การออกแบบปั้มสูบน้ำผ่านสารกรอง

โดย

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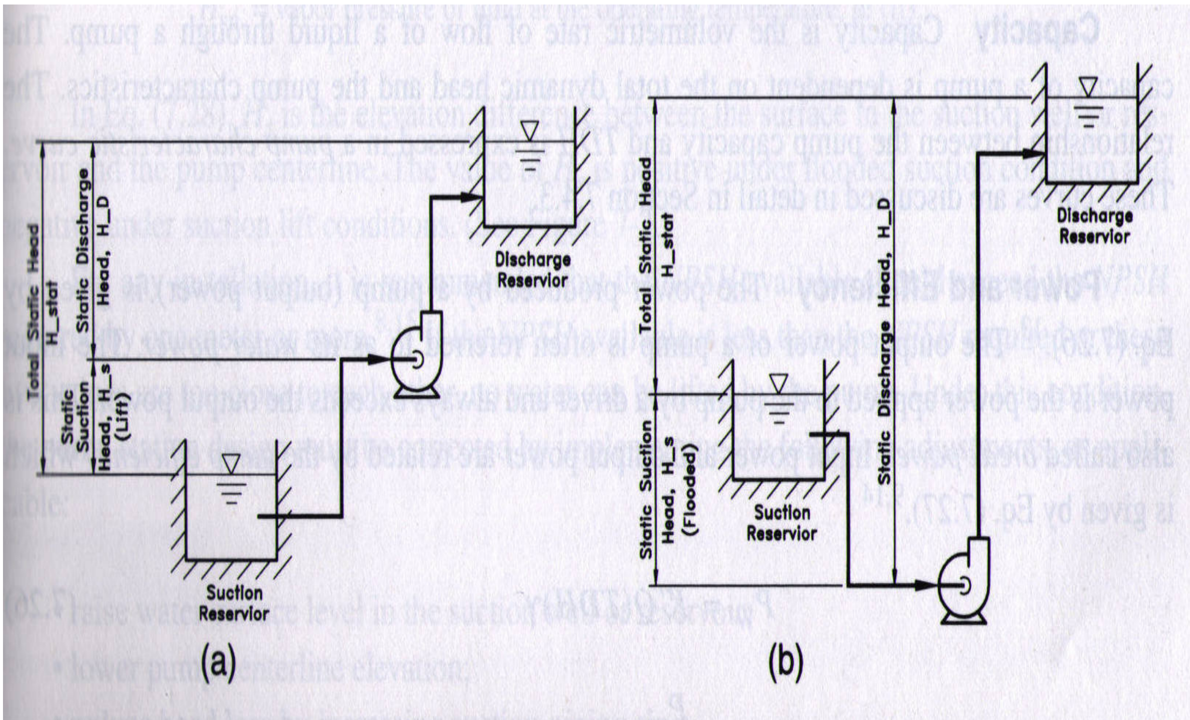
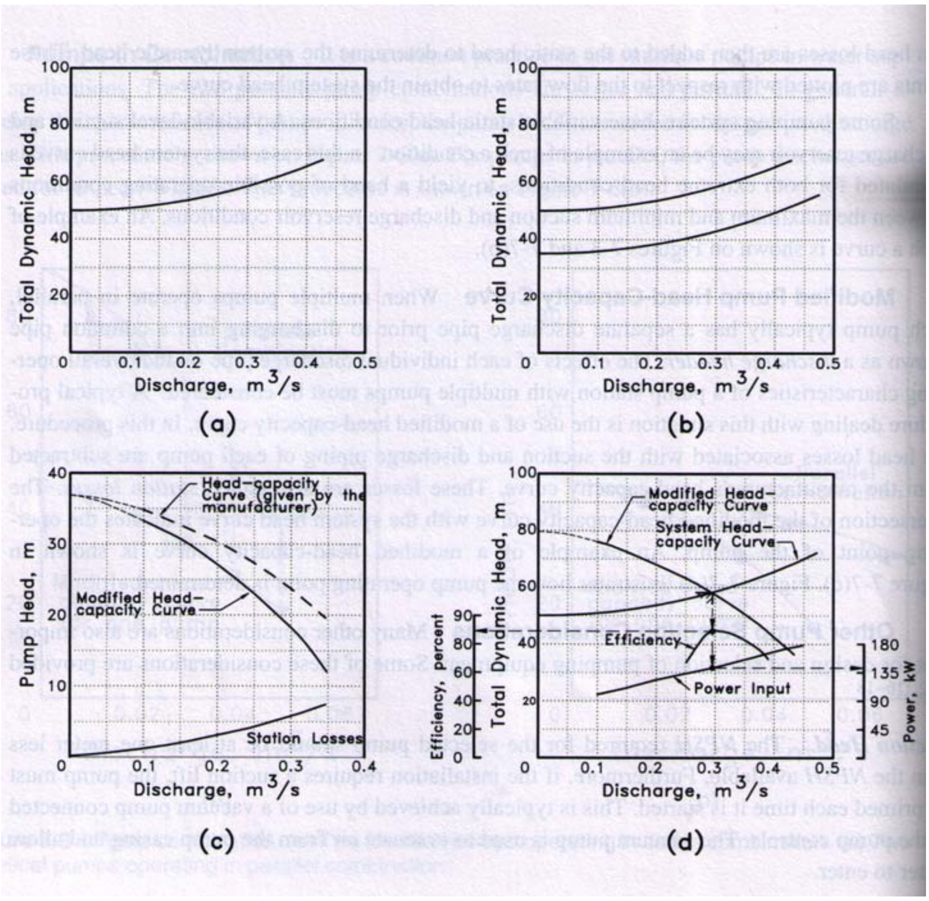


Figure 7-3 Definition sketches for determination of pump total static heads. (a) Lift suction head. (b) Flooded suction head.


Total Dynamic Head, m
Discharge, m³/s
(a)
(b)
Pump Head, m
Head-capacity Curve (given by the manufacturer)
Modified Head-capacity Curve
Station Losses
(c)
Modified Head-capacity Curve
System Head-capacity Curve
Efficiency
Power Input
Efficiency, percent
Power, kW
(d)

Calculate Head Loss in Suction Pipe

1.Flow rate	=	15	m^3/hr	
2. Static Suction Lift	=	2	m.	(pipe length)
3. Static Discharge Head	=	10	m.	(pipe length)
4. Suction Pipe Diameter	=	2	in	
	=	0.0508	m.	
5. Discharge Pipe Diameter	=	2	in	
	=	0.0508	m.	

$$Equation \quad Q = Av$$

$$A = \frac{\pi D^2}{4}$$

$$\therefore \quad v = \frac{Qx4}{\pi D^2}$$

$\therefore \quad v = 7400.72$ m/hr $= 2.055755$ m/sec

1. Calculate headloss in Suction Pipe

1.1 Minor losses due entrance

$$Equation \quad h_m = K\frac{v^2}{2g}$$

where

h_m = headloss inlet pipe (m)

v = water velocity in suction pipe (m/s)

g = Acceleration due to gravity 9.81 m/s^2

Entrance	K
Pipe Project into tank	0.83
End of pipe flushed with tank	0.5
Slightly rounded	0.23
Bell mouthed	0.04
Use	0.5

$\therefore \quad h_m = 0.1077$ m.

1.2 Minor Head losses in Pressure Conduits

$$h = k\frac{v^2}{2g}xnumber$$

Table 1 Minor Head losses in Pressure Conduits

Item	K factor	Number	Total Minor head loss
1. Gate Valve			
- Full open	0.19	1	0.040926
- One-fourth closed	1.15		0
- One - half closed	5.6		0
- Three - forths closed	24		0
- Typical value	1		0
2. Butterfly Valve			
- Full open	0.3		0
- 20^o	1.4		0
- Angle closed 40^o	10		0
- 60^o	94		0
- Typical value	1.2		0
3. Check valve			
- K = 1.5 - 2.5	1.5		0
4. Plug Valve	1		0
5. Elbow (45 -61 cm diameter)			
- 22.5^o (K = 0.1 - 0.2)	0.1		0
- 45^o (K = 0.2 - 0.3)	0.2		0
- 90^o (K = 0.25 - 0.6)	0.25		0
6. Tee			
- Run to run (K = 0.25 - 0.6)	0.25		0
- Branch to run(K= 0.6 - 1.8)	0.6		0
- Run to branch(K=0.6 - 1.8)	0.6		0

Table 1 Minor Head losses in Pressure Conduits (contrinues)

Item	K factor	Number	Total Minor head loss
7. Reduer (with angle of divergence 10^{o} - 20^{o}) K = 0.15 - 0.2	0.15		0
8. Increaser (with angle of divergence 10^{o} - 20^{o}) K = 0.05 - 0.3	0.05		0
		Total	0.040926

1.3 Friction losses in the pipe are typically calculated from Dracy-Weisbach

$$\text{Equation} \quad h_f = f \frac{L}{D} \frac{v^2}{2g}$$

where

h_f = total friction head loss in suction or discharge pipes,(m)

L = length of pipe,(m) (suction or discharge pipes)

D = diameter of the pipe,(m)

v = velocity in the pipe,(m/s)

f = coefficient of friction (Dracy - Weisbach) page 636(integrated design of water treatment facilities)

g = acceleration due to gravity, 9.81 m/s^2

Table 2 Approximate Minor Head Losses in Fittings and Valves (page 98, water and wastewater technology)

Fitting and Valve	Equivalent Length (Diameters of pipe)	Loss Coefficient k
1. Tee (run)	20	0.6
2. Tee (branch)	60	1.8
3.90° bend-		
Short radius	32	0.9
Medium radius	27	0.75
Long radius	20	0.6
4. 45° bend	15	0.42
5. Gate Valve (full open)	17	0.48
(open 1:4)	1000	
6. Swing check valve(open)	135	3.7
7. Butterfly valve (open)	40	1.2
8. Glove valve (open)	200	
9. Check valve(full open)	150	
10. Check valve with strainer	400	

Table 3 Approximate Minor Head Losses in Fittings and Valves in term Equavalent Pipe Length(L_e)

Fitting and Valve	Equivalent Length (Diameters of pipe)	Pieces	Diameter suction pipe (m.)	Equivalent Pipe(L_e) (m.)
1. Tee (run)	20		0.0508	0
2. Tee (branch)	60		0.0508	0
3.90° bend-				0
Short radius	32		0.0508	0
Medium radius	27		0.0508	0
Long radius	20		0.0508	0
4. 90° Standard	30	1	0.0508	1.524
4. 45° bend	15		0.0508	0
5. Gate Valve (full open)	17		0.0508	0
(open 1:4)	1000		0.0508	0
6. Swing check valve(open)	135		0.0508	0
7. Butterfly valve (open)	40	1	0.0508	2.032
8. Glove valve (open)	200		0.0508	0
9. Check valve(full open)	150		0.0508	0
10. Check valve with strainer	400		0.0508	0
			Total (L_e)	3.556

∴ Equivalent length in Suction pipe (L_{suc}) = suction pipe length + L_e

= 2 + 3.556

L_{suc} = 5.556

Table 4 Relation between surface conditions and friction coefficien

Condition	Friction Coefficient			
	n (Manning's)	C (Hazen's)	f (Darcy's)	Notes
Very smooth surface	0.01	140	0.0002	PVC Pipe clean cement lined pipe
Fair condition surface	0.013	120	0.0012	Unlined pipe
Rough surface	0.016	100	0.0025	Rusted pipe

Pipe Material : PVC ∴ f = 0.0002

Theory

$$Equation \quad h_f = f \frac{L}{D}\frac{v^2}{2g}$$

∴ h_f = 0.004712 m.

∴ Total Head Loss in Suction Pipe : h_m + Mior head losses in Pressure Conduits + h_f

Total Head Loss in Suction Pipe : 0.153337

Calculate Head Loss in Discharge Pipe

1.Flow rate	=	15	m^3/hr	=	0.004167	m^3/s
2. Static Suction Lift	=	2	m.	(pipe length)		
3. Static Discharge Head	=	10	m.	(pipe length)		
4. Suction Pipe Diameter	=	2	in			
	=	0.0508	m.			
5. Discharge Pipe Diameter	=	2	in			
	=	0.0508	m.			

$$Equation \quad Q = Av$$

$$A = \frac{\pi D^2}{4}$$

$$\therefore \quad v = \frac{Qx4}{\pi D^2}$$

$\therefore$ v = 7400.72 m/hr = 2.055755 m/sec

2. Calculate headloss in Discharge Pipe

2.1 Minor losses due exit

Exit	K
conduit to still water	1

$$Equation \quad h_m = K\frac{v^2}{2g}$$

where

h_m = headloss inlet pipe (m)

v = water velocity in discharge pipe (m/s)

g = Acceleration due to gravity 9.81 m/s^2

$\therefore$ h_m = 0.215399 m.

2.2 Minor Head losses in Pressure Conduits

$$h = k\frac{v^2}{2g}xnumber$$

Table 5 Minor Head losses in Pressure Conduits

Item	K factor	Number	Total Minor head loss
1. Gate Valve			
- Full open	0.19	1	0.040926
- One-fourth closed	1.15		0
- One - half closed	5.6		0
- Three - forths closed	24		0
- Typical value	1		0
2. Butterfly Valve			
- Full open	0.3		0
- 20^o	1.4		0
- Angle closed 40^o	10		0
- 60^o	94		0
- Typical value	1.2		0
3. Check valve			
- K = 1.5 - 2.5	1.5		0
4. Plug Valve	1		0
5. Elbow (45 -61 cm diameter)			
- 22.5^o (K = 0.1 - 0.2)	0.1		0
- 45^o (K = 0.2 - 0.3)	0.2		0
- 90^o (K = 0.25 - 0.6)	0.25		0
6. Tee			
- Run to run (K = 0.25 - 0.6)	0.25		0
- Branch to run(K= 0.6 - 1.8)	0.6		0
- Run to branch(K=0.6 - 1.8)	0.6		0

Table 5 Minor Head losses in Pressure Conduits (contrinues)

Item	K factor	Number	Total Minor head loss
7. Reduer (with angle of divergence 10^{o} - 20^{o}) K = 0.15 - 0.2	0.15		0
8. Increaser (with angle of divergence 10^{o} - 20^{o}) K = 0.05 - 0.3	0.05		0
		Total	0.040926

2.3 Friction losses in the pipe are typically calculated from Dracy-Weisbach

$$Equation \quad h_f = f \frac{L}{D} \frac{v^2}{2g}$$

where

h_f = total friction head loss in suction or discharge pipes,(m)

L = length of pipe,(m) (suction or discharge pipes)

D = diameter of the pipe,(m)

v = velocity in the pipe,(m/s)

f = coefficient of friction (Dracy - Weisbach) page 636(integrated design of water treatment facilities)

g = acceleration due to gravity, 9.81 m/s^2

Table 6 Approximate Minor Head Losses in Fittings and Valves (page 98, water and wastewater technology)

Fitting and Valve	Equivalent Length (Diameters of pipe)	Loss Coefficient k
1. Tee (run)	20	0.6
2. Tee (branch)	60	1.8
3.90^{o} bend-		
Short radius	32	0.9
Medium radius	27	0.75
Long radius	20	0.6
4. 45^{o} bend	15	0.42
5. Gate Valve (full open)	17	0.48
(open 1:4)	1000	
6. Swing check valve(open)	135	3.7
7. Butterfly valve (open)	40	1.2
8. Glove valve (open)	200	
9. Check valve(full open)	150	
10. Check valve with strainer	400	

Table 7 Approximate Minor Head Losses in Fittings and Valves in term Equavalent Pipe Length(L_e)

Fitting and Valve	Equivalent Length (Diameters of pipe)	Pieces	Diameter suction pipe (m.)	Equivalent Pipe(L_e) (m.)
1. Tee (run)	20		0.0508	0
2. Tee (branch)	60		0.0508	0
3.90^o bend-				0
Short radius	32		0.0508	0
Medium radius	27		0.0508	0
Long radius	20		0.0508	0
4. 90^o Standard	30	1	0.0508	1.524
4. 45^o bend	15		0.0508	0
5. Gate Valve (full open)	17		0.0508	0
(open 1:4)	1000		0.0508	0
6. Swing check valve(open)	135		0.0508	0
7. Butterfly valve (open)	40	1	0.0508	2.032
8. Glove valve (open)	200		0.0508	0
9. Check valve(full open)	150		0.0508	0
10. Check valve with strainer	400		0.0508	0
			Total (L_e)	3.556

∴ Equivalent length in Suction pipe (L_{suc}) = suction pipe length + L_e

= 2 + 3.556

L_{suc} = 5.556

Table 8 Relation between surface conditions and friction coefficien

ออกแบบปั้มสูบน้ำ(ผ่านสารกรอง2)head loss in discharge pipe

Condition	Friction Coefficient			
	n (Manning's)	C (Hazen's)	f (Darcy's)	Notes
Very smooth surface	0.01	140	0.0002	PVC Pipe clean cement lined pipe
Fair condition surface	0.013	120	0.0012	Unlined pipe
Rough surface	0.016	100	0.0025	Rusted pipe

Pipe Material : PVC ∴ f = 0.0002

Theory

$$Equation \quad h_f = f \frac{L}{D} \frac{v^2}{2g}$$

∴ h_f = 0.004712 m.

∴ Total Head Loss in Discharge Pipe = h_m + Mior head losses in Pressure Conduits + h_f

Total Head Loss in Discharge Pipe = 0.2610366

Calculate Head Loss in Influent Pipe

1.Flow rate	=	15	m^3/hr	=	0.004167	m^3/s
2. Static Suction Lift	=	2	m.	(pipe length)		
3. Static Discharge Head	=	10	m.	(pipe length)		
4. Suction Pipe Diameter	=	2	in			
	=	0.0508	m.			
5. Discharge Pipe Diameter	=	2	in			
	=	0.0508	m.			

$$Equation \quad Q = Av$$

$$A = \frac{\pi D^2}{4}$$

$$\therefore \quad v = \frac{Qx4}{\pi D^2}$$

$\therefore$ v = 7400.72 m/hr = 2.055755 m/sec

3. Calculate headloss in Inlet Pipe

3.1 Minor losses due entrance

Entrance	K
conduit to still water	0.5

$$Equation \quad h_m = K\frac{v^2}{2g}$$

where

h_m = headloss inlet pipe (m)

v = water velocity in entrance pipe (m/s)

g = Acceleration due to gravity 9.81 m/s^2

$\therefore$ h_m = 0.1077 m.

3.2 Minor Head losses in Pressure Conduits

$$h = k\frac{v^2}{2g}xnumber$$

Table 9 Minor Head losses in Pressure Conduits

Item	K factor	Number	Total Minor head loss
1. Gate Valve			
- Full open	0.19	1	0.040926
- One-fourth closed	1.15		0
- One - half closed	5.6		0
- Three - forths closed	24		0
- Typical value	1		0
2. Butterfly Valve			
- Full open	0.3		0
- 20^{o}	1.4		0
- Angle closed 40^{o}	10		0
- 60^{o}	94		0
- Typical value	1.2		0
3. Check valve			
- K = 1.5 - 2.5	1.5		0
4. Plug Valve	1		0
5. Elbow (45 -61 cm diameter)			
- 22.5^{o} (K = 0.1 - 0.2)	0.1		0
- 45^{o} (K = 0.2 - 0.3)	0.2		0
- 90^{o} (K = 0.25 - 0.6)	0.25		0
6. Tee			
- Run to run (K = 0.25 - 0.6)	0.25		0
- Branch to run(K= 0.6 - 1.8)	0.6		0
- Run to branch(K=0.6 - 1.8)	0.6		0

Table 9 Minor Head losses in Pressure Conduits (contrinues)

Item	K factor	Number	Total Minor head loss
7. Reduer (with angle of divergence 10^{o}- 20^{o}) K = 0.15 - 0.2	0.15		0
8. Increaser (with angle of divergence 10^{o}- 20^{o}) K = 0.05 - 0.3	0.05		0
		Total	0.040926

3.3 Friction losses in the pipe are typically calculated from Dracy-Weisbach

$$Equation \quad h_f = f \frac{L}{D} \frac{v^2}{2g}$$

where

h_f = total friction head loss in suction or discharge pipes,(m)

L = length of pipe,(m) (suction or discharge pipes)

D = diameter of the pipe,(m)

v = velocity in the pipe,(m/s)

f = coefficient of friction (Dracy - Weisbach) page 636(integrated design of water treatment facilities)

g = acceleration due to gravity, 9.81 m/s^2

Table 10 Approximate Minor Head Losses in Fittings and Valves (page 98, water and wastewater technology)

Fitting and Valve	Equivalent Length (Diameters of pipe)	Loss Coefficient k
1. Tee (run)	20	0.6
2. Tee (branch)	60	1.8
3.90° bend-		
Short radius	32	0.9
Medium radius	27	0.75
Long radius	20	0.6
4. 45° bend	15	0.42
5. Gate Valve (full open)	17	0.48
(open 1:4)	1000	
6. Swing check valve(open)	135	3.7
7. Butterfly valve (open)	40	1.2
8. Glove valve (open)	200	
9. Check valve(full open)	150	
10. Check valve with strainer	400	

Table 11 Approximate Minor Head Losses in Fittings and Valves in term Equavalent Pipe Length(L_e)

Fitting and Valve	Equivalent Length (Diameters of pipe)	Pieces	Diameter suction pipe (m.)	Equivalent Pipe(L_e) (m.)
1. Tee (run)	20		0.0508	0
2. Tee (branch)	60		0.0508	0
3.90° bend-				0
Short radius	32		0.0508	0
Medium radius	27		0.0508	0
Long radius	20		0.0508	0
4. 90° Standard	30	1	0.0508	1.524
4. 45° bend	15		0.0508	0
5. Gate Valve (full open)	17		0.0508	0
(open 1:4)	1000		0.0508	0
6. Swing check valve(open)	135		0.0508	0
7. Butterfly valve (open)	40	1	0.0508	2.032
8. Glove valve (open)	200		0.0508	0
9. Check valve(full open)	150		0.0508	0
10. Check valve with strainer	400		0.0508	0
			Total (L_e)	3.556

∴ Equivalent length in Suction pipe (L_{suc}) = suction pipe length + L_e

= 2 + 3.556

L_{suc} = 5.556

Table 12 Relation between surface conditions and friction coefficien

Condition	Friction Coefficient			
	n (Manning's)	C (Hazen's)	f (Darcy's)	Notes
Very smooth surface	0.01	140	0.0002	PVC Pipe clean cement lined pipe
Fair condition surface	0.013	120	0.0012	Unlined pipe
Rough surface	0.016	100	0.0025	Rusted pipe

Pipe Material : PVC ∴ f = 0.0002

Theory

$$Equation \quad h_f = f\frac{L}{D}\frac{v^2}{2g}$$

∴ h_f = 0.004712 m.

∴ Total Head Loss in Influent Pipe = h_m + Mior head losses in Pressure Conduits + h_f

Total Head Loss in Influent Pipe = 0.153337

Calculate Head Loss Through Media

4 Choose Single filter media and Backwash by pump

Flow Rate	=	15	m^3/hr
Number of Filtration Tank	=	3	Tank
Flow Rate per Tank	=	5	m^3/hr
∴ Flow Rate Per Tank for Design	=	8	m^3/hr
Calculate Entrance Pipe Size			
Give Water Velocity	=	0.60	m/s
From d	=	$\sqrt{\frac{4Q}{\pi v}}$	
∴ d	=	0.067	m.
or	=	100	mm.
Caculate dimensional requirements (circular basin)			
Design Criteria Filtration rate	=	5-10	$m^3/hr/m^2$
Choosed	=	5	$m^3/hr/m^2$
∴ Surface Area for each Filtration Tank	=	1.5	m^2
Diameter Basin	=	1.382	m
Acture Diameter	=	1.4	m
Choose Backwash Rate	=	0.8	m/min
Backwash Times	=	10	min
Backwash/Day	=	1	Time
Water Loss	=	11	m^3/day
Flow Rate	=	**8.0**	m^3/hr
Acture Filtration Rate	=	**5.3**	$m^3/hr/m^2$
Acture Filtration Rate if Backwash 1 Tank	=	8.0	$m^3/hr/m^2$
or Flow Rate per Tank if Backwash 1 Tank	=	**12**	m^3/hr

Choosed Media

Sand Media

- Effective size 0.45 - 0.65 mm. average 0.5 mm.
- Uniformity coefficie 1.40 - 1.70
- Depth 0.65 m

Anthracite Media

- Effective size 0.7 - 2 mm. average 1.35 mm.
- Uniformity coefficie 1.3 - 1.8
- Depth 0.3 - 0.6 m.

$$Equation \quad N_R = \frac{D_p \rho_L v}{\mu}$$

Where N_R = Renolds number

D_p = Media grain diameter,(m)

ρ_L = Density of water, (kg/m^3) 25^o C = 997.1 kg/m^3

v = filtration velocity,(m/s)

μ = absolute viscosity, N-s/m^2(kg.m/s^2)

25^o C = 0.0009 N-s/m^2

$$Equation \quad f = 150\frac{(1-e)}{N_R} + 1.75$$

Where f = friction factor

e = porosity ratio (usually 0.4 - 0.5)

N_R = Renolds number

$$Equation \quad Carmen-Kozeny \quad h_L = \frac{f}{\phi}\frac{(1-e)}{e^3}\frac{L}{d}\frac{v^2}{g}$$

Where h_L = head loss, (m)

f = friction factor

e = porosity ratio (usually 0.4 - 0.5)

L = media depth,(m)

d = media grain diameter,(m)

v = filtration velocity,(m/s)

g = acceleration due to gravity 9.81 m/s^2

ϕ = particle shape factor (usually 0.85 to 1) 1

4.1 Calculations of Head Loss through Clean Filter Media

Layer	Size,(mm)	Depth,(m)	Porosity (e)	Reynolds Number N_R	Friction Coefficient f	Head Loss h_L (m)
Anthracite Layer	1.0	0.5	0.48	1.64361	49.2065	0.02566665
Sand Layer	0.5	0.25	0.4	0.8218	111.265	0.115716941
Total Depth of the media layer		0.75	Total head loss through clean filter media			0.141383591

4.2 Calculations of Head Loss through the Gravel Support

Layer	Size,(mm)	Depth,(m)	Porosity (e)	Reynolds Number N_R	Friction Coefficient f	Head Loss h_L (m)
Top Layer	1.0	0.5	0.45	1.64361	51.9444	0.03478009
Second Layer	1.0	0.5	0.45	1.64361	51.9444	0.03478009
Third Layer	0.5	0.25	0.40	0.8218	111.265	0.11571694
Bottom Layer	0.5	0.25	0.40	0.8218	111.265	0.11571694
Total Depth of the gravel layer		0.75	Total head loss through the gravel layer			0.150497036

4.3 Calculations of Head Loss through the underdrain system

$$Equation \quad H_L = k_1 v^2$$

where

H_L = head loss through the underdrain, m

k_1 = head loss constant that varies with the type of underdrain system

(generally is given by the manufacture)

(for the tile underdrain selected k_1 = 0.0005

v = filtration velocity, m/hr

$\therefore$ H_L = 0.0141 m.

Total Head loss across the filter Media at Q_{design}

= Head Loss Through Clean Filter + Head Loss Through the Gravel Support + Head Loss the Underdrain

= 0.291880627 m.

Calculate Head Loss in Effluent Pipe

1.Flow rate	=	15	m^3/hr	=	0.004167	m^3/s
2. Static Suction Lift	=	2	m.	(pipe length)		
3. Static Discharge Head	=	10	m.	(pipe length)		
4. Suction Pipe Diameter	=	2	in			
	=	0.0508	m.			
5. Discharge Pipe Diameter	=	2	in			
	=	0.0508	m.			

$$Equation \quad Q = Av$$

$$A = \frac{\pi D^2}{4}$$

$$\therefore \quad v = \frac{Qx4}{\pi D^2}$$

$\therefore$ v = 7400.72 m/hr = 2.055755 m/sec

3. Calculate headloss in Inlet Pipe

3.1 Minor losses due entrance

Entrance	K
conduit to still water	0.5

$$Equation \quad h_m = K\frac{v^2}{2g}$$

where

h_m = headloss inlet pipe (m)

v = water velocity in entrance pipe (m/s)

g = Acceleration due to gravity 9.81 m/s^2

$\therefore$ h_m = 0.1077 m.

3.2 Minor Head losses in Pressure Conduits

$$h = k\frac{v^2}{2g} x number$$

Table 9 Minor Head losses in Pressure Conduits

Item	K factor	Number	Total Minor head loss
1. Gate Valve			
- Full open	0.19	1	0.040926
- One-fourth closed	1.15		0
- One - half closed	5.6		0
- Three - forths closed	24		0
- Typical value	1		0
2. Butterfly Valve			
- Full open	0.3		0
- 20^{o}	1.4		0
- Angle closed 40^{o}	10		0
- 60^{o}	94		0
- Typical value	1.2		0
3. Check valve			
- K = 1.5 - 2.5	1.5		0
4. Plug Valve	1		0
5. Elbow (45 -61 cm diameter)			
- 22.5^{o} (K = 0.1 - 0.2)	0.1		0
- 45^{o} (K = 0.2 - 0.3)	0.2		0
- 90^{o} (K = 0.25 - 0.6)	0.25		0
6. Tee			
- Run to run (K = 0.25 - 0.6)	0.25		0
- Branch to run(K= 0.6 - 1.8)	0.6		0
- Run to branch(K=0.6 - 1.8)	0.6		0

Table 9 Minor Head losses in Pressure Conduits (contrinues)

Item	K factor	Number	Total Minor head loss
7. Reduer			
(with angle of divergence			
10^{o} - 20^{o})			
K = 0.15 - 0.2	0.15		0
8. Increaser			
(with angle of divergence			
10^{o} - 20^{o})			
K = 0.05 - 0.3	0.05		0
		Total	0.040926

3.3 Friction losses in the pipe are typically calculated from Dracy-Weisbach

$$Equation \quad h_f = f \frac{L}{D} \frac{v^2}{2g}$$

where

h_f = total friction head loss in suction or discharge pipes,(m)

L = length of pipe,(m) (suction or discharge pipes)

D = diameter of the pipe,(m)

v = velocity in the pipe,(m/s)

f = coefficient of friction (Dracy - Weisbach) page 636(integrated design of water treatment facilities)

g = acceleration due to gravity, 9.81 m/s^2

Table 10 Approximate Minor Head Losses in Fittings and Valves (page 98, water and wastewater technology)

Fitting and Valve	Equivalent Length (Diameters of pipe)	Loss Coefficient k
1. Tee (run)	20	0.6
2. Tee (branch)	60	1.8
3.90^{o} bend-		
Short radius	32	0.9
Medium radius	27	0.75
Long radius	20	0.6
4. 45^{o} bend	15	0.42
5. Gate Valve (full open)	17	0.48
(open 1:4)	1000	
6. Swing check valve(open)	135	3.7
7. Butterfly valve (open)	40	1.2
8. Glove valve (open)	200	
9. Check valve(full open)	150	
10. Check valve with strainer	400	

Table 11 Approximate Minor Head Losses in Fittings and Valves in term Equavalent Pipe Length(L_e)

Fitting and Valve	Equivalent Length (Diameters of pipe)	Pieces	Diameter suction pipe (m.)	Equivalent Pipe(L_e) (m.)
1. Tee (run)	20		0.0508	0
2. Tee (branch)	60		0.0508	0
3.90^{o} bend-				0
Short radius	32		0.0508	0
Medium radius	27		0.0508	0
Long radius	20		0.0508	0
4. 90^{o} Standard	30	1	0.0508	1.524
4. 45^{o} bend	15		0.0508	0
5. Gate Valve (full open)	17		0.0508	0
(open 1:4)	1000		0.0508	0
6. Swing check valve(open)	135		0.0508	0
7. Butterfly valve (open)	40	1	0.0508	2.032
8. Glove valve (open)	200		0.0508	0
9. Check valve(full open)	150		0.0508	0
10. Check valve with strainer	400		0.0508	0
			Total (L_e)	3.556

∴ Equivalent length in Suction pipe (L_{suc}) = suction pipe length + L_e

= 2 + 3.556

L_{suc} = 5.556

Table 12 Relation between surface conditions and friction coefficient

Condition	Friction Coefficient			
	n (Manning's)	C (Hazen's)	f (Darcy's)	Notes
Very smooth surface	0.01	140	0.0002	PVC Pipe clean cement lined pipe
Fair condition surface	0.013	120	0.0012	Unlined pipe
Rough surface	0.016	100	0.0025	Rusted pipe

Pipe Material : PVC ∴ f = 0.0002

Theory

$$Equation \quad h_f = f \frac{L}{D} \frac{v^2}{2g}$$

∴ h_f = 0.004712 m.

∴ Total Head Loss in Effluent Pipe = h_m + Mior head losses in Pressure Conduits + h_f

Total Head Loss in Effluent Pipe = 0.153337

3. Total Dynamic Head(TDH)

1. Head Loss in Suction Pipe = 0.153337

2. Head Loss in Discharge Pipe = 0.261037

3. Head Loss in Influent Pipe = 0.153337

4. Head Loss Through Media = 0.291881

5. Head Loss in Effluent Pipe = 0.153337

∴ Head Loss (pipe + media) = 1 + 2 + 3 + 4 + 5

1.012928

6. Total Static Head = 12

$$Equation \quad Total\ Dynamic\ Head = Total\ Static\ Head + Headloss(pipe + media)$$

∴ Total Dynamic Head = 13.01293 m.

4. Power Requirement (Theory) or power output of the pump (water power)

$$Equation \quad P_w = Q(m^3/s)xTDH\ (m)x\gamma(KN/m^3) \quad KW$$

$$Equation \quad P_w = Q(m^3/s)xTDH\ (m)x9.81(KN/m^3)$$

$$Equation \quad P_w = \frac{Q(ft^3/s)xTDH(ft)x62.4lb/ft^3}{550} \quad HP$$

P_w = 0.531903 $KN.m/s$ $\quad$ $Watt = N.m/s = kg.m/s^2.m/s$

∴ P_w = 0.531903 KW

5. Pump Power Requirement

$$Equation \quad P_p = \frac{P_w}{\eta}$$

where

P_p = Pump Power Requirement,(KW)

Efficiency of pump and motor (50% - 60%) Choose η = 60%

(Usually 70 - 90%)

∴ P_p = 0.886506 KW

From 0.7457 KW = 1 HP

∴ 0.886506 KW = 1.188824 HP

Table 7-8 Typical Electrical Motor Efficiencies

Motor Power Rating, kW	Typical Efficiency, percent
1–5	70–80
5–7.5	80–85
7.5–20	85–88
20 and above	88–92

Source: Reference 26.

$$Equation: \boxed{\rho \quad = \quad \frac{\gamma(N/m^3)}{g(m/s^2)}}$$

$$Equation: \boxed{F \quad = \quad m(kg)xa(m/s^2)}$$

$$\therefore \quad \boxed{F \quad = \quad ma \quad (kg.m/s^2 \quad = \quad N)}$$

$$\therefore \quad \boxed{\rho \quad = \quad \frac{\gamma(kg.m/s^2)/m^3}{g(m/s^2)} \quad (kg/m^3)}$$

$$Equation:$$

$$\therefore \quad \boxed{\gamma \quad = \quad \rho g \quad (N/m^3)}$$

where

$$\rho\, H_2O \quad = \quad 1000 \quad kg/m^3$$

$$g \quad = \quad 9.81 \quad m/s^2$$

$$\therefore \quad \boxed{\gamma \quad = \quad 1000(kg/m^3)x9.81(m/s^2)}$$

$$\therefore \quad \boxed{\gamma \quad = \quad 9.81 \quad K(kg.m/s^2)/m^3}$$

$$\therefore \quad \boxed{\gamma \quad = \quad 9.81 \quad KN/m^3}$$