

Axial piston variable pump A4VBO series 10 and 30



- ▶ Optimized high-pressure pump for maximum power requirement up to 500 bar
- ▶ Sizes 71, 125, 250, 450
- ▶ Nominal pressure 450 bar
- ▶ Maximum pressure 500 bar
- ▶ Open circuit

Features

- ▶ Variable pump with axial piston rotary group in swashplate design for hydrostatic drives in open circuit as well as operation with boosted inlet
- ▶ The flow can be continuously changed by adjusting the swashplate.
- ▶ Robust pump with very long service life
- ▶ Low operating noise
- ▶ Through drive possibility
- ▶ Axial and radial load capacity of drive shaft
- ▶ Modular design
- ▶ High power density
- ▶ Optical swivel angle indicator
- ▶ Good power to weight ratio
- ▶ Short control times
- ▶ Internal and external bearing flushing
- ▶ Inside-reservoir installation possible

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Type code

01	02	03	04	05	06	07	08	09	10	11	12	
	A4VB	O			/		V		-		25	

Rotary group version

01	High-speed version	-	-	•	-	H
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Axial piston unit

02	Variable, swashplate design, nominal pressure 450 bar, maximum pressure 500 bar	A4VB
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Operating mode

03	Pump, open circuit	O
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Size (NG)

04	Geometric displacement, see table of values on page 7	71	125	250	450
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Control device

		Data sheet						
05	Customer compact solution: electro-hydraulic control with proportional valve and with AWAX – position transducer (prepared for customer-specific control system)	92076	○	○	○	○	HM2C	
	Digital, electro-hydraulic control, with control valve	Digital electro-hydraulic pump control system	●	●	●	●	HS5..	
		..internal control pressure supply	●	●	●	-	HS5V.	
		Digital, electro-hydraulic control system, with OBE control valve for electric displacement and pressure control and torque limitation at external control pressure supply	●	●	●	●	HS5E..	
		..internal control pressure supply	●	●	●	-	HS5EV.	
	Power controller	Mechanically adjustable	92064	●	●	-	-	LR2
	Electrohydraulic control system	Internal control pressure supply	92088	●	●	●	-	DFE1
		External control pressure supply of swiveling range 0 to +100%		●	●	●	-	DFE1Z

Series

06	Series 1, index 0	●	-	-	-	10
	Series 3, index 0	-	●	●	●	30

Direction of rotation

07	Viewed on drive shaft	Clockwise	R
		Counter-clockwise	L

Sealing material

08	FKM (fluorocarbon rubber)	V
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Drive shaft

09	Splined shaft DIN 5480, without undercut	-	-	-	●	R
	Splined shaft DIN 5480	●	●	●	-	Z

Mounting flange

10	Based on ISO 3019-2 metric	4-hole	●	●	●	-	B
		8-hole	-	-	-	●	H
















Working port

11	SAE flange port B and S , lateral offset 90°, fastening thread metric 2. pressure port B ₁ vs. B - plugged for delivery with flange plate	25
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● = Available ○ = On request - = Not available

01	02	03	04	05	06	07	08	09	10	11	12
	A4VB	O		/			V		-		25

Through drive (for mounting options, see page 28)

12	Flange ISO 3019-2 (metric)	Hub for splined shaft							
	Diameter	Mounting ¹⁾	Diameter		71	125	250	450	
	With through drive	Without conversion option			●	-	-	●	K...
		For universal through drive, see data sheet 95581			-	●	●	-	U...
	125, 4-hole		32x2x14x9g ²⁾		○	○	○	○	31
	140, 4-hole		40x2x18x9g ²⁾		●	●	●	○	33
	160, 4-hole		50x2x24x9g ²⁾		-	●	●	○	34
	224, 4-hole		60x2x28x9g ²⁾		-	-	●	○	35
			70x3x22x9g ²⁾		-	-	-	○	77
	315, 8-hole		80x3x25x9g ²⁾		-	-	-	○	43
					-	-	-	●	97
	80, 2-hole		3/4 in 11T 16/32DP ³⁾		○	○	○	○	B2
	100, 2-hole		7/8 in 13T 16/32DP ³⁾		●	○	○	○	B3
			1 in 15T 16/32DP ³⁾		●	○	○	○	B4
	125, 4-hole		1 in 15T 16/3 2DP ³⁾		●	○	○	○	E1
	125, 2-hole		1 1/4 in 14T 12/24DP ³⁾		○	○	○	○	B5
			1 1/2 in 17T 12/24DP ³⁾		-	○	○	○	B6
	160, 4-hole		1 1/4 in 14T 12/24DP ³⁾		○	○	○	○	B8
	180, 4-hole		1 1/2 in 17T 12/24DP ³⁾		-	○	○	○	B9
			1 3/4 in 13T 8/16DP ³⁾		-	-	○	○	B7
	Flange ISO 3019-1 (SAE)		Hub for splined shaft						
	Diameter	Mounting	Diameter		71	125	250	450	
	82-2 (A)		5/8 in 9T 16/32DP ³⁾		●	●	●	○	01
			3/4 in 11T 16/32DP ³⁾		○	○	○	○	52
	101-2 (B)		7/8 in 13T 16/32DP ³⁾		●	●	●	○	68
			1 in 15T 16/32DP ³⁾		○	●	●	○	04
			1 1/4 in 14T 12/24DP ³⁾		○	○	○	○	06
	127-4 (C)		1 in 15T 16/32DP ³⁾		○	○	○	○	E2
			1 1/4 in 14T 12/24DP ³⁾		○	○	○	○	15
	127-2 (C)		1 1/4 in 14T 12/24DP ³⁾		○	○	●	○	07
			1 1/2 in 17T 12/24DP ³⁾		-	●	●	○	24
	152-4 (D)		1 1/2 in 17T 12/24DP ³⁾		-	○	○	○	96
			1 3/4 in 13T 8/16DP ³⁾		-	○	○	○	17
	Prepared for through drive, plugged with pressure-resistant cover				●	●	●	●	99

● = Available ○ = On request - = Not available

Notice

- ▶ Observe the project planning notes (page 33).
- ▶ In addition to the type code, please specify the relevant technical data when placing your order.
- ▶ For notes on combination pumps, see page 28)

1) Mounting holes pattern viewed on through drive with control at top.
 2) Splined hub × 8H according to DIN 5480
 3) Hub for splined shaft according to ANSI B92.1a, 30° pressure angle, flat root, side fit, tolerance class 5

Hydraulic fluids

The A4VBO variable pump is designed for operation with HLP mineral oil according to DIN 51524.

Application instructions and requirements for hydraulic fluid selection, behavior during operation as well as disposal and environmental protection should be taken from the following data sheets before the start of project planning:

- ▶ 90220: Hydraulic fluids based on mineral oils and related hydrocarbons
- ▶ 90221: Environmentally acceptable hydraulic fluids
- ▶ 90222: Fire-resistant, water-free hydraulic fluids (HFDR/HFDU)

Selection of hydraulic fluid

Bosch Rexroth evaluates hydraulic fluids on the basis of the Fluid Rating according to the technical data sheet 90235.

Hydraulic fluids with positive evaluation in the Fluid Rating are listed in the following data sheet:

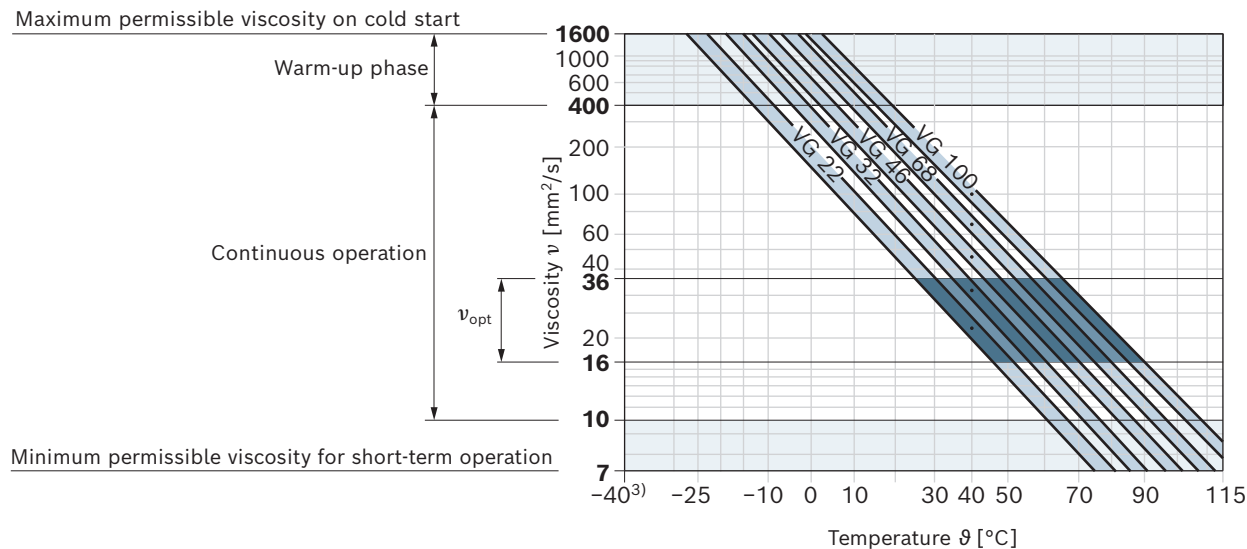
- ▶ 90245: Bosch Rexroth fluid rating list for Rexroth hydraulic components (pumps and motors)

The hydraulic fluid should be selected so that the operating viscosity in the operating temperature range is within the optimum range (v_{opt} ; see selection diagram).

Viscosity and temperature of hydraulic fluids

	Viscosity	Shaft seal	Temperature ²⁾	Remarks
Cold start	$v_{max} \leq 1600 \text{ mm}^2/\text{s}$	FKM	$\vartheta_{St} \geq -25^\circ\text{C}$	$t \leq 3 \text{ min}$, without load ($p \leq 50 \text{ bar}$) Permissible temperature difference between axial piston unit and hydraulic fluid in the system maximum 25 K
Warm-up phase	$v = 1600 \dots 400 \text{ mm}^2/\text{s}$			$t \leq 15 \text{ min}$, $p \leq 0.7 \times p_{nom}$ und $n \leq 0.5 \times n_{nom}$
Continuous operation	$v = 400 \dots 10 \text{ mm}^2/\text{s}$ ¹⁾	FKM	$\vartheta_{St} \leq +110^\circ\text{C}$	Measured at port T
	$v_{opt} = 36 \dots 16 \text{ mm}^2/\text{s}$			Optimal operating viscosity and efficiency range
Short-term operation	$v_{min} = 10 \text{ mm}^2/\text{s}$	FKM	$\vartheta_{St} \leq +110^\circ\text{C}$	$t \leq 3 \text{ min}$, $p \leq 0.3 \times p_{nom}$, measured at port T

▼ Selection diagram



1) This corresponds, for example on the VG 46, to a temperature range of +4 °C to +85 °C (see selection diagram)

2) Special version, please contact us

3) If the temperature at extreme operating parameters cannot be adhered to, please contact us.

Filtration of the hydraulic fluid

Finer filtration improves the cleanliness level of the hydraulic fluid, which increases the service life of the axial piston unit.

A cleanliness level of at least 20/18/15 is to be maintained according to ISO 4406

At a hydraulic fluid viscosity of less than 10 mm²/s (e.g. due to high temperatures during short-term operation) at the drain port, a cleanliness level of at least 19/17/14 under ISO 4406 is required.

Examples of temperatures of hydraulic fluids at a viscosity of 10 mm²/s:

- ▶ 73 °C at HLP 32
- ▶ 85 °C at HLP 46

Bearing flushing

Bearing flushing is required for a safe, continuous operation under the following operating conditions:

- ▶ Operation with borderline conditions for temperature and viscosity
- ▶ With vertical installation (drive shaft facing upwards) for lubricating the front bearing and the shaft seal.

Bearing flushing is realized at port **U** in the area of the front flange of the variable pump. The flushing fluid flows through the front bearing and discharges with the pump drain at the drain port.

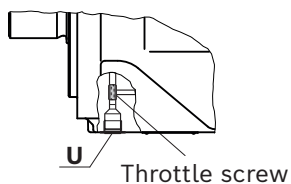
The following flushing flows are recommended depending on size:

NG	71	125	250	450
q_{Sp} l/min	4	5	10	20

For the flushing flows indicated, there is a pressure differential of approx. 2 (Series 10) or 3 (Series 30) bar between port **U** (including fitting) and the housing area.

Note for NG 125 and 250 series 30

When using external bearing flushing, the throttle screw in port **U** must be turned to the stop.

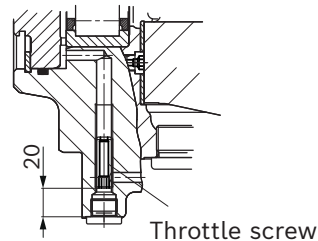


Notice

For details on the viscosity and temperatures of the hydraulic fluids, please see page 4.

Notice to size 450

One of the bearing flushings extracted from the feed pressure to be applied from outside is present. If an external bearing flushing is used, the throttle screw in port **U** is to be screwed out to 20 mm.

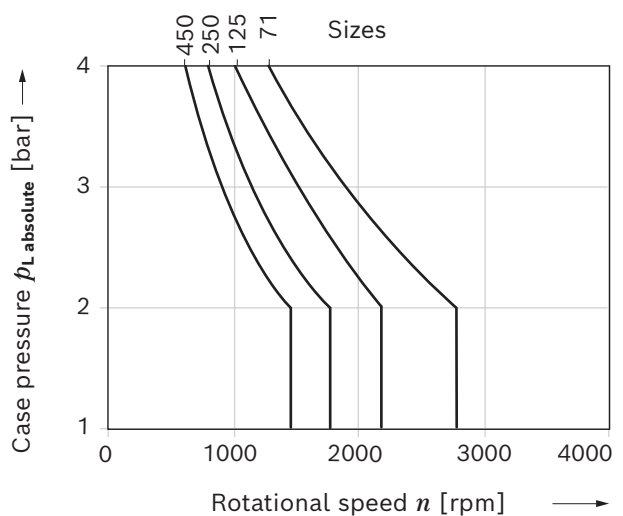


Shaft seal

Permissible pressure load

The service life of the shaft seal is influenced by the rotational speed of the axial piston unit and the leakage pressure in the housing (case pressure). Momentary ($t < 0.1$ s) pressure peaks of up to 6 bar absolute are acceptable. The service life of the shaft seal decreases with increasing frequency of pressure peaks and increasing mean differential pressure. A slide ring seal is available for higher housing pressures for certain sizes. The pressure in the housing must be equal to or greater than the ambient pressure.

▼ Characteristic curve case pressure



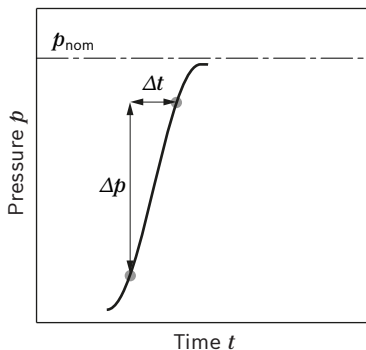
Flow direction

S to B

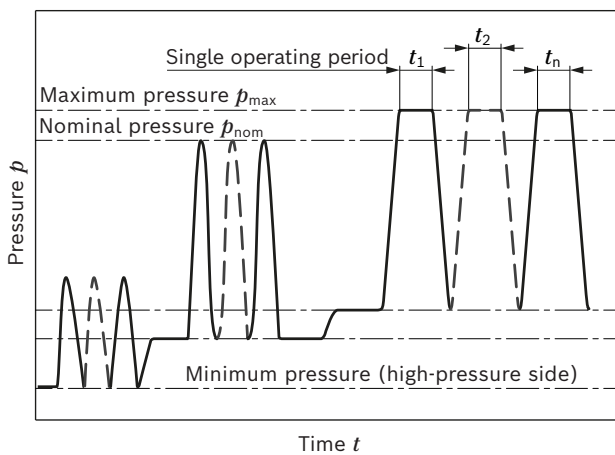
Working pressure range

Pressure at working port B		Definition
Nominal pressure p_{nom}	450 bar	The nominal pressure corresponds to the maximum design pressure.
Maximum pressure p_{max}	500 bar	The maximum pressure corresponds to the maximum working pressure within a single operating period. The sum of the single operating periods must not exceed the total operating period (maximum number of cycles: approx. 1 million).
Single operating period	1 s	
Total operating period	300 h	
Minimum pressure $p_{B absolute}$ (high-pressure side)	15 bar ¹⁾	Minimum pressure on the high-pressure side (B) which is required in order to prevent damage to the axial piston unit. The minimum pressure depends on the rotational speed and the swivel angle.
Rate of pressure change $R_{A max}$	16000 bar/s	Maximum permissible speed of pressure build-up and reduction during a pressure change across the entire pressure range.
Pressure at suction port S (inlet)		
Minimum pressure $p_{S min}$ NG 71 ... 250	≥ 0.8 bar absolute	Minimum pressure at suction port S (inlet) which is required to prevent damage to the axial piston unit. The minimum pressure is dependent on the rotational speed and displacement of the axial piston unit (see diagram "Maximum permissible rotational speed NG71 bis 250" (speed limit) or "Pre-charge pressure at suction port (S) at NG 450").
Pre-charge pressure $p_{S absolute}$ NG 450	≥ 3 bar absolute	
Maximum pressure $p_{S max}$	≤ 30 bar	
Case pressure at port T, K ₁ , K ₂ , R(L)		
Max. static pressure $p_{L max}$	4 bar absolute	Maximum 1.2 bar higher than inlet pressure at port S, but not higher than $p_{L max}$. A drain line to the reservoir is required.
Pressure peaks $p_{L peak}$	6 bar absolute	$t < 0.1$ s

▼ Rate of pressure change $R_{A max}$



▼ Pressure definition



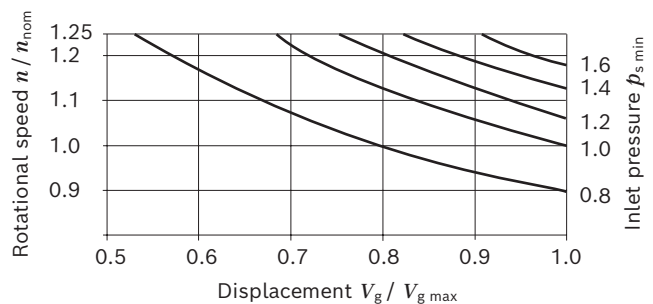
Total operating period = $t_1 + t_2 + \dots + t_n$

Notice

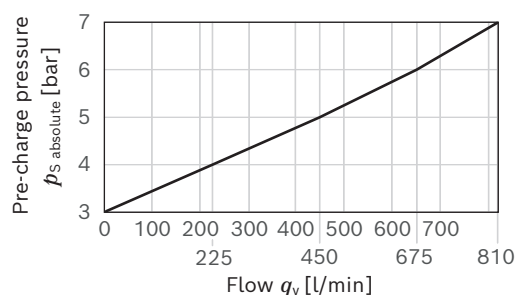
Working pressure range applies when using hydraulic fluids based on mineral oils. Please contact us for values for other hydraulic fluids.

Maximum permissible rotational speed NG 71 ... 250 (speed limit)

($p_{S absolute}$ = inlet pressure [bar])



Pre-charge pressure at suction port (S) at NG 450



1) Lower values on request

Technical data

Size	NG	71	125	250	450
Geometric displacement, per revolution	$V_{g \max}$ cm ³	71	125	250	450
Maximum rotational speed ¹⁾	at $V_{g \max}$ ²⁾	n_{nom} rpm	2200	1800	1800
	at $V_g \leq V_{g \max}$ ³⁾	n_{max} rpm	2700	2200	1800
Flow	at n_{nom} and $V_{g \max}$	q_v l/min	156	225	450
	at 1500 rpm	q_v l/min	107	188	375
Power	at n_{nom} , $V_{g \max}$ and $\Delta p = 450$ bar	P kW	117	169	337
	at 1500 rpm	P kW	80	141	281
Torque	at $V_{g \max}$ and $\Delta p = 450$ bar ²⁾	M_{max} Nm	508	894	1791
	and $\Delta p = 100$ bar ²⁾	M Nm	113	199	398
Rotary stiffness of drive shaft	Shaft end R	c kNm/rad	–	–	–
	Shaft end Z	c kNm/rad	146	263	543
Moment of inertia	J_{TW} kgm ²	0.0121	0.03	0.0959	0.3325
Maximum angular acceleration ⁴⁾	α rad/s ²	11000	8000	4800	2800
Case volume	V l	2.5	5	10	14
Weight (without through drive) approx.	m kg	65	100	195	390

Determination of the characteristics

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

$$\text{Torque } M = \frac{V_g \times \Delta p}{20 \times \pi \times \eta_{\text{hm}}} \quad [\text{Nm}]$$

$$\text{Power } P = \frac{2 \pi \times M \times n}{60000} = \frac{q_v \times \Delta p}{600 \times \eta_t} \quad [\text{kW}]$$

Key

V_g	=	Displacement per revolution [cm ³]
Δp	=	Differential pressure [bar]
n	=	Rotational speed [rpm]
η_v	=	Volumetric efficiency
η_{hm}	=	Hydraulic-mechanical efficiency
η_t	=	Total efficiency ($\eta_t = \eta_v \times \eta_{\text{hm}}$)

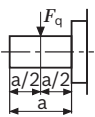
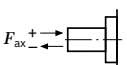
Notice

- ▶ Theoretical values, without efficiency and tolerances; values rounded
- ▶ Operation above the maximum values or below the minimum values may result in a loss of function, a reduced service life or in the destruction of the axial piston unit. We recommend checking loads through tests or calculation/simulation and comparing them with the permissible values.

- 1) The values are applicable:
 - for the optimum viscosity range from $\nu_{\text{opt}} = 36$ to 16 mm²/s
 - with hydraulic fluid based on mineral oils
- 2) The values apply at absolute pressure $p_{\text{absolute}} = 1$ bar at the suction port **S**. For NG 450, please select the required pre-charge pressure according to the diagram on page 6.
- 3) For NG 71 ... 250 Maximum rotational speed (speed limit) for increased inlet pressure p_{absolute} at suction port **S** and $V_g < V_{g \max}$, see diagram page 6.

- 4) The data are valid for values between the minimum required and maximum permissible rotational speed. Valid for external excitation (e.g. diesel engine 2 to 8 times rotary frequency; cardan shaft twice the rotary frequency). The limit value is only valid for a single pump. Factor in the load capacity of the connecting parts.

Permissible radial and axial loading on the drive shafts

Size	NG	71	125	250	450	
Maximum radial force at distance $a/2$		$F_{q \max}$ N	1200	1600	2000	3000
Maximum axial force		$+ F_{ax \max}$ N $- F_{ax \max}$ N	800	1000	1800	2200

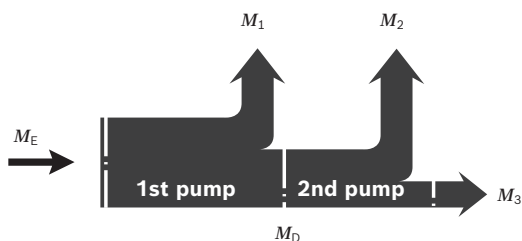
Notice

- ▶ The values given are maximum values and do not apply to continuous operation. All loads of the drive shaft reduce the bearing service life.

Permissible input and through-drive torques

Size	NG	71	125	250	450		
Torque at $V_{g \max}$ and $\Delta p = 450 \text{ bar}^1$	M_{\max}	Nm	508	894	1791	3220	
Max. input torque on drive shaft ²⁾							
	Splined shaft	R	$M_{E \max}$ Nm	–	–	6440	
	Splined shaft	Z	$M_{E \max}$ Nm	1055	1786	3412	–
Maximum through-drive torque	$M_{D \max}$	Nm	480	780	1400	3220	

▼ **Distribution of torques**



Torque at 1st pump	M_1
Torque at 2nd pump	M_2
Torque at 3rd pump	M_3
Input torque	$M_E = M_1 + M_2 + M_3$
	$M_E < M_{E \max}$
Through-drive torque	$M_D = M_2 + M_3$
	$M_D < M_{D \max}$

1) Efficiency not considered

2) For drive shafts free of radial force

Characteristic curves

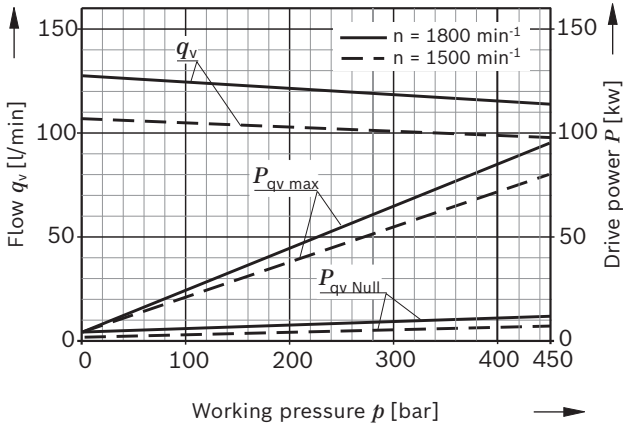
Drive power and flow

(Operating fluid: hydraulic fluid ISO VG 46 DIN 51519,
 $t = 50\text{ }^\circ\text{C}$)

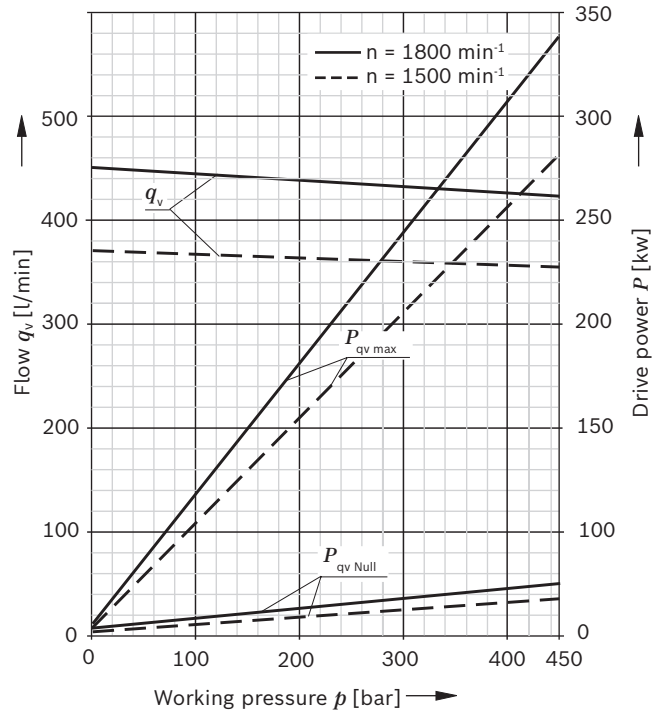
Total efficiency $n_t = \frac{q_v \times p}{P_{q_v \text{ max}} \times 600}$

Volumetric efficiency $n_v = \frac{q_v}{q_v \text{ theor}}$

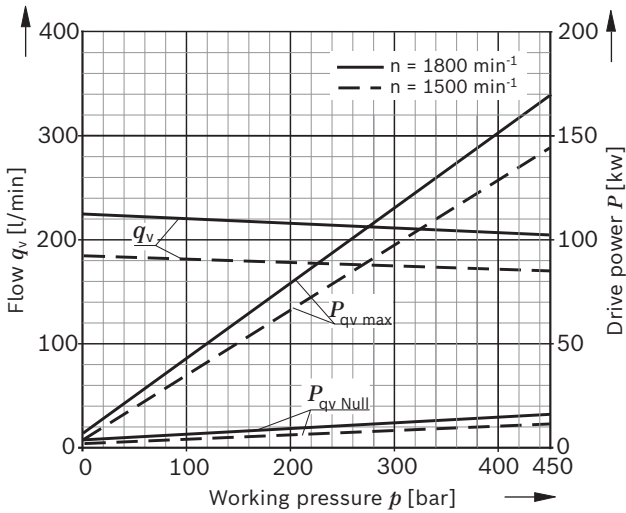
▼ Size 71



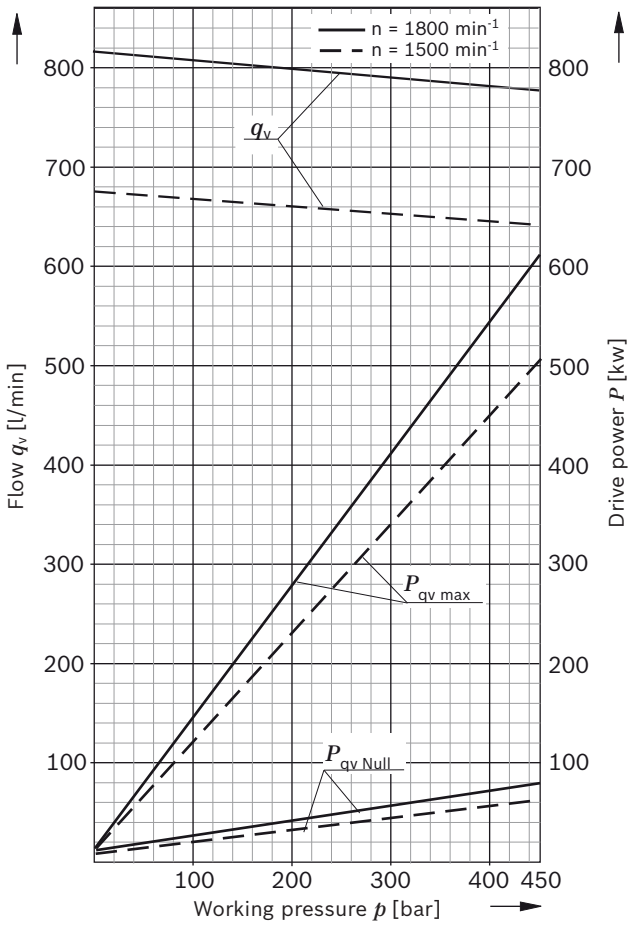
▼ Size 250



▼ Size 125



▼ **Size 450**

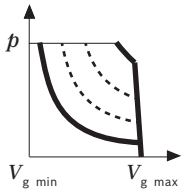


Overview of control device

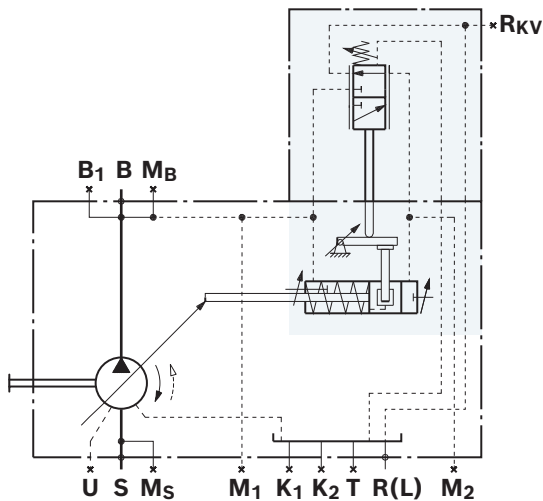
Power controller LR2 with hyperbolic characteristic curve (for further information, see data sheet 92064)

The hyperbolic power controller keeps the specified drive power constant at the same drive speed.

▼ Characteristic curve



▼ Example: circuit diagram LR2 NG 40 to 71



Digital electro-hydraulic pump control system HS5. (for further information, see data sheet 92076)

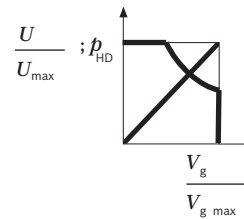
The continuous displacement control is accomplished by means of a proportional valve and electrical feedback of the swivel angle.

The HS5P control system is equipped with a mounted pressure transducer, which means that it can be used for electric pressure and power control.

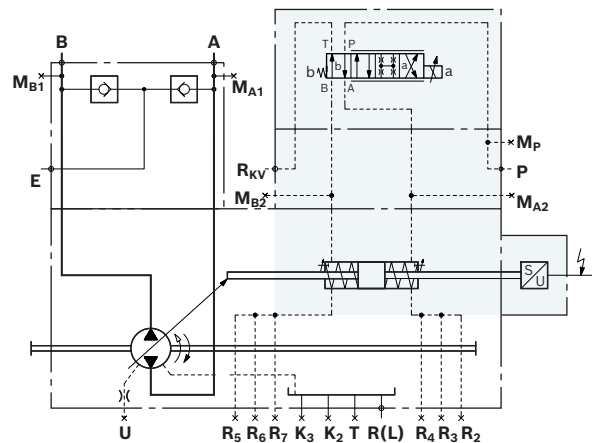
Optional:

- ▶ Proportional valve (HS5);
- ▶ Short circuit valve (HSK, HS5K, HS5KP);
- ▶ For the under oil application (HS5M);
- ▶ With internal control pressure supply (HS5V);
- ▶ Control system with integrated digital On Board Electronics OBE (HS5E).

▼ Characteristic curve



▼ Example: circuit diagram HS5 NG450

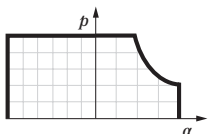


Electro-hydraulic control system DFE1

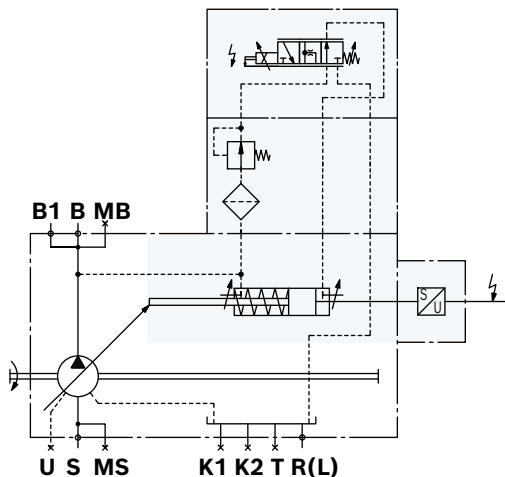
(see data sheet 92088)

An electrically actuated proportional valve controls the power, pressure and swivel angle of the A4VBO...DFE1 variable pump. The current at the proportional valve determines the position of the swashplate angle and thus the flow of the pump via the stroking piston and the position transducer. (DFE1Z with internal control pressure supply)

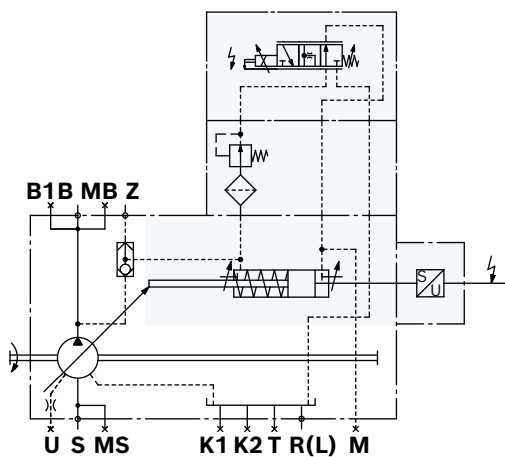
▼ Characteristic curve DFE1



▼ Circuit diagram DFE1

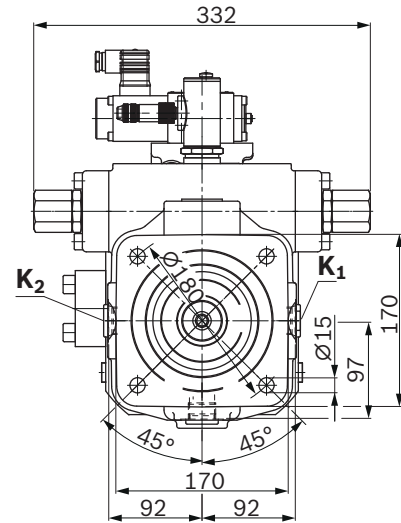
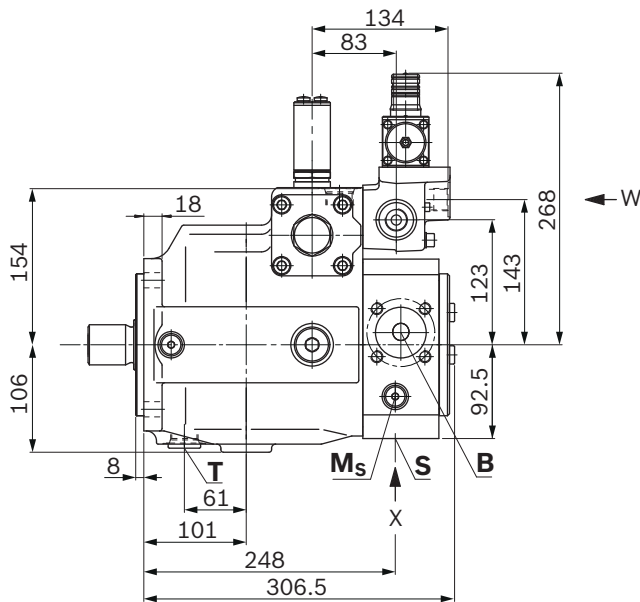


▼ Circuit diagram DFE1Z

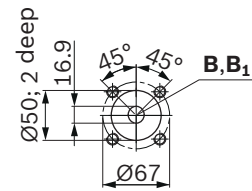


Dimensions, size 71

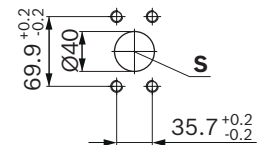
HS5 – electro-hydraulic control with proportional valve



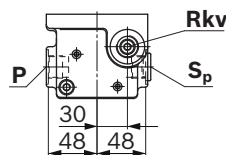
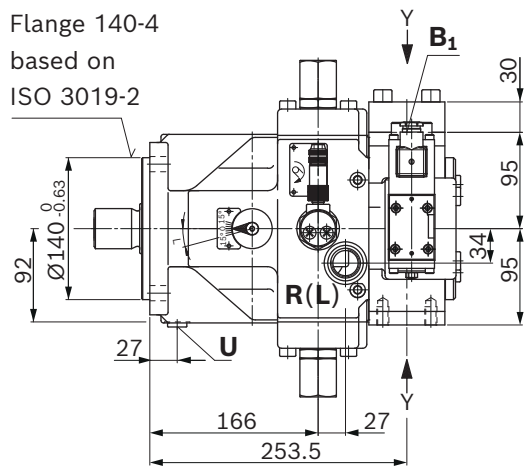
Detail Y



Detail X



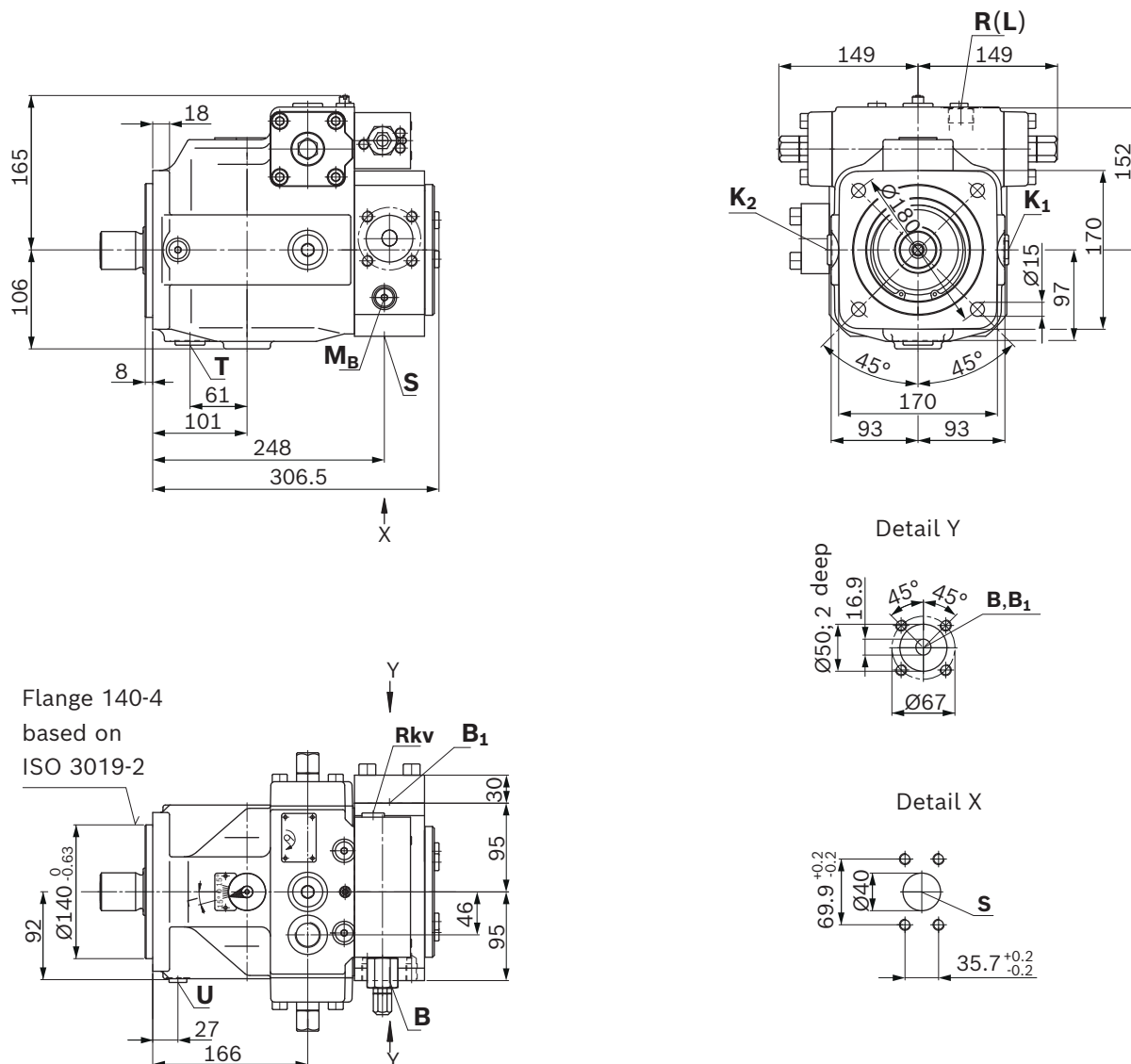
Detail W



► For connection table, see page 15

Dimensions, size 71

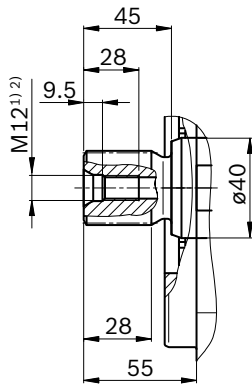
LR2 – power controller with hyperbolic characteristic curve, basic setting $V_{g \max}$, mechanically adjustable



► For connection table, see page 15

▼ **Splined shaft DIN 5480**

Z – W40x2x18x9g



Ports	Standard	Size	p_{\max} [bar] ³⁾	State ⁷⁾	
B	Working port (high-pressure series) Fastening thread	Based on ISO/DIS 6164-3 DIN 13	DN-16 M12 × 1.75; 18 deep	500	O
B₁	Working port (high-pressure series) Fastening thread	Based on ISO/DIS 6164-3 DIN 13	DN-16 M12 × 1.75; 18 deep	500	X
S	Suction port (standard pressure series) Fastening thread	SAE J518 ⁴⁾ DIN 13	1 1/2in M12 × 1.75; 20 deep	30	O
M_B	Measuring working pressure	ISO 6149	M14 × 1.5; 11.5 deep	500	X
M_S	Measuring suction pressure	ISO 6149	M14 × 1.5; 11.5 deep	30	X
T	Fluid drain	ISO 6149 ⁵⁾	M27 × 2; 16 deep	6 absolute	X ⁶⁾
K₁, K₂	Filling – air bleeding, return flow (drain port)	ISO 6149 ⁵⁾	M27 × 2; 19 deep	6 absolute	X ⁶⁾
R(L)	Filling – air bleeding, return flow (drain port)	ISO 6149 ⁵⁾	M27 × 2; 16 deep	6 absolute	O ⁶⁾
R_{kv}	Control fluid return flow (with HS5)	DIN 3852 ⁵⁾	M22 × 1.5; 14 deep	4	O
P	Control pressure (for HS5(P))	DIN 3852	M22 × 1.5; 14 deep	350	O
S_p	Control pressure accumulator (for HS5(P))	DIN 3852	M22 × 1.5; 14 deep	350	X
R_{kv}	Control fluid return flow (with LR2)	DIN 3852 ⁵⁾	M18 × 1.5; 12 deep	45	X
Z	Control pressure (for DFE1Z and DFE1Y)	ISO 6149	M14 × 1.5; 15.5 deep	50	O
U	Bearing flushing	ISO 6149	M14 × 1.5; 11.5 deep	6 absolute	X

1) Center bore according to DIN 332

2) Thread according to DIN 13

3) Depending on the application, momentary pressure peaks can occur.
Keep this in mind when selecting measuring devices and fittings.

4) Metric fastening thread is a deviation from standard.

5) The countersink may be deeper than specified in the standard.

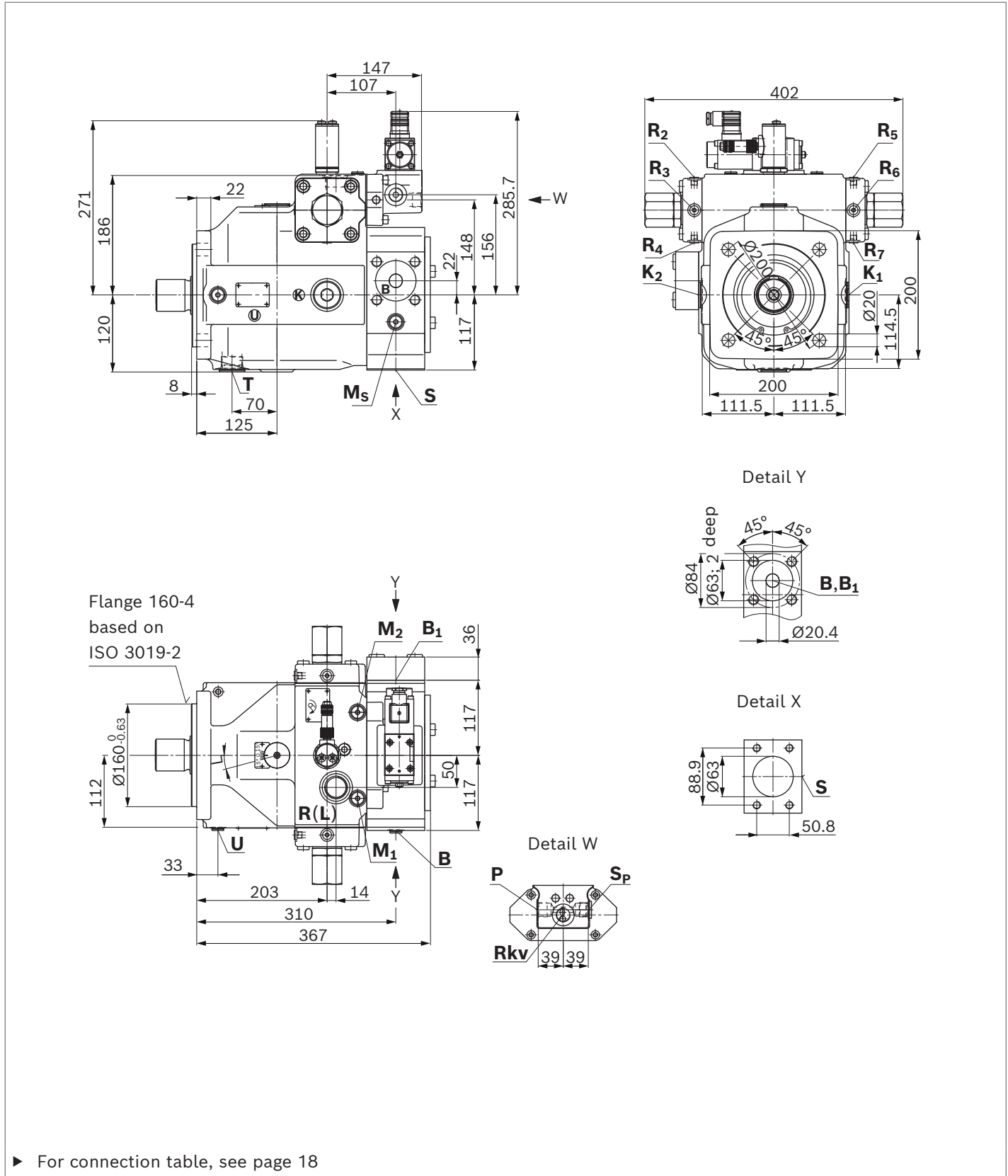
6) Depending on the installation position, T₁, K₂, K₃ or R(L) must be connected (see also installation instructions on pages 30 to 32).

7) O = Must be connected (plugged on delivery)

X = Plugged (in normal operation)

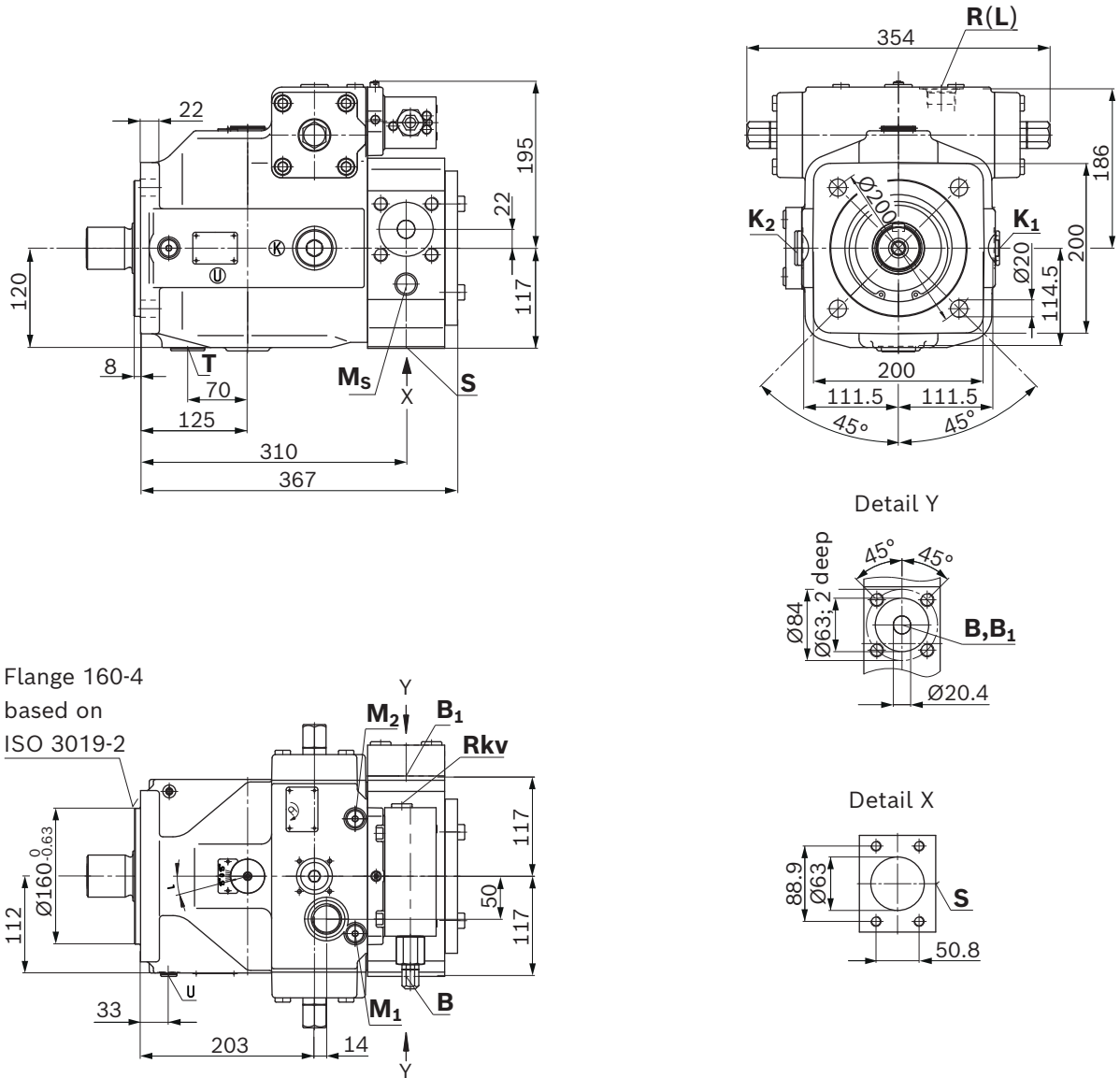
Dimensions, size 125

HS5 – electro-hydraulic control with proportional valve



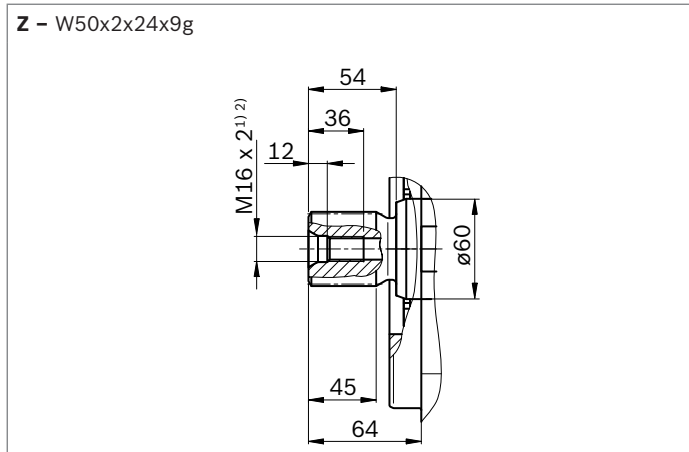
Dimensions, size 125

LR2 – power controller with hyperbolic characteristic curve, basic setting $V_{g\ max}$, mechanically adjustable



► For connection table, see page 18

▼ **Splined shaft DIN 5480**



Ports	Standard	Size	p_{max} [bar] ³⁾	State ⁷⁾
B	Working port (high-pressure series) Fastening thread	Based on ISO/DIS 6164-3 DIN 13	DN-20 M16 × 2; 24 deep	500 O
B₁	Working port (high-pressure series) Fastening thread	Based on ISO/DIS 6164-3 DIN 13	DN-20 M16 × 2; 24 deep	500 X
S	Suction port Fastening thread	SAE J518 ⁴⁾ DIN 13	2 1/2 in M12 × 1.75; 18 deep	30 O
M_B	Measuring working pressure	ISO 6149	M14 × 1.5; 11.5 deep	500 X
M_S	Measuring suction pressure	ISO 6149	M14 × 1.5; 11.5 deep	30 X
M₁, M₂	Measuring control pressure	ISO 6149	M14 × 1.5; 12 deep	350 X
T	Fluid drain	ISO 6149 ⁵⁾	M33 × 2; 18 deep	6 absolute X ⁶⁾
Rkv	Control fluid return flow (with HS5)	DIN 3852 ⁵⁾	M22 × 1.5; 15.5 deep	6 O
Rkv	Control fluid return flow (with LR2)	DIN 3852 ⁵⁾	M18 × 1.5; 12 deep	100 O
P	Control pressure	DIN 3852 ⁵⁾	M22 × 1.5; 14 deep	350 O
S_p	Control pressure accumulator	DIN 3852 ⁵⁾	M22 × 1.5; 14 deep	350 X
R₂-R₇	Air bleeding the control	DIN 3852 ⁵⁾	M10 × 1; 10 deep	350 O
K₁, K₂	Filling – air bleeding, return flow (drain port)	ISO 6149 ⁵⁾	M33 × 2; 18 deep	6 absolute X ⁶⁾
R(L)	Filling – air bleeding, return flow (drain port)	ISO 6149 ⁵⁾	M33 × 2; 18 deep	6 absolute O ⁶⁾
Z	Control pressure (for DFE1Z and DFE1Y)	ISO 6149	M14 × 1.5; 15.5 deep	50 O
U	Bearing flushing	ISO 6149	M14 × 1.5; 11.5 deep	6 absolute X

1) Center bore according to DIN 332

2) Thread according to DIN 13

3) Depending on the application, momentary pressure peaks can occur.
Keep this in mind when selecting measuring devices and fittings.

4) Metric fastening thread is a deviation from standard.

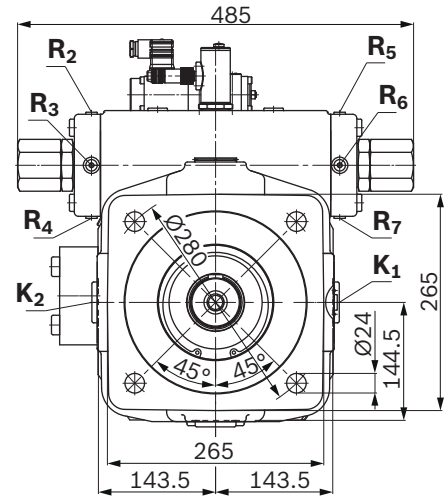
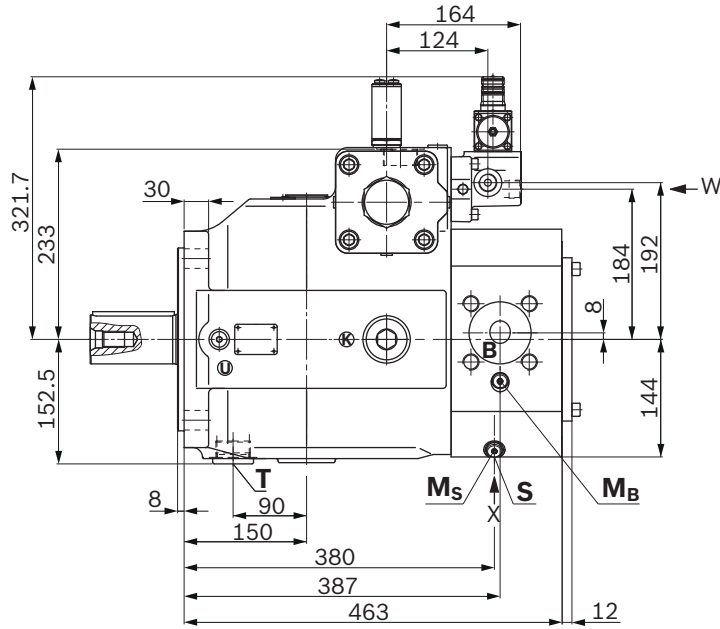
5) The countersink may be deeper than specified in the standard.

6) Depending on the installation position, T₁, K₂, K₃ or R(L) must be connected (see also installation instructions on pages 30 to 32).

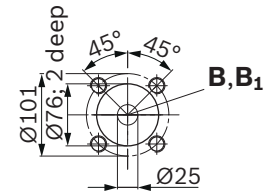
7) O = Must be connected (plugged on delivery)
X = Plugged (in normal operation)

Dimensions, size 250

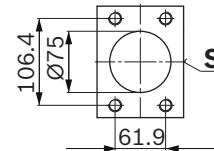
HS5 – electro-hydraulic control with proportional valve



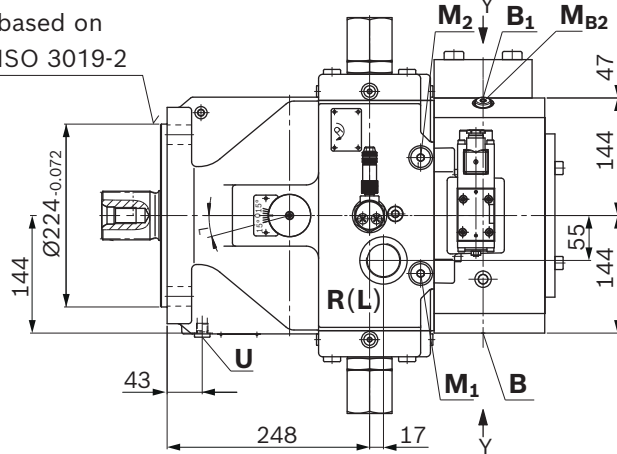
Detail Y



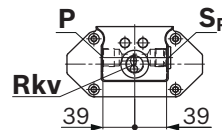
Detail X



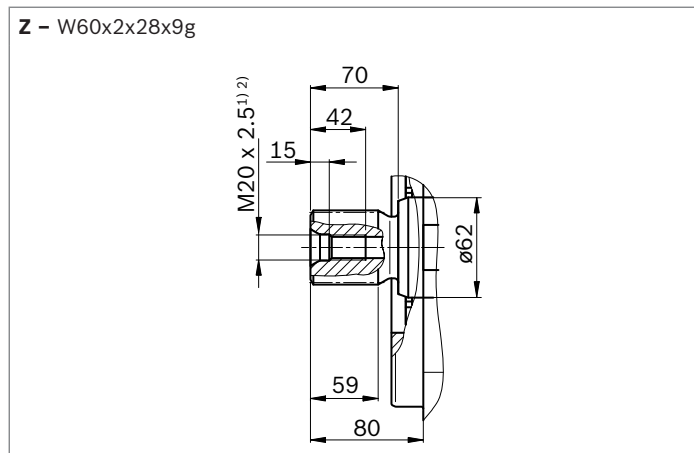
Flange 224-4
 based on
 ISO 3019-2



Detail W



▼ **Splined shaft DIN 5480**



Ports	Standard	Size ²⁾	p_{\max} [bar] ³⁾	State ⁷⁾
B	Working port (high-pressure series) Fastening thread	Based on ISO/DIS 6164-3 DIN 13	DN-25 M20 × 2.5; 24 deep	500 O
B₁	Working port (high-pressure series) Fastening thread	Based on ISO/DIS 6164-3 DIN 13	DN-25 M20 × 2.5; 24 deep	500 X
S	Suction port Fastening thread	SAE J518 ⁴⁾ DIN 13	3 in M16 × 2; 24 deep	30 O
M_B	Measuring working pressure	ISO 6149	M14 × 1.5; 12 deep	500 X
M_S	Measuring suction pressure	ISO 6149	M14 × 1.5; 12 deep	30 X
M₁, M₂	Measuring control pressure	ISO 6149	M18 × 1.5; 12 deep	350 X
T	Fluid drain	ISO 6149 ⁵⁾	M42 × 2; 20 deep	6 absolute X ⁶⁾
Rkv	Control fluid return flow (with HS5)	DIN 3852 ⁵⁾	M22 × 1.5; 12 deep	6 O
Rkv	Control fluid return flow (with LR2)	DIN 3852 ⁵⁾	M18 × 1.5; 12 deep	100 O
P	Control pressure	DIN 3852 ⁵⁾	M22 × 1.5; 14 deep	350 O
S_p	Control pressure accumulator	DIN 3852 ⁵⁾	M22 × 1.5; 14 deep	350 X
R₂-R₇	Air bleeding the control	DIN 3852 ⁵⁾	M10 × 1; 10 deep	350 O
K₁, K₂	Filling – air bleeding, return flow (drain port)	ISO 6149 ⁵⁾	M42 × 2; 20 deep	6 absolute X ⁶⁾
R(L)	Filling – air bleeding, return flow (drain port)	ISO 6149 ⁵⁾	M42 × 2; 20 deep	6 absolute O ⁶⁾
Z	Control pressure (for DFE1Z and DFE1Y)	ISO 6149	M14 × 1.5; 15.5 deep	50 O
U	Bearing flushing	ISO 6149	M14 × 1.5; 12 deep	6 absolute X

1) Center bore according to DIN 332 (thread according to DIN 13)

2) Observe the notes in the instruction manual concerning the maximum tightening torques.

3) Depending on the application, momentary pressure peaks can occur. Keep this in mind when selecting measuring devices and fittings.

4) Metric fastening thread is a deviation from standard.

5) The countersink may be deeper than specified in the standard.

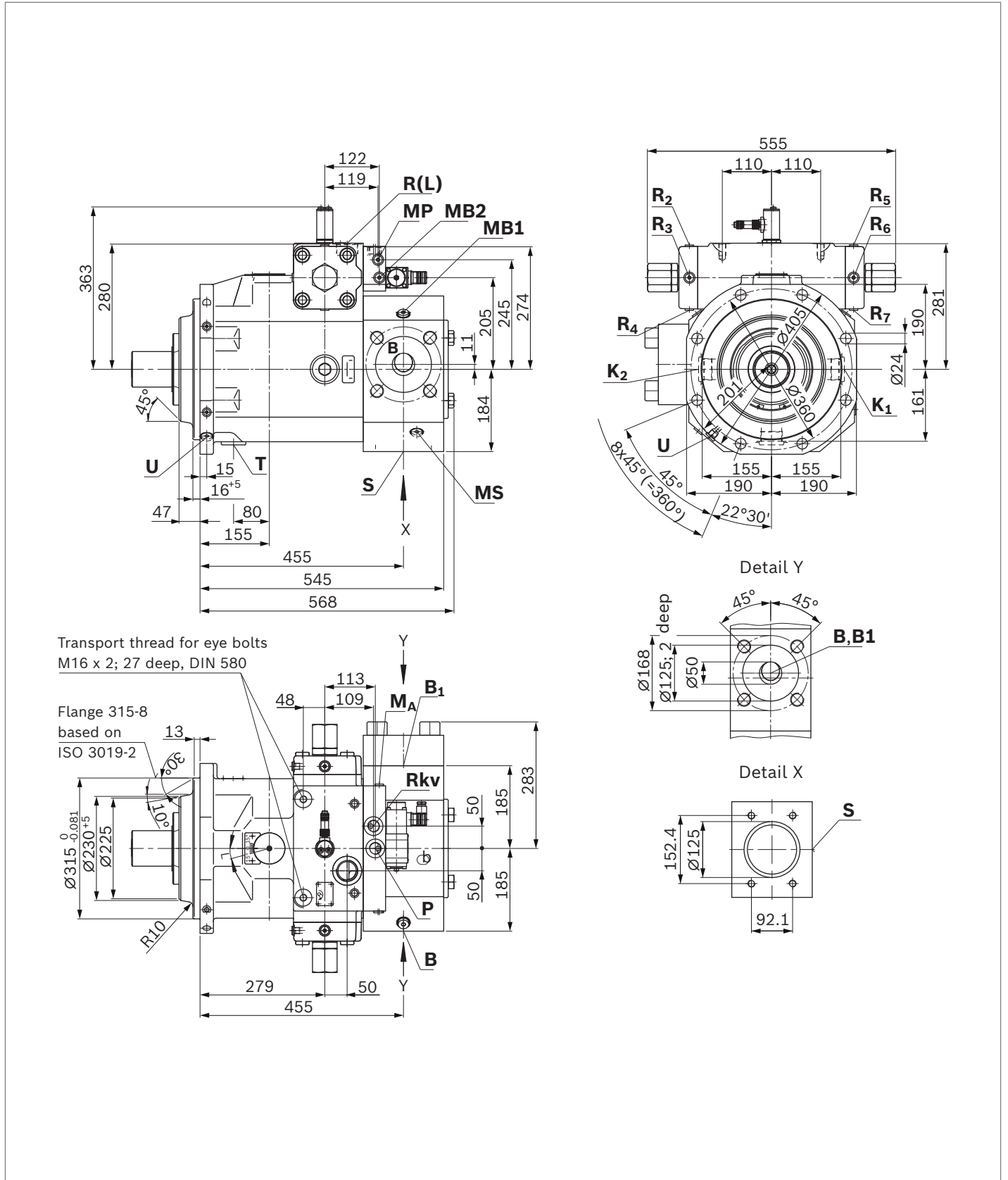
6) Depending on the installation position, T₁, K₂, K₃ or R(L) must be connected (see also installation instructions on pages 30 to 32).

7) O = Must be connected (plugged on delivery)

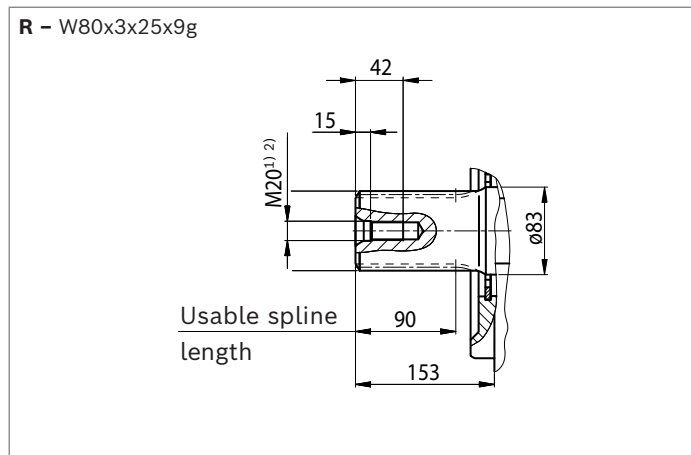
X = Plugged (in normal operation)

Dimensions, size 450

HS5 – electro-hydraulic control with proportional valve



▼ **Splined shaft DIN 5480**



Ports		Standard	Size	p_{\max} [bar] ³⁾	State ⁷⁾
B	Working port (high-pressure series) Fastening thread	Based on ISO/DIS 6164-3 DIN 13	DN-50 M30 × 3.5; 45 deep	500	O
B₁	Working port (high-pressure series) Fastening thread	Based on ISO/DIS 6164-3 DIN 13	DN-50 M30 × 3.5; 45 deep	500	X
S	Suction port Fastening thread	SAE J518 ⁴⁾ DIN 13	5 in M16 × 2; 24 deep	30	O
M_B	Measuring working pressure	ISO 6149	M18 × 1.5; 14.5 deep	500	X
M_S	Measuring suction pressure	ISO 6149	M18 × 1.5; 14.5 deep	30	X
T	Fluid drain	DIN 3852 ⁵⁾	M48 × 2; 22 deep	6 absolute	X ⁶⁾
Rkv⁸⁾	Control fluid return flow	DIN 3852 ⁵⁾	M27 × 2; 16 deep	4	O
P	Control pressure	DIN 3852 ⁵⁾	M27 × 2; 16 deep	350	O
R₂-R₇	Air bleeding the control	DIN 3852 ⁵⁾	M14 × 1; 12 deep	350	O
M_{A2}, M_{B2}, M_P	Measuring control pressure	DIN 3852 ⁵⁾	M14 × 1; 12 deep	350	O
K₁, K₂	Filling – air bleeding, return flow (drain port)	DIN 3852 ⁵⁾	M48 × 2; 22 deep	6 absolute	X ⁶⁾
R(L)	Filling – air bleeding, return flow (drain port)	DIN 3852 ⁵⁾	M48 × 2; 22 deep	6 absolute	O ⁶⁾
U	Bearing flushing	ISO 6149	M18 × 1.5; 14.5 deep	6 absolute	X

1) Center bore according to DIN 332

2) Thread according to DIN 13

3) Depending on the application, momentary pressure peaks can occur.
Keep this in mind when selecting measuring devices and fittings.

4) Metric fastening thread is a deviation from standard.

5) The countersink may be deeper than specified in the standard.

6) Depending on the installation position, **T₁**, **K₂**, **K₃** or **R(L)** must be connected (see also installation instructions on pages 30 to 32).

7) O = Must be connected (plugged on delivery)

X = Plugged (in normal operation)

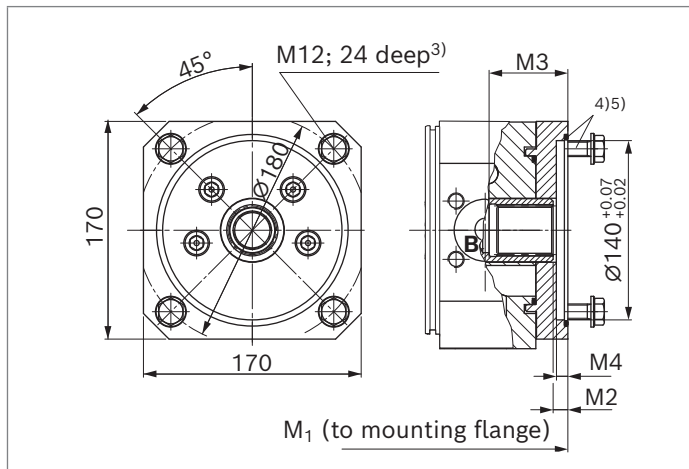
8) The **Rkv** port must be unloaded to the reservoir

Dimensions for through drives

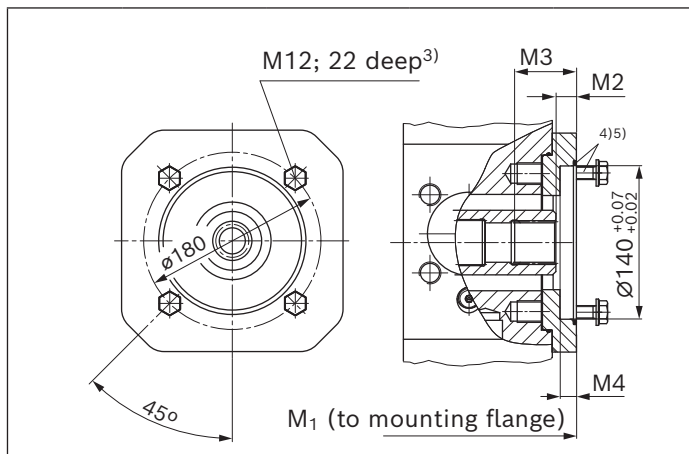
Flange ISO 3019-2 (metric)		Hub for splined shaft ¹⁾	Availability across sizes				Code
Diameter	Mounting ²⁾		71	125	250	450	
140-4		N40 × 2 × 18 × 8H	●	-	-	○	K33
			-	●	●	-	U33
160-4		N50 × 2 × 24 × 8H	-	●	●	-	U34
			-	-	-	○	K34

● = Available ○ = On request - = Not available

▼ 140-4



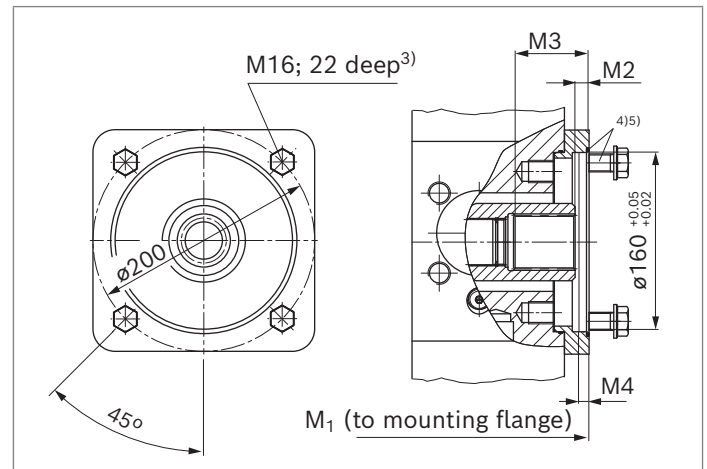
K33					
NG	M1	M2	M3	M4	
71	316	11.5	61.5	9	



U33					
NG	M1	M2	M3	M4	
125	377	12.5	56.3	9	
250	485	12.5	61.4	9	

1) According to DIN 5480
2) Mounting holes pattern viewed on through drive with control at top

▼ 160-4



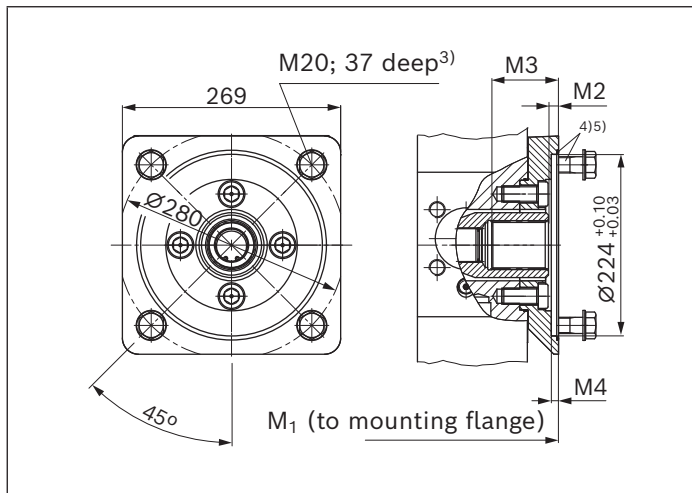
U34					
NG	M1	M2	M3	M4	
125	377	12.5	64.1	9	
250	485	12.5	66.5	9	

3) Thread according to DIN 13.
4) O-ring and mounting bolts included in delivery.
5) Design recommended according to VDI 2230, bolt quality 8.8 according to ISO 898-1

Flange ISO 3019-2 (metric)		Hub for splined shaft ¹⁾	Availability across sizes				Code
Diameter	Mounting ²⁾		71	125	250	450	
224-4		N60 × 2 × 28 × 8H	-	-	●	-	U35
			-	-	-	○	K35
315-8		N80 × 3 × 25 × 8H	-	-	-	○	K43
			-	-	-	●	K97

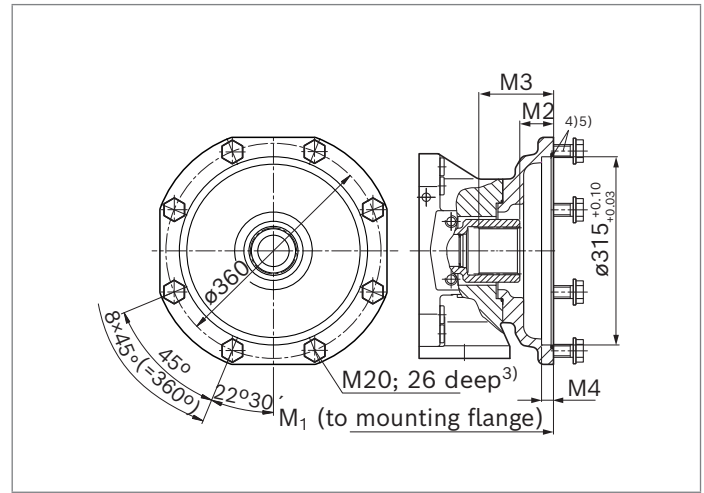
● = Available ○ = On request - = Not available

▼ **224-4**



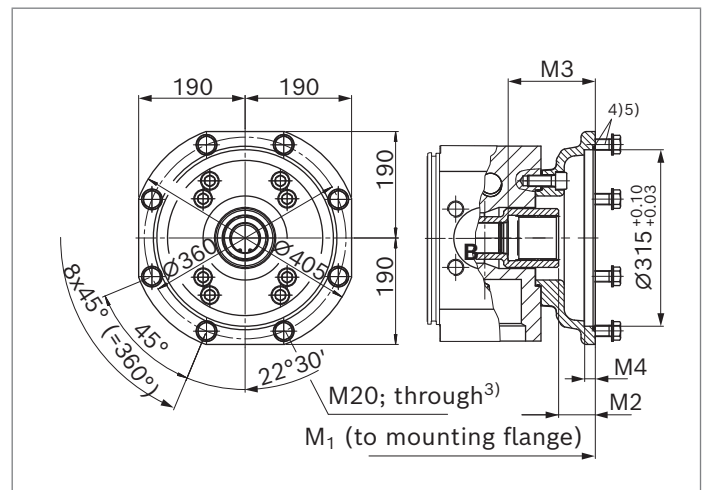
U35					
NG	M1	M2	M3	M4	
250	501	12.5	87.5	9	

▼ **315-8**



K43					
NG	M1	M2	M3	M4	
450	630	53.5	125.4	19	

▼ **315-8**



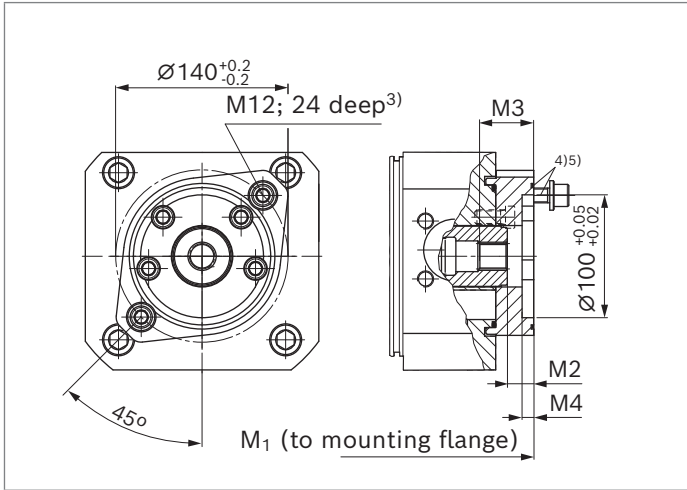
K97					
NG	M1	M2	M3	M4	
450	642	65.5	155.5	19	

- 1) According to DIN 5480
- 2) Mounting holes pattern viewed on through drive with control at top
- 3) Thread according to DIN 13
- 4) O-ring and mounting bolts included in delivery.
- 5) Design recommended according to VDI 2230, bolt quality 8.8 according to ISO 898-1

Flange ISO 3019-2 (metric)		Hub for splined shaft ¹⁾		Availability across sizes				Code
Diameter	Mounting ²⁾	Diameter		71	125	250	450	
100-2	☛	7/8 in	13T 16/32DP	●	-	-	○	KB3
		1 in	15T 16/32DP	●	-	-	○	KB4
125-4	☞	1 in	15T 16/32DP	●	-	-	○	KE1

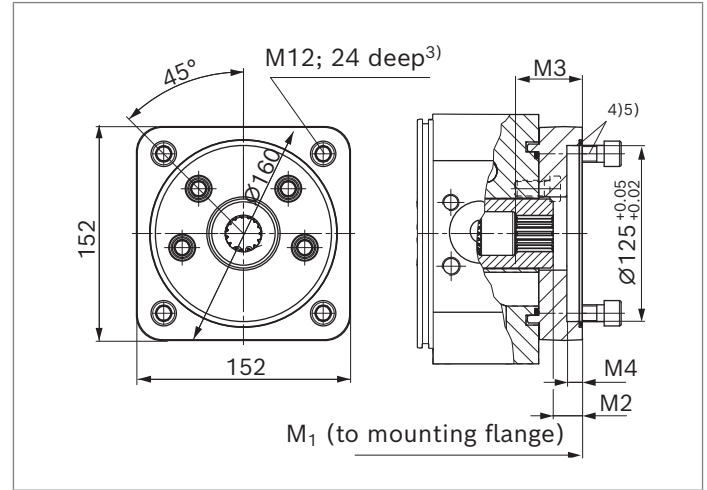
● = Available ○ = On request - = Not available

▼ **100-2**

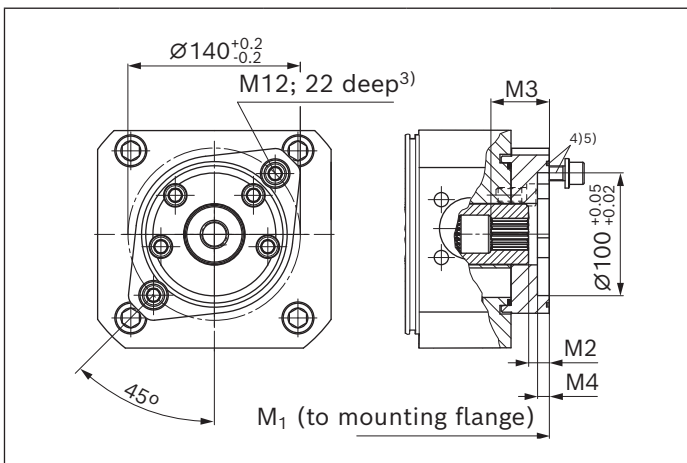


KB3					
NG	M1	M2	M3	M4	
71	322	20.4	43.5	8	

▼ **160-4**



KE1					
NG	M1	M2	M3	M4	
71	322	19.9	49	10	



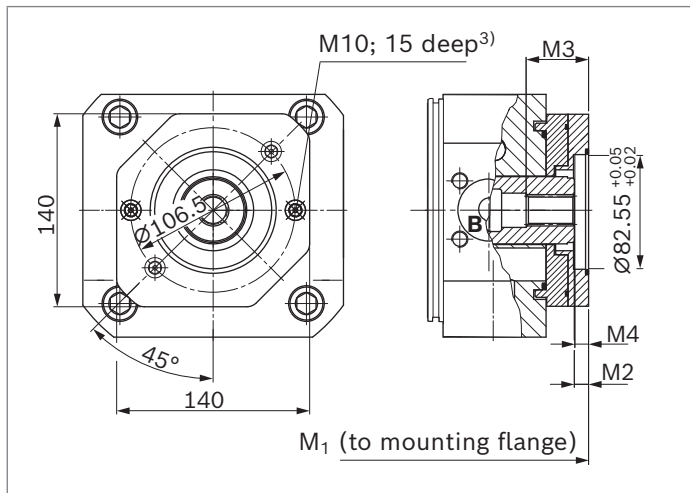
KB4					
NG	M1	M2	M3	M4	
71	322	20	49.4	8	

- 1) According to DIN 5480
- 2) Mounting holes pattern viewed on through drive with control at top
- 3) Thread according to DIN 13.
- 4) O-ring and mounting bolts included in delivery.
- 5) Design recommended according to VDI 2230, bolt quality 8.8 according to ISO 898-1

ISO 3019-1 flange (SAEJ744)		Hub for splined shaft ¹⁾		Availability across sizes				Code
Diameter	Mounting ²⁾	Diameter		71	125	250	450	
82-2 (A)	••	5/8 in 9T 16/32DP		•	-	-	○	K01
	•, •, ••			-	•	•	-	U01
101-2 (B)	••	7/8 in 13T 16/32DP		•	-	-	○	K68
	•, •, ••			-	•	•	-	U68

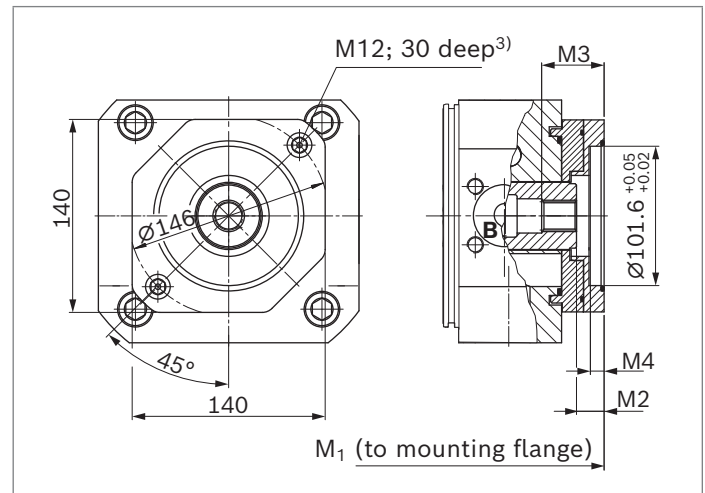
• = Available ○ = On request - = Not available

▼ **82-2**

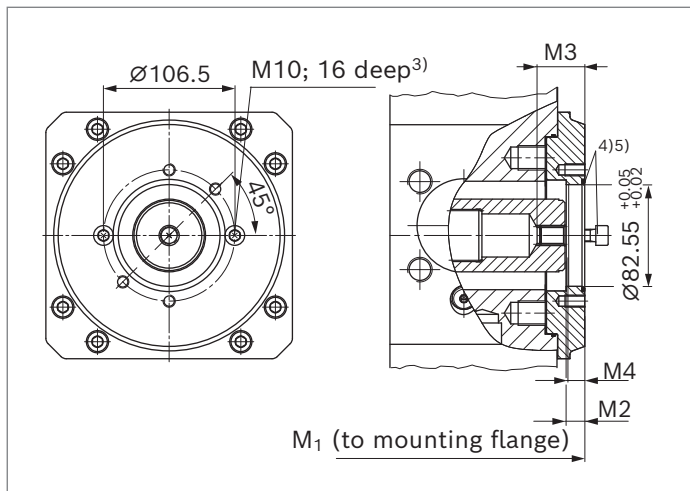


K01					
NG	M1	M2	M3	M4	
71	330	10.5	36	10	

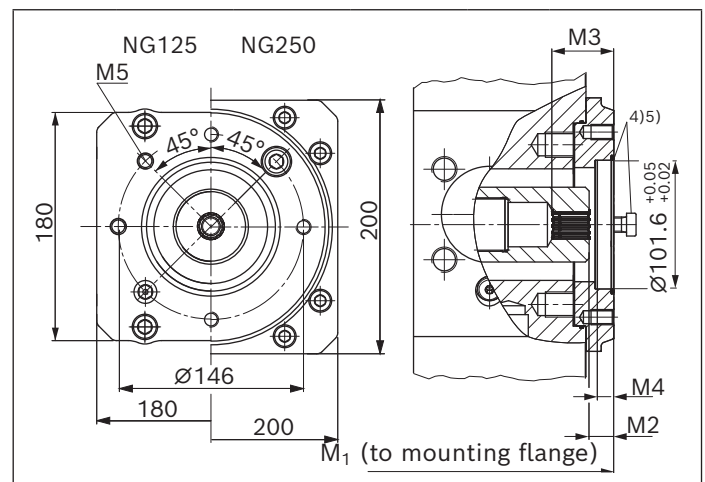
▼ **101-2**



K68					
NG	M1	M2	M3	M4	
71	322	20.5	43.6	10	



U01					
NG	M1	M2	M3	M4	
125	377	10.3	36	13	
250	485	16	35.4	13	



U68						
NG	M1	M2	M3	M4	M5 ³⁾	
125	377	18.5	43.5	13	M12; 22 deep	
250	485	19.5	42.6	13	M12; 18 deep	

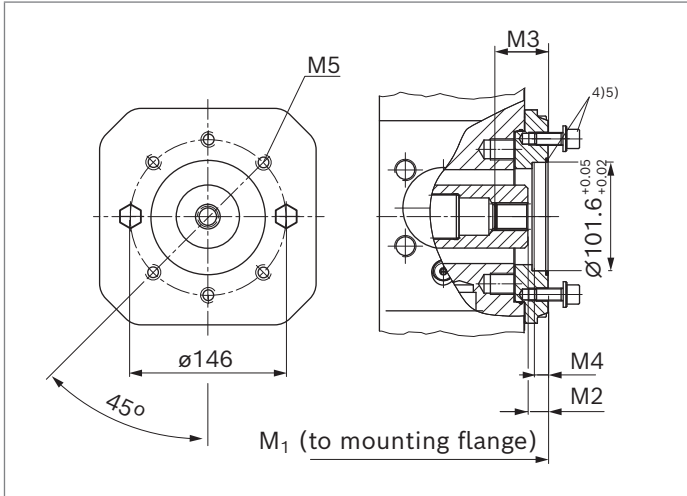
1) In accordance with ANSI B92.1a, 30° pressure angle, flat root, side fit, tolerance class 5
2) Mounting holes pattern viewed on through drive with control at top

3) Thread according to DIN 13.
4) O-ring and mounting bolts included in delivery.
5) Design recommended according to VDI 2230, bolt quality 8.8 according to ISO 898-1

ISO 3019-1 flange (SAEJ744)		Hub for splined shaft ¹⁾		Availability across sizes				Code
Diameter	Mounting ²⁾	Diameter		71	125	250	450	
101-2 (B)		1 in	15T 16/32DP	-	●	●	-	U04
127-2 (C)		1 1/4	14T 12/24DP	-	○	●	-	U07
		1 1/2	17T 12/24DP	-	●	●	-	U24

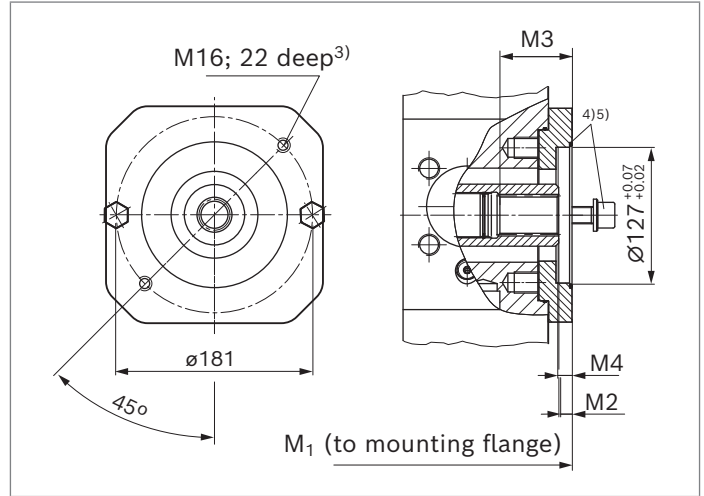
● = Available ○ = On request - = Not available

▼ **101-2**



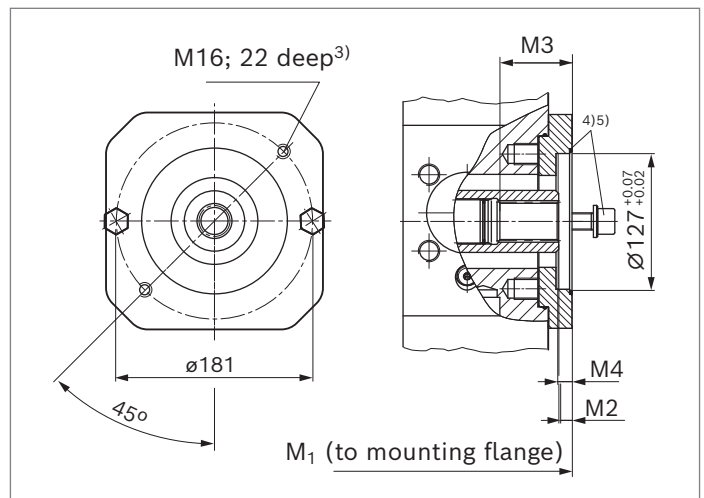
U04					
NG	M1	M2	M3	M4	M5 ³⁾
125	377	18.9	48.3	13	M12; 22 deep
250	485	18.9	48.3	13	M12; 18 deep

▼ **127-2**



U07				
NG	M1	M2	M3	M4
250	485	20.9	58.8	13

▼ **127-2**



U24				
NG	M1	M2	M3	M4
125	377	10.4	60.4	13
250	485	12.4	67.4	13

- 1) In accordance with ANSI B92.1a, 30° pressure angle, flat root, side fit, tolerance class 5
- 2) Mounting holes pattern viewed on through drive with control at top
- 3) Thread according to DIN 13.
- 4) O-ring and mounting bolts included in delivery.
- 5) Design recommended according to VDI 2230, bolt quality 8.8 according to ISO 898-1

Overview of mounting options

Through drive			Mounting options – 2nd pump				
Flange ISO 3019-2 (metric)	Hub for splined shaft	Code	A4VBO NG (shaft)	A4VSO A4VSG A4FO NG (shaft)	A10V(S)O/31 ¹⁾ NG (shaft)	A10V(S)O/5x NG (shaft)	External gear pump
140-4	W40x2x18x9g ²⁾	K33 U33	71 (Z)	71 (Z)	–	–	–
160-4	W50x2x24x9g ²⁾	U34	125 (Z)	125 (Z) 180 (Z)	–	–	–
		K34	125 (Z)	125 (Z) 180 (Z)			
224-4	W60x2x28x9g	U35	250 (Z)	250 (Z)			
		K35	250 (Z)	250 (Z)			
315-8	W80x3x25x9g ²⁾	K43	–	500 (Z)	–	–	–
315-8	W80x3x25x9g ²⁾	K97	450 (R)	–	–	–	–
Flange ISO 3019-1 (SAE J744)	Hub for splined shaft	Code	A4VBO NG (shaft)	A4VSO A4VSG A4FO NG (shaft)	A10V(S)O/31 with mounting flange C NG (shaft)	A10V(S)O/5x NG (shaft)	External gear pump
82-2 (A)	5/8 in ³⁾	K01 U01	–	–	–	–	AZPF ⁴⁾ NG 4 ... 22
101-2 (B)	7/8 in ³⁾	K68 U68	–	–	28 (S)	28 (S)	AZPN ⁴⁾ NG 20 ... 32
	1 in ³⁾	K04 U04	–	–	45 (S)	45 (S)	PGH4
127-2 (C)	1 1/2 in ³⁾	K24 U24	–	–	100 (S)	85/100 (S)	PGH5

1) If a through drive for an A10V(S)O with R-shaft is desired, please contact us.

2) According to DIN 5480

3) In accordance with ANSI B92.1a

4) Rexroth recommends special versions of the gear pumps, please contact us.

By using combination pumps, it is possible to have independent circuits without the need for splitter gearboxes.

When ordering combination pumps the type designations for the first and the second pump must be joined by a "+" and are combined into one part number. Each single pump should be ordered according to type code.

Notice

- ▶ The combination pump type code is shown in shortened form in the order confirmation.

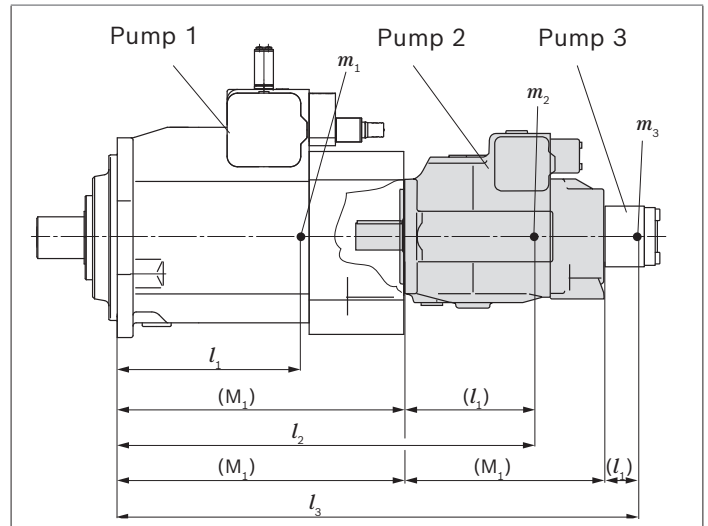
Example:

A4VBO 125 HS5/30R+A4VBO 71 HS5/10R

- ▶ Each through drive is plugged with a **non-pressure-resistant** cover. This means the units must be sealed with a pressure-resistant cover before commissioning. Through drives can also be ordered with a pressure-resistant cover. Please specify in plain text.

A tandem pump, with two pumps of equal size, is permissible without additional supports, assuming that the dynamic mass acceleration does not exceed maximum 10 g (= 98.1 m/s²).

For combination pumps consisting of more than two pumps, a calculation of the mounting flange regarding the permissible mass torque is required (please contact us).



m_1, m_2, m_3	Weight of pump	[kg]
l_1, l_2, l_3	Distance from center of gravity	[mm]
$T_m = (m_1 \cdot l_1 + m_2 \cdot l_2 + m_3 \cdot l_3) \cdot$		$\frac{1}{102}$ [Nm]

Calculation for multiple pumps	
l_1	= Front pump distance from center of gravity (values from "Permissible moments of inertia" table)
l_2	= Dimension "M1" from through drive drawings (page 24 to 25) + l_1 of the 2nd pump
l_3	= Dimension "M1" from through drive drawings (page 24 to 25) of pump 1 + "M1" of pump 2 + l_1 of pump 3.

Permissible moments of inertia

Size			71	125	250	450
Static	T_m	Nm	2000	4200	9300	15600
Dynamic at 10 g (98.1 m/s ²)	T_m	Nm	200	420	930	1560
Weight	m	kg	65	100	200	390
Distance from center of gravity	l_1	mm	140	170	210	230

Installation instructions

General

The axial piston unit must be filled with hydraulic fluid and air bled during commissioning and operation. This must also be observed following a longer standstill as the axial piston unit may empty via the hydraulic lines. Particularly in the installation position "drive shaft upwards," filling and air bleeding must be carried out completely as there is, for example, a danger of dry running. The leakage in the housing area must be directed to the reservoir via the highest drain port (**T**, **K₁**, **K₂**, **R(T)**). For combination pumps, the leakage must be drained off at each single pump.

If a shared drain line is used for several units, make sure that the respective case pressure in each unit is not exceeded. The shared drain line must be dimensioned to ensure that the maximum permissible case pressure of all connected units is not exceeded in any operating condition, particularly at cold start. If this is not possible, separate drain line must be laid, if necessary.

To prevent the transmission of structure-borne noise, use elastic elements to decouple all connecting lines from all vibration-capable components (e.g. reservoir, frame parts). Under all operating conditions, the suction and drain lines must flow into the reservoir below the minimum fluid level. The permissible suction height h_S results from the total pressure loss. However, it must not be higher than $h_{S \max} = 800$ mm. The minimum suction pressure at port **S** must also not fall below 0.8 bar absolute (with size of 71 to 250) or 5 bar absolute (with size 450) during operation and during a cold start.

When designing the reservoir, ensure that there is adequate distance between the suction line and the drain line. We recommend using a baffle (baffle plate) between suction line and drain line. A baffle improves the air separation ability as it gives the hydraulic fluid more time for desorption. Apart from that, this prevents the heated return flow from being drawn directly back into the suction line. The suction port must be supplied with air-free, calmed and cooled hydraulic fluid.

Notice

In certain installation positions, an influence on the adjustment or control can be expected. Gravity, dead weight and case pressure can cause minor characteristic shifts and changes in actuating time.

Installation position

See the following examples **1** to **7**.

Further installation positions are available upon request.

Recommended installation positions: **1** and **2**

Key	
F	Filling / air bleeding
R(L)	Filling / air bleeding
S	Suction port
T	Drain port
U	Flushing port
K₁, K₂	Flushing port
SB	Baffle (baffle plate)
$h_{t \min}$	Minimum required immersion depth (200 mm)
h_{\min}	Minimum required distance to reservoir bottom (100 mm)
$h_{S \max}$	Maximum permissible suction height (800 mm)

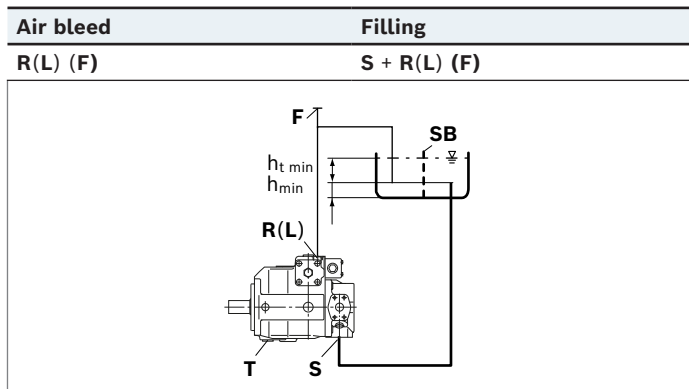
Notice

Port **F** is part of the external piping and must be provided on the customer side to make filling and air bleeding easier.

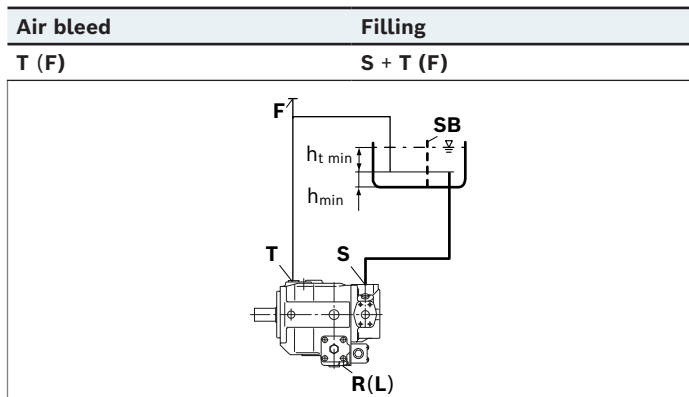
Below-reservoir installation (standard)

Below-reservoir installation means that the axial piston unit is installed outside of the reservoir below the minimum fluid level.

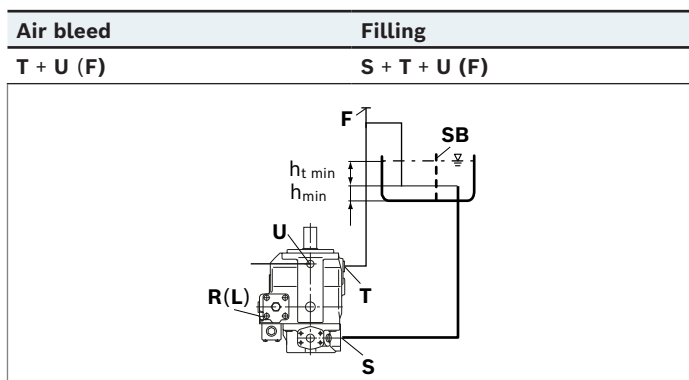
▼ Installation position 1



▼ Installation position 2



▼ Installation position 3



For key, see page 30

Above-reservoir installation

Above-reservoir installation means that the axial piston unit is installed above the minimum fluid level of the reservoir.

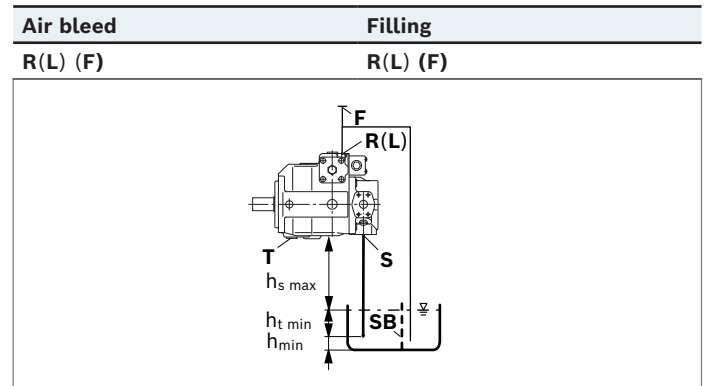
Observe the maximum permissible suction height

$h_{s \max} = 800 \text{ mm}$.

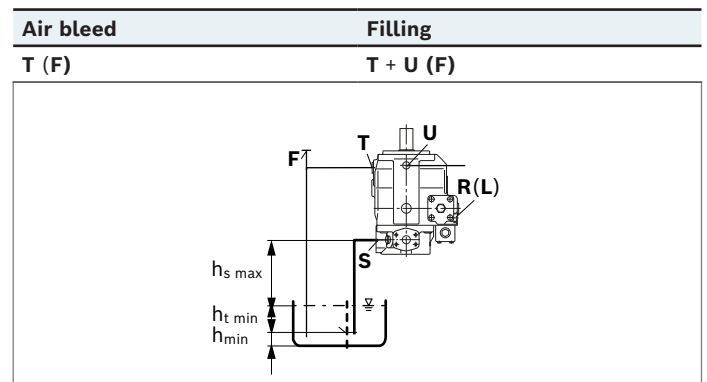
Notice

A boost pump is required with size 450

▼ Installation position 4



▼ Installation position 5



Inside-reservoir installation

Inside-reservoir installation is when the axial piston unit is installed in the reservoir below the minimum fluid level. The axial piston unit is completely below the hydraulic fluid if the minimum fluid level is equal to or below the upper edge of the pump, see chapter "**Above-reservoir installation**".

Axial piston units with electric components (e.g., electric controls, sensors) must not be installed in a reservoir below the fluid level.

The exception is control HS5M

The proportional valve which is not included in scope of delivery can be positioned outside the reservoir in the system and piped up via the provided ports **X₁** and **X₂** of the pump.

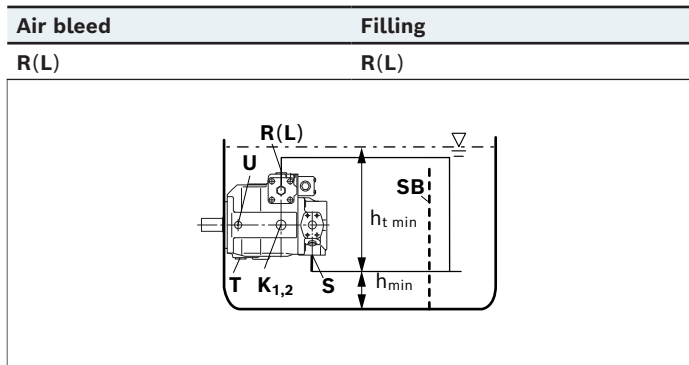
The unit can be installed in the reservoir together with the position transducer mounted at the pump.

Approved for HLP fluids according to DIN 51524 only.

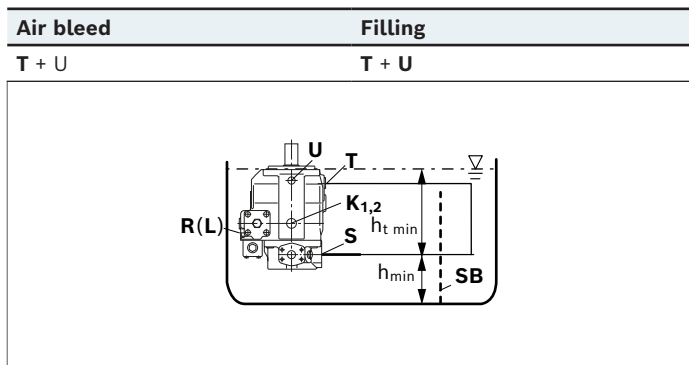
Notice

- We recommend to provide the suction port **S** with a suction pipe and for the drain port **T** or **R(L)** to be piped. In this case, the other drain port must be plugged. The housing of the axial piston unit is to be filled via **R(L)** or **T** (see installation position 6 to 7) before the pipework is fitted and the reservoir is filled with hydraulic fluid.

▼ Installation position 6



▼ Installation position 7



For key, see page 30

Project planning notes

- ▶ The axial piston variable pump A4VBO is intended to be used in an open circuit.
- ▶ The project planning, installation and commissioning of the axial piston unit requires the involvement of skilled personnel.
- ▶ Before using the axial piston unit, please read the corresponding instruction manual completely and thoroughly. If necessary, this can be requested from Bosch Rexroth.
- ▶ Before finalizing your design, please request a binding installation drawing.
- ▶ The specified data and notes contained herein must be observed.
- ▶ Depending on the operating conditions of the axial piston unit (working pressure, fluid temperature), the characteristic curve may shift.
- ▶ The characteristic curve may also shift due to the dither frequency or control electronics.
- ▶ Preservation: Our axial piston units are supplied as standard with preservation protection for a maximum of 12 months. If longer preservation protection is required (maximum 24 months), please specify this in plain text when placing your order. The preservation periods apply under optimal storage conditions, details of which can be found in the data sheet 90312 or the instruction manual.
- ▶ Not all configuration variants of the product are approved for use in a safety function according to ISO 13849. Please consult the proper contact at Bosch Rexroth if you require reliability parameters (e.g., $MTTF_d$) for functional safety.
- ▶ Depending on the type of control used, electromagnetic effects can be produced when using solenoids. Applying a direct voltage signal (DC) to solenoids does not create electromagnetic interference (EMI) nor is the solenoid affected by EMI. Electromagnetic interference (EMI) potential exists when operating and controlling a solenoid with a modulated direct voltage signal (e.g. PWM signal) Appropriate testing and measures should be taken by the machine manufacturer to ensure other components or operators (e.g. with pacemaker) are not affected by this potential.
- ▶ The pressure control (hydraulic or electronic) is not an adequate safeguard against pressure overload. Therefore, a pressure relief valve must be provided in the hydraulic system (integrated into the pump or externally in the system). In this connection, observe the technical limits of the pressure relief valve.
- ▶ For controllers requiring external pilot pressure, sufficient control fluid must be provided to the associated ports to ensure the required pilot pressures for the respective controller function. These controllers are subject to leakage due to their design. An increase in control fluid demand has to be anticipated over the total operating time. The design of the control fluid supply must thus be sufficiently large. If the control fluid is too low, the respective controller function may be impaired and undesired system behavior may result.
- ▶ For drives that are operated for a long period of time with constant rotational speed, the natural frequency of the hydraulic system can be stimulated by the excitation frequency of the pump (rotational speed frequency x 9). This can be prevented with suitably designed hydraulic lines.
- ▶ Please note the details regarding the tightening torques of port threads and other threaded joints in the instruction manual.
- ▶ The ports and fastening threads are designed for the p_{max} permissible pressures of the respective ports, see the connection tables. The machine or system manufacturer must ensure that the connecting elements and lines correspond to the specified conditions of use (pressure, flow, hydraulic fluid, temperature) with the necessary safety factors.
- ▶ The service ports and function ports are only intended to accommodate hydraulic lines.

Safety instructions

- ▶ During and shortly after operation, there is a risk of burning on the axial piston unit and especially on the solenoids. Take the appropriate safety measures (e.g. by wearing protective clothing).
- ▶ Moving parts in control equipment (e.g. valve spools) can, under certain circumstances, get stuck in position as a result of contamination (e.g. contaminated hydraulic fluid, abrasion, or residual dirt from components). As a result, the hydraulic fluid flow and the build-up of torque in the axial piston unit can no longer respond correctly to the operator's specifications. Even the use of various filter elements (external or internal flow filtration) will not rule out a fault but merely reduce the risk. The machine/system manufacturer must test whether remedial measures are needed on the machine for the application concerned in order to bring the driven consumer into a safe position (e.g., safe stop) and ensure any measures are properly implemented.

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