Rexroth
Bosch Group

Installation and Start-up for Axial Piston Equipment

AA10- FM, FO, FE, VM, VO, & VE. A10- VO & VSO. A4- FSM, FSO, FSP, VSG/H, & VSO. 2A4- VSE. A2- FM & FO. A6-VM. A7-VO.

RA 90 400/05.93

Content

This data sheet contains installation and start-up instructions for axial piston units. In addition , you will find details regarding "Inspection, Maintenance, and Trouble-Shooting".

This data sheet is divided into the following sections:

General

These installation specifications are intended for use with axial piston units from Rexroth. Adherence to these recommendations has a decisive effect on the service life of the units. These specifications refer to standard units and standard internal elements.

A basic requirement is that the housing of the unit is completely filled with fluid on commissioning or re-commissioning and that it remains full when operating.

Commissioning or re-commissioning without filling the housing or with too little fluid in the housing will lead to damage to or immediate and complete destruction of the rotary group.
For each type, the ideal filling orientation is specified. Only in this position can complete filling be ensured. On commissioning or re-commissioning, this position should be maintained.
In the following text, we will differentiate between installation position (pump/motor to tank) and installation orientation (pump/motor shaft vertical, horizontal etc.)

Installation Position

The following installation positions are possible, see fig. 1.

ⓐ Pump/motor alongside or under the tank (below the minimum fluid level) or where the upper point on the unit housing is level with or below the minimum fluid level. Avoid this position if low noise levels are required.

ⓑ Pump/motor in the tank (below the minimum fluid level). When installing the unit inside the tank, (c) applies if the unit is above the minimum fluid level.

ⓒ Pump/motor above the tank (above the minimum fluid level).

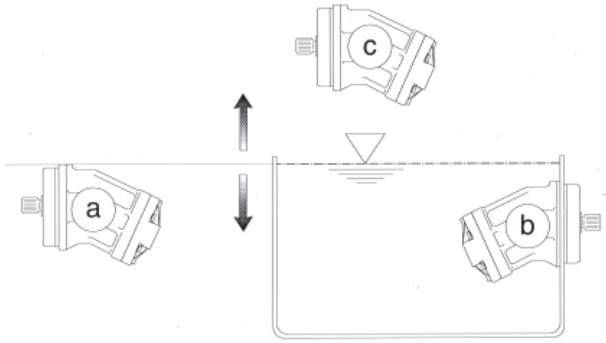


Fig. 1:

Installation Orientation

The following installation orientations are possible, see fig. 2.

① horizontal: drive shaft horizontal

② vertical: drive shaft up

③ vertical: drive shaft down

④ at side: drive shaft horizontal

Intermediate installation orientations require additional measures or are not permitted. Please discuss any other requirements with us at the project stage.

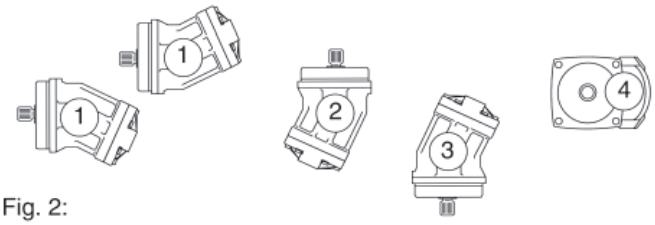


Fig. 2:

Piping

The installation position and installation orientation determine the layout of the suction, leakage and bleed lines. For all installation positions and installation orientations it should be noted, that the highest "T" port is connected. Furthermore, the end of the drain line may not finish "above immersion depth 'E'" below the minimum fluid level in the tank.

Pipes

Cold bend with a pipe bending device, without reducing the section at the bend. A minimum bend radius of 3 x D should be maintained (Fig. 3).

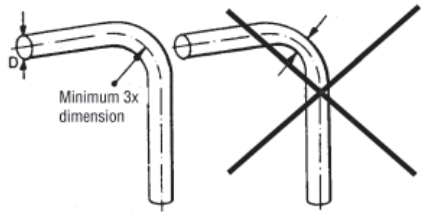


Fig. 3

After bending, cut to length and deburr. Clean thoroughly before installation. Close both ends with plastic plugs.

Cleaning rags and other fibrous materials are a hazard to hydraulics.

Pickle warm-bent pipes, e.g. with hydrochloric acid (20%; 5-10 minutes) or other commercially available solutions. Monitor the pickling process. After pickling, neutralize with a soda solution (10%; 10-20 minutes). Flush out with fluid or diesel fluid and close pipe ends. A visual check must always be carried out after pickling and flushing. If necessary, provide additional dividing points for bends which cannot be inspected (Fig. 4). Any residue remaining at points which cannot be inspected will be loosened by pressure and flow shocks occurring during operation of the system and can cause considerable damage. This applies, of course, equally to welded pipes.

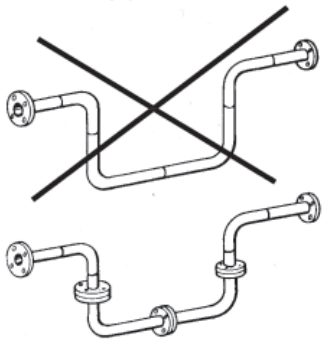


Fig. 4

Pipes should be laid free of tension, in order to avoid additional loads on pipes, flanges and fittings (leakage). Secure pipelines with flexible clamps (physically transmitted noise). Observe manufacturer's instructions when assembling fittings (Fig. 9).

Hoses

In hydraulics, hose lines are used to connect points which move relative to one another. In addition, hoses help to damp physically transmitted noise.

It is essential to observe the installation instructions and technical information provided by the manufacturer with regard to installation and use (see examples, Fig. 5).

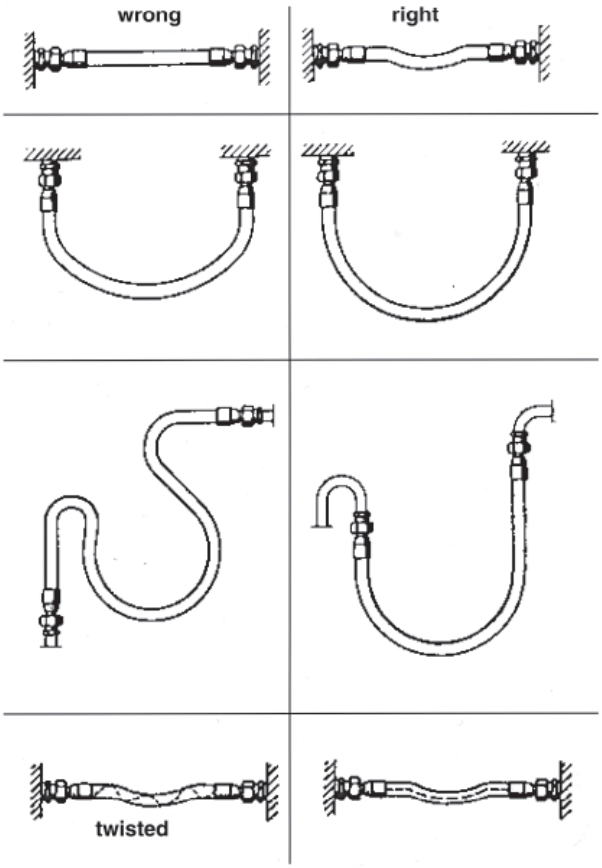


Fig. 5

High Pressure Lines

Make sure pipes, hoses and connections have sufficient bursting strength. In this connection, the settings of the pressure relief valves in the circuit should be checked and if necessary reduced (Fig. 6)

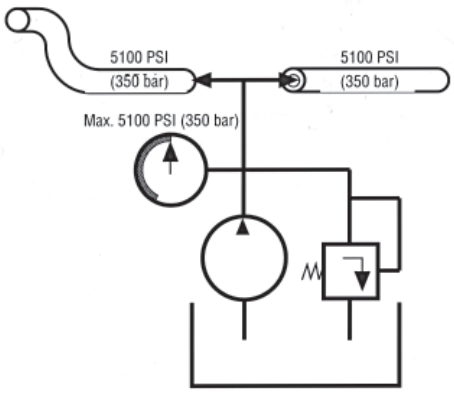


Fig. 6:

Leakage Line
Leakage lines should be laid out so that the housing always remains filled with fluid and ingress of air at the radial seal is prevented, even during long periods of inoperation. Under no circumstances must the back pressure in the housing exceed 29 PSI (abs.) (2 bar) or fall below 11.6 PSI (abs.)(0.8 bar). If the unit is installed high above the tank, check whether backpressure valve is necessary. The leakage line should always enter the tank below the minimum fluid level.

Gauge Connections
Pre-installed, easily accessible gauge connections in the operating, leakage fluid, and control pressure lines simplify pressure readings during start-up and trouble-shooting. The connections should be located near the appropriate functions.

Suction Line
The suction line - pipe or hose - should be as short and straight as possible.

The pipe section should be such that the negative pressure at the suction port never falls below 11.6 PSI (abs.) (0.8 bar) and never rises above 29 PSI (abs.) (2 bar). Make sure connection points are airtight and that hoses are sufficiently pressure resistant against external air pressure. Use plastic hoses with supporting mesh. Make sure there are no kinks in the hose when installing.

In general, and for all installation positions and installation orientations, a minimum pressure at the suction port "S" is specified:

minumum suction pressure ≥ 11.5 PSI (0.8 bar abs)

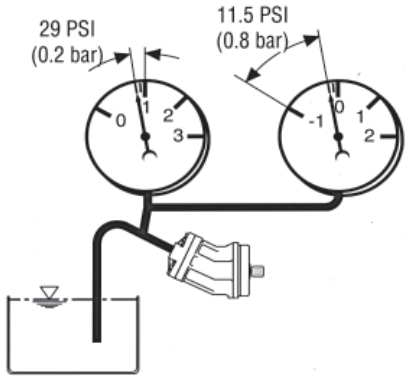


Fig. 7:

If the pressure falls below this specified value, damage can occur or the unit destroyed. The maximum suction pressure (suction and leakage chamber connected, A7V, Br 5) and/or leakage fluid pressure (suction and leakage fluid chamber separate, all other units) is determined by the maximum casing pressure.

Special Information
All connecting lines (suction, pressure, and leakage fluid lines) have to be connected with the tank via flexible elements in order to lower the noise level.

When the system is not in operation, the lines eventually empty by themselves through the weight of the fluid.

Fluids with a higher density are harder to draw; they also sink faster; therefore, the different specific densities of fluids have to be taken into consideration. RA 90 223 lists the borderline velocities for fluids with a high density (≥ petroleum 0.87gpm).

Please note: With variable displacement units which are installed in certain installation orientation/positions, the adjustment or control might be affected. Force of gravity, own weight, and internal housing pressure might cause slight shifts in curves and cycles.

Input/Output Drive
Flexible couplings and splined shafts may be used. The permissible axial (F_A) and radial (F_R) loading on the drive shaft, and speed limits are detailed in the relevant catalog sheets.

The input and output drive elements should be drawn on to the drive shaft using the threaded hole in the end of the drive shaft.

Hammering or jolting on will cause damage to the rotary group. This applies equally when dismantling.

When using flexible couplings, the input/output drive should be checked for freedom from resonance. Prevent fretting corrosion on coupling halves either by tensioning against the drive shaft or by adequate lubrication.

Direction of Rotation
Is always defind as viewed on the drive shaft and indicated by a directional arrow. It is not possible to change the direction of rotation of the drive without conversion of the pump.

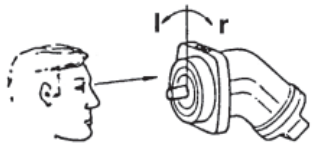


Fig. 8:

Filling the unit

Separate suction and drain chambers.
All installation orientations (and also for intermediate orientations not shown) are to be arrived at after the optimum filling orientation. The housing is to be filled from the highest drain port. Ports which will be required later must be closed by means of pipe bends or check valves. This prevents air entering the unit when turning it into its installation orientation. When installing the unit inside the tank (below the minimum fluid level), it should be noted, that the ports are then only opened after the tank has been filled and when the unit is below fluid level. The sequence of operations is shown in fig. 9.

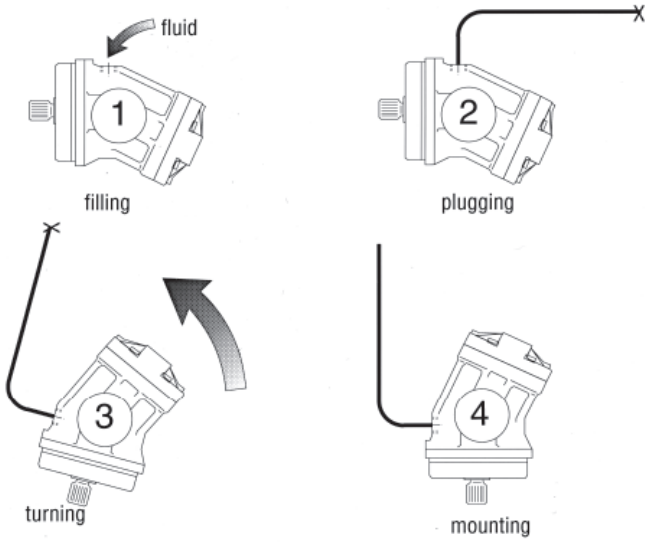


Fig. 9

Suction and case internally connected

Filling of the housing in these units (A7V, Br 5) is not possible. The unit is filled when the tank is filled as the fluid flows in via the "S" port. The units are bled via the highest "T" port in the housing.

Installation

Installation Position ⓐ

Pump/motor alongside or below the tank (below the minimum fluid level).

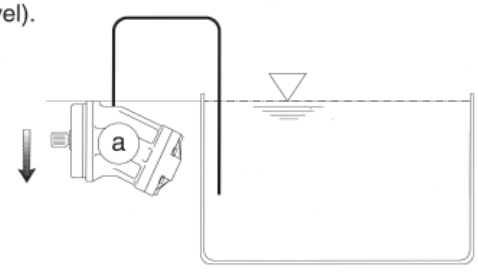


Fig. 10

The maximum height difference between the tank and the unit is dependent upon the maximum case pressure (a height of 1 meter below fluid level ≈ 14.5 PSI (0.1 bar) pressure.

With units in which the suction and drain chambers are connected internally, complete bleeding of the unit must be carried out, as it is not possible to filll the housing. Bleeding must take place via the highest bleed or drain port.

Installation Position ⓑ

Pump/ motor inside the tank (below the minimum fluid level).

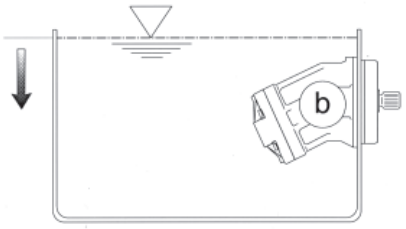


Fig. 11:

With units in which the suction and drain chamers are connected internally, complete bleeding of the unit must be carried out, as it is not possible to fill the housing. In units with separate suction and drain chambers, the unit must be filled before installation. The connections may then only be opened when they are below fluid level in order to avoid the entry of air and loss of fluid.

Installation position ⓒ applies with installation in the tank, above minimum fluid level.

Installation Position ⓒ

Pump/ motor above the tank (above the minimum fluid level).

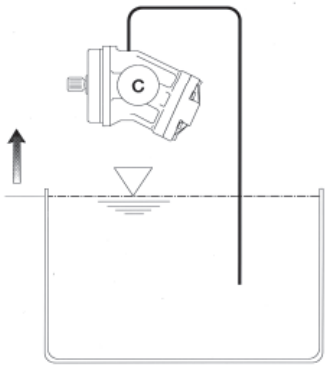


Fig. 12:

In this position, the highest drain port "T" must be connected to tank via a non return valve. The height difference between the unit and the tank can be negated in this way and the weight of the fluid column in the drain line causing a negative pressure at the case drain port does then not need to be considered (a height of 1 meter above the fluid level causes ≈ 0.1 bar negative pressure). When selecting the cracking pressure of the valve, the maximum housing pressure must be observed. See the relevant data sheet.

Max. valve cracking pressure $\Delta p \leq 7.3$ PSI (0.5 bar)

The higher the cracking pressure the higher the resulting case pressure. This leads to a reduced shaft seal life (see shaft seal diagrams in the individual data sheets).

When using overhead reservoirs the following points are to be taken into consideration:

- Maximum suction height
- Suction line(s)
- Lowest possible flow velocity
- Initial filling of unit before start-up
- Measures to be taken to prevent the unit from emptying out during longer shut-down periods (syphoning effect)

With long stationary periods, the fact that the unit may slowly empty itself due to internal leakage through the service line must also be taken into account.

Fitting leak free valves in the service lines can overcome this problem.

These measures do not mean that regular checking of the fluid level inside the housing can be overlooked. This check can be made at the highest drain port or bleed port.

If the fluid level has fallen, the unit should be re-commissioned if required.

Mounting on Gearboxes

We recommend that the gear fluid level is regularly monitored by remote signalling and/or that shorter inspection intervals than normally specified. If the gear fluid level is too high or too low, this can lead to damage to the gearbox. Drive shaft plug-in connections should be protected against fretting corrosion (Lubricate with gear oil, or if not possible use special grease).

Because of the concealed mounting, after installing the unit it is no longer possible to check whether the mounting hole diameter (d) is centering the unit (play), or whether there are thrust forces acting on the drive shaft of the unit (installation length).

This check must therefore be carried out before installation during assembly (Fig. 13).

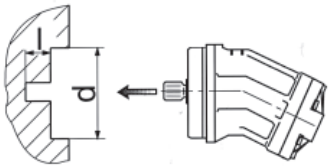


Fig. 13:

Intermediate flanges should be installed in such a way that they only fit in the correct mounting position (Fig. 14).

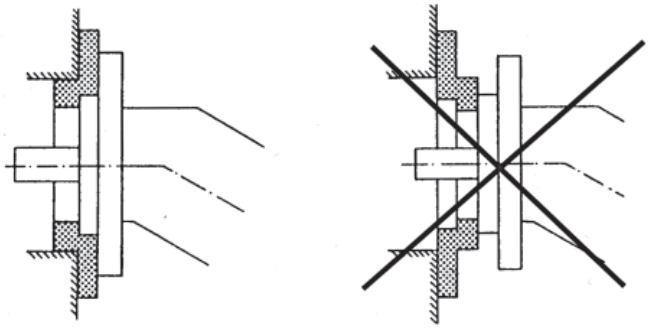


Fig. 14:

Suction

Suction Height »H«

The permissible suction height is the result of the total pressure loss:

Suction Height »H« ≤ 31.5 inches (800 mm)

Minimum immersion level »E«

For installation positions ⓑ and ⓒ the recommended minimum immersion level »E« must be maintained. This dimension applies to suction, leakage and bleed lines, see fig. 15.

Minimum dimension »E« ≥ 8 inches (200 mm)

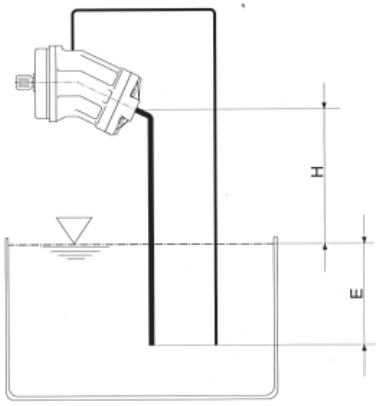


Fig. 15:

Minimum distances »T_h« and »S_h«

Dimension »T_h« for the highest leakage fluid port and dimension »S_h« for suction port »S« must be maintained. The bleed port »U« is not used in this case. In mobile installations, the tank layout must be carefully designed in order to prevent air being sucked in, see fig. 16.

Dimension »T_h« ≥ 2 inches (50 mm)
Dimension »S_h« ≥ 8 inches (200 mm)

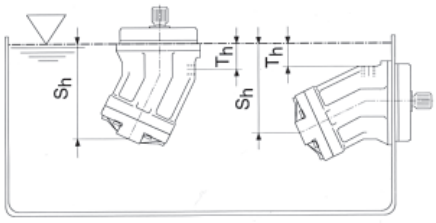


Fig. 16:

Note:

The »optimum filling positions« and the permissible »installation positions« and »installation orientations« are shown on the following pages.

Any other installation positions and installation orientations not listed are not permitted by Rexroth Brueninghaus as certain changes have to be made to the units. Please consult the factory.

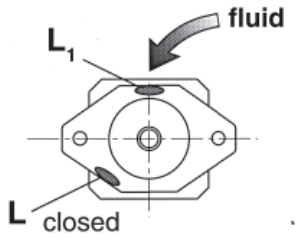
The piping shown should on ly be taken as a reference. It has only been shown to indicate the principles involved.

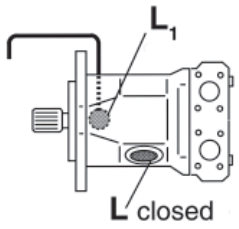
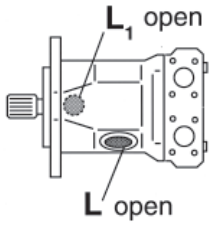
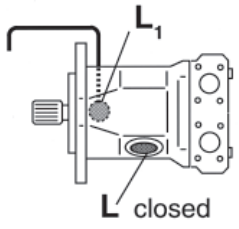
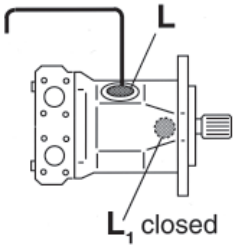
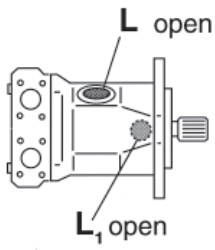
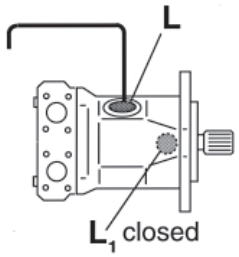
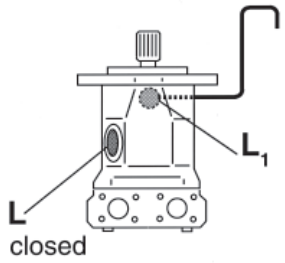
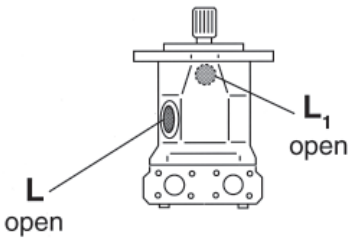
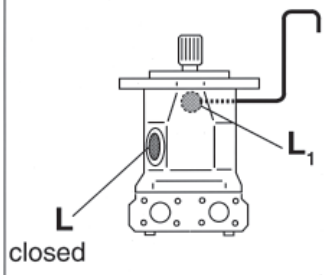
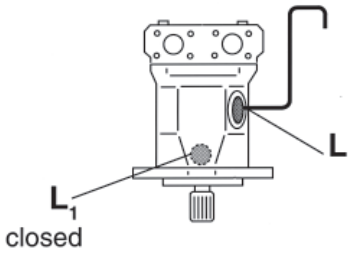
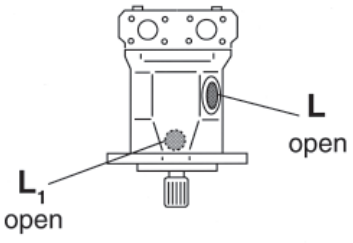
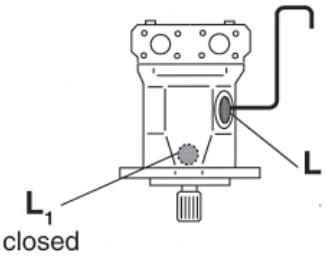
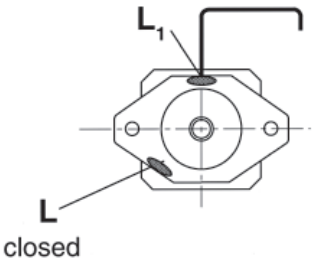
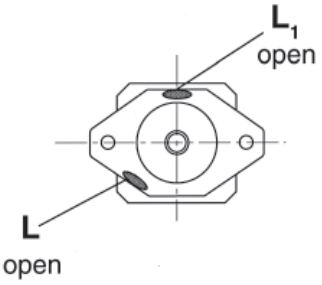
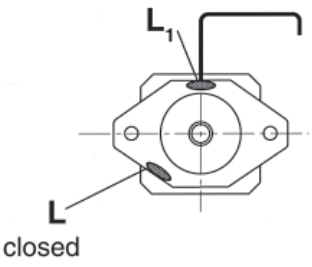
Installation and Start-up of Axial Piston Units

Fixed displacement motor AA10 FM/3
RA 91 172

Fixed displacement pump AA10 FO/3
RA 91 480

optimum filling orientation:

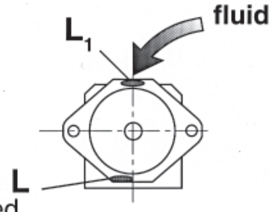


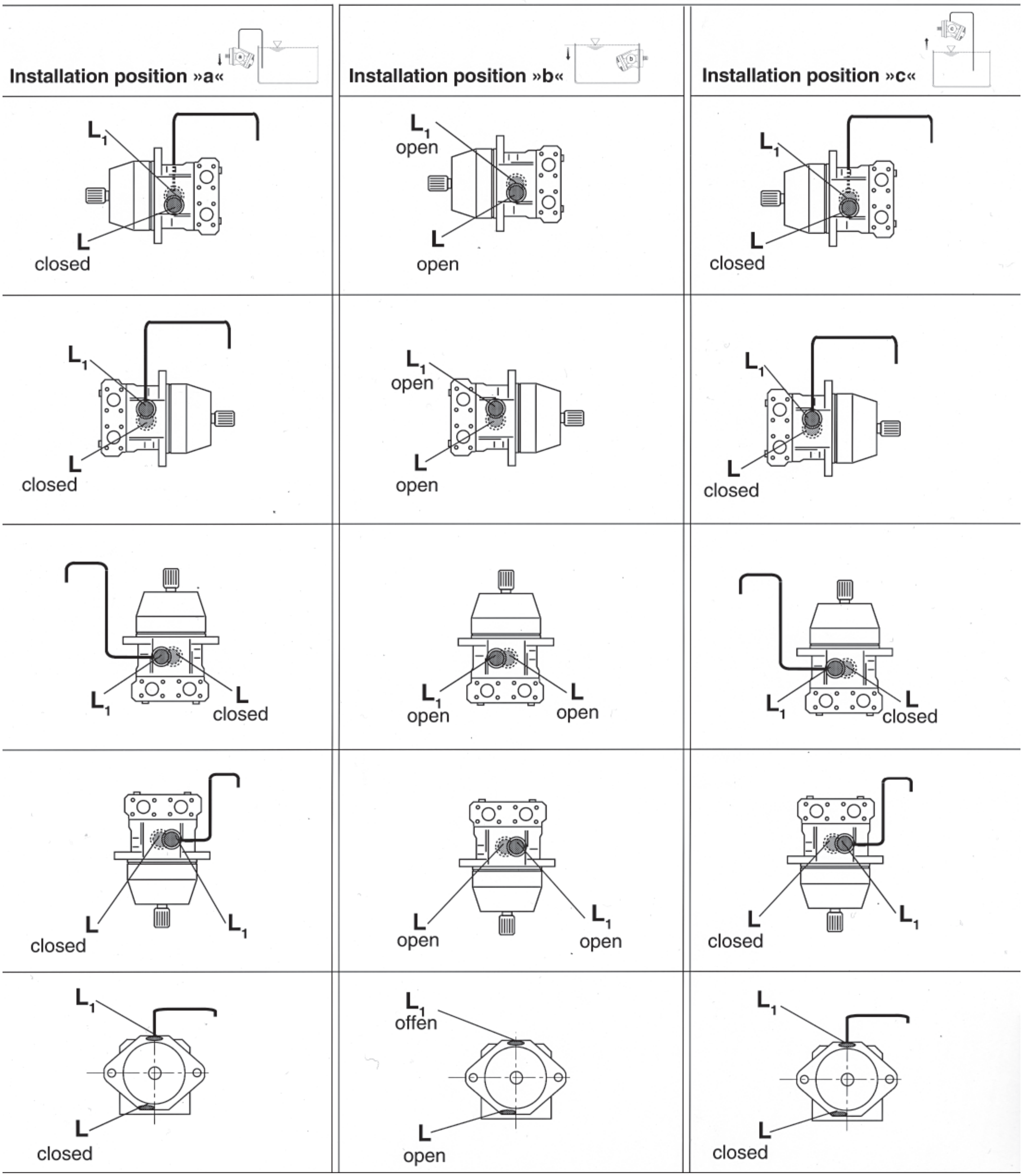
Installation position »a«	Installation position »b«	Installation position »c«
		
		
		
		
		

Fixed displacement motor AA10 FE/3

RA 91 172

optimum filling orientation:



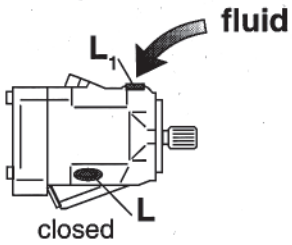


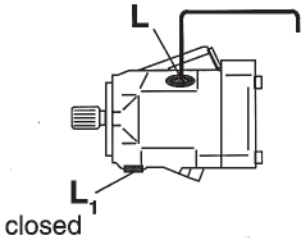
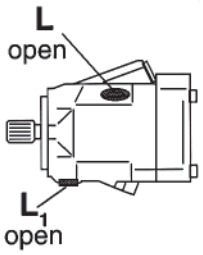
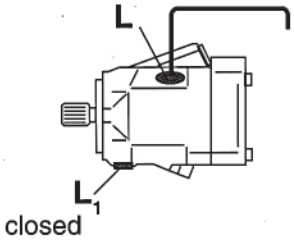
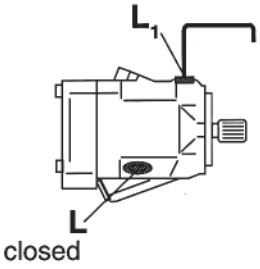
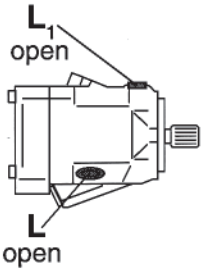
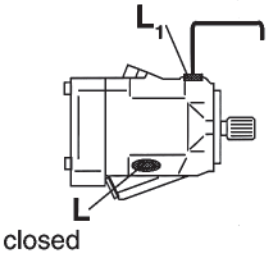
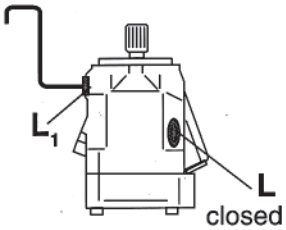
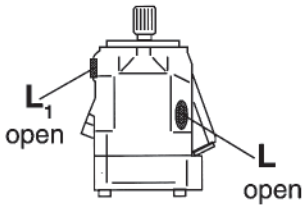
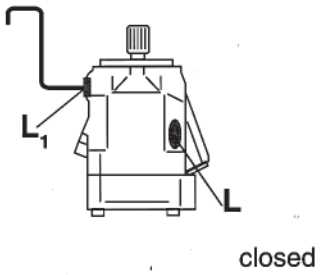
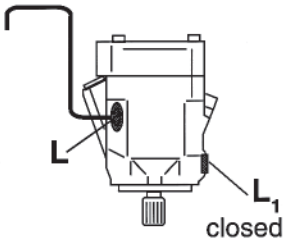
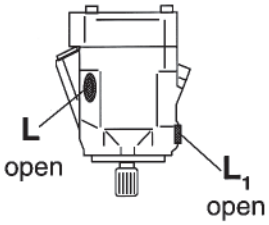
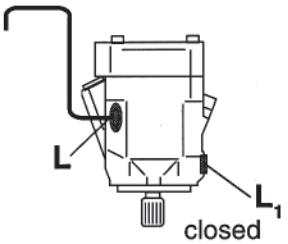
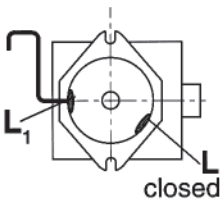
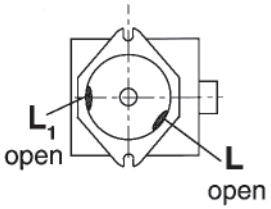
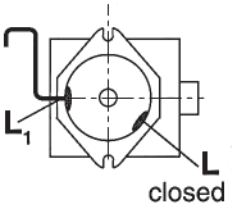
Installation and Start-up of Axial Piston Units

Variable displacement motor AA10 VM/5
RA 91 703

Fixed displacement pump AA10 VO/5
RA 92 703

optimum filling orientation:

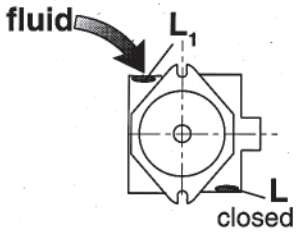


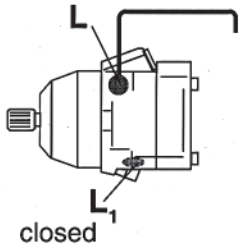
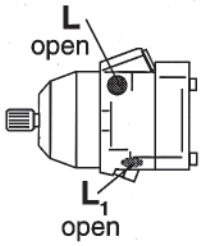
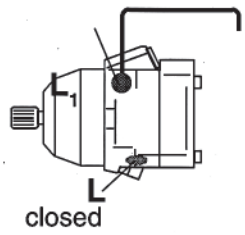
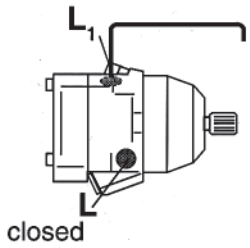
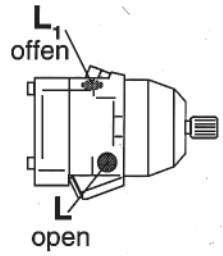
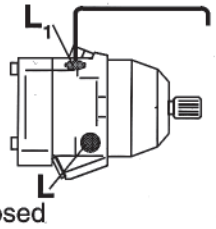
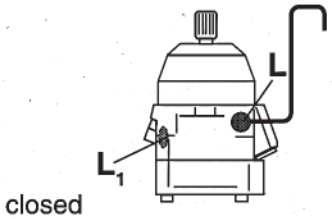
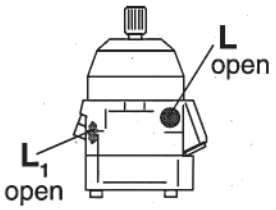
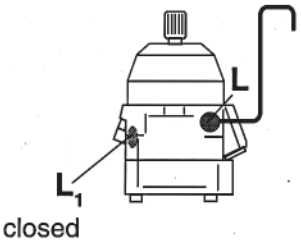
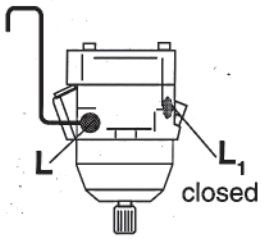
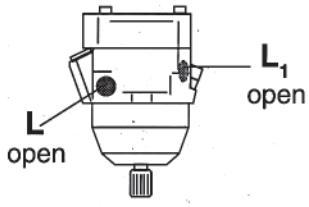
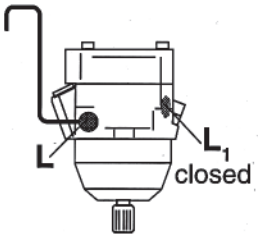
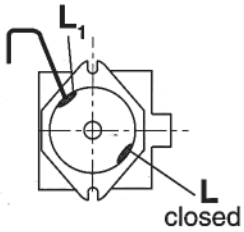
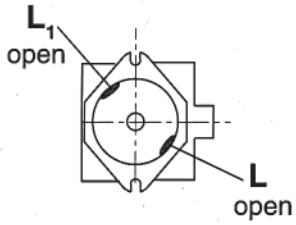
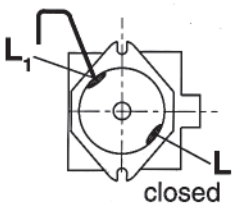
Installation position »a«	Installation position »b«	Installation position »c«
		
		
		
		
		

Variable displacement motor AA10 VE/5

RA 91 703

optimum filling orientation:



Installation position »a«	Installation position »b«	Installation position »c«
		
		
		
		
		

Installation and Start-up of Axial Piston Units

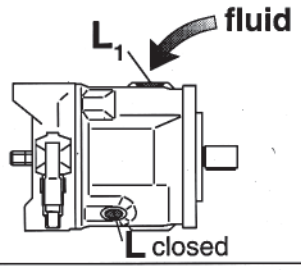
Variable displacement pump A10 VO/3

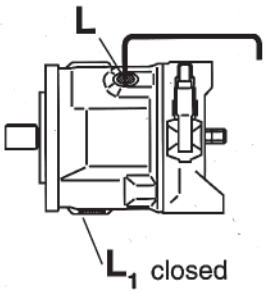
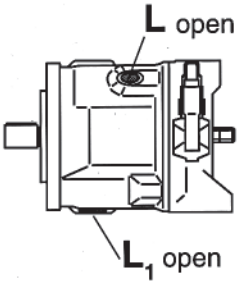
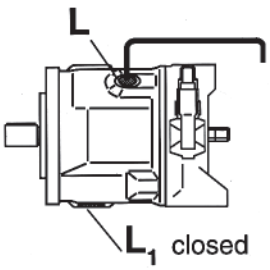
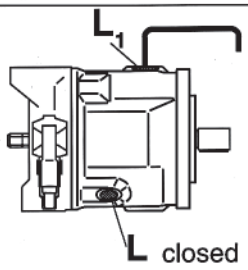
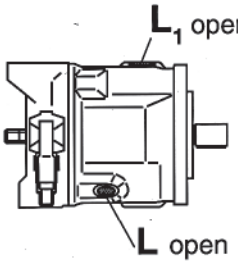
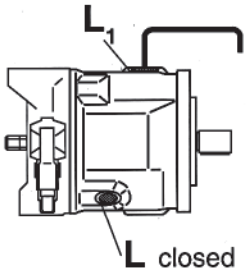
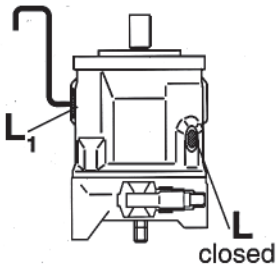
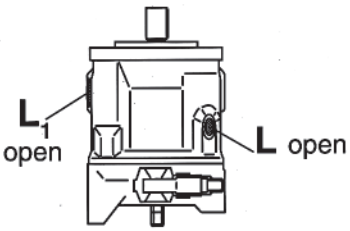
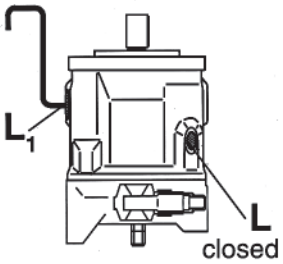
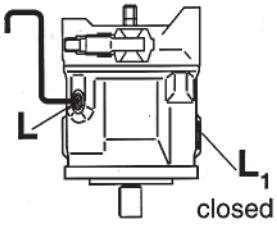
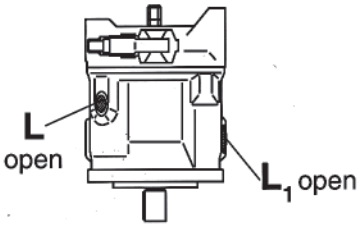
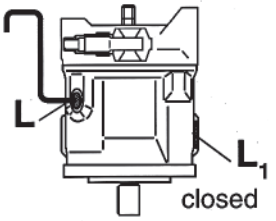
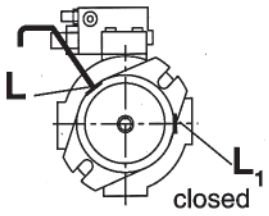
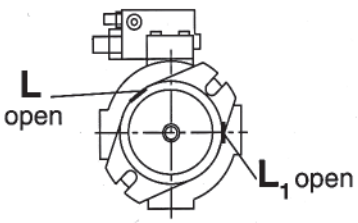
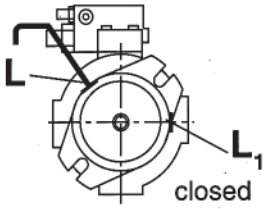
RA 92 701

A10 VSO/3

RA 92 711; RA 92 712

optimum filling orientation:



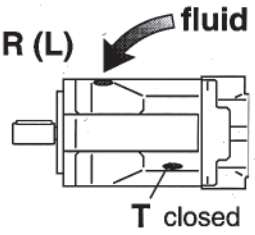
Installation position »a«	Installation position »b«	Installation position »c«
		
		
		
		
		

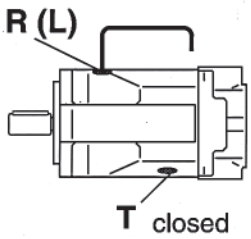
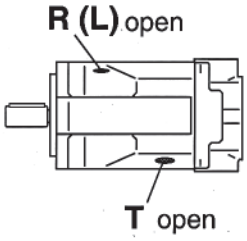
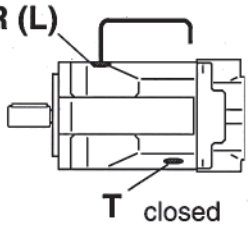
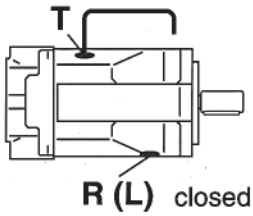
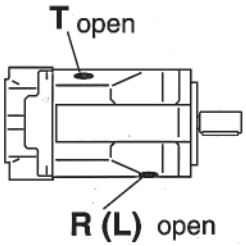
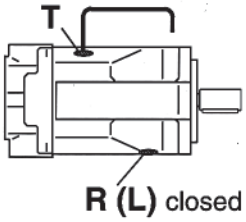
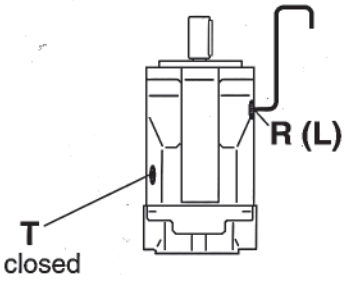
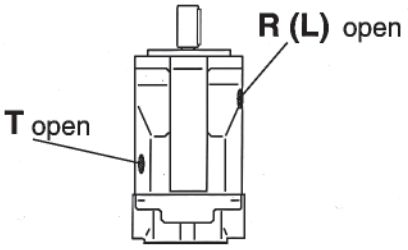
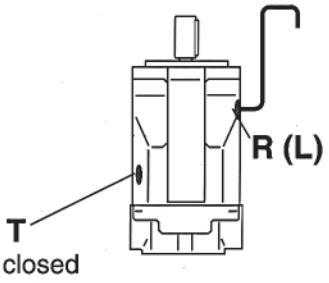
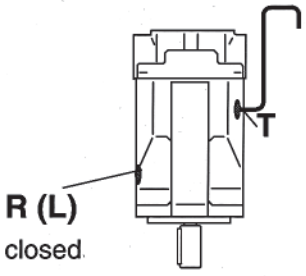
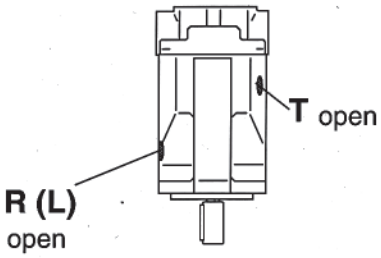
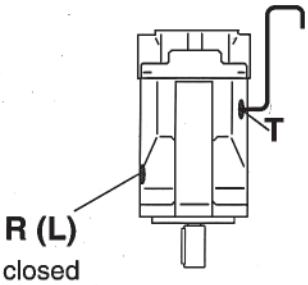
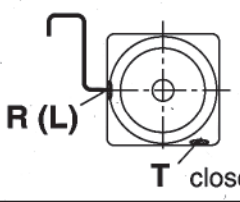
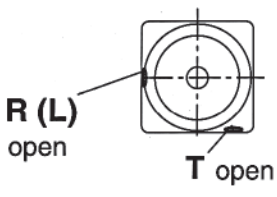
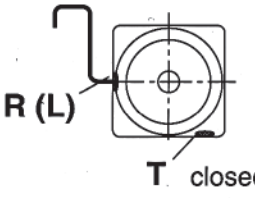
Installation and Start-up of Axial Piston Units

Fixed displacement motor A4 FSM
RA 91 120

Fixed displacement pump A4 FSO
RA 91 455

optimum filling orientation:



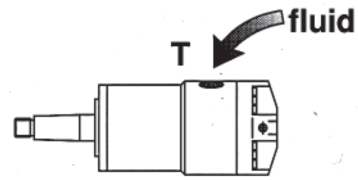
Installation position »a«	Installation position »b«	Installation position »c«
		
		
		
		
		

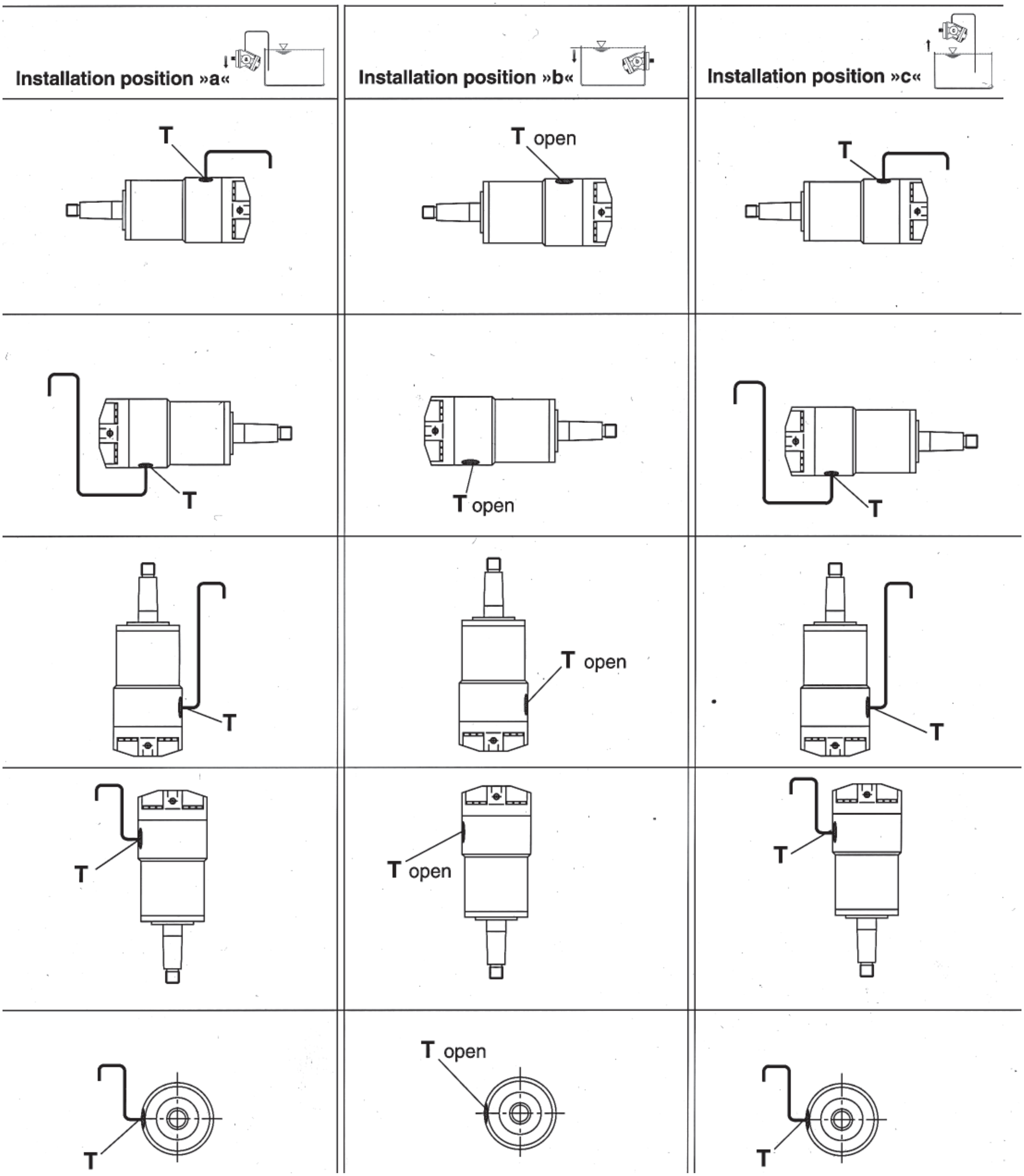
Installation and Start-up of Axial Piston Units

Fixed displacement motor A4 FSP
2A4 FSP

RA 91 125

optimum filling orientation:

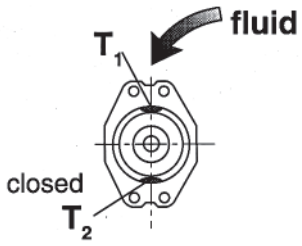


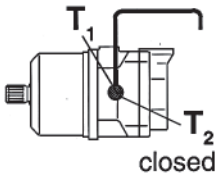
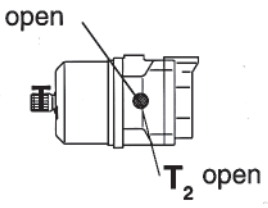
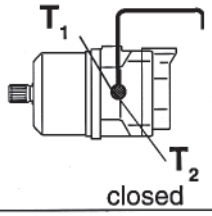
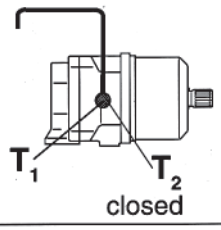
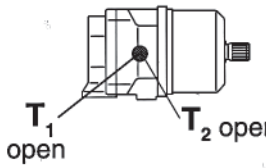
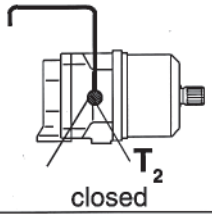
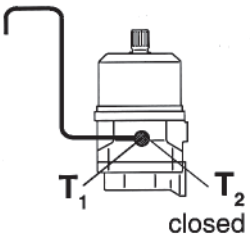
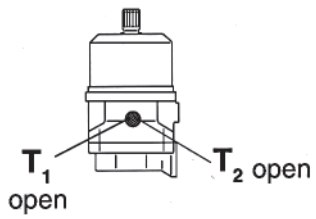
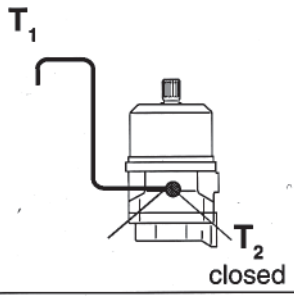
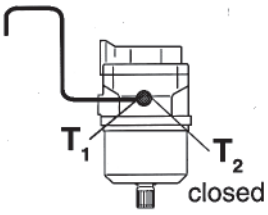
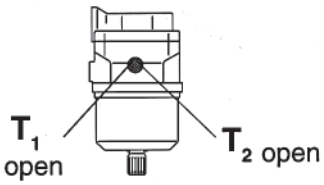
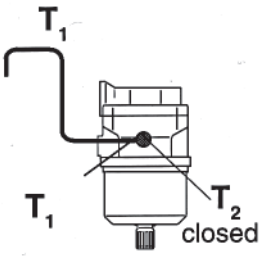
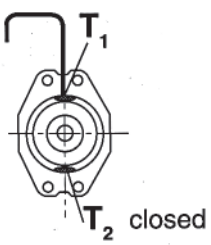
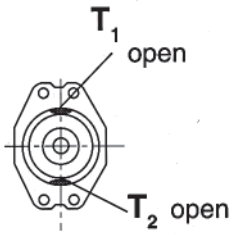
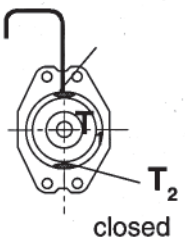


Plug-in motor AA4 VSE

RA 91 808

optimum filling orientation:



Installation position »a«	Installation position »b«	Installation position »c«
		
		
		
		
		

Installation and Start-up of Axial Piston Units

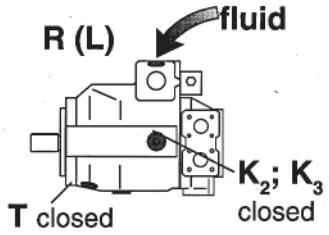
Variable pump A4 VSG/ H

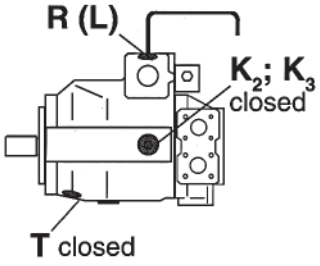
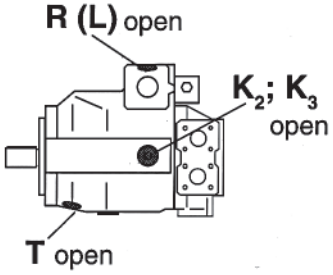
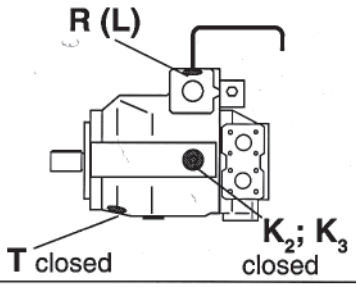
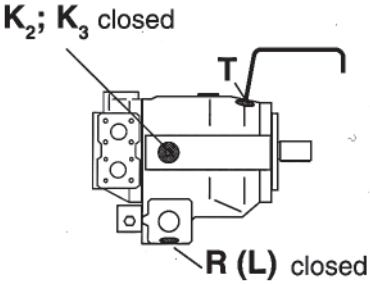
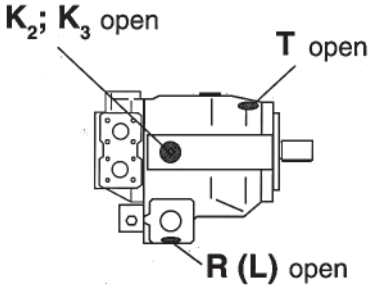
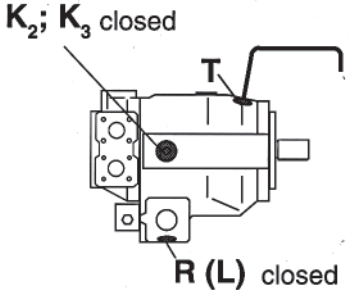
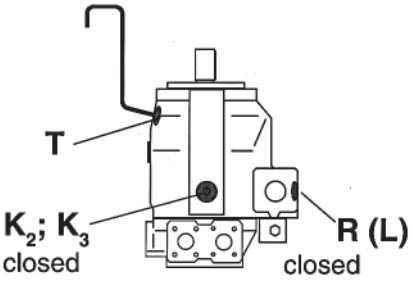
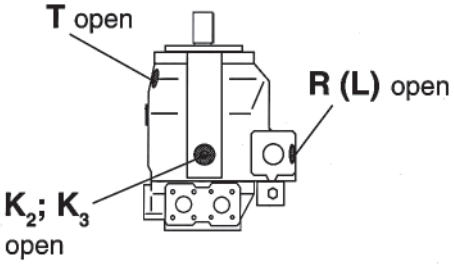
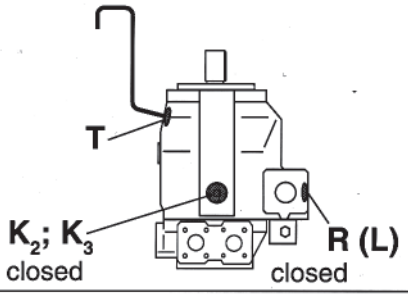
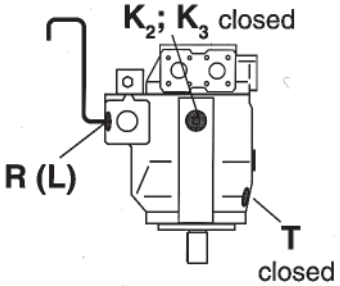
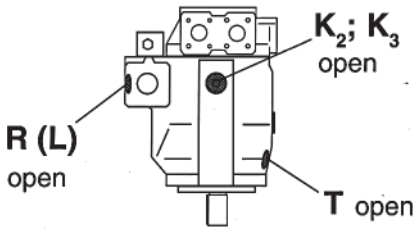
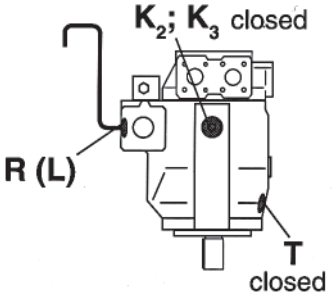
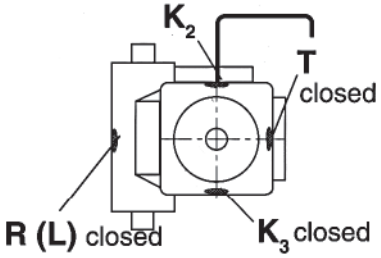
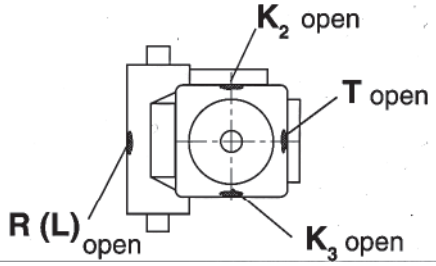
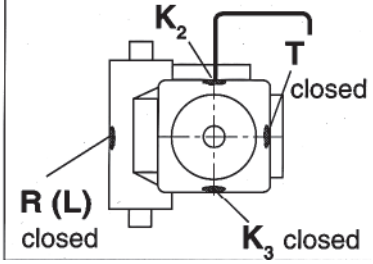
RA 92 100/ 92 110
RA 92 101

Variable pump A4 VSO

RA 92 050/ RA 92 051

optimum filling orientation:



Installation position »a«	Installation position »b«	Installation position »c«
		
		
		
		
		

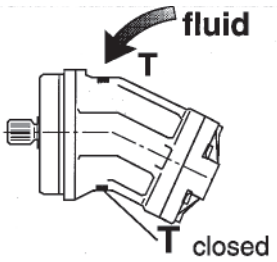
Fixed displacement motor A2 FM/6

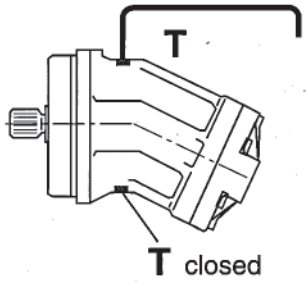
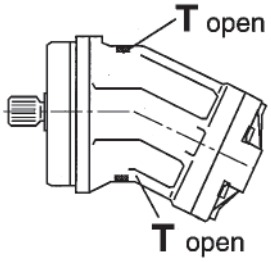
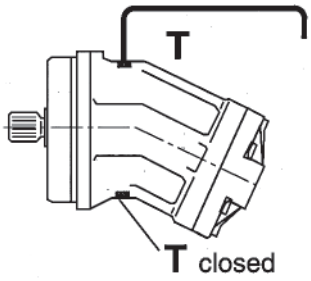
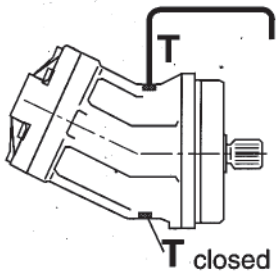
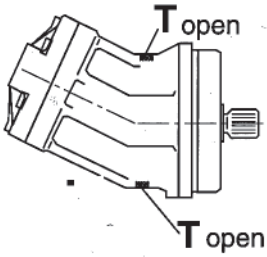
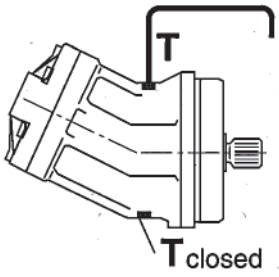
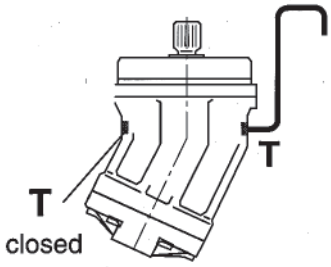
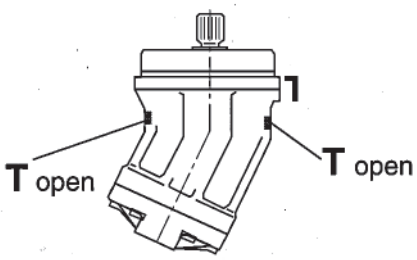
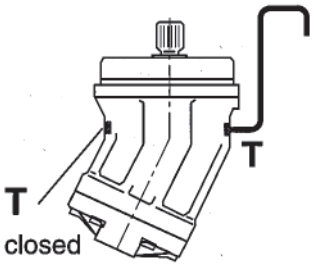
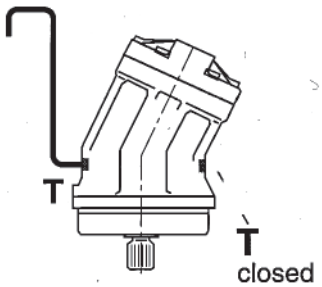
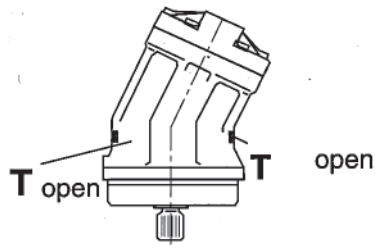
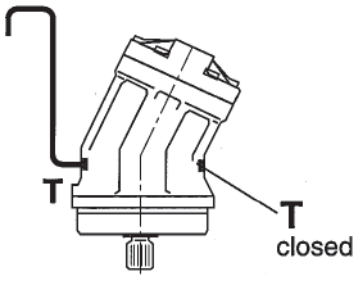
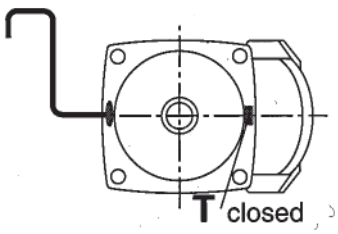
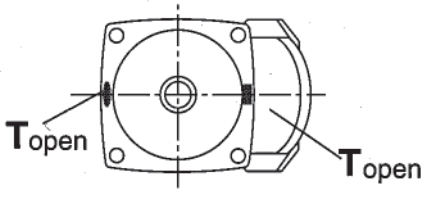
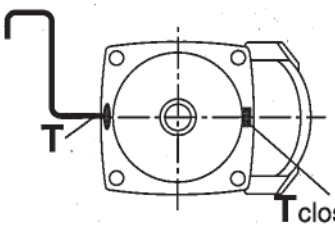
RA 91 025

Fixed displacement pump A2 FO/6

RA 91 425

optimum filling orientation:



Installation position »a«	Installation position »b«	Installation position »c«
		
		
		
		
		

Installation and Start-up of Axial Piston Units

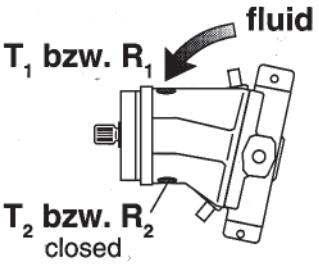
Variable displacement motor A6 VM/ 63

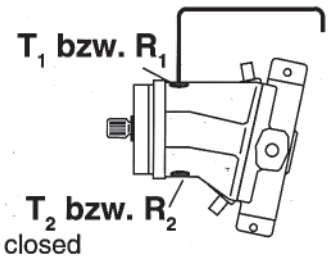
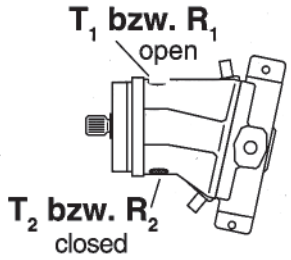
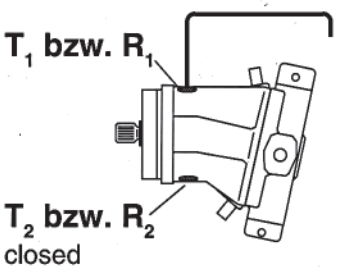
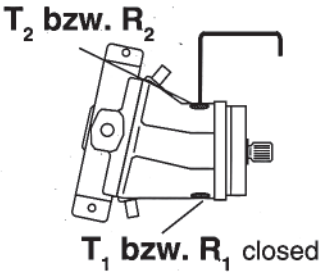
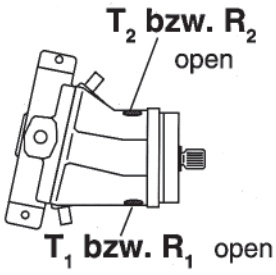
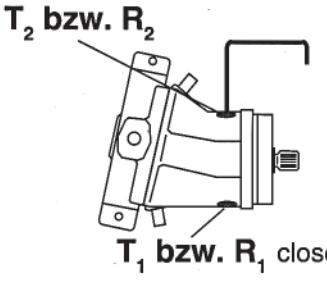
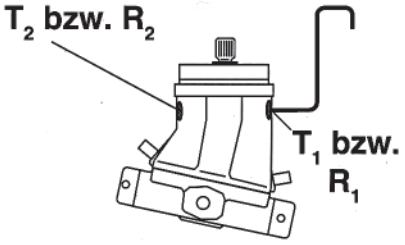
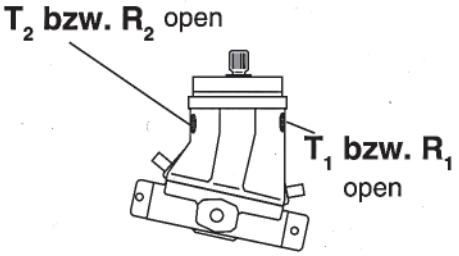
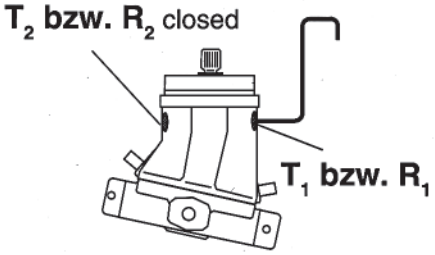
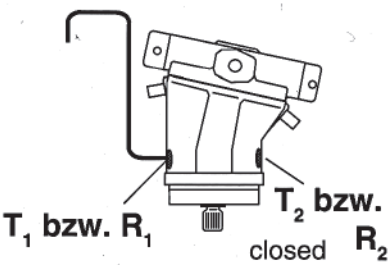
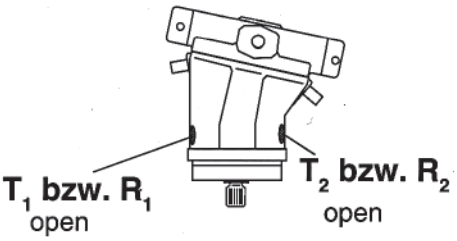
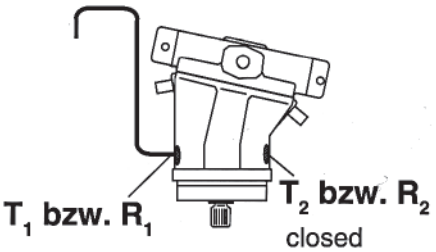
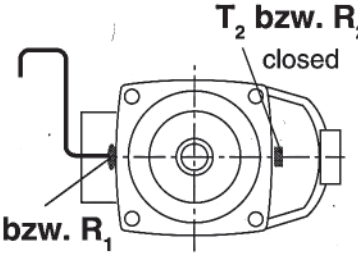
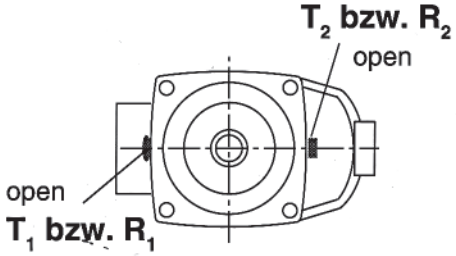
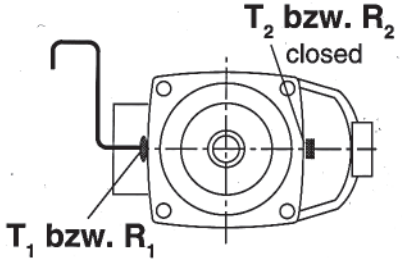
RA 91 603

Variable displacement pump A7 VO/63

RA 92 203

optimum filling orientation:

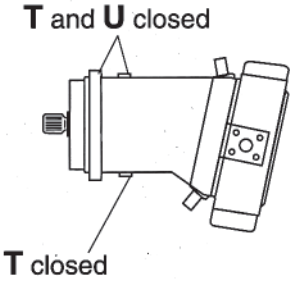
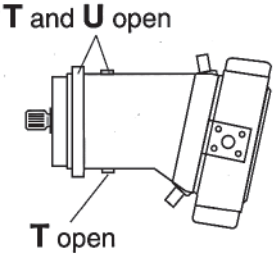
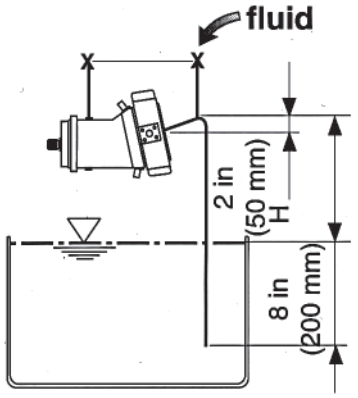
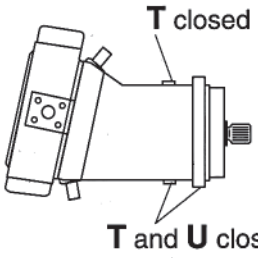
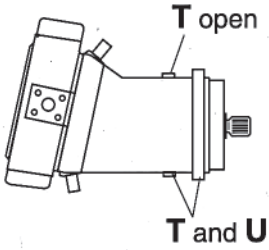
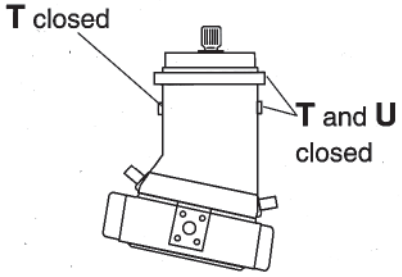
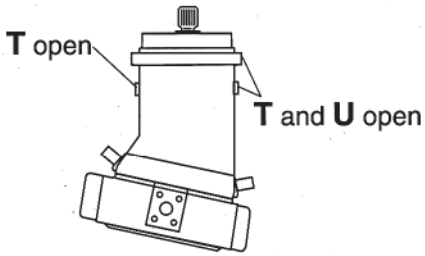
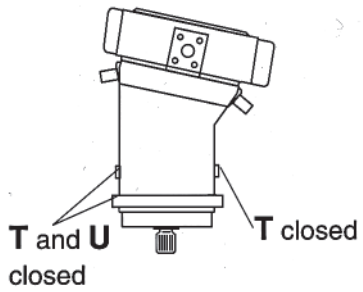
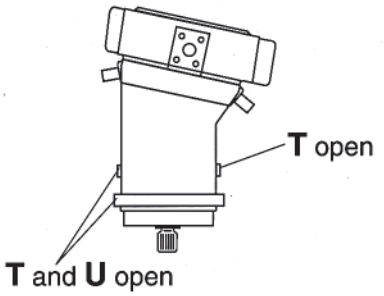
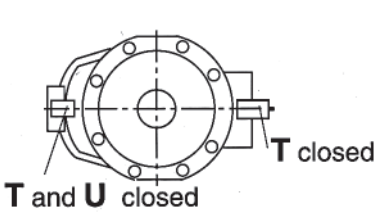
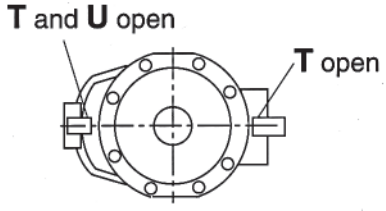


Installation position »a«	Installation position »b«	Installation position »c«
		
		
		
		
		

Variable displacement pump A7 V/5.1

RA 92 210

filling not possible

Installation position »a«	Installation position »b«	Installation position »c«
		
		
		
		
		

Special Measures

- Maintain max. speed and suction pipe length requirements
- 2 shaft seals in order to prevent the ingress of air (make note on ordering code)
- Horizontal installation only with bent axis to top
- Fill pump and bleed pump housing before commissioning or re-commissioning
- Swivel out to full swivel angle and set max. operating pressure $p_{HD} \leq 145$ PSI (10 bar) before commissioning.
- Limit pump to residual flow $V_{g\,min} \geq 5\%\ V_{g\,max.}$
- Impossible with stalled (zero stroke) operation

Notes on Tank, Filter, Cooler and Fluid

Fluid Tank

In order to maintain a good heat balance, the tank must be of a suitably large size.

For mobile systems we recommend:

$$V = 1.2...1.25 \cdot (Q/5.....Q/3 + \text{total EZ})$$

Include 10 - 15% air space

Q = Total value of pump flows in L/min

EZ = Total value of single-acting cylinders in L.

V = Tank capacity in L.

Q/5 = Only when absolutely essential because of available space.
If at all possible, increase to Q/3

For industrial systems we recommend:

$$V = 1....2 \times Q$$

This is because enclosed rooms lower temperature differences and dust deposits have an unfavorable effect on heat dissipation. The dimensioning of the return lines wil also have an effect on heat dissipation (large temperature difference from surrounding area).

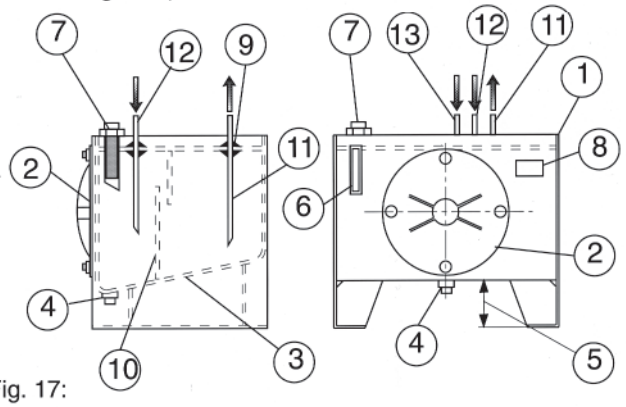


Fig. 17:

Various Items Essential to a Tank Design:

Anti-torsion design (accomodate extra equipment)

Leakage fluid "drip lip" (1) to catch escaping fluid when changing equipment

Clean-out cover (2)
The hole should be big enough to allow access to all surfaces and corners inside the tank.

Suitable tank floor (3) and drain plug (4). The tank floor should be equipped with a drain plug at the lowest point to facilitate draining and flushing.

Floor clearance (5)
A tank of 40 liters and up should have a floor clearance of 150 mm to facilitate cooling, cleaning, and transporting. The floor clearance allows air to circulate.

Fluid level indicator (6)
This is used to read the maximum and minimum fluid level from outside. The long design facilitates readings between levels. The fluid level monitor must be easily accessible. Fluid which exits through leaking equipment is always contaminated and must not re-enter the tank. The fluid level has to be topped off in time to prevent the fluid from reaching minimum level.
When checking for the minimum fluid level, temporary fluid removal through cylinders has to be taken into consideration as well as a possibly sloping position of the unit.

Filler breather filter (7)
An air filter has to be provided to vent the tank and clean the air entering the tank. Make sure that the rate of air flow is greater than the maximum fluctuating volume of the tank. A design too small might lead to a vacuum or excess pressure in the tank which has to be avoided. The tank opening has to be provided with a filter mesh.
The tank should be filled through a permanent filter only. New fluid from new barrels is usually contaminated.

A nameplate (8) should be attached to the tank in a visible spot marking the tank as a hydraulic fluid tank. It should also list the fluid specification, the fluid volume, the fluid change intervals, and the name of the replacement filter cartridge.

All pipe ducts have to be airtight (9)

Baffles (10) inside the tank are important to prevent turbulence inside the tank, get dirt to settle, and have air expel. In the mobile hydraulics industry baffles also help to prevent the fluid level from sinking below the minimum level caused by centrifugal forces when going into curves, accelerating, braking, etc.

The inside of the tank has to be coated with an fluid proof coating protecting it against corrosion. This has to be preceded, of course, by a thorough cleaning.

With low outside temperatures a heater has to be installed in the tank. Immobile fluid might burn, therefore, the heating power must not exceed a maximum of 200 Watt/dm_2 - tank bottom area. The thermostat regulating the heater has to be located near the heater at 1/2 to 2/3 of the height of approximately 10-20 degrees above the temperature at which maximum viscosity has been reached. The heater should be located near the suction line.

Suction lines (11) should be laid aproximately 2 inches (50 mm) above the tank floor.
The input diameter should be increased through an angled cut and be directed toward the fluid stabilizing side.

Return lines (12) have to be installed far enough below the fluid surface to ensure safe immersion. On the other hand, they should not end too closely to the bottom because fluid turbulence may be created at the surface due to the high exit velocity which would create air bubbles. The exit port of the return line should be cut at an angle just like the entry port of the suction line and it has to be pointed at the tank wall so that the

fluid flows alongside the tank wall. This will improve the heating process. Turbulences toward the suction side have to be avoided (baffle). If the return line is over dimensioned, the line might run empty. Empty lines contain air which then gets back into the tank through the return fluid causing familiar problems.

This affects return lines from pressure relief valves in particular. The problem can be remedied by installing a check valve with a small opening pressure - please consult factory.
Leakage fluid lines must be separated from return lines. They have to discharge into the tank below the minimum fluid level.

When combining several leakage fluid lines into one consolidation line, the cross section has to be sufficiently large. The back pressure must not exceed 29 PSI (2 bar abs). For this reason do not install any filters or coolers into leakage fluid lines. The pressure must not sink below 11.5 PSI (0.8 bar abs.); if necessary, install pressurizing valves.

Particularly in the case of future series production, it would be feasible to watch (in the prototype) the flow in the fluid tank through plexiglass windows. This can help to improve the fluid tank.

Air does not just enter through the suction line, it can also be "created" in hydraulic systems if the fluid pressure falls below the atmospheric pressure. Some of the components which often experience negative pressure are valves - particularly throttle valves and orifices in return lines. This is caused by the "Venturi" effect (a reduction in the cross section) which causes negative pressure which causes air to separate. Too small directional control valves might cause the same problems. Air ingress can also be the cause of pressure fluctuations behind weak seals. If the external pressure is exceeded, air enters the system through the seal. This was observed with vertically arranged lifting cylinders with high speeds and pumps installed above the tank.

One last point - displacement of air with first start-ups: hydraulic cylinders certainly should be equipped with venting screws. Also, the highest point in the system should be equipped with venting equipment, particularly if the pipes have large nominal widths. Larger power units have to be filled separately before start-up.

Filters

The cleanliness of the hydraulic fluid and the life of the hydraulic system are interdependent. Continuous filtration of the hydraulic fluid and additional measures, such as flushing during commissioning and following any assembly work on the system, are therefore particularly important.

In open and semi-closed circuits, full flow filtration of the return fluid is recommended, and in closed circuits full flow filtration of the boost return fluid. Suction filters for boost pumps have also been used with considerable success. Practical experience shows that suction filters in open circuits for main pumps should be avoided, since they represent a potential danger to pump suction characteristics. Maintenance errors can lead to cavitation.

We recommend the use of paper filter inserts in the form of disposable cartridges. If wire mesh inserts are used, then the manufacturer's instructions on the cleaning of the filter element must be followed exactly. Some manufacturers offer factory cleaning of filter elements, and this should be taken advantage of when available. The dirt absorption capacity of the filter when new will, of course, no longer be attainable.

The filter size should be selected for at least double the nominal flow - taking into account the flow resistance when the fluid is cold or contaminated. In systems where cylinders are installed, particular account must be taken of the large return flows, which do not correspond to the pump flow but are the product of cylinder stroking speed and pump flow.

The maximum permissible loading of the filter must be observed. The filter should always be installed before the fluid cooler, since the increase in viscosity after the cooler increase the flow resistance and therefore at the same differential pressure the limit of the filter's dirt absorption capacity is reached noticeably earlier.

It is important to have easy access to the filter, since filters which are difficult to get at for maintenance purposes are only ever serviced once!

We recommend that, instead of a bypass valve, the filters be equipped with a clogging indicator and a pressure - resistant filter element.

Fluid should only be filled into the tank via permanent filters. Because of the high viscosity of the cold fresh fluid, filling is a very time consuming process. In order to shorten the process, we recommend fitting a hand pump with check valve, with which fluid is sucked out of the barrel and fed to the tank via the check valve and the return line filter in the system. Under no circumstances should the insert in the filler filter be easily removable, since its removal would mean the constant addition of unfiltered fresh fluid to the tank.

An air filter should be fitted for tank ventilation. If the volume of air exchange is not large, then on mobile systems the tank can also be connected to the air filter for the internal combustion engine. (Check in each individual case). The pore size of the air filter should be the same as that of the hydraulic fluid filter.

Heat Exchangers

Air-fluid or water-fluid cooling of the secondary flow is normally adequate. The amount of heat to be dissipated depends on the type and construction of the hydraulic circuit, the load cycle and the heat radiating area being significant factors. On average, a cooling capacity of around 15% to 20% of the installed drive power is sufficient. When commissioning, this should be checked by taking temperature measurements. »Torque converter coolers« as fitted to diesel engines are in most cases adequate to dissipate heat from a hydrostatic transmission.

Fluid-air heat exchangers should be arranged well away from the warm exhaust air from the prime mover. In enclosed areas, adequate ventilation must be provided. Heat exchangers must meet the cleanliness requirements of a hydraulic circuit. They should therefore be free of dirt, rust, welding and soldering residue.

In systems with cylinders, flow surges frequently occur in the return line which in turn cause pressure shocks. It is therefore important to ensure that the bursting strength of the cooler is sufficient. This should be checked when commissioning by taking measurements at the cooler inlet.

To protect the cooler when starting from cold, a cooler bypass in the form of a check valve with a pressure of approximately 29 to 73 PSI (2 to 5 bar) should be installed.

It is important that dust is removed from the cooling fins on air-fluid heat exchangers at regular intervals.

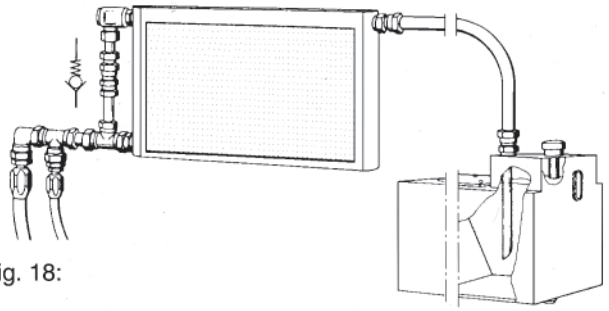


Fig. 18:

Storage

Hydraulic fluid containers stored in the open air should not be kept upright, but preferably in a horizontal position. If this is not possible, then tip the canister slightly by propping on a block (see diagram), so as to keep water away from the stoppers. (fig. 19)

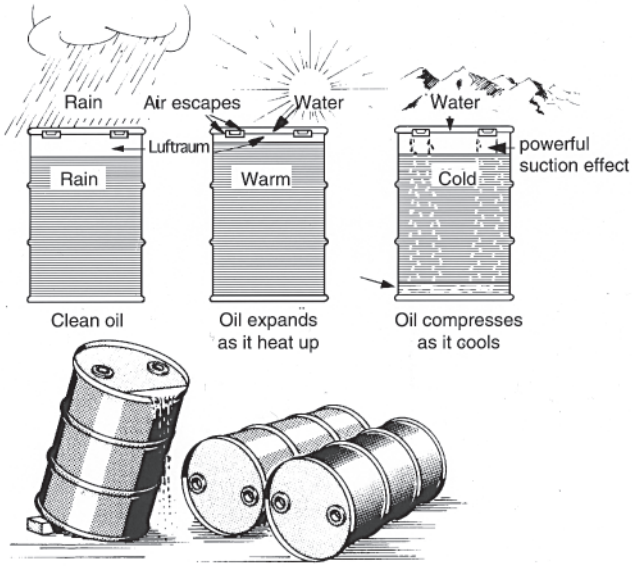


Fig. 19:

Hydraulic Fluids

This important topic is discussed in detail in leaflets RA 90 200 (petroleum fluid), RA 90 221 (Environmentally Safe Pressure Fluids) RA 90 223 (HF Fluids). Briefly, the most important points are:

Protection Against Wear/Reduction of Wear

At very high hydrostatic pressures, mating surfaces frequently operate under maximum friction conditions. Anti-wear additives immunize the surface of the metal and therefore reduce the tendency to wear. With regard to the pressure and wear characteristics of fluids, these are in accordance with the damage force grades of the FZG test:

Nominal pressure: 1160-1810 PSI (80 - 125 bar) Pressure grade 0 Damage force grade 5	Nominal Pressure: 1810-2900 PSI (125 - 200 bar) Pressure grade 1 Damage force grade 5 - 6
Nominal pressure: 2900-3625 PS (200 - 250 bar) Pressure grade 2 Damage force grade 7 - 9	Nominal pressure: 3625-5075 PSI (250 - 320 bar) Pressure grade 3 Damage force grade 10

Fig. 20:

Viscosity

We recommend that the fluid viscosity is chosen, so that at operating temperature a viscosity of

74.5 - 167 SUS (16 - 36 mm^2/s)

is achieved, thus achieving optimum efficiency and service life.

The leakage fluid temperature is influenced by both pressure and speed and is always higher than the tank temperature.

At no point in the system, however, must the temperature be higher than 176° F or 194° F (80° C or 90° C). If it is not possible to maintain these temperatures because of extreme operating temperatures or high ambient temperatures, we ask that you consult the factory.

Commissioning

Summary

It is essential to observe the special installation and operating instructions for the components, together with their operating parameters. In addition, we recommend the following information sheets:

- VDI Guidelines for Commissioning and Maintenance of Fluid Hydraulic Systems

- CETOP Recommendations

Check Required Before Filling with Operating Fluid

- Tank cleaned and thoroughly flushed?

- Pipelines cleaned and correctly laid, free of tension?

- Pipe fittings, flanges tightened? (Identify with color marking)

- Pipelines correctly connected in accordance with installation drawing and/or piping diagram?

- Pressure accumulators charged with nitrogen? It is recommended to note the gas pre-load on the accumulator itself (e.g. with a sticker) and on the hydraulic circuit, so that later comparatory checks are possible.

- Coupling between drive motor and pump (or hydraulic motor) correctly assembled and aligned?

- Drive motor correctly connected?

- Filter elements of specified pore size?

- Filter correctly installed in direction of flow?

- Measuring devices necessary for commissioning connected?

- Electrical control and regulating devices - do these have correct voltages and currents?

- Is the seal material compatible with the specified hydraulic fluid?

Hydraulic Fluid

All types of hydraulic fluid on a petroleum base are more or less suitable for use. The exact choice of fluid is determined by its wear and temperature-viscosity characteristics, taking into consideration oxidation and corrosion protection, material compatibility and air/water separation characteristics.

Preferred hydraulic fluids are petroleum based fluids type HL, HLP (HM-SIO) and HV as per DIN 51524, Parts 1 to 3 (see also RA 90 220).

For special fluids and for selection criteria, please see RA 90 223 and RA 90 221.

Tank filled with specified fluid up to max. fluid level mark?

Pump housing/motor housing filled with fluid?

Filter and heat exchanger filled with fluid?

Checks Required After Filling the Tank and Housings with Fluid

- Are isolating valves, particularly in the suction line, fully open?

- Is the direction of rotation of the drive motor the same as that specified for the pump?
  Switch on for short period and test or use starter to run without load.

- Check position of directional valves and if necessary move into required position - bypass without pressure.

- Unlead machine, jack up vehicle, brakes and locks on.

- If a boost/pilot fluid pump is fitted, this should be commissioned first.

- Start motor - run internal combustion engine at idling speed.

- In closed circuits, in order to bleed the main pressure line loosen fitting on motor side if boost is on pump side and conversely loosen fitting on pump side if boost is on motor side.

- Swivel pump approx. 5° and listen for noise. Insofar as this is possible with the control devices fitted, otherwise start at full flow.

- Bleed System.

- Carefully loosen bleed screws or fittings at highest point in system. When the escaping fluid is free of bubbles, filling is complete. Re-tighten fittings.

- Monitor fluid level in tank continuously and if necessary top up.

- Check functions without load, if possible operating manually.

- Before carrying out functional testing of the electro-hydraulic control or automatic operation without load, make sure the Emergency Off function is operating.

- When operating temperature has been reached, put the system under load.

- Check monitoring and measuring devices and compare readings with data given in hydraulic circuit.

- Listen for any unusual noises.

- Check fluid level and if necessary top up.

- Check or reset the setting of pressure relief valves by loading or braking the system.

- Check for leakage. Do not tighten any loose fittings immediately - tighten only when the system is not under pressure!

- Switch off drive.

- Tighten all fittings and plugs, even if there is no evidence of leakage. Note: on certain types of non-throttling swivel joints, the screwed section and the plug must be tightened separately.

- Check fluid level.

- Full functional test of the system. Compare measured values with the permissible or required data (pressure, speed, settings of additional control devices).

- Jerky movements indicate the presence of air pockets. A certain amount of these air pockets can be eliminated by swivelling the pump out in one or both directions for a short time with the serviced unit under load or braked. The system is completely bled when all functions can be carried out smoothly and continuously and there is no foaming on the surface of the fluid. In our experience, foaming should have stoped by one hour after start-up at the latest.

- Check temperature.

- Switch off drive.

- Remove filter inserts and inspect for residue.

- Cut open paper cartridges. The presence of dirt indicates a lack of cleanliness in the system.

- Clean filter inserts, replace paper cartridges.

- If further contamination is found in the filters, additional flushing of the system is necessary in order to prevent premature failure of system components.

- Record all settings in an acceptance protocol. This protocol should also form the basis for the inspection and maintenance book which will later be kept. This will record the necessary inspection intervals for the various parts of the system and what variations are found from the data recorded during commissioning.

Beginning of operations at low temperatures

The already established steps for the beginning of operations are still valid at low temperatures, but the following facts are to be noted:

- For all variable displacement units in operation at full power, the borderline temperature is

  maximal t = -13° F (-25° C)

  Lower temperatures require special measures.

- Borderline viscosity without compressive load but with less than 30% displacement

  $\nu_{cold\ 1} \leq$ 23,175 SUS (5000 mm²/s)

- Borderline viscosity without compressive load but with less than 30% displacement

  $\nu_{cold\ 2} \leq$ 11,588 SUS (2500 mm²/s)

- Borderline viscosity with full pressure and displacement loads, temporary

  $\nu_{cold\ 3} \leq$ 4,640 SUS (1000 mm²/s)

It must usually be verified that the optimal operation viscosity is reached at the self-establishing operating temperature, after the start phase and after a run-through of the above viscosity.

$\nu_{opt.}$ = 167 to 75 SUS (36 to 16 mm²/s)

Notes:

- The filling of the unit is not practically possible equal to or higher than = 13,905 SUS (3000 mm²/sec.); then the fluid does not flow through the bearings. In this case, the power unit and machinery materials must be heated. The power unit may not re-empty during installation; this makes the prefilling of the S and T pipelines necessary.
  Another possibility is to fill the cold unit with a low-viscosity pressure fluid. Then it is necessary to test if the new mixed viscosity satisfies the requirements and if the two fluids are miscible.

- In cases where the drive comes from internal combustion machines (ICM), it is noteworthy that, with separate preheating for a reduction in the cold-start phase, the hydraulics must also be preheated; or appropriate equipment guarantees a viscosity-dependent start of operation.
  Since the ICM rapidly runs through the cold-start phase, the operators get the impression that the hydraulics too are warm and capable of being loaded. But the limiting viscosity, which does not permit a load, still lies ahead.
  The commonly practiced method of heating cold hydraulics through pressure limit valves, is unreliable due to disadvantages associated with it!

Flushing and Clealiness Grades

Summary

We recommend that flushing of the system be carried out before every commissioning of a new system, or following repairs.
Flushing should also be carried out if there are indications of contamination in the system.
The pore size of the flushing filter should match that of the hydraulic system, but should nevertheless correspond to a

value of β_{30} - 100. Flushing filters should have no bypass valve, but should be equipped with a clogging indicator.

The flushing filter inserts should be pressure resistant. We recommend the use of 2 filters - a coarse, cleanable metal fiber filter being installed before the actual fine filter with disposable paper cartridge.

Separate Pump and Filter Station

This station is also used to fill the system. It is portable and therefore suitable for use wherever required. After flushing, with valves in neutral position, operate all serviced units and components under zero pressure. Finally, inspect filters; the system can now be connected ready for operation.

Note:

Protect against overload with motor protection switch. Compare pressure for operation without load with permissible pressure of components installed in the filter station. For closed circuits, the filter station is only suitable for filling the system and components.

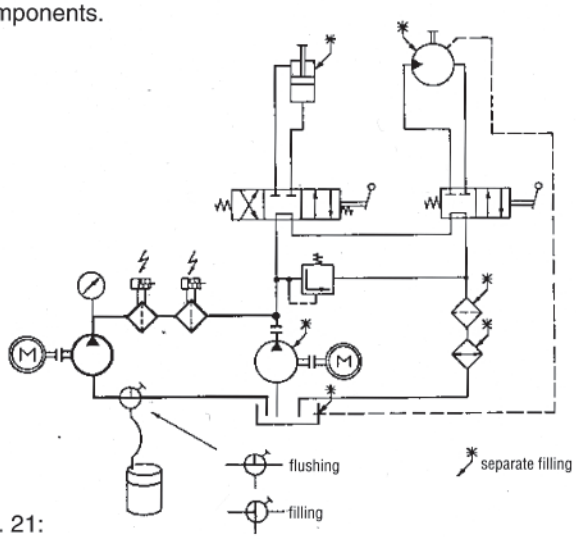


Fig. 21:

Flushing in Bypass Circuit

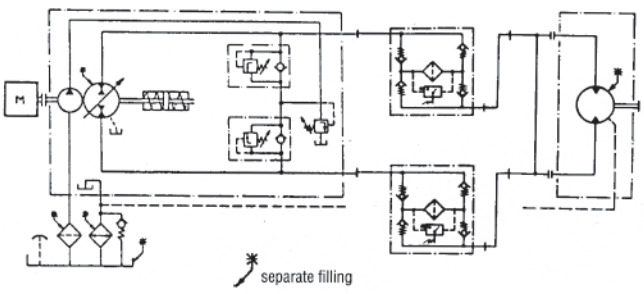
Serviced units such as hydraulic motors and cylinders are by means of a filter combination and should if possible be operated at low speed and without load.

This will prevent damage by dirt particles, until these are completely filtered out, as can occur at high speeds and high pressures.

The reversal of the flow direction for the filters is compensated by the rectifier plate.

This circuit should also be used for closed hydraulic circuits.

For closed circuit (Fig. 22:)



For open circuit

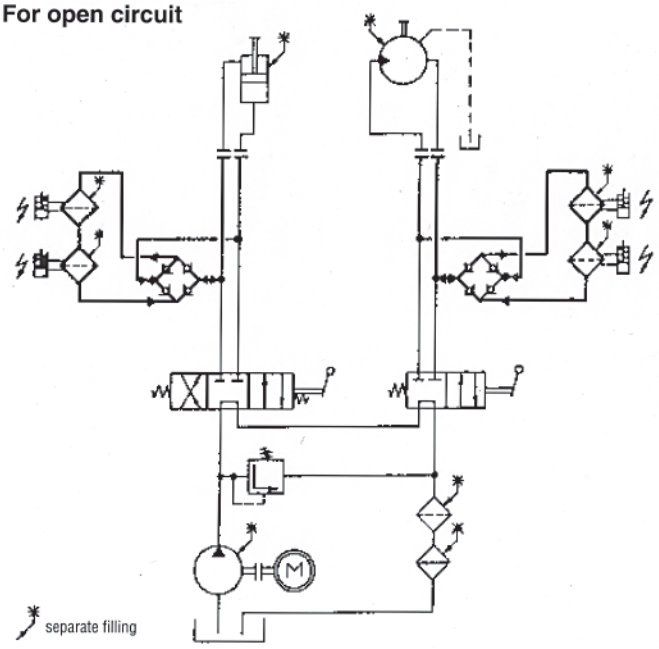


Fig. 23:

Flushing with Filter Combination

The system filter in a completed system is replaced by a filter combination, which is either removed again after flushing or can remain in place for a longer period.

Note:

This flushing circuit is only suitable for open circuits and is only worthwhile if the flushing filters are finer than the system filter.

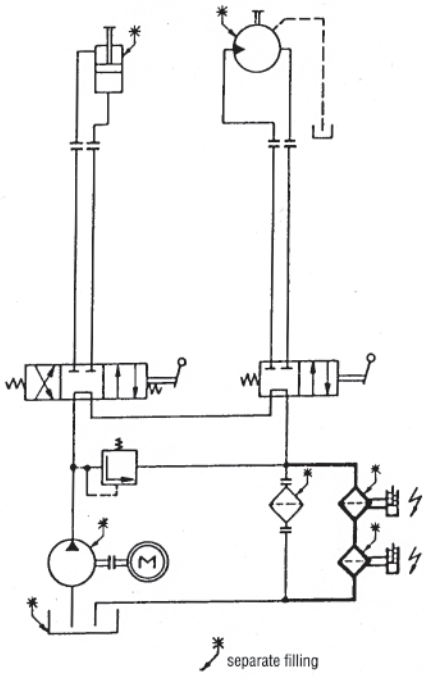


Fig. 24:

Cleanliness Grades

	ISO/ DIS	NAS	SAE
Standard	4406	1638	
Grade	18/ 15	9	6

In order to achieve these values, filters should normally have a minimum ß-value of:

$$ß_{30} = 100$$

To SAE, ASTM, AIA
e.g. to SAE:

Micron	Grade						
0	1	2	3	4	5	6	
5 - 10	2.700	4.600	9.700	24.000	32.000	87.000	128.000
10 - 25	670	1.340	2.680	5.360	10.700	21.400	42.000
25 - 50	93	210	380	780	1.510	3.130	6.500
50 -100	16	28	56	110	225	430	1.000
> 100	1	3	5	11	21	41	92

Inspection, Maintenance and Trouble Shooting

Inspection

Summary

Any defects or abnormalities noticed by operating personnel must be rectified immediately, their cause sought and effectively eliminated. Those inspection points not already being continuously monitored should be checked daily immediately after commissioning. Findings should be recorded in an inspection book. Longer inspection intervals (e.g. weekly or monthly) can then be introduced as required. Signalling devices at automatically monitored inspection points should be checked monthly.

Inspection Points

- Loose pipe connections or component fixings

- External leakage

- Abnormal noises and vibration

- Functional deficiencies, e.g. drop in torque or speed and drop in pressure or flow

- Contamination of filters (filter clogging indicator only correct when system is at operating temperature)

- External contamination and damage, particularly on air/fluid heat exchangers

- Check accumulator charging pressure in line with manufacturer's instructions (annually)

- Rusting of inside of tank

- Water separation following long periods of inoperation

- Foaming in tank

- The hydrauic fluid:
  In our experience, inspection of the hydraulic fluid is an area subject to many errors and neglect. Nevertheless, the condition of the hydraulics can be quickly and reliably assessed from the condition of the hydraulic fluid. Because of its importance, and in order to give a few pointers, the inspection of the hydraulic fluid is described in greater detail below.

Inspection of the Hydraulic Fluid

The hydraulic fluid is one of the most important components of a hydraulic system and fulfills a number of duties. In addition to the known inspection points, such as:

- Level in tank

- Discoloration (milky, dark, foaming)

- Temperature in tank

which must be continuously monitored, additional checks are necessary.

In particular, evaluation of the hydrauic fluid in the system and the changes undergone since new allows irregularities in the hydraulics - the cause of future machine damage - to be identified at an early stage. Laboratory tests are especially recommended because of their highly reliable findings. The cost involved is usually quickly recouped by lengthened fluid change intervals.

If operating temperature falls below the minimum permissible value (viscosity limits), pre-warming of the fluid is necessary. During this, make sure that the fluid is being circulated, since the thermal movement of the fluid is not sufficient (fire risk). It is recommended to warm up the system when starting at minimum operating temperature. This is carried out by operating the system under low load conditions. Speeds should be no higher than the medium range.

Inspection Methods and Intervals

Initially, proceed in accordance with the following guidelines. Thereafter the optimum intervals for testing the hydraulic fluid can be determined by the laboratory.

Less than	13 gallons: (50 liters)	Change according to maintenance instructions.
	13 - 66 gallons: (50 - 250 liters)	Bi-annually; evaluation by sight and odor as described on page 2.
	132 gallons: (500 liters)	Annual inspection in laboratory.

Visual and Odor Testing of Hydraulic Fluids on Petroleum Fluid Base

	Findings	Action
Color	Slight darkening without bottom sediment	None. Fluid darkens with use.
	Pronounced darkening with bottom sediment	Filter fluid, on large systems follow up with laboratory test.
	Cloudiness	See next section.
Contamination by foreign matter	Clean and clear, no sediment.	None.
	Clean and clear, small amount of sediment	Shorten test intervals.
	Floating contamination (clouding) or deposited contamination	Filter fluid, clean system. Inspect system filter - residue found usually gives better indication of cause. On large systems follow up with laboratory test.
Water in Fluid	Clouding (emulsion) visible water separation	Detect water by a spatter test. Drain off water deposists. Separate or change fluid. HLPD or HD engine fluids bond a small percentage of water without danger. However, shorter inspection intervals are then necessary to monitor the water content.
Foaming	Increased foaming Foam escaping from tank	Check airtightness of suction line and fluid level in tank.
Odor	Odor of scorched fluid	Normally no cause for concern. If occurring in conjuction with other changes (build-up of residue and pronounced darkening), see foregoing sections.
	Sour odor (with darkening and bottom sediment)	Immediate fluid change and cleaning of system.

Seek out the cause of the problem and eliminate!

Visual and Odor Testing of Fire-Resistant Fluids

	Findings	Action
HFA	Foul smell, brown discoloration	Measure pH value with litmus paper; add biozide or change fluid. Cleaning of system with systematic cleaner may be necessary.
	Emulsifying or fluid separation	Laboratory inspection Where there is fluid separation or penetration of foriegn fluid, remove fluid layer.
	Floating or deposited contamination	Change fluid or clean. Where large volumes are involved, carry out laboratory tests.
	Foaming	Add foam dispersant or harder water.
HFC	Clear change in color or appearance of fresh fluid	Laboratory test
	Water content	Continuous laboratory tests - important!
	Foaming	Laboratory test; consult with supplier and add suitable foam dispersant.
	Water on surface, clouding	Remove water, if in doubt carry out laboratory test.
HFD	Layer of fluid on surface	Remove fluid, if necessary change fluid (impaired fire-resistance properties.)
	Floating/deposited contamination	Clean fluid, check filters. If heavy contamination is found, laboratory test.
	Foaming	Consult supplier.
	Smell of disinifectant	Immediate laboratory test (ageing).

Instructions on Taking Fluid Sample

- The fluid sample must be taken while the system is running and at operating temperature.

- Equipment and containers used must be absolutely clean. Many laboratories supply their own hermetically sealed sample containers.

- Samples should be taken via valves provided for the purpose on the tank or return line. If using a siphon, take sample near the pump suction inlet. Samples taken near the tank floor or the drain plug will give a false picture due to dirt, mud or water.

- Evaluate by sight and smell in tapered sedimentation tubes.

- Laboratory samples should be taken in accordance with their instructions.

In addition to the results of your own evaluation, the machine running time and the volume and type of any top-up fluid should be recorded.
1/4 gallon (1 liter) of fluid is normally required for laboratory tests, less for »sight and odor« testing.

Maintenance

Summary

Our products require no routine maintenance. Maintenance work is therefore confined to the care of the fluid and changing of filters. Maintenance intervals vary from system to system and depend on operating and application conditions.
In our experience, up to 80% of faults and damage occurring in hydraulic fluid systems can be attributed to wrong choice of fluid or inadequate servicing of the fluid.
In the following, this point has therefore been given particular attention.
Naturally, the separate instructions of both the machine and the fluid manufacturers must also be observed in the same way.

Maintenance of Hydraulic Fluid

- Top up fluid to required level via filter (continuously; filter of same pore size as system filter).

- After long shutdown periods drain off water deposits (in the morning).

- Additional maintenance of fluids by secondary flow filtration with portable filter station.

- When the fluid is not continuously monitored, change every 1000 - 5000 operating hours, or at least once a year or as indicated by laboratory tests.
  In systems with a high thermal loading, shorter fluid change intervals are desirable.

- Winter/Summer operation must be taken into consideration if the fluid used is not capable of bridging both temperature ranges while still ensuring that the optimum operating viscosity at operating temperature is obtained.

- Clean fluid tank at every fluid change.

- Refill only via filter. The filter pore size must be at least as fine as that of the system filter. To reduce filling time, hand or electrically operated portable pump/filter stations are recommended.

Maintenance of Fluid Filter

- Always change filter insert following start-up. We recommend the use of paper filters for commissioning, which can then be cut open and will give a good indication of the cleanliness of the system. In doubtful cases, flush the system.

- If the filters are not continuously monitored, change the insert every 500 operating hours. Paper inserts cannot be cleaned. Metal fiber elements only to a limited extent, by the manufacturer.

- With continously monitored filters, the inserts should be changed immediately after the first warning signal when the system is at operating temperature.

- After removal, the inserts should be thoroughly inspected. If an abnormal amount of dirt is found, the cause must be sought. In such cases, the inspection interval must always be shortened. If in doubt, flush the system.

- A supply of filter inserts should be kept at the machine in their original packaging to protect from dirt.

Maintenance of Air Filter

- As a general rule, carry out maintenance at the same time as the fluid filter.

- A particularly dusty or damp environment can mean shorter maintenance intervals or re-location of the filter.

-The pore size of the filter insert must be the same as that of the fluid filter.

Maintenance of the Heat Exchanger

- Water/fluid heat exchangers normally require no routine maintenance, however the manufacturer's instructions should be observed.

- Air/fluid heat exchangers - at the time of changing the filter element, the air side should be thoroughly cleaned. Under particularly dusty conditions (harvesting machines), daily cleaning may be necessary.

Additional Maintenance Points

- Check gas charge of pressure accumulator and if necessary top up.

-Replace wear parts (seals, hoses).

- Lubricate all points requiring hand lubrication according to instructions (universal drive shafts, plug connections).

Notes:
- Water deposits in the tank causes the fluid level to rise and gives a misleadingly high fluid level.

- Mark fluid type used on tank with sticker.

- Escaping leakage fluid is always dirty and must not be returned to the tank.

- If repairs or modifications are carried out in the system, flushing and filter inspection must be carried out again as described for initial commissioning.

- For transport over long distances, sea voyages, storage, etc., the units must be conserved.

- Hydraulic systems, even when already commissioned, must be protected against corrosion when shut down for long periods.

- When re-commissioned, all preservative materials must be carefully removed, and inspection and maintenance initially carried out twice as frequently as previously.

- Additional notes on systems using special fluids are to be found in our data sheet RA 90 223, or the publications of the fluid manufacturer.

Troubleshooting

Summary

Troubleshooting is described here in general terms. Special instructions for individual products are described in their relevant operating instructions. Particular emphasis is placed on the central importance of the hydraulic fluid in a hydraulic system. The notes given here apply to hydraulic fluids on a petroleum base, but can also be applied in principle to other fluids.

Causes of Dirty Fluid

Solid contamination particles in the fluid are the cause of most damage in fluid hydraulic systems.
They can cause spontaneous failures, but in most cases cause gradual wear, leading to reduced power and efficiency and consequent machine breakdowns and repairs. If inspection of the fluid shows the dirt content to be too high, then the following are possible causes:

- Inadequate or neglected system cleaning and flushing prior to commissioning and following repairs.

- Dirty transport conditions; unsuitable storage areas.

- Fluid change not carried out.

- Dirty service equipment.

- Absence of, or too coarse, clogged or defective filter inserts.

- Air filter on hydraulic fluid tank too coarse.

- Hydraulic fluid tank not airtight (pipe inlets not airtight, cleaning openings, etc.)

- Metal or seal wear particles from pumps, motors, valves or cylinders.

- Rust particles from tank lid.

- Ingress of dirt via faulty seals (wiper rings on cylinders).

- Leakage fluid returned to tank.

Causes of Water in Hydraulic Fluid

Water entering the hydraulic fluid encourages wear, contamination and corrosion of the system, changes the properties of the ffluid and can thus lead to faults in the system. Possible causes of abnormally high water content in hydraulic fluids are:

- Ingress of watery cutting fluid.

- Penetration of rain or cleaning water.

- Condensation as a result of temperature fluctuations and/or fluctuating fluid volume in the tank.

- Leaking heat exchanger.

- Failure to drain off deposited water from the hydraulic fluid tank at regular intervals.

Causes of Air Bubbles in the Fluid

Air bubbles contained in the fluid can cause irritating noise (cavitation), malfunctions and damage to the system. The following are the main causes for the formation and retention of air bubbles in the fluid:

- Wrong choice of fluid or dirty fluid.

- Hydraulic fluid tank too small or of wrong design (fluid life too short, turbulence of fluid returning to tank and being resucked).

- Negative pressure areas not airtight (e.g. suction lines, pumps, throttle valves).

- Formation of air bubbles as a result of pressure drop (e.g. due to sharp pipe bends, kinks in hoses).

- Inadequate bleeding of system (during initial commissioning; following repairs).

- Sieves or filters before suction line too fine.

Causes of Surface Foaming in Hydraulic Fluid

Surface foaming can result in foam being sucked in through the pump or foam escaping from the fluid tank. The following are the main causes of excessive surface foaming:

- Excessive contamination of the fluid (dirt, water, ageing products, conservation materials, solvents, etc.)
- Unsuitable tank design.
- Circulating speed too high.
- Absence of, or ineffective baffle plate.

Causes of Abnormally High External Leakage

Leakage losses frequently call for larger top-up volumes than a complete fluid change. Leakage losses are expensive: 1 leakage point leaking one drop per every 5 seconds causes an annual loss of approximately 200 liters of hydraulic fluid, not to mention the associated environmental damage.
Frequent causes of escaping fluid are:

- Leakage from pipe connections on components.
- Inadequate inspection and maintenance of system.
- Faulty cylinder and shaft seals.
- Inaccessible pipe connections (make the finding and elimination of leakages more difficult).
- Faulty hoses.
- Absence of seal protection (e.g. wipers, bellows, protective cover) at points at risk from dirt or metal chips.

Causes of Overheating of the Fluid

As a rule, the fluid temperature in the hydraulic fluid tank should not exceed 194° F (90° C).
Too high fluid temperatures shorten the life of the hydraulic fluid, seals and hoses.
They encourage the formation of residue and increase wear.
Possible causes of excessive fluid temperatures are:

- Pump flow too large (excessive throttling).
- Hydraulic fluid tank too small or of unsuitable design.
- Cooler not fitted, too small, incorrectly set, dirty, or cooler bypass valve open.
- Pipes undersized.
- Pressure relief valve incorrectly set, dirty or defective, pressure regulator (pressure cut-off) set above the setting of the safety valve.
- Heating due to external influences (sunshine, furances, high ambient temperatures, faulty air-conditioning).
- Air in fluid (compression heat).
- Fluid level too low.
- Metal or seal wear on pumps, valves, motors or cylinders.
- If fluid used is of wrong viscosity, this can lead to thermal overloading. In this event, overheating is not confined to the tank, but can also occur in the individual units.