EWC 2231
Building Services I:Plumbing

Course Teacher:

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Water Distribution System

Introduction

- 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.

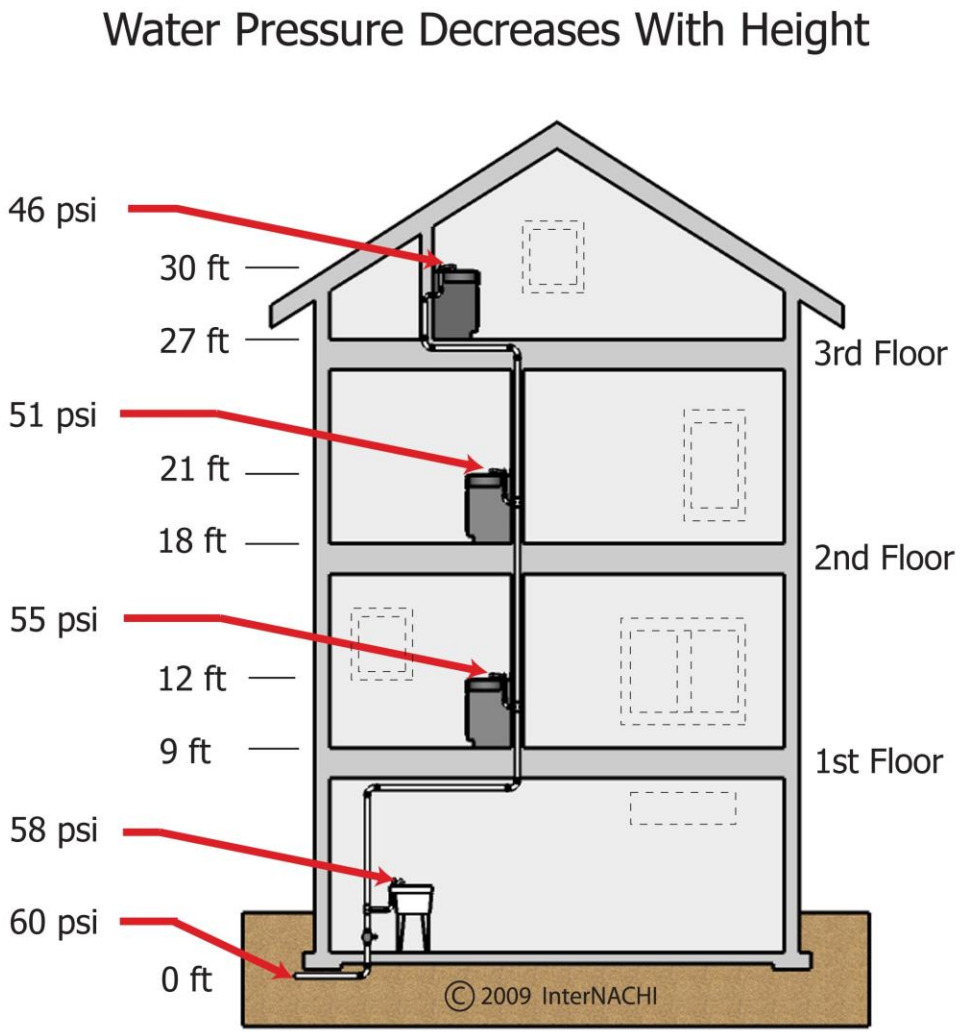
Types of Distribution System

- 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.



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.

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.

Example I: A 10 story building has a floor to floor height of 10', a pressure of 15psi is needed to flush toilet. What is the required water pressure at the base of the building? (consider static head only)

Total lift = 10story x 10'
= 100 feet

Static pressure = 100*4.33/10psi
= 43.3 psi

Therefore,
Pressure required= 43.3psi + 15psi (toilet) = 58.3psi

Different Up Feed System

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

- Booster pump system
- Hydro-pneumatic tank system

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.

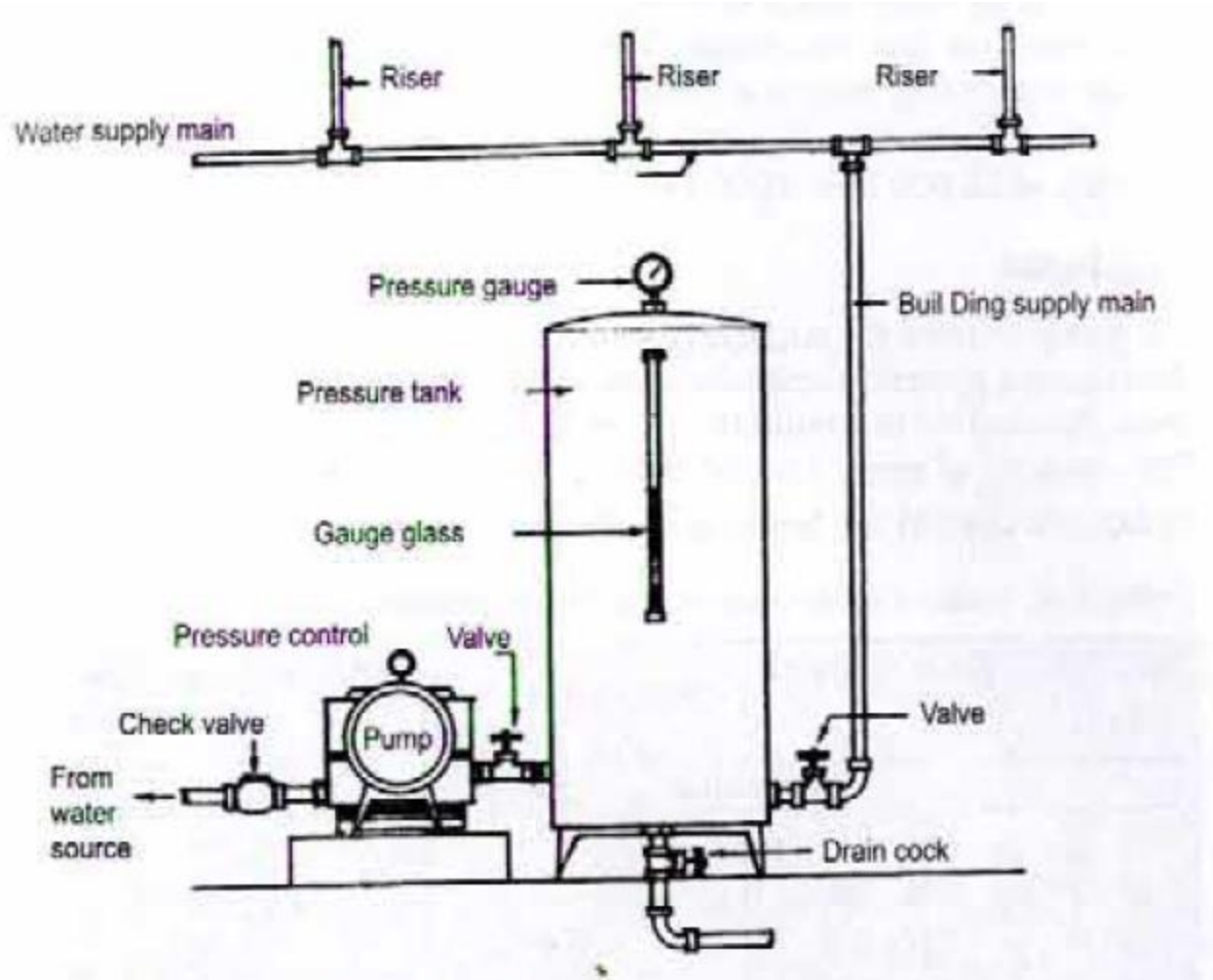
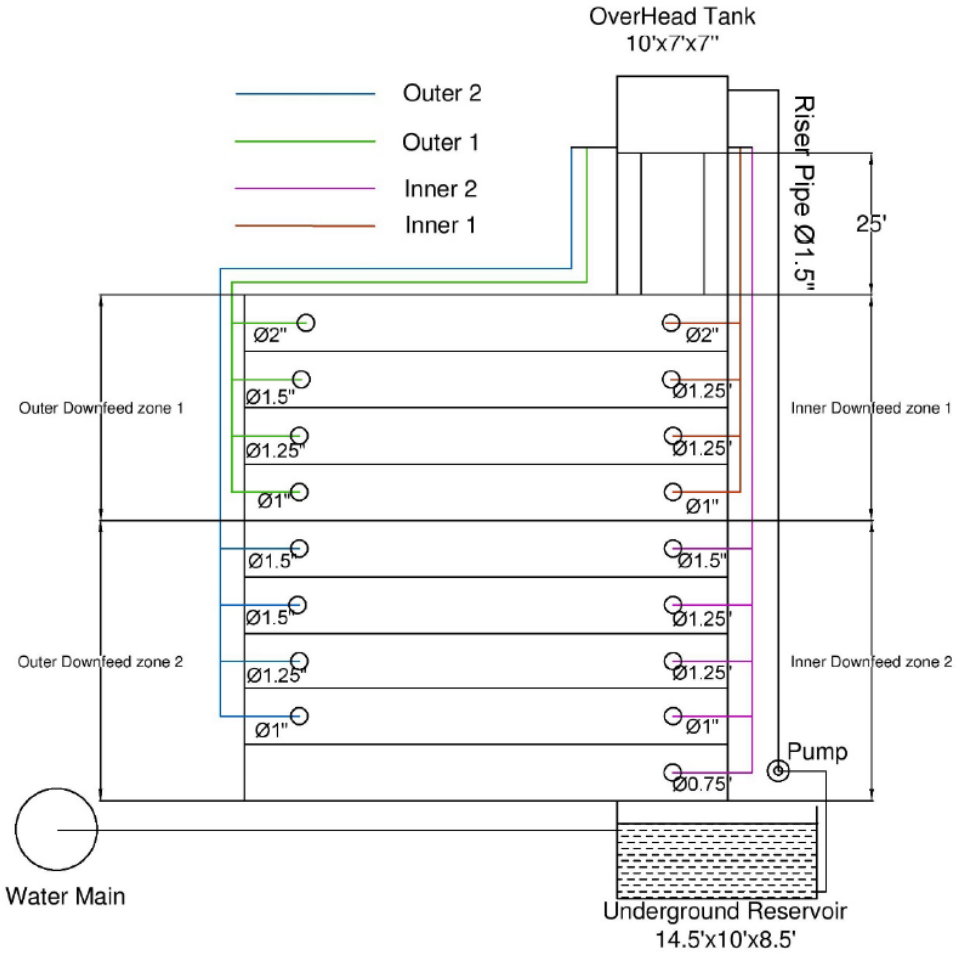


Fig 7.5 Hydro pneumatic tank system

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

Pressure at any point is determined by distance from outlet of tank

- Height of zone served is determined by max allowable pressure on the fixtures at the bottom
    - Max pressure approx. 45 – 60psi
    - Max height of zone (60psi / .434psi per ft) or about 138ft
    - Beyond max height, pressure-reducing valve needed

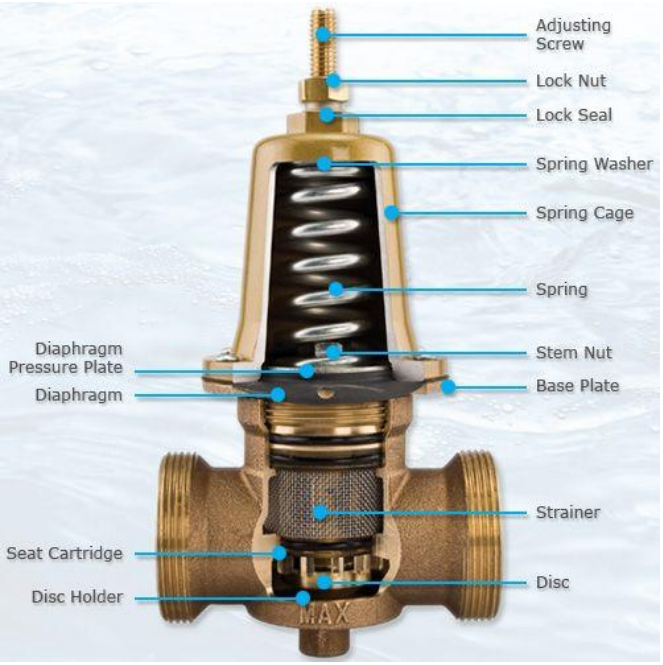
- Fixtures at top of zone must have min pressure to work properly
    - Example: flush toilet needs 15psi then water tank must be min of 15/.434 or 35’ above the fixture
    - Actual distance slightly greater to overcome friction

Excessive Water Pressure

If water pressure is excessive in a water distribution system, then it will cause damage to the components of the system. The damages that may occur are as follows-

- Bursting of pipe
- Failure of joints and for supports
- Fracture of valve and equipment
- Producing noise in pipe
- Splashing of water from faucet

Water distribution pipe in a building shall be maintained at a pressure so that none of their fittings shall are subject to a water head greater than 35 m (approximately 50 psi).



Principles governing the design

– Absolutely no risk of contamination
  - no cross connection
  - no back flow

– Water supply and drainage pipe should not be laid very close to each other

– Enough protection for pipe damage

– Adequate pressure should be maintained

Layout

– The lay-out of water supply pipes should be simple and direct as far as possible

– The pipes should be laid out as straight as possible – Water supply and drainage pipe should not be laid

– The lay-out should be such as to admit of easy inspection and repair

– The lay-out should be free from the occurrence of air pockets, sediment traps and noise transmission.

General Features of Distribution System Design according to BNBC

- The water supply system shall be designed to supply minimum but requisite quantity of water to all fixtures, devices and appurtenances in every section of the building with adequate pressure. The design requirements of a water supply system are presented in Table 8.5.6.
- For a down feed water distribution system (roof tank supply), static pressure due to gravity increases with increasing floor height (4.32 psi or 0.3 Bar per floor of 10 ft. height at non flow condition). Therefore, water distribution pipe in a building shall be maintained at a pressure so that none of their fittings shall are subject to a water head greater than 35 m (approximately 50 psi).
- The distribution system shall be maintained at a pressure not less than those specified in Table 8.5.6 during peak demand period.
- The minimum size of supply pipe for different fixtures shall be in accordance with Table 8.5.6. The fixture supply shall not terminate more than 0.76 m (2.5 ft) from the point of connection to the fixture. A reduced size flexible water connection pipe shall be used.
- The water flow velocity in the distribution system shall be controlled to minimize the possibility of water hammer.
- The design of water distribution system shall conform to approved engineering practices.

Table 8.5.6: Water Supply System Design Requirements

Fixture	Supply Control	Minimum Size of Supply Pipe (mm)	Required Flow Pressure (kPa)	Required Flow Rate (lpm)
Bathroom group	Flush tank	-	55	--
Bathroom group	Flushometer valve	-	55	--
Bathtub	Faucet	13	55	15.1
Clothes washer		13	55	--
Combination fixture	Faucet	13	55	--
Dishwashing machine		13	55	10.4
Drinking fountain	Faucet	13	55	2.8
Kitchen sink	Faucet	13	55	9.5
Laundry tray	Faucet	13	55	15.1
Wash basin	Faucet	19	55	--
Pedestal urinal	Flush tank	13	55	56.8
Pedestal urinal	Flushometer valve	19	100	56.8
Restaurant sink	Faucet	19	55	--
Service sink	Faucet	13	55	11.4
Shower head	Mixing valve	13	55	11.4
Water closet	Flush tank	19	55	11.4
Water closet	Flushometer tank	19	55	6.1
Water closet	Flushometer valve	25	100	132
For fixture not listed here but maximum supply size requirement		13 19 25	55 55 100	-- -- --

Note: 1 psi = 6.895 kPa (1 kPa = 0.145 psi), 1 gallon = 3.785 liter

5.11 WATER DISTRIBUTION IN TALL BUILDINGS

5.11.1 Distribution Methods

In tall buildings some of the fixtures at the lower level may be subject to excessive pressure. The sanitary appliances and fittings in tall buildings shall not be subject to a pressure of greater than 350 kPa. This shall be achieved by one or a combination of the following two methods :

a) Zoning Floors by Intermediate Tank : High rise buildings shall be zoned by providing intermed4ate tanks on different floors, each feeding a zone ranging from 5-6 storeys so that the plumbing fixtures are not subjected to excessive pressure. Distribution in each zone shall be through independent down-take pipes from intermediate tanks as shown in Figures 8.5.C.3(a), 8.5.C.3(b), 8.5.C.3(c) and 8.5.C.3(d) of Appendix- 8.5.C. The floors on which an intermediate tanks are located shall be fed from the story above it.

i) System Incorporating Intermediate Tanks Supplied by Storage Tank - Water required for the building shall be pumped from the underground tank to the storage tank. The intermediate tanks shall be fed from the storage tank through a separate down take pipe.

ii) System Incorporating Intermediate Tanks Supplied by Independent Pumps - Alternatively the intermediate tanks may be supplied from the underground tank through independent pumps

b) **System Incorporating Pressure Reducing Valves:** The excessive pressures suffered by different fixtures shall be minimized by pressure reduction valves.

c) **Hydro-Pneumatic System:** This system may be adopted where the source is independent of public water supply system. In this system the supply shall be through a pneumatic pressure vessel fitted with accessories like non-return and pressure relief valves. The pump and compressor shall be automatically controlled through an electric control panel to provide air and water as and when needed.

Design of Water Pipe

Flow Rate

- The flow rate of a fixture is the volume of water flowing in a given time.
- Flow rate is expressed in cfs (gpm)

SL. No.	Fixture	Flow rate (gpm)
1	Ordinary lavatory faucet	2.0
2	Self-closing basin faucet	2.5
3	Sink faucet, 3/8 in.	4.5
4	Sink faucet, 1/2 in.	4.5
5	Bathtub faucet	6.0
6	Laundry tub faucet, 1/2 in.	5.0
7	Shower	5.0
8	Ball cock for water closet	3.0
9	Flushometer valve for water closet	15-35
10	Flushometer valve for urinal	15.0
11	Drinking fountain	0.75
12	Sill cock or wall hydrant	5.0

Probable Flow Rate

- The probability that all the faucets in a building or a section of the piping system will be in use at the same moment is quite unusual
- So the estimated demand load for fixtures used intermittently on any supply pipe is calculated using water supply fixture units (WSFU)

Water Supply Fixture Unit

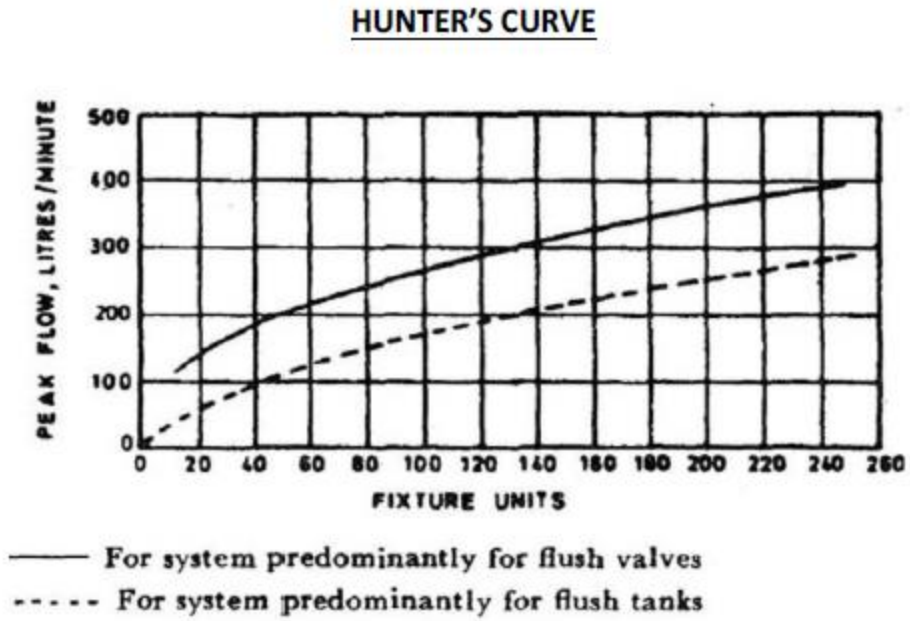
The water supply fixture unit is a factor so chosen that load producing effects of different kinds of plumbing fixtures and their conditions of service can be expressed approximately as a multiple of the factor. It depends on-

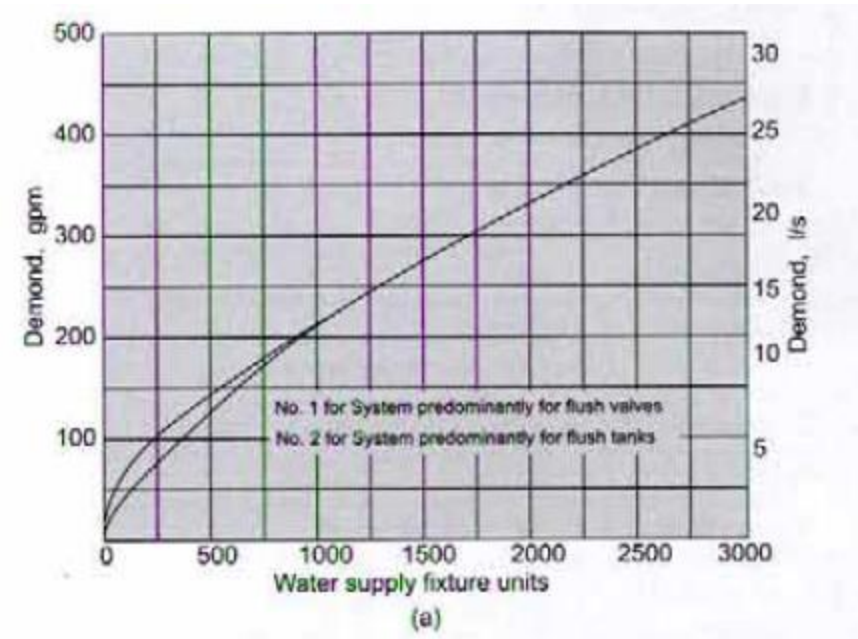
- Demand of water by the fixture when it is being used
- The average time of water actually flowing when being used
- The frequency with which the fixture is likely to be used

Sl. No.	Fixtures		Fixture units
1.	Ablution tap	a. Occasionally used, e.g. for WCs, baths, etc. b. Public places, common baths, etc.	1 3
2.	Bath tubs (supply taps)	a. Private. b. Public.	2 4
3.	Shower stall,	a. Private. b. Public.	2 4
4.	Wash basin,	a. Private b. Public	1 2
5.	Surgeons wash basins		2
6.	Kitchen sinks	a. Domestic b. Hotels, canteens, etc.)	2 4
7.	Drinking fountains (connection to water cooler)		1
8.	Bidet		3
9.	Water-closet	a. Flush tank (Private) b. Flush tank (Public) c. Flush Valve (Public)	3 5 10
10.	Urinals	a. Flush tank (Public) b. Flush valve (Public, ¾ in.) c. Flush Valve (Public, 1 in.)	3 5 10
11	Dish washing machine		1
12	Laundry machine,3.6 kg		2
13	Lawn sprinklers (Standard type , each head)		1

Water Supply Fixture Unit for Different Types of Fixtures

- First, Total Fixture Unit for a supply pipe need to be calculated.
- Then Probable flow is determined using the following graph:





- An alternate approach:

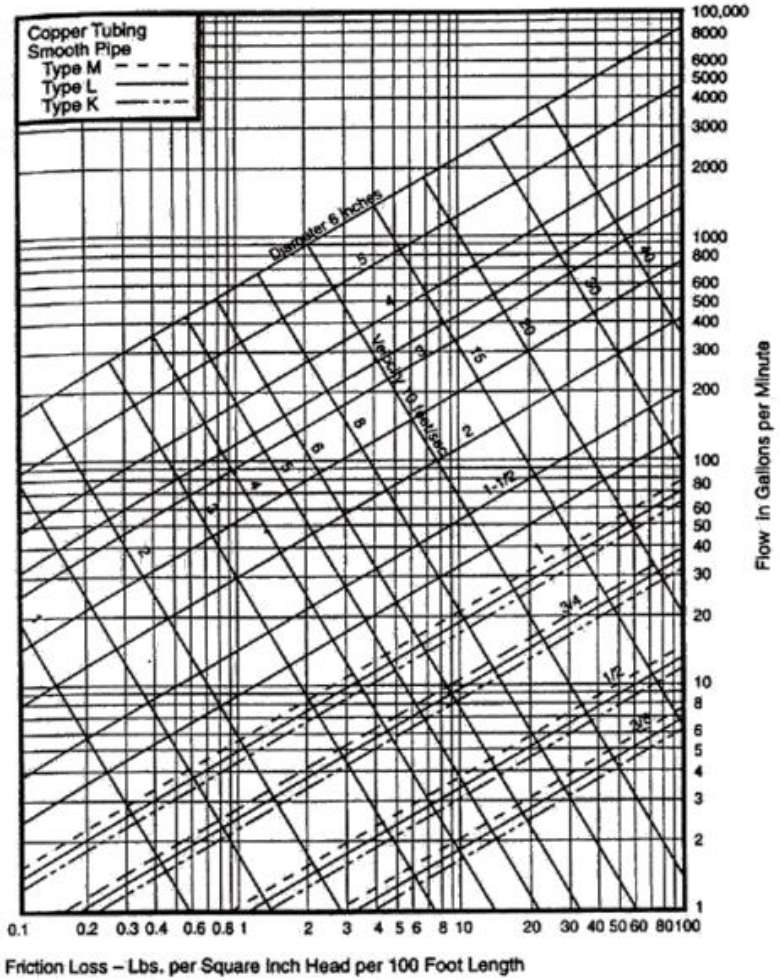
No. of fixture units	Probable effective fixture units*	
	System with flush tanks demand	System with flush valves demand
20	2	4.7
40	3.3	6.3
60	4.3	7.4
80	5.1	8.3
100	5.7	9.1
120	6.4	9.8
140	7.1	10.4
160	7.6	11.0

No. of fixture units	Probable effective fixture units*	
	System with flush tanks demand	System with flush valves demand
180	8.2	11.6
200	8.6	12.3
220	9.2	12.7
240	9.6	13.1
300	11.4	14.7
400	14.0	17.0
500	16.7	19.0
600	19.4	21.1
700	21.4	23.0
800	24.1	24.5
900	26.1	26.1

- Effective Fixture units = Unit rate of flow
- 1 unit rate of flow = 1 cft/mt = 28.316 l.p.m
- 1 lpm= 0.264 gpm

It may be noted from the Table that the probable demand load in the system with flush valves is higher than that in the system with flush tanks and the variation in either case decreases as the number of fixture unit increases till at 900 fixture units, the variation evens out and both values merge.

Supply pipe diameter is selected using the following diagram:



Two methods:

- Limiting Velocity method
- Limiting Friction Loss method