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Hydraulic Fluids for Parker Axial Piston Pumps Series PV

A recommendation for the hydraulic fluid selection

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General

The hydraulic fluid is an important component of any 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 causal related to an improper condition of the hydraulic fluid.
The selection and the maintenance / control of the fluid for a hydraulic system is 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, 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.

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

A high influence on the **dynamic power transmission** is coming from the viscosity of the hydraulic fluid. A high viscosity, that means a „thick“ fluid, leads to a worse fluidity and that means:

- higher pressure losses in pipes and components,
- reduction of hydraulic-mechanic efficiency,
- more pressure drop in suction line, filling losses, cavitation,
- sealing and lubrication gaps are not getting 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 viskositys-temperature-index needs highest attention. Some of the selection criteria are:

- function principle of hydraulic pumps and motors used in the system,
- nominal pressure, nominal temperatur (and range),
- environmantal temperature (and range),
- length of piping.

The following limits are to be considered:

- optimum working viscosity regarding efficiency, economy and safety

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

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

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

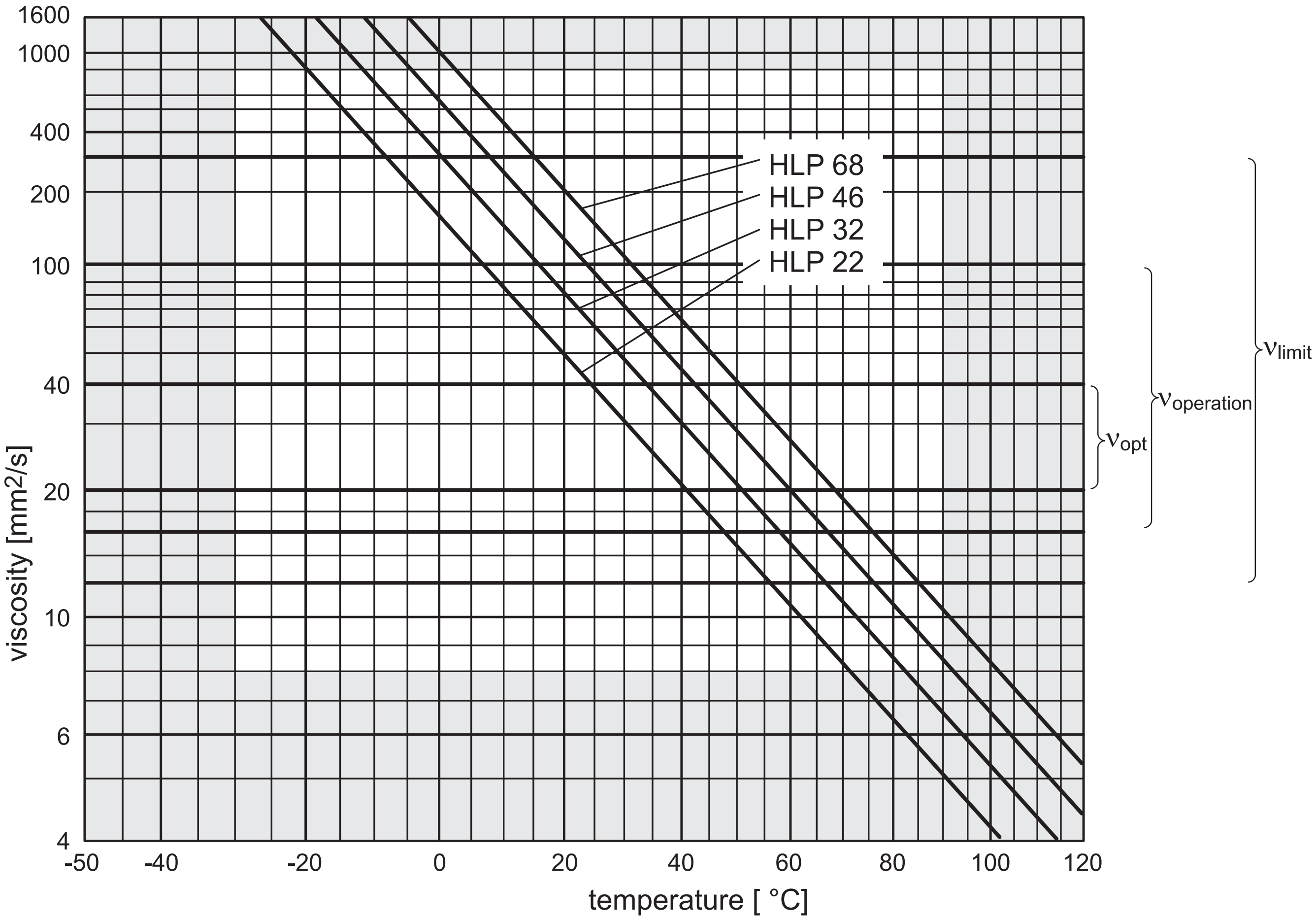
  $\nu_{min} = 8 \text{ mm}^2/\text{s}$
- highest start up viscosity, suction limit of pumps, only for short time when suction line is short and straight

  $\nu_{Start} = 1000 \text{ mm}^2/\text{s}$
- the recommended temperature range (fluid temperature) 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 ati 40°C:

VG 22	arktic conditions, extremely long pipes;
VG 32	winterlye conditions;
VG 46	normal conditions, closed buildings;
VG 68	tropical conditions.

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



Viscosity-temperature-diagram for mineral oil

Wear protection resp. wear reduction

In hydraulic components there are many gliding contacts partly under high (side) loads. Beside the correct viscosity, which on one hand is responsible for the required supply of lubricating fluid to the gap, 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°Cstart temperature and 8,3 m/s circumferance speed).

Depending on the nominal working pressure the following „Schadenskraftsufe“ 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 1, normal working load conditions, „Schadenskraftstufe“ 6 – 10;
- HLP-fluids according to DIN 51 524 part 2, higher working load conditions, „Schadenskraftsstufe“ > 10.

Modern HLP-fluids today usually come with a „Schadens-kraftstufe“ >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 should be at least

30 N/mm², measured in accordance to DIN 51 347-2.

For dynamic heavily loaded hydraulic systems and fast cycling machines (frequent changes of load pressures between low pressures and high pressures, fast cycling presses, plastic injection molding machines etc.) this value should not be below

50 N/mm², measured in accordance to DIN 51 347-2.

But a fluid can maintain its wear prohibiting capabilities only, when it is not conaminated with hard and aggressive particles. Therefor in the interest of a long functional life of all components the **filtration of the hydraulic fluid** need 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 cleanliness level of 20/18/15 according to ISO 4406:1999 is required.
The characteristic values indicate, how many particles in the size range > 4µm (1. value), > 6 µm (2. value) and > 14 µm (3. value) 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/ml.

That illustrates, that 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 cleanliness level only for general and low pressure applications is good enough.

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

Such a cleanliness level can be achieved with main stream or bypass filters having a b-value of $b_{10} \geq 75$. This value means, that, when flowing through the filter, 1/75 of all particles > 10 µm in the fluid pass the filter element.

This review shows:

- A reservoir filled with 100 l of such fluid contains billions of contamination particles.
- Even a „10µ-filter" will let pass millions of particles > 10 µm.

On top of that it 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 pefect 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. The viscosity, the lubricity, the aging and other significant features are direct or indirect depending on the temperature. That indicates, that the thermal balance of a hydraulic system needs to be considered during the layout and design. On one hand the fluid is stressed by a high temperature, on the other hand the fluid is the media to transport the heat away from resistors, orifices and other throttling devices and friction zones. Therefor 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 lack of lubricity or finally lead to a destruction of the fluid itself.

A final comment to **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 leakfree. 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 extremely sensitive. Temperature, chemical incompatibility and mechanical damages are the most frequent causes for a failöure of this system. Please contact Parker if you have any question to 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 makes 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 basing on natural ingredients**
  - good lubricaction, viscosity-temperature characteristic 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.
  - should never be mixed with mineral oil based fluids.
  - internal coating of reservoirs etc. to be compatible with the fluid. Check with fluid supplier.
- **Fluids basing on esters (synthetical esters)**
  - The same remarks as for the natural based fluids are valid.
- **Fluids basing on polyglycol (not HFC/water glycol)**
  - good lubricaction, viscosity-temperature characteristic 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 for mineral oil. Therefore the max. input speeds for self priming pumps are to be reduced by 20%.
  - use fluorcarbon as seal material. Our hydraulic components are tested with mineral oil; they need to be completely made empty befor installation!
  - normal paints and coatings are destroyed. Please contact fluid supplier!
  - Never mix with mineral oil, solid sediments are going to develop and will block filters, orifices etc.!

Note: even bio-degradable fluids need to be disposed according to special disposing rules (like mineral oil).

Prior to the use of these fluids we recommend to contact fluid 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: (poly-glycole)	35 – 55% water;
HFD	water free fluids (phosphate ester, polyol ester, polyether-polyol).	

The operation with HFC and HFD fluids can involve certain restrictions (maximum speed, pressure limitation, bearing life reduction).

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.