Water Supply and Sewerage Network

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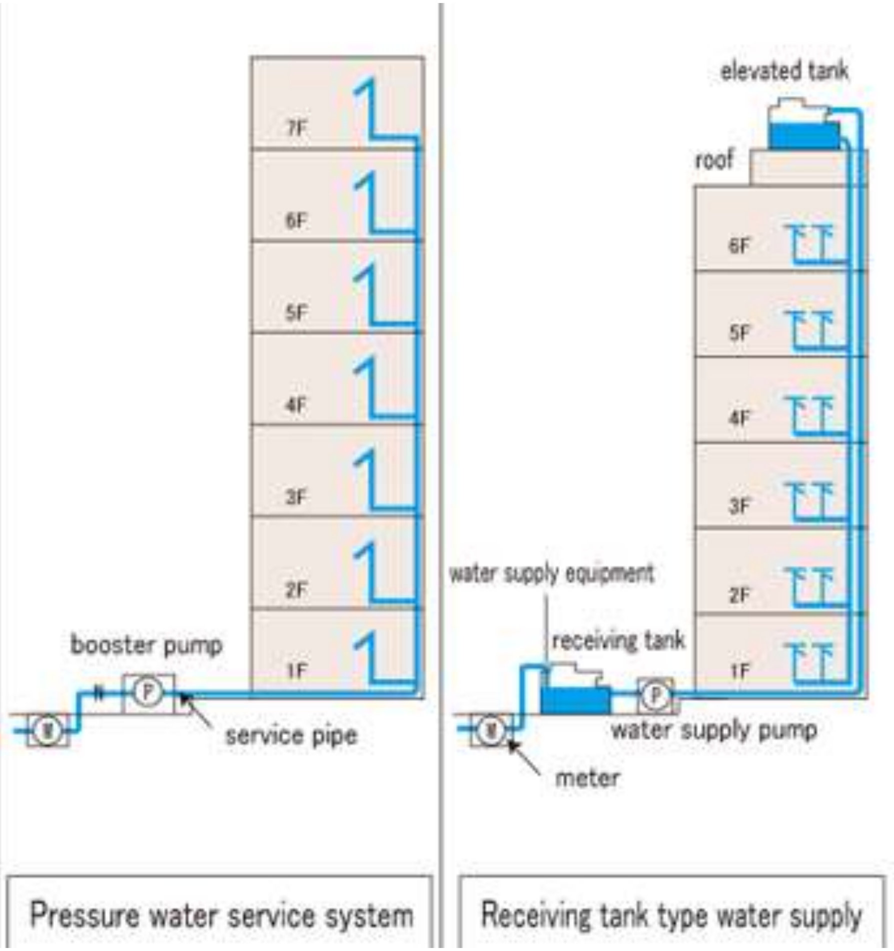
Water Distribution Systems in Buildings

The water pressure decreases with the water flow in the pipes due to the friction between the water and the internal walls of the pipes. Also, accessories such as valves and other parts in the water network affect pressure reduction. Therefore, the accessories are usually substituted as part of the length of the network at a rate ranging between (7-15)% of the length of the pipe to be designed.

When designing, the following points should be taken into account:

1. The amount of water pressure available in the network.
2. The required water pressure inside the building.
3. Levels and lengths of feeding branches for each floor.
4. The water tank height above the buildings on which the upper floors rely for supply.

The process of designing cold and hot water pipes in multi-story buildings can be done in two ways:



1. Hazen-Williams Method

$$\boxed{Q = 0.274\, C\, D^{2.63}\, S^{0.54}}$$

Q … m^3/sec $\qquad$ D … m

2. Slope Method (Hydraulic Gradient)

In this method, the slope of the hydraulic pressure line is calculated by dividing the loss in head pressure over the total length of the pipeline (after adding the equivalent length of the accessories to the pipeline).

$$\boxed{S = \frac{h_L}{L}}$$

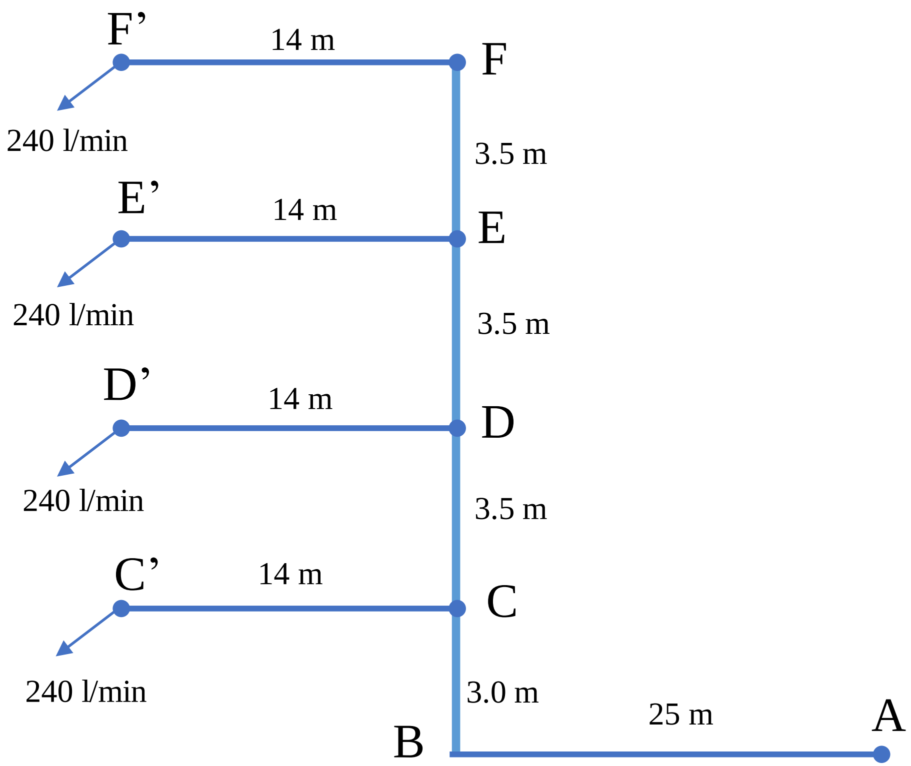
The hydraulic gradient line is the basis for calculating the pipe diameter required for each pipeline through the following relationship:

$$\boxed{D = 7.4515 \sqrt[5]{\frac{Q^2 * f}{S}}} \qquad Q \;\ldots l/min \qquad D \;\ldots\; mm$$

To find out the pressure at the branching points of the main feeder's pipe, the slope of the hydraulic pressure is calculated for each branch path from the main supply source to the farthest fixture in the floor separately. Then the lowest pressure (the minimum slope of the hydraulic pressure line) is used to determine the branches' pressure drop.

Example: For the four levels of the building shown in the figure, the average demand is 240 l/min for each level. Design the pipeline and find the diameter for each pipe if the required pressure head is 2 m in all units. The head pressure in the main source is 22m, and the friction factor is 0.027 for all pipes.

Solution



For the pipeline ABCC'

Length = (25+3+14)*1.1 = 46.2m

Head = (22-2-3) = 17 m

$$S = \frac{h_L}{L} = \frac{17}{46.2} = 0.368\ m/m$$

For the pipeline ABDD'

Length = (25+6.5+14)*1.1 = 50.05m

Head = (22-2-6.5) = 13.5 m

$$S = \frac{h_L}{L} = \frac{13.5}{50.05} = 0.269\ m/m$$

For the pipeline ABEE'

Length = (25+10+14)*1.1 = 53.9m

Head = (22-2-10) = 10 m

$$S = \frac{h_L}{L} = \frac{10}{53.9} = 0.185\ m/m$$

For the pipeline ABFF'

Length = (25+13.5+14)*1.1 = 57.75m

Head = (22-2-13.5) = 6.5 m

$$S = \frac{h_L}{L} = \frac{6.5}{57.75} = 0.113\ m/m$$

$Min\ S = 0.113\ m/m$

To find out the pressure at the branching points of the main feeder's pipe

$$\boxed{H = \left(Main\ Pressure\ - Pressure\ at\ Unit\ - Elevation\ - (S_{Min} * L)\right)}$$

$$H_C = \left(22 - 2 - 3\ - (0.113 * 28)\right) = 13.89\ \text{m}$$

$$H_D = \left(22 - 2 - 6.5\ - (0.113 * 31.5)\right) = 9.94\ \text{m}$$

$$H_E = \left(22 - 2 - 10\ - (0.113 * 35)\right) = 6.04\ \text{m}$$

$$H_F = \left(22 - 2 - 13.5\ - (0.113 * 38.5)\right) = 2.15\ \text{m}$$

To find out the hydraulic slope for each branch pipeline

$$S_{CC'} = \frac{H_C}{L_{CC'} * 1.1} = \frac{13.89}{14 * 1.1} = 0.89\ m/m$$

$$S_{DD'} = \frac{H_D}{L_{DD'} * 1.1} = \frac{9.94}{14 * 1.1} = 0.64\ m/m$$

$$S_{EE'} = \frac{H_E}{L_{EE'} * 1.1} = \frac{6.04}{14 * 1.1} = 0.4\ m/m$$

$$S_{FF'} = \frac{H_F}{L_{FF'} * 1.1} = \frac{13.89}{14 * 1.1} = 0.14\ m/m$$

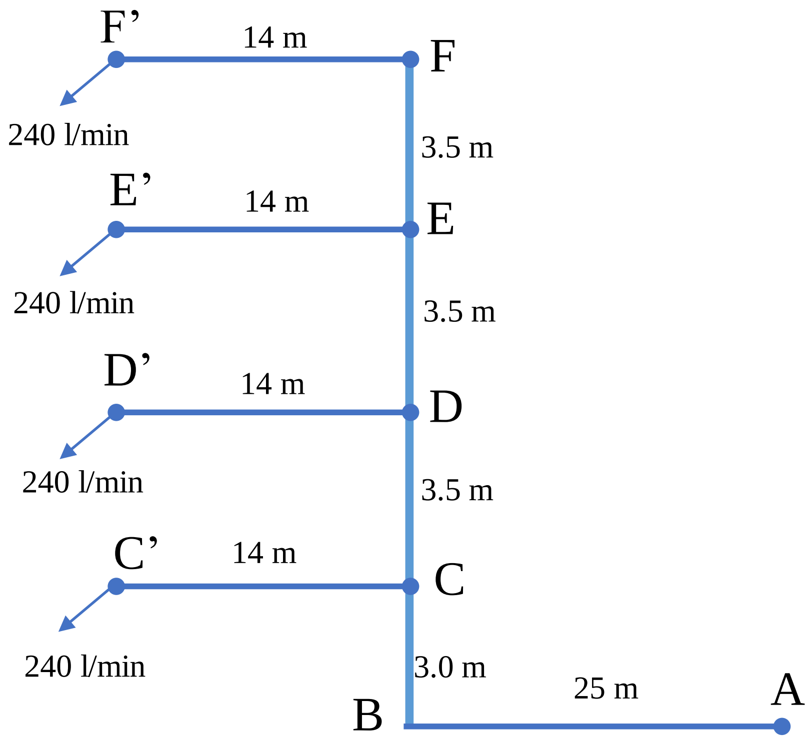
$$\boxed{Q = 8\sqrt{Q'}}$$

Final Table

$$\boxed{D = 7.4515 \sqrt[5]{\frac{Q^2 * f}{S}}}$$

$$f = 0.027$$

Line	*S (m/m)*	*Q′* *l/min*	$Q = 8\sqrt{Q'}$ *l/min*	*D (mm)*	*D used (mm)*
ABC	0.113	960	248	50.7	50
CD	0.113	720	214	47.8	50
DE	0.113	480	175	44.1	50
EF	0.113	240	124	38.4	38
CC’	0.89	240	124	25.4	25
DD’	0.64	240	124	27.2	25
EE’	0.4	240	124	29.8	32
FF’	0.14	240	124	36.8	38



Example: For the building shown in the figure, find the diameter for the pipeline from the 10th floor to the 6th floor. The required head in units is 2 m, and the average demand on each floor is 240 l/min.

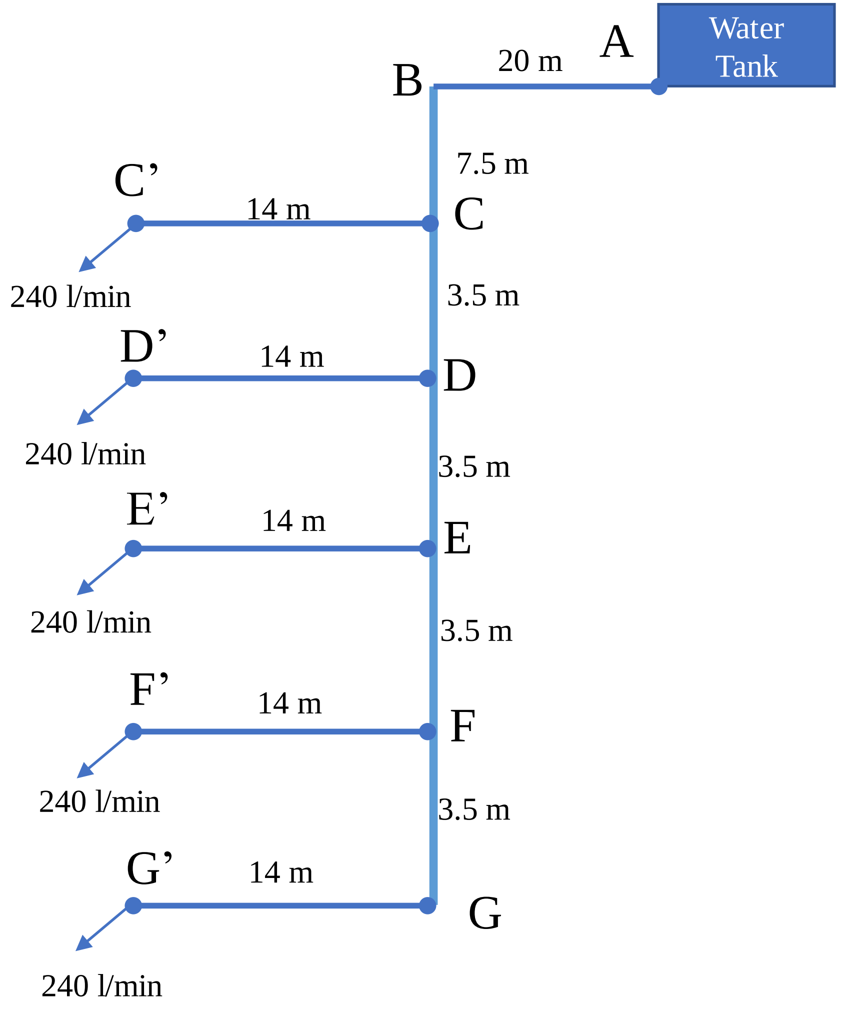
Solution

Find the (S) For the pipeline

$$\boxed{S = \frac{h_L}{L}}$$

Line	*Head in Line (m)*	*Head in Unit (m)*	*Losses in Head (m)*	*Length of pipeline + 10% (m)*	*S (m/m)*
ABCC’	7.5	2	5.5	45.65	0.12
ABDD’	11	2	9	49.5	0.18
ABEE’	14.5	2	12.5	53.35	0.23
ABFF’	18	2	16	57.2	0.28
ABGG’	21.5	2	19.5	61.05	0.32

$$Min\ S = 0.12 m/m$$



$$H = \left(Main\ Pressure\ - Pressure\ at\ Unit\ - (S_{Min} * L)\right)$$

$$H_C = \left(7.5 - 2 - (0.12 * 27.5)\right) = 2.2 \text{ m}$$

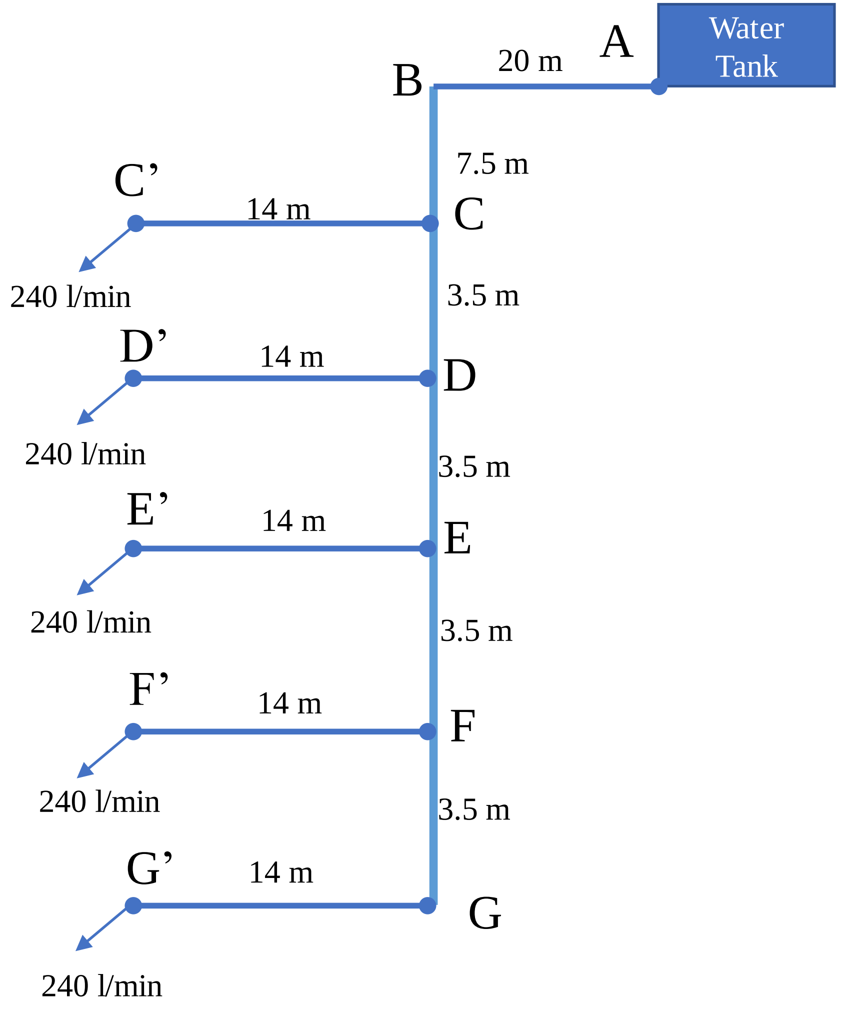
$$H_D = \left(11 - 2 - (0.12 * 31)\right) = 5.28 \text{ m}$$

$$H_E = \left(14.5 - 2 - (0.12 * 34.5)\right) = 8.36 \text{ m}$$

$$H_F = \left(18 - 2 - (0.12 * 38)\right) = 11.44 \text{ m}$$

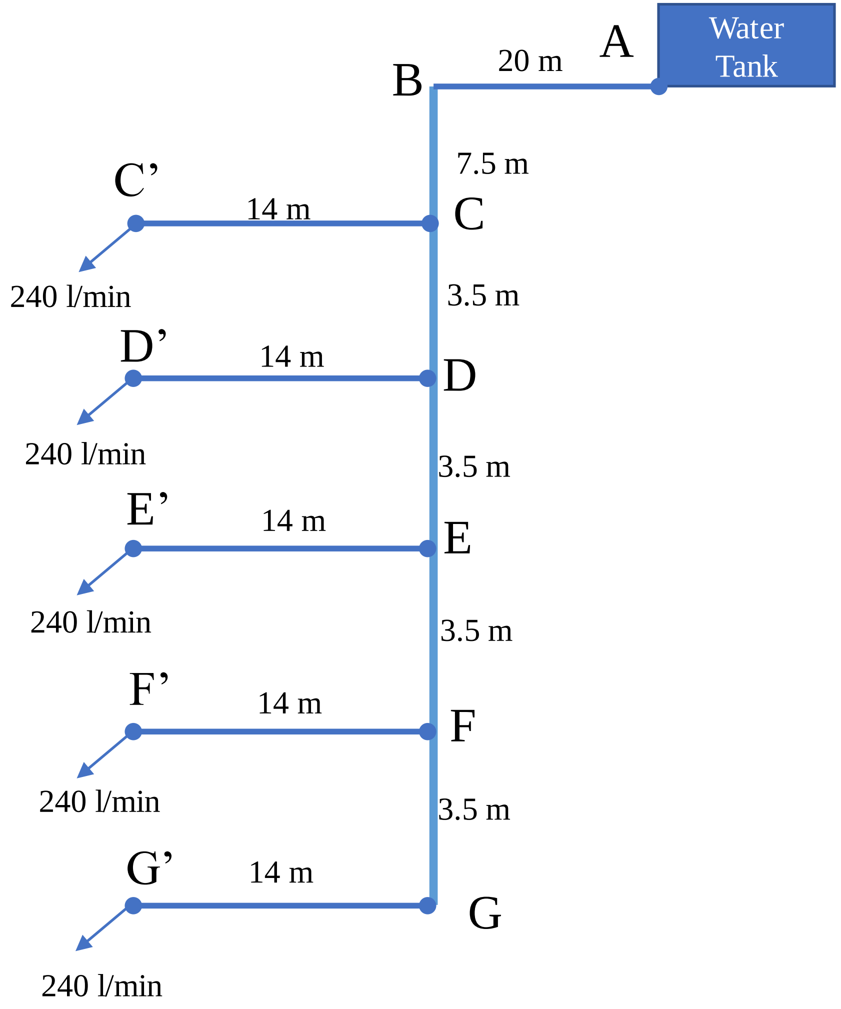
$$H_G = \left(21.5 - 2 - (0.12 * 41.5)\right) = 14.52 \text{ m}$$

Pipeline	*Available Head (m)*	*Length of pipeline + 10% (m)*	*S (m/m)*
CC’	2.2	15.4	0.14
DD’	5.28	15.4	0.34
EE’	8.36	15.4	0.54
FF’	11.44	15.4	0.74
GG’	14.52	15.4	0.94



Final Table

Line	*S (m/m)*	Q' l/min	$Q=8\sqrt{Q'}$ l/min	*D (mm)*	*D used (mm)*
ABC	0.12	1200	277	52.8	63
CD	0.12	960	248	50.5	50
DE	0.12	720	215	47.7	50
EF	0.12	420	175	44	50
FG	0.12	240	124	38.3	38
CC’	0.14	240	124	37	38
DD’	0.34	240	124	31	32
EE’	0.54	240	124	28.4	32
FF’	0.74	240	124	22.6	25
GG’	0.94	240	124	25.4	25



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