Pumping stations and water transport

Pumps and pumping stations
ct5550

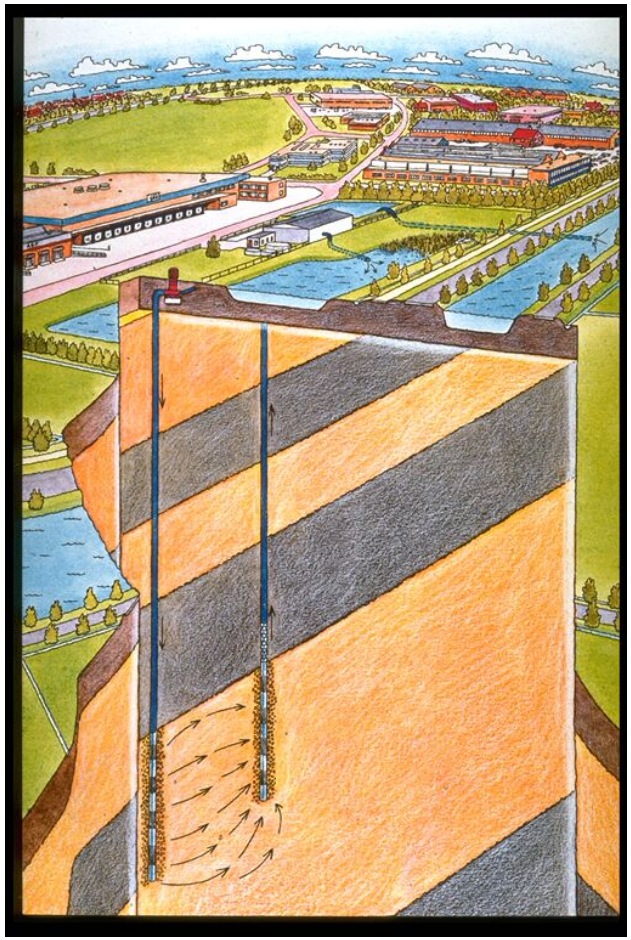
February 8, 2008

Delft University of Technology

Introduction

- Basic function is energy feeding
- Actually lifting water or pressurising water
- Compensating energy losses:
  - Energy loss due to drive mechanism
  - Friction losses in pipes
  - Deceleration losses
- Parameters: volume flow and pressure
  - Q=f(h)

Pumping ground water



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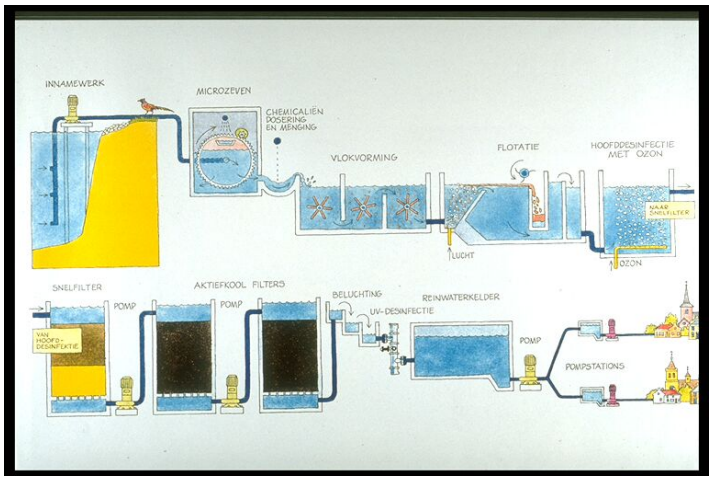
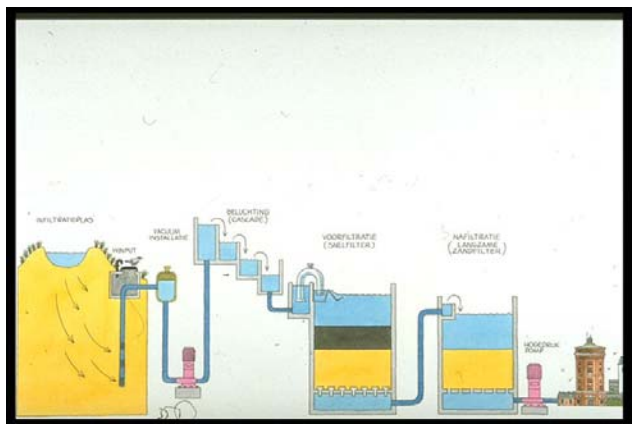
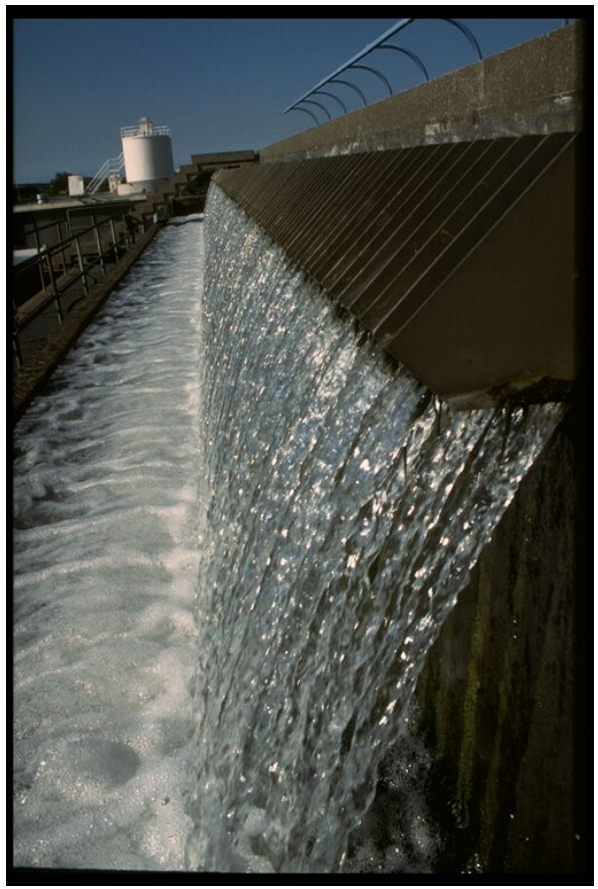
Treatment







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Transport through pipes

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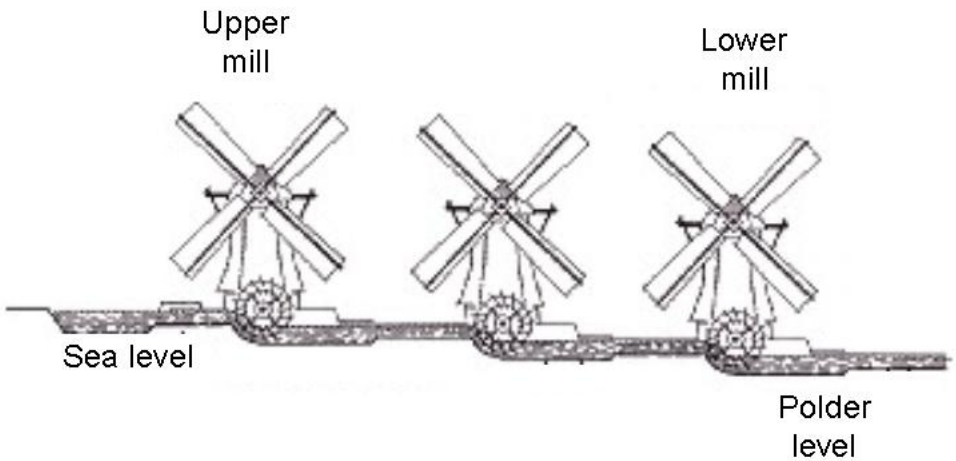
Controlling rain water wash out



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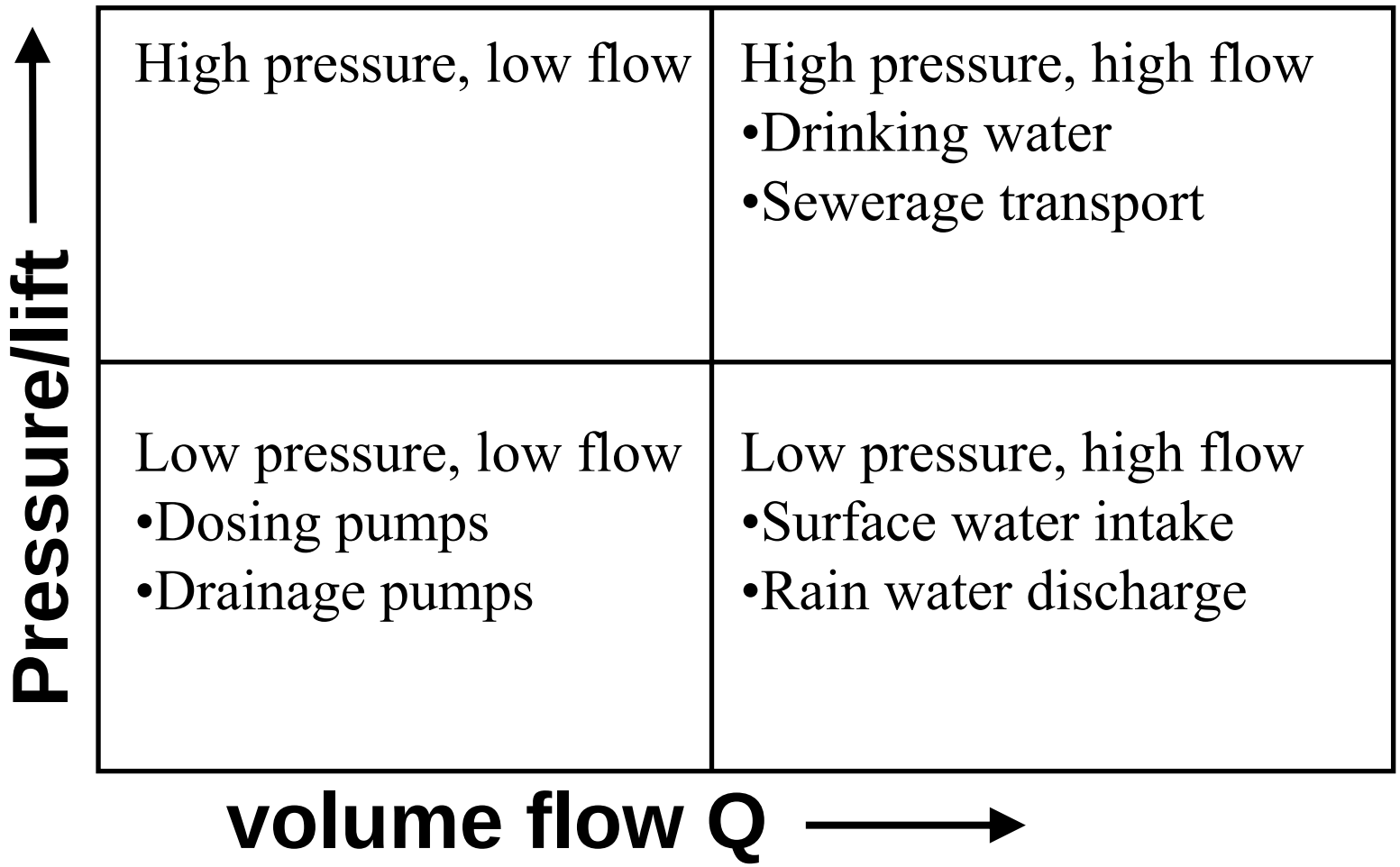
Classification of pumps



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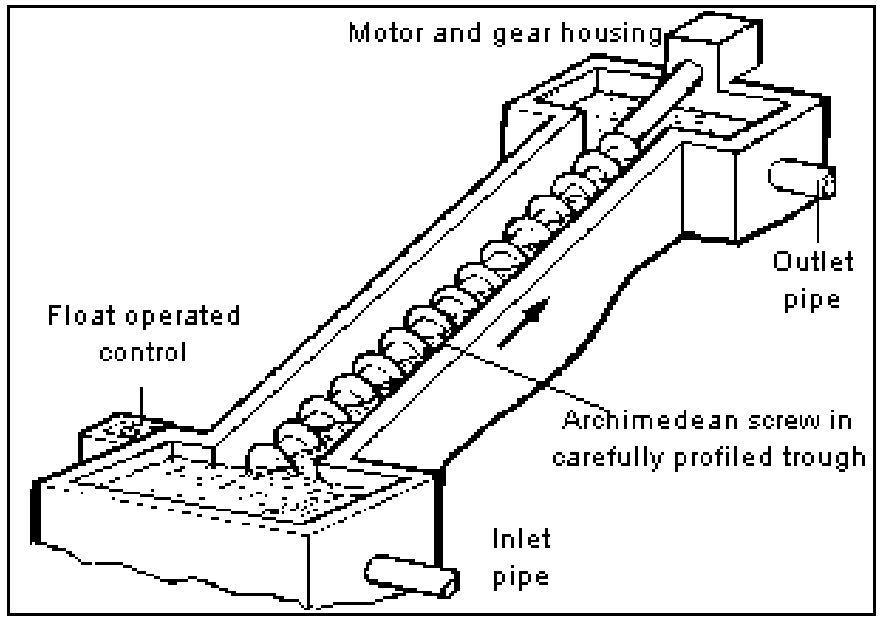
Pump type: 'Open' pump

- Lift water between open surfaces
  - Archimedean Screw pumps
  - Polder pumps



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Pump type: ‘Closed’ pump

- Water is pressurised in a closed vessel
- Energy is converted to pressure and velocity

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Pump characteristics

- Q-H curve
- Efficiency curve
- Power curve
- NPSH characteristic

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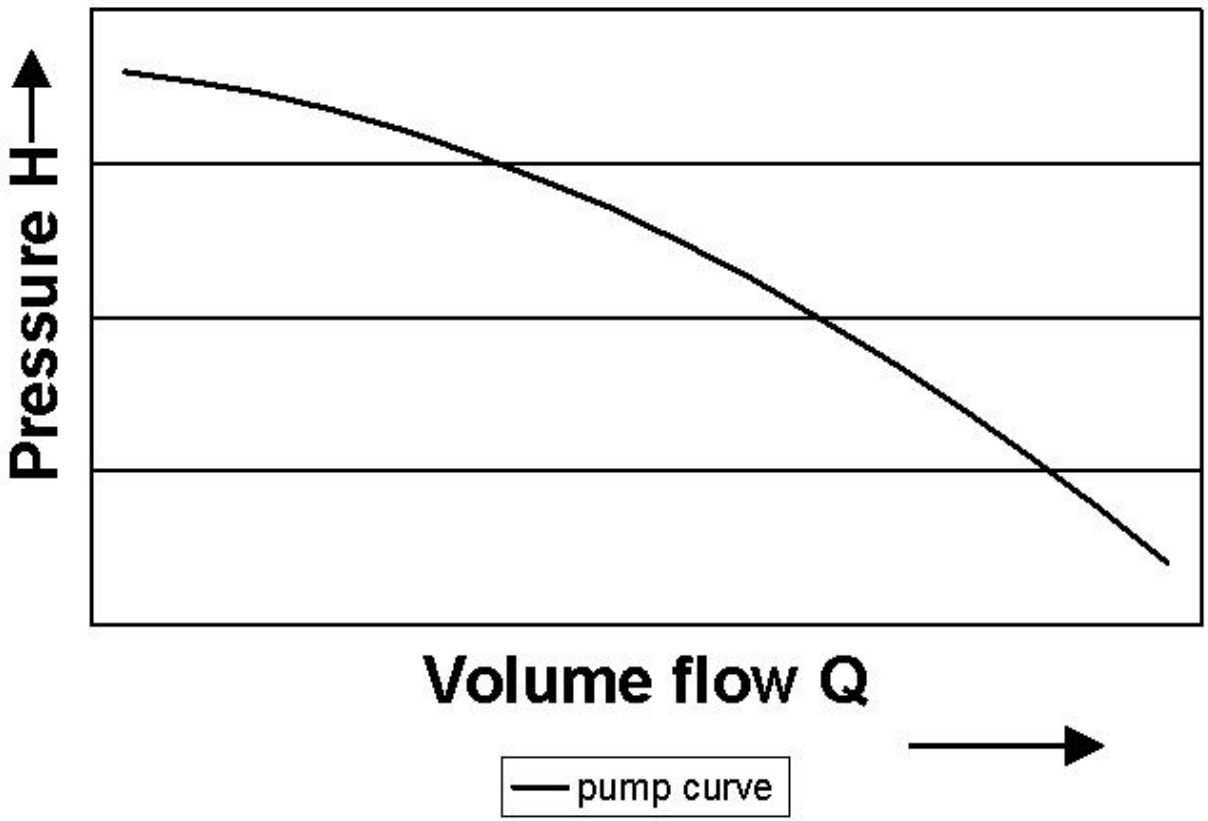
Q-H curve



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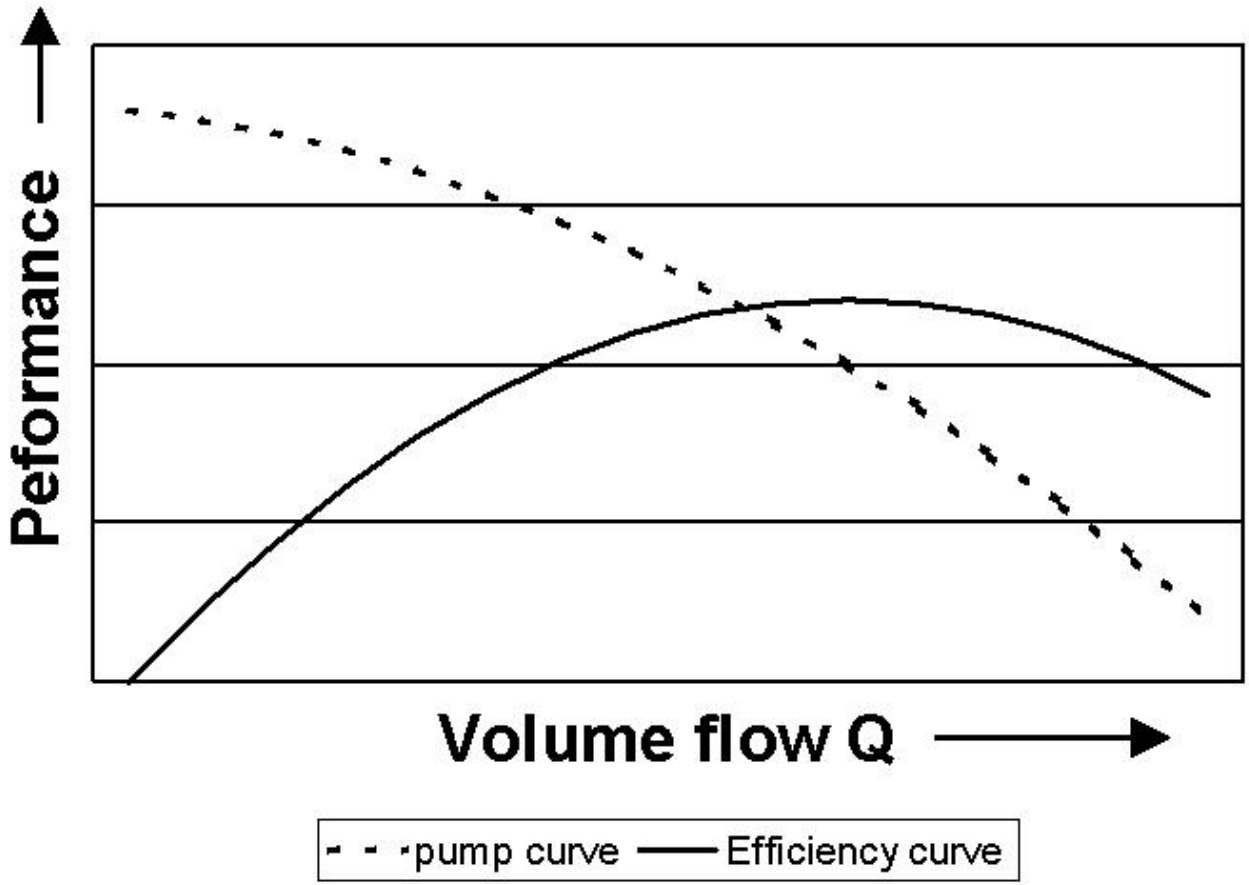
Performance / efficiency curve



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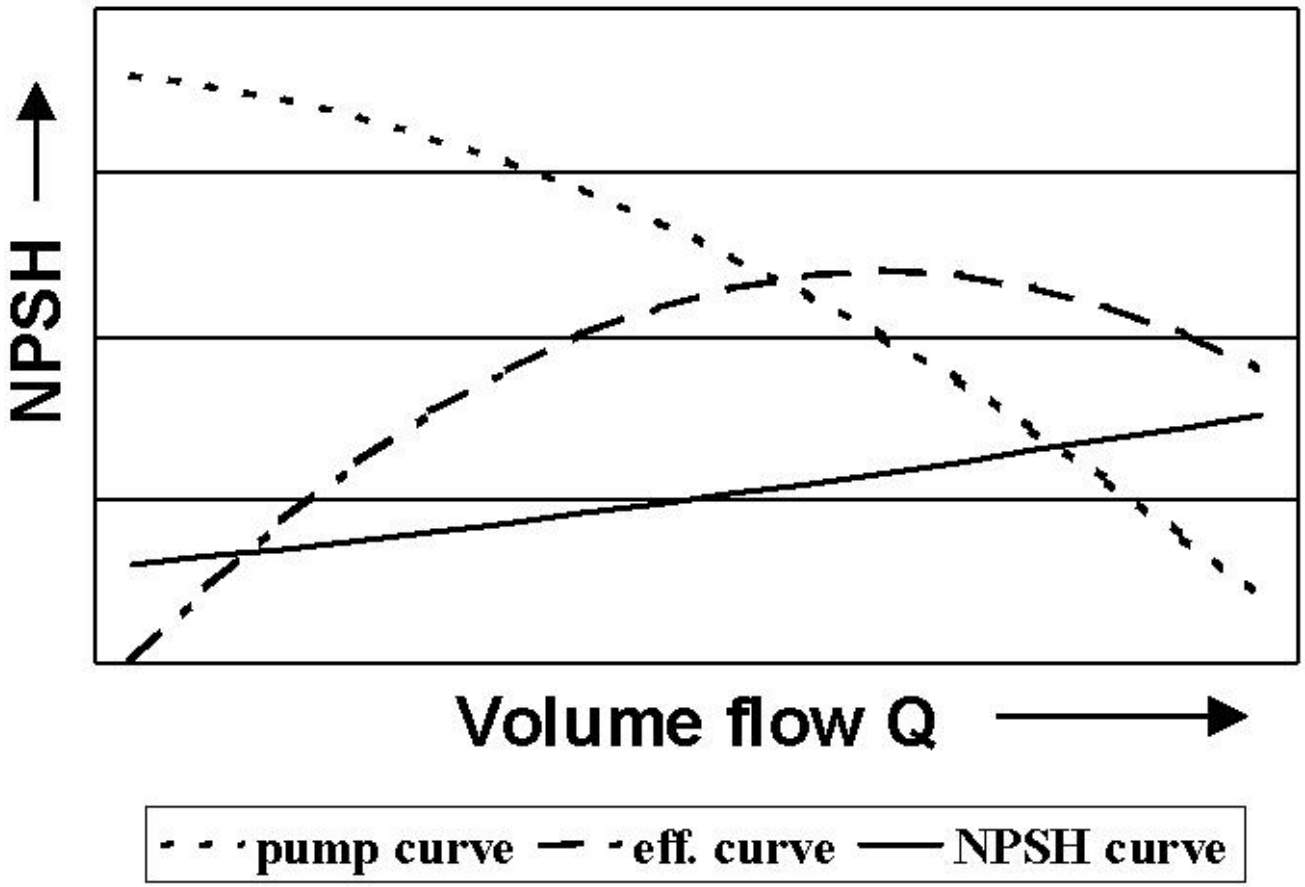
Net Positive Suction Head



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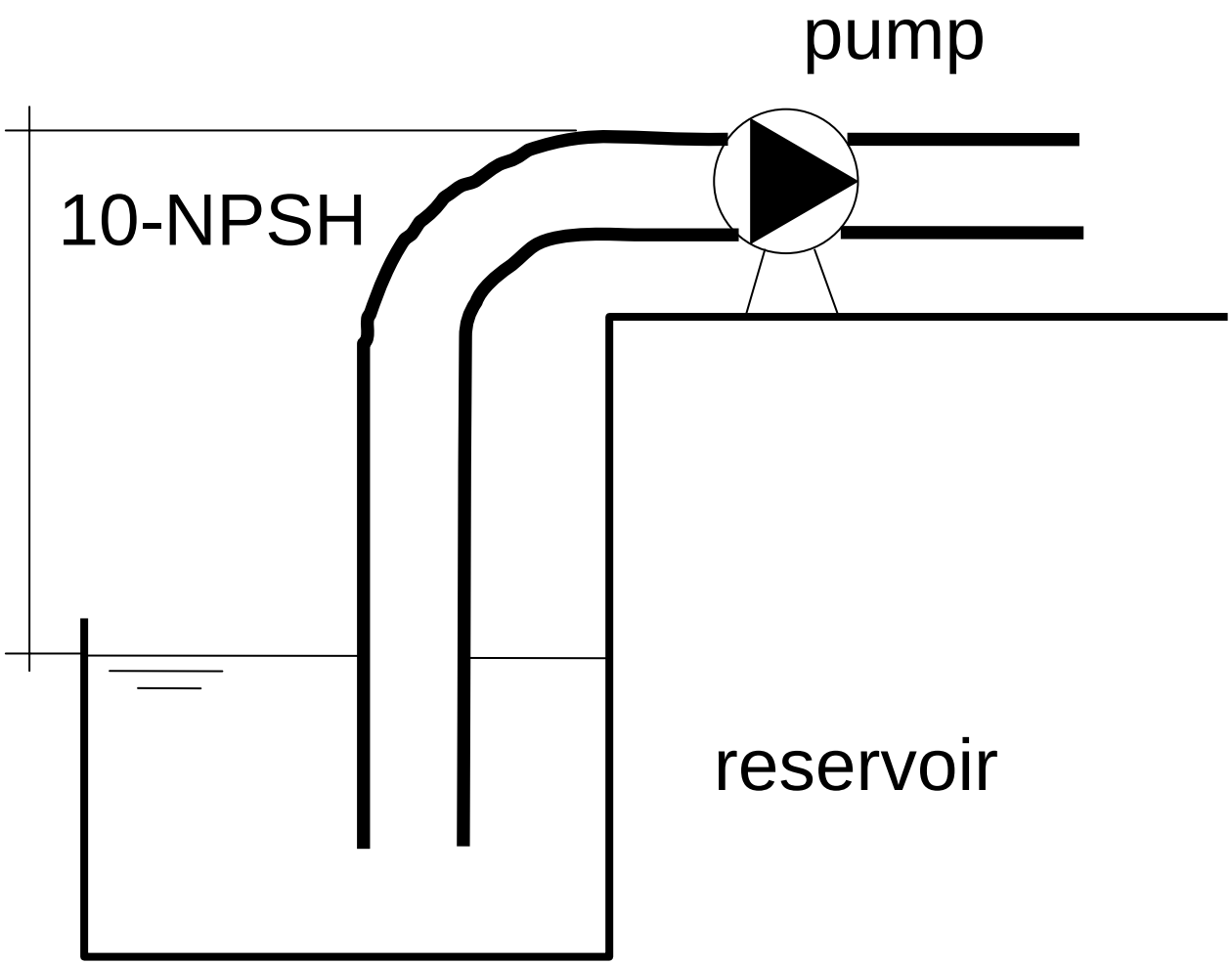
Net Positive Suction Head



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Effect of cavitation

- Vapour bells as result of negative pressures
- Bells are pressurised in the high pressure zones
- Bells act like small grains before dissolving

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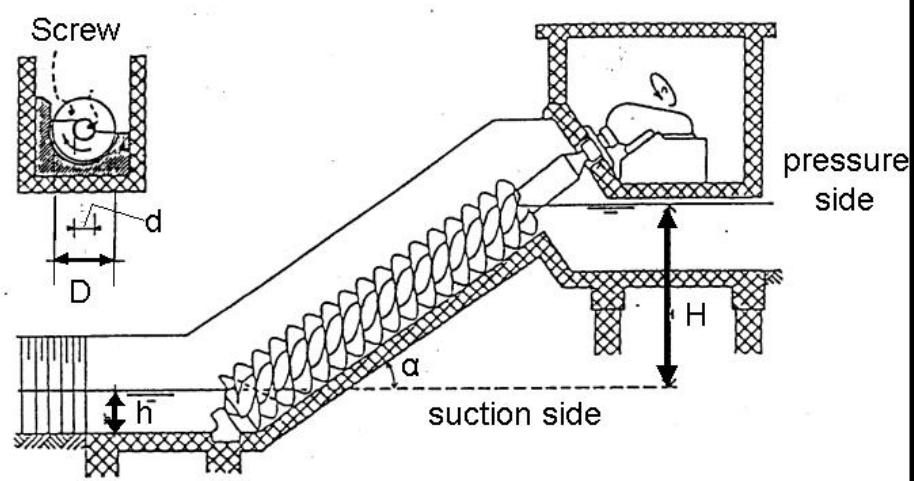
Pump types: Archimedean screws



$$Q = k*n*D^3$$

Values of k

d/D	a = 22°	
	S=1D	S=1,2D
0.3	0.331	0.336
0.4	0.350	0.378
0.5	0.345	0.380
0.6	0.315	0.351

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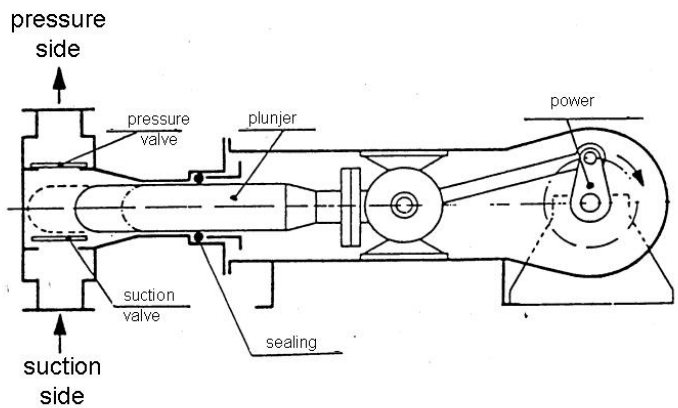
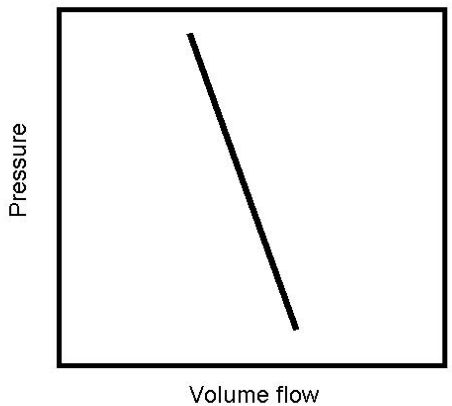
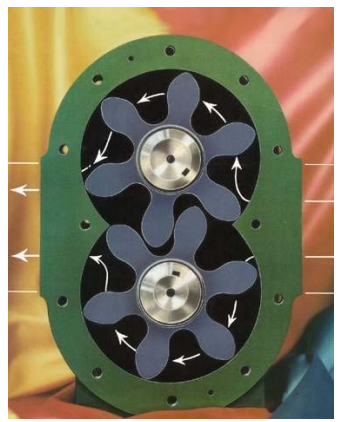
Pump type: displacement pumps





Steep pump curve displacement pump



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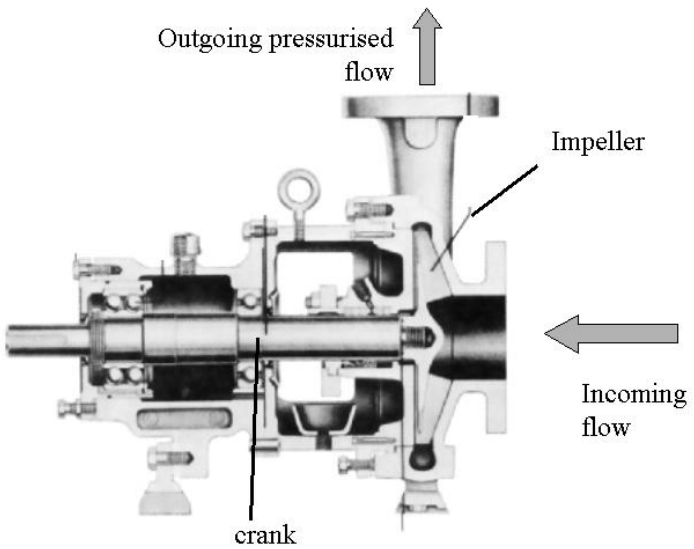
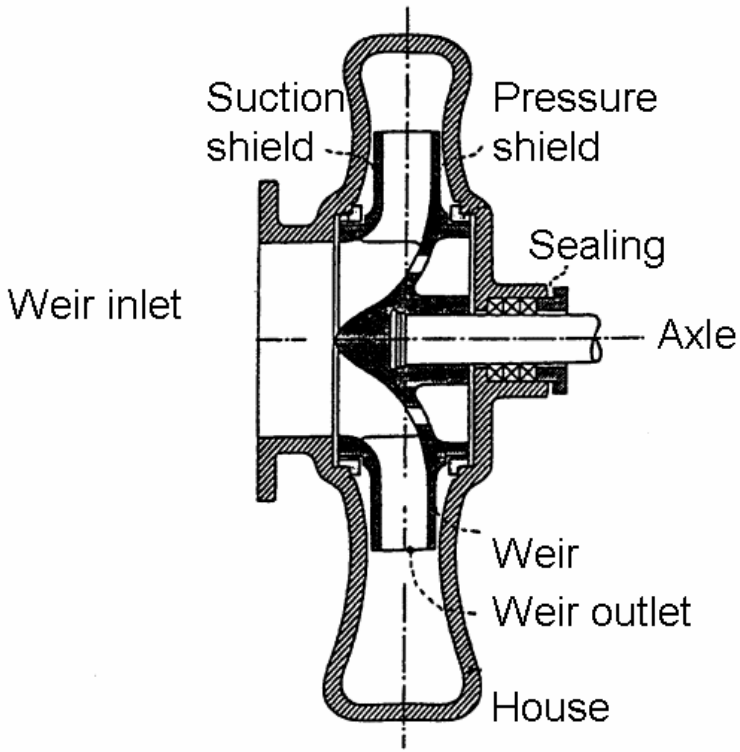
Pump types: Impellor pumps





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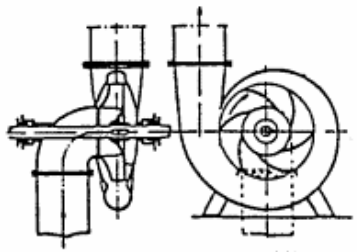
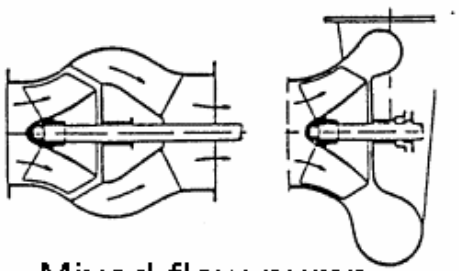
Pump types: impellor pumps



Centrifugal pump

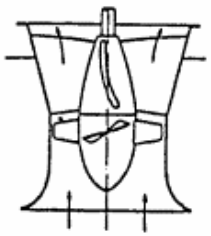
Centrifugal blade



Mixed flow pump

Mixed flow blade

Propellor pump



Propellor blade

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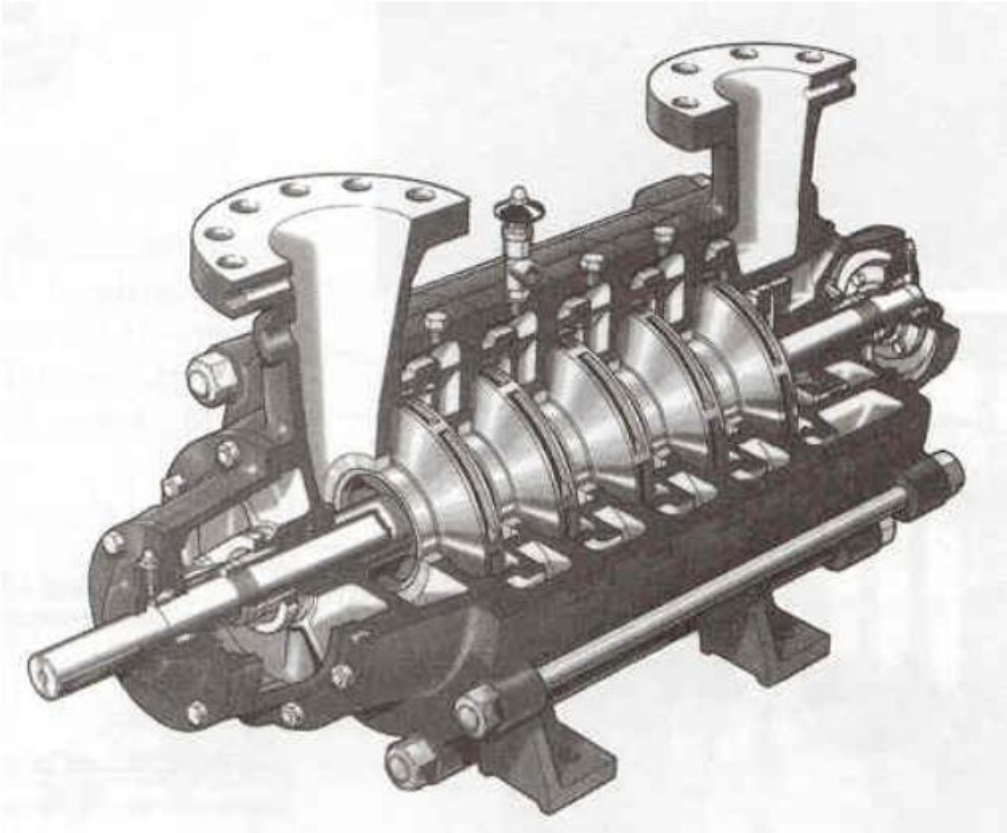
Examples of impellor pumps



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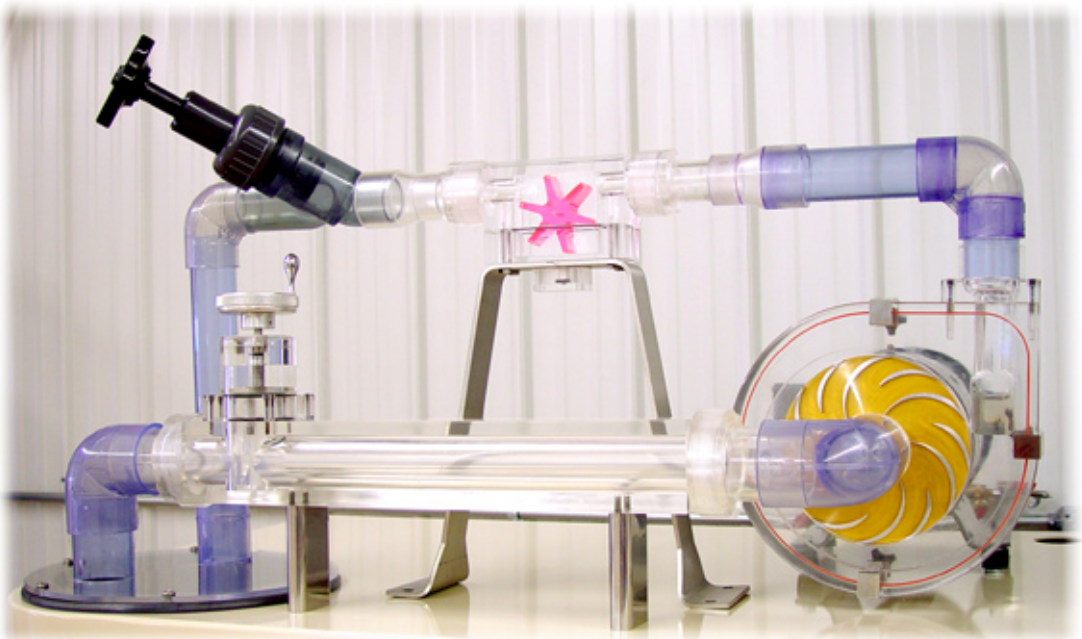
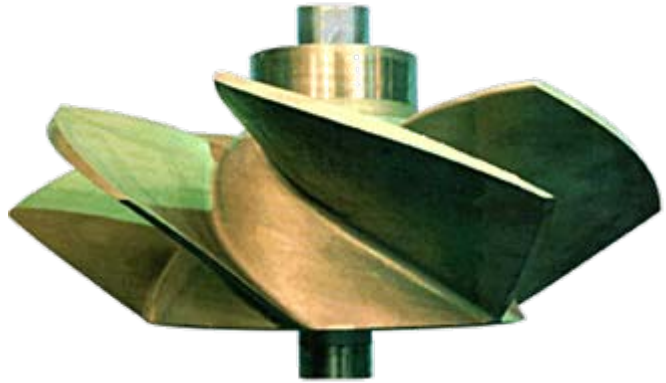
Examples





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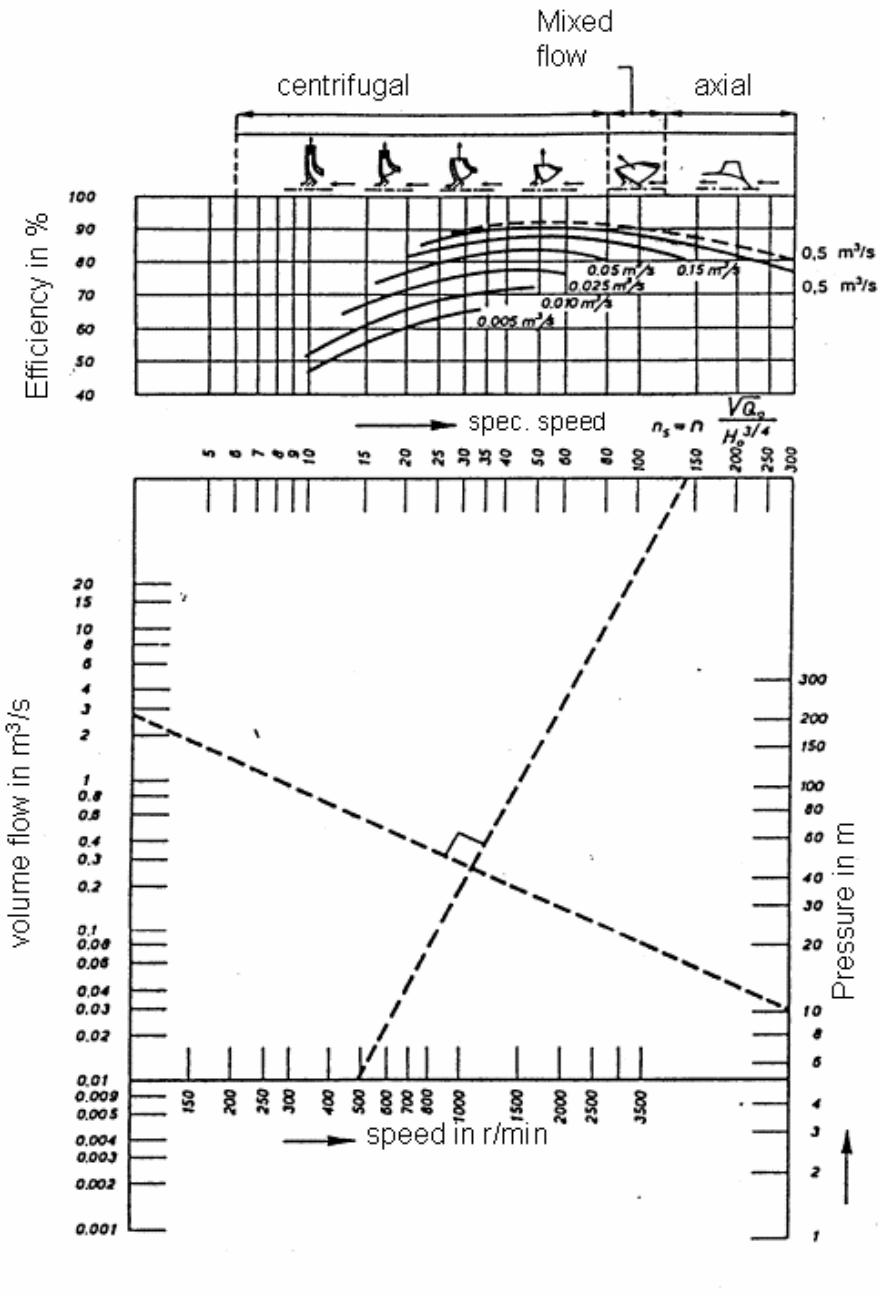
Example of blade

Specific speed

$$N_s = \frac{n\sqrt{Q}}{\sqrt[3]{H^4}}$$



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Pipe characteristics

- Energy loss in a pipe is mainly friction loss

$$\Delta H = \xi \frac{u^2}{2g};\ \text{friction: } \xi = \frac{\lambda \mathrm{L}}{\mathrm{D}};\frac{0,02 \cdot 100}{0,1} = 20$$

$$\text{local: } \xi = 0,1 \rightarrow\ 3$$

- Pressure drop is quadratic proportional to velocity (volume flow): $\Delta H = f(Q^2)$

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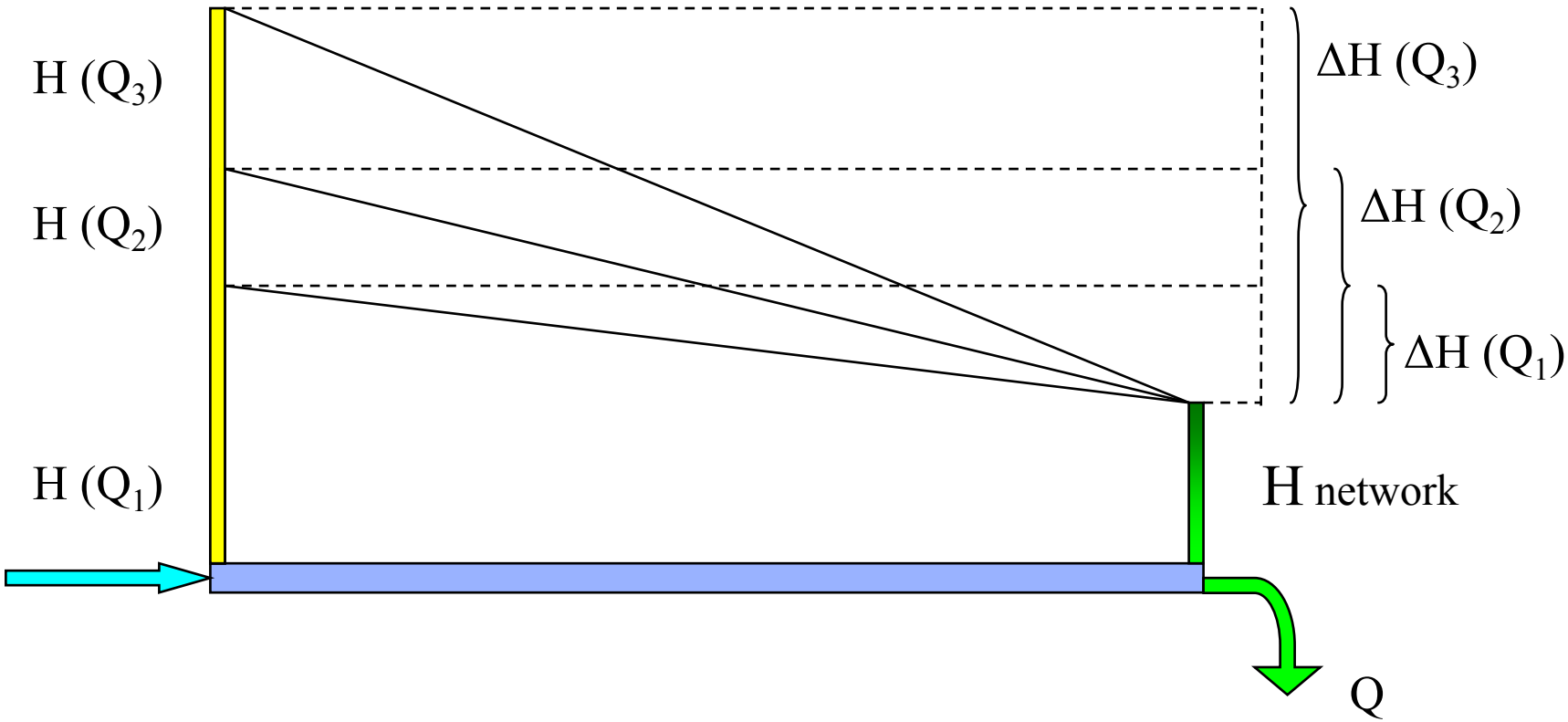
Pipe characteristic



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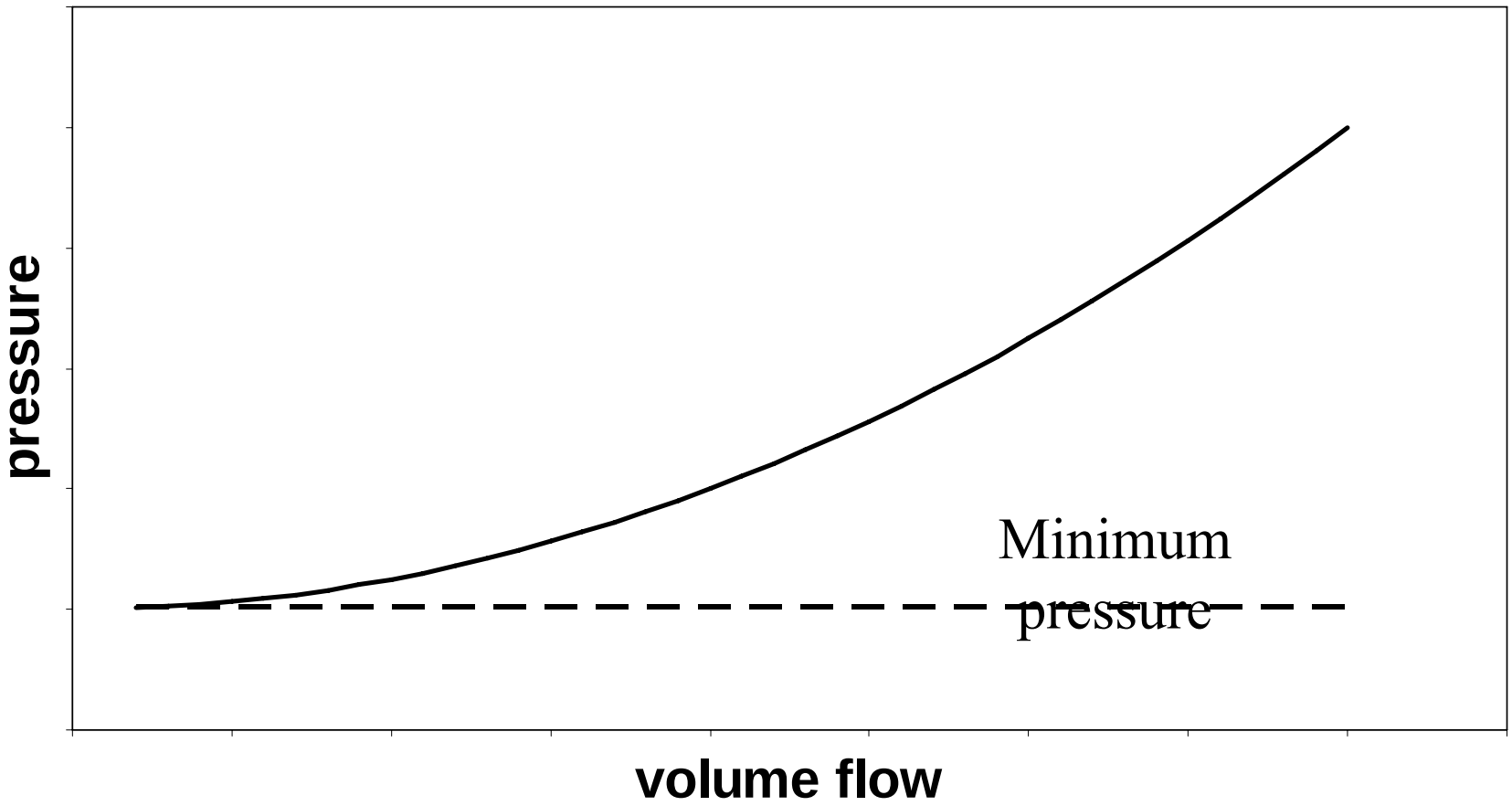
Pipe characteristic



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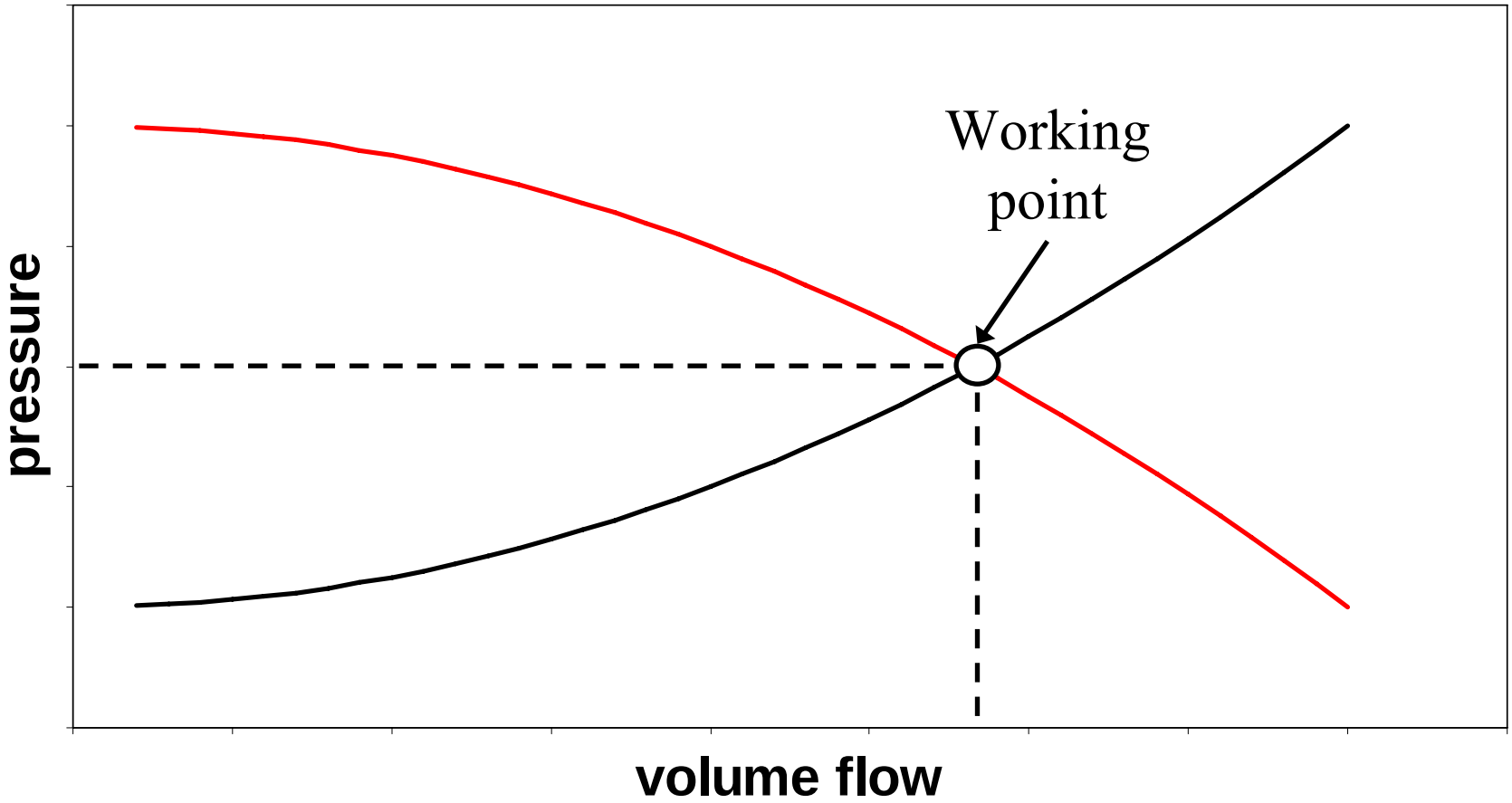
Working point



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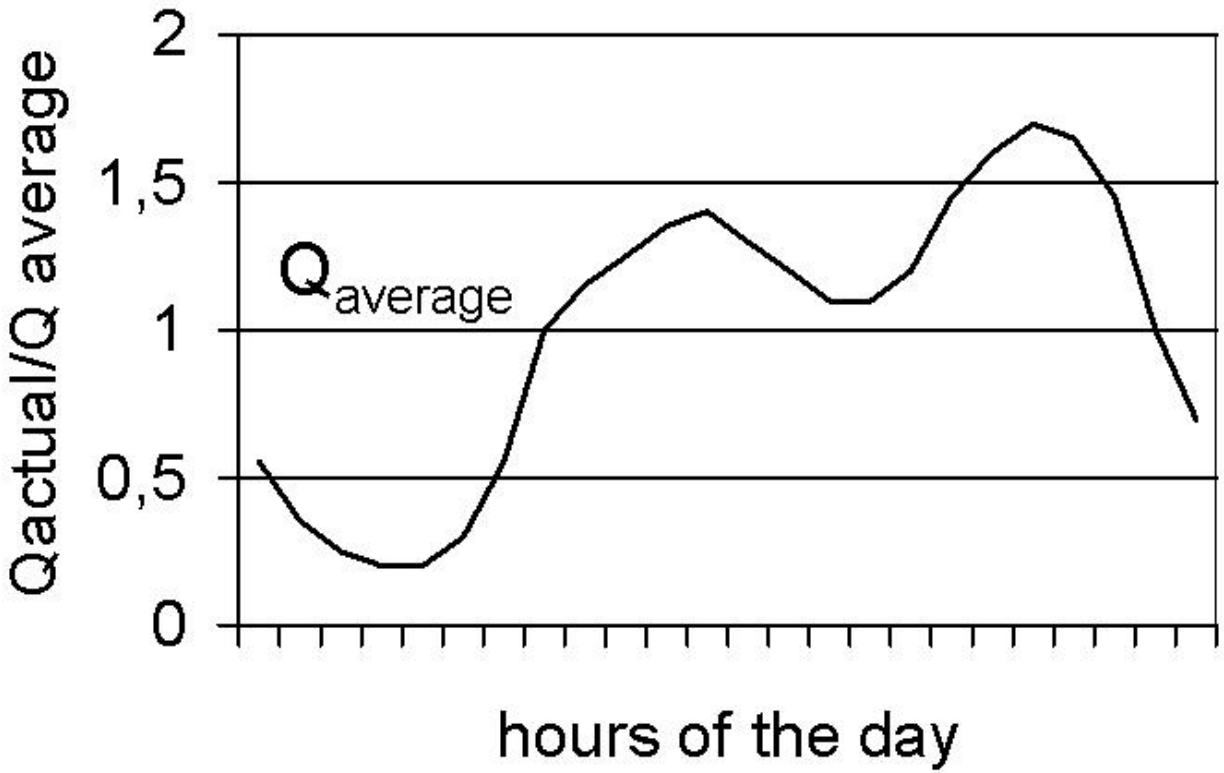
Demand curve



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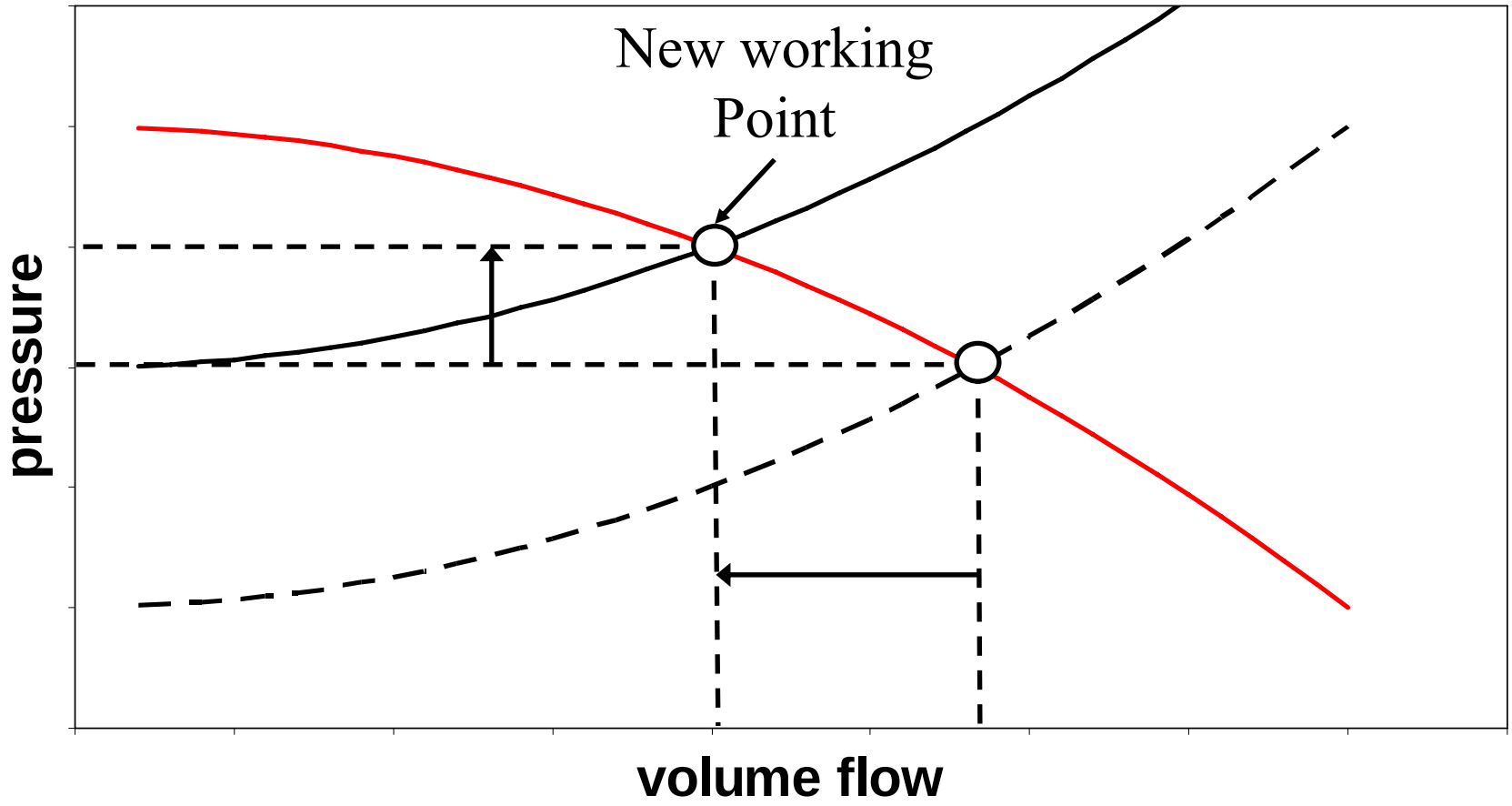
Working point



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Flow control

- Traditional pumps work on one speed
- Flow control is possible by throttling valves (increasing pipe resistance)
- Consequence is higher pressure
  - More leakage
  - Waste of energy
- Variable speed pump

Conventional pump regulation

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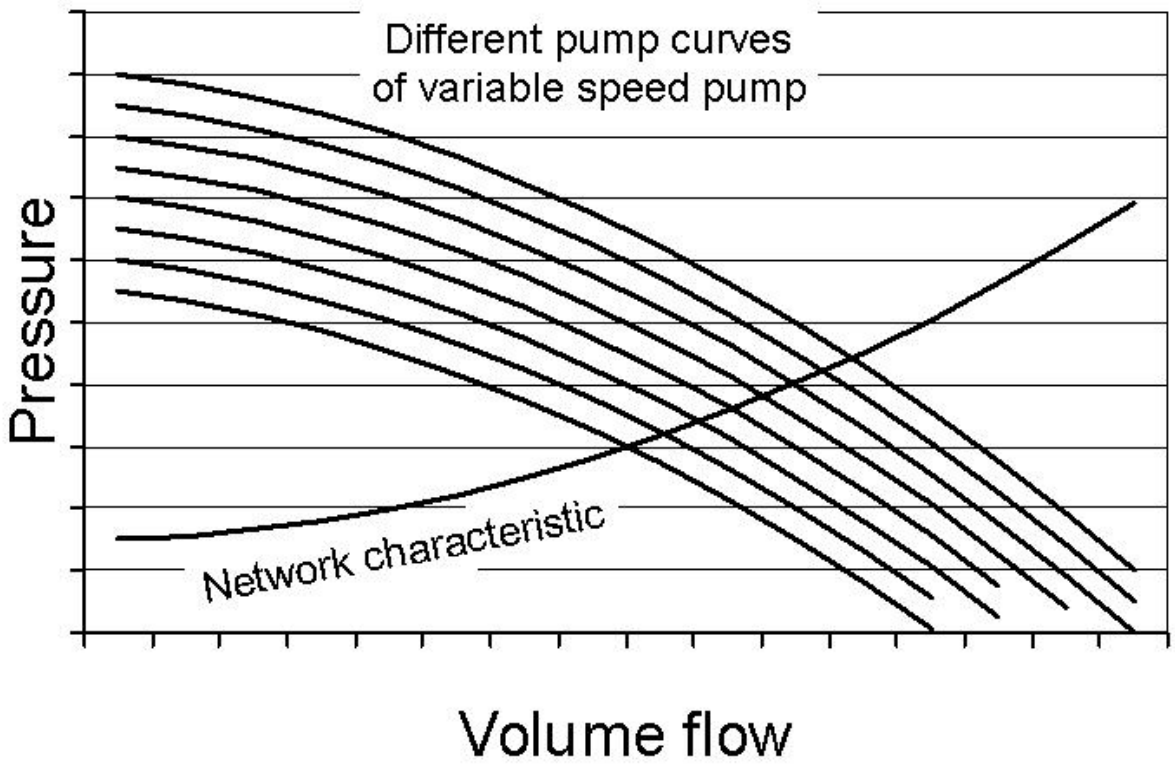
Variable speed pump



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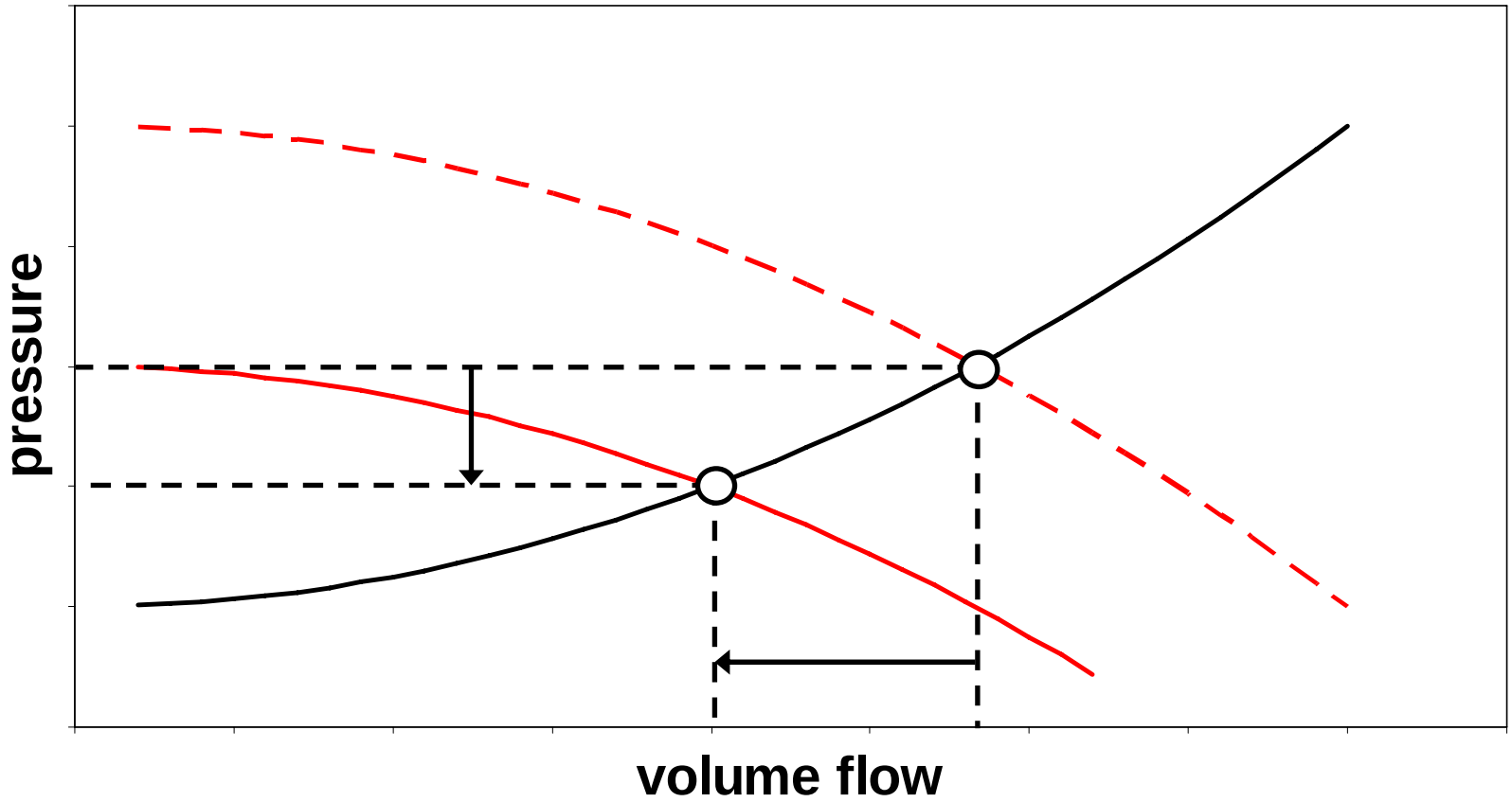
Working point with variable speed pump



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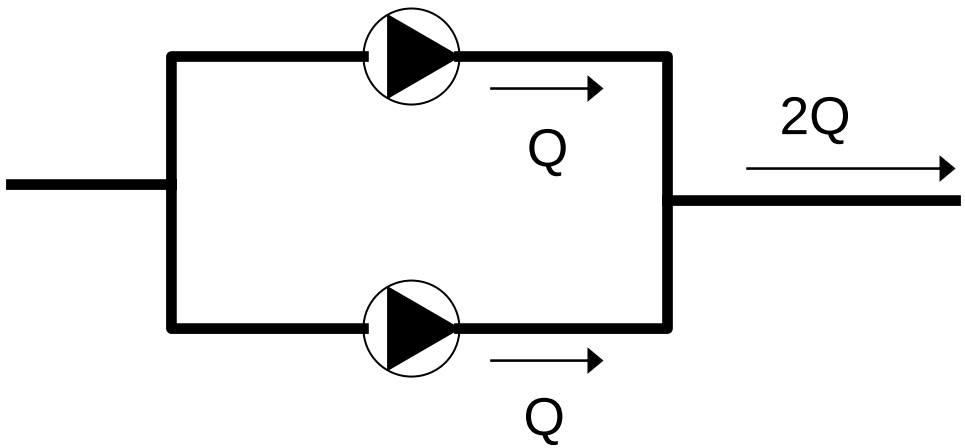
Pumps in parallel (more flow)

- Pumps work individually
- Flows can be added



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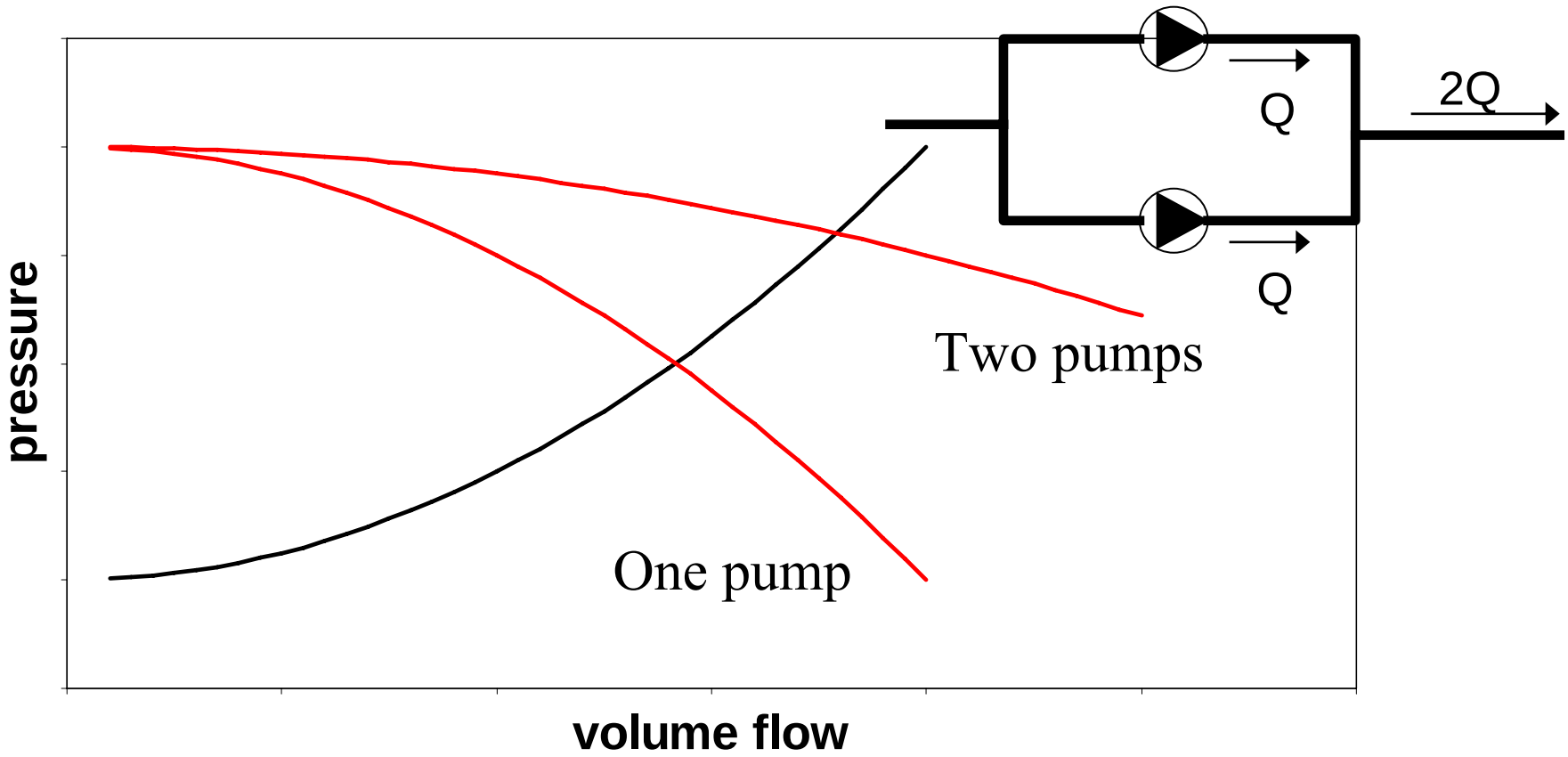
Pumps in parallel (more flow)



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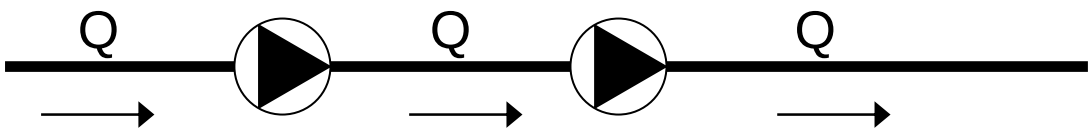
Pumps in series

- Pumps work individually
- Pressures are added



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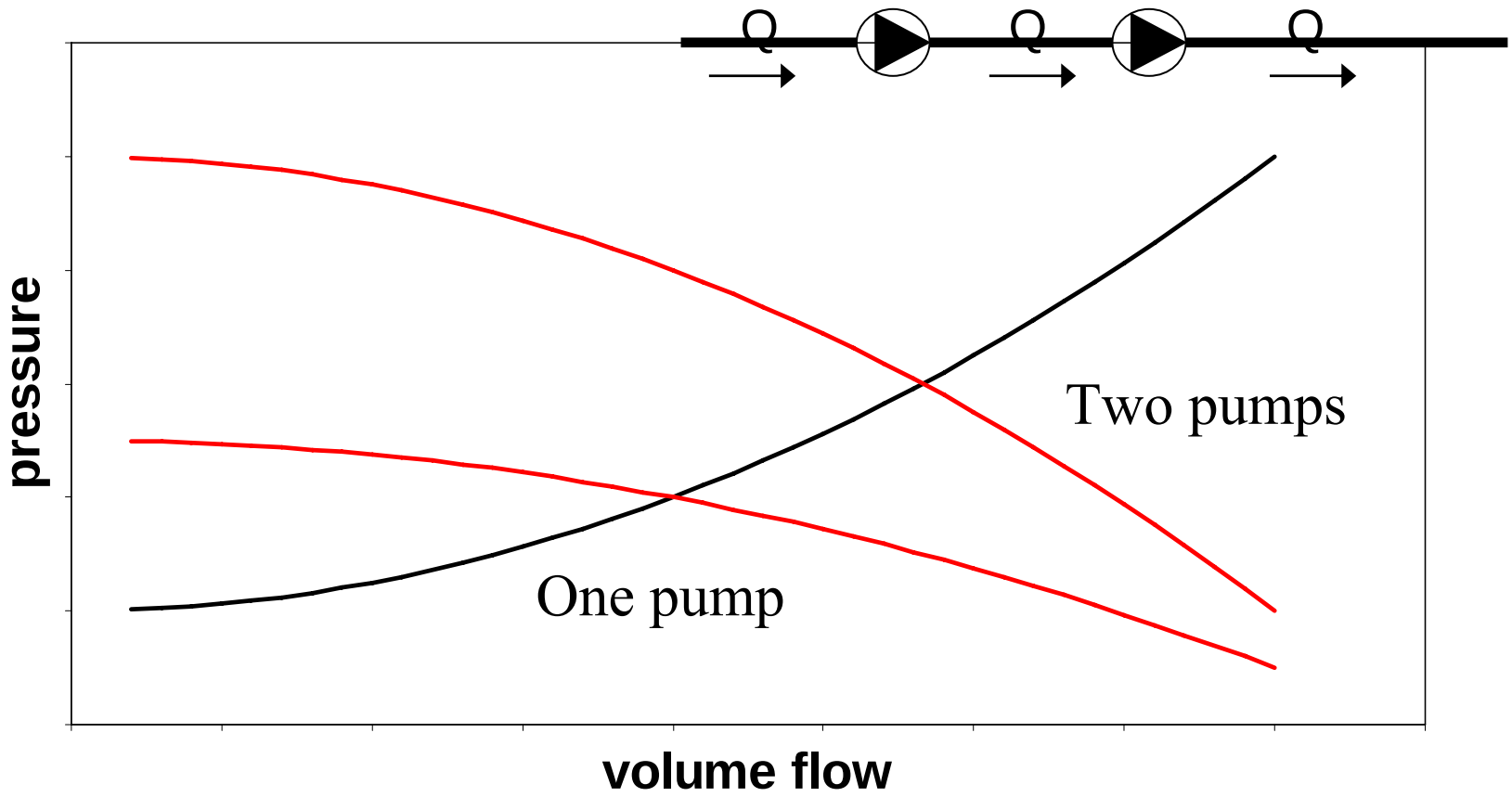
Pumps in series (more pressure)



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Design of pumping stations

- Determine pipe/network characteristic
- 'Construct' pump curve
- Design pump schedule

- Network calculation software is inevitable

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Pictures of pumping stations and pump lay outs

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Pumping station

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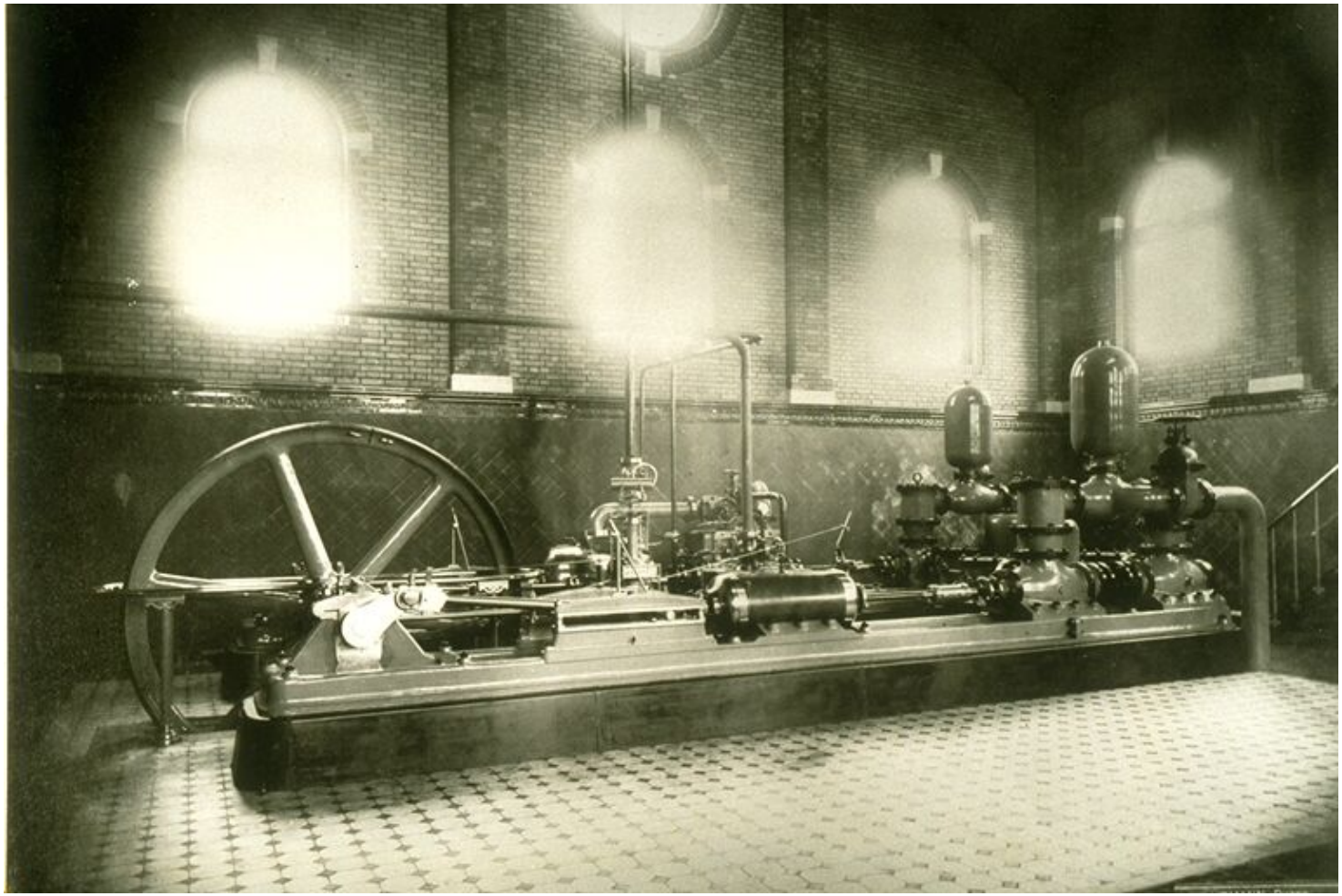
Energy input

- Electrical
- Fuel motors
- Back up/emergency power

Power systems



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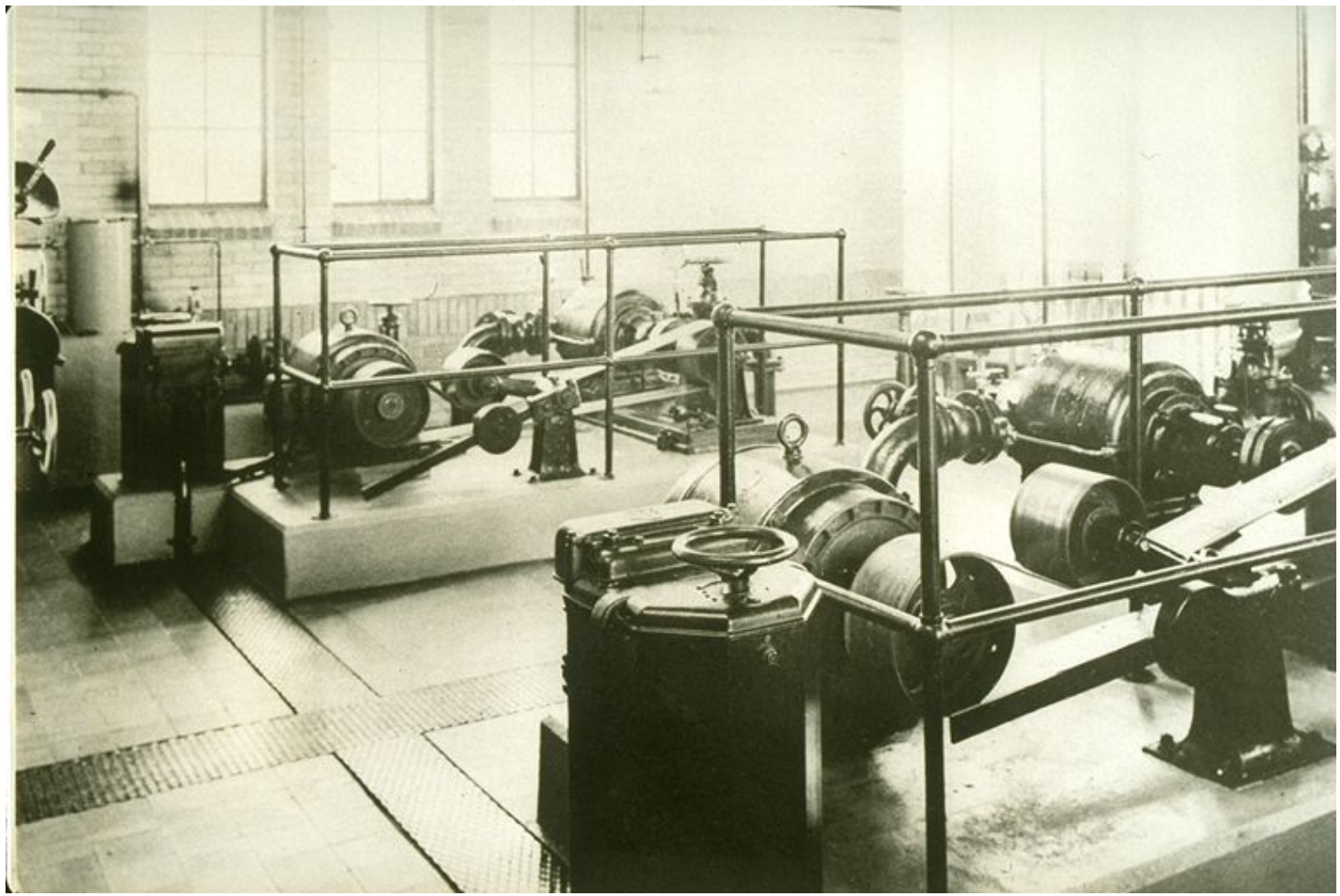
Power systems



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Power systems

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Power systems

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Pump system

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Operation lay out

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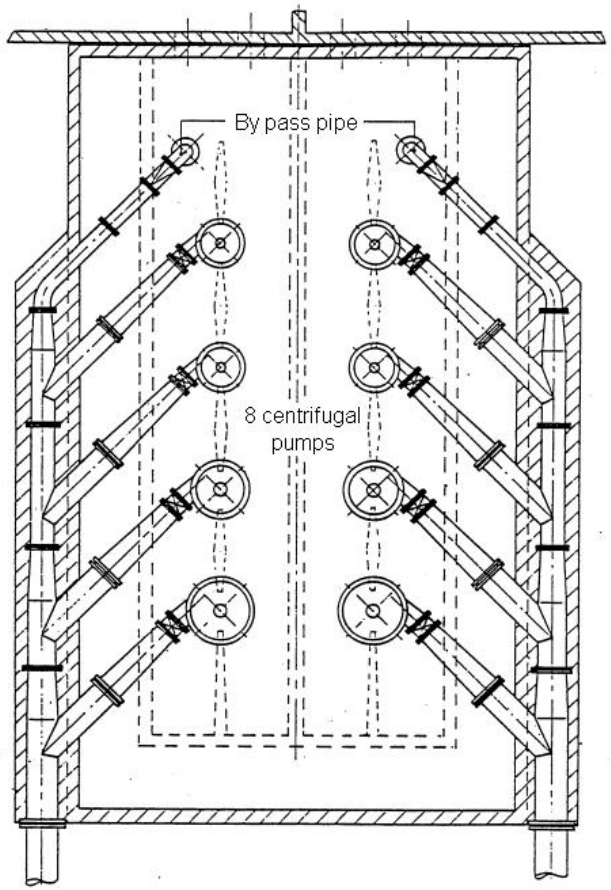
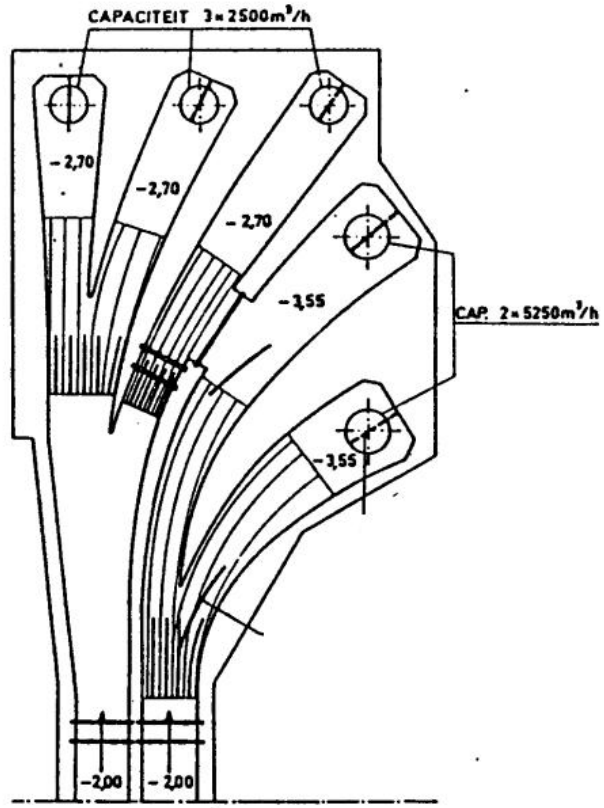
Pump lay out ‘hydraulically smooth’





Hydraulic design of pump lay out

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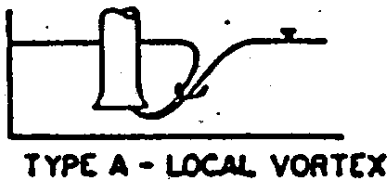
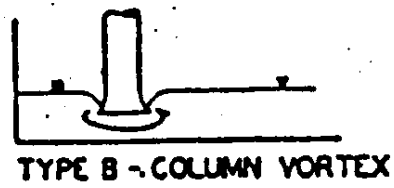
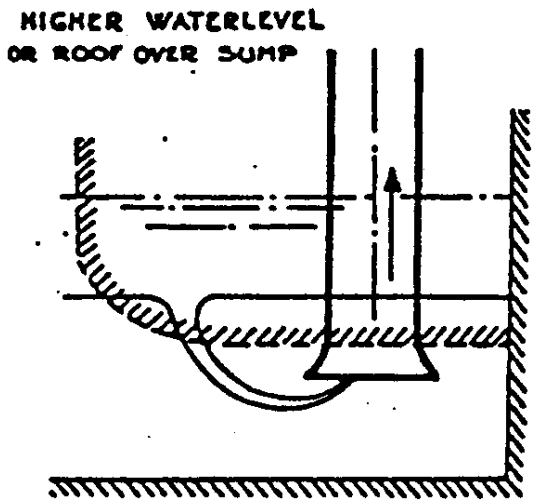
Attention to details





Vortex formation



Vortex suppression

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