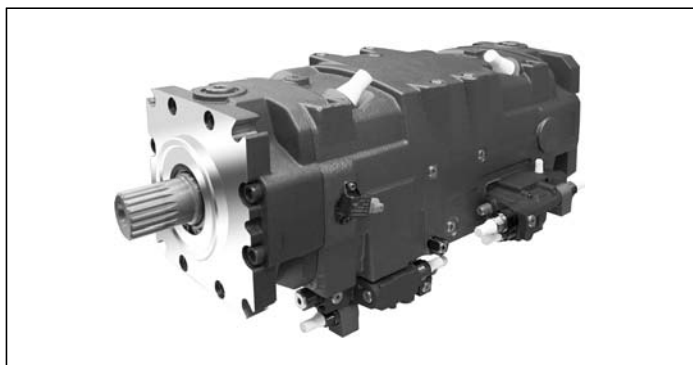# Axial piston variable double pump
A28VLO Series 10

RE 93110
Edition: 04.2016
Replaces: 12.2015

▶ Sizes 280
▶ Nominal pressure 350 bar
▶ Maximum pressure 420 bar
▶ Open circuit

Features

▶ Variable axial piston double pump of swashplate design for hydrostatic drives in open circuit.
▶ For use preferably in mobile applications
▶ Flow is proportional to the drive speed and displacement.
▶ The flow can be infinitely varied by adjusting the swashplate angle.
▶ One suction port, two pressure ports.
▶ Special control devices program for mobile applications, with different control and regulation functions.
▶ Compact design
▶ High efficiency
▶ High power density
▶ Low noise level

Contents

Ordering code

01	02	03	04	05	06	07	08	09	10	11		12	13	14	15	16	17	18	19	20	21		22
A28V	LO	280									/	10		R	V	E4		1	K0	0000	0	–	

Axial piston unit

01	Double pump, variable swashplate design				A28V

Operation mode — 280

02	Pump, open circuit	with charge pump	●	LO

Sizes (NG)

03	Geometric displacement, see "Technical data" on page 8	280

Pump 1: control devices: basic controller

The basic controller can be combined with at most two additional controllers (05, 06, 07)

04	Single power control	fixed setting			●	LR
	override	electric-proportional	negative control	U = 12 V	●	L3
				U = 24 V	●	L4
		hydraulic-proportional,	negative control		●	L5
			positive control		●	L6
	Summation power controller	override hydraulic-proportional, high pressure	negative control	with stop	●	CR
		Combination of CR and L5 = C5			●	C5
	Pressure control with one-side swiveling	fixed setting			●	DR
		electric-proportional with integrated pilot valve for external pilot pressure supply	positive control	U = 24 V	o	D2[2]
	Stroke control[1]	override electric-proportional	positive control	U = 12 V	●	E1
				U = 24 V	●	E2

Pump 1: Additional control: Pressure controller

05	Without additional control (without symbol)	●	
	with one-side swiveling, fixed setting	●	DR

Pump 1: additional control for basic controller L4 and CR[1]: stroke control or unloading

06	Without additional control (without symbol)					●	
	Stroke control	override electric-proportional	positive control	U = 12 V		●	E1
				U = 24 V		●	E2
	Stroke control	hydraulic-proportional, control pressure	negative control	Δp = 20 bar		●	H3
			positive control			●	H4
		hydraulic-proportional, control pressure	negative control	Δp = 35 bar		●	H5
			positive control			●	H6

Pump 1: Additional control: load sensing

07	Without additional control (without symbol)	●	
	Load sensing, internal pump pressure, fixed setting	●	S0

Pump 2: control combination

08	Identical with pump 1	●	1
	Various controls, please contact us	●	2

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[1] The stroke control systems can be combined with either pressure controllers or load sensing controllers. A combination of all three controllers is not possible

[2] Not combinable with other controllers

01	02	03	04	05	06	07	08	09	10	11		12	13	14	15	16	17	18	19	20	21	22
A28V	LO	280									/	10		R	V	E4		1	K0	0000	0	–

Depressurized basic position and external control pressure supply — 280

09	Maximum swivel angle ($V_{g\,max}$)		
	Without external control pressure supply (standard for power and pressure controllers)	●	A
	With external control pressure supply (integrated shuttle valve, standard for negative stroke control)	●	B
	Minimum swivel angle ($V_{g\,min}$)		
	With external control pressure supply (integrated shuttle valve, standard for positive stroke control)	●	C

Connector for solenoids[3] (see page 29)

10	Without connector (only for hydraulic controls)		●	0
	DEUTSCH connector		●	P
	AMP connector (Junior-Timer), 2-pin (only for D2 controller)		○	S

Swivel angle indicator

11	Without optical swivel angle indicator		●	0
	With electric swivel angle sensor[4] as per data sheet 95150	Power supply 5 V DC	●	B
		Power supply 8 V - 32 V DC	●	K

Series

12	Series 1, Index 0	10

Configuration of port and fastening threads

13	ANSI, all fastening threads according to ASME B1.1, all port threads with O-ring seal according to ISO 11926	○	A
	Metric, all fastening threads according to DIN 13, all port threads with O-ring seal according to ISO 6149	●	M

Direction of rotation

14	With view on drive shaft	clockwise	R

Sealing material

15	FKM (fluor-caoutchouc)	V

Mounting flanges

16	SAE J744	165-4	●	E4

Drive shaft

17	Splined shaft ANSI B92.1a	2 1/4 in 17T 8/16DP	●	T3
	Splined shaft DIN 5480	W60x2x28x9g	●	A4

● = Available   ○ = On request   – = Not available

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[3] Connectors for other electric components may deviate

[4] Please contact us if the swivel angle sensor is used for control

01	02	03	04	05	06	07	08	09	10	11		12	13	14	15	16	17	18	19	20	21	22
A28V	LO	280									/	10		R	V	E4		1	K0	0000	0	–

Service line port | | | | | | | | | | | | | | | | | | | 280 | | |
| 18 | SAE service line port **A**, **B** at side, SAE-suction port **S** at bottom | | ● | 1 |

Control fluid pump and pressure relief valve
| 19 | Without integrated control oil pump, without pressure-relief valve | ● | K0 |

Through drive
| 20 | Without through drive[5] | ● | 0000 |

Speed sensor
| 21 | Without | ● | 0 |

Standard/special version
| 22 | Standard version | 0 |
| | Special version | S |

Note
▶ Note the project planning notes on page 32.
▶ In addition to the ordering code, please specify the relevant technical data when placing your order.

● = Available   ○ = On request   – = Not available

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5) With through drive on request

Bosch Rexroth AG, RE 93110/04.2016

Hydraulic fluids

The A28V(L)O variable pump is designed for operation with HLP mineral oil according to DIN 51524.
Application instructions and requirements for hydraulic fluids 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)

Notes on selection of hydraulic fluid
The hydraulic fluid should be selected such that the operating viscosity in the operating temperature range is within the optimum range (v_{opt} see selection diagram).
Note
At no point of the component may the temperature be higher than 115 °C. The temperature difference specified in the table is to be taken into account when determining the viscosity in the bearing.
If the above conditions cannot be maintained due to extreme operating parameters, please contact the responsible member of staff at Bosch Rexroth.

Viscosity and temperature of hydraulic fluids

	Viscosity	Temperature	Comment
Cold start	$v_{max} \leq 1600$ mm²/s	$\theta_{St} \geq -40$ °C[1]	$t \leq 3$ min, without load (20 bar $\leq p \leq 50$ bar, $n \leq 1000$ rpm
Permissible temperature difference		$\Delta T \leq 25$ K	between axial piston unit and hydraulic fluid
Warm-up phase	$v <$ 1600 to 400 mm²/s	θ = -40 °C to −25 °C	at $p \leq 0.7 \times p_{nom}$, $n \leq 0.5 \times n_{nom}$ and $t \leq 15$ min
Continuous operation	v = 400 to 10 mm²/s		This corresponds, for example on the VG 46, to a temperature range of +5 °C to +85 °C (see selection diagram)
		θ = −25 °C to +110 °C	measured at port **T** Note the permissible temperature range of the shaft seal (ΔT = approx. 5 K between bearing/shaft seal and port **T**)
	v_{opt} = 36 to 16 mm²/s		Range of optimum operating viscosity and efficiency
Short-term operation	$v_{min} \geq 7$ mm²/s		$t <$ 3 min, $p < 0.3 \times p_{nom}$

▼ **Selection diagram**
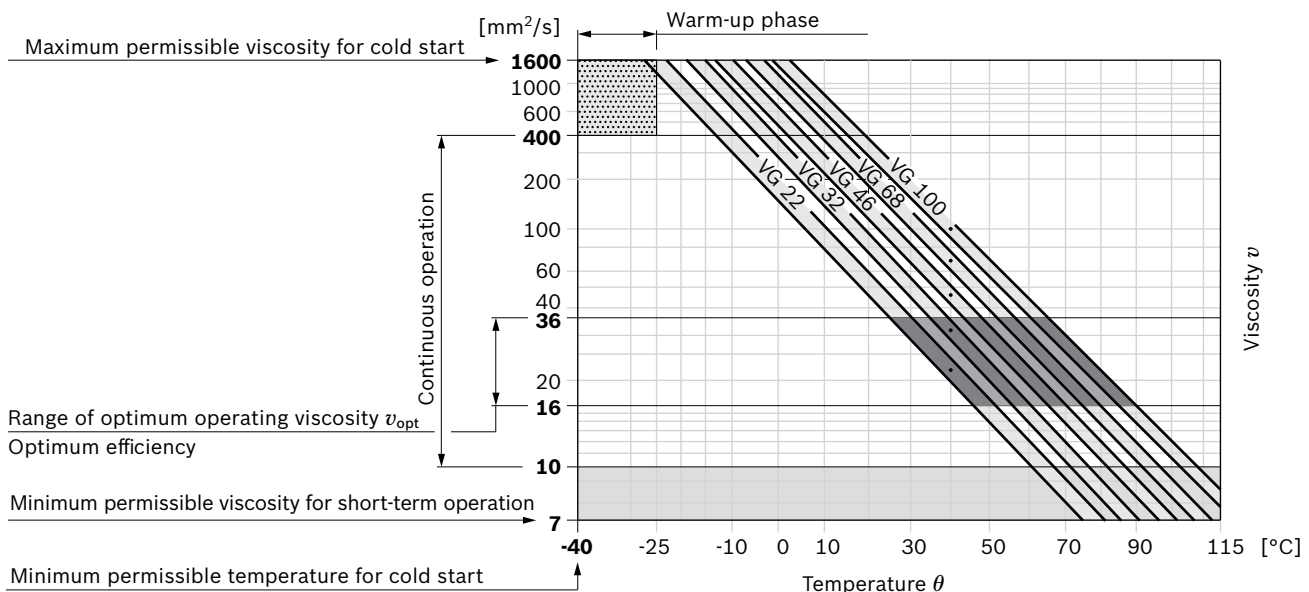
[1] At temperatures below −25 °C, an NBR shaft seal is required (permissible temperature range −40 °C bis +90 °C)

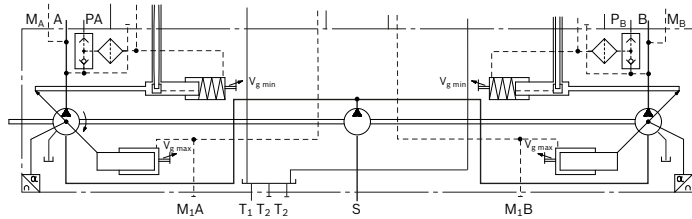**Filtration of the hydraulic fluid**

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

In order to guarantee the functional reliability of the axial piston unit it is necessary to carry out a gravimetric evaluation of the hydraulic fluid to determine the particle contamination and the cleanliness level according to ISO 4406. A cleanliness level of at least 20/18/15 must be maintained. At very high hydraulic fluid temperatures (90 °C to maximum 115 °C), a cleanliness class of at least 19/17/14 according to ISO 4406 is necessary.

Please contact us if the above classes cannot be observed.

Charge pump (impeller)

The charge pump is a circulating pump with which the A28VLO 280 is filled and therefore can be operated at higher speeds. This also simplifies cold starting at low temperatures and high viscosity of the hydraulic fluid. Externally increasing the inlet pressure is therefore unnecessary in most cases. Charging the reservoir with compressed air is not permissible.
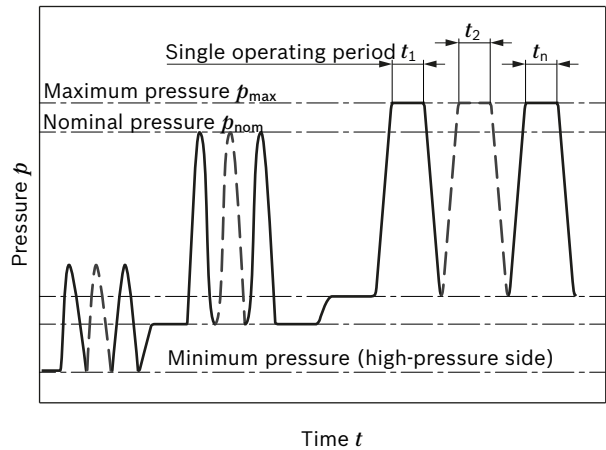
Operating pressure range

Pressure at working line port A		Definition
Nominal pressure p_{nom}	350 bar	The nominal pressure corresponds to the maximum design pressure.
Maximum pressure p_{max}	420 bar	The maximum pressure corresponds to the maximum working pressure within the single operating period. The sum of the single operating periods must not exceed the total operating period.
Single operating period	10 s	
Total operating period	300 h	
Minimum pressure $p_{A\,abs}$ (high-pressure side)	15 bar	Minimum pressure on the high-pressure side (**A**) 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 (see diagram).
Rate of pressure change $R_{A\,max}$	16000 bar/s	Maximum permissible rate of pressure build-up and pressure reduction during a pressure change over the entire pressure range.
Pressure at suction port S (inlet)		
Minimum pressure $p_{S\,min}$	≥ 0.7 bar absolute	Minimum pressure at suction port **S** (inlet) that is required in order to avoid damage to the axial piston unit. The minimum pressure depends on the speed and displacement of the axial piston unit.
Maximum pressure $p_{S\,max}$	≤ 2 bar absolute	
Drain pressure at port T_1, T_2, T_3		
Maximum pressure $p_{L\,max}$	4 bar	Maximum 1.2 bar higher than inlet pressure at port **S**, but not higher than $p_{L\,max.}$ A case drain line to the reservoir is required.
Peak Pressure $p_{L\,peak}$	7 bar	t< 0.1 s

▼ **Rate of pressure change** $R_{A\,max}$
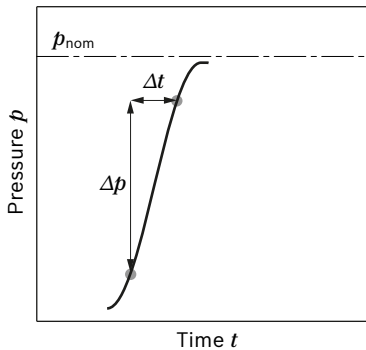
▼ **Pressure definition**

Total operating period = $t_1 + t_2 + ... + t_n$

Note

Operating pressure range valid when using hydraulic fluids based on mineral oils. Values for other hydraulic fluids, please contact us.

Technical data

With charge pump (A28VLO)

Size		NG		280
Displacement, geometric, per revolution by rotary group		$V_{g\,max}$	cm³	280
		$V_{g\,min}$	cm³	0
Maximum rotation-al speed[1]	at $V_{g\,max}$[2]	n_{nom}	rpm	1900
	at $V_g \leq V_{g\,max}$[3]	n_{max}	rpm	1900
Flow	at n_{nom} and $V_{g\,max}$	q_v	L/min	2 x 532
Power	at n_{nom}, $V_{g\,max}$ and Δp = 350 bar	P	kW	2 x 310
Torque	at $V_{g\,max}$ and Δp = 350 bar[2]	T	Nm	2 x 1560
Rotary stiffness drive shaft	2 1/4 in 17T 8/16DP T3	c	kNm/rad	519
	W60x2x28x9g A4	c	kNm/rad	645
Moment of inertia rotary group		J_{TW}	kgm²	0.198
Maximum angular acceleration[4]		α	rad/s²	4200
Case volume		V	L	9.5
Weight (without through drive) approx.		m	kg	305

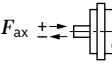| Determining the operating characteristics			
Flow	q_v	$= \dfrac{V_g \times n \times \eta_v}{1000}$	[l/min]
Torque	T	$= \dfrac{V_g \times \Delta p}{20 \times \pi \times \eta_{hm}}$	[Nm]
Power	P	$= \dfrac{2\,\pi \times T \times n}{60000} = \dfrac{q_v \times \Delta p}{600 \times \eta_t}$	[kW]
Key			
V_g	=	Displacement per revolution [cm³]	
Δp	=	Differential pressure [bar]	
n	=	Rotational speed [rpm]	
η_v	=	Volumetric efficiency	
η_{hm}	=	Hydraulic mechanical efficiency	
η_t	=	Total efficiency ($\eta_t = \eta_v \times \eta_{hm}$)	
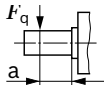
[1] The values are applicable:
  – for the optimum viscosity range from v_{opt} = 36 to 16 mm²/s
  – with hydraulic fluid on the basis of mineral oils
[2] The values apply at absolute pressure p_{abs} = 1 bar at suction port **S**.

[3] Maximum rotational speed (rotational speed limit) in the case of increasing the inletpressure p_{abs} at suction port **S** and $V_g < V_{g\,max}$.
[4] The data are valid for values between the minimum required and maximum permissible speed. Valid for external excitation (e. g. diesel engine 2 to 8 times rotary frequency; cardan shaft twice the rotary frequency). The limiting value is only valid for a single pump. The load capacity of the connection parts must be considered.

Permissible radial and axial forces of the drive shafts

Size		NG	280	280
Drive shaft			2 1/4	W60
Maximum radial force at distance a (from shaft collar)	F_q ↓ (diagram) a →	$F_{q\,max}$	N	18000	23600
		a	mm	40	29
Maximum axial force	F_{ax} ± (diagram)	$+\,F_{ax\,max}$	N	1800	1800
		$-\,F_{ax\,max}$	N	850	850

Note

▶ 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 testing the loads by means of experiment or calculation / simulation and comparison with the permissible values.

▶ Special requirements apply in the case of belt drives. Please contact us.

Permissible input torques

Size			NG		280
Torque at $V_{g\,max}$ and Δp = 350 bar[1]			T_{max}	Nm	3120
Input torque at drive shaft, maximum[2]					
	T3	2 1/4 in	$T_{E\,max}$	Nm	4380
	A4	W60	$T_{E\,max}$	Nm	5780
Maximum through-drive torque			$T_{D\,max}$	Nm	–

▼ **Distribution of torques**
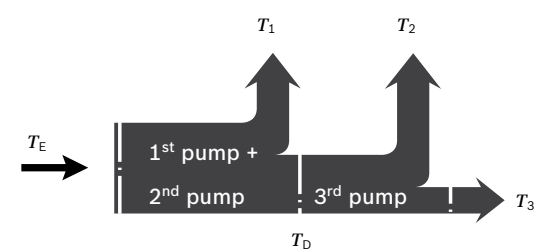
Torque at 1st pump + 2nd pump	T_1			
Torque at 3rd pump	T_2			
Torque at 4th pump	T_3			
Input torque	T_E	=	$T_1 + T_2 + T_3$	
	T_E	<	$T_{E\,max}$	
Through-drive torque	T_D	=	$T_2 + T_3$	
	T_D	<	$T_{D\,max}$	

[1] Efficiency not considered
[2] For drive shafts free of radial force

Power control

LR – Power controller, fixed setting

The power controller regulates the displacement of the pump depending on the operating pressure so that a given drive power is not exceeded at constant drive speed.
The precise control with a hyperbolic control characteristic, provides an optimum utilization of available power.
The operating pressure acts on a rocker via a measuring piston moved together with the control. An externally adjustable spring force counteracts this, it determines the power setting. The depressurized basic position is $V_{g\,max}$.
If the operating pressure exceeds the set spring force, the control valve will be actuated by the rocker and the pump will swivel back from the basic setting $V_{g\,max}$ toward $V_{g\,min}$.
Here, the leverage at the rocker may be shortened and the operating pressure may rise in the same relation as the displacement is reduced ($p_B \times V_g$ = constant; p_B = operating pressure; V_g = displacement).
The hydraulic output power (characteristic LR) is influenced by the efficiency of the pump.
Setting range for beginning of control 50 to 350 bar
When ordering, state in plain text:
▶ Drive power P [kW]
▶ Drive speed n [rpm]
▶ Maximum flow $q_{V\,max}$ [l/min]
Please contact us if you need a power diagram.

▼ **Characteristic LR**
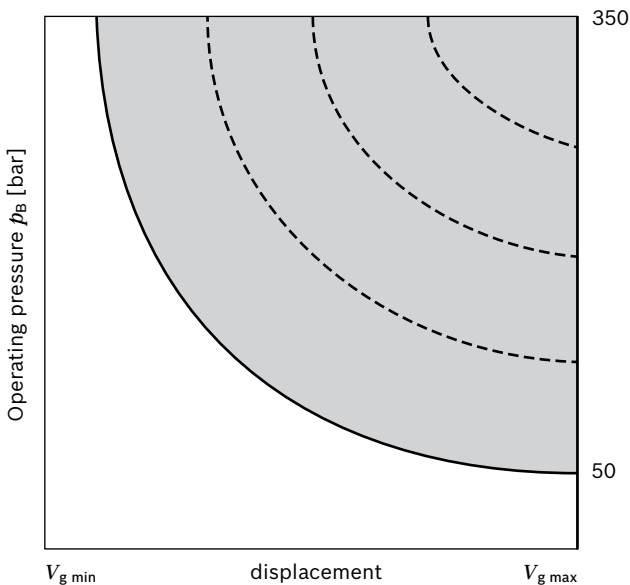
▼ **Circuit diagram LR**
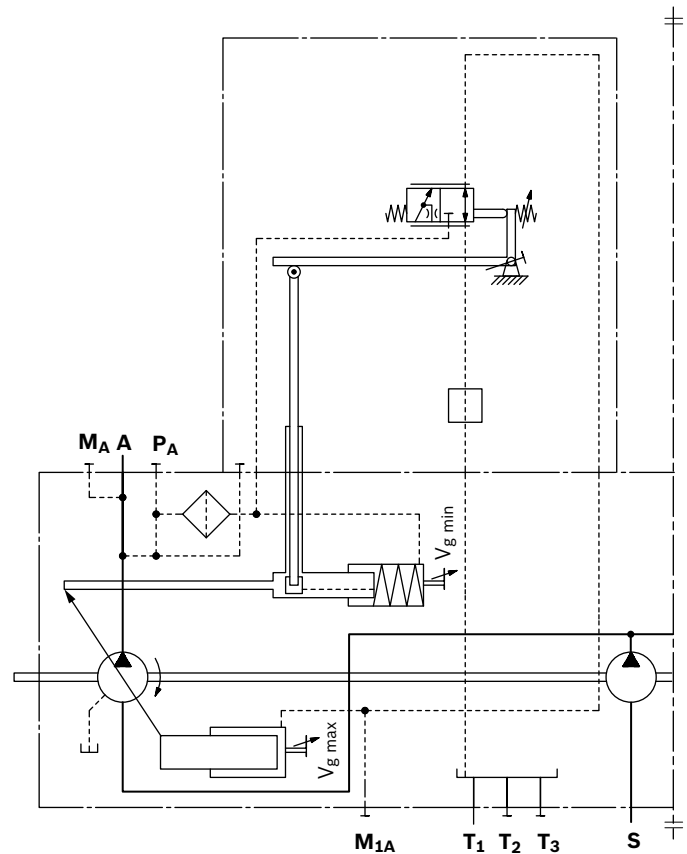
Illustrated for purposes of clarity, only pump A

### L3/L4 – Power controller, electric-proportional override (negative control)

A control current acts against the adjustment spring of the power control via a proportional solenoid.

The mechanically adjusted basic power setting can be reduced by means of different control current settings. Increasing control current = reduced power.

If the pilot control signal is variably controlled via a load limiting control, the power draw of all consumers is adjusted to the power draw possible for the diesel engine (e.g. electronic load limiting control LLC (data sheet 95310) in BODAS controller RC2-2).

Technical data, solenoid	L3	L4
Voltage	12 V (±20%)	24 V (±20%)
Control current		
Beginning of control	400 mA	200 mA
End of control	1200 mA	600 mA
Limiting current	1.54 A	0.77 A
Nominal resistance (at 20 °C)	5.5 Ω	22.7 Ω
Dither frequency	100 Hz	100 Hz
Duty cycle	100%	100%
Type of protection: see connector version page 29		

When ordering, state in plain text:
▶ Drive power P [kW] at beginning of control
▶ Control current I [mA] at drive power P [kW]
▶ Drive speed n [rpm]
▶ Maximum flow $q_{V\,max}$ [l/min]

▼ **Effect of power override through current increase**
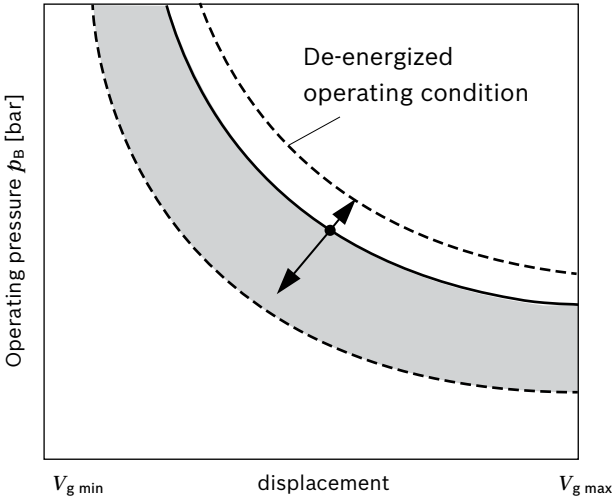
Note

In operating condition **L3** de-energized (jump 400 to 0 mA): Power increase by a factor of 2 of the table values.
In operating condition **L4** de-energized (jump 200 to 0 mA): Power increase by a factor of 1 of the table values.

Circuit diagram L4
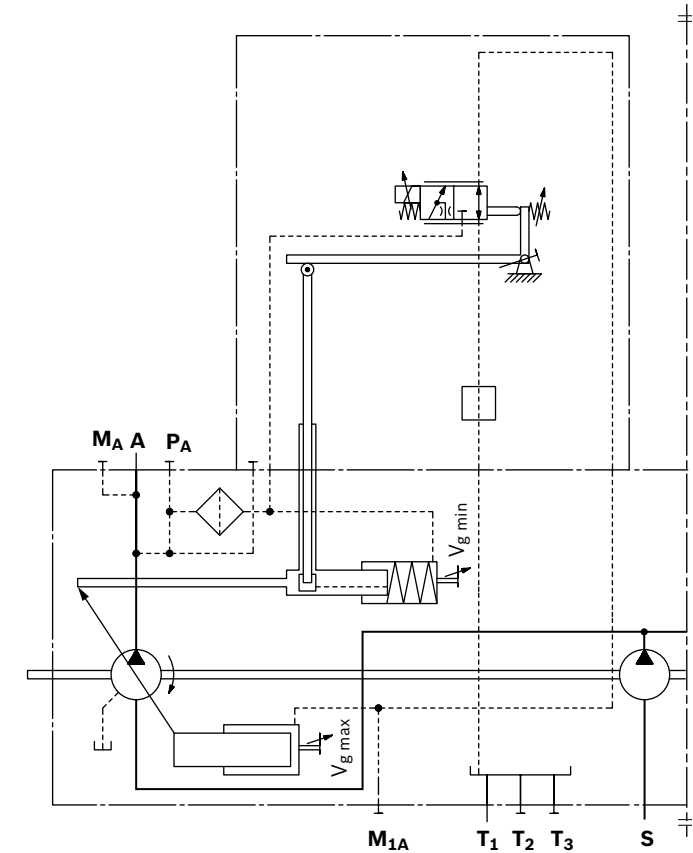
Illustrated for purposes of clarity, only pump A

Reduction of power by control current to the proportional solenoids with **L3**[1]
Power reduction/control current [kW /100 mA]

	Rotational speed [rpm]		
Size	1000	1500	1800
280	11.4	17.1	20.5

Reduction of power by control current to the proportional solenoids with **L4**[1]
Power reduction/control current [kW/100 mA]

|	Rotational speed [rpm]		
Size	1000	1500	1800
280	22.9	34.4	41.2

[1] Values in the tables are reference points. Determination of the exact power override on request.

L5 – Power controller, hydraulic-proportional override (negative control)

A pilot pressure acts against the adjustment spring of the power control via a valve.

The mechanically adjusted basic power setting can be reduced by means of different pilot pressure settings.

Increasing pilot pressure = reduced power.

▶ Maximum permissible pilot pressure $p_{St\,max}$ = 100 bar

If the pilot pressure signal is adjusted by a load limiting control, the power reduction of all consumers is reduced to match the available power from the diesel engine.

Reduction of power by pilot pressure at port **L5**

Power reduction/pilot pressure [kW/bar]

Size	Rotational speed [rpm]		
	1000	1500	1800
280	4.4	6.6	7.9

Values in the tables are reference points. Determination of the exact power override on request.

When ordering, state in plain text:

▶ Drive power P [kW] at beginning of control
▶ Pilot pressure p_{st} [bar] in **L5** at drive power P [kW]
▶ Drive speed n [rpm]
▶ Maximum flow $q_{V\,max}$ [l/min]

▼ **Effect of power override through pilot pressure increase**
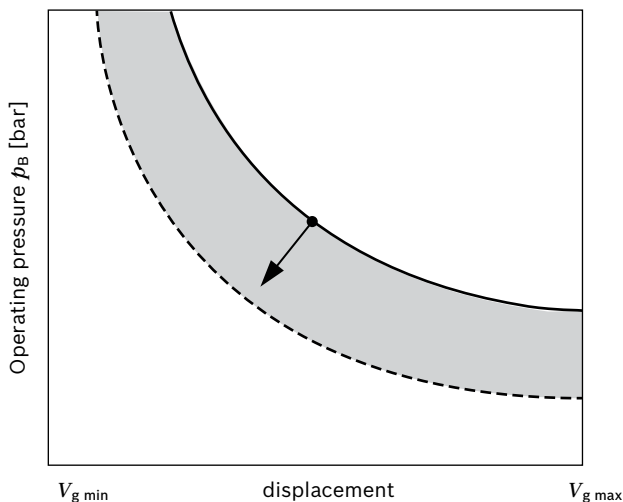
▼ **Circuit diagram L5**
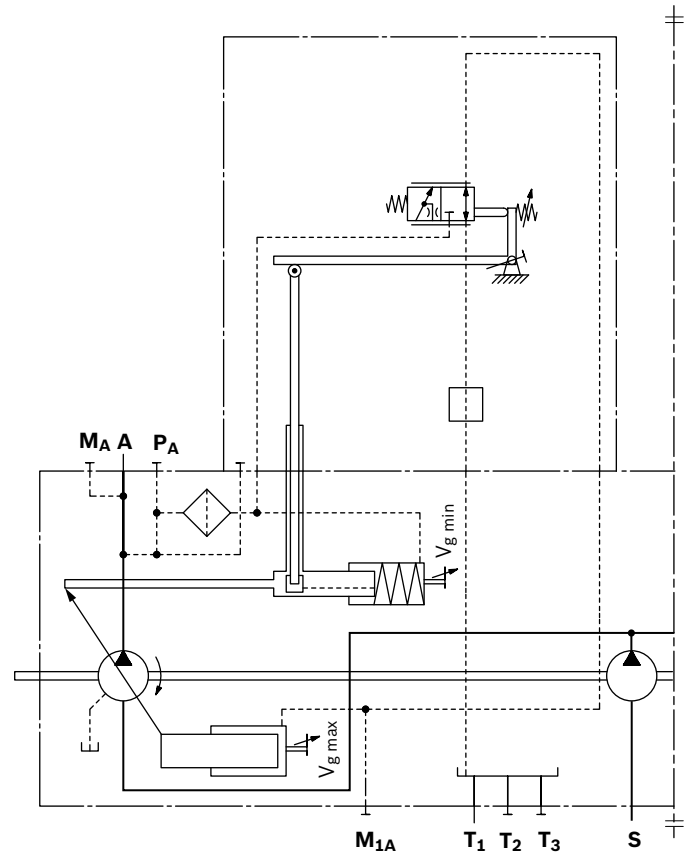
Illustrated for purposes of clarity, only pump A

Change in beginning of control in bar when pilot pressure is changed from minimum to maximum.

The factor pilot pressure to beginning of control is 1:7.

CR – Summation hp-control of two power-controlled pumps, high-pressure-related override (with stop)

With two pumps of the same size working in different circuits, the CR controller limits the overall power.

The CR works like the normal LR with a fixed maximum power setting along the power hyperbola. The high-pressure-related override reduces the power setpoint in dependence on the operating pressure of the other pump. That happens proportionally below the beginning of control and is blocked by a stop when the minimum power is reached. Here, the **CR** port of the one pump has to be connected to the **M**$_A$ port of the other pump.

The maximum power of the first pump is reached when the second pump is working at idle when depressurized. When defining the maximum power, the idle power of the second pump has to be taken into account.

The minimum power of each pump is reached when both pumps are working at high pressure. The minimum power usually equates to 50% of the total power.

Power that is released by the pressure control or other overrides remains unconsidered.

Setting range for beginning of control is 50 bar to 300 bar. When ordering, please specify separately for each pump:

▶ Maximum drive power P_{max} [kW]
▶ Minimum drive power P_{min} [kW]
▶ Drive speed n [rpm]
▶ Maximum flow $q_{V\,max}$ [l/min]
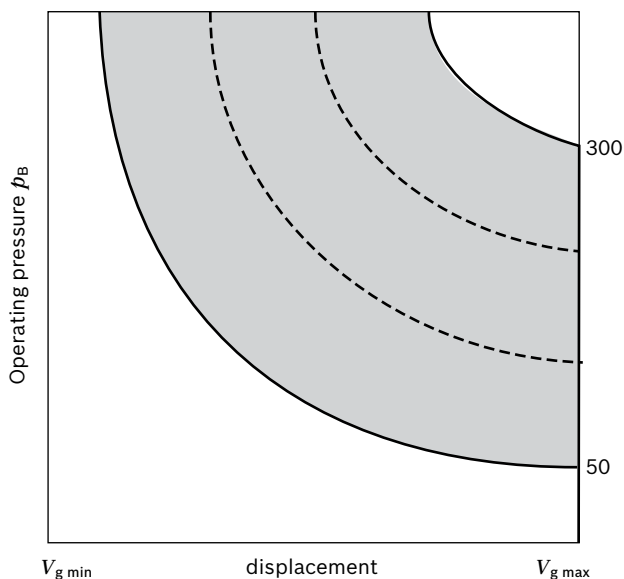
▼ **Circuit diagram CR**
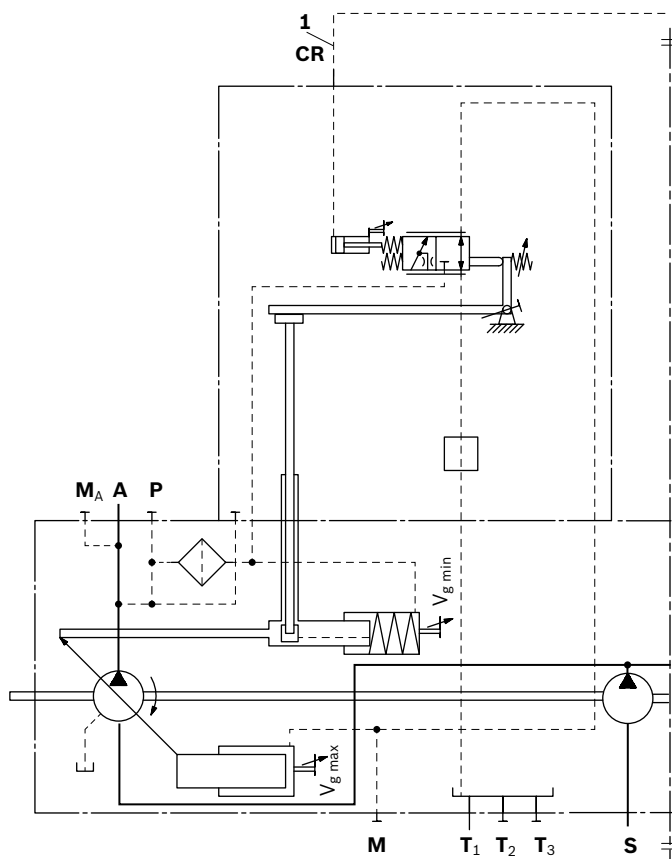
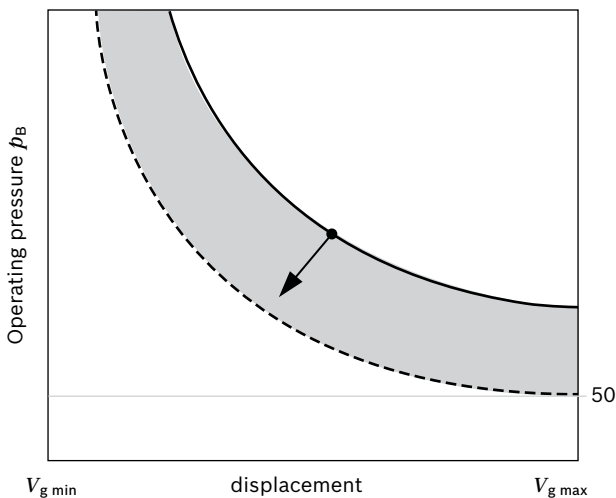**1** Piping is not included in the scope of delivery.
Illustrated for purposes of clarity, only pump A

▼ **Characteristic CR**

▼ **Effect of power override of a pump with increasing pressure in the 2nd pump**

H3 – Stroke control, hydraulic-proportional, pilot pressure (negative control)
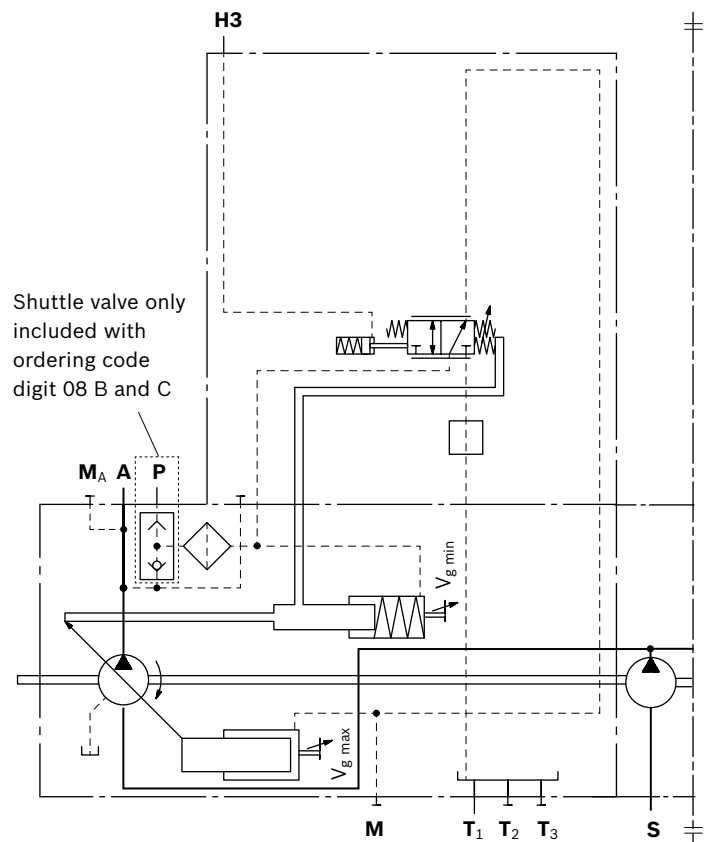
With pilot-pressure-related control, the pump displacement is adjusted in proportion to the pilot pressure applied at port **H3**.

Basic position without pilot signal is $V_{g\,max}$. Mechanically depressurized basic position is $V_{g\,max}$ (see ordering code digit 09, letter B).

▶ Adjustment from $V_{g\,max}$ to $V_{g\,min}$
   With increasing pilot pressure, the pump swivels to a smaller displacement.

▶ Setting range for beginning of control (at $V_{g\,max}$)
   5 bar to 10 bar, standard is 10 bar. State beginning of control in plain text in the order.

▶ Maximum permissible pilot pressure $p_{St\,max}$ = 100 bar

The necessary control fluid is taken from the operating pressure or the external control pressure applied to port **P**. If the pump is to be adjusted from the basic position $V_{g\,min}$ or from a low operating pressure, port **P** must be supplied with an external control pressure of at least 30 bar, maximum 50 bar.

Note

If no external control pressure is applied to **P**, the version "Maximum swivel angle ($V_{g\,max}$), without external control pressure supply" is to be ordered (see ordering code 09, letter A).

▼ **Circuit diagram H3**

Shuttle valve only included with ordering code digit 08 B and C

Illustrated for purposes of clarity, only pump A

▼ **Characteristic H3 (negative)**
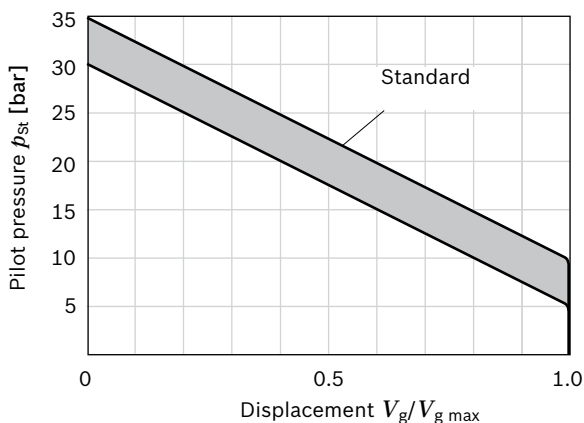
Increase in pilot pressure $V_{g\,max}$ to $V_{g\,min}$: Δp = 25 bar
When ordering, state in plain text:

▶ Beginning of control [bar] at $V_{g\,max}$

H5 – Stroke control, hydraulic-proportional, pilot pressure (negative control)

With pilot-pressure-related control, the pump displacement is adjusted in proportion to the pilot pressure applied at port **H5**.

Basic position without pilot signal is $V_{g\,max}$, which includes the mechanically depressurized basic position $V_{g\,max}$ (see ordering code digit 08).
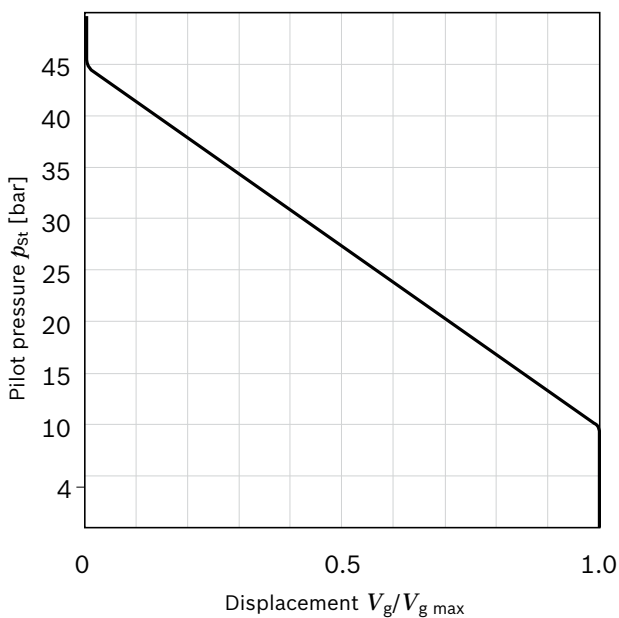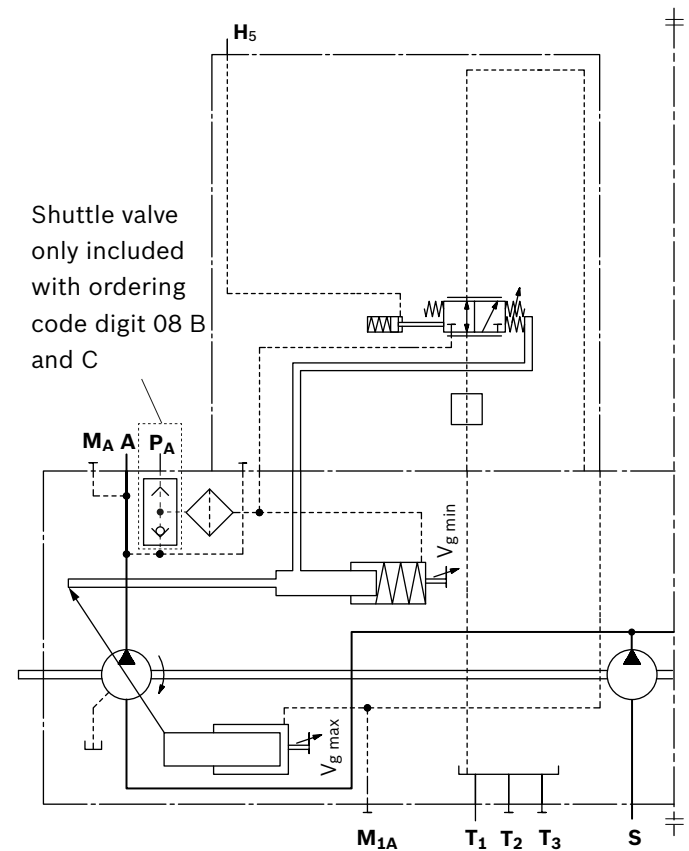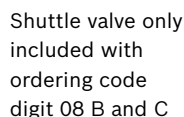
▶ Maximum permissible pilot pressure $p_{St\,max}$ = 100 bar
▶ Adjustment from $V_{g\,max}$ to $V_{g\,min}$
   With increasing pilot pressure, the pump swivels to a smaller displacement.
▶ Beginning of control (at $V_{g\,max}$) 10 bar

The necessary control power is taken from the operating pressure or the external control pressure applied to port **P**. If the pump is to be adjusted at low operating pressure, port **P** must have an external control pressure supply of at least 30 bar, maximum 50 bar.

> **Note**
> If no external control pressure is applied to **P**, the version "Maximum swivel angle ($V_{g\,max}$), without external control pressure supply" is to be ordered (see ordering code digit 08, A).

▼ **Circuit diagram H5**

Shuttle valve only included with ordering code digit 08 B and C

Illustrated for purposes of clarity, only pump A

▼ **Characteristic H5 (negative)**

Increase in pilot pressure $V_{g\,max}$ to $V_{g\,min}$: Δp = 35 bar

H6 – Stroke control, hydraulic-proportional, pilot pressure (positive control)

With pilot-pressure-related control, the pump displacement is adjusted in proportion to the pilot pressure applied at port **H6**.

Basic position without pilot signal is $V_{g\,min}$, which includes the mechanically depressurized basic position $V_{g\,min}$ (see ordering code digit 08).

▶ Maximum permissible pilot pressure $p_{St\,max}$ = 100 bar
▶ Adjustment from $V_{g\,min}$ to $V_{g\,max}$
   With increasing pilot pressure the pump swivels to a larger displacement.
▶ Beginning of control (at $V_{g\,min}$) 10 bar.

The necessary control power is taken from the operating pressure or the external control pressure applied to port **P**. If the pump is to be adjusted from the zero basic setting or from a low operating pressure, port **P** must be supplied with an external control pressure of at least 30 bar, maximum 50 bar.

> **Note**
>
> If no external control pressure is applied to **P**, the version "Maximum swivel angle ($V_{g\,max}$), without external control pressure supply" is to be ordered (see ordering code digit 08, A).

▼ **Circuit diagram H6**

Illustrated for purposes of clarity, only pump A

▼ **Characteristic H6 (positive)**

Increase in pilot pressure $V_{g\,min}$ to $V_{g\,max}$: Δp = 35 bar

Stroke control

E1/E2 – Stroke control, electric, proportional (positive control)

With the electrical stroke limiter with proportional sole-noid, the pump displacement is steplessly adjusted in proportion to the current via the magnetic force. Basic position without pilot signal is $V_{g\,min}$, which includes the mechanically depressurized basic position $V_{g\,min}$ (see ordering code digit 08).

With increasing control current the pump swivels to a higher displacement (from $V_{g\,min}$ to $V_{g\,max}$).

The necessary control fluid is taken from the operating pressure or the external control pressure applied to port **P**. If the pump is to be adjusted from the basic position $V_{g\,min}$ or from a low operating pressure, port **P** must be supplied with an external control pressure of at least 30 bar, maximum 50 bar.

Note

If there is no external control pressure applied to **P**, the version "Maximum swivel angle ($V_{g\,max}$), without external control pressure supply" must be ordered (see ordering code digit 08, A).
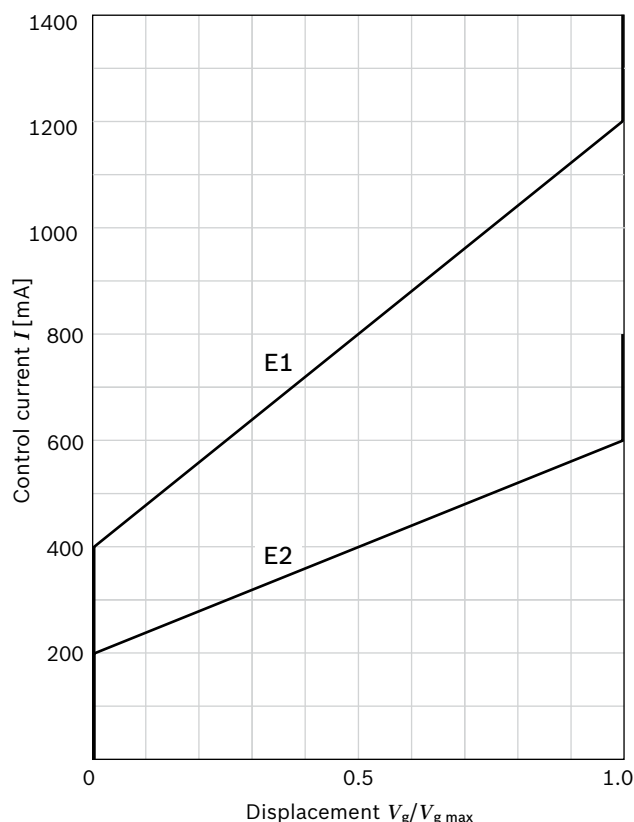
BODAS RC controllers with application software and analog amplifier RA are available for controlling the proportional solenoids.

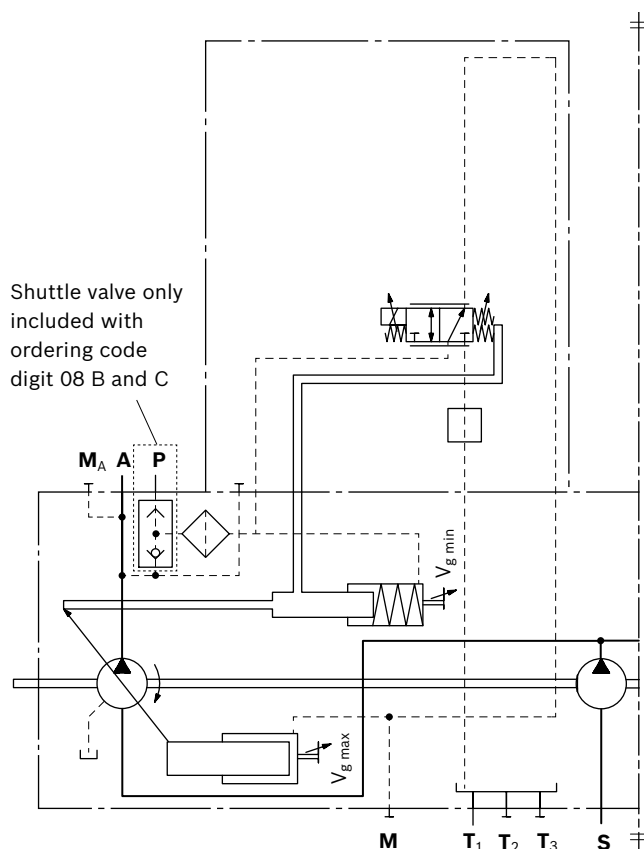Further information can also be found on the Internet at www.boschrexroth.com/mobile-electronics.

Technical data, solenoid	E1	E2
Voltage	12 V (±20%)	24 V (±20%)
Control current		
Beginning of control at $V_{g\,min}$	400 mA	200 mA
End of control at $V_{g\,max}$	1200 mA[1]	600 mA[2]
Limiting current	1.54 A	0.77 A
Nominal resistance (at 20 °C)	5.5 Ω	22.7 Ω
Dither frequency	100 Hz	100 Hz
Duty cycle	100%	100%
Type of protection: see connector version page 29		

When ordering, state in plain text:
▶ Drive speed n [rpm]
▶ Maximum flow $q_{V\,max}$ [l/min]
▶ Minimum flow $q_{V\,min}$ [l/min]

▼ **Circuit diagram E1/E2**

▼ **Characteristic E1/E2**

Shuttle valve only included with ordering code digit 08 B and C

1) Because of the control hysteresis, a control current of up to 1300 mA may be required for the $V_{g\,max}$ position.
2) Because of the control hysteresis, a control current of up to 650 mA may be required for the $V_{g\,max}$ position.
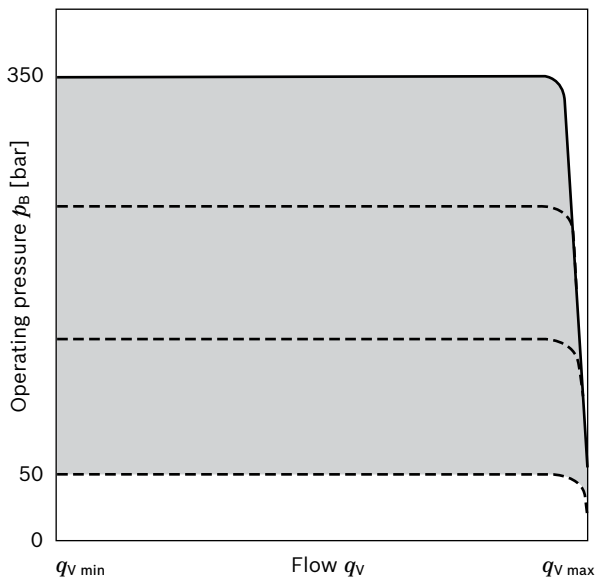
Pressure controller

DR – Pressure controller with one-sided swiveling, fixed setting

The pressure controller limits the maximum pressure at the pump outlet within the control range of the variable pump. The variable pump only supplies as much hydraulic fluid as is required by the consumers. If the operating pressure exceeds the pressure setting at the pressure valve, the pump will regulate to a smaller displacement to reduce the control differential.

▶ Initial position in depressurized state: $V_{g\,max}$
▶ Setting range for pressure control: 50 to 350 bar.

▼ **Characteristic DR**

▼ **Circuit diagram DR**

Illustrated for purposes of clarity, only pump A

Hydraulic $V_{g\,min}$ stop

The hydraulic $V_{g\,min}$ stop opens the valve outlet to the case drain chamber when a minimum position is reached, damping the controller and reducing overshoot. This can cause a connection from high pressure or external control pressure via the controller and the hydraulic $V_{g\,min}$ stop to the case drain chamber.

When ordering, state in plain text:
▶ Pressure setting p [bar] at pressure controller DR
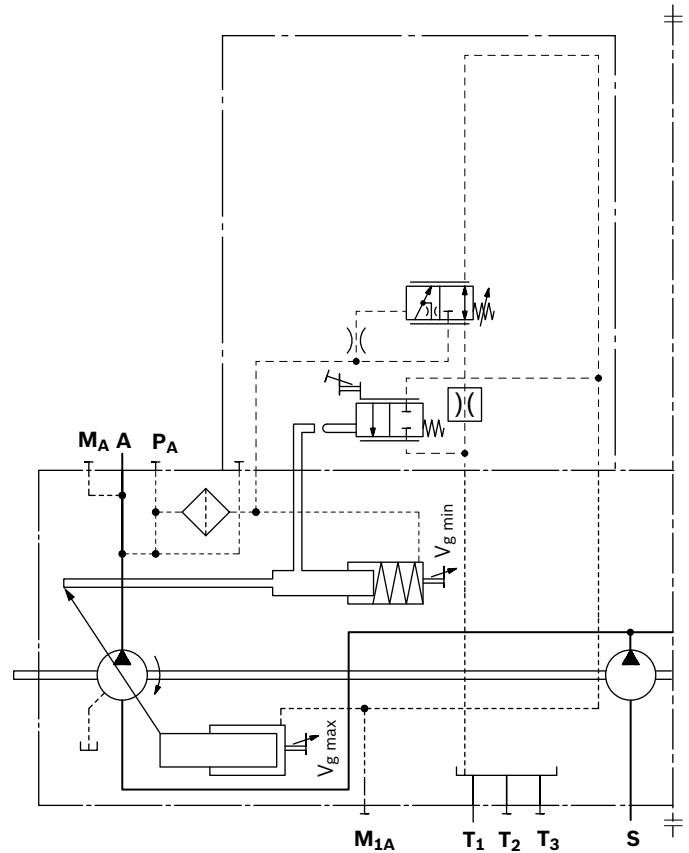
D2 – Proportional pressure control with one-side swiveling, electric override (M2 with two-side swiveling) (positive control)

The pressure controller keeps the pressure in a hydraulic system constant within its control range even under varying flow conditions. The variable pump only supplies as much hydraulic fluid as is required by the consumers.
If the operating pressure exceeds the setting at the integrated pressure control valve, the pump is automatically swiveled back to reduce the control differential.
▶ Initial position in depressurized state: $V_{g\,max}$
▶ Pressure controller basic setting: 32 bar/300 mA

The basic setting of the pressure controller can be overridden. The pressure control value is proportional to the electrical current acting on the solenoids of the pressure reducing valve.
▶ Pressure setting overridden:
32 bar/300 mA to 350 bar/750 mA
▶ Auxiliary pressure for controlling D2 at port **Y**:
p_{min} = 40 bar; p_{max} = 50 bar.
Port **X** acts solely as a measuring port (p_{max} 50 bar). Pressurization leads to an impermissible increase in pressure.

Notice

Applying current above the limit of 750 mA to the proportional solenoid results in an impermissible increase in pressure.
Make sure that currents above the permissible limit are not applied to the proportional solenoid.
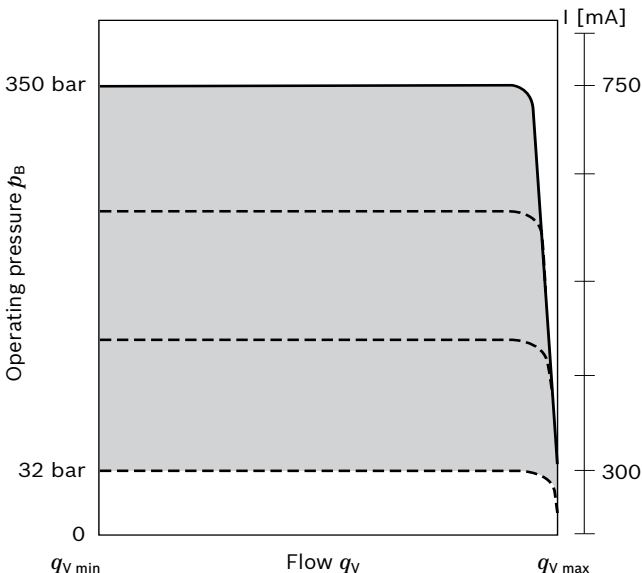
Technical data, solenoid	D2	D2
Voltage	24 V	24 V
Control current		
Beginning of control at $V_{g\,min}$		300 mA
End of control at $V_{g\,max}$		750 mA
Current limit	750 mA	750 mA
Nominal resistance (at 20 °C (68 °F))	12 Ω	12 Ω
Dither frequency	200 Hz	200 Hz
Duty cycle	100%	100 %
Type of protection: see connector version page 63		

The following electronic controllers and amplifiers are available for controlling the proportional solenoids:

BODAS RC controllers Series	Data sheet
20	95200
21	95201
22	95202
30	95203
and application software	95230
Analog amplifier RA	95230

▼ **Circuit diagram D2**

▼ **Characteristic D2**
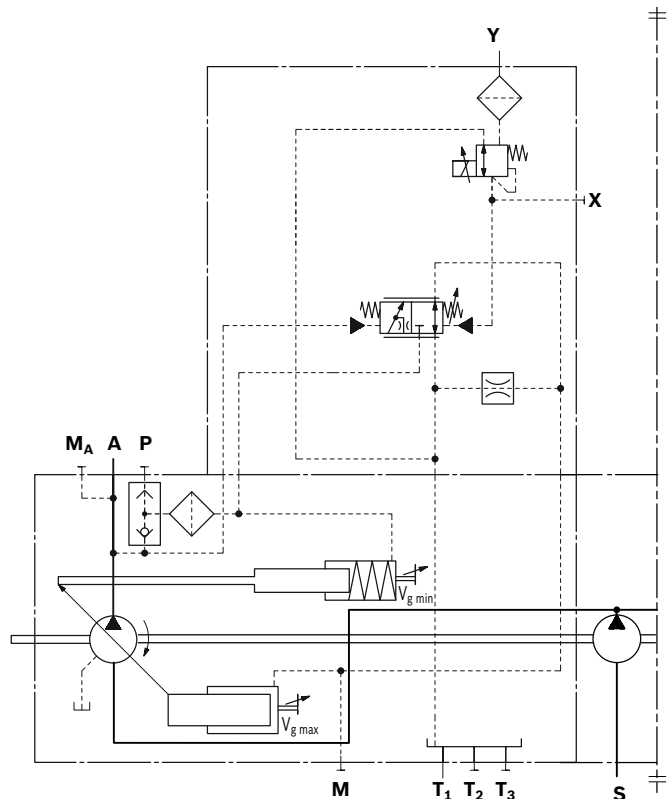
DRS0 – Pressure control with load sensing

The load sensing controller works as a load-pressure controlled flow controller and adjusts the displacement of the pump to the volume required by the consumer.

The flow of the pump is then dependent on the cross section of the external metering orifice (**1**), which is located between the pump and the consumer. Below the setting of the pressure controller and within the control range of the pump, the flow is not dependent on the load pressure.

The metering orifice is usually a separately located load sensing directional valve (control block). The position of the directional valve spool determines the opening cross-section of the metering orifice and thus the flow of the pump.

The load sensing controller compares pressure before and after the sensing orifice and keeps the pressure drop (differential pressure Δp) across the orifice – and therefore the flow – constant.

If the differential pressure Δp at the metering orifice rises, the pump is swiveled back (toward $V_{g\,min}$). If the differential pressure Δp drops, the pump is swiveled out (toward $V_{g\,max}$) until equilibrium at the metering orifice is restored.

$\Delta p_{measuring\,orifice} = p_{pump} - p_{consumer}$

▶ Setting range for Δp 14 to 30 bar (please state in plain text)
▶ Standard adjustment 14 bar

The stand-by pressure in zero stroke operation (metering orifice closed) is slightly higher than the Δp-setting.

▼ **Characteristic DRS0**
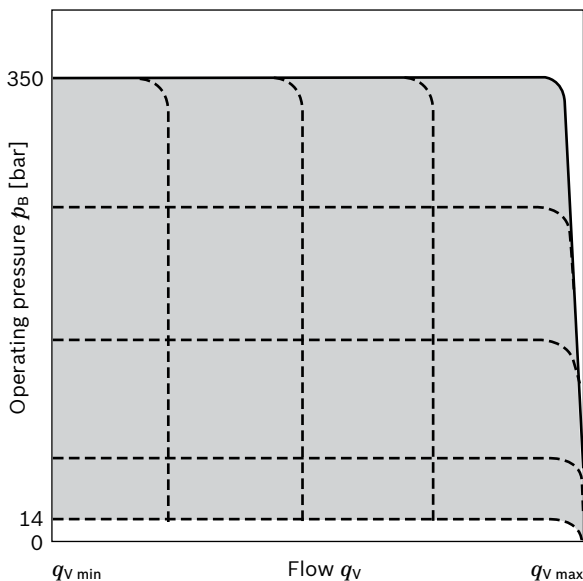

Hydraulic $V_{g\,min}$ stop

The hydraulic $V_{g\,min}$ stop opens the valve outlet to the case drain chamber when a minimum position is reached, damping the controller and reducing overshoot. This can cause a connection from high pressure or external control pressure via the controller and the hydraulic $V_{g\,min}$ stop to the case drain chamber.

When ordering, state in plain text:
▶ Pressure setting p [bar] at pressure controller DR
▶ Differential pressure Δp [bar] at load sensing controller S0

▼ **Circuit diagram DRS0**
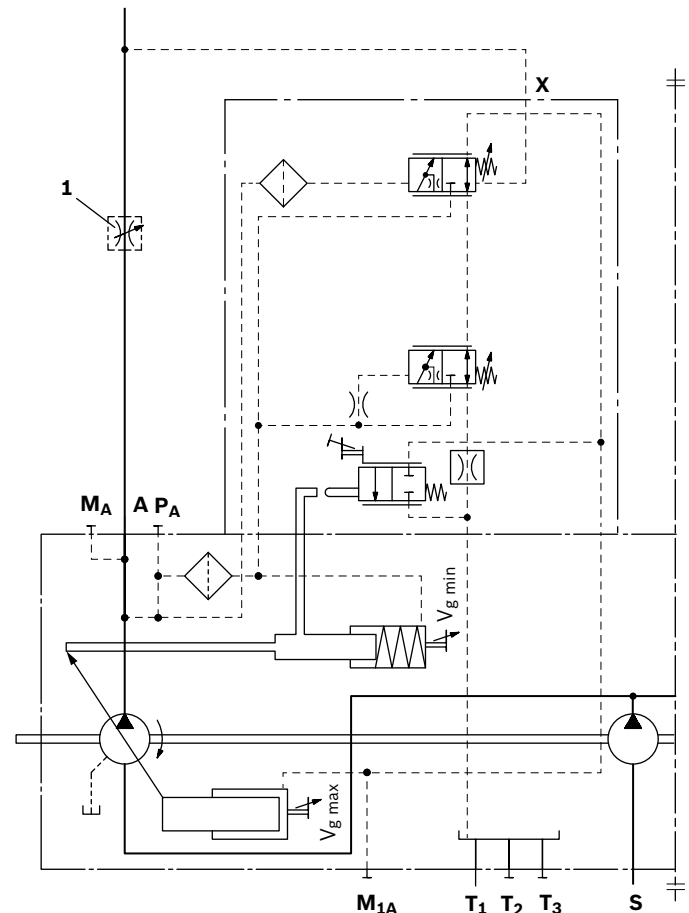
Illustrated for purposes of clarity, only pump A

1 The measuring orifice (control block) is not included in the scope of delivery.

C5H3 – Cross-sensing control with power-controlled double pumps, stroke control, hydraulic-proportional, pilot-pressure related

The method of function is made up of controllers L5 and CR to C5.

For the operation, refer to chapters "L5 – Power controller, hydraulic-proportional override (negative control)" on page 13 and "CR – Summation hp-control of two power-controlled pumps, high-pressure-related override (with stop)" on page 14.
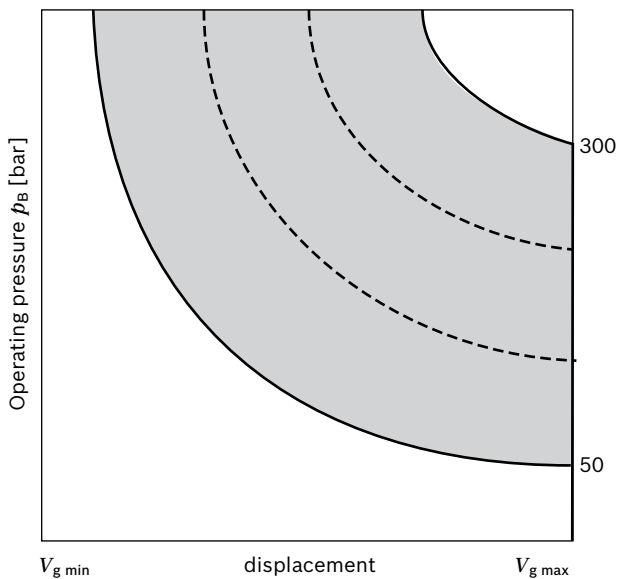
The function of H3 controller "H3 – Stroke control, hydraulic-proportional, pilot pressure (negative control)" can be found on page 15.

Setting range for beginning of control 50 to 300 bar

When ordering, please specify:

▶ Maximum drive power P_{max} [kW]
▶ Minimum drive power P_{min} [kW]
▶ Drive speed n [rpm]
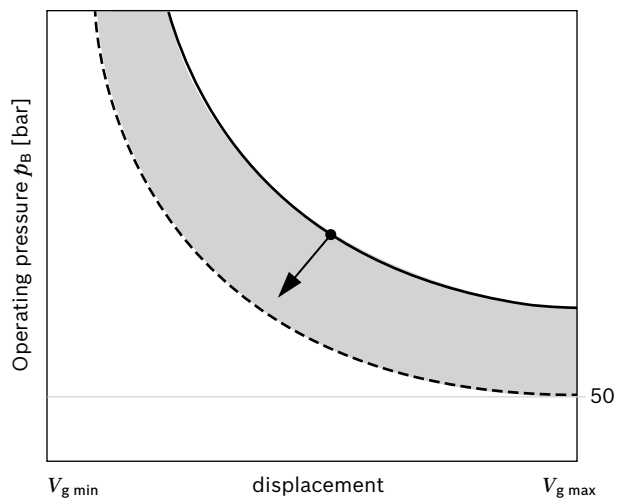▶ Maximum flow $q_{V\,max}$ [L/min]
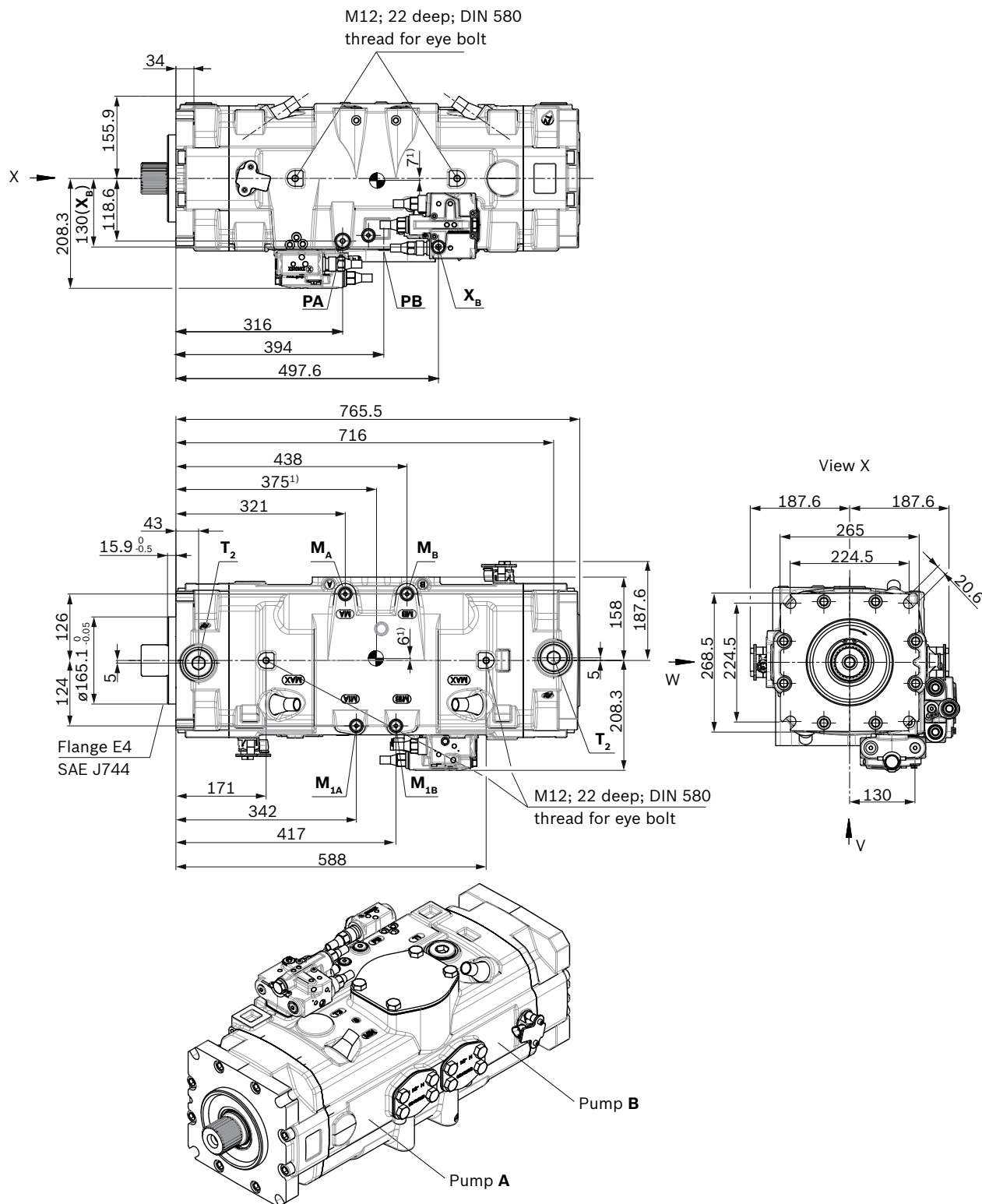
▼ **Characteristic CR**

▼ **Circuit diagram CR**
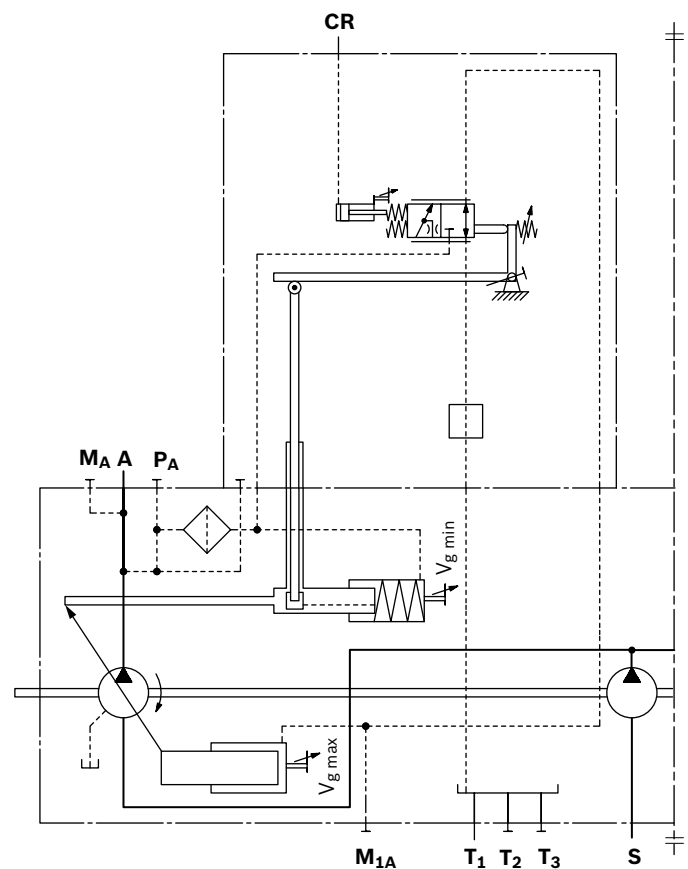
Illustrated for purposes of clarity, only pump A

▼ **Effect of power override of a pump with increasing pressure in the 2nd pump**

Dimensions, size 280

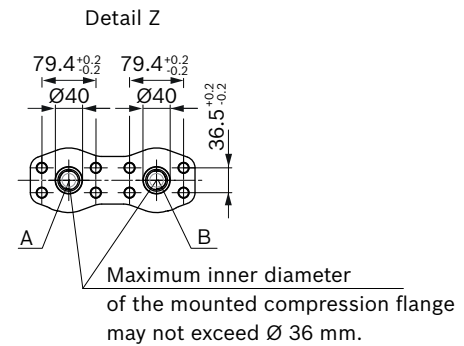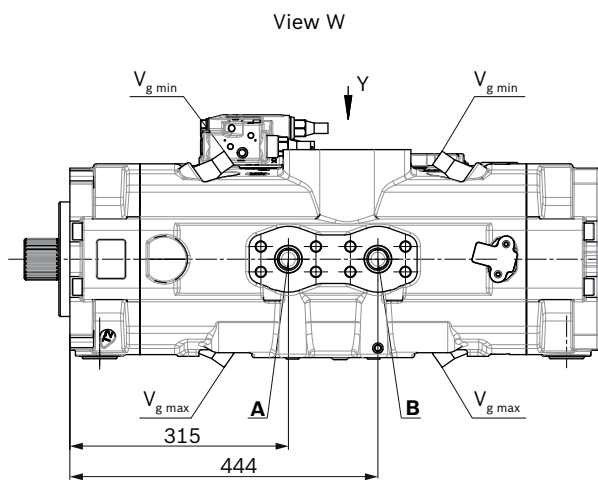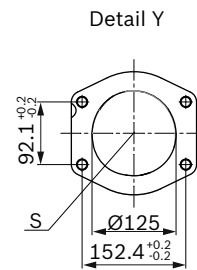**LRDRS0 – Power controller with pressure controller, load sensing and with electric swivel angle sensor (Part 1/2)**
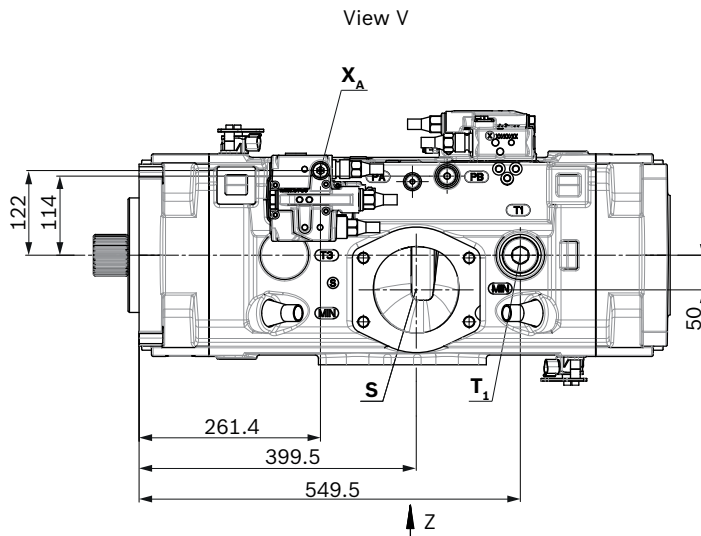Clockwise rotation

M12; 22 deep; DIN 580
thread for eye bolt

34

155.9

118.6

208.3

130 (X_B)

$7^{1)}$

X

PA   **PB**   **X_B**

316

394

497.6

765.5

716

438

$375^{1)}$

321

43

$15.9^{0}_{-0.5}$

T_2   **M_A**   **M_B**

126

$165.1^{0}_{-0.05}$ ⌀

5

124

Flange E4
SAE J744

171

342

417

588

M_{1A}   **M_{1B}**

$6^{1)}$

158

187.6

5

208.3

T_2

W

M12; 22 deep; DIN 580
thread for eye bolt

View X

187.6   187.6

265

224.5

20.6

268.5

224.5

130

V

Pump **B**

Pump **A**

1) Center of gravity

LRDRS0 – Power controller with pressure controller, load sensing and with electric swivel angle sensor (Part 2/2)
Clockwise rotation

View V

X_A

122
114

50

261.4
399.5
549.5

Z

S   **T₁**

Detail Y

$92.1^{+0.2}_{-0.2}$

S   Ø125

$152.4^{+0.2}_{-0.2}$

View W

$V_{g\,min}$ Y $V_{g\,min}$

$V_{g\,max}$ **A**   **B** $V_{g\,max}$

315
444

Detail Z

$79.4^{+0.2}_{-0.2}$ $79.4^{+0.2}_{-0.2}$

Ø40   Ø40

$36.5^{+0.2}_{-0.2}$

A   B

Maximum inner diameter
of the mounted compression flange
may not exceed Ø 36 mm.

Additional information about ports and shaft ends can be found on page 25

SAE−version

Ports			Standard	Size[2]	$p_{max\,abs}$ [bar][7]	State[9]	
Pump A	**Pump B**					Pump A	Pump B
A	**B**	Service line port Fastening thread	SAE J518[5] ASME B1.1	1 1/2 in 5/8-11UNC-2B; 35 deep	420	O	O
S		Suction port Fastening thread	SAE J518[5] ASME B1.1	5 in 5/8-11UNC-2B; 35 deep	30	O	
T₁	–	Drain port	ISO 11926[6]	1 5/8; 19.5 deep	10	X[8]	–
T₂	**T₂**	Drain port	ISO 11926[6]	1 5/8; 19.5 deep	10	O[8]	O[8]
CR	**CR**	Pilot signal (only at CR)	ISO 11926	9/16-18UNF-2B; 13 deep	420	O	O
H.	**H.**	Pilot signal (only at H3, H4, H5, H6)	ISO 11926	9/16-18UNF-2B; 13 deep	100	O	O
L.	**L.**	Override power control (only at L3, L4. L5, L6)	ISO 11926	9/16-18UNF-2B; 13 deep	100	O	O
M₁ₐ	**M₁ᵦ**	Measuring, control pressure	ISO 11926[6]	9/16-18UNF-2B; 13 deep	420	X	X
Mₐ	**Mᵦ**	Measuring, operating pressure A, B	ISO 11926[6]	9/16-18UNF-2B; 13 deep	420	X	X
Pₐ	**Pᵦ**	External control pressure (Ordering code digit 9 version B or C = with external control pressure supply)	ISO 11926[6]	9/16-18UNF-2B; 13 deep	50	O	O
		Port **P** is without function (Ordering code digit 9 version A = without external control pressure supply)	ISO 11926[5]	3/4-16UNF-2B; 12.5 deep	420	X	X

Metric version

| Ports			Standard	Size[2]	$p_{max\,abs}$ [bar][7]	State[9]	
Pump A	**Pump B**					Pump A	Pump B
A	**B**	Service line port Fastening thread	SAE J518[5] DIN 13	1 1/2 in M16 x 2; 24 deep	420	O	O
S		Suction port Fastening thread	SAE J518[5] DIN 13	5 in M16 x 2; 24 deep	30	O	
T₁	–	Drain port	ISO 6149[6]	M42 x 2; 19.5 deep	10	X[8]	–
T₂	**T₂**	Drain port	ISO 6149[6]	M42 x 2; 19.5 deep	10	O[8]	O[8]
CR	**CR**	Pilot signal (only at CR)	ISO 6149	M14 x 1.5; 11.5 deep	420	O	O
H.	**H.**	Pilot signal (only at H3, H4, H5, H6)	ISO 6149	M14 x 1.5; 11.5 deep	100	O	O
L.	**L.**	Override power control (only at L3, L4, L5, L6)	ISO 6149	M14 x 1.5; 11.5 deep	100	O	O
M₁ₐ	**M₁ᵦ**	Measuring, control pressure	ISO 6149[6]	M14 x 1.5; 12 deep	420	X	X
Mₐ	**Mᵦ**	Measuring, operating pressure A, B	ISO 6149[6]	M14 x 1.5; 12 deep	420	X	X
Pₐ	**Pᵦ**	External control pressure (Ordering code digit 9 version B or C = with external control pressure supply)	ISO 6149[6]	M14 x 1.5; 11.5 deep	50	O	O
		Port **P** is without function (Ordering code digit 9 version A = without external control pressure supply)	ISO 6149[6]	M18 x 1.5; 14.5 deep	420	X	X

▼ **Splined shaft SAE J744**
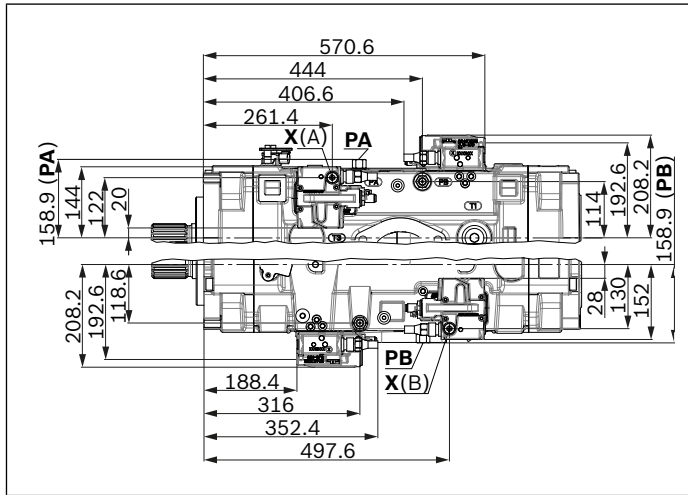
T3 – 2 1/4 in 17T 8/16DP[1)]
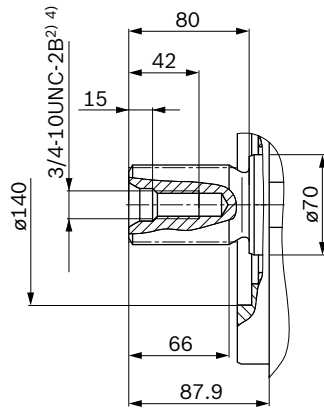

▼ **Splined shaft DIN 5480**

A4 – W60x2x28x9
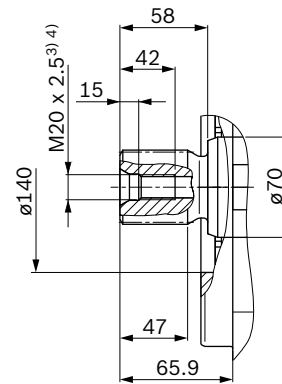
[1)] ANSI B92.1a, 30° pressure angle, flat root, side fit, tolerance class 5
[2)] Thread according to ASME B1.1
[3)] Centering bore according to DIN 332 (thread according to DIN 13)
[4)] Observe the general instructions on page 32 concerning the maximum tightening torques.
[5)] Metric fixing thread is a deviation from standard.
[6)] The spot face can be deeper than as specified in the standard

[7)] Depending on the application, momentary pressure peaks may occur. Keep this in mind when selecting measuring devices and fittings.
[8)] Depending on installation position, T_1, T_2 or T_3 must be connected (see also Installation instructions on pages 30 and 31).
[9)] O = Must be connected (plugged on delivery)
X = Plugged (in normal operation)

▼ **xxS0 – Additional controller; Load sensing, internal pump pressure, fixed setting**

▼ **E1/E2 – Stroke control electric-proportional**

▼ **L3/L4 – Power controller, electric-proportional override**

▼ **L5/L6 – Power controller, hydraulic-proportional override**
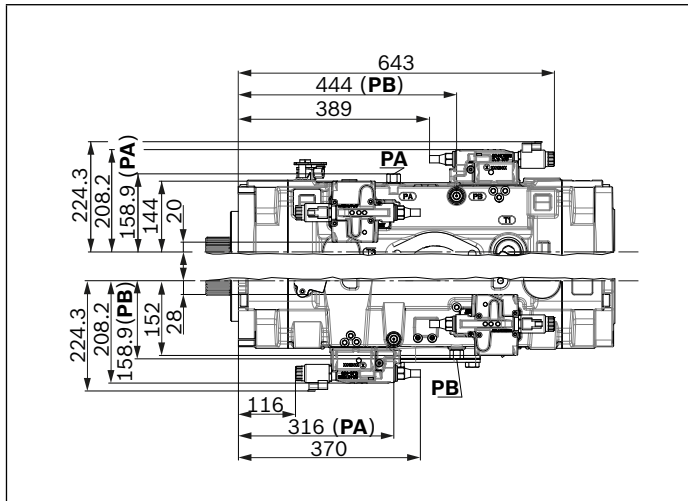
▼ **CR – Power controller, hydraulic-proportional override, high pressure, with stop**
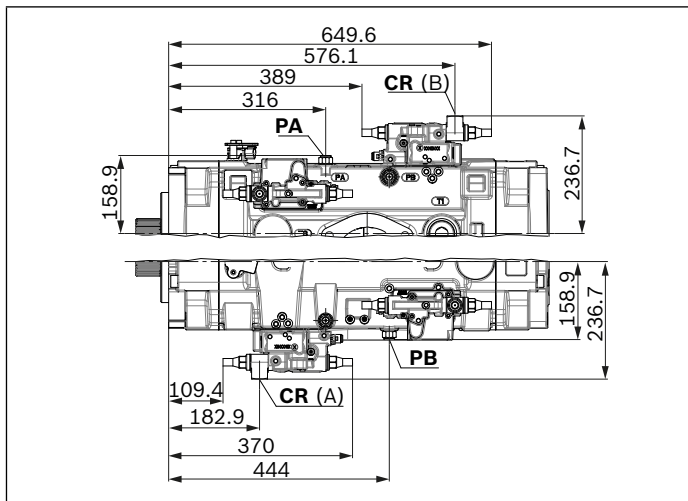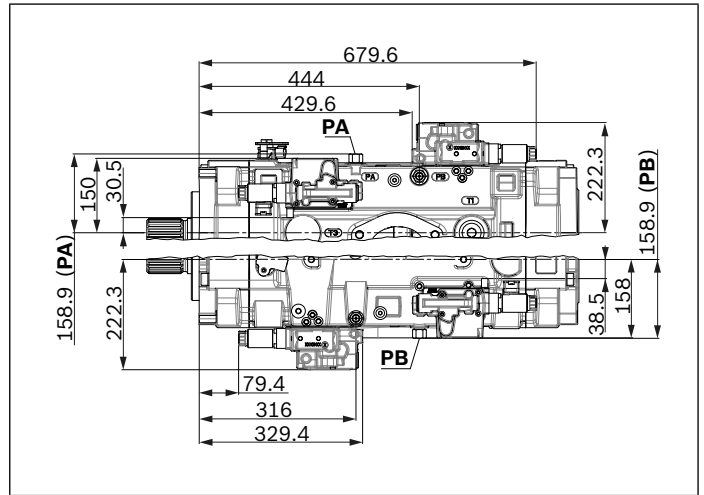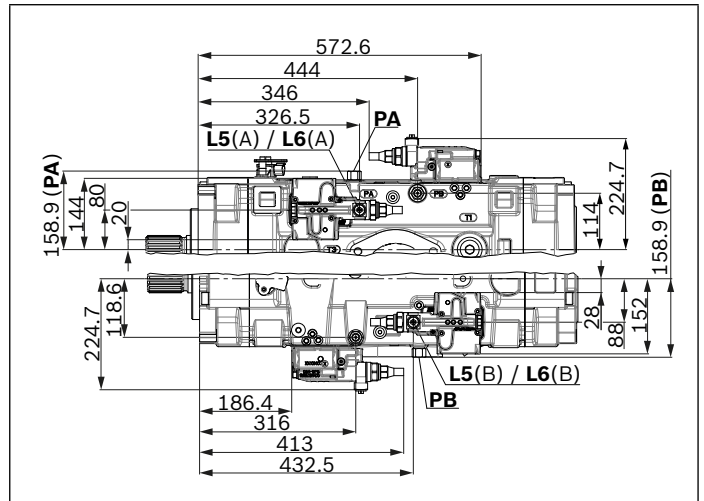
▼ **DR – Pressure controller**
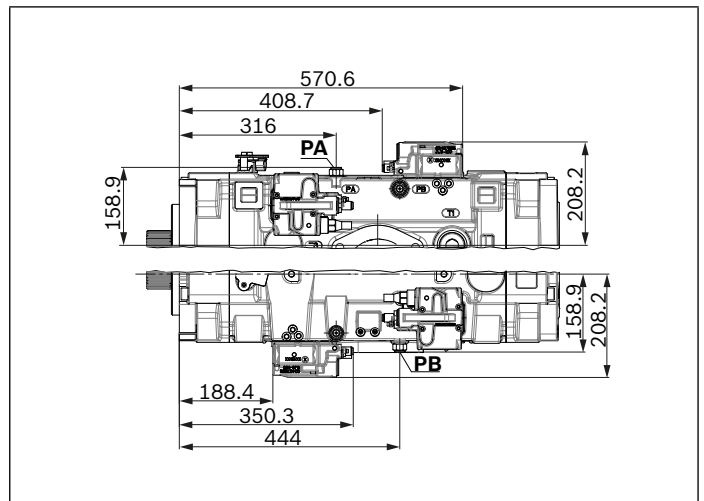
▼ **H3/H4/H5/H6 – Stroke control, hydraulic-proportional, pilot
pressure**
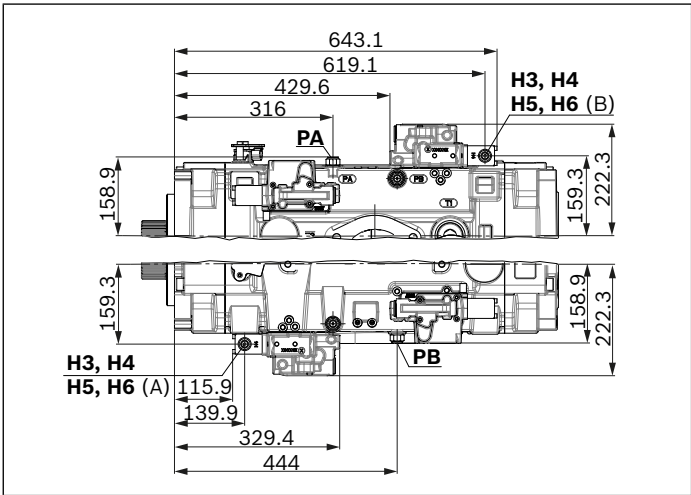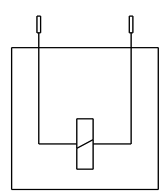
Connector for solenoids

DEUTSCH DT04-2P-EP04

Molded connector, 2-pin, without bidirectional suppressor diode

There is the following type of protection with mounted mating connector:
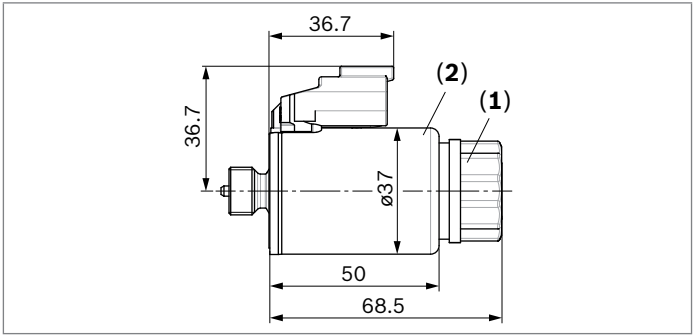
▶ IP67 (DIN/EN 60529) and
▶ IP69K (DIN 40050-9)

▼ **Circuit diagram symbol**

▼ **Mating connector DEUTSCH DT06-2S-EP04**

Consisting of	DT designation
1 housing	DT06-2S-EP04
1 wedge	W2S
2 sockets	0462-201-16141

The mating connector is not included in the scope of delivery. This can be supplied by Bosch Rexroth on request (material number R902601804).

Changing connector orientation

If necessary, you can change the position of the connector by turning the solenoid.

To do this, proceed as follows:

▶ Loosen the mounting nut (**1**) of the solenoid.
  To do this, turn the mounting nut (**1**) one revolution counter-clockwise.
▶ Turn the solenoid body (**2**) to the desired orientation.
▶ Re-tighten the mounting nut.
  Tightening torque: 5+1 Nm.
  (WAF 26, 12-sided DIN 3124)

On delivery, the position of the connector may differ from that shown in the brochure or drawing.

AMP Junior-Timer, 2-pin

Type of protection:

▶ IP69K (DIN 40050-9)

The mating connector is not included in the scope of delivery. This can be supplied by Bosch Rexroth on request (material number R901022127); see also data sheet 08006.

▶ Outer diameter of conductor 2.2 mm to 3.0 mm

Manual override

When power supply to the vehicle is interrupted, maximum operating pressure can be established by means of a manual override so that the vehicle can be driven under its own power from a danger zone.
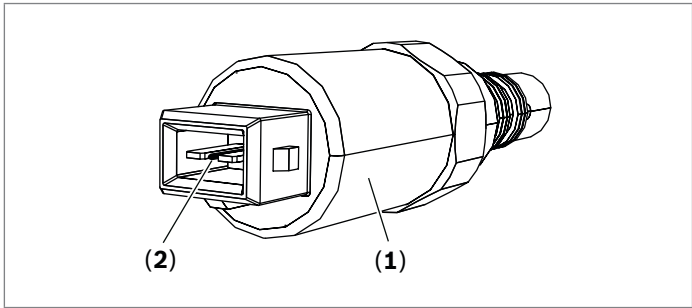
To activate the manual override:

▶ Unplug the electrical connector from the pressure reducing valve (**1**).
▶ Using a pointed tool, press both PINs (**2**) in up to the stop.
  Both PINs must remain in the depressed position!

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 case drain fluid in the case interior must be directed to the reservoir via the highest drain port (T_1, T_2, T_3).

For combinations of multiple units, the case drain fluid must be drained off at each pump. If a shared drain line is used for this purpose, make sure that the case pressure in each pump is not exceeded. In the event of pressure differences at the drain ports of the units, the shared drain line must be changed so that the minimum permissible case pressure of all connected units is not exceeded in any situation. If this is not possible, separate drain lines must be laid if necessary.

To achieve favorable noise values, decouple all connecting lines using elastic elements and avoid above-reservoir installation.

In all operating conditions, the suction line and drain line must flow into the reservoir below the minimum fluid level. The permissible suction height h_S results from the overall loss of pressure. 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 (without charge pump) or 0.7 bar absolute (with charge pump) during operation and during a cold start.

When designing the reservoir, ensure adequate distance between the suction line and the case drain line. This prevents the heated, return flow from being drawn directly back into the suction line.

> ### Note
>
> In certain installation positions, an influence on the control characteristic curves can be expected. Gravity, dead weight and case pressure can cause minor characteristic shifts and changes in response time.
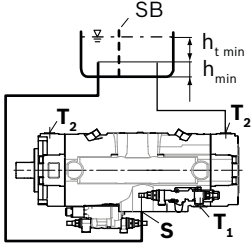
Installation position

See examples **1** to **6** below.

Further installation positions are available upon request.

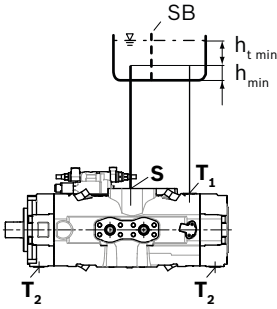Recommended installation position: **1** and **2**

Below-reservoir installation (standard)

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

Installation position	Air bleeding	Filling
1	T_2	$S + T_2$
2	T_1	$S + T_1$

Above-reservoir installation

Above-reservoir installation means that the axial piston unit is installed above the minimum fluid level of the reservoir. To prevent the axial piston unit from draining, a height difference $h_{ES\,min}$ of at least 25 mm at port **T₂** is required in position 6. Observe the maximum permissible suction height $h_{S\,max} = 800$ mm.

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

Installation position		Air bleeding	Filling
3		**F**	**T₂ (F)**
4		**S (F)**	**T₁ (F)**

Key	
F	Filling / air bleeding
S	Suction port
T	Drain port
SB	Baffle (baffle plate)
$h_{t\,min}$	Minimum required immersion depth (200 mm)
h_{min}	Minimum required distance to reservoir base (100 mm)
$h_{ES\,min}$	Minimum necessary height required to protect the axial piston unit from draining (25 mm)
$h_{S\,max}$	Maximum permissible suction height (800 mm)

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 electrical components (e.g., electric control, sensors) may not be installed in a reservoir below the fluid level.

Exception: Installation of the pump with E2/E6 control only with HIRSCHMANN connector and if mineral hydraulic fluids are used and the fluid temperature in the reservoir does not exceed 80 °C

Installation position		Air bleeding	Filling
5		via the highest available port **T₂**	automatically via the open port **T₂** due to position below hydraulic fluid level
6		via the highest available port **T₁**	automatically via the open port **T₁** due to position below hydraulic fluid level

Note

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

Project planning notes

▶ The A28V(L)O variable pump is designed to be used in open circuits.

▶ Project planning, installation and commissioning of the axial piston units requires the involvement of skilled personnel.

▶ Before using the axial piston unit, please read the corresponding instruction manual completely and thoroughly. If necessary, request it from Bosch Rexroth.

▶ Before finalizing your design, request a binding installation drawing.

▶ The data and notes contained herein must be adhered to.

▶ Depending on the operating condition of the axial piston unit (operating 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 preservative protection for a maximum of 12 months. If longer preservative protection is required (maximum 24 months), please specify this in plain text when placing your order. The preservation times apply under optimal storage conditions, details of these conditions can be found in the data sheet 90312 or the instruction manual.

▶ Not all variants of the product are approved for use in safety functions according to ISO 13849. Please consult the responsible contact person 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. When a direct current is applied, solenoids do not cause electromagnetic interference nor is their operation impaired by electromagnetic interference.
Other behavior can result when a modulated direct current (e.g. PWM signal) is applied. Potential electromagnetic interference for persons (e.g. persons with a pacemaker) and other components must be tested by the machine manufacturer.

▶ Pressure controllers are not safeguards against pressure overload. Be sure to add a pressure relief valve to the hydraulic system.

▶ Service line ports:
  – The ports and fixing threads are designed for the specified peak pressure. The machine or system manufacturer must ensure that the connecting elements and lines correspond to the specified operating conditions (pressure, flow, hydraulic fluid, temperature) with the necessary safety factors.
  – The service line ports and function ports can only be used 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 appropriate safety measures (e.g. by wearing protective clothing).

▶ Moving parts in control equipment (e.g. valve spools) can, under certain circumstances, get blocked in position as a result of contamination (e.g. impure hydraulic fluid, abrasion, or residual dirt from components). As a result, the flow of hydraulic fluid 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 filter) 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 set the consumer being driven to a safe position (e.g. safe stop) and if necessary to ensure it is properly implemented.