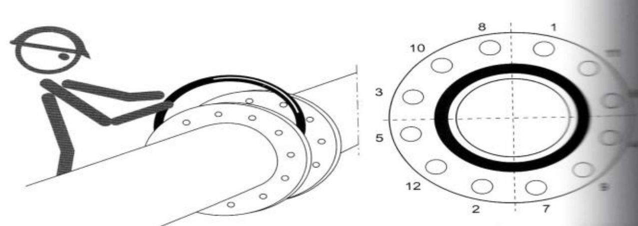
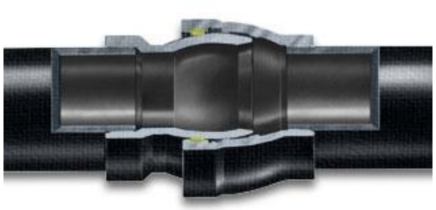
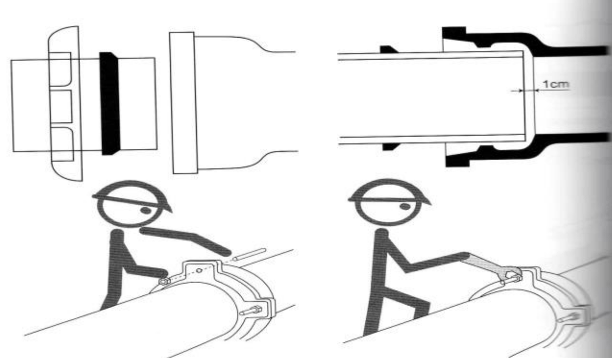
Water Supply Network

Flanged joints

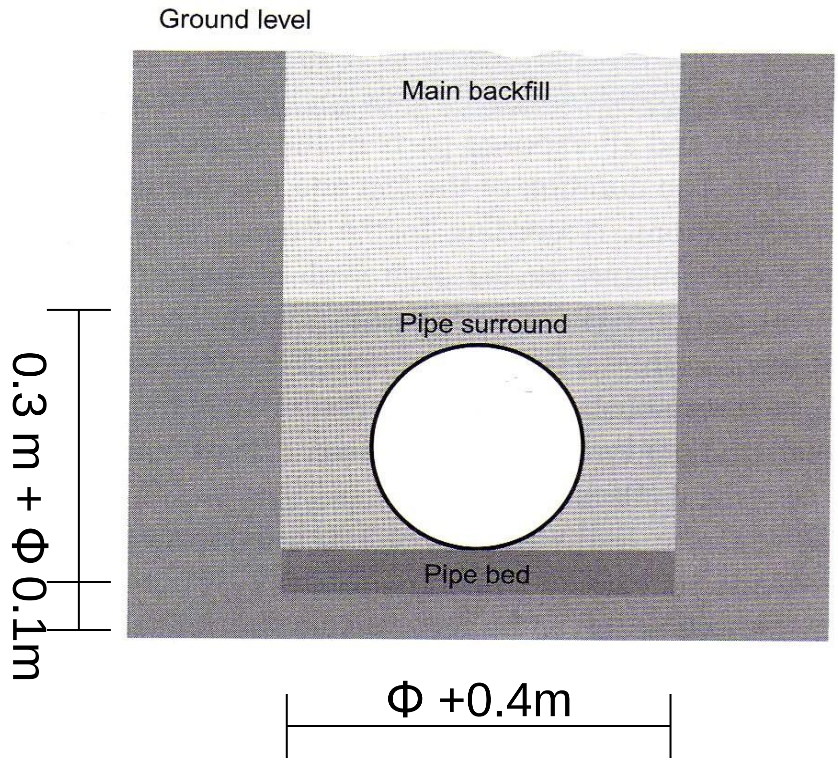




Gland joints



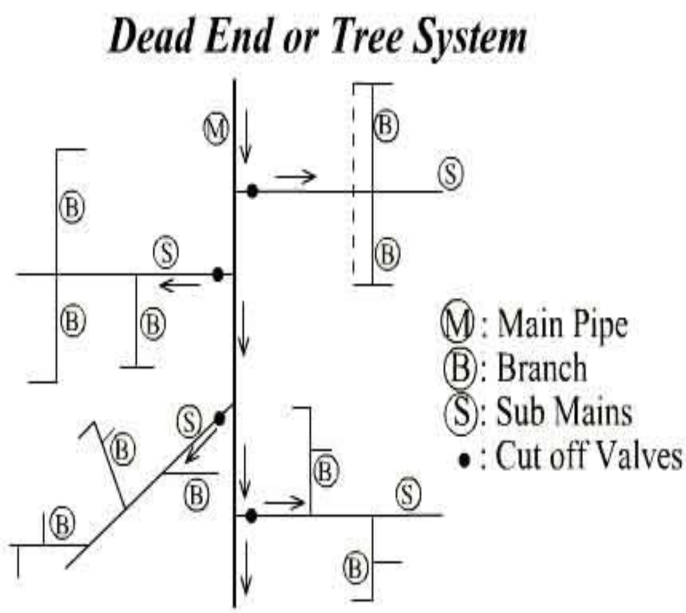
Installation of water pipe



Planning of water distribution systems

Tree system (dead end system)

It is suitable for old towns and cities having no definite pattern of roads.



Advantages:

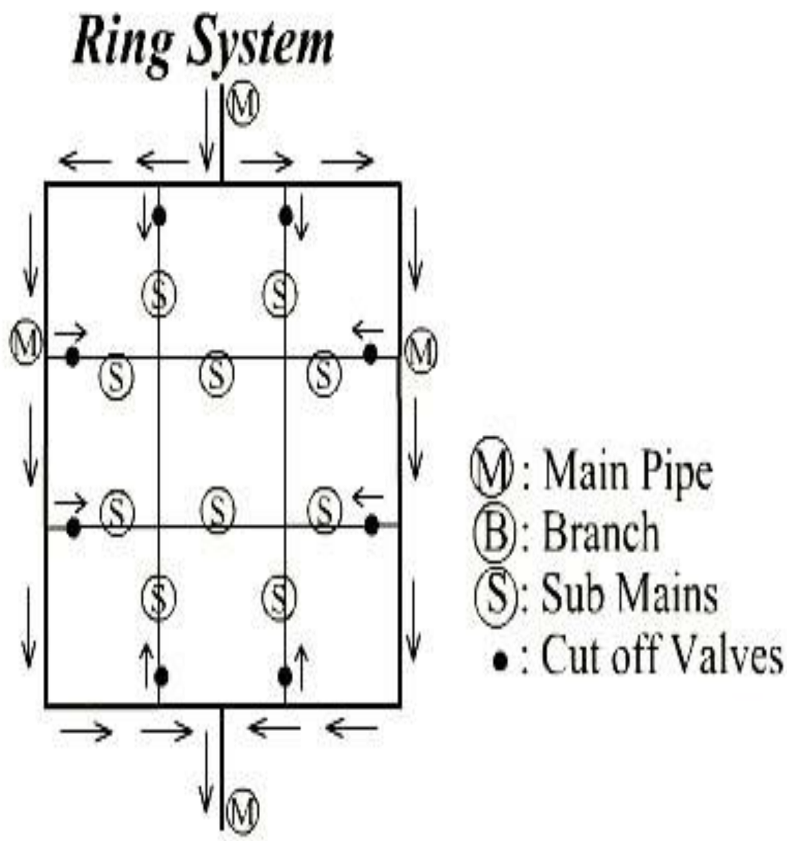
- Simple in design and construction.
- Low cost.

Disadvantages:

- Dead ends tend to reduce the pressure and pollute water.
- There are not enough valves to control the network.
- Difficulties in extension of the network.

Loop (Ring) system

The supply main is laid all along the peripheral roads and sub mains branch out from the mains.



Advantages:

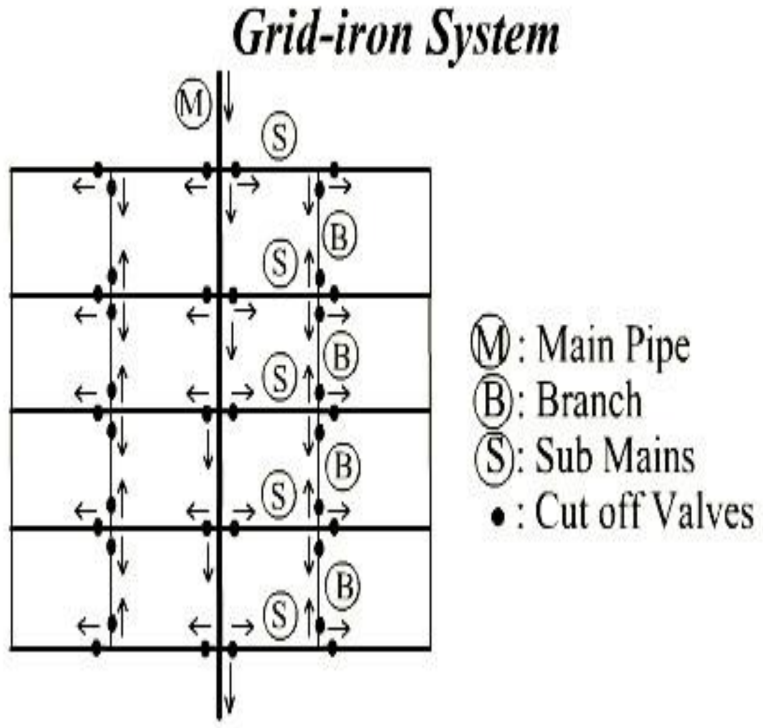
- Reduce the dead ends.
- There are valves on the lateral pipes to control the network.
- It is easy to extend the network.
- The water can reach every point in two directions.

Disadvantages:

- There are some of dead ends.

Grid iron system

It is suitable for cities with rectangular layout, where the water mains and branches are laid in rectangles.



Advantages:

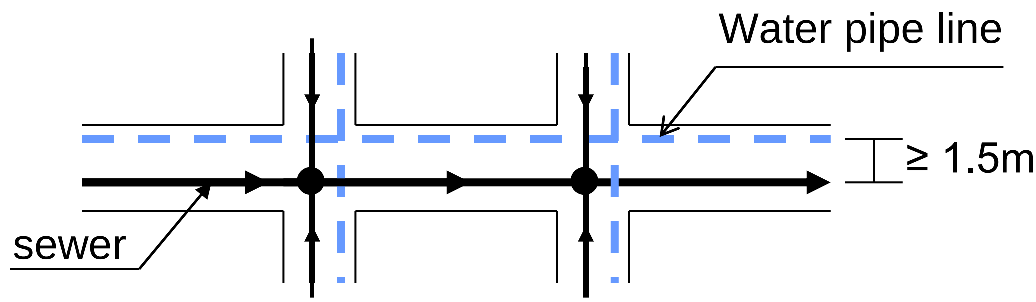
- Reduction in dead ends tends to improve the pressure.
- There are valves on the lateral pipes to control the network.
- It is easy to extend the network.
- The water can reach every point in two directions.

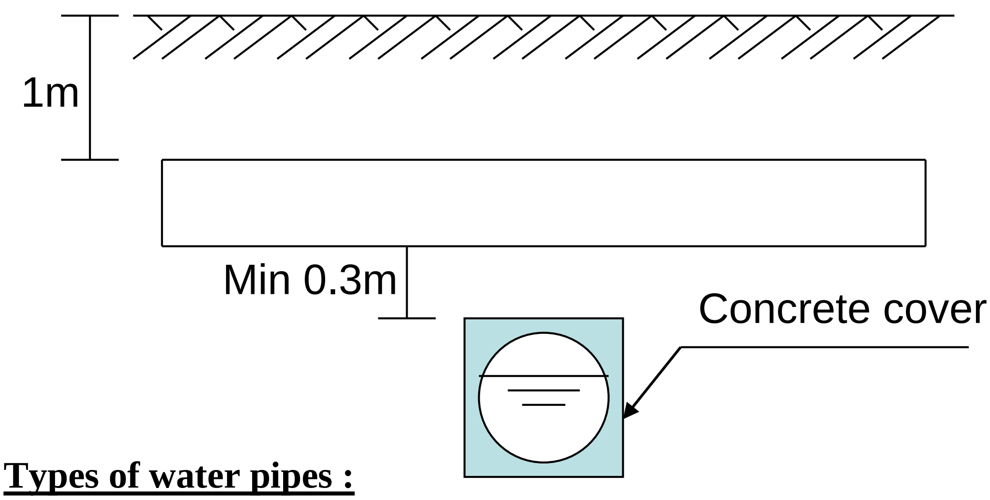
Disadvantages:

- There are some of dead end

Comparison elements	Tree system	Loop system	Grid iron system
Cost	Minimum	Moderate	High
Dead ends	Many	Moderate	None
The range of damages due to broken pipe	Huge	Moderate	Limited
Water quality	Poor	Moderate	High
Water pressure at the ends	Low	Moderate	High

Crossing of pipe line and sewer





Types of water pipes :

- Cast iron
- Ductile cast iron
- Steel
- Plastic pipes (e.g. UPVC).

pipes type	Diameter (mm)
U.P.V.C	200 – 700
Polly ethylene high density	200 – 700
G.R.P	200 – 2800
Ductile cast iron	200 – 900
Pre-stressed concrete	600 – 3000

Design Criteria of pipes networks

1- The minimum diameter of pipe = 150 mm.
2- The velocity = 0.8 – 1.5 m/s.
3- The hydraulic gradient (S) = 1 %◦ - 3 %◦.
4- The pressure at the farthest and highest point in the network ≥ 25 m.
5- The valves ≤ 300 mm installed directly on the pipe line.
6- The valves ≥ 300 mm installed in valves room.
7- The design discharge
- For transmission main
  $Q_d = Q_{max\ daily} + Q_f$
- For main and secondary line
  $Q_d = Q_{max\ daily} + Q_f$ or $Q_{max\ hourly}$
- For minor distribution
  $Q_d = Q_f$
- For service connection
  $Q_d = Q_{max\ hourly}$

Fire demands

Population (capita)	Qf (l/s)
10,000	20
25,000	25
50,000	30
100,000	40
More than 200,000	50

Design of water network

- Equivalent pipes method.
- Method of sections
- Method of circles.
- Hardy cross method.

Equivalent pipe method

Equivalent pipe is a method of reducing a combination of pipes into a simple pipe system for easier analysis of a pipe network, such as a water distribution system.

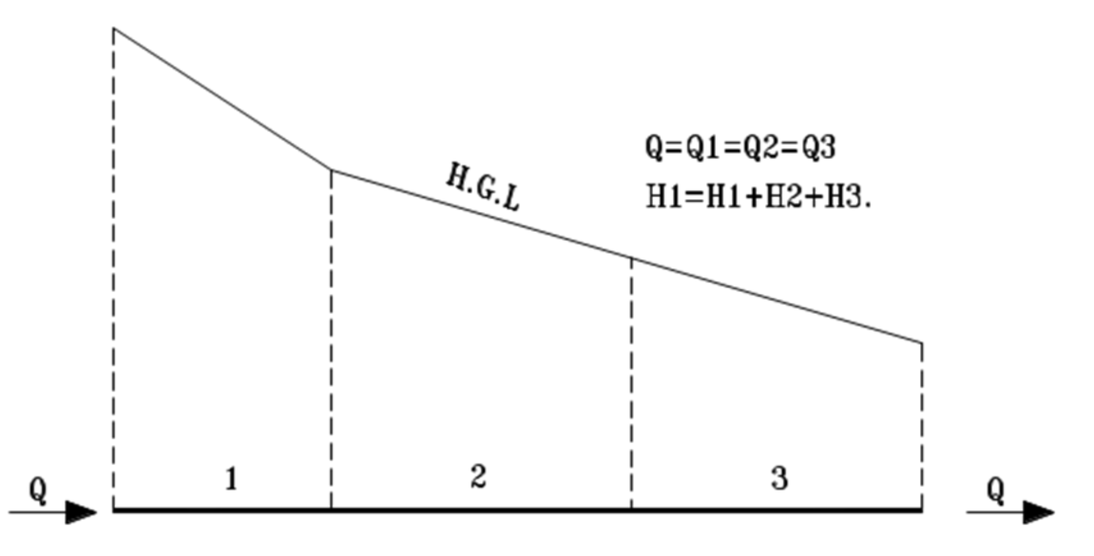
An equivalent pipe is an imaginary pipe in which the head loss and discharge are equivalent to the head loss and discharge for the real pipe system. There are three main properties of a pipe: diameter, length, and roughness. As the coefficient of roughness, C, decreases the roughness of the pipe decreases. For example, a new smooth pipe has a roughness factor of C = 140, while a rough pipe is usually at C = 100. To determine an equivalent pipe, you must assume any of the above two properties. Therefore, for a system of pipes with different diameters, lengths,

and roughness factors, you could assume a specific roughness factor (most commonly C = 100).

The most common formula for computing equivalent pipe is the Hazen-Williams formula.

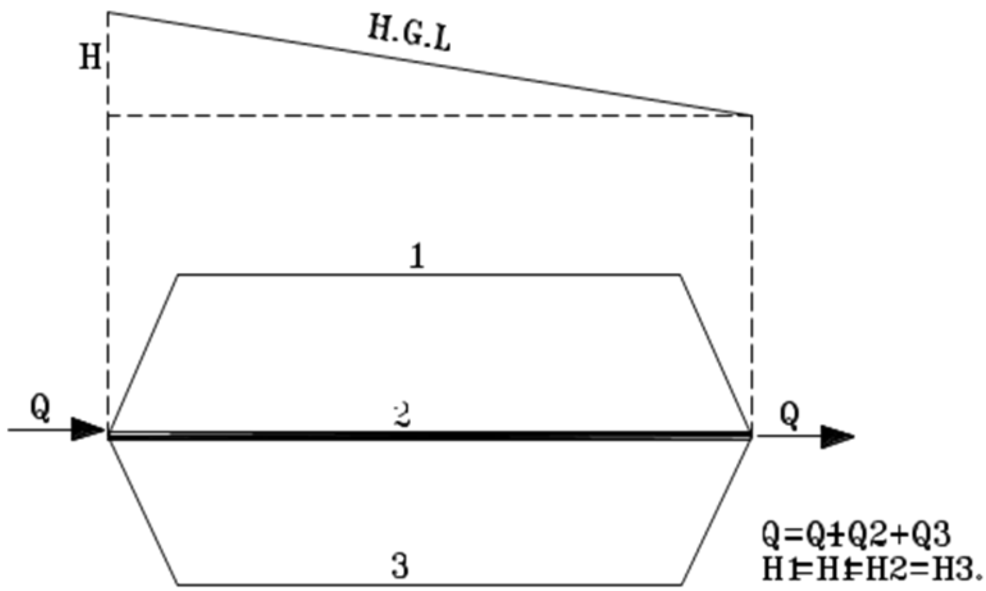
For example, pipes of different sizes connected in series can be replaced by an equivalent pipe of one diameter as follows:

Assume a quantity of discharge and determine the head loss in each section of the line for this flow, then using the sum of the sectional head losses and the assumed discharge, enter the chart to find the equivalent pipe diameter.



Pipes in series

For pipe systems connected in parallel, a head loss is assumed, and the quantity of discharge through each of the pipes is calculated for that head loss. Then the sum of the discharges and the assumed head loss are used to determine the equivalent pipe diameter.



Pipes in parallel

<u>Hydraulic design of water network</u>

<u>The equations used in the design of water network:</u>

1- Q = A x v discharge equation

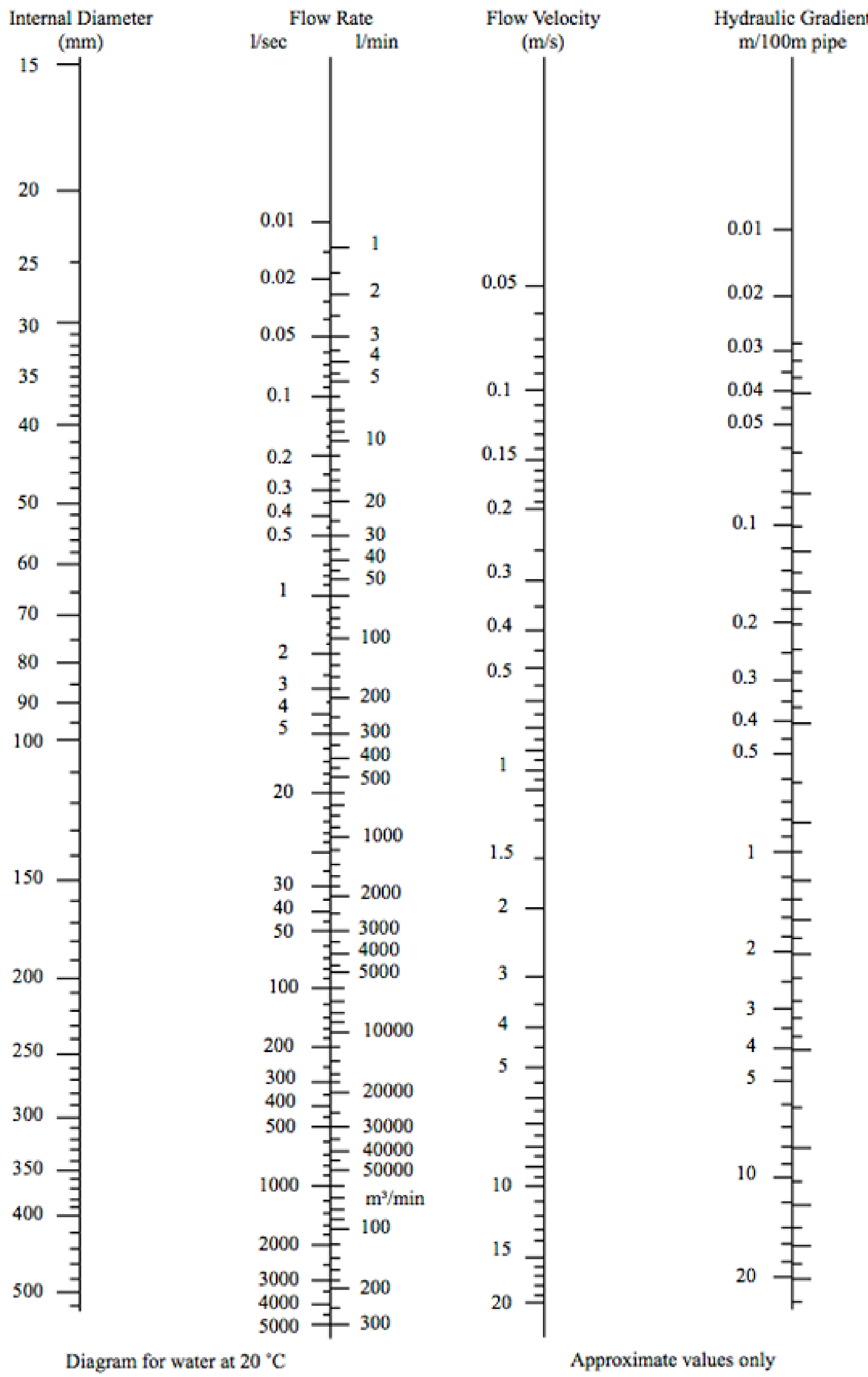
2- $hf = \frac{flv^2}{2gd}$ Darcy - weisbach equation

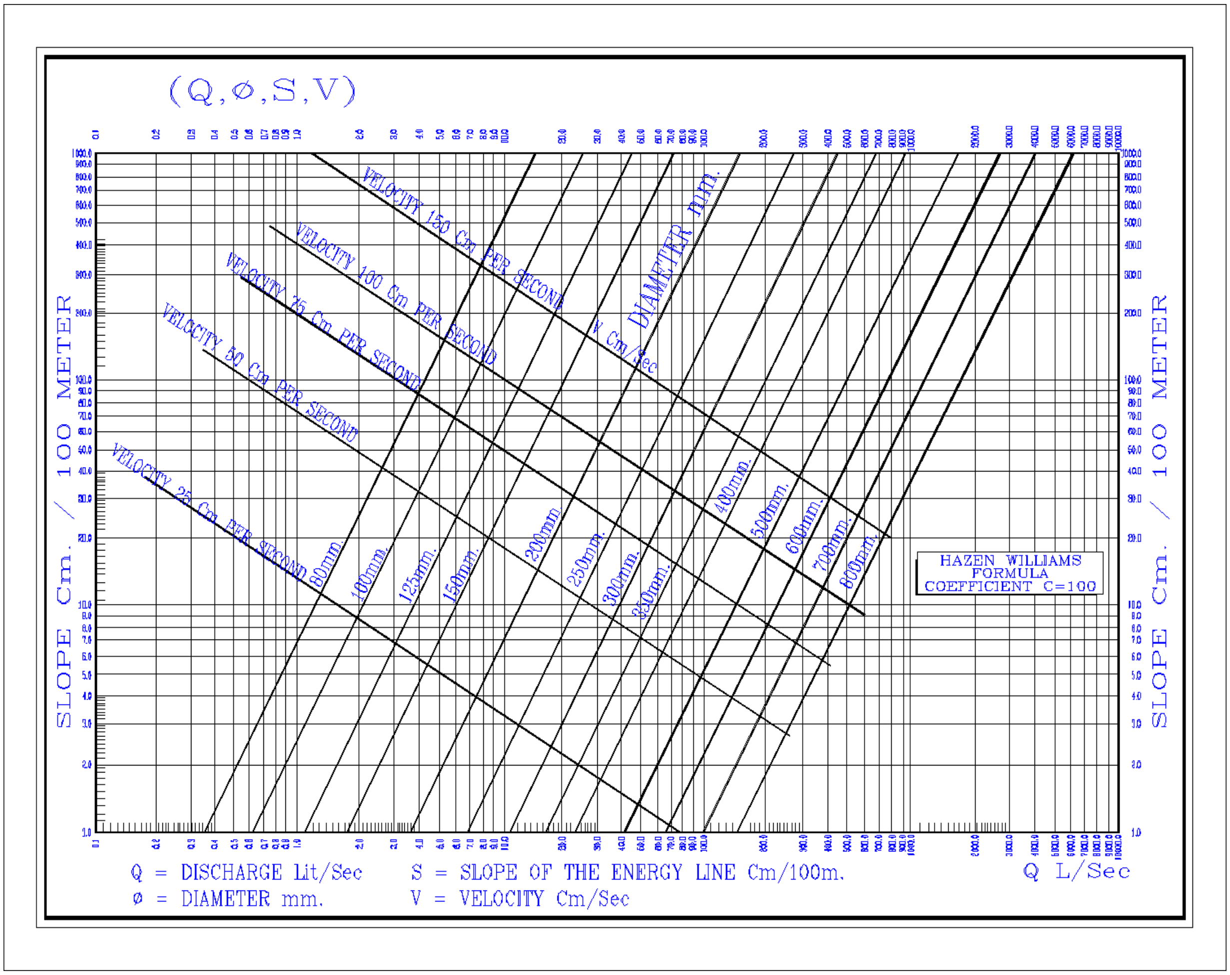
3- v = 0.355 x C x $R^{0.63}$ x $S^{0.54}$ Hazen William equation

$$R = \frac{A}{p} = \frac{d}{4}$$

$$Q = 0.278 \times C \times D^{2.63} \times S^{0.54}$$

Hazen William monograph





<u>Example 1:</u>

If a 400 mm water main (C =100) is discharging a flow of 150 lit/ sec, what is the velocity of flow and head loss?

<u>Solution:</u>

Q = 150 lit/ sec = 0.15 m^3/sec

D = 400 mm = 0.40 m

- Using (Hazen – Williams formula)

$$Q = 00.278\ C\ D^{2.63} S^{0.54}$$

$$S^{0.54} = \frac{0.15}{0.278 \times 100 \times (0.4)^{2.63}} = 0.060065$$

S = 0.00547 m/m = 5.47 m/1000m

- Using the Hazen Williams monograph

Q = 150 lit/sec & D = 400mm

We get V = 1.19

S = 5.45 m/ 1000 m

Example 2:

Design the main water supply pipe line for a city of population 30000 capita and average annual water consumption 200 l/c/d, consider required fire flow is 30 lit/sec.

Solution:

Q_{av} = pop x q_{av} / 24 x 60 x 60

= 30,000 x 200 / 24 x 60 x 60 = 69.44 l/s

$Q_{max\ daily}$ = 1.8 x Q_{av}

= 1.8 x 69.44 = 125 l/s

$Q_{max\ daily}$ + Q_f =125 +30 = 155 l/s

$Q_{max\ hourly}$ = 2.5 x Q_{av}

= 2.5 x 69.44 = 173.61 l/s

Q_d = 173.61 l/s

Assume S = 2 ‰ , Q_d = 173.61 l/s from Hazen Williams monograph

We get D = 520 mm ≈ 500 mm V = 0.83 m/sec

Example of pipes of different sizes connected in series

Find the equivalent pipe.

1- Assume Q = 100 l/s

2- For the pipe AB from the monograph (Q=100 l/s , ø= 350mm) get S =4.5 ‰

S = hf / L

4.5 /1000 = hf_{AB} /1000 Then hf_{AB} = 4.5 m

For the pipe BC from the monograph (Q=100 l/s , ø= 250mm) get S =24 ‰

S = hf / L

24 /1000 = hf_{BC} /800 Then hf_{AB} = 19.2 m

Total head loss h_T = hf_{AB} + hf_{BC}

h_T = 4.5+19.2 = 23.7 m

4- Assume ø = 300 mm

From the monograph

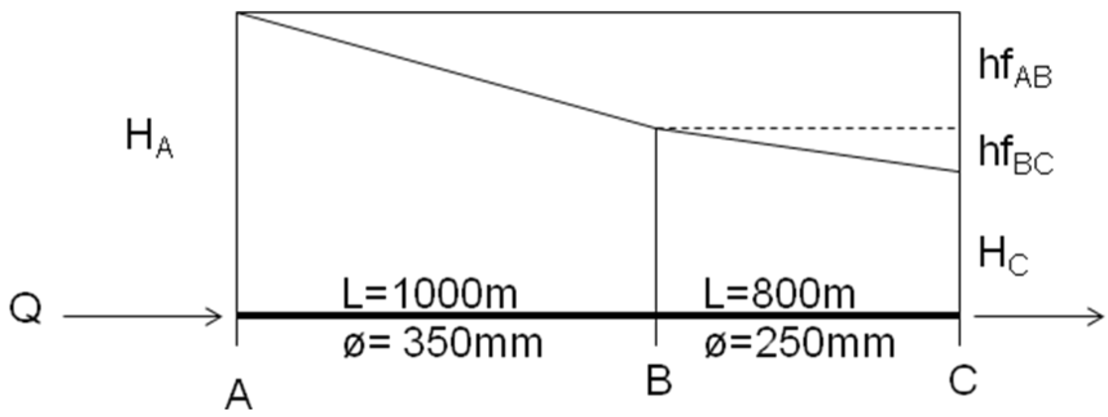
(Q=100 l/s , ø= 300mm)

get Se =9.5 ‰

Se /1000 = h_T / Le

Le = 23.7 x1000 / 9.5

= 2495.74 m



Example of pipes of different sizes connected in parallel

Find the equivalent pipe.

1- The head loss in the parallel pipes are equal assume hf = 10 m

$Q_T = Q_1 + Q_2$

2- For the track ABCD: hf1=10m , L1=1000m , Ø1 = 250 mm

S1 = hf1 / L1

S1 = 10 / 1000 = 10 ‰

From the monograph (S1= 10 ‰ , Ø1 = 250 mm) get Q1 = 65 l/s

For the track AFED: hf2=10m , L2=1000m , Ø1 = 300 mm

S2 = hf2 / L2

S2 = 10 / 1000 = 10 ‰

From the monograph (S2 =10 ‰ , Ø2 = 300 mm) get Q2 = 105 l/s

3- The discharge of the equivalent pipe

$Q_T = Q_1 + Q_2$

= 65 + 105 = 170 l/s

Assume Øe = 300 mm

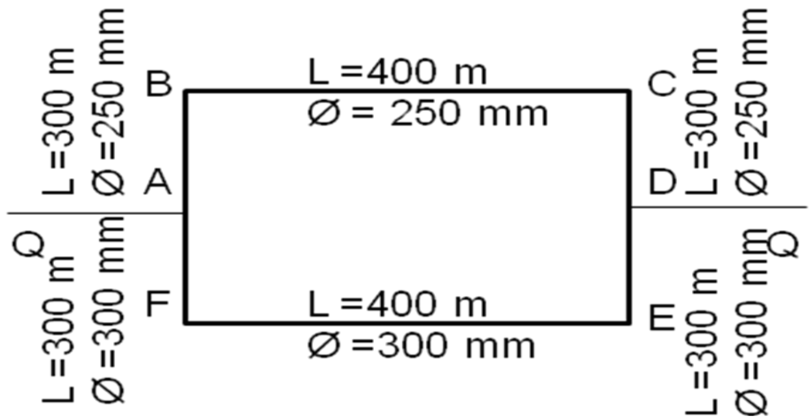
From the monograph (Q_T =170 l/s

, Øe = 300 mm) get Se = 26 ‰

Se = hf_T / Le

Le = 10x1000/26

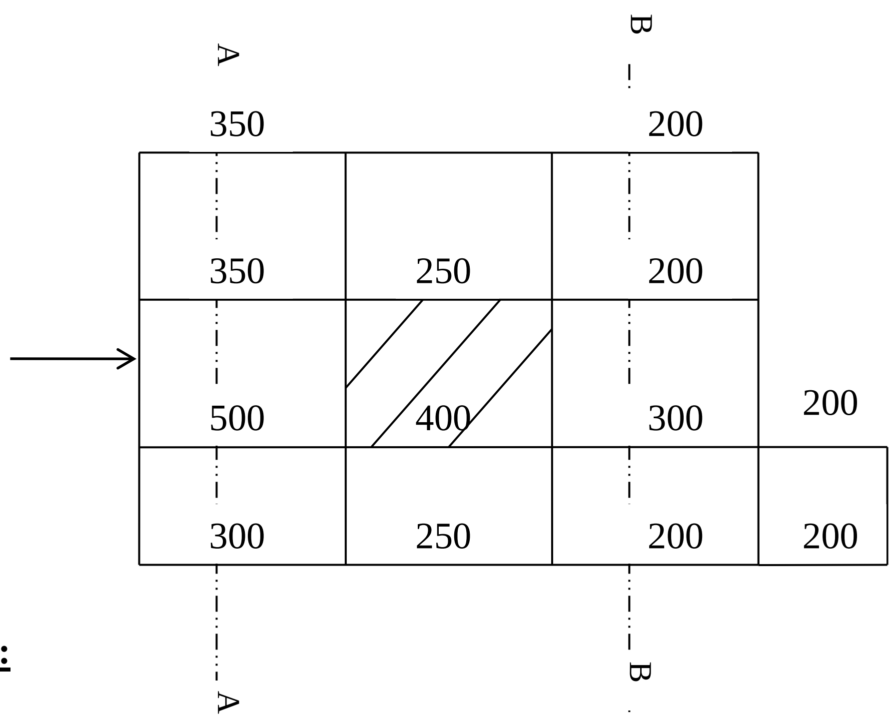
Le = 384.62 m



Method of sections

Example:

- The population served by Section A – A is 70 % of the population.
- The population served by Section B – B is 20 % of the population.
- Population = 100,000 capita.
- Average water consumption = 200 l/c/d.



Solution:

Section A – A:

Population = 0.7 x 100,000 = 70,000 capita

Qav = pop x qav / 24 x 60 x 60

= 70,000 x 200 / 24 x 60 x 60 = 162 l/s

Qmax daily = 1.8 x Qav

= 1.8 x 162 = 291.67 l/s

Qmax daily + Qf = 291.67 +40 = 331.67 l/s

Qmax hourly = 2.5 x Qav

= 2.5 x 162 = 405 l/s

Qd = 405 l/s

<u>Number of pipes cut by section A – A:</u>

2 ϕ 350 , 1 ϕ 500 , 1ϕ 300

Assume S = 20 cm / 100 m.

Qact = 2 x 85 + 210 + 55 = 435 l/s

<u>Chick:</u>

Qact – Qd / Qd x 100 = 435 – 405 / 405 x 100 = 7.4 %

$\pm$ 10 % ok

<u>Section B – B:</u>

Population = 0.2 x 100,000 = 20,000 capita

Qav = pop x qav / 24 x 60 x 60

= 20,000 x 200 / 24 x 60 x 60 = 46.3 l/s

Qmax daily = 1.8 x Qav

= 1.8 x 46.3 = 83.34 l/s

Qmax daily + Qf = 83.34 + 25 = 108.34 l/s

Qmax hourly = 2.5 x Qav

= 2.5 x 46.3 = 115.75 l/s

Qd = 115.75 l/s

<u>Number of pipes cut by section B – B:</u>

3 ϕ 200 , 1ϕ 300

Assume S = 20 cm / 100 m.

Qact = 3 x 18 + 55 = 109 l/s

<u>Chick:</u>

Qact – Qd / Qd x 100 = 109 – 115.75 / 115.75 x 100 = - 5.83 %

$\pm$ 10 % ok