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<th>Alumne:</th>
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<th>Director/Tutor:</th>
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DOCUMENT Nº 3: DOCUMENTS ANNEXOS

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For better understanding of the following chapters, we firstly will define and explain the technical terms relating to pump technology used in this brochure. The reader will find these terms in alphabetical order in the index. Measures and conversion formulae are summarised in a table.

**Flow rate [m$^3$/h]**

The flow rate is the effective volume flowing per unit of time through the discharge connection of a pump.

In order to optimize the pump design, the flow rate must be accurately determined.

**Total head [m]**

The total head is the effective mechanical energy transferred by a pump to the fluid as a function of the weight force of the fluid.

The total head results as follows:

$$H = H_{geo} + H_v + p$$

It consists of:

- the difference in height to overcome between the suction side and the discharge side of an installation.
  $$H_{geo} = H_{geo0} + H_{geo}$$

- the friction loss resulting from pipe walls, fittings and valves within the plant.
  $$H_v = H_{vs} + H_{vd}$$

- the pressure difference
  $$p = p_a + p_e$$

**Power consumption**

The power consumption is the total energy transferred by the pump to the discharge flow.
Looking at two parallel plates with the surface $A$ and the distance $y$, displaced against each other as a result of a force $F_{\text{action}}$ with a velocity $v$, a force $F_{\text{reaction}}$ opposes to this displacement and increases with increasing dynamic viscosity of the medium between the two plates.

The shear stress $\tau$ increases in proportion to the shear velocity $D$ and the dynamic viscosity $\eta$.

$$\tau = D \times \eta$$

The ratio of $v$ to $y$ is defined as shear velocity $D$.

$$D = \frac{v}{y}$$

Thus the resulting dynamic viscosity $\eta$:

$$\eta = \frac{\tau}{D}$$
Thus, the dynamic viscosity $\eta$ is a characteristic parameter of the fluid concerned and depends on the temperature. Therefore the viscosity is always indicated together with the corresponding temperature.

**Ideal viscous flow behaviour:**

Fluids with an ideal viscous flow behaviour are called Newtonian fluids. They are viscous fluids with linear molecules. They show a proportional flow behaviour.

Typical Newtonian fluids are: water, salad oil, milk, sugar solutions, honey.
Pseudoplastic flow behaviour:

The flow behaviour of fluids depends on their physicochemical properties. Adding a filling agent to a pure solvent will increase the viscosity and change the flow behaviour.

With increasing shear stress, in general the viscosity of highly molecular products in solutions and melts tends to decrease.

Such a flow behaviour is called pseudoplastic.

Examples of pseudoplastic flow behaviour: condensed milk, orange juice

Irreversible flow behaviour:

Fluids deformed under applied shear stress in a way that the structure after the destructive phase (shear time) can not be restored show an irreversible flow behaviour.

The result is a permanent, shear time dependent change of viscosity.

Example for irreversible flow behaviour: Yoghurt
Depending on the Reynolds number, the flow passing through a pipe shows specific, typical flow patterns with different physical properties.

In this context the generation of a laminar or turbulent flow is of particular concern.

In case of a laminar flow, the particles move in a streamline form and parallelly to the pipe axis without being mixed.

The roughness of the inside wall of pipes has no effect on the friction loss.

You will find a laminar flow mainly with high viscous fluids.

The loss of head changes linearly with the flow velocity.

In case of a turbulent or vortical flow the particles are mixed because of the movement along the pipe axis and an additional, transverse movement.
The roughness of the pipe inside has great effect on the friction loss.

Turbulent flows are mainly found with water or fluids similar to water.

The loss on pump head varies by square of the flow velocity.

The Reynolds number describes the correlation between the flow velocity $v$, the viscosity $\eta$ and the inner diameter of the pipe $d$.

The Reynolds number has no dimension.

$$Re = \frac{v \times d \times \rho}{\eta}$$

Row velocity $v$ [m/s]  
Viscosity $\eta$ [Pa s]  
Inner pipe diameter $d$ [mm]  
Density $\rho$ [kg/dm$^3$]

With a Reynolds number of 2320 the laminar flow passes to a turbulent flow.

**Laminar flow $<$ Re$_{krit}$ $=$ 2320 $<$ turbulent flow**

**Example:**

In one second, 2 litres of acetic acid passes through a pipe with a nominal bore of 50 mm. The acetic acid has a kinematic viscosity of $\eta = 1.21$ mPa s $= 0.00121$ Pa s and a density of $1.04$ kg/dm$^3$.

Is the flow laminar or turbulent?

The average flow velocity amounts to:

$$v = \frac{Q}{A} = \frac{Q}{\frac{d^2 \times \pi}{4}} = \frac{2 \times 1000}{\frac{50^2 \times \pi}{4}} = 1.02 \text{ m/s}$$

$Q$ [l/s]  
$d$ [mm]  
v [m/s]
Thus the calculated Reynolds number is:

\[ Re = \frac{v \times d \times \rho}{\eta} = \frac{1.02 \times 5.0 \times 1.04}{0.00121} = 43634 \]

The Reynolds number exceeds the critical Reynolds number \( Re_{krit} = 2320 \). The flow is turbulent.

**NPSH value [m]**

NPSH is the abbreviation for Net Positive Suction Head

Besides the flow rate \( Q \) and the pump head \( H \), the NPSH value is one of the most important characteristic parameter of a centrifugal pump.

**NPSH value of the pump**

The NPSH value of the pump depends on the design and speed of the pump. The higher the speed of the pump, the higher the NPSH value will be.

The NPSH value is measured on a pump test stand and cannot be modified without supplementary means.

**NPSH value of the plant**

The NPSH value of the plant depends on the loss of head including the losses in fittings and apparatus in the line of the plant, and should be always checked by calculation.

\[
\text{NPSH} = \frac{p_e + p_o - p_d}{\rho \times g} + \frac{v^2}{2g} + H_{geo} - H_{VS}
\]

where:
- \( p_e \) = pressure at the inlet cross section of the plant [bar]
- \( p_o \) = pressure at the outlet cross section of the plant [bar]
- \( p_d \) = vapour pressure of the fluid at the middle of the suction connection of the pump [bar]
- \( p_a \) = air pressure at the installation site of the pump [bar]
- \( H_{VS} \) = loss of head of the suction line, from the inlet cross section of the plant to the inlet cross section of the pump [m]
- \( H_{geo} \) = geodetic suction height (negative, in case of flooded suction) [m]
- \( \rho \) = density of the fluid [kg/m³]
- \( v_e \) = inlet flow velocity [m/s]

**Diagrams:**

1. Diagram showing the NPSH calculation with labels for \( p_e, p_o, p_d, p_a, H_{geo}, H_{VS}, v_e, \rho \), and \( g \).
2. Diagram illustrating the geometric arrangement of the pump and plant with labeled distances for \( H_{geo}, H_{VS}, p_e, p_o, p_d, p_a, \) and \( v_e\).
In order to ensure a correct operation of the pump the following condition must be given:

\[ N_{\text{PSH plant}} > N_{\text{PSH pump}} \]

Boiling fluids with a velocity up to 0.3 m/s are a special case.

In this case: \( p_E = p_D \) as \( \frac{v_b^2}{2g} \) and \( H_{\text{vs}} \) become negligible resulting in:

\[ N_{\text{PSH plant}} = H_{\text{agco}} \]
already during design of the plant and piping layout in front of and behind the pump, losses can be limited when considering:

- the pipe diameter is sufficiently dimensioned,
- less fittings are used,
- fittings with low friction loss are selected,
- short pipe runs are planned.

The diagram shows the loss of head for straight pipe runs as a function of a pipe length of 100 m and a given flow velocity \( v \) depending on the flow rate and the pipe diameter.
Loss of head calculation

Example:
Row rate \( Q = 25 \text{ m}^3/\text{h} \)
Pipe diameter \( d = 50 \text{ mm} \)
From the diagram results:
Row velocity \( v = 3.5 \text{ m/s} \)
Loss of head \( H_v = 35 \text{ m}/100 \text{ m} \)

The loss of head in fittings can be determined almost exactly when using adequate pipe lengths.

The loss of head in a fitting is considered equal to a straight pipe with corresponding length.

This calculation is valid only for water and fluids similar to water.

With the same diameter of pipes and fittings we can simplify the calculation.

Equivalent pipe lengths in meter for fittings
(valid for \( \text{Pe} \geq 100,000 \) and roughness \( k \leq 0.04 \text{ mm} \))

<table>
<thead>
<tr>
<th>Diameter DN [mm]</th>
<th>25</th>
<th>40</th>
<th>50</th>
<th>65</th>
<th>80</th>
<th>100</th>
<th>125</th>
<th>150</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard valve</td>
<td>2.1</td>
<td>4.6</td>
<td>7.5</td>
<td>11.0</td>
<td>14.0</td>
<td>20.0</td>
<td>28.0</td>
<td>37.0</td>
</tr>
<tr>
<td>Free-flow valve</td>
<td>0.7</td>
<td>0.9</td>
<td>1.2</td>
<td>1.5</td>
<td>1.8</td>
<td>2.2</td>
<td>2.9</td>
<td>3.7</td>
</tr>
<tr>
<td>90° valve</td>
<td>3.2</td>
<td>5.0</td>
<td>7.2</td>
<td>10.0</td>
<td>13.0</td>
<td>17.0</td>
<td>23.0</td>
<td>31.0</td>
</tr>
<tr>
<td>Elbow 90° R = 4 ( d )</td>
<td>0.5</td>
<td>0.6</td>
<td>0.7</td>
<td>0.9</td>
<td>1.2</td>
<td>1.5</td>
<td>1.9</td>
<td>2.3</td>
</tr>
<tr>
<td>Elbow 90° R = 3 ( d )</td>
<td>0.7</td>
<td>0.9</td>
<td>1.1</td>
<td>1.4</td>
<td>1.7</td>
<td>2.2</td>
<td>2.8</td>
<td>3.5</td>
</tr>
<tr>
<td>Tee (diffusion)</td>
<td>1.6</td>
<td>2.0</td>
<td>2.5</td>
<td>3.3</td>
<td>4.0</td>
<td>4.8</td>
<td>5.7</td>
<td>6.8</td>
</tr>
<tr>
<td>Tee (junction)</td>
<td>2.0</td>
<td>2.6</td>
<td>3.2</td>
<td>4.4</td>
<td>5.8</td>
<td>7.5</td>
<td>10.0</td>
<td>13.0</td>
</tr>
</tbody>
</table>
**Loss of head calculation**

**Example:**

- **Flow rate** $Q = 25 \text{ m}^3/\text{h}$
- **Straight pipe length** $l = 150 \text{ m}$
- **Diameter** $\text{DN} = 50 \text{ mm}$
- **Elbow 90°** 4 pieces
- **Free-flow valves** 2 pieces

from diagram (page 16):

- $v = 3.5 \text{ m/s}$
- $H_v = 35 \text{ m/100 m pipe length}$

from table:

- equivalent pipe length 4 elbows: $l_{\text{bend}} = 1.1 \times 4 = 4.4 \text{ m}$
- equivalent pipe length 2 free-flow valves: $l_{\text{slide}} = 1.2 \times 2 = 2.4 \text{ m}$
- straight pipe length: $l_{\text{pipe}} = 150.0 \text{ m}$
- total pipe length $l_{\text{total}} = 156.8 \text{ m}$

**Loss of head:**

\[
H_{\text{V,\,Lam}} = \frac{\Delta p_{\text{V}}}{100} \times l_{\text{total}} = 52 \text{ m}
\]

with laminar flow (high viscosities) the loss of head $\Delta p_{\text{V}}$ can be calculated using the Hagen-Poiseuille formula:

\[
\Delta p_{\text{V}} = \frac{\nu \times 32 \times \rho \times l}{d^4 \times 10^3}
\]

$H_v \cup 10 \approx \Delta p_{\text{V}}$
Once the required total head has been calculated, the pump type can be selected and the required pump can be sized by means of the Fristam pump curves.

The viscosity of the fluid is an important parameter for the pump selection and leads us to the right decision.

**Fristam centrifugal pumps** are equipped with open impellers which are suitable for the transfer of liquids with viscosities up to 1000 mPa s.

**Centrifugal pumps** have the following features:

- Pulsation free transfer without alteration of flow rate and total head.
- High reliability in operation due to low number of moving parts.
- High operating speed, directly coupled to high-speed electric motors.
- Small dimensions and therefore low space requirement.
- Low operating costs.
- Excellent performance control by speed adjustment.

**Fristam positive displacement pumps**

Usually it is recommended to use positive displacement pumps for low flow rates and high pressures. Even though the viscosity of the fluid would not require its use, because a centrifugal pump would work under these conditions with a very low efficiency rate.

**Note:**

In the following chapters, the various pump types, centrifugal and positive displacement are described with tips for the correct selection of the pump size. Each general pump type description is followed by a section dealing with the correct use of the pump curves provided.
Centrifugal pumps

Features of the centrifugal pump

Centrifugal pumps are fluid-kinetic machines designed for power increase within a rotating impeller. Therefore it is also called the hydrodynamic pumping principle.

According to this principle, the fluid is accelerated through the impeller. In the outlet connection of the centrifugal pump, the resulting increase in speed is converted into delivery head.

Q/H curve

In centrifugal pumps the delivery head H depends on the flow rate Q. This relationship, also called pump performance, is illustrated by curves.

During a bench test, the pump is operated at constant speed and the values Q and H are determined for the various operating points. In order to allow a comparison between the various pump types these measurements are carried out using only water as liquid. With these operating points a Q/H curve be drawn connecting the points on the graph.

Once the flow rate Q is defined and the delivery head H is calculated, the operating point of the plant can be determined. Usually the operating point is not on the Q/H curve of the pump. Depending on the required delivery head, the centrifugal pump will find its operating point when the plant curve and pump curve meet. The flow rate rises from Q₁ to Q₂.
The required operating point is obtained by adapting the pump to the specified operating conditions.

This can be done by the following actions:

- throttling the flow
- correcting the diameter of the impeller
- adjusting the speed of the drive

Partially closing a throttle valve or mounting an orifice plate into the discharge pipe of the pump will increase the pressure drop. The plant curve is shifted.

The operating point B1 (intersection point between pump curve and plant curve) moves on the pump curve to B2.

**Note:** throttling reduces the overall efficiency.

A throttle control or a mounted orifice plate is the less expensive control regarding the investment expenses. In case of significant power requirement, an economic appraisal is highly recommended.

The friction loss in an orifice plate can be calculated easily:

\[
\Delta p_v = \zeta \times \frac{P}{2} v_1^2 \times 1 \times 10^{-5} \quad \rho \text{[kg/m$^3$]} \\
\rho \text{[kg/m$^3$]} \\
v_1 \text{[m/s]} \\
\Delta p_v \text{[bar]}
\]
Centrifugal pumps

See the values $\zeta$ stated in the table below.

<table>
<thead>
<tr>
<th>Aperture ratio $m = (d/D)^2$</th>
<th>Resistance value $\zeta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05</td>
<td>600</td>
</tr>
<tr>
<td>0.1</td>
<td>250</td>
</tr>
<tr>
<td>0.2</td>
<td>50</td>
</tr>
<tr>
<td>0.3</td>
<td>20</td>
</tr>
<tr>
<td>0.4</td>
<td>4</td>
</tr>
</tbody>
</table>

Calculation:

- take the figure stated in the table for $d$, see table $\zeta$, calculate $\Delta p_v$.
- if $\Delta p_v$ varies from the required value, take new value for $d$ and calculate once more $\Delta p_v$.

A correction of the impeller diameter is to be favoured when a permanent reduction of flow rate or differential head is required. The performance of the pump is adjusted towards the duty point by reducing the impeller diameter.

The operating point is shifted from B1 to B2. This is the point where the new pump curve meets the plant curve.

The required impeller diameter can be determined easily using following formulae:

$$N = \text{power consumption}$$
$$D = \text{impeller diameter}$$
$$Q = \text{flow rate}$$
$$H = \text{total head}$$

Note: the efficiency of the pump decreases with increasing correction.
A great number of various operating points can be set continuously, when modifying the pump speed using a variable speed drive or frequency inverter. The operating point moves on the pump curve from B to B2.

Considering the overall efficiency, this is the best way of flow control. Using a variable-speed drive or a frequency inverter additional costs can arise and should be evaluated in an economic appraisal.

The flow rate changes linearly to the speed.

The total head changes with the square of speed.

The power consumption changes with the third power of the speed.

In the case of pumps connected in parallel the fluid flows are added with corresponding delivery head. This applies to pumps even with different Q/H curve.
**Pumps connected in series**

A multistage centrifugal pump performs as single stage pumps connected in series.

**Note:**
A stationary pump in a system creates a considerable pressure drop. Therefore it is recommendable to install a bypass around pumps which are connected in series.

The overall performance curve of centrifugal pumps connected in series can be calculated by adding the differential head of each pump at the relevant flow rate.

---

**Cavitation**

Cavitation can be recognised by a strongly increased noise level of the pump with a simultaneous reduced flow rate.

**What causes cavitation in centrifugal pumps?**

The lowest pressure point in a pump occurs at the inlet of the pump impeller. Due to local pressure reduction part of the fluid may evaporate generating small vapour bubbles. These bubbles are carried along by the fluid and implode instantly when they get into areas of higher pressure. These implosions can create local pressure peaks up to 100,000 bar.

If a pump is cavitating over longer periods, the impeller, the pump housing and cover will wear out. The surface is typically perforated and pitted.
How to avoid cavitation?

We should ensure that at all points of the pump, the fluid pressure is higher than the vapour pressure at the corresponding temperature. Take the pressure stated in the vapour-pressure table of the product to be transferred.

The NPSH value of the plant must be at least 0.5 m higher than the NPSH value of the pump.

For a safe and cavitation free operation the following formular is valid:

\[
\text{NPSH}_{\text{plant}} > \text{NPSH}_{\text{pump}} + 0.5 \text{ m}
\]

The vapour pressure of the product is dependent on the temperature and will rise with increasing temperature.

If the product is pumped at different temperatures the maximum vapour pressure should be used to determine the NPSH value of the plant.
Centrifugal pump types

The *Fristam* centrifugal pump range consists of following pump types:

- **Fristam centrifugal pump FP**
  The design principle of the *Fristam* centrifugal pump FP with open impeller and optimised volute guarantees shear sensitive handling of and minimum heat transfer to the product. Viscosities up to 1000 mPa are no problem. The fluid may contain air or gas, may be homogeneous or contain additives. Low NPSH values make it possible to use the pump also under unfavourable conditions. The *Fristam* centrifugal pump FP is designed as a pump for flooded suction and fully suitable for CIP and SIP application.

- **Fristam multistage centrifugal pump FM**
  The centrifugal pump FM is designed as a multistage pump especially developed for high delivery heads. The centrifugal pump FM can be used for difficult pressure conditions such as feed pump for filters, heat exchangers and fillers, as well as for recirculation and as booster pump in membrane filtration and reverse osmosis plants.

- **Fristam self-priming centrifugal pump FZ**
  The centrifugal pump FZ works on the water ring-side channel principle. Impellers with radial blades transfer the pressure energy to the liquid. Close clearances make it possible to obtain an excellent suction performance. Thus it is possible to pump gaseous products and to deaerate the suction line. This ensures also an optimum drain of the plant.
The selection between the pump types FP and FM also depends on the required flow rate.
Centrifugal pumps

Centrifugal pump FP

Selecting the correct size

Example:
Flow rate $Q_A = 90 \text{ m}^3/\text{h}$
Total head $H_A = 75 \text{ m}$

Step 1:
Select the pump size.

FP sizes

Size selection

Selected pump size: FP 3552
**Step 2:**
Enter the operating point of your plant into the pump diagram.

If the duty point is not exactly on the pump curve, the performance of the pump can be adjusted by throttling the flow, reducing the impeller diameter or adjusting the output speed of the drive. (see page 21–23)

**FP 3552**

Impeller diameter resulting from the diagram = 230 mm
Step 3: Find the power consumption of the pump at the point in the diagram where the power curve of the impeller used meets the design flow rate.

Select the motor with the next higher power rating.

Power consumption according to the diagram: \( N = 26 \text{ kW} \)
selected motor: \( 30.0 \text{ kW} \)

Step 4: Check the efficiency

\[
\eta = \frac{Q \times H \times \rho}{367 \times N}
\]

\[
\text{with } \rho = 1 \text{ kg/dm}^3 \Rightarrow \eta = 0.7 \Rightarrow 70\%
\]
Step 5:
Check if $NPSH_{\text{plant}} > NPSH_{\text{pump}}$

Resulting NPSH value of the pump from the diagram = 2.4 m
Selecting the correct size

Example:
Flow rate \( Q_a = 30 \, \text{m}^3/\text{h} \)
Total head \( H_a = 24 \, \text{m} \)

Size selection

Step 1:
select the pump size whose curve is above to the operating point of the plant.

Selected pump size: FZ 22
Centrifugal pumps

Note:
The performance of FZ pumps can be adjusted to the required operating point only by throttling the flow (see page 21/22) or variation of the speed (see page 23). It is not possible to modify the impeller diameter.
Step 2:
Find the power consumption of the pump at the point in the diagram where the power curve meets the design flow rate. Select the motor with the next higher power rating.

From the diagram: \( N = 6.7 \text{ kW} \), selected motor: 7.5 kW

**Multistage centrifugal pump FM**
The selection is carried out the same way as single-stage centrifugal pumps FP are selected (See page 28).
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.
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.

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

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.

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 allover. 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.
Selection of design

The design selection depends amongst other:

- Is a self-priming pump required?

  - No
  - Fristam rotary lobe pump FL, maximum total head 120 m (12 bar)
  - Yes
  - 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 FK, maximum total head 200 m (20 bar)
- Fristam circumferential piston pump FKL, maximum total head 250 m (25 bar)

Circumferential piston pumps FK, 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.
**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**

![Diagram showing FK pump selection for different cases: water, 10 mPa s, and 10,000 mPa s.](image)

For case 1: water
  - Selected: FK 40

For case 2: 10 mPa s

For case 3: 10,000 mPa s

Positive displacement pumps

Example:

\[ Q = 3000 \text{ l/h} \]
\[ H = 120 \text{ m} \]
\[ p = 12 \text{ bar} \]
\[ \eta = 1 \text{ mPa s} \]

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
\[ \eta \leq 1 \text{ mPa s} \]

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

Case 1: viscosity
η ≤ 1 mPa s

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

\( p = \) pressure [bar]
\( V = \) viscosity factor
\( n = \) speed [1/min], stated in the diagram
\( C = \) flow rate/revolution [l/rev.]

<table>
<thead>
<tr>
<th>RC</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>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.07</td>
<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:
\[
N = \frac{(2 \times 12 + 1.8) \times 380 \times 0.26}{1000} = 2.5 \text{ kW}
\]
Positive displacement pumps

Example:
Q = 3000 l/h
H = 120 m ∪ p = 12 bar
η = 10 mPa s

Step 1:
speed correction

Case 2:
viscous product
η up to 200 mPa s

Pressure correction diagram

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

Examples:
120 m ∼ 12 bar, viscosity of 10 mPa s
read pump speed at 3,8 bar

stated in the diagram: p = 3.8 bar.

Define now the speed required for the corrected pressure.
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 \( V = 2.0 \)
Positive displacement pumps

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 $H = 38 \text{ m}$
$C$ = flow rate/revolution [l/rev.]

<table>
<thead>
<tr>
<th>FC</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>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.07</td>
<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:

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

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

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

**FK 40**

Stated in the diagram: \( n = 220 \text{ 1/min} \)

Case 3:
viscous product
\( \eta = 200–100,000 \text{ mPa s} \)
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] \( \times H/10 \)
- \( V \) = viscosity factor
- \( n \) = speed [1/min], stated in the diagram
- \( C \) = flow rate/revolution [l/rev]

Example:

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

Case 3:
viscous product
\( \eta = 200–100,000 \text{ mPa s} \)
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
for case number 2: $10 \text{ mPa s}$
for case number 3: $10,000 \text{ mPa s}$
selected: FL 75 L
Row rate $Q = 2000 \text{ l/h}$
Total head $H = 60 \text{ m}$
$\eta = 1 \text{ mPa s (water)}$.

**Step 1:**
read speed $n [\text{1/min}]$.

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

![Graph showing flow rate vs speed with a point at 380 l/min]

read: speed $n = 380 \text{ l/min}$
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 $\cup H/10$
$V =$ 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>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.106</td>
<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:

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

Case 2: Viscous product \( \eta \) up to 500 mPa s

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Row rate</td>
<td>( Q = 2000 \text{ l/h} )</td>
</tr>
<tr>
<td>Total head</td>
<td>( H = 60 \text{ m} )</td>
</tr>
<tr>
<td>Viscosity</td>
<td>( \eta = 10 \text{ mPa s} )</td>
</tr>
</tbody>
</table>

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 \( p = 3.3 \text{ bar} \))
Positive displacement pumps

Step 2:
read speed at $H = 33$ m ($\cup 3.3$ bar)

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

read: speed $n = 300$ 1/min
Positive displacement pumps

Case 2: viscous product η up to 500 mPa s

Step 3: define viscosity factor

Stated in the diagram: viscosity factor V = 2.0
**Step 4:**
Calculate absorbed power $N$ [kW] to select the pump drive.

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

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

<table>
<thead>
<tr>
<th></th>
<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>
</tr>
</thead>
<tbody>
<tr>
<td>$C$</td>
<td>0.106</td>
<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>
<td></td>
</tr>
</tbody>
</table>

Example:

$$N = \frac{(2 \times 6 + 2) \times 300 \times 0.389}{1000} = 1.63 \text{ kW}$$
Positive displacement pumps

Case 3: Viscous product
\[ \eta = 500 - 100,000 \text{ mPa s} \]

<table>
<thead>
<tr>
<th>Row rate</th>
<th>Q = 2000 l/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total head</td>
<td>H = 60 m ((\cong 6 \text{ bar}))</td>
</tr>
<tr>
<td>Viscosity</td>
<td>(\eta = 10,000 \text{ mPa s})</td>
</tr>
</tbody>
</table>

Step 1:
read speed at \(H = 0 \text{ m}\), as \(\eta > 500 \text{ mPa s}\)

Read: \(n = 90 \text{ 1/min}\)
Step 2:
define viscosity factor

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

Viscosity factor \( V = 9.0 \)
Step 3:

Calculate absorbed power $N$ [kW].

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

$p =$ pressure in bar $\cup H/10$

$V =$ viscosity factor

$n =$ speed at $H = 0$

$C =$ flow rate/revolution [l/rev.]

Example:

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

Case 3:

Viscous product

$\eta = 500–100,000 \text{ mPa s}$
Mechanical seals are devices to seal machines between rotating parts (shafts), and stationary parts (pump housing).

There are two types of mechanical seals:
- single mechanical seals
- double mechanical seals

Mechanical seals consist of two surfaces which slide against each other. The surfaces are pressed together by a spring. Between these two surfaces a fluid film is generated by the pumped product.

This fluid film prevents that the mechanical seal touches the stationary ring. The absence of this fluid film will result in frictional heat and the destruction of the mechanical seal (dry run of the pump).
Mechanical seal selection

The spring is in the product. The product pressure acts additional to the spring on the rotating seal part.

Therefore standard mechanical seals are used only for a pressure up to 10 bar. For higher pressures, balanced mechanical seals are used.

Double mechanical seals

In this case two mechanical seals are arranged in series. The inboard or, “primary seal” keeps the product in the pump housing. The outboard or, “secondary seal” prevents leakage of the flush liquid into the atmosphere.

The double mechanical seals can be provided by Fristam in two different arrangements:

• Back to Back
• Face to Face

These mechanical seal arrangements are used,

• if a fluid product leakage needs to be avoided,
• when aggressive media are used or at high pressures and temperatures,
• for many polymerising, sticky media and media which tend to sedimentation,
• for vacuum applications.
Two rotating seal rings are arranged facing away from each other "Back to Back". The lubricating film is generated by the barrier fluid.

The barrier pressure in the case of a "Back to Back" arrangement should be 1.5 up to 2.0 bar above the product pressure in the seal area.

Mechanical seals with a "Back to Back" arrangement are mainly used in the chemical industry. In case of a leakage, the barrier liquid penetrates the product.
The spring loaded rotary seal faces are arranged face to face and slide from the opposite direction to one or two stationary seal part(s).

The mechanical seals with a "Face to Face" arrangement are often used in the food industry in particular for products which tend to stick and for vacuum applications. The barrier pressures are very low (0.2 bar). In the case of leakage the product penetrates the barrier liquid.

In the case of hot products the barrier liquid also acts as a cooling agent for the mechanical seal.
Fristam has many years of experience in the manufacture of mechanical seals and is able to provide the best mechanical seal for any application.

Standard mechanical seals in conformity with DIN 24960 can be mounted without problems.

<table>
<thead>
<tr>
<th>Material</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Carbons</td>
<td>Good antifrictional properties, high temperature stability. Chemical stability is to be tested.</td>
</tr>
<tr>
<td>synthetic resin, impregnated</td>
<td></td>
</tr>
<tr>
<td>2. Metals</td>
<td>Good chemical stability.</td>
</tr>
<tr>
<td>Chromium-Nickel-Molybdenum</td>
<td></td>
</tr>
<tr>
<td>3. Metal carbides</td>
<td>Low thermal conductivity, but high hardness and wear resistance.</td>
</tr>
<tr>
<td>Tungsten carbide</td>
<td></td>
</tr>
<tr>
<td>3.2 Silicon carbide</td>
<td>Hardness greater than with tungsten carbide, outstanding chemical stability, good antifrictional properties and thermal conductivity, but very brittle.</td>
</tr>
<tr>
<td>4. Ceramics</td>
<td>High quality aluminium oxide, high wear resistance, good chemical stability, low thermal conductivity, sensitive to thermal shocks</td>
</tr>
</tbody>
</table>

Seal face materials
<table>
<thead>
<tr>
<th>Elastomers</th>
<th>Material</th>
<th>Range of temperatures</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Nitrile</td>
<td>-30 up to +100°C</td>
<td>Resistant to water, vapour, mineral and vegetable shortening (fat) and oils, alcohol, salt solutions. Not resistant to aromatic and chlorine hydrocarbons, acids and alkaline solutions.</td>
<td></td>
</tr>
<tr>
<td>2. EPDM</td>
<td>-50 up to +150°C</td>
<td>Good thermal properties, can be used for alcoholic solutions, diluted acids and concentrated alkaline solutions. Not resistant to mineral and vegetable shortening (fat) and oils, and hydrocarbons.</td>
<td></td>
</tr>
<tr>
<td>3. Viton (FKM)</td>
<td>-25 up to +200°C</td>
<td>Good thermal resistivity, water resistant, vapour resistant, resistance to mineral and vegetable fat and oils, to alcohol, to acids and alkaline solutions, salt solutions. Not resistant to ketones such as acetone and ester.</td>
<td></td>
</tr>
<tr>
<td>4. PTFE</td>
<td>-20 up to +200°C</td>
<td>Best chemical and thermal resistivity to all aggressive liquids, elasticity ensured through use of Viton-caoutchouc or EP-core material.</td>
<td></td>
</tr>
</tbody>
</table>
The transfer of hygienic, high quality products requires a clean pump. Therefore at the end of a production process the pumps must be cleaned immediately. The plant needs to be clean and free from germs before starting a new production cycle.

Cleaning is the operation to remove all traces of product from the plant. A properly cleaned surface is free from visible, perceptible or chemically detectable dirt deposits (residue).

The standard cleaning process for plants is the CIP - (Cleaning in Place). This implies cleaning without dismantling of the plant by means of CIP fluids.

In the food industry a CIP process requires the following steps:
- preliminary rinsing with water
- flushing with alkaline solution
- intermediate rinsing with water
- flushing with acid
- rinsing with clean water

To clean the unit efficiently a turbulent flow of the CIP fluid is required. A minimum flow velocity in pipes is usually 2 m/s.

Viscous fluids are often transferred by positive displacement pumps at low flow velocities. In order to obtain the flow rate required for CIP it may be necessary to fit an additional cleaning pump such as a centrifugal pump.

**Fristam** pumps are fully CIP capable. They are characterised by:
- welded and ground joints
- round edges and angles
- smooth joining
- no narrow gaps and dead legs
- O-rings immersed in the pump housing
- smooth, nonporous internals with a high surface finish
Pump cleaning

After CIP cleaning an additional sterilisation in place process (SIP) may be required when highly sensitive products are handled, inactivating any micro-organisms which might be still present in the pump.

The sterilisation can be carried out by means of chemicals, hot water or steam. In the dairy industry the sterilisation temperature is approximately 145°C.
### Units of measure and conversion

#### Units of measure

<table>
<thead>
<tr>
<th>Term</th>
<th>Symbol</th>
<th>Unit used in practice</th>
<th>Coherent unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow rate</td>
<td>Q</td>
<td>m³/h</td>
<td>l/h</td>
</tr>
<tr>
<td>Total head</td>
<td>H</td>
<td>m</td>
<td>m</td>
</tr>
<tr>
<td>NPSH-value</td>
<td>NPSH</td>
<td>m</td>
<td>m</td>
</tr>
<tr>
<td>Power consumption</td>
<td>N</td>
<td>kW</td>
<td>Nm/s</td>
</tr>
<tr>
<td>Pump efficiency</td>
<td>η</td>
<td>%</td>
<td>–</td>
</tr>
<tr>
<td>Speed</td>
<td>n</td>
<td>1/min</td>
<td>1/s</td>
</tr>
<tr>
<td>Pressure</td>
<td>p</td>
<td>Pa</td>
<td>N/m²</td>
</tr>
<tr>
<td>Density</td>
<td>ρ</td>
<td>kg/dm³</td>
<td>kg/m³</td>
</tr>
<tr>
<td>Fluid flow velocity</td>
<td>ν</td>
<td>m/s</td>
<td>m/s</td>
</tr>
<tr>
<td>Local gravitational acceleration</td>
<td>g</td>
<td>m/s²</td>
<td>m/s²</td>
</tr>
</tbody>
</table>

**Used indices:**
- geo = total discharge head
- S = suction side
- D = discharge side
- E = inlet cross section
- A = discharge cross section
- V = loss

**Conversion**

<table>
<thead>
<tr>
<th>Term</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure p</td>
<td>Pascal</td>
</tr>
<tr>
<td>Total head</td>
<td>Meter</td>
</tr>
<tr>
<td>Dynamic viscosity</td>
<td>mPa s</td>
</tr>
</tbody>
</table>

- 1 mPa s = 1 cP
- 100 kPa = 1 bar
- 1 m² = 0.1 bar

*) valid only for water
<table>
<thead>
<tr>
<th>Topic</th>
<th>Page(s)</th>
</tr>
</thead>
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<td>Cavitation</td>
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<td>20</td>
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<td>Centrifugal pumps parallely connected</td>
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<td>30</td>
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<td>Centrifugal pumps, Q/H curve</td>
<td>20</td>
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<td>Centrifugal pumps, selection criteria</td>
<td>27</td>
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<tr>
<td>Centrifugal pumps, size selection</td>
<td>28, 32</td>
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<tr>
<td>Centrifugal pump types</td>
<td>26</td>
</tr>
<tr>
<td>Conversion</td>
<td>69</td>
</tr>
<tr>
<td>Correction of the impeller diameter</td>
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<td>Flow behavior of fluids</td>
<td>10</td>
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<tr>
<td>Flow rate</td>
<td>8</td>
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<td>Laminar flow</td>
<td>12</td>
</tr>
<tr>
<td>Loss of head caused by fittings</td>
<td>17</td>
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<td>Loss of head in straight pipe runs</td>
<td>16</td>
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<tr>
<td>NPSH value</td>
<td>14</td>
</tr>
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<td>NPSH value of the plant</td>
<td>14</td>
</tr>
<tr>
<td>NPSH value of the pump</td>
<td>14</td>
</tr>
<tr>
<td>Orifice plate calculation</td>
<td>21</td>
</tr>
<tr>
<td>Positive displacement pump, features</td>
<td>35</td>
</tr>
<tr>
<td>Positive displacement pump, operating scheme</td>
<td>35</td>
</tr>
<tr>
<td>Power consumption of the pump</td>
<td>8, 30, 33, 42, 46, 49, 53, 57, 60</td>
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<tr>
<td>Pump efficiency</td>
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<tr>
<td>Pump speed control</td>
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<tr>
<td>Pump type selection</td>
<td>19</td>
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<tr>
<td>Q/H curve of centrifugal pumps</td>
<td>20</td>
</tr>
<tr>
<td>Reynolds number</td>
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<tr>
<td>Single mechanical seals</td>
<td>61</td>
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<tr>
<td>Throttling the flow</td>
<td>21</td>
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<tr>
<td>Total head</td>
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<tr>
<td>Turbulent flow</td>
<td>12</td>
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<tr>
<td>Types of flow</td>
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<tr>
<td>Units of measure</td>
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<td>Vapour pressure</td>
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<tr>
<td>Viscosity</td>
<td>9, 36</td>
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zulässige Leistungsschwankungen ± 5%
alle Angaben gelten für Wasser bei 20°C

Saugseite : DN 65
Druckseite : DN 50

n = 1450 min⁻¹
zulässige Leistungsschwankungen ± 5%
alle Angaben gelten für Wasser bei 20°C

Name: Tho
Datum: 21.01.10

FP 3521

Saugseite: DN 65
Druckseite: DN 50

n = 1750 min⁻¹

0428 83 1001
zulässige Leistungsschwankungen ± 5%      Name : Tho
alle Angaben gelten für Wasser bei 20°C      Datum : 21.01.10
Saugseite : DN 65      FP 3522
Druckseite : DN 50      n = 2900 min⁻¹
Jan-10
0428 85 1001
zulässige Leistungsschwankungen ± 5%
alle Angaben gelten für Wasser bei 20°C

Saugseite : DN 65
Druckseite : DN 50

Name : Tho
Datum : 21.01.10

FP 3522
0428 87 1001
n = 3500 min⁻¹
Schalldruckangaben in [dB (A)]

zulässige Leistungsschwankungen ± 5%
alle Angaben gelten für Wasser bei 20°C

Name : Tho
Datum : 21.01.10

Saugseite : DN 65
Druckseite : DN 50
n = 1450 min⁻¹

Jan-10

FP 3521
0428 81 1002
Schalldruckangaben in [dB (A)]

zulässige Leistungsschwankungen ± 5%
alle Angaben gelten für Wasser bei 20°C
Datum: 21.01.10

Saugseite: DN 65
Druckseite: DN 50
n = 1750 min⁻¹

FP 3521
0428 83 1002

Jan-10
Schalldruckangaben in [dB (A)]
zulässige Leistungsschwankungen ± 5%
alle Angaben gelten für Wasser bei 20°C
Datum: 21.01.10
FP 3522

Saugseite : DN 65
Druckseite : DN 50
n = 3500 min⁻¹
0428 87 1002
Jan-10
zulässige Leistungsschwankungen ± 5%  
alle Angaben gelten für Wasser bei 20°C  
Name : Tho  
Datum : 21.01.10  
Saugseite: DN 65  
Druckseite: DN 50  
n = 1450 bis 3500 min⁻¹  
0428 89 1001
zulässige Leistungsschwankungen ± 5%
alle Angaben gelten für Wasser bei 20°C

Name: Tho
Datum: 21.01.10

Saugseite: DN 65
Druckseite: DN 50
n = 1450 bis 3500 min⁻¹

FP 3520
0428 89 1002
zulässige Leistungsschwankungen ± 5%
alle Angaben gelten für Wasser bei 20°C
Name: Tho
Datum: 21.01.10
Saugseite: DN 65
n = 1450 bis 3500 min⁻¹
Druckseite: DN 50
0428 89 1003
Jan-10

FP 3520
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<th>Motor</th>
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<td>n</td>
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<td>58</td>
<td>22.5</td>
</tr>
<tr>
<td>FPE 721/722</td>
<td>79</td>
<td>22.5</td>
</tr>
<tr>
<td>FPE 741/742</td>
<td>96</td>
<td>20.5</td>
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<td>FPE 3401/3402</td>
<td>55</td>
<td>23</td>
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<tr>
<td>FPE 3451/3452</td>
<td>141</td>
<td>33</td>
</tr>
<tr>
<td>PFP 3521/3522</td>
<td>80</td>
<td>29</td>
</tr>
<tr>
<td>FPE 3531/3532</td>
<td>95</td>
<td>31.5</td>
</tr>
<tr>
<td>FPE 3541/3542</td>
<td>115</td>
<td>33</td>
</tr>
<tr>
<td>FPE 3551</td>
<td>138</td>
<td>38</td>
</tr>
</tbody>
</table>

Maße øg, g1, k und Motor-
gewichte sind abhängig
vom Motorhersteller.

Dimensions øg, g1 and k and
motor weights are dependent
on motor execution.

Maße unverbindlich
dimensions without
obligation.
Model:
Model No.:
## 1. Disassembly  
1.1 General  
1.2 Impeller  
1.3 Complete disassembly  

## 2. Assembly  
2.1 General  
2.1.1 Setting the gap  
2.1.2 Screw tightening torque  
2.2 FPE assembly  
2.3 FPE with double shaft seal
1. Disassembly

1.1 General

- Disconnect the pump from the power supply so that it is de-energised.
- If fitted, close the shut-off valve in the suction pipe and discharge pipe.
- Undo the suction/discharge connections and remove the pump from the system.

In the case of dangerous pumping media, legal and works safety directions must be observed.

For highly polished surfaces: When tightening or untightening the impeller nut please use softer material tool inlets (copper sheet) in order to prevent surface damage.

1.2 Impeller and shaft seal

- Unscrew the cover and drain the pump, clean it, if necessary.
- Undo the impeller nut.
- Pull off the impeller from the shaft and remove the feather key.
- Carefully dismantle the shaft seal parts in accordance with the order-related documentation.

1.3 Complete disassembly

- Undo the clamping screw resp. hex-screws between casing and lantern (only for 1051/2, 1151/2, 1231/2, 1251/2, 101/102 - 200, 101/102 - 250).
- Pull off the casing.
- Undo the screws between the motor flange and clamping disc/lantern.
- Pull off the clamping disc/lantern.
- Undo the screws of the shrink-fit ring.
- Release the tensioning rings from the clamping ring.
- Pull off the pump’s hollow shaft from the motor shaft.
- Pull off the shrink-fit ring from the pump’s hollow shaft.

2. Assembly

2.1 General

Before assembling the pump, the following has to be done:

- The parts have to be cleaned.
- The sealing area has to be cleaned.
- All parts have to be checked for precision fit and, if necessary, reworked, with the exception of the sliding surfaces of the shaft seal.
- Worn parts have to be replaced.
- O-rings and gaskets always have to be replaced before assembly.

2.1.1 Setting the gap

The gap size of the pump must be reset in accordance with Tab 1.

<table>
<thead>
<tr>
<th>Pump Type</th>
<th>Axial gap</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Impeller/ cover</td>
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<tr>
<td>711/712</td>
<td>0.5 mm</td>
</tr>
<tr>
<td>721/722</td>
<td></td>
</tr>
<tr>
<td>741/742</td>
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</tr>
<tr>
<td>3401/3402</td>
<td></td>
</tr>
<tr>
<td>3521/3522</td>
<td></td>
</tr>
<tr>
<td>3531/3532</td>
<td>0.5 mm</td>
</tr>
<tr>
<td>3541/3542</td>
<td>1.0 mm</td>
</tr>
<tr>
<td>3451/3552</td>
<td></td>
</tr>
<tr>
<td>3551/3552</td>
<td></td>
</tr>
<tr>
<td>751/752</td>
<td></td>
</tr>
<tr>
<td>1051/1052</td>
<td>0.7 mm</td>
</tr>
<tr>
<td>1151/1152</td>
<td>0.6 mm</td>
</tr>
<tr>
<td>1231/1232</td>
<td></td>
</tr>
<tr>
<td>1251/1252</td>
<td>1.0 mm</td>
</tr>
<tr>
<td>101/102-200</td>
<td>1.5 mm</td>
</tr>
<tr>
<td>101/102-250</td>
<td>0.5 mm</td>
</tr>
<tr>
<td></td>
<td>1.2 mm</td>
</tr>
</tbody>
</table>

Tab. 1: Gap sizes
2.1.2 Screw tightening torque

The screw tightening torque in the tables below must be complied with.

<table>
<thead>
<tr>
<th></th>
<th>M 6</th>
<th>M 8</th>
<th>M 10</th>
<th>M 12</th>
<th>M 16</th>
<th>M 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nm</td>
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<td>25</td>
<td>49</td>
<td>85</td>
<td>210</td>
<td>420</td>
</tr>
</tbody>
</table>

Tab. 2: Class 8.8 steel screws

<table>
<thead>
<tr>
<th></th>
<th>M 6</th>
<th>M 8</th>
<th>M 10</th>
<th>M 12</th>
<th>M 16</th>
<th>M 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nm</td>
<td>7,3</td>
<td>17,5</td>
<td>35</td>
<td>60</td>
<td>144</td>
<td>281</td>
</tr>
</tbody>
</table>

Tab. 3: Stainless steel screws A2-70 and A4-70

2.2 Pump assembly

1. Remove the feather key from the motor shaft.
2. Degrease the motor shaft and bore of the hollow shaft.
3. Insert half feather key into the motor shaft (only for bigger motors above >30 kW).
4. Seal the motor shaft around the shaft shoulder with a sealing gel (e.g. Stucarit sealing gel 309).
5. Push the hollow shaft with shrink-fit ring onto the motor shaft up to the shaft shoulder.
6. Tighten the hexagon socket screws of the shrink-fit ring in diagonally opposite sequence (see Tab. 4).

<table>
<thead>
<tr>
<th>Hexagon socket screw</th>
<th>Tightening torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>M 5</td>
<td>6 Nm</td>
</tr>
<tr>
<td>M 6</td>
<td>12 Nm</td>
</tr>
</tbody>
</table>

Tab. 4: Tightening torque for the fastening screws of the shrink-fit ring

7. Check the hollow shaft for concentricity and align.

Concentricity tolerance:
- max. 0.06 mm for motors below 30 kW
- max. 0.08 mm for motors above 30 kW

8. Screw the clamping disc/lantern to the motor flange.
9. Insert the shaft seal housing or stationary ring with O-ring into the pump casing and secure (in accordance with the order-related documentation).
10. Screw pump casing and clamping disc/lantern together so as to be fingertight.
11. Fit the front seal set of the shaft seal. Cut the Nylon lock ring and put it into the prepared groove behind the thread of the shaft.
12. Insert the O-ring into the impeller nut. Push the impeller on to the pump shaft. Secure the impeller against twisting and tighten the impeller nut with 100 Nm.
13. Set the gap size of the cover, impeller and casing by shifting the pump casing within the clamped joint, resp. measure the gap size and adjust by fitting shims between casing and lantern (only for 1051/2, 1151/2, 1231/2, 1251/2, 101/102 – 200, 101/102 – 250) (see Tab. 1: Gap sizes).
14. Tighten the clamping screw with the following torque:
   - M 10 with 45 Nm
   - M 12 with 75 Nm
   or hex-screws with torque specified.
15. Place the cover with O-ring onto the casing and tighten.

2.3 Pumps with double shaft seal

1. Remove the feather key from the motor shaft.
2. Degrease the motor shaft and bore of the hollow shaft.

For pumps in FPE execution radial gasket needs to be fitted onto a speedy - sleeve.

3. Use a piece of pipe (length between 120 to 150 mm) to push the sleeve onto the shaft. Inner diameter of pipe 23 mm (for 22 mm shaft), 36 mm (for 35 mm shaft).

For pumps in FPE execution with 22 mm shaft only:

- Sealing cover with radial gasket to be fitted to pump housing.
- Flushing pipes in vertical direction, then threaded pins to be fixed manually.

4. Insert half feather key into the motor shaft (only for bigger motors above 30 kW).
5. Seal the motor shaft around the shaft shoulder with sealing gel (e.g. Stucarit sealing gel 309).
6. Push the hollow shaft with shrink-fit ring onto the motor shaft up to the shaft shoulder.
7. Tighten the hexagon socket screws of the shrink-fit ring in diagonally opposite sequence (see Tab. 4).
8. Check the hollow shaft for concentricity and align.

Concentricity tolerance:
- max. 0.06 mm for motors below 30 kW
- max. 0.08 mm for motors above 30 kW
9. Screw the clamping disc/lantern to the motor flange. **For pumps in FP...V execution only:** Push rear mechanical seal unit onto the shaft (according to the order-related documentation).

10. Insert the shaft seal housing or stationary ring with O-ring into the pump casing and secure (in accordance with the order-related documentation).

11. Screw pump casing and clamping disc/lantern together so as to be fingertight.

12. Flushing pipes to screw into the sealing cover to be sealed with sealing paste.

13. Fit the front seal set of the shaft seal. Cut the Nylon lock ring and put it into the prepared groove behind the thread of the shaft.

14. Insert the O-ring into the impeller nut. Push the impeller onto the pump shaft. Secure the impeller against twisting and tighten the impeller nut with 100 Nm.

15. Set the gap size of the cover, impeller and casing by shifting the pump casing within the clamped joint, resp. measure the gap size and adjust by fitting shims between casing and lantern (only for 1051/2, 1151/2, 1231/2, 1251/2, 101/102 – 200, 101/102 – 250) (see Tab. 1: Gap sizes).

16. Tighten the clamping screw with the following tightening torque:
   - M 10 with 45 Nm
   - M 12 with 75 Nm
   or hex-screws with torque specified.

17. Place the cover with O-ring onto the casing and tighten.

   Each time the impeller is assembled, a check must be made to ensure that it does not chafe at any point, and the Nylon lock ring has to be replaced.
Please see www.fristam.de for addresses and further information.
Kreiselpumpen FP / Centrifugal Pumps FP
n=1450 min⁻¹

zulässige Leistungsschwankungen ± 5%
alte Angaben gelten für Wasser bei 20°C

0400 71 1002 / 07.03
Kreiselpumpen FP / Centrifugal Pumps FP
n=2900 min⁻¹

zulässige Leistungsschwankungen ± 5%
alle Angaben gelten für Wasser bei 20°C

0400 75 1002 / 07.03
zulässige Leistungsschwankungen ± 5%
alle Angaben gelten für Wasser bei 20°C
Saugseite : DN 40
Druckseite : DN 40
n = 1450 min⁻¹
Datum : 27.04.00
Name : Thomsen
0413 81 1001
zulässige Leistungsschwankungen ± 5%
alle Angaben gelten für Wasser bei 20°C

Name: Thomsen
Datum: 31.03.00

Saugseite: DN 80
Druckseite: DN 50

n = 1450 min⁻¹
0482 81 1001
zulässige Leistungsschwankungen ± 5%
alle Angaben gelten für Wasser bei 20°C

Name: Thomsen
Datum: 29.05.00
FP 3521

Saugseite: DN 65
Druckseite: DN 50
n = 1450 min⁻¹
0428 81 1001
zulässige Leistungsschwankungen ± 5%
alte Angaben gelten für Wasser bei 20°C

Name: Thomsen
Datum: 31.05.00

Saugseite: DN 65
Druckseite: DN 50

FP 3531
n = 1450 min⁻¹
0438 81 1001
zulässige Leistungsschwankungen ± 5%
alle Angaben gelten für Wasser bei 20°C

Name: Thomsen
Datum: 17.10.00

Saugseite: DN 100
Druckseite: DN 80

n = 1450 min⁻¹

FP 1231

0474 81 1001
zulässige Leistungsschwankungen ± 5%
alte Angaben gelten für Wasser bei 20°C

Name: Thomsen
Datum: 15.11.00

Saugseite: DN 125
Druckseite: DN 100

n = 1450 min⁻¹

0468 81 1001
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alle Angaben gelten für Wasser bei 20°C  
Name : Thomsen  
Datum : 27.04.00  
Saugseite : DN 50  
Druckseite : DN 40  
n = 2900 min⁻¹  
0413 85 1001
zulässige Leistungsschwankungen ± 5%  
alle Angaben gelten für Wasser bei 20°C  

Saugseite : DN 50  
Druckseite : DN 40  
n = 2900 min⁻¹  

Name : Thomsen  
Datum : 25.07.00  
FP 722  
0423 85 1003
zulässige Leistungsschwankungen ± 5%
alle Angaben gelten für Wasser bei 20°C

Saugseite : DN 80
Druckseite : DN 50

Name : Thomsen
Datum : 31.03.00

n = 2900 min⁻¹

FP 752
0482 85 1001
zulässige Leistungsschwankungen ± 5%  Name : Thomsen  FP 3542
alle Angaben gelten für Wasser bei 20°C  Datum : 29.08.00  0448 85 1001
Saugseite : DN 80  n = 2900 min⁻¹
Druckseite : DN 65  08.00
zulässige Leistungsschwankungen ± 5%  Name : Thomsen
alle Angaben gelten für Wasser bei 20°C    Datum : 15.11.00
Saugseite : DN 125   FP 102-200
Druckseite : DN 100  n = 2900 min⁻¹  0466 85 1001
11.00
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### Ausführung A (execution A): mit Kalotten und Verkleidung

- ss adj. feet and shroud

### Ausführung C (execution C): mit Kalotten ohne Verkleidung

- ss adj. feet without shroud

### Motor (motor)

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Dimensions φd, k and motor weights are dependent to motor execution.

MaBe unverbindlich dimensions without obligation.
Ausführung A: mit Kalotten und Verkleidung
mit Kalotten and Verkleidung

Ausführung C: mit Kalotten ohne Verkleidung
mit Kalotten without shroud

Ausführung D: ohne Kalotten mit Verkleidung
with motor foot and shroud

### Pumpen - Pumpen

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Maße ø, k und Motor-gewichte sind abhängig vom Motorfabrikat.
Dimensions ø, k and motor weights are dependent to motor execution.

Maße unverbindlich
dimensions without obligation.
Ausführung: A - mit Kalotten und Verkleidung
Execution: A - ss adj. feet with shroud

Ausführung: C - mit Kalotten ohne Verkleidung
Execution: C - ss adj. feet without shroud

Maße og, gt, k und Motor-gewichte sind abhängig vom Motorfabrikat.
Dimensions og, gt and k and motor weights are dependent on motor execution.

Maße unverbindlich
Dimensions without obligation
Ausführung: B - mit Motorfuß ohne Verkleidung

Execution: B - with motor feet without shroud

Maße φg, g1, k und Motorgewichte sind abhängig vom Motorfabrikat.

Dimensions φg, g1 and k and motor weights are dependent on motor manufacturer.

Maße unverbindlich
dimensions without obligation

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Maße und Motorgewichte sind abhängig vom Motorfabrikat.

dimensions are dependent on motor execution.

Maße unverbindlich
dimensions without obligation
Kreiselpumpe
centrifugal pump
FPE 750/3400/3300
bis
H/4,5kW
400/9/0/5/0/04

Pumpe
pump

Gewindestutzen DIN 11851
thread DIN 11851
c - DN
H - DN

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Klemmscheibe
clamping disc

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Motor
motor

P (kW)

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Dimensions g, g1, k and motor weights are dependent to motor execution.

Ausführung : B - ohne Verkleidung
Execution : B - with out shroud
Maße d, g, h, l und Motor-
gewichte sind abhängig
vom Motorfabrikat.
Ausführung: A - mit Kelotten und Verkleidung
Execution: A - ss adj. feet and shroud

Ausführung: C - ohne Verkleidung
Execution: C - without shroud

Maße Øg, g1, k und Motorgewichte sind abhängig vom Motorfabrikat.
Dimensions g, g1, k and motor weights are dependent to motor execution.

Maße unverbindlich
dimension without obligation
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Maße unverbindlich, dimension without obligation.
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**Maße unverbindlich**

*Dimension without obligation*
Maße unverbindlich dimensions without obligation

dimensions øg, gt, k, a, p and motor weights are dependent on motor execution.

Pumpe pump

Typ type

FPE 75/752 145 44 380 -- 103 80 -- 205 245 -- 50

Gewindeutzen DIN 11851 thread DIN 11851

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Verkleidg. shroud

| ød | 4000 | 636  | 379 |
| k1 | 307  | 307  | 307 |
| H1 | 140  | 500  | 500 |

Ausführung D: mit Motorfuß und Verkleidung
Execution D: with motor feet and shroud

Fristam PUMPS
English translation of the original operating instructions
Assembly Instructions

Centrifugal Pump
FP Series

Pump Type:

Pump No.:
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1 Introduction

1.1 Foreword
This operator’s manual describes all FP centrifugal pump sizes, models, and versions.
Information on the model, size, and version of your pump can be found on the rating plate on your pump and in the "Order-Related Documents" in the attached documents.

1.2 Manufacturer
FRISTAM Pumpen KG (GmbH & Co.)
Kurt-A.-Körber-Chaussee 55
21033 Hamburg
GERMANY
Tel.: +49-40 - 72556 - 0
Fax: +49-40 - 72556 - 166
E-mail: info@fristam.de

1.3 Scope of Supply
The package includes the following items:
- Pump with motor = pump unit
  optional: without motor
- Covers for pipe fittings
- Optional: assembly kit
- Fristam accessories (if applicable)
- Documentation
  ► Check the shipment for completeness and damage. Immediately notify Fristam of any missing items or damage.

1.4 Pump Without Motor (Optional)
The pump can optionally be supplied without a motor. In this case, continue reading up to and including Chapter 3, "Design and Function," page 7, and then skip to Chapter 11, "Appendix 2 – Assembly Instructions (Optional)," page 33.

1.5 Scope of Documentation
The documentation includes the following items:
- This operator’s manual
  - Appendix 1 with maintenance, lubrication, and tightening torque tables
  - Appendix 2 with assembly instructions
- Attached documents:
  - Order-Related Documents
  - Supplier Documentation (motor, coupling, etc.)
  - Documentation on Fristam accessories (if applicable)
  - Certificates (materials certificates, etc.), if applicable
  - Declaration of Conformity or Declaration of Incorporation

1.6 Display Conventions
List items are preceded by dashes:
- Part 1
- Part 2
Handling instructions that must be performed in a specified order are numbered:
1. Turn device on.
2. Turn device off.
Handling instructions that do not need to be performed in a specified order are preceded by triangular bullets:
► Action
► Action

1.6.1 Safety Instructions

⚠️ DANGER
A safety instruction with the signal word "Danger" indicates personal hazards causing death or serious injury.

⚠️ WARNING
A safety instruction with the signal word "Warning" indicates personal hazards that may lead to death or serious injury.

⚠️ CAUTION
A safety instruction with the signal word "Caution" indicates personal hazards that may lead to mild to moderate injuries.

⚠️ NOTICE
A safety instruction with the signal word "Note" warns of the possibility of material damage.
2 Safety

2.1 Basic Safety Instructions
► Please read this operator’s manual completely before using the pump and keep it available at the pump installation location.
► Heed the applicable national regulations of the owner’s country and the company’s work and safety regulations.
► All work described here may only be performed by qualified experts with caution.
► Danger of contamination: Heed legal and operational safety regulations when pumping dangerous media.

2.2 Intended Use
The standard FP centrifugal pump versions are designed for use in the food industry, the pharmaceutical and biotechnology industry, and CIP process technology.
They can be used to pump liquids with dynamic viscosities of up to 1200 mPa s and media temperatures of up to 150°C. The medium can contain a slight amount of air or gas, be homogeneous, or contain a small amount of additives.
Each pump is designed according to customer requirements. The seal materials have been selected for the respective medium. The pump may only be used to pump the medium it was designed for (see Order-Related Documents in the attached documents).

2.3 Improper Use
The standard FP centrifugal pump versions may not be used in explosive atmospheres. Special explosion-proof versions are available for this.
Pumping of media other than those specified can destroy the pump.
Standard pump units from Fristam are described in this operator’s manual. If nonstandard items or extras are installed, the operator assumes the responsibility for operation.

2.4 Warning and Instruction Labels
► Do not alter or remove the labels on the pump.
► Immediately replace damaged or lost labels with ones that are true to the originals.

2.4.1 Direction of Rotation
Fig. 1 “Impeller Direction of Rotation” label
This label shows the direction of rotation of the impeller. It is located at the front on the pump cover.

2.4.2 Hot Surface
Fig. 2 Safety label: “Hot Surface”
This label indicates that parts can become hot during operation or, if applicable, that hot media is being pumped. Only touch the pump if you are wearing suitable gloves.

2.4.3 No Dry Running
Fig. 3 Safety label: “No Dry Running”
This label indicates that the pump cannot be run dry. There must always be medium in the suction line and the pump when the pump is started. Otherwise, the pump will be damaged.

2.4.4 Rating Plate
Fig. 4 Pump unit rating plate
1 Manufacturer
2 Type: pump series, pump size, model, version
3 SN: serial number of the pump
4 H: discharge head [m]
5 P: motor output [kW]
6 Year of manufacture
7 mttl: mass (total) [kg]
8 nR: rated speed [1/min]
9 Q: flow rate [m³/h]
10 CE mark

2.5 Noise Emissions
 ► The local noise exposure regulations must be complied with. For noise emission values for the pumps, please see Chapter 10.1, “Specifications,” page 27.
2.6 Disposal

2.6.1 Disposal of Transportation Package
► Recycle the transportation package.

2.6.2 Models KF and L 1: Disposal of Grease
► Dispose of grease and objects saturated with grease in an environmentally friendly manner in accordance with applicable regulations.

2.6.3 Models L 2, L 3, and L 4: Disposal of Lubricating Oil
► Dispose of oil and objects saturated with oil in an environmentally friendly manner in accordance with applicable regulations.

2.6.4 Disposal of Pump
1. Carefully clean the pump. Dispose of residues in an environmentally friendly manner in accordance with applicable regulations.
2. Dismantle the pump into its constituent parts.
3. Dispose of the pump parts in an environmentally friendly manner in accordance with applicable regulations.

2.6.5 Disposal of Electrical and Electronic Scrap
► Dispose of electrical and electronic scrap in accordance with applicable directives.

3 Design and Function

3.1 Principles of Design

3.1.1 Pump Head (A)

Fig. 5 Principles of design of pumps illustrated using the FPE model

A Pump head
B Lantern
C Electric motor

Fig. 6 Pump head

11 Discharge line connection
12 Shaft seal
13 Impeller
14 Pump cover
15 Suction line connection
16 Pump casing

Shaft Seal (12)
Two seal types are available for use:
− Single shaft seal
− Double shaft seal

With the double shaft seal, there are two additional connections for the sealing liquid on the pump casing. These connections are not shown in the following figures.
Impeller (13)
Open impellers are standardly used in the FP pump series.

Pump Cover (14)
The connection for the suction line is located on the pump cover.

Pump Casing (16)
The connection for the discharge line is located on the pump casing. The impeller and the shaft seal are built into the pump casing.

3.1.2 Lantern (B) and Electric Motor (C)

![Fig. 7 Lantern and electric motor]

Lantern (17)
The lantern is present in all models except the special motor. The lantern connects the pump casing to the motor. Two different versions are possible, depending on pump size:

- The pump casing is screwed to the lantern via a flange connection.
- The pump casing is inserted into the lantern and mounted with a clamp.

Models with lanterns:
- FPE and FP…V
- KF
  An additional bearing for the pump shaft is located inside the lantern with base.
- L
  An additional bearing for the pump shaft is located inside the lantern with base. The pump shaft is connected to the motor via a coupling.

Electric Motor (19)
The following motor types can be mounted:

- IEC standard motor with key and shaft pin in the following models:
  - IM B3: model with base
  - IM B5: model with flange
  - IM B3/5: model with flange and base
With the IEC standard motor, a Fristam pump shaft is clamped to the motor shaft pin.
- Special motor with Fristam pump shaft
With the special motor, the Fristam pump shaft is already integrated and connected permanently to the motor.

3.2 Models
The model is indicated on the rating plate. See Chapter 2.4.4, "Rating Plate," page 6.
The following are shown as examples:

- Lantern clamp-mounted
- Without enclosure

3.2.1 Model FP

![Fig. 8 Model FP]

Motor: Special motor
Design: Without lantern

3.2.2 Model FPE or FP…V

![Fig. 9 Model FPE or FP…V]

Motor: IEC standard motor, model B3/B5
Design: With lantern

3.2.3 Model KF

![Fig. 10 Model KF]
3.2.4 Model L

Fig. 11 Model L

Motor: IEC standard motor, model B5
Design: Compact bearing support with base

3.3 Pump Key

Fig. 12 Type designation example

<table>
<thead>
<tr>
<th>21</th>
<th>Pump type</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>Supplementary character 1</td>
</tr>
<tr>
<td>23</td>
<td>Pump size</td>
</tr>
<tr>
<td>24</td>
<td>Supplementary character 2</td>
</tr>
</tbody>
</table>

(21) Pump Type

FP Special motor with extended motor shaft
FPE Attached pump shaft
FP...V Extended insert shaft as pump shaft

(22) Supplementary Character 1

S Open impeller with large clearance to casing
R Semiopen impeller with large clearance to cover
H High-pressure pump
X Impeller for high pressures
Z Casing with circulation line

(24) Supplementary Character 2

A, B, C, D Versions; see Chapter 3.4, "Versions," page 9:

KF Compact bearing support with base
L1, L2, L3 Bearing block with coupling
V Stainless steel lantern, double shaft seal, Ø75mm at lantern neck

H Pump casing with heating jacket
h Pump cover with heating jacket

3.4 Versions

<table>
<thead>
<tr>
<th>Version</th>
<th>Enclosure</th>
<th>Spherical Cap</th>
<th>Legs</th>
<th>Motor Foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>With</td>
<td>With</td>
<td>Without</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Without</td>
<td>Without</td>
<td>With</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Without</td>
<td>With</td>
<td>Without</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>With</td>
<td>Without</td>
<td>With</td>
<td></td>
</tr>
</tbody>
</table>

Table 1 Versions

Note: If the (optional) pump without motor is supplied, please first read Chapter 11, "Appendix 2 – Assembly Instructions (Optional)" on page 33.

4 Transportation

4.1 Transportation

Transportation may only be performed by trained personnel.
The pump can be moved using an industrial truck or a crane.
Always move the pump in the installation condition.

4.1.1 Safety Instructions

► Danger of injury from falling or unsecured parts.
  – Only use suitable means of conveyance and hoists. Information on pump weight can be found on the pump's rating plate as well as in the Order-Related Documents in the attached documents.
  – Before moving the pump secure it to prevent it from tipping over. Secure the pump to the pallet with tie-down straps, or screw the pump to the pallet.
  – Do not leave the pump in a raised position for longer than necessary.

► Damage to pump by contamination, impact, or moisture.
  – Remove the protective film just prior to installation.
  – Remove the pipe fitting covers just prior to connection to the pipes.

4.1.2 Moving With Industrial Trucks

Preparation

► Ensure that the pump is adequately secured to the pallet.

Procedure

1. Pick up the pallet with the forks on the industrial truck.
2. Carefully move the pallet to the designated location and set down.

Fig. 13 Moving with industrial truck

4.1.3 Moving With Crane

⚠️ WARNING ⚠️

Falling Parts

Death from crushing, pinching of extremities, material damage.

- Do not lift the pump at the eyebolts on the motor and pump casing to move because these eyebolts are not designed for the total weight.

- Only use hoists that are designed for the total weight of the pump.

- Ensure that the area below the pump is clear of people.

⚠️ WARNING ⚠️

Swinging Parts

Crushing and serious injuries.

- Start and stop the crane with pump smoothly.

- Ensure that the danger zone of the pump is clear of people.

Auxiliary Equipment

Hoists: round slings tested in accordance with DIN EN 1492-1 and 1492-2

Preparation

- Remove load-securing devices.

Procedure

1. Wrap the round sling twice around the back end of the motor. Do not lay over the fan shroud (see Fig. 14 Moving with crane).

2. Lay the other end of the round sling between the lantern and the pump casing. Do not lay the round sling over any sharp edges or corners.

3. Guide both loops to the crane hook and rotate by 180° to ensure that the belt will not slip on the hook.

4. For double shaft seal:

   Note: Round sling compresses sealing water tubes. Material damage to double shaft seal.

   - Do not lay the round sling on the sealing water tubes.

5. Position the center of gravity to ensure that the pump is lifted horizontally.

6. Lift the pump.

Fig. 14 Moving with crane

5 Storage

5.1 Safety Instructions

- Corrosion: Condensation can build up under a tarp and destroy the pump.
  - Ensure adequate ventilation.

5.2 Storage Conditions

- Store the pump as follows:
  - Dry, in low humidity
  - Protected against frost and heat, optimally at a temperature of 20°C to 25°C
  - Ventilated
  - Dust-free

5.3 Long-Term Storage

For a storage time of longer than six months, heed the following:

- The shaft seals must be specially treated before long-term storage:

  - For single shaft seal

    The impeller nut must be loosened so that the seal can relax and the elastomers do not stick together.

  - For double shaft seal

    Remove the complete shaft seal and store separately to prevent the elastomers from sticking together.

Information on the shaft seal can be found in the Order-Related Documents.
► All movable pump parts must be rotated every three months.

5.3.1 Storage of Elastomers
Storage Conditions
- Storage temperature between +5°C and +20°C
- Relative air humidity below 70%
- No direct sunlight
- Deformation-free storage

5.4 Recommissioning
► After long-term storage and before commissioning, check seals, bearings, and lubrication.

6 Installation

6.1 Safety Instructions
► Danger of injury from falling parts.
  - Wear safety shoes.
  - Check load capacity and attachment of hoists.
► Danger of injury from unstable assembly.
  - Tighten screws to the specified tightening torque (see Chapter 10.1.1, "Tightening Torques for Screws and Nuts," page 27).
  - Use a torque wrench or an impact driver with adjustable torque.
► Material damage from swinging during adjustment of spherical cap feet.
  - Use spherical cap base plates.

6.2 Installation Location
For standard pumps, the installation location must meet the following requirements:
- Nonexplosive atmosphere
- Dust-free environment
- Ambient temperature: −20°C to +40°C
- Moisture and salt contents in ambient air:
  The values are given in the motor supplier documentation. It can be found in the attached documents.
- Foundation sized adequately for the pump weight
- Horizontal and level installation surface, adequate installation surface strength for pump mass
- Adequate clearance for maintenance work
- Adequate air supply for motor cooling

6.3 Reduction of Noise and Vibration

6.3.1 Primary Measures
► Operate the pump in the optimum working range.
  - Do not starve the pump. Avoid throttling too much. Only operate with a low flow rate if necessary for regulation purposes.
  - Do not operate with very high flow rates. Optionally install a flow controller in the discharge line.
  - Operate the pump without cavitation (see Chapter 6.4.1, "Installation of Pipes," page 12).
► Decouple the suction and discharge lines from vibrations.
  - Support lines.
  - Align lines.
  - Install vibration isolators.

6.3.2 Secondary Measures
► Take structural measures such as the following:
  - Acoustic paneling
  - Enclosure in housing

6.4 Pump Fixation
Models FP/FPE/FP...V
► Versions A and C:
  Set up the pump on the spherical cap bearings and align.
► Versions B and D:
  Screw the pump on the motor foot to the foundation.

Model KF
► Versions A and C:
  Set up the pump on the spherical cap bearings and align.
► Versions B and D:
  Screw the pump on the compact bearing support with base to the foundation.

Model L
► Versions A and C:
  Set up the pump on the spherical cap bearings and align.
► Versions B and D:
  Screw the pump on the base frame to the foundation.

Carriage (Optional)
1. Set up the pump at the installation location. Lock the locks on the rollers (if present) or secure the carriage with chocks.
2. Ground the carriage to dissipate electrostatic charge.
3. Position hose line to ensure that it cannot be damaged.
6.4.1 Installation of Pipes

► Lay and connect pipes as follows:

- Keep the pipe resistance as low as possible: Avoid unnecessary installation of valves, elbows, and abrupt pipe transitions.

- Design pipe cross section so that no unnecessary pressure losses or cavitation occurs in the suction area and so that the condition $\text{NPSH}_a > \text{NPSH}_r$ is fulfilled. Verify this in the project planning stage.

- Always lay the suction lines so that they are continuously rising: Rule out the possibility of air pockets and dips in pipes.

6.5 Electrical Connection

Electrical connection may only be performed by a qualified electrician.

1. Heed the connection values on the motor’s rating plate. The specified voltage must not be exceeded.

2. Connect the motor according to the circuit diagram in the terminal box of the motor.

3. Protect cable feedthroughs against penetration by moisture.

4. Turn on the motor for 2 to 3 seconds. Compare the direction of rotation of the motor fan wheel against the direction indicated by the arrow on the pump head.

5. Reverse the polarity if necessary.

6.6 Connection of Sealing or Quenching Liquid (Optional)

For versions with double shaft seals, the gap must be flushed with sealing or quenching liquid.

► Use a suitable medium, e.g., water, as a sealing or quenching liquid.

► Install and seal the supplied flushing tubes.

► Install the sight glass in the drain line.

6.7 Cleaning

Only use cleaning agents that comply with the hygiene guidelines for the respective pumping medium.

1. Before sealing the pump ensure that there are no foreign objects inside the pump or pipes.

2. Seal the pump.

3. Connect the pipes.

4. Thoroughly clean the pump and the pipe system before initial use.
7 Operation

7.1 Safety Instructions

► Danger of burning: Pumping of hot media can cause the pump to become very hot. Check the temperature before touching the pump.

► Noise emissions: The A-weighted sound pressure level of the pumps can be greater than 80 dBA. Always wear ear protectors in the vicinity of the running pump.

► Danger of bursting: If the allowable pressure and temperature ranges are exceeded, the pump may burst or become leaky. The pressure and temperature ranges for the pump must be complied with; see Order-Related Documents in the attached documents.

► Danger of bursting: Cold extinguishing agents used to extinguish a pump fire can cause the hot pump to burst. Do not cool the pump down excessively when extinguishing the fire.

► Pump running in reverse direction despite emergency shut-off: If the pump is shut off using the emergency shut-off function, it will run in reverse direction due to the pumping medium in the discharge line. Install a check valve in the discharge line.

► Destruction of shaft seal when pump runs in reverse direction. Reverse running destroys the springs in the shaft seal. Always operate the pump in the direction of rotation. See Chapter 2.4.1, "Direction of Rotation," page 6.

7.2 Commencement of Operation

NOTICE

Damage to Shaft Seals

If the pump runs without a pumping medium, the mechanical seal will be damaged.

► Ensure that the pumping medium always reaches the upper edge of the outlet side before and during operation.

NOTICE

Damage to Double Shaft Seals

If the pump runs without a sealing medium, the shaft seal will be damaged.

Ensure that during operation:

– The sealing liquid flows with the necessary pressure through the double shaft seal.
– The temperature of the sealing liquid T is maintained at < 70°C.

1. Open the valve in the suction line.
2. Close the valve in the discharge line.

3. Fill the pump and the suction line up to the upper edge of the pump with pumping medium. Allow air pockets that are present to escape.

4. Turn on the motor. The pump now pumps against the closed valve in the discharge line. This will limit the starting current.

5. Slowly open the valve in the discharge line and adjust to the working point.

7.3 Monitoring of Operation

During operation heed the following points:

► Damage to shaft seal: Regulation of the pump output via the suction-side valve can lead to damage of the pump and the shaft seals. Regulate the pump output only by means of the discharge-side valve.

► Damage to pumping medium: If during operation the valve in the discharge line is closed abruptly or for a long period of time, water hammers can occur in the pump and lead to damage to the pump and/or the pumping medium. During operation do not close the valve in the discharge line abruptly or for a long period of time.

► Damage to pump: Exceeding of the output can lead to damage of the pump and the shaft seals. Do not exceed the maximum speed of 3,600 rpm.

► Damage to motor during operation with frequency converter: If the speed is too low, the motor will overheat. Please refer to the motor supplier documentation in the attached documents.

7.4 Stopping of Operation

1. Turn off the motor.

2. Close the valve in the suction line to prevent dry running of the pump.

3. Close the valve in the discharge line.

7.5 Pump Decommissioning

1. Turn off the motor.

2. Close the valve in the suction line.

3. Close the valve in the discharge line.

4. De-energize the pump.

5. Empty the pump.

6. Clean the pump.

7. Dry the pump.

8. Protect the interior of the pump from moisture, e.g., with silica gel.

9. Seal the pipe connections with caps to prevent penetration of dirt and foreign objects.

10. Please see Chapter 5, "Storage," page 10 for additional steps.
7.6 Cleaning in Place

7.6.1 CIP Process
The FP series pumps are suitable for the CIP (Cleaning In Place) process. The following guidelines apply to the CIP process:

Example of a Cleaning Cycle
1. Perform preliminary flush with water.
2. Perform caustic flush with lye (NaOH; see Table 2 CIP cleaning).
3. Perform intermediate flush with water.
4. Perform acid flush with nitric acid (HNO₃; see Table 2 CIP cleaning).
5. Flush with water.

The pump’s differential pressure should be 2–3 bar so that adequate flow rates are reached.

If values deviate from these specifications, please contact Fristam.

7.6.2 SIP Process
The FP series pumps can only be used with the SIP (Sterilization In Place) process with the prior approval of Fristam.
Suitability depends on the selected elastomers.
The maximum process temperature is 145°C.

8 Faults

For information on faults, possible causes, and remedies, please see Chapter 10.4, "Troubleshooting Table," page 28.

8.1 Safety Instructions

- Danger of burning: Pumping of hot media can cause the pump to become very hot. Check the temperature before touching the pump.
- Pump running in reverse direction despite emergency shut-off: If the pump is shut off using the emergency shut-off function, it can continue to run in reverse direction due to the pumping medium in the discharge line. Install a check valve.

9 Maintenance

For information on maintenance intervals, please see Chapter 10.2, "Maintenance Intervals," page 27.

9.1 Safety Instructions

- Rotating parts: Danger of injury. Before removing the coupling guard and guard plate, turn off the pump motor and prevent it from being able to be turned on accidentally.
- Danger of burning: Pumping of hot media can cause the pump to become very hot. Check the temperature before touching the pump.
- Electric shock: Liquids flowing through the system result in buildup of electrostatic charge. Ground the pipes and the pump.
- Uncontrolled outflow of liquids: Before maintenance or adjustment of the pump:
  - Close the suction and discharge valves in front of and behind the pump.
  - Block off the sealing or quenching liquid line.
- Leaking liquids: Acid burns and contamination. Before opening the pump completely empty the pump casing.
- Tension cracks: Do not rapidly cool the pump. Material damage from scratching of polished surfaces. For a polished surface, use a copper socket wrench socket.

9.2 Replacement Parts

Use of replacement parts that are not approved by Fristam Pumpen KG (GMBH & Co.) can lead to serious personal injury and material damage. If you have any questions regarding approved replacement parts, please contact Fristam.

Fristam registers all shipped pumps. For ordering replacement parts from Fristam, you require the following information:
Serial number: see
- rating plate or
- number stamped into pump casing.

9.3 Inspection of Sealing and Quenching Liquid (Optional)

For pumps equipped for "sealing liquid" or "quenching liquid," the sealing liquid head must be checked daily.

- Check the sealing liquid head and compare with the specified value.
  The specified value can be found in the Order-Related Documents on the "Sectional Drawing" of the shaft seal. The Order-Related Documents are attached to this operator's manual.
- The sealing liquid is heated by hot pumping medium and by operation of the pump.
Ensure that the temperature \( T \) of the sealing liquid is \(< 70^\circ\text{C} \) during operation.

### 9.4 Lubrication of Motor Bearings

► Lubricate the motor bearings in accordance with the motor manufacturer’s specifications (see "Motor Supplier Documentation").

### 9.5 Lubrication of Shaft Bearing

#### 9.5.1 Models FP, FPE, and FP...V

The models FP, FPE, and FP...V do not have additional shaft bearings, and hence no shaft bearing lubrication is necessary.

#### 9.5.2 Models L 2, L 3, and L 4

For the models L 2, L 3, and L 4, the oil must be changed at regular intervals.

1. Turn on the motor and let it run until the normal operating temperature is reached.
2. Turn off the motor and prevent it from being able to be turned on accidentally.
3. Place a suitable oil collection container under the oil drain plug.
4. **Caution!** Danger of burning from hot oil.
   - Wear suitable protective gloves.
   - Loosen and remove the oil drain plug.
5. Drain the oil completely and dispose of oil in accordance with local regulations.
6. Clean and remount the oil drain plug and seal.
7. Fill with new oil (see Chapter 10.3, "Lubricant Table," page 28). For the required amount, please see Table 3 Oil volumes.

#### 9.5.3 Model L1

► Do not relubricate the deep groove ball bearing, but replace it completely.

   - At constant operating conditions, the raising of power consumption, noise level or vibration indicates that wear has occurred. Replace the deep groove ball bearing consequently.

<table>
<thead>
<tr>
<th>Model</th>
<th>Bearing Grease Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>10 g</td>
</tr>
</tbody>
</table>

Table 4 Bearing grease amount: model L1

### Prerequisites

- Pump head has been removed.
- Motor with coupling has been removed.

### Procedure

1. Take the cover (25) off of the bearing block (26).
2. Remove the bearing cap (27) on the pump side.
3. Remove the bearing cap (28) on the motor side.
4. Force out the shaft in the direction of the pump head.
   
   **Note:** All parts that are gray in the above two figures remain on the shaft.
5. Clean the surfaces of all parts and check for damage. Replace if necessary.
6. Relubricate the angular contact ball bearing. See Table 4 Bearing grease amount: model L1.

7. Press the pump shaft with the bearing into the bearing block.

8. Mount the bearing cap on the motor side.

9. Mount the bearing cap on the pump side.

10. Mount the cover (25).

9.5.4 Model KF

► Do not relubricate the deep groove ball bearing, but replace it completely.

– At constant operating conditions, the raising of power consumption, noise level or vibration indicates that wear has occurred. Replace the deep groove ball bearing consequently.

► Grease the cylindrical roller bearing with bearing grease.

<table>
<thead>
<tr>
<th>Model</th>
<th>Bearing Grease Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>KF 1</td>
<td>20 g</td>
</tr>
<tr>
<td>KF 2</td>
<td>40 g</td>
</tr>
<tr>
<td>KF 3</td>
<td>60 g</td>
</tr>
</tbody>
</table>

Table 5 Bearing grease amounts: model KF

Prerequisites

– Pump head has been removed.
– Motor has been removed.

Procedure

1. Remove the bearing cap (31).

2. Force out the pump shaft (29) with the bearing toward the motor side.

3. Remove the bearing nut (32) and the guard plate (33).

4. Remove the outer race of the cylindrical roller bearing.

   Note: All parts that are gray in the above figure remain on the shaft.

5. Clean the surfaces of all parts and check for damage. Replace if necessary.

6. Relubricate the cylindrical roller bearing (29). See Table 5 Bearing grease amounts: model KF.

7. Put the outer race back onto the shaft.

8. Place the guard plate and the bearing nut on the shaft, and tighten the bearing nut.

9. Press the pump shaft with the bearing back into the lantern.

10. Mount the bearing cap (31).

9.6 Motor Replacement

Special Motor

1. Turn off the motor and prevent it from being able to be turned on accidentally.

2. Remove the pump head (see Chapter 9.8, "Pump Head Removal," page 17).

3. Replace the special motor.

4. Replace the mechanical seal if necessary, and mount the pump head (see Chapter 9.10, "Pump Head Attachment," page 19).

IEC Standard Motor for FPE and FP...V

1. Turn off the motor and prevent it from being able to be turned on accidentally.

2. Remove the pump head (see Chapter 9.8, "Pump Head Removal," page 17).

3. Take the lantern off of the motor.

4. Remove the shaft.

5. Replace the motor.


7. Mount the lantern.

8. Only for flange connection: Check the clearance if necessary (see Chapter 9.9, "Checking of the Clearances," page 18).

9. Replace the mechanical seal, and mount the pump head (see Chapter 9.10, "Pump Head Attachment," page 19).

IEC Standard Motor for Model KF

1. Turn off the motor and prevent it from being able to be turned on accidentally.

2. Take the motor off of the compact bearing support with base.


4. Insert the key of the old motor into the new motor.

5. Screw the motor to the compact bearing support with base.

IEC Standard Motor for Model L

1. Turn off the motor and prevent it from being able to be turned on accidentally.

2. Remove the coupling guard.
3. Detach the motor from the base frame or the foundation.
4. Take the coupling parts off of the motor.
6. Mount the coupling parts onto the replacement motor (proceed as described in Chapter 9.12, "Model L: Coupling Replacement," page 25 to replace the coupling).
7. Place the replacement motor on the base frame or the foundation.
8. Check the parallel and angular misalignment of the shafts.

![Fig. 23 Parallel misalignment](image)

![Fig. 24 Angular misalignment](image)

9. Minimize deviations from the angular and parallel misalignment. Realign the shafts if necessary.
10. Screw the motor to the base frame or the foundation.
11. Mount the coupling guard.

### 9.7 Shaft Seal Replacement

The shaft seal must be replaced if:
- Pumping medium or sealing or quenching liquid flows out of the pump on the atmosphere side.
- Sealing liquid leaks into the pumping medium.

**Procedure**

1. Remove the pump head (see Chapter 9.8, "Pump Head Removal," page 17).
2. Replace the mechanical seal, and mount the pump head (see Chapter 9.10, "Pump Head Attachment," page 19). Perform the following tasks according to the given shaft seal:
   - Preassemble the seals on the shaft.
   - Preassemble the pump casing.
   - Mount the pump casing on the lantern.
   - Mount the mechanical seal.
   - Mount the impeller.
   - Screw on the pump cover.

### 9.8 Pump Head Removal

#### 9.8.1 Preparation

1. Turn off the motor and prevent it from being able to be turned on accidentally.
2. Close the valve in the discharge line.
3. Close the valve in the suction line.
4. Completely empty the pump.

#### 9.8.2 Procedure

1. Loosen the nuts (34) on the pump cover.
2. Remove the nuts, the washers, the pump cover (35), and the cover seal (36).

![Fig. 25 Pump cover](image)

3. **WARNING:** Risk of injury when stopping the impeller by hand. Block the impeller (40) with a wooden wedge. Loosen the impeller nut (37), and remove with the O-ring (38).
4. Take the snap ring (39), the impeller (40), and the key (41) off of the shaft.
5. Only for pumps with double shaft seals: Remove the flushing tubes for sealing or quenching liquid.
TIP: For large pump casings, there is an M 12 thread on the top of the casing. An eyebolt can be screwed into the thread for suspension of the pump head from a crane.

6. Pull the pump head with the pump-side shaft seal off of the shaft as follows:

6a. Clamp connection variant
   1. Loosen the clamp bolt.
   2. Slightly spread the clamp connection with a wedge.
   3. Pull the pump casing out of the clamp connection.

6b. Flange connection variant
   1. Loosen the fastening screws on the flange and remove.
   2. Remove the pump casing.

7. Take the shaft seal out of the pump casing.

9.9 Checking of the Clearances

The position of the impeller is determined by the position on the shaft.

The clearances are set through the position of the pump casing with respect to that of the impeller.

Prerequisites
- Pump casing is connected firmly to the lantern.
- Pump cover has been removed.
- The impeller has been mounted and the impeller nut tightened.

9.9.1 Measurement of the Impeller–Pump Cover Clearance

1. Measure the height $H$ of the pump cover (42) using vernier calipers.

2. Measure the clearance $A$ between the pump casing (43) and the impeller (44) using vernier calipers.

Fig. 27 Height

Fig. 28 Clearance

3. Calculate the clearance ($\text{clearance} = A - H$).

4. Compare the clearance with Table 6 Clearances.

9.9.2 Measurement of the Impeller–Casing Clearance

1. Measure the clearance between the impeller and the casing using a leaf feeler gauge (Fig. Impeller–casing clearance).

2. Compare the clearance with Table 6 Clearances.

Fig. 29 Impeller–casing clearance

<table>
<thead>
<tr>
<th>Pump Size</th>
<th>Impeller–Pump Cover</th>
<th>Impeller–Casing</th>
</tr>
</thead>
<tbody>
<tr>
<td>711/712</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>721/722</td>
<td>0.5</td>
<td>0.7</td>
</tr>
<tr>
<td>741/742</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>751/752</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>3401/3402</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>3521/3522</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>3531/3532</td>
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<td>1.5</td>
</tr>
<tr>
<td>3541/3542</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>3451/3452</td>
<td>1.0</td>
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</tr>
<tr>
<td>1151/1152</td>
<td>2.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Table 6 Clearances
9.10 Pump Head Attachment

The pump assembly is dependent on the respective pump size and model as well as the respective shaft seal (see Order-Related Documents in the attached documents).

**Incorrect Elastomers**

Pump leakiness.

► Ensure that the elastomers are appropriate for the condition of the pumping medium. Please refer to the Order-Related Documents.

**Preparation**

► Clean all pump parts and check for damage and accuracy of fit.
► If necessary, rework or replace pump parts.
► Assemble in clean conditions, carefully, and using little force. The seals could be permanently deformed or break in part.
► Replace all O-rings.
► To reduce friction, wet the O-rings and the sliding faces with water, alcohol, or silicone grease.
► Clean the sealing surfaces of the mechanical seals with a degreaser, e.g., OKS 2610 Universal Cleaner. Do not allow the sealing surfaces to come into contact with oil or grease and do not touch with your fingers afterwards.

**Tip:** The joint retaining compound “Euro Lock A64.80,” e.g., is suitable for gluing in bearings and bushings.

**Tip:** The screw retaining compound “Euro Lock A24.10,” e.g., is suitable for gluing in set screws.

9.10.1 Clearance Setting for Flange Connection

**Note:** For pumps with flange connections, the clearance is set using shims. To determine the exact number and thicknesses of shims needed, first mount the impeller nut, the impeller, and the key as follows and then remove again.

1. Slide the pump casing (45) and the shims (46) over the shaft to the flange (47) and screw on.

2. Slide the seal driver onto the shaft.
3. Slide the key and the impeller onto the shaft.
4. Tighten the impeller nut.
5. Check the clearances (see Chapter 9.9, “Checking of the Clearances,” page 18).
6. Remove the impeller nut, the impeller, and the key.
7. Remove the pump casing.
8. If the clearance is incorrect:
   ► Adjust the clearance using the appropriate shims.

9.10.2 Mounting of Seals

The shaft seal built into the respective pump is given in the attached documents in the form of a Sectional Drawing and a Replacement Parts List.

The assembly of standard shaft seals is described in the following sections with the application cases A to F. The version for your order can deviate from this.

If anything is unclear or if you require further information, please contact Fristam.

<table>
<thead>
<tr>
<th>Application Case</th>
<th>Pump</th>
<th>Shaft Seal</th>
<th>Pump Sizes</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>FP/FPE</td>
<td>Single</td>
<td>340/350/700/1150/1230</td>
</tr>
<tr>
<td>B</td>
<td>FP/FPE</td>
<td>Single</td>
<td>1250</td>
</tr>
<tr>
<td>C</td>
<td>FPE</td>
<td>With quench</td>
<td>340/350/700, with clamp connection: ø 60 mm</td>
</tr>
<tr>
<td>D</td>
<td>FPE</td>
<td>With quench</td>
<td>340/350/740, with clamp connection: ø 100 mm 1150/1230/750, with flange connection</td>
</tr>
<tr>
<td>E</td>
<td>FP/FP...V</td>
<td>Double</td>
<td>340/350/700/1150/1230</td>
</tr>
<tr>
<td>F</td>
<td>FP/FPE</td>
<td>Double</td>
<td>1250</td>
</tr>
</tbody>
</table>

Table 7 Standard shaft seals
Application Case A

In the above figure, parts are grouped according to assembly steps:

I  Preassembly of the pump casing
II Completion of assembly on the shaft

To preassemble the pump casing (I):

1. Glue the cylindrical pin (562.60) into the mechanical seal chamber (47-2.60) with a retaining compound.
   
   Note: Glue in the cylindrical pin so that it will later not touch the shaft but still completely engage in the slot on the stationary seal ring (475.60).

2. Place O-rings (412.60) and (412.61) into the mechanical seal chamber.

3. Guide the preassembled mechanical seal chamber into the pump casing (101).

4. Place the thrust collar (474.63) on the pump casing and secure with snap ring (93-1.60).
   
   Preassembly of the pump casing is now finished.

5. Equip the stationary seal ring (475.60) with an O-ring (412.65).

6. Guide the stationary seal ring into the mechanical seal chamber.
   
   Note: Guide in so that the cylindrical pins on the mechanical seal chamber engage in the slots on the stationary seal ring.
   
   Preassembly of the mechanical seal chamber is now finished.

7. Mount the preassembled pump casing (101) on the shaft as described in Chapter 9.10.3, "Mounting of the Pump Casing," page 24.

To complete assembly on the shaft (II):

8. Equip the rotating seal ring (472.60) with an O-ring (412.63).

9. Equip the seal driver (485.60) with O-rings (412.62) and (412.64).

10. Slide the rotating seal ring with the thrust collar (474.60), the spring (478.60), and the seal driver onto the shaft. Let the folded end of the spring snap into the rotating seal ring.

11. Finish the assembly of the shaft seal by attaching the impeller; see Chapter 9.10.4, "Mounting of the Impeller," page 24.
Application Case B

To preassemble the pump casing:

1. Glue the cylindrical pin (562.60) into the mechanical seal chamber (47-1.60) with a retaining compound.
2. Insert the O-ring (412.60) into the mechanical seal chamber.
3. Use socket screws (914.60) to fasten the mechanical seal chamber to the pump casing (101).
4. Equip the stationary seal ring (475.50) with an O-ring (412.52) and guide into the mounted mechanical seal chamber on the pump side.

Note: The cylindrical pins on the mechanical seal chamber must engage in the slots on the stationary seal ring.

To complete assembly on the shaft:

5. Slide the rotating seal ring (472.50) with the O-rings (412.51), (412.62), and (412.10), the thrust collar (474.50), the spring (477.50), and the seal driver (54-3.60) onto the shaft. Let the folded end of the spring snap into the rotating seal ring.
6. Finish the assembly of the shaft seal by attaching the impeller; see Chapter 9.10.4, "Mounting of the Impeller," page 24.

Application Case C

In the above figure, parts are grouped according to assembly steps:

I Preassembly on the shaft
II Preassembly of the pump casing
III Completion of assembly on the shaft

To preassemble on the shaft (I):

1. **Caution!** Cutting injuries from sharp-edged shaft protective sleeves. Wear suitable protective gloves.
   - Slide the shaft protective sleeve (524.60) onto the shaft using an assembly tool (auxiliary pipe). Position on the shaft: See Sectional Drawing.

   Preassembly of the shaft is now finished.

To preassemble the pump casing (II):

2. Insert an O-ring (412.69) into the groove on the pump casing (101).
3. Insert the rotary shaft seal (421.60) into the seal cover (471.60).

   Note: Heed the installation direction for the rotary shaft seal. See Sectional Drawing.
4. Slide the seal cover onto the pump casing on the motor side. Align the drill holes for the sealing liquid connections vertically.
5. Apply a screw retaining compound to the set screws (904.60) and fasten the seal cover.

   Preassembly of the pump casing is now finished.

To complete assembly on the shaft (III):

6. Apply a retaining compound to the cylindrical pin (562.60), and glue cylindrical pin into the spacer bushing (543.60).
Note: Glue in the cylindrical pin so that it will later not touch the shaft but still completely engage in the slot on the stationary seal ring (475.60).

7. Use a retaining compound to glue the spacer bushing into the seal chamber of the pump casing (101).


9. Equip the stationary seal ring (475.60) with an O-ring (412.65).

10. Slide the stationary seal ring onto the shaft so that the cylindrical pin on the spacer bushing engages in the slot on the stationary seal ring.

11. Equip the rotating seal ring (472.60) with an O-ring (412.63).

12. Equip the rotating seal ring with the thrust collar (474.60) and the spring (478.60) and slide onto the shaft. Let the folded end of the spring snap into the slot on the rotating seal ring.

13. Equip the seal driver (543.60) with O-rings (412.64) and (412.62) and slide onto the shaft.

14. Finish the assembly of the shaft seal by attaching the impeller; see Chapter 9.10.4, "Mounting of the Impeller," page 24.

Application Case D

To preassemble the pump casing (II):

2. Glue the cylindrical pin (562.60) into the mechanical seal chamber (47-2.60) with a retaining compound.

Note: Glue in the cylindrical pin so that it will later not touch the shaft but still completely engage in the slot on the stationary seal ring (475.60).

3. Install O-rings (412.60) and (412.61) from the outside and a rotary shaft seal (421.60) from the inside of the mechanical seal chamber.

Note: Heed the installation direction for the rotary shaft seal. See Sectional Drawing.

4. Equip the stationary seal ring (475.60) with an O-ring (412.65).

5. Guide the stationary seal ring into the mechanical seal chamber and install together in the pump casing (101).

Note: The cylindrical pins on the mechanical seal chamber must engage in the slots on the stationary seal ring.

6. Place the thrust collar (474.63) on the assembly in the pump casing and secure with snap ring (93-1.60).

Preassembly of the pump casing is now finished.

7. Mount the preassembled pump casing (101) on the shaft as described in Chapter 9.10.3, "Mounting of the Pump Casing," page 24.
To complete assembly on the shaft (III):

8. Equip the rotating seal ring (472.60) with an O-ring (412.63).

9. Equip the seal driver (485.60) with O-rings (412.62) and (412.64).

10. Slide the rotating seal ring with the thrust collar (474.60), the spring (478.60), and the seal driver onto the shaft.
   Note: Let the folded end of the spring snap into the slot on the rotating seal ring.

11. Finish the assembly of the shaft seal by attaching the impeller; see Chapter 9.10.4, "Mounting of the Impeller," page 24.

Application Case E

In the above figure, parts are grouped according to assembly steps:

I Assembly of the shaft seal on the shaft on the motor side
II Assembly of the shaft seal on the shaft on the pump side

To assemble the shaft seal on the motor side (I):

1. Only for FP...V: Secure the set collar (50-3.60) to the shaft using set screws (904.61).
   Apply a screw retaining compound to the set screws. Position on the shaft: See Sectional Drawing.

2. Slide the washer (550.62) onto the shaft.

3. Equip the rotating seal ring (472.61) with an O-ring (412.66).

4. Slide the spring (479.60) with the thrust collar (474.61) and the rotating seal ring (472.61) onto the shaft. Let the folded end of the spring snap into the slot on the rotating seal ring.


6. Insert the O-ring (412.67) into the stationary seal ring (475.61) and insert into the mechanical seal chamber (47-2.60).
   Assembly of the shaft seal on the motor side is now finished.

To assemble the shaft seal on the pump side (II):

7. To assemble the shaft seal on the pump side, proceed as described in Chapter, "Application Case A," page 20.

Application Case F

To assemble the motor-side shaft seal (IV) on the shaft:
9.10.3 Mounting of the Pump Casing

Pump With Flange Connection

1. Slide the preassembled pump casing (48) with the shims (49) over the shaft to the flange (50) and screw on (see Chapter 10.1, “Specifications,” page 27).

2. Only for double shaft seal: Slide the motor-side seal set onto the pump shaft.

3. Install the entire shaft seal housing with seals into the pump casing and secure to prevent slippage.

4. Slide the pump casing over the pump shaft into the clamp connection and slightly tighten the clamp bolt.

5. Slide the pump-side seal set onto the shaft.

6. Insert the key, the slotted plastic ring, and the impeller.

7. Insert the O-ring into the impeller nut, block the impeller to prevent it from twisting, and tighten the impeller nut.

<table>
<thead>
<tr>
<th>Thread</th>
<th>Tightening Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>M16</td>
<td>100 Nm</td>
</tr>
<tr>
<td>M24</td>
<td>200 Nm</td>
</tr>
</tbody>
</table>

Table 8 Tightening torques for impeller nuts

8. Adjust the clearances by sliding the pump head inside the clamp connection (see Chapter 9.9, “Checking of the Clearances,” page 18). Align the surface of the outlet side (discharge line connection) horizontally while doing so.

9. Tighten the clamp bolt:

<table>
<thead>
<tr>
<th>Thread</th>
<th>Tightening Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>Special motor M10</td>
<td>36 Nm</td>
</tr>
<tr>
<td>Standard motor M10</td>
<td>45 Nm</td>
</tr>
<tr>
<td>M12</td>
<td>75 Nm</td>
</tr>
</tbody>
</table>

Table 9 Tightening torques for clamp connection


9.10.4 Mounting of the Impeller

1. Force open the plastic snap ring (53) and insert into the shaft groove.

2. Slide the key (55) and the impeller (54) onto the shaft.

3. Caution: Risk of injury when stopping the impeller by hand.

   Block the impeller with a wooden wedge.

4. Screw the impeller nut (51) with the O-ring (52) onto the shaft and tighten (tightening torque = 100 Nm).
9.10.5 Pump Sealing

Slide the pump cover (58) with the O-ring (59) onto the pump casing and screw on with washers (57) and nuts (56).

9.11 Models FPE and FP...V: Mounting and Alignment of the Pump Shaft

Note: After the IEC motor has been replaced the pump shaft must be mounted and aligned.

**CAUTION**

**Rotating Parts**

Brusing and serious injuries.

- Turn off the motor and prevent it from being able to be turned on accidentally.

1. Take the key out of the motor shaft pin.
2. For electric motors with outputs higher than 30 kW: Insert the supplied half-key.
3. Degrease the motor shaft pin and the drill hole on the pump shaft using a cleaner, e.g., OKS 2610 Universal Cleaner.
4. Grind the motor shaft pin and the edges of the key slot with grinding paper to eliminate unevenness and burrs.
5. Apply a sealing gel, e.g., Stucarit 309, to the motor shaft pin in the region of the shaft shoulder.
6. Slide the pump shaft with the shrink ring onto the motor shaft pin up to the shaft shoulder.
7. Tighten the screws crosswise on the shrink ring:

<table>
<thead>
<tr>
<th>Thread</th>
<th>Tightening Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>M5</td>
<td>6 Nm</td>
</tr>
<tr>
<td>M6</td>
<td>12 Nm</td>
</tr>
<tr>
<td>M8</td>
<td>30 Nm</td>
</tr>
</tbody>
</table>

8. Place a dial gauge onto the pump shaft to check the runout tolerance.

9. Check the runout of the pump shaft as a function of motor output.
   - Motor < 30 kW: max. runout tolerance = 0.06 mm
   - Motor > 30 kW: max. runout tolerance = 0.08 mm
10. Straighten the pump shaft if necessary.

9.12 Model L: Coupling Replacement

Only use couplings approved by Fristam. The coupling must be appropriate for the characteristic curve of the pump. If you have any questions, please contact Fristam.

**Procedure**

1. Turn off the motor and prevent it from being able to be turned on accidentally.
2. Remove the coupling guard.
3. Remove the coupling tire.
4. Detach the motor from the base frame or the foundation and remove.
5. Dispose of the old coupling parts in an environmentally friendly manner.
6. Place new coupling parts (tires, flanges, possibly clamping rings) on the drive shaft and on the gear shaft.
7. Place the motor on the base frame or the foundation and slightly tighten the fastening screws.
8. Check the parallel and angular misalignment of the shafts.

Fig. 48 Parallel misalignment

Fig. 49 Angular misalignment
9. Minimize deviations from the angular and parallel misalignment. Realign the shafts if necessary.

10. Screw the motor to the base frame or the foundation.

11. For information on the spacing between the two coupling flanges, please see the coupling installation manual. See "Supplier Documentation" in the attached documents.

12. Fasten the coupling flanges with the given spacing onto the shaft.

13. Fasten the coupling tire. Tighten the screws uniformly and crosswise. Heed the given tightening torques in the coupling installation manual.

14. Mount the coupling guard.
10 Appendix 1

10.1 Specifications

10.1.1 Tightening Torques for Screws and Nuts

Material: Steel, Strength Class: 8.8

<table>
<thead>
<tr>
<th>Thread</th>
<th>M6</th>
<th>M8</th>
<th>M10</th>
<th>M12</th>
<th>M16</th>
<th>M20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Torque [Nm]</td>
<td>11</td>
<td>27</td>
<td>54</td>
<td>93</td>
<td>230</td>
<td>464</td>
</tr>
</tbody>
</table>

Material: Stainless Steel, Strength Class: 70

<table>
<thead>
<tr>
<th>Thread</th>
<th>M6</th>
<th>M8</th>
<th>M10</th>
<th>M12</th>
<th>M16</th>
<th>M20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Torque [Nm]</td>
<td>7.4</td>
<td>17.5</td>
<td>36</td>
<td>62</td>
<td>150</td>
<td>303</td>
</tr>
</tbody>
</table>

Material: Stainless Steel, Strength Class: 80

<table>
<thead>
<tr>
<th>Thread</th>
<th>M6</th>
<th>M8</th>
<th>M10</th>
<th>M12</th>
<th>M16</th>
<th>M20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Torque [Nm]</td>
<td>10</td>
<td>24</td>
<td>49</td>
<td>80</td>
<td>203</td>
<td>393</td>
</tr>
</tbody>
</table>

10.1.2 Noise Emissions

<table>
<thead>
<tr>
<th>Pump Size</th>
<th>Noise Level [dBA]</th>
</tr>
</thead>
<tbody>
<tr>
<td>711/712</td>
<td>75</td>
</tr>
<tr>
<td>721/722</td>
<td>71</td>
</tr>
<tr>
<td>741/742</td>
<td>79</td>
</tr>
<tr>
<td>751/752</td>
<td>78</td>
</tr>
<tr>
<td>3401/3402</td>
<td>71</td>
</tr>
<tr>
<td>3521/3522</td>
<td>74</td>
</tr>
<tr>
<td>3531/3532</td>
<td>79</td>
</tr>
<tr>
<td>3541/3542</td>
<td>78</td>
</tr>
<tr>
<td>3551/3552</td>
<td>81</td>
</tr>
<tr>
<td>1151/1152</td>
<td>89</td>
</tr>
<tr>
<td>1231/1232</td>
<td>79</td>
</tr>
<tr>
<td>1251/1252</td>
<td>92</td>
</tr>
<tr>
<td>101/102-200</td>
<td>80</td>
</tr>
<tr>
<td>101/102-250</td>
<td>82</td>
</tr>
</tbody>
</table>

Table 10 Noise emissions

The specified values apply to operation of the pump at the best efficiency point (see "Pump Characteristic Curve"). The noise level can differ greatly at other working points.

10.2 Maintenance Intervals

<table>
<thead>
<tr>
<th>Model</th>
<th>Interval</th>
<th>Maintenance Task</th>
<th>Chapter</th>
</tr>
</thead>
<tbody>
<tr>
<td>All with &quot;Sealing and Quenching Liquid&quot; option</td>
<td>Once a day</td>
<td>Check the sealing or quenching liquid.</td>
<td>See Chapter 9.3, &quot;Inspection of Sealing and Quenching Liquid (Optional),&quot; page 14.</td>
</tr>
<tr>
<td>L 2, L 3, L 4</td>
<td>Once a day</td>
<td>Check the oil level.</td>
<td>See Chapter 9.5, &quot;Lubrication of Shaft Bearing,&quot; page 15.</td>
</tr>
<tr>
<td>KF 2, KF 3</td>
<td>5,000 h</td>
<td>Lubricate the shaft bearing.</td>
<td>See Chapter 9.5.4, &quot;Model KF,&quot; page 16.</td>
</tr>
<tr>
<td>KF 1</td>
<td>6,000 h</td>
<td>Lubricate the shaft bearing.</td>
<td>See Chapter 9.5.3, &quot;Model K1,&quot; page 15.</td>
</tr>
<tr>
<td>L 2</td>
<td>8,000 h</td>
<td>Change the oil.</td>
<td>See Chapter 9.5.2, &quot;Models L 2, L 3, and L 4,&quot; page 15.</td>
</tr>
<tr>
<td>L 3</td>
<td>8,000 h</td>
<td>Change the oil.</td>
<td>See Chapter 9.5.2, &quot;Models L 2, L 3, and L 4,&quot; page 15.</td>
</tr>
<tr>
<td>L 4</td>
<td>8,000 h</td>
<td>Change the oil.</td>
<td>See Chapter 9.5.2, &quot;Models L 2, L 3, and L 4,&quot; page 15.</td>
</tr>
<tr>
<td>L1</td>
<td>19,000 h</td>
<td>Lubricate the shaft bearing.</td>
<td>See Chapter 9.5, &quot;Lubrication of Shaft Bearing,&quot; page 15.</td>
</tr>
<tr>
<td>All</td>
<td>When necessary</td>
<td>Replace the shaft seal.</td>
<td>See Chapter 9.7, &quot;Shaft Seal Replacement,&quot; page 17.</td>
</tr>
<tr>
<td>All</td>
<td>When necessary</td>
<td>Replace the motor.</td>
<td>See Chapter 9.6, &quot;Motor Replacement,&quot; page 16.</td>
</tr>
</tbody>
</table>

Table 11 Maintenance intervals

For information on motor maintenance intervals, please see the motor operator’s manual.
10.3 Lubricant Table

<table>
<thead>
<tr>
<th>Model</th>
<th>ARAL</th>
<th>BP</th>
<th>DEA/Texaco</th>
<th>ELF</th>
<th>ESSO</th>
<th>Mobil</th>
<th>Shell</th>
</tr>
</thead>
<tbody>
<tr>
<td>KF bearing support</td>
<td>Aralub HTR2</td>
<td>Energrease HTG</td>
<td>Paragon EP 2</td>
<td>GRX 500</td>
<td>HT Grease 275</td>
<td>Mobiltemp SHC 100</td>
<td>Darina Grease 2</td>
</tr>
<tr>
<td>Cylindrical roller bearing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L 1 Bearing block</td>
<td>Aralub HTR2</td>
<td>Energrease HTG</td>
<td>Paragon EP 2</td>
<td>GRX 500</td>
<td>HT Grease 275</td>
<td>Mobiltemp SHC 100</td>
<td>Darina Grease 2</td>
</tr>
<tr>
<td>L 2 Bearing block</td>
<td>Vitam DE 46</td>
<td>Energol HLP-D</td>
<td>Actis HLDP 46</td>
<td>Elfolna HLDP</td>
<td>HLDP-Oel 46</td>
<td>HLDP 46</td>
<td>Hydrol DO 46</td>
</tr>
<tr>
<td>L 3, L 4 Bearing block</td>
<td>Turboral 30W</td>
<td>Energol HD-S30</td>
<td>Cronos Super SAE 30</td>
<td>ELF Performance XR 30</td>
<td>Essolube HDX plus 30</td>
<td>Delvac 1300</td>
<td>Rotella MX</td>
</tr>
</tbody>
</table>

Table 12 Lubricant table

Other brand-name lubricants with equivalent qualities and viscosities may also be used.

10.4 Troubleshooting Table

<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump either does not pump or pumps irregularly.</td>
<td>Suction line blocked/clogged.</td>
<td>Open/clean suction line.</td>
</tr>
<tr>
<td></td>
<td>Suction filter contaminated.</td>
<td>Clean suction filter.</td>
</tr>
<tr>
<td></td>
<td>Discharge-side shut-off valve closed.</td>
<td>Open discharge line.</td>
</tr>
<tr>
<td></td>
<td>Pump not completely filled with liquid.</td>
<td>Install pipe system so that casing is still filled with liquid when pump is off.</td>
</tr>
<tr>
<td></td>
<td>Pump with geodesic suction head liquid level falls at standstill.</td>
<td>Install foot valve in suction line.</td>
</tr>
<tr>
<td></td>
<td>Suction line leaky (drawing in air).</td>
<td>Seal suction line.</td>
</tr>
<tr>
<td></td>
<td>Foot valve blocked or contaminated.</td>
<td>Reestablish proper function of foot valve; clean.</td>
</tr>
<tr>
<td></td>
<td>Suction head too high.</td>
<td>Lower pump; reduce suction head.</td>
</tr>
<tr>
<td></td>
<td>Air pocket in suction line.</td>
<td>Lay suction line at steady incline.</td>
</tr>
<tr>
<td></td>
<td>Excessive air or gas in pumping medium.</td>
<td>Install vent valve.</td>
</tr>
<tr>
<td></td>
<td>Air ingress at shaft seal.</td>
<td>Check shaft seal installation. Replace elastomers.</td>
</tr>
<tr>
<td></td>
<td>Cavitation at impeller inlet; resistance in suction line too high; suction head too high. NPSHa values not adapted to pump.</td>
<td>Optimize suction line; increase inlet height; lower media temperature; contact Fristam.</td>
</tr>
</tbody>
</table>

Flow rate too high.

|                                                                        | Discharge-side valve opened too wide.                                       | Throttle valve.                            |
|                                                                        | Discharge line diameter too large.                                          | Reduce nominal pipe size; insert orifice plate. |
|                                                                        | Impeller diameter too large.                                                | Trim impeller outside diameter. Reduce speed with frequency converter. Contact Fristam. |

Table 13 Troubleshooting table
<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow rate too low; discharge head too low.</td>
<td>Selected pump too small.</td>
<td>Contact Fristam.</td>
</tr>
<tr>
<td></td>
<td>Selected impeller diameter too small.</td>
<td>Contact Fristam. Replace impeller.</td>
</tr>
<tr>
<td></td>
<td>Direction of rotation of motor incorrect.</td>
<td>Exchange connections on motor terminal box.</td>
</tr>
<tr>
<td></td>
<td>Speed too low (voltage incorrect).</td>
<td>Correct connection according to motor rating plate.</td>
</tr>
<tr>
<td></td>
<td>Nominal pipe sizes too small.</td>
<td>Use larger pipe diameters.</td>
</tr>
<tr>
<td></td>
<td>Pipe resistances in suction and/or discharge line too high.</td>
<td>Optimize pipe system; reduce elbows and valves. Contact Fristam.</td>
</tr>
<tr>
<td></td>
<td>Pipe clogged or full of deposits.</td>
<td>Clean pipes.</td>
</tr>
<tr>
<td></td>
<td>Foreign objects/deposits in impeller.</td>
<td>Remove impeller and clean.</td>
</tr>
<tr>
<td></td>
<td>Impeller incorrectly adjusted.</td>
<td>Check impeller clearance and readjust.</td>
</tr>
<tr>
<td></td>
<td>Density of pumping medium too high.</td>
<td>Contact Fristam.</td>
</tr>
<tr>
<td></td>
<td>Viscosity of pumping medium too high.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Metal noise.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Foreign objects in pump interior.</td>
<td>Disassemble, inspect, and repair.</td>
</tr>
<tr>
<td></td>
<td>Impeller catching.</td>
<td>Readjust impeller clearance; tighten impeller nut using torque wrench.</td>
</tr>
<tr>
<td></td>
<td>Pump/shaft seal running dry.</td>
<td>Immediately supply pumping medium; open suction valve.</td>
</tr>
<tr>
<td></td>
<td>Flow noise.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Operation contrary to design in overload or part-load range.</td>
<td>Adjust working point to design.</td>
</tr>
<tr>
<td></td>
<td>Flow losses in suction line too high.</td>
<td>Increase nominal sizes; shorten line; prevent outgassing.</td>
</tr>
<tr>
<td></td>
<td>Cavitation.</td>
<td>Check condition for NPSH rating; contact Fristam.</td>
</tr>
<tr>
<td></td>
<td>Vibrations.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Suction and discharge lines stressing pump impermissibly.</td>
<td>Support pipes so that pump is not stressed; possibly install vibration dampers; keep water hammers away from pump.</td>
</tr>
<tr>
<td></td>
<td>Excessive heating of shaft bearing.</td>
<td>Bearing damage.</td>
</tr>
<tr>
<td></td>
<td>Motor power consumption too high.</td>
<td>Flow rate too high.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Impeller diameter too large.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Viscosity and/or density of pumping medium too high.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Massive damage to shaft bearing; shaft deformed.</td>
</tr>
</tbody>
</table>

Table 13 Troubleshooting table
### Problem | Possible Cause | Remedy
--- | --- | ---
Leakage at shaft seal. | Impeller nut loose. | Remove impeller; inspect shaft shoulder. Check shaft seal; tighten impeller nut to required torque; possibly replace part.
| Shaft seal or rotary shaft seal mechanical damage/wear. | | Replace shaft seal and elastomers; possibly switch materials. Contact Fristam.
| Shaft seal running dry; suction head too high; pumping media temperature too high. | | Increase pump inlet pressure; decrease suction head; use double shaft seal; contact Fristam.
| Sealing water head too high. | | Adjust using throttle valve.
| Sealing water head too low. | | Replace rotary shaft seal.
| Water tubes clogged (resulting in damage to rotary shaft seal); sealing water not clean. | | Clean water tubes; adjust water inlet and outlet; use drinking water-quality water with temperature of max. 70°C.
| Temperature of pumping medium too high. | | Contact Fristam; convert to double shaft seal.

Table 13 Troubleshooting table

1. The "geodesic suction head" is the vertical distance between the suction-side liquid level and the center of the impeller.
10.5 Number Key

The number key is for the attached Sectional Drawing. When ordering replacement parts, please specify the Part Number and the Name.

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Name</th>
<th>Part Number</th>
<th>Name</th>
<th>Part Number</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>Pump casing</td>
<td>479</td>
<td>Left spring</td>
<td>801</td>
<td>Flange motor</td>
</tr>
<tr>
<td>108</td>
<td>Stage casing</td>
<td>481</td>
<td>Bellows</td>
<td>87-1</td>
<td>Gearbox</td>
</tr>
<tr>
<td>160</td>
<td>Cover</td>
<td>482</td>
<td>Bellows support</td>
<td>87-2</td>
<td>Gear cover</td>
</tr>
<tr>
<td>13-1</td>
<td>Back casing panel</td>
<td>484</td>
<td>Spring retainer</td>
<td>87-3</td>
<td>Gear cap</td>
</tr>
<tr>
<td>13-2</td>
<td>Housing insert</td>
<td>485</td>
<td>Seal driver</td>
<td>87-4</td>
<td>Gear base</td>
</tr>
<tr>
<td>130</td>
<td>Casing part</td>
<td>500</td>
<td>Ring</td>
<td>839</td>
<td>Contact</td>
</tr>
<tr>
<td>132</td>
<td>Spacer</td>
<td>50-1</td>
<td>Split lock washer</td>
<td>872</td>
<td>Gearwheel</td>
</tr>
<tr>
<td>154</td>
<td>Intermediate wall</td>
<td>50-2</td>
<td>V-ring</td>
<td>89-1</td>
<td>Filler piece</td>
</tr>
<tr>
<td>156</td>
<td>Outlet side</td>
<td>50-3-60</td>
<td>Set collar</td>
<td>89-2</td>
<td>Spherical cap frame</td>
</tr>
<tr>
<td>18-1</td>
<td>Spherical cap bearing</td>
<td>504</td>
<td>Spacer ring</td>
<td>89-3</td>
<td>Motor Foot</td>
</tr>
<tr>
<td>18-2</td>
<td>Vibration damper</td>
<td>520</td>
<td>Sleeve</td>
<td>89-4</td>
<td>Handle</td>
</tr>
<tr>
<td>182</td>
<td>Base</td>
<td>523</td>
<td>Shaft sleeve</td>
<td>89-5</td>
<td>Protective cap</td>
</tr>
<tr>
<td>21-1</td>
<td>Synchronizing shaft</td>
<td>524</td>
<td>Shaft protective sleeve</td>
<td>89-6</td>
<td>Wheel</td>
</tr>
<tr>
<td>213</td>
<td>Drive shaft</td>
<td>525</td>
<td>Spacer sleeve</td>
<td>89-8</td>
<td>Flat bar steel</td>
</tr>
<tr>
<td>23-1</td>
<td>Rotor</td>
<td>54-1</td>
<td>Cover housing</td>
<td>89-9</td>
<td>Motor bracket</td>
</tr>
<tr>
<td>26-1</td>
<td>Bracket for mechanical seal chamber</td>
<td>54-2</td>
<td>Bushing</td>
<td>89-10</td>
<td>Motor bracket</td>
</tr>
<tr>
<td>230</td>
<td>Impeller</td>
<td>54-3</td>
<td>Stationary bushing</td>
<td>89-11</td>
<td>Spherical cap base support</td>
</tr>
<tr>
<td>32-1</td>
<td>Angular contact ball bearing</td>
<td>540</td>
<td>Bushing</td>
<td>892</td>
<td>Base plate</td>
</tr>
<tr>
<td>32-2</td>
<td>Cylindrical roller bearing</td>
<td>543</td>
<td>Spacer bushing</td>
<td>894</td>
<td>Console</td>
</tr>
<tr>
<td>32-3</td>
<td>Deep groove ball bearing</td>
<td>55-1</td>
<td>Serrated lock washer</td>
<td>897</td>
<td>Guide piece</td>
</tr>
<tr>
<td>32-4</td>
<td>Tapered roller bearing</td>
<td>550</td>
<td>Washer</td>
<td>90-1</td>
<td>Stud bolt</td>
</tr>
<tr>
<td>321</td>
<td>Radial ball bearing</td>
<td>551</td>
<td>Spacer washer</td>
<td>90-3</td>
<td>Tapered pin</td>
</tr>
<tr>
<td>322</td>
<td>Radial roller bearing</td>
<td>554</td>
<td>Washer</td>
<td>90-4</td>
<td>Half-length taper grooved pin</td>
</tr>
<tr>
<td>325</td>
<td>Needle bearing</td>
<td>561</td>
<td>Grooved pin</td>
<td>90-5</td>
<td>Eyebolt</td>
</tr>
<tr>
<td>330</td>
<td>Bearing support</td>
<td>56-1</td>
<td>Roll pin</td>
<td>900</td>
<td>Screw</td>
</tr>
<tr>
<td>331</td>
<td>Bearing block</td>
<td>56-2</td>
<td>Grooved pin with round head</td>
<td>901</td>
<td>Hex cap screw</td>
</tr>
<tr>
<td>341</td>
<td>Drive lantern</td>
<td>560</td>
<td>Pin</td>
<td>902</td>
<td>Threaded stud</td>
</tr>
<tr>
<td>344</td>
<td>Bearing support lantern</td>
<td>562</td>
<td>Cylindrical pin</td>
<td>903</td>
<td>Screw plug</td>
</tr>
<tr>
<td>350</td>
<td>Bearing housing</td>
<td>59-2</td>
<td>Dished-type lock washer</td>
<td>904</td>
<td>Set screw</td>
</tr>
<tr>
<td>360</td>
<td>Bearing cap</td>
<td>59-3</td>
<td>Shrink ring</td>
<td>909</td>
<td>Adjusting screw</td>
</tr>
<tr>
<td>40-4</td>
<td>Half-length taper grooved pin</td>
<td>59-4</td>
<td>Lantern</td>
<td>91-1</td>
<td>Slotted cheese head screw</td>
</tr>
<tr>
<td>400</td>
<td>Flat seal</td>
<td>59-5</td>
<td>Membrane</td>
<td>913</td>
<td>Bleed screw</td>
</tr>
<tr>
<td>410</td>
<td>Profile seal</td>
<td>642</td>
<td>Oil level sight glass</td>
<td>914</td>
<td>Socket screw</td>
</tr>
<tr>
<td>411</td>
<td>Gasket</td>
<td>680</td>
<td>Enclosure</td>
<td>92-1</td>
<td>Star knob nut, long</td>
</tr>
<tr>
<td>412</td>
<td>O-ring</td>
<td>68-1</td>
<td>Support plate</td>
<td>92-2</td>
<td>Star knob nut, short</td>
</tr>
<tr>
<td>421</td>
<td>Rotary shaft seal</td>
<td>68-2</td>
<td>Foam strip</td>
<td>92-3</td>
<td>Cap nut</td>
</tr>
<tr>
<td>422</td>
<td>Felt ring</td>
<td>68-3</td>
<td>Bracket for enclosure</td>
<td>92-4</td>
<td>Rotor nut</td>
</tr>
<tr>
<td>433</td>
<td>Mechanical seal</td>
<td>68-4</td>
<td>Orifice plate</td>
<td>92-5</td>
<td>Forcing screw</td>
</tr>
<tr>
<td>45-1</td>
<td>Thrust ring</td>
<td>68-5</td>
<td>CF guard plate</td>
<td>92-6</td>
<td>Rotor fastener</td>
</tr>
<tr>
<td>451</td>
<td>Stuffing box housing</td>
<td>681</td>
<td>Coupling guard</td>
<td>92-7</td>
<td>Nut with flange</td>
</tr>
<tr>
<td>454</td>
<td>Stuffing box ring</td>
<td>701</td>
<td>Bypass line</td>
<td>920</td>
<td>Hex nut</td>
</tr>
<tr>
<td>47-1</td>
<td>Spring with washer</td>
<td>710</td>
<td>Pipe</td>
<td>921</td>
<td>Shaft nut</td>
</tr>
<tr>
<td>47-2</td>
<td>Mechanical seal chamber</td>
<td>711</td>
<td>Connection pipe</td>
<td>922</td>
<td>Impeller nut</td>
</tr>
<tr>
<td>47-3</td>
<td>Wedge seal</td>
<td>715</td>
<td>Hose pipe</td>
<td>923</td>
<td>Bearing nut</td>
</tr>
<tr>
<td>47-5</td>
<td>Ring nut</td>
<td>722</td>
<td>Flange adapter</td>
<td>93-1</td>
<td>Snap ring</td>
</tr>
<tr>
<td>471</td>
<td>Seal cover</td>
<td>723</td>
<td>Flange</td>
<td>930</td>
<td>Retainer</td>
</tr>
<tr>
<td>472</td>
<td>Rotating seal ring</td>
<td>724</td>
<td>blind flange</td>
<td>931</td>
<td>Retaining washer</td>
</tr>
<tr>
<td>474</td>
<td>Thrust collar</td>
<td>733</td>
<td>pipe clamp</td>
<td>932</td>
<td>Snap ring</td>
</tr>
<tr>
<td>475</td>
<td>Stationary seal ring</td>
<td>751</td>
<td>Valve housing</td>
<td>940</td>
<td>Key</td>
</tr>
<tr>
<td>476</td>
<td>Stationary seal ring support</td>
<td>755</td>
<td>Valve bolt</td>
<td>941</td>
<td>Woodruff key</td>
</tr>
<tr>
<td>477</td>
<td>Mechanical seal spring</td>
<td>756</td>
<td>Valve spring</td>
<td>950</td>
<td>spring</td>
</tr>
<tr>
<td>478</td>
<td>Right spring</td>
<td>759</td>
<td>Valve plate</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
10.6 EC Declaration of Conformity

The manufacturer: Fristam Pumpen KG (GmbH & Co.)
Kurt-A.-Körber-Chaussee 55
21033 Hamburg
GERMANY

hereby declares that the following product:

- Centrifugal pumps types: FP, FPE, FP...V, FPH, FPEH, FPH...V, FSPE, FSP...V, FM, FZ, FC, CF, CFE
- Positive Displacement pumps types: FK, FKL, FL, FL2, FL3
- Powder mixer typ: PM
- Serial number: see title page of the operating instructions

conforms to the requirements of the Machinery Directive (2006/42/EC).

The following harmonized standards have been applied:

- DIN EN 12100-1 Safety of machinery
  Basic concepts, general principles for design, Part 1: Basic terminology, methodology
- DIN EN 12100-2 Safety of machinery
  Basic concepts, general principles for design, Part 2: Technical principles

Authorized documentation representative: Horst Helms
Phone.: +49(040) 72556-107
Address: see address of the manufacturer

Hamburg, 27. January 2011

Horst Helms / Head of Quality Management
11 Appendix 2 – Assembly Instructions (Optional)

11.1 Safety Instructions
These assembly instructions are addressed solely to specialized employees.

11.2 Scope
These assembly instructions apply to pumps supplied without motors (optional) and preassembled.

Fig. 50 Incomplete machine: pump without motor, coupling, or base frame illustrated using models KF and L

The following specifications in the "Original Operator’s Manual" for complete machines do not apply in this case:
- Chapter 10.6, “EC Declaration of Conformity,” page 32,
- Chapter 10.1.2, “Noise Emissions,” page 27
- Chapter 2.4.4, “Rating Plate,” page 6.

11.3 Rating Plate

![Rating plate for pump without drive](image)

The following specifications in the "Original Operator’s Manual" for complete machines do not apply in this case:
- Chapter 10.6, “EC Declaration of Conformity,” page 32,
- Chapter 10.1.2, “Noise Emissions,” page 27
- Chapter 2.4.4, “Rating Plate,” page 6.

11.4 Moving Without Motor
Transportation may only be performed by trained personnel. The pump can be moved using an industrial truck or a crane. Always move the pump in the installation condition.

11.4.1 Safety Instructions
Falling or Unsecured Parts
Severe crush injuries.
- Always wear gloves when performing transportation-related work.
Incorrect Positioning of Pump for Transportation
Leakage of caustic, toxic, or contaminating liquids. Personal injury and material damage from contamination.
- Always move the pump in the installation condition.
Open, Unsealed Pipe Fittings
Material damage from contamination, impact, or moisture in the pump.
- Remove the pipe fitting covers just prior to connection to the pipes.

11.4.2 Moving With Industrial Trucks

⚠️ WARNING ⚠️

Unsecured Parts
Serious injuries from crushing, pinching of extremities, material damage.
- Before moving the pump secure it to prevent it from tipping over. Secure the pump to the pallet with tie-down straps, or screw the pump to the pallet.

Preparation
Ensure that the pump is adequately secured to the pallet, for example, with straps; see Fig. 52, “Moving with pallet truck,” page 33.

Procedure
1. Pick up the pallet with the forks on the industrial truck.
2. Carefully move the pallet to the designated location and set down.

![Moving with pallet truck](image)
11.4.3 Moving With Crane

**WARNING**

Falling Parts
Death from crushing, pinching of extremities, material damage.
- Only use suitable means of conveyance and hoists that are designed for the total weight of the pump.

Information on the pump weight can be found on the pump’s rating plate as well as in the Order-Related Documents in the attached documents.
- Do not leave the pump in a raised position for longer than necessary.
- Ensure that the area below the pump is clear of people.

**WARNING**

Swinging Parts
Crushing and serious injuries.
- Start and stop the crane with pump smoothly.
- Ensure that the danger zone of the pump is clear of people.

Auxiliary Equipment
- Hoists: round slings tested in accordance with DIN EN 1492-1 and 1492-2
- Eyebolt and suitable eyebolt lifting devices

Preparation
- Remove load-securing devices.

To move the KF pump with the round sling:

Procedure
1. Wrap the round sling twice around the lantern neck (see Fig. 53, "Moving with crane," page 34).
2. Guide the other end of the round sling to the crane hook and hook on.
3. Position the center of gravity to ensure that the pump is lifted horizontally.
4. Lift the pump.

To move the L pump with the round sling:

Procedure
1. Wrap the round sling twice around the back end of the bearing block (see Fig. 53, "Moving with crane," page 34).
2. Lay the other end of the round sling around the suction port on the pump cover. Do not lay the round sling over any sharp edges or corners.
3. Guide both loops to the crane hook and rotate by 180° to ensure that the belt will not slip on the hook.
4. Position the center of gravity to ensure that the pump is lifted horizontally.
5. Lift the pump.

11.5 Installation Location
Please see the operator’s manual Chapter 6.2, “Installation Location,” page 11 for the basic installation location requirements.

11.6 Pump Installation

11.6.1 Model KF

Prerequisites (Customer-Side)
- Suitable motor

**NOTICE**

Incorrectly Designed Motor
Destruction of pump.
- Only use motors that have been adapted to the pump characteristic curves. If you have any questions, please contact Fristam.

Procedure
1. Insert the key into the slot on the motor.
2. Slide the motor shaft into the compact bearing support.
3. Screw the motor to the compact bearing support. Tighten screws crosswise.

11.6.2 Model L

Prerequisites (Customer-Side)
- Suitable gear motor
- Adequately sized coupling
- Common installation surface for gear motor and pump so that pump shaft can be aligned with gear motor shaft
Incorrectly Designed Motor and Coupling

Destruction of pump and coupling.

- Only use motors and couplings that have been adapted to the pump characteristic curves. If you have any questions, please contact Fristam.

Note: Please see the coupling supplier documentation for reference dimensions for the coupling.

Procedure

1. Mount the coupling parts on the pump shaft and the gear shaft.
2. Place the pump on the base frame or the foundation so that the pump shaft can be connected to the gear shaft with the coupling.
3. Screw the threaded fastener slightly into the pump base.
4. Check the parallel and angular misalignment of the pump and gear shafts.
5. Minimize deviations from the angular and shaft misalignment. If necessary, realign or add shims.
6. Screw the pump and gear to the base frame or the foundation.
7. Fasten the coupling according to the coupling manufacturer’s specifications.
8. Install a noncontact, barrier-providing protective device (coupling guard) in accordance with Section 1.4, entitled “Required Characteristics of Guards and Protective Devices,” of the Machinery Directive 2006/42/EC.
9. The pump is now installed. Do not commission the pump unless the requirements of the EC Machinery Directive are met for the complete machine.

Note: Continue with Chapter 4, “Transportation,” page 9.
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<td>8. Blank-off Unit</td>
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TO THE OWNER

This Instruction Manual is your guide when dealing with your GL&V/Celleco equipment.

GL&V/Celleco recommends you study it carefully, and ensure its availability to those who install, maintain and operate the equipment on a daily basis. This document will be of no value to you if it is locked away when your personnel need it!

Furthermore it is important that you:

- keep this instruction manual and other documentation for the life of the equipment,
- incorporate any amendments in the text, and
- pass the documentation on to any subsequent holder or user of the equipment.

GL&V/Celleco will not be responsible for any breakdown of the equipment caused by the owner’s failure to follow the instructions in this document.

This Instruction Manual describes the authorized way to use the equipment. GL&V/Celleco will take no responsibility for injury or damage if the equipment is used in any other way.

NOTICE ON SAFETY PRECAUTIONS

Before attempting to unpack, install and operate this unit, please read through the relevant parts of the manual. Pay particular attention to all dangers, warnings, cautions and notes. Failure to do so could result in serious injury to personnel or damage to the equipment.

Use of Danger, Warning, Caution and Notes:

Danger, Warning, Caution and Notes used in this manual have the following significance:

Danger
Failure to observe this information could result in immediate danger to life.

Warning
Failure to observe this information can result in major personal injury or loss of life.

Caution
Failure to observe this information can result in minor injury or damage to equipment.

Note
Information that requires special emphasis.
1 Order Specification

Customer:

Order No:

Product:

Application:

Main Spec.:

Dimension Drawing:

Foundation Drawing:

Flow Sheet:

Motor Voltage:

Other Notes:
The Cleanpac 350 is a 5” diameter hydrocyclone. The cleaners have o-rings that seal the feed and the accept. The reject outlet is equipped with a sight glass that enables observation of the reject flow. The lower cone is equipped with a service valve that enables unplugging while the cleaners are operating.

The bank units come in horizontal and vertical assemblies, which may have one, two or four rows of cleaners. For safety reasons there are retainer clamps, which ensure that the cleaner cannot be blown out of the unit in case of over pressure due to a faulty startup.

The capacity of the CLP 350 cleaner is dependent on the pressure drop between the feed and accept headers:

<table>
<thead>
<tr>
<th>Pressure Drop (Fp - Ap)</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard Inlet Head</td>
</tr>
<tr>
<td>100 kPa (14 psi)</td>
<td>365 l/min (96 USGPM)</td>
</tr>
<tr>
<td>120 kPa (17 psi)</td>
<td>400 l/min (106 USGPM)</td>
</tr>
<tr>
<td>150 kPa (21 psi)</td>
<td>450 l/min (118 USGPM)</td>
</tr>
</tbody>
</table>

Max. accept pressure allowed for a standard performance CLP 350 Bank is 150 kPa. Max. accept pressure allowed for a reinforced performance of CLP 350 Bank is 300 kPa.

Min. and recommended accept pressure for CLP 350 Bank, that is not connected to a RCC unit, is 35 kPa.
2 Principle of Operation

CLEANPAC 350 BANK CLEANER

ACCEPT OUTLET

O-ring

Inlet head

Upper mantle

Detection hole

Nut

Lower mantle

Detection hole

Plug

Plug

Sight glass

Rubber hose

Hose clamps

REJECT OUTLET

O-rings

FEED INLET

O-ring

Upper cone

Seal ring

Lower cone
Plant erection should be done in accordance with instructions stated on the certified drawings. Note that a control valve is to be installed on each header serving several banks apart from possible bank isolation valves.

Do not use pipe connections for lifting purposes. When lifting a horizontal bank, use the holes on the framework. When lifting a vertical bank, ropes should be tied to the interconnecting plates.

If the plant is placed more than 5 meters above the white water level, a vacuum breaker valve should be installed.
3 Installation

All cleaner units should be equipped with pressure transmitters on the feed, accept and reject headers. The cleaner units are supplied with 1" diameter pipe couplings to accept Paper Machine Component (PMC) pneumatic pressure transmitters. If another type or brand of transmitter is used, they should be installed adjacent to the existing PMC couplings. Pressure transmitters should be connected to a gauge panel that is close to each cleaner stage to aid in adjusting the correct operating pressures.

The location of the pressure transmitters are specified on the certified drawings provided by GL&V/Celleco. No attempt should be made to locate these transmitters elsewhere and correct for elevation as this only leads to confusion and instrument error.

All instruments should be of the transmitter-receiver (1:1 repeater) type to isolate the gauges from the vibration common in most piping installations.

Each PMC transmitter should have a clean, dry regulated air supply set at 35 kPa above the calibrated range of the transmitter. For example, a 0-100 kPa transmitter should have a 140 kPa air supply. GL&V/Celleco strongly recommend against the use of improperly sized PMC transmitters due to their consistent inaccurate readings. For example, a 0-700 kPa transmitter should not be used with a 140 kPa air supply to cover a 0-100 kPa gauge.

The use of a locally mounted diaphragm stock gauges is not recommended by GL&V/Celleco. Aside from the vibration problem, most of these are found to be temperature sensitive, which in turn leads to inaccurate pressure readings on this type of gauge.

If the final stage is equipped with a RCC unit, or if the final stage does not require a control valve, then a reject pressure transmitter is not required on the reject line of that stage.
3 Installation

Tools

The following tools are provided for mounting a bank cleaner:

Tool No. 1 is used for securing the inlet head to ease removal of the upper cone.
Part No. 6088 5662-01

Tool No. 2 is used for loosening of the upper shell and the lower nut. The lower nut should only be hand tightened.
Part No. 6088 3650-01/6088 3557-01

A standard flat head screwdriver is used for the hose clamps.

Mounting Procedure

1. Put both O-rings on the feed and accept connections of the cleaner head and lubricate with silicone.

Caution

Note that only silicone lubricants should be used. Other lubricants may contain petroleum distillates, which will cause deterioration of the O-rings and seals.
2. Mount the rubber hoses to the reject pipe connections on the reject header.

3. Lubricate the feed and accept pipe connections on the headers and insert the accept end of the cleaner into the accept connection on the accept header.

   Make sure that the o-ring does not roll over.

4. Press the inlet part of the cleaner into the feed connection of the feed header.

5. Insert the sight glass into the rubber hose mounted on the reject header.
6. Press the cleaner into final position making sure that the lug heel fits into the notch in the support plate. For types 2 and 4 the outer cleaners should fit into the corresponding slots on the inner cleaner.

7. Install the retainer clamp and tighten the wing nut.

Note that the retainer clamp is asymmetrical.

8. Tighten the clamps on the rubber reject hoses.
4 Replacing the Lower Cone

1. Loosen the lower nut. Use Tool No. 2 if needed.
2. Loosen the hose clamp on the sight glass.
3. Lift out the lower part of the cleaner.
4. Unscrew the sight glass of the lower shell and remove the inner cone from the outer blue shell.
5. Replace worn out parts.

6. **Cleanout Plug Design**
   Before mounting the cleanout plug, insert the new inner lower cone into the outer blue shell making sure that the sight glass o-ring is in place.

   Fix the inner cone in the blue shell by inserting the sightglass into the reject opening. The sight glass should be hand tightened only! Install the seal on the upper part of the cone and mount the cleanout plug.
Continued from page 12.

7. **Ball Valve Design**
   Place the end cap into the blue shell. Drop down the ball so that the shaft is coming out of the hole. Insert the new inner lower cone making sure that the sight glass o-ring is in place. Fix the inner cone in the blue shell by inserting the sight glass into the reject opening according to picture C. The sight glass is to be hand tightened only! Mount the handle and the washer. Lock the nut. Install the seal on the upper part of the cone.

8. Mount the complete lower cone by inserting the sight glass into the rubber reject hose. Align the lower cone with the upper cone being sure that the seal does not roll over. Hand tighten the lower cone nut to the upper cone.

9. Tighten the hose clamps on the reject hose.
5 Replacing the Upper Cone or Inlet Head

1. Remove the cleaner from the bank by loosening the finger nut and remove the retainer clamp securing the cleaner to the unit. Loosen the hose clamp on the sight glass. Remove the cleaner from the bank structure.

2. Mount Tool No. 1 in a vice or weld to a work table. Remove the head from the upper cone using Tool No. 2.

3. Loosen the lower nut by hand (or with Tool No. 2).

4. Inspect the cleaner head and make sure it is clean.

5. Reassemble with the new head or upper head. Make sure that the o-ring is in place.
6 Maintenance

The cleaner installation is to be inspected regularly every shift.

Check the cleaner for plugging by observing the flow through the sight glass. If plugged, see instructions in Section 7.

The operating pressures of the cleaner system should not be adjusted on a shift-to-shift or day-to-day basis. The primary stage provides the efficiency and capacity needed to satisfy the stock flow and cleanliness to the head box. The second, third and successive stages recover the fiber rejected from the primary stage and minimize sewer losses.

Once the pressures have been set by a GL&V/Celleco representative, the pressure control valves should be left alone. The system should be tested (feed, accepts and rejects) for consistency and operating pressures should be recorded at least once a week.

There are detection vents in the outer blue shell of the upper and the lower cones. When the upper or the lower cone wears out, water will leak through the outer blue shell and through the detection vents.

A red plug with a sealing o-ring is provided to be inserted into the detection vent to prevent stock spills and to "flag" the cleaner for maintenance during the next shutdown.

Be observant of possible leakage at the o-ring connections.

At service, inspect the o-rings with regard to aging, attacks of chemicals and deformation (stiffness). Change when necessary.
7 Trouble-shooting

The most common problems encountered are:

A. a plugged cleaner,
B. premature upper cone wear,
C. premature lower cone wear,
D. low reject rate causing premature cone wear.

Plugged Cleaner

Shutting the bank down to unplug a cleaner is not necessary. It is very probable that the personnel unplugging the cleaner will get wet with water and stock. Take care to protect the personnel with proper protective gear. This is especially important since stock can reach temperatures that causes burns. Employ proper safety precautions since chemicals in the stock are harmful. To unplug the lower cone, perform the following:

1. Prepare a clean out lance by connecting a 1/4" O.D. tube to a 400 kPa water source. The tube should be about 45 cm long and should contain a valve for control.

2. Unscrew the plastic plug on the bottom of the plugged cleaner. Removing the plastic plug may cause the cleaner to clear itself and splash stock on personnel. Wear rain suits and other protective gear. If the cleaner does clear itself, allow the rejects to flow out of the cleaner for a few seconds. Replace the plug and see that rejects move through the sight glass normally.

3. If the cleaner is still plugged, insert the clean-out lance into the opening at the bottom of the cleaner. Turn on the water and lance out the material that plugs the cleaner. Gently work the lance into the cleaner about 3 cm at a time turning the water on and off to loosen the plug. Watch the flow through the reject sight glass. When the flow resumes, remove the lance and replace the plastic plug.

If the cleaner plugs again shortly after unplugging it, there may be some debris in the cleaner that is larger than the reject opening or the bottom plug opening. This large piece of debris cannot get out without removing the lower cone. Mark this cleaner and remove the lower cone and clean out the debris on the next scheduled shutdown. Remember that the longer a cleaner operates plugged, the faster it wears out.
7 Trouble-shooting

Upper Cone Wear

Premature cone wear in the upper cone is caused by running the cleaner with the lower cone plugged. Small bits of metal, concrete, tile, nuts, bolts, welding rods, slag, etc. are all capable of getting into the system during construction. This material will settle on white water chest and silo floors. Every time a pump is restarted, more debris is kicked up from the chest or silo floor and gets into the cleaners. Once inside the cleaner, this debris will plug the reject opening. The lower cone will become completely filled with sand. This plug will extend into and fill part of the upper cone. The upper cone will then start to wear due to the swirling action and abrasiveness of the sand.

To prevent premature wear in the upper cone, check for plugged cleaners on a regular shift-to-shift basis and unplug any cleaners that do not show flow in the sight glass.

Lower Cone Wear

Premature cone wear in the lower cone is caused by foreign material that is small enough to enter the cleaner, but larger than the cleaner's reject opening.

Inside the cleaner, this debris will either plug the reject opening and cause wear in the upper cone, as mentioned earlier, or spin inside the lower cone thus causing wear. Usually, a grooved or ring wear pattern will be evident.

To prevent premature wear in the lower cone, flush the piping and clean out all white water chests before start-up. To prevent any further debris from the stock entering the cleaners, a trash screen should be installed on the thick stock line between the machine and blend chests, and on the broke line.

Low Reject Rate

Other than foreign material, a very low reject rate can cause premature cone wear due to holding the debris in the cleaner longer than it is necessary. Low reject rate will also impair efficiency.
Blank-off units are provided when all of the cleaners in a single stage are not needed. The unit is supplied in two different designs, one for blank-off of cleaners (part No. 6088 5629-05) and one for blank-off of the feed and accept connections in the bank structure (part No. 6091 1941).

Installing a Blank-off Unit with Part No. 6088 5629-05:

1. Blank the feed orifice using the small hooked bolt and one nylon disc. Install two nuts making sure that they will not vibrate loose.

2. The accept orifice is blanked by using the long bolt and two nylon discs. Put one disc on the bolt and position the bolt in the way that the bolt head and one disc are inside the cleaner. Put the other disc onto the threaded end keeping this disc on the outside of the cleaner. Install with two nuts making sure that these will not vibrate loose.

3. The reject orifice is easily blanked by using a filled reject plug in place of the normal clear sight glass.

*Detailed drawing on page 19.
Details for Blank-off Unit, Part. No. 6088 5629-05

- Hook with washer
- Tie-rod with 2 washers
- Plugged slight glass
Blank-off unit, Part No. 6091 1941

1. Plug
2. Plate
3. Bolt
4. Reject Plug
9 Safety Instructions

**CAUTION**

No parts of the cleaner may be dismounted during operation, except for the cleaning plug in the lower part of the cleaner.

At temp. above 45°C (113°F), be aware of the burning danger.

Do always use safety gloves and safety glasses when cleaning during operation.

Because O-rings and gaskets age, especially at high working temperatures, leakage can arise; therefore, the plant should not be placed close to any busy passage in the factory.
Advertencia: es importante que antes de realizar el montaje del manómetro verifique la idoneidad de su utilización, ya que al tratarse de un elemento de presión y pese a los elementos de seguridad incorporados, estos no cubren las deficiencias de la instalación o su correcta especificación.

Antes de realizar el montaje del instrumento, se deben tener en cuenta una serie de precauciones en lo relativo a su uso:

Cuando está sometido a ligeras vibraciones mecánicas debe elegirse un modelo lleno de glicerina para amortiguar la aguja y el mecanismo de transmisión y obtener una lectura más precisa, si las vibraciones son intensas, debe montarse en una zona alejada de las mismas mediante el uso de un tubo capilar.

En el caso de que las vibraciones sean dinámicas (produced por pulsaciones leves en el seno del fluido) procederemos a la colocación de un amortiguador de pulsaciones, fijo o regulable según las características de la instalación.

Ante la posibilidad de golpes de ariete que puedan superar el rango marcado como final de escala deberemos acoplar un limitador de presión para protegerlo de las mismas o como medida de seguridad.

Cuando la temperatura del fluido supera los 65 °C, aconsejamos el uso de un tubo sífon y en casos de altas temperaturas un enfriador de aletas.

Cuando se trabaje con fluidos peligrosos, riesgo de explosión o tóxicos, como medida de seguridad recomendamos la instalación de un limitador de flujo, de forma que por si por alguna incidencia se produjera un escape, fisura o rotura del tubo Bourdon, el limitador únicamente permitiría la fuga de un caudal fijo y conocido de fluido.

Si el fluido de proceso es viscoso, con sólidos en suspensión, agresivo ó alimentario, debe acoplarse un separador (o sello químico), cuyo diseño y materiales sean adecuados al fluido y proceso.

El montaje de todos estos elemento puede realizarse “in situ” en el proceso y no requiere intervención de nuestro personal, a excepción de cuando los manómetros están montados en separador, que por tener un líquido interno de transmisión, deben realizarse en fábrica.

La posición del manómetro siempre debe ser vertical, a menos que en el momento del pedido y de su fabricación se haya especificado otra posición (esta vendrá indicada en la esfera). Hay que tener en cuenta que la calibración del instrumento se realiza en posición vertical, por lo que un cambio en la orientación afectaría a la precisión de la lectura.

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El conexionado debe realizarse con el debido cuidado para no dañar las rosquas. Se debe tomar el instrumento con la mano y ajustarlo a la conexión de la instalación dando dos o tres giros. En este momento, asegurándonos de que rosca adecuadamente, debemos acabar de apretarlo con una llave según se indica en las figuras 1.2 y 1.3, nunca con las manos o con una llave que no actúe sobre el rácior del instrumento (figura 1.1).

En el caso de conexión GAS con tuercas loca (figura 1.2), apretar con una llave la tuercas loca y con otra el rácior del instrumento procurando que esté en la orientación que deseamos y siendo la tuercas la que gire. Tener en cuenta que para rosca BSP la estanqueidad se obtiene por el asiento del rácior, por lo que se debe montar una junta plana para su cierre.

Para conexiones NPT, el cierre estanco se obtiene por el ajuste de las rosquas para lo que se recubrirá la conexión del rácior con cinta teflón (u otro material según las características de la instalación y fluido) y el montaje debe realizarse según la figura 1.3.

En el caso de que el manómetro esté montado en un panel (tipos 40 ó 60) o sobre montaje mural (tipo 30) la conexión se realizará mediante dos llaves (según la figura 1.2) para no aplicar esfuerzo de apriete sobre el dispositivo de fijación del aparato.

En caso de ir lleno de glicerina, una vez instalado el manómetro en la línea, se procederá a referenciar la presión interior del manómetro a la presión exterior. Para ello deberá cortarse un tetón que viene previsto para tal fin y que se encuentra habitualmente en la parte superior del manómetro. De no realizarse esta operación la presión generada en el interior de la cámara por el efecto de los cambios de temperatura ambiente podrían afectar a la precisión de lectura del instrumento o hacer saltar la válvula pudiendo entrar elementos extraños que ensucien la glicerina o dañen el mecanismo de transmisión.

Es importante que cuando un instrumento tenga acoplado un elemento separador o sello químico, con o sin capilar, el proceso de acoplamiento a la instalación se realice actuando únicamente sobre la tuercas de la parte inferior del separador, según indica la figura 3.2.
La presión se transmite de la membrana al tubo Bourdon mediante un líquido transmisor estanco, que si pierde su estanqueidad a causa de la manipulación de la unión roscada entre el separador y el capilar o instrumento, este no funcionará.

**Contactos eléctricos:**

Conexiónado según esquemas de HT 08.01, asegurándose de que los voltajes e intensidades son adecuados a los mismos.

Debe asegurarse de que las características de protección eléctrica de los contactos son las adecuadas al fluido y condiciones ambientales de la instalación.

La regulación de los puntos de alarma se realizará con la llave que se suministra, presionando y girando los contactos hasta la posición deseada.

Consultar normas aplicables en la hoja técnica.
MANTENIMIENTO

El mantenimiento que precisa este tipo de instrumentos se reduce al líquido de llenado, elementos de seguridad y correcto funcionamiento.

- Cambio de aceite de amortiguación cuando esté sucio y no permita la correcta visión de la aplicación. MEI suministra este aceite como recambio.

- Comprobar que el tapón de seguridad esté en perfecto estado, ya que los agentes externos pueden endurecer la goma y ésta no actuar a la presión prefijada. Así mismo es importante cambiar el visor si por alguna circunstancia se agrieta o rompe.

- Su correcto funcionamiento se puede detectar a primera instancia comprobando que la posición de la aguja es la lógica de la escala en relación al proceso (cuando la aguja está en cero o en una posición fija).

Para corregir estos errores debemos reparar o recalibrar el instrumento. Si se posee banco de calibración y se trata de un error uniforme a lo largo de toda la escala, el ajuste se puede realizar mediante la colocación de la aguja en su posición correcta (mediante el tornillo de regulación que poseen algunas agujas, girando en sentido horario se desplazará en sentido ascendente y viceversa, o sacando y volviendo a poner la aguja –para ello se requieren herramientas especiales).

Si no posee banco de calibración o la descalibración detectada no es constante en toda la escala, debe remitir el aparato a fábrica.

En cualquier caso debe remitirse el aparato a fábrica con su accesorio cuando se trata de separadores, amortiguadores o limitadores.

Recomendamos que los instrumentos se verifiquen como mínimo una vez al año, según condiciones de trabajo.

Mantenimiento específico para los contactos eléctricos: regularmente debe comprobarse el funcionamiento simulando su actuación.

Mediante la llave de regulación, llevar la pata del contacto hasta sobrepasar la posición de la aguja indicadora de presión para que cambie el contacto.

En caso de detectar fallos, aunque sean intermitentes, aconsejamos cambiar el contacto, ya que se trata de un elemento de seguridad.

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AVERÍAS FRECUENTES:

La aguja indicadora no vuelve al origen al eliminar la presión del circuito.

Este problema se presenta habitualmente por tres razones:

**El manómetros ha recibido un golpe** que ha hecho que el engranaje, utilizado en el mecanismo multiplicador que transforma la deformación del elemento sensible en giro de la aguja indicadora, salte uno de los dientes del engranaje, o bien que la inercia de la masa del manómetro a deformado el elemento sensible.

**El manómetro a sufrido una sobrepresión** que ha deformado el elemento sensible.

Hemos de pensar que ese elemento ha de deformarse elásticamente y de forma proporcional a la presión recibida y que por esa razón la forma del elemento y sus espesores son de vital importancia.

Por ejemplo en los tubos Bourdon, la sección del tubo es elíptica y el tubo tiene una forma de C. Cuando la presión aumenta el tubo tiende a cambiar su forma de C en I para de esa forma aumentar su volumen, pero si eso no es suficiente el siguiente paso es cambiar la sección de elipse a circunferencia para obtener el mismo objetivo.

Lamentablemente hay un punto de deformación de la C, a partir del cual el muelle ya no recobra su forma original y por lo tanto pierde sus características elásticas, lo mismo le pasa si varia la elipse de su sección.

Hay que tener en cuenta que la sobre-presión ejercida por un golpe de ariete (incremento o decremento brusco de la presión) puede llegar a ser de 20 veces la presión nominal de la línea, por lo que al cerrar o abrir una válvula o bomba, la presión de una línea a 10 bar de presión puede llegar a 200 bar y por lo tanto deformar permanentemente el elemento de medida.

Para eliminar estos problemas podemos poner antes del manómetro un amortiguador de la presión, un limitador o restringir de alguna manera el acceso de la presión al manómetro.

**El orificio de conexión se obtura** o el fluido en el interior del manómetro deja de comportarse como un fluido compresible (empieza a solidificarse)

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Tipos de manómetros:

La gran variedad de manómetros existentes en el mercado, se ha originado por sus innumerables aplicaciones en la industria. Sin embargo el tipo más utilizado es el manómetro de Bourdon y sus variantes, aunque es necesario tener presente el intervalo de presiones en el que se trabaja y la exactitud que se requiera.

Manómetro Bourdon

El principio de medida en el que se basa este instrumento es el sensor conocido como tubo Bourdon. El sistema de medida está formado por un tubo aplanado de bronce o acero, cerrado, en forma de “C” de ¾ de circunferencia para la medición de bajas presiones, o enrollado en forma de espiral para la medición de bajas presiones y que tiende a enderezarse proporcionalmente al aumento de la presión; este movimiento se transmite mediante un elemento transmisor y multiplicador que mueve la aguja indicadora sobre una escala graduada. La forma, el material y el espesor de las paredes dependen de la presión que se quiera medir.

El conjunto de medida está formado por un tubo Bourdon soldado a un racord de conexión, Por lo general este conjunto es de latón, pero en el caso de altas presiones y también cuando hay que medir presiones de fluidos corrosivos se hacen de aceros especiales.

La exactitud de este tipo de manómetros depende en gran parte del tubo, por esa razón sólo deben emplearse tubos fabricados con las normas más estrictas y envejecidos cuidadosamente por los fabricantes.

El elemento de transmisión incorpora una biela para su ajuste.

La norma aplicable para los manómetros Bourdon es la UNE-EN 837-1.

El almacenamiento y transporte del aparato deberá realizarse con el normal cuidado al tratarse de elementos muy sensibles a los golpes y vibraciones.

Los manómetros industriales pueden dividirse según distintas características:

Por su diámetro, es decir por el tamaño de la esfera en la que puede leerse la indicación de la presión para la que está diseñado el aparato. Los más corrientes son los siguientes diámetros nominales en mm.: 40, 50, 63, 80, 100, 160 y 250 mm.

Los diámetros 40 y 50 mm. Son habitualmente utilizados en conducciones para presiones comprendidas entre 2,5 bar y 60 bar, y en modelos muy económicos con conexiones en latón, cajas protectoras en ABS y precisiones del 2,5%, aunque es posible su fabricación en otros rangos de presión, materiales y precisiones. Industrias típicas que utilizan estos manómetros son: reguladores de presión, neumática, industria contra incendios, etc.

El diámetro 63 mm. Es habitual en la industria para conexiones de ¼, y el diámetro 100 para conexiones de ½. Es corriente su utilización en todos los materiales dependiendo de la aplicación a cubrir, desde aparatos en caja de ABS o acero, hasta manómetros fabricados íntegramente en acero inoxidable, pasando por los manómetros llenos de glicerina con conexiones en latón y caja protectora en acero inoxidable.

Los diámetros 160 y 250 mm. Son habitualmente utilizados para aplicaciones de laboratorio y lo más común es que se fabriquen en acero inoxidable y/o en precisiones elevadas (0,5%, 0,25%,...etc.).

Pero insistimos en que cualquier variación de medidas, materiales, precisión y rango son en principio posibles, otra cosa es que sean tan poco frecuentes que se conviertan en prototipos.

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Por su elemento sensible, es decir por el componente mecánico elástico utilizado como elemento que genere la deformación proporcional a la presión.

Habitualmente la elección de ese componente está en función del rango de presión a medir.

Cápsula o membrana para presiones comprendidas entre 5 mbar y 600 mbar

Fuelle: formado por un fuele metálico con o sin resorte, y utilizado para medir presiones relativamente bajas (hasta 7 bar) y presiones absolutas

Tubo bourdon para presiones comprendidas entre 1 bar y 60 bar

Tubo helicoidal para presiones superiores o iguales a 100 bar

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Por los materiales utilizados en su fabricación:

Sistema de medida en latón y el resto en los materiales más baratos posibles tales como ABS o acero.

Mixtos con sistemas de medida en latón y cajas protectoras en acero inoxidable, habitualmente utilizados llenos de glicerina para amortiguar las vibraciones mecánicas.

Inoxidable: con sistemas en Inoxidable AISI 316 y cajas protectoras en acero inoxidable llenas o no de líquido amortiguador (glicerina*)

* cuando los manómetros llevan contactos eléctricos suele utilizarse como líquido amortiguador la silicona que no es conductiva.

Por si llevan líquido amortiguante: en este caso se diferencia entre manómetros secos (sin líquido amortiguante) y manómetros con glicerina.

Manómetros de columna líquida:

Este tipo de manómetros es la forma más sencilla de dispositivo para medir presiones, donde la altura, carga o diferencia de nivel, a la que se eleva un fluido en un tubo vertical abierto conectado a un aparato que contiene un líquido, es una medida directa de la presión en el punto de unión y se utiliza con frecuencia para Mostar el nivel de líquidos en tanques o recipientes.

Puede utilizarse el mismo principio con indicadores de tubo en U, en el cual, conocida la densidad del líquido empleado en él, la carga o altura constituye una medida de la presión relacionándola con la correspondiente a la atmosférica. La figura 1a muestra el manómetro fundamental de tubo en U. Otro dispositivo equivalente (figura 1b), cuando es necesario (como en el caso de la presión de un gas) que la presión se mida por la altura o carga de algún fluido distinto de aquel cuya presión se busca.

Figura 1a. Manómetros abiertos
La mayoría de estos manómetros pueden ser utilizados como manómetros abiertos o como manómetros diferenciales, cuando indican la diferencia entre dos presiones diferentes de la atmosférica. El fluido manométrico que forma la columna líquida en estos indicadores puede ser cualquier líquido que no se mezcle con el fluido a presión. Para altos vacíos o presiones elevadas y grandes diferencias de presión el líquido del medidor debe ser de una gran densidad por esto casi siempre se utiliza como fluido manométrico el mercurio y para las bajas presiones líquidos de menor densidad como el agua, alcohol, kerosén, etc.

Los manómetros abiertos dan lecturas en altura, cm. de mercurio o altura de fluido manométrico, luego para el cálculo de la presión manométrica del fluido de proceso (punto A de la figura 1a) se recurre a fórmulas como la siguiente:

\[ d_a = \frac{(H_m d_m - K d_m)}{g_c} \]

Donde:

- \( d_a \) es la densidad del fluido A
- \( d_m \) es la densidad del mercurio
- \( K \) es la distancia entre el fluido manométrico y el fluido cuya presión se quiere averiguar.
- \( g \) es la aceleración local debida a la gravedad
- \( g_c \) es una constante adimensional

Dentro de los manómetros diferenciales tenemos el tubo en U diferencial, el cual mide la diferencia de presiones entre los orificios de toma A y B (figura 3) en altura de fluido manométrico, luego la diferencia de presión se expresa mediante la siguiente ecuación:

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\[
d_a - d_b = \left( H_m (d_m - d_a) + k_a d_a - k_b d_b \right) \frac{g}{g_c}
\]

donde
\( k_a, k_b \) son las distancias verticales de la superficie del fluido manométrico por encima de A y B respectivamente.
\( d_a, d_b \) son las densidades de los fluidos en A y B.

Otro tipo, es el tubo en U diferencial invertido (figura 3), en el que el fluido que llena el tubo en U puede ser un gas o un fluido ligero, y el cual es frecuentemente usado para medir diferencia de presiones en líquidos cuando las columnas abiertas líquidas son extraordinariamente elevadas, o cuando el líquido a presión no puede exponerse a la atmósfera.

![Figura 4](image)

Por último están los manómetros de columna líquida que miden directamente la presión absoluta del fluido, siempre que el espacio encima del mercurio sea el “vacío total o el vacío perfecto”, luego en una medida con referencia a una presión nula, como los tubos en U cerrados (figura 4) o el barómetro de mercurio que registra directamente la presión absoluta de la atmósfera en función de la altura de la columna de mercurio (figura 5). La presión barométrica normal es 760 mm Hg a 0ºC (equivalente a 14,7 lb/pulg² o a 1 atm).

![Figura 5. Barómetro de Mercurio](image)

Cuando la presión se mida en términos de una altura de columna de líquido, que no sea de mercurio o de agua (para los cuales ya se conoce el valor de la presión estándar o normal) es fácil convertir la altura de un líquido a otro por medio de las siguientes expresiones:

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**TIPOS DE MANÓMETROS**

$$p = \frac{dg}{g_c}$$

en donde:

- \(d\) = densidad del líquido
- \(h\) = altura de la columna

Obteniendo la relación de esta expresión para dos sustancias diferentes se tendrá la relación entre las alturas de las dos columnas de líquido.

Altura fluido 1/ altura fluido 2 = densidad fluido 2 / densidad fluido 1.

Una variante de este tipo de manómetros son los manómetros de columna inclinada usados para medir diferencias de presiones muy pequeñas, ya que estos tienen la ventaja sobre los manómetros de columna de líquido por la amplificación de la lectura. El tubo en U inclinado (figura 10) se utiliza porque la longitud de la altura o carga puede multiplicarse varias veces por la inclinación de la columna líquida y la escala será más ancha. Si la lectura \(R\) se toma como se indica y \(R_0\) es la lectura cero, \(H_m\) estará dado por \(H_m = (R - R_0)\ \text{sen} \theta\) y el cálculo de \(dA - dB\) es de la misma forma que para el tubo en U vertical.
Flanged seals with flush diaphragm S-P

**Diaphragm seal dimensions**

<table>
<thead>
<tr>
<th>Version</th>
<th>Diaphragm diameter Dm</th>
<th>Contact face diameter d1</th>
<th>Diameter of bolt circle K</th>
<th>External diameter D</th>
<th>Thickness d</th>
<th>Diameter of holes L</th>
<th>Number of holes</th>
</tr>
</thead>
<tbody>
<tr>
<td>DN50 PN40/ 2” ANSI 150</td>
<td>59</td>
<td>102</td>
<td>125</td>
<td>165</td>
<td>22</td>
<td>18</td>
<td>4</td>
</tr>
<tr>
<td>DN60 PN40</td>
<td>59</td>
<td>92</td>
<td>120,5</td>
<td>150</td>
<td>20</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>3” ANSI 150</td>
<td>88</td>
<td>138</td>
<td>160</td>
<td>200</td>
<td>24</td>
<td>18</td>
<td>8</td>
</tr>
<tr>
<td>DN100 PN40</td>
<td>88</td>
<td>162</td>
<td>190</td>
<td>235</td>
<td>24</td>
<td>22</td>
<td>8</td>
</tr>
<tr>
<td>4” ANSI 150</td>
<td>89</td>
<td>158</td>
<td>190,5</td>
<td>230</td>
<td>24</td>
<td>20</td>
<td>8</td>
</tr>
</tbody>
</table>

**Application**

The diaphragm seal is a pressure-transmitting, diaphragm-type device. The pressure signal is sent to the cooperating pressure measuring device (pressure transmitter, pressure gauge) through manometric liquid filling the space between the separating diaphragm of the seal and the pressure measuring device. The diaphragm seal task is to isolate the pressure measuring device from damaging impacts caused by either medium or installation:

- low or high temperature, increased viscosity, impurities;
- vibrations of the installation (remote diaphragm seal).
Recommended minimum measuring range (bar),
depending on the type of the set: pressure measuring device - diaphragm seal

<table>
<thead>
<tr>
<th>Pressure measuring device</th>
<th>Diaphragm seal type</th>
<th>DN50 / 2&quot;</th>
<th>DN80 / 3&quot;</th>
<th>DN100 / 4&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart transmitters*</td>
<td>direct</td>
<td>0.25</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>remote (2 m)</td>
<td>1</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>PCE-28</td>
<td>direct</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>remote (2 m)</td>
<td>1</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>PC-50</td>
<td>direct</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>remote (2 m)</td>
<td>1</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Ø63 gauge</td>
<td>direct</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>remote (2 m)</td>
<td>2.5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Ø100 gauge</td>
<td>direct</td>
<td>6</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>remote (2 m)</td>
<td>6</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Ø160 gauge</td>
<td>direct</td>
<td>6</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>remote (2 m)</td>
<td>6</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

* The ranges given in the table for the smart transmitters should be taken as set ranges.

**Recommendations**

The essential metrological problem at diaphragm seals operational use is an absolute thermal zero error, resulting from the thermal expansion of the manometer liquid. The expansion effect must be compensated for with the separating diaphragm flexibility.

To minimise this effect, it is advisable to:
- use capillaries as short as possible, in this way the volume of manometer liquid will be reduced;
- use the greater diameter seals, in order to maximise the separating diaphragm flexibility;
- locate the capillaries in the places, in which the temperature fluctuations will be minimal.

**Additional absolute zero error resulting from ambient temperature fluctuations, depending on the type of the set: pressure transmitter - diaphragm seal**

<table>
<thead>
<tr>
<th>Diaphragm seal type</th>
<th>Absolute zero error per 10°C for the diaphragm seal</th>
</tr>
</thead>
<tbody>
<tr>
<td>DN50 / 2&quot;</td>
<td>DN80 / 3&quot;</td>
</tr>
<tr>
<td>DN100 / 4&quot;</td>
<td></td>
</tr>
<tr>
<td>direct</td>
<td>0.5 mbar</td>
</tr>
<tr>
<td>remote (2 m capillary)</td>
<td>3 mbar</td>
</tr>
<tr>
<td></td>
<td>0.4 mbar</td>
</tr>
<tr>
<td></td>
<td>0.4 mbar</td>
</tr>
<tr>
<td></td>
<td>1 mbar</td>
</tr>
<tr>
<td></td>
<td>1 mbar</td>
</tr>
</tbody>
</table>

**Temperature range of measured medium**

<table>
<thead>
<tr>
<th>Manometric liquid</th>
<th>Underpressure measurements</th>
<th>Overpressure measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>high-temperature (DC)</td>
<td>-10...150°C</td>
<td>-10...315°C</td>
</tr>
<tr>
<td>low-temperature (AK)</td>
<td>not recommended for measurement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>of pressures &lt; 0.5 bar ABS</td>
<td>-60...200°C</td>
</tr>
</tbody>
</table>

Note: When operating with an ambient temperature of < -15°C, heating of capillaries filled with DC fluid is recommended.

**Special versions**

- Other standard ANSI or DIN
- Filled with edible oil (medium temp. -10...150°C)
- Direct diaphragm seal for medium temp. over 150°C
- Others

**Ordering procedure**

Direct diaphragm seal: pressure measuring device / S-P – DN..... / special version (description)

Remote diaphragm seal: pressure measuring device / S-PK – DN..... / K = ..... m / ..... / special version (description)

Transmitter or gauge – see the code in the appropriate catalogue sheet

Diaphragm seal version
Capillary length
Type of manometric liquid – DC (high-temperature), AK (low-temperature)

**Example:** PCE-28 pressure transmitter, EEx version, measuring range 0 ÷ 1 bar, cable connection, direct flanged seal with flush diaphragm

PCE-28 / EEx / 0 ÷ 1 bar / PK / S-P – DN50

Maximum pressure for PN40 – 40 bar
Maximum pressure for ANSI 150 – 150 psi
Material of diaphragm and flange 316Lss

Important:
- contact face in diaphragm seal DN50 have a milled slot for a gasket (acc. to DIN 2512 FormN). Version without any slot available on request. (acc. to DIN 2526 FormE)
- standard outlet capillary from flange:
  - direct mounted diaphragm seal - axial
  - remote mounted diaphragm seal - radial

Note: When operating with an ambient temperature of < -15°C, heating of capillaries filled with DC fluid is recommended.
Differential pressure transmitter PRE-28

PK type
Electrical cable connection
Degree of protection IP-67
The cable electrical connection, contact with the atmosphere through the capillary inside the cable. The cable length 3m (other cable lengths available, if required)

Example connection of impulse line

Black (−)  Red (+)  SW27

Transmitter PRE-28
Process connection P type
Static pressure limit 40 bar

PK type
DIN 43650 connector
Degree of protection IP-65

Transmitter PRE-28 – version with type C process connection to be mounted together with a valve manifold
Static pressure limit 250 or 320 bar

NEW

Applications

- Overloads up to 320 bar total static pressure
- Accuracy 0.25%
- Any range from 0…16 mbar up to 0…25 bar

Installation

The PRE-28 transmitter is applicable to the measurement of differential pressure of gases, vapours and liquids.

The active element is a piezoresistance silicon sensor separated from the medium by separating diaphragm and a specially selected type of manometric fluid. The special design of the transducive sensing element ensures withstanding the pressure surges and overloads of up to 320 bar. The electronics is placed in a casing with a degree of protection IP65, IP67, depending on the type of electrical connection applied.

Potentiometers can be used to shift the zero position and the range by up to 10%, without altering the settings.

Materials: Wetted parts: type P process conn. 316Lss type C process conn. 316ss
Diaphragm: Hastelloy C 276
Casing: 304ss

Hysteresis, repeatability: 0.05%
Thermal compensation range: 0+ 70 C
Operating temperature range: -25÷80 C
Medium temperature range: -25÷120 C (direct measurement)

When the special process connections are required for the measurement of levels and pressures (e.g. at food and chemical industries), the transmitter is provided with an Aplisens diaphragm seal. The differential pressure transmitters with diaphragm seals are described in detail in the further part of the catalogue.

CAUTION: the medium must not be allowed to freeze in the impulse line or close to the process connection of the transmitter.
## Technical data

### Measuring Range

<table>
<thead>
<tr>
<th>Measuring Range</th>
<th>100 mbar</th>
<th>1 bar</th>
<th>2 bar</th>
<th>25 bar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overpressure Limit</td>
<td>100 mbar</td>
<td>250 bar (option 320 bar)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Static Pressure Limit</td>
<td>250 bar (option 320 bar)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accuracy</td>
<td>0.4%</td>
<td>0.25%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long term stability</td>
<td>0.2% / year</td>
<td>0.1% / year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal error</td>
<td>Typically 0.3% / 10°C</td>
<td>Typically 0.2% / 10°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zero shift error for static pressure*</td>
<td>0.1% / 10 bar</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Zeroing the transmitter in conditions of static pressure can eliminate this error.

### Output signal

- 4...20 mA, two wire transmission
- 0...10 V, three wire transmission

### Power supply

- 10.5...36 V DC (EEx 12...28 V)
- 15...30 V DC – three wire transmission

### Error due to supply voltage changes

0.005% (FSO) / V

### Load resistance

- (for current output) \( R[\Omega] \leq \frac{U_{\text{out}}[\text{V}]}{0.02 \text{A}} \times 0.85 \)
- (for supply output) \( R \geq 5 \text{k}\Omega \)

### Electrical diagrams

- 4-20 mA output signal
- 0-10 V output signal

### Ordering procedure

#### Model

- PRE-28

#### Code

- EExia
- Tlen
- PD
- PZ
- PK

#### Description

- Differential pressure transmitter.
- Version for oxygen service (sensor filled with Fluorolube fluid).
- Marine Certificate DNV Ex II 1/2G Ga/Gb Ex ia IIC T4/T5/T6, I M1 Ex ia 1, II 1D Ex ia D20 T105C (only for transmitters with 4...20mA output)
- 316SS housing, IP66, packing gland M20x1,5.

#### Measuring range

- \( I_{\text{in}} \text{[required units]} \)
- Measuring range in relation to 4mA and 20mA (or 0 and 10V) output.
- Units: bar, MPa, kPa, etc.

#### Output signal

- 4...20 mA, two wire transmission
- 0...10 V, three wire transmission

#### Power supply

- 10.5...36 V DC (EEx 12...28 V)
- 15...30 V DC

#### Error due to supply voltage changes

0.005% (FSO) / V

#### Load resistance

- (for current output) \( R[\Omega] \leq \frac{U_{\text{out}}[\text{V}]}{0.02 \text{A}} \times 0.85 \)
- (for supply output) \( R \geq 5 \text{k}\Omega \)

#### Electrical diagrams

- 4-20 mA output signal
- 0-10 V output signal

#### Process connections

- Thread 1/4NPT F on the cover flanges, diaphragms material Hastelloy C 276, cover flanges material SS316L. Allows mounting with a valve manifold.
- Thread M20x1.5 (male) with Ø9hole, diaphragms material Hastelloy C 276, wetted parts SS316L.
- Diaphragm seal (see chapter of diaphragm seals) mounted on Hi side of transmitter, Lo side 1/4NPT Female

#### Accessories

- Mounting bracket for 2" pipe (to C process conn.), mat. zinced steel
- Mounting bracket for 2" pipe (to P process conn.), mat. stainless steel
- Connector to weld impulse pipes dia. 12 and 14 mm, material 15HM(SO) or SS 316(S). Only process connection P type.
- Adapter for differential pressure transmitters with C type process connection, output thread 1/2NPT F. Material 316 LS3

#### Other specification

- Description of required parameters

### Example

**Differential pressure transmitter, version EExia, measuring range 0...160 mbar, output signal 4...20 mA, C type process connection, electrical process connection with DIN43650 connector**

**PRE-28/EExia/0...160 mbar/PD/C**
Smart differential pressure transmitter with two diaphragm seals model APR-2200ALW or APRE-2200

- Several applications, including hydrostatic measurement of levels in pressure tanks, density and phase boundaries
- Ability to configure measuring range locally
- Digital PROFIBUS PA signal
- 4...20 mA output signal + HART protocol
- Accuracy 0.1%
- ATEX certificates (intrinsic safety, explosion proof)
- Fully welded active measuring element which guarantees tightness of oil system for many years.

Example of a filter loss measurement

Recommendations

The version of the transmitter with two remote diaphragm seals is recommended for the measurement of pressure differences when the hydrostatic pressure of the manometric fluid in the capillaries (which depends on the vertical spacing of the seals) is significantly less than the measuring range of the transmitter. The best metrological results are obtained when the applied capillaries are identical, as short as possible, and terminated with identical seals. At such a configuration additional temperature errors, related to the remote sealing, affect both of the measurement chambers of the differential pressure transmitter in the same way, and thus cancel each other out.
The transmitter with a direct diaphragm seal (connected to the positive measurement chamber) and a remote diaphragm seal (connected to the negative chamber) is recommended for hydrostatic measurements of: levels, densities, phase boundaries and pressure differences (with differentiated height of pulse source points*).

In such a configuration, at ambient temperature changes, two opposite phenomena appear concurrently.

Thermal expansion causes the change in the volume (and hence also the change in density) of the manometric fluid in the capillary, which results in a change of the hydrostatic pressure related to the vertical spacing of the seals. This phenomenon is counteracted by the elastic reaction of the diaphragm of the upper diaphragm seal, which is displaced by the change in volume of manometric fluid. Based on tests and experiments, the Aplisens transmitters are provided with carefully selected seal diaphragms, which guarantee compensation of the errors resulted from the ambient temperature changes.

The best metrological results are obtained using assembly, which include DN 80, DN 100, A 109 and S-Comp diaphragm seals or S-Mazut, S-DIN and S-Clamp diaphragm seals with a diameter of at least 65 mm, where the length of the capillary is \((1...1.3) \times \) (vertical spacing of seals). It is recommended using identical diaphragm seals at the both upper and lower connection points.

* The difference in height of pulse source points, at which the hydrostatic pressure of the manometric fluid is comparable to or greater than the range of the transmitter.
Example versions

Transmitter with two types of diaphragm seal: one – direct diaphragm seal and the other – remote diaphragm seal. The example with S-T.

Type APRE-2200PD
Angle electrical connector DIN 43650
Degree protection IP 65

Type APRE-2200PZ
Field casing with a packing gland M20×1.5
Degree of protection IP 65

Note: The appropriate configuration of the complete set of pressure transmitter, diaphragm seals and capillaries, as well as the proper selection of manometric fluid, depends on several factors, including the physical and chemical properties, temperature range of the medium, the vertical spacing of the diaphragm seals, the measuring range, static pressure range, range of ambient temperatures and the technical specifications for mechanical connection of the diaphragm seals to the pressure devices.
Application and construction
The differential pressure transmitter is applicable to the measurement of pressure differences of: gases, vapours and liquids in cases where it is necessary to use seals and the pressure pulse source points may be several metres apart. Typical applications include the hydrostatic measurement of: levels in closed tanks, densities and phase boundaries, and the measurement of a filter loss, pressure differences between media in pasteurisers etc. The available range of the diaphragm seals allows measurement at great majority of media. The active element is a piezoresistant silicon sensor separated from the medium by a distance sealing system. The special design of the measuring unit means that it can withstand pressure surges and overloads of up to 40 bar. The electronic circuits are enclosed in a casing with a degree of protection IP 65 or IP66.

Configuration
The settings of the following metrological parameters can be changed:

- the units of pressure in which the range is configured,
- start and end points of the range, time constant,
- inverted characteristic (output signal 20 ÷ 4 mA).

Communication
The transmitter is configured and calibrated using a KAP-03 communicator, some other communicators (HART) or a PC using an RS-HART converter and Aplisens RAPORT-02 configuration software.

The data interchange with the transmitter enables the users the transmitter identification, as well as reading of the currently measured differential pressure value, output current and percent of range width.

Measuring ranges

<table>
<thead>
<tr>
<th>Nominal measuring range (FSO)</th>
<th>Minimum set range</th>
<th>Vertical spacing of diaphragm seals</th>
<th>Maximum set range width, considering the actual vertical spacing of the diaphragm seals (m)</th>
<th>Static pressure limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>-160...160 mbar</td>
<td>0.1 m H₂O</td>
<td>&lt; 1.7 m</td>
<td>[1.6 + (vertical spacing of seals x 0.94)] m H₂O</td>
<td>40 bar</td>
</tr>
<tr>
<td>-0.5...0.5 bar</td>
<td>0.5 m H₂O</td>
<td>≤ 6 m</td>
<td>[5 + (vertical spacing of seals x 1.04)] m H₂O</td>
<td>40 bar</td>
</tr>
<tr>
<td>-1.6...2 bar</td>
<td>1.5 m H₂O</td>
<td>≤ 15 m</td>
<td>[20 + (vertical spacing of seals x 1.04)] m H₂O</td>
<td>40 bar</td>
</tr>
<tr>
<td>-1.6...16 bar</td>
<td>1 bar</td>
<td>≤ 15 m</td>
<td>16 bar</td>
<td>40 bar</td>
</tr>
</tbody>
</table>

CAUTION: The maximum vertical diaphragm seal spacing shown in the table applies to level measurement, ensuring that it is possible to set the zero point of the transmitter when the tank is empty. For measurements of density or phase boundaries (in the sugar, chemical or refinery industries) the vertical spacing of the diaphragm seals can be larger.

Metrological parameters

Accuracy ≤ ±0.1% (FSO)
The other parameters as given in the sheet for the smart differential pressure transmitter APR-2000ALW/APRE-2000.

Sealing effect errors – as given in the relevant diaphragm seal sheet in chapter III (Diaphragm Seals), concerning the distance seal.

NOTE: The additional absolute zero error due to ambient temperature can be compensated by configuring the transmitter, seals and capillaries in accordance with the recommendations on pages 38 and 39.


Operating conditions

Operating temperature range (ambient temperature) -25...85°C
APR-2200ALW/EEx and APRE-2200/EEx -25...80°C

Medium temperature range – as given in the appropriate diaphragm seal sheet (remote seal)

Special versions, certificates:
EExia – ATEX Intrinsic safety
EExd – ATEX explosion proof
100 bar, 160 bar – static pressure limit – 100 bar or 160 bar
Non-standard basic range
Others

Electrical diagrams for transmitters with HART protocol

APRE-2200PZ APRE-2200PD APR-2200ALW Version: APR-2000ALE with 0…5 or 0…20mA output signal
SMART DIFFERENTIAL PRESSURE TRANSMITTER APR-2200AL/Profibus PA/W

Construction
The transmitter electronic system performs the digital processing of measurement and generates the output signal with the communication module according to Profibus PA standard. The transmitter function performance bases on profile 3.0 of Profibus PA standard.

The casing is made of high-pressure casting of aluminium alloy, IP-65 rated. The casing design allows using a local liquid crystal graphical display, 90° turn of display, 0–355° turn of casing relative to the sensor, and the choice of direction at cable insertion.

The measuring ranges, according to the table, page 41.

Communication
The communication with the transmitter is achieved in two ways:
- cyclic – the transmitter sends primary measured value (4 bytes IEEE754) and status containing the information on the current state of transmitter and measurement validity (1 byte).
- acyclic – this way of communication is used to device configuration and to read both primary measured value and the status.

Configuration
Full configuration of transmitter settings, adjustment of the display mode, transmitter zeroing and calibration in relation to pressure standards proceeds with the PDM (Process Device Manager) software, by Siemens. The EED program library, worked out by Aplisens for cooperation with this transmitter, is helpful in the configuration. Other commercial configuration software (e.g. Commuwin by Endress and Hauser, DTM/FDT tools) make transmitter configuration possible in the range of basic commands.

Enclosed to APR-2200AL/Profibus PA is GSD file comprising the description of the transmitter basic properties such as transmission rate, type and format of input data, list of additional functions. GSD file is necessary for the software serving as a device for network configuration and makes the correct connection the appliance to Profibus network possible. The universal file GSD, designed for standard pressure transmitters made according to profile at revision 3 Profibus standard, may also be applicable to APR-2200AL/Profibus PA.

The pressure transmitter APR-2200AL/Profibus PA does not have the hardware address switch This address may be adjusted with accessible configuration software.

Measurements in the areas under explosion hazard
For pressure measurements in the areas under explosion hazard the Atex intrinsically safe transmitters, II 1/2G EExia IIB/T5 are available

Metrological parameters
Accuracy ≤ ±0.1% (FSO)
Other parameters: as for APR-2200ALW.
Sealing effect errors: as given on the relevant diaphragm seal sheet in chapter Diaphragm Seals, in relation to the distance seal
NOTE: The additional absolute zero error due to ambient temperature can be compensated by configuring the trans- mitter, diaphragm seals and capillaries in accordance with the recommendations on pages 38, 39.

Electrical parameters
Power supply (from DP/PA coupler )
10,5 –28V DC
12.05 –28V DC - when display illumination switched on
Power supply from intrinsically safe coupler according to FISCO requirements.
V=17.5VDC
I=0.38A for IIB
I=0.36A for IIC
Current consumption 14mA

Output parameters
Output signal Digital communication signal Profibus – PA (according to EN 50170)
PA function slave
Physical layer IEC61158-2
Transmission range 31,25kBit/S
Modulation Manchester II

Operating conditions
Operating temperature range (ambient temp.): –25..85°C
EEx version: –25..65°C
Medium temperature range: as given on the appropriate diaphragm seal

Ordering procedure
(See next page)

Examples:
Ordering code to APRE-2200:
Smart differential pressure transmitter APRE-2200, nominal measuring range -1.6+2 bar, on the (+) side a DN80 PN40 direct diaphragm seal, 100mm tube, on the (-) side a DN80 PN40 remote diaphragm seal, capillary length 8m.
APRE-2200PD / -1,6÷ 2 bar/ (+) S-T DN80; T=100mm/ (-)S-PK DN80; K=8m

Ordering code to APR-2200ALW:
Smart differential pressure transmitter APR-2200ALW with display, nominal measuring range -0.5+0.5 bar, with two remote diaphragm seals, capillaries length 2x K=2,5m
APR-2200ALW / -0,5÷ 0,5bar/ (+) S-PK DN80; K=2,5m/ (-)S-PK Dn80/ K=2,5m

Ordering code to APR-2200AL/ProfibusPA:
Smart differential pressure transmitter APR-2200AL/ProfibusPA, nominal measuring range -0.5+0.5 bar, with two remote diaphragm seals, capillaries length 2x K=2,5m
APR-2200AL/Profibus PA / -0,5÷ 0,5/ (+) S-PK DN80; K=2,5m/ (-)S-PK DN80; K=2,5m

Electrical diagrams
(See next page)
## Ordering procedure APR-2200ALW

<table>
<thead>
<tr>
<th>Model</th>
<th>Codes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>APR-2200</td>
<td></td>
<td>Smart differential pressure transmitter.</td>
</tr>
<tr>
<td>Casing, Output signal,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>→ ALW………………………</td>
<td></td>
<td>Aluminium housing, IP66/IP67, with display, output 4–20mA + Hart</td>
</tr>
<tr>
<td>ALE………………………</td>
<td></td>
<td>Aluminium housing, IP66/IP67, with display, output 4–20mA + Hart 0–20mA+ Hart, 0–5mA+ Hart,</td>
</tr>
<tr>
<td>AL/Profibus PA……………</td>
<td></td>
<td>Aluminium housing, IP66/IP67, without display, output Profibus PA</td>
</tr>
<tr>
<td>AL/Profibus PA/W………….</td>
<td></td>
<td>Aluminium housing, IP66/IP67, with display, output Profibus PA</td>
</tr>
<tr>
<td>ALW/SS……………………</td>
<td></td>
<td>316ss stainless steel housing, IP66/IP67, with display, output 4–20mA + Hart</td>
</tr>
</tbody>
</table>

### Versions, Certificates*

- **/EEx ia………………….**
  - Ex II 1/2G Exia IIC T5 (not available for ALE version)
- **/EEx d…………………...**
  - Ex II 1/2G ExiaD IIC T5/T6 (not available for ALE version)
  - Ex II 1/2D ExiaD 20T/95T100 (not available for ALE version)

- **/100bar……………….**
  - Static pressure limit – 100bar
- **/160bar……………….**
  - Static pressure limit – 160bar

### Nominal measuring range

- **(*) not-standard ranges available on request**
  - -160÷160mbar (-16÷16kPa)
  - -0.5÷0.5bar (-50÷50kPa)
  - -1.6÷2bar (-16÷200kPa)
  - -1.6÷16bar (-16÷1600kPa)

### Measuring set range

- ... [ required units]…
  - Start and end of calibrated range in relation to 4mA and 20mA output

### Process connections

- **/(+…….**
  - Direct diaphragm seal or remote diaphragm seal mounted on the (+) side of the transmitter – code as given in the relevant diaphragm seal sheet

- **/(-…….**
  - Remote diaphragm seal mounted on the (-) side of the transmitter – code as given in the relevant diaphragm seal sheet (chapter III – seals)

### Electrical connection

- **/US……………**
  - Packing gland M20x1,5
  - Thread 1/2NPT Female

### Accessories

- **/FI25…………**
  - Mounting bracket type Fi25 for 2" pipe, material 304ss

### Other specification

- ... Description of required parameters

## Ordering procedure APRE-2200

<table>
<thead>
<tr>
<th>Model</th>
<th>Codes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>APRE-2200</td>
<td></td>
<td>Smart differential pressure transmitter.</td>
</tr>
<tr>
<td>Casing, Output signal,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>→ PD……………………..</td>
<td></td>
<td>Housing IP65 with DIN43650 connector, without display, output 4–20mA + Hart, packing gland M20x1,5,</td>
</tr>
<tr>
<td>PZ……………………..</td>
<td></td>
<td>304SS housing, IP66/IP67, without display, output 4–20mA + Hart packing gland M20x1,5</td>
</tr>
<tr>
<td>PZ/316…………………..</td>
<td></td>
<td>304SS housing, IP66, without display, output 4–20mA + Hart</td>
</tr>
</tbody>
</table>

### Versions, Certificates*

- **/EExia……………….**
  - Ex II 1/2G Exia IIC T5/T6/T100
  - Ex II 1/2D ExiaD 20T/95T100

- **/100bar……………..**
  - Static pressure limit – 100bar
- **/160bar……………..**
  - Static pressure limit – 160bar

### Nominal measuring range

- **(*) not-standard ranges available on request**
  - -160÷160mbar (-16÷16kPa)
  - -0.5÷0.5bar (-50÷50kPa)
  - -1.6÷2bar (-16÷200kPa)
  - -1.6÷16bar (-16÷1600kPa)

### Measuring set range

- ... [ required units]…
  - Start and end of calibrated range in relation to 4mA and 20mA output

### Process connections

- **/(+…….**
  - Direct diaphragm seal or remote diaphragm seal connected to the (+) side of the transmitter – code as given in the relevant diaphragm seal sheet

- **/(-…….**
  - Remote diaphragm seal connected to the (-) side of the transmitter – code as given in the relevant diaphragm seal sheet (chapter III – seals)
To simplify the mathematical operations we introduce the density coefficient of the medium \( X_{\rho} \).

\[
X_{\rho} = \frac{\rho_{\text{medium}}}{\rho_{\text{water at 4°C}}} \quad \text{[g/cm}^3\text{]} \times \text{[g/cm}^3\text{]}
\]

Since the density of water at 4°C is 1 g/cm\(^3\), the density coefficient \( X_{\rho} \) is numerically equal to the density of the medium expressed in g/cm\(^3\). To determine the hydrostatic pressure of a column of liquid in mm H\(_2\)O, it is sufficient to multiply the height of the column \( h \) [mm] by the density coefficient of the liquid \( X_{\rho} \). Since it is easy to determine the hydrostatic pressure in mm H\(_2\)O and the transmitter can be configured in those units, in the descriptions of measurement methods given below we will make use of pressures expressed in mm H\(_2\)O and the density coefficient \( X_{\rho} \).

### Configuration of the transmitter to measure the level of liquid in a tank

#### The measurement task:
To convert a variation in the level of a liquid with density \( \rho = 0.87\) g/cm\(^3\) between 0 and \( h_{\text{max}} \) to a variation in the output signal from 4 to 20 mA.

1. Install the transmitter in its working position on an empty tank.
2. Make the electrical connections of the transmitter, providing for the ability to use HART communication.
3. Connect the KAP-02 communicator, identify the transmitter and select the “configuration” function.
4. On the configuration menu select the “Reranging” procedure.
5. On the “Reranging” menu:
   a) change the units of measurement to mm H\(_2\)O at 4°C;
   b) enter the values for the start (\( X_{\rho} \times h_{\text{min}} \) [mm]) and end (\( X_{\rho} \times h_{\text{max}} \) [mm]) of the measurement range, namely 0 and \( (0.87\ h_{\text{max}} \) [mm]) respectively;
   c) to compensate for the hydrostatic pressure of the manometric fluid, the start of the measurement range should be set using regulated pressure; when subject to the action of only the manometric fluid (empty tank) the transmitter will shift the start and end-points of the range, compensating for the value of that pressure.

When the transmitter has been configured in this way it is ready to be used to carry out the given measurement task.

If it is not possible to empty the tank to configure the transmitter, the hydrostatic pressure of the manometric fluid should be calculated by multiplying the vertical spacing of the diaphragm seals by the density coefficient of the oil in the capillaries. This pressure should be taken into account when entering the values for the start and end of the range:

\[
\text{Start [mm H}_2\text{O]} = -H \ [\text{mm}] \times X_{\rho_{\text{oil}}}
\]

\[
\text{End [mm H}_2\text{O]} = h_{\text{max}} \ [\text{mm}] \times X_{\rho_{\text{measured liquid}}} - H \ [\text{mm}] \times X_{\rho_{\text{oil}}}
\]

\( \rho_{\text{oil}} \) for DC-550 oil is equal to 1.068 g/cm\(^3\)

\( \rho_{\text{oil}} \) for AK-20 oil is equal to 0.945 g/cm\(^3\)

### Configuration of the transmitter to measure density of liquids

#### The measurement task:
To convert a variation in liquid density from \( \rho_{\text{min}} = 0.6\) g/cm\(^3\) to \( \rho_{\text{max}} = 1.2\) g/cm\(^3\) to a variation in the output signal from 4 to 20 mA, with the vertical spacing of the diaphragm seals equal to \( H = 3000 \) mm. The sealing system is filled with DC-550 oil with density \( \rho_{\text{oil}} = 1.068 \) g/cm\(^3\).

1. Calculate the value of the start of the range as follows:
\[
H_{\text{start}} \times (X_{\rho_{\text{min}}} - X_{\rho_{\text{oil}}}) =
\]
\[
= 3000 \times (0.6 - 1.068) = -1404 \text{ [mm H}_2\text{O]}
\]
2. Calculate the value of the end of the range as follows:
\[
H_{\text{end}} \times (X_{\rho_{\text{max}}} - X_{\rho_{\text{oil}}}) =
\]
\[
= 3000 \times (1.2 - 1.068) = 396 \text{ [mm H}_2\text{O]}
\]
3. Set the zero point of the transmitter with the diaphragm seals positioned at the same level.
4. Install the transmitter in its working position.
5. Make the electrical connections to the transmitter, providing for the possibility of using HART communication.
6. Connect the KAP-02 communicator, identify the transmitter and select the "configuration" function.
7. On the configuration menu select "Reranging" procedure.
8. On the “Reranging” menu:
   a) change the measurement units to mm H₂O at 4°C;
   b) enter the calculated values for the start (–1404) and end (396) of the range.

When the transmitter has been configured in this way it is ready to be used to carry out the given measurement task.

Note: If it is possible to fill the space between the seals with a liquid whose density corresponds to the start of the measurement range, the start of the range of the transmitter can be set using regulated pressure.

Measurement of phase boundary
The height of the phase boundary of liquids of different densities is determined by measuring the average density of the medium between the seals.

Example:
Calculate the measurement range start and end points for an APRE-2200 transmitter configured to measure phase boundary height in the range 0–1000 mm between liquids of density \( \rho_1 = 0.7 \) g/cm³ and \( \rho_2 = 1.0 \) g/cm³, where the vertical spacing of the seals \( H = 1600 \) mm. The sealing system uses DC-550 oil with a density of 1.068 g/cm³.

To determine the start of the measurement range, calculate the pressure difference at the transmitter when the tank is filled with the lighter liquid only:

\[
H = 1600 \text{ mm} \\
0 \leq h < 1000 \text{ mm} \\
\rho_1 = 0.7 \text{ g/cm}^3 \\
\rho_2 = 1.0 \text{ g/cm}^3 \\
\rho_{\text{oil}} = 1.068 \text{ g/cm}^3
\]

\[4...20 \text{ mA} \]

\[\Delta P\]

\[\rho_1\]

\[\rho_2\]

\[H = 1600 \text{ mm} \]

\[0 \leq h < 1000 \text{ mm} \]

\[\rho_{\text{oil}} = 1.068 \text{ g/cm}^3\]

\[\text{To determine the start of the measurement range, calculate the pressure difference at the transmitter when the tank is filled with the lighter liquid only:}\]

\[1600 \text{ [mm]} \times (0.7 - 1.068) = -588.8 \text{ [mm H}_2\text{O]}\]

\[\text{To determine the end-point of the range, add the increase in pressure resulting from the appearance of a 1 metre column of the heavier liquid:}\]

\[-588.8 \text{ [mm H}_2\text{O}] + (1.0 - 0.7) \times 1000 \text{ [mm]} = -288.8 \text{ [mm H}_2\text{O]}\]

Additional remarks
The settings of the transmitter can be adjusted with reference to laboratory results from density measurements carried out on samples of the liquid being measured. This is most often necessary when the measurement takes place in a pipeline segment where the flow velocity of the measured liquid reaches several m/s.

Increasing the vertical spacing of the diaphragm seals widens the range and often improves measurement accuracy.

In planning the spacing of the diaphragm seals, ensure that the pressure difference at the transmitter lies within the basic range.

The maximum vertical spacing of the diaphragm seals (H) depends on the transmitter’s basic range and the boundary values for the density of the measured liquid (\( \rho_{\text{min}}; \rho_{\text{max}} \)).

If \( \rho_{\text{min}} < \rho_{\text{oil}} < \rho_{\text{max}} \), the seal spacing H should satisfy the following conditions:

\[
H [\text{mm}] \leq \frac{\text{lower boundary of range} [\text{mm H}_2\text{O}]}{X_{\rho_{\text{min}}} - X_{\rho_{\text{oil}}}}
\]

\[
H [\text{mm}] \leq \frac{\text{upper boundary of range} [\text{mm H}_2\text{O}]}{X_{\rho_{\text{max}}} - X_{\rho_{\text{oil}}}}
\]

Example:
Determine the maximum vertical spacing of the seals for the APRE-2200 / -10...10 kPa transmitter when measuring the density of liquid between 0.6 and 1.2 g/cm³. The sealing system uses AK-20 silicone oil with a density of 0.945 g/cm³.

The lower boundary of the range of the transmitter is \(-10 \text{ kPa} = –1020 \text{ mm H}_2\text{O}\)

\[
H [\text{mm}] \leq \frac{-1020}{0.6 - 0.945} \Rightarrow \quad H [\text{mm}] \leq \frac{-1020}{-0.345} \Rightarrow \quad H [\text{mm}] \leq 2957
\]

The upper boundary of the range of the transmitter is +10 kPa = 1020 mm H₂O

\[
H [\text{mm}] \leq \frac{1020}{1.2 - 0.945} \Rightarrow \quad H [\text{mm}] \leq \frac{1020}{0.255} \Rightarrow \quad H [\text{mm}] \leq 4000
\]

In the example, both conditions are satisfied when the spacing of the seals is not more than 2957 mm.