Hydraulic Systems Vendor Literature

Section 04-01-08

Komatsu has made every effort to make this manual as accurate as possible based on the information available at the time of publication and printing. Continuous improvement and advancement of product design may cause changes to machines which may not have been included in this publication. Komatsu reserves the right to make changes and improvements at any time. To ensure the most current information, please contact your service center.

Vendor Literature

VL 34A - Danfoss-Hydrostatic Steering Unit OSPB-OSPC (EN.21.AC.02)

VL 34B - Danfoss-Flow Amplifier OSQA/OSQB Service Manual (HN.25.D2.93)

VL 77-1 – Danfoss PVG 32 Proportional Valves

VL 77-2 – Danfoss PVE-Series 4 Technical Information

VL 77-3 – PVG 16 & 32 Service Assembly/Disassembly Guide

VL 112 – Denison Hydraulic Vane Pump Trouble Shooting Guide

VL 113 – Rexroth Axial Piston Variable Pump A10V0 (US-Version)

VL 114 – Rexroth Axial Piston Variable Double Pump (A20VO)

VL 115 – Rexroth Axial Piston Variable Pump (A11VO)

NOTICE

The vendor literature in this section covers a variety of different components. Check your model before using the literature. Some literature shows slightly different components. It is essential to use the Komatsu Parts Manual that was issued for the machine on which work is being performed, to order parts.

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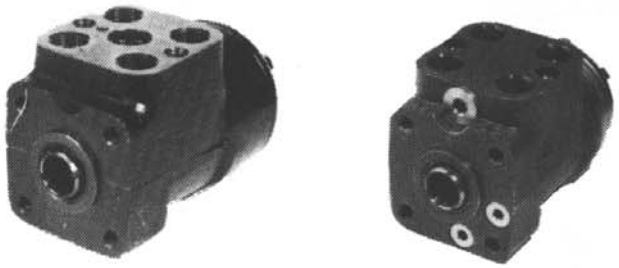
DANFOSS

SERVICE MANUAL

Danfoss

Hydrostatic Steering Unit OSPB/OSPC

HN.21.AC.02 replaces HN.21.AB.52; HN.21.AB.52



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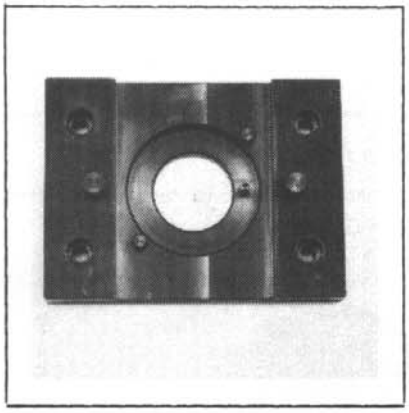
VL 34A

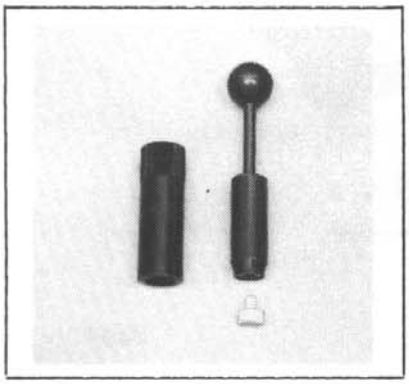
Cost-free repairs

We would point out that cost-free repairs as mentioned in Danfoss General Conditions of Sale, are carried out only at Danfoss Nordborg or at service shops authorized by Danfoss (page 29).

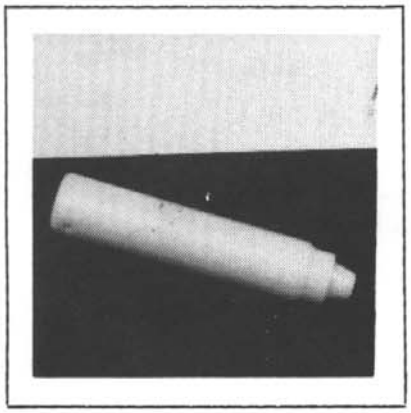
TOOLS



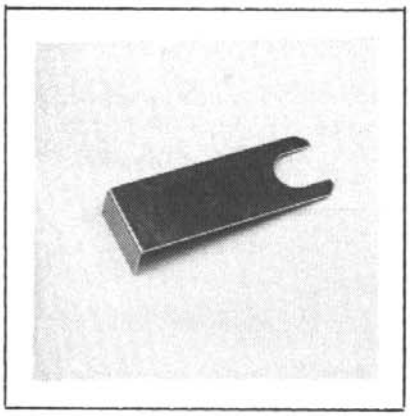
A Holding tool. Code no.: SJ 150-9000-2.



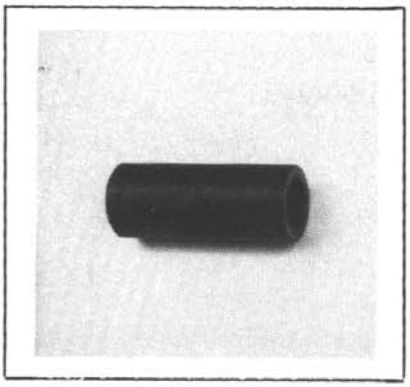
B Assembly tool for o-ring and kin-ring.
Code no. SJ 150-9000-11.



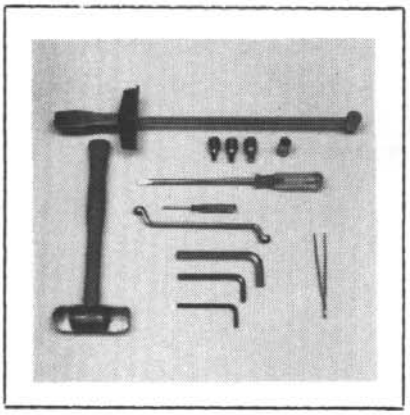
C Assembly tool for lip seal.
Code no. SJ 150-9000-17.



D Assembly tool for cardan shaft.
Code no. SJ 150-9000-3.



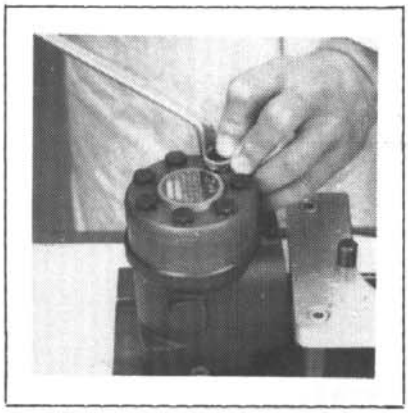
E Assembly tool for dust seal.
Code no. SJ 150-9000-22.



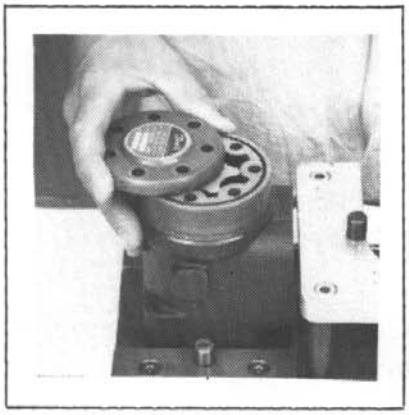
F Torque wrench 0-7 daNm.
13 mm socket spanner.
6, 8 and 12 mm hexagon sockets.
12 mm screwdriver.
2 mm screwdriver.
13 mm ring spanner.
6, 8 and 12 mm hexagon socket spanners.
Plastic hammer.
Tweezers.

The tools named under point F are not available from Danfoss.

DISMANTLING

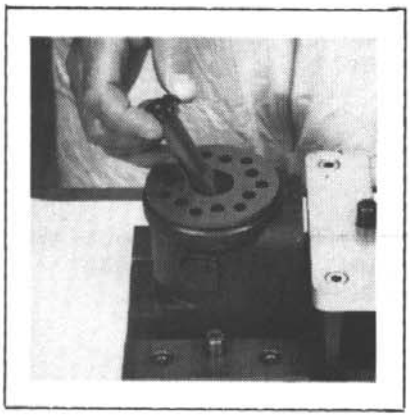


1 Dismantle steering column from steering unit and place the steering unit in the holding tool. Screw out the screws in the end cover (6-off plus one rolled pin).

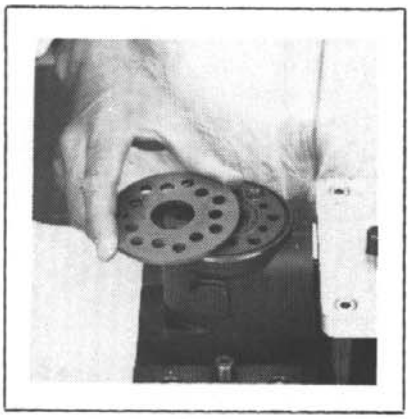


2 Remove the end cover, sideways.

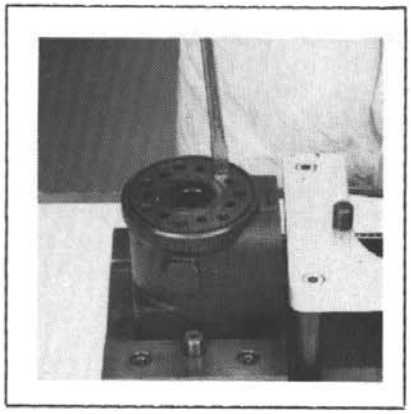
3 Lift the gearwheel set (with spacer if fitted) off the unit. Take out the two o-rings.



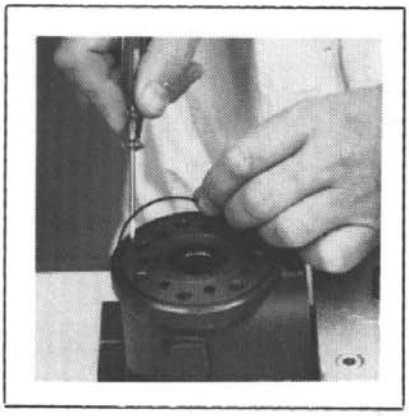
4 Remove cardan shaft.



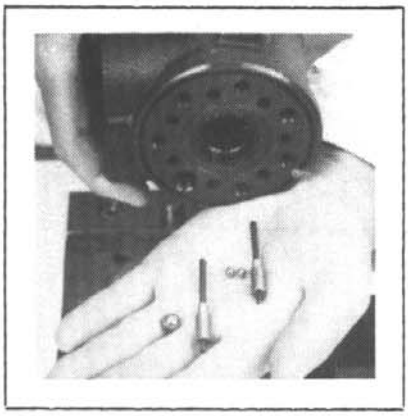
5 Remove distributor plate.



6 Screw out the threaded bush over the check valve.



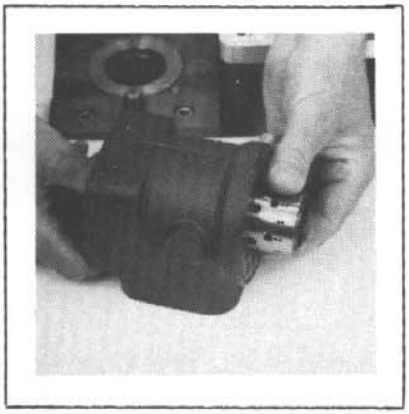
7 Remove o-ring.



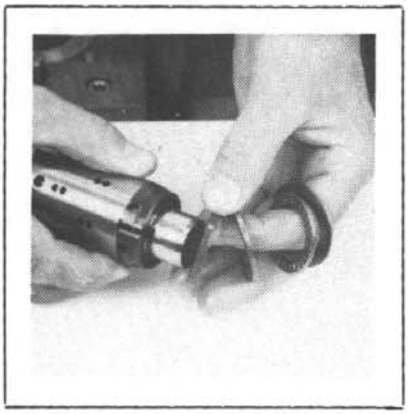
8 OSPB; OSPB LS; OSPBX LS:
Shake out the check valve ball (ø 8 mm).

OSPC; OSPC LS; OSPC LSR:
Shake out the check valve ball and suction valve pins and balls.

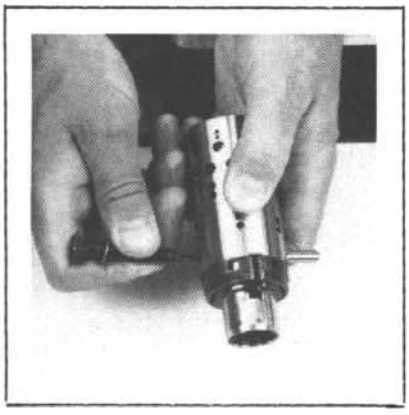
Note: On some pins in the OSPC there are two springs (see page 30, pos. 28). See also spare parts list for OSPC HN.21.L1.52.



9 Take care to keep the cross pin in the sleeve and spool horizontal. The pin can be seen through the open end of the spool. Press the spool inwards and the sleeve, ring, bearing races and needle bearing will be pushed out of the housing together.

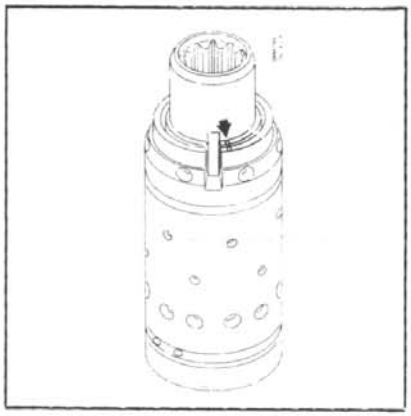


10 Take ring, bearing races and needle bearing from sleeve and spool. The outer (thin) bearing race can sometimes "stick" in the housing, therefore check that it has come out.



11 Press out the cross pin. Use the rolled pin from the end cover.

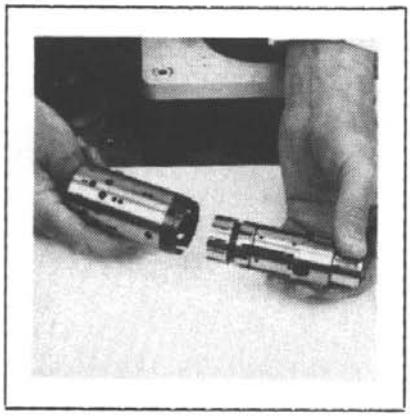
Note 11a!



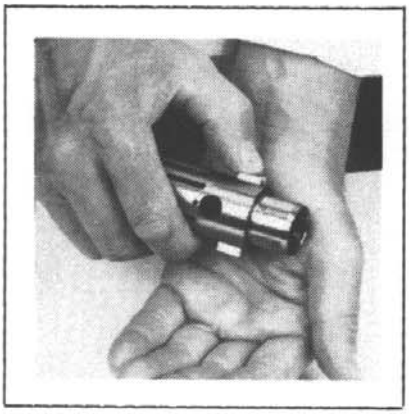
11a OSPB CN and OSPC CN

A small mark has been made with a pumice stone on both spool and sleeve close to one of the slots for the neutral position springs (see drawing).

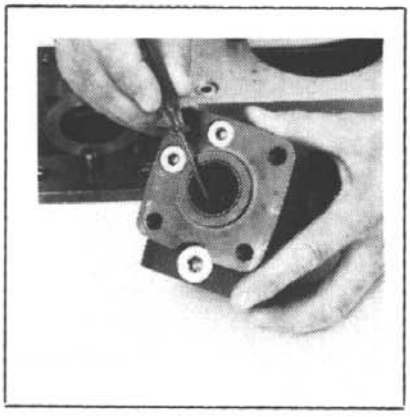
If the mark is not visible, remember to leave a mark of your own on sleeve and spool before the neutral position springs are dismantled.



12 Carefully press the spool out of the **sleeve.**

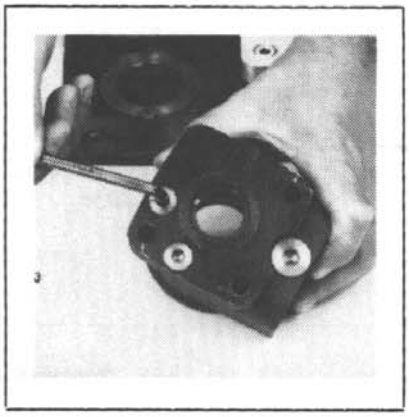


13 Press the neutral position springs out of their slots in the spool.

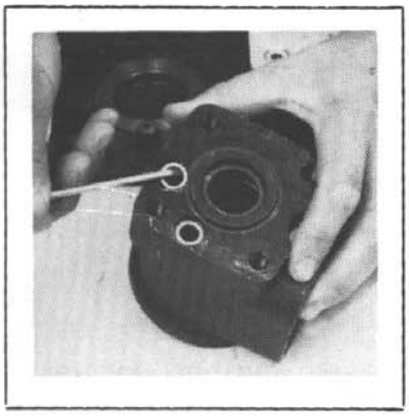


14 Remove dust seal and o-ring/kin-ring.

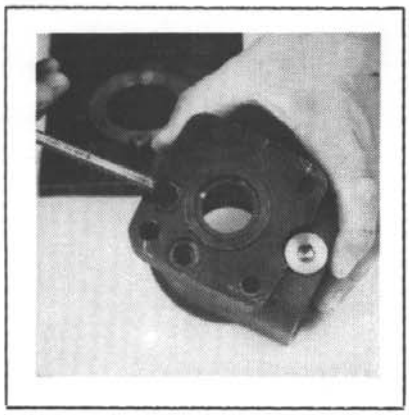
Dismantling the dual shock valves for OSPC/OSPC LS



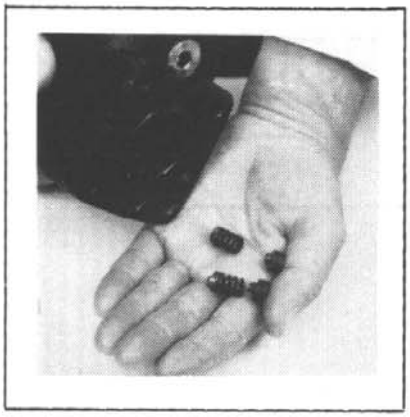
15 Remove plugs from shock valves using a 6 mm hexagon socket spanner.



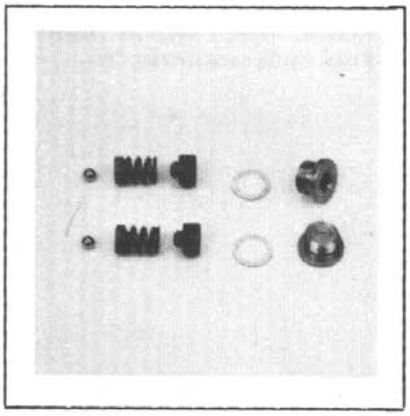
16 Remove seal washers (2-off).



17 Unscrew the setting screws using a 6 mm hexagon socket spanner.

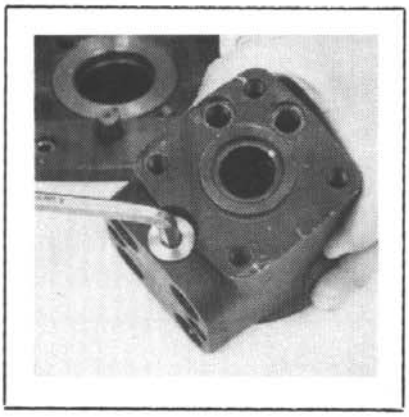


18 Shake out the two springs and two valve balls into your hand. The valve seats are bonded into the housing and cannot be removed.

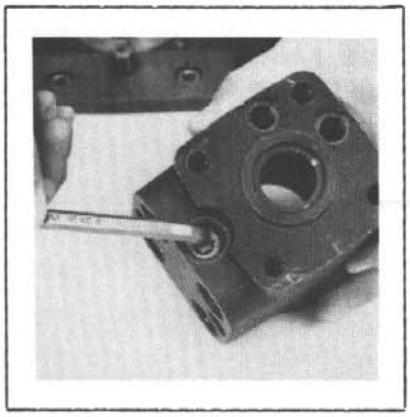


19 The dual shock valves are now dismantled.

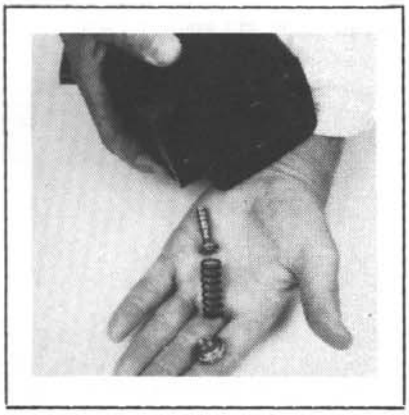
Dismantling the pressure relief valve (cartridge) for OSPC



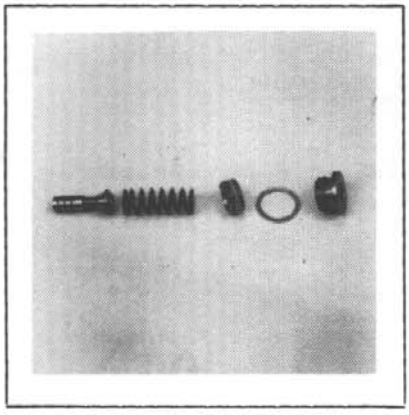
20 Screw out the plug using an 8 mm hexagon socket spanner. Remove seal washers.



21 Unscrew the setting screw using an 8 mm hexagon socket spanner.

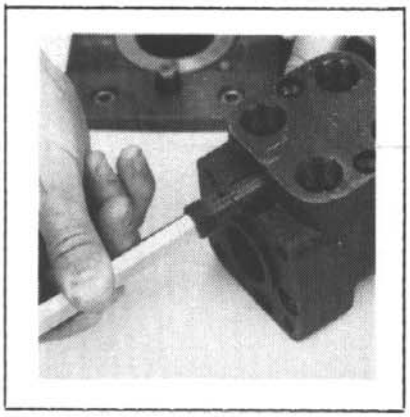


22 Shake out spring and piston. The valve seat is bonded into the housing and cannot be removed.

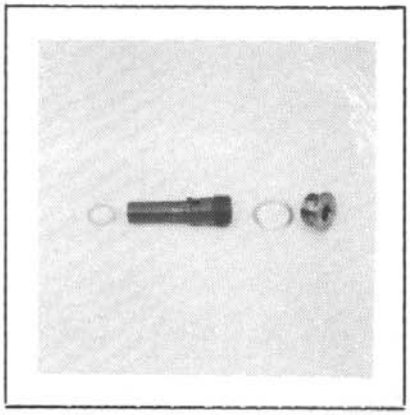


23 The pressure relief valve is now dismantled.

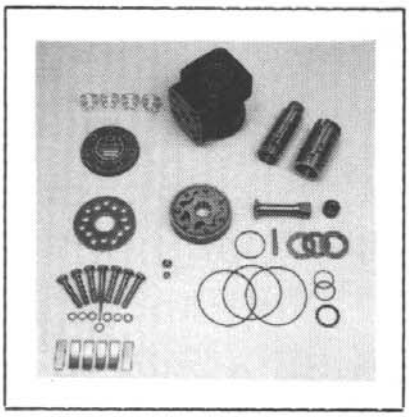
Dismantling the pressure relief valve (cartridge) for OSPC LS/OSPC LSR



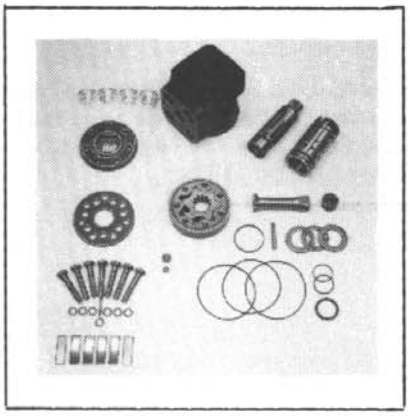
24 Screw out the pressure relief valve using an 8 mm hexagon socket spanner. Remove the seal ring. If the valve is defective it must be replaced (see OSPC spare parts list, HN.21.L1.52).



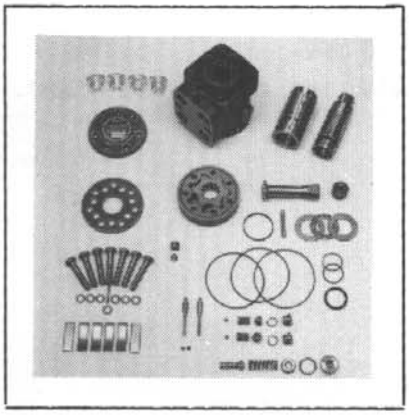
25 The pressure relief valve is now dismantled.



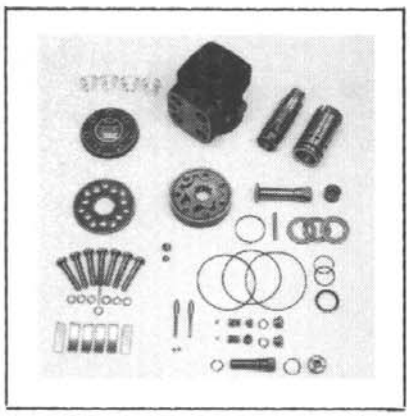
26 The steering unit OSPB is now completely dismantled.



27 The steering unit OSPB LS is now completely dismantled.



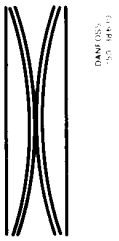
28 The steering unit OSPC is now completely dismantled.



29 The steering unit OSPC LS is now completely dismantled.

Cleaning
Clean all parts carefully in Shellsol K or the like.
Inspection and replacement
Replace all seals and washers. Check all parts carefully and make any replacements necessary.
Lubrication
Before assembly, lubricate all parts with hydraulic oil.

Assembly pattern and colour code for neutral position springs for OSP-steering units



STANDARD SPRINGS (GREY)

2-off flat, grey: code no. 150-0720
4-off curved, grey: code no. 150-0721

GREY SET
Spare set: code no. 150-4209

WEAK SPRINGS (BLUE)

2-off flat, blue: code no. 150-0748
2-off curved, blue: code no. 150-0749

BLUE SET
Spare set: code no. 150-4265

STRONG SPRINGS (GREY AND BLUE)

2-off flat, grey: code no. 150-0720
4-off curved, blue: code no. 150-0749

GREY/BLUE SET
Spare set: code no. 150-4207

STIFF SPRINGS (YELLOW)

2-off flat, yellow: code no. 150N0602
2-off curved, yellow: code no. 150N0603

YELLOW SET
Spare set: code no. 150-4269

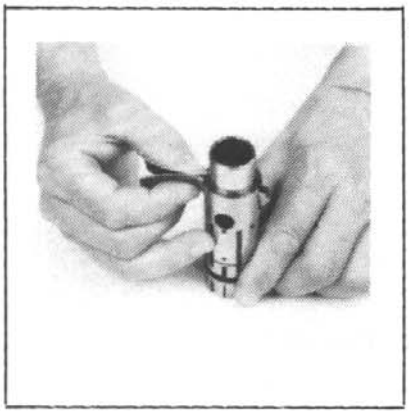
REASSEMBLY

30 Assemble spool and sleeve.

Note

OSPB LS, OSPBX LS, OSPC LS and OSPC LSR
When assembling spool and sleeve only one of two possible ways of positioning the spring slots is correct. There are three slots in the spool and three holes in the sleeve in the end of the spool/sleeve opposite to the end with spring slots. Place the slots and holes opposite each other so that parts of the holes in the sleeve are visible through the slots in the spool.

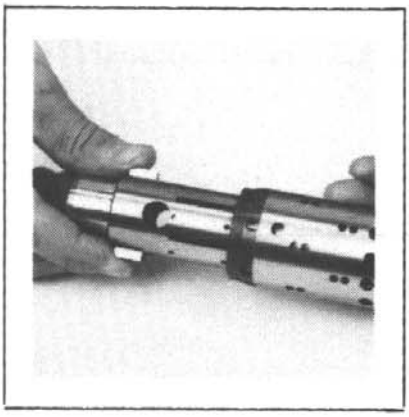
OSPB CN and OSPC CN
Assemble the spool/sleeve and make sure the marks on spool and sleeve are opposite each other (see drawing page 7).



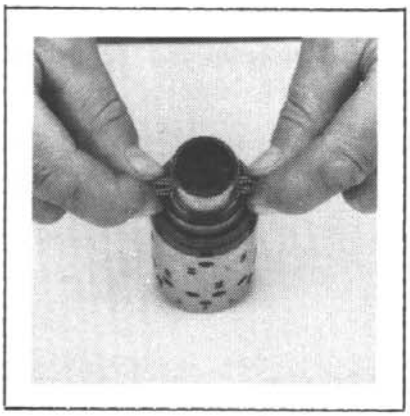
31 Place the two flat neutral position springs in the slot.

Place the curved springs between the flat ones and press them into place (see assembly pattern, page 13).

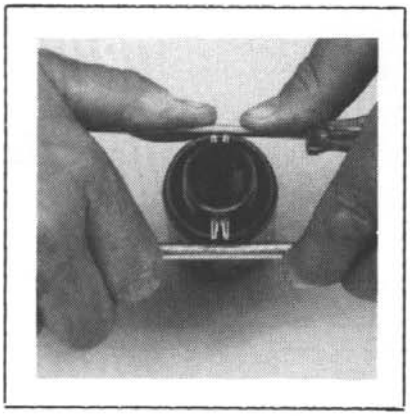
32 Line up the spring set.



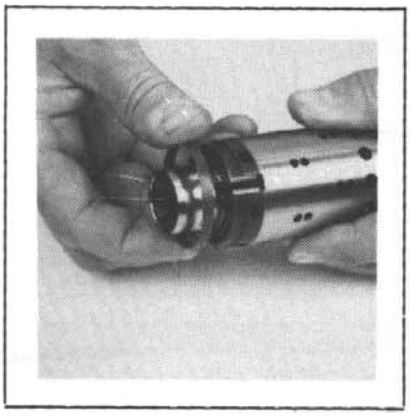
33 Guide the spool into the sleeve. Make sure that spool and sleeve for OSPB LS, OSPBX LS, OSPC LS and OSPC LSR are placed correctly in relation to each other (see page 14).



34 Press the springs togehter and push the neutral position springs into place in the sleeve.

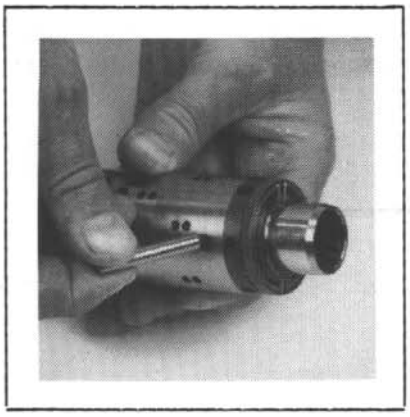


35 Line up the springs and centre them.

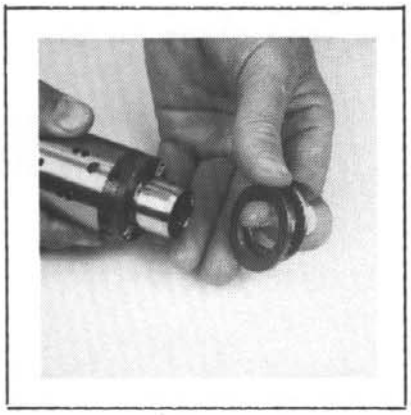


36 Guide the ring down over the sleeve.

Note: The ring should be able to rotate - free of the springs.



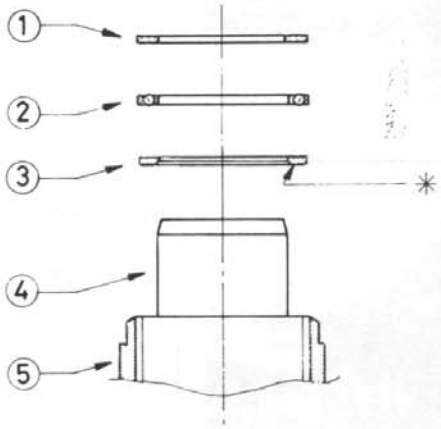
37 Fit the cross pin into the spool/sleeve.



38 Fit bearing races and needle bearing as shown on below drawing.

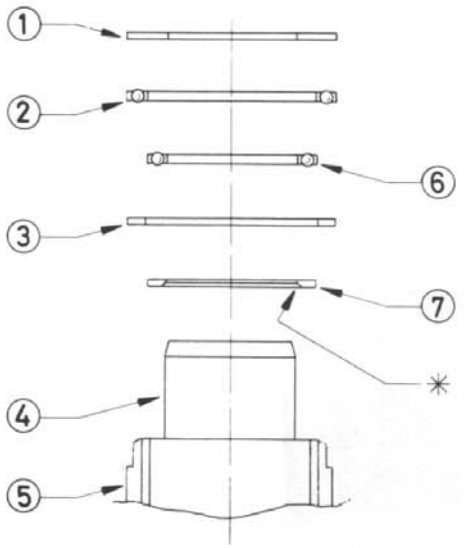
Assembly pattern for standard bearings

1 Outer bearing race
2 Needlebearing
3 Inner bearing race
4 Spool
5 Sleeve



Assembly pattern for double bearings

1 Washer for axial bearing
2 Outer needlebearing
3 Outer bearing race
4 Spool
5 Sleeve
6 Inner needlebearing
7 Inner bearing race



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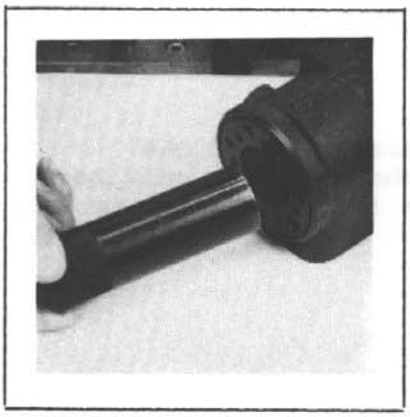
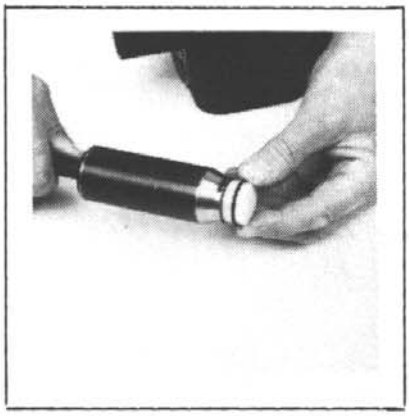
The inside chamfer on the inner bearing race must face the inner spool.

Installation instructions for o-ring/kin-ring (standard)

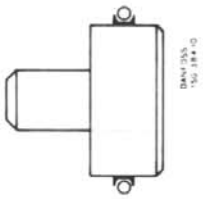


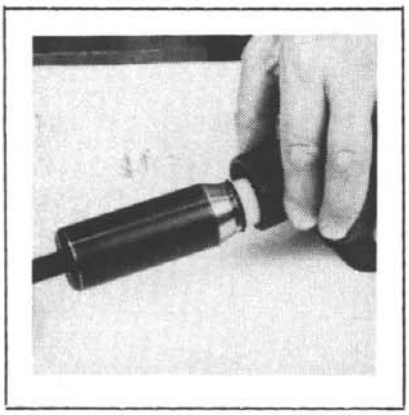
39 Turn the steering unit until the bore is horizontal. Guide the outer part of the assembly tool into the bore for the spool/sleeve.

VL 34A

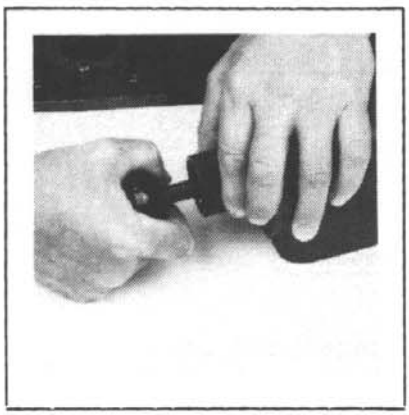


40 Grease o-ring and kin-ring with hydraulic oil and place them on the tool.

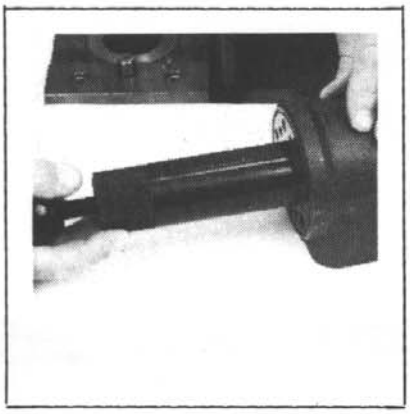




41 Hold the outer part of the assembly tool in the bottom of the steering unit housing and guide the inner part of the tool right to the bottom.

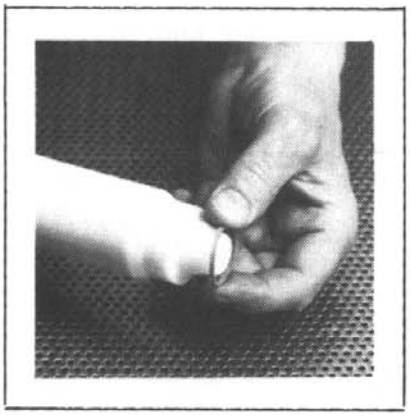


42 Press and turn the o-ring/kin-ring into position in the housing.

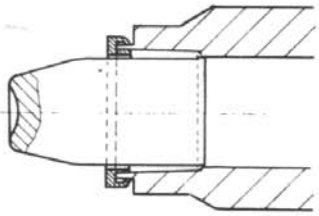


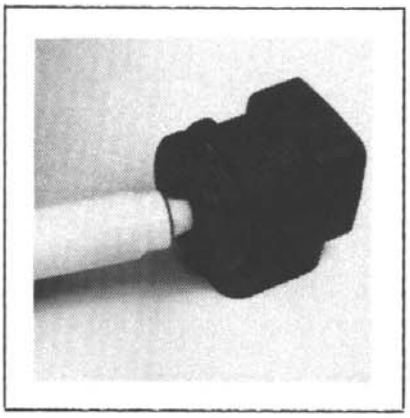
43 Draw the inner and outer parts of the assembly tool out of the steering unit bore, leaving the guide from the inner part in the bore.

Installation instructions for lip seal (see HN.21.A1.02)

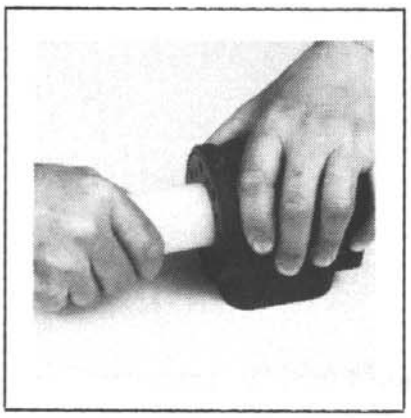


44 Lubricate the lip seal with hydraulic oil and place it on the assembly tool.

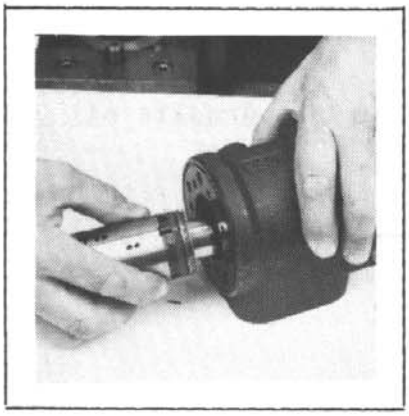




45 Guide the assembly tool right to the bottom.



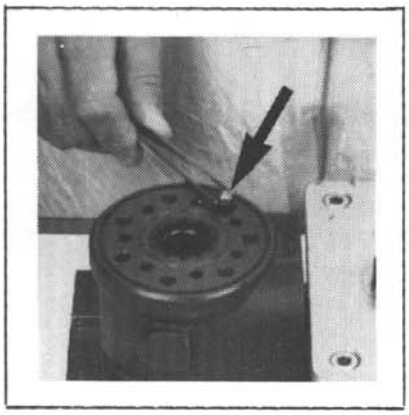
46 Press and turn the lip seal into place in the housing.



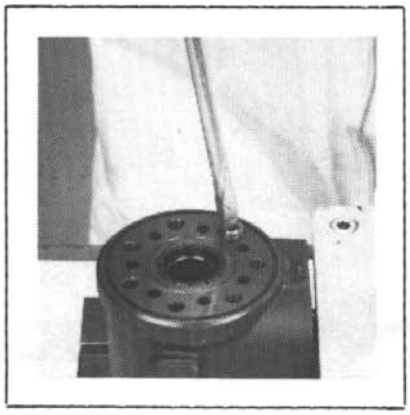
47 With a light turning movement, guide the spool and sleeve into the bore.

Note: Fit the spool set holding the cross pin horizontal.

48 The spool set will push out the assembly tool guide. The o-ring and kin-ring are now in position.

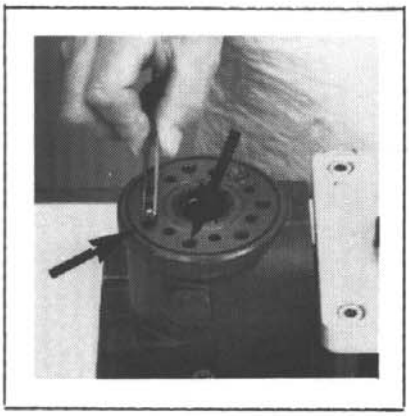


49 Turn the stearing unit until the bore is vertical again. Put the check valve ball into the hole indicated by the arrow.

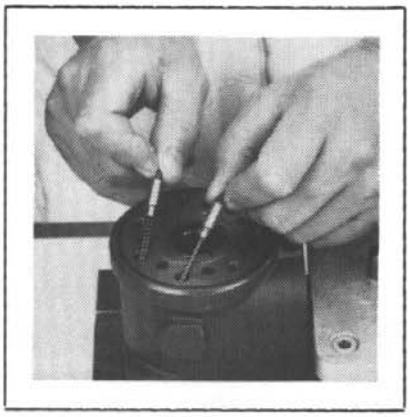


50 Screw the threaded bush lightly into the check valve bore. The top of the bush must lie just below the surface of the housing.

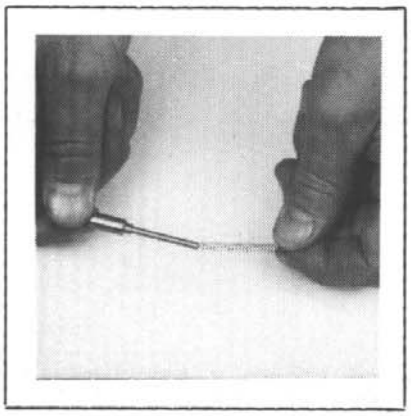
Assembly of the two suction valves for OSPC/OSPC LS/OSPC LSR



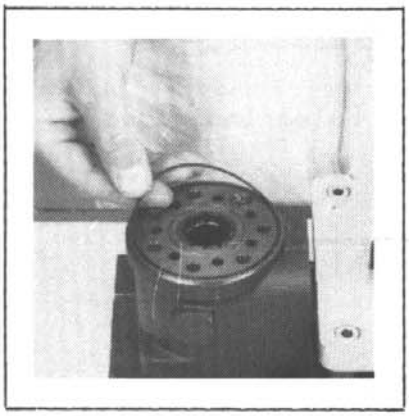
51 Place a ball in the two holes indicated by the arrows.



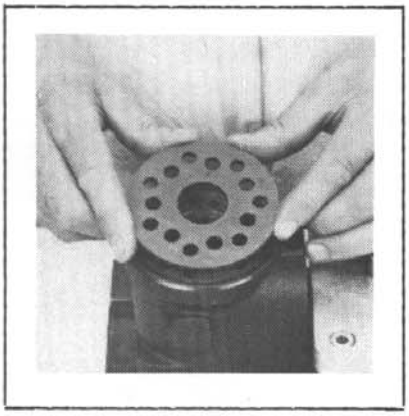
52 Place a pin in the same two holes.



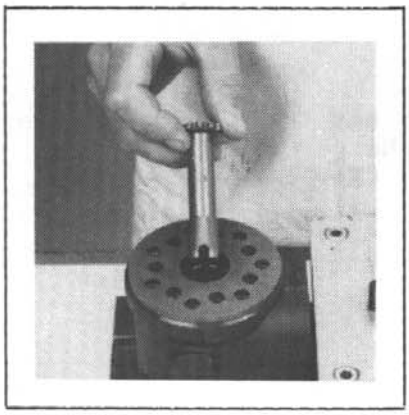
53 In some cases a spring has to be fitted (see page 30, pos. 28) on the pin before it is placed in the housing. (See OSPC spare parts list, HN.21.L1.52).



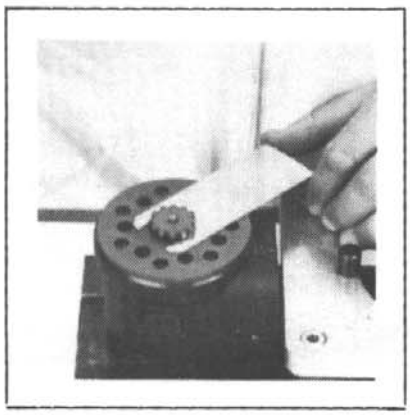
54 Grease the o-ring with mineral oil approx. viscosity 500 cSt at 20°C.



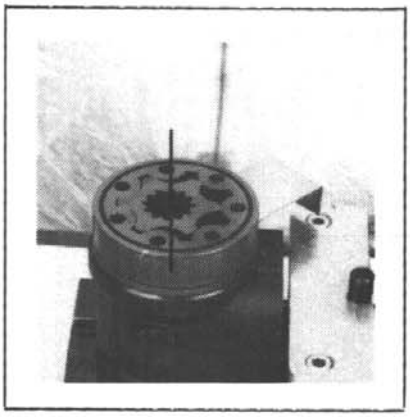
55 Place the distributor plate so that the channel holes match the holes in the housing.



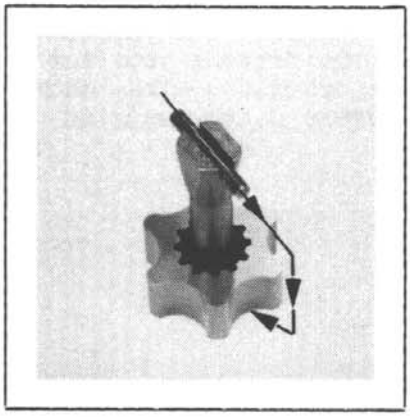
56 Guide the cardan shaft down into the bore so that the slot is parallel with the connection flange.



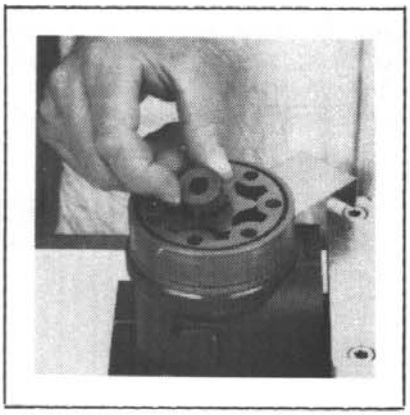
57 Place the cardan shaft as shown - so that it is held in position by the mounting fork.



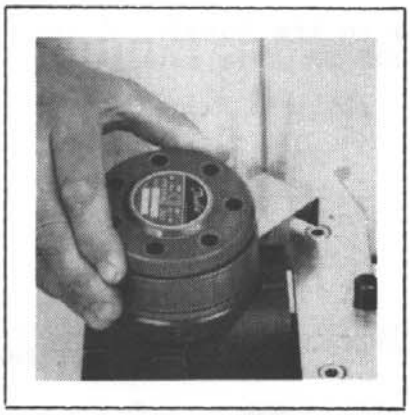
58 Grease the two o-rings with mineral oil approx. viscosity 500 cSt at 20°C and place them in the two grooves in the gear rim. Fit the gearwheel and rim on the cardan shaft.



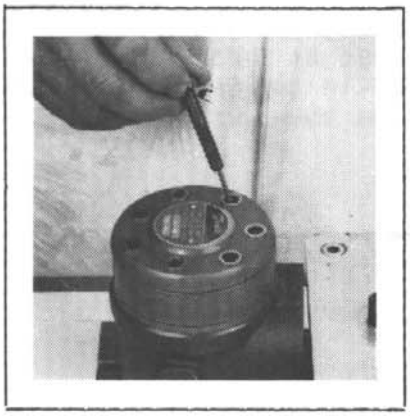
59 Important: Fit the gearwheel (rotor) and cardan shaft so that a tooth base in the rotor is positioned in relation to the shaft slot as shown. Turn the gear rim so that the seven through holes match the holes in the housing



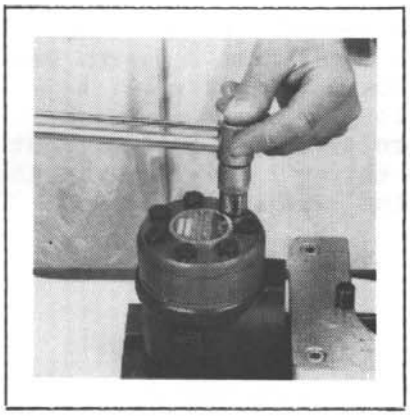
60 Fit the spacer, if any.



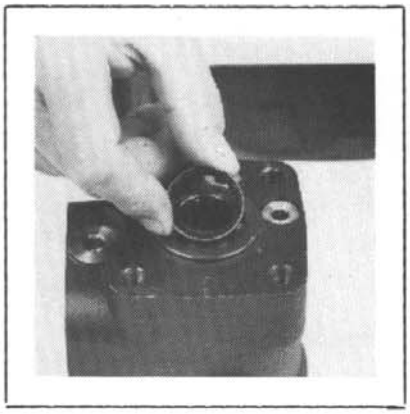
61 Place the end cover in position.



62 Fit the rolled pin with washers and place it in the hole shown.

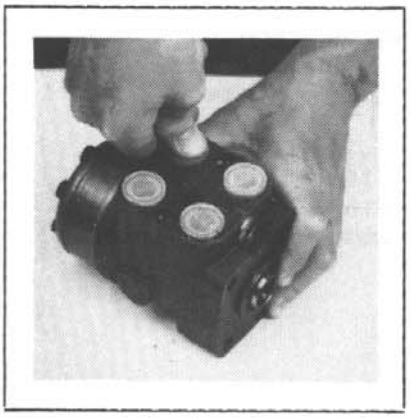


63 Fit the six screws with washers and insert them. Cross-tighten all the screws and the rolled pin with a torque of 3.0 +/-0.6 daNm. The OSPB, OSPB LS and OSPBX LS can now be function tested.



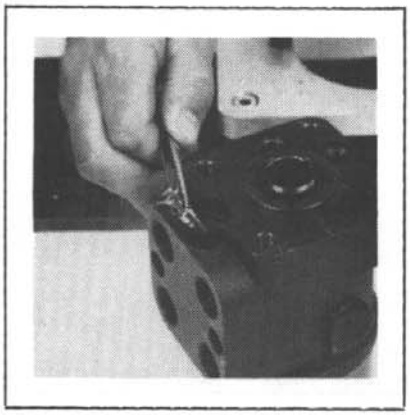
64 Place the dust seal ring in the housing. With the OSPC, PSPC LS and OSPC LSR the dust seal ring must be placed only after the pressure relief valve and shock valves have been fitted.

65 Fit the dust seal ring in the housing using special tool SJ 150-9000-22 (see page 3; E) and a plastic hammer.

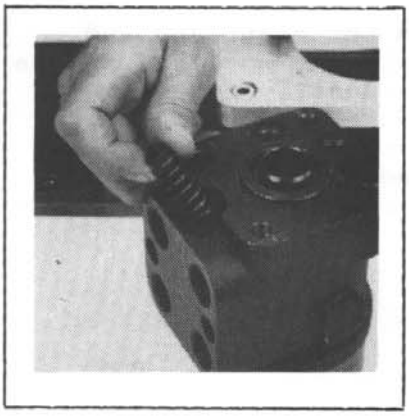


66 Press the plastic plugs into the connection ports. Do not use a hammer!

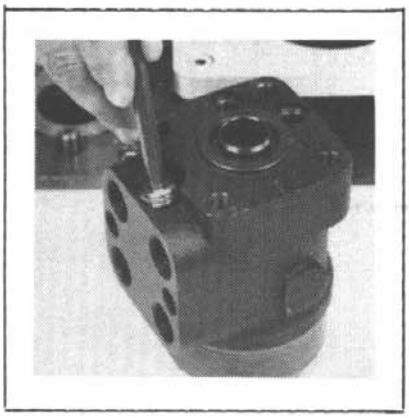
Assembly of the pressure relief valve for OSPC



67 Fit the piston.

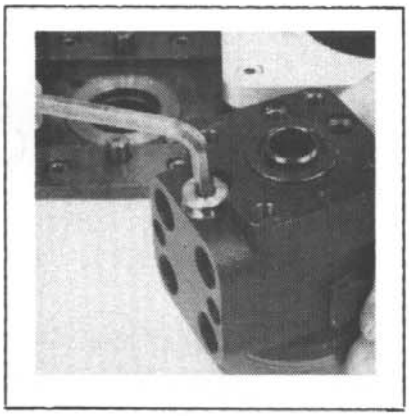


68 Fit the spring.



69 Screw in the setting screw with an 8 mm hexagon socket spanner. Make the pressure setting on a panel or the vehicle.

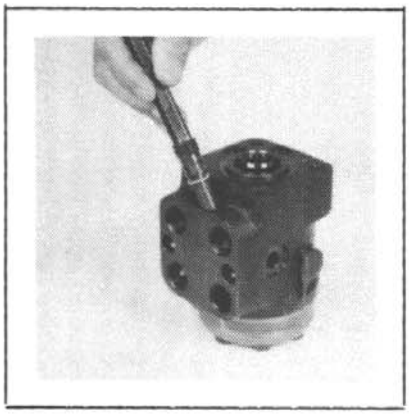
Ø 1.7 spring for 50 - 70 bar.
Ø 1.9 spring for 70 - 105 bar.
Ø 2.1 spring for 110 - 155 bar.
(See OSPC spare parts list HN.21.L1.52).



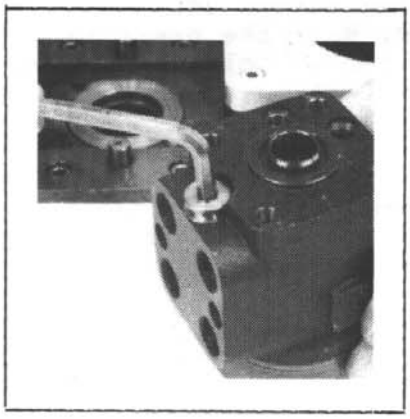
70 Screw plug with dust seal into the housing using an 8 mm hexagon socket spanner.

Tightening torque: 5 +/-1 daNm.

Assembly of the pressure relief valve (cartridge) for OSPC LS/OSPC LSR



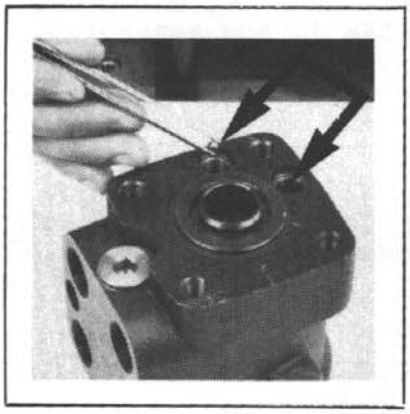
71 Place the seal ring on the cartridge and screw the cartridge into the housing using a 12 mm hexagon socket spanner. Tightening torque: 5 +/-1 daNm. Make the pressure setting on a panel or the vehicle. The cartridge is factory-set at 175 bar. Use a 4 mm hexagon socket spanner. (See OSPC spare parts list HN.21.L1.52 for setting range).



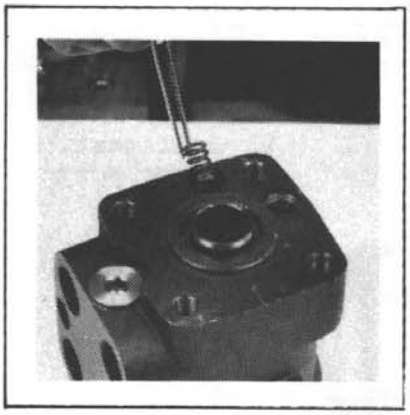
72 Screw plug with seal ring into the housing using an 8 mm Allen key.

Tightening torque: 5 +/-1 daNm.

Assembly of the dual shock valves for OSPC/OSPC LS/OSPC LSR

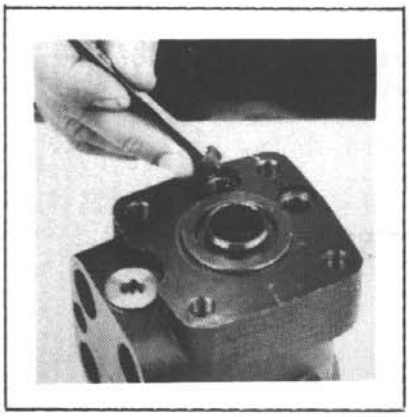


73 Put a ball in the two holes indicated by the arrows.

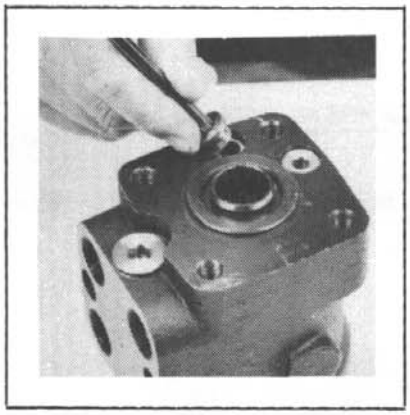


74 Place springs and valve cones over the two balls.

Note: The blue spring applies to setting range 90-180 bar. The untreated spring applies to setting range 190-260 bar. (See OSPC spare parts list HN.21.L1.52).



75 Screw in the two setting screws using a 6 mm hexagon socket spanner. Make the pressure setting on a panel or the vehicle. (See OSPC spare parts list HN.21.L1.52).



76 Screw plug with seal ring into the two shock valves and tighten them with a torque of 3 +/-0 daNm using a 6 mm hexagon socket spanner.

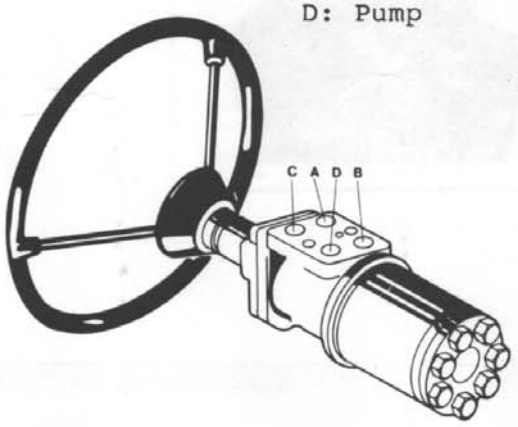
Steering unit type OSPB, OSPB LS, OSPBX LS, OSPC, OSPC LS or OSPC LSR is now assembled.

Max. tightening torque and hydraulic connections

Screwed connection	Max. tightening torque daNm (lbf in)			
	With cutting edge	With copper washer	With aluminium washer	With o-ring
1/4 BSP.F	4 (350)	2 (180)	3 (270)	
M 10 x 1	4 (350)	2 (180)	3 (270)	2 (180)
3/8 BSP.F	6 (530)	2 (180)	5 (440)	
1/2 BSP.F	10 (900)	3 (270)	8 (700)	
3/4 BSP.F	16 (1400)	5 (440)	13 (1150)	
7/16-20 UNF				2 (180)
9/16-18 UNF				5 (440)
3/4-16 UNF				6 (530)
7/16-14 UNF				7 (620)
1 1/16-12 UNF				9 (800)
1 5/8-12 UNF				20 (1750)
M 18 x 1,5	7 (620)	2 (180)	5 (440)	5 (440)
M 22 x 1,5	10 (900)	3 (270)	8 (700)	7 (620)

Mounting screws	Tightening torque daNm (lbf in)
M 10 x 1	6,5 ± 0,5 (580 ± 40)
M 10	3,0 ± 0,5 (270 ± 40)
3/8-16 UNC	3,0 ± 0,5 (270 ± 40)

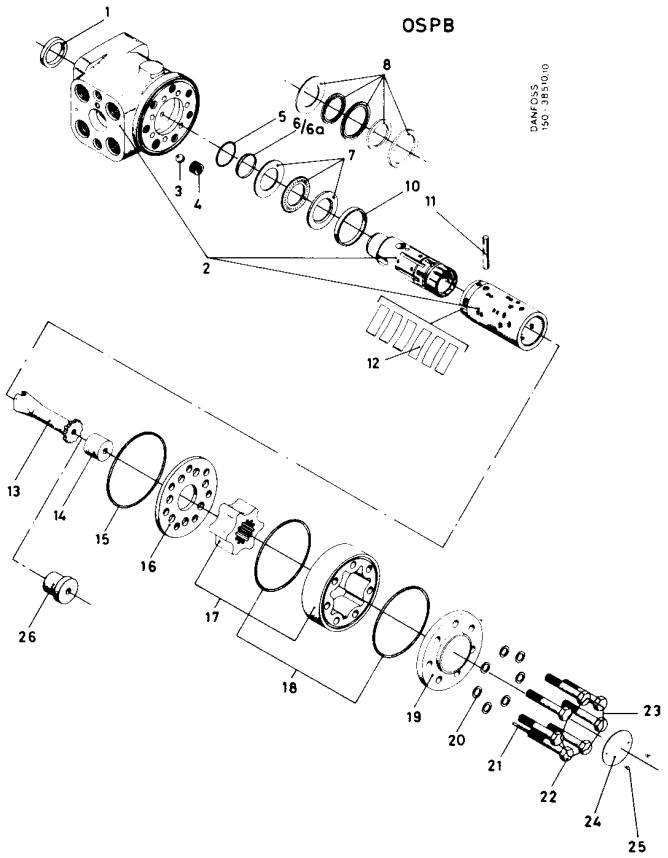
A: Left port
B: Right port
C: Tank
D: Pump



Service Shops

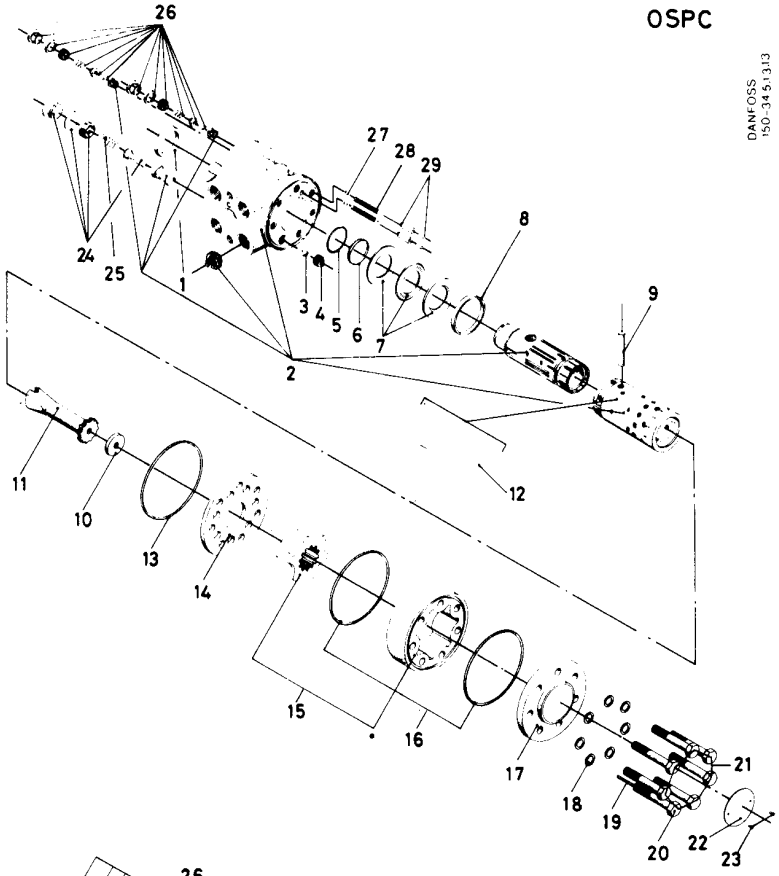
Asean	:	Danfoss Industries Pte. Ltd., Singapore
Australia	:	Russel Armstrong, Melbourne
Austria	:	Hainzl Industriesysteme, G.m.b.H., Linz
Belgium	:	N.V. Danfoss S.A., Bruxelles
Denmark	:	H. Søndergaard A/S, Måløv
Finland	:	OY Danfoss AB, Helsinki
France	:	Danfoss S.A.R.L., Trappes (Paris)
FRG	:	Danfoss Handelsgesellshaft mbH, Offenbach/Main
Great Britain	:	Danfoss Limited, Greenford
Italy	:	Sordella & C. Oleodinamica s.r.l., Torino
Netherlands	:	ITHO B.V., Schiedam
Norway	:	Danfoss Norge, Rud (Oslo)
Spain	:	Danfoss S.A., Madrid
Sweden	:	Transventor Hydraulik AB, Västra Frölunda
U.S.A.	:	Danfoss Inc., Mahwad, New Jersey

Item	Spare Parts
1	Dust seal ring
2	Housing + spool + sleeve
3	Ball ø 8,5 mm
4	Thread bushing
5	O-ring 25, 12x1,78 mm, is used with kin-ring (item 6)
6	Kin-ring
6a	Lip seal
7	Bearing assembly
8	Bearing assembly
10	Ring I/D 39,6x0,7x4,5 mm
11	Cross pin ø6 x 41 mm
12	Neutral position spring
13	Cardan shaft
14	Spacer
15	O-ring ø80,50 x 1,50 mm
16	Distributor plate
17	Gear wheel
18	O-ring ø75,92 x 1,78 mm
19	End cover
20	Washer ø8,2x11,9x1,0 mm
21	Rolled pin
22	Screw w. bore
23	Screw
24	Rating plate
25	Drive screw
26	Spacer

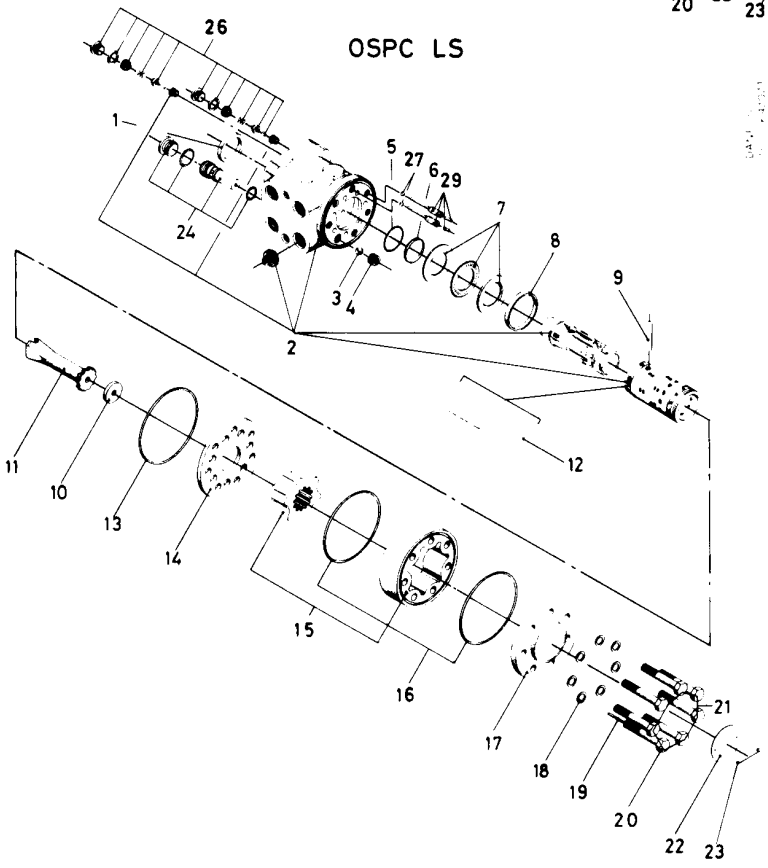


Item	Spare Parts
1	Dust seal ring
2	Housing, spool and sleeve
	Check valve and the seats for relief and dual shock valves are locktited
3	Ball ø8,5 mm
4	Thread bushing
5	O-ring used with kin-ring (item 6)
6	Kin-ring
7	Bearing assembly
8	Ring
9	Cross pin
10	Spacer
11	Cardan shaft
12	Set of springs
13	O-ring
14	Distributor plate
15	Gear wheel set
16	O-ring
17	End cover
18	Washer
19	Rolled pin
20	Screw w. bore
21	Screw
22	Name plate
23	Drive screw
24	Complete relief valve
25	Spring wire ø1,7x36,6 long
26	Complete dual shock valve
27	Ball ø3/16 in
28	Spring
29	Rolled pin

OSPC



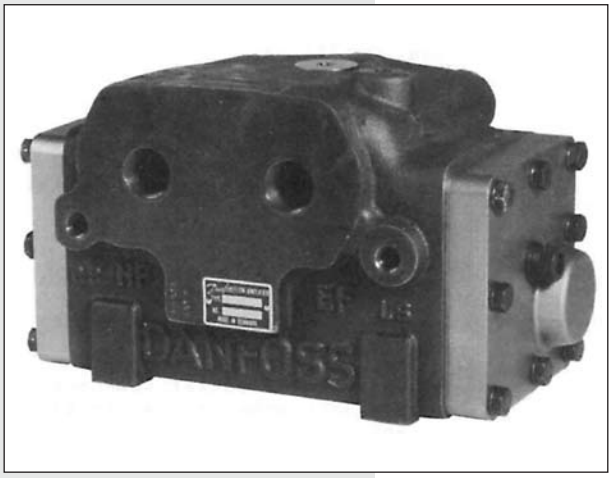
OSPC LS



SAUER DANFOSS

Flow-Amplifier
OSQA / OSQB

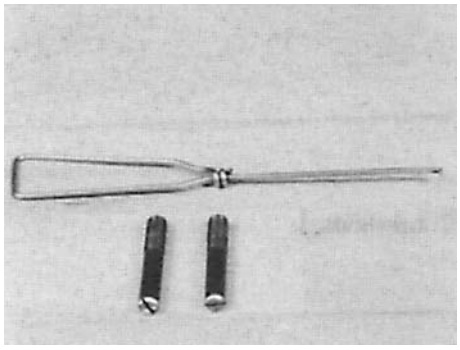
Service Manual



VL 34B

A

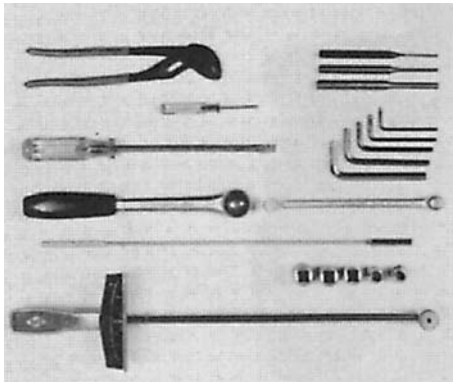
Guide screws	Material :	M8x1
Hook	Material :	Wire



Tools

B

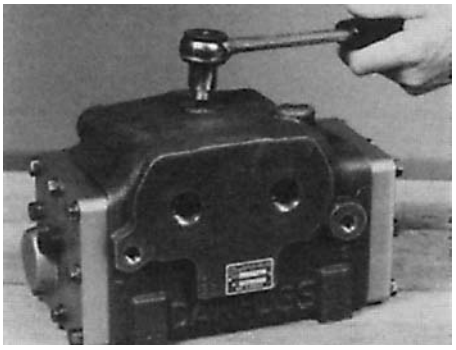
- Hexagon keys 4, 5, 6, 8, and 10 mm
- Ratchet for socket spanners
- Hexagon socket for external hexagon 13, 17, and 19 mm
- Hexagon socket for internal hexagon 8 and 10 mm
- Multigrip pliers
- Ring spanner 13 mm
- Screwdrivers 3 and 10 mm
- Steel mandrels 3, 5 and 8 mm
- Torque wrench for 12 daNm [1060 lbf in]
- Magnetic rod



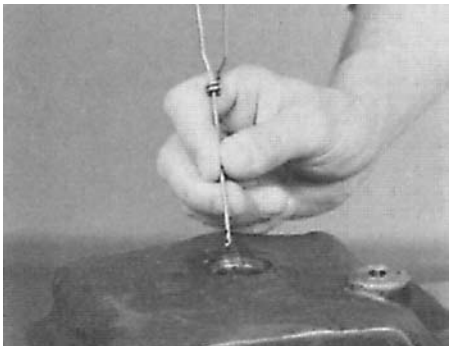
Tools mentioned in A and B cannot be bought from Sauer-Danfoss.

Dismantling Counter Pressure Valve

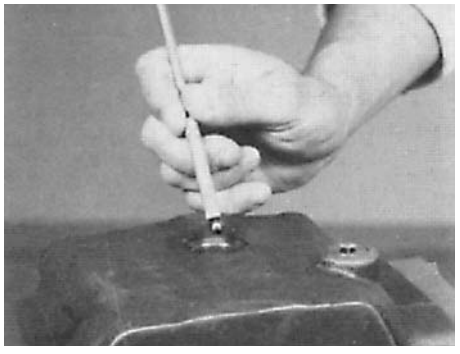
1 Unscrew plug with O-ring (hexgon socket for 8 mm internl hexagon).



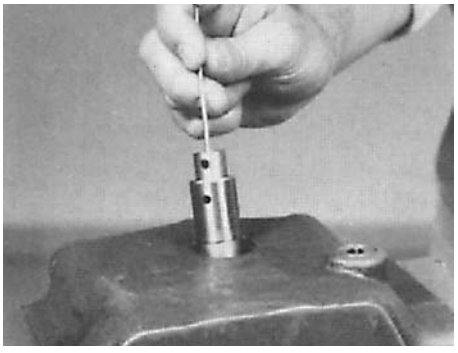
2 Take out small spring (hook).



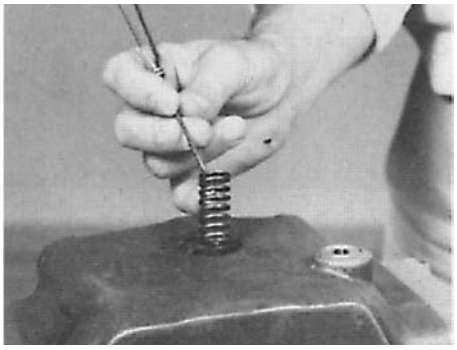
3 Take out ball (magnetic rod).



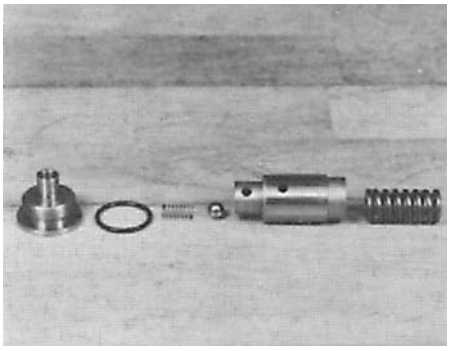
4 Take out piston.



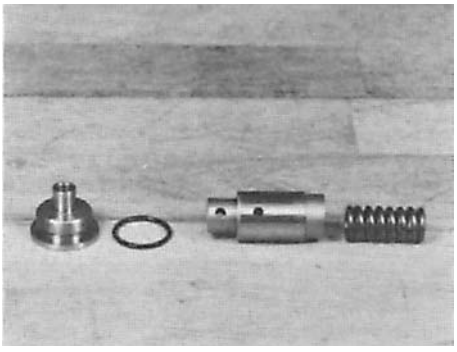
5 Take out spring.



6 Counter pressure valve shown dismantled.

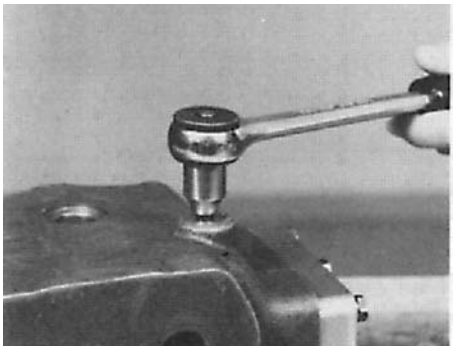


7 Counter pressure valve with orifice shown dismantled.

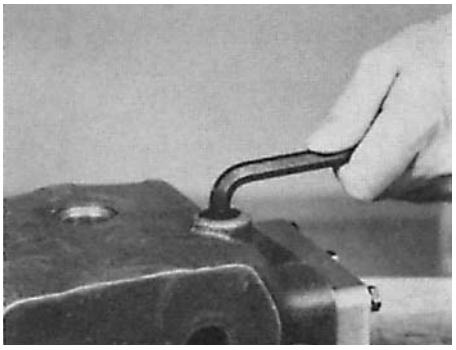


Removing Pressure Relief Valve

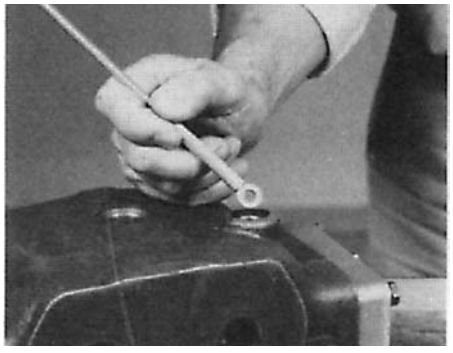
8 Unscrew plug with washer (hexagon socket for 8 mm internal hexagon).



9 Unscrew pressure relief valve (10 mm hexagon key).

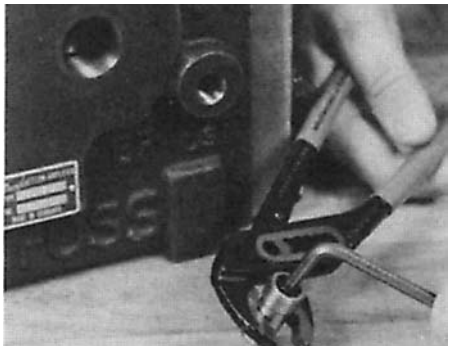


10 Take out washer (magnetic rod).

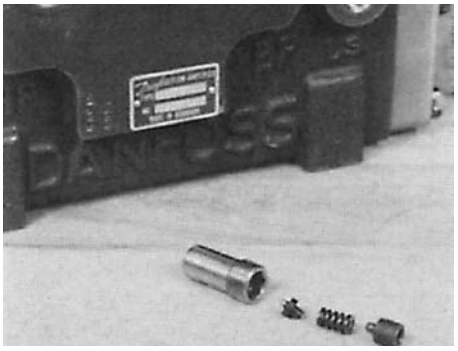


Dismantling Pressure Relief Valve

11 Hold cartridge (multigrip pliers) and unscrew the adjustment screw (5 mm hexagon key).

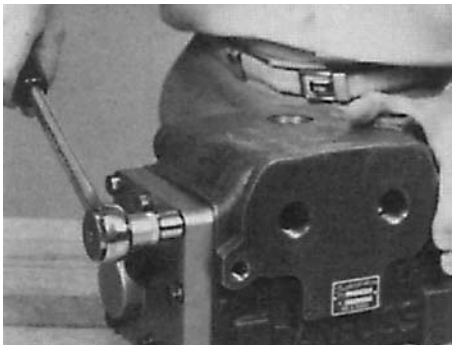


12 Pressure relief valve shown dismantled.

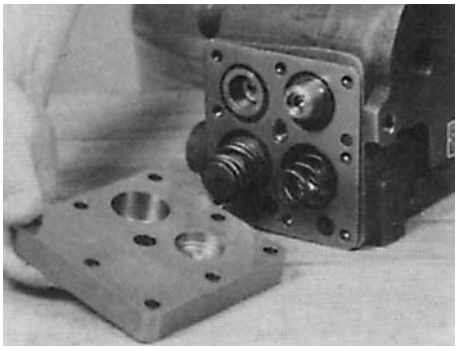


Removing End Cover at PP-Connection

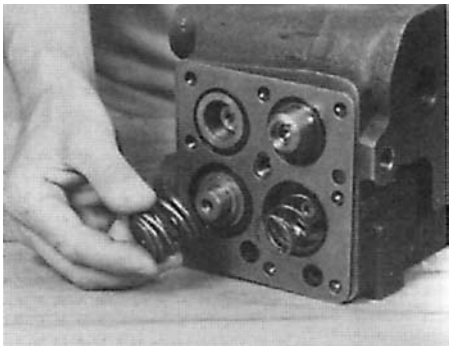
13 Unscrew screw with spring washer using hexagon socket for 13 mm external hexagon and 10 mm internal hexagon.



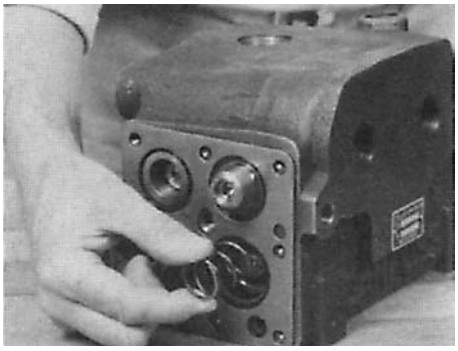
14 Remove end cover.



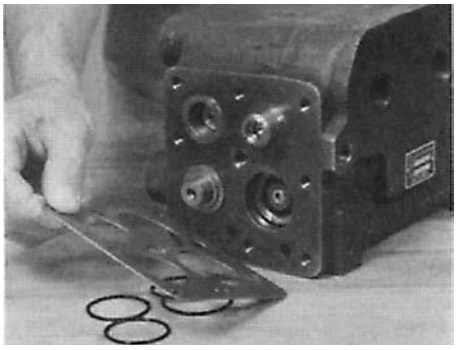
15 Remove stop and 2 springs.



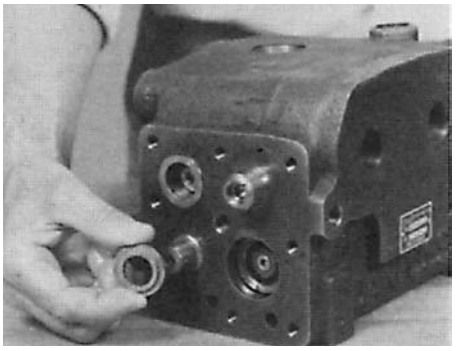
16 Remove spring.



17 Remove plate and 6 O-rings.

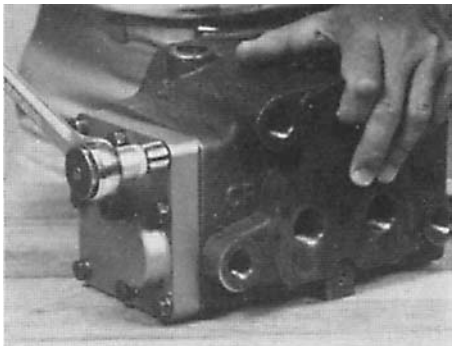


18 Remove spring guide.

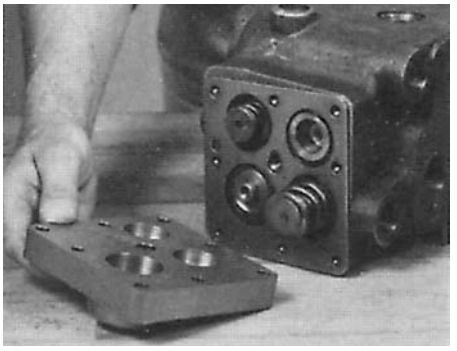


Removing End Cover at LS-Connection

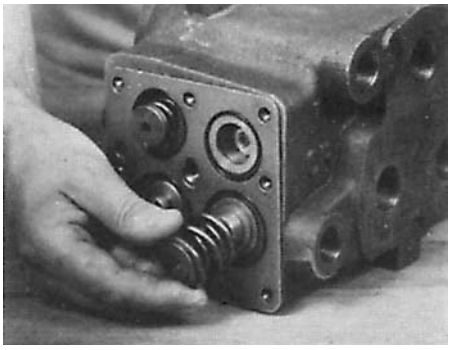
19 Unscrew screws with spring washer using hexagon socket for 13 mm external hexagon and 10 mm internal hexagon.



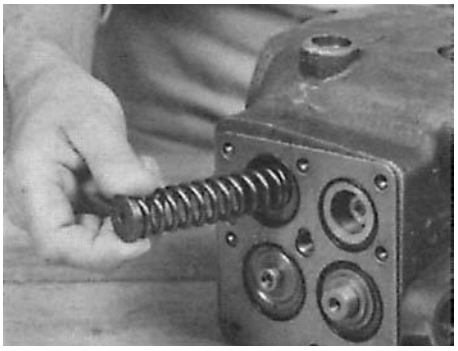
20 Remove end cover.



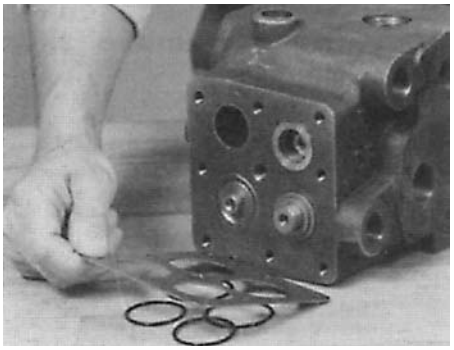
21 Remove stop and 2 springs.



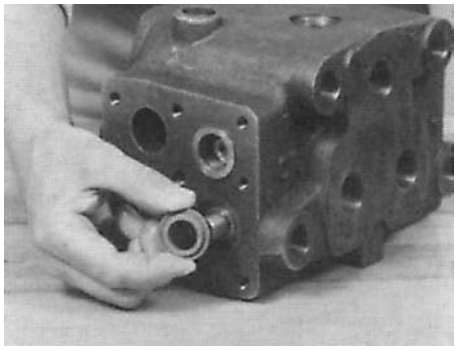
22 Remove stop and spring.



23 Remove plate and 4 O-rings.

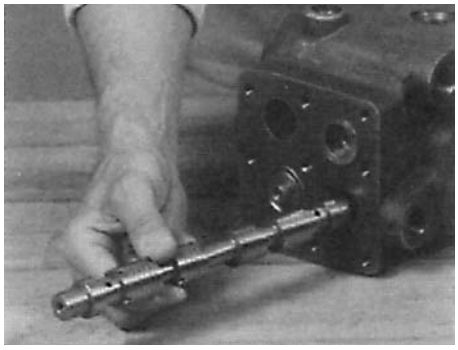


24 Remove spring guide.

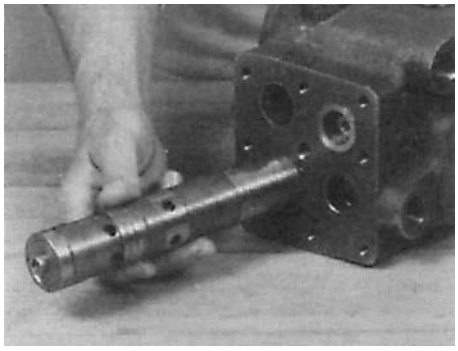


Removing Spools

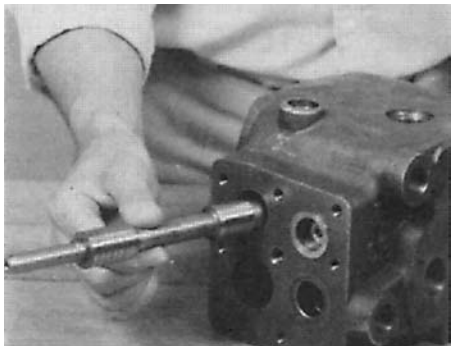
25 Remove directional spool.



26 Remove amplifier spool.

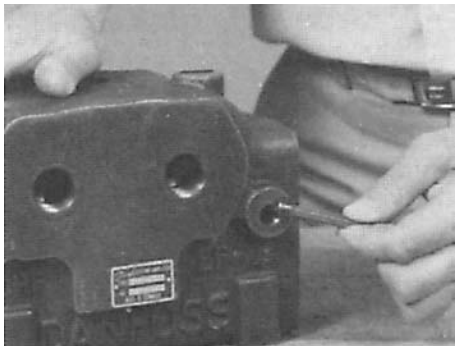


27 Remove priority valve spool.

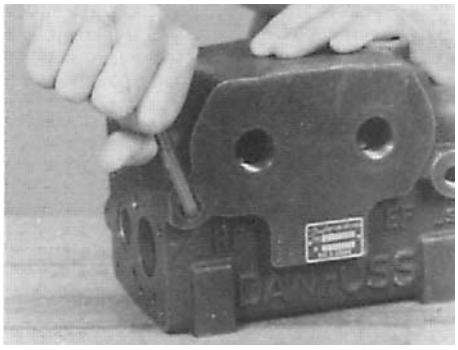


Removing Orifices and Throttle Check Valve

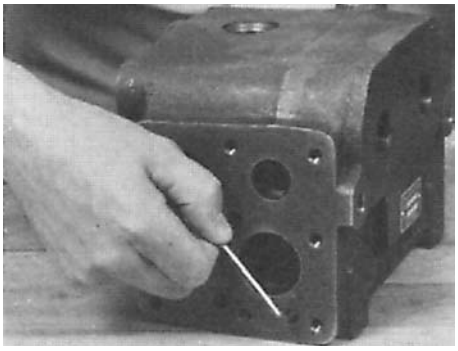
28 Unscrew orifice in LS-connection with 6 mm hexagon key.



29 Unscrew throttle check valve in PP-connection with 6 mm hexagon key.

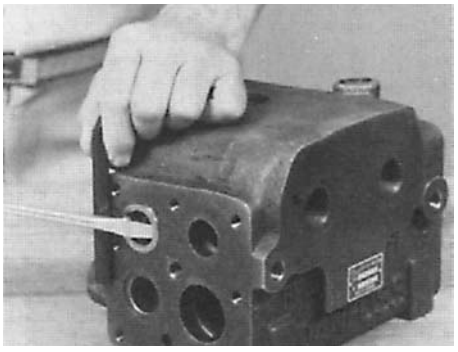


30 Unscrew orifice in housing with 4 mm hexagon key.



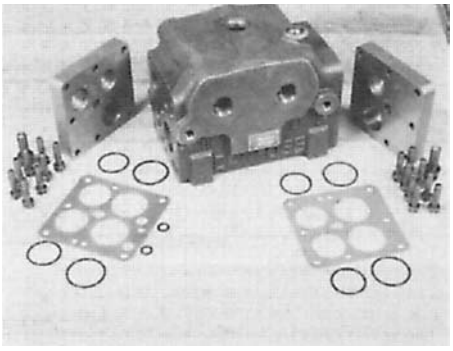
Removing Shock Valves

31 Remove shock valve with screwdriver and hexagon key.

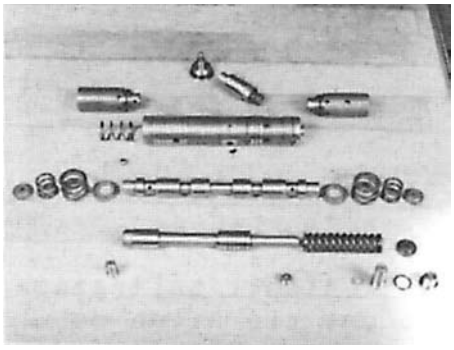


Overview of Dismantled Parts

32 Housing and end cover with accessories.

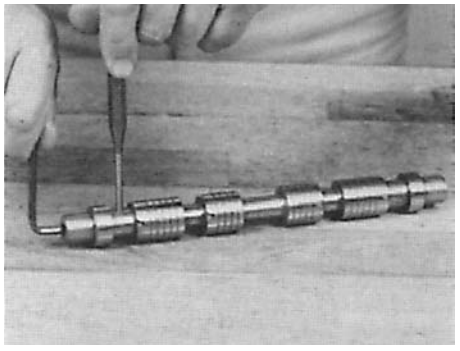


33 Spool with accessories.

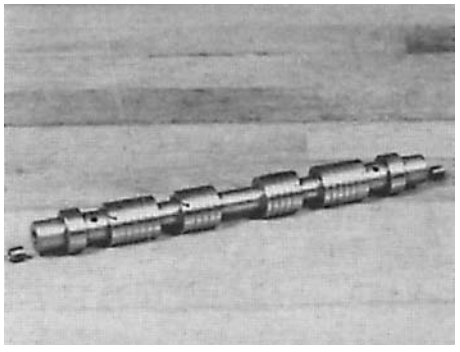


Dismantling of Directional Spool

34 Unscrew orifice with 4 mm hexagon key. Use a mandrel.

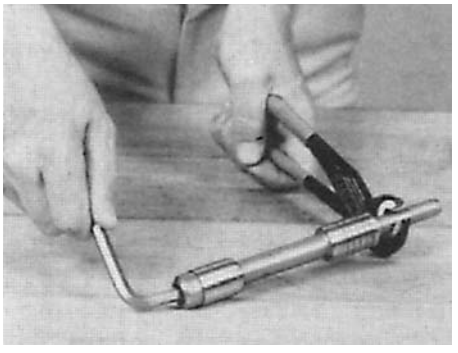


35 Directional spool shown dismantled.

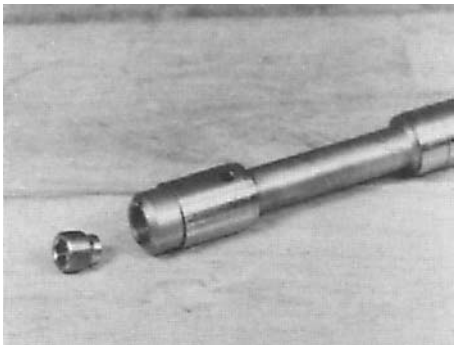


Dismantling of Priority Valve Spool

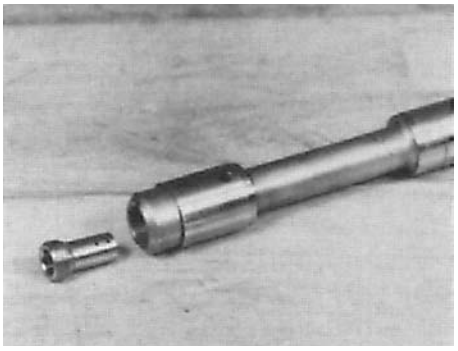
36 Unscrew plug or throttle check valve with 8 mm hexagon key.



37 Priority valve spool with plug for external PP shown dismantled.



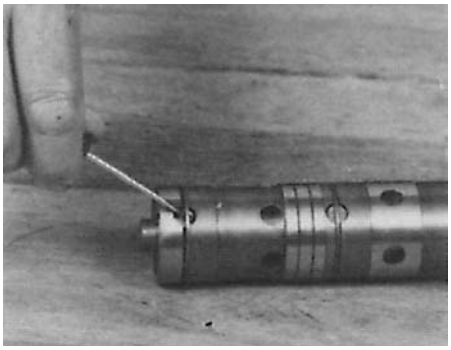
38 Priority valve spool with throttle check valve for internal PP shown dismantled.



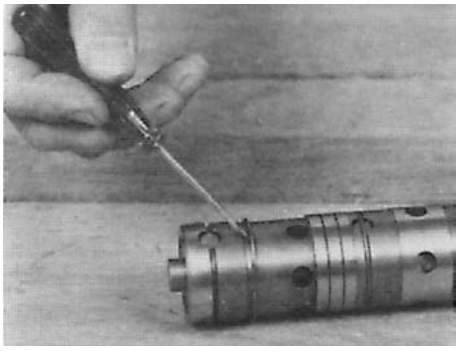
Dismantling of Amplifier Spool

39 Carefully remove the spring ring from the recess with 3 mm screwdriver.

Note: Avoid damage to the spring ring.

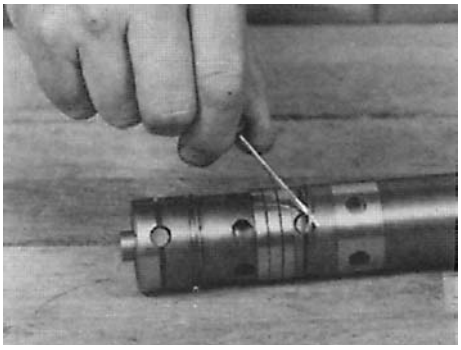


40 Carefully guide the spring ring back.

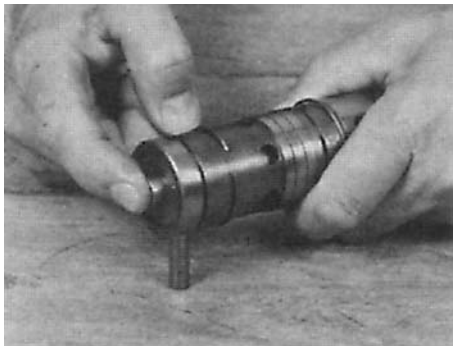


41 Carefully take the spring ring from the recess and guide it back with 3 mm screwdriver.

Note: Avoid damage to the spring ring.

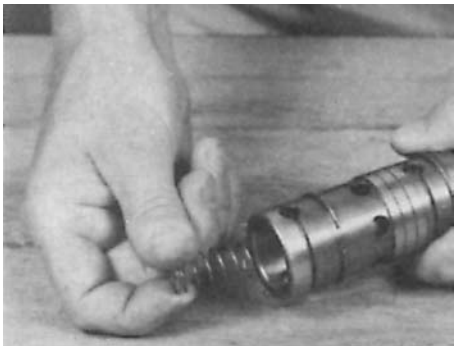


42 Press pin out gently with finger.



43 Take out plug.

44 Take out spring.

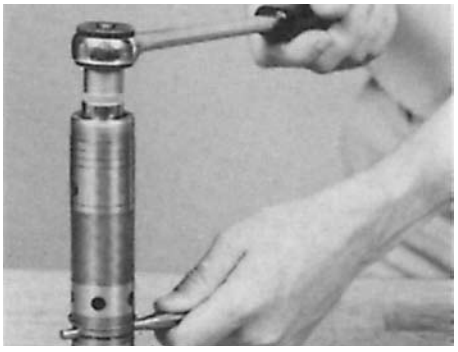


45 Take out pin with 3 mm screwdriver.

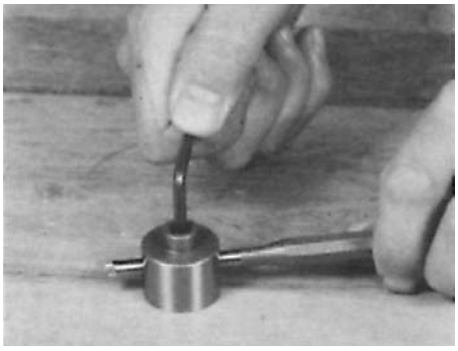
46 Take out inner spool.

47 Unscrew check valve with hexagon socket for 17 mm external hexagon and mandrel in the pin hole.

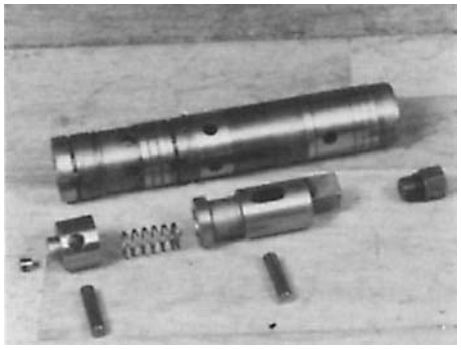
Note: Avoid damaging the spool surface.



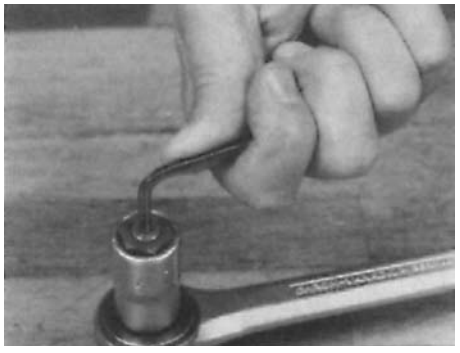
48 Unscrew orifice out of plug with 4 mm hexagon key. Use a mandrel.



49 Amplifier spool shown dismantled.

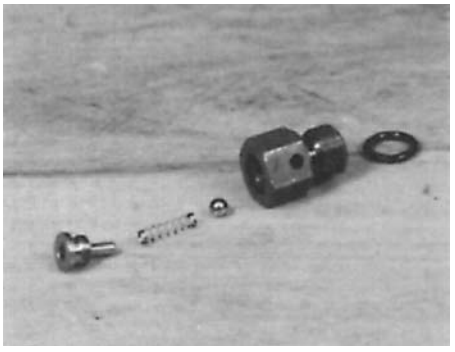


50 Unscrew plug with 4 mm hexagon key and hexagon socket for 17 mm external hexagon.



Dismantling of Check Valve

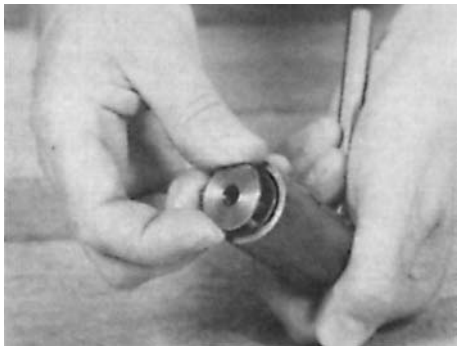
51 Check valve shown dismantled.



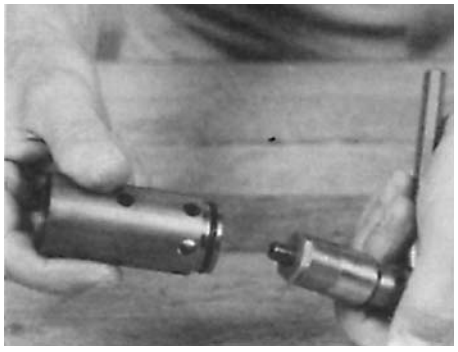
Dismantling of Shock Valve/Suction Valve

52 Unscrew locknut with hexagon socket for 13 mm external hexagon. Use a mandrel.

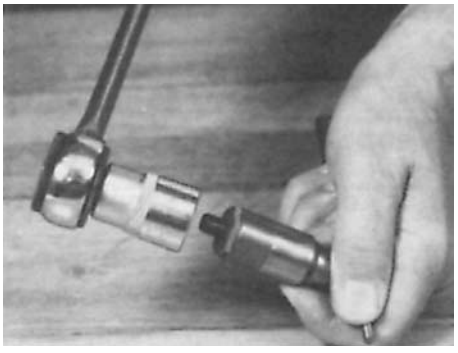
53 Take out disc and spring.



54 Take off housing.

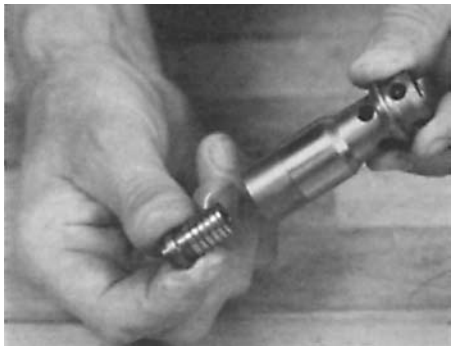


55 Unscrew pilot valve with hexagon socket for 19 mm external hexagon. Use a mandrel.

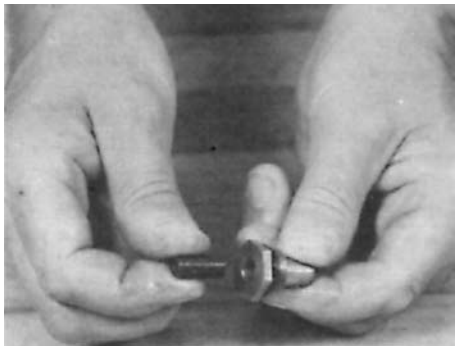


56 Take out pilot valve and spring.

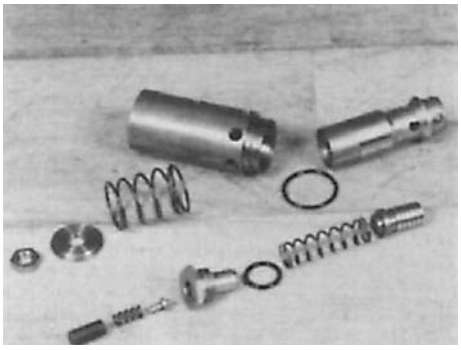
57 Take out spool.



58 Unscrew adjustment screw and take out spring and ball.



59 Shock valve/suction valve shown dismantled.



Cleaning

Clean all parts carefully with low aromatic kerosene.

Inspection and Replacement

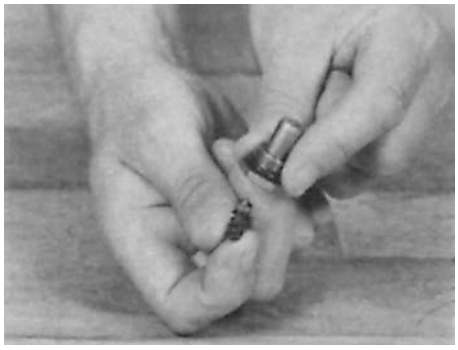
Replace all gaskets and sealing washers. Check all other parts carefully and replace if necessary.

Lubrication

Before assembly, lubricate all parts with hydraulic oil.

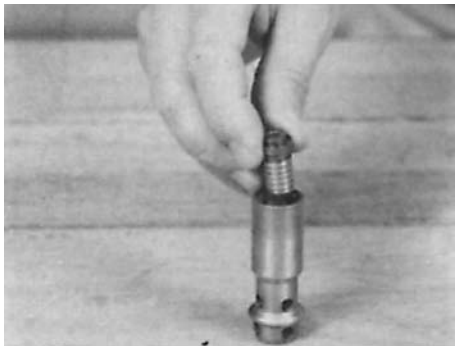
Assembly of Shock Valve/ Suction Valve

60 Guide spring with cone into housing.

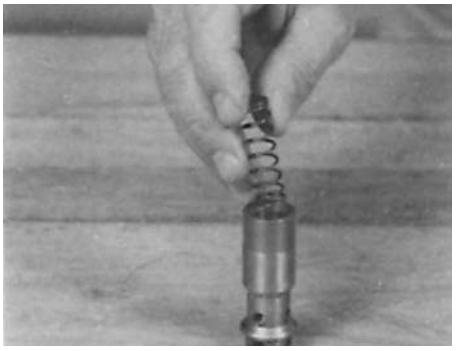


61 Fit adjustment screw.

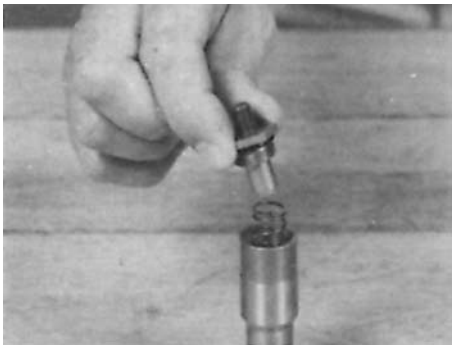
62 Fit spool.



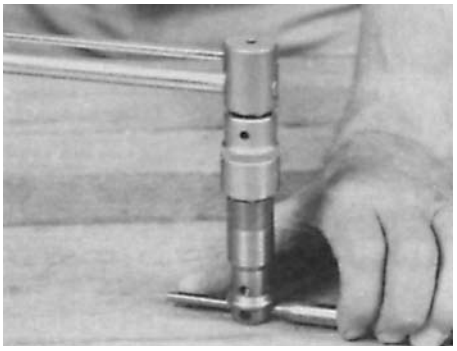
63 Fit spring.



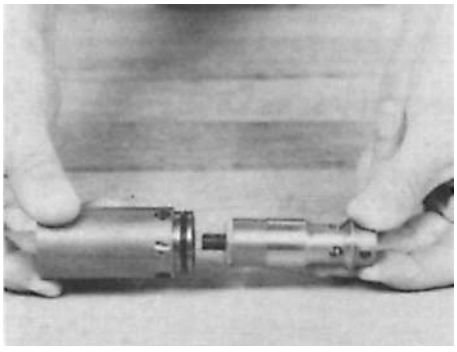
64 Fit pilot valve. Remember O-ring.



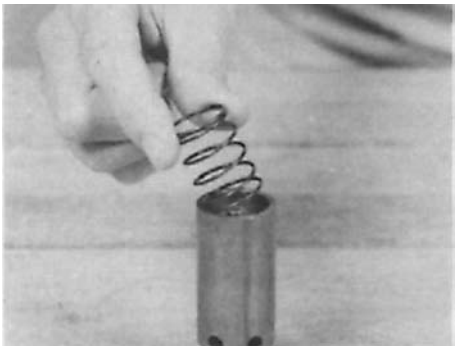
65 Tighten with torque wrench for 19 mm external hexagon. Use a mandrel. Tightening torque: 2 ± 0.5 daNm. [175 ± 45 lfb in].



66 Fit housing.

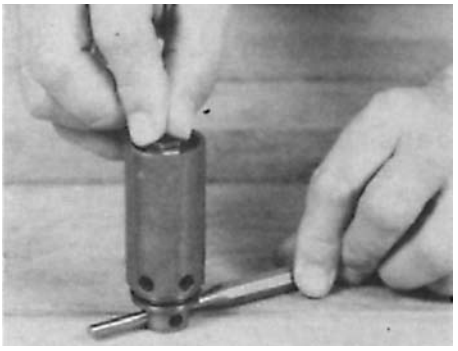


67 Fit spring.



68 Fit disc.

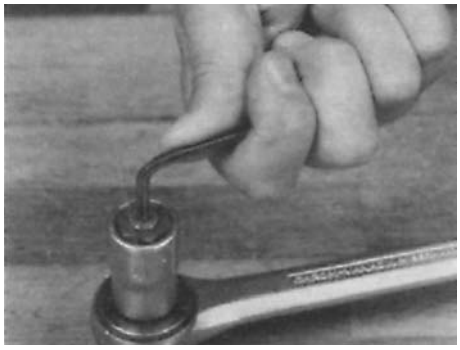
69 Fit locknut.
Tightening torque 1.5 ± 0.2 daNm
[135 ± 29 lbf in].



Contact Sauer-Danfoss Service Shop for adjustment

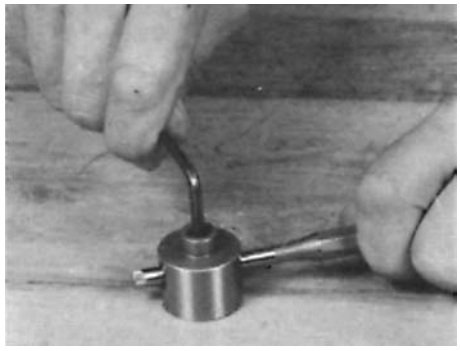
Assembly of Check Valve

70 Fit ball, spring and plug. Tightening torque: 0.5 ± 0.1 daNm. [45 ± 10 lbf in].



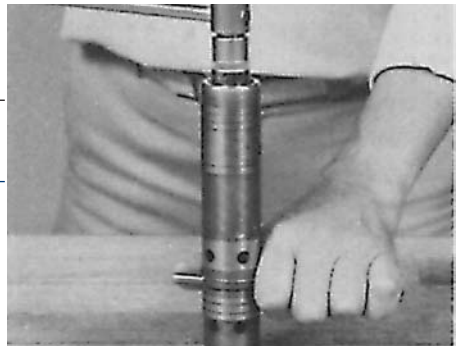
Assembly of Amplifier Spool

71 Fit orifice in plug. Tightening torque: 0.5 ± 0.1 daNm. [45 ± 90 lbf in].



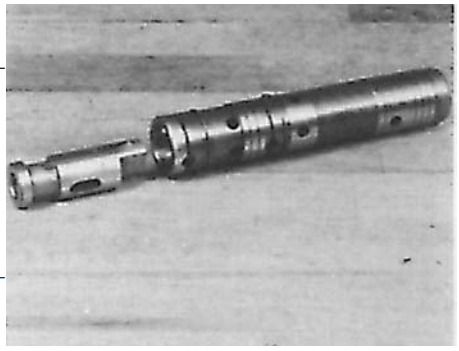
72 Fit check valve. Tightening torque: 2 ± 0.3 daNm. [175 ± 25 lbf in].

Note: Avoid damaging spool surface. Remember O-ring.



73 Place inner spool in the correct position.

Note: When assembling OSQA 5 and OSQB 5 there are two ways of placing the inner spool, only one is correct. The pilot channel witch is faced upwards must be lined up with one of the 5 amplification holes in the outer spool.



74 Guide inner spool in.

75 Fit pin.

76 Push spring ring into position.
Place spring ring into the recess with end facing away from pin holes.

77 Fit spring.

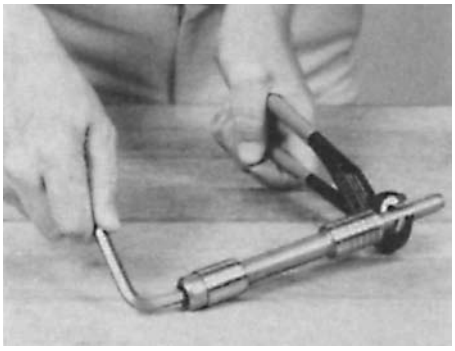
78 Fit plug.

79 Fit pin.

80 Push spring ring into position. Place spring ring into the recess with ends facing away from pin holes.

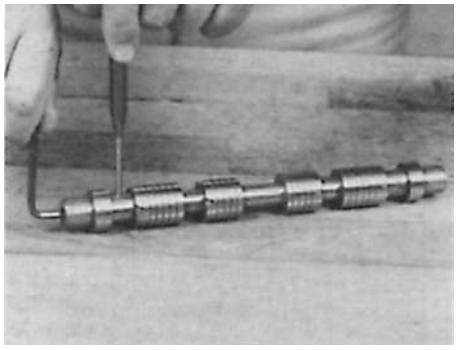
Assembly of Priority Valve Spool

81 Fit prop or throttle check valve. External pp: plug. Internal pp: throttle check valve. Tightening torque: 1 ± 0.3 daNm. [90 ± 25 lbf in].



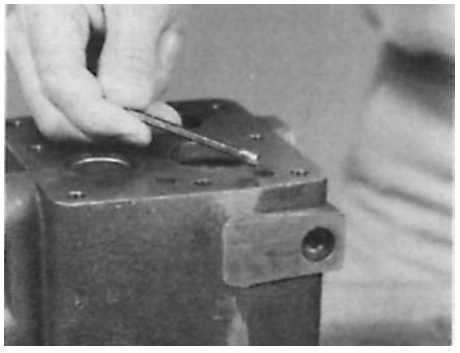
Assembly of Directional Spool

82 Screw in orifice. Tightening torque: 0.5 ± 0.1 daNm [45 ± 10 lbf in].

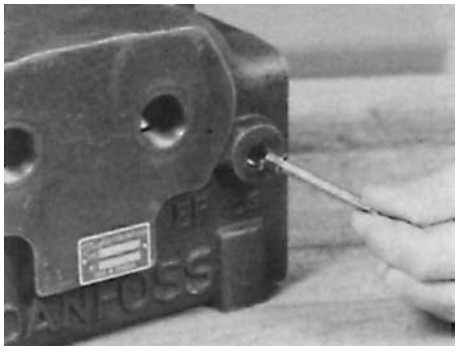


Installation of Orifice and Throttle Check Valve

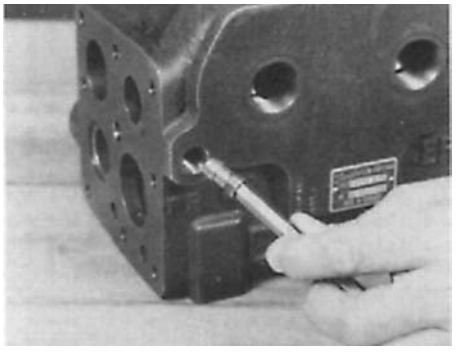
83 Fit orifice in housing. Tightening torque: 0.5 ± 0.1 daNm. [45 ± 10 lbf in].



84 Fit orifice in LS-connection. Tightening torque: 1 ± 0.3 daNm. [90 ± 25 lbf in].



85 Fit throttle check valve in PP-connection. Tightening torque: 1 ± 0.3 daNm. [90 ± 25 lbf in].



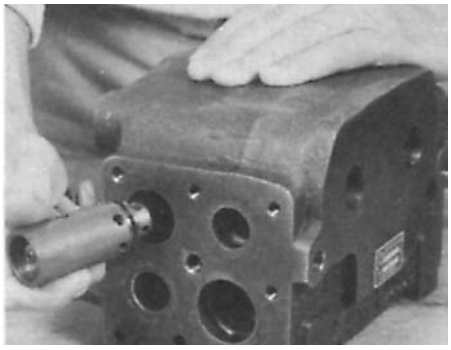
Comments on Flow Amplifiers with Internal PP:

1 ¼ BSP.F in PP-connection. Fit washer and plug. Tightening torque 4 ± 0.3 daNm [355 ± 25 lbf in].

2 7/16 – 20 UNF in PP-connection: fit O-ring and plug. Tightening torque: 1.5 ± 0.5 daNm [135 ± 45 lbf in].

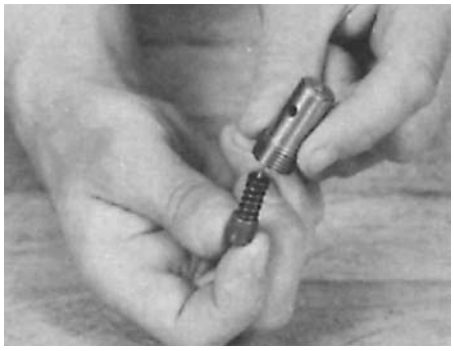
Installation of Shock Valves

86 Guide shock valve in and secure it by hand. Remember O-ring.

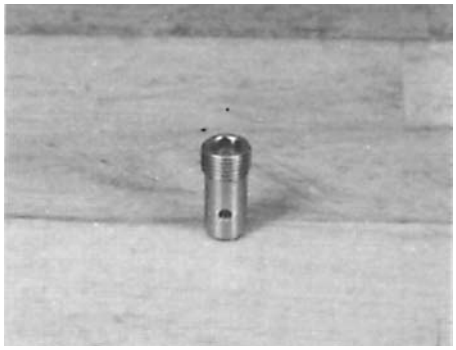


Assembly of Pressure Relief Valve

87 Guide adjustment screw, spring and cone up into the cartridge.



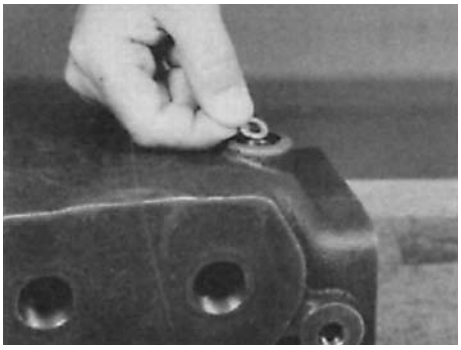
88 Screw the adjustment screw so far in that the 10 mm hexagon fully engages.



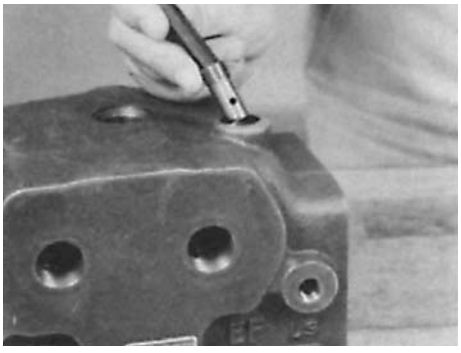
Contact Sauer-Danfoss service shop for adjustments.

Installation of Pressure Relief Valve

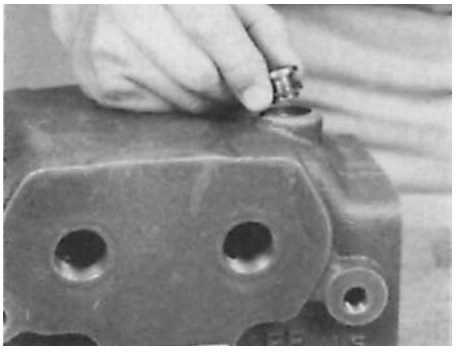
89 Let the washer drop into the hole.



90 Fit pressure relief valve. Tightening torque: 3 ± 0.3 daNm. [265 ± 25 lbf in].

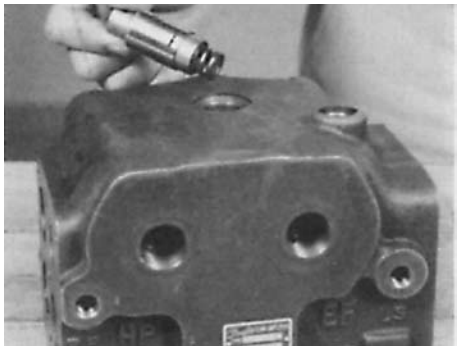


91 Fit plug washer. Tightening torque: 6 ± 0.5 daNm. [530 ± 45 lbf in].

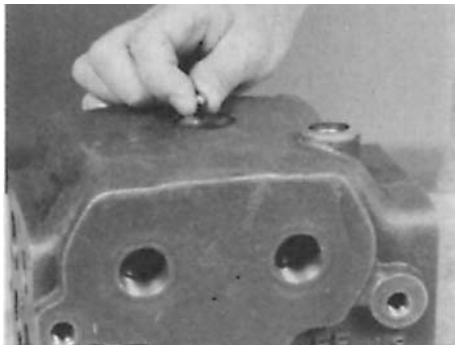


Installation of Back Pressure Valve

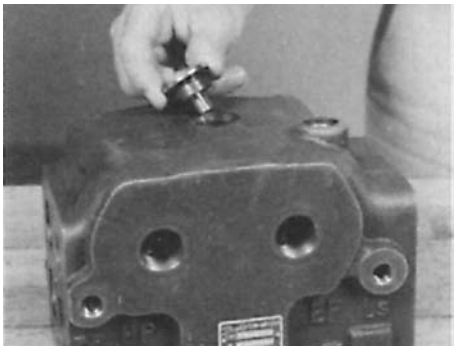
92 First fit spring in position with vaseline. Fit assembled piston and spring.



93 Let the ball drop down.



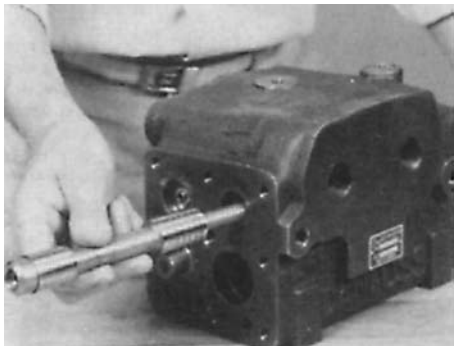
94 Fit spring in plug with vaseline.
Fit assembled plug and spring.
Remember O-ring. Tightening torque:
2.5 ± 0.3 daNm. [220 ± 25 lbf in].



Installation of Spools

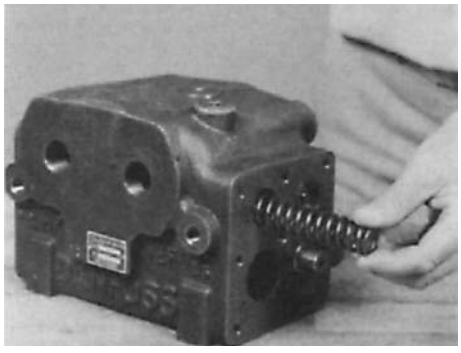
95 Fit directional spool. Fit priority valve spool.

Note: Spring control must be placed in correct position against LS-connection.

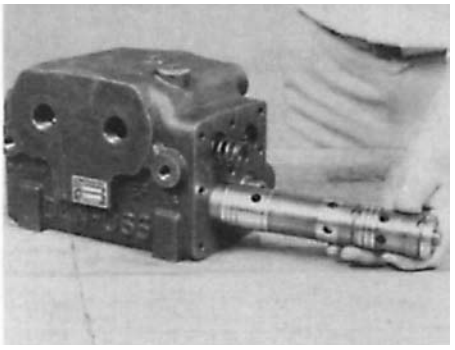


96 Fit spring.

Note:Spring must be by the LS-connection



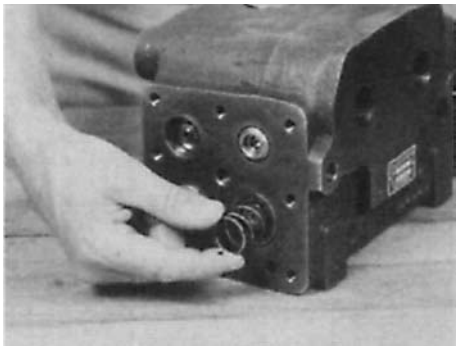
97 Fit amplifier spool. Note: the orifice must be placed in correct position against LS-connection.



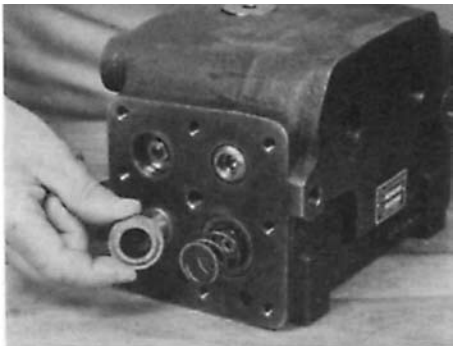
Installation of End Cover at PP-Connection

98 Fit spring with vaseline on amplifier spool.

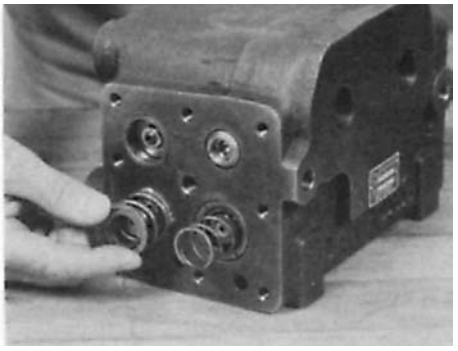
Note: The spring must be fitted at the PP-connection.



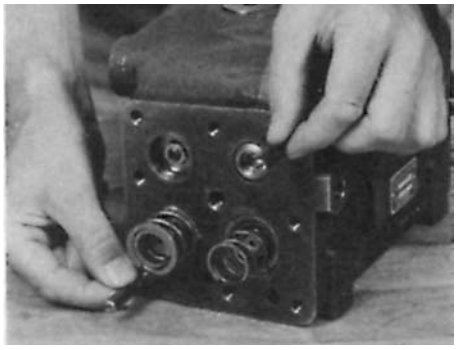
99 Fit spring guide with vaseline.



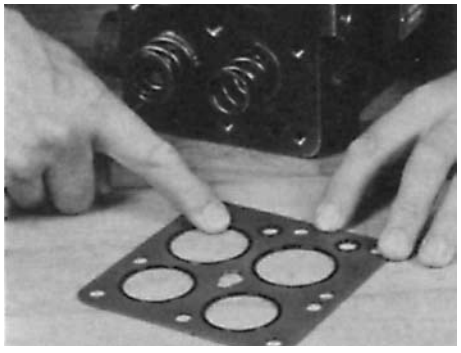
100 Fit large and small springs with vaseline.



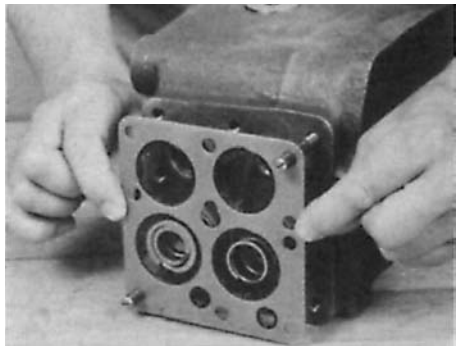
101 Fit guide screws.



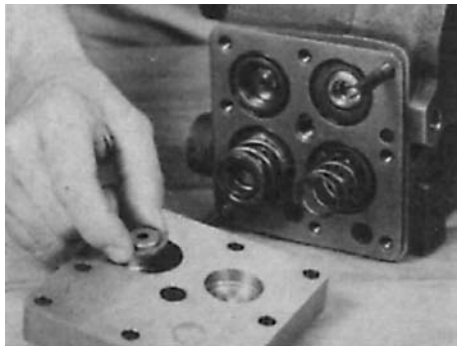
102 Fit 4 large and 2 small O-rings.



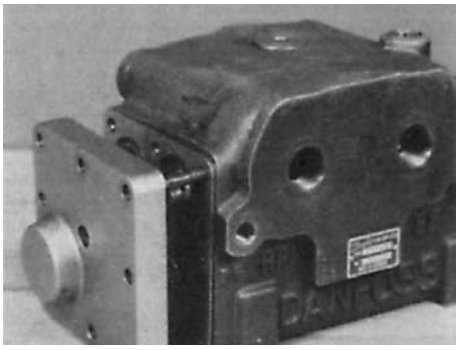
103 Guide plate in.



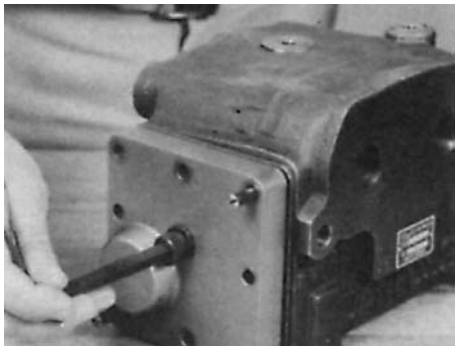
104 Fit stop (thickness: 5mm) in end cover with vaseline.



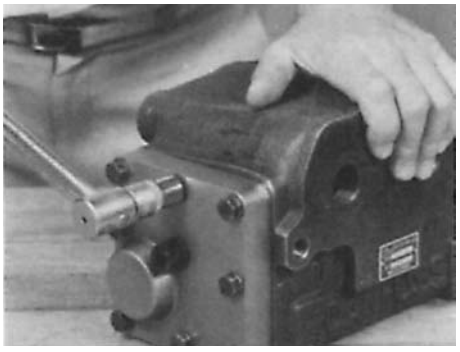
105 Guide end cover in.



106 Fit screw with spring washer.

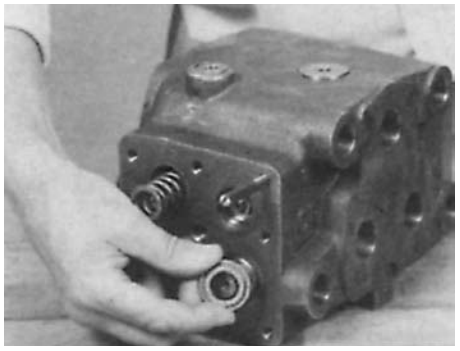


107 Fit screw with spring washer.
Tightening torque: 2.5 + 0.5 daNm.
[220 + 45 lbf in].
Tightening torque for large screws:
8 ± 1 daNm. [710 ± 90 lbf in].

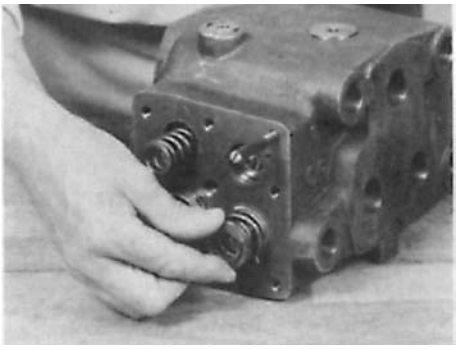


Installation of End Cover at LS-Connection

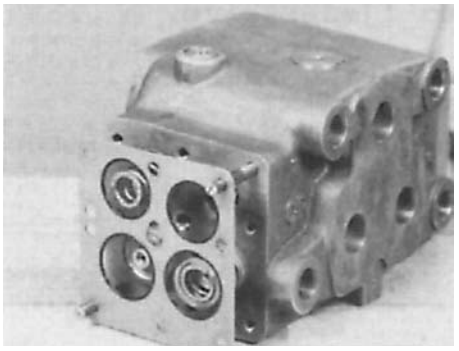
108 Fit guide screws.
Fit remote control with vaseline.



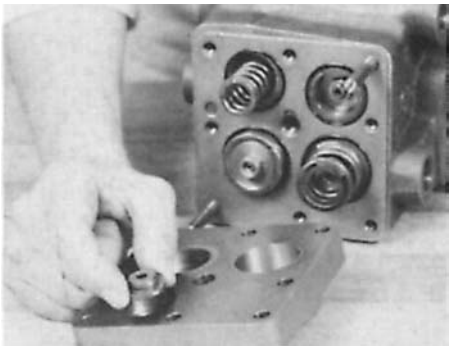
109 Fit large and small springs with vaseline.



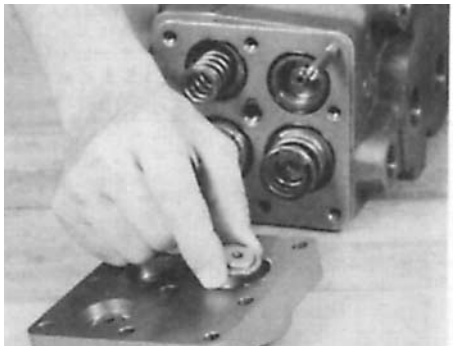
110 Guide in plate with 4 O-rings.



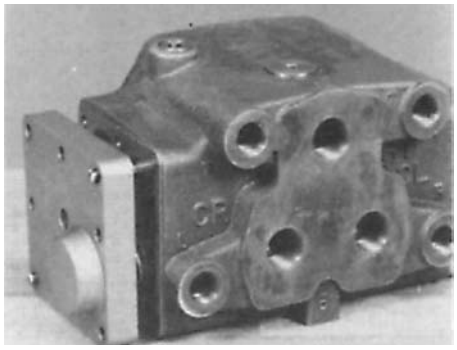
111 Fit stop for priority valve spool (thickness: 8mm) with vaseline.



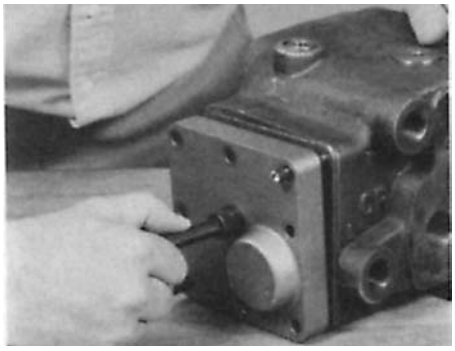
112 Fit stop for directional spool (thickness: 5 mm) with vaseline.



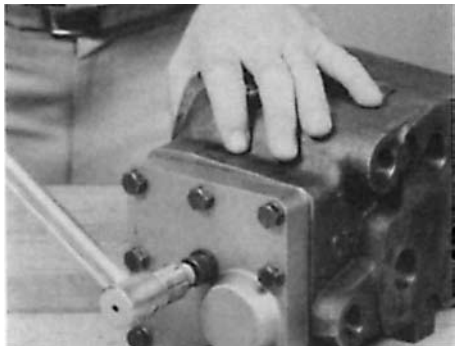
113 Guide in end cover.



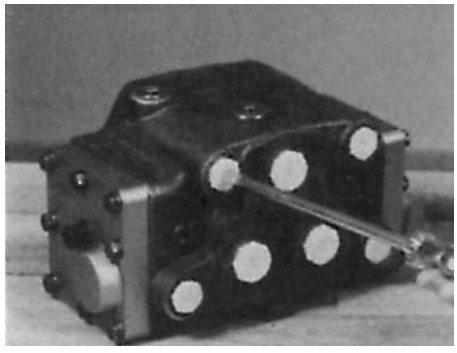
114 Fit large screw with spring washer.



115 Fit screw with spring washers.
Tightening torque: 2.5 + 0.5 daNm.
[220 ± 45 lbf in].
Tightening torque for large screw:
8 ± 1 daNm. [710 ± 90 lbf in].



116 Fit plastic plugs.



OSQA/OSQB is now assembled and ready for installation.

Spare Parts

Spare Parts		Code no
Set of seals		
Complete (NBR)		150F0278
End covers only (Viton)		11020933
Relief valve kit		
After oct 2004		11011038
Shock and suction valve complete		
Setting pressure		
Bar	psi	
140-160	2030-2320	150F0281
165-185	2395-2685	150F0282
200-220	2900-3190	150F0286
215-235	3120-3410	150F0283
230-250	3335-3625	150F0284
270-290	3915-4205	150F0285

For other parts please contact Sauer-Danfoss Technical Support Team.

Notes

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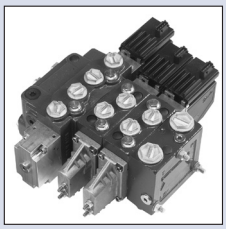
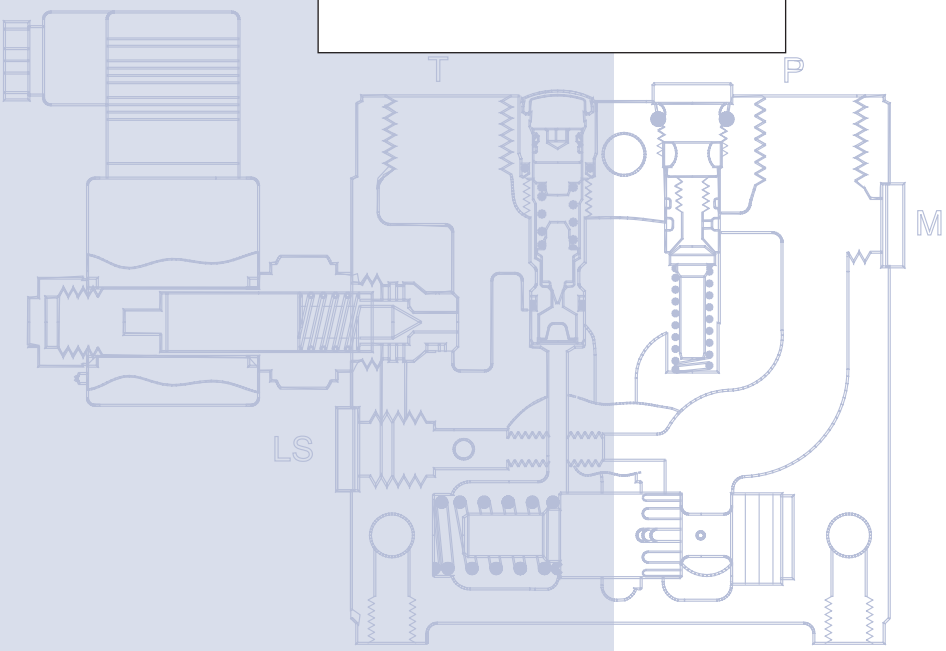
Genuine Parts

PVG 32
Proportional Valves

Service Manual





HISTORY OF REVISIONS

Table of Revisions

Date	Page	Changed	Rev.
November 2012	41	Revised torque on assembly nuts	AE
December 2011	41	Revised torque on assembly nuts	AD
October 2010	last	new back page	AC
March 2010	last	Fix Osaka address	AB
August 2008	-	First edition	AA

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Service Manual
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OVERVIEW

This manual includes information for servicing PVG 32 valves. It includes a description of the units and their individual components, troubleshooting information, and minor repair procedures.

Performing minor repairs may require removal from the vehicle/machine. Thoroughly clean the unit before beginning maintenance or repair activities. Since dirt and contamination are the greatest enemies of any type of hydraulic equipment, follow cleanliness requirements strictly. This is especially important when changing the system filter and when removing hoses or plumbing.

A worldwide network of Sauer-Danfoss Global Service Partners is available for major repairs. Sauer-Danfoss trains and certifies Global Service Partners on a regular basis. You can locate your nearest Global Service Partner using the distributor locator at www.sauer-danfoss.com.

For specifications and operating parameters on PVG 32 valves, refer to *PVG 32 Technical Information Manual* **520L0344**.

Do not attempt to service PVG valves without build sheet specifications for reference.

GENERAL INSTRUCTIONS

Follow these general procedures when repairing PVG 32 valves.

Remove the unit

Chock the wheels on the vehicle or lock the mechanism to inhibit movement. Prior to performing repairs, remove the unit from the vehicle/machine. Be aware that hydraulic fluid may be under high pressure and/or hot. Inspect the outside of the valve stack and fittings for damage. Cap hoses after removal to prevent contamination.

Keep it clean

Cleanliness is a primary means of assuring satisfactory motor life, on either new or repaired units. Clean the outside of the valve thoroughly before disassembly. Take care to avoid contamination of the port connections on the valve stack. Clean parts using a clean solvent wash and air dry.

As with any precision equipment, keep all parts free of foreign materials and chemicals. Protect all exposed sealing surfaces and open cavities from damage and foreign material. If left unattended, cover the valve with a protective layer of plastic.

Replace all O-rings and gaskets

Sauer-Danfoss recommends you replace all O-rings. Lightly lubricate all O-rings with clean petroleum jelly prior to assembly.

Secure the unit

For repair, place the unit in a stable position with the shaft pointing downward. Secure the motor while removing and torquing controls, and valves.

SAFETY PRECAUTIONS

Always consider safety precautions before beginning a service procedure. Protect yourself and others from injury. Take the following general precautions whenever servicing a hydraulic system.

Unintended machine movement

⚠ Warning

Unintended movement of the machine or mechanism may cause injury to the technician or bystanders. To protect against unintended movement, secure the machine or disable/disconnect the mechanism while servicing.

Flammable cleaning solvents

⚠ Warning

Some cleaning solvents are flammable. To avoid possible fire, do not use cleaning solvents in an area where a source of ignition may be present.

Fluid under pressure

⚠ Warning

Escaping hydraulic fluid under pressure can have sufficient force to penetrate your skin causing serious injury and/or infection. This fluid may also be hot enough to cause burns. Use caution when dealing with hydraulic fluid under pressure. Relieve pressure in the system before removing hoses, fittings, gauges, or components. Never use your hand or any other body part to check for leaks in a pressurized line. Seek medical attention immediately if you are cut by hydraulic fluid.

Personal safety

⚠ Warning

Protect yourself from injury. Use proper safety equipment, including safety glasses, at all times.

Hazardous material

⚠ Warning

Hydraulic fluid contains hazardous material. Avoid prolonged contact with hydraulic fluid. Always dispose of used hydraulic fluid according to state and federal environmental regulations.

ACRONYMS

This table provides a definition of commonly used terms.

P = Proportional V = Valve	
PVP	Pump side module
PVPV/M	Pump side module
PVB	Basic module
PVLA	Anti-cavitation valve
PVLP	Shock and anti-cavitation valve
PVS/PVSI	End plate
PVAS (PVP, PVPV/M)	Assembly kit for PVP, PVPV/M
PVPX, LS	LS Unloading valve
PVPC	Plug for external pilot oil supply
PVBS	Main spool
PVM	Mechanical activation
PVMD	Cover for mechanical activation
PVH	Cover for hydraulic activation
PVMF	Cover for mechanical float
PVMR	Cover for friction detent PVMR or float position
PVEH, PVES, PVEA	Electrical activation
PVEM	Electrical activation
PVEO	Electrical activation

PVG 32 GROUP WITH OPEN CENTER PVP (PVB WITH FLOW CONTROL SPOOL)

When the pump starts, and the main spools in the individual basic modules (11) are in the neutral position, oil flows from the pump, through connection P, across the pressure adjustment spool (6) to tank. The oil flow led across the pressure adjustment spool determines the pump pressure (stand-by pressure).

When one or more of the main spools actuate, the highest load pressure is fed through the shuttle valve circuit (10) to the spring chamber behind the pressure adjustment spool (6), and completely or partially closes the connection to tank.

Pump applies pressure to the right-hand side of the pressure adjustment spool (6). The pressure relief valve (1) opens if the load pressure exceeds the set value, diverting pump flow back to tank.

In a pressure-compensated basic module the compensator (14) maintains a constant Pressure drop across the main spool—both when the load changes and when a module with a higher load pressure is actuated.

With a non pressure-compensated basic module incorporating a load drop check valve (18) in channel P, the check valve prevents return oil flow. The basic module can have the load drop check valve in channel P for functions with over-center valves.

The shock valves PVLP (13) with fixed setting and the suction valves PVLA (17) on ports A and B are used for the protection of the individual working function against overload and/or cavitation.

An adjustable Load Sensing (LS) pressure limiting valve (12) can be built into the A and B ports of pressure-compensated basic modules to limit the pressure from the individual working functions.

The LS pressure limiting valves save energy compared to the shock valves PVLP. With PVLP all the oil flow to the working function flows across the combined shock and suction valves to tank if the pressure exceeds the fixed setting. With LS pressure limiting valves, an oil flow of about 2 l/min [0.5 US gal/min] flows across the LS pressure limiting valve to tank if the pressure exceeds the valve setting.

PVG 32 GROUP WITH CLOSED CENTER PVP (PVB WITH FLOW CONTROL SPOOL)

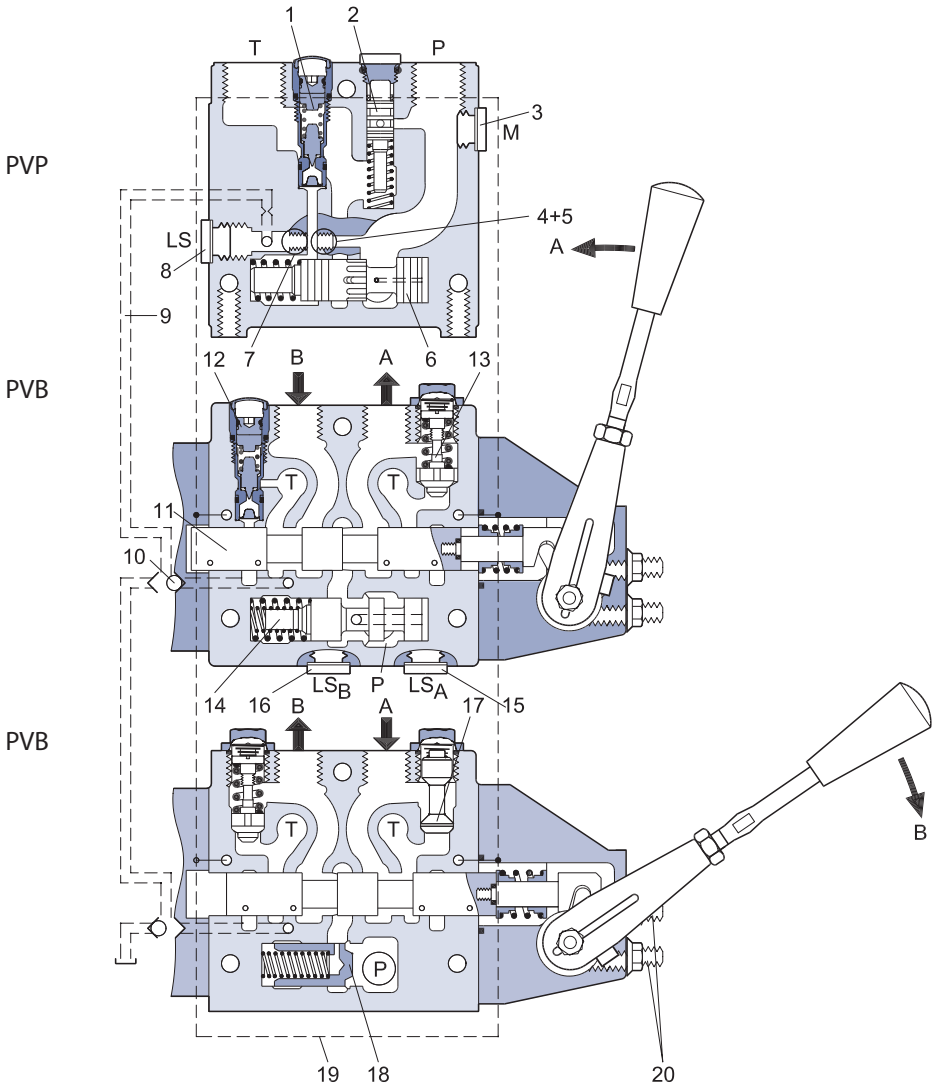
In the closed center version, an orifice (5) and a plug (7) are fitted instead of the plug (4). This means that the pressure adjustment spool (6) only opens to tank when the pressure in channel P exceeds the set value of the pressure relief valve (1).

In LS systems, the load pressure flows to the pump regulator via the LS connection (8).

In the neutral position the pump control sets the displacement so that leakage in the system is compensated to maintain the set stand-by pressure. When a main spool is actuated, the pump regulator adjusts the displacement to maintain the set differential pressure between P and LS.

The pressure relief valve (1) in PVP should be set at a pressure of approximately 30 bar [435 psi] above maximum system pressure (set on the pump or external pressure relief valve).

PVG 32 SECTIONAL DRAWING

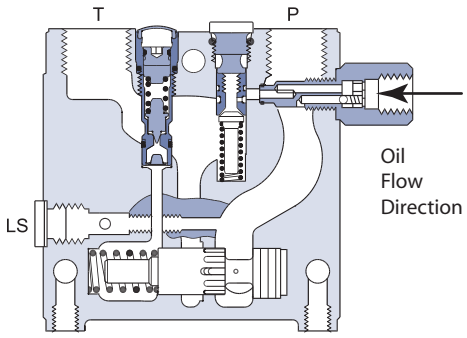


1. Pressure relief valve
2. Pressure reduction valve for pilot oil supply
3. Pressure gauge connection
4. Plug, open centre
5. Orifice, closed centre
6. Pressure adjustment spool
7. Plug, closed centre
8. LS connection
9. LS signal
10. Shuttle valve
11. Main spool
12. LS pressure limiting valve
13. Shock and suction valve, PVLP
14. Pressure compensator
15. LS connection, port A
16. LS connection, port B
17. Suction valve, PVLA
18. Load drop check valve
19. Pilot oil supply for PVE
20. Max. oil flow adjustment screws for ports A and B

PVPC PLUG FOR EXTERNAL PILOT OIL SUPPLY

PVPC with check valve for open center PVP

PVPC, with check valve, is used in systems where it is necessary to operate the PVG 32 valve by means of the electrical remote control without pump flow.
When the external solenoid valve is opened, oil from the pressure side of the cylinder is fed via the PVPC through the pressure reducing valve to act as the pilot supply for the electrical actuators. This means that a load can be lowered by means of the remote control lever without starting the pump. The built-in check valve prevents the oil from flowing via the pressure adjustment spool to tank.



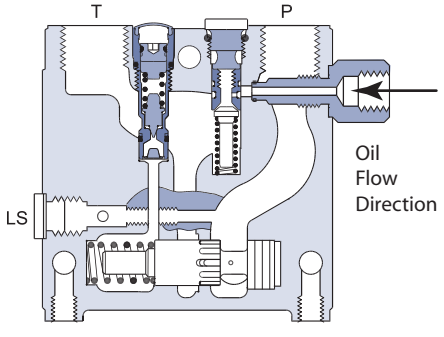
157-114.11

With the pump functioning normally, the external solenoid valve is closed to ensure that the load is not lowered due to the pilot supply oil flow requirement of approximately 1 l/min [0.26 US gal/min].

With closed center PVP, the external pilot oil supply can be connected to the pressure gauge connection without the use of a PVPC plug.

PVPC without check valve for open center PVP

PVPC, without check valve, is used in systems where it is necessary to supply the PVG 32 valve with oil from a manually operated emergency pump without directing oil flow to the pilot oil supply (oil consumption about 1 l/min) [0.25 US gal/min].
When the main pump is working normally, the oil is directed through the PVPC plug through the pressure reduction valve to the electrical actuators.
When the main pump flow fails, the external shuttle valve ensures that the oil flow from the manually operated emergency pump is used to pilot open the over center valve and lower the load. The load can only be lowered using the mechanical operating lever of the PVG 32 valve.



157-193.11

For specifications on PVG 32 valves, refer to *PVG 32 Technical Information Manual* **520L0344**.

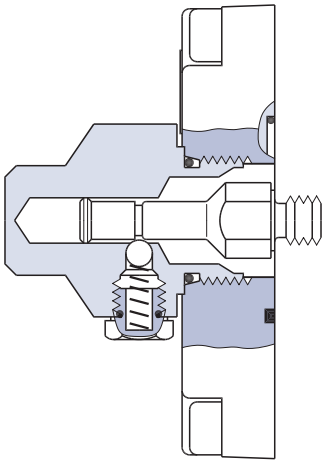
With closed center PVP, the external pilot oil supply can be connected to the pressure gauge connection without the use of a PVPC plug.

FRICTION DETENT

PVMR Friction detent

The friction detent PVMR allows the directional spool to be held in any position, resulting in infinitely variable, pressure compensated flow. The spool position will be held indefinitely without the necessity of holding the mechanical lever.

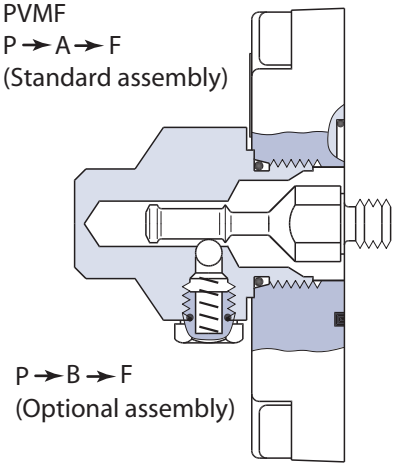
PVMR should only be used together with PVB basic modules with pressure compensator.



157-204.10

PVMF Mechanical float position lock

This allows the float spool to be held in the float position after release of the mechanical handle.



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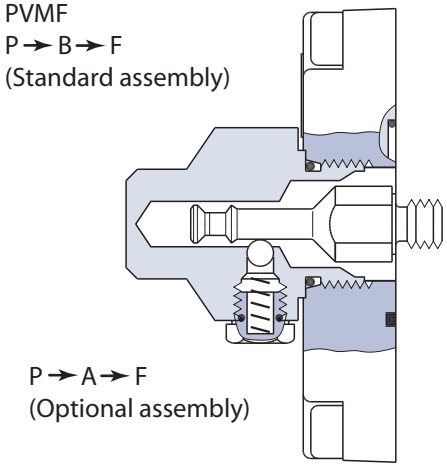

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PVBS, MAIN SPOOLS FOR FLOW CONTROL (STANDARD)

When using standard flow control spools, the pump pressure is determined by the highest load pressure. This is done either via the pressure adjustment spool in open center PVP (fixed displacement pumps) or via the pump regulator (variable displacement pumps).

In this way the pump pressure will always correspond to the load pressure plus the stand-by pressure of the pressure adjustment spool or the pump regulator.
This will normally give optimum and stable adjustment of the oil flow.

PVBS, MAIN SPOOLS FOR FLOW CONTROL (WITH LINEAR CHARACTERISTICS)

PVBS main spools with linear characteristic have less dead band than standard spools and a completely proportional ratio between control signal and oil flow in the range beyond the dead band.

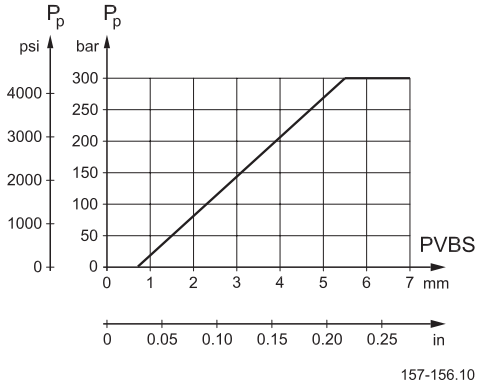
⚠ Warning

PVBS with linear characteristic must never be used together with PVEM electrical actuators.

The interaction between the small dead band of the spools and the hysteresis of the PVEM actuator of 20% involves a risk of building up a LS pressure in neutral position.

PVBS, MAIN SPOOLS FOR PRESSURE CONTROL

In a few systems load sensing pump pressure may result in unstable adjustment of the oil flow and a tendency towards system hunting. This may be the case with working functions that have a large moment of inertia or over-center valves. In such systems main spools for pressure control can be advantageous. The spools are designed in such a way that the pump pressure is controlled by the spool travel. The main spool must be displaced until the pump pressure just exceeds the load pressure before the working function is applied.



If the main spool is held in this position, the pump pressure will remain constant – even if the load pressure changes – giving a stable system.
The use of pressure control spools, however, also means that:
- the oil flow is load dependent
- the dead band is load dependent
- the pump pressure can exceed the load pressure by more than is usual.

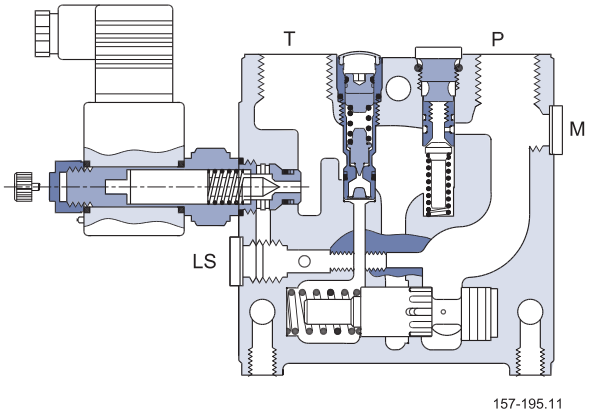
Due to these factors use pressure control spools only when you know for certain that problems with stability will arise – or already have arisen.
Use $LS_{A/B}$ when pressure stability is an issue.

PVPX ELECTRICAL LS UNLOADING VALVE

PVPX is a solenoid LS unloading valve. PVPX is fitted into the pump side module enabling a connection to be made between the LS and the tank lines. Thus the LS signal can be relieved to tank by means of an electric signal.

For a PVP pump side module in open center version the relief to tank of the LS signal means that the pressure in the system is reduced to the sum of the tank port pressure plus the neutral flow pressure for the pump side module.

For a PVP pump side module in closed center version, relief to tank of the LS signal occurs when the pressure is reduced by the sum of the tank port pressure for the pump side module plus the stand-by pressure of the pump.



Caution

Protect yourself from injury. Use proper safety equipment, including safety glasses, at all times.

OVERVIEW

This section provides general steps to follow if undesirable system conditions are observed. Follow the steps listed until the problem is solved. Some of the items will be system specific. Always observe the safety precautions listed in the *Introduction* section, page 6, and related to your specific equipment.

Confirm that valve is built properly according to the specification sheet.

⚠ Warning
This troubleshooting guide for the PVG valve assemblies does not cover valves that have been altered from original valve build specifications

If necessary, install a lever to the valve to verify proper mechanical function.

Refer to *PVG 32 Technical Information Manual* **520L0344** for valve configuration information.

Refer to *PVG 32 Parts Manual* **11006794** for part numbers.

TROUBLESHOOTING A PVG VALVE

THINK - before troubleshooting a problem.
Every fault location process should follow a logical and systematic order.
It is wisest to start at the beginning:

- Is the oil level correct when the pump is operating?
- Is the condition of oil and filters acceptable?
- Are pressure, flow, and flow direction as specified?
- Is the oil temperature too high or too low (oil viscosity)?
- Are there any unusual vibrations or noise (cavitation)?

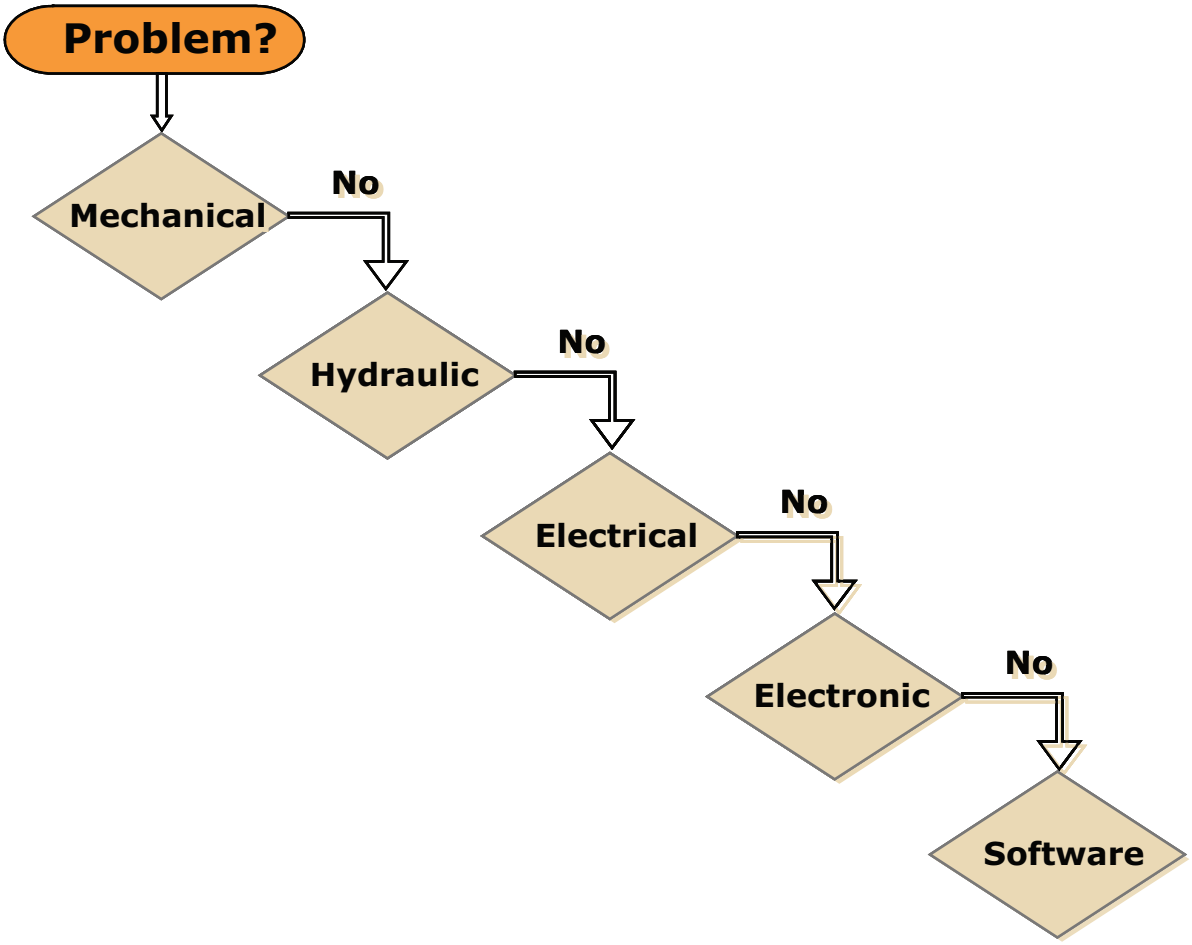
If the driver of the vehicle is available, ask him:

- What type of fault it is and how it affects the system?
- How long he has felt that something has been wrong?
- If he has "fiddled" with the components?
- If he has any hydraulic and electrical diagrams available?

Diagrams are often found in the instructions included with vehicles/machines. Unfortunately they are often so technical that they are not of much use in a fault location situation. However; the diagram usually shows the order of, and the connections between, the individual components.
When a defective component is identified, clean the component and its surroundings before removal.
Remove loose paint from pipes and fittings.

Cover all holes, hoses and pipe ends with plugs or seal with, for example, plastic bags after removal to avoid the entry of dirt during repairs.
Never disassemble hydraulic components outside.
Perform repairs in a workshop on a clean workbench (covered with clean cloth or newspaper).
Make sure that a Sauer-Danfoss service manual for with the product is handy.
Follow the instructions word for word during disassembly and assembly.
If these instructions are not followed closely the system may not operate correctly after repairs are completed.
Note that in some cases special tools are necessary for assembling the product.
Our service manuals give full guidance on use of special tools.

Troubleshooting flow chart



P107 823

NO CYLINDER/MOTOR RESPONSE IN EITHER DIRECTION WHEN REMOTE CONTROLLER IS ACTUATED

Cause	Check	Corrective action
Verify if fault is mechanical, electrical or hydraulic	Operate manual lever to confirm mechanical or electrical or hydraulic	If moving the manual lever operates the cylinder/ motor check electrical or hydraulic
Sticking main spool	Remove manual, electrical, and hydraulic actuators from the valve section. Remove main spool from valve section and inspected for damage. If no damage reinstall the main valve spool and it should move freely in the valve section bore.	Replace the valve module and main spool. If any damage is found on the main spool
	Check movement of manual lever when electrical controller is operated	If manual lever does not move check electrical voltage signal from controller, wiring at the PVE module
	Check movement of manual lever when hydraulic controller is operated	If manual lever does not move check hydraulic controller pressure at the PVG valve module - 25 Bar [360 PSI]
	If none of the above check pump per manufacturers recommended procedure	Repair or replace pump per manufacturers recommended procedure
Internal filters blocked	Check for blockage in internal filters	Remove blockage

CYLINDER/MOTOR RESPONDS IN ONE DIRECTION ONLY

Cause	Check	Corrective action
Verify if fault is mechanical, electrical or hydraulic	Operate manual lever in both directions to confirm if mechanical or electrical or hydraulic	If moving the manual lever operates the cylinder/ motor in both directions check electrical or hydraulic
	If operating the manual lever strokes the cylinder/motor in one direction only, check manual stop screw adjustment	Back out manual stop on manual controller and torque the jam not to 8 Nm [70 lbf•in] Do not exceed maximum torque
	Check movement of manual lever when electrical controller is operated	If manual lever does not move in one direction check electrical signal from controller and wiring at the PVE module
	Check movement of manual lever when hydraulic controller is operated	If manual lever does not move in both directions check hydraulic pressure at the PVG module
Air in system	Entrained air generates heat under pressure	Look for foam or bubbles in reservoir. Check for leaks on inlet side of charge pump.
Internal leakage	Excessive internal leakage may overheat the system.	Install loop flushing defeat option and monitor case flow. If case flow is excessive, motor may require major repair. Contact Sauer-Danfoss Service.
Shock valves	Swap and see if problem follows	Replace valves
Solenoid actuation	If power is OK from controller	Repair wiring to PVE module
Main spool travel restricted	Stop on manual controller turned in too far	Back out manual stop on manual controller
Remote electrical controller	Insufficient signal from electrical controller	Repair or replace electrical controller
PVEO connections	Incorrect PVE/PVEO connections	Connect correct way
Remote hydraulic controller PVRH	Insufficient pilot oil pressure from remote hydraulic controller Pressure needs to be 25 Bar [360 psi]	Repair or replace remote hydraulic controller

MAIN VALVE SPOOL MOVES WITHOUT OIL PASSING TO CYLINDER/MOTOR

Cause	Check	Corrective action
Insufficient oil supply to valve	Check the pump per manufacturers procedure	Repair or replace pump per manufacturers procedure
Optional pressure compensator in valve section not functioning	Check compensator spool	Replace spool
Insufficient load pressure at compensator spring chamber	LS drilling holes plugged	Clean or replace
Cylinder/motor load too high for pressure setting of the system	Check pressure at the valve	If pressure is set to spec. per valve lower load on cylinder/motor
Blocked LS galleries	Inspect for blockage in LS galleries	Remove blockage in LS galleries
Shuttle valve faulty	Inspect shuttle valve	Repair or replace
Blocked LS lines to pump controller	Inspect LS lines from PCG to pump controller	Remove blockage in LS lines from the PVG valve to pump controller
Oil bypassing at shock valve/anti-cavitation check valve	Check if stuck open or damaged	Replace valve
Internal leakage in cylinder/motor	Inspect for by-passing of oil per cylinder/motor manufacture per manufactures procedure	Repair or replace cylinder/motor per manufactures procedure
Too much leakage in LS spool in pump control	Check bleed orifice in LS control	Use a LS pump control with no bleed orifice
Blocked thermal orifice	check thermal orifice (blocked)	Replace thermal orifice
Load too high for system	Check for proper system pressure	Adjust pressure to valve specification
Internal leakage in cylinder/motor	Inspect for bypassing of oil per cylinder/motor manufacturer specification	Repair or replace cylinder/motor
Shock valve or anti-cavitation check valve faulty	Inspect for damage and contamination	Repair or replace cylinder/motor
System relief valve pressure set too low for load	Install pressure gauge and check pressure	Adjust pressure to system specification Lower load
Cylinder/motor load too high for pressure settings of system	Check load pressure at PVB-LS port	Reduce load pressure if exceeds maximum pressure limit of the system
	Maximum system pressure should be approx. 25 Bar [365 PSI] above highest load pressure	Adjust maximum system pressure if necessary
	Adjust pump pressure compensator setting if necessary	

CYLINDER/MOTOR OPERATES WITHOUT REMOTE CONTROLLER BEING OPERATED

Cause	Check	Corrective action
Spool control tension rod loose	Confirm torque on spool control tension rod	Torque to 8 Nm [70 lbf•in]
Electrical feedback transducer not in neutral position	Check the feedback pin in the PVE. It should be loose	Replace transducer
Remote electrical controller neutral position switch faulty	Disconnect the connection at the PVE. It should come back to neutral	Repair or replace faulty switch or wiring at remote controller
Sticking pressure control valve in remote hydraulic controller	Disconnect the hydraulic signal line from valve	Repair or replace faulty remote hydraulic controller
Sticking main spool in valve section	Remove manual, electrical, and hydraulic actuators from the valve section. Remove main spool from valve section and inspected for damage. If no damage reinstall the main valve spool. Spool should move freely in the valve section bore.	Replace the valve module and main spool if any damage is found on the main spool
Internal fault in the PVE/PVEH/PVEM/ PVEO	PVEO check continuity. All other PVE, check LED (Red means internal error)	Replace faulty PVE/PVEH/PVEM/PVEO
Contamination in the hydraulic oil	Take oil samples to confirm	Flush hydraulic system. Fill with clean filtered oil.

CYLINDER/MOTOR RESPONDS SLOWLY TO REMOTE ELECTRICAL OR HYDRAULIC CONTROLLER ACTUATION

Cause	Check	Corrective action
Insufficient system pressure	Install pressure gauge and record pressure	If pressure is low adjust pressure setting to valve specification or pump manufacturers specification
Main spool travel limited	Check stops on manual lever controller end for proper adjustment. Refer to *Component troubleshooting* section, page 22.	Adjust the manual lever stops and torque the jam nuts to 8 Nm [70 lbf•in] Do not exceed maximum torque
Incorrect signal voltage from electrical controller	Check the signal voltage from the controller with a volt meter	If signal voltage is incorrect repair or replace electrical controller
Incorrect hydraulic pressure signal from remote hydraulic controller	Check pressure from the remote hydraulic controller - 25 Bar [360 PSI]	If pressure is too low, repair or replace remote hydraulic controller per manufacturers instructions.
Insufficient pilot oil - all sections	Check pilot for contamination and correctly assembled parts - 10-15 bar [145-218 psi] Electric - 25 bar [360 psi] Hydraulic	Replace inlet module NOTE: Check with S-D TST
Insufficient LS pump stand by pressure	Check pilot PSI - 10-15 bar [145-218 psi] Electric - 25 bar [360 psi] Hydraulic	Adjust or replace pump
Flow is not load independent	PVLP check for cracks Check LS pressure vs load pressure	Replace valve

ERRATIC CYLINDER/MOTOR RESPONSE TO ELECTRICAL OR HYDRAULIC CONTROLLER OPERATION

Cause	Check	Corrective action
Electrical actuator faulty	Check signal from controller to PVE	Repair or replace PVE
Main spool centering spring damaged	Check tension rod for correct torque or damage	Torque to 8 Nm [70 lbf•in] or replace
Main spool position feedback transducer signal incorrect	Check feedback pin for damage	Replace PVE
Contamination in hydraulic oil	Take oil sample	Flush complete system. Fill reservoir with clean filtered fluid per OEM specification
Air in hydraulic pilot lines	Check for air trapped in signal lines from the controller to the valve section module	Bleed air from the hose connection at the valve section
Hydraulic remote actuator faulty	Check signal pressure from the remote hydraulic controller	Repair or replace cylinder/motor
Low hydraulic oil supply	Check fluid level in reservoir	Fill reservoir with clean filtered fluid per OEM specification

HYDRAULIC OIL SUPPLY

Cause	Check	Corrective action
Pump not running	Check prime mover for operation	Repair or replace prime mover
	Check condition of drive coupling	Repair or replace drive coupling
Insufficient oil in reservoir	Check fluid level in reservoir	Fill with clean filtered oil
Leaking or burst supply hose	Inspect lines to valve stack	Repair or replace damaged hose
Relief valve malfunction	Check for contamination and operation of relief valve	Repair or replace relief valve
Isolating valves are closed	Check that all isolating valves are open and clear	
Faulty pump control	Check pump compensator for correct operation and setting per pump manufacturers	Repair or replace pump compensator per pump manufacturers recommendations
Low standby pressure in PVP - open center pump	Check idle standby pressure - 10 Bar [145 PSI]	Replace
	Check condition of compensator spool spring	Replace module due to worn components
Low standby pressure in pump control - variable pump	Check pump LS control for operation and setting Stand by pressure should be 15 bar [220 psi] minimum	Repair or replace LS control per pump manufacturers procedures
PVP pressure relief valve faulty	Check pressure relief valve spool and spring for freedom of operation	Replace
PVP orifices blocked	Check PVP orifices for blockage	Remove blockage
Internal filters blocked	Check for blockage in internal filters	Remove blockage
Supply lines blocked	Inspect supply lines for blockages	Remove blockage
Internal hydraulic pilot pressure insufficient	Inspect pilot oil pressure reducing valve for proper operation	Repair or replace
Blocked LS galleries	Check LS galleries for blockage	Clean blockage from LS galleries
Shuttle valves faulty	Check LS system shuttle valves for wear and damage	Replace as needed

Check for contamination per specification **HPP 030**. Refer to *Design Guideline for Hydraulic Fluid Cleanliness, Technical Information Manual* **520L0467**. If fluid is out of spec., flush hydraulic system and fill with clean filtered oil.

ELECTRICAL SUPPLY

Cause	Check	Corrective action
No electrical power	Check electrical circuit	Repair as needed
	Verify emergency stop switch is in the proper operating position	Reset
Neutral position switch faulty	Check operation of neutral position switch in remote controller (if connected in circuit) PVRE/PVRES/PVREL	Replace switch
Incorrect signal voltage	Check voltage levels at solenoid plug	
	Proportional operation - Refer to page 43	
	Udc: Supply voltage (100%)	
	Us: Supply signal voltage (25-50-75%)	
	Ground: Live or ground connection	
	On-Off Operation	
	Udc: Supply voltage if selected	
	Us: Supply voltage if selected	
	Ground: Live or ground connection	
Solenoid valve faulty PVHC	Check coil resistance	Check data for resistance
Insufficient pilot supply	Check pilot pressure - 10-15 bar [145-218 psi]/PVHC 25 bar [360 psi]	Replace
Main spool position feedback transducer signal incorrect	Test oil for contamination and or water content	If oil contamination is too high, flush hydraulic system or replace oil if necessary. If problem persists change PVE
Incorrect PVE connections	Check that the proportional remote electrical controller has not been connected to an ON-OFF PVEO solenoid	Connect wires correctly

HYDRAULIC (REMOTE) PILOT CONTROL PRESSURE

Cause	Check	Corrective action
Insufficient pilot pressure	Check pilot oil pressure 5-15 bar [72-220 psi] delta between A and B port on remote	
	PVG32: 5-15 Bar [72-217 PSI]	
Insufficient pilot oil supply	Check pilot oil flow rate is adequate	
	Pilot flow should be 1.0 L/min [0.264 GPM] per section	
	Check pilot lines for blockage	Remove blockage
Air in pilot line	Check for trapped air in pilot lines	Bleed air from pilot lines at PVH
Pilot lines incorrectly sized	Check pressure drop	Check and reduce length or pilot lines
		Increase diameter of pilot lines
		Use steel tube for long pilot line runs
Hydraulic remote pilot operator faulty	Check operation of hydraulic remote pilot controller	Repair or replace
	Check supply pressure to hydraulic remote controller - minimum 25 bar [360 psi]	Repair or replace
	Check and inspect movement of pressure control valve in hydraulic controller	Repair per manufacturers procedure, or replace
	Check operation of remote hydraulic controller	Clean and/or repair as necessary

PRESSURE RELIEF VALVE

Description: Adjustable relief valve. Adjustment range 50 Bar [700 PSI] to 350 Bar [5000 PSI].

Location: The relief is in all PVP Inlet modules

Function: Provides maximum pressure setting above pump pressure setting 30 Bar [450 PSI] Delta for open center and closed inlet sections

Failure mode	Cause	Corrective action
Will not build pressure	Contamination	While under pressure, back out to minimum pressure and allow oil to leak by for approx. 5 seconds and then readjust to correct pressure - Replace valve
External leaking	Damaged seat and poppet	Replace complete assembly
Pressure setting is wrong	Pressure adjustment backs off (on open center application)	Adjust to model code specification
Instability when PC and inlet relief has too low of a delta between them	PC at pump should be set 20 bar below relief valve	Adjust to model code specification

Serviceability: Non serviceable.

Valve removal tool P/N: **155L6485**. Torque to 20 Nm [180 lbf•in].

PRESSURE REDUCING PILOT VALVE

Description: Pressure reducing valve at fixed pressure.

Location: The pressure reducing valve is a option in some PVP Inlet modules.

Function: Provides 10-15 bar [145-218 psi] internal pressure for electrical (PVE) actuators or provide 25 Bar (360 PSI) (PVHC) and supply for external remote hydraulic actuators (HRC). These pressures are only present when the load pressures are high enough to satisfy the required regulated pressure. The open center system at low pump flow may only develop 9 Bar (130 PSI)

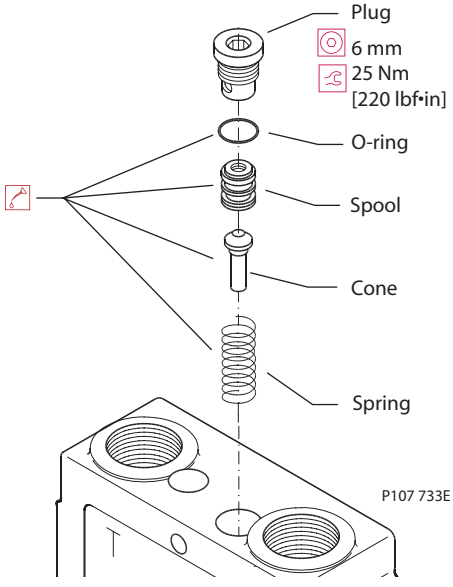
PRESSURE REDUCING PILOT VALVE (CONTINUED)

Failure mode	Cause	Corrective action
Main spools are slow, driven by PVE 13 Bar [190 PSI] pilot system	Contamination	Disassemble and clean
	Pump pressure too low - below 9 Bar [130 PSI]	Closed center: System increase stand-by to 13 Bar [190 PSI] Open center: Check gear per pump manufacture procedure Check system for other components before valve inlet that may provide a path tank
	High tank port pressure. Do not exceed 40 Bar [580 PSI] tank pressure (For PVPs without **T0** option)	Clear restrictions in return system.
	Oil viscosity 460 mm^2/S [2128 SUS] too high (cold oil or incorrect viscosity oil)	Warm up system or replace oil with correct viscosity
Main spools will not move mechanically or electrical	For **T0** option only not being connected to tank or restricted to tank	Connect **T0** (PVP) port option to tank or remove restriction
	Internal pressure reducing valve parts misassembled	Reassemble the internal pressure reducing valve parts correctly
PVHC 25 bar [360 psi] pilot system - main spools are slow	Contamination	Disassemble and clean
	Pump pressure too low - below 20 Bar [290 PSI]	Closed center: System increase stand-by to 20 Bar [290 PSI] Open center: Check gear per pump manufacturers procedure Check system for other components before valve inlet that may provide a path tank
	High tank port pressure. Tank pressure should not exceed 40 Bar [580 PSI] (For PVPs without **T0** option)	Check for restrictions in return system and remove
	Oil viscosity - 460 mm^2/S [2128 SUS] too high (cold oil or incorrect viscosity oil)	Warm up system or replace oil with correct viscosity

Serviceability: All internal components can be removed from the cavity, cleaned, inspected and reassembled back into the valve

1. Use a 6 mm internal hex wrench to remove the plug, and then remove all the other internal components in the cavity
2. Clean all components with clean solvent
3. Replace any damaged components. Lubricate with clean hydraulic oil
4. Correctly reassemble the components back into the cavity and torque the plug to 25 Nm [221 lbf•in] (use an M5 screw to install spool).

Pressure reducing pilot valve



PRESSURE GAUGE CONNECTION

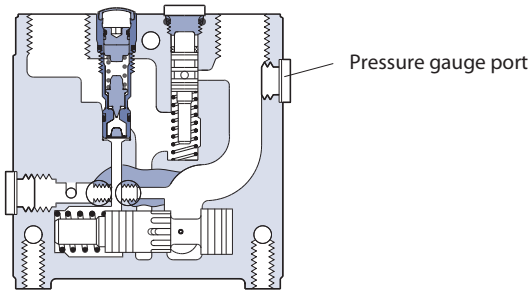
Description: Port to install a pressure gauge to check pressure relief valve setting to valve specification.

Location: On inlet cover to valve stack.

1. Use a 6 mm internal hex to remove and install plug.
2. Torque plug to 35 Nm [308 lbf•in].

Failure mode	Cause	Corrective action
Leaking	Bad seal	Replace with new seal (same type as original seal)

Pressure gauge port



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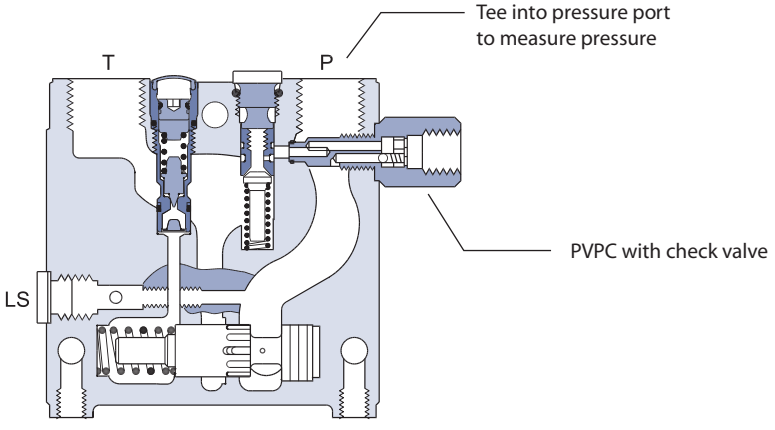
When valve is equipped with the PVPC option use a running tee to measure pressure. Torque tee to hose adaptor torque specification.

PVPC with check valve



P107 734E

OPEN CENTER PLUG

Description: Plug that is installed in the inlet cover for a system with a fixed displacement pump.

Location: In the PVP module (Inlet cover).

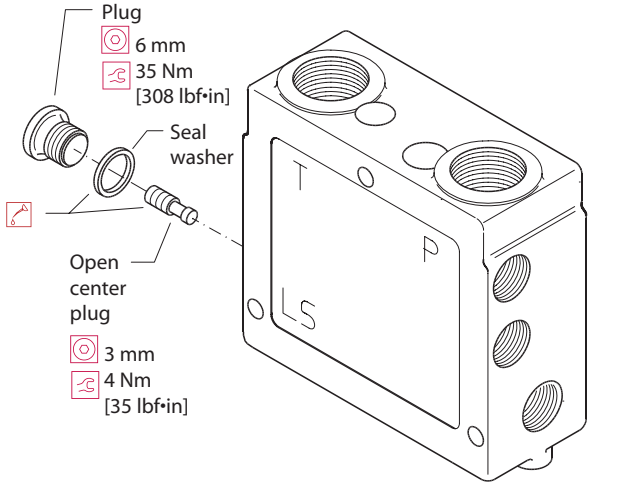
Function: Connection for the load sense signal to shift the unloading spool to build main system pressure and provides a connection to the main system relief valve.

Failure mode	Cause	Corrective action
Valve operates at system relief setting at all times	Open center plug is not seated properly	Reinstall plug and torque to 4 Nm [35 lbf•in] using a 3 mm internal hex wrench

Serviceability: Open center plug is serviceable.

1. Use a 6 mm internal hex to remove cavity plug from valve.
2. Use a 3 mm internal hex to remove open center plug.
3. Clean or replace open center plug.
4. Install open center plug.
5. Torque plug to 4 Nm [35 lbf•in].
6. Install new seal washer and install cavity plug. Torque to 35 Nm [130 lbf•in].

Open center plug



P107 736E

CLOSED CENTER PLUG AND ORIFICE

Description: Plug that is installed in the inlet cover for a system with a variable displacement pump.

Location: In the PVP module (Inlet cover).

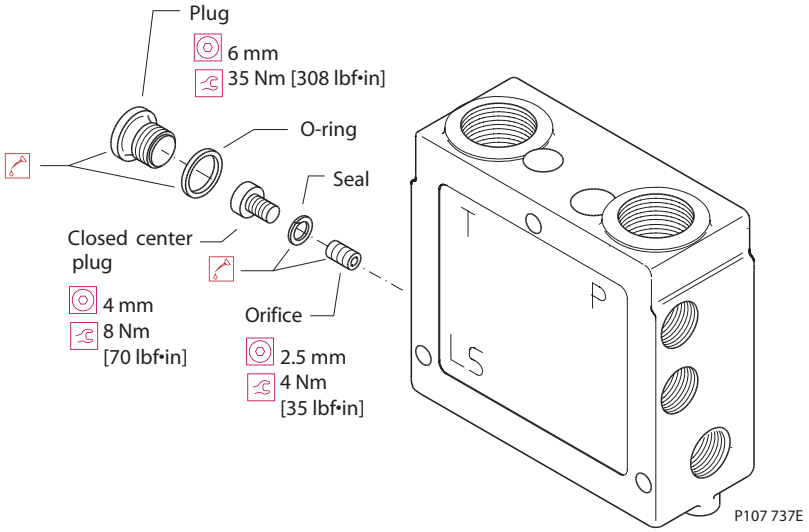
Function: Allow connection for the load sense signal to the pump and provide connection to the main system relief valve.

Failure mode	Cause	Corrective action
Valve operates at system relief setting at all times	Plug and orifice are not seated properly	Reinstall orifice and torque to 4 Nm [35 lbf•ft] using a 3 mm internal hex wrench. Reinstall plug and torque to 8 Nm [71 lbf•in] using a 8 mm internal hex wrench
Can not adjust main relief above pump pressure setting of 30 Bar [450 psi] Delta for closed inlet sections	Orifice is plugged	Remove and clean orifice. Reinstall

Serviceability: Closed center plug and orifice are serviceable.

1. Use a 6 mm internal hex to remove cavity plug from valve.
2. Use a 4 mm internal hex to remove closed center plug.
3. Use a 2.5 mm internal hex to remove orifice.
4. Clean or replace orifice. Install orifice. Torque to 4 Nm [35 lbf•in].
5. Install new seal and install closed center plug. Torque to 8 Nm [71 lbf•in].
6. Install new O-ring and install plug. Torque to 35 Nm [130 lbf•in].

Closed center plug



PRESSURE ADJUSTMENT SPOOL

Description: Main pump flow unloading spool.

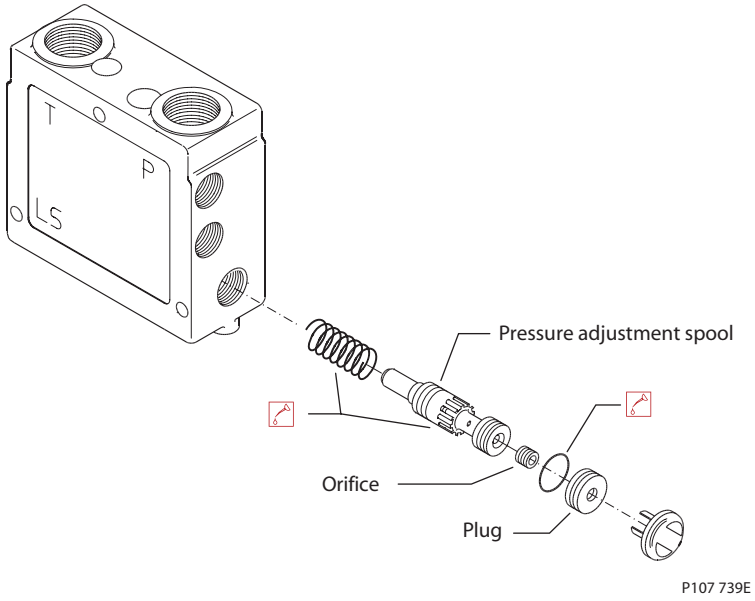
Location: PVP (inlet) module.

Function: For open center systems it is the main relief and unloading spool
For closed center systems it is the main relief spool.

Failure mode	Cause	Corrective action
In open center systems the valve sections are unstable	High wear allows leakage to tank	Replace compete module
The adjusted pressure will not remain static in a closed center system	Low viscosity oil allowing high leakage around spool to tank.	Remove and clean orifice. Reinstall
	High wear	Replace compete module

Serviceability: Spool is not serviceable. Replace complete module.

Pressure adjustment spool



LS CONNECTION

Description: Port for LS signal for LS (static) option only controller for variable flow pump.

Location: PVP (inlet) module.

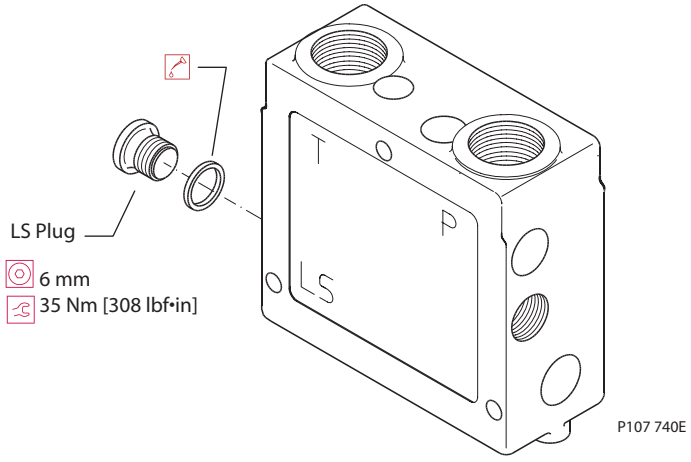
Function: Provide a signal to the variable pump controller to create a pressure differential to have the pump come on stroke for a closed center system.

Failure mode	Cause	Corrective action
In closed center systems the valve sections are unstable	Insufficient LS flow to satisfy pump controller	Ensure that the LS controller on the pump does not have excessive internal leakage - 0.4 l/min [0.106 gal/min]. Repair or replace the variable pump controller per pump manufactures specifications If there is more than one valve in the system ensure that the LS shuttles are all working properly
	Excessive air entrained in the hydraulic oil	Ensure that the oil has enough dwell time in tank, has good anti-foaming agent, and pump inlet vacuum is within manufacturers specifications
	Air trapped in LS line	Bleed air for LS line at highest point
Valve operation is slow to respond or does not respond	Insufficient LS flow to satisfy pump controller	If more than one section, ensure that the LS controller on the pump does not have excessive internal leakage. Repair or replace the variable pump controller per pump manufactures specifications
	Excessive air entrained in the hydraulic oil	Ensure that the oil has enough dwell time in tank, has good anti-foaming agent, and pump inlet vacuum is within specifications
	Air trapped in LS line	Bleed air for LS line at highest point

PVG valve is mounted above hydraulic oil reservoir when shut down and sits idle for some time, the valve could be voided of oil and this would cause the valve to operate erratically and be slow to respond.

Serviceability: Port is serviceable. Need to connect hose to LS port on pump.

LS connection plug



LS SIGNAL

Description: The PVG32 uses an internal LS signal network for both Open Center and Closed Center systems. In Open Center systems the internal LS signal network provides a resolved load sense signal to the pressure adjustment spool controlling the proper amount of flow and pressure to the operating valve sections. In Closed Center systems the internal LS signal network provides a resolved load sense signal directly to the LS pump control which in turn provides the proper amount of flow and pressure to the operating valve sections.

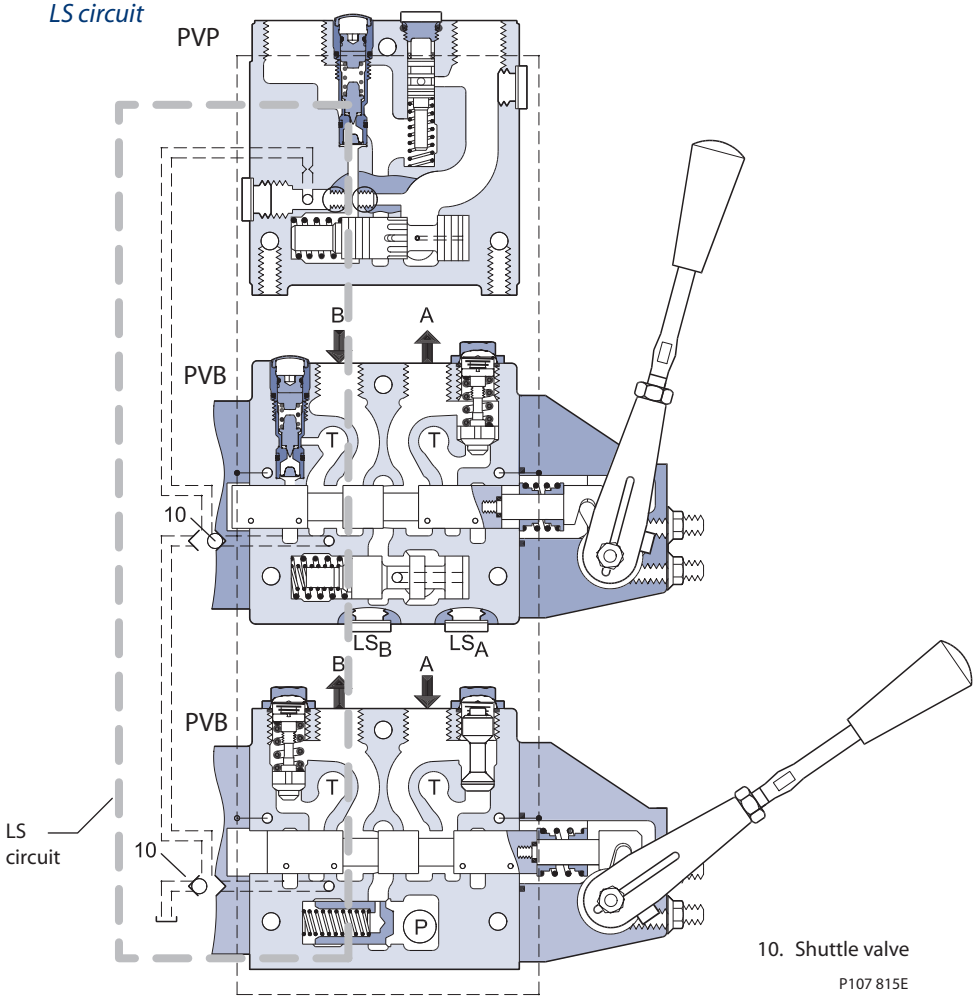
Location: PVP/PVB Modules.

Function: Directs the highest load pressure to either OC or CC pump control to satisfy the operating valve section.

Failure mode	Cause	Corrective action
No pump pressure developed in one or more valve sections	LS passages blocked or restricted	Disassemble valve. Inspect passages for blockage

Serviceability: Not serviceable. Ensure entire system is clean.

LS circuit



10. Shuttle valve

P107 815E

SHUTTLE VALVE

Description: Self cleaning internal shuttle system.

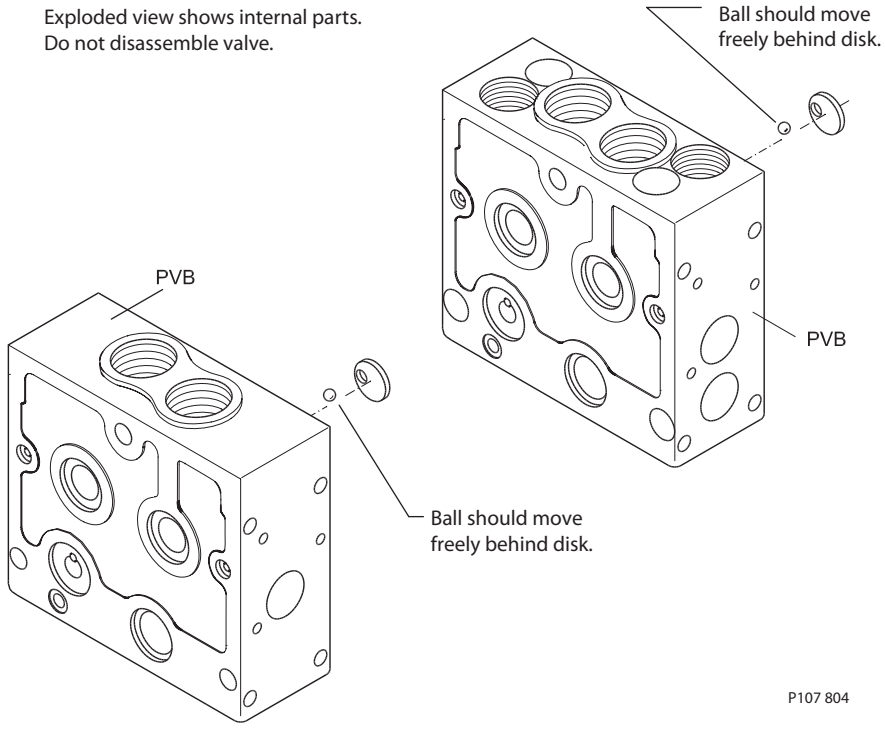
Location: PVB (valve section) module.

Function: Determines which valve section is developing highest load pressure.

Failure mode	Cause	Corrective action
Valve sections will not build pressure (NOTE: Normally it will be one section, but not all sections)	Worn shuttle disc	Replace complete module (seat is pressed into module)
	Excessive air entrained in the hydraulic oil	Ensure that the oil has enough dwell time in tank, has good anti-foaming agent, and pump inlet vacuum is within specifications

Serviceability: Not serviceable. Ensure entire system is clean.

Shuttle valve



LS PRESSURE LIMITING VALVE

Description: Optional adjustable pilot relief valve.

Location: PVB (spool body section) module.

Function: Controls the maximum working pressure delivered to each work port.

There is one LS pressure limiting valve for each work port.

Failure mode	Cause	Corrective action
Section will not build pressure in one spool direction	Contamination	While under pressure back out to minimum pressure and allow oil to leak by for approx. 5 seconds and then readjust to correct pressure - Ensure system is clean - Replace PVB
External leaking	Low cartridge torque	Torque to 20 Nm [177 lbf•in] maximum Replace complete assembly
Pressure adjustment backs off	Adjust pressure to valve specifications	If adjustment doesn't hold, replace valve

Serviceability: Adjustable and non-serviceable. If adjustment does not solve the problem, replace complete cartridge.

Valve removal tool P/N: **155L6485**. Torque to 20 Nm [177 lbf•in].

LS A, B SHUTTLE

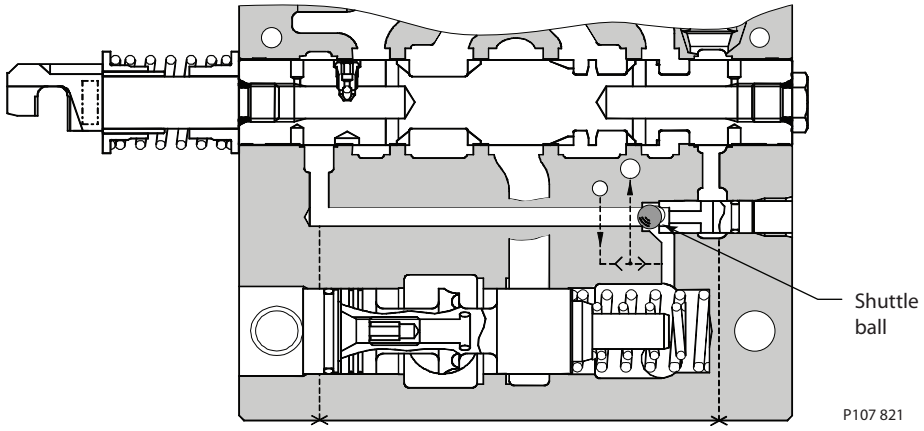
Description: The shuttle valve isolates the LS(A) and LS(B) load sense signal.

Location: Option PVB module with only load sense relief.

Function: Ensure that each pressure limiter valve can create separate pressures for A and B LS signal.

Failure mode	Cause	Corrective action
Will not build pressure in A or B work port	Contamination preventing shuttle ball from building load sense relief pressure	Replace complete PVB module

LS A, B shuttle



MAIN SPOOL

Description: Main directional control.

Location: PVB (valve section) module.

Function: Controls oil flow from pump to work ports A or B.

Failure mode	Cause	Corrective action
Section will not build pressure in one spool direction	Load sense passages in spool are blocked	Flush out load sense passages in the spool. Spool will need to be removed to clean
Main valve spool stuck in valve body (if being used with electrical actuator)	Refer to *Pressure reducing valve* section, page 22	Replace PVM and PVE. Be sure that pilot valve is assembled correctly.
Mechanical actuator main valve spool stuck in valve body	Hard particle binding spool in bore	Look down into the A and B work ports to see if the particle can be removed while the spool is in the valve body. Replace valve section. NOTE: Valve body and spool will need to be replaced per valve specifications
Main spool stuck in valve body	Tie rod over torqued	Replace tie rod kit which includes section seals and torque to 28 Nm [248 lbf•in]
	Valve stack mounting surface is not flat causing a bind on the valve stack	Ensure the mounting surface is flat*

* Flatness in millimeters - T= 0.35 mm X number of PVB modules + 1

MAIN SPOOL (CONTINUED)

Serviceability: Main spool is serviceable depending on failure mode.

1. Remove manual actuator using a 5 mm internal hex wrench to remove the 4 mounting screws.

CAREFULLY place the main spool in to an appropriate fixture or vice with card board, rubber hose or heavy shop towels on the jaws and tighten just enough to keep the spool from turning in the vice. DO NOT over tighten the main spool in the vice as it will be distorted and or scratched on sealing lands and the spool will need to be replaced.

2. Remove the tension rod end using a 13 mm open end wrench.

3. Remove the plug at the other end using an 11 mm, or if it has a detent option, use a 12 mm open end wrench.

3. Flush out openings into the main spool cavity at each end.

4. Install plug with a 11 mm or 12 mm open end wrench. Torque to 8 Nm [70 lbf•in].

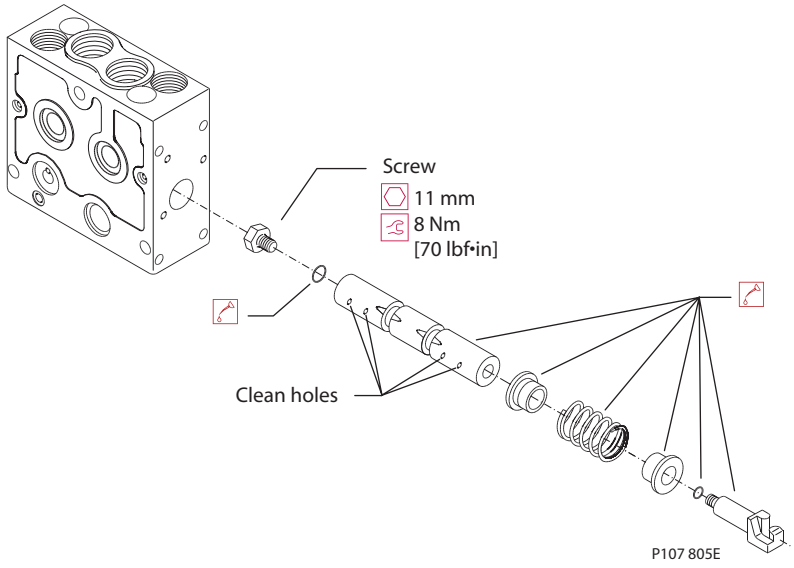
5. Install centering spring and tension rod using a 13 mm open end wrench and torque to 8 Nm [70 lbf•in].

6. Carefully reinstall the main valve spool into the valve housing. Do not force the main spool back into the housing as you will damage the sealing lands in the valve housing. The spool should move freely in the main spool bore when fully installed.

7. Install a manual actuator. Reassemble in reverse order and torque the 4 mounting screws to 8 Nm [70 lbf•in]

If section does not build pressure in one direction, wrong spool may have been installed in valve.

Main spool



SHOCK AND ANTI-CAVITATION VALVE PVLP

Description: Optional work ports non adjustable pressure relief valve.

Location: PVB (valve section) Module.

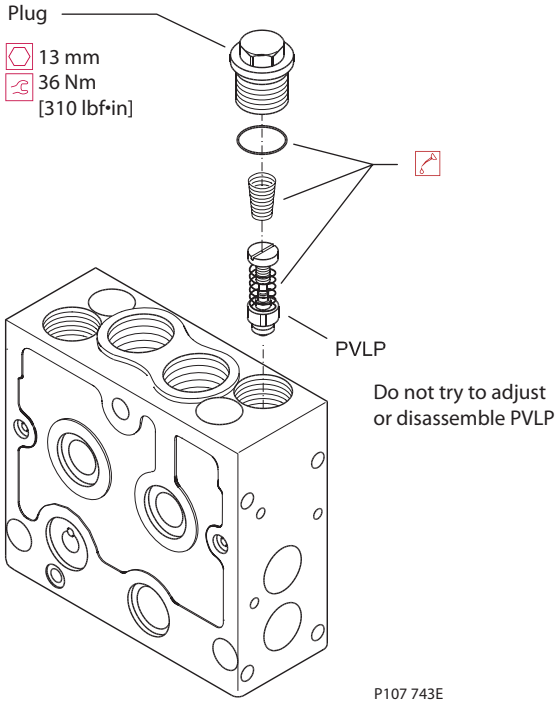
Function: Removes any transient pressure spikes generated by the load.
The shock valves PVLP with fixed setting and the anti-cavitation valves PVLA on ports A and B are used for the protection of the individual work function against overload and/or cavitation.

There is one shock valve for each work port.

Failure mode	Cause	Corrective action
Will not build pressure in A or B port	Valve may be damaged and not able to seal	Replace with correct part number per valve specification

Serviceability: This valve may be disassembled and cleaned, however, internal parts are not available separately. If you suspect valve malfunction, replace with a new valve and test system operation.

PVLP valve



PRESSURE COMPENSATOR

Description: Optional pressure compensator maintains a constant pressure drop across the main spool.

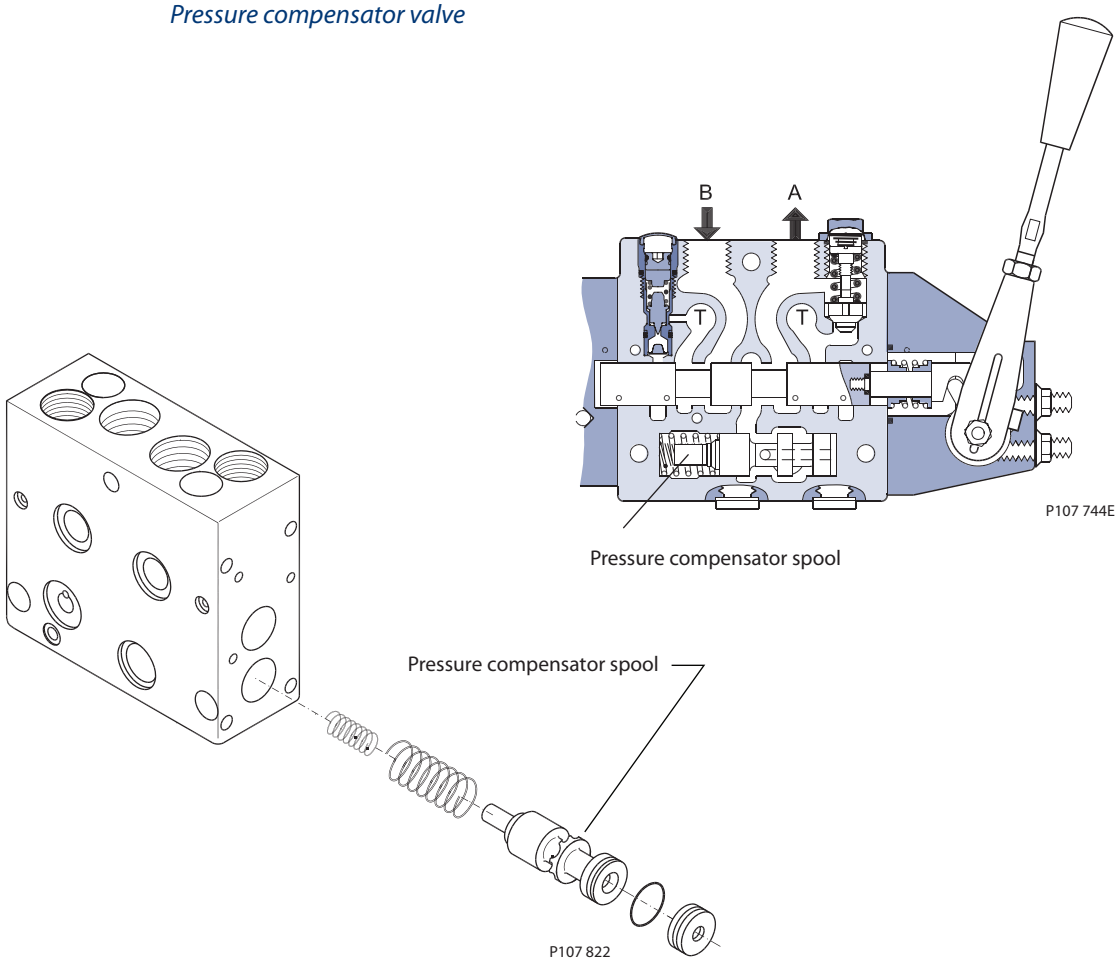
Location: PVB (Valve section) Module.

Function: In a pressure-compensated basic module the compensator maintains a constant pressure drop across the main spool – both when the load changes and when a module with a higher load pressure is actuated.

Failure mode	Cause	Corrective action
Valve section unstable flow	High wear allows leakage	Replace complete module
LS pressure limiting valve pressure adjustment will not remain static	High wear	Replace complete module

Serviceability: Pressure compensator is not serviceable. If you suspect valve malfunction, replace complete module.

Pressure compensator valve



LOAD DROP CHECK VALVE

Description: Keeps the load from dropping when transitioning from spool neutral to lifting the load.

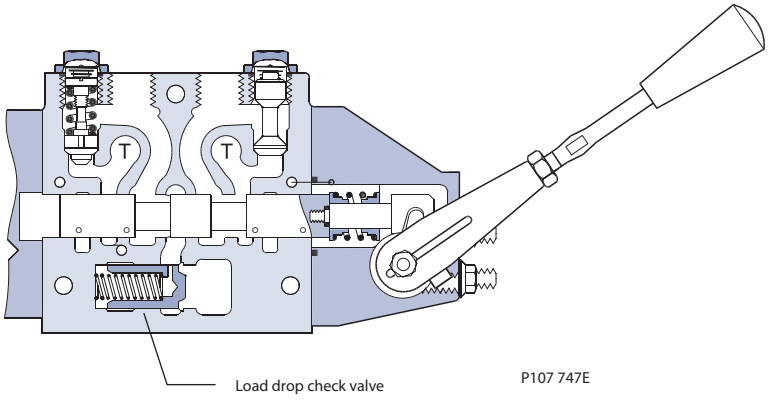
Location: PVB (valve section) module.

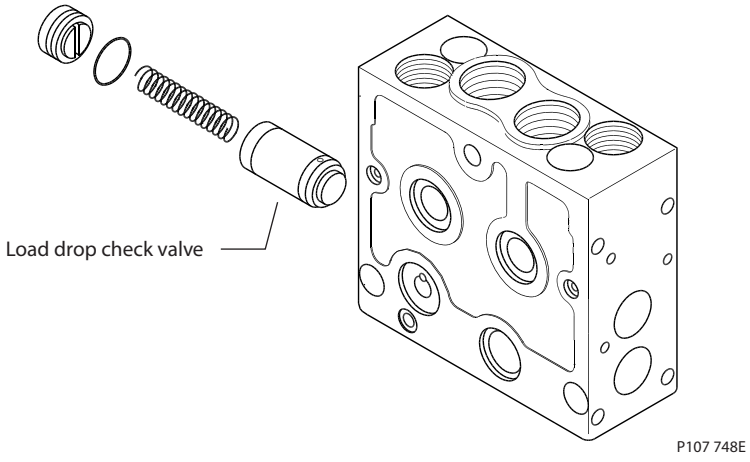
Function: Optional drop check to keep the load from dropping. Prevents high pressure functions from supplying low pressure functions when both are actuated simultaneously.

Failure mode	Cause	Corrective action
Load drops excessively when trying to lift load	Worn parts.	Replace complete PVB module
	Hard particle in seat area does not allow the seat to seal	Replace complete module

Serviceability: Load drop check valve is not serviceable. If you suspect valve malfunction, replace complete module.

Load drop check valve





MAXIMUM OIL FLOW ADJUSTMENT SCREWS FOR PORTS A AND B

Description: Optional mechanical flow limiter.

Location: PVM manual control handle.

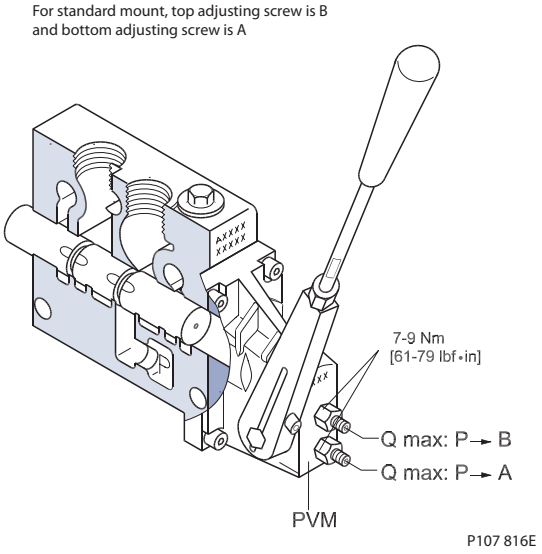
Function: Determines the stroke of the main spool in the PVB.

Failure mode	Cause	Corrective action
Cylinder/motor functions too slow or too fast	Mechanical stop screws out of adjustment per valve spec.	Use a 8mm open end wrench to loosen the jam nut and then 3mm internal hex wrench to adjust the mechanical adjusting screw CCW to increase speed. After adjusting hold the adjusting screw and torque the jam nut to 8 Nm [70 lbf•in] maximum
Leaking past adjusting screws	Check torque on seal nut 8 Nm [71 lbf•in]	Retorque or replace seal nuts

Caution

When adjusting main spool flow ensure that electrical or hydraulic actuators are not active at the time, if so equipped.

Adjusting screws for ports A and B



PVM MODULE

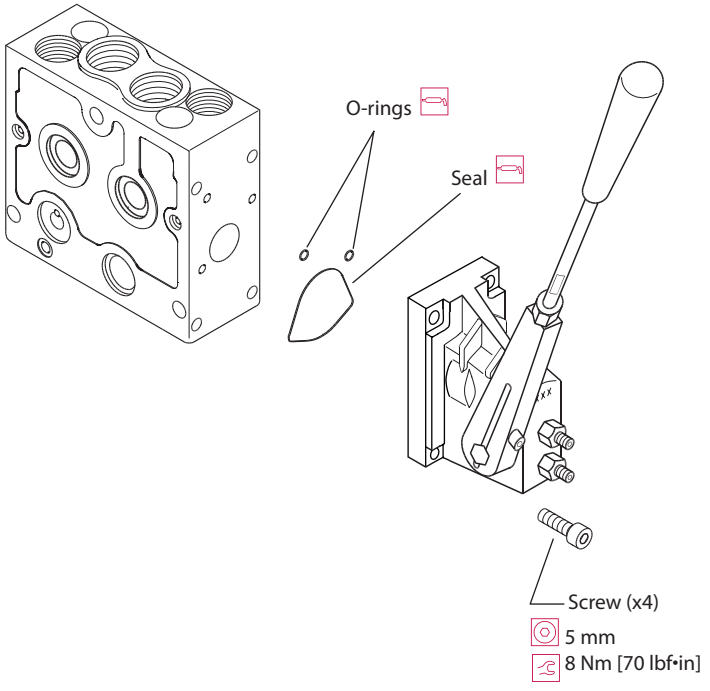
Description: Manual control lever.

Location: Mounted on either end of the PVB main spool.

Function: Manual override capable of limiting the stroke of the main spool, and is used to center the spool in neutral.

Failure mode	Cause	Corrective action
Leaking externally between PVM and PVB	Back pressure is exceeding 40 Bar [580 PSI] on tank line	Replace PVM module, seals, and lower tank port pressure
	T0 port not connected to tank or restricted or blocked	Connect to tank, remove restriction, and remove blockage

PVM module



PVS MODULE

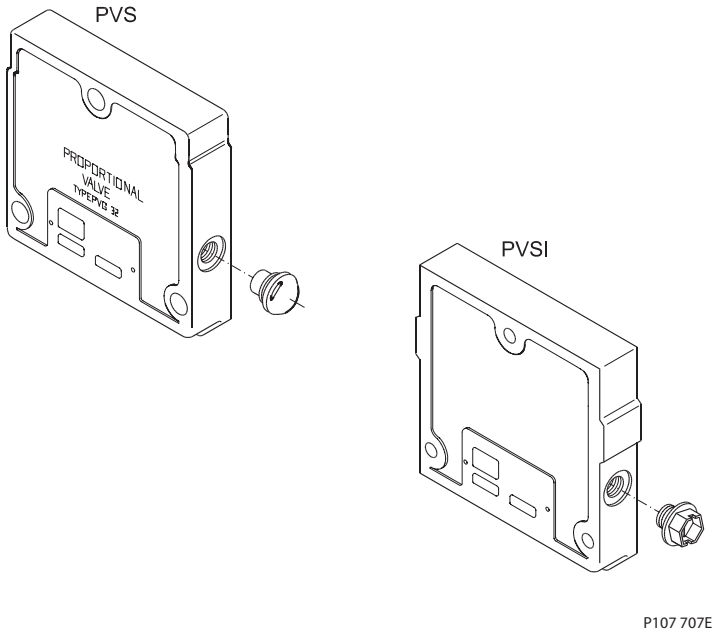
Description: End cover.

Location: Mounted on the last PVB of the valve stack.

Function: Serves as blanking cover and drain for LS circuit.

Failure mode	Cause	Corrective action
Leaking externally between PVS and PVB	Back pressure is exceeding 40 Bar [580 PSI] on tank line	Replace PVS module, seals, and lower tank line pressure
	Maximum pressure: Aluminum - 300 bar [4500 psi] Steel - 350 bar [5000 psi]	Reduce system pressure

PVS plugs



P107 707E

For specifications and operating parameters on PVG 32 valves, refer to *PVG 32 Technical Information Manual* **520L0344**.

PVPVM MODULE

Description: Mid-inlet module only for closed center systems.

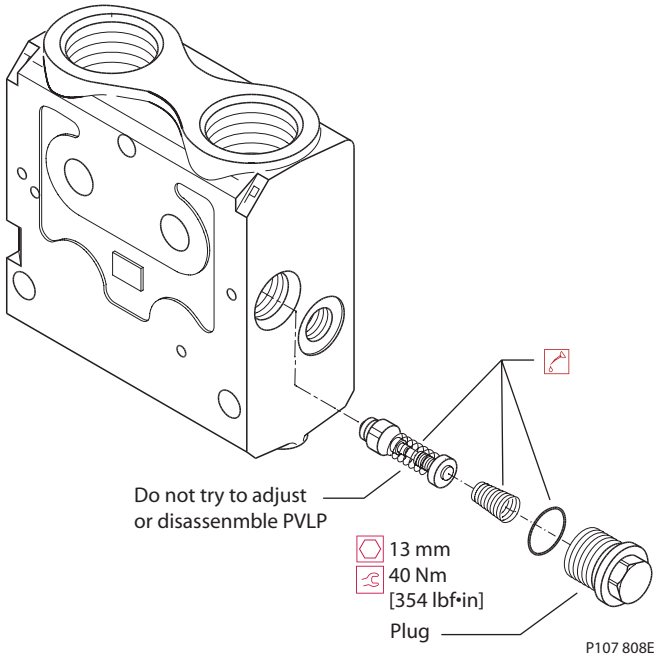
Location: Mounted between multiple PVB's in a valve stack.

Function: Provides pressure and tank connections to the valve stack allowing increased flow.

Failure mode	Cause	Corrective action
Leaking externally between PVPVM and PVB	Uneven mounting surface and mounting screw torque	Ensure the valve stack is mounted on a even surface and torque down correctly
	Tie rods torqued too tight	Replace tie rod kit which include section seals and torque to 28 Nm [248 lbf•in]
	Flow exceeding 61 gpm	Lower flow to 61 gpm, and replace the tie rod kit and seals
Valve stack can not build pressure per valve spec.	Option PVLP (shock valve) not seating correctly in cavity caused by valve not being installed correctly or it has failed	Install components correctly or replaced damaged components

* Flatness in millimeters - T= 0.35 mm X number of PVB modules + 1

PVPVM module



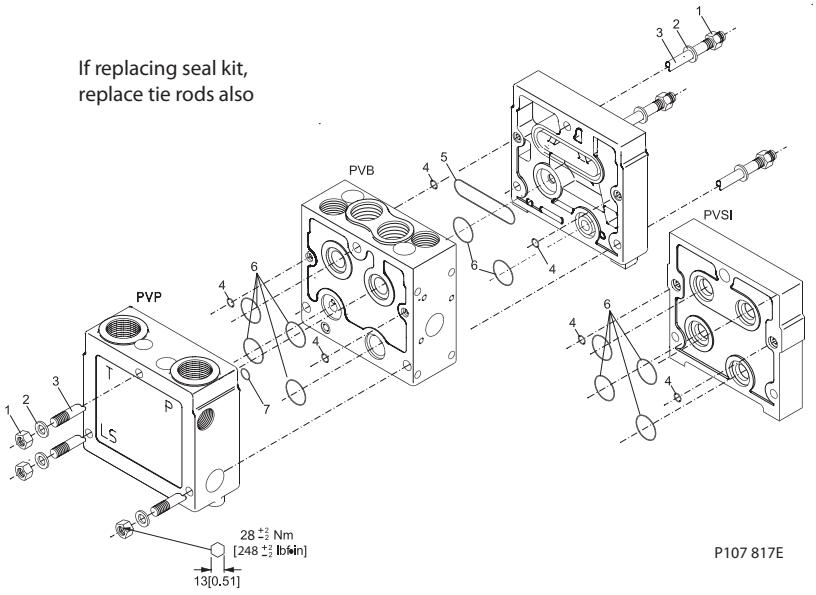
PVAS MODULE

Description: Tie rod kit.

Location: Through the valve stack.

Function: Holds the stack together.

Failure mode	Cause	Corrective action
Leaking externally between sections	Tie rods under torqued	Check and retorque - 28 Nm [248 lbf•in]
	Tie rods torque too tight	Replace and retorque - 28 Nm [248 lbf•in]



PVPX LS UNLOADING VALVE (REFER TO PAGE 13 FOR VALVE OPERATION)

Description: Optional two way two position solenoid.

Location: In the PVP.

Function: A safety device that dumps load sense to tank to prevent the pump from building pressure.

Failure mode	Cause	Corrective action
Manual override leaking externally	Not torqued correctly	Check and retorque to 45 Nm [400 lbf•in]
	High usage	Replace per valve specification
	Manual override is bent	Replace per valve specification
Solenoid will not shift	Coil not working	Replace coil per valve specification Check with OHM meter: 12 volt system - 8.7 OHMs 24 volt system - 33 OHMs
	Too high or too low of voltage	Confirm voltage in system from remote controller: 12 volt system should not exceed 13.2 volts 24 volt system should not exceed 26.4 volts

PVEH, PVES, PVEA ELECTRICAL ACTUATORS

Description: Proportional electrical actuator.

Location: On the end of the main spool of the PVB.

Function: Convert an electrical command to move the main spool to a set position.

Troubleshooting considerations

Wiring Check: It is highly possible that in the case of one PVE failing that there could be a poor connection between the joystick and the PVE in question. The PVE is reverse polarity protected and suppression protected; however an intermittent connection could degrade the input electronics to a point of failure. Inspect all wiring and connectors for corrosion and or pinch points.

Hirshman Receptacle and Mating Connector: Each PVE is supplied with a field installable 4-pin Hirshman mating connector and gasket. It is recommended that the gasket be installed between the mating connector and PVE receptacle also the rubber grommet be sealed around a multi-wire jacket in order to seal off moisture from the wiring connections. The PVE is rated for IP65 only when the Hirshman connector is sealed.

Temperature Capability: The PVE is rated for 1000 hours @ 160 °F. ambient temperature. Oil temperature wise, the area of the valve that creates the highest horsepower loss usually creates the highest temperature in the system. If one PVE section is operated more frequently than others this would create more heat than any other part of the valve. Under these conditions it is extremely important to insure that the hydraulic system is well cooled. Oil temperature measurements at the reservoir and at the center of the PVG32 valve stack. The valve should be mounted to provide the best ventilation for the PVE electronics. Poor filtration and low fluid levels may also add to temperature.

Failure mode	Cause	Corrective action
Does not work in either direction LED is green	No control voltage from the electrical controller	Check voltage from the electrical controller (25% to 75% of supply)
	Command pin wire in mating connector is broken	Repair broken wire
	Connector corroded - This condition is caused by water ingression or ground connection	Replace PVE and mating connector
Does not work in either direction LED is off	No power from the battery	Check power to electrical actuator
	Power pin wire in mating connector is broken	Repair broken wire
	Connector corroded - This condition is caused by water ingression or ground connection	Replace PVE and mating connector
	Ground connection must be hard wired straight from the battery or from the electrical controller	Repair ground connection
LED is flashing Red	Control signal is out of range	Check wiring harness for short
Works in one direction (Assuming that the manual control lever and the main spool move freely both directions)	No control voltage from the electrical controller	Ensure voltage from the electrical controller exists for that direction
	Lack of voltage to actuator (Minimum voltage 11 volts for 12 volt system and 22 volts for 24 volt system)	Check system voltage
	Electrical actuator is defective	Replace electrical actuator per spec. on the valve
Works intermittently (if LED is green it indicates a long on/off	Loose connection between the electrical actuator and controller	Repair connector
	Electrical actuator is defective	Replace electrical actuator per spec. on the valve
	Short in wiring harness	Repair wiring harness

PVEH, PVES, PVEA ELECTRICAL ACTUATORS (CONTINUED)

Failure mode	Cause	Corrective action
Works with no command from controller	Short in wiring harness	Repair wiring harness
	Electrical actuator position feed back out of adjustment	Replace the electrical actuator per valve spec.
	Fine particulate contamination	Replace PVE or electric actuator per valve specs.

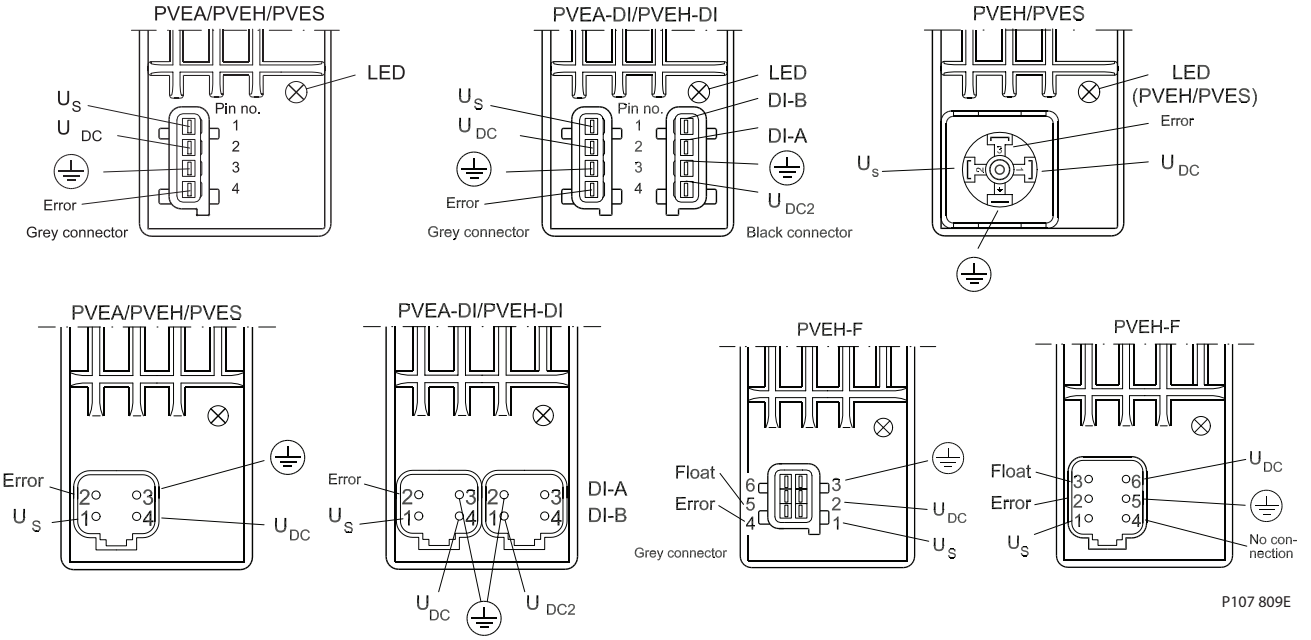
Checking input control signal:

1. Install volt meter to ground pin connection and signal pin with PVE in circuit.
2. Turn the power on for the electrical controller.
3. Actuate the electrical controller and read the voltage.
4. The control voltage should be per the electrical controller output signal.

On electrical actuators - coil resistance can not be measured at the pins.

When replacing an electrical actuator be sure that it has the same part number on it to ensure original functionality.

If filter in the electrical actuator has pieces of contamination trapped in it, this is a good indication that the complete system is contaminated and needs to be flushed. The filter in the electrical actuator can be removed and cleaned.



PVEO ON/OFF ELECTRICAL ACTUATOR

Description: Proportional electrical actuator.

Location: On the end of the main spool of the PVB.

Function: Convert an electrical command to move the main spool to a set position.

Failure mode	Cause	Corrective action
Does not work in either direction	No control voltage from the electrical controller	Check voltage from the electrical controller Resistance check (measures between pin 2 and ground): 17 OHMs for 12 volt systems 63 OHMs for 24 volt systems
	Command pin wire in mating connector is broken	Repair broken wire
	Connector corroded	Replace PVE and mating connector - This condition is caused by water ingression or ground connection
	24 volt electrical actuator used on a 12 volt system	Replace with the correct electrical actuator for a 24 volt system
	No power from the battery	Check power to electrical actuator
	Power pin wire in mating connector is broken	Repair broken wire
	Ground connection must be hard wired straight from the battery or from the electrical controller	Repair ground connection
Works in one direction (Assuming that the manual control lever and the main spool moves freely both directions)	No control voltage from the electrical controller	Check voltage from the electrical controller is there for that direction
	Lack of voltage to actuator (Minimum voltage 11 volts for 12 volt system and 22 volts for 24 volt system	Check system voltage
	Electrical actuator is defective	Replace electrical actuator per spec. on the valve
Works intermittently	Loose connection between the electrical actuator and controller	Repair connector
	Electrical actuator is defective	Replace electrical actuator per spec. on the valve
	Short in wiring harness	Repair wiring harness
Works with no command from controller	Fine contamination	Replace the electrical actuator per valve spec. and flush the complete system and fill with filtered oil
	Short in wiring harness	Repair wiring harness

PVPC PLUG FOR EXTERNAL PILOT CONTROL

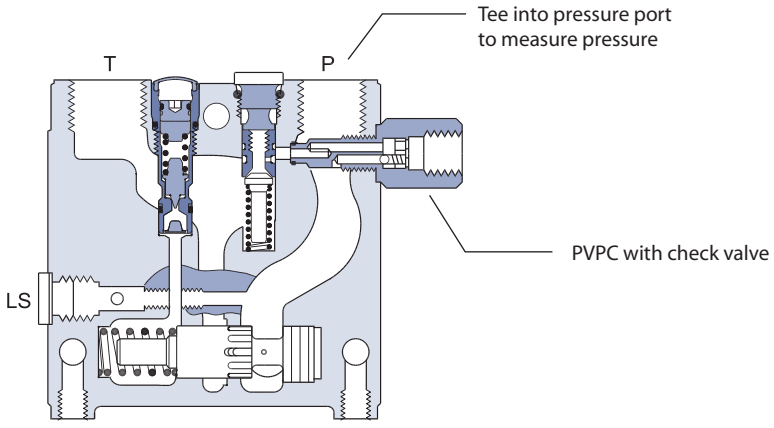
Description: Pilot oil supply from another pump.

Location: On the end of the PVP.

Function: Provides a hydraulic pilot supply to the valve stack.

Failure mode	Cause	Corrective action
Main spool moves slow, or not at all, in all sections	External hydraulic pilot pressure is too low	Check external hydraulic pressure from pilot pump and/or restrictions

PVPC plug for external pilot



P107 734E

PVMR FRICTION MODULE

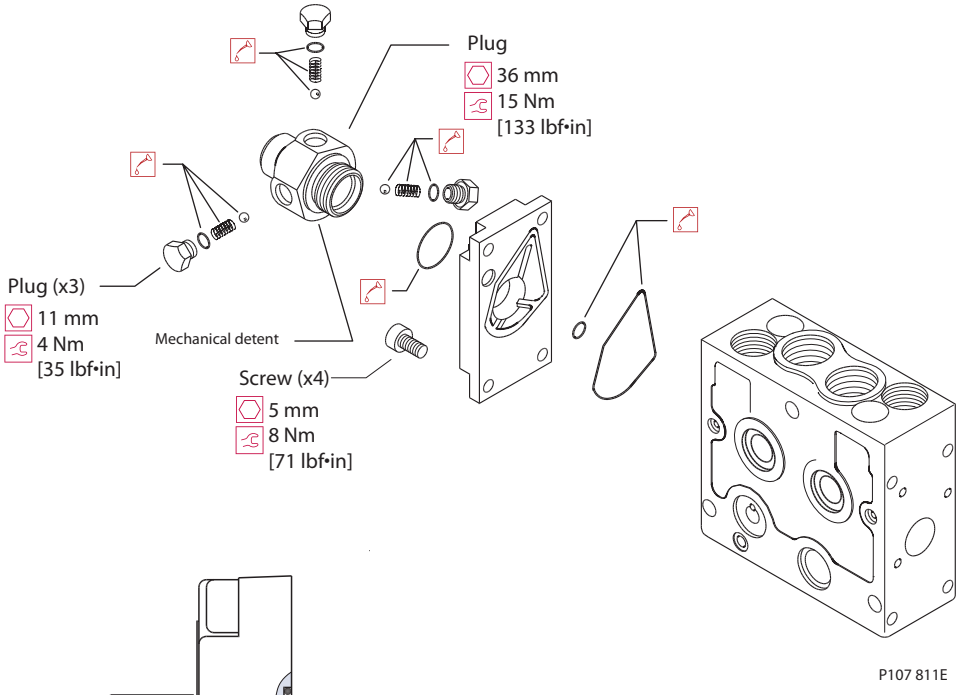
Description: Mechanical friction hold.

Location: Mounted on main spool in the PVB.

Function: Infinite mechanical positioning of the main spool.

Failure mode	Cause	Corrective action
Flow changes	Excessive flow across the main spool	Reduce flow (100 l/min or less)
	Vibration	Reduce vibration
	Broken spring	Replace broken springs
Flow changes or will not stay in detent	Check for proper assembly of parts	Install parts correctly per specification sheet

PVMR module



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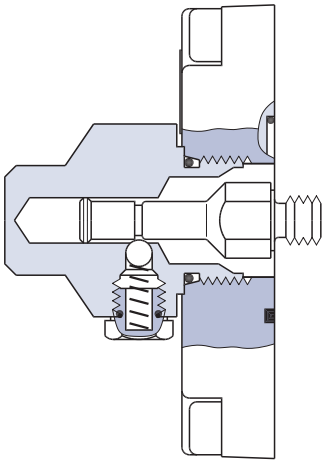

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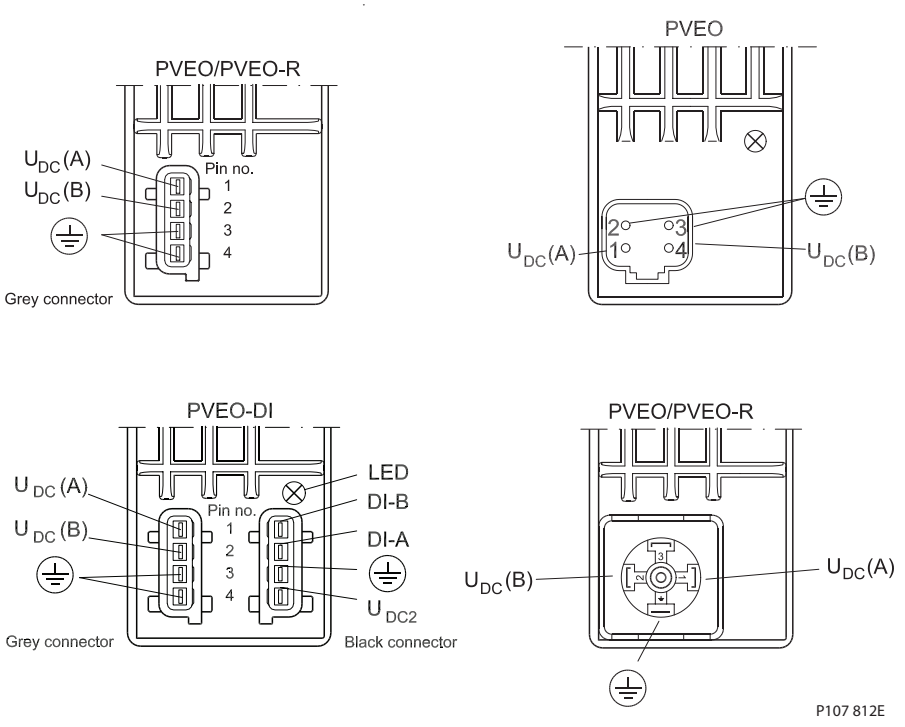
PVEO ON/OFF ELECTRICAL ACTUATOR (CONTINUED)

Checking input control signal:

1. Install a volt meter to the ground pin connection and to the signal pin.
2. Turn the power on for the electrical controller.
3. Actuate the electrical controller and read the voltage.
4. The control voltage should be per the electrical controller output range.

When replacing an electrical actuator be sure that it has the same part number on it to ensure original functionality.



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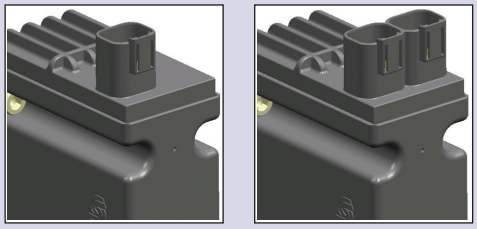
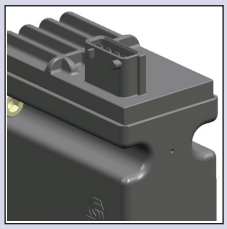
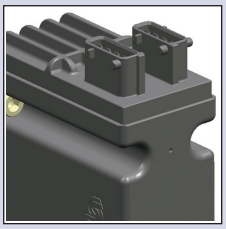
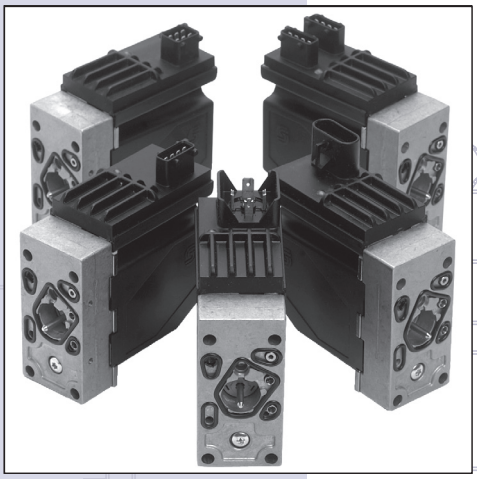
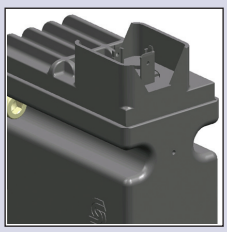
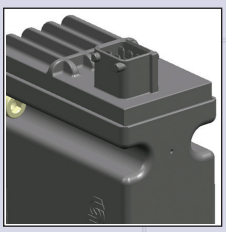
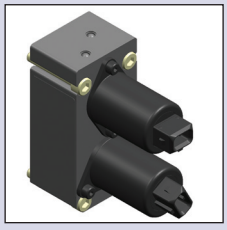
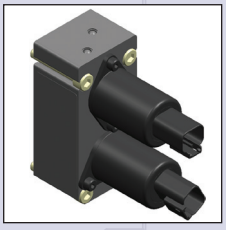
Technical Information



COMPLIANT

Revision History

Table of Revisions

Date	Page	Changed	Rev
Jun 2011	All	Major update	FA
Jan 2012	44-45	Various changes	FB
May 2012	All	Major update	GA
Aug 2012	All	Various, new articles about -NP, 1 page more moved all.	GB

List of Abbreviations

Abbreviation	Description
ASIC	**A**pplication **S**pecific **I**ntegrated **C**ircuit - the part of the PVE where spool position is controled to follow setpoint
ATEX	Certificated for use in explosive environment
AVC	**A**uxillery Valve Comand - ISOBUS/J1939 standard signal for valve control
AVCTO	**A**uxillery Valve Comand Time Out - Fault monitoring setting
AVEF	**A**uxillery Valve Estimated Flow - ISOBUS/J1939 standard signal for valve feedback
CAN	**C**ontroller **A**rea **N**etwork - Communication method used by PVED
CLC	**C**losed Loop **C**ircuit
CRC	**C**yclic **R**edundancy **C**heck - Method for ensuring validity of data.
-DI	PVE with **D**irection **I**ndication
DM1	**D**iagnostic **M**essage **1** - J1939 message informing about present fault
DM2	**D**iagnostic **M**essage **2** - J1939 message informing about fault history
DM3	**D**iagnostic **M**essage **3** - J1939 message clearing fault history
DSM	**D**evice **S**tate **M**achine. Deterministic description of system process
ECU	**E**lectronic Control Unit
EH	**E**lectro **H**ydraulic
-F	PVE for **F**loat spool. Two variants: 4 pin with float at 75%. 6 pin with separate float.
FMEA	**F**ailure **M**ode **E**ffect **A**nalysis
ISOBUS	Communication standard for CAN
J1939	Communication standard for CAN
LED	**L**ight **E**mitting **D**iode
LS	**L**oad **S**ensing
LVDT	**L**inear **V**ariable **D**ifferential **T**ransducer - Position sensor
NC	**N**ormally **C**losed solenoid valve in PVE
NC-H	**N**ormally **C**losed standard solenoid valve - like in PVE**H**
NC-S	**N**ormally **C**losed solenoid valve **S**uper - like in PVES
NO	**N**ormally **O**pen solenoid valve in PVE

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Front cover illustrations:V310299, V310300, V310294, V310292 ,V310295, V310291, F300704, drawing 157-506.

List of Abbreviations (continued)

Abbreviation	Description
PLC	**P**rogrammable **L**ogical **C**ircuit
PLUS+1™	Trademark for Sauer-Danfoss controllers and programming tool
POST	**P**ower **O**n **S**elf **T**est. Boot up evaluation for PVED
Pp	**P**ilot **P**ressure. The oil gallery for PVE actuation
PVB	**P**roportional **V**alve **B**asic module - valve slice
PVBS	**P**roportional **V**alve **B**asic module **S**pool
PVBZ	**P**roportional **V**alve **B**asic module **Z**ero leakage
PVE	**P**roportional **V**alve **E**lectric actuator
PVEA	**PVE** variant with 2-6 % hysteresis
PVED	**PVE** variant **D**igital controlled via CAN communication
PVEH	**PVE** variant with 4-9% **H**ysteresis
PVEM	**PVE** variant with 25-35% hysteresis
PVEO	**PVE** variant with **O**N/OFF actuation
PVEP	**PVE** variant **P**WM controled
PVES	**PVE** variant with 0-2% hysteresis
PVEU	**PVE** variant with $\mathbf{U_S}$ 0-10V
PVG	**P**roportional multi-section **V**alve **G**roup
PVHC	**PV** variant with **C**urrent controlled valve actuator
PVM	**P**roportional **V**alve Manual control with handle
PVP	**P**roportional **V**alve Pump side module.Inlet
PVS	**P**roportional **V**alve end plate
PVSK	**P**roportional **V**alve end plate crane. Inlet module with **S**pool Control
PWM	**P**ulse **W**idth **M**odulation
S4 DJ	**S**eries **4** **D**igital **J**1939 service tool software for PVED-CC
SAE	**S**ociety **A**utomotive **E**ngineering
-R	PVE with **R**amp function
-NP	PVE with solenoid disable in **N**eutral **P**osition
-SP	PVE with **S**pool **P**osition feedback
uC	**M**icro-**C**ontroller
uCSM	**M**icro-**C**ontroller **S**tate **M**achine
$\mathbf{U_{DC}}$	Power supply **D**irect **C**urrent; also called V_{bat} for battery voltage
$\mathbf{U_S}$	Steering voltage for the PVE control; also called V_S

PVE Series 4 for PVG 32, PVG 100 and PVG 120, Including PVHC
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Reference

Sauer-Danfoss Doc **520L0344**, *PVG 32 Proportional Valve Groups, Technical Information*.
Sauer-Danfoss Doc **520L0720**, *PVG 100 Proportional Valve Groups, Technical Information*.
Sauer-Danfoss Doc **520L0356**, *PVG 120 Proportional Valve Groups, Technical Information*.
Sauer-Danfoss Doc **520L0665**, *PVED-CC Electro Hydraulic actuator, Technical Information*
Sauer-Danfoss Doc **11070179**, *PVED-CX Electro Hydraulic actuator, Technical Information.*
Sauer-Danfoss Doc **11051935**, *PVG 32 Metric ports, Technical Information.*

Standards

- International Organization for Standardization ISO 13766 Earth moving machinery - *Electromagnetic compatibility*.
- EN 50014:1997 +A1, A2: 1999
- EN 50028: 1987. For ATEX approved PVE
  - IEC EN 61508
  - ISO 12100-1 / 14121
  - EN 13849 (Safety related requirements for control systems)
  - Machinery Directive 2006/42/EC" (1st Edition December 2009)

PVE with connector variants:

Hirschmann or DIN *Deutsch* *AMP*

Warnings

Please work through all warnings before implementing actuators in any application. The list of warnings must not be seen as a full list of potential dangers. Depending on application and use other potential dangers can occur.

Warnings are listed next to the most relevant section and repeated in a special section at the end of Technical Data.

⚠ Warning

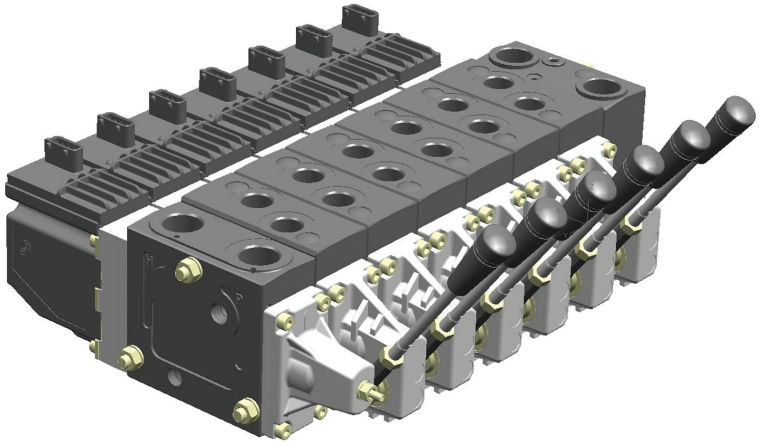
All brands and all types of directional control valves – including proportional valves – can fail and cause serious damage. It is therefore important to analyze all aspects of the application. Because the proportional valves are used in many different operation conditions and applications, the machine builder/ system integrator alone is responsible for making the final selection of the products – and assuring that all performance, safety and Warning requirements of the application are met.

Introduction

PVE Series 4 is the common name for the Sauer-Danfoss PVG electrical actuator.

This technical information covers our voltage controlled PVE and our current controlled PVHC actuator. For the PVHC please see in the PVHC section. The digital actuators PVED-CC and PVED-CX are covered in their special technical information.

PVE controlled PVG with PVSK



PVE stands for Proportional Valve Electrical actuator.

The Sauer-Danfoss PVE is built on more than thirty years experience of electrical valve control and is the perfect fit for our high performance proportional valves PVG32, PVG100 and PVG120, as it is for our EH steering.

All our products are developed in close cooperation with system manufacturers from the mobile hydraulic market. That is the reason for our high performance in all market segments

The PVE can be controlled from a switch, a joystick, a PLC, a computer or a Sauer-Danfoss PLUS+1™ micro-controller.

The PVE is available in multiple variants. A short list here just gives the main variations.

Available PVE variants

Actuation	On/Off
	Proportional - Closed loop controlled
	Proportional - Direct control
Control signal	Voltage
	PWM
	Current (PVHC)
Precision	Standard precision
	High precision
	Super high precision
Feedback	Spool position
	Direction indicator
	Error
	None
Connectors	Deutsch
	AMP
	DIN/Hirschmann
Fault detection and reaction	Active
	Passive
	None
Power supply	11V – 32V multi-voltage
	12V
	24V

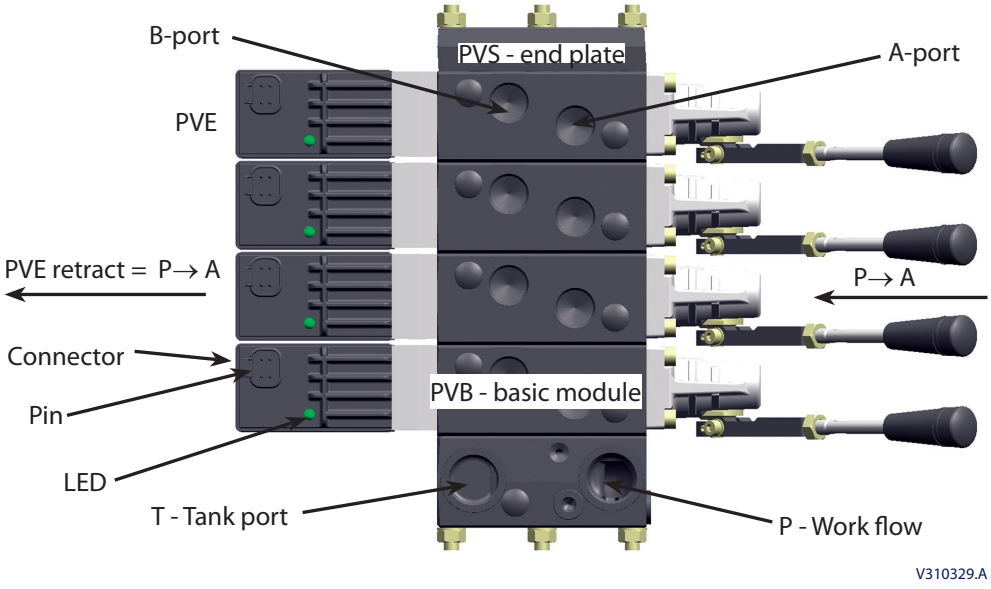
Overview

The PVG is a sectional spool valve stack with up to 12 individually controlled proportional valves. With the PVE the PVG can be operated as single valves or several valves in cooperation.

The oil flow out of the work section (A- or B-port) can be controlled by a combination of the following:

- PVE controlling the spool position using pilot oil pressure.
- A handle (PVM) in mechanical interface with the spool.

PVG 32 structural lay-out with naming



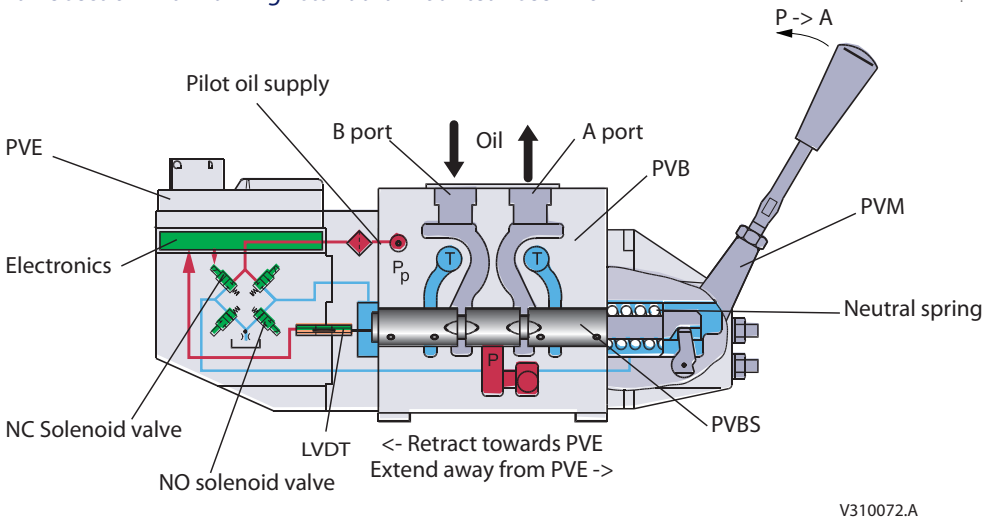
PVG Functionality

The PVG valve distributes oil from pump flow to a particular work function in the application via a specific valve section. This is done by moving the spool (PVBS).

Depending on the choice of components the oil work flow enters the PVG through the PVP (proportional valve pump side module), a PVSK, a mid inlet or other system interface and enters the PVB (proportional valve basic module) via the P gallery and leaves through the T gallery. The PVP/PVSK also supplies the Pilot oil pressure (Pp) for the PVE to activate the spool (PVBS). Special designed float spools also allow oil flow in both directions between A- and B-port not opening to pump nor tank.

When looking at the figure you see the valve section from PVP towards PVS with the PVM and PVE standard mounted. When PVM and PVE are interchanged it's called option mounted.

Valve section with naming - standard mounted - seen from PVP



Oil out of A-port = PVM pushed towards PVB = retract = LVDT moves into PVE.

With the spool in neutral, default position when held by the neutral spring, the connection to the application via ports is blocked.

Moving the PVBS towards the PVE, as in the figure, opens a connection between P and A and also between B and T. This is done by either pushing the PVM or activating the PVE.

The PVE moves the PVBS by letting Pilot Oil Pressure (Pp) push on the right end of the PVBS and releasing pressure from the left end.

For details on PVG 32 please see *PVG 32 Proportional Valve Groups, Technical Information,* **520L0334**.

PVE Functionality

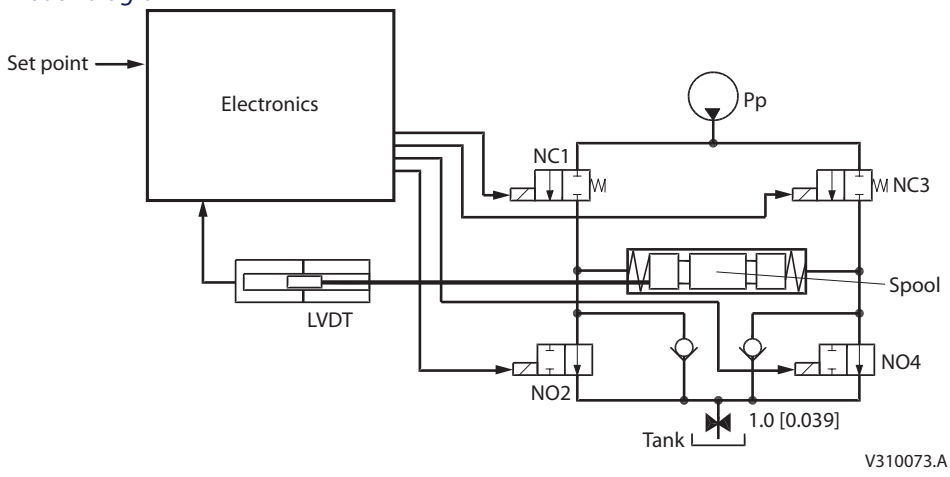
This section has focus on how the PVE works and interacts. The description here is general and variant specific descriptions will all refer to this.

The PVE is an electro mechanical device, meaning that functionality is depending on mechanical, hydraulic, electrical and control conditions given by PVE, PVG, application and vehicle. The result of this is that implementing operation and safety conditions also must include vehicle specific considerations.

Hydraulic subsystem

The hydraulic subsystem is used for moving the spool and thereby open the valve for work flow.

Pilot oil diagram



The hydraulic sub system moves the spool and thereby opens the valve for work flow. The heart in the hydraulic subsystem is the solenoid valve bridge which controls the Pilot Pressure (Pp) on spool ends. It consist of four poppet valves, the two upper are normally closed (NC) and the two lower are normally open (NO). The Pp will work against the PVBS neutral spring when the spool is moved out of blocked (neutral) and together with the spring when going in blocked. This combined with a larger opening in the NO than in the NC will give a faster movement towards blocked than out of blocked.

When the PVE is powered the solenoids are all put in closed state. To move the PVBS to the right NC1 and NO4 are opened and NC3 and NO4 are kept closed.

The activation of the solenoid valves represents oil consumption and thereby also a pressure drop in the pilot oil gallery. By simultaneous use of multiple PVE the Pp can fall and result in performance problems.

The two check valves next to the NO are anti-cavitation valves.
The orifice to tank reduces tank pressure spikes and can also be used for ramp function.

⚠ Warning

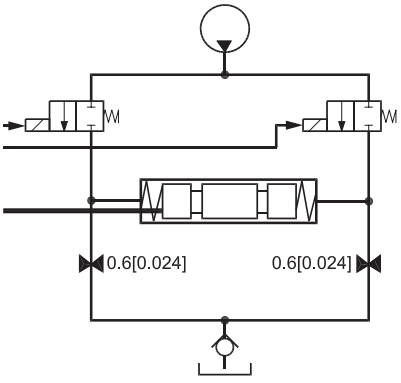
Obstacles for the Pilot oil pressure (Pp) can have direct influence on spool control. Reduced Pp will limit spool control. Too high Pp can harm the PVE.

PVE Functionality (continued)

Warning
PVEA is not for use on PVG 100.

Hydraulic variants: PVEA

NO2 and NO4 are replaced with orifices.



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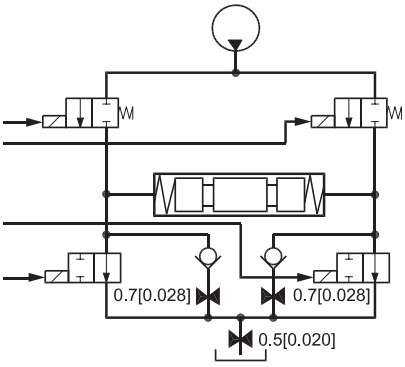
PVE with ramp

Tank orifice has smaller diameter.



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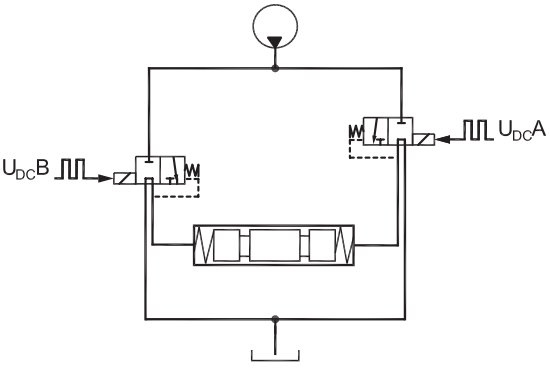
Hydraulic variant: PVHC

The PVHC does not work as a PVE and does not have transducer, anti cavitation nor protection against tank pressure spikes.
It is necessary to use the PVHC in combination with 25 bar [362.6 psi] pilot pressure, and standard FC spools fitted for hydraulic actuation. See *PVG 32 Proportional Valve Groups, Technical Information* **520L0344**, *PVG 100 Proportional Valve Groups, Technical Information* **520L0720**, and *PVG 120 Proportional Valve Groups, Technical Information* **520L0356**.

Because of the 25 bar pilot pressure, it is not possible to combine PVHC with PVE on a PVG.

Hydraulic variant: PVHC



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With electrical proportional actuation, the main spool position is adjusted so that its position corresponds to an electrical control signal.

The control signal is converted into a hydraulic pressure signal that moves the main spool in the PVG. This is done by means of two proportional pressure-reducing valves.

The electrical actuator can be controlled either by a current amplifier card, or directly from a programmable micro-controller.

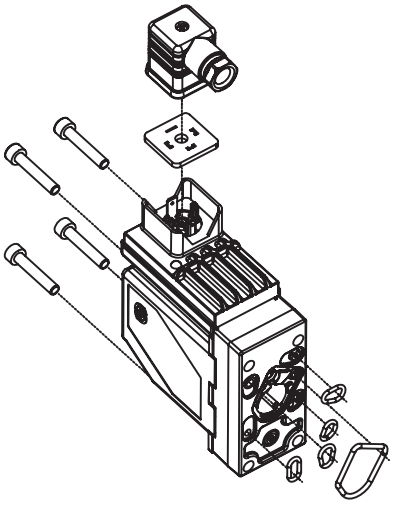
PVE Functionality (continued)

Mechanical Subsystem

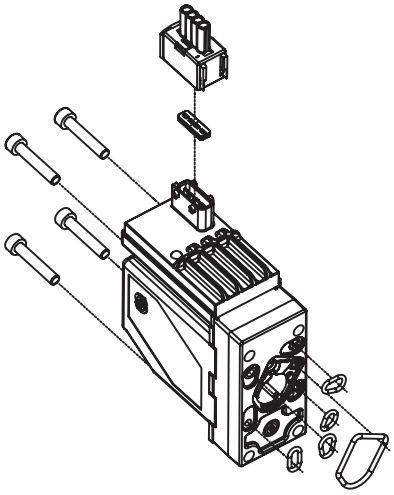
The mechanical subsystem gives interface to valve and control system and provides protection to hydraulic and electrical/electronic subsystem. The LVDT, not used on all variants, gives feed back to electronics on spool position. The LVDT is calibrated in production and recalibration should only be done in special cases. The standard PVE has an aluminum block for distributing pilot oil. PVE with anodized block are available.

The connector gives the electrical interface to power and control system. Sauer-Danfoss have a variety of connectors. We know that tradition and the aspects of serviceability are important when our customers choose. We have chosen the Deutsch connector as our main solution. The quality of wiring has direct influence on water integrity and signal quality therefore disturbance or changes in cabling can influence safety and performance.

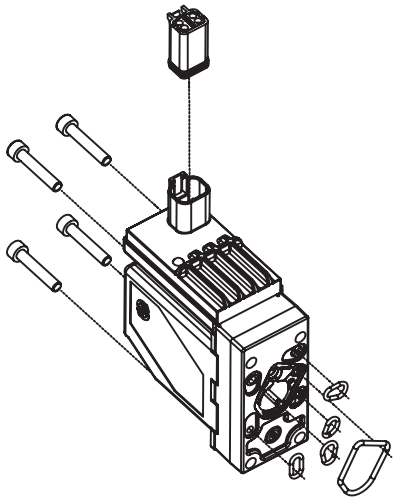
PVE, Hirschmann/DIN connector



PVE, AMP connector



PVE, Deutsch connector



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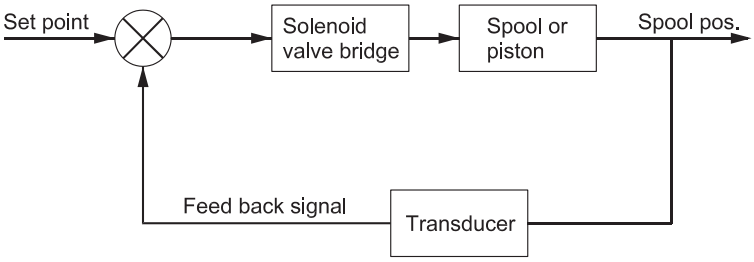
PVE Functionality (continued)

Electronic subsystem

The PVE (A/ H/ M/ S/ U) control signal is a low current voltage, a PWM can also be used. The PVEP has build-in a PWM evaluation and cannot be controlled by proportional voltage. The control signal is referred to as U_S.

Function blocks for electronics



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The PVE features Closed Loop Control (CLC). This is made possible by on board electronics and an integrated feedback transducer that measures spool movement. The integrated electronics compensate for flow forces on the spool, internal leakage, changes in oil viscosity, pilot pressure, etc. This results in lower hysteresis and better resolution.

In principle the set-point determines the level of pilot pressure which moves the main spool. The position of the main spool is sensed in the LVDT which generates an electric feed-back signal registered by the electronics. The variation between the set-point signal and feed-back signal actuates the solenoid valves. The solenoid valves are actuated so that hydraulic pilot pressure drives the main spool into the correct position.

The LVDT (Linear Variable Differential Transducer) is an inductive transducer with very high resolution. When the LVDT is moved by the main spool a voltage is induced proportional to the spool position. The use of LVDT gives contact-free connection between mechanics and electronics. This means an extra long lifetime and no limitation as regards the type of hydraulic fluid used.

The PVEO and PVHC do not have embedded control electronics and do not support closed loop control.

Safety and Monitoring

The choice of PVE also decides the level of feedback and safety. PVE are available with fault monitoring, spool direction indication, spool position feedback and separate float control.

The fault monitoring is available in PVEA/H/S/P/U and is a utilization of the ASIC.

Direction Indication is available in PVEO/A/H and they are dual powered PVE where separate pins give an active feedback for spool movement.

Spool position is available in PVES and is a precise feedback on a separate pin for actual spool position.

The separate float control is a protection against unintended float activation.

The PVEM, PVEO and PVHC do not have fault monitoring.

Fault monitoring and reaction

The fault monitoring system is available in two versions:

- **Active fault monitoring** provides a **Warning** signal and deactivates the solenoid valves. A reboot of the PVE is required to reactivate.
- **Passive fault monitoring** provides a **Warning** signal only. A reboot is not required.

Both active and passive fault monitoring systems are triggered by the same four main events:

1. *Control signal monitoring*
   The Control signal voltage (U_S) is continuously monitored. The permissible range is between 15% and 85% of the supply voltage. Outside this range the section will switch into an error state. A disconnected U_S pin (floating) is recognized as neutral set point.

2. *Transducer supervision*
   The internal LVDT wires are monitored.
   If the signals are interrupted or short-circuited, the PVE will switch into an error state.

3. *Supervision of spool position*
   The actual position must always correspond to the demanded position (U_S).
   If the actual spool position is further out from neutral than the demanded spool position (>12%, PVEA: >25%) or in opposite direction, the PVE will switch into an error state. With neutral/blocked setpoint the tolerance is +- 0,5 mm relative the calibrated neutral position. Spool position closer to neutral and in same direction will not cause an error state. The situation is considered *"in control"*.

4. *Float monitoring*
   Float must be entered or left within a time limit. On the six pin float PVE too high delay will cause an error state. The float Time Outs has own thresholds. Only relevant for the six pin PVEH-F.

Safety and Monitoring (continued)

Active fault reaction is activated after 500 ms of error (PVEA: 750 ms).

- The solenoid valve bridge is disabled and the PVBS is released to spring control
- The error pin is powered*
- The LED change color
- The state is memorized and continues until PVE reboot

Passive fault reaction is activated after 250 ms of error (PVEA: 750 ms)

- The solenoid valve bridge is **NOT** disabled and the PVBS is **NOT** released
- The error pin is powered*
- The LED change color
- The state is active for minimum 100 ms and is reset when error disappears

* for PVE with direction indication both DI pins goes low by fault.

⚠ Warning

Error pins from more PVEs may not be interconnected.
Not activated error pins are connected to ground and will disable any active signal.
Error pins are signal pins and can only supply very limited power consumption.

To avoid the electronics in undefined state a general supervision of power supply (U_{DC}) and internal clock frequency is implemented. This function applies to PVEA, PVEH, PVEP, PVES and PVEU independently of fault monitoring version and PVEM - and will not activate fault monitoring.

The solenoid valves are disabled when:

- the supply voltage exceeds 36 V
- the supply voltage falls below 8.5 V
- the internal clock frequency fails

Safety and Monitoring (continued)

Fault monitoring overview

Type	Fault monitoring	Delay before error out	Error mode	Error output status	Fault output on PVE [1]	LED light	Memory (reset needed)
PVEO PVEM PVHC	No fault monitoring	-	-	-	-	-	-
PVEA PVEH PVEP PVES PVEU	Active	500 ms (PVEA: 750 ms)	No fault	Low	< 2 V	Green	-
			Input signal faults	High	~U_{DC}	Flashing red	Yes
			Transducer (LVDT)			Constant red	
			Close loop fault				
	Passive	250 ms (PVEA: 750 ms)	No fault	Low	< 2 V	Green	-
			Input signal faults	High	~U_{DC}	Flashing red	No
			Transducer (LVDT)			Constant red	
			Close loop fault				
PVE Float six pin	Active	500 ms	Float not active	High	~U_{DC}	Constant red	Yes
		750 ms	Float still active				

1) Measured between fault output pin and ground.

⚠ Warning

It's up to the customer to decide on the required degree of safety for the system.

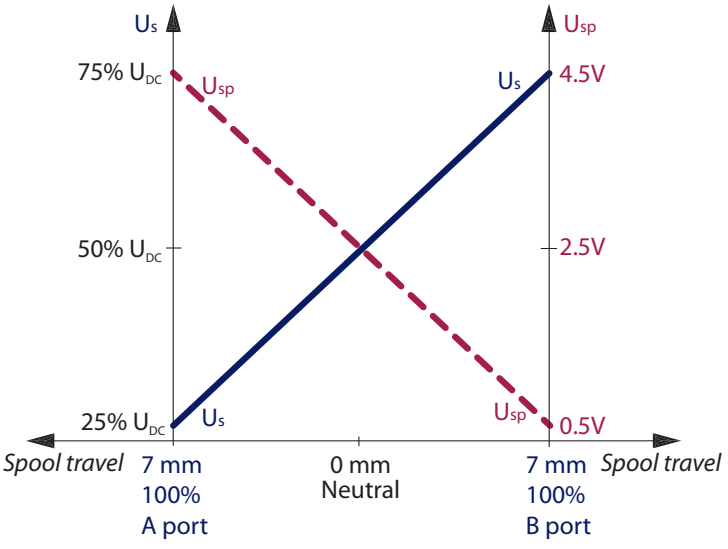
For PVE with direction indication:

- both DI pins go low when error is active.
- when U_{DC1} is disabled, U_S is not monitored and defined as 50%.

Spool Position Feedback (-SP)

The –SP functionality is a 0,5V to 4,5V feedback, inverted in direction relative to U_S with 2,5V as neutral value.

Spool Position Feedback



Direction Indication Feedback (-DI)

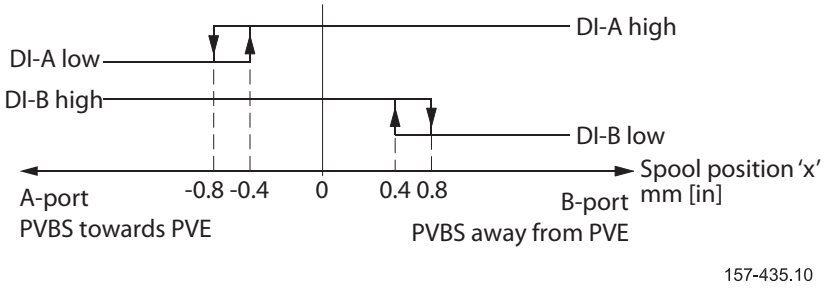
PVE with build in indication for spool movement direction are available.

The PVE–DI has dual power supply. U_{DC1} only supplies solenoid valves. U_{DC2} supplies electronics and feed back. The PVE does not work without U_{DC2}. DI-A and DI-B are relative standard mounting. The input signal fault monitoring is disabled if U_{DC1} is disabled. DI-A and DI-B are relative standard mounting.

The DI has two direction feeedback signals with output high (close to U_{DC}) when the spool is in neutral position. If the spool moves out of neutral position, the direction signal switches to low (< 0.2 V). One of the signals goes low by spool ~0,8 mm out of neutral and high by spool within 0,4 mm out of neutral.

Both direction indication signals go low when the error indicator goes high.

Direction Indication Feedback



As shown in the figure, both "DI-A" and "DI-B" signals are "High" when the spool is in neutral position.
When the spool is moving in the A direction, the "DI-A" signal goes "Low" and the "DI-B" signal stays "High".
The reverse is true when the spool is moved in the B direction.

Values for both Direction Indicators, pin A and pin B

Transition to low from high	0.8 ± 0.1 mm [0.031 in]
Transition to high from low	0.4 ± 0.1 mm [0.015 in]
Transition to low both pins	error pin goes high
Maximum load of "DI-A" , "DI-B"	50 mA
Voltage DI high by load 20 mA	> U_{DC} – 1.5 V
Voltage DI high by load 50 mA	> U_{DC} – 2.0 V
Voltage DI low	< 0.2 V

Solenoid disabling function (-NP)

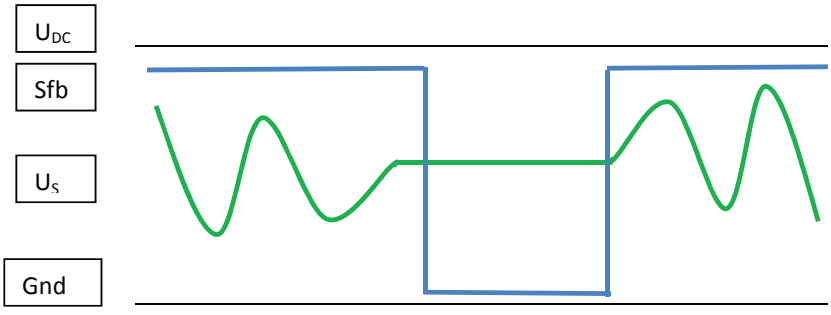
PVEH-NP and PVEA-NP have a build in feature that disables the solenoids by US at 50% and gives a feedback on the solenoid status. This is done to facilitate application monitoring.

The fault monitoring is still activated but the closed loop will remain passive until the control signal shifts.

U_S disable range		48 % U_{DC} to 52 % U_{DC}
Solenoid disable reaction time	**From active to passive**	750 ms <-> 1000 ms
	From passive to active	0 ms <-> 50 ms
Solenoid feedback signal	**Maximum load**	50 mA
	Voltage if solenoid active by load 20 mA	> U_{DC} – 1.5 V
	Voltage if solenoid active by load 50 mA	> U_{DC} – 2.0 V
	Voltage if solenoid passive	< 1 V

PVEH-F (six pin) has also the disable function but not the feedback.
Our general recommendation is disabling of PVE that are not in active use.

Solenoid disabling function (-NP) curves



Building in Safety

All brands and all types of control valves (incl. proportional valves) can fail. Thus the necessary protection against the serious consequences of function failure should always be built into the system. For each application an assessment should be made for the consequences of pressure failure and uncontrolled or blocked movements.

To determine the degree of protection that is required to be built into the application, system tools such an FMEA (Failure Mode and Effect Analysis) and Hazard and Risk Analysis can be used.

FMEA (Failure Mode and Effect Analysis) IEC EN 61508

FMEA is a tool used for analyzing potential risks. This analytical technique is utilized to define, identify, and prioritize the elimination or reduction of known and/or potential failures from a given system before it is released for production.
Please refer to IEC FMEA Standard 61508.

Hazard and Risk Analysis ISO 12100-1 / 14121

This analysis is a tool used in new applications as it will indicate whether there are special safety considerations to be meet according to the machine directives EN 13849. Dependent on the determined levels conformety this analysis will detirmine if any extra requirements for the product design, development process, production process or maintenance, i.e. the complete product life cycle.

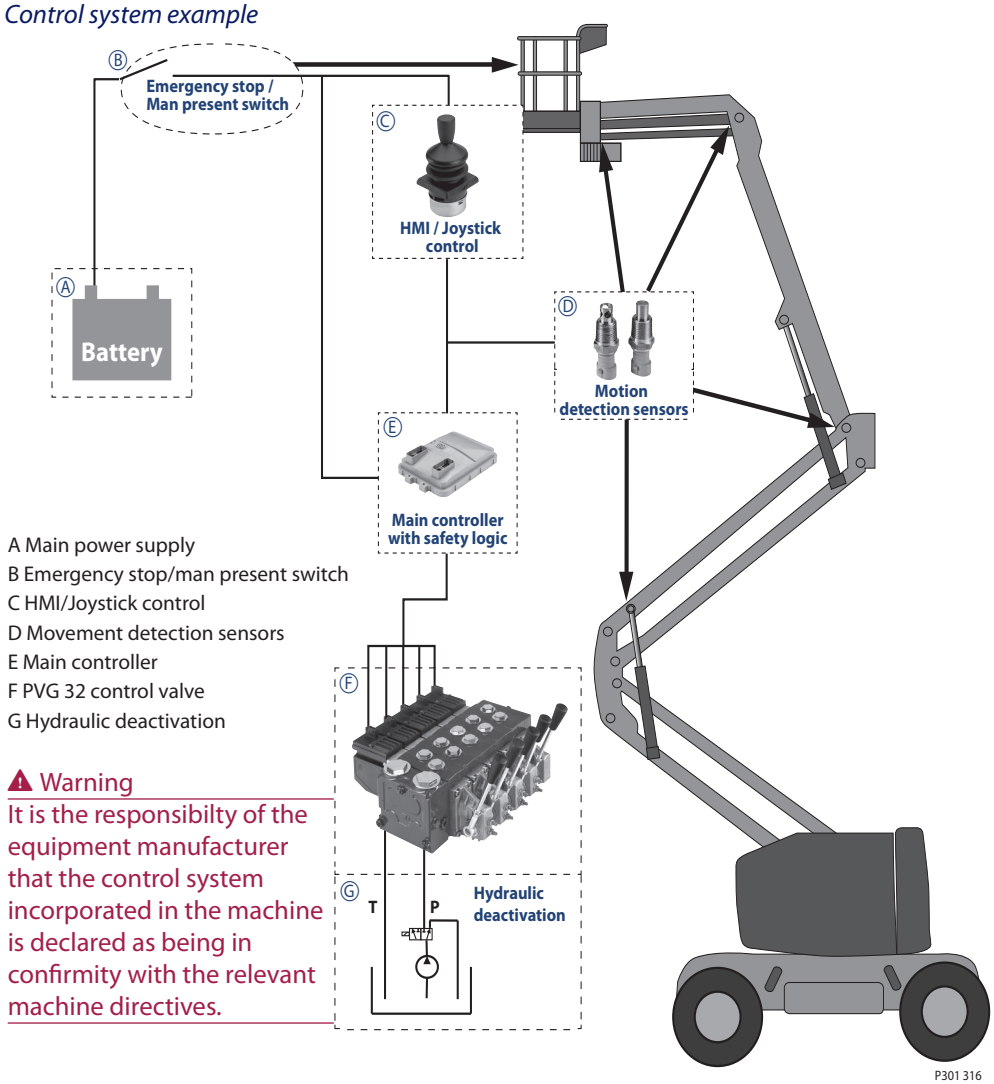
⚠ Warning

All brands and all types of directional control valves – including proportional valves – can fail and cause serious damage. It is therefore important to analyze all aspects of the application. Because the proportional valves are used in many different operation conditions and applications, the machine builder/ system integrator alone is responsible for making the final selection of the products – and assuring that all performance, safety and Warning requirements of the application are met.

Control System Example

Example of a control system for manlift using PVE Fault monitoring input signals and signals from external sensors to ensure the PLUS+1™ main controllers correct function of the manlift.

Control system example

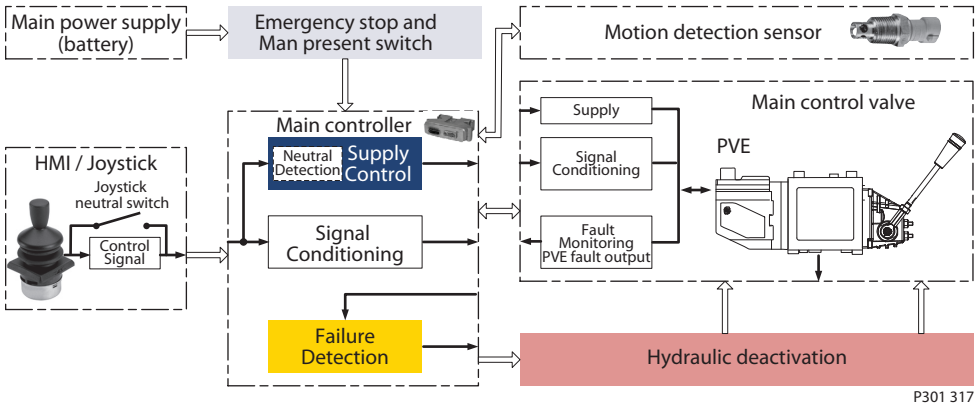


A Main power supply
B Emergency stop/man present switch
C HMI/Joystick control
D Movement detection sensors
E Main controller
F PVG 32 control valve
G Hydraulic deactivation

⚠ Warning

It is the responsibilty of the equipment manufacturer that the control system incorporated in the machine is declared as being in confirmity with the relevant machine directives.

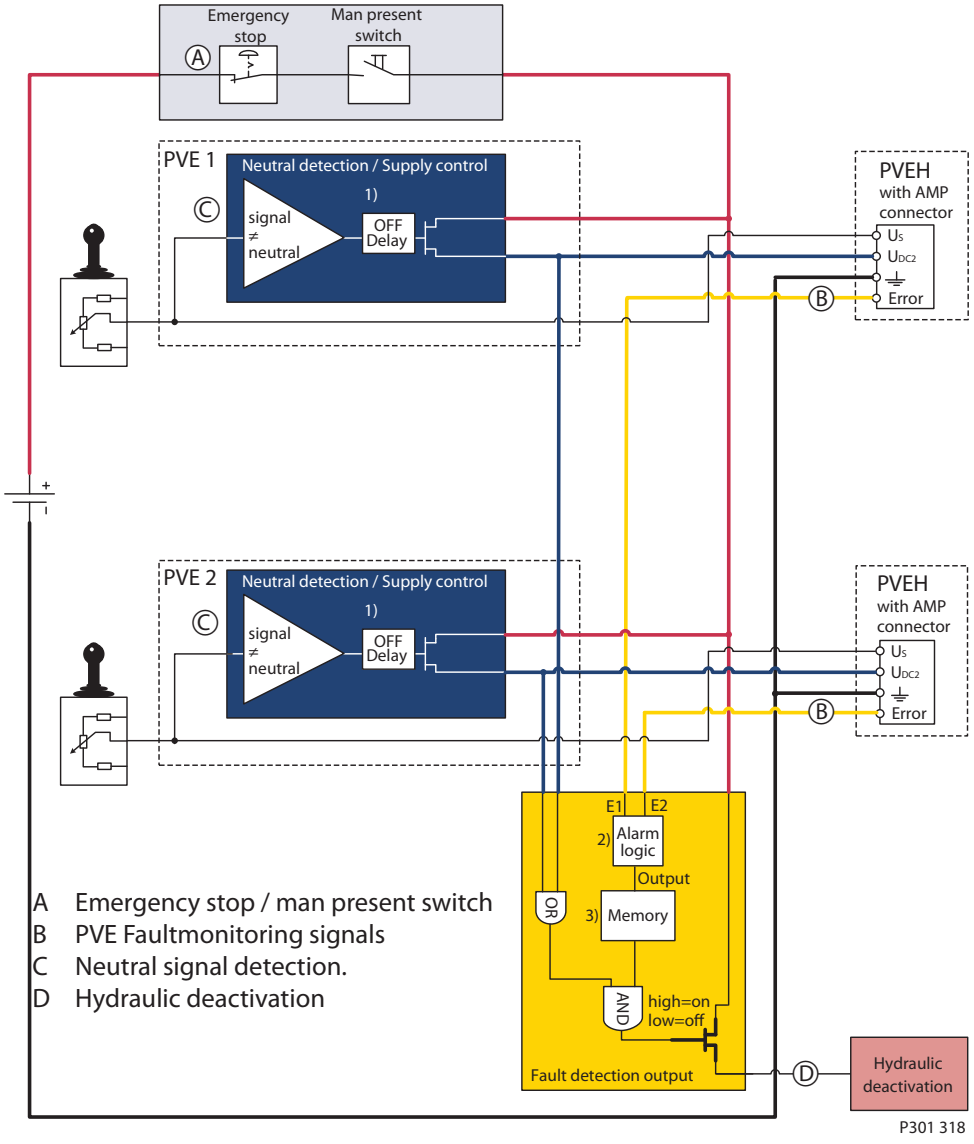
Electrical block diagram for above illustration



Control System Example (continued)

Example of a typical wiring block diagram using PVEH with neutral power off switch and fault monitoring output for hydraulic deactivation.

Typical wiring block diagram example



System Control Logic e.g. PLUS+1™ for signal monitoring and triggering signal for deactivation of the hydraulic system.

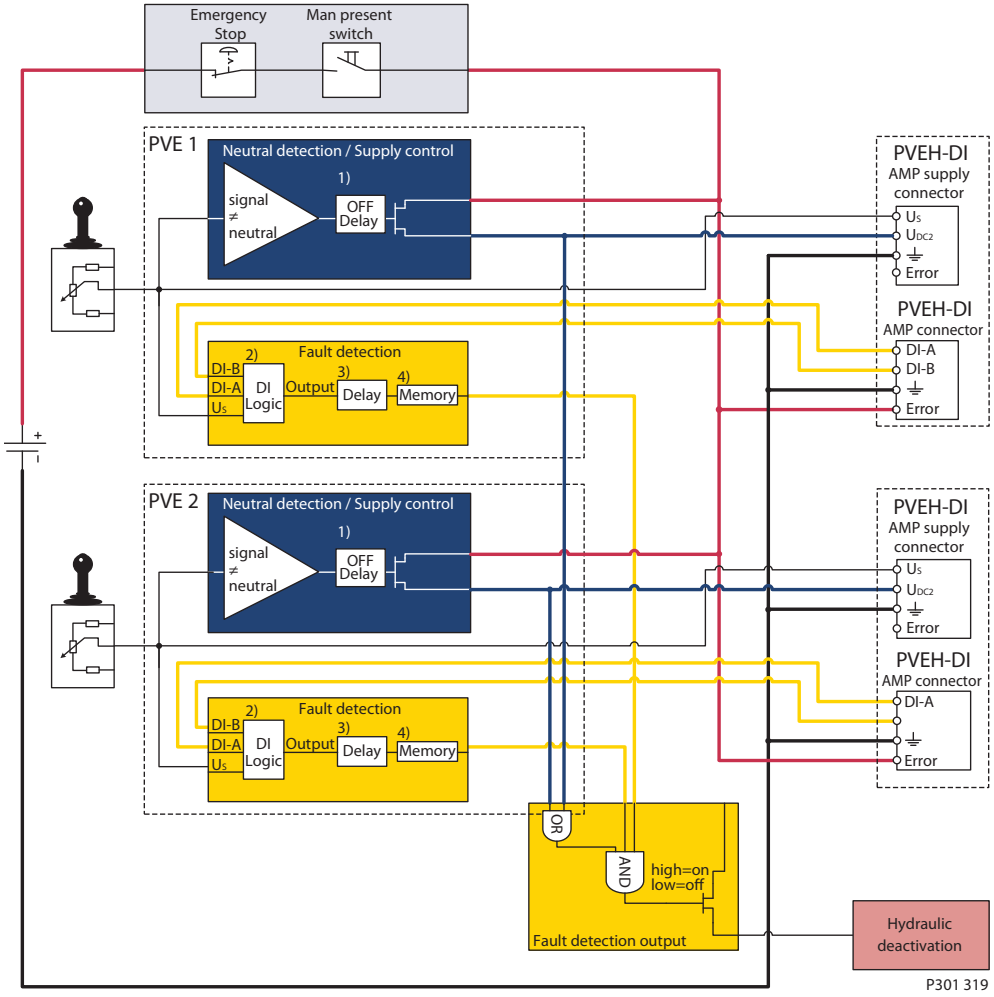
⚠ Warning

It is the responsebilty of the equipment manufacturer that the control system incorporated in the machine is declared as being in confirmity with the relevant machine directives.

Control System Example (continued)

Similar to previous example using fault monitoring for deactivation of the hydraulic system with extra fault inputs using the PVE's with DI (Direction Indication) function.

Example of fault monitoring for deactivation of the hydraulic system



System Control Logic e.g. PLUS+1™ for signal monitoring and triggering signal for deactivation of the hydraulic system.

⚠ Warning

It is the equipment manufacturers responsibility to ensure that the control system incorporated in the machine is declared as being in conformity with the relevant machine directives.

Other non-electrical modules which can be used in connection with hydraulic deactivation at different levels.

Control System Example (continued)

PVG32– Mainly used in system with fixed displacement pumps

- PVSK, commonly used in crane application - full flow dump
- PVPE, full flow dump for the PVG 120

PVG100 – Alternative LS dump or pilot supply disconnect

- PVPP, pilot oil supply shut off
- External cartridge valve connecting LS Pressure to Tank
- External cartridge valve connecting main Pressure to Tank

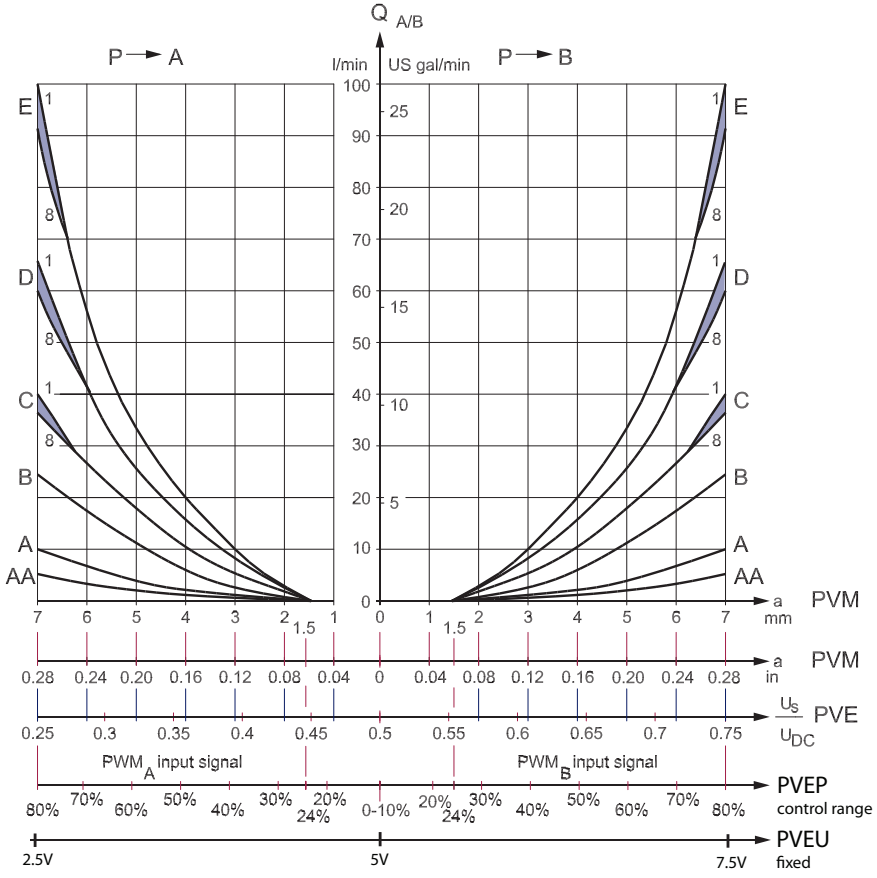
PVG120 – Pump disconnect/block for variable pumps

- PVPX, LS dump to tank

PVE Control by Voltage

- The PVE is controlled with a low current voltage signal.
- The spool stroke is proportional to the control voltage (U_S).
- The power is supplied via the supply wire (U_{BAT} or U_{DC}).
- The ratio U_S/U_{DC} defines the actuation. For PVEU a defined voltage.
- A not connected U_S pin (floating) is recognized as $U_S = ½U_{DC}$.

PVE characteristic – control by voltage



Values for standard mounted PVE (PVEA/M/H/S)

Function	Signal voltage (U_S)
Neutral	$U_S = 0.5 \cdot U_{DC}$
Q: P → A	$U_S = (0.5 \rightarrow 0.25) \cdot U_{DC}$
Q: P → B	$U_S = (0.5 \rightarrow 0.75) \cdot U_{DC}$

PLUS+1™ compliance

PVEA, PVEH, PVES, PVEO, PVEP and PVED can be controlled by PLUS+1.
The U_{DC} has a capacitance of 2,2 uF which can give problems with some micro-controller power supply. To eliminate this problem Sauer-Danfoss has designed a special resistance supply and control cable.

Caution
PVEM is not PLUS+1 compliant.

ATEX PVE

The Sauer-Danfoss PVE ATEX portfolio has the same monitoring and control characteristics as the equivalent standard PVE.

PVE Control by Voltage (continued)

PVEU–PVE with fixed control signal range

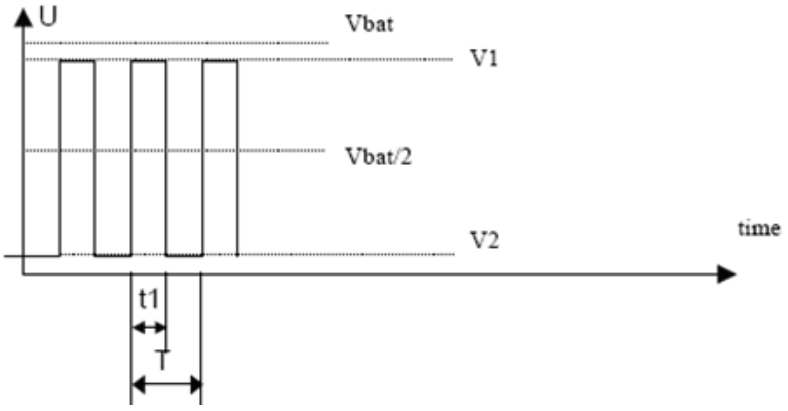
The PVEU (PVE 0-10V) is designed for PLC/ microcontroller(uC) control hence the U. The control signal U_S is fixed 0 V to 10 V independent of supply voltage U_{DC}.

Signal voltage - PVEU

Function	Signal voltage PVEU
Neutral	5V
Q: P → A	5V → 2,5V
Q: P → B	5V → 7,5V

PVE controlled with PWM signal

The standard PVE, PVEA/M/H/S, can also be controlled by a pulse with modulated PWM signal.
The V1 and V2 for PWM must be symmetrically located around U_{DC2} and V1≤ U_{DC}.



Duty cycles for PVE (PVEA/M/H/S/U)

Function	Duty cycle (dc) PVEA/M/H/S
Neutral	50% dc
Q: P → A	50% dc → 25% dc
Q: P → B	50% dc → 75% dc

Recommended PWM frequency for PVE

PVE type	PWM frequency
PVEM	> 200 Hz
PVEA/H/S/U	> 1 kHz

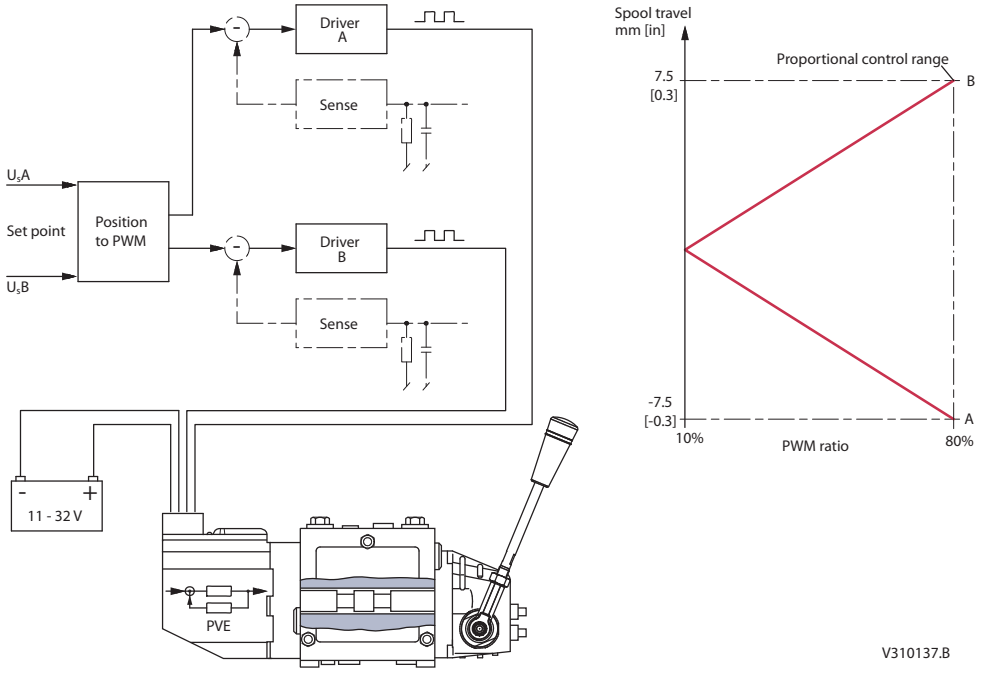
⚠ Warning
The PWM is not evaluated by the PVE so variance/failure in period (T) will not be detected.

PVE Control by Voltage (continued)

PVEP

The PVEP is designed for PWM control signals only.

PVEP schematic and characteristic



Caution

It is important that the power supply (U_{DC}) is connected before the PWM signal.

PWM signals are low power voltage signals; hence no current drivers are needed. Current control is not possible with PVEP. The PVEP can also be connected to a control signal like used for PVHC.

The PVEP performs a true time difference measurement on the PWM input, thus there is no filtering or conversion involved.

PWM frequency can be chosen between 100 to 1000 Hz.

PVEP signals

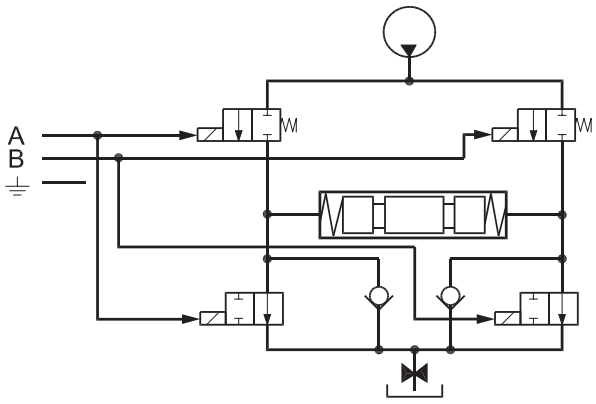
Duty cycle A-signal (pin 1)	Duty cycle B-signal (pin 2)	Function	Error Pin output (pin 3)
0%	0%	Neutral	Low
10%	0%		
0%	10%		
≥ 10%	≥ 10%	Fault (Error)	High
< 10%	10 → 80%	B-port flow	Low
10 → 80%	< 10%	A-port flow	Low
A > 86%	B > 86%	Fault (Error)	High

PVEO

PVE ON/OFF activation

The PVEO has two independent powered sets of solenoids. By powering a set of pins the actuator is activated. By standard mounted PVE the A set gives full flow on A port and B gives on B port. Both directions activated at same time will keep the spool in neutral.

PVEO schematic and characteristic



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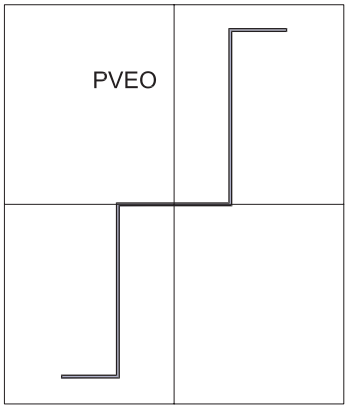

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⚠ Warning

The PVEO is designed to have U_{DC}=12 V or U_{DC}=24 V.
The solenoids might be activated by voltage down to 6 V.

PVE for Float Spool

Sauer-Danfoss has developed two PVE variants to support the float spool. The float spool is a ¾ spool, where as the standard is a ⅔ spool giving another characteristic and maximum stroke. These variations are covered by the built-in electronics.

There are two variants of float PVBS.

- Float B – 1,5 mm dead band, max flow at 4,8 mm. Float at B = 8 mm, from 6 mm partial float.
- Float A – 0,8 mm dead band, max flow at 5,5 mm. Float at A = 8 mm, from 6,2 mm partial float (PVBZ).

PVEM-F and PVEH-F with four pin connector are for float B and give no built-in protection against entering float.
PVEH-F with six pin connector is for float A and gives protection against entering float by using low Us. The float signal has priority to the Us in the PVEH-F six pin.

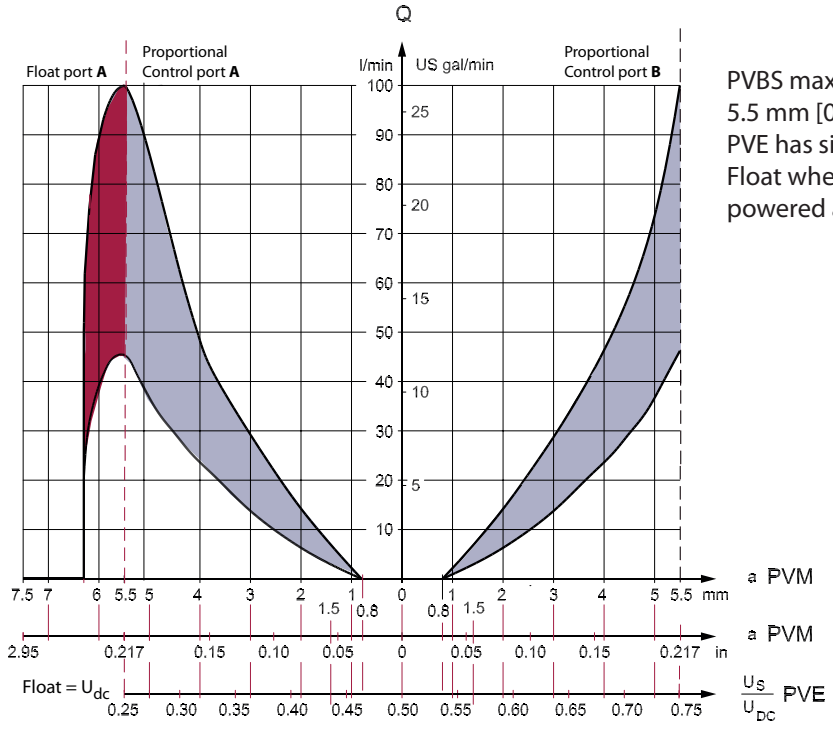
Variants of the float spool PVBS

Float	PVE	PVBS	Progressive control	Float control
A	PVEH-F (6 pin)	Dead band 0.8 mm Max float at 5.5 mm	U_S: 25% -> 75% U_{DC}	U_{DC} to float pin Has priority
B	PVEH-F (4 pin)	Dead band 1.5 mm Max float at 4.8 mm	U_S: 35% -> 65% U_{DC}	U_S= 75% U_{DC}

PVE for float spools are not designed for standard ⅔ spools.

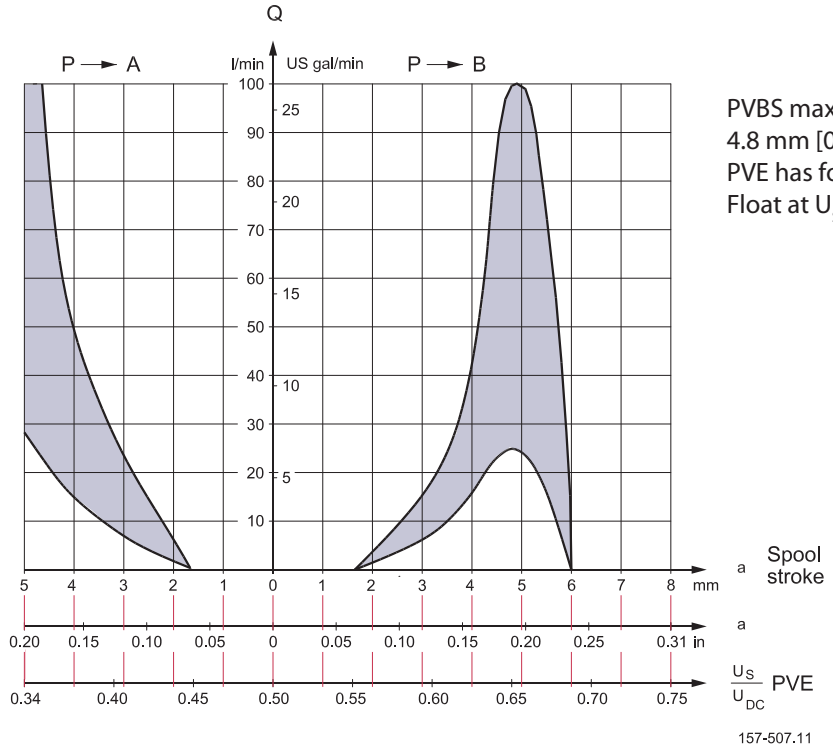
PVE to the Float Spool (continued)

PVE characteristic – Float A



PVBS maximum float is 5.5 mm [0.22 in].
PVE has six pins.
Float when special pin powered at U_{DC}.

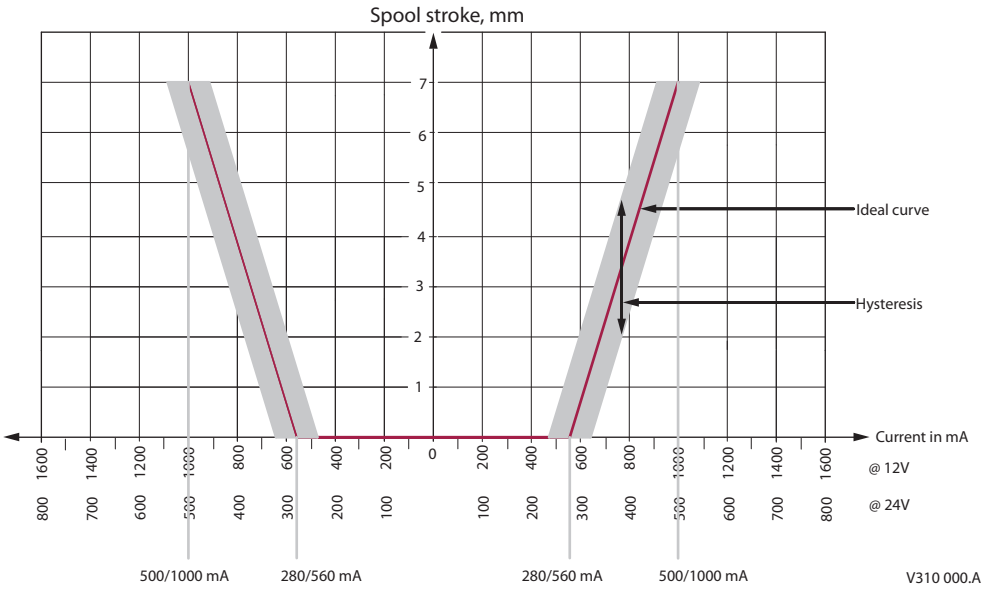
PVE characteristic – Float B



PVBS maximum float is 4.8 mm [0.19 in].
PVE has four pins.
Float at $U_S / U_{DC} = 0.75$

PVHC control

PVHC characteristic



PVHC current response and hysteresis @ 25 bar Pp, 21 ctS, 25 °C.

The PVHC control is done by dual Pulse Width Modulated (PVM) high current supply 100-400 Hz PWM control signals.

The PVHC does not have fault monitoring.
The PVHC does not have internal closed loop control of the spool.

The PVHC has high hysteresis. The hysteresis is affected by viscosity, friction, flow forces, dither frequency and modulation frequency. The spool position will shift when conditions are changed e.g. temperature change.

For PVG controlled by PVHC hysteresis is influenced by lever (PVM).

Hysteresis

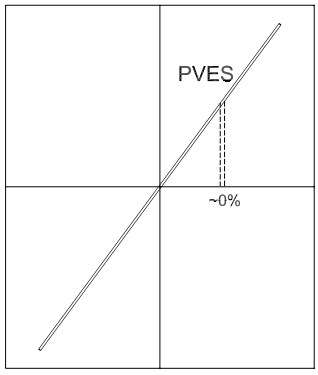
The controllability of the PVE depends on the solenoid valve bridge and the electronic capacity of the module.

Hysteresis is a measurement on spool position precision and repeatability. Hysteresis is not a description of position maintaining.

PVES Series 4

The PVES has an ASIC closed loop circuit and the NC-S solenoids.

PVES voltage, position diagram



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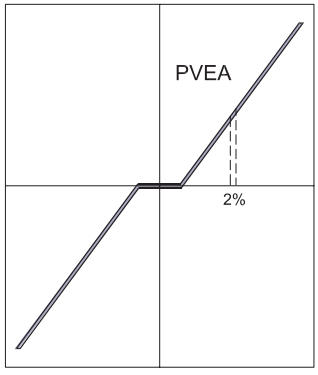
PVEA Series 4

The PVEA has an ASIC closed loop circuit, standard NC solenoids and orifice instead of NO solenoids.

PVEA voltage, position diagram



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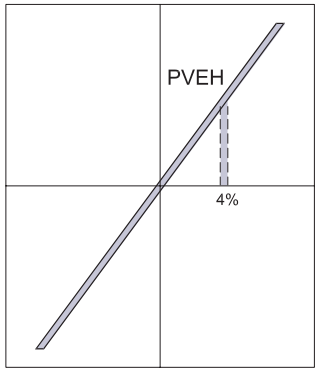
Caution

PVEA is not for use on PVG 100.

PVEH Series 4

The PVEH has an ASIC closed loop circuit and the standard NC solenoids.

PVEH voltage, position diagram



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PVE hysteresis overview

PVE	S	A	H	M
Maximum	2 %	6 %	8.6 %	35 %
Typical	<½ %	2 %	4 %	25 %

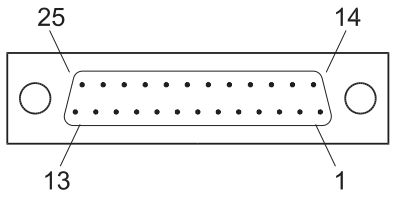
- PVEP has the PVES characteristic.
- PVEU is available with both standard PVEH and super fine PVES characteristic.
- PVHC has hysteresis like PVEM at fixed temperature and viscosity.

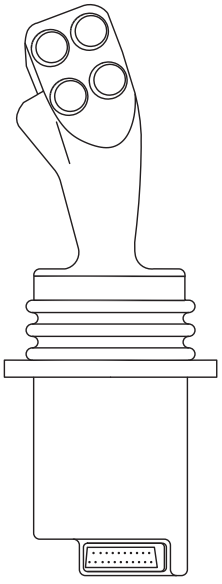
For PVHC temperature and viscosity shifts control signal effect.

Example of Use

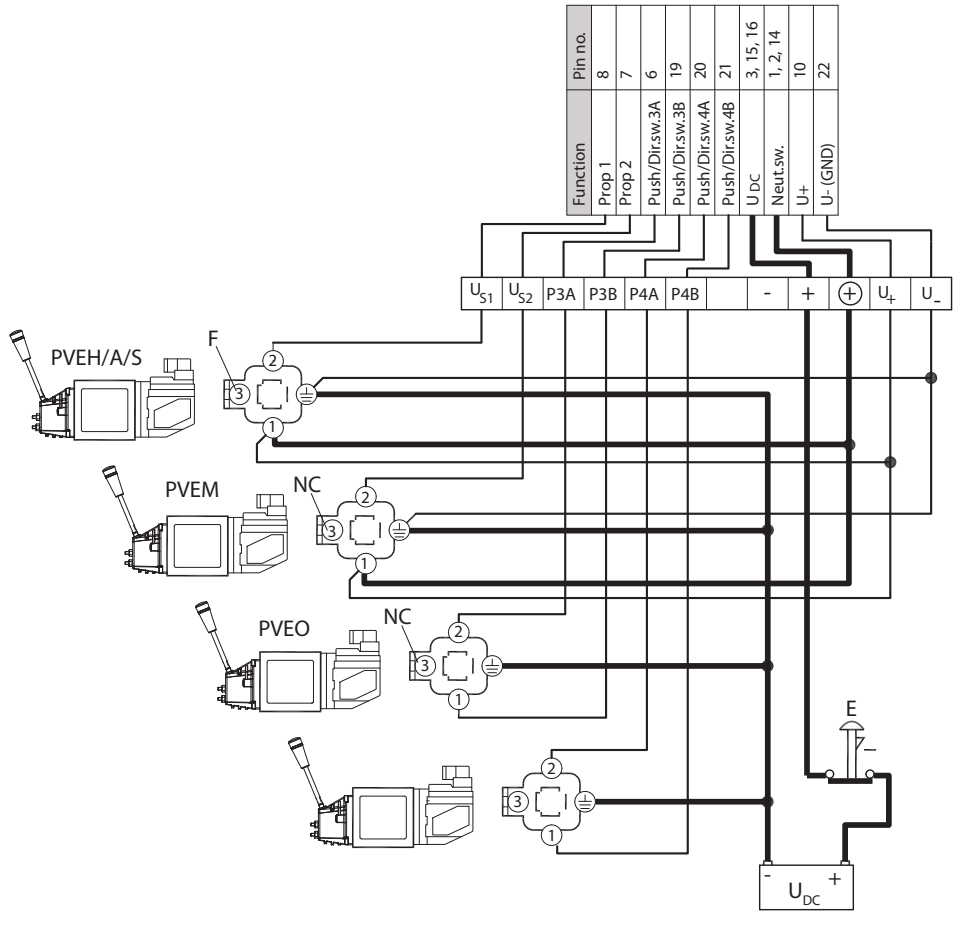
Signal leads must not act as supply leads at the same time unless the distance between the actuator module PVE and terminal board is less than 3 m [3.3 yards] and the lead cross-section is min. 0.75 mm² [AWG 18].

25 Pin SUB-D connector with M3 screws (MIL-DTL-24308)





E : Emergency stop
F : Signal output, fault monitoring
NC : Not connected
——: Signal leads
——: Supply leads



V310116.A

Operating Parameters

Declaration of conformity.

The PVEA/H/P/S/U have CE marking according to the EU directive EMC Directive 2004/108/EC. The declarations are available at Sauer-Danfoss.
The PVEO/M and PVHC are not subject to this directive.

⚠ Warning

The PVE is designed for use with pilot oil supply. Use without oil supply can harm the system. The PVE is designed for use with pilot pressure range 10 to 15 bar [145 to 220 psi]. Intermittent pressure peaks up to 50 bar [725 psi] can be accepted.
Intermittent is no longer than 5 seconds and not more than once per minute.

The following technical data are from typical test results. For the hydraulic system mineral based hydraulic oil with a viscosity of 21 mm^2/s [102 SUS] and a temperature of 50 °C [122 °F] was used.

PVHC

PVHC control specification

Supply voltage U_{DC}	12 V_{DC}	24 V_{DC}
Controller output current	0 – 1500 mA	0 – 750 mA
Pilot pressure	20 – 25 bar [290-363 psi]	
Resistance	4.75 Ω ± 5%	20.8 Ω ± 5%
Response time	150 – 200 ms	
PWM frequency	100 → 400 Hz	

Reaction time PVHC

From neutral position to max. spool travel at power on	max.	0.235s
	rated	0.180s
	min.	0.120s
From max. spool travel to neutral position at power off	max.	0.175s
	rated	0.090s
	min.	0.065s

Operating Parameters (continued)

PVEO and PVEM

PVEO and PVEM control specification

Supply voltage U_{DC}	rated	12 V_{DC}	24 V_{DC}
	range	11 → 15 V	22 → 30 V
	max. ripple	5%	
Current consumption	typical	740 mA	365 mA
	minimum	550 mA	290 mA
	maximum	820 mA	420 mA
Current via DI	maximum	100 mA	

Reaction time PVEO and PVEM

Reaction time in seconds		**PVEO**	**PVEO-R**	**PVEM**
From neutral position to max. spool travel at power on	max.	0.235s	0.410s	0.700s
	rated	0.180s	0.350s	0.450s
	min.	0.120s	0.250s	0.230s
From max. spool travel to neutral position at power off	max.	0.175s	0.330s	0.175s
	rated	0.090s	0.270s	0.090s
	min.	0.065s	0.250s	0.065s
From neutral position to max. spool travel by constant power	max.	–		0.550s
	min.			0.210s
From max. spool travel to neutral position by constant power	max.			0.150s
	min.			0.040s

PVEA, PVEH, PVES and PVEU

PVEA, PVEH, PVES and PVEU control specification

Supply voltage U_{DC}	rated	11 → 32 V
	max. ripple	5 %
Current consumption at rated voltage		0.57 (0.33) A @ 12 V 0.3 (0.17) A @ 24 V
Signal voltage	neutral	0.5 x U_{DC} (PVEU 5V)
	A-port ↔ B-port	0.25 → 0.75 • U_{DC}
Signal current at rated voltage		0.25 → 0.70 mA
Input impedance in relation to 0.5 • U_{DC}		12 kΩ
Power consumption		7 (3.5) W
Error pin max current		100 mA

Reaction time PVEA, PVEH, PVES and PVEU in sec. (minus PVG 120)

Supply voltage	**Function**		**PVEA Prop. fine**	**PVEH, PVEP, PVES, PVEU**
Disconnected by means of neutral switch	Reaction time from neutral position to max. spool travel	max.	0.500	0.230
		rated	0.320	0.150
		min.	0.250	0.120
	Reaction time from max. spool travel to neutral position	max.	0.550	0.175
		rated	0.400	0.090
		min.	0.300	0.065
Constant voltage	Reaction time from neutral position to max. spool travel	max.	0.500	0.200
		rated	0.320	0.120
		min.	0.250	0.050
	Reaction time from max. spool travel to neutral position	max.	0.250	0.100
		rated	0.200	0.090
		min.	0.150	0.065

Operating Parameters (continued)

PVEP

PVEP control specification

Supply voltage U_{DC}	**range**	11 → 32 V
	max. ripple	5%
	over voltage (max. 5 min)	36 V
PWM control range (duty cycle)		10 → 80%
PWM frequency		100 → 1000 Hz
PWM input voltage swing		0 → U_{DC}
PWM Trigger point		70% of U_{DC}
Input impedance (standard pull down)		5 kΩ
Input capacitor		---
Power consumption		7 W
Error voltage:	**Fault**	U_{DC}
	No Fault	< 2 V

All connector terminals are short-circuit protected, protected against reverse connection and their combinations. Connecting error pins from two or more PVE's will cause the surveillance system to malfunction.

Oil consumption

Function		**Supply Voltage**	**PVEA**	**PVEH/ M/ O/ U - PVHC prop. high**	**PVEP /S / U prop. super**
Pilot oil flow for PVE	neutral*	OFF	0 l/min [0 US gal/min]	0 l/min [0 US gal/min]	0.3 l/min [0.106 US gal/min]
	locked*	ON	0.4 l/min [0.106 US gal/min]	0.1 l/min [0.026 US gal/min]	0.1 l/min [0.026 US gal/min]
	continuous actuations*		1.0 l/min [0.264 US gal/min]	0.7 l/min [0.185 US gal/min]	0.8 l/min [0.211 US gal/min]

* 12 bar [174 psi] and 21 mm²/s [102 SUS]

Oil viscosity

Oil viscosity	range	12 → 75 mm²/s [65 ÷ 347 SUS]
	min.	4 mm²/s [39 SUS]
	max.	460 mm²/s [2128 SUS]

Oil temperature

Oil temperature	range	30 → 60°C [86 ÷ 140°F]
	min.	-30°C [-22°F]
	max.	90°C [194 °F]

Pilot pressure PVE

Pilot pressure (relative to T pressure)	nom.	13.5 bar [196 psi]
	min.	10.0 bar [145 psi]
	max.	15.0 bar [217 psi]

Pilot pressure PVHC

Pilot pressure (over tank)*	nom.	25 bar [363 psi]
	min.	21 bar [305 psi]
	max.	25 bar [363 psi]

* Designed to be used with hydraulic activated spools.

Operating Parameters (continued)

Operating temperature

	Min	Max
Ambient	-30˚C [-22˚F]	60˚C [140˚F]
Stock	-40˚C [-40˚F]	90˚C [194˚F]
Recommended long time storage in packaging	10˚C [50˚F]	30˚C [86˚F]

Filtering in the hydraulic system

Required operating cleanliness level	18/16/13 (ISO 4406, 1999 version)

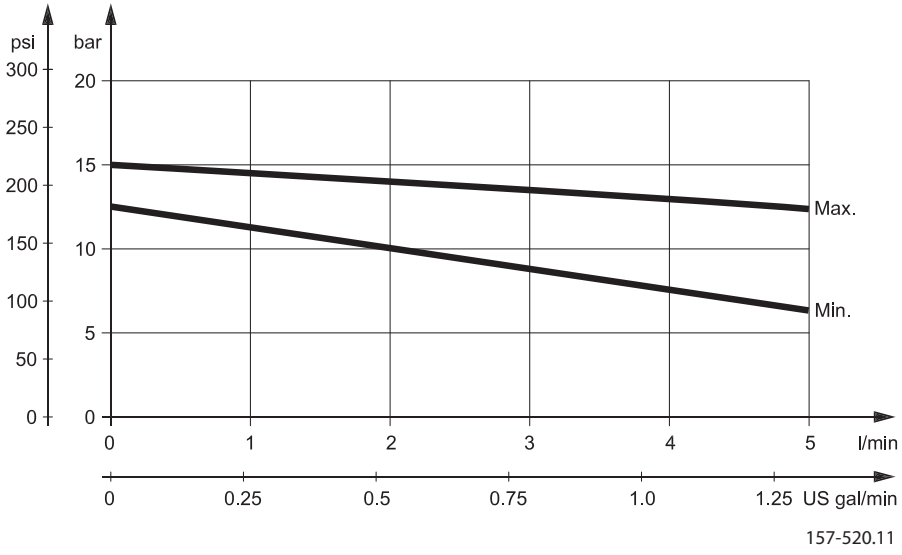
For further information see Sauer-Danfoss documentation *Hydraulic Fluids and Lubricants, Technical Information* **520L0463.**

Enclosure and connector

Version of connector	Hirschmann connector	AMP JPT connector	Deutsch connector
Grade of enclosure*	IP 65	IP 66	IP 67

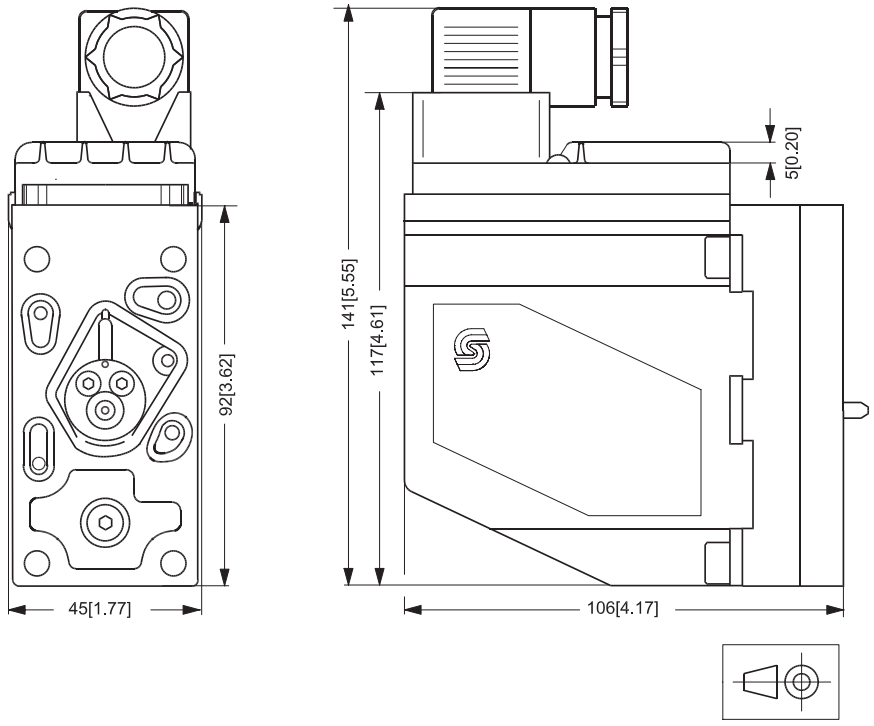
* According to the international standard IEC 529
NB: In particulary exposed applications, protection in the form of screening is recommended.

PVP modules, Pilot pressure curves



PVE dimensions for PVG 32 and PVG 100

PVE with Hirschmann connector for PVG 32 and PVG 100



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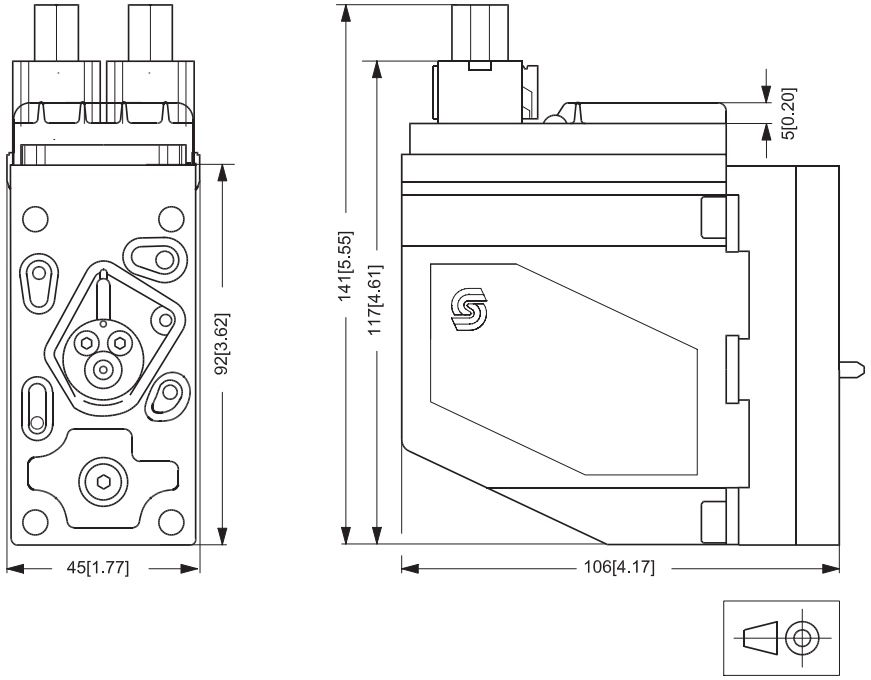
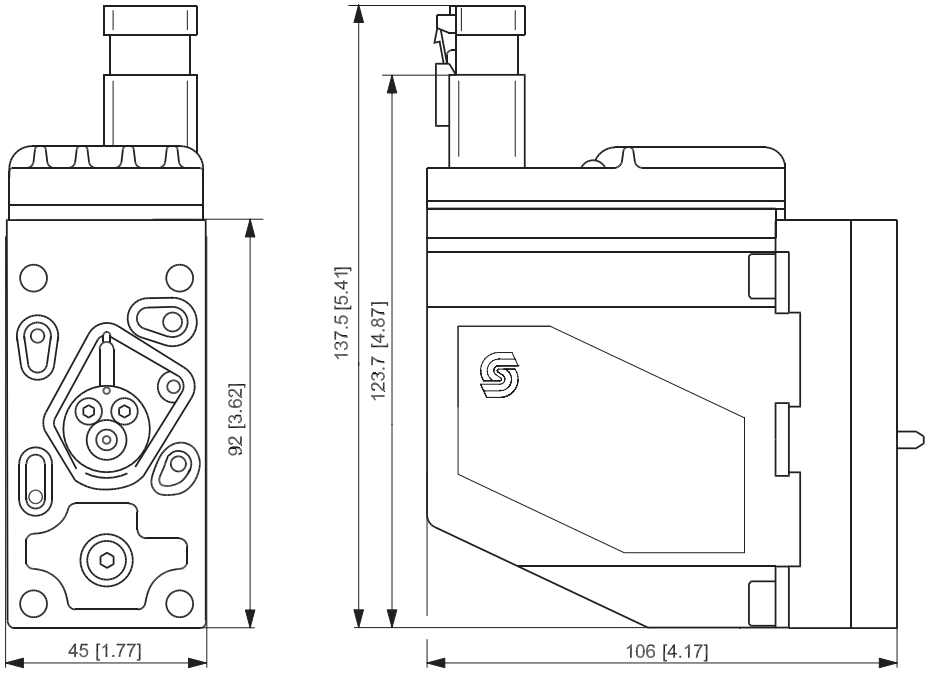
PVE with AMP connector for PVG 32 and PVG 100



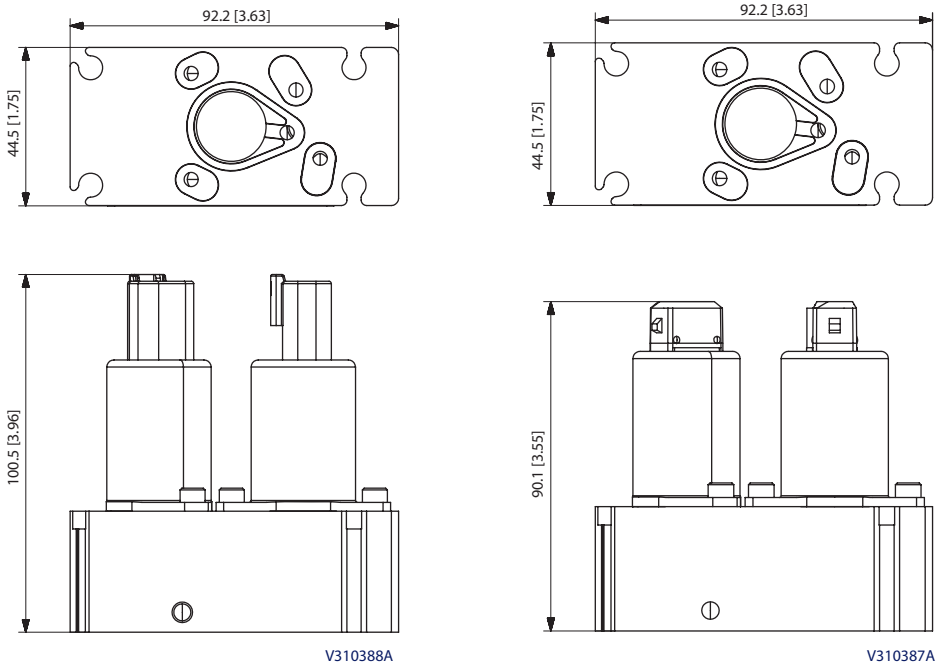
157-394.14

PVE dimensions for PVG 32 and PVG 100 (continued)

PVE with Deutsch connector for PVG 32 and PVG 100



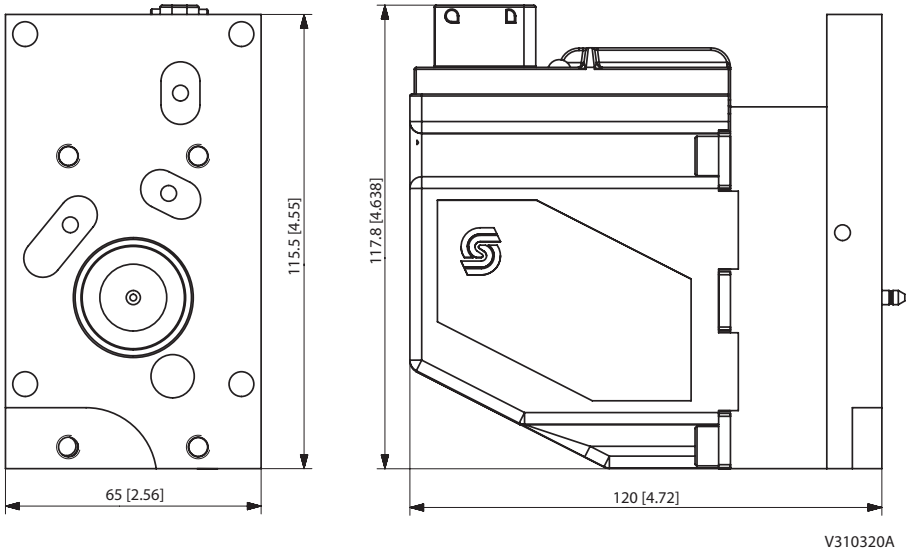
PVHC for PVG 32 and PVG 100



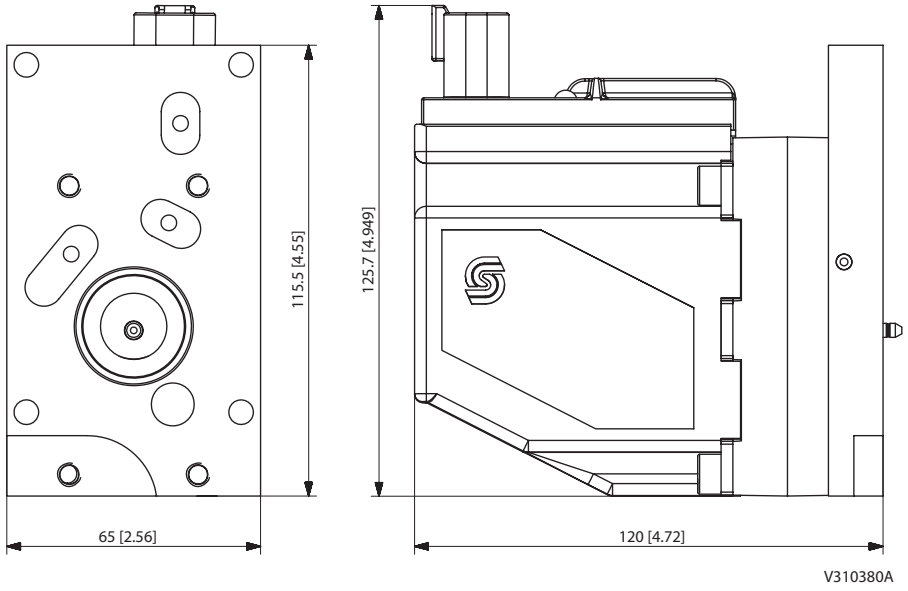
with Deutsch connectors *with AMP connectors*

PVE dimensions for PVG 120

PVE with AMP connector for PVG 120



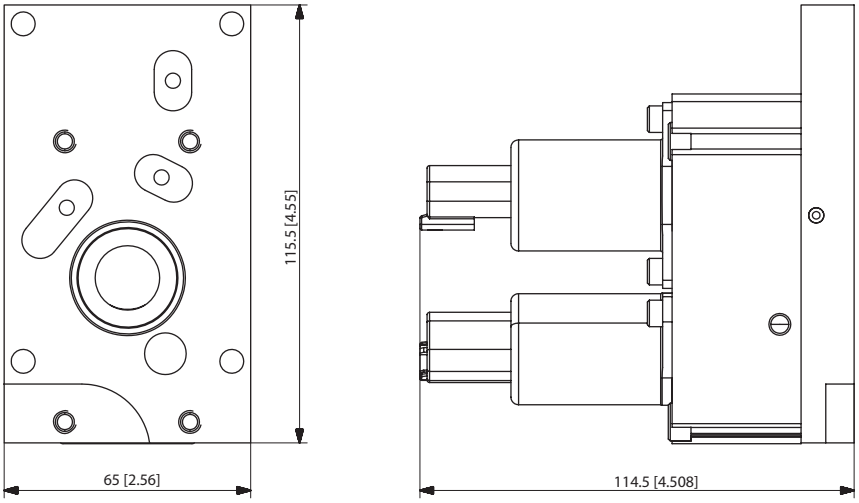
PVE with Deutsch connector for PVG 120



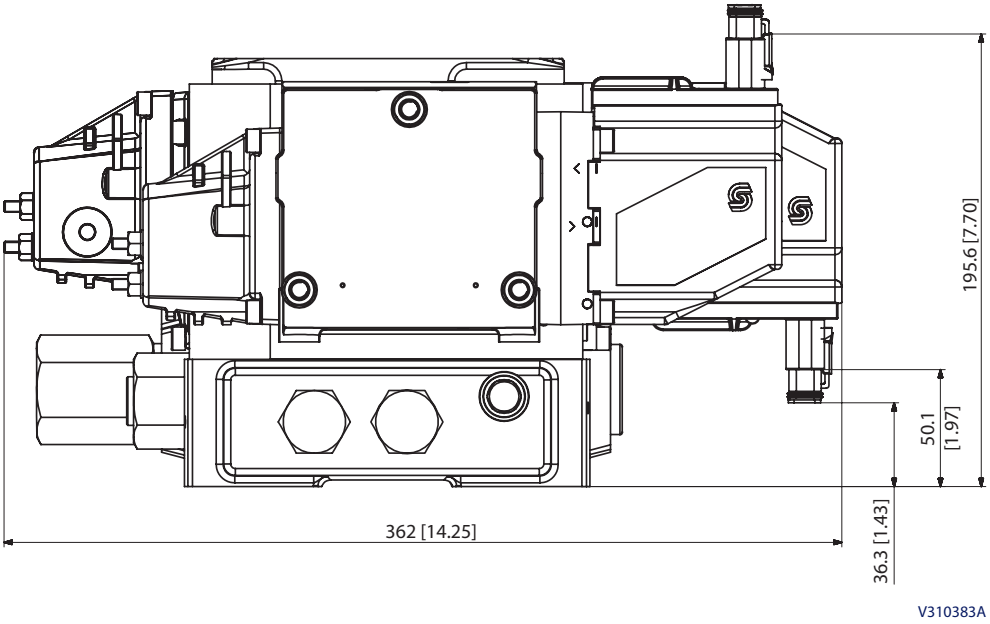
Please notice that connector needs extra space for mounting.

General Dimensions (continued)

PVHC with Deutsch connector for PVG 120



PVG 120 and PVG 32 combo with Deutsch connector



PVE pinout

Connection PVEO with direction indication (DI)

Connector 1	A U_{DC}	B U_{DC}	Gnd	Gnd
AMP (grey)	p 1	p 2	p 3	p 4

Connector 2	DI-B	DI-A	Gnd	U_{DC2}
AMP (black)	p 1	p 2	p 3	p 4

Connection PVEO standard

Connector	A	B
AMP/Hirschmann/ DIN	pin 1	pin 2
Deutsch	pin 1	pin 4

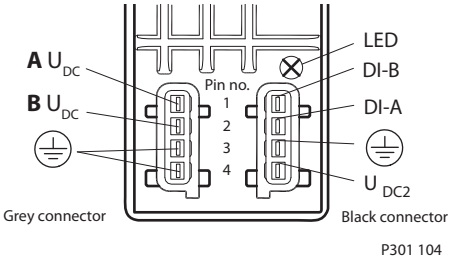
Function	A (pin 1)	B (pin 2)
Neutral	0	0
Q: P → A	U_{DC}	0
Q: P → B	0	U_{DC}

Control all PVEO

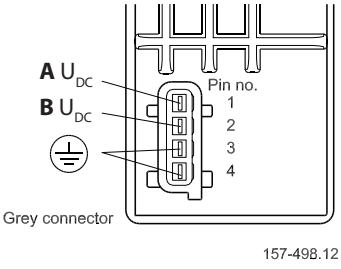
Connector	A	B
AMP/Hirschmann/ DIN	pin 1	pin 2
Deutsch	pin 1	pin 4

- Ground pins are internally connected.
- Pin 3 is not connected on Hirschmann/DIN version of PVEO.
- U_{DC2} supplies electronics for feedback signal on PVEO-DI.

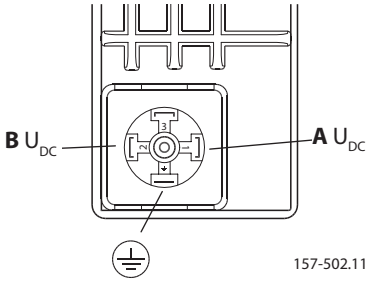
AMP version of PVEO–DI



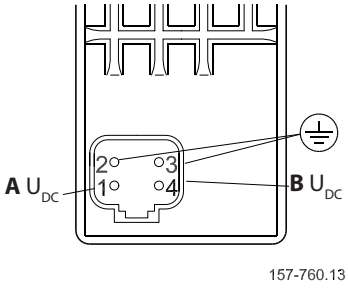
AMP version of PVEO/PVEO–R



Hirschmann/DIN version of PVEO / PVEO–R



Deutsch version of PVEO



PVE pinout (continued)

Standard PVE

Connection PVEA/PVEH/PVEM/PVES/PVEU - also with float B four pin

Connector	U_S	U_{DC}	Gnd	Error
AMP	pin 1	pin 2	pin 3	pin 4
Hirschmann/ DIN	pin 2	pin 1	gnd	pin 3
Deutsch	pin 1	pin 4	pin 3	pin 2

- On PVEM the error pin is not used and not connected (pin 3 Hirschmann/DIN).
- Ground pins are internally connected.

Control (U_S) for standard mounted PVEA/ PVEH/ PVEM/ PVES

Function	Voltage relative	PWM
Neutral	0,5 • U_{DC}	50%
Q: P → A	0,5 → 0,25 • U_{DC}	50% → 25%
Q: P → B	0,5 → 0,75 • U_{DC}	50% → 75%

Control (U_S) for standard mounted PVEU

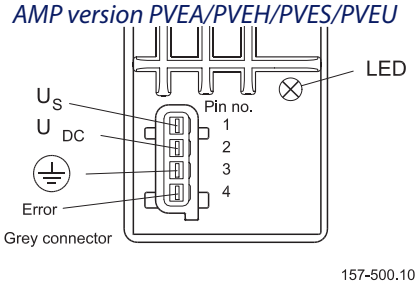
Function	PVEU
Neutral	5 V
Q: P → A	5 V → 2,5 V
Q: P → B	5 V → 7,5 V

Control (U_S) for standard mounted PVEH/ PVEM float B four pin version

Function	Voltage relative	PWM
Neutral	0,5 • U_{DC}	50%
Q: P → A	0,5 → 0,34 • U_{DC}	50% → 34%
Q: P → B	0,5 → 0,65 • U_{DC}	50% → 65%
Float	0,75 • U_{DC}	75%

PVEM is not PLUS+1 compliant.

AMP version PVEA/PVEH/PVES/PVEU



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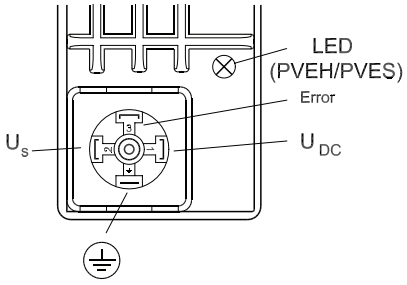
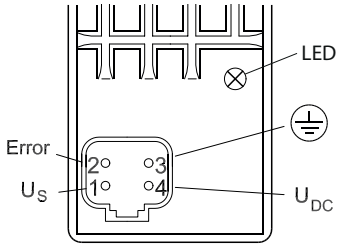
Hirschmann/DIN version PVEH/PVEM/ PVES/PVEH float B/PVEM float B



Deutsch version PVEA/PVEH/PVES/PVEU/ PVEH float B



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PVE pinout (continued)

Standard PVE with DI

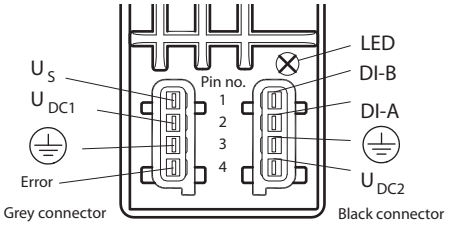
Connection PVE with direction indication (DI)

Connector 1	U_S	U_{DC1}	Gnd	Error
AMP (grey)	p 1	p 2	p 3	p 4
Deutsch	p 1	p 4	p 3	p 2

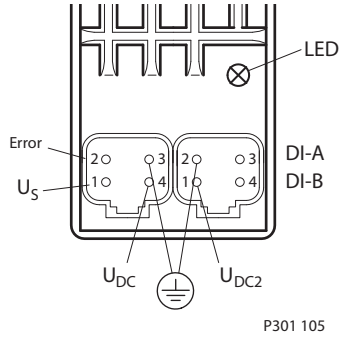
Connector 2	DI-B	DI-A	Gnd	U_{DC2}
AMP (black)	p 1	p 2	p 3	p 4
Deutsch	p 4	p 3	p 2	p 1

- Ground pins are internally connected.
- U_{DC2} only supplies electronics for feedback signal and error pin on PVEA-DI / PVEH-DI. Two separate power sources can be used.

AMP version PVEA–DI/PVEH–DI



Deutsch version PVEA–DI/PVEH–DI

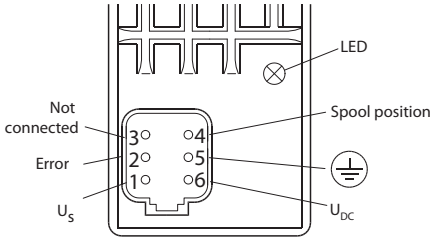


Standard PVE with SP

Connection PVE with Spool Position (SP)

Connector	U_S	Error	SP	Gnd	U_{DC}
Deutsch	p 1	p 2	p 4	p 5	p 6

Deutsch version PVES–SP

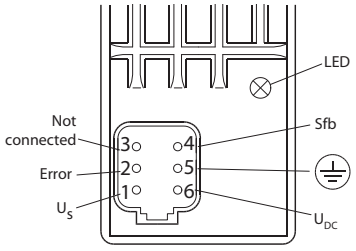


Standard PVE with NP

Connection PVE with Neutral Power off (NP)

Connector	U_S	Error	Sfb	Gnd	U_{DC}
Deutsch	p 1	p 2	p 4	p 5	p 6

Deutsch version PVES–NP



Control (U_S) for standard mounted PVEA–DI/ PVEH–DI, PVES-SP, PVEA-NP, PVEH-NP

Function	U_S	PWM
Neutral	$0{,}5 \cdot U_{DC}$	50%
Q: P → A	$0{,}5 \rightarrow 0{,}25 \cdot U_{DC}$	50% → 25%
Q: P → B	$0{,}5 \rightarrow 0{,}75 \cdot U_{DC}$	50% → 75%

PVE pinout (continued)

PVE with separate Float pin

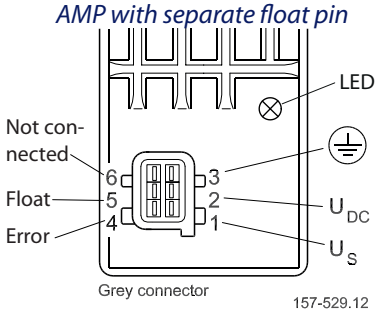
Connection PVEH with float A six pin

Connector	U_S	U_{DC}	Float	Ground	Error
AMP	pin 1	pin 2	pin 5	pin 3	pin 4
Deutsch	pin 1	pin 6	pin 3	pin 5	pin 2

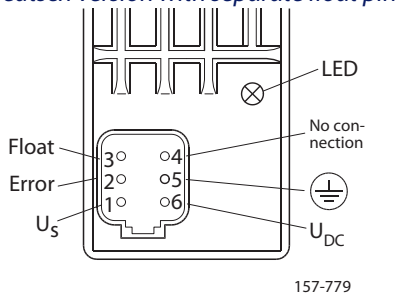
Control (U_S) for standard mounted PVEH/ PVEM float A six pin version

Function	PWM A	PWM B
Neutral	0,5 • U_{DC}	50%
Q: P → A	0,5 → 0,25 • U_{DC}	50% → 25%
Q: P → B	0,5 → 0,75 • U_{DC}	50% → 75%
Float	U_{DC} on float pin	

AMP with separate float pin



Deutsch version with separate float pin



PVE with PWM controled – PVEP

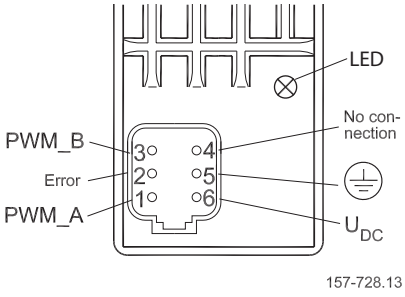
Connection PVEP

Connector	PWM A	Error	PWM B	Gnd	U_{DC}
Deutsch	p 1	p 2	p 3	p 5	p 6

Control (U_S) for standard mounted PVEP

Function	Voltage relative	PWM
Neutral	< 10%	< 10%
Q: P → A	10% → 80%	< 10%
Q: P → B	< 10%	10% → 80%

Deutsch version with PVEP



Proportional Version (continued)

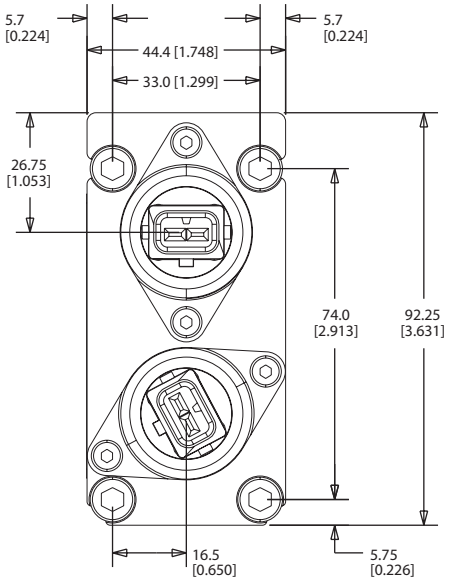
PVHC connection

- 100-400 Hz PWM control signals.
- Each connector controls one direction and must have U_{DC} and ground
- No constraints on pin for U_{DC} and ground.

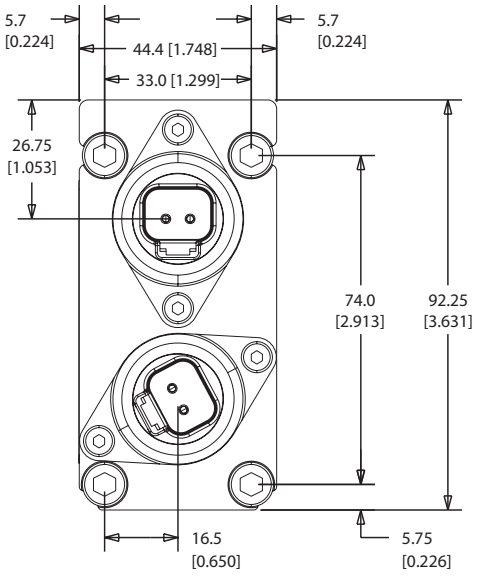
Input control

Parameter	Control range	
	12 V	24 V
Controller output current range	0 - 1500 mA	0 - 750 mA

PVHC with AMP



PVHC with Deutsch



Product Warnings

⚠ Warning
Not applying to the Operational Conditions can compromise safety.

⚠ Warning
All brands and all types of directional control valves – including proportional valves – can fail and cause serious damage. It is therefore important to analyze all aspects of the application. Because the proportional valves are used in many different operation conditions and applications, the machine builder/ system integrator alone is responsible for making the final selection of the products – and assuring that all performance, safety and Warning requirements of the application are met.

⚠ Warning
A PVG with PVE can only perform according to description if conditions in this Technical Information are met.

⚠ Warning
In particularly exposed applications, protection in the form of a shield is recommended.

⚠ Warning
When the PVE is in fault mode the quality of performance and validity of feedback is limited depending on the fault type.

⚠ Warning
Error pins from more PVEs may not be connected. Inactive error pins are connected to ground and will disable any active signal.

⚠ Warning
Error pins are signal pins and can only supply very limited power consumption.

⚠ Warning
Deviation from recommended torque when mounting parts can harm performance and module.

⚠ Warning
Adjustment of the position transducer (LVDT) will influence calibration, and thereby also safety and performance.

⚠ Warning
When replacing the PVE, the electrical and the hydraulic systems must be turned off and the oil pressure released.

⚠ Warning
PVEA is not for use on PVG 100.

⚠ Warning
Hydraulic oil can cause both environmental damage and personal injury.

⚠ Warning
Module replacement can introduce contamination and errors to the system. It is important to keep the work area clean and components should be handled with care.

⚠ Warning
After replacement of modules or cables wiring quality must be verified by a performance test.

⚠ Warning
By actuation at voltage below nominal PVG will have reduced performance.

⚠ Warning
The PVE is not designed for use with voltage outside nominal.

⚠ Warning
Obstacles for the Pilot oil can have direct influence on spool control.

⚠ Warning
Reduced pilot oil pressure will limit spool control.

⚠ Warning
Too high pilot oil pressure can harm the PVE.

PVE Code Numbers for use on PVG 32 and PVG 100

Deutsch connector code numbers

Feature		S	std.	float A	float B	DI	NP	SP	Fast-no memory	ramp
Connector			**1x4**	**1x6**	**1x4**	**2x4**	**1x6**	**1x6**	**1x4**	
PVEA*	active	–	157B4792			157B4796	11105542			
	passive		11107365							
PVEH	active		157B4092	157B4398		157B4096	11105543			
	passive		157B4093		157B4392					
PVES	active	S	157B4892						157B4894	
	passive	S	11089276					11108994		
PVEP	active	S	11034832*							
PVEU	passive	S	11089090							
PVEO	12V	–	157B4291							11109080
	24V		157B4292							11109092

*S = super fine hysteresis, 1x4 = one plug four pins, * 1x6 = one plug six pins*

AMP connector code numbers

Feature		S	std.	float A	DI	anodized	ramp-ano	ramp
Connector			**1x4**	**1x6**	**2x4**	**1x4**	**1x4**	**1x4**
PVEA*	active	–	157B4734		157B4736			
	passive		157B4735		157B4737	157B4775		
PVEH	active		157B4034	157B4338	157B4036	157B4074		
	passive		157B4035		157B4037	157B4075		
PVES	active	S	157B4834					
	passive	S	157B4835			157B4865		
PVEU	active	S	11089091					
	active	–	157B4044					
	passive		157B4045					
PVEO	12V		157B4901		157B4905			157B4903
	24V		157B4902		157B4906	157B4272	157B4274	157B4904

*S = super fine hysteresis, 1x4 = one plug four pins, * 1x6 = one plug six pins*

⚠ Warning

PVEA is not for use on PVG 100.

PVE Code Numbers for use on PVG 32 and PVG 100 (continued)

Hirschmann/DIN connector code numbers

Feature		S	std.	float B	anodized	ramp
Connector			**1x4**	**1x4**	**1x4**	**1x4**
PVEH	active		157B4032	157B4332		
	passive		157B4033		157B4073	
PVES	active	S	157B4832			
	passive	S	157B4833			
PVEM	12 V		157B4116	157B4416		157B4516
	24 V		157B4128	157B4428		157B4528
PVEO	12 V		157B4216		157B4266	157B4217
	24 V		157B4228		157B4268	157B4229

S = super fine hysteresis, 1x4 = one plug four pins

ATEX (24 V) connector code numbers

Cable type		S	PFOP	PFOP	PFOP, cable dir PVB	BFOU
Flying wire			**5 m**	**10 m**	**5 m**	**5 m**
PVEH	passive		11084101	11084109	11084092	11084098
PVES		S	11084102	11084110	11084093	11084099
PVEO			11084100	11084108	11084051	11084097

S = super fine hysteresis,

AMP/Deutsch code numbers for PVHC

Connector		Code Number
PVHC AMP	12 V	11112037
	24 V	11112036
PVHC Deutsch	12 V	11112038
	24 V	11112039

PVE Code Numbers for use on PVG 120

AMP code numbers

Feature		anodized
Connector		**1x4**
PVEH	active	155G4094
	passive	155G4095
PVEO	12 V	155G4282
	24 V	155G4284

1x4 = one plug four pins

Hirschmann/DIN code numbers

Feature		anodized
Connector		**1x4**
PVEH	active	155G4092
	passive	155G4093
PVES	passive	11111210
PVEO	12 V	155G4272
	24 V	155G4274

Deutsch code numbers

Feature		anodized
Connector		**1x4**
PVEH	passive	11111206
PVES	passive	11111207
PVEO	12 V	11110601
	24 V	11110652
PVHC	12 V	11110597
	24 V	11110598

ATEX (24 V) connector code numbers

Cable type		PFOP	PFOP	PFOP, cable dir PVB	BFOU
Flying wire		**5 m**	**10 m**	**5 m**	**5 m**
PVEH	passive	11084104	11084112	11084096	11084107
PVEO		11084103	11084111	11084095	11084106

PVE Accessories

Connector code numbers

Code number	Description	
157B4992	AMP CONNECTING KIT (GREY)	4 pin with housing, contact and wire sealing
157B4993	AMP CONNECTING KIT (BLACK)	4 pin with housing, contact and wire sealing
984L3165	EL-PLUG, ON-OFF black	Hirschmann DIN connector set*

Set of seals code numbers

Code number	Description	Actuator
157B4997	Set of seals	PVE for PVG 32/ PVG 100
155G8519		PVE for PVG 120 (also interface plate/PVB for PVHC)
11061235		PVHC for PVG 32/ PVG 100

Cables code numbers

Feature		Wire colors						Length	Code number
Connector		**pin 1**	**pin 2**	**pin 3**	**pin 4**	**pin 5**	**pin 6**		
Deutsch	4 pin	white	blue	yellow	red	—	—	4 m	11007498
	4 pin	white	blue	yellow	red	—	—	4 m	11099720 *24V
	6 pin	white	blue	yellow	red	black	green	4 m	11007513
AMP	4 pin	white	blue	yellow	red	—	—	4 m	157B4994
	4 pin	white	blue	yellow	red	—	—	4 m	11099719 *24V
	6 pin	white	red	black	yellow	green	blue	5 m	157B4974
AMP/black coding	4 pin	white	blue	yellow	red	—	—	4 m	157B4995 **-DI

Cables are with oil resistant coating.
*24V Special cable for use with PLUS+1 MC microcontroller in 24V systems.
** -DI Additional cable for PVE with direction indication.

Connector Code Numbers at Other Suppliers

Connector part numbers for purchase at other suppliers

Connector		House	wire sealing (blue)	JPT contact (loose piece)	sealing mat between male-female part
Deutsch female	4 pin	DT06-4S	—	—	—
	6 pin	DT06-6S			
AMP female/grey	4 pin	2-967059-1	828904-1	929930-1	963208-1
	6 pin	2-963212-1	—		963205-1
AMP female/black	4 pin	1-967059-1			—
AMP crim tool		169400-1			
AMP die set for crimp tool		734253-0			

These connector code numbers are not Sauer-Danfoss numbers.

PVED Code Numbers for use on PVG 32 and PVG 100

Cables code numbers for PVED-CC

Feature		Wire colors				Description	Code number
Connector		**pin 1**	**pin 2**	**pin 3**	**pin 4**		
Deutsch	4 pin	white	blue	yellow	red	4 m cable	11007498
AMP	4 pin	white	blue	yellow	red	4 m cable	157B4994
AMP/black	4 pin	white	blue	yellow	red	4 m cable	157B4995
Service tool interface cable/ AMP						4 m cable	157B4977
AMP						0.1m loop cable	157B4987
AMP/black						Terminator	157B4988
Deutsch						0.1m loop cable	11007531
Deutsch						Terminator	11007561
Deutsch						Terminator dummy	11007563

CAN Interface

10104136	CG 150 CAN USB interface

Connector		**2x4**
Deutsch	SW 2.68	11079033
AMP	SW 2.68	11079034

1x4 = one plug four pins

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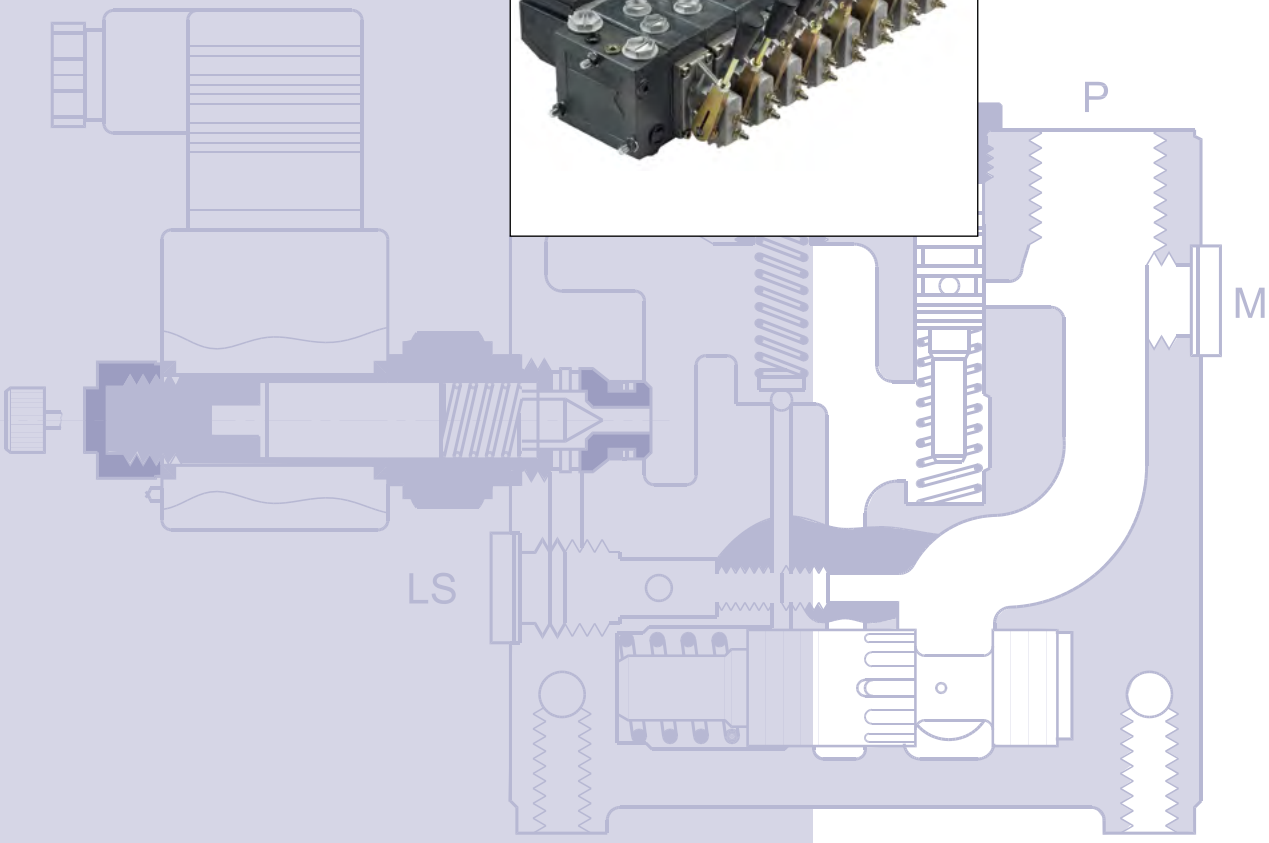
Genuine Parts

PVG 16 and PVG 32 Service Assembly/ Disassembly Guide

Service Manual



Revision History

Table of Revisions

Date	Page	Changed	Rev
Dec 2012	-	New edition	AA
Aug 2013	19	Torgue change in drawing	AB

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Front cover:157-516, F301056, F301306 and F301302

PVG 16, PVG 32 Service Assembly/Disassembly Guide
Service Manual
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General Description

PVG 16 and PVG 32 is a hydraulic load sensing valve designed to give maximum flexibility, from a simple load sensing directional valve to an advanced electrically controlled load-independent proportional valve.

The PVG 16 and PVG 32 modular systems make it possible to custom build up a valve group to meet customer requirements. The compact external dimensions of the valve remain unchanged whatever combination is specified.

Features of PVG 16 and PVG 32

- Load-independent flow control:
  - Oil flow to an individual function is independent of the load pressure of this function
  - Oil flow to one function is independent of the load pressure of other functions
- Good regulation characteristics
- Energy-saving
- Up to 12 basic modules per valve group
- Several types of connection threads
- Low weight
- Compact design and installation

PVG Modules

PVP, pump side modules

- Built-in pressure relief valve
- Pressure gauge connection
- Versions:
  - Open center version for systems with fixed displacement pumps
  - Closed center version for systems with variable displacement pumps
  - Pilot oil supply for electrical actuator built into the pump side module
  - Pilot oil supply for hydraulic actuation built into the pump side module
  - Versions prepared for electrical LS unloading valve PVPX

PVB, basic modules

- Interchangeable spools
- Depending on requirements the basic module can be supplied with:
  - Integrated pressure compensator in channel P
  - Load holding check valve in channel P
  - Shock/suction valves for A and B ports
  - LS pressure limiting valves individually adjustable for ports A and B
  - Different interchangeable spool variants
  - All versions suitable for mechanical, hydraulic and electrical actuation

PVG Modules (continued)

Actuation modules

The basic module is always fitted with mechanical actuator PVM and PVMD, which can be combined with the following as required:

- Electrical actuator (11 - 32 V ⎓):
  - PVES – proportional, Super
  - PVEH – proportional, High performance
  - PVEH-F – proportional high performance, Float
  - PVEA – proportional low hysteresis
  - PVEM – proportional, Medium performance
  - PVEO – ON/OFF
  - PVEU – proportional, voltage control, 0-10 V
  - PVED-CC – Digital CAN controlled J1939/ISOBUS
  - PVED-CX – Digital CAN controlled CANopen X-tra safety
  - PVEP – PWM voltage controlled (11-32V)
  - PVHC – High Current actuator for PVG
- PVMR, cover for Mechanical detent
- PVMF, cover for Mechanical Float
- PVH, cover for Hydraulic actuation

Rated Pressure

Product	Rated pressure
PVG 16 and PVG 32 with PVS	300 bar [4351 psi]
PVG 16 and PVG 32 with PVSI	350 bar [5076 psi]
PVG 16 and PVG 32 with PVBZ	250 bar [3626 psi]
PVG 16 and PVG 32 with HIC steel	350 bar [5076 psi]
PVG 16 and PVG 32 with HIC aluminium	210 bar [3046 psi]
PVG 120/32 with PVS	300 bar [4351 psi]
PVG 120/32 with PVSI	350 bar [5076 psi]
PVG 100/32 with PVS	300 bar [4351 psi]
PVG 100/32 with PVSI	350 bar [5076 psi]

Maximum continuous P-port pressure.

Accessories

Remote control units

- Electrical remote control units:
  - PVRE, PVRET
  - PVREL
  - PVRES
  - Prof 1
  - Prof 1 CIP
  - JS120
  - JS1000 Ball grip
  - JS1000 PROgrip
  - JS2000
  - JS6000
  - JS7000
- Hydraulic remote control unit:
  - PVRHH

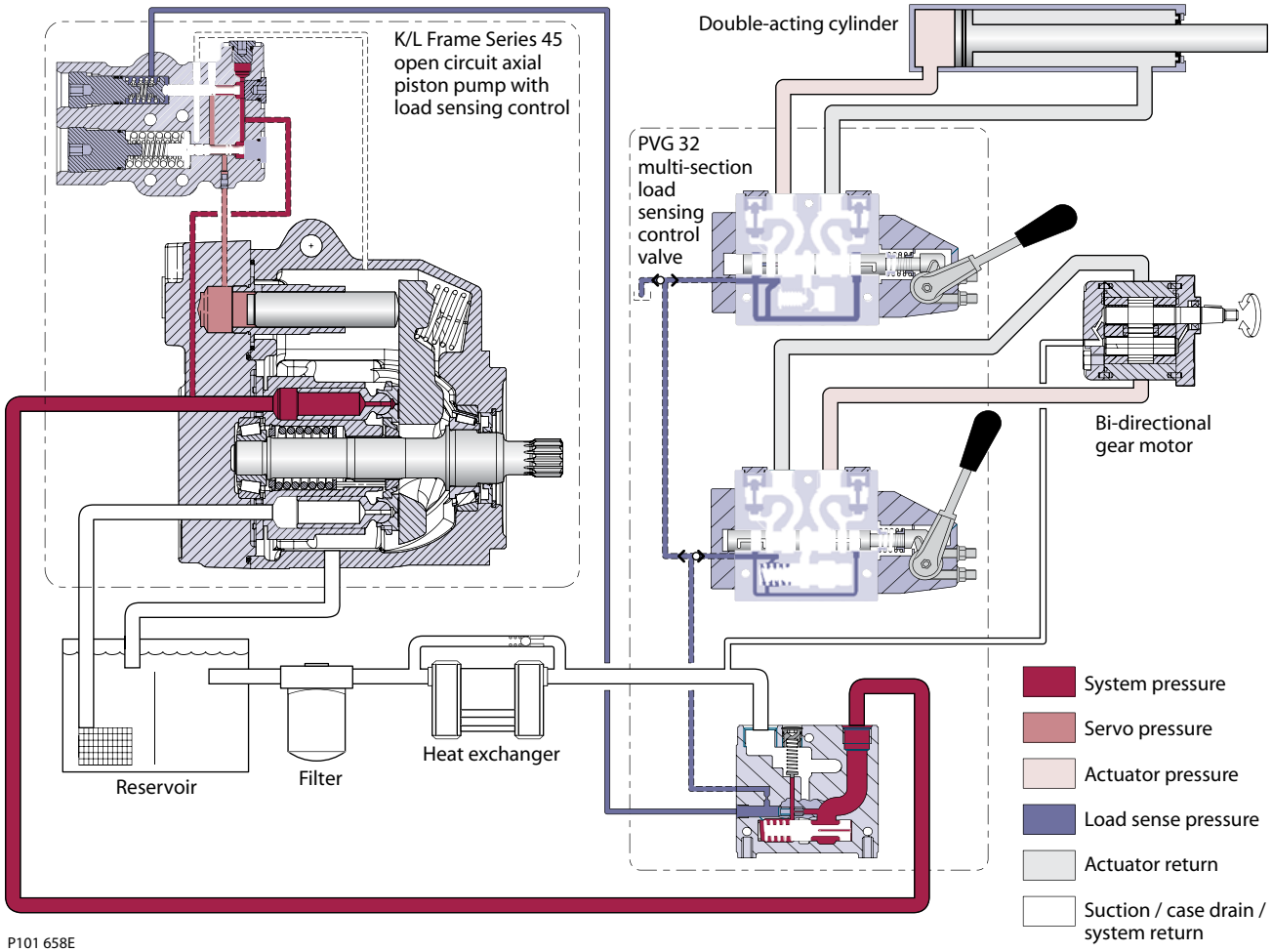
PVG 16, PVG 32 and Open Circuit Load Sense Example

The pump receives fluid directly from the reservoir through the inlet line. A screen in the inlet line protects the pump from large contaminants. The pump outlet feeds directional control valves such as PVG-32's, hydraulic integrated circuits (HIC), and other types of control valves. The PVG valve directs and controls pump flow to cylinders, motors and other work functions. A heat exchanger cools the fluid returning from the valve. A filter cleans the fluid before it returns to the reservoir.

Flow in the circuit determines the speed of the actuators. The position of the PVG valve spool determines the flow demand. A hydraulic pressure signal (LS signal) communicates demand to the pump control. The pump control monitors the pressure differential between pump outlet and the LS signal, and regulates servo pressure to control the swashplate angle. Swashplate angle determines pump flow.

Actuator load determines system pressure. The pump control monitors system pressure and will decrease the swashplate angle to reduce flow if system pressure reaches the PC setting. A secondary system relief valve in the PVG valve acts as a back-up to control system pressure.

Pictorial circuit diagram



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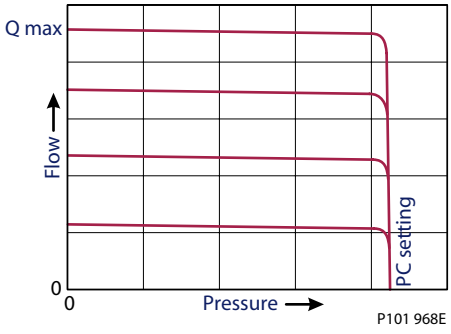
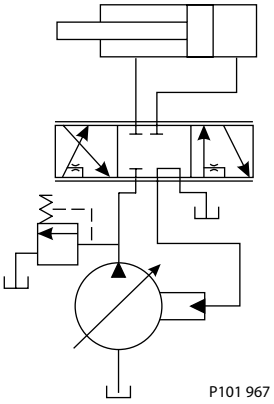
Load Sensing Controls

The LS control matches system requirements for both pressure and flow in the circuit regardless of the working pressure. Used with a closed center control valve, the pump remains in low-pressure standby mode with zero flow until the valve is opened. The LS setting determines standby pressure.

Typical operating curve



Load sensing circuit



Most load sensing systems use parallel, closed center, control valves with special porting that allows the highest work function pressure (LS signal) to feed back to the LS control. **Margin pressure** is the difference between system pressure and the LS signal pressure. The LS control monitors margin pressure to read system demand. A drop in margin pressure means the system needs more flow. A rise in margin pressure tells the LS control to decrease flow.

LS control with bleed orifice

The load sense signal line requires a bleed orifice to prevent high-pressure lockup of the pump control. Most load-sensing control valves include this orifice. An optional internal bleed orifice is available, for use with control valves that do not internally bleed the LS signal to tank.

Load Sensing Controls

Integral PC function

The LS control also performs as a PC control, decreasing pump flow when system pressure reaches the PC setting. The pressure compensating function has priority over the load sensing function.

Each section includes control schematic diagrams, setting ranges, and response / recovery times for each control available. Response is the time (in milliseconds) for the pump to reach zero displacement when commanded by the control. Recovery is the time (in milliseconds) for the pump to reach full displacement when commanded by the control. Actual times can vary depending on application conditions.

For additional system protection, install a relief valve in the pump outlet line.

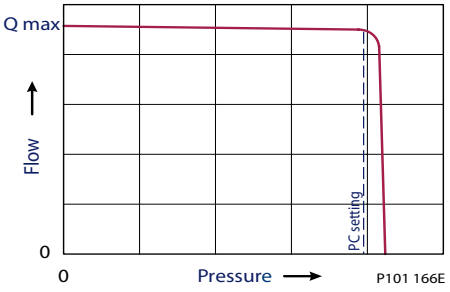
Load sensing system characteristics

- Variable pressure and flow
- Low pressure standby mode when flow is not needed
- System flow adjusted to meet system requirements
- Lower torque requirements during engine start-up
- Single pump can supply flow and regulate pressure for multiple circuits
- Quick response to system flow and pressure requirements

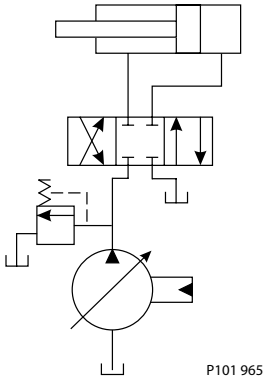
Pressure Compensated Controls

The PC control maintains constant system pressure in the hydraulic circuit by varying the output flow of the pump. Used with a closed center control valve, the pump remains in high pressure standby mode at the PC setting with zero flow until the function is actuated. This condition is often called **a dead head condition**.

Typical operating curve



Simple closed-center circuit



Once the closed center valve is opened, the PC control senses the immediate drop in system pressure and increases pump flow by increasing the swashplate angle.
The pump continues to increase flow until system pressure reaches the PC setting.
If system pressure exceeds the PC setting, the PC control reduces the swashplate angle to maintain system pressure by reducing flow. The PC control continues to monitor system pressure and changes swashplate angle to match the output flow with the work function pressure requirements. If the demand for flow exceeds the capacity of the pump, the PC control directs the pump to maximum displacement. In this condition, actual system pressure depends on the actuator load.

Each section includes control schematic diagrams, setting ranges, and response / recovery times for each control available. **Response** is the time (in milliseconds) for the pump to reach zero displacement when commanded by the control. **Recovery** is the time (in milliseconds) for the pump to reach full displacement when commanded by the control. Actual times can vary depending on application conditions.

For additional system protection, install a relief valve in the pump outlet line

Pressure compensated system characteristics

- Constant pressure and variable flow
- High pressure standby mode when flow is not needed
- System flow adjusts to meet system requirements
- Single pump can provide flow to multiple work functions
- Quick response to system flow and pressure requirements

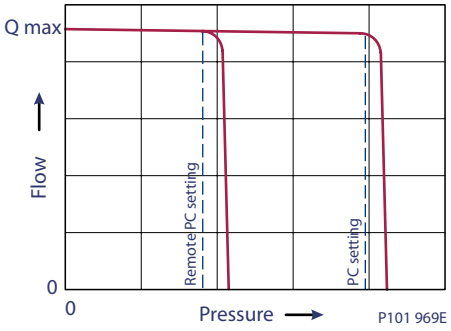
Typical applications for pressure compensated systems

- Constant force cylinders (bailers, compactors, refuse trucks)
- On/off fan drives
- Drill rigs
- Sweepers
- Trenchers

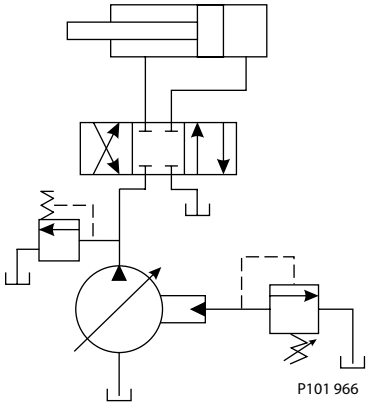
Remote Pressure Compensated Controls

The remote PC control is a two-stage control that allows multiple PC settings. Remote PC controls are commonly used in applications requiring low and high pressure PC operation.

Typical operating curve



Closed center circuit with remote PC



The remote PC control uses a pilot line connected to an external hydraulic valve. The external valve changes pressure in the pilot line, causing the PC control to operate at a lower pressure. When the pilot line is vented to reservoir, the pump maintains pressure at the load sense setting. When pilot flow is blocked, the pump maintains pressure at the PC setting. An on-off solenoid valve can be used in the pilot line to create a low-pressure standby mode. A proportional solenoid valve, coupled with a microprocessor control, can produce an infinite range of operating pressures between the low pressure standby setting and the PC setting.

Each section includes control schematic diagrams, setting ranges, and response / recovery times for each control available. **Response** is the time (in milliseconds) for the pump to reach zero displacement when commanded by the control. **Recovery** is the time (in milliseconds) for the pump to reach full displacement when commanded by the control. Actual times can vary depending on application conditions.

Size the external valve and plumbing for a pilot flow of 3.8 l/min [1 US gal/min]. For additional system protection, install a relief valve in the pump outlet line.

Remote pressure compensated system characteristics

- Constant pressure and variable flow
- High or low pressure standby mode when flow is not needed
- System flow adjusts to meet system requirements
- Single pump can provide flow to multiple work functions
- Quick response to system flow and pressure requirements

Typical applications for remote pressure compensated systems

- Modulating fan drives
- Anti-stall control with engine speed feedback
- Front wheel assist
- Road rollers
- Combine harvesters
- Wood chippers

Safety in Application

All makes and all types of control valves (incl. proportional valves) can fail, thus the necessary protection against the serious consequences of function failure should always be built into the system. For each application an assessment should be made for the consequences of pressure failure and uncontrolled or blocked movements.

To determine the degree of protection that is required to be built into the application, system tools such an FMEA (Failure Mode and Effect Analysis) and Hazard and Risk Analysis can be used.

FMEA (Failure Mode and Effect Analysis) IEC EN 61508

FMEA is a tool used for analyzing potential risks. This analytical technique is utilized to define, identify, and prioritize the elimination or reduction of known and/or potential failures from a given system before it is released for production.
Please refer to IEC FMEA Standard 61508.

Hazard and Risk Analysis ISO 12100-1 / 14121

This analysis is a tool used in new applications as it will indicate whether there are special safety considerations to be met according to the machine directives EN 13849. Dependent on the determined levels conformity this analysis will detirmine if any extra requirements for the product design, development process, production process or maintenance, i.e. the complete product life cycle.

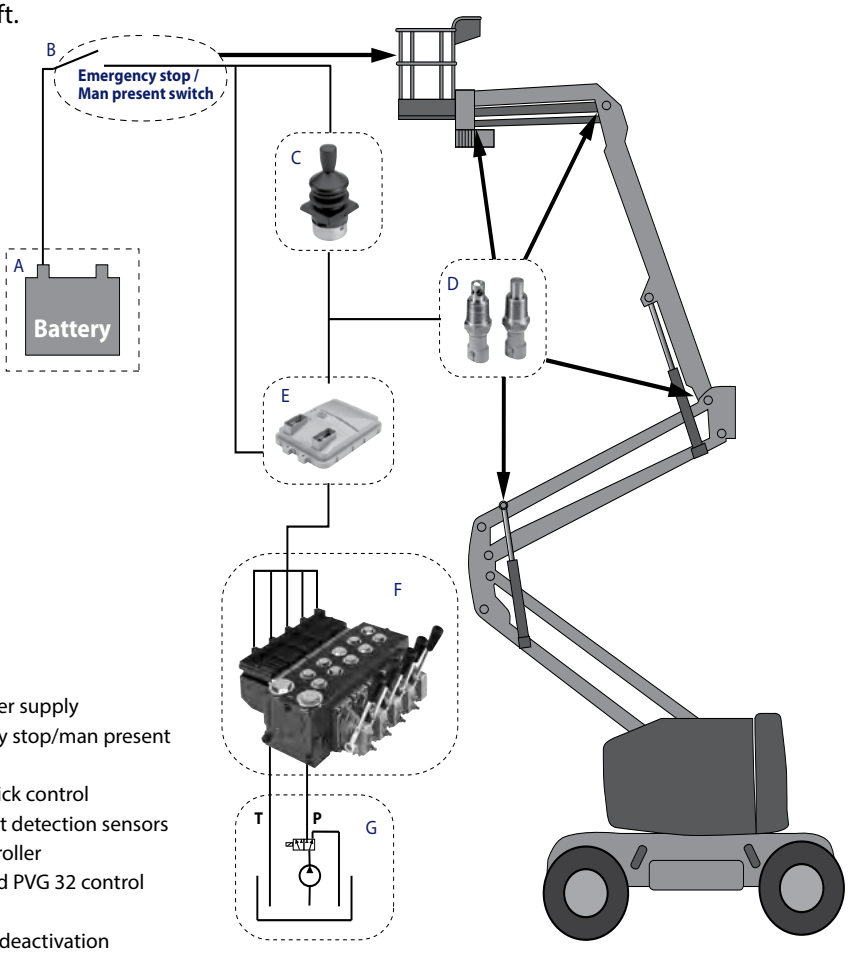
⚠ Warning

All makes/brands and types of directional control valves – inclusive proportional valves – can fail and cause serious damage. It is therefore important to analyze all aspects of the application.
Because the proportional valves are used in many different operation conditions and applications, the manufacturer of the application is alone responsible for making the final selection of the products – and assuring that all performance, safety and warning requirements of the application are met.
The process of choosing the control system – and safety levels – is governed by the machine directives EN 13849 (Safety related requirements for control systems).

Safety in Application (continued)

Control System Examples

Example of a control system for manlift using PVE Fault monitoring input signals and signals from external sensors to ensure the PLUS+1™ main controllers correct function of the manlift.

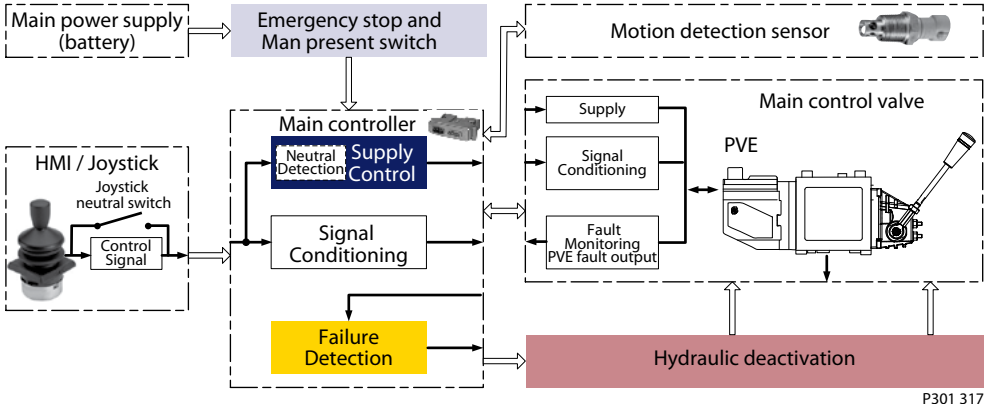


A Main power supply
B Emergency stop/man present switch
C HMI/Joystick control
D Movement detection sensors
E Main controller
F PVG 16 and PVG 32 control valve
G Hydraulic deactivation

⚠ Warning

It is the responsibility of the equipment manufacturer that the control system incorporated in the machine is declared as being in confirmity with the relevant machine directives.

Electrical block diagram for above illustration



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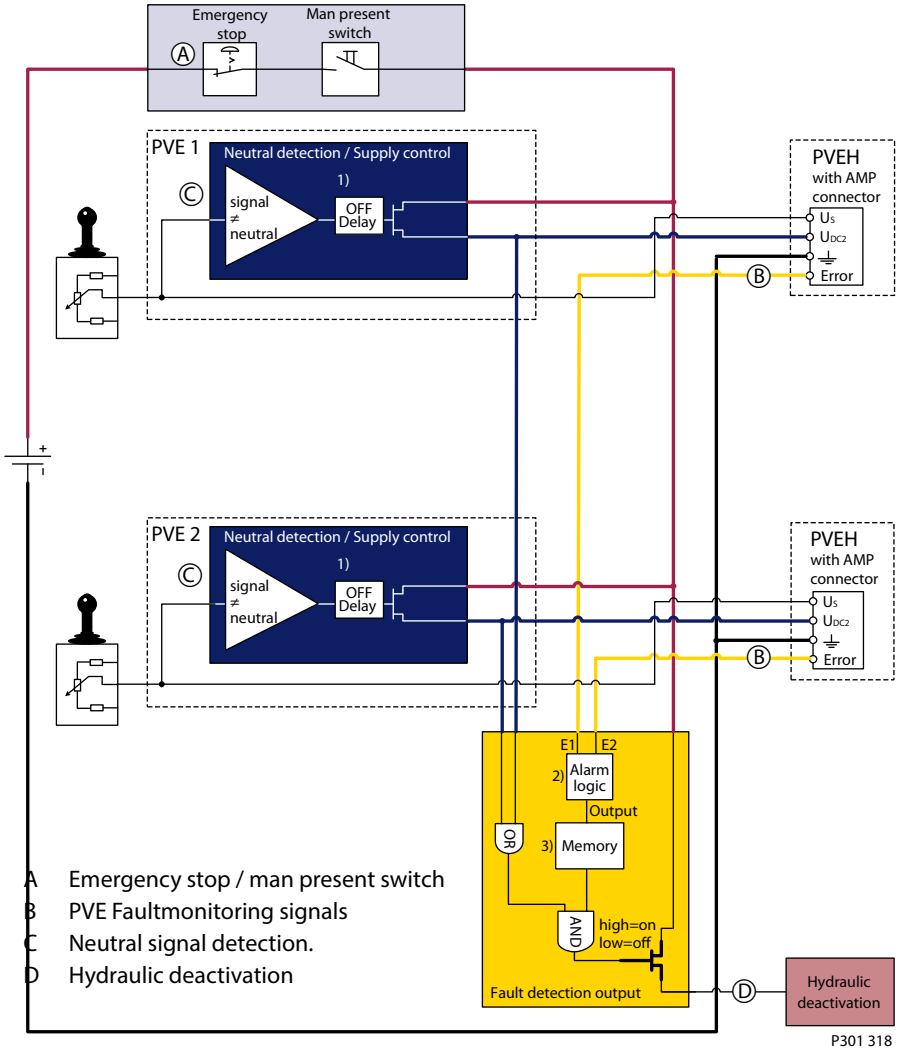
Safety in Application (continued)

Example of a typical wiring block diagram using PVEH with neutral power off switch and fault monitoring output for hydraulic deactivation.



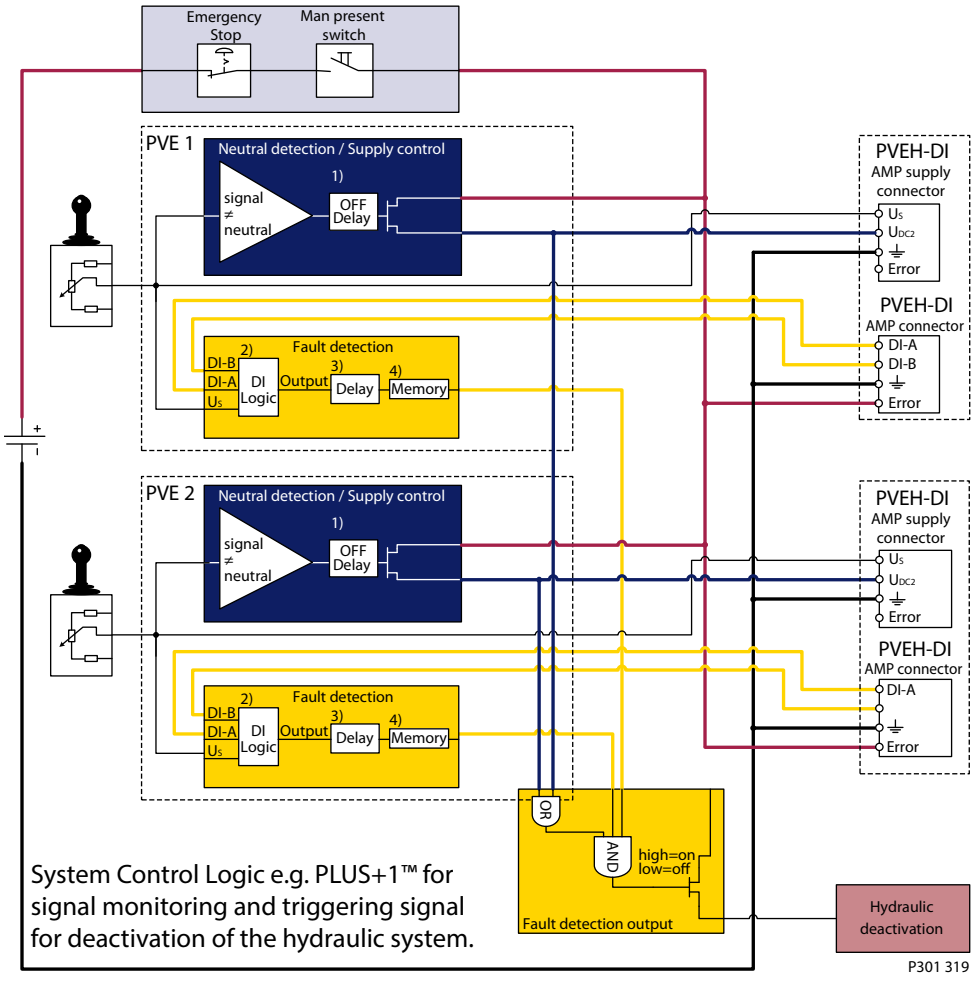
System Control Logic e.g. PLUS+1™ for signal monitoring and triggering signal for deactivation of the hydraulic system.

⚠ Warning

It is the responsibility of the equipment manufacturer that the control system incorporated in the machine is declared as being in confirmity with the relevant machine directives.

Safety in Application (continued)

Example of fault monitoring for deactivation of the hydraulic system with extra fault inputs using the PVE's with DI (Direction Indication) function.



⚠ Warning

It is the responsibility of the equipment manufacturer that the control system incorporated in the machine is declared as being in confirmity with the relevant machine directives.

Other modules which can be used in connection with hydraulic deactivation at different levels.

PVG 32 – Mainly used in system with fixed displacement pumps

- PVSK, commonly used in crane application - full flow dump
- PVPX, LS dump to tank

PVG 100 – Alternative LS dump or pilot supply disconnect

- PVPP, pilot oil supply shut off
- External cartridge valve connecting LS Pressure to Tank
- External cartridge valve connecting main Pressure to Tank

PVG 120 – Pump disconnect/block for variable pumps

- PVPE, full flow dump for the PVG 120
- External cartridge valve connecting LS Pressure to Tank

PVG 16 and PVG 32 with Open Center PVP (fixed displacement pump) • PVB with Flow Control Spool

When the pump is started and the main spools in the individual basic modules (11) are in the neutral position, oil flows from the pump, through connection P, across the pressure adjustment spool (6) to tank. The oil flow led across the pressure adjustment spool determines the pump pressure (stand-by pressure).

When one or more of the main spools are actuated, the highest load pressure is fed through the shuttle valve circuit (10) to the spring chamber behind the pressure adjustment spool (6), and completely or partially closes the connection to tank to maintain pump pressure.

Pump pressure is applied to the right-hand side of the pressure adjustment spool (6). The pressure relief valve (1) will open should the load pressure exceed the set value, diverting pump flow back to tank.

In a pressure-compensated basic module the compensator (14) maintains a constant pressure drop across the main spool – both when the load changes and when a module with a higher load pressure is actuated.

With a non pressure-compensated basic module incorporating a load drop check valve (18) in channel P, the check valve prevents return oil flow.

The basic module can be supplied without the load drop check valve in channel P for functions with over-center valves.

The shock valves PVLP (13) with fixed setting and the suction valves PVLA (17) on ports A and B are used for the protection of the individual working function against overload and/or cavitation.

An adjustable LS pressure limiting valve (12) can be built into the A and B ports of pressure-compensated basic modules to limit the pressure from the individual working functions. Please see *the sectional drawing* on the next page for better understanding of this example.

The LS pressure limiting valves save energy compared with the shock valves PVLP:
- with PVLP all the oil flow to the working function will be led across the combined shock and suction valves to tank if the pressure exceeds the fixed setting.
- with LS pressure limiting valves an oil flow of about 2 l/min [0.5 US gal/min] will be led across the LS pressure limiting valve to tank if the pressure exceeds the valve setting.

PVG 16 and PVG 32 with Closed Center PVP (variable displacement pump) • PVB with Flow Control Spool

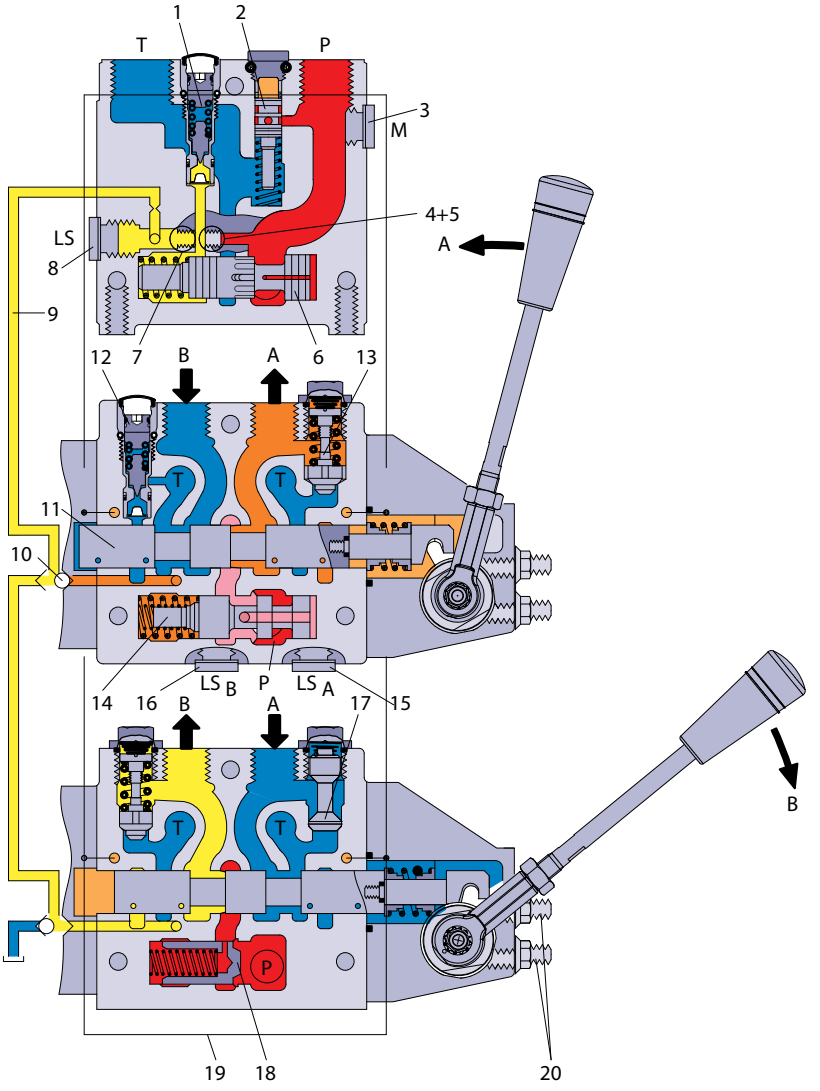
In the closed center version of PVP an orifice (5) and a plug (7) have been fitted instead of the plug (4). This means that the pressure adjustment spool (6) will only open to tank when the pressure in channel P exceeds the set value of the pressure relief valve (1).

In load sensing systems the load pressure is led to the pump control via the LS connection (8).

In the neutral position the pump load sense control sets the displacement so that leakage in the system is compensated, to maintain the set stand-by pressure.
When a main spool is actuated the pump load sense control will adjust the displacement so that the set differential pressure (margin) between P and LS is maintained.

The pressure relief valve (1) in PVP should be set at a pressure of approx. 30 bar [435 psi] above maximum system pressure (set on the pump or external pressure relief valve).

PVG 16 and PVG 32 with Closed Center PVP), PVB with Flow Control Spool



General Conditions

The specification sheet is compiled by the sales department for assembly of a new PVG 16 and PVG 32 valve groups.

1. Before, during and after the assembly/disassembly of new PVG groups, absolute cleanliness and care must be observed with regard to internal and external parts of the units concerned.
2. Use non-volatile, petroleum based solutions for cleaning valves and/or modules.
3. Replace all parts considered likely to cause malfunction during subsequent testing.
4. Replace all loose O-rings (without exceptions) with new O-rings.
5. Lubricate all moving parts with hydraulic oil before assembly.
6. Lubricate all O-rings with petroleum jelly.

Refer to *Service Manual* **520L0515** for module designations, item and spare parts numbers.

Assembly

The basic assembly sequence for PVG 16 and PVG 32 group is as follows:

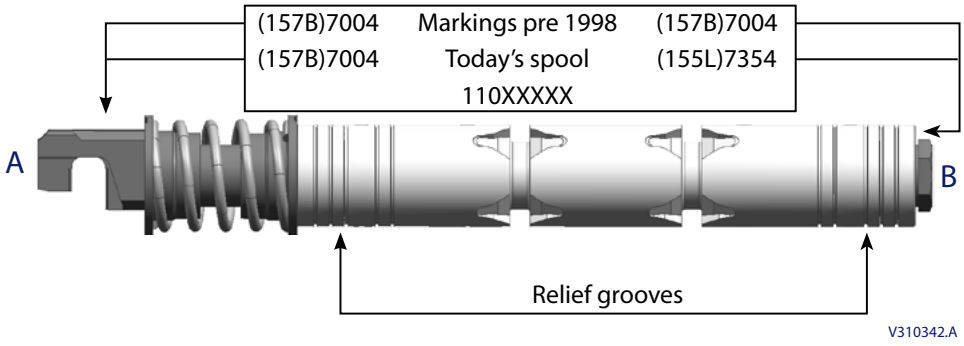
1. Starting from the end plate place the module with (PVS, PVSP, PVSK) the tie rod bolts with the long threaded end pointing upwards ready for mounting of PVB modules.
2. Place all lubricated O-rings in their respective grooves in the different modules.
3. Locate the basic modules (PVB) against the PVP (PVS, PVSP, PVSK) using the tie rod bolts for alignment between the PVP and the PVB modules making sure the LS shuttle valve is able to move freely.
4. Place the PVP (the PVS if a valve group has midinlet, or HIC) as the last module and place the washers and nuts in position and hand tighten the valve.
5. Place the valve on a plain and level surface and tighten the assembly to a torque of 2.2 +0.3/-0 N•m (195 + 25/-0 lbf•in) using a 13 mm socket.
   Max. level tolerance is 0.5 mm per section e.g. this means with 8 PVB sections max. allowable height difference between the mounting holes would be 4 mm (this would also be seen as a twist in the valve group assembly).

The valve assembly is to be assembled in accordance with the specification sheet.

Assembly (continued)

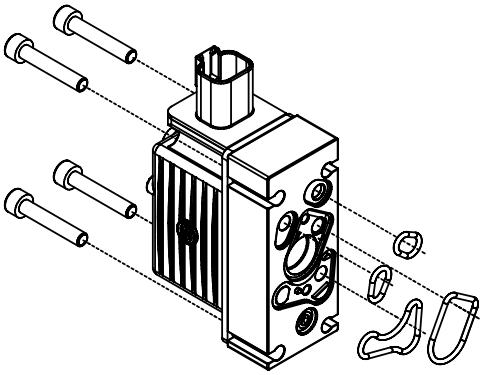
6. Install the spools (PVBS) into the PVB's.
The assembled spool is marked with two four-digit numbers (see *the figure below*).
The number in the end of the spool where the plug is fitted, "B", is the drawing number of the spool and indicates that this end must face towards the "B" port of the valve.
The other number, stamped on the side the PVBS pull rod "A", is the module number of the assembled main spool.
For spool assemblies with remote hydraulic spools, the centering spring is different. The standard spring has a wire diameter of 1.9 mm. The remote hydraulic spring (5-15 bar) has a wire diameter of 2.8 mm.

   PVG 16 and PVG 32 are symmetrical, which allows for valve groups to be "option mounted" This can be one by inserting the spools from the "B" port side and mounting the PVM's on the "B" port side of the PVB assembly.

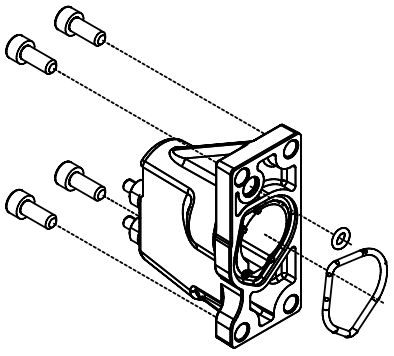


7. Assemble the mechanical actuators to the valve (see *the figure below*). Before fitting the PVM into engagement with the PVBS tension rod, the driver arm must be pushed towards the PVB before engagement will occur. Once the driver arm is engaged, rotate the mechanical actuator while pressing the PVM until the PVM is flush against the PVB housing.
Tighten the four (4) mounting screws to a torque of 0.8 +0/-0.5 N•m [70 +0/-4.5 lbf•in] using a 5 mm hex driver.

Assembly of PVE, electrical actuation



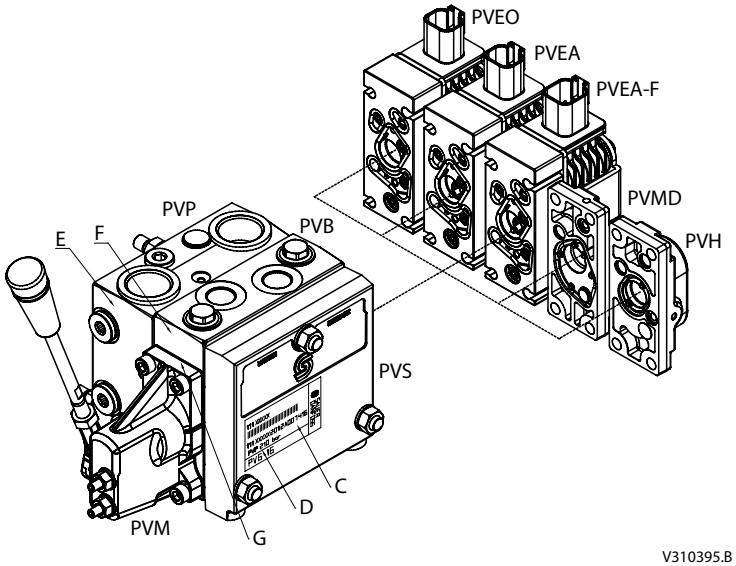
Assembly of PVM, mechanical actuation



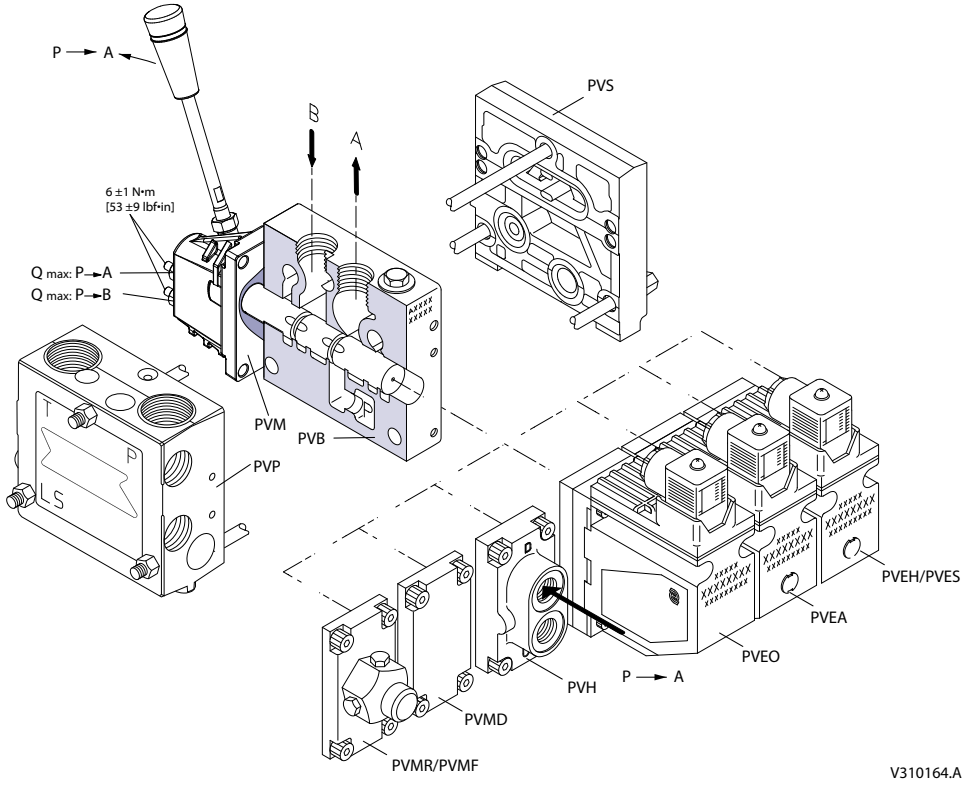
V310413.A

Assembly (continued)

Assembly of PVG 16



Assembly of PVG 32



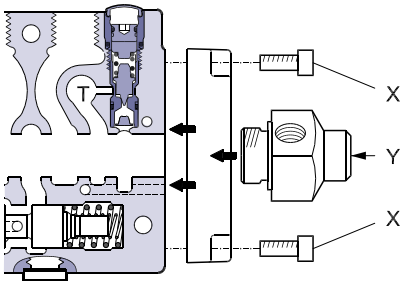
Assembly (continued)

8. Assemble the actuators. The manual cover PVMD or the remote hydraulic end cover must be installed with the arrow pointing upwards towards the "A/B" port.

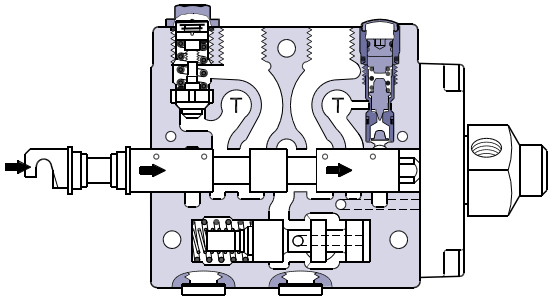
   The PVE's must be installed with the connectors pointing upwards towards the "A/B" port. The torque for the four (4) mounting screws is 0.8 + 0/-0.5 N•m [70 +0/-4.5 in. lbs.] using a 5 mm hex drive.

   Common to all types of PVE's is a small nylon filter in the "P" channel, under the O-ring. Insure that the transducer stem on the PVE's with closed loop feedback interfaces with the end of the PVBS without any restrictions.

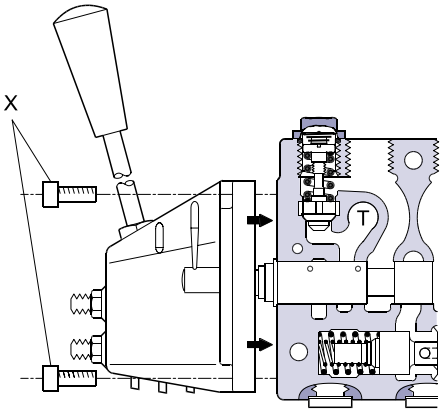
   New and unused PVE units can be mounted without neutral adjustment to the LVDT transducer. If an adjustment is required, contact the service department.
   For control options with mechanical detent (PVMR) or mechanical float (PVMF) function, please follow instructions in the previous section describing assembly of the PVMD or PVH remote with reference to *the below pictures*.



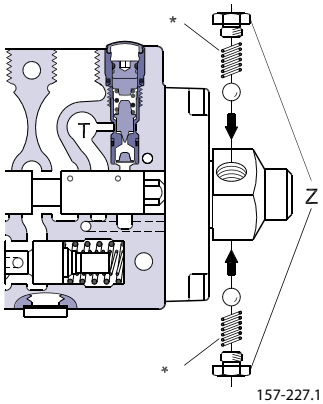
157-224.11



157-225.11



157-226.11



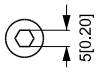
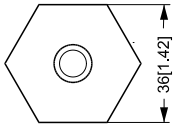
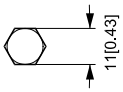
157-227.11

*	Spring Identification
PVMF	Painted blue
PVMR	Non-painted

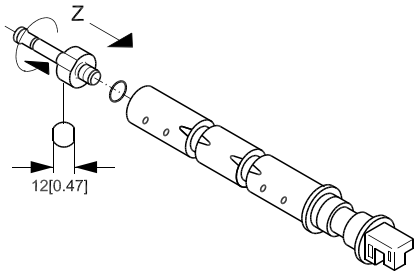
Assembly (continued)

For torque tighting values of the large hexagon (Y) with the detent assembly function, please see *the table below.*

Tightening Torques and Widths Across Flats

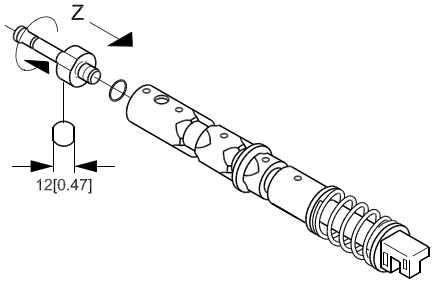
	X	Y	Z
With across flats			
Tightening torque	8 ±0.5 N•m [70 ±4.5 lbf•in]	15 ±2 N•m [135 ±20 lbf•in]	4 ±1 N•m [35 ±9 lbf•in]

PVMR, detent option without a neutral spring



157-219.12

PVMF, mechanical float option

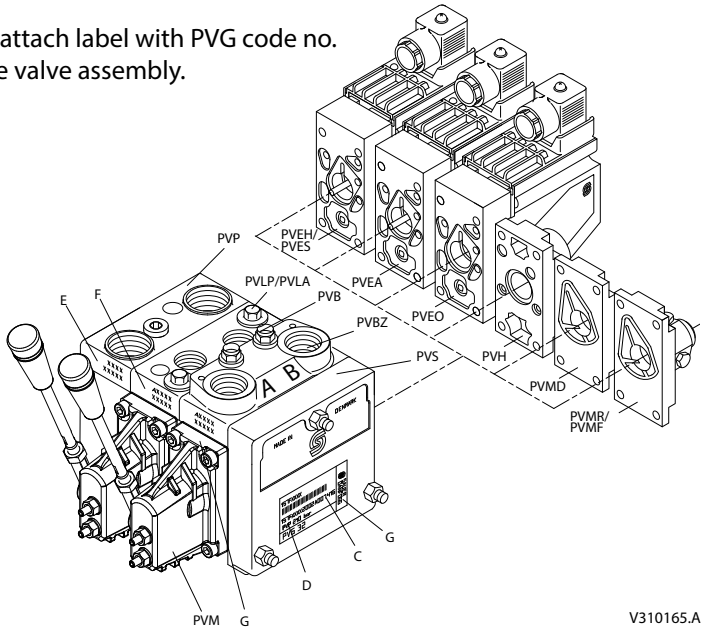


157-221.12

The valve assembly is to be assembled in accordance with the specification sheet.

9. Assemble the shock/check (PVLP) valves into the PVB's. The top of the PVLP valve is marked with the last three digits of the module code number. This number also indicates the valve pressure setting @ 15.1 l/min [4 US gal/min]. Be careful not to swap plugs and valves. The PVLA module carries no markings. The torque for the plug is 4.0 ± 0.3 N•m [355 ± 25 lbf•in].

10. Issue/attach label with PVG code no. for the valve assembly.



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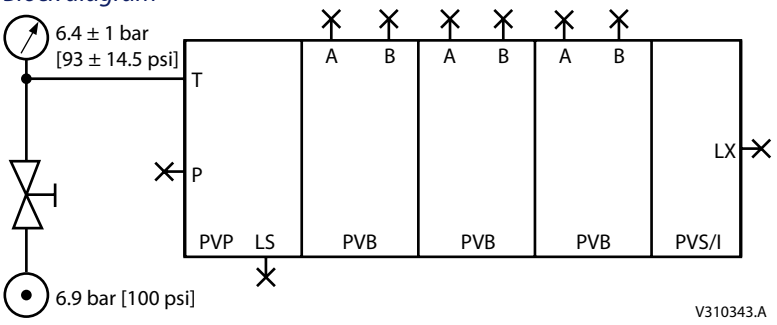
Leak test

After all components have been assembled and tightened to the proper specifications, a leak test with compressed air must be performed.

1. Block off all "A" and "B" ports with steel plugs.

2. Block off the "P" port with a steel plug in the PVP. Screw the compressed air connection into the "T" port. (see *the figure below*).

Block diagram



3. Apply compressed air at 6.9 bar [100 psi] for 5 minutes. At the same time, activate all PVM control levers in order to fill fill all channels, chambers and cavities with an air.

4. Shut off the compressed air so that pressure is confined in the entire valve.
The permissible pressure drop in the valve is 0.5 bar [7 psi] per minute maximum.
Small leaks can be traced by pouring a small amount of oil onto the place where the leak is thought to be present.

5. Try correcting small leaks by retightening the assembly. Large leaks usually indicate forgotten or squeezed O-rings.

Pressure setting after assembly

All relief valves must be set with a gauge located in the gauge port of the PVP.

Groups with CLOSED CENTER PVP'S can be tested as assembled for all pressure relief settings.

Groups with OPEN CENTER PVP'S and PVB'S with shock valves (PVLP) and LS_A/LS_B valves with opening pressure lower than the pressure setting in the PVP. The PVP must be modified temporarily to CLOSED CENTER. After the relief settings are made, the PVP must be corrected to OPEN CENTER. All other with OPEN CENTER PVP'S can be tested as assembled.

The PVP pressure relief valve and LSA/LSB pressure relief valves must be set by applying oil pressure on the "P" port in the PVP. The "T" port must be connected to tank.
All "A" and "B" ports must be blocked off with steel plugs.

The quantity of oil supplied to the valve assembly must be at least 15 l/min [4 US gal/min].

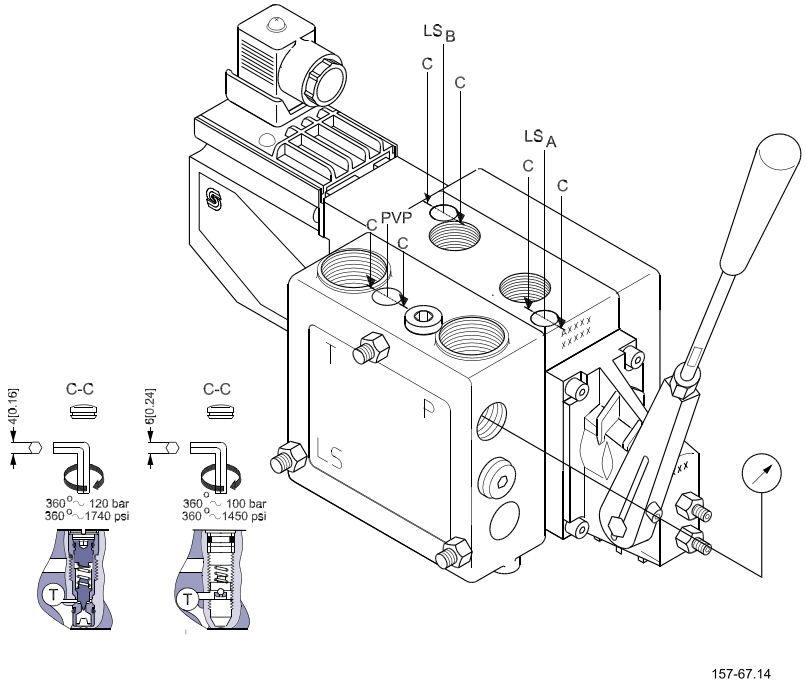
The CLOSED CENTER PVP module can be set by applying pressure to the "P" port.

The OPEN CENTER PVP module can be set by applying pressure to the "P" port and activating the spool in the A or B direction dead headeding the A or B port.

LS_A/LS_B valves must be set one at a time by activating the spool in the PVB section in the direction of the LS valve to be adjusted.

It is assumed that the PVP module has a higher setting than the LS_A/LS_B valves.

Adjustment of the relief valve is accomplished by using a 4 mm hex wrench.
For relief valve version and location please see *the figure below.*



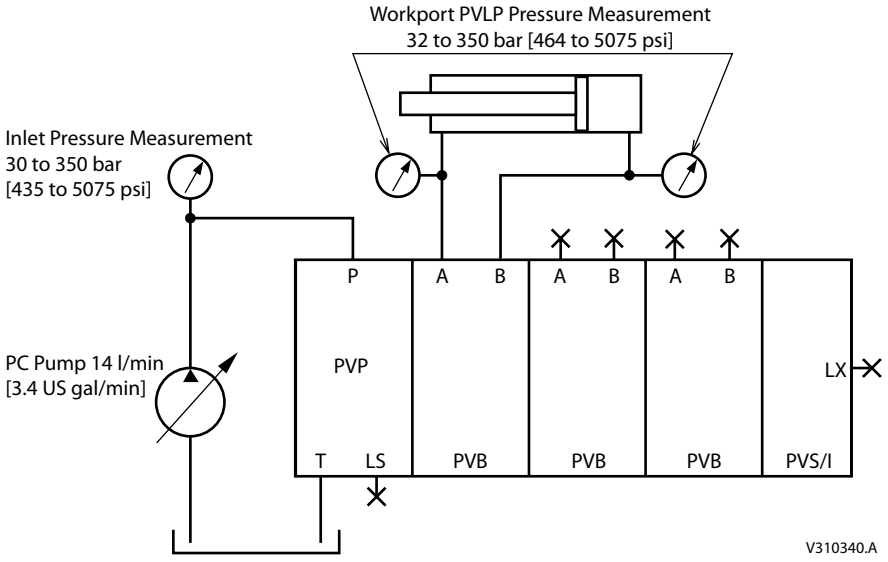
157-67.14

Function testing

Function testing insures the correct dynamic manual and electrical operation of the PVG 16 and PVG 32 valve assembly. This test should be performed after completing the pressure adjustments.

Each section of the assembly must be tested:

1. With the pump connected as described in the *"PRESSURE SETTING AFTER ASSEMBLY"* section, remove the plugs from the section to be tested. Connect the "A" port of the valve to the rod end of the cylinder and the "B" port to the base end of the cylinder (see *the figure below*).



2. Shift the control lever of the tested section towards the valve and observe cylinder retraction. Shift the same control lever away from the valve and observe cylinder extension. Repeat several times. On valve groups with PVM's on the "B" side, the cylinder movement will be opposite when shifting the handle in the same direction.

3. Check the spool travel smoothness in both directions.

4. Check the metering of the spool in both directions. Can you control the speed of the cylinder/motor, slow/fast?

5. Check to see if the LS signal at the PVP drops off, when the spool is in the neutral position. This signal also should not build up pressure in the neutral position.

6. Shift the spool to one direction manually and let go of the control lever. The valve should center itself. If the control lever sticks in any position, check for binding of the spool. This is to be checked in both directions.

Function testing (continued)

7. Utilizing a controller package, connect the EL-PLUG connector to the PVE. Set the controller to the corresponding PVE. Insure that the proper voltage and joystick are being used. Similar to manual testing of the valve, eclectically shift the valve to allow flow out the "A" port.

   Check to see if the PVM control level shifts in the correct direction. This should also be done in the "B" direction. Check to insure that once the controller is not activated the valve centers itself. Observe that the spool responds to any change in the signal from the joystick. Any change in position of the joystick should relate to a change in the PVM control lever. Check the metering of the PVEM/H's.

8. After all sections have been tested, insure that all relief valves are adjusted correctly. Refer to the *"PRESSURE SETTING AFTER ASSEMBLY"* section for any adjustments.

9. Remove all steel plugs, fittings and hoses. Drain the oil from the valve group. Install plastic plugs in all ports & rubber cap (155L6377) over all pressure adjustments.

10. A certified PVG valve test report must be completed & accompany every valve, e.g. see *PVG 32 PROPORTIONAL VALVE TEST REPORT* on the next page.

Sections with open ported spools will experience cylinder extension in the neutral position.

Recommended equipment and hand tools to assemble PVG 16 and PVG 32:

- Socket driver, Allen wrench = 2.5, 3, 4, 5, 6, 8 mm.
- Sockets = 3/8 drive deep well 13 mm.
- Combo – wrenches = 10, 13 mm
- Torque wrench = 3/8 drive 0 – 10 N•m [0-885 in. lbs.]
- Ball driver hex = 4, 5, 6, 8 mm
- Plastic hammer

Test Report

SAUER DANFOSS DAIKIN

TEST REPORT
PROPORTIONAL VALVE PVG 32
For Test Procedure, Refer to Service Instructions SI 167B8000-

PVG NO. 157 0

0 Specified Relief Setting: ..... 0 bar
Relief Set at: ..... bar

FUNCTION	A-Port	B-Port	Coil Type and Serial No.
Manual Operation: Detent Operation: Hydraulic Operation: Solenoid Operation:	Tested OK? ☐ Shocks ☐ Specified ..... bar Setting ..... bar	Tested OK? ☐ Shocks ☐ Specified ..... bar Setting ..... bar	157 ..... 194 ..... S/N .....

1 Spool Code verified: .....
LS_A Specified: ..... Set: ..... bar
LS_B Specified: ..... Set: ..... bar

2 Spool Code verified: .....
LS_A Specified: ..... Set: ..... bar
LS_B Specified: ..... Set: ..... bar

3 Spool Code verified: .....
LS_A Specified: ..... Set: ..... bar
LS_B Specified: ..... Set: ..... bar

4 Spool Code verified: .....
LS_A Specified: ..... Set: ..... bar
LS_B Specified: ..... Set: ..... bar

5 Spool Code verified: .....
LS_A Specified: ..... Set: ..... bar
LS_B Specified: ..... Set: ..... bar

6 Spool Code verified: .....
LS_A Specified: ..... Set: ..... bar
LS_B Specified: ..... Set: ..... bar

7 Spool Code verified: .....
LS_A Specified: ..... Set: ..... bar
LS_B Specified: ..... Set: ..... bar

8 Spool Code verified: .....
LS_A Specified: ..... Set: ..... bar
LS_B Specified: ..... Set: ..... bar

9 Spool Code verified: .....
LS_A Specified: ..... Set: ..... bar
LS_B Specified: ..... Set: ..... bar

10 Spool Code verified: .....
LS_A Specified: ..... Set: ..... bar
LS_B Specified: ..... Set: ..... bar

All Codes Correct? ☐
Assembly Bolts Torqued? ☐
Re-Torqued after Test? ☐
M.D.A. Labels Fitted? ☐
Solenoid Test Voltage: ☐
B/No.& Date Stamp on Endplate? ☐
No. of Valve Builds: ☐
Build: ☐ of

Tested by: Date:

Any Special Requirements? _____ Describe Below:

Checked? .....

Any Documents to Accompany Valve? ____

Checked? .....

Order Specification

Subsidiary/Dealer		PVG No.	
Customer		Customer Part No.	
Application		Revision No.	

Section v	Function	A-Port v				B-Port v
0			157B		157B	
		157B	p =	bar	157B	
1		**a** 157B	157B		157B **16**	157B **c**
		b 157B	LS_A	bar	LS_B bar	157B **b**
2		**a** 157B	157B		157B **16**	157B **c**
		b 157B	LS_A	bar	LS_B bar	157B **b**
3		**a** 157B	157B		157B **16**	157B **c**
		b 157B	LS_A	bar	LS_B bar	157B **b**
4		**a** 157B	157B		157B **16**	157B **c**
		b 157B	LS_A	bar	LS_B bar	157B **b**
5		**a** 157B	157B		157B **16**	157B **c**
		b 157B	LS_A	bar	LS_B bar	157B **b**
6		**a** 157B	157B		157B **16**	157B **c**
		b 157B	LS_A	bar	LS_B bar	157B **b**
7		**a** 157B	157B		157B **16**	157B **c**
		b 157B	LS_A	bar	LS_B bar	157B **b**
8		**a** 157B	157B		157B **16**	157B **c**
		b 157B	LS_A	bar	LS_B bar	157B **b**
9		**a** 157B	157B		157B **16**	157B **c**
		b 157B	LS_A	bar	LS_B bar	157B **b**
10		**a** 157B	157B		157B **16**	157B **c**
		b 157B	LS_A	bar	LS_B bar	157B **b**
11		**a** 157B	157B		157B **16**	157B **c**
		b 157B	LS_A	bar	LS_B bar	157B **b**
12		**a** 157B	157B		157B **16**	157B **c**
		b 157B	LS_A	bar	LS_B bar	157B **b**
		157B				157B
13		**a** 157B	157B		157B **16**	157B **c**
		b 157B	LS_A	bar	LS_B bar	157B **b**
14	End section		157B			
15	PVAS section		157B			
	"Reserved for Painting"		157B			
	Comments:					
	Filled in by:					Date:

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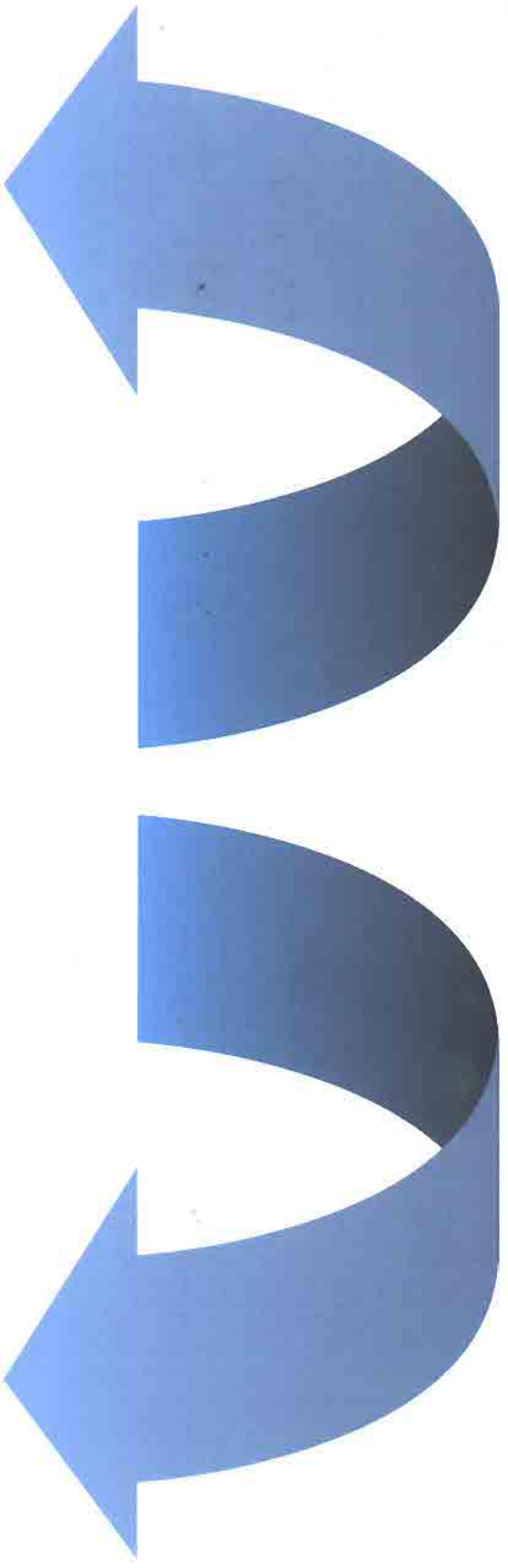
DENISON HYDRAULICS

VANE TROUBLESHOOTING GUIDE

1 - EN0721 - A 02 / 99 / 5000 / replaces SI - EN175 - A

DENISON Hydraulics

VANE TROUBLESHOOTING GUIDE



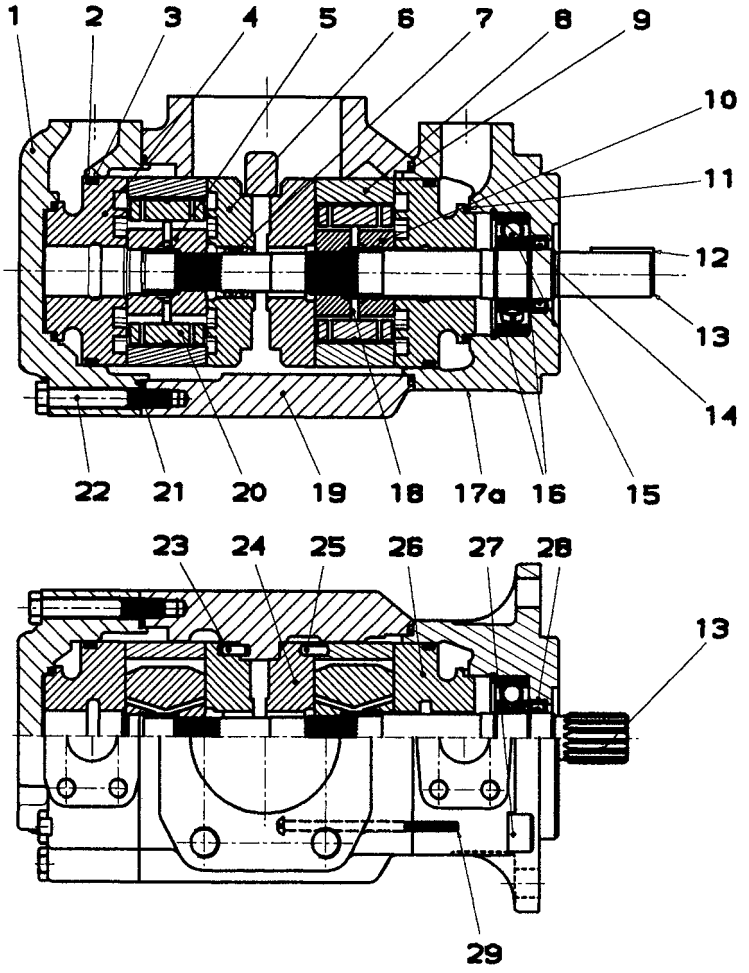
VANE TROUBLESHOOTING GUIDE

V - COMPONENT ANALYSIS CHART

	Pages	bushing	cam ring	pins	rotor	screws	seals	shaft	side plates	vanes	Pages
PUMP	12							x			12
	13							x			13
	14							x			14
	15	x	x					x	x		15
	16						x	x	x		16
	17					x			x		17
	18								x		18
	19		x		x			x	x		19
	20								x		20
	21		x							x	21
	22				x			x			22
	23		x		x						23
	24										24
	25										25
	26								x		26
	27		x						x	x	27
	28								x		28
	29										29
	30		x						x		30
	31		x	x	x					x	31
	32				x						32
	33									x	33
	34		x							x	34
	35		x		x				x	x	35
	36				x				x	x	36
	37										37
	38		x		x					x	38
	39		x		x						39
	40				x				x		40
	41				x						41
	42										42
	43										43
	44										44
MOTOR	45							x			45
	46		x		x				x		46
	47						x		x		47
	48		x						x	x	48
	49				x						49

VANE TROUBLESHOOTING GUIDE

VANE PUMP COMPONENTS DESIGNATION



Part nb.	part designation	Part nb.	part designation
1	End cap	**16**	Round section ring
2	Square section seal P1 & P2	**17**	Mounting cap
3	Back-up ring P1 & P2	**18**	Pin-vane holdout (P1 & P2)
4	Pressure port plate P2	**19**	Housing
5	Rotor-insert assembly P2	**20**	Vane P1 & P2
6	Rear port plate P2	**21**	Square section seal
7	Bush	**22**	Screw
8	Cam ring P1 & P2	**23**	Dowel pin
9	O ring	**24**	Rear port plate P1
10	Rotor-insert assembly P1	**25**	Dowel pin
11	Square section seal P1 & P2	**26**	Pressure port plate
12	Key	**27**	Screw
13	Keyed shaft	**28**	Shaft seal
14	Splined shaft	**29**	Screw
15	Ball bearing		

VANE TROUBLESHOOTING GUIDE

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I -2 HOW TO USE THIS GUIDE 2

I -3 WHY A DENISON VANE PUMP SHOULD NOT BREAK DOWN 2

I -4 BASIC PRECAUTIONS FOR A LONG LIFE TIME 5

II ANALYSIS OF FAILURES 6

II -1 MECHANICAL FAILURES 7

II -2 THE CONSEQUENCES OF MECHANICAL FAILURES 12

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VANE TROUBLESHOOTING GUIDE

I INTRODUCTION

I-1 Presentation

The main goal of this guide is to help all the DENISON vane pump users to understand the principal causes of destruction of these pumps and motors in service. Our past experience has shown that the failures, occurring in the first 500 hours of service, are premature failures. Failing to follow instructions or ignoring the correct application limits and functioning of the units inevitably leads to premature failures. It is important to point out that 80 % of the failures are linked to fluid contamination incidents (chapter II-4).
This guide comes as an addition to the existing "Installation, operation and overhaul instructions" available bulletin S1-EN081.

I-2 How to use this guide

• **"The most common causes", chapter II** (pages 6 to 43): details of the major incidents you may encounter (cavitation, aeration, misalignment...) and their consequences on the vane pumps. While **chapter III** (pages 44 to 49) will concern the **vane motors.**

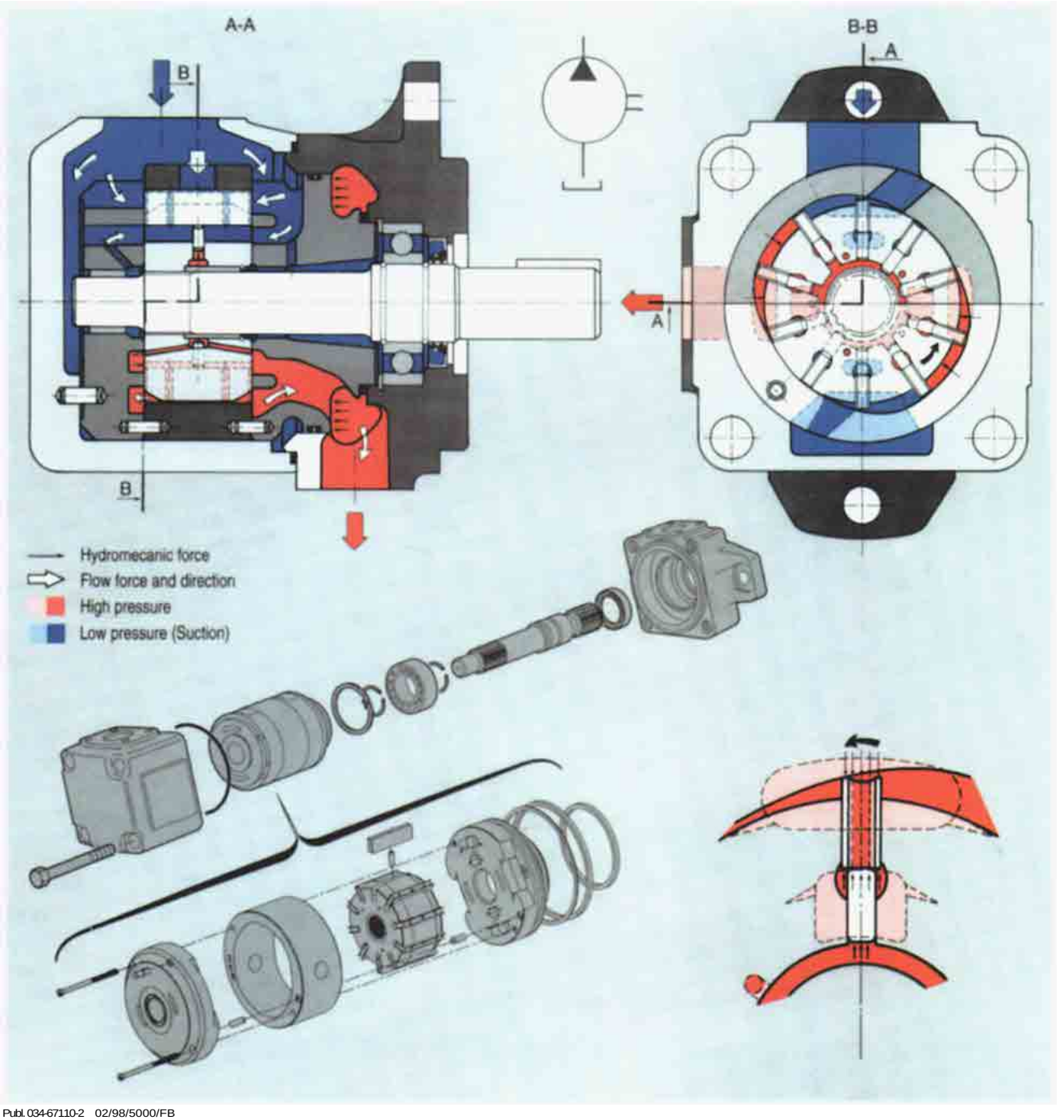
• **"Fault finding while the pump is running", chapter IV** (pages 50 to 60): the troubleshooting tables for vane pumps and motors. If you have a problem in working conditions, "the troubleshooting table" will help you to find out what is wrong (FAILURE-CAUSE-SOLUTION).

• **"Interpret the physical damages on components", chapter V:** The first page (folded) shows a chart which summarizes all the pictures of failed components. This will enable you to recognize the failed component and to understand the cause of this failure.

I-3 Why a DENISON Vane pump should not break down

Unlike most other hydraulic technologies, the DENISON vane pump design is hydraulically balanced. You cannot calculate the life time of these pumps by calculating the life time of the ball bearing as no internal load (neither axial nor radial) is applied on the shaft. The only purpose of the ball bearing in the Denison vane pump is to absorb any external shaft misalignment or abnormal coupling loads.
As shown on the drawings hereafter, the two symmetrical high pressure zones have a self centering effect on the rotating components.
This is a hydrostatic balanced pump, axially and radially.

DENISON HYDRAULICS
Vane Pumps
Single series T6 - T7 - B-C-D-E sizes



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DENISON Hydraulics

Each single vane is independently loaded in order to always be maintained on the cam ring contour. The specific Denison pin design reduces the possible internal leakage, reduces the possible vane/cam ring wear (due to a precise balancing of the forces under and over the vanes), lowers considerably the noise level, allowing higher pressure capabilities, extends the life time...

Added to this licensed pin design, Denison has engineered the double vane lip technology. This vane technology combined with the pin design gives unique overall performances. The double lips allow the pressure all around the vane to be the same on the top as on the bottom and as on the sides of it. This is possible because of the double lips and the balancing through the holes in the vanes. Here again, the components are hydrostatically balanced. Another advantage of the double lip design is the fact that the first lip seals the low pressure area and the other one seals the high pressure area. This increases the life time of the pump when working with contaminated oil. The wear, due to the particles of pollution, will have a negative effect, mainly on the first lip. The second lip, working in the high pressure area, keeps its original seal to maintain high volumetric efficiency.

This technology is unique because the wear is compensated. The effect of contamination on the Denison vane design is not a major issue of pump failure as for other pump technologies.

Every port plate and cam ring has a surface treatment to increase the life time capabilities.

On each cam ring, for example, a dry lubricant coating is laid on the cam profile. This coating will assure, even in bad priming conditions, a good start-up minimizing the risk of micro-seizures. With this dry lubricant coating, the deficiency of oil is compensated but not replaced. This is done for short term deficiencies.

Our passed experience shows that the most common failures are linked to the quality of the oil. As soon as there is a lack of lubricity, the failure is imminent. In addition to the pressure and the mechanical failures, all the problems are usually a lack of lubrication (rupture of the film of oil). The followings are some examples of the common causes:

- air in the oil (cavitation, aeration),
- solid large size particles,
- chemical agents (water, wrong additives, tar...),
- too high or too low viscosity,
- overheating (shaft alignment),
- flow of the system coming back to the pump,
- poor quality of oil loosing its main chemical characteristics,

This is why good filtration, good thermal stability, good quality of oil, a good design (hose design, bleeder, tank design ...), correct hydraulic knowledge (...) will always increase the life time of all hydraulic components.

The DENISON vane pump technology is a heavy duty engineering design that will last years if elementary precautions are taken.

I-4 Basic precautions for a long life time:

The Denison vane products are designed for long life. Some minor precautions can help to avoid premature breakdowns:

- have a correct air bleed at start-up,
- always check the oil velocity (inlet & outlet). This should then give the correct sizes of hoses & connectors: maximum velocity of 1,9 m/sec. for the inlet & 6 m/sec. for the outlet,
- no strainer on the inlet line is preferred (250 microns minimum and check the pressure drop when the Viscosity rises),
- always pay attention to the viscosity of the oil versus temperature. Even a small change in temperature can have a big effect on the viscosity. A good quality return line filter is the best solution.
- check the pressure at the inlet port, (position of the tank, shaft rotational speed...),
- ratio flow/tank capacity: is cooling required ?
- good shaft alignment is a classic "weakness", as well as proper coupling with the driving source. The lubrication of these links is also something to look after,
- proper oil selection versus application condition: viscosity index, viscosity grade (ISO 32,46, 68...), environment (biodegradability, fire resistance, normal conditions), pumping temperature range, filterability, deaeration, thermal stability are the basics to consider for a good fluid,
- if the pump is used on a very fast pressure cycling machine, attention should be paid to the relationship between the pressure rise/fall gradient and the inlet pressure in order to avoid cavitation. We recommend maximum limits of 5000 bar per second (72500 PSI/ second) for pressure rise and 6000 bar per second (87000 PSI) for presssure fall.

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II ANALYSIS OF FAILURES

The systematic analysis of failures permits the causes to be determined logically, these failures being either distortion, shearing, surface seizure or scoring.

If the failure is shearing, we can almost certainly say it is the consequence of a brutal or a fatigue failure. A brutal failure is due to sudden increase in loads exceeding the material strength limit or its resistance to shocks. A fatigue failure is the result of the tensile limit of the sensitive point of a component.

Studying the crystalline faces will allow us to determine the mechanical causes that provoked the failure. This troubleshooting guide has been prepared to allow everyone to quickly reach a satisfactory conclusion. A precise and professional analysis to determine the problem is not really the purpose of this guide.

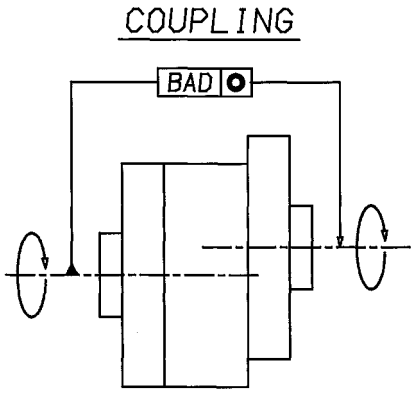
II-1: MECHANICAL FAILURES

Mechanical failures are due to physical external parameters that change the mechanical structure of the materials. The causes of these incidents are mostly axial and radial shaft overloads. Rotary bending (flexion) and torsion (twisted) fatigue failures.

II-1-1 - Problems on shafts:

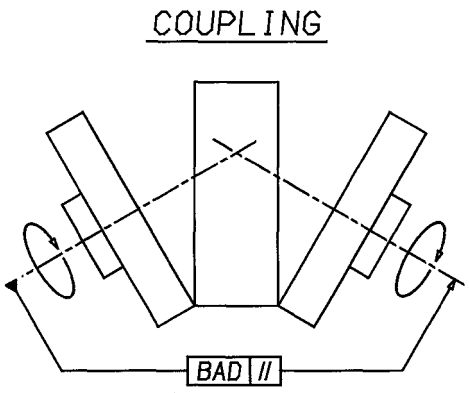
bad alignment, bad mechanical link (bracket, chassis deformation, bad bell housing, too loose damping elements...) can create:

a) misalignment



consequence page
- Fretting P 12, II-2-1
- Shaft rupture P 12, II-2-2-1
  P 13, II-2-2-2
- Rear bushing P 15, II-2-5-1
  P 15, II-2-5-2
  P 15, II-2-5-3
- Cam ring marked P 15, II-2-6
- Shaft seal problem P 16, II-2-7
- Dissymmetrical wear on port plate P 16, II-2-8
- Ball bearing worn or destroyed

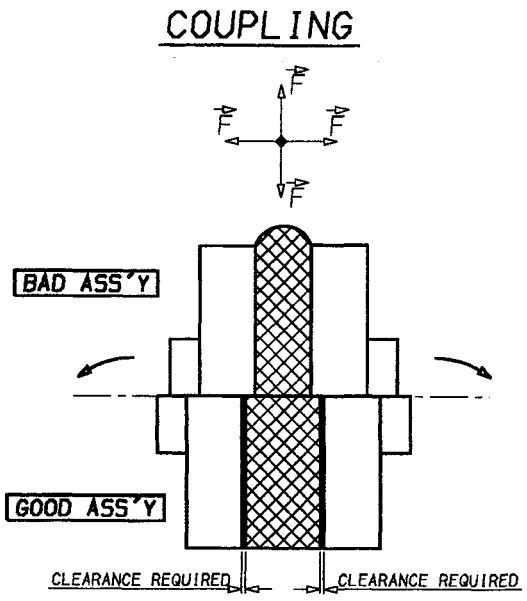
b) out of squareness



- Fretting P 12, II-2-1
- Shaft rupture P 12, II-2-2-1
  P 13, II-2-2-2
- Rear bushing P 15, II-2-5-1
  P 15, II-2-5-2
  P 15, II-2-5-3
- Cam ring marked P 15, II-2-6
- Shaft seal problem P 16, II-2-7
- Dissymmetrical wear on port plate P 16, II-2-8
- Ball bearing worn or destroyed

II-1: MECHANICAL FAILURES (continuation)

II-1-1-1 - Too tight gap between the two coupling flanges (axial loads/radial loads).



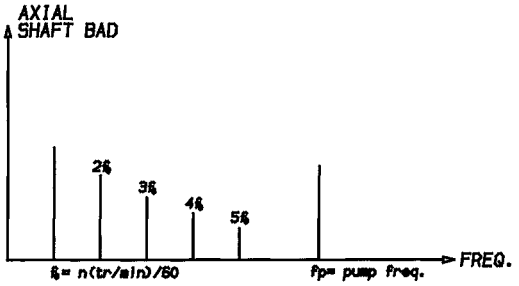
consequence page

- Fretting corrosion P 12, II-2-1
- Shaft rupture P 12, II-2-2-1
  P 13, II-2-2-2
- Ball bearing worn out
- Rear bushing P 15, II-2-5-1
  P 15, II-2-5-2
  P 15, II-2-5-3

- Check with the coupling manufacturer to convenient clearance required depending on the torque.

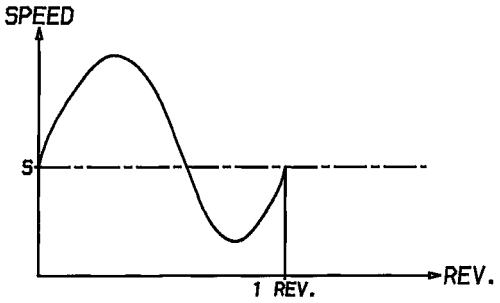
II-1-1-2 - Unbalanced coupling = radial load.

II-1-1-3 - Too high load on a belt driven system (belt drives not recommended).



- Shaft rupture P 13, II-2-2-2
- Bushing P 15, II-2-5
- Cam ring marked P 15, II-2-6
- Shaft seal problem P 16, II-2-7
- Dissymmetrical wear on port plate P 16, II-2-8

II-1-1-4 - Non-homokinetic transmission due to unbalanced cardan shaft (or universal joint) means inconstant shaft speed.



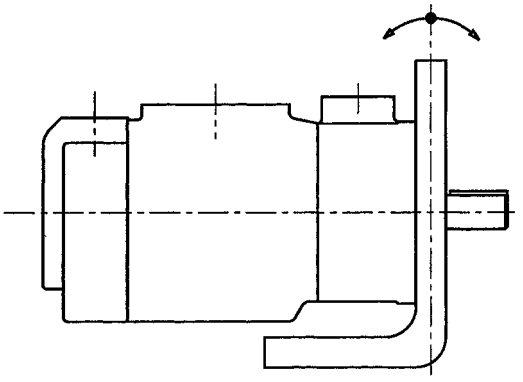
II-1-1-5 - Too great moment of inertia due to heavy couplings (like chain couplings) or very large diameter couplings.

- Shaft rupture P 13, II-2-2-2
- Bushing P 15, II-2-5
- Cam ring marked P 15, II-2-6
- Shaft seal problem P 16, II-2-7

II-1: MECHANICAL FAILURES (continuation)

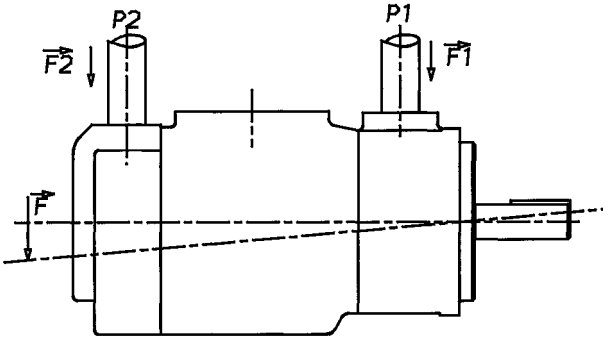
consequence page

II-1-1-6 - Bracket chassis deformation (when pump under load).



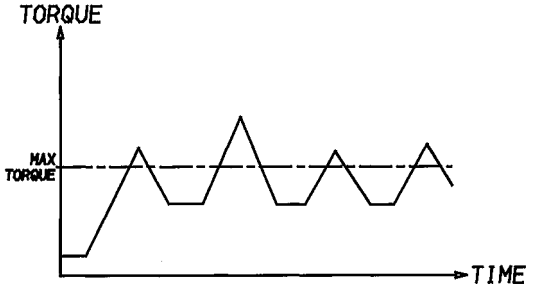
- Shaft rapture P 12, II-2-2-1
  P 13, II-2-2-2
- Bushing problems P 15, II-2-5
- Marked cam ring P 15, II-2-6
- Seal problems P 16, II-2-7
- Wear on port plate P 16, II-2-8

II-1-1-7 - Hose strain (reaction) force (brutal pressure compression / decompression, rigid hoses mounting strain...).



- Shaft rapture P 12, II-2-2-1
  P 13, II-2-2-2
- Bushing problems P 15, II-2-5
- Marked cam ring P 15, II-2-6
- Seal problems P 16, II-2-7
- Wear on port plate P 16, II-2-8

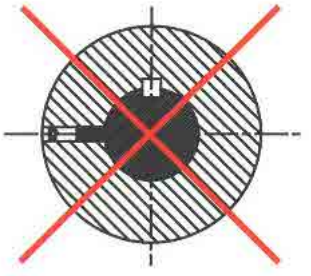
II-1-1-8 - Over torque limits (too high pressure versus displacement for the capacity of the shaft chosen).



- Shaft rapture P 13, II-2-2-3 (torsional fatigue)
- Shaft wear P 14, II-2-3
  P 14, II-2-4

II-1-2 - Bad shaft/coupling connection:

II-1-2-1 - "Coupling screw" not properly positioned on the key (keyed shaft).

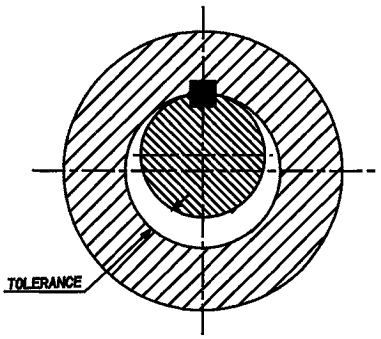


- Shaft rapture P 12, II-2-2-1
  P 13, II-2-2-2
- Rear bushing P 15, II-2-5-1
  P 15, II-2-5-2
  P 15, II-2-5-3

II-1: MECHANICAL FAILURES (continuation)

II-1-2-2 - Bad manufacturing (machining) of the couplings:

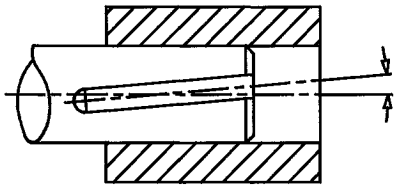
- bad diameter fit tolerance between the shaft diameter and the coupling diameter



consequence page

- Fretting P 12, II-2-1
- Shaft rupture P 13, II-2-2-3
- Shaft worn out P 14, II-2-4

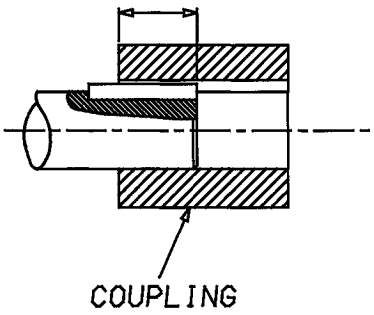
- key way in the coupling is not properly centered with the main bore axis



- Shaft rupture P 14, II-2-3
  P 14, II-2-4

- bad heat treatment (too high or too low)

II-1-2-3 - Shaft not properly utilized (too small surface of spline or key used)



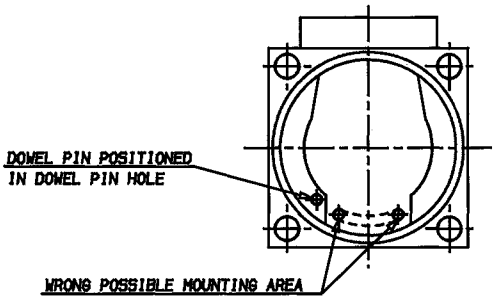
- Wear of the splines P 14, II-2-3
- Wear of the key P 14, II-2-4

II-1-2-4 - Bad (or no) lubrication of splined shafts/coupling.

Denison Hydraulics requires for the lubrication of the shafts a grease with "disulfide of molybdenum" base.

- Spline wear P 14, II-2-3

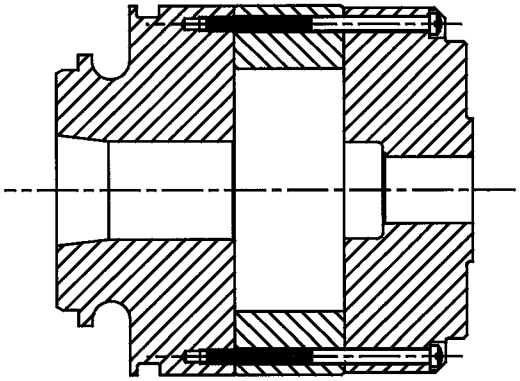
II-1-3 - Cartridge dowel pin not positioned correctly in the housing.



- Dowel pin rupture P 16, II-2-9
- No pressure possible
- Unconstant flow
- Cavitation
- Noisy

II-1: MECHANICAL FAILURES (continuation)

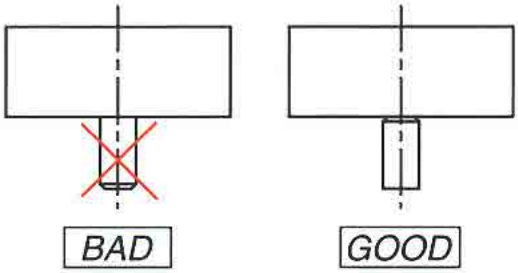
II-1-4 - Cartridge screws not properly mounted (after a cartridge modification, no precaution has been taken to see if the rotor/vanes could rotate freely in the newly built cartridge. Some vanes can have tilted and therefore be squeezed inbetween the port plates). These screws should be lightly tightened as they just hold pieces together to obtain a cartridge. After reassembling a cartridge, always check if the rotor & vanes can rotate freely in the cartridge.



consequence page

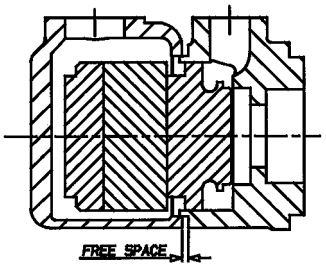
- Vane marks P 11, II-1-7
- Vane marks P 17, II-2-12

II-1-5 - Hollow pin-vane hold-out wrongly mounted in the T6*M, Mobile version (pin up side down).



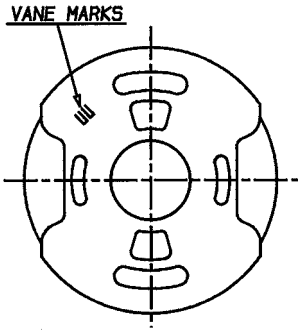
- Noisy
- Flow unstable

II-1-6 - Loose pump fasteners (after modifying the pump, the screws were not tightened at the proper torque and worked loose).



-Broken screws P 17, II-2-11

II-1-7 - Marks on distribution plates that disturb the cycle of the pump. Even a small scratch between the inlet & the pressure area can destabilize the vane.



- Vane marks P 17, II-2-12
- Noisy
- Pressure limited
- Flow unconstant

II-2: THE CONSEQUENCES OF MECHANICAL FAILURES:

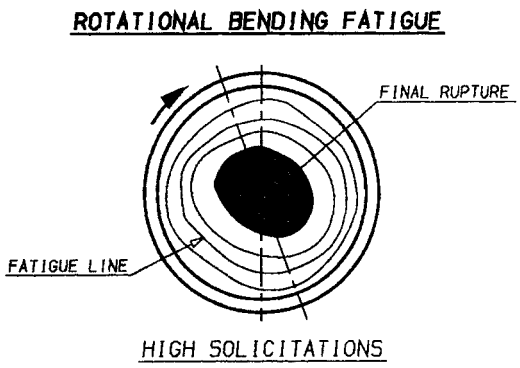
II-2-1 - Fretting corrosion.

This phenomenon appears when the solicitations are great and when there is a slight vibration movement. These movements will "create" metallic oxides. Being very abrasive, they will weaken the structure of the component and will favour start-up of the fatigue rupture (twisted).

II-2-2 - Fatigue shaft rupture:

II-2-2-1

- Perpendicular, center, rotational bending fatigue rupture.



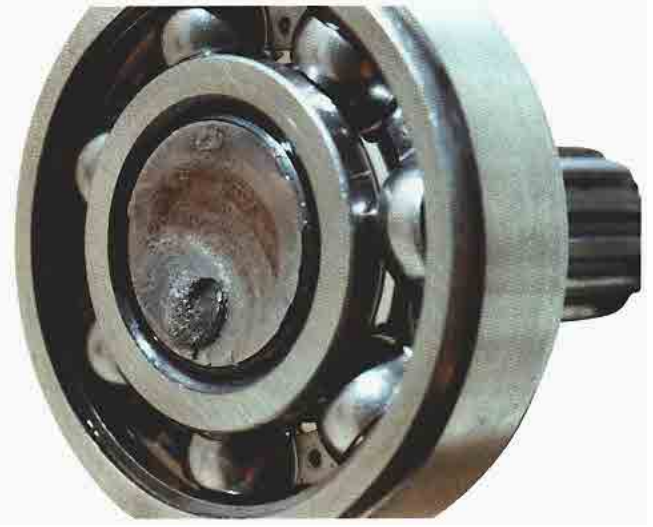
incident page

- Bad shaft / coupling link P 9, II-1-2-1
- Bad coupling manufacturing P10, II-1-2-2
- Bad grease when assembly

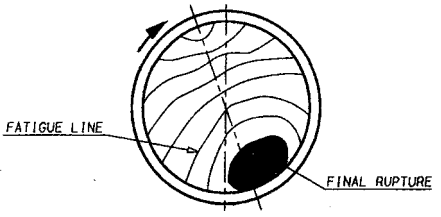
- Bad alignment P 7, II-1-1a
- Out of squareness P 7, II-1-1b
- Unbalanced coupling P 8, II-1-1-2
- Too high radial load P 8, II-1-1-3
- Non homokinetic P 8, II-1-1-4
- Too great moment of inertia P 8, II-1-1-5
- Bracket chassis deformation P 9, II-1-1-6
- Hose strain force P 9, II-1-1-7
- Bad shaft / coupling link P 9, II-1-2-1

II-2: THE CONSEQUENCES OF MECHANICAL FAILURES: (continuation)

II-2-2-2 - Perpendicular, over-center rotational bending fatigue rupture.



ROTATIONAL BENDING FATIGUE



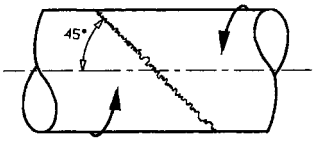
LOW SOLICITATIONS

incident page

- Bad alignment P 7, II-1-1a
- Out of squareness P 7, II-1-1b
- Unbalanced coupling P 8, II-1-1-2
- Too high radial load P 8, II-1-1-3
- Non homokinetic P 8, II-1-1-4
- Too great moment of inertia P 8, II-1-1-5
- Bracket chassis deformation P 9, II-1-1-6
- Hose strain force P 9, II-1-1-7
- Bad shaft / coupling link P 9, II-1-2-1

II-2-2-3 - Twisted torsional rupture.

TORSIONAL FATIGUE



- Fretting corrosion P 12, II-2-1
- Over torque limits P 9, II-1-1-8

II-2: THE CONSEQUENCES OF MECHANICAL FAILURES:

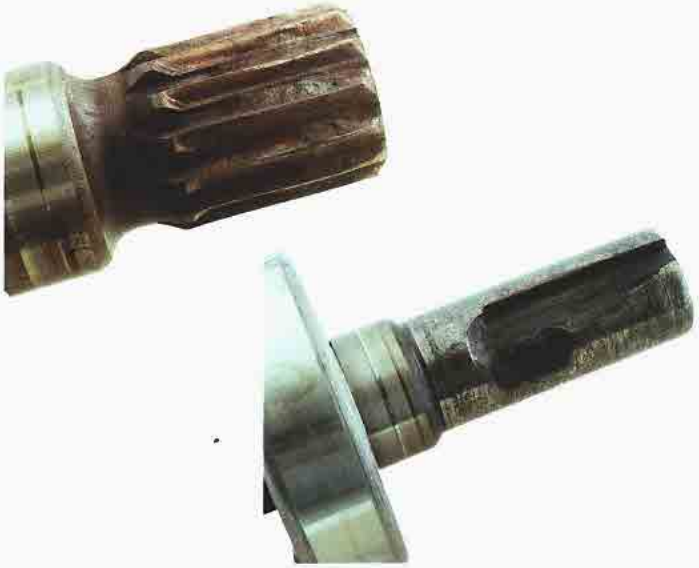
II-2-2-4

- Perpendicular, torsional fatigue rupture.

incident page

- Torsional fatigue with peak torque values
  P 9, II-1-1-8

II-2-3 - Shaft splines/ keyed shaft worn out on total length.



- Bad shaft / coupling connection
  P 10, II-1-2-2
- Bad lubricant (Grease)
- Over torque values
  P 9, II-1-1-8
- Highly cycled

II-2-4 - Shaft splines/ keyed shaft worn out on part of the length.

- Over torque values
  P 9, II-1-1-8
- Utilized key surface or splined surface too small
  P 10, II-1-2-3

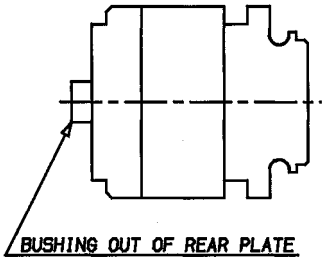
II-2: THE CONSEQUENCES OF MECHANICAL FAILURES: (continuation)

II-2-5 - Bushing/bearing problems

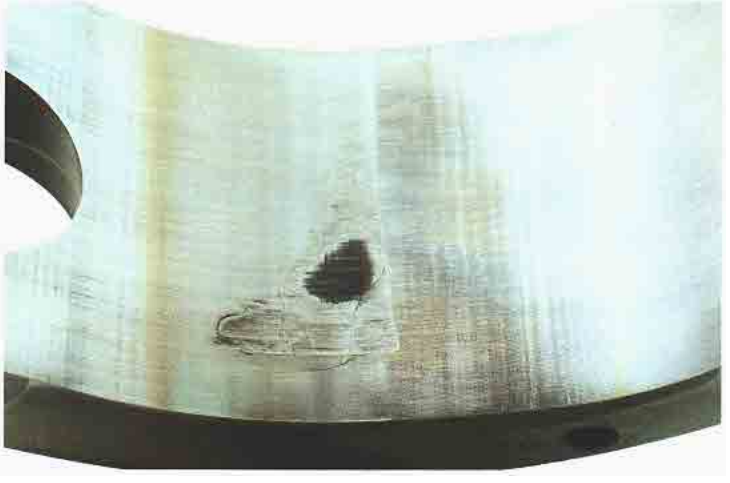
II-2-5-1 - Front or back bearing/bushing with heavy wear

II-2-5-2 - Bushing "welded" on the shaft

II-2-5-3 - Back bushing moving out of the rear port plate



II-2-6 - Cam ring marked by the rotor on the smallest diameter. If the contact between the rotor and the cam ring is important, it will transform the hardness of the cam ring and create local tensions (cracks).



incident page

- Problems on shafts
  P 7, 8, 9, II-1-1
- Bad shaft / coupling connection
  P 9, 10, II-1-2

- Problems on shafts
  P 7, 8, 9, II-1-1
- Bad shaft / coupling connection
  P 9, 10, II-1-2

- Problems on shafts
  P 7, 8, 9, II-1-1
- Bad shaft / coupling connection
  P 9, 10, II-1-2

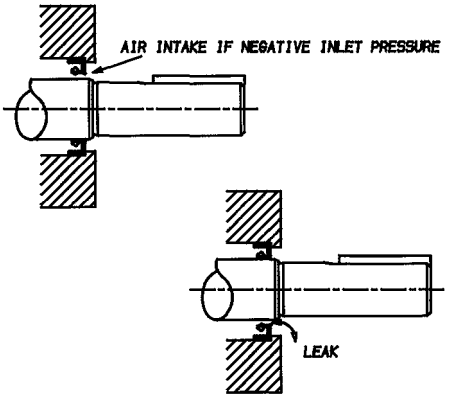
- Problems on shafts
  P 7, 8, 9, II-1-1
- Bad shaft / coupling connection
  P 9, 10, II-1-2

II-2: THE CONSEQUENCES OF MECHANICAL FAILURES: (continuation)

incident page

II-2-7 - Seal loosing contact with the shaft on one area:

- air intake



- Problems on shafts P 7, 8, 9, II-1-1
- Bad shaft / coupling connection P 9, 10, II-1-2

- leakage

- Problems on shafts P 7, 8, 9, II-1-1
- Bad shaft / coupling connection P 9, 10, II-1-2

II-2-8 - Dissymmetrical wear on the side plates

- Problems on shafts P 7, 8, 9, II-1-1
- Bad shaft / coupling connection P 9, 10, II-1-2

II-2-9 - Dowel pin broken

- Over torque limits P 9, II-1-1-8
- Cartridge not properly mounted in the housing P 10, II-1-3

II-2-10 - Noisy

- Hollow pin-vane P 11, II-1-5

VANE TROUBLESHOOTING GUIDE

II-2: THE CONSEQUENCES OF MECHANICAL FAILURES: (continuation)

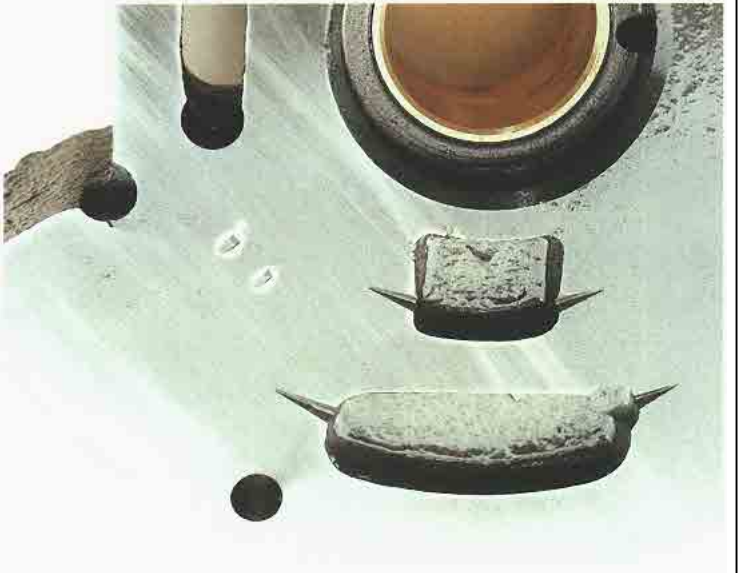
incident page

II-2-11 - <u>Broken screws</u>

- Loose pump fasteners P 11, II-1-6

II-2-12 - <u>Parallel marks on the port plate</u> (vane marks)

- Tilted vanes marked the port plate but the pump did not rotate.



- Cartridge not properly assembled P 11, II-1-4

- Tilted vanes but the pump did rotate. The result is scars on the port plate.

- Cartridge not properly assembled P 11, II-1-4

II-3 : PRESSURE FAILURES: OVERSHOOT & PRESSURE GRADIENTS

II-3-1 - PRESSURE OVERSHOOT

Although system pressures are rising constantly, the pressure overshoot also rises. The effects on pumps, whichever technology is used, are bad. We have split-up this description into two different categories: "Instant pressure overshoot" and "Cycled overpressurization". The final consequences of these are the same, that is to say the failure of components. We will see that the failing components are damaged differently if it is Instant pressure overshoot or Cycled overpressurization. The valves and the pipes rigidity and length around the pumps have a great impact on these pressure peaks. It can be a system problem or a valve problem that opens the main security valve. The pump is or is not protected by a check valve. The fact is that the pressure rises over the initial settings or designed settings. This problem is mainly seen when the valves tend to open (or close for a check valve) too slowly. These pressure peaks can reach 2 to 5 times the pressure settings. Not readable with standard manometer, electronic sensors recording traces will show the facts. When the check-valve closes itself too slowly, the flow will come backwards into the pump. This problem will be seen in the cycled overpressurization.

II-3-2 - INSTANT PRESSURE OVERSHOOT:

This a brutal high peak of pressure. The consequence is that the mechanical strength of the material is exceeded.
This will cause some brutal failures of components such as the side plates (on the high pressure distribution area), the rotor (split), the cam ring (cracked), the shaft (broken), the dowel pin (cut in two).

II-3-3 - THE CONSEQUENCES OF INSTANT PRESSURE OVERSHOOT:

II-3-3-1 - Cracks or rupture of the pressure plate

II-3-3 - THE CONSEQUENCES OF INSTANT PRESSURE OVERSHOOT: (continuation)

II-3-3-2 - Cracks or rupture of the rotor

II-3-3-3 - Cam ring cracked

II-3-3-4 - Shaft broken: perpendicular "clean cut"

II-3-3 - THE CONSEQUENCES OF INSTANT PRESSURE OVERSHOOT: (continuation)

II-3-3-5 - Dowel pin cut in two

II-3-4 CYCLED OVERPRESSURIZATION:

The pressure rating of the system is just over the allowed pressure specified.

This will give, on a long term, a fatigue failure. It is the sum of the pressures exceeding limits that will weaken the mechanical strength of the components. These specific failures are seen on the following components: cam ring, vanes, shaft, side plates, rotor splines or the rotor rupture between the two vane slots bulbs of the rotor (as page 19, II-3-3-2).

Another effect is the deflection of the cam rings' external diameter due to this overpressure. The consequence of this expansion is to reduce the space between the rotor OD and the minor diameter of the cam ring. When this gap is too narrow, the rotor may come in contact with the cam ring. If both cam deflection and shaft misalignment happen at the same time, then the contact often arises.

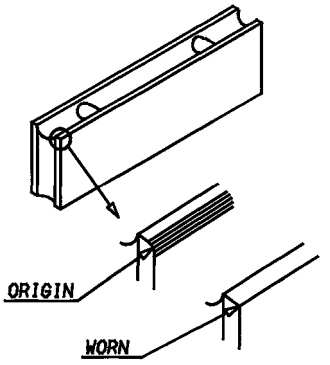
Another distortion effect is this overpressure pushing on the pressure plate. The deflection of the pressure plate will, in its center, reduce the normal clearance between the port plates and the rotor. The film of oil lubricating these components will be reduced. Its temperature will rise because of the narrow gap and a friction welding will result. The total seizure will then be the consequence if the local temperature rises too high.

The system is not secured with a check valve or this check valve is too slow to open.

During the opening time of the "slow" relief valve, the flow delivered from actuators or the pump has to go somewhere. Usually, the relief valve opens and this flow goes back to the tank. Here, not being able to go back to the tank, the flow will go back to the pump. If the check valve closes fast enough, the pressure will increase and accelerate the relief valve opening to allow the flow back to the tank. If there is no check valve or if it is too slow, the flow will return to the pump. This flow will then push the rotor forwards, which will wear the rotors' splines. The gap between the rotor & the side plates will then be increased and create a local cavitation. This local cavitation will suck the oil lubricating the sides. Without enough oil, the local overheat will start a pump seizing. The vanes will have marks on both sides, the splines of the shaft and the rotor will be worn (on both splined teeth flanks)...

II-3-5 THE CONSEQUENCES OF CYCLED OVERPRESSURIZATION:

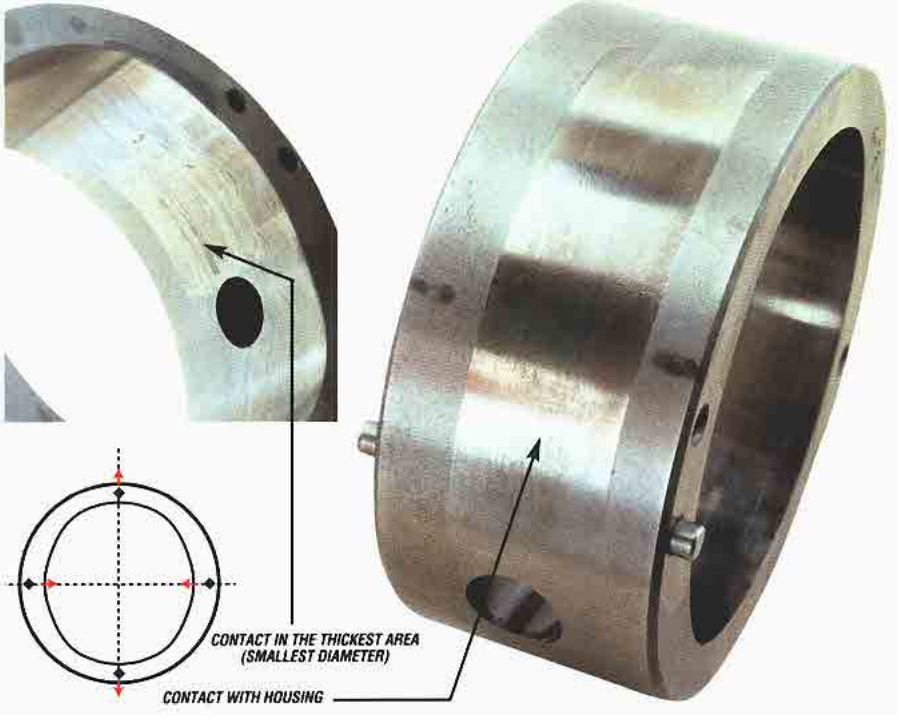
II-3-5-1 - Vanes



II-3-5-2 - Cam ring:

-rupture/cracks

- rotor/cam ring contact in the "small diameter"



II-3-5 THE CONSEQUENCES OF CYCLED OVERPRESSURE: (continuation)

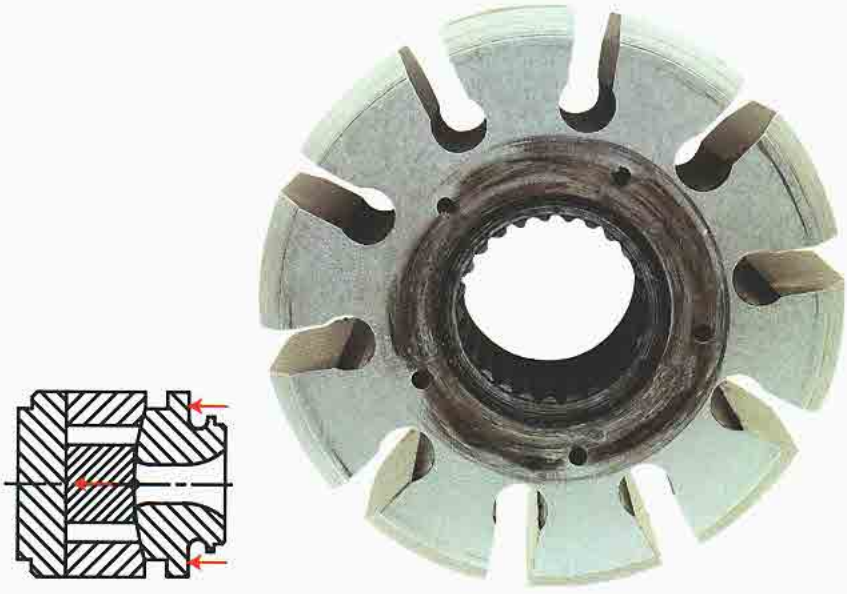
II-3-5-3 - Shaft:

- internal splines worn

- rupture:
torsional fatigue ruptures
Perpendicular: few cycles but very high torque

Twisted: often under high cycling

II-3-5-4 - Side plates deformations = contact on the smallest diameter of the rotor.



II-3-6 PRESSURE GRADIENTS

This pressure increase/decrease decay, in bar per second, is known by most people but often forgotten in the basic hydraulic systems. The velocity of this increase/decrease is very important. Beyond the fact that it stresses the raw material, it has some big effects on the velocity of the oil. These sudden pressure changes modify the internal leakage of the pumps. Depending on the pumps' technology, these allowable pressure gradients are more or less important. The Denison vane technology can be used safely up to 6000 bar per second. Over these limits, phenomena such as cavitation, hose decompression effect (...) can appear. A positive inlet pressure and no inlet strainer are recommended to avoid a too high inlet vacuum.

II-3-7 CONSEQUENCES OF TOO HIGH PRESSURE GRADIENTS:

II-3-7-1 - Cam ring fatigue rupture

II-3-7-2 - Rotor/side plates seizure: This is due to a very strong cavitation when the pressure decrease is dramatic. The sudden flow required is so important that the instant local velocity rises and creates the cavitation.

II-4 PHYSICAL, CHEMICAL OR HYDRAULIC FAILURES

All the following failures are linked, one way or another, to the quality of the lubricant, the poor filtration or the poor inlet conditions. Either there is some contamination (air, particles, water...), or some temperature problems, or a poor oil edging, or cavitation or fluid aeration problems.

II-4-1 Start-up without a proper air bleed. 25

II-4-2 Air pollution (contamination): 25

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  - ¤ Description 25
  - ¤ Consequences 26
- Cavitation-Deaeration 28
  - ¤ Description 28
  - ¤ Consequences 29

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II-4-4 Consequences of solid particle contamination 33

II-4-5 Water contamination 37

II-4-6 Consequences of Water contamination 38

II-4-7 Viscosity failures 39

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II-4-9 Unsuitable fluids: 41
  - ¤ Wrong Viscosity choice 41
  - ¤ Filterability 41
  - ¤ Oxidation 42
  - ¤ Bad deaeration capabilities 42
  - ¤ Polluted fluids 42
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II-4-10 Unsuitable grease 43

II-4-1 START-UP WITHOUT A PROPER AIR BLEED.

The vane pumps are designed and manufactured with a dry lubricant capability. The dry graphite lubricant coating on the cam ring and the surface treatment on the distribution plates are done to lubricate during start-ups.

- If the suction column of oil does not build up, the pump will not be lubricated enough and be damaged. The consequence of this bad lubrication is local overheating. Depending on how long this defect lasts, the consequences can go up to the seizure between the port plates and the rotor. The local temperature is so high that the film of oil between the components disappears, and then the metal to metal contact will create the friction and then the "welding seizure".
- If the column of oil does build up but the air bleed is not complete, the pump will not work properly. The pressure will not build up correctly, the flow could be lower than the one required, the pumping will be erratic and noisy.
- If the inlet velocity is too low, under 0,5 m/sec., the air will stay trapped in the pump and in the inlet pipe.

The consequences of incorrect air bleed are seen in the next paragraph.

II-4-2 AIR CONTAMINATION (creating the foaming of the oil):

When we talk about air in the oil, it is the simplification of a complex chemical transformation. What we will call air is more a mix of different gases than air. This explains why under pressure, these gases will implode and create a very high local temperature.

The pressure creates the ignition and the gases will combust at temperatures as high as 1300°C. The result is the destruction of the fluid giving to it a black color and a "burnt" smell. This phenomenon is also known as the "Lorentz" or "diesel" effect.

II-4-2-1-Aeration:

Description : this phenomenon is the fact that some air is brought into the system and, with the turbulence of the flow, generates a foamed substance.

This new "fluid" has lost all the requirements of the original fluid and, therefore, lost all the capabilities of a standard hydraulic fluid. The consequences of such a transformation are different depending on the quantity of air brought into the system.

This problem could be caused by different external problems, independent or not:

- suction pipe not sealed under vacuum, therefore sucking air,
- deteriorated shaft seal (or high radial load creating an air intake),
- inlet tube in front of the return line (amplifying the foaming),
- turbulence created by a high velocity around the inlet tube (not enough suction surface),
- return line coming back to the reservoir over the oil level. It is required that the lowest point of the return line must always be under the oil level (five times the pipe diameter),

- oil level of the reservoirs too low compared to the suction level,
- too small tank (high velocity in the tank,)
- fluid in movement (bad tank design on mobile applications),
- bad deaeration capabilities of the fluid and/or the tank. Baffles can help "pushing" the air to the surface. If the "vein flow" is too rapid and if no baffle is there to bring to the surface these bubbles, they will go back to the inlet area. This air going to the pump will deteriorate it.
- bad baffle design. If the fluid is to pass over the baffle, the maximum speed has to stay under 0.5 meter per second to avoid turbulence,
- Venturi effect on a return pipe,
- anti-siphon holes drilled in the return pipes,
- water pollution that will create steam due to local overheating. This steam in contact with oil will create foaming (for more details, please go to page 35, chapter II-4-5, water contamination).

II-4-2-2- Consequences of Aeration:

The vanes are going to be completely unbalanced due to the abnormal fluid compressibility (due to quantity of air in the oil). The vanes, usually hydrostatically balanced (without air), will move sideways with such erratic movements that the vanes will destroy their lubricant film of oil that links them to the side plates. Doing so, the vanes, hardened metal pieces, will start to wear the side plates in die cast or ductile iron.

The marks will start in the discharge area and, depending on the quantity of air, will more or less create a groove.

During all these turbulences, the most noticeable fact is going to be an unusual noise level.

II-4-2-2-1 - If the quantity of air is erratic or not too heavy, the effects are scores only on the port plates in the suction area

II-4-2-2- Consequences of Aeration: (continuation)

II-4-2-2-2 - If under very severe aeration, this groove can mark deeply the port plates from the suction area to the outlet area. The width of the groove is then the width of the vane.

II-4-2-2-3 - In very heavy air conditions, the vane is so unbalanced that it can even sometimes break (itself).

II-4-2-2-4 - Noisy

II-4-2-2- Consequences of Aeration: (continuation)

II-4-2-2-4 - Noisy (continuation)

Before obtaining such a disastrous wear, the vanes being so unsteady will make a lot of noise, the flow will not be the one required and/or the pressure level will not be obtained. The physical aspect of the oil will be "milky" on the surface as the oil and the air create a foam.

II-4-2- AIR CONTAMINATION (continuation)

II-4-2-3 - Cavitation-Deaeration:

Description : When a depression arises in the suction port, the gas (combustible) and aromatic essences dissolved in the fluid (6 to 7 %) will evaporate. Depending on the type of fluid, this deaeration will occur between 100 and 150 mm of HG (around -0.2 bar). Under this depression (or vacuum), small bubbles of a diameter of .2 to .3 mm will be formed. The natural appearance of oil is translucent. Under cavitation and because of these small "bubbles", the fluid will have a "cloudy" appearance. Depending on the value of the vacuum, the quantity of suspended bubbles will be more or less important. As these bubbles have a small diameter, they will reach the surface of the oil tank very slowly (bad deaeration characteristics). As an example, 100 liters of a foamed oil by cavitation will take 4 hours to become translucent again. When the fluid reaches local hot temperatures and is compressed (at the "critical pressure"), these bubbles implode and create a shock wave. known as the diesel effect, the impact of these "combustion explosions", will create erosion in the shape of the crater (cavities) when located near a metallic surface. These detached metallic particles are very likely to cause, on a medium term base, a seizure between the pumps' moving parts.

II-4-2-3 - Cavitation-Deaeration: (continuation)

This problem can be caused by different external problems (independent or linked):

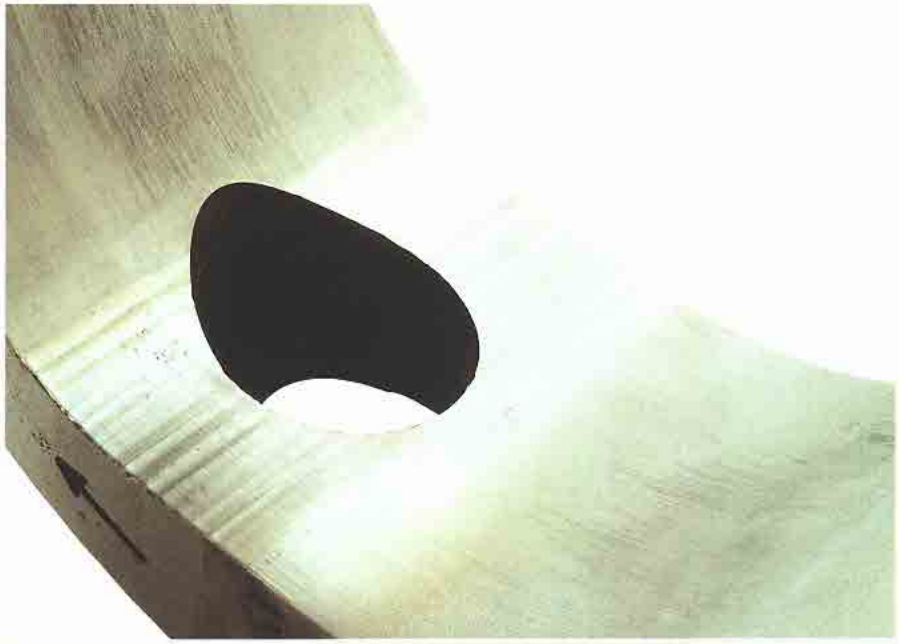
- suction strainer :
- clogged by a foreign contaminant,
- clogged by a too high viscosity,
- too small in flow rate/pressure drop.
- (Filtration on the return line and no suction strainer is still what we recommend to avoid the above mentioned problems).
- too long inlet hose,
- too small inlet hose (too small section on the whole piping or restricted in one area),
- inlet tube, in the tank, too close from the panel of the tank,
- inlet tube, in the tank, with a too small suction surface creating local turbulence (deaerating the fluid). Cut the tube on a angle to increase this suction surface and avoid local high Velocities,
- too high or too low inlet velocity (0.5 to 1.9 meter per second is the velocity required),
- tank too far away from the pump (horizontally or vertically),
- excessive shaft speed,
- air filter on the tank clogged or not well dimensioned generating a vacuum in the tank.
- reservoirs' oil level too low compared to the suction level (when all cylinders are extended for example),
- inlet tube in front of the return line (amplifying the foaming),
- too small tank (high velocity in the tank),
- bad deaeration capabilities of the oil and of the tank. Baffles can help "pushing" the air to the surface. If the "vein flow" is too rapid and if no baffle is there to bring to the surface these bubbles, they will go back to the inlet area. This air in the pump will deteriorate it.
- bad filtration dimension on return line. Under dimension will increase the velocity and deaerate the oil.

II-4-2-4 - Consequences when the pump is cavitating:

II-4-2-4-1 - Noise level : much higher than usual. Under pressure, this noise level is amplified.

II-4-2-4 - Consequences when the pump is cavitating: (continuation)

II-4-2-4-2 - Ripples on the cam ring: the vanes are hydrostatically balanced to avoid excessive loads on the vane lips. Under suction cycle, the pin compensates the out of balance load due to the cam profile. When the depression is over the design limits, the vane bounces, creating ripples on the cam ring profile. The depth of these marks is proportional to the strength of the depression.

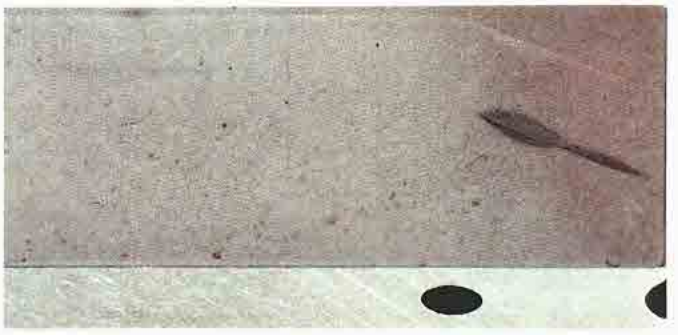


II-4-2-4-3 - Craters: these erosion craters are sometimes difficult to observe as the pump may have already seized.
These craters come from erosion, caused either by an explosion/implosion, either by depressurisation.
When the fluid trapped between the two vanes is sucked in with a certain percentage of air in suspension, an explosion can occur. When this trapped volume is compressed, these air bubbles explode and create craters in the side plates in the area between the suction port and the pressure port, around the pressure bleed slots.

II-4-2-4 - Consequences when the pump is cavitating: (continuation)

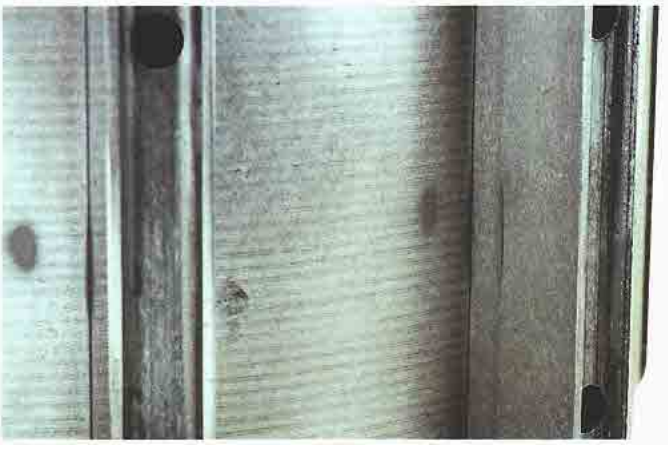
II-4-2-4-3 - Craters (continuation)

- vanes



- pins

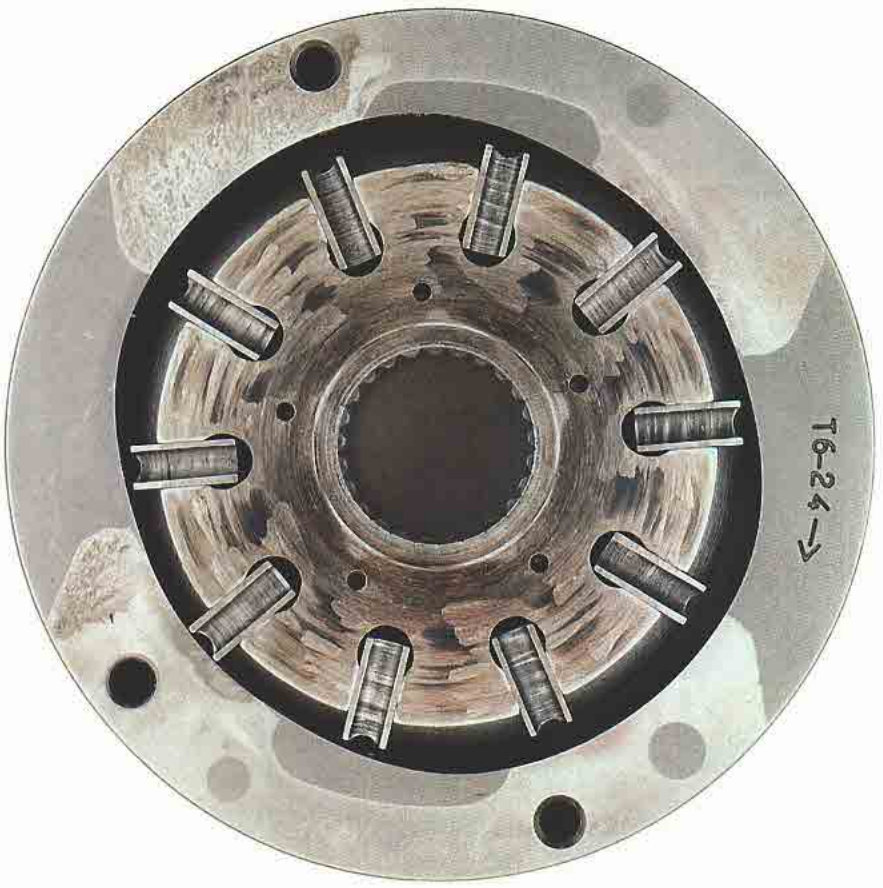
II-4-2-4-4 - "Black marks": The local depression consequences can be seen on the vanes (top lips and on the center of the vane), on the port plates (in the inlet area) and on the center of the cam ring (just after the inlet "feeding hole"). These "black marks" can be transformed into small craters in the port plates near the outlet bleed slots as the air bubbles explosion occurs.



II-4-2-4 - Consequences when the pump is cavitating: (continuation)

III-4-2-4-5 - Seizure of the pump.

Due to a lack of fluid, the vacuum generated, when really severe, will suck the oil on the side of the pump (between the rotor and the side plates). This will have the effect of breaking the film of oil that lubricates these surfaces. The surfaces will then heat-up and this local over-heat will modify the standard lubricity into a dry friction. The result is a seizure between the rotor and the side plates. (This heavy contamination coming from the digging of craters, the particles can also badly lubricate the pump and lead to the seizure.)



II-4-3 SOLID PARTICLE CONTAMINATION:

Unlike a lot of different technologies, the Denison vane units do not generate pollution.
Even if this has become an important topic and a lot of education has been done around the cleanliness of the fluid, the pollution by particles stays one of the greatest causes of pumps' destruction. The consequences are either a rapid wear or a premature breakdown (large size particles over 25 µm). In a hydraulic circuit, the pump is the flow/pressure generator. Being so, it becomes the most sensitive unit to pollution and, therefore, will be the first component to fail.

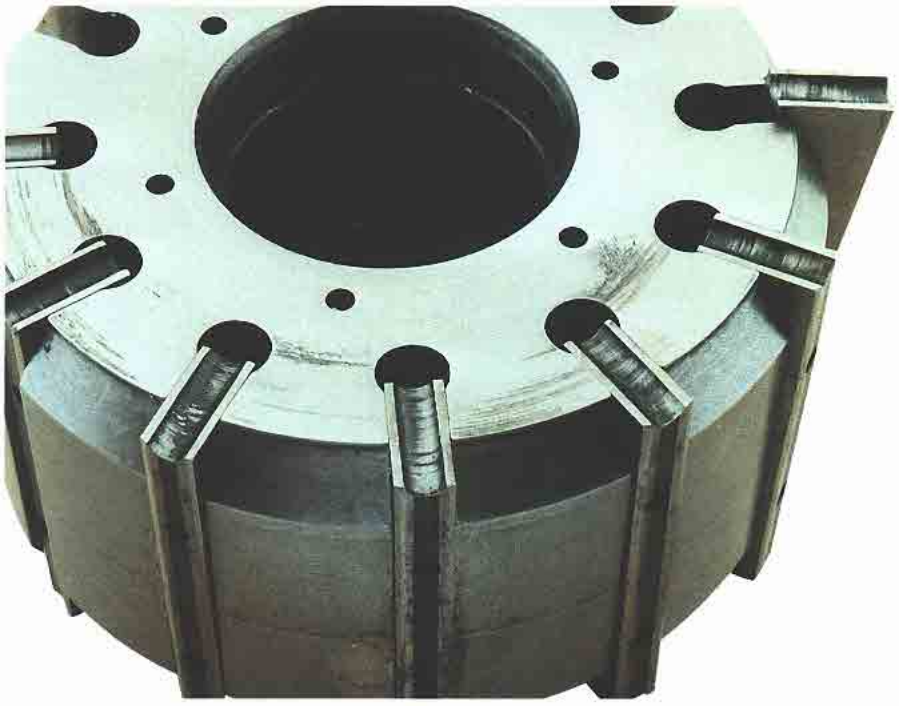
Nature of particles :
The main particles are made up of metallic oxide, silica, carbon and organic materials.
Origin of particles :
- A common large particle is the metallic oxide coming from welding burrs when the welded piping has not been cleaned-up properly.
- The silica comes from the surrounding dust. This dust will enter into the system through cylinders' sealing, through air intakes (absence of air filters), dirty environment and the tank not properly sealed ...

II-4-4 CONSEQUENCES OF SOLID PARTICLE CONTAMINATION:

Depending on the size of the particles, the consequences can go from a gentle ground finish on the vane lips, cam surface, side plates to the total destruction of the cartridge.

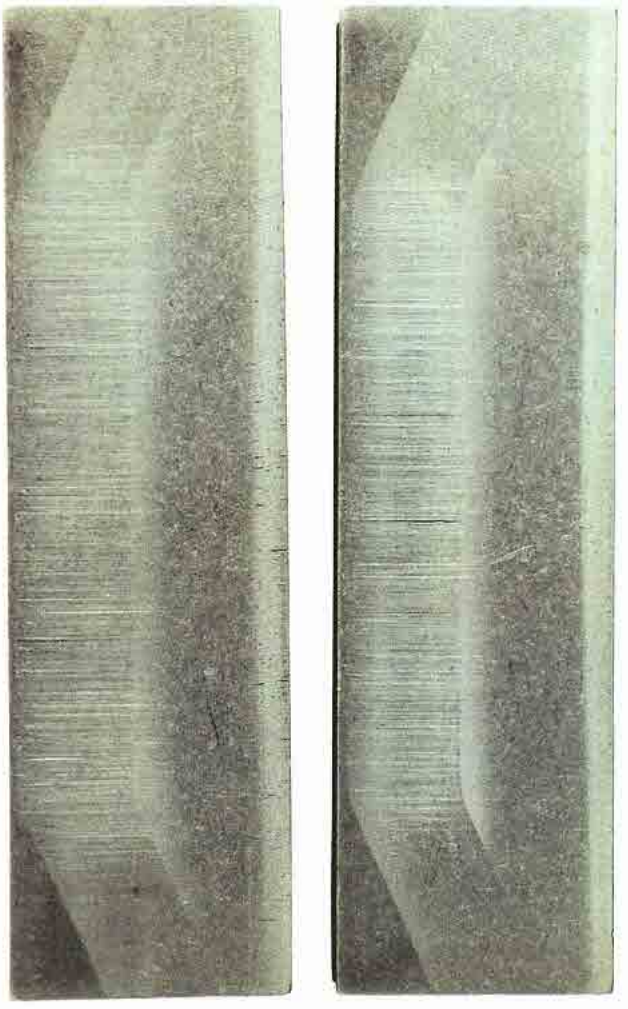
It is obvious that under perfect filtration conditions, the rubbing of the vanes in the rotor is reduced to a minimum by the action of the oil under pressure which is located all around the vanes.

II-4-4-1 - Vanes:
a)
- The vane lips edges. The particles in the fluid will have a grinding effect between the top of the lip and the cam ring profile. When the contaminant is too big or too stiff, the vane lip edges can break.



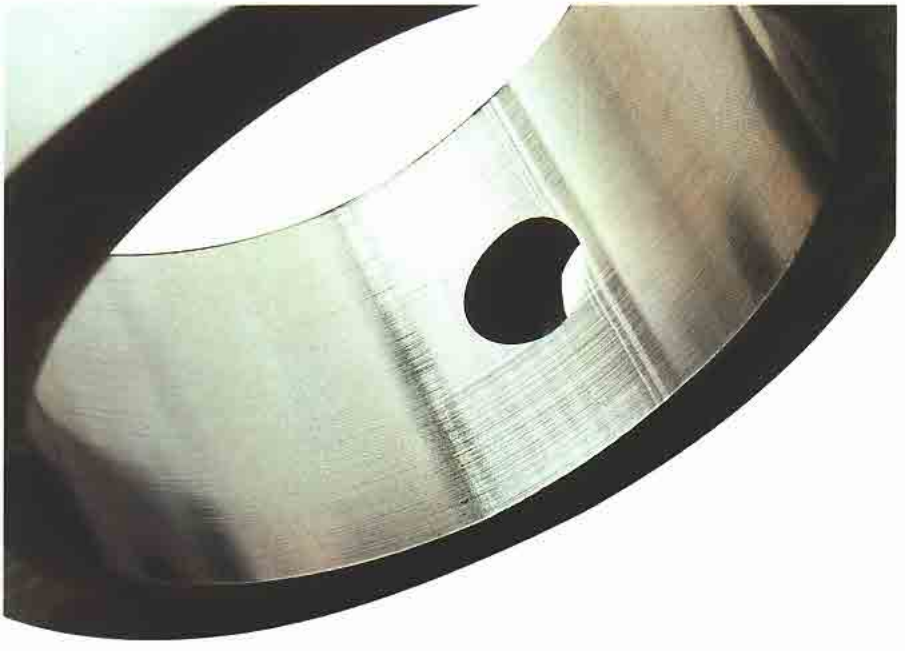
II-4-4 CONSEQUENCES OF PARTICLE CONTAMINATION: (continuation)

II-4-4-1 - Vanes (continuation)
b)
- The vane surface. The film of oil between the vanes and the rotor being contaminated, there will be a rubbing effect in this area. These rubbing marks (pollution marks) will be vertical and of the height of the vanes' translation (displacement).



II-4-4-2 - Cam ring:

- Between the vane lip and the cam ring, the film of oil is contaminated. This will wear the inner surface of the cam ring.



II-4-4 CONSEQUENCES OF PARTICLE CONTAMINATION: (continuation)

- On the edge of the cam ring contour, (with a slight chamfer when new), you will find a sharp angle (edge). If the wear is heavy, the cam ring can have little burrs in this area.

II-4-4-3 - Rotor/vanes:
In the rotors' slots, the rubbing wear between the slots and the vanes will also lead to vertical pollution marks. (P 32 II-4-4-2 b)

II-4-4-4 - Rotor/side plates:
When the particles in suspension in the fluid are greater than half of the clearance between the thickness of the rotor and the thickness of the cam ring, seizure occurs in the peripheral diameter of the rotor and the port plates.

II-4-4 CONSEQUENCES OF PARTICLE CONTAMINATION: (continuation)

II-4-4-5 - Rotor - The rubbing effect will also appear in-between the side of the rotor and the side plates. This will create a torque between the two vane slaps. This torque causes a reasonably high level of fatigue in the materials' weakest area, between the two bulb slots of the rotor. If this fatigue level exceeds the design limits, this portion of the rotor will break.

II-4-4-6 - Rotor/side plates/vanes: Big contamination particles damages (like the "carbon" welding balls) are usually seen on the port plates (blocked in the slots) or/and on the top of the vanes/rotor. Each time, they will have an effect on the vane lips, either on the top either on the sides. The "rubbing" action will either destroy the vane lips or weld the vane to the rotor, break the cam ring...

II-4-4-7 - Side plates: Another sign of contaminated oil is some possible erosion craters on the port plates at the inlet/suction bleed slots area. These erosion craters would come from the abrasive fine particles in a local high velocity area.

II-4-5 WATER CONTAMINATION:

Description:

Depending on the type of fluid, the water contamination can be different. For mineral oils, this limit should not exceed 500 ppm (particles per million). This limit for the esters and the vegetable oils is maximum 500 ppm. The water contamination will modify the chemical structure of the fluid (oxidation of the fluid increases the TAN*). Having an excess of water, this water can be transformed into steam under the action of the pressure. Another effect of this excess is the modification of the "compressibility module".

- The fluid will be destroyed and lose its characteristics / performance. The oxidation of the fluid will modify the TAN. The higher acidity of the fluid will destroy the additives. This, added to the local heat created, will transform (or carbonize) the fluid. It will modify the molecular structure. The colour of the fluid will turn creamy (milky).
- Destroying the additives means the lubricity will be worse, the thermic stability very poor...
- The excess of water can also bring in bacteria that can damage the fluid. A gelatinous mass in the tank and in some components is a way to observe this phenomenon.
- The most common consequence is the appearance of rust on all metallic surfaces. This will modify the nature of the contacts between surfaces. This can lead to start local micro-seizures due to a lack of convenient lubricant.
- When polluted with water, the whole system must be cleaned up and then drained two or three times until obtaining a clean translucent oil when running.

This water pollution can come from various causes:

- condensation coming from a high hydrometric level (big temperature variations),
- a leak in the water exchanger,
- tank not water-tight,
- storage of the oil barrel outside vertically,
- high pressure water cleaning of the machines (water going under the seals of cylinders on off-highway vehicles for example).

*TAN : Total Acid Number.

II-4-6 CONSEQUENCES OF WATER CONTAMINATION:

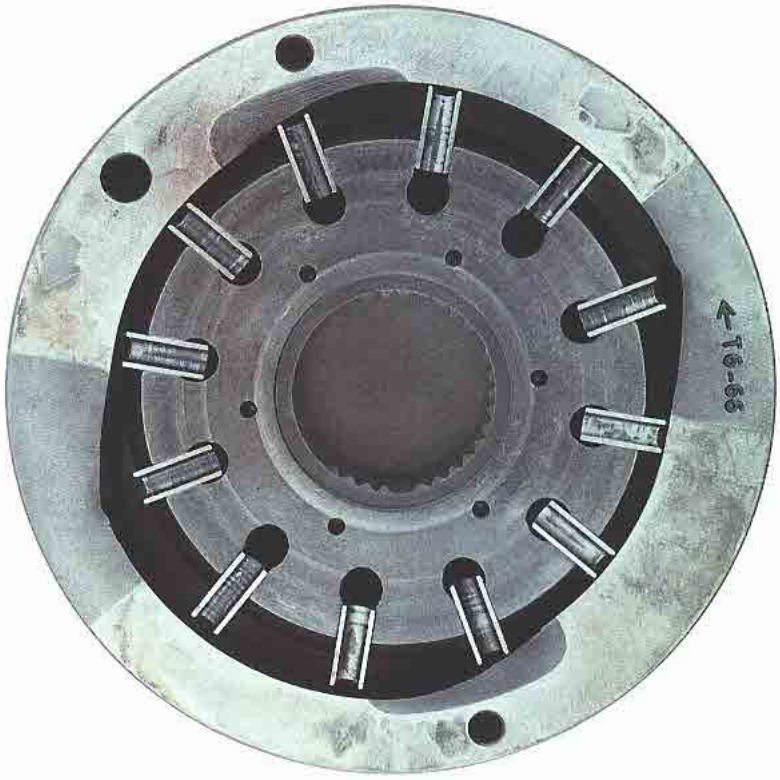
II-4-6-1 - Deposit can then be seen on the vanes. This deposit will modify the performances of the pump because of the deterioration of the mechanical efficiency (the varnish will "stick" the vanes in the slots of the rotor).
On the cartridge, it changes the colour of the bronze bushing (due to the modification of the acidity) and leaves a deposit on the external diameter.

II-4-6-2 - The fluid can produce foaming because of the steam. The specificity of the foaming oil due to water is a milky or creamy typical aspect. The consequences are identical to the aerated fluid.

II-4-6 CONSEQUENCES OF WATER CONTAMINATION: (continuation)

II-4-6-3 - The fluid compressibility will fluctuate and therefore destabilize the vanes. This will be seen on the cam ring surface full of ripples and on the sharp vane lips edges. In this case, the noise level will be high and the flow & pressure capabilities deteriorated.

II-4-6-4 - Due to these fluid transformations, the mechanical consequences go from performance being deteriorated to the destruction of the pump if the local temperatures are extreme (Here, phosphate oil additive deposit).



II-4-7 VISCOSITY FAILURES.

Depending on the environment, the temperatures can considerably modify the original wanted Viscosity. The influence of the temperature differences on the Viscosity is enormous.

The vane components are designed to work for a wide possible range of Viscosity. When a problem occurs, the Viscosity is either too high or too low.

When the Viscosity is too high, over 2000 cSt (9240 SSU), the problem is that the fluid has a big resistance and the Velocity will drop. This resistance can create local vacuum, that is to say deaeration of the fluid. This will ruin the lubricity of the pump.

Under heavy Viscosity and low rotation, the vanes can stick and stay stuck in the rotor. The consequence is that there is no flow coming out of the pump.

II-4-7 VISCOSITY FAILURES.

When the Viscosity is too low, under 8 cSt (52 SSU), it will decrease the film thickness designed to lubricate all the components in motion. If the Viscosity is very low, it could mean that the temperature is high. Tests carried out have shown that a tank temperature of 50°C (122°F) could mean a local temperature in the pump of up to 130°C (266°F). If the viscosity is calculated on the tanks temperature, we can easily figure out the very low viscosity when the oil is at 130°C (266°F).

II-4-8 CONSEQUENCES OF VISCOSITY FAILURES.

II-4-8-1 - Too high viscosity:
- Seizure due to the high cavitation not allowing the rotating group to be lubricated.

II-4-8-2 - Too low viscosity:
- Erosion on the port plates.

II-4-8 CONSEQUENCES OF VISCOSITY FAILURES: (continuation)

- Scars on the side plates & rotor due to a bad lubricity.

II-4-9 UNSUITABLE FLUIDS:

Viscosity index choice:

If the fluid was chosen by an OEM in Norway for a local sale but the application is to work in Saudi Arabia, the choice of the fluid will have to take into consideration the specific application environment.

Forgetting this can lead into deep trouble. Too high Viscosity will probably cause cavitation and a lack of lubrication, too low Viscosity will lead to a too thin film of oil and therefore create a local heat point.

In both extremes, the consequences can be fatal breakdowns.

Filterability:

If the fluid does not have good filterability properties, the filters will be clogged rapidly. The flow will have to go through the by-pass and therefore not be filtrated anymore and will heat-up the system (due to the open by-pass).

Bad filterability can either come from a low quality fluid, or from a fluid sensitive to any contaminant destroying its chemical homogeneity (water, solvants, grease...).

II-4-9 UNSUITABLE FLUIDS: (continuation)

Oxidation resistance:

Contaminants can modify the acidity of the fluid and therefore become very corrosive. Such a modified fluid will corrode the steel components and produce corrosion residues. These residues will increase the Viscosity. Increased Viscosity will increase the pressure drops. Increased pressure drops will then increase the temperature and cause local overheat.

Deaeration capabilities:

This is another very important topic. If the fluid chosen requires too long time to allow the air to reach the surface of the tank, this can become a big problem. Air in big quantities has a destroying effect on all pump technologies. If the flow versus the size of the tank is small, if the tank design is incorrect (inlet near return line for example), if the tank is slightly pressurized (due on purpose), the oil will not deaerate fast enough. The air bubbles will then be sucked by the pump. Under pressure, these bubbles will then explode.

Polluted fluid:

This is an important topic and, nowadays, well known at least for the solid particle contamination. The manufacturing clearances becoming tighter and tighter, a good filtration is required. This even though our double lip technology resists fairly well to pollution.
Another pollution is the impact of another fluid creating a reaction between the original fluid and the contaminant. The fluids are more and more high technical products. They also become more and more sensitive to their environment and any contaminant can destroy the original characteristics. It is common for example to see fluids "destroyed" by a high water content (chemical, other fluid, particles). Refined oils will even be more sensitive than brand new ones.

Density:

It is important to know the specific gravity of the fluid used. Because the density from one fluid to another can vary a lot, the suction head has to be designed with that parameter. The specific gravity of a standard oil (ISO 46) will be around 0.88. The specific gravity of a water-glycol (60 glycol/ 40 water) will be around 1.08. Knowing this value, just check the minimum required Absolute pressure in our catalogs to optimize your system.

II-4-9 UNSUITABLE FLUIDS: (continuation)

Conclusion on the fluids:

A common problem is the deterioration of the fluid. This deterioration can come either from the quality of the fluid (low quality or not used as recognized fluid manufacturer), or from an external pollution, (solid particles, other fluids, chemical transformations, water), or from air. The consequences always lead to a low performing pump or to a premature breakdown.

II-4-10 Unsuitable grease:

Bad lubricant on the shaft and coupling assembly. We recommend for all grease lubricants to be based with disulfide of molybdenum. The main characteristic of this grease is that it is the best for heavy duty applications. It has a very good specific load characteristic, avoids stick-slip and fretting corrosion, has a good penetrability and enables easy dismantle.

VANE MOTOR

III SPECIFICS OF VANE MOTOR FAILURES AND CAUSES

Because the motor is a receptor in the hydraulic circuit, the incidents are not very common. It will be much easier to go through the various typical failures you can possibly be confronted to with vane motors.

III-1 - Torque over the catalog limits:

Front shaft rupture

Internal splines distortion

III SPECIFICS OF VANE MOTOR FAILURES AND CAUSES (continuation)

III-2- Bad air bleed

or air intake = incorrect rear cover lubrication. Possible seizure between the rotor and the rear cover.

III-3- Over-pressure on A or B:

Rotor rupture

Port block cracked

III SPECIFICS OF VANE MOTOR FAILURES AND CAUSES (continuation)

III-4-Over-pressureinthe drainline:

shaft seal blow off (extruded).

III-5- Excess of Air in the fluid: coming from the system, coining from an air intake between the pump and the motor or even coming from the front shaft seal.

- Possible seizure between the rotor and the rear cover.
- Possible heavy wear on the port plates.

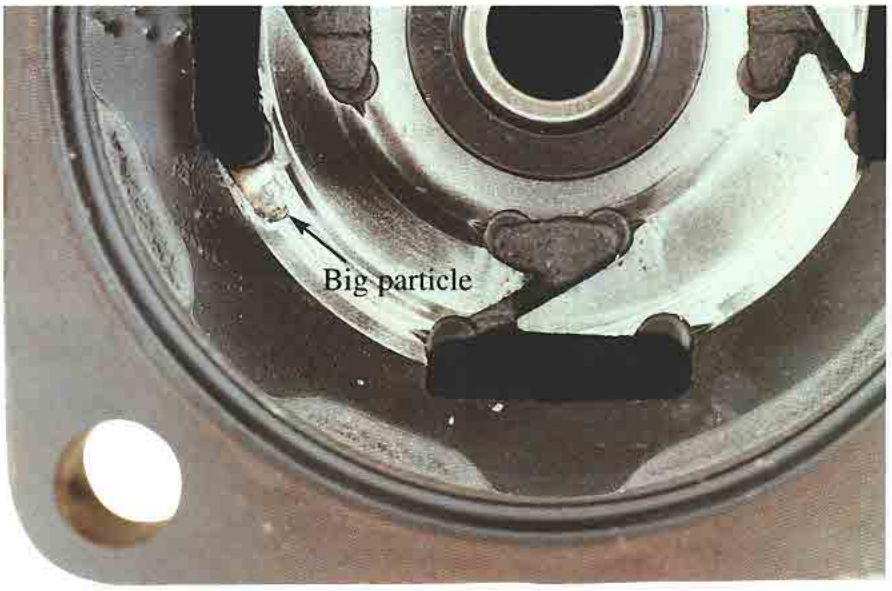
III-6-Cavitation: the speed of the motor is higher than the flow coming to the motor. Heavy cavitation will lead to seizure.

III SPECIFICS OF VANE MOTOR FAILURES AND CAUSES (continuation)

III-7- Pollution.

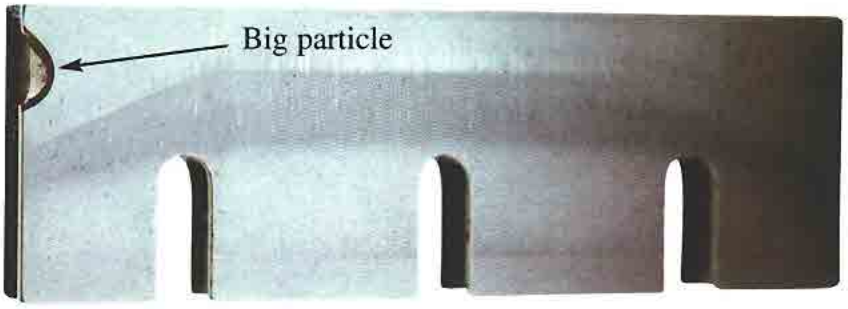
The pollution consequences will be seen on various areas:

- In the rotor slots
  - Grinding on both sides of the slots.
  - Traces of the "spring areas" of the vanes digging in.



- On the side of the rotor / port plates.

- On the vanes
  One big particle (welding ball) and small vertical scars.



- In the came ring
  (Scars due to big particles).

III SPECIFICS OF VANE MOTOR FAILURES AND CAUSES (continuation)

III-8- Too low viscosity:

If the temperature rises and the fluid becomes very "liquid", the film of oil required to lubricate the components is going to be too thin. This can lead to micro-seizures and to a total seizure if this film of oil is minor.

CONCLUSION:

The DENISON vane technology is hydrostatically balanced, axially and radially. As each and every single pump, motor or cartridge (sold as spare part) is tested in our production plant on test benches before shipment, the quality of these components is certified. Our experience has shown us that if :

- **the inlet characteristics,**
- **the operating limits (pressures, RPM, Viscosity...)**
- **the mechanical alignment,**
- **the fluids' quality (in the time),**

are in the limits given in the Denison Hydraulics catalogue requirements, you are sure to obtain a high and long performing pump/motor.

These few requirements are the major parame ters to check when working within the catalogue values.

IV TROUBLESHOOTING TABLE

This following section is there to help you when the hydraulic system or component does not work as required. These solutions are the most common ones we have seen and experienced in the field. Please always remember that a clean system and a correct air bleed will solve a lot of incidents.

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VANE TROUBLESHOOTING GUIDE

IV -1 TROUBLESHOOTING TABLE FOR PUMPS

IV-1-1 - No flow, no pressure	a) Is the pump rotating ?	a-1) Check if the coupling is rotating. If not, check the rotation of the electric motor. a-2) Check the keys of the pump and E motor shaft. a-3) Check if the shaft is not broken.
	b) Is the rotation in the correct direction?	b-1) Check if the rotation of the pump corresponds to the arrow on the name plate. b-2) Check if the wiring of the electric motor is correct.
	c) Is the air bleed-off done?	c-1) Check that no air is still located in the pressure line. Loosen a connector.
	d) How are the inlet conditions?	d-1) Check if the inlet gate valve is not closed. d-2) Check the oil level. d-3) Check if the inlet hose in the tank is under the oil tank level. d-4) Check if an air intake is not disturbing the inlet (missing inlet flange seal, air trapped in suction line as examples). d-5) Check if the pump is not located too high above the oil level. d-6) Check if the tank is not completely sealed. Then the lack of atmospheric pressure will not allow the pump to prime. d-7) Check if all connections and seals are air-tight.
	e) Is the Viscosity not too high?	e-1) Check if the oil characteristics are not incompatible with the temperature and the pumps requirements. Too high Viscosity will "stick" the vein fluid and enable the pump to suck the oil correctly.
	f) Is the pump flow not going somewhere else?	f-1) Check the hydraulic circuit and the main sequences. Doing so, you will check if all the valves are set or work properly.

IV -1 TROUBLESHOOTING TABLE FOR PUMPS (continuation)

IV-1-1 - No flow, no pressure (continuation)	f) Is the pump flow not going somewhere else ? (continuation)	f-2) Check if the main relief valve is not set at an extremely low pressure and therefore bringing all the flow back to the tank. f-3) Check if in the directional valves the spools are not sticking in a position that brings the flow back to the tank. f-4) check if the check valve is not mounted "upside down".
	g) Is the receptor working correctly?	g-1) Check if the motor does not let all the flow leak internally. g-2) Check if the cylinder inner seals are not ruined.
	h) Is the speed high enough?	h-1) Check if the minimum speed is reached. Mobile pumps require 400 rpm and industrial pumps require 600 rpm.
IV-1-2 - Not enough flow (or not the flow required)	a) Are the components OK?	a-1) Check the displacement of the pump. a-2) Check if the speed of the pump is not too low or too high (E motor or thermic engine sized too small so dropping the speed too low...). a-3) Check if the main relief valve is not set at an extremely low pressure and therefore venting some flow back to the tank. a-4) Check if in the directional valves the spools are not sticking in a position that brings part of the flow back to the tank. a-5) Check if the hydraulic motor is not leaking internally due to a bad efficiency, low viscosity... a-6) Check if the cylinder inner seals are not ruined and therefore allow internal leakage.
	b) Is the connection from the tank to the pump correct?	b-1) Check if there is no air intake between the pump and the inlet pipe (bad seals for example). b-2) Check if the inlet hose is convenient for the required velocity (0,5 < V < 1,9 m/s).

IV -1 TROUBLESHOOTING TABLE FOR PUMPS (continuation)

IV-1-2 - Not enough flow (or not the flow required) (continuation)	b) Is the connection from the tank to the pump correct? (continuation)	b-3) Check if the pump is not too high compared to the oil level or if the pump is not too far from the tank (check the inlet absolute pressure with the catalog values). b-4) Check if the gate valve is not semi-open. b-5) Check if the inlet strainer is sized correctly (250 m mesh mini.) or not clogged.
	c) Is the tank design correct?	c-1) Check if the oil level is correct. c-2) Check if the suction pipe is under the oil level during the complete cycle of the machine. c-3) Check if the inlet hose fitted in the tank is cut with an angle wider than 45°. c-4) Check if this inlet hose is not too close to the tank wall or to the bottom of the tank and therefore limits the "vein flow". c-5) Check if the suction hose is not located near the return line and therefore sucking a lot of air coming from these turbulences. c-6) Check if baffles are required to allow correct deareation of the fluid. c-7) Check if the air filter is not clogged or under seized (not well dimensioned). c-8) Check if the tank is not fully tight, not allowing the atmospheric pressure to apply.
	d) Is the oil convenient?	d-1) Check if the oil characteristics are not incompatible with the pumps requirements. d-2) Check if the viscosity is not too high, therefore "sticking" some vanes in the rotor or blocking the vein fluid. d-3) Check if the high temperature does not destroy the viscosity of the fluid. Doing so, the internal leakage will "consume" the flow.

IV -1 TROUBLESHOOTING TABLE FOR PUMPS (continuation)

IV-1-3- No pressure	a) Is the hydraulic circuit correctly designed?	a-1) Check the hydraulic circuit schematic.
	b) Is the circuit correctly piped?	b-1) Compare the schematic to the piped circuit.
	c) Are the components working properly?	c-1) Check the main sequences. Doing so, you will check if all the valves are set or work properly. c-2) Check if the main relief valve is not set at an extremely low pressure and therefore bringing all the flow back to the tank. c-3) Check if in the directional valves the spools are not sticking in a position that brings the flow back to the tank.
IV-1-4 - Not enough pressure	a) Check as when "no pressure" IV-1-3.	
	b) Is the system well dimensioned?	b-1) Check if the flow required is not over the available flow and therefore cannot build-up pressure..
	c) Is there an internal leakage somewhere that maintains a certain pressure?	c-1) Check all the possible faulty components, from the pump to all the receptors and intermediates (high pressure seals, mechanical wear...).
IV-1-5 - Uncommon noise level	a) Is the noise coming from the pump?	a-1) Check the mechanical link of the shaft pump : alignment, balancing of the coupling or Universal joint, key properly fastened, ... a-2) Check if the air bleed has been done correctly. a-3) Check if there is no air intake from the tank to the pump (nor through the shaft seal).

IV -1 TROUBLESHOOTING TABLE FOR PUMPS (continuation)

IV-1-5 - Uncommon noise level (continuation)	a) Is the noise coming from the pump? (continuation)	a-5) Check if the hose strain force does not create this noise. a-6) Check if the oil level is correct. a-7) Check if the oil in the tank is not aerated. a-8) Check if the strainer is not clogged or under-dimensioned. a-9) Check if the inlet pipe is under the oil level. a-10) Check if the air filter is not clogged or too small. a-11) Check if the speed is not incompatible with the catalog values. a-12) Check if the oil is compatible with the catalog recommendations. a-13) Check if the inlet pressure is not higher than the outlet pressure.
	b) Is the noise coming from the surroundings?	b-1) Check the hoses and see if the noise in not coming back to the pump this way. b-2) Check the pressure piping and see if its length dumps or amplifies the noise. b-3) Check if the structure of the tank is stiff enough to avoid amplification/resonance. b-4) Check the E motor fan. b-5) Check the balancing of the E motor. b-6) Check the water cooler and its theoretical limits. b-7) Check the filtration unit, its capacity and if the noise does not come from the opened by-pass valve.
IV-1-6 - Unusual heat level	a) Does the heat appear when the pump is running without pressure?	a-1) Check the oil level and the suction pipe. Is the oil coming to the pump (check the length of the pipe, its internal diameter, all that could influence the inlet pressure)? a-2) Check if the air bleed has been done correctly. a-3) Check if the flow versus the volume of oil in the tank is correct to obtain a good cooling effect.

IV -1 TROUBLESHOOTING TABLE FOR PUMPS (continuation)

IV-1-6 - Unusual heat level (continuation)	a) Does the heat appear when the pump is running without pressure? (continuation)	a-4) Check if a cooler is required or, if there is one, if it is well dimensioned. a-5) If there is a cooler, check if it is working (example for water cooler: is the water flow open or sufficient). a-6) Check if the hydraulic circuit is not bringing back the flow directly to the inlet port. Doing so, it would create a very small closed circuit not able to cool down the fluid. a-7) Check the quality of the fluid. a-8) Check the velocity of the fluid. a-9) Check the filtration unit, its capacity and if the heat does not come from the open by-pass valve or if it is under-dimensioned (bigger delta P).
	b) Does the heat appear when the pump is running with pressure?	b-1) Check the viscosity. b-2) Check the pressure rating. b-3) Check if the cooler is working correctly or well dimensioned. b-4) Check if the relief valve is not creating this heat because always open. b-5) Check if any other component in the system is not creating this heat due to an internal defect. b-6) Check if there is a big temperature differential between the inlet and the outlet.
IV-1-7 - Shaft seal leakage	a) Is the seal destroyed?	a-1) Check the alignment and the correct power transmission (non homokinetic movement, high radial force as examples). a-2) Check the inlet pressure and compare it to the catalog values. a-3) Check if the bad suction conditions do not create a vacuum that could even reverse the seal lip.

IV -1 TROUBLESHOOTING TABLE FOR PUMPS (continuation)

IV-1-7 - Shaft seal leakage (continuation)	a) Is the seal destroyed? (continuation)	a-4) Check if the external environment is not too dirty and therefore ruining the seal.
	b) Is the seal only leaking?	b-1) Check the alignment of the front shaft and check if there is not any radial load. b-2) Check if seal lip has not been cut during a maintenance operation. b-3) Check if the inlet pressure is not over or under the catalog values. This has to be done for the whole cycle because the inlet pressure can vary from time to time. b-4) Check if the seal material has not been modified due to a too warm environment. The seal can vulcanize and stop sealing correctly. b-5) Check the acidity of the oil that can "burn" the seals material. It will therefore destroy the elasticity of the sealing. b-6) Check if the chosen seal (high pressure seal for example) is not too stiff for the use. If the environment requires some elasticity due to a gentle misalignment, a high pressure seal will not be able to follow the movement and therefore leak.

IV -2 TROUBLESHOOTING TABLE FOR MOTORS

IV-2-1 - No rotation	a) Is the flow coming to the motor?	a-1) Check the circuit and the hydraulic schematic. Is the piping OK? a-2) Check the setting of the main pressure relief valve. Check if it not settled at an extremely low pressure. a-3) Check if the pump is giving a flow. a-4) Check if the directional valve(s) allowing the flow to go to the motor is energized. If it is, check if the spool is in its correct position and not sticking in a position that would deviate the flow somewhere else. a-5) Check if a check valve would not have been improperly mounted.
	b) Is the torque required higher than the system settings?	b-1) Check if the pressure settings are correct. b-2) Check if the load is not superior to the torque capabilities of the motor.
	c) Is the pump OK?	c-1) Check if the pump is working correctly.
	d) Are the motors internal drain check valves working properly?	d-1) Check if a failing check valve would not allow some flow to go back to the tank and therefore limit the flow to the motor.
	e) How is the motor piped?	e-1) Check the nature of the connectors. If, for example, the "self sealing couplings" type connectors are well fitted into each other.
IV-2-2 - Stalls easily	a) Is the load near the limits of the system?	a-1) Check the relief valve setting and compare it to the theoretical pressure required to deliver the convenient torque.
	b) Are the motors internal drain check valves working properly?	b-1) Check if a failing check valve would not allow some flow to go back to the tank and therefore limit the flow to the motor.
	c) Is the flow going to the motor sufficient?	c-1) Check the minimum flow required by the motor. c-2) Check the flow of the pump or the valve feeding the motor.

IV -2 TROUBLESHOOTING TABLE FOR MOTORS (continuation)

IV-2-3 - Not enough speed	a) Is the speed lower than desired?	a-1) Check the theoretical displacement of the motor versus the theoretical flow of the pump. a-2) Check that the flow of the pump is really coming to the motor. a-3) Check that the working pressure & speed are not incompatible with the catalog values of the motor. a-4) Check the oil temperature. Check then that the low viscosity of the oil is not having a big effect on the internal leakage of the motor. a-5) Check the air bleed-off.
IV-2-4 - Erratic speed	a) Is the motor loosing speed erratically?	a-1) Check if the limit of the allowable torque is not reached once a while. a-2) Check if the driven load does not transmit some inconstant load (high pressure piston water pumps with an unbalanced technology). a-3) Check if the flow coming from the pump is constant.
IV-2-5 - Unusual noise level	a) Is the motor running?	a-1) Check if there is no air intake aerating the motor badly (through the front shaft seal for example). a-2) Check if the motor is not cavitating. It could be that the inertia of the load is such that it drives the motor faster than the flow coming from the pump. a-3) Check if the oil is not proper for the use. a-4) Check if the air bleed has been done properly.
	b) When the motor is breaking?	b-1) Check the back pressure to see if the replenishment pressure is not too low, leading to cavitation of the motor.
IV-2-6 - Unusual heat	a) Is the oil arriving to the motor already hot?	a-1) Check if a cooler is required or if there is one if it is well dimensioned. a-2) If there is a cooler, check if it is working (example for water cooler: is the water flow opened or sufficient). a-3) Check if the hydraulic circuit is not bringing back the flow directly to the inlet port. Doing so, it would create a very small closed circuit not able to cool down the fluid.

IV -2 TROUBLESHOOTING TABLE FOR MOTORS (continuation)

IV-2-6 - Unusual heat (continuation)	a) Is the oil arriving to the motor already hot? (continuation)	a-4) Check the quality of the fluid. a-5) Check the velocity of the fluid (5 to 6 meters/second max.). a-6) Check the filtration unit, its capacity. a-7) Check if the heat does not come from an open by-pass valve.
	b) Is the oil heating up when going through the motor?	b-1) Check the speed of rotation versus the catalog values. b-2) Check the pressure rating. b-3) Check the fluid. b-4) Check the viscosity.
IV-2-7 - Shaft seal leakage	a) Is the seal leaking when pressurized?	a-1) Check if the lips of the seal are not ruined (lack of lubricity leading to vulcanization of the rubber, external pollution...). a-2) Check if the shaft is not marked by a groove in the usual seal lip contact area. a-3) Check the shuttle valves. a-4) Check the pressure in the drain line on the motor. Long piping, elbows, small diameter, too high oil viscosity, other common drain flows in the same pipe can lead to high drain pressures. a-5) Check if there is no high overshoot at start-up that would create a high instant internal leakage. a-6) Check, when using a "rapid connector", if it is well locked. a-7) Check the alignment of the shafts. a-8) Check if there is no unbalanced driven load that could create a gap between the shaft and the seal. a-9) Check if the radial force is not too high (belt drives for example).
	b) Is the seal leaking when standing still?	a-1) Check if the seal is not damaged. a-2) Check if the shaft does not have any scratches. a-3) Check if the ball bearing is not ruined. a-4) Check if the drain line does not create a back pressure.

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Axial Piston Variable Pump A10VO (US-Version)

RA-A 92703/12.11 1/60
Replaces: 11.07
RE 92708/03.08
and RE 92707/11.10

Data sheet

Series 52/53
Size NG10 to 100
Nominal pressure 3600 psi (250 bar)
Peak pressure 4600 psi (315 bar)
Open circuits

Series 52

Series 53

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Features

- Variable pump in axial piston swashplate design for hydrostatic drives in an open circuit
- The flow is proportional to the drive speed and the displacement. The flow can be steplessly varied by adjusting the swashplate angle.
- Stable storage for long service life
- High permissible drive speed
- Favorable power-to-weight ratio - compact dimensions
- Low noise
- Excellent suction characteristics
- Axial and radial load capacity of drive shaft
- Pressure and flow control
- Electro-hydraulic pressure control
- Power control
- Electro-proportional swivel angle control
- Short response times

Type code for standard program

A10V(S)	O			/	5			–	V				
01	02	03	04		05	06	07		08	09	10	11	12

	Axial piston unit	10	18	28	45	60[1]	63	85	100	
01	Swashplate design, variable,	●	–	–	–	–	–	–	–	A10VS
	nominal pressure 3600 psi (250 bar), maximum pressure 4600 psi (315 bar)	–	●	●	●	●	●	●	●	A10V

	Operation mode	
02	Pump, open circuit	O

	Size (NG)	10	18	28	45	60[1]	63	85	100
03	Geometric displacement, see table of values on page 7	10	18	28	45	60[1]	63	85	100

	Control device			10	18	28	45	60[1]	63	85	100	
04	Pressure control			●	●	●	●	●	●	●	●	DR
	with flow control, hydraulic											
	X-T open			●	–	●	●	●	–	●[3]	–	DFR
				–	●	–	–	–	●	●[2]	●	DRF
	X-T plugged			●	–	●	●	●	–	●[3]	–	DFR1
				–	●	–	–	–	●	●[2]	●	DRS
	Electrically overridable (negative characteristic)			–	❍	❍	❍	–	●	●	❍	EF.D.[4]
	with pressure cut-off, remotely operated											
	hydraulic			●	●	●	●	●	●	●	●	DRG
	electrical	negative characteristic	U = 12 V	–	●	●	●	●	●	●	●	ED71
			U = 24 V	–	●	●	●	●	●	●	●	ED72
		positive characteristic	U = 12 V	–	●	●	●	●	●	●	●	ER71[5]
			U = 24 V	–	●	●	●	●	●	●	●	ER72[5]
	Power control with pressure cut-off											
	Start of control	145 to 510 psi	(10 to 35 bar)	–	●	●	●	–	●	●	●	LA5D
		520 to 1015 psi	(36 to 70 bar)	–	●	●	●	–	●	●	●	LA6D
		1030 to 1520 psi	(71 to 105 bar)	–	●	●	●	–	●	●	●	LA7D
		1535 to 2030 psi	(106 to 140 bar)	–	●	●	●	–	●	●	●	LA8D
		2045 to 3335 psi	(141 to 230 bar)	–	●	●	●	–	●	●	●	LA9D
	remotely operated	Start of control	see LA.D	–	●	●	●	–	●	●	●	LA.DG
	Flow control, X-T plugged	Start of control	see LA.D	–	●	●	●	–	●	●	●	LA.DS
	Flow control, electrically overridable (negative characteristic), X-T plugged	Start of control	see LA.D	–	●	●	●	–	●	●	●	LA.S

1) Series 52 units are delivered as standard with 3.66 in³ (60 cm³). Higher values on request.
2) Series 53 only with D flange
3) Series 52 only with C flange
4) See RE 92709
5) The following must be taken into account during project planning:
Excessive current levels (I > 1200 mA with 12 V or I > 600 mA with 24 V) to the ER solenoid can result in undesired increase of pressure which can lead to pump or system damage:
- Use I_{max} current limiter solenoids.
- An intermediate plate pressure controller can be used to protect the pump in the event of overflow.
An accessory kit with intermediate plate pressure controller can be ordered from Bosch Rexroth under part number R902490825.

● = available ❍ = on request – = not available

Type code for standard program

A10V(S)	O			/	5			–	V				
01	02	03	04		05	06	07		08	09	10	11	12

			10	18	28	45	60[1]	63	85	100	
04	Electro-proportional control (positive characteristic) with										
	pressure control	U = 12 V	–	●	●	●	–	●	●	❍	**EP1D**
		U = 24 V	–	●	●	●	–	●	●	❍	**EP2D**
	Pressure and flow control, X-T open (load sensing)	U = 12 V	–	●	●	●	–	●	●	❍	**EP1DF**
		U = 24 V	–	●	●	●	–	●	●	❍	**EP2DF**
	Pressure and flow control, X-T plugged (load sensing)	U = 12 V	–	●	●	●	–	●	●	❍	**EP1DS**
		U = 24 V	–	●	●	●	–	●	●	❍	**EP2DS**
	Electrohydraulic pressure control	U = 12 V	–	●	●	●	–	●	●	❍	**EP1ED**
		U = 24 V	–	●	●	●	–	●	●	❍	**EP2ED**
	Pressure and flow control with controller cut-off, X-T open (load sensing)	U = 12 V	–	●	●	●	–	●	●	❍	**EK1DF**
		U = 24 V	–	●	●	●	–	●	●	❍	**EK2DF**
	Pressure and flow control with controller cut-off, X-T plugged (load sensing)	U = 12 V	–	●	●	●	–	●	●	❍	**EK1DS**
		U = 24 V	–	●	●	●	–	●	●	❍	**EK2DS**
	Electrohydraulic pressure control with controller cut-off	U = 12 V	–	●	●	●	–	●	●	❍	**EK1ED**
		U = 24 V	–	●	●	●	–	●	●	❍	**EK2ED**

Series

05	Series 5, index 2	●	–	●	●	●	–	●	–	**52[2]**
	Series 5, index 3	–	●	●	●	–	●	●	●	**53[3][4]**

Direction of rotation

06	With view on drive shaft	clockwise	**R**
		counter clockwise	**L**

Seals

07	FKM (fluor-caoutchouc)	**V**

Drive shaft

			10	18	28	45	60[1]	63	85	100	
08	Splined shaft ANSI B92.1a	standard shaft	●	●	●	●	●	●	●	●	**S**
		similar to shaft „S“ however for higher input torque	–	●	●	●	●	●	–	–	**R**
		reduced diameter, not for through drive	●	●	–	●	●	●	●	●	**U**
		similar to shaft "U", however for higher torque	–	–	–	●	●	●	●	●	**W**
	Parallel shaft SAE with key, not for through drive		●	–	●	●	●	–	–	–	**K[7]**
	Tapered with Woodruff key		–	–	●	●	●	–	–	–	**C[7]**

1) Series 52 units are delivered as standard with 3.66 in³ (60 cm³). Higher values on request.
2) Control DR, DFR, DFR1, DRG, ED and ER: delivery with size 10, 28, 45, 60 and 85[6] only in series 52
3) Control DR, DRF, DRS, DRG, ED and ER: delivery with size 18, 63, 85[5] and 100 only in series 53
4) Control EF., LA.., EP.. and EK.. Delivery with size 18 to 100 only in series 53
5) Control DRF and DRS: delivery with size 85 only with D flange in series 53
6) Control DFR, DFR1: delivery with size 85 only with C flange in series 52
7) only series 52

● = available ❍ = on request – = not available

Type code for standard program

A10V(S)	O			/	5			–	V				
01	02	03	04		05	06	07		08	09	10	11	12

	Mounting flange		10	18	28	45	60[1]	63	85	100	
	ISO 3019-1 (SAE)	2-bolt	●	●	●	●	●	●	●	●	C
		4-bolt	–	–	–	–	●	●	●[2]	●	D

	Service line port	10	18	28	45	60[1]	63	85	100	
10	SAE flange port at rear, UNC fixing thread (not for through drive)	–	●	●	●	●	●	●	●	61
10	SAE flange port on opposite side, UNF fixing thread (for through drive)	–	●	●	●	●	●	●	●	62
10	UNF threaded ports, rear (not for through drive)	●	–	–	–	–	–	–	–	64

	Through drive			10	18	28	45	60[1]	63	85	100	
11	Without through drive, standard for versions 61 and 64			●	●	●	●	●	●	●	●	N00
	SAE J744 flange	coupling for splined shaft[3]										
	Diameter	diameter										
	82-2 (A)	5/8 in	9T 16/32DP	–	●	●	●	●	●	●	●	K01
		3/4 in	11T 16/32DP	–	●	●	●	●	●	●	●	K52
	101-2 (B)	7/8 in	13T 16/32DP	–	–	●	●	●	●	●	●	K68
		1 in	15T 16/32DP	–	–	–	●	●	●	●	●	K04
	127-4 (C)	1 1/4 in	14T 12/24DP	–	–	–	–	●	●	●	●	K15
		1 1/2 in	17T 12/24DP	–	–	–	–	–	–	●	●	K16
	127-2 (C)	1 1/4 in	14T 12/24DP	–	–	–	–	–	–	●	●	K07
		1 1/2 in	17T 12/24DP	–	–	–	–	–	–	●	●	K24

	Connector for solenoids	10	18	28	45	60[1]	63	85	100	
12	DEUTSCH molded connector, 2-pin – without suppressor diode	–	●	●	●	●	●	●	●	P

1) Series 52 units are delivered as standard with 3.66 in³ (60 cm³). Higher values on request.
2) Only available in series 53. For controller designation and series assignment, please refer to positions 04, 05, including footnotes.
3) Coupling for splined shaft as per ANSI B92.1a

● = available ❍ = on request – = not available

Technical data

Hydraulic fluid

Prior to project design, please see our data sheets RE 90220 (mineral oil) and RE 90221 (environmentally acceptable hydraulic fluids) for detailed information regarding the choice of hydraulic fluid and application conditions.

When using environmentally acceptable hydraulic fluids, the limitations regarding technical data and seals must be observed. Please contact us. When ordering, indicate the hydraulic fluid that is to be used.

Operating viscosity range

For optimum efficiency and service life we recommend that the operating viscosity (at operating temperature) be selected the range

ν_{opt} = opt. operating viscosity 80 to 170 SUS (16 to 36 mm²/s)

referred to reservoir temperature (open circuit).

Limits of viscosity range

For critical operating conditions the following values apply:

ν_{min} = 60 SUS (10 mm²/s)
for short periods (t ≤ 1 min)
at max. perm. case drain temperature of 239 °F (115 °C).

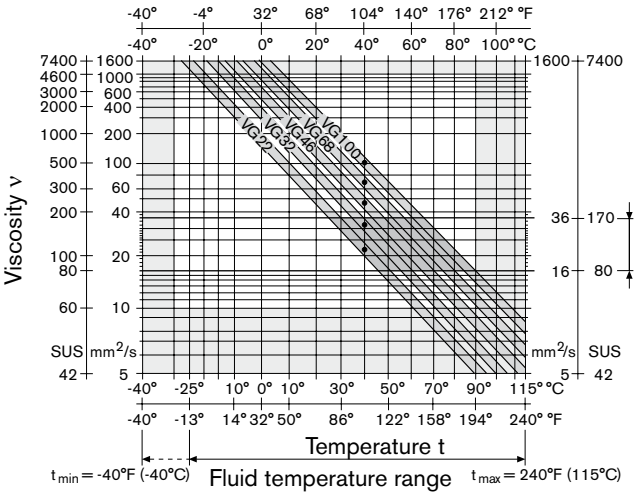
Please note that the max. case drain temperature of 115 °C is also not exceeded in certain areas (for instance bearing area). The fluid temperature in the bearing area is approx. 7 °F (5 K) higher than the average case drain temperature.

ν_{max} = 7500 SUS (1600 mm²/s)
for short periods (t ≤ 1 min)
on cold start
(p ≤ 435 psi (30 bar), n ≤ 1000 rpm,
t_{min} -13 °F (-25 °C))

Depending on the installation situation, special measures are necessary at temperatures between -40 °F (-40°C) and -13 °F (-25°C). Please contact us.

For detailed information on operation with low temperatures see data sheet RE 90300-03-B.

Selection diagram



Notes on the selection of the hydraulic fluid

In order to select the correct hydraulic fluid, it is necessary to know the operating temperature in relation to the ambient temperature. In an open circuit this is the reservoir temperature.

The fluid should be selected so that within the operating temperature range, the viscosity lies within the optimum range (ν_{opt}), see shaded section of the selection diagram. We recommend to select the higher viscosity grade in each case.

Example: at an ambient temperature of X °F (°C) the operating temperature in the reservoir is 140 °F (60 °C) . In the optimum operating viscosity range (ν_{opt}; shaded area) this corresponds to viscosity grades VG 46 resp. VG 68; VG 68 should be selected.

Important
The case drain temperature is influenced by pressure and input speed and is always higher than the reservoir temperature. However, at no point in the component may the temperature exceed 239 °F (115 °C). The temperature difference specified on the left is to be taken into account when determining the viscosity in the bearing.

Please contact us if the above conditions cannot be met due to extreme operating parameters.

Filtration of the fluid

The finer the filtration the better the fluid cleanliness class and the longer 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 fluid to determine the particle contamination and the cleanliness class according to ISO 4406. A cleanliness class of at least 20/18/15 must be achieved.

At very high hydraulic fluid temperatures (195 °F (90 °C) to maximum 239 °F (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.

Technical data

Operating pressure range

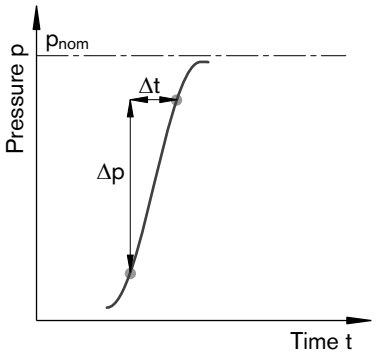
Pressure at service line port B

Nominal pressure p_{nom} _____ 3600 psi (250 bar) absolute

Maximum pressure p_{max} _____ 4600 psi (315 bar) absolute
Single operating period_____ 2.5 ms
Total operating period _____ 300 h

Minimum pressure (high-pressure side) ___145 psi (10 bar)

Rate of pressure change $R_{A\ max}$_ 235000 psi/s (16000 bar/s)



Pressure at suction port S (inlet)

Minimum pressure $p_{S\ min}$ _____ 10 psi (0.8 bar) absolute
Maximum pressure $p_{S\ max}$ _____75 psi (5 bar) absolute

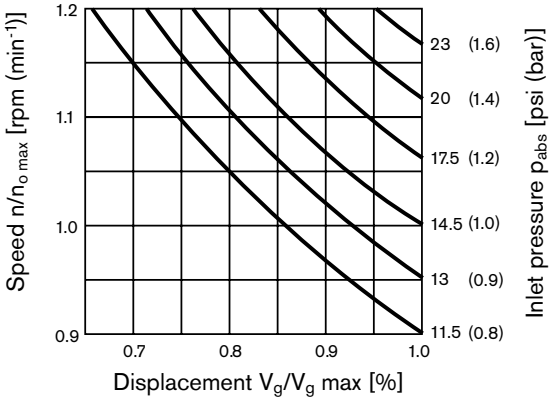
Case drain pressure

Maximum permissible case drain pressure
(at port L, L_1):
Maximum 7.5 psi (0.5 bar) higher than the inlet pressure at port S, however not higher than 30 psi (2 bar) absolute.

$p_{L\ max\ abs}$ _____ 30 psi (2 bar)

Maximum permissible speed (limit speed)

Permissible speed by increasing inlet pressure p_{abs} at suction opening S or at $V_g \leq V_{g\ max}$.



Definition

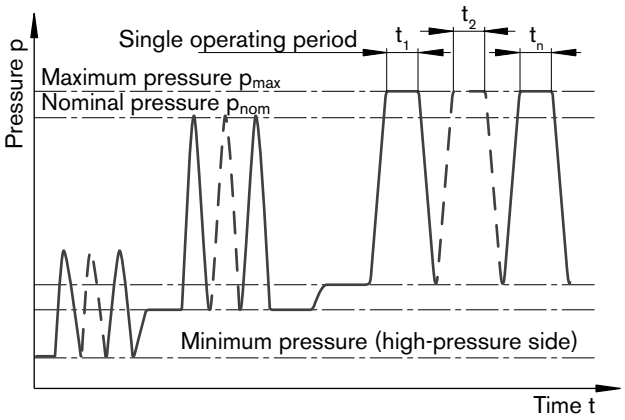
Nominal pressure p_{nom}
The nominal pressure corresponds to the maximum design pressure.

Maximum pressure p_{max}
The maximum pressure corresponds to the operating pressure within the single operating period. The total of the single operating periods must not exceed the total operating period.

Minimum pressure (high-pressure side)
Minimum pressure on the high-pressure side (B) that is required in order to prevent damage to the axial piston unit.

Minimum pressure (inlet) open circuit
Minimum pressure at suction port S (inlet) that is required to prevent damage to the axial piston unit. The minimum pressure depends on the speed and displacement of the axial piston unit.

Rate of pressure change R_A
Maximum permissible pressure build-up and pressure reduction speed with a pressure change over the entire pressure range.



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

Notes

Technical data

Table of values (theoretical values, without efficiencies and tolerances: values rounded)

Size	NG			10	18	28	45	60[1]	63[2]	85	100
Geometrical displacement per revolution	$V_{g\,max}$		in^3	0.64	1.10	1.75	2.75	3.66	3.84	5.18	6.10
			(cm^3)	(10.5)	(18)	(28)	(45)	(60)	(63)	(85)	(100)
Speed[3]											
maximum at $V_{g\,max}$	n_{nom}		rpm	3600	3300	3000	2600[4]	2600	2600	2500	2300
maximum at $V_g < V_{g\,max}$	$n_{max\,perm}$		rpm	4320	3960	3600	3120	3140	3140	3000	2500
Flow at n_{nom} and $V_{g\,max}$	$q_{v\,max}$		gpm	9.7	15.6	22	31	41	43	55	60
			(l/min)	(37)	(59)	(84)	(117)	(156)	(163)	(212)	(230)
at n_E = 1500 rpm and $V_{g\,max}$	$q_{vE\,max}$		gpm	4	7.1	1.1	18	24	25.1	34	39
			(l/min)	(15)	(27)	(42)	(68)	(90)	(95)	(128)	(150)
Power at Δp = 3600 psi (250 bar)											
at n_{nom}, $V_{g\,max}$	P_{max}		HP (kW)	22 (16)	34 (25)	47 (35)	65 (49)	88 (65)	90 (68)	119 (89)	130 (96)
at n_E = 1500 rpm and $V_{g\,max}$	$P_{E\,max}$		HP	9.4	15	24	38	50	52	71	84
			(kW)	(7)	(11)	(18)	(28)	(37)	(39)	(53)	(62)
Torque at $V_{g\,max}$ and Δp = 3600 psi (250 bar)	T_{max}		lb-ft	31	52	82	132	175	184	247	293
			(Nm)	(42)	(71)	(111)	(179)	(238)	(250)	(338)	(398)
Δp = 1440 psi (100 bar)	T		lb-ft	13	21	33	53	70	74	102	117
			(Nm)	(17)	(29)	(45)	(72)	(95)	(100)	(135)	(159)
Rotary stiffness, drive shaft S	c		lb-ft/rad	6760	8082	16400	37500	48100	48100	105100	105100
			(Nm/rad)	(9200)	(11000)	(22300)	(37500)	(65500)	(65500)	(143000)	(143000)
R	c		lb-ft/rad	–	10870	19400	30240	51200	51200	–	–
			(Nm/rad)	–	(14800)	(26300)	(41000)	(69400)	(69400)	–	–
U	c		lb-ft/rad	5020	5870	–	22130	36290	36390	75900	75900
			(Nm/rad)	(6800)	(8000)	–	(30000)	(49200)	(49200)	(102900)	(102900)
W	c		lb-ft/rad	–	–	–	25370	39830	39830	86960	86960
			(Nm/rad)	–	–	–	(34400)	(54000)	(54000)	(117900)	(117900)
K/C	c		lb-ft/rad	7965	–	19770	32380	54506	–	–	–
			(Nm/rad)	(10800)	–	(26800)	(43900)	(73900)	–	–	–
Moment of inertia rotary group	J_{TW}		$lbs\text{-}ft^2$	0.0142	0.2207	0.0403	0.0783	0.1329	0.1329	0.2848	0.2848
			(kgm^2)	(0.0006)	(0.00093)	(0.0017)	(0.0033)	(0.0056)	(0.0056)	(0.012)	(0.012)
Angular accel., max.[5]	α		rad/s^2)	8000	6800	5500	4000	3300	3300	2700	2700
Filling capacity	V		gal	0.05	0.06	0.08	0.13	0.21	0.21	0.26	0.26
			(L)	(0.2)	(0.25)	(0.3)	(0.5)	(0.8)	(0.8)	(1)	(1)
Weight (without through drive) approx.	m		lbs (kg)	17 (8)	25 (11.5)	31 (14)	40 (18)	48.5 (22)	48.5 (22)	75 (34)	75 (34)

1) Only series 52
2) Only series 53
3) The values are applicable:
   - for absolute pressure p_{abs} = 15 psi (1 bar) at the suction port S
   - for the optimum viscosity range of ν_{opt} = 80 to 170 SUS (16 to 36 mm^2/s)
   - for mineral-based operating materials with a specific mass of 0.88 kg/l.
4) Please contact us regarding higher speeds
5) The scope of application lies between the minimum necessary and the maximum permissible drive speeds.
   Valid for external excitation (e.g. diesel engine 2- to 8-fold rotary frequency, cardan shaft 2-fold rotary frequency). The limiting value is only valid for a single pump. The loading capacity of the connecting parts must be taken into account.

Technical data

Note

Exceeding the maximum or falling below the minimum permissible values on page 8 can lead to a loss of function, a reduction in operational service life or total destruction of the axial piston unit. We recommend checking the loading with tests or calculations / simulations and comparison with the permissible values.

Determination of size

Flow $q_V = \frac{V_g \cdot n \cdot \eta_V}{231\ (1000)}$ [gpm (l/min)]

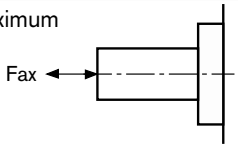
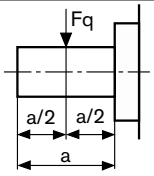
Torque $T = \frac{V_g \cdot \Delta p}{24\ (20) \cdot \pi \cdot \eta_{mh}}$ [lb-ft (Nm)]

Power $P = \frac{2\pi \cdot T \cdot n}{33.000\ (60000)} = \frac{q_V \cdot \Delta p}{1.714\ (600) \cdot \eta_t}$ [HP (kW)]

V_g = Geometric displ. per revolution in in^3 (cm^3)
Δp = Differential pressure in psi (bar)
n = Speed in rpm
η_V = Volumetric efficiency
η_{mh} = Mechanical-hydraulic efficiency
η_t = Total efficiency ($h_t = h_V \cdot h_{mh}$)

Technical data

Permissible radial and axial forces on the drive shaft

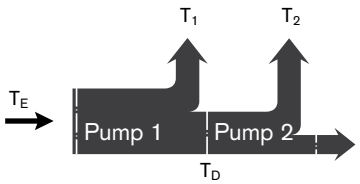
Size	NG		10	18	28	45	60/63	85	100
Radial force maximum at a/2 	$F_{q\ max}$	lbf (N)	56 (250)	78 (350)	270 (1200)	337 (1500)	382 (1700)	450 (2000)	450 (2000)
Axial force maximum 	$+ F_{ax\ max}$	lbf (N)	90 (400)	157 (700)	225 (1000)	337 (1500)	450 (2000)	675 (3000)	675 (3000)

Permissible input and through-drive torques

Size	NG		10	18	28	45	60/63	85	100
Torque at $V_{g\ max}$ and $\Delta p = 3600$ psi (250 bar)[1]	T_{max}	lb-ft (Nm)	31 (42)	52 (71)	82 (111)	132 (179)	184 (250)	293 (338)	293 (398)
Input torque for drive shaft, maximum[2]									
S	$T_{E\ max}$	lb-ft (Nm)	93 (126)	91 (124)	198	319	630	1157	1157
	DIA	in	3/4	3/4	7/8	1	1 1/4	1 1/2	1 1/2
R	$T_{E\ max}$	lb-ft (Nm)	–	110 (150)	166 (225)	295 (400)	479 (650)	–	–
	DIA	in	–	3/4	7/8	1	1 1/4	–	–
U	$T_{E\ max}$	lb-ft (Nm)	44 (60)	43 (59)	–	139 (188)	226 (306)	463 (628)	463 (628)
	DIA	in	5/8	5/8	–	7/8	1	1 1/4	1 1/4
W	$T_{E\ max}$	lb-ft (Nm)	–	–	–	162 (220)	292 (396)	447 (650)	447 (650)
	DIA	in	–	–	–	7/8	1	1 1/4	1 1/4
K	$T_{E\ max}$	lb-ft (Nm)	78 (106)	–	107 (145)	156 (212)	325 (441)	–	–
	DIA	in (mm)	0.750 (19.05)	–	0.8750 (22.225)	1.000 (25.4)	1.2500 (31.75)	–	–
C[3]	$T_{E\ max}$	lb-ft (Nm)	–	–	107 (145)	156 (212)	325 (441)[4]		
Maximum through-drive torque for drive shaft									
S	$T_{D\ max}$	lb-ft (Nm)	–	80 (108)	118 (160)	235 (319)	357 (484)	515 (698)	515 (698)
R	$T_{D\ max}$	lb-ft (Nm)	–	89 (120)	130 (176)	270 (365)	357 (484)	–	–

1) Without considering efficiency
2) For drive shafts free of radial load
3) only series 52
4) only size 60

Distribution of torques

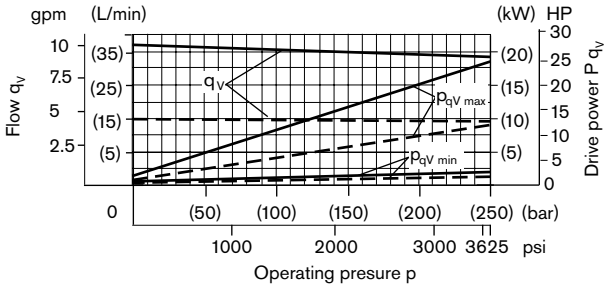


Technical data

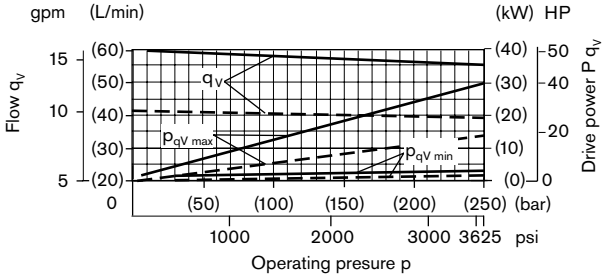
Drive power and flow

Operating material:
Hydraulic fluid ISO VG 46 DIN 51519, t = 50 °C

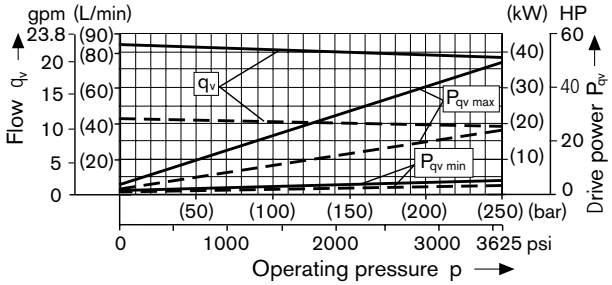
Size 10
- - - - n = 1500 rpm
——— n = 3600 rpm



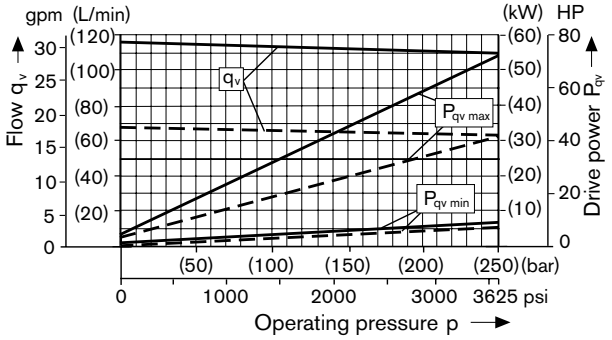
Size 18
- - - - n = 1500 rpm
——— n = 3300 rpm



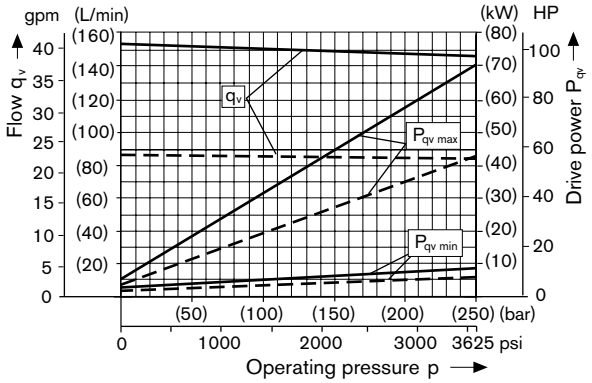
Size 28
- - - - n = 1500 rpm
——— n = 3000 rpm



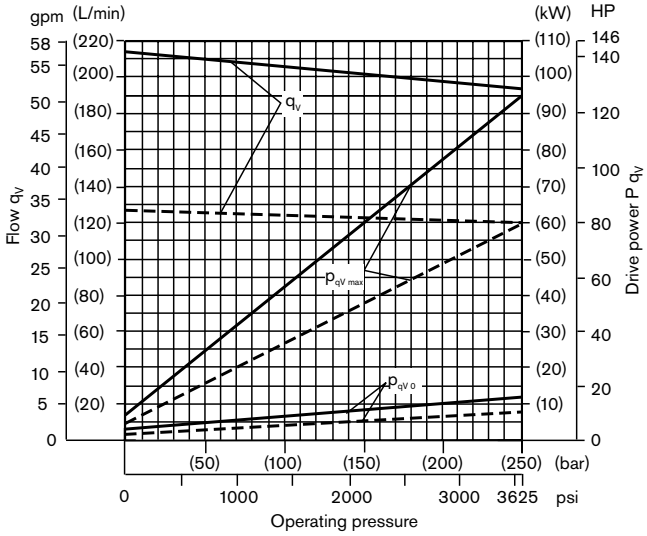
Size 45
- - - - n = 1500 rpm
——— n = 2600 rpm



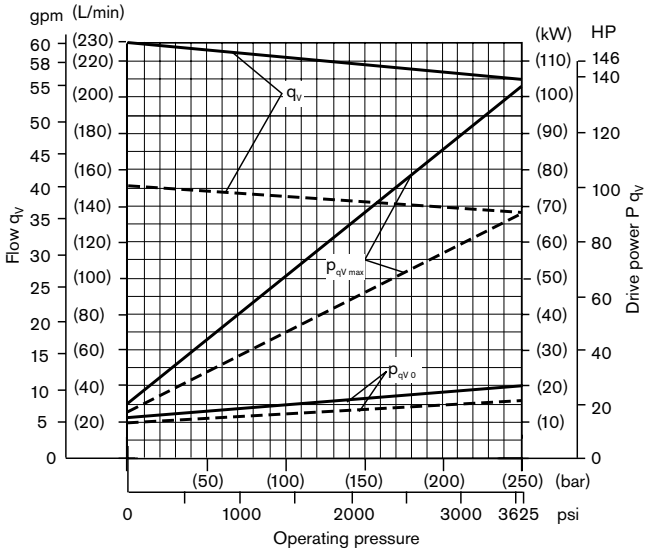
Size 60/63
- - - - n = 1500 rpm
——— n = 2600 rpm



Size 85
- - - - n = 1500 rpm
——— n = 2500 rpm



Size 100
- - - - n = 1500 rpm
——— n = 2300 rpm

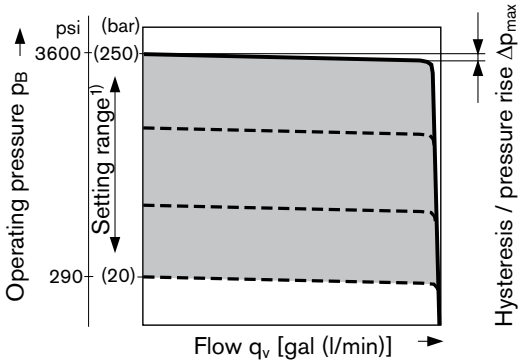


DR – Pressure control

The pressure control limits the maximum pressure at the pump output within the pump control range. The variable pump only supplies as much hydraulic fluid as is required by the consumers. If the operating pressure exceeds the target pressure set at the pressure valve, the pump will regulate towards a smaller displacement. The pressure can be set steplessly at the control valve.

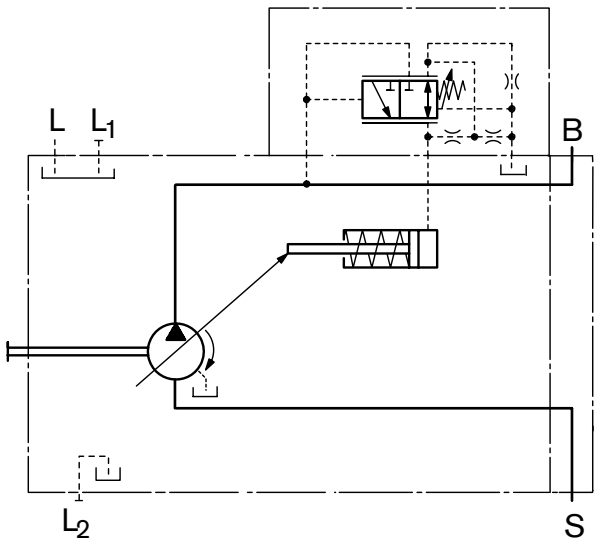
Static characteristic

(at n_1 = 1500 rpm; t_{fluid} = 120 °F (50 °C))



1) In order to prevent damage to the pump and the system, this setting range is the permissible setting range and it is not allowed to exceeded.
The range of possible settings at the valve are greater.

Circuit diagram



	Port for
B	Service line
S	Suction line
L, $L_{1,2}$	Case drain fluid ($L_{1,2}$ plugged)

Controller data

Hysteresis and repeatability Δp _____ maximum 45 psi (3 bar)

Pressure rise, maximum

NG		10	18	28	45	60/63	85	100
Δp	psi	90	90	90	90	115	175	200
	(bar)	(6)	(6)	(6)	(6)	(8)	(12)	(14)

Control fluid consumption_____ max. approx. 0.8 gpm (3 l/min)

Flow losses at q_{Vmax} see page 11.

DRG – Pressure control remotely operated

The DRG control valve overrides the function of the DR pressure controller (see page 12).

A pressure relief valve can be externally piped to port X for remote setting of pressure below the setting of the DR control valve spool. This relief valve is not included in the delivery contents of the pump.

The differential pressure at the control valve is set as standard to 290 psi (20 bar). The control fluid volume at port X is approx. 0.4 gpm (1.5 l/min). If another setting is required (range from 145 to 320 psi (10 to 22 bar)) please state this in clear text.

As a separate pressure relief valve we can recommend:

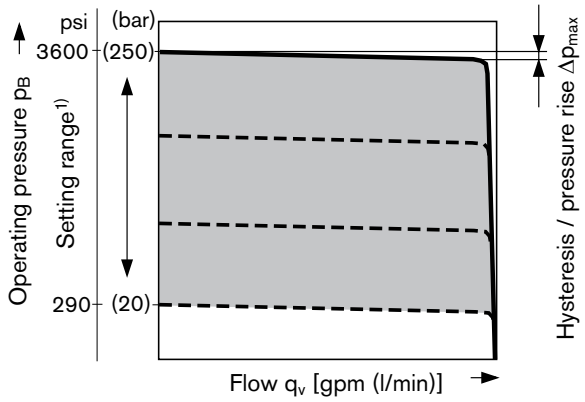
DBDH 6 (hydraulic) to RE 25402 or

DBETR-SO 381 with orifice dia. 0.03 in (0.8 mm) in P (electric) to RE 29166.

The max. length of piping should not exceed 6.6 ft (2 m).

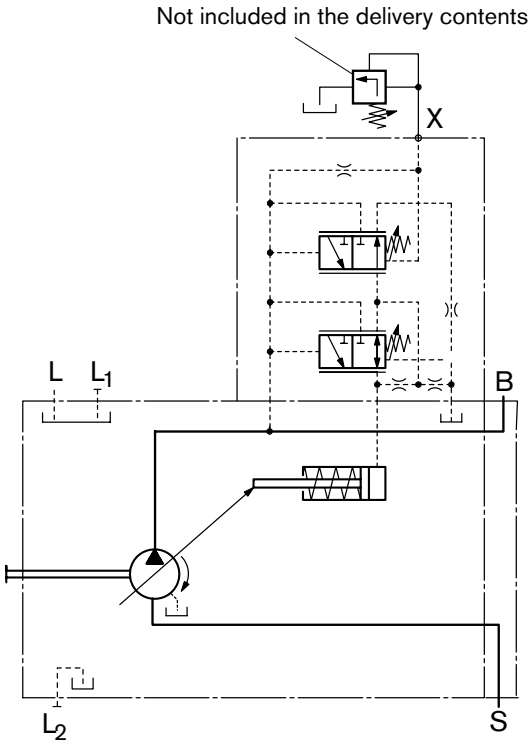
Static characteristic

(at n_1 = 1500 rpm; t_{fluid} = 120 °F (50 °C))



1) In order to prevent damage to the pump and the system, this setting range is the permissible setting range and it is not allowed to be exceeded.
The range of possible settings at the valve is higher.

Circuit diagram



	Port for
B	Service line
S	Suction line
L, $L_{1,2}$	Case drain fluid ($L_{1,2}$ plugged)
X	Pilot pressure

Controller data

Hysteresis and repeatability Δp _____ maximum 45 psi (3 bar)

Pressure rise, maximum

NG		10	18	28	45	60/63	85	100
Δp	psi	90	90	90	90	115	175	200
	(bar)	(6)	(6)	(6)	(6)	(8)	(12)	(14)

Control fluid consumption____max. approx. 1.2 gpm (4.5 l/min)

Flow losses at q_{Vmax} see page 11.

DRF (DFR) DRS (DFR1) – Pressure and flow control

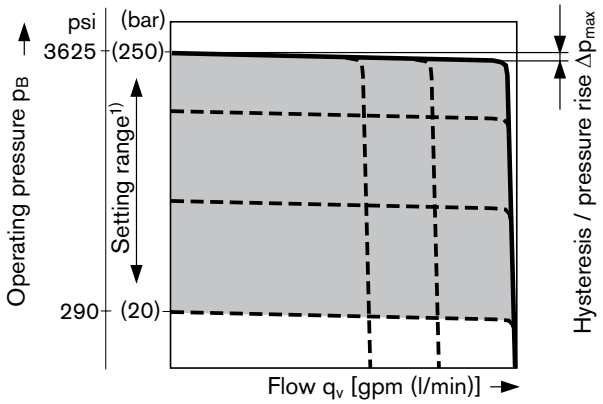
In addition to the pressure control function (see page 12), a variable orifice (e.g. directional valve) is used to adjust the differential pressure upstream and downstream of the orifice. This is used to control the pump flow. The pump flow is equal to the actual required flow by the consumer, regardless of changing pressure levels.

The pressure control overrides the flow control function.

Note
The DRS (DFR1) valve version has no connection between X and the reservoir. Unloading the LS-pilot line must be possible in the valve system.
Because of the flushing function sufficient unloading of the X-line must also be provided.

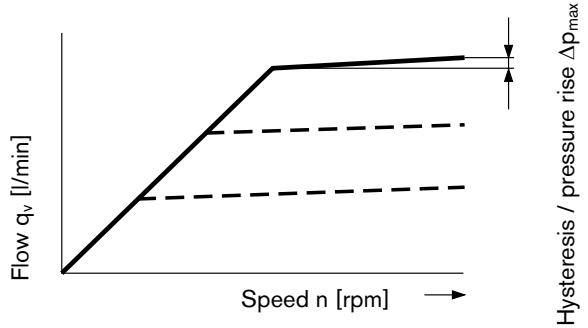
Static characteristic

Flow control at n_1 = 1500 rpm; t_{fluid} = 120 °F (50 °C))



1) In order to prevent damage to the pump and the system, this setting range is the permissible setting range and it is not allowed to be exceeded.
The range of possible settings at the valve is higher.

Static characteristic at variable speed

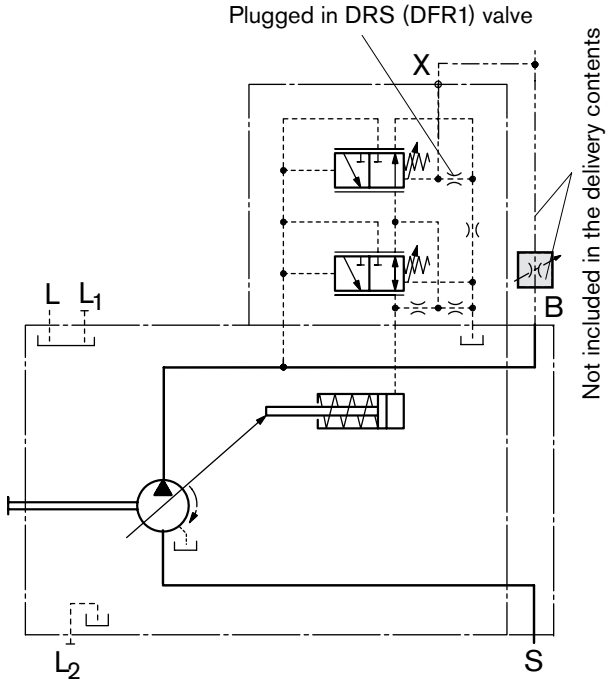


Possible connections at port B
(not included in the delivery, order separately)

LS mobile control blocks
Mobile control blocks M4 - 12 (RE 64276)
Mobile control blocks M4 - 15 (RE 64283)

LUDV mobile control blocks
Mobile control blocks M6 - 15 (RE 64284)
Mobile control blocks M7 - 22 (RE 64295)

Circuit diagram



	Port for
B	Service line
S	Suction line
L, L1,2	Case drain fluid ($L_{1,2}$ plugged)
X	Pilot pressure

Differential pressure Δp

Standard setting: 200 to 320 psi (14 to 22 bar).
If another setting is required, please state in clear text.
Relieving the load on port X to the reservoir results in a zero stroke ("standby") pressure which lies about 15 to 30 psi (1 to 2 bar) higher than the differential pressure Δp). No account is taken of system influences.

Controller data

Data pressure control DR, see page 12.
Maximum flow deviation measured with drive speed n = 1500 rpm.

NG		10	18	28	45	60/63	85	100
$\Delta q_{v\,max}$	gpm	0.13	0.24	0.26	0.48	0.66	0.83	0.83
	(l/min)	(0.5)	(0.9)	(1.0)	(1.8)	(2.5)	(3.1)	(3.1)

Control fluid consumption
DRF (DFR) __ maximum approx. 0.8 to 1.2 gpm (3 to 4.5 l/min)
DRS (DFR1) _____ maximum approx. 0.8 gpm (3 l/min)
Volume flow loss at q_{Vmax}, see page 11.

LA... – Pressure, flow and power control

Pressure control equipped as DR(G), see page 12 (13).
Flow control equipped as DRF, DRS, see page 14.

In order to achieve a constant drive torque with varying operating pressures, the swivel angle and with it the output flow from the axial piston pump is varied so that the product of flow and pressure remains constant.

Flow control is possible below the power control curve.

When ordering please state the power characteristics to be set ex works in clear text, e.g. 27 HP (20 kW) at 1500 rpm.

Controller data

For pressure controller DR data, see page 12.
For flow control FR data, see page 13.

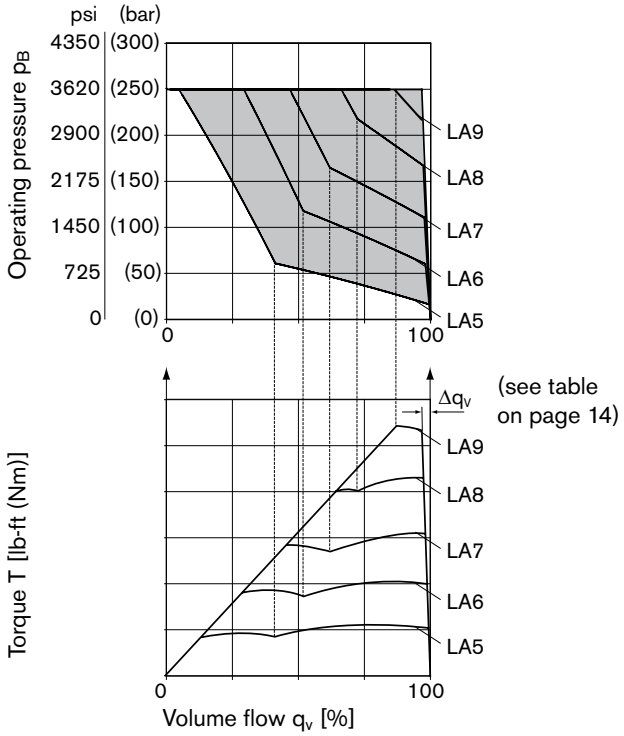
Controller data
Maximum control fluid consumption, see page 14
Volume flow loss at q_{Vmax}, see page11.

Start of control	Torque T [lb-ft (Nm)] for size						Order code
[psi ((bar)]	18	28	45	63	85	100	
145 to 510 (10 to 35)	2.80 - 8.92 (3.8 - 12.1)	4.4 - 14 (6 - 19)	7.4 - 22.1 (10 - 30)	11 - 32 (15 - 43)	15 - 42 (20 - 57)	18 - 49.5 (24 - 68)	**LA5**
520 to 1015 (36 to 70)	8.92 - 17.2 (12.2 - 23.3)	14 - 26.5 (19.1 - 36)	22.2 - 43.5 (30.1 - 59)	32 - 61 (43.1 - 83)	42 - 83 (57.1 - 112)	49.5 - 97.1 (68.1 - 132)	**LA6**
1030 to 1520 (71 to 105)	17.2 - 24.9 (23.4 - 33.7)	26.6 - 38.4 (36.1 - 52)	43.6 - 62 (59.1 - 84)	61 - 88 (83.1 - 119)	83 - 118) (112.1 - 160)	97.1 - 139.4 (132.1 - 189)	**LA7**
1535 to 2030 (106 to 140)	24.9 - 33.2 (33.8 - 45)	38.4 - 51.6 (52.1 - 70)	62 - 83 (84.1 - 112)	88 - 116 (119.1 - 157)	118 - 156 (160.1 - 212)	139.4 - 183.6 (189.1 - 249)	**LA8**
2045 to 3335 (141 to 230)	33.2 - 55.2 (45.1 - 74.8)	51.7 - 86.3 (70.1 - 117)	83 - 139 (112.1 - 189)	116 - 195 (157.1 - 264)	156 - 263 (212.1 - 357)	183.3 - 309 (249.1 - 419)	**LA9**

Conversion of the torque values in power [kW]:

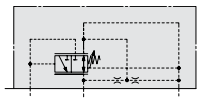
$$P = \frac{T}{3.5\ (6.4)}\ \text{[HP (kW)] (at 1500 rpm)} \quad \text{or} \quad P = \frac{2\pi \bullet T \bullet n}{33.000\ (60000)}\ \text{[HP (kW)] (for speeds, see table on page 8)}$$

Static curves and torque characteristic

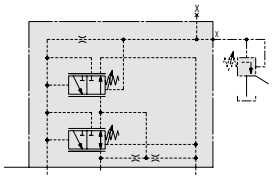


(see table on page 14)

Circuit diagram (LAXD) with pressure cut-off

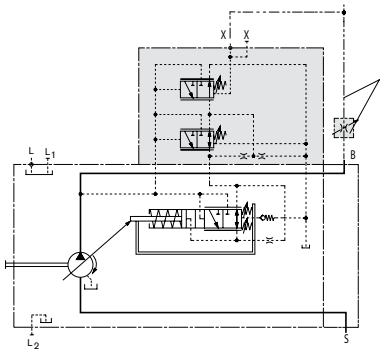


Circuit diagram (LAXDG) with pressure cut-off, remotely operated



Not included in the delivery contents

Circuit diagram (LAXDS) with pressure and flow control



Not included in the delivery contents

EP – Electro-proportional control

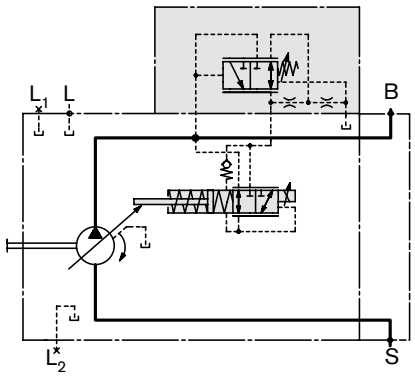
Electro-proportional control makes a stepless and reproducible setting of the pump displacement possible directly via the swashplate. The control force of the control piston is applied by a proportional solenoid. The control is proportional to the current (for start of control, see table right).

In a depressurized state, the pump is swiveled to its initial position ($V_{g\,max}$) by an adjusting spring. If the operating pressure exceeds 200 psi (14 bar), the pump will swivel from $V_{g\,max}$ to $V_{g\,min}$ without control by the solenoid (control current < start of control). A PWM signal is used to control the solenoid.

EP.D: The pressure control regulates the pump displacement back to $V_{g\,min}$ after the set target pressure has been reached.

A minimum operating pressure of 200 psi (14 bar) is needed for control. The necessary control fluid is taken from the high pressure.

Circuit diagram EP.D



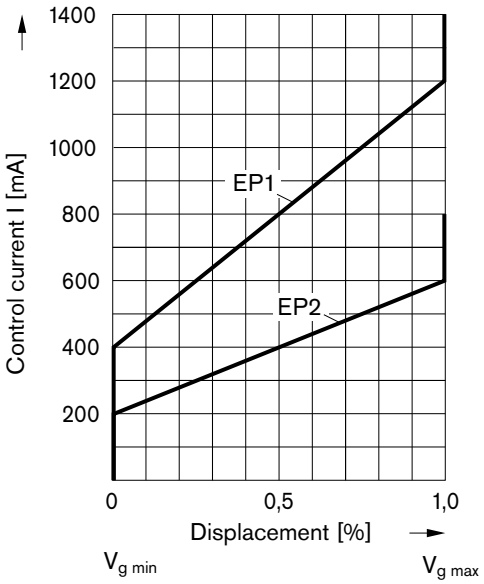
	Port for
B	Service line
S	Suction line
L, $L_{1,2}$	Case drain fluid ($L_{1,2}$ plugged)
X	Control pressure

Technical data, solenoid	EP1	EP2
Voltage	12 V (±20 %)	24 V (±20 %)
Control current		
Start of control at $V_{g\,min}$	400 mA	200 mA
End of control at $V_{g\,max}$	1200 mA	600 mA
Limiting current	1.54 A	0.77 A
Nominal resistance (at 68 °F (20 °C))	5.5 Ω	22.7 Ω
Dither frequency	100 to 200 Hz	100 to 200 Hz
Actuated time	100 %	100 %
For protection rating, please refer to "Socket version" on page 55		

Operating temperature range at valve -4 °F to 239 °F (-20 °C to +115 °C)

Characteristic EP1/2

Hysteresis < 5 %



Note

The spring return at the controller is not a safety device

Dirt contamination (contaminated hydraulic fluid, wear or residual dirt from system components) could cause the controller to stick in an undefined position. The volume flow of the axial piston unit will then no longer follow the commands of the operator.

Check whether remedial measures for your application are needed on your machine in order to put the driven consumer in a safe state (e.g. immediate stop).

EK – Electro-proportional control with controller cut-off

The variant EK... is based completely on the variant EP... (see page 16).

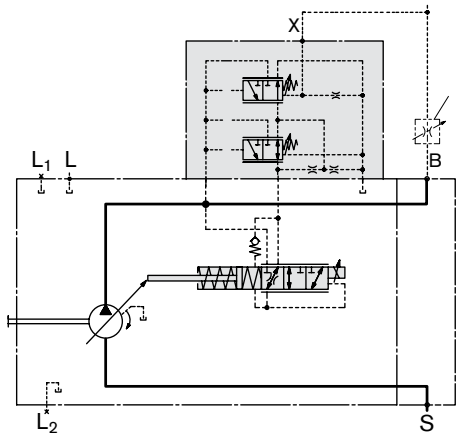
In addition to the electro-proportional control function, a controller cut-off is integrated in the electric characteristic.
The pump then swivels to $V_{g\,max}$ if the control signal is lost (e.g. cable break) and then works with the DRF settings (see page 14). The controller cut-off is only intended for short-term use and not for permanent use if the control signal is lost. If the control signal is lost, the pump swivel times will be reduced by the EK valve.
A PWM signal is used to control the solenoid.

A minimum operating pressure of 200 psi (14 bar) is needed for control. The necessary control fluid is taken from the high pressure.

The $V_{g\,max}$ position is maintained by the force of the adjusting spring. To overcome the force of this spring, the solenoid must be subjected to excessive current (I_{res}).

Observe the instructions regarding the project design on page 2

Circuit diagram EK.DF



	Port for
B	Service line
S	Suction line
L, $L_{1,2}$	Case drain fluid ($L_{1,2}$ plugged)
X	Control pressure

Note

The spring return at the controller is not a safety device

Dirt contamination (contaminated hydraulic fluid, wear or residual dirt from system components) could cause the controller to stick in an undefined position. The volume flow of the axial piston unit will then no longer follow the commands of the operator.

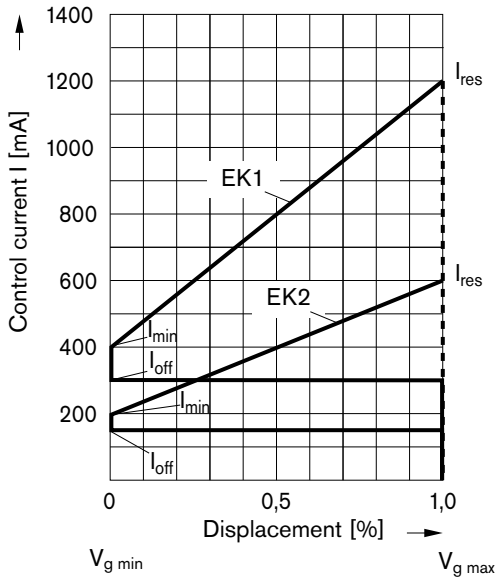
Check whether remedial measures for your application are needed on your machine in order to put the driven consumer in a safe state (e.g. immediate stop).

Technical data, solenoid	EK1	EK2
Voltage	12 V (±20 %)	24 V (±20 %)
Control current		
Start of control at $V_{g\,min}$	400 mA	200 mA
End of control at $V_{g\,max}$	1200 mA	600 mA
Limiting current	1.54 A	0.77 A
Nominal resistance (at 68 °F (20 °C))	5.5 Ω	22.7 Ω
Dither frequency	100 to 200 Hz	100 to 200 Hz
Actuated time	100 %	100 %
For protection rating, please refer to "Socket version" on page 55		

Operating temperature range at valve -4 °F to 239 °F (-20 °C to +115 °C)

Characteristic EK

Hysteresis < 5 %



	EK1.	EK2.
I_{min} [mA]	400	200
I_{max} [mA]	1200	600
I_{off} [mA]	< 300	< 150
I_{res} [mA]	> 1200	> 600

For changes in current, ramp times of > 200 ms must be observed.

EP(K).DF / EP(K).DS – EP(K) with pressure and flow control

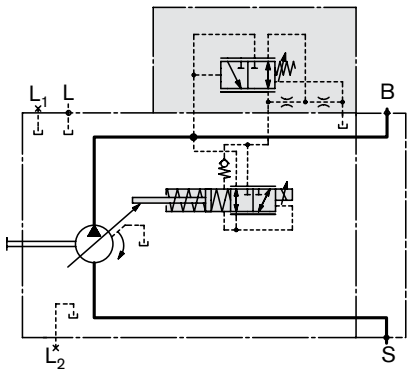
A hydraulic pressure flow control is superimposed on the electro-proportional control.
The pressure control regulates the pump displacement back to $V_{g\ min}$ after the set target pressure has been reached.
This function is super-imposed on the EP or EK control, i.e. the control-current dependent function is executed below the target pressure.
Setting range from 290 to 3600 psi (20 to 250 bar). For the pressure flow control, see page 14.

Pressure control has priority over electro-proportional control and flow control.

With flow control, the pump flow can be influenced in addition to pressure control. The pump flow is thus equal to the actual amount of hydraulic fluid required by the consumer. This is achieved using the differential pressure at the consumer (e.g. orifice).

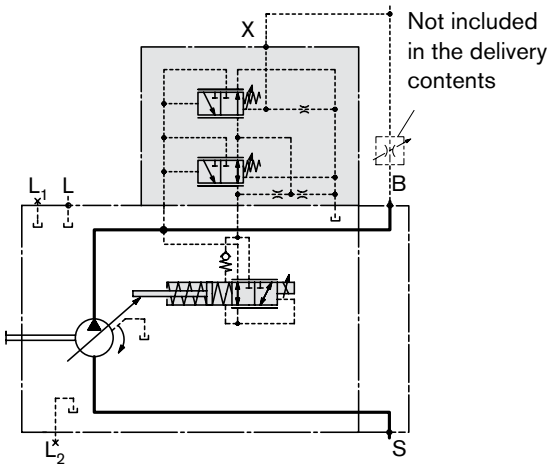
The EP.DS or EK.DS version has no connection between X and the reservoir (load sensing). Please refer to the notes on page 14.

Circuit diagram EP.D



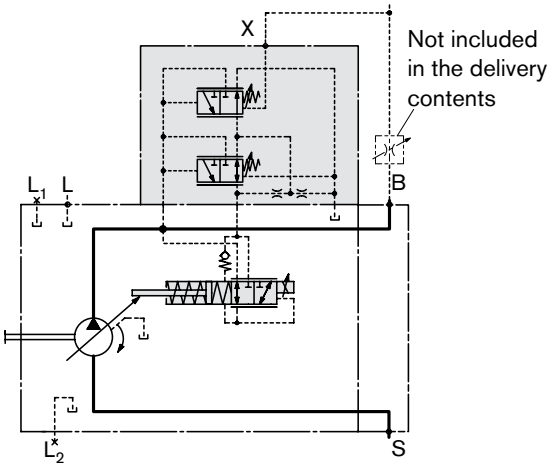
	Port for
B	Service line
S	Suction line
L, $L_{1,2}$	Case drain fluid ($L_{1,2}$ plugged)

Circuit diagram EP.DF



	Port for
B	Service line
S	Suction line
L, $L_{1,2}$	Case drain fluid ($L_{1,2}$ plugged)
X	Control pressure

Circuit diagram EP.DS



	Port for
B	Service line
S	Suction line
L, $L_{1,2}$	Case drain fluid ($L_{1,2}$ plugged)
X	Control pressure

EP(K).ED – EP(K) with electro-hydraulic pressure control

The ED valve is set to a certain pressure by a specified variable solenoid current.

When a change is made at the consumer (load pressure), the position of the control piston will shift.

This causes an increase or decrease in the pump swivel angle (flow) in order to maintain the electrically set pressure level.

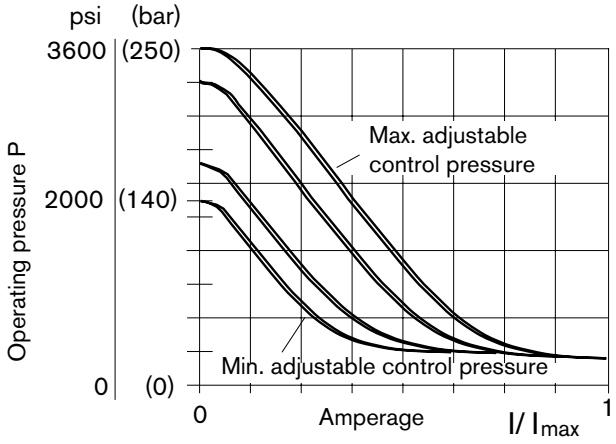
The pump thus only delivers as much hydraulic fluid as the consumers can take. The pressure can be set steplessly by the solenoid current.

As the solenoid current signal drops towards zero, the pressure will be limited to p_{max} by an adjustable hydraulic pressure cut-off (negative characteristic, e.g. for fan drives). A PWM signal is used to control the solenoid.

For further information and technical data of the solenoids for ED(ER) control please refer to pages 20 and 21.

Static current-pressure characteristic ED
(negative characteristic)

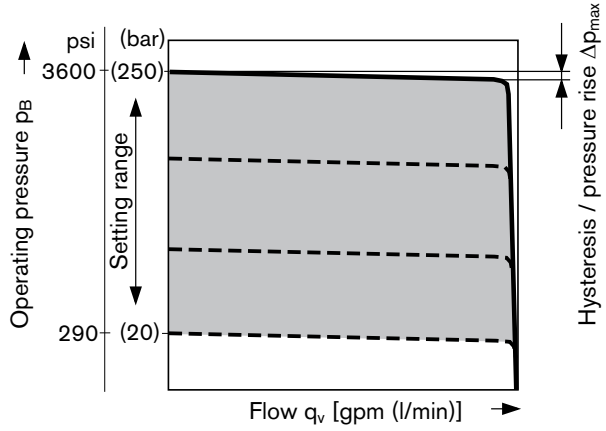
(measured with pump in zero stroke)



Hysteresis static current-pressure characteristic
< 45 psi (3 bar).

Static flow-pressure characteristic

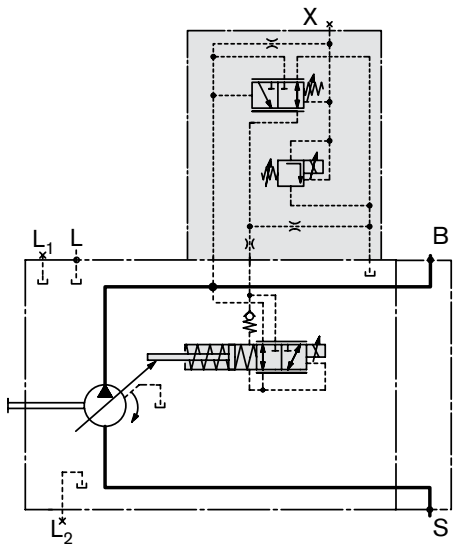
(at n= 1500 rpm; t_{fluid} = 120 °F (50 °C))



Controller data

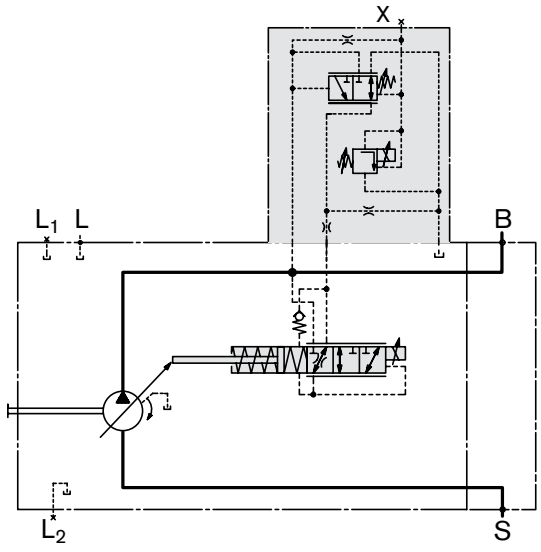
Standby standard setting: 290 psi (20 bar). Other values on request. Hysteresis / pressure rise Δp 60 psi (4 bar)

Circuit diagram EP.ED



	Port for
B	Service line
S	Suction line
L, L1,2	Case drain fluid ($L_{1,2}$ plugged)
X	Control pressure

Circuit diagram EK.ED



	Port for
B	Service line
S	Suction line
L, L1,2	Case drain fluid ($L_{1,2}$ plugged)
X	Control pressure

ED – Electro-hydraulic pressure control

The ED valve is set to a certain pressure by a specified variable solenoid current.

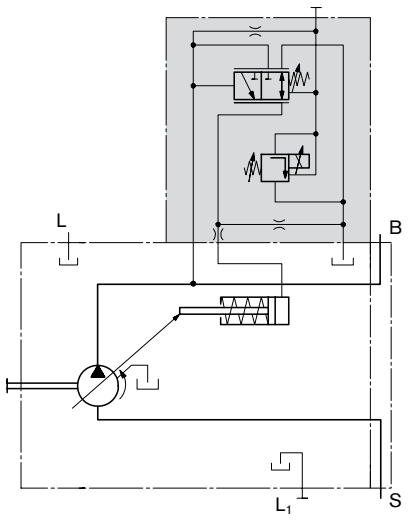
When a change is made at the consumer (load pressure), the position of the control piston will shift.

This causes an increase or decrease in the pump swivel angle (flow) in order to maintain the electrically set pressure level.

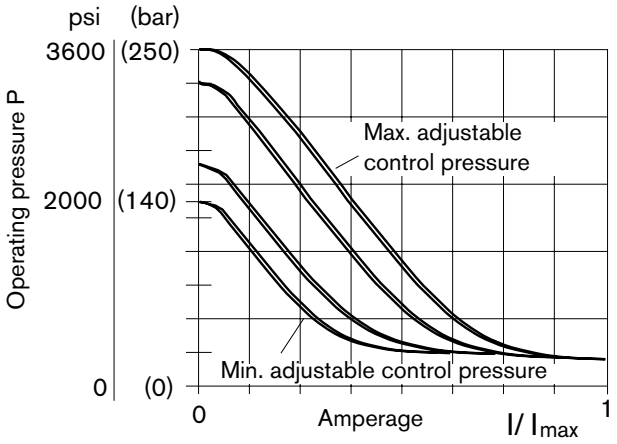
The pump thus only delivers as much hydraulic fluid as the consumers can take. The desired pressure level can be set steplessly by varying the solenoid current.

As the solenoid current signal drops towards zero, the pressure will be limited to p_{max} by an adjustable hydraulic pressure cut-off (secure fail safe function in case of a loss of power, e.g. for fan drives).
The response time characteristic of the ED-control was optimized for the use as a fan drive system.
When ordering, state the type of application in clear text.

Circuit diagram ED..

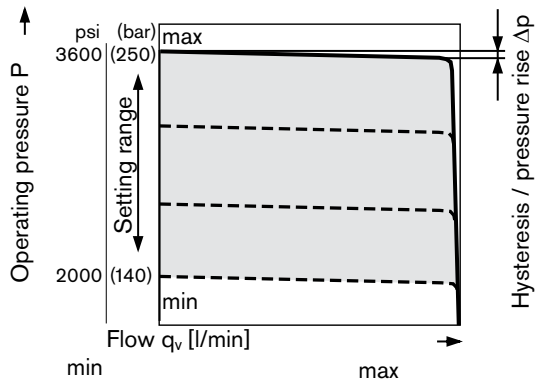


Static current-pressure characteristic ED
(measured at pump in zero stroke – negative characteristic)



Hysteresis static current-press. characteristic < 45 psi (3 bar)

Static flow-pressure characteristic
(at n= 1500 rpm; t_{fluid} = 120 °F (50 °C))



Controller data
Standby standard setting 290 psi (20 bar), other values on request.

Hysteresis and pressure rise _____ Δp < 60 psi (4 bar).
Control flow consumption_____ 0.8 to 1.2 gpm (3 to 4.5 l/min).

	Port for
B	Service line
S	Suction line
L, L_1	Case drain (L_1 plugged)

Technical data, solenoid	ED71	ED72
Voltage	12 V (±20 %)	24 V (±20 %)
Control current		
Control begin at $q_{v\,min}$	100 mA	50 mA
End of control at $q_{v\,max}$	1200 mA	600 mA
Limiting current	1.54 A	0.77 A
Nominal resistance (at 68 °F (20 °C))	5.5 Ω	22.7 Ω
Dither frequency	100 to 200 Hz	100 to 200 Hz
Actuated time	100 %	100 %
For protection rating, please refer to "Socket version" on page 55		

Operating temperature range at valve -4 °F to 239 °F (-20 °C to +115 °C)

ER – Electro-hydraulic pressure control

The ER valve is set to a certain pressure by a specified variable solenoid current.

When a change is made at the consumer (load pressure), the position of the control piston will shift.

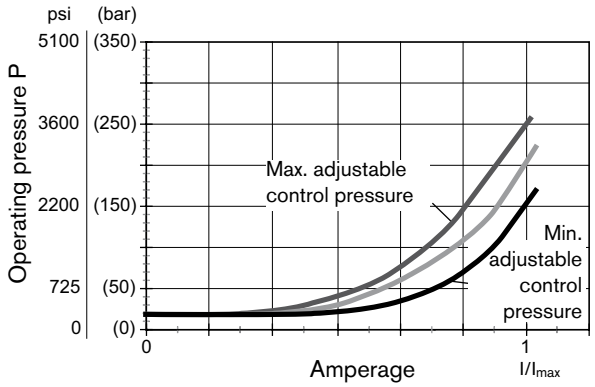
This causes an increase or decrease in the pump swivel angle (flow) in order to maintain the electrically set pressure level.

The pump thus only delivers as much hydraulic fluid as the consumers can take. The desired pressure level can be set steplessly by varying the solenoid current.

As the solenoid current signal drops towards zero, the pressure will be limited to p_{min} (stand by).

Observe the project planning notes on page 2.

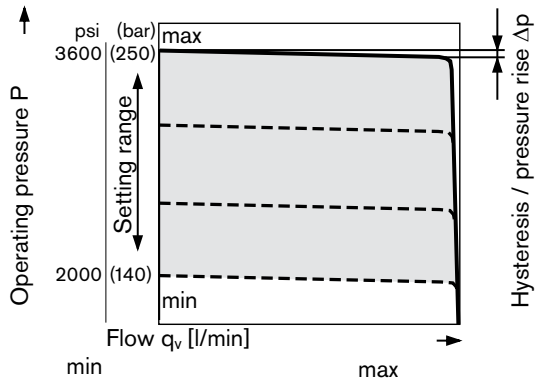
Static current-pressure characteristic ER
(measured with pump in zero stroke – positive characteristic)



Hysteresis static current-pressure characteristic < 45 psi (3 bar)

Influence of pressure setting on stand by ± 30 psi (2 bar)

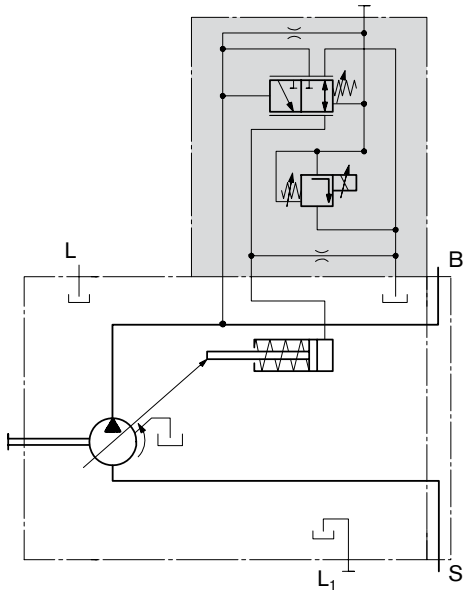
Static flow-pressure characteristic
(at n= 1500 rpm; t_{fluid} = 120 °F (50°C))



Controller data
Standby standard setting 200 psi (14 bar), other values on request.

Hysteresis and pressure rise _____ Δp < 60 psi (4 bar).
Control flow consumption_____ 0.8 to 1.2 gpm (3 to 4.5 l/min).

Circuit diagram ER..



	Port for
B	Service line
S	Suction line
L, L_1	Case drain (L_1 plugged)

Technical data, solenoid	ED71	ED72
Voltage	12 V (±20 %)	24 V (±20 %)
Control current		
Control begin at $q_{v\,min}$	100 mA	50 mA
End of control at $q_{v\,max}$	1200 mA	600 mA
Limiting current	1.54 A	0.77 A
Nominal resistance (at 68 °F (20 °C))	5.5 Ω	22.7 Ω
Dither frequency	100 to 200 Hz	100 to 200 Hz
Actuated time	100 %	100 %
For protection rating, please refer to "Socket version" on page 55		

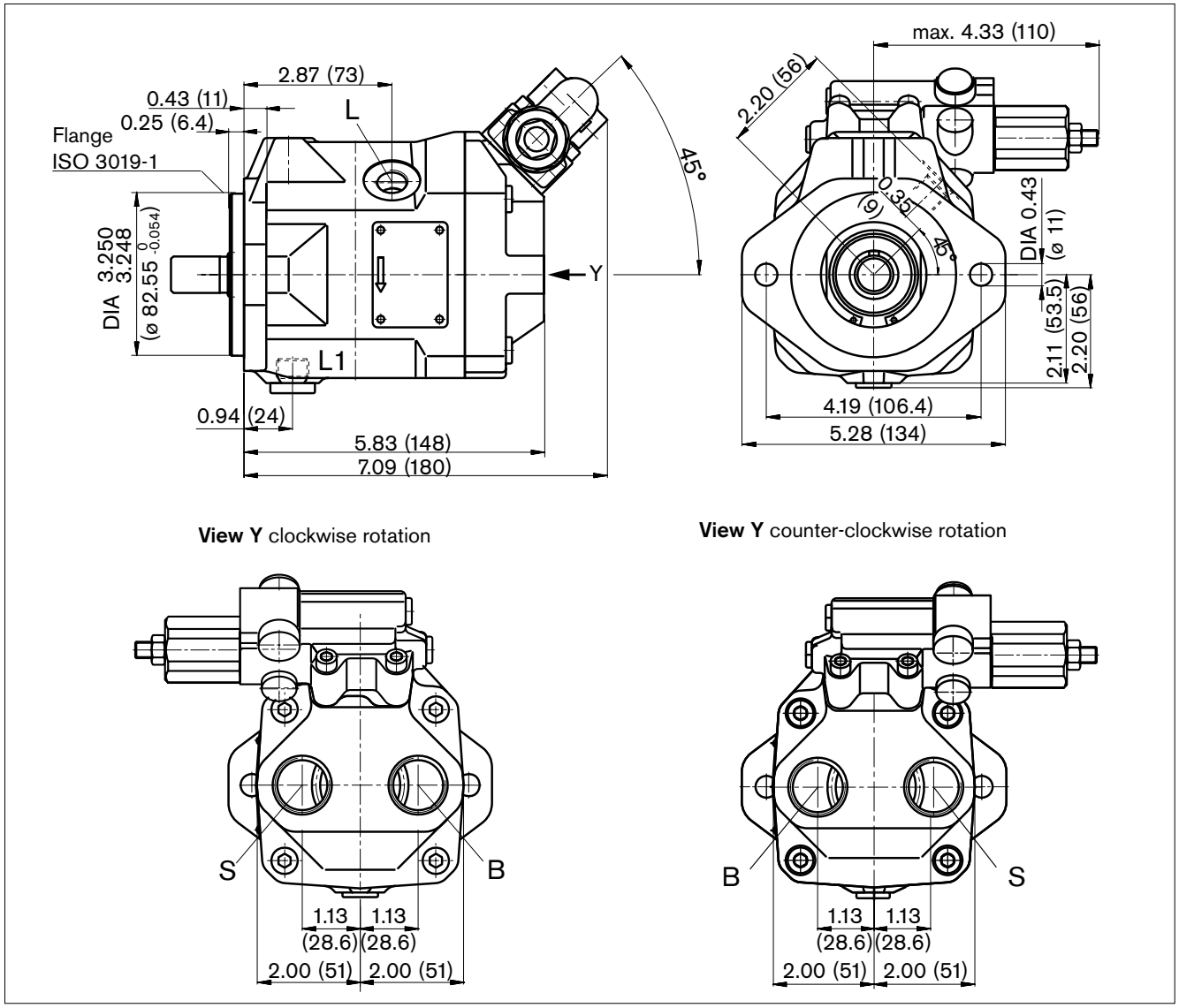
Operating temperature range at valve -4 °F to 239 °F (-20 °C to +115 °C)

Dimensions, size 10

Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

DR – Hydraulic pressure controller

Centering flange **SAE** version; series 52

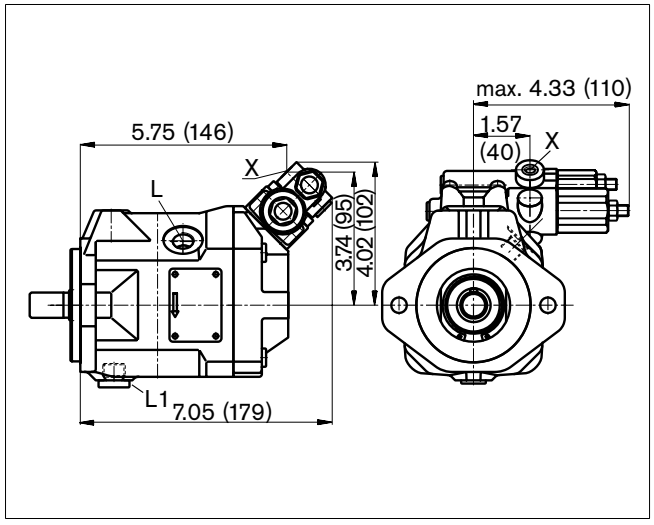


View Y clockwise rotation

View Y counter-clockwise rotation

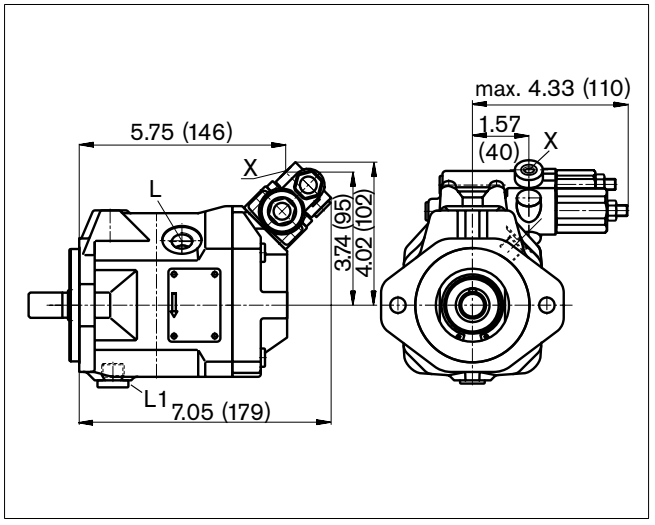
DRG

Pressure and flow control, remote controlled



DFR / DFR1

Pressure and flow control



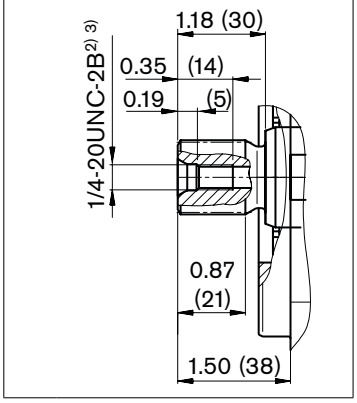
For details of connection options and drive shafts, please refer to page 23

Dimensions, size 10

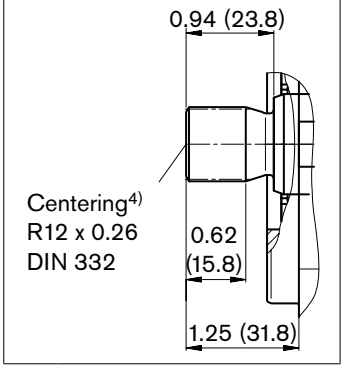
Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

Drive shaft

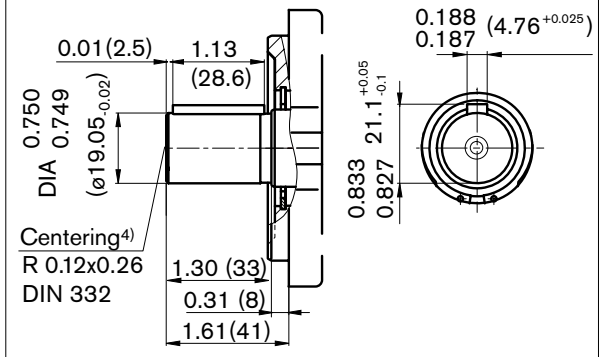
S Splined shaft 3/4 in
11T 16/32DP[1] (SAE J744)



U Splined shaft 5/8 in
9T 16/32DP[1] (SAE J744)



K Parallel shaft key



Ports

Designation	Port for	Standard	Size[3]	Maximum pressure [psi (bar)][5]	State
B	Service line	ISO 11926	1 1/16-12UNF-2B; 0.79 (20) deep	4600 (315)	O
S	Suction line	ISO 11926	1 1/16-12UNF-2B; 0.79 (20) deep	75 (5)	O
L	Case drain fluid	ISO 11926[6]	9/16-18UNF-2B; 0.47 (12) deep	30 (2)	O[7]
L_1	Case drain fluid	ISO 11926[6]	9/16-18UNF-2B; 0.47 (12) deep	30 (2)	X[7]
X	Pilot pressure	ISO 11926[5]	7/16-20UNF-2B; 0.45 (11.5) deep	4600 (315)	O

1) ANSI B92.1a, 30° pressure angle, flat root, side fit, tolerance class 5
2) Thread according to ASME B1.1
3) For the maximum tightening torques the general instructions on page 60 must be observed.
4) Coupling axially secured, e.g. with a clamp coupling or radially mounted clamping screw
5) Depending on the application, momentary pressure spikes can occur. Consider this when selecting measuring equipment and fittings.
6) The spot face can be deeper than as specified in the standard.
7) Depending on the installation position, L or L_1 must be connected (please refer to pages 56 and 57)

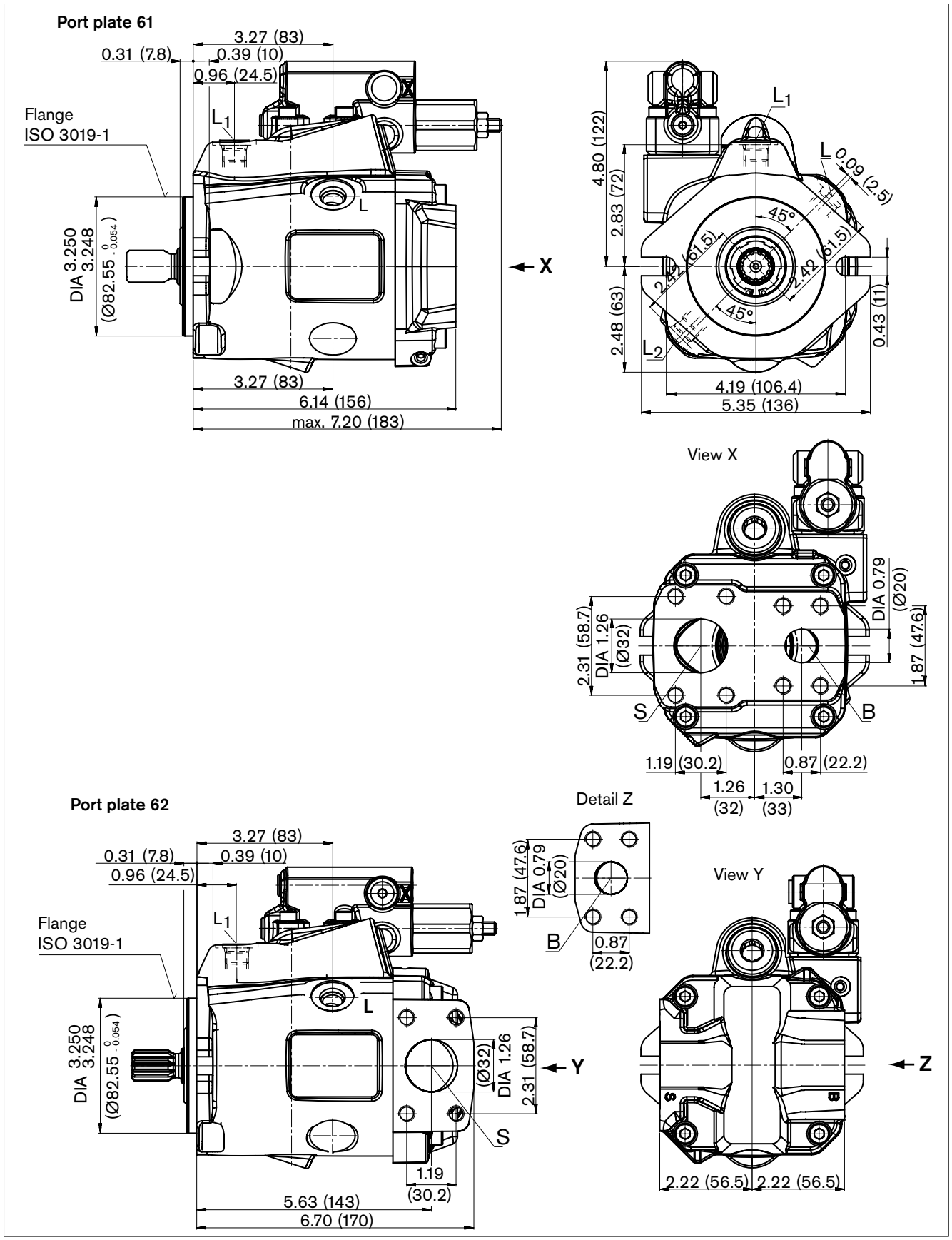
O = Must be connected (plugged on delivery)
X = Plugged (in normal operation)

Dimensions, size 18[1)]

Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

DR – Hydraulic pressure controller

Clockwise rotation, series 53



1) Dimensions of service line ports turned through 180° for counter-clockwise rotation

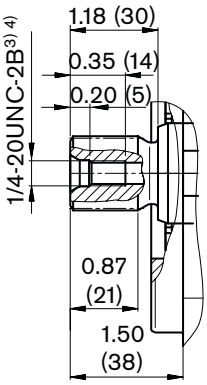
For details of connection options and drive shafts, please refer to page 25

Dimensions, size 18

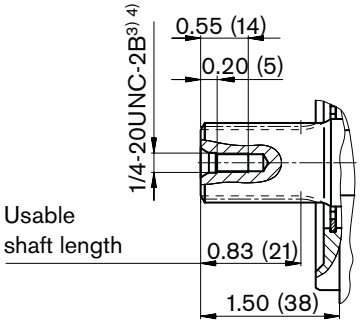
Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

Drive shaft

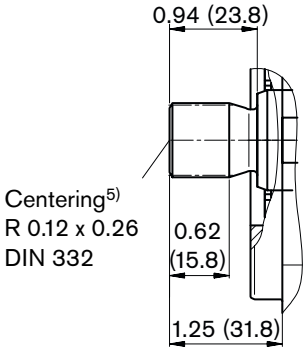
S Splined shaft 3/4 in
11T 16/32DP[1] (SAE J744)



R Splined shaft 3/4 in
11T 16/32DP[1)2)] (SAE J744)



U Splined shaft 5/8 in
9T 16/32DP[1] (SAE J744)



Ports

Designation	Port for	Standard	Size[4)]	Maximum pressure [psi (bar)][6)]	State
B	Service line, fixing thread	SAE J518 ASME B1.1	3/4 in 3/8-16UNC-2B; 0.75 (19) deep	4600 (315)	O
S	Suction line, fixing thread	SAE J518 ASME B1.1	1 1/4 in 7/16-14UNC-2B; 0.79 (20) deep	75 (5)	O
L	Case drain fluid	ISO 11926[7)]	3/4-16UNF-2B; 0.47 (12) deep	30 (2)	O[8)]
L_1, L_2	Case drain fluid	ISO 11926[7)]	3/4-16UNF-2B; 0.47 (12) deep	30 (2)	X[8)]
X	Pilot pressure	ISO 11926[7)]	7/16-20UNF-2A; 0.45 (11.5) deep	4600 (315)	O

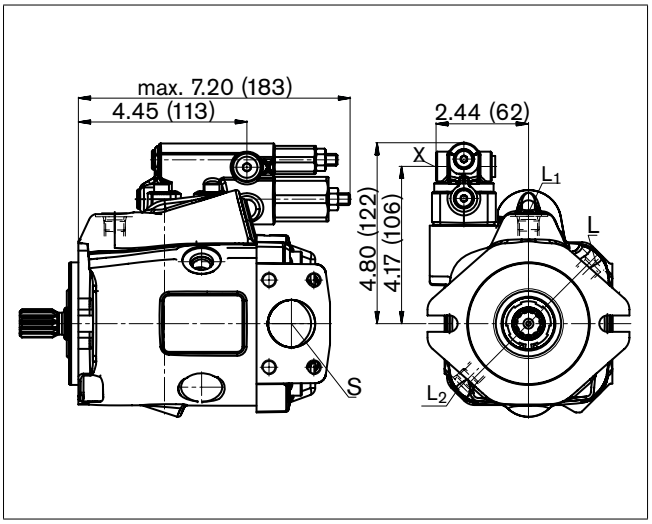
1) ANSI B92.1a, 30° pressure angle, flat root, side fit, tolerance class 5
2) Splines according to ANSI B92.1a, run out of spline is a deviation from standard
3) Thread according to ASME B1.1
4) For the maximum tightening torques the general instructions on page 60 must be observed
5) Coupling axially secured, e.g. with a clamp coupling or radially mounted clamping screw
6) Depending on the application, momentary pressure spikes can occur. Keep this in mind when selecting measuring equipment and fittings
7) The spot face can be deeper than as specified in the standard
8) Depending on the installation position, L, L_1 or L_2 must be connected (please refer to installation instructions on pages 56, 57)

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

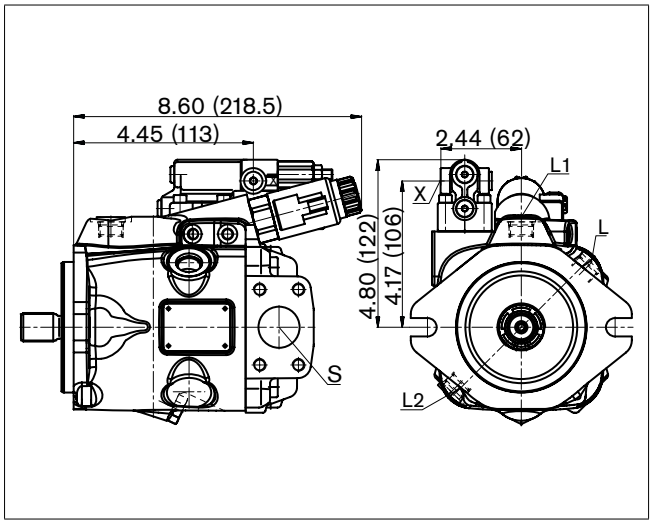
Dimensions, size 18

Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

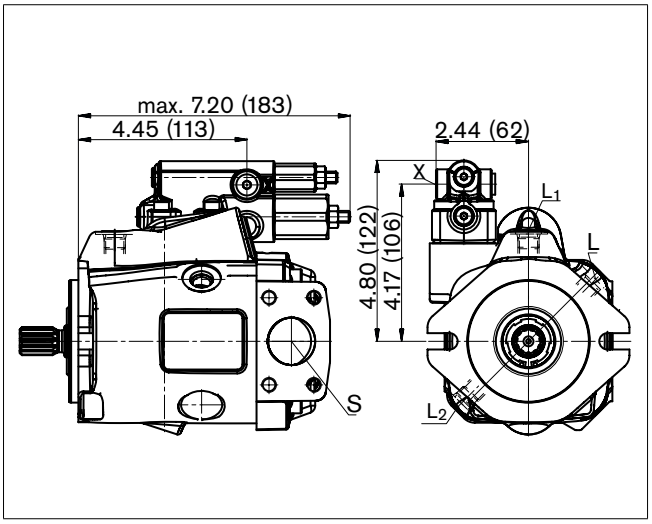
DRG
Pressure controller, remote controlled, **series 53**



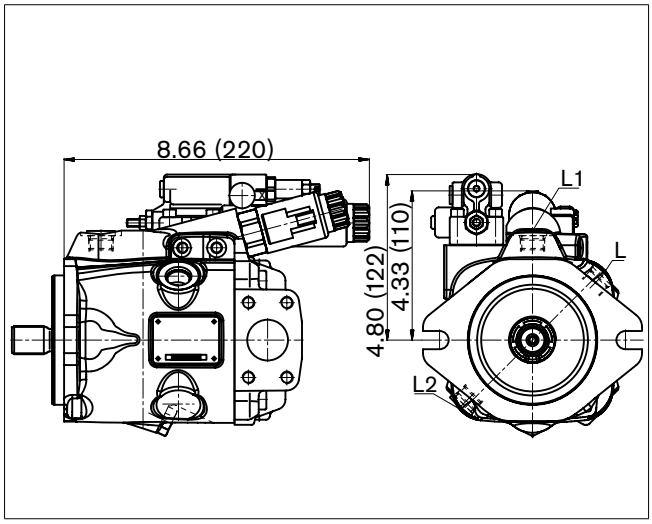
EP.D. / EK.D.
Electro-proportional control, **series 53**



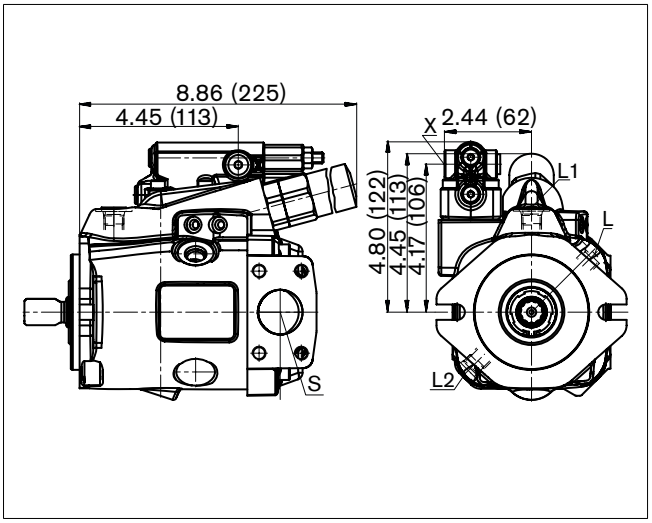
DRF/DRS
Pressure and flow control, **series 53**



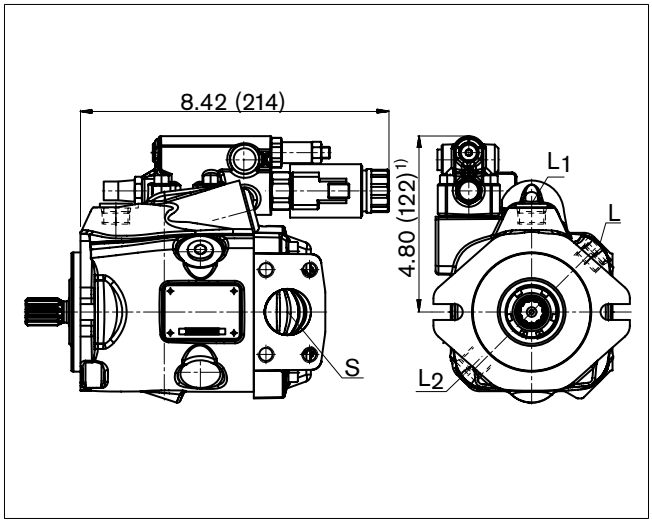
EP.ED / EK.ED
Electro-proportional control, **series 53**



LA.D.
Pressure, flow and power control, **series 53**



ED7. / ER7.
Electro-hydraulic pressure control, **series 53**



1) ER7.: 6.18 inches (157 mm) if using an intermediate plate pressure controller.

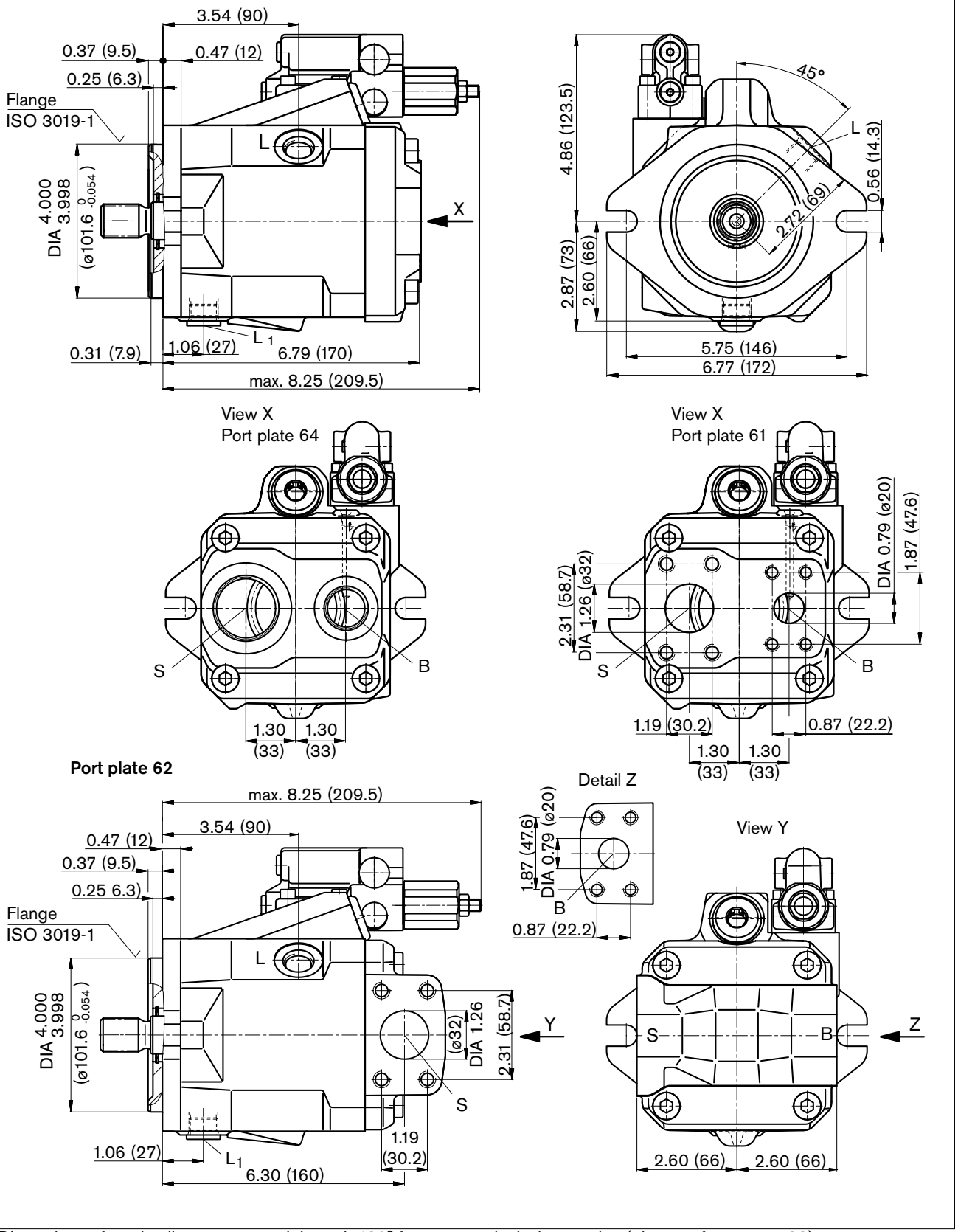
Dimensions, size 28[1)2)]

Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

DR – Hydraulic pressure controller

Clockwise rotation, **series 52**

Port plate 61/64



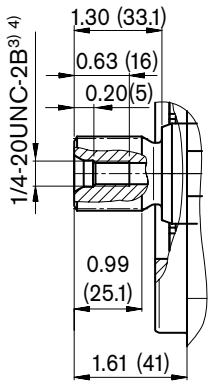
1) Dimensions of service line ports turned through 180° for counter-clockwise rotation (please refer to page 28)
2) Primary dimensions for pump apply for series 52 and 53

Dimensions, size 28

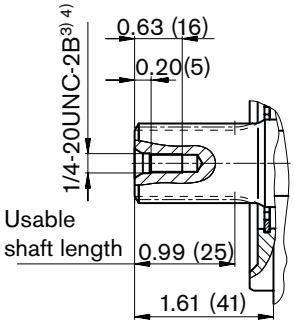
Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

Drive shaft

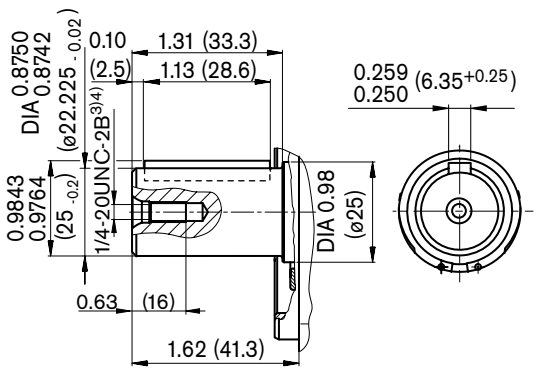
S Splined shaft 7/8 in 13T 16/32DP[1] (SAE J744)



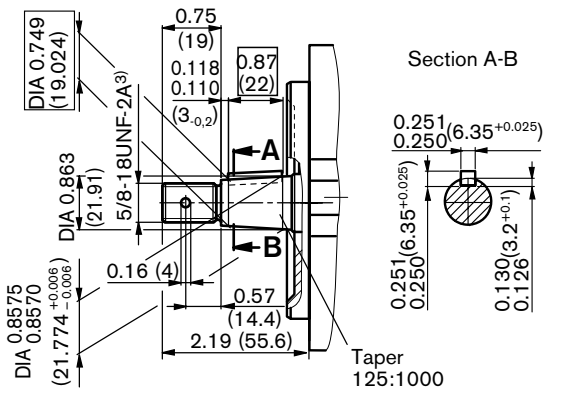
R Splined shaft 7/8 in 13T 16/32DP[1)2)] (SAE J744)



K[5)] Parallel keyed shaft



C[5)] Tapered with woodruff key (ISO 3019-1)



Ports

Designation	Port for	Standard	Size[4)]	Maximum pressure [psi (bar)][6)]	State
B; Port plate 61/62	Service line, fixing thread	SAE J518 ASME B1.1	3/4 in 3/8-16UNC-2B; 075 (19) deep	4600 (315)	O
B; Port plate 64	threaded	ISO 11926[7)]	1 1/16-12UNF-2B; 079 (20) deep	4600 (315)	O
S; Port plate 61/62	Suction line, fixing thread	SAE J518 ASME B1.1	1 1/4 in 7/16-14UNC-2B; 0.79 (20) deep	75 (5)	O
S; Port plate 64	threaded	ISO 11926[7)]	1 5/8-12UN-2B; 0.79 (20) deep	75 (5)	O
L	Case drain fluid	ISO 11926[7)]	3/4-16UNF-2B; 0.47 (12) deep	30 (2)	O[9)]
L_1, L_2[8)]	Case drain fluid	ISO 11926[7)]	3/4-16UNF-2B; 0.47 (12) deep	30 (2)	X[9)]
X	Control pressure	ISO 11926[7)]	7/16-20UNF-2B; 0.45 (11.5) deep	4600 (315)	O

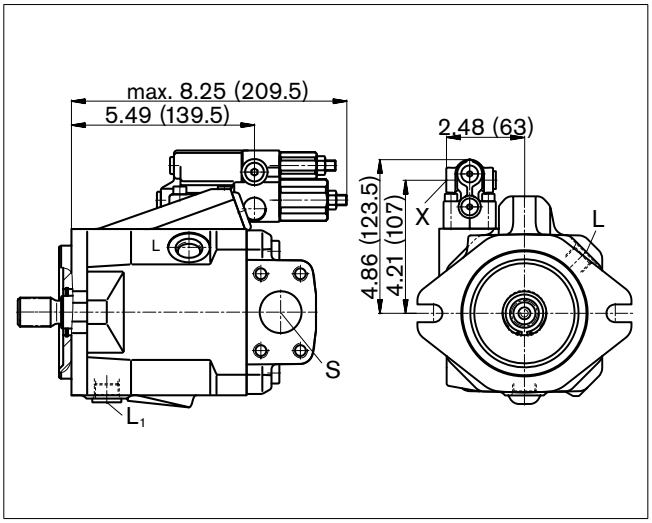
1) ANSI B92.1a, 30° pressure angle, flat root, side fit, tolerance class 5
2) Splines according to ANSI B92.1a, run out of spline is a deviation from standard.
3) Thread according to ASME B1.1
4) For the maximum tightening torques the general instructions on page 60 must be observed.
5) Only series 52
6) Depending on the appl., momentary press. spikes can occur. Consider this when selecting measuring equipment and fittings.
7) The spot face can be deeper than as specified in the standard.
8) Only series 53
9) Depending on the installation position, L, L_1 or L_2 must be connected (please refer to installation instructions on pages 56, 57)
O = Must be connected (plugged on delivery)
X = Plugged (in normal operation)

Dimensions, size 28

Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

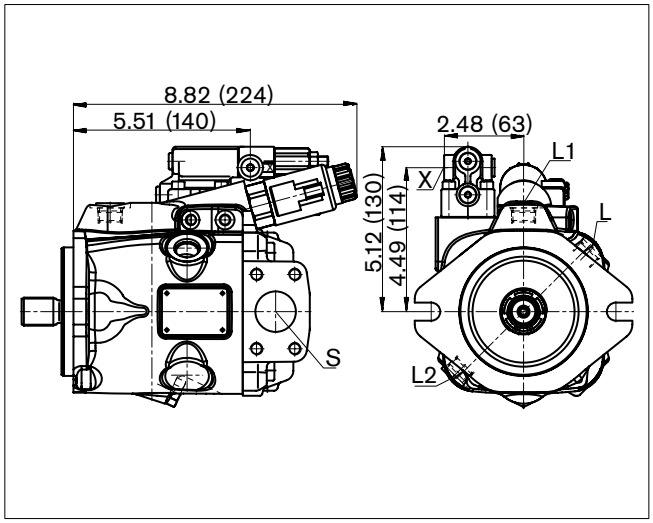
DRG

Pressure controller, remote controlled, **series 52**



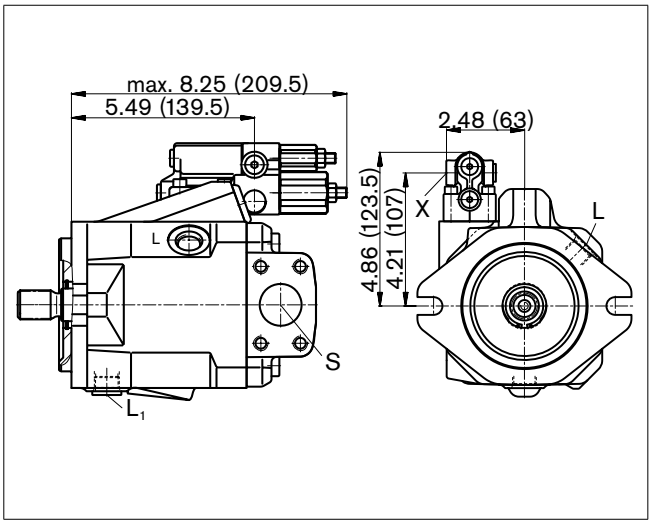
EP.D. / EK.D.

Electro-proportional control, **series 53**



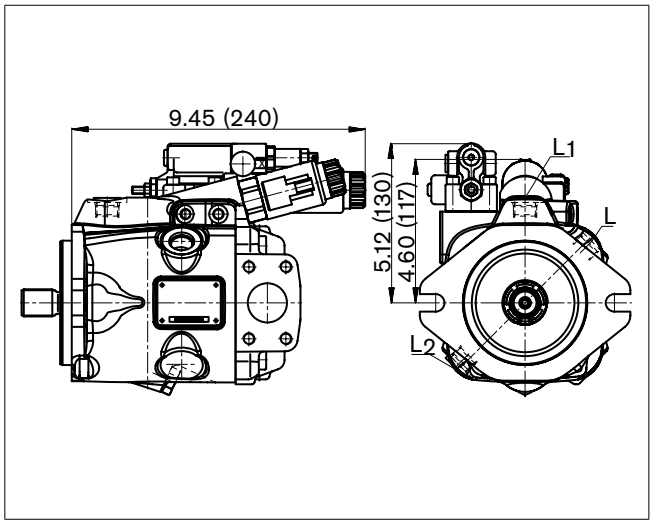
DFR / DFR1

Pressure and flow control, **series 52**



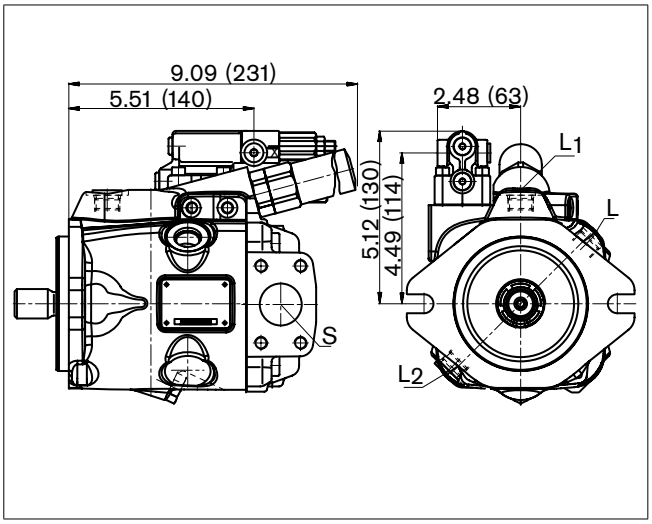
EP.ED / EK.ED

Electro-proportional control, **series 53**



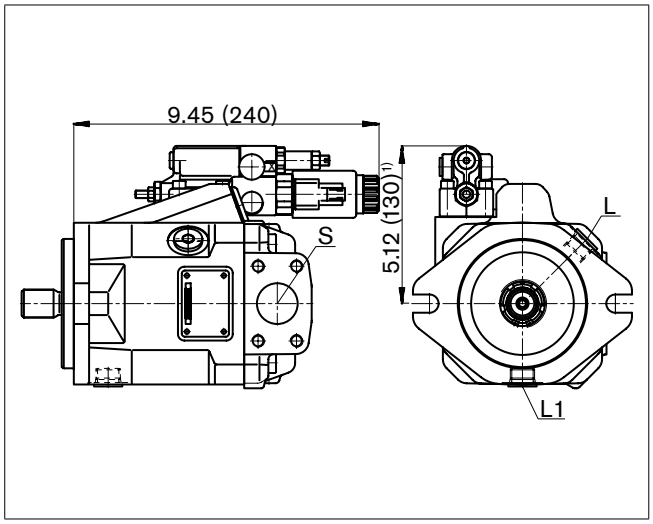
LA.D.

Pressure, flow and power control, **series 53**



ED7. / ER7.

Electro-hydraulic pressure control, **series 52**



1) ER7.: 6.26 inches (159 mm) if using an intermediate plate pressure controller.

For details of connection options and drive shafts, please refer to page 28

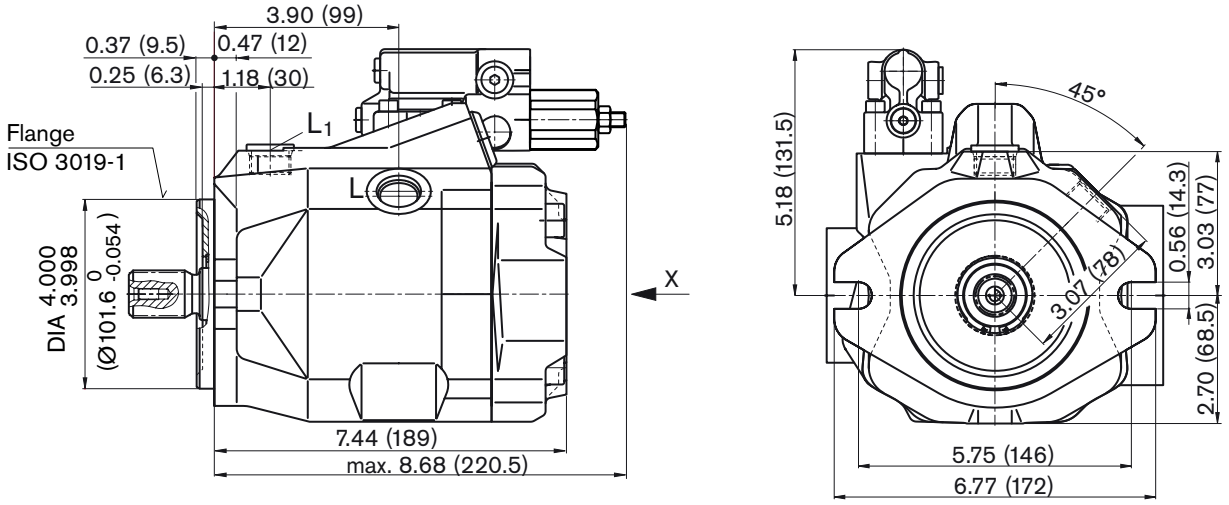
Dimensions, size 45[1)]

Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

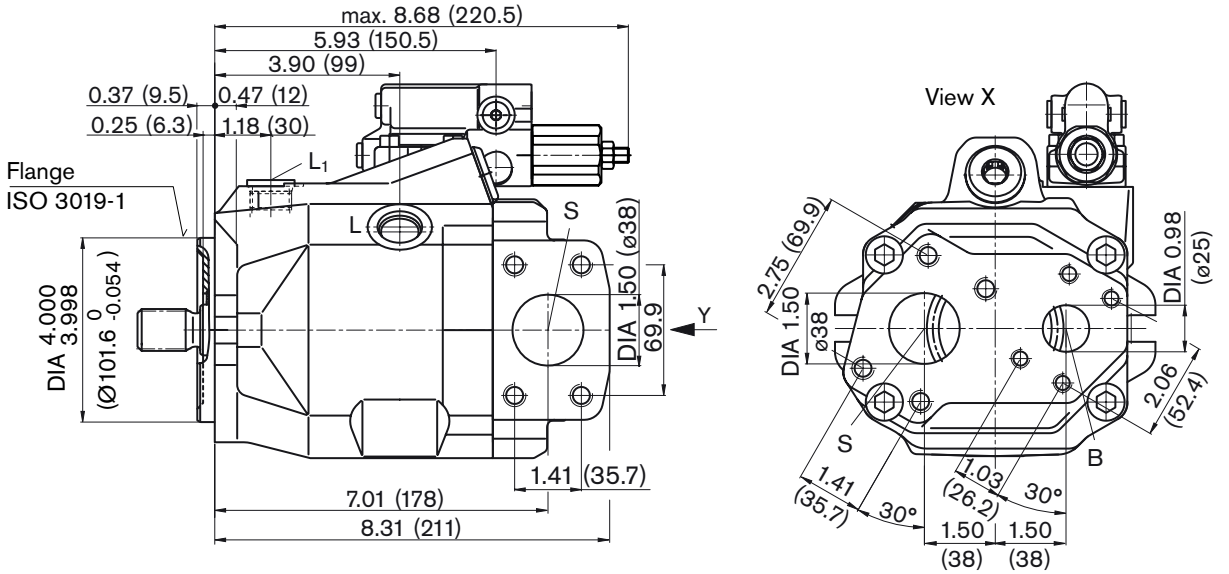
DR – Hydraulic pressure controller

Clockwise rotation, **series 52**

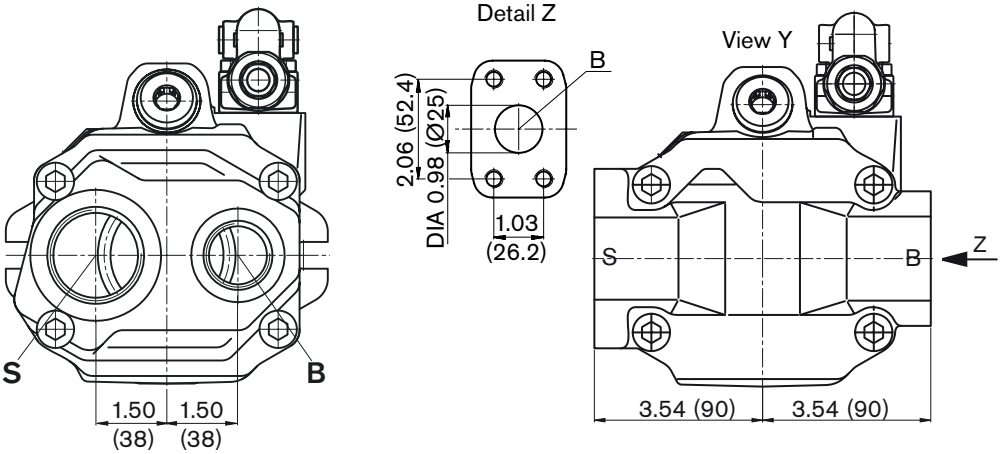
Port plate 61



Port plate 62



Port plate 64



Dimensions of service line ports turned through 180° for counter-clockwise rotation

1) Primary dimensions for pump apply for series 52 and 53

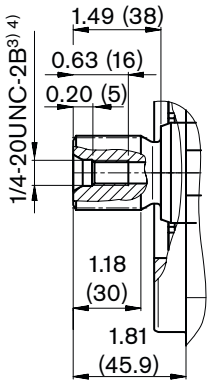
For details of connection options and drive shafts, please refer to page 31, 32

Dimensions, size 45

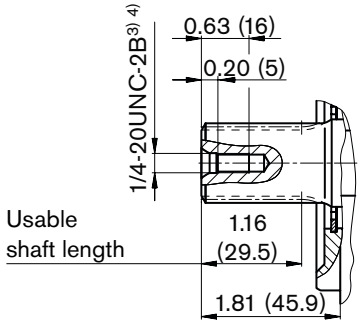
Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

Drive shaft

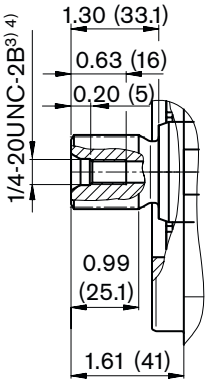
S Splined shaft 1 in
15T 16/32DP[1] (SAE J744)



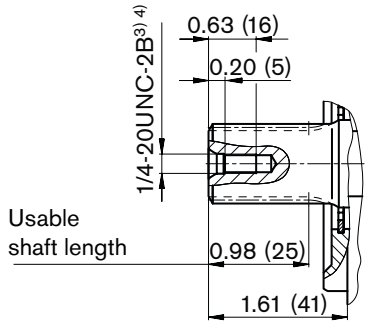
R Splined shaft 1 in
15T 16/32DP[1][2] (SAE J744)



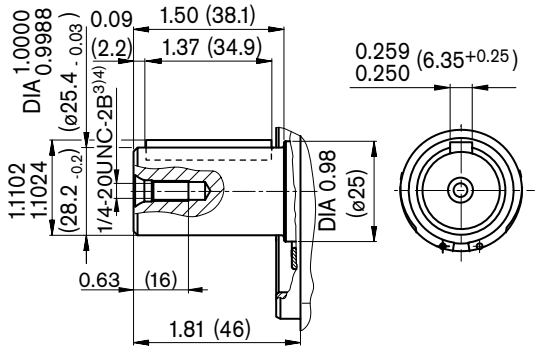
U Splined shaft 7/8 in
13T 16/32DP[1] (SAE J744)



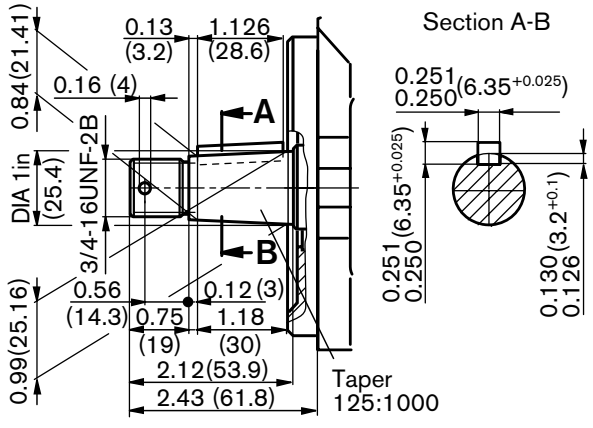
W Splined shaft 7/8 in
13T 16/32DP[1][2] (SAE J744)



K[5] Parallel keyed shaft



C[5] Tapered with woodruff key
(ISO 3019-1)



1) ANSI B92.1a, 30° pressure angle, flat root, side fit, tolerance class 5
2) Splines according to ANSI B92.1a, run out of spline is a deviation from standard.
3) Thread according to ASME B1.1
4) For the maximum tightening torques the general instructions on page 60 must be observed.
5) Only series 52

Dimensions, size 45

Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

Ports

Designation	Port for	Standard	Size[1]	Maximum pressure [psi (bar)][2]	State
B Port plate 61/62	Service line, fixing thread	SAE J518 ASME B1.1	1 in 3/8-16UNC-2B; 0.71 (18) deep	4600 (315)	O
B; Port plate 64	Fixing thread	ISO 11926	1 5/16-12UN-2B; 0.79 (20) deep	4600 (315)	O
S	Suction line, fixing thread	SAE J518 ASME B1.1	1 1/2 in 1/2-13UNC-2B; 0.87 (22) deep	75 (5)	O
S; Port plate 64	Fixing thread	ISO 11926	1 7/8-12UN-2B; 0.79 (20) deep	75 (5)	O
L	Case drain fluid	ISO 11926[3]	7/8-14UNF-2B; 13 deep	30 (2)	O[5]
L_1, L_2[4]	Case drain fluid	ISO 11926[3]	7/8-14UNF-2B; 13 deep	30 (2)	X[5]
X	Control pressure	ISO 11926[3]	7/16-20UNF-2A; 11.5 deep	4600 (315)	O

1) For the maximum tightening torques the general instructions on page 60 must be observed.
2) Depending on the application, momentary pressure spikes can occur. Consider this when selecting measuring equipment and fittings.
3) The spot face can be deeper than as specified in the standard.
4) Only for series 53
5) Depending on the installation position, L, L_1 or L_2 must be connected (please refer to installation instructions on pages 56, 57)

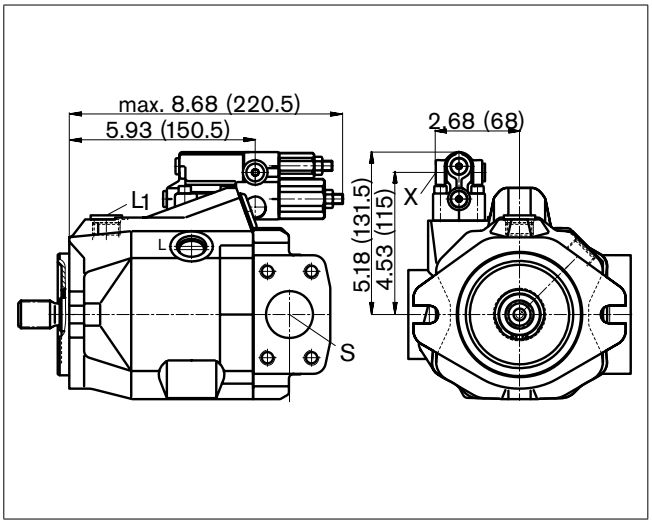
O = Must be connected (plugged on delivery)
X = Plugged (in normal operation)

Dimensions, size 45

Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

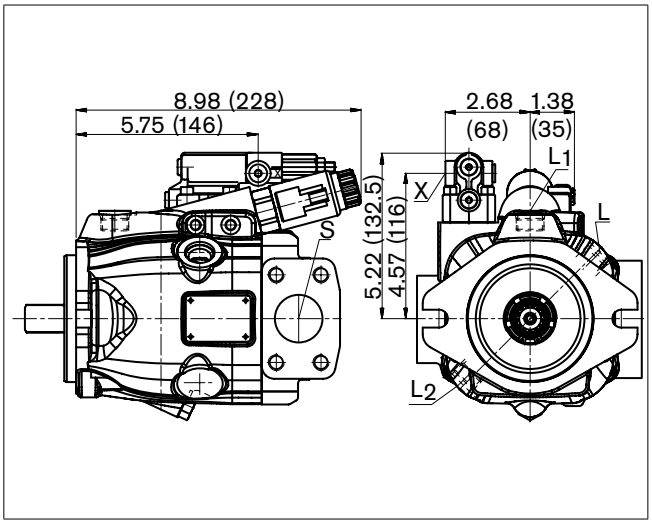
DRG

Pressure controller, remote controlled, **series 52**



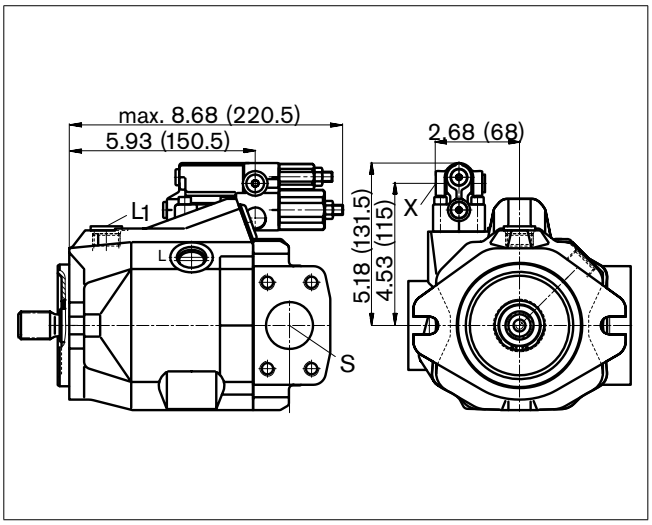
EP.D. / EK.D.

Electro-proportional control, **series 53**



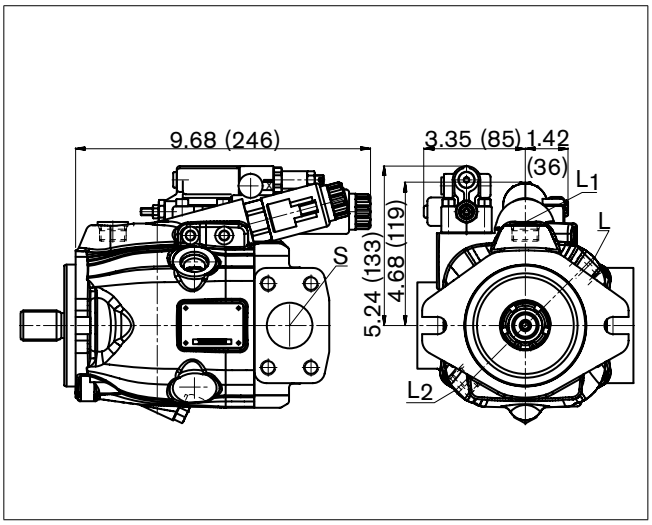
DFR / DFR1

Pressure and flow control, **series 52**



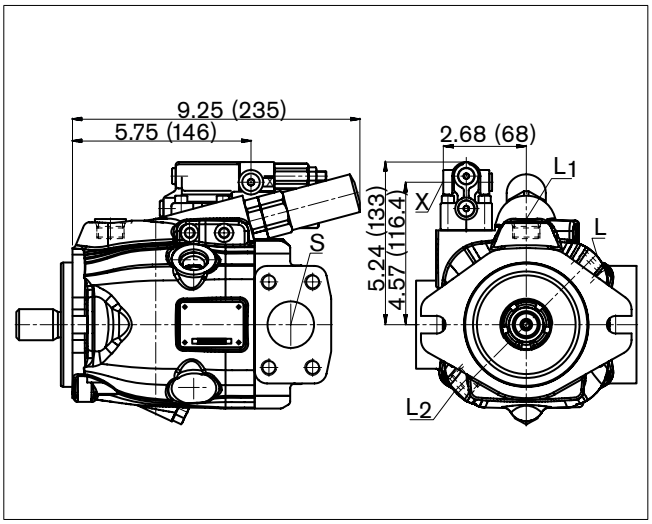
EP.ED / EK.ED

Electro-proportional control, **series 53**



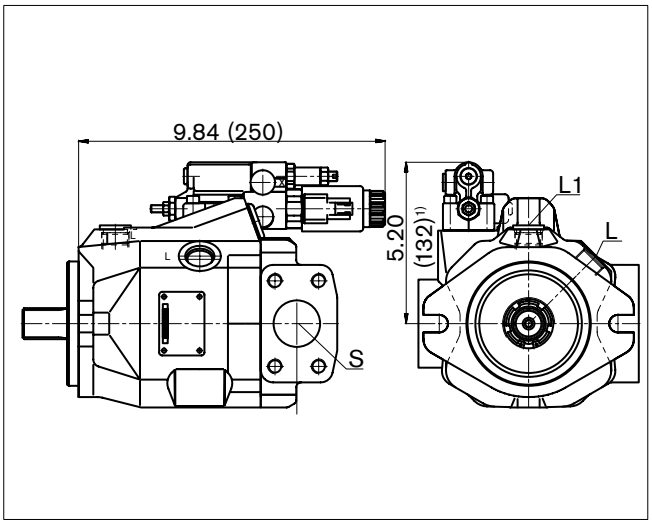
LA.D.

Pressure, flow and power control, **series 53**



ED7. / ER7.

Electro-hydraulic pressure control, **series 52**



1) ER7.: 6.57 inches (167 mm) if using an intermediate plate pressure controller.

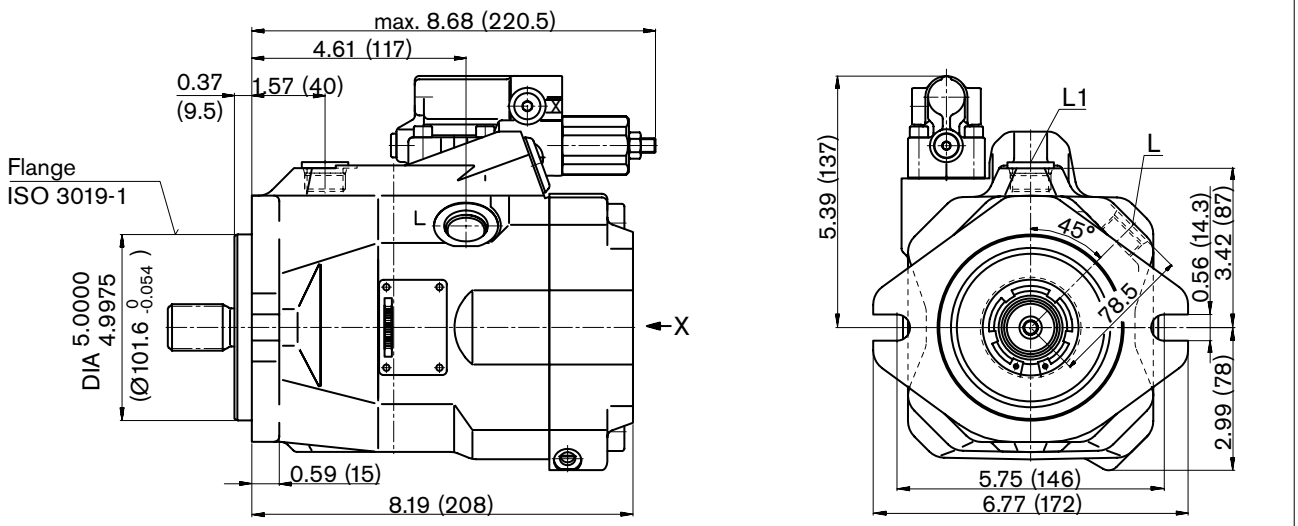
Dimensions, size 60

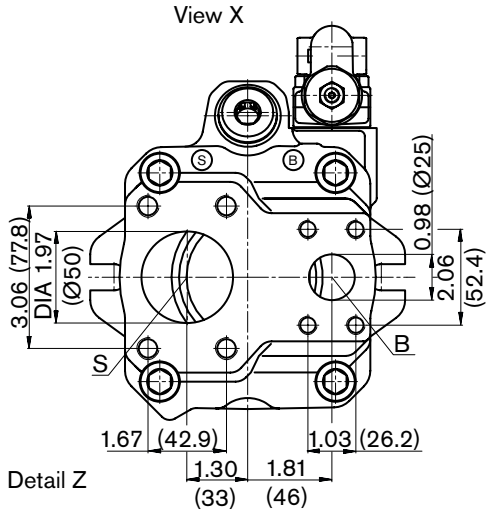
Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

DR – Hydraulic pressure controller

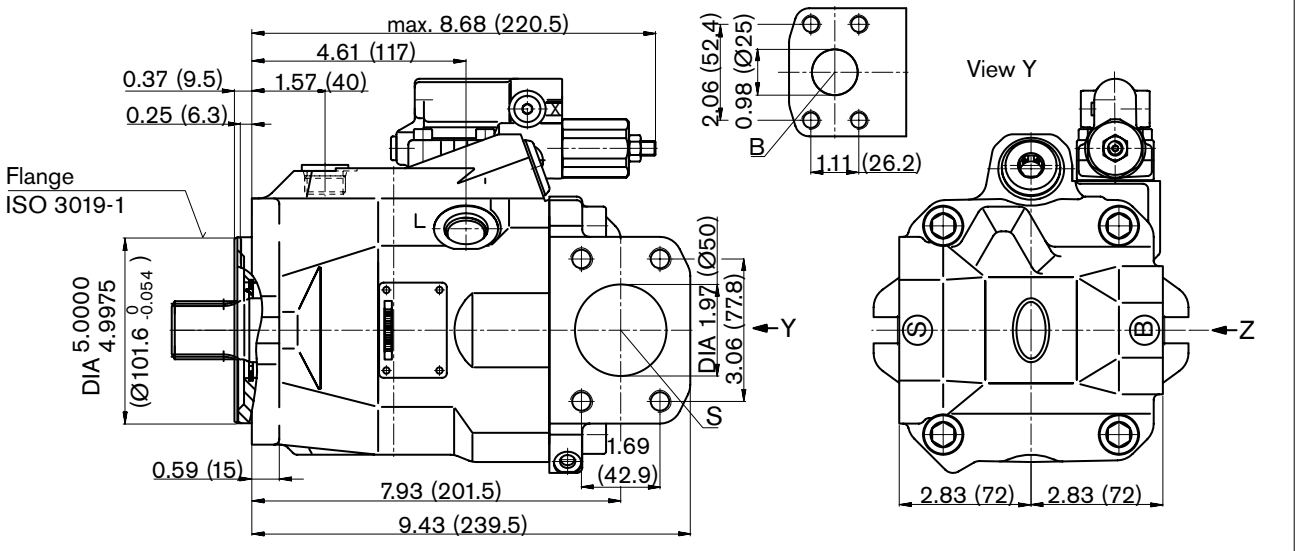
Mounting flange C, clockwise rotation, **series 52**

Port plate 61





Port plate 62



1) Dimensions of service line ports turned through 180° for counter-clockwise rotation

For details of connection options and drive shafts, please refer to page 38, 39

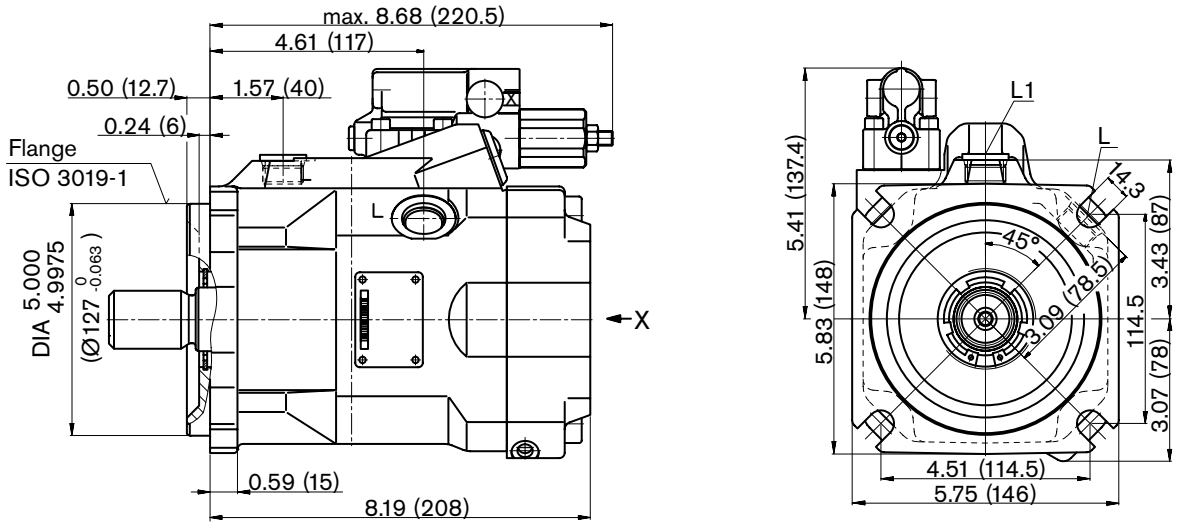
Dimensions, size 60

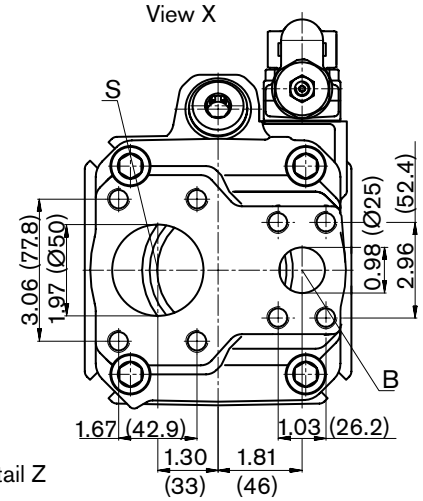
Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

DR – Hydraulic pressure controller

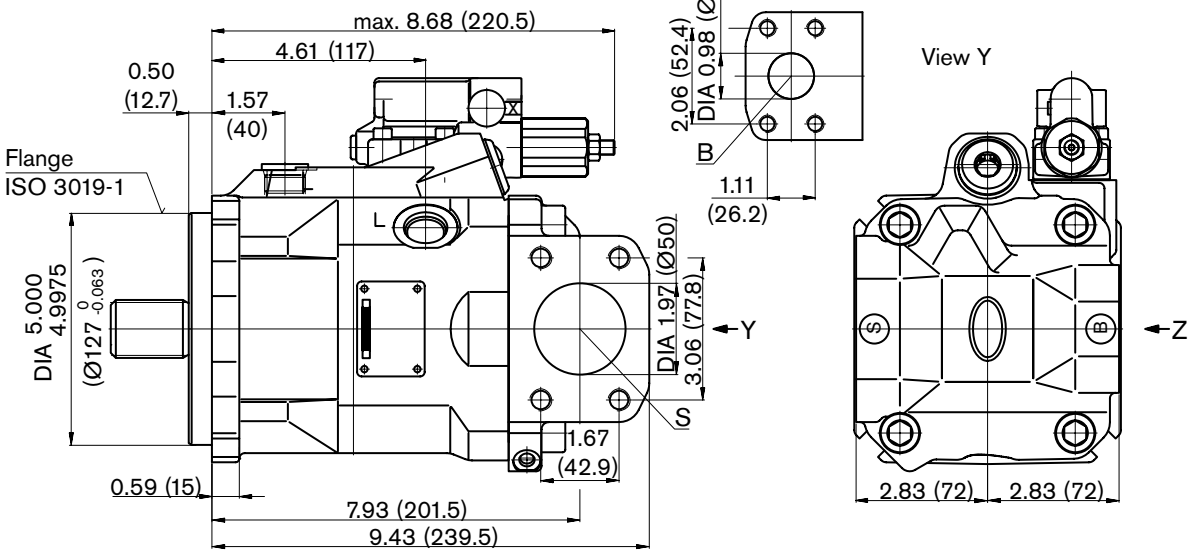
Mounting flange D, clockwise rotation, **series 52**

Port plate 61





Port plate 62



1) Dimensions of service line ports turned through 180° for counter-clockwise rotation

For details of connection options and drive shafts, please refer to page 38, 39

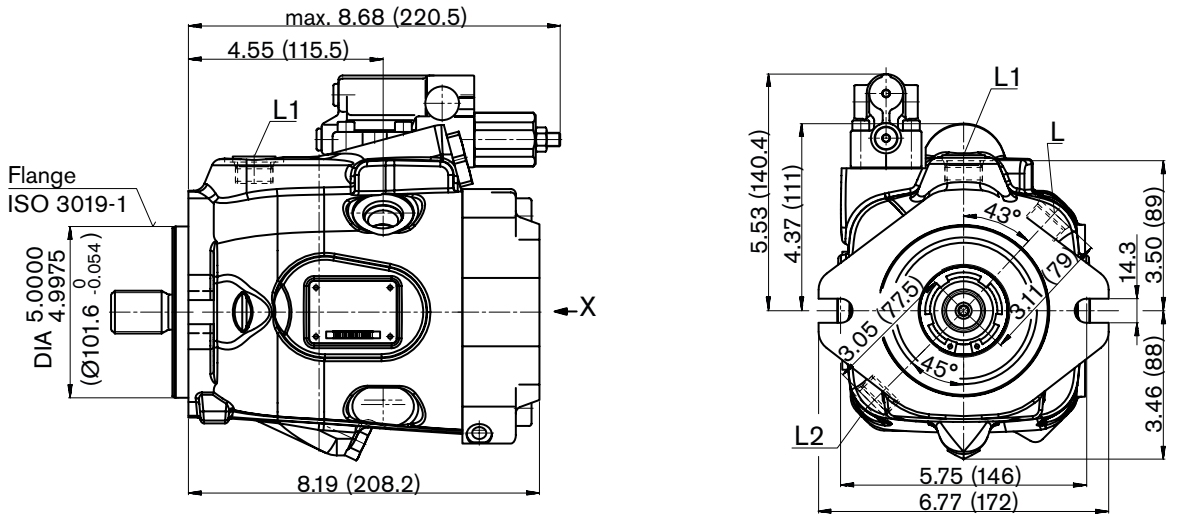
Dimensions, size 63[1)]

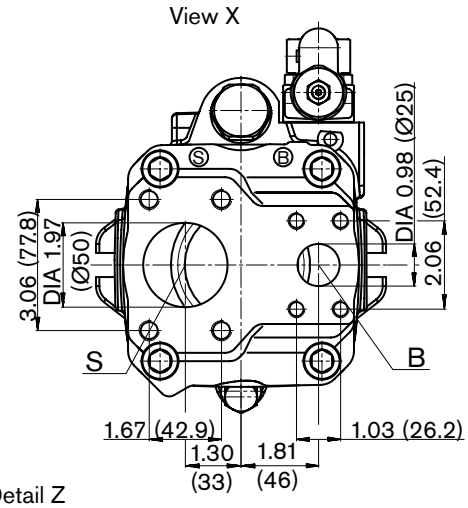
Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

DR – Hydraulic pressure controller

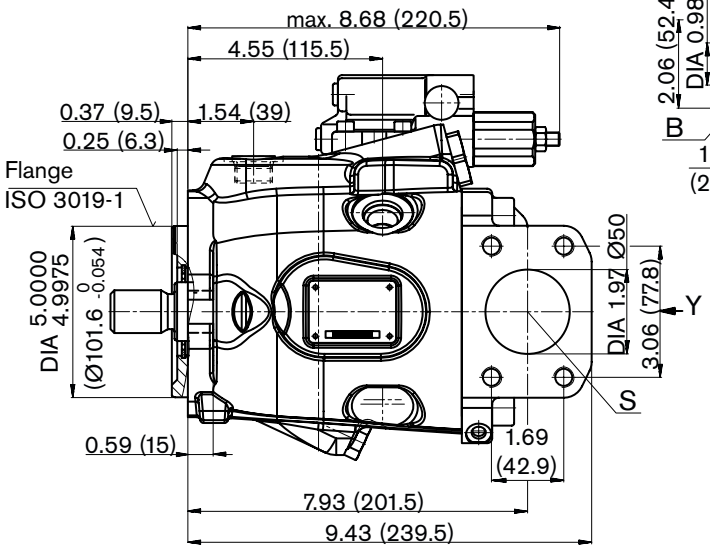
Mounting flange C, clockwise rotation, **series 53**

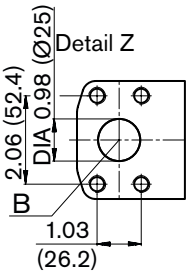
Port plate 61

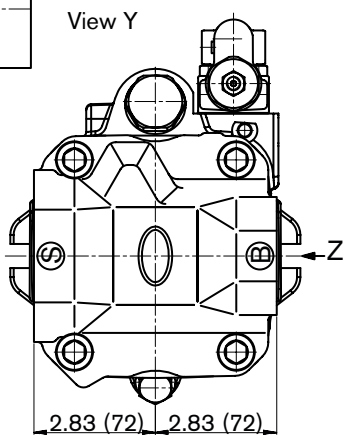




Port plate 62







1) Dimensions of service line ports turned through 180° for counter-clockwise rotation

For details of connection options and drive shafts, please refer to page 38, 39

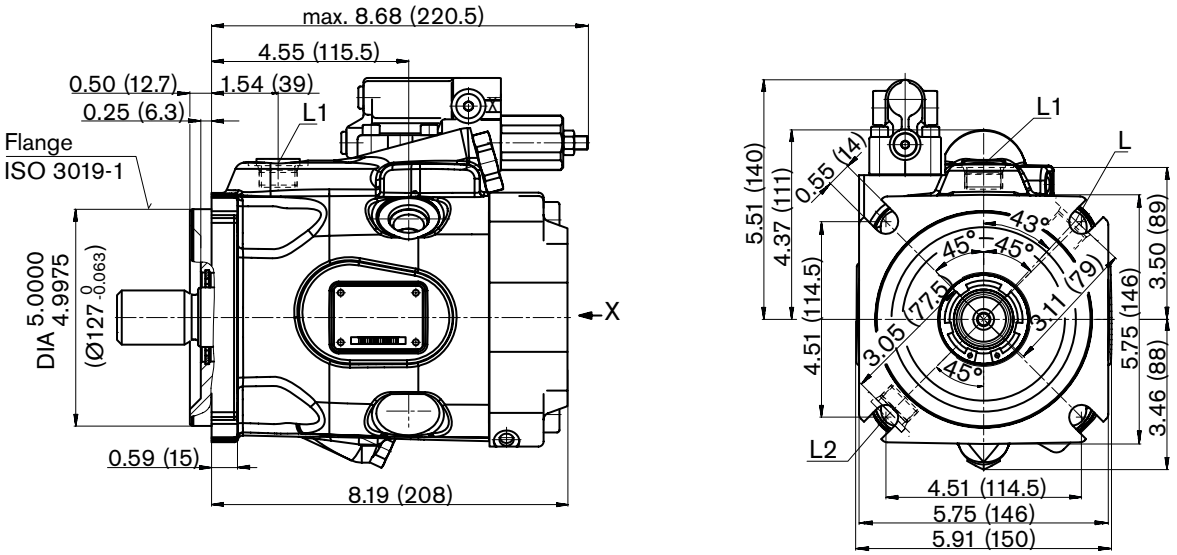
Dimensions, size 63[1)]

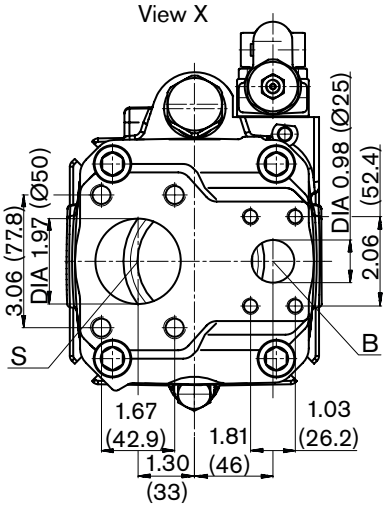
Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

DR – Hydraulic pressure controller

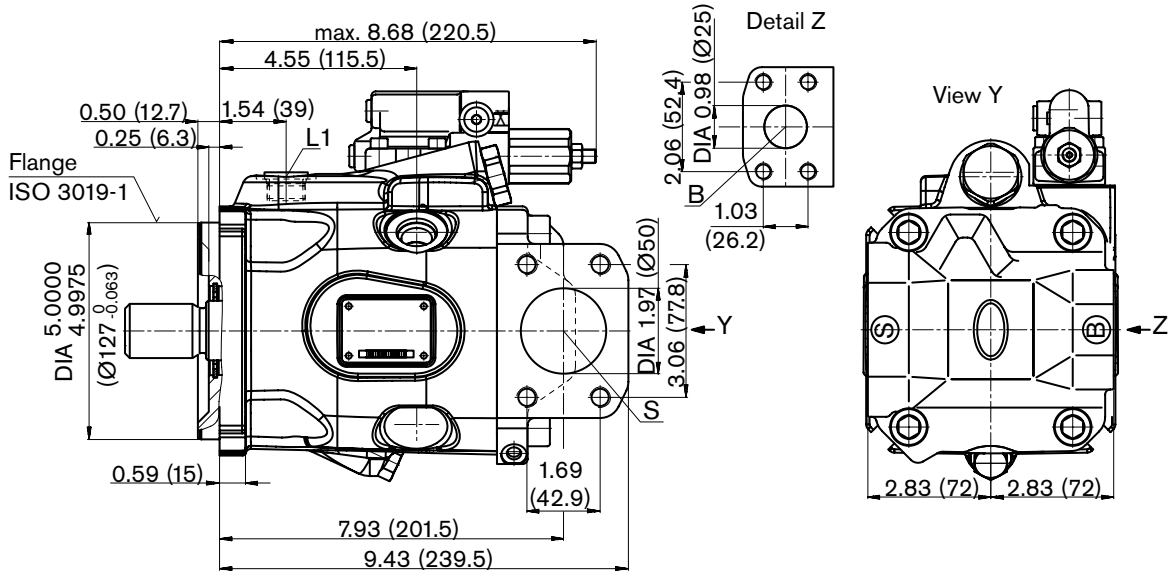
Mounting flange D, clockwise rotation, **series 53**

Port plate 61





Port plate 62



1) Dimensions of service line ports turned through 180° for counter-clockwise rotation

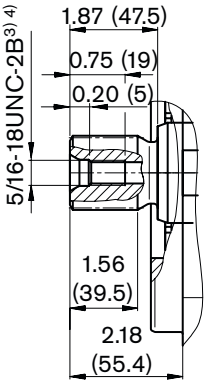
For details of connection options and drive shafts, please refer to page 38, 39

Dimensions, size 60 / 63

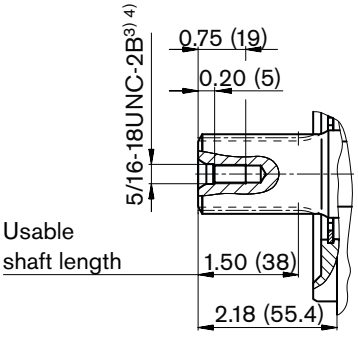
Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

Drive shaft

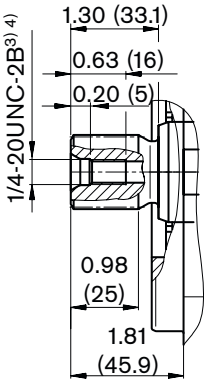
S Splined shaft 1 1/4 in
14T 12/24DP[1] (SAE J744)



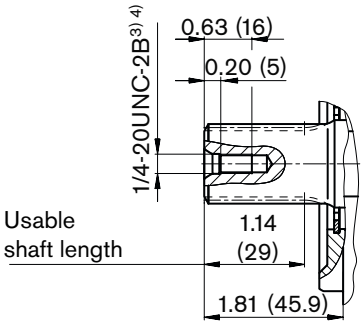
R Splined shaft 1 1/4 in
14T 12/24DP[1][2] (SAE J744)



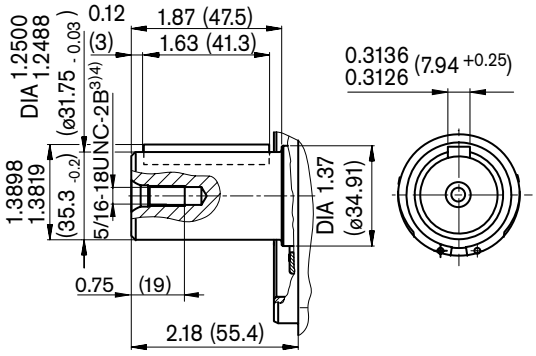
U Splined shaft 1 in
15T 16/32DP[1] (SAE J744)



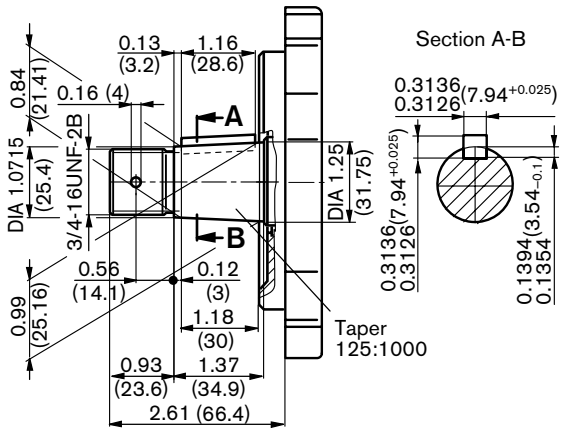
W Splined shaft 1 in
15 T 16/32DP[1][2] (SAE J744)



K[5] Parallel keyed shaft



C[5] Tapered with woodruff key
(ISO 3019-1)



1) ANSI B92.1a, 30° pressure angle, flat root, side fit, tolerance class 5
2) Splines according to ANSI B92.1a, run out of spline is a deviation from standard.
3) Thread according to ASME B1.1
4) For the maximum tightening torques the general instructions on page 60 must be observed.
5) Only series 52

Dimensions, size 60 / 63

Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

Ports

Designation	Port for	Standard	Size[1)]	Maximum pressure [psi (bar)][2)]	State
B	Service line, fixing thread	SAE J518 ASME B1.1	1 in 3/8-16UNC-2B; 0.71 (18) deep	4600 (315)	O
S	Suction line, fixing thread	SAE J518 ASME B1.1	2 in 1/2-13UNC-2B; 0.87 (22) deep	75 (5)	O
L	Case drain fluid	ISO 11926[3)]	7/8-14UNF-2B; 0.51 (13) deep	30 (2)	O[5)]
L_1, L_2[4)]	Case drain fluid	ISO 11926[3)]	7/8-14UNF-2B; 0.51 (13) deep	30 (2)	X[5)]
X	Control pressure	ISO 11926[3)]	7/16-20UNF-2A; 0.45 (11.5) deep	4600 (315)	O

1) For the maximum tightening torques the general instructions on page 60 must be observed.
2) Depending on the application, momentary pressure spikes can occur. Consider this when selecting measuring equipment and fittings.
3) The spot face can be deeper than as specified in the standard.
4) Only for series 53
5) Depending on the installation position, L, L_1 or L_2 must be connected (please refer to installation instructions on pages 56, 57)

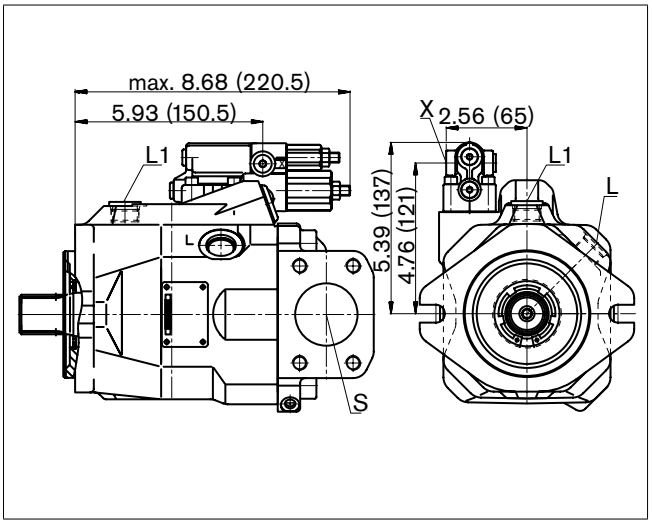
O = Must be connected (plugged on delivery)
X = Plugged (in normal operation)

Dimensions, size 60 / 63

Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

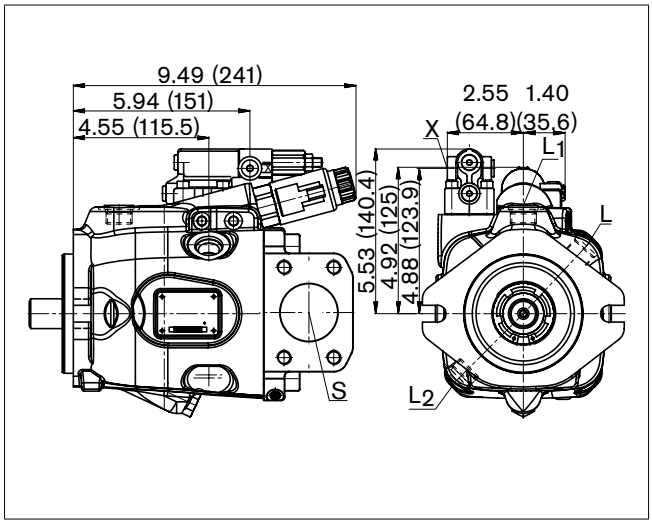
DRG

Pressure controller, remote controlled, **series 52**



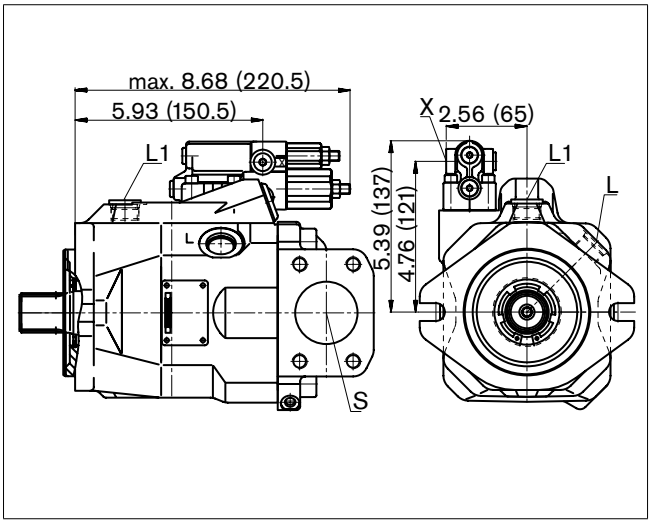
EP.D. / EK.D.

Electro-proportional control, **series 53**



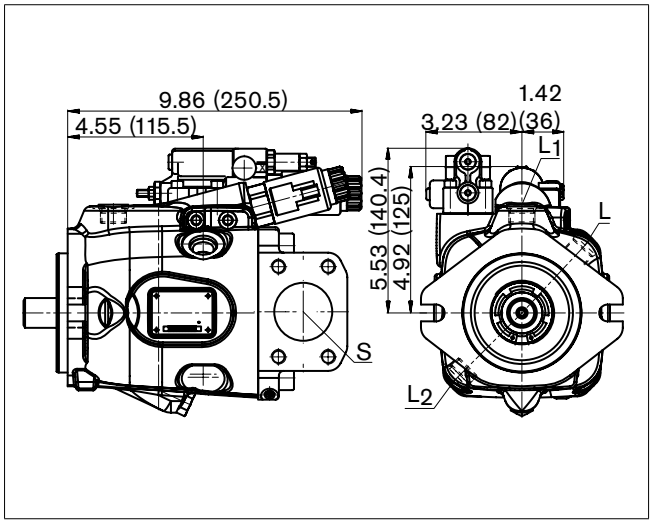
DFR / DFR1 (DRF/DRS)

Pressure and flow control, **series 52 (series 53)**



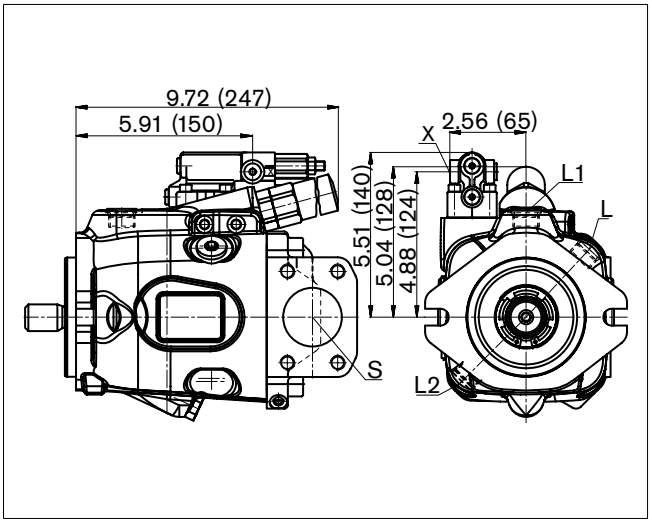
EP.ED / EK.ED

Electro-proportional control, **series 53**



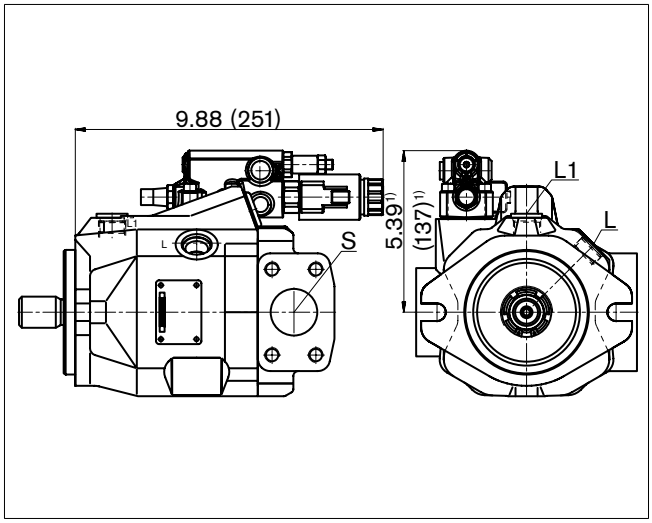
LA.D.

Pressure, flow and power control, **series 53**



ED7. / ER7.

Electro-hydraulic pressure control, **series 52**



1) ER7.: 6.77 inches (172 mm) if using an intermediate plate pressure controller.

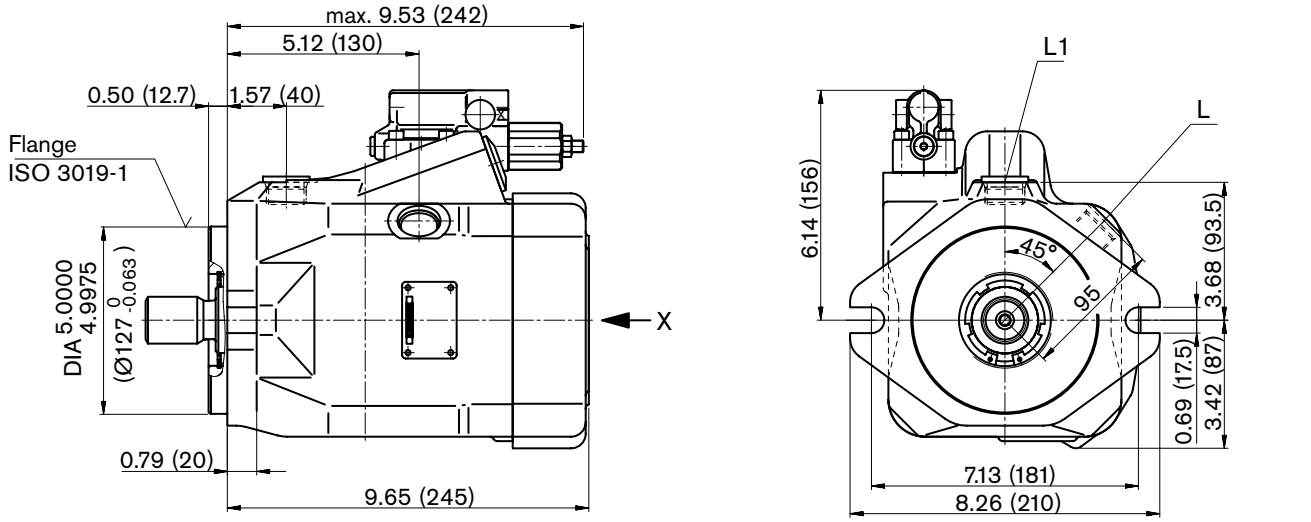
Dimensions, size 85[1)]

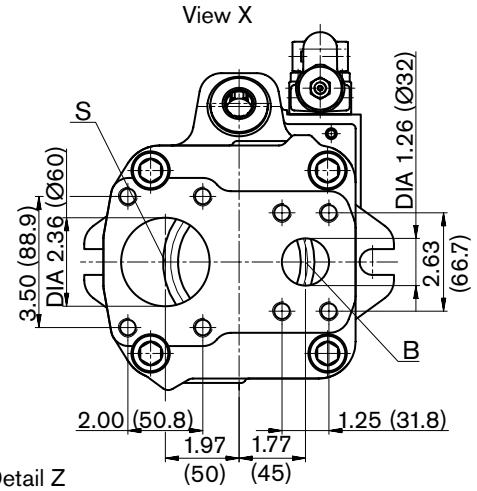
Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

DR – Hydraulic pressure controller

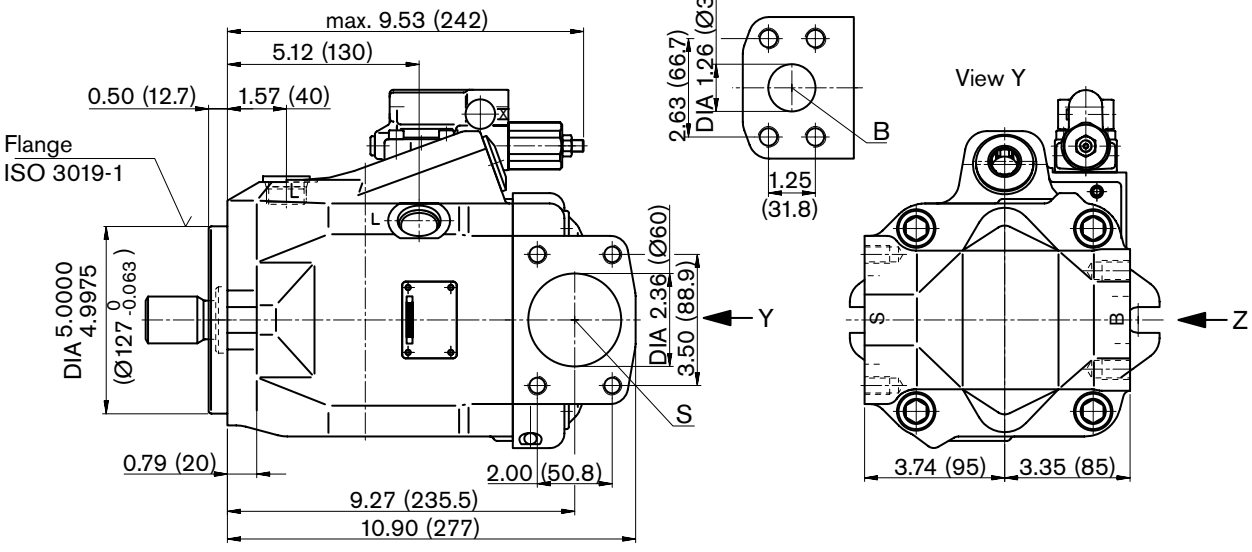
Mounting flange C, clockwise rotation, **series 52**

Port plate 61





Port plate 62



1) Dimensions of service line ports turned through 180° for counter-clockwise rotation

For details of connection options and drive shafts, please refer to page 43

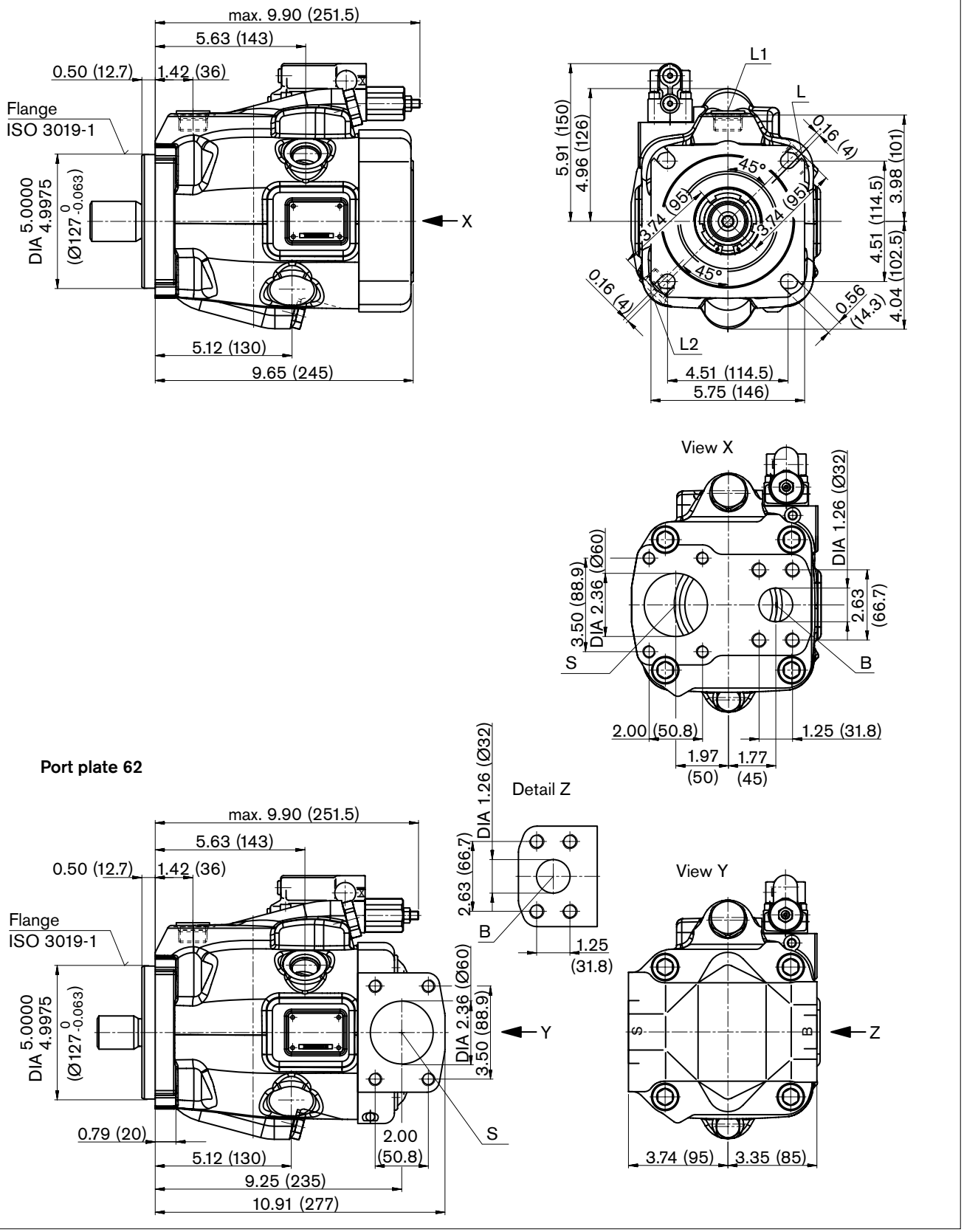
Dimensions, size 85[1)]

Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

DR – Hydraulic pressure controller

Mounting flange D, clockwise rotation, **series 53**

Port plate 61



1) Dimensions of service line ports turned through 180° for counter-clockwise rotation

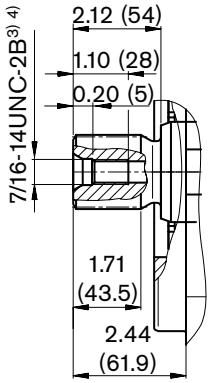
For details of connection options and drive shafts, please refer to page 43

Dimensions, size 85

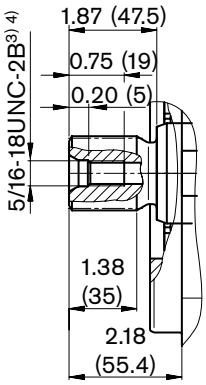
Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

Drive shaft

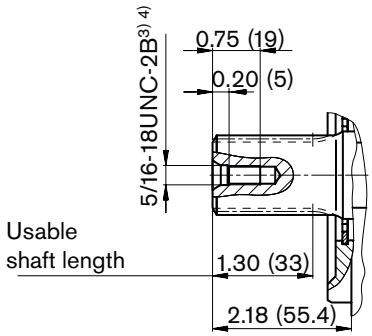
S Splined shaft 1 1/2 in
17T 12/24DP[1] (SAE J744)



U Splined shaft 1 1/4 in
14T 12/24DP[1] (SAE J744)



W Splined shaft 1 1/4 in
14T 12/24DP[1)2)] (SAE J744)



Ports

Designation	Port for	Standard	Size[4)]	Maximum pressure [psi (bar)][5)]	State
B	Service line, fixing thread	SAE J518 ASME B1.1	1 1/4 in 1/2-13UNC-2B; 0.75 (19) deep	4600 (315)	O
S	Suction line, fixing thread	SAE J518 ASME B1.1	2 1/2 in 1/2-13UNC-2B; 1.07 (27) deep	75 (5)	O
L	Case drain fluid	ISO 11926[6)]	1 1/16-12UNF-2B; 0.59 (15) deep	30 (2)	O[8)]
L_1, L_2[7)]	Case drain fluid	ISO 11926[6)]	1 1/16-12UNF-2B; 0.59 (15) deep	30 (2)	X[8)]
X	Control pressure	ISO 11926[6)]	7/16-20UNF-2A; 0.45 (11.5) deep	4600 (315)	O

1) ANSI B92.1a, 30° pressure angle, flat root, side fit, tolerance class 5
2) Splines according to ANSI B92.1a, run out of spline is a deviation from standard
3) Thread according to ASME B1.1
4) For the maximum tightening torques the general instructions on page 60 must be observed.
5) Depending on the application, momentary pressure spikes can occur. Consider this when selecting measuring equipment and fittings.
6) The spot face can be deeper than as specified in the standard.
7) Only for series 53
8) Depending on the installation position, L, L_1 or L_2 must be connected (please refer to installation instructions on pages 56, 57)

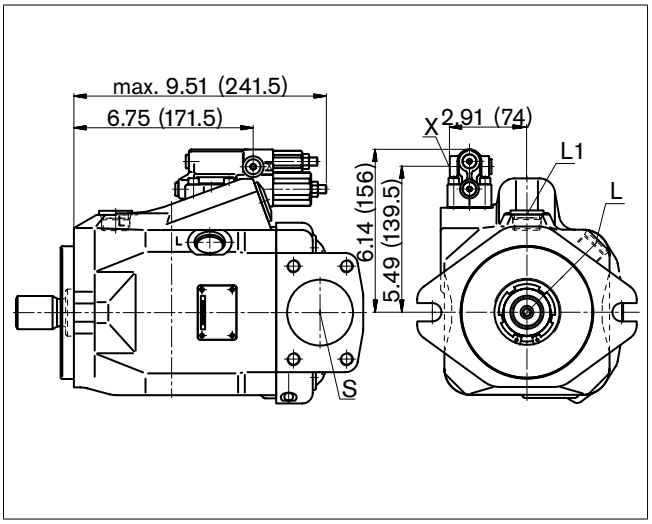
O = Must be connected (plugged on delivery)
X = Plugged (in normal operation)

Dimensions, size 85, mounting flange C

Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

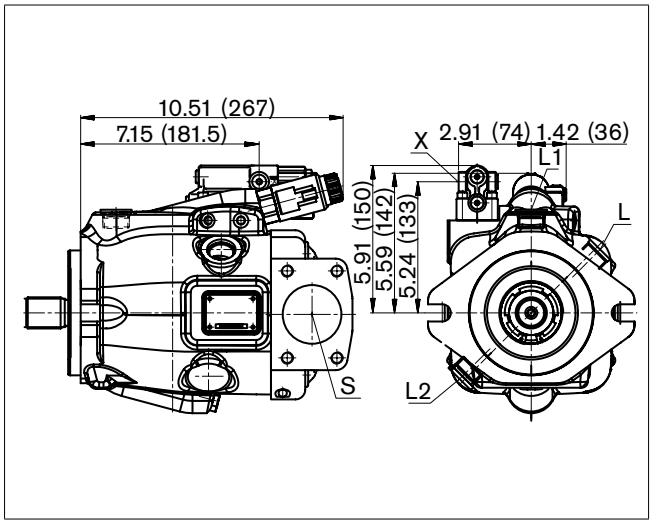
DRG

Pressure controller, remote controlled, **series 52**



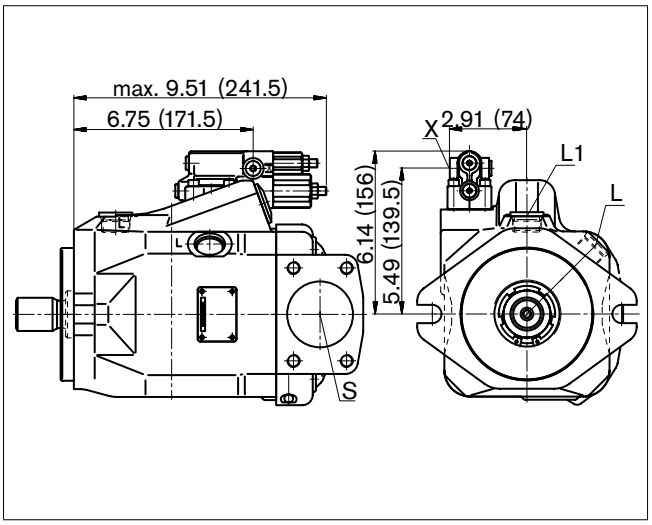
EP.D. / EK.D.

Electro-proportional control, **series 53**



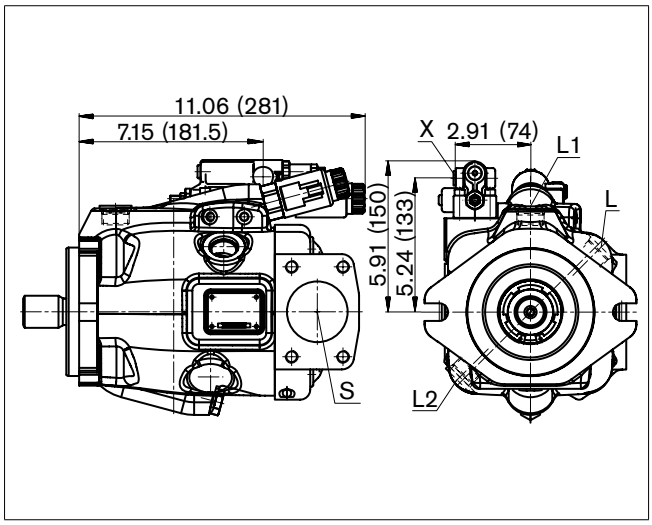
DFR / DFR1

Pressure and flow control, **series 52**



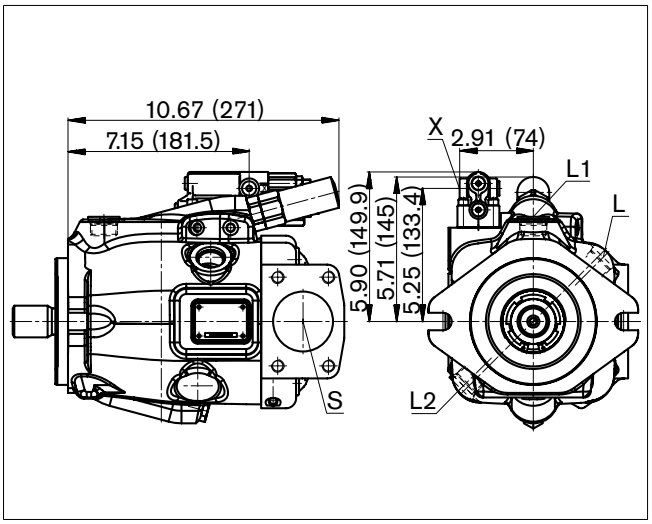
EP.ED / EK.ED

Electro-proportional control, **series 53**



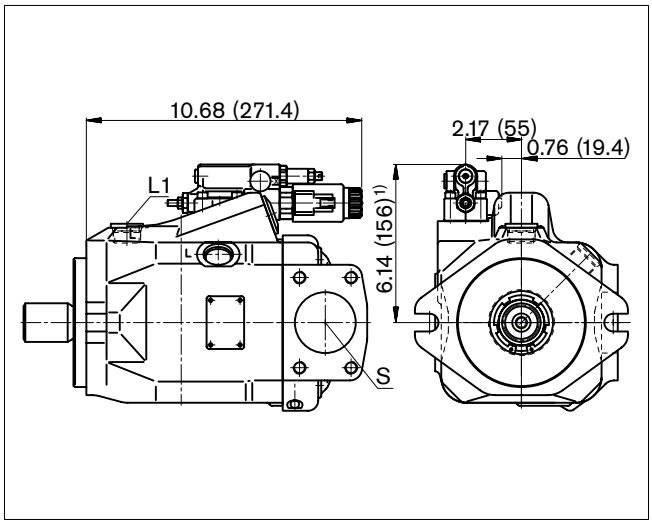
LA.D.

Pressure, flow and power control, **series 53**



ED../ ER..

Electro-hydraulic pressure control, **series 52**



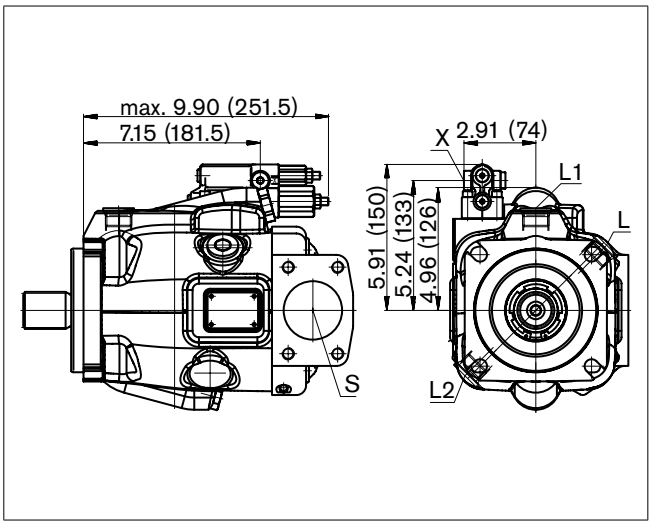
1) ER7.: 191 mm if using an intermediate plate pressure controller.

Dimensions, size 85, mounting flange D

Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

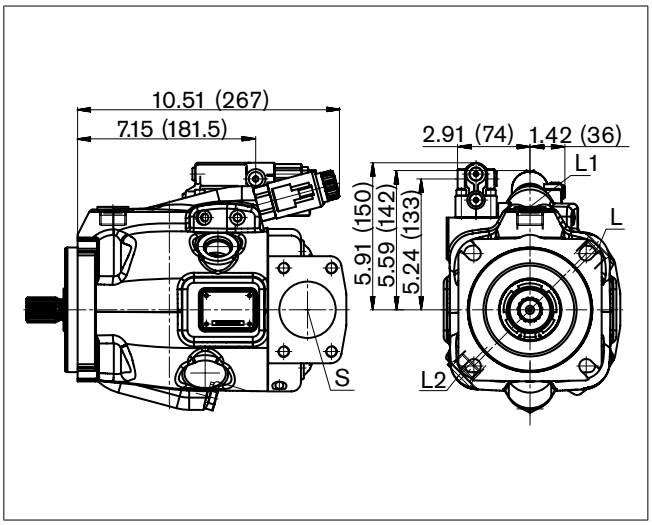
DRF/DRS

Pressure and flow control, **series 53**



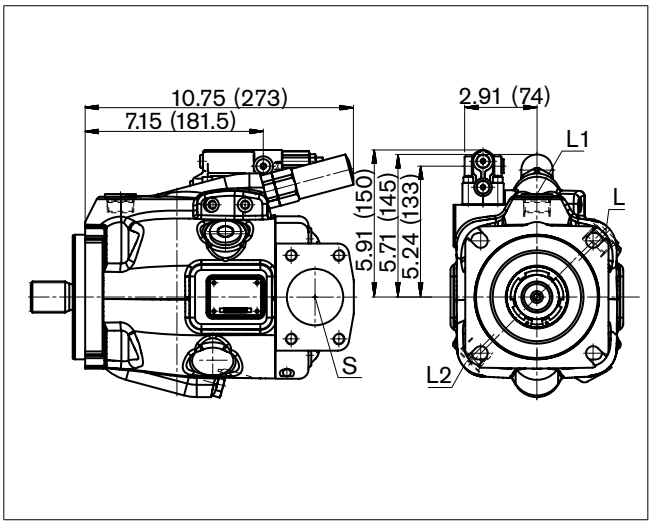
EP.D. / EK.D.

Electro-proportional control, **series 53**



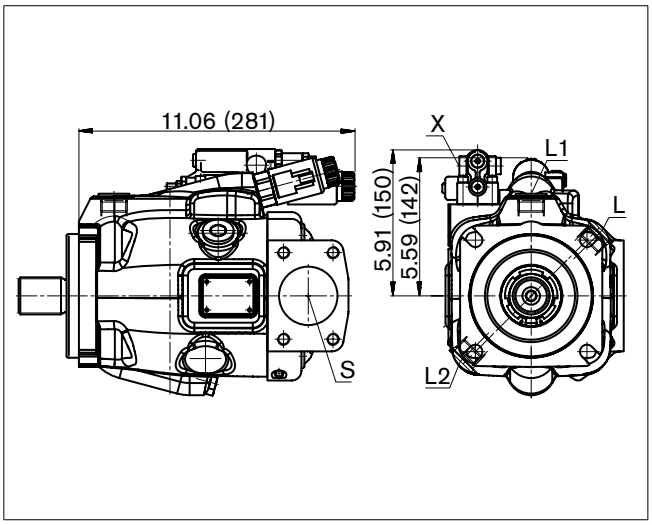
LA.D.

Pressure, flow and power control, **series 53**



EP.ED / EK.ED

Electro-proportional control, **series 53**



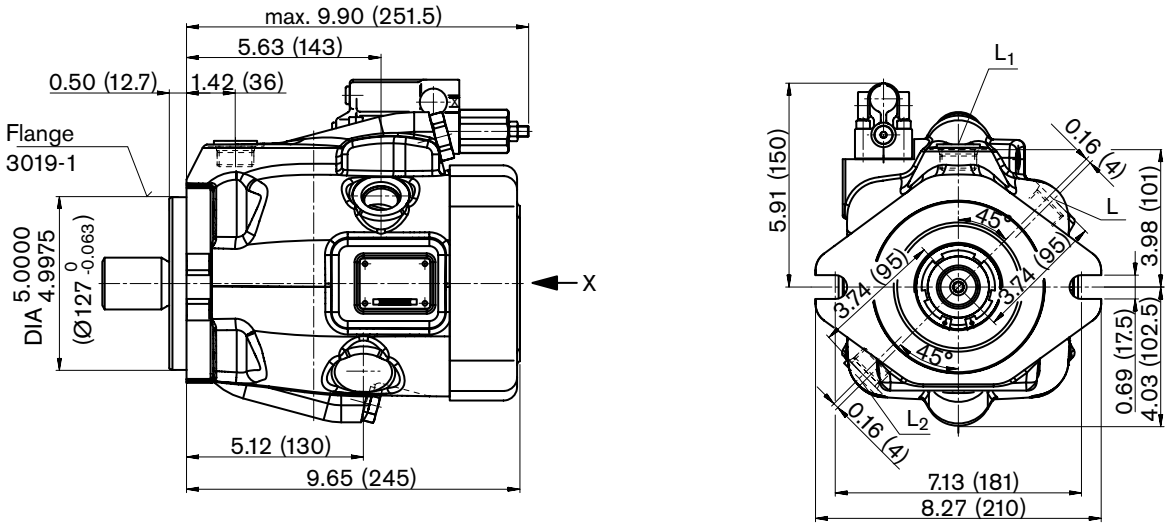
Dimensions, size 100[1)]

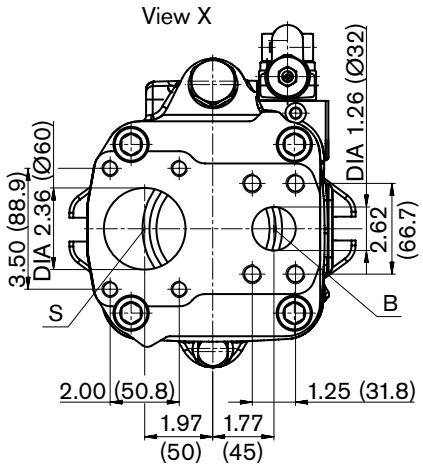
Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

DR – Hydraulic pressure controller

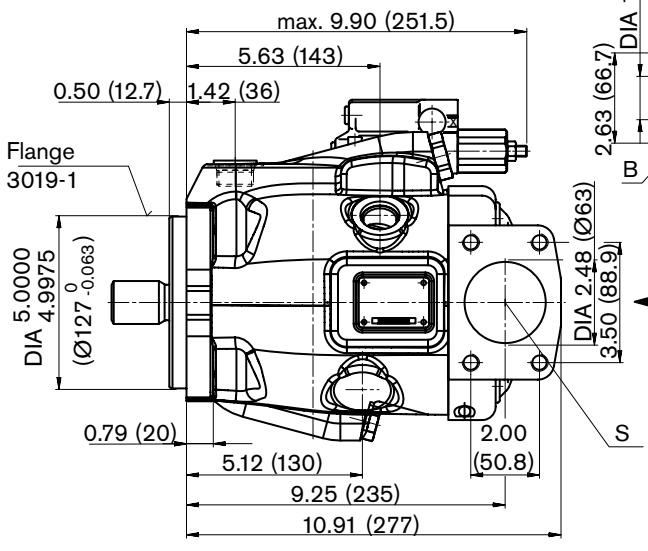
Mounting flange C, clockwise rotation, **series 53**

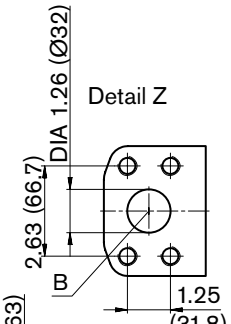
Port plate 61

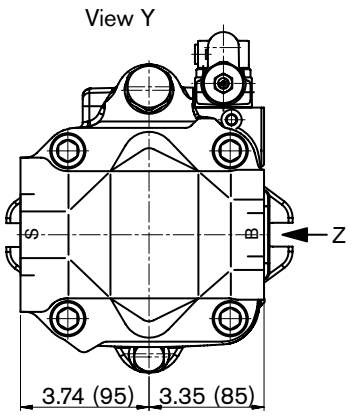




Port plate 62







1) Dimensions of service line ports turned through 180° for counter-clockwise rotation

For details of connection options and drive shafts, please refer to page 49

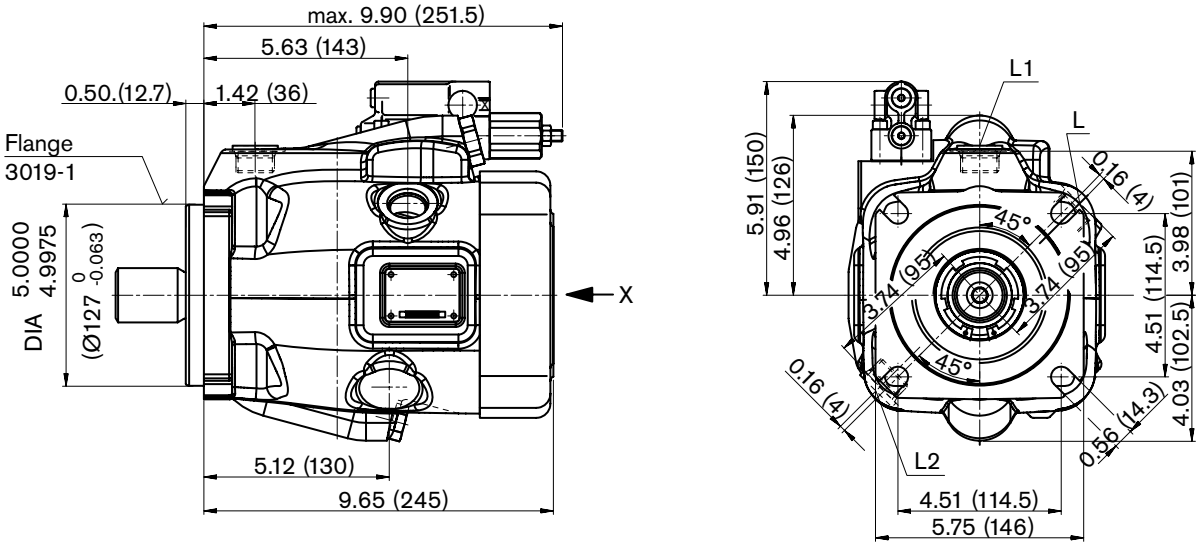
Dimensions, size 100[1)]

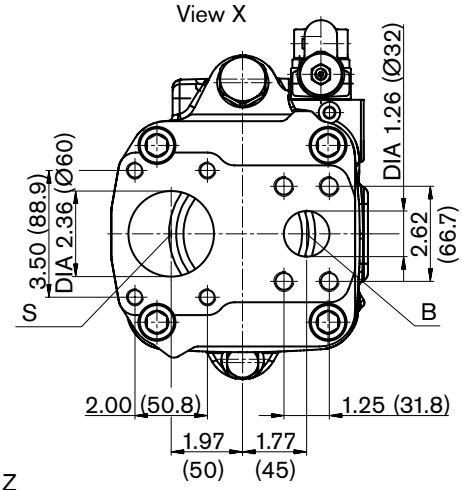
Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

DR – Hydraulic pressure controller

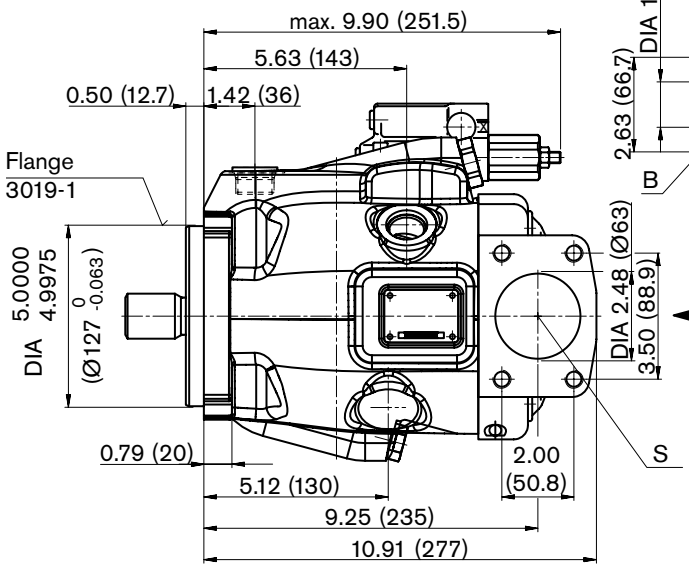
Mounting flange D, clockwise rotation, **series 53**

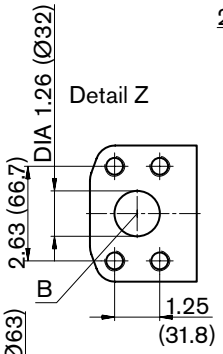
Port plate 61

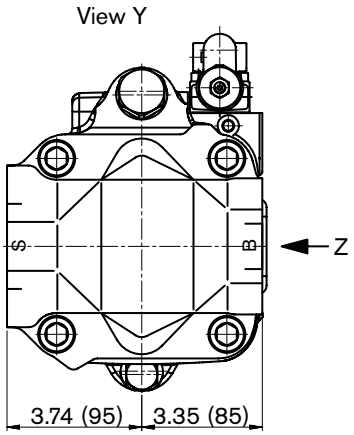




Port plate 62







1) Dimensions of service line ports turned through 180° for counter-clockwise rotation

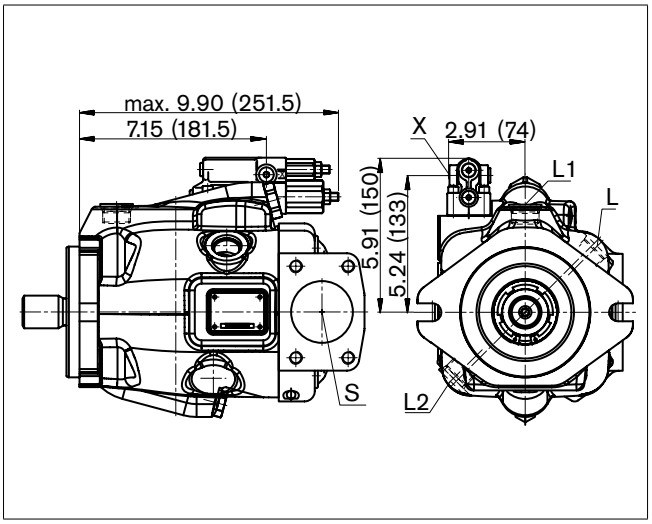
For details of connection options and drive shafts, please refer to page 49

Dimensions, size 100

Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

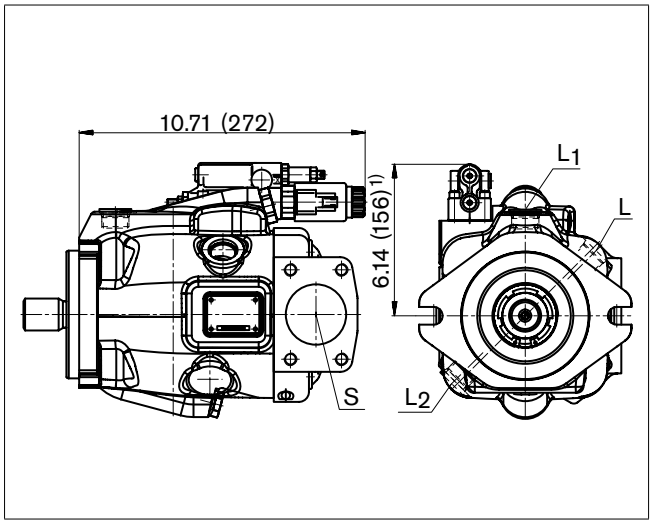
DRG

Pressure controller, remote controlled, **series 53**



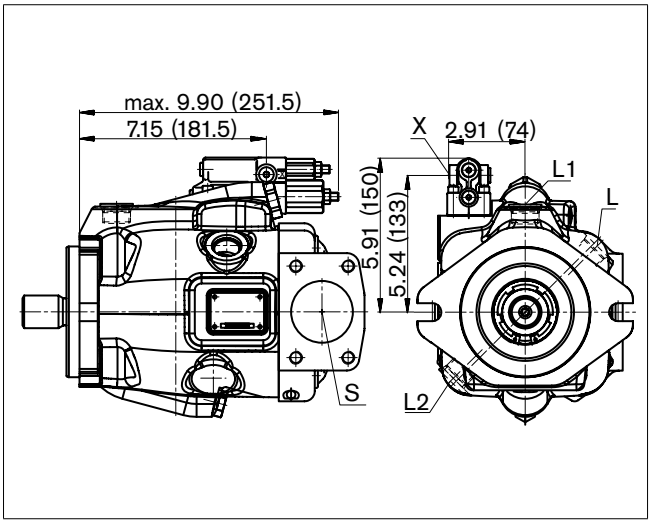
ED../ ER..

Electro-hydraulic pressure control, **series 53**



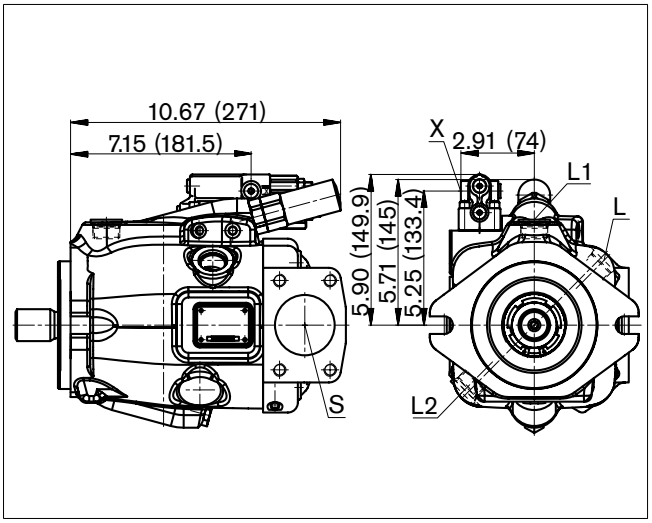
DRF/DRS

Pressure and flow control, **series 53**



LA.D.

Pressure, flow and power control, **series 53**

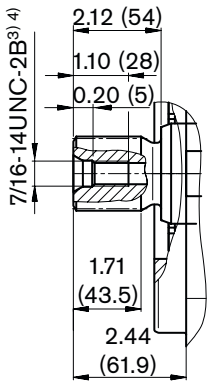


1) ER7.: 7.52 inches (191 mm) if using an intermediate plate pressure controller.

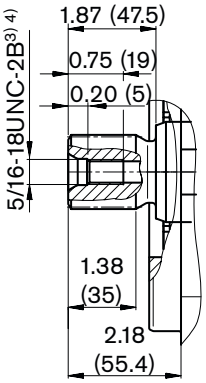
Dimensions, size 100

Drive shaft

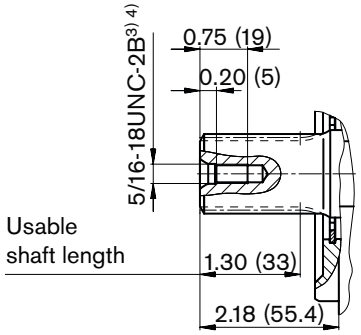
S Splined shaft 1 1/2 in
17T 12/24DP[1] (SAE J744)



U Splined shaft 1 1/4 in
14T 12/24DP[1] (SAE J744)



W Splined shaft 1 1/4 in
14T 12/24DP[1][2] (SAE J744)



Ports

Designation	Port for	Standard	Size[4]	Maximum pressure [bar][5]	State
B	Service line, fixing thread	SAE J518 ASME B1.1	1 1/4 in 1/2-13UNC-2B; 0.75 (19) deep	4600 (315)	O
S	Suction line, fixing thread	SAE J518 ASME B1.1	2 1/2 in 1/2-13UNC-2B; 1.07 (27) deep	75 (5)	O
L	Case drain fluid	ISO 11926[6]	1 1/16-12UNF-2B; 0.59 (15) deep	30 (2)	O[8]
L_1, L_2	Case drain fluid	ISO 11926[6]	1 1/16-12UNF-2B; 0.59 (15) deep	30 (2)	X[8]
X	Control pressure	ISO 11926[6]	7/16-20UNF-2A; 0.45 (11.5) deep	4600 (315)	O

1) ANSI B92.1a, 30° pressure angle, flat root, side fit, tolerance class 5
2) Splines according to ANSI B92.1a, run out of spline is a deviation from standard.
3) Thread according to ASME B1.1
4) For the maximum tightening torques the general instructions on page 60 must be observed.
5) Depending on the application, momentary pressure spikes can occur. Consider this when selecting measuring equipment and fittings.
6) Metric fixing thread is a deviation from standard.
7) The spot face can be deeper than as specified in the standard.
8) Depending on the installation position, L, L_1 or L_2 must be connected (please refer to installation instructions on pages 56, 57)

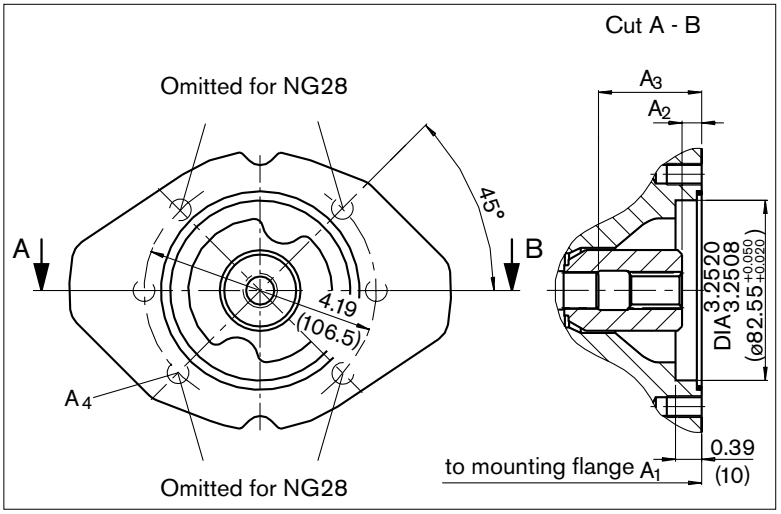
O = Must be connected (plugged on delivery)
X = Plugged (in normal operation)

Dimensions through drive

Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

K01 flange SAE J744 - 82-2 (A)
Coupling for splined shaft in accordance with ANSI B92.1a-1996

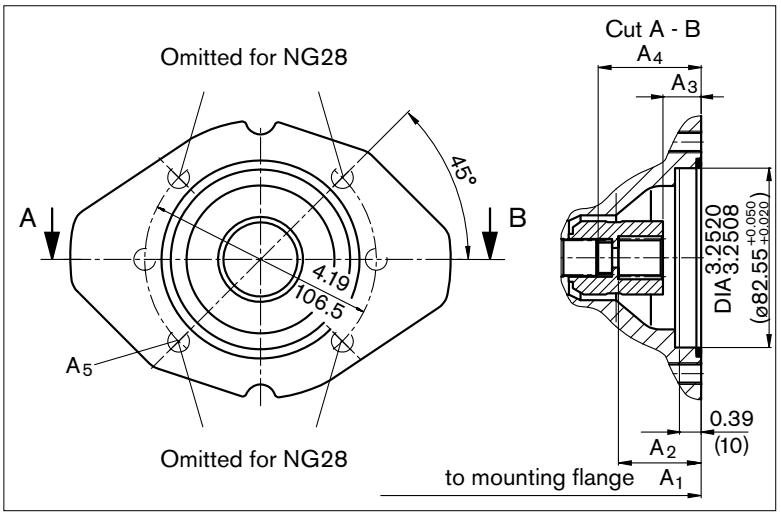
5/8 in 9T 16/32 DP[1] (SAE J744 - 16-4 (A))



NG	A_1	A_2	A_3	A_4[2]
18	7.17 (182)	0.37 (9.3)	1.70 (43.3)	M10 x 1.5, 0.57 (14.5) deep
28	8.03 (204)	0.39 (9.9)	1.85 (47)	M10 x 1.5, 0.63 (16) deep
45	9.02 (229)	0.42 (10.7)	2.09 (53)	M10 x 1.5, 0.63 (16) deep
60/63	10.03 (255)	0.37 (9.5)	2.32 (59)	M10 x 1.5, 0.63 (16) deep
85	11.89 (302)	0.53 (13.4)	2.68 (68)	M10 x 1.5, 0.79 (20) deep
100	11.89 (302)	0.53 (13.4)	2.68 (68)	M10 x 1.5, 0.79 (20) deep

K52 flange SAE J744 - 82-2 (A)
Coupling for splined shaft in accordance with ANSI B92.1a-1996

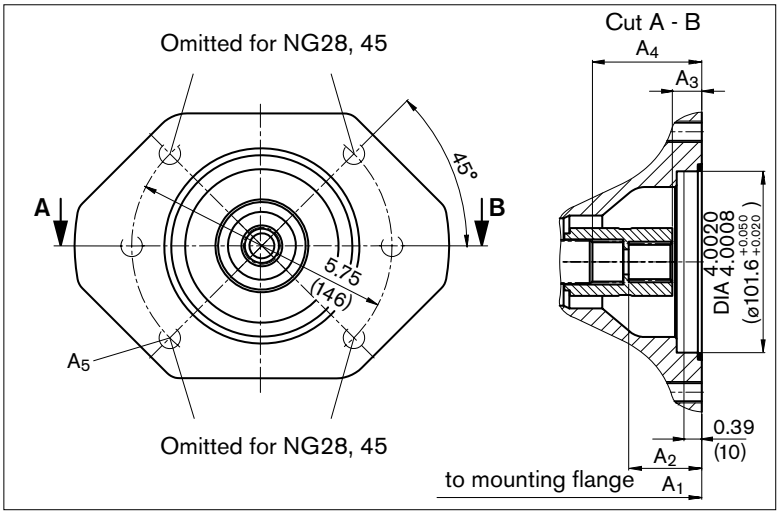
3/4 in 11T 16/32 DP[1] (SAE J744 - 19-4 (A-B))



NG	A_1	A_2	A_3	A_4	A_5[2]
18	7.17 (182)		0.37 (9.3)	1.70 (43.3)	M10 x 1.5, 0.57 (14.5) deep
28	8.03 (204)	1.54 (39.3)	0.74 (18.8)	1.85 (47)	M10 x 1.5, 0.63 (16) deep
45	9.02 (229)	1.55 (39.4)	0.75 (18.9)	2.09 (53)	M10 x 1.5, 0.63 (16) deep
60/63	10.03 (255)	1.55 (39.4)	0.75 (18.9)	2.40 (61)	M10 x 1.5, 0.63 (16) deep
85	11.89 (302)	1.74 (44.1)	0.93 (23.6)	2.56 (65)	M10 x 1.5, 0.79 (20) deep
100	11.89 (302)	1.74 (44.1)	0.93 (23.6)	2.56 (65)	M10 x 1.5, 0.79 (20) deep

K68 flange SAE J744 - 101-2 (B)
Coupling for splined shaft in accordance with ANSI B92.1a-1996

7/8 in 13T 16/32 DP[1] (SAE J744 - 22-4 (B))



NG	A_1	A_2	A_3	A_4	A_5[2]
28	8.03 (204)	1.66 (42.3)	0.70 (17.8)	1.85 (47)	M12 x 1.75, 0.71 (18) deep
45	9.02 (229)	1.67 (42.4)	0.71 (17.9)	2.09 (53)	M12 x 1.75, 0.71 (18) deep
60/63	10.03 (255)	1.67 (42.4)	0.71 (17.9)	2.32 (59)	M12 x 1.75, 0.71 (18) deep
85	11.89 (302)	1.83 (46.5)	0.87 (22)	2.72 (69)	M12 x 1.75, 0.79 (20) deep
100	11.89 (302)	1.83 (46.5)	0.87 (22)	2.72 (69)	M12 x 1.75, 0.79 (20) deep

1) 30° pressure angle, flat base, flank centering, tolerance class 5
2) Thread according to DIN 13, observe the general instructions on page 60 for the maximum tightening torques.

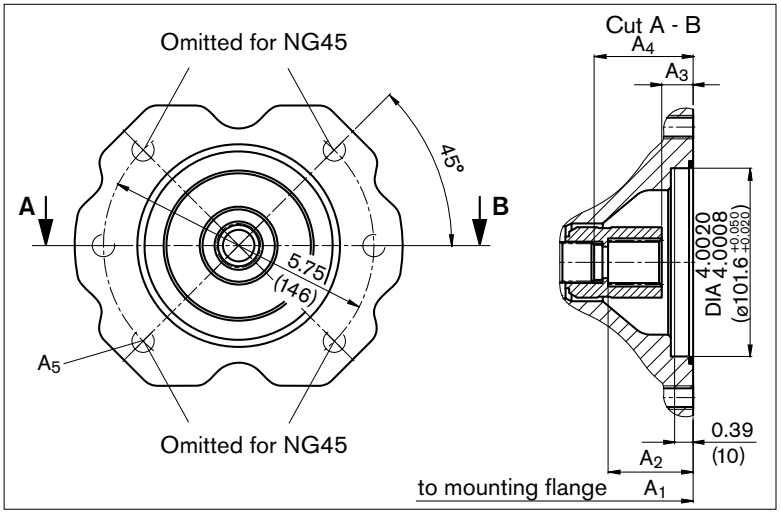
Dimensions through drive

Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

K04 flange SAE J744 - 101-2 (B)

Coupling for splined shaft in accordance with ANSI B92.1a-1996

1 in 15T 16/32 DP[1] (SAE J744 - 25-4 (B-B))

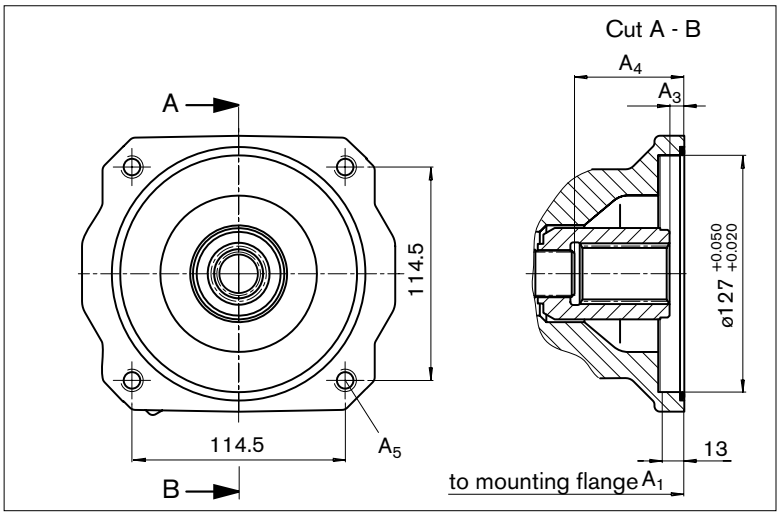


NG	A_1	A_2	A_3	A_4	A_5[2]
45	9.02 (229)	1.88 (47.9)	0.74 (18.9)	2.10 (53.4)	M12 x 1.75, 0.71 (18) deep
60/63	10.03 (255)	1.87 (47.4)	0.72 (18.4)	2.32 (58.9)	M12 x 1.75, 0.71 (18) deep
85	11.89 (302)	2.01 (51.2)	0.87 (22.2)	2.72 (69)	M12 x 1.75, 0.79 (20) deep
100	11.89 (302)	2.01 (51.2)	0.87 (22.2)	2.72 (69)	M12 x 1.75, 0.79 (20) deep

K15 flange SAE J744 - 127-4 (C)

Coupling for splined shaft in accordance with ANSI B92.1a-1996

1 1/4 in 14T 12/24 DP[1] (SAE J744 - 32-4 (C))

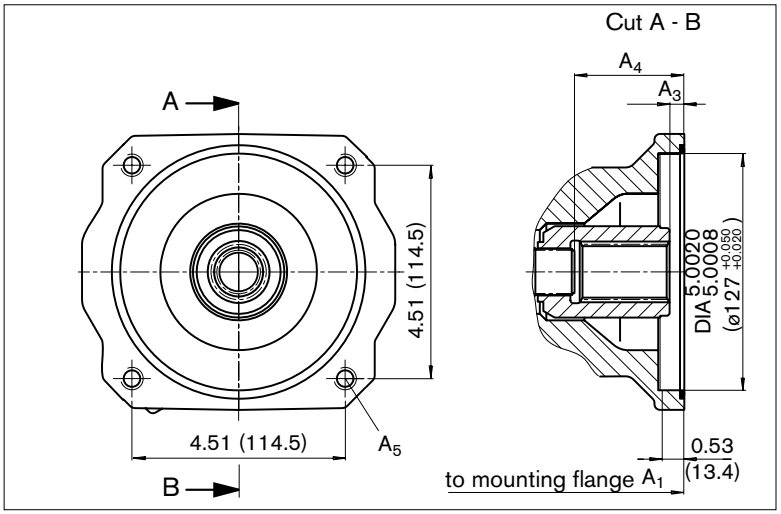


NG	A_1	A_2	A_3	A_4[2]
60/63	10.03 (255)	0.31 (8)	2.32 (59)	M12 x 1.75, 0.63 (16) deep
85	11.87 (301.5)	0.51 (13)	2.67 (67.9)	M12 x 1.75, through
100	11.87 (301.5)	0.51 (13)	2.67 (67.9)	M12 x 1.75, through

K16 flange SAE J744 - 127-4 (C)

Coupling for splined shaft in accordance with ANSI B92.1a-1996

1 1/2 in 17T 12/24 DP[1] (SAE J744 - 32-4 (C))



NG	A_1	A_2	A_3	A_4[2]
85	11.87 (301.5)	0.51 (13)	2.67 (67.9)	M12 x 1.75, through
100	11.87 (301.5)	0.51 (13)	2.67 (67.9)	M12 x 1.75, through

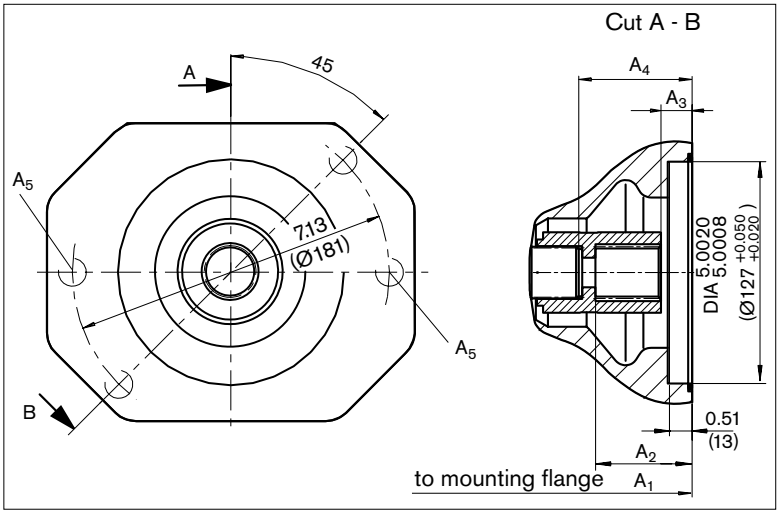
1) 30° pressure angle, flat base, flank centering, tolerance class 5

2) Thread according to DIN 13, observe the general instructions on page 60 for the maximum tightening torques.

Dimensions through drive

Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

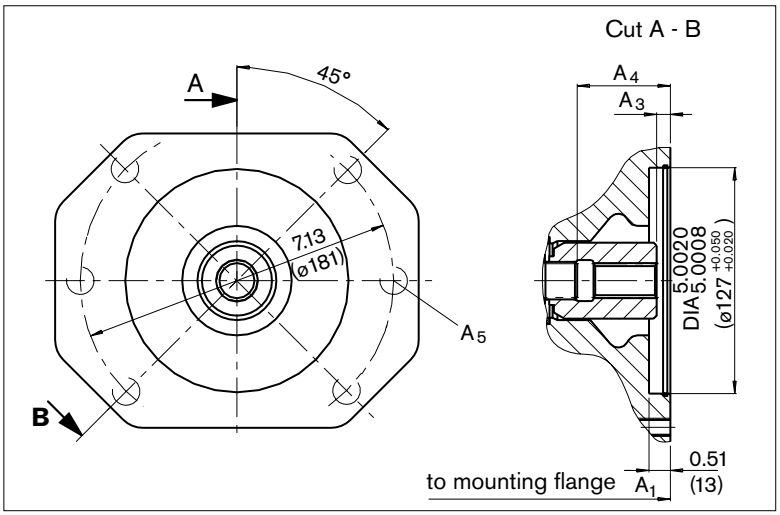
K07 flange SAE J744 - 127-2 (C)
Coupling for splined shaft in accordance with ANSI B92.1a-1996



1 1/4 in 14T 12/24 DP[1] (SAE J744 - 32-4 (C))

NG	A_1	A_2	A_3	A_4[2]
85	11.87 (301.5)	0.51 (13)	2.67 (67.9)	M12 x 1.75, through
100	11.87 (301.5)	0.51 (13)	2.67 (67.9)	M12 x 1.75, through

K24 flange SAE J744 - 127-2 (C)
Coupling for splined shaft in accordance with ANSI B92.1a-1996



1 1/2 in 17T 12/24 DP[1] (SAE J744 - 38-4 (C-C))

NG	A_1	A_2	A_3	A_4[2]
85	11.89 (302)	0.31 (8)	2.68 (68)	M16 x 2, 0.94 (24) deep
100	11.89 (302)	0.31 (8)	2.68 (68)	M16 x 2, 0.94 (24) deep

1) 30° pressure angle, flat base, flank centering, tolerance class 5
2) Thread according to DIN 13, observe the general instructions on page 60 for the maximum tightening torques.

Summary mounting options

Through-drive[1]			Mounting option – 2nd pump			
Flange	Coupling for splined shaft	Short des.	A10V(S)O/5x NG (shaft)	A10VO/31 NG (shaft)	Gear pump design (NG)	**Through drive available for NG**
82-2 (A)	5/8 in	**K01**	10 (U)	18 (U)	F (5 to 22)	18 to 100
	3/4 in	**K52**	10 (S) 18 (U) 18 (S, R)	18 (S, R)	–	18 to 100
101-2 (B)	7/8 in	**K68**	28 (S, R) 45 (U, W)[1]	28 (S, R) 45 (U, W)	N/G (26 to 49)	28 to 100
	1 in	**K04**	45 (S, R) 60, 63 (U, W) [2]	45 (S, R) –	–	45 to 100
127-4 (C)	1 1/4 in	**K15**	60, 63 (S, R)	–	–	63 to 100
	1 1/2 in	**K16**	85 (S) 100 (S)	–	–	85 to 100
127-2 (C)	1 1/4 in	**K07**	85 (U, W) 100 (U, W)	71 (S, R)	–	85 to 100
	1 1/2 in	**K24**	85 (S) 100 (S)	–	–	85 to 100

1) Not for NG28 with K68
2) Not for NG28 with K04

Combination pumps A10VO + A10VO

Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

When using combination pumps it is possible to have multiple, mutually independent circuits without the need for a splitter gearbox.

When ordering combination pumps the model codes for the first and the second pump must be joined by a "+".

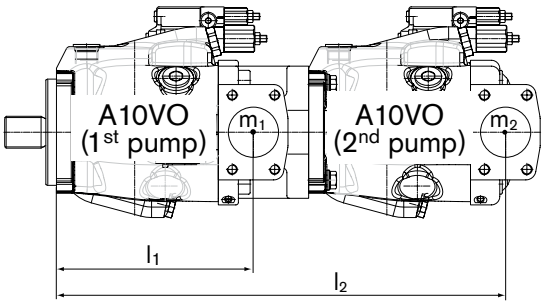
Order example:
A10VO85DRS/53R-VSC12K04+
A10VO45DRF/53R-VSC11N00

The tandem pump comprising two identical sizes is permissible without additional supports taking into account a maximum dynamic mass acceleration of 10 *g* (= 98.1 m/s²).

For combination pumps comprising more than two pumps, the mounting flange must be calculated for the permissible moment of inertia.

Permissible moment of inertia

NG			10	18	28	45	60/63	85	100
Permissible moment of inertia									
static	T_m	lb-ft	–	–	656	664	1010	2270	2270
		(Nm)	–	–	(890)	(900)	(1370)	(3080)	(3080)
dynamic at 10 *g* (98.1 m/s²)	T	lb-ft	–	–	65	66	101	227	227
		(Nm)	–	–	(89)	(90)	(137)	(308)	(308)
Mass with through-drive plate	m_1	lbs	–	–	37.5	53	62	99	99
		(kg)	–	–	(17)	(24)	(28)	(45)	(45)
Mass without through drive (e.g. 2nd pump)	m	lbs	18	25	31	40	48.5	75	75
		(kg)	(8)	(11.5)	(14)	(18)	(22)	(34)	(34)
Distance center of gravity	l_1	in	–	3.23	3.19	3.74	3.94	4.80	4.80
		(mm)	–	(82)	(81)	(95)	(100)	(122)	(122)



m_1, m_2, m_3 Mass of pumps [lbs (kg)]

l_1, l_2, l_3 Distance center of gravity [in (mm)]

$$T_m = (m_1 \cdot l_1 + m_2 \cdot l_2 + m_3 \cdot l_3) \cdot \frac{1}{12\ (102)}$$ [lb-ft (Nm)]

Connector for solenoids

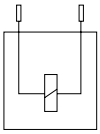
Before finalizing your design request a certified installation drawing.
Dimensions in inches and (mm).

DEUTSCH DT04-2P-EP04, 2-pin

Molded, without bidirectional suppressor diode _____ **P**
Protection according to DIN/EN 60529 _____ IP67
Protection according to DIN 40050-9 _____ IP69K

Circuit symbol

Without bidirectional suppressor diode



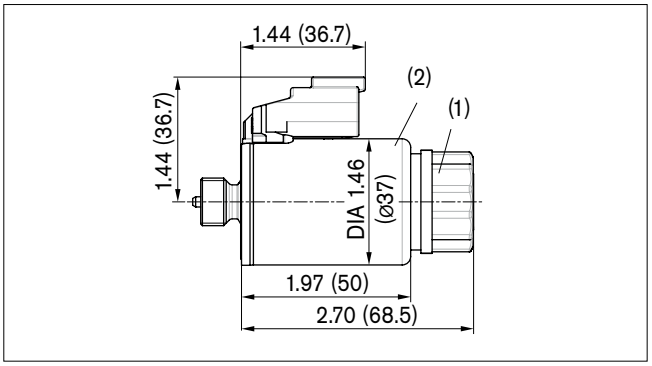
Mating connector

DEUTSCH DT06-2S-EP04
Bosch Rexroth Mat. No. R902601804

Consisting of:

	DT designation
– 1 case	DT06-2S-EP04
– 1 wedge	W2S
– 2 sockets	0462-201-16141

The mating connector is not included in the delivery contents. This can be supplied by Bosch Rexroth on request.



Changing connector position

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

To do this, proceed as follows:

1. Loosen the mounting nut (1) of the solenoid. To do this, turn the mounting nut (1) one revolution counter-clockwise.
2. Turn the solenoid body (2) to the desired position.
3. Retighten the mounting nut of the solenoid. Tightening torque: $3.7^{+0.7}$ lb-ft (5^{+1} Nm) (size WAF 26, 12kt DIN 3124).

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

Electronic controls

Control	Electronics function	Electronics		Further information
Electric pressure control	Controlled power outlet	RA	analog	RE 95230
		RC2-2/21 [1]	Digital	RE 95201

1) Power outlets for 2 valves, can be actuated separately
2) only 24V nominal voltage

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 empty via the hydraulic lines.

Especially with the installation position "drive shaft upwards" or "drive shaft downward", attention must be paid to a complete filling and air bleeding since there is a risk, for example, of dry running.

The case drain fluid in the case interior must be directed to the reservoir via the highest case drain port (L_1, L_2, L_3).

For combinations of multiple units, make sure that the respective case pressure in each unit 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 case drain line must flow into the reservoir below the minimum fluid level. The permissible suction height h_S is a result of the overall pressure loss, but may not be greater than $h_{S\ max} = 31.50$ in (800 mm). The minimum suction pressure at port S must also not fall below 12 psi (0.8 bar) absolute during operation.

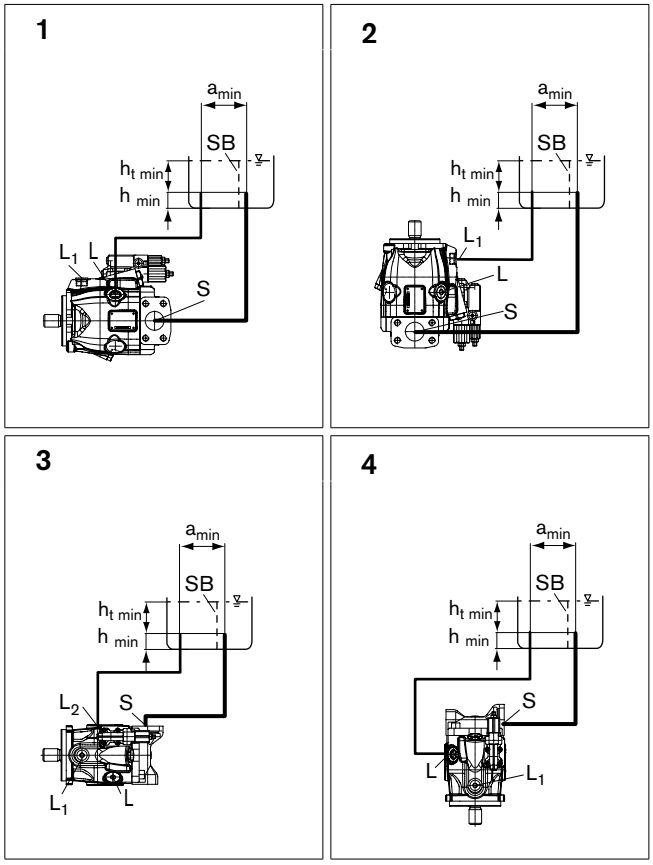
Installation position

See the following examples 1 to 12.
Additional installation positions are available upon request.

Recommended installation positions: 1 and 3.

Below-reservoir installation (standard)

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



Installation position	Air bleed	Filling
1	L	S + L
2	L_1	S + L_1
3[1)]	L_2	S + L_2
4	L	S + L

Key, see page 57

1) Only series 53

Installation instructions

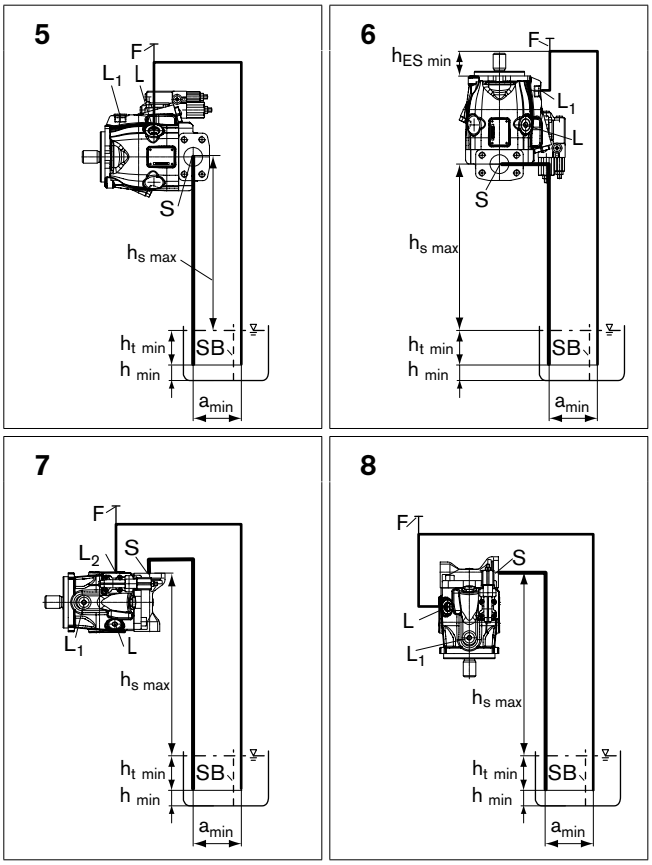
Above-reservoir installation

Above-reservoir installation means 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 0.98 in (25 mm) is required in installation position 6.

Observe the maximum permissible suction height $h_{S\ max}$ = 31.50 in (800 mm).

A check valve in the case drain line is only permissible in individual cases. Consult us for approval.

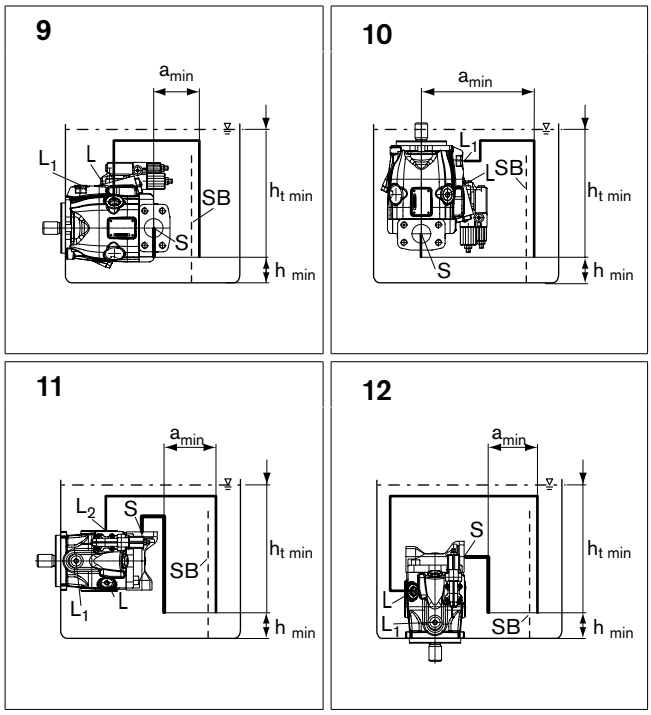


Installation position	Air bleed	Filling
5	F	L, L_1 (F)
6	F	L_1 (F)
7[1)]	F	S + L_2 (F)
8	F	S + L (F)

1) Only series 53

Inside-reservoir installation

Inside-reservoir installation means the pump is installed within the minimum reservoir fluid level.
Axial piston units with electrical components (e.g. electric control, sensors) may not be installed in a reservoir below the fluid level.



Installation position	Air bleed	Filling
9	L_1	L, L_1
10	L_1	L, L_1
11[1)]	L_2	S
12	L	S + L

S	Suction port
F	Filling / air bleeding
L, L_1	Case drain port
SB	Baffle (baffle plate)
$h_{t\ min}$	Minimum necessary immersion depth (7.87 in (200 mm))
h_{min}	Minimum necessary spacing to reservoir base (3.94 in (100 mm))
$h_{ES\ min}$	Minimum necessary height needed to protect the axial piston unit from draining (0.98 in (25 mm)).
$h_{S\ max}$	Maximum permissible suction height (21.50 in (800 mm))
a_{min}	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.

Notes

Notes

General instructions

– The A10VO pump is designed to be used in open circuit.

– Project planning, installation and commissioning of the axial piston unit require the involvement of qualified personnel.

– Before operating the axial piston unit, please read the appropriate instruction manual thoroughly and completely. If necessary, request these from Bosch Rexroth.

– During and shortly after operation, there is a risk of burns on the axial piston unit and especially on the solenoids. Take appropriate safety measures (e.g. by wearing protective clothing).

– Depending on the operating conditions of the axial piston unit (operating pressure, fluid temperature), the characteristics may shift.

– Service line ports:

- The ports and fixing threads are designed for the specified maximum pressure. The machine or system manufacturer must ensure that the connecting elements and lines correspond to the specified application conditions (pressure, flow, hydraulic fluid, temperature) with the necessary safety factors.

- The service line ports and function ports are only designed to accommodate hydraulic lines.

– Pressure cut-off and pressure control do not provide security against pressure overload. A separate pressure relief valve is to be provided in the hydraulic system.

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

– The product is not approved as a component for the safety concept of a general machine according to DIN EN ISO 13849.

– The following tightening torques apply:

- Fittings:
  Observe the manufacturer's instruction regarding the tightening torques of the used fittings.

- Fixing screws:
  For fixing screws with metric ISO thread according to DIN 13 or thread according to ASME B1.1, we recommend checking the tightening torque individually according to VDI 2230.

- Female threads in axial piston unit:
  The maximum permissible tightening torques $M_{G\ max}$ are maximum values for the female threads and must not be exceeded. For values, see the following table.

- Threaded plugs:
  For the metal threaded plugs supplied with the axial piston unit, the required tightening torques of the threaded plugs M_V apply. For values, see the following table.

Ports		Maximum permissible tightening torque for female threads $M_{G\ max}$	Required tightening torque for threaded plugs M_V	Size of hexagon socket of threaded plugs
Standard	Thread size			
ISO 11926	7/16-20UNF-2B	40 Nm	18 Nm	3/16 in
	9/16-18UNF-2B	80 Nm	35 Nm	1/4 in
	3/4-16UNF-2B	160 Nm	70 Nm	5/16 in
	7/8-14UNF-2B	240 Nm	110 Nm	3/8 in
	1 1/16-12UN-2B	360 Nm	170 Nm	9/16 in

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Subject to change.

Rexroth
Bosch Group

Axial Piston
Variable Double Pump A20VO

RE 93 100/05.06 1/16
Replace: 07.03

Technical data sheet

Series 1

Sizes	Nominal pressure/ Peak pressure
60	250/315 bar
95...520	350/400 bar

for open circuits

Contents

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Unit Dimensions, Size 260 (with impeller)	12
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Features

- Variable pump with two axial piston rotary groups in swash-plate design for use in open circuit hydrostatic drives
- For use in mobile and stationary applications
- The pump consists of proven components from the A11VO (RE 92500), A10VO/53 (RE 92703) or A4VSO (RE 92050) variable pumps
- The pump operates under self-priming condition, with tank pressurisation or with charge pump (sizes 190...260)
- A wide variety of controls are available
- Setting of the constant power control is possible via external adjustments, even when the unit is operating (only with power contol).
- The pump is available with a through drive to mount a gear pump or a second axial piston pump
- Output flow is proportional to drive speed and pump displacement and is steplessly variable between maximum and zero displacement

Ordering Code / Standard Program

A20V		O			/	10		–					
01	02	03	04	05		06	07		08	09	10	11	12

Axial piston unit

01	Swashplate design, variable (Back to back - design)	A20V

	Charge pump (impeller)	**60**	**95**	**190**	**260**	**520**	
02	without charge pump (no code)	●	●	–	–	●	
	with charge pump	–	–	●	●	–	L

Operation

03	Double pump, open circuit	O

Size

04	≈ Displacement $V_{g\,max}$ in cm^3 (per rotary group)	60	95	190	260	520

	Control devices	**60**	**95**	**190**	**260**	**520**	
05	see RE 92703 (A10VO/53)	●	–	–	–	–	
	see RE 92500 (A11VO)	–	●	●	●	–	
	see RE 92050 (A4VSO) and RE 92060, RE 92064, RE 92076	–	–	–	–	●	

Series

06	Series 1, Index 0	10

Direction of rotation

07	viewed on shaft end	clockwise	R
		counter-clockwise	L

Seals

08	NBR (nitril-caoutchouc), shaft seal ring in FKM (fluor-caoutchouc)	●	●	●	●	–	N
	FKM (fluor-caoutchouc)	–	–	–	–	●	V

	Shaft end	**60**	**95**	**190**	**260**	**520**	
10	Splined shaft DIN 5480	–	●	●	●	●	Z
	Splined shaft, ANSI B92.1a-1976	●	●	–	–	–	S
		–	–	●	●	–	T
	Parallel keyed shaft, DIN 6885	–	–	–	–	●	P

	Mounting flange	**60**	**95**	**190**	**260**	**520**	
09	SAE J744 – 4-hole	●	●	●	●	–	D
	To fit flywheel housing (conformin to SAE J617) of internal combustion engine (details on request)	–	●	●	–	–	G
	ISO 3019-2 – 8-hole	–	–	–	–	●	H

	Service line ports	**60**	**95**	**190**	**260**	**520**	
11	Two service line ports and one scution port at site, opposite (fastening thread metric)	●	●	●	●	–	24
	At the site two service line ports each, opposite and one suction port displaced by 90° (fastening thread metric)	–	–	–	–	●	26

	Boost pump and through drive[1])		**60**	**95**	**190**	**260**	**520**	
12	without boost pump, without through drive		●	●	●	●	–	N00
	without boost pump, with through drive							
	Flange SAE J744	Splined shaft hub						
	82-2 (A)	5/8 in 9T 16/32DP (A)	❍	❍	❍	❍	–	K01
	127-2 (C)	1 1/4in 14T 12/24DP (C)	–	–	–	–	●	K07
	with through drive shaft, without hub, without intermediate flange, closed by a cover		–	–	–	–	●	K99

● = available ❍ = available on request – = not available

[1]) Please contact us

Technical Data

Table of values (theoretical values, without efficiencies η_{mh} and η_v; values rounded)

Size	*without* **charge pump** *with* **charge pump**		60	95	190	260	520
Displacement	$V_{g\,max}$	cm^3	60	93,8	192,7	260	520
(per rotary group)	$V_{g\,min}$	cm^3	0	0	0	0	0
Speed							
maximal [1]) at $V_{g\,max}$	n_{max}	min^{-1}	2700	2350	2500 [2])	2300 [2])	1450
Speed max. [3])							
at $V_g \leq V_{g\,max}$	n_{max}	min^{-1}	3200	2780	2500	2300	1720
Flow							
at n_{max} and $V_{g\,max}$	$q_{v\,max}$	L/min	2x162	2x220	2x482	2x598	2x754
Power at $q_{V\,max}$ and $\Delta p = 350$ bar	P_{max}	kW	135[4])	257	562	698	880
Torque at $V_{g\,max}$							
at long-term ($\Delta p = 350$ bar)	T_{max}	Nm	477 [4])	1045	2147	2897	5793
max. perm., short term ($\Delta p = 400$ bar)	T_{max}	Nm	602 [4])	1194	2454	3310	6621
Moment of inertia (of the rotating parts)	J	kgm^2	0,0113	0,0346	0,0604	0,0912	0,696
Mass approx.	m	kg	44				640

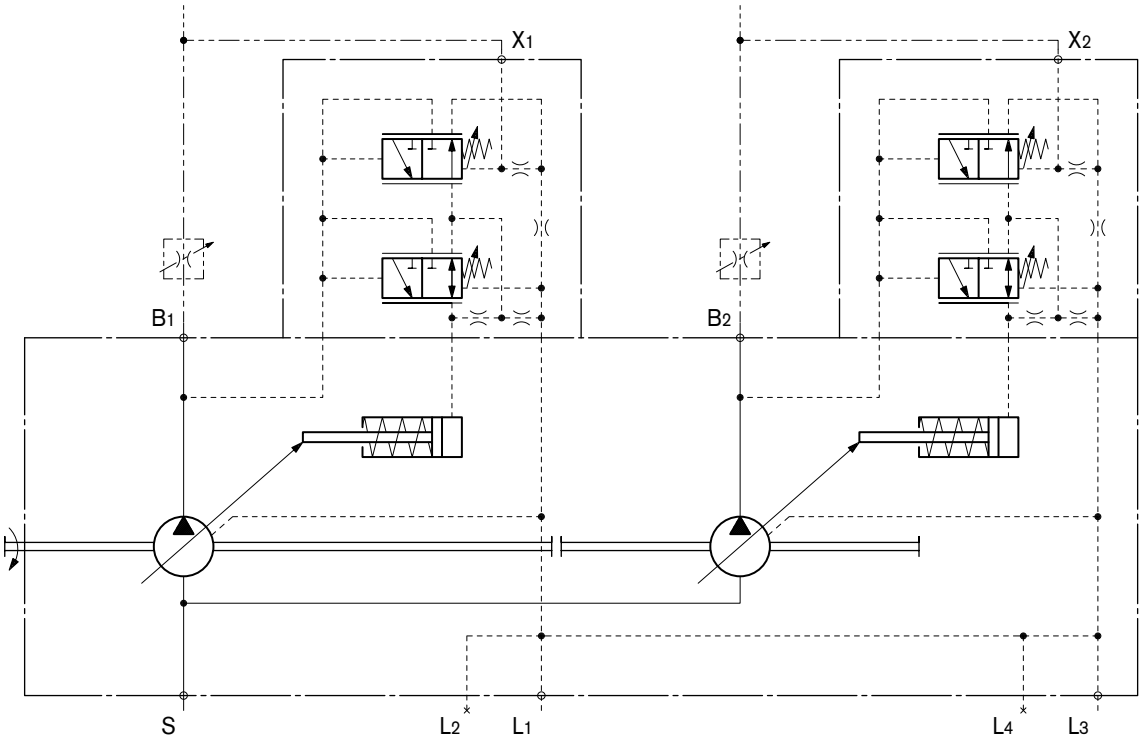
[1]) The values are quoted for an absolute pressure (p_{abs}) of 1 bar at suction port S and mineral operating fluid.
[2]) The values are quoted for an absolute pressure (p_{abs}) of at least 0.8 bar at suction port S and mineral operating fluid.
[3]) The values are quoted for $V_g < V_{g\,max}$ or increase of the input pressure p_{abs} at suction port S.
[4]) $\Delta p = 250$ bar (long-term operation) or rather 315 bar (short term).

Through Drive

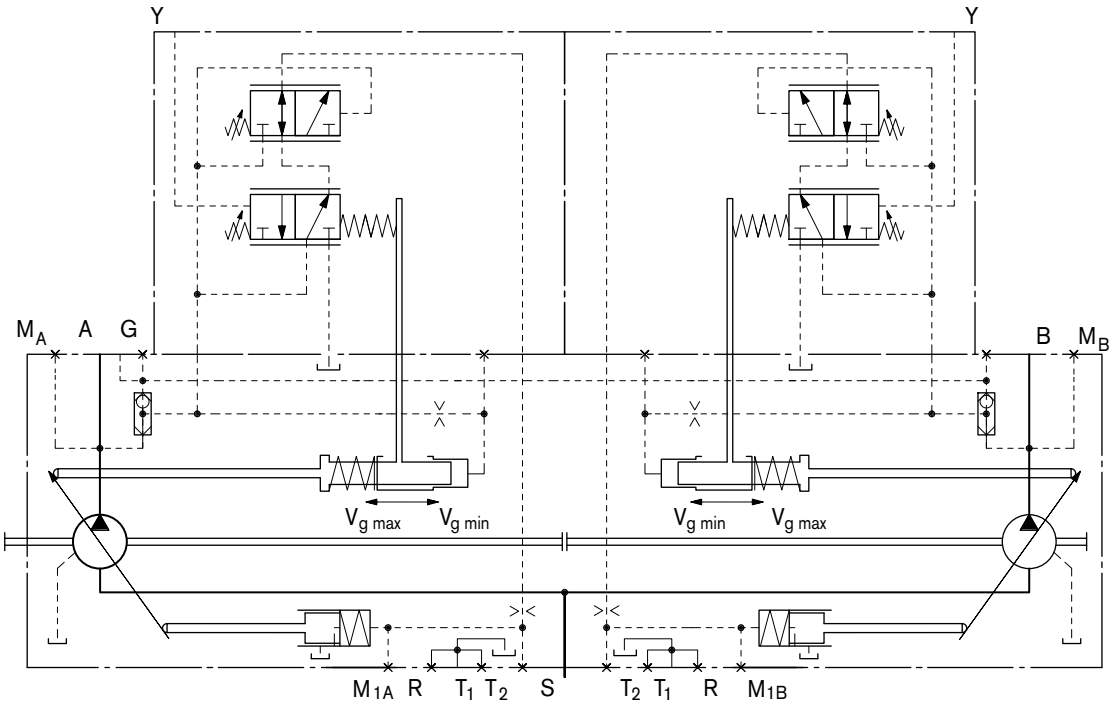
Please contact us.

Control Devices

Example circuit diagram Size 60: DFR

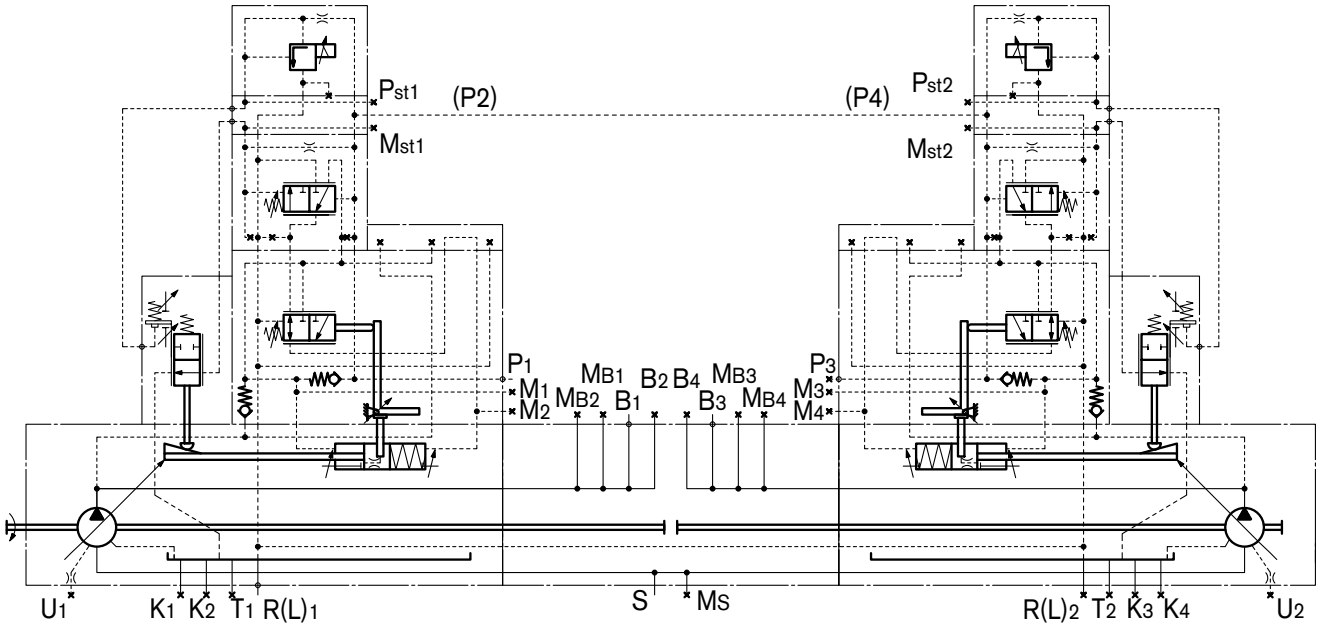


Example circuit diagram Size 95...260: HD1D



Control Devices

Example circuit diagram Size 520: LR2DN



Further technical datas as soon as control devices see

for size 60 _____ RE 95703 (A10VO/53)

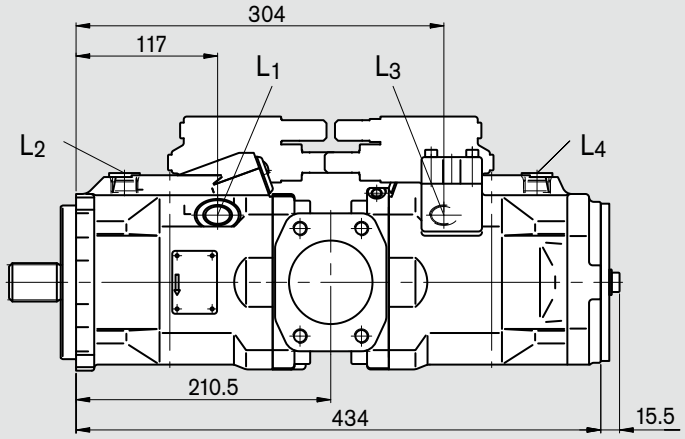
for sizes 95 ... 260 _____ RE 92500 (A11VO)

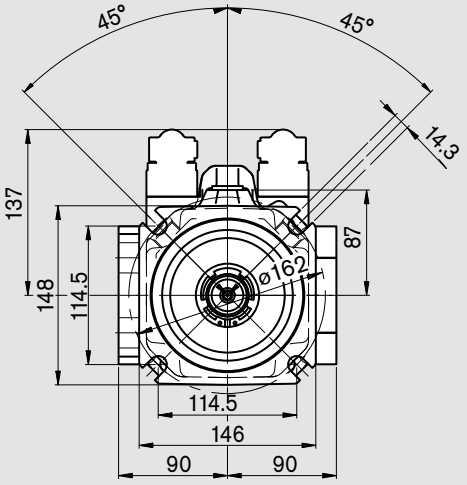
for size 520 _____ RE 92050 (A4VSO), RE 92060, RE 92064, RE 92076

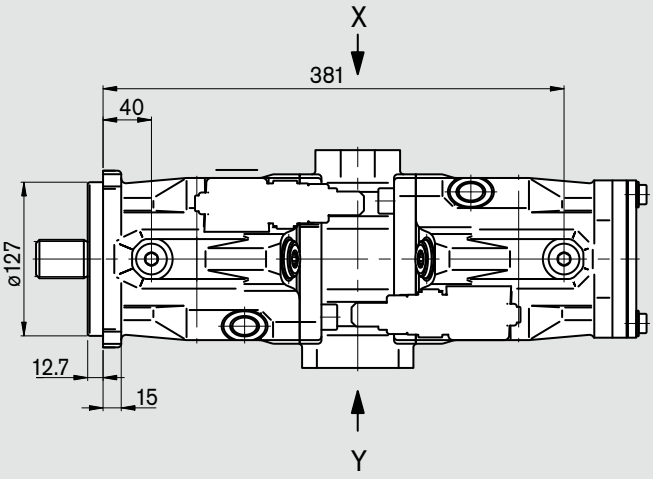
Unit Dimensions, Size 60

Before finalizing your design, please request a approved installation drawing.
Dimensions in mm

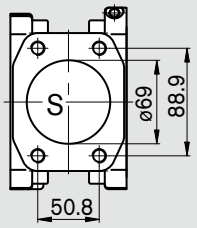
For controller selection see RE 92703 (A10VO/53)



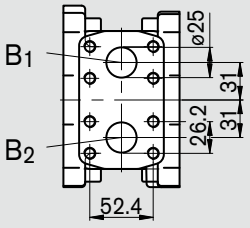




View Z



View Y

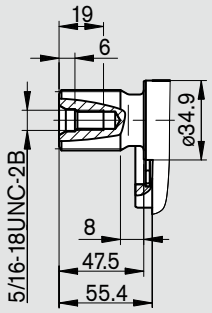


Unit Dimensions, Size 60

Before finalizing your design, please request a approved installation drawing.
Dimensions in mm

Shaft end

S Splined shaft
1 1/4in 14T 12/24DP [1])
(SAE J744 – 32-4 (C))



Ports

B_1, B_2	Service ports (High pressure series)	SAE J518	1in	
	Fastening thread	DIN 13	M10x1,5; 17 deep [2])	
S	Suction port	SAE J518	2 1/2 in	
	Fastening thread	DIN 13	M12x1,75; 20 deep [2])	
$L_{1,2,3,4}$	Case drain	DIN 3852	7/8-14UNF-2B	240 Nm [2])

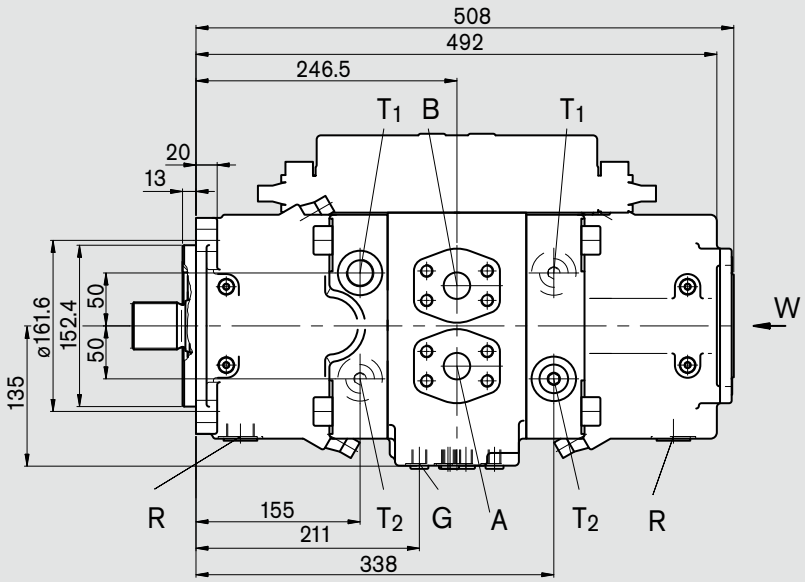
[1]) ANSI B92.1a-1976, pressure angle 30°, flat rood, side fit, tolerance class 5

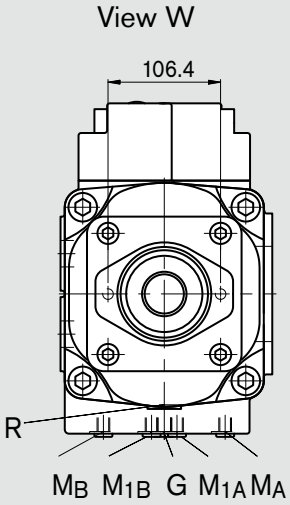
[2]) please observe the general notes for the max. tightening torques on page 16

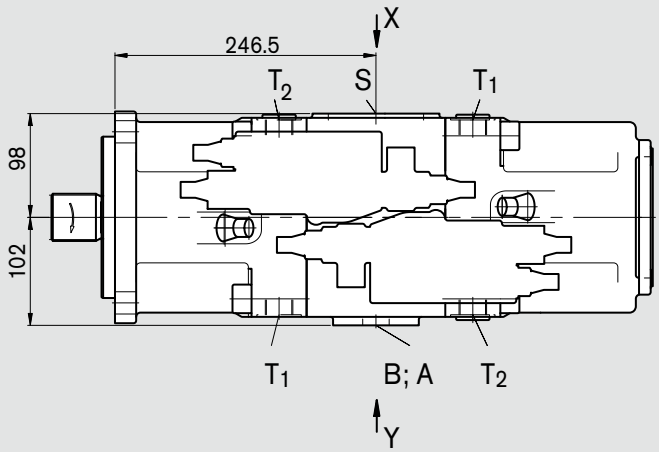
Unit Dimensions, Size 95

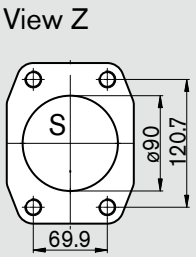
Before finalizing your design, please request a approved installation drawing.
Dimensions in mm

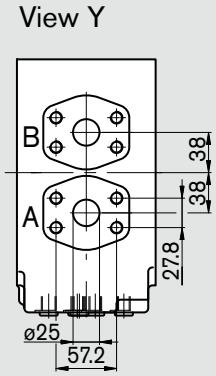
For controller selection see RE92500 (A11VO)









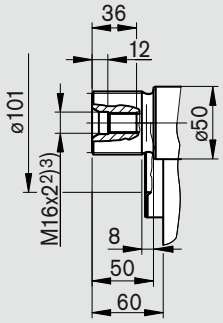


Unit Dimensions, Size 95

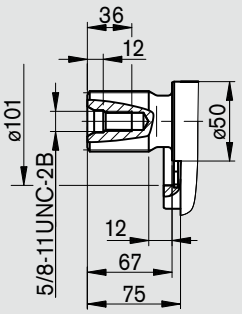
Before finalizing your design, please request a approved installation drawing.
Dimensions in mm

Shaft ends

Z Splined shaft DIN 5480
W45x2x30x21x9g



S Splined shaft
1 3/4in 13T 8/16DP [1)]
(SAE J744 – 44-4 (D))



Ports

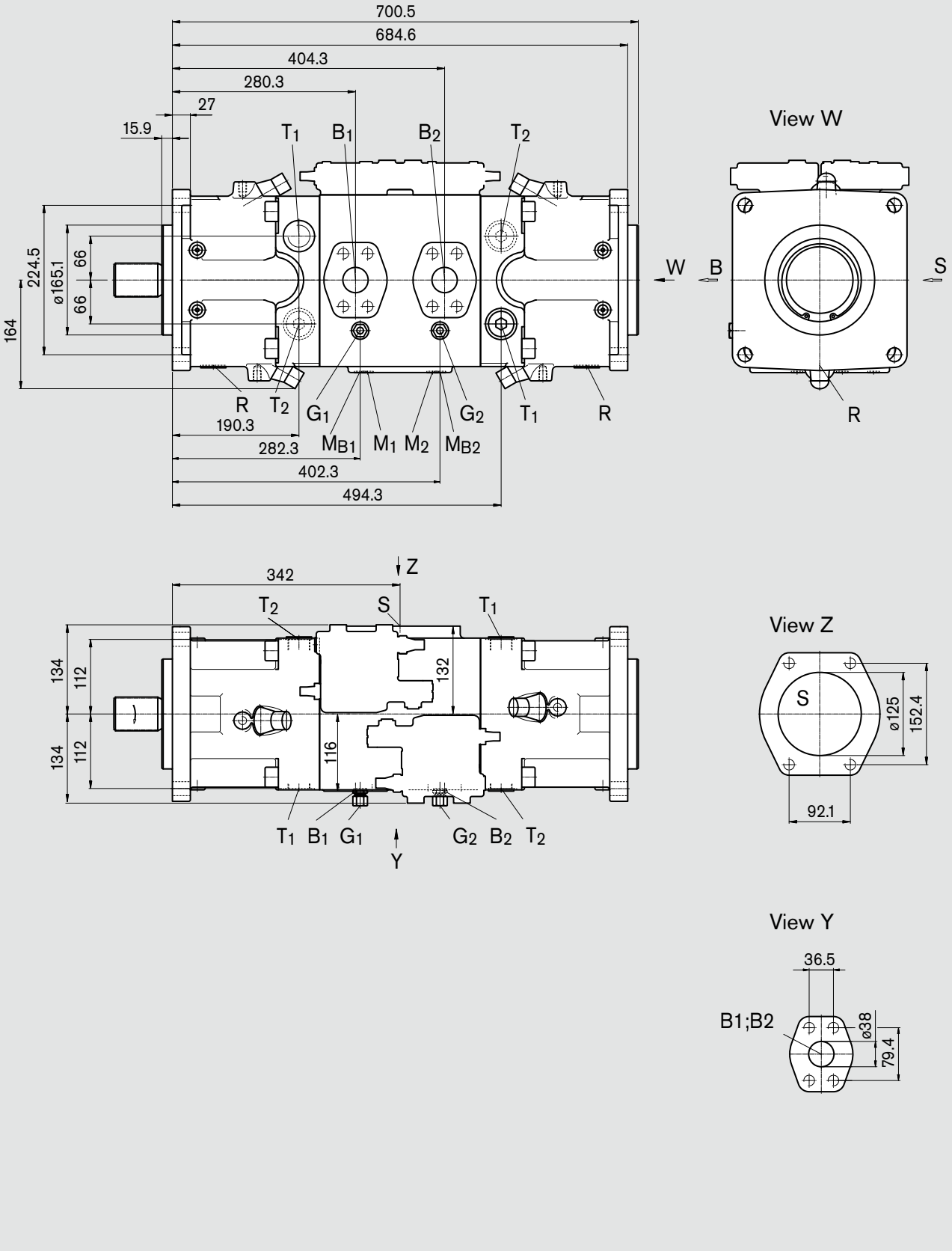
A, B	Service ports (High pressure series)	SAE J518	1in	
	Fastening threads	DIN 13	M12x1,75; 17 deep [3)]	
S	Suction port (standard series)	SAE J518	3 1/2 in	
	Fastening threads	DIN 13	M16x2; 24 deep [3)]	
T_1, T_2	Case drain	DIN3852	M26x1,5; 14 deep	230 Nm [3)]
M_A, M_B	Gauge point positioning chamber	DIN3852	M12x1,5; 12 deep	50 Nm [3)]
M_{A1}, M_{B1}	Gauge point for service port	DIN3852	M12x1,5; 12 deep	50 Nm [3)]
R	Air bleed, drain port	DIN3852	M26x1,5; 14 deep	230 Nm [3)]
G	Control pressure port (controller) [4)]	DIN3852	M14x1,5; 12 deep	80 Nm [3)]

[1)] ANSI B92.1a-1976, pressure angle 30°, flat rood, side fit, tolerance class 5
[2)] Center bore according to DIN 332 (thread according to DIN13)
[3)] please observe the general notes for the max. tightening torques on page 16
[4)] At design with stroke limiter (H..., U2), HD and EP with fitting GE10-PLM (in other case is port G plugged)

Unit Dimensions, Size 190 (with impeller)

Before finalizing your design, please request a approved installation drawing.
Dimensions in mm

For controller selection see RE92500 (A11VO)

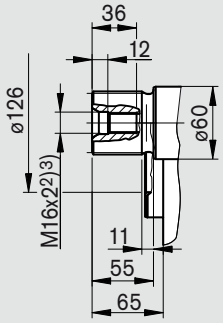


Unit Dimensions, Size 190 (with impeller)

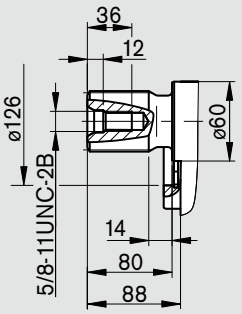
Before finalizing your design, please request a approved installation drawing.
Dimensions in mm

Shaft ends

Z Splined shaft DIN 5480
W50x2x30x24x9g



T Splined shaft
2in 15T 8/16DP 1)
(SAE J744 – 50-4 (F))



Connections

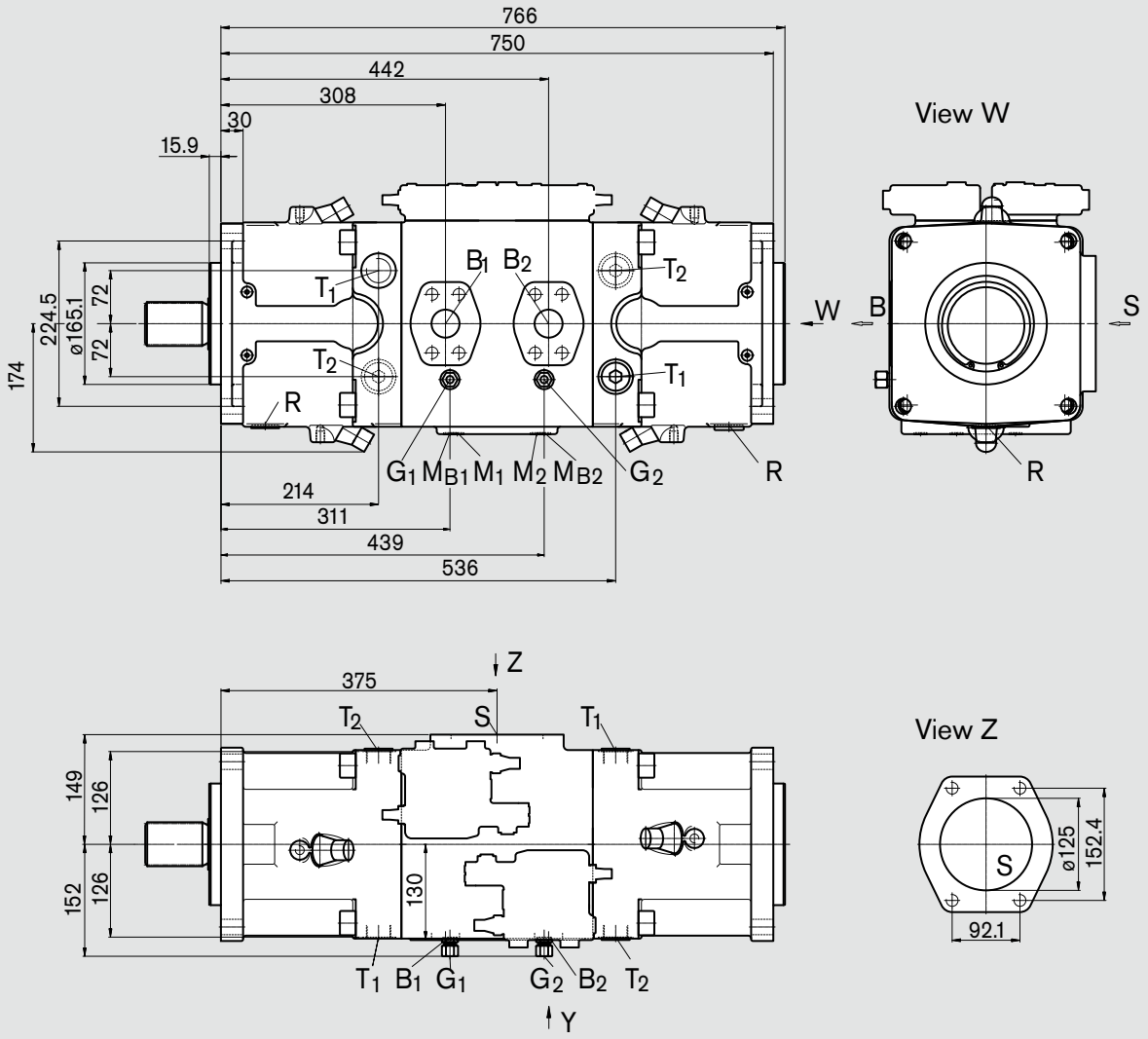
B_1, B_2	Service ports (High pressure series)	SAE J518	1 1/2 in	
	Fastening threads	DIN 13	M16x2; 21 deep	
S	Suction port (standard series)	SAE J518	5 in	
	Fastening threads	DIN 13	M16x2; 23 deep	
T_1, T_2	Case drain	DIN3852	M33x2; 18 deep	540 Nm 4)
M_1, M_2	Gauge point positioning chamber	DIN3852	M12x1,5; 12 deep	50 Nm 4)
M_{B1}, M_{B2}	Gauge point for service port	DIN3852	M12x1,5; 12 deep	50 Nm 4)
R	Air bleed, drain port	DIN3852	M33x2; 16 deep	540 Nm 4)
G_1, G_2	Control pressure port (controller) 4)	DIN3852	M14x1,5; 12 deep	80 Nm 4)

1) ANSI B92.1a-1976, pressure angle 30°, flat rood, side fit, tolerance class 5
2) Center bore according to DIN 332 (thread according to DIN13)
3) please observe the general notes for the max. tightening torques on page 16
4) At design with stroke limiter (H..., U2), HD and EP with fitting GE10-PLM (in other case is port G plugged)

Unit Dimensions, Size 260 (with impeller)

Before finalizing your design, please request a approved installation drawing.
Dimensions in mm

For controller selection see RE92500 (A11VO)

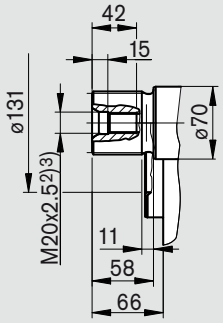


Unit Dimensions, Size 260 (with impeller)

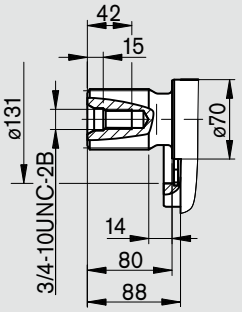
Before finalizing your design, please request a approved installation drawing.
Dimensions in mm

Shaft ends

Z Splined shaft DIN 5480
W60x2x30x28x9g



T Splined shaft
2 1/4in 17T 8/16DP [1)]



Connections

B_1, B_2	Service ports (High pressure series)	SAE J518	1 1/2 in	
	Fastening threads	DIN 13	M16x2; 21 deep [3)]	
S	Suction port (standard series)	SAE J518	5 in	
	Fastening threads	DIN 13	M16x2; 23 deep [3)]	
T_1, T_2	Case drain	DIN3852	M33x2; 18 deep	540 Nm [3)]
M_1, M_2	Gauge point positioning chamber	DIN3852	M12x1,5; 12 deep	50 Nm [3)]
M_{B1}, M_{B2}	Gauge point for service port	DIN3852	M12x1,5; 12 deep	50 Nm [3)]
R	Air bleed, drain port	DIN3852	M33x2; 16 deep	540 Nm [3)]
G_1, G_2	Control pressure port (controller) [3)]	DIN3852	M14x1,5; 12 deep	80 Nm [3)]

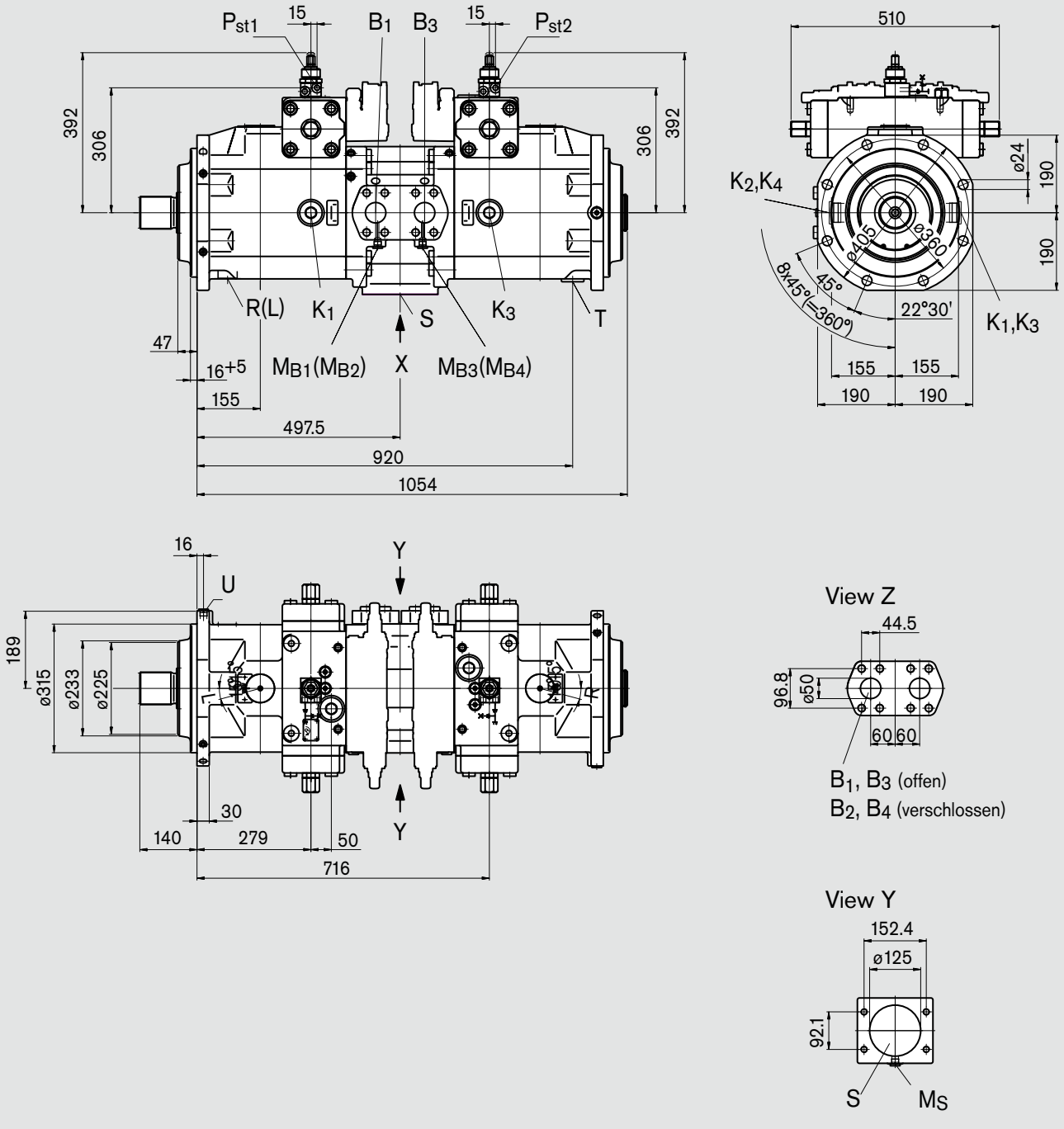
[1)] ANSI B92.1a-1976, pressure angle 30°, flat rood, side fit, tolerance class 5
[2)] Center bore according to DIN 332 (thread according to DIN13)
[3)] please observe the general notes for the max. tightening torques on page 16
[4)] At design with stroke limiter (H..., U2), HD and EP with fitting GE10-PLM (in other case is port G plugged)

Unit Dimensions, Size 520

Before finalizing your design, please request a approved installation drawing.
Dimensions in mm

For controller selection see RE92064 (A4VS)

Picture for counter-clockwise

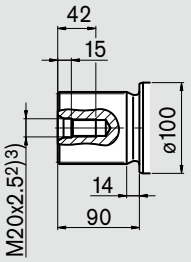


Unit Dimensions, Size 520

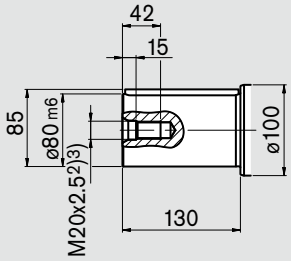
Before finalizing your design, please request a approved installation drawing.
Dimensions in mm

Shaft ends

Z Splined shaft DIN 5480
W80x3x30x25x9g



P Parallel keyed shaft
DIN 6885



Connections

B_1 - B_4	Service line ports (High pressure series)	SAE J518	2 in	
	Fastening threads	DIN 13	M20x2,5; 24 deep [3)]	
S	Suction port (standard series)	SAE J518	5 in	
	Fastening threads	DIN 13	M16x2; 24 deep [3)]	
K_1 - K_4	Flush ports		M48x2; 22 deep	960 Nm [3)]
M_{B1}, M_{B4}	Gauge point for operating pressure	DIN3852	M18x1,5; 12 deep	140 Nm [3)]
M_S	Gauge point for suction port	DIN3852	M18x1,5; 12 deep	140 Nm [3)]
P_{st1}, P_{st2}	Pilot pressure port		M14x1,5; 12 deep	80 Nm [3)]
R (L)	Air bleed, drain port	DIN3852	M48x2; 22 deep	960 Nm [3)]
T	Case drain	DIN3852	M48x2; 22 deep	960 Nm [3)]
U	Flush port	DIN3852	M18x1,5; 12 deep	140 Nm [3)]

[1)] ANSI B92.1a-1976, pressure angle 30°, flat rood, side fit, tolerance class 5
[2)] Center bore according to DIN 332 (thread according to DIN13)
[3)] please observe the general notes for the max. tightening torques on page 16
[4)] At design with stroke limiter (H1) with fitting GE10-PLM (in other case is port G plugged)

General Notes

– The pump A20VO is designed to be used in open circuits.

– Project planning, assembly and commissioning of the pump require the invovement of trained personnel.

– The working and functional ports are only designed to accommadate hydraulic piping.

– There is a danger of burns from the pump and especially the solenoids during and shortly after operation. Suitable safety precautions, e.g. protective clothing plan.

– The characteristic curve may shift depending on the operating status (operating pressure, fluid temperature) of the pump.

– Tightening torques:
  - The tightening torques specified in this data sheet are maximum values and may not be exceeded (maximum value for screw thread). Manufacturer specifications for the max. permissible tightening torques of the used fittings must be observed!
  - For DIN 13 fastening screws we recommend checking the tightening torque individually according to VDI 2230 Edition 2003.

– The data and information contained herein must be adhered to.

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The data specified above only serve to describe the product. No statements concerning a certain condition or suitability for a certain application can be derived from our information. The information given does not release the user from the obligation of own judgment and verification. It must be remembered that our products are subject to a natural process of wear and aging.

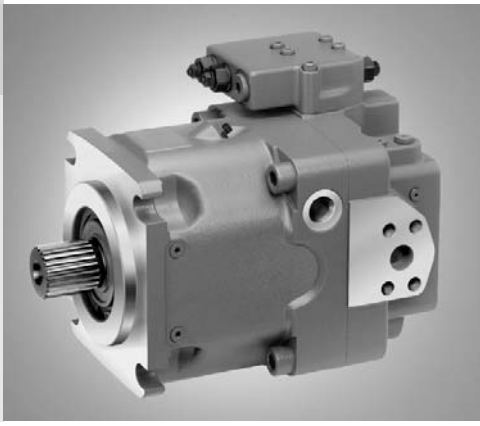
Subject to change.

Rexroth
Bosch Group

Axial Piston Variable Pump A11VO

RE 92500/10.09 1/64
Replaces: 06.09

Data sheet



Series 1
Size NG40 to 260
Nominal pressure 350 bar
Maximum pressure 400 bar
Open circuit

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Features

- Variable axial piston pump of swashplate design for hydrostatic drives in open circuit hydraulic system.
- Designed primarily for use in mobile applications.
- The pump operates under self-priming conditions, with tank pressurization, or with an optional built-in charge pump (impeller).
- A comprehensive range of control options is available matching any application requirement.
- Power control option is externally adjustable, even when the pump is running.
- The through drive is suitable for adding gear pumps and axial piston pumps up to the same, i.e. 100% through drive.
- The output flow is proportional to the drive speed and infinitely variable between $q_{V\,max}$ and $q_{V\,min} = 0$.

Ordering Code / Standard Program

A11V		O			/	1			–	N							
01	02	03	04	05		06	07	08		09	10	11	12	13	14	15	16

Axial piston unit

01	Swashplate design, variable, nominal pressure 350 bar, maximum pressure 400 bar	**A11V**

	Charge pump (impeller)	**40**	**60**	**75**	**95**	**130**	**145**	**190**	**260**	
02	without charge pump (no code)	●	●	●	●	●	●	●	●	
	with charge pump	–	–	–	–	●	●	●	●	**L**

Operation

03	Pump, open circuit	**O**

Size

04	≈ Displacement $V_{g\,max}$ in cm³	**40**	**60**	**75**	**95**	**130**	**145**	**190**	**260**

Control unit

05	Power control			LR					●	●	●	●	●	●	●	●	**LR**
	with override	cross sensing	negative	LR		C			●	●	●	●	●	●	●	●	**LR .C**
		high-pressure related	negative	LR3					●	●	●	●	●	●	●	●	**LR3**
		pilot-pressure related	negative	LG1					●	●	●	●	●	●	●	●	**LG1**
			positive	LG2					●	●	●	●	●	●	●	●	**LG2**
		electric U = 12 V	negative	LE1					❍	❍	❍	●	●	●	●	●	**LE1**
		U = 24 V	negative	LE2					❍	●	●	●	●	●	●	●	**LE2**
	with pressure cut-off				D				●	●	●	●	●	●	●	●	**L . D. .**
		hydraulic, 2-stage			E				●	●	●	●	●	●	●	●	**L . E. .**
		hydraulic, remote controlled					G		●	●	●	●	●	●	●	●	**L . . G.**
	with load sensing							S	●	●	●	●	●	●	●	●	**L . . .S**
		electric, prop. override, 24 V						S2	❍	❍	❍	●	●	●	●	●	**L . . .S2**
		hydraulic, prop. override						S5	❍	❍	❍	●	●	●	●	●	**L . . .S5**
	with stroke limiter	negative characteristic	Δp = 25 bar					H1	●	●	●	●	●	●	●	●	**L . . .H1**
			Δp = 10 bar					H5	●	●	●	●	●	●	●	●	**L . . .H5**
		positive characteristic	Δp = 25 bar					H2	●	●	●	●	●	●	●	●	**L . . .H2**
			Δp = 10 bar					H6	●	●	●	●	●	●	●	●	**L . . .H6**
			U = 12 V					U1	●	●	●	●	●	●	●	●	**L . . .U1**
			U = 24 V					U2	●	●	●	●	●	●	●	●	**L . . .U2**
	Pressure control			DR					●	●	●	●	●	●	●	●	**DR**
		with load sensing		DRS					●	●	●	●	●	●	●	●	**DRS**
		remote controlled		DRG					●	●	●	●	●	●	●	●	**DRG**
		for parallel operation		DRL					●	●	●	●	●	●	●	●	**DRL**
	Hydraulic control,		Δp = 10 bar	HD1					●	●	●	●	●	●	●	●	**HD1**
	pilot-pressure related	(positive characteristic)	Δp = 25 bar	HD2					●	●	●	●	●	●	●	●	**HD2**
		with pressure cut-off			D				●	●	●	●	●	●	●	●	**HD.D**
		with pressure cut-off, remote controlled			G				❍	●	❍	❍	❍	❍	●	●	**HD. G**
	Electric control		U = 12 V	EP1					●	●	●	●	●	●	●	●	**EP1**
	with proportional solenoid	(positive characteristic)	U = 24 V	EP2					●	●	●	●	●	●	●	●	**EP2**
		with pressure cut-off			D				●	●	●	●	●	●	●	●	**EP. D**
		with pressure cut-off, remote control			G				●	●	●	●	●	●	●	●	**EP. G**

In case of controls with several additional functions, observe the order of the columns, only one option per column is possible (e.g. LRDCH2). The following combinations are not available for the power control: LRDS2, LRDS5, L...GS, L...GS2, L...GS5, L...EC and the combination L...DG in conjunction with the stroke limiters H1, H2, H5, H6, U1 and U2.

Ordering Code / Standard Program

A11V		O			/	1			–	N							
01	02	03	04	05		06	07	08		09	10	11	12	13	14	15	16

Series

06		**1**

Index

07		Size 40 ... 130	**0**
		Size 145 ... 260	**1**

Direction of rotation

08	Viewed from shaft end	clockwise	**R**
		counter-clockwise	**L**

Seals

09	NBR (nitrile-caoutchouc), shaft seal ring in FKM (fluor-caoutchouc)	**N**

Shaft end (see page 8 for permissible input and through drive torques)		**40**	**60**	**75**	**95**	**130**	**145**	**190**	**260**	
10	Splined shaft DIN 5480 for single and combination pump	●	●	●	●	●	●	●	●	**Z**
	Parallel keyed shaft DIN 6885	●	●	●	●	●	●	●	●	**P**
	Splined shaft ANSI B92.1a–1976 for single pump	●	●	●	●	●	●	●	●	**S**
	Splined shaft ANSI B92.1a–1976 for combination pump	●	●	●	–[1]	–[1]	–[1]	●	●	**T**

Mounting flange		**40**	**60**	**75**	**95**	**130**	**145**	**190**	**260**	
11	SAE J744 – 2-hole	●	●	–	–	–	–	–	–	**C**
	SAE J744 – 4-hole	–	–	●	●	●	●	●	●	**D**
	SAE J617 [2] (SAE 3)	–	–	–	●	●	●	●	–	**G**

Service line ports		**40**	**60**	**75**	**95**	**130**	**145**	**190**	**260**	
12	Pressure and suction port SAE, at side, opposite side (with metric fastening threads)	●	●	●	●	●	●	●	●	**12**

Through drive (see page 58 for attachments)					**40**	**60**	**75**	**95**	**130**	**145**	**190**	**260**	
13	Flange SAE J744 [3]		Coupler for splined shaft										
	–		–		●	●	●	●	●	●	●	●	**N00**
	82-2	(A)	5/8in	9T 16/32DP (A)	●	●	●	●	●	●	●	●	**K01**
			3/4in	11T 16/32DP (A-B)	❍	●	❍	●	●	●	❍	❍	**K52**
	101-2	(B)	7/8in	13T 16/32DP (B)	●	●	●	●	●	●	●	●	**K02**
			1 in	15T 16/32DP (B-B)	●	●	●	●	●	●	●	●	**K04**
			W35	2x30x16x9g	●	●	●	●	●	●	●	●	**K79**
	127-2	(C) [4]	1 1/4in	14T 12/24DP (C)	–	●	●	●	●	●	●	●	**K07**
			1 1/2in	17T 12/24DP (C-C)	–	–	–	●	●	●	●	●	**K24**
			W30	2x30x14x9g	–	●	●	●	●	●	●	●	**K80**
			W35	2x30x16x9g	–	●	●	●	●	●	●	●	**K61**
	152-4	(D)	1 1/4in	14T 12/24DP (C)	–	–	●	●	●	●	●	●	**K86**
			1 3/4in	13T 8/16DP (D)	–	–	–	–	●	●	●	●	**K17**
			W40	2x30x18x9g	–	–	●	●	●	●	●	●	**K81**
			W45	2x30x21x9g	–	–	–	●	●	●	●	●	**K82**
			W50	2x30x24x9g	–	–	–	–	●	●	●	●	**K83**
	165-4	(E)	1 3/4in	13T 8/16DP (D)	–	–	–	–	–	–	●	●	**K72**
			W50	2x30x24x9g	–	–	–	–	–	–	●	●	**K84**
			W60	2x30x28x9g	–	–	–	–	–	–	–	●	**K67**

Ordering Code / Standard Program

A11V		**O**			**/**	**1**			**–**	**N**							
01	02	03	04	05		06	07	08		09	10	11	12	13	14	15	16

	Swivel angle indicator (page 59)	**40**	**60**	**75**	**95**	**130**	**145**	**190**	**260**	
14	without swivel angle indicator (no symbol)	●	●	●	●	●	●	●	●	
	with optical swivel angle indicator	●	–	●	●	●	●	●	●	**V**
	with electric swivel angle sensor	●	–	●	●	●	●	●	●	**R**

	Connector for solenoids (page 60)	**40**	**60**	**75**	**95**	**130**	**145**	**190**	**260**	
15	DEUTSCH connector molded, 2-pin – without suppressor diode	●	●	●	●	●	●	●	●	**P**

Standard / special version

16	Standard version	without symbol	
		combined with attachment part or attachment pump	**-K**
	Special version		**-S**
		combined with attachment part or attachment pump	**-SK**

[1] **S**-shaft suitable for combination pump!
[2] To fit the flywheel case of the combustion engine
[3] 2 ≙ 2-hole; 4 ≙ 4-hole
[4] Size 190 and 260 with 2 + 4-hole flange

● = available ❍ = on request – = not available ▭ = preferred program

Technical Data

Hydraulic fluid

Before starting project planning, please refer to our data sheets RE 90220 (mineral oil), RE 90221 (environmentally acceptable hydraulic fluids) and RE 90223 (HF hydraulic fluids) for detailed information regarding the choice of hydraulic fluid and operating conditions.

The variable pump A11VO is not suitable for operating with HFA, HFB and HFC. If HFD or environmentally acceptable hydraulic fluids are being used, the limitations regarding technical data and seals mentioned in RE 90221 and RE 90223 must be observed.

When ordering, please indicate the used hydraulic fluid.

Operating viscosity range

For optimum efficiency and service life, select an operating viscosity (at operating temperature) within the optimum range of

ν_{opt} = optimum operating viscosity 16 to 36 mm²/s

depending on the tank temperature (open circuit).

Limits of viscosity range

The limiting values for viscosity are as follows:

ν_{min} = 5 mm²/s
Short-term (t < 3 min)
At max. perm. temperature of t_{max} = +115°C.

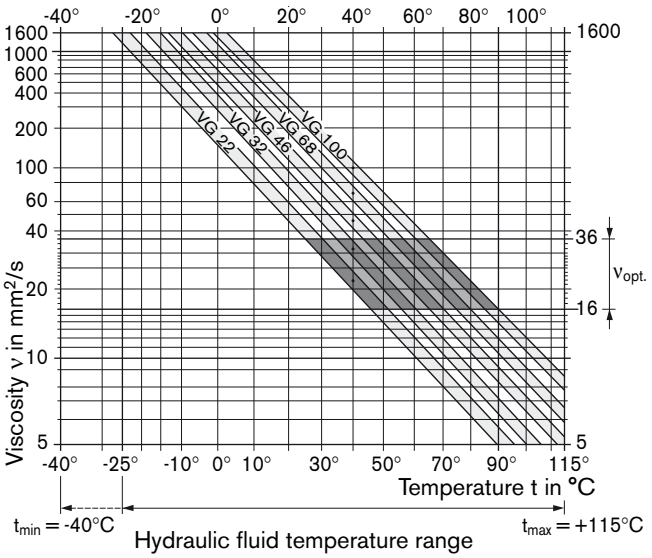
ν_{max} = 1600 mm²/s
Short-term (t < 3 min)
At cold start (p ≤ 30 bar, n ≤ 1000 rpm, t_{min} = -40°C).
Only for starting up without load. Optimum operating viscosity must be reached within approx. 15 minutes.

Note that the maximum hydraulic fluid temperature of 115°C must not be exceeded locally either (e.g. in the bearing area). The temperature in the bearing area is – depending on pressure and speed – up to 5 K higher than the average case drain temperature.

Special measures are necessary in the temperature range from -40°C and -25°C (cold start phase), please contact us.

For detailed information about use at low temperatures, see RE 90300-03-B.

Selection diagram



Details regarding the choice of hydraulic fluid

The correct choice of hydraulic fluid requires knowledge of the operating temperature in relation to the ambient temperature: in an open circuit the tank temperature.

The hydraulic fluid should be chosen so that the operating viscosity in the operating temperature range is within the optimum range ($\nu_{opt.}$) – see the shaded area of the selection diagram. We recommended that the higher viscosity class be selected in each case.

Example: At an ambient temperature of X°C an operating temperature of 60°C is set. In the optimum operating viscosity range (ν_{opt}; shaded area) this corresponds to the viscosity classes VG 46 and VG 68; to be selected: VG 68.

Please note:
The case drain temperature, which is affected by pressure and speed, is always higher than the tank temperature. At no point in the system may the temperature be higher than 115°C.

If the above conditions cannot be maintained due to extreme operating parameters, please contact us.

Filtration

The finer the filtration, the higher the cleanliness level of the hydraulic fluid and the longer the service life of the axial piston unit.

To ensure functional reliability of the axial piston unit, the hydraulic fluid must have a claenliness level of at least

20/18/15 according to ISO 4406.

At very high hydraulic fluid temperatures (90°C to max. 115°C, not permitted for sizes 250 to 1000) at least cleanliness level

19/17/14 according to ISO 4406 is required.

If the above classes cannot be observed, please contact us.

Technical Data

Operating pressure range

Inlet

Absolute pressure at port S (suction port)
Version *without* charge pump

$p_{abs\ min}$ 0.8 bar
$p_{abs\ max}$ 30 bar

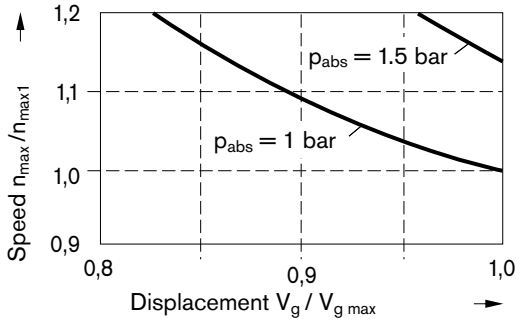
If the pressure is > 5 bar, please ask.

Version *with* charge pump

$p_{abs\ min}$ 0.6 bar
$p_{abs\ max}$ 2 bar

Maximum permissible speed (speed limit)

Permissible speed by increasing the inlet pressure p_{abs} at the suction port S or at $V_g \leq V_{g\ max}$



Outlet

Pressure at port A or B

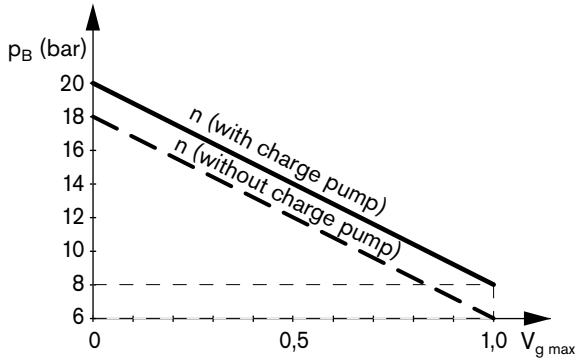
Nominal pressure p_N 350 bar
Maximum pressure p_{max} 400 bar

Nominal pressure: Max. design pressure at which fatigue strength is ensured.

Maximum pressure: Max. operating pressure which is permissible for short-term (t < 1s).

Minimum operating pressure

A minimum operating pressure $p_{B\ min}$ is required in the pump service line depending on the speed, the swivel angle and the displacement (see diagram).



Case drain pressure

The case drain pressure at the ports T_1 and T_2 may be a maximum of 1.2 bar higher than the inlet pressure at the port S but not higher than

$p_{L\ abs.\ max}$ 2 bar.

An unrestricted, full size case drain line directly to tank is required.

Temperature range of the shaft seal ring

The FKM shaft seal ring is permissible for case drain temperatures of -25°C to +115°C.

Note:
For applications below -25°C, an NBR shaft seal ring is necessary (permissible temperature range: -40°C to +90°C).
State NBR shaft seal ring in clear text in the order.

Flushing the case

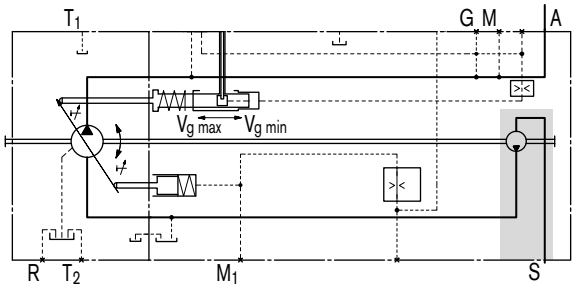
If a variable pump with control unit **EP, HD, DR** or stroke limiter (**H., U.**,) is operated over a long period (t > 10 min) with flow zero or operating pressure < 15 bar, flushing of the case via ports "T_1", "T_2" or "R" is necessary.

Size	40	60	75	95	130	145	190	260
$q_{V\ flush}$(l/min)	2	3	3	4	4	4	5	6

Flushing the case is unnecessary in versions with charge pump (A11VLO), since a part of the charge flow is directed to the case.

Charge pump (impeller)

The charge pump is a circulating pump with which the A11VLO (size 130...260) 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. Tank charging is therefore unnecessary in most cases. A tank pressure of a max. 2 bar is permissible with charge pump.



Technical Data

Table of values (theoretical values, without efficiency and tolerances; values rounded)

Size	A11VO		40	60	75	95	130	145	190	260
Displacement	$V_{g\,max}$	cm^3	42	58.5	74	93.5	130	145	193	260
	$V_{g\,min}$	cm^3	0	0	0	0	0	0	0	0
Speed										
maximum at $V_{g\,max}$ [1]	n_{max}	rpm	3000	2700	2550	2350	2100	2200	2100	1800
maximum at $V_g \le V_{g\,max}$ [3]	n_{max1}	rpm	3500	3250	3000	2780	2500	2500	2100	2300
Flow at n_{max} and $V_{g\,max}$	$q_{v\,max}$	l/min	126	158	189	220	273	319	405	468
Power at $q_{v\,max}$ and $\Delta p = 350$ bar	P_{max}	kW	74	92	110	128	159	186	236	273
Torque at $V_{g\,max}$ and $\Delta p = 350$ bar	T_{max}	Nm	234	326	412	521	724	808	1075	1448
Rotary stiffness	Z shaft	Nm/rad	88894	102440	145836	199601	302495	302495	346190	686465
	P shaft	Nm/rad	87467	107888	143104	196435	312403	312403	383292	653835
	S shaft	Nm/rad	58347	86308	101921	173704	236861	236861	259773	352009
	T shaft	Nm/rad	74476	102440	125603	–	–	–	301928	567115
Moment of inertia for rotary group	J_{TW}	kgm^2	0.0048	0.0082	0.0115	0.0173	0.0318	0.0341	0.055	0.0878
Angular acceleration, max. [4]										
	α	rad/s^2	22000	17500	15000	13000	10500	9000	6800	4800
Filling capacity	V	l	1.1	1.35	1.85	2.1	2.9	2.9	3.8	4.6
Mass (approx.)	m	kg	32	40	45	53	66	76	95	125

Size	A11VLO (with charge pump)		130	145	190	260
Displacement	$V_{g\,max}$	cm^3	130	145	193	260
	$V_{g\,min}$	cm^3	0	0	0	0
Speed						
maximum at $V_{g\,max}$ [2]	n_{max}	rpm	2500	2500	2500	2300
maximum at $V_g \le V_{g\,max}$ [3]	n_{max1}	rpm	2500	2500	2500	2300
Flow at n_{max} and $V_{g\,max}$	$q_{v\,max}$	l/min	325	363	483	598
Power at $q_{v\,max}$ and $\Delta p = 350$ bar	P_{max}	kW	190	211	281	349
Torque at $V_{g\,max}$ and $\Delta p = 350$ bar	T_{max}	Nm	724	808	1075	1448
Rotary stiffness	Z shaft	Nm/rad	302495	302495	346190	686465
	P shaft	Nm/rad	312403	312403	383292	653835
	S shaft	Nm/rad	236861	236861	259773	352009
	T shaft	Nm/rad	–	–	301928	567115
Moment of inertia for rotary group	J_{TR}	kgm^2	0.0337	0.036	0.0577	0.0895
Angular acceleration, max. [4]						
	α	rad/s^2	10500	9000	6800	4800
Filling capacity	V	l	2.9	2.9	3.8	4.6
Mass (approx.)	m	kg	72	73	104	138

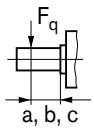
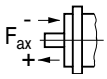
[1] The values apply at absolute pressure (p_{abs}) 1 bar at the suction port S and mineral hydraulic fluid.
[2] The values apply at absolute pressure (p_{abs}) of at least 0.8 bar at the suction port S and mineral hydraulic fluid.
[3] The values apply at $V_g \le V_{g\,max}$ or in case of an increase in the inlet pressure p_{abs} at the suction port S (see diagram page 6)
[4] – The area of validity is situated between 0 and the maximum permissible speed.
It applies for external stimuli (e.g. engine 2-8 times rotary frequency, cardan shaft twice the rotary frequency).
– The limit value applies for a single pump only.
– The loading on the connection parts has to be considered.

Caution:
Exceeding the permissible limit values could cause a loss of function, reduced service life or the destruction of the axial piston unit. The permissible values can be determined by calculation.

Technical Data

Permissible radial and axial loading on drive shaft

The values stated are maximum data and not permissible for continuous operation

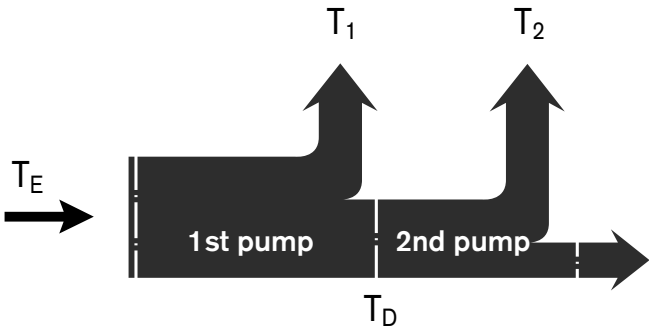
Size			Size	40	60	75	95	130	145	190	260
Radial force, max. at distance a, b, c (from shaft collar)		$F_{q\,max}$	N	3600	5000	6300	8000	11000	11000	16925	22000
		a	mm	17.5	17.5	20	20	22.5	22.5	26	29
		$F_{q\,max}$	N	2891	4046	4950	6334	8594	8594	13225	16809
		B	mm	30	30	35	35	40	40	46	50
		$F_{q\,max}$	N	2416	3398	4077	5242	7051	7051	10850	13600
		c	mm	42.5	42.5	50	50	57.5	57.5	66	71
Axial force, max.			N	1500	2200	2750	3500	4800	4800	6000	4150

Permissible input and through drive torques

Size		Size	40	60	75	95	130	145	190	260
Torque (at $V_{g\,max}$ and $\Delta p = 350$ bar [1])	T_{max}	Nm	234	326	412	521	724	808	1075	1448
Input torque, max. [2]										
at shaft end P Shaft key DIN 6885	$T_{E\,perm.}$	Nm	468 ø32	648 ø35	824 ø40	1044 ø45	1448 ø50	1448 ø50	2226 ø55	2787 ø60
at Z shaft end DIN 5480	$T_{E\,perm.}$	Nm	912 W35	912 W35	1460 W40	2190 W45	3140 W50	3140 W50	3140 W50	5780 W60
at S shaft end ANSI B92.1a-1976 (SAE J744)	$T_{E\,perm.}$	Nm	314 1 in	602 1 1/4 in	602 1 1/4 in	1640 1 3/4 in	1640 1 3/4 in	1640 1 3/4 in	1640 1 3/4 in	1640 1 3/4 in
at T shaft end ANSI B92.1a-1976 (SAE J744)	$T_{E\,perm.}$	Nm	602 1 1/4 in	970 1 3/8 in	970 1 3/8 in	– –	– –	– –	2670 2 in	4070 2 1/4 in
Through drive torque, max. [3]	$T_{D\,perm.}$	Nm	314	521	660	822	1110	1110	1760	2065

[1] Efficiency not considered
[2] For drive shafts with no radial force
[3] Observe max. input torque for shaft **S**!

Torque distribution



Determining the nominal value

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

Torque $T = \frac{V_g \cdot \Delta p}{20 \cdot \pi \cdot \eta_{mh}}$ Nm

Power $P = \frac{2\,\pi \cdot T \cdot n}{60{,}000} = \frac{q_v \cdot \Delta p}{600 \cdot \eta_t}$ kW

V_g = Displacement per revolution in cm^3
Δp = Differential pressure in bar
n = Speed in rpm
η_v = Volumetric efficiency
η_{mh} = Mechanical-hydraulic efficiency
η_t = Overall efficiency ($\eta_t = \eta_v \cdot \eta_{mh}$)

LR – Power Control

The power control regulates the displacement of the pump depending on the operating pressure so that a given drive power is not exceeded at constant drive speed.

$p_B \bullet V_g = \text{constant}$

p_B = operating pressure
V_g = displacement

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. An externally adjustable spring force counteracts this, it determines the power setting.

If the operating pressure exceeds the set spring force, the control valve is actuated by the rocker, the pump swivels back (direction $V_{g\,min}$). The lever length at the rocker is shortened and the operating pressure can increase at the same rate as the displacement decreases without the drive powers being exceeded ($p_B \bullet V_g$ = constant).

The hydraulic output power (characteristic LR) is influenced by the efficiency of the pump.

State in clear text in the order:

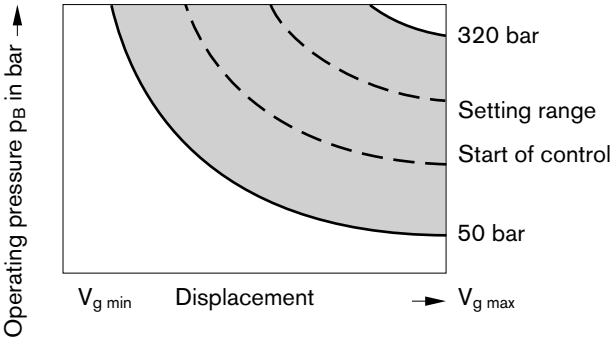
– drive power P in kW

– drive speed n in rpm

– max. flow $q_{V\,max}$ in l/min

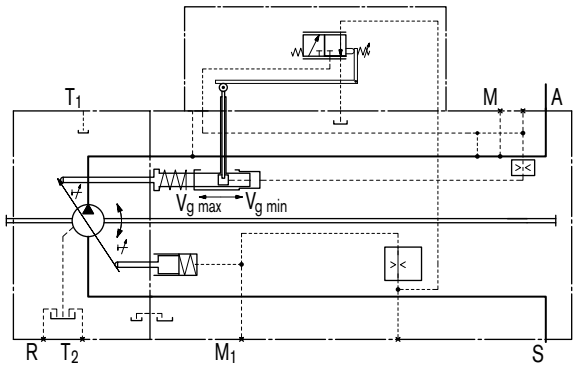
After clarifying the details a power diagram can be created by our computer.

Characteristic LR

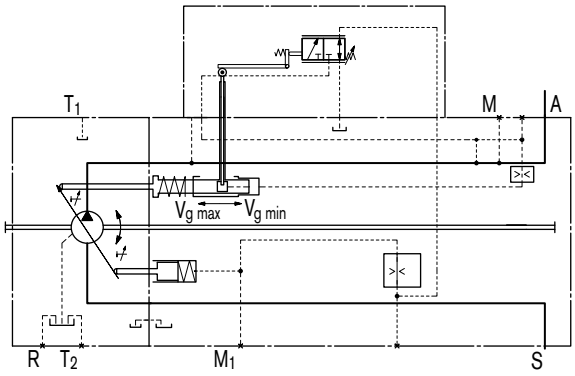


Circuit diagram LR

Size 40 ... 145



Size 190 ... 260



LR – Power Control

LRC Override with cross sensing

Cross sensing control is a summation power control system, whereby the total power, of both the A11VO and of a same size A11VO power controlled pump mounted onto the through drive, are kept constant.

If a pump is operating at pressures below the start of the control curve setting, then the surplus power not required, in a critical case up to 100%, becomes available to the other pump. Total power is thus divided between two systems as demand requires.

Any power being limited by means of pressure cut-off or other override functions is not taken into account.

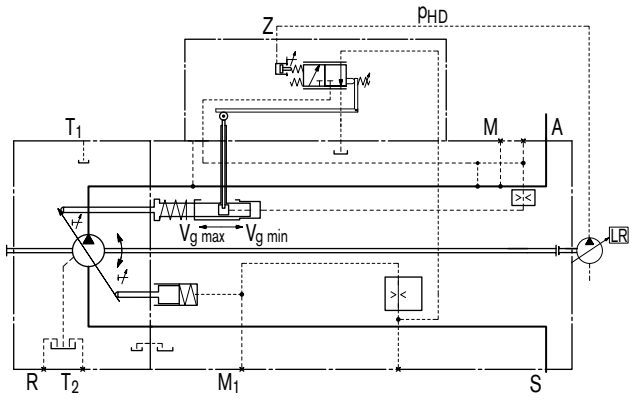
Half side cross sensing function

When using the LRC control on the 1st pump (A11VO) and a power-controlled pump without cross sensing attached to the through drive, the power required for the 2nd pump is deducted from the setting of the 1st pump. The 2nd pump has priority in the total power setting.

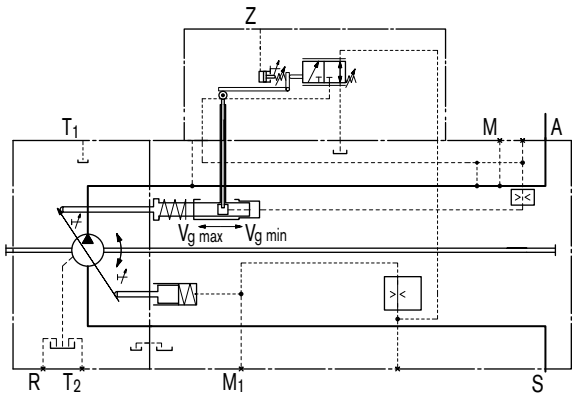
The size and start of control of the power control of the 2nd pump must be specified for rating the control of the 1st pump.

Circuit diagram LRC

Size 40 ... 145



Size 190 ... 260



LR3 High-pressure related override

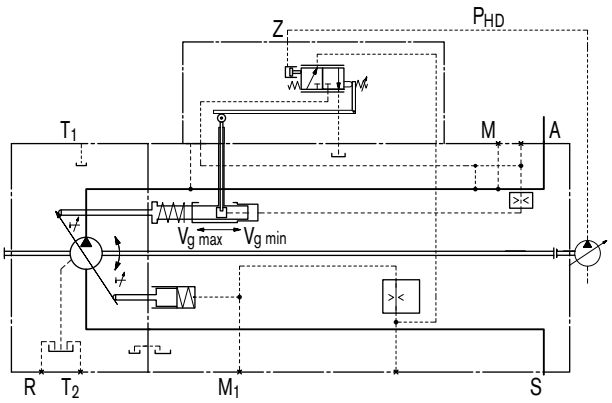
The high-pressure related power override is a total power control in which the power control setting is piloted by the load pressure of an attached fixed pump (port Z).

As a result the A11VO can be set to 100% of the total drive power. The power setting of the A11VO is reduced proportional to the load-dependent rise in operating pressure of the fixed pump. The fixed pump has priority in the total power setting.

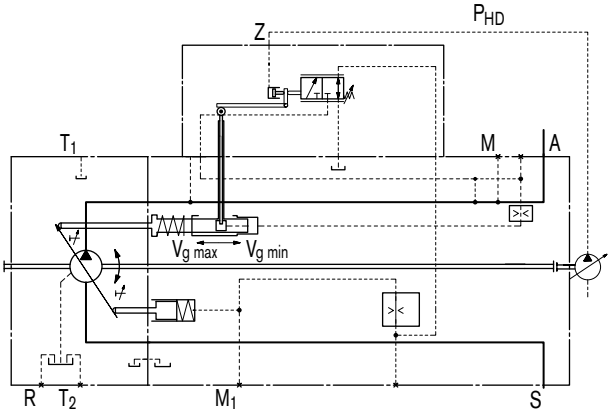
The measuring area of the power reduction pilot piston is designed as a function of the size of the fixed pump.

Circuit diagram LR3

Size 40 ... 145



Size 190 ... 260



LR – Power Control

LG1/2 Pilot-pressure related override

This power control works by overriding the control setting with an external pilot pressure signal. This pilot pressure acts on the adjustment spring of the power regulator via port Z.

The mechanically adjusted basic setting can be hydraulically adjusted by means of different pilot pressure settings, enabling different power mode settings.

If the pilot pressure signal is then adjusted by means of an external power limiting control, the total hydraulic power consumption of all users can be adapted to the available drive power from the engine.

The pilot pressure used for power control is generated by an external control element that is not a component part of the A11VO (e.g. see also data sheet RE 95310, Electronic Load Limiting Control, LLC).

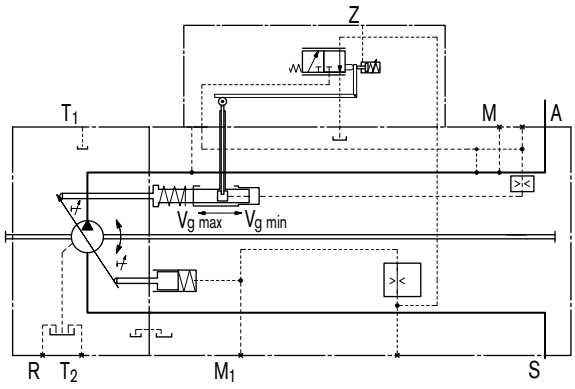
LG1 Negative power override

Power control with negative override, LG1: the force resulting from the pilot pressure is acting against the mechanical adjustment spring of the power control.

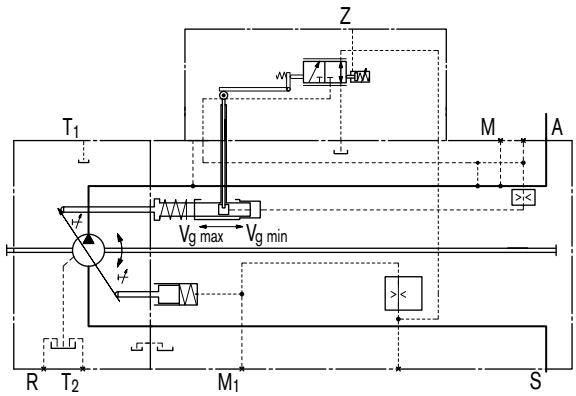
Increasing the pilot pressure reduces the power setting.

Circuit diagram LG1

Size 40 ... 145



Size 190 ... 260



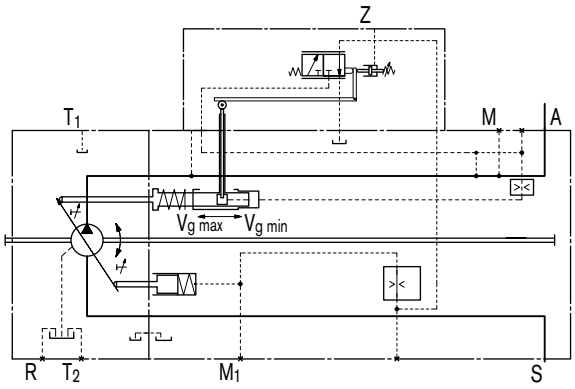
LG2 Positive power override

Power control with positive override, LG2: the force resulting from the pilot pressure is additive the mechanical adjustment spring of the power control.

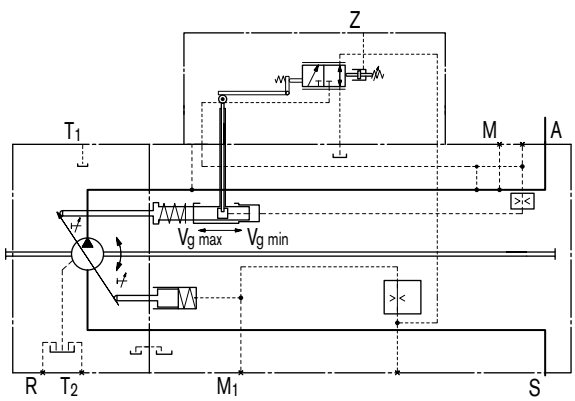
An increase in pilot pressure increases the power output.

Circuit diagram LG2

Size 40 ... 145



Size 190 ... 260



LR – Power Control

LE1/2 Electric override (negative)

Contrary to hydraulic power control override, the basic power setting is reduced by an electric pilot current applied to a proportional solenoid. The resulting force is acting against the mechanical power control adjustment spring.

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

Increase in current = decrease in power

If the pilot current signal is adjusted by a load limiting control the power consumption of all actuators will be reduced to match the available power from the diesel engine.

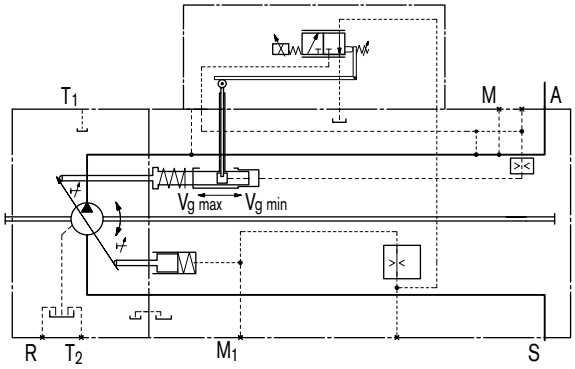
A 12V (LE1) or 24V (LE2) supply is required for the control of the proportion solenoid.

Technical data - Solenoids

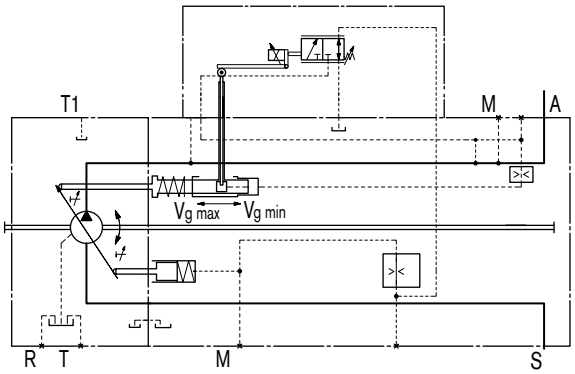
	LE1	LE2
Voltage	12 V (±20 %)	24 V (±20 %)
Control current		
Start of control	400 mA	200 mA
End of control	1200 mA	600 mA
Limiting current	1.54 A	0.77 A
Nominal resistance (at 20°C)	5.5 Ω	22.7 Ω
Dither frequency	100 Hz	100 Hz
Actuated time	100 %	100 %
Type of protection	see connector version, page 60	

Circuit diagram LE1/2

Size 40 ... 145

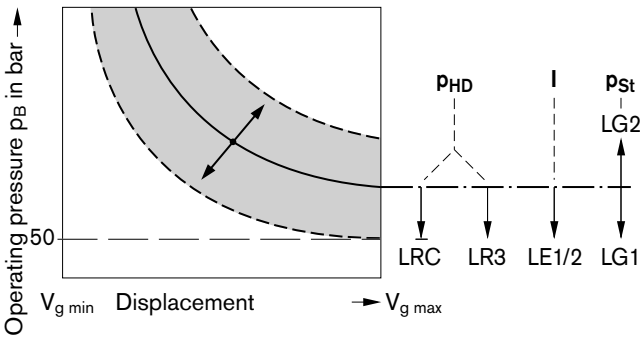


Size 190 ... 260



Overview of power overrides

Effect of power overrides at rising pressure or current



LR – Power Control

LRD Power control with pressure cut-off

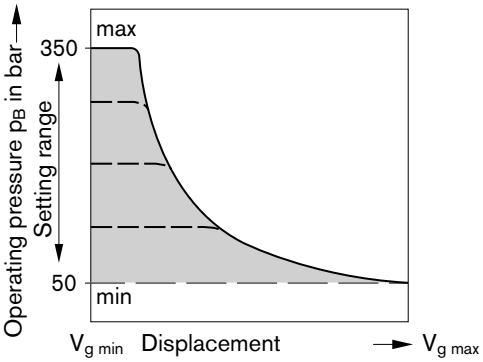
The pressure cut-off corresponds to a pressure control which adjusts the pump displacement back to $V_{g\,min}$, when the pressure setting is reached.

This function overrides the power control, i.e. below the preset pressure value, the power function is effective.

The pressure cut-off function is integrated into the pump control module and is preset to a specified value at the factory.

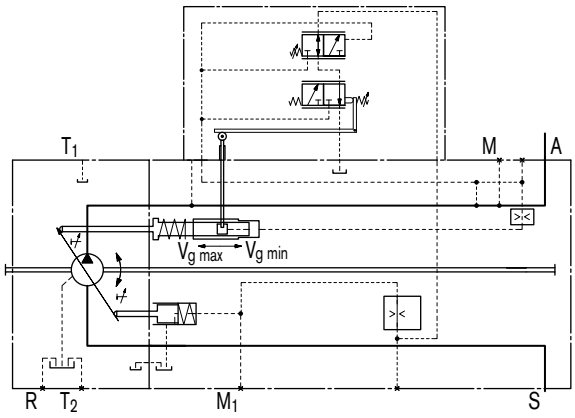
Setting range from 50 to 350 bar

Characteristic LRD

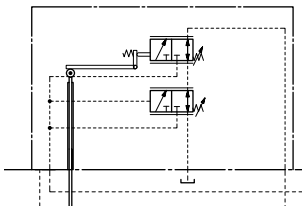


Circuit diagram LRD

Size 40...145



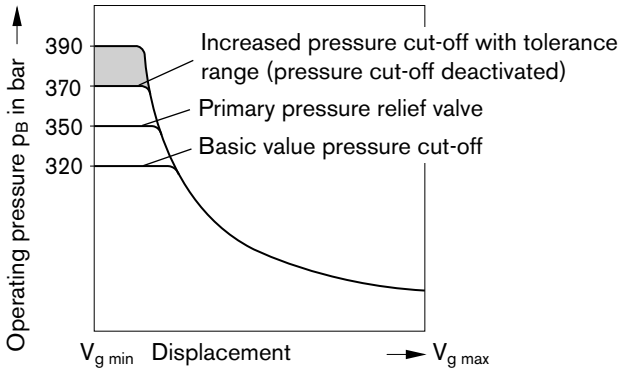
Size 190...260



LRE Power control with pressure cut-off, 2-stage

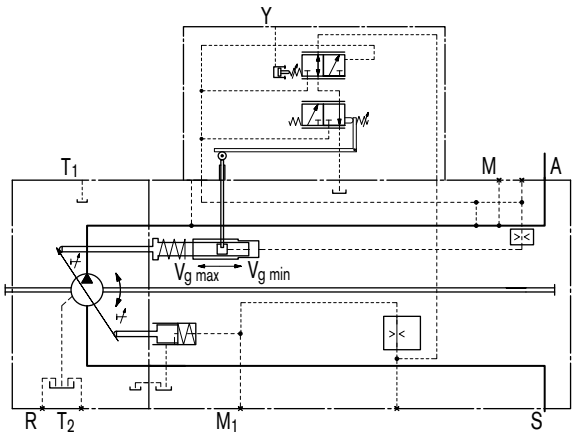
By connecting an external pilot pressure to port Y, the basic value of the pressure cut-off can be increased by 50 $^{+20}$ bar and a 2nd pressure setting implemented.
This value is usually above the primary pressure relief valve setting and therefore disables the pressure cut-off function.
The pressure signal at port Y must be between 20 and 50 bar.

Characteristic LRE

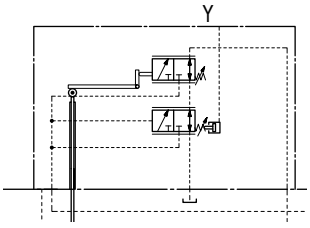


Circuit diagram LRE

Size 40...145



Size 190...260



LRG Power control with pressure cut-off, hydraulically remote controlled

See page 21 for description and characteristic (pressure control remote controlled, DRG)

LR – Power Control

LRDS Power control with pressure cut-off and load sensing

The load sensing control is a flow control option that operates as a function of the load pressure to regulate the pump displacement to match the actuator flow requirement.

The flow depends here on the cross section of the external sensing orifice (1) fitted between the pump outlet and the actuator. The flow is independent of the load pressure below the power curve and the pressure cut-off setting and within the control range of the pump.

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

The load sensing control compares pressure before and after the sensing orifice and maintains the pressure drop across the orifice (differential pressure Δp) and with it the pump flow constant.

If the differential pressure Δp increases at the sensing orifice, the pump is swivelled back (towards $V_{g\,min}$), and, if the differential pressure Δp decreases, the pump is swivelled out (towards $V_{g\,max}$) until the pressure drop across the sensing orifice in the valve is restored.

$\Delta p_{orifice} = p_{pump} - p_{actuator}$

The setting range for Δp is between 14 bar and 25 bar.

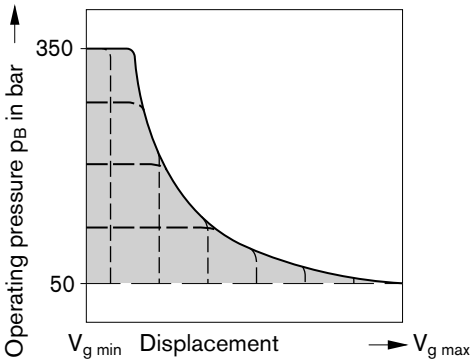
The standard differential pressure setting is 18 bar. (Please state in clear text when ordering).

The stand-by pressure in zero stroke operation (sensing orifice plugged) is slightly above the Δp setting.

In a standard LS system the pressure cut-off is integrated in the pump control. In a LUDV (flow sharing) system the pressure cut-off is integrated in the LUDV control block.

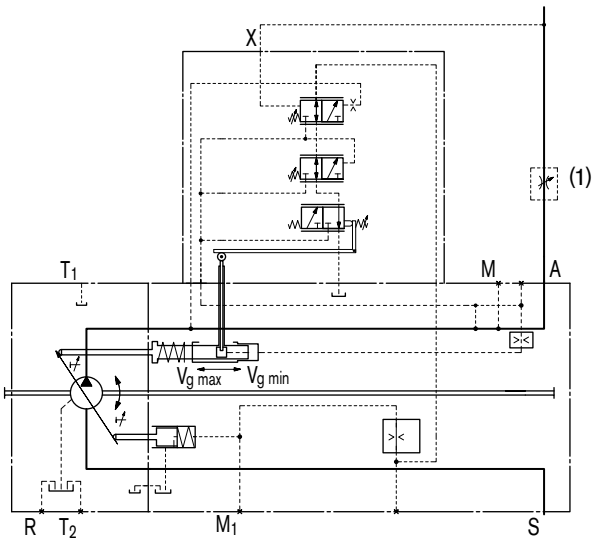
(1) The sensing orifice (control block) is not included in the pump supply.

Characteristic LRDS

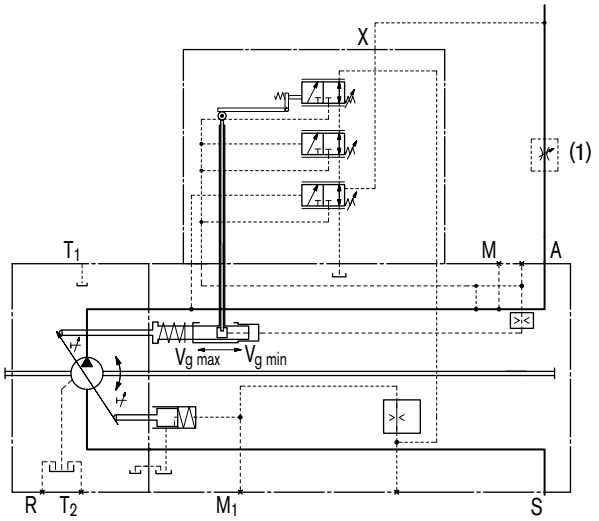


Circuit diagram LRDS

Size 40 ... 145



Size 190 ... 260



LR – Power Control

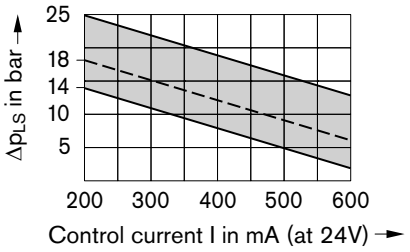
LRS2 Power control with load sensing, electric override

This control option adds a proportional solenoid to override to the mechanically set load sensing pressure. The pressure differential change is proportional to the solenoid current.

Increasing current = smaller Δp-setting

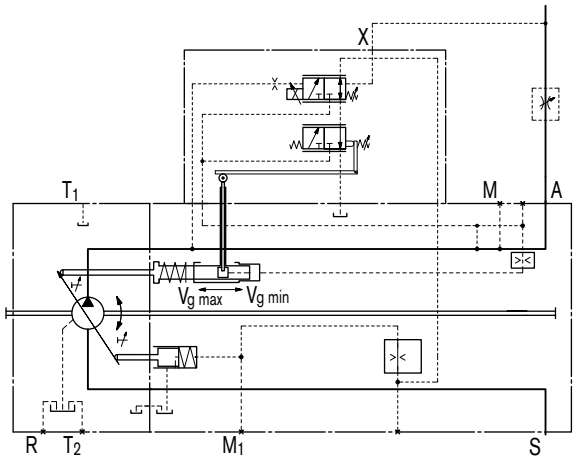
See following characteristic for details (example). Please consult us during the project planning phase.
For solenoid specification, see page 12 (LE2)

Characteristic LRS2

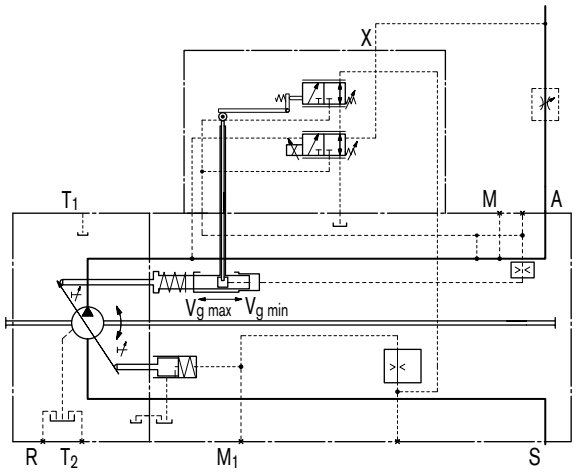


Circuit diagram LRS2

Size 40 ... 145



Size 190 ... 260



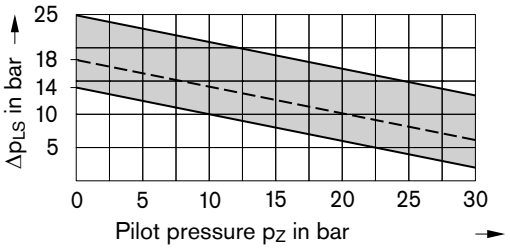
LRS5 Power control with load sensing, hydraulic override

This control option adds an external proportional pilot pressure signal (to port Z) to override the mechanically set load sensing pressure.

Increasing pilot pressure = smaller Δp-setting

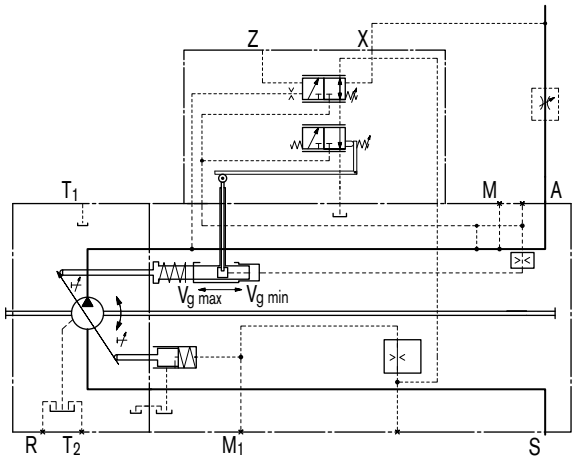
See following characteristic for details (example). Please consult us during the project planning phase.

Characteristic LRS5

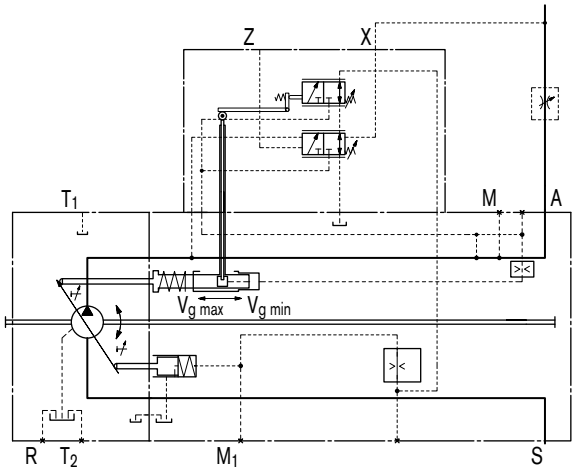


Circuit diagram LRS5

Size 40 ... 145



Size 190 ... 260



LR – Power Control

LR... Power control with stroke limiter

The stroke limiter can be used to vary or limit the displacement of the pump continuously over the whole control range. The displacement is set in LRH with the pilot pressure p_{St} (max. 40 bar) applied to port Y or in LRU by the control current applied to the proportional solenoid. A DC current of 12V (U1) or 24V (U2) is required to control the proportional solenoid.

The power control overrides the stoke limiter control, i.e. below the hyperbolic power characteristic, the displacement is controlled by the control current or pilot pressure. When exceeding the power characteristic with a set flow or load pressure, the power control overrides and reduces the displacement following the hyperbolic characteristic.

To permit operation of the pump displacement control from its starting position $V_{g\,max}$ to $V_{g\,min}$, a minimum control pressure of 30 bar is required for the electric stroke limiter LRU1/2 and the hydraulic stroke limiter LRH2/6.

The required control pressure is taken either from the load pressure, or from the externally applied control pressure at the G port.

To ensure functioning of the stroke limiter even at low operating pressure, port G must be supplied with external control pressure of approx. 30 bar.

Note:
If no external control pressure is connected at G, the shuttle valve must be removed.

Note

The spring return feature in the controller is not a safety device

The spool valve inside the controller can get stuck in an undefined position by internal contamination (contaminated hydraulic fluid, abrasion or residual contamination from system components). As a result, the axial piston unit can no longer supply the flow specified by the operator.

Check whether your application requires that remedial measures be taken on your machine in order to bring the driven consumer into a safe position (e.g. immediate stop).

LR – Power Control

LRH1/5 Hydraulic stroke limiter (negative characteristic)

Control from $V_{g\,max}$ to $V_{g\,min}$

With increasing pilot pressure the pump swivels to a smaller displacement.

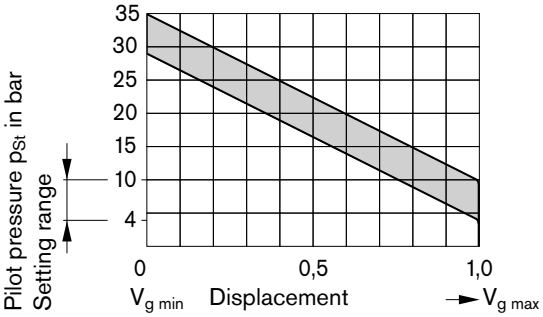
Start of control (at $V_{g\,max}$), can be set _____ from 4 – 10 bar

State start of control in clear text in the order.

Starting position without control signal (pilot pressure): $V_{g\,max}$

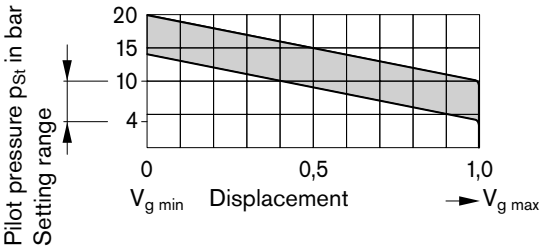
Characteristic H1

Increase in pilot pressure ($V_{g\,max} - V_{g\,min}$) _____ $\Delta p = 25$ bar



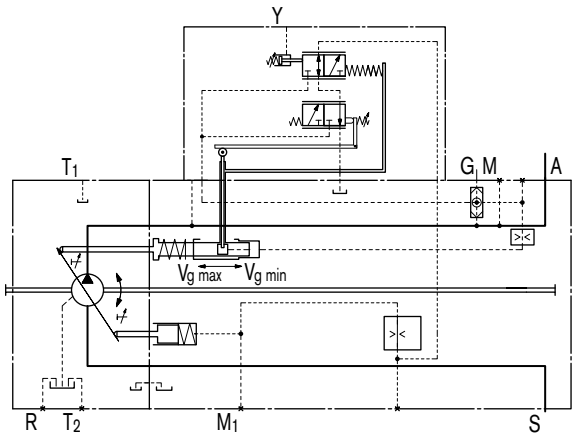
Characteristic H5

Increase in pilot pressure ($V_{g\,max} - V_{g\,min}$) _____ $\Delta p = 10$ bar

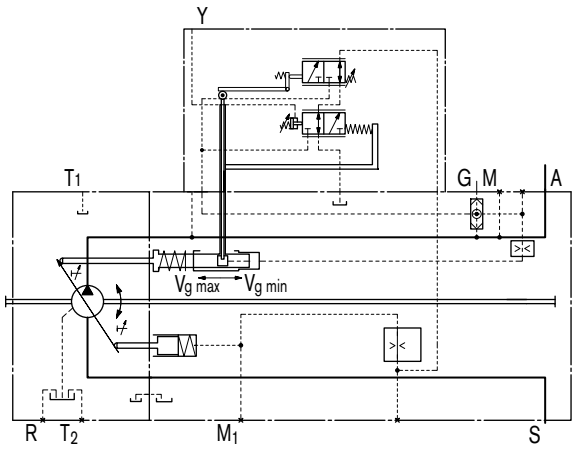


Circuit diagram LRH1/5

Size 40 ... 145



Size 190 ... 260



LR – Power Control

LRH2/6 Hydraulic stroke limiter (positive characteristic)

Control from $V_{g\,min}$ to $V_{g\,max}$

With increasing pilot pressure the pump swivels to a higher displacement.

Start of control (at $V_{g\,min}$), can be set _____ from 4–10 bar

State start of control in clear text in the order.

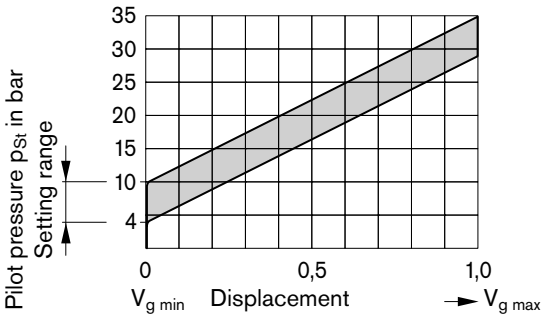
Starting position without control signal (pilot pressure):

– at operating pressure and external control pressure < 30 bar: $V_{g\,max}$

– at operating pressure or external control pressure > 30 bar: $V_{g\,min}$

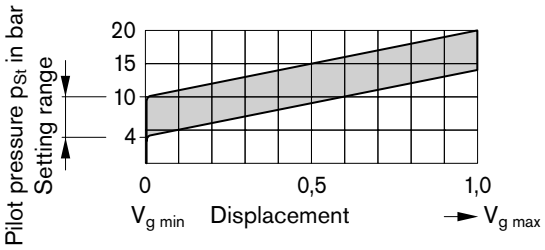
Characteristic H2

Increase in pilot pressure ($V_{g\,min} - V_{g\,max}$) _____ $\Delta p = 25$ bar



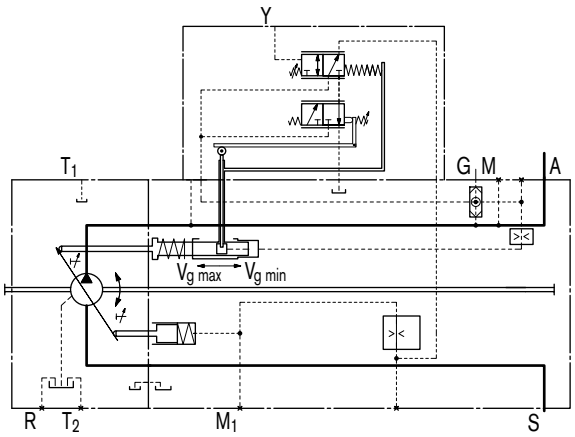
Characteristic H6

Increase in pilot pressure ($V_{g\,min} - V_{g\,max}$) _____ $\Delta p = 10$ bar



Circuit diagram LRH2/6

Size 40 ... 145



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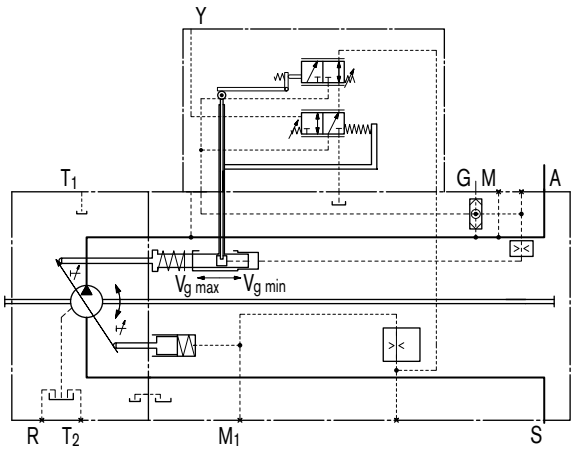


LR – Power Control

LRU1/2 Electric stroke limiter (positive characteristic)

Control from $V_{g\,min}$ to $V_{g\,max}$

With increasing control current the pump swivels to a higher displacement.

Technical data - solenoids

	LRU1	LRU2
Voltage	12 V (±20 %)	24 V (±20 %)
Control current		
Start of control at $V_{g\,max}$	400 mA	200 mA
End of control at $V_{g\,min}$	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
Actuated time	100 %	100 %
Type of protection	see connector version, page 60	

Starting position without control signal (control current):

– at operating pressure and external control pressure < 30 bar: $V_{g\,max}$

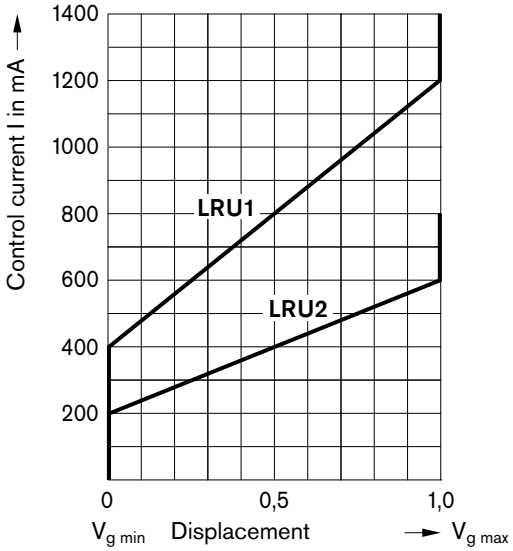
– at operating pressure or external control pressure > 30 bar: $V_{g\,min}$

The following electronic controllers and amplifiers are available for actuating the proportional solenoids (see also www.boschrexroth.com/mobile-electronics):

– BODAS controller RC
  Series 20 ____ RE 95200
  Series 21 ____ RE 95201
  Series 22 ____ RE 95202
  Series 30 ____ RE 95203
  and application software

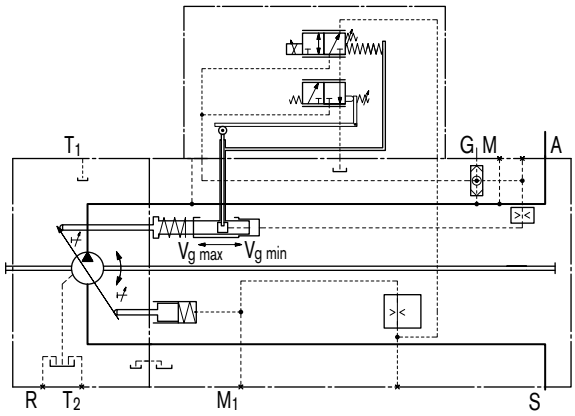
– Analog amplifier RA ____ RE 95230

Characteristic LRU1/2

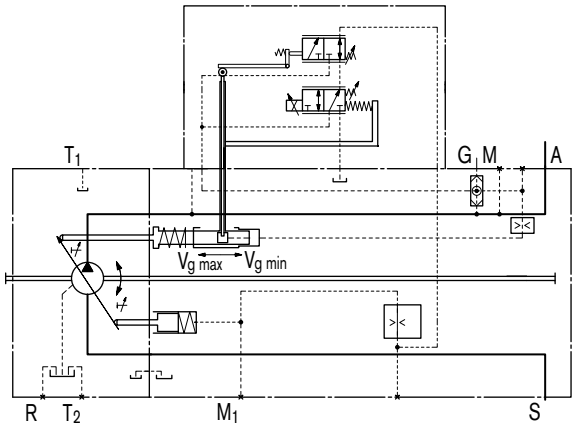


Circuit diagram LRU1/2

Size 40 ... 145



Size 190 ... 260



DR – Pressure Control

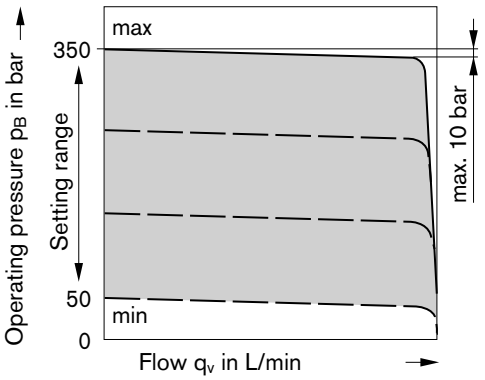
DR Pressure control

The pressure control keeps the pressure in a hydraulic system constant within its control range even under varying flow conditions. The variable pump only moves as much hydraulic fluid as is required by the actuators. If the operating pressure exceeds the setpoint set at the integral pressure control valve, the pump displacement is automatically swivelled back until the pressure deviation is corrected.

Starting position in depressurized state: $V_{g\,max}$

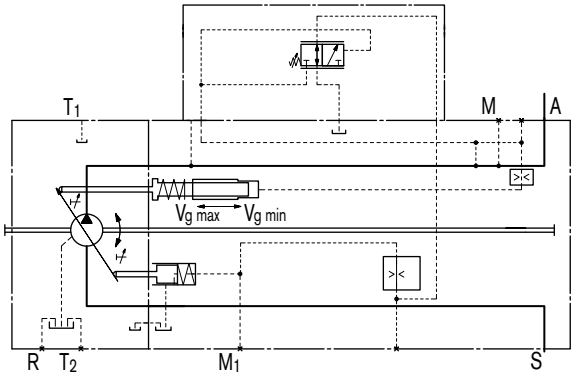
Setting range from 50 to 350 bar.

Characteristic: DR

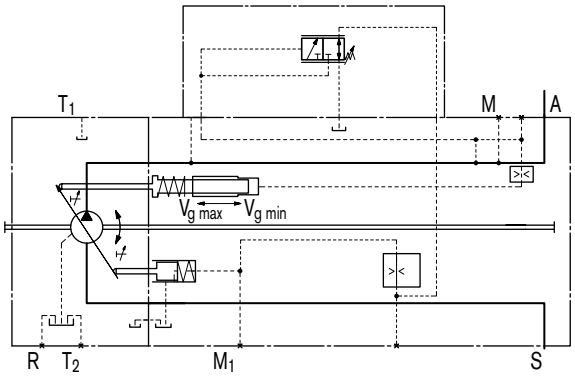


Circuit diagram DR

Size 40 ... 145



Size 190 ... 260



DR – Pressure Control

DRS Pressure control with load sensing

The load sensing control is a flow control option that operates as a function of the load pressure to regulate the pump displacement to match the actuator flow requirement.

The flow depends here on the cross section of the external sensing orifice (1) fitted between the pump outlet and the actuator. The flow is independent of the load pressure below the pressure cut-off setting and within the control range of the pump.

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

The load sensing control compares pressure before and after the sensing orifice and maintains the pressure drop across the orifice (differential pressure Δp) and with it the pump flow constant.

If the differential pressure Δp increases at the sensing orifice, the pump is swivelled back (towards $V_{g\,min}$), and, if the differential pressure Δp decreases, the pump is swivelled out (towards $V_{g\,max}$) until the pressure drop across the sensing orifice in the valve is restored.

$\Delta p_{orifice} = p_{pump} - p_{actuator}$

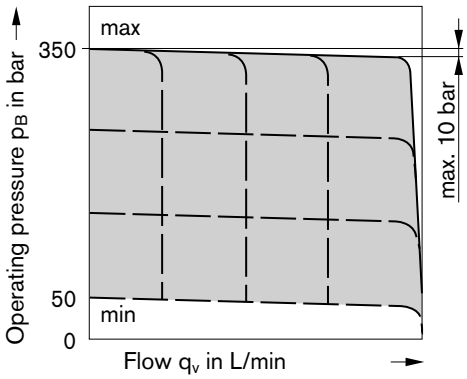
The setting range for Δp is between 14 bar and 25 bar.

The standard differential pressure setting is 18 bar. (Please state in clear text when ordering).

The stand-by pressure in zero stroke operation (sensing orifice plugged) is slightly above the Δp setting.

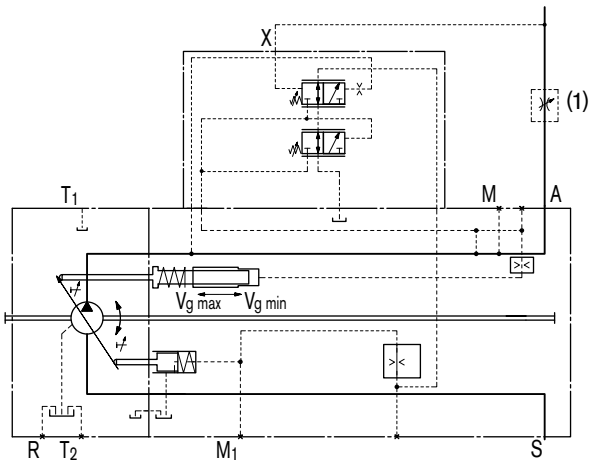
(1) The sensing orifice (control block) is not included in the pump supply.

Characteristic: DRS

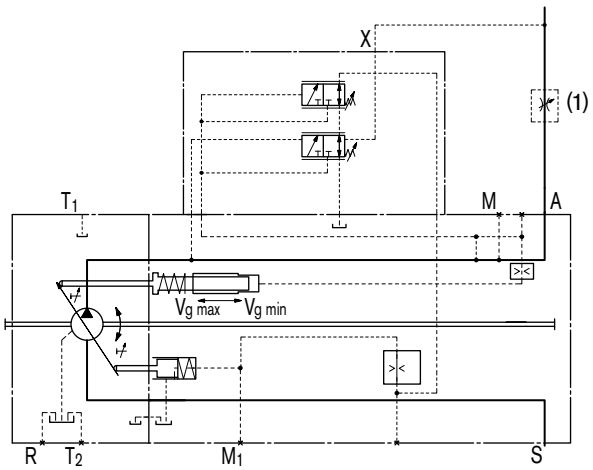


Circuit diagram DRS

Size 40 ... 145



Size 190 ... 260



DR – Pressure Control

DRG Pressure control, remote controlled

The remote control pressure cut-off regulator permits the adjustment of the pressure setting by a remotely installed pressure relief valve (1). Pilot flow for this valve is provide by a fixed orifice in the control module.

Setting range from 50 to 350 bar.

In addition the pump can be unloaded into a standby pressure condition by an externally installed 2/2-way directional valve (2).

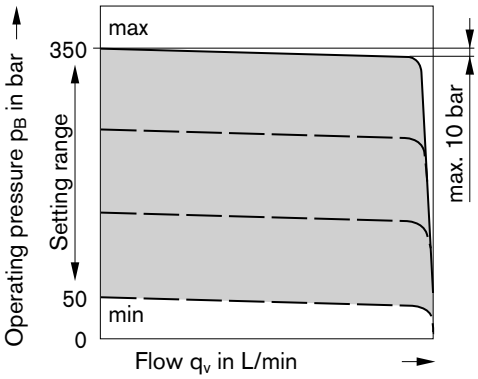
Both functions can be used individually or in combination (see circuit diagram).

The external valves are not included in the pump supply.

As a separate pressure relief valve (1) we recommend:

DBDH 6 (manual control), see RE 25402

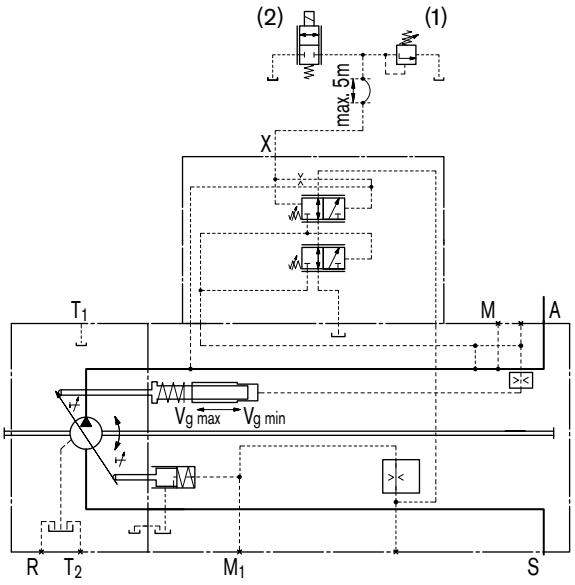
Characteristic: DRG



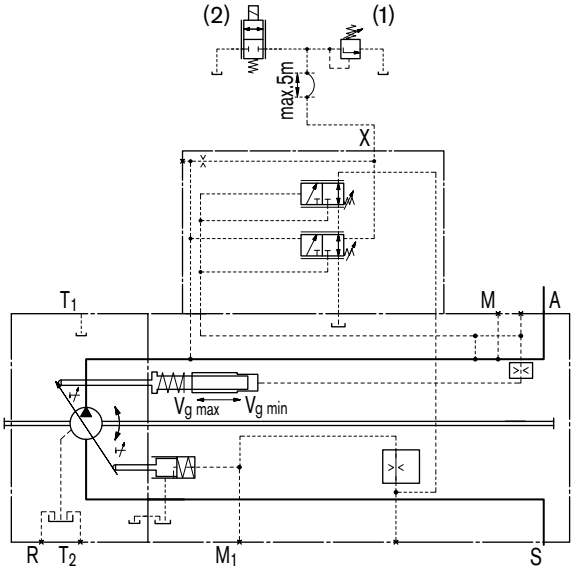
Note: The remote controlled pressure cut-off is also possible in combination with LR, HD and EP.

Circuit diagram DRG

Size 40 ... 145



Size 190 ... 260



DR – Pressure Control

DRL Pressure control for parallel operation

The pressure control DRL is suitable for pressure control of several axial piston pumps A11VO in parallel operation pumping into a common pressure header.

The parallel pressure control has a pressure rise characteristic of approx. 15 bar from $q_{v\,max}$ to $q_{v\,min}$. The pump regulates therefore to a pressure dependent swive angle. This results in stable control behavior, without the need of "staging" the individual pump compensators.

With the externally installed pressure relief valve (1) the nominal pressure setting of all pumps connected to the system is adjusted to the same value.

Setting range from 50 to 350 bar.

Each pump can be individually unloaded from the system by a separately installed 3/2-way directional valve (2).

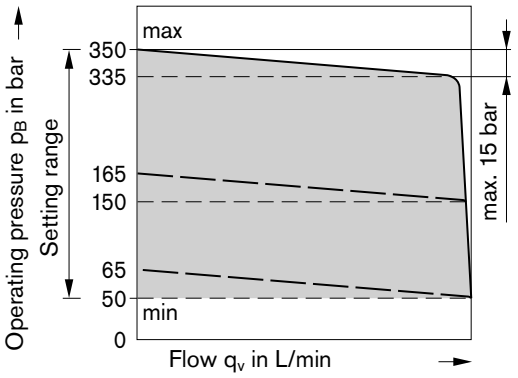
The check valves (3) in the service line (port A) or control line (port X) must be provided generally.

The external valves are not included in the pump supply.

As a separate pressure relief valve (1) we recommend:

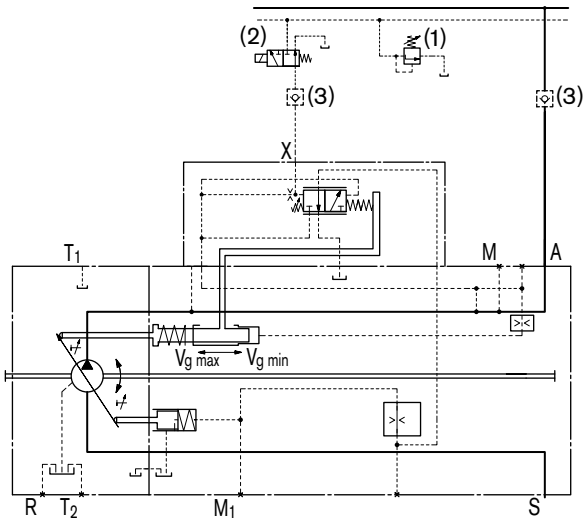
DBDH 6 (manual control), see RE 25402

Characteristic DRL

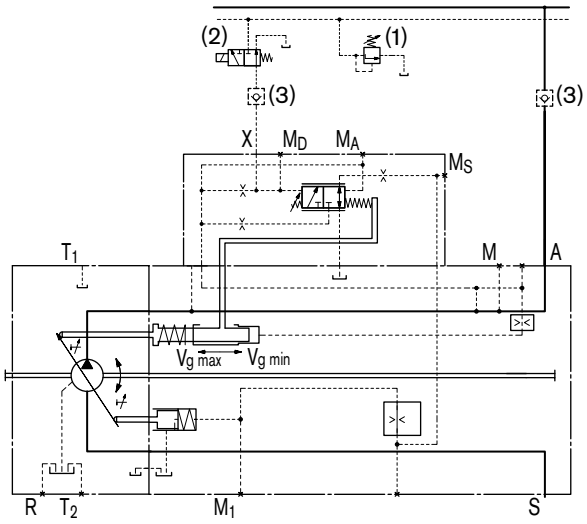


Circuit diagram DRL

Size 40 ... 145



Size 190 ... 260



HD – Hydraulic Control, Pilot-Pressure Related

With the pilot-pressure related control the pump displacement is adjusted in proportion to the pilot pressure applied to port Y. Maximum permissible pilot pressure $p_{St\ max} = 40$ bar

Control from $V_{g\ min}$ to $V_{g\ max}$.

With increasing pilot pressure the pump swivels to a higher displacement.

Start of control (at $V_{g\ min}$), can be set _____ from 4–10 bar

State start of control in clear text in the order.

Starting position without control signal (pilot pressure):

– at operating pressure and external control pressure < 30 bar: $V_{g\ max}$

– at operating pressure or external control pressure > 30 bar: $V_{g\ min}$

A control pressure of 30 bar is required to swivel the pump from its starting position $V_{g\ max}$ to $V_{g\ min}$.

The required control pressure is taken either from the load pressure, or from the externally applied control pressure at the G port.

To ensure the control even at low operating pressure < 30 bar the port G must be supplied with an external control pressure of approx. 30 bar.

Note:
If no external control pressure is connected at G, the shuttle valve must be removed.

Note

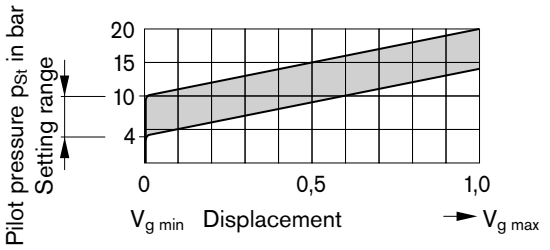
The spring return feature in the controller is not a safety device

The spool valve inside the controller can get stuck in an undefined position by internal contamination (contaminated hydraulic fluid, abrasion or residual contamination from system components). As a result, the axial piston unit can no longer supply the flow specified by the operator.

Check whether your application requires that remedial measures be taken on your machine in order to bring the driven consumer into a safe position (e.g. immediate stop).

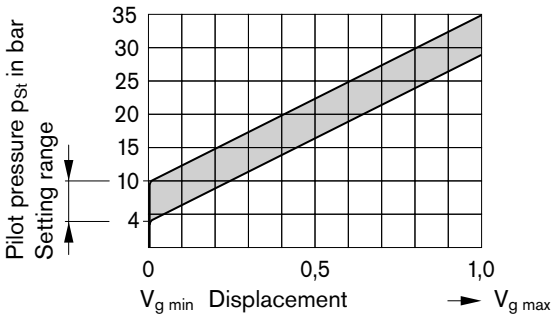
Characteristic HD1

Increase in pilot pressure $V_{g\ min}$ to $V_{g\ max}$ _____ $\Delta p = 10$ bar



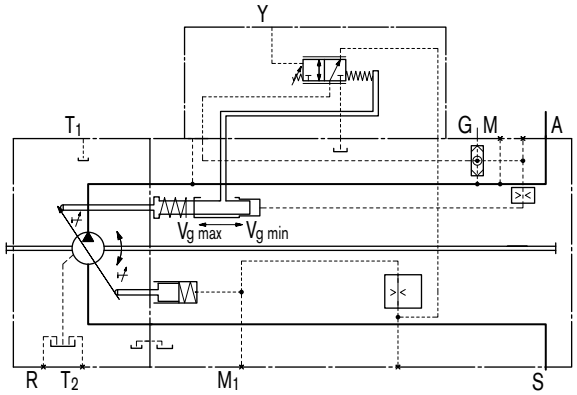
Characteristic HD2

Increase in pilot pressure $V_{g\ min}$ to $V_{g\ max}$ _____ $\Delta p = 25$ bar



Circuit diagram HD

Size 40 ... 260



HD – Hydraulic Control, Pilot-Pressure Related

HD.D Hydraulic control with pressure cut-off

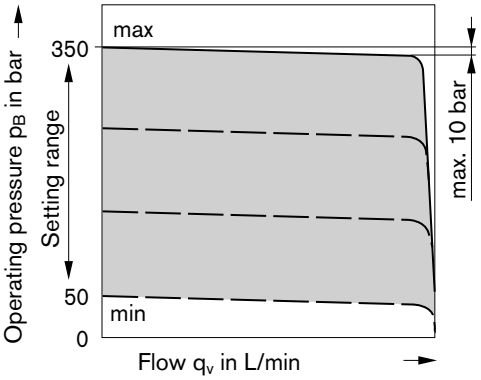
The pressure cut-off corresponds to a pressure control which adjusts the pump displacement back to $V_{g\,min}$ when the pressure setting is reached.

This function overrides the HD control, i.e. the pilot-pressure related displacement control is functional below the pressure setting.

The pressure cut-off function is integrated into the pump control module and is preset to a specified value at the factory.

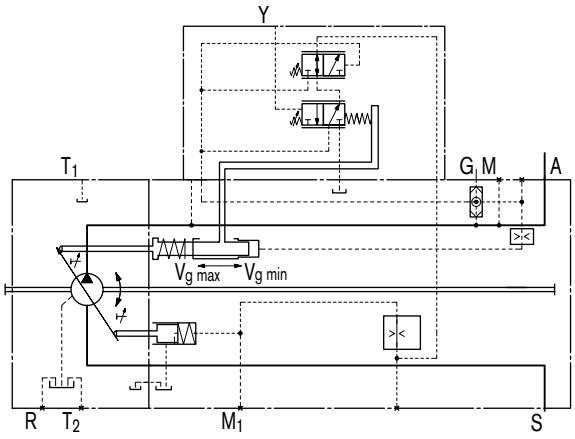
Setting range from 50 to 350 bar.

Pressure cut-off characteristic D

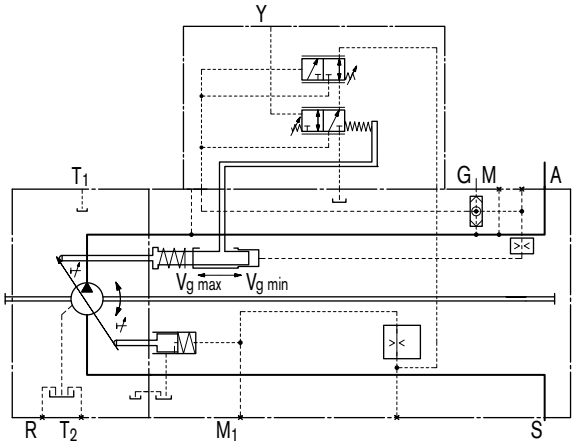


Circuit diagram HD.D

Size 40 ... 145



Size 190 ... 260



EP – Electric Control with Proportional Solenoid

With the electric control with proportional solenoid, the pump displacement is adjusted proportionally to the solenoid current, resulting in a magnetic control force, acting directly onto the control spool that pilots the pump control piston.

Control from $V_{g\,min}$ to $V_{g\,max}$

With increasing control current the pump swivels to a higher displacement.

Starting position wthout control signal (control current):

– at operating pressure and external control pressure < 30 bar: $V_{g\,max}$

– at operating pressure or external control pressure > 30 bar: $V_{g\,min}$

A control pressure of 30 bar is required to swivel the pump from its starting position $V_{g\,max}$ to $V_{g\,min}$.

The required control pressure is taken either from the load pressure, or from the externally applied control pressure at port G.
To ensure the control even at low operating pressure < 30 bar the port G must be supplied with an external control pressure of approx. 30 bar.

Note:
If no external control pressure is connected at G, the shuttle valve must be removed.

Note:
Install pump with EP control in the oil tank only when using mineral hydraulic oils and an oil temperature in the tank of max. 80°C.

The following electronic control units and amplifiers are available for actuating the proportional solenoids (see also www.boschrexroth.com/mobilelektronik):

– BODAS controller RC
  Series 20 ____ RD 95200
  Series 21 ____ RD 95201
  Series 22 ____ RD 95202
  Series 30 ____ RD 95203
  and application software

– Analog amplifier RA ____ RE 95230

Technical data, solenoid at EP1, EP2

	EP1	EP2
Voltage	12 V (±20 %)	24 V (±20 %)
Control current		
Start of control at $V_{g\,min}$	400 mA	200 mA
End of control at $V_{g\,max}$	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
Actuated time	100 %	100 %
Type of protection	see connector version, page 60	

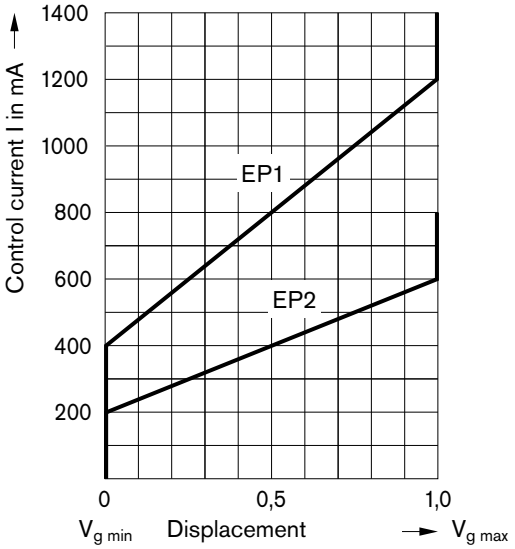
Note

The spring return feature in the controller is not a safety device

The spool valve inside the controller can get stuck in an undefined position by internal contamination (contaminated hydraulic fluid, abrasion or residual contamination from system components). As a result, the axial piston unit can no longer supply the flow specified by the operator.

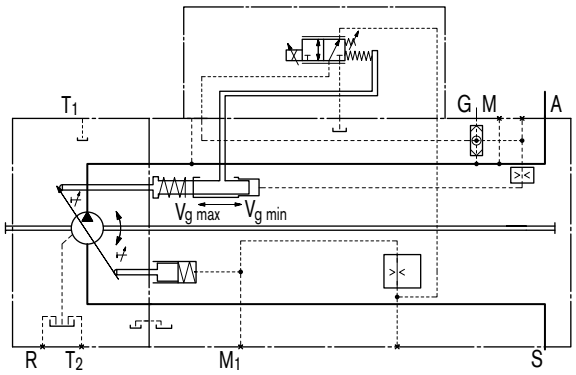
Check whether your application requires that remedial measures be taken on your machine in order to bring the driven consumer into a safe position (e.g. immediate stop).

Characteristic EP1/2



Circuit diagram EP1/2

Size 40 ... 260



EP – Electric Control with Proportional Solenoid

EP.D Electric control with pressure cut-off

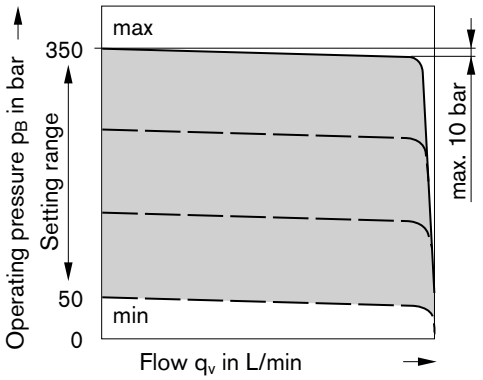
The pressure cut-off corresponds to a pressure control which adjusts the pump displacement back to $V_{g\,min}$ when the pressure setting is reached.

This function overrides the EP control, i.e. the control current related displacement control is functional below the pressure setting.

The valve for the pressure cut-off is integrated in the control case and is set to a fixed specified pressure value at the factory.

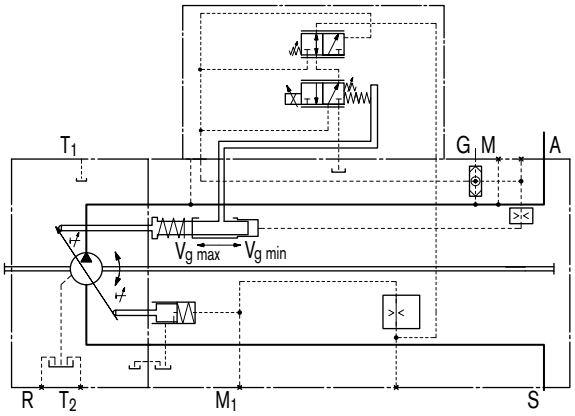
Setting range from 50 to 350 bar

Pressure cut-off characteristic D

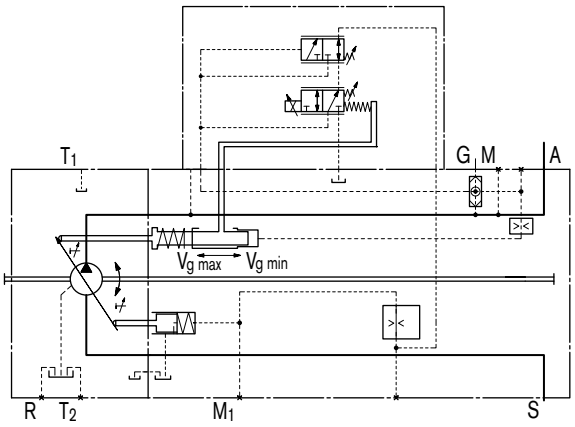


Circuit diagram EP.D

Size 40 ... 145



Size 190 ... 260



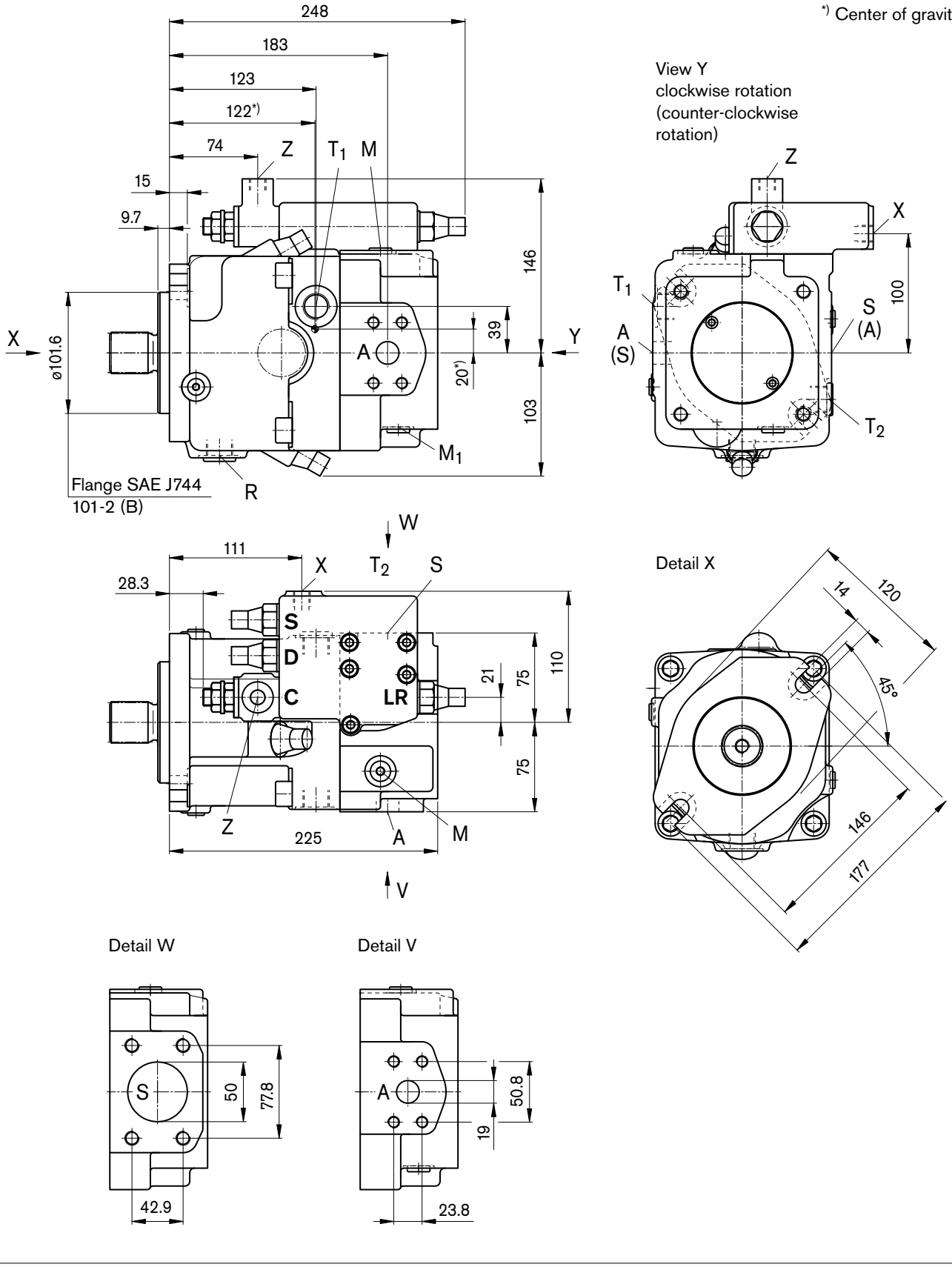
Dimensions, Size 40

Before finalizing your design, please request a certified drawing. Dimensions in mm.

LRDCS

Power control LR with pressure cut-off D, cross sensing control C and load sensing control S

*) Center of gravity

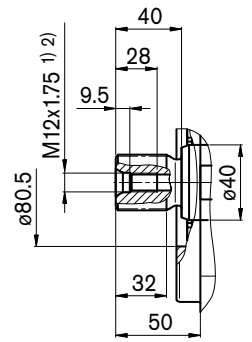


Dimensions, Size 40

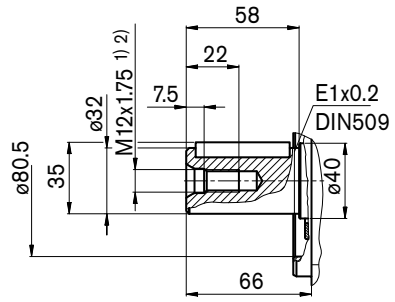
Before finalizing your design, please request a certified drawing. Dimensions in mm.

Shaft ends

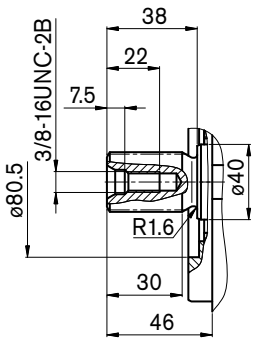
Z Splined shaft DIN 5480
W35x2x30x16x9g



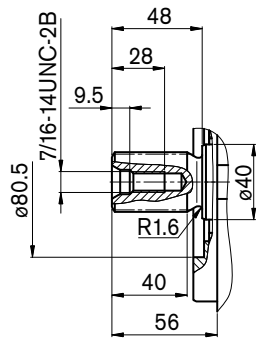
P Parallel keyed shaft DIN 6885,
AS10x8x56



S Splined shaft SAE J744
1 in 15T 16/32 3)



T Splined shaft SAE J744
1 1/4 in 14T 12/24DP 3)



Ports

Designation	Function	Standard	Size[2]		Max. pressure (bar) [4]	State
A	Service line port Fixing thread	SAE J518 DIN 13	3/4 in M10x1.5;	 16 deep	400	O
S	Suction port Fixing thread	SAE J518 DIN 13	2 in M12x1.75;	 17 deep	30	O
T_1, T_2	Tank port	DIN 3852	M22x1.5;	14 deep	10	[5]
R	Air bleed	DIN 3852	M22x1.5;	14 deep	10	X
M_1	Measurement point, positioning chamber	DIN 3852	M12x1.5;	12 deep	400	X
M	Measurement point, service line port	DIN 3852	M12x1.5;	12 deep	400	X
X	Pilot pressure port in version with load sensing (S) and remote controlled pressure cut-off (G)	DIN 3852	M14x1.5	12 deep	400	O
Y	Pilot pressure port in version with stroke limiter (H...), 2-stage pressure cut-off (E) and HD	DIN 3852	M14x1.5;	12 deep	40	O
Z	Pilot pressure port in version with cross sensing (C) and power override (LR3) power override (LG1)	DIN 3852	M14x1.5;	12 deep	 400 40	O
G	Port for control pressure (controller) in version with stroke limiter (H.., U2), HD and EP with screw union GE10 - PLM (otherwise closed)	DIN 3852	M14x1.5;	12 deep	40	O

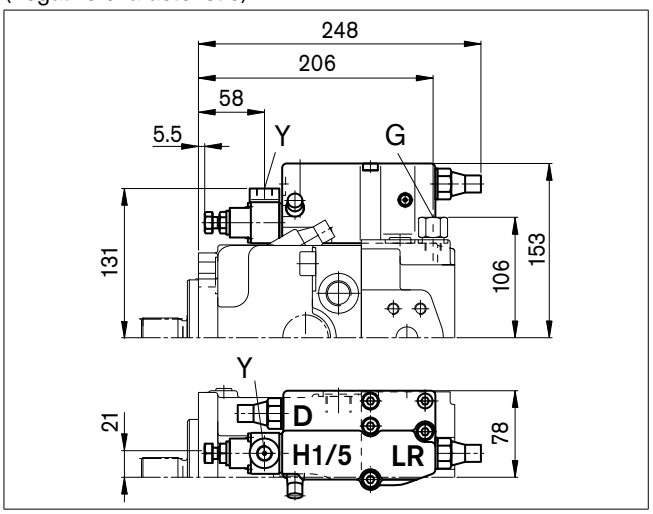
[1] Center bore according to DIN 332 (thread acc. to DIN 13)
[2] For max. tightening torque, please refer to general notes on page 64
[3] ANSI B92.1a-1976, 30° pressure angle, flat root, side fit, tolerance class 5
[4] Depending on adjustment data and operating pressure
[5] Depending on installation position, T1 or T2 must be connected (see also page 61)
O = Open, must be connected (closed on delivery)
X = Closed (in normal operation)

Dimensions, Size 40

Before finalizing your design, please request a certified drawing. Dimensions in mm.

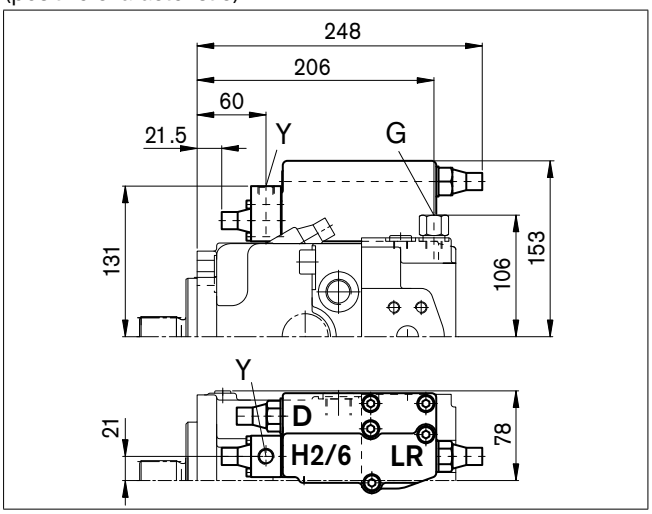
LRDH1/LRDH5

Power control with pressure cut-off and hydraulic stroke limiter (negative characteristic)



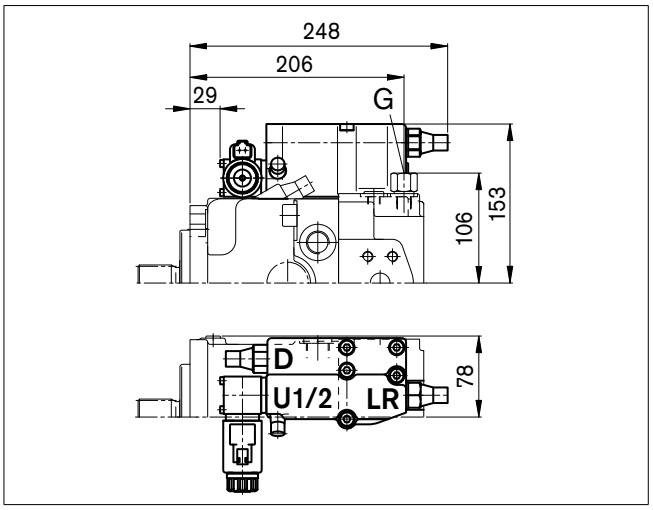
LRDH2/LRDH6

Power control with pressure cut-off and hydraulic stroke limiter (positive characteristic)



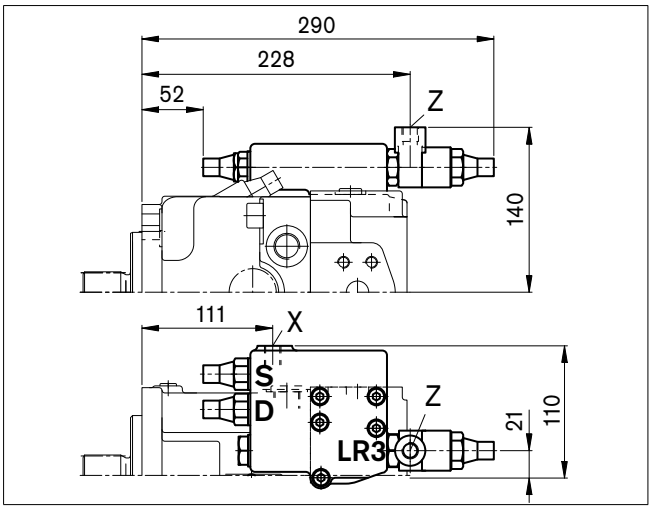
LRDU1/LRDU2

Power control with pressure cut-off and electric stroke limiter (positive characteristic)



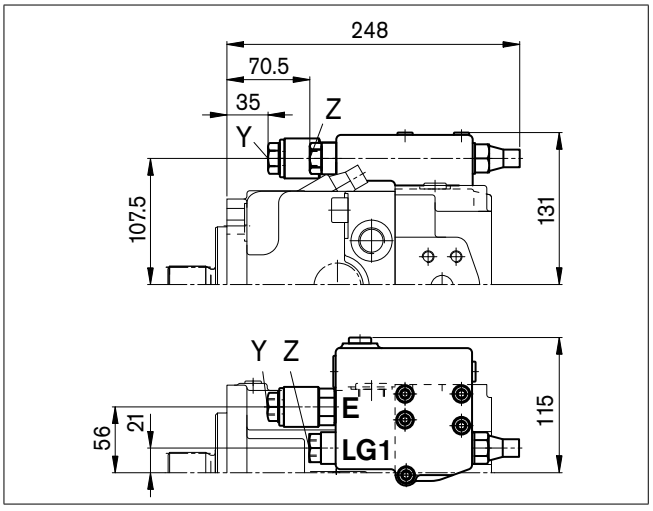
LR3DS

Power control with high-pressure related override, pressure cut-off and load sensing control



LG1E

Power control with pilot-pressure related override (negative) and 2-stage pressure cut-off



LG2E

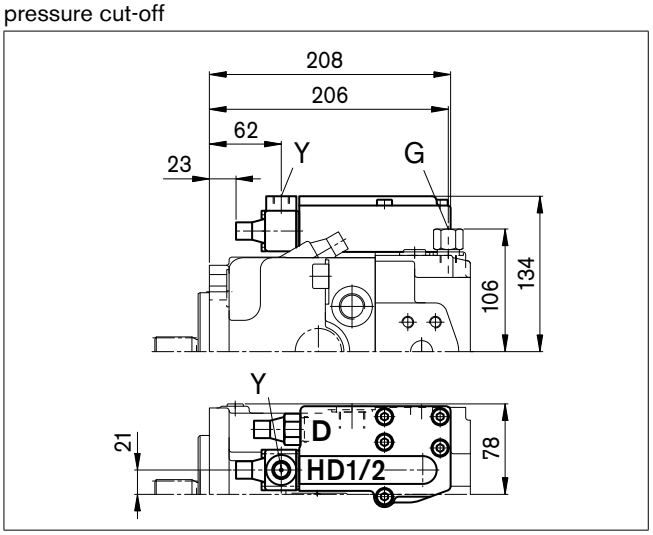
Power control with pilot-pressure related override (positive) and 2-stage pressure cut-off

Dimensions, Size 40

Before finalizing your design, please request a certified drawing. Dimensions in mm.

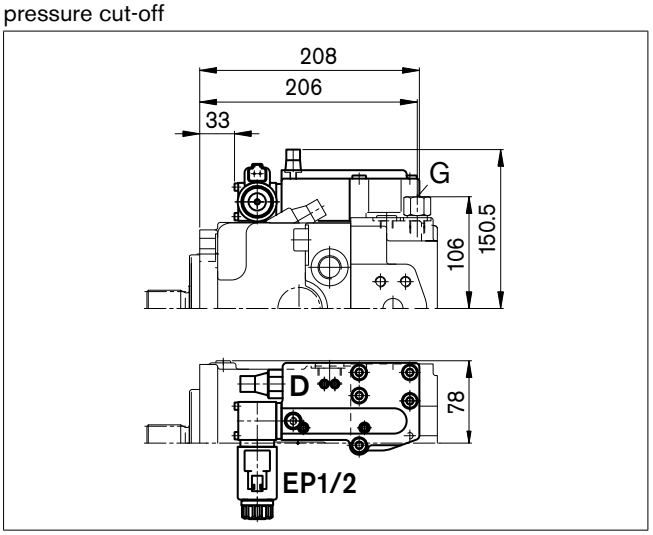
HD1D/HD2D

Hydraulic control, pilot-pressure related with pressure cut-off



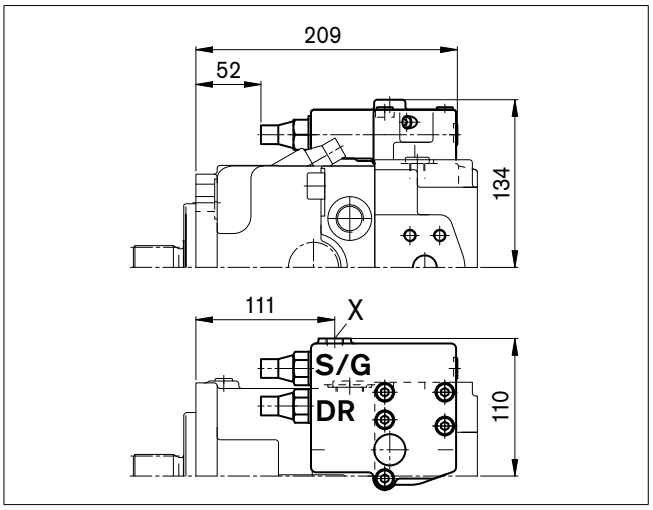
EP1D/EP2D

Electric control with proportional solenoid and pressure cut-off



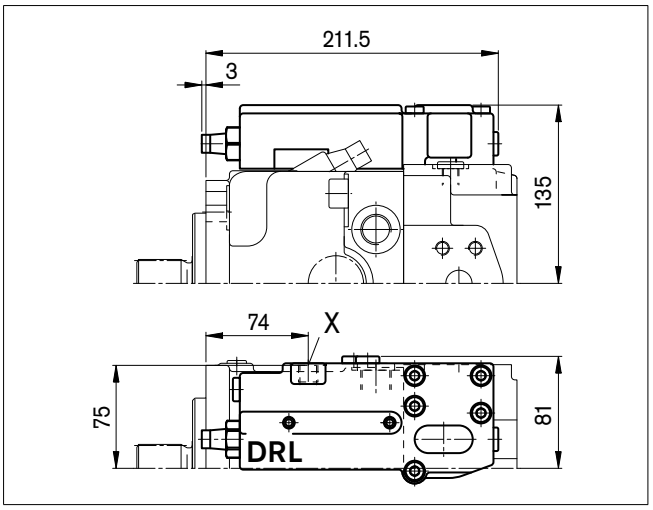
DRS/DRG

Pressure control with load sensing control
Pressure control remote controlled



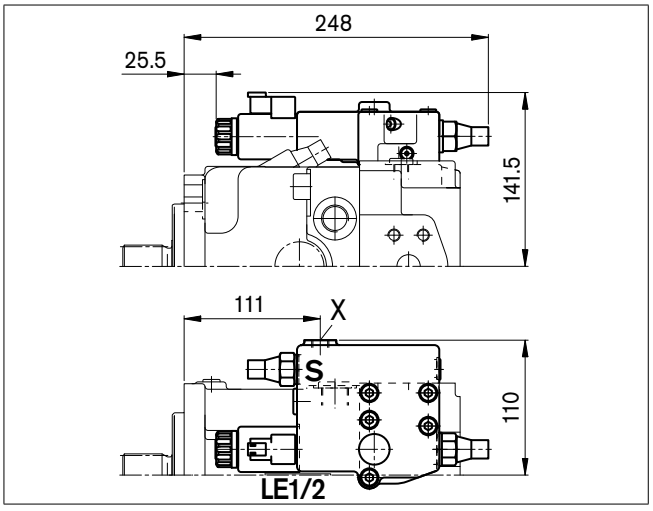
DRL

Pressure control for parallel operation



LE1S/LE2S

Power control with electric override (negative) and load sensing control



LE2S2/LE1S5/LE2S5

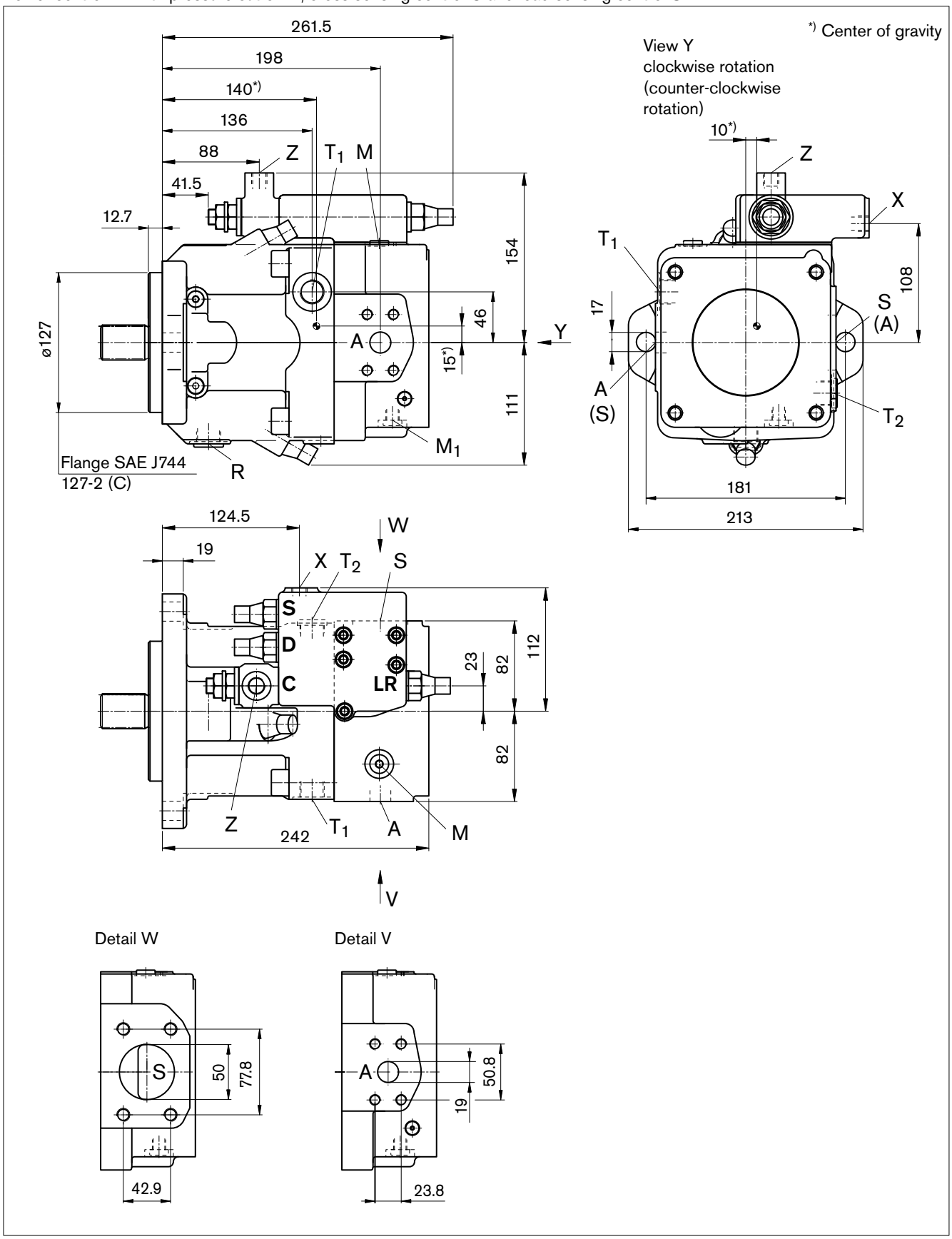
Power control with electric override (negative) and load sensing control, override

Dimensions, Size 60

Before finalizing your design, please request a certified drawing. Dimensions in mm.

LRDCS

Power control LR with pressure cut-off D, cross sensing control C and load sensing control S

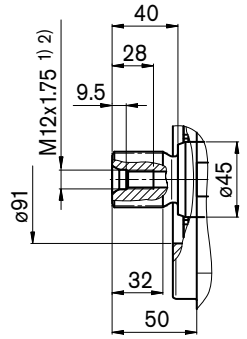


Dimensions, Size 60

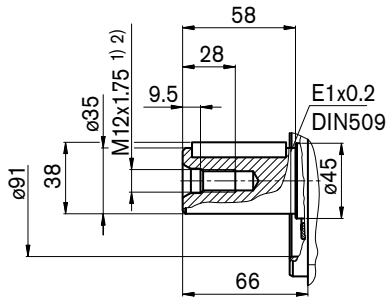
Before finalizing your design, please request a certified drawing. Dimensions in mm.

Shaft ends

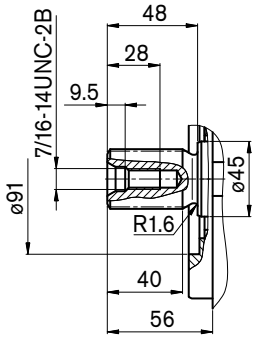
Z Splined shaft DIN 5480
W35x2x30x16x9g



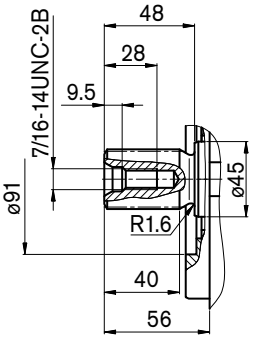
P Parallel keyed shaft DIN 6885,
AS10x8x56



S Splined shaft SAE J744
1 1/4 in 14T 12/24DP 3)



T Splined shaft SAE J744
1 3/8 in 21T 16/32DP 3)



Ports

Designation	Function	Standard	Size[2]		Max. pressure (bar) [4]	State
A	Service line port Fixing thread	SAE J518 DIN 13	3/4 in M10x1.5;	 17 deep	400	O
S	Suction port Fixing thread	SAE J518 DIN 13	2 in M12x1.75;	 20 deep	30	O
T_1, T_2	Tank port	DIN 3852	M22x1.5;	14 deep	10	[5]
R	Air bleed	DIN 3852	M22x1.5;	14 deep	10	X
M_1	Measurement point, positioning chamber	DIN 3852	M12x1.5;	12 deep	400	X
M	Measurement point, service line port	DIN 3852	M12x1.5;	12 deep	400	X
X	Pilot pressure port in version with load sensing (S) and remote controlled pressure cut-off (G)	DIN 3852	M14x1.5	12 deep	400	O
Y	Pilot pressure port in version with stroke limiter (H...), 2-stage pressure cut-off (E) and HD	DIN 3852	M14x1.5;	12 deep	40	O
Z	Pilot pressure port in version with cross sensing (C) and power override (LR3) power override (LG1)	DIN 3852	M14x1.5;	12 deep	 400 40	O
G	Port for control pressure (controller) in version with stroke limiter (H.., U2), HD and EP with screw union GE10 - PLM (otherwise closed)	DIN 3852	M14x1.5;	12 deep	40	O

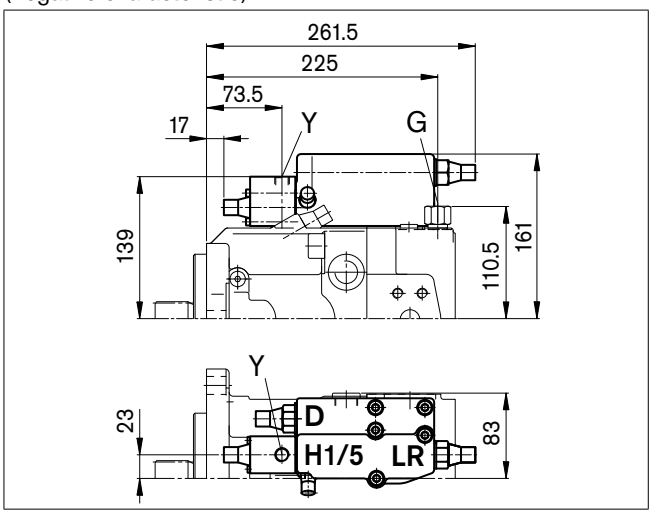
[1] Center bore according to DIN 332 (thread acc. to DIN 13)
[2] For max. tightening torque, please refer to general notes on page 64
[3] ANSI B92.1a-1976, 30° pressure angle, flat root, side fit, tolerance class 5
[4] Depending on adjustment data and operating pressure
[5] Depending on installation position, T1 or T2 must be connected (see also page 61)
O= Open, must be connected (closed on delivery)
X = Closed (in normal operation)

Dimensions, Size 60

Before finalizing your design, please request a certified drawing. Dimensions in mm.

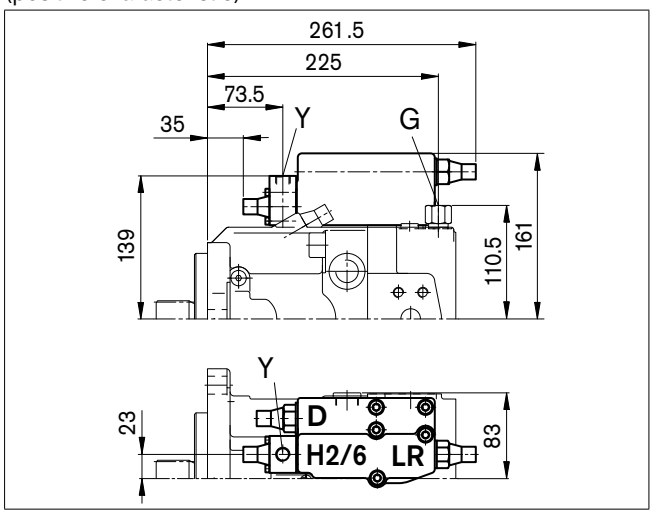
LRDH1/LRDH5

Power control with pressure cut-off and hydraulic stroke limiter (negative characteristic)



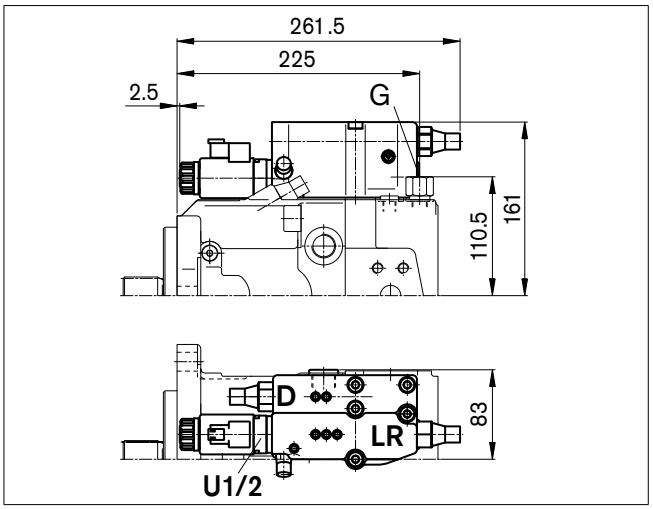
LRDH2/LRDH6

Power control with pressure cut-off and hydraulic stroke limiter (positive characteristic)



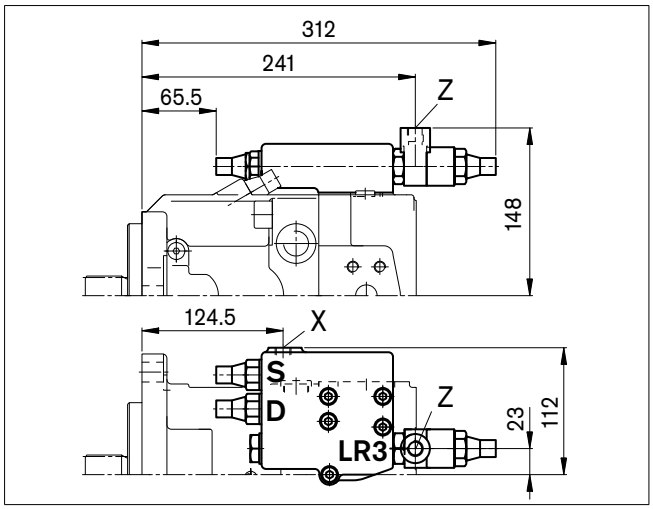
LRDU1/LRDU2

Power control with pressure cut-off and electric stroke limiter (positive characteristic)



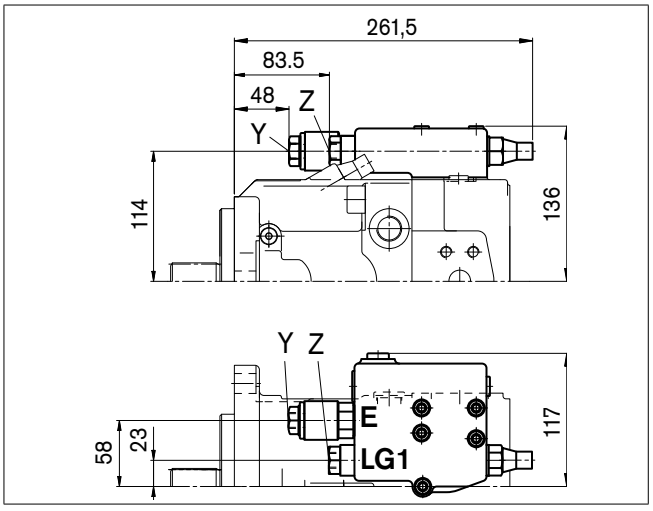
LR3DS

Power control with high-pressure related override, pressure cut-off and load sensing control



LG1E

Power control with pilot-pressure related override (negative) and 2-stage pressure cut-off



LG2E

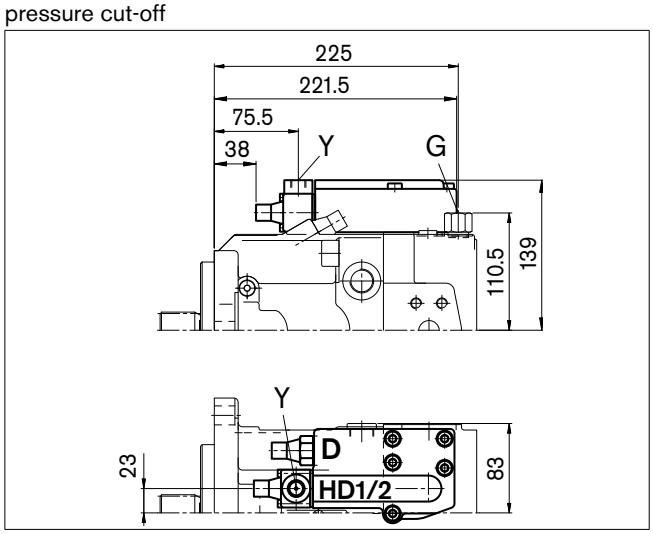
Power control with pilot-pressure related override (positive) and 2-stage pressure cut-off

Dimensions, Size 60

Before finalizing your design, please request a certified drawing. Dimensions in mm.

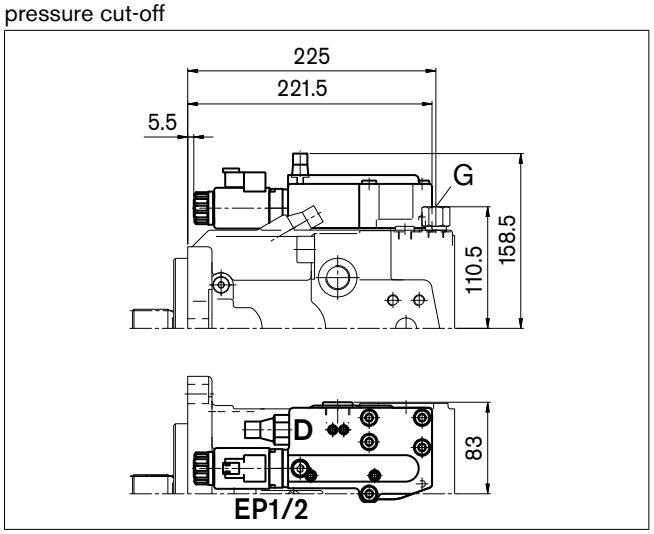
HD1D/HD2D

Hydraulic control, pilot-pressure related with pressure cut-off



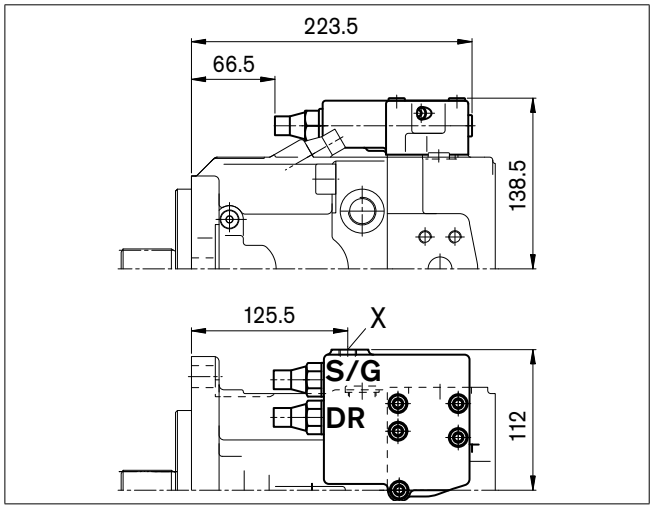
EP1D/EP2D

Electric control with proportional solenoid and pressure cut-off



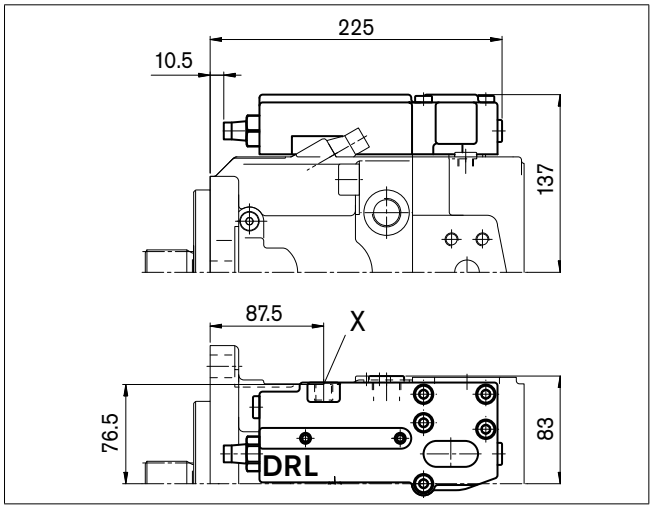
DRS/DRG

Pressure control with load sensing control
Pressure control remote controlled



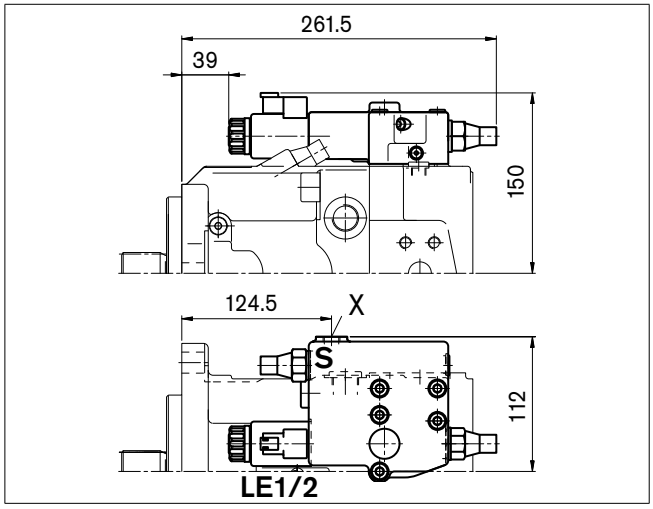
DRL

Pressure control for parallel operation



LE1S/LE2S

Power control with electric override (negative) and load sensing control



LE2S2/LE1S5/LE2S5

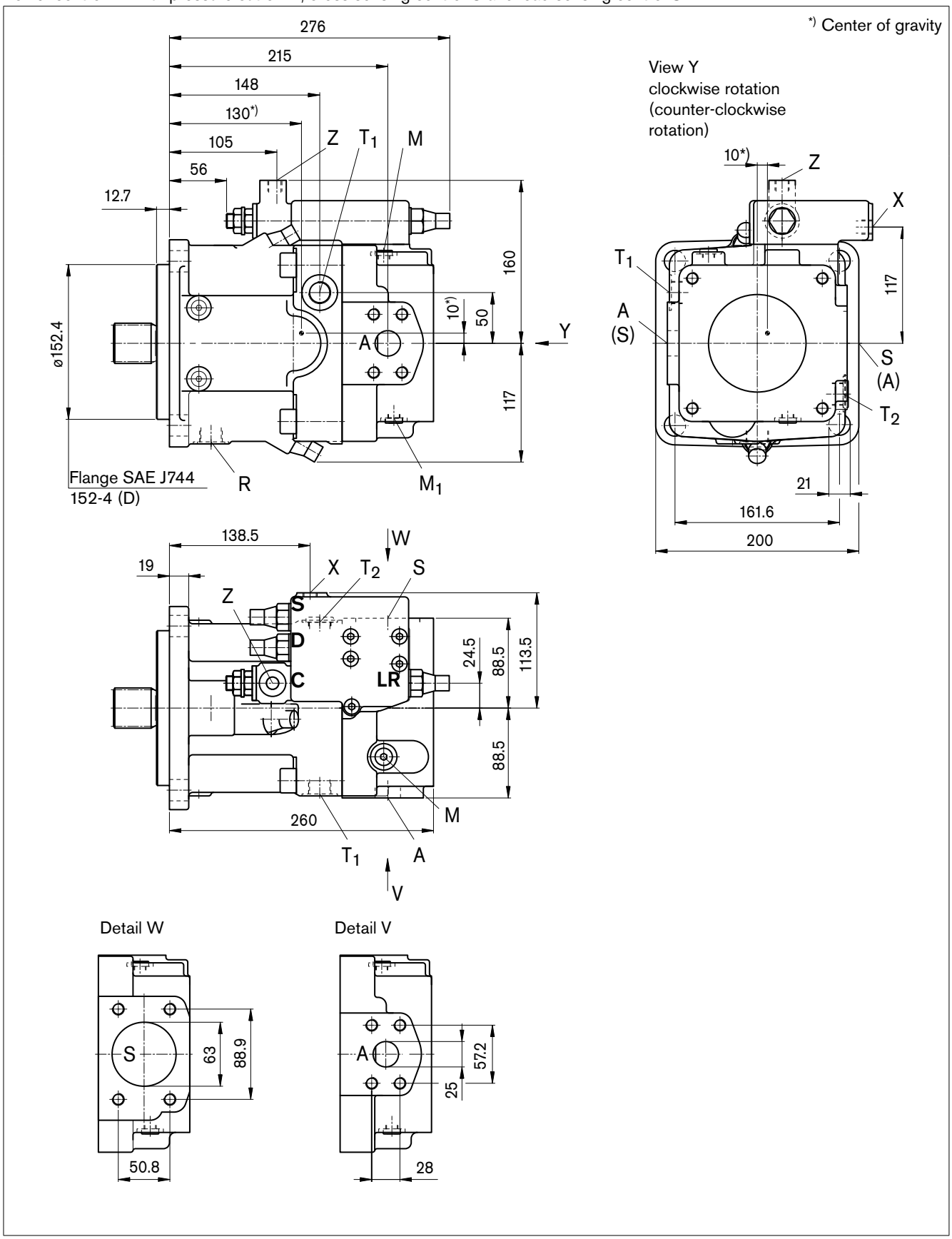
Power control with electric override (negative) and load sensing control, override

Dimensions, Size 75

Before finalizing your design, please request a certified drawing. Dimensions in mm.

LRDCS

Power control LR with pressure cut-off D, cross sensing control C and load sensing control S

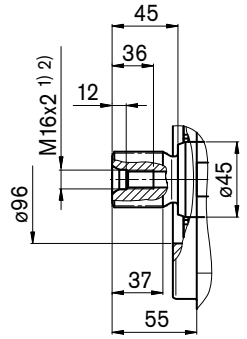


Dimensions, Size 75

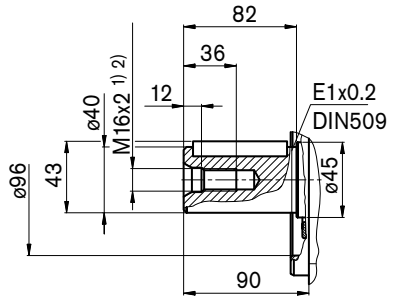
Before finalizing your design, please request a certified drawing. Dimensions in mm.

Shaft ends

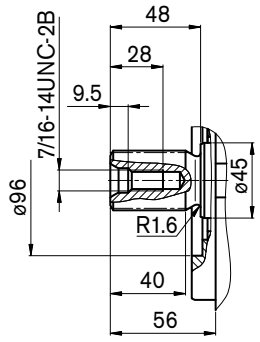
Z Splined shaft DIN 5480
W40x2x30x18x9g



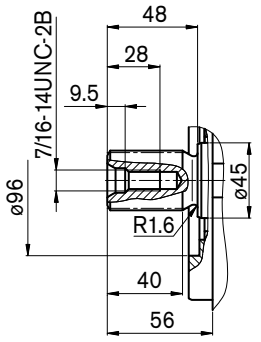
P Parallel keyed shaft DIN 6885
AS12x8x80



S Splined shaft SAE J744
1 1/4 in 14T 12/24DP 3)



T Splined shaft SAE J744
1 3/8 in 21T 16/32DP 3)



Ports

Designation	Function	Standard	Size[2]		Max. pressure (bar) [4]	State
A	Service line port Fixing thread	SAE J518 DIN 13	1 in M12x1.75;	 17 deep	400	O
S	Suction port Fixing thread	SAE J518 DIN 13	2 1/2in M12x1.75;	 17 deep	30	O
T_1, T_2	Tank port	DIN 3852	M22x1.5;	14 deep	10	[5]
R	Air bleed	DIN 3852	M22x1.5;	14 deep	10	X
M_1	Measurement point, positioning chamber	DIN 3852	M12x1.5;	12 deep	400	X
M	Measurement point, service line port	DIN 3852	M12x1.5;	12 deep	400	X
X	Pilot pressure port in version with load sensing (S) and remote controlled pressure cut-off (G)	DIN 3852	M14x1.5	12 deep	400	O
Y	Pilot pressure port in version with stroke limiter (H...), 2-stage pressure cut-off (E) and HD	DIN 3852	M14x1.5;	12 deep	40	O
Z	Pilot pressure port in version with cross sensing (C) and power override (LR3) power override (LG1)	DIN 3852	M14x1.5;	12 deep	 400 40	O
G	Port for control pressure (controller) in version with stroke limiter (H.., U2), HD and EP with screw union GE10 - PLM (otherwise closed)	DIN 3852	M14x1.5;	12 deep	40	O

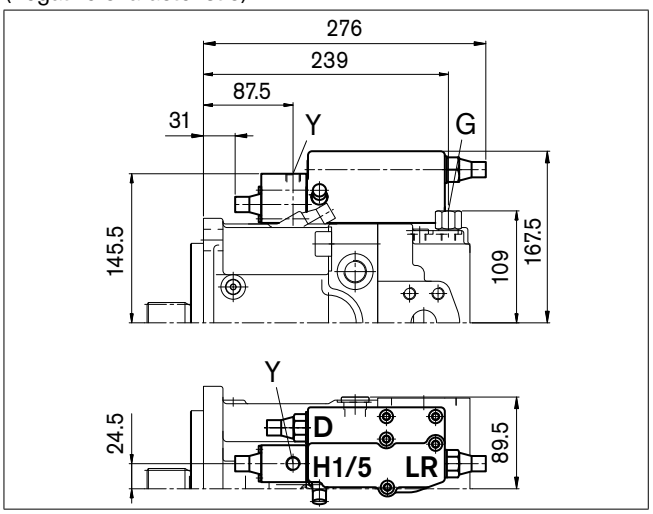
[1] Center bore according to DIN 332 (thread acc. to DIN 13)
[2] For max. tightening torque, please refer to general notes on page 64
[3] ANSI B92.1a-1976, 30° pressure angle, flat root, side fit, tolerance class 5
[4] Depending on adjustment data and operating pressure
[5] Depending on installation position, T1 or T2 must be connected (see also page 61)
O = Open, must be connected (closed on delivery)
X = Closed (in normal operation)

Dimensions, Size 75

Before finalizing your design, please request a certified drawing. Dimensions in mm.

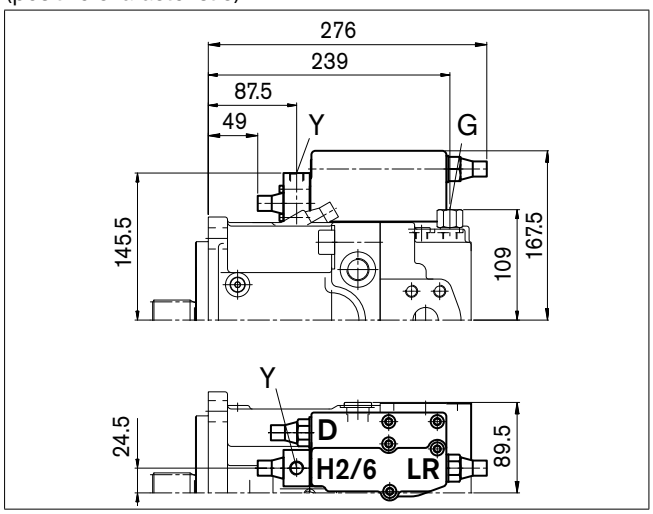
LRDH1/LRDH5

Power control with pressure cut-off and hydraulic stroke limiter (negative characteristic)



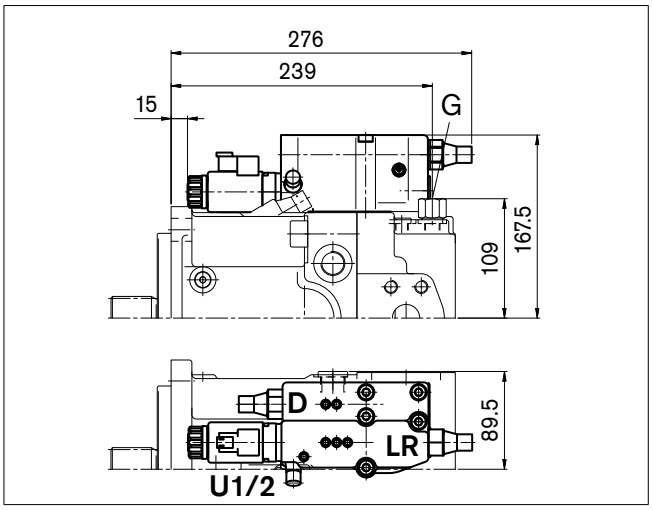
LRDH2/LRDH6

Power control with pressure cut-off and hydraulic stroke limiter (positive characteristic)



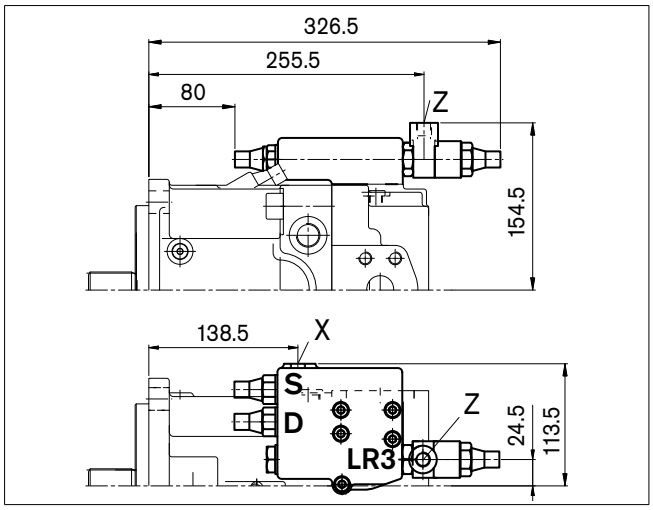
LRDU1/LRDU2

Power control with pressure cut-off and electric stroke limiter (positive characteristic)



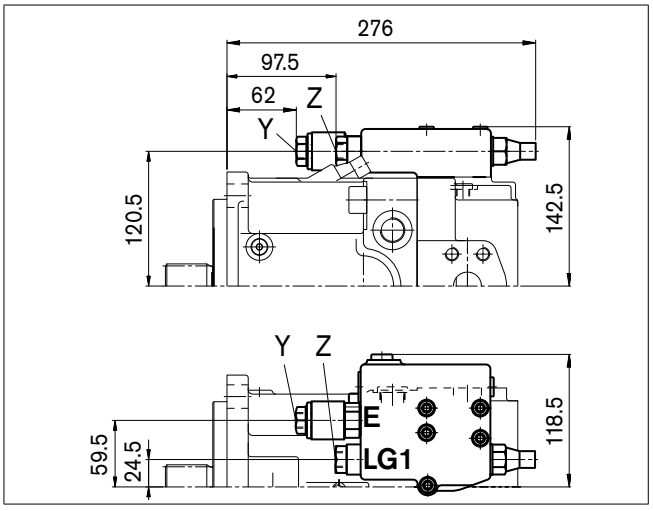
LR3DS

Power control with high-pressure related override, pressure cut-off and load sensing control



LG1E

Power control with pilot-pressure related override (negative) and 2-stage pressure cut-off



LG2E

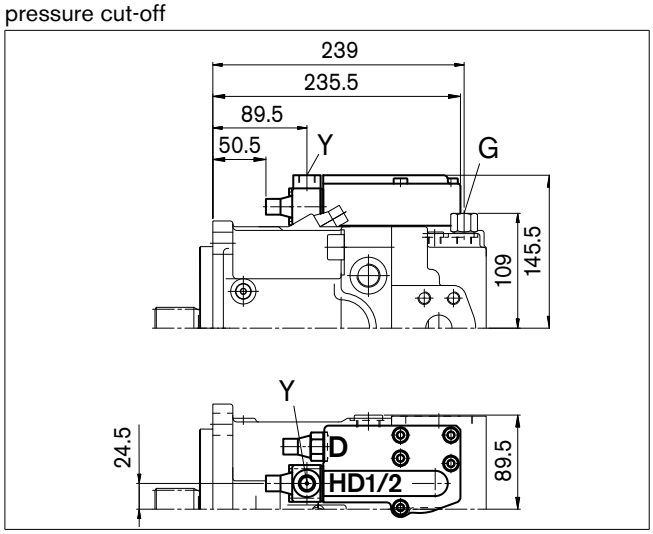
Power control with pilot-pressure related override (positive) and 2-stage pressure cut-off

Dimensions, Size 75

Before finalizing your design, please request a certified drawing. Dimensions in mm.

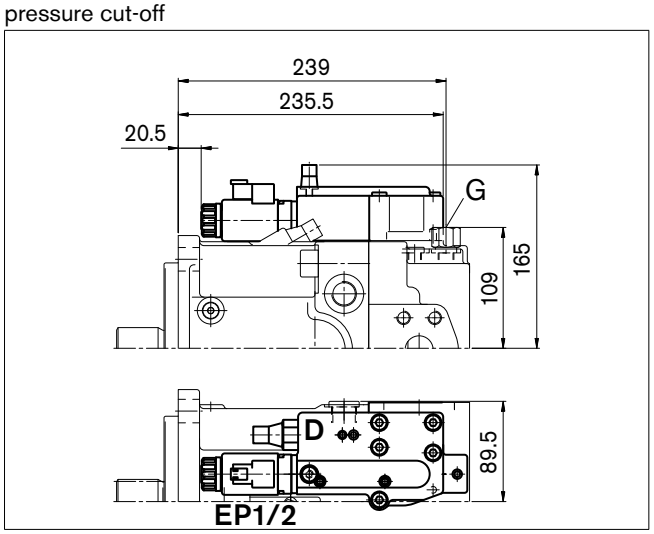
HD1D/HD2D

Hydraulic control, pilot-pressure related with pressure cut-off



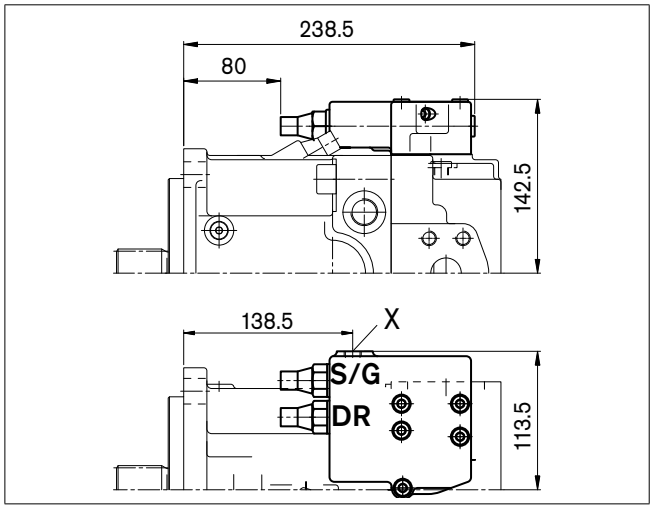
EP1D/EP2D

Electric control with proportional solenoid and pressure cut-off



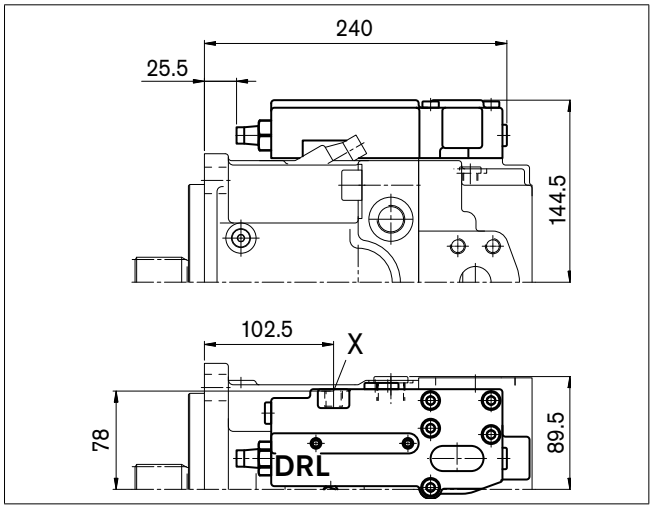
DRS/DRG

Pressure control with load sensing control
Pressure control remote controlled



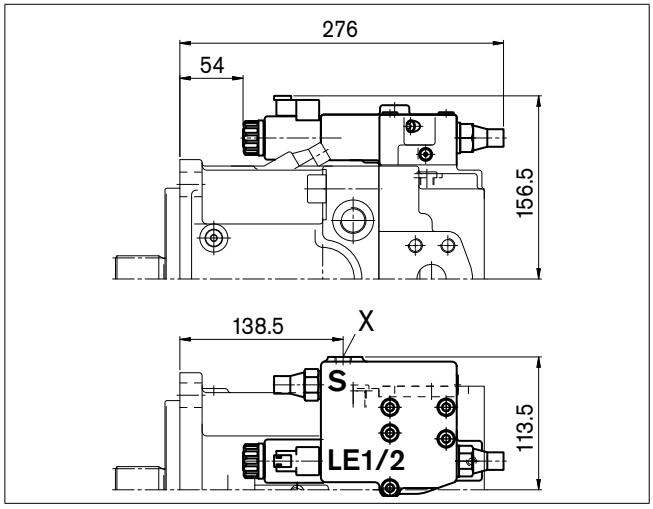
DRL

Pressure control for parallel operation



LE1S/LE2S

Power control with electric override (negative) and load sensing control



LE2S2/LE1S5/LE2S5

Power control with electric override (negative) and load sensing control, override

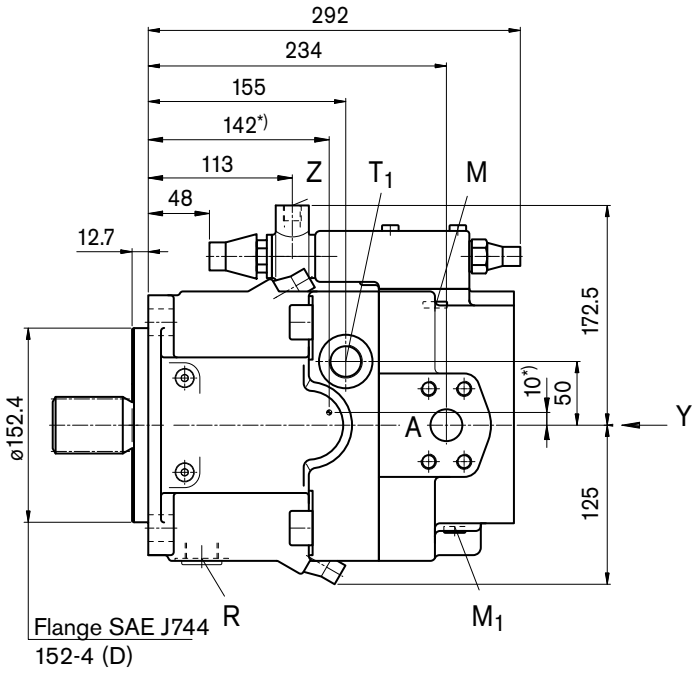
Dimensions, Size 95

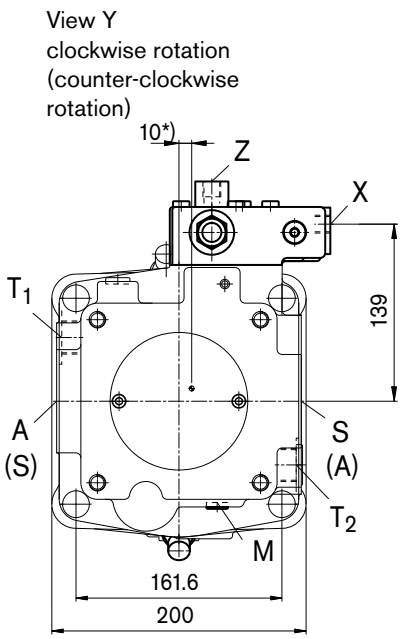
Before finalizing your design, please request a certified drawing. Dimensions in mm.

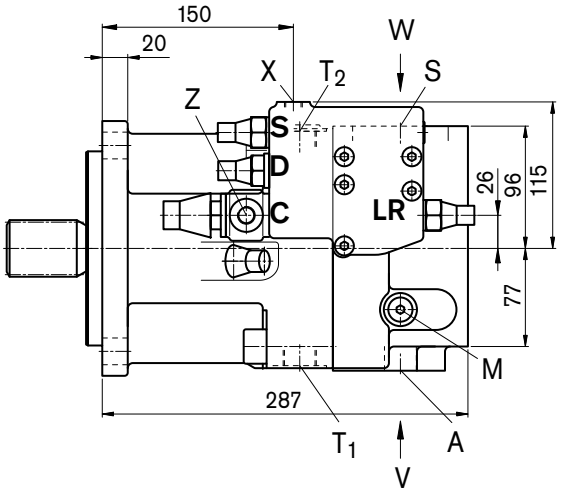
LRDCS

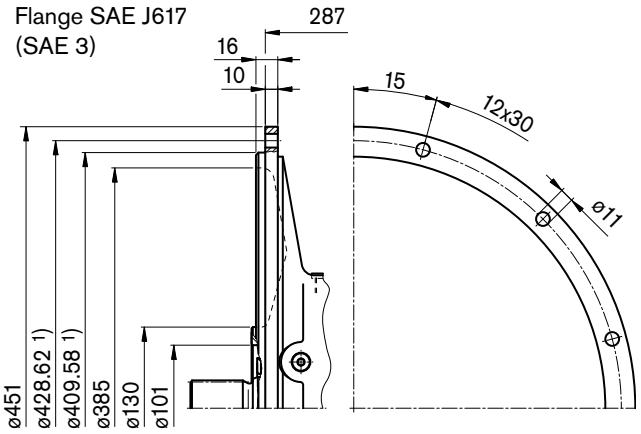
Power control LR with pressure cut-off D, cross sensing control C and load sensing control S

*) Center of gravity

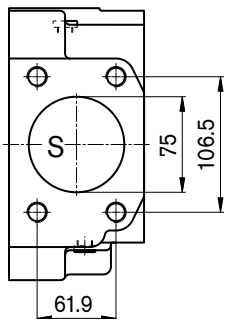




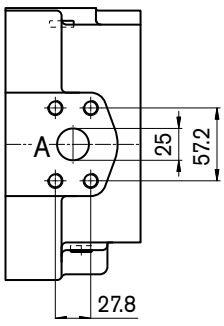




Detail W



Detail V



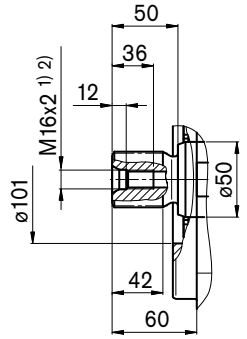
1) Dimensions according to SAE J617-No. 3, for connection to the flywheel case of the combustion engine

Dimensions, Size 95

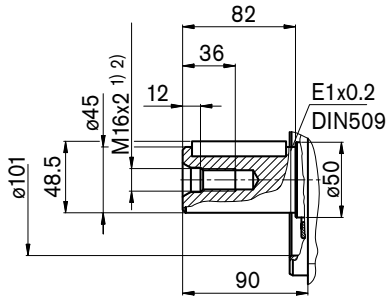
Before finalizing your design, please request a certified drawing. Dimensions in mm.

Shaft ends

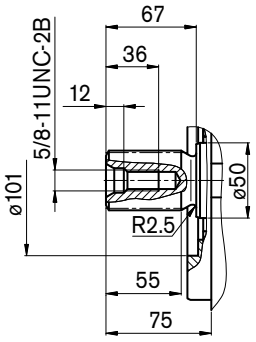
Z Splined shaft DIN 5480
W45x2x30x21x9g



P Parallel keyed shaft DIN 6885 – AS14x9x80



S Splined shaft SAE J744
1 3/4 in 13T 8/16DP 3)



Ports

Designation	Function	Standard	Size[2]		Max. pressure (bar) [4]	State
A	Service line port Fixing thread	SAE J518 DIN 13	1 in M12x1.75;	 17 deep	400	O
S	Suction port Fixing thread	SAE J518 DIN 13	3 in M16x2;	 24 deep	30	O
T_1, T_2	Tank port	DIN 3852	M26x1.5;	16 deep	10	[5]
R	Air bleed	DIN 3852	M26x1.5;	16 deep	10	X
M_1	Measurement point, positioning chamber	DIN 3852	M12x1.5;	12 deep	400	X
M	Measurement point, service line port	DIN 3852	M12x1.5;	12 deep	400	X
X	Pilot pressure port in version with load sensing (S) and remote controlled pressure cut-off (G)	DIN 3852	M14x1.5	12 deep	400	O
Y	Pilot pressure port in version with stroke limiter (H...), 2-stage pressure cut-off (E) and HD	DIN 3852	M14x1.5;	12 deep	40	O
Z	Pilot pressure port in version with cross sensing (C) and power override (LR3) power override (LG1)	DIN 3852	M14x1.5;	12 deep	 400 40	O
G	Port for control pressure (controller) in version with stroke limiter (H.., U2), HD and EP with screw union GE10 - PLM (otherwise closed)	DIN 3852	M14x1.5;	12 deep	40	O

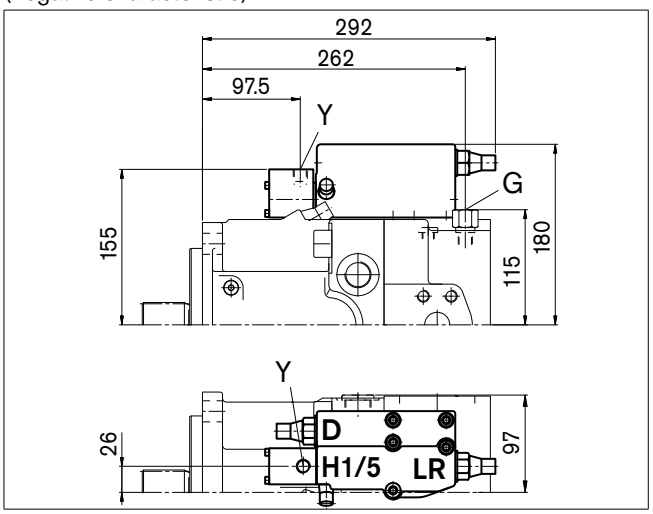
[1] Center bore according to DIN 332 (thread acc. to DIN 13)
[2] For max. tightening torque, please refer to general notes on page 64
[3] ANSI B92.1a-1976, 30° pressure angle, flat root, side fit, tolerance class 5
[4] Depending on adjustment data and operating pressure
[5] Depending on installation position, T1 or T2 must be connected (see also page 61)
O = Open, must be connected (closed on delivery)
X = Closed (in normal operation)

Dimensions, Size 95

Before finalizing your design, please request a certified drawing. Dimensions in mm.

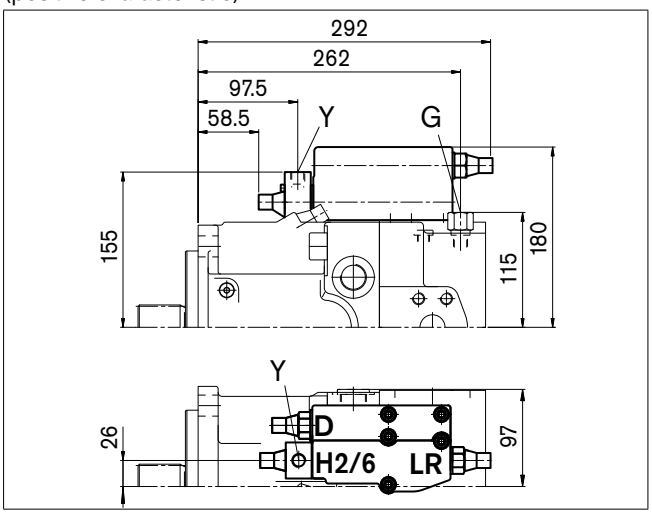
LRDH1/LRDH5

Power control with pressure cut-off and hydraulic stroke limiter (negative characteristic)



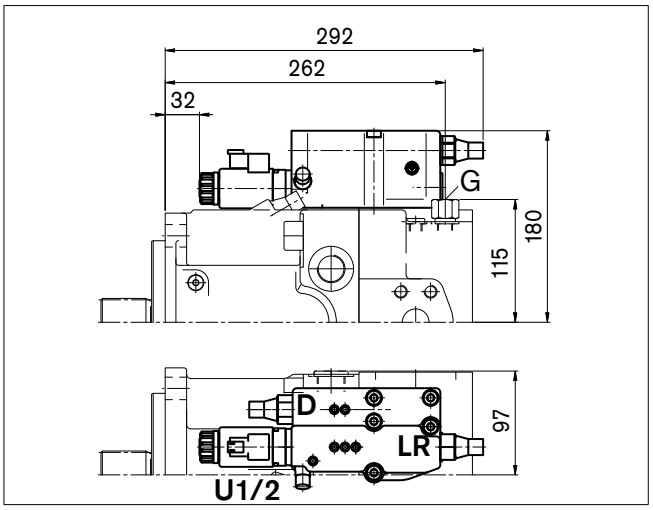
LRDH2/LRDH6

Power control with pressure cut-off and hydraulic stroke limiter (positive characteristic)



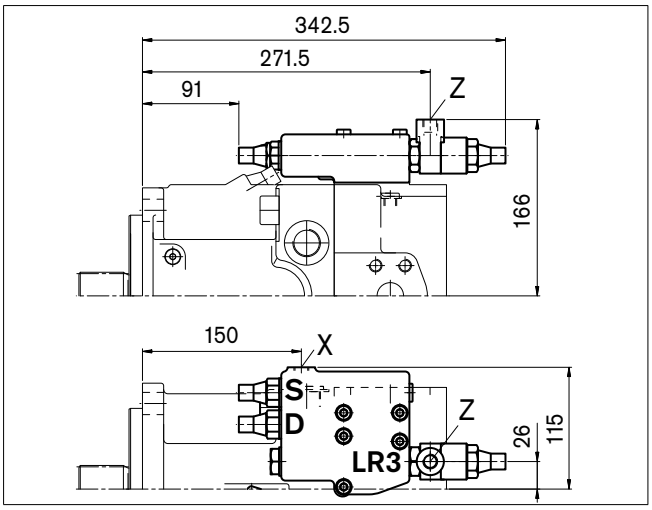
LRDU1/LRDU2

Power control with pressure cut-off and electric stroke limiter (positive characteristic)



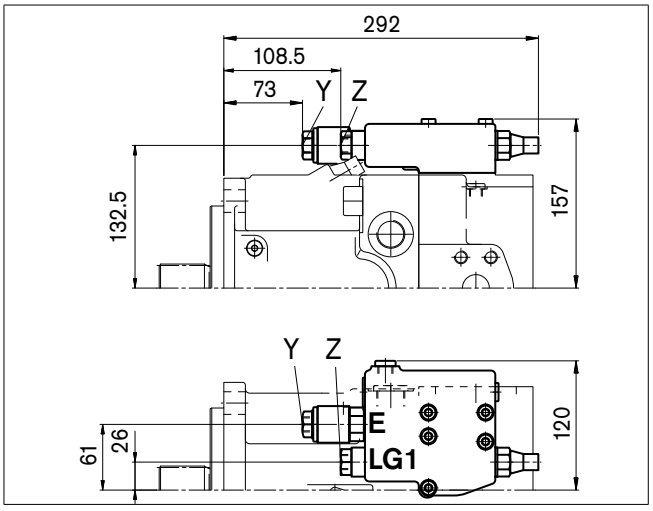
LR3DS

Power control with high-pressure related override, pressure cut-off and load sensing control



LG1E

Power control with pilot-pressure related override (negative) and 2-stage pressure cut-off



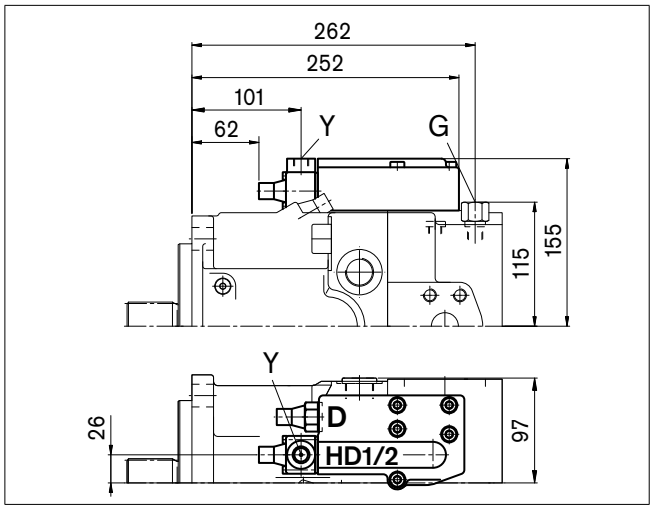
LG2E

Power control with pilot-pressure related override (positive) and 2-stage pressure cut-off

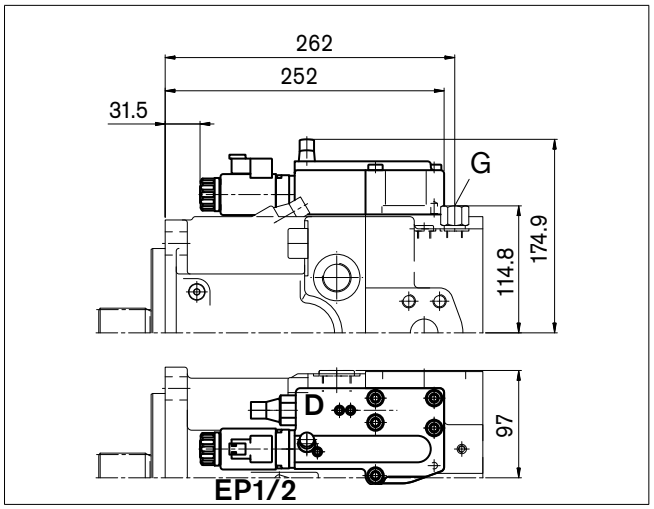
Dimensions, Size 95

Before finalizing your design, please request a certified drawing. Dimensions in mm.

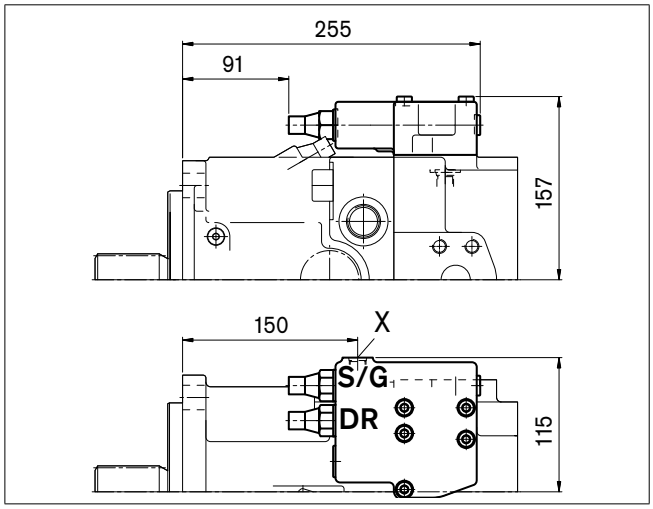
HD1D/HD2D
Hydraulic control, pilot-pressure related with pressure cut-off



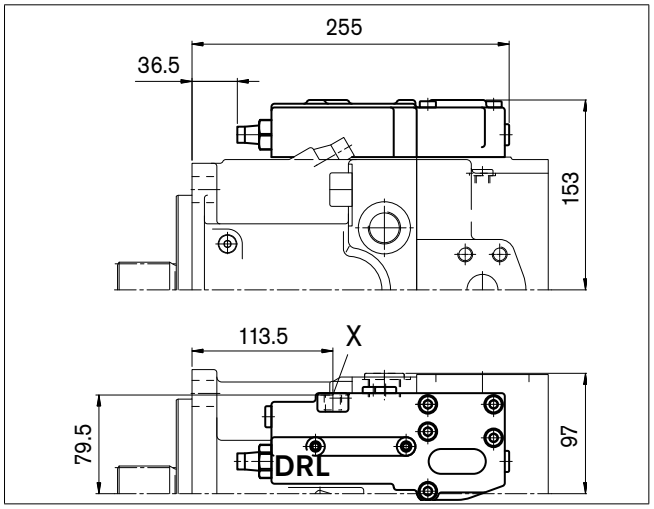
EP1D/EP2D
Electric control with proportional solenoid and pressure cut-off



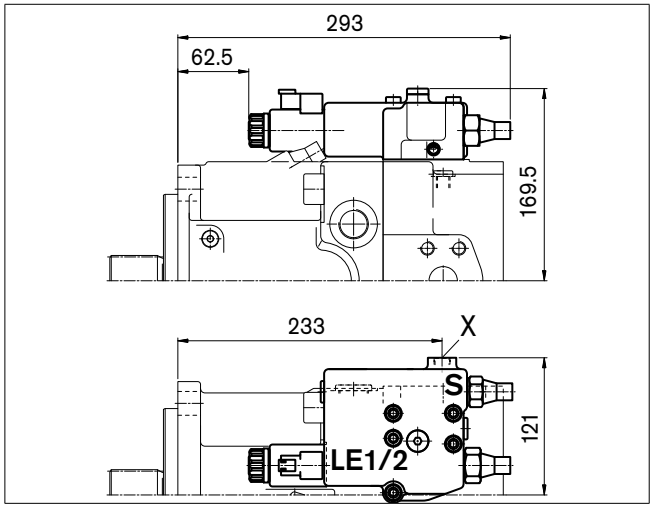
DRS/DRG
Pressure control with load sensing control
Pressure control remote controlled



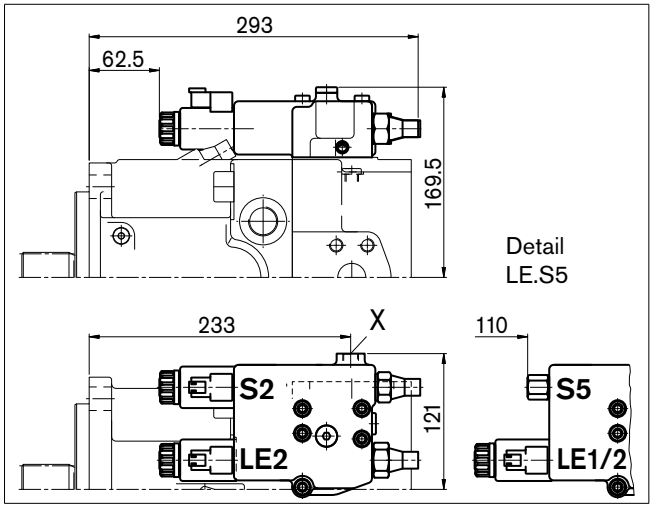
DRL
Pressure control for parallel operation



LE1S/LE2S
Power control with electric override (negative) and load sensing control



LE2S2/LE1S5/LE2S5
Power control with electric override (negative) and load sensing control, override

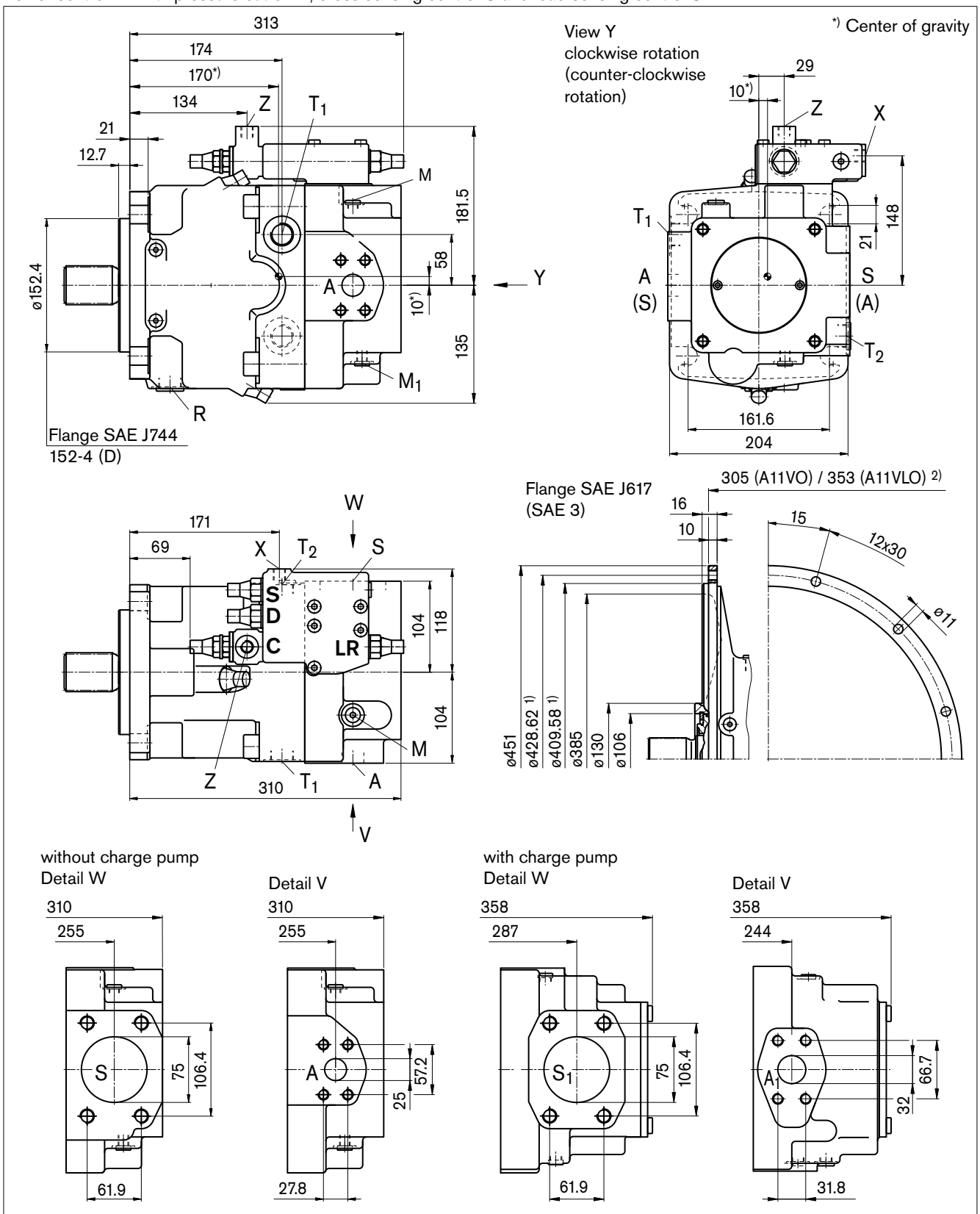


Dimensions, Size 130/145

Before finalizing your design, please request a certified drawing. Dimensions in mm.

LRDCS

Power control LR with pressure cut-off D, cross sensing control C and load sensing control S



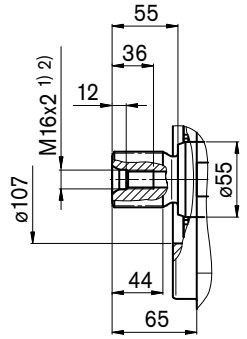
1) Dimensions according to SAE J617-No. 3, for connection to the flywheel case of the combustion engine
2) The case or length dimension with flange SAE 3 is 5 mm shorter than the standard case.

Dimensions, Size 130/145

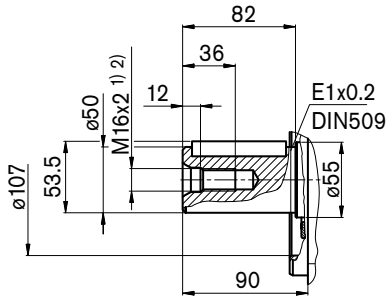
Before finalizing your design, please request a certified drawing. Dimensions in mm.

Shaft ends

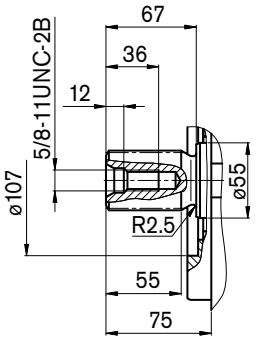
Z Splined shaft DIN 5480
W50x2x30x24x9g



P Parallel keyed shaft DIN 6885,
AS14x9x80



S Splined shaft SAE J744
1 3/4 in 13T 8/16DP 3)



Ports

Designation	Function	Standard	Size[2]		Max. pressure (bar) [4]	State
A	Service line port Fixing thread	SAE J518 DIN 13	1 in M12x1.75;	17 deep	400	O
A_1	Service line port Fixing thread	SAE J518 DIN 13	1 1/4 in M14x2;	19 deep	400	O
S, S_1	Suction port Fixing thread	SAE J518 DIN 13	3 in M16x2;	24 deep	30 2[6]	O
T_1, T_2	Tank port	DIN 3852	M26x1.5;	16 deep	10	[5]
R	Air bleed	DIN 3852	M26x1.5;	16 deep	10	X
M_1	Measurement point, positioning chamber	DIN 3852	M12x1.5;	12 deep	400	X
M	Measurement point, service line port	DIN 3852	M12x1.5;	12 deep	400	X
X	Pilot pressure port in version with load sensing (S) and remote controlled pressure cut-off (G)	DIN 3852	M14x1.5	12 deep	400	O
Y	Pilot pressure port in version with stroke limiter (H...), 2-stage pressure cut-off (E) and HD	DIN 3852	M14x1.5;	12 deep	40	O
Z	Pilot pressure port in version with cross sensing (C) and power override (LR3) power override (LG1)	DIN 3852	M14x1.5;	12 deep	 400 40	O
G	Port for control pressure (controller) in version with stroke limiter (H.., U2), HD and EP with screw union GE10 - PLM (otherwise closed)	DIN 3852	M14x1.5;	12 deep	40	O

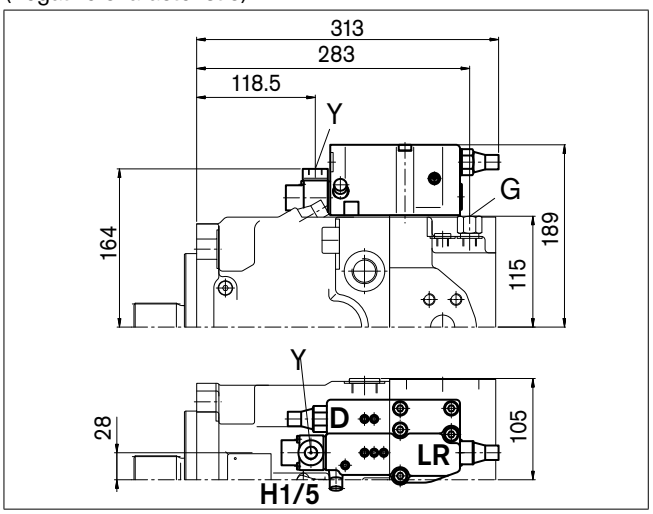
[1] Center bore according to DIN 332 (thread acc. to DIN 13)
[2] For max. tightening torque, please refer to general notes on page 64
[3] ANSI B92.1a-1976, 30° pressure angle, flat root, side fit, tolerance class 5
[4] Depending on adjustment data and operating pressure
[5] Depending on installation position, T1 or T2 must be connected (see also page 61)
[6] with charge pump
O = Open, must be connected (closed on delivery)
X = Closed (in normal operation)

Dimensions, Size 130/145

Before finalizing your design, please request a certified drawing. Dimensions in mm.

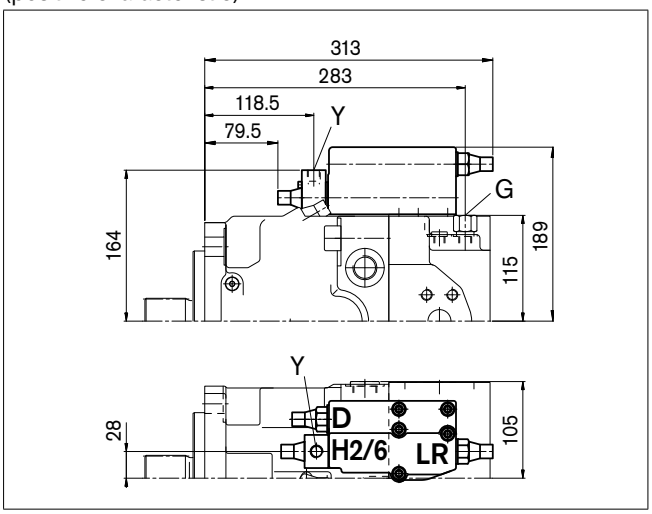
LRDH1/LRDH5

Power control with pressure cut-off and hydraulic stroke limiter (negative characteristic)



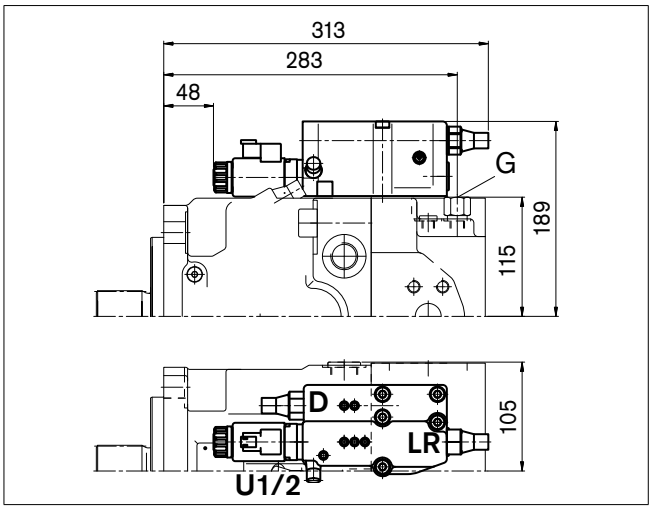
LRDH2/LRDH6

Power control with pressure cut-off and hydraulic stroke limiter (positive characteristic)



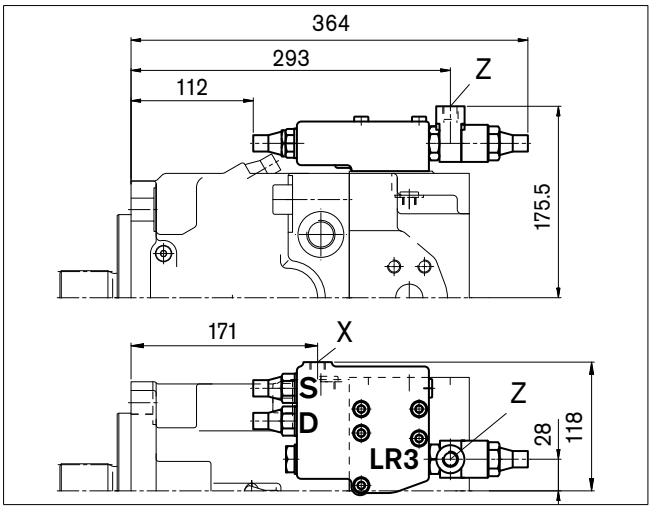
LRDU1/LRDU2

Power control with pressure cut-off and electric stroke limiter (positive characteristic)



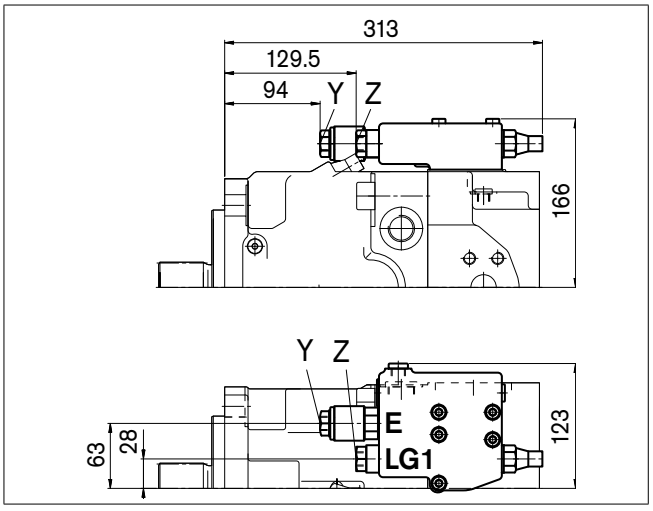
LR3DS

Power control with high-pressure related override, pressure cut-off and load sensing control



LG1E

Power control with pilot-pressure related override (negative) and 2-stage pressure cut-off



LG2E

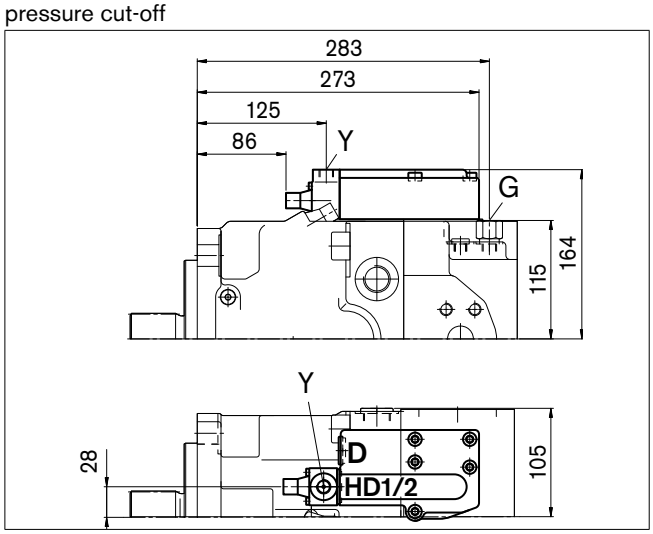
Power control with pilot-pressure related override (positive) and 2-stage pressure cut-off

Dimensions, Size 130/145

Before finalizing your design, please request a certified drawing. Dimensions in mm.

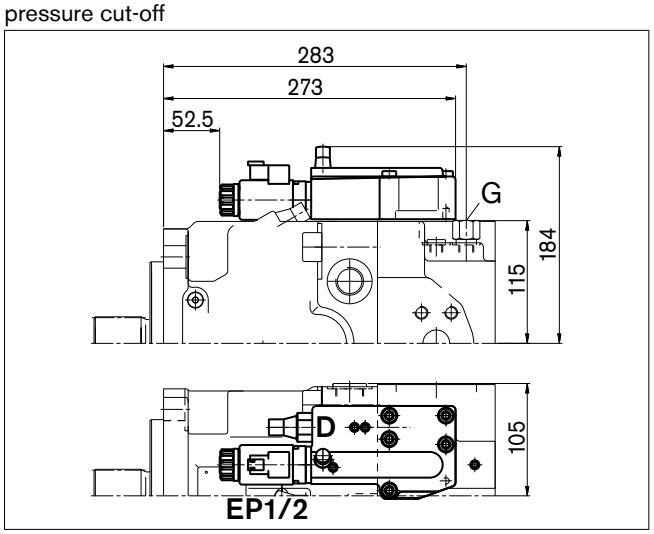
HD1D/HD2D

Hydraulic control, pilot-pressure related with pressure cut-off



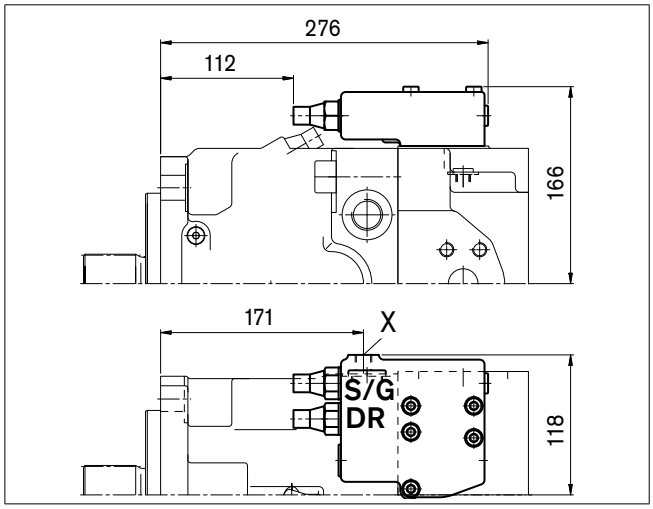
EP1D/EP2D

Electric control with proportional solenoid and pressure cut-off



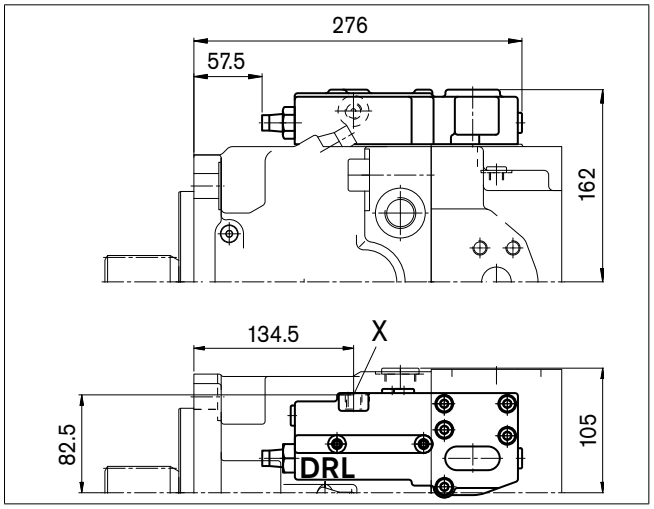
DRS/DRG

Pressure control with load sensing control
Pressure control remote controlled



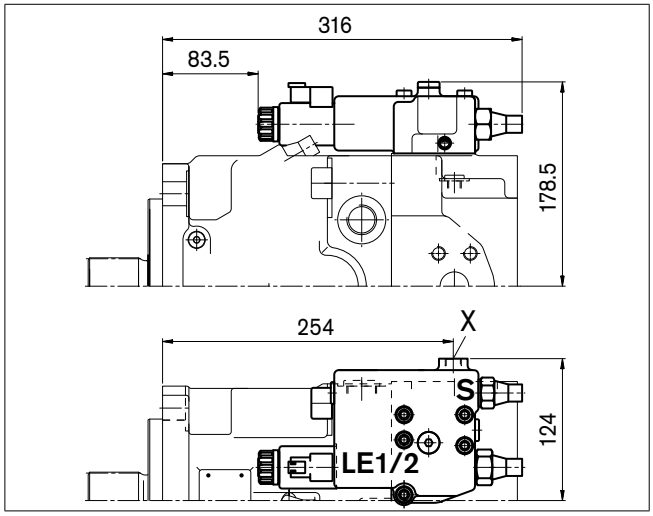
DRL

Pressure control for parallel operation



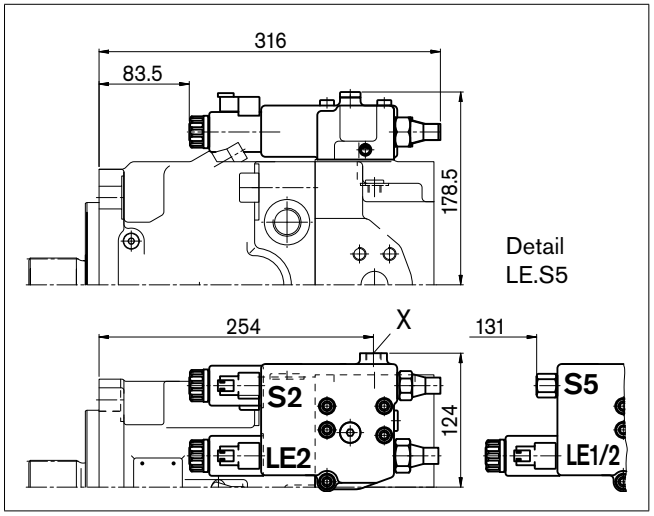
LE1S/LE2S

Power control with electric override (negative) and load sensing control



LE2S2/LE1S5/LE2S5

Power control with electric override (negative) and load sensing control, override

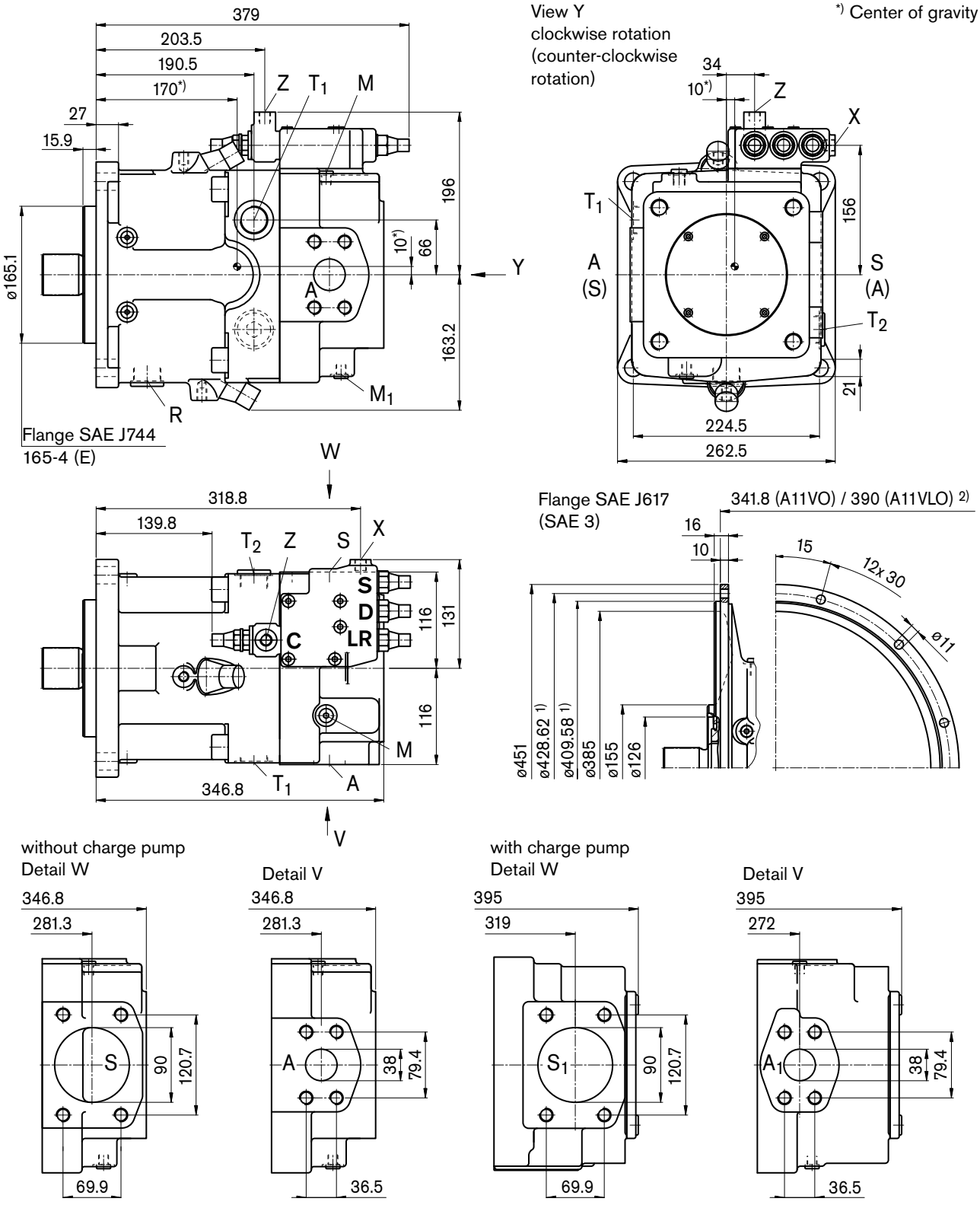


Dimensions, Size 190

Before finalizing your design, please request a certified drawing. Dimensions in mm.

LRDCS

Power control LR with pressure cut-off D, cross sensing control C and load sensing control S



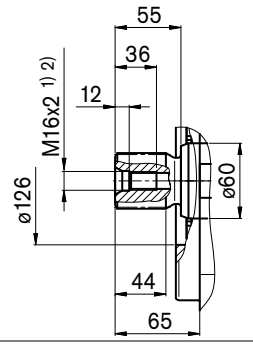
1) Dimensions according to SAE J617-No. 3, for connection to the flywheel case of the combustion engine
2) The case or length dimension with flange SAE 3 is 5 mm shorter than the standard case.

Dimensions, Size 190

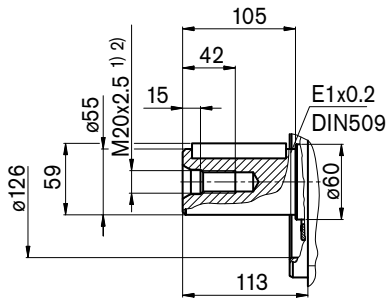
Before finalizing your design, please request a certified drawing. Dimensions in mm.

Shaft ends

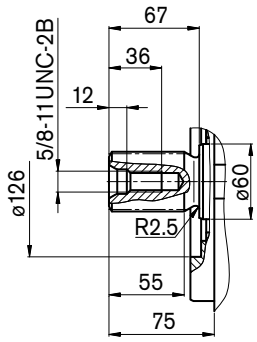
Z Splined shaft DIN 5480
W50x2x30x24x9g



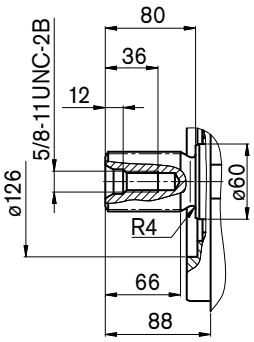
P Parallel keyed shaft DIN 6885,
AS16x10x100



S Splined shaft SAE J744
1 3/4 in 13T 8/16DP 3)



T Splined shaft SAE J744
2 in 15T 8/16DP 3)



Ports

Designation	Function	Standard	Size[2)]		Max. pressure (bar) [4)]	State
A, A_1	Service line port Fixing thread	SAE J518 DIN 13	1 1/2 in M16x2;	21 deep	400	O
S, S_1	Suction port Fixing thread	SAE J518 DIN 13	3 1/2 in M16x2;	24 deep	30 2[6)]	O
T_1, T_2	Tank port	DIN 3852	M33x2;	18 deep	10	[5)]
R	Air bleed	DIN 3852	M33x2;	18 deep	10	X
M_1	Measurement point, positioning chamber	DIN 3852	M12x1.5;	12 deep	400	X
M	Measurement point, service line port	DIN 3852	M12x1.5;	12 deep	400	X
X	Pilot pressure port in version with load sensing (S) and remote controlled pressure cut-off (G)	DIN 3852	M14x1.5	12 deep	400	O
Y	Pilot pressure port in version with stroke limiter (H...), 2-stage pressure cut-off (E) and HD	DIN 3852	M14x1.5;	12 deep	40	O
Z	Pilot pressure port in version with cross sensing (C) and power override (LR3) power override (LG1)	DIN 3852	M14x1.5;	12 deep	 400 40	O
G	Port for control pressure (controller) in version with stroke limiter (H.., U2), HD and EP with screw union GE10 - PLM (otherwise closed)	DIN 3852	M14x1.5;	12 deep	40	O

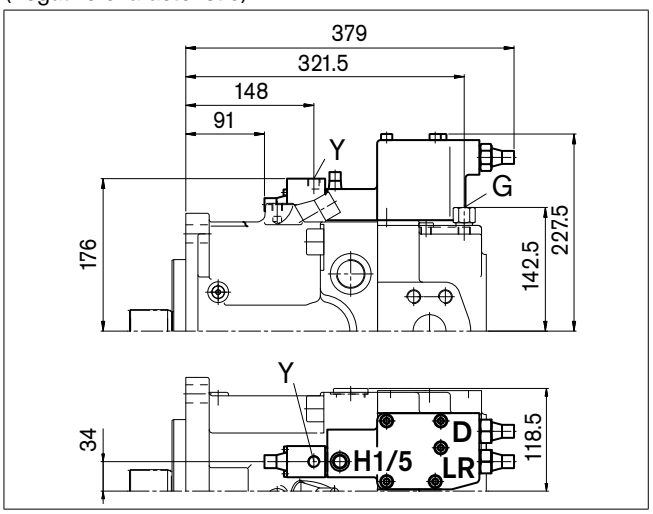
1) Center bore according to DIN 332 (thread acc. to DIN 13)
2) For max. tightening torque, please refer to general notes on page 64
3) ANSI B92.1a-1976, 30° pressure angle, flat root, side fit, tolerance class 5
4) Depending on adjustment data and operating pressure
5) Depending on installation position, T1 or T2 must be connected (see also page 61)
6) with charge pump
O = Open, must be connected (closed on delivery)
X = Closed (in normal operation)

Dimensions, Size 190

Before finalizing your design, please request a certified drawing. Dimensions in mm.

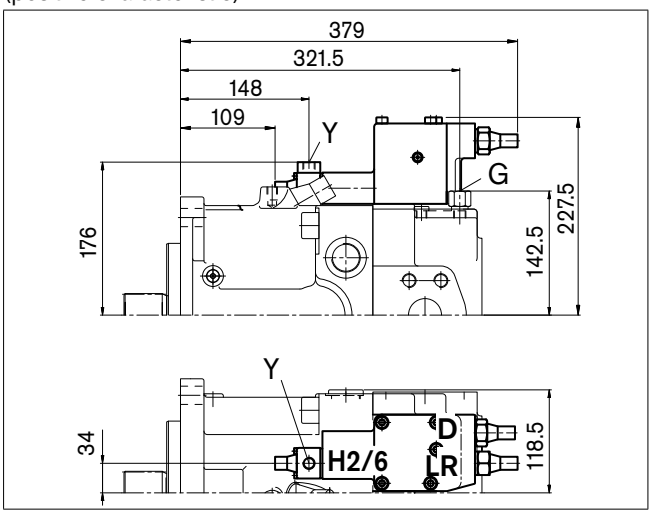
LRDH1/LRDH5

Power control with pressure cut-off and hydraulic stroke limiter (negative characteristic)



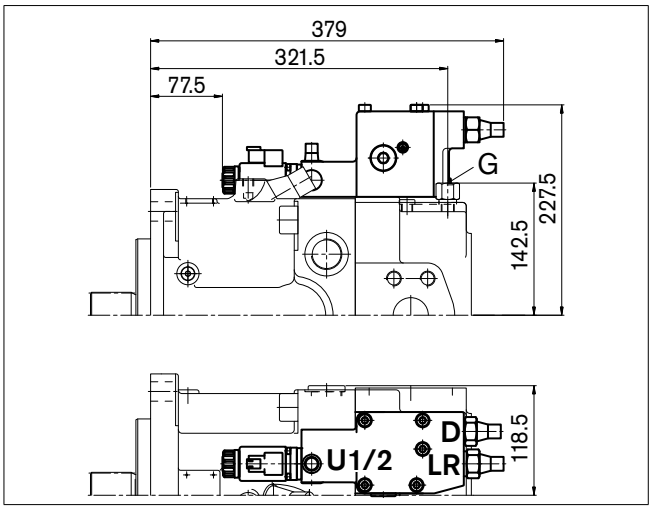
LRDH2/LRDH6

Power control with pressure cut-off and hydraulic stroke limiter (positive characteristic)



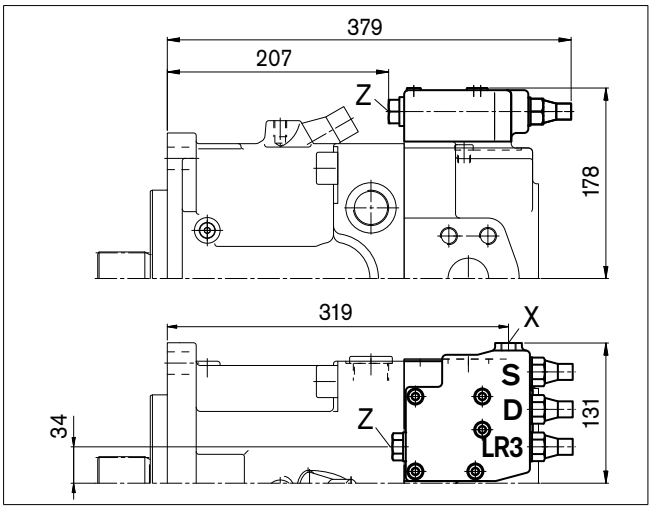
LRDU1/LRDU2

Power control with pressure cut-off and electric stroke limiter (positive characteristic)



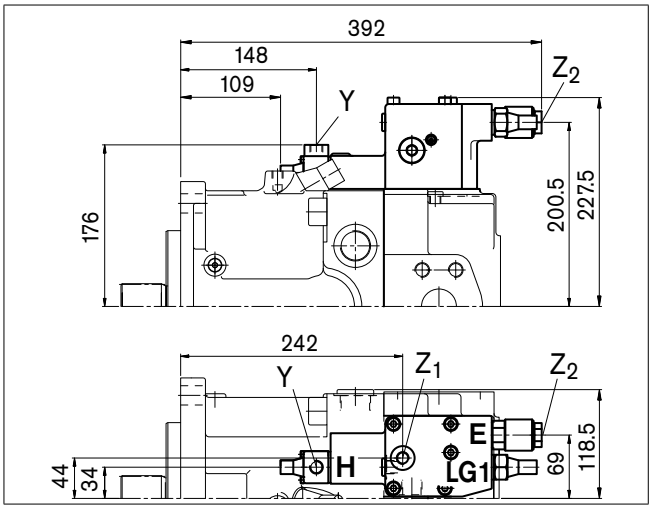
LR3DS

Power control with high-pressure related override, pressure cut-off and load sensing control



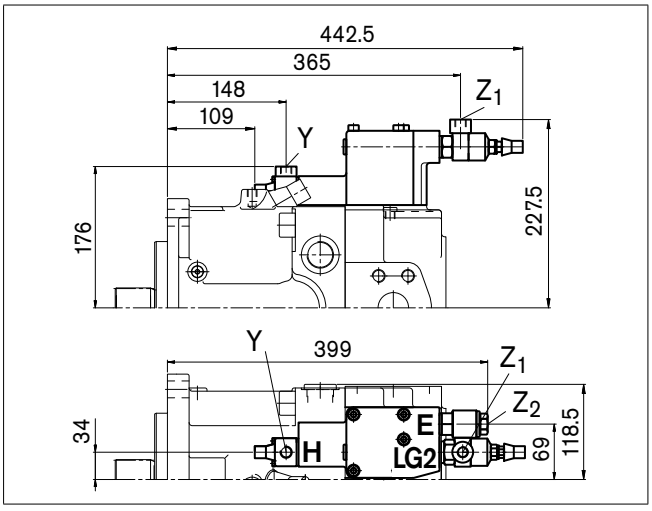
LG1EH

Power control with pilot-pressure related override (neg.), 2-stage pressure cut-off and hydr. stroke limiter



LG2EH

Power control with pilot-pressure related override (pos.), 2-stage pressure cut-off and hydr. stroke limiter

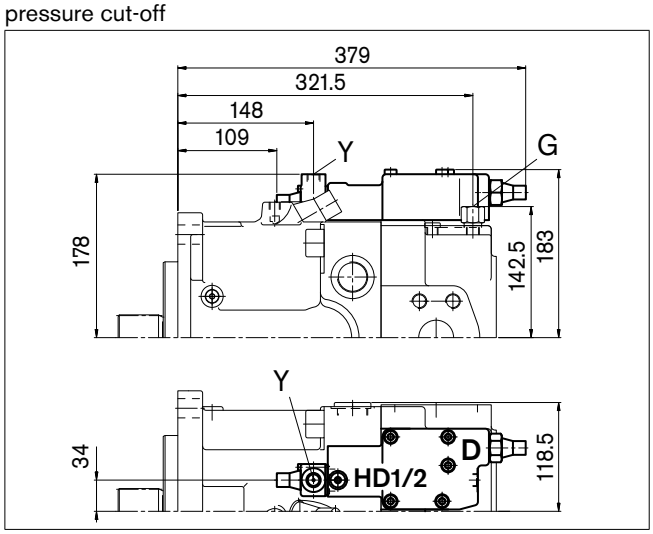


Dimensions, Size 190

Before finalizing your design, please request a certified drawing. Dimensions in mm.

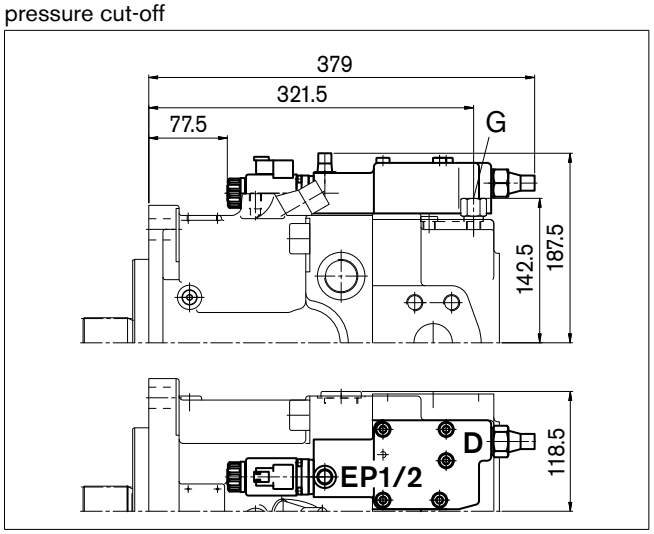
HD1D/HD2D

Hydraulic control, pilot-pressure related with pressure cut-off



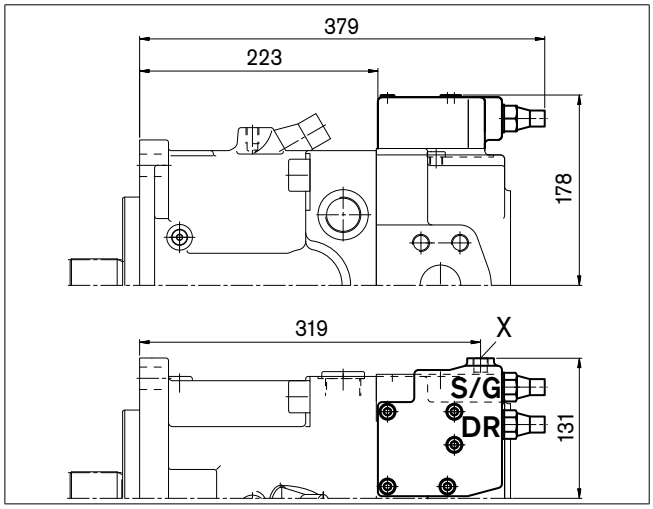
EP1D/EP2D

Electric control with proportional solenoid and pressure cut-off



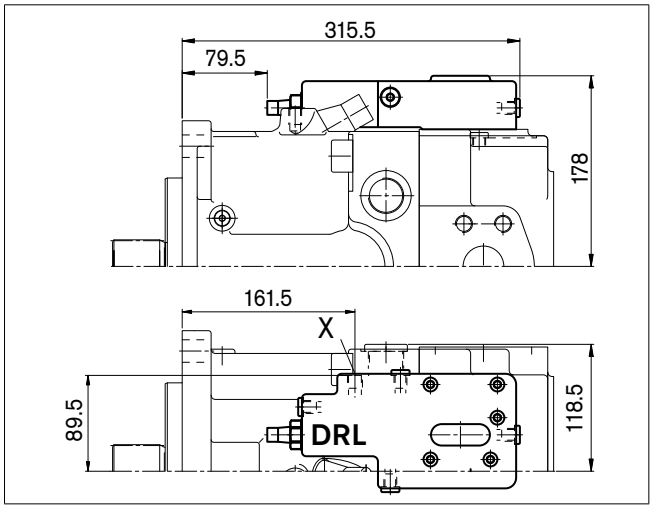
DRS/DRG

Pressure control with load sensing control
Pressure control remote controlled



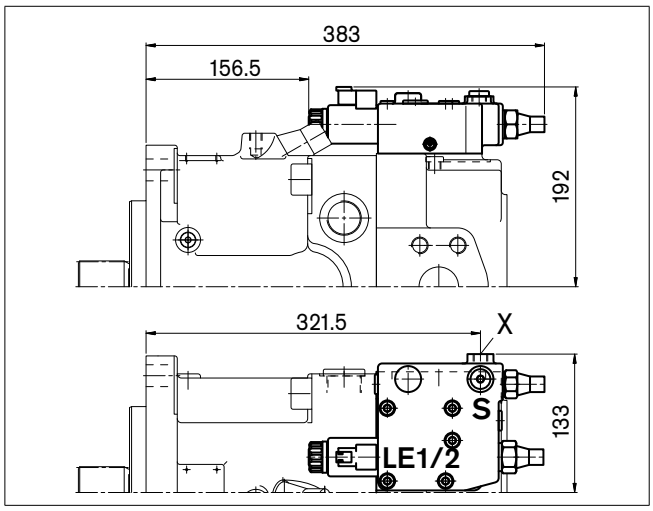
DRL

Pressure control for parallel operation



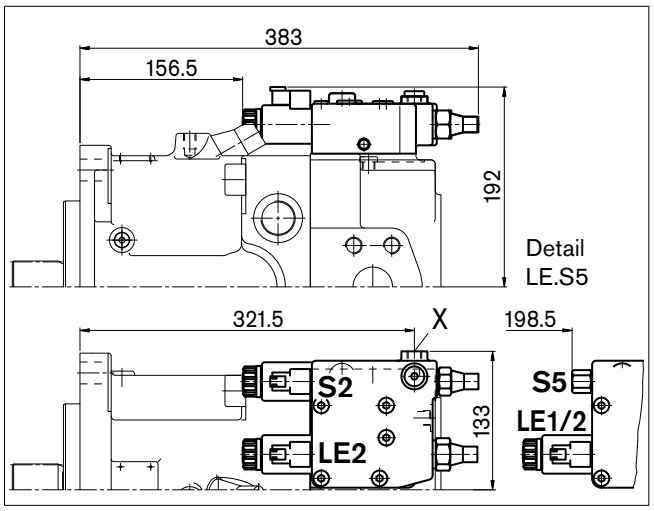
LE1S/LE2S

Power control with electric override (negative) and load sensing control



LE2S2/LE1S5/LE2S5

Power control with electric override (negative) and load sensing control, override

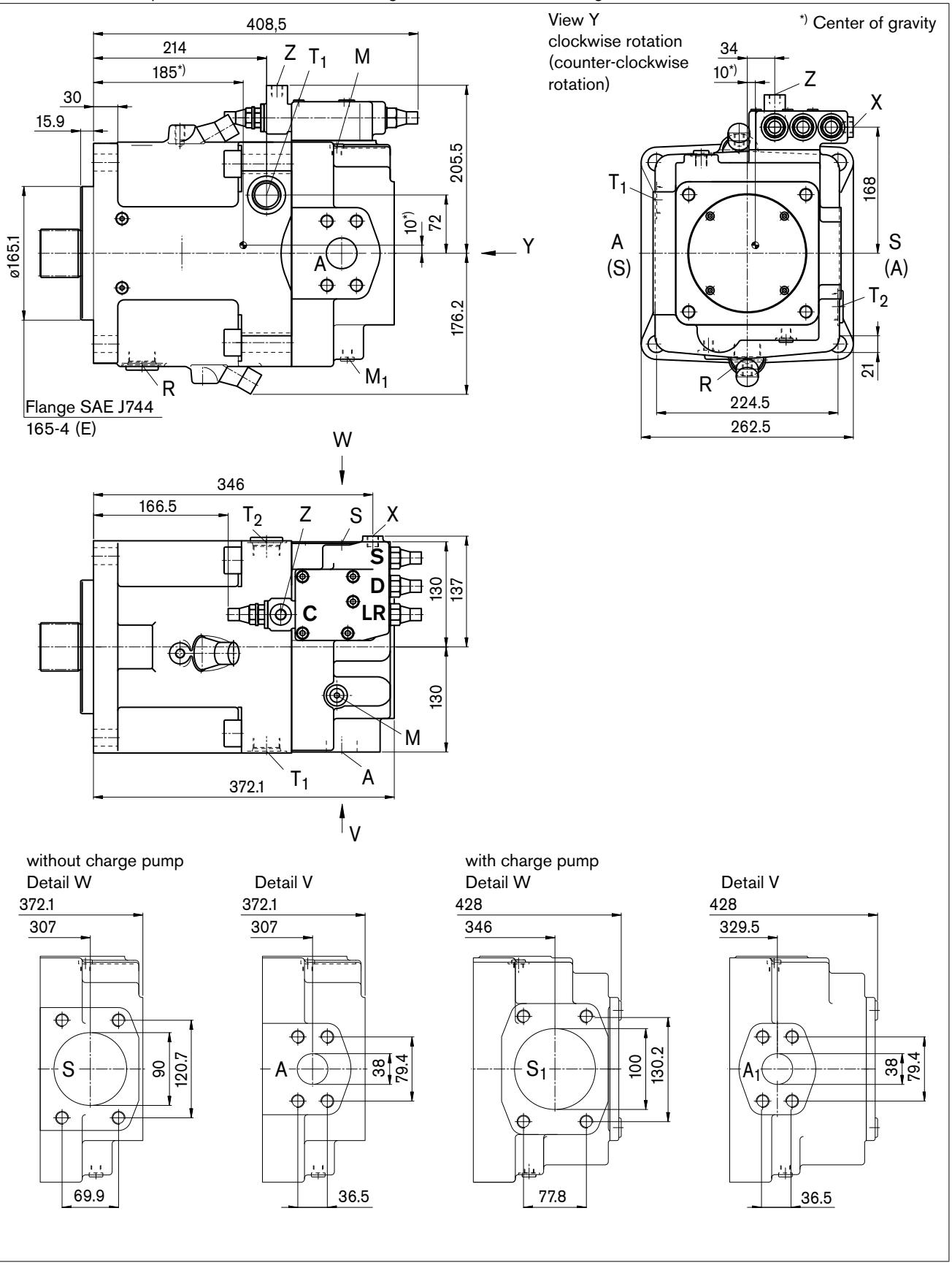


Dimensions, Size 260

Before finalizing your design, please request a certified drawing. Dimensions in mm.

LRDCS

Power control LR with pressure cut-off D, cross sensing control C and load sensing control S

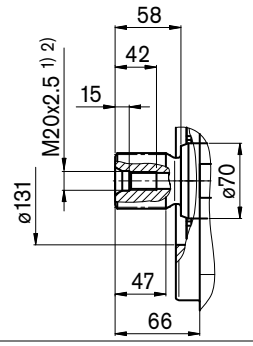


Dimensions, Size 260

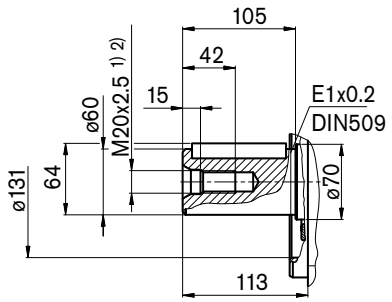
Before finalizing your design, please request a certified drawing. Dimensions in mm.

Shaft ends

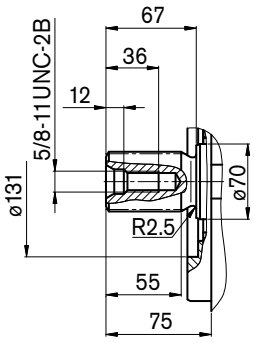
Z Splined shaft DIN 5480
W60x2x30x28x9g



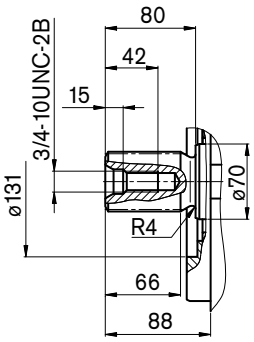
P Parallel keyed shaft DIN 6885,
AS18x11x100



S Splined shaft SAE J744
1 3/4 in 13T 8/16DP 3)



T Splined shaft SAE J744
2 1/4 in 17T 8/16DP 3)



Ports

Designation	Function	Standard	Size[2]		Max. pressure (bar) [4]	State
A, A_1	Service line port Fixing thread	SAE J518 DIN 13	1 1/2 in M16x2;	21 deep	400	O
S	Suction port Fixing thread	SAE J518 DIN 13	3 1/2 in M16x2;	24 deep	30	O
S_1	Suction port Fixing thread	SAE J518 DIN 13	4 in M16x2;	21 deep	2[6]	O
T_1, T_2	Tank port	DIN 3852	M33x2;	16 deep	10	[5]
R	Air bleed	DIN 3852	M33x2;	16 deep	10	X
M_1	Measurement point, positioning chamber	DIN 3852	M12x1.5;	12 deep	400	X
M	Measurement point, service line port	DIN 3852	M12x1.5;	12 deep	400	X
X	Pilot pressure port in version with load sensing (S) and remote controlled pressure cut-off (G)	DIN 3852	M14x1.5	12 deep	400	O
Y	Pilot pressure port in version with stroke limiter (H...), 2-stage pressure cut-off (E) and HD	DIN 3852	M14x1.5;	12 deep	40	O
Z	Pilot pressure port in version with cross sensing (C) and power override (LR3) power override (LG1)	DIN 3852	M14x1.5;	12 deep	 400 40	O
G	Port for control pressure (controller) in version with stroke limiter (H.., U2), HD and EP with screw union GE10 - PLM (otherwise closed)	DIN 3852	M14x1.5;	12 deep	40	O

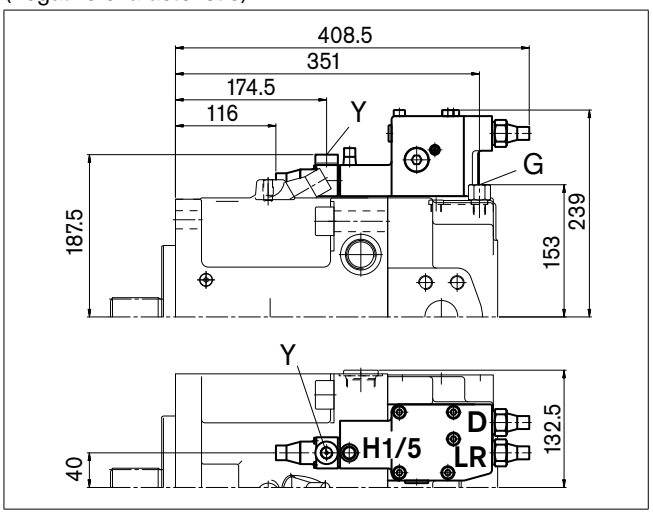
1) Center bore according to DIN 332 (thread acc. to DIN 13)
2) For max. tightening torque, please refer to general notes on page 64
3) ANSI B92.1a-1976, 30° pressure angle, flat root, side fit, tolerance class 5
4) Depending on adjustment data and operating pressure
5) Depending on installation position, T1 or T2 must be connected (see also page 61)
6) with charge pump
O = Open, must be connected (closed on delivery)
X = Closed (in normal operation)

Dimensions, Size 260

Before finalizing your design, please request a certified drawing. Dimensions in mm.

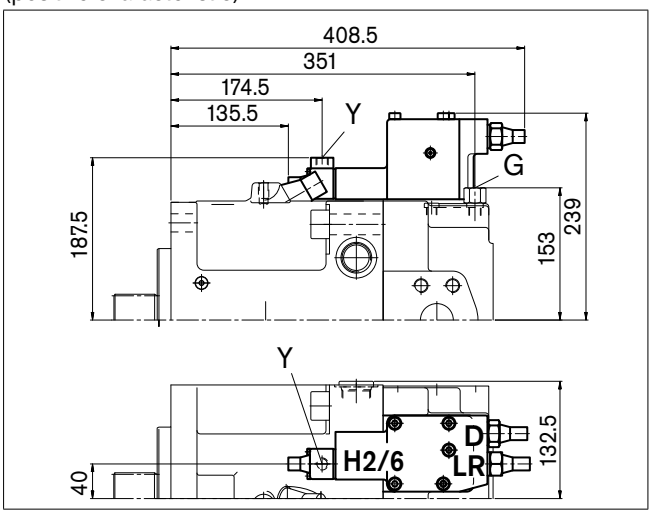
LRDH1/LRDH5

Power control with pressure cut-off and hydraulic stroke limiter (negative characteristic)



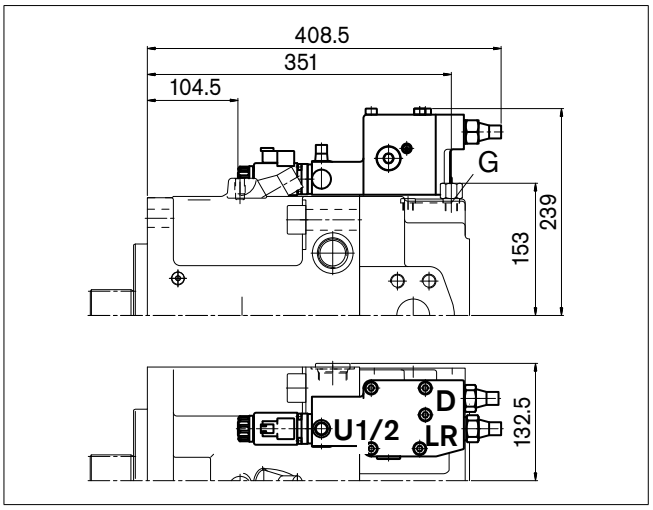
LRDH2/LRDH6

Power control with pressure cut-off and hydraulic stroke limiter (positive characteristic)



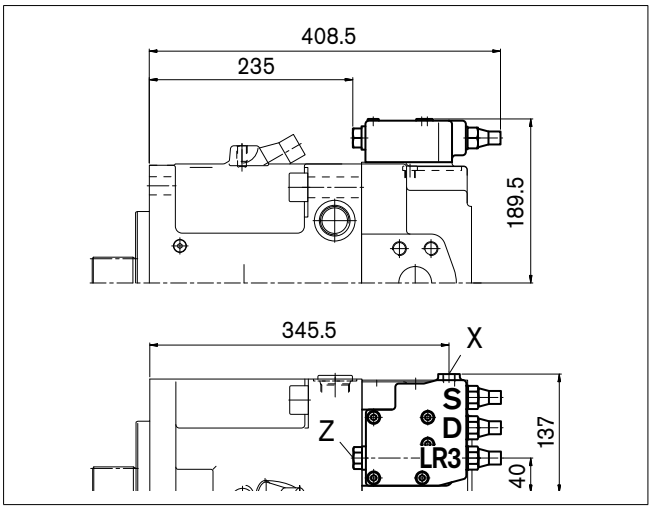
LRDU1/LRDU2

Power control with pressure cut-off and electric stroke limiter (positive characteristic)



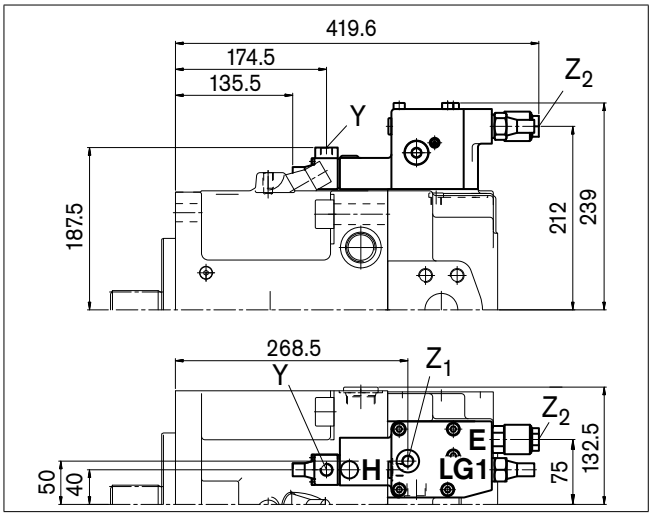
LR3DS

Power control with high-pressure related override, pressure cut-off and load sensing control



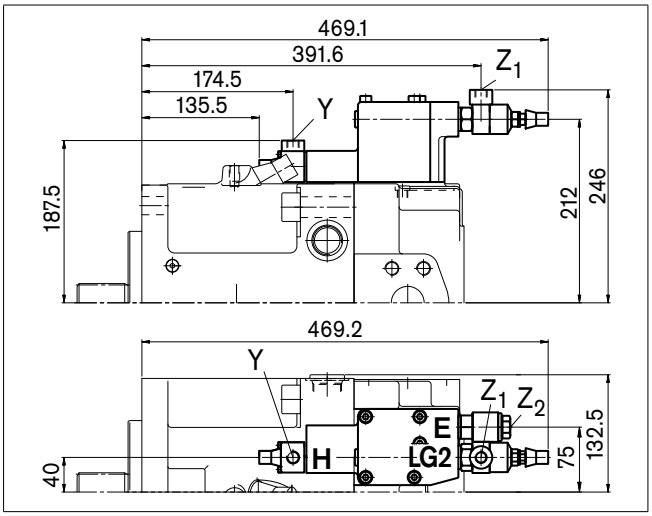
LG1EH

Power control with pilot-pressure related override (neg.), 2-stage pressure cut-off and hydr. stroke limiter



LG2EH

Power control with pilot-pressure related override (pos.), 2-stage pressure cut-off and hydr. stroke limiter

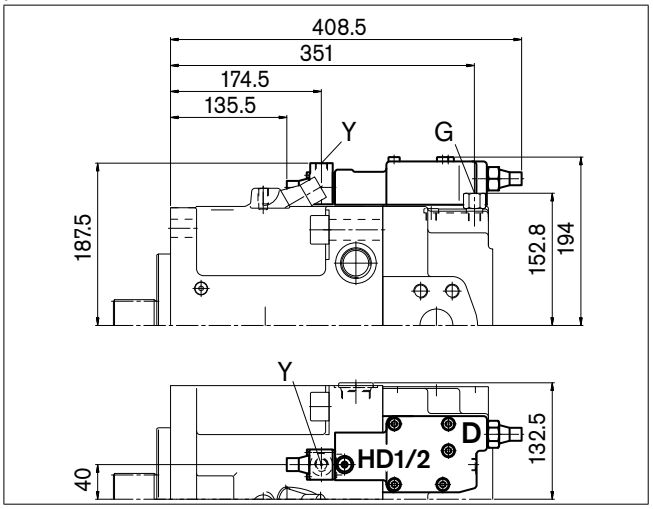


Dimensions, Size 260

Before finalizing your design, please request a certified drawing. Dimensions in mm.

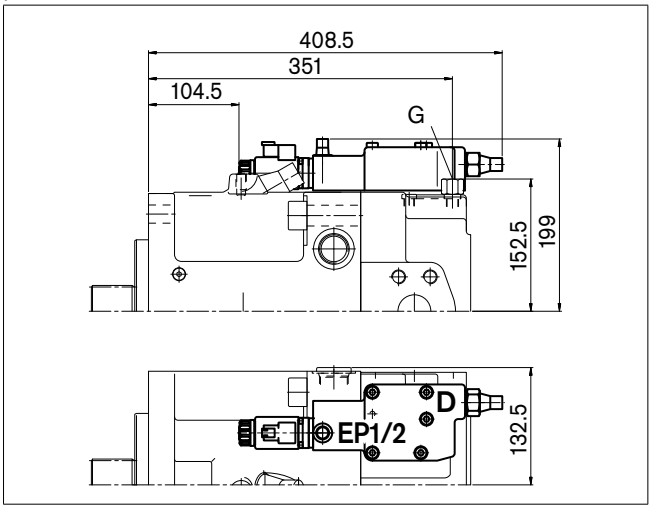
HD1D/HD2D

Hydraulic control, pilot-pressure related with pressure cut-off



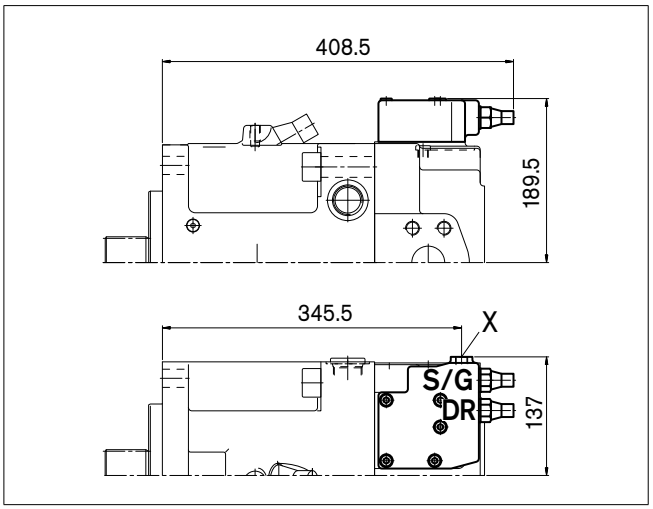
EP1D/EP2D

Electric control with proportional solenoid and pressure cut-off



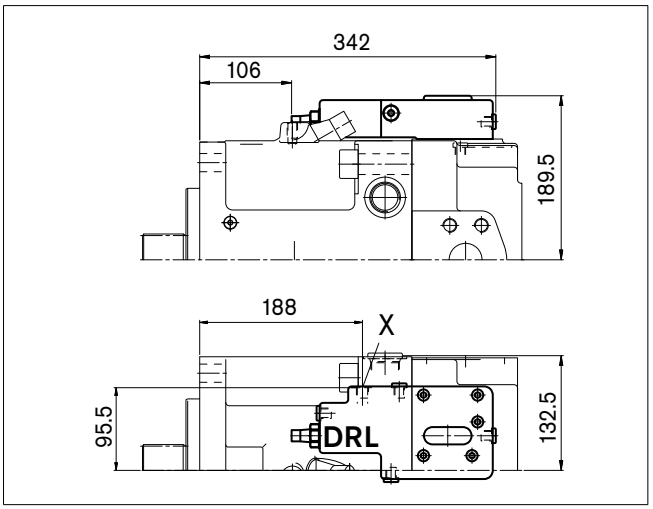
DRS/DRG

Pressure control with load sensing control
Pressure control remote controlled



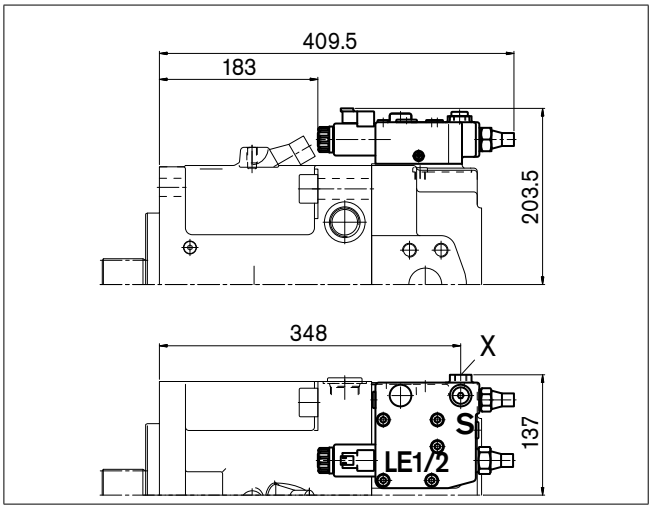
DRL

Pressure control for parallel operation



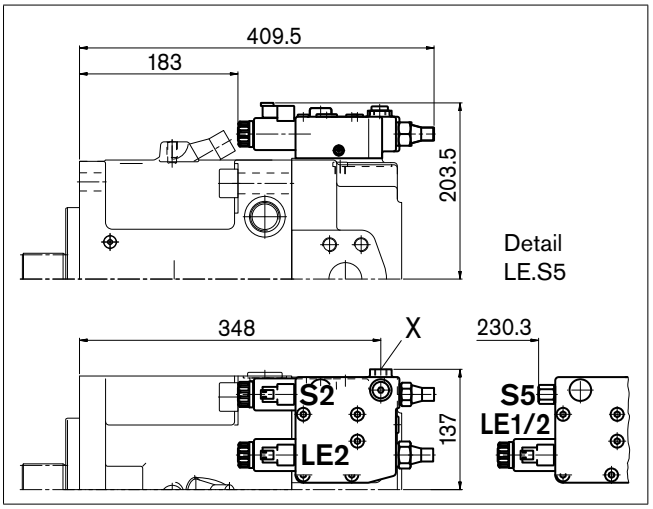
LE1S/LE2S

Power control with electric override (negative) and load sensing control



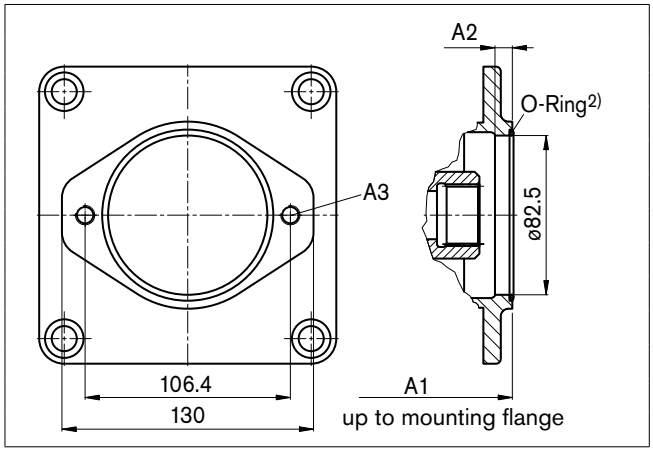
LE2S2/LE1S5/LE2S5

Power control with electric override (negative) and load sensing control, override



Through Drive Dimensions

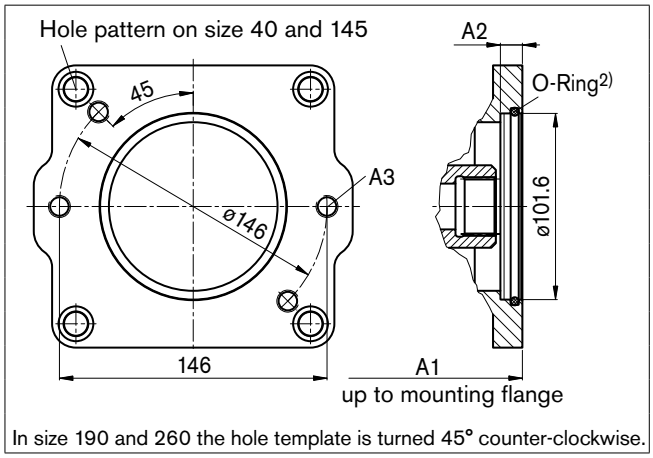
Flange SAE J744 – 82-2 (A) **Coupler** for splined shaft acc. to ANSI B92.1a-1976 5/8 in 9T 16/32 DP[1] (SAE J744 – 16-4 (A)) **K01**
3/4 in 11T 16/32 DP[1] (SAE J744 – 19-4 (A-B)) **K52**



Size	A1 K01	A1 K52	A2	A3[3]
40	240	240	8	M10x1.5; 15 deep
60	257	257	–	M10x1.5; 15 deep
75	275	275	–	M10x1.5; 15 deep
95	306	306	–	M10x1.5; 12.5 deep
130/145	329	329	–	M10x1.5; 12.5 deep
130/145*	363	363	–	M10x1.5; 12.5 deep
190	359.8	359.8	–	M10x1.5; 13 deep
190*	394	394	–	M10x1.5; 13 deep
260	385	385	–	M10x1.5; 13 deep
260*	427.3	427.3	–	M10x1.5; 13 deep

*) Version with charge pump

Flange SAE J744 – 101-2 (B) **Coupler** for splined shaft acc. to ANSI B92.1a-1976 7/8 in 13T 16/32 DP[1] (SAE J744 – 22-4 (B)) **K02**
1 in 15T 16/32 DP[1] (SAE J744 – 25-4 (B-B)) **K04**
Coupler for splined shaft acc. to DIN 5480 W35x2x30x16x9g **K79**

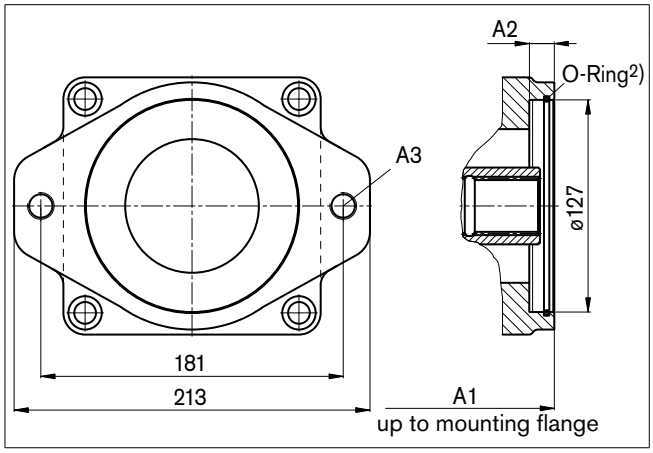


In size 190 and 260 the hole template is turned 45° counter-clockwise.

Size	A1 K02	A1 K04	A1 K79	A2	A3[3]
40	244	244		10	M12x1.75; 19 deep
60	261	261	261	10	M12x1.75; 19 deep
75	279	279		10	M12x1.75; 19 deep
95	303	303	303	10	M12x1.75; 16 deep
130/145	326	326	326	10	M12x1.75; 16 deep
130/145*	360	360	360	10	M12x1.75; 16 deep
190	371.8	369.8	361.8	–	M12x1.75; 15 deep
190*	404	404	394	–	M12x1.75; 15 deep
260	395	395	395	–	M12x1.75; 15 deep
260*	437.5	437.5	437.5	–	M12x1.75; 15 deep

*) Version with charge pump

Flange SAE J744 – 127-2 (C) **Coupler** for splined shaft acc. to ANSI B92.1a-1976 1 1/4 in 14T 12/24 DP[1] (SAE J744 – 32-4 (C)) **K07**
1 1/2 in 17T 12/24 DP[1] (SAE J744 – 38-4 (C-C)) **K24**
Coupler for splined shaft acc. to DIN 5480 W30x2x30x14x9g **K80**
W35x2x30x16x9g **K61**



Size	A1 K07	A1 K24	A1 K80	A1 K61	A2	A3[3]
60	272	–	265	265	13	M16x2; 20 deep
75	290	–	283	283	13	M16x2; 20 deep
95	318	318	318	318	13	M16x2; 16 deep
130/145	330	330	330	330	13	M16x2; 20 deep
130/145*	364	364	364	364	13	M16x2; 20 deep

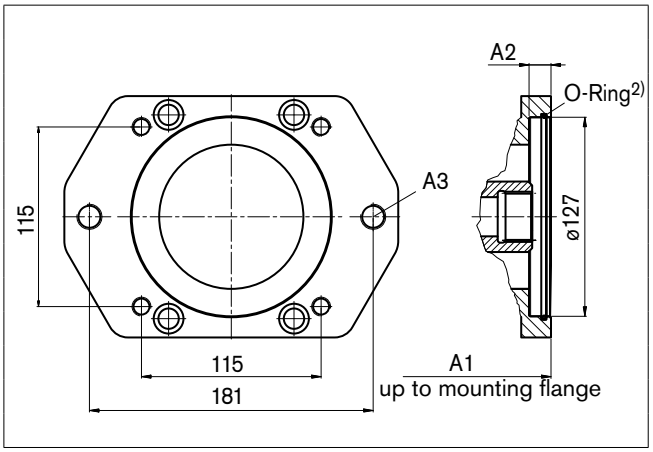
*) Version with charge pump

Note:
The mounting flange may be turned through 90°. Standard position as illustrated. Please state in clear text if required.

1) 30° pressure angle, flat root, side fit, tolerance class 5
2) O-ring included in the delivery contents
3) DIN 13, for max. tightening torque, please refer to general notes on page 64

Through Drive Dimensions

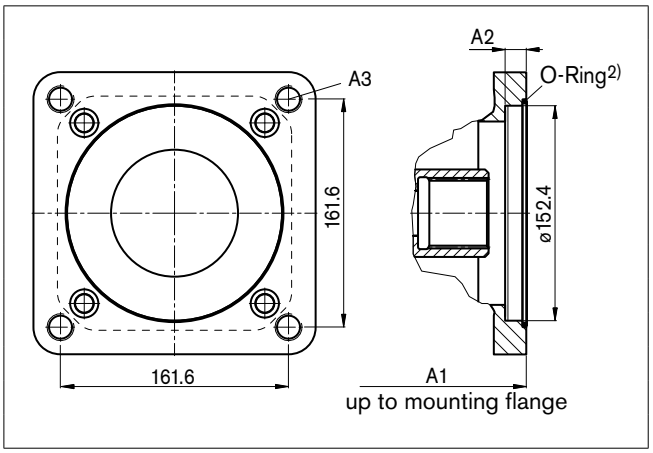
Flange SAE J744–127-2+4 (A) **Coupler** for splined shaft acc. to ANSI B92.1a-19761 1/4 in 14T 12/24 DP[1] (SAE J744 – 32-4 (C) **K07**
1 1/2 in 17T 12/24 DP[1] (SAE J744 – 38-4 (C-C)) **K24**
Coupler for splined shaft acc. to DIN 5480 W30x2x30x14x9g **K80**
W35x2x30x16x9g **K61**



Size	A1 K07	K24	K80	K61	A2	A3[3]
190	367.8	367.8	367.8	367.8	13	M16x2; 19 deep
190*	400	400	400	400	13	M16x2; 19 deep
260	391.5	391.5	391.5	391.5	13	M16x2; 19 deep
260*	433.5	433.5	433.5	433.5	13	M16x2; 19 deep

*) Version with charge pump

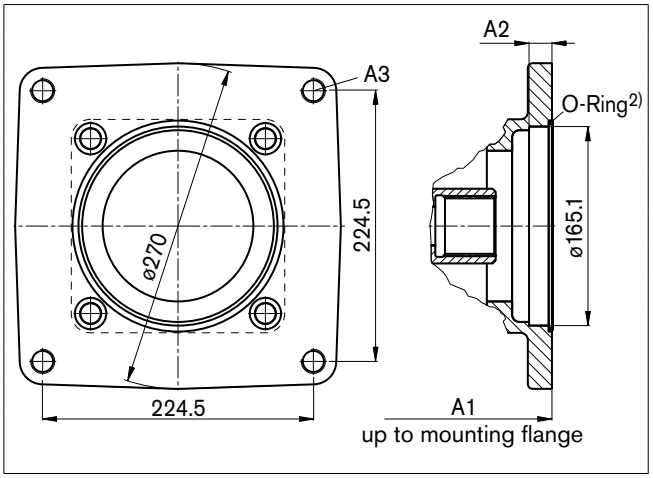
Flange SAE J744 – 152-4 (D) **Coupler** for splined shaft acc. to ANSI B92.1a-1976 1 1/4 in 14T 12/24 DP[1] (SAE J744 – 32-4 (C)) **K86**
1 3/4 in 13T 8/16 DP[1] (SAE J744 – 44-4 (D)) **K17**
Coupler for splined shaft acc. to DIN 5480 W40x2x30x18x9g **K81**
W45x2x30x21x9g **K82**
W50x2x30x24x9g **K83**



Size	A1 K86	K17	K81	K82	K83	A2	A3[3]
75	290	–	290	–	–	13	M20x2.5; 28 deep
95	317	327	317	317	–	30	M20x2.5; 25 deep
130/145	340	350	340	340	340	30	M20x2.5; 25 deep
130/145*	374	384	374	374	374	30	M20x2.5; 25 deep
190	392	392	392	392	392	13	M20x2.5; 22 deep
190*	424	424	424	424	424	13	M20x2.5; 22 deep
260	417	417	417	417	417	13	M20x2.5; 22 deep
260*	459	459	459	459	459	13	M20x2.5; 22 deep

*) Version with charge pump

Flange SAE J744 – 101-2 (E) **Coupler** for splined shaft acc. to ANSI B92.1a-1976 1 3/4 in 13T 16/32 DP[1] (SAE J744 – 32-4 (C)) **K72**
Coupler for splined shaft acc. to DIN 5480 W50x2x30x24x9g) **K84**
W60x2x30x28x9g **K67**



Size	A1 K72	K84	K67	A2	A3[3]
190	376.8	376.8	–	19	M20x2.5; 20 deep
190*	409	409	–	19	M20x2.5; 20 deep
260	417	400	400	19	M20x2.5; 20 deep
260*	459	442.5	442.5	19	M20x2.5; 20 deep

*) Version with charge pump

Note:
The mounting flange may be turned through 90°. Standard position as illustrated. Please state in clear text if required.

[1] 30° pressure angle, flat root, side fit, tolerance class 5
[2] O-ring included in the delivery contents
[3] DIN 13, for max. tightening torque, please refer to general notes on page 64

Overview of Attachments for A11V(L)O

Through drive	A11VO		Attachment – 2nd pump							Through drive
Flange	Coupler for splined shaft	Code	A11VO Size (shaft)	A10V(S)O/31 Size (shaft)	A10V(S) O/53 Size (shaft)	A4FO Size (shaft)	A4VG Size (shaft)	A10VG Size (shaft)	External gear pump	available for size
82-2 (A)	5/8 in	K01	–	18 (U)	10 (U)	–	–	–	Frame size F Size 4-22 [1]	40...260
	3/4 in	K52	–	18 (S)	10 (S)	–	–	–	–	40...260
101-2 (B)	7/8 in	K02	–	28 (S, R) 45 (U)	28 (S, R) 45 (U, W)	16, 22, 28 (S)	–	18 (S)	Frame size N Size 20-32 [1] Frame size G Size 38-45 [1]	40...260
	1 in	K04	40 (S)	45 (S, R)	45 (S, R) 60 (U, W)	–	28 (S)	28, 45 (S)	–	40...260
	W35	K79	40 (Z)	–	–	–	–	–	–	40...260
127-2 (C)	1 1/4 in	K07	60 (S)	71 (S, R) 100 (U)	60 (S) [2] 85 (U)	–	40, 56, 71 (S)	63 (S)	–	60...260
	1 1/2 in	K24	–	100 (S)	85 (S)	–	–	–	–	95...260
	W30	K80	–	–	–	–	40, 56 (Z)	–	–	60...260
	W35	K61	60 (Z)	–	–	–	40, 56 (A) 71 (Z)	–	–	60...260
152-4 (D)	1 1/4 in	K86	75 (S)	–	–	–	–	–	–	75...260
	1 3/4 in	K17	95, 130, 145 (S)	140 (S)	–	–	90, 125 (S)	–	–	130...260
	W40	K81	75 (Z)	–	–	–	125 (Z)	–	–	75...260
	W45	K82	95 (Z)	–	–	–	90, 125 (A)	–	–	95...260
	W50	K83	130, 145 (Z)	–	–	–	–	–	–	130...260
165-4 (E)	1 3/4 in	K72	190, 260 (S)	–	–	–	180, 250 (S)	–	–	190...260
	W50	K84	190 (Z)	–	–	–	180 (Z)	–	–	190...260
	W60	K67	260 (Z)	–	–	–	–	–	–	260

[1] Rexroth recommends special versions of the gear pumps. Please ask.
[2] Only A10VO with 4-hole mounting flange can be mounted to A11V(L)O 190 and 260.

Combination Pumps A11VO + A11VO

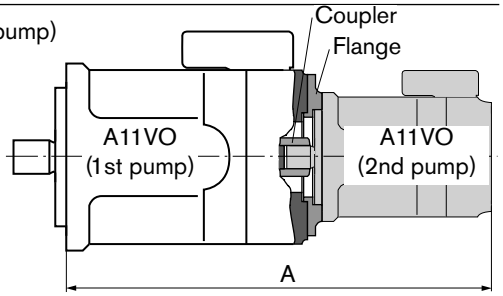
Total length A [1]

A11VO	2nd pump									
1st pump	Size 40	Size 60	Size 75	Size 95	Size 130/145	Size 130/145 [2]	Size 190	Size 190 [2]	Size 260	Size 260 [2]
Size 40	–	–	–	–	–	–	–	–	–	–
Size 60	490	507	–	–	–	–	–	–	–	–
Size 75	–	525	550	–	–	–	–	–	–	–
Size 95	528	560	577	604	–	–	–	–	–	–
Size 130/145	551	572	600	627	650	698	–	–	–	–
Size 130/145 [2]	585	606	634	661	684	732	–	–	–	–
Size 190	586.8	609.8	652	679	702	750	723.6	772.3	–	–
Size 190 [2]	619	642	684	711	734	782	755.8	804.5	–	–
Size 260	620	633.5	677	704	727	775	746.8	795.5	772	828
Size 260 [2]	662.5	675.5	719	746	769	817	789.3	838	814.5	870.5

[1] When using the Z shaft (splined shaft DIN 5480) for the attached pump (2nd pump)
[2] Version with charge pump

When ordering combination pumps, the type designations of the 1st and 2nd pumps must be connected by a "+".
Ordering code 1st pump + Ordering code 2nd pump

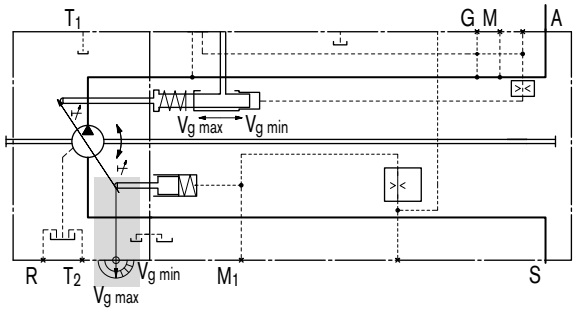
Ordering example:
A11VO130LRDS/10R-NZD12K61 + A11VO60LRDS/10R-NZC12N00

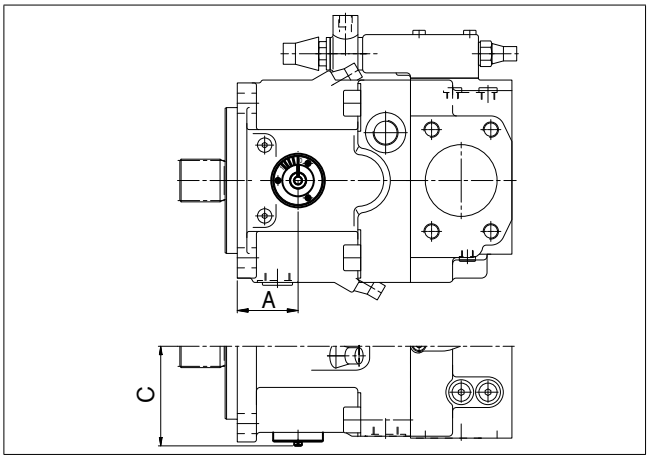


Swivel Angle Indicator

Optical swivel angle indicator, V

With the optical swivel angle indicator, a mechanical pointer on the side of the pump case displays the position of the swivel angle of the pump.



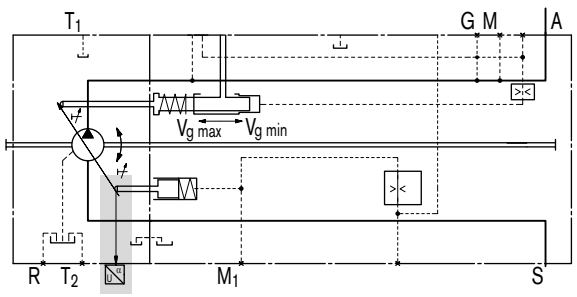


Size	A	C
40	50.5	84.0
60	not available	
75	60.7	97.0
95	63,5	104.0
130	70.9	112.0
190	87.6	123.5
260	87.6	137.0

Electric swivel angle sensor, R

With the electric swivel angle indicator the swivel position of the pump is measured by an electric swivel angle sensor. It has a robust, sealed case and integrated electronics designed for automotive applications.

As an output the Hall effect swivel angle sensor supplies a voltage signal proportional to the swivel angle (see technical parameters).



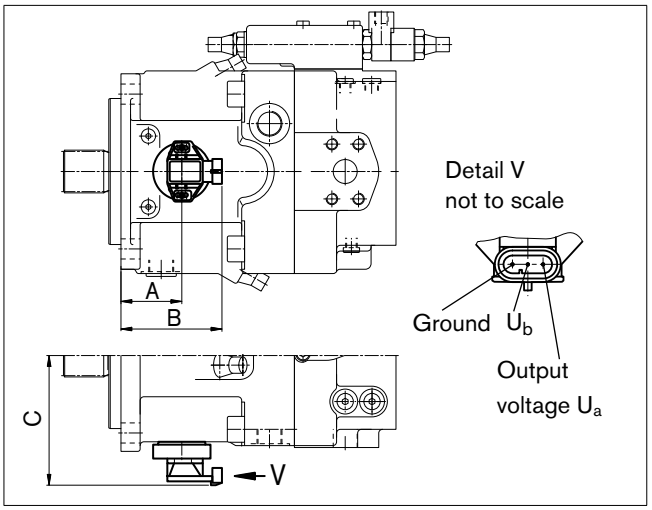
Parameters		
Supply voltage U_b	10...30 V DC	
Output voltage U_a	2.5 V ($V_{g\,min}$)	4.5 V ($V_{g\,max}$)
Reverse-connect protection	Short-circuit-proof	
EMC stability	Details on request	
Operating temperature range	-40°C...+125°C	
Vibration resistance Sinusoidal vibration EN 60068-2-6	10 *g* / 5...2000 Hz	
Shock resistance: Continuous shock IEC 68-2-29	*25 g*	
Resistance to salt spray DIN 50021-SS	96 h	
Type of protection DIN/EN 60529	IP67 and IP69K	
Case material	synthetic material	

Mating connector

AMP Superseal 1.5; 3-pin,
Rexroth mat. no. R902602132

Consisting of:	AMP no.
– 1 female connector case, 3-pin	282087-1
– 3 single wire seals, yellow	281934-2
– 3 female connector contacts 1.8–3.3 mm	283025-1

The mating connector is not included in the delivery contents. This can be delivered by Rexroth on request.



Size	A	B	C
40	50.5	88.5	118.3
60	not available		
75	60.7	98.7	131.3
95	63.5	101.5	138.3
130	70.9	108.9	146.3
190	87.6	125.6	157.8
260	87.6	125.6	171.3

Connector for Solenoids

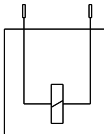
DEUTSCH DT04-2P-EP04, 2-pin

molded, without bidirectional suppressor diode
(standard) **P**

Type of protection according to DIN/EN 60529:
IP67 and IP69K

Circuit diagram symbol

without bidirectional
suppressor diode

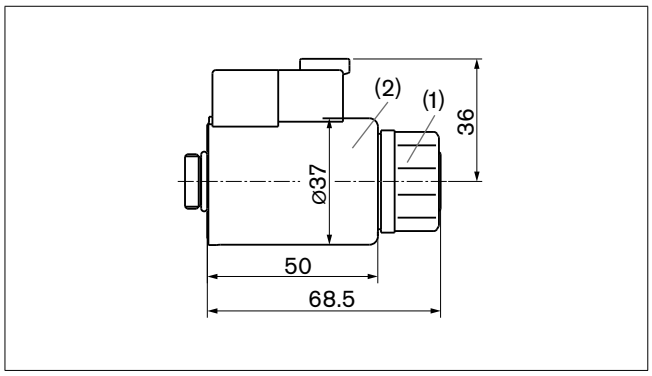


Mating connector

DEUTSCH DT06-2S-EP04
Rexroth mat. no. R902601804

Consisting of:	DT designation
– 1 case	DT06-2S-EP04
– 1 wedge	W2S
– 2 female connectors	0462-201-16141

The mating connector is not included in the delivery contents.
This can be delivered by Rexroth on request.



Note for round solenoids:

The position of the connector can be changed by turning the solenoid body.

Proceed as follows:

– 1. Loosen fixing nut (1)

– 2. Turn the solenoid body (2) to the desired position.

– 3. Tighten the fixing nut
Tightening torque of fixing nut: 5^{+1} Nm
(width across the flats WAF 26, 12kt DIN 3124)

Installation Notes

General

During commissioning and operation, the axial piston unit must be filled with hydraulic fluid and air bled. This is also to be observed following a relatively long standstill as the system may empty via the hydraulic lines.

The case drain in the case interior must be directed to the tank via the highest tank port (T_1, T_2). The minimum suction pressure at port S must not fall below 0.8 bar absolute (without charge pump) or 0.6 bar (with charge pump).

In all operational conditions, the suction line and case drain line must flow into the tank below the minimum fluid level.

Installation position

See examples below. Additional installation positions are available upon request.

Below-tank installation (standard)

Pump below the minimum fluid level of the tank.

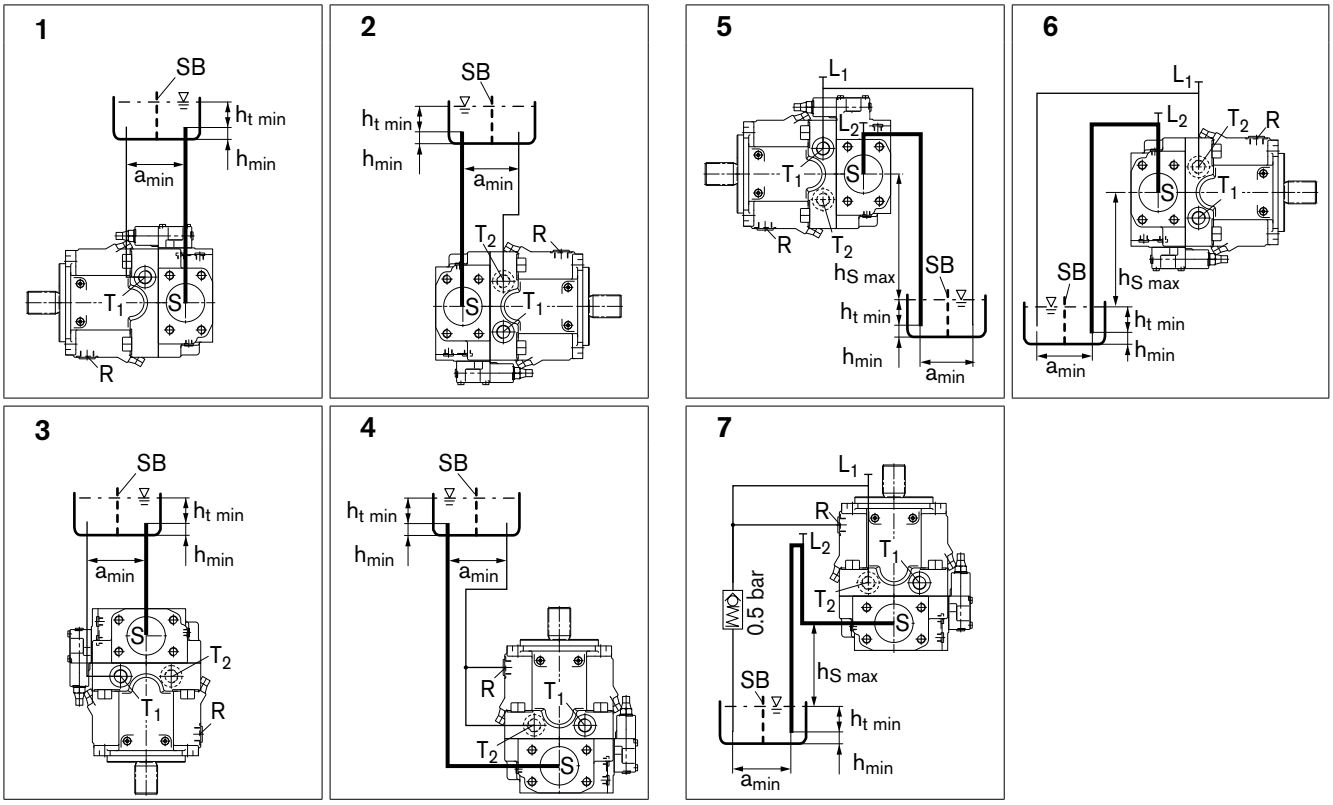
Recommended installation positions: 1 and 2.

Above-tank installation

Pump above the minimum fluid level of the tank.

Observe the maximum permissible suction height $h_{s\,max} = 800$ mm.

The version A11VLO (with charge pump) is not designed for installation above the tank.
Recommendation for installation position 7 (shaft up): A check valve in the case drain line (opening pressure 0.5 bar) can prevent the case interior from draining.
For control options with pressure control, displacement limiters, HD and EP control, the minimum displacement setting must be $V_g \geq 5\%\ V_{g\,max}$.



$h_{s\,max} = 800$ mm, $h_{t\,min} = 200$ mm, $h_{min} = 100$ mm, SB = Silencer plate (baffle plate)

When designing the tank, ensure adequate space a_{min} between the suction line and the case drain line to prevent the heated, returned fluid from being directly drawn back out.

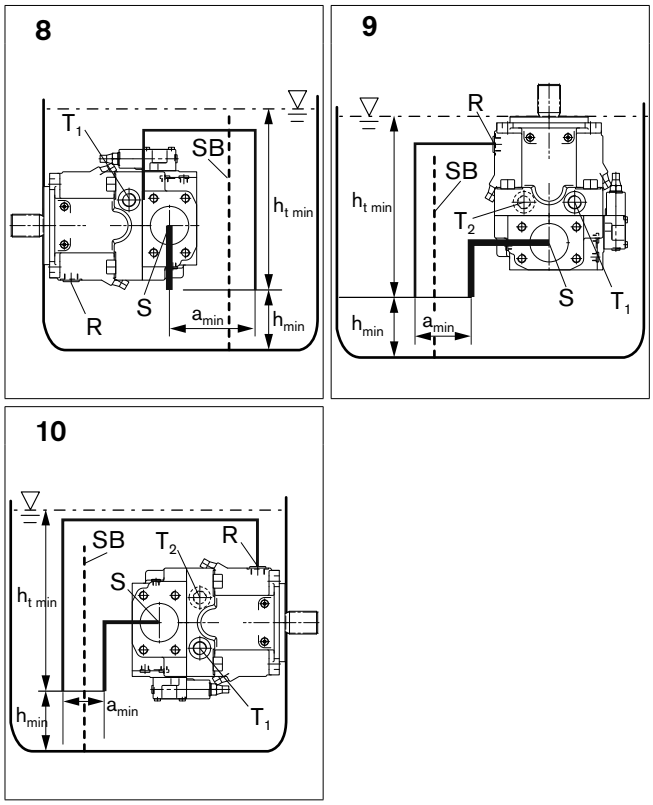
Installation position	Air bleeding	Filling
1	T_1	S + T_1
2	R	S + T_2
3	T_1/T_2	S + T_1/T_2
4	R	S + T_1/T_2

Installation position	Air bleeding	Filling
5	$L_1 + L_2$	L_2 (S) + L_1 (T_1)
6	R + L_2	L_2 (S) + L_1 (T_2)
7	$L_1 + L_2$	L_2 (S) + L_1 (T_1/T_2)

Installation Notes

Tank installation

Pump below the minimum fluid level in the tank.



$h_{s\,max}$ = 800 mm, $h_{t\,min}$ = 200 mm, h_{min} = 100 mm,
SB = Silencer plate (baffle plate)

When designing the tank, ensure adequate space a_{min} between the suction line and the case drain line to prevent the heated, returned fluid from being directly drawn back out.

Installation position	Air bleeding	Filling
8	T_1	automatically via all open T_1, T_2, R and S ports, though position below the hyraulic fluid level
9	R	
10	R	

Notice

General Notes

– The A11VO pump is designed to be used in open circuits.

– Project planning, assembly and commissioning of the axial piston unit require the involvement of qualified personnel.

– The service line ports and function ports are only designed to accommodate hydraulic lines.

– During and shortly after operation, there is a risk of burns on the axial piston unit and especially on the solenoids. Take appropriate safety measures (e. g. by wearing protective clothing).

– Depending on the operational state of the axial piston unit (operating pressure, fluid temperature), the characteristic may shift.

– Pressure ports:
The ports and fixing threads are designed for the specified maximum 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 data and notes contained herein must be adhered to.

– The following tightening torques apply:

- Threaded hole for axial piston unit:
The maximum permissible tightening torques $M_{G\,max}$ are maximum values for the threaded holes and must not be exceeded. For values, see the following table.

- Fittings:
Observe the manufacturer's instruction regarding the tightening torques of the used fittings.

- Fixing screws:
For fixing screws according to DIN 13, we recommend checking the tightening torque individually according to VDI 2230.

- Locking screws:
For the metal locking screws supplied with the axial piston unit, the required tightening torques of locking screws M_V apply. For values, see the following table.

– The product is not approved as a component for the safety concept of a general machine according to DIN EN ISO 13849.

Thread size		Max. permissible tightening torque of the screw thread M_{Gmax}	Required tightening torque for locking screws M_V	WAF Hexagon socket
M12x1.5	DIN 3852	50 Nm	25 Nm	6 mm
M14x1.5	DIN 3852	80 Nm	35 Nm	6 mm
M22x1.5	DIN 3852	210 Nm	80 Nm	10 mm
M26x1.5	DIN 3852	230 Nm	120 Nm	12 mm
M33x2	DIN 3852	540 Nm	310 Nm	17 mm

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The data specified above only serve to describe the product. No statements concerning a certain condition or suitability for a certain application can be derived from our information. The given information does not release the user from the obligation of own judgement and verification. It must be remembered that our products are subject to a natural process of wear and aging.

Subject to change.