Plumbing System

Introduction

Plumbing is the system of pipes, drains, fittings, valves, and fixtures installed for the distribution of potable water for drinking, heating and washing in a building, and drainage of wastewater and storm water from the building.

The water supply system must accomplish two objectives:

- provision of sufficient amount of water to serve each fixture.
- provision of no opportunity of backflow of used water into the water supply pipes.

The drainage system must accomplish two objectives:

- wastewater must be removed quickly with minimum chance for stoppage of drains or leakage.
- entrance of vermins and. sewer gas or foul smelling air from the drainage system into the house must be prevented.

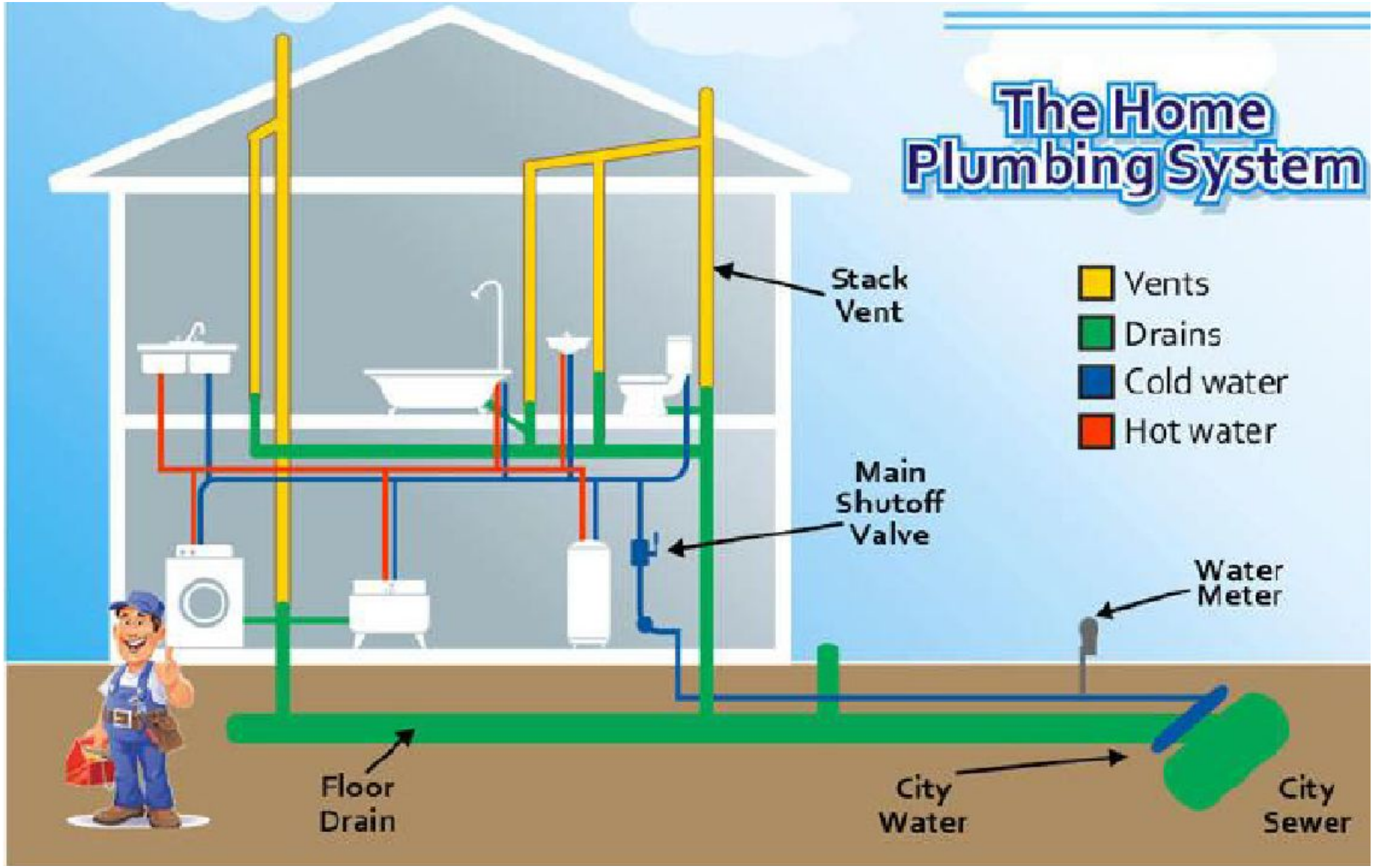
History of Plumbing



Indus Valley Drainage System (3000 BC)

Roman Aqueducts




The Home Plumbing System
Stack Vent
Vents
Drains
Cold water
Hot water
Main Shutoff Valve
Water Meter
Floor Drain
City Water
City Sewer





Scope of Plumbing

- Water supply system related
- Waste disposal related.
- Storm water management related.
- Gas supply related.

Scope of Plumbing

Water supply system related

- Cold water supply.
- Hot water supply.
- Chilled water supply.
- Water treatment for building occupants.
- Pump selection, installation and maintenance.
- Steam and hot-water boiler selection and related works.
- Fire suppression system.
- Garden hydrant system
- Fountain, cascade and water fall.
- Swimming pool water supply, treatment **and** conditioning.
- Interior-scape irrigation: Manual and automatic.

Scope of Plumbing

Waste disposal related.

- Plumbing fixture, pipe equipment selection, installation and maintenance.
- Soil, waste and vent piping system.
- Building sewer.
- Basement drainage and pumping.
- Sewage pump selection and installation.
- Swimming pool, fountain, water body drainage.
- Wastewater recycling and reuse.

Scope of Plumbing

Storm water management related.

- Rainwater collection, storage, disinfection, and distribution.
- Storm water drainage.

Gas supply related.

- Fuel gas supply in building.

Governing principles of plumbing system in a building

1) should be sufficient water pressure available to serve each fixtures.
2) should be no opportunity for backflow of water.
3) Wastewater/liquid waste should be quickly removed with minimum possibilities of stoppage of drains or leakage.
4) Entrance of sewer gases, foul odour inside the building should be prevented.
5) should not any risk involved in the contamination of water supply for domestic purpose by x-connection between watersupply pipe and drainage pipe.
6) The facilities and storage for fire fighting should be provided.
7) The pipes should be protected from possible damages while lying underground or even over the ground.

Governing principles of plumbing system in a building

8) The pipes should be laid as straight as possible to minimize the frictional loss.
9) The pipes and fittings should be fully protected against corrosion and frost.
10) The pipes layout should be such as to admit of easy inspection and repair.
11) The pipes and fittings should be thoroughly water-tight due to prevent the damage for leakage.
12) The changes in diameter and direction of pipe should be gradual to avoid undue loss of water-head.
13) Installation is not done so as to impair the structural safety of the building.
14) Each stack should be suitably covered on top above roof.

Design Approach

- Safety
- Sanitation
- Good environment
- Convenience
- Comfort
- Economy
- Durability
- Legality

Types of pipes used in Plumbing System

Materials	Galvanised iron pipes	Cast iron pipes	Unplasticsized PVC pipes	Rigid PVC pipes
Diameter	used for small diameter	Up to 60 mm	Ranging from 16 mm to 315mm	Ranging from 32 to 315 mm
Property	Best for services and internal connections	they don't echo when water moves through	Corrosion resistant , Chemical resistance	Same as Unplasticsized PVC Pipes



Galvanised iron pipes



Cast iron pipes



Unplasticsized PVC pipes



Rigid PVC pipes

Sanitary Drainage Systems

- There are basically two types of drainage systems - *sanitary drainage system and storm water drainage system.*
- The system that drains waste water from sinks, tubs, showers, lavatories, and soil matter from toilets is known as the *sanitary drainage system,* and the other system that collects storm water from roofs, yards, and areaways is known as the *storm water drainage system.*
- These systems may be used separately, each draining into a public sewer, a private cesspool, or septic tank. When both systems are combined, they are known as a *combined drainage system.*

Wastewater Removal

1. Wastewater is carried to the sanitary sewer or septic tank through the building drainage system consisting of horizontal and vertical pipes.

2. These pipes are isolated from the water supply system and must be sized for sufficient capacity, have the proper slope and venting, and have provisions for cleanouts.

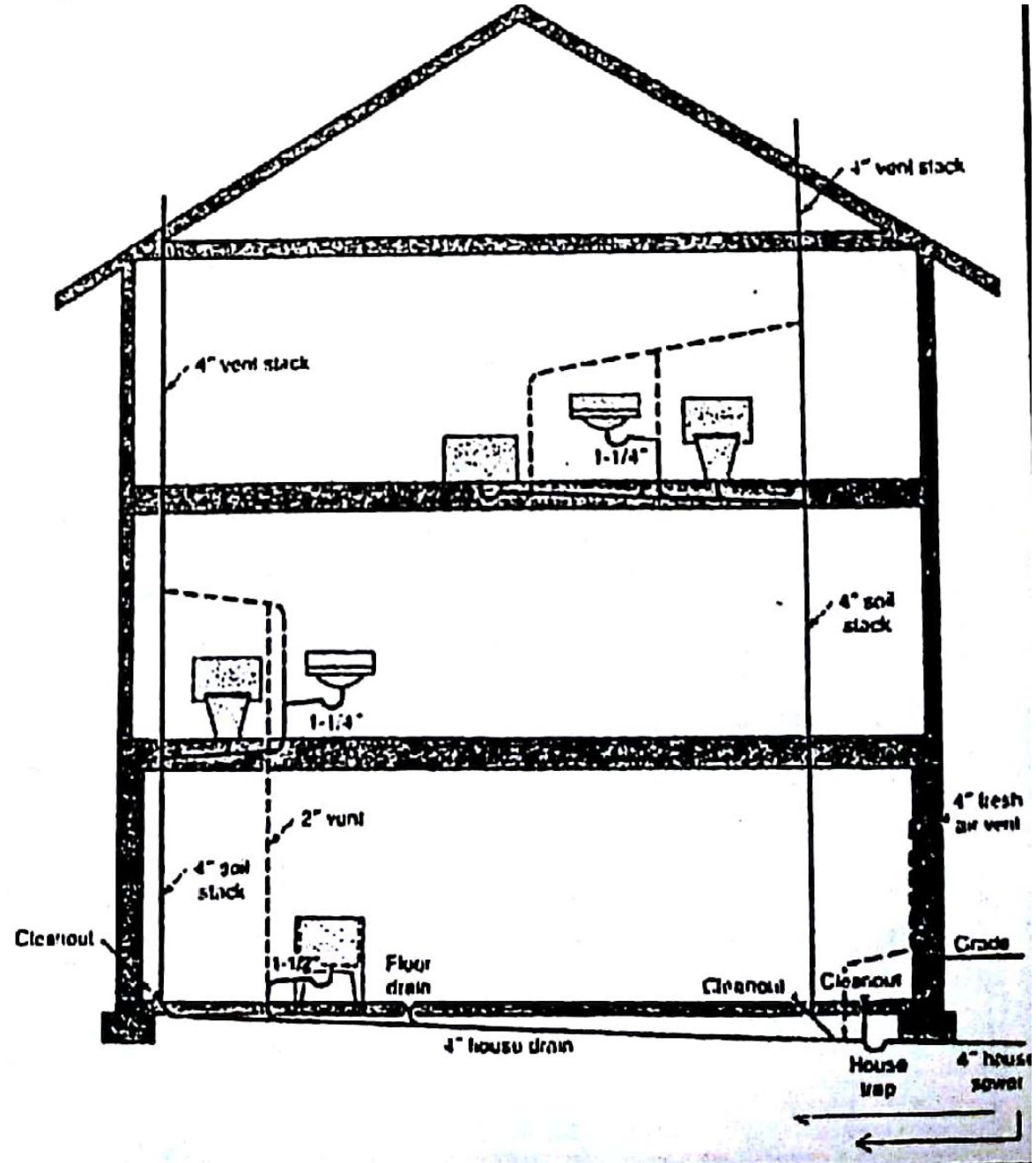
3. Typically it is practical to drain as many of the fixtures as possible into a single main drain.

4. The drainage system is not under pressure and depends on gravity to carry the wastewater to the sewer.

Wastewater Drainage System

The piping that makes up a sanitary system is generally as follows:

House sewer
House drain
Soil, waste, vent stacks
Fixture branches
Fixture traps
Fixtures
Fixture vents



HOUSE SEWER :

1. The house sewer is that portion of pipe that extends to the public sewer pipe in the street to about 3 to 5 ft from the house.
2. The minimum pipe diameter for the house sewer is 3 in. Larger sizes are of course required when serving a greater number of fixtures.

HOUSE DRAIN :

The house drain is the horizontal pipe inside the house into which the vertical soil and waste stacks discharge.

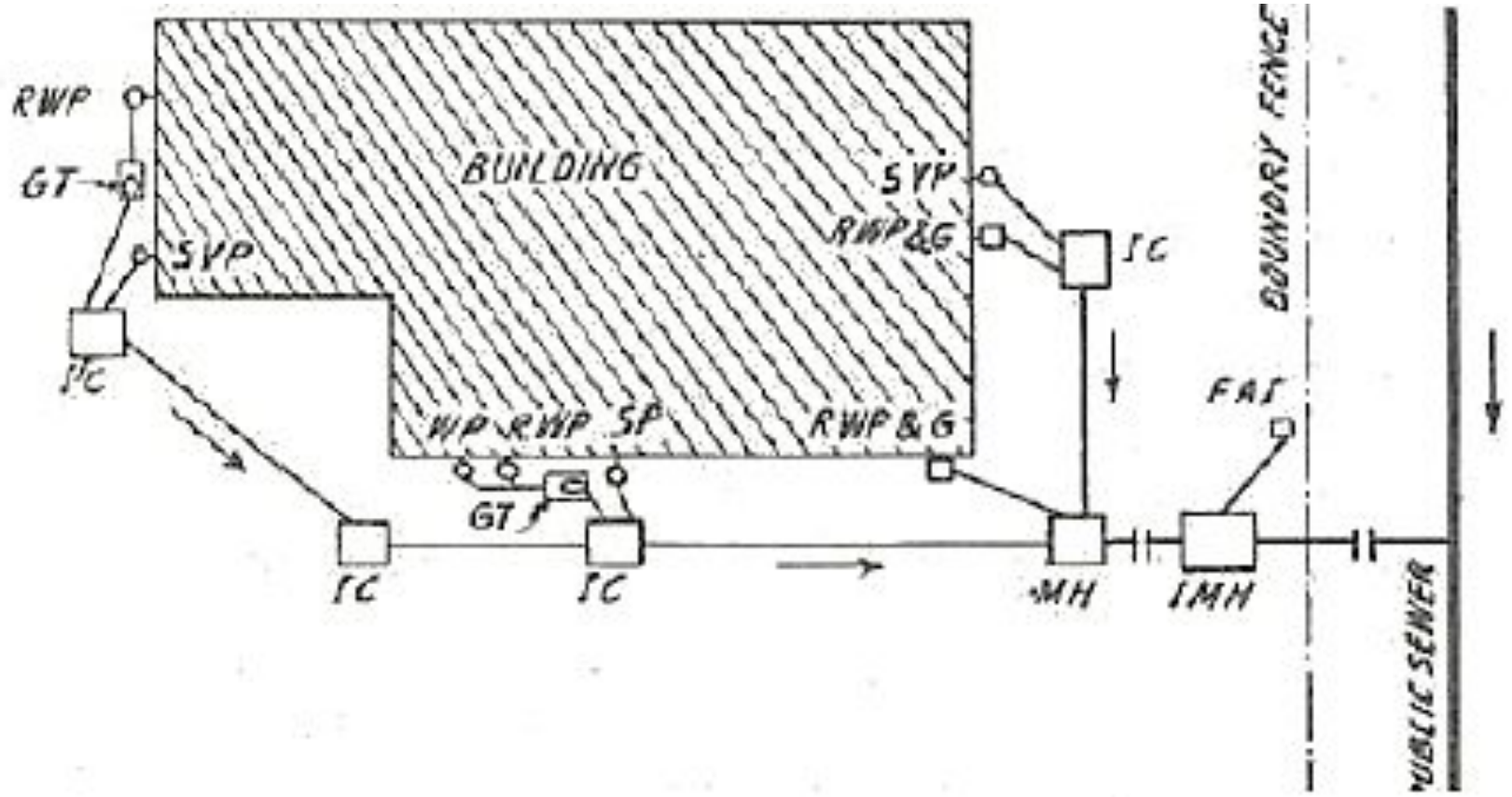
SOIL, WASTE, AND VENT STACKS :

1. Soil, waste, and vent stacks are the vertical pipes of the drainage system.
2. The soil stack receives the soil matter from the water closets and urinals.
3. The waste stack receives wastewater from all types of fixtures except water closets and urinals.
4. If a stack receives both soil matter and sullage, it is termed as a soil stack.
5. Vent stacks are used only to allow movement of air through the system.

FIXTURE BRANCHES AND BRANCH VENTS :

1. The fixture branch is the horizontal pipe running from the fixture trap to the vertical soil or waste stacks.
2. The fixture branch vents are the horizontal piping that run from near the fixture trap, then overhead of the fixture to the vent stack. Branch vents are arranged so that waste matter flowing through the fixture branch cannot clog and foul the vents.

Grades of Horizontal House Sewer Drainage pipes should have a minimum slope of ¼ inch per ft toward the point of disposal. Where this is not practicable due to depth of a street sewer or the arrangement of the structural features, pipes 4 inch or larger dia may have a slope of not less than 1/8 inch per ft should be provided.

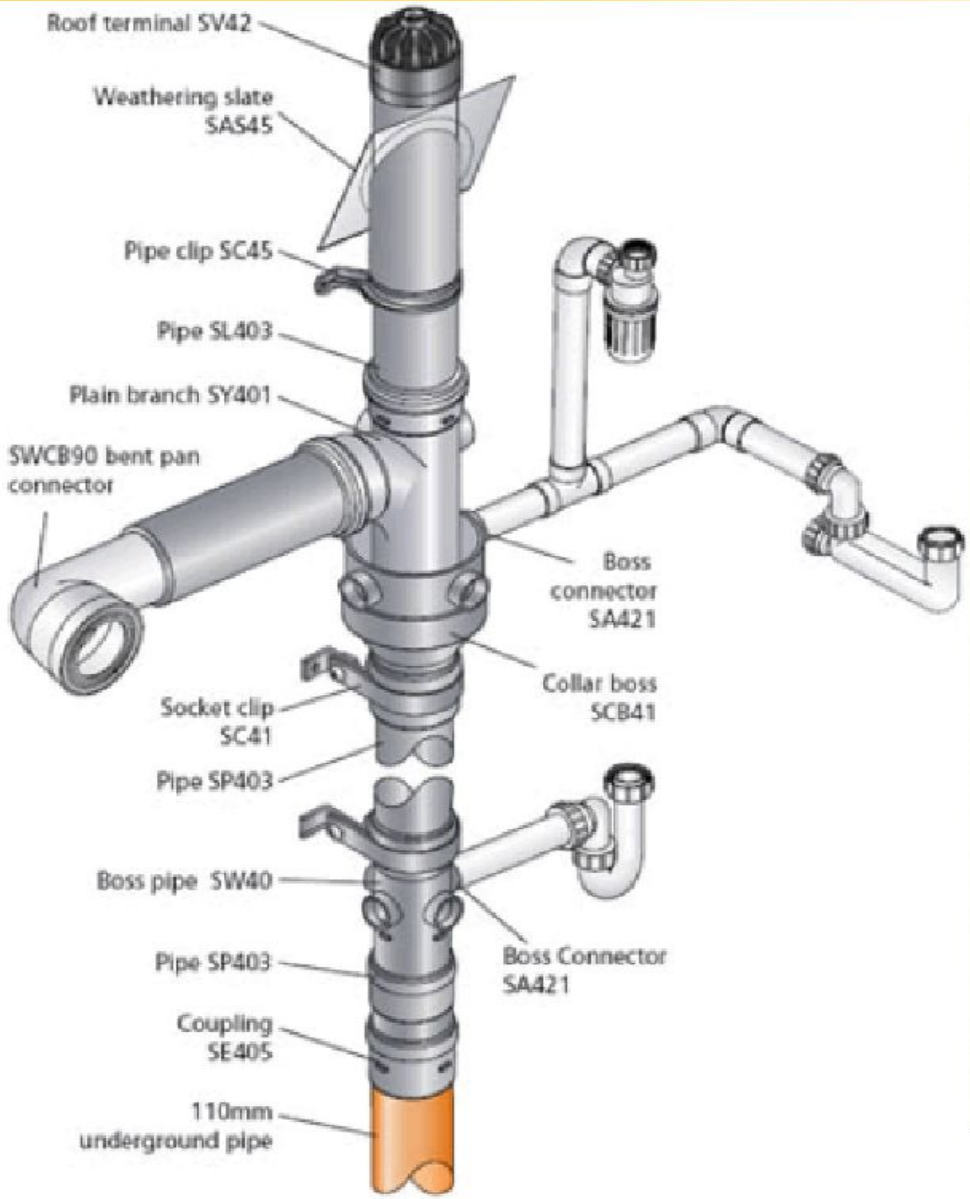


Conventions

SP	=	Soil pipe	GT	=	Gully Trap
WP	=	Waste pipe	MH	=	Manhole
SVP	=	Soil vent pipe	IC	=	Inspection chamber
RWP	=	Rain water pipe	IMH	=	Intercepting manhole
RWP & G	=	Rainwater pipe and gully	FAI	=	Fresh air inlet

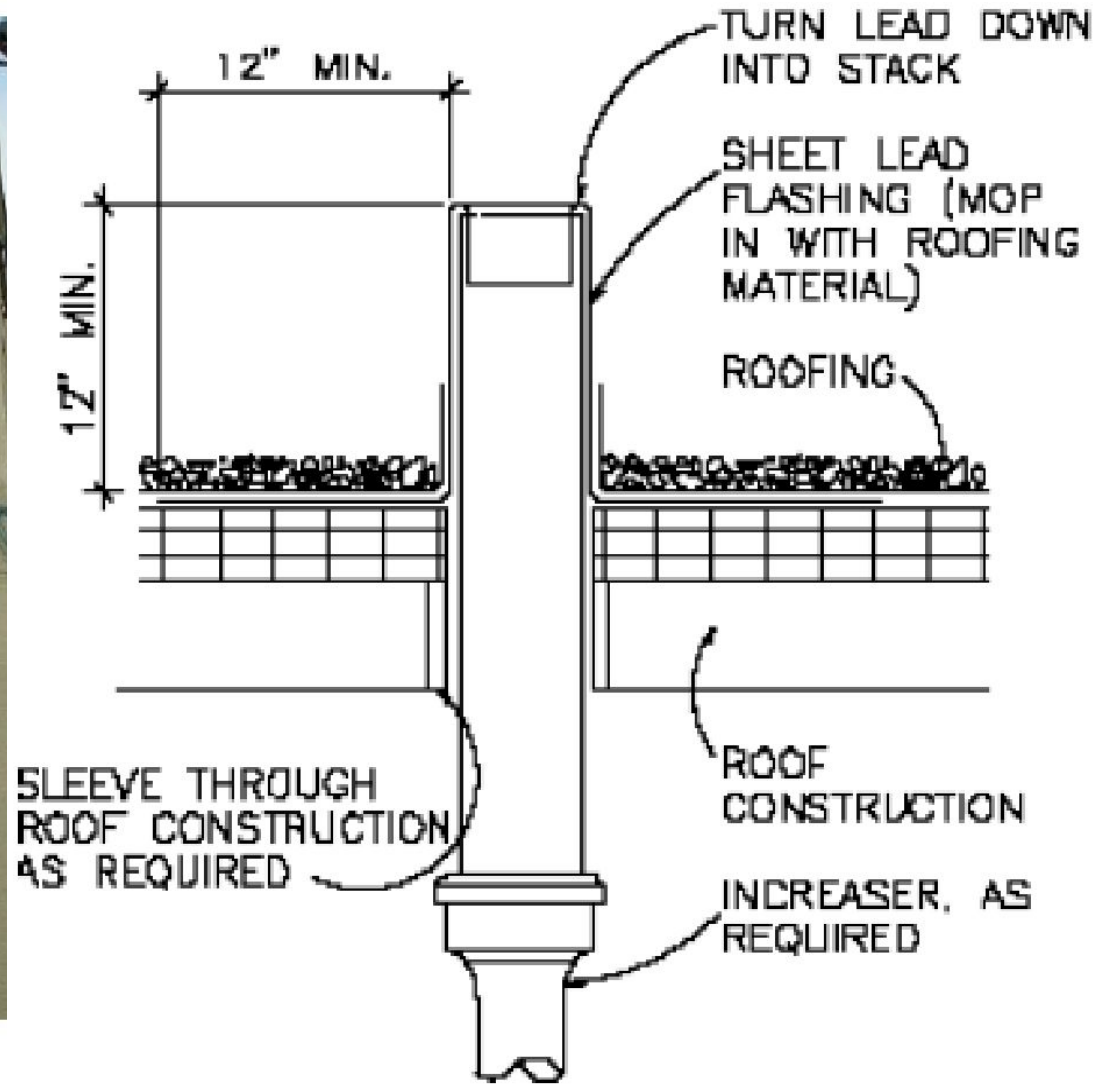
Fig. 1.18. Typical Lay-out of House Drainage System.

SOIL TACK



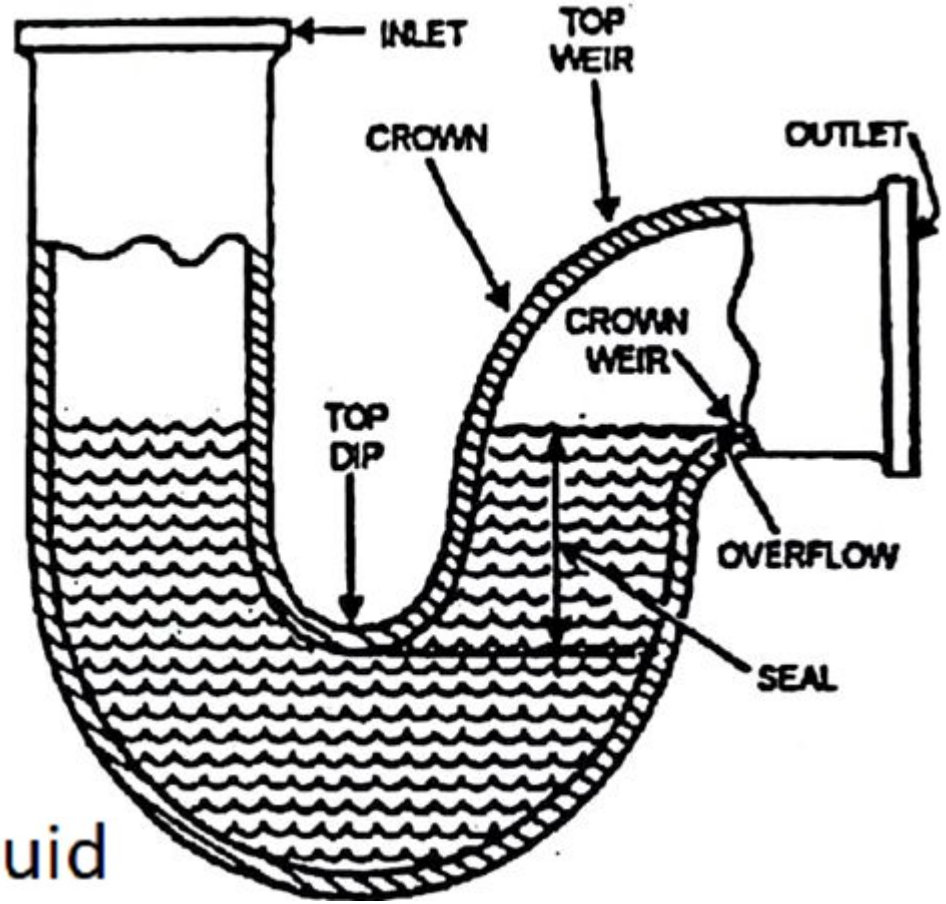


VENTS



Traps

Traps are fittings placed in drainage pipes, which prevent the passage of foul air or gases through drains, waste or soil pipes and thus prevent their entry into the interior of the houses or buildings. This is possible because traps are equipped with water seals having a minimum depth of 25 mm.



Trap Seal is the maximum vertical depth of liquid that a trap will retain, measured between the crown weir and the top of the dip of the trap.

Traps

Quality of the traps:

Good Traps should have following Qualities:

- ✓ Should provide enough water seal or trap seal (around 50 mm) with large surface area.
- ✓ Interiors surface should be smooth so that the flow is not obstructed which enables self cleansing.
- ✓ An access door should be provided for cleaning the trap.
- ✓ It should be made of non- adsorbent material.

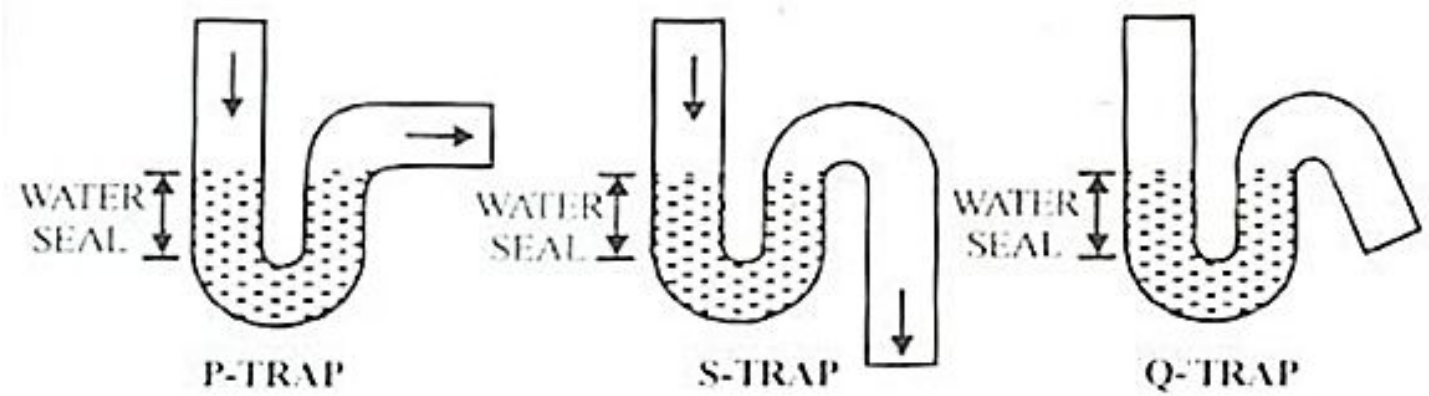
Strength of a trap:

The strength of a trap is the ability of its water seal to resist the passage of air or gas through it. The strength of a trap is determined by the vertical height to which water in the trap can raise above the dip.

Types of Traps

- According to shape
  - P Trap
  - Q Trap
  - S Trap
- According to use
  - Floor trap
  - Gully Trap
  - Intercepting Trap

Types of Traps





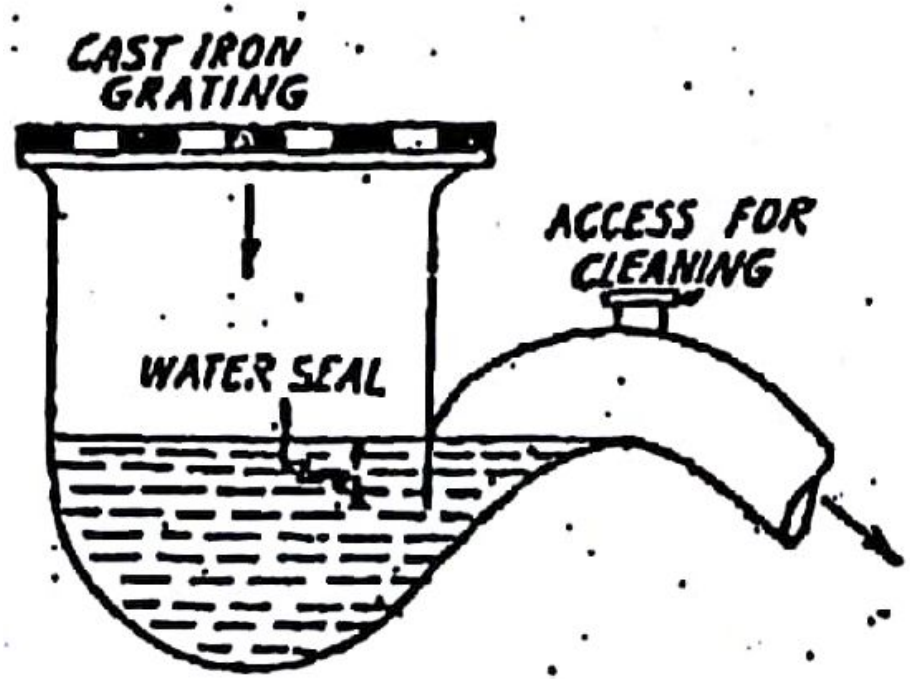
A P-trap is a bend in a drain and waste pipe which contains a pocket of water, blocks toxic, foul-smelling sewer gases (like methane) from traveling through the pipe inside home.

S-traps are a type of plumbing trap that blocks sewer gases in sinks and other plumbing fixtures which traps wastewater before it drains to the sewer line, creating a water seal that prevents gases from flowing up through the drain.

Q-trap is a common SWR fittings used in combination with Push fit & Solfit Pipes. It prevents transmission of unfavorable odors from the washroom to the living area. Commonly used in shower areas and WC drain areas.

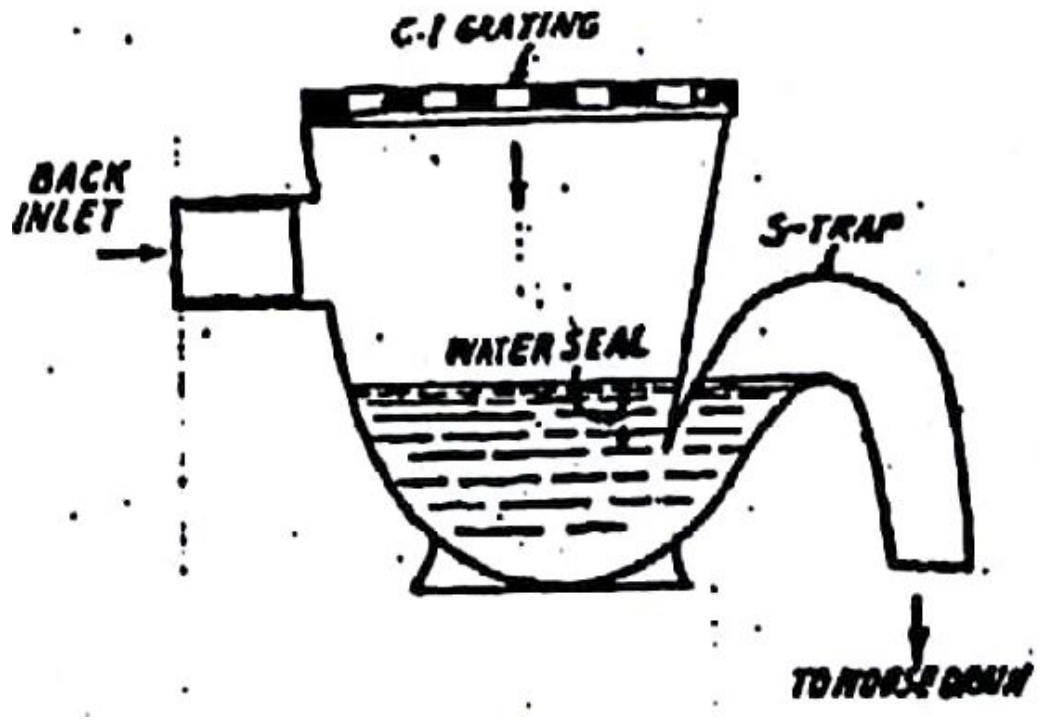
Floor Traps

- Used primarily for admitting surface wash or wastewater from floors of baths and kitchen.
- A grating is provided at the top of the trap to exclude coarse solid matter.



Gully Traps

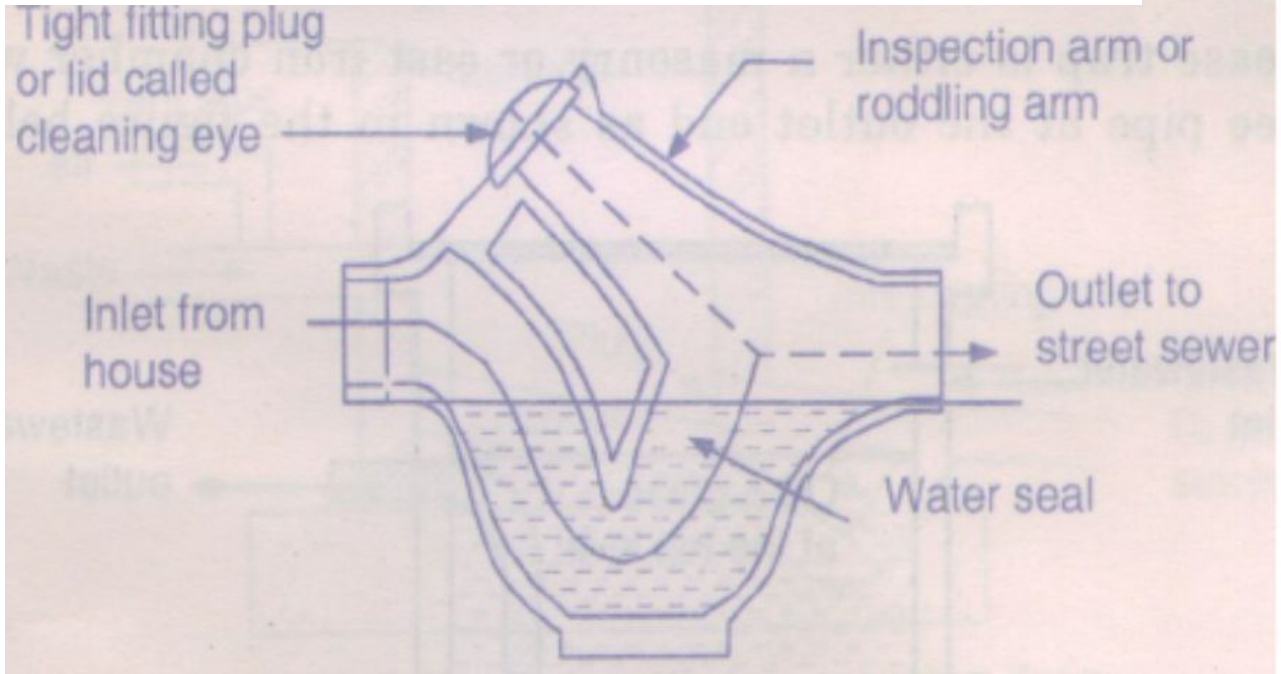
- Also called GULLIES.
- Used for reception of wastewater from baths, sinks and wash basins. Also collects stormwater.
- May have P-trap or S-trap.
- Water seal depth is 50-75 mm.
- A grating is provided at the top of the trap to exclude coarse solid matter.



Intercepting Traps

- Used at the junction of the house drain and house sewer.
- Primary objective is to prevent the foul gases entry from public/municiple sewer.
- Harmful pathogens are not entered in house drains.
- Well designed and constructed interceptors can quickly remove foul matter of house drain to municipal sewers
- Water seal is sufficiently deep as much as 75 mm.
- Has an opening at the top called rodding arm or inspection arm or cleaning eye for periodically cleaning.

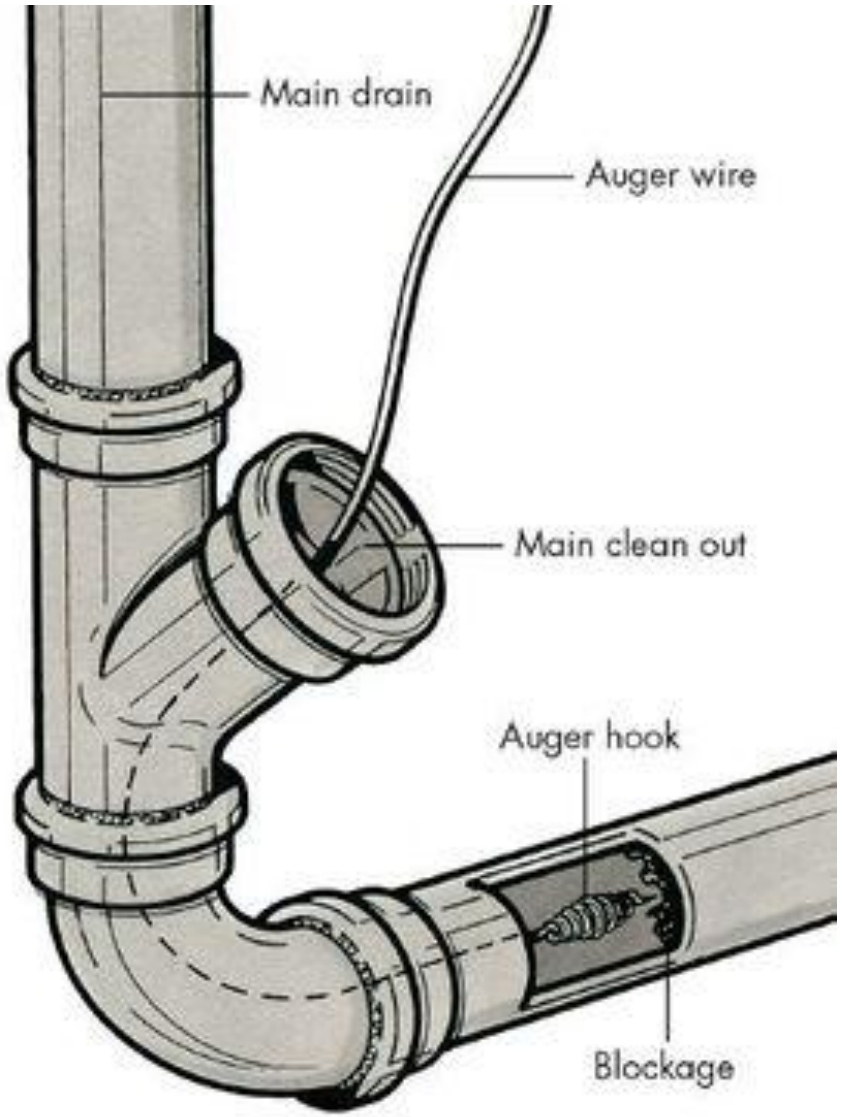




Cleanouts

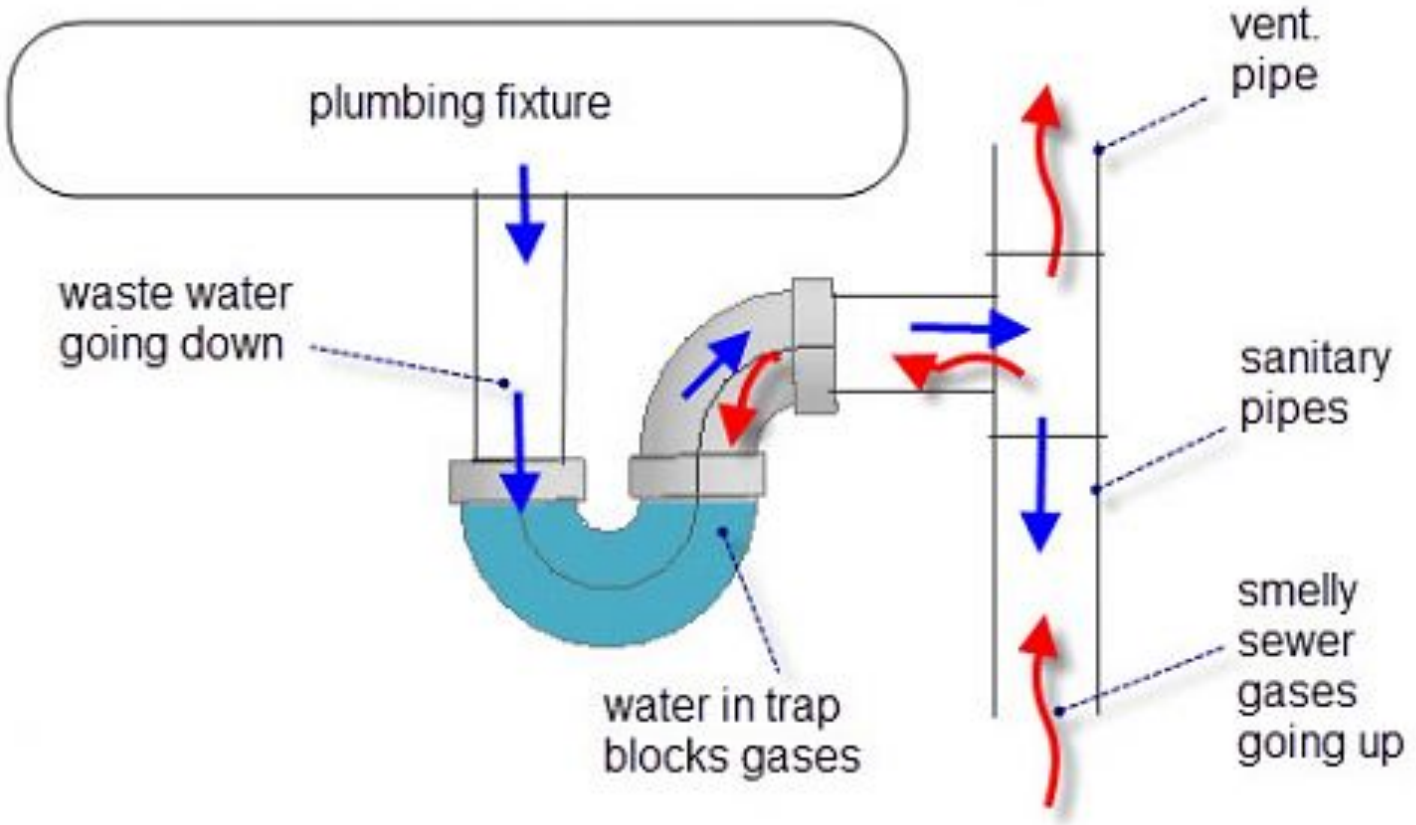
A plumbing cleanout is a cleanout fitting with a removable plug that is found in a building drainage system. It is designed to help keep clear any type of debris that could cause any type of stoppage in the water drain lines.

Cleanouts are usually placed at the connection point between the sewer lines and the drain lines where the base is located of a vertical stack and at all places were the pipe direction changes at 90 degrees.



Water Seal

Sewer gas is prevented by the back-flow prevention of the **water seal** in bottom of the trap (It “traps” the water). Sewer gas can contain many smells and odors and may smell like rotten eggs, but can also be poisonous. The traps installed in the plumbing lines help to form a seal of water within the plumbing trap.

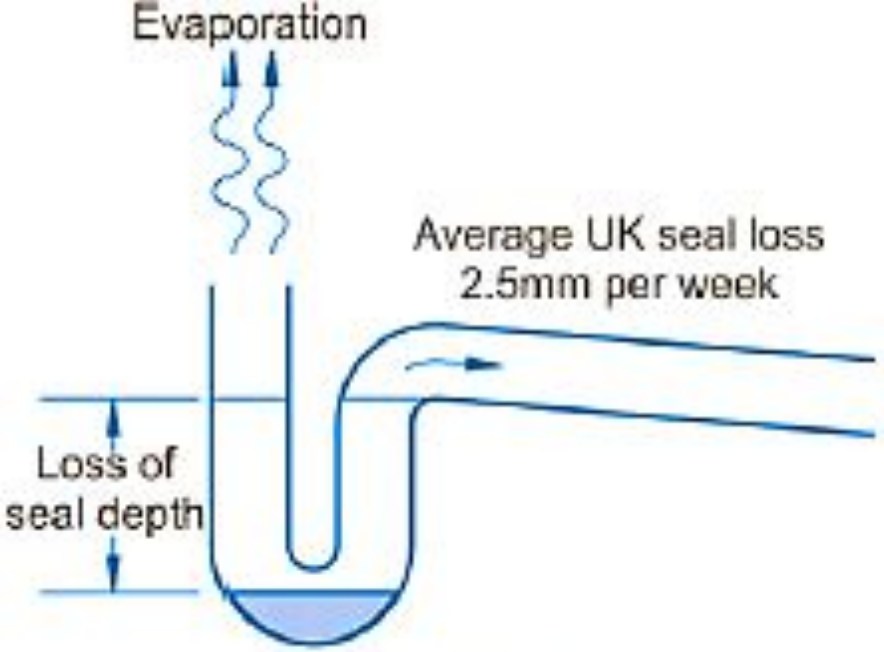


Loss of Trap Seals

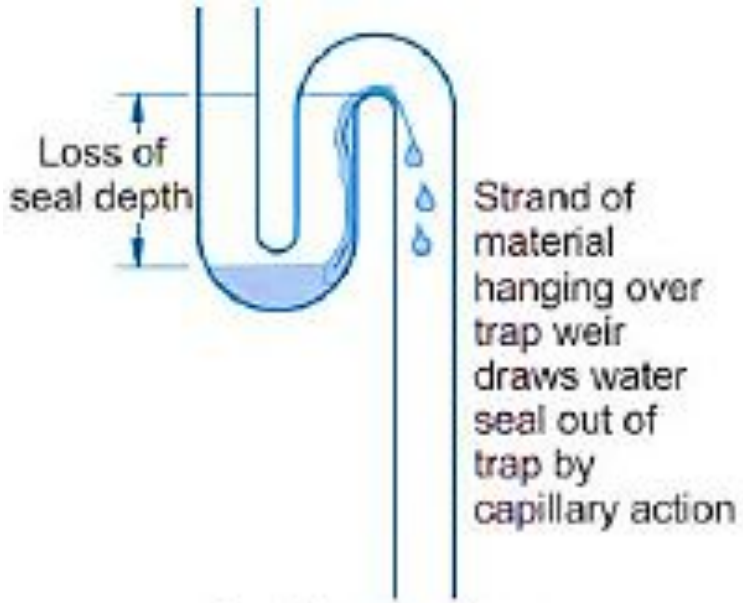
- Trap seal loss occurs **when the seal of the trap is lost as a result of poor practice** and by not following the regulations with regard to sanitation pipework installation. If a trap seal losses, smells from the sanitary appliances would enter the building.
- The main reasons of losing the water seal are:
  - Evaporation
  - Capillary action
  - Momentum
  - Leakage
  - Wind effect
  - Compression or back pressure
  - Induced siphonage
  - Self siphonage

Loss of Trap Seals

- ***Evaporation:*** Trap seals can be lost due to evaporation when fixtures are not used for long periods of time. This is especially true in warm or hot climates. When a trap seal evaporates, you can replenish the water seal by running water into the fixture. If this is not possible or convenient, then the drain opening may be sealed with a cap to prevent sewer gases from entering the structure. The rate is approximately 2.55 mm per week, so a 25 mm seal would last for 10 weeks.
- ***Capillary action:*** This is another rare occurrence which happens in ‘S’ trap when a piece of porous material being caught over the bend of a trap absorbs water and deposits it down the waste discharge pipe.



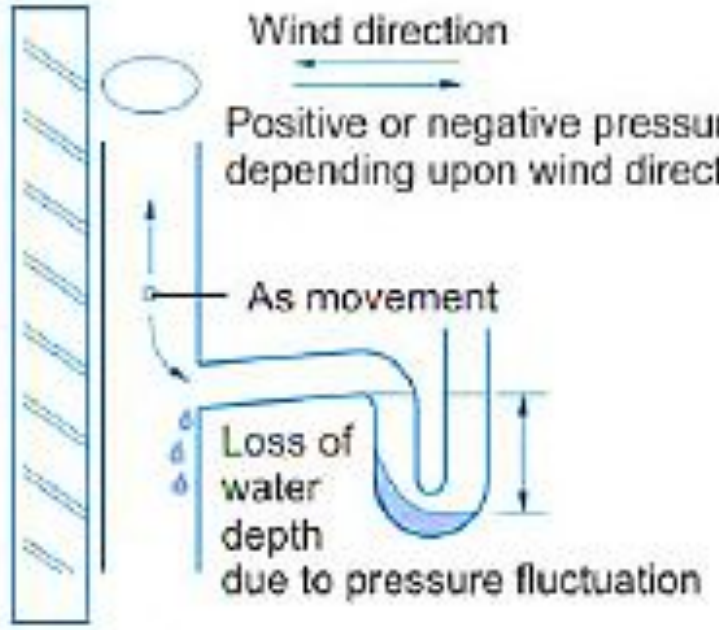
Evaporation



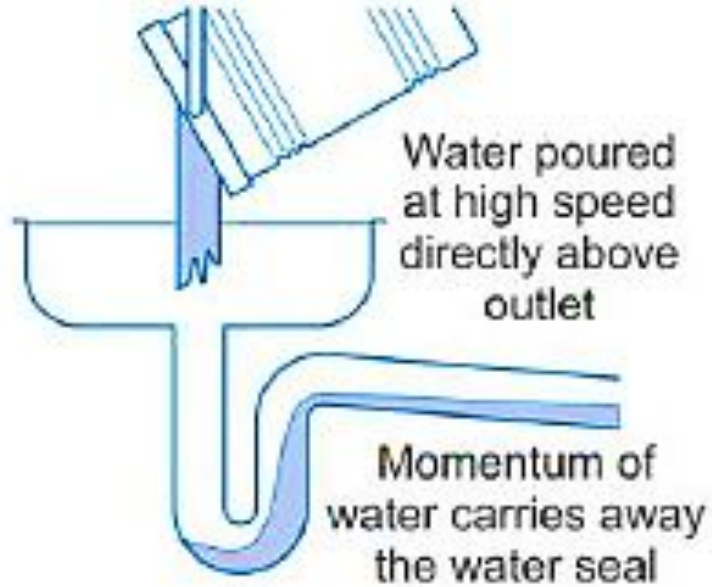
Capillary action

Loss of Trap Seals

- ***Wind Effect:*** This is caused by the effect of the wind which passes over the top of the ventilation pipe and thus causes pressure fluctuations.
- ***Momentum:*** This is caused by a sudden discharge of water from a bucket. Due to velocity water is discharged and it shoots around the trap bend and goes down the waste pipe, leaving no seal.



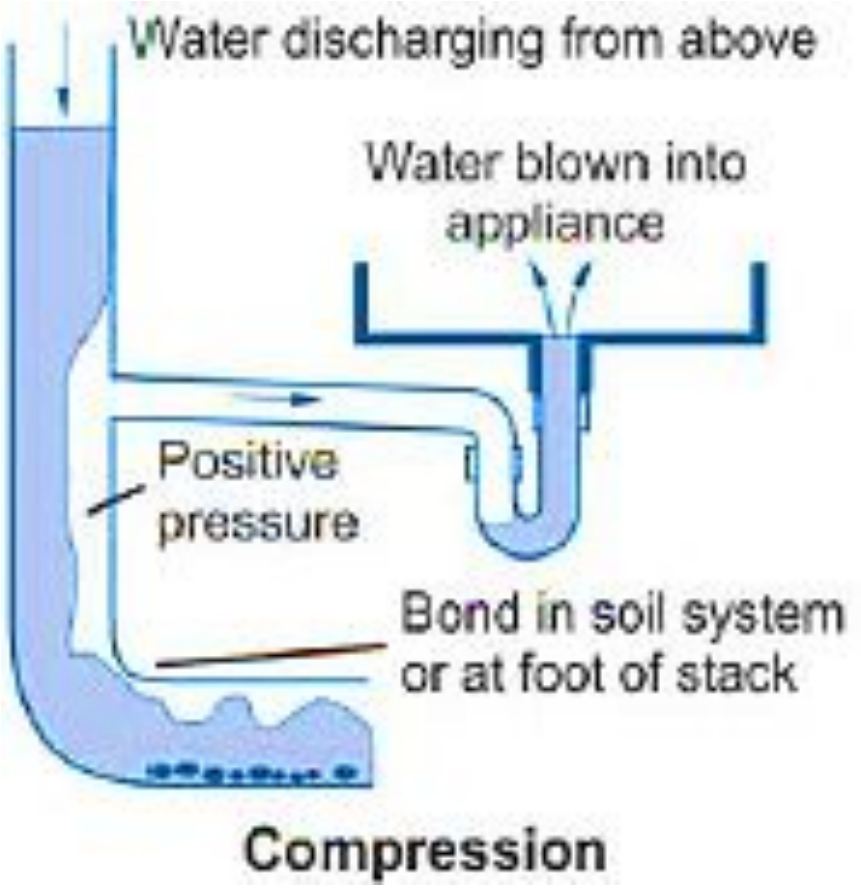
Wind effect (wavering out)



Momentum

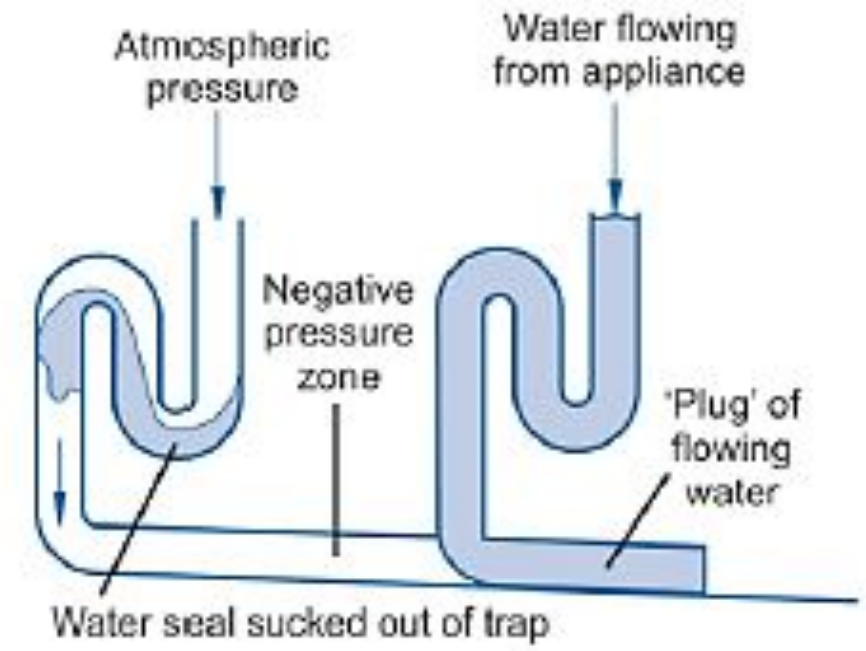
Loss of Trap Seals

- ***Leakage:*** It is caused by a fault in the trap or plumbing installation and water on the floor would be apparent.
- ***Compression or back pressure:*** This occurs in high rise buildings. When water is discharged down to the main discharge stack, air is compressed at the base of the stack. A waste pipe connected to the stack in the pressure zone may have the seal of the trap lost by the compressed air forcing out the water. Detergent foam increases the risk of compression.

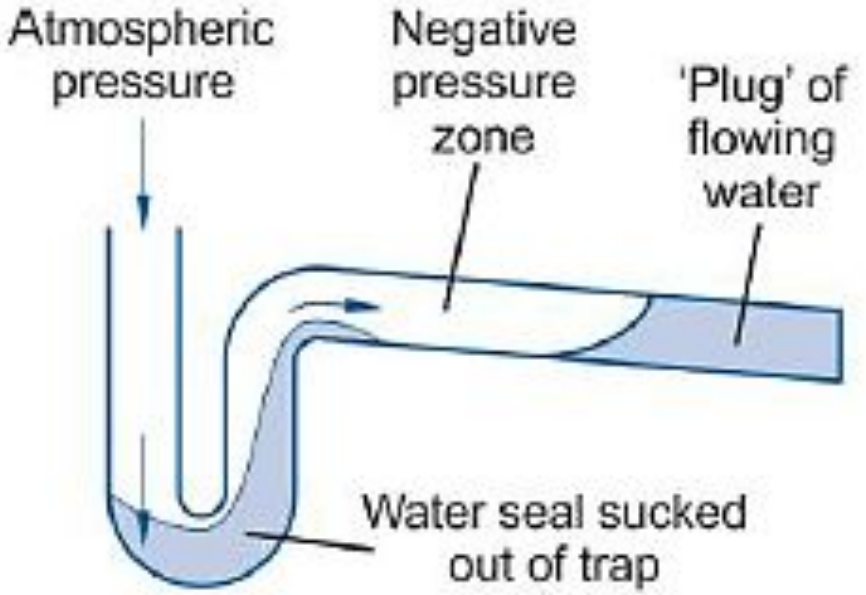


Loss of Trap Seals

- ***Induced siphonage:*** This is caused by discharge of water from another sanitary appliance connected to the same discharge pipe. In either a vertical or horizontal main waste pipe, as water flows down the pipe and passes the branch pipe connected to it, it draws air from it, thus creating a partial vacuum and subsequently siphonage of the trap takes place.
- ***Self Siphonage:*** This is caused by appliances such as wash basins and other small appliances, due to their curved shape, and is caused by a moving plug of water in the waste pipe. A partial vacuum is created at the outlet of the trap, thus causing siphonage action takes place.



Induced siphonage



Self siphonage

Building Drainage System

- Two Pipe System
- One Pipe System
- Single Stack system
- Partially ventilated Single Stack system

Plumbing systems: Types

Two pipe system:

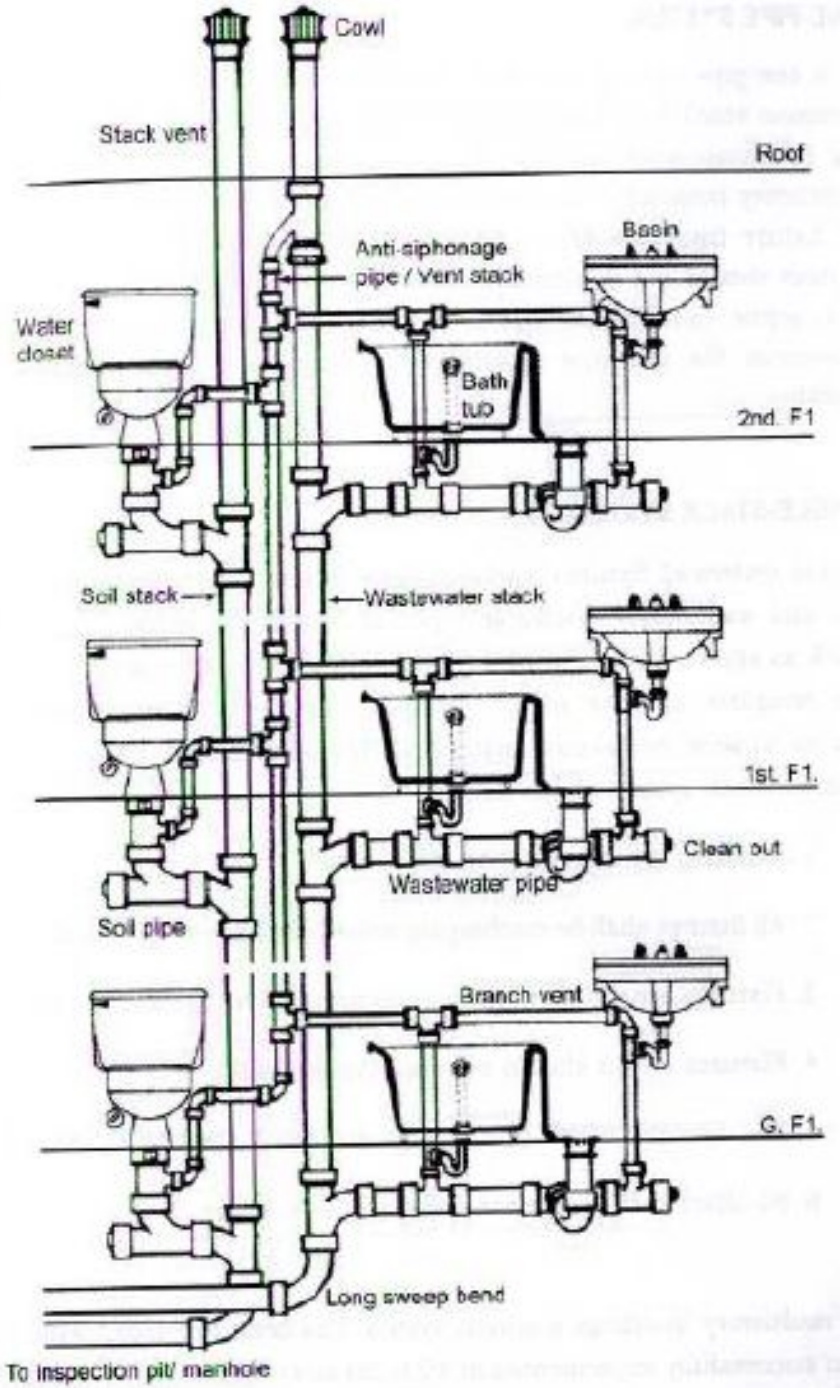
In two-pipe system, two separate piping and stacks are installed for conveyance of wastes generated from building.

Elements:

– Soil pipe
– Waste pipe
– Anti siphonage Pipe

Advantages of Two pipe system:

– Ensures segregation of the foul sewage from waste water
– No danger of back flow of sewage into waste fittings in case of blockage of soil pipe
– Separate waste stack permits arrest of solids from kitchen in gulley traps thus preventing from entering the sewer
– Reduce waste load for septic tank where there is no public sewer



Plumbing systems: Types

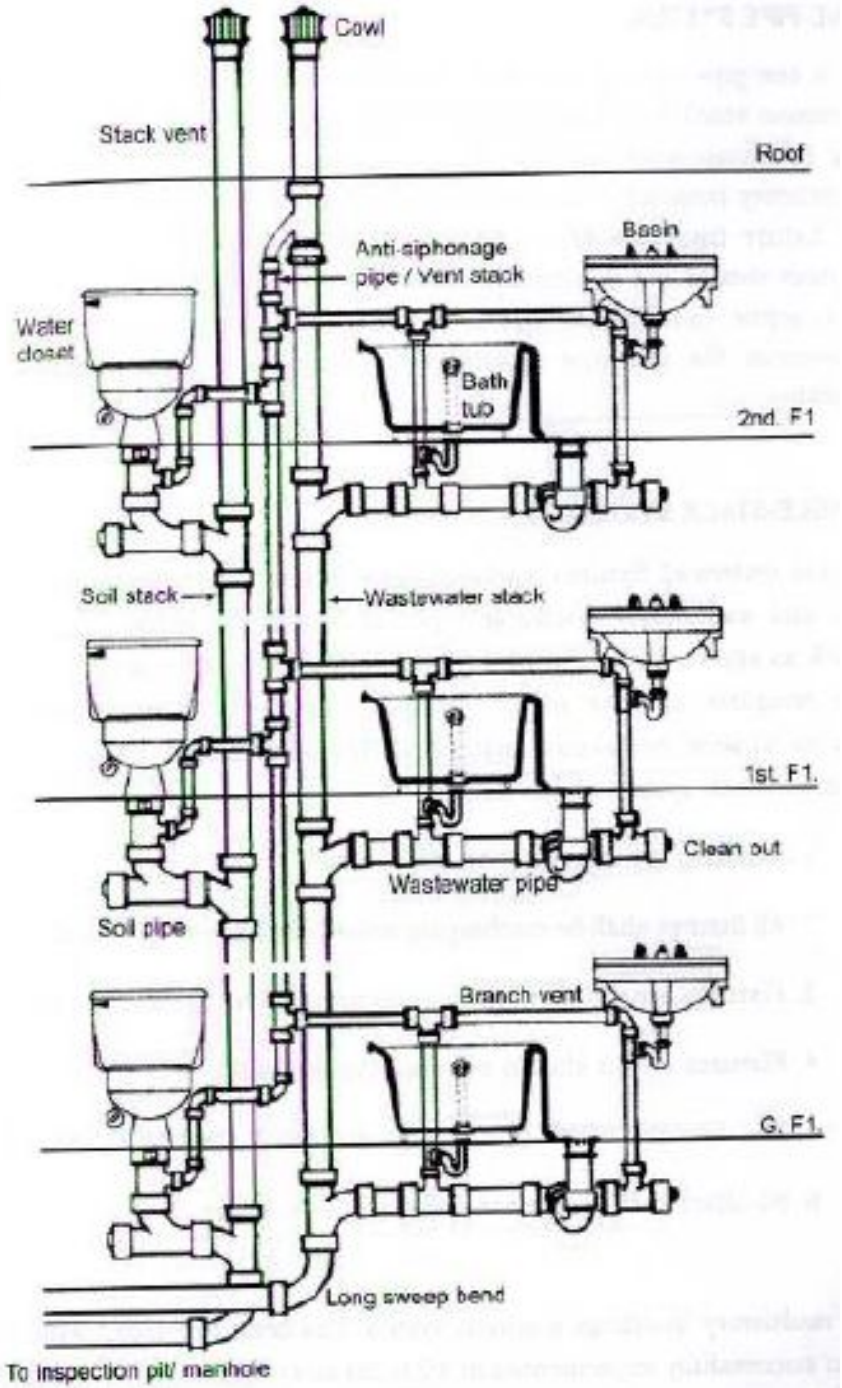
Disadvantages of Two pipe system:

– Requires comparatively more pipes so it is not economical

– Long external horizontal runs are required to reach external walls and lines connected to the sewer.

– Requires more space

– Installation of more pipes needs more joints. So probability of leakage through joints increases



Plumbing systems: Types

One pipe system:

In one-pipe system, both soil and waste fittings are discharged into a common stack with the addition of trap ventilation pipes.

Advantages of One pipe system:

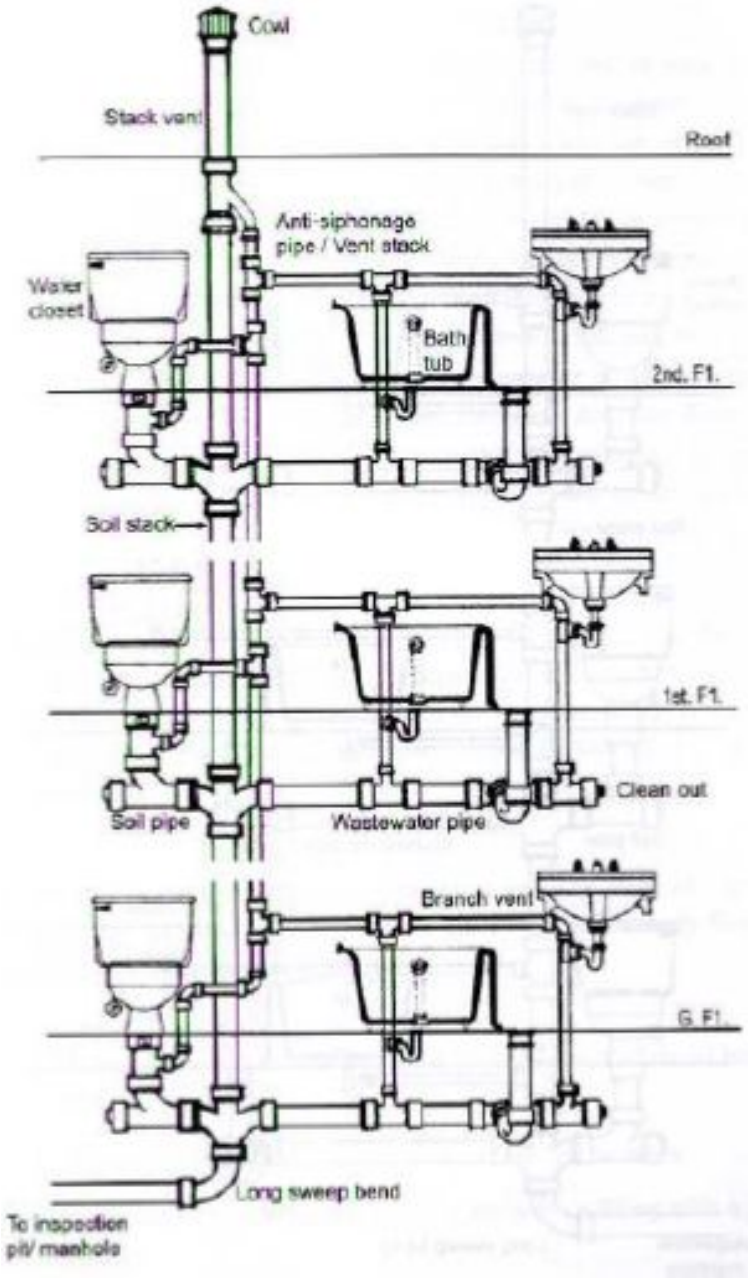
– Now widely used in modern multistoried building

– High quality of pipes, fittings and installation techniques ensures reduction of blockage problem

– Requires lesser space in pipe shafts and ducts

Disadvantages of One pipe system:

– Costlier than single stack system



Plumbing systems: Types

Single stack system:

In this system, all fixtures discharge directly into a common stack.

-No ventilation pipe

Advantages of single stack system:

– Simplicity in lay out, design, plumbing of the sanitary fixtures

– Improved external appearances

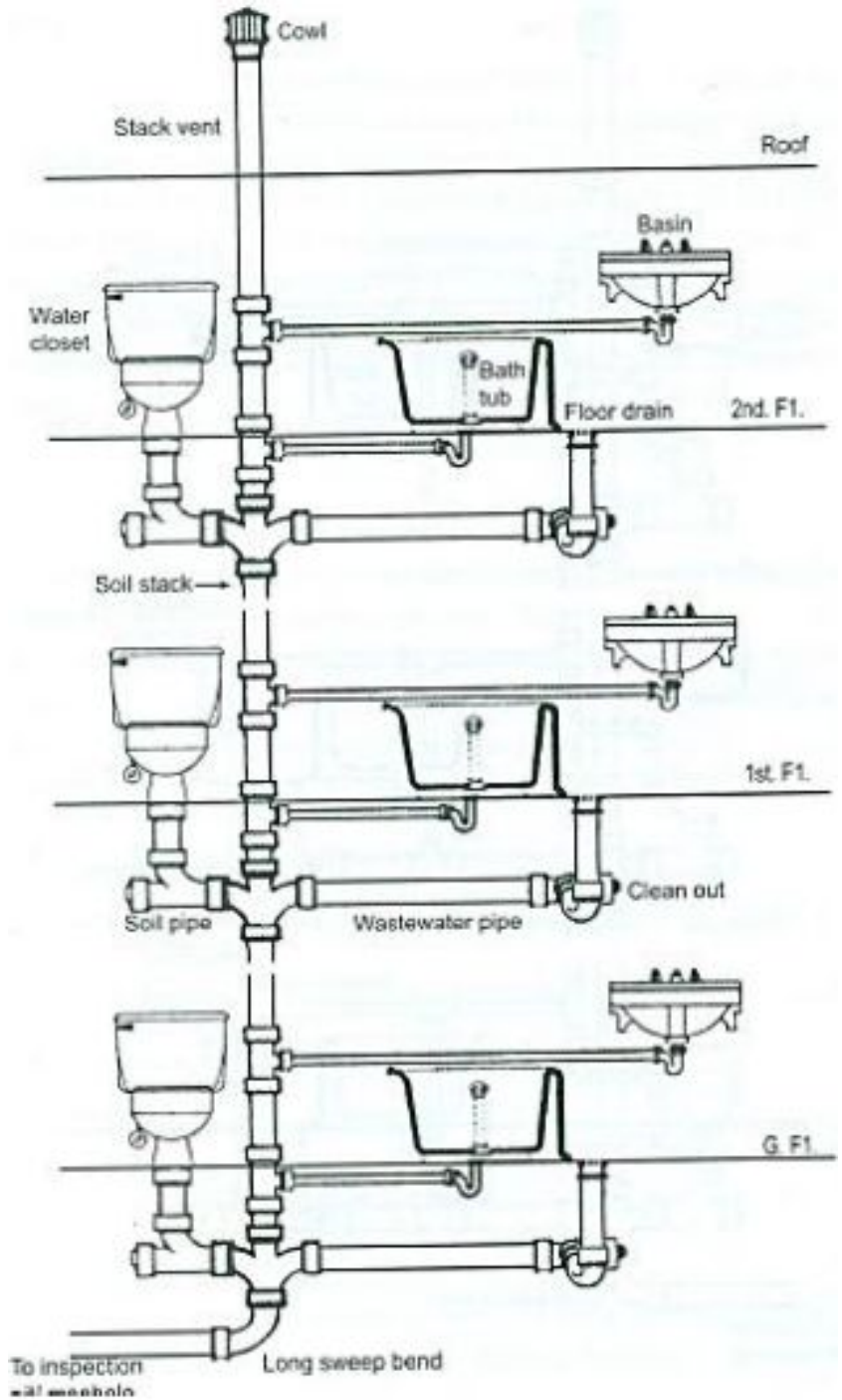
– More compact system

Disadvantages of single stack system:

– Air and waste from drainage pipes may be forced up through traps by back pressure due to blockage or bad design

– Water in the seal may be evaporated in dry season or in absence of flushing for a long time

– Self siphonage due to sudden discharge from appliance sucking away its own trap seal, due to discharge of another appliance in the system.



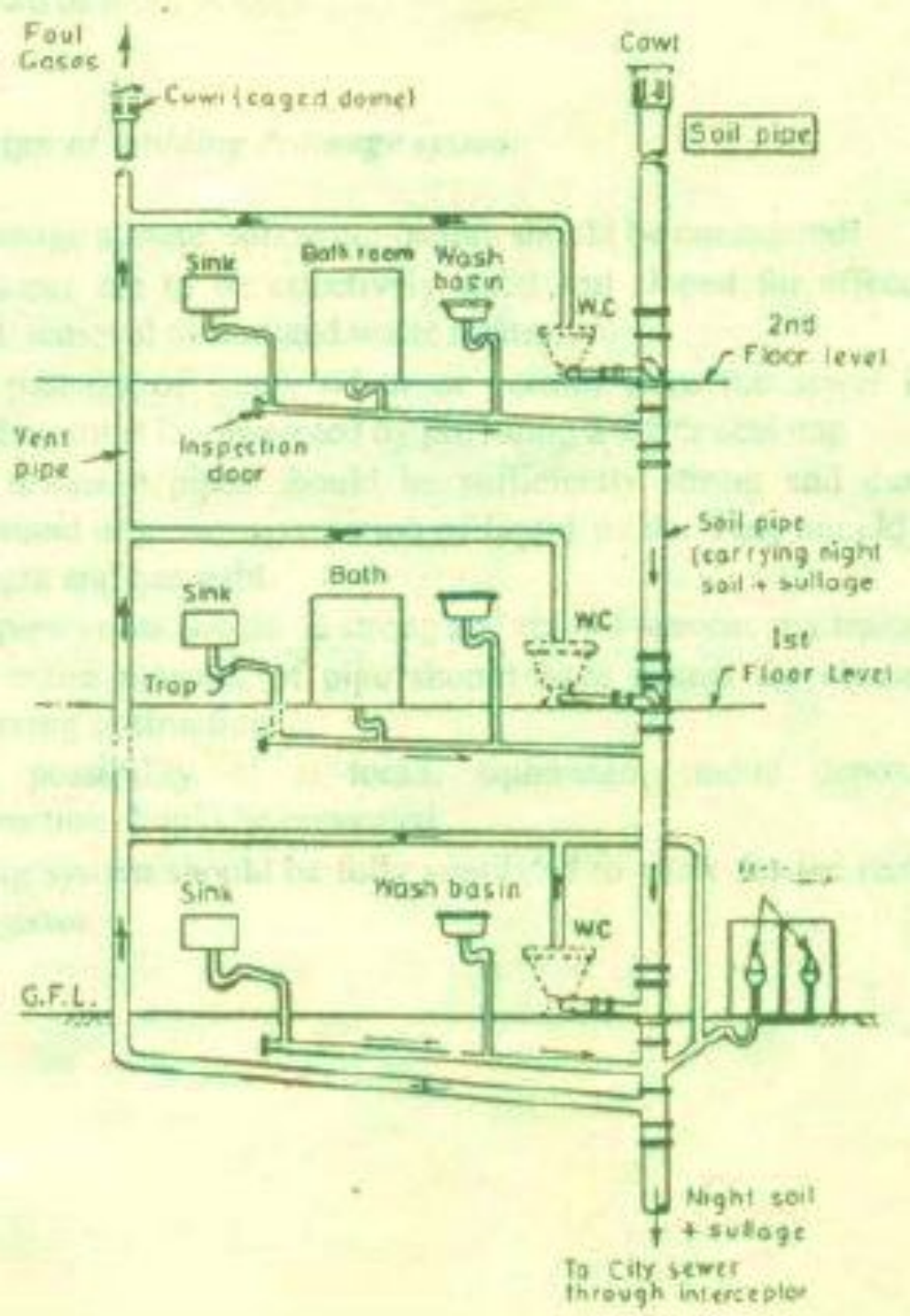
System	Types of Pipes	Advantages	Disadvantages
Dual Pipe	1. Waste single stack pipe 2. Soil single stack pipe	1. More effective drainage	1.Require two types of pipe 2. Complicated installation work
Single Pipe	1. Waste and soil single stack pipe 2. Vent pipe	1. Require only one main pipe 2. Easier to install	1. Vent pipe installation is complicated 2. Require more pipelines for vent pipe
Single Stack	1. Waste and soil single stack pipe	1. Require only one single stack pipe	1. Ventilation is less efficient

Plumbing systems: Types

Partially Ventilated Single Stack System:

A modification of one-pipe system is the partially ventilated one-pipe system. In this, the vent pipe ventilates only the traps of the water closets while the soil pipe discharges sewage and waste matter from sanitary fixtures as in the case of single stack system. As such it is more economical and has a simple arrangement of plumbing.

- Improved form of single stack system
- Traps of WC are separately ventilated by relief vent pipe.
- Sullage fixtures are not connected to the vent pipe.
- Less costly



SYSTEMS MOST PREVALENT IN WORLD

- US - ONE PIPE SYSTEM SINCE 1934.
- UK - ONE PIPE SYSTEM
- EUROPE - ONE PIPE SYSTEM
- INDIA - TWO PIPE MOSTLY

BANGLADESH - ??

Water Distribution System

- The layout of water distribution piping is basically a combination of horizontal or vertical piping arrangements designed to supply water from a source to points of use at different locations.
- Depending upon the location of supply in respect to the source of water, the distribution system is termed as up feed or down feed system.

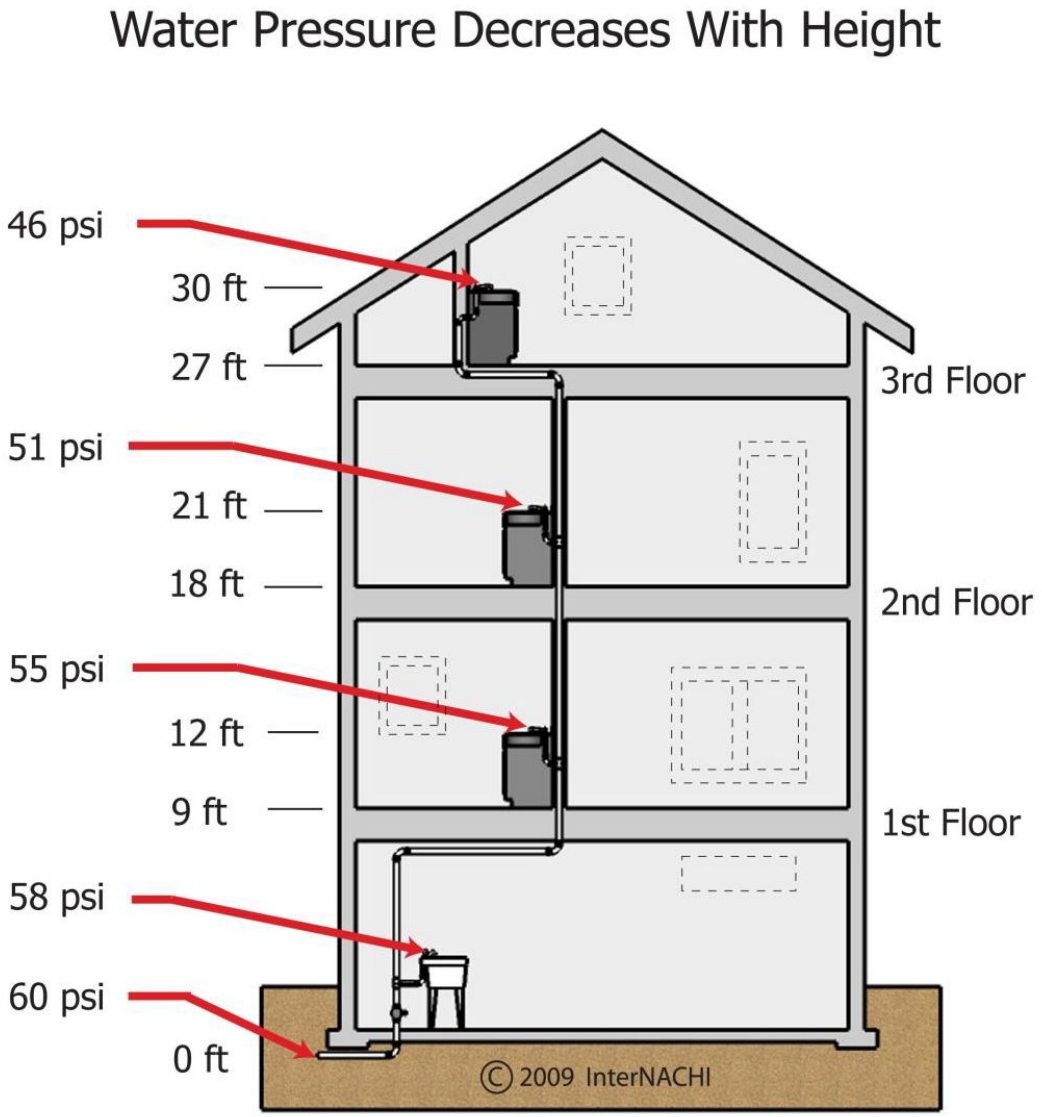
Types of Distribution System

- Up feed system
- Down feed system

Up Feed System

System with piping above the main or pressure tank is called up feed system.

- In this system, as water is forced to rise from the main or reservoir, pressure is lost in overcoming the static head and friction offered to water flow.
- At the uppermost and furthest outlet, enough pressure must be ensured to operate the faucet.



Up Feed System

Advantages of Up Feed System

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

Up Feed System

Disadvantages of Up Feed System

- It has high operating and maintenance cost
- Sophisticated control system and knowledgeable maintenance staff is required
- Water supply is interrupted due to power failure
- Instantaneous pressure fluctuation may be greater

Up Feed System

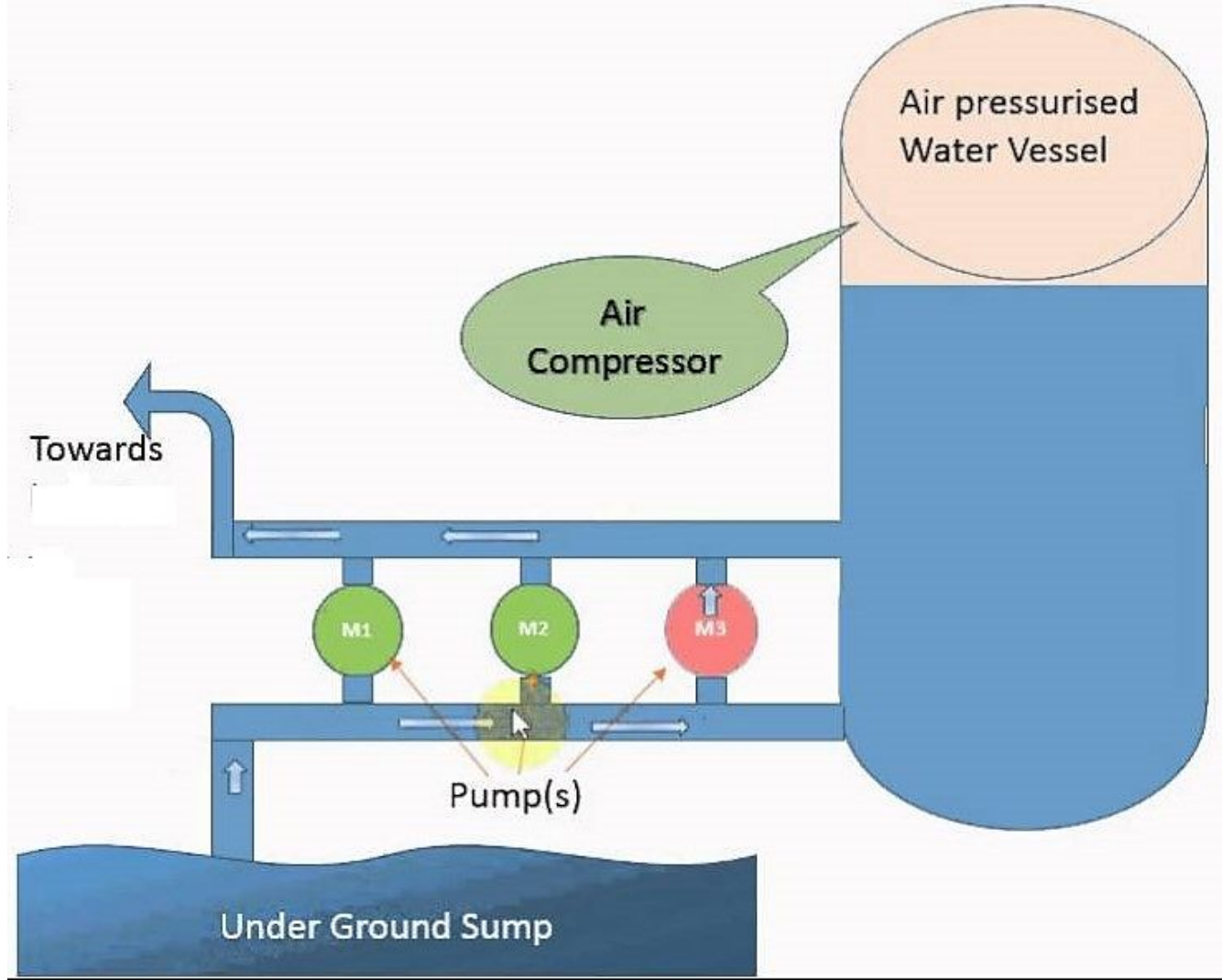
Generally two systems are adopted in a building for an up feed distribution.

Booster Pump System

- A booster pump system is generally employed when pressure in water supply main is insufficient and variable. Booster pump draws water from the supply main or underground reservoir and supplies water at desired pressure, directly to the points of uses.

Hydro Pneumatic Tank System

- Hydro Pneumatic tank system consist of a pneumatic water tank used in connection with a water pump. The pneumatic tank is simply a water tank partly filled with air. It acts as an equalizer of the water demand. Air volume in the tank is maintained supplying air by an air compressor.

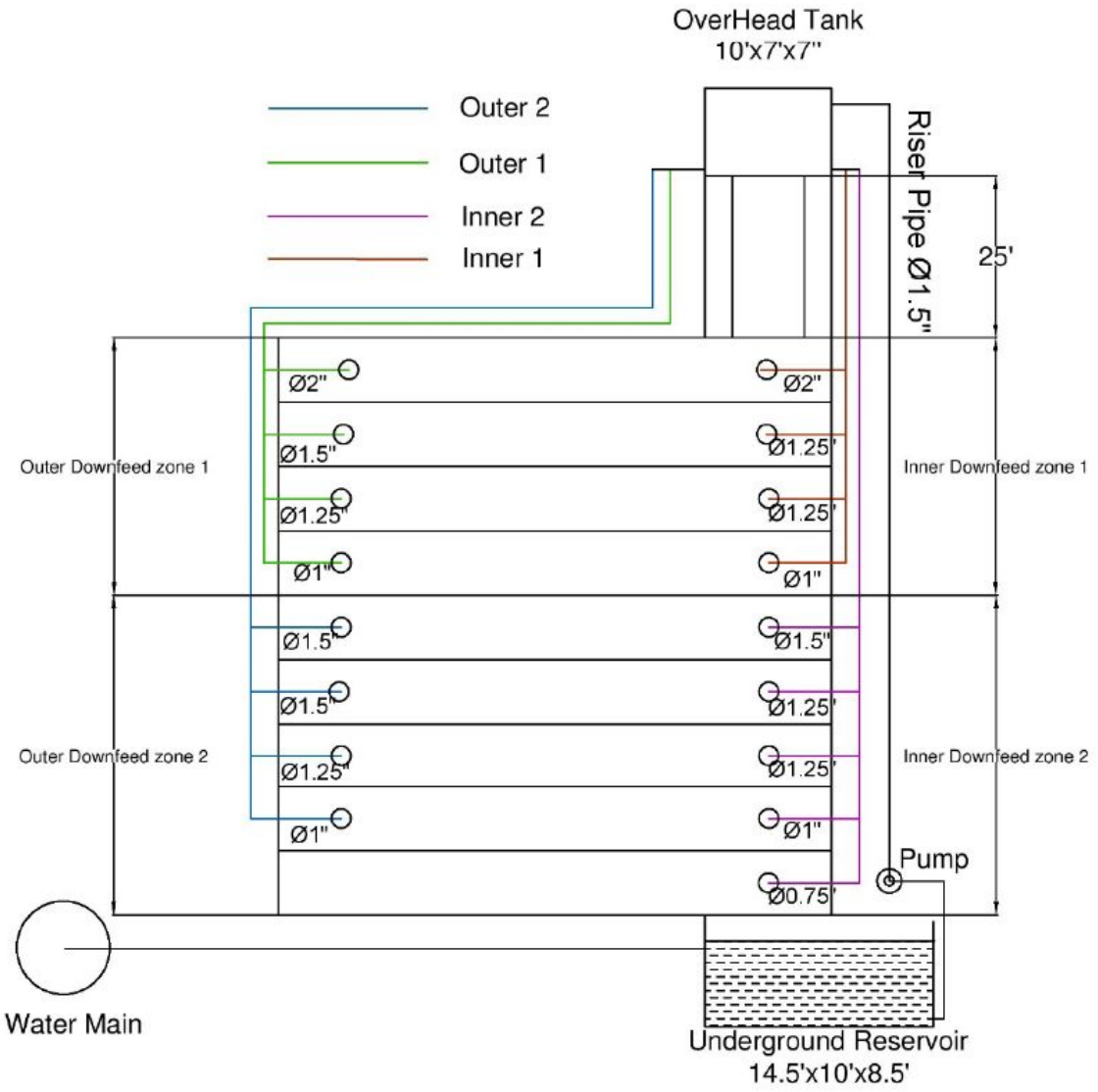


Hydro Pneumatic Tank System

Down Feed System

When the source is located at an elevated position than the points of use then the supply system is called a down feed system

- In this system static head is available for overcoming friction to flow through piping and for obtaining adequate delivery pressure at faucets.
- Water distribution from overhead tanks to faucets in the lower floors is the down feed system



Down Feed System

Advantages of Down Feed System

- Provides a reserve against failure of the mains supply
- Reduce possibility of mains pressure dropping and back siphonage of water from sanitary appliances into the main
- Reduce pressure on the installation which minimizes noise and wastage
- Not affected by power interruption
- Time needed to replace broken parts does not affect water supply

Down Feed System

Disadvantages of Down Feed System

- Water is subject to contamination
- High maintenance cost
- Occupies valuable space
- Requires stronger foundation and other structure to carry additional load of tank and water

Plumbing fixtures

- Plumbing fixtures are installed receptacles, devices or appliances to an existing plumbing system which are designed to receive pure water and discharge wastes.

The fixtures most commonly included in toilet and kitchen are:

- Lavatory
- Sink
- Bathtub
- Water Closet
- Sink
- Faucet

FIXTURES

There are different types of fixtures available such as washbasins , taps ,etc .



WC with Q Trap



Wall Hung WC



Wash Basin



WC with S Trap



Taps



Plumbing fixtures

Flush Tank/Flush Cistern: A chamber in which water is accumulated and discharged rapidly for flushing out water closets and urinals.

Flush Valve: A flush valve is a device located at the bottom of a tank for the purpose of flushing water closets and similar fixtures and is closed by direct water pressure or some other mechanical means.

Fixture Unit: A fixture unit (F.U.) is a quantity in terms of which the load producing effects on the plumbing systems of different kinds of plumbing fixtures are expressed on some arbitrary chosen scale. A fixture unit is not a flow rate unit but a design factor.

Riser: A water supply pipe which extends vertically one full story or more to convey water to branches or fixtures or to OH tank.

Flush tank vs Flush valve





Rate of flow and required pressure during flow for different fixtures

Fixture	Flow Pressure (psi)	Flow Rate (gpm)
Lavatory faucet	8	3.0
Lavatory faucet, self-closing	12	2.5
Sink faucet, $^{3}/_{8}$ in	10	4.5
Sink faucet, $^{1}/_{2}$ in	5	4.5
Laundry-tub cock, $^{1}/_{2}$ in	5	5.0
Bathtub faucet, $^{1}/_{2}$ inch	5	5.0
Shower, $^{1}/_{2}$ inch	12	5.0
Water closet, Ball cock flush tank	15	3.0
Water closet, flush valve type	10 to 20	15 to 40
WC FV, 1 inch @ 25psi	25	35
WC FV, 1 inch @ 15psi	15	27
WC FV, $^{3}/_{4}$ inch @ 15psi	15	15
Urinal, Flush valve	15	15
Garden hose, 50 feet and sill cock	30	5.0

Demand weight of fixtures in fixture units

Fixture of Group[b]	Occupancy	Type of Supply Control	Weight in Fixture Units[c]
Water closet	Public**	Flush valve*	10
Water closet	Public	Flush tank*	5
Pedestal urinal	Public	Flush valve	10
Stall or wall urinal, 1″	Public	Flush valve	5
Stall or wall urinal, $^{3}/_{4}$″	Public	Flush tank	3
Lavatory	Public	Faucet	2
Bathtub	Public	Faucet	4
Shower head	Public	Mixing valve	4
Service sink	Office, etc.	Faucet	4
Kitchen sink	Hotel or restaurant	Faucet	4
Water closet	Private**	Flush valve	6
Water closet	Private	Flush tank	3
Lavatory	Private	Faucet	1
Bathtub	Private	Faucet	2
Shower head	Private	Mixing valve	2
Bathroom group	Private	Flush valve for closet	8
Bathroom group	Private	Flush tank for closet	6
Separate shower	Private	Mixing valve	2
Kitchen sink	Private	Faucet	2
Laundry machine	Private	Automatic	2
Laundry machine	Commercial (8 lb)	Automatic	3
Laundry machine	Commercial (16 lb)	Automatic	4

Sustainable Plumbing Practices

"Sustainable plumbing practices reduce water and energy consumption, minimize waste, and promote eco-friendly living."

Water Conservation

- Low-flow showerheads and faucets
- Dual-flush toilets
- Rainwater harvesting systems

Energy Efficiency

- Solar water heaters
- Efficient pumps and motors
- Insulated pipes

Sustainable Plumbing Practices

Waste Reduction

- Greywater reuse systems
- Composting toilets
- Biodegradable cleaning products

Eco-Friendly Materials

- Recycled pipes and fittings
- Sustainable materials (bamboo, recycled plastic)
- Lead-free and low-lead products

Design of Water Supply System of a Building

a. Design of Water Supply Main

- Estimate total fixture units of the building.
- Determine water supply demand in gpm (from demand load curve).
- Selection of the required pipe size to allow design flow and determine the allowable frictional loss in the selected pipe size.
- Zoning of water distribution

- Lower floors can be up feed from the service main pressure.
- Upper floor must be supplied by down feed risers from elevated tank.

Design of Water Supply System of a Building

b. Determination of Up feed Zone (from the service main)

- In an up feed zone, P = p + 0.434h + f

where, P = service main pressure, psi

p = pressure drop through water meter, piping and equipment, psi.

h = height from the main to the top fixture served by up feed zone, ft.

f = fixture pressure, psi

- Pressure drop through the piping will be determined based on the selection of pipe and demand flow. Comparatively larger pipe dia can be selected to conserve pressure for the up feed zone.
- Pressure drop through water meter will be obtained from manufacturer's data

Design of Water Supply System of a Building

c. Determination of Down feed Zone (from the overhead tank)

- Position of overhead tank, P = 0.434h

where, P = minimum allowable pressure for a fixture, psi (depends on type of fixture)

h = height from the overhead tank to the topmost fixture served by down feed zone, ft.

Design of Water Supply System of a Building

d. Check the available pressure allowable to overcome friction loss (Up feed zone)

$p = P – (p' + 0.434h + f + b)$

Where, p = pressure drop due to friction through piping, fitting and equipment, psi

P = service main pressure, psi

p′ = pressure drop through the water meter, psi.

h = height from the main to the top fixture served by up feed zone, ft.

f = maximum fixture pressure, psi

b =fixture branch pressure, psi (usually 1 psi)

Design of Water Supply System of a Building

e. Check the available pressure allowable to overcome friction loss (Down feed zone)

$p = 0.434h - f - b$

where,

p = pressure drop due to friction through piping, fitting and equipment, psi.

h = height from the overhead tank to lowest fixture served by down feed zone (ft)

f = maximum fixture pressure, psi

b =fixture branch pressure, psi (usually 1 psi)