CHAPTER 1: WATER SUPPLY SYSTEMS

Unit of learning code CON/CU/PL/CR/01/5/A

Related Unit of Competency in Occupational Standard; Water supply and systems

1.1 Introduction to the unit of learning

This unit specifies the competencies required to install water supply and systems. It involves preparing working drawings, identifying materials, quantifying and costing, identifying and using pipework tools and equipment, installing pipe works, designing simple pipework and install water distribution system. It applies in the construction industry.

1.2 Summary of Learning Outcomes

1. Prepare working drawings
2. Identify materials, quantify and cost
3. Identify and use pipework tools and equipment
4. Install pipe works
5. Design simple pipework
6. Install Water distribution system

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1.2.1 Learning Outcome 1: Prepare working drawing

1.2.1.1 Introduction to the learning outcome

This outcome specifies the competencies required to prepare working drawings. It involves preparing working drawings, interpreting different types of drawings like architectural, mechanical, electrical, plumbing, manufacture and others during standard installation of water pipes and systems in buildings. It applies in the construction industry.

1.2.1.2 Performance Standard

1. Drawings are identified and selected based on the working drawings.
2. Scale of the drawing is read based on the drawing.
3. Measurements are converted based on best practice.
4. Symbols are identified based on standard practices.
5. Isometric pipework drawings are sketched based on best practice.
6. Simple working drawings are prepared based on specifications

1.2.1.3 Information Sheet

Engineering drawing is a two dimensional representation of three dimensional objects. In general, it provides necessary information about the shape, size, surface quality, material, manufacturing process, etc., of the object. It is the graphic language from which a trained person can visualize objects.

Drawings prepared in one country may be utilized in any other country irrespective of the language spoken. Hence, engineering drawing is called the universal language of engineers. Any language to be communicative, should follow certain rules so that it conveys the same meaning to everyone.

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Terms and Concepts

Sketch; A sketch is a quickly executed, freehand drawing that is usually not intended as a finished work.

Assembly drawings; Assembly drawings show how different parts go together, identify those parts by number, and have a parts list, often referred to as a bill of materials.

Construction plan; is a detailed document, both written and visual which outlines how you will complete a **project** or portion of one

Elevation; refers to an orthographic projection of the exterior (or sometimes the interior) faces of a building that is a two-dimensional drawing of the building

Section view; is a view used on a drawing to. Show an area or hidden part of an object by. Cutting away or removing some of that object.

Section; shows a view of a structure as though it had been sliced in half or cut along another imaginary plane.

Classifications of drawing

Engineering drawing; it's a two-dimensional visual representation of three-dimensional objects and are used as a universal means of communication in industry.
Such drawings should be clear, concise and accurate. They should convey all information complete and specified once only about:

- Information about the shapes, sizes and position of components
- Material requirements
- Instructions about the method of manufacture

Engineering drawing has three main parts;

- One or more views of an engineering component/object or an assembly of components
- Dimensions, symbols, explanatory and instruction notes
- A title blocks

Assembly drawing

A drawing that shows the various parts of a machine in their correct working locations is an assembly drawing.

Manufacturing Drawing

They detailed component specifications. These are mostly used by suppliers, manufacturers, and contractors to understand production quantities, materials required, and processes to be followed during the delivery and installation of these components on-site.
Engineering drawings are extremely important as they provide a plethora of information to the manufacturer, including:

- Type of material required for manufacturing and supply
- Detailed product dimensions
- Surface and cosmetic finishes
- Welding information
- Hardware requirements

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Types of Working Drawing; what is working drawing in construction cannot be understood without knowing about its types. In construction, working drawing is further of 5 types. These include the following:

- Architectural Drawing
- Structural Drawing
- Electrical Drawing
- Plumbing and Sanitary Drawings
- Finishing Drawing

Plumbing drawings

A **plumbing drawing** is a type of technical drawing that provides visual representation and information relating to a plumbing system.

Uses of plumbing drawings.

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It is used to convey the engineering design to plumbers or other workers who will use them to help install the plumbing system.

It is also used to show clearly the location of fixtures, sanitary ware, pipework, valves and so on, and illustrates how fresh water is to be supplied into a building and waste water removed. To illustrate the separate hot and cold water supply, the pipe runs will usually be colored red and blue respectively. Drainage pipes should be illustrated with the grade (slope) indicated. Where manholes are included, a manhole schedule should detail the name, invert level, cover level, and depth.

Plumbing layout is usually drawn into a copy of the floor plan for proper orientation with existing plumbing fixtures, walls and partition outlines, and other utility features.

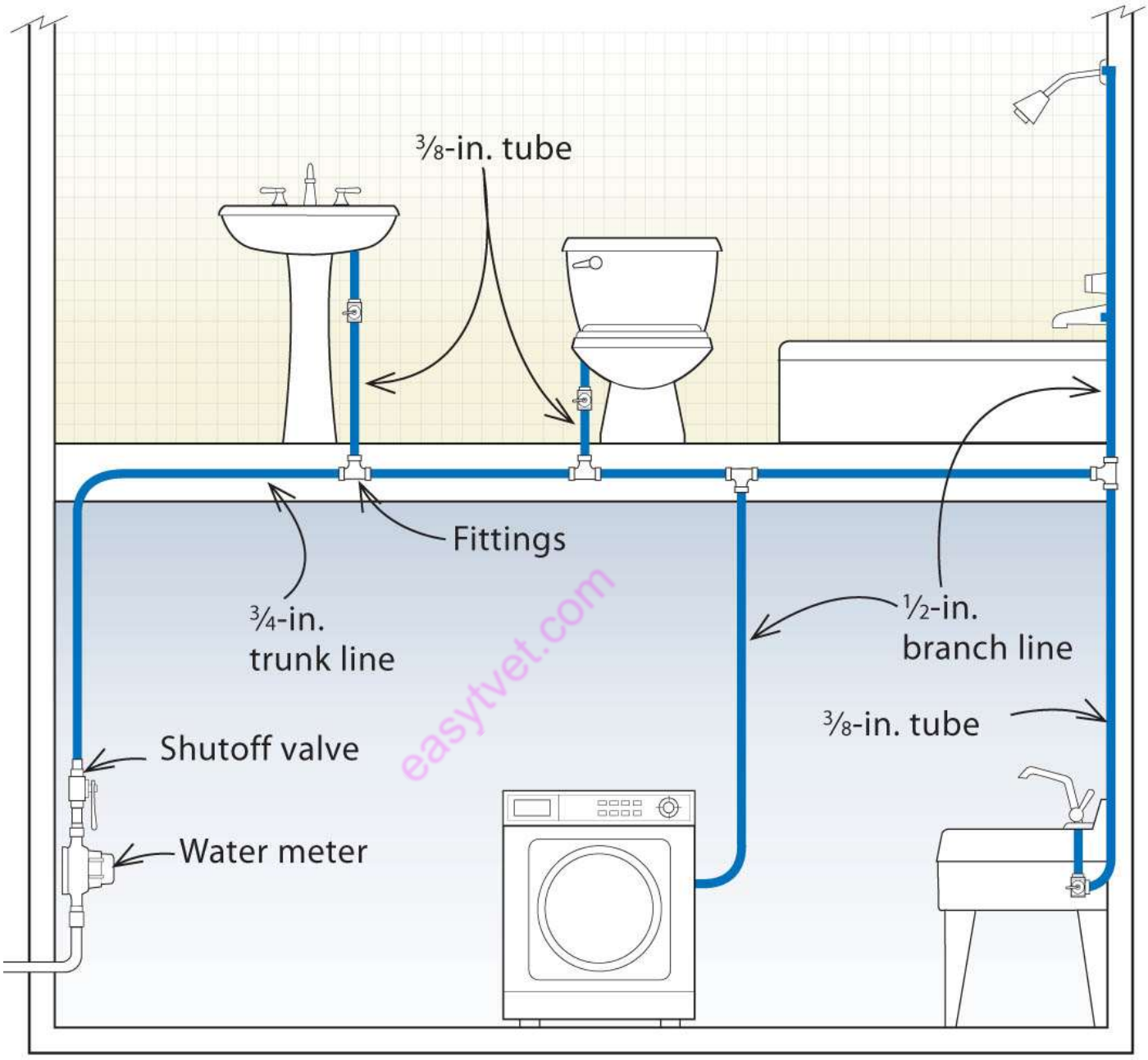


Figure 121:: Plumbing Layout

Isometric plumbing drawing.

It is a drawing with details representing pipes, fittings, and fixtures at a 45° angle, in plain terms it's the plumbing drawing scheme. The goal is to represent three-dimensional designs on two-dimensional drawings

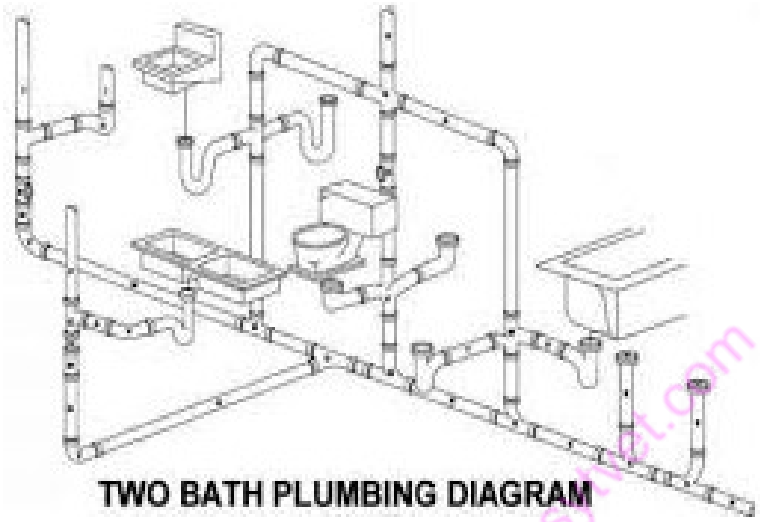


Figure 122: isometric drawing

Features of Piping Isometric Drawing

It is not drawn to the scale, but it is proportionate with exact dimensions represented. Pipes are drawn with a single line irrespective of the line sizes, as well as the other configurations such as reducers, flanges, and valves. pipes are shown in the same size.

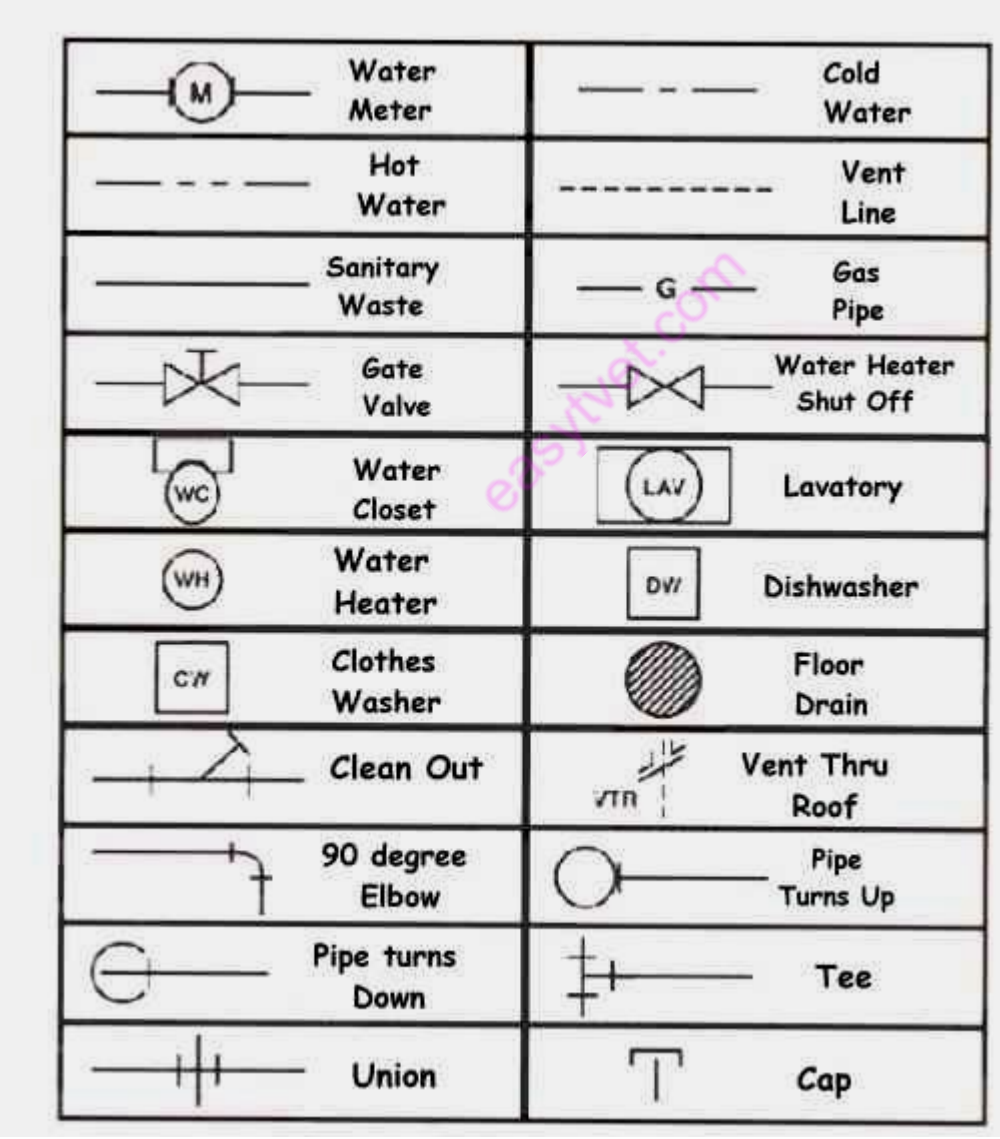
DRAWING SYMBOLS

Because of the small scale used in most drawings, standard graphic symbols are used to present complete information concerning construction items and materials. These typ ical symbols are used so frequently in construction drawings that their meanings must be familiar not only to the preparer, but to the user as well.

Plumbing symbols

Symbol is a form of a sign that may have deep meaning.

Plumbing symbols are used when drawing house plans and diagrams. The purpose of these symbols is to indicate where the different elements of your plumbing system are located.



Plumbing symbols.

Floor plan

A **floor plan** is a drawing to scale, showing a view from above, of the relationships between rooms, spaces, traffic patterns, and other physical features at one level of a structure.

Dimensions are usually drawn between the walls to specify room sizes and wall lengths. Floor plans may also include details of fixtures like sinks, water heaters, furnaces, etc. Floor plans may include notes for construction to specify finishes, construction methods, or symbols for electrical items.

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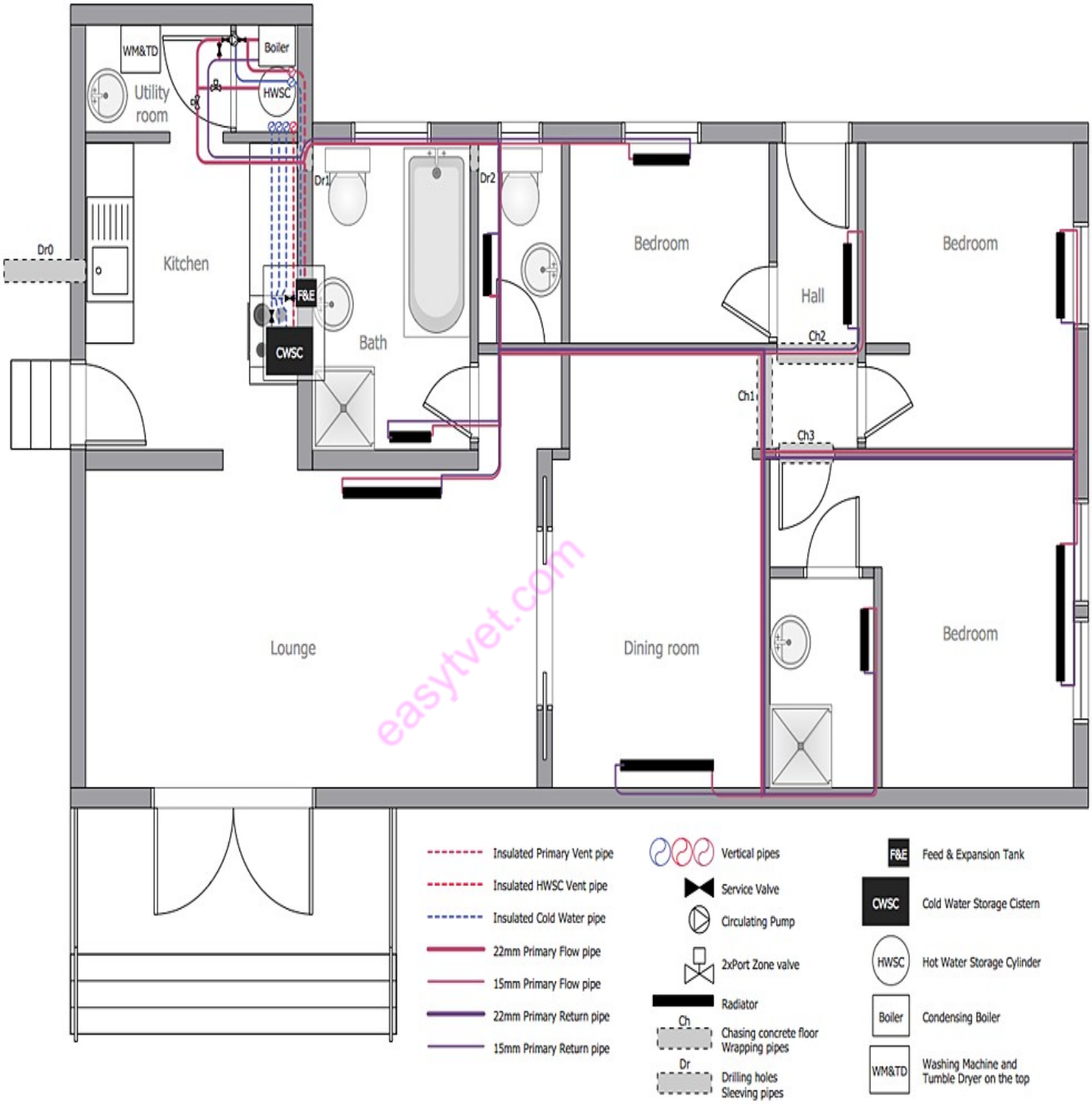

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Floor plan

SCALE DRAWING

Scaling is a drawing method used to enlarge or reduce a drawing in size while keeping the proportions of the drawing the same. Scales are generally expressed as ratios and the most common scales used in furniture drawing are **1:1**, **1:2**, **1:5**, and **1:10** for reducing and possibly **2:1** for enlarging.

Scaling is used to either:

- **Reduce** the drawing in size so that it will fit onto the page, or
- **Enlarge** the drawing in size so that all required details are clearly visible.

Drawings can be scaled up or down using either a calculator or a scale rule.

To scale a drawing using a calculator:

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- **Divide** the measurement by the scale if you want to **reduce** the drawing in size, or
- **Multiply** the measurement by the scale if you want to **increase** it in size.

Example 1: Scaling down

- A 50mm line is to be drawn at a scale of **1:5** (ie 5 times less than its original size). The measurement **50mm** is **divided** by **5** to give **10mm**. A 10mm line is drawn.
- A 50mm line is to be drawn at a scale of **1:2**. The measurement **50mm** is **divided** by **2** to give **25mm**. A 25mm line is drawn.

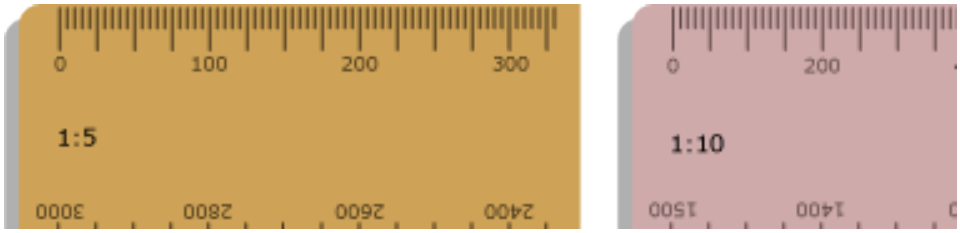
Example 2: Scaling up

- A 50mm line is to be drawn at a scale of **5:1** (ie 5 times more than its original size). The measurement **50mm** is **multiplied** by **5** to give **250mm**. A 250mm line is drawn.
- A 50mm line is to be drawn at a scale of **2:1**. The measurement **50mm** is **multiplied** by **2** to give **100mm**. A 100mm line is drawn.

To scale a drawing using a scale rule:

Scale rules allow us to directly set out measurements onto a drawing without having to convert them to their scaled sizes by using a calculator first.

The whole process is made easier because these conversions are already made for us. On a scale rule which has divisions of **1:5**, each division represents 5mm and the measurements on the rule indicate this.



On a scale rule which has divisions of **1:10** each division represents 10mm and the measurements on the rule indicate this.

This is an example of a scaled drawing. Notice that the elevation is drawn at a scale of 1:10. Included in the drawing is detail A, and this is drawn additionally at a scale of 1:1, or full size.

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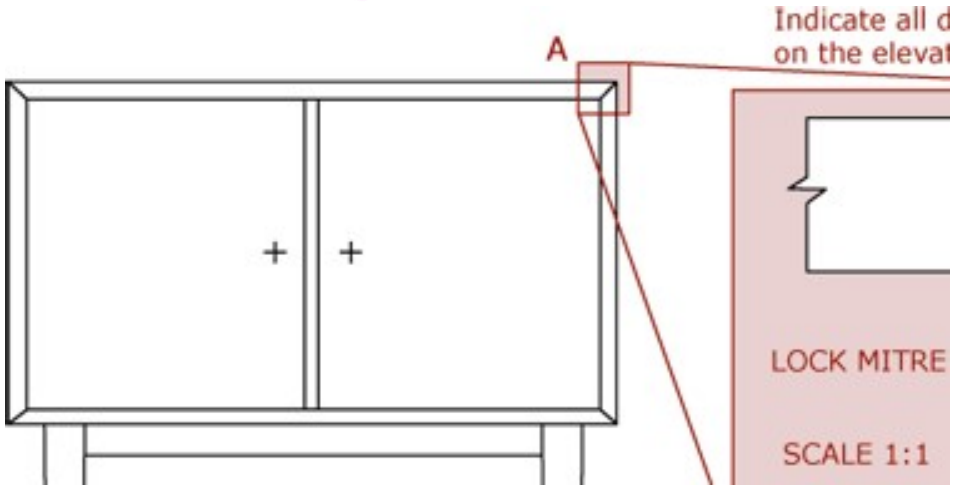

MEASUREMENTS

Measurement is the transformation of drawn information into descriptions and quantities, undertaken to value, cost, and price construction work, as well as enabling effective management.

Imperial measurements

Miles, feet and inches are old units of length. These are known as imperial units of length but are not now commonly used in mathematics. There are 12 inches in a foot. An inch is roughly equal to 2.5 centimeters.

How can you convert imperial measurement to metric measurements?

- 1 foot (12 inches) is equal to 30 centimeters
- 1 inch is about 25 millimeters or 2.54 centimeters
- A 3-foot measurement is almost exactly 1 meter

What is Metric System?

The metric system is a system of measurement that uses the meter, liter, and gram as base units of length (distance), capacity (volume), and weight (mass) respectively.

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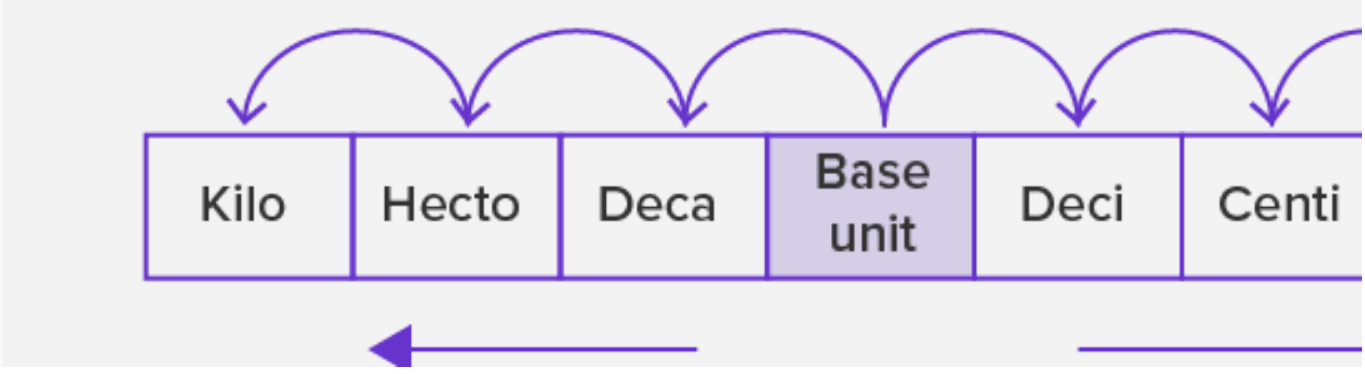
To measure smaller or larger quantities, we use units derived from the metric units



- The given figure shows the arrangement of the metric units, which are smaller or bigger than the base unit.
- The units to the right of the base unit are smaller than the base unit. As we move to the right, each unit is 10 times smaller or one-tenth of the unit to its left. So, a ‘deci’ means one-

tenth of the base unit, ‘centi’ is one-tenth of ‘deci’ or one-hundredth of the base unit and ‘milli’ is one-tenth of ‘centi’ or one-thousandth of the base unit.

Linear Measure

10 millimeters (mm) =	1 centimeter (cm)	
10 centimeters =	1 decimeter (dm)	= 100 millimeters
10 decimeters =	1 meter (m)	= 1,000 millimeters
10 meters =	1 dekameter (dam)	
10 dekameters =	1 hectometer (hm)	= 100 meters
10 hectometers =	1 kilometer (km)	= 1,000 meters

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Area Measure

100 square millimeters (mm^2) =	1 sq centimeter (cm^2)
10,000 square centimeters =	1 sq meter (m^2)
=	1,000,000 sq millimeters
100 square meters =	1 are (a)
100 ares =	1 hectare (ha)
=	10,000 sq meters
100 hectares =	1 sq kilometer (km^2)

=	1,000,000 sq meters

Volume Measure

10 milliliters (ml) =	1 centiliter (cl)	
10 centiliters =	1 deciliter (dl)	= 100 milliliters
10 deciliters =	1 liter (l)	= 1,000 milliliters
10 liters =	1 dekaliter (dal)	
10 dekaliters =	1 hectoliter (hl)	= 100 liters
10 hectoliters =	1 kiloliter (kl)	= 1,000 liters

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How to Measure Pipe and Fitting Sizes

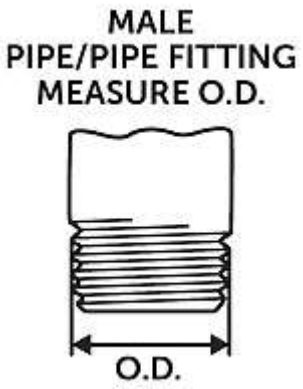
Convert Actual Diameter to Nominal Diameter

The easiest way to find what nominal pipe size you need is to use follow these steps and use the conversion chart below.

For Male Threads

1. Measure the Outside Diameter (OD) of your pipe or pipe fitting:

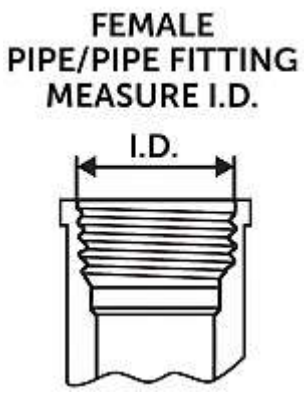
- Wrap a string around the pipe
- Mark the point where the string touches together
- Use a ruler or measuring tape to find the length between the tip of the string and the mark you made (circumference)
- Divide the circumference by 3.14159



2. Use the chart on this page to find the nominal diameter (pipe size).

For Female Threads

1. Measure the Inside Diameter (ID) of your pipe or pipe fitting (use a ruler or tape measure).
2. Use the chart on this page to find the nominal diameter (pipe size).



Nominal Diameter Conversion Chart

(All Measurements in Inches)

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Outside or Inside Diameter	Decimal Equivalent	Nominal Diameter	Typical Threads Per Inch
5/16	0.313	1/16	27
13/32	0.405	1/8	27
35/64	0.540	1/4	18
43/64	0.675	3/8	18
27/32	0.840	1/2	14
1-3/64	1.050	3/4	14
1-5/16	1.315	1	11-1/2
1-21/32	1.660	1-1/4	11-1/2

1-29/32	1.900	1-1/2	11-1/2
2-3/8	2.375	2	11-1/2
2-7/8	2.875	2-1/2	8
3-1/2	3.500	3	8
4	4.000	3-1/2	8
4-1/2	4.500	4	8

Pipes vs. Tubing

Pipe and tubing are not measured the same way. Tubing is measured and named based on the actual outside diameter of the tube.

PEX, or Cross-Linked Polyethylene Tubing, is another technology fast becoming popular, and it is measured and named by inside diameter.

Example:

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Pipe vs. Tubing	**Outside Diameter**
1/2” size pipe	27/32”
1/2” size tubing	1/2”

1.2.1.4 Learning Activities

Practical activity

- Study the architectural drawing below and identify the plumbing symbols used.

Figure 123: Floor Plan

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1.2.1.5 Self-Assessment

1. What is a plumbing layout?
2. Drawing symbols are very crucial in every drawing, state their purpose.
3. What is the purpose of scales in drawings?
4. Define metric measurement giving examples.
5. List four types of drawings a plumber shall encounter in the site while installing sanitary appliance.

1.2.1.6 Tools, Equipment, Supplies and Materials

Tools/Equipment:	Materials:
• Drawing boards • T square • Set square • Blueprint machine/printer • Steel rule • Lettering stencil • Scale rule	• Drawing papers • Drawing pencils • Drawing sets • Masking tape • Construction drawings • Classroom and classroom resources • Manufacturer's drawings

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1.2.1.7 References

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1.2.1.8 Model Answers

1. What is a plumbing layout?

The plumbing layout is usually drawn into a copy of the floor plan for proper orientation with existing plumbing fixtures, walls and partition outlines, and other utility features.

2.2.1.1 **Drawing symbols are very crucial in every drawing, state their purpose**.

Drawing symbols are used to

present complete information concerning construction items and materials**.**

2.2.1.1 What is the purpose of scales in drawings?

Scaling is a drawing method used to enlarge or reduce a drawing in size while keeping the proportions of the drawing the same

2.2.1.1 Define metric measurement giving examples.

The metric system is a system of measurement that uses the meter, liter, and gram as base units of length (distance), capacity (volume), and weight (mass) respectively.

5) List four types of drawings a plumber shall encounter in the site while installing sanitary appliances

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- Architectural Drawing
- Structural Drawing
- Plumbing and Sanitary Drawings
- Finishing Drawing
- Electrical Drawing
- Mechanical drawing

1.2.2 Learning Outcome 2: Identify materials, quantify and cost

1.2.2.1 Introduction to the learning outcome

This outcome specifies the competencies required to install water supply and systems. It involves, identifying materials, quantifying and costing during standard installation of water pipes and systems in buildings. It applies in the construction industry.

1.2.2.2 Performance Standard

1. Materials are identified and selected based on working drawings and specifications

2. Materials are quantified and costed as per the market rate
3. Materials schedule are prepared based on best practice
4. Supplies are identified based on specifications

1.2.2.3 Information Sheet

The process of project cost estimation is central to setting up the foundation for making key decisions, taking initiatives, budgeting activities and controlling expenditures. Cost forecasts and projections are used to establish a set of metrics against which project success will be measured, and to communicate work progress to the stakeholders at any given point in time.
Definition of terms.

- **Cost estimates;** A *cost estimate* establishes the base line of the project cost at different stages of development of the project.
- **Bills of quantities:** A Bill of Quantities (BoQ) lists the total materials required to complete the architect's design for a construction project, such as a house or other structure
- **Construction cost estimating** is the process of forecasting the cost of building a physical structure.

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Pipe materials and supplies

Pipe Material Selection

Pipe exteriors must be able to withstand demanding surrounding conditions, such as high and ambient temperatures, different levels of humidity, and some degree of wear. Due to these conditions, it is essential to consider the type of fluid contained within the system, the internal temperatures, and the internal pressure.
Therefore, careful consideration should be given to the material. There are a number of factors that should be considered before choosing the plumbing materials:

1) **Corrosive water**

Problems such as corrosive water can cause damage to the system, which is made of metal. Repeated failures of the plumbing system can cause the system to last for only a couple of years. To choose the right material, check the quality of water with local department or installer. You should know how the system gets affected by the quality of the plumbing materials. Certain types of pipes are corroded easily, resulting in contamination. Plumbing materials such as PEX do not tend to corrode and maintains the quality of the water.

2) **Water pressure**

Choose the materials that perform well under high water pressure. PVC pipes vary in thickness depending on the location they are used. Plastic products are designed for applications with high pressure.

3) **Water flow**

For low operating cost and better water flow, the surface of pipes should be smooth. Brass piping provides long lasting benefits that does not rust the interior and maintains the smoothness inside the pipe.

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4) **Heat & temperature**

There are some plumbing materials that cannot withstand high temperature e.g pvc pipes. Hence, one should choose the material that tolerates high temperature. Pipes that carry hot water need to be protected so that the heat loss is nominal. Different materials with insulating properties are used to carry hot water.

5) **Sunlight**

The UV rays from the sun can deteriorate the quality of plastic pipes. A number of factors like how deep it is, where it is being installed, rate of flow etc. determine the life of plastic piping. In other words, exposed pipes need a lot of attention and maintenance.(i.e,a ppr and G.I pipe can withstand exposure to sunlight)

6) **Characteristics of material**

There are different types of materials such as Copper, PVC, PEX, and CPVC etc. that are used depending upon their application. There are some other plumbing pipes that include – brass,

galvanized iron and black mild steel pipe. The ability of a pipe to take stress is evaluated on the type of application.GALVANISED Iron pipes are also used to carry water.

Figure 124: Plumbing Material

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Common Pipe Materials

The most common types of plumbing piping materials are:

- Cast iron for plumbing waste lines
- PVC (PolyVinyl Chloride) for plumbing waste lines
- Chromed brass for plumbing waste lines
- Chromed copper for water supply lines
- Galvanized iron for water supply lines
- Copper (rigid and flexible) for water supply lines
- CPVC (Chlorinated Poly-Vinyl Chloride) for water supply lines
- PEX (Cross-linked Polyethylene) for water supply lines
- Black iron for gas pipe

Ppr-for water supply

Cast iron

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Appearance: Large-diameter heavy metal pipe, dull black with a rough, mottled surface.

Description: High-quality sanitary waste drain pipe that is heavy and deadens the sound of flowing wastewater very well. This pipe is strong and long-lasting but hard to cut—often requiring a special cutting tool with sharp chain cutting wheels. Repairs are often made using plastic PVC piping. Cast iron is rarely used in new construction; instead many use plastic PVC or ABS (acrylonitrile butadiene styrene) pipe.

Prevalent Use: Use for main soil stack waste lines and vent pipes.

Cutting and Fitting: Requires heavy-duty reciprocating saw or a special cutting tool called a cast-iron pipe cutter. Securing cast-iron pipes and fittings together is done using special methods, including lead in soil pipe joints.

PVC (Poly-Vinyl Chloride)

Appearance: White rigid plastic.

Description: PVC is now the de-facto standard in-home waste line materials. It is a strong, chemical-resistant rigid pipe that is heat resistant and easily cut and fit. It is often used to repair sections of broken cast-iron waste pipe as well as repairs to other drain lines.

Prevalent Use: Use for sanitary waste lines, vent pipes, and drain traps.

Cutting and Fitting: PVC pipe is easily cut with a hacksaw or tubing cutter. The sections are joined together mechanically, using plastic pressure fittings for later removal, or permanently joined using special chemical solvent.

Chromed Brass

Appearance: Bright, shiny chrome-finished pipe of larger diameter (more than one inch).

Description: Chromed brass is often used in place of PVC for exposed waste line applications, such as “P” traps or other drain traps where appearance is important.

Prevalent Use: Exposed drains and traps.

Cutting and Fitting: Easily cut with a hacksaw, and joined with slip fittings.

Chromed Copper

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Appearance: Bright, shiny chrome finished pipe of smaller diameter (3/8” or less).

Description: Chromed copper pipe is often used where the appearance of exposed water supply lines is important.

Prevalent Use: Exposed water supply lines, such as supply tubing for toilets or pedestal sinks.

Cutting and Fitting: Easily cut with a tubing cutter or hacksaw, and joined with chromed brass compression fittings.

Galvanized Iron

Appearance: Dull silver-gray rigid metal pipe.

Description: Galvanized iron pipe was once a popular method of plumbing water supply lines in the home, but it gradually fails due to corrosion and rust. For this reason, it is no longer commonly used and has been largely replaced with copper pipe or PEX plastic pipe. Galvanized iron pipe is difficult to cut and join and not easily fabricated on site. Repairs are usually done by replacing the pipes with copper or PEX.

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Prevalent Use: Water supply lines and drain lines.

Cutting and Fitting: Can be cut using a reciprocating saw or hacksaw. The pipe is joined by using threaded galvanized iron fittings.

Copper (Rigid and Flexible)

Appearance: Dull, copper-colored metal pipe.

Description: Copper pipe comes in two types: rigid and flexible. The rigid type comes in several wall thicknesses: K, L, and M. Type M is the one normally used for water supply pipes. Copper is more corrosion resistant and readily available. Copper is a soft metal and can be

easily cut and fabricated. It is also prone to damage, may develop pinholes over time, and can rupture from frozen water in pipes.
Rising costs for copper have caused PEX and CPVC to be used more frequently. Copper comes in three grades:

- M for thin wall pipe (used mainly inside homes);
- L for thicker wall pipe (used mainly outside for water services); and
- K, the thickest (used mainly between water mains and the water meter).

Prevalent Use: Rigid copper pipes are used for longer runs of water supply, and in some cases as waste lines. Flexible copper is used in short runs, for water supply, and for the water supply tubing for refrigerators and dishwashers. Copper may also be used for gas piping.

Cutting and Fitting: Copper pipe is easily cut with a tubing cutter or hacksaw. Sections are joined together with soldered copper connectors or copper compression fittings. The flexible copper pipe may also be terminated by flaring its end and using brass flare fittings.

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CPVC (Chlorinated Poly Vinyl Chloride)

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Appearance: Dull white or cream-colored plastic.

Description: CPVC is a cheaper rigid plastic that is designed to withstand high pressure and temperature.

Prevalent Use: CPVC is used for hot and cold water supply piping.

Cutting and Fitting: The pipe is easily cut with a tubing cutter or hacksaw. CPVC is joined permanently together using plastic fittings and solvent glue, or with grip fittings where the pipes may need to be disassembled in the future

PEX (Cross-linked Polyethylene)

Appearance: Typically blue (cold water), red (hot water), or white flexible plastic pipe.

Description: PEX is made of cross-linked HDPE (high-density polyethylene) polymer and is an incredible piping material that has been in use. PEX is strong and flexible, withstanding temperatures from below 32 F to 200 F. PEX is corrosion resistant, and unlike copper pipe, it will not develop pinholes. Because PEX is flexible and uses fewer connections and fittings, it is easier and faster to install. The reduced number of required fittings in a PEX system also reduces the possibility of leaks.

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Prevalent Use: Water supply, radiant heating pipe and upgrade of older systems.

Cutting and Fitting: PEX is cut and fit with specialized fittings and tools.

Black mild steel

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Appearance: Dull black rigid pipe, usually one inch or less in diameter.

Description: Black pipe looks almost exactly like galvanized iron pipe, except it is darker and specifically designed for gas applications.

Prevalent Use: Natural gas or propane supply pipes. It is often used for feeding gas supply to the furnace, boiler, or water heater.

Cutting and Fitting: Can be cut using a reciprocating saw or hacksaw. The pipe is joined using threaded black pipe fittings.

PPR Pipe

PPR pipe is a straight and rigid cylindrical pipe, made from Polypropylene Random Copolymer plastic, produced through a continuous extrusion process. They are commonly offered in green or white color, and in outer diameter sizes ranging from 20mm to 110mm making the pipe walls far thicker than PVC. PPR pipe is accompanied by a series of connection fittings, parts, and accessories available for every pipe diameter.

Application of PPR Pipe

- **PP-R pipes** are used to install hot and cold water systems, including central heating systems.
- **PP-R pipes** are a part of building heating system, including floor, wall and radiant heating systems.

PP-R pipes can be directly purified water drinking water supply system

The main specification followed are as follows;

- Manufacturer's specification; this is where the manufacturer specifies where to use specific materials; where to GI, pvc or even brass.
- Clients' specifications based on economic and ergonomic factors; here the client is the final decision maker depending on what he/she likes the most and can afford it (there is no problem with finances as long as it's available in the market).
- Standard specifications; these are from the industrial experts i.e., experienced, they advise you accordingly as to why you should prefer one material over the other.

Types of Pipe Fittings

- Adaptor
- Barb
- Coupling
- Cross
- Double Tapped Bushing
- Elbow
- Mechanical Sleeve
- Nipple
- Plug and Cap
- Reducer
- Tee
- Union
- Wye

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Adaptor

Adaptors connect pipes that are not the same type. Because an adaptor can be male or female on one end, it can turn a pipe male or female.

Barb

A barb connects hoses to pipes. It is usually male at one end. The other has a barbed tube, which is a ridged and tapered cone.

It may also have a type of clamp to keep it secure. Barbs are made of plastic if they carry cold water and brass if they carry hot water.

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Coupling

A coupling makes it easy to connect two pipes that have the same diameter and are the same type. It's also used to repair a broken or leaking pipe. Along with a normal coupling, two other types are the **compression coupling** and **slip coupling**.

The compression fitting is connected between two pipes via rubber seals or gaskets on both sides which prevents leaking. A slip coupling includes two pipes, one of which slides out of the other pipe to a various length, to repair a specific length of damaged pipe.


Cross

A cross fitting has openings on all four of its ends and can connect four pipes. Cross fittings come with three inlets and an outlet or three outlets and an inlet.

Because they are the connecting point for four pipes, they are under more stress than other types of fittings and typically built tougher than other fittings.

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Double Tapped Bushing

This is a type of nipple, but it has threading on both the inside and the outside. Because this center hole is threaded (tapped) from both top and bottom, it’s referred to as double-tapped.

A double tapped bushing is also a type of reducer, but does not have a reducer’s flexibility. A double tapped bushing is usually female.

Elbow

Not surprisingly, this sort of fitting has a bend that reminds you of the arm joint. They help the flow of water change direction. Elbows come in several degrees, including 22.5, 45, and 90 degrees.

Reducer elbow variations also exist for when the piping diameters being connected are different. Elbow fittings can be made of different materials, and most are female.

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Mechanical Sleeve

This connects two pipes through the use of a screw or other device. This makes the fitting easy to install. The mechanical sleeve or coupling is usually made of rubber that is inserted inside a metal jacket (stainless steel clamp).

When the clamp is tightened, it compresses the rubber inside to make a tight seal. Because this fitting can be slightly flexed, it can accommodate small misalignments in hard to install locations.

Nipple

This is a short fitting that can be made of metals such as copper, brass or steel or chlorinated polyvinyl chloride (CPVC). Instead of connecting two pipes, a nipple connects two fittings.
If it has a continuous threading, it is a closed nipple. They are usually male and come in varying lengths.

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Plug and Cap

Plugs and caps are both used to close up pipe openings during inspections and repairs. The main difference is that a plug is male while a cap is female. Most often, caps and plugs are threaded. Plugs and caps are made of several materials, including metal, plastic or rubber and can be welded, soldered, glued, or threaded into the pipe.

Reducer

This fitting makes a flow smaller and thus reduces it. Reducers come in two types. The concentric reducer joins two pipes on the same axis, and the eccentric reducer is used to join pipes of different diameters.

The **concentric reducer** looks like a cone, while **eccentric reducers** look somewhat like bells with offset center lines. They prevent air bubbles in the pipes.

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Tee

A tee has an inlet and an outlet and is shaped like the letter “T.” These fittings come in different sizes and are considered sturdier than the cross fitting.

A diverter tee is used in heating systems that use water. They come with directional markings and need to be installed correctly for the system to operate.

Union

Unions can have either male or female threads. They are similar to couplings, but the difference is unions are easy to remove making them convenient for maintenance or a planned future replacement.

A coupling, on the other hand, is more permanent and needs to be cut out. A union contains three parts: nut, male end, and female end. The nut is used to join the male and female ends.

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Wye

Built in the shape of the letter “Y,” this fitting is made to connect three pipes. Y fittings allow the pipes to change their elevations and to branch out into fresh water lines or drains.

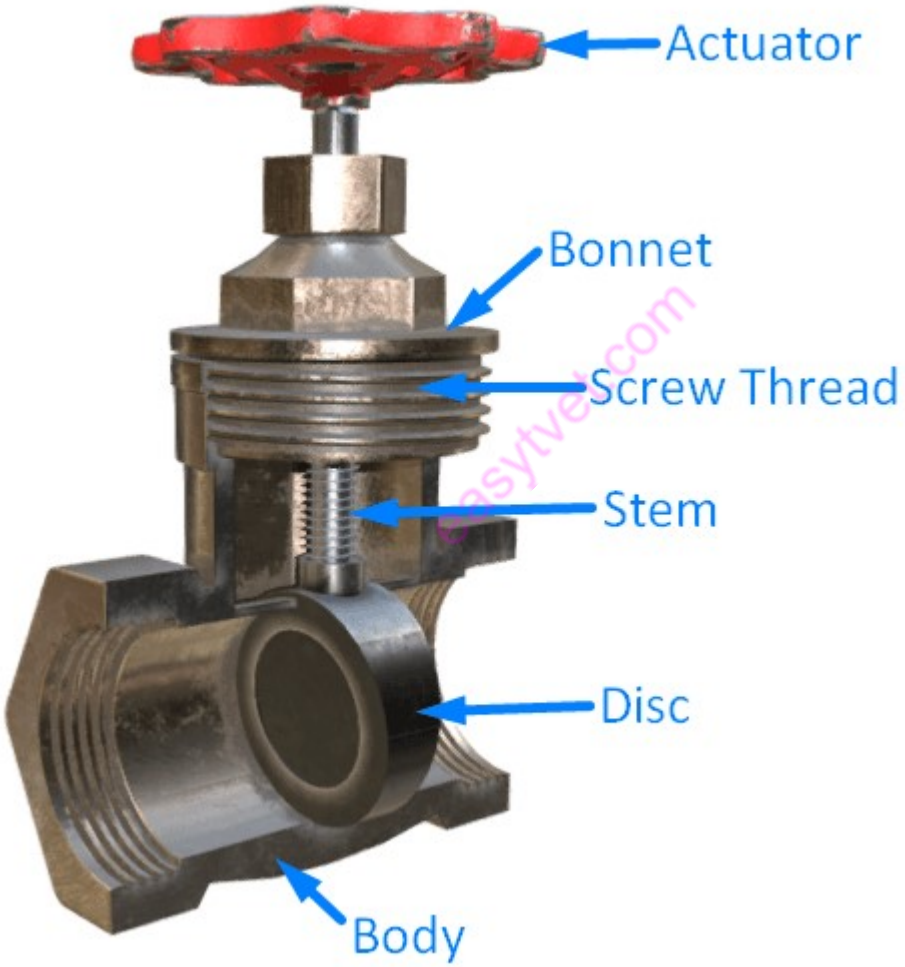
Wyes are similar to tee fittings but the smoother angling reduces friction and turbulence in the water. This fitting is most commonly used to connect a vertical drainpipe to a horizontal one.

TYPES OF VALVES

Valves are mechanical devices used to control, direct, and regulate the flow of water by opening, closing, or partially obstructing the flow. They can be made up of different materials like bronze, PVC, brass, etc. There are different types of valves namely;

Gate Valve

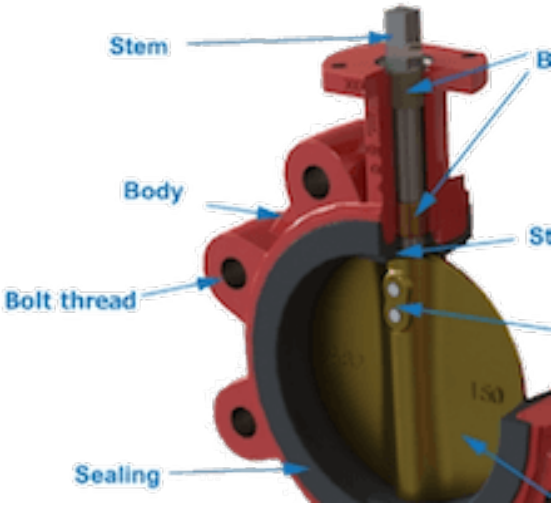
Gate valve is the most widely used type of valve in plumbing systems. It includes a wedge-shaped metal gate that can be lowered (with the use of a twist-type handle or knob) to stop the flow of water or raised to allow the flow to continue.



Butterfly Valve

This valve has a rotating metal disc that allows and inhibits the water flow, creating an image similar to that of a butterfly due to which is called a butterfly valve.

These valves are very compact, light, and relatively short, making them significantly lighter than the other types.



Ball Valve

Ball valves are the most reliable and common type of valves used to regulate the flow of water. It involves a rotating sphere with a hole that is attached to a lever handle to operate the valve.

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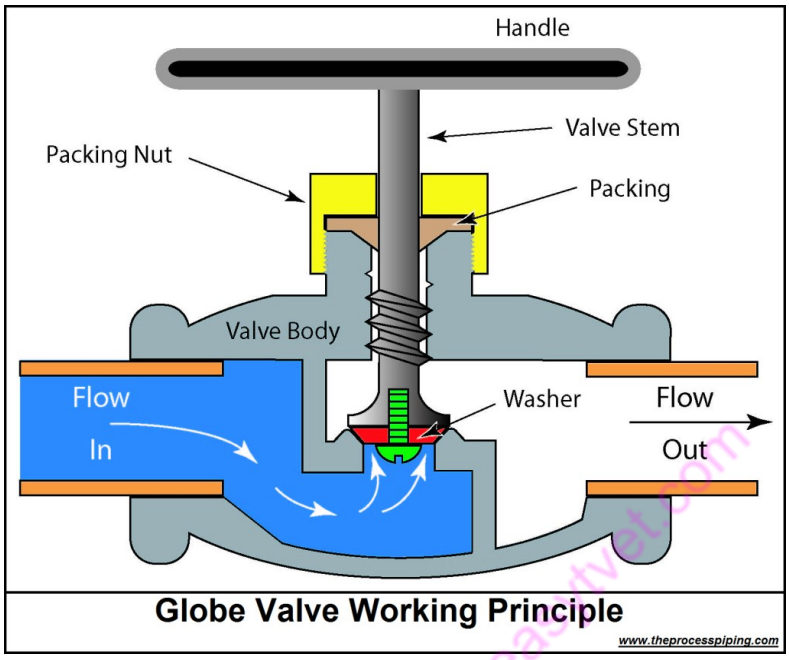
Globe Valve

The Globe valve is commonly used to regulate or limit the water flow in plumbing applications, where the flow needs to be adjusted regularly.

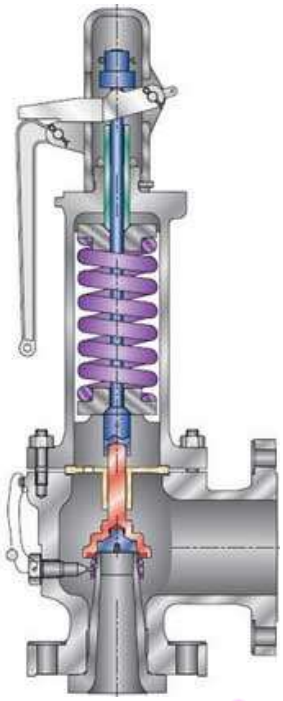
The interior design features contain a stopper on the end of a valve stem that is raised and lowered by the valve's twist knob. Globe valves get their name due to the globe-like or ball-like appearance of their body.



Pressure Relief Valve

Pressure relief valves are used in the plumbing system to reduce water pressure to the desired limit and protect equipment or piping systems from bursting. The mechanism consists of a spring and diaphragm adjusted to a specific limit, depending on the pressure of the water supply.

The pressure relief valves are also known as **pressure-reducing valves**, **pressure safety valves**, and **pressure balance valves**.



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Factors to consider when selecting an ideal supplier a supplier

When choosing the ideal plumbing supplier for your needs, whether they're home plumbing or commercial, larger scale projects, you need to weigh up the differences, options and benefits between various plumbing suppliers.

Choosing the best plumbing supplier should be based on mainly;

- availability of the required materials
- the lower price shall be termed as most economical
- the highest quality materials shall be considered
- the distance of the required material shall be a factor.

Plumbing Estimates:

The Basics

Set the tone when meeting clients for the first time by offering them a plumbing estimate with all the details needed to hire your company. A thorough and clear outline of the estimate can help you land the job!

Cost estimation is an extremely important stage of a project in any industry requiring work in the field, and invoicing a plumbing business is no different than construction job estimation for that matter. While you can offer a verbal estimate, a written one helps make your business look more professional. Check the average estimations range in your local area and create the outline ahead of time so it's easy to plug in the information, plus the consistency is helpful for you and your potential clients. Cover the following points:

- Contact information
- Summary of the project
- Materials list
- Cost estimate
- Permits required
- Your insurance and licensure details
- Work guarantee

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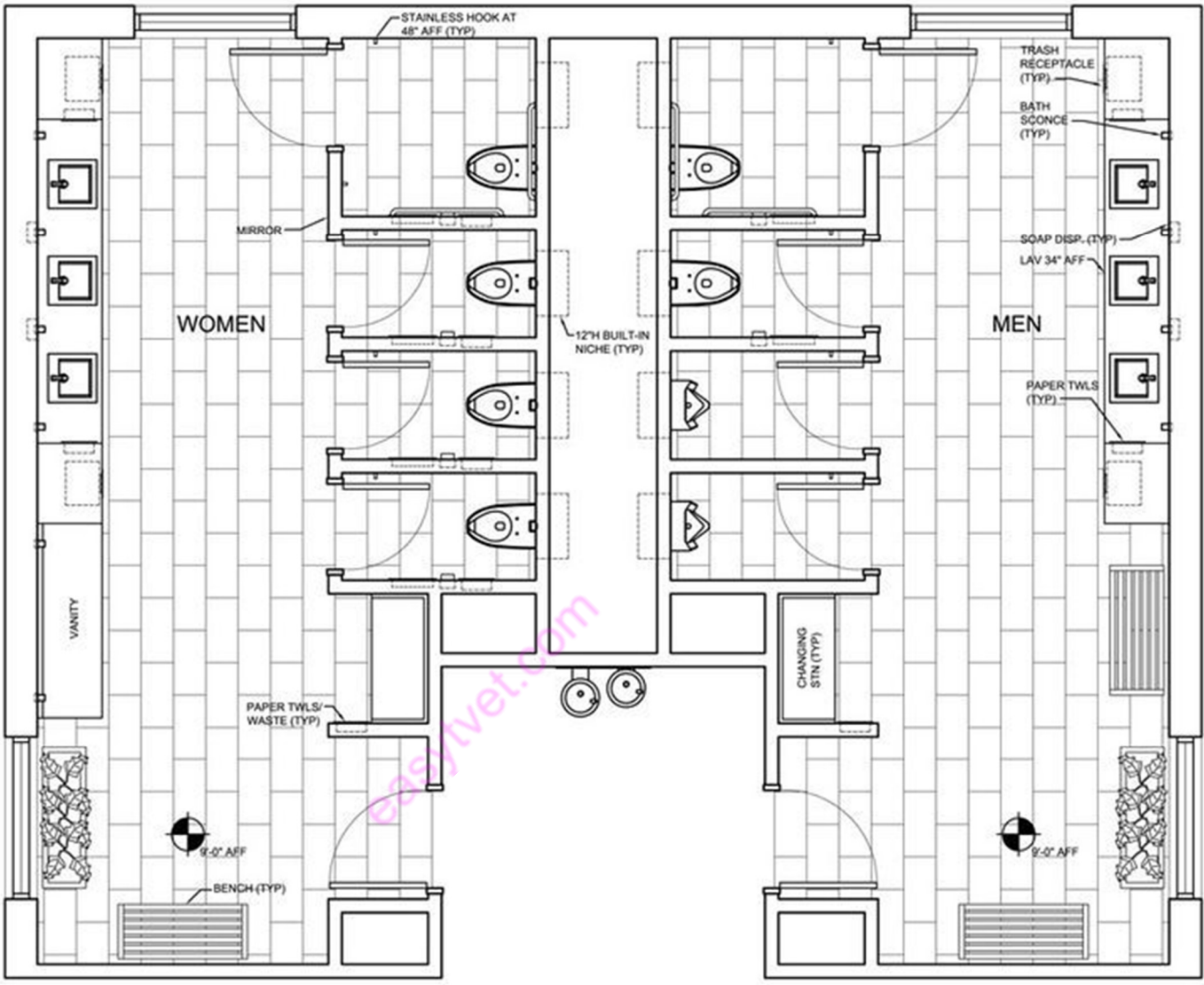
1.2.2.4 Learning Activities

You are required to Study the floor plan below and;

- Identify and select the materials based on the working drawing
- Quantify and cost the materials using the current market rate.



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1.2.2.5 Self-Assessment

1. State where the following types of pipes are used.
    i. **CPVC**

ii. **Cast iron**

iii. **PP-R pipes**

2. Define a valve

3. List four factors that should be considered before selecting a supplier.

4. Which type of valve is used to reduce the water pressure in the pipe systems?

1.2.2.6 Tools, Equipment, Supplies and Materials

Table 4: Tools, Equipment, Supplies and Materials

Tools/Equipment:	**Materials:**
• Pipe wrench • Pipe cutter • Hacksaw • Pipe Threading Equipment • Vise - Bench • Tap and Punch • Files • Screwdrivers • Drill with various sizes of bits • Mallet • Ball hammer • Masonry chisel • PPR machine / Heat Fusion • equipment • Pipe bender	• Hardhat • Gloves • Dustcoat / overall • Safety shoes / boots • Various types of pipe support • Sandpapers • Threading oil • Thread tape • Assorted pipes • Assorted fittings

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1.2.2.7 References

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1.2.2.8 Model answers

1) State where the following types of pipes are used.

i. **CPVC** is used for hot and cold water supply piping.
ii. **Cast iron** Use for main soil stack waste lines and vent pipes
iii. **PP-R pipes** are used to install hot and cold water systems, including central heating systems.

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2) Define a valve

Valves are mechanical devices used to control, direct, and regulate the flow of water by opening, closing, or partially obstructing the flow

3) Choosing the best plumbing supplier should be based on mainly;

- availability of the required materials
- the lower price shall be termed as most economical
- the highest quality materials shall be considered
- The distance of the required material shall be a factor.

4) Which type of valve is used to reduce the water pressure in the pipe systems?

Pressure relieve valve

1.2.3 Learning Outcome 3: Identify and use pipework tools and equipment

1.2.3.1 Introduction to the learning outcome

This outcome specifies the competencies required in identifying, using pipework tools and equipment's as it applies in the construction industry.

1.2.3.2 Performance Standard

1. Personal Protective Equipment is used in line with occupational safety and health requirements
2. Pipework tools and equipment are identified based on job requirements.
3. Pipework tools and equipment are used based on best practice and manufacturer's manual.
4. Pipework tools and equipment are cared for and maintained based on manufacturer's manual and workplace policy
5. Pipework tools and equipment are stored based on work place policy.

1.2.3.3 Information Sheet

A plumber requires several tools for the fitting work for plumbing, fixing a tap or to carryout repairs. These tools help the plumber in performing his/her work properly, and therefore it is important that the tools are used systematically and handled carefully to avoid any damage. They should be kept at a designated place after use. The tools can be categorized as per the nature of work like holding tools, fitting tools, cutting tools, pipe threading and bending tools, etc.

Personal Protective Equipment (PPES)

Protective gears are essential in all plumbing services, such as pipe installation, system repairs, etc. The right personal protective equipment for a plumber comprises of gloves, boots, overall/dustcoat eye protection, protective helmet, and eye protection. Also, sometimes a plumber may need respiratory protective equipment. Eye protection is essential when the plumber is using power tools.

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PPE. 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.

Figure 125: PPEs

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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.

2. Head Protection

Protective helmets are important in a plumbing site because they prevent injuries from flying or falling objects. Falling or flying objects might lead to severe head injuries, which will cost a plumber a huge amount of money in the long run. Therefore, it's a great idea to invest in a suitable protective helmet.

3. Hand and Skin Protection

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.

TYPES OF TOOLS AND EQUIPMENTS

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The major tools used in plumbing are categorized as:

Holding tools

- Bench vice
- Pipe vice

Fitting tools

- Pipe wrenches
- Water-pump plies
- Spanners

Cutting tools

- Pipe cutter
- Hacksaw

Pipe bending tools

- Pipe bending machine
- Threading dies

Other tools

- Chisel
- Hammer
- Chain wrench
- Rover jumper
- Trowel
- Screw driver
- File
- Plier
- Caulking tools
- Drill machine
- Drill bit
- Hanger
- Measuring tape
- Plumb rule and bob
- Spirit level
- Spade
- Shovel
- Pickaxe
- Mortar pan
- Mason square
- Water level tube

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Holding tools.

Tools which are used for holding the pipes, pipe fittings and fixtures for plumbing operations are called holding tools. Some of the commonly used holding tools are mentioned below.

Bench vice

A vice is a tool used for holding an object for various tasks like filing, chipping, sawing, threading, tapping, bending, etc. The bench vice has two jaws, one of which is fixed and the

other is movable. These jaws are fitted with plates for a better grip on the object during the task. The vice size depends on the width of the jaw. A bench vice is fixed to a table or a bench through a bolt. A vice is opened and closed with the help of a handle attached to a spindle. In this way, the object is held tightly. Bench vices hold the objects and allow use of other tools to complete the tasks

Pipe vice

It is a tool used for holding a pipe for carrying out assembly, disassembly, threading, cutting, etc. Pipe vices are of two types: (i) Open side pipe vice (ii) Fixed side pipe vice Standard sizes of vices are 80 mm, 105 mm, 130 mm, 170 mm, etc., as per the opened size of the jaws.

Fitting tools.

While holding tools are used to keep the objects in place, fitting tools are used for carrying out various plumbing operations like cutting, tightening, fixing and other small tasks.

Pipe Wrenches

These are hand tools used for tightening and loosening the nuts and bolts. Wrenches hold slippery or small nuts and bolts for loosening or tightening them. Mostly, two types of wrenches are used—adjustable and non-adjustable. These are useful particularly in case of odd-sized nuts and bolts. These tools hold a pipe and pipe fittings for screwing or unscrewing. This is a very common tool, especially for small diameter pipes up to 50 mm.

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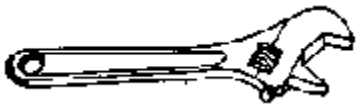
Adjustable spanner

This type of wrench is used to loosen or tighten the nuts and bolts of any odd and regular sizes. It is used for tightening and loosening valves, cocks, geysers, flexible pipes, etc. It is a good maintenance tool for repair of plumbing items like valves, cocks, pumps, etc.



Water-pump plier

It is a common plier used by plumbers for holding, tightening and loosening work during fixing process. Steel is used for manufacturing water-pump pliers. These are available in only one standard size of 250 mm length. The maximum width possible between the two jaws is 40 mm.

Spanners

This tool is used for tightening and loosening nuts and bolts of standard size. The standard spanners used are:

Ring spanners

These spanners have full circular closed ring at both ends. It is difficult to slip and cause damage. It is made through forging process, with a burnished finish or a chrome-plating.

Combination spanners

These spanners are open at one end and closed at the other.

Cutting tools

Tools that are used for cutting the pipes, fixtures and bolts, etc., are known as cutting tools. Some of the commonly used cutting tools are mentioned below.

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Pipe cutter

This is a manual tool used to cut a pipe at the work site, especially when it is difficult to use a hacksaw frame. This tool has a sharp, round cutting wheel which is pressed with to and fro rotary motion for cutting a pipe.

Hacksaw

This tool is generally used with both the hands. It cuts material like plastic pipe, steel rod, angle iron, sheets, iron pipes, etc. It can also be used for cutting the bolt heads and nuts when they are jammed. Important parts of a hacksaw are—handle, frame, blade and adjusting wing nut.

Pipe bending tools

In most of the plumbing operations, pipes are required to be bent at different angles as per requirement, for which pipe bending tools are used. Some of these tools are mentioned below.

Pipe bending machine

This equipment is used to bend or turn pipes. The size and strength of the machine depends upon the diameter of the pipe and the type of the pipe material to be bent. The mechanical or hand-operated pipe bending machines are available for 3/8– 1″ diameter pipes. For higher ranges, i.e., 1/2–2″, 1/2 – 3″, 1/2– 4″ and 2– 6″, hydraulic hand-operated machines are used.

OTHER TOOLS.

Apart from the already mentioned holding, fitting, cutting and bending tools, various other tools are also used in plumbing operations. These are listed below.

Chisel

It is made of hard metal and is mostly used for cutting concrete surface and making grooves in the walls with the help of a hammer.

Hammer

These are general purpose workshop hand tools used for straightening of sections, riveting, striking of nails and inserting the component by striking, inserting keyways and fitting by striking.

Chain wrench

The common holding tools do not help much in case of large diameter pipes. For these, chain wrenches are used. A chain wrench consists of a toothed block, a handle and a chain. The chain is round, grooved and held on the toothed end of the block. The chain grips the pipe fitting and screws or unscrews. The chain wrench is available in 3″, 4″, 6″, 8″ and 12″,with the length 475 mm, 585 mm, 834 mm, 1100 mm and 1360 mm respectively. These sizes are designated by the maximum diameter of the pipe it can hold.

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Screwdriver

This tool is often used by plumbers to fit the screws. Screwdrivers have a sharp tip which can easily fit into various screws.

Files

These hand tools are used for a variety of work, like removing of sharp edges, metal removal, shaping of jobs, smoothening of surfaces, finishing, producing different shapes, etc. The file has five parts: tang, heel, face, edge and point or tip. Various types of files of different shapes like hand round, pillar, square, three square, half round, flat, knife edge and needle file are used as per the work.

Pliers

They are important tools used for holding small objects and for tightening or loosening various parts. Several types of pliers are used by a plumber during work. Pliers can be used for cutting purpose also.

Caulking tools

For filling the gaps in the wall, caulking tools are used. This tool helps in filling and removing material in the building.

Drill machine

One of the common but important tools used for making a hole in a metal or wood, or concrete surface. A drill machine is fitted with a cutting tool like a drill bit. The attachment is tightened with a key.

Drill bits

These are the tools used to make cylindrical holes by cutting the material. Bits are fitted in a tool which rotates it and make the hole. For non-cylindrical shaped holes, specialised bits are used.

Hangers

The purpose of a pipe hanger is to hold or support a pipe or a group of pipes from a slab, beam, ceiling or other structural elements.

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Measuring tape

It is used for measuring the length of an item. The measuring tape is manufactured in various material like steel, cloth and PVC.

Plumb rule and bob

This is a useful tool to ensure verticality and uniformity during construction of walls, columns and wooden frames like doors and windows. It also helps in levelling the surface of the floor. It consists of a holding pipe, thread and a plumb bob made of wood and metal. The plumb bob is connected to the holding pipe with the thread.

Spirit level

It is used to check the horizontality or levelling of the floor, roof, door, window frame

Trowel

It is used for mixing cement and sand for masonry work. It is used for plastering the surface.

Spade

A spade is used for digging purpose and for mixing cement, sand and concrete.

Water level tube

This tube is used to check and transfer water levels, etc.

EQUIPMENT MAINTENANCE

It includes routine upkeep as well as corrective repair work. Equipment may include heavy workshop machines.

Types of maintenance

There 4 general types of maintenance; corrective, preventive, risk-based and condition-based maintenance.

1. **Corrective maintenance**; Maintenance is carried out following detection of an anomaly and aimed at restoring normal operating conditions.
2. **Preventive maintenance**; Maintenance carried out at predetermined intervals or according to prescribed criteria, aimed at reducing the failure risk or performance degradation of the equipment

Below is a preventive maintenance checks of a water pump.

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Preventive maintenance checks	
Daily	• Cleaning • Lubricating oil • Coolant level • Report minor defects
Weekly	• Lubricating oil • Coolant level • Filters • Hydraulic & pneumatic lines
Monthly	• Spindle drive belt • Hydraulic pumps & oil • Movement of axes
Biannually	• Machine alignment • Replace oils & filters

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3. **Risk-based maintenance**; Maintenance carried out by integrating analysis, measurement and periodic test activities to standard preventive maintenance

4. **Condition-based maintenance**; Maintenance based on the equipment performance monitoring and the control of the corrective actions taken as a result.

the surface being worked on.

Why is it important to use the correct tools and equipment?

Each tool is precisely designed for a specific purpose, so choosing the correct tool will also decrease the amount of effort required to get a job done right without causing damage to either the equipment or

Tools and equipment storage

Why should tools and equipment be securely stored?

You are responsible for making sure that all tools and equipment are well organized and maintained in good working condition. They should be stored in a separate secure place so that they are safe and easy to find. This is usually best done in a place which is separate from the office.

Proper storage of tools and equipment

Section a space on your building and make it a storage place for tools.

Tools Preparation and Storage

Preparation

- Clean tools after each use
- Repair any broken parts
- defective tools must be isolated
- Use metal protectant spray on all metal parts
- Never store tools on the unprepared ground
- Get creative with storage options the heavy ones near/on the prepared raised ground and the lighter ones on top
- Make a list of all items that are stored

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Storage

To keep these tools safe and in good working condition, it's better to keep them in and not limited to:

- Racks
- Cabinets
- Drawers
- Pegs on wall
- Shelves
- Tool boxes

Make sure to label the boxes with its contents so you will be able to find the tool when you need it. Keep an inventory list of the tools that you have and where they are stored.

Figure 126: pegging on wall

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1.2.3.4 Learning Activities

Practical activities

Below is a pipework installation, you are required to study it and;

- Identify the Personal Protective Equipment used in line with occupational safety and health requirements
- Identify the Pipework tools and equipment to be used.

1.2.3.5 Self-Assessment

1. Types of personal protective equipment (PPE) to guarantee your safety
2. Which are four safety risks a plumber faces on places of work?
3. What is the importance of tools in plumbing?
4. What tools do plumbers use to unclog drains?
5. Which material will you use to threaded pipe connection to prevent leakage?
6. I need to cut a new piece of copper pipe for the supply run to my sink. What are the best tools and techniques to use?

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1.2.3.6 Tools, Equipment, Supplies and Materials

Tools/Equipment:	Materials:
• Pipe wrench • Pipe cutter • Hacksaw • Pipe Threading Equipment • Bench-vice • Tap and Punch • Files • Screwdrivers • PPR machine / Heat Fusion • equipment • Pipe bender	• Hardhat • Gloves • Dustcoat / overall • Safety shoes / boots • Various types of pipe support • Threading oil • Thread tape • Pipe clamp • Adhesive

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1.2.3.8 Model Answers

1. **Types of personal protective equipment (PPE) to guarantee your safety**
    - Safety for the head. Wearing a helmet offers protection and can prevent head injuries.
    - Protect your eyes.
    - Hearing protection.
    - Maintain a good respiration.
    - Protect your hands with the right gloves.
    - Protection for the feet.
    - Wear the correct work clothing
2. **Which are four safety risks a plumber faces on places of work?**

    Any four

- Exposure of hazardous substances like lead, Sulphur dioxide
- Exposure to combustible and flammable materials
- Working in awkward positions
- Lifting of heavy objects
- Risks of eye injuries from flying particles
- Burns from hot equipment or steam lines
- Risks of electric shocks while working for ground water pipes

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3. **What is the importance of tools in plumbing?**

    A plumber requires several tools for the fitting work for plumbing, fixing a tap or to carryout repairs. These tools help the plumber in performing his/her work properly, and therefore it is important that the tools are used systematically and handled carefully to avoid any damage

4. **What tools do plumbers use to unclog drains**?

To dislodge clogs located farther down the drainpipe, use a cable auger, or plumber's snake, a long, flexible steel cable wound around a spool that's fitted with a hand crank

5. **Which material will you use to threaded pipe connection to prevent leakage?**
    - Teflon tape

6. **I need to cut a new piece of copper pipe for the supply run to my sink. What are the best tools and techniques to use?**

    It's best to use a pipe cutter with a specially designed blade for copper pipe. You can also use a fine-toothed hacksaw, but making a straight cut with it is more difficult. After you've cut the pipe, clean off any burrs (inside or out) with a half-round file.

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1.2.4 Learning Outcome 4: Install pipe works

1.2.4.1 Introduction to the learning outcome

This outcome specifies the competencies required to install pipe works as it applies in the construction industry.

1.2.4.2 Performance Standard

1. Positions of pipes are set out and marked based on working drawings
2. Pipes are threaded based on standards and specifications.
3. Pipes are jointed in accordance with best practices and manufacturer's instructions.
4. Pipes are cut based on type of pipe, drawing specifications and job requirements
5. Flanged joints are prepared based on best practices
6. Pipes are bent based on type of pipe, drawing specifications and requirements of the job.
7. Pipes are fitted based on drawing specifications.
8. Housekeeping is conducted as per workplace procedures
9. Safety and health practices are observed based on OSHA functionality tests are conducted based on best practices.
10. Faults in functionality and leakage are corrected based on best practice

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1.2.4.3 Information Sheet

Pipes transport water from the sources of water supply to the points of distribution; convey waste from residential and commercial buildings and other civic facilities to the treatment facility or the point of discharge.

Terms and concept

Couplings; A coupling (or coupler) (used in piping or plumbing) is a very short length of pipe or tube, with a socket at one or both ends that allows two pipes or tubes to be joined, welded (steel), brazed or soldered (copper, brass etc.) together.

Adapters; they are used to connect dissimilar pipes.

Unions; A union is a threaded fitting which allows the pipe work to be separated and reconnected without any horizontal movement in the pipe.

Caps; Pipe caps act as protective device and are designed to protect pipe ends of various shapes

Plugs; they are also used for blocking the ends of pipes to prevent the entry of dirt and other contaminants during construction, maintenance or repair of pipelines.

Elbows/bends; It is used to connect two pipes with same or different nominal diameters, and to make the pipe and thus the fluid direction turn to a certain direction of 45 degree or 90 degree.

Tee-Connection; It is a short piece of pipe with a lateral outlet. Pipe Tee is used to connect pipelines with a pipe at a right angle with the line.

Cross; is a kind of pipe fitting that be used in the place where four pipes meet together.

Reducers; A reducer is a kind of pipe fitting used in process piping that reduces the pipe size from a larger bore to a smaller bore (inner diameter).

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

Figure 127: Plumbing fittings

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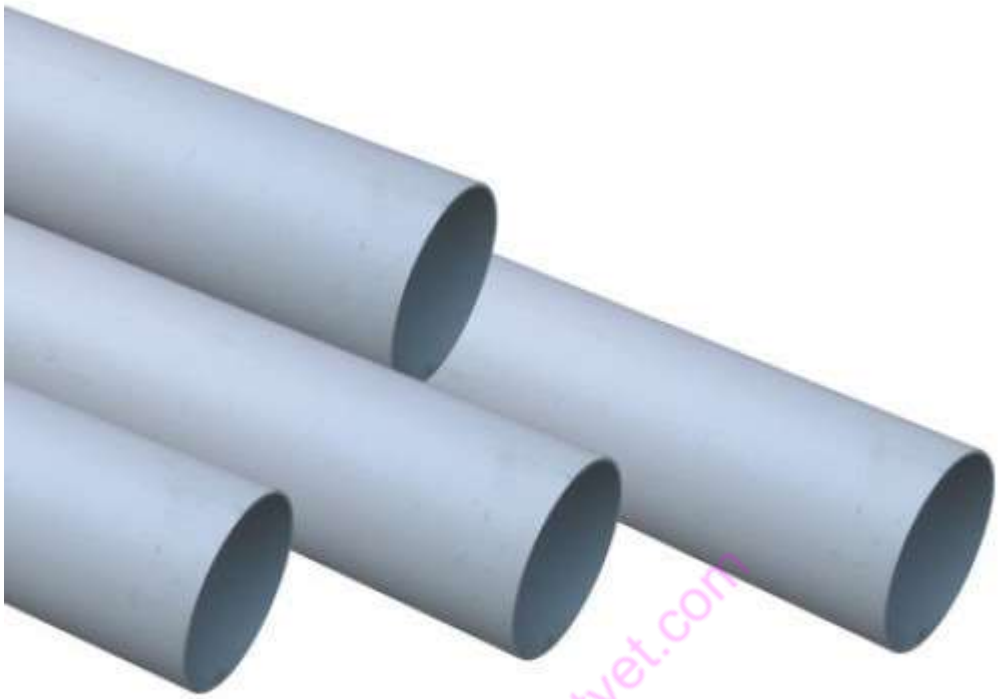
Types of pipes

PVC pipes (Polyvinyl Chloride)

PVC pipes are used in a wide variety of piping applications, from transportation of drinking water over drainage solutions to advanced fire-sprinkler systems. This popularity owes to a unique combination of properties: safety, durability/cost-efficiency, environmental performance and recyclability.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G.I (Galvanized Iron) pipes

Description: Galvanized iron pipe was once a popular method of plumbing water supply lines in the home, but it gradually fails due to corrosion and rust. For this reason, it is no longer commonly used and has been largely replaced with copper pipe or PEX plastic pipe. Galvanized iron pipe is difficult to cut and join and not easily fabricated on site by the homeowner. Repairs are usually done by replacing the pipes with copper or PEX.

Prevalent Use: Water supply lines and drain lines in older homes.

PPR pipes

PPR pipe is a straight and rigid cylindrical pipe, made from Polypropylene Random Copolymer plastic, produced through a continuous extrusion process. They are commonly offered in green or white color, and in outer diameter sizes ranging from 20mm to 110mm making the pipe walls far thicker than PVC. PPR pipe is accompanied by a series of connection fittings, parts, and accessories available for every pipe diameter.

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Application of PPR Pipe

- **PP-R pipes** are used to build hot and cold water systems, including central heating systems.
- **PP-R pipes** are a part of building heating system, including floor, wall and radiant heating systems.
- **PP-R pipes** can be directly purified water drinking water supply systems.

- **Mild steel**

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Mild Steel (MS) pipes are manufactured using low carbon (less than 0.25%) steel. Due to low carbon content the pipes do not harden and are easy to use. As MS Pipes are made from mild steel they can easily be welded and formed in various shapes and sizes for pipelining and tubing purposes. These are generally used for drinking water supply i.e. Plumbing, Firefighting, but can also be used in various other Industrial and Engineering applications. These pipes are usually coated with other metals/paints/varnish etc. to prevent it from rusting but extra care should be taken to prevent it under extreme conditions.

- Copper

Appearance: Dull, copper-colored metal pipe.

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Description: Copper pipe comes in two types: rigid and flexible. The rigid type comes in several wall thicknesses: K, L, and M. Type M is the one normally used for water supply pipes. Copper has proven itself over the decades to be corrosion resistant and very reliable. Copper is a soft metal and can be easily cut and fabricated. It is also prone to damage, may develop pinholes over time, and can rupture from frozen water in pipes.
Rising costs for copper in recent years have caused PEX and CPVC to be used more frequently. Copper pipe costs as much as three times as much as PEX. **Copper**. Copper comes in three grades:

- M for thin wall pipe (used mainly inside homes);
- L for thicker wall pipe (used mainly outside for water services); and
- K, the thickest (used mainly between water mains and the water meter).

Prevalent Use: Rigid copper pipes are used for longer runs of water supply, and in some cases as waste lines in the home. Flexible copper is used in short runs, for water supply, and for the water supply tubing for refrigerators and dishwashers. Copper may also be used for gas piping.

Cutting and Fitting: Copper pipe is easily cut with a tubing cutter or hacksaw. Sections are joined together with soldered copper connectors or copper compression fittings. The flexible copper pipe may also be terminated by flaring its end and using brass flare fittings.

- **CPVC**

Appearance: Dull white or cream-colored plastic.

Description: CPVC is an inexpensive rigid plastic that is designed to withstand high pressure and temperature.

Prevalent Use: CPVC is used for hot and cold water supply piping.

Cutting and Fitting: The pipe is easily cut with a tubing cutter or hacksaw. CPVC is joined permanently together using plastic fittings and solvent glue, or with grip fittings where the pipes may need to be disassembled in the future.


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Traps and valves

These include all the main fittings that are used to control flow, shut – off or isolate, draw – off and drain – off water in hot and cold water systems. There are many types available in a range of materials, shape and suit a variety of applications. Traditionally, most are made of brass, bronze and gunmetal because metals are durable and resistant to corrosion.

Increasingly, many are now being made from plastics, because of its resistance to corrosion, low cost and ease to manufacture.

Taps

Taps are designed for general of the flow gradually. The tap is generally made of a spindle connected to a controlling head and the jumper. When the head is turned anti- clockwise, to open the tap, the spindle gradually raises the jumper off the seat and let water flow through the tap. When turned the head is turned clockwise, to shut the tap, the spindle screws down the spindle to lower the jumper on to the seat and shut of the flow. The gradual operation of taps lowers the general risk of water hammer. NB: Water Hammer: this occurs when water flow is stopped instantly causing kinetic energy created in the flow to be passed on to the pipes and fittings in the system causing vibration and noise and possibly damaging the system

They are several taps, which include

1. Bib taps
2. Pillar taps
3. Stop taps / stop cocks
4. Drain taps
5. Mixer taps

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1. Bib taps

These are draw - off taps fitted above sanitary appliance such as sinks or to supply water for buckets or hoses**.**

2. Pillar taps

These are draw – off taps fitted to sanitary appliances like sinks, wash basins and baths. They have a long – threaded shank that allows them to be fitted into the appliance. Pillar taps should be high – necked to buckets fit underneath

3. Stop Taps/ stop cocks

These are used to shut off water or control the rate of flow in pipelines. They are commonly fitted to incoming water main in the building or on the feed pipe to individual appliances to shut off the water flow for repair and maintenance.

4. Drain taps

These are fitted to the low point of all systems for drawing down the system.
They are controlled by a removable key to prevent an authorized use.

5. Mixer tap

These are basically a pair of pillar taps, hot and cold, joined together by a common or mixing chamber and / or delivery spout to provide a mixed flow of hot and cold water.

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Valves

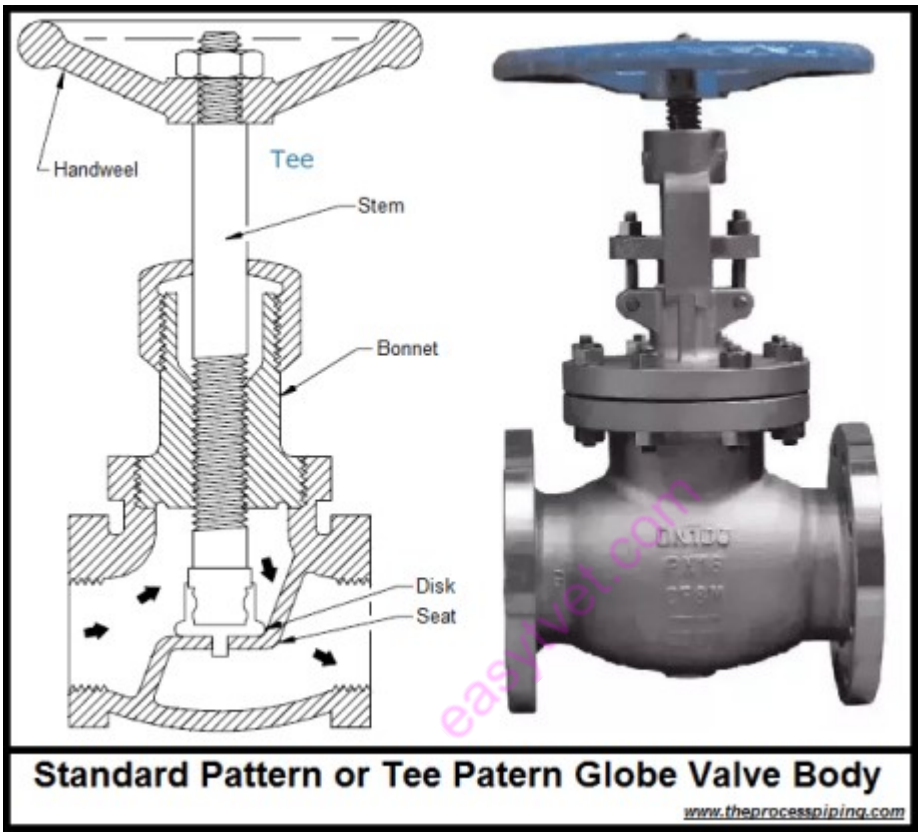
A valve is a device that regulates, directs or controls the flow of a fluid (gases, liquids, fluidized solids, or slurries) by opening, closing, or partially obstructing various passageways
There are several valves available for use by plumber. They include.

1. Globe valves
2. Gate valves
3. Plug valve/ plug cork
4. Ball cork
5. Float valve/ ball valve

1 .Globe valves

They just look like gate valves from the outside but are screw - down operation in operation, just like the stop tap.

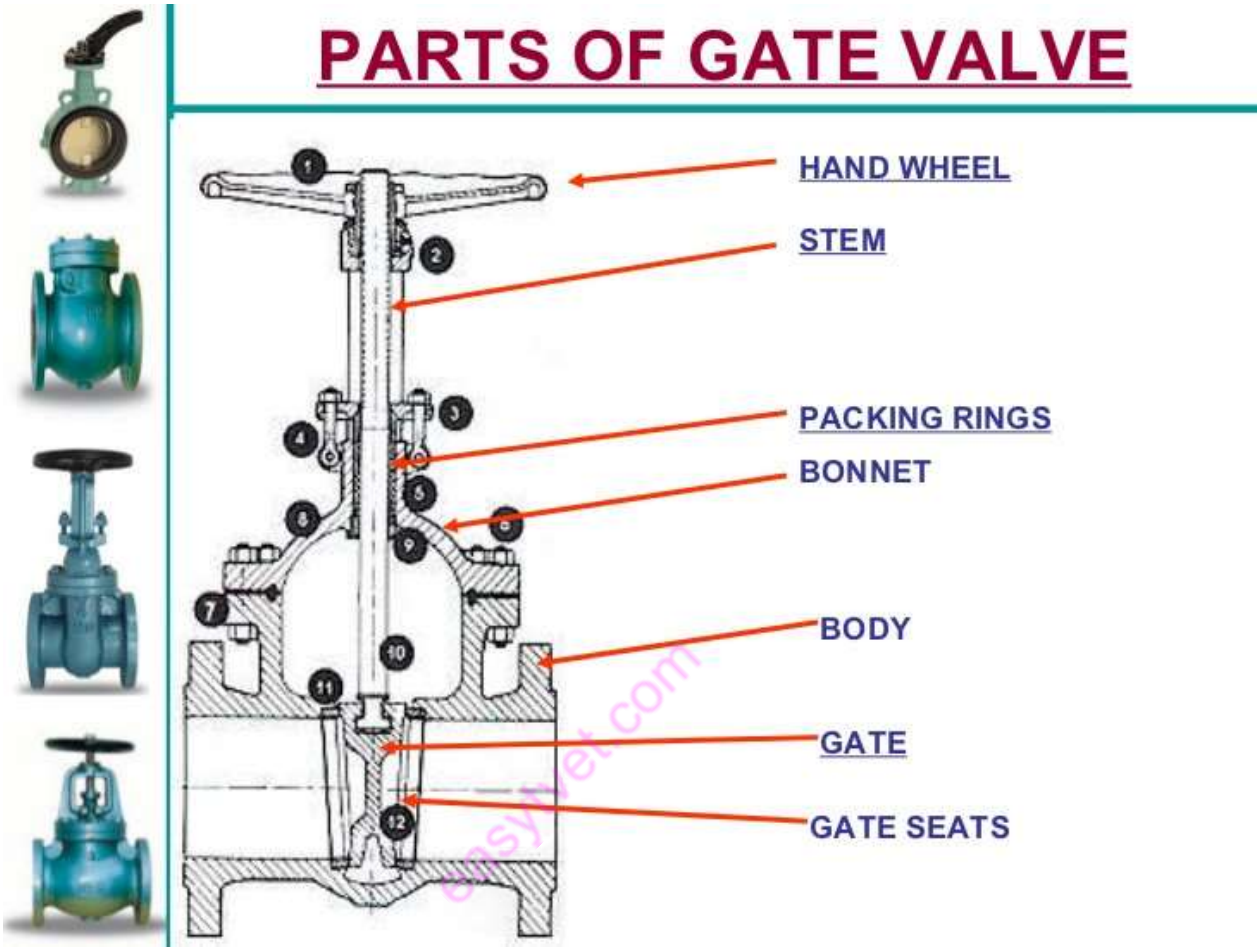
They are made with female thread connections



2. Gate valve

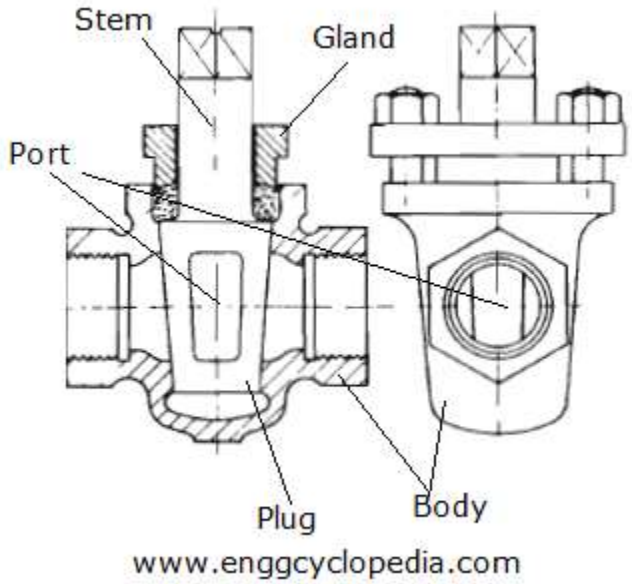
A gate valve, also known as a sluice valve, is a valve that opens by lifting a barrier (gate) out of the path of the fluid. Gate valves require very little space along the pipe axis and

hardly restrict the flow of fluid when the gate is fully opened.



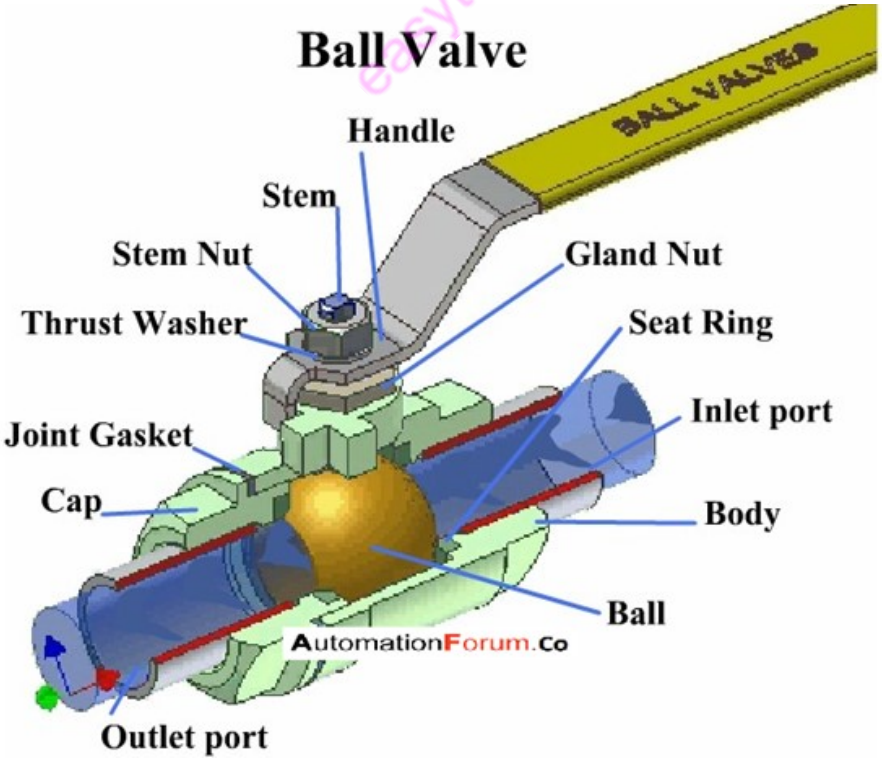
3. Plug cock

A plug valve is shaped like a cylinder or cone and can be rotated inside the valve body to control flow of fluids. Plug valves have one or more hollow passageways often placed horizontally to allow ease of flow through the valve when open.



4. Ball cork

A ball valve is a form of quarter-turn valve which uses a hollow, perforated and pivoting ball to control flow through it. It is open when the ball's hole is in line with the flow and closed when it is pivoted 90-degrees by the valve handle.



5. Float valve/ ball valve

A ball valve/ float valve is a mechanism or machine for filling water tanks, such as those found in flush toilets, while avoiding overflow and backflow.

Pipe joints

Pipes are connected with the help of joints. A variety of joints are used in an assembly of pipes. Connecting two or more pipes together is called a fitting. Various types of joints could be used in a pipe as per the requirement. Joints are also used for multiple pipe connections, and are an important component of the plumbing system. Generally, the pipe joint fitted can easily sustain the pressure created in the pipe.

Various types of pipe joints are as follows.

1. Threaded joint
2. Welded joint (butt welded, socket welded)
3. Brazed joint
4. . Soldered joint
5. Grooved joint
6. Flanged joint
7. . Compression joint

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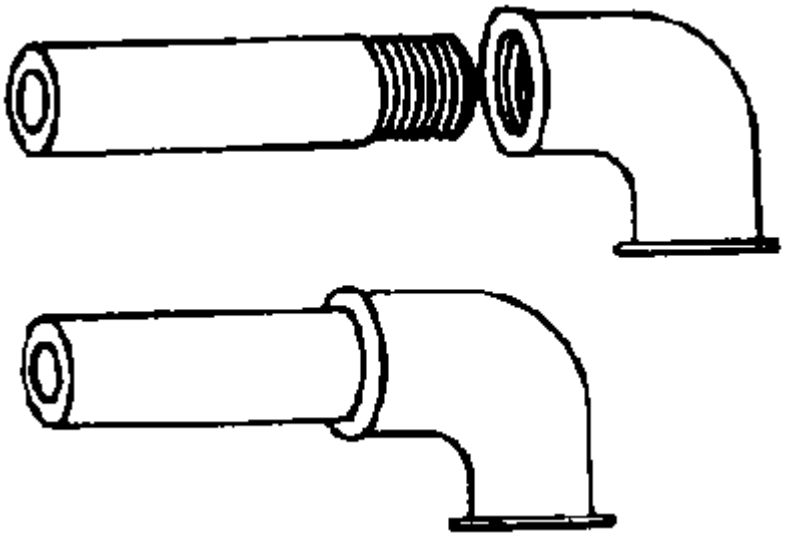
1. **Threaded joint**

   When pipes are joined by screwing in threads which are provided in the pipe, it is called a threaded joint. The threads are also made in various pipes like PVC, CI pipes, copper

pipes and GI pipes, etc. Threaded joints are used from 6 mm diameter to 300 mm



diameter pipes.

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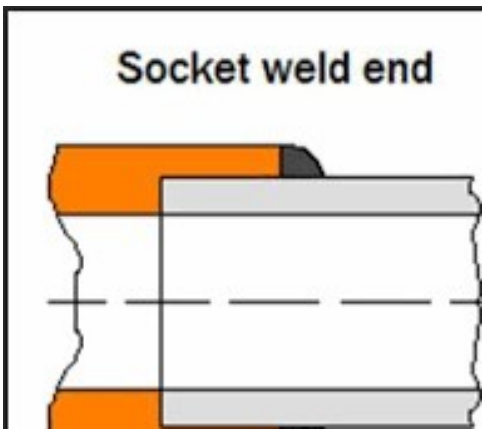
2. **Welded joints (Butt-welded joints)**

   It is one of the most common methods of joining pipes used in large infrastructure like commercial, institutional and industrial systems. Cost of material are low, but the labour

costs are more due to the no availability of trained welders and fitters.

3. **Socket-welded joints**

These are used when there is a high chance of leakage in the joints. Pipes are joined as putting one into other and welded around the joint. Pipes having different diameters are suitable for this type of a joint. Socket-welded joint gives good results as compared to other joints.



4. **Brazed joints**

When pipes are joined with the help of molten filler material at above 840°C, it is called brazing. Brazing is done for connecting copper pipes or copper alloy pipes. It is important to note that the melting point of the parent material (pipe material) should be higher than the filler material. Brazed joints have less mechanical strength, and are

preferred in case of moderate temperatures

5. Soldered joints

Soldering and brazing are similar activities. In soldering, the filler material melts below 840oC. With the help of soldering, copper and copper alloy pipes are joined. During soldering, flux or metal joining material is used to prevent oxidation due to the flame. Soldered joints are suitable for low temperature areas and have low mechanical strength.

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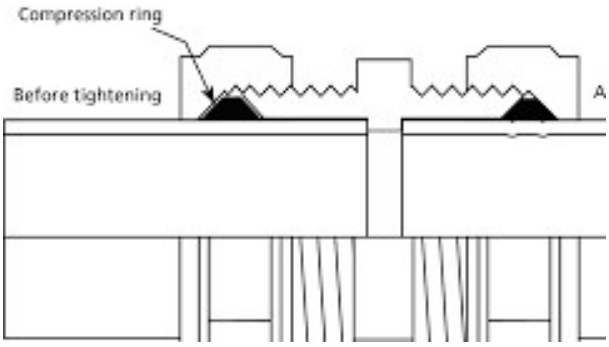
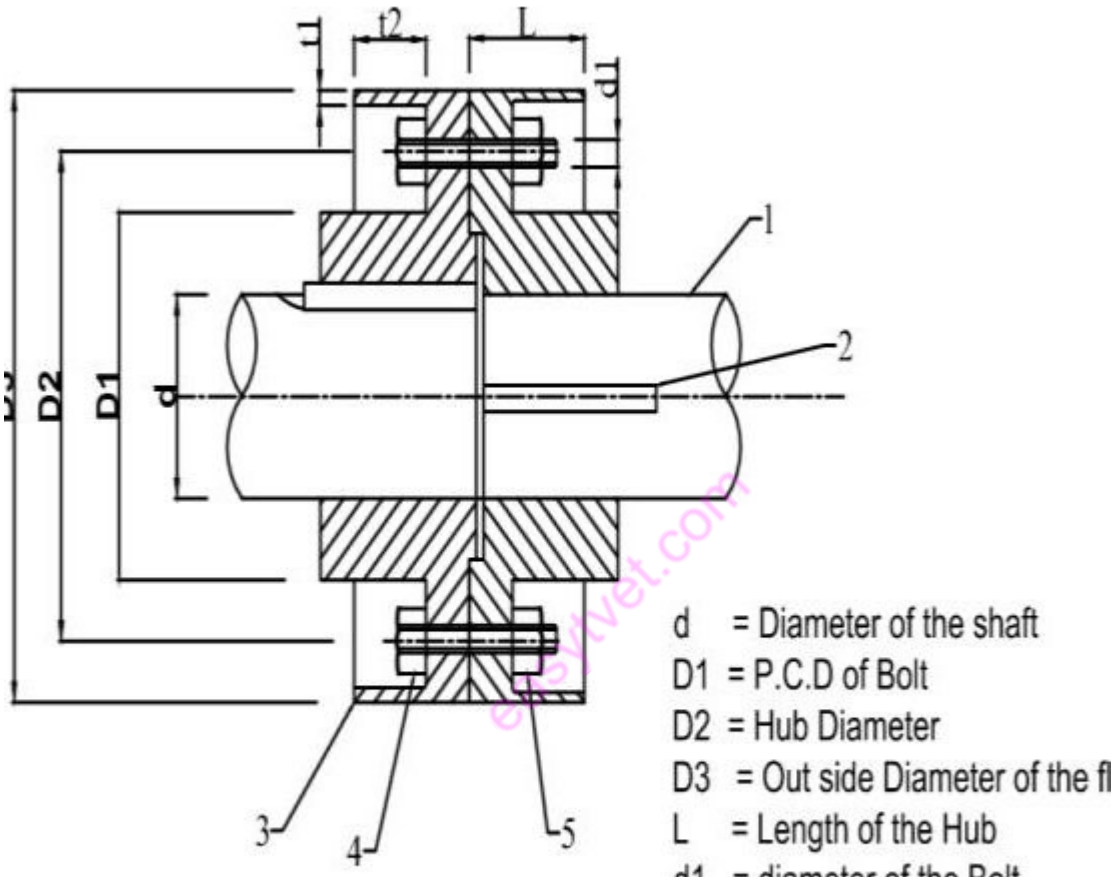
6. **Compression joints**

These are applied to join the pipe without any preparations. The cost of installation of these joints is very economical. The pipes having plain ends are joined by fixing fittings at their ends, and such a joint is called a compression joint. The pipe ends are joined with threaded fittings or couplings. Joints are placed properly to check the flow pressure, otherwise, leakage may occur. These fittings are manufactured from different types of material. Selection of fittings is done as per requirement



Flanged Joint (with fittings)

The flanged joint design means that pipes are secured by external screws, providing additional joint support for the transportation of substances at high pressure.



- **Piping systems**

  Hot water

  Identify the type of hot water system from layout diagrams

  There are a number of hot water systems in use in the UK. Some of these are open vented systems that remain open to the atmosphere and some provide instantaneous hot

water through combination boilers and multipoint water heaters. The differences between each system will become apparent as we work through the system layouts. We will look at:

a). Direct systems

- Containing a back boiler
- Containing a hot water immersion heater

b).In-direct systems

- Single feed, self-venting systems
- Double feed systems with a hot water heating coil

c).Thermal store

d).Instantaneous hot water heaters

- Single point (point of use) heater
- Multipoint heaters

e). Combination boilers

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- ✓ **Direct system of hot water**

A **direct water supply system** is one where the raising main feeds directly the cold **water** taps and a multi-point **water** heater. The mains **water** comes in via a rising main and directly feeds all the cold taps and a multi-point **water** heater - so all the taps and other **water** feeds are at mains **water** pressure.

Indirect system of hot water

With an indirect water system, the copper hot water cylinder contains a coil of pipe. This coil forms part of a run of pipework attached to the boiler. It is heated directly by the boiler. Indirectly, it heats the water in the cylinder. The coil, or "heat exchanger" forms

part of the central heating circuit, and its water heating abilities are purely a by-product of its main function, which is to heat the radiators. This heating is called the "primary" circuit, the pipes running to and from the boiler are called the primary flow and return. The hot water tank operates in exactly the same way as the direct system.

To identify an indirect system, you will see two water tanks in your loft. The second, smaller one, is the feed for the primary circuit. It will top up the system when necessary and will also have a vent pipe over the top. The level of water in this tank will be considerably lower to allow the water to rise as it expands when it gets hot without overflowing.

- **Cold water**

Direct system of cold water

Direct systems source water straight from the mains water supply. All pipes to the cold drew off points are taken directly from the rising main

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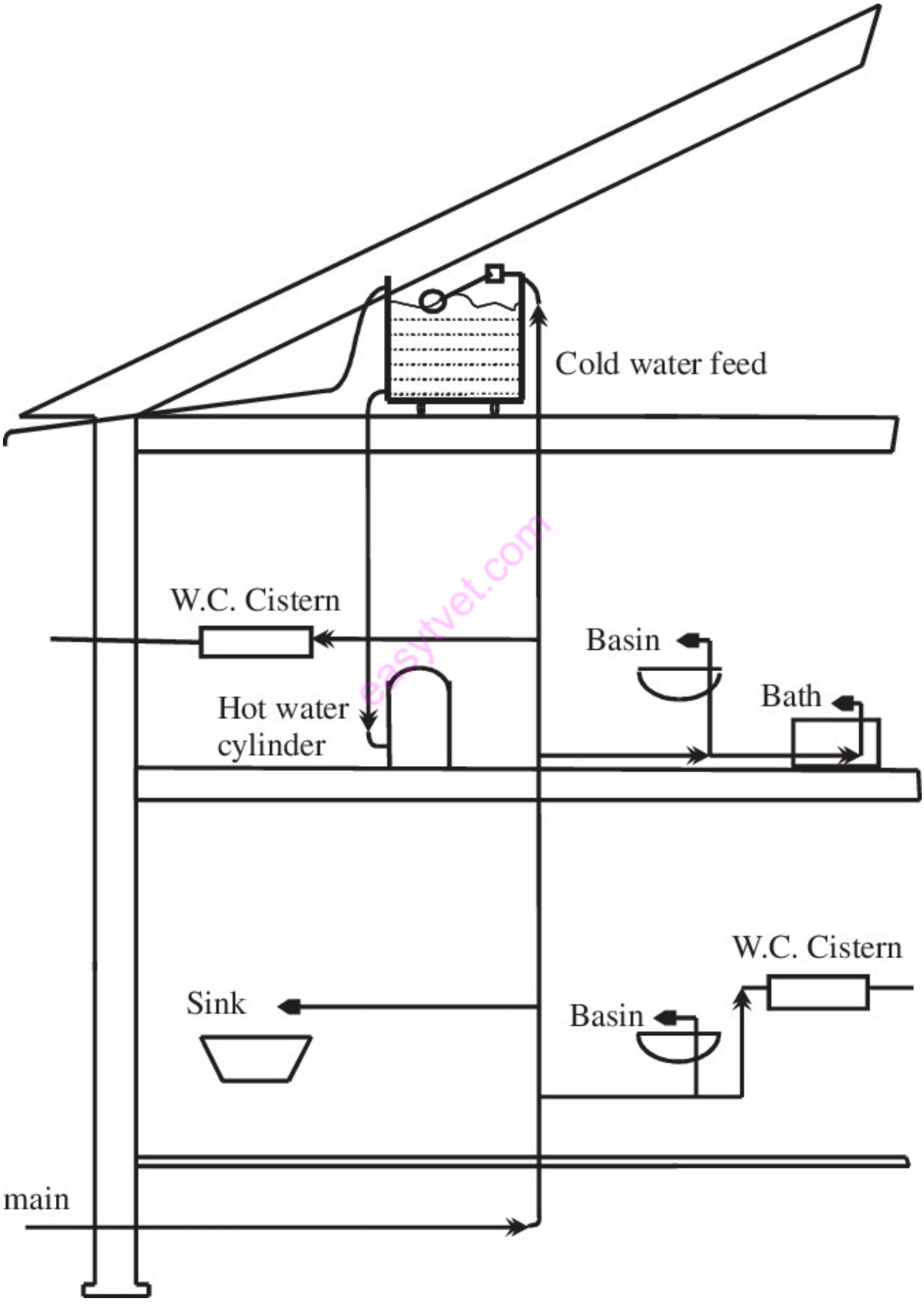
Cold water feed
W.C. Cistern
Basin
Bath
Hot water
cylinder
W.C. Cistern
Sink
Basin
main

Indirect System of Cold Water Supply

An indirect water supply system is the most common type found in modern houses.
The mains water comes in via a rising main and directly feeds at least one cold tap at the kitchen sink with 'potable' water. The rising main also feeds a storage tank at a high point in the building from where the water is fed to all the other taps using gravity.

Adhesives

Plumbing adhesive is used for sealing leaks, repairing tears, securing tiles, fixing footwear and mending glassware. It bonds aluminum, metal, copper, brass, ABS, PVC, fiberglass and tile.

Depending on the application, the industrial adhesive systems should be:

- **Waterproof:** it goes without saying that the adhesive bonding together two pieces of pipe containing liquids, should not let any of it through.
- **Chemical resistant:** depending on the purpose of the installation, the PVC bonding should be resistant to the feed including all chemicals it may be exposed to. For example, the horticulture industry installations used for delivering fertilizers, must not let the fertilizer affect the pipes and bonds.
- **Resistant to high pressure and discharge:** some industrial pipeline installations are used for delivering and discharging fluids in high pressure conditions. Therefore, the PVC adhesives used in these, must not be affected by the process and vice versa.
- **Safe to use with potable water:** many PVC pipelines are designed to deliver drinking water. Adhesives used for these pipes must comply with food and safety regulations to make sure no residue will end up in the potable water.

Pipe fittings

Pipe Fittings are defined as the piping components that help in pipe routing for directional changes, size changes, and branch connections. Piping Elbows, Piping Reducers, Tee Connections, Outlet Connections, Caps, Crosses, etc are pipe fittings and widely used in both

the piping and plumbing industry. Different pipe fittings serve different functions as per layout or process requirements. Pipe fittings are manufactured as separate items and procured separately. Pipe fittings are connected to piping using various end connections. Pipe fittings play an important role in the proper functioning of pipes and tubes in various applications.

- **Elbows**: Used to change the angle or direction of the pipe run. Most commonly in 90 degrees and 45 degree turns. The sweep of the fitting describes how fast a transition or change in direction is made.
- **Street Elbows:** One end of the pipe fitting has male threads and the other end has female threads. These are common in galvanized steel and copper pipe. They are convenient because they do away with the need for a nipple and work well in tight quarters.
- **Tee Fittings:** Shaped like the letter T. Allows for branch lines.
- **Couplings:** Used to join two straight pieces of pipe of the same diameter.
- **Reducers:** Used to join pipes of different diameters. Makes a gradual change in diameter.
- **Bushings:** Used to make the diameter of a pipe fitting smaller. They are different from reducers because they make an abrupt change in diameter and take little space.
- **Unions:** Used to join pieces of pipe where pipes cannot be turned or when a piece of equipment may have to be removed for maintenance or replacement.
- **Adaptor Fittings:** Used to change the end of a non-threaded pipe to male or female threads as needed. Most commonly used in copper and plastic plumbing jobs.
- **Caps:** Used to close the end of a dead-end pipe.
- **Plugs:** Used to close an ending on a pipe fitting normally used for inspection or cleanout.
- **Nipples:** Short lengths of pipe threaded at both ends.
- **Wyes:** Used primarily to gain inside access to DWV (drain-waste-vent) systems.
- **Valves:** Devices that control the flow of liquid or gas through or from a pipe. (Compression valves, ball valves, sleeve-cartridge valves, ceramic disc valves, etc)

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- **PVC Fittings:** Come in a wide variety of configurations and may be glued (S) or threaded (T)
- **Copper Tubing Fittings:** Use compression fittings. Common fittings are couplings, ells, and tees.

Examples of assorted fittings.

Pipe bending.

Pipe bending is a technique used in various metal forming processes with the aim of increasing the fabrication capabilities of plumbing fixtures. The pipe can be bent at varying angles and in different directions. The simplest curve turns the tube at an angle of 90 degrees forming an elbow.

Pipe bending machines are typically human powered, pneumatic powered, hydraulic assisted, or electric servo motor. In the pipe bending operation the tube may be supported internally or externally to preserve the cross section of the pipe. In operations where there is flexibility in the shape of the pipe, the pipe does not need to be supported, however there will be some deformation in the both the cross section of the overall pipe and the wall thickness in different areas of the bend.

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Physical Effects on Pipe and Tube from Bending

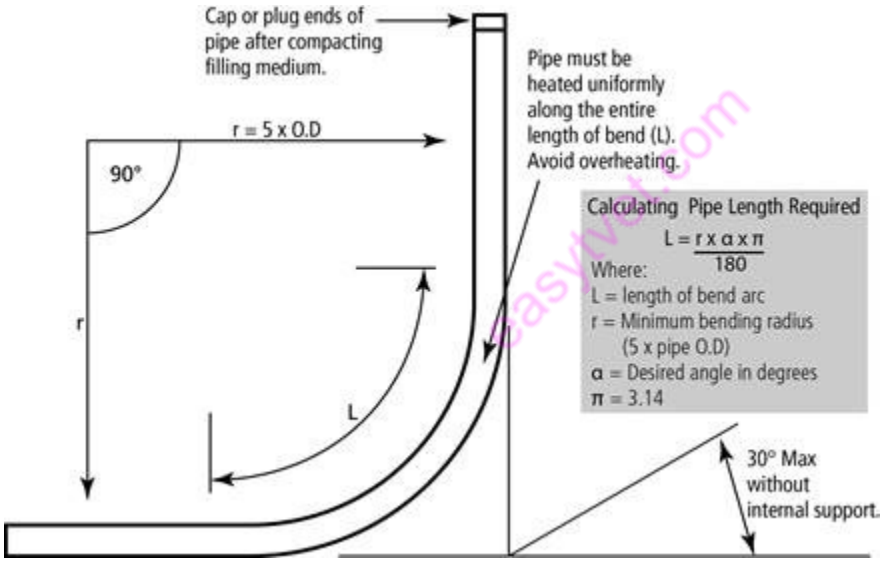
Depending on the bending method used and the material qualities of the pipe or tube being bent some of the following physical effects can be seen after bending:

- Wrinkles on the inner side of the bend
- Stretching of the wall on the outer side of the bend
- Thinning of the wall thickness on the outer side of the bend

- Deformation of the cross section of the pipe or tube causing it to reduce and form an oval shape.

Heat Bending Plastic Pipes

Bending of plastic pipes may be desirable under certain conditions where long radius bends and unusual configurations are required. It is possible to bend various sizes and wall thicknesses of rigid PVC-U, PVC-C and ABS pipe using heat bending techniques for long-radius sweeps for conduit and flow conditions. Irregular angles and U-bends for thermal compensation, and offsets in congested areas can be successfully achieved.



Good housekeeping through OSHA's rules for walking and working surfaces

It's clear to see that housekeeping practices have an impact meeting OSHA's general requirement for walking and working surfaces. The rule states:

- Housekeeping is to be clean, orderly, and sanitary.

- Floors are to be clean and dry.
- Aisles and passageways are to have sufficient clearance. They are to be kept clear, without obstructions that could create a hazard.
- Permanent aisles are to be marked.

Some examples of violations of these rules are: blocked aisles, material lying across an aisle or on the floor, wet or oily floors, or material overhanging high shelves.

Housekeeping solutions

As a good plumber you need to perform the following as housekeeping procedures.

- You should protect the existing works and sanitary appliances
- You should clean your working area at all times during work progress.
- Clearing work area after the job should be done immediately.
- Keeping of work area tidy is always necessary.

Common Plumbing Problems

- Faulty Faucets. The sound of a dripping tap is commonly associated with insanity.
- Leaking Pipes. Pipes make up the bulk of plumbing problems, especially in old houses.
- Dripping faucets.
- Slow draining sink.
- Clogged bath or shower drain.
- Clogged toilet.
- Running toilet.
- Faulty water heater.
- Low water pressure.
- Jammed garbage disposal.
- Low water pressure.

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INSPECTION AND TESTING

INSPECTION

Work should be inspected during installation and tests applied on completion, care being taken that all work to be encased or concealed is tested before it is finally enclosed.

Range of inspection - Pipe systems should be tested for tightness and for hydraulic performance. Inspection should be carried out to ensure the following:

a) Work accords with the drawings and specifications;

b) All pipe brackets, clips, etc., are securely fixed;

c) Fixings are correctly spaced.

d) Pipe is protected where necessary by insulation;

e) Embedded pipework is properly protected before sealing-in;

f) All access covers, caps or plugs:

- are so made that the internal faces truly complete the internal bore,
- are accessible,
- cause no obstruction in the pipe bore, and
- are well jointed.

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TESTING OF THE SYSTEM

- **Smoke test**; forces smoke-filled air through a sanitary sewer line. The smoke under pressure will fill the main line plus any connections and then follow the path of any leak to the ground surface, quickly revealing the source of the problem.
- **Water test**; the lower end of the pipeline is sealed using a drain plug and the section under test is filled with water. A head of water is created, following a period of settlement and acclimatization, the level of water in the head is monitored for a specified period and the loss of water measured and checked.
- **Air test**; it is done by isolating the section of pipe that needs to be tested using plugs, and setting two different pressures for five minutes each. Any change in pressure over those five-minute time periods is measured and recorded.
- **Pressure test**; it is performed to ensure the safety, reliability, and leak tightness of pressure systems. A pressure test is required for a new pressure system before use or an existing pressure system after repair or alteration. There are two methods for pressure tests: hydrostatic and pneumatic.

1.2.4.4 Learning Activities

With the help of your trainer, you are required to install indirect system of cold water below.

Practical activities.

- Positions the pipes, set out and marked based on below working drawing.
- Thread pipes and carry out pipe jointing
- Cut Pipes based on type of pipe
- Carry out pipe bending based on jobs requirement
- Pipes are fitted based on drawing specifications.

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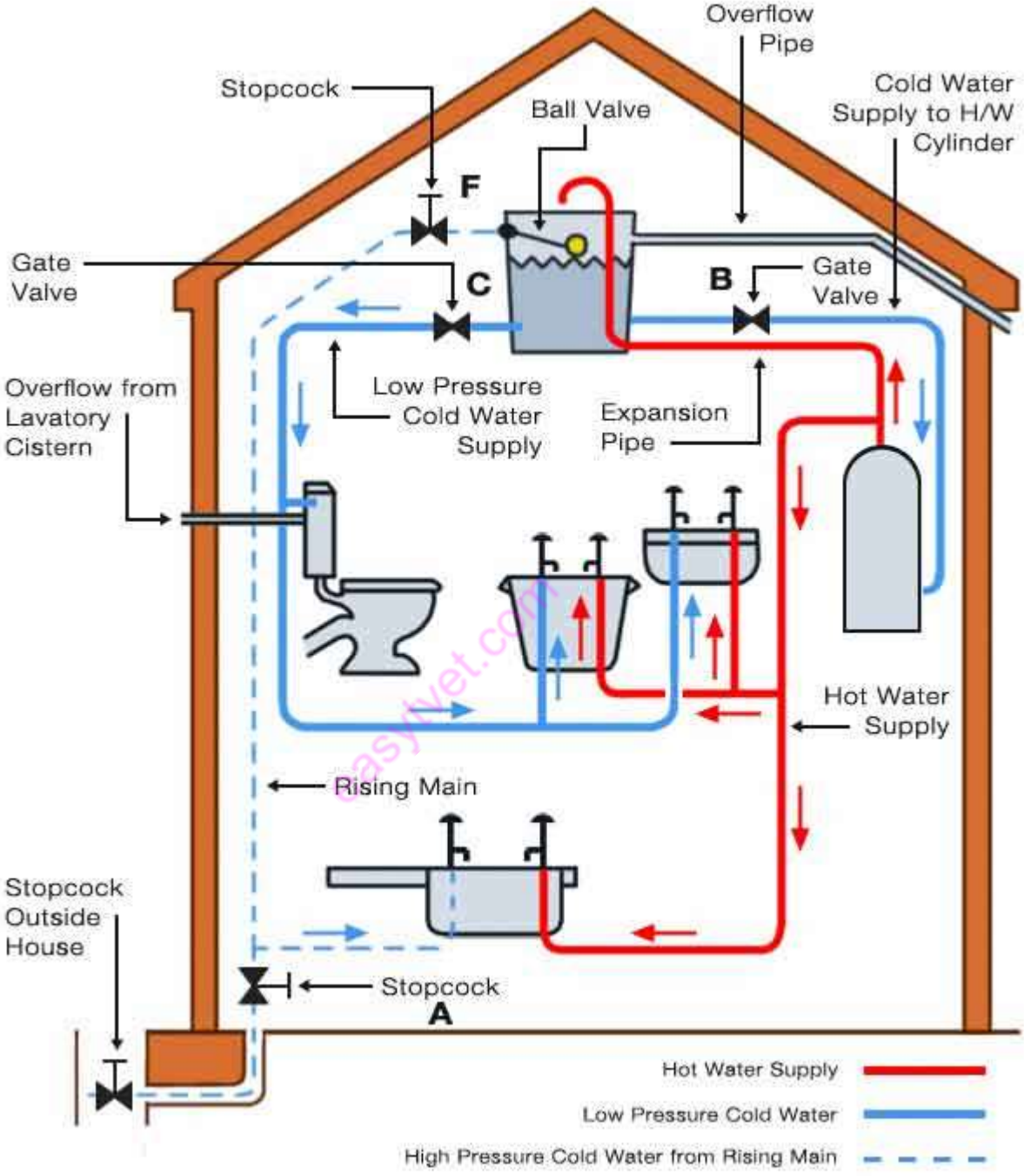

1.2.4.5 Self-Assessment

1) Define a valve and state various types.
2) Precautions should you take while Executing Layout of Pipes
3) State any three physical Effects on Pipe and Tube from Bending
4) State the use of the following fittings.
    - Caps
    - Plugs
    - Nipples
5) Which three methods are suitable for testing modern Drainage Water vent systems (DWV systems) for leaks?

1.2.4.6 Tools, Equipment, Supplies and Materials

Tools/Equipment:	**Materials:**
• Pipe wrench • Pipe cutter • Hacksaw • Pipe Threading Equipment • Vise - Bench • Tap and Punch • Files • Screwdrivers • Drill with various sizes of bits • Mallet • Ball hammer • Masonry chisel • PPR machine / Heat Fusion	• Hardhat • Gloves • Dustcoat / overall • Safety shoes / boots • Various types of pipe support • Sandpapers • Threading oil • Thread tape • Caulking material

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• equipment • Pipe bender	

1.2.4.7 References

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https://www.youtube.com/watch?v=ghcdZRUZ0MU

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1.2.4.8 Model answers

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

   Examples

- Globe valves
- Gate valves
- Plug valve/ plug cork
- Ball cork
- Float valve/ ball valve

2. **Precautions while Executing Layout of Pipe**
   - Pipe work and appliances should be arranged in such a way that allows close grouping of connections with water closet near main soil pipe.
   - The branch pipes should be kept short to reduce noise.
   - When the basin and bath are at some distance from the stack, it would be cheaper and simpler to combine the waste pipes into one.
   - Any bends in the waste pipe should be of large radius.
   - The pipe work in branch connections should be arranged to allow free drainage for the system.
   - All connections to main or branch pipes should be arranged in such a way that prevents cross flow from one appliance to another.
   - Branch connections should be of large radius along the invert.
   - The minimum diameter of soil and waste stacks should be 100 mm and 75 mm respectively.
   - When the pipes are covered, hard to find along the internal face of the walls, they should be of cast iron.

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- All pipes including those laid on external face of the wall should be of cast iron on the ground floor.

3. **State any three physical Effects on Pipe and Tube from Bending**

- Wrinkles on the inner side of the bend
- Stretching of the wall on the outer side of the bend
- Thinning of the wall thickness on the outer side of the bend
- Deformation of the cross section of the pipe or tube causing it to reduce and form an oval shape.

4. **State the use of the following fittings.**

- **Caps:** Used to close the end of a dead-end pipe.
- **Plugs:** Used to close an ending on a pipe fitting normally used for inspection or cleanout.
- **Nipples:** Short lengths of pipe threaded at both ends.

5. **Which three methods are suitable for testing modern Drainage Water vent systems (DWV systems) for leaks?**

Air

Water

Smoke

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1.2.5 Learning Outcome 5: Design simple pipework

1.2.5.1 Introduction to the learning outcome

This outcome specifies the competencies required to design simple pipework as it applies in the construction industry.

1.2.5.2 Performance Standard

1. Number and type of ***appliances*** are identified based on working drawings

2. Flow rates are calculated based on flow charts
3. Pipes are ***sized*** based on standards

1.2.5.3 Information Sheet

System layout and pipework

The water supply system must be designed to achieve appropriate water pressure and flow, and to avoid contamination to potable water.

Water pressure

If the aim is to provide for building users' needs while also using water efficiently, the right water pressure is crucial. If water pressure is too low, this will be inconvenient for building users – for example, because showers have poor water flow, and baths take a long time to fill. If pressure is too high, this will lead to wastage of water, as well as high wear and tear on the system.

Water flow rate

The Building Code requires that sanitary fixtures and appliances have adequate water supply at an adequate flow rate.

Flow rate is affected by:

- Water pressure
- Pipe diameters – The smaller the internal diameter of the pipe, the lower the pressure and flow rate. (Note that pipes are generally referred to by their inside nominal diameter (DN), but it is actually the internal diameter that counts; a pipe rated as DN 15 may have an actual inside diameter ranging between 10–18 mm.)
- Water temperature – higher temperatures will tend to raise pressure and flow rates (note: also see materials below).

Flow rate and pipe size Acceptable Solutions

Pipes must be sized to achieve flow rates set out in accordance with Table 3 (see table below), or the pipes must be sized in accordance with Table 5..

When calculating pipe size, the speed of the water (velocity) moving through the pipes must not exceed 3.0 m/s.

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When calculating pipe size, the speed of the water (velocity) moving through the pipes must not exceed 3.0 m/s.

Table 5: Acceptable flow rates for fixtures and appliances

Fixture	Flow rate (l/s) and temperature °C
Basin	0.1 at 45 °C
Bath	0.3 at 45°C
Sink	0.2 at 60°C (hot) and 0.2 (cold)
Shower	0.1 at 42°C
Laundry tub	0.2 at 60°C (hot) and 0.2 (cold)
Dishwasher and washing machine	0.20

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System layout

In the design process, the layout of the plumbing system will largely follow room layout. Nonetheless, there are many things to consider which relate to Code compliance, building users' comfort, and sustainability.

When planning a water supply layout, the following must be considered:

- Pipe runs and lengths – Keep pipe runs as short as possible. Pass pipes close to fixtures to minimize the number of branches and unnecessary elbows, tees and joints. Having longer pipe runs and more fixtures will reduce flow rate, increase heat losses, and increase use of materials
- Point of entry into the building – This should be into a utility space such as garage/laundry and include an accessible isolating valve, line strainer and pressure limiting valve (if required)
- Water heating system – Locate centrally to reduce the length of pipe runs to fixtures because longer pipe runs require more water to be drawn off before hot water is discharged. Install a separate point-of-use water heater for fixtures that are more than 10 m from the main water heater
- Noise prevention – Avoid running pipes over or near bedrooms and living areas.

Backflow

Backflow is the unplanned reversal of flow of water (or water and contaminants) into the water supply system. The system must be designed and used to prevent contamination from backflow

Mains connection

Where the water source is a mains supply, the network utility operator is responsible for the water supplied to the property boundary. The property owner is then responsible for providing the pipework to bring the water into the building.

An isolating valve must be fitted at the point of connection to allow for maintenance and repair of the building's water supply system if required.

Pipe materials and specifications

The pipes used in a building must not contaminate potable water supply, and must be suitable for the water pressure, flow rate and temperature of water they will be carrying. This will be influenced by the materials used and also by other factors such as the wall thickness.

Other considerations are durability, ease of installation, cost, and sustainability. Common materials for domestic water supply include copper, polybutylene (PB), polyethylene (PE), polypropylene (PP-3 or PP Type 3), and cross-linked polyethylene (PEX).

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Domestic Hot Water Service Systems - Design Procedure

Hot water supply must be adequate to meet building users' needs while also keeping them safe. It should also support efficient use of both energy and water.

Design procedure for domestic hot water service systems

The design of a hot water service system may follow the procedure:

1. Determine the demand of hot water from the consumers - quantity and temperature
2. Select the type, capacity and heating surface of the calorifier - or heat exchanger
3. Select the source of heat available.
4. Design the pipe scheme and determine the size of the pipes

The Demand of Hot Water - quantity and temperature

Hot water is normally supplied to fittings and their consumers at *50 - 60 °C*. For canteens and professional kitchen temperatures of *65 °C* are often required to satisfy hygienic standards. Hot water should not be stored at temperatures below *60 °C (140 °F)* to avoid the risk of **contamination**.

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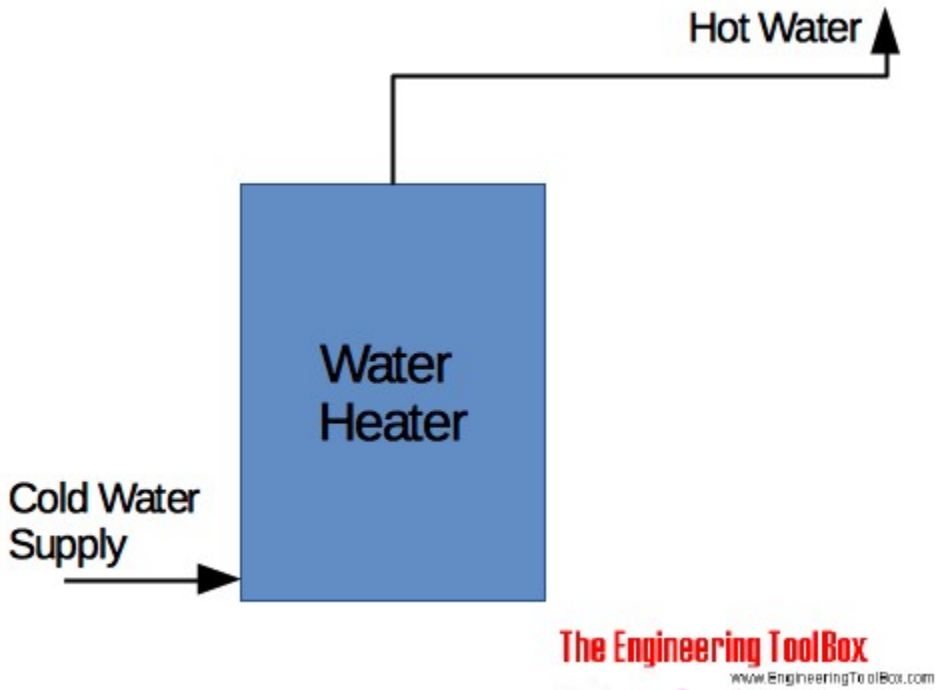
Where lower temperatures are necessary for safety reasons - as in kindergartens, centers for disabled etc. - the hot water temperature should not exceed *40 - 50 °C*. Special care should be taken - like regular disinfection of fittings - to avoid infections.

Note! Hot water can be stored at higher temperatures and reduced to lower supply temperatures by mixing in cold water in blender valves. Storing the hot water at a higher temperatures increases the system overall capacity and reduces the need of storage volume.

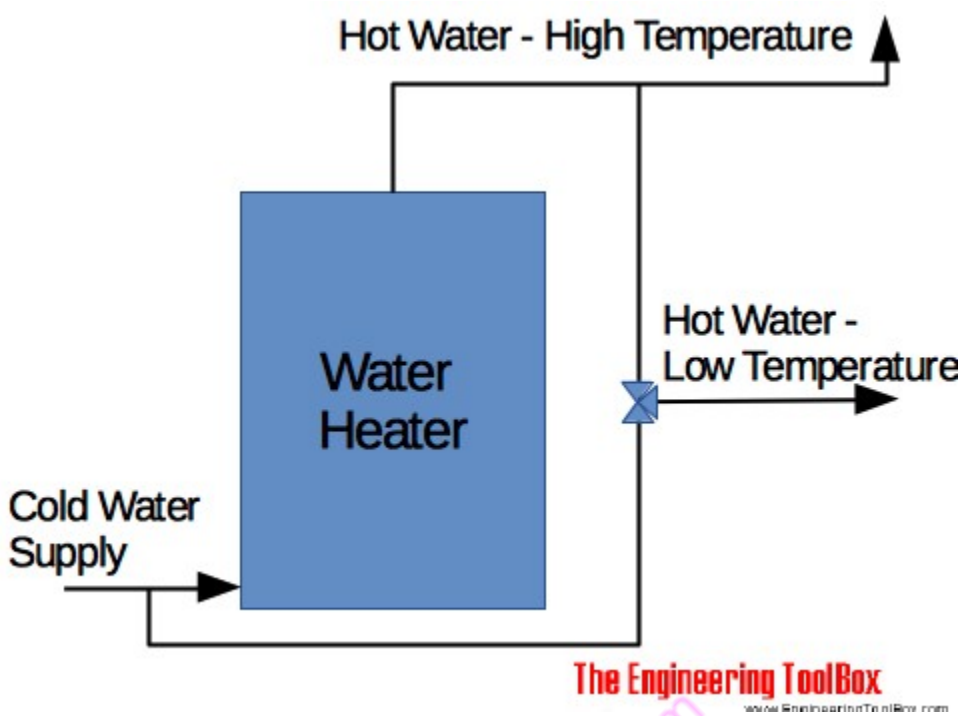
Water Heater - Single Temperature

The water is heated and stored in the same storage tank at the same temperature as supplied to the consumers.



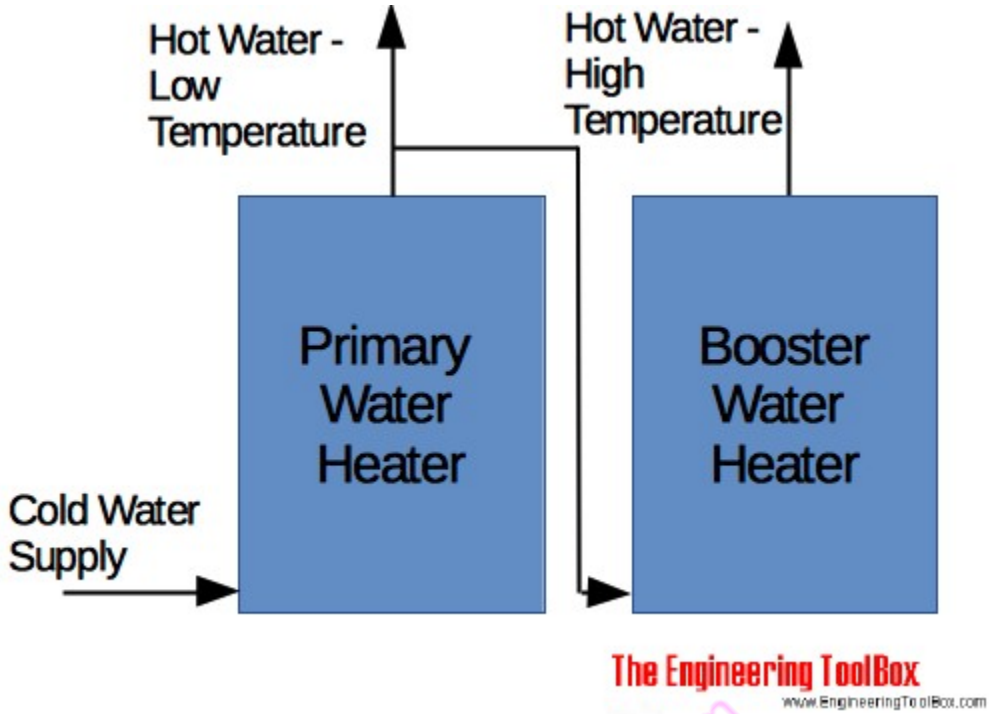
Water Heater - Two Temperature with Mixing Valve

The water is heated and stored in the same storage tank at higher temperature than supplied to most of the consumers. The hot water is mixed down to consumer temperature with cold water before supplied to the fittings.



Water Heater - Two Temperature with Boosting Tank

The water is heated and stored at consumer temperature before distributed to normal consumers. Water from this store is supplied to another heater and storage tank where the water is heated to higher temperatures before distribution.



The quantity of hot water is determined by number of occupants and their consumption habits. Timing is very important since consumption varies over the day.

Key Coding; it's a good idea to code your map to keep the different elements straight like:

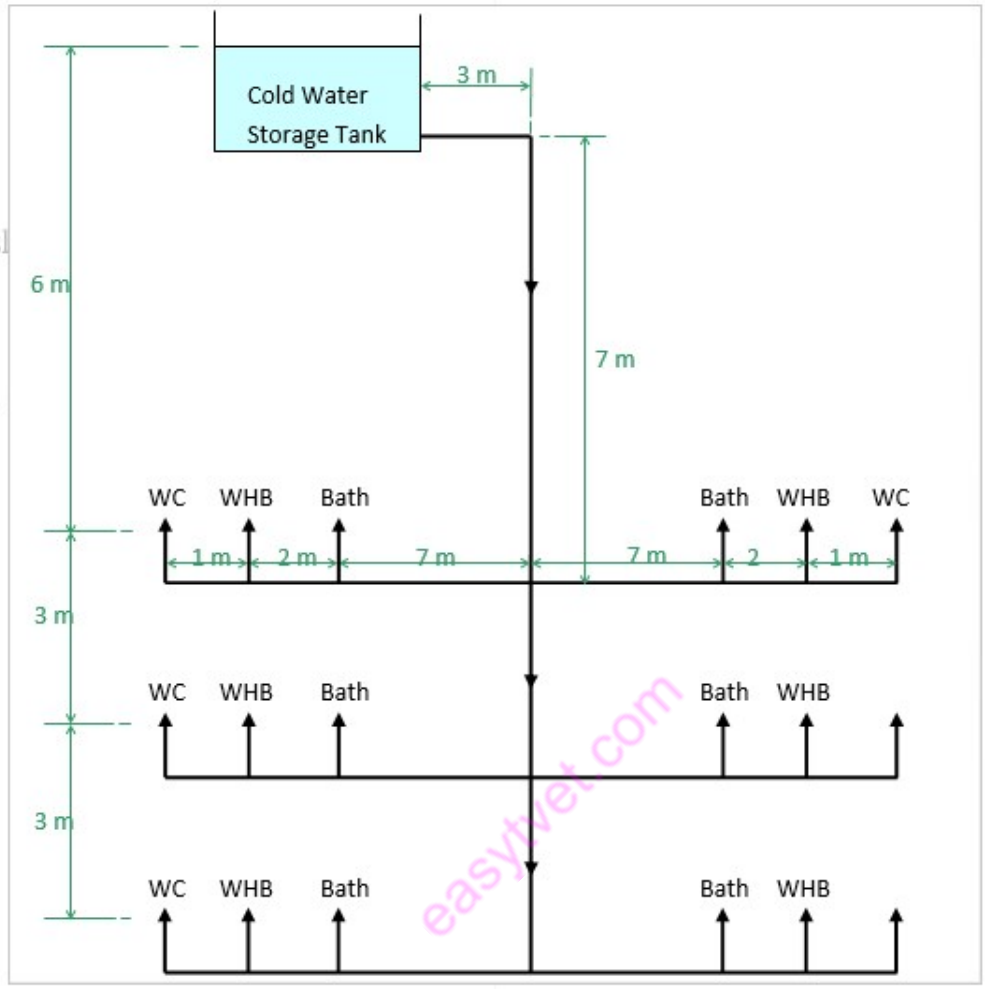
- Show drainpipes with solid lines and supply lines with broken lines.
- Indicate vertical runs with note on the overhead view.
- Mark hot and cold supply lines with colored pencils and color-code drains and vents.
- Point to pipe sizes with a curved leader line to avoid mistaking the leader for a pipe.

Pipe Sizing Procedure for water supply system

NON-PRESSURISED COLD WATER PIPE SIZING

• This method is pipe sizing where the pressure available is not from a pump but from the head available from the tank.

• The higher the tank is above the outlets the more head will be available to force the water through the outlets and overcome pipe work resistances.



Pipe Size Procedure

- Divide system into sections.
- Calculate demand units if simultaneous demand is effective.
- Estimate flow rates in each section.
- Estimate pipe diameter.
- Measure the pipe run for the section.
- Calculate length of pipe equal to resistance of fittings.
- Calculate effective pipe length.
- Determine pressure loss due to friction for pipe

- Calculate pressure consumed by friction.
- Calculate cumulative pressure consumed

Domestic water pipe sizing

The sizing of domestic water supply system must be based on the minimum pressure available for the building in question. The designer must ensure that the required pressure is maintained at the most hydraulically remote fixture and that proper and adequate quantities of flow are maintained at all fixtures. In addition, the designer must ensure that reasonable velocities are maintained in all piping. The velocity of water flowing in a pipe should not exceed 10 feet/sec and should be designed for 7-8 feet per second or less, because high velocities will increase the rate of corrosion leading to pipe failure and cause undesirable noises in the system and increase the possibility of hydraulic shock. The designer should compute and/or know the following:

1. Hydraulically remote fixture
2. Available main pressure
3. Pressure required at individual fixtures
4. Static pressure losses (height of highest fixture relative to main pressure)
5. Water demand (total system, and each branch, fixture)
6. Pressure loss due to friction
7. Velocity

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Pipe sizes

May include but not limited to:

- 13mm
- 19mm
- 25mm
- 32mm
- 38mm

PIPING CALCULATION:

LINE SIZING:

- Pipe Line is sized based on continuity equation

Q= A x V

Where

- Q= Flow (m^3/sec)
- A= Inside cross section area of pipe (m^2)
- V= Velocity (m/sec)

  From the above equation its clear that;
- When the diameter of the pipe increases the area of the cross-section increases as well as its volume thereby increasing quantity/flow of the water/ liquid and vice versa.

Types of water supply system

1. **Cold water supply**

Two types of cold water supply systems

- Direct
- Indirect**.**

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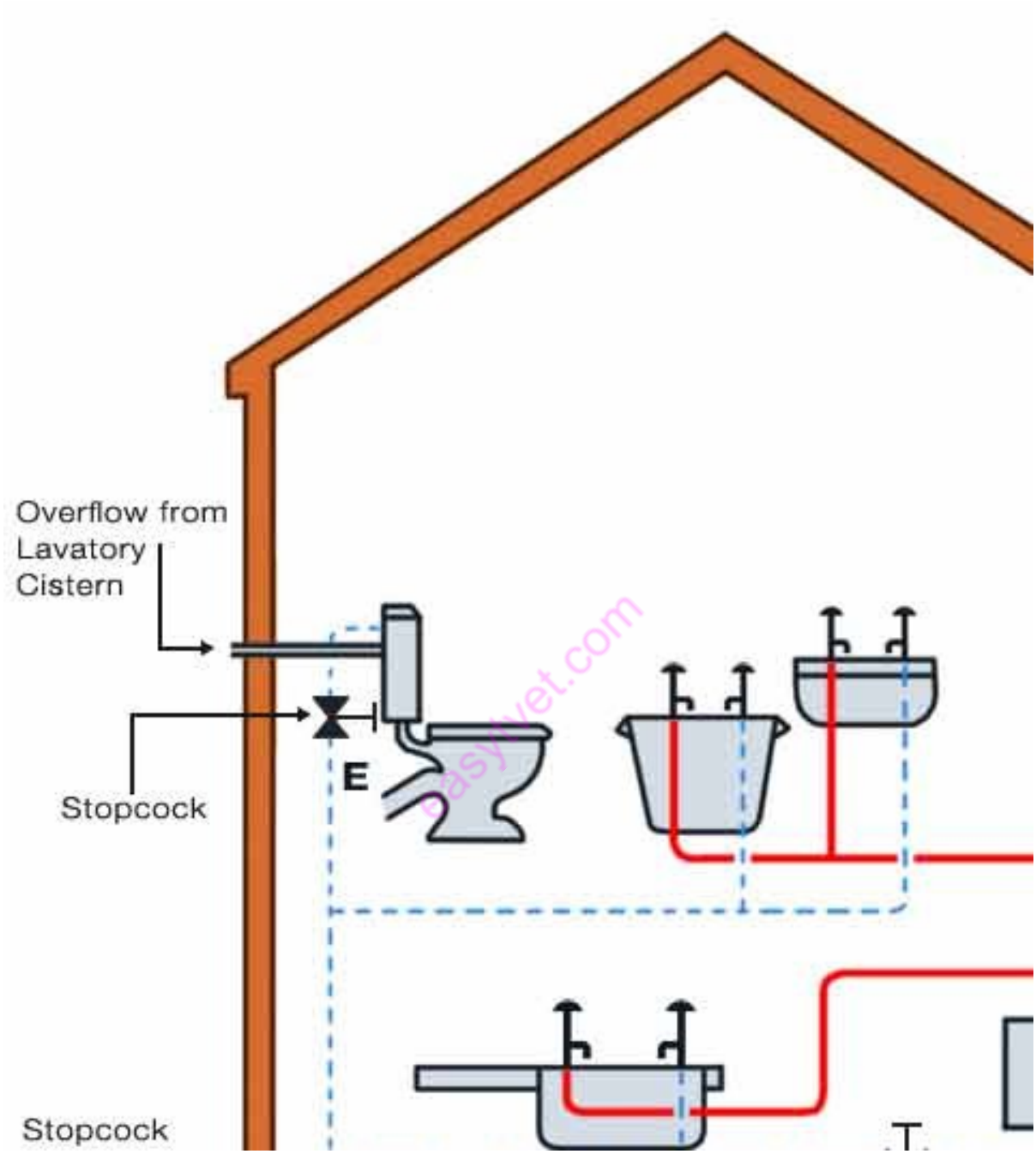
Direct water supply

A direct water supply system is one where the raising main feeds directly the cold water taps and a multi-point water heater.

The mains water comes in via a rising main and directly feeds all the cold taps and a multi-point water heater - so all the taps and other water feeds are at mains water pressure. Note that in this article, we are dealing with just the hot and cold water supplies to the taps etc., we are not dealing with the central heating system.

The picture below shows a direct cold water system where cold water is distributed all over the house at mains pressure.

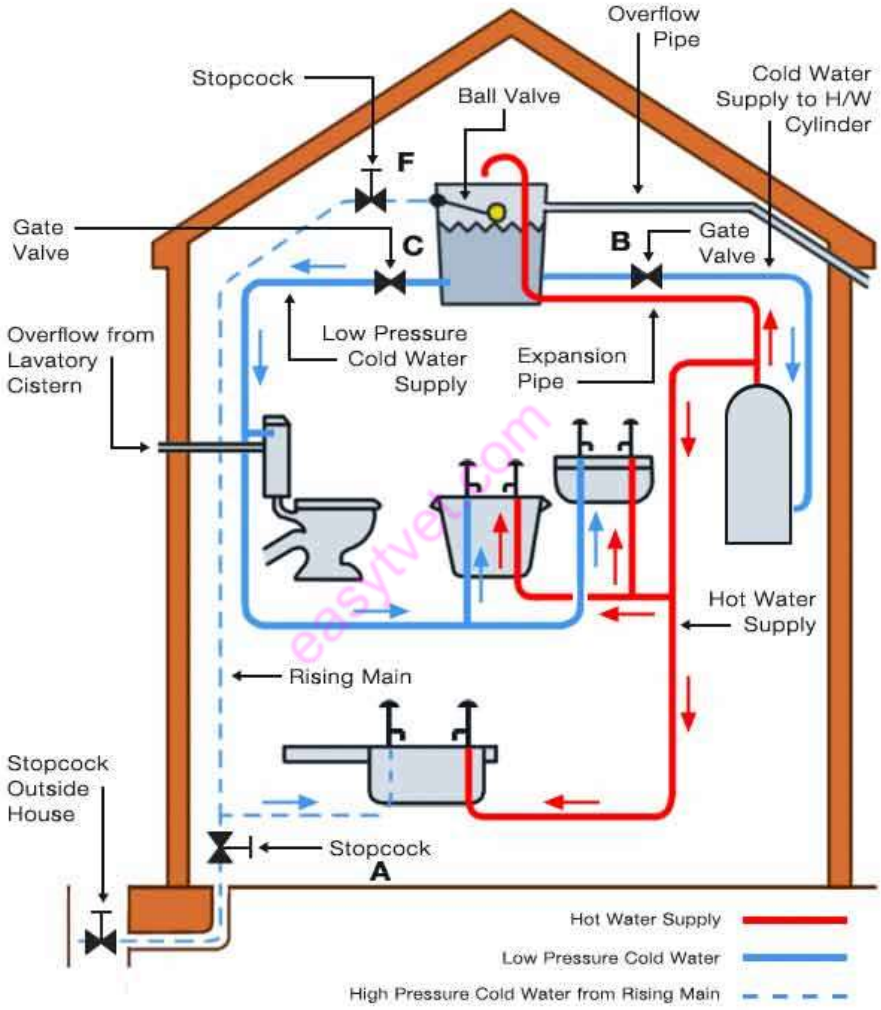


Indirect Cold Water System

In the indirect cold water system, water comes into house via rising main. It is then branched off to feed at least one tap (in the image above, this is the kitchen and outside tap and the boiler

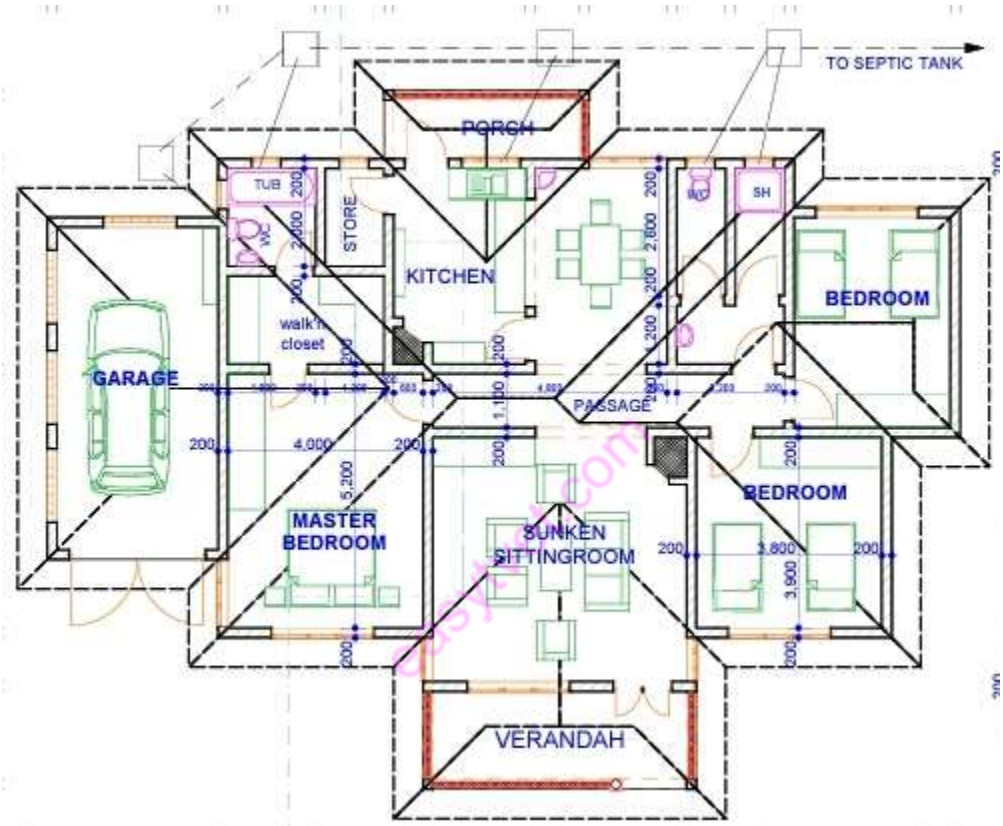
next to the sink) and then continues to a storage tank in the loft. From here it is distributed to the other taps in the house. Overflow pipes are marked The position of stopcocks etc is marked on the diagram below which also shows the hot water path.

Domestic indirect water system



1.2.5.4 Learning Activities

- Design a simple isometric pipe work drawing for the cold water supply for the plan below.;
- Assume any other relevant information.



1.2.5.5 Self-Assessment

1) State two types of cold water supply.
2) Highlight the procedure for designing domestic hot water
3) Distinguish direct from indirect water supply.
4) Explain the term ”backflow” Backflow is the unplanned reversal of flow of water (or water and contaminants) into the water supply system

1.2.5.6 Tools, Equipment, Supplies and Materials

- **Drawing boards**
- **T squares**
- **Set squares**
- **Drawing sets**
- **Drawing paper**
- **Protractors**
- **Eraser Shield**
- **Pencils**
- **Erasers**
- **Masking tapes**
- **Paper clips**
- **Drawing curves**
- **Technical drawing software'**

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1.2.5.7 References

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1.2.5.8 Model Answers.

1) **State two types of cold water supply.**
    - Direct system
    - Indirect system
2) **Highlight the procedure for designing domestic hot water**

- Determine the demand of hot water from the consumers - quantity and temperature
- Select the type, capacity and heating surface of the calorifier - or heat exchanger
- Select the source of heat available.
- Design the pipe scheme and determine the size of the pipes

3) **Distinguish direct from indirect water supply.**
   In **direct supply**, all the household appliances (fixtures) receive water directly from the mains (i.e direct supplies from the authorities that collects water from source, treats it and distribute same while in **indirect water supply system**, water is first filled into cistern (tank; overhead or underground) from mains and the appliances receive water from the cistern(tank) mostly overhead water tank.
4) **Explain the term "backflow"**
   Backflow is the unplanned reversal of flow of water (or water and contaminants) into the water supply system

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1.2.6 Learning Outcome 6: Install Water distribution system

1.2.6.1 Introduction to the learning outcome

This outcome specifies the competencies required to install water distribution systems as it applies in the construction industry.

1.2.6.2 Performance Standard

1. Water distribution systems is identified and interpreted based on the drawing
2. Positions of pipes are set out and marked based on working drawings
3. Water distribution materials and supplies are estimated based on the drawing.
4. Tools and equipment are identified according to job requirement.
5. Water distribution system is installed based on codes of practice
6. Housekeeping is conducted as per workplace procedures
7. Functionality tests are conducted based on best practices.
8. Faults in functionality and leakage are corrected based on best practice.
9. Safety and health practice are observed based on OSHA.

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1.2.6.3 Information Sheet

A water distribution system is a part of water supply network with components that carry potable water from a centralized treatment plant or wells to water consumers in order to adequately deliver water to satisfy residential, commercial, industrial and firefighting requirements. A water distribution system consists of pipes, storage facilities, pumps, and other accessories.

Requirements of an adequate distribution system

- Water quality should not deteriorate while in the distribution pipes.
- The system should be capable of supplying water to all the intended places with sufficient pressure head.
- It should be capable of supplying the requisite amount of water during firefighting.
- The layout should be such that no consumer is without water supply, during the repair of any section of the system.
- All the distribution pipes should preferably be laid one metre from or above sewer lines.
- It should be fairly watertight to keep losses (e.g. due to leakage) to a minimum.

Network type

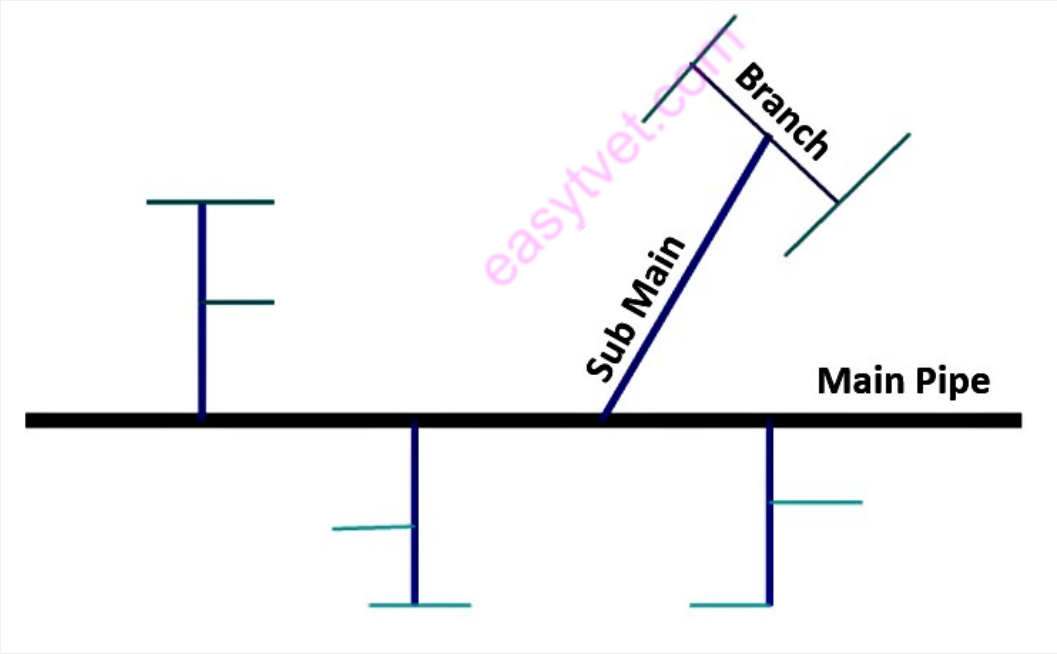
There are four principal methods to design a distribution system:

- Dead end or tree system
- Gridiron system
- Circular or ring system
- Radial system

1. Dead-end or tree distribution system

Description

In the dead end system (also called tree system), one main pipeline runs through the centre of the populated area and sub-mains branch off from both sides. The sub-mains divide into several branch lines from which service connections are provided.



Schematic design of a dead-end distribution system. Source: GONU (2009)

Advantages dead-end System:

- The design calculation is simple and easy.
- A smaller number of cut-off valves are required and the operation and maintenance cost is low.
- Pipe laying is simple

Disadvantages dead-end system:

- The system is less successful in maintaining satisfactory pressure in remote areas and is therefore not favoured in modern waterworks practice
- One main pipeline provides the entire city, which is quite risky
- The head loss is relatively high, requiring larger pipe diameter, and/or larger capacities for pumping units. Dead ends at line terminals might affect the quality of water by allowing sedimentation and encouraging bacterial growth due to stagnation. Water hammer could also cause burst of lines. A large number of scour valves are required at the dead ends, which need to be opened periodically for the removal of stale water and sediment
- The discharge available for firefighting in the streets is limited due to high head loss in areas with weak pressure

2. Gridiron distribution system

Description:

In this system the main supply line runs through the centre of the area and sub mains branch off in perpendicular directions. The branch lines interconnect the sub-mains. This system is ideal for cities laid out on a rectangular plan resembling a gridiron. The distinguishing feature of this system is that all of the pipes are interconnected and there are no dead ends. Water can reach a given point of withdrawal from several directions, which permits more flexible operation, particularly when repairs are required.

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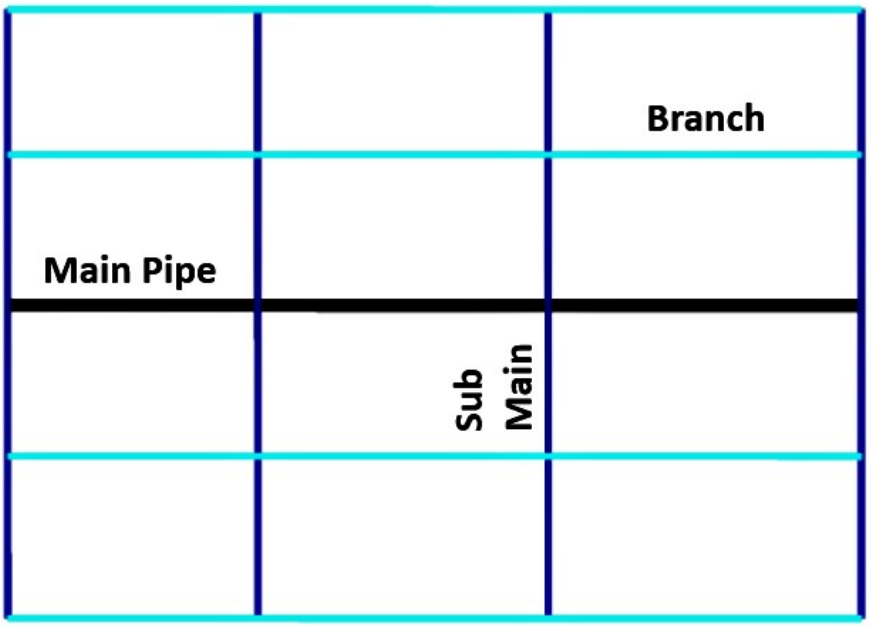


Design of the Gridiron distribution system. Source: GONU (2009)

Advantages of the Gridiron distribution system:

- The free circulation of water, without any stagnation or sediment deposit, minimises the chances of pollution due to stagnation.
- Because of the interconnections water is available at every point with minimum loss of head.
- Enough water is available at street fire hydrants, as the hydrant draws water from the various branch lines.
- During repairs, only a small area of distribution is affected.

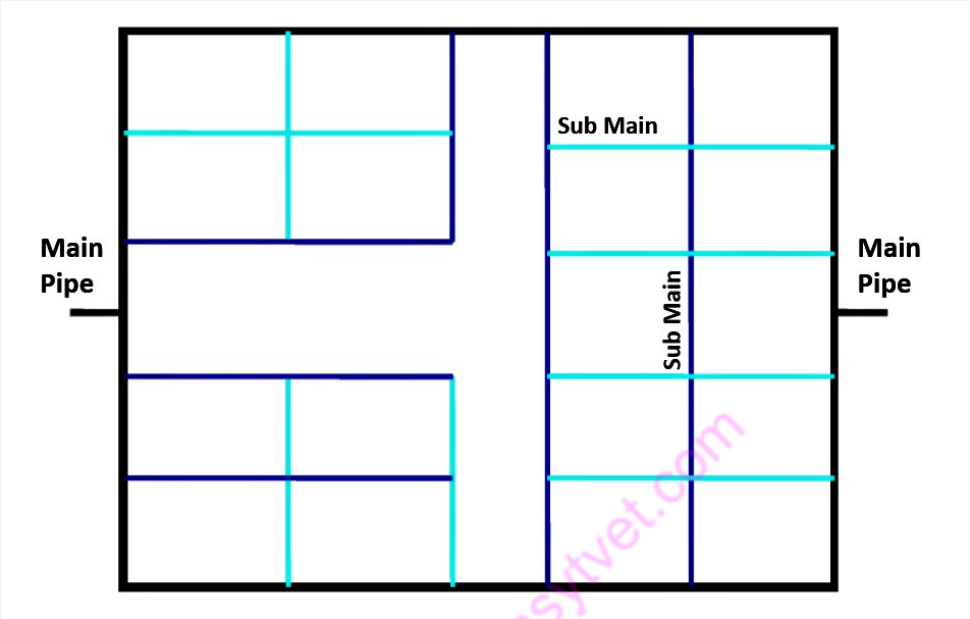
Disadvantages of the Gridiron distribution system:

- A large number of cut-off valves are required.
- The system requires longer pipe lengths with larger diameters.
- The analysis of discharge, pressure and velocities in the pipes is difficult and cumbersome.
- The cost of pipe laying is higher.

3. Circular or ring distribution system

Description:

In a circular or ring system, the supply main forms a ring around the distribution area. The branches are connected cross-wise to the mains and also to each other. This system is most reliable for a town with well-planned streets and roads. The advantages and disadvantages of this system are the same as those of the gridiron system. However, in case of fire, a larger quantity of water is available, and the length of the distribution main is much higher.

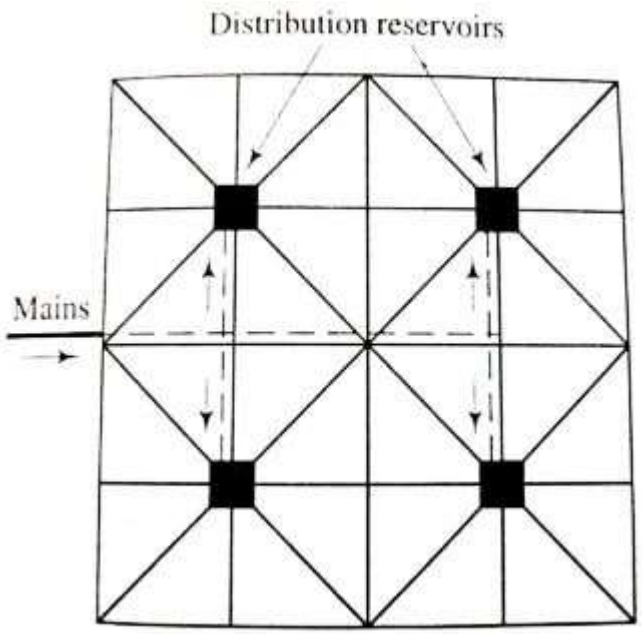


Design of a ring distribution system.

4. Radial distribution system

Description:

In this system, the whole area is divided into a number of distribution districts. Each district has a centrally located distribution reservoir (elevated) from where distribution pipes run radially towards the periphery of the distribution district. This system provides swift service, without much loss of head. The design calculations are much simpler.



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Supply Water System

There are two main water systems;

- **Direct Water Supply System:** All water outlets of a house receive water directly from the mains. Portable water is available at all faucets. This is possible where water source delivers water throughout and with high water pressure, sufficient enough to deliver water at an adequate pressure at all taps.
- **Indirect Water Supply System:** Water from mains is conveyed to storage water tanks. Water is then delivered to the house from water storage tank. This system is adopted where water supply from mains is not available throughout the day. It is also used when water pressure in mains is not sufficient enough to deliver water at all faucets with adequate pressure.

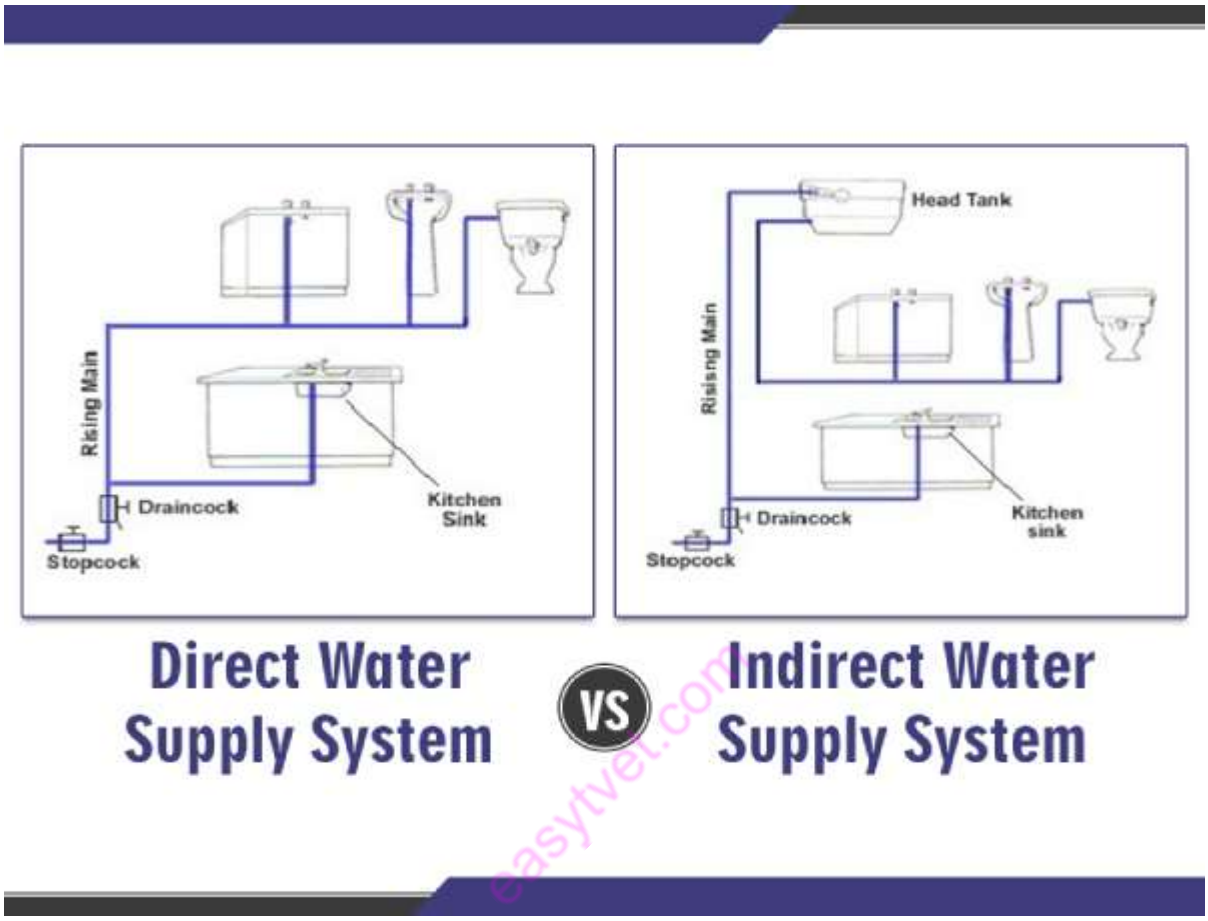

Figure 128: water systems

Direct Water Supply System

Advantages:

- Reduces pipe works and cost of same, as pipes to and from tank for cold water are omitted.
- Good quality drinking water is available at all taps.
- Energy is saved as pumps are not required to pump water to cistern/tanks.
- Installation cost is reduced compared to indirect water supply because no storage tank is required and even reduces maintenance cost of tank (underground as well as overhead).
- It reduces the chances of bacterial contamination.
- Water quality is maintained.

Disadvantages:

- If water is supplied only for specific period of time continuous water flow will not be available and such system cannot survive. As throughout water supply would not be available.
- Pipes have leakage due to high pressures.
- If main pipe gets damaged whole water supply to the home has to be stopped till main is fixed

Indirect Water Supply System

Advantages:

- It imposes less pressure on distribution network, as rising main is not connected to all fixtures directly.
- There is no threat of pipe burst.
- If main is damaged or when water supply is stopped during certain time period; water can still be made available to users from the storage tanks.
- Less wear and tear of all fixtures because of less pressure and plumbing materials.
- Water leakages are less because water pressure will be less from tank and less water will escape and have less loss.

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Disadvantages:

- Normally, storage water tanks are kept on roof top due to which there is not enough pressure on immediate lower floor causing problem in working of showers and flush valves in particular.
- Water stored in storage tank degrades over a period of time from quality point of view.
- Additional pipe network is required for carrying water to storage tank and from storage tank to appliances, increasing cost of pipe works and of course of pumps.
- Clean water may not be available at all taps.
- If sufficient pressure is not available, booster pumps are required for getting water at pressure like 7 to 10m height.
- You have to regularly operate and maintain pumps.

- The tank will always need maintenance and may create problem of leakages.
- The tank adds cost to the building.
- The tank also adds to the dead weight of the building.

Tools and equipment's.

- Tubing Cutter
- Hacksaw
- Hole saw kit
- Pipe and tube benders
- Mole grips
- Plumber's torch
- Thread sealing tape
- Pliers
- Press fitting systems
- Flashlight
- Ratcheting pipe threader set

Plumber Wrenches

- Pipe wrench
- Adjustable wrench
- Basin wrench
- Faucet key
- Torque wrench
- Internal pipe wrench

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Plumbing Safety Tools

- Gloves
- Goggles
- Heat shields or pads

Testing

- **Smoke test**; forces smoke-filled air through pipe line. The smoke under pressure will fill the main line plus any connections and then follow the path of any leak to the ground surface, quickly revealing the source of the problem.
- **Air test**; it is done by isolating the section of pipe that needs to be tested using plugs, and setting two different pressures for five minutes each. Any change in pressure over those five-minute time periods is measured and recorded.
- **Pressure test**; it is performed to ensure the safety, reliability, and leak tightness of pressure systems. A pressure test is required for a new pressure system before use or an existing pressure system after repair or alteration. There are two methods for pressure tests: hydrostatic and pneumatic.

Good housekeeping through OSHA's rules for installation of hot and cold water system (revisit)

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- Housekeeping is to be clean, orderly, and sanitary.
- Floors are to be clean and dry.
- Aisles and passageways are to have sufficient clearance. They are to be kept clear, without obstructions that could create a hazard.

Good housekeeping practices should include but not limited to;

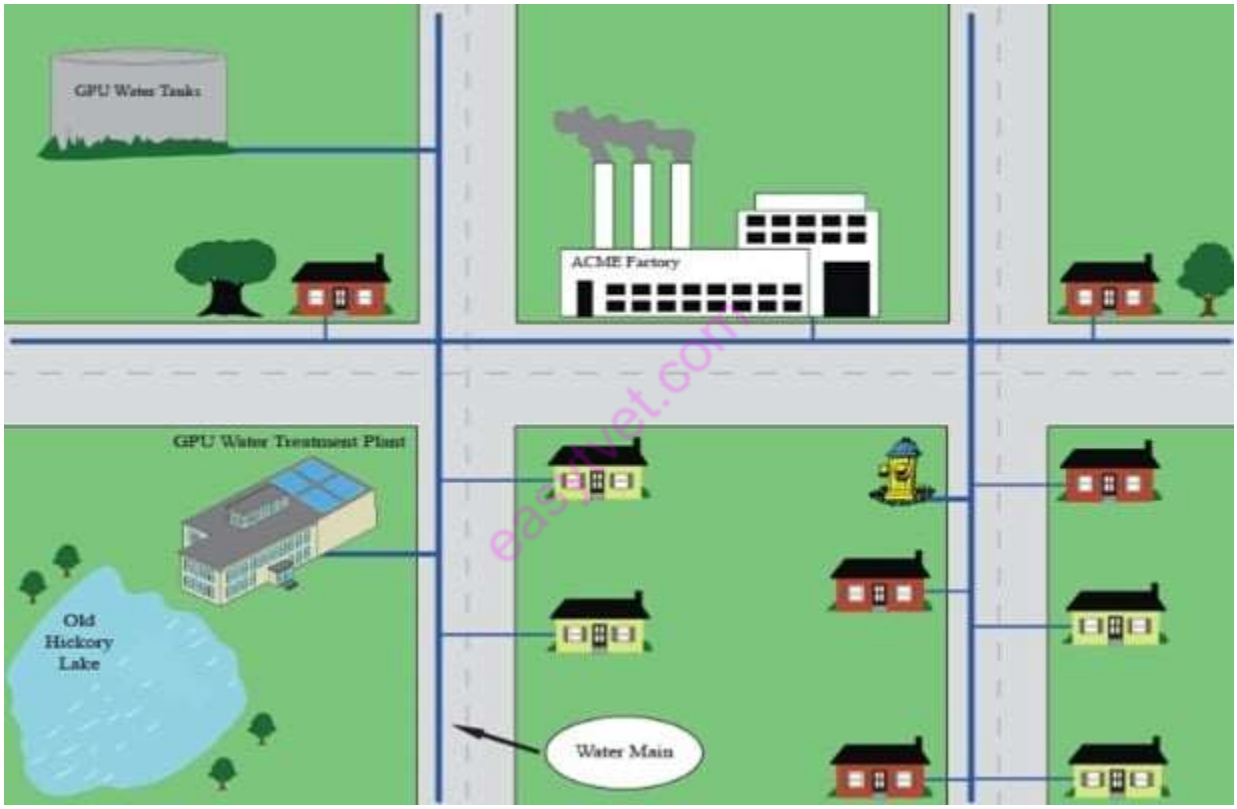
- Floors being kept dry at all times.
- Disposal containers used for liquids or solids that may turn putrid not leaking, and they must have tight fitting covers;
- Sweepings, wastes, and refuse being removed always.
- All exit routes being free and unobstructed i.e., no materials or equipment should be placed, permanently or temporarily, within the exit route.

- Permanent aisles being marked clearly

1.2.6.4 Learning Activities

Below is a system layout of water distribution, with the help of your trainer you are required to ;

- Identify the Water distribution systems based on the drawing
- Positions of pipes are set out and marked based on working drawings
- Identify Tools and equipment according to job requirement.
- Install Water distribution system



1.2.6.5 Self-Assessment

1) Explain the term “water distribution system:
2) List any three requirements of an adequate distribution system.
3) State any two disadvantages of dead end system

4) State four principal method of designing a distribution system.
5) Sketch the dead end or tree system.

1.2.6.6 Tools, Equipment, Supplies and Materials

Tools/Equipment:	**Materials:**
• Pipe wrench • Pipe cutter • Hacksaw • Pipe Threading Equipment • Bench-vice • Tap and Punch • Files • Screwdrivers • Drill with various sizes of bits • Mallet • Ball hammer • Masonry chisel • PPR machine / Heat Fusion • equipment • Pipe bender • House keeping equipments. •	• Hardhat • Gloves • Dustcoat / overall • Safety shoes / boots • Various types of pipe support • Sandpapers • Threading oil • Thread tape • Caulking material

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1.2.6.7 References

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1.2.6.8 Model Answers

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1. **Explain the term "water distribution system:**
   A water distribution system is a part of water supply network with components that carry potable water from a centralized treatment plant or wells to water consumers in order to adequately deliver water to satisfy residential, commercial, industrial and firefighting requirements
2. **List any three requirements of an adequate distribution system.**

- Water quality should not deteriorate while in the distribution pipes.
- The system should be capable of supplying water to all the intended places with sufficient pressure head.
- It should be capable of supplying the requisite amount of water during firefighting.
- The layout should be such that no consumer is without water supply, during the repair of any section of the system.
- All the distribution pipes should preferably be laid one metre from or above sewer lines.
- It should be fairly watertight to keep losses (e.g. due to leakage) to a minimum.

3. **State any two disadvantages of dead end system**

- The system is less successful in maintaining satisfactory pressure in remote areas and is therefore not favoured in modern waterworks practice
- One main pipeline provides the entire city, which is quite risky
- The head loss is relatively high, requiring larger pipe diameter, and/or larger capacities for pumping units.
- The discharge available for firefighting in the streets is limited due to high head loss in areas with weak pressure

4. **State four principal method of designing a distribution system.**
    - Dead end or tree system
    - Gridiron system
    - Circular or ring system
    - Radial system

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5. **Sketch the dead end or tree system.**