Plumbing System

What is Plumbing?

-The word Plumbing comes from the Latin word “Plumbum” which means lead as pipes were once made from lead

❖ It is the art and science of installing the entire system of piping, drain fittings, valves, valve assemblies, and devices in a building for the distribution of water (for drinking, heating and washing); the removal of liquid wastes, wastewater and stormwater from the building; and the ventilation to remove foul gas and odour as well.

What is a Plumbing System ?

- It includes the fixtures and fixture traps; the soil pipes, waste pipes, vent pipes; the building drain and building sewer; the storm drainage pipes; with their devices, appurtenance and connections to all within or adjacent to the building.

- Plumbing System=

  water supply system (cold and hot) + drainage system (WW/liquid waste and storm water) + ventilation

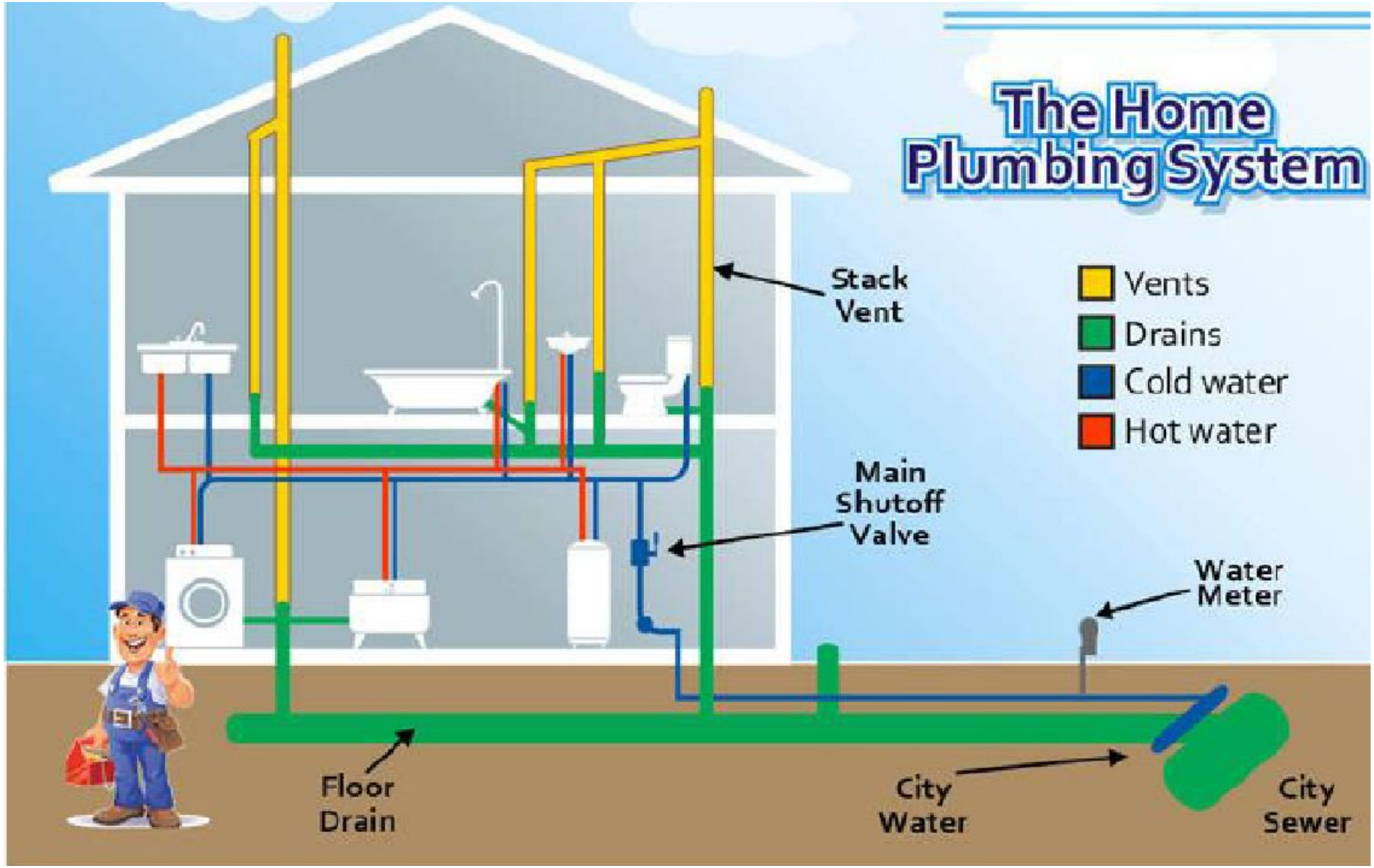
History of Plumbing



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, nitration, disinfection, and distribution.
- Storm water drainage.

Gas supply related.

- Fuel gas supply in building.
- Special gas like

Plumbing System

Objectives:

- To supply fresh water to various parts of a building.
- To collect, convey the produced liquid waste or wastewater of a building and then discharge into a sewerage system from the building.
- To collect, convey and discharge the stormwater
- To act as ventilation for removing foul gas (Methane, Hydrogen Sulfide, Nitrogen, Carbon Monoxide) and odor; and to allow air to enter the system

Functions:

"Supply-Drain-Vent" these three are the main functions of the plumbing system in a typical home.

Governing principles of plumbing system in a building

1) There should be sufficient water pressure available to serve each fixtures.
2) There 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) There 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. It should have a earth cover of at least 30 cm when laid underground. When laid above the ground and open to the environment, it should run clear of wall with a clearance of 2.5 cm.

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) Burring of pipes in walls or floors should be avoided.
12) The pipes and fittings should be thoroughly water-tight due to prevent the damage for leakage.
13) The changes in diameter and direction of pipe should be gradual to avoid undue loss of water-head.
14) Installation is not done so as to impair the structural safety of the building.
15) 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



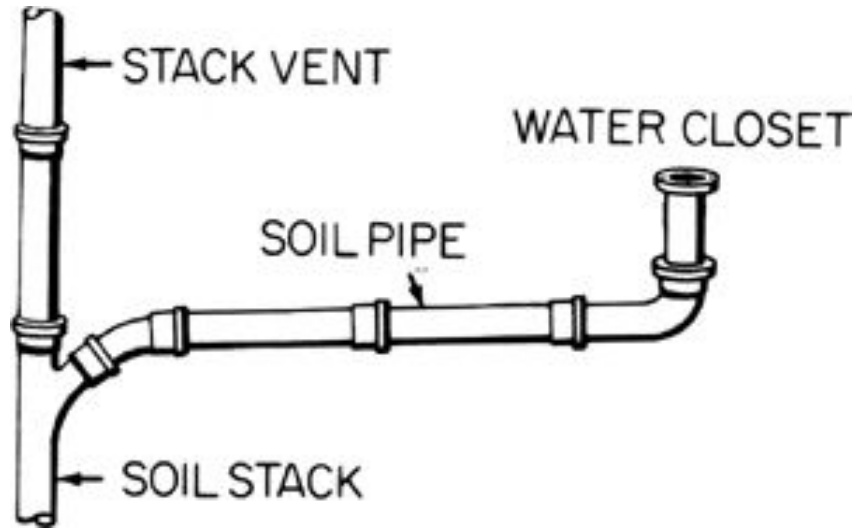






Terms and definition

- A plumbing stack, also called a plumbing vent or a vent stack, is **a long, vertical pipe extending out of your roof that directs wastewater from all the fixtures in your home to a municipal or private sewer system**.



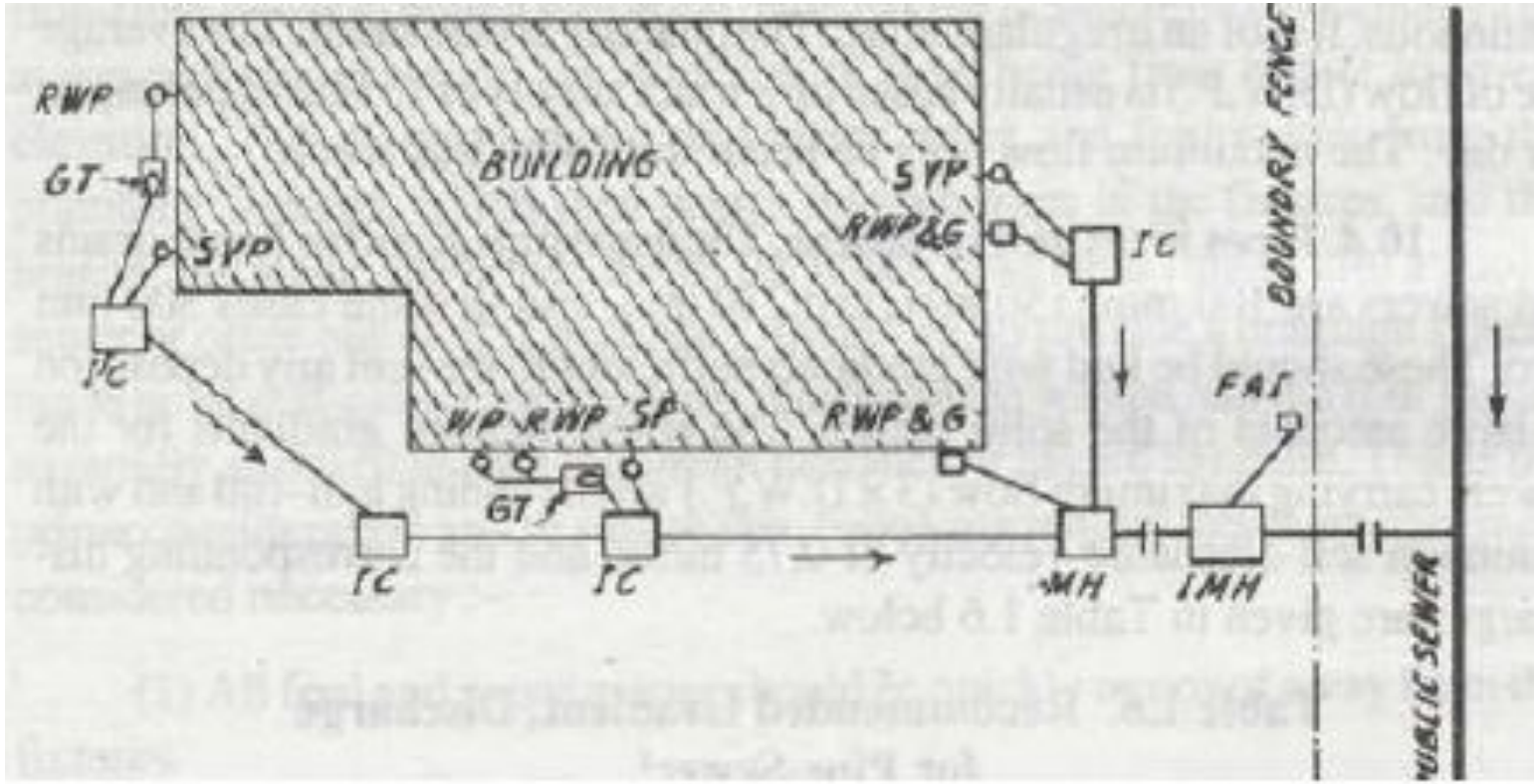
- ***Soil stack/pipe*** is any pipe which conveys the discharge of water closets or fixtures having similar functions with or without the discharge from other fixtures to the building drain or building sewer.
- ***Waste stack/pipe*** is a pipe which carries liquid wastes free from fecal matter.
- ***Vent stack/pipe*** is a pipe or system installed to provide air flow to or from a drainage system or to provide a circulation of air within such system to protect trap seals from siphonage and back pressure
- ***Relief vent*** is a vent the primary function of which is to provide circulation of air between drainage and vent system

Terms and definition

- ***Sewer*** is a pipe or conduit, generally closed but temporarily not flowing full, for carrying sewage.
- ***Building drain*** is the part of the lowest piping of a drainage system which receives the discharge from soil, waste and other drainage pipes inside the walls of the building and conveys it to the building sewer beginning 3 ft outside the building
- ***House sewer*** is a pipe conveying the discharge from the building drain and conveys it to a public sewer, individual sewage disposal system or other point of disposal.
- ***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.

Categories of Sanitary Drainage Piping

- Soil pipe (soil stack)
- Wastewater pipe (waste stack)
- Vent pipe (vent stack)
- Building drain
- Building sewer

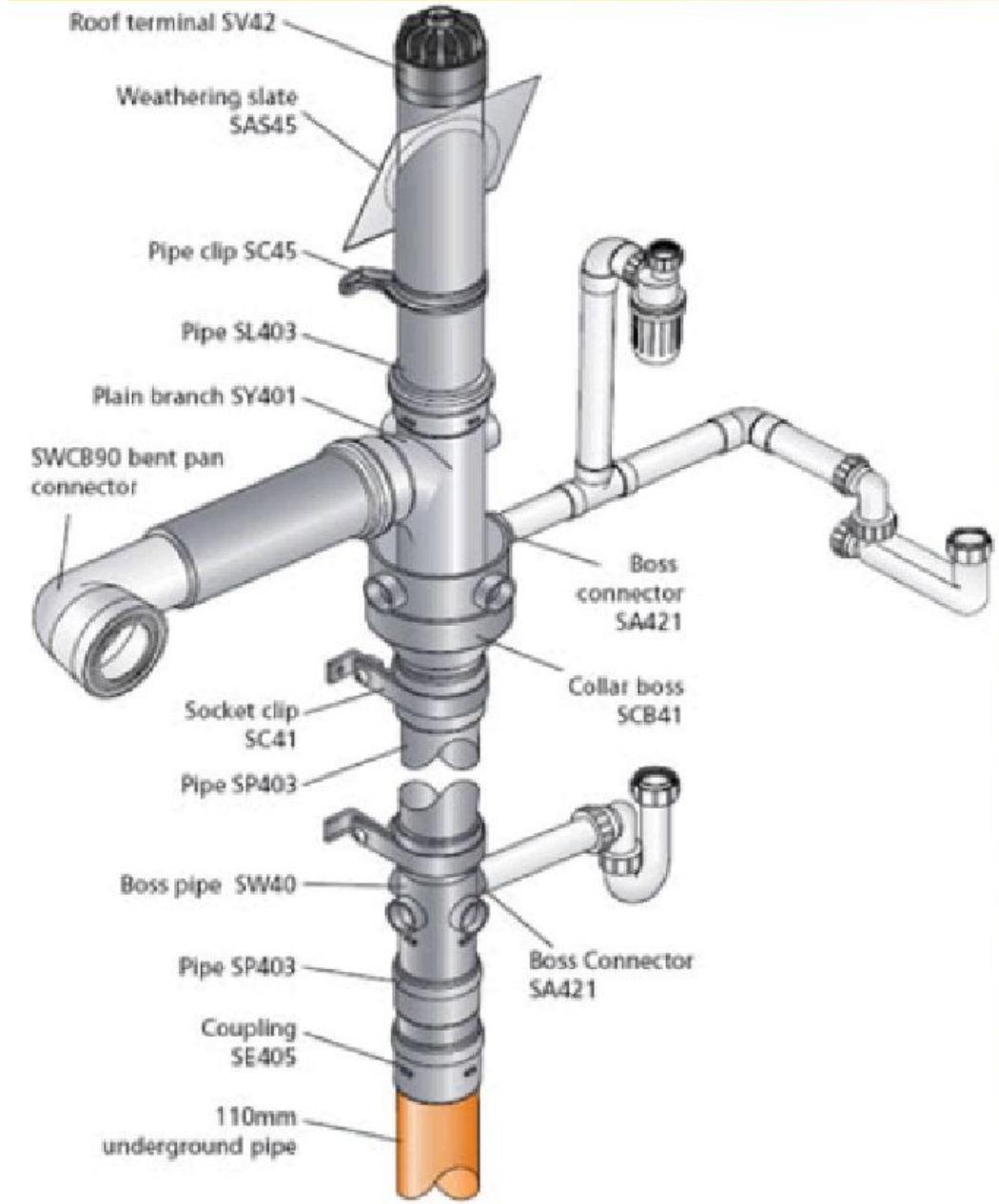


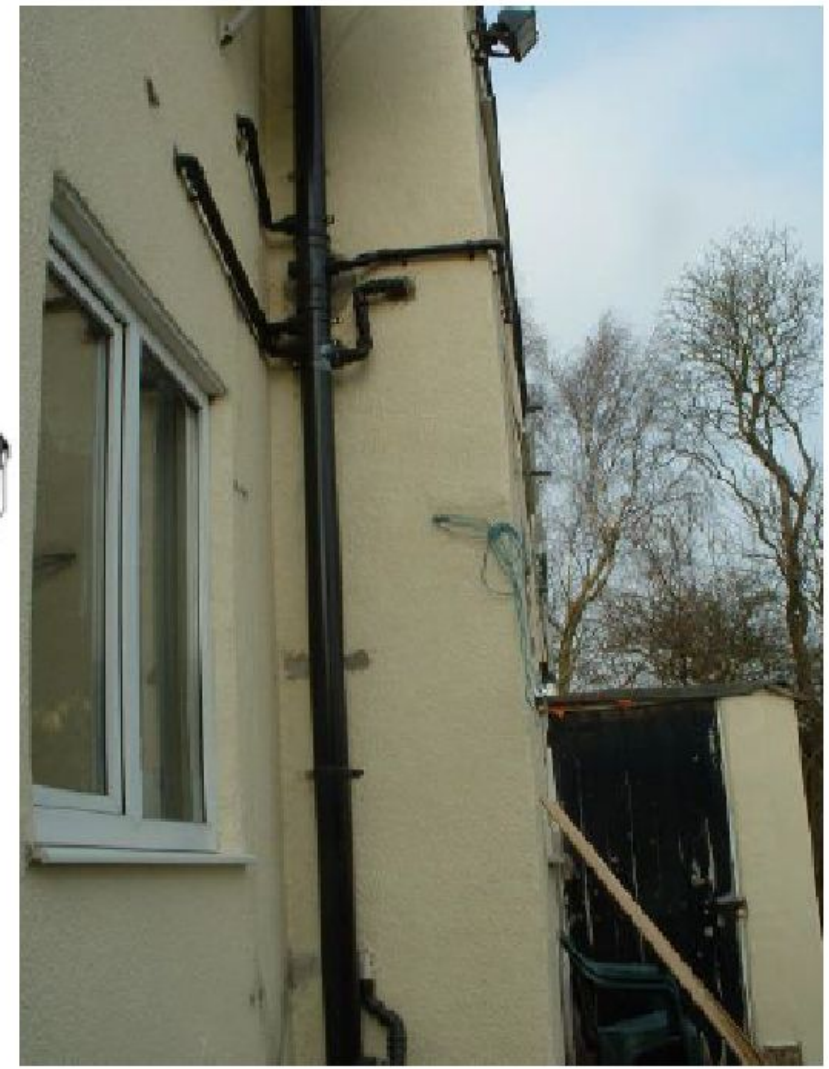
Conventions

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

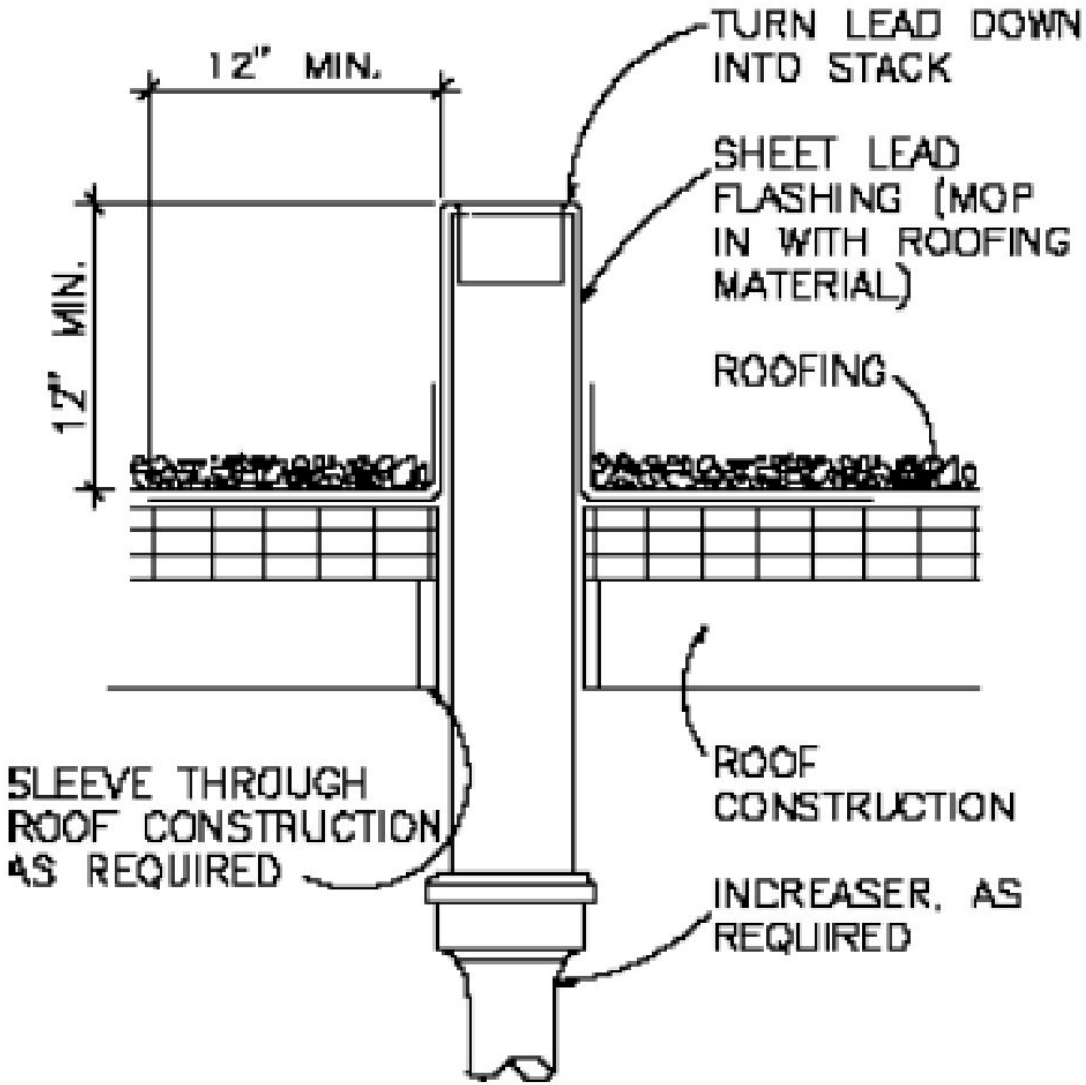
Fig. 1.18. Typical Lay-out of House Drainage System.

SOIL TACK


Roof terminal SV42
Weathering slate SAS45
Pipe clip SC45
Pipe SL403
Plain branch SY401
SWCB90 bent pan connector
Boss connector SA421
Collar boss SCB41
Socket clip SC41
Pipe SP403
Boss pipe SW40
Boss Connector SA421
Pipe SP403
Coupling SE405
110mm underground pipe



VENTS


12" MIN.
12" MIN.
TURN LEAD DOWN INTO STACK
SHEET LEAD FLASHING (MOP IN WITH ROOFING MATERIAL)
ROOFING
SLEEVE THROUGH ROOF CONSTRUCTION AS REQUIRED
ROOF CONSTRUCTION
INCREASER, AS REQUIRED

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.

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.

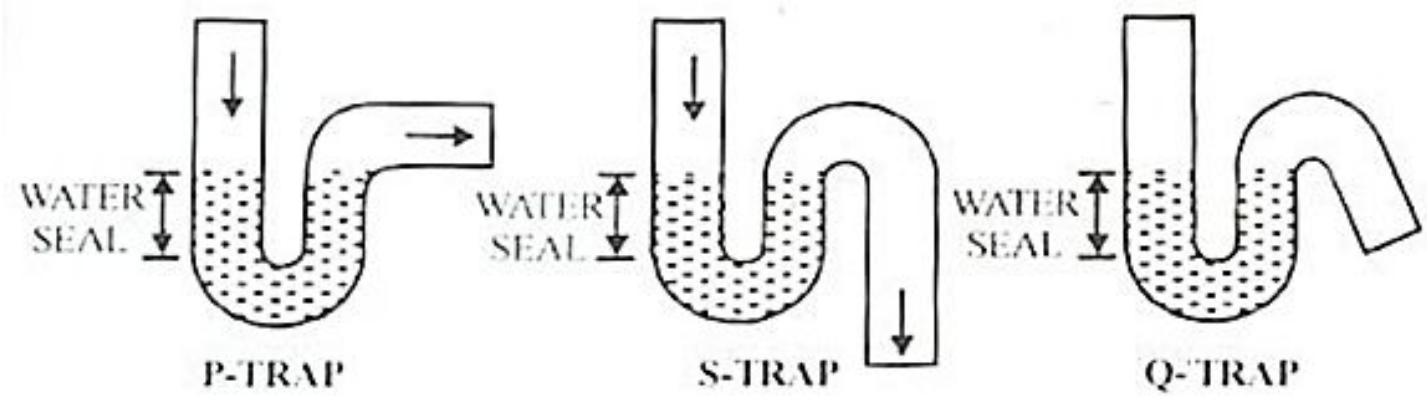
Strength of a trap:

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

- 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.
- 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.

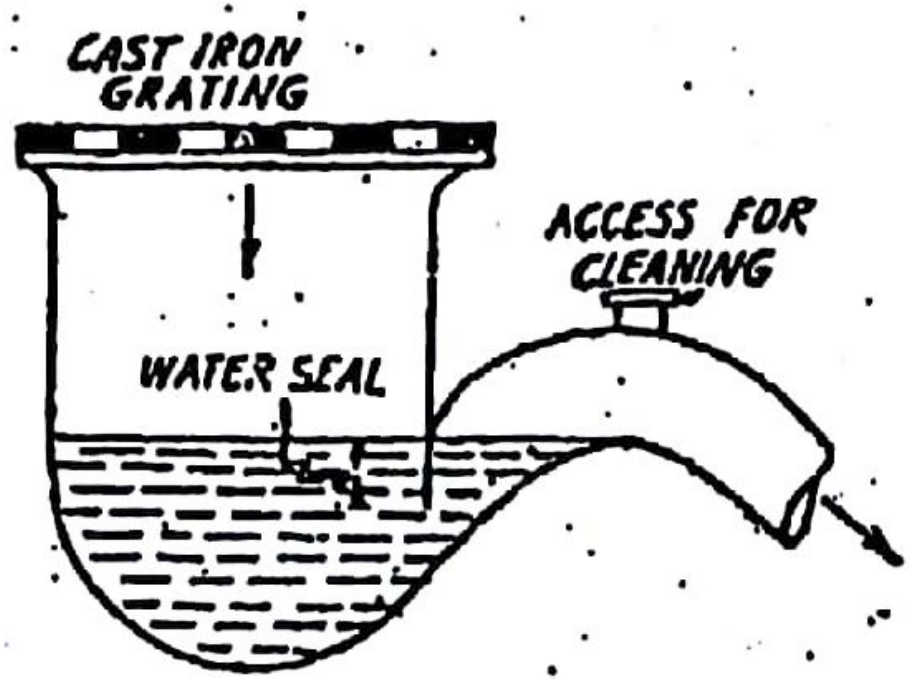
S-traps are a type of plumbing trap that blocks sewer gases in sinks and other plumbing fixtures which traps wastewater before it drains to the sewer line, creating a water seal that prevents gases from flowing up through the drain.

Q-trap is a common SWR fitting 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.

Types of Traps

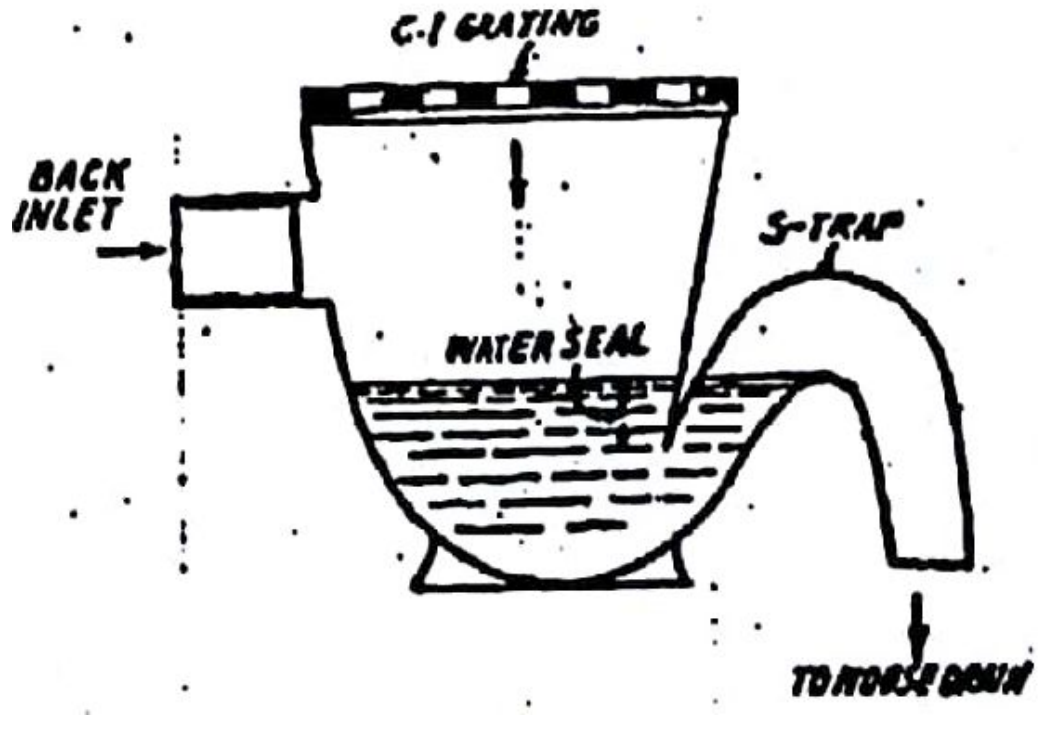
Floor Traps

- 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 deapth is 50-75 mm.
- A grating is provided at the top of the trap to exclude coarse solid matter.

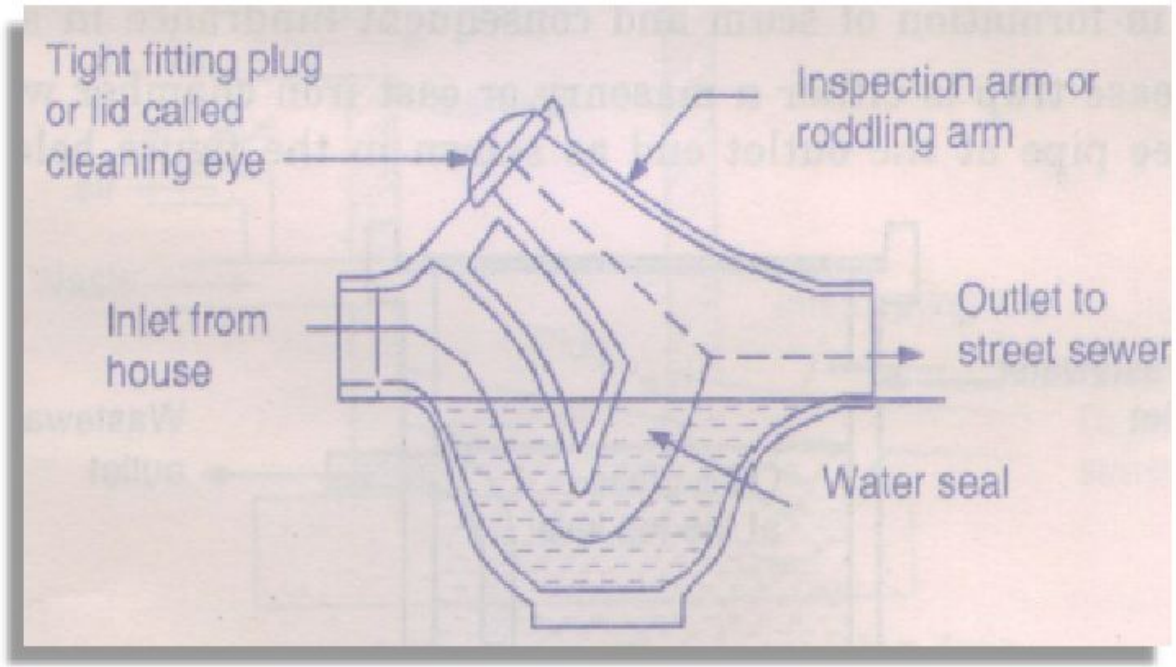


Types of Traps

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.



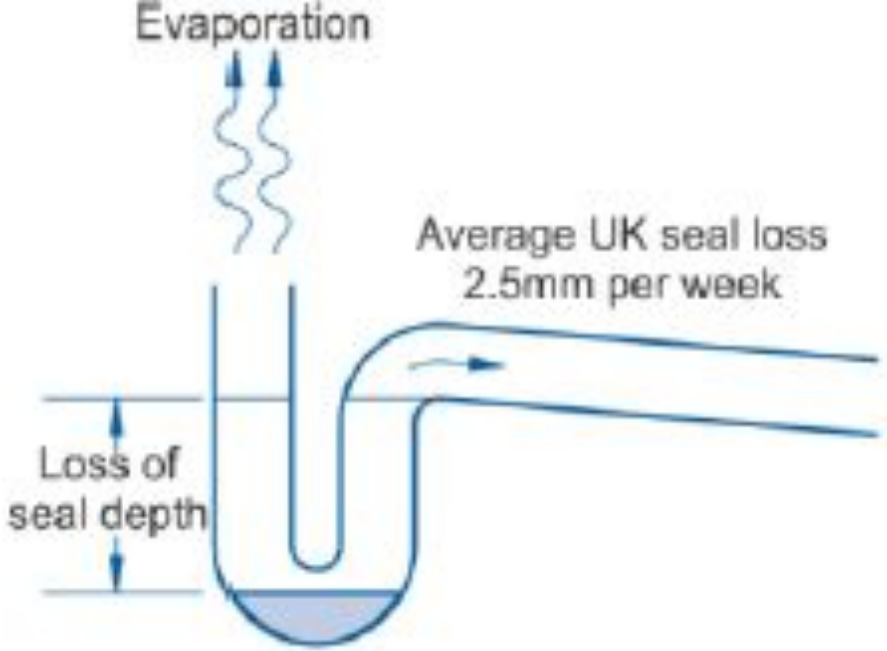


Loss of Trap Seals

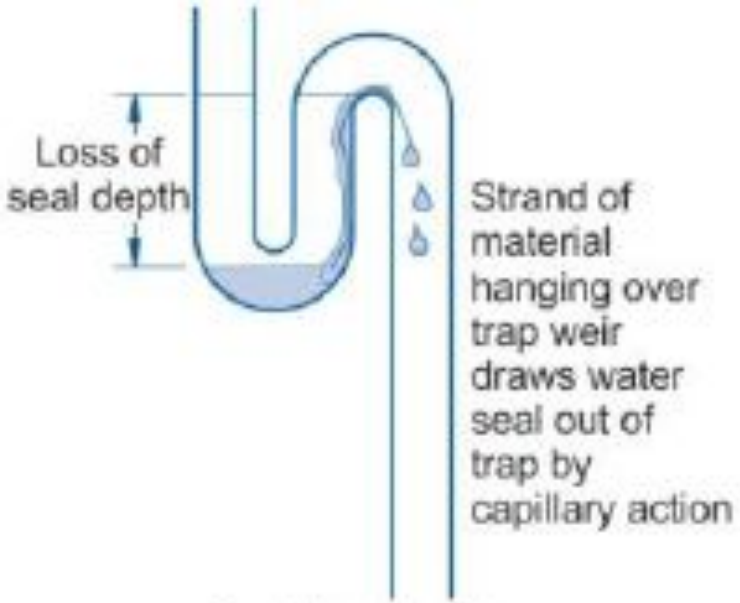
- Trap seal loss occurs **when the seal of the trap is lost as a result of poor practice** and by not following the regulations with regard to sanitation pipework installation.
- If a trap seal losses, smells from the sanitary appliances would enter the building.
- The main reasons of losing the water 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 week.
- ***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.



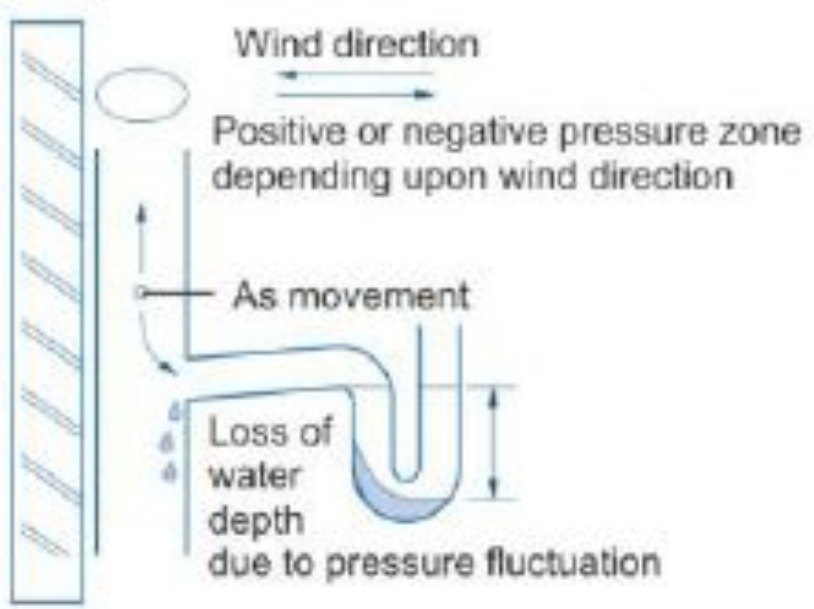
Evaporation



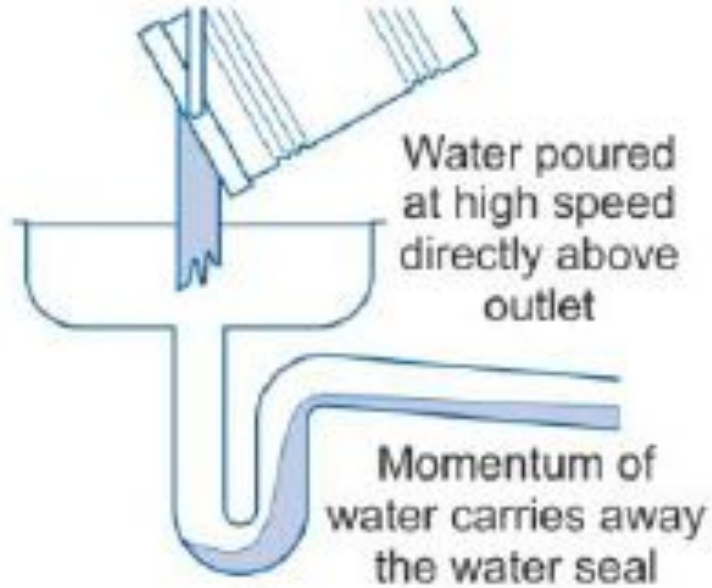
Capillary action

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.



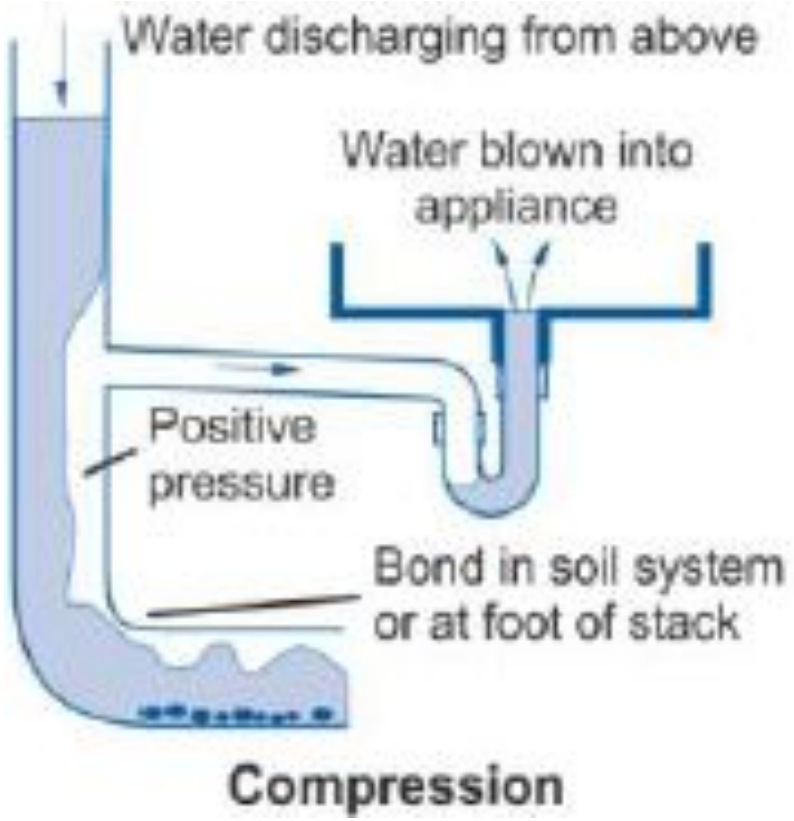
Wind effect (wavering out)



Momentum

Loss of Trap Seals

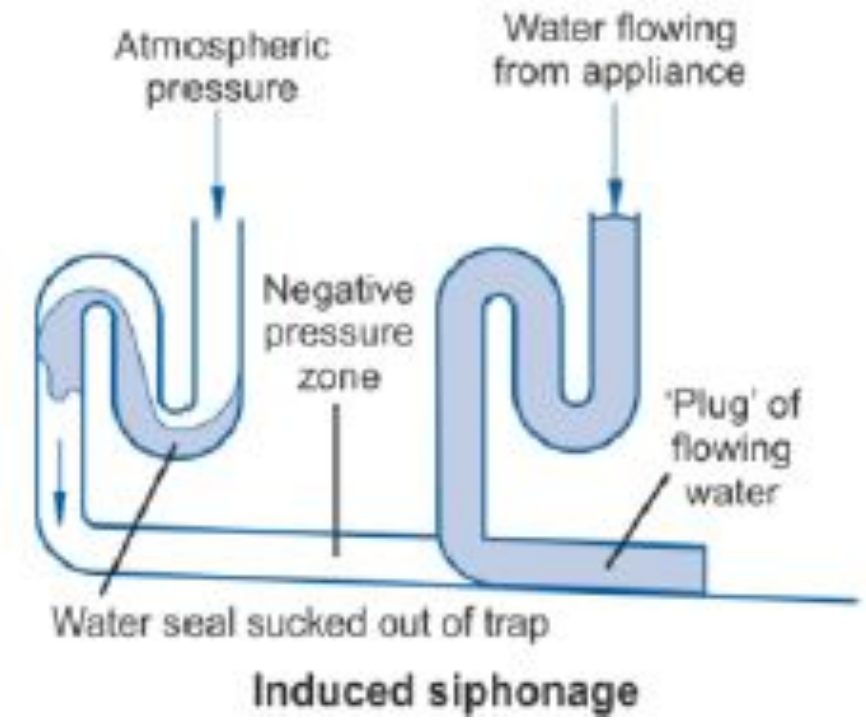
- ***Leakage:*** It is caused by a fault in the trap or plumbing installation and water on the floor would be apparent.
- ***Compression or back pressure:*** This occurs in high rise buildings. When water is discharged down to the main discharge stack, air is compressed at the base of the stack. A waste 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.



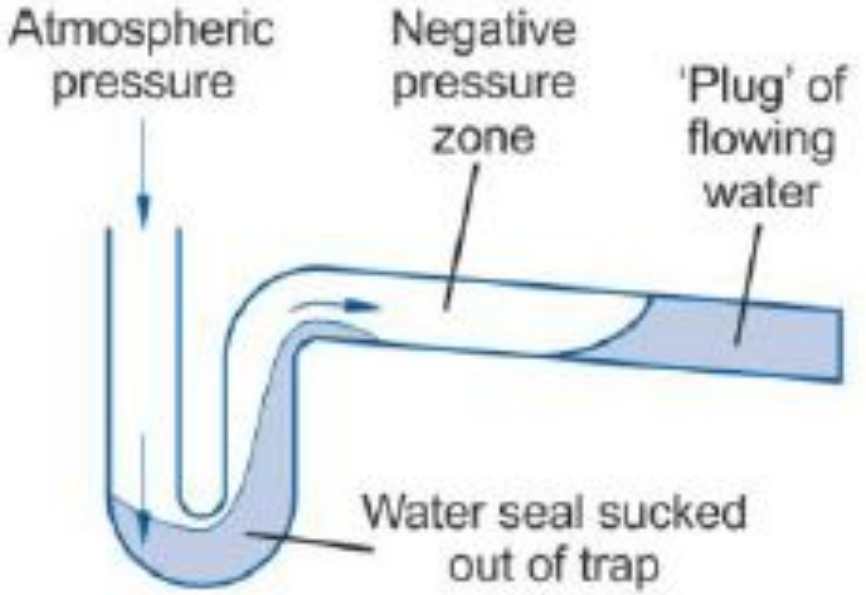
Compression

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:

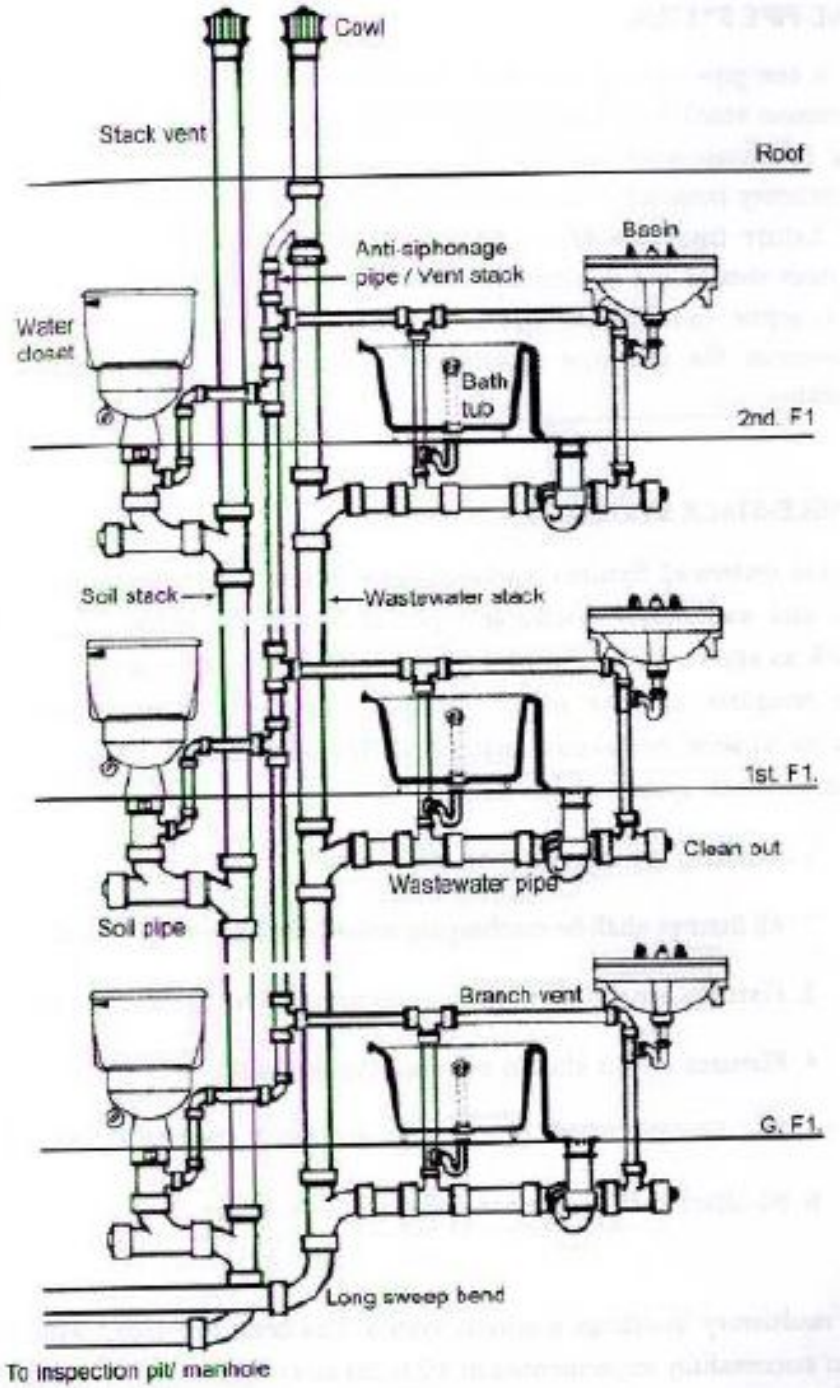
In two-pipe system, two separate piping and stacks are installed for conveyance of wastes generated from building.

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

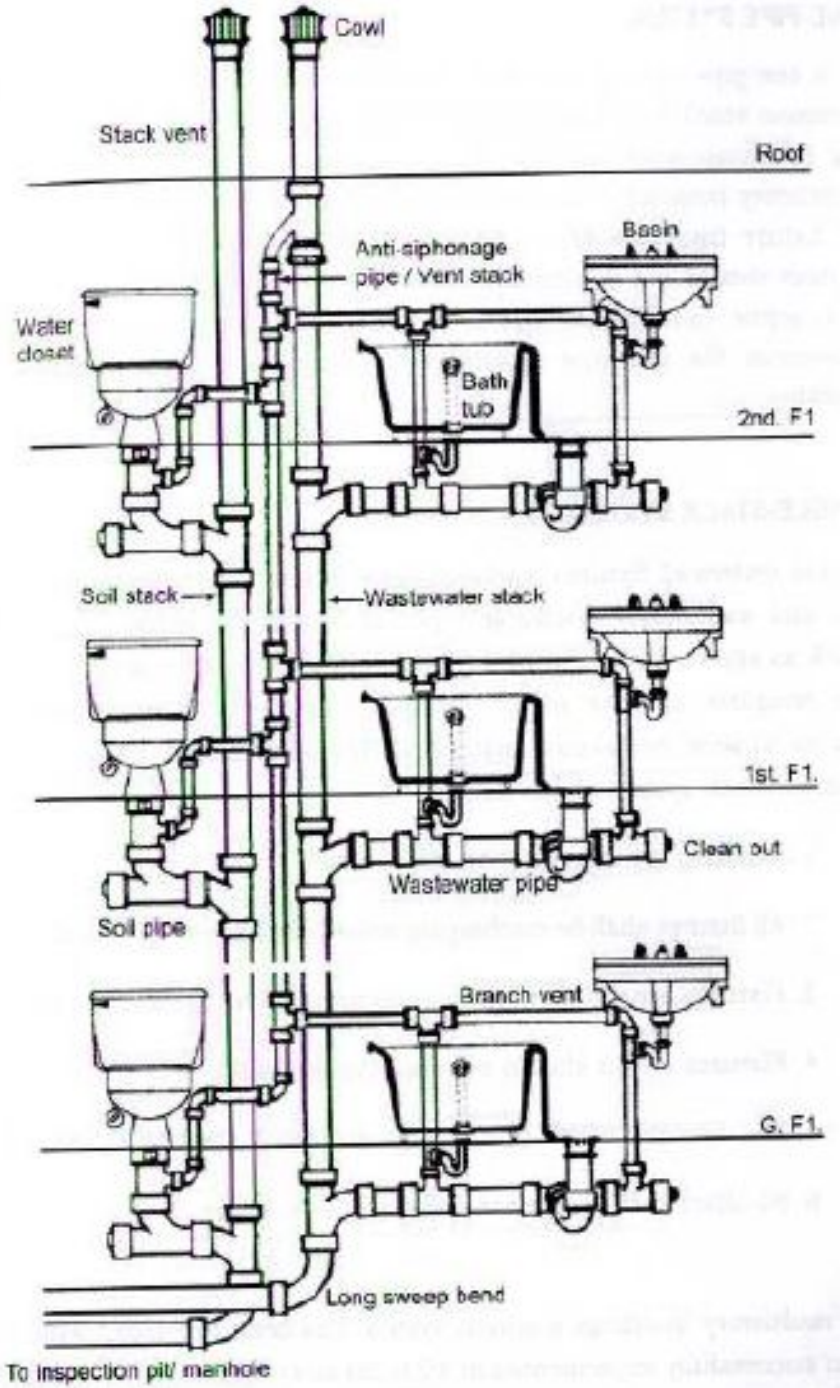
Disadvantages of Two pipe system:

– 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. Provision of gulley trap becomes difficult

– 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:

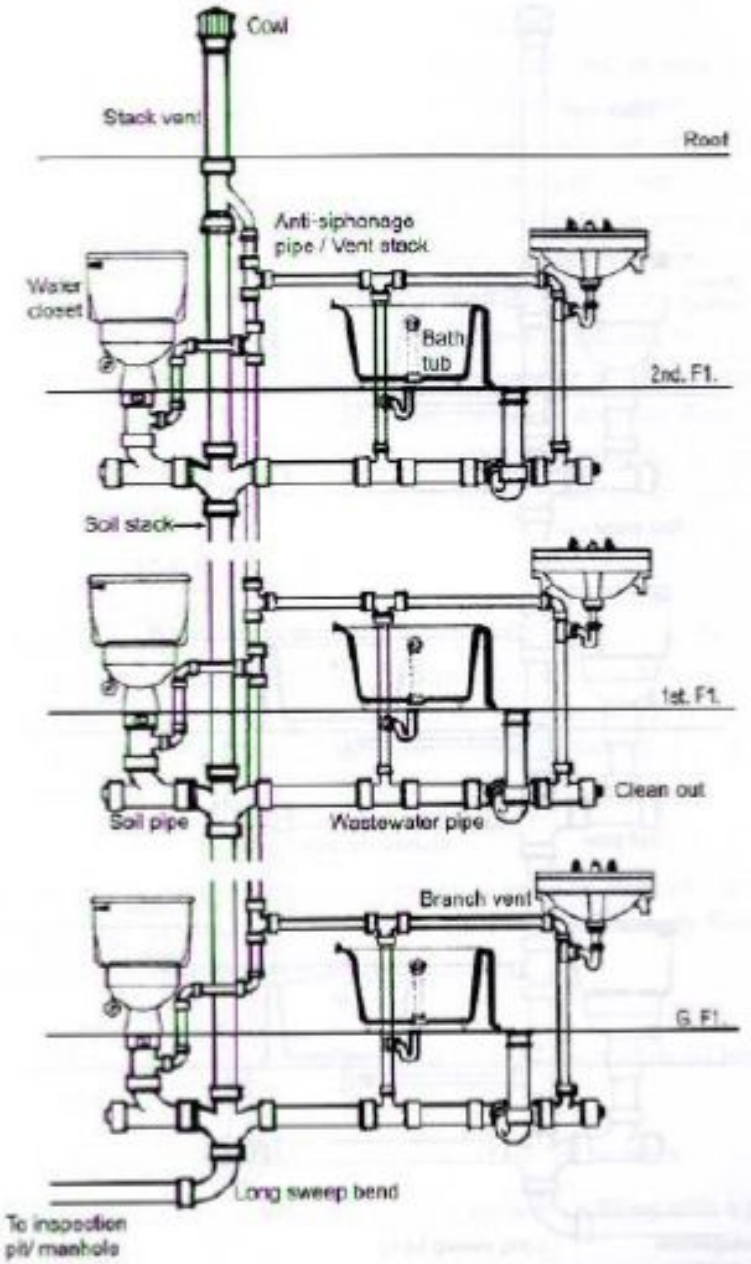
– Now widely used in modern multistoried building

– 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

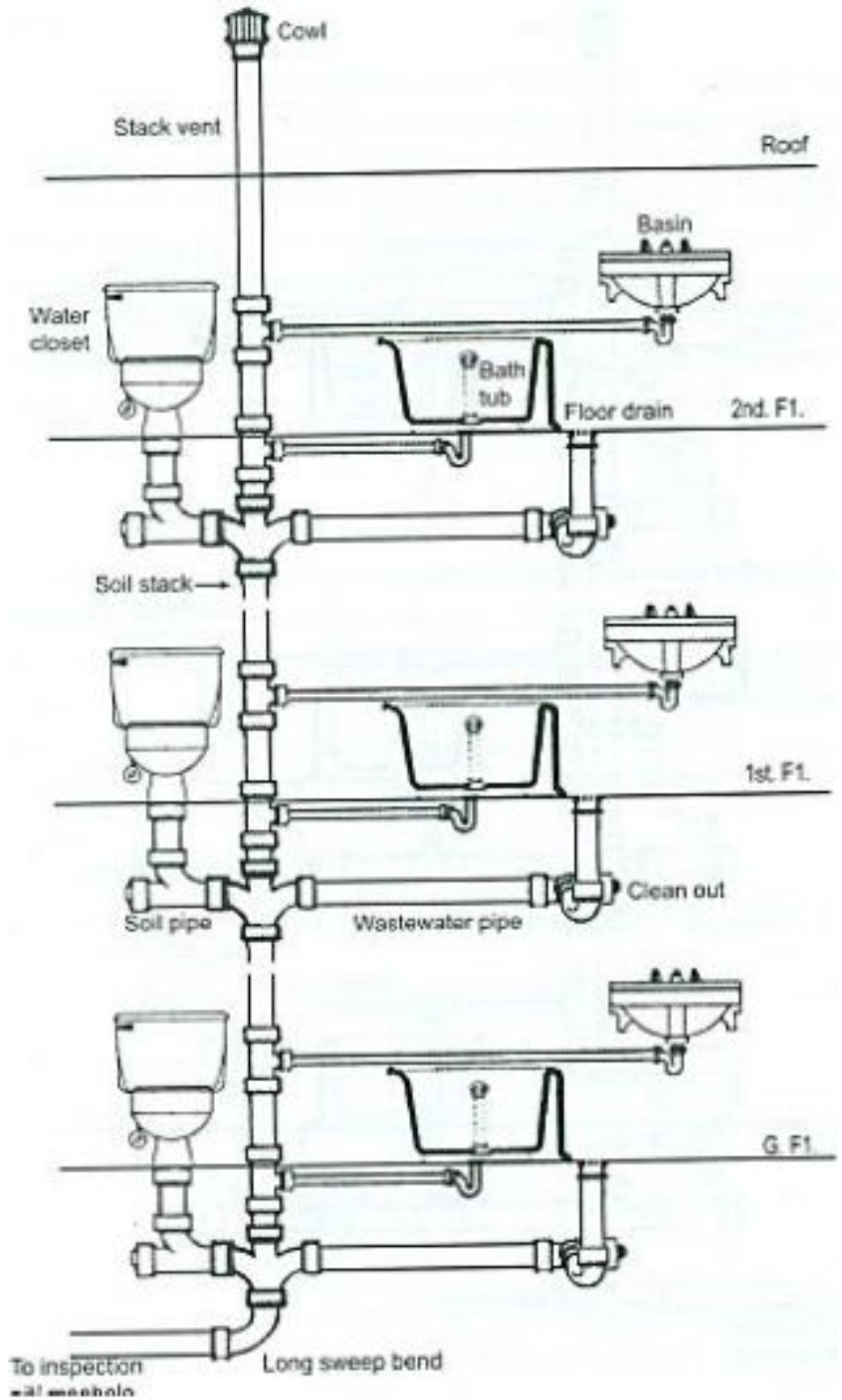
– More compact system

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.

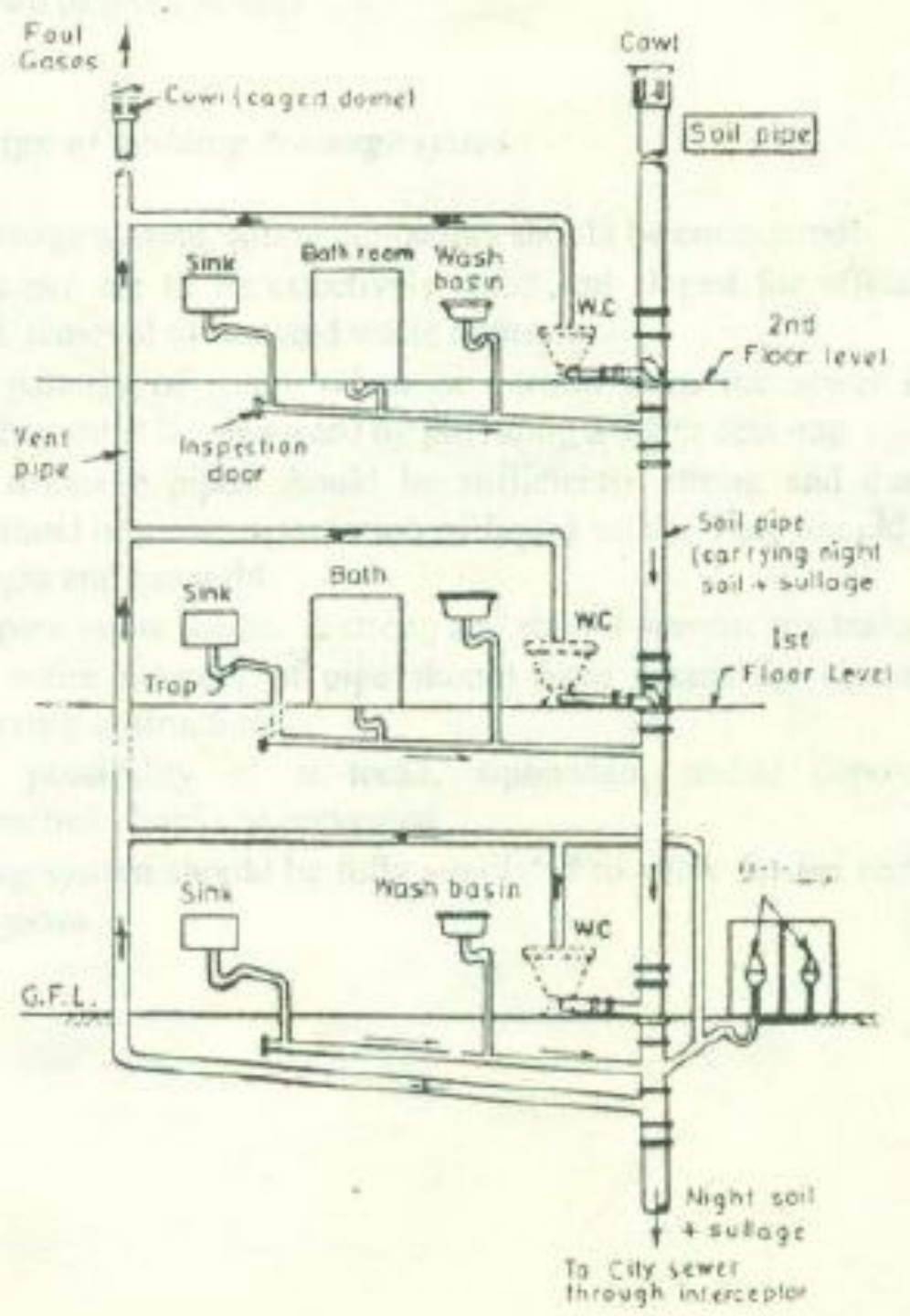


Plumbing systems: Types

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



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.

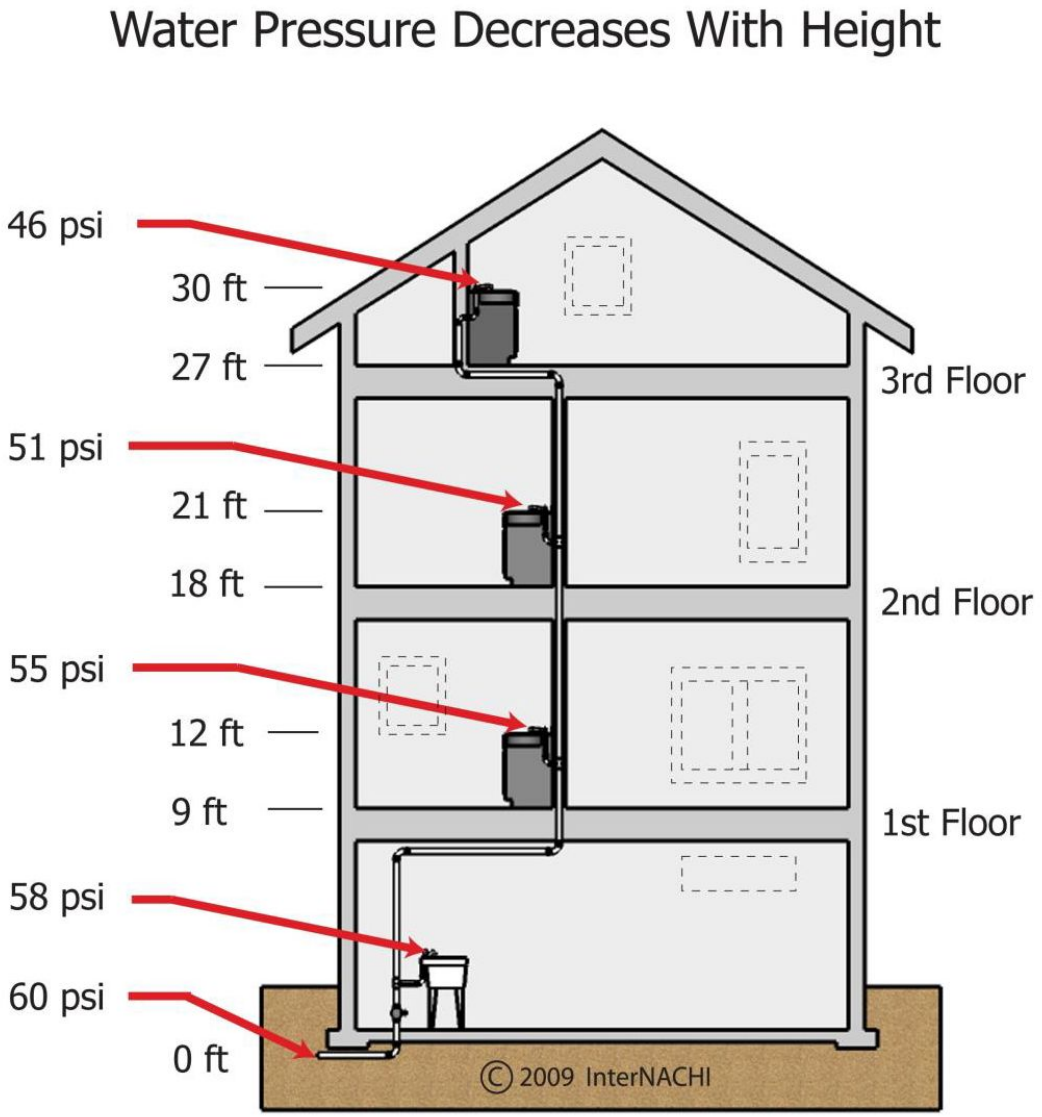
Types of Distribution System

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

Up Feed System

Disadvantages of Up Feed System

- It has the highest 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
- The installation does not impose a large weight on the structure.

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.

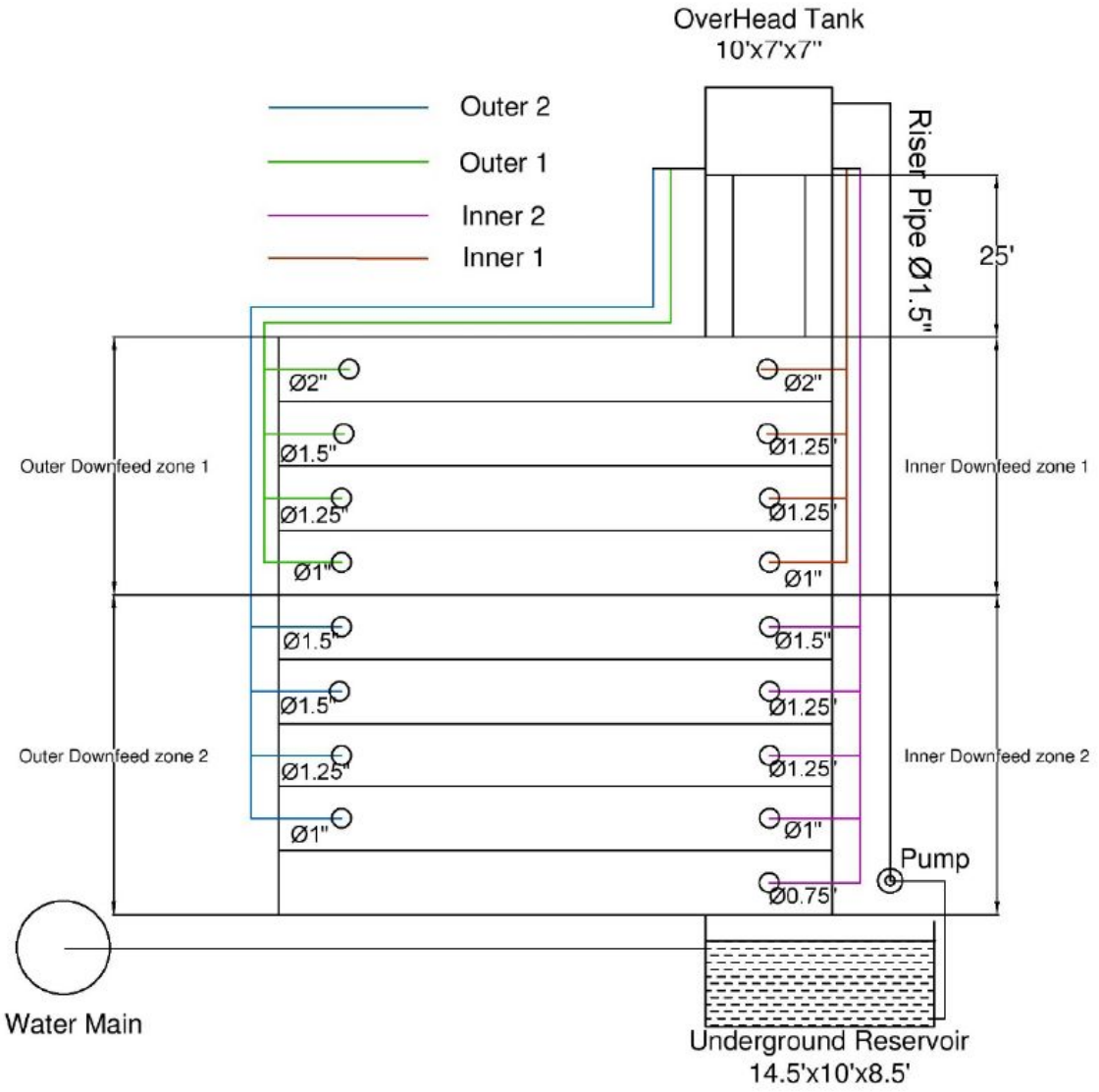
Hydro Pneumatic Tank System

- 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.

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
- Economy of water mains and the size of the service pipes
- Reduced possibility of mains pressure dropping which could lead to back siphonage of water from sanitary appliances into the main
- Reduced pressure on the installation which minimizes noise and wastage and enables appliances like hot water cylinders of reasonable gauge to be used.
- Heating and hot water supply apparatus can be vented to the storage cistern thereby minimizing safety valve requirements.

Down Feed System

Disadvantages of Down Feed System

- Space and support must be provided for the storage cistern.
- Storage cisterns may become dirty especially if not provided with a cover.
- Drinking water is supplied directly from the main.
- The reduced pressure means that the distributing pipes have to be larger.

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

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.

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

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)