Module 8: Hazen Williams Equation and Equivalent Pipes (CIVL 318)

Hazen-Williams Equations

$$Q = \frac{C\,D^{2.63}\left(\frac{h_L}{L}\right)^{0.54}}{279000}, \qquad h_L = L\left(\frac{279000\,Q}{C\,D^{2.63}}\right)^{1.852}, \qquad D = \left(\frac{279000\,Q}{C\left(\frac{h_L}{L}\right)^{0.54}}\right)^{0.3802}$$

Equivalent-Length Ratios for Fittings

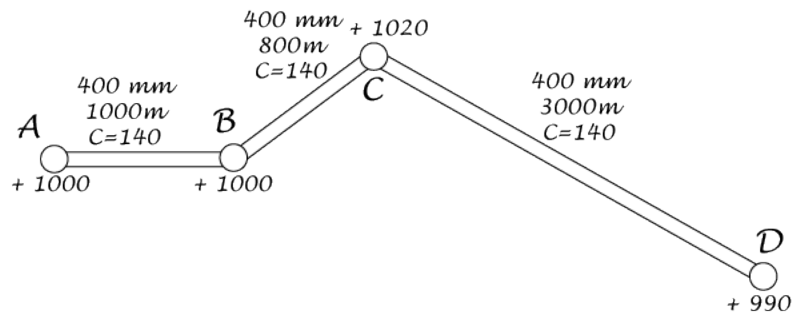
Type	L_e/D
Globe valve — fully open	340
Angle valve — fully open	150
Gate valve — fully open	8
— 3/4 open	35
— 1/2 open	160
— 1/4 open	900
Check valve — swing type	100
Check valve — ball type	150
Butterfly valve — fully open — 2-8"	45
— 10-14"	35
— 16-24"	25
Foot valve — poppet disc type	420
Foot valve — hinged disc type	75
90° standard elbow	30
90° long radius elbow	20
90° street elbow	50
45° standard elbow	16
45° street elbow	26
Close return bend	50
Standard tee — flow through run	20
Standard tee — flow through branch	60
Gradual enlargement — 15° cone angle	8
Gradual enlargement — 20° cone angle	15
Gradual enlargement — 30° cone angle	23
Gradual reduction — 15° to 40° cone angle	2
Pipe entrance — inward projecting	50
Pipe entrance — square	25
Pipe entrance — rounded	10
Venturi meter	100

Example 1

For the pipeline shown, calculate the pressure at B, given that the pressure at A is $700\,\text{kPa}$.

The pipes are cement-lined Hyprescon with a diameter of $400\,\text{mm}$ and a roughness coefficient of $C = 140$. Flow through the system is $200\,\text{L/s}$.

Elevations are as indicated.

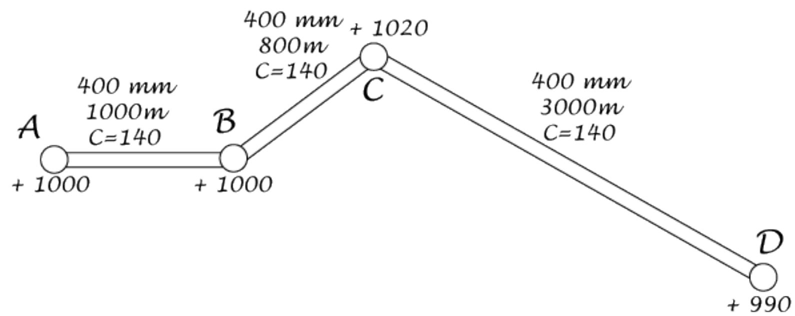


Exercise 1

For the pipeline shown, calculate the pressure at C and D, given that the pressure at A is 700 kPa.

The pipes are cement-lined Hyprescon with a diameter of 400 mm and a roughness coefficient of $C = 140$. Flow through the system is 200 L/s.

Elevations are as indicated.



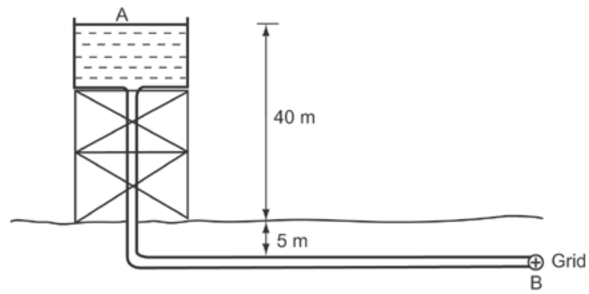
Example 2

Water flows from a storage tank through a welded steel pipe that is 1200 m long and 350 mm in diameter, entering a distribution grid at point 'B'. Assume C=100. Determine:

(1) The pressure at 'B' when the flow is 150 L/s

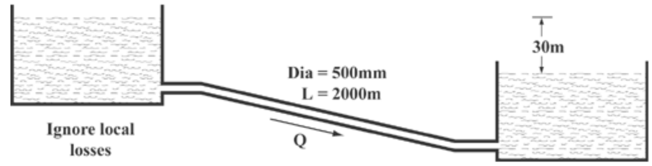
(2) The maximum flow rate into the grid when the minimum allowable pressure at 'B' is 400 kPa.

Minor losses are negligible compared to friction losses.



Exercise 2

Water flows from one reservoir down to another, through a 500 mm diameter pipe that is 2000 m in length. The difference in elevation between the surfaces of the two reservoirs is 30 m.



Determine:

(1) The flow with high density polyethylene pipe (HDPE) with $C = 140$

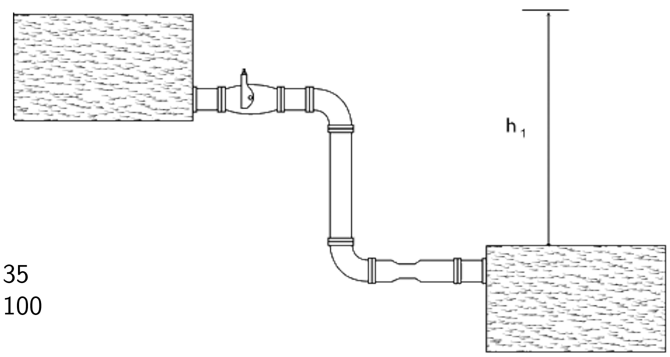
(2) The flow with welded steel with $C = 100$

(3) The diameter of HDPE pipe required for a flow of 1200 L/s

Disregard minor losses.

Example 3

In a water treatment plant, water flows from a filter down to a clear well through the pipe system shown. The pipe is welded steel with a diameter of $300\,\text{mm}$ and roughness coefficient $C = 130$. The total length of pipe is $50\,\text{m}$. Elevation difference h_1 between the tanks is 5 m.

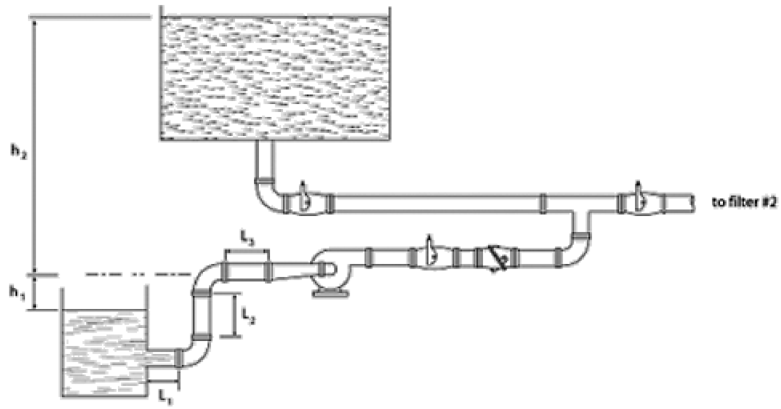


Equivalent length ratios, L_e/D, are:

Entrance and exit losses:	50	Butterfly valve:	35
Large radius elbows:	25	Venturi meter:	100

Determine the flow through the system.

Example 4



In a water treatment plant, backwash water is pumped from the clear well through the pipe system shown to the filter. The required backwash flow is $10\,\mathrm{L/s}$ per square meter of filter area (the filter dimensions are $10\,\mathrm{m}$ by $15\,\mathrm{m}$. The inlet pipe is made of welded steel $(C = 130)$, has a diameter of $1000\,\mathrm{mm}$ and a total length $(L_1 + L_2 + L_3)$ of $10\,\mathrm{m}$. The outlet pipe, from the pump to the filter, is also welded steel, has a diameter of $700\,\mathrm{mm}$ and a length of $70\,\mathrm{m}$.

The two elevation differences are $h_1 = 2\,\mathrm{m}$ and $h_2 = 10\,\mathrm{m}$.

Equivalent length ratios, L_e/D, are:

Entrance:	10	Elbow (inlet):	25
Eccentric Reducer:	2	Butterfly Valve:	40
Check Valve:	120	Elbow (outlet):	35
Tee Connection:	60		

Neglect exit losses into the filter.

Determine:

(1) The head losses on the inlet side (clear well to pump)

(2) The head losses on the outlet side (pump to filter)

Exercise 3

This exercise is a continuation of the previous example. Determine:

(3) The head added by the pump

(4) The pressure at the pump outlet

Example 5

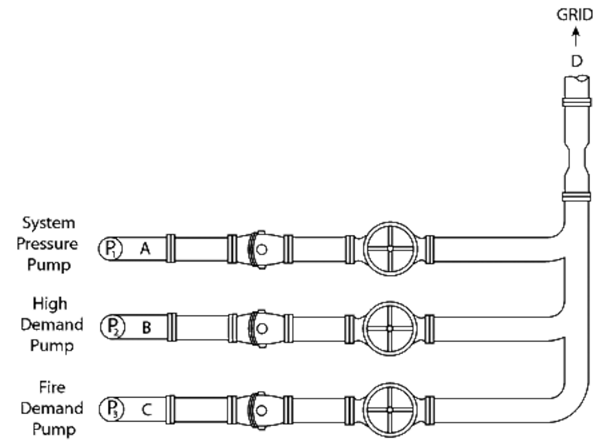
The pumps and piping system are used to supply a municipal grid. Pump P_1 runs continuously and maintains the basic pressure in the distribution grid beyond point D. There is no flow from pumps P_2 and P_3. (Pump P_2 is, in addition to P_1, used during periods of high demand and all pumps are used during fire flow demands.)

The elevations are the same at the pump and the discharge point D. The outlet pipe, from the pump to point D, is welded steel $(C = 130)$ with a diameter of 200 mm and a total length between fittings of 10 m.

The minimum pressure required at D is 500 kPa for a design flow of 150 L/s.

Equivalent length ratios, L_e/D, are:

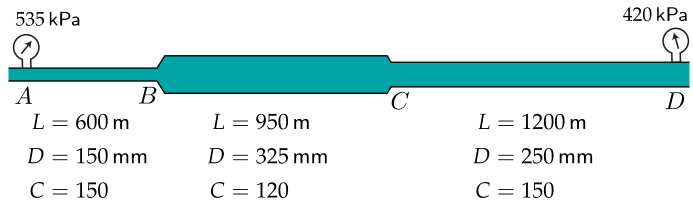
Check Valve:	120	Gate Valve:	15
Tee Connection:	60	Venturi Meter:	100



Determine:

(1) the head losses between A and D
(2) the pressure at A required for the required pressure and flow at D

Example 6



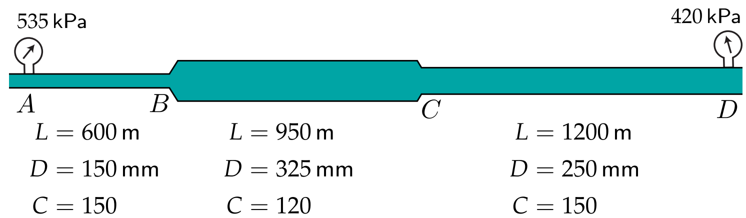
Determine Q, the volume flow rate from A to D, through the system shown. Ignore minor losses and assume that A and D are at the same elevation.

Example 7

a) Determine the diameter of a pipe with length $L = 1000\,\text{m}$ and resistance coefficient $C = 100$ that is equivalent to $785\,\text{m}$ of new Schedule 40 12-in steel pipe ($D = 303.2\,\text{mm}, C = 130$).

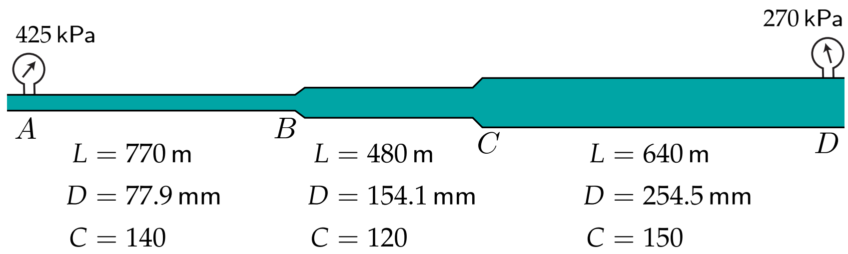
b) Verify that this equivalent pipe has the same headloss as the 12-in steel pipe for two arbitrary flows (choose a couple of flows at random, different from the flow used in part a).

Example 8



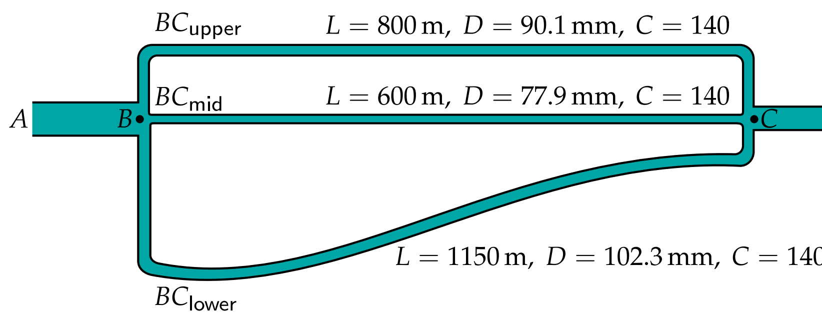
Use the equivalent pipe technique to determine Q, the volume flow rate from A to D, through the system shown. Ignore minor losses and assume that A and D are at the same elevation.

Exercise 4



Use the equivalent pipe technique to determine Q, the volume flow rate from A to D, through the system shown. Ignore minor losses and assume that A and D are at the same elevation.

Example 9

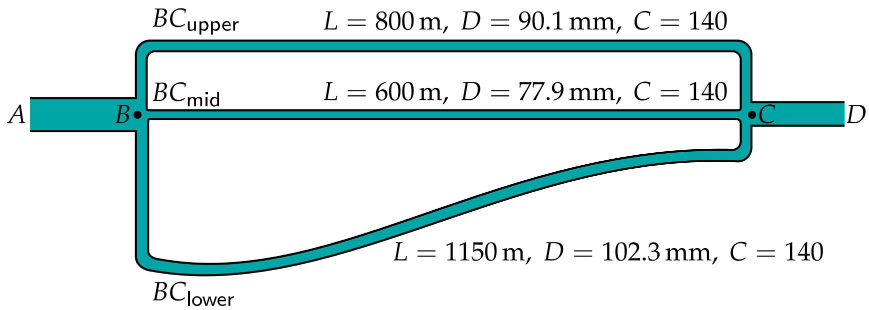


Given a flow of $18\,\text{L/s}$ and ignoring minor losses:

a) Determine the volume flow rate through each of the parallel pipes between B and C.

b) Determine the headloss due to friction between B and C.

Example 10: (Alternate - easier! - than previous method)

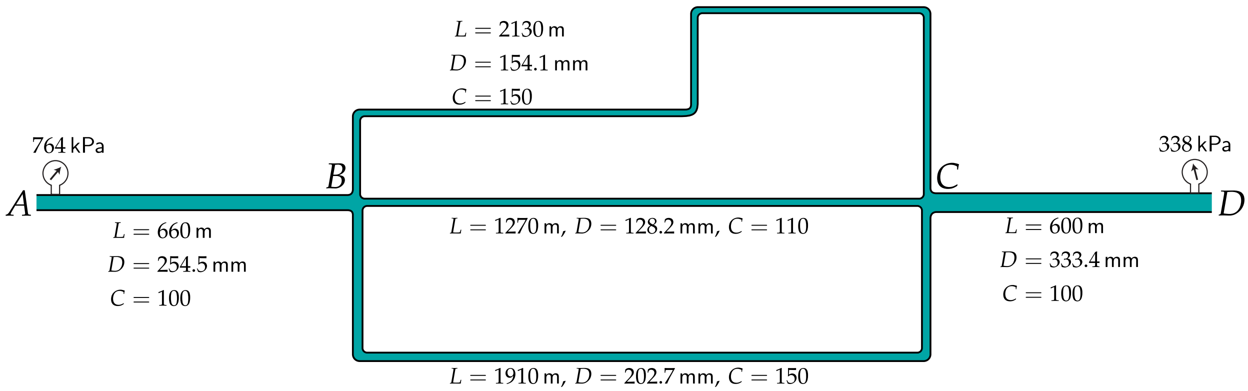


Given a flow of 18 L/s and ignoring minor losses:

a) Determine the percentage of the flow that goes through each parallel pipe by choosing a convenient headloss between B and C.

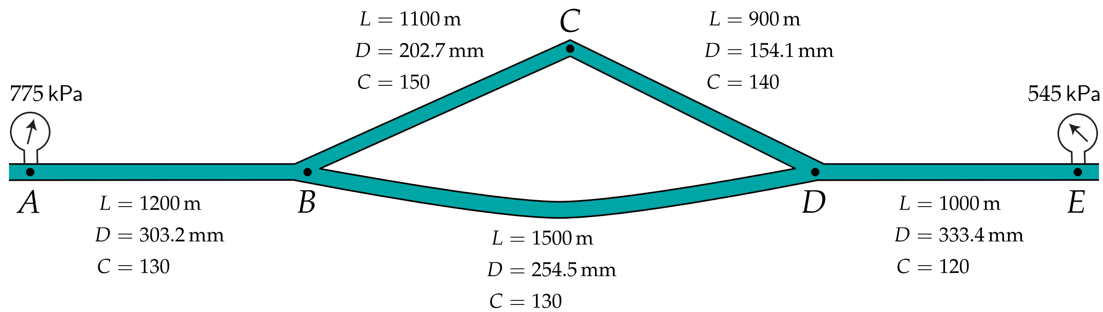
b) Determine the volume flow rate through each of the parallel pipes.

Example 11



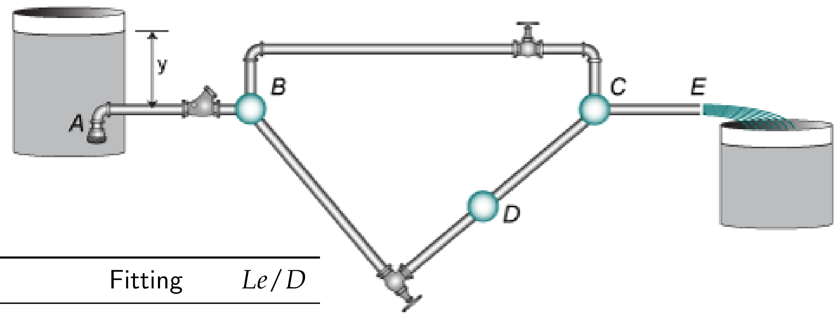
A, B, C and D are at the same elevation. Determine the flow through the system from A to D. (Ignore minor losses.)

Exercise 5



Determine Q. All pipes have the same elevation. Disregard minor losses.

Exercise 6



	Fitting	Le/D
	Angle Valve	150
	Check Valve	100
	Elbow	50
	Foot Valve	75
	Gate Valve	35

Pipe	Length (m)	diam (mm)	C
AB	10	500	125
BC	2000	275	150
BD	1500	250	100
DC	1000	300	100
CE	10	500	125

Given that $y = 6.7\,\text{m}$, determine the flow through the system.
(Nodes B and E are at the same elevation. Disregard exit losses.)