Variable Axial Piston Pump
416 series

TECHNICAL CATALOGUE

PSM-HYDRAULICS

2011
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General information

416 series pumps – worldwide usage product, designed for the global market.

Purpose

416 series pumps are intended for operation in hydrostatic transmissions. The pumps convert the shaft rotation mechanical energy into the working fluid energy. Hydraulic pump flow is proportional to the shaft rotation frequency and working displacement. Working displacement volume is steplessly regulated from zero up to the max volume into each side. Fluid flow direction can be reversed by swash-plate inclination angle change into the opposite side from neutral position.

Application

Intended for application in mobile and stationary installations in set with hydrostatic transmissions.

Design

Variable displacement swash-plate axial-piston.

Size range

416 series pumps with the following working displacement:

- 416.0.71 - 71 cm³
- 416.0.90 - 90 cm³
- 416.0.110 - 110 cm³
- 416.0.125 - 125 cm³

Operating pressure

- max - 400 bar
- peak - 450 bar

Connection

- mounting flanges:
  - SAE C (Ø127 mm) 4 bolt
  - SAE C (Ø127 mm) 4+2 bolts
  - SAE D (Ø152,4 mm) 4 bolt
  - SAE D (Ø152,4 mm) 4+2 bolts

- operating pressure ports:
  - SAE 1" 3000psi
  - SAE 1" 6000psi

- case drain ports:
  - as per GOST 26065 / ISO 6149-1
  - as per ISO 9974-1 / DIN 3952-1
  - as per ISO 11926-1

- shaft ends:
  - as per GOST 6033-80
  - as per ANSI B92.1a
  - as per DIN5480

Controls

- servocontrol
- electrical proportional (12VDC, 24VDC)
- electrical proportional without feedback (12VDC, 24VDC)
- electrical 3-position (12VDC, 24VDC)
- hydraulic proportional
- hydraulic proportional without feedback

Built-in options

- charge pump
- charge pressure valve
- check-safety valves

Requirement options

- through drives options
- cut-off valve
- mechanical stroke limiter
- shaft speed sensor
- build-in filter
- build-in amplifier
416 series pumps description.

The pump has cast iron housing with:
- swash-plate which rests on two roller bearings mounted sideways in the housing;
- the main shaft, passing through the pump, on the front side rests on roller bearing also mounted in the housing. On the back side the shaft rests on the friction bearing which is mounted in the rear cap.
- pump rotary group driven through spline connection of cylinders block and main shaft. Rotary group pistons feet are pressed to the swash-plate and slide on it during the rotary group rotation;
- gasket cap mounted on pump housing from mounting flange side. The gasket mounted in the gasket cap provides the pump housing leak proofness on the main shaft.

The pumps are equipped with various versions of back caps.
- gerotor type charge pump;
- charge valve;
- two check-safety valves;
- cut-off valve + two check valves;
- built-on filter.

The pumps are equipped with various versions of control mechanisms.
Hydraulic scheme of hydrostatic transmission.

Hydrostatic transmission is a close loop hydraulic system consisting of hydraulic pump and hydraulic motor. Hydrostatic transmission is intended to convey the mechanical energy from drive engine to the article actuating device.

The main close loop.

The hydraulic motor main ports are connected to the pump main ports with hydraulic lines. The working fluid flows in any direction from the pump to hydraulic motor and then returns to the pump in this close loop. Each of the hydraulic lines can be under high pressure. In operation mode the swash plate position determines which of the lines is under high pressure and also determines the working fluid flow direction.

Drain circuit and heat exchange.

The drain lines are necessary for hydraulic motor and pump in order to remove the hot fluid from drain chambers. Hydraulic motor should be connected with drain line through the drain hole located in the upper zone in order to provide hydraulic motor drain chamber filling. Hydraulic motor drain line is recommended to be connected with pump lower drain hole, unified leakages outlet into hydraulic tank is performed through the pump upper drain hole. The heat exchanger is intended for the cooling of working fluid from drain leaks before the fluid gets into hydraulic tank.

The pump hydraulic circuit diagram

A, B – operating pressure ports
A1, B1 – operating pressure gauge ports
X1, X2 – control pressure gauge ports
T1, T2 – case drain ports
T3 – shaft speed sensor installation port
R – air bleed
S – charge pump suction in line port
Fa, Fe – filter connection ports / charge pressure control ports
### Ordering Code

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>N</th>
<th>O</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>/</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

- = standard
○ = optional
- = not available

#### A - series
- **code**: description
- 416: series 416

#### B - product version
- **code**: description
- 0: basic

#### C - displacement
- **code**: displacement
- 71: 71 ccm/rev
- 90: 90 ccm/rev
- 110: 110 ccm/rev
- 125: 125 ccm/rev

#### D - rotation
- **code**: description
- R: right
- L: left

#### E - mounting flange
- **code**: description
- Y2: SAE J744 – 4 hole
- Y3: SAE D J744 – 4+2 hole
- Y4: SAE C J744 – 4+2 hole
- Y5: SAE D J744 – 4 hole

#### F - shaft end
- **code**: description
- A2: splined shaft W35x2x30x16x9g DIN5480
- A3: splined shaft W40x2x30x18x9g DIN5480
- A4: splined shaft W45x2x30x21x9g DIN5480
- S1: splined shaft 1 1/4" 1/4-28 ANUSA92.1a
- S2: splined shaft 1 3/8" 21T 16/32DP ANSI B92.1a
- S3: splined shaft 1 1/2" 23T 16/32DP ANSI B92.1a
- S4: splined shaft 1 3/4" 13T 8/16DP ANSI B92.1a
- H3: splined shaft 1 1/2" 23T 16/32DP ANSI B92.1a with installed flange
- K1: tapered Ø34.92mm, 1 3/8", 1:8
- K2: tapered Ø38.1mm, 1 1/2", 1:8
- K3: tapered Ø44.45mm, 1 3/4", 1:8
- K4: tapered Ø45 mm, 1:10
- K5: tapered Ø55 mm, 1:10

#### G - end cap ports
- **code**: description
- F2: SAE 1" 3000PSI / M36x2
- F3: SAE 1" 6000PSI / M42x2
- F4: SAE 1 1/4" 6000PSI / M48x2

#### H - high pressure valve settings
- **code**: description
- A: $\Delta P_{min} = 250$ bar
- B: $\Delta P_{min} = 300$ bar
- C: $\Delta P_{min} = 350$ bar
- D: $\Delta P_{min} = 400$ bar
- E: $\Delta P_{min} = 420$ bar

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- Suction line
  - 1: M27x2, 18 mm, ISO 6149-1
  - 2: M36x2, 26 mm, ISO 9974-1 / DIN 3852-1
  - 3: M42x2, 24 mm, ISO 6149-1
  - 4: M480, 26 mm, ISO 9974-1 / DIN 3852-1

- System ports (high pressure)
  - 1: SAE 3/4" 6000PSI (23.8 x 30.8 mm, M10-7H)
  - 2: SAE 1" 3000PSI (26.2 x 52.4 mm, M10-7H)
  - 3: SAE 1" 6000PSI (27.8 x 57.2 mm, M12-6H)
  - 4: SAE 1 1/4" 6000PSI (31.75 x 66.68 mm, M14-6H)
## I - end cap options

<table>
<thead>
<tr>
<th>code</th>
<th>description</th>
<th>416.0.71</th>
<th>416.0.90</th>
<th>416.0.110</th>
<th>416.0.125</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SAE flange ports A and B at opposite side / PRV</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>2</td>
<td>SAE flange ports A and B at opposite side / PRV, COV</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

### I - valves
- 0: check valves (CV)
- 1: pressure-relief valves (PRV)
- 2: pressure-relief valves (PRV), cut-off valve (COV)

## J - controls

<table>
<thead>
<tr>
<th>code</th>
<th>description</th>
<th>416.0.71</th>
<th>416.0.90</th>
<th>416.0.110</th>
<th>416.0.125</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>without control</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>HD</td>
<td>proportional hydraulic without feedback</td>
<td>●</td>
<td>●</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>HP</td>
<td>proportional hydraulic</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>P</td>
<td>proportional servocontrol</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>E1</td>
<td>electrical 3-position (12VDC)</td>
<td>●</td>
<td>●</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>E2</td>
<td>electrical 3-position (24VDC)</td>
<td>●</td>
<td>●</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>E3</td>
<td>proportional electrical (12VDC)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>E4</td>
<td>proportional electrical (24VDC)</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</table>

## K - auxiliary mounting pad

<table>
<thead>
<tr>
<th>code</th>
<th>description</th>
<th>416.0.71</th>
<th>416.0.90</th>
<th>416.0.110</th>
<th>416.0.125</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>none</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>A</td>
<td>flange SAE A (Ø82.55 mm); splined 9T 16/32DP ANSI B92.1a</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>B</td>
<td>flange SAE B (Ø101.6 mm); splined 13T 16/32DP ANSI B92.1a</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>X</td>
<td>flange SAE B-B (Ø101.6 mm); splined 15T 16/32DP ANSI B92.1a</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>C</td>
<td>flange SAE C (Ø127 mm); splined 17T 16/32DP ANSI B92.1a</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>M</td>
<td>flange SAE C (Ø127 mm); splined 17T 16/32DP ANSI B92.1a</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>K</td>
<td>flange (Ø360 mm); splined D-6x13x16</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>L</td>
<td>flange (Ø90 mm); splined D-6x21x25</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>T</td>
<td>flange (Ø480 mm); splined 20XH/X1.5x9g GOST 6033-80</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>H</td>
<td>flange (Ø125 mm); splined 35x2x30x14x9g DIN 5480</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>D</td>
<td>flange (Ø140 mm); splined 35x2x30x16x9g DIN 5480</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
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</table>

## L - displacement limitation

<table>
<thead>
<tr>
<th>code</th>
<th>description</th>
<th>416.0.71</th>
<th>416.0.90</th>
<th>416.0.110</th>
<th>416.0.125</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>without displacement limiter</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>V</td>
<td>with mechanical limiter</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
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</table>

## M - filtration

<table>
<thead>
<tr>
<th>code</th>
<th>description</th>
<th>416.0.71</th>
<th>416.0.90</th>
<th>416.0.110</th>
<th>416.0.125</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>external, charge pump suction line filtration</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>F2</td>
<td>external, charge pump pressure line filtration</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>F3</td>
<td>internal, charge pump pressure line filtration</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
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</table>

## N - special features

<table>
<thead>
<tr>
<th>code</th>
<th>description</th>
<th>416.0.71</th>
<th>416.0.90</th>
<th>416.0.110</th>
<th>416.0.125</th>
</tr>
</thead>
<tbody>
<tr>
<td>NN</td>
<td>none</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>IN</td>
<td>case drain ports 7/8-14UNF-2B ISO 11926-1</td>
<td>●</td>
<td>●</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>RN</td>
<td>case drain ports M22x1,5 ISO 9974-1 / DIN 3852-1</td>
<td>○</td>
<td>○</td>
<td>-</td>
<td>-</td>
</tr>
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</table>

## O - shaft seal

<table>
<thead>
<tr>
<th>code</th>
<th>description</th>
<th>416.0.71</th>
<th>416.0.90</th>
<th>416.0.110</th>
<th>416.0.125</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>NBR</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>F</td>
<td>FKM</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

## P - climatic version and category of disposition

<table>
<thead>
<tr>
<th>code</th>
<th>description</th>
<th>416.0.71</th>
<th>416.0.90</th>
<th>416.0.110</th>
<th>416.0.125</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y1</td>
<td>temperate climate, placing on open air</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>T1</td>
<td>tropical climate, placing on open air</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
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</table>
### Technical characteristics.

<table>
<thead>
<tr>
<th>Type range</th>
<th>416.0.71</th>
<th>416.0.90</th>
<th>416.0.110</th>
<th>416.0.125</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working displacement $V_g$, cm$^3$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- min $V_{g\min}$</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>- max $V_{g\max}$</td>
<td>71</td>
<td>90</td>
<td>110</td>
<td>125</td>
</tr>
<tr>
<td>Shaft rotation speed $n$, rpm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- min $n_{\min}$</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>- max $n_{\max}$, at input pressure = 0.8 bar</td>
<td>3050</td>
<td>3050</td>
<td>3000</td>
<td>3000</td>
</tr>
<tr>
<td>- peak $n_{\peak}$, at input pressure = 2 bar</td>
<td>3300</td>
<td>3300</td>
<td>3200</td>
<td>3200</td>
</tr>
<tr>
<td>Flow $Q$, l/min</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- minimal $Q_{\min}$</td>
<td>33.73</td>
<td>42.75</td>
<td>52.25</td>
<td>59.38</td>
</tr>
<tr>
<td>- nominal $Q_{nom}$</td>
<td>134.9</td>
<td>171.00</td>
<td>156.75</td>
<td>178.37</td>
</tr>
<tr>
<td>- max $Q_{\max}$</td>
<td>205.72</td>
<td>260.78</td>
<td>313.50</td>
<td>356.25</td>
</tr>
<tr>
<td>Operating pressure (difference) $\Delta P$, bar</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- nominal $\Delta P_{\nom}$</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>- max working $\Delta P_{\max}$</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>- peak $\Delta P_{\peak}$</td>
<td>450</td>
<td>450</td>
<td>450</td>
<td>450</td>
</tr>
<tr>
<td>Charge pressure $P_p$, bar</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- at $V_g=0$, $n_{\min}$</td>
<td>27</td>
<td>27</td>
<td>27</td>
<td>27</td>
</tr>
<tr>
<td>- at $V_g \neq 0$, $n_{\nom}$</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Charge pump input pressure (absolute) $P_p$, bar</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- min working</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>- min short-term (t&lt;5 min) (at idling)</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Drain pressure $P_{dr}$, bar</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- max working</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>- max short-term (t&lt;5 min)</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Power $N$, kW</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- nominal $N_{\nom}$, at $n_{\nom}, V_{g\max}, P_{\nom}$</td>
<td>60.44</td>
<td>76.28</td>
<td>70.00</td>
<td>79.40</td>
</tr>
<tr>
<td>- max $N_{\max}$, at $n_{\max}, V_{g\max}, P_{\max}$</td>
<td>146.32</td>
<td>184.95</td>
<td>222.54</td>
<td>252.54</td>
</tr>
<tr>
<td>- peak $N_{\peak}$, at $n_{\peak}, V_{g\max}, P_{\peak}$</td>
<td>177.84</td>
<td>224.86</td>
<td>266.71</td>
<td>302.71</td>
</tr>
<tr>
<td>Torque $T$, N•m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- nominal $T_{\nom}$, at $n_{\nom}, V_{g\max}, P_{\nom}$</td>
<td>288.61</td>
<td>364.21</td>
<td>445.77</td>
<td>505.46</td>
</tr>
<tr>
<td>- max $T_{\max}$, at $n_{\max}, V_{g\max}, P_{\max}$</td>
<td>458.11</td>
<td>579.07</td>
<td>708.38</td>
<td>803.87</td>
</tr>
<tr>
<td>- peak $T_{\peak}$, at $n_{\peak}, V_{g\max}, P_{\peak}$</td>
<td>514.61</td>
<td>650.69</td>
<td>795.91</td>
<td>903.34</td>
</tr>
<tr>
<td>Volume efficiency</td>
<td>0.95</td>
<td>0.95</td>
<td>0.95</td>
<td>0.95</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>67</td>
<td>67</td>
<td>80</td>
<td>80</td>
</tr>
</tbody>
</table>

### Calculation of size

- **Flow** $Q = \frac{V_g \cdot n \cdot \eta_v}{1000}$ l/min
- **Torque** $T = \frac{V_g \cdot \Delta P}{20 \cdot \pi \cdot \eta_{mh}}$ N•m
- **Power** $N = \frac{Q \cdot \Delta P}{600 \cdot \eta_t}$ kW

Where:
- $Q$ – flow, l/min
- $T$ – torque, N•m
- $N$ – power, kW
- $V_g$ – pump displacement, cm$^3$
- $n$ – shaft rotation frequency, rpm
- $\Delta P$ – pressure difference, bar
- $\eta_v$ – volume efficiency
- $\eta_{mh}$ – hydro-mechanical efficiency
- $\eta_t = \eta_v \cdot \eta_{mh}$ – overall efficiency
Working fluid requirements.

Working fluid temperature:
- Max constant: +75°C
- Max peak (short-term): +100°C
- Min short-term (at cold start): -40°C

Working fluid cinematic viscosity:
- Optimal (constant): 20-35 mm²/sec (cSt)
- Max startup: 1500 mm²/sec (cSt)
- Min short-term: 10 mm²/sec (cSt)

Working fluid purity:
- At least 12th class as per GOST 17216-71
- At least 18/15th class as per ISO/DIN 4406

Allowed radial and axial loads on shaft.

Hydraulic pump bearing lifetime directly depends on the forces acting on pump shaft from outside.

The scheme of acting forces is given on the figure:

\[ M = F \cdot L \]  
- \( M \) – torque
- \( F_{\text{out}} \) – axial force from hydraulic pump
- \( F_{\text{in}} \) – axial force into hydraulic pump

In order to avoid hydraulic motors premature failure it is necessary to observe the restrictions on outer forces on hydraulic motor output shaft.

The values of peak loads on shaft are given in the table.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>416.0.71</th>
<th>416.0.90</th>
<th>416.0.110</th>
<th>416.0.125</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radial load ( F_r ), N</td>
<td>1800</td>
<td>3500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cradle/shoulder L, mm</td>
<td>23.4</td>
<td>23.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Axial load ( F_{\text{in}} ), N</td>
<td>2140</td>
<td>2110</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Axial load ( F_{\text{out}} ), N</td>
<td>843</td>
<td></td>
<td>475</td>
<td></td>
</tr>
</tbody>
</table>
Charge pump. Charge valve.

The pumps are equipped with mounted in the back cap booster pump of gerotor type and charge valve.

Gerotor type charge pump is intended:
- provides flow to make up internal leakage, maintain a positive pressure in the main circuit
- provide flow for cooling and filtration
- to provide flow and pressure for the control system

Spline bushing rotates the gear by the key. The gear rotates the wheel. The gear with the wheel comprise the gerotor type charge pump.

Charge valve is intended to provide flow and pressure for the control system

Charge pump displacement.

<table>
<thead>
<tr>
<th>size</th>
<th>416.0.71</th>
<th>416.0.90</th>
<th>416.0.110</th>
<th>416.0.125</th>
</tr>
</thead>
<tbody>
<tr>
<td>V, cm³</td>
<td>19.8</td>
<td>26.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Charge pump input pressure:
- min working (absolute) = 0.8 bar
- min short-term, at cold start (t<5 min) (absolute) = 0.5 bar

Charge valve adjustment pressure = 27+1 bar (by default).

The charge pressure is adjusted at:
- pump shaft speed n = 1500 rpm; Charge pressure can be adjusted in negotiation with the consumer.
- working fluid temperature in the loop t = +45…50º C.
Check-safety valves.

The pumps has built-on two check-safety valves mounted in the back cap. Check-safety valves of double action are intended for the restriction of the peak pressure in working lines and for the working fluid flow from charge pump into the main pump suction line.

Swash-plate neutral position.

Swash-plate is inclined.

At swash-plate neutral position check safety valves operate as check valves providing lines A and B with the working fluid from charge pump. A and B lines pressure conforms to the charge pressure.

Check-safety valve operation in check valve mode

At swash-plate inclination into one of the sides the corresponding check-safety valve operates as a safety valve (line A), the other valve (line B) stays in the mode of check valve charging the rotary group suction line with the working fluid from charge pump.

Check-safety valve operation in safety valve mode

The valve core shifts into the valve housing pressing the weak spring. The valve lets the working fluid pass from charge pump into the main pump suction line. The fluid pressure corresponds the charge pressure.

Check-safety valve adjustment pressure (difference) $\Delta P = 350 \pm 5$ bar (by default).

Valve operation is adjusted at
- pump shaft speed $n = 1500$ rpm;
- working fluid temperature in the loop $t = +45 \ldots +50^\circ$C.

Check safety valve operation can be adjusted in negotiation with the consumer.

Hydraulic circuit diagram
Cut-off valve.

The pumps can be equipped with cut-off valve. The cut-off valve is mounted in the pump back cap. Two check valves are installed in the back cap together with cut-off valve.

The cut-off valve prevents high pressure safety valves operation at acceleration and braking which allows avoiding hydraulic system overheating connected with safety valves operation. As safety valves open only for the pressure peaks periods the heat release in this case is minimal in connection with short-term opening.

Cut-off valve acts by regulation principle when pressure increasing in one of the pressure lines till the certain value leads to the valve nipple shift connecting the control line with drain line. At this time the control line pressure drops till the drain pressure which leads the servo piston returning into the neutral position, and pump working displacement decreasing till zero. The throttle separating the charge and regulation lines does not let the charge pressure drop till the drain pressure.

The pressure from A and B pressure lines is brought to the cut-off valve through two check valves.

The cut-off valve operation is adjusted 10...30 bar lower than safety valves operation adjustment.

Cut-off valve adjustment pressure = 350+5 bar (by default).

Cut-off valve operation is adjusted at:
- pump shaft rotation speed $n = 1500 \text{ rpm}$;  
- working fluid temperature in the loop $t = +45 \ldots 50^\circ\text{C}$.

Cut-off pressure can be adjusted in negotiation with consumer.

Hydraulic circuit diagram
Servocontrol.

Proportional servocontrol control converts a mechanical input signal to a hydraulic signal that tilts the cradle swashplate through an angular rotation varying the pump’s displacement from full displacement in one direction to full displacement in the opposite direction.

The pump displacement is proportional to the lever rotation angle.

The manual displacement control has a mechanical feedback mechanism which moves a servo valve in the proper relationship to the input signal and the angular position of the swashplate. The control is designed so that the angular rotation of the swashplate is proportional to the mechanical input signal.

Hydraulic Circuit

The control characteristic

A, B – operating pressure ports (high pressure)
A1, B1 – operating pressure gauge ports
X1, X2 – control pressure gauge ports
T1, T2 – case drain ports
S – charge pump suction port
R – air bleed
F – charge pressure gauge port

External control handle requirements:
- dead zone ±2°
- proportional zone 2°..26°
- maximum zone 26°..30°

Torque on lever:
- start of control 2.8Nm
- end of control 8.0Nm

Maximum torque on control lever 14Nm.

Attention! Excess of the given value can damage the pump. In case of possible excess of the maximum torque on the lever it is necessary to install additional (external) limiter of an angle.

<table>
<thead>
<tr>
<th>Shaft rotation</th>
<th>Lever rotation</th>
<th>Flow direction</th>
<th>Control pressure gauge port</th>
<th>High pressure gauge port</th>
</tr>
</thead>
<tbody>
<tr>
<td>left</td>
<td>left</td>
<td>A &gt;&gt; B</td>
<td>X1</td>
<td>B1</td>
</tr>
<tr>
<td></td>
<td>right</td>
<td>B &gt;&gt; A</td>
<td>X2</td>
<td>A1</td>
</tr>
<tr>
<td>right</td>
<td>left</td>
<td>B &gt;&gt; A</td>
<td>X1</td>
<td>A1</td>
</tr>
<tr>
<td></td>
<td>right</td>
<td>A &gt;&gt; B</td>
<td>X2</td>
<td>B1</td>
</tr>
</tbody>
</table>
Electrical Proportional Control.

Electrical proportional control is intended for transformation of an electrical control signal in an amplified hydraulic signal, which by means of servo piston moving the swash plate (on an angle ±20º) causes linear change of a pump displacement in each way.

The pump displacement is proportional to the control current delivered at the solenoid.

The control PWM-signal affects a proportional solenoid.

The solenoid will convert PWM-signal to mechanical movement of a control valve spool.

Proportionality of pump displacement change is provided with presence of a mechanical feedback between servo cylinder and a spool valve of the control mechanism.

### Hydraulic Circuit

- **A, B** – operating pressure ports (high pressure)
- **A1, B1** – operating pressure gauge ports
- **X1, X2** – control pressure gauge ports
- **E1, E2** – solenoid connector
- **T1, T2** – case drain ports
- **S** – charge pump suction port
- **R** – air bleed
- **F** – charge pressure gauge port

### The control characteristic

<table>
<thead>
<tr>
<th>Nominal voltage</th>
<th>12VDC</th>
<th>24VDC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start of control (a), Imin, mA</td>
<td>600</td>
<td>300</td>
</tr>
<tr>
<td>End of control (b), Imax, mA</td>
<td>1500</td>
<td>750</td>
</tr>
<tr>
<td>Maximum current (c), Ipeak, mA</td>
<td>2500</td>
<td>1000</td>
</tr>
<tr>
<td>Resistance @ (at 20 ºC)</td>
<td>2.3W ±7%</td>
<td>13.4W ±7%</td>
</tr>
<tr>
<td>Duty cycle</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Protection to IEC 529</td>
<td>IP65</td>
<td></td>
</tr>
<tr>
<td>PWM frequency</td>
<td>50 – 200Hz</td>
<td></td>
</tr>
<tr>
<td>Solenoid connector</td>
<td>DIN 43650</td>
<td></td>
</tr>
</tbody>
</table>

### Pump output flow direction vs. input signal

<table>
<thead>
<tr>
<th>shaft rotation</th>
<th>solenoid</th>
<th>flow direction</th>
<th>control pressure gauge port</th>
<th>high pressure gauge port</th>
</tr>
</thead>
<tbody>
<tr>
<td>left</td>
<td>E1</td>
<td>A =&gt; B</td>
<td>X1</td>
<td>B1</td>
</tr>
<tr>
<td>right</td>
<td>E2</td>
<td>B =&gt; A</td>
<td>X2</td>
<td>A1</td>
</tr>
<tr>
<td></td>
<td>E1</td>
<td>A =&gt; B</td>
<td>X1</td>
<td>A1</td>
</tr>
<tr>
<td></td>
<td>E2</td>
<td>A =&gt; B</td>
<td>X2</td>
<td>B1</td>
</tr>
</tbody>
</table>
Electrical Proportional Control without Feedback.

Electrical proportional control is intended for transformation of an electrical control signal in an amplified hydraulic signal, which by means of servo cylinder moving the swash plate (on an angle ±20º) causes linear change of a pump displacement in each way.

The pump displacement is proportional to the solenoid signal current, but it also depends upon system pressure.

The control mechanism is based on two proportional reducing valves with electrocontrol. Each valve is established in a control line of the servo cylinder. At giving of an electric signal of control, the valve proportionally regulates size of pressure in either side of servo cylinder.

At change of system pressure, the control characteristic also changes (see The control characteristic).

At switching-off of the PWM-signal of control, the reducing valve is disconnected, servo cylinders springs return a swashplate in a neutral position.

The hydraulic circuit includes:

- A, B – operating pressure ports (high pressure)
- A1, B1 – operating pressure gauge ports
- X1, X2 – control pressure gauge ports
- E1, E2 – solenoid connector
- T1, T2 – case drain ports
- S – charge pump suction port
- R – air bleed
- F1 – charge pressure gauge port

### Hydraulic Circuit

#### The control characteristic

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Nominal voltage</th>
<th>12VDC</th>
<th>24VDC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start of control, Imin, mA</td>
<td></td>
<td>600</td>
<td>300</td>
</tr>
<tr>
<td>End of control, Imax, mA</td>
<td></td>
<td>1300</td>
<td>650</td>
</tr>
<tr>
<td>Maximum current, Ipeak, mA</td>
<td></td>
<td>1500</td>
<td>750</td>
</tr>
</tbody>
</table>
| Resistance @ (at 20 ºC)       |                 | 5.3W ±5% | 21.2W ±5% |}

 Protection to IEC 529: IP65

 PWM frequency: 100Hz

 Solenoid connector: AMP Junior Timer

<table>
<thead>
<tr>
<th>Pump output flow direction vs. input signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>shaft rotation</td>
</tr>
<tr>
<td>left</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>right</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Electrical 3-Position Control.

Electrical 3-position control uses an electric input signal to switch the pump to a full stroke position in each side.

General view

The top view of the pump

3-position electrical control is the solenoid operated directional valve.

At switching-off of the input signal, servo cylinders springs return a swashplate in a neutral position.

Hydraulic Circuit

The control characteristic

<table>
<thead>
<tr>
<th>Nominal voltage</th>
<th>12VDC</th>
<th>24VDC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum current, I_{peak}, mA</td>
<td>2500</td>
<td>1000</td>
</tr>
<tr>
<td>Resistance @ (at 20 ºC)</td>
<td>2.3 W ±7%</td>
<td>13.4 W ±7%</td>
</tr>
<tr>
<td>Duty cycle</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Protection to IEC 529</td>
<td>IP65</td>
<td></td>
</tr>
<tr>
<td>Solenoid connector</td>
<td>DIN 43650</td>
<td></td>
</tr>
</tbody>
</table>

Pump output flow direction vs. input signal

<table>
<thead>
<tr>
<th>shaft rotation</th>
<th>solenoid</th>
<th>flow direction</th>
<th>control pressure gauge port</th>
<th>high pressure gauge port</th>
</tr>
</thead>
<tbody>
<tr>
<td>left</td>
<td>E1</td>
<td>A =&gt; B</td>
<td>X1</td>
<td>B1</td>
</tr>
<tr>
<td></td>
<td>E2</td>
<td>B =&gt; A</td>
<td>X2</td>
<td>A1</td>
</tr>
<tr>
<td>right</td>
<td>E1</td>
<td>B =&gt; A</td>
<td>X1</td>
<td>A1</td>
</tr>
<tr>
<td></td>
<td>E2</td>
<td>A =&gt; B</td>
<td>X2</td>
<td>B1</td>
</tr>
</tbody>
</table>
Hydraulic Proportional Control.

Hydraulic proportional control is intended for transformation of an hydraulic control signal in an amplified hydraulic signal, which by means of servo piston moving the swash plate (on an angle ±20º) causes linear change of a pump displacement in each way.

The pump displacement is proportional to the control pressure.

General view

The top view of the pump

The hydraulic displacement control uses a hydraulic input signal to operate a servo valve, which distributes hydraulic pressure to either side of a servo cylinder. The servo cylinder tilts the swashplate, thus varying the pump’s displacement from full displacement in one direction to full displacement in the opposite direction.

The control has a mechanical feedback mechanism which moves the servo valve in relation to the input signal and the angular rotation of the swashplate. The hydraulic displacement control is designed so the angular position of the swashplate (pump displacement) is proportional to the hydraulic input signal pressure.

Hydraulic Circuit

The control characteristic

<table>
<thead>
<tr>
<th>Pump output flow direction vs. input signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>shaft rotation</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>left</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>right</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

A, B – operating pressure ports (high pressure)
A1, B1 – operating pressure gauge ports
X1, X2 – control pressure gauge ports
Y1, Y2 – control pressure ports
T1, T2 – case drain ports
S – charge pump suction port
R – air bleed
F – charge pressure gauge port

The control characteristic

Control pressure
- start of control (a), Pmin, bar 6.0
- end of control (b), Pmax, bar 18.0
Hydraulic Proportional Control without FeedBack.

Control pressure applied directly to the servo cylinder through either ports X1 or X2 (see The top view of pump). The pump displacement is proportional to the control pressure, but it also depends upon system pressure.

At change of system pressure, the control characteristic also changes (see The control characteristic).

At switching-off of the input signal, servo cylinders springs return a swashplate in a neutral position.

A, B – operating pressure ports (high pressure)
A1, B1 – operating pressure gauge ports
X1, X2 – control pressure ports
T1, T2 – case drain ports
S – charge pump suction port
R – air bleed
F – charge pressure gauge port

<table>
<thead>
<tr>
<th>Shaft Rotation</th>
<th>Control Port</th>
<th>Flow Direction</th>
<th>Control Pressure Gauge Port</th>
<th>High Pressure Gauge Port</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left</td>
<td>X1, X2</td>
<td>B =&gt; A, A =&gt; B</td>
<td>X1, X1</td>
<td>B1, A1</td>
</tr>
<tr>
<td>Right</td>
<td>X2</td>
<td>A =&gt; B</td>
<td>X2</td>
<td>A1</td>
</tr>
</tbody>
</table>

Pump output flow direction vs. input signal

The control characteristic

- start of control, \( P_{\text{min}} \), bar 6.0
- end of control, \( P_{\text{max}} \), bar 22.0
Auxiliary mounting pads

All 416 series pumps can be coupled with auxiliary mounting pads. The pumps can be delivered either in assembly with additional pumps or with coupling option so that the consumer can mount additional units. To choose the technical characteristics of additional units (pumps) see the technical information of the section "Torque".

To order the coupled pumps the complete designation of the mounted units should be given, f.i.:
416.0.71RY45SFF22C2E4/MVF1NNFT1 + 416.0.71RY25S22C21E2/AVF1NNFT1

To order the pump with auxiliary mounting pad the code of required coupling version should be given in field J, f.i.:
416.0.90RY45SFF22C2E4/AVF1NNFT1
Filtration.

Option F1. External filtration. Standard program.

The filter is mounted separately from the pump.

Filtration in charge pump suction line.

Technical requirements for the filter:
- rated flow 100 l/min
- max flow 130 l/min
- filtration fineness 10 µm
- filtering element material paper
- pressure change on filtering element: at \( v = 30 \text{ mm/s} \) (cSt), \( n = 1500 \text{ rpm} \) \( \Delta P = 0.1 \text{ bar} \)

The filter should have:
- by pass valve

The filter is not included into the pump delivery set.

Option F2. External filtration.

The filter is mounted separately from the pump.

Filtration in charge pump pressure line.

Connected to Fa and Fe channels on pump back cap.

Technical requirements for the filter:
- rated flow 70 l/min
- max flow 130 l/min
- filtration fineness 16 µm
- filtering element material fiberglass
- pressure change on filtering element: at \( v = 30 \text{ mm/s} \) (cSt), \( n = 1500 \text{ rpm} \) \( \Delta P = 0.2 \text{ bar} \)

The filter should have:
- filtering element contamination indicator
- by pass valve

The filter is not included into the pump delivery set.

Option F3. Internal filtration.

The filter is built-in in to the pump.

Filtration in charge pump pressure line.

Technical requirements for the filter:
- rated flow 70 l/min
- max flow 130 l/min
- filtration fineness 16 µm
- filtering element material fiberglass
- pressure change on filtering element: at \( v = 30 \text{ mm/s} \) (cSt), \( n = 1500 \text{ rpm} \) \( \Delta P = 0.2 \text{ bar} \)

The filter should have:
- filtering element contamination indicator
- by pass valve

The filter is not included into the pump delivery set.
Overall-mounting dimensions. Size range 71, 90 cm².

Main dimensions.

<table>
<thead>
<tr>
<th>A, B</th>
<th>operating pressure ports</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>suction port</td>
</tr>
<tr>
<td>T1, T2</td>
<td>case drain ports</td>
</tr>
<tr>
<td>A1, B1</td>
<td>operating pressure gauge ports</td>
</tr>
<tr>
<td>X1, X2</td>
<td>control pressure gauge ports</td>
</tr>
<tr>
<td>R</td>
<td>air bleed</td>
</tr>
<tr>
<td>Fa</td>
<td>charge pressure gauge ports</td>
</tr>
<tr>
<td>Fa, Fe</td>
<td>pressure filter ports</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>option</th>
<th>code</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>F2…</td>
</tr>
<tr>
<td>G</td>
<td>F3…</td>
</tr>
<tr>
<td>G</td>
<td>F…2</td>
</tr>
<tr>
<td>G</td>
<td>F…3</td>
</tr>
<tr>
<td>M</td>
<td>IN</td>
</tr>
<tr>
<td>M</td>
<td>RN</td>
</tr>
</tbody>
</table>

- standard program
Overall-mounting dimensions. Size range 71, 90 cm³.

Controls

**Electrical proportional**
Option I: E3 (12VDC), E4 (24VDC)

**Electrical proportional without feedback**
Option I: E5 (12VDC), E6 (24VDC)

**Hydraulic proportional**
Option I: HP

**Hydraulic proportional without feedback**
Option I: HD

**Electrical 3-position**
Option I: E1 (12VDC), E2 (24VDC)
Overall-mounting dimensions. Size range 71, 90 cm³.

Shaft ends

W35x2x30x16x9g DIN5480
Option F: A2

W40x2x30x18x9g DIN5480
Option F: A3

W45x2x30x21x9g DIN5480
Option F: A4

1 3/8" 21T 16/32pitch ANSI B92.1a
Option F: S2

1 1/2" 23T 16/32pitch ANSI B92.1a
Option F: S3

1 3/4" 13T 8/16pitch ANSI B92.1a
Option F: S4

1 1/4" 14T 12/24pitch ANSI B92.1a
Option F: S1
Overall-mounting dimensions. Size range 71, 90 cm³.

Built-in pressure filter

Hydraulic circuit diagram

Clogging indicator
connector DIN 43650
port Fa
M18x1.5-14
GOST 25065 / ISO 6149-1
port Fa
M12x1.5-12
GOST 25065 / ISO 6149-1

Connector pins
1 2 3
Overall-mounting dimensions. Size range 71, 90 cm³.

Mounting flanges.


Flange SAE D, 4 bolt. Option E: Y5.

Flange SAE D, 4+2 bolts. Option E: Y3.
Overall-mounting dimensions. Size range 71, 90 cm³.

Auxiliary mounting pads.

Flange SAE A, spline 9 teeth, 16/32 pitch. Option J: A.


Flange SAE B, spline 13 teeth, 16/32 pitch. Option J: B.
Overall-mounting dimensions. Size range 71, 90 cm$^2$.

Auxiliary mounting pads.

Flange SAE B-B, spline 15 teeth, 16/32 pitch. Option J: X.
Overall-mounting dimensions. Size range 110, 125 cm³.

Main dimensions.

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<td></td>
<td>M</td>
<td>standard program</td>
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SAE 1" 6000psi; M12-6Hx17; 57.2 x 27.8mm
SAE 1 1/4" 6000psi; M14-7Hx19; 66.7x31.75mm
M48x2, 26mm
M33x2-15 GOST 25064 / ISO 6149-1
7/8-14UNF-2B ISO 11926-1
M22x1.5-12 GOST 25065 / ISO 6149-1
M12x1.5-14 GOST 25065 / ISO 6149-1
M12x1.5-12 GOST 25065 / ISO 6149-1
M18x1.5-12 GOST 25065 / ISO 6149-1
M18x1.5-12 GOST 25065 / ISO 6149-1
Overall-mounting dimensions. Size range 110, 125 cm$^3$.

Controls.

Electrical proportional
Option I: E3 (12VDC), E4 (24VDC)

Hydraulic proportional
Option I: HP

Electro 3-position
Option I: E1 (12VDC), E2 (24VDC)

Electrical proportional without feedback
Option I: E5 (12VDC), E6 (24VDC)

Hydraulic proportional without feedback
Option I: HD
Overall-mounting dimensions. Size range 110, 125 cm³.

Shaft ends.

W40x2x30x18x9g DIN5480
Option F: A3

W45x2x30x21x9g DIN5480
Option F: A4

1 1/4" 14T 12/24pitch ANSI B92.1a
Option F: S1

1 3/8" 21T 16/32pitch ANSI B92.1a
Option F: S2

1 1/2" 23T 16/32pitch ANSI B92.1a
Option F: S3

1 3/4" 13T 8/16pitch ANSI B92.1a
Option F: S4
Overall-mounting dimensions. Size range 110, 125 cm³.

Built-in pressure filter.

Hydraulic circuit diagram.
Overall-mounting dimensions. Size range 110, 125 cm³.

Mounting flanges.


Flange SAE D, 4 bolt. Option E: Y5.

Flange SAE D, 4+2 bolts. Option E: Y3.
Overall-mounting dimensions. Size range 110, 125 cm³.

Auxiliary mounting pads.

Flange SAE A, spline 9 teeth, 16/32 pitch. Option J: A.


Flange SAE B, spline 13 teeth, 16/32 pitch. Option J: B.
Overall-mounting dimensions. Size range 110, 125 cm³.

Auxiliary mounting pads.

Flange SAE B-B, spline 15 teeth, 16/32 pitch. Option J: X.
Recommendations for mounting.

For faultless operation of 416 series pumps the requirements of the present section should be complied with.

Recommended pump direction – control mechanism should be located at the top or sideways (see Fig.).

Pump drain chamber should be always filled with working fluid. Before the first launch of the pump the air should be disinfated from the pump housing through port R and drain port T located at the upper point.

Charge pump and input channel of suction line should always be filled with working fluid.

Drain line and suction line are recommended to be connected as per the schemes given on the Fig.

Hole T3 in pump housings is intended for the mounting of the shaft speed sensor. Hole T3 is similar to holes T1 and T2. The hole is allowed to be used for draining.

Pump location above hydraulic tank level.

Pump location below hydraulic tank level.

Other pump direction is possible in negotiation with the manufacturer.