PSM HYDRAULICS

Variable Axial Piston Pump
416 series

TECHNICAL CATALOGUE

PSM-HYDRAULICS

2011

Contents

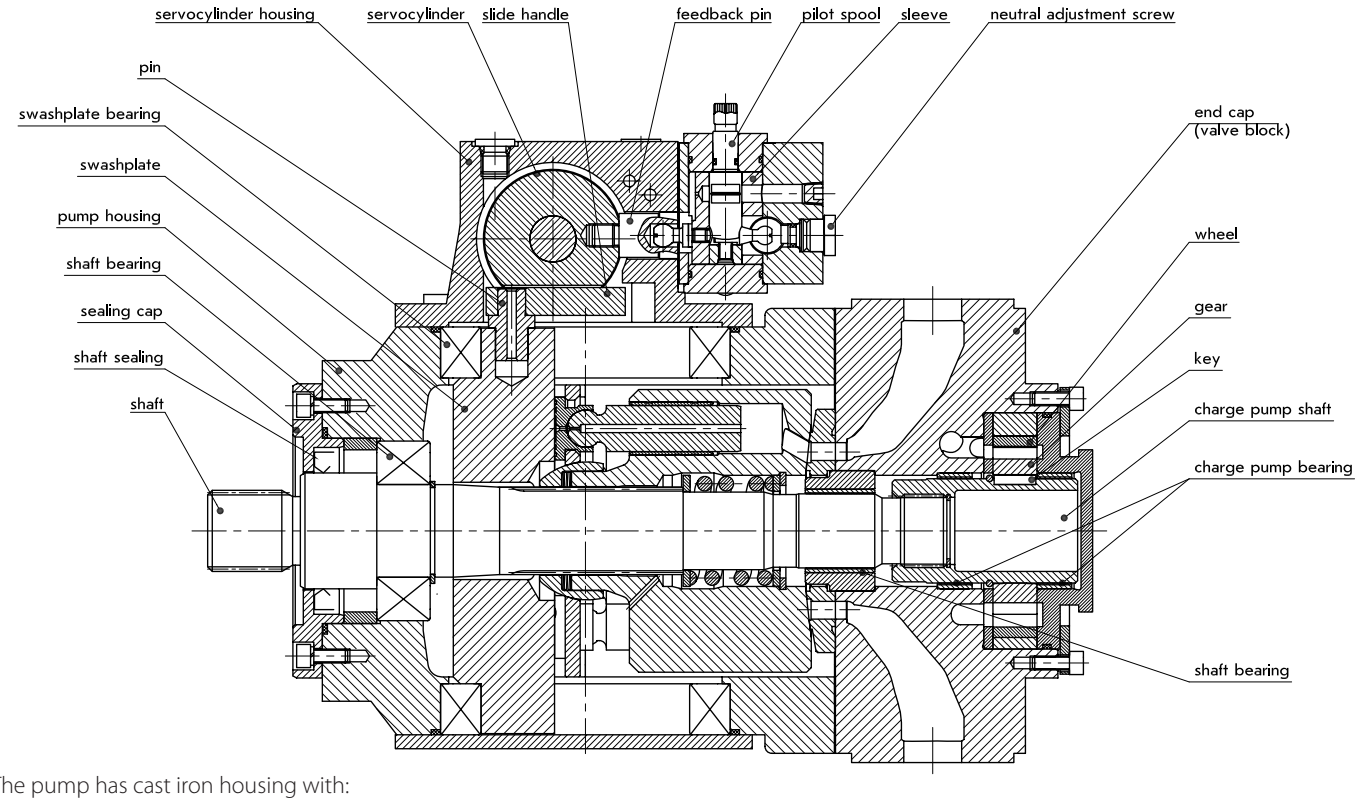
General information

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 cm^3. 416.0.90 - 90 cm^3. 416.0.110 - 110 cm^3. 416.0.125 - 125 cm^3.	
Operating pressure	max peak	- 400 bar - 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.

Section view

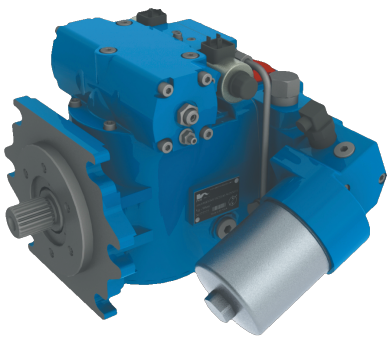


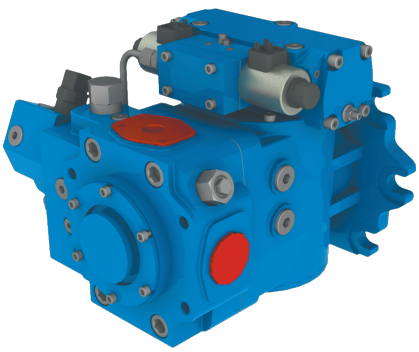
The pump has cast iron housing with:
- swash-plate which rests on two roller bearings mounted sideways in the housing;
- the main shaft, passing through the pump, on the front side rests on roller bearing also mounted in the housing. On the back side the shaft rests on the friction bearing which is mounted 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.
The pump back cap includes:
- gerotor type charge pump;
- charge valve;
- two check-safety valves;
- cut-off valve + two check valves;
- built-on filter.

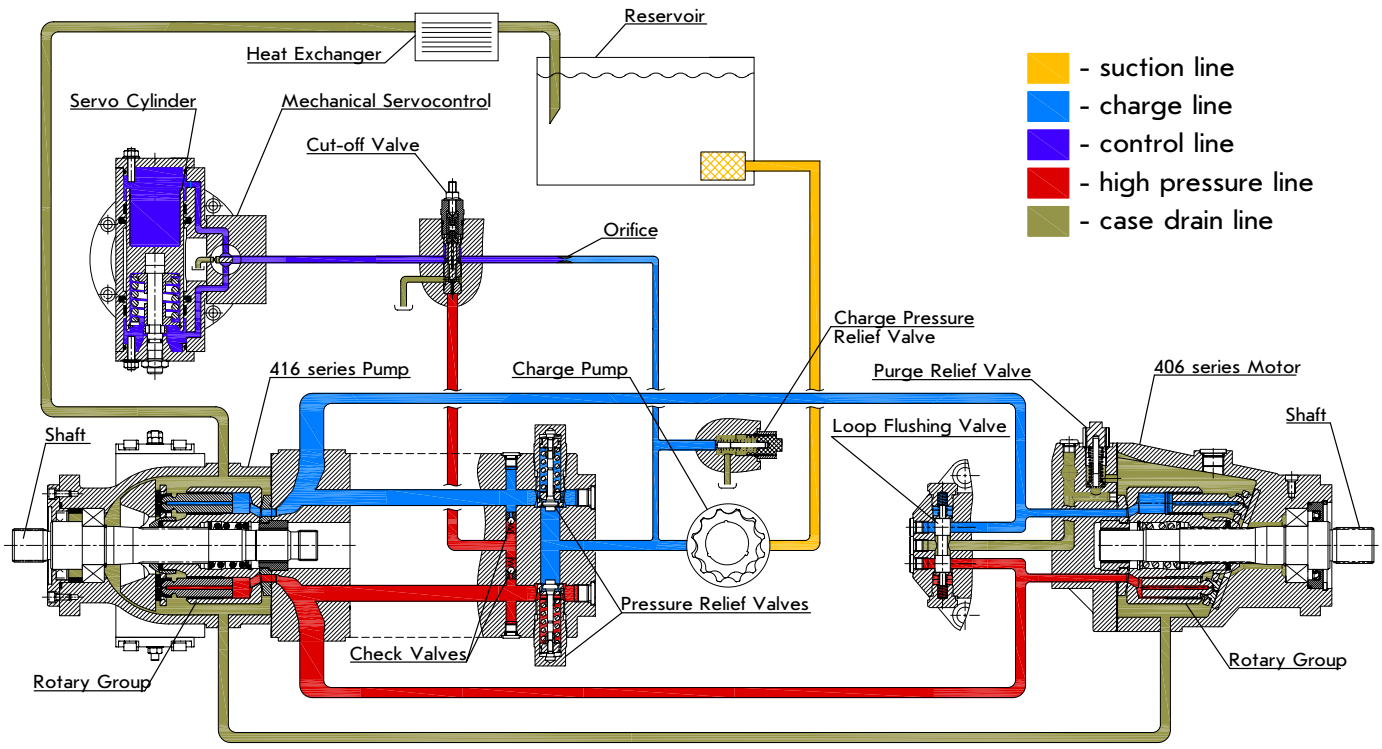
The pumps are equipped with various versions of control mechanisms.

General view





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.

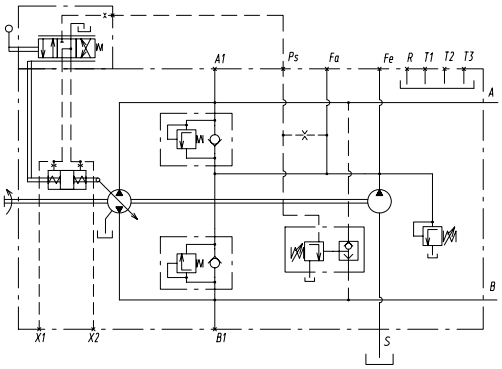
The main close loop.

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 in 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

A				B		C			D	E		F		G		H	I		J		K		L	M		N		O	P	
4	1	6	.	0	.															/										

● = standard
o = optional
- = not available

A - series

code	description
416	series 416

B - product version

code	description	416.0.71	416.0.90	416.0.110	416.0.125
0	basic	●	●	●	●

C - displacement

code	displacement	416.0.71	416.0.90	416.0.110	416.0.125
71	71 ccm/rev	●	-	-	-
90	90 ccm/rev	-	●	-	-
110	110 ccm/rev	-	-	●	-
125	125 ccm/rev	-	-	-	●

D - rotation

code	description	416.0.71	416.0.90	416.0.110	416.0.125
R	right	●	●	●	●
L	left	●	●	●	●

E - mounting flange

code	description	416.0.71	416.0.90	416.0.110	416.0.125
Y2	SAE C J744 – 4 hole	●	●	●	●
Y3	SAE D J744 – 4+2 hole	●	●	●	●
Y4	SAE C J744 – 4+2 ohole	●	●	o	o
Y5	SAE D J744 – 4 hole	o	o	o	o

F - shaft end

code	description	416.0.71	416.0.90	416.0.110	416.0.125
A2	splined shaft W35x2x30x16x9g DIN5480	●	●	-	-
A3	splined shaft W40x2x30x18x9g DIN5480	●	●	●	●
A4	splined shaft W45x2x30x21x9g DIN5480	●	●	●	●
S1	splined shaft 1 1/4" 14T 12/24DP ANSI B92.1a	o	o	-	-
S2	splined shaft 1 3/8" 21T 16/32DP ANSI B92.1a	●	●	o	o
S3	splined shaft 1 1/2" 23T 16/32DP ANSI B92.1a	●	●	●	●
S4	splined shaft 1 3/4" 13T 8/16DP ANSI B92.1a	o	o	o	o
H3	splined shaft 1 1/2" 23T 16/32DP ANSI B92.1a with installed flange	●	●	●	●
K1	tapered Ø34,92mm, 1 3/8", 1:8	o	o	o	o
K2	tapered Ø38,1mm, 1 1/2", 1:8	o	o	o	o
K3	tapered Ø44,45mm, 1 3/4", 1:8	o	o	o	o
K4	tapered Ø45 mm, 1:10	o	o	o	o
K5	tapered Ø55 mm, 1:10	-	-	o	o

G - end cap ports

code			description	416.0.71	416.0.90	416.0.110	416.0.125
F	2	2	SAE 1" 3000PSI / M36x2	●	●	-	-
F	3	3	SAE 1" 6000PSI / M42x2	●	●	-	-
F	3	4	SAE 1" 6000PSI / M48x2	-	-	●	●
F	4	4	SAE 1 1/4" 6000PSI / M48x2	-	-	o	o

↓ ↓

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	M48x2, 26 mm, ISO 9974-1 / DIN 3852-1

system ports (high pressure)	
1	SAE 3/4" 6000PSI (23,8 x 50,8 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)

H - high pressure valve settings

code	description	416.0.71	416.0.90	416.0.110	416.0.125
A	ΔP_{rv} = 250 bar	●	●	●	●
B	ΔP_{rv} = 300 bar	●	●	●	●
C	ΔP_{rv} = 350 bar	●	●	●	●
D	ΔP_{rv} = 400 bar	●	●	●	●
E	ΔP_{rv} = 420 bar	●	●	●	●

I - end cap options

code		description	416.0.71	416.0.90	416.0.110	416.0.125
2	1	SAE flange ports A and B at opposite side / PRV	●	●	●	●
2	2	SAE flange ports A and B at opposite side / PRV, COV	●	●	●	●

↓ ↓ valves

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

ports options

1	SAE flange ports A and B at same side
2	SAE flange ports A and B at opposite side

J - controls

code	description	416.0.71	416.0.90	416.0.110	416.0.125
B	without control	●	●	●	●
HD	proportional hydraulic without feedback	●	●	o	o
HP	proportional hydraulic	o	o	o	o
P	proportional servocontrol	●	●	●	●
E1	electrical 3-position (12VDC)	●	●	o	o
E2	electrical 3-position (24VDC)	●	●	o	o
E3	proportional electrical (12VDC)	o	o	o	o
E4	proportional electrical (24VDC)	o	o	o	o

K - auxiliary mounting pad

code	description	416.0.71	416.0.90	416.0.110	416.0.125
N	none	●	●	●	●
A	flange SAE A (Ø82,55 mm); splined 9T 16/32DP ANSI B92.1a	o	o	o	o
Z	flange SAE A-A (Ø82,55 mm); splined 11T 16/32DP ANSI B92.1a	o	o	o	o
B	flange SAE B (Ø101,6 mm); splined 13T 16/32DP ANSI B92.1a	o	o	o	o
X	flange SAE B-B (Ø101,6 mm); splined 15T 16/32DP ANSI B92.1a	o	o	o	o
C	flange SAE C (Ø127 mm); splined 15T 16/32DP ANSI B92.1a	o	o	o	o
M	flange SAE C (Ø127 mm); splined 21T 16/32DP ANSI B92.1a	o	o	o	o
R	flange SAE C (Ø127 mm); splined 14T 12/24DP ANSI B92.1a	o	o	o	o
K	flange (Ø60 mm); splined D-6x13x16	o	o	o	o
L	flange (Ø90 mm); splined D-6x21x25	o	o	o	o
T	flange (Ø80 mm); splined 20xH7x1.5x9g GOST 6033-80	o	o	o	o
H	flange (Ø125 mm); splined 30x2x30x14x9g DIN 5480	o	o	o	o
D	flange (Ø140 mm); splined 35x2x30x16x9g DIN 5480	o	o	o	o

L - displacement limitation

code	description	416.0.71	416.0.90	416.0.110	416.0.125
N	without displacement limiter	●	●	●	●
V	with mechanical limiter	●	●	●	●

M - filtration

code	description	416.0.71	416.0.90	416.0.110	416.0.125
F1	external, charge pump suction line filtration	●	●	●	●
F2	external, charge pump pressure line filtration	●	●	●	●
F3	internal, charge pump pressure line filtration	●	●	o	o

N - special features

code	description	416.0.71	416.0.90	416.0.110	416.0.125
NN	none	●	●	●	●
IN	case drain ports 7/8-14UNF-2B ISO 11926-1	●	●	o	o
RN	case drain ports M22x1,5 ISO 9974-1 / DIN 3852-1	o	o	-	-

O – shaft seal

code	description	416.0.71	416.0.90	416.0.110	416.0.125
B	NBR	●	●	●	●
F	FKM	●	●	●	●

P - climatic version and category of desposition

code	description	416.0.71	416.0.90	416.0.110	416.0.125
У1	temperate climate, placing on open air	●	●	●	●
T1	tropical climate, placing on open air	●	●	●	●

Technical characteristics.

Type range	416.0.71	416.0.90	416.0.110	416.0.125
Working displacement V_g, cm³.				
- min $V_{g\,min}$	0	0	0	0
- max $V_{g\,max}$	71	90	110	125
Shaft rotation speed n, rpm				
- min n_{min}	500	500	500	500
- nominal n_{nom}	2000	2000	2000	2000
- max n_{max}, at input pressure = 0.8 bar	3050	3050	3000	3000
- peak n_{peak}, at input pressure = 2 bar	3300	3300	3200	3200
Flow Q, l/min				
- minimal Q_{min}	33.73	42.75	52.25	59.38
- nominal Q_{nom}	134.9	171.00	156.75	178.37
- max Q_{max}	205.72	260.78	313.50	356.25
- peak Q_{peak}	222.59	282.15	334.40	380.00
Operating pressure (difference) ΔP, bar				
- nominal ΔP_{nom}	250	250	250	250
- max working ΔP_{max}	400	400	400	400
- peak ΔP_{peak}	450	450	450	450
Charge pressure P_n, bar				
- at V_g=0, n_{nom}	27	27	27	27
- at V_g≠0, n_{nom}	23	23	23	23
Charge pump input pressure (absolute) P_c, bar				
- min working	0.8	0.8	0.8	0.8
- min short-term (t<5 min) (at idling)	0.5	0.5	0.5	0.5
Drain pressure P_{dr}, bar				
- max working	2.5	2.5	2.5	2.5
- max short-term (t<5 min)	5	5	5	5
Power N, kW				
- nominal N_{nom} (at n_{nom}, $V_{g\,max}$, P_{nom})	60.44	76.28	70.00	79.40
- max N_{max} (at n_{max}, $V_{g\,max}$, P_{max})	146.32	184.95	222.54	252.54
- peak N_{peak} (at n_{peak}, $V_{g\,max}$, P_{peak})	177.84	224.86	266.71	302.71
Torque T, Nm				
- nominal T_{nom} (at $V_{g\,max}$, P_{nom})	288.61	364.21	445.77	505.46
- max T_{max} (at $V_{g\,max}$, P_{max})	458.11	579.07	708.38	803.87
- peak T_{peak} (at $V_{g\,max}$, P_{peak})	514.61	650.69	795.91	903.34
Volume efficiency	0.95	0.95	0.95	0.95
Weight, kg	67	67	80	80

Calculation of size

$$\text{Flow } Q = \frac{V_g \cdot n \cdot \eta_v}{1000} \quad \text{l/min}$$

$$\text{Torque } T = \frac{V_g \cdot \Delta P}{20 \cdot \pi \cdot \eta_{mh}} \quad \text{N•m}$$

$$\text{Power } N = \frac{Q \cdot \Delta P}{600 \cdot \eta_t} \quad \text{kW}$$

Where:
Q – flow, l/min
T – torque, N•m
N – power, kW
V_g – pump diplacement, cm³
n – shaft rotation frequency, rpm
ΔP – pressure difference, bar
η_v – volume efficiency
η_{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 mm^2/sec (cSt)
max startup	1500 mm^2/sec (cSt)
min short-term	10 mm^2/sec (cSt)
Working fluid purity:	at least 12th class as per GOST 17216-71 at least 18/15th class as per ISO/DIN 4406

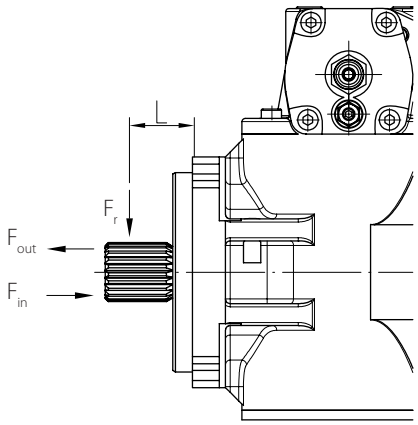
Allowed radial and axial loads on shaft.

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:

$M_r = F_r \cdot L$ – torque
F_{out} – axial force from hydraulic pump
F_{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.

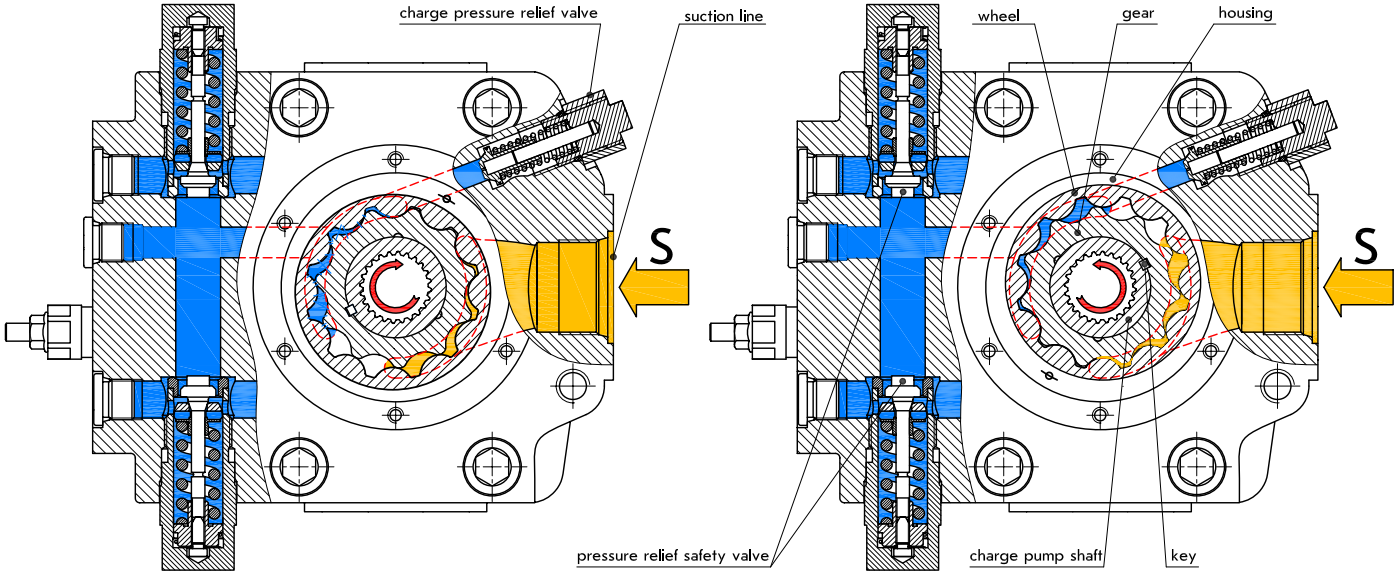


The values of peak loads on shaft are given in the table.

Parameter	416.0.71	416.0.90	416.0.110	416.0.125
Radial load F_r, N	1800		3500	
Cradle/shoulder L, mm	23.4		23.4	
Axial load F_{in}, N	2140		2110	
Axial load F_{out}, N	843		475	

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.

size	416.0.71	416.0.90	416.0.110	416.0.125
V, cm^3	19.8		26.5	

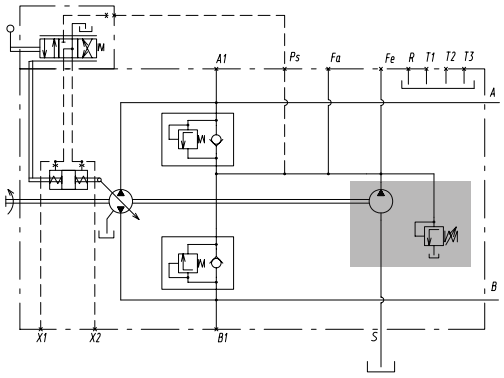
Charge pump input pressure:
- min working (absolute) = 0.8 bar
- min short-term, at cold start (t<5 min) (absolute) = 0.5 bar

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

The charge pressure is adjusted at:
- pump shaft speed n = 1500 rpm;
- working fluid temperature in the loop t = +45…50° C.

Charge pressure can be adjusted in negotiation with the consumer.

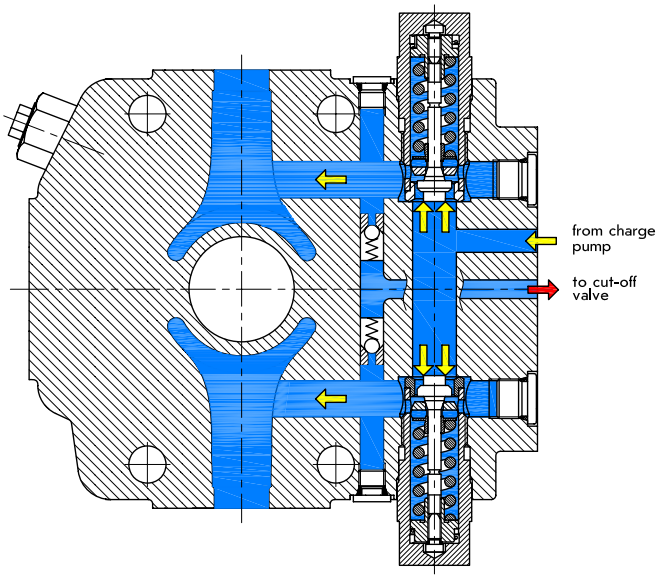
Hydraulic circuit diagram



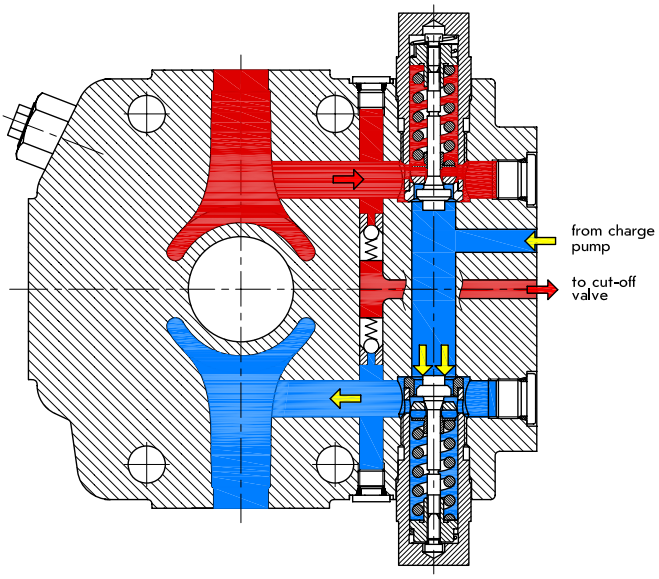
Check-safety valves.

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.



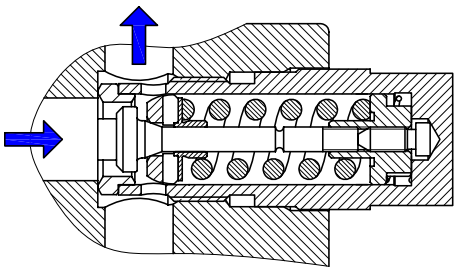
Swash-plate is inclined.



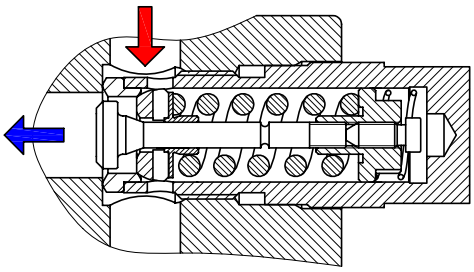
At swash-plate neutral position check safety valves operate as check valves providing lines A and B with the working fluid from charge pump. A and B lines pressure conforms to the charge pressure.

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 check valve mode



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.

At achieving the pressure in pump pressure line corresponding the safety valve adjustment, the latter functions, pressing the main spring and allowing the fluid pass between saddle and valve.

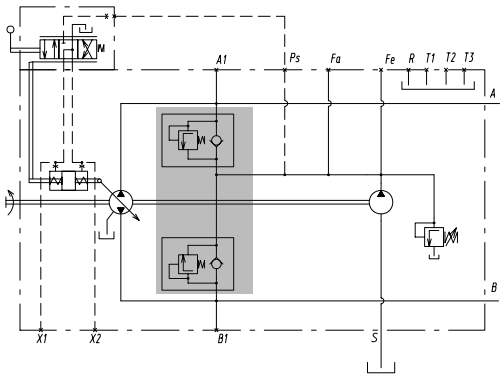
Check-safety valve adjustment pressure (difference) $\Delta P = 350^{+5}$ bar (by default).

Valve operation is adjusted at

- pump shaft speed — n = 1500 rpm;
- working fluid temperature in the loop — t = +45…50ºC.

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

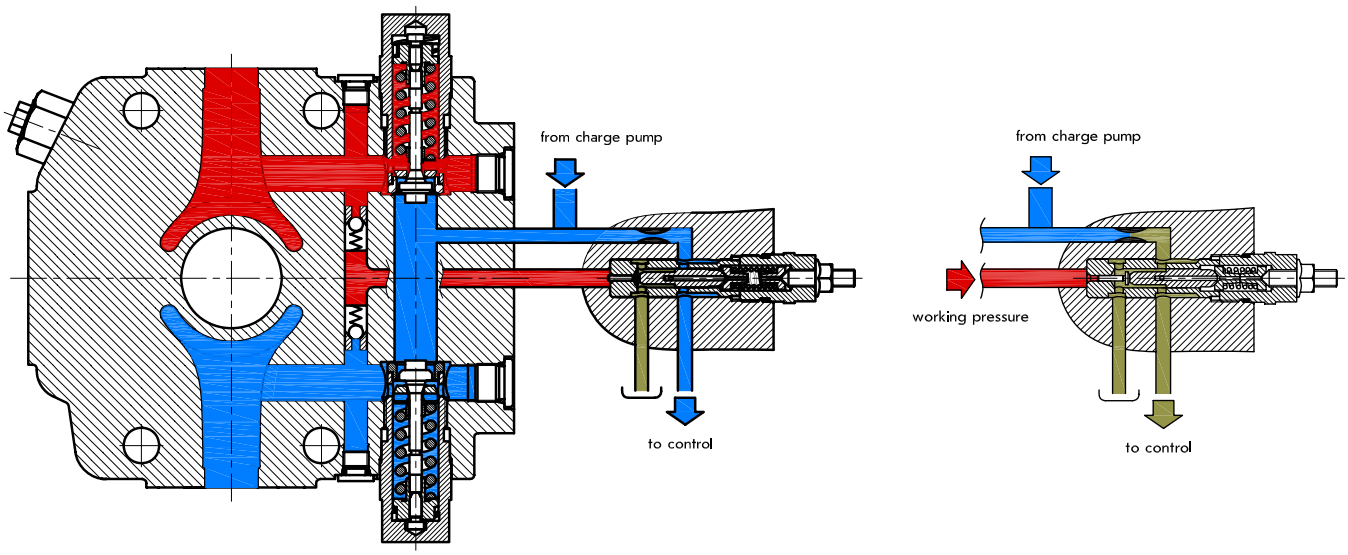
Hydraulic circuit diagram



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.

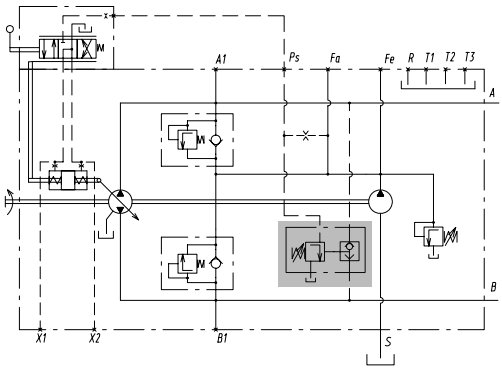
Cut-off valve adjustment pressure = 350^{+5} bar (by default).

Cut-off valve operation is adjusted at:

- pump shaft rotation speed n = 1500 rpm;
- working fluid temperature in the loop t = +45…50ºC.

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

Hydraulic circuit diagram

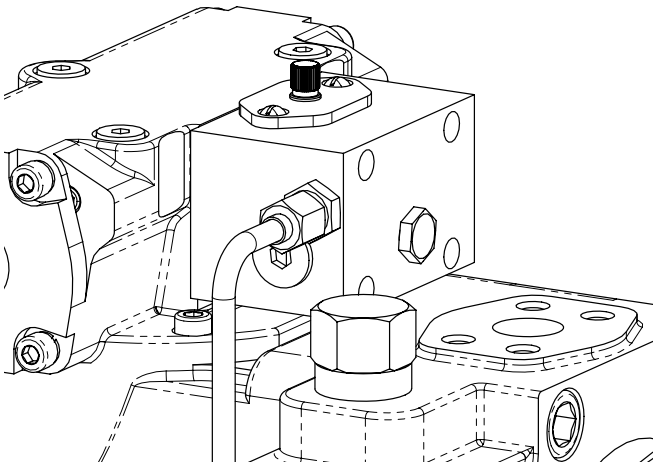


Servocontrol.

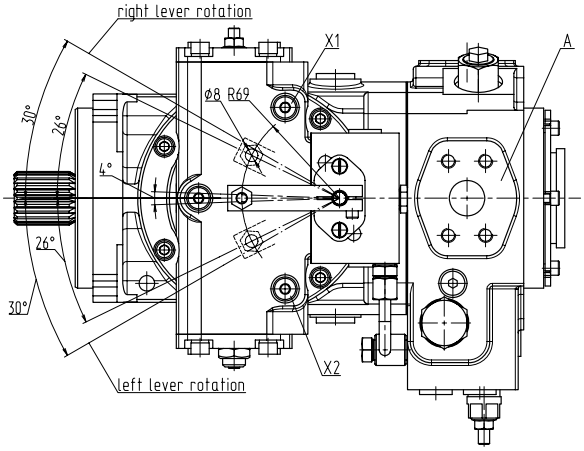
Proportional servocontrol control converts a mechanical input signal to a hydraulic signal that tilts the cradle swashplate through an angular rotation varying the pump's displacement from full displacement in one direction to full displacement in the opposite direction.

The pump displacement is proportional to the lever rotation angle.

General view

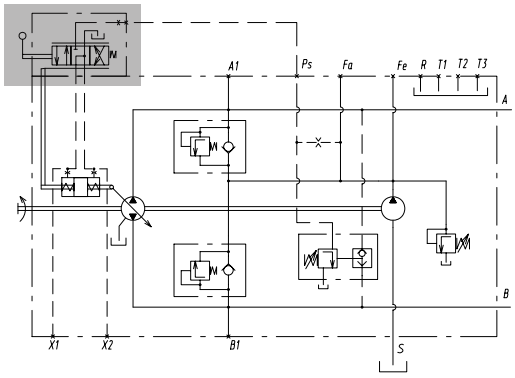


The top view of the pump

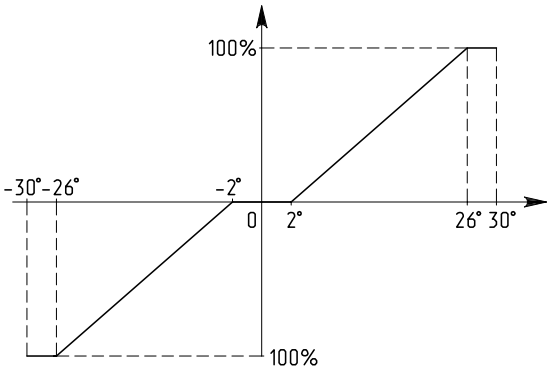


The manual displacement control has a mechanical feedback mechanism which moves a servo valve in the proper relationship to the input signal and the angular position of the swashplate. The control is designed so that the angular rotation of the swashplate is proportional to the mechanical input signal.

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_a – charge pressure gauge port

External control handle requirements:

- dead zone	±2º
- proportional zone	2º…26º
- maximum zone	26º…30º

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 instal additional (external) limiter of an angle.

Pump output flow direction vs. control handle rotation

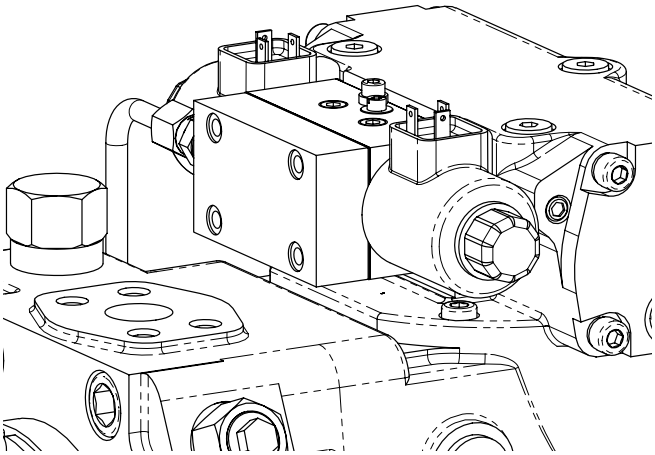
shaft rotation	lever rotation	flow direction	control pressure gauge port	high pressure gauge port
left	left	A => B	X1	B1
	right	B => A	X2	A1
right	left	B => A	X1	A1
	right	A => B	X2	B1

Electrical Proportional Control.

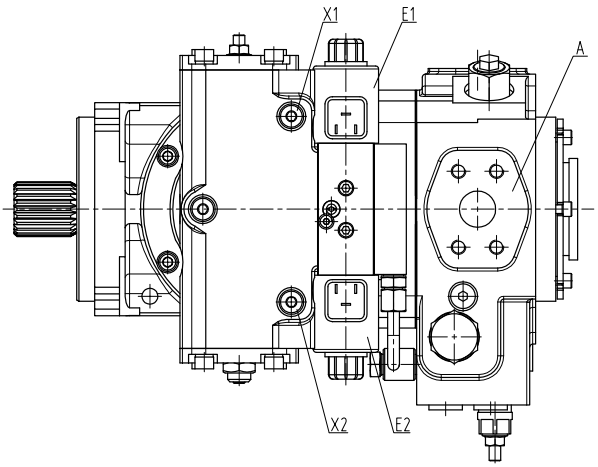
Electrical proportional control is intended for transformation of an electrical control signal in an amplified hydraulic signal, which by means of servo piston moving the swash plate (on an angle ±20º) causes linear change of a pump displacement in each way.

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

General view



The top view of the pump

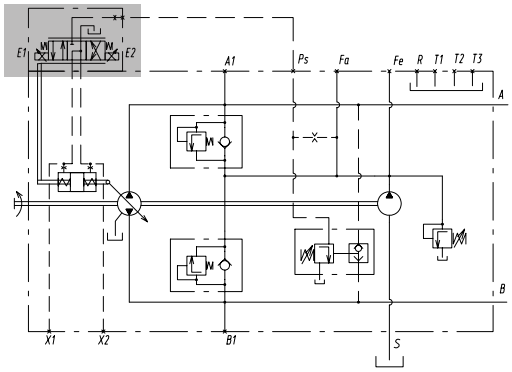


The control PWM-signal affects a proportional solenoid.

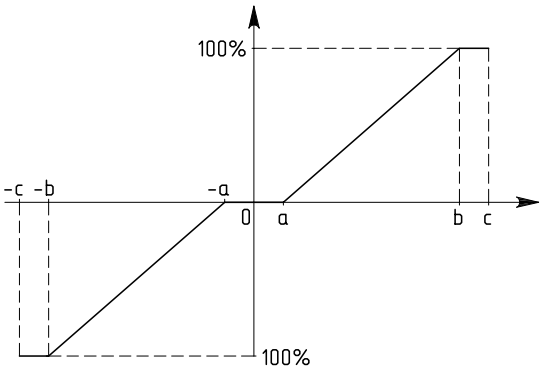
The solenoid will convert PWM-signal to mechanical movement of a control valve spool.

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



The control characteristic



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_a – charge pressure gauge port

The control characteristic

Nominal voltage	12VDC	24VDC
Start of control (a), I_{min}, mA	600	300
End of control (b), I_{max}, mA	1500	750
Maximum current (c), I_{peak}, mA	2500	1000
Resistance @ (at 20 ºC)	2.3W ±7%	13.4W ±7%
Duty cycle	100%	
Protection to IEC 529	IP65	
PWM frequency	50…200Hz	
Solenoid connector	DIN 43650	

Pump output flow direction vs. input signal

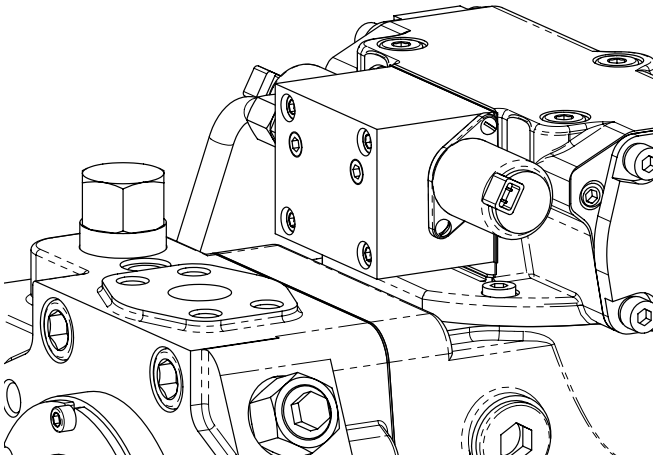
shaft rotation	solenoid	flow direction	control pressure gauge port	high pressure gauge port
left	E1	A => B	X1	B1
	E2	B => A	X2	A1
right	E1	B => A	X1	A1
	E2	A => B	X2	B1

Electrical Proportional Control without FeedBack.

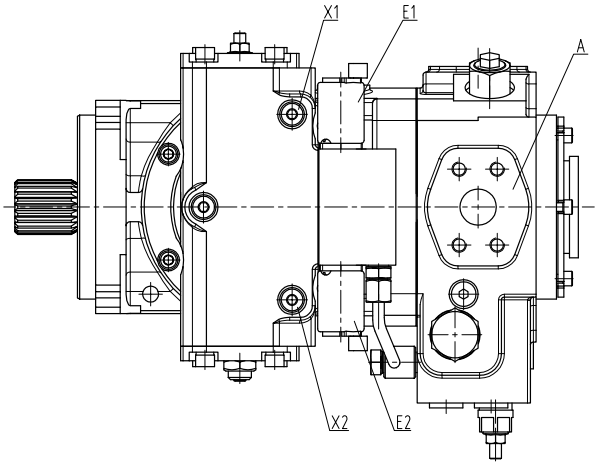
Electrical proportional control is intended for transformation of an electrical control signal in an amplified hydraulic signal, which by means of servo cylinder moving the swash plate (on an angle ±20º) causes linear change of a pump displacement in each way.

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

General view



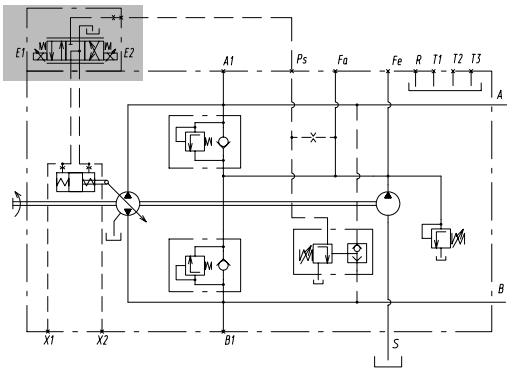
The top view of the pump



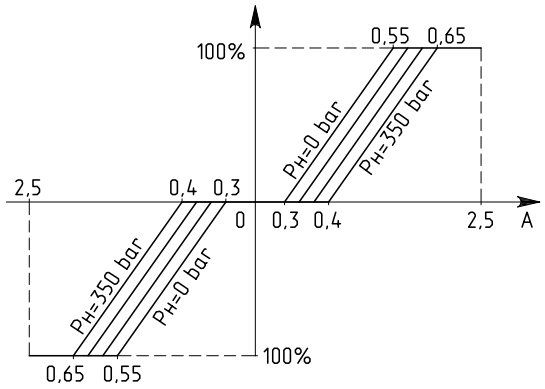
The control mechanism is based on two proportional reducing valves with electrocontrol. Each valve is established in a control line of the servo cylinder. At giving of an electric signal of control, the valve proportionally regulates size of pressure in either side of servo cylinder.

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.

Hydraulic Circuit



The control characteristic (at 24VDC)



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_a – charge pressure gauge port

The control characteristic

Nominal voltage	12VDC	24VDC
Start of control, I_{min}, mA	600	300
End of control, I_{max}, mA	1300	650
Maximum current, I_{peak}, mA	1500	750
Resistance @ (at 20°C)	5.3W ±5%	21.2W ±5%
Duty cycle	100%	
Protection to IEC 529	IP65	
PWM frequency	100Hz	
Solenoid connector	AMP Junior Timer	

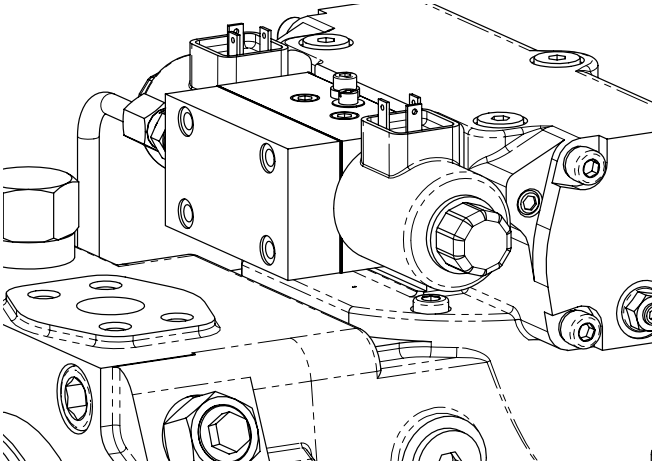
Pump output flow direction vs. input signal

shaft rotation	solenoid	fluid direction	control pressure gauge port	high pressure gauge port
left	E1	A => B	X1	B1
	E2	B => A	X2	A1
right	E1	B => A	X1	A1
	E2	A => B	X2	B1

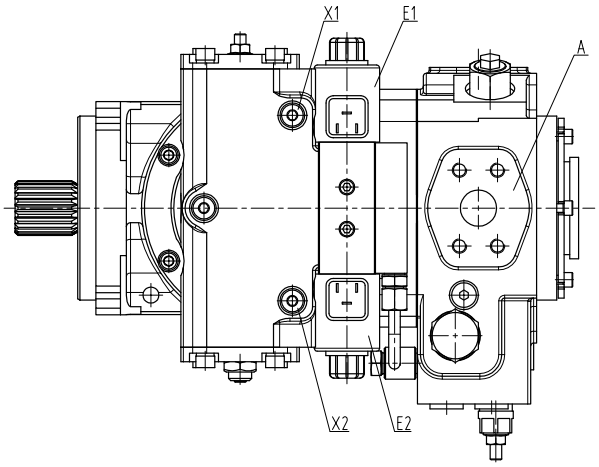
Electrical 3-Position Control.

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

General view



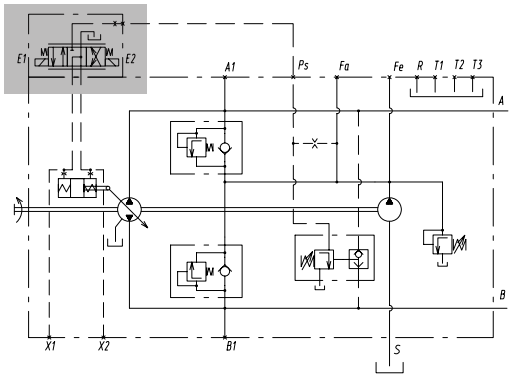
The top view of the pump



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

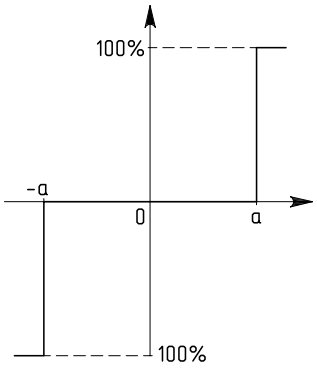
At switching-off of the input signal, servo cylinders springs return a swashplate in a neutral position.

Hydraulic Circuit



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_a – charge pressure gauge port

The control characteristic



The control characteristic

Nominal voltage	12VDC	24VDC
Maximum current, I_{peak}, mA	2500	1000
Resistance @ (at 20 °C)	2.3W ±7%	13.4W ±7%
Duty cycle	100%	
Protection to IEC 529	IP65	
Solenoid connector	DIN 43650	

Pump output flow direction vs. input signal

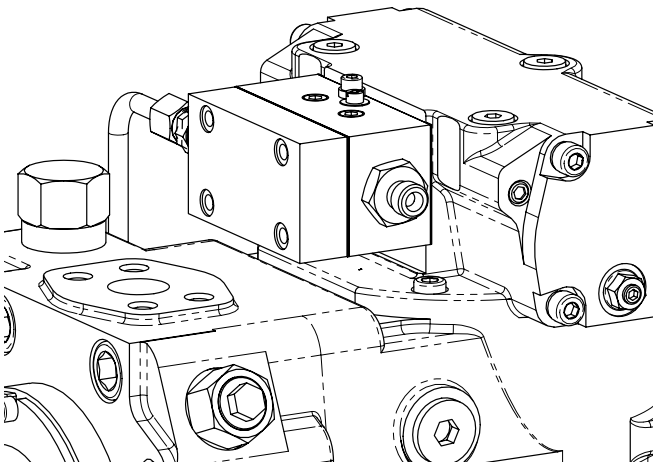
shaft rotation	solenoid	flow direction	control pressure gauge port	high pressure gauge port
left	E1	A => B	X1	B1
	E2	B => A	X2	A1
right	E1	B => A	X1	A1
	E2	A => B	X2	B1

Hydraulic Proportional Control.

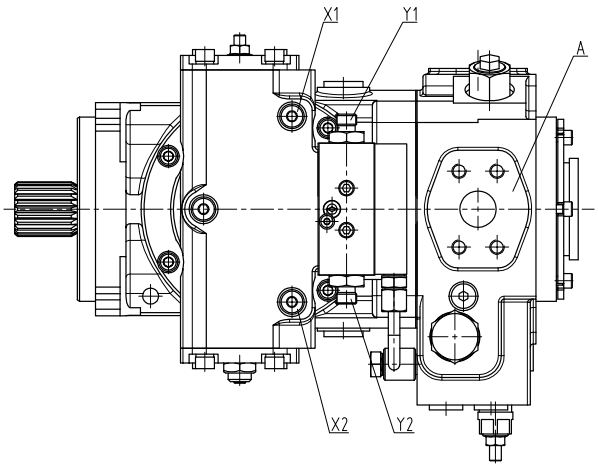
Hydraulic proportional control is intended for transformation of an hydraulic control signal in an amplified hydraulic signal, which by means of servo piston moving the swash plate (on an angle ±20º) causes linear change of a pump displacement in each way.

The pump displacement is proportional to the control pressure.

General view

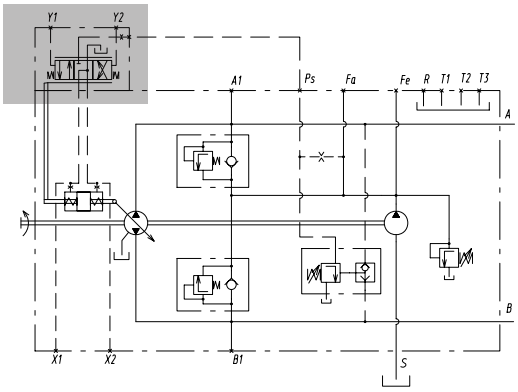


The top view of the pump



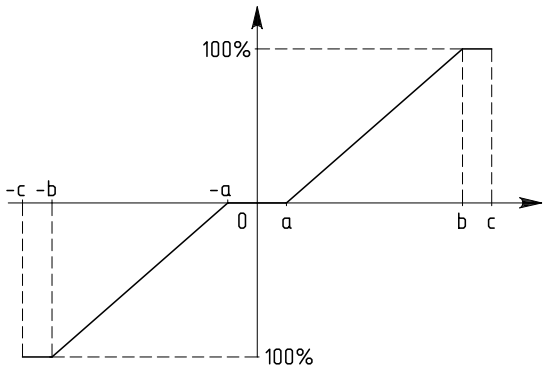
The hydraulic displacement control uses a hydraulic input signal to operate a servo valve, which distributes hydraulic pressure to either side of a servo cylinder. The servo cylinder tilts the swashplate, thus varying the pump's displacement from full displacement in one direction to full displacement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



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_a – charge pressure gauge port

The control characteristic



The control characteristic

Control pressure	
- start of control (a), P_{min}, bar	6.0
- end of control (b), P_{max}, bar	18.0

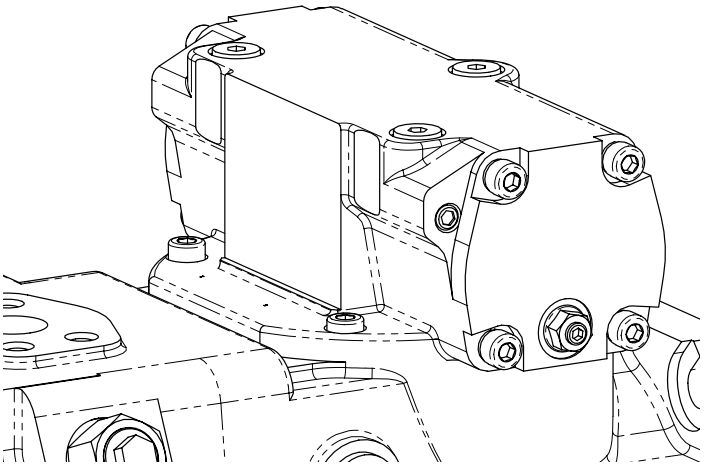
Pump output flow direction vs. input signal

shaft rotation	control port	flow direction	control pressure gauge port	high pressure gauge port
left	Y1	A => B	X1	B1
	Y2	B => A	X2	A1
right	Y1	B => A	X1	A1
	Y2	A => B	X2	B1

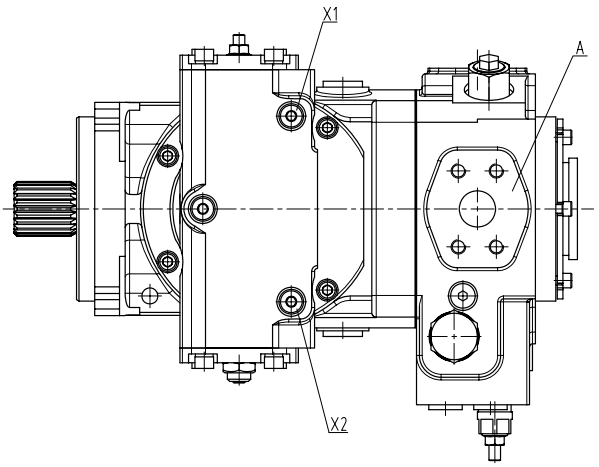
Hydraulic Proportional Control without FeedBack.

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.

General view



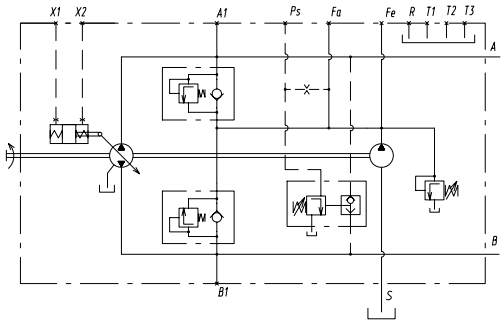
The top view of the pump



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

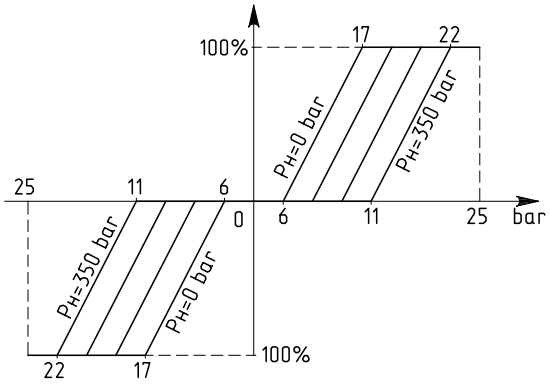
At switching-off of the input signal, servo cylinders springs return a swashplate in a neutral position.

Hydraulic Circuit



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_a – charge pressure gauge port

The control characteristic



The control characteristic

Control pressure	
- start of control, P_{min}, bar	6.0
- end of control, P_{max}, bar	22.0

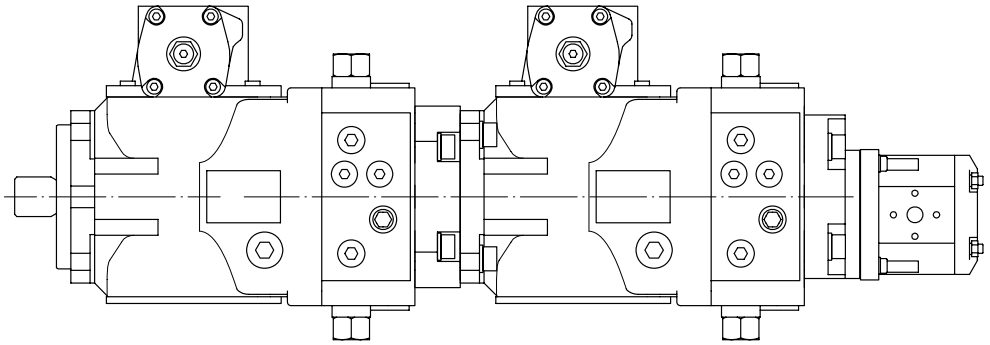
Pump output flow direction vs. input signal

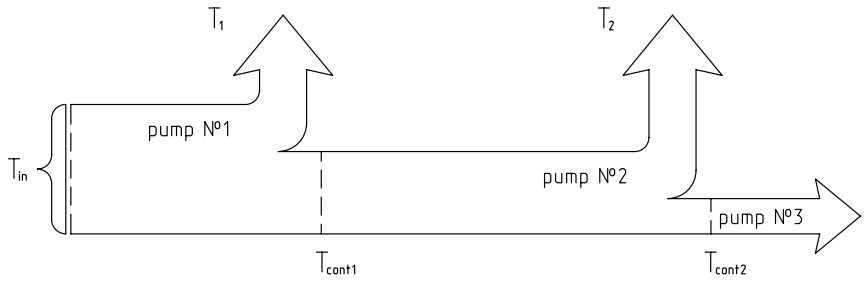
shaft rotation	control port	flow direction	control pressure gauge port	high pressure gauge port
левое	X1	A => B	X1	B1
	X2	B => A	X2	A1
правое	X1	B => A	X1	A1
	X2	A => B	X2	B1

Torque

Allowed torque values on input and output (coupled) pump shafts are given in the following Table depending on the shaft spline end and pump working displacement at ΔP = 400bar and maximum displacement.

	code	416.0.71	416.0.90	416.0.110	416.0.125
Torque consumed by pump, T_1 (T_2), Nm		451	572	700	795
Input torque, T_{in}, Nm					
spline W35x2x30x16x9g DIN 5480	A2	912	912	-	-
spline W40x2x30x18x9g DIN 5480	A3	1460	1460	1460	1460
spline W45x2x30x21x9g DIN 5480	A4	2190	2190	2190	2190
spline 1 1/4" 14T 12/24DP ANSI B92.1a	S1	602	602	-	-
spline 1 3/8" 21T 16/32DP ANSI B92.1a	S2	970	970	970	970
spline 1 1/2" 23T 16/32DP ANSI B92.1a	S3	690	690	690	690
spline 1 3/4" 13T 8/16DP ANSI B92.1a	S4	1640	1640	1640	1640
Continuous torque, T_{cont}, Nm		750	750	912	912





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.:
416.0.71RY4S3F22C22E4/**M**VF1NNFT1 + 416.0.71RY2S2F22C21E2/**A**VF1NNFT1

To order the pump with auxiliary mounting pad the code of required coupling version should be given in field J, f.i.:
416.0.90RY4S3F22C22E4/**A**VF1NNFT1

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:

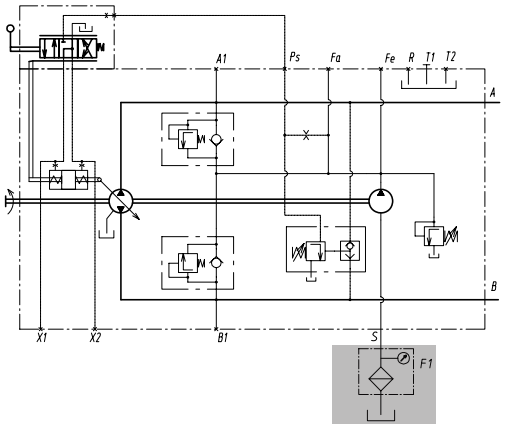
- rated flow	100 l/min
- max flow	130 l/min
- filtration fineness	10 µm
- filtering element material	paper
- pressure change on filtering element:	
at v = 30 mm²/sec (cSt), n = 1500 rpm	ΔP = 0.1 bar

The filter should have:

- by pass valve	ΔP = 0.2 bar

The filter is not included into the pump delivery set.

The pump hydraulic circuit diagram with external filtration.



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:

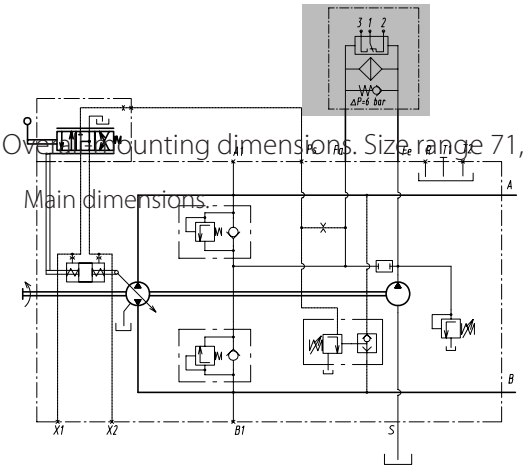
- rated flow	70 l/min
- max flow	130 l/min
- filtration fineness	16 µm
- filtering element material	fiberglass
- pressure change on filtering element:	
at v = 30 mm²/sec (cSt), n = 1500 rpm	ΔP = 0.2 bar

The filter should have:

- filtering element contamination indicator	ΔP = 5 bar
- by pass valve	ΔP = 6 bar

The filter is not included into the pump delivery set.

The pump hydraulic circuit diagram with external filtration.



Overall mounting dimensions. Size range 71, 90 cm³.

Main dimensions.

Option F3. Internal filtration.

The filter is built-in in to the pump

Filtration in charge pump pressure line.

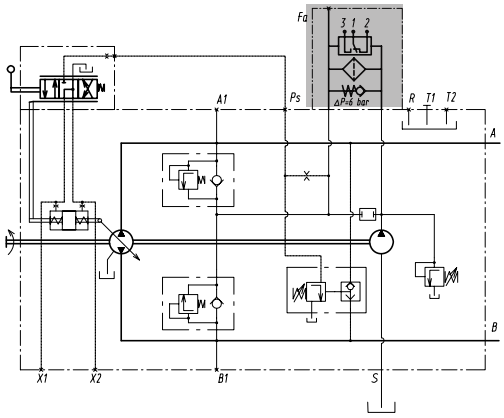
Technical requirements for the filter:

- 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 mm²/sec (cSt), n = 1500 rpm	ΔP = 0.2 bar

The filter should have:

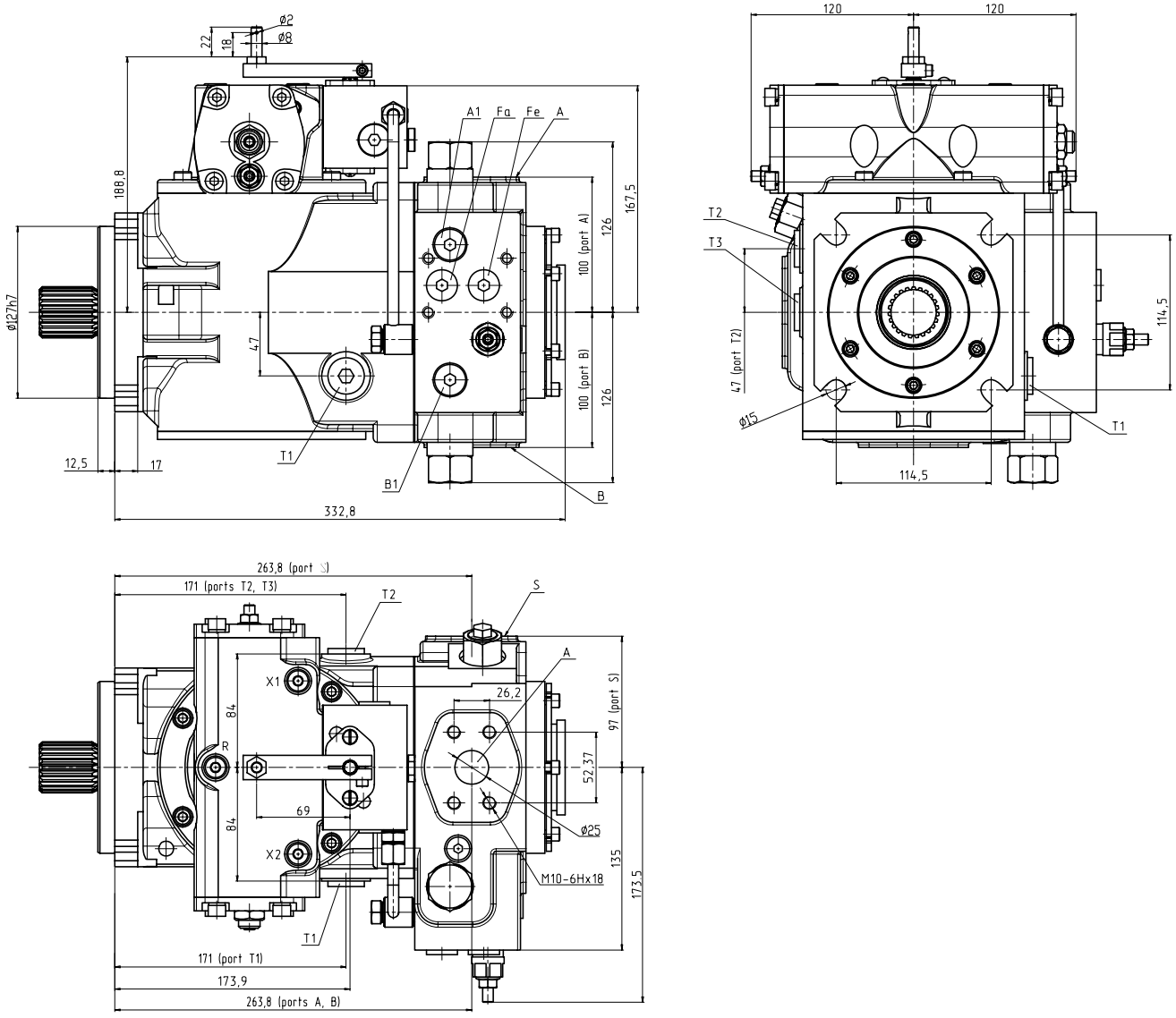
- filtering element contamination indicator	ΔP = 5 bar
- by pass valve	ΔP = 6 bar

The pump hydraulic circuit diagram with internal filtration.



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

Main dimensions.

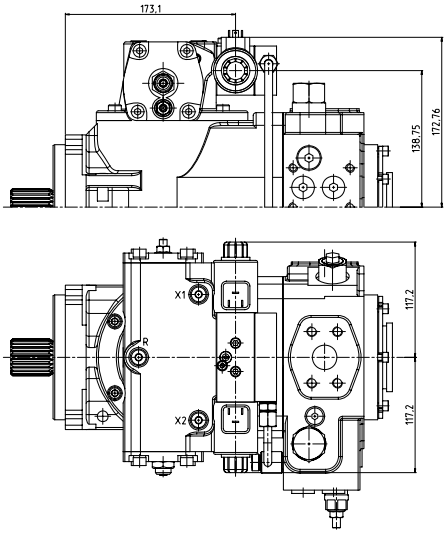


			option	code
A, B	operating pressure ports	SAE 1" 3000psi; M10-6Hx18; 52.4 x 26.2mm	G	F2…
		SAE 1" 6000psi; M12-6Hx17; 57.2 x 27.8mm	G	F3…
S	suction port	M36x2, 26mm	G	F…2
		M42x2, 24mm	G	F…3
T1, T2	case drain ports	M22x1.5-15 GOST 25064 / ISO 6149-1	-	standard program
		7/8-14UNF-2B ISO 11926-1	M	IN
		M22x1.5-26 DIN 3852-1 / ISO 9974-1	M	RN
A1, B1	operating pressure gauge ports	M18x1.5-12 GOST 25065 / ISO 6149-1	-	standard program
X1, X2	control pressure gauge ports	M12x1.5-14 GOST 25065 / ISO 6149-1	-	standard program
R	air bleed	M12x1.5-12 GOST 25065 / ISO 6149-1	-	standard program
Fa	charge pressure gauge ports	M18x1.5-12 GOST 25065 / ISO 6149-1	-	standard program
Fa, Fe	pressure filter ports	M18x1.5-12 GOST 25065 / ISO 6149-1	-	standard program

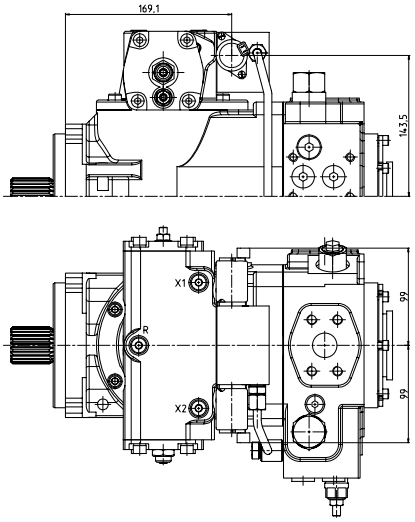
Overall-mounting dimensions. Size range 71, 90 cm³.

Controls

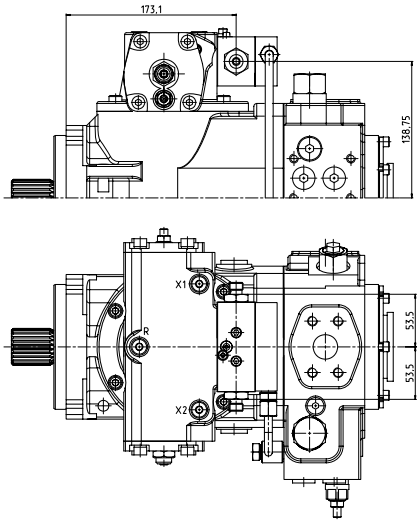
Electrical proportional
Option I: E3 (12VDC), E4 (24VDC)



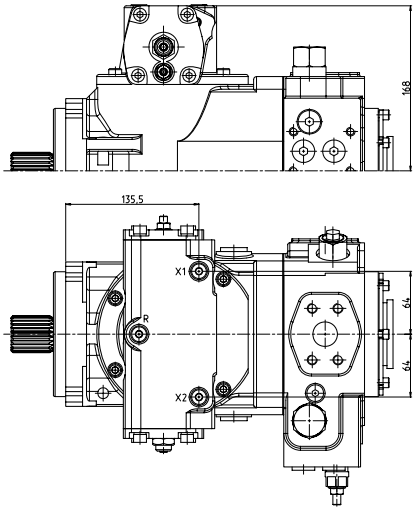
Electrical proportional without feedback
Option I: E5 (12VDC), E6 (24VDC)



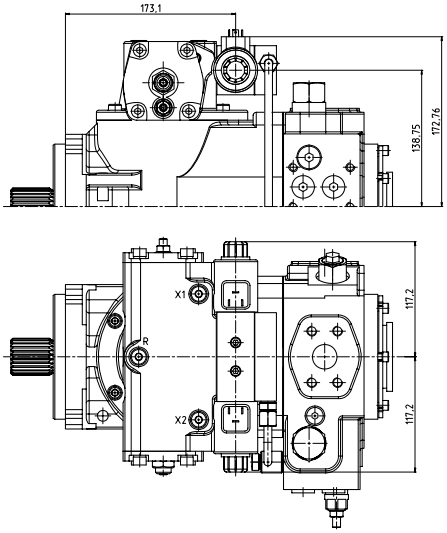
Hydraulic proportional
Option I: HP



Hydraulic proportional whithout feedback
Option I: HD



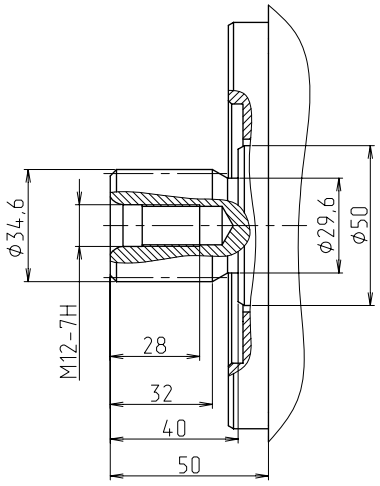
Electrical 3-position
Option I: E1 (12VDC), E2 (24VDC)



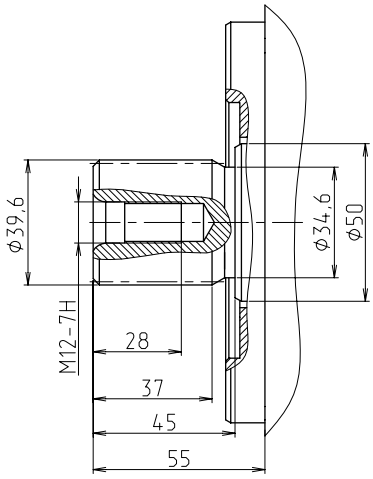
Overall-mounting dimensions. Size range 71, 90 cm³.

Shaft ends

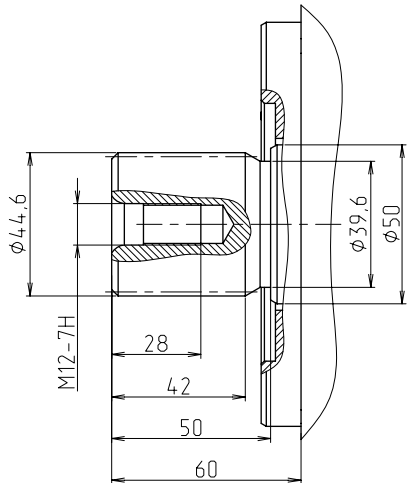
W35x2x30x16x9g DIN5480
Option F: A2



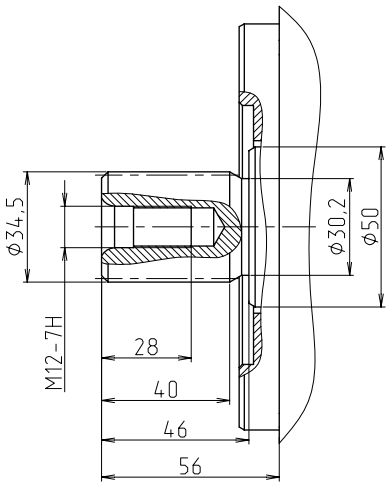
W40x2x30x18x9g DIN5480
Option F: A3



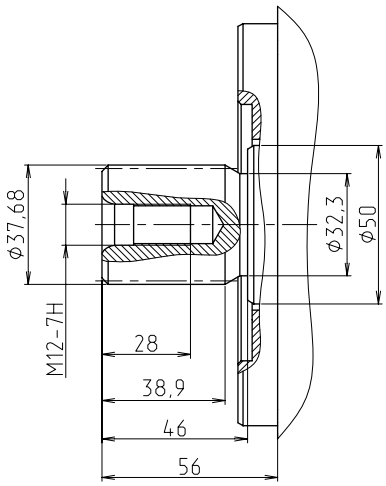
W45x2x30x21x9g DIN5480
Option F: A4



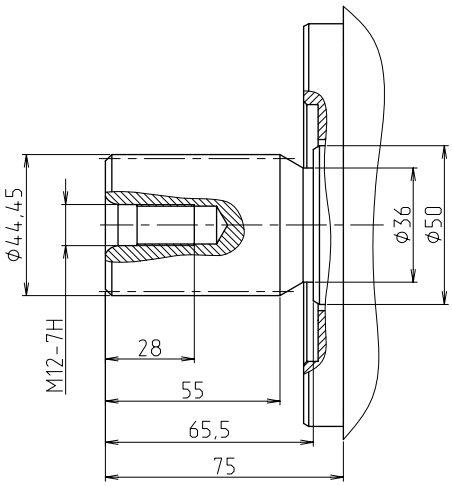
1 3/8" 21T 16/32pitch ANSI B92.1a
Option F: S2



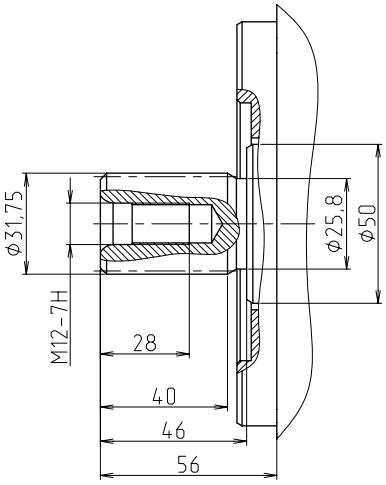
1 1/2" 23T 16/32pitch ANSI B92.1a
Option F: S3



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

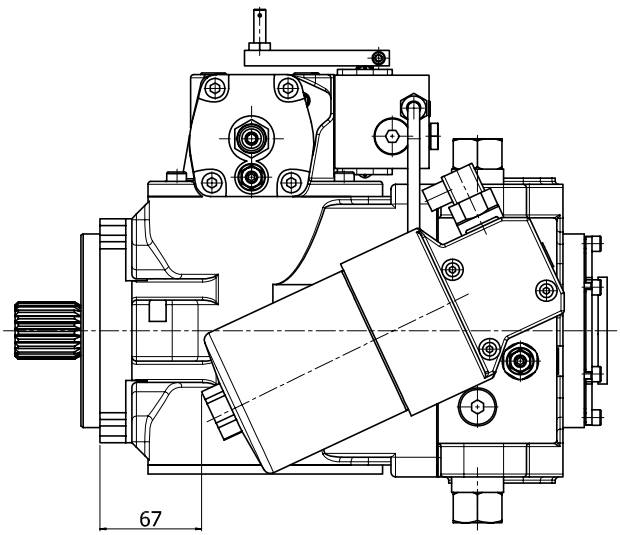


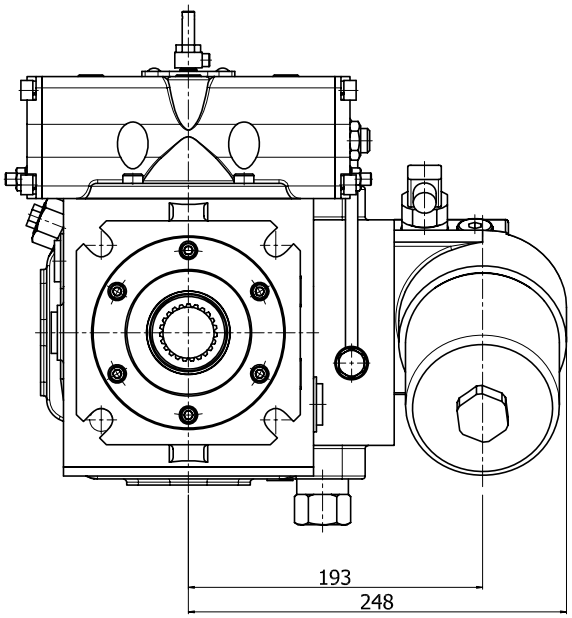
1 1/4" 14T 12/24pitch ANSI B92.1a
Option F: S1

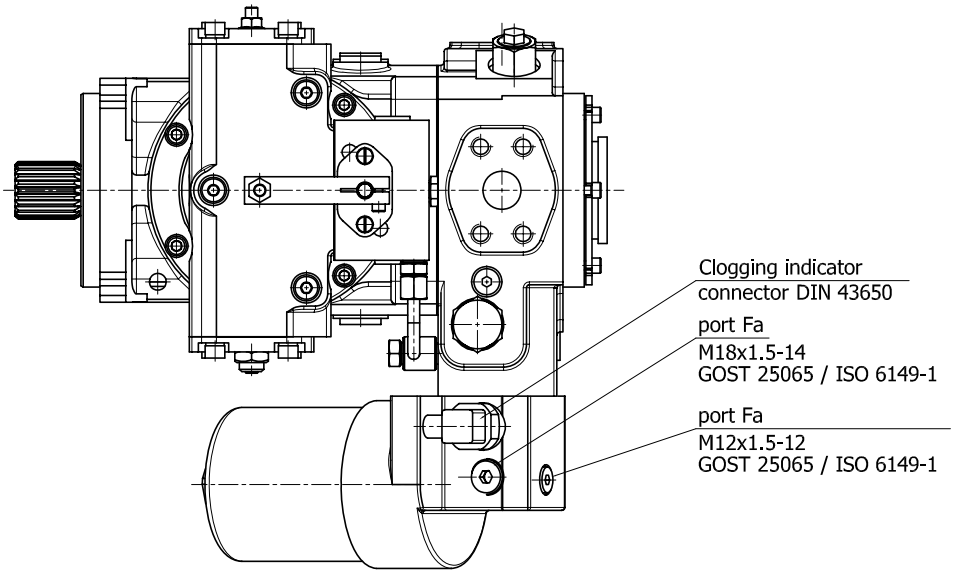


Overall-mounting dimensions. Size range 71, 90 cm³.

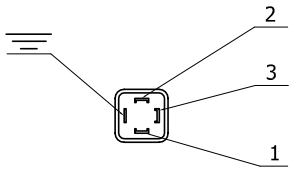
Built-in pressure filter



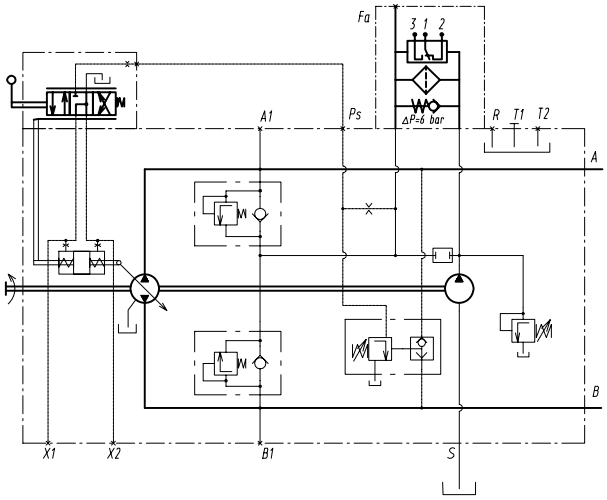




Connector pins



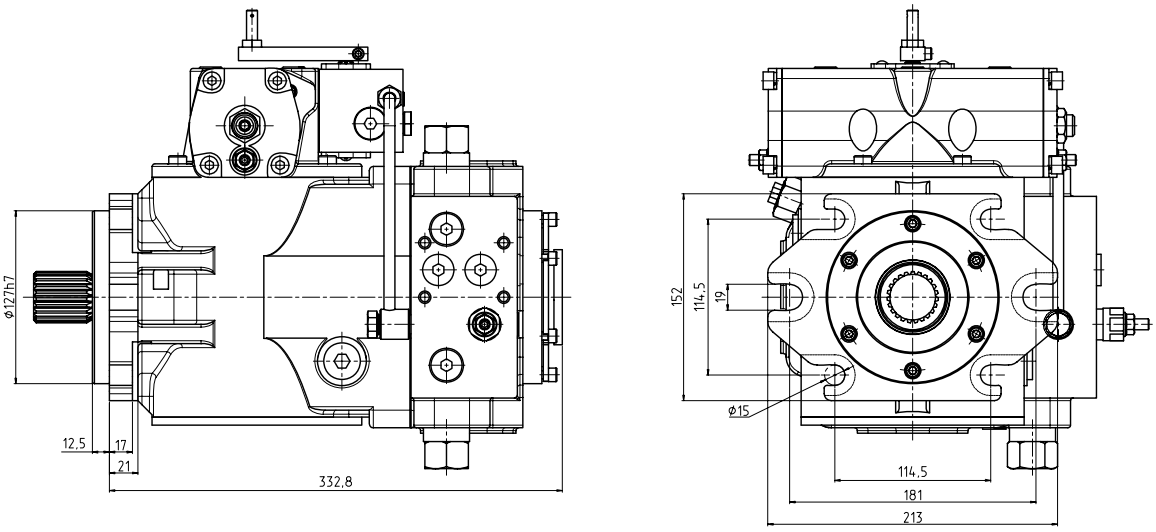
Hydraulic circuit diagram



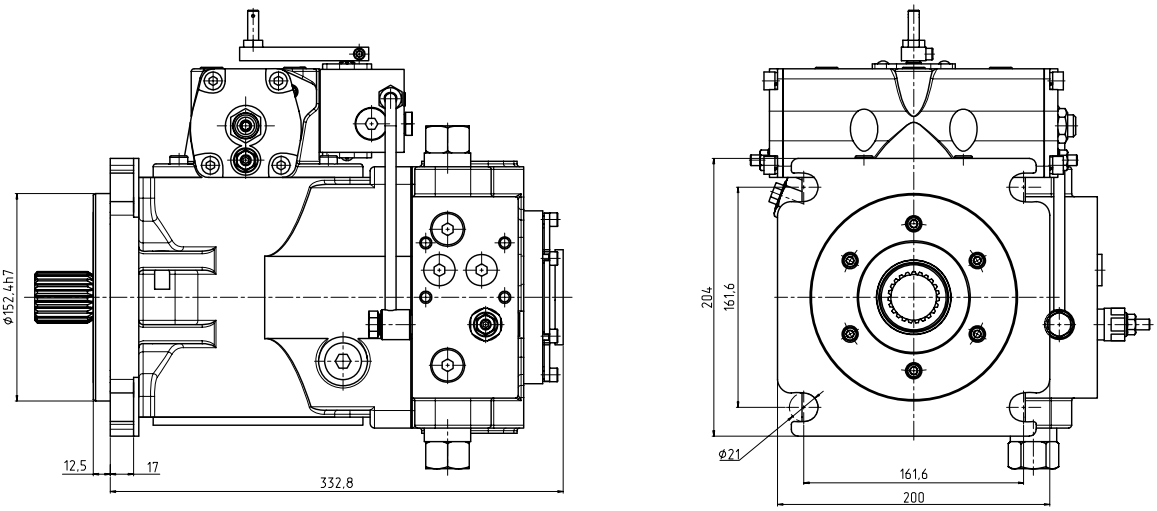
Overall-mounting dimensions. Size range 71, 90 cm³.

Mounting flanges.

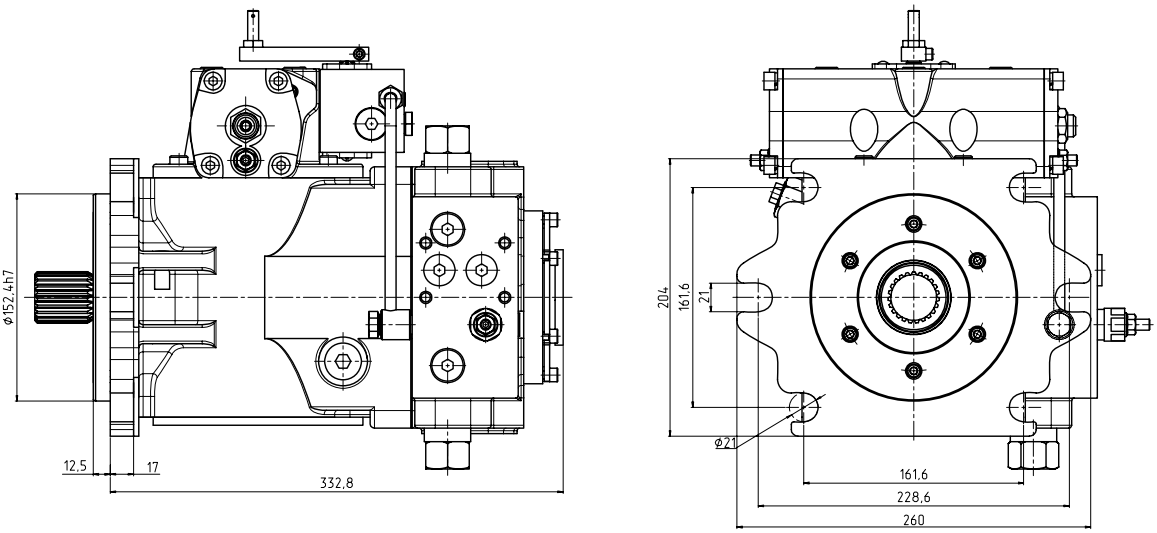
Flange SAE C, 4+2 bolts. Option E: Y4.



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



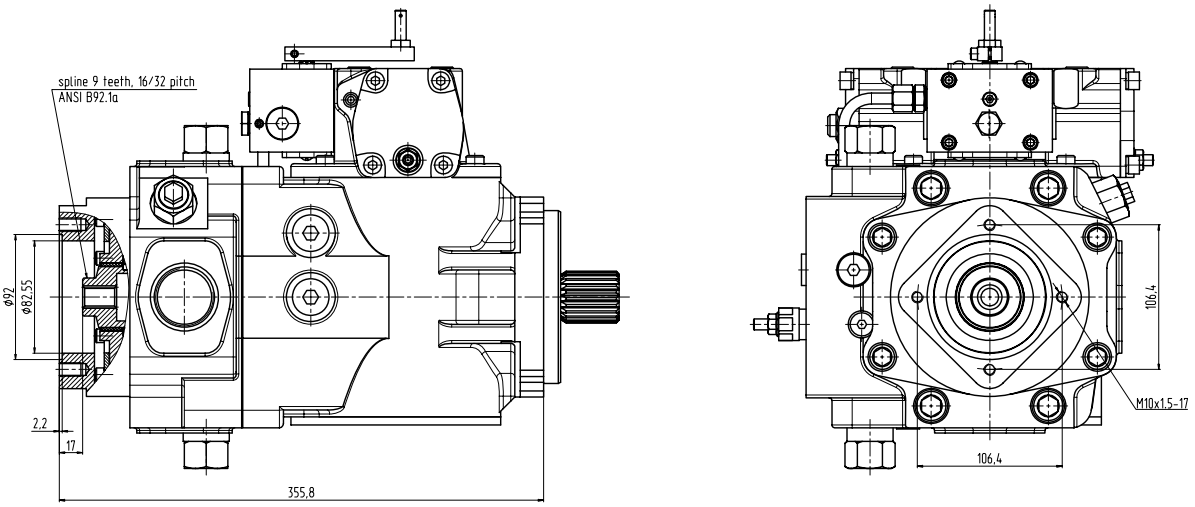
Flange SAE D, 4+2 bolts. Option E: Y3.



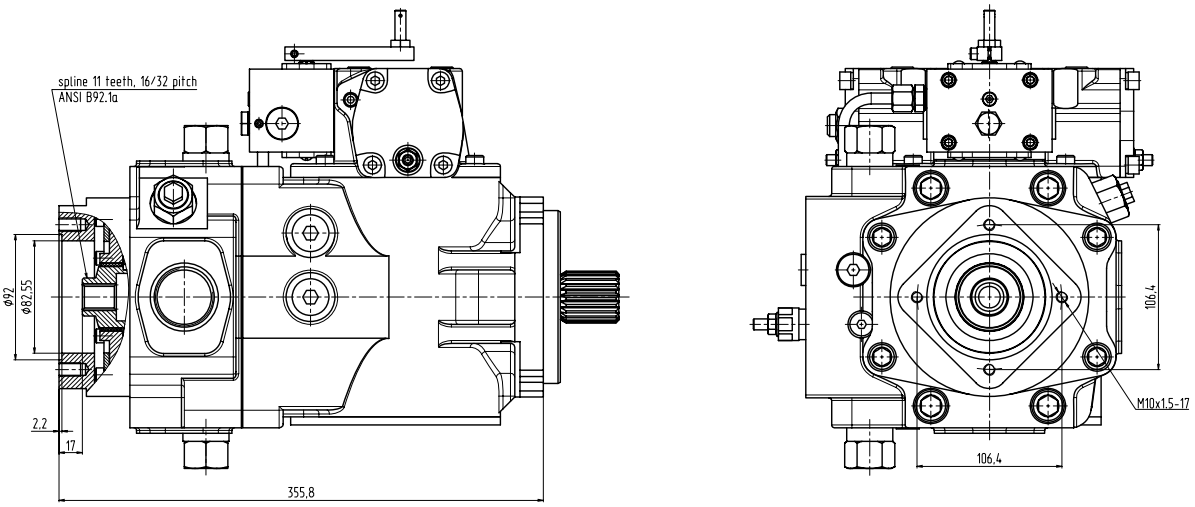
Overall-mounting dimensions. Size range 71, 90 cm³.

Auxiliary mounting pads.

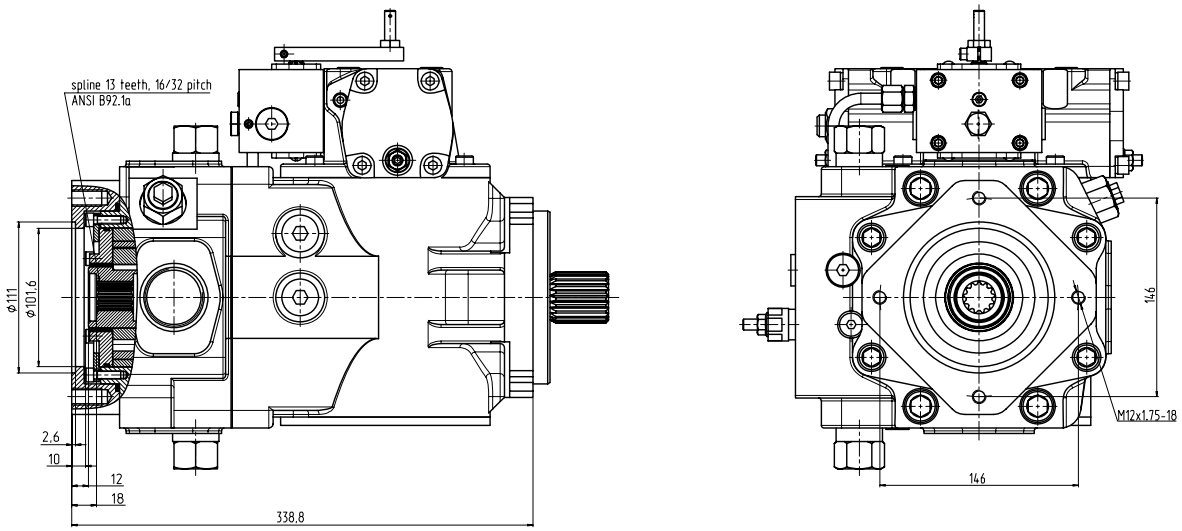
Flange SAE A, spline 9 teeth, 16/32 pitch. Option J: A.



Flange SAE A-A, spline 11 teeth, 16/32 pitch. Option J: Z.



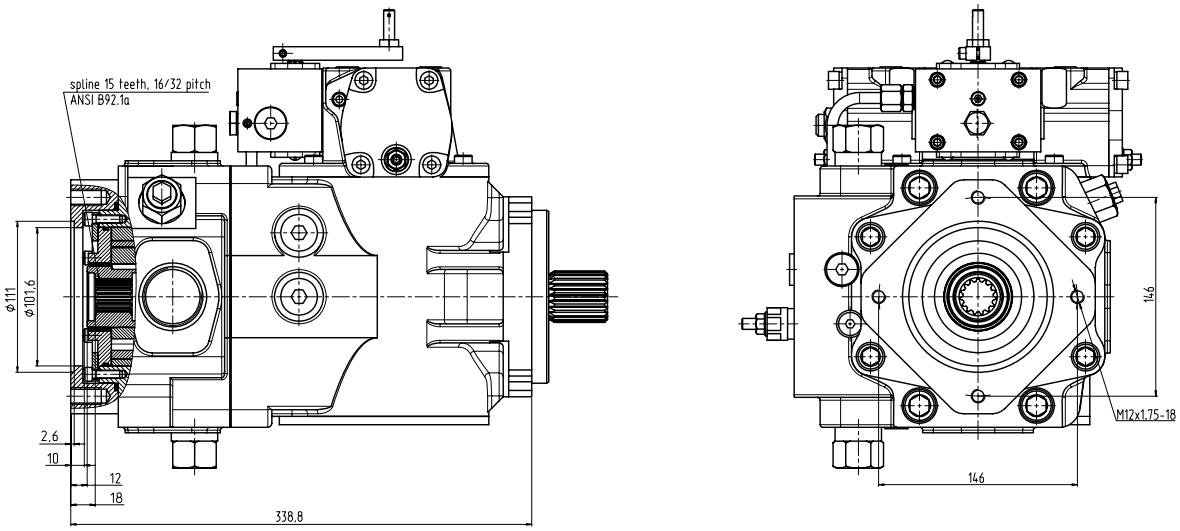
Flange SAE B, spline 13 teeth, 16/32 pitch. Option J: B.



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

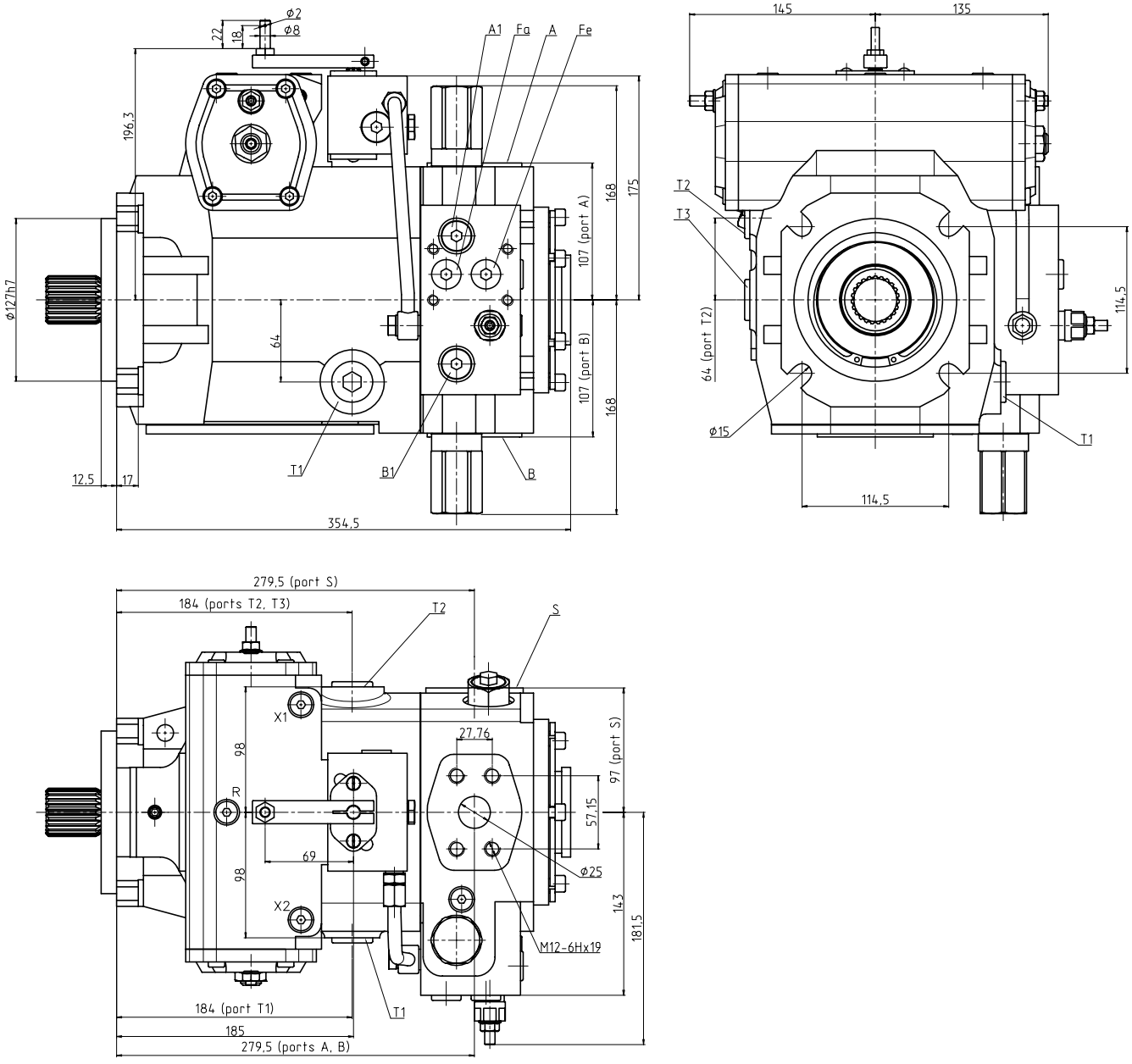
Auxiliary mounting pads.

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



Overall-mounting dimensions. Size range 110, 125 cm³.

Main dimensions.

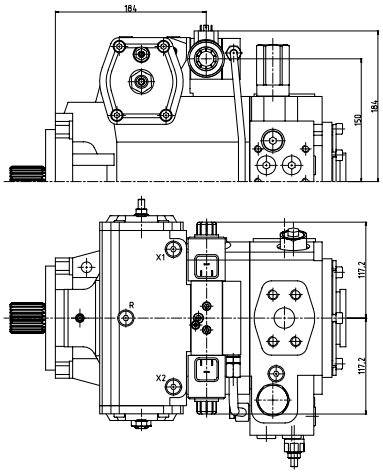


			option	code
A, B	operating pressure ports	SAE 1"6000psi; M12-6Hx17; 57.2 x 27.8mm	G	F3…
		SAE 1 1/4"6000psi; M14-7Hx19; 66.7x31.75mm	G	F4…
S	suction port	M48x2, 26mm	G	F…4
T1, T2	case drain ports	M33x2-15 GOST 25064 / ISO 6149-1	-	standard program
		7/8-14UNF-2B ISO 11926-1	M	IN
A1, B1	operating pressure gauge ports	M22x1.5-12 GOST 25065 / ISO 6149-1	-	standard program
X1, X2	control pressure gauge ports	M12x1.5-14 GOST 25065 / ISO 6149-1	-	standard program
R	air bleed	M12x1.5-12 GOST 25065 / ISO 6149-1	-	standard program
Fa	chagre pressure gauge port	M18x1.5-12 GOST 25065 / ISO 6149-1	-	standard program
Fa, Fe	pressure filter ports	M18x1.5-12 GOST 25065 / ISO 6149-1	-	standard program

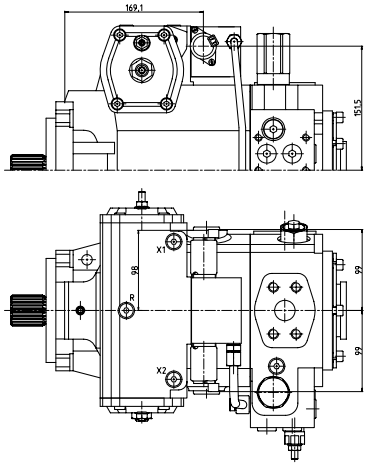
Overall-mounting dimensions. Size range 110, 125 cm³.

Controls.

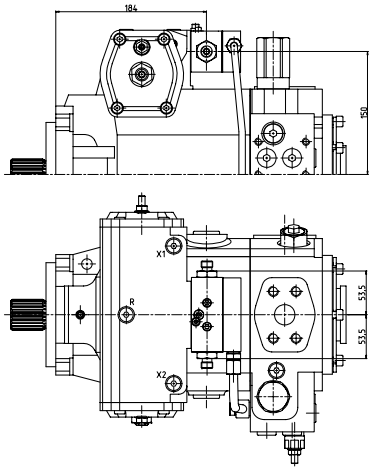
Electrical proportional
Option I: E3 (12VDC), E4 (24VDC)



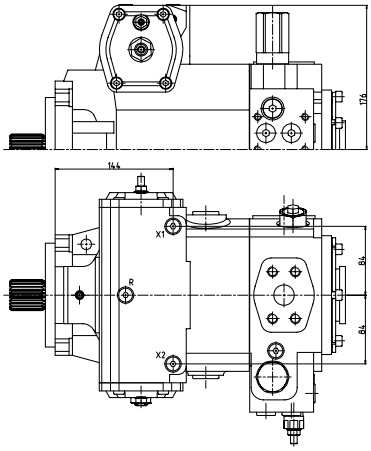
Electrical proportional without feedback
Option I: E5 (12VDC), E6 (24VDC)



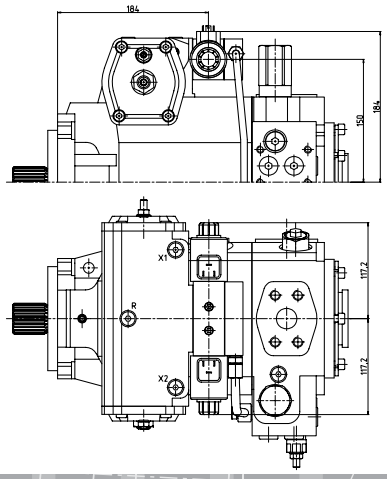
Hydraulic proportional
Option I: HP



Hydraulic proportional without feedback
Option I: HD



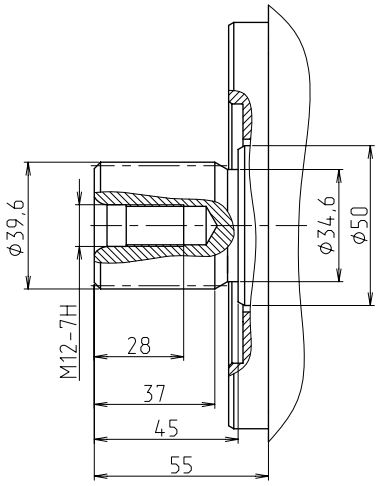
Electro 3-position
Option I: E1 (12VDC), E2 (24VDC)



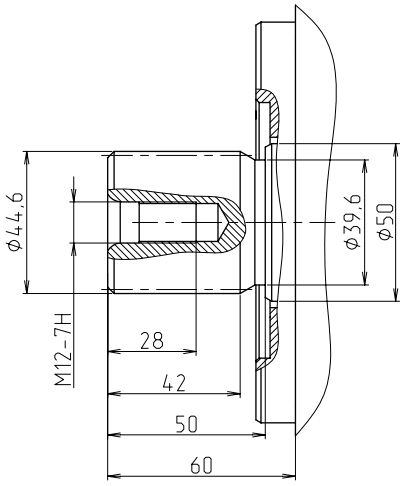
Overall-mounting dimensions. Size range 110, 125 cm³.

Shaft ends.

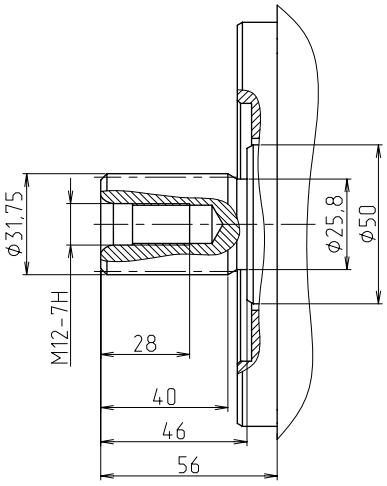
W40x2x30x18x9g DIN5480
Option F: A3



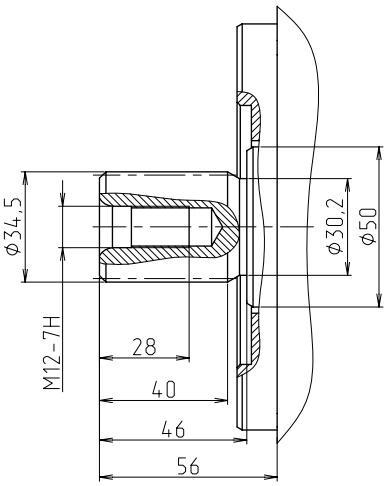
W45x2x30x21x9g DIN5480
Option F: A4



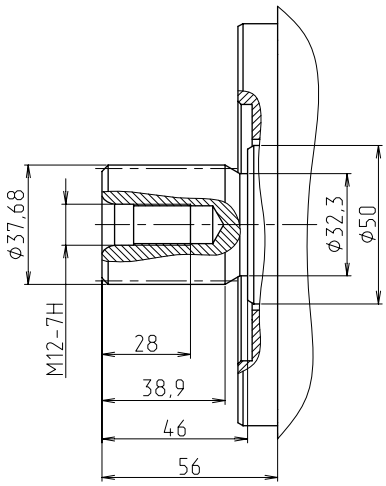
1 1/4" 14T 12/24pitch ANSI B92.1a
Option F: S1



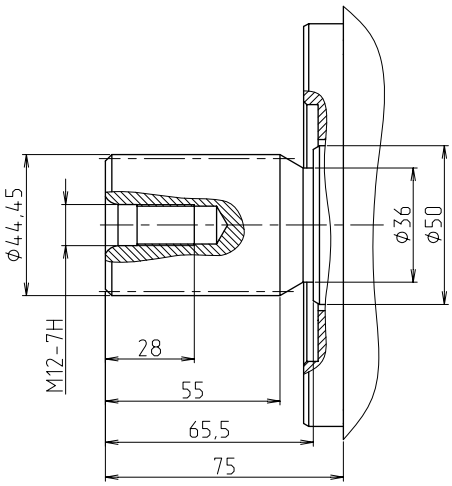
1 3/8" 21T 16/32pitch ANSI B92.1a
Option F: S2



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

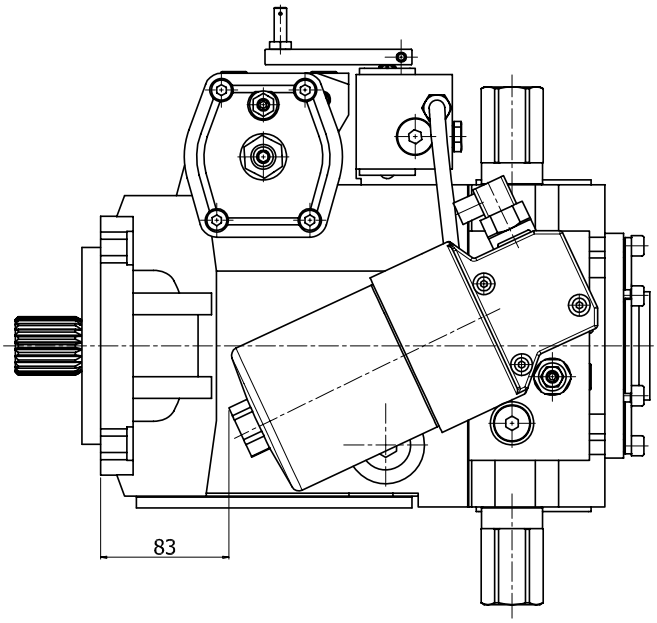


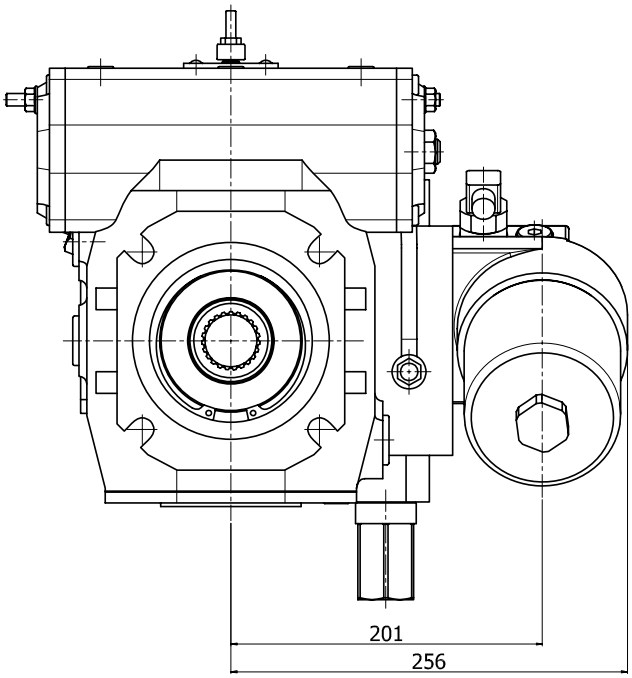
1 3/4" 13T 8/16pitch ANSI B92.1a
Option F: S4

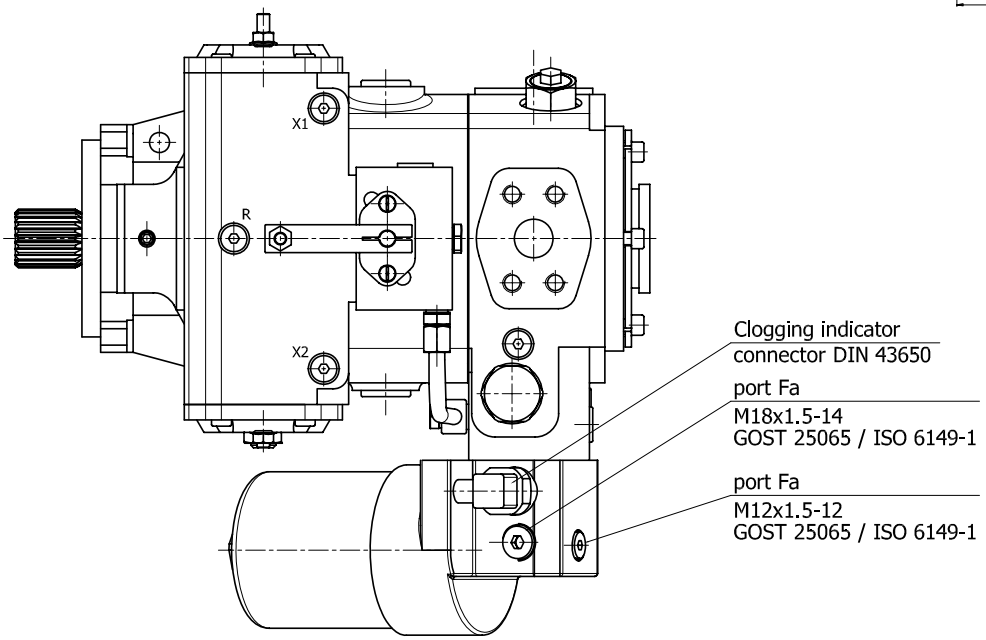


Overall-mounting dimensions. Size range 110, 125 cm³.

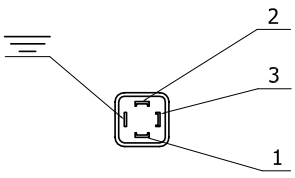
Built-in pressure filter.



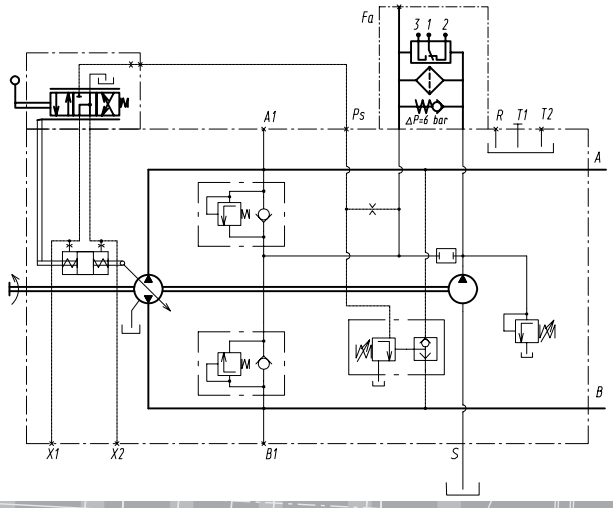




Connector pins



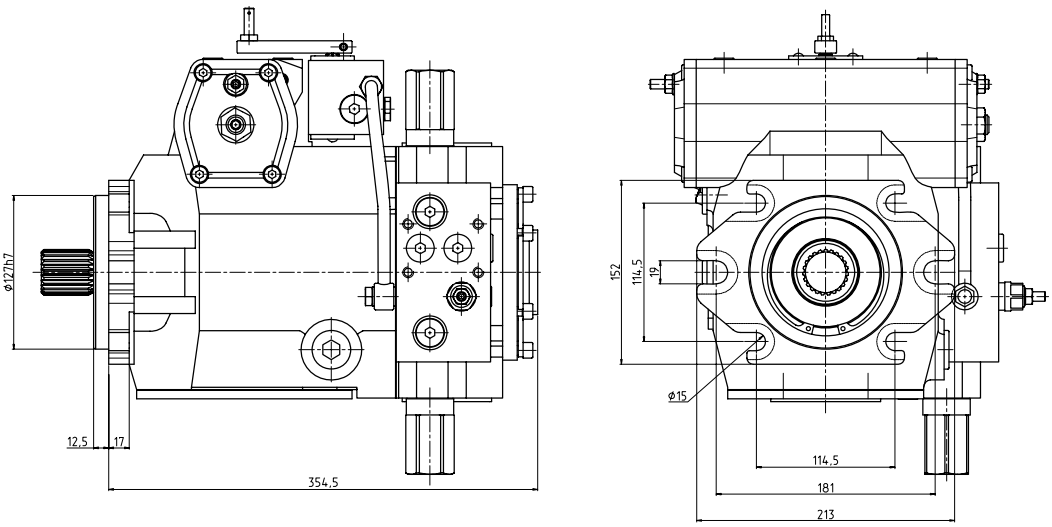
Hydraulic circuit diagram.



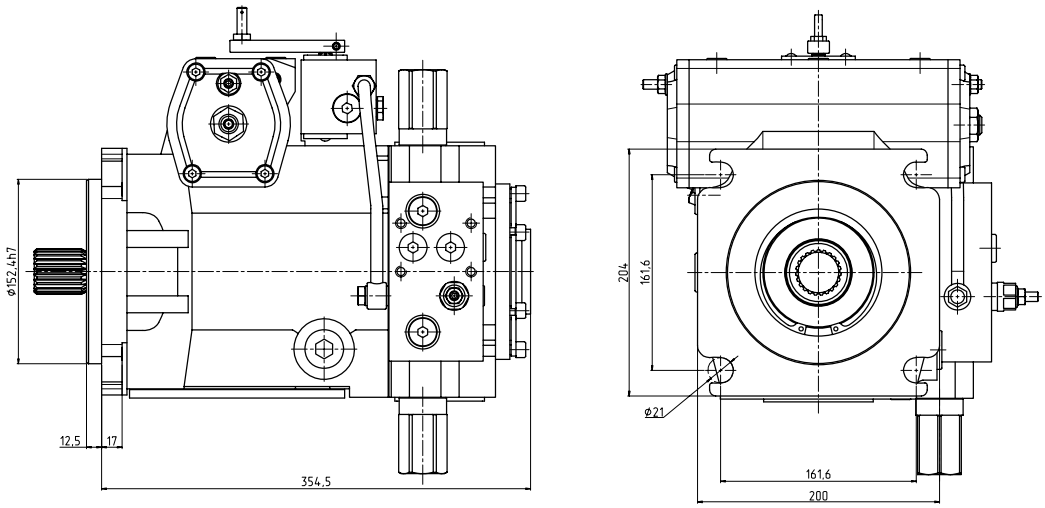
Overall-mounting dimensions. Size range 110, 125 cm³.

Mounting flanges.

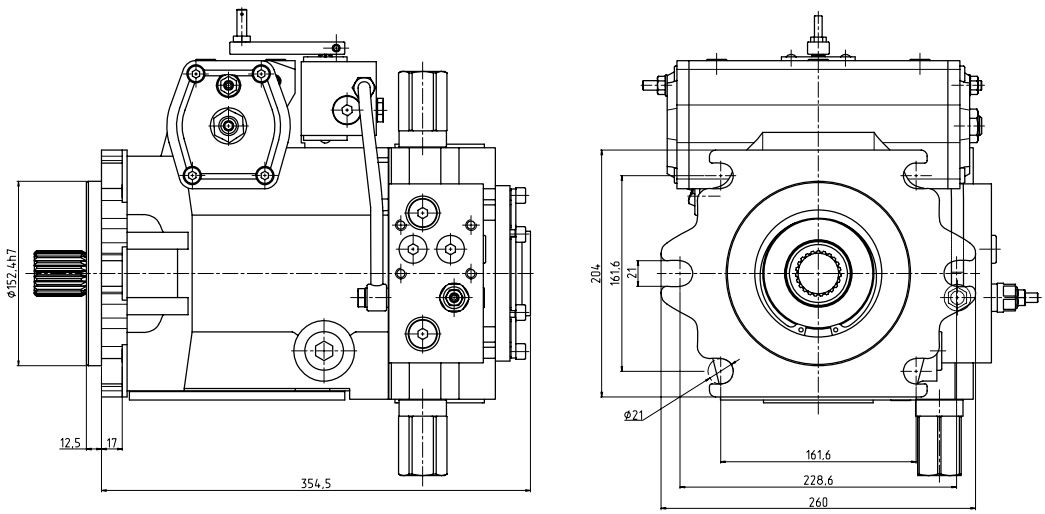
Flange SAE C, 4+2 bolts. Option E: Y4.



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



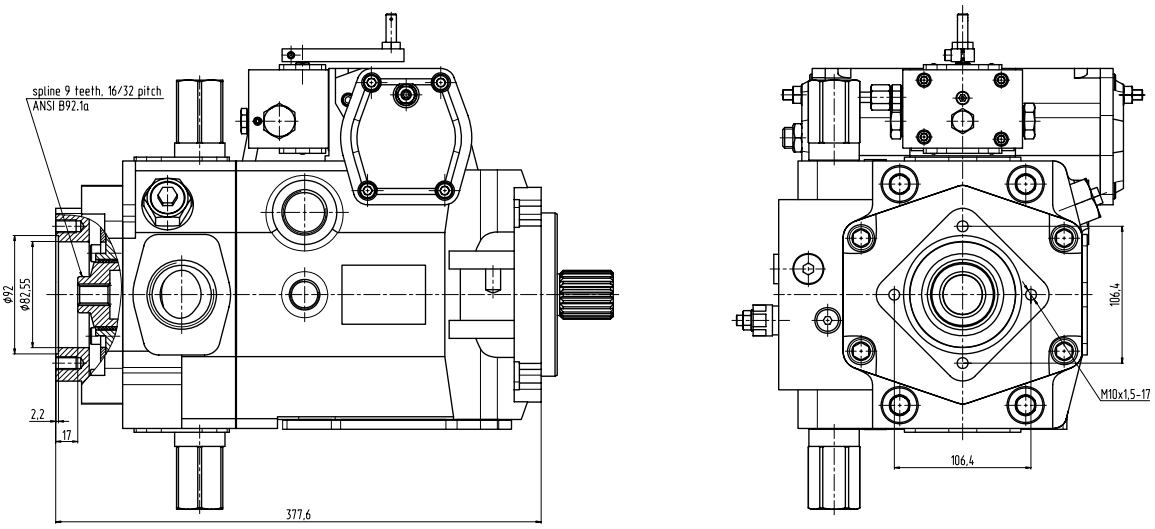
Flange SAE D, 4+2 bolts. Option E: Y3.



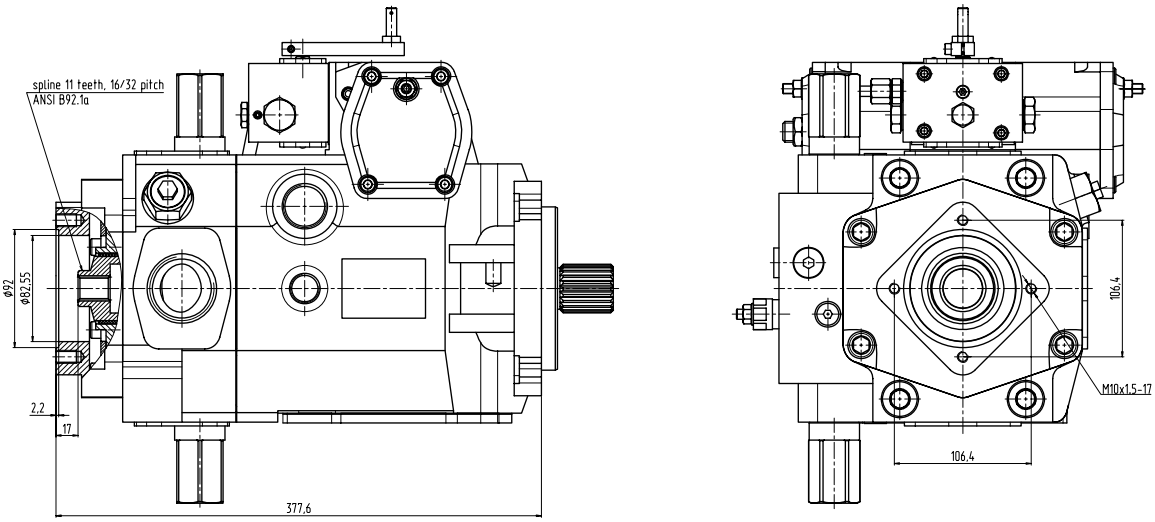
Overall-mounting dimensions. Size range 110, 125 cm³.

Auxiliary mounting pads.

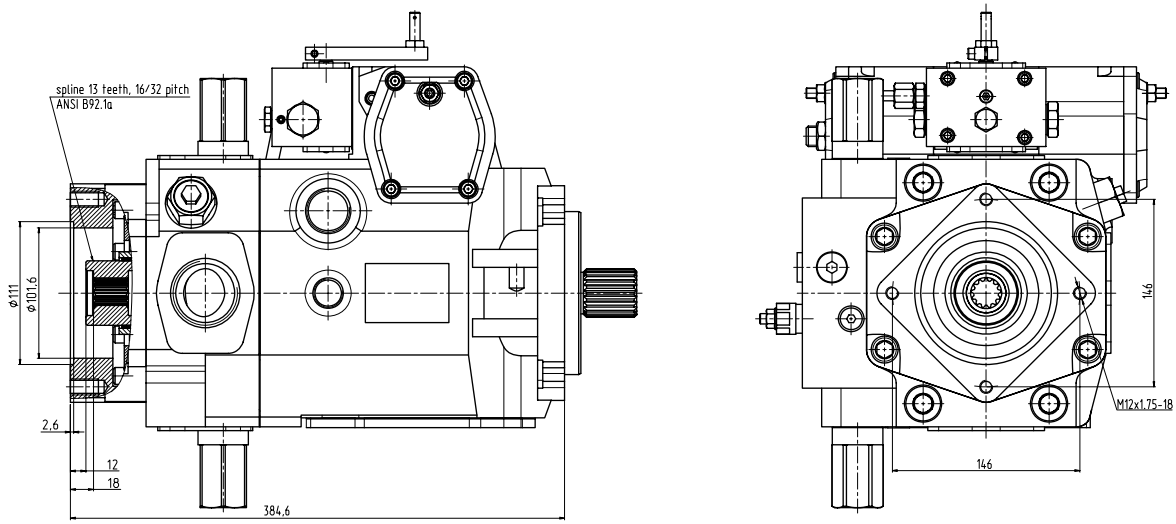
Flange SAE A, spline 9 teeth, 16/32 pitch. Option J: A.



Flange SAE A-A, spline 11 teeth, 16/32 pitch. Option J: Z.



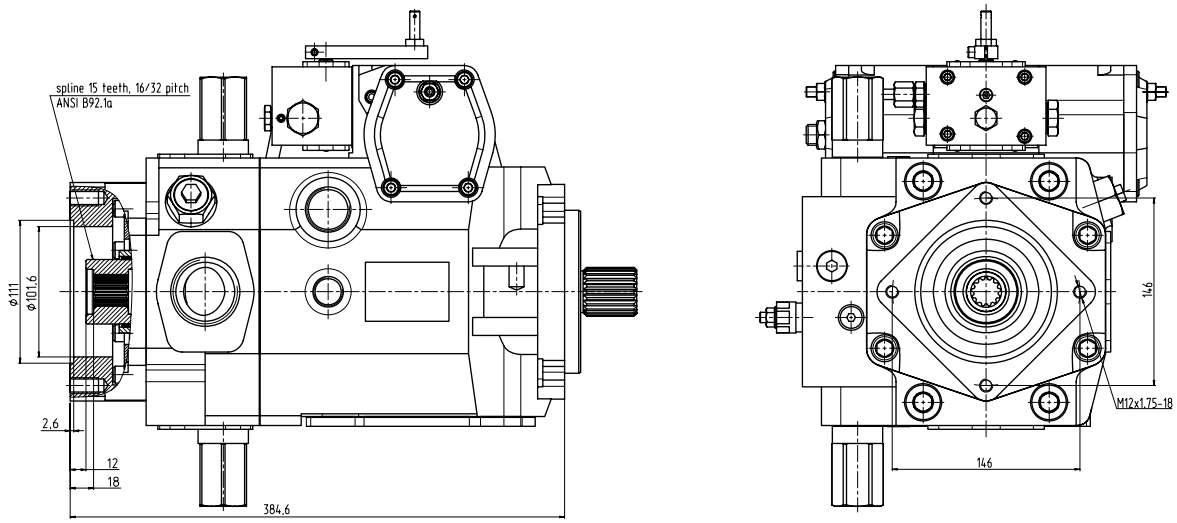
Flange SAE B, spline 13 teeth, 16/32 pitch. Option J: B.



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.

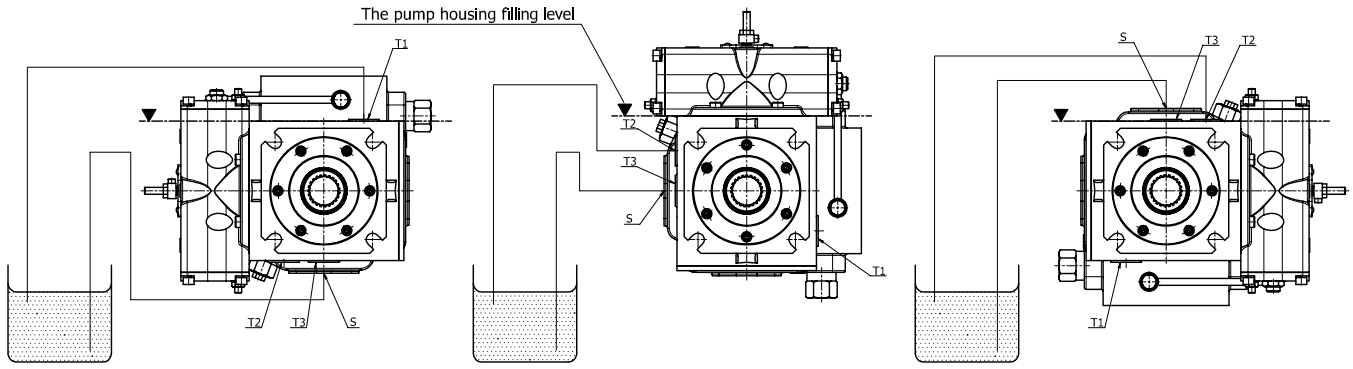
For faultless operation of 416 series pumps the requirements of the present section should be complied with.

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

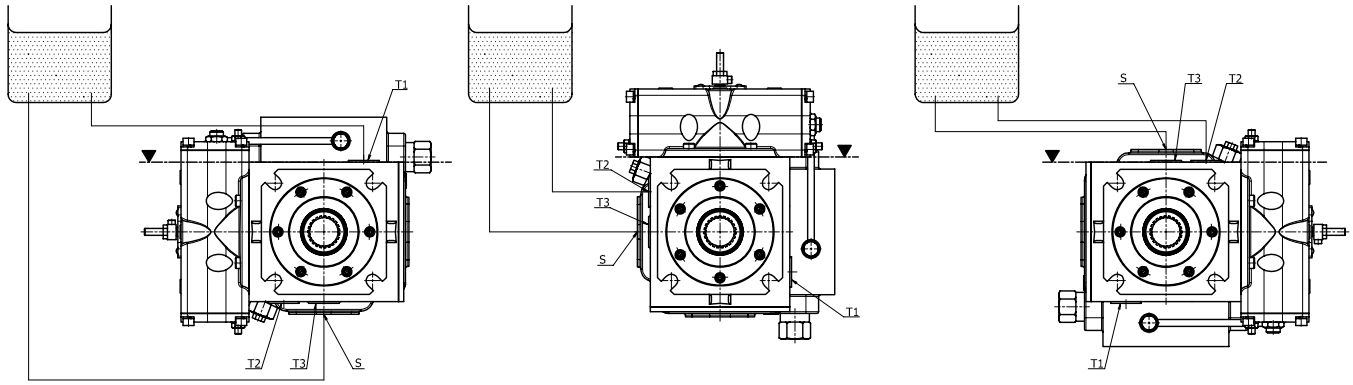
Pump drain chamber should be always filled with working fluid. Before the first launch of the pump the air should be disinflated from the pump housing through port R and drain port T located at the upper point.
Charge pump and input channel of suction line should always be filled with working fluid.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