Types of siphons

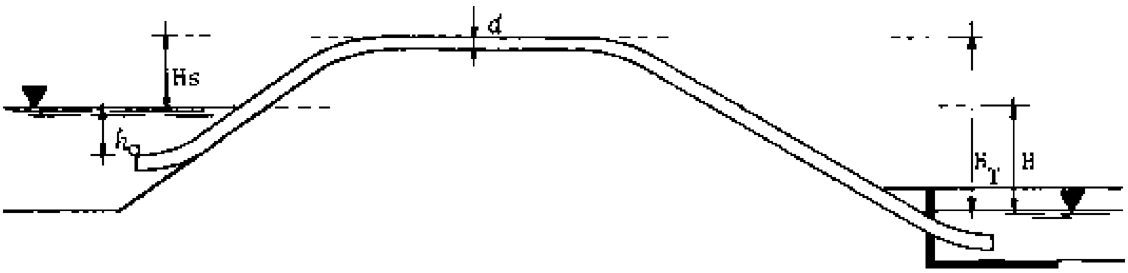
	Diameter (mm)	Length (m)	Discharge (m^3/sec)
a) Small, mobile	25 - 120	< 5	0.00025 - 0.015
b) Medium, movable	120 - 200	< 10	0.015 - 0.050
c) Large, stabile	200 - 1 200	< 100	0.050 - 3.10

Table 14 Recommended Minimum Velocities in Pipes for Siphons

Pipe diameter (mm)	Velocity (m/sec)
120	1.0
200	1.5
250	1.55
300	1.6
400	1.7
450	1.8
500	1.9
600	2.2
800	2.4
1 000	2.6
1 200	2.6

3.7.2 Discharge of siphon

Figure 16. Details of the siphon



Calculating formulas

$$Q = CA\sqrt{2g}H, \ m^3/sec \quad (3.33)$$

where

C = discharge coefficient
A = cross-sectional area of the pipe, m^2
H = head, m

The discharge coefficient C can be calculated by the formula

$$C = \frac{1}{\sqrt{1+\lambda\frac{1}{d}+\sum k}} \quad (3.34)$$

where

λ = friction factor = 0.02 (steel pipe)
1 = length of the siphon, m
d = diameter of the siphon, m
Σ k = all local loss coefficients along the siphon

Table 19 lists local loss coefficients for a variety of the fixtures.

The allowable pressure head for siphon

$$\frac{P}{\gamma} = 0.9\frac{P_0}{\gamma} - \frac{P_v}{\gamma} - 1.0,\ m \quad (3.35)$$

where

$\frac{P_0}{\gamma}$ = atmospheric pressure head at the location, m

Altitude in m	0	500	1 000	1 500	2 000	3 000
$\frac{P_0}{\gamma}$ in m	10.3	9.8	9.2	8.6	8.1	7.2

$\frac{P_v}{\gamma}$ = vapour pressure of the water

Water temperature °C	10	20	30
$\frac{P_v}{\gamma}$ in m	0.123	0.24	0.43

The allowable suction head of the siphon is:

$$H_s \le \frac{P}{\gamma} + \frac{v^2}{2g}\sum h_{l_s} \quad (3.36)$$

where

v = velocity in the pipe, m/sec

$$\sum h_{l_1} = \text{all the upstream head losses along the pipe, m}$$

The maximum allowable downstream head of the siphon is:

$$H_T \leq \frac{P}{\gamma} + \frac{v^2}{2g} \sum h_{l_2} \qquad (3.37)$$

where

$$\sum h_{l_2} = \text{all the downstream head losses along the pipe, m}$$

Depth of water above the entrance of the siphon

(a) Entrance with vertical axis

v		D	h	
(m/sec)		(m)	(m)	
1.5	0.1	- 0.3	2 D, but min.	0.3
1.5 - 2.5	0.3	- 0.8	1 D	0.7
> 2.5	>	1.0	1.7 D	2.0

(b) Entrance with horizontal axis

$$h_0 = 1.3\left[\frac{v^2}{2g} + \frac{v\left(1+\sqrt{k_e}\right)^2}{2g}\right] \qquad (3.38)$$

where

k_e = entrance loss coefficient

(c) Entrance with inclined axis

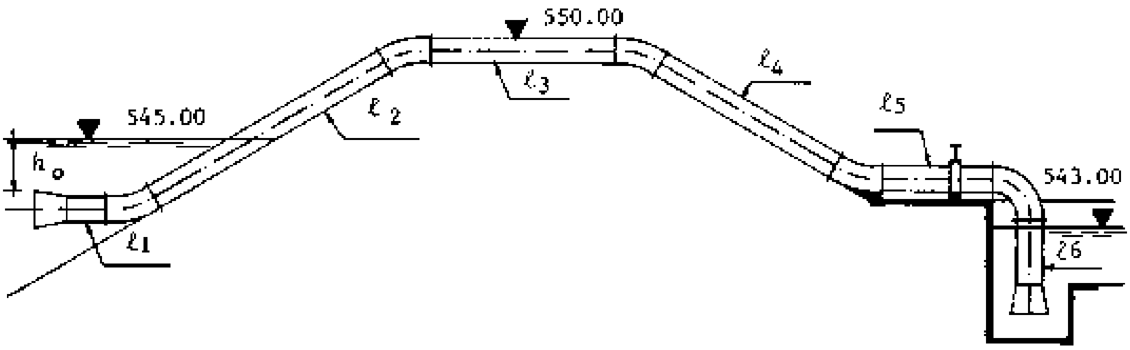
$$h_0 = 1.3\left[\frac{v^2}{2g} + \frac{v\left(1+\sqrt{k_e^2}\right)}{2}\right] + 2d\sin\alpha \qquad (3.39)$$

where α = angle of the tilt in degree

Example 7

Design the siphon shown in Figure 17 for a discharge of 350 l/sec if water temperature is 30°C.

Figure 17. Details of the siphon



Solution

3 Considering the designed discharge Q = 0.35 m^3/sec the siphon is a large one. The velocity is calculated by the following formula assuming that its diameter is 400 mm.

$$v = \frac{4Q}{d^2\pi} = \frac{4 \times 0.35}{0.40^2 \times 3.14} = 2.79\,\text{m/sec}$$

As this velocity is higher than the recommended minimum one in Table 14 hence, the selected diameter is satisfactory.

The next step is to determine the water depth above the entrance of the siphon by using Equation (3.38)

$$h_0 = 1.3\left[\frac{v^2}{2g} + \frac{v\left(1+\sqrt{k_e}\right)^2}{2g}\right]$$

v = 2.79 m k_e = 0.1

then

$$h_0 = 1.3\left[\frac{2.79^2}{19.62} + \frac{2.79 \times \left(1+\sqrt{0.1}\right)^2}{19.62}\right] = 1.08\text{m} \quad \text{say } 1.10\text{m}$$

The discharge coefficient of the siphon is defined from Equation (3.34)

$$C = \frac{1}{\sqrt{1 + \lambda\frac{1}{d} + \sum k}}$$

$\lambda = 0.02$
$l = l_1 + l_2 + l_3 + l_4 + l_5 + l_6 = 1.80 + 14.0 + 8.70 + 13.0 + 5.0 + 1.50 = 44$ m
$d = 0.40$ m

Computation of the local loss coefficient using Table 19

Diffusor inlet	0.1
Fraction bends (30°)	4×0.09 = 0.36
Fraction bends (90°)	0.34
Valve	0.07
Outlet diffusor	0.5
	Σ k = 1.37

Substitution of the above values into the equation gives:

$$C = \frac{1}{\sqrt{1 + 0.02\frac{44}{0.40} + 1.37}} = 0.47$$

The allowable suction head of the siphon is obtained if we use Equation (3.35)

$$\frac{P}{\gamma} = 0.9\frac{P_0}{\gamma} - \frac{P_v}{\gamma} - 1.0$$

where

$$\frac{P_0}{\gamma} = 9.75\,\mathrm{m}$$

$$\frac{P_v}{\gamma} = 0.43\,\mathrm{m}$$

then

$$\frac{P}{\gamma} = 0.9 \times 9.75 - 0.43 - 1.0 = 7.35\mathrm{m}$$

The suction head of the siphon is defined from Equation (3.36)

$$H_s = \frac{P}{\gamma} - \frac{v^2}{2g} \times \sum h_{l_i}$$

where

$$\frac{P}{\gamma} = 7.35\,\mathrm{m}$$

$$\sum h_{l_1} = \frac{v^2}{2g}\left(1 + k_e + 3k_{fb} + \lambda\frac{l_1 + l_2 + l_3}{d}\right) = \frac{2.79^2}{19.62}\left(1 + 0.1 + 3\times0.09 + 0.02\frac{1.8 + 14 + 8.70}{0.40}\right) = 1.03\,m$$

then

H_s = 7.35 - 1.03 = 6.32 m
H_{effs} = 550 - 545 - 5.0 m

The allowable downstream head of the siphon is determined from Equation (3.37)

$$H_T = \frac{P}{\gamma} + \frac{v^2}{2g}\sum h_{l_2}$$

where

$$\frac{P}{\gamma} = 7.35m$$

$$\sum h_{l_2} = \frac{v^2}{2g}\left(k_{fb} + k_v + k_0 + k_b + \lambda\frac{l_4 + l_5 + l_6}{d}\right) = \frac{2.79^2}{19.62}\left(0.09 + 0.07 + 0.34 + 0.5 + 0.02\frac{13 + 10 + 1.5}{0.40}\right) = 0.88m$$

then

H_T = 7.35 + 0.88 = 8.23 m
H_{effT} = 550 - 543 = 7.00 m

The design of the siphon is satisfactory because both H_{effs} and H_{effT} are below their allowable values.

The discharge of the siphon is defined by the formula (3.33)

$$Q = CA\sqrt{2gH}$$

where

C = 0.47
A = 0.126 m^2
H = 545 - 543 = 2.0 m

then

$$Q = 0.47\times0.126\sqrt{19.62\times2.0} = 0.37m^3/sec$$

This is acceptable, since the designed Q = 0.35 m^3/sec.