HYTRES

HYDRAULISCHE COMPONENTEN & SYSTEMEN

GENERAL MANUAL

HYDRAULIC POWER UNITS & SYSTEMS

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General manual for hydraulic systems in Dutch

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1 INTRODUCTION

This is a manual for the proper and safe use of hydraulic systems. Read this manual before installation. Keep this manual so that you can consult it at any time. The hydraulic system may only be used by authorised persons who have taken note of the information in this manual and have sufficient knowledge to carry out work on hydraulic and electrical circuits and systems.

EMISSION	INTENDED USE
The hydraulic power unit may contain residual hydraulic oil in the tank and/or components when purchased. This is residual oil in the final functional test.	The hydraulic system is intended to be used to generate hydraulic power (pressure and flow). Hydraulic power is transported to one or more actuators (motors, cylinders, etc.) by means of hoses and/or pipes to be connected to the power unit. The actuators can be operated by one or more control valves. (Mechanical, hydraulic, pneumatic and/or electric).

WARRANTY AND DELIVERY CONDITIONS

HYTRES B.V. is a member of the Royal Dutch Metal Union (Koninklijke Metaalunie) (the Dutch employers' organisation for SMEs in the metal sector) and is subject to its General Terms and Conditions, which are referred to as the 'METAALUNIEVOORWAARDEN' ('METAALUNIE CONDITIONS'), filed with the Court Registry in Rotterdam on 1 January 2014.

A copy of the complete Metaalunie Conditions can be downloaded from www.HYTRES.com.

– Damage to or costs arising from the product as a result of non-compliance with the instructions in this manual (including, but not limited to: safety precautions and operating instructions) are not covered by the warranty.

– If any components are replaced by spare parts, supplied by third parties, or for which our express consent has not been obtained, all responsibility of Hytres B.V. with respect to the delivered product shall lapse.

– The manual supplied with the product can in no way be invoked to make any claim under warranty for the malfunctioning of the hydraulic system or the occurrence of any loss or damage (consequential or otherwise) whatsoever.

– For optimal use, with a minimum of operational stops, it is important that the hydraulic system is designed and executed according to the requirements of the installation or end user, and that it is used for its intended purpose and periodic maintenance is carried out by qualified personnel.

2 APPLICATION

The hydraulic system is intended to be used to generate hydraulic power (pressure and flow). Hydraulic power is transported to one or more actuators (motors, cylinders, etc.) by means of hoses and/or pipes to be connected to the power unit. The actuators can be operated by one or more control valves. Depending on the supplied hydraulic system, the installed power may vary.

UNAUTHORISED USE

Failure to observe any instructions, warnings and/or safety precautions and as stated in this user manual may cause injury!

→ The hydraulic system must be used for the purpose for which it was designed.

→ Modifications to or use of the hydraulic system for purposes other than those specified above are strictly prohibited. This prohibition also applies to all modifications of or changes to components other than those originally delivered.

→ Do not overload the hydraulic system in any way, and ensure it is protect therefrom.

→ Do not operate the hydraulic system if parts are damaged or missing.

→ Immediately stop the hydraulic system in case of hose or pipe rupture, broken cylinders or other components.

→ Do not perform any repairs or maintenance work with the system running. First, disconnect the power/fuel supply.

→ Do not insert objects into rotating parts such as cooler fans and/or electric motors.

SAFETY FUNCTION

To prevent the hydraulic system from exceeding the maximum pressure, it is equipped with a hydraulic safety device. It can be set at the factory to the desired working pressure and may only be adjusted by experts.

3 SAFETY INSTRUCTIONS

Please read the following safety instructions before installing and/or operating the hydraulic system.
Follow the instructions carefully and keep them in a safe place so that you can consult them at any time.

GENERAL SAFETY INSTRUCTIONS

- The hydraulic system is intended exclusively for the supply of hydraulic power specifically for the application for which the hydraulic system was designed and constructed. ***The use of the hydraulic system for purposes other than those for which it was designed is expressly prohibited!***
- If lifting or lifting and/or hoisting equipment is used when installing the hydraulic system, operators must also be familiar with the method of control and operation of the lifting and/or hoisting equipment used.
- Commissioning of the hydraulic system should only be done by persons instructed or certified to do so, and in accordance with the instructions in this manual.
- The hydraulic system must only be operated by authorised persons.
- Operators of the hydraulic system shall at all times be familiar with the mode of operation.
- Maintenance/repair of the hydraulic system should only be done by the supplier or third parties designated by the supplier.
- Improper repairs can lead to significant hazards!
- A hydraulic system is a power source. Parts may become hot due to intensive use, improper connection or overload. Avoid touching hot parts at all times.
- Wear eye protection at all times when working with or on hydraulic systems; if the unit produces more than 85 dB, you are required to wear hearing protection.
- Always read the manual before using the hydraulic system.

SAFETY INSTRUCTIONS FOR TRANSPORT

- The hydraulic system may only be lifted using the lifting eyes provided for this purpose.
- Make sure that nobody can be on, beside or underneath the hydraulic system during the transport and/or lifting of the hydraulic system in connection with possible tipping or falling.
- Observe the weight of hydraulic system in connection with the maximum manual lifting weight of 25 kg.

SAFETY INSTRUCTIONS FOR COMMISSIONING

- Ensure that the hydraulic system is placed on a secure, flat, stable and load-bearing surface.
- Please familiarise yourself with any hydraulic and/or electrical diagrams supplied. Avoid improper connection of cables or wiring at all times. This can lead to life-threatening situations!
- Protect the entire electrical circuit sufficiently against moisture. A voltage of at most 50 V AC or 120 V DC is not dangerous for people.
- Ensure that the switch box is secured properly (e.g. it is automatically disconnected when the cabinet is opened).
- Provide the switch box with the correct instructions and stickers.
- Only allow qualified and competent personnel to work with electricity!
- Ensure that the earth connection is good and has been inspected.
- When using voltage circuits, the system must be designed correctly and safety aspects must be taken into account.
- The low voltage must be stable, deviations must not exceed ±10% for on/off magnets and must not exceed ±5% for proportional magnets (measured at the coils).
- If the low-voltage circuit is large, ensure that sufficient power can be supplied by the transformer.
  Consider any already installed peripherals, such as coolers, parameter monitoring / protection devices, lighting, etc.
- Avoid unexpected / incorrect start-up of the hydraulic system at all times.
- Avoid leakage or spillage of oil due to the risk of slipping at all times.
- Always avoid absorption through the skin or mouth of oil if oil is released for any reason whatsoever.
- Avoid contact with high-pressure liquids at all times. High-pressure fluids can easily spray through clothing or skin, resulting in serious injury.

SAFETY INSTRUCTIONS FOR OPERATION

- Avoid unexpected / incorrect start-up of the hydraulic system at all times.
- Avoid contact with high-pressure liquid at all times. High-pressure fluids can easily spray through clothing or skin, resulting in serious injury.
- Avoid contact with live parts at all times.
- The hydraulic system can be designed as an electrical device. In order to avoid a risk of shock, injury and fire, the safety instructions must always be observed.
- Never use the hydraulic system when the workplace is damp or wet.
- Never use the hydraulic system in the rain.
- Avoid leakage or spillage of oil due to the risk of slipping at all times.

SAFETY INSTRUCTIONS FOR MAINTENANCE AND REPAIR

- Avoid unexpected / incorrect start-up of the hydraulic system at all times.
- Avoid contact with high-pressure liquid at all times. High-pressure fluids can easily spray through clothing or skin, resulting in serious injury.
- Avoid contact with live parts at all times.
- Ensure that the accumulators are depressurised during repair and install relief valves / safety valves.
- Accumulators are pressure vessels. Pay attention to the risk of explosion.
- Avoid leakage or spillage of oil due to the risk of slipping at all times.
- Cylinders can remain under pressure through balancing valves or controlled non-return valves.
- Ensure that the cylinder is mechanically free.
- Provide a clean working environment, free of oil or obstacles.
- Provide adequate protection around moving or rotating parts; be careful to avoid crush hazard.
- Rubber and plastic hoses must be replaced with equivalent hoses after 6 years. Hoses in stock may be used unassembled until 4 years after the production date. When assembled, only 2 years.
- Use only original or equivalent parts.
- Always use sound and good tools.
- Observe the safety precautions as laid down by the labour inspectorate and/or other authorities.

Failure to comply with the above rules and measures shall constitute gross negligence. The supplier cannot be held liable for any loss or damage if you fail to comply with the above safety regulations and measures.

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- Avoid contact with high-pressure liquid at all times. High-pressure fluids can easily spray through clothing or skin, resulting in serious injury.
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HAZARD SYMBOLS AND PICTOGRAMS

Ensure that hazard symbols are placed on the hydraulic system and that they are kept complete and legible. Replace any damaged and illegible hazard symbols. Examples include:


General hazard symbol: Caution!


Risk of electric shock


Risk of slipping


Harmful substances


Risk of rotating and moving parts


Risk of high temperatures

PROTECTIVE EQUIPMENT

The following Personal Protective Equipment (PPE) must be worn:

- Face shield or safety goggles
- Hearing protection: noise level > 85 dB(A)
- Safety shoes

4 COMMISSIONING

PRELIMINARY SURVEY

Before installing the hydraulic system, with components and peripheral equipment, it is necessary to determine where the components are to be installed. This will depend on several factors:

- Place the hydraulic system and components, requiring regular maintenance, in such a place that it will be possible to carry out subsequent inspection and maintenance in a reasonable manner.
- External temperature influences from the environment. It should be obvious that high ambient temperatures will reduce the heat emission to the environment, but low temperatures also require extra attention. The ideal oil temperature is between 38 and 50 degrees Celsius, with a maximum temperature of 60 to 68 degrees Celsius. Above this, the service life of the oil will be greatly reduced. This also applies to the components used.
- Noise transmission / nuisance to the environment. Attention should be paid to the installation of damping rubber on units, engines and possibly cylinders, use of hoses, pipes with suitable pipe brackets and possibly placing accumulators to collect pressure waves.
- Consult the end user or machine operator thoroughly beforehand.

INSTALLATION AND ASSEMBLY

Always follow the instructions of the manufacturer or supplier when installing components, coupling parts, hoses and pipes. The following standards of cleanliness must be observed during installation and assembly:

1. Hoses, coupling parts and pipes are never clean on the inside after they have been processed and must therefore always be cleaned before installation. Either by rinsing, by being blown through with lint-free paper or cotton, soaked in oil or special equipment commercially available. This operation must be repeated until everything is completely clean. If the pipes are hot bent or welded, the pipes must be treated with a product means of removing slag and loose material. Rinse afterwards, first with plenty of water and high speed, then with hot water before drying the pipes. Final rinse with oil for corrosion protection. If the installation of already manufactured hoses, couplings and pipes has yet to be done, they must be plugged and protected against corrosion, moisture and dust. The same also applies to exposed parts on the hydraulic system and components.
2. Keep the workplace clean during installation and assembly, otherwise this will cause extreme contamination in the new system to be started.
3. Work with the correct and clean tools and use clean oil for any installation of components. Oil straight from the drums is not clean enough and can even contain water due to condensation during storage!

As with any hydraulic system, the key to a successful operational system, and a long service life, is strict maintenance of cleanliness and good oil filtration. Failure to comply with these conditions will result in improper operation of pumps, valves and components and can lead to serious damage and failure of the system.

DIMENSIONING OF HOSES AND PIPES

By choosing the correct diameters for hoses and pipes, the pressure drop in the system can be kept as low as possible. The greater the resistance, the greater the operational loss. It is important to avoid causes of pressure drop, such as: right-angled screw couplings. Where appropriate, the use of smooth bends is recommended. If the length of the pipes is very long, or if the oil velocity is high, then it makes sense to choose larger pipe diameters. Please note:

- Pipe diameters are given in external diameters! Use a flow diagram to determine the correct dimensioning.
- Seamless cold-drawn precision steel tubes according to DIN 2445/2-1974 must be used for pipes.
- Depending on the working pressure, hoses can be used with two wire braid hoses according to DIN 20022/EN853, four wire braid hoses according to DIN 20023/EN856, or plastic hose according to SAE.
- Always ensure a stress-free installation of both hoses and pipes.
- Avoid mechanical damage caused by intersecting pipes and/or hoses or incorrectly mounted mounting brackets.
- Never spray hoses with lacquer or paint, keep the hoses away from external chemical influences and keep them away from heat sources.

OPERATIONAL STAFF

Installation and assembly must be carried out by skilled personnel with specialist training. They should be aware of the high level of responsibility, particularly in terms of safety. Incorrectly assembled die rings, incorrectly assembled hoses and the like can result in life-threatening situations. The machine manufacturer must be aware of the fact that a CE declaration must be supplied in which it assumes full responsibility for the supplied machinery and indicates how the system is to be used correctly.

- Correct start-up and running-in of hydraulic systems are of great importance for a reliable and problem-free system. The service life of components, especially pumps, often ends prematurely because the most basic conditions have been ignored.
- A common cause is the failure to observe cleanliness during installation, assembly and start-up. Even at the highest level of cleanliness and care, it is impossible to prevent contamination from occurring in a new system.
- During startup, particles will also come off the moving parts. Therefore, it is important not to place a full load on the system before these particles have completely filtered away.

FILLING THE HYDRAULIC SYSTEM

Reservoir	- Before filling, check the reservoir for contamination. - Fill the tank with clean oil of the correct type and by means of a good filling system up to the maximum level. - The filling system must be equipped with a particulate filter with an Absolute Micron Rating (AMR) of at least 10 microns, in which the suction line of the filling system may not suck from the very bottom of the vessel, so that any water and larger impurities are left in the vessel. - If it is not possible to fill the tank with a good filling system or filler cap, use clean cans or funnels to fill the reservoir via the return filter.
Suction filters	- When installing spin-on filters, they must be completely filled, with all air being removed before the element is put back in place. - Then vent the filter housing. - Check the filter for correct installation and any leakage.
Gear pumps	- In general, these do not require any additional inspection. - If the pump is outside the tank, the suction line must be vented, or if the pump is above the oil level, filled with oil. - In all cases, check all connections for leaks and restrictions (shut-off valves).

Plunger & Rotary vane pumps	- Vent the suction pipe of the pump at the highest point. - Check the suction line for leaks and restrictions (shut-off valves and closed suction filters). - Fill the pump housing with clean filtered oil at the highest located leak-off oil connection.
Cylinders	- Cylinders, especially large cylinders, can be filled with oil beforehand. The big advantage of this is that the oil level in the tank will not drop too much during commissioning and that as little air as possible will enter the system.
Gear boxes	- Gearboxes, planetary gearboxes, wheel axles, etc., are at all times supplied without oil. Fill them according to the manufacturer's specifications, with the type of oil specified by the manufacturer. Also pay attention to the thermal load, in connection with possible cooling.

START-UP OF THE OPEN LOOP SYSTEM

Electrical

A number of conditions must be met in both stationary and mobile applications:

- When using voltage circuits, the entire system must be designed correctly, and safety aspects must be taken into account.
- The low voltage must be stable, deviations must not exceed ±10% for on/off magnets and must not exceed ±5% for proportional magnets (measured at the coils).
- If the low-voltage circuit is large, ensure that sufficient power can be supplied. Consider any already installed peripherals, such as coolers, parameter monitoring / protection devices, lighting, etc.
- Protect the entire electrical circuit sufficiently against moisture: A voltage of at most 50 V AC or 120 V DC is not dangerous for people.
- Ensure that the earth connection is good and has been inspected.
- Ensure that the switch box is secured properly (e.g. it is automatically disconnected when the cabinet is opened).
- Provide the box with the correct instructions and stickers.
- Only allow qualified and competent personnel to work with electricity!

Hydraulic

- Before starting up, check the piping, flanged connections and screw couplings are correctly installed. In addition to major damage, if pipes come loose, this can also cause injury.
- Ensure the circuit has been depressurised at start-up. With gear pumps and adjustable pumps, this is done by means of a free connection from P to T in the valve block.
- With a constant-pressure pump by means of a bypass valve between P and T.
- In the case of a closed pump-motor unit, the output, and striker plate adjustment, must be completely neutral.

Direction of rotation of the pump

The correct direction of rotation must first be checked. This is displayed on the pump and electric motor:

Direction of rotation	*Dutch*	*English*	*Spanish*	*Italian*
Right	R	CW	D	D
Left	L	CCW	I	S

The direction of rotation of the pump is determined from the shaft side. This can be checked as follows:
– In the case of an internal combustion engine, a short start is made, so that the engine cannot start up.
– With an electric motor, the motor is briefly switched on and immediately switched off again.

First running-in phase

During the first running-in phase, the pump must be run completely depressurised, to remove any remaining air in the suction line, filters and any control lines. In mobile systems in combination with an internal combustion engine, this should be done at the lowest possible speed.

- During this running-in phase, make sure that the pump is really supplying oil, as an air lock may occur in the suction filter or in the suction line!
- Also, check that the pump cannot suck false air from incorrectly tightened couplings or leakage through the suction filter. In general, false air can be recognised by a crackling sound and excessive foam formation in the tank. Observe the oil level in the reservoir during this running-in phase.
- Leave the system to circulate for at least 15 minutes without pressure so that the oil can warm up, so that the system can be checked for leakage.

Once the hydraulic system has warmed up, the underpressure in the suction line measured directly at the pump must not be lower than:

- Gear pumps: 0.3 bar maximum,
- Adjustable pumps: pressure difference between housing pressure and suction pressure

If these values are exceeded, this must be adjusted by increasing the size of the suction line or by a limited pre-pressure on the tank. The pressure must not exceed the maximum specified housing pressure of the pump or any components installed. If the housing pressure is too high, the pump will be damaged or broken.

Adjusting the safety valve

The safety valve can be adjusted at the factory to the desired maximum pressure. The safety valve can be sealed. If the seal is broken, the warranty on the hydraulic system shall lapse.

Adjusting the feedback pressure of the adjustable pump

If the pump is fitted with a pressure regulator, this determines the maximum system pressure. A separate shock safety valve has been installed for optimum safety. The shock safety valve must be set at a value that is approx. 25 bar higher than the required system pressure.
If the feedback pressure has not been set, proceed as follows:

- Drive in the adjusting screw of the pressure regulator until the maximum value has been reached.
- Then loosen the adjusting screw of the shock safety valve completely (lowest possible value) and set one of the control valves, for instance the pre-selector valve for a closed gate or a cylinder function, to such a position that the system pressure can reach the required level.
- Then gently drive in the adjusting screw of the shock safety valve until the required value has been reached, which is approx. 25 bar higher than the required system pressure.
- Once this value has been set, the pressure compensator must be turned back until the required system pressure has been reached.
- Check whether power consumption remains below installed power.
- Seal the adjusting devices once the correct feedback pressure has been set.

First trial run

- Once the pump is functioning properly and the system has been adjusted, the various functions can be started up one by one.
- Try to start up the functions with as little load as possible. Repeat this process several times in order to de-aerate the system as much as possible.
- Continually check the level in the reservoir during this trial run and replenish if necessary. Let the system reach the required pressure for the various functions and check the flanged connections and screw couplings for any leakage.
- Let the cylinders complete a full cycle and check whether the cylinders are properly encased in the housing. Also check for jamming, alignment errors and parts that become stuck.
- Adjust the cylinders on the basis of buckling load diagrams that are available. Install gate safety devices if the buckling limit is exceeded at the normal system pressure.
- Let the motors run at full power and check if the rotational speed is correct and the motor has sufficient run-out capacity for high mass moments of inertia. If necessary, install cross-over valves with feed-through flaps in order to reduce the

engine's run-out time and to compensate for any leakage loss.

Adjusting the balancing valves

Balancing valves can be installed if cylinders or motors start to gain on the pump yield as a result of external load. Balancing valves can only be adjusted during actual use, while under pressure. There are two options for adjusting:

1. Maximum holding pressure approx. 25 bar lower than system pressure (pressure measured between the cylinder and the balancing valve).
2. Balancing valve pressure approx. 25 bar higher than maximum induced pressure (pressure measured between the cylinder and the balancing valve).

Setting the parameters

Once the system has been completely set, such devices as pressure and limit switches and temperature and any level monitoring devices, can be set.

- For adjusting pressure switches, a manometer must be placed parallel to the switch. In this way, the exact setting of the pressure switch can be determined.
- For limit switches, the speed of response of the valve and the stopping speed of the mechanism in question has to be taken into account because of mass inertia.
- The temperature monitoring device must be set to the correct maximum temperature. If the device controls a cooler, take into account the fact that after the first signal and before the temperature of the cooler has stabilised, the temperature will rise before it drops (= inertia). For this reason, the temperature monitoring device must be set at a temperature below the maximum permitted temperature.
- The level control device must be adjusted in such a manner that during normal operation the oil level can fluctuate above the critical level without the device being activated.

4.0 STARTING UP THE CLOSED-CIRCUIT SYSTEM

Preparatory work

- Before starting up, fill the hydraulic system with oil as much as possible.
- Air will be forced out of the hydraulic system during the start-up phase. This may result in the machine becoming temporarily uncontrollable. In that situation, an external influence such as a small load may cause it to roll away.
- In order to guarantee safety, hydrostatically driven vehicles must be placed on blocks, i.e. with their wheels off the ground. In the case of winches and the like, the drive mechanism must be able to run freely without causing an action such as raising of steel cables.
- To obtain the filling pressure, start briefly until the filling pressure has been obtained. Or pre-fill the system.
- Keep safety in mind when deploying the system and be prepared for unexpected movements.
- Never let a closed pump-motor unit run without oil; this will result in irreparable damage.

Filling and de-aerating components

- The system must be filled with clean, filtered oil before it is put into operation.
- When assembling spin-on filters, the filter element must be completely filled to avoid the formation of any air locks during the start-up phase.
- The suction pipe connected to the filling pump must be de-aerated or filled as close to the pump as possible.
- The pump housing and the motor housing must be filled with clean, filtered oil. The highest point must be used for this. This point is generally the connection point for a leakage pipe.

Filling a high-pressure system with a special filling device

- The best method of filling a closed pump-motor unit is by using a filling device, which fills the entire high-pressure system (internally) under pressure. The filling device consists of a gear pump with a yield of 5 to 6 litres per minute, a pressure limiting valve (set at 20 bar or lower, if required) and a fine filter with an Absolute Micron Rating (AMR) of 10 microns. The filling device is connected to the manometer connection of the feed pump.
- Connect the de-aeration pipes to the manometer connections of the high-pressure gate and connect the latter to the tank.
- Switch on the filling device and let it run until the oil flowing out of both the manometer connections of the high-pressure gates is clear and free of air bubbles.
- Remove the filling device and the de-aeration pipes and mount measurement nipples or manometers to these gates.
- Check the oil level in the reservoir and replenish with clean and filtered oil if necessary.

First running-in phase of a closed pump-motor unit

During the first running-in phase, a closed pump-motor unit must run at as low a load as possible in order to pump out the air in the filters, pipes, pump housing and motor housing.
If no filling device has been used, proceed as follows:

Phase 1:

- The adjustable plunger pump must be in the neutral position.
- Switch on the drive mechanism at the lowest possible rotational speed for approximately 10 to 15 seconds.
- Check the oil level in the reservoir and replenish with clean and filtered oil if necessary.
- Switch off the drive mechanism for 2 to 3 minutes in order to stabilise the oil flow, enabling any residual air to escape. Repeat this procedure at least 5 times.
- Continually check the oil level in the reservoir and also pay attention to any leakage. During this procedure, the supply pressure must reach the set value, which is generally approximately 20 to 30 bar. If the supply pressure does not reach this value, the running-in phase must be stopped immediately. Check again to ensure that the suction connection has been properly de-aerated, there are no air locks and the suction pipe is sufficiently free. Once these matters have been checked, the above-mentioned procedure should be repeated until the supply pressure reaches the required level.

Phase 2:

- Increase the rotational speed of the drive mechanism somewhat and very slowly adjust the pump to one-fourth of the total stroke volume and leave the pump in this position for at least 30 seconds.
- Adjust the pump back to the neutral position and then very slowly adjust it in the other direction to one-fourth of the total stroke volume. Leave the pump in this position for at least 30 seconds and then move it back to the neutral position. The manometer reading for the supply pressure must remain at the set value during this procedure. The manometer readings of the high-pressure gates should also indicate a stable value, depending on the load. The manometer reading for the return pipe of the motor should be virtually the same as the manometer reading for the supply pressure.
- Repeat this procedure until the leak-off oil or rinse oil is clear and free of air bubbles.
- If a special filling device has been used, Phase 1 can be carried out over a shorter period of time. However, a 1-minute rest period should be observed.

Removal of residual air and trial run

- Once the first running-in phase has been properly completed, the system can be brought to the required temperature in order to remove residual air. This can be done by gradually increasing the rotational speed and the load.
- Check before the trial run whether multiple disc brakes or holding brakes, which are controlled by the supply pressure supply, or externally, are functioning properly, so that action can be taken in the event of an emergency.
- Gradually increase the load, continually checking the pressure readings on the manometers. Always keep safety in mind!
- Finally, check whether the maximum operating pressure complies with the required or indicated values, as the components have been pre-selected for a particular pressure level. Levels in excess of this pre-selected pressure level may result in serious damage.

System check

Before a new hydraulic system – particularly a prototype – becomes operational, it is advisable to perform a complete circuit test during a trial run under circumstances that are comparable to the actual operating circumstances, including the most extreme situations.
This circuit test is necessary in order to be able to claim a guarantee in the event of system damage and should be carried out by specialised, expert technicians using electronic measuring equipment. The measured values should be compared to the component data issued by the manufacturer, particularly the nominal operating pressure, maximum operating pressure, peak pressure, supply pressure, oil flow and speed of response of the pump and motor.
The system can only be approved and is only eligible for a guarantee once this data has been measured and printed by a recorder connected to the electronic measuring equipment. If this procedure is not followed, liability for the system rests entirely with the end user.

5 MAINTENANCE

Every machine with a hydraulic system, whether mobile or stationary, is supplied with a user's manual and a CE statement. Maintenance instructions are important. In order for maintenance to be performed correctly, the end user must know how to act. The transfer of this knowledge is the task of the machine manufacturer.

PREVENTATIVE MAINTENANCE

Regular inspections of the hydraulic system are important economically. Downtime resulting from overdue maintenance will almost always turn out to be more expensive. Consequently, scheduled inspections must take place at pre-determined times, after a certain number of running hours, during which key components are checked preventively to avoid costly repair and downtime. Following the direction of the oil flow (starting with the reservoir) is an effective method to ensure that all components are inspected.

SCHEDULED MAINTENANCE

The first overhaul should be performed 100 running hours after the system has been put into operation. At the very least, this overhaul should include replacing the filters and checking the oil. In addition, the entire installation must be inspected thoroughly. Keep the following points in mind during the inspection:

- After the first overhaul, a major maintenance inspection must be performed after 300 running hours and subsequently after every 500 running hours, or earlier, depending on the load and the operating conditions. A major maintenance inspection should be performed at least annually. In the end, the frequency of maintenance inspections is determined by external influences and the load to which the installation is subjected.
- The filters and oil must always be replaced during a major overhaul. If necessary, oil replacement can be postponed on the basis of an analysis by a specialist firm.

Moreover, it is essential to follow the points below in order to optimise the maintenance inspection.

Reservoir

The oil level must be correct, and the oil must be of the prescribed quality and viscosity. For larger installations, it may be advisable to have an oil sample analysed. There are specialised independent firms that can offer advice as to whether the oil should be replaced or whether it can still be used until the next planned periodic overhaul. These firms examine such properties as acidity, viscosity and degree of contamination. If you wish to avoid commissioning an expensive analysis, visual inspection is also possible, albeit highly unreliable. Rough conclusions can be drawn about the condition of the oil based on its smell (sour or burnt), colour (yellow or milky), and degree of contamination. Always use the same brand and quality of oil for replenishing and changing. Different brands and qualities should never be mixed without written permission from the oil supplier.

Suction pipe

The suction pipe should be inspected for damage and any protruding parts of the steel braid reinforcement of the tube. Screw couplings must be checked for leakage and tightened if necessary.
Particular attention should be paid to plastic and rubber tubes without steel braid reinforcement as these are subject to deformation resulting from high oil temperatures and the suction force of the pump, which can restrict the passage to the pump.

Pumps

The pump must be checked for leakage along the pump shaft and external leakage near regulators, covers and mounted pipes. Pay particular attention to nearby oil traces, such as oil splatters on the floor or chassis components. Check the drive clutch for damage to the plastic stars, play on the detachable bearings or universal joint shafts, correct V-belt tension, etc.
The various circuits on the pressurised side should be checked separately, following the direction of the oil flow. Also pay attention to leakage near screw couplings and changes in noise levels (possibly caused by bearings).

Tubes and pipes

Inspect the pipework for leakage and damage. Check if pipe brackets are attached properly or show any fractures. Also look for any wear of the pipes near brackets and ensure that the location of the pipes is such that they are not obstructed. Check the tubes thoroughly for deformation, damage and corrosion. Replace rubber and plastic hoses by equivalent hoses after six years. Hoses in stock may be used unassembled until 4 years after the production date. When assembled, only 2 years. Use of the wrong tubes or tubes that are too old may result in life-threatening situations and substantial environmental and mechanical damage.

Filters

If indicators have been installed, filters can be checked for impurities quite simply. If no indicators have been installed, the filters can be inspected visually. The condition of certain components can then be ascertained, if necessary after obtaining expert advice.
Filters should always be replaced when the oil is replaced. Keep filter fineness in mind when doing so. Also perform regular checks of the ventilation filters on the reservoir in connection with underpressure or overpressure in the tank.

Cooler

Perform regular checks of the cooler radiator for impurities in connection with decreasing cooling capacity. A cooler containing compressed air must be cleaned against the direction of air flow. Never use steam cleaners as they will damage the system. In principle, heat exchangers are maintenance free if the cooling medium is cooling fluid. Replace the cooling fluid in accordance with the supplier's instructions.
Never mix cooling fluids of different brands or compositions without permission from the supplier.
If tap water or groundwater is used as a cooling medium, the cooler must be checked regularly for calcium or manganese deposits, etc. Internal contamination causes sharp decreases in cooling capacity.

Intermediate and built-on valves

Intermediate and built-on valves, such as balancing valves, cross-over valves, controlled non-return valves, etc., should be visually checked for leakage and damage. When in doubt, disassemble, check and, if necessary, replace them.
There should be no load on built-on valves (oil pressure or external load). Watch out for unmanageable situations!

Cylinders

Cylinders must be inspected for leakage along the gasket(s) near the shaft. If necessary, gaskets should be replaced preventively.
Also look for damage to the shaft (scratches and wear). When in doubt, consult an expert about the appropriate course of action.
Also inspect the attachment of the cylinder, particularly at damaged hinge loops and ball heads.
Check the connection between the tubes and the cylinder, paying particular attention to areas subject to wear, and to whether the connections are without pressure.
There should be no load on built-on cylinders. Pay attention to controlled non-return valves and balancing valves and lock the mechanical part to avoid unmanageable situations.

Gear boxes

Perform regular checks of the oil level using a gauge glass or sounding rod. Oil in gear boxes should be replaced with the same frequency as hydraulic oil. Let the oil flow out when it is warm, heeding multiple drainage points, if any. Also check whether the de-aeration filter, which is mounted to the gearbox by default, is open. Clean it with cleaning fluid if necessary.
Always use the same brand and quality of oil for replenishing and changing. Never mix different brands or compositions without permission from the oil supplier.

Accumulators

When in doubt, the nitrogen pressure can be checked using special equipment.
A number of safety rules must be observed before starting work on an accumulator.
The accumulator must be completely depressurised on the oil side.
Open the short-circuit tap so that pressure can flow off to the tank. A short-circuit tap is compulsory!
Never refill an accumulator with oxygen or compressed air as this creates a risk of explosion! Instead, accumulators should only be refilled with nitrogen.
Never fill accumulators in excess of the maximum permitted filling pressure, which should be stamped on the accumulator, together with the maximum permitted operating pressure. Exceeding either of these two values creates a risk of explosion.

Planning

Plan preventive maintenance inspections well in advance, in consultation with suppliers if necessary.
Ensure that the inspection is performed by expert personnel or hire temporary personnel when in doubt. Try to take account of seasonal variations, peak pressure, weekends and holidays. Also keep in mind that crucial components must be in stock.

6 HYDRAULIC OIL

CHOICE OF OIL

Energy transfer is the main function of the oil used in the system. In addition, it also lubricates the components and should be able to carry impurities, wear particles and heat out of the system. Required oil properties:

- Good lubricating properties
- Good dirt-absorbing properties
- Appropriate viscosity for its purpose
- Good antifoam additive
- Good air-separating properties
- Good water-separating properties

The type of oil should be chosen depending on the conditions of use. There are three basic types of oil to choose from: * Mineral oil (most common type of oil)
* Synthetic oil
* Organic oil

With synthetic oil, attention should be paid to whether it is phosphate-ester based, in which case special gaskets are required.
Organic oil should only be used under certain conditions as it can be highly hygroscopic (= water absorbent) and may have a short life-span, depending on the conditions. In selecting a type of oil, consult with the oil supplier and the supplier of the hydraulic system. Once a decision has been taken, the type and brand of oil should be clearly indicated on the hydraulic system. The end user should also be informed as different types and brands of oil cannot simply be mixed. The various additives used by the different brands may start to react with one another, leading to the loss of the required properties of the oil. Contact your oil supplier if you have any doubts about replenishing oil. Under normal operating conditions (38 to 50°C), the viscosity for gear pumps and plunger pumps should be approximately between 32 and 46 cSt. Before using oil under extreme conditions, it is sensible to consult your oil supplier about the right choice.

PROPERTIES THAT DETERMINE WHICH HYDRAULIC OIL SHOULD BE USED

When selecting the right type of hydraulic oil, the following important properties should be taken into account:

- Viscosity
- Viscosity index VI and/or viscosity class VG (viscosity at 40°C)
- Pour point

The properties of the hydraulic oil should be appropriate for each specific usage and environment.

Viscosity

Hydraulic oil has a low viscosity when it is thin (liquid) and a high viscosity when it is viscous. Viscosity is proportional to temperature: when the temperature rises, viscosity decreases and when the temperature drops, viscosity increases. Hydraulic installations, especially mobile vehicles, operate under extreme temperature fluctuations. Consequently, the viscosity range is essential. The hydraulic oil must be liquid enough to flow through filters, suction pipes, return pipes and the various components without a great deal of resistance. However, the hydraulic oil should not be too thin. If this is the case, the (lubricating) oil film will break, which will cause internal mechanical damage.

Viscosity index and a viscosity class

The viscosity index (VI) (expressed as a number) is used to express the relationship between the temperature and viscosity of hydraulic oil. Viscosity-temperature diagrams show the operational temperature range of hydraulic oil at various viscosity indices. The temperature range is limited by a given maximum and minimum viscosity index. Most types of hydraulic oil have a VI between 90 and 110. Hydraulic oil with a VI of more than 110, but between 130 and 200, is not very sensitive to temperature changes and is characterised by good start-up properties and minimal loss of power at low temperatures. For high temperatures, hydraulic oil with a high viscosity index can be used to ensure effective sealing and less wear.
The high load-bearing capacity of hydraulic oil with a high viscosity index prevents damage and machine downtime, lowers operating costs and increases the life span of the installation.

Pour point

Hydraulic oil remains liquid when the pour point is reached at a low temperature. The lowest operating temperature permitted during start-up of the installation should be well above the pour point temperature. In other words, the minimum start-up viscosity should be compliant with the instructions of the pump manufacturer. The minimum start-up temperature of the installation can be deduced from this.

CONDITIONS FOR THE USE OF HYDRAULIC OIL

Hydraulic oil must be free from impurities as these negatively affect the operation, life span and reliability of the system.

Sources of contamination

Sources and effects of contamination:

Air	Cavitation. 'Diesel effect' combustion. Hydraulic oil becomes compressible. More noise produced
Water	Oil ages more quickly; Oil produces foam more quickly; Negative effect on lubricating properties
Temperature too low	Increase in viscosity; Danger of cavitation; Increased resistance in pipes and valves; Delay in control valves; Decrease in yield; Substantial pressure loss in filters, resulting in opening of by-pass valves or tearing of filter elements
Temperature too high	Decrease in viscosity; Oil ages more quickly; Thickness of lubricating film may decrease; Increase in internal leakage; Decrease in yield; Negative effect on properties and functions of gaskets
Dirt particles	Extreme wear on components; Clogging of choking elements; Increased energy losses as a result of internal leakage; Valves become increasingly difficult or impossible to control

Filtration value

Filter performance is expressed as a Beta ratio. The higher this ratio, the better the filtration. The Beta ratio can be converted into a measure of efficiency, expressed as a percentage. This method is generally accepted in the sector. In practice, a Beta ratio of 75 is used.

Filtration fineness

Ultimately, the fineness and material of the filter determine whether the system meets the requirements of the cleanliness class in question in combination with a Beta ratio of 75. Filter elements are usually made from paper or fibreglass. Fibreglass filters meet virtually all the relevant requirements.

	Recommended degree of cleanliness		**Filtration fineness**	**Filter element**
Application	ISO 4406	NAS 1638	Beta ratio of 75	Fibreglass (A) Paper (P)
Servo systems / High-pressure systems Die-casting machines	15/11	4–6	6	A06
Proportional valves / Industrial hydraulics	16/131	7–8	10	A
Mobile hydraulics / General mechanical engineering / Medium-pressure systems	18/14	8–9	16	A10
Low-pressure systems / Heavy industry / Water hydraulics	19/15	9–11	25	A25

Safety and health measures regarding the use of hydraulic oil

Anyone working on installations where hydraulic oil, lubricating oil, grease or preservatives are used must observe the following rules:

- Do not let the skin come into prolonged contact with the fluid. Clean the skin carefully after contact. Wear dry clothing. Do not eat or drink during the work.
- Do not let the skin come into contact with hot machine components or fluids above 60°C.
- Avoid contact with the eyes. Should this occur, flush with copious amounts of water and contact a physician.
- Fluids must be stored in accordance with official regulations. Fire-extinguishers and emergency exits must be present.
- In the event of a fire hazard, it is sensible to use a highly incombustible fluid.
- Any fluid spilled should be cleaned up immediately to prevent slipping.
- Fluids may not end up in the ground or in surface water.
- Concrete floors must be impervious to fluid.
- Waste fluid must be removed and recycled by a specialist firm.
- Never attempt to plug leaks in the system by hand.

Storage

Hydraulic fluid must be stored in spaces that meet applicable legal standards. The temperature must be kept as constant as possible to avoid condensation. Ensure sufficient circulation of stock. Opened drums must be closed to avoid contamination and condensation.

7 SUPPLY OF PARTS

As is the case for any mechanical installation, hydraulic installations are subject to wear and tear.
In order to avoid costly downtime, we recommend that you build up a stock of a limited number of crucial components, particularly if the installation contains components that are unique or difficult to replace, such as cylinders, adjustable pumps and motors, proportional valves, electronic control devices, etc.
Spare parts should be ordered using the parts list and the hydraulic diagram, if present. When placing your order, always indicate the correct brand, model number and any identification number.

8 MALFUNCTIONS

Despite all the care that we have devoted to your installation, malfunctions may occur, even if you have followed the maintenance instructions. Troubleshooting should be done by qualified and professional personnel. If necessary, our technical sales department or our maintenance department can provide technical support. Before attempting to trace the malfunction, we recommend that you think matters through and become acquainted with the hydraulic system.
Troubleshooting must be done in a logical and systematic manner. In general, you should start with the reservoir.

1. Is the oil level correct?
2. Are the filters in good condition?
3. Are the pressure, oil flow and direction of flow as indicated?
4. Is the oil temperature correct (viscosity)?
5. Are there are any vibrations or noises (caused by cavitation)?
6. Is the electrical circuit in working order?
7. Is the emergency control gear in working order?
8. Did the malfunction occur suddenly or arise gradually?
9. Have any modifications been implemented recently?
10. And so on.

Once the location of a malfunctioning component has been established, the surrounding area should be thoroughly cleaned before the component is repaired or replaced. The exact cause of the malfunction should also be traced. Any parts that have broken off should be located in connection with possible future instances of malfunction. Hydraulic components should never be disassembled in the open air. Instead, perform disassemblies in specially equipped workshops.

A list of possible problems and their remedies is given below.

INSTALLATION PRODUCES EXCESSIVE NOISE (PUMP CAVITATES, SUCTION PROBLEMS)	
CAUSES	*REMEDIES*
Suction pipe or filter is obstructed.	Remove the obstruction; clean or replace the element in question.
Suction pipe is too narrow.	Replace with a suction pipe with a larger diameter.
Too many bends in the suction pipe.	Reduce the number of bends or use a larger passage.
Medium is too cold	Heat the medium using a heating element.
Malfunctioning feed pump	Repair or replace the feed pump.
Tank cannot 'breathe'.	Install an aerating filter.
Viscosity of the medium is too high.	Replace the oil with an oil type with a lower viscosity.

AIR IN OIL	
CAUSES	*REMEDIES*
Oil level in tank is too low.	Fill tank to the correct level.
Return pipe ends above oil level in tank.	Extend return pipe until it is below oil level.
Shaft seals are air-permeable	Replace shaft seals
Pipe connections in suction pipe are air-permeable.	Tighten the piping or replace the pipe connection.
Malfunctioning feed pump	Repair or replace the feed pump.
Tank cannot 'breathe'.	Install an aerating filter.
Viscosity of the medium is too high.	Replace the oil with an oil type with a lower viscosity.
Suction hose is porous.	Replace the suction hose.

MECHANICAL VIBRATIONS	
CAUSES	*REMEDIES*
Pipes are in contact and vibrant.	Improve the piping by means of pipe clamps.
Shaft couplings are not aligned or secured.	Align the couplings and secure them.
Safety valve vibrates due to: wear and tear; incorrect adjustment; or the machine is under too much load, resulting in oil overflow	Replace the valve. Check adjustment. Lower the load on the machine or determine whether the pressure can be increased.
Pump is worn out or damaged.	Repair or replace the pump.
Hydraulic motor is worn or damaged.	Repair or replace the hydraulic motor.

PUMP SUPPLIES INSUFFICIENT OIL AND/OR DOES NOT REACH REQUIRED PRESSURE LEVEL	
CAUSES	*REMEDIES*
Incorrect direction of rotation of the drive motor.	Change the direction of rotation.
Air in the system.	See Chapter 3.

SYSTEM TEMPERATURE IS TOO HIGH, CAUSING LEAKAGE	
CAUSES	*REMEDIES*
Oil viscosity is too low.	Replace the oil with the correct type of oil (see Chapter 5).
Cooling system not functioning properly as a result of insufficient size, incorrect adjustment or contamination of the cooler.	Check if sufficient cooling medium is being transported, clean the cooler, readjust the cooling system or install a larger cooler.
Safety valve setting is too low.	Reset the safety valve (according to the instructions).
Oil circulation is not depressurised in neutral position.	Check the neutral position of the valve; there may be a power failure.

Too much leakage as a result of worn-out pumps, control valves, hydraulic motors or cylinders	Check, repair or replace the worn-out components in order to determine the location of the leak.

INCORRECT PUMP SPEED	
CAUSES	*REMEDIES*
The drive clutch is slipping.	Lock or repair the coupling.
The drive motor is defective or dimensioned too small.	Repair the drive motor or fit a larger motor.

LEAKAGE FROM THE HIGH-PRESSURE SIDE TO THE LOW-PRESSURE SIDE OF THE SYSTEM	
CAUSES	*REMEDIES*
The system is contaminated to the extent that safety valves, relief valves or other components remain open.	Disassemble, clean and assemble the valve in question; determine whether it is necessary to fill the system with new oil or even to flush it.

MALFUNCTIONING FEED PUMP IN A CLOSED SYSTEM	
CAUSES	*REMEDIES*
Damaged pump, malfunctioning drive mechanism, damaged or contaminated valves, incorrect viscosity, contaminated feed filter.	Repair or replace the damaged pump, drive mechanism or valves; replace the oil with a type that is appropriate for the conditions and compliant with regulations; clean or replace the filter element. See Chapter 4 for additional information.