1. Plumbing

Plumbing Is any system that conveys fluids for a wide range of applications. Plumbing uses pipes, valves, plumbing fixtures, tanks, and other apparatuses to convey fluids. Heating and cooling, waste removal, and potable water delivery are among the most common plumbing uses, but it is not limited to these applications. The word derives from the Latin for lead, *plumbum*, as the first effective pipes used in the Roman era were lead pipes. In the developed world, plumbing infrastructure is critical to public health and sanitation.

1.1 Systems

The major categories of plumbing systems or subsystems are:

a. potable cold and hot tap water supply
b. plumbing drainage venting
c. sewage systems and septic systems with or without hot water heat recycling and graywater recovery and treatment systems
d. Rainwater, surface, and subsurface water drainage
e. fuel gas piping
f. Hydronics, i.e., heating and cooling systems using water to transport thermal energy, as in district heating systems, like the New York City steam system.

1.2 Water Pipes

A ***water pipe*** is a pipe or tube, frequently made of plastic or metal, that carries pressurized and treated fresh water to a building (as part of a municipal water system) and inside the building.

1.2.1 Difference between pipes and tubes

The difference between pipes and tubes is a matter of sizing. For instance, PVC pipe for plumbing applications and galvanized steel pipe are measured in iron pipe size (IPS). Copper tube, CPVC, PeX and other tubing is measured nominally, basically an average diameter. These sizing schemes allow for universal adaptation of transitional fittings. For instance, 1/2" PeX tubing is the same size as 1/2" copper tubing. 1/2" PVC, on the other hand, is not the same size as 1/2" tubing and therefore requires either a threaded male or female adapter to connect them. When used in agricultural irrigation, the singular form "pipe" is often used as a plural.

The thicknesses of the water pipe and tube walls can vary. Because piping and tubing are commodities, having a greater wall thickness implies a higher initial cost. Thicker walled pipe generally implies greater durability and higher pressure tolerances. Pipe wall thickness is denoted by various schedules or large bore polyethylene pipe in the UK by the Standard Dimension Ratio (SDR), defined as the pipe diameter ratio to its wall thickness. Pipe wall thickness increases with schedule and is available in schedules 20, 40, 80, and higher in special cases. The schedule is largely determined by the system's operating pressure, with higher pressures commanding greater thickness. Wall thickness does not affect pipe or tubing size. A pipe is typically formed via casting or welding, whereas a tube is made through extrusion. The pipe normally has thicker walls and may be threaded or welded.

1.2.2 Some water supply line size facts simplified

Increasing the water supply line size to just one pipe size larger makes a dramatic difference. Individuals who are not in the plumbing trade do not realize that understanding length and understanding area are different factors.

As an example, 1 1/4″ is only 25% larger than 1″. But in terms of area, the inside area of these size pipes (water supply tubing) is a difference of about 56% greater. As another example, let's compare 1 1/2″ pipe to 2″ pipe. The difference in the area inside an 1 1/2″ pipe compared to a 2″ pipe is around 77%.

Fig. 1 Different size lines

In terms of the water supply line size table, whose key component is gallons per minute, the differences are even more dramatic. Basing calculations of an average run of pipe of 50′, an 1 1/4″ line provides 16 gallons per minute. On the other hand, a 1″ line only provides 9 gallons per minute. Therefore a 1 1/4″ line provides almost 77% more gallons per minute than a 1″ line.

The gallon per minute calculations on the sizing table are also based upon some other vital assumptions. All flow calculations are based upon connecting to the proper size of tap connection on the city water main. They are also based upon the building being on level ground. As an example, a house located on a hill or raised ground will decrease the flow rate.

What does all this mean to the average property owner? It means that increasing the size by just one side of the water supply line provides dramatic benefits for a nominal amount of money. The photo below clearly illustrates this point. But it should also be noted that if the inside plumbing on a building is undersized, no benefit will be derived by increasing the service line size unless the inside plumbing is also increased.

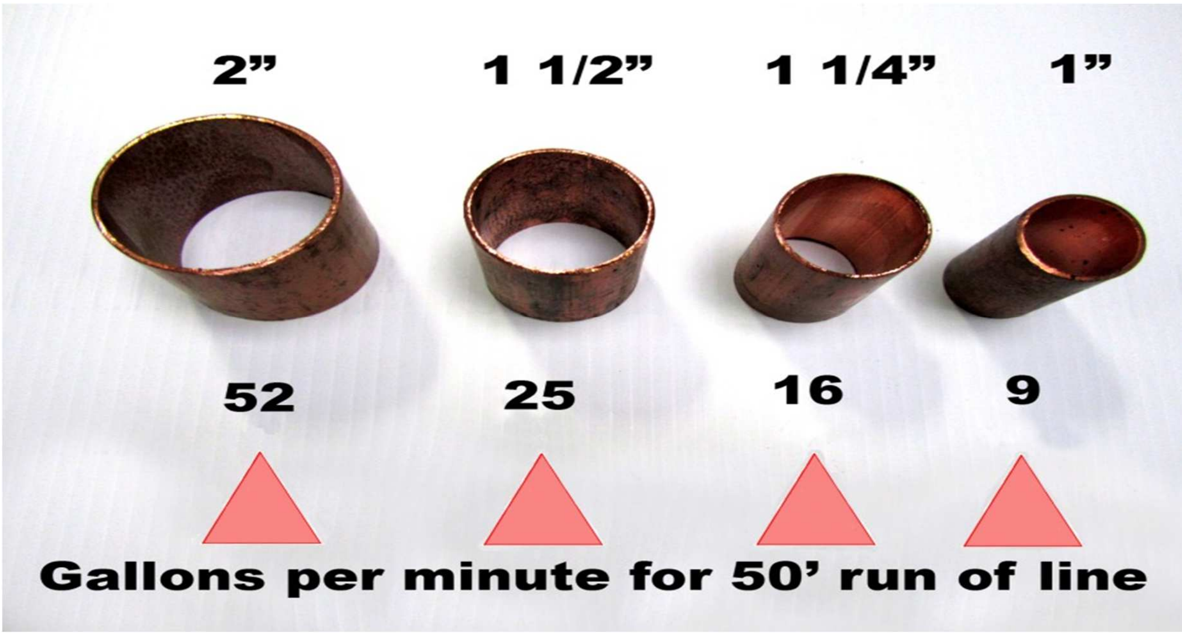


Fig. 2 Different size lines provide dramatically different flow rates

1.2.3. Calculating The Correct Water Supply Line Size For the Property

The water line size is vital to providing an adequate water volume to the occupants of a building. Three main factors determine the correct water supply line size, referred to as the water service line. The three factors are as follows:

1. Plumbing fixture count: A calculation using all of the plumbing fixtures in a building.
2. The pipe run's length: The main inside control valve's distance to the city water main connection.
3. Classification of the building: Residential and Commercial buildings have different sizing requirements.

1.2.4. What is the water supply line size typically required?

A 1″ water service line supplies a typical one-family house. A one-family house typically has the following plumbing fixtures present:

- Kitchen sink
- Laundry tray
- Dishwasher
- Washing machine
- Full bathroom
- An external hose connection.

A two-family house can virtually never size out for a 1″ service line. The only exception would be the extremely odd case of a city water main being located under the public sidewalk. The house would have to have no front yard whatsoever, which would result in only a 15′ run of pipe. This is a very uncommon and rare situation.

In the case of a three-family house, an 1 1/2″ service line is typically required. Again the exception would be if the length of the run of pipe was only 35′ or less. In most cases, a six-family house or greater will require a 2″ water service line.

Every type of plumbing fixture has an estimated gallon per minute factor. All of the plumbing fixtures inside a building combine to factor into the building's required water service line size.

1. Cases vary in determining the proper water supply line size

The actual reality is that most older buildings, those built before 1990 or so, will frequently have lines smaller than suggested above. In many cases, this results in no ill-effects. However, each case will vary. For example, in some neighborhoods, there are six family homes served by lead water service lines smaller than 1″. In extreme cases like this, the water pressure drops and inadequate volume are everyday issues for the occupants. Remember, even if you've gotten used to it, a pressure drop when using water in your home is not normal. No home or property was designed for this to happen. ((**LET AN EXPERT SIZE YOUR WATER SERVICE LINE))**

2. Sizing tables differ for residential and commercial properties

The sizing table differs dramatically for commercial property as compared to a residential property. There is a good reason for that. The chief reason is that a plumbing fixture typically gets used much more frequently in a commercial space. For example, a sink in a one family house is used sparingly compared to a sink inside a busy restaurant.

Fixture count is the gallons per minute value each plumbing fixture is attributed in the sizing table. For example, sizing table sinks, dishwashers, and washing machines are attributed to a fixture count of 4. While like residential plumbing fixtures have exactly 1/2 that fixture count. As a result, commercial properties typically require much larger water service lines than residential properties to meet code.

Why the length of the run is a factor?

Part of supplying water to a building is based upon pressurized water passing through the water supply line. The line itself provides resistance to the water flow. Therefore the length of the run is a major factor. The longer the run, the fewer gallons per minute can flow through the service line.

A long run of pipe affects the size of the line required

The run's length has a dramatic effect on the supply capabilities of each water service line size. For example, the typical water service line will lose approximately 33% of its water delivery capability when the length of the run is increased from 30′ to 60′. As a specific example, an 1 1/4″ line can deliver approximately 21 gallons per minute over a 30′ run, yet only approximately 14 gallons per minute over a 60′ run.

While the run length is a major factor for all water supply line size calculations, it becomes more of a factor when the run is unusually long. When a building has a large setback from the property or is on a very wide roadway, it is easy to overlook this factor. In cases where there is a long run, it would be an error to strictly base the water supply line size on the fixture count.

1.2.5. Typical signs of inadequate water volume or water pressure

Occupants of a building may have longstanding issues with insufficient water volume or pressure and accept it as normal. It should be understood that water pressure and water volume are two separate and distinct issues. Water pressure is the force that water flows from a plumbing fixture. Water volume is the amount of water present to service an entire building.

Three typical issues that result from volume or pressure problems are as follows:

1. Water temperature changes when water is used in the building, such as a toilet being flushed.
2. Loss of water pressure when a shower or washing machine is being used.
3. Change in water pressure or volume when a lawn sprinkler system kicks on.

2. Water Supply Network

water supply network or **water supply system** is a system of engineered hydrologic and hydraulic components that provide water supply. A water supply system typically includes the following:

1. A drainage basin (sources of drinking water)
2. A raw water collection point (above or below ground) where the water accumulates, such as a lake, a river, or groundwater from an underground aquifer. Raw water may be transferred using uncovered ground-level aqueducts, covered tunnels, or underground water pipes to water purification facilities.
3. Water purification facilities. Treated water is transferred using water pipes (usually underground).
4. Water storage facilities such as reservoirs, water tanks, or water towers. Smaller water systems may store the water in cisterns or pressure vessels. Tall buildings may also need to store water locally in pressure vessels to reach the upper floors.
5. Additional water pressurizing components such as pumping stations may need to be situated at the outlet of underground or aboveground reservoirs or cisterns (if gravity flow is impractical).
6. A pipe network for distribution of water to consumers (which may be private houses or industrial, commercial, or institution establishments) and other usage points (such as fire hydrants)
7. Connections to the sewers (underground pipes or aboveground ditches in some developing countries) are generally found downstream of the water consumers. Still, the sewer system is considered a separate system rather than part of the water supply system.

Fig.1 The Central Arizona Project Aqueduct transfers untreated water

Fig.2 Pressurizing the water is required between the small water reserve and the end-user

Fig.3 Most (treated) water distribution happens through underground pipes

2.1 Pipes

There are **two kinds** of pipes that make up a conventional residential plumbing system:

- Water supply pipes.
- Wastewater drainage pipes.

The main difference between the two is that water supply pipes are connected to the main water supply and are thus under pressure. Coldwater pipes are also smaller than drainage pipes. These pipes further divide into hot water pipes, routed to the boiler or water heater, and cold water pipes, which supply water to fixtures directly.

Now, in most cases, domestic cold water pipes and hot water pipes are quite similar. The reason comes down to demand and preexisting pressure. Since cold water pipes are connected to the main supply, the cold water supply in fixtures is already available at the minimum required flow rate.

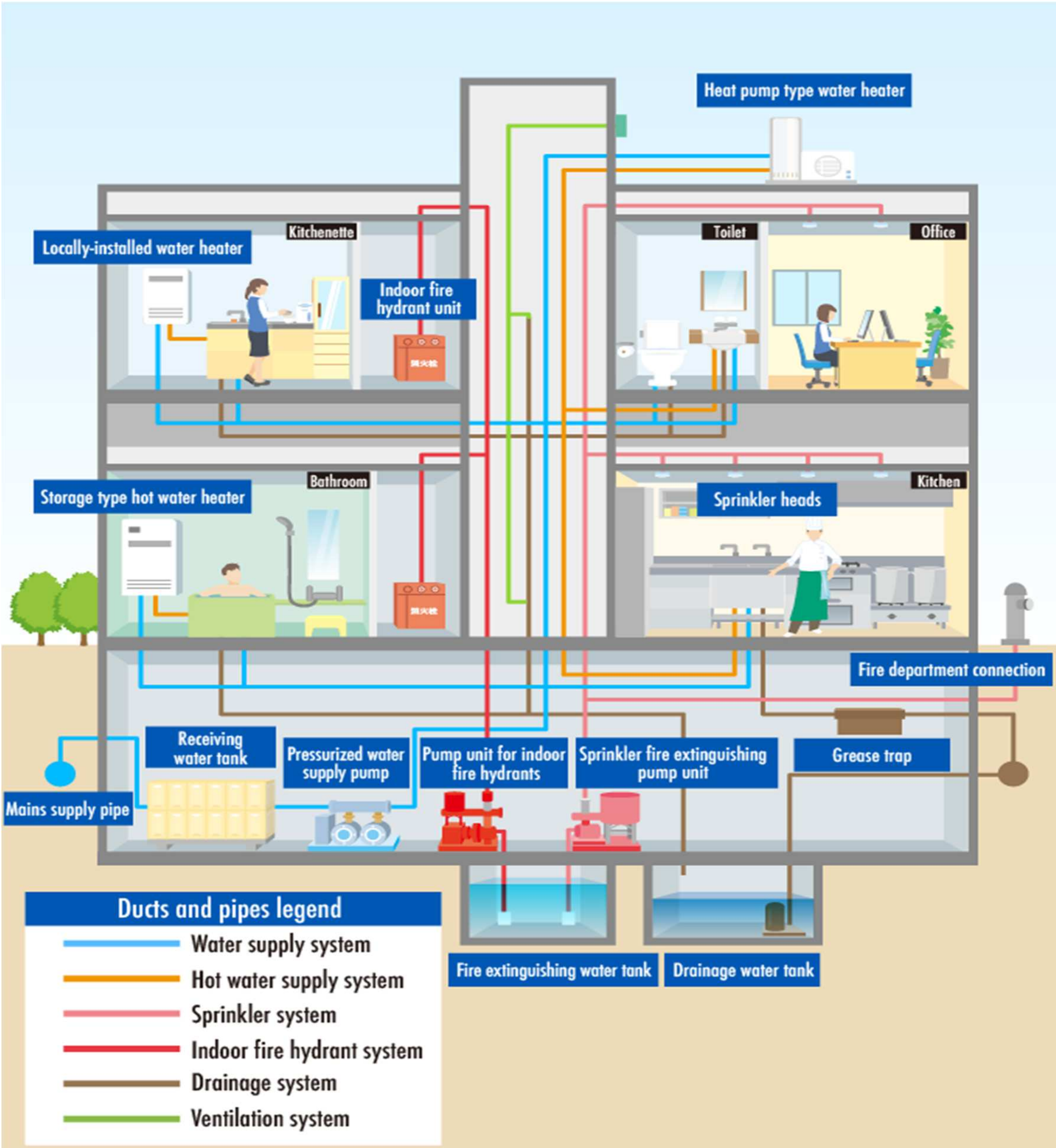


Fig.4 Pipes legend

2.1.1 The Types of Pipes and Fixture for Different Uses

a. Water System

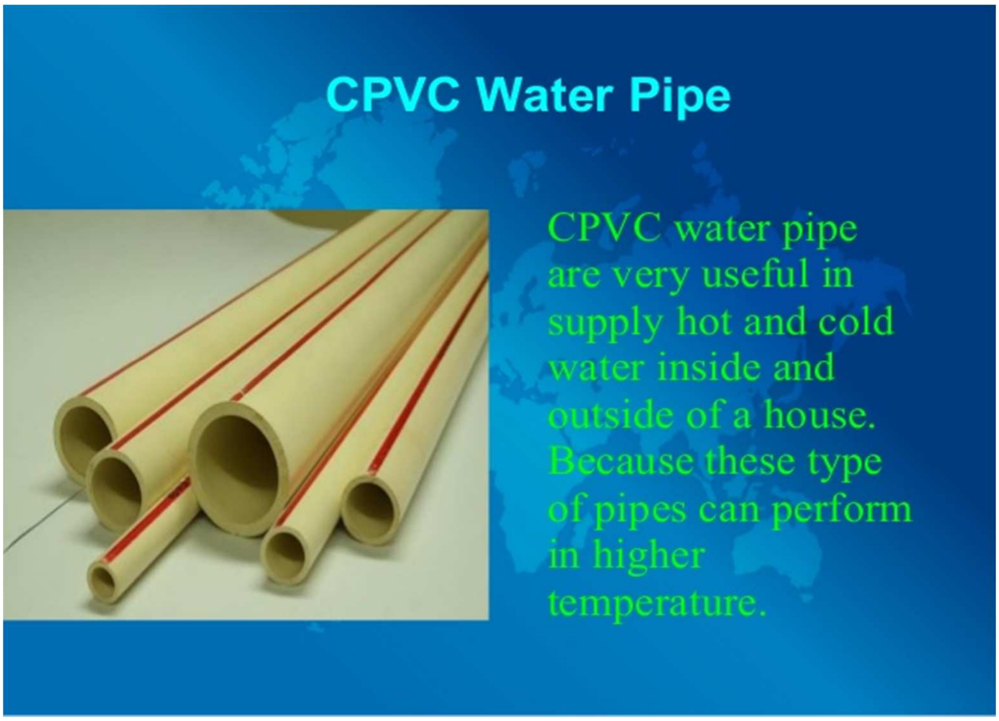


Fig.5 CPVC Water Pipe

Fig.6 Concrete Water Pipe

Fig.7 PVC Water Pipe

b. Water inside Building

Fig.8 Types of pipes inside the building

c. Fitting

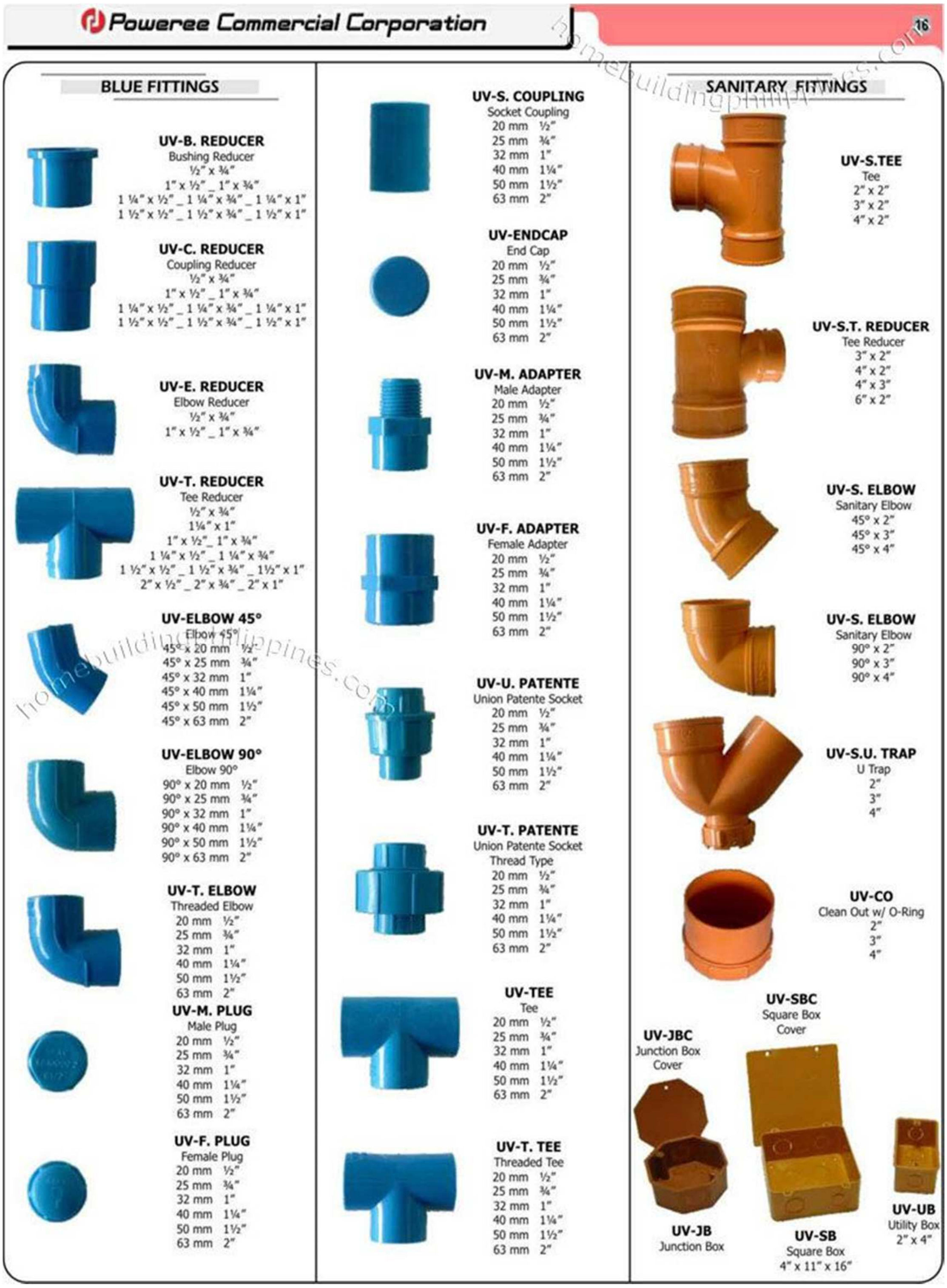
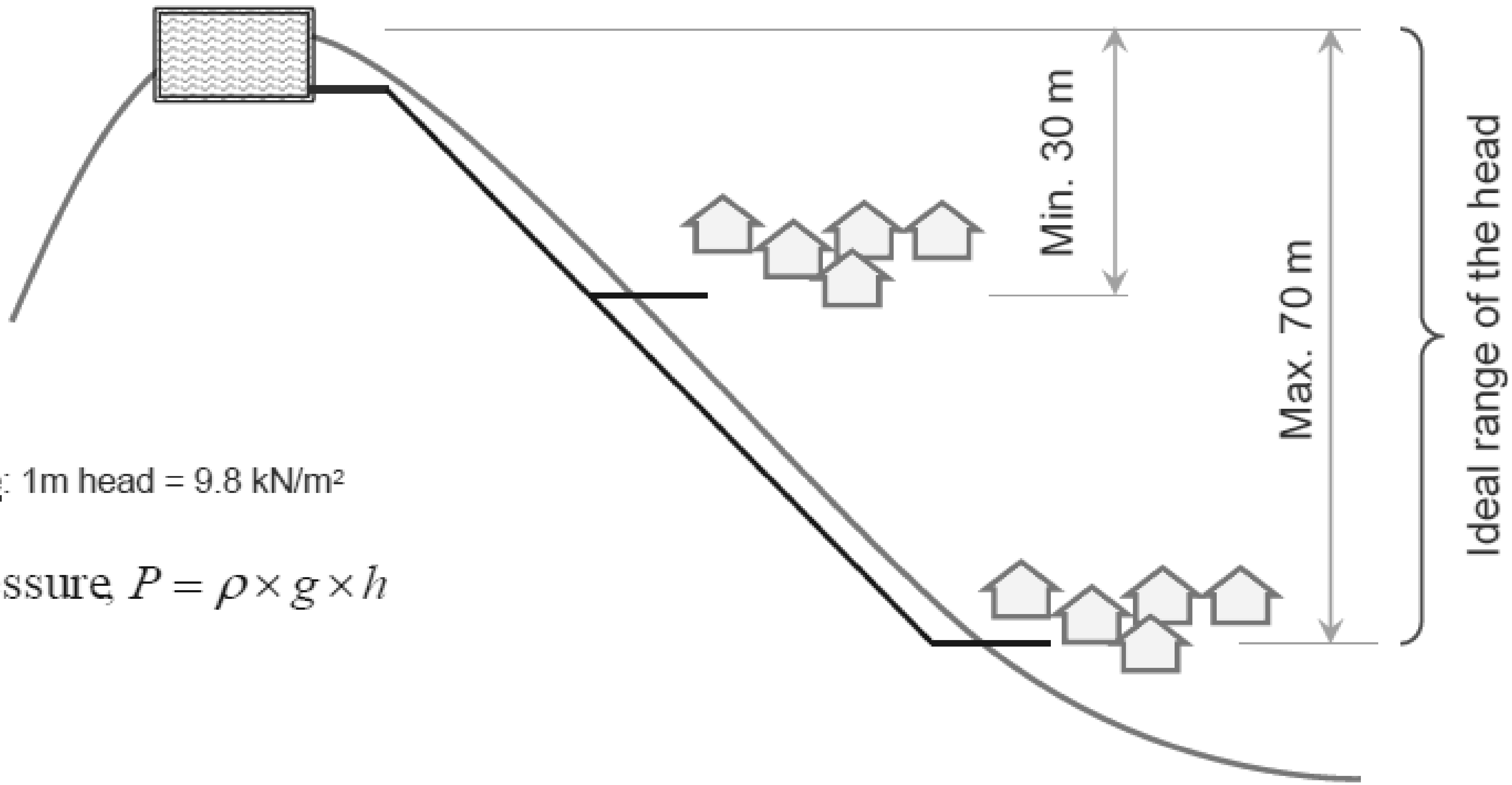


Fig.9 Fitting Type

Service Reservoir

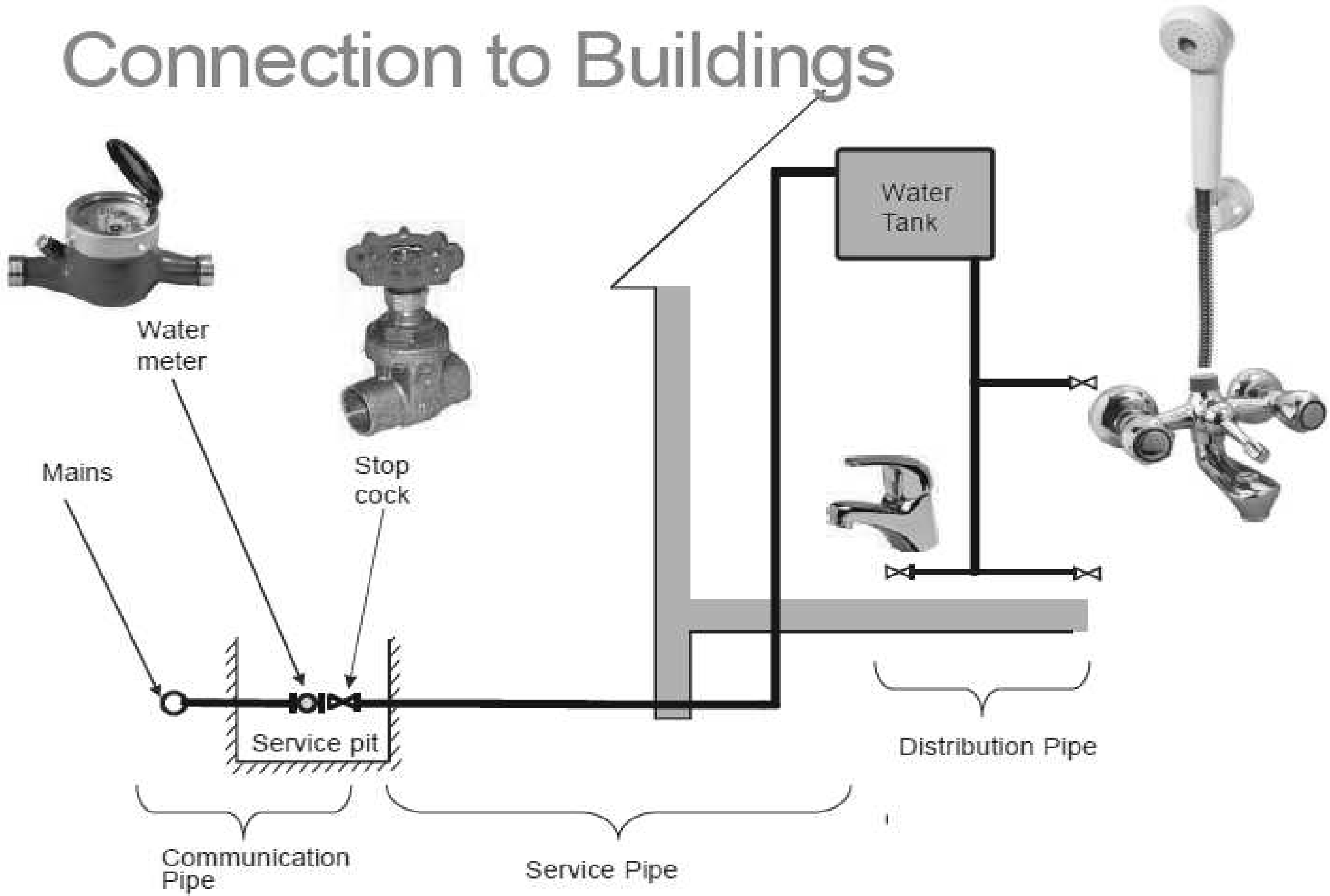
This is a large water tank sited to give ideal range of static head where possible (30m-70m) height.



Note: 1m head = 9.8 kN/m²

Pressure $P = \rho \times g \times h$

Connection to Buildings



Storage Capacity of Tanks

Storage capacity per person for different building types

Type of Building	Storage per person (Liters)
Dwelling houses and flats	91
Hostels	91
Hotels	136
Offices without canteens	37
Offices with canteens	45
Restaurants	7
Day Schools	27
Boarding schools	91
Nurses homes and medical quarters	114

Volumes of water used by each appliance

Appliance		Volume of Cold water (Liters)
Wash basin		
	Hand wash	5
	Wash	10
	Hair Wash	20
Shower		40
Bath		110
W.C		10
Washing Machine		150
Sink		
	Wash up	15
	Cleaning	10

Example for Determining Storage Capacity of Water Tanks

Example: You are designing a boarding school of 200 students and staff. What should be the volume of the cold water tank?

Solution:

Example for Determining Storage Capacity of Water Tanks

From the first table for a boarding school the storage required is 91 Liters per person. Therefore the total volume required is:

- ***Volume*** = 91 L/person x 200 persons = 18200 L

This is the same as 18.2 m3 or 18.2

Cold Water Storage Calculations

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

Building purpose	Storage/person/24 hrs	
Boarding school	90 litres	
Day school	30	
Department store with canteen	45	(3)
Department store without canteen	40	(3)
Dwellings	90	(1)
Factory with canteen	45	
Factory without canteen	40	
Hostel	90	
Hotel	135	(2) (3)
Medical accommodation	115	
Office with canteen	45	
Office without canteen	40	
Public toilets	15	
Restaurant	7 per meal	

Cold Water Storage Calculations

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

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

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

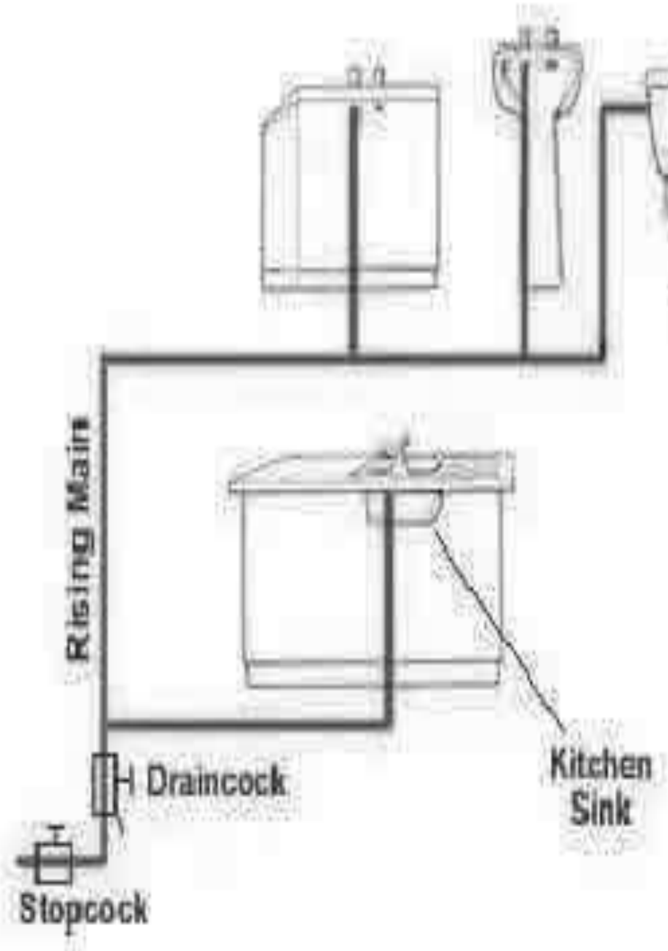
1000/10 = 100 persons × 40 litres = 4000 litres (24 hrs)

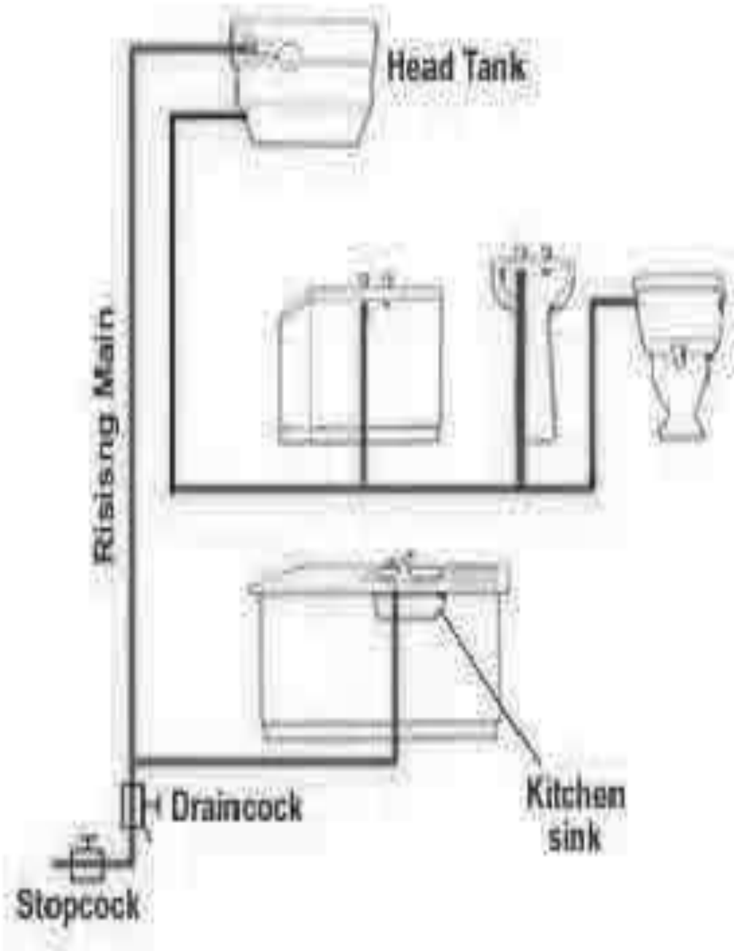
= 1667 litres (10 hrs)

Method of supplying water:

- **Direct Water Supply System**
- All appliances of a house are directly connected to the main supply line of Municipality/city government/ supply company.
- **Indirect Water Supply System**
- Only the kitchen sink and storage tank is connected to the main supply line. All other appliances are fed with water from the storage tank on the terrace of the house.

Direct Vs. Indirect

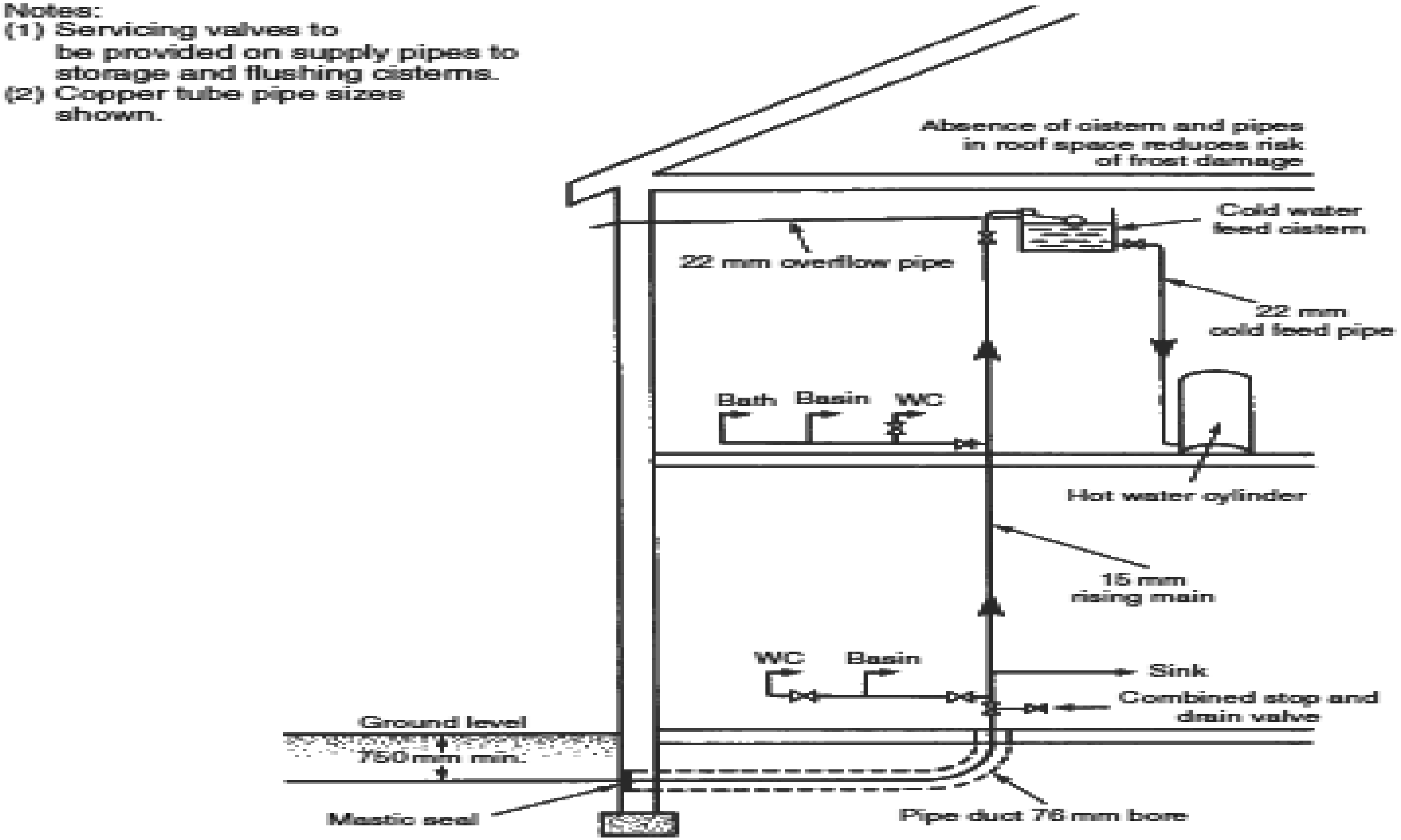




Direct System of Cold Water Supply

- **For efficient operation, a high pressure water supply is essential particularly at periods of peak demand. Pipework is minimal and the storage cistern supplying the hot water cylinder need only have 115 liters capacity. The cistern may be located within the airing cupboard or be combined with the hot water cylinder. Drinking water is available at every draw-off point and maintenance valves should be fitted to**
- **isolate each section of pipework. With every outlet supplied from the main, the possibility of back siphonage must be considered.**

Direct System of Cold Water Supply



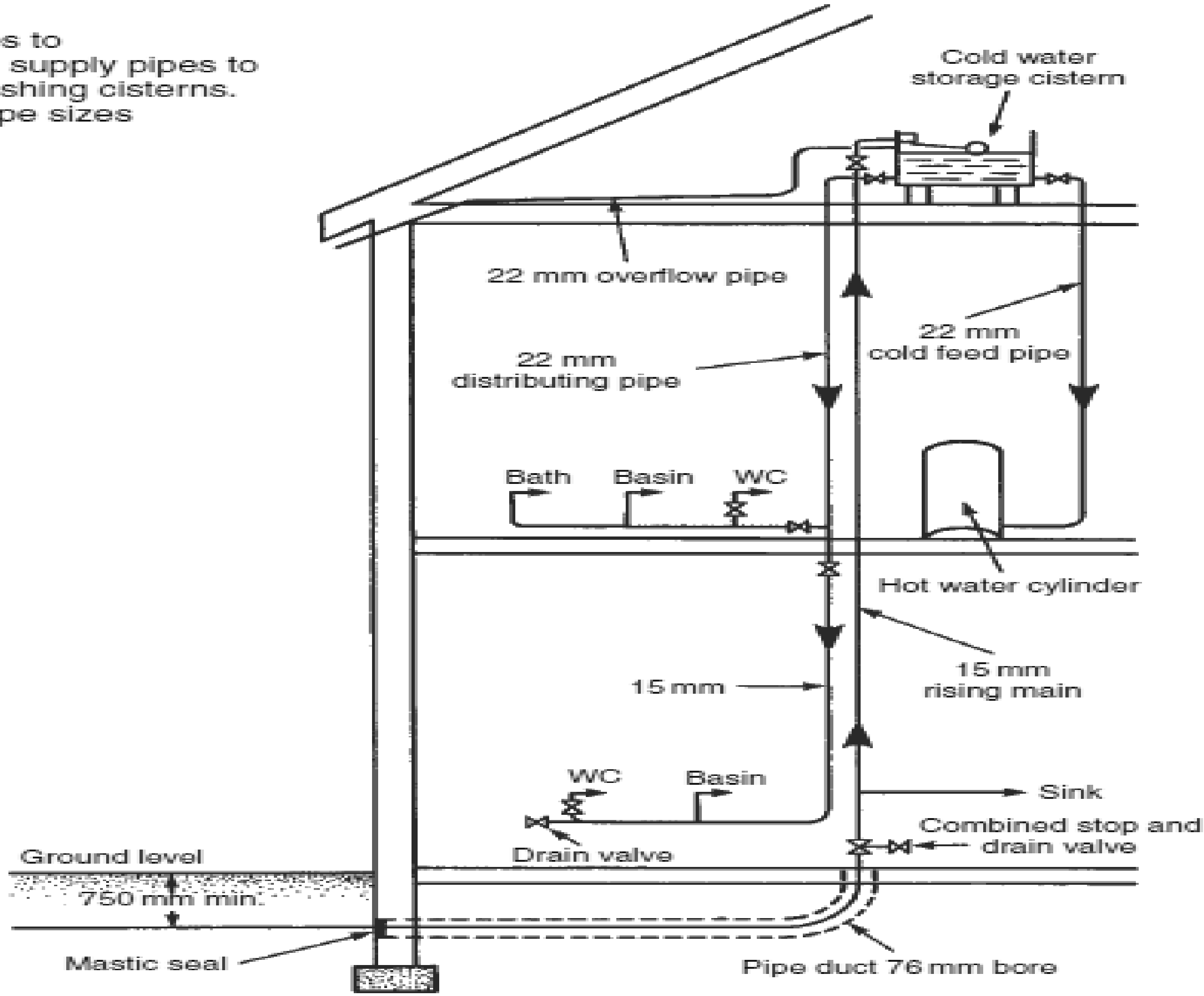
Ref.: The Water Supply (Water Fittings) Regulations 1999.

Indirect System of Cold Water Supply

- **The indirect system of cold water supply has only one drinking water outlet, at the sink. The cold water storage cistern has a minimum capacity of 230 liters, for location in the roof space. In addition to its normal supply function, it provides an adequate emergency storage in the event of water main failure. The system requires more pipework than the direct system and is therefore more expensive to install, but uniform pressure occurs at all cistern-supplied outlets.**

Indirect System of Cold Water Supply

Notes:
(1) Servicing valves to be provided on supply pipes to storage and flushing cisterns.
(2) Copper tube pipe sizes shown.



Ref.: The Water Supply (Water Fittings) Regulations 1999.

Direct water supply

- Direct Water Supply System provides potable water to all fixtures including bath, bathroom basin and kitchen sink. Rising main (the pipe that supplies municipal water to a house) directly supplies water to all the taps (faucets). All fixtures receives water from water supply authority at the pressure same as that of main. Generally, pressure of 0.5kg/cm^2 to 1.00kg/cm^2 i.e head of 5m to 10m is required at all taps. Main pressure is usually high because mains have to supply water to downstream areas, taking care of level variations.

Direct water supply

- To reduce the pressure and to maintain constant pressure depending on the location at which water enters house, a pressure reducing valve is sometimes introduced at the main and than the water is distributed to other pipes of the house. The pressure of hot water and cold water should be same at the faucet.

Indirect water supply

- Indirect water supply system is the most common type in modern houses, in countries like India, Pakistan, and countries in Asia and Africa. Here, water enters house from the rising main (main pipe from where water enters house), which is branched off into kitchen sink and storage tank either underground or overhead. Only kitchen sink receives potable water directly from municipal mains. All the other appliances receive water from the storage tank. The storage tank is kept at height so that water comes down into fixtures through gravity at sufficient pressure.

Pressure of water

- **Direct Water Supply System**

Water directly comes from main, it has high pressure and sometimes a pressure reducing valve is required to save from damage due to higher pressure.

- **Indirect Water Supply System**

In order to get sufficient pressure, water storage tank has to be at some height, which is not always achieved and hence the user on the floor just below suffer from lower pressure, due to which shower, flush, etc. do not work efficiently.

Quality of water

- **Direct Water Supply System**

Better water quality as water directly comes after treatment.

- **Indirect Water Supply System**

Water quality is affected as water is stored in storage tanks and then supplied to appliances.

Distribution of Pipes

- **Direct Water Supply System**

Water enters house from main supply pipe and is branched off to all fixtures and hence less length and cost.

- **Indirect Water Supply System**

Water enters house from main supply pipe and is branched off to kitchen sink and water storage tank either overhead or underground. Then all other fixtures receive water from storage tank.

Maintanance

- **Direct Water Supply System**

Requires less maintenance compared to indirect water supply system.

- **Indirect Water Supply System**

Tanks (overhead at some level/underground with pumps) require regular maintenance, cleaning, protection from UV rays.

Water Supply

Direct Water Supply System

- Water supply is continuous throughout day. Ifwater supply is only for certain period of time in a day, it is cumbersome, as user would be without water for certain time of day.
- If main supply pipe is damaged, whole water supply of house will have to be stopped till it is repaired.

Indirect Water Supply System

- Once water is stored in storage tank it can be used at any hour of a day, but a definite storage capacity is needed.
- In case if any pipe is damaged only that fixture water supply is stopped. Rest fixtures gets water supply from tank.

Wastage &Leakages

- **. Direct Water Supply System**

More water is wasted compared to indirect water supply system.

- **Indirect Water Supply System**

Minimal wastage of water.

- **Direct Water Supply System**

Pipes may leak due to high pressure water flowing through them.

- **Indirect Water Supply System**

Chances of water leakages from water storage tank.

Capacity of Pumps at Source &Economy

- **Direct Water Supply System: Economical** as less pipe works and no storage tanks.
- **Indirect Water Supply System: Extra** cost of pipes and tanks, which is substantial.

Direct Water Supply System: Huge pressure i.e high capacity pumps are required to reach upper stories.

- **Indirect Water Supply System: Moderate** pressure will do, as water will be supplied only at ground level.

The most common one?

- Direct water supply system is most common in developed countries like America and European countries. Whereas, developing countries like India, Pakistan and other Asian, African countries opt for indirect water supply system.

Pipe Sizing Procedure for water supply system

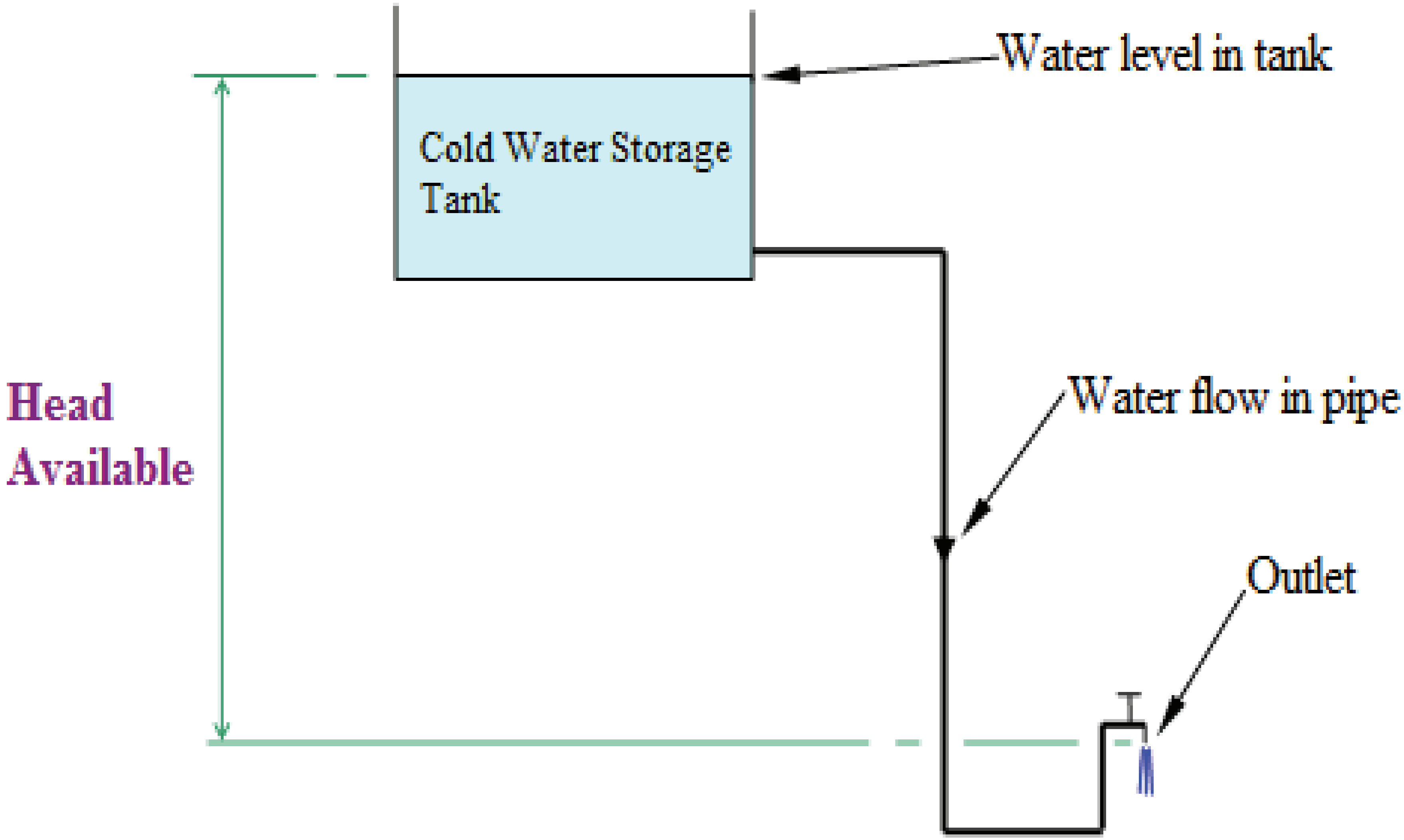
NON-PRESSURISED COLD WATER PIPE SIZING

- 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 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.



Water level in tank
Cold Water Storage
Tank
Head
Available
Water flow in pipe
Outlet

HEAD AVAILABLE

- The Head Available develops water pressure and this water pressure is used up in overcoming the frictional resistance of the pipe and in creating the velocity pressure for water flow at the outlet.
- p1 - p2 = frictional resistance + velocity pressure
- Or,
- h1 - h2 = head loss in pipe due to friction + velocity head
- **Where p = pressure (N/m2)**
- **h = head (m)**

- In practice, to avoid additional velocity pressure calculations, it is usual to calculate the available pressure by considering the difference in levels between the bottom of the storage tank and the height of the draw-off points.
- The pressure losses in the system are frictional pipe losses and velocity pressure loss through sanitary fittings such as taps, cistern ball valves and shower heads.
- Velocity head loss through fittings is as follows:-
- Pillar taps 1m
- Shower head 1.5m
- Ball valve 1m

Fig 1.9 Equivalent pipe length cont...

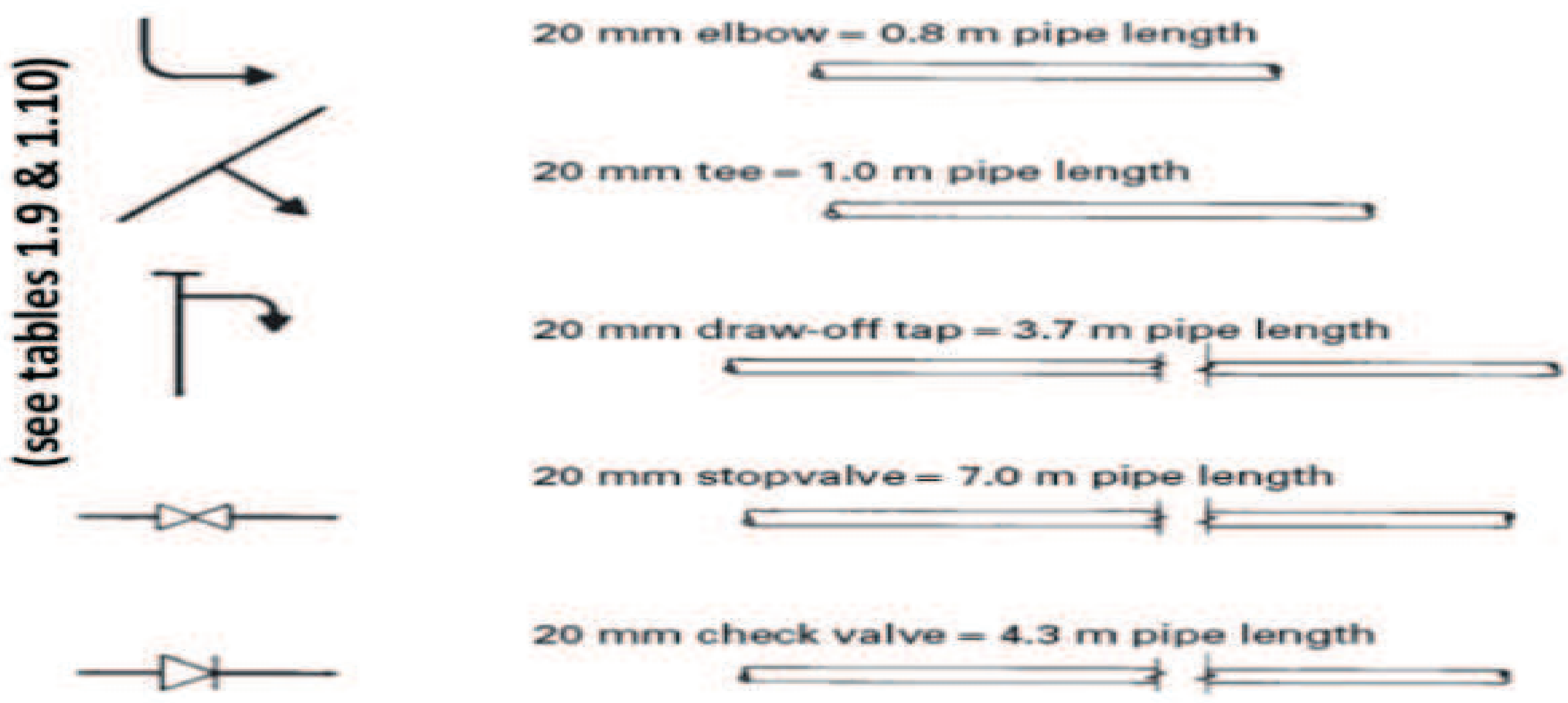


Table 1.9 Equivalent pipe lengths (copper, stainless steel and plastics)

Bore of pipe (mm)	Equivalent pipe length (m)			
	Elbow	Tee	Stopvalve	Check valve
12	0.5	0.6	4.0	2.5
20	0.8	1.0	7.0	4.3
25	1.0	1.5	10.0	5.6
32	1.4	2.0	13.0	6.0
40	1.7	2.5	16.0	7.9
50	2.3	3.5	22.0	11.5
65	3.0	4.5	---	---
73	3.4	5.8	34.0	---

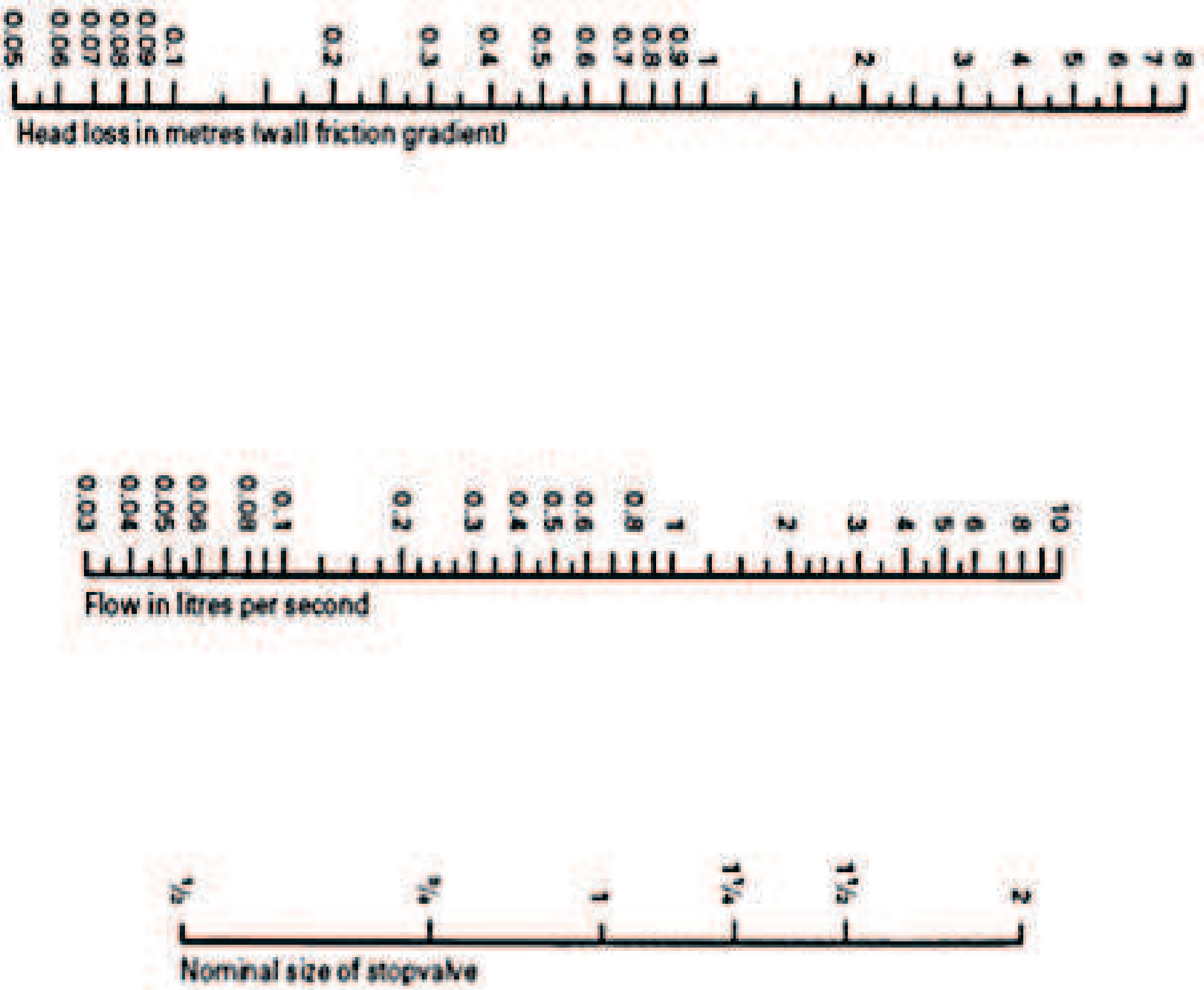
(Source: Garrett, R. H., 2008. *Hot and Cold Water Supply)*

Table 1.10 Typical head losses and equivalent pipe lengths for taps

Nominal size of tap	Flow rate (l/s)	Head loss (m)	Equiv. pipe length (m)
G1/2- DN 15	0.15	0.5	3.7
G1/2- DN 15	0.20	0.8	3.7
G3/4- DN 20	0.30	0.8	11.8
G1- DN 25	0.60	1.5	22.0

(Source: Garrett, R. H., 2008. *Hot and Cold Water Supply)*

Figure 1:12 Head loss through stop valves



Note Gate valves and spherical plug valves offer little or no resistance to flow provided they are fully open.

WATER FLOW RATES

- Cold water flow rates for sanitary appliances for small installations may be found from the table below.

Approximate hot or cold water demand	Flow rate (l/s)
Basin (spray tap)	0.05
Basin (tap)	0.15
Bath (private)	0.30
Bath (public)	0.60
Flushing cistern	0.10
Shower (nozzle)	0.15
Shower (100mm rose)	0.40
Sink (15mm tap)	0.20
Sink (20mm tap)	0.30
Wash fountain	0.40

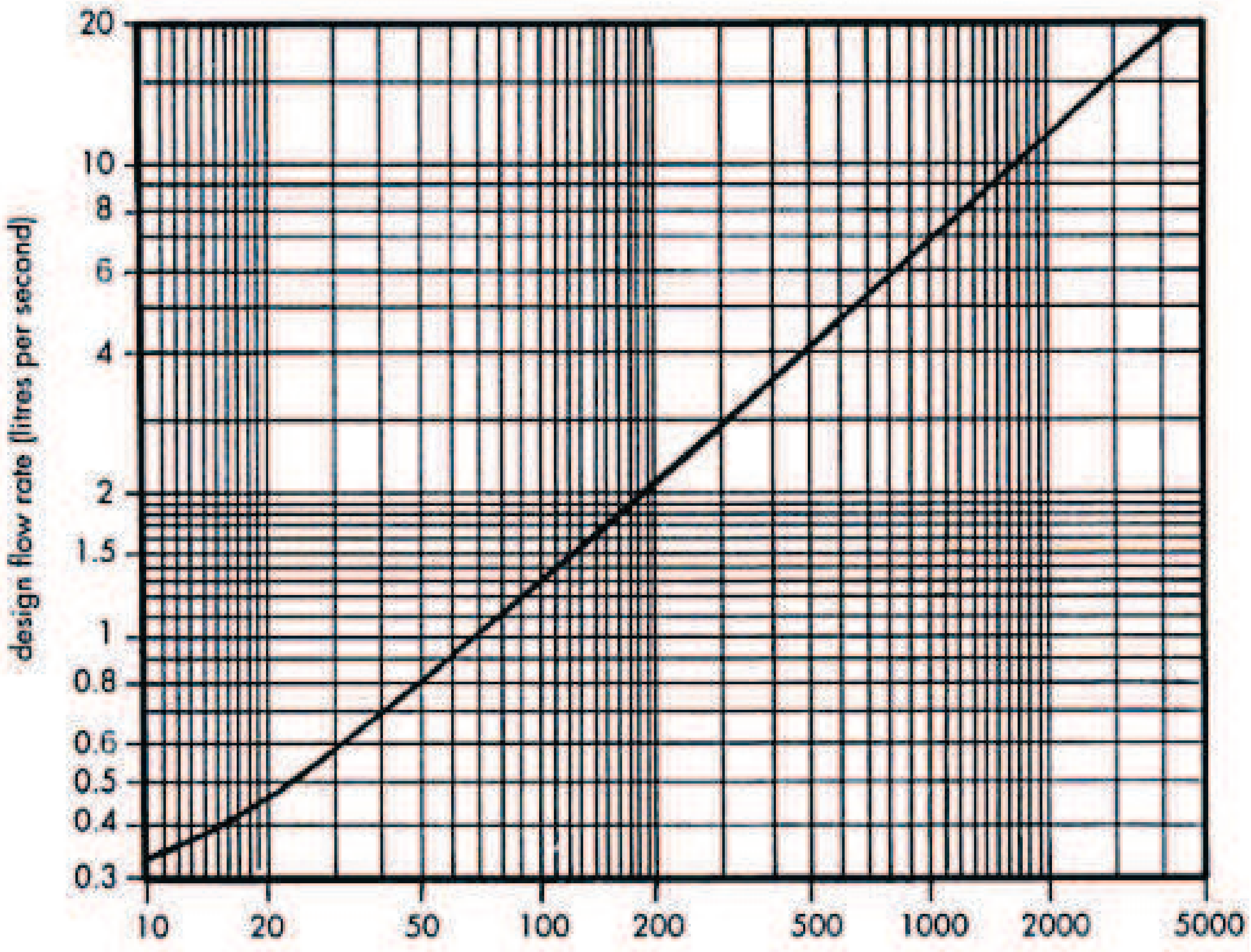
Pipe Size Procedure

- 1. Divide system into sections.
- 2. Calculate demand units if simultaneous demand is effective.
- 3. Estimate flow rates in each section.
- 4. Estimate pipe diameter.
- 5. Measure the pipe run for the section.
- 6. Calculate length of pipe equal to resistance of fittings.
- 7. Calculate effective pipe length.
- 8. Determine pressure loss due to friction for pipe
- 9. Calculate pressure consumed by friction.
- 10. Calculate cumulative pressure consumed.

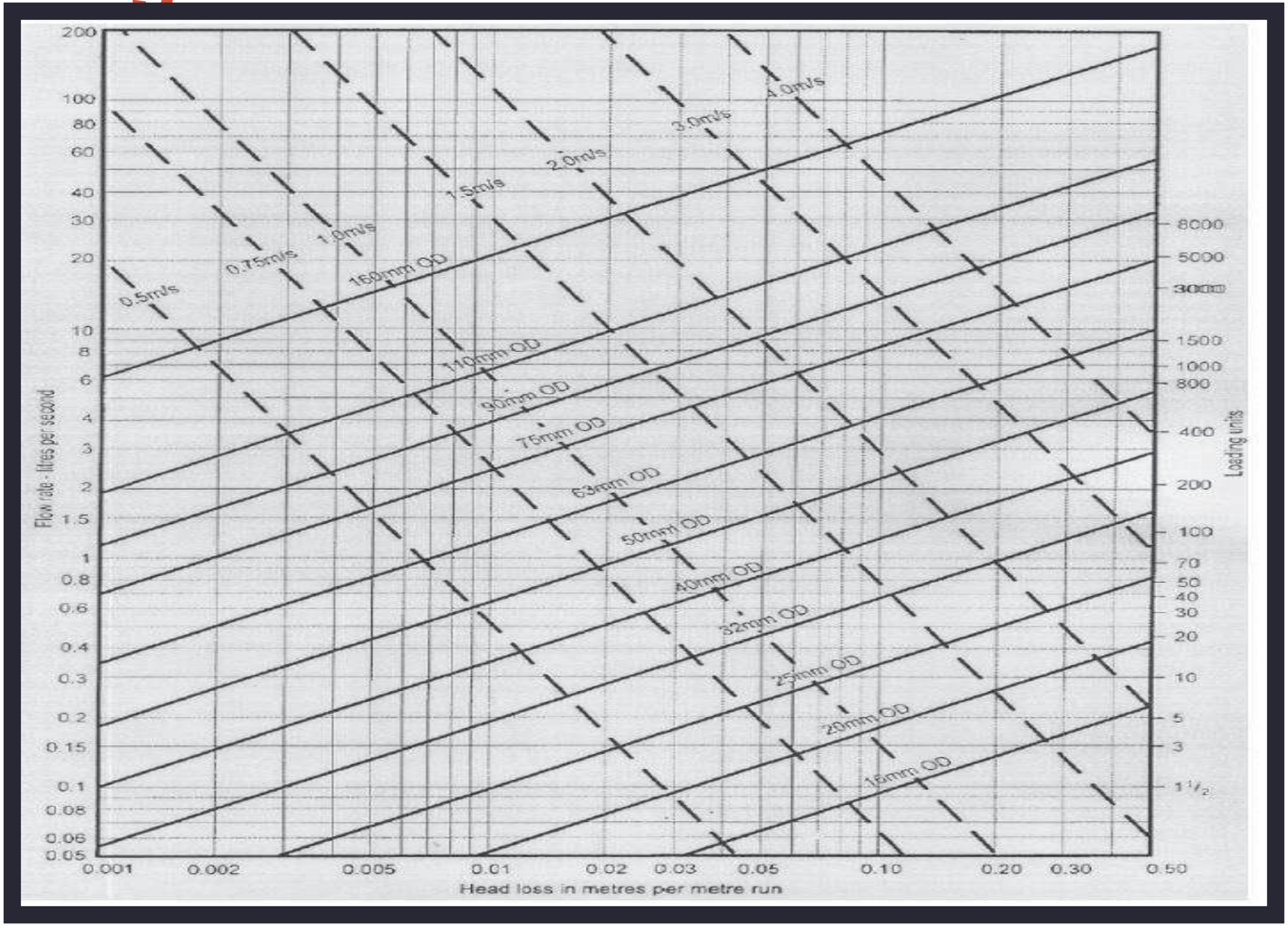
Below given table is to achieve loading units of appliances

S.NO	DWELLINGS AND FLATS	LOADING UNITS
1	WC FLUSHING CISTERN(TANK)	2
2	WASH BASIN	1 ½
3	BATH	10
4	SINK	5
5	SHOWER(WITH NOZZLE)	3
6	PUBLIC BATH	22
	OFFICES	
1	WC FLUSHING CISTERN	2
2	WASH BASIN	3
	SCHOOLS AND INDUSTRIAL BUILDINGS	
1	WC FLUSHING CISTERN	2
2	WASH BASIN	3
3	LAB SINK	1

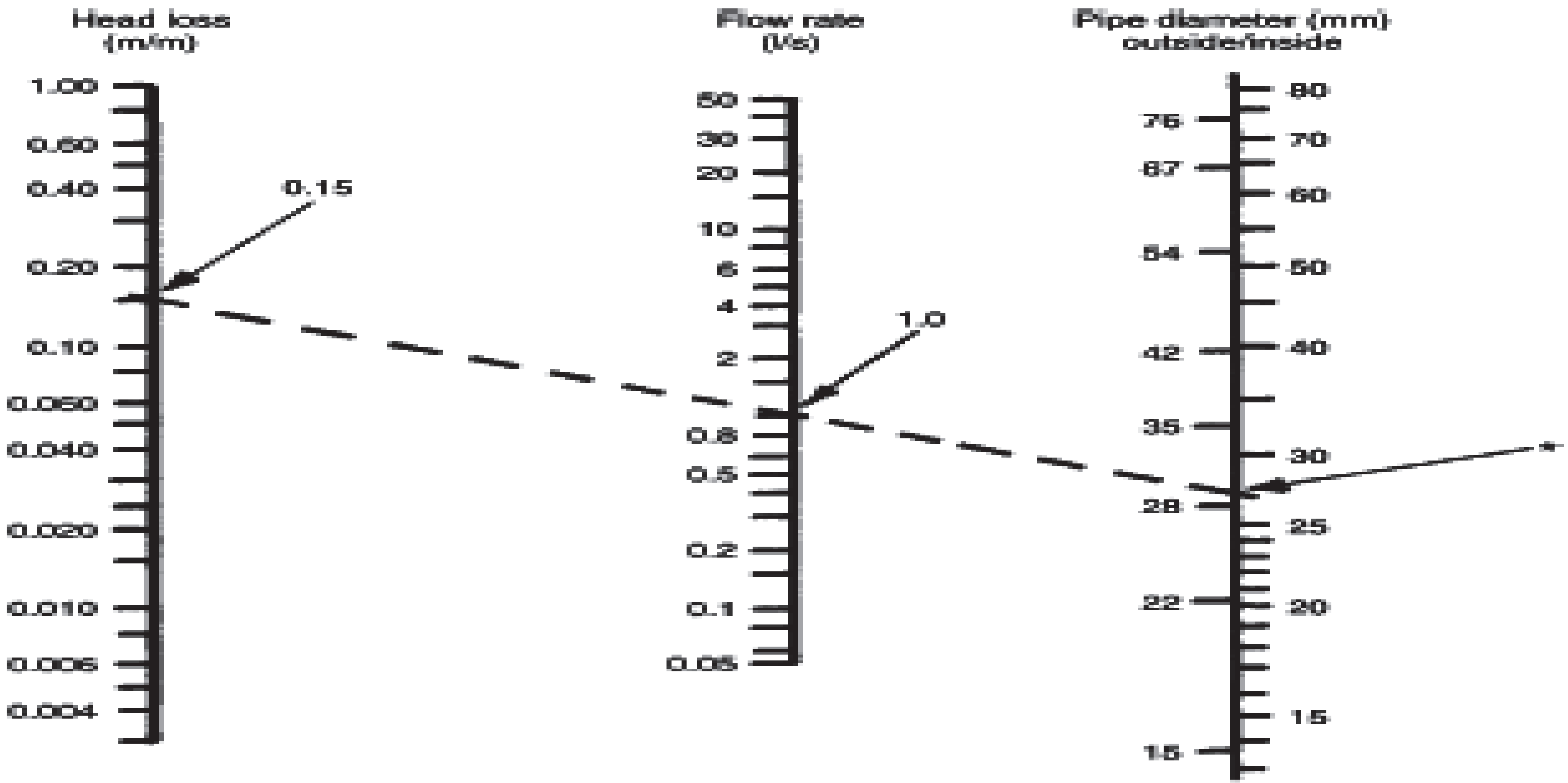
For calculating the flow rate of water liter per second refer to this chart



The chart given below is to select pipe sizing.



The chart given below is to select pipe sizing.



Pipe sizing-Introduction

Correct pipe sizes will ensure adequate flow rates at appliances and avoid problem caused by over sizing and under sizing;

Over sizing will mean:

- additional and unnecessary installation costs;
- delays in obtaining hot water at outlets;
- increased heat losses from hot water distributing pipes.

Under sizing may lead to:

- inadequate delivery from outlets and possibly no delivery at some outlets during simultaneous use;
- some variation in temperature and pressure at outlets, especially showers and other mixers;
- some increase in noise levels.

How to measure head loss

Pressure or head loss in pipework systems can be expressed as the relationship between available pressure (kPa) or head (m) and the effective length (m) of pipework

Length of pipe equal to Resistance

Equivalent pipe length

- **Equivalent pipe length** Is the expression of friction resistances to flow through valves and fittings in terms of pipe lengths having the same resistance to flow as the valve or fitting.

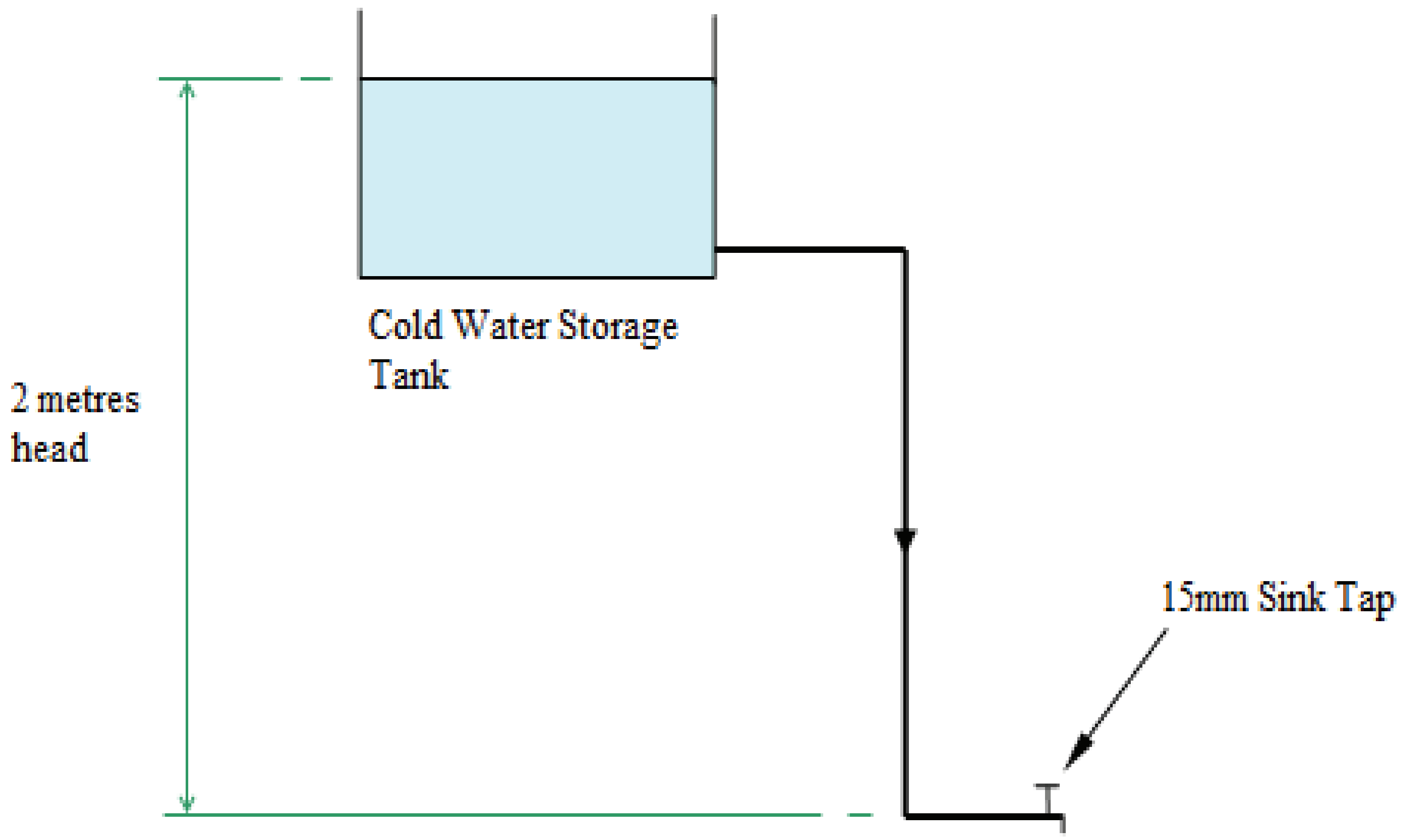
EXAMPLE 1

Determine a suitable pipe size for the system shown below.

DATA

Fittings include the following; exit from tank or large vessel, 3No. Bends, 1No. Gate valve, 1No. 15mm tap, Length of pipe run is 8 meters and copper pipe is to be used.

The flow rate for a 15mm Sink Tap from above Table is 0.2 l/s.



Cold Water Storage
Tank
2 metres
head
15mm Sink Tap

Example 1

- The pressure available to force the water through the pipe work and tap comes from the head of water above the tap. The formula below gives the relationship between pressure and head.
- $P = \rho x\ g\ x\ h$
- Where;
- P = pressure (N/m2)
- ρ= density (1000 kg/m3 for water)
- g = acceleration due to gravity (9.81 m/s2)
- h = head (m)
- Therefore: P = 1000 x 9.81 x 2.0 = 19,620 N/m2
- The resistance to flow is from the fittings and pipe work.

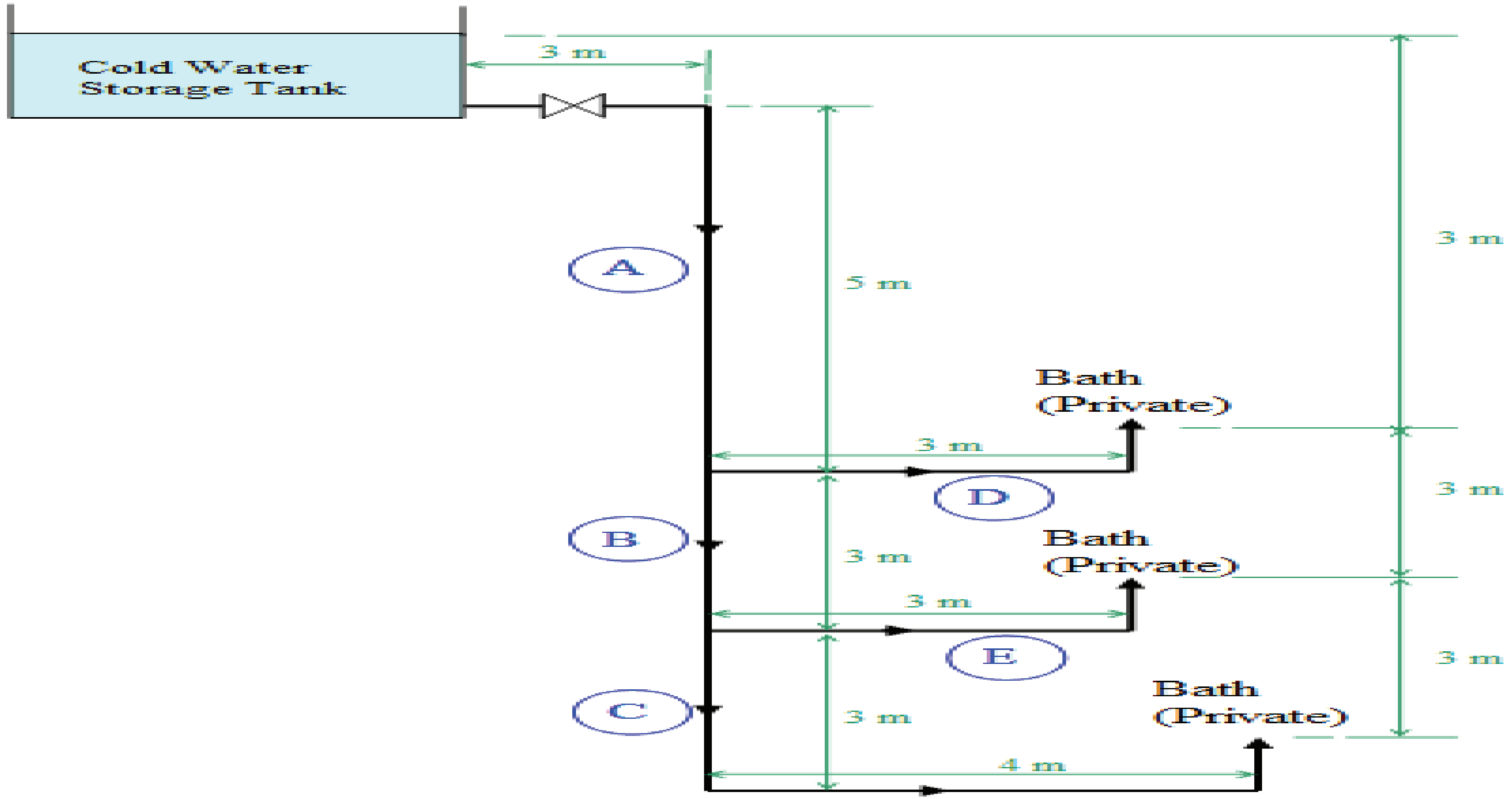
EXAMPLE 2

Determine suitable pipe sizes for the system shown below.

The building is a three-storey Nursing Home. Copper pipe is to be used. Flow rates are to be obtained from above Table?

EXAMPLE 2 (Cont)

Determine The pipe sizes, flow rates and pressures on the drawing below

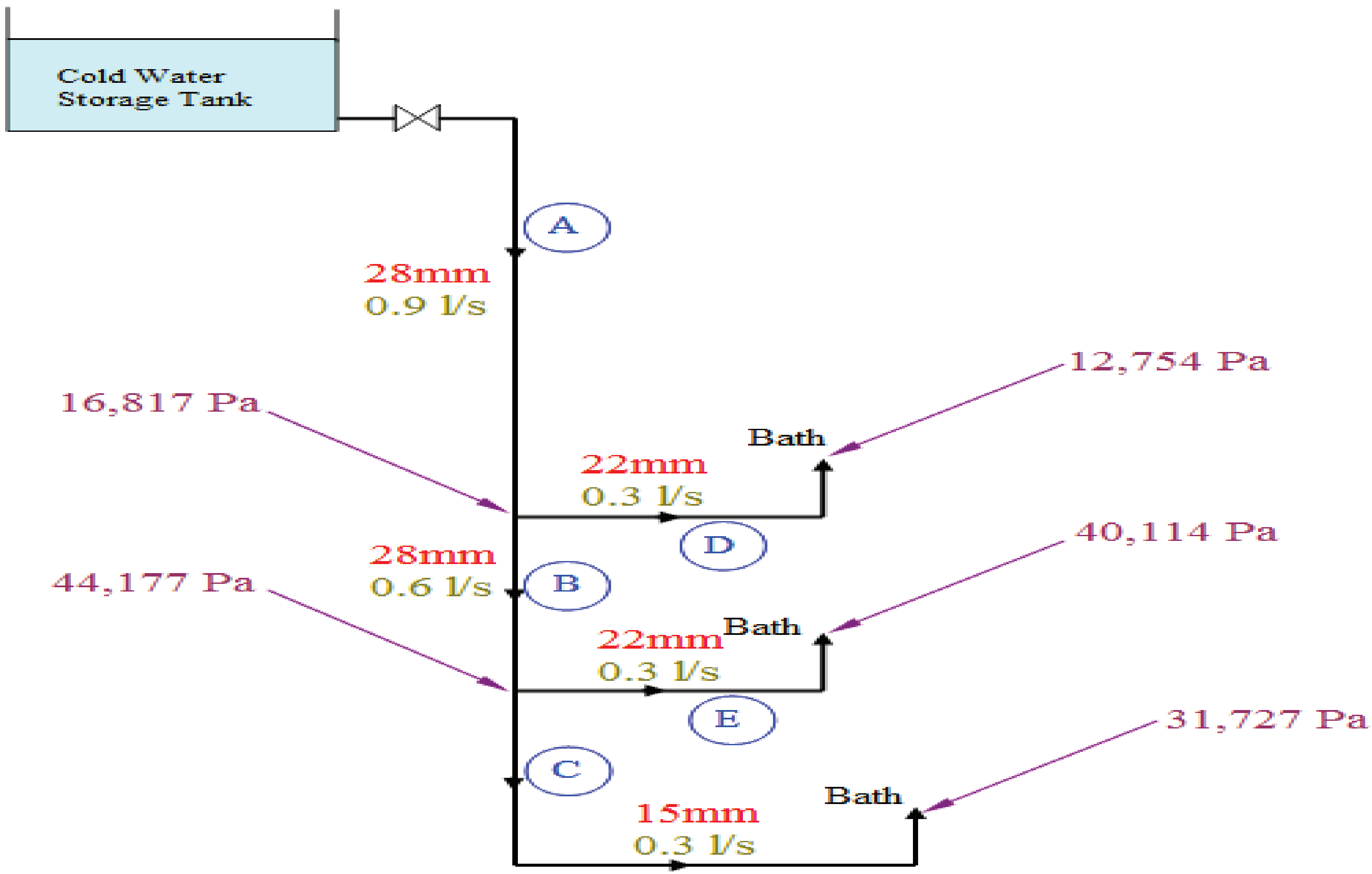


HOT AND COLD WATER PIPE SIZING TABLE

1	2	3	4	5	6	7	8	9	10	11	1
Ref	**Demand Units if required**	**Flow Rate** **(l/s)**	**Estimated Pipe Dia.** **(mm)**	**Measured Pipe Run** **(m)**	**Length of Pipe Equal to Resistance's** **(m)**	**Effective Pipe Length Col . 5 + 6** **(m)**	**Pipe Pressure Loss** **(Pa/m)**	**Pressure Consumed Col. 7 x 8** **(Pa)**	**Total Pressure Consumed** **(Pa)**	**Pressure Available at End of Section** **(Pa)**	**Fi Pi Si** **(m**
A		0.9	28	8.0	ζ Factors for fittings: 1No.Exit large vessel = 0.4 1No.Gate Valve = 0.3 1 No. Bend = 1.0 1 No.28 x 28 x 22 tee = 0.2 ----------- Total 1.9 T.E.L. = Total ζ x le = 1.9 x 1.1 = 2.09 m	8 + 2.09 = 10.09 m	1250	12,613	12,613	Static pressure = 3m x 9810 = 29,430 Press. Available = 29,430 – 12,613 = **16,817 Pa**	2
B		0.6	28	3.0	1No.28 x 22 x 22 tee ζ = 0.20 with 28 x 22 reducer: $A_2 / A_1 = \pi \times 0.011^2 / \pi \times 0.014^2$. = 0.617 gives ζ = 0.25 ----------- Total 0.45 T.E.L. = Total ζ x le = 0.45 x 1.0 = 0.45m	3.0 + 0.45 = 3.45 m	600	2,070	12,613 + 2,070 = 14,683	Static pressure = 6m x 9810 = 58,860 Press. Available = 58,860 – 14,683 = **44,177 Pa**	2
C		0.3	22	7.0	1No.Bend = 1.0 1No. Angle valve bath tap = 5.0 ---------- - Total 6.0 T.E.L. = Total ζ x le = 6.0 x 0.7 = 4.2 m	7.0 + 4.2 = 11.2 m	625	7,000	14,683 + 7,000 = 21,683	Static pressure = 9 m x 9810 = 88,290 Press. Available = 88,290 – 21,683 = **66,607 Pa**	2

D		0.3	22	3.0	1No. Angle valve bath tap = 5.0 T.E.L. = Total ζ x le = 5.0 x 0.7 = 3.5 m	3.0 + 3.5 = 6.5 m	625	4,063	12,613 + 4,063 = 16,676	Static pressure = 3m x 9810 = 29,430 Press. Available = 29,430 – 16,676 = **12,754 Pa**	22
E		0.3	22	3.0	1No. Angle valve bath tap = 5.0 T.E.L. = Total ζ x le = 5.0 x 0.7 = 3.5 m	3.0 + 3.5 = 6.5 m	625	4,063	4,063	Static pressure = 6m x 9810 = 58,860 Press. Available = 58,860 – 14,683 = 44,177 Pa – 4,063 = **40,114 Pa**	22
Re-calculate pipe ref. C for 15mm pipe											
C		0.3	15	7.0	1No. 28 x 15 x 22 tee (already included) with 2 No.28 x 15 reducers: $A_2 / A_1 = \pi \times 0.0075^2 / \pi \times 0.014^2$. = 0.287 gives ζ = 0.47 2No. Reducers = 0.94 1No.Bend = 1.0 1No. Angle valve bath tap = 5.0 ----------- Total 6.94 T.E.L. = Total ζ x le = 6.94 x 0.5 = 3.47 m	7.0 + 3.47 = 10.47 m	4000 estimated	41,880	41,880 + 14,683 = 56,563	Static pressure = 9 m x 9810 = 88,290 Press. Available = 88,290 – 56,563 = **31,727 Pa**	15

The pipe sizes, flow rates and pressures are indicated on the drawing below.



- **PIPE SIZING PROCEDURE**
- 1. Reference the pipe section.
- 2. Calculate flow rates from Table below.
- 3. Estimate flow rates in each section.
- 4. Estimate pipe diameter from pipe sizing tables.
- 5. Measure the pipe run from drawings.
- 6. Calculate length of pipe equal to resistance of fittings.
- The Total equivalent length of a fitting = Equivalent Length x Pressure Loss factor z (Zeta).
- 7. Calculate effective pipe length.

- 8.Determine pressure loss due to friction from Tables.
- 9. Calculate pressure consumed due to friction (Pa) = effective pipe length (m) x pressure loss due to friction (Pa/m)
- 10. Calculate total pressure consumed = Friction loss + Static pressure loss
- 11. Determine pressure at start of section.
- 12. Calculate pressure available at end of section = Pressure at start of section - Total pressure consumed
- If pressure available at end of section is less than the maximum allowable pressure drop then we can accept this pipe size.

- 13. Determine pressure required at end of section, this can be the minimum pressure that is required for terminal equipment.
- 14. If the pressure available at the end of the section is more than or equal to the pressure required at the end of the section then the pipe size is correct.

Drainage System

The arrangement provided in a house or building for collecting or conveying wastewater through drain pipes, by gravity, to join either a public sewer or a domestic septic tank is termed as house drainage or building drainage.

1. Terminologies related to Drainage

   Wastewater: Water, when used for different purpose like domestic, commercial, industrial, etc., receives impurities and become wastewater. Thus wastewater is used water, and it has physical, chemical, and biological impurities in it.

   Sewage: The wastewater coming from W.C. and containing human excreta.

   Sewer: A pipe carrying sewage/wastewater.

   Soil Pipe: It is a pipe carrying sewage from W.C.

   Vent Pipe: A vertical pipe that provides circulation of air to and from the drainage system.

   Stack: A general term used for any vertical line of soil, waste, or vent piping.

   Cleanout: An access opening to allow cleanout of the pipe.

   Waste Pipe: A pipe carries sullage from bathrooms, kitchens, sinks, washbasins, etc.

   Sewerage System: A system of sewers of different types and sizes in a town collecting wastewater from the town and carrying it to the wastewater treatment plant.

   Sanitary Sewer: A sewer pipe that carries only sewage.

Storm Sewer: A sewer pipe that carries stormwater or other drainages (excluding sewage).

Building Sewer: Part of the drainage system from the building to the public, private, or individual sewer disposal system.

Sewer Main: A sewer pipe installed and maintained by the public entity and on public property.

2. Components of Drainage System

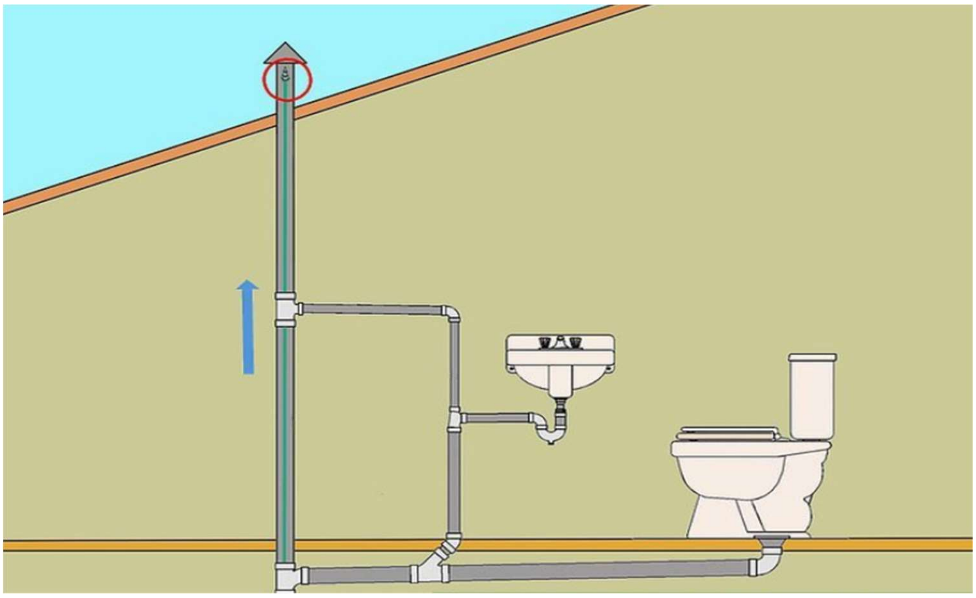
   Pipes, Traps, Sanitary Fitting, and Chambers.

   A. *Pipes:* In-house drainage system pipes may be designated depending upon the function, as shown below.

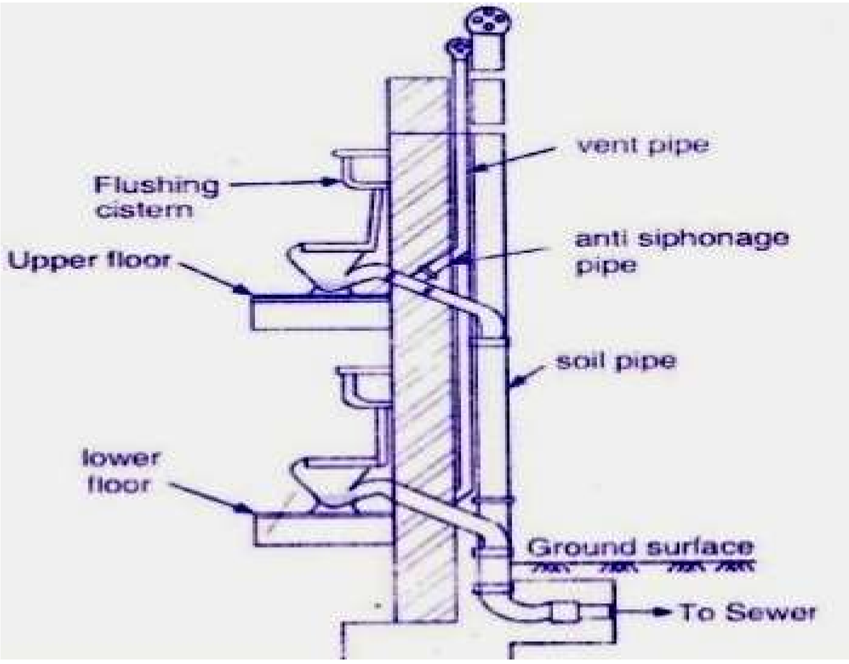
      Soil Pipe: A pipe carrying human sewage from W.C.

Waste Pipe: A pipe carries sullage.

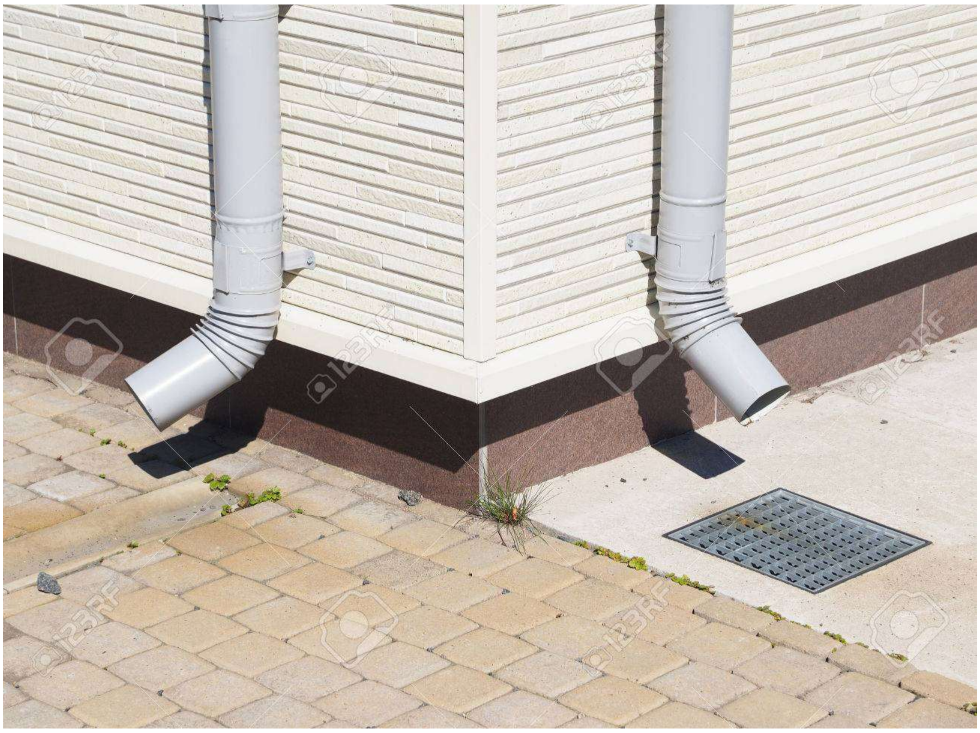
<u>Vent Pipe</u>: A pipe installed to provide airflow or the drainage system or provide air circulation in the drainage system to protect the traps' water seal against siphonage and backflow.



<u>Antisiphonage Pipe</u>: The pipe is installed to preserve the water seal in the trap through proper ventilation.



Rainwater pipe: a pipe carries rainwater.



Pipe Sizes:	Soil pipe	100mm
	Waste pipe: horizontal	30-50mm
	Waste pipe: vertical	75mm
	Rainwater pipe:	75mm
	Vent pipe:	50mm

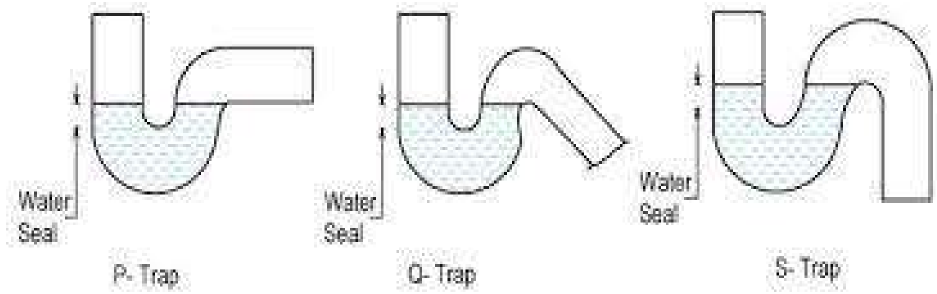
B. *Traps*: Traps are U-shaped fixtures that have a water seal in them. This water in the trap creates a seal that prevents gas from passing from the drain pipes back into the building's occupied space. Essentially all plumbing fixtures, including sinks, bathtubs, and toilets, must be equipped with either an internal or external trap.

Traps are classified, *depending upon the shapes*, as:

P-Trap: Exit into the wall behind the sink.

Q-Trap: Is used in toilets underwater closet.

S- Trap: This is usually used with a siphonage pipe.



Traps According to Shapes

Traps are classified, *based on the use*, as:

Floor Traps (Nahni Trap): This is generally used to admit sullage from the floors of rooms, bathrooms, kitchen, etc., into the sullage pipe. It is provided with cast iron or stainless steel or galvanized gratings (Jallis) at its top to prevent the entry of larger matter, thereby reducing blockage.

Gully trap: This is provided at a junction of a roof drain and another drain from the kitchen or bathroom.

Intercepting Traps: It is provided at the junction of a house sewer and municipal sewer to prevent the entry of foul gases of municipal sewer into the house drainage system.

C. *Sanitary Fittings*: They are used in the house drainage system.

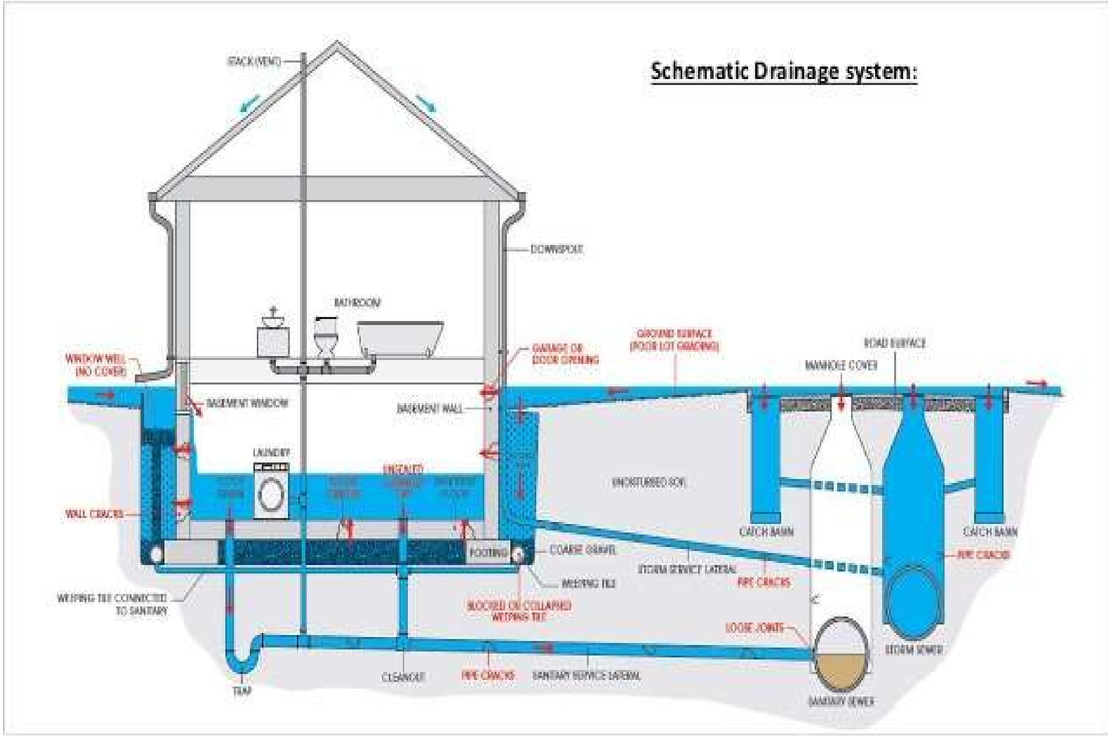
Wash Basin: These are plumbing fixtures mainly used for handwashing.

Sinks: They are the plumbing fixtures provided in kitchens for cleaning utensils.

Bathtubs: A circular waste hole at the bottom of the bathtub is provided for drainage purposes. Bath Tub is the plumbing fixtures provided in the bathroom for taking a bath.

Water Closets: A water closet is a pan-like water flushed plumbing fixture designed to directly remove human excreta and dispose of the same into the soil pipe through the trap.

3. Basic Principles of Drainage system:
    A. House Drainage should be preferably laid by the building's side to facilitate the easy repair and better maintenance.
    B. The sewage or sullage should flow under the force of gravity.
    C. The house sewer should always be straight.
    D. The entire system should be well ventilated from start to end.
    E. The house sewer should be connected to the utility hole such that the invert level is sufficiently higher to avoid the backflow of sewage in the house sewer.
    F. Wherever there is a change in the direction of the sewer line in the premises, provide an inspection chamber at the junction.
    G. House sewer joints should be leakproof because leakage, if any, shall create an odour problem and leak wastewater, infiltrate in the ground, and reduce the bearing capacity of soil below the foundation, which is not desirable.
    H. Rainwater from roofs or open courtyards should not be allowed to flow through the house sewers. Siphonage action can never be permitted, and therefore adequate ventilation systems should be installed.



4. Types of Drainage Systems:

   A. **<u>Two pipe systems:</u>** This is the best and most improved plumbing system. Two sets of vertical pipes; one for excreta (night soil) as soil pipe and another for sullage as a waste pipe. The soil and waste pipes are separately ventilated by providing a separate vent pipe or anti-siphon age pipe. This system has four vertical pipes.

   B. **<u>One pipe system</u>**: Instead of using two separate pipes for excreta and sullage, only one vertical main pipe is provided, collecting night soil and sullage water. The main pipe is ventilated at the top; also, a separate vent pipe is provided. This system has two vertical pipes.

C. **<u>Single stack system</u>**: This system has a single pipe for soil, waste, and vent without any separate ventilation pipe. It uses only one pipe, which carries night soil and sullage, and the same pipe is extended up to 2 m above roof level with a cowl to act as a vent pipe to remove gases.

D. **<u>Partially Ventilated Single Stack System:</u>** This is an improved form of the single stack system, where the traps of the water closets are ventilated, by a separate vent pipe, called relief vent pipe. This system uses two pipes as in the single pipe system. The single soil and waste pipe are connected to the vent pipe, and thus, costs are reduced.

5. Greywater Recycling: Greywater flows to the Surge tank, filtered through the coarse filter. Then it is Pumped into the Sand filter; then, it is disinfected and then pumped into the Greywater tank. And now this can again be used for Flushing purposes.

Vent System

It means an assembly of pipes and fittings that connects a drainage system with outside air for air circulation and the protection of trap seals in the drainage system.

1. Terminologies related to Vent
   a. **<u>Vent Header</u>**: a vent pipe that connects any combination of vent stacks to the outside air.
   b. **<u>Vent Pipe</u>**: a pipe that is part of a venting system.
   c. **<u>Vent Stack</u>**: a vent pipe connected at its upper end to a vent header or that terminates in outside air and is connected at its lower end to the soil-or-waste stack at or below the lowest soil-or-waste pipe connection.

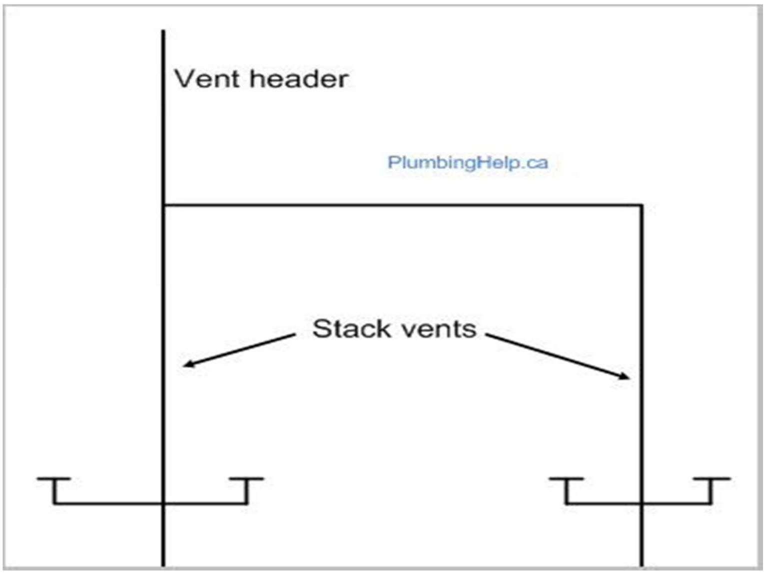


Fig. 1 Vent headers and Stack vents

   d. **<u>Wet Vent</u>**: a soil-or-waste pipe that also serves as a vent pipe and extends from the most downstream wet-vented fixture connection to the most upstream fixture connection.

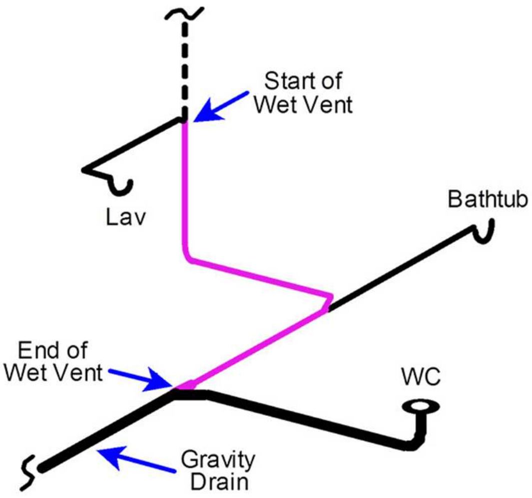


Fig. 2 Wet Vent

e. **<u>Yoke Vent</u>**: a vent pipe connected at its lower end to a soil-or-waste stack and its upper end to a vent stack or a branch vent connected to a vent stack.

f. **<u>Branch Vent:</u>** a vent pipe connected at its lower end to the junction of 2 or more vent pipes, and its upper end, either to another branch vent or to a stack vent, vent stack, or vent header, or terminates in the open air.

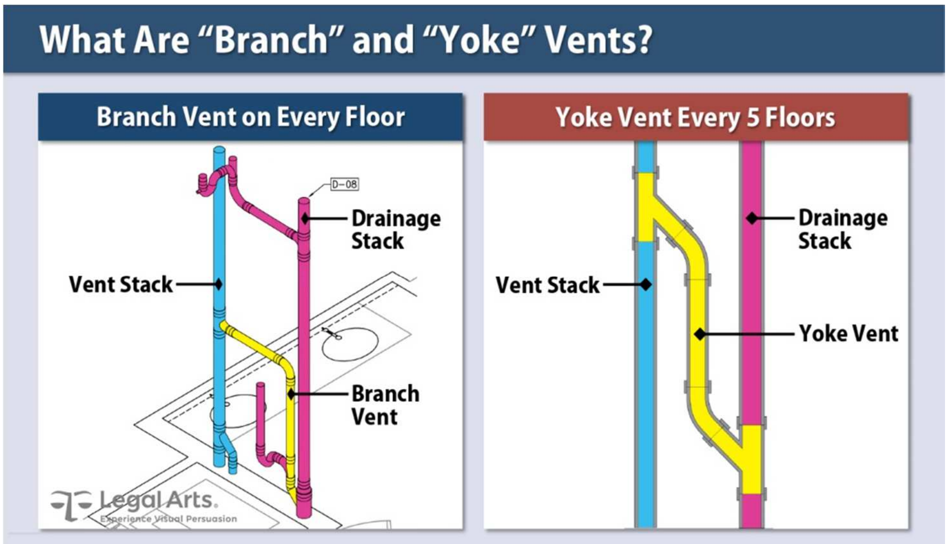


Fig. 3 Branch and Yoke Vents

g. **<u>Relief Vent</u>**: a relief vent that provides additional air circulation upstream and downstream of an offset in a soil-or-waste stack.

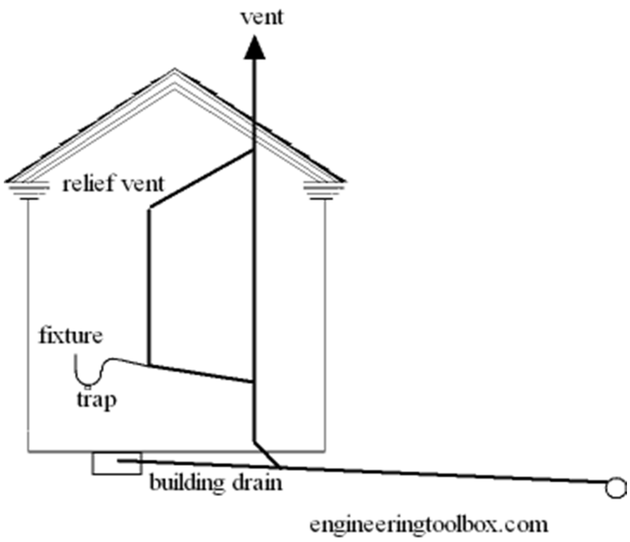


Fig. 4 Relief Vent

h. **<u>Individual Vent</u>**: a vent pipe that serves one fixture.

i. **<u>Dual Vent:</u>** a vent pipe that serves two fixtures and connects at the junction of the trap arms

Fig. 5 Individual and Dual Vents

j. <u>Continuous Vent:</u> a vent pipe is an extension of a vertical section of a branch or fixture drain.

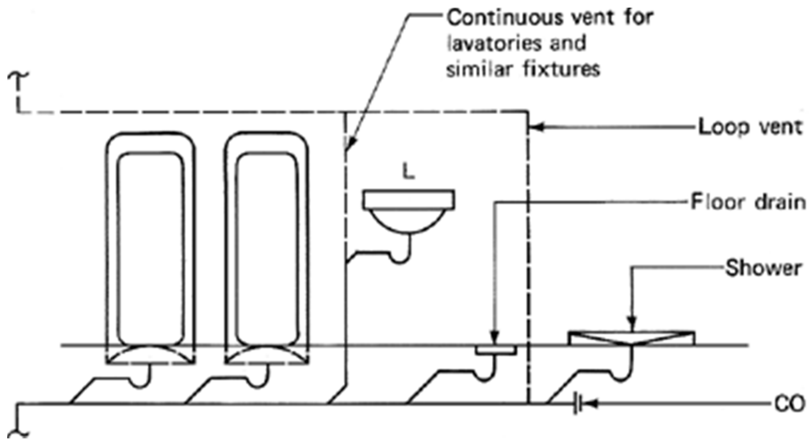


Fig. 6 Continuous Vent

k. <u>Circuit Vent:</u> a vent pipe that serves many fixtures and connects to the most upstream fixture's fixture drain.

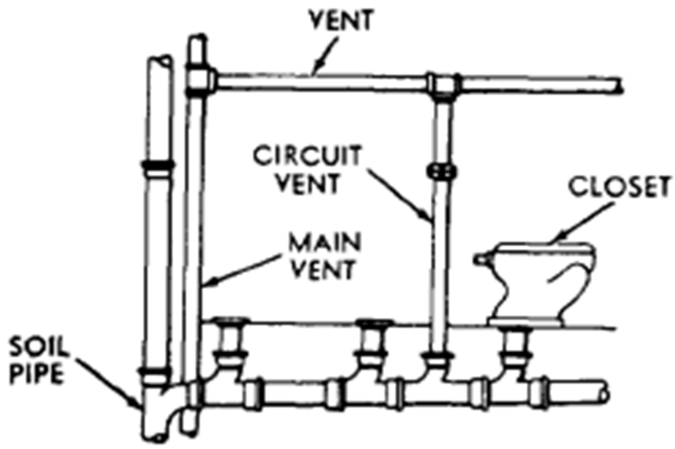


Fig. 7 Circuit Vent

2. Basic Principles of the Vent system

a. Vent pipes, often narrower than drainpipes, need not slope like drainpipes. Normally they run level or plumb unless there is an obstacle to work around.

b. Vent pipes must be installed so they stay dry; This means that they should emerge from the top of the drainpipe, either straight vertically or at no less than a 45-degree angle from horizontal, so that water cannot back up into them.

c. The horizontal portion of a revent pipe must be at least 6 inches above the fixture's flood level or the highest point to which water can rise. (On a sink, the flood level is the sink rim or overflow hole.)

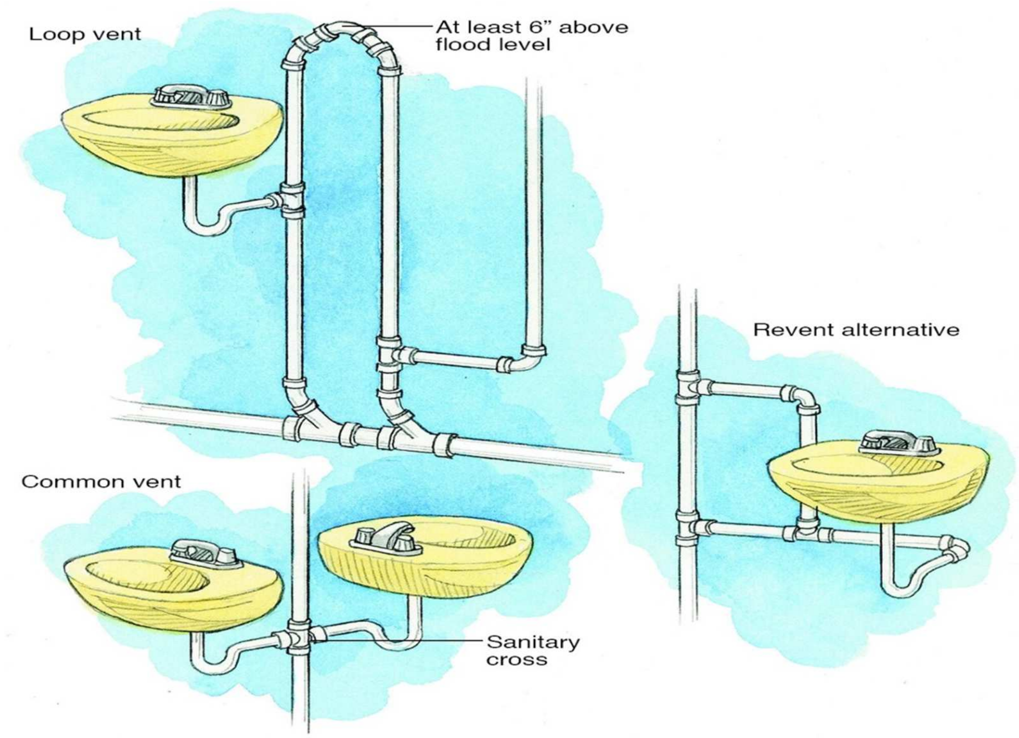


Fig. 8 Installed Vents

Sanitary Appliances

a. Minimum Fixture Clearance.

b. Keep the minimum clearance between fixtures and between appliances and walls.

c. Keep access to cleaning.

d. Supply both hot and cold water.

e. Hot water is controlled from the left side of the faucet.

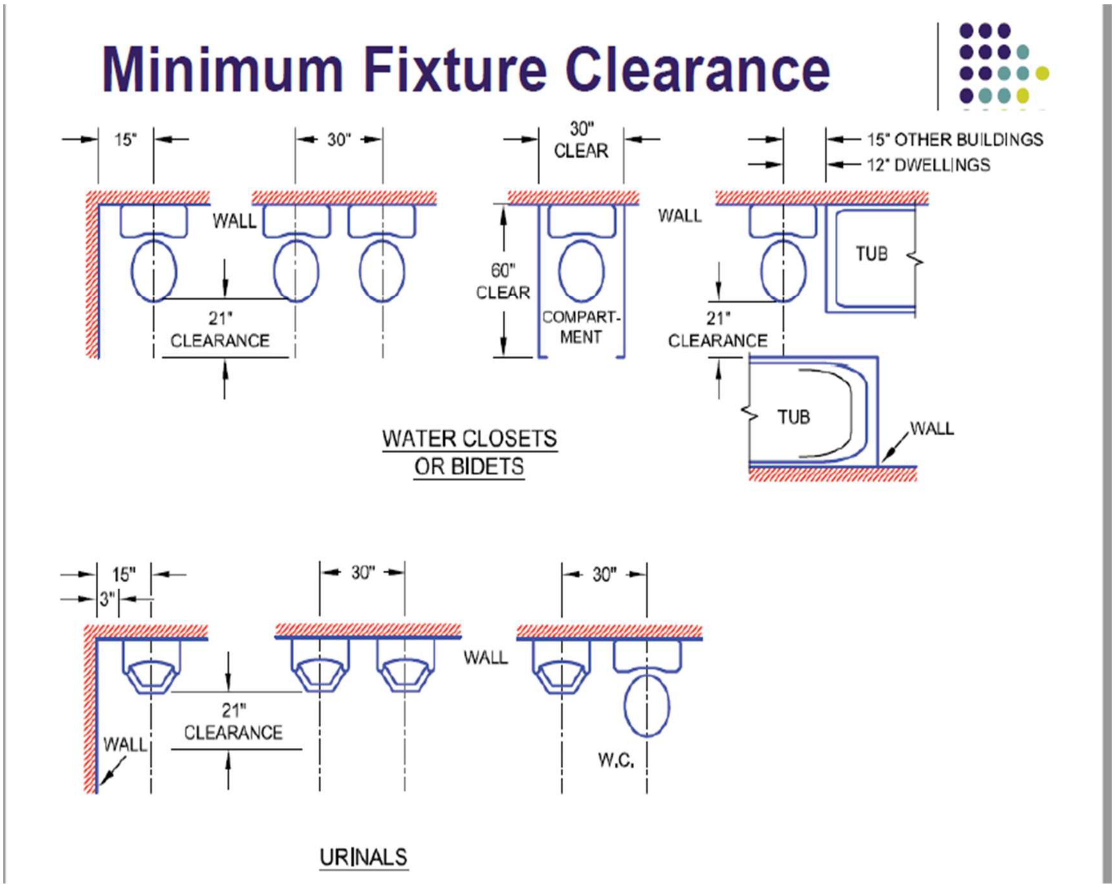


Fig.9a Minimum Fixture Clearance

Minimum Fixture Clearance

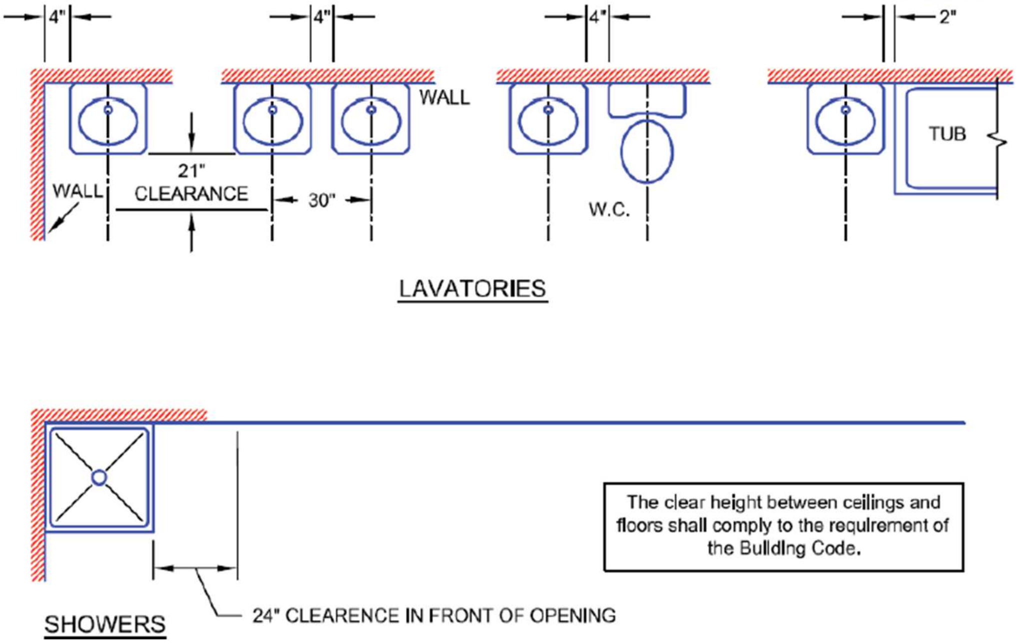


Fig. 9b Minimum Fixture Clearance

Swimming Pool

1. The definition

An artificial pool for swimming in, which is "above ground" or "in-ground."

2. The Types

They depend on the type of material they are constructed from.

2.1 Concrete Swimming Pools:

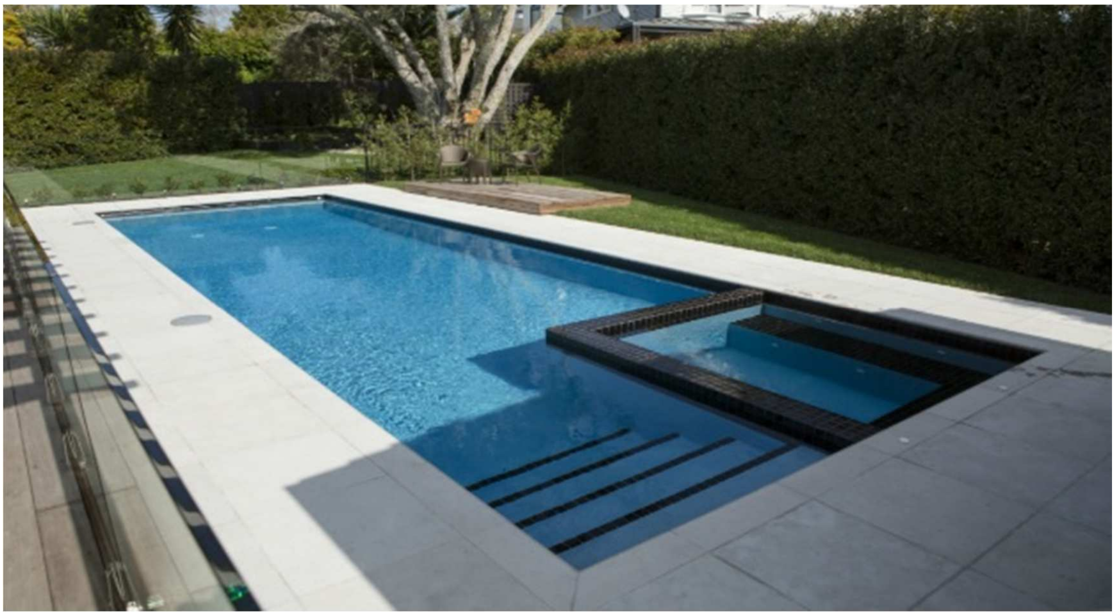


Fig.1 Concrete swimming pool

A concrete pool is a completely customized swimming pool solution. It can be placed virtually anywhere and give you unlimited design possibilities. You can choose the size, shape, and depth and add features such as vanishing edges, steps, beach entries, rockeries, and much more. Finishing options include ceramic tiles, natural pebble, colored quartz, epoxy resin paints, vinyl lining, and a range of other finishes.

2.2 Fiberglass Composite Swimming Pools:

Fig.2 Fiberglass swimming pool

Fiberglass composite pools come in varied styles, shapes, sizes, colors, and finishes. They are quick and easy to install and perfect for hard to access areas. Some fiberglass pools have the options of water features, in-floor cleaning, or in-built spa pools.

2.3 Vinyl Liner Pools

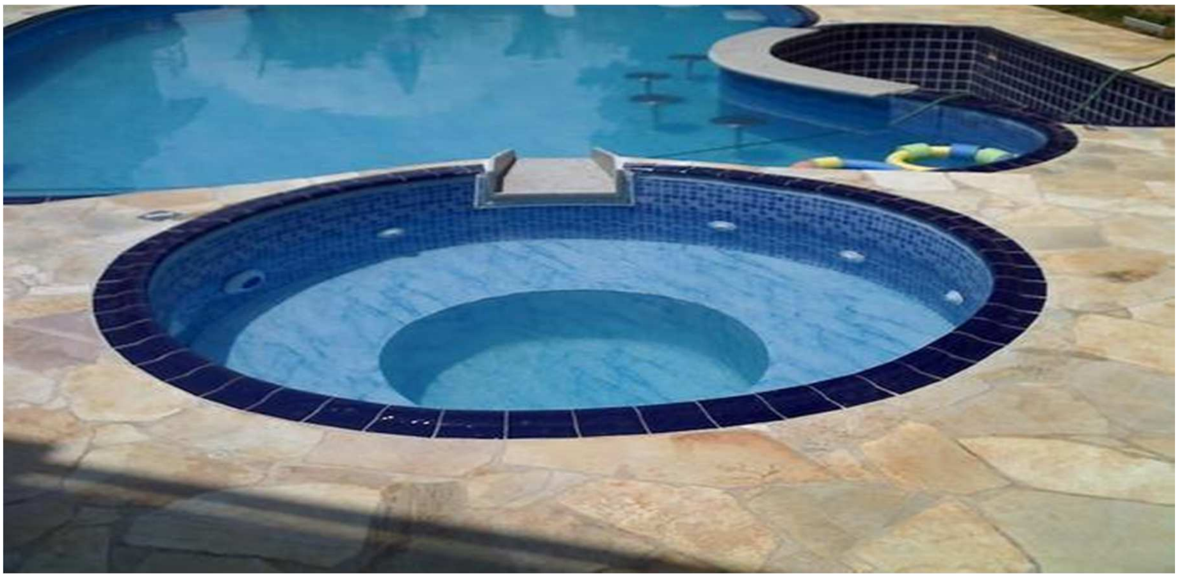


Fig.3 Vinyl liner swimming pool

A vinyl-lined pool is a popular and cost-effective option. The vinyl lining is usually tailor-made to suit the size and shape of your swimming pool. Modern vinyl lined pools can have concrete, plastic, or steel walls.

3. Cleaning the Pool

Cleaning the swimming pool can seem like a time consuming and daunting task. Still, the wide range of automatic and semi-automatic cleaning available today means you have a clean, sparkling pool with minimal effort.

3.1 Suction Cleaners

Suction cleaners are semi-automatic pool cleaners powered by your pool pump and connected to the skimmer box. They clean the pool by moving across the pool's surface on a random orbit. Dirt and debris are collected in the pool's filtration system and removed by backwashing.

3.2 Robotic Cleaners

The Robotic pool cleaner is an all-in-one, self-contained cleaning system and is available in various sizes to suit domestic and commercial swimming pools. The robots feature a built-in pump, motor, and filter powered by a low voltage generator. A robotic cleaner works by mapping out the pool area then cleaning it with a set period; it collects debris in its internal storage and filters the water simultaneously.

3.3 Pressure Cleaners

Pressure cleaners use an additional booster pump to pressurize filtered water from the pool return line and blasts the swimming pool's surface. Debris is collected both by the cleaner's collection containers and the pool filtration system.

3.4 In-floor Cleaning System

In-Floor cleaning systems use nozzles installed together with your swimming pools and require virtually no maintenance after installation. These cleaners use and separate pump and distribution system that directs debris to collection points where the pool filter removes it.

4. Heating the Pool

When you have invested a large amount of money in a swimming pool, we believe you should be able to enjoy it beyond the summer months, or even all year round.

A comfortable swimming tempter is around 25 - 26°C; additional heating will usually stay between 18 - 20°C. While your swimming pool will absorb heat during the day, it can lose as much as five °C overnight, making it difficult to keep the pool at a consistent temperature naturally.

4.1 Gas Pool Heating

A gas heater is a cost-effective way to heat your swimming pool to a comfortable swimming temperature year-round. It can provide "on-demand" heating, which means your pool will be at the temperature you want it, when you want it, regardless of the weather conditions.

When you're choosing a gas heater for your swimming pool, you should consider the following:

- Swimming pool size
- Maximum desired temperature
- Heat-up time
- Your swimming season

4.2 Heat Pumps

A heat pump is a very energy-efficient heating option for your pool and a great alternative for areas that don't have a natural gas connection. It uses the same technology as reverse-cycle air conditioners, extracting heat from the air and transferring it to water through various processes.

When choosing a heat pump, you should consider the following factors:

- Geographic location and climate*
- Maximum desired temperature
- Swimming pool size

- Heat pump location
- Desired swimming season

*Heat pumps perform better in warmer, tropical climates

4.3 Solar Pool Heating

A solar heating system of the right size can keep your pool at a comfortable swimming temperature and extend your swimming season.

Solar pool heaters use energy and heat from the sun to be best suited to sunny areas. They're one of the most economical and environmentally-friendly heating options and when combined with a gas booster, provide the most efficient temperature control, regardless of the sun.

When choosing a solar heating system, you should consider the following:

- Swimming pool size
- Roof orientation and shade
- Pool & roof color
- Amount of shade and wind
- Your desired swimming season

5. Designing and Installing the Swimming Pool

Designing and installing a swimming pool requires a specialist design to address:

- the building structure and management of the environment (taking into account shape, size, depth, tank, etc.)
- specific techniques (such as filtration, the circulation system – pumps, inlets and outlets, pipework, etc.)

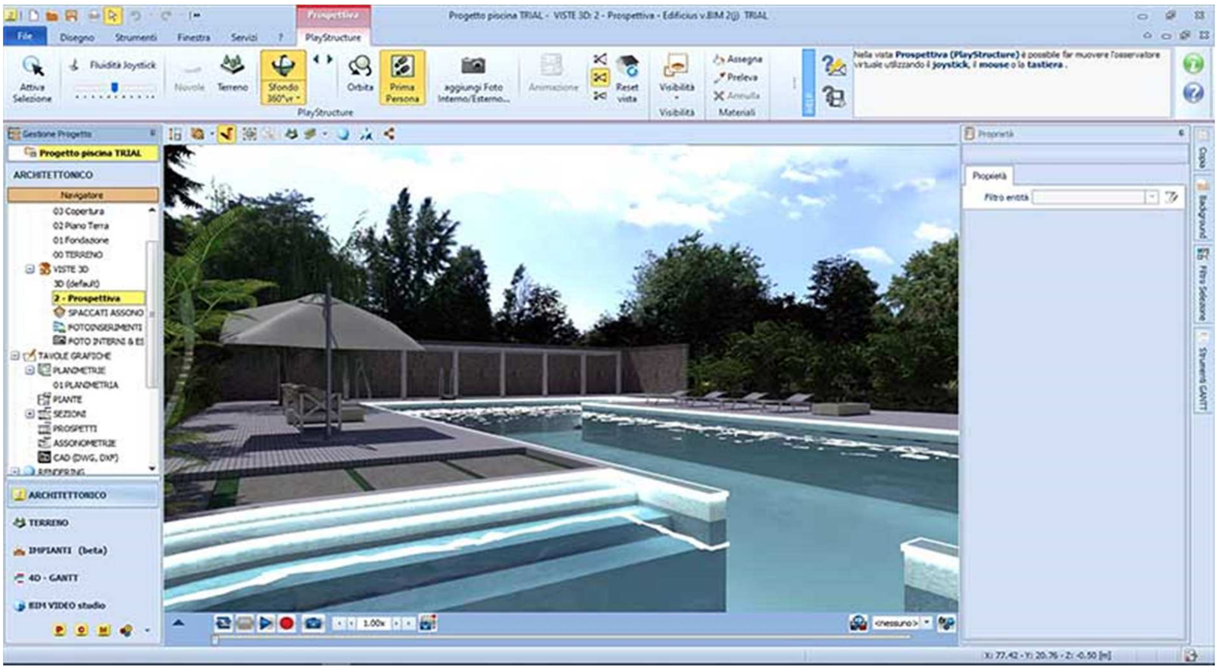


Fig.4 Software designing of swimming pool

First of all, to implement a complete swimming pool project, it is necessary to know the environmental and technical implications that may be faced, which will need to be solved in depth.

Fig.5 Top view of swimming pool

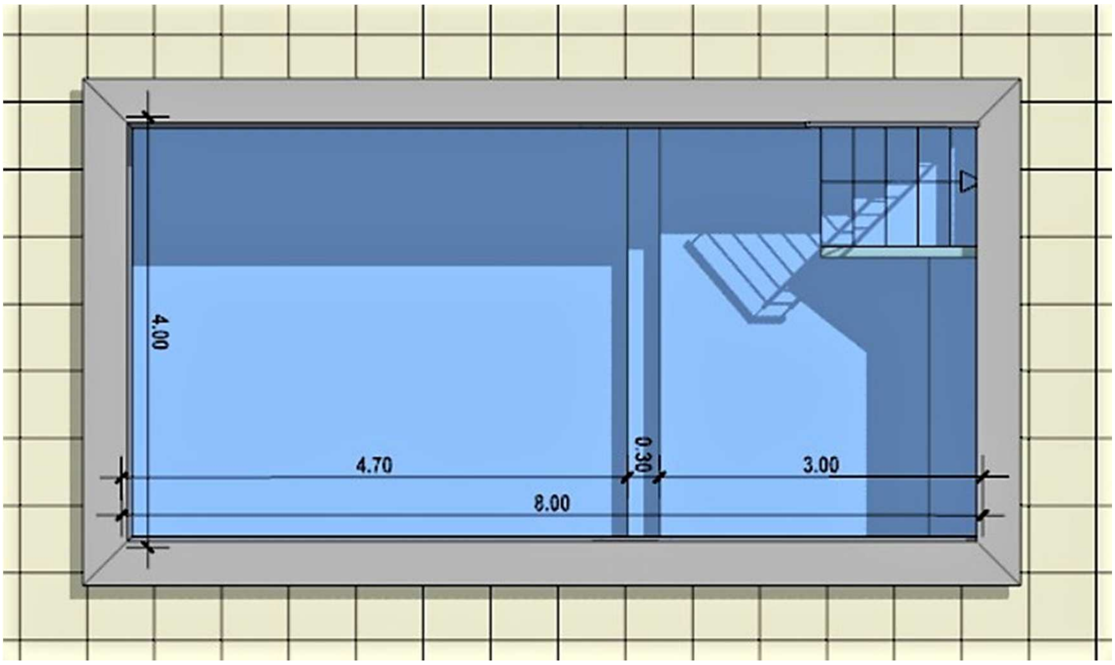


Fig.6 rehabilitation swimming pool – floor plant produced with Edificius

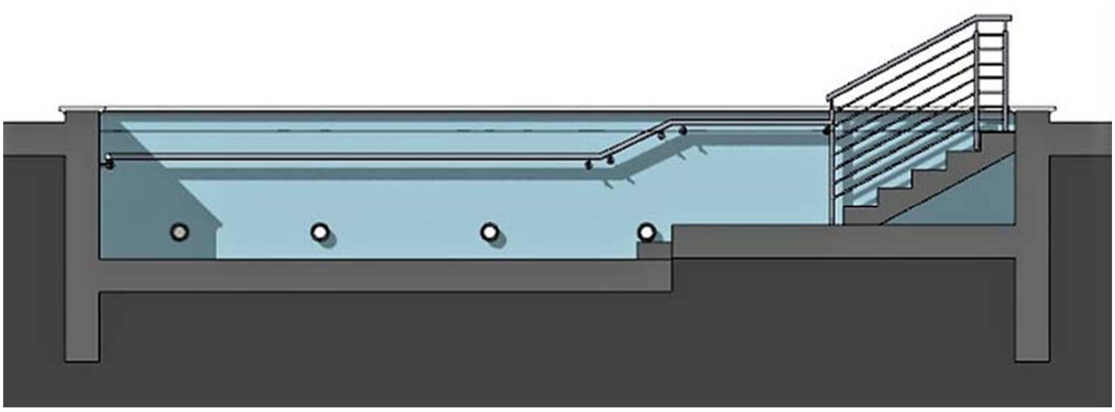


Fig.7 rehabilitation swimming pool- cross-section produced with Edificius

Concerning water depth shape types, several alternatives can be adopted. Not all of them can be applicable since a lot depends on the swimming pool perimeter shape. Generally, we could refer to four shapes of water depth:

1. **Flat**: same depth at both ends of the swimming pool.
2. **Sloped**: pool floor gradient starts with a 50 cm depth and progressively continues down to the desired depths
3. **Spooned**: the bottom is first sloping and then creates a sinking with the shape of a spoon to ensure maximum depth in the diving area
4. **U-shaped**: the deepest part is at the center of the pool.

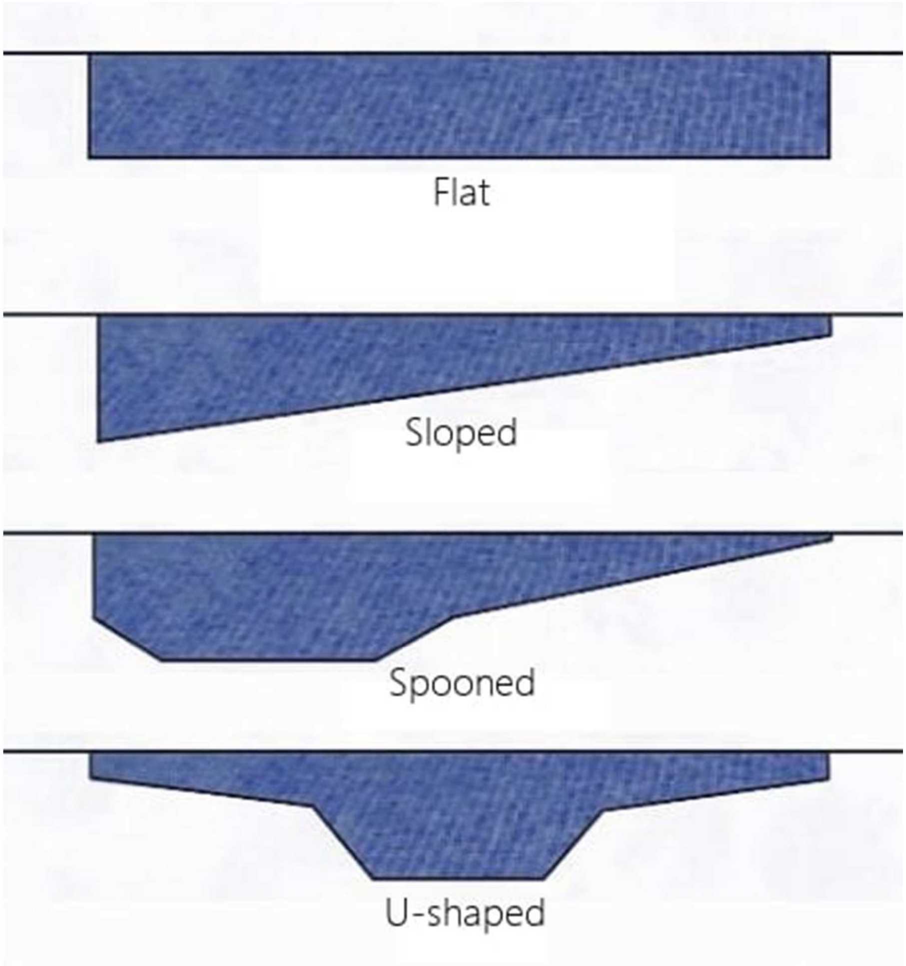


Fig.8 Types of different shape

Pool Algae Prevention & Treatment

1. Introduction

There are around 20,000 different types of Algae. It is possible and, in fact, quite common to get more than one type of Algae present in a pool at the same time.

2. The groups

The different types of Algae up can be classified into four groups:

Green - The most common group of several thousand different types. Including Green, Blue-Green, and Brown.

Black - Most often called Black Spot of a dozen different types.

Mustard - a single type, so-called because it resembles Mustard Powder, i.e., it is fine Yellow-Brown dust.

Pink - a single type, also known as Pink Slime or simply Red Algae.

3. Algae need to grow:-

Sunlight - Algae need Sunlight to photosynthesize. This fact explains why Algae is more prevalent in summer and why a pool covered in winter grows little Algae.

Nitrogen - Like all plants, Algae need Nitrogen.

Carbon Dioxide - Algae photosynthesize Carbon Dioxide.

Phosphate - Algae, like all living things, need Phosphate.

Water - Algae need water to grow, but Algae spores can remain viable for weeks in a dry state; this is very important when treating Mustard Algae.

4. Algae caused to grow in Pools

Algae spores are always present in the air - The day-to-day management of a swimming pool includes preventing these Algae spores from germinating. Algae prevention is daily business.

Low Chlorine level - If the Free Chlorine level has been allowed to drop below 3.0 PPM in Summer, for whatever reason, then Algae will grow.

High pH - Algae prefer high pH. It should also be remembered that Chlorine is much less effective at high pH. High pH is the single biggest cause of pool problems today!

Poor Water Circulation - Algae grow where the circulation is poor. On the steps, in the corners, in cracks and crevices, and between the pebbles in pebble pools.

Lack of brushing - In all pool handovers, the owner is told to brush the pool's walls and bottom every week. How many pool owners do you know to do this? Most types of Algae need a surface to cling to; a good brush will prevent this.

No Super chlorination - Super chlorination is the addition of three times the daily dose of Chlorine to the pool every two weeks. The main function of this is to burn out Chloramines (Ammonia compounds), which provide Nitrogen for algae growth, use up Free Chlorine, and are not good sanitizers. An added benefit of Super chlorination is that this high level of Chlorine kills Algae spores. The introduction of saltwater chlorinators means that these days Super chlorination is rarely done.

High Phosphate - Even if the Free Chlorine level and water balance are OK, a high Phosphate level will encourage Algae to grow. To rectify this, either use Starver to remove Phosphate or, if the Phosphate level is above 5.0ppm, empty the pool and refill with fresh water.

5. Fundamental Rules for Treatment of Algae

There are four fundamental rules in treating Algae:

1. The more Algae - the more Chlorine or Algaecide will be required.

2. The lower the pH, the better (Chlorine works better at low pH), but remember that people should not swim below pH 6.8.

3. The more brushing - the better, especially for Black Spot Algae.

4. The longer the Algae has been present—the longer it will take to kill it.

Design the Bathroom for Parking Area

Bathrooms intended for independent use by persons with disabilities shall have a minimum internal width of 2.5 m and an internal length of 2.7m. Sanitary ware shall be laid out to allow for a 1500mm diameter turning circle within the bathroom. The bathroom size shall be increased if any sanitary ware, fixture, or obstruction impinges on the 1500 mm turning circle.

The bath in an accessible bathroom should have a minimum length of 1600 mm and a minimum width of 700 mm with a slip-resistant, flat base. The bath rim of a bath for independent use should be 480 mm above floor level at the transfer end. Any grab rails fitted to the rim should not project above this height.

Where space is available, a securely fixable transfer seat the same width as the bath and extending beyond the head of the bath by at least 400 mm should be provided for ambulant disabled users and wheelchair users with the top surface set at bath rim height. Grab rails should be 25 to 32 mm in diameter, fixed with a clearance between the rail and the wall of 50 mm to 60 mm, and with a good grip when wet. The grab rails should be made of a material that does not rust.

Design the Bathroom for Comfort Station

A public toilet is a room or small building with toilets (or urinals) and sinks that do not belong to a particular household. Rather, the toilet is available for use by the general public, customers, travelers, employees of a business, school pupils, prisoners, etc. Public toilets are commonly separated into male and female facilities. Increasingly, public toilets are accessible to people with disabilities. Public toilets are known by many other names depending on the country. Examples are restroom, bathroom, men's room, women's room in the U.S., washroom in Canada, toilets, lavatories, water closet (W.C.), ladies and gents Europe.

Some public toilets are free of charge, while others charge a fee. In the latter case, they are also called pay toilets and sometimes have a charging turnstile.

Public toilets are typically found in many different places: inner-city locations, offices, factories, schools, universities, and other places of work and study. Similarly, museums, cinemas, restaurants, entertainment venues usually provide public toilets. Railway stations, filling stations, and long-distance public transport vehicles such as trains, ferries, and planes usually provide toilets for general use. Portable toilets are often available at large outdoor events.

Design the Entry

Doorless entry

Modern public toilets may be designed with a labyrinth entrance (doorless entry), which prevents the spread of disease that might otherwise occur when coming in contact with a door. Doorless entry provides visual privacy while simultaneously offering a measure of security by allowing the passage of sound. Doorless entry also helps deter vandalism; fewer audible clues to another person entering discourages some vandals. Doorless entry may also be achieved simply by keeping an existing door propped open, closed only when necessary.

Coin-operated entry

Pay toilets usually have some form of a coin-operated turnstile or an attendant who collects the fee.

Privacy

People often expect a high level of privacy when using public toilets. Privacy expectations may include toilet cubicles, cubicle doors, urinal partitions, and similar.

The World Health Organization states that toilets should be "suitable, private and safe to use for all intended users, taking into consideration their gender, age and physical mobility (e.g., disabled, sick, etc.)" and "All shared or public toilets should have doors that can be locked from the inside, and lights".

Service access

Modern public toilets often have a service entrance, utility passage, and the like that run behind all the fixtures. Sensors are installed in a separate room, behind the fixtures. Usually, the separate room is just a narrow corridor or passageway.

Sensors

Sensor-operated fixtures (faucets, soap dispensers, hand dryers, paper towel dispensers) prevent disease spread by allowing patrons to circumvent the need to touch common surfaces. Sensor-operated toilets also help conserve water by limiting the amount used per flush and require less routine maintenance. Each sensor views through a small window into each fixture. Sometimes the metal plates that house the sensor windows are bolted on from behind to prevent tampering. Additionally, all electrical equipment is safely behind the walls, so the electric shock is no danger.

Cisterns (tanks)

Older toilets infrequently have service ducts, and often in old toilets that have been modernized, the toilet cistern is hidden in a tiled over purpose-built 'box'. Often old toilets still have high-level cisterns in the service ducts. On the outside, the toilet is flushed by a handle (just like an ordinary low-level cistern toilet), although behind the wall. This trend of hiding cisterns and fittings behind the walls started in the late 1930s in the United States and the United Kingdom from the 1950s, and by the late 1960s, it was unusual for toilet cisterns to be visible in public toilets. In some buildings such as schools, however, a cistern can still be visible, although high-level cisterns had become outdated by the 1970s. Many schools now have low-level cisterns.

Fixtures

By their nature, public toilets see heavy usage, so that they may rely on a flush meter with a stronger and louder flush than a home toilet. Some high-vandalism settings, such as beaches or stadiums, will use metal toilets. Public toilets generally contain several of the following fixtures:-

a. **In the lockable cubicle (stall)**

A dispenser of toilet seat covers

- Toilet with toilet seat; whereas a home toilet seat has a lid, a public toilet may or may not
- Toilet paper, often within a lockable dispenser
- Coat hook
- "Pull-down" purse holder

- Bin for menstrual products; this may be classified as clinical waste and be subject to special regulations concerning the disposal
- Dispenser for flushable paper toilet seat covers.

b. At the point of handwashing

Faucets (taps) note some are at a lower level for children and wheelchair users

- Antiseptic handwash dispenser or soap dispensers, pump bottles, or auto dispensers
- Mirror (usually over sinks)
- Paper towel dispenser (sometimes they have auto-sensors for a touchless dispensing)
- Garbage can (a rubbish bin)
- Hand dryer (used manually or with auto-sensors).

c. Elsewhere

- Vending machines diapers (nappies), painkillers, energy, perfume, breath mints, facial tissue, confectionery, soap, or sanitary napkins or tampons
- Air fresheners or odor control systems
- Infant changing table, often fold-down (usually in women's rooms, but increasingly also in men’s rooms)
- Sometimes showers are also present, often with soap, shampoo, or similar dispensers (often at truck stops).

The layout of Bathroom for Different Types

1. Introduction

A bathroom is a room for personal hygiene activities, generally containing a toilet, a sink (basin), a bathtub, a shower, etc. In some countries, the toilet is usually included in the bathroom, whereas other cultures consider this insanitary or impractical and give that fixture a room of its own. The toilet may even be outside of the home in the case of pit latrines. It may also be a question of available space in the house whether the toilet is included in the bathroom or not.

Historically, bathing was often a collective activity, which took place in public baths. In some countries, the shared social aspect of cleansing the body is still important, for example, with sento in Japan and the "Turkish bath" (also known by other names) throughout the Islamic world.

In North American English, the word "bathroom" may mean any room containing a toilet, even a public toilet (although in the United States, this is more commonly called a restroom and in Canada a washroom).

2. Design Considerations

2.1 Towels

Bathrooms often have one or more towel bars or towel rings for hanging towels.

2.2 Furniture

Some bathrooms contain a bathroom cabinet for personal hygiene products and medicines and drawers or shelves (sometimes in column form) for storing towels and other items.

2.3 Bidet

Some bathrooms contain a bidet, which might be placed next to a toilet.

2.4 Plumbing

A bathroom design must account for both hot and cold water, in significant quantities, for cleaning the body. The water is also used for moving solid and liquid human waste to a sewer or septic tank. Water may be splashed on the walls and floor, and hot, humid air may cause condensation on cold surfaces. From a decorating point of view, the bathroom presents a challenge. Ceiling, wall, and floor materials and coverings should be impervious to water and readily and easily cleaned. The use of ceramic or glass and smooth plastic materials is common in bathrooms for their cleaning ease. Such surfaces are often cold to the touch; however, water-resistant bath mats or even bathroom carpets may be used on the floor to make the room more comfortable. Alternatively, the floor may be heated, possibly by strategically placing resistive electric mats under floor tile or radiant hot water tubing close to the floor surface's underside.

2.5 Electricity

Electrical appliances, such as lights, heaters, and heated towel rails, generally need to be installed as fixtures, with permanent connections rather than plugs and sockets. This minimizes the risk of electric shock. Ground-fault circuit interrupter electrical sockets can reduce electric shock risk and are required for bathroom socket installation by electrical and building codes in the United States and Canada. In some countries, such as the United Kingdom, only special sockets suitable for electric shavers and electric toothbrushes are permitted in bathrooms and are labeled as such.

UK building regulations also define what type of electrical fixtures, such as light fittings (i.e., water-/splash-proof), may be installed in the areas (zones) around and above baths and showers.

2.6 Lighting

Bathroom lighting should be uniform, bright, and must minimize glare. For all the activities like shaving, showering, grooming, etc., one must ensure equitable lighting across the entire bathroom space. The mirror area should have at least two light sources at least 1 foot apart to eliminate any shadows on the face. Skin tones and hair color are highlighted with a tinge of yellow light. Ceiling and wall lights must be safe for use in a bathroom (electrical parts need to be splash-proof) and must carry appropriate certification

.

Fig.1 Bathroom from Argentina in which the walls are decorated with turquoise-and-white mosaics.

Fig.2 Bathroom from Belgium

Fig.3 An early 20th-century bathroom in the Beamish Museum, near Durham, England

Refuse Storage System

1. Introduction

Waste management (or waste disposal) includes the activities and actions required to manage waste from its inception to its final disposal; This includes collecting, transport, treating, and disposing of waste and monitoring and regulating the waste management process.

Waste can be solid, liquid, or gas, and each type has different disposal and management methods. Waste management deals with all types of waste, including industrial, biological, and household. In some cases, waste can pose a threat to human health. Waste is produced by human activity, for example, the extraction and processing of raw materials. Waste management is intended to reduce the adverse effects of waste on human health, the environment, or aesthetics.

Waste management practices are not uniform among countries (developed and developing nations); regions (urban and rural areas), and residential and industrial sectors can all take different approaches. A large portion of waste management practices deals with municipal solid waste (MSW), which is the bulk of the waste created by household, industrial, and commercial activity.

2. *Ways of Collection*

Municipal solid waste is collected in several ways:

1. *House-to-House:* Waste collectors visit each house to collect garbage.
2. *Community Bins*: Users bring their garbage to community bins placed at fixed points in a neighborhood or locality. The municipality or it's designated pick up MSW according to a set schedule.
3. *Curbside Pick-Up*: Users leave their garbage directly outside their homes according to a garbage pick-up schedule set with the local authorities (secondary house-to-house collectors not typical.
4. *Self-Delivered*: Generators deliver the waste directly to disposal sites or transfer stations or hire third-party operators (or the municipality).
5. *Contracted or Delegated Service*: Businesses hire firms(or municipalities with municipal facilities) who arrange collection schedules and charges with customers. Municipalities often license private operators and may designate collection areas to encourage collection efficiencies.

Fig.4 Example of Separate Garbage Containers

Collected MSW can be separated or mixed depending on local regulations. Generators can be required to separate their waste at source, e.g‘. into "wet" (food waste, organic matter) and "(dry recyclables), and possibly a third stream of "waste", or residue. Waste that is un-segregated could be separated into organic and recycling streams at a sorting facility. The degree of separation can vary over time and by city. 'Separation' can be a misnomer as waste is not separated but rather is placed out for collection in separate containers without first being 'mixed' together.

Often, MSW is not separated or sorted before it is taken for disposal, especially in developing countries. Still, recyclables are removed by waste pickers before collection, during the collection process, and at disposal sites.