How to determine the total head

1. Formula for calculating the total head

(1) In case of receiving tank type

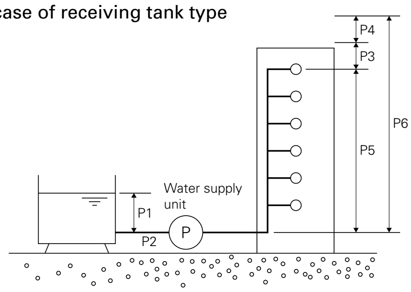


Fig. 1 Positive suction type

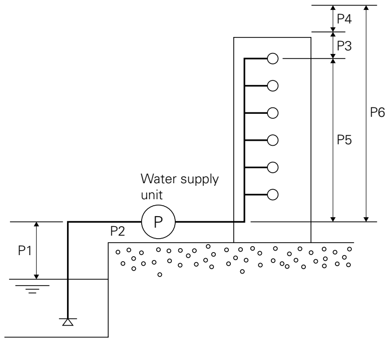


Fig. 2 Negative suction type

● Total head P6-(P1-P2) = P2 + P3 + P4 + P5-P1
P1 = positive suction (+)
negative suction (-)

P1: Height difference between water level of the receiving tank and water supply unit

P2: Pressure loss of the water supply pipe and water supply apparatus on the suction pipe side of the water supply unit

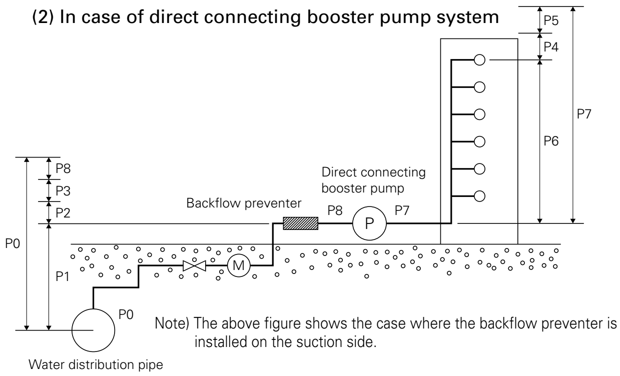
P3: Pressure loss of the water supply pipe and water supply apparatus on the discharge pipe side of the water supply unit

P4: Pressure required to use the water supply apparatus at the highest end

P5: Actual pump head (head difference between the water supply unit and the water supply apparatus at the highest end)

P6: Discharge pressure of the water supply unit P6=P3+P4+P5

(2) In case of direct connecting booster pump system



Note) The above figure shows the case where the backflow preventer is installed on the suction side.

Fig.3

● Total head *1 P7-P8 = (P1 + P2 + P3 + P4 + P5 + P6)-P0

P0: Water distribution pipe water pressure

P1: Height difference between the water distribution pipe and the direct connecting booster pump unit

P2: Head loss of the water supply pipe and water supply apparatus on the suction side of the direct connecting booster pump unit

P3: Head loss of the direct connecting booster pump unit (loss by backflow preventer)*2

P4: Head loss of water supply pipes and water supply apparatus on the discharge side of the direct connecting booster pump unit

P5: Pressure required to use the water supply apparatus at the highest end

P6: Height difference between the direct connecting booster pump unit and the water supply apparatus at the highest end

P7: Discharge pressure of the direct connecting booster pump unit

P8: Pump suction side effective pressure

NOTE) *1 The total pump head indicates what was pressurized by direct connecting booster pump unit.
*2 P3 is the sum of the loss by backflow preventer and loss in the unit. In our selection diagram, the performance is displayed after subtracting the loss in the unit, so only the loss by backflow preventer is shown.

2. Materials related to total pump head calculation

(1) Minimum required pressure for water supply equipment

Table 1 Minimum required pressure for instruments

Name of fixtures	Required pressure (when flowing) [kPa]
Generall faucet	30
Lavatory flushing valve *	70
Urinal faucet	30
Urinal flush valve	70
Shower	70
Instantaneous gas water heater	
No. 4-5	40
No. 7-16	50
No. 22-30	80

Note * Same for tankless lavatory

Cited Document: The Society of Heating, Air-Conditioning and Sanitary Engineers of Japan: Handbook of Heating, Air-Conditioning and Sanitary Engineering, 14th edition

(2) Pressure loss

Pressure loss includes pressure loss at the inlet and outlet of pipes, pressure loss due to pipe friction, pressure loss due to water meters and water supply apparatus, pressure loss due to bending, branching, and cross-sectional change of the pipe. Major items of these are friction pressure loss of pipes, pressure loss due to water meters and water supply apparatus, and others can be omitted in calculation because they have little effect.

● Determination of water supply pipe diameter

Determine the pipe diameter used to calculate the pressure loss. The diameter of the water supply pipe is determined based on the flow diagram (Fig.4 to Fig.7) according to the piping material used in accordance with the limits of the instantaneous maximum water supply and flow velocity. Generally, the flow rate should be kept below 2m/s because too high a flow rate can cause flow sound or water hammer.

● How to determine the pressure loss

Calculate the equivalent pipe length using "A. Pressure loss of joints and valves" and add the actual total straight pipe length to the sum of the values to obtain the total equivalent pipe length. Multiply this by the pressure loss per unit length of various piping according to "B. Pressure loss of piping (flow rate diagram (Fig.4 to Fig.7)" to get the total pressure loss.

Many types of joints and valves are used in the water supply system, and it is very complicated to calculate the pressure loss due to these joints and valves one by one. Therefore, the pressure loss due to joints and valves is calculated by replacing the pressure loss of straight pipes which corresponds to the pressure loss of straight pipes of the same diameter.

A. Pressure loss of joints and valves

Table 2 Equivalent pipe lengths of joints and valves (for steel pipes and stainless steel pipes)

Nominal diameter		Equivalent pipe length [m]							
A	Su	90° elbow	45° elbow	90°T tube (shunt)	90°T tube (Direct Current)	Gate valve*1	Ball valve*1	Angle valve, foot valve swing type check valve*2	Socket
13	13	0.30	0.18	0.45	0.09	0.06	2.27	2.4	0.09
20	20	0.38	0.23	0.61	0.12	0.08	3.03	3.6	0.12
25	25	0.45	0.30	0.76	0.14	0.09	3.79	4.5	0.14
32	40	0.61	0.36	0.91	0.18	0.12	5.45	5.4	0.18
40	50	0.76	0.45	1.06	0.24	0.15	6.97	6.8	0.24
50	60	1.06	0.61	1.52	0.30	0.21	8.48	8.4	0.30
65	75	1.21	0.76	1.82	0.39	0.24	10.00	10.2	0.39
80	80	1.52	0.91	2.27	0.45	0.30	12.12	12.0	0.45
100	100	2.12	1.21	3.18	0.61	0.42	19.09	16.5	0.61
120	125	2.73	1.52	3.94	0.76	0.52	21.21	21.0	0.76
150	150	3.03	1.82	4.55	0.91	0.61	25.45	21.0	0.91
200	200							33.0	
250	250							43.0	

NOTE For stainless steel pipes for general piping, this table is used because there is no specific data.
*1 Bronze castings
*2 50A or less: bronze casting, 65A or more: cast iron

Table 3 Equivalent pipe lengths of pipe joints and valves (rigid vinyl chloride lined steel pipe for water supply)

Nominal diameter	Equivalent pipe length [m]							
Nominal diameter [mm]	90° elbow	45° elbow	90°T (Branch flow)	90°T (Straight flow)	Gate valve	Ball valve	Angle valve	Check valve
15	3.0*1	2.3*1	3.8*1	1.2*1	3.5*2	4.5	2.4	5.5*2
20	3.1*1	2.2*1	3.8*1	1.6*1	2.3*2	6.0	3.6	2.7*2
25	3.2*1	1.8*1	3.3*1	1.2*1	1.7*2	7.5	4.5	2.9*2
32	3.6*1	2.3*1	4.0*1	1.4*1	1.3*2	10.5	5.4	3.2*2
40	3.3*1	1.9*1	3.6*1	0.9*1	1.7*2	13.5	6.6	2.6*2
50	3.3*1	1.9*1	3.5*1	0.9*1	1.9*2	16.5	8.4	3.7*2
65	4.4*1	2.4*1	4.4*1	1.1*1	0.48	19.5	10.2	4.6
80	4.6*1	2.4*1	4.9*1	1.3*1	0.63	24.0	12.0	5.7
100	4.7*1,4.2	2.7*1,2.4	6.6*1,6.3	1.5*1,1.2	0.81	37.5	16.5	7.6
125	5.1	3.0	7.5	1.5	0.99	42.0	21.0	10.0
150	6.0	3.6	9.0	1.8	1.20	49.5	24.0	12.0
200	6.5	3.7	14.0	4.0	1.40	70.0	33.0	15.0
250	8.0	4.2	20.0	5.0	1.70	90.0	43.0	19.0

Note 1) The foot valve is the same as the angle valve, and the check valve is the swing type.
2) Use the data for steel pipes for data without *2.
*1 Pipe end anti-corrosion type, according to the Japan Pipe Fittings Association data.
*2 Pipe end anti-corrosion type,, according to the data by K Company and Y Company.

B. Piping pressure loss

Calculate the pressure loss per unit length of various piping.

Hazen-Williams equations are commonly used in water supply facilities. In addition, the Weston equation is said to fit well with pipes of 50mm or less, and is applied in the case of the direct connection method of water supply. Calculate the pressure loss per unit length using the flow rate diagram (Fig. 4 to Fig. 7) for each type of piping based on the Hazen-Williams equation.

1) Hazen-Williams equation

$H = 10.666 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L$

$V = 0.35464 \cdot C \cdot D^{0.63} \cdot I^{0.54}$

$Q = 0.27853 \cdot C \cdot D^{2.63} \cdot I^{0.54}$

2) Weston's equation

$H = (0.0126+(0.01739\text{-}0.1087D)/V^{0.5})(L/D)(V^2/2g)$

H: Friction pressure loss (m) for length L (m)
C: Flow rate coefficient (see Table 10)
D: Pipe inner diameter (m)
Q: Flow rate (m^3/s)
L : Length of pipe (m)
V : Average flow velocity in tube (m/s)
I = H/L: hydraulic gradient
g : Gravitational acceleration (9. 8m/s)

Table 4 Flow coefficients of various pipes

Pipe type	C
New brass pipes, new copper pipes, new lead pipes, new cement lined cast iron pipes or steel pipes, new asbestos cement pipes	140
New steel pipes, new cast iron pipes, old brass pipes, old copper pipes, rigid polyvinyl chloride pipes	130
Old cement lining pipes, ceramic pipes	110
Old cast iron pipes, old steel pipes	100

Cited Document: The Society of Heating, Air-Conditioning and Sanitary Engineers of Japan: Handbook of Heating, Air-Conditioning and Sanitary Engineering, 14th edition

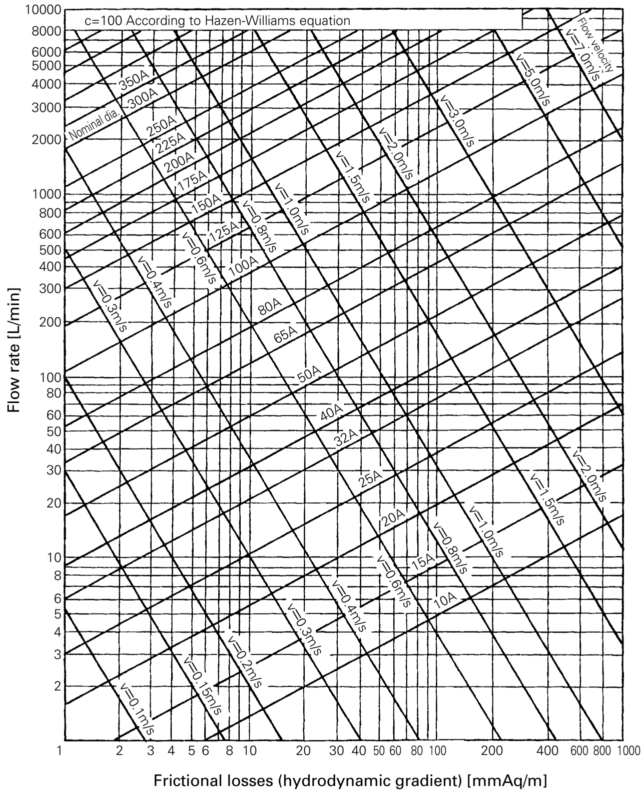


Fig. 4 Flow rate diagram of carbon-steel pipe (JIS G 3452) for pipes (HAS-S 206-1982)

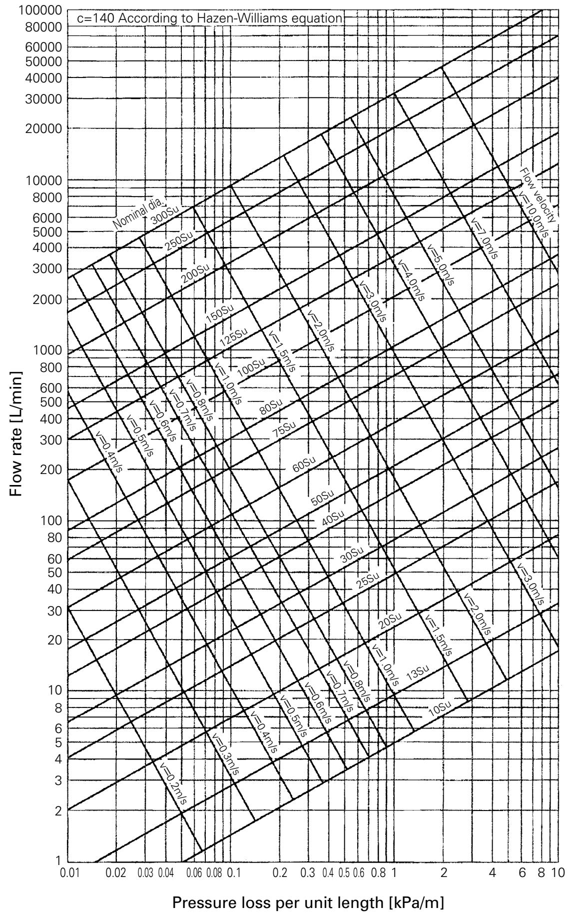


Fig. 5 Flow rate diagram of stainless-steel pipe for ordinary pipes (SHASE-S 206-2009)

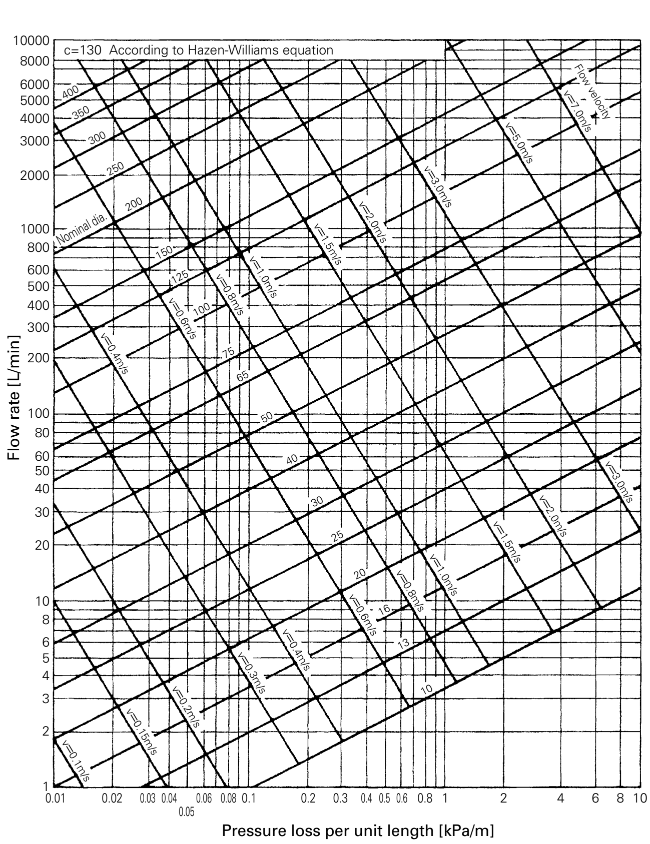


Fig. 6 Flow rate diagram of rigid vinyl chloride pipe (SHASE-S 206-2009)

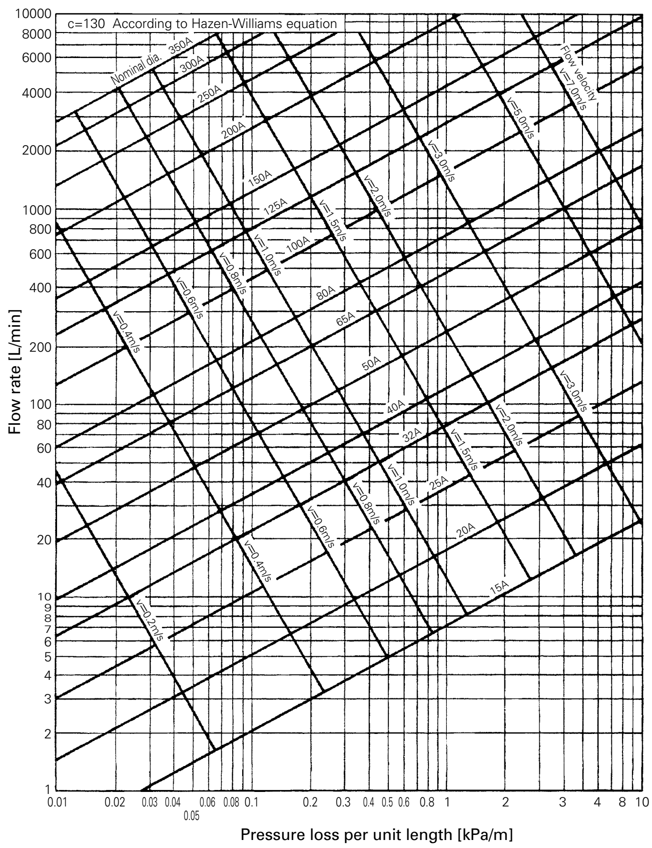


Fig. 7 Flow rate diagram of rigid vinyl chloride lined steel pipe (SHASE-S 206-2009)