Positive displacement pumps are hydrostatic machines. They operate with a positive transfer and should not work against a closed system.

All rotary pumps are designed after the same principle. Two rotors are arranged on parallel shafts and driven by an external synchronous gear box.

The rotors rotate in opposite directions to each other. Small radial and axial clearances assure that they have no contact with each other, or the pump body. The rotors are designed to form a barrier between the suction and pressure side of the pump in any position. The sealing is only maintained by narrow gaps. There are no additional seals or valves.

The increasing cavity between the rotors on the suction side is filled with the product. The product is displaced in a circumferential direction and discharged on the pressure side as the cavity between the rotors is collapsing. This generates a constant flow from the suction to the discharge side of the pump.

Rotary pumps ensure a gentle fluid transfer with minimum stress or damage to the product.
**Positive displacement pumps**

With positive displacement pumps the flow rate $Q$ is linear dependent on the pump speed $n$.

On a test stand the flow rate is determined for various speeds and total head. In order to allow a comparison between the various pump designs and types, these tests are always carried out with water.

Once the flow rate $Q$ and the total head $H$ have been determined, a pump speed $n$ that corresponds to this operating point will result from the diagram.

The positive displacement pump is usually operated with a fixed speed drive. The flow rate is constant.

**Performance curve**  
(only for water)

- **Pump speed**
  The flow rate can be adjusted to the various operating conditions by changing the pump speed.

- **Viscosity**
  The viscosity of the product must be always taken into consideration for the design and selection of the pump type.

  Fluids with higher viscosities require more time to enter the displacement chamber. In those cases the pump speed must be adjusted accordingly to avoid cavitation which reduces the volumetric efficiency and increases the wear. A pump operating with cavitation creates a considerable noise level.

- **Clearance losses**
  Regardless of the low clearance between the rotor and the pump body, a slip from the pressure side back to the suction side will be generated when waterlike products are transferred.

  In case of circumferential piston pumps the slip stops at a product viscosity of about 200 mPa s and at about 500 mPa s in the case of rotary lobe pumps.
Fristam supplies two different positive displacement pump designs depending on the application.

- **Fristam** circumferential piston pumps FK and FKL
  The circumferential piston pumps type FK and FKL have a very narrow clearance in the pump chamber and a gland sealing all over. Due to these design features circumferential piston pumps have an outstanding suction performance and are suitable for high differential heads.

- **Fristam** rotary lobe pumps FL
  Due to the gland/line sealing, rotary lobe pumps type FL are mainly used for flooded suction conditions. They reach slightly lower differential heads than the circumferential piston pumps especially at low viscous products, but can run at higher speeds.

Circumferential piston pumps and rotary lobe pumps can be used for hot products
- up to approx. 90 °C using rotors with standard dimensions
- up to approx. 150 °C using rotors with high temperature dimensions.

They are suitable for automatic cleaning (CIP process) and sterilisation (SIP process).

The pumps can be supplied with horizontal or vertical ports. Various types of connections such as flanges, clamps or different threads are available.
Positive displacement pumps

Selection of design
The design selection depends amongst other:

[Diagram]

Is a self-priming pump required?
- no
- yes

Fristam rotary lobe pump FL
Fristam circumferential piston pump FK; FKL

An additional selection criteria is the difference in pressure performance of the various types:

- Fristam rotary lobe pumps FL, maximum total head 120 m (12 bar)
- Fristam circumferential piston pump RK, maximum total head 200 m (20 bar)
- Fristam circumferential piston pump FKL, maximum total head 250 m (25 bar)

Circumferential piston pumps RK, FKL
The Fristam circumferential piston pumps are manufactured with very close clearances. Thus they can generate a small vacuum in the suction pipeline. Due to the atmospheric pressure or system pressure the product is forced into the pump chambers.
Positive displacement pumps

Example:

Flow rate \( Q = 3000 \text{ l/h} \)
Total head \( H = 120 \text{ m} \)

Pump to be used for products with different viscosities.

FK pump basic selection diagram

for case 1: water

\[ \text{case 2: } 10 \text{ mPa s} \quad | \quad \text{selected: FK 40} \]
\[ \text{case 3: } 10,000 \text{ mPa s} \]
Positive displacement pumps

Example:

\[ Q = 3000 \text{l/h} \]
\[ H = 120 \text{m} \]
\[ \eta = 1 \text{mPa s} \]

**Case 1: viscosity**
\[ \eta \leq 1 \text{mPa s} \]

**Step 1:**
read speed \( n \) [1/min]

resulting from the diagram: speed \( n = 380 \text{ 1/min} \)
Step 2: define viscosity factor

Case 1: viscosity
\[ \eta \cup 1 \text{ mPa s} \]

Viscosity factor \( V = 1.8 \)
Positive displacement pumps

**Case 1: viscosity \( \eta \leq 1 \text{ mPa s} \)**

**Step 3:** Calculate the power \( N \) [kW] required for the pump drive.

\[
p = \text{pressure} \ [\text{bar}]
\]

\[
V = \text{viscosity factor}
\]

\[
n = \text{speed} \ [\text{1/min}], \text{stated in the diagram}
\]

\[
C = \text{flow rate/revolution} \ [\text{l/rev.}]
\]

<table>
<thead>
<tr>
<th>FK</th>
<th>25</th>
<th>25/30</th>
<th>40</th>
<th>40/45</th>
<th>48</th>
<th>50</th>
<th>50/75</th>
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<tbody>
<tr>
<td>C</td>
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<td>0,11</td>
<td>0,26</td>
<td>0,36</td>
<td>0,77</td>
<td>1,1</td>
<td>1,37</td>
</tr>
</tbody>
</table>

**Example:**

\[
N = \frac{(2 \times 12 + 1.8) \times 380 \times 0.26}{1000} = 2.5 \text{ kW}
\]
Example:
Q = 3000 l/h
H = 120 m \cup p = 12 \text{ bar}
\eta = 10 \text{ mPa s}

Step 1:
speed correction

Pressure correction diagram

FK 25 - 50/75
with viscosities of 1-200 mPa s
as a function of the pressure

Examples:
120 m \sim 12 \text{ bar}, \text{ viscosity of } 10 \text{ mPa s}
read pump speed at 3.8 bar

stated in the diagram: p = 3.8 \text{ bar}.

Define now the speed required for the corrected pressure.

Case 2:
viscous product
\eta \text{ up to } 200 \text{ mPa s}
Positive displacement pumps

Case 2: viscous product \( \eta \) up to 200 mPa s

Step 2: read speed \( n \) [1/min]

Stated in the diagram: speed \( n = 300 \) 1/min
Step 3: define viscosity factor

Case 2: viscous product \( \eta \) up to 200 mPa s

stated in the diagram: viscosity factor \( V = 2.0 \)
Case 2: Viscous product \( \eta \) up to 200 mPa s

Step 3: Calculate power consumption \( N \) [kW] to select the pump drive.

\[
N = \frac{(2 \times p + V) \times n \times C}{1000}
\]

\( p \) = pressure in bar \( \cup \) \( H/10 \)
\( V \) = viscosity factor
\( n \) = speed with \( H = 38 \) m
\( C \) = flow rate/revolution [l/rev.]

<table>
<thead>
<tr>
<th>FC</th>
<th>25</th>
<th>25/30</th>
<th>40</th>
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Example:

\[
N = \frac{(2 \times 12 + 2) \times 300 \times 0.26}{1000} = 2.03 \text{ kW}
\]
Example:

\( Q = 3000 \text{ l/h} \)
\( H = 120 \text{ m}\) \( \Rightarrow p = 12 \text{ bar} \)
\( \eta = 10,000 \text{ mPa s} \)

**Step 1:**
read speed with \( H = 0, \eta > 200 \text{ mPa s} \)

**Case 3:**
viscous product
\( \eta = 200-100,000 \text{ mPa s} \)

Stated in the diagram: \( n = 220 \text{ l/min} \)
Positive displacement pumps

Case 3:
viscous product
\( \eta = 200-100,000 \text{ mPa s} \)

Step 2:
read viscosity factor \( V \).

\[ V = 9.0 \]

stated in the diagram: \( V = 9.0 \)
Step 3:
Calculate the absorbed power $N$ [kW] to select the pump drive.

$$N = \frac{(2 \times p + V) \times n \times C}{1000}$$

$p =$ pressure [bar] $\cup$ H/10
$V =$ viscosity factor
$n =$ speed [1/min], stated in the diagram
$C =$ flow rate [l/rev]

Example:

$$N = \frac{(2 \times 12 + 9.0) \times 220 \times 0.26}{1000} = 1.9 \text{ kW}$$

Case 3:
viscous product
$\eta = 200 \text{–} 100,000 \text{ mPa s}$
Positive displacement pumps

Rotary lobe pump FL

Example:
Flow rate \( Q = 2000 \text{ l/h} \)
Total head \( H = 60 \text{ m} \)

Selection
Pump to be used for products with different viscosities.

FL - basic selection diagram

for case number 1: water
 case number 2: 10 mPa s | selected: FL 75 L
 case number 3: 10,000 mPa s ≠
Positive displacement pumps

Row rate \( Q = 2000 \text{ l/h} \)
Total head \( H = 60 \text{ m} \)
\( \eta = 1 \text{ mPa s (water).} \)

Step 1:
read speed \( n \) [1/min].

Case 1: viscosity
\( \eta \cup 1 \text{ mPa s} \)

read: speed \( n = 380 \text{ 1/min} \)
Positive displacement pumps

Case 1: viscosity \( \eta \leq 1 \text{ mPa s} \)

Step 2: define viscosity factor

Stated in the diagram: viscosity factor \( V = 1.8 \)
Step 3: Calculate the absorbed power $N$ [kW] to select the pump drive.

$$N = \frac{(2 \times p + V) \times n \times C}{1000}$$

$p =$ pressure in bar $\cup \frac{H}{10}$
$V =$ viscosity factor
$n =$ speed with $H = 0$
$C =$ flow rate/revolution [l/rev]

<table>
<thead>
<tr>
<th>FLF</th>
<th>55S</th>
<th>55L</th>
<th>75S</th>
<th>75L</th>
<th>100S</th>
<th>100L</th>
<th>120S</th>
<th>120L</th>
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</thead>
<tbody>
<tr>
<td>C</td>
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<td>0.152</td>
<td>0.283</td>
<td>0.389</td>
<td>0.69</td>
<td>1.07</td>
<td>1.80</td>
<td>2.54</td>
</tr>
</tbody>
</table>

Example:

$$N = \frac{\left(2 \times 6 + 1.8 \right) \times 380 \times 0.389}{1000} = 2.04 \text{ kW}$$
Positive displacement pumps

Case 2: viscous product up to 500 mPa s

Row rate \( Q = 2000 \text{ l/h} \)
Total head \( H = 60 \text{ m} \)
Viscosity \( \eta = 10 \text{ mPa s} \)

Step 1:
define correction for the speed

\[ H = 60 \text{ m} \cup 6 \text{ bar} \]

Pressure correction diagram

FL 55 - 130
with viscosities of 1-500 mPa s as a function of the pressure

Example:
6 bar, Viscosity of 10 mPa s
read pump speed of 3.3 bar

read speed at \( H = 33 \text{ m} \) (equal to \( p = 3.3 \text{ bar} \))
Step 2:
read speed at $H = 33 \text{ m (}\cup 3.3 \text{ bar)}$

Case 2:
viscous product
$\eta$ up to 500 mPa s

read: speed $n = 300 \text{ 1/min}$
Positive displacement pumps

**Case 2:** Viscous product up to 500 mPa s

**Step 3:** Define viscosity factor

Stated in the diagram: Viscosity factor $V = 2.0$
Step 4:
Calculate absorbed power $N \text{[kW]}$ to select the pump drive.

$$N = \frac{(2 \times p + V) \times n \times C}{1000}$$

$p = \text{pressure in bar}$ $\cup$ $H/10$
$V = \text{viscosity factor}$
$n = \text{speed at } H = 0$
$C = \text{flow rate/revolution [l/rev]}$

<table>
<thead>
<tr>
<th></th>
<th>FLF</th>
<th>55S</th>
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</table>

Example:

$$N = \frac{\left(2 \times 6 + 2 \right) \times 300 \times 0.389}{1000} = 1.63 \text{ kW}$$

Case 2:
viscous product
$\eta$ up to 500 mPa s
Positive
displacement
pumps

<table>
<thead>
<tr>
<th>Case 3: viscous product</th>
<th>Row rate</th>
<th>Q = 2000 l/h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total head</td>
<td>H = 60 m (≈ 6 bar)</td>
</tr>
<tr>
<td></td>
<td>viscosity</td>
<td>η = 10,000 mPa s</td>
</tr>
</tbody>
</table>

Step 1:
read speed at H = 0 m, as η > 500 mPa s

![Graph showing flow rate vs speed for different heads and viscosities.](image)

read: n = 90 1/min
Positive displacement pumps

Step 2:
define viscosity factor

Case 3:
viscous product
\( \eta = 500-100,000 \text{ mPa s} \)

Viscosity factor \( V = 9.0 \)
Positive
displacement
pumps

Case 3:
viscous product
η = 500–100,000 mPa s

Step 3:
calculate absorbed power N [kW].

\[ N = \frac{(2 \times \eta + V) \times n \times C}{1000} \]

\( \eta \) = pressure in bar \( \cup \) H/10
\( V \) = viscosity factor
\( n \) = speed at H = 0
\( C \) = flow rate/revolution [l/rev.]

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<tr>
<th>FLF</th>
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<th>55L</th>
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Example:

\[ N = \frac{(2 \times 6 + 9) \times 90 \times 0.389}{1000} = 0.74 \text{ kW} \]