Notes

A hydraulic system that operates economically, safely, and trouble-free requires careful planning, as well as proper installation and start-up. Conscientious maintenance has a considerable effect on the service life of the hydraulic elements.

The following methods are to be observed when starting up and performing maintenance. There are helpful tips for fault correction in the trouble-shooting section.

The information given in these instructions are of a general nature and require other professional procedures. The commissioning of the hydraulic equipment must be in accordance with the putting into operation of the entire machine or installation and shall be done by experts who have the special hydraulic knowledge. For a safe and successful start-up, the information for installation and commissioning of each component particularly must be observed.

Technical safety instructions

The hydraulic system is to be planned and executed so that personnel cannot be endangered during possible malfunctions. This requires that the diverse pumps and devices are operated within their specified operating pressure ranges. Possible damage to the system and the electrical control system must be limited to a minimum.

Welding performed afterwards on oil reservoir may only be carried out by specialists at their own risk. Remaining oil and the cleaning cover must be removed.

Preventive steps must be introduced to avoid danger through the welding work.

Further measures must be arranged, depending on where the hydraulic system is set up, such as whether an oil receiver must be provided in water protection areas, etc. Or whether hardly inflammable liquids must be used with an increased fire hazard.

Hydraulic accumulator

For putting in operation and using accumulators the national rules, guidelines and regulations must be observed.

⚠ **Hydraulic accumulators must be pre-charged only with nitrogen. Therefore the filling up of the accumulator must be done according to the instructions of the producer by using only the special tools.**

The testing documents of the hydraulic accumulators and safety valves must be stored separately. If necessary, they must be presented to the safety commissioner. It`s not allowed to remove the lead seal of the safety valves. Observe information signs.

Transport

The power unit or the completely mounted manifold was properly packed and handed over to the transport company. If there are damages, please contact the manufacturer or your transport company.

For further transportation the hydraulic must be handled with care.

Storage

The power unit, manifolds and components must be protected from contamination, and from mechanical and weather damage.

Suitable measures must be taken to prevent corrosion if they are stored for longer periods of time without final painting.

Mounting

The pipe connection joints of the unit must be connected with the externally mounted devices and manifolds or the machine according to the positions shown in the hydraulic scheme.

Particularly the following points are to be observed:

- Use cold-drawn precision steel pipes, with the exception of nominal widths bigger than or equal NW50.
- Observe pipe cross-sections and permissible working pressure.
- Remove plastic plugs immediately before beginning pipeline work.
- Assemble pipe bends using bending devices.
- The pipe cross-section may not be pinched when bending.
- The pipes, after being cut to their exact lengths, are to be thoroughly debarred and cleaned.
- Fittings corresponding to pressure and environmental conditions are to be used on the system, and the manufacturer's assembly instructions followed.
- Pipelines are to be lain and tightened without stress.
- Heat-treated pipes must be mechanically cleaned and descaled.
- Drain lines are not to be crimped, and if possible, at a falling angle to the tank, above the oil level.
- If hose lines must be used, they must be selected according to the pressure and the environmental conditions of the system. Note their stability, working pressure, and nominal width.
- The pipes must be sufficiently mounted with pipe brackets to avoid vibrations.
- It is advisable to provide venting connections at the highest position in the pipeline network.
- The power units, the manifolds and the connected parts of the system must be installed and mounted safely for operation.

Fluids

In order to facilitate the selection of suitable fluids, we refer to the following chapter. This contains information about appropriate oil types. The fluids must meet the requirements of DIN 51524 sections 1 and 2.

Separate instructions must be observed for other fluids (e.g. compatibility with sealing materials).

Commissioning

⚠ **Start-up may only be carried out by specialists. Particularly the special instructions of the manufacturer and the producer of the components must be observed.**

The hydraulic scheme, the parts list, and the control system flow chart should be present. The planned pressure setting must be indicated for all pressure valves in the hydraulic scheme.

Starting-up safety instructions

Before start-up the assembly of the complete hydraulic equipment must be inspected by specialists. Particularly the following points are to be observed:

- Mounting of pipes including clamping
- Accurate connection of pressure and return pipes
- Accurate connection of the pilot pressure pipes
- Accurate assembly of the hydraulic components
- Accurate connection of the power unit
- Accurate connection of the manifolds
- Accurate connection of the cylinder and hydraulic motors
- Accurate connection of the electrics
- Hydraulic equipment must be mounted safely for the operation.
- Parts of the entire system where driven by the hydraulics must be mounted safely for the operation.

Before start-up of the hydraulic system the specialists must prepare all necessary requirements to protect individuals and parts of the system against damage.

The start-up must be done very carefully according to the safety regulation.

Filling

Before the hydraulic fluid is poured into the tank, its interior must be checked again for cleanliness, and be cleaned if necessary.

The tank is to be filled using a fine filter, so that the desired cleanliness class of the fluid is ensured when starting up. Special filling units or equipment provided with the system are especially suitable for this, e.g. the return line filter.

The oil type is indicated on a separate sign next to the filling opening.

Flushing

After filling the reservoir with fluid we recommend the flushing of the fluid inside the hydraulic system where the fluid flushes around many times in the reservoir.

Before starting the flushing the servo-valves and proportional-valves must be removed and replaced by flushing plates to avoid damages of these valves according contamination. Start-up up of the components and the function of the entire system should only begin once the required minimum cleanliness and the operating temperature are reached.

It is recommended to flush the long pipelines by short circuiting the pressure and return lines, especially for large, central pressure oil stations. This prevents the installation dirt from entering the pilot valves (especially important for servo and proportional valves) or the drives (cylinder, hydro-motors, etc.). The diverse measures should be coordinated during design.

Electrical connections

Are the correct current and voltage types available?

- Motor
  Check available current with the E-motor type plate.
- Solenoids
  Are the type of current (~ or =) and the voltage correct? Check the labels of these devices.
- Plugs
  The electronic connections must be done according to the technical rules by using the appropriate plugs.
- Grounding
  Power units, parts of the system and single mounted components must be grounded.

Pumps and devices

The pump case must be filled with the clean operating hydraulic fluid before start-up to lubricate the bearing with oil.

Particularly the special start-up instructions for pumps and hydraulic and electric devices must be observed.

The following section contains only the most important aspects.

- Pumps

  It is advantageous to keep the pressure setting low at first when starting the pump for the first time. The pressure compensator for variable displacement pumps and the pressure limiting valve for fixed displacement pumps are set to approx. 15 - 20 bar.

- Pressure valves

  Depending on the machine function, first begin with a minimum pressure setting. Enter pressure onto the measuring location plate after the final pressure is established.

  An exception are the design-tested and preset accumulator safety valves.
- Pressure unloading valves

  For setting the pressure unloading valves according the pressure information in hydraulic schematic particularly the start-up instructions for this valve must be observed.
- Throttle valves

  Set every drive (cylinder etc.) in steps via the throttle or flow control valves at the desired speed or stroke time.
- Directional valves

  Select the direction using the electric control system for electrically operated valves.

⚠ **Manual override of the solenoid requires a suitable tool.**

- Proportional valves

  Proportional pressure flow and DC valves must be first started with a low electrical command signal.
- Hydraulic accumulators

  If hydraulic accumulators are assembled into the system, these must be verified at and/or filled up to the correct gas pre-load level. Suitable testing and filling equipment is necessary.

⚠ **Hydraulic accumulators may only be filled with nitrogen for reasons of safety. The pre-loading coordinated with the working pressure is indicated in the hydraulic scheme.**

In general, the following applies:

Gas pre-loading = min. working pressure x 0.9

After testing or filling, the hydro-storage can be switched into the system via ball valve.

Switch on

First the motor is quickly switched on and directly switched off to determine the rotation direction. The correct rotation direction is indicated by an arrow on the pump housing. If the rotation direction is incorrect, reverse the polarity of the e-motor. The pump is started by multiple short start-ups (on-off operation). After approx. 1 min run time, the working pressure can be set to its nominal value (see also **'Trouble-shooting'**. **1.1** and **1.2**).

Start-up information provided by the pump manufacturer has higher priority than these instructions.

Air bleeding

Air in the hydraulic system is very disadvantageous and undesirable for the control system. The system must be carefully vented, especially for the first start-up, for oil changes, or when lines and valves were opened. All functions are run through, one after the other, in no-load operation with low pressure and with full cylinder stroke.

The pipeline network is vented at its highest point. The fitting can be loosened a little so that the air can escape with only a small amount of oil escaping. When the oil is no longer foaming, the fitting is retightened.

If the air bleeding cylinder is provided with venting screws, these should be used for venting. It must be noted, however, that the full cylinder stroke must be travelled several times. These venting screws must be at the top for horizontally arranged cylinders.

After filling the cylinder, the oil level in the tank must be checked, and refilled as necessary.

Filter

The function and service life of pumps and hydro-devices are strongly affected by the cleanliness of the fluid. Dirt is the greatest enemy of hydraulic systems. There are three important sources of dirt to watch out for:

- Contamination arising during installation, installation dirt
- Contamination arising during operation, operation dirt
- Impurities from the environment

The correct filtering method is specified during system planning or determined by the necessary cleanliness class. Depending on requirements, pressure or return line filtering as well as additional bypass flow filtration is used. Only a return line filter with $\beta_{25} \geq 75$ (25 µm filter) is used for noncritical systems. Thus contamination of the tank is prevented, and the pump only sucks in clean oil. Pressure filters are used for systems with higher demands, e.g. smallest oil flows (Q > 200 cm³/min) or high, constant pressure on pressure valves.

Pressure filters are to be installed whenever proportional valves are used. Typically, filters with fineness of $\beta_{10} \geq 75$ (10 µm) or $\beta_3 \geq 75$ (3 µm) are used. Filters can only fulfil their function when built-in filter cartridges are cleaned or replaced in time, especially in the initial operating period. During operation, the level of pollution is checked by mechanical or electrical level. For further information, see **'Oil change'.**

Servicing and maintenance

Service work may only be carried out by specialists. This requires knowledge of the machine's functions regarding switching on and off, as well as measures of safety engineering.

⚠ **Work on systems that include accumulators may only be carried out after the fluid pressure is unloaded.**

Regular inspection

The hydraulic system is subject to a simple inspection at short, regular intervals. An automatic monitoring system is already partly provided. Particularly the following is inspected:

- Oil level in the tank
- Working temperature is not to exceed 60ºC
- Condition of the fluid (visual inspection, colour and smell of the hydraulic oil)
- Working pressures
- Gas pre-load pressure on the accumulator
- Leaks on the pump, valves, and pipelines
- Filter elements, for cleanliness (see **'Filter'**)
- Hose must be checked according to conditions and age.
- All mechanical and electronic sensors must be checked on function.
- All parts of the entire system must be checked on damage.
- Cleanness must be checked.
- All safety equipment and labelling must be checked

Oil change

The frequency of oil changes is dependent on:

- Kind of liquid (ageing)
- Filtering
- Operating and environmental conditions (operating temperature)

Prescribed change intervals

The required cleanliness class as per ISO 4406 or NAS 1638 is dependent on the use of hydraulic components. It requires conscientious planning for filtering and periodic fluid inspection in order to guarantee the desired service life of the pumps and devices. Under these conditions, an oil change can be considerably delayed, or, depending on the evaluation of laboratory tests, completely omitted.

We refer to the service of well known oil or filter suppliers concerning fluid laboratory tests.

It is mandatory to inspect the breather filters regularly.

Spare parts

Original spare parts are to be used for repairs. For questions about purchasing spare parts or for malfunctions, please contact our After Sales Service.

Warrantry

Fault correction without charge is only possible within the framework of the arranged guarantee. The information given in these instructions are of a general nature and require other professional procedures. Assistance with installation, start-up, and maintenance by our personnel can be arranged according to our service conditions.

Additional regulations and guidelines

Particularly we recommend the following regulations and guidelines

- International standard ISO 4413
- German standard VDMA 24572

  Checklist for the inspection of hydraulic systems in industrial machines

1. Excessive noise in the system

Cause	Reason	Remedy
1.1 Cavitation in the system	Suction filter is blocked.	Clean or recondition.
	Internal width of the suction line is too small. Or: Objects in the suction line.	Install pipes with larger internal width.
	Too many bends in the suction line.	Lay new pipes or use pipes with larger internal width.
	Local constrictions in the suction line, e.g. partially closed valve, spring is too strong in check valve, damaged pipe or kinked hose.	Make valves accessible or change pipes or hoses are to be repaired or replaced.
	Fluid is too cold.	Use electric heating to warm pressure fluid to the recommended temperature.
	Viscosity of fluid is too high.	Check fluid.
	Vapour forms.	Lower working temperature to the correct value: Refill fluid or replace with suitable fluid.
	Feed pump fails.	Repair feed pump or replace.
	Speed of pump is too high.	Check speed of the motor (see also specifications in the hydraulic plan).
	Completely sealed tank.	Install breather.
	Suction line is too small or too long.	Increase diameter of the suction line.
1.2 Foam or air in the fluid	Fluid level in the tank is too low.	Refill oil. For systems with strongly changing oil level: Only fill between the min. and max. oil level.
	Incorrect tank design.	Improve design.
	Return line ends in tank above the fluid level.	Lay return flow line lower than the fluid level.
	Incorrect fluid.	Replace with the correct fluid, if necessary, contact the system supplier.
	Shaft seal on pump allows air to penetrate.	Replace seal.
	Fitting in the suction line allows air to invade.	Tighten fitting or replace.
	Porous suction hose.	Recondition hose.
	Poor air bleeding.	Vent system.

1. Excessive noise in the system

Cause	Reason	Remedy
1.3 Mechanical vibrations	Faulty alignment or loose coupling	Aligning or tightening
	Vibrations in the pipelines	Tighten or improve mounting.
	Pump defective or damaged	Repair or replace.
	Unsuitable pump type	Replace with more suitable pump type.
	Drive defective or damaged	Repair or replace.
	Unsuitable drive type	Replace with more suitable drive type.
	Pressure valve is unstable (oscillates).	Set correctly or replace with more suitable valve.

2. No pressure or insufficient pressure

Cause	Reason	Remedy
2.1 Pump does not deliver correctly.	Penetration of air into the suction lines	See error **1.2**
2.2 High pump temperature	Worn out or damaged pump	Repair or replace
	Too little fluid viscosity	See error **1.1**
	Insufficient or incorrectly adjusted cooling	Improve cooling line or adjust correctly. Ensure flow of cooling water.
2.3 Pump speed is too low or drive performance too small.	Coupling or belts slip or motor is faulty.	Remove defect parts.
	Motor is too small.	Use the correct driving motor.
2.4 Loss due to leakage from the pressure side in the return line	Incorrect pressure setting	Correct setting.
	Safety valve does not close because of dirt or there are defective parts.	Clean, repair or replace damaged parts.
	Directional valve or another valve is open because dirt or some other defective part is present, or due to electrical failure.	Damaged device is to be determined, adjusted, cleaned, repaired, or replaced.
	Damage to the cylinder hole, piston rod, or seal.	Damaged parts are to be repaired,replaced.
	Failure of piston seal, because the seal material is not suitable for the fluid used.	Use seals made of the correct material.
2.5 Feed pump fails (only for piston pump with feed pump).	Damaged pump, faulty drive, unsuitable fluid viscosity	See error **1.3**

3. Pressure pulsations or flow fluctuations

Cause	Reason	Remedy
3.1 Cavitation in the pump	See error **1.1**	See error **1.1**
3.2 Foam or air in the fluid	See error **1.2**	See error **1.2**
3.3 Mechanical vibrations	See error **1.3**	See error **1.3**
3.4 Unstable pressure relief or safety valves	See error **1.3**	See error **1.3**
	Damaged valve seat.	Repair or replace.
	Valve has insufficient or no damping.	Install a more suitable device or damping equipment.
3.5 Valves stick.	Contamination	Drain fluid, clean system and parts, fill with clean fluid.
	Defective or warped	Replace device, remove warping.
3.6 Unsteady pump delivery	Unsuitable pump type or pump design	Replace with more suitable pump after contacting the pump system manufacturer.
3.7 Air in the system, which causes an irregular or yielding motion.	System is incompletely vented.	see error **1.2**
	Electrical system is defective e.g. valves switch constantly.	Find and remove faults.

4. Too little or no pressure flow

Cause	Reason	Remedy
4.1 Cavitation of the pump	See error **1.1**	See error **1.1**
4.2 Foam formation or air in the fluid	See error **1.2**	See error **1.2**
4.3 Defective pump	See error **1.2**	See error **1.2**
4.4 Pump speed is too low or drive performance too small.	See error **2.3**	See error **2.3**
4.5 Loss due to leakage from the pressure side to the return line	See error **2.4**	See error **2.4**
4.6 Pump runs in the wrong direction of rotation.	Motor rotation direction is incorrect.	Reverse the e-motor.

5. Liquid temperature is too high

Cause	Reason	Remedy
5.1 Overflow losses	Pressure setting on pump is too high or safety valve is set too low.	Correct setting.
	Oil flows out at accumulator safety block.	Close accumulator drain valve on accumulator safety block.
5.2 Loss due to leakage from the pressure side in the return line	Valves function poorly and seals are faulty.	See error **2.4**
	Fluid has incorrect viscosity (viscosity is too low).	Remove fluid and fill up system with fluid that has viscosity recommended by the manufacturer.
5.3 Fluid is delivered under pressure via safety and pressure limiting circulation valve into the tank, although pressure fluid is not needed.	Design of switching for system is not correct.	Provide the correct control system, e.g. switching to depressurised.
	Faulty function of the air bleeding system as a result of dirt or faulty parts	Clean, or if necessary, repair.
	Safety pressure is set too low.	Correct setting.
5.4 Insufficient cooling	Failure of the cooling water supply	Check cooling water supply, temperature and function of shut-off valve.
	Failure of the ventilating fan	Check function of the oil-air-heat exchanger acc. to manufacturers instruction.
	Deposits in the cooling water line	Clean.
5.5 Insufficient carrying away of heat	System has insufficient cooling surface to carry off delivered heat.	Install cooling system and/or increase tank capacity and surface.
	An increase in machine performance without corresponding increase in the cooling capacity	Improve cooling system and/or tank capacity and surface.
5.6 Overheated pump	Wear in the pump.	Repair or replace.
	Working with fluid whose viscosity is too low	See error **5.2**
	Insufficient flushing of the pump	Increase diameter of the drain line and provide a flushing of the pump housing.
5.7 Fluid circulates too quickly.	Fluid supply is insufficient.	Increase fluid capacity.
	Fluid level is too low in the system.	Fill up system to the recommended level.
5.8 Too much viscous friction.	Cross-section is too small in the pipelines and valves.	Install pipes and valves that have the correct size.

General

The hydraulic fluid is an important component of every operating hydraulic systems. The fluid covers several tasks:

- Power transmission
- Wear protection resp. wear reduction
- Heat transfer

The importance of the fluid may be seen in the following statement: “Statistical data indicate that more than 80% of all failures of hydraulic components are cause-related to an improper condition of the hydraulic fluid.”

The selection and the maintenance and/or control of the fluid for a hydraulic system are of major importance. The main criteria for this selection are given in the following.

Power transmission

An important index for the power transmission behaviour of a hydraulic fluid is the bulk module E_{oil}, measured in bar. It describes, how much the volume of a fluid content is reduced under pressure.

A “hard“ hydraulic fluid (high bulk module) transmits pressures very fast and leads to a stiff hydraulic system. This is appreciated in closed loop controlled systems. ”Stiff“ systems are achieved by small pressurized volumes, hard surrounding walls (pipes instead of flexible hoses) and high viscose fluids. Beside that pressure increases the bulk module of mineral oil.

A “soft“ hydraulic system is more subject to instability, but it is in general quieter, because high frequent pressure ripple is damped better.

The air content of the fluid plays an important role. Mineral oil contains some 9% air in solution under atmospheric pressure. If caused by underpressure in a hydraulic circuit (pump inlet, high fluid velocity in orifices or by turbulences due to high return line speed into the reservoir), part of this air occurs as bubbles, the systems stiffness is drastically reduced, which can cause several problems.

The viscosity of the hydraulic fluid has a high influence on the **dynamic power transmission** . A high viscosity, that means a “thick“ fluid, leads to a worse fluidity, which means:

- Higher pressure losses in pipes and components
- Reduction of hydraulic-mechanical efficiency
- More pressure drop in suction line, filling losses, cavitation
- Sealing and lubrication gaps are not fully filled, loss of lubrication.

A too low viscosity leads to the following problems:

- Higher leakage across all sealing gaps in the pump and in valves
- Thinner lubrication film causes more direct metal-to-metal contact and more wear in glide and roller bearings.

For these reasons the selection of the right viscosity and the best viscosity: temperature index need highest attention. Some of the selection criteria are:

- Function principle of hydraulic pumps and motors used in the system
- Nominal pressure, nominal temperature (and range)
- Environmental temperature (and range)
- Length of piping

The following limits are to be considered:

- Optimum working viscosity regarding efficiency, economy and safety

  $\nu_{opt} = 20 – 40\ mm^2/s$
- Working viscosity for full operability

  $\nu_{operation} = 16 – 100\ mm^2/s$
- Viscosity limits for reduced operating conditions (speed of rotation, pressure, load cycle)

  $\nu_{limit} = 12 – 300\ mm^2/s$
- Lowest viscosity limit, start of the damaging metal-to-metal contact, only for short time and max. 50% nominal pressure

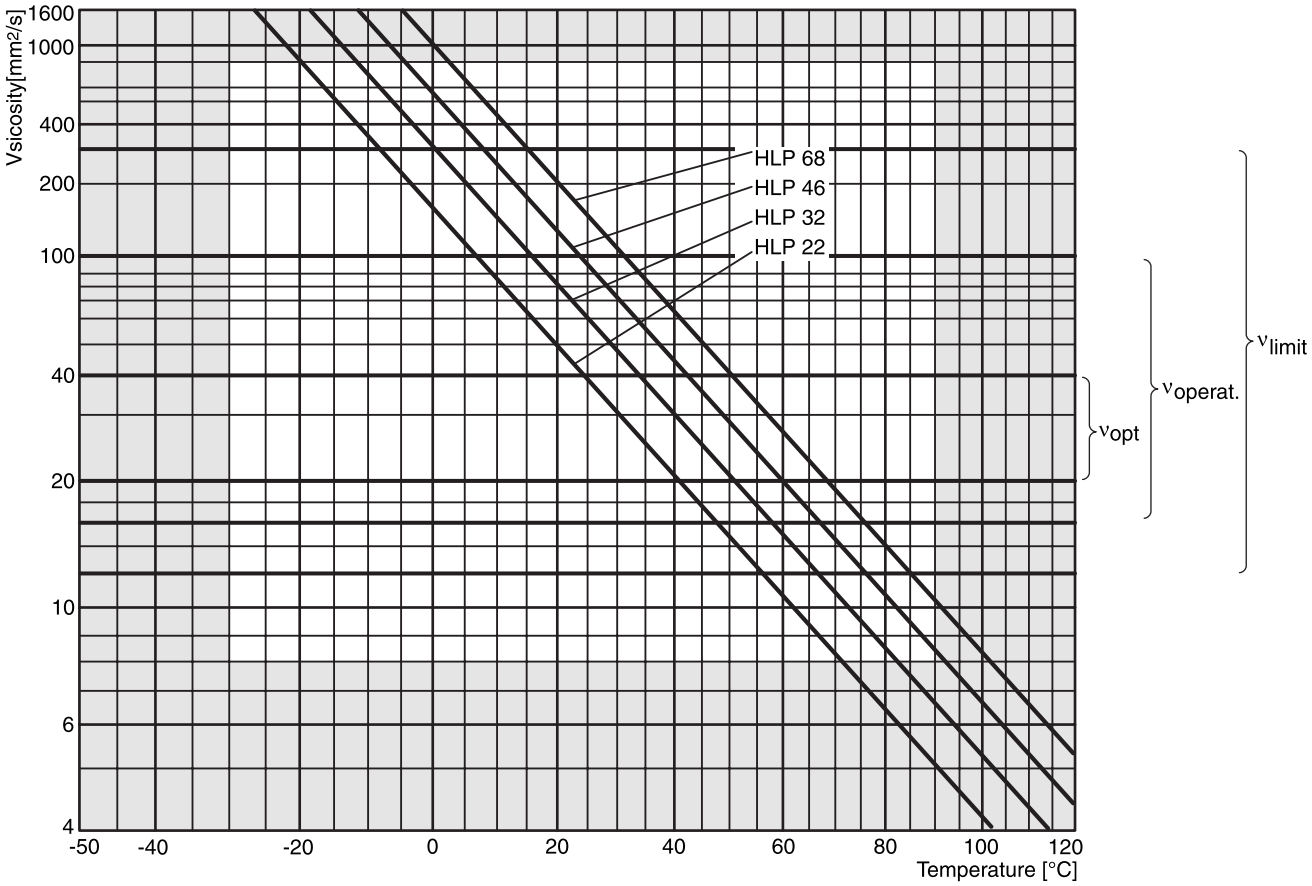
  $\nu_{min} = 8\ mm^2/s$
- Highest start up viscosity, suction limit of pumps, only for short time when suction line is short and straight

  $\nu_{Start} = 800\ mm^2/s$
- The recommended temperature range (fluid tempe- rature) for the operation of a hydraulic system is between 30°C and 70°C, -30°C as the lowest and +90°C as the highest limit never should be exceeded depending on a fluid capable of these temperatures.

Mineral oil is offered in different viscosity classes (VG, viscosity grade). The characteristic number describes the nominal viscosity in mm ²/s at 40°C:

VG 22	arctic conditions, extremely long pipes	VG 46	normal conditions, closed buildings
VG 32	wintery conditions	VG 68	tropical conditions

Viscosity:temperature diagram for mineral oil



The correlation between viscosity and temperature usually is described in the double logarithmic Ubbelohde diagram.

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Wear protection resp. wear reduction

In hydraulic components there are many gliding contacts partly under high (side) loads. Beside the correct viscosity, which on the one hand is responsible for the required supply of lubricating fluid to the gap, and on the other hand assures a stable lubricating film, the wear reduction capability of the hydraulic fluid is of major importance.

The describing parameter, the “Schadenskraftstufe“ (load carrying capability), is determined in the FZG normal test A/8.3/90 according to DIN 51 354 part 2 (gear transmission test rig, 12 defined load steps at 90°C start temperature and 8.3 m/s circumferance speed).
Depending on the nominal working pressure the following “Schadenskraftstufe“ is recommended

nominal pressure [bar]	“Schadenskraftstufe“
80 – 125	≥ 5
125 – 200	5 – 6
200 – 250	7 – 9
250 – 320	≥ 10
> 320	≥ 12

Max pressure limit: 1.25 x nominal pressure

Mineral oils are offered according to DIN 51 524 in different fluid types:

- HL-fluids according to DIN 51 524 part 2, normal working load conditions, “Schadenskraftstufe“ 6 – 10
- HLP-fluids according to DIN 51 524 part 3, higher working load conditions, “Schadenskraftsstufe“ > 10

Modern HLP fluids today usually come with a “Schadenskraftstufe“ >12. They are equipped with wear prohibiting additives, which ensure a high safety of operation even under severe working conditions.

Beside the wear reduction due to the elasto-hydrodynamic properties of the hydraulic fluid, which are expressed in the FZG value, the behavior of the fluid in a mixed friction situation is very important for the use of a fluid in heavy duty hydraulic applications. In hydraulic components mixed friction occurs permanently, because the velocity difference between two components in contact very often is below the minimum velocity for hydrodynamic lubrication.

During mixed friction, i. e.: at a direct metal-to-metal contact between two surfaces, the “lubricity” of a fluid is most important. The lubricity is measured according to DIN 51 347 and is expressed as a specific load in N/mm², at which wear does not yet occur. This value sometimes also is called the “Brugger Value”.

It is measured in a test device, which moves two cylindrical test elements under a defined load. On one of the test elements a wear mark is created. This wear mark grows during the first seconds of the test, but then stays for several minutes at a constant size. The size of this wear mark gives a reading for the specific “wear free” load for this particular fluid in N/mm².

For general applications
this value has to be at least:
30 N/mm², measured in accordance with DIN 51 347-2.

For heavily loaded hydraulic equipment and fast cycling machines and/or high dynamic loads,
this value should not be below:
50 N/mm², measured in accordance with DIN 51 347-2.

But a fluid can maintain its wear prohibiting capabilities only, when it is not contaminated with hard and aggressive particles. Therefore in the interest of a long functional life of all components the **filtration of the hydraulic fluid** needs special attention.

The sealing and gliding gaps in hydraulic components typically are in the range of 3 – 10 µm. That means they are in the same size range as most of the particles found in a hydraulic fluid.

The smaller the number of particles in a hydraulic fluid, the lower the wear of the hydraulic components will be. And wear is by nearly 90% the root cause for failure of hydraulic pumps and motors.

To ensure a disruption-free operation of a general hydraulic system, at least a fluid quality (cleanliness level) of 20/18/15 according to ISO 4406 is required. The characteristic values indicate, how many particles in the size range >2 µm (value 1), >5µm (value 2) and >15 µm (value 3) are present in one ml of a fluid. The value 20 stands for 5.000 – 10.000 particles per ml, the 18 stands for 1.300 – 2.500 particles per ml, and the 15 for 160 – 320 particles per ml.

That illustrates that in a hydraulic fluid of the cleanliness level 20/18/15, still a huge number of particles is distributed in the fluid content. That also indicates that this fluid quality is good enough only for general and low pressure applications.

When the requirements in functional safety and operational life are higher, or with high-pressure applications, Parker recommends a cleanliness level 18/16/13 according to ISO 4406. The fluid then is allowed to contain 320 – 640 particles >5µm and 40 – 80 particles >15 µm per ml.

To achieve such a cleanliness level the hydraulic circuit must be equipped with a suitable filtration system. But it has to be considered that filters never perform an absolut cleaning of the fluid. A filter element with a ß-value of e.g.: $ß_{10} \geq 75$ does not retain all particles larger than 10µm. Still 1/75 of all particles larger than 10µm will pass the element. This review shows:

- A reservoir filling of 100 l contains billions of contamination particles.
- Even a “10µ filter“ will let pass millions of particles > 10 µm.

On top of that, the following needs to be considered:

- Across a breather and through the piston rod seal and wiper of a hydraulic cylinder, particles can enter a hydraulic system.
- Wear on pumps, motors and valves adds more particles to the fluid.
- Mineral oil delivered in barrels typically has a cleanliness level of 21/19/16 according to ISO 4406 or worse.

Therefore it is very important to pay highest attention also to the systems filtration in respect of its layout, its supervision and its maintenance.

The load to the fluid in hydraulic systems leads to its **aging**. Therefore the fluid needs to be checked for its perfect condition. This check should be performed at least twice a year and include as a minimum requirement the determination of neutralization number, viscosity, colour index and cleanliness level.

The operational life of the fluid depends very much on the operating pressure, the operating temperature, the circulation number (delivery of all pumps divided by the reservoir content) and the type of the fluid. General statements to the average time of usage therefore are impossible.

Heat dissipation

The temperature has an important influence on the properties of the hydraulic fluid. Viscosity, lubricity, aging and other significant features depend directly or indirectly on the temperature. That indicates that the thermal balance of a hydraulic system needs to be considered during the layout and design. On the one hand the fluid is stressed by a high temperature, on the other hand the fluid is the medium to transport the heat away from resistors, orifices and other throttling devices and friction zones. Therefore during layout it has to be made sure that nowhere in the system a local overheating by dissipated heat can occur. That could destroy seals, lead to a failure of components due to a lack of lubricity or finally lead to a destruction of the fluid itself.

A final comment on **seals**. A good hydraulic system should not show that it operates with a fluid. There should be no leakage at all. In general hydraulic components are leak-free. More than 90% of all problems occur at interfaces:

- Ports
- Flange interfaces of valves
- Connectors

The assembly of the system is the main cause for problems in this area.

Nevertheless the system ‘hydraulic fluid & elastomeric seal’ is extremely sensitive. Temperature, chemical incompatibility and mechanical damages are the most frequent causes for a failure of this system. Please contact Parker if you have any question about this topic.

Parker does not give an explicit recommendation for a certain fluid product, fluid brand or fluid manufacturer. The permanent research and development in the field of hydraulic fluids and seal materials make it impossible to test all possible combinations for compatibility with our components. The recommendations made here and the discussion of possible restrictions, relevant standards and other useful literature should help to select the right fluid for a hydraulic system and to design the power unit in a way that it is able to fulfill all requirements.

Special fluids for environment protection

All statements made above are in principle also valid for these fluids. Regarding the selection/definition of the required viscosity level, the cleanliness level and the lubrication and wear protection behaviour, all criteria discussed in the mineral oil section have to be applied accordingly.

The following special fluid features and conditions are to be considered:

Fluids based on natural ingredients

- Good lubrication, viscosity:temperature characteristics better than standard mineral oil.
- Density slightly higher than mineral oil, therefore check for good suction conditions!
- Pourpoint approx. -30°, therefore not suitable for low temperature operation.
- Accelerated aging. First fluid change after 500 h, second change after another 1.000 h. Then all 2.000 h or annually, if less than 2.000 h annual operation.
- High affinity to water. The ingression of water has to be avoided under all conditions. At temperature above 50°C destroys the fluid if water is present.
- Can be mixed with mineral oil (under loss of biological degradability!).
- Internal coating of reservoirs etc.to be compatible with the fluid. Check with fluid supplier.

Fluids based on esters (synthetical esters)

- The same remarks as for fluids based on natural ingredients.

Fluids based on polyglycol (not HFC/water glycol)

- Good lubrication, viscosity:temperature characteristics better than standard mineral oil.
- Aging/durability according to actual knowledge similar to mineral oil.
- Pourpoint approx. -40°C, be careful at low temperatures!
- Density significantly higher than at mineral oil. Therefore the max. input speeds for self priming pumps are to be reduced by 20%.
- Use fluorocarbon as seal material. Our hydraulic components are tested with mineral oil; they need to be emptied completely before installation!
- Normal paints and coatings are destroyed. Please contact fluid supplier!
- Never mix with mineral oil, solid sediments will develop and block filters, orifices etc. .

Note: Even bio-degradable fluids need to be disposed of according to special disposing rules (like mineral oil). Prior to the use of these fluids we recommend to contact our specialists.

Fluids according to DIN 51 502 (HF fluids)

These fluids are fire resistant. The following classes are used:

HFA oil in water emulsion: 95 – 98% water

HFB water in oil emulsion: >40% water

HFC water containing solutions: 35 – 55% water (polyglycol)

HFD water-free fluids (mainly phosphoric acid ester)

The operation of Parker hydraulic components with HFD fluids within the limits of the fluid suppliers specification (temperature range, filtration, seal material compatibility) and the viscosity limits of our components is possible without restrictions.

The operation with HFC involves certain restrictions regarding pressure limitation and bearing life reduction in rotating units. Please contact our specialists.
Parker does not give a general release for the operation with HFA and HFB fluids. In certain cases a special approval can be given upon request.

If you are not sure wether our products can be used with a special fluid or not, please call us. Our specialists are glad to answer your questions and to give you any necessary support.

Notes

Notes

Please consult
your local Parker partner
for regulations
in effect.

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