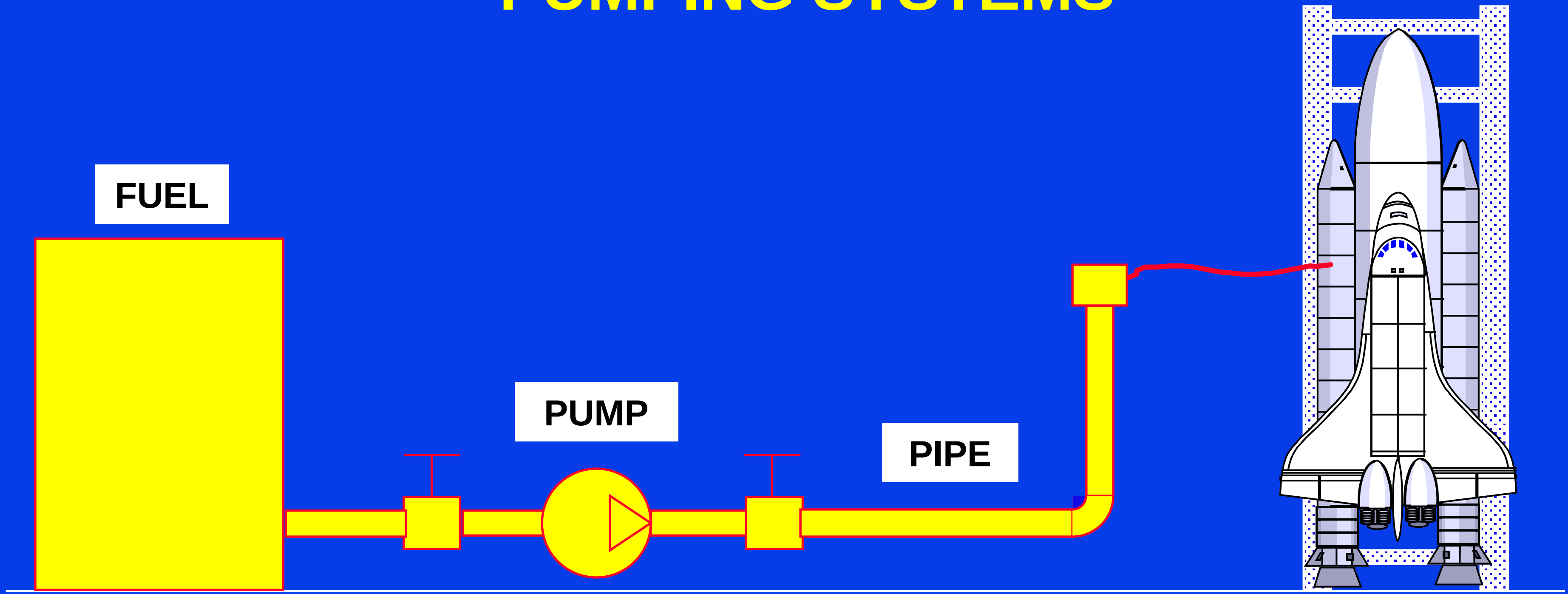
PUMPS
Theory and application

TERMS TO KNOW

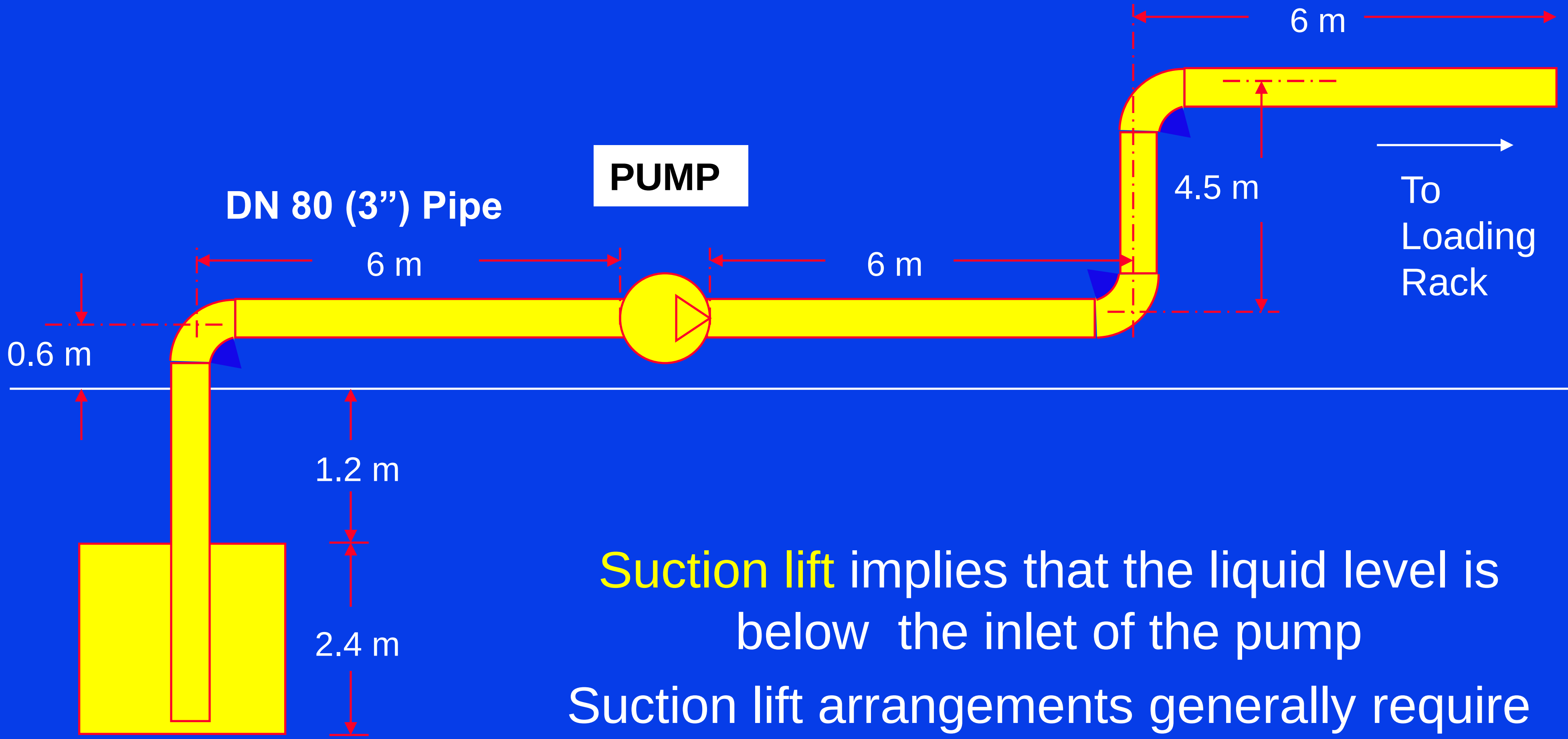
- Pumping System
- Suction lift
- Suction head
- Capacity (Flow Rate)
- Total Dynamic Head
- Static Head
- Dynamic Head
- System Curve
- Pump hydraulics
- Head
- NPSH

PUMPING SYSTEMS



- A pumping system consists of:
- all of the piping
- vessels
- and other types of equipment (valves, meters, elbows, etc.) that are ultimately interconnected to form a path for liquid to flow

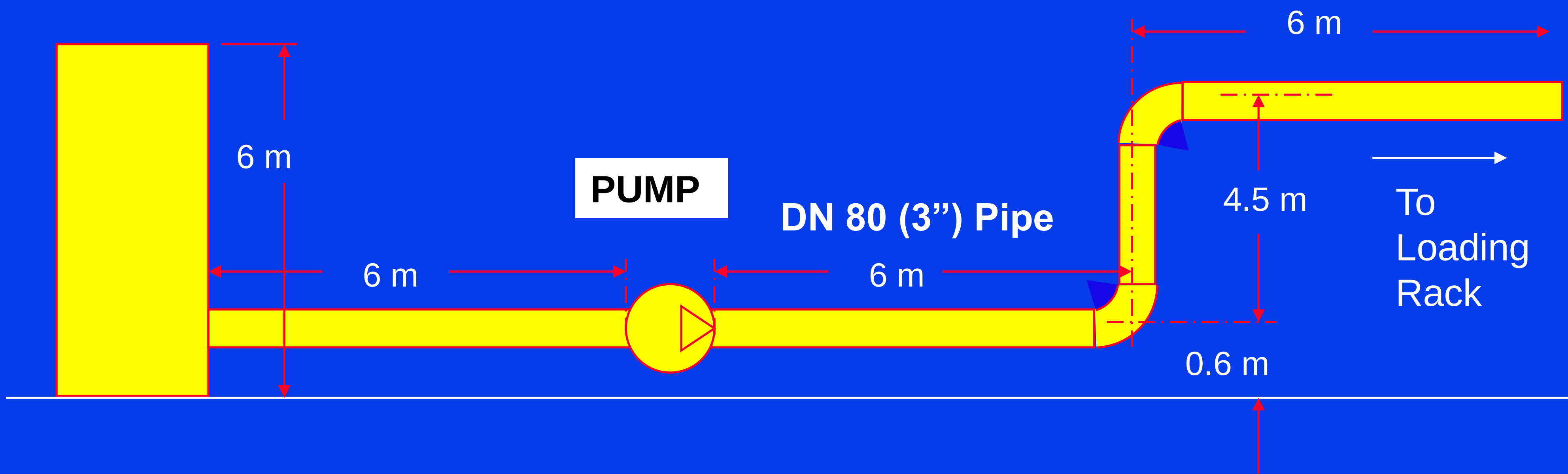
PUMPING SYSTEMS
" SUCTION LIFT "



Suction lift implies that the liquid level is below the inlet of the pump

Suction lift arrangements generally require a self-priming pump or manual priming

PUMPING SYSTEMS
" SUCTION HEAD "



Suction head implies that the liquid level is above the inlet of the pump

Flooded suction arrangements can use a straight centrifugal pump

Self-priming pumps are often used to handle liquids with high vapor pressures to avoid "vapor lock"

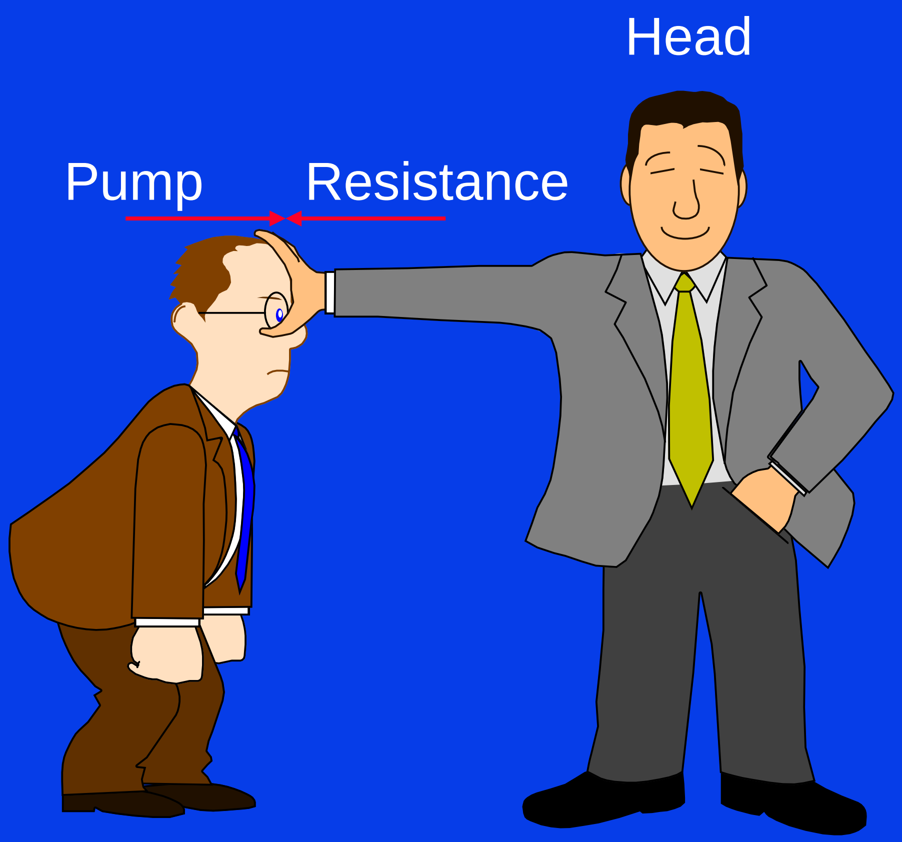
PUMPING SYSTEMS
" CAPACITY "

- The amount of liquid flowing through a pumping system is known as the capacity or flow rate

PUMPING SYSTEMS
" TOTAL DYNAMIC HEAD "

- A pump must overcome the resistance of a pumping system in order to cause a liquid to flow completely through the system

- Resistance to liquid flow is known as a pumping system's Head

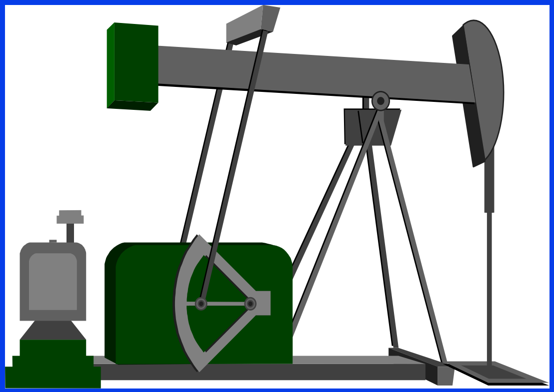


PUMPING SYSTEMS
“ TOTAL DYNAMIC HEAD ”

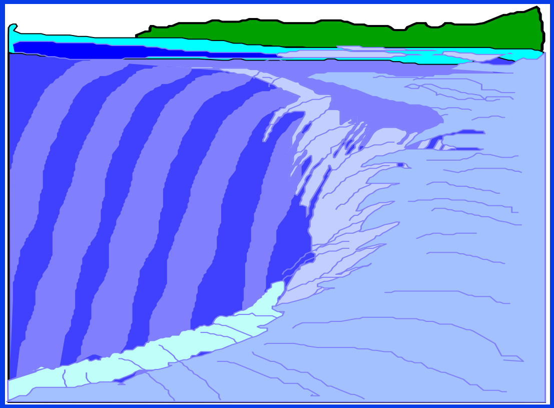
Total Dynamic Head is the sum of two parts:

Total Dynamic Head = Static Head + Dynamic Head

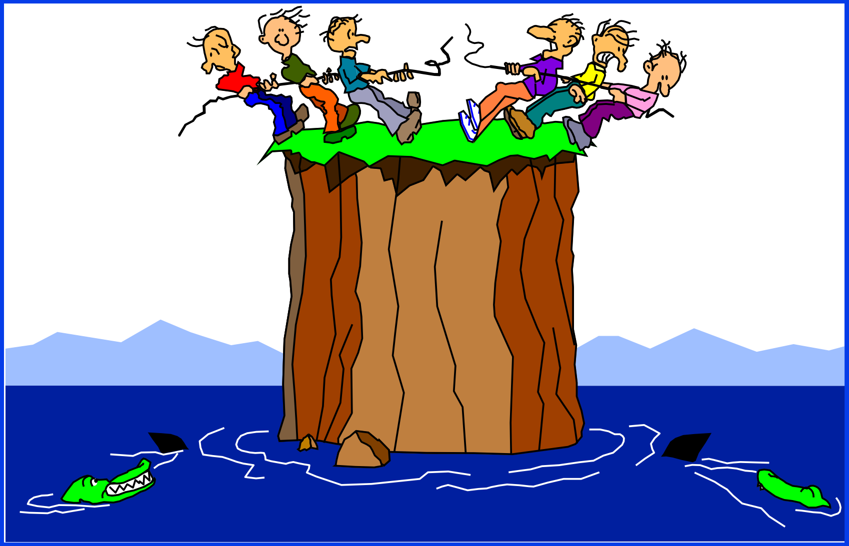
- Static head represents the resistance of a pumping system before the liquid is set into motion



- Dynamic head represents the resistance of a pumping system while the pumped fluid is in motion

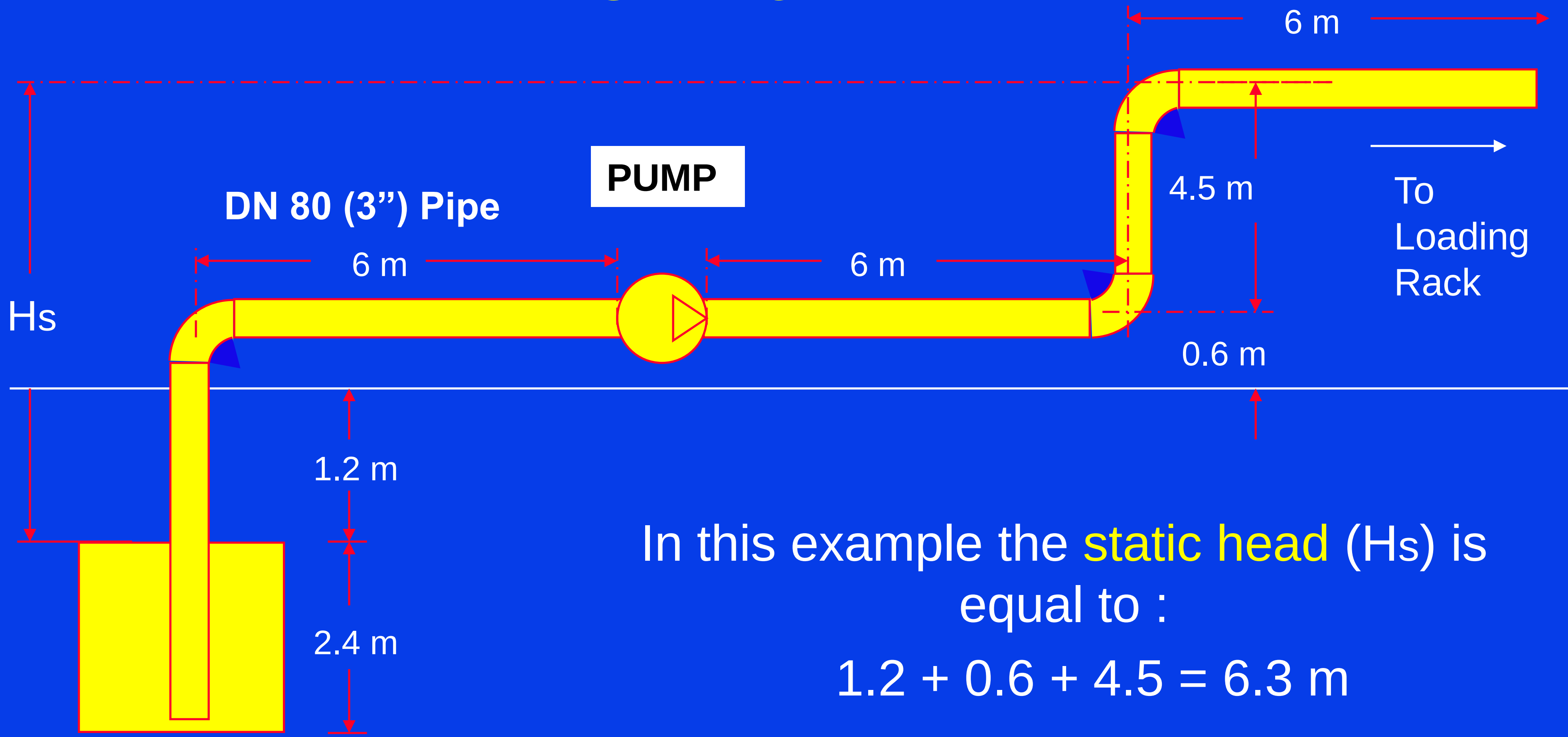


PUMPING SYSTEMS
“ STATIC HEAD ”



- The primary component of Static head is the elevation difference between :
  - the surface of the liquid at the point of suction
  - the surface of the liquid at the point of discharge
- Static head also accounts for the pressure differential between the point of suction and the point of discharge
- Static head does not vary with capacity

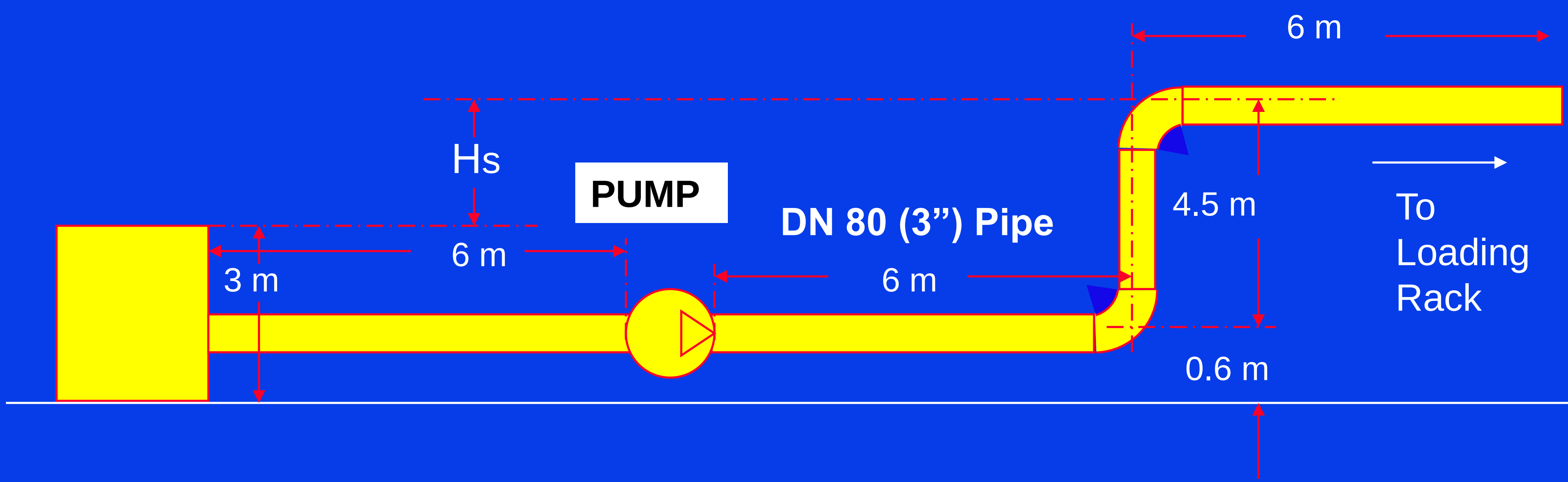
PUMPING SYSTEMS
“ STATIC HEAD ”



In this example the static head (Hs) is equal to :

1.2 + 0.6 + 4.5 = 6.3 m

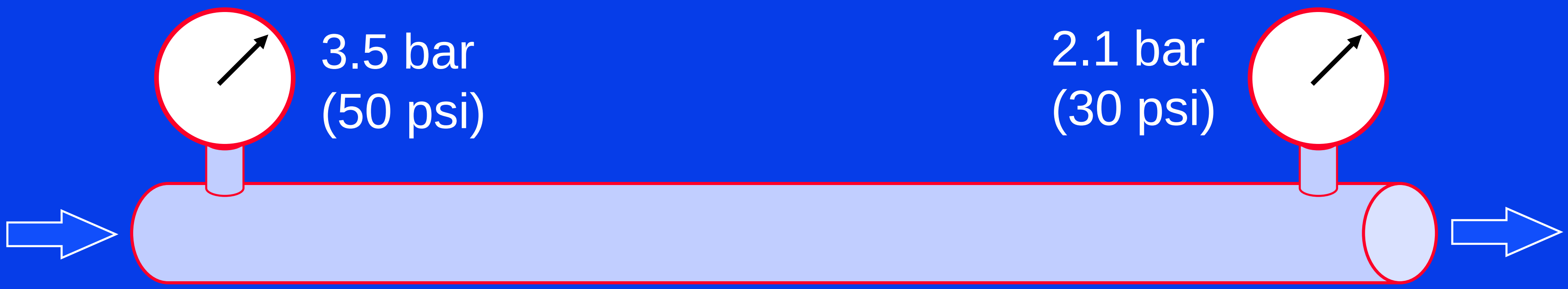
PUMPING SYSTEMS
" STATIC HEAD "



In this example the static head (Hs) is equal to :

4.5 + 0.6 - 3 = 2.1 m

PUMPING SYSTEMS
" DYNAMIC HEAD "



- Dynamic head losses are those losses that are realized once fluid begins to flow through the pumping system
- Dynamic head losses are a function of capacity

PUMPING SYSTEMS
“ FRICTION HEAD LOSSES ”

- **Every component of a pumping system has associated friction losses**
- Friction loss tables can be obtained from the component manufacturer or various other reference sources
- Friction losses are a function of capacity and component size

FITTINGS AND VALVES FRICTION LOSSES

Fittings and valves		diameter in mm (DN)											
		25	32	40	50	65	80	100	125	150	200	250	300
		equivalent lenght in m											
Elbow	45 °	0,3	0,3	0,6	0,6	0,9	0,9	1,2	1,5	2,1	2,7	3,3	3,9
	90°	0,6	0,9	1,2	1,5	1,8	2,1	3,0	3,6	4,2	5,4	6,6	8,1
	90° long radius	0,6	0,6	0,6	0,9	1,2	1,5	1,8	2,4	2,7	3,9	4,8	5,4
Fittings	Tee	1,5	1,8	2,4	3,0	3,6	4,5	6,0	7,5	9,0	10,5	15,0	18,0
	Cross	1,5	1,8	2,4	3,0	3,6	4,5	6,0	7,5	9,0	10,5	15,0	18,0
Gate valve		-	-	-	0,3	0,3	0,3	0,6	0,6	0,9	1,2	1,5	1,8
Non-return valve		1,5	2,1	2,7	3,3	4,2	4,8	6,6	8,3	10,4	13,5	16,5	19,5

This table considers fittings made in steel (coefficient C = 120) .

If you have different material , multiplied by :

1.38 if cast iron (C = 100)

0.76 if stainless steel or copper (C = 140)

PIPE FRICTION LOSS

Friction losses (for 100 m of new straight cast iron pipes)

Flow			Nominal diameter in mm and inches													
			15	20	25	32	40	50	65	80	100	125	150	175	200	250
m^3/h	l/min		1/2"	3/4"	1"	1¼"	1½"	2"	2½"	3"	4"	5"	6"	7"	8"	10"
3	50	V	4.72	2.65	1.7	1.04	0.66	0.42								
		hr	246	58.2	21.1	5.6	1.75	0.61								
3.6	60	V		3.18	2.04	1.24	0.8	0.51								
		hr		82	30	8	2.48	0.86								
4.2	70	V		3.72	2.38	1.45	0.93	0.59								
		hr		110	40	10.8	3.33	1.14								
4.8	80	V		4.25	2.72	1.66	1.06	0.68								
		hr		141	51.5	13.9	4.3	1.46								
5.4	90	V			3.06	1.87	1.19	0.76	0.45							
		hr			64	17.5	5.4	1.82	0.46							
6	100	V			3.4	2.07	1.33	0.85	0.5							
		hr			79	21.4	6.6	2.22	0.56							
9	150	V				3.11	1.99	1.27	0.75	0.5						
		hr				47	14.2	4.74	1.21	0.43						
12	200	V				4.15	2.65	1.7	1.01	0.66						
		hr				82	24.5	8.1	2.1	0.74						
15	250	V				5.18	3.32	2.12	1.26	0.83	0.53					
		hr				126	37.5	12.3	3.2	1.12	0.36					
18	300	V					3.98	2.55	1.51	1	0.64					
		hr					53	17.3	4.5	1.58	0.51					
24	400	V					5.31	3.4	2.01	1.33	0.85					
		hr					92	29.5	7.8	2.7	0.89					
30	500	V					6.63	4.25	2.51	1.66	1.06	0.68				
		hr					140	44.8	12	4.13	1.36	0.48				
36	600	V						5.1	3.02	1.99	1.27	0.82				
		hr						63	16.9	5.8	1.93	0.68				
42	700	V						5.94	3.52	2.32	1.49	0.95				
		hr						84	22.6	7.8	2.6	0.9				
48	800	V						6.79	4.02	2.65	1.70	1.09	0.75			
		hr						108	29	10	3.35	1.16	0.43			
54	900	V						7.64	4.52	2.99	1.91	1.22	0.85			
		hr						134	36	12.5	4.2	1.45	0.54			
60	1000	V							5.03	3.32	2.12	1.36	0.94			
		hr							44.5	15.2	5.14	1.76	0.66			
90	1500	V							7.54	4.98	3.18	2.04	1.42	1.04		
		hr							96	32.6	11.2	3.77	1.42	0.68		
120	2000	V								6.63	4.25	2.72	1.89	1.39	1.06	0.68
		hr								56	19.4	6.5	2.43	1.18	0.58	0.16

V = Water speed (m/sec)
hr = Friction losses (m/100 m of pipe)
Multiply friction losses by :
0,8 for stainless steel pipes
1,25 for slighty rusty steel pipes
1,7 for encrusted pipes (in which scales reduce inner diameter)
0,7 for aluminium pipes
0,7 for PVC and PE pipes
1,3 for fiber-cement pipes

Hazen-William's formula :

$$p = \frac{6{,}05 \times Q^{1{,}85} \times 10^{6}}{C^{1{,}85} \times d^{4{,}87}} \times L$$

P = friction loss (meter/1 meter of pipe)

Q = flow (litres/minute)

C = coefficient in according to type of pipe

for cast iron pipes = 100

for steel pipes = 120

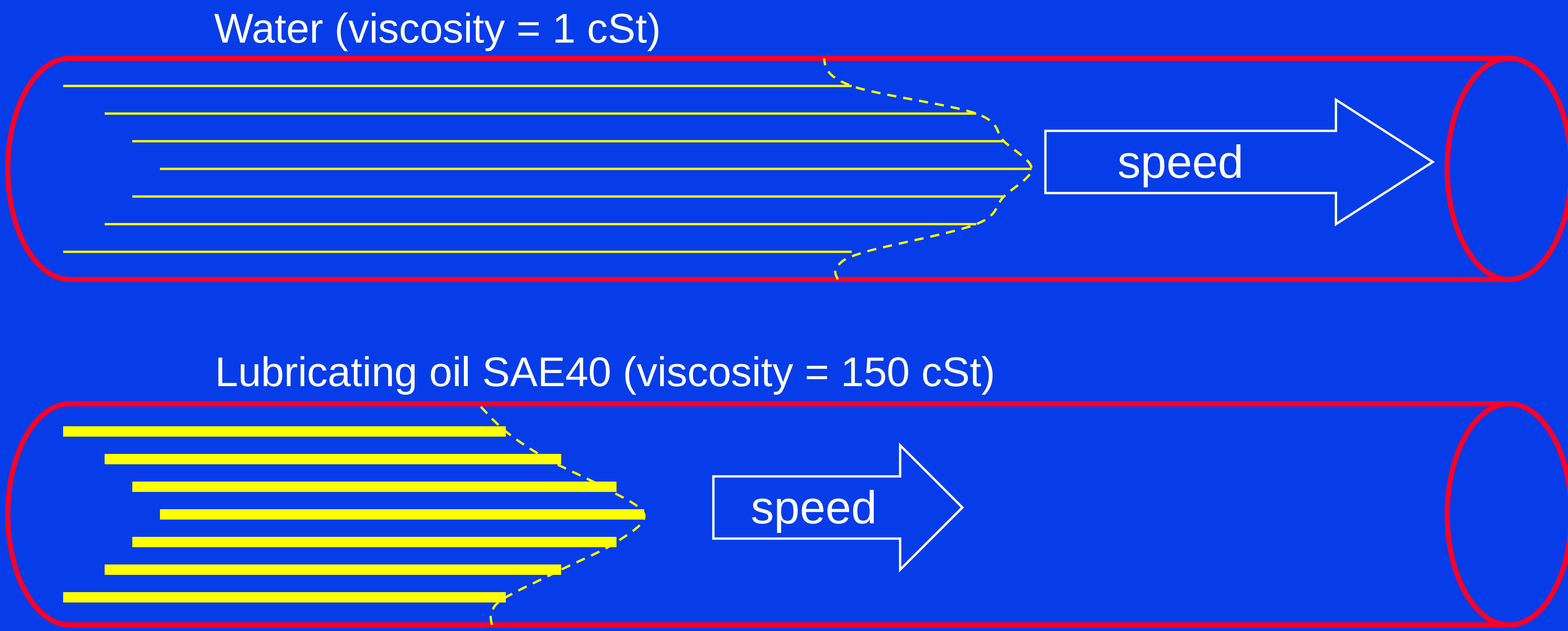
for stainless steel and copper pipes = 140

d = inner diameter (mm)

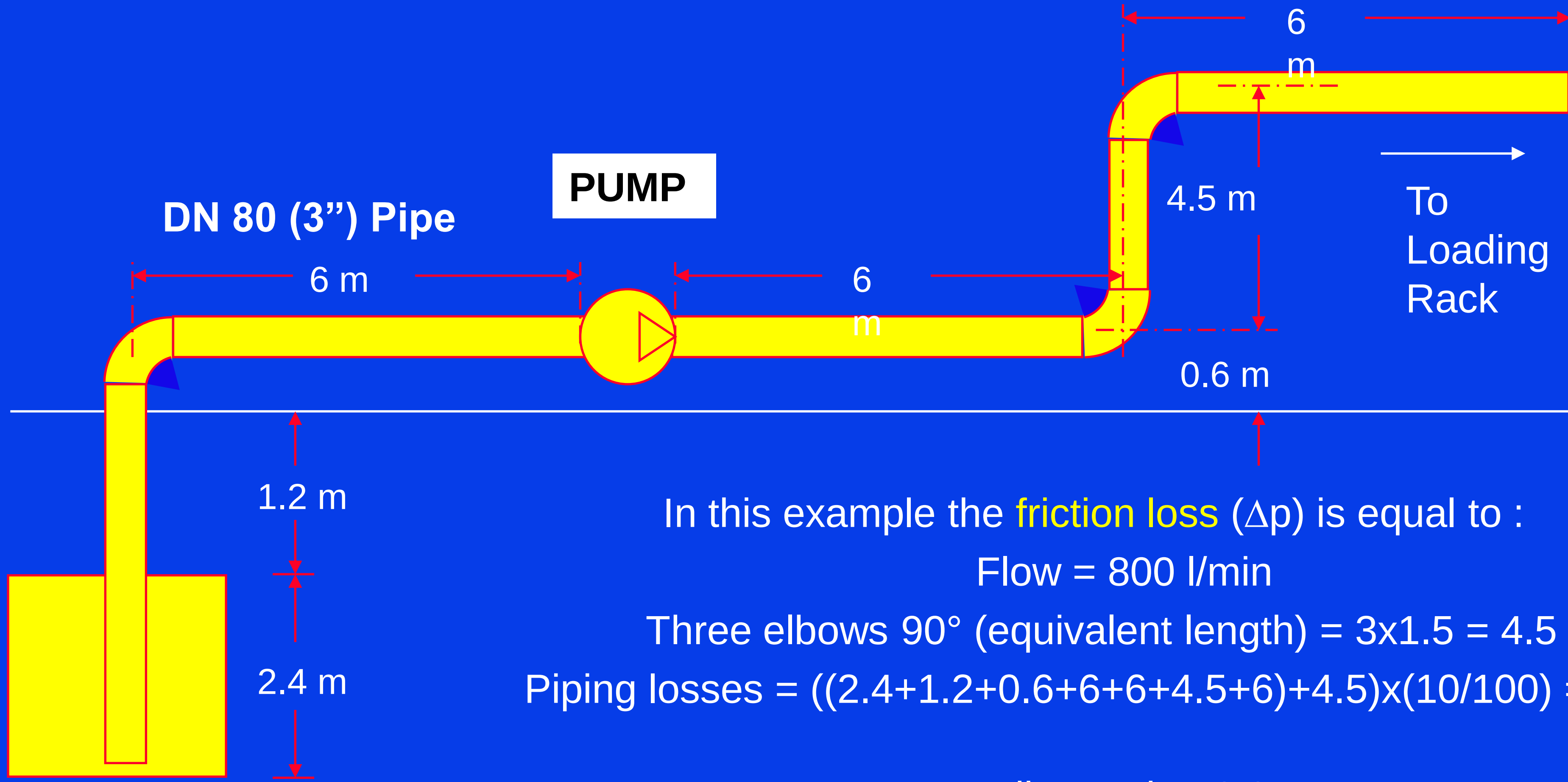
L = pipe lenght (m)

PUMPING SYSTEMS
" FRICTION HEAD LOSSES "

- A typical friction loss table for piping illustrates friction losses as a function of capacity, pipe diameter, pipe length and viscosity



PUMPING SYSTEMS
“ FRICTION HEAD LOSSES ”



In this example the friction loss (Δp) is equal to :

Flow = 800 l/min

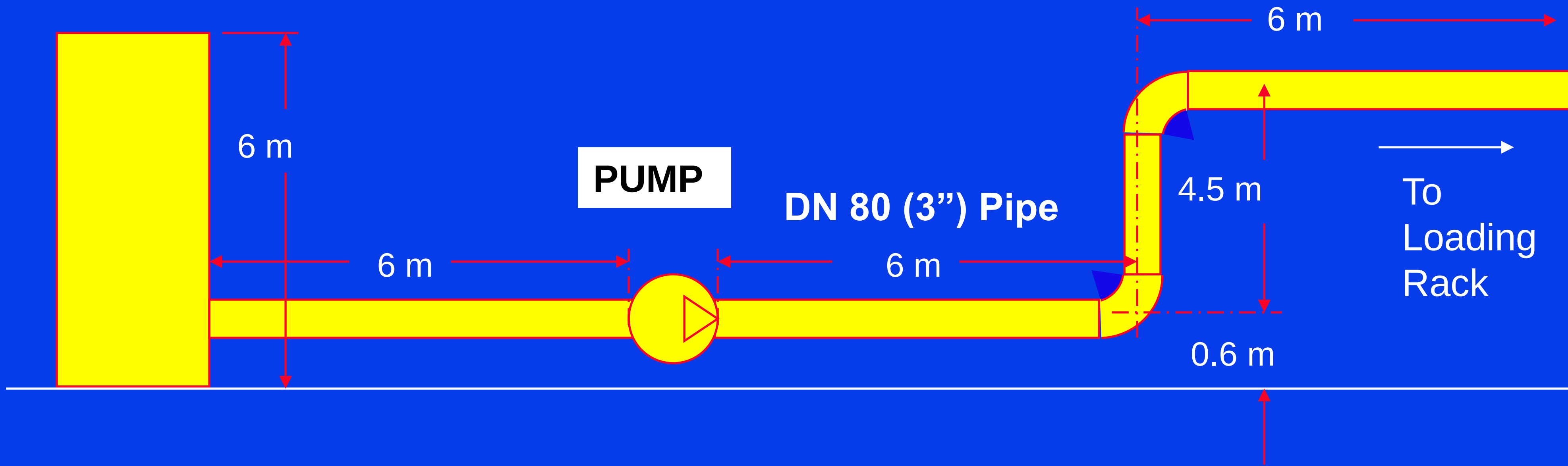
Three elbows 90° (equivalent length) = 3x1.5 = 4.5 m

Piping losses = ((2.4+1.2+0.6+6+6+4.5+6)+4.5)x(10/100) = 3.12 m

Loading rack = 2.8 m

Total friction losses = 3.12+2.8 = 5.92 m

PUMPING SYSTEMS
“ FRICTION HEAD LOSSES ”



In this example the friction losses (Δp) is equal to :

Flow = 800 l/min

Two elbows 90° (equivalent length) = 2x1.5 = 3.0 m

Piping losses = ((6+6+4.5+6)+3.0)x(10/100) = 2.55 m

Loading rack = 2.8 m

Total friction losses = 2.55+2.8 = 5.35 m

PUMPING SYSTEMS
" TOTAL DYNAMIC HEAD "

- The pumping system's total dynamic head is simply the sum of the system's static head and dynamic head

Static Head

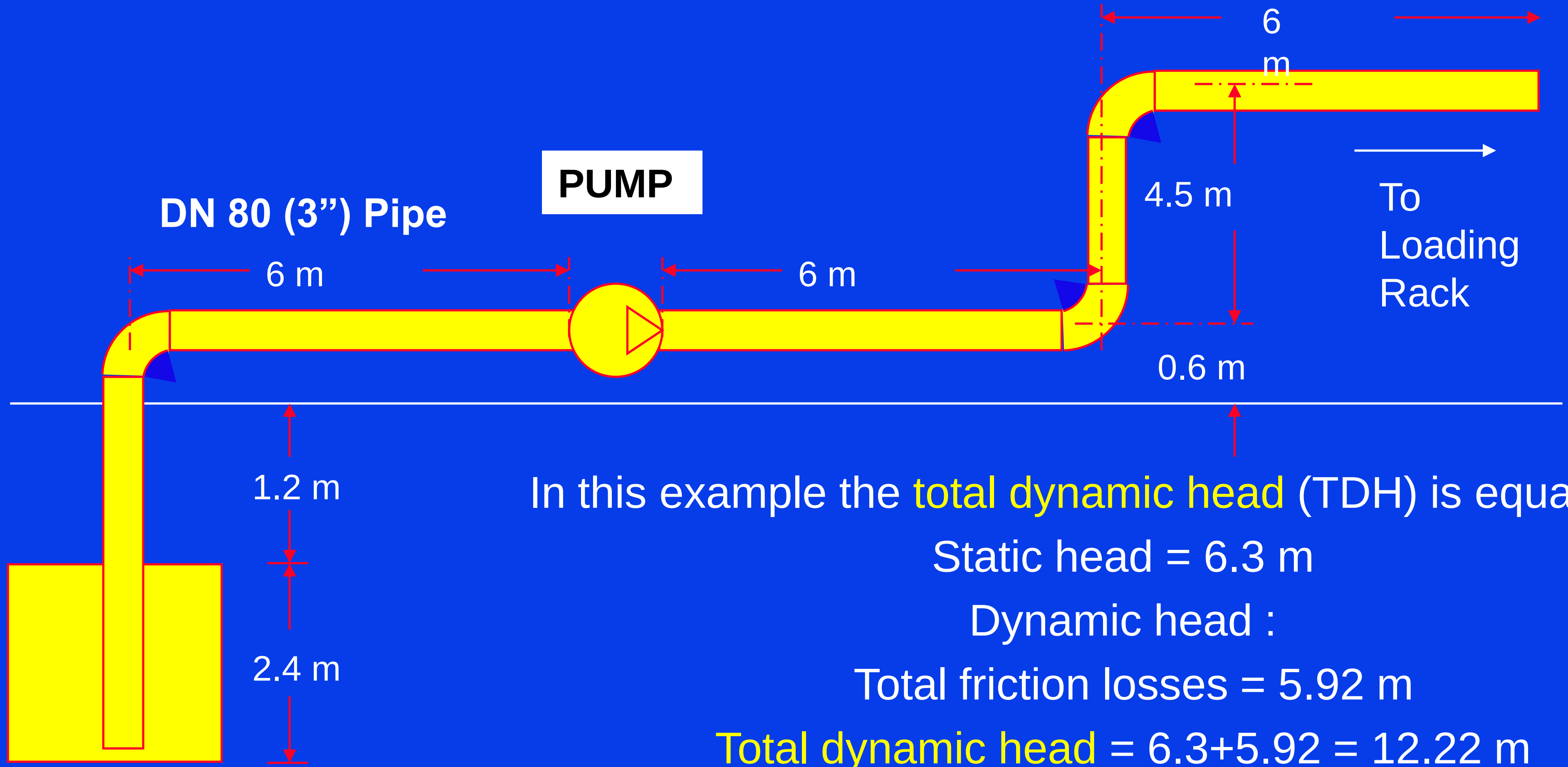
+

Dynamic Head

=

Total Dynamic Head

PUMPING SYSTEMS
“ TOTAL DYNAMIC HEAD ”



In this example the total dynamic head (TDH) is equal to :

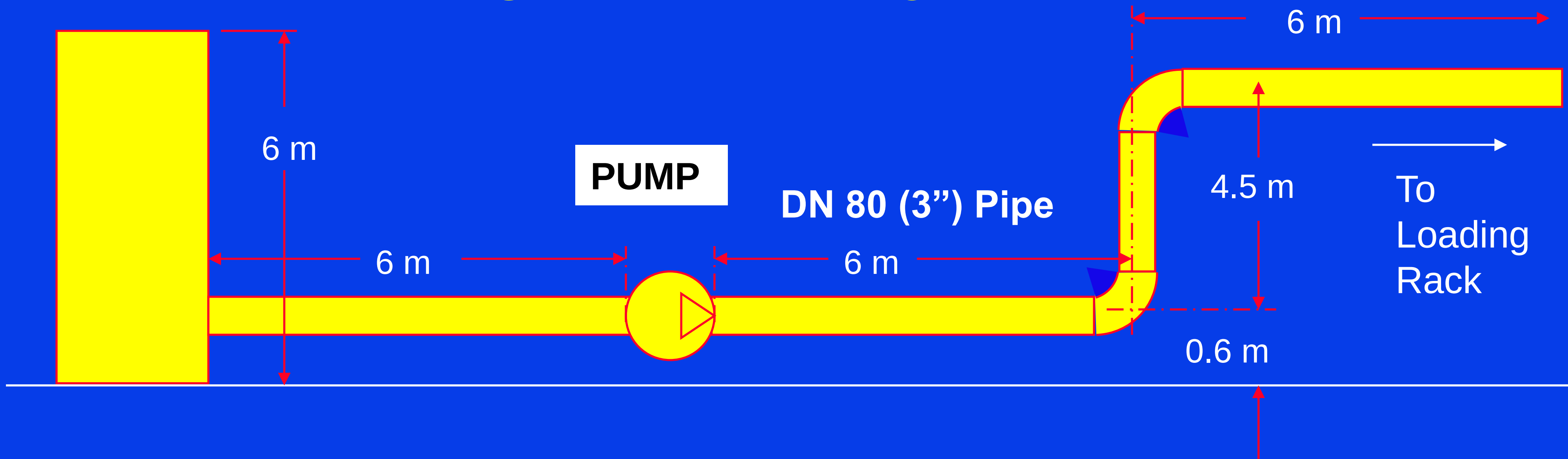
Static head = 6.3 m

Dynamic head :

Total friction losses = 5.92 m

Total dynamic head = 6.3+5.92 = 12.22 m

PUMPING SYSTEMS
" TOTAL DYNAMIC HEAD "



In this example the total dynamic head (TDH) is equal to :

Static head = -0.9 m

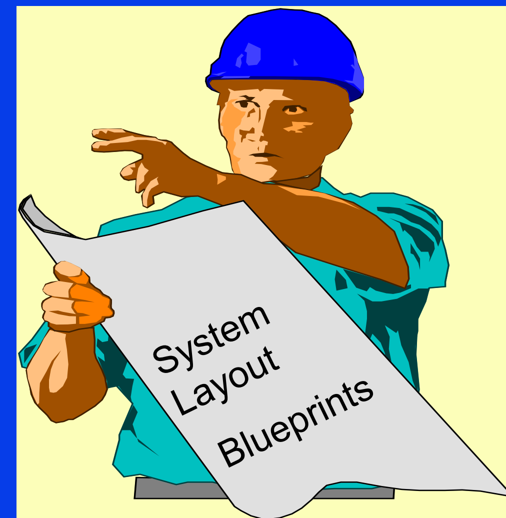
Dynamic head :

Total friction losses = 5.35 m

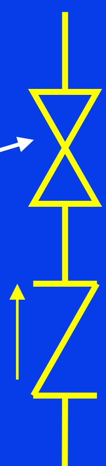
Total dynamic head = -0.9+5.35 = 4.45 m

PUMPING SYSTEMS
“ MENTAL NOTE ”

- It is a good system design practice to include suction and discharge valves in a pumping system.

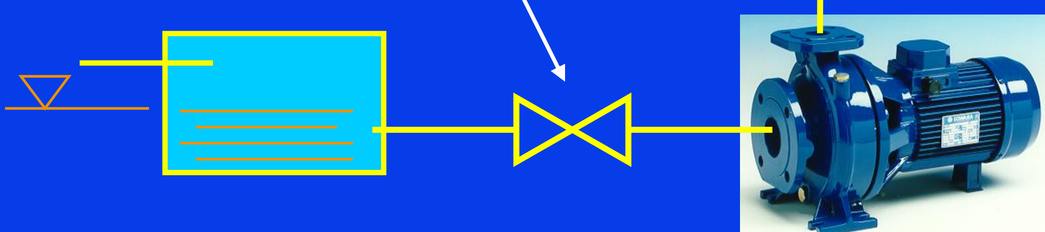


- Using the discharge valve as a throttling valve to control the pump



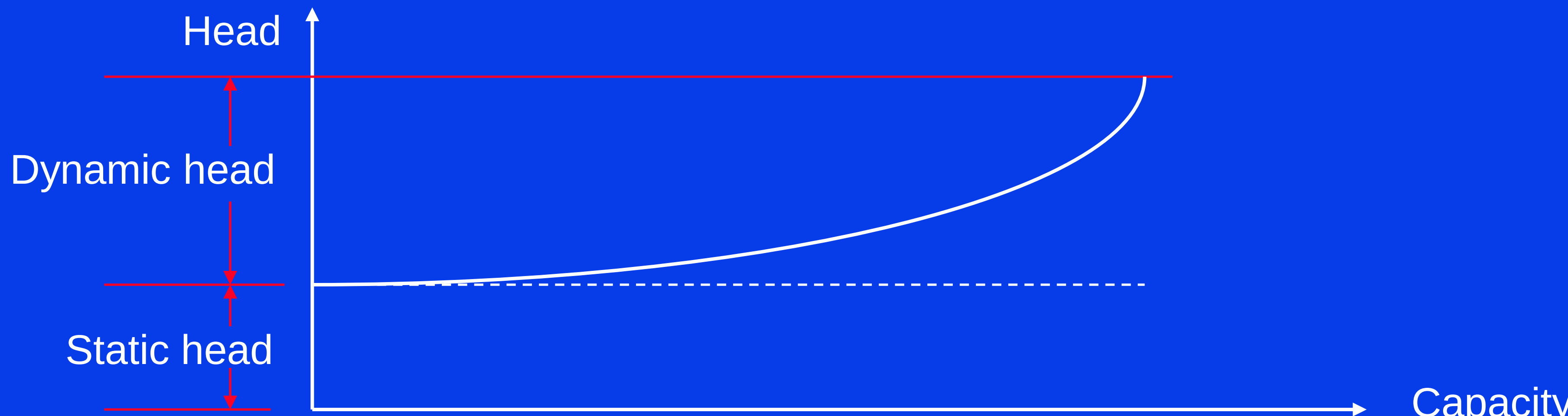
- Isolating the pump for maintenance considerations

- A check valve may also be required in high discharge head applications (to prevent water flowing back through the pump)



PUMPING SYSTEMS
" SYSTEM CURVE "

A System Curve is a graphical representation of the resistance behaviour (TDH) of a piping system over it's entire capacity range

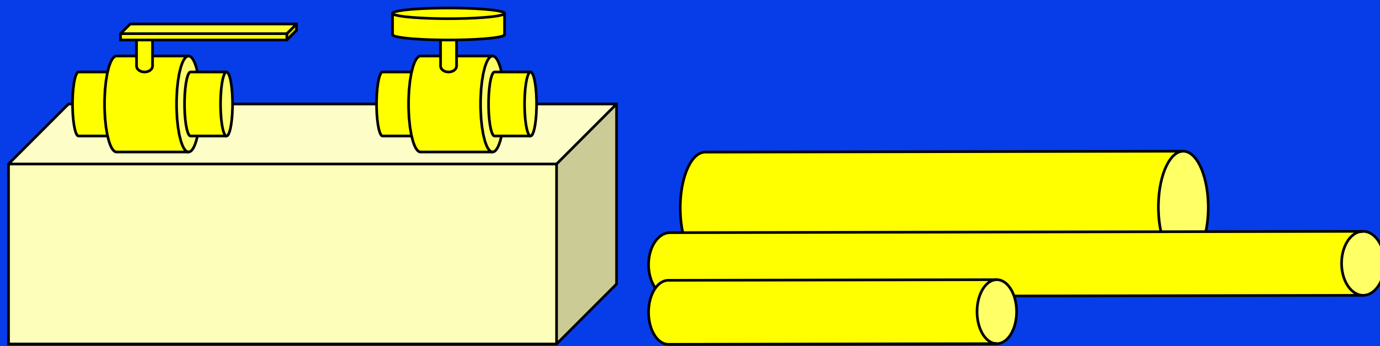


- A system curve shows:

- the static head component (which is constant over the entire capacity range)
- the dynamic head component (which increases with capacity)

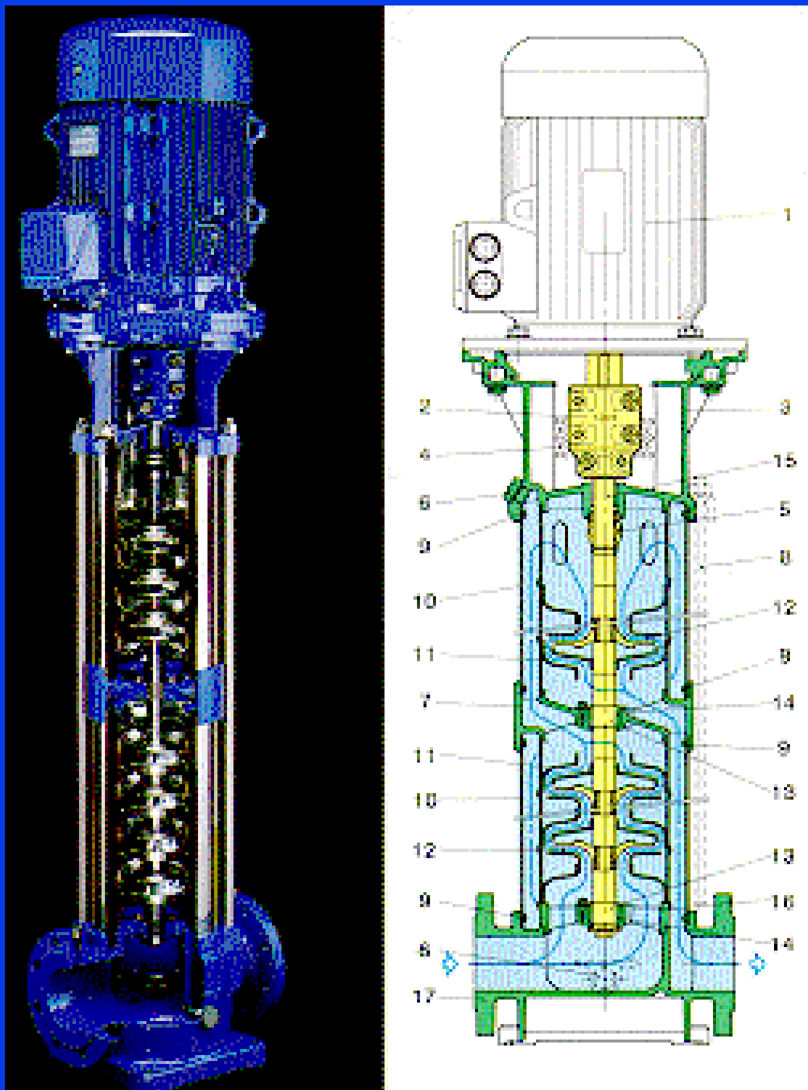
PUMPING SYSTEMS
" SYSTEM CURVE "

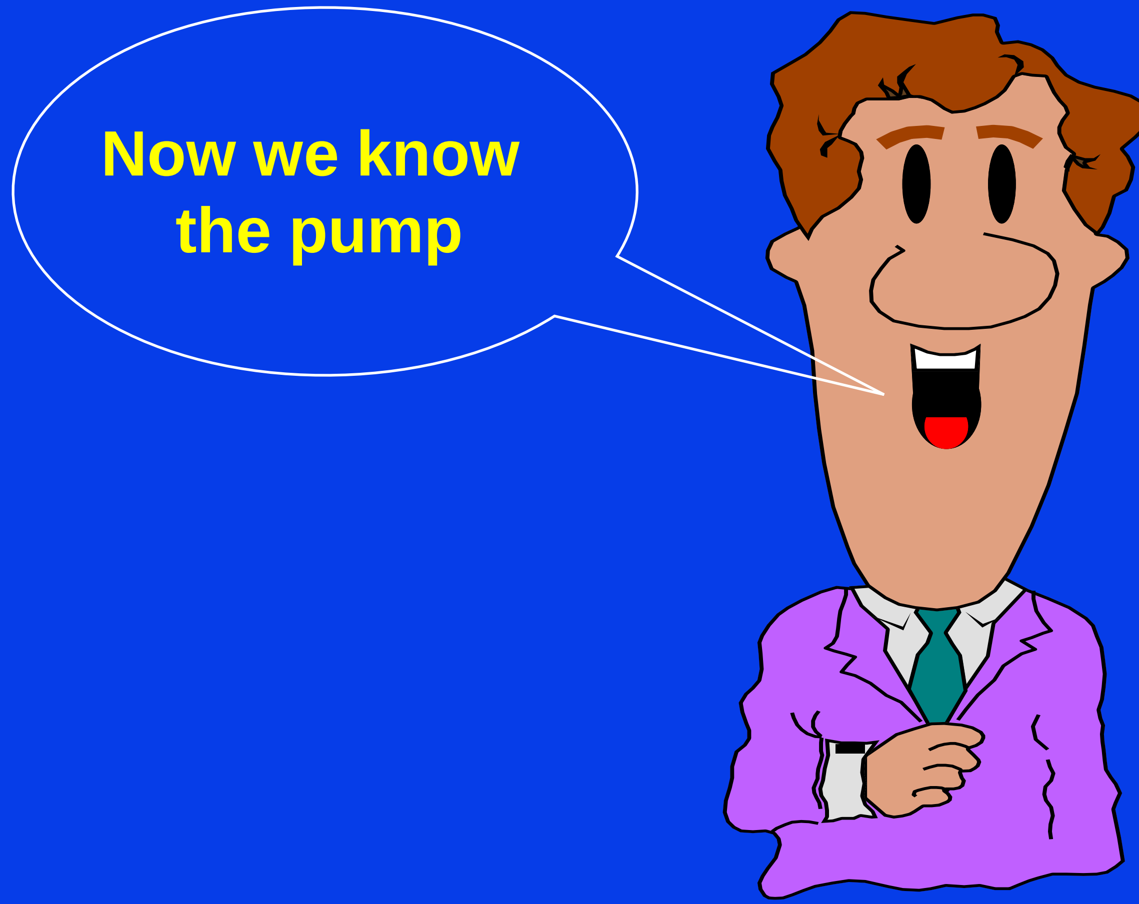
The system designer can change the shape of the System curve by altering the size of piping, type of equipment, and physical layout of the pumping system



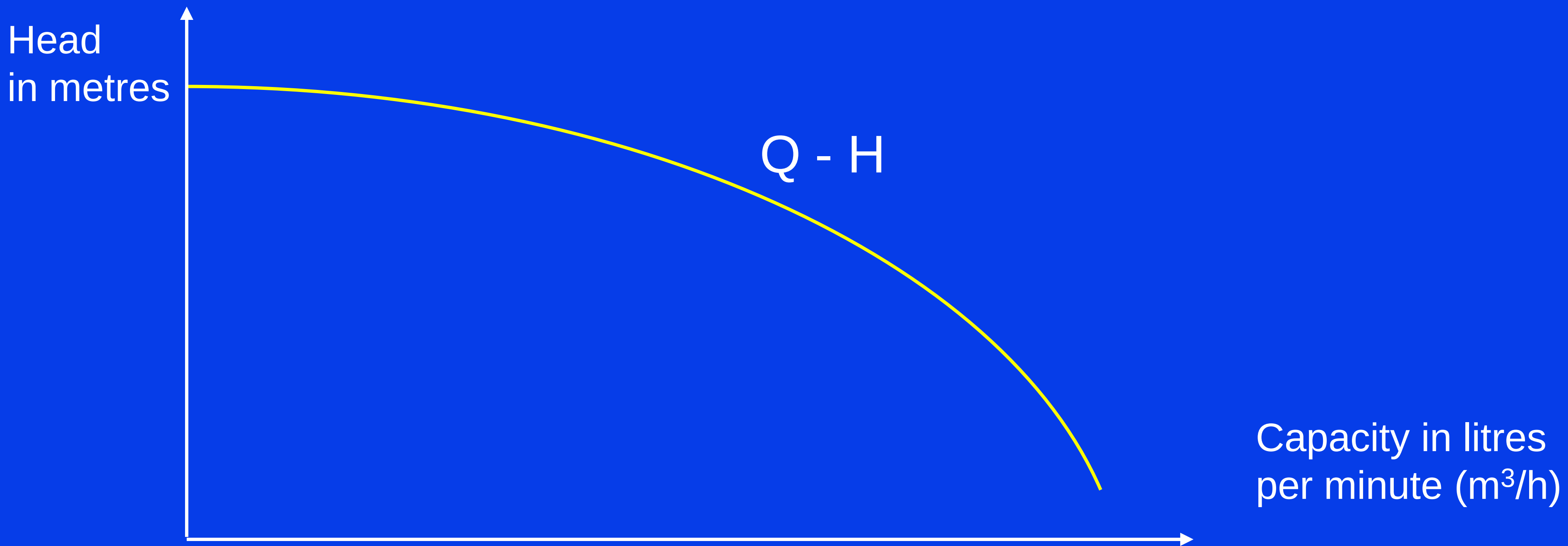
The end user can change the shape of the System curve by opening or closing system valves, changing equipment or piping layouts, and varying the liquid levels in the suction or discharge tanks

PUMP HYDRAULICS





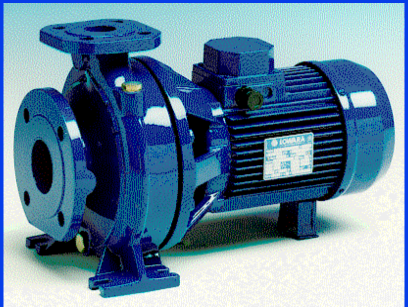
PUMP HYDRAULICS
“ CENTRIFUGAL PUMP CURVE ”

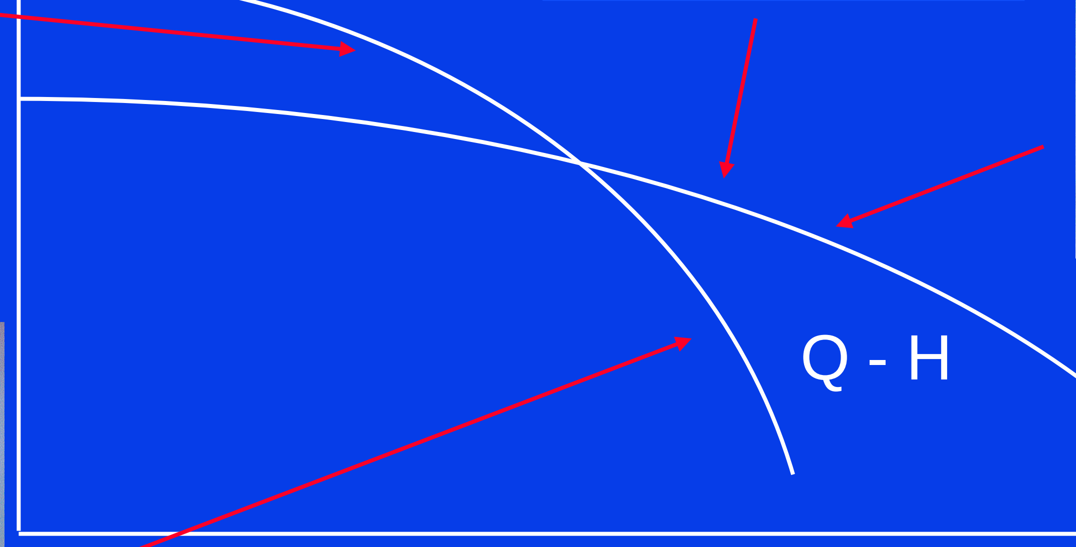


The performance of a centrifugal pump is graphically represented on a head-capacity curve

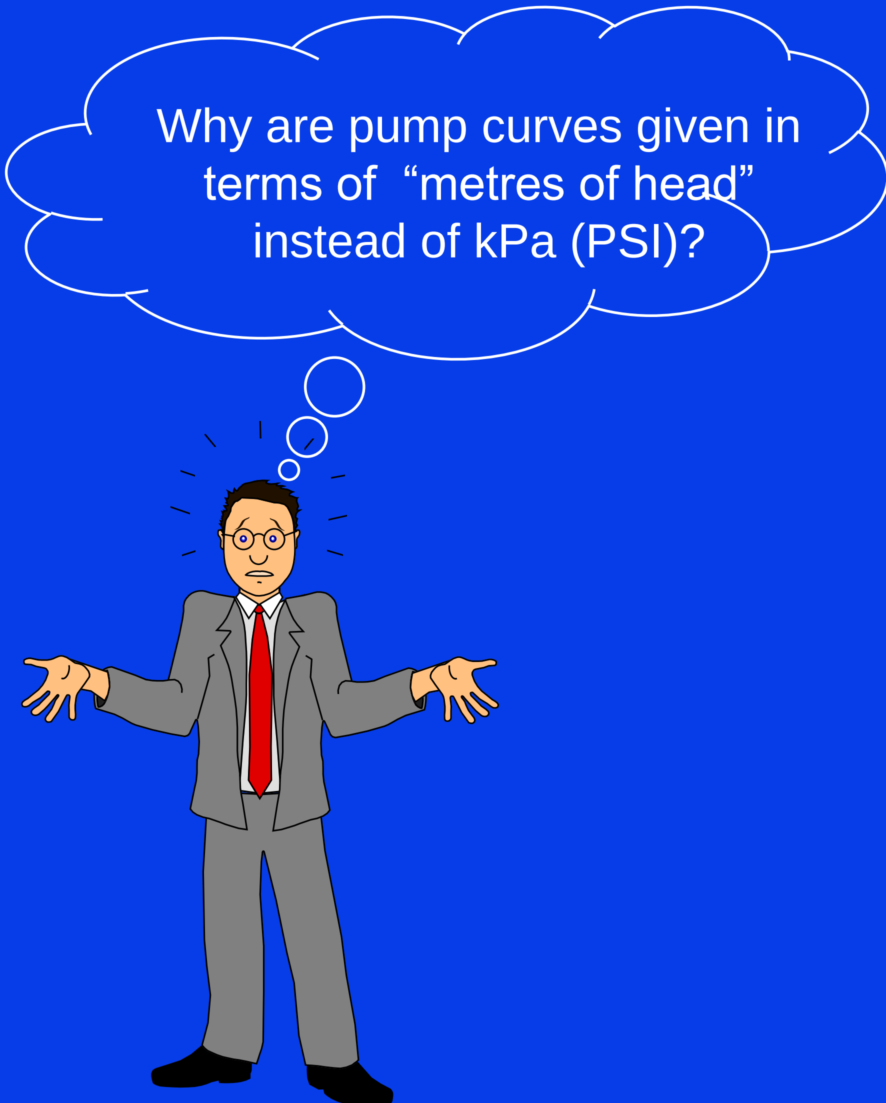
The shape of a Head-Capacity curve is a function of the size and design of the pump, the impeller diameter, and the speed of operation

PUMP HYDRAULICS
“ CENTRIFUGAL PUMP CURVE ”

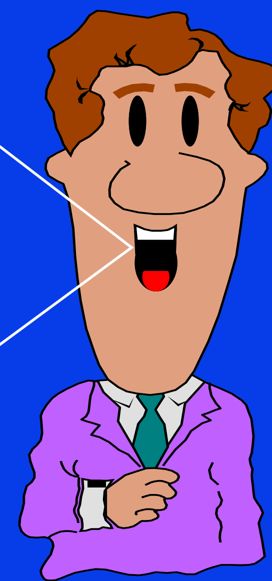




PUMP HYDRAULICS
“ CENTRIFUGAL PUMP CURVE ”



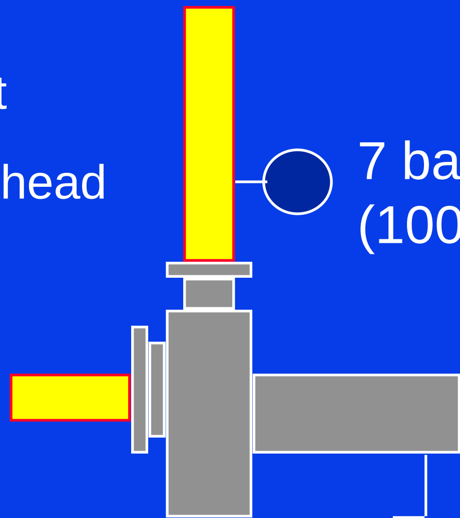
- A given pump will generate the same “metres of head”’ regardless of the liquid being pumped but...
- ...the discharge pressure will vary with the specific gravity of the liquid!
- Centrifugal pumps develop head - not pressure!



PUMP HYDRAULICS
“ HEAD - PRESSURE ”

Water at

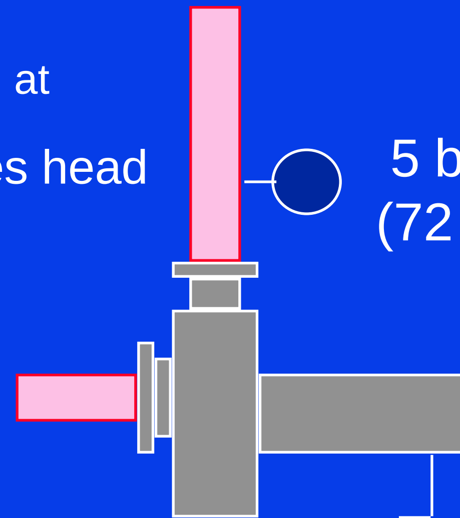
70 metres head



7 bar
(100 psi)

Petrol at

70 metres head

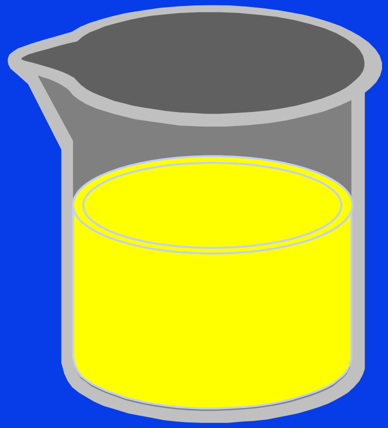


5 bar
(72 psi)

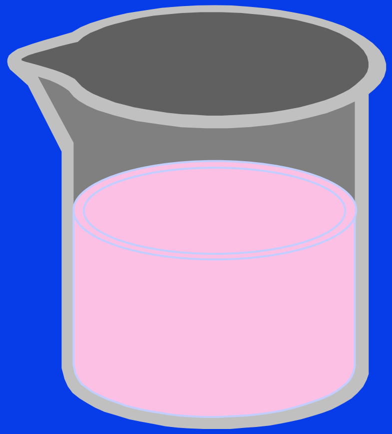
Two identical pumps operating in identical systems will develop the same “head” but...

discharge gauges will give different readings if the specific gravity of the liquids being pumped is different

PUMP HYDRAULICS
“ SPECIFIC GRAVITY ”



Water
= 1 Kg/litre (8.33 lbs/gal)



Petrol
= 0.72 Kg/litre (6.0 lbs/gal)

- Specific gravity is the ratio of the weight of a liquid to its volume
- Relative specific gravity is the ratio of the weight of a liquid to the weight of water
- The relative specific gravity of gasoline is 0.72 / 1 = 0.72

PUMP HYDRAULICS
“ SPECIFIC GRAVITY ”

- Is very important because :

It affects the absorbed power (brake horsepower) requirements of the pump

absorbed power by pump = capacity x head x specific gravity ÷ efficiency

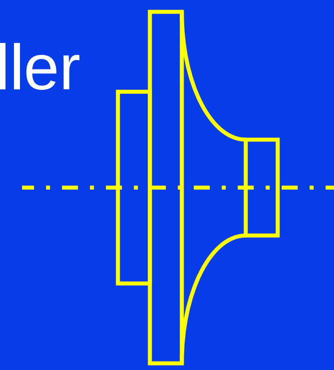
All pressure information is converted to “metres of head “ by using the specific gravity of the liquid being pumped

More on this later...Now back to our show!

PUMP HYDRAULICS
“ CENTRIFUGAL PUMP CURVE ”

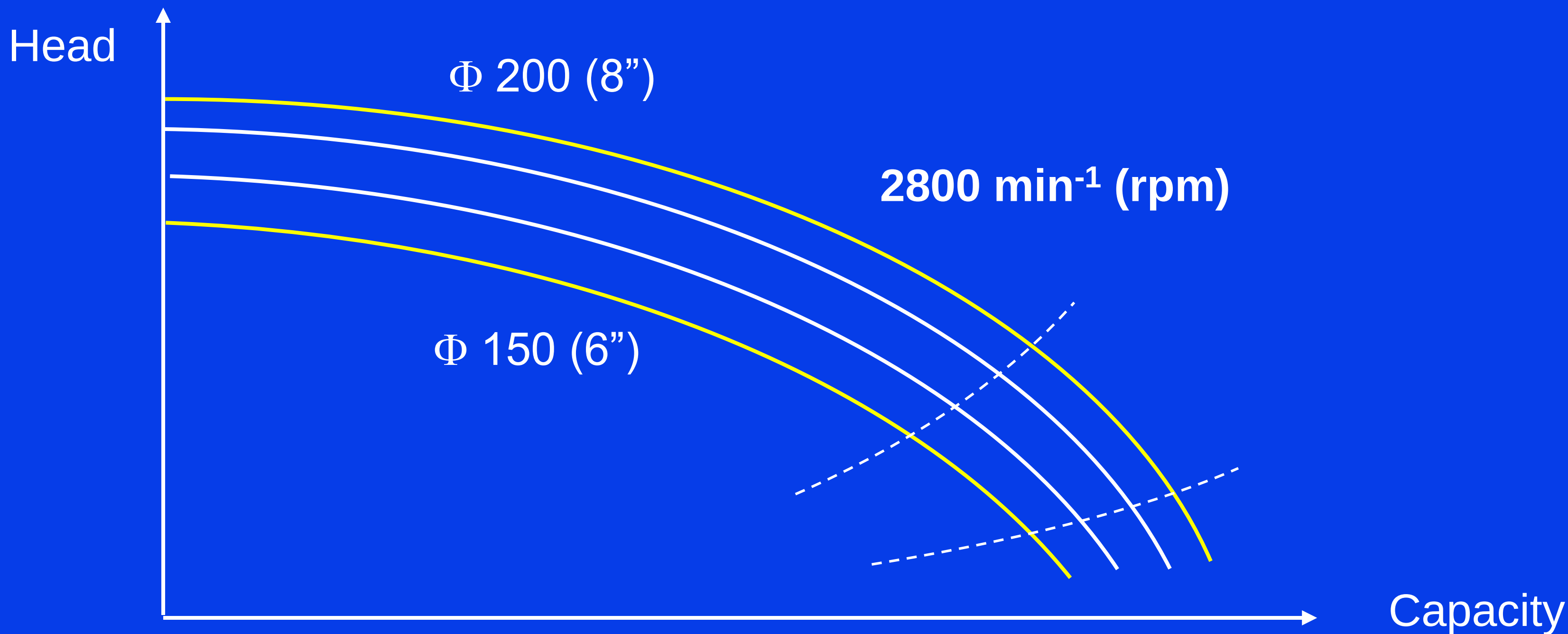
- The H-Q curve for a particular pump is a function of :

- The impeller diameter



- And the speed of operation

PUMP HYDRAULICS
“ CENTRIFUGAL PUMP CURVE ”



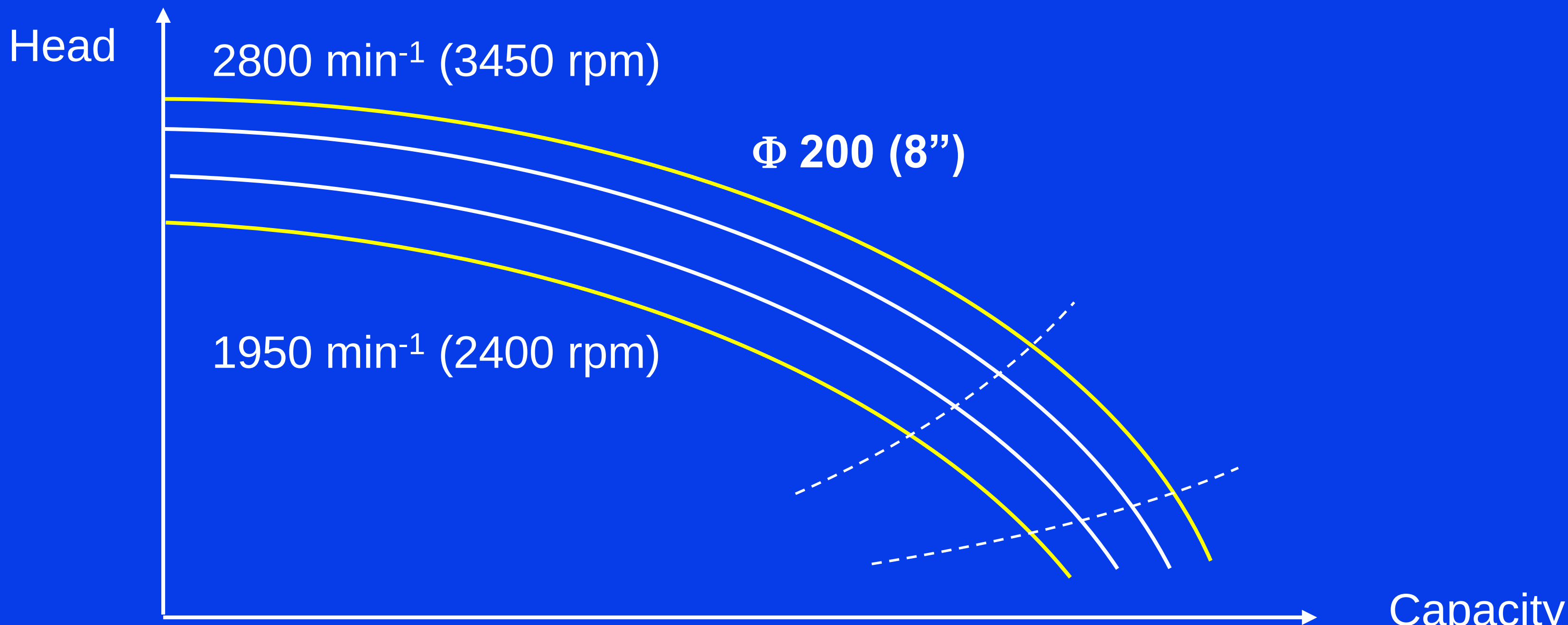
Holding speed constant, the H-Q curve for any given pump can be shifted by varying the impeller diameter

Affinity laws :

capacity $Q_1 / Q_2 = d_1 / d_2$

head $H_1 / H_2 = (d_1 / d_2)^2$

PUMP HYDRAULICS
" CENTRIFUGAL PUMP CURVE "



Holding impeller diameter constant, the H-Q curve for any given pump can be shifted by varying the pump speed

Affinity laws :

capacity $Q_1 / Q_2 = n_1 / n_2$

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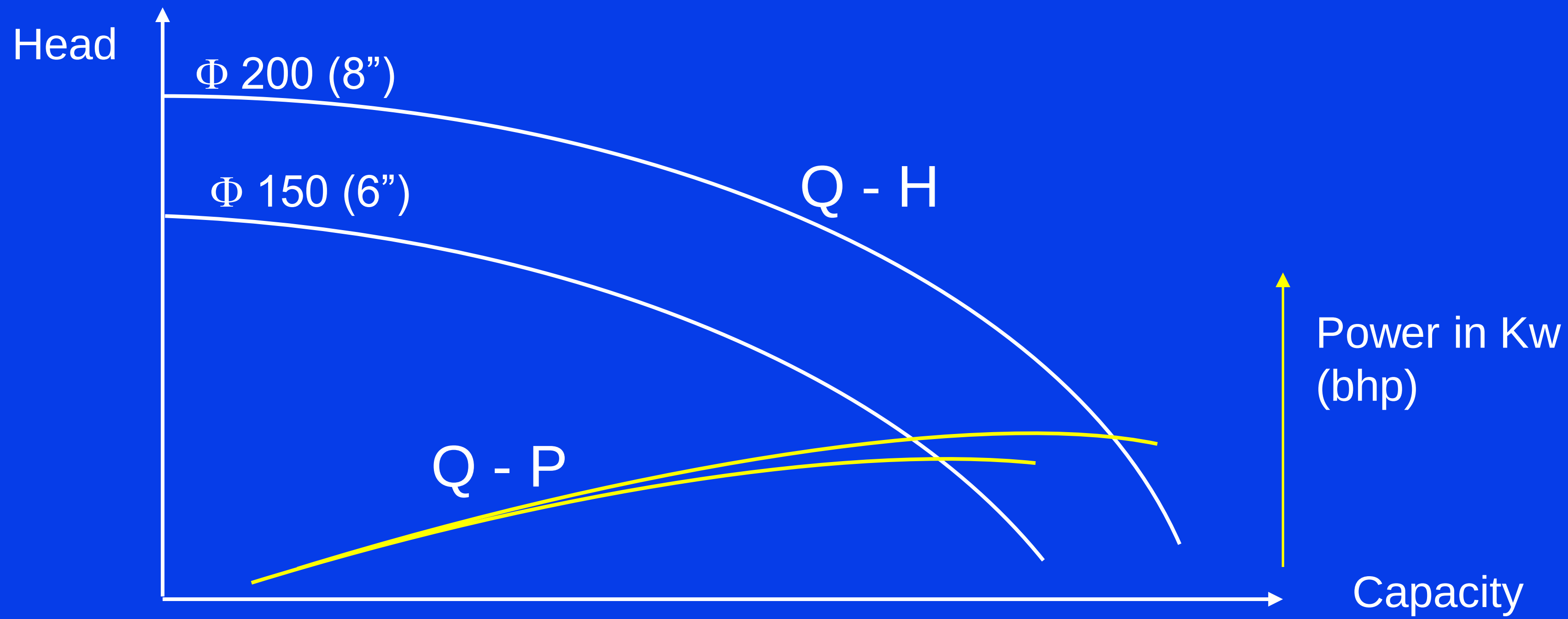
PUMP HYDRAULICS
" CENTRIFUGAL PUMP CURVE "



Pump curves typically show the "absorbed power"(brake horsepower) required to operate the pump at various points along it's Head-Capacity curve

The absorbed power shown on the curve is based on pumping water (specific gravity = 1.0)

PUMP HYDRAULICS
" CENTRIFUGAL PUMP CURVE "

The actual absorbed power must be corrected for specific gravity

Absorbed power Correction

Simply multiply the absorbed power shown on the curve by the specific gravity of the liquid being pumped

For example, if it takes 4 Kw (5.5 Hp) to pump water it will take

4 x 0.72 = 2.9 Kw (4 Hp)

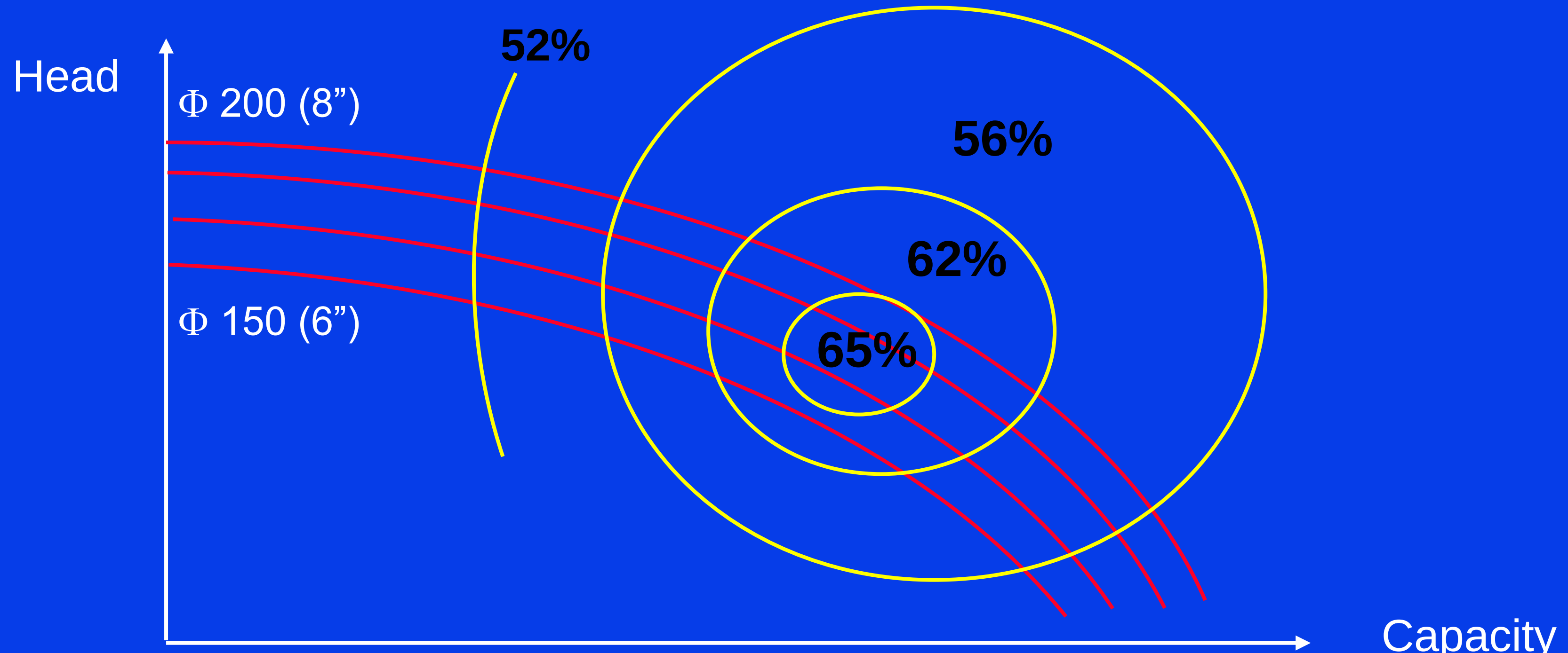
to pump the same amount of petrol at the given head

$$P\ (Hp) = \frac{\text{Capacity (l/s)} \times \text{Head (m)} \times \text{Specific gravity (t/m}^3\text{)}}{75 \times \text{Efficiency}}$$

$$P\ (Kw) = \frac{\text{Capacity (l/s)} \times \text{Head (m)} \times \text{Specific gravity (t/m}^3\text{)}}{102 \times \text{Efficiency}}$$

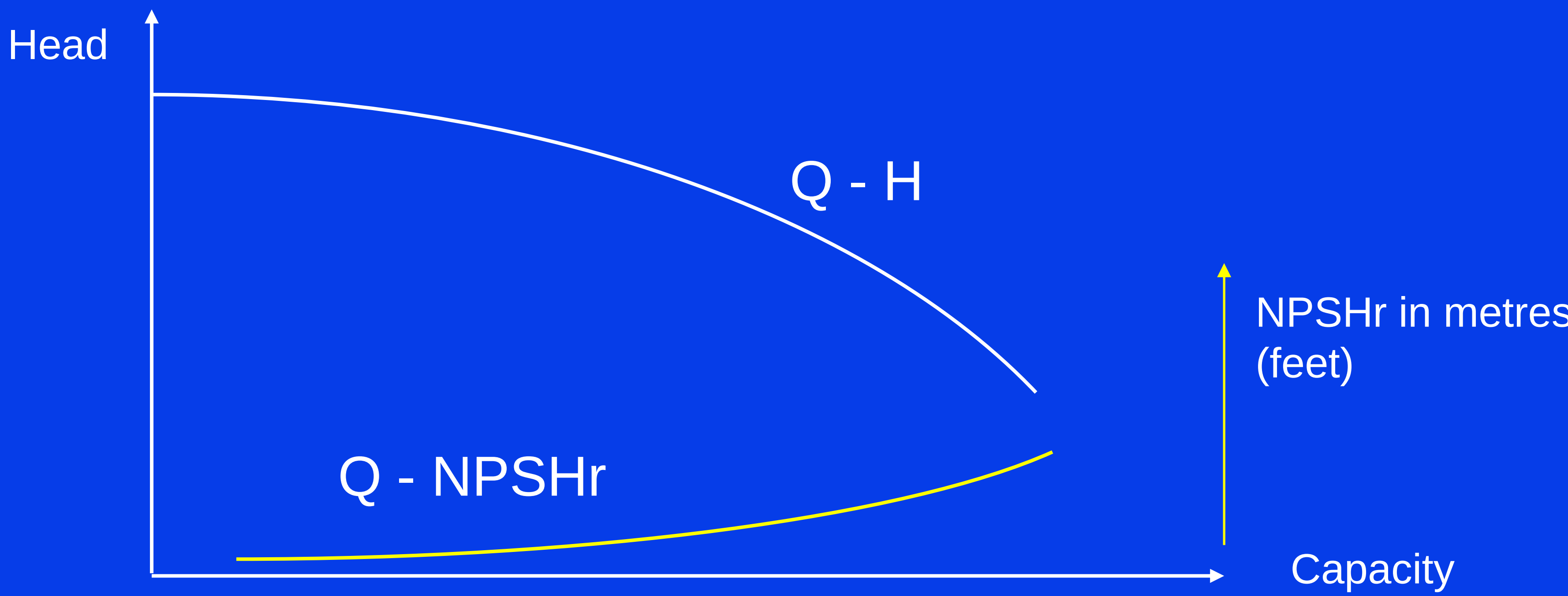
PUMP HYDRAULICS
“ CENTRIFUGAL PUMP CURVE ”

Centrifugal pump curves typically show hydraulic efficiency points



The best efficiency point (BEP) is the highest efficiency point on the curve

PUMP HYDRAULICS
“ CENTRIFUGAL PUMP CURVE ”



Pump curves typically show the Net Positive Suction Head Required to operate the pump at each point along it’s Head-Capacity curve

PUMP HYDRAULICS
“ NPSHr ”

Net Positive Suction Head Required

...is an extremely important parameter to consider

...refers to the internal losses of a centrifugal pump

...is determined by laboratory testing

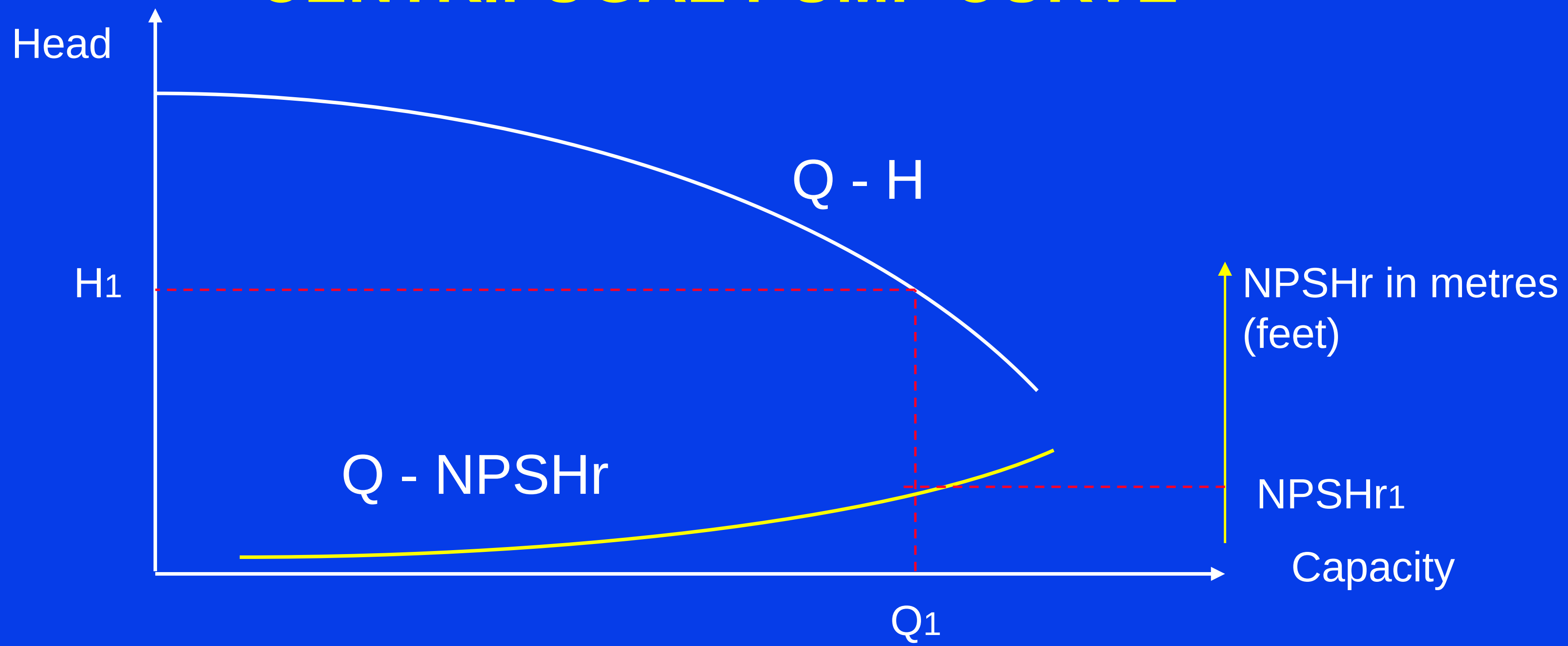
...varies with:

each pump

with pump capacity

with pump speed

PUMP HYDRAULICS
“ CENTRIFUGAL PUMP CURVE ”



NPSHr increases with capacity

The NPSHr value for a particular application is determined at the designed flow rate

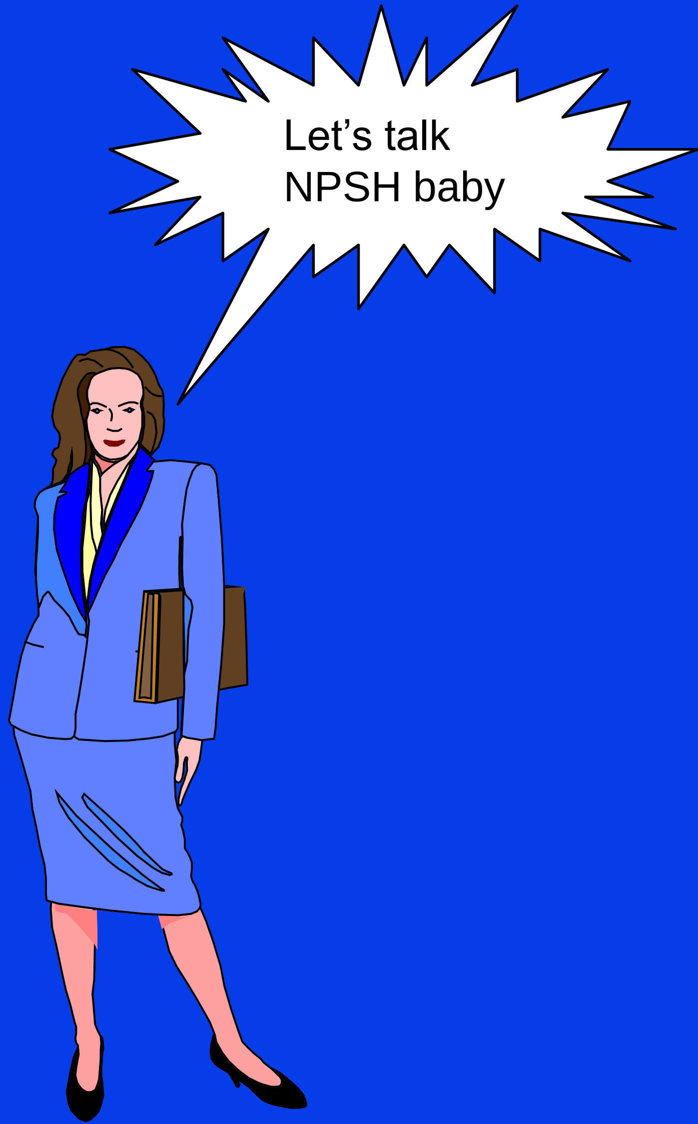
PUMP HYDRAULICS
" MENTAL NOTE "

- NPSH Available from the system

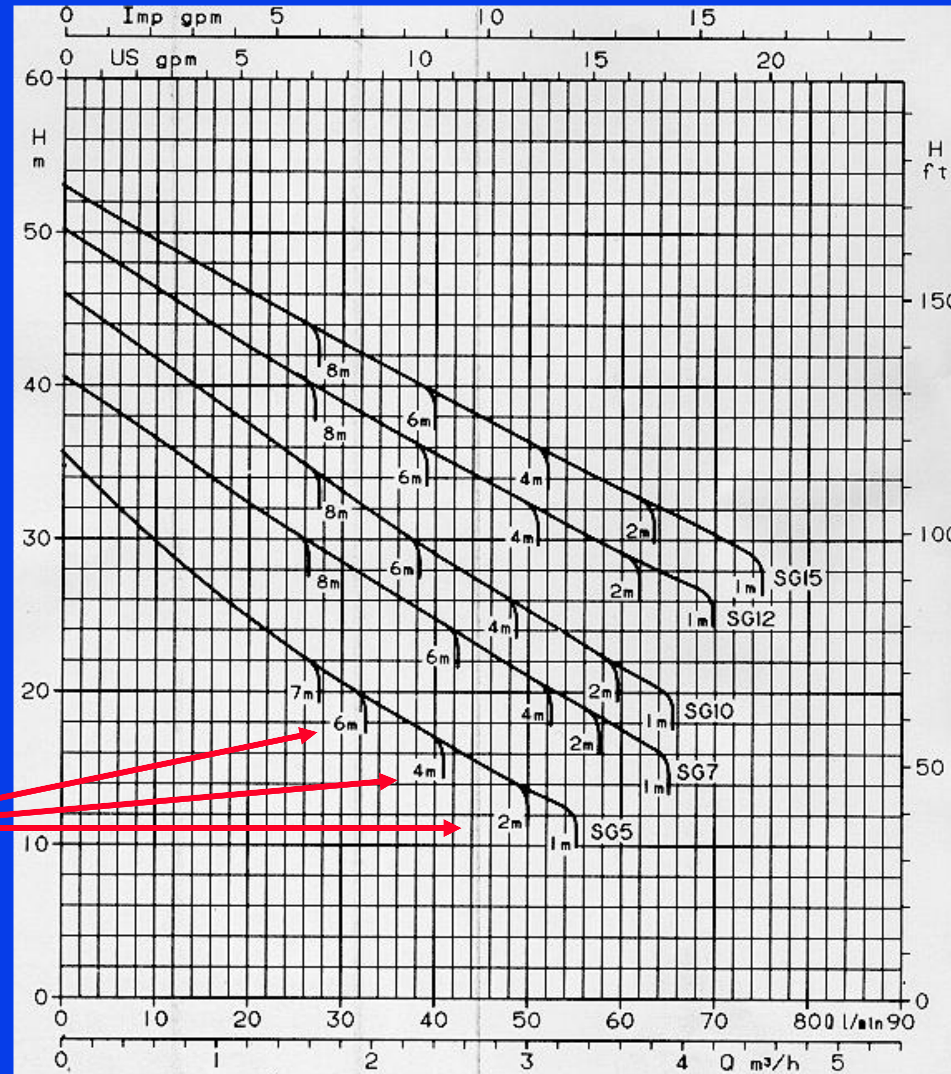
  MUST ALWAYS BE GREATER

  than the NPSH Required by the pump

- More on NPSHa/NPSHr later...

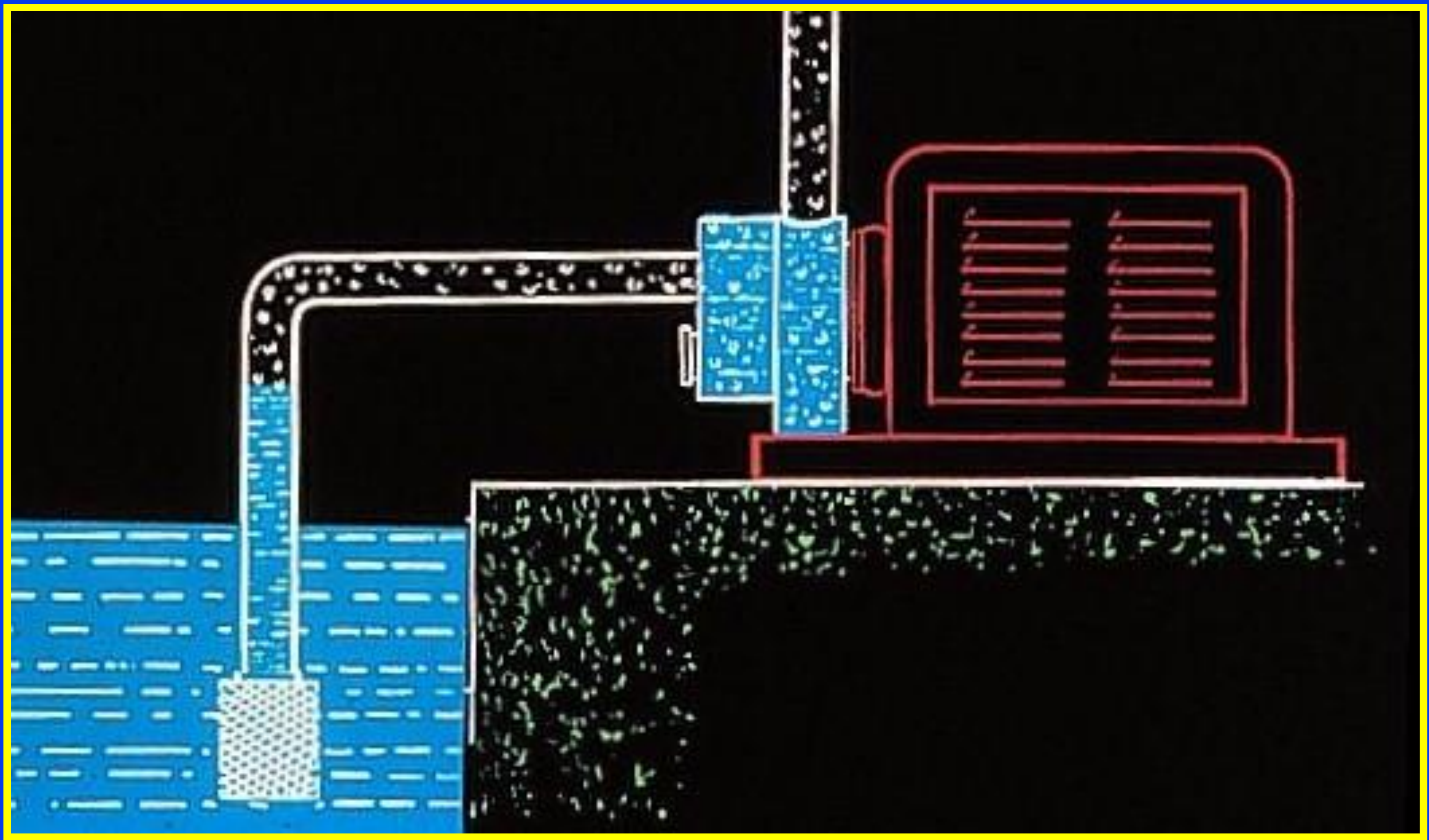


PUMP HYDRAULICS
“ CENTRIFUGAL PUMP CURVE ”



Self-priming pump curves typically provide information on the suction lift capability of the particular pump

PUMP HYDRAULICS
“ THE SUCTION SIDE ”



PUMP HYDRAULICS
" THE SUCTION SIDE "

◆ Suction Side Limitations

- The importance of keeping within the suction side limitations of any pump cannot be emphasized too greatly

KEEP IN MIND THAT...

...90% of all pump problems are due to poor suction conditions!

PUMP HYDRAULICS
“ NPSHa ”

Net Positive Suction Head Available

NPSH available is the term that describes whether the pressure on the suction side is adequate for proper pump operation

Self-priming applications must also consider the amount of air the pump is required to evacuate

PUMP HYDRAULICS
“ NPSHa ”

- Proper system design allows for the highest possible NPSHa

Factors affecting NPSH available include :

Pressure acting on the surface of the liquid

Relative elevation of the liquid

Friction losses in the suction piping

Velocity of the liquid in the suction piping

Vapor pressure of the liquid

These factors constitute a system’s dynamic suction condition and must be carefully considered before a final pump selection can be made

PUMP HYDRAULICS
“ MENTAL NOTE ”

- Proper system design allows for the highest possible NPSHa

- NPSHa **must be sufficiently greater than** NPSHr in order to prevent:

Poor pump performance

Excessive vibration

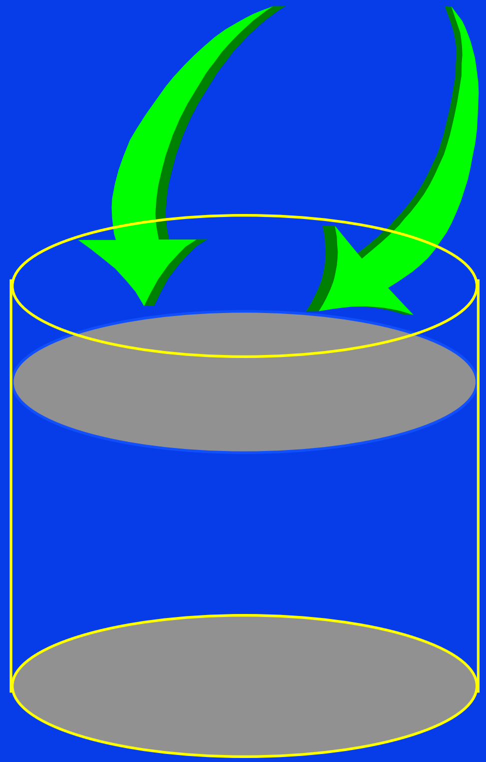
Noisy operation

Premature failure of components

Cavitation

PUMP HYDRAULICS
“ NPSHa ”

- Pressure Acting On The Surface Of The Liquid



- Pressure acting on the surface of a liquid “pushes” it into the pump

Atmospheric pressure

Pressurised tank

Vacuum tank

The pressure on the liquid is the major contributor to the NPSHa of a system

PUMP HYDRAULICS
" MENTAL NOTE "

Pressure values must be converted to "metres of head" using the following formula :

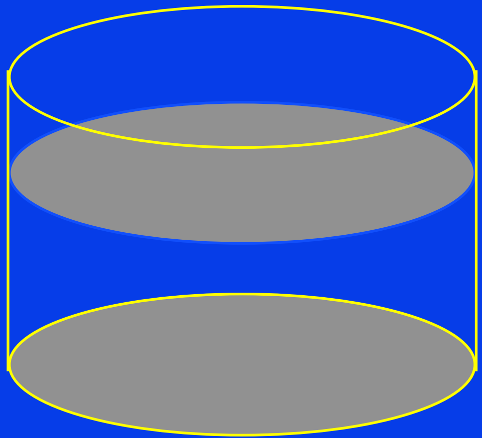
Metres of head = (bar x 10) / specific gravity
(KPa x 0.01 x 10) / specific gravity

Atmospheric pressure at sea level = 1 bar (14.7 psi)

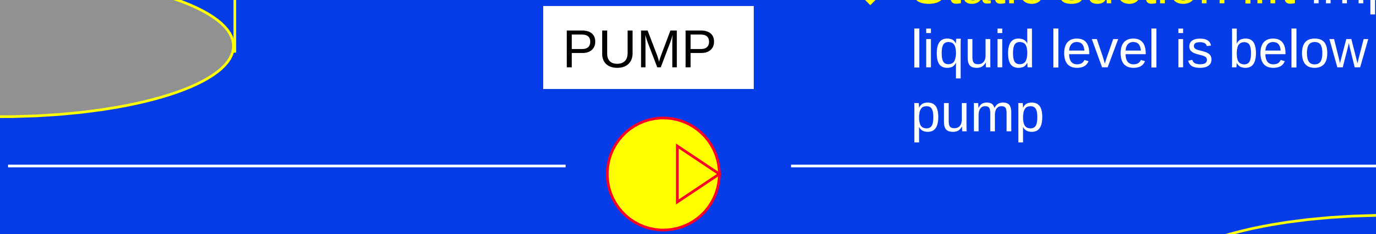
Pressurised vessel = Absolute pressure gauge reading

Vacuum vessel = Vacuum gauge reading

PUMP HYDRAULICS
“ NPSHa ”



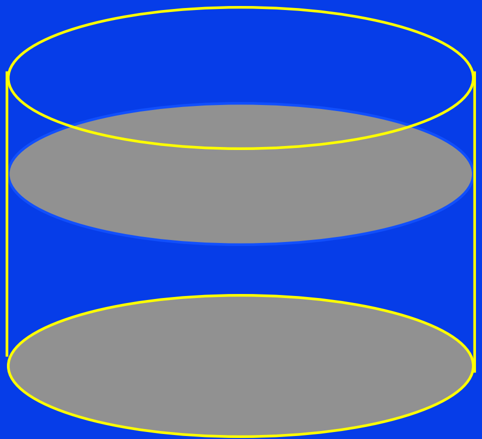
- Static suction head implies that the liquid level is above the inlet of the pump



- Static suction lift implies that the liquid level is below the inlet of the pump

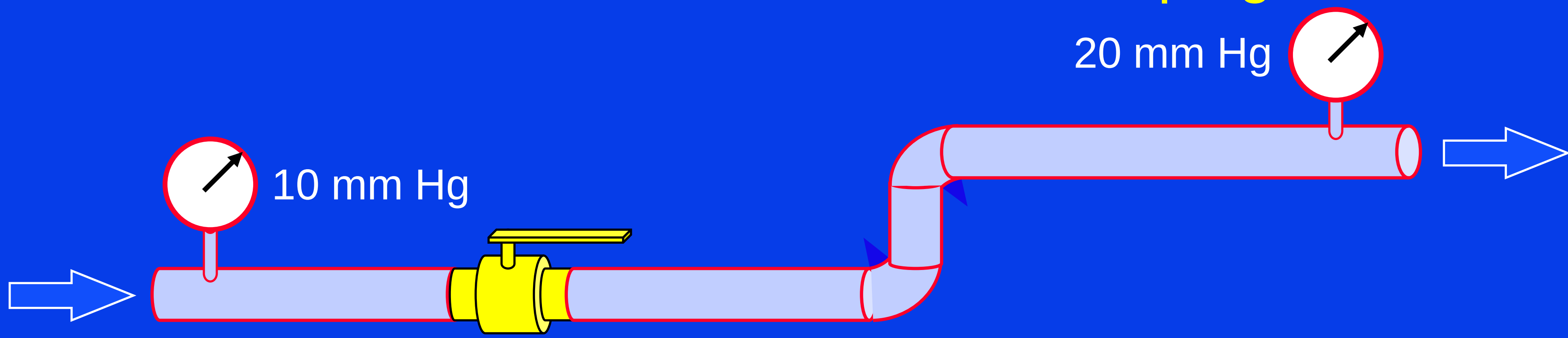
Static suction head increases NPSHa because gravity helps pull liquid into the pump

Static suction lift decreases NPSHa because the pump must work against gravity

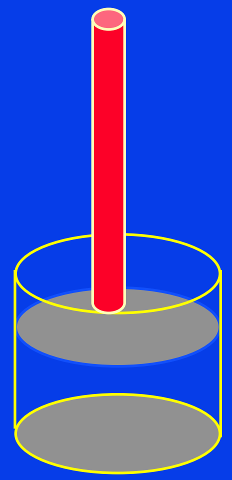


PUMP HYDRAULICS
" NPSHa "

◆ Friction Losses In The Suction Piping



- ◆ Friction losses in suction piping decreases NPSHa
- ◆ Factors affecting friction losses include :
- ◆ Size of piping
- ◆ Length of piping
- ◆ Fittings and equipment

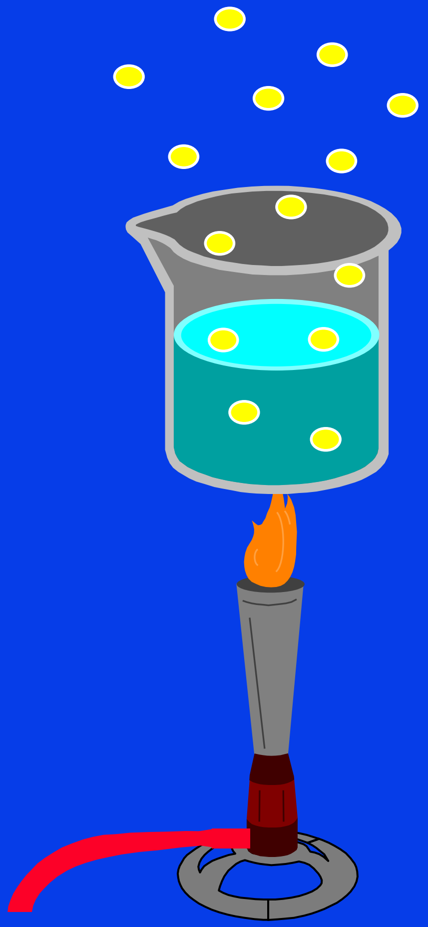


760 mm Hg = 1 atm = 10.33 m H_2O = 1.013 bar = 1013 mbar

PUMP HYDRAULICS
" NPSHa "

◆ Vapor pressure of the liquid

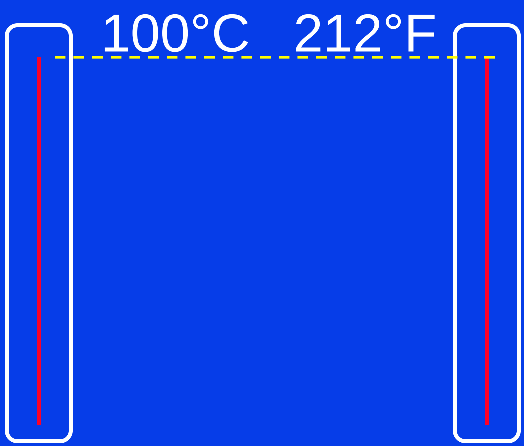
- The vapor pressure of the liquid must be carefully considered to insure proper pump operation

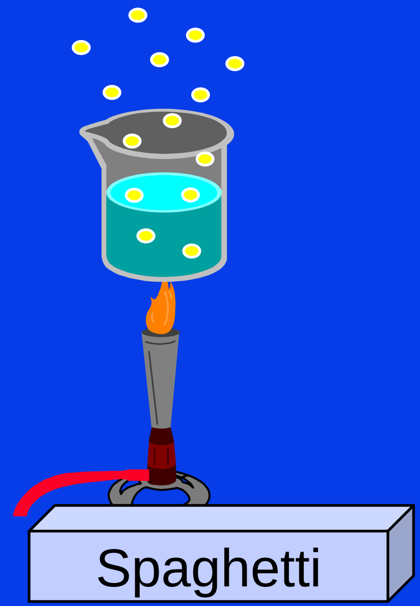


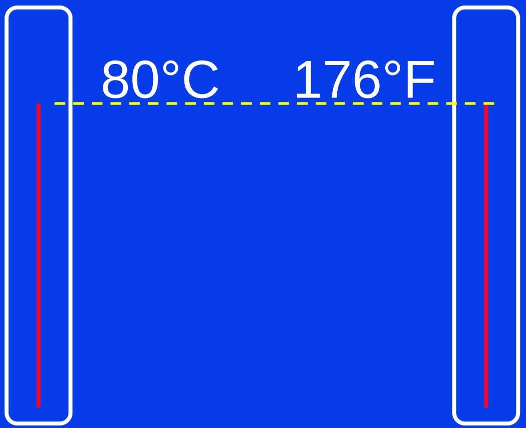
- Vapor pressure indicates the dividing line between a liquid and its gaseous state
- Vapor pressure typically varies with temperature
- The pressure in the suction line must never fall below the vapor pressure of the liquid

PUMP HYDRAULICS
“ NPSHa ”

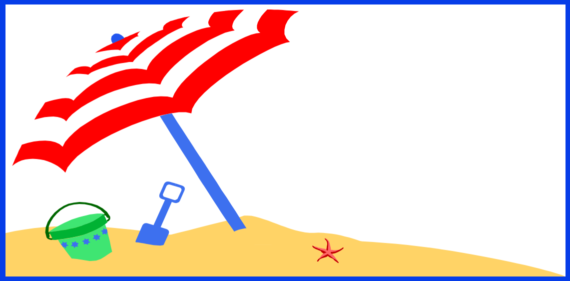
- Vapor pressure of the liquid







- At sea level
- On the mountain



PUMP HYDRAULICS
“ NPSHa ”

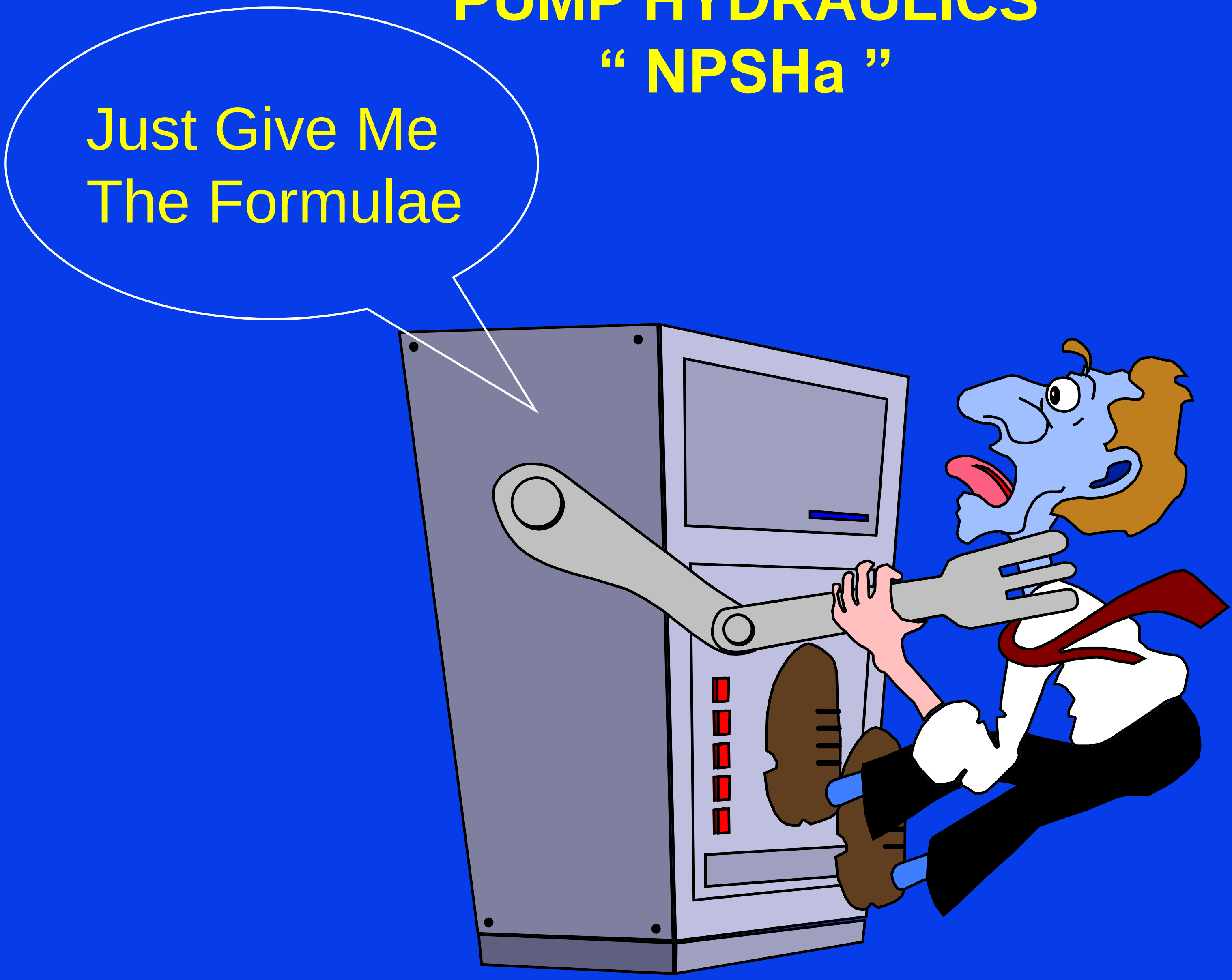
◆ Vapor pressure of the liquid

A liquid with a vapor pressure of 0.56 bar (8 psi) @ 38°C (100°F) requires at least 0.56 bar (8 psi) of pressure acting on it’s surface to stay a liquid

The pressure in a fluid handling system must be equal to or greater than the vapor pressure of the liquid at every point throughout that system

Without sufficient pressure the liquid will flash into a gas and become unpumpable.

PUMP HYDRAULICS
“ NPSHa ”



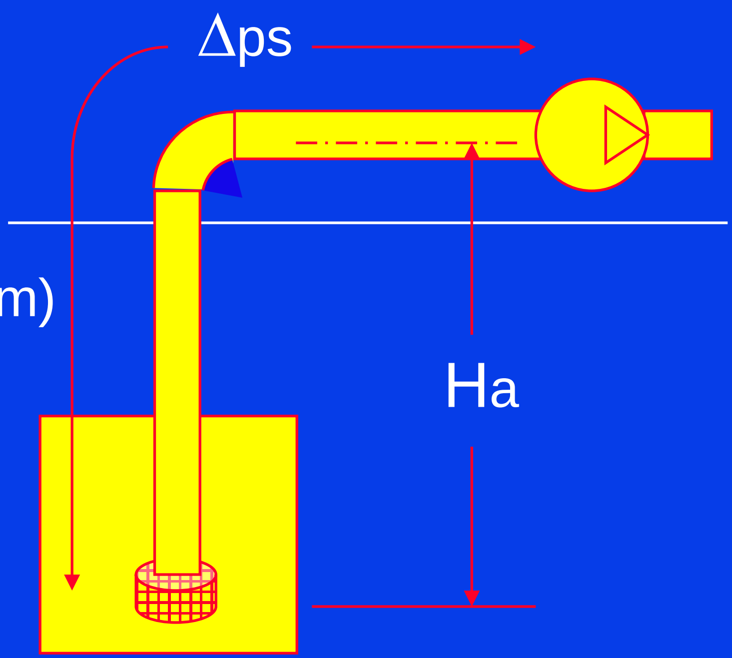
PUMP HYDRAULICS
“ NPSHa ”

- QUICK FORMULA

$$Ha = 10.33 - (NPSHr + 0.5) - \Delta ps - Kt - Kh$$

Where :

Ha	= Suction height (m)
10.33	= Maximun suction limit (m)
NPSHr	= NPSH required by pump (m)
0.5	= Safety margin (m)
Δps	= Friction losses of the suction piping system (m)
Kt	= Reducing coefficient due to temperature (m)
Kh	= Reducing coefficient due to altitude (m)



PUMP HYDRAULICS
“ NPSHa & NPSHr ”

NPSHr < NPSHa

NPSHa + NPSHr < 10.33 m (33.9’)

Liquid :

water

Atmospheric

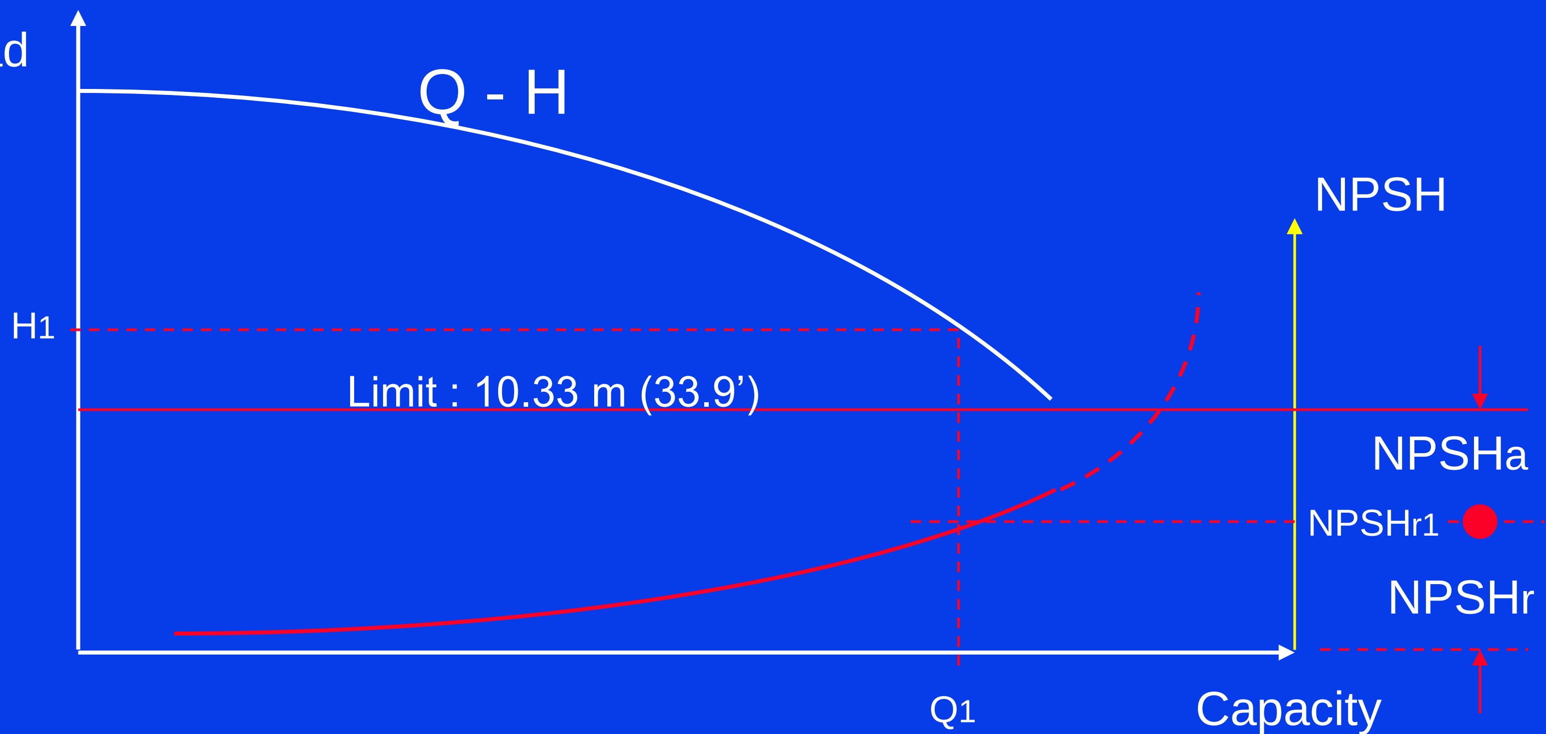
pressure :

1 bar (14.7 psi)

at sea level

Temperature :

20°C (68°F)



◆ If NPSHa + NPSHr > 10.33 m ⟶ CAVITATION !!

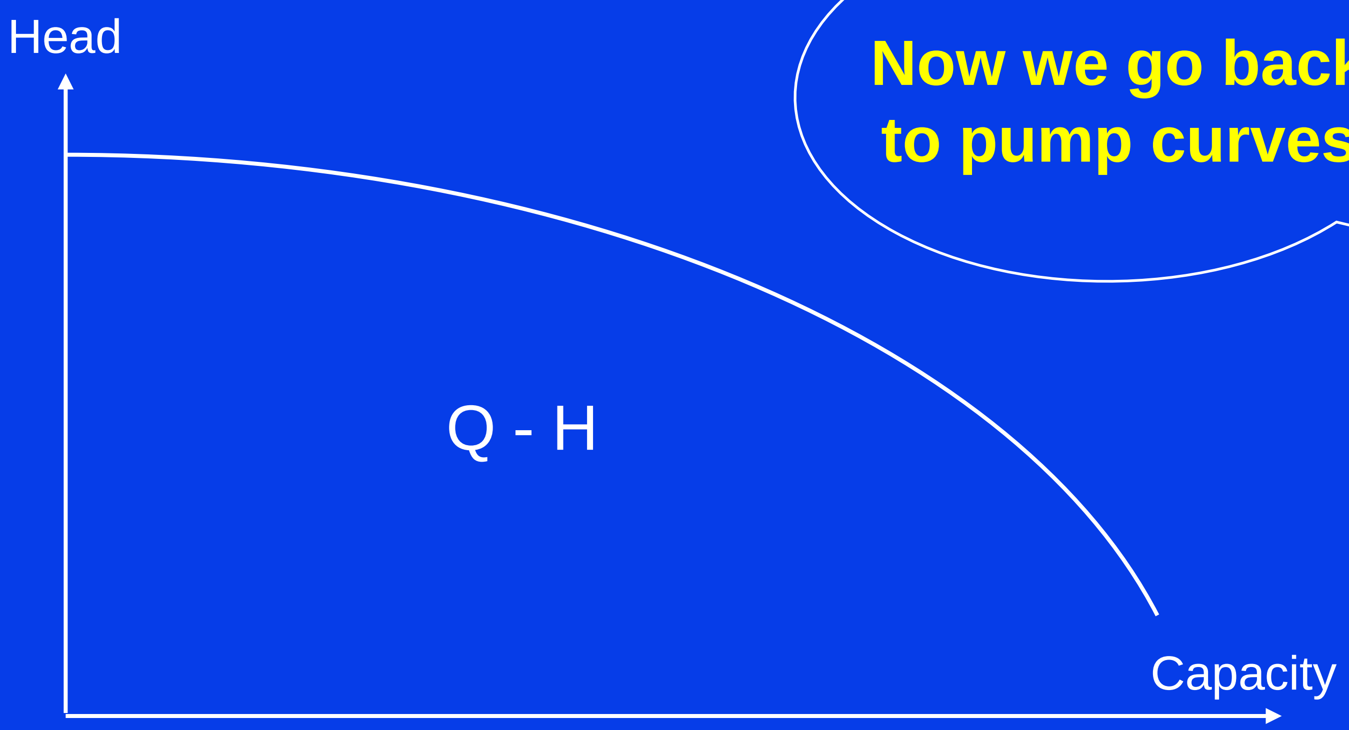
PUMP HYDRAULICS
“ NPSHa & NPSHr ”

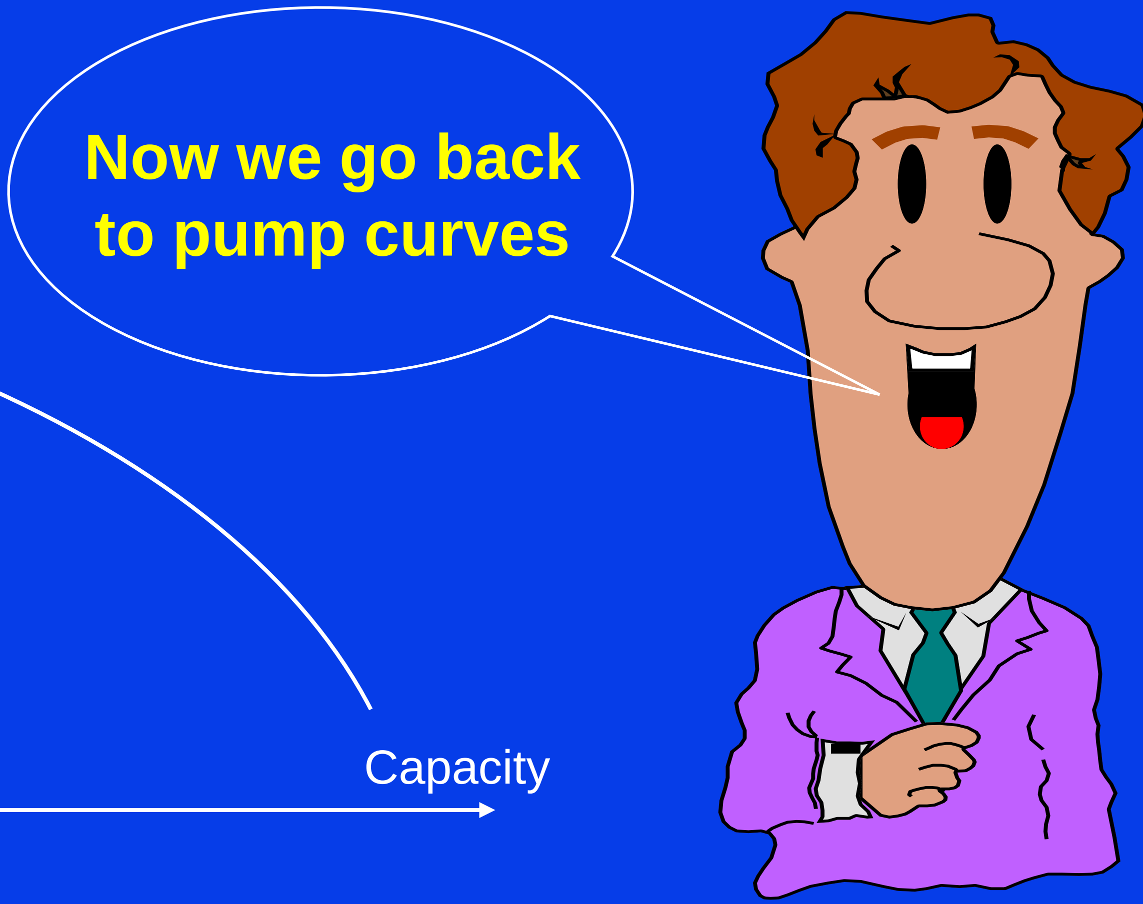
◆ Reducing coefficients

Temperature °C	°K	Coefficient Kt (m)
30	86	0.4
40	104	0.8
50	122	1.3
60	140	2.0
70	158	3.2
80	176	4.8
90	194	7.1

Altitude m	Coefficient Kh (m)
0	0.00
500	0.55
1000	1.10
1500	1.65
2000	2.20
2500	2.75
3000	3.30

PUMP HYDRAULICS
" CENTRIFUGAL PUMP CURVE "

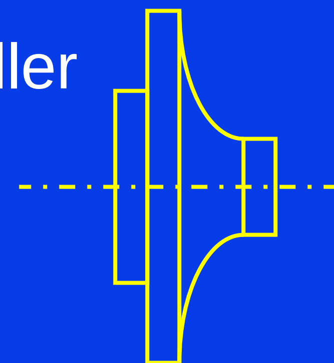




PUMP HYDRAULICS
" CENTRIFUGAL PUMP CURVE "

- The NPSH-Q & Power-Q curves for a particular pump are a function of :

- The impeller diameter



- And the speed of operation

PUMP HYDRAULICS
“ CENTRIFUGAL PUMP CURVE ”

AFFINITY LAWS

FLOW	**Example**

$Q_1 / Q_2 = n_1 / n_2$ 1/2

HEAD

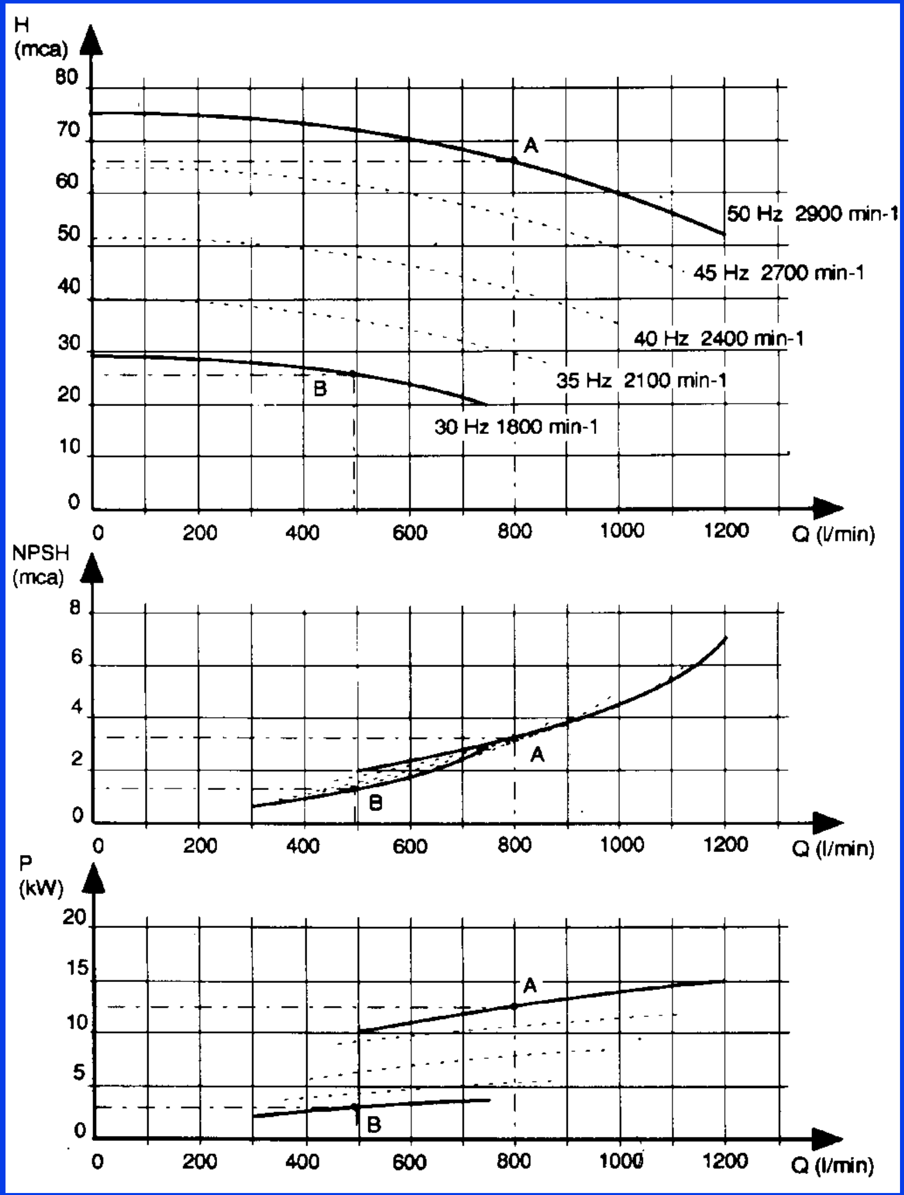
$H_1 / H_2 = (n_1 / n_2)^2$ 1/4

NPSH

$NPSH_1 / NPSH_2 = (n_1 / n_2)^2$ 1/4

POWER

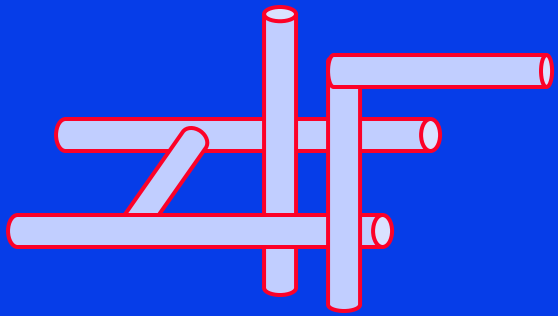
$P_1 / P_2 = (n_1 / n_2)^3$ 1/8

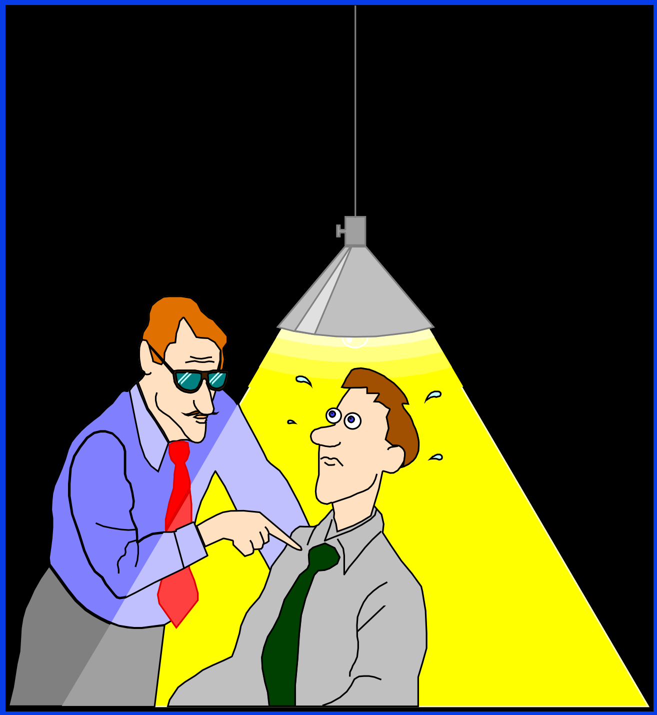


PUMP HYDRAULICS
" SELECTING A PUMP "

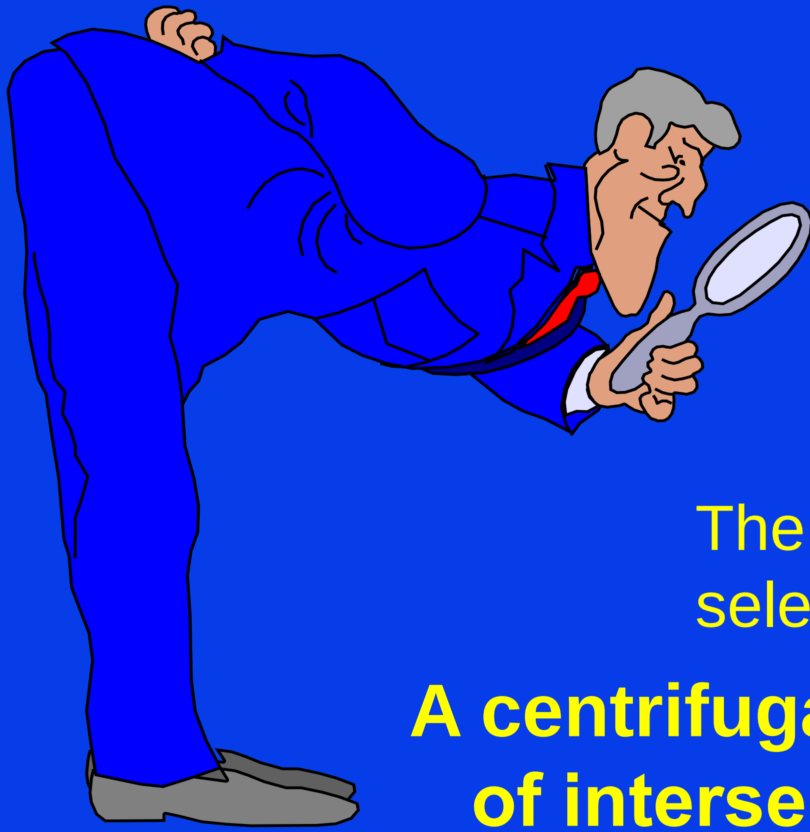
- In order to properly select a pump you need to know the facts :

- Liquid characteristics
- Pumping system design
- TDH
- Capacity
- NPSHa





PUMP HYDRAULICS
“ MENTAL NOTE ”



The first rule of centrifugal pump selection:

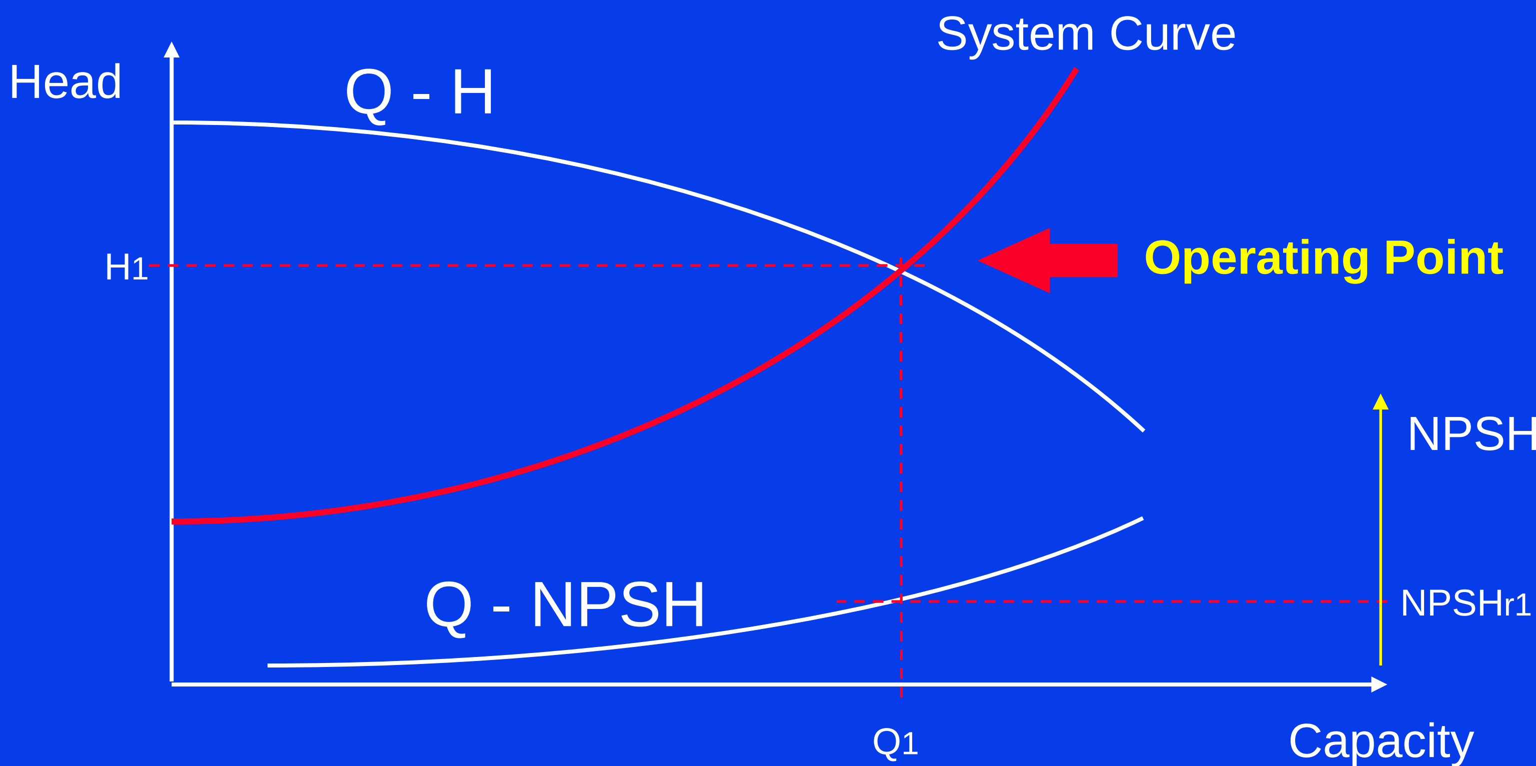
- **Head determines Capacity**

The second rule of centrifugal pump selection:

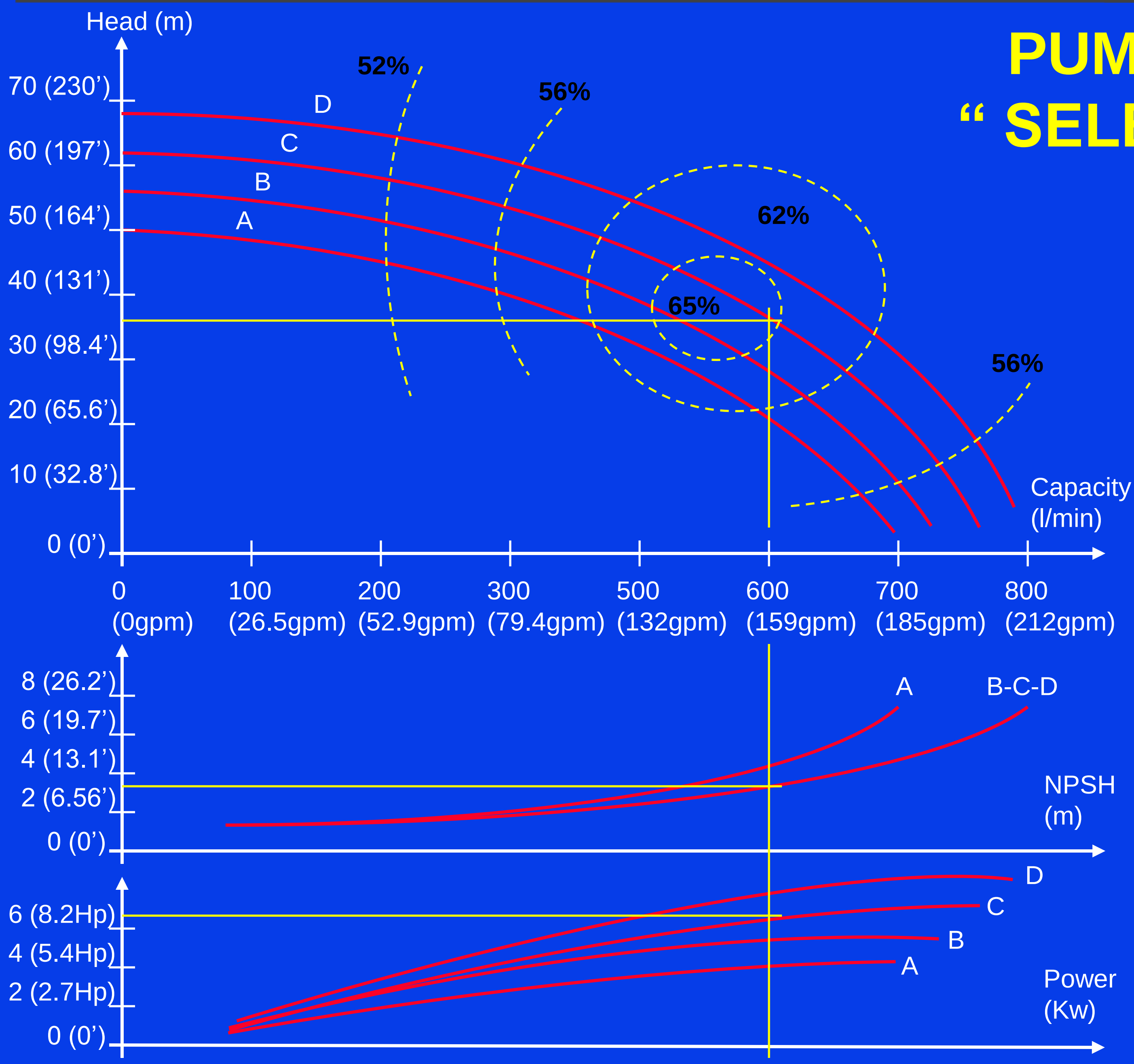
A centrifugal pump will operate at the point of intersection between the pump’s H-Q curve and the System curve

(Providing NPSHa is greater than NPSHr)

PUMP HYDRAULICS
“ SELECTING A PUMP ”



PUMP HYDRAULICS
" SELECTING A PUMP "

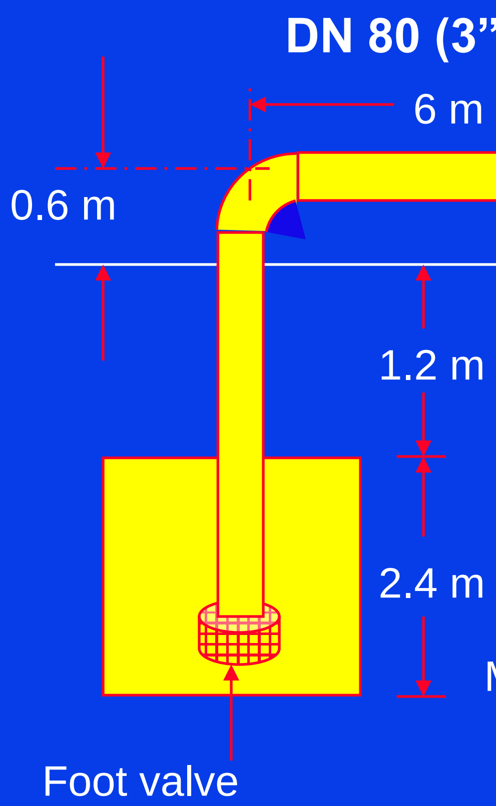


- Capacity requested : 600 l/min
- TDH requested : 35 m

Pump performances

- Capacity : 600 l/min
- Head :35 m
- NPSHr : 3.2 m
- Absorbed power :6.5 Kw

PUMP HYDRAULICS
" CENTRIFUGAL PUMP CURVE "

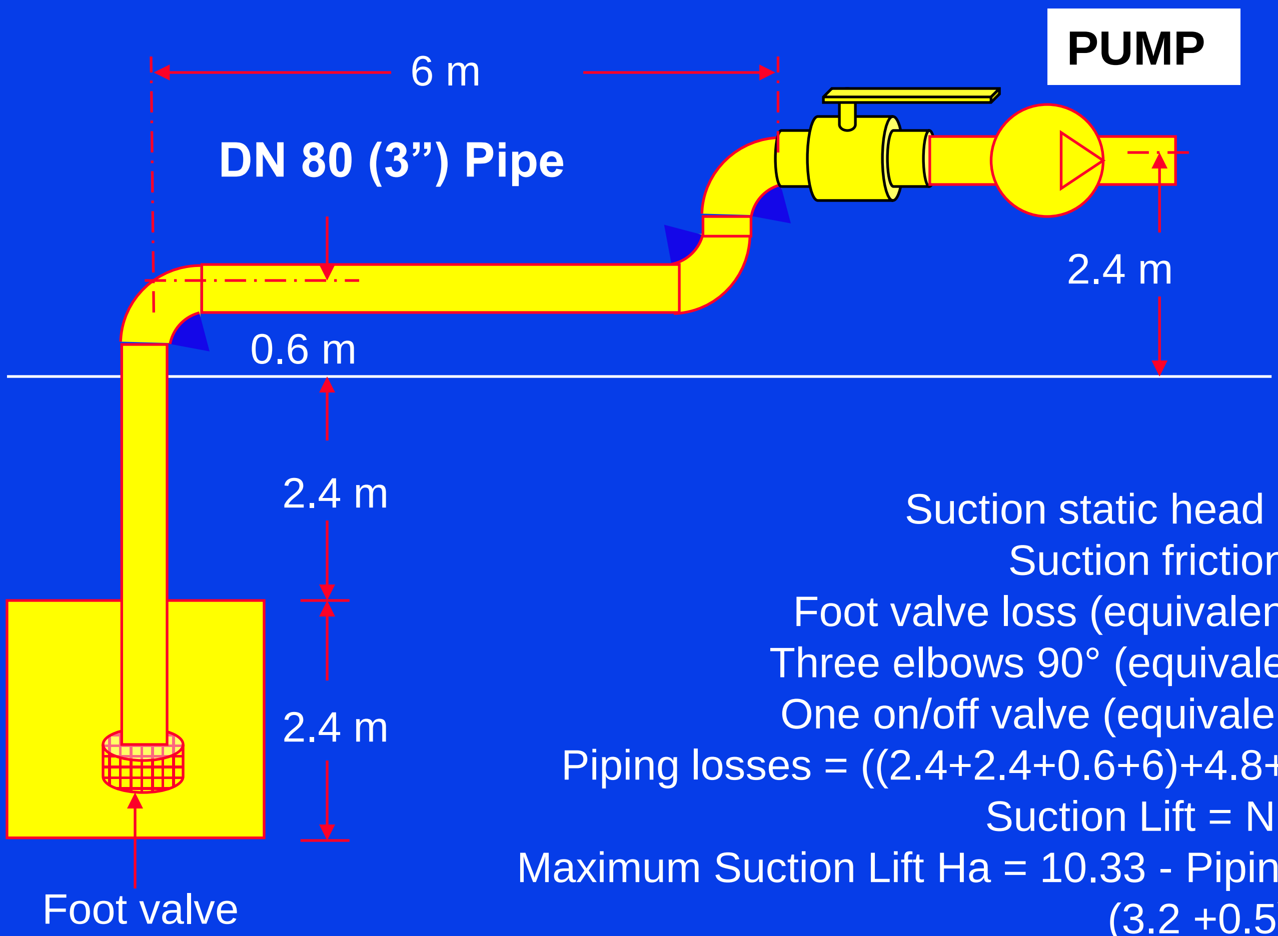


Liquid water
Atmospheric pressure :1 bar (14.7 psi) at sea level
Temperature : 20°C (68°F)

Suction static head = 1.2 + 0.6 = 1.8 m
Suction friction losses (Δp) :Foot valve loss (equivalent length) = 1x4.8 = 4.8 m
One elbow 90° (equivalent length) = 1x2.1 = 2.1 m
One on/off valve (equivalent length) = 1x0.3 = 0.3 m
Piping losses = ((2.4+1.2+0.6+6)+4.8+2.1+0.3)x(5.8/100) = 0.92 m
Maximum Suction Lift = NPSHa - NPSHr
Maximum Suction Lift (Ha)= 10.33 - Piping Losses -(NPSHr + 0.5) = 10.33 - 0.92 - (3.2 +0.5) = 5.71m

We can use this pump

PUMP HYDRAULICS



Liquid : water
Atmospheric pressure :1 bar
(14.7 psi) at sea level
Temperature : 20°C (68°F)

Suction static head = 2.4 + 2.4 = 4.8 m
Suction friction losses (Δp) :
Foot valve loss (equivalent length) = 1x4.8 = 4.8 m
Three elbows 90° (equivalent length) = 3x2.1 = 6.2 m
One on/off valve (equivalent length) = 1x0.3 = 0.3 m
Piping losses = ((2.4+2.4+0.6+6)+4.8+6.2+0.3)x(5.8/100) = 1.3m Maximum
Suction Lift = NPSHa - NPSHr
Maximum Suction Lift Ha = 10.33 - Piping Losses -(NPSHr + 0.5) = 10.33 - 1.3 - (3.2 +0.5) = 5.3m

We can use this pump but carefully