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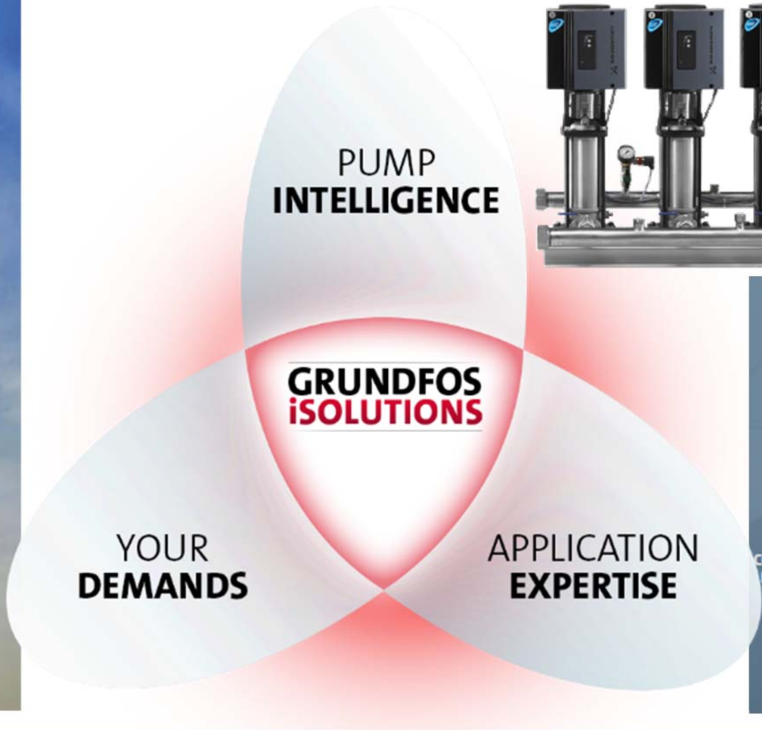
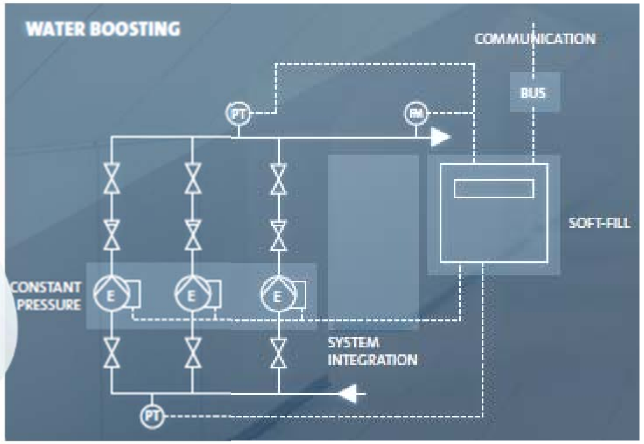
The intelligent approach to optimal system and application performance





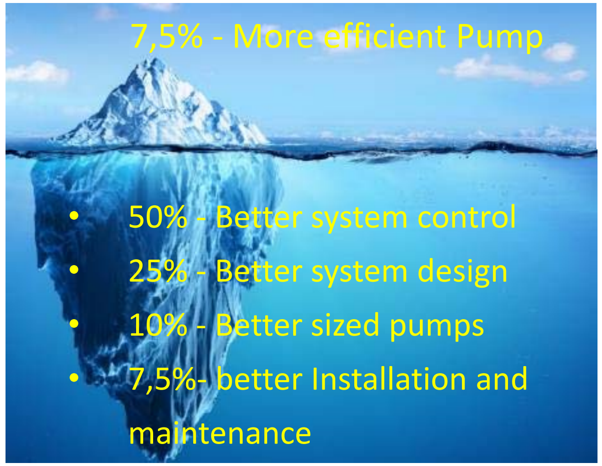
SOME PUMP FACTS

10 % *the world's electricity consumption*

Life Cycle Cost

Actual Operating Efficiency

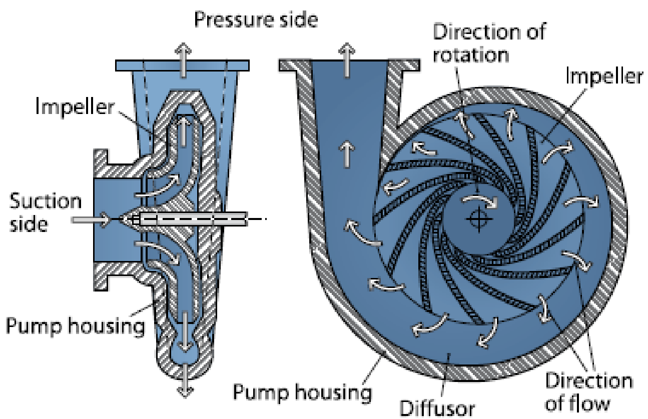
Potential Savings



1. Introduction to Centrifugal Pump

1.2 Principle of the centrifugal pump

- The impeller spins & throws water out.
- Low pressure is formed in the inlet.
- **Atmospheric pressure** pushes more water in.



Centrifugal pump, cross section

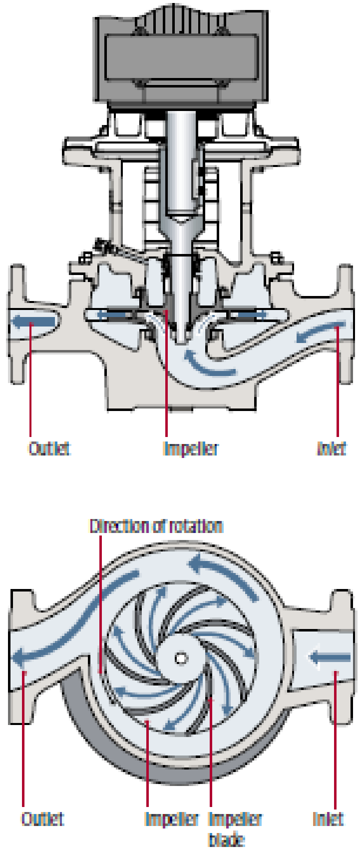


Figure 1.1: Fluid path through the centrifugal pump.

1.2 Hydraulic Components

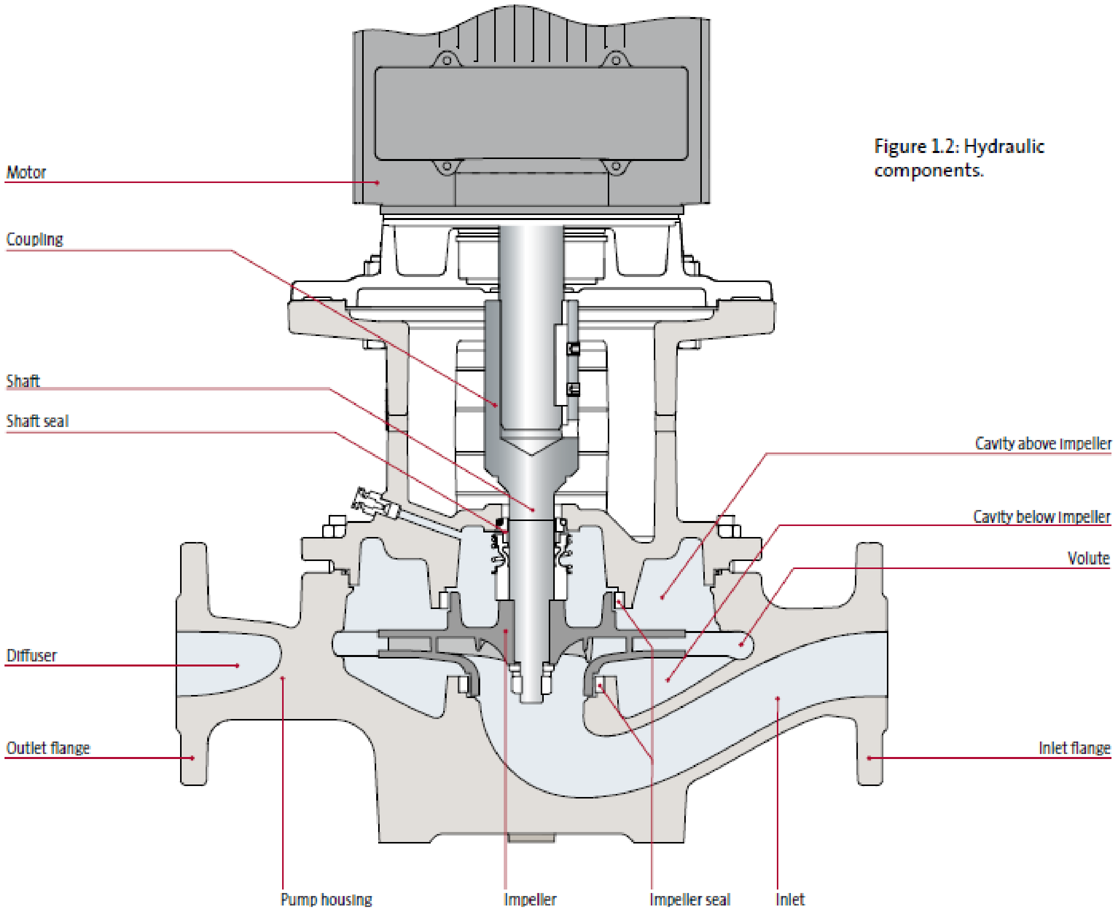


Figure 1.2: Hydraulic components.

1.2 Hydraulic Components

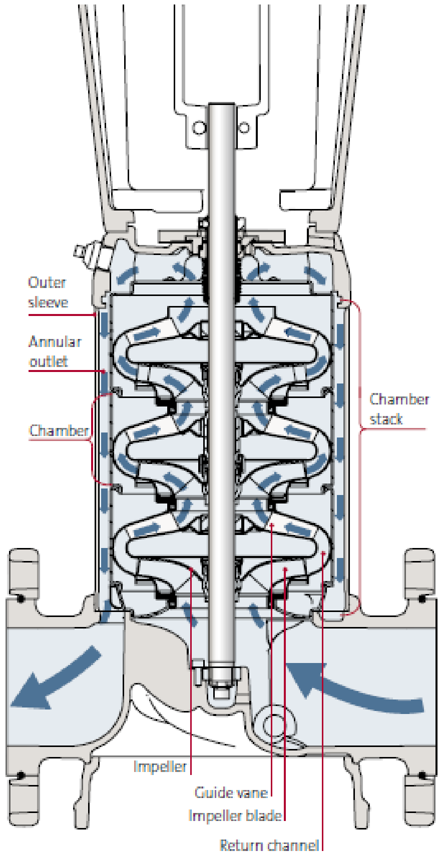
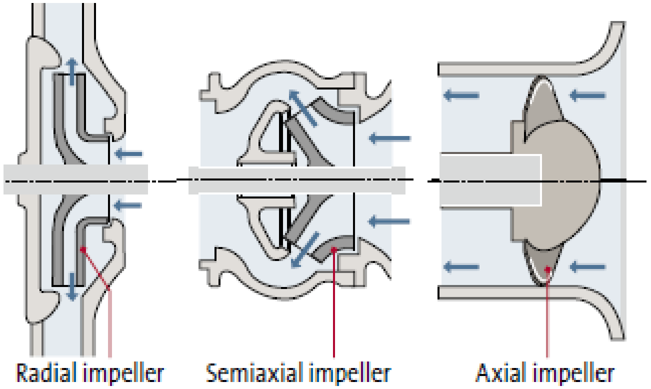


Figure 1.22: Hydraulic components in an inline multistage pump.

1.3 Impellers



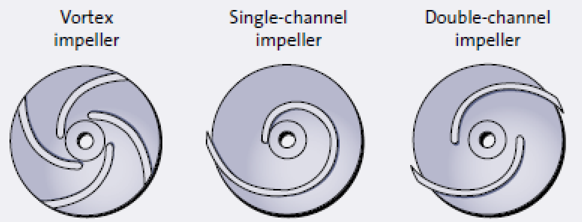
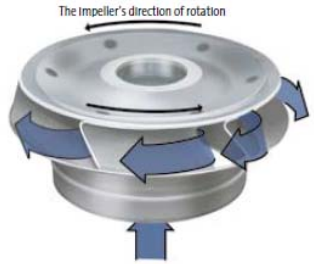


Fig. 1.2.15: Impeller types for wastewater



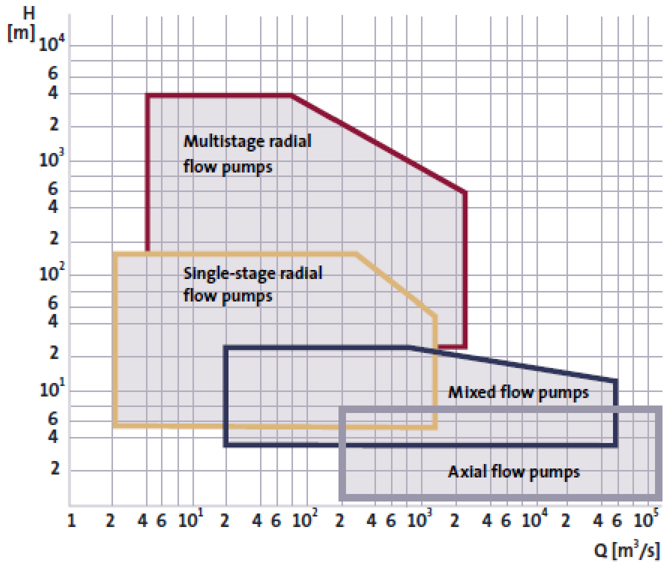
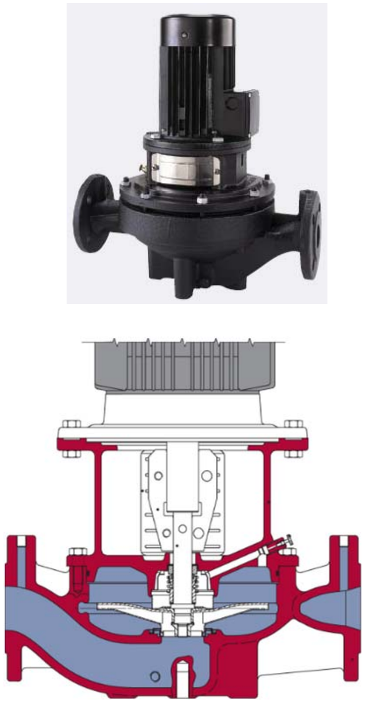
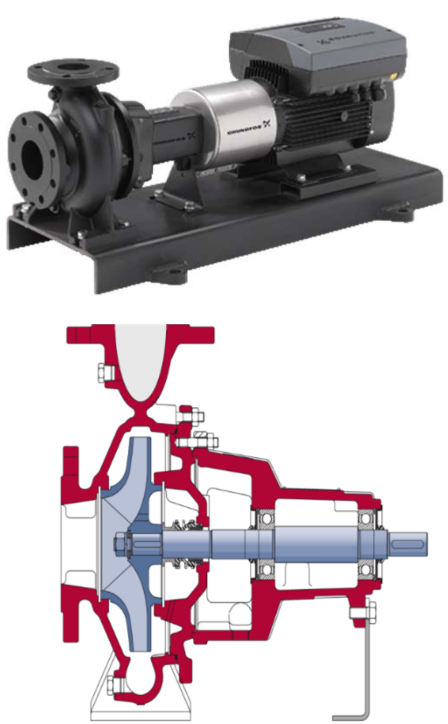


Fig. 1.1.3: Flow and head for different types of centrifugal pumps

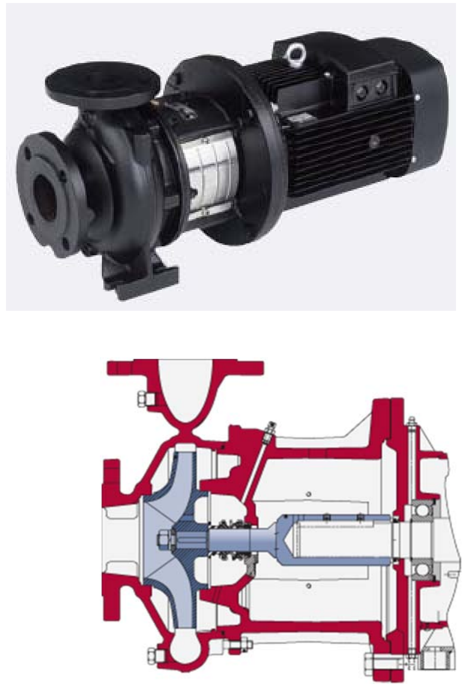
2. Pump Types – Single stage



Inline single-stage
TP range



Horizontal norm pump long-coupled
NK and NKG range



Horizontal norm pump close-coupled
NB and NBG range

2. Pump Types – Single stage, split case, double suctions

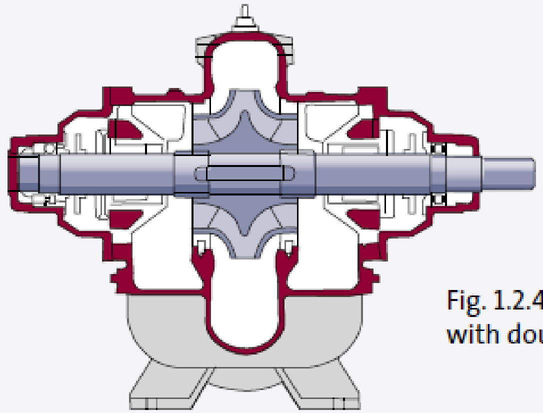
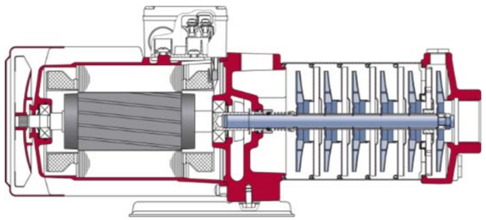


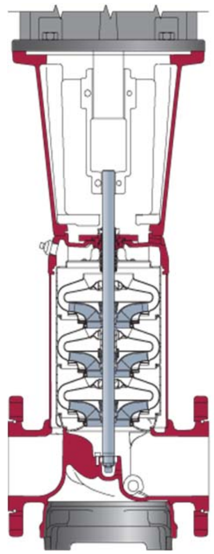
Fig. 1.2.4: Split-case pump with double-suction impeller

2. Pump Types – Single stage, split case, double suctions

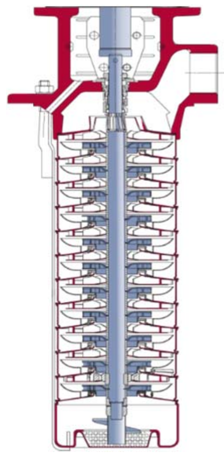
2. Pump Types - Multistage



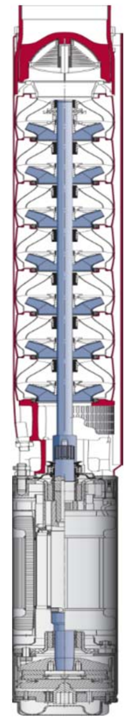
Horizontal multistage pump
CM range



Vertical inline
multistage pump
CR range



Immersible
multistage pump
MTR range



Submersible
multistage pump
SP range

2. Pump Types – other pump designs

Centrifugal wastewater pump

SE range

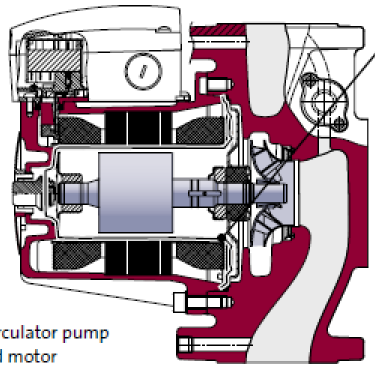
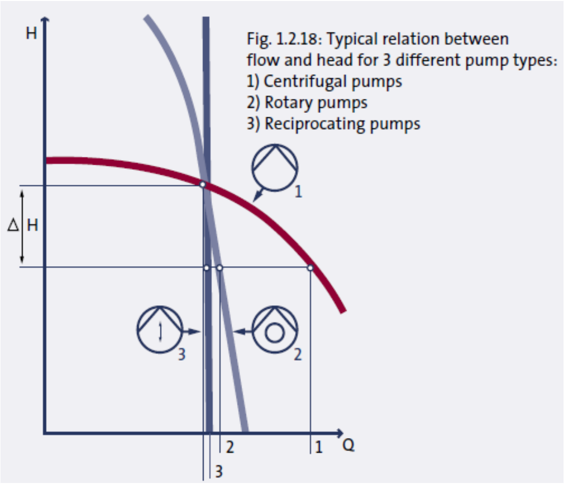


Fig. 1.2.7: Circulator pump with canned motor

2. Pump Types – Positive displacement pump

Smart Digital Dosing
DDE/DDC/DDA

Mechanical Dosing
DMX/DMH

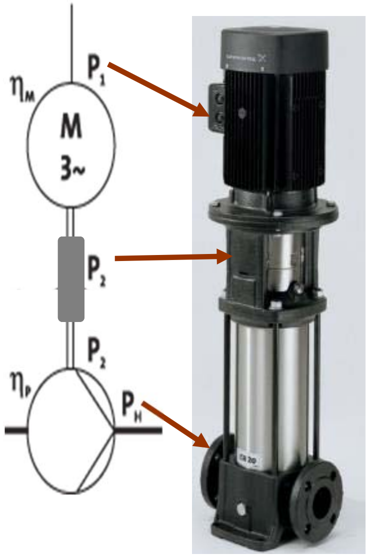


2. Pump Types – Complete-set Booster system

Multi E system: 2-3 pumps with integrated VFD, IE5 motor

Hydro MPC: 2-6 pumps with advanced function

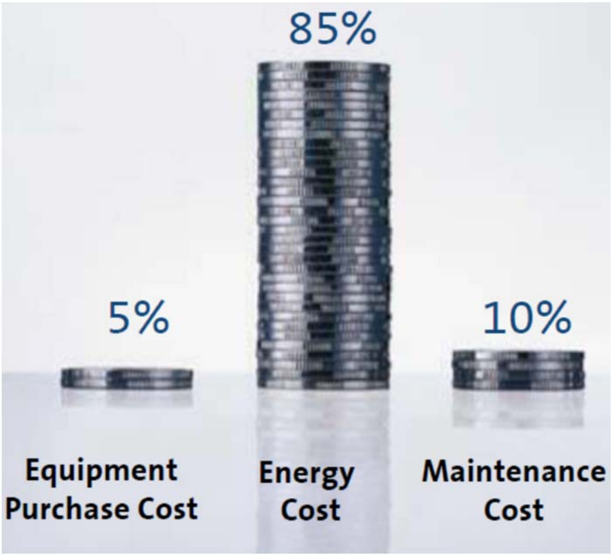
How does the pump consume power?



$$\eta_M = \frac{P_2}{P_1}$$

$$\eta_P = \frac{P_H}{P_2}$$

$P_H = 2.72 \,.\, Q \,.\, \mathbf{H}$ [W]



$$\mathbf{P_1} = P_H / \boldsymbol{\eta_P} \,.\, \eta_M$$

Pump efficiency: η_p

The efficiency is the relation between the supplied power and the utilised amount of power. In the world of pumps, the efficiency η_p is the relation between the power, which the pump delivers to the water (P_H) and the power input to the shaft (P_2):

$$\eta_p = \frac{P_H}{P_2} = \frac{\rho \cdot g \cdot Q \cdot H}{P_2}$$

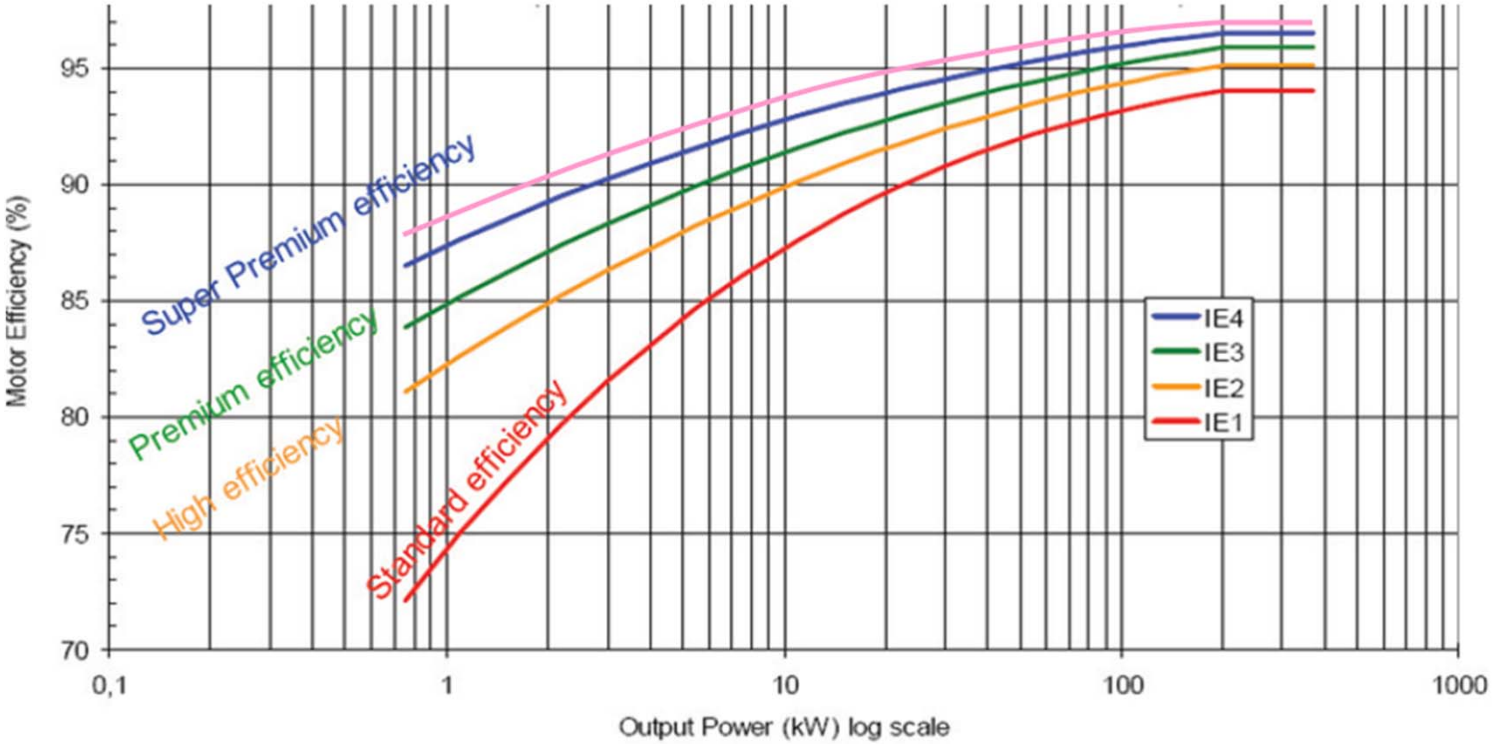
where:
ρ is the density of the liquid in kg/m^3,
g is the acceleration of gravity in m/s^2,
Q is the flow in m^3/s and H is the head in m.

For water at 20°C and with Q measured in m^3/h and H in m, the hydraulic power can be calculated as :

$$P_H = 2.72 \cdot Q \cdot H \text{ [W]}$$

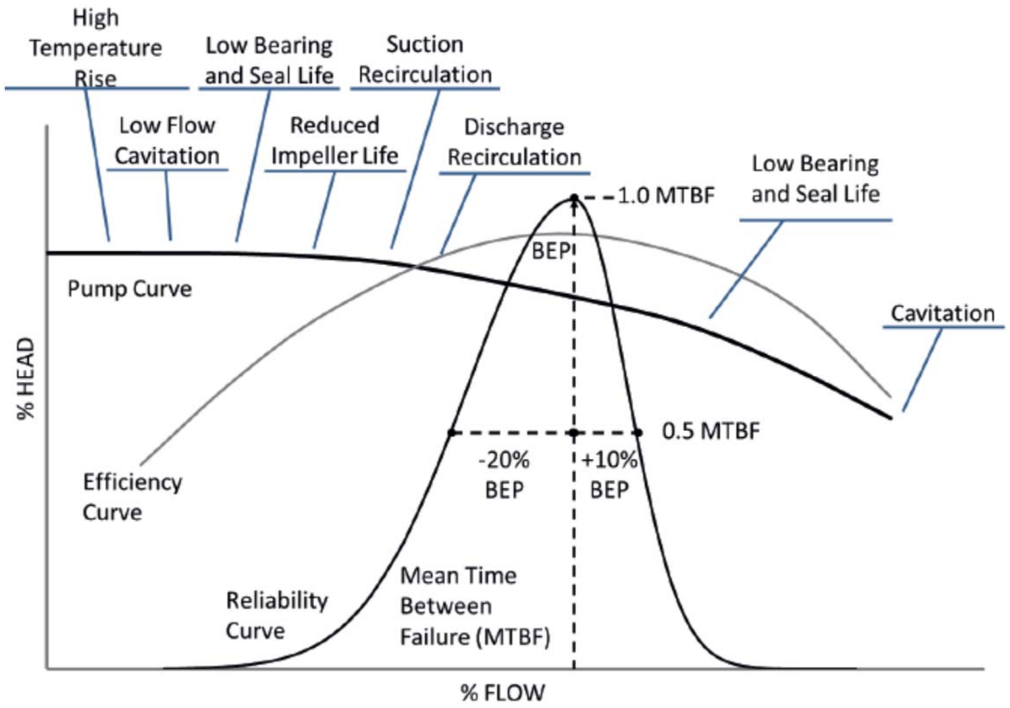
Motor efficiency: η_M

$$P_1 = P_H / \eta_P \cdot \eta_M$$



Pump efficiency η_P – Pump Sizing - BEP and Reliability

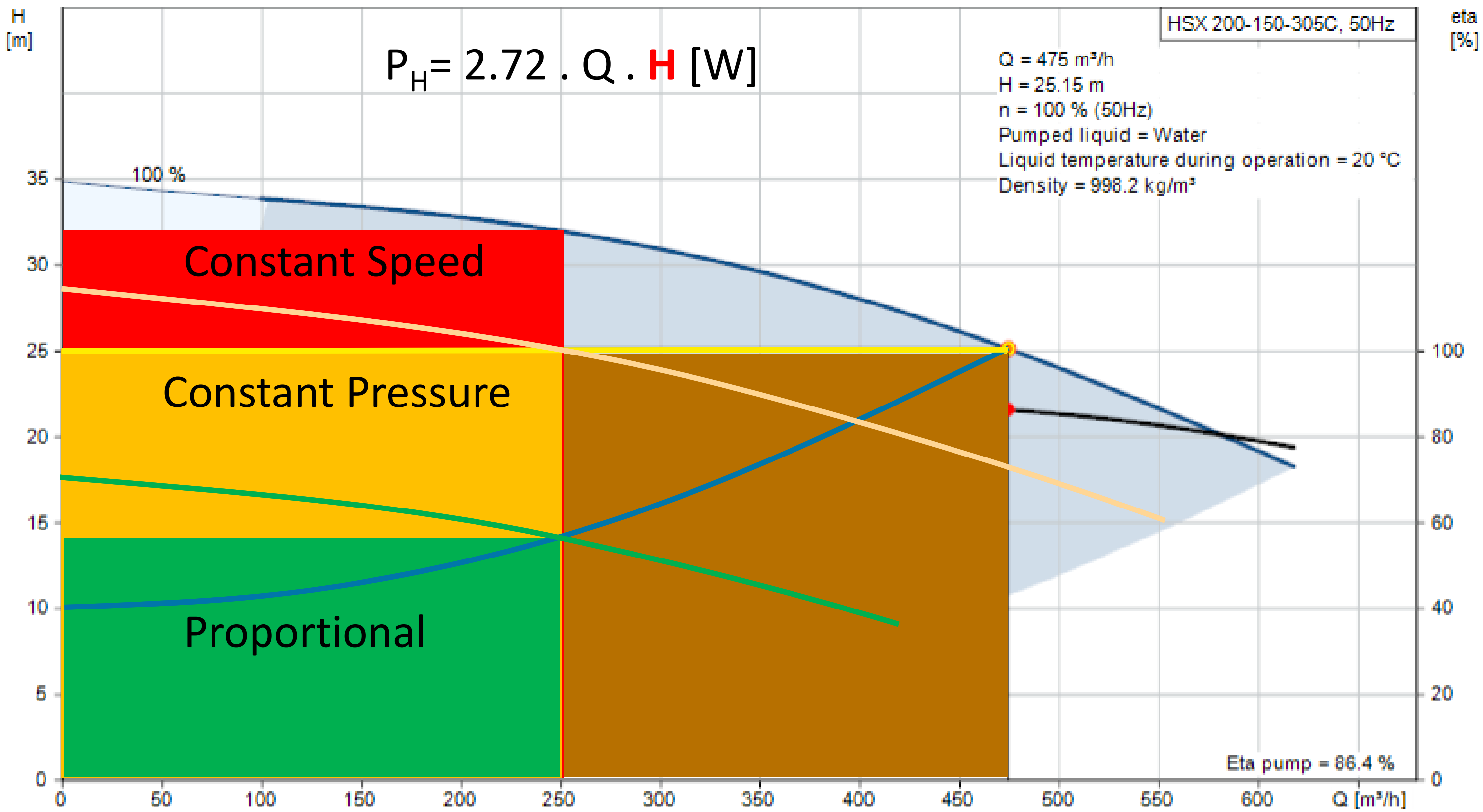
$$P_1 = P_H / \eta_P \cdot \eta_M$$

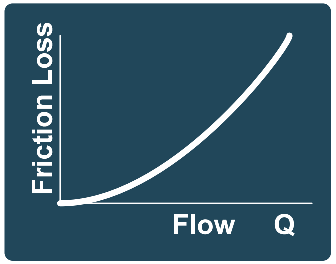


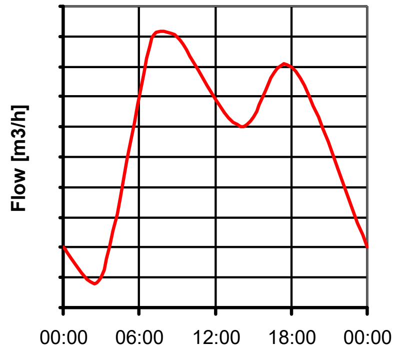
Pumps are often oversized and operating far from their Best Efficiency Point (BEP). This not only waste considerable amounts of energy but also shorten pump life time.

Control methods VS Power consumption?

$P_1 = P_H / \eta_P \cdot \eta_M$







PRESSURE IN THE DISTRIBUTION SYSTEM

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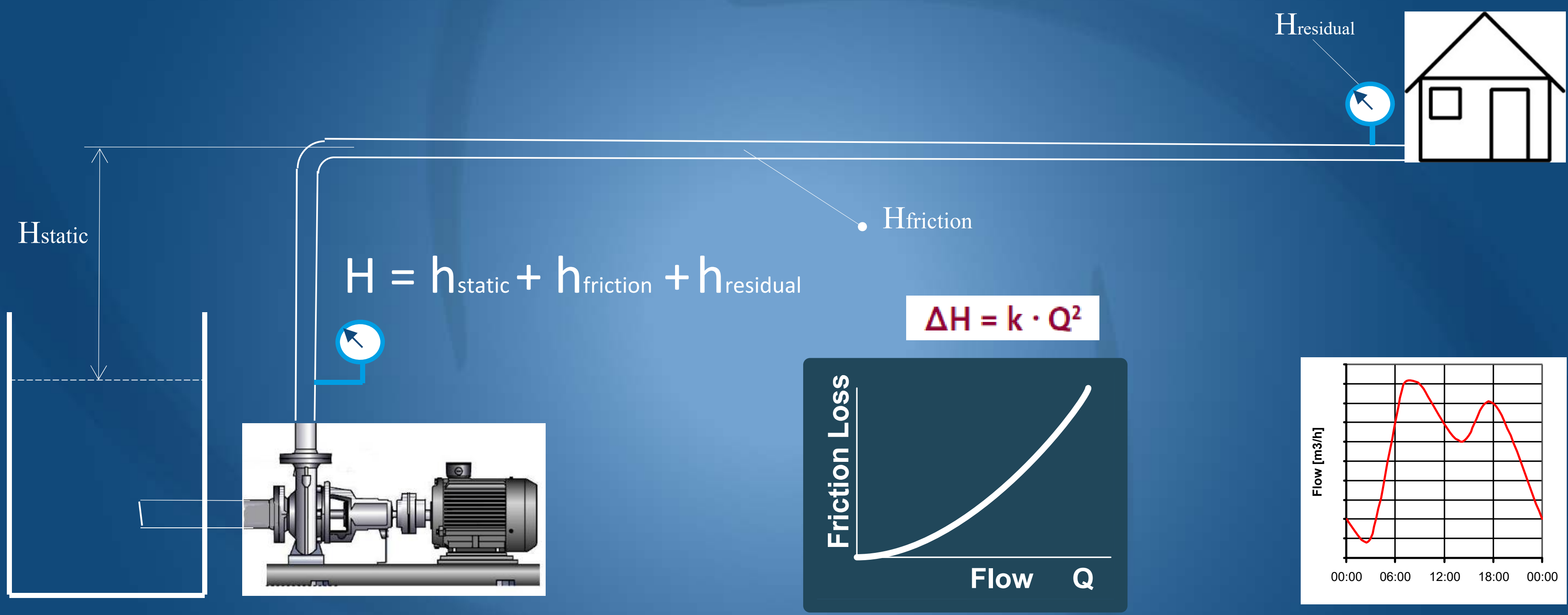

Typical Water consumption profile

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PUMP APPLICATIONS

TOTAL HEAD: HỆ THỐNG TUẦN HOÀN KÍN

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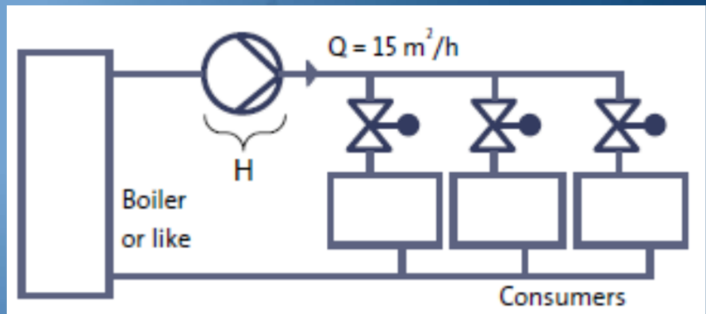
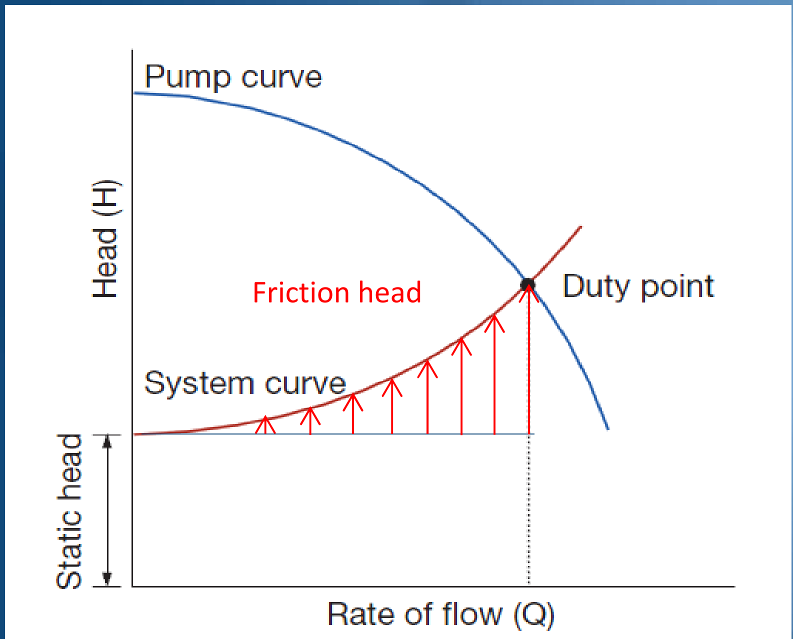
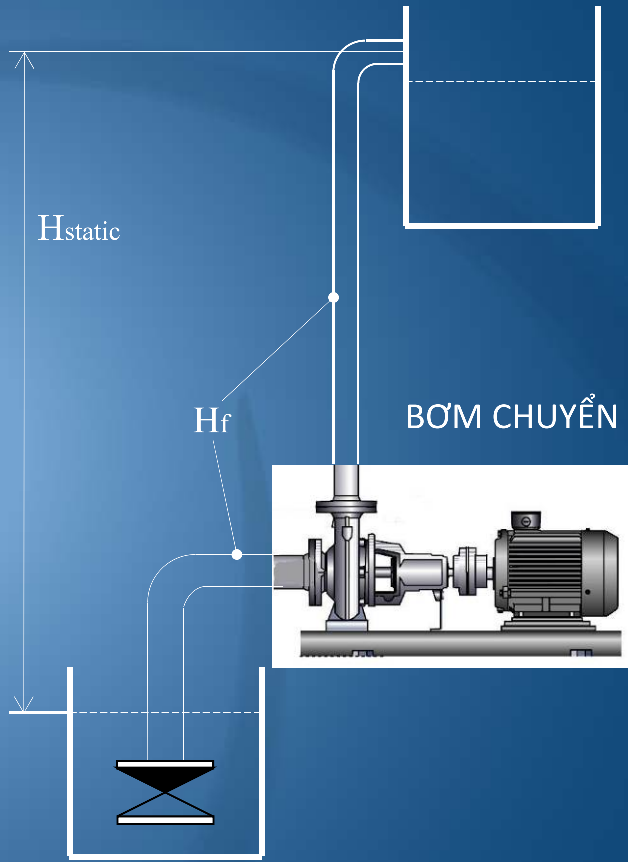
$$H = h_{friction}$$



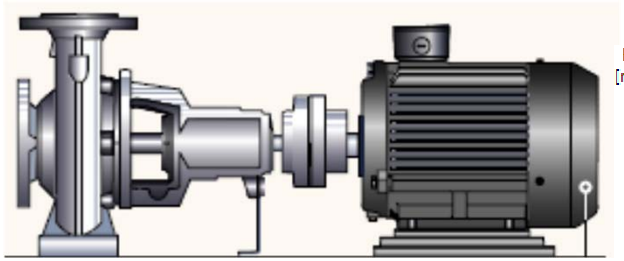
TOTAL HEAD: HỆ THỐNG CHUYỂN TẢI

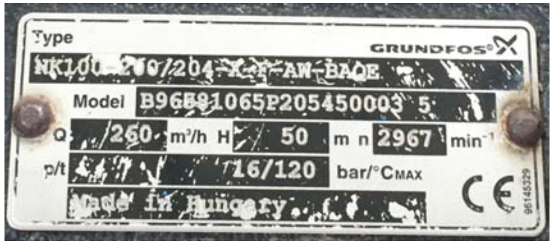
$$H = h_{static} + h_{friction}$$

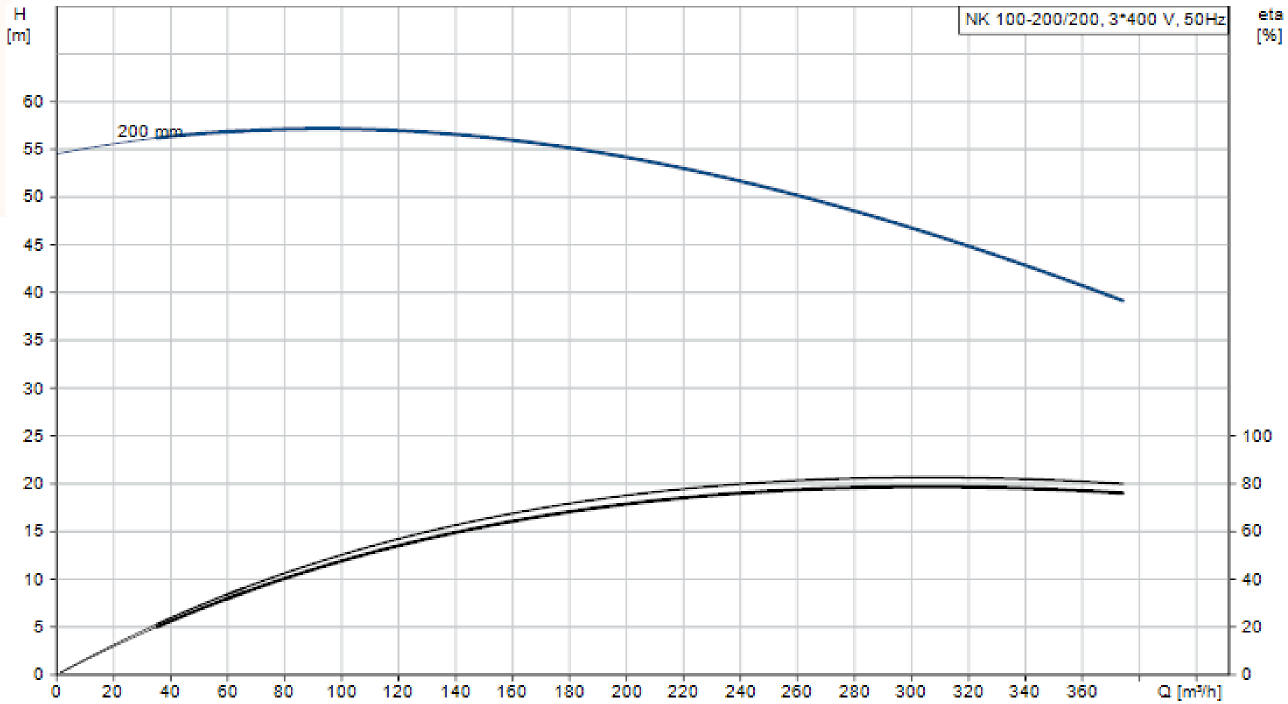




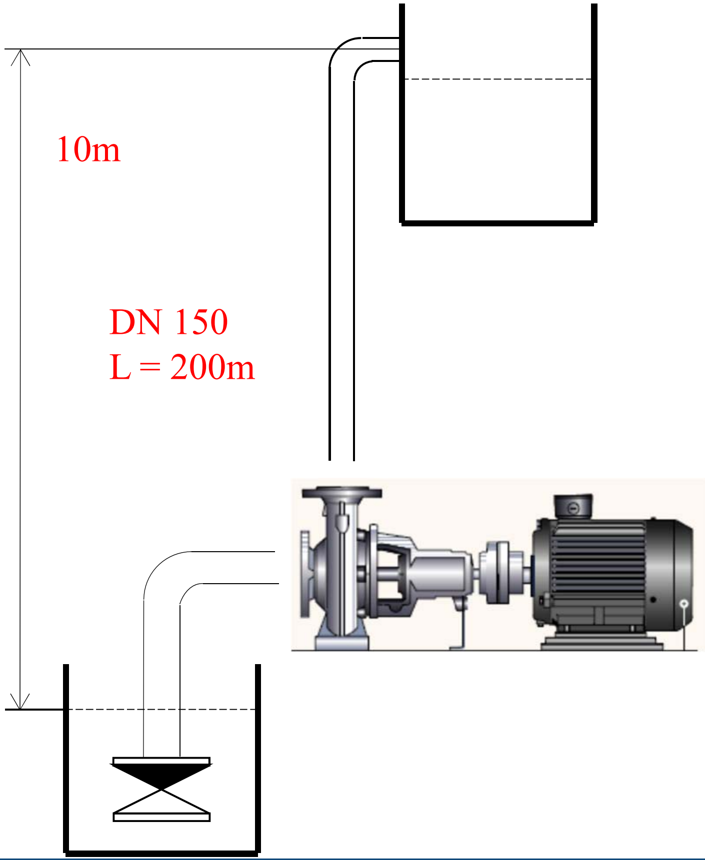
1. Introduction to Centrifugal Pump

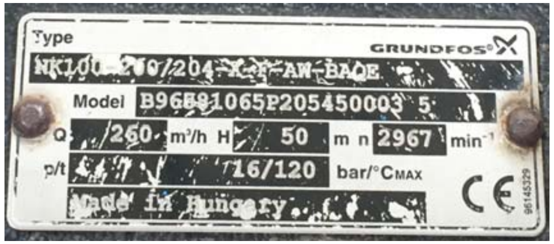


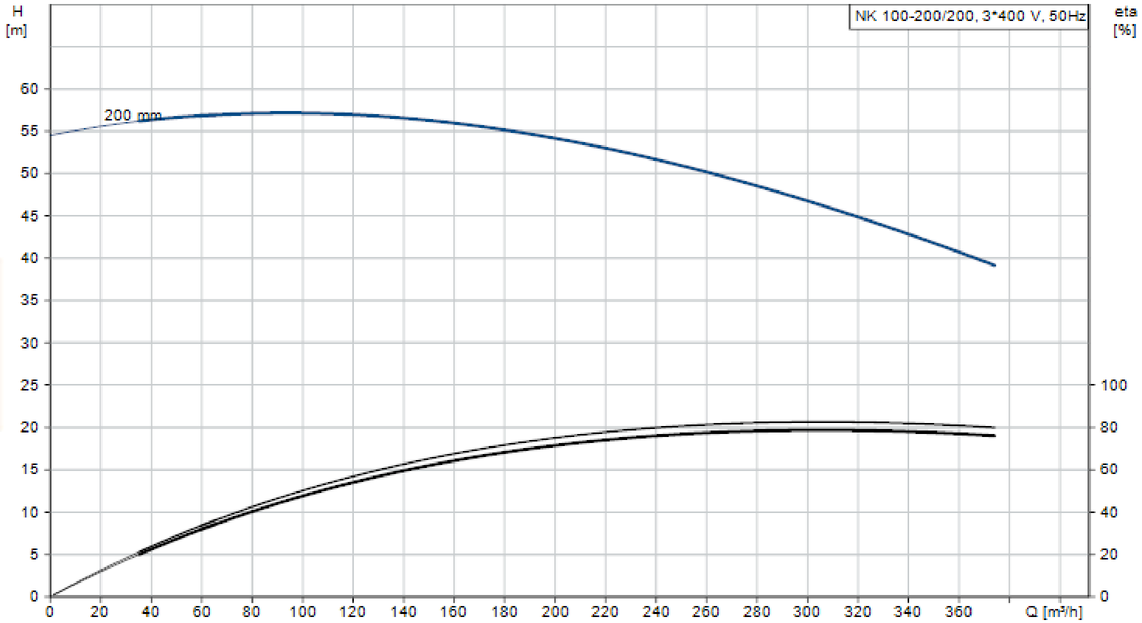




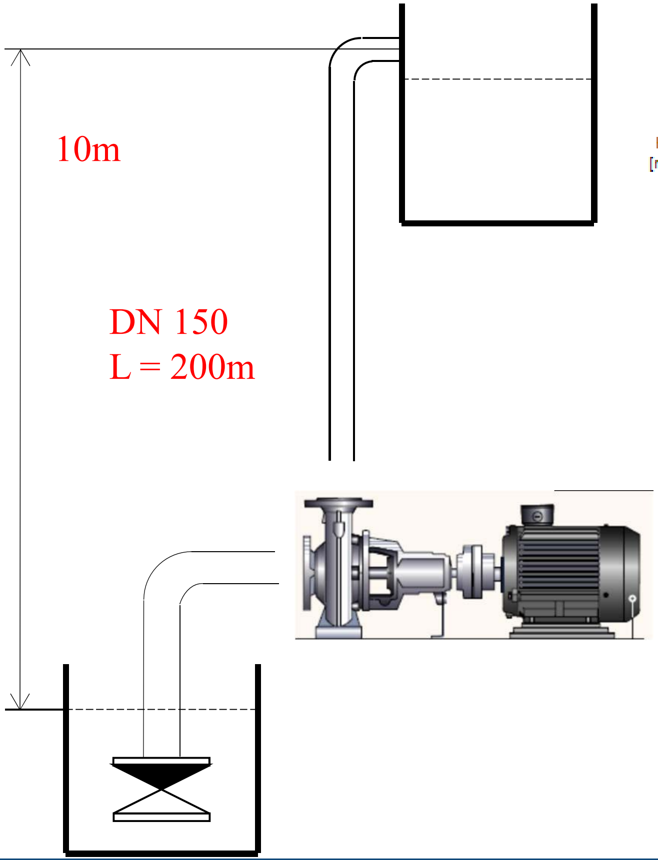
1. Introduction to Centrifugal Pump

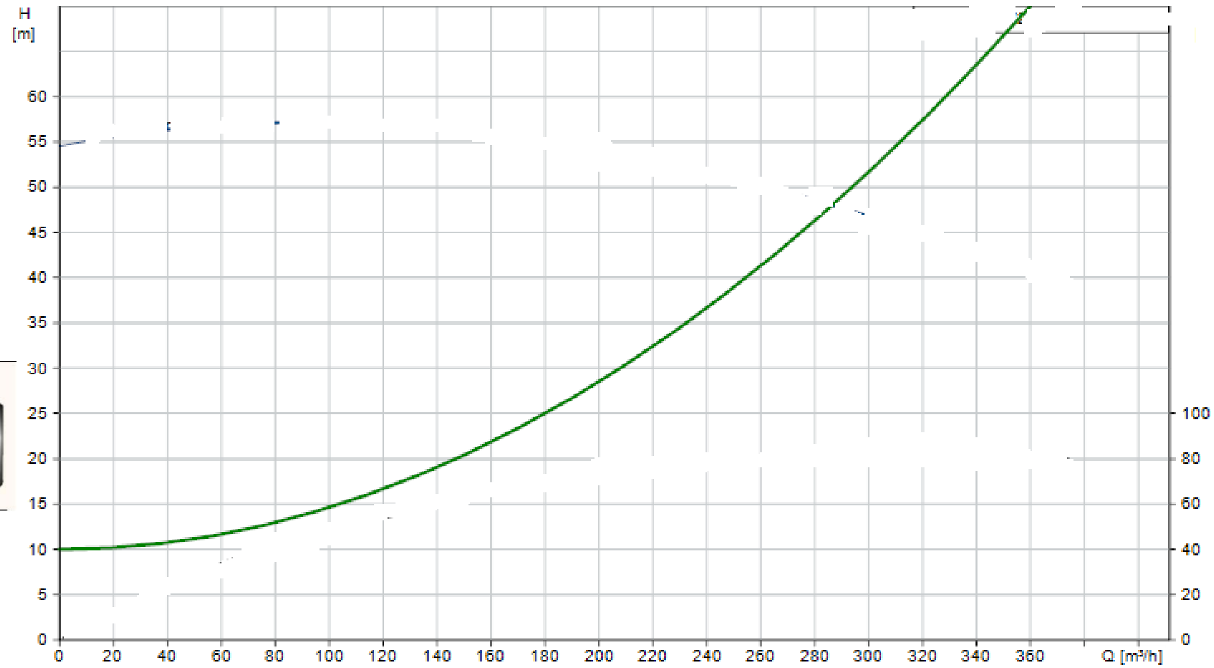




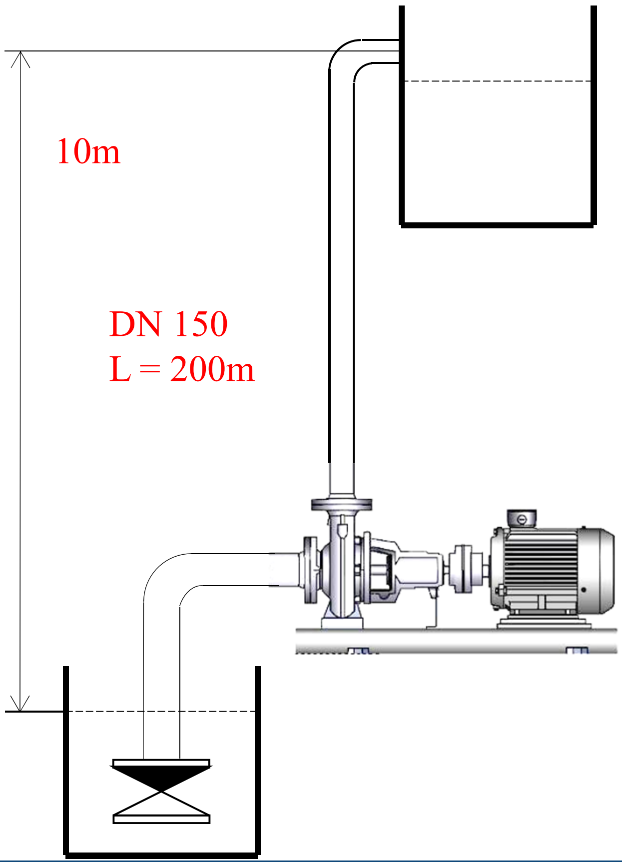


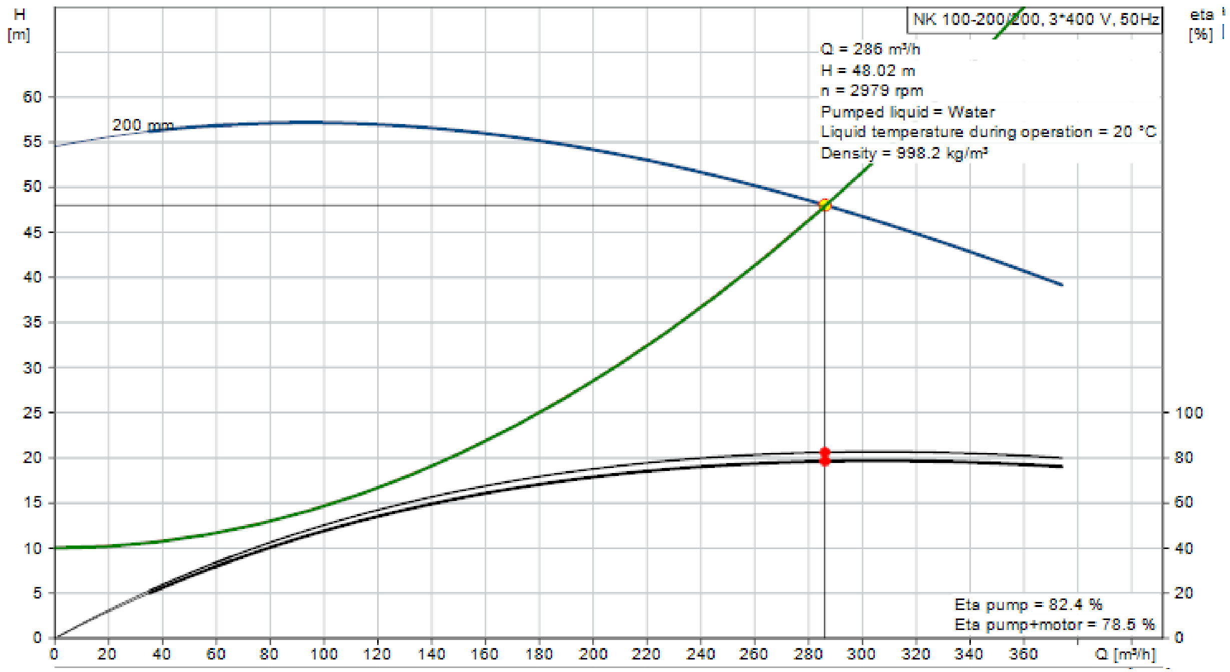
1. Introduction to Centrifugal Pump



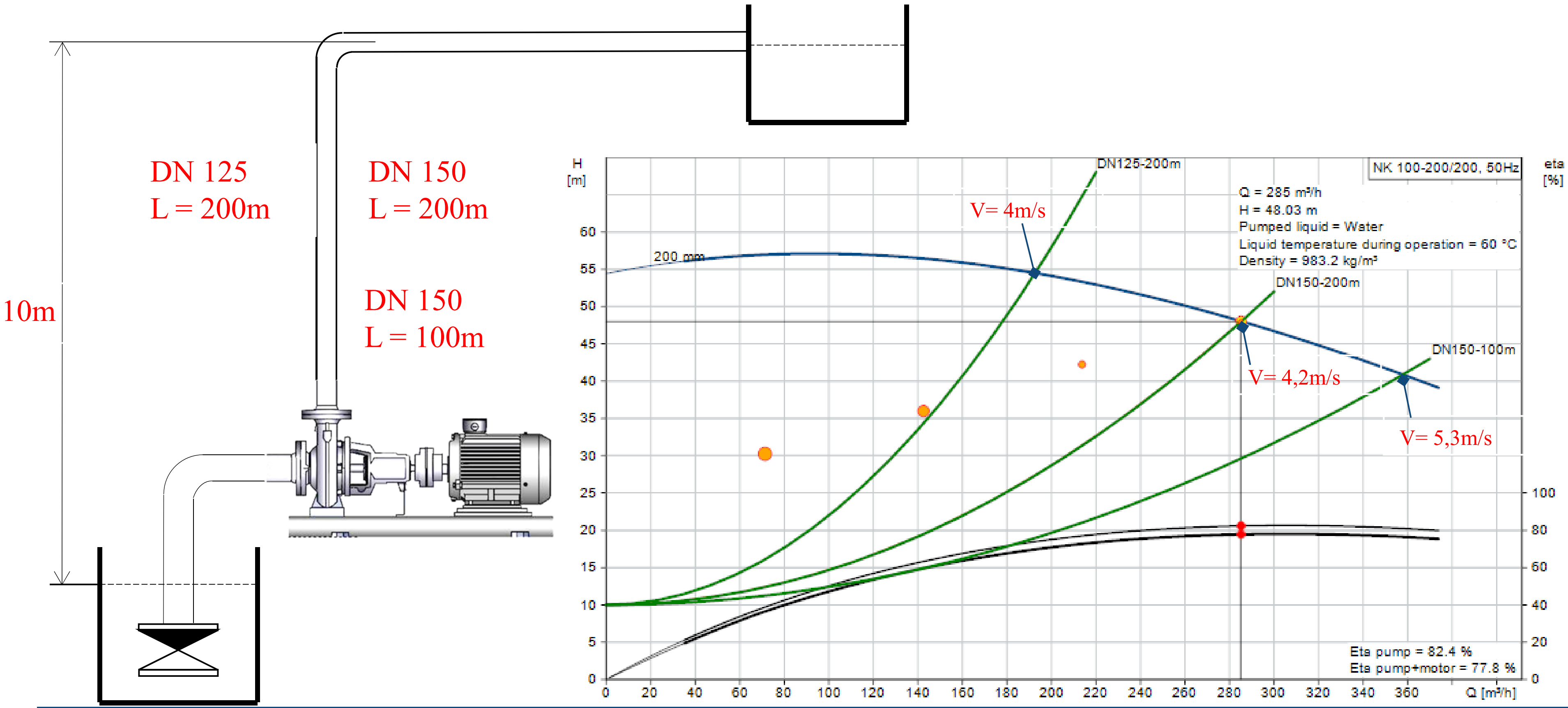


1. Introduction to Centrifugal Pump





1. Introduction to Centrifugal Pump



TOTAL HEAD: HỆ THỐNG CẤP NƯỚC TRỰC TIẾP

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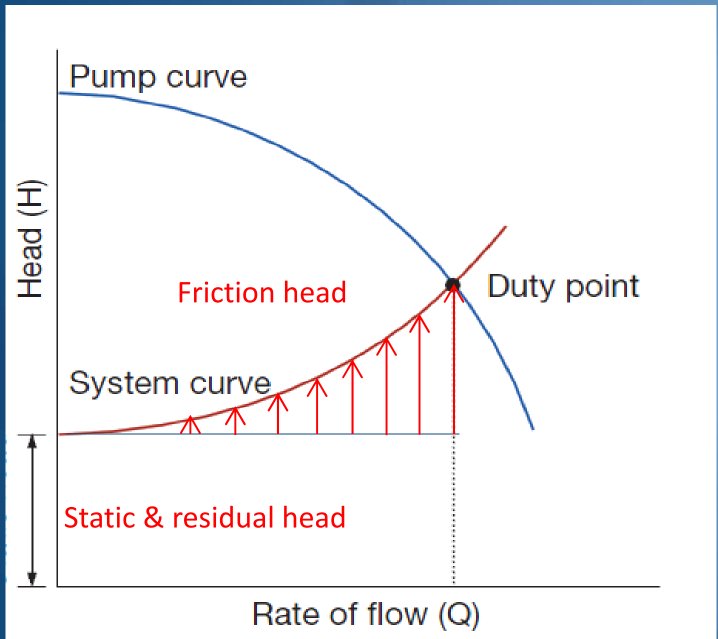
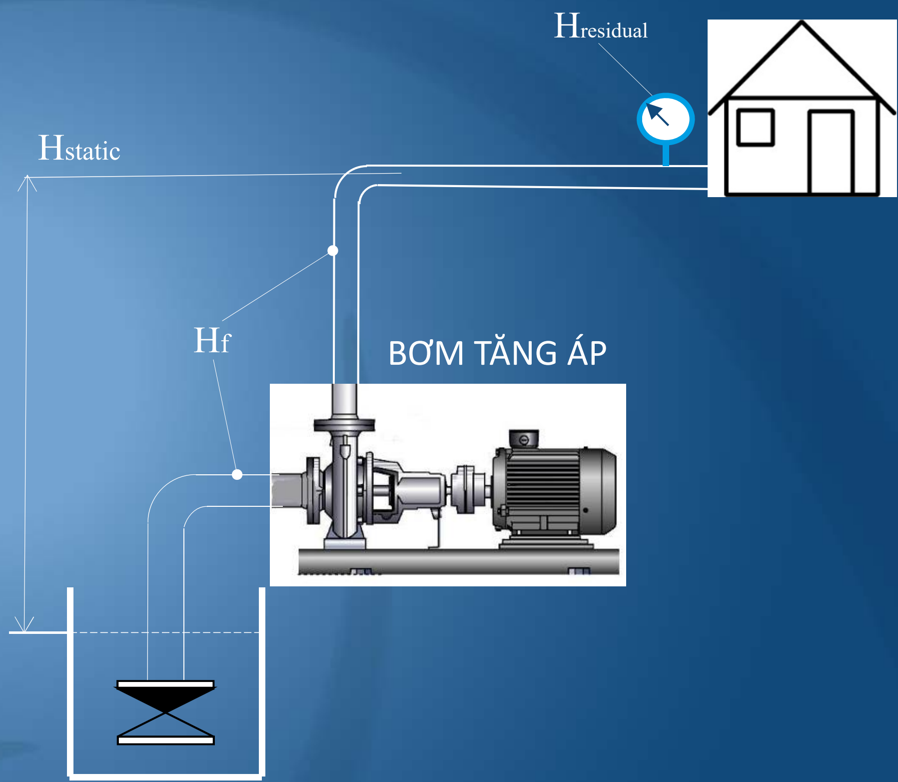
$$H = h_{static} + h_{friction} + h_{residual}$$





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DESIGN:

$$\Delta H = k \cdot Q^2$$

Đường cong hệ thống – hfriction

Để tính mất áp ta cần biết:

- Lưu lượng
- Chiều dài đường ống, van, co
- Vật liệu ống/tình trạng
- Đường kính ống

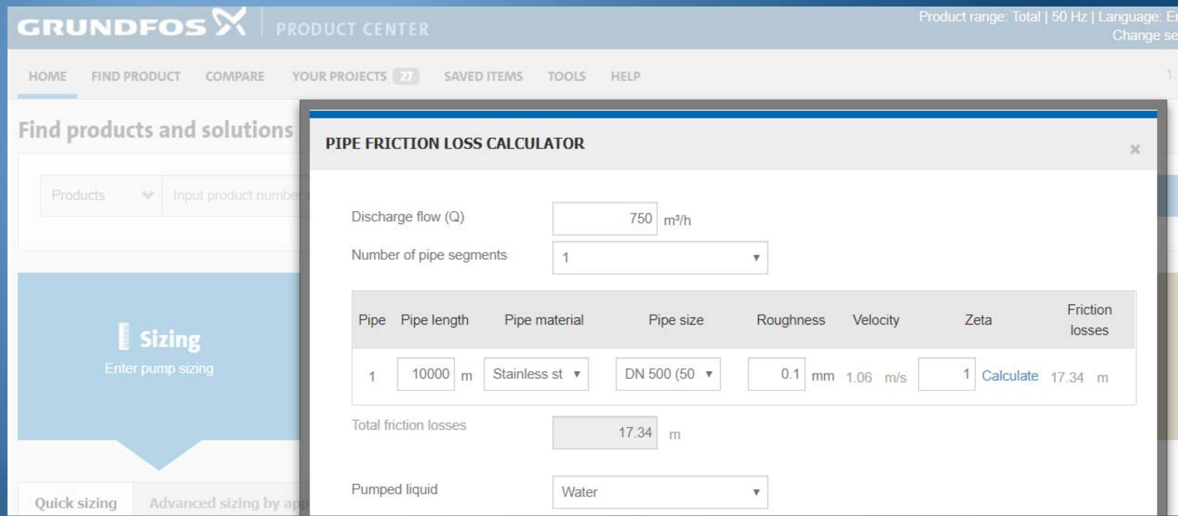
- Ta cần xác định đường kính ống sao cho vừa đủ theo lưu lượng, không quá lớn, không quá nhỏ.
- Tham khảo: ống cần đủ lớn sao cho tốc độ dòng chảy không lớn hơn 2m/s:

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

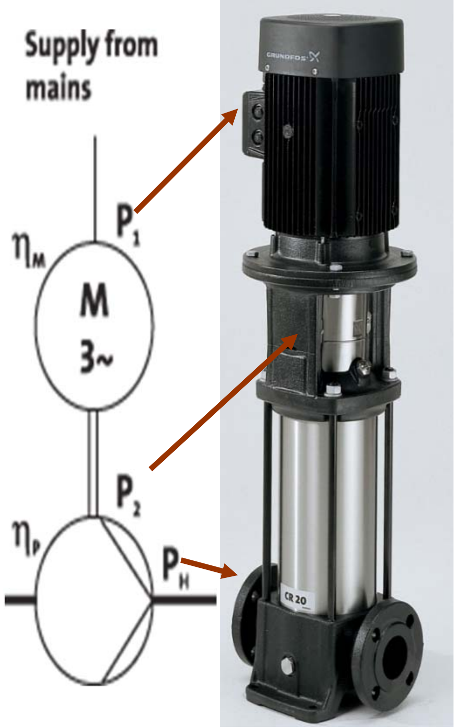
where:
v is the velocity in [m/s]
Q is the volume flow in [m^3/s]
D is the port diameter in [m]

Ví dụ:

- Lưu lượng: 750m3/h
- Chiều dài đường ống: 10km
- Vật liệu ống/tình trạng: ống thép/mới
- Đường kính ống: 450 mm
- Cao độ vật lý: 21m

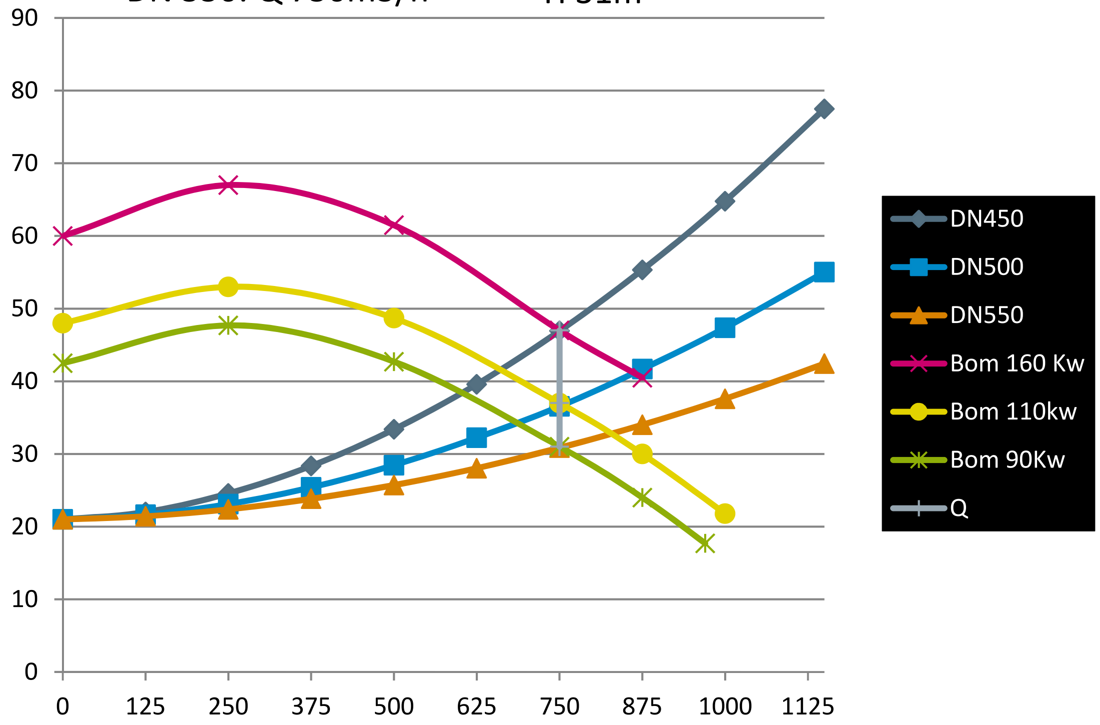


Design:



$P_H = 2.72 \cdot Q \cdot H$ [W]

- DN 450: Q 750m3/h H 47m
- DN 500: Q 750m3/h H 37m
- DN 550: Q 750m3/h H 31m



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CHỌN BƠM

Hãy chọn đúng bơm, bơm chất lượng tốt, hiệu suất cao.

Vài câu hỏi thêm ngoài Q - H:

- Một bơm hay nhiều bơm?
- Không gian lắp đặt?
- Bơm hút âm?
- Bơm 2 cực hay 4 cực?
- Cao độ so với mực nước biển?
- Nguồn điện: một pha hay 3 pha, 50Hz hay 60Hz?
- Thông tin chất lỏng bơm - nhiệt độ, tạp chất, hóa chất...?

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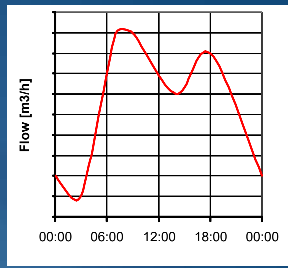
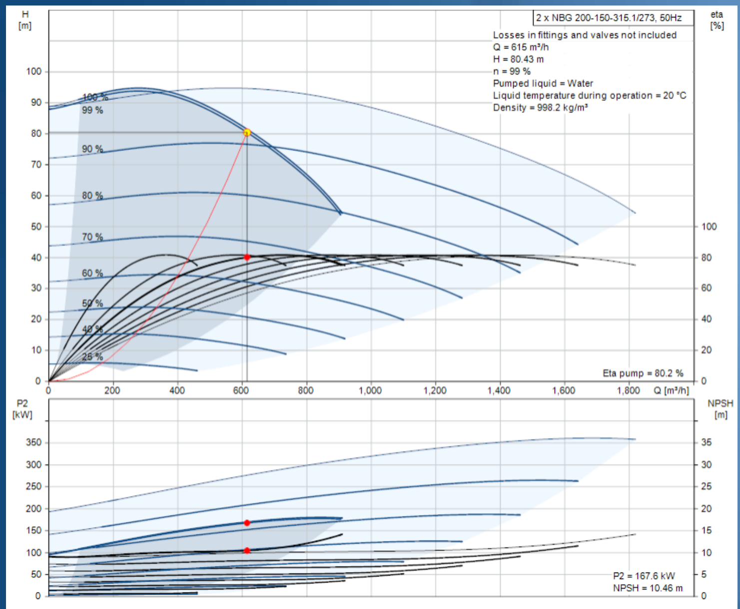
Số lượng bơm trong một hệ thống bơm.

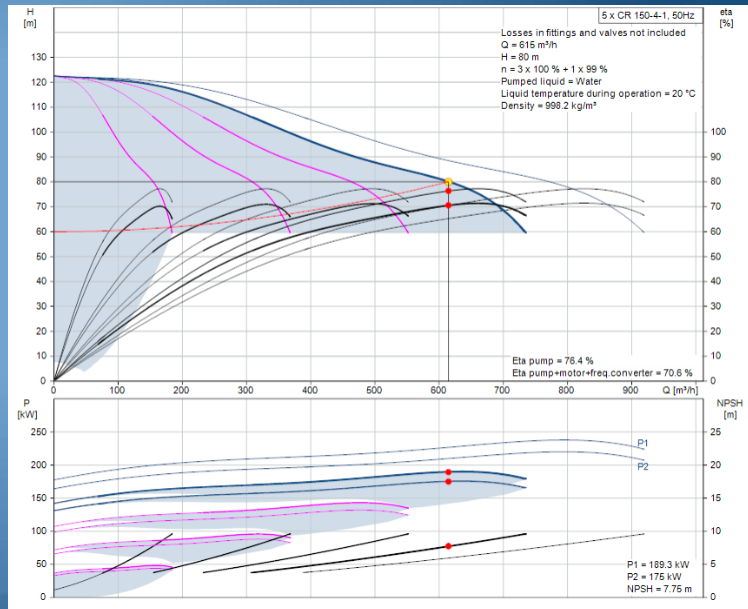
- Ta cần biết lưu lượng cực đại và cả lưu lượng tối thiểu của hệ thống.
- Bơm nên vận hành trong khoảng từ 50% đến 120 lưu lượng định mức.
- Hệ thống không nên quá 6 bơm, nên có 1 bơm standby.



N = Qmax/2Qmin +1 dự phòng

N = 600/2x85 +1 = 4 +1





→ Hệ 2 bơm lớn (200kw/pump, 1 dự phòng) VS Hệ 5 bơm nhỏ (45kw/pump, 1 dự phòng)

Bơm tưới cỏ 200kw

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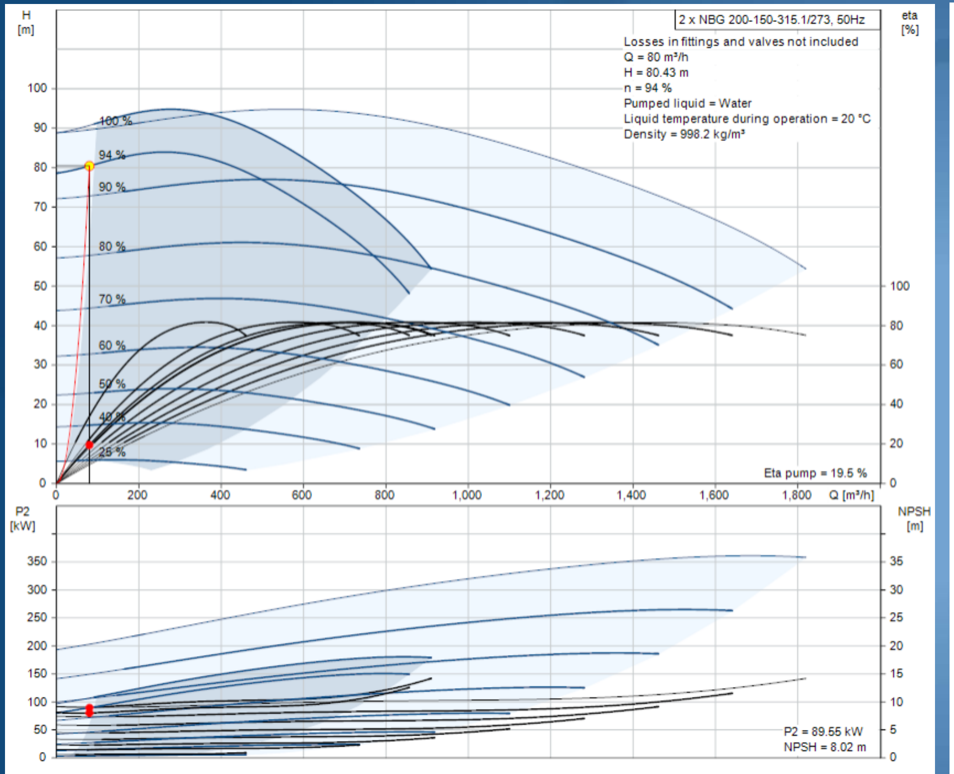

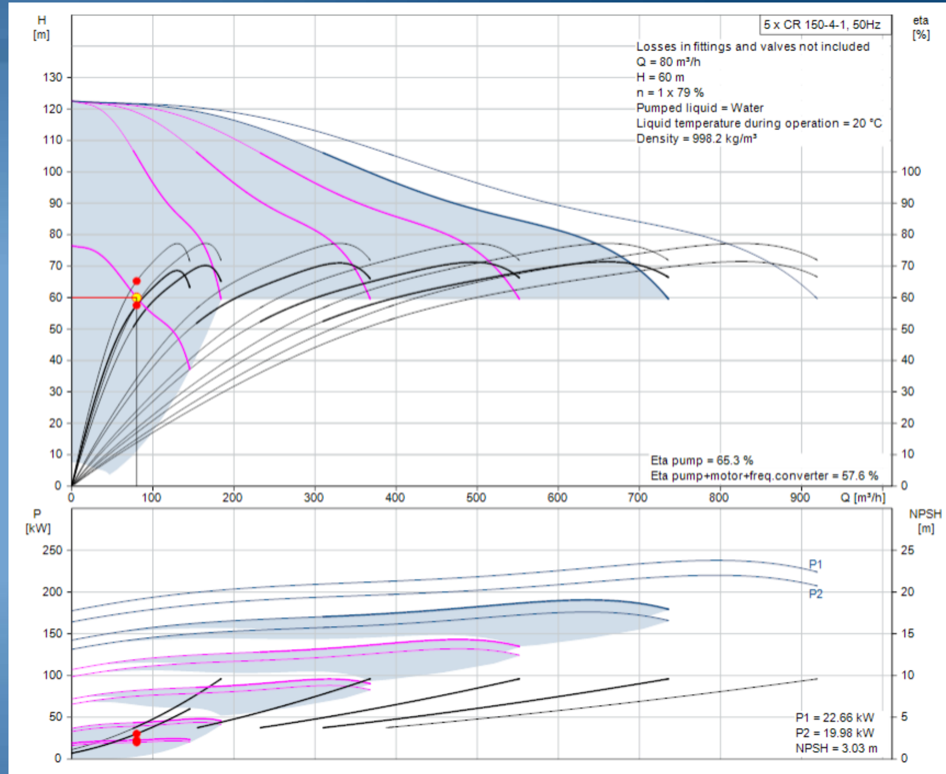

→ **Khi vận hành ở nhu cầu lưu lượng thấp, hệ 5 bơm nhỏ cho hiệu suất cao hơn rất nhiều VS hệ 2 bơm lớn.**

2. CHỌN BƠM:

Bơm 2 cực hay 4 cực? Hãy chọn đúng.

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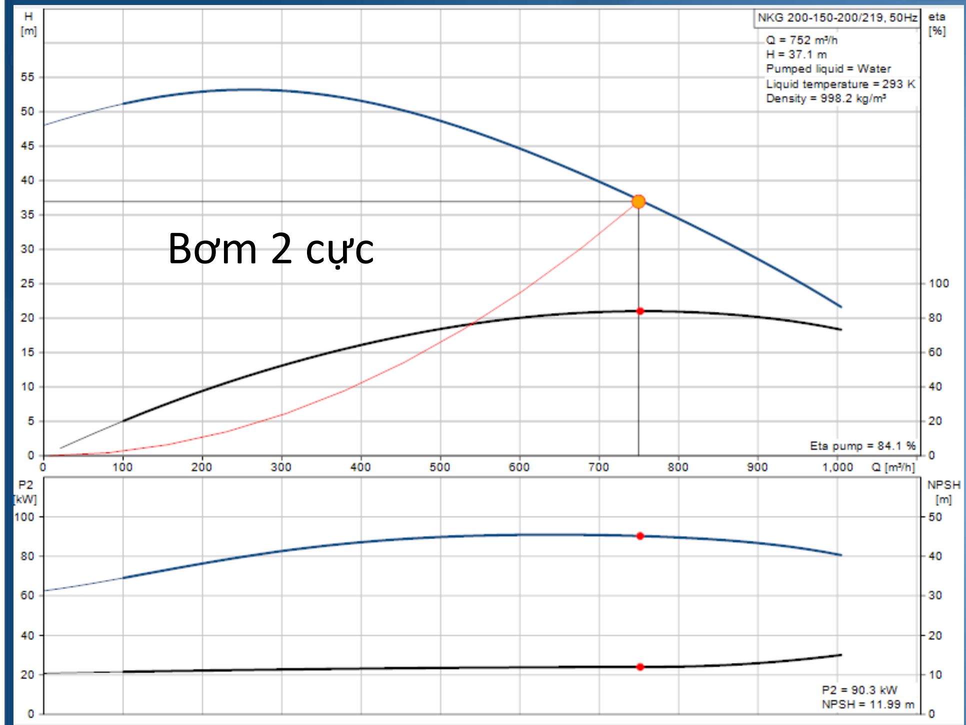

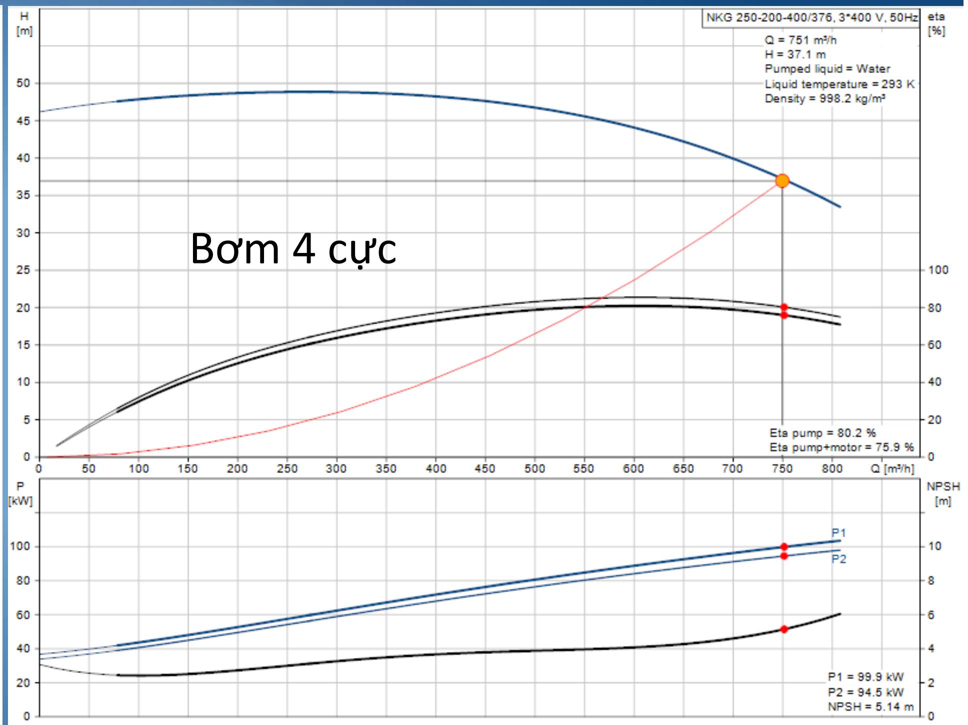

CHỌN BƠM:

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Bơm 2 cực hay 4 cực? chọn đúng theo nhu cầu.

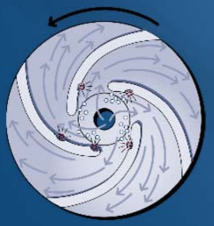
So sánh bơm 2 cực (2.900 RPM) và bơm 4 cực (1.450 RPM)				
No.	Tiêu chí	Bơm 2 cực	Bơm 4 cực	Ghi chú
1	Kích thước đầu bơm	Nhỏ hơn	Lớn hơn	
2	Giá thành	Rẻ hơn	Đắt hơn	
3	NPSH	Cao hơn (hút cạn hơn)	Thấp hơn (hút sâu hơn)	Không có ý nghĩa với bơm tuần hoàn kín như chiller.
4	Đường cong	Dốc hơn	Phẳng hơn	Điểm làm việc thực tế có thể ngoài đường cong bơm, bị quá tải với bơm 4 cực.
5	Công suất động cơ	Như nhau		
6	Tuổi thọ	Như nhau		
7	Hiệu suất	Như nhau		
8	Độ ồn	Cao hơn một chút	**Thấp hơn một chút**	

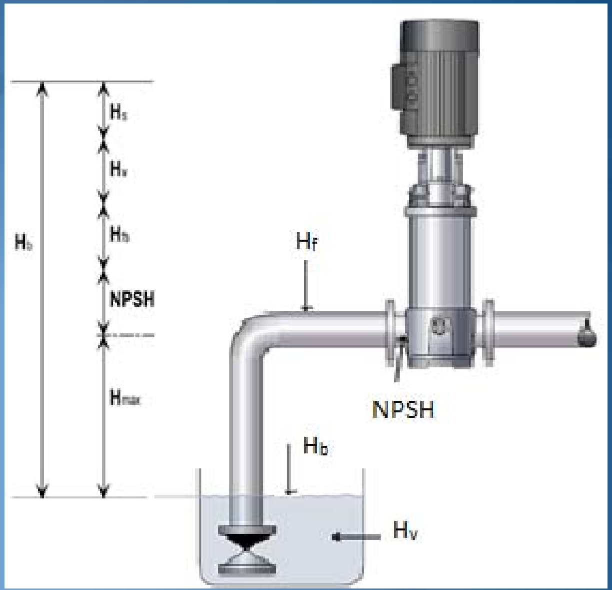
SELECTING PUMP: No cavitation

Để bơm không bị xâm thực, công thức sau được dùng để tính chiều sâu hút tối đa:

$$h_{max} = H_b - H_f - NPSH - H_v - H_s$$

- Hmax - Chiều sâu hút tối đa.
- Hb - áp suất khí quyển tại nơi đặt bơm.
- Hf - Mất áp trên tuyến ống hút.
- NPSH, cột áp cửa hút dương thực, tìm trên đường cong NPSH của bơm ở điểm lưu lượng cao nhất.
- Hv – áp suất hóa hơi của chất lỏng- tra theo nhiệt độ.
- Hs - hệ số an toàn, thường lấy từ 0,5 – 1 m, với chất lỏng chứa gas thì lấy bằng 2m.





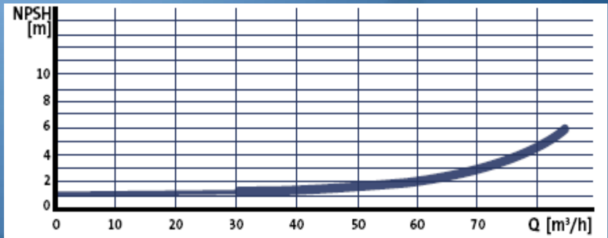
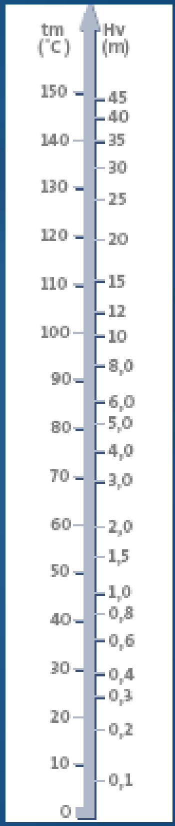
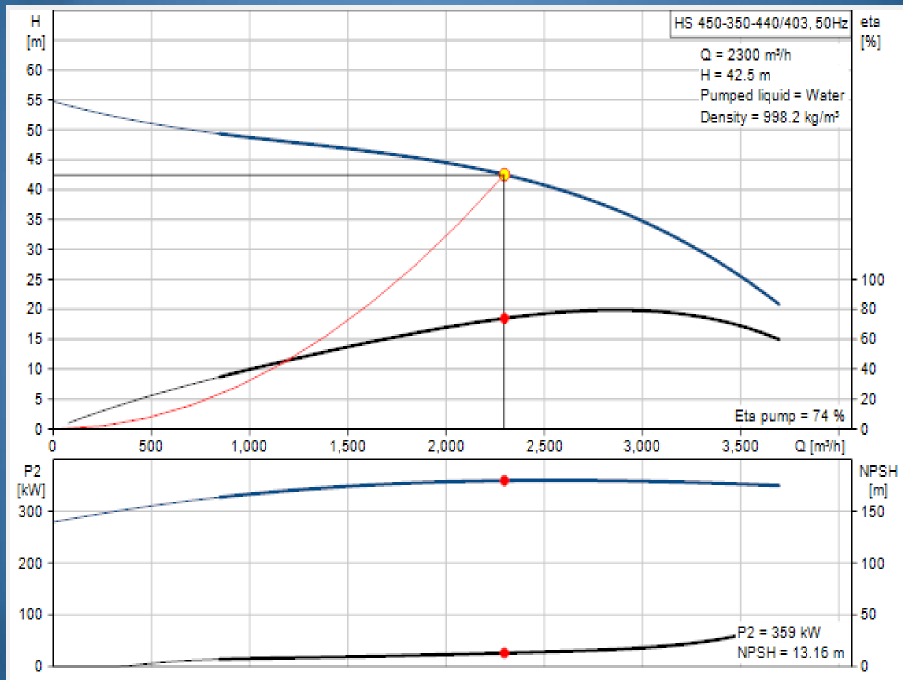


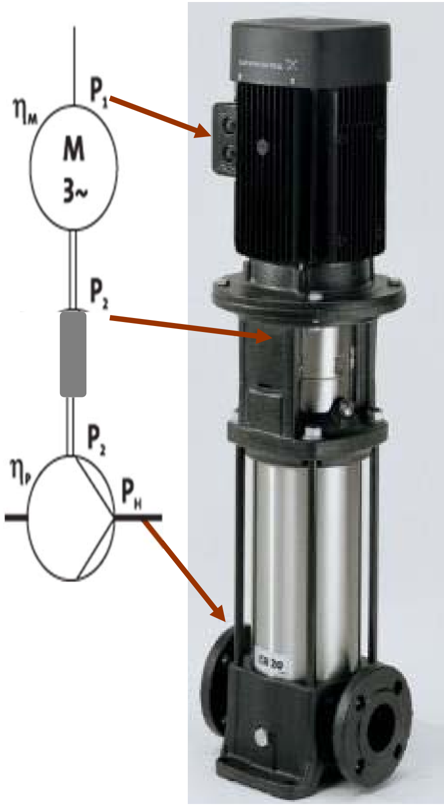
Fig. 1.1.9: The NPSH-curve of a typical centrifugal pump



Bơm bị khí xâm thực:



PUMP CURVES



$$\eta_M = \frac{P_2}{P_1}$$

$$\eta_P = \frac{P_H}{P_2}$$

$$P_H = 2.72 \cdot Q \cdot H \ [W]$$

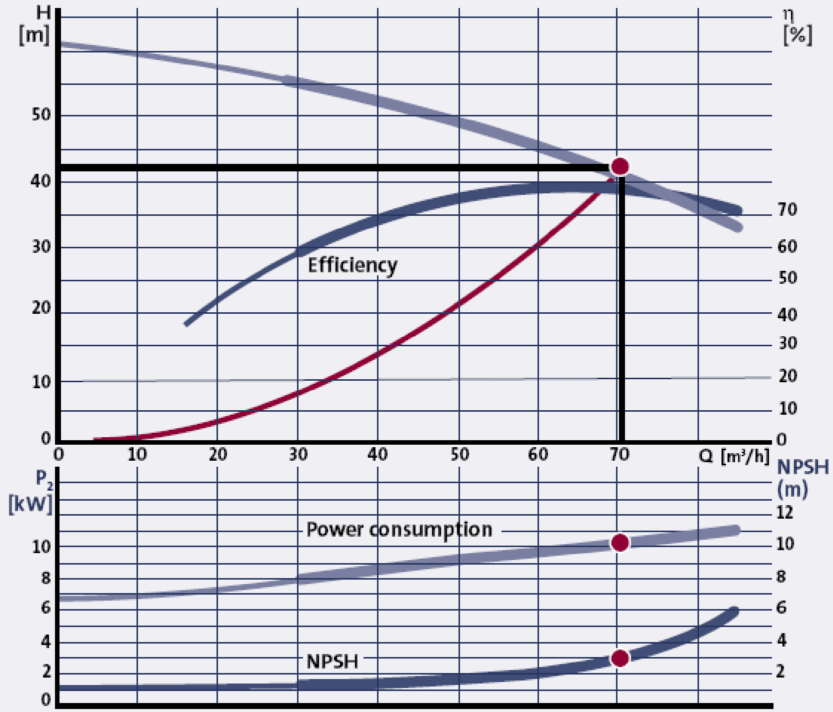
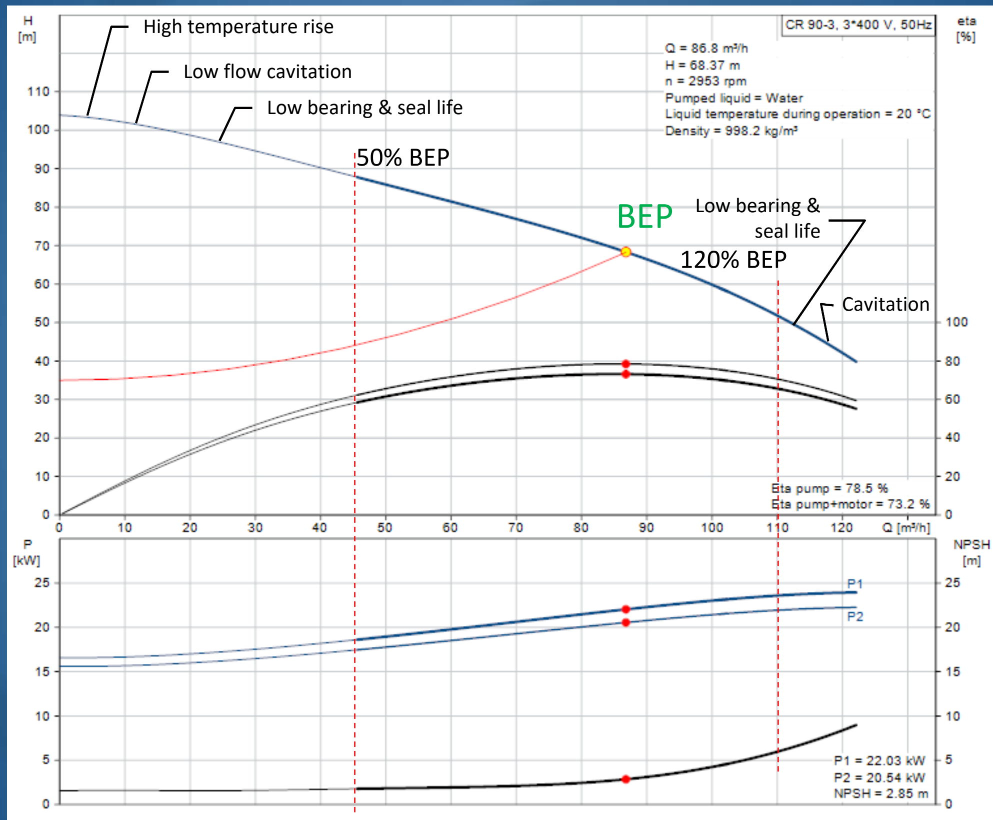


Fig. 1.1.4: Typical performance curves for a centrifugal pump. Head, power consumption, efficiency and NPSH are shown as a function of the flow

DÃY LÀM VIỆC - ĐIỂM LÀM VIỆC TỐT NHẤT

GRUNDFOS SERVICE & SOLUTIONS



HIỆU SUẤT THIẾT BỊ VS HIỆU SUẤT VẬN HÀNH

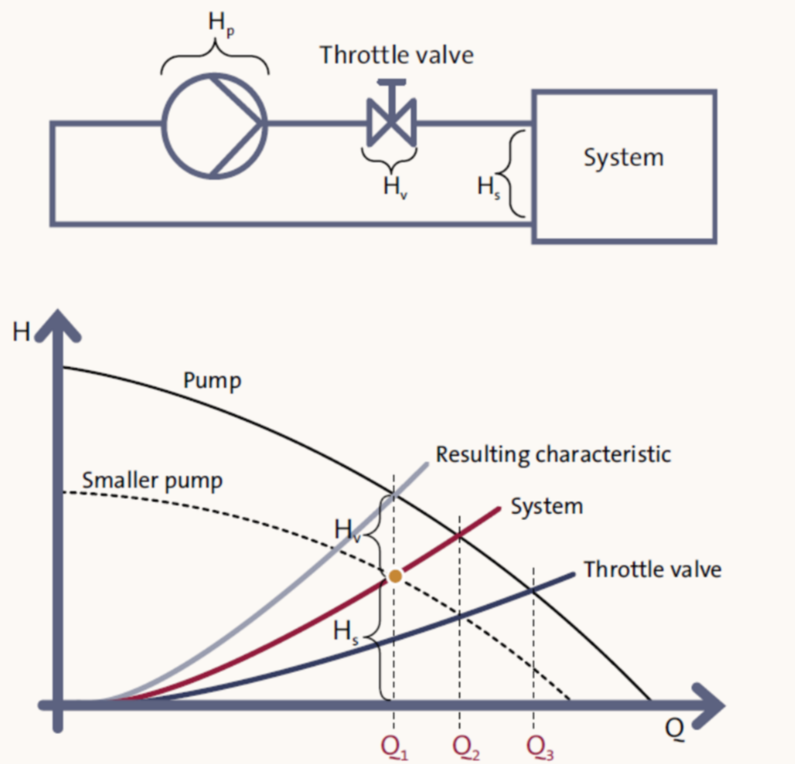
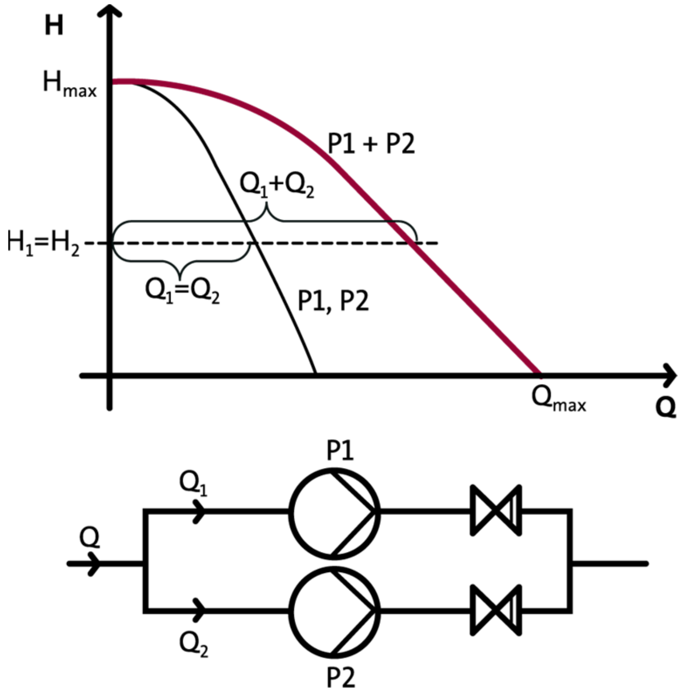


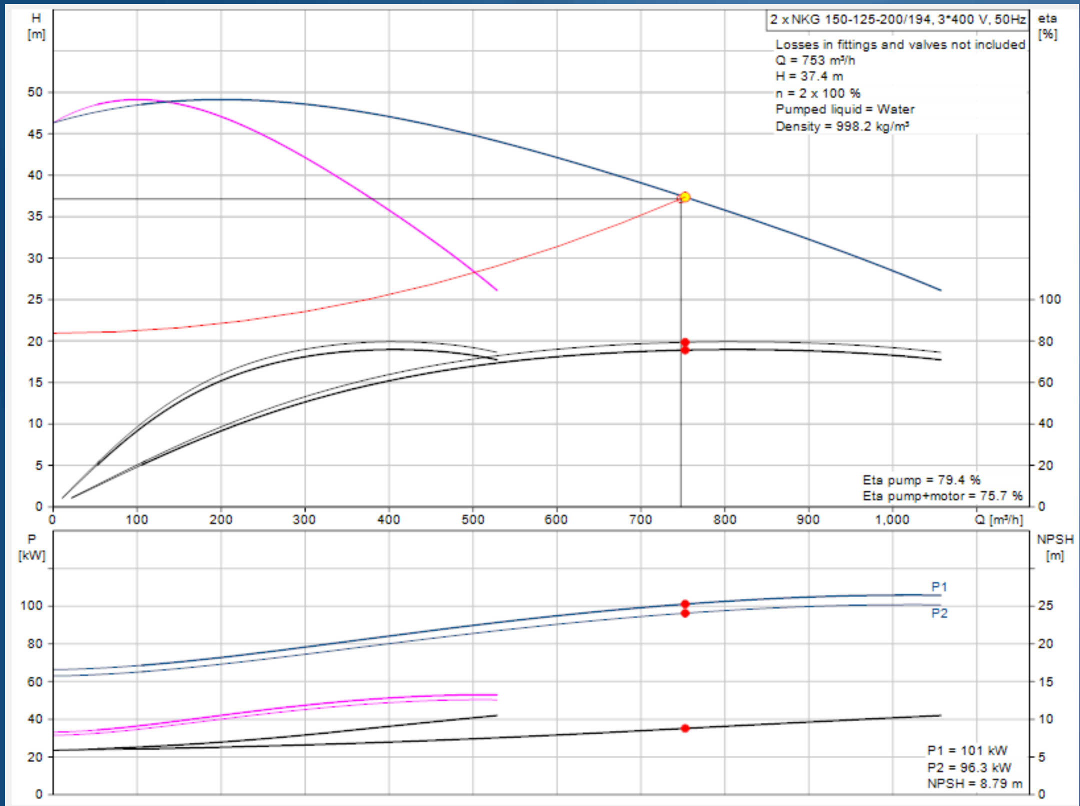
Fig.: 4.1.2: The throttle valve increases the resistance in the system and consequently reduces the flow.

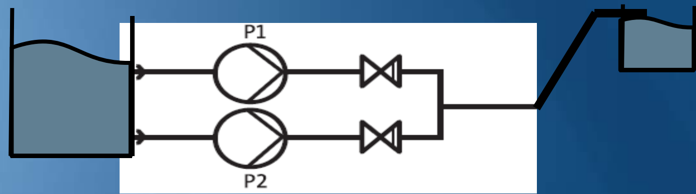
6.1 Pumps connected in parallel - Equal sized pumps



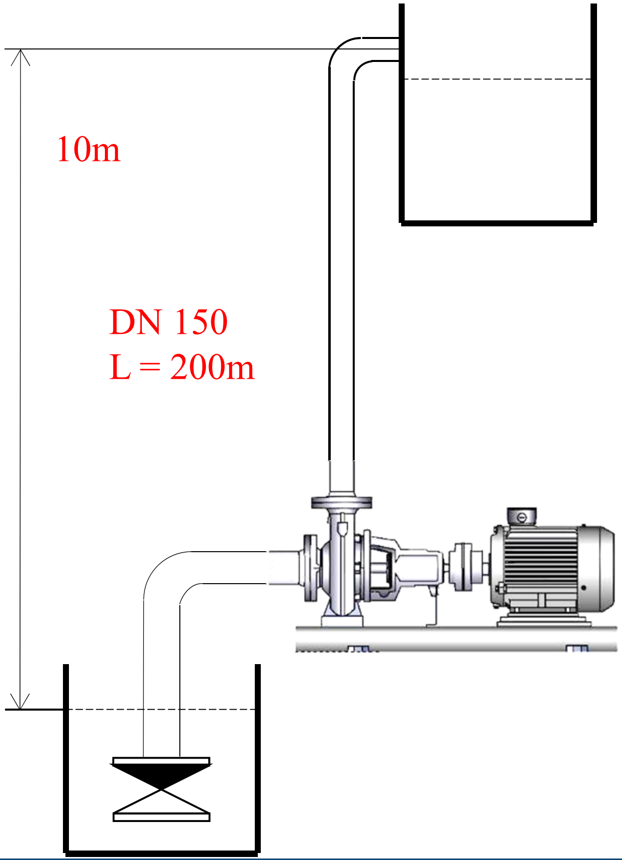
BƠM VẬN HÀNH SONG SONG

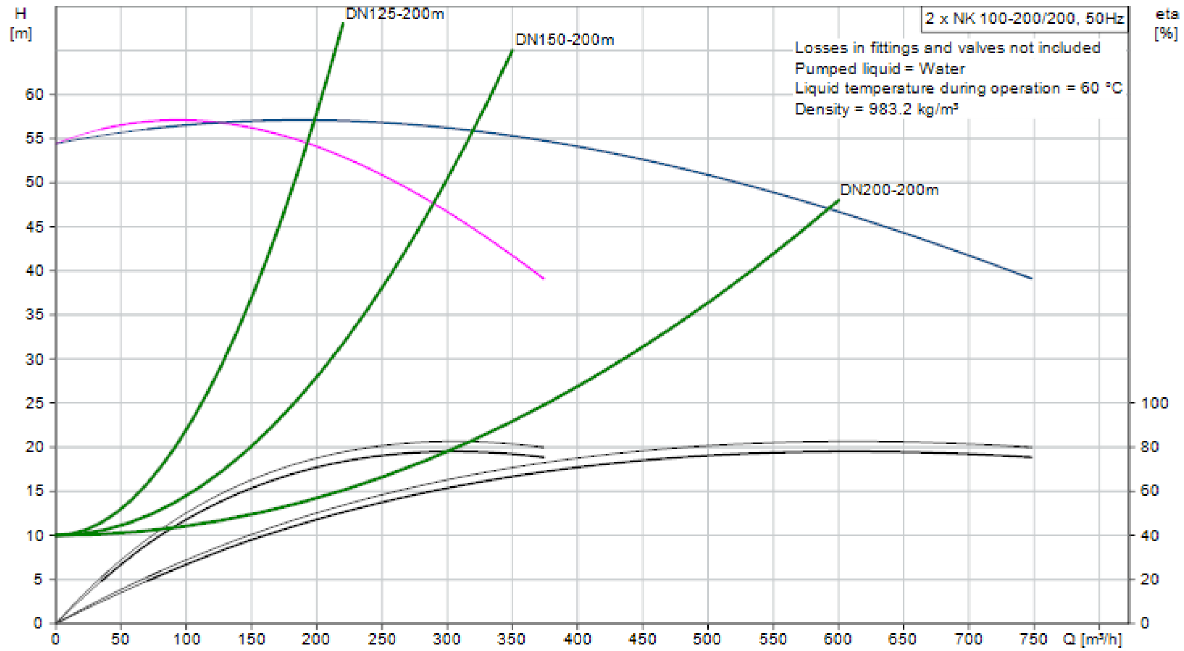
Thông hiểu điểm làm việc thực tế:



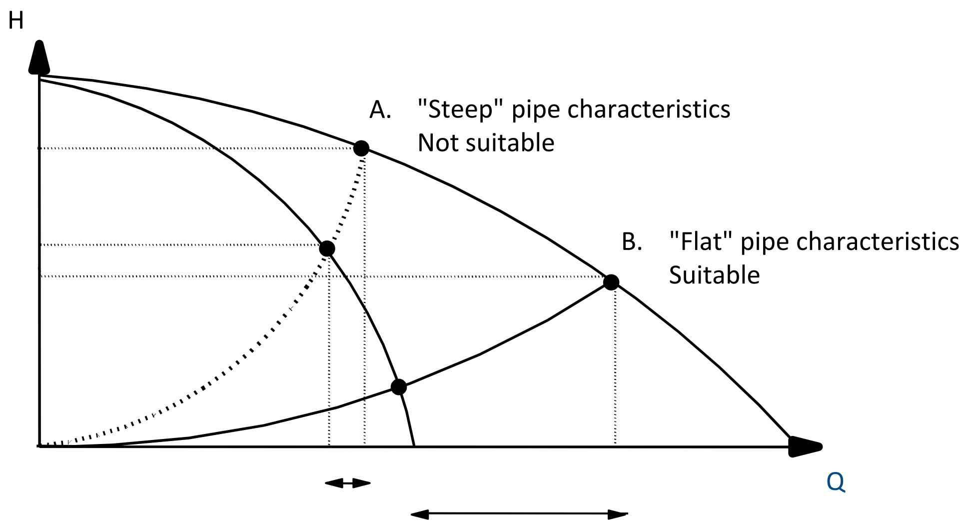


1. Introduction to Centrifugal Pump

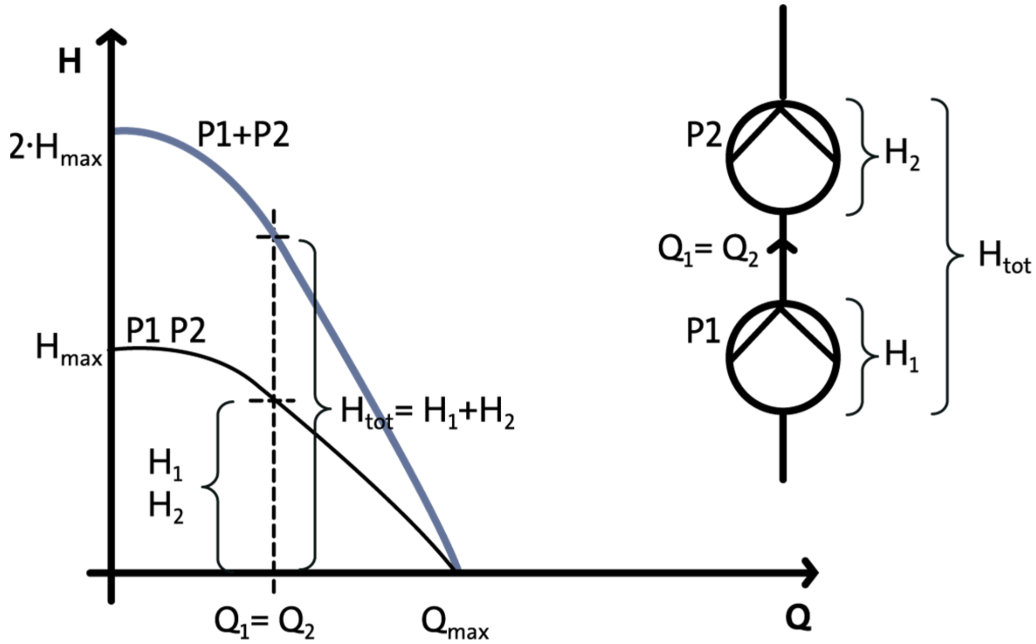




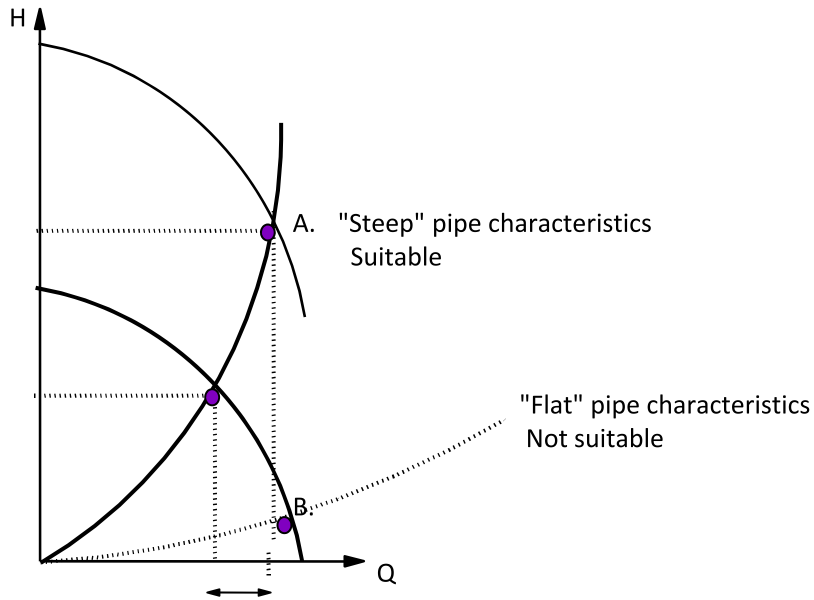
Pumps connected in parallel - Equal sized pumps



6.2 Pumps connected in series - Equal sized pumps



Pumps connected in series - Equal sized pumps



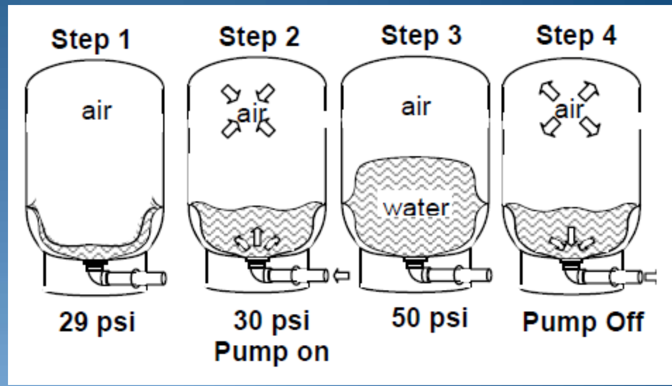
PRESSURE TANK

An energy storage device

Bình tăng áp lực:

- Giảm số lần tắt/mở bơm
- Hấp thụ xung động áp suất - búa nước.

➢ Precharge pressure = Cut-in – 2 PSI



Tank Sizing For Pump Cycle Control

Information Needed

1. Pump Output (1) 15 GPM
2. Desired Runtime* (2) 2 Min.
3. Pump Cut-In (3) 40 psig
4. Pump Cut-Out (4) 60 psig

Tank Volume Selection

5. Drawdown Line(1) x Line(2) (5) 30 Gallons
6. Acceptance Factor (6) .27
7. Tank Size Needed Line(5) ÷ Line(6) (7) 111 Gallons

*Recommended Minimum Runtime
Up to 3/4 hp: 1 Minute
1 to 2 hp: 2 Minutes
2 hp and up: 3 Minutes

Acceptance Factors

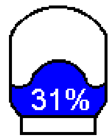
Cut-Out \ Cut-In	20	25	30	35	40	45	50
30	.22	.11					
35	.30	.20	.10				
40	.37	.27	.18	.09			
45	.42	.34	.25	.17	.08		
50	.46	.39	.31	.23	.15	.08	
55	.50	.43	.36	.29	.22	.14	.07
60	.54	.47	.40	.33	.27	.20	.13
65	.56	.50	.44	.38	.31	.25	.19
70	.59	.53	.47	.41	.35	.30	.24

Determining Acceptance Factors

$$\text{Acceptance Factor} = 1 - \frac{P_1 + 14.7}{P_2 + 14.7}$$

Example: Where $P_1 = 30\text{psi}$, $P_2 = 50\text{psi}$

$$1 - \frac{30+14.7}{50+14.7} = .31$$



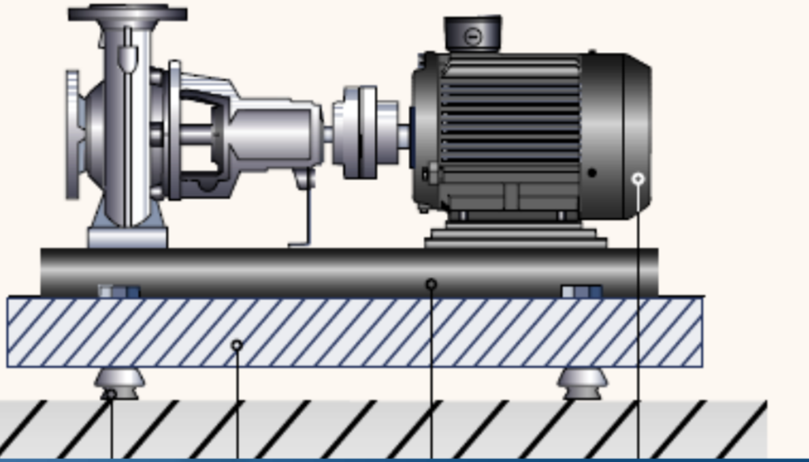
As seen, with the precharge set to 30psi, the tank will have filled 31% by the time the water pressure reaches 50psi.

BỆ QUÁN TÍNH

Foundation suspended on vibration dampeners
Optimum solution with controlled vibration transmission, see figure 2.1.9.

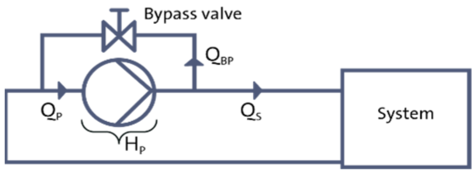
As a rule of thumb, the weight of a concrete foundation should be 1.5 x the pump weight. This weight is needed to get the dampeners to work efficiently at low pump speed.

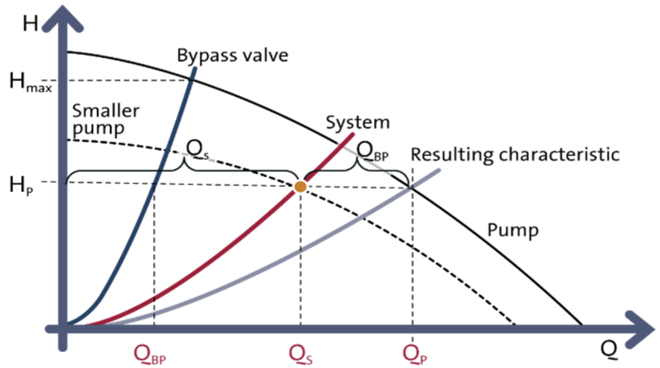
Fig. 2.1.9: Foundation suspended on vibration dampeners



Adjusting pump performance

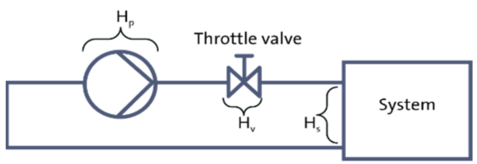
1. Bypass control

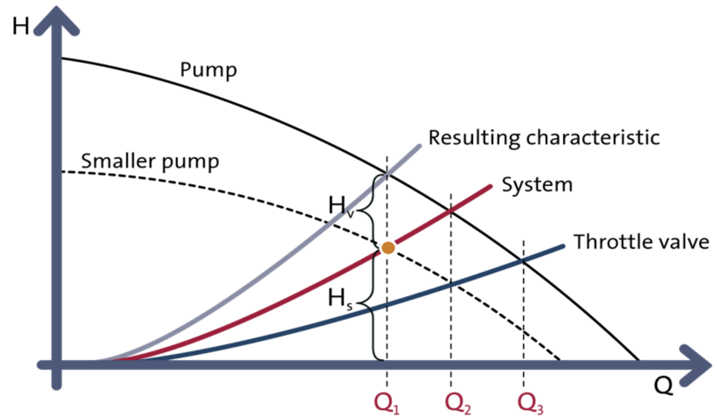




Adjusting pump performance

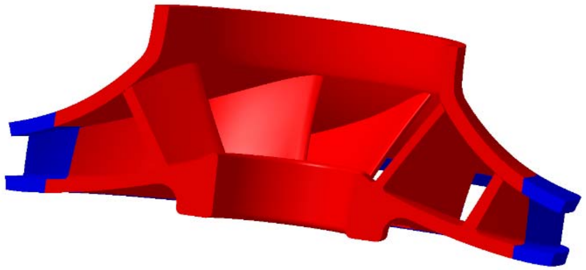
2. Throttle control



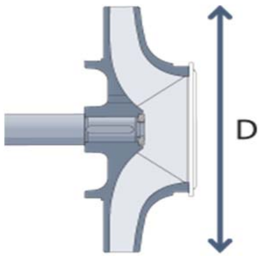


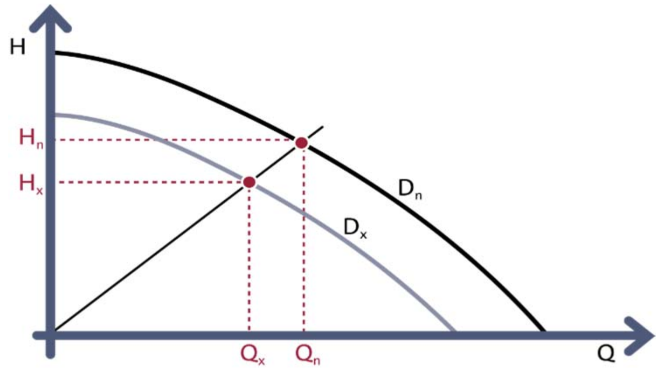
Adjusting pump performance

3. Modifying impeller diamete



$$\frac{Q_n}{Q_x} = \left(\frac{D_n}{D_x}\right)^2 ; \frac{H_n}{H_x} = \left(\frac{D_n}{D_X}\right)^2 ; \frac{P_n}{P_x} = \left(\frac{D_n}{D_x}\right)^4 ; \frac{\eta_n}{\eta x} = 1$$

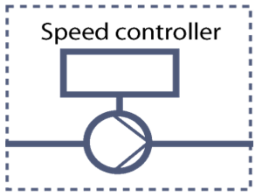


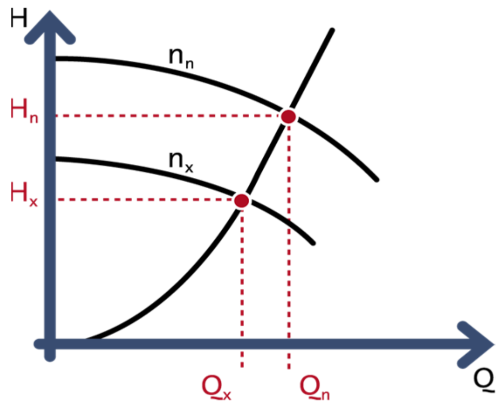


Adjusting pump performance

4. Speed control

$$\frac{Q_n}{Q_x} = \frac{n_n}{n_x}; \frac{H_n}{H_x} = \left(\frac{n_n}{n_x}\right)^2; \frac{P_n}{P_x} = \left(\frac{n_n}{n_x}\right)^3; \frac{\eta_n}{\eta_x} = 1$$





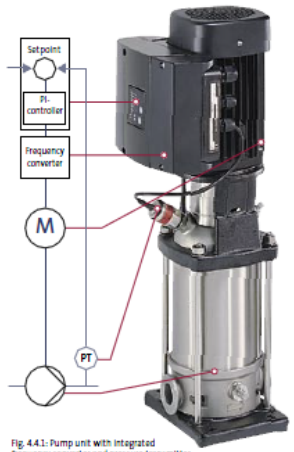


Fig. 4.4.1: Pump unit with integrated frequency converter and pressure transmitter