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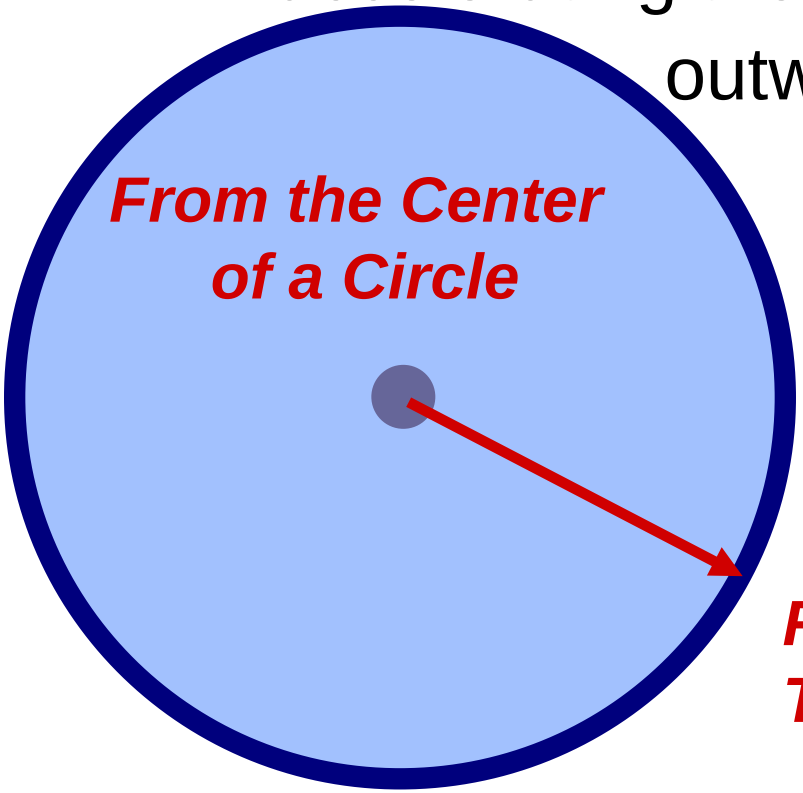
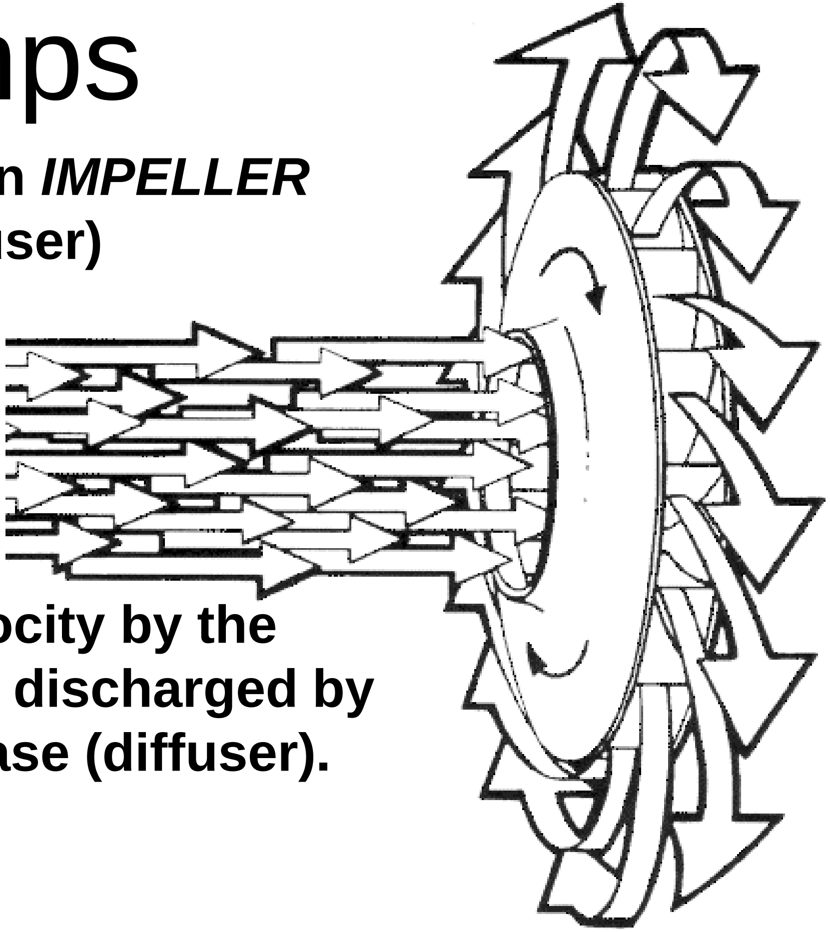
Centrifugal Pumps

A machine for moving fluid by accelerating the fluid *RADIALLY* outward.



Centrifugal Pumps

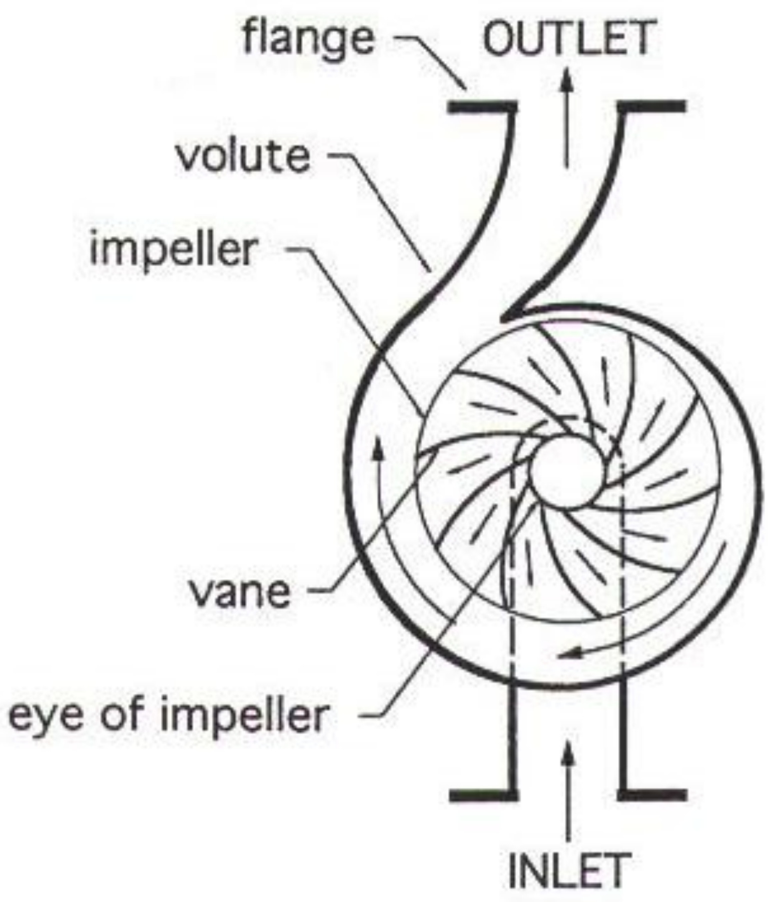


- **This machine consists of an *IMPELLER* rotating within a case (diffuser)**
- **Liquid directed into the center of the rotating impeller is picked up by the impeller's vanes and accelerated to a higher velocity by the rotation of the impeller and discharged by centrifugal force into the case (diffuser).**

Centrifugal Pumps

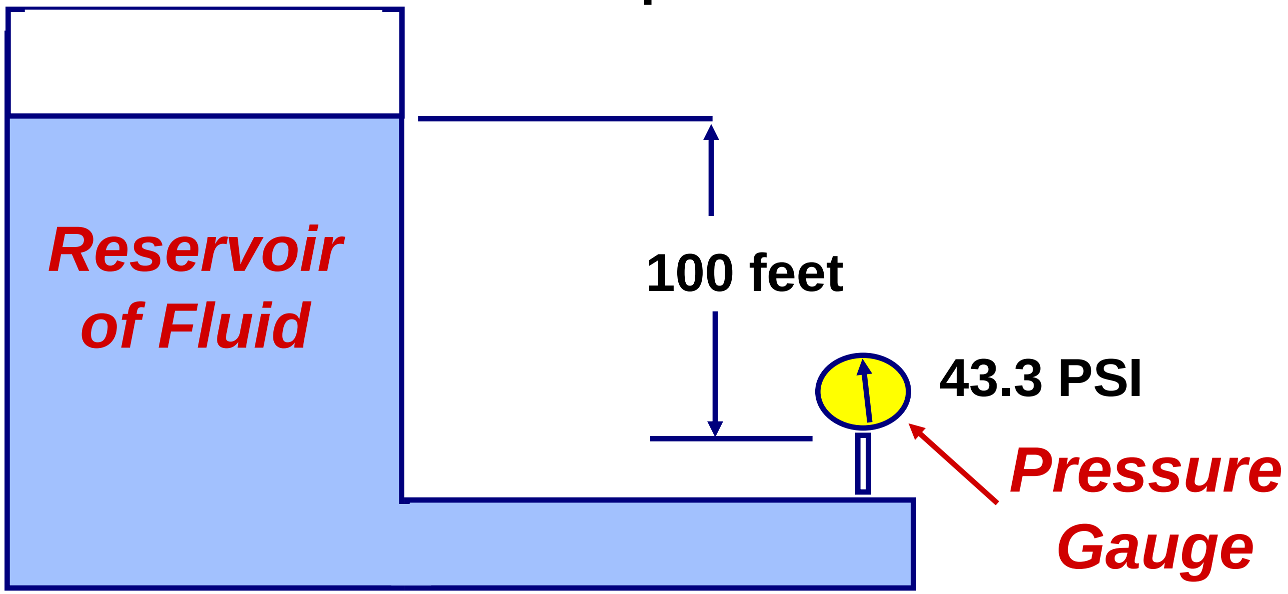
- A collection chamber in the casing converts much of the Kinetic Energy (energy due to velocity) into *Head* or Pressure.

Pump Terminology



"Head"

- **Head is a term for expressing feet of water column**
- **Head can also be converted to pressure**



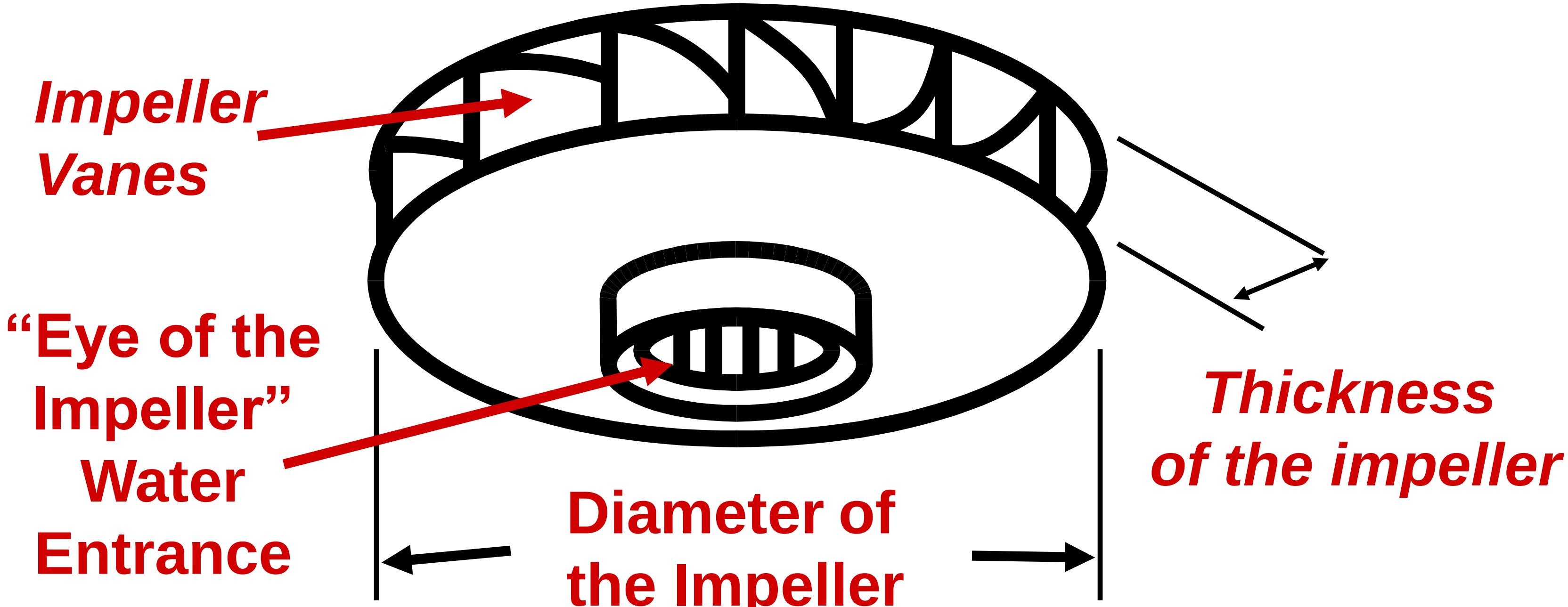
Conversion Factors Between Head and Pressure

- **Head (feet of liquid) =Pressure in PSI x 2.31 / Sp. Gr.**
- **Pressure in PSI = Head (in feet) x Sp. Gr. / 2.31**
- **PSI is Pounds per Square Inch**
- **Sp. Gr. is Specific Gravity which for water is equal to 1**
  - **For a fluid more dense than water, Sp. Gr. is greater than 1**
  - **For a fluid less dense than water, Sp. Gr. is less than 1**

Head

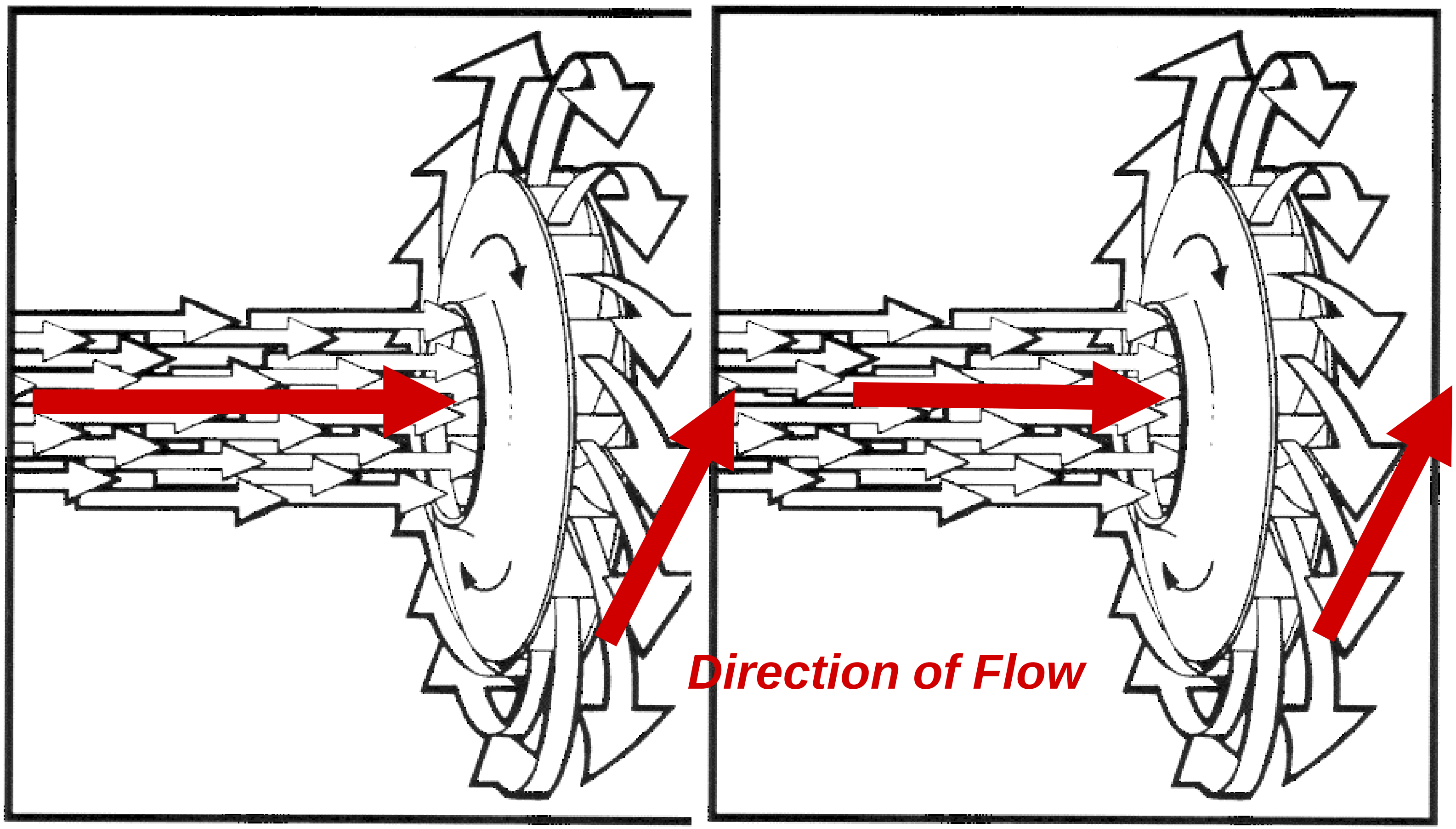
- Head and pressure are interchangeable terms provided that they are expressed in their correct units.
- The conversion of all pressure terms into units of equivalent head simplifies most pump calculations.

Centrifugal Impellers



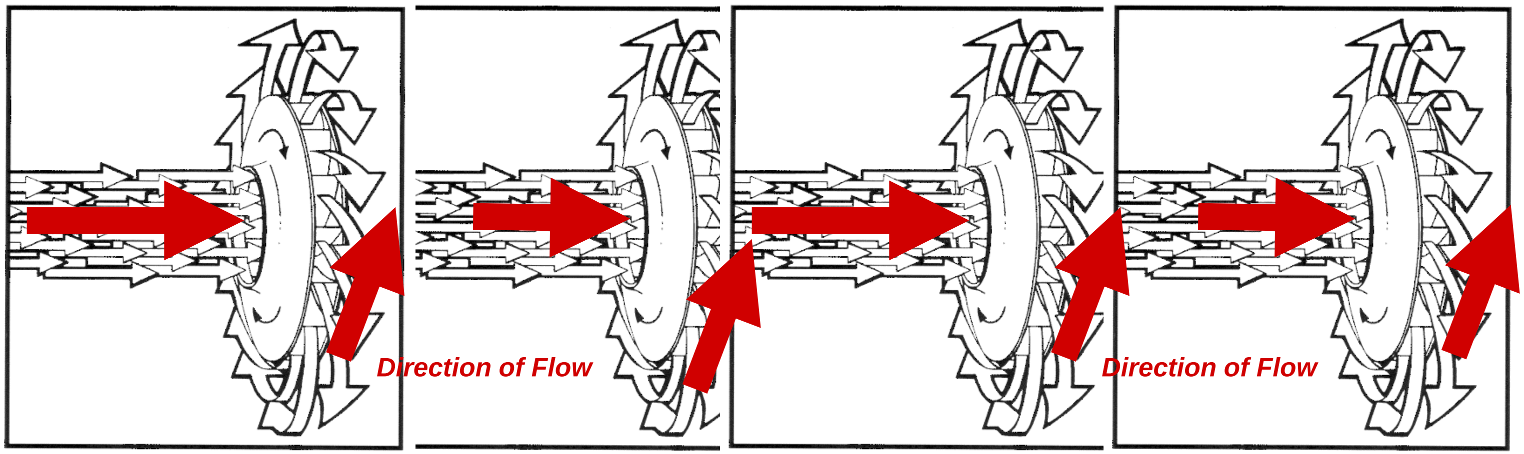
- Thicker the Impeller- More Water
- Larger the DIAMETER - More Pressure
- Increase the Speed - More Water and Pressure

Two Impellers in Series



- Twice the pressure
- Same amount of water

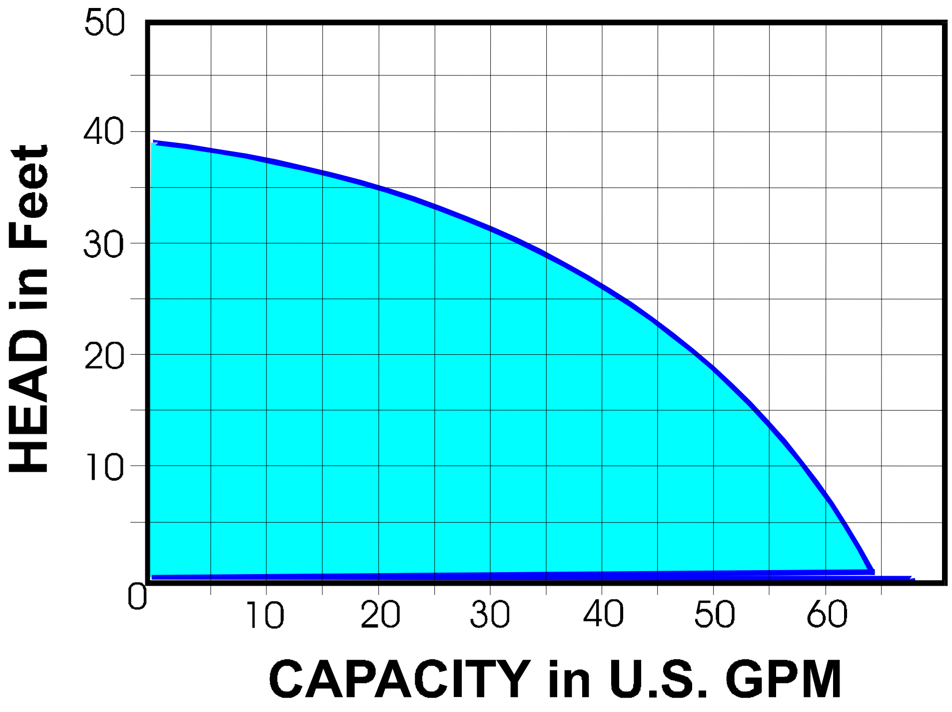
Multiple Impellers in Series



- Placing impellers in series increases the amount of head produced
- The head produced = # of impellers x head of one impeller

Pump Performance Curve

- **A mapping or graphing of the pump's ability to produce head and flow**



Pump Performance Curve

Step #1, Horizontal Axis

- The pump's flow rate is plotted on the horizontal axis (X axis)
- Usually expressed in Gallons per Minute

Pump Flow Rate →

Pump Performance Curve

Step #2, Vertical Axis

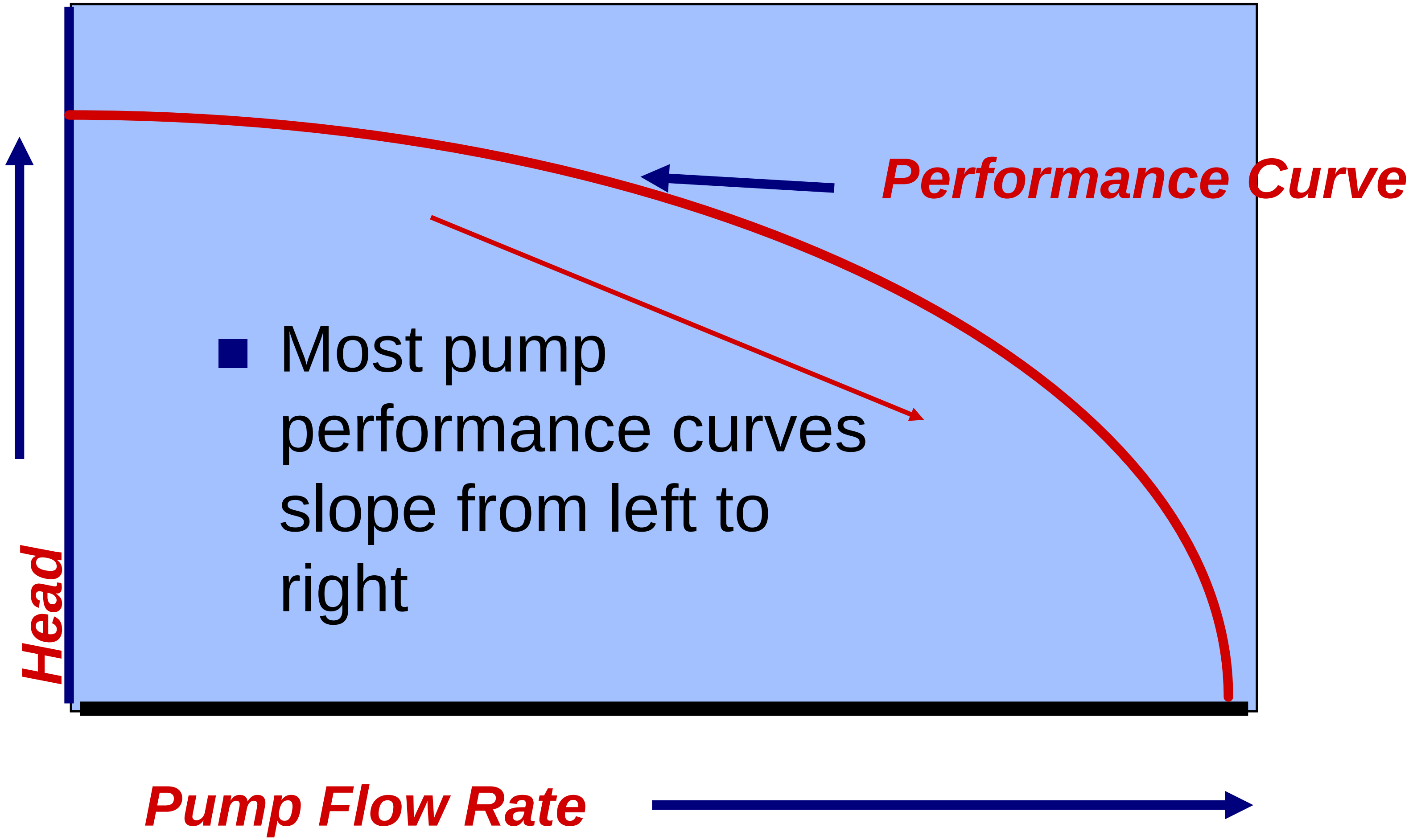
- The head the pump produces is plotted on the vertical axis (Y axis)
- Usually express in Feet of Water

Head

Pump Flow Rate

Pump Performance Curve

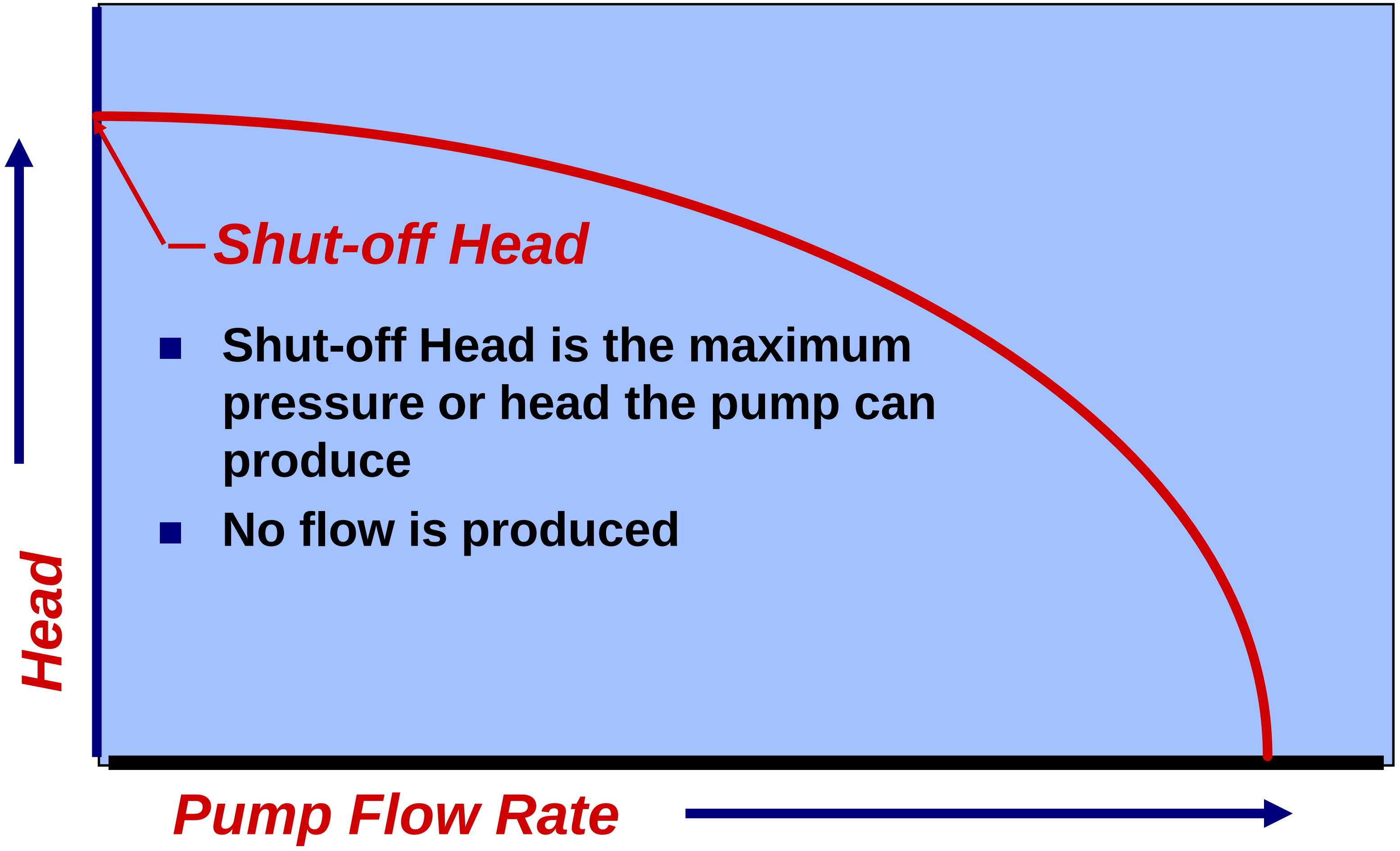
Step #3, Mapping the Flow and the Head



- Most pump performance curves slope from left to right

Pump Performance Curve

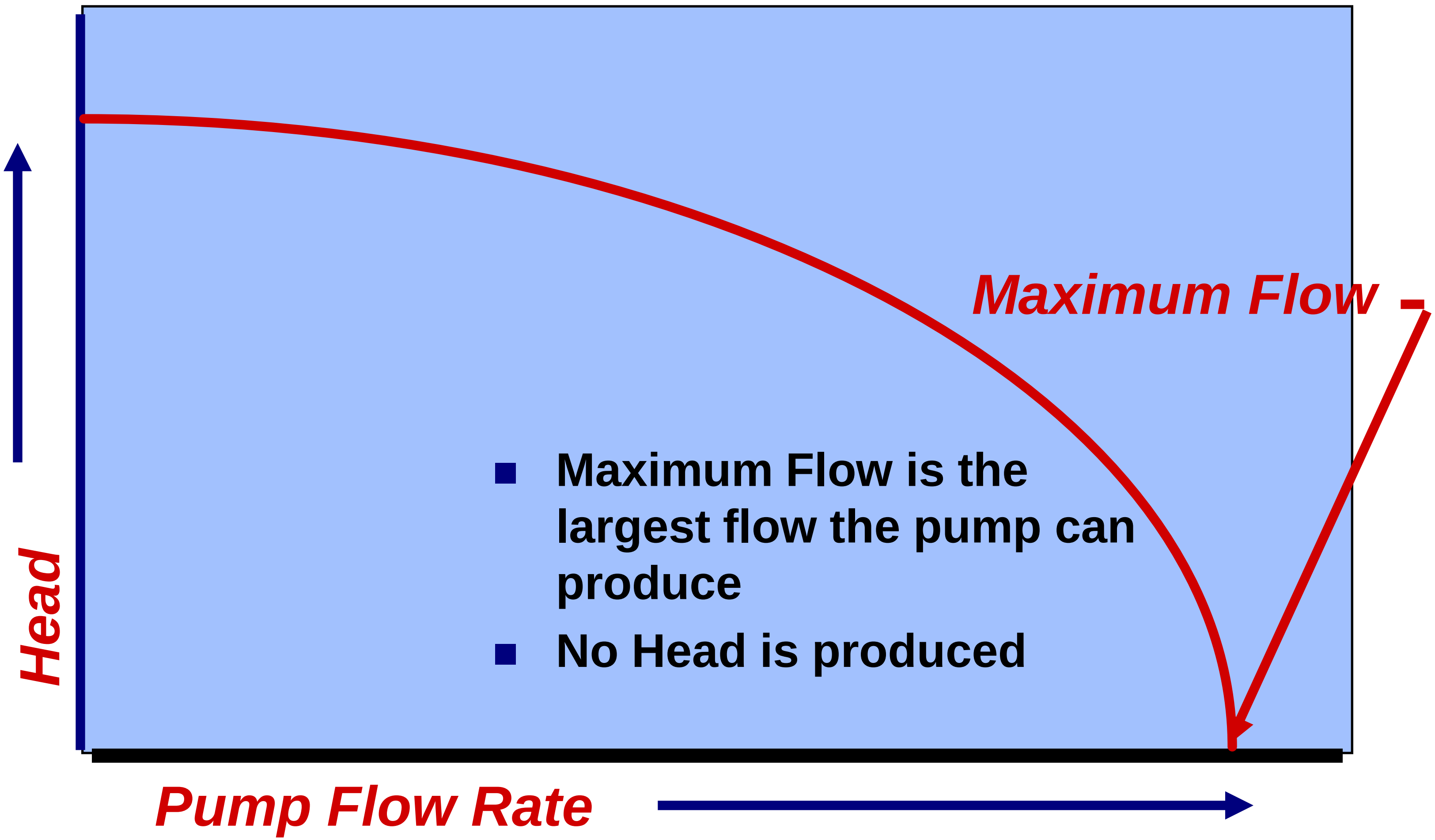
Important Points



- Shut-off Head is the maximum pressure or head the pump can produce
- No flow is produced

Pump Performance Curve

Important Points



- **Maximum Flow is the largest flow the pump can produce**
- **No Head is produced**

System Performance Curves

- System Performance Curve is a mapping of the head required to produce flow in a given system
- A system includes all the pipe, fittings and devices the fluid must flow through, and represents the friction loss the fluid experiences

System Performance Curve

Step #1, Horizontal Axis

- **The System's flow rate in plotted on the horizontal axis (X axis)**
- **Usually expressed in Gallons per Minute**

System Flow Rate

System Performance Curve

Step #2, Vertical Axis

- **The head the system requires is plotted on the vertical axis (Y axis)**
- **Usually express in Feet of Water**

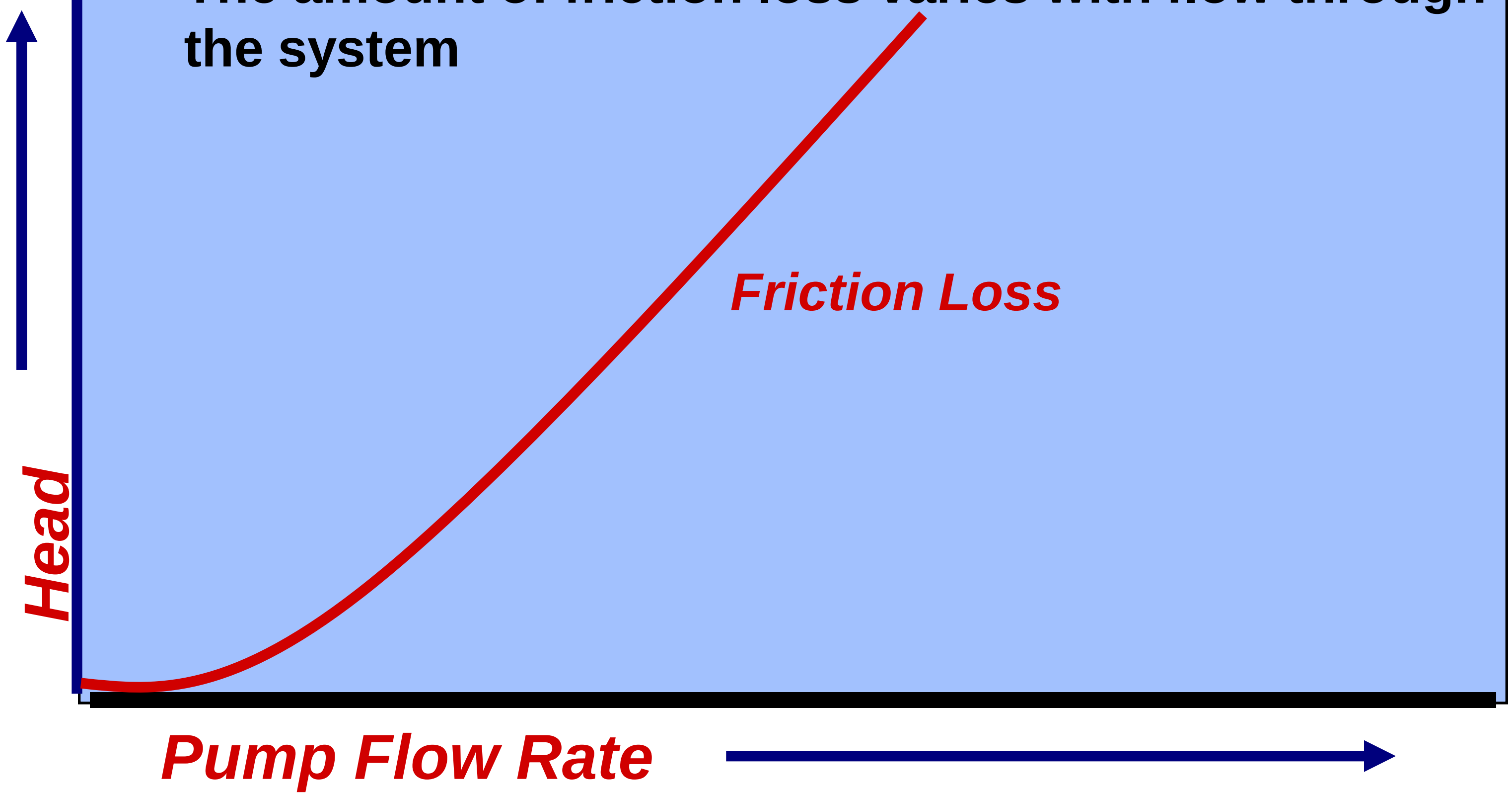
Head

Pump Flow Rate

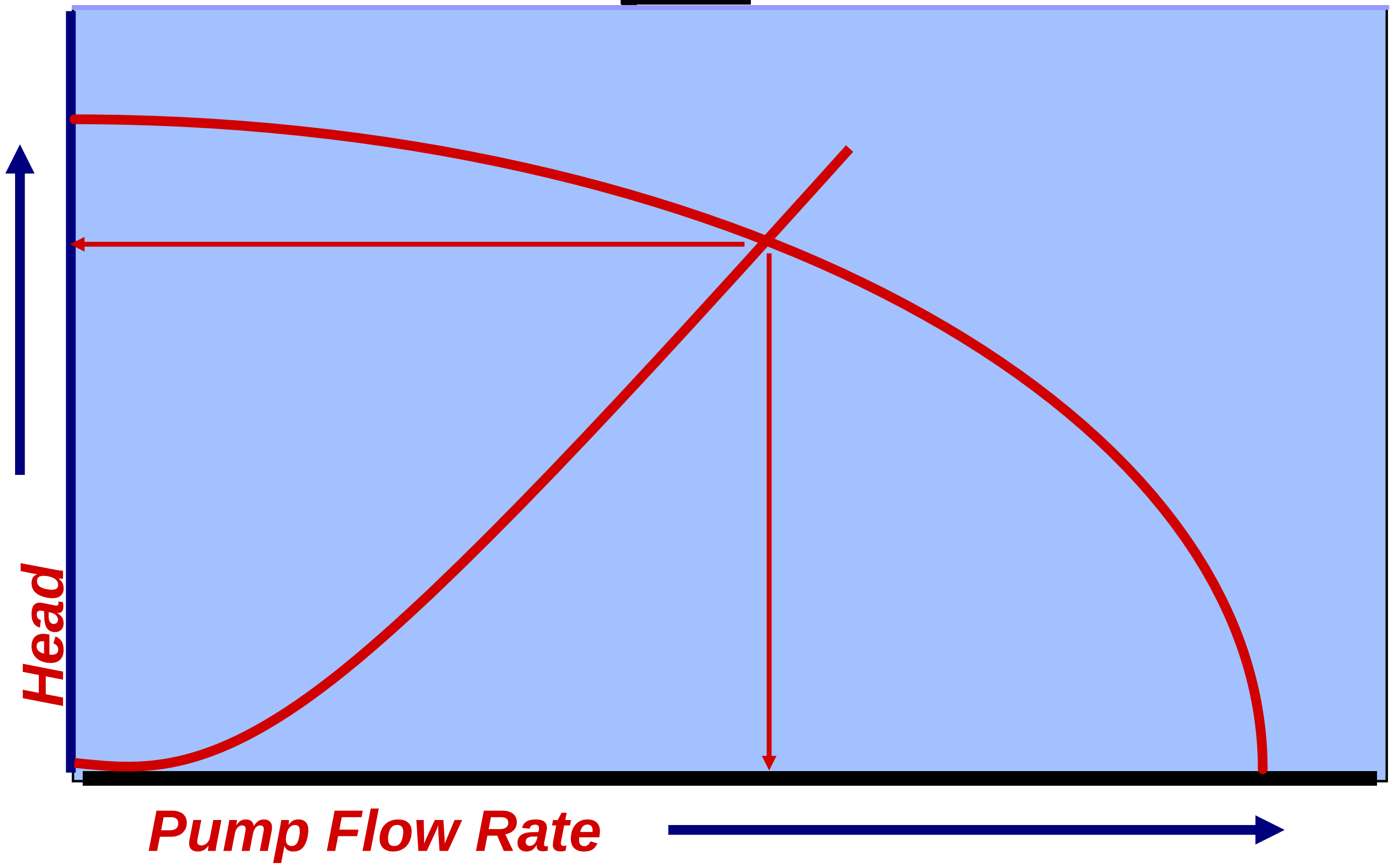
System Performance Curve

Step #3, Curve Mapping

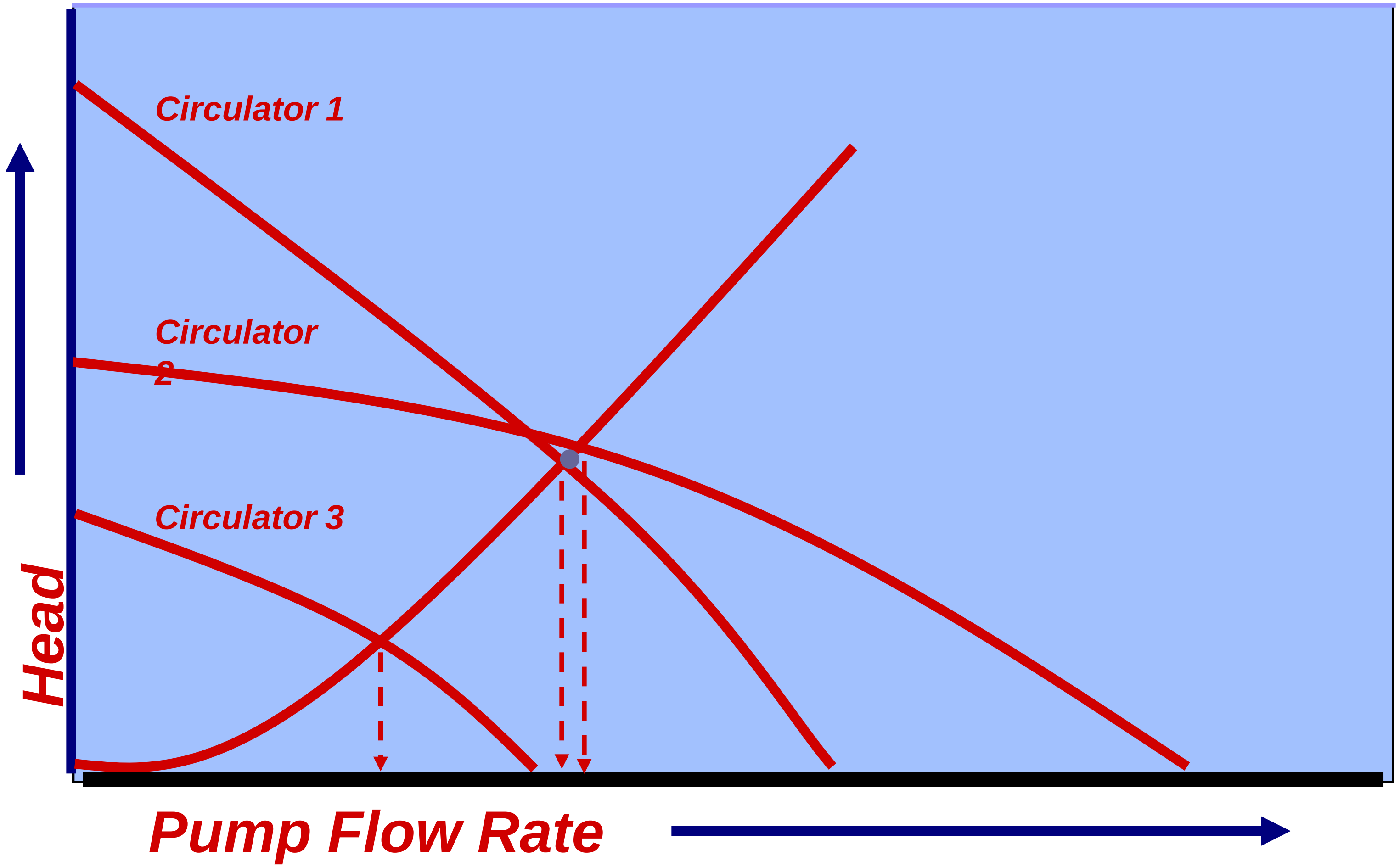
- **The friction loss is mapped onto the graph**
- **The amount of friction loss varies with flow through the system**



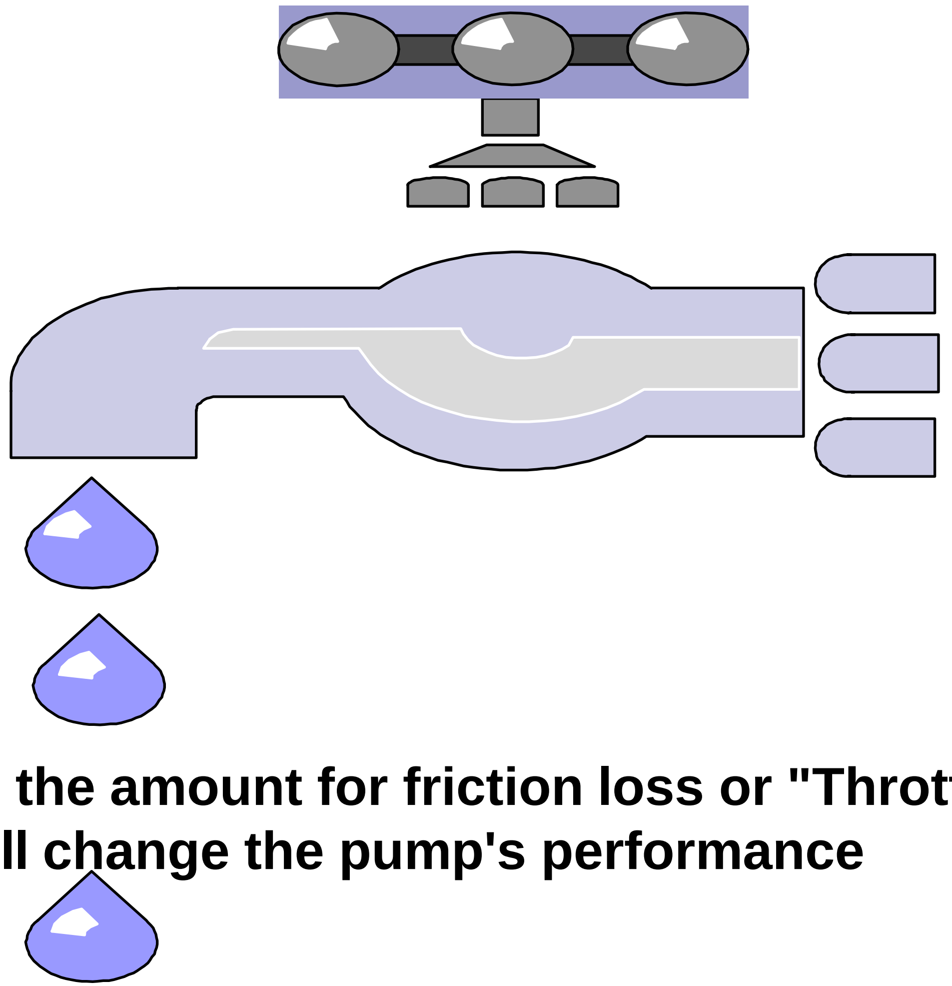
The point on the system curve that intersects the pump curve is known as the <u>operating point</u>.



PUMP SELECTION

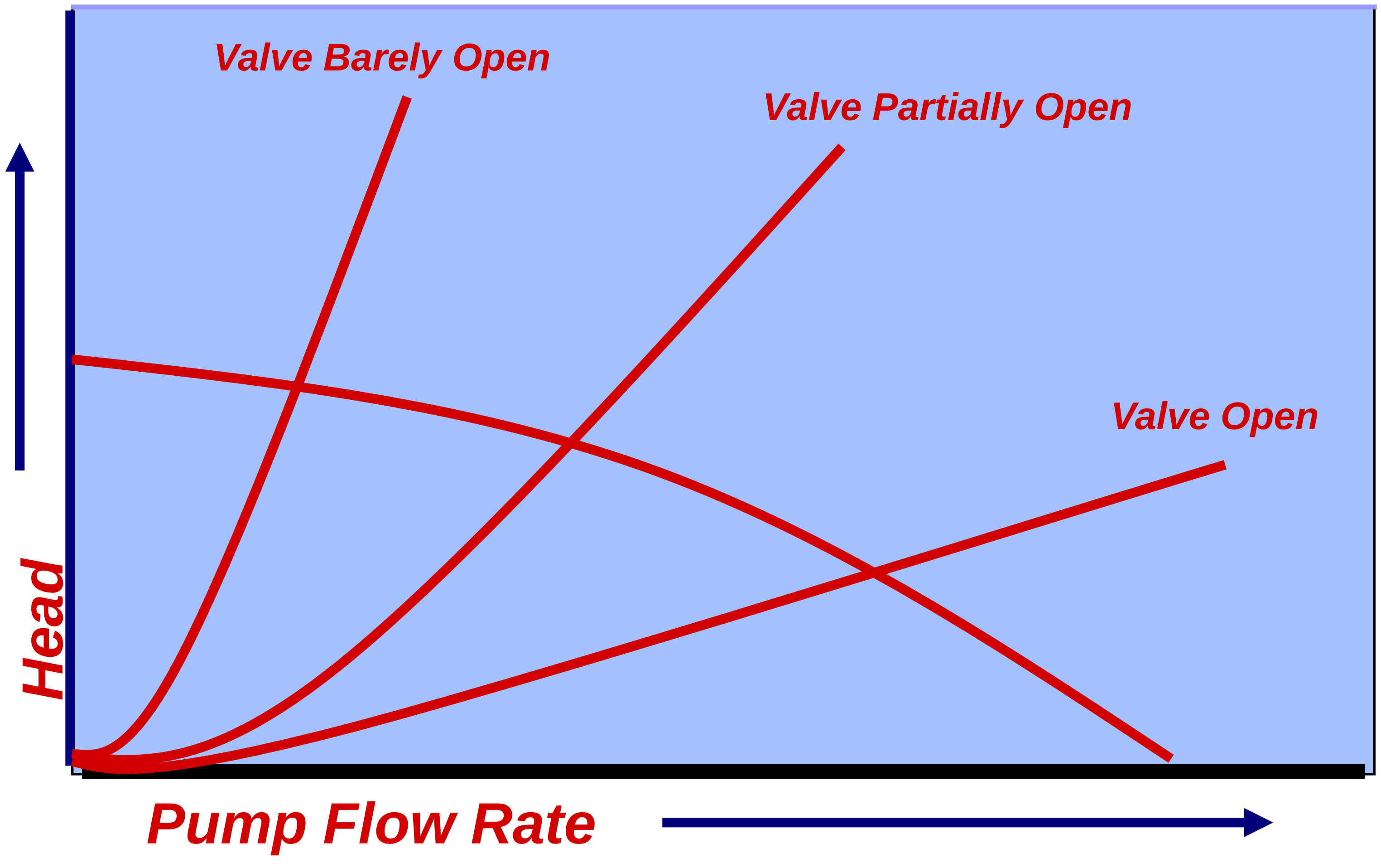


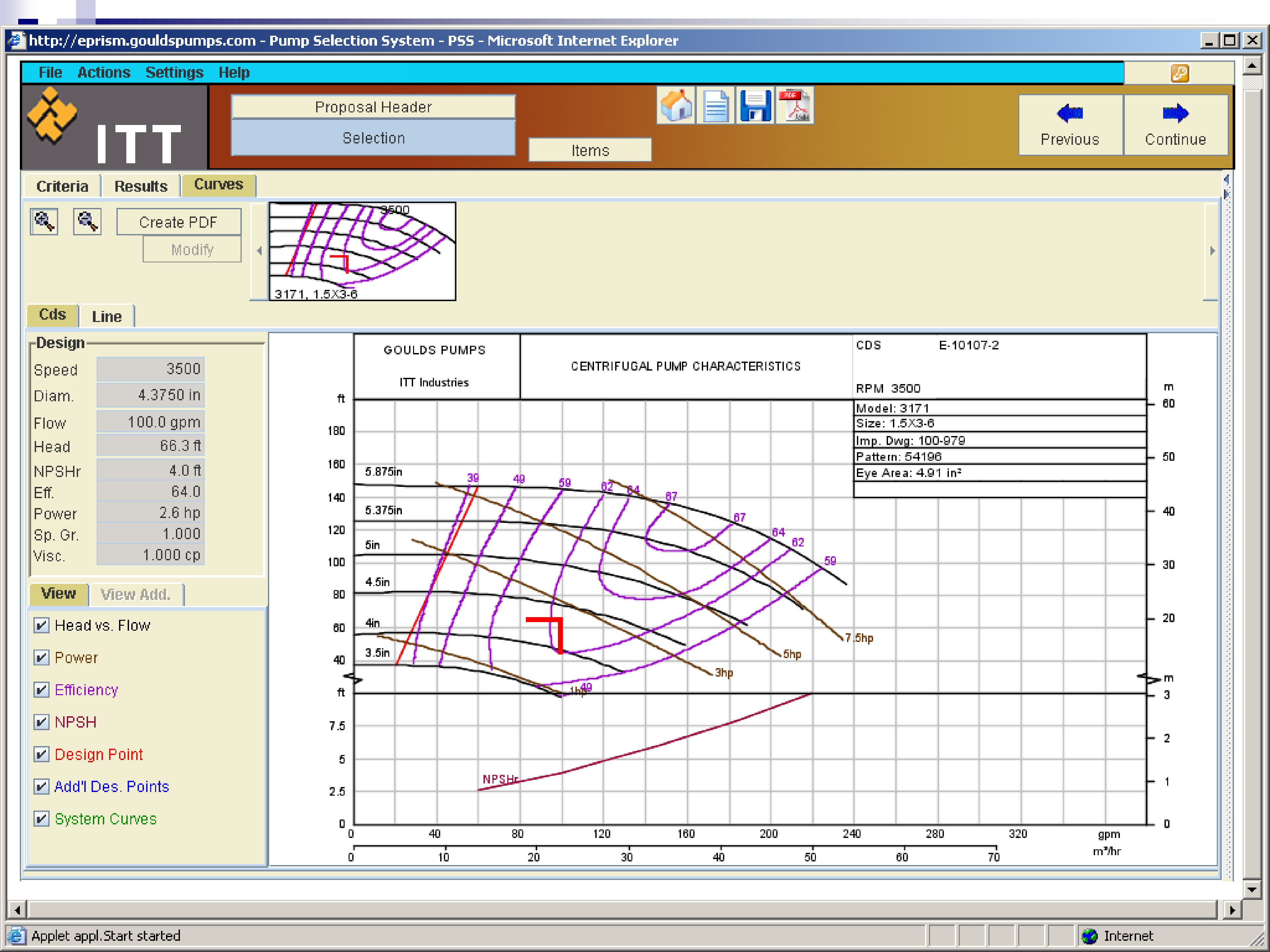
Controlling Pump Performance



- **Changing the amount for friction loss or "Throttling the Pump" will change the pump's performance**

PUMP SELECTION




http://eprism.gouldspumps.com - Pump Selection System - PSS - Microsoft Internet Explorer
File
Actions
Settings
Help
ITT
Proposal Header
Selection
Items
Previous
Continue
Criteria
Results
Curves
Create PDF
Modify
3500
3171, 1.5X3-6
Cds
Line
Design
Speed 3500
Diam. 4.3750 in
Flow 100.0 gpm
Head 66.3 ft
NPSHr 4.0 ft
Eff. 64.0
Power 2.6 hp
Sp. Gr. 1.000
Visc. 1.000 cp
View
View Add.
Head vs. Flow
Power
Efficiency
NPSH
Design Point
Add'l Des. Points
System Curves
GOULDS PUMPS
ITT Industries
CENTRIFUGAL PUMP CHARACTERISTICS
CDS
E-10107-2
RPM 3500
Model: 3171
Size: 1.5X3-6
Imp. Dwg: 100-979
Pattern: 54196
Eye Area: 4.91 in²
5.875in
5.375in
5in
4.5in
4in
3.5in
39
49
59
62
64
67
7.5hp
5hp
3hp
1hp
NPSHr
ft
m
gpm
m³/hr
Applet appl.Start started
Internet

Piping Design Equations Heuristics for Pipe Diameter

Liquids:

$$D = 2.607\left(\frac{w}{\rho}\right)^{0.494}$$

Gases:

$$D = 1.065\left(\frac{w^{0.408}}{\rho^{0.343}}\right)$$

$D = Diameter, inches$

$w = Mass\ Flowrate, 1000\ lb/hr$

$\rho = Density, lb/ft^3$

Energy Loss in Piping Networks Incompressible Fluids

$$\frac{144}{\rho}\left(P_1 - P_2\right) + \frac{1}{2g}\left(v_1^2 - v_2^2\right) = \left(z_2 - z_1\right) + h_L$$

$$\rho = Density,\ lb/\ ft^3$$

$$P = Pressure,\ lb_f\ /in^2$$

$$v = Velocity,\ ft/sec$$

$$g = Gravitational\ Acceleration,\ 32.174\ ft/s^2$$

$$z = Elevation,\ ft$$

$$h_L = Head\ loss,\ ft$$

$$h_L = \frac{0.00259\left(\sum K\right)Q^2}{d^4}$$

$$Q = Volumetric\ Flowrate,\ gpm$$

$$d = Pipe\ Diameter,\ in$$

$$\sum K = Sum\ of\ all\ fittings$$

$$K = f\,\frac{L}{D},\ straight\ pipe$$

$$K = \left(1 - \frac{d_1^2}{d_2^2}\right)^2,\ Sudden\ enlargement$$

Friction Loss Factors for Fittings

Fitting	K
Standard 90º Elbow	$30f_T$
Standard 45º Elbow	$16f_T$
Standard Tee	$20f_T$ Run $60\ f_T$ Branch
Pipe Entrance	0.78
Pipe Exit	1.0

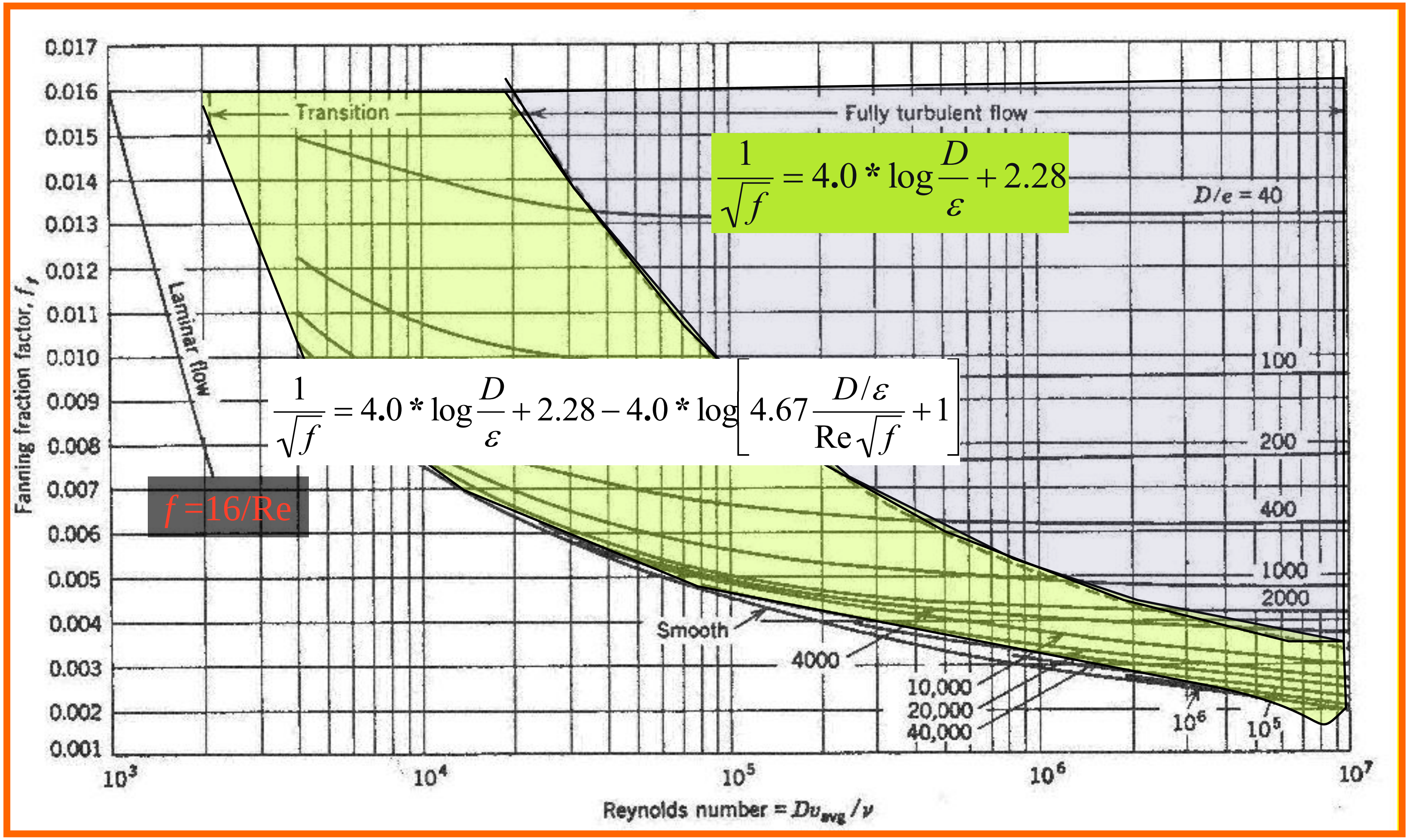
Friction Loss Factors for Valves

Valve	K
Gate valve	$8f_T$
Globe Valve	$340f_T$
Swing Check Valve	$100f_T$
Lift Check Valve	$600f_T$
Ball Valve	$3f_T$

$$\sqrt{K} = \frac{29.9d^2}{C_V^2}$$

$$C_V = Valve\ Coefficient$$

Fanning Diagram



Energy Loss in Valves

- Function of valve type and valve position
- The complex flow path through valves can result in high head loss (of course, one of the purposes of a valve is to create head loss when it is not fully open)
- E_v are the loss in terms of velocity heads