through the vise.

The main screw is an essential part. It is so vital that if the main screw is not manufactured based on the type or comes with flaws creating weaknesses, the vise will not hold well at all.

5. Handle

The handle has a lever attached to it.

Applying too much force on the handle can be tempting. But if done out of proportion, it can lead to explosive results. The power applied to move the handle multiplies and gets accompanied by the actions of the main screw. While clamping, if any material observes a bend, it’s best to stop and reverse the handle to release the pressure level.

6. The Anvil

This can come in handy form when light-shaping of materials.

7. Serrated Jaws

This is the actual point where the vise meets with whatever it is you are fastening. Take precautions with anything other than metal. The jaws can do a ‘damage job’ when too much pressure is applied.

8. Pipe Jaws

These pipe jaws can be found inside the sliding and static jaw. They allow you to hold pipes and other oddly shaped objects in place, and present you with the prerogative to cut them easily.

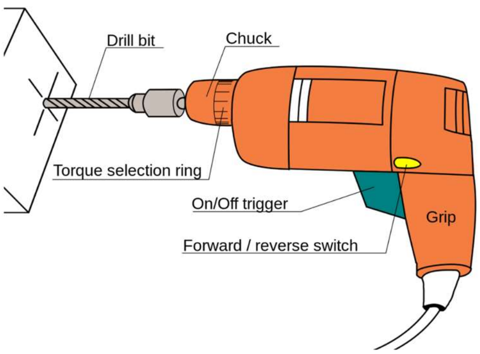
- Spanner

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

Spanner

- Drill with various sizes of bits

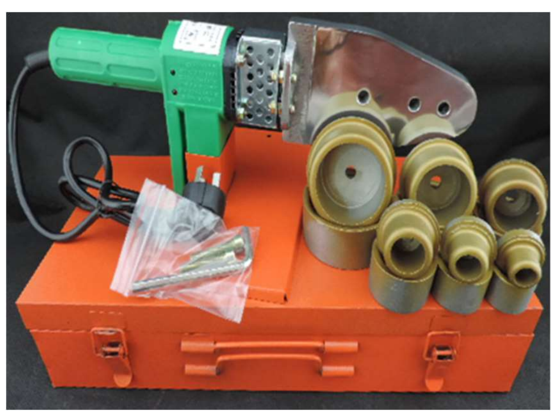
It is a tool primarily used for making round holes or driving fasteners. It is fitted with a bit, either a drill or driver, depending on application, secured by a chuck. Some powered drills also include a hammer function.



Drill and Bits

- PPR machine / Heat Fusion equipment

It is a pipe welding machine set used for welding plastic pipes.



Ppr Machine

- Pliers

These are used everyday by plumbers. Easily tighten or loosen nuts and bolts that wrenches can't grab onto.

Pliers

- Pipe bender

It is used for bending pipes. Fix wooden stopper to one end of the pipe. Fill the pipe with sand completely. Fix wooden stopper from other side of pipe. Fix the pipe in the machine. Location of the bend should be in center of pulley. Tight the screw. Bend the pipe with help of lever till required bend. Remove stopper and sand from pipe.

: Pipe Bender

PPES

Plumbing Safety Tools

PPE can be defined as safety gear that protects plumbers against safety or health risks when handling the job. The main objective of a protective gear for a plumber is to reduce plumber exposure to hazards related to plumbing.

Below are essential PPE for plumbers commonly used on plumbing and their benefits.

PPEs

1. Face and Eye Protection

Spectacles, safety goggles, and full-face shields are essential protective gears a plumber should consider using when handling the task. This safety gears are commonly used when handling power tools. This safety equipment helps the plumber to effectively and efficiently complete the task.

2. Head Protection

Protective helmets are important in a plumbing site because they prevent injuries from flying or falling objects. Recently, due to advanced technology, some hard hats are equipped with accessories, such as earmuffs and shields. A plumber should consider buying a well-fitted protective helmet to prevent inconveniences. Too small or too large hard hats are inappropriate to use. Falling or flying objects might lead to severe head injuries.

3. Hand and Skin Protection

Plumbing projects typically require the use of hands. Recently, there have been many reported cases of hand injuries resulting from lack of hand protective gear. Also, a plumber can suffer from various occupational skin diseases, such as skin cancer, dermatitis, and other severe skin injuries.

Hand gloves are essential because they lower the risk of hand and skin diseases. There are different types of gloves that can be used as PPE for plumbers. These types include cut-resistant gloves, rubber gloves, heat-resistant gloves, chainsaw gloves. Gloves are essential when a plumber is handling tasks that involve hot materials, electricity, and slippery objects.

4. Respiratory Protection

Production of toxic substances is common in plumbing sites. Respiratory protection gears, such as respirators, are designed to protect a plumber from fumes, dust, and other dangerous substances that could lead to respiratory problems. Respiratory protection gears are important in areas where there’s air contamination.

5. Hearing Protection

Noise pollution in plumbing sites can lead to permanent hearing impairment. Earplugs and earmuffs are the common hearing protection equipment in plumbing projects. Note that earplugs are effective in reducing low-frequency noise, whereas earmuffs are effective in preventing high-frequency noise.

Water Pumping

Pumping Machinery is used for transfer of water from one place to another and pumping of water from water source. Pumping is required for

a. Lifting water from the source (surface or ground) to purification works or the service reservoir.
b. Transfer of water from source to distribution system.
c. Pumping water from sump to elevated/ground surface tanks.

Pump house (civil works) is constructed for installation of pumping machinery.

Pump House is designed for life of at least 30 years, while pumping machinery is designed for at least 15 years lifespan.

Pumping Machinery consists of 3 major components:

a. Pump for lifting of water

The function of pump is to transfer water to higher elevation or at higher pressure. Pumps are driven by electricity or diesel or even solar power. They are helpful in pumping water from the sources, that is from intake to the treatment plant and from treatment plant to the distribution system or service reservoir.

b. Electric/diesel/solar powered motor

For pumping, 3 phase electric connection is required.

c. Panel board

Panel board consists of circuit breaker or switch and fuse, starter level controls etc. for transmission of electric supply.

PUMPING SYSTEMS

i. Total Dynamic Head

In order to accurately predict the performance of a pump in a specific application, the total head losses must be considered. These losses include, but are not limited to:

- Total static head;
- Losses due to pipe size, length, and material;
- Losses due to pipe appurtenances.

ii. Friction Losses in Conduits

When water moves through a closed conduit, the flow creates heat due to the friction of the two surfaces (water against conduit). A steel pipe will produce more friction than will any plastic pipe.

Friction increases with the increased length of pipe or hose, and also with a deceased diameter of pipe or hose. Increased friction slows down the water, effectively decreasing the discharge capacity and actual discharge of a given pipe.

iii. Suction Head

Atmospheric pressure at sea level limits the suction head of centrifugal pumps to 10.3 m (33.9 feet). However, this head would only be obtained if a perfect vacuum could be created in the pump. In reality, the suction head of centrifugal pumps is limited to about 7.9 m (26 feet).

Pump performance (capacity or pressure) is highest when the pump is operated close to the water's surface.

Increasing the suction head will decrease the discharge head and consequently the discharge capacity of the pump. Very importantly, suction head should be kept to the smallest value possible to reduce the likelihood of cavitation10. Cavitation can also occur if the suction pipe is restricted. A suction hose with a smaller diameter than the suction port should not be used as cavitation can quickly damage a pump.

iv. Discharge Head

As the pump discharge head increases in height, the pump capacity decreases and the available pressure at the end of the discharge pipe also decreases. At maximum head, the capacity of a pump drops to zero and no pressure is available at the end of the discharge line. The pump performance curves show the relationship between discharge capacity and total head.

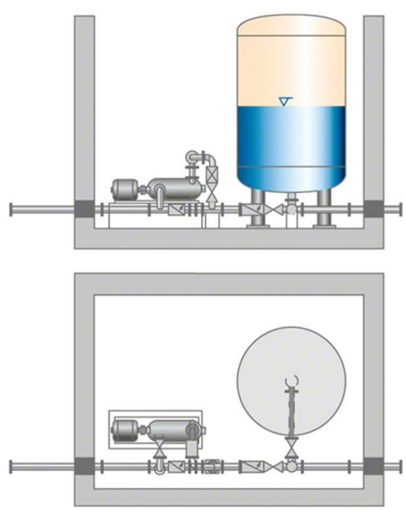
v. Pipe Restrictions

When water hits any restriction (valve or a reducer), only a partial amount of the flowing water is be allowed to pass through. Restrictions increase the friction and decrease the discharge capacity at the end of the pipe.

Pressure booster system

If the standard pressure of an existing water supply system is unable to ensure supply to consumers located at higher elevations, e.g. in high-rise buildings or elevated residential areas, it is necessary to boost the water pressure. This is accomplished by installing one or more booster pumps in a bypass line to the main water supply pipe.

In order to prevent any pumping in a closed circuit, a check valve is fitted in the main water supply pipe between the booster pumps' suction and discharge connections.



Booster Pump

Pressure booster system: Pump installed in bypass line with lift check valve and accumulator

Advantages of the Booster Pump System

- It requires the least floor space.
- It generally has the lowest initial cost.
- It is the most flexible system in terms of available flow and pressure to meet a variety of distribution requirements.
- The installation does not impose a large weight on the building structure.

Disadvantages of the Booster Pump System

- It has the highest operating cost.
- It has the the highest maintenance cost.
- Its control system is sophisticated and requires a knowledgeable maintenance
- It has couplings and variable-speed drives that require considerable maintenance.
- It will shut down the water supply for the entire building if there is an electrical power failure.
- The instantaneous fluctuations in water pressure during normal use may begreater than in the other systems.

- Direct pumping

Direct Inline Pumping (DIP) is a pumping methodology that can carry gravity-fed effluent away from the point of entry without requiring a wet-well.
Direct supply is simulated with two parallel pumps, one running at a constant speed (CSP) while the second, a variable speed pump (VSP) is fed by a variable frequency driver that during the simulation is adjusted to provide 20 m at the less favorable node avoiding over pressures at any time.

- Indirect pumping

In a case of indirect excitation, the absorption / pumping band is significantly shifted to shorter wavelengths and several processes of energy transfer.
Indirect supply, the pump is controlled by the tank's water level and, in order to avoid as much as possible pumping during on-peak hours, by the time as well.

- Zoned system

Zoned pumping system can be accomplished in one of two ways:

i. Multiple circulator pumps
ii. A single circulator pump and zone valves.

Multiple zones can be implemented using either multiple, individually controlled circulator pumps or a single pump and multiple zone valves.
Each approach has advantages and disadvantages.

Multiple pump system
Advantages:

- Lower total cost of ownership when zone valve failure and repair costs are taken into account.
- More robust and reliable system.
- Simple mechanical and control design ("SPST thermostats")
- Redundancy: If one zone pump fails, the others can remain working
- Far superior method of linking multiple heat sources. Such as gas and solid fuel in one system.

Disadvantages:

- Higher initial installation cost. Circulator pumps cost more than zone valves
- Higher power consumption. Operating circulators draw more power any time the zone is actively heating. Zone valves, by comparison, draw little power at any time and many designs only draw power while in transition from open to close or vice versa.

Zone valve system

Advantages:

- Lower initial installation cost.
- Lower power consumption.
- Ease of maintenance certain models.

Disadvantages:

- Zone valves are inherently more unreliable and prone to a very high failure rate. Zone valves operated by electric timing motors aren't "fail safe" (failing to the "open" condition).
- No inherent redundancy for the pump. A zone-valved system is dependent upon a single circulator pump. If it fails, the system becomes completely inoperable.
- The system can be harder to design, requiring both "SPDT" thermostats or relays and the ability of the system to withstand the fault condition whereby all zone valves are closed simultaneously.

Classification of Pumps.

Classified by use, pumps are called:

- Low service
- High service
- Deep well, booster
- Sewage, sludge
- Boiler feed
- Chemical
- Proportional feeders
- Air blowers

Low-service pumps operate at low discharge heads to lift water from sources of supply to water-treatment works.

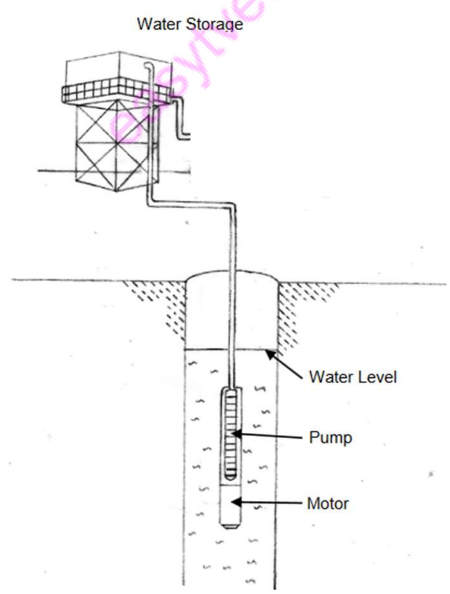
High-service pumps operate at high discharge heads to deliver water to distribution systems. Proportional feeders are used for dosage of solutions of chemicals or liquid chemicals.

The standard classification of pumps may be divided into four general classes with a section devoted to each class.

TYPES OF PUMPS

1. Turbine Pump (Deep well)

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



Turbine Pump

2. Sump pumps

Sump pumps move water from your basement out of your home. A sump is a naturally constructed pit, usually a hole carved below the main surface of your basement floor. This pit, known as a **basin**, holds the sump pump.

The pump is equipped with valves that sense escalating water levels or pressure. When the water gets too high, sump pumps automatically pump excess water out of the basement and away from your property using a discharge line. This line, called an **effluent**, connects the sump pump to a designated drainage area.

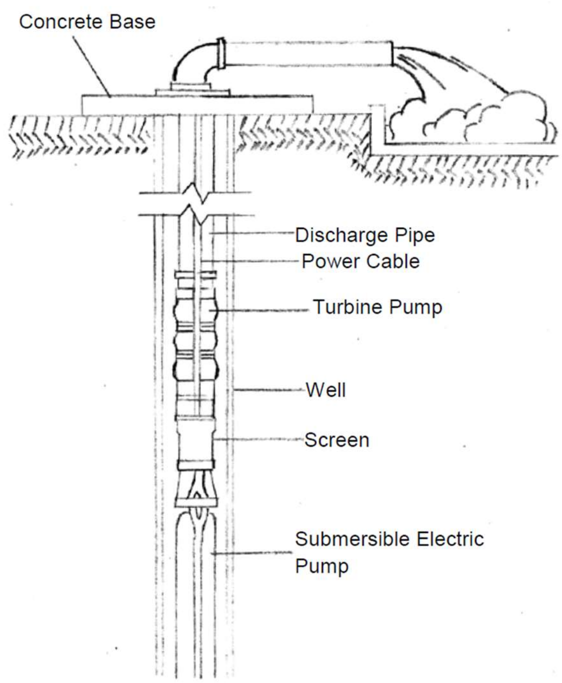
Two main types of sump pumps exist:

a. Submersible sump pumps, which are totally hidden in your sump basin
b. Pedestal sump pumps, which are mounted above floor level on columns that protrude out of the sump basin

a. Submersible pumps

It is designed such that it can be introduced into a well casing and lowered to the bottom of the well. It is highly used for pumping from bore well and underground sumps. Such pumps are used for water yield of 100 liters per minute.

It is driven by an electric motor, which is directly attached to the pumping element and therefore totally submerged. This pump type is mainly used where electric power is available or ideally in combination with a Solar Pumping System.



Submersible Pump

The main parts of a submersible pump are:

- Electric motor enclosed in a stainless-steel sleeve.
- Pump body with multiple impellers, foot valve and strainer.
- Rising main of GI or stainless-steel pipes connected with sockets or PVC- hose. If a hose is used, the motor with connected pump body has to be hung from the top of the well by a stainless-steel cable.
- Electrical cable for connecting the motor to the starting panel (power source).
- Starting panel.

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

b. Pedestal pumps

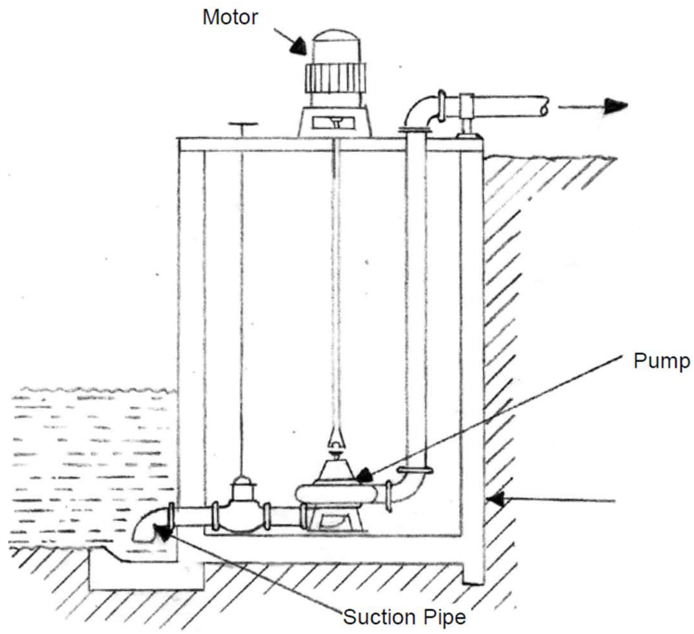
Pedestal sump pumps drain water in smaller-diameter sump pits that cannot accommodate submersible sump pumps. They have the pump motor above the sump pit and are mounted on top of a long tube sitting at the bottom of the sump pit. The pump impeller on the inside of the tube turns to transfer the water. Pedestal sump pumps (also known as upright sump pumps) have a long rod with a float on the end to turn the switch on and off, though the switch may sometimes be turned on in a different way.

Pedestal Pump

3. Centrifugal pump

It is used for pumping water from well/sump. It is a type of velocity pump where water is moved through continuous application of power. These type of pumps are used widely in water supply schemes containing sand, silt etc.

Centrifugal force is made use of in lifting water. Electrical energy is converted to potential or pressure energy of water. The pump consists of following parts: Casing, Delivery Pipe, Delivery Valve, Impeller, Prime Mover, Suction Pipe, Strainer and Foot Valve.



Centrifugal Pump

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

4. Booster pumps

A water booster pump helps increase the pressure and volume of water that flows from your faucet or shower head. A booster pump increases low water pressure and flow. It provides the extra boost needed to bring your water pressure to the desired level. A water booster pump provides pressure to move water from a storage tank or throughout a whole house or commercial facility.

Most water booster pumps, have the following core components:

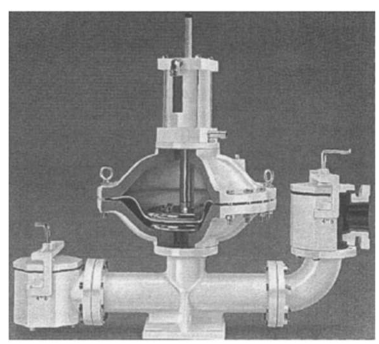
- Motor
- Impellers

- Inlet and outlet
- Pressure or flow sensing device

5. Reciprocating pump

Reciprocating pumps are a type of positive displacement pump which use alternating force and suction – using a piston or diaphragm – to create a steady, pulsing flow, with one or more check valves to regulate and direct flow through the system. The pump chamber is repeatedly expanded and contracted to draw the fluid through an intake valve and force it out through the other end. They are able to generate high pressures.

These pumps range from small, hand-powered pumps, to big pumping systems. Due to the broad range of pumps that are classed as reciprocating pumps, they play an integral role in a number of sectors including private, public and commercial/industrial sectors in applications such as irrigation, public water supplies, fire safety systems and where viscous liquids need to be moved.



Reciprocating Pump

The key components used in reciprocating pumps are

- **Piston, Plunger or a diaphragm:** All these parts have the basic functionality of moving the liquid inside the cylinder. The piston is a lubricated sliding shaft which moves inside the cylinder and pushes the liquid in forward and backward motion, creating a cavity and a high volume pressure at the outlet. In a diaphragm pump, the diaphragm is used to avoid leaking of the liquid since it completely seals the liquid to penetrate outside, and hence they are especially useful when the liquids are dangerous or toxic. In a plunger pump, there is a high-pressure seal which is stationary and a smooth cylindrical plunger slides through the seal.
- **Crank and Connecting rod:** Crank is a circular disk attached to the motor and used to transfer the rotary motion of the motor to the piston. Piston, in turn, moves in a reciprocating motion with help of a connecting rod.
- **Suction pipe:** Liquid flows from this pipe into the cylinder. One side of the pipe is immersed in the liquid and the other end is connected to the cylinder.
- **Delivery pipe:** This can be understood as an outlet pipe. One end is connected to the cylinder while the other is towards the discharge/Outlet.
- **Suction and Delivery valve:** It adjusts the rate of the flow of liquid at the suction and discharge points.

Reciprocating pumps are different from Centrifugal pumps on basis of its working, features, applications etc. The main difference is that Impellers are used in Centrifugal pumps whereas in reciprocating pumps piston is used to move the liquid. Centrifugal pumps continuously discharge the liquid, unlike reciprocating pumps. They are used for high viscous fluid and are lighter in weight, less expensive as compared to reciprocating pumps.

We look at the most common types of reciprocating pumps below.

Types of reciprocating pumps

1. Piston pumps

Piston pumps (also known as well service pumps, high pressure pumps or high viscosity pumps) use one or more reciprocating pistons to move fluid through a cylindrical chamber which are usually driven by an electric motor, internal combustion engine or other power source through a crankshaft or connecting rod.

These pumps have contracting and expanding cavities that move in a reciprocating motion rather than a circular (rotary) motion, alternately drawing the fluid in and then pushing it out under pressure.

These pumps can be single acting where the piston moves in both directions to complete a full pumping cycle, or doubling acting where there are two sets of check valves (one on each side of the piston) with fluid on both sides of the piston and a full pumping cycle being completed each time the piston moves from one end to the other.

Piston pumps are commonly used as hydraulic pumps to power heavy machinery or in smaller applications such as paint sprayers..

2. Plunger pumps

Plunger pumps operate in the same way as piston pumps, but rather than using pistons, they use plungers to move fluid through a cylindrical chamber, typically driven by electric motors, but steam and hydraulic drives are also used.

These pumps work with the drive moving one or more plungers back and forth inside the cylinder. This cylinder comes with packing rings to prevent the fluid from leaking past the plunger as it moves. At the end of the cylinder there is a pumping chamber with two check valves located at the inlet and outlet which stop the fluid from reversing direction as it passes through. Fluid is drawn into the chamber as the plunger moves away from it, creating a vacuum, and the fluid is pushed out of the chamber and into the system as the plunger moves towards it.

Plunger pumps can come with one or more plungers and sets of check valves. Where there are two, it is known as a duplex pump; where there are three, it is called a triplex pump; and where there are five, it is known as a quintiplex pump. Triplex and quintiplex versions are commonly used.

These pumps produce high pressures, and due to the reciprocating plunger they are also capable of producing pulsations, with the fewer plungers in the pump, the higher the pressure pulsations it is able to produce. Many systems include a pulsation dampener at the pump discharge that absorbs pulsations to significantly reduce the pressure pulsations further downstream.

As they can generate high levels of pressure and tend to be sturdily built, they are commonly used in applications where highly viscous or heavy fluids such as oil need to be moved. Smaller, lighter duty versions are used in applications such as pressure washes.

3. Diaphragm pumps

Diaphragm pumps use a flexible diaphragm to create a vacuum at the chamber inlet to draw the fluid in, with the volume of the pumping chamber decreasing and forcing the fluid out of the discharge as the diaphragm moves in the opposite direction.

Like piston and plunger pumps, diaphragm pumps have check valves at the inlet and outlet of the pump to prevent the fluid from moving backwards.

These pumps are highly reliable as they have no internal parts that rub against each other, and contain no sealing or lubricating oils within the pump head which eliminates the chance of oil vapour leakage or contamination of the pumped fluid.

They are highly reliable because they do not include internal parts that rub against each other. They also contain no sealing or lubricating oils within the pumping head, meaning there is no chance of oil vapor leakage or contamination of the handled media

Diaphragm pumps can be classed as one of four types depending on the drive mechanism:

- *Mechanically actuated* types use a gear set or other mechanical mechanism to transfer the rotation of the motor to move the diaphragm. Flow can be varied by changing the stroke length or pump speed
- *Hydraulically actuated* types use an intermediate hydraulic fluid on the non-product side of the diaphragm. The fluid is pressurised by a plunger in order to flex the diaphragm. This is the main difference between this type and mechanically actuated types where the plunger is attached to the diaphragm in order to flex it. Flow is varied in this type by adjusting the pump speed or the amount of contained hydraulic fluid
- *Solenoid* types have an electric motor that controls the solenoid by alternately energising and de-energising it which causes the diaphragm to flex. Flow is varied by changing the pump speed
- *Air operated double diaphragm (AODD)* types are a double acting pump which have two sets of check valves and use two diaphragms which are driven by compressed air alternately between the diaphragm via a shuttle valve. Flow can be adjusted by varying the air pressure supplied to the pump

These pumps can be further divided into single or double acting types depending on the number of diaphragms and how many sets of valves there are.

- Single acting types have one diaphragm and one set of valves, and are characteristic of mechanical drive type pumps
- Double acting types (or double diaphragm) have two diaphragms and two sets of valves, with AODD type pumps an example of this type

Diaphragm pumps are used in a number of applications including commercial, industrial, municipal and science. They are commonly used as metering pumps to deliver precise volumes of fluid for treating water (for example drinking water, wastewater, boiler water and swimming pool water), and process applications where high pressures, metering of fluids or a seamless pump is required or beneficial. AODD pumps in particular are used where fluids containing solids need to be moved but where no electricity is available.

4. Bladder pumps

Bladder pumps are non-contact, pneumatically operated pumps. They have a flexible, squeezable bladder in a rigid outer casing, which expands and contacts to displace fluids. Hydrostatic pressure is used to draw the fluid into the bladder and pass it through a check valve at the bottom of the pump. The check valve closes when the bladder is full to prevent backflow, and fluid is pumped up to the surface via injected gas pressure which squeezes the bladder. When the bladder is empty, gas pressure is reduced and the check valves opened again to restart the process.

These pumps are easy to operate, portable, small in diameter and can pump large volumes of fluid relative to their size.

Bladder pumps come in a range of sizes, materials and models, including models for deep wells, narrow or obstructed casings, and small volume models for low yield wells.

Criteria for Pump Selection for water supply

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

INSTALLATION

How to Install a General Water Storage Tank

The following are the most basic steps for installing the most common types of water storage tanks.

1. Build a Base or Foundation

Regardless of the kind of tank being installed, a flat and level base will be needed for the tank to stand on. Concrete is mostly used for the foundation, or a more affordable method of spreading a thick layer of compacted construction material. The point is to create an even surface that is wider than the tank itself.

2. Install Overflow Drainage (for rain harvesting)

When installing a water harvester, an overflow spout will be needed. Some tanks come with an overflow assembly already installed; others may require a technician to install one. The installer only needs to drill a hole; attach a gasket and, if necessary, a filter; and then drill some screws in place to secure the fixture. This will make sure that any excess water has a place to escape to and does not erode the concrete foundation due to overflow water dripping on it.

3. Connect to a Water Source

If the water source for the tank is a well, a pressure tank will be needed to direct the well water to the storage tank. Getting this network of pipes and fittings level and properly pressurized is a challenge and should be handled by a plumber or contractor with the right expertise.

If the water tank is intended for harvesting rainwater, then some sort of rain catcher of drainage system will be needed to direct the rain to the tank. In most cases this is just a roof gutter system with a downspout and some fill piping that runs to the tank's inlet.

This is typically called a "dry" delivery system. A "wet" delivery system is a bit more complicated and is often used when the storage tank is far from a collection source like a gutter downspout. These systems direct harvested rainwater through underground pipes and rely on gravity and pressure to direct the water up into the tank inlet. Wet systems are generally more secure, efficient, and aesthetically pleasing since much of the piping is buried underground.

Whether wet, dry, or collected from a well, a storage tank is going to need filters. If the water is only being used for irrigation purposes then only hard matter and leaf debris will be needed to be kept out, but if it is harvested for drinking water then a more sophisticated filtration system will be required. That, too, may require the help of a professional.

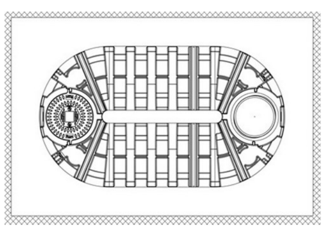
If the tank is being placed underground, there is need to install risers to elevate the inlet and gaskets to an aboveground access point. This is where water directed from a well or collection source will be directed. Once the risers are attached, the excavated land will be filled with backfill. As storage tanks are vulnerable to warping under pressure, the hole must be filled in evenly and in layers of compacted material. This is another complicated step that may require a professional.

4. Install Pressure System (for Well Water Systems)

Any sort of pressurized plumbing system will require extra hardware. In most cases, what will be needed at the very least is, a check valve, a pressure tank, a relief valve, a pressure switch, and a boiler drain. These tools help regulate the amount of pressure applied to the water line that runs from the well (or other source) to the storage tank inlet. Pressure systems are complicated as is, and those fixed to underground water storage tanks will only require greater professional expertise to install.

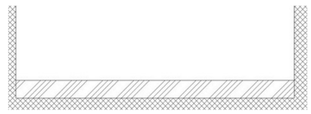
Installation Guide for Underground Water Tanks:

1. Excavate - Measure the length and width of the tank. Add 18” - 24” on both ends and sides of the tank and mark those dimensions on the ground. Excavate to a depth that will provide a minimum of 6” and a maximum of 48” of cover over the top of the tank.



2. Prepare Base - Remove any roots and rake the bed flat. The preferred tank bedding material is well packed pea gravel with minimums of 6” in soil terrain and 12” in rock

terrain. Sand or native soil can be used but it must be flowable, compactable and free from rock. After measuring and filling in the pea gravel base, compact and level before setting the tank



3. Tank - Place the tank in the middle of the hole. Begin pushing the tank back and forth to allow the pea gravel base to fill in the ribs along the bottom of the tank.

4. Install Connections - Install bulkhead fittings in tank. You must plumb with a flexible hose directly from the bulkhead fitting. This prevents any movement that could break the fitting and put extra stress on the tank. Extra fittings that are installed in this tank are the responsibility of the owner.

5. Add Risers - Remove lid and gasket that is supplied with the tank. These components are used in step (d).
   a) Silicone around tank and screw on the first riser.
   b) Bolt the riser to the tank using the 2 supplied bolts and nuts.
   c) Repeat steps (a) and (b) with additional risers.
   d) Add lid and gasket to the top riser installed.

6. Backfill - First, begin filling in the center of the tank with pea gravel or recommended material and compact. Make sure all gaps under the tank are completely filled. Backfill with 12” layers and compact each layer before the next layer is added. Always compact evenly around the entire tank. Make sure to compact backfill under pipes.

SUPPORTS

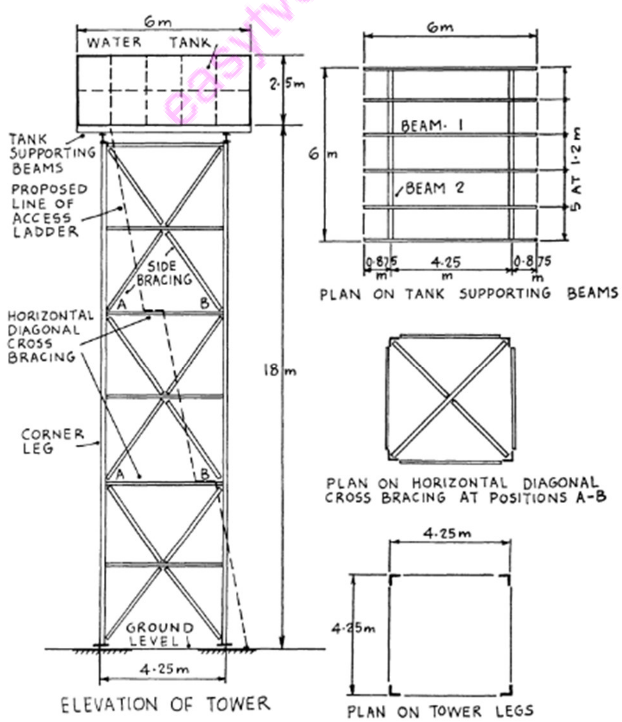
- Steel Pipes

Steel water tank support frames are suitable for raising the tank, allowing pump sets or other equipment to be positioned underneath.

a. Tank-supporting steel pipes.
   The spacing of the steel pipes will depend upon the size of the units from which the tank is built.

b. Corner legs. A suitable spacing for the corner legs must be decided. It is desirable that the legs should be spaced as far apart as possible to give a good width of base to resist overturning. Alternatively, it may be considered advisable to narrow the spacing of the Legs to allow the tank-supporting beams to cantilever over the sides of the tower.

DESIGN OF BRACED TOWER



Braced Tower

- Concrete

It is more expensive but will last the longest if constructed correctly. It looks neat and tidy. You may need to install drains depending on which way the water flows or how close it is to your house.

Flat concrete plinth- ensuring the plinth is level and that it extends 150mm beyond the tank internal length and width dimensions.

- Timber

Where tanks are to be supported by trussed rafters, the size type and position of the tank needs to be clearly indicated.

- Masonry

The elevated storage tank or reservoir offers advantages because it provides a reserve supply of water which is quickly available and also because it is adapted to intermittent windmill pumping.

A masonry silo provides a desirable support for an elevated water supply tank.

- Compact Earth

Pea Gravel: A solid option. Comes at a reasonable price and holds itS shape a lot better than sand. Pea gravel also needs to be supported so it doesn't degrade over time. This option filters water a lot better than sand. I highly recommend this.

Dirt/Clay: This is similar to using sand. If not supported correctly, it can run away very quickly during a storm or heavy rain.

Positioning (location)

Underground

Sump: Sump is used as additional storage at village/town level or cluster level. It is not used for direct distribution of water. Rather, it is used as intermediate or contingency storage, to store water before it is pumped to ESR/GSR.

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

Advantages of sub-surface tanks:

- Underground tanks offer a cheaper to install due to its lower cost of reinforcements needed
- during construction, as compared to surface tanks. This is due because ground support
- provides the strength needed to hold the water
- They are appropriate in places where space above ground is limited; and they can be made
- larger than surface tanks
- The water is sometimes cooler
- Larger volumes of water can be stored.

Disadvantages:

- Pump or some kind abstraction device (such as rope and bucket) is required to lift the water. Except where the ground gradient permits and where gravity outlets are constructed.
- Higher possibility of contamination and sedimentation sediment inflow.
- They cannot be easily drained for cleaning.
- If not well managed e.g. properly covered, they pose danger to children and small animals.
- Leaks or failures are more difficult to detect
- Tree roots can damage the structure from beneath
- Flotation of the tank may occur if groundwater level is high, and
- Heavy vehicles driving over a tank or other weight can damage the structure.

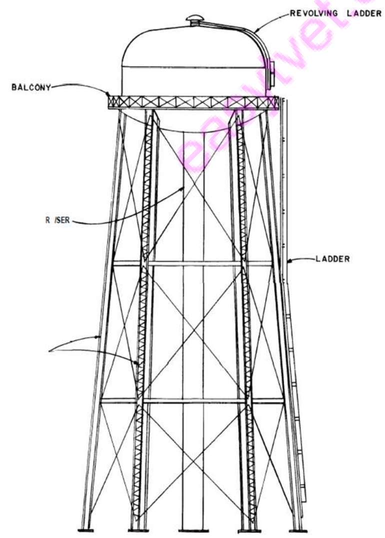
On-ground

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

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

Above ground (elevated)

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



Elevated Storage Tank

Advantages:

- Cheaper to install – Tanks installed aboveground are a lot cheaper and easier to install than underground tanks. There's no need to reinforce the tank or excavate the land around it, as you would have to with an underground tank, and you don't have to worry about leveling the backfill so that it holds the tank in the right place.

- Easier to maintain – Compared to underground tanks, aboveground tanks are easier to monitor for scratches and breaches. They're also much easier to fix, since there's no need to dig down to the source of a leak.

Disadvantages

- Aboveground tanks are more vulnerable to extreme weather that could create cracks or holes
- Theft or vandalism.

Housekeeping

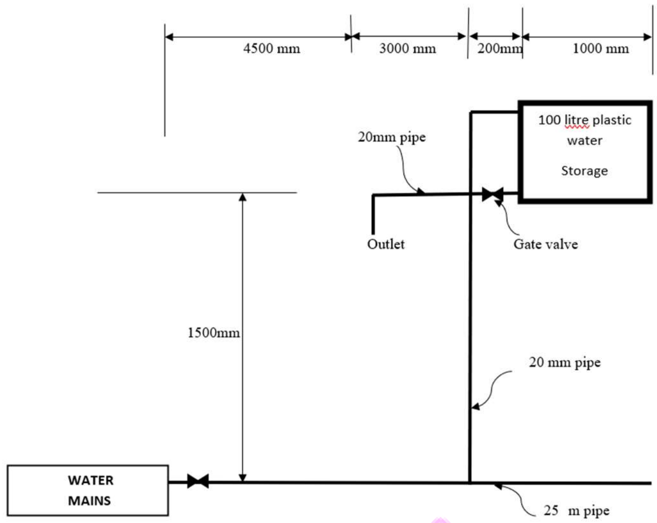
The following aspects need to be considered:

- Protecting existing works and sanitary appliances
- Clearing work area
- Cleaning work area
- Keeping work area tidy

5.2.3.4.Learning Activities

In this assessment, the candidate will be required to carry out practical tasks on:

a) installing a water storage tank, 100litres at a 1.5m distance from the ground and installing a centrifugal pump in the system mains and conducting a water test on the pipe appliance as shown on the diagram below



b) In this assessment, the candidate is required to complete the following tasks:

i. Collect all the required resources and materials
ii. Clearing and levelling the ground area
iii. Constructing steel supports
iv. Positioning the tank
v. Fixing the water tank fittings
vi. Measuring and cutting the pipes to the correct dimensions
vii. Installing the water pump
viii. Positioning the pipes
ix. conducting water test on the setup
x. Perform housekeeping operations

5.2.3.5.Self-Assessment

1. What are some personal safety habits practiced when installing storage tanks?

2. What is the purpose of a valve?

3. Which of the following is the correct classification of pumps?
   a. Physical principle of operation
   b. Mechanical principle of operation
   c. Chemical principle of operation
   d. Biological principle of operation

4. Displacement pump is classified on the basis of _____________
   a. Mechanical operation of principle
   b. Type of power
   c. Type of service
   d. Efficiency

5. Which of the following pump is classified based on the type of service?
   a. Displacement pump
   b. Centrifugal pump
   c. Deep well pump
   d. Electric driven pump

6. Which of the following pump is based on the type of power?
   a. Low lift pump
   b. High lift pump
   c. Air lift pump
   d. Steam engine pump

7. A booster pump is based on _____________
   a. Mechanical operation of principle
   b. Type of power
   c. Type of service

d. Efficiency

8. Consider the following statements.
   i. Capacity of the pump
   ii. Number of pump units
   iii. Discharge condition

The selection of a particular type of pump depends on which of the following?
   a. i, ii, iii
   b. i only
   c. ii, iii
   d. i, iii

9. The centrifugal pump has a ______ flow.
   a. Variable
   b. Uniform
   c. Continuous
   d. Constant

10. The maximum efficiency of a centrifugal pump is _____________
   a. 50%
   b. 60%
   c. 85%
   d. 100%

11. What controls the inlet of water into storage tanks and where should it be located
12. A water storage and pipe network is called a distribution system. This refers to the tanks and pipes used to get water from a source and/or the treatment plant to a house, building or other place of use. What are the distribution system components?

13. What are the uses of the following tools:

i. Pipe reamer,
ii. pipe wrench

14. What is the importance of having storage tanks?

15. How do we ensure that the ground to install the storage tanks is levelled?

5.2.3.6.Tools, Equipment, Supplies and Materials

Functional Plumbing Workshop with the following:

Tools and Equipment

- Pipe wrench
- Pipe cutter
- Hacksaw
- Pipe Threading Equipment
- Vice - Bench
- Pliers
- Tap and Punch
- Files
- Screwdrivers
- Drill with various sizes of bits
- Mallet
- Ball hammer
- PPR machine / Heat Fusion equipment
- Pipe bender
- Sealant gun

Supplies and Materials

- Fittings

- Back nuts
- Cisterns
- Valves
- Sealant
- Water proofing agents

5.2.3.7.References

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Nissen-Petersen, E. 1990. Water Tanks with Guttering and Hand-pump. Manual No. 1 of Harvesting Rainwater in Semi-arid Africa. Danida, Kenya.

Julie fryer., 2011., The complete guide to water storage

5.2.3.8.Model Answers

1. What are 3 personal safety habits practiced when installing storage tanks
    - **Wearing protective garments**
    - **Using the correct tools and equipment for the correct task**
    - **Safety goggles**
    - **Always working on a safe platform**
    - **Wearing helmets,**
    - **Storing all tools appropriately**

2. What is the purpose of a valve?

- **control the flow rate of fluid into distribution system**

3. Which of the following is the correct classification of pumps?
    a. Physical principle of operation
    b. Mechanical principle of operation
    c. Chemical principle of operation
    d. Biological principle of operation

4. Displacement pump is classified on the basis of _____________
    a. Mechanical operation of principle
    b. Type of power
    c. Type of service
    d. Efficiency

5. Which of the following pump is classified based on the type of service?
    a. Displacement pump
    b. Centrifugal pump
    c. Deep well pump
    d. Electric driven pump

6. Which of the following pump is based on the type of power?
    a. Low lift pump
    b. High lift pump
    c. Air lift pump
    d. Steam engine pump

7. A booster pump is based on _____________
    a. Mechanical operation of principle
    b. Type of power

c. **Type of service**
d. Efficiency

8. Consider the following statements.
   i. Capacity of the pump
   ii. Number of pump units
   iii. Discharge condition

   The selection of a particular type of pump depends on which of the following?
   a. i, ii, iii
   b. i only
   c. ii, iii
   d. i, iii

9. The centrifugal pump has a ______ flow.
   a. Variable
   b. Uniform
   c. Continuous
   d. Constant

10. The maximum efficiency of a centrifugal pump is _____________
   a. 50%
   b. 60%
   c. 85%
   d. 100%

11. What controls the inlet of water into storage tanks and where should it be located
   Float-operated valve: Installed close to the top of the tank

12. A water storage and pipe network is called a distribution system. This refers to the tanks and pipes used to get water from a source and/or the treatment plant to a house, building or other place of use. What are the distribution system components?

- **Storage tanks.**
- **Reservoirs.**
- **Pumps.**
- **Meters.**
- **Pipes.**
- **Valves.**

13. What are the uses of the following tools:

i. Pipe reamer,
   - **used to remove internal burrs from steel or copper pipes**

ii. pipe wrench
   - **tightening or loosening fittings and pipes**

14. What is the importance of having storage tanks?

- **Storage is particularly important where the supply water is treated before distribution to consumers, because it means the treatment plant does not need to be sized to treat the peak flow that consumers require. The storage reservoir provides a buffer between the treatment plant and the consumers.**
- **Storage can also help to maintain pressure levels by evening out the flow in a network. The most extreme example of this is in restricted-flow systems where every customer has their own tank, which is topped up by a small constant flow from the distribution pipe network.**

- **The storage can be used to provide chlorine contact time for the inactivation of micro-organisms and as a reserve of treated water in the event of a power cut or treatment plant malfunction.**

15. How do we ensure that the ground to install the storage tanks is levelled?

- **Use dumpy level**
- **Use theodolite**
- **Use spirit levels**

5.2.4 Learning Outcome 4: Test and commission storage and auxiliary fittings

5.2.4.1.Introduction to the learning outcome

This learning outcome specifies the content of competencies required to Test and commission storage and auxiliary fittings. It includes, types of tests and faults in storage and auxiliary fittings.

5.2.4.2.Performance Standard

1. Functionality of the Storage and auxiliary fittings are tested based on manufacturer's manual and requirements.
2. Faults in Storage and auxiliary fittings are corrected based on best practice.
3. Commission the storage system as per the client's/ contract requirements.

5.2.4.3.Information Sheet

TEST AND COMMISSION STORAGE AND AUXILIARY FITTINGS

Objectives of the Testing and Commissioning Works

The objectives of the T&C works are:

a. To verify proper functioning of the equipment/system after installation

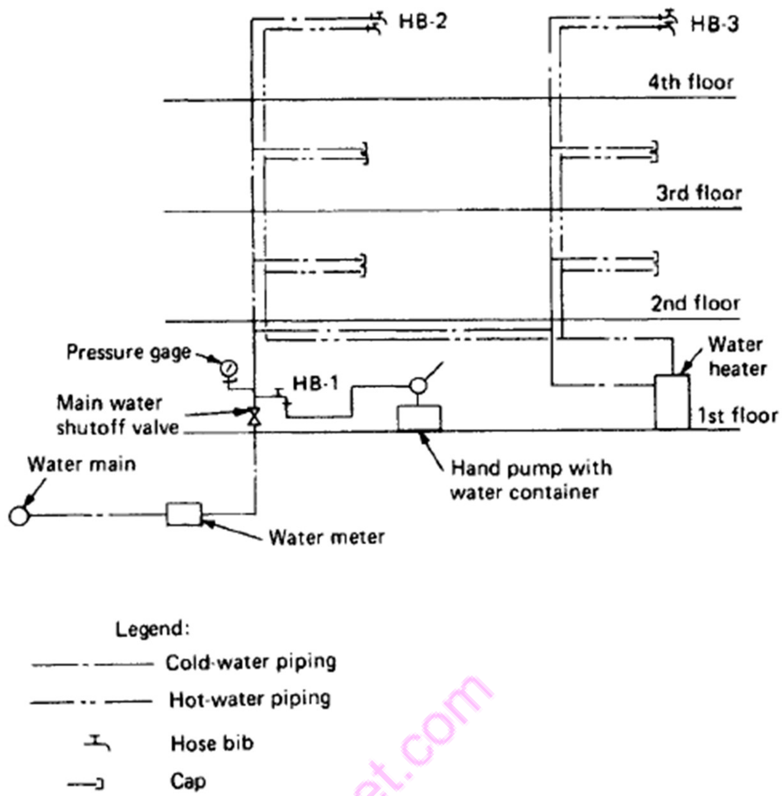
b. To verify that the performance of the installed equipment/systems meet with the specified design intent through a series of tests and adjustments
c. To capture and record performance data of the whole installation as the baseline for future operation and maintenance.

Testing the Rough Piping Installation

The following steps should be taken in testing the piping system before the fixtures, faucets, trim, and final connections are made to the equipment:

1. Install hose bibs for filling the piping system with water and to permit the evacuation of air from (i.e., venting) the system.
   There should be a hose bib (or similar device) at the bottom of the piping system for filling the system with water and at least one more at the highest point of the system for venting.
   Depending on the size and piping layout, several other hose bibs may be required for venting the system.

2. Cap all openings.
   All connections to future fixtures must be capped so they are watertight. Temporary caps will be removed after the pressure test, described below, is completed.



Piping Layout

3. Fill the system with potable water.
   With the bib at the top of the piping system in the open position, fill the system with water through the hose bib located at the bottom position. Air will then be forced out of the piping through the top bibs.
   During the time the piping system is being filled, all hose bibs for venting must be open. When water emerges from all the open hose bibs, all air in the system has been displaced by water. Then all hose bibs must be tightly closed.

4. Attach a pump and a pressure gauge to the piping system.
   Depending on the size of the piping system, the pump (used to create pressure in the system) may be a manual pump or a centrifugal pump activated by an electric motor.

In general, a manually operated pump is satisfactory for most applications. Water should then be pumped into the system until the pressure gage indicates the pressure desired for the test.

5. Subject the piping system to a hydrostatic test. The magnitude of the test pressure that is required by various codes or jurisdictions is different, but it is usually recommended that test pressure be equal to or higher than the following:
   a. % times the pressure at which the piping system will operate. Water pressure of existing water supplies can be obtained from the local water department.
   b. 125 psi (862 kPa).
6. Sustain the maximum pressure for a period of at least 3 h.
   After the test pressure is attained, close hose bib HB-1. Maximum pressure should be sustained for this period of time without any loss of pressure, as determined from readings of the pressure gage. If pressure is maintained, the system is watertight. If the pressure decreases, there is a leak in the system. The pipes should then be inspected to determine the location of the leaks. The leaks should be repaired and a new pressure test performed. This process must be repeated until it is shown that the maximum pressure is maintained without pressure loss for at least 3 h.

7. If during the testing procedure, the water supply system may be subject to freezing, an air test may be substituted for the hydrostatic test of Step 6.
   The air test is carried out as follows. First replace the water pump with an air compressor.
   Then raise the air pressure to 40 psi (276 kPa). At this pressure, check for leaks by applying liquid soap to the joints and connections. When all leaks appear to have been corrected, raise the air pressure to a value equal to 1% times the water pressure to which the system will be subjected. With the air compressor turned off and the hose bib HB-1 shut off, the pressure must be maintained within the system for a period of at least 2 h. If this is not the case, then previously undetected leaks must be found and repaired and the entire system retested.

Testing the Complete Plumbing System

After the rough piping installation has been shown to be watertight and has been accepted, then the following steps should be taken:

1. Install and connect all faucets, fixtures, hose connections, trim, and valves.
2. Connect the water piping system to the water supply.
3. Subject the entire system to the hydrostatic test of Step 5, above. Check for leaks. When all leaks have been detected and repaired, proceed with the operation test of the next step.
4. All bibs, fixtures, flush valves, pumps, tanks, and other appurtenances should be activated to show that the water quantities required for proper operation are adequate and that their operation is satisfactory.

DISINFECTING THE WATER SUPPLY SYSTEMS IN BUILDINGS

After the above testing has been completed, all aerators, filters, and strainers should be cleaned (after disinfection, they must be replaced), and the entire system should be flushed with portable water to rid it of impurities and debris.

Water should be run through the piping by opening the various faucets and valves until, by visual inspection, the water appears to be running clean, and no impurities such as sand, rust, and similar small particles are observed in the bowls of the plumbing fixtures.

The following procedure, performed by approved applicators or qualified personnel, is recommended:

1. One of the following chemicals, all of which add chlorine to the water, may be used to disinfect water:

    - chlorine gas

- chlorine liquid
- sodium
- hypochlorite
- calcium hypochlorite

2. Inject a disinfecting agent through the hose bib located at the water service entrance. The injection should take place at a slow and even rate. The flow of this disinfection agent into the main connected to the public water supply is prohibited. Therefore, during disinfection, either the water supply connection should be disconnected or the main water valve should be effectively shut off to prevent any contamination from entering the main water supply.

3. Allow the disinfecting agent to flow into the system by opening hose bibs or faucets in each branch until the chlorine residual concentration is not less than 50 ppm of available chlorine. Then close all valves and accessories. Allow the chlorinated water to stand in the system for a period of not less than 24 hr.

4. After the 24-hr period of retention, the residual chlorine should not be less than 5 ppm. If it is less, the above process must be repeated.

5. If the concentration of residual chlorine is 5 ppm or greater, flush the system thoroughly with portable water before it is put in service.

6. The flushing should continue until;

    i. the residual chlorine in the system, as measured by orthotolidin tests, is not greater than that in the main water supply
    ii. biological tests show that there is absence of coliform organisms. Such water samples should be taken from faucets located at the highest floor and farthest from the main water supply.

7. If it is impractical to disinfect the water storage tank by the above means, then the entire interior of the tank should be swabbed with a solution containing 200 ppm of available chlorine and allowed to stand for at least 3 hrs before flushing.

8. After final flushing of the system has been completed, at least one water sample should be obtained from the cold-water line and the hot-water line. Water samples must be submitted to a state laboratory which should certify that the water does not contain organisms in excess of standards for potable water.

TYPES OF TESTS

Plumbing system inspection and tests

These tests are for the purpose of ensuring correct work, free from defects arising in construction and manufacture. There are three different methods of testing the plumbing system - the water test, air test and peppermint test or smoke test. Of these, the water, peppermint, and smoke tests are most commonly used.

The water and air tests are chiefly used as the first test on new work. When it comes to the final test, either the peppermint or smoke test may be applied.

On old work in residences and other finished and occupied buildings, the water test cannot be applied, owing to the damage that might result. Under these conditions, either the peppermint or smoke test should be used.

- Water test

Most plumbing codes allow air or water to be used for preliminary testing of drainage, vent, and plumbing pipes. After the fixtures are in place, their traps should be filled with water and a final test made of the complete drainage system.

Procedure:

The water test shall be applied to the drainage and vent systems either in its entirety or in sections. If applied to the entire system, all openings in the piping shall be tightly closed, except the highest opening, and the system filled with water to a point of overflow.

If the system is tested in sections, each opening shall be tightly plugged except the highest opening of the section under test, and each section shall be filled with water, but no section shall be tested with less than a ten (10) foot (3m) head of water.

In testing successive sections, at least the upper ten (10) feet (3m) of the next proceeding section shall be tested, so that no joint or pipe in the building (except the uppermost ten (10) foot (3m) of the system) shall have been submitted to a test of less then a ten.(10) foot (3m) head of water. The water shall be kept in the system, or the portion under test, for at least fifteen (15) minutes.

- Air test

An air test is made by sealing all pipe outlets and subjecting the piping to an air pressure throughout the system. The system should be tight enough to permit maintaining this pressure for at least 15 min without the addition of any air.

- Smoke test

The smoke test is another test that can be applied to roughed-in new work. It is used most frequently, however, in testing old work, or in testing new work after the fixtures have been set. The manner of applying a smoke test is to close all openings, the same as for the water test, and also the openings at the roof. The testing machine, which is made especially for this purpose, is then connected to the piping system, and the smoke turned into the pipes.

Oily waste or rags are placed in the machine and lighted, thus generating a heavy smoke which will entirely fill the pipes, and escape through any leaks that may exist—which are thereby easily detected. The smoke test is preferred by many, as it is cleaner than the water test, should any leaks develop, and there is no wetting down of the building.

- Peppermint test

The peppermint test is applied by putting about two ounces of oil of peppermint into the system at the roof, after all openings have been closed as with the other tests, and pouring about a gallon of hot water into the piping, immediately closing the opening with a plug kept at hand for the purpose. The fumes of the peppermint are supposed to travel throughout the system of piping, and to penetrate any existing leaks, the presence of which can then be detected from the characteristic smell. There being no pressure applied in this test, there is a possibility of the odour not escaping through very small leaks; and this test, therefore, is not so reliable as the water or smoke tests.

The person who puts the peppermint in the piping should not try to look for leaks, as he will carry the odour around with him through the building, and is apt to imagine that he smells leaks where in reality they do not exist.

- Building sewer test

  Building sewers shall be tested by plugging the end of the building sewer at its point of connection with the public sewer or private sewer disposal system and completely filling the building sewer with water from the lowest to the highest point thereof, or by approved equivalent low pressure air test, or by another test as may be prescribed by the Administration Authority. The building sewer shall be watertight at all points.

- Water piping

Upon completion of a section or of the entire hot and cold water supply system, it shall be tested and proved tight under a water pressure not less than the working pressure in which it is to be used.

The water used for tests shall be obtained from a potable source of supply. A fifty (50) pound per square inch (344.5 kPa) air pressure may be substituted for the water test. In either method of test, the piping shall withstand the test without leaking for a period of not less than fifteen (15) minutes.

5.2.4.4.Learning Activities

Practical task

You are required to:

i. carry out carry out testing on a piping system for leaks.
ii. Identify the leakage
iii. Repair the leakage

Scenario:

You are finished with the installation of an elevated water tank that is to supply water to your client's residence. The client is very happy with your work, his only concern is whether the system is 100% airtight.

In his opinion, a small leakage, although undetected might lead to significant water damage at a later stage. How would you test for the tightness of the system?

5.2.4.5.Self-Assessment

1. This condition is the result of low pressures within a pump, which creates boiling water and vapor bubbles.
   a. Air Lock
   b. Water Hammer
   c. Cavitation
   d. Plugging

2. What are some of the problems associated with pipe work?

3. How do we carry out the water method of testing a piping system for leaks?
4. Which of the following is suitable for testing a piping system for leaks?
    a. Air
    b. Water
    c. Smoke
    d. Gas

5. A final air test is a test of the plumbing fixtures and their connections to the sanitary drainage system
    a. False
    b. True

6. For some installations, several plumbing systems can be tested and inspected simultaneously, such as the building sewer and water service when they are installed in the same trench
    a. False
    b. True

7. An air test is a plumbing system test in which inlets and outlets to the system are sealed and air is forced into the system until a uniform air pressure of 5 psi is reached and maintained for 15 min without additional air being added to the system
    a. False
    b. True

5.2.4.6.Tools, Equipment, Supplies and Materials

Functional Plumbing Workshop with the following:

Tools and Equipment

- Pipe wrench

- Pipe cutter
- Hacksaw
- Pipe Threading Equipment
- Vice - Bench
- Pliers
- Tap and Punch
- Files
- Screwdrivers
- Drill with various sizes of bits
- Mallet
- Ball hammer
- PPR machine / Heat Fusion equipment
- Pipe bender
- Sealant gun

Supplies and Materials

- Fittings
- Back nuts
- Cisterns
- Valves
- Sealant
- Water proofing agents

5.2.4.7.References

Fred Hall & Roger Greeno., 2009., Building services handbook incorporating current building & Construction regulations., 5th Edidition

David V. Chadderton., 2007., Building Services Engineering., 5th Edition

Julie fryer., 2011., The complete guide to water storage

5.2.4.8.Model Answers

1. This condition is the result of low pressures within a pump, which creates boiling water and vapor bubbles.
    a. Air Lock
    b. Water Hammer
    c. Cavitation
    d. Plugging

2. What are some of the problems associated with pipe work?
    Leakages
    Blockages
    Air lock
    Water hammer

3. How do we carry out the water method of testing a piping system for leaks?
    close all the opening then allow water to run through the system under pressure in case of any leak in the system, the water already will try to ooze out of the leaking area.

4. Which of the following is suitable for testing a piping system for leaks?
    a. Air
    b. Water
    c. Smoke
    d. Gas

5. A final air test is a test of the plumbing fixtures and their connections to the sanitary drainage system
    c. False
    d. True

6. For some installations, several plumbing systems can be tested and inspected simultaneously, such as the building sewer and water service when they are installed in the same trench
    c. False
    d. True

7. An air test is a plumbing system test in which inlets and outlets to the system are sealed and air is forced into the system until a uniform air pressure of 5 psi is reached and maintained for 15 min without additional air being added to the system
    c. False
    d. True