Grundfos ECADEMY

Pump hydraulics

Pump performance curves
and calculations

GRUNDFOS

Possibility in every drop

Learning outcomes

After this course you should be able to:

- Read and understand pump performance curves
- Know how to calculate water, brake and electrical horsepower
- Know how to calculate Net Positive Suction Head
- Know how to use the affinity laws to calculate the effects pump speed and impeller diameter have on capacity, head and horsepower requirements

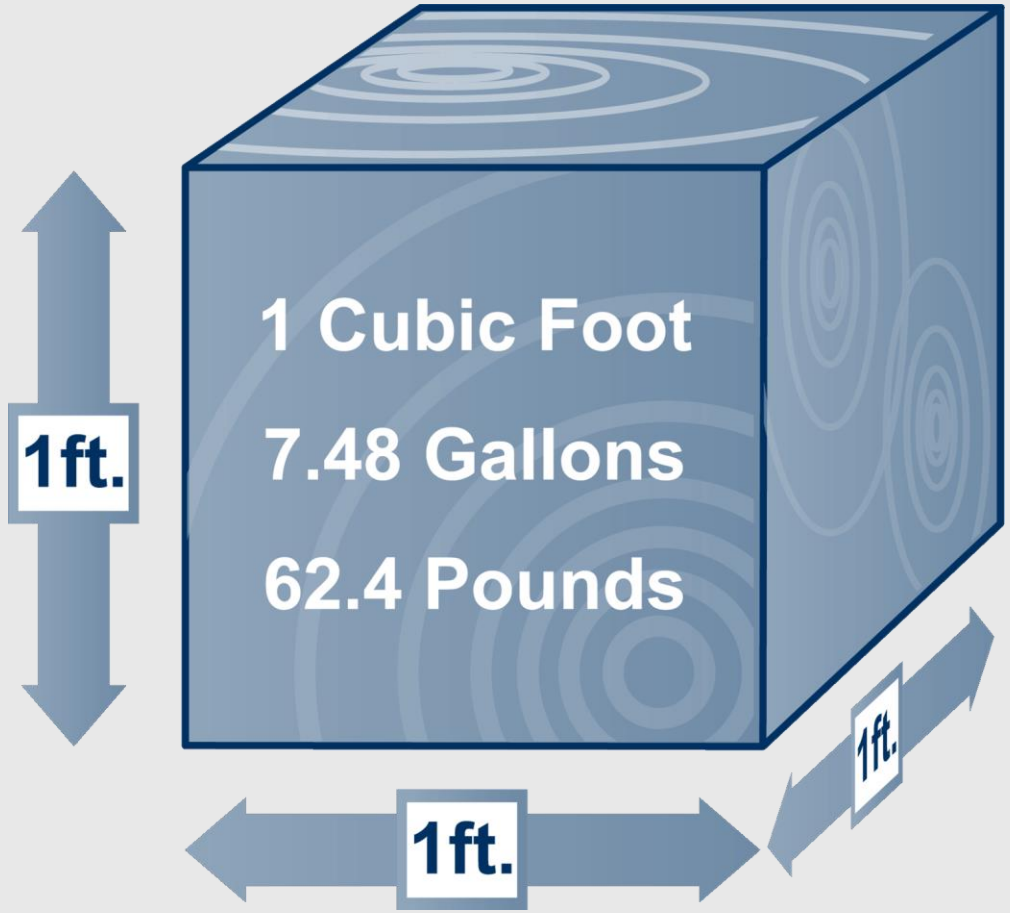
Learning outcomes

This course will also familiarize you with the following terms:

- Pressure & Head
- Flow & Velocity
- Specific Gravity
- Static Conditions
- Dynamic Conditions
- Suction Head
- Suction Lift
- Horsepower
- Efficiency
- Affinity Laws
- Atmospheric Pressure
- Vapor Pressure
- NPSH
- Pump Curves

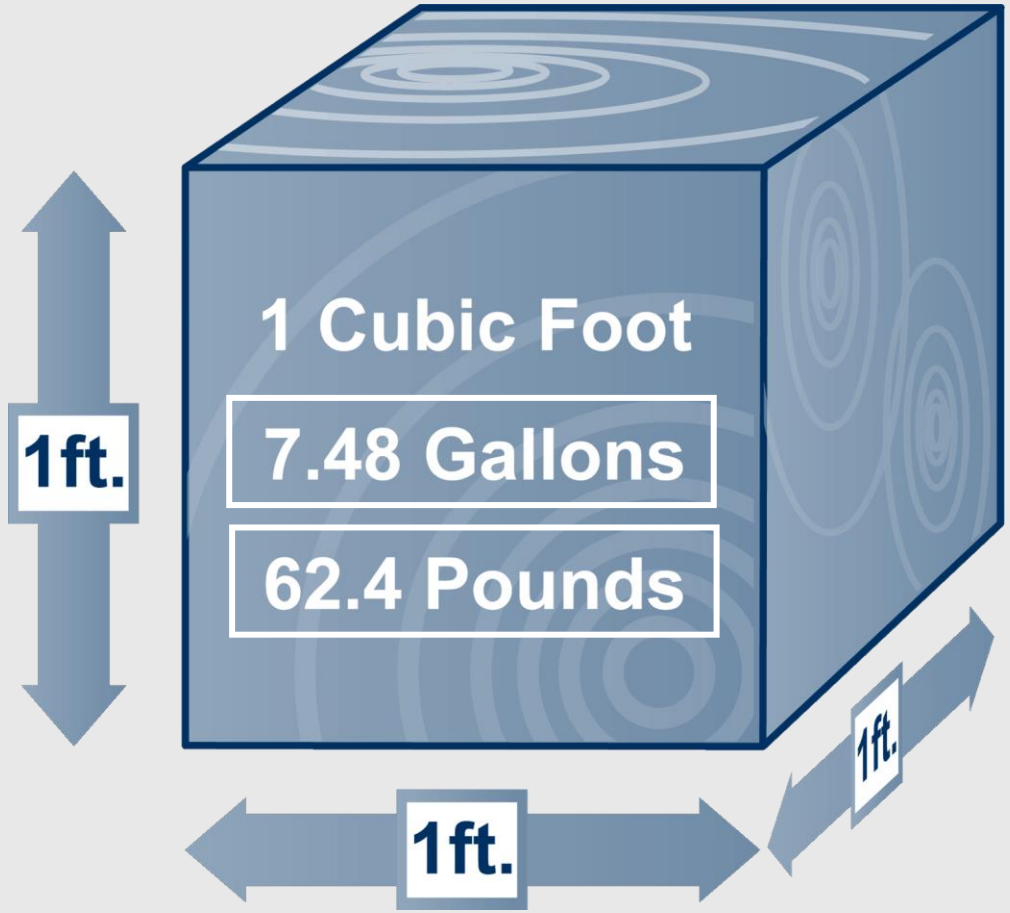
Hydraulic basics

- To better understand pressure and head, we will start with the properties of water.
- One cubic foot of water contains 7.48 gallons and weighs 62.4 pounds.



Hydraulic basics

- We can then calculate the weight of one gallon of water
- This is 62.4 pounds
- Divided by 7.48 gallons
- This turns out to be 8.34 pounds per gallon.



Pressure head

- Pump performance is measured with gauges showing pressure in psi (pounds per square inch) while pump ratings are shown in feet of head or just plain “head”.
- Let’s find the relationship between 1 foot of head and psi.
- We know that one cubic foot of water weighs 62.4 pounds
- In one square foot there 144 square inches (12 by 12 inches)
- This means the one foot of head equals 64.4 lbs / 144 in2 = 0.433 psi

$$1 \text{ foot of head} = \frac{62.4 \text{ lbs}}{144 \text{ in}^2} = 0.433 \text{ psi}$$

Pressure head

- One foot of head equals 0.433 psi.
- Now let us determine how many feet there are for each psi.
- We can do that by a simple division.
- For those of you who have used this conversion before, now you know where the 2.31 comes from!

$$1\ \text{psi} = \frac{1\ \text{psi}}{0.433\ \text{psi/ft}} = 2.31\ \text{ft}$$

Pressure head conversion examples

First we'll convert 85 psi to feet of head

- We can do that by dividing with 0.433.
- Or by multiplying with 2.31 which is more common.

Next we'll convert 85 feet to psi

- Either by dividing by 2.31 .
- Or multiplying by 0.433.

$$85\ \text{psi} = \frac{85\ \text{psi}}{0.433\ \text{psi/ft}} = 196.3\ \text{ft}$$

$$85\ \text{psi} \times 2.31\ \text{ft/psi} = 196.3\ \text{ft}$$

$$85\ \text{ft} = \frac{85\ \text{ft}}{2.31\ \text{ft/psi}} = 36.8\ \text{psi}$$

$$85\ \text{ft} \times 0.433\ \text{psi/ft} = 36.8\ \text{psi}$$

Flow and velocity

- To better understand hydraulics it is necessary to know the relationship between flow and velocity.
- Flow(Q) is equal to the fluid velocity (V) times the cross sectional area (A) of the pipe.
- If the flow is known the velocity can be determined by dividing the flow by the area.
- Another useful relationship to know is that one cubic feet per second (cfs) is equal to 448 gallons per minute.
- For the cross sectional area of a pipe, we use the formula for the area of a circle which is pi times the radius squared or pi times the diameter squared divided by four.
- The internal diameter needs to be used as pipe thicknesses vary.

$$Q = VA$$

Q - Flow in cubic feet per second (ft^3/s or cfs)
V = Velocity in feet per second, ft/sec
A = Cross sectional area of the pipe in square feet, ft^2

$$V = Q/A$$

$$1cfs = 448gpm$$

$$A = \pi r^2 \quad \text{or} \quad A = \pi d^2/4$$

Flow and velocity examples

- So let's work through a couple examples.
- The flow meter at a well shows a flow rate of 1,100 gallons per minute. We would like to know the velocity so convert this flow rate to cubic feet per second.
- We know that there's 448 gpm in one cubic feet per seconds
- So we can simply divide 1,100 by 448 which give us 2.45 cubic feet per second.

$$Q = 1{,}100\text{gpm}$$

$$1\text{cfs} = 448\text{gpm}$$

$$Q = \frac{1{,}000\text{gpm}}{448\text{gpm}} = 2.45\text{cfs}$$

Flow and velocity examples

- Here's an example showing how to calculate the liquid velocity.
- The pump from our previous example is discharging into a 10 inch line. Find the velocity of the water in the line in feet per second.
- First we must convert the diameter in inches to the radius in feet. We do that by dividing the 5 inches by 12.
- If we then take the flow in cubic feet per seconds and divide it by the cross sectional area of the pipe, which is pi times the radius squared or 4.49 feet per second.

$$Q = 2.45\text{cfs}$$

$$r = \frac{5\text{in}}{12\text{in/ft}} = 0.417\text{ft}$$

$$V = \frac{2.45\text{ft}^3/\text{s}}{\pi(0.417\text{ft})^2} = 4.49\text{fps}$$

Specific gravity (sg)

- Specific gravity is the relationship of the weight of a substance to the weight of an equal volume of a reference substance, which in most cases, is water at 20 degrees Celsius or 68 degrees Fahrenheit.
- Where specific gravity has its biggest impact is pump horsepower. Pumping a liquid with a specific gravity greater than water, such as oil or a polymer will require additional horsepower.
- There is an equation for calculating the horsepower (Hp) to account for Specific Gravity.
- Multiply the water horsepower to specific gravity to get the actual horsepower requirement.

Water horsepower X sg
= Horsepower requirement

Specific gravity (sg)

- This table shows how the specific gravity of water changes with temperature. As water gets hotter, the actual horsepower requirement reduces.

Water Temp ° C (F)	sg	BHp
4 (39.2)	1.000	100.0
60 (140)	0.983	98.3
100 (212)	0.958	95.8
125 (257)	0.939	93.9
150 (302)	0.917	91.7

Specific gravity (sg)

- Remember our equation for converting feet of head to psi?
- If the liquid being pumped is lighter or heavier than water, the equation needs to include an adjustment for specific gravity.
- The table here shows how the specific gravity of a liquid impacts pressure with the same amount of head.

$$\frac{\text{Head}_{ft} \text{ X sg}}{2.31_{ft/psi}} = \text{pressure}_{psi}$$

Gravity	Head in feet	psi
0.75	246	79.9
1.00	246	106.5
1.20	246	127.8

Specific gravity (sg) example

- A customer has purchased a boiler feed pump rated for 100 gpm at 300 feet of head to pump water at 250 degrees F (s.g. = 0.94). With a suction pressure of 20 psi, what would be the expected discharge pressure at 100 gpm?
- First convert pump head to psi while correcting for the specific gravity of 0.94. Doing this we get 122 psi. This is what the pump will add to the liquid at 100 gpm.
- For the discharge pressure, we need to add the 122 psi to the pump inlet pressure of 20 psi for a total discharge pressure of 142 psi.

$$\frac{300_{ft} \text{ X } 0.94}{2.31_{ft/psi}} = 122_{psi}$$

$$122_{psi} + 20_{psi} = 142_{psi}$$

Hydraulic considerations of the pump piping systems

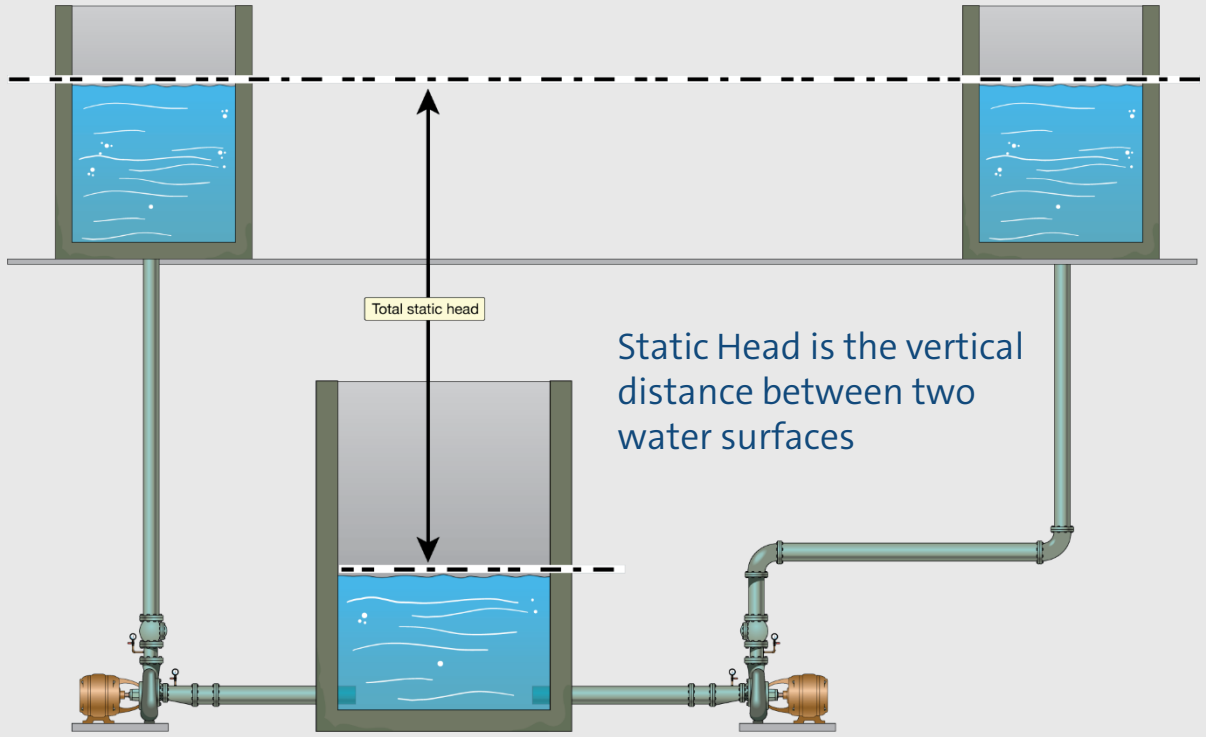
- There are two pump piping conditions, Static and Dynamic.
- In the static condition the pump is switched off .
- In the dynamic condition the pump is on.
- In both conditions all references are in feet of head.

Static condition:
Pump is off

Dynamic condition:
Pump is on

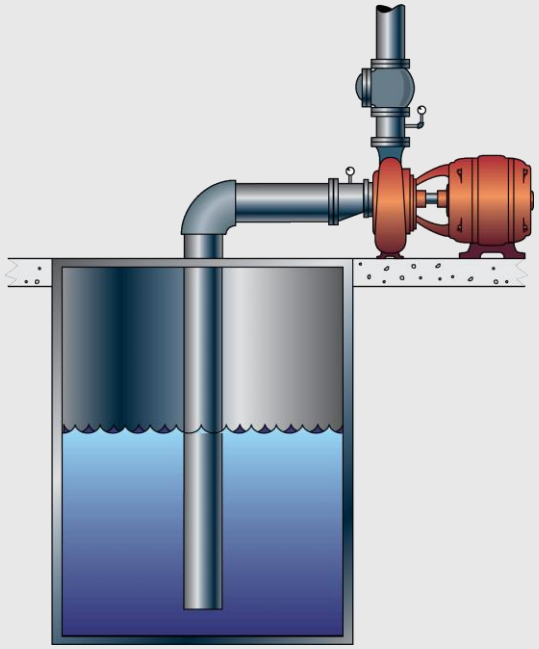
Static conditions

- Let’s take a look at static conditions.
- Shown here is an example of static head.
- Static head is the vertical distance between two water surfaces.
- The piping going from the pump to each tank shown here is different but the static head in both cases is the same.

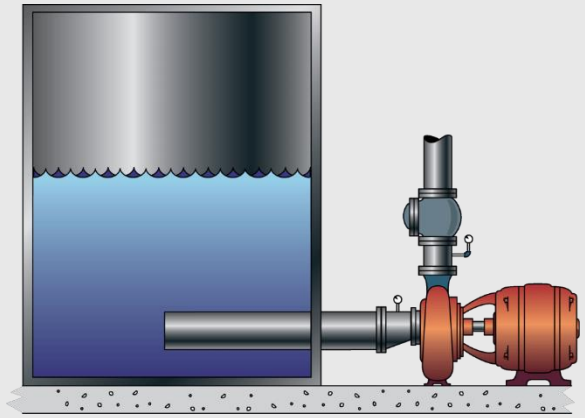


Static conditions

- The water level from the supply to the pump inlet will either be below the pump or above the pump.
- When the water level is below the pump inlet that is known as a suction lift condition.
- When the water level is above the pump inlet the condition is known as suction head or flooded suction.



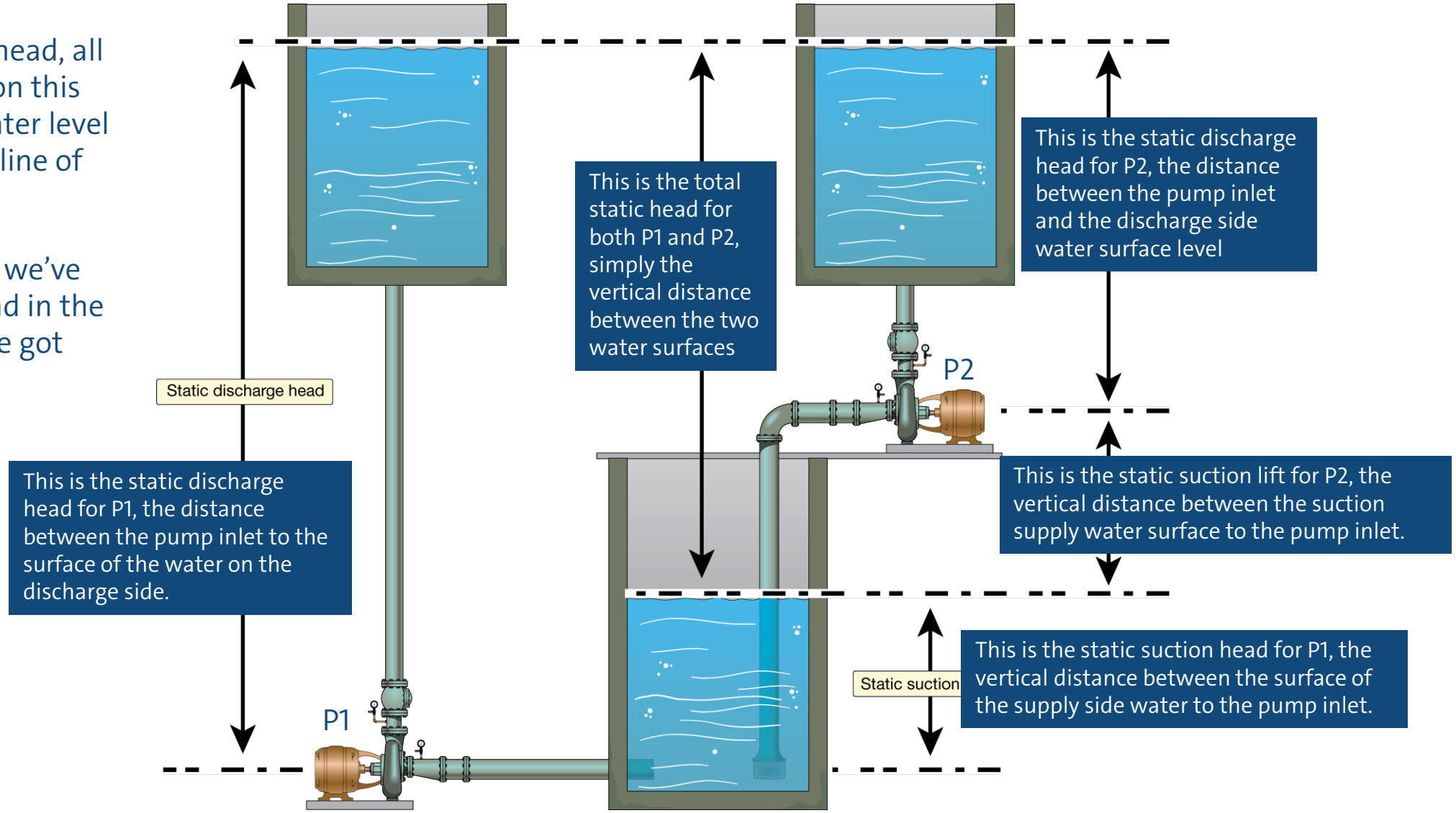
Suction lift



Suction head

Static conditions

- In terms of static head, all distances shown on this diagram relate water level back to the centerline of the pump inlet.
- In the bottom left we've got pump 1 (P1) and in the middle-right we've got pump 2 (P2).



Static conditions summary

- Static condition
  - Pump off

- Total Static Head
  - The vertical difference between water levels
  - The vertical location of the pump does not change the total static head
  - Static head is a physical distance

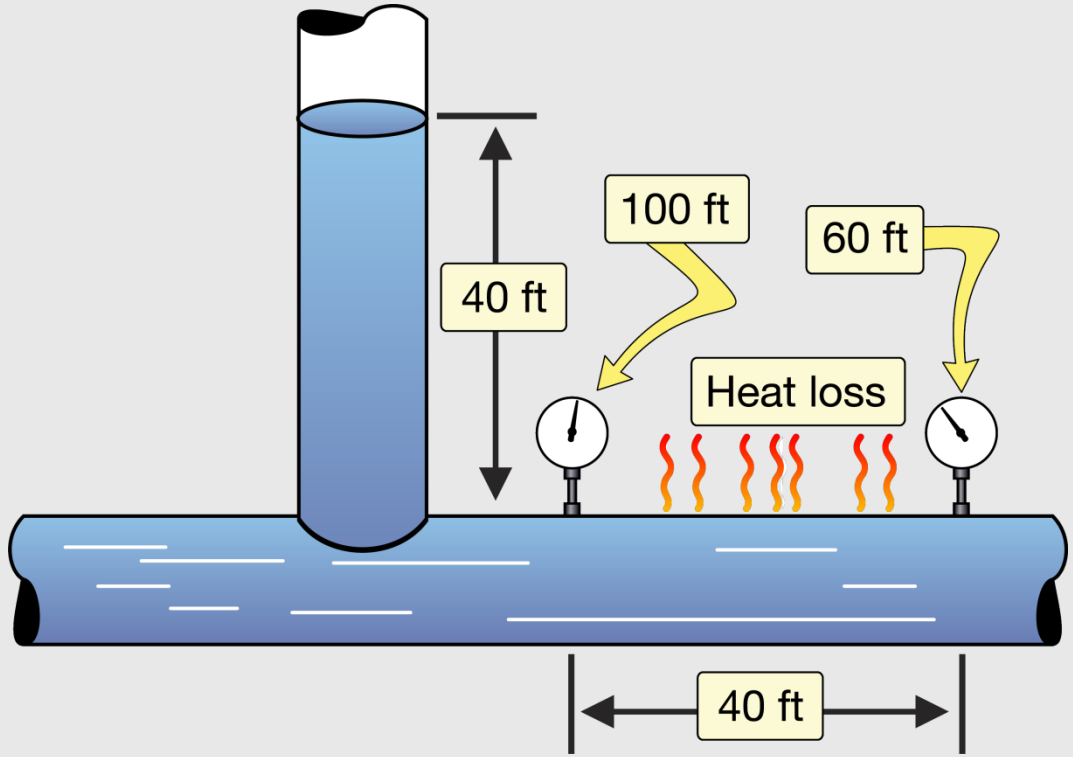
Dynamic conditions

- Let’s move on the dynamic conditions.
- Dynamic conditions are expressed in feet of head. Unlike static conditions, which are physical distances remember, dynamic conditions are a theoretical distance.
- The main component of dynamic conditions is head loss through piping and fittings.
- Head loss can be divided into two groups, major losses and minor losses.
- Major losses are due to losses in the piping, minor losses are due to losses in pipe fittings.
- The other component of dynamic conditions is velocity head.



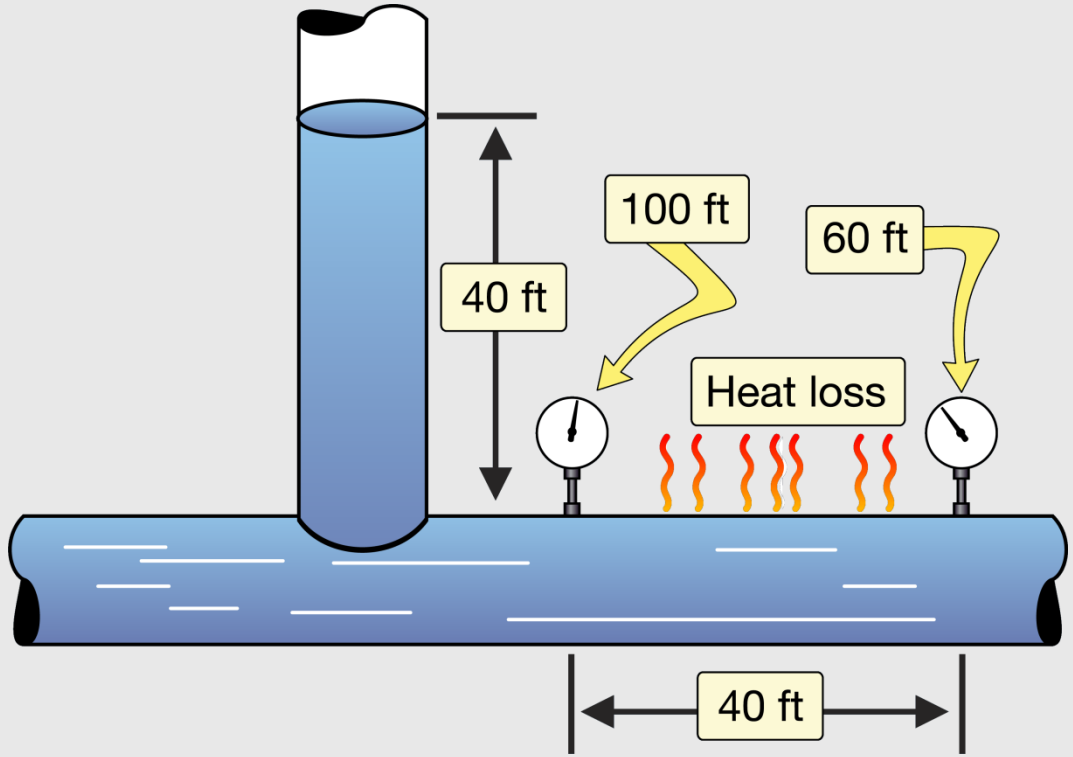
Dynamic conditions

- Head loss, expressed as H_f or H_L is a loss of energy due to friction.
- Where does this energy go?
- The work of friction between the water and pipe surface results in an energy transfer from pressure head to heat.



Dynamic conditions

- So to sum up head loss in the example shown here;
- The amount of energy required to overcome 40 feet of friction is equal to the amount of energy to lift the water vertically 40 feet.
- Remember, dynamic conditions are theoretical distances in feet where static conditions are true physical distances.
- The 40 feet shown here is not 40 feet of pipe, it's 40 feet of head loss due to friction.



Major losses

- Some equations have been developed and the first one is the Darcy Weisbach equation, also known simply as the Darcy equation where:
- H_f = Head loss in feet
- L = Length of pipe in feet.
- D = Inside diameter of pipe in feet
- V = Velocity in feet per seconds
- g = Acceleration due to gravity which is 32.2 feet per second squared
- f = Friction factor

$$H_f = \frac{f\,L\,V^2}{D\,2g}$$

Major losses

- The second equation is know as the Hazen-Williams equation where:
- H_f – Head loss in feet/1,000 feet <note to developer, state
- Q = Flow in gpm
- D = Diameter of the pipe in inches
- C = Friction factor (ranges from 60 to 160)

$$H_f = \left[\frac{147.85\,Q}{C\,D^{2.63}} \right]^{1.852}$$

Major losses

- Both equations can be used to determine head loss in piping.
- The Darcy-Weisbach equation uses a friction factor “f” which is based on the physical roughness of the pipe.
- The Hazen-Williams equation uses a “C” factor which is based on the hydraulic roughness of the pipe.
- The Hazen-Williams is the most common of the two for which easy to use tables have been developed.

$$H_f = \frac{f\,L\,V^2}{D\,2g}$$

$$H_f = \left[\frac{147.85\,Q}{C\,D^{2.63}} \right]^{1.852}$$

Major losses

- Here's an example of a table developed using the Hazen-Williams equation for pipe sizes ranging from one half inch to six inches.

Friction Loss Table

Friction loss of water in feet per 100 feet length of pipe. Based on Hazen-Williams formula using C=100. Size of standard pipe in inches.

U.S. Gals / min	1/2" Vol ft./Sec	1/2" Loss in Feet	3/4" Vol ft./Sec	3/4" Loss in Feet	1" Vol ft./Sec	1" Loss in Feet	1 1/4" Vol ft./Sec	1 1/4" Loss in Feet	1 1/2" Vol ft./Sec	1 1/2" Loss in Feet	2" Vol ft./Sec	2" Loss in Feet	2 1/2" Vol ft./Sec	2 1/2" Loss in Feet	3" Vol ft./Sec	3" Loss in Feet	4" Vol ft./Sec	4" Loss in Feet	5" Vol ft./Sec	5" Loss in Feet	6" Vol ft./Sec	6" Loss in Feet	U.S. Gals / min
2	2.10	7.40	1.20	1.90	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	2
4	4.21	27.0	2.41	7.0	1.49	2.14	0.86	0.57	0.63	0.26	****	****	****	****	****	****	****	****	****	****	****	****	4
6	6.31	57.0	3.61	14.7	2.23	4.55	1.29	1.20	0.94	0.56	0.61	0.20	****	****	****	****	****	****	****	****	****	****	6
8	8.42	98.0	4.81	25.0	2.98	7.80	1.72	2.03	1.26	0.95	0.82	0.33	0.52	0.11	****	****	****	****	****	****	****	****	8
10	10.52	147.0	6.02	38.0	3.72	11.70	2.14	3.05	1.57	1.43	1.02	0.50	0.65	0.17	0.45	0.07	****	****	****	****	****	****	10
12	****	****	7.22	53.0	4.46	16.40	2.57	4.30	1.89	2.01	1.23	0.79	0.78	0.23	0.54	0.10	****	****	****	****	****	****	12
16	****	****	9.02	80.0	5.60	25.0	3.21	6.50	2.36	3.00	1.53	1.08	0.98	0.36	0.68	0.15	****	****	****	****	****	****	16
18	****	****	10.84	108.2	6.69	35.0	3.86	9.10	2.83	4.24	1.84	1.49	1.18	0.50	0.82	0.21	****	****	****	****	****	****	18
20	****	****	12.03	136.0	7.44	42.0	4.29	11.10	3.15	5.20	2.04	1.82	1.31	0.61	0.91	0.25	0.51	0.06	****	****	****	****	20
26	****	****	****	****	9.30	64.0	5.36	16.60	3.80	7.30	2.55	2.73	1.63	0.92	1.13	0.38	0.64	0.09	****	****	****	****	26
30	****	****	****	****	11.15	89.0	6.43	23.00	5.51	11.0	3.06	3.84	1.96	1.29	1.36	0.54	0.77	0.13	0.49	0.04	****	****	30
35	****	****	****	****	13.02	119.0	7.51	31.20	6.30	14.7	3.57	6.10	2.29	1.72	1.59	0.71	0.89	0.17	0.57	0.06	****	****	35
40	****	****	****	****	14.88	152.0	8.58	40.0	7.08	18.8	4.08	6.60	2.61	2.20	1.82	0.91	1.02	0.22	0.65	0.08	****	****	40
45	****	****	****	****	****	****	9.65	50.0	7.87	23.2	4.60	8.20	2.94	2.80	2.04	1.15	1.15	0.28	0.73	0.09	****	****	45
50	****	****	****	****	****	****	10.72	60.0	8.66	28.4	5.11	9.90	3.27	3.32	2.27	1.38	1.28	0.34	0.82	0.11	0.57	0.04	50
55	****	****	****	****	****	****	11.78	72.0	9.44	34.0	5.62	11.8	3.59	4.01	2.45	1.58	1.41	0.41	0.90	0.14	0.62	0.05	55
60	****	****	****	****	****	****	12.87	85.0	10.23	39.6	6.13	13.1	3.92	4.65	2.72	1.92	1.53	0.47	0.98	0.16	0.67	0.06	60
65	****	****	****	****	****	****	13.92	99.7	11.02	45.9	6.64	16.1	4.24	5.40	2.89	2.16	1.60	0.53	1.06	0.19	0.74	0.076	65
70	****	****	****	****	****	****	15.01	113.0	11.80	53.0	7.15	18.4	4.58	6.20	3.18	2.57	1.79	0.63	1.14	0.21	0.79	0.08	70
75	****	****	****	****	****	****	16.06	129.0	12.59	60.0	7.66	20.9	4.91	7.10	3.33	3.00	1.91	0.73	1.22	0.24	0.85	0.10	75
80	****	****	****	****	****	****	17.16	145.0	13.38	68.0	8.17	23.7	5.23	7.90	3.63	3.28	2.04	0.81	1.31	0.27	0.91	0.11	80
85	****	****	****	****	****	****	18.21	163.8	14.71	75.0	8.68	26.5	5.56	8.10	3.78	3.54	2.17	0.91	1.39	0.31	0.96	0.12	85
90	****	****	****	****	****	****	19.30	180.0	14.95	84.0	9.19	29.4	5.88	9.80	4.09	4.08	2.30	1.00	1.47	0.34	1.02	0.14	90
95	****	****	****	****	****	****	****	****	15.74	93.0	9.70	32.6	6.21	10.80	4.22	4.33	2.42	1.12	1.65	0.38	1.08	0.15	95
100	****	****	****	****	****	****	****	****	17.31	102.0	10.21	35.8	6.54	12.00	4.54	4.96	2.55	1.22	1.63	0.41	1.13	0.17	100
110	**8"**	**PIPE**	****	****	****	****	****	****	18.89	122.0	11.23	42.9	7.18	14.50	6.00	6.00	2.81	1.46	1.79	0.49	1.25	0.21	110
120	****	****	****	****	****	****	****	****	20.46	143.0	12.25	60.0	7.84	16.80	6.45	7.00	3.06	1.17	1.96	0.58	1.36	0.24	120
130	****	****	****	****	****	****	****	****	22.04	166.0	13.28	68.0	8.48	18.70	6.91	8.10	3.31	1.97	2.12	0.67	1.47	0.27	130
140	0.90	0.08	****	****	****	****	****	****	****	190.0	14.30	67.0	9.15	22.30	6.35	9.20	3.67	2.28	2.29	0.76	1.59	0.32	140
150	0.96	0.09	****	****	****	****	****	****	****	****	15.32	76.0	9.81	25.50	6.82	10.50	3.82	2.62	2.45	0.88	1.70	0.36	150
160	1.02	0.10	****	****	****	****	****	****	****	****	16.34	86.0	10.46	29.00	7.26	11.80	4.08	2.91	2.61	0.98	1.82	0.40	160
170	1.08	0.11	**10"**	**PIPE**	****	****	****	****	****	****	17.36	96.0	11.11	31.10	7.71	13.30	4.33	3.26	2.77	1.08	1.92	0.45	170
180	1.15	0.13	****	****	****	****	****	****	****	****	18.38	107.0	11.76	35.70	8.17	14.00	4.60	3.61	2.94	1.22	2.04	0.50	180
190	1.21	0.14	****	****	****	****	****	****	****	****	19.40	118.0	12.42	39.60	8.63	15.50	4.84	4.01	3.10	1.35	2.16	0.55	190
200	1.28	0.15	****	****	****	****	****	****	****	****	20.42	129.0	13.07	43.10	9.08	17.80	5.11	4.40	3.27	1.48	2.27	0.62	200
220	1.40	0.18	0.90	0.06	****	****	****	****	****	****	22.47	154.0	14.38	52.00	9.99	21.30	5.62	5.20	3.59	1.77	2.50	0.73	220

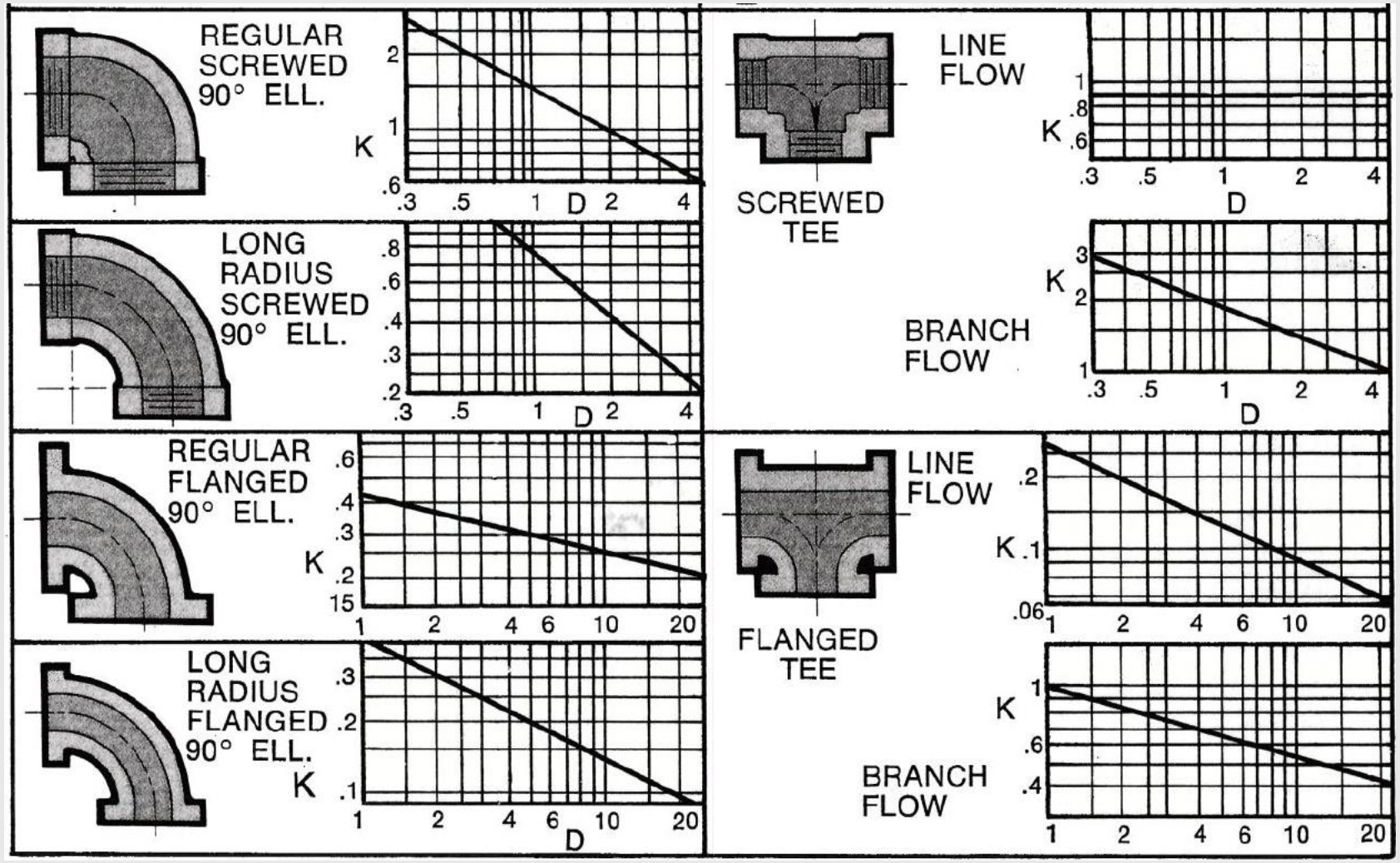
Minor losses

- To determine minor losses there are two methods;
- One is to use a formula containing a K factor
- The head loss, H_2, is equal to the K factor times the velocity squared divided by 2 times the gravitational acceleration “g”.
- The other involves using tables based on equivalent length of pipe.

$$H_2 = K \frac{V^2}{2g}$$

Minor losses

- For the various pipe fittings, K factors have been developed as shown here in these charts.



Minor losses

- Alternatively, tables have been developed that simply show the equivalent length of pipe for various fitting types based on the fitting size.

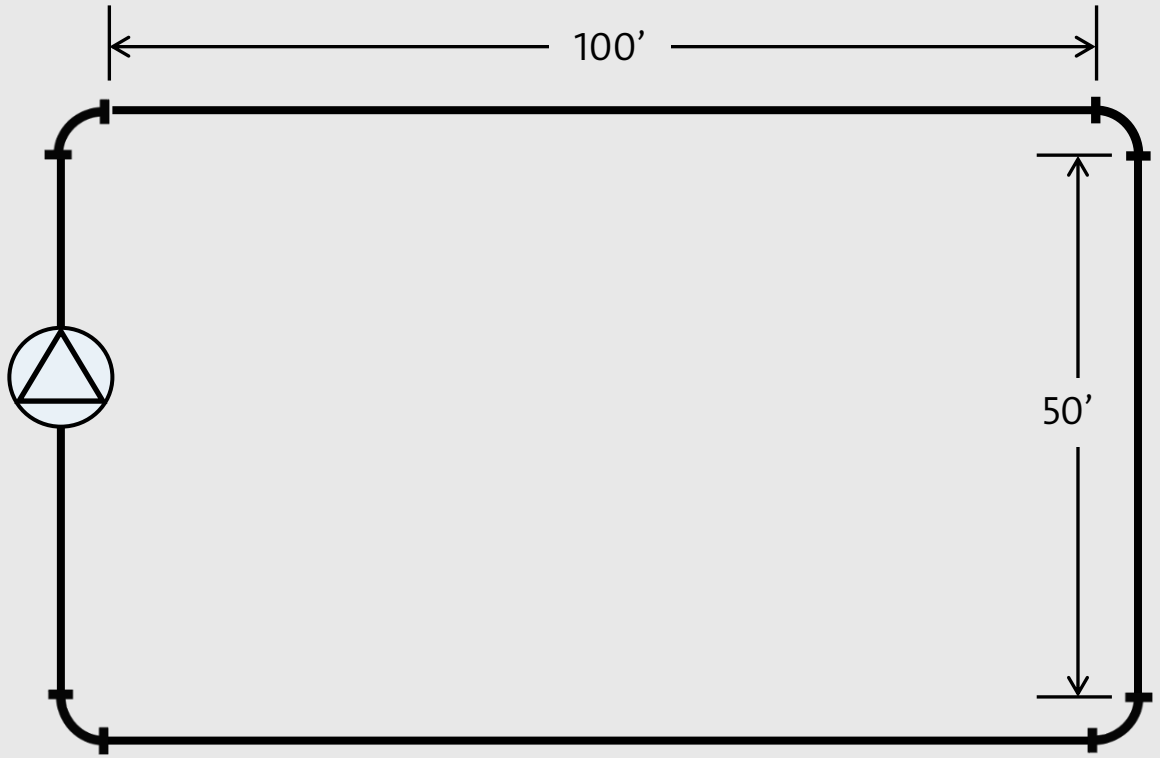
Table 5-21 Allowance for Friction Loss in Valves and Threaded Fittings

Diameter of Fitting, in. (mm)	Equivalent Length of Pipe for Various Fittings, ft (m)						
	90° Standard Elbow	45° Standard Elbow	Standard Tee 90°	Coupling or Straight Run of Tee	Gate Valve	Globe Valve	Angle Valve
⅜ (10)	1 (0.3)	0.6 (0.2)	1.5 (0.5)	0.3 (0.09)	0.2 (0.06)	8 (2.4)	4 (1.2)
½ (15)	2 (0.6)	1.2 (0.4)	3 (0.9)	0.6 (0.18)	0.4 (0.12)	15 (4.6)	8 (2.4)
¾ (20)	2.5 (0.8)	1.5 (0.5)	4 (1.2)	0.8 (0.24)	0.5 (0.15)	20 (6.1)	12 (3.7)
1 (25)	3 (0.9)	1.8 (0.6)	5 (1.5)	0.9 (0.27)	0.6 (0.18)	25 (7.6)	15 (4.6)
1¼ (32)	4 (1.2)	2.4 (0.7)	6 (1.8)	1.2 (0.4)	0.8 (0.24)	35 (10.7)	18 (5.5)
1½ (40)	5 (1.5)	3 (0.9)	7 (2.1)	1.5 (0.5)	1 (0.3)	45 (13.7)	22 (6.7)
2 (50)	7 (2.1)	4 (1.2)	10 (3.1)	2 (0.6)	1.3 (0.4)	55 (16.8)	28 (8.5)
2½ (65)	8 (2.4)	5 (1.5)	12 (3.7)	2.5 (0.8)	1.6 (0.5)	65 (19.8)	34 (10.4)
3 (75)	10 (3.1)	6 (1.8)	15 (4.6)	3 (0.9)	2 (0.6)	80 (24.4)	40 (12.2)
4 (100)	14 (4.3)	8 (2.4)	21 (6.4)	4 (1.2)	2.7 (0.8)	125 (38.1)	55 (16.8)
5 (125)	17 (5.2)	10 (3.1)	25 (7.6)	5 (1.5)	3.3 (1)	140 (42.7)	70 (21.3)
6 (150)	20 (6.1)	12 (13.7)	30 (9.1)	6 (1.8)	4 (1.2)	165 (50.3)	80 (24.4)

Note: Allowances are based on nonrecessed threaded fittings. Use one-half the allowance for recessed threaded fittings or streamline solder fittings.

Knowledge check #1

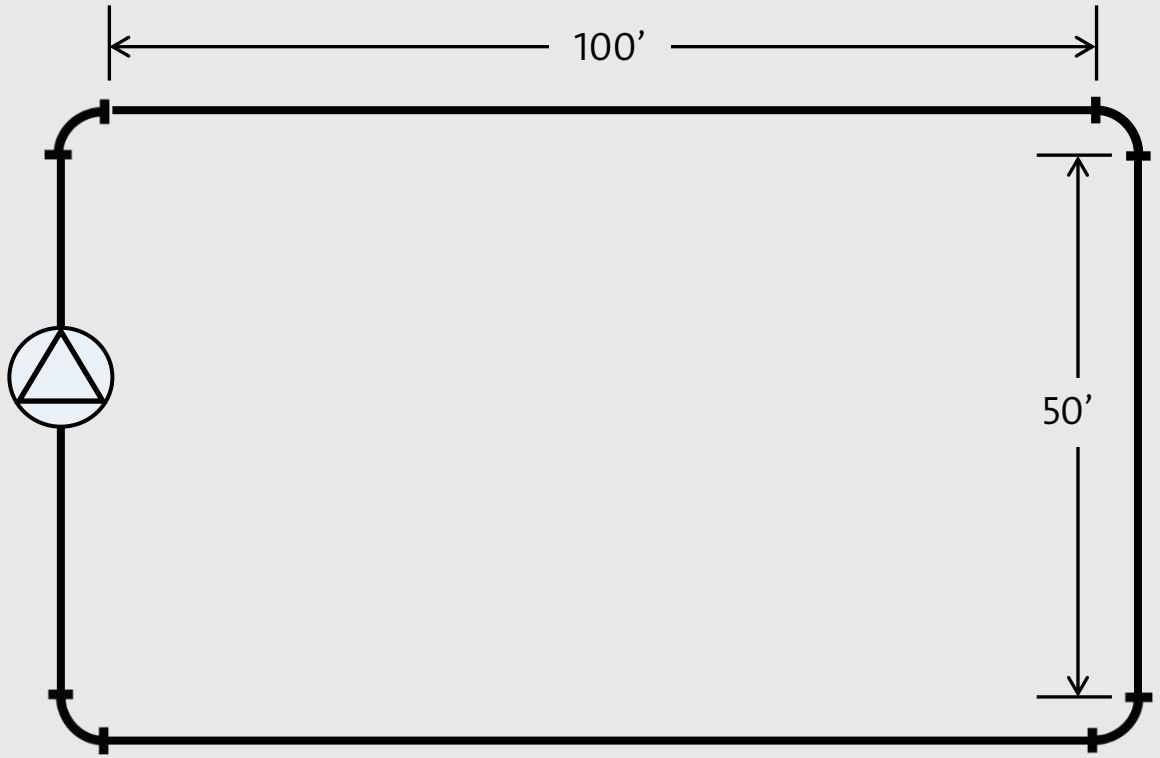
- Calculate the head loss in the simple piping loop shown.
- The following information was obtained from the previous pressure loss charts and tables:
- For 2” pipe, the head loss per 100 feet of length at 60 gpm is 13.1 feet of head.
- A 2” regular flanged 90 degree elbow had an equivalent pipe length of 7 feet.



Knowledge check #1

Solution

- For the total length of straight pipe there are two sections of 100 feet and two sections of 50 feet so in total 300 feet
- The total equivalent length of the elbows is 7’ times 4 which is 28 total feet of pipe length.
- So the total equivalent of all the pipe and fittings is 300 feet plus 28 feet for a total of 328 feet
- So for the head loss we get 328 feet times 13.1 feet per 100 feet of pipe length which is 42.97
- Rounding off we get 43 feet of head loss for this simple piping loop at 60 gpm.



Minor losses

- One other way to determine minor losses through valves is what is known as a Cv value, or valve coefficient.
- Head loss through pump isolation valves and check valves are often represented by a valve coefficient.
- The valve coefficient (Cv) is the amount of water flow through a valve that will create a pressure drop of one psi.
- The Cv is equal to the flow Q, divided by the square root of the difference in pressure across the valve divided by the liquid specific gravity.
- So for water with a specific gravity of one point zero, the Cv value is simply the flow divided by the square root of the differential pressure across the valve.

$$C_v = \frac{Q}{\sqrt{\Delta p / sg}}$$

For water with sg = 1

$$C_v = \frac{Q}{\sqrt{\Delta p}}$$

Minor losses

- Shown here is a table with Cv values for butterfly valves.
- Note there are different Cv values based on how far open or closed the valve is.

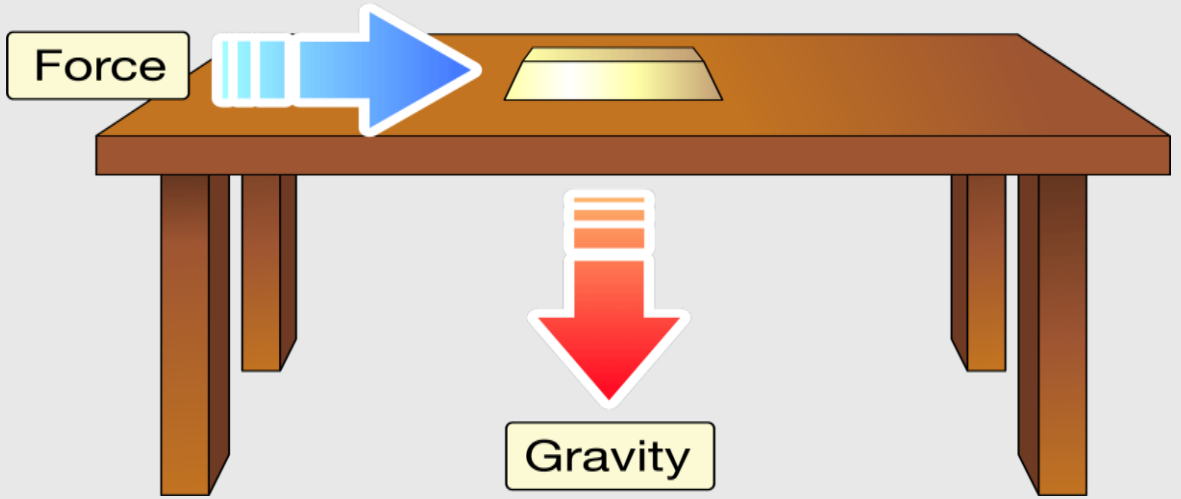
Butterfly Valve Cv Values

Valve Size	Cv at Various Butterfly Disc Positions							Full 90° Open Cv
	20°	30°	40°	50°	60°	70°	80°	
2"	4.06	14.2	26.3	44.5	70.6	105	135	159
2-1/2"	6.17	20.9	38.6	65.3	140	156	215	266
3"	13.6	31.4	57.9	98.0	156	240	342	457
4"	23.9	55.1	102	173	274	423	625	860
5"	37.2	85.6	158	268	426	656	970	1,320
6"	53.3	123	227	384	610	941	1,420	2,020
8"	94.3	217	401	679	1,080	1,660	2,500	3,540
10"	145	334	617	1,040	1,660	2,560	3,830	5,580
12"	209	481	888	1,500	2,390	3,690	5,620	8,080
14"	335	670	1,226	1,935	2,893	4,406	6,752	9,578
16"	443	886	1,622	2,560	3,827	5,829	8,933	12,671
18"	567	1,138	2,075	3,275	4,896	7,457	11,429	16,211
20"	711	1,422	2,609	4,116	6,156	9,377	14,371	20,385
24"	1,038	2,078	3,792	5,985	8,947	13,628	20,887	29,627

Minor losses

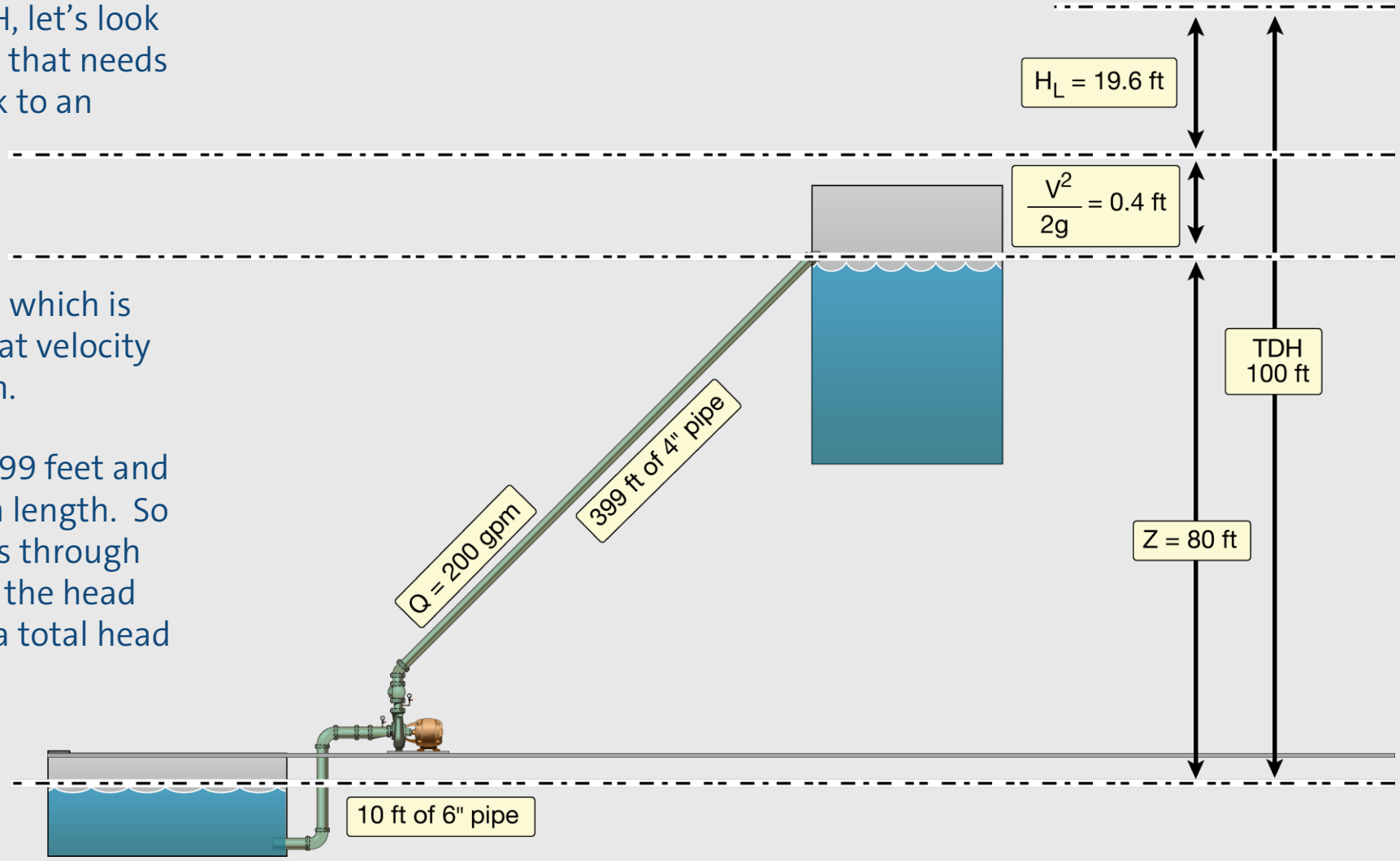
$$\text{Velocity head}_{ft} = \frac{V^2}{2g}$$

- The smallest of the minor losses is velocity head.
- Velocity head is simply the velocity squared divided by 2 times the acceleration due to gravity (g).
- Velocity head is the head required to get water into motion.
- An example of velocity head would be a book lying on a table. The initial force you would have apply to start sliding the book across the table is an example of velocity head.



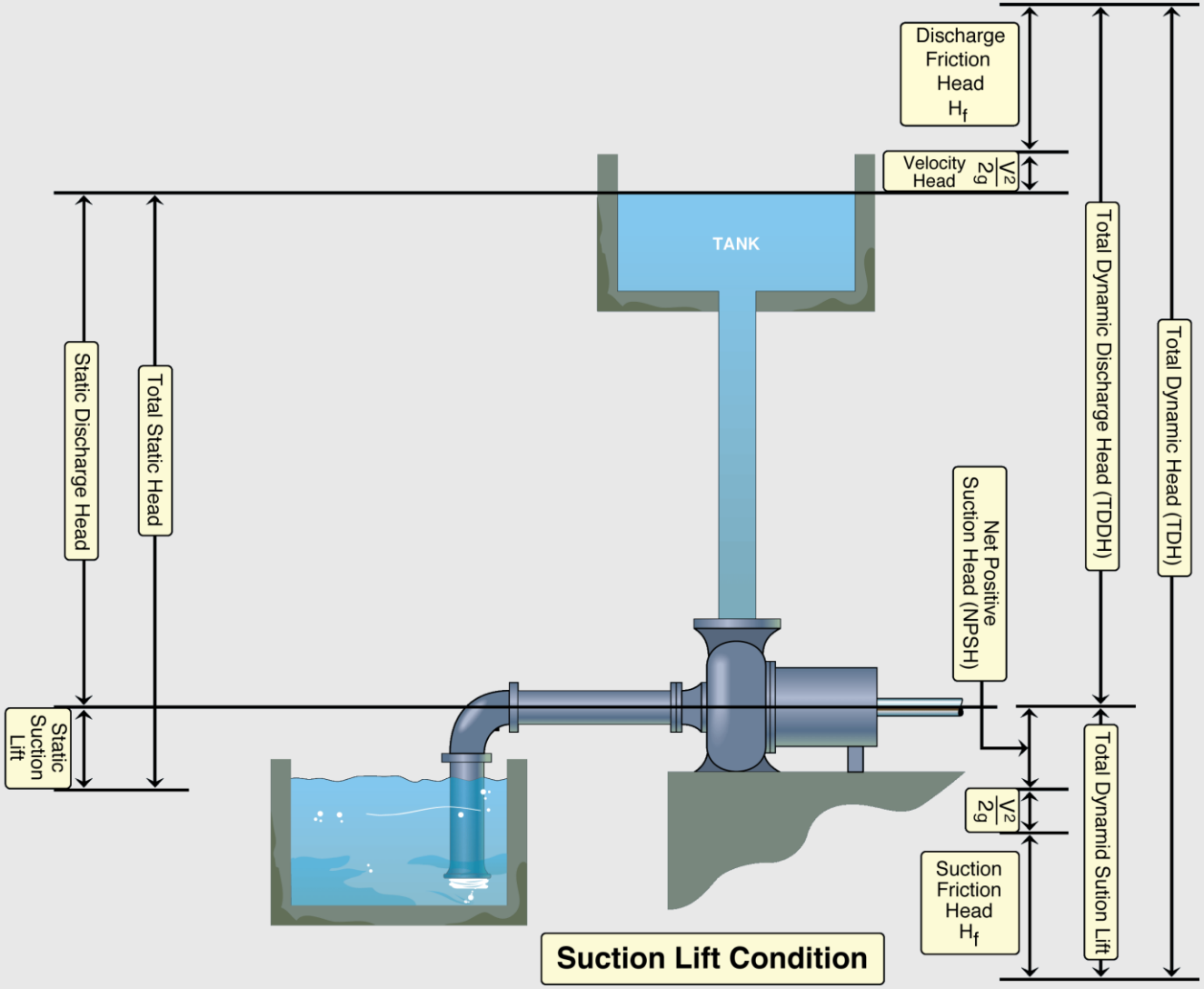
Total dynamic head

- As an example of calculatingTDH, let's look at a simple water transfer pump that needs to move water from a lower tank to an upper tank.
- The static head, Z, is 80ft.
- The velocity head is only 0.4 feet which is typical so it is not uncommon that velocity head is left out of the calculation.
- The 4" discharge pipe length is 399 feet and the 6" suction piping is 10 feet in length. So taking into account the head loss through both sections of pipe along with the head loss through the elbows we get a total head loss of 19.6 feet.
- Adding these all together we get a TDH of 80 + 19.6 + 0.4 = 100 feet.



Total dynamic head

- When the water level is below the centerline of the pump inlet, it is called a Suction Lift Condition



Total dynamic head

- When the water level is above the centerline of the pump inlet, it is called a Flooded Suction Condition

