Pressure fluids - notes for selection

The operation behavior of a hydraulic application mainly depends on the quality of the utilized pressure fluid.
The selection of the pressure fluid is determined by the opera-ting conditions of the system such as:

- **Temperature (see viscosity classification)**
- **Nomenclature (some pressure fluids may be unacceptable because of undesired reactions with metals, seals etc.)**
- **Kind of application (e.g. ecologically compatible pressure fluids)**
- **Ambient conditions (e.g. use of already available pressure fluids)**

The following viscosity ranges and temperature ranges apply to HAWE equipment

Temperature range:	Ambient: approx. -40...+80°C (Attention: Air driven pumps type LP +5...+80°C) Pressure fluid: -25...+80°C, Taking into account viscosity range or additional restrictions.
Permissible temperature during start:	-40°C (observe start-viscosity!), as long as the service temperature is at least 20K higher for the following operation Biologically degradable or fire inhibiting pressure fluids generally not over max. +60...+70°C.
Viscosity range:	min. approx. 4 mm²/s, max. approx. 1500 mm²/s optimum service approx. 10...500 mm²/s

Pressure fluid	Characteristics	Unusual features / restrictions
Mineral oils		
• Pressure fluids HLP (DIN 51524 part 2)	Mineral oil with additives improving corrosion, oxidation and wear protection	Common hydraulic oil
• Pressure fluids HL (DIN 51524 part 1)	Mineral oil without wear protecting additives	No wear protection additives therefore not suitable for gear pumps. HAWE-pumps type: Z, RZ, MP..-Z, HK..Z Observe manufacturer's specifications for other devices!
• Pressure fluids HVLP (DIN 51524 part 3)	Mineral oil with same additives as HLP, but with increased viscosity index for use in higher temperature ranges	Additives improving the viscosity index show drawbacks concerning e.g. shear strength (viscosity drop during load by 30%), fall out of water and air. Use only, if temperature range requires this. Observe fluid manufacturer's specification !
• Undoped oil H e.g. - lubricating oils (DIN 51517 part 1) - white oil (e.g. USDA H1)	Mineral oil without additives	Only for systems for intermittent service (S2 or S3 operation), due to the missing additives (low lubricating characteristic). White oil is mainly used in systems for food processing.
• Special fluids for aviation (MIL H-5606) for off-shore applications (NATO H 540)	Mineral oils are based as a rule on naphtenic based oil with wide temperature range	Seals made of flour rubber FPM (e.g. Viton) might be required, depending on pressure fluid. Observe fluid manufacturer's specification !
• Other mineral oils Engine oils type HD (e.g. DIN 51511) Automatic transmission fluid type ATF (AQA Suffix A) Diesel fuel Test oil for diesel injection pumps	Mineral oils which basically were developed for other application purposes.	More or less well suited pressure fluids. Observe whether it contains additives preventing corrosion and oxidation as well as material compatibility (especially with seals). Attention: Increased leakage with directional spool valves. Observe fluid manufacturer's specification !

Ecologically compatible pressure fluids VDMA 24568 and 24569		
• Seed oil type HETG	Fluids based on seed oils e.g. rape or sunflower with additives show only low temperature strength (< 60...70°C)	Not suited for oil immersed hydraulic power packs type HC, MP, FP, HK, all valves with wet armature solenoids as well as control systems utilizing many throttles. Fluids type HETG show a tendency to gum, aging, and sticking at higher temperature (> 60...70°C). Their use should be avoided !
• Polyethyleneglycol HEPG PEG-Polyethylene (may be solved in water) PPG-Polypropylene (can't be solved in water)	Fluids based on Polyethyleneglycol (PAG) Similar qualities i.e. service life, lubricating characteristics and pressure resistance, like mineral oil	No restrictions with regard to the operation behavior, but it • is harmful to standard enamel (does not apply to two-pot enamel) • will clog cellulose filters (use only glass fiber or metallic filters)! • shows bad lubrication characteristic with material pairings steel / light alloy or brass • is not suitable for pumps type HC, MP, FP, HK, RZ, Z and connection blocks with filter type A.F., AF, BF, EF, FF
• Synthetical ester HEES (carbon acid ester, diester, polyester)	Similar qualities i.e. service life, lubricating characteristics and pressure resistance, like mineral oil	No restrictions with regard to the operation behavior Contact with PVC should be avoided.
Fire inhibiting pressure fluids conforming DIN 51502		
• HFA (pressurized water, emulsions)	Emulsion, oil solved in water (water content > 80%) max. temp. range approx. 60°C	There is the danger of corrosion and cavitation due to the high water content, therefore only devices intended for it, should be used (some pump versions of type R, directional seated valves acc. to D 7300). Max. oper. pressure of the pump 50...60% (danger of cavitation) Min. oil content > 4% • No use of oil immersed hydraulic power packs - danger of short-cuts - applies to pumps type HC, MP, FP, HK • No cellulose filters - danger of clogging
• HFC	Glycol / water solution (water content < 35%) max. temp. range approx. 60°C	No restrictions with regard to the operation behavior, but it • is harmful to standard enamel (does not apply to two-pot enamel) • will clog cellulose filters (use only glass fiber or metallic filters)! • shows bad lubrication characteristic with material pairings steel / light alloy or brass • is not suitable for pumps type HC, MP, FP, HK, RZ, Z and connection blocks with filter type A.F., AF, BF, EF, FF
• HFD HFDR phosphoric ester HFDS chlorinated hydrocarbon HFDT blend of HFDR and HFDS HFDU other composition	Fluids without water content, similar qualities like mineral oil	No restrictions with regard to the operation behavior, but it • requires seals out of FPM (FKM) (see also section "Seals")
Special fluids		
• AT-Brake fluid	Brake fluid based on glycol (DOT 4)	No restrictions with regard to the operation behavior, but devices must be equipped with EPDM or SBR-seals when operated with brake fluid. (see also section "Seals")
• SKYDROL	Fluid intended for aviation (e.g. HyJet IV)	Only devices fitted with seals made of EPDM/SBR can be employed (see also sect. “Seals”)

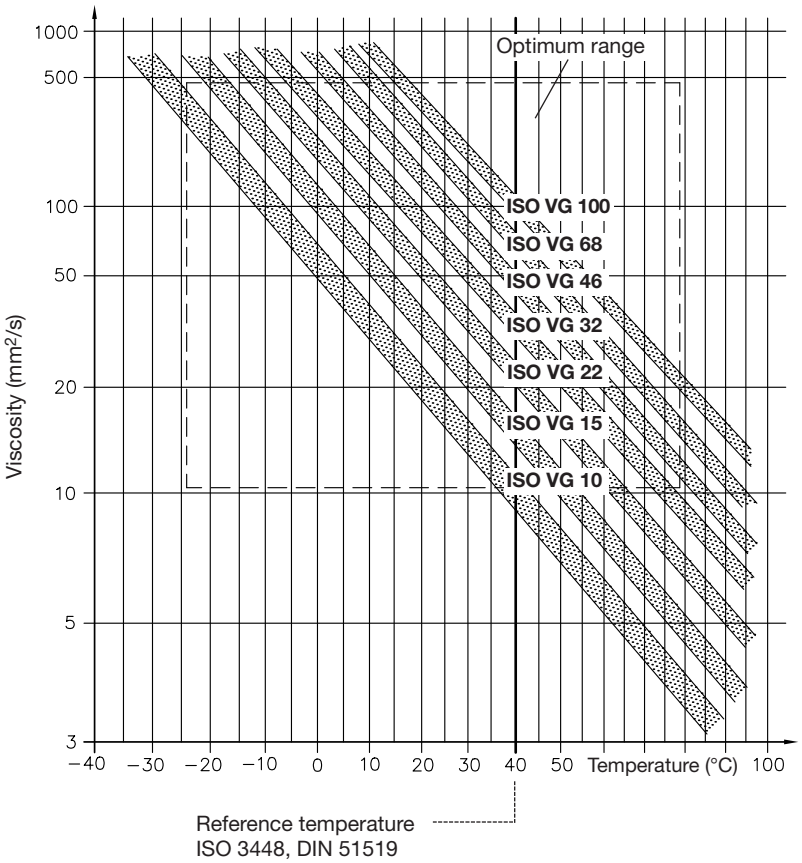
Selection of the viscosity

The industrial standard “ISO Viscosity classification for liquid lubricants” (ISO 3448, DIN 51519) lists 18 viscosity classes, but only the viscosity classes ISO VG10 to ISO VG68 are of common interest for hydraulic systems. The index No. behind ISO VG informs about the nom. viscosity at 40°C. The temperature behavior illustrated in the curve applies to mineral oil only. The behavior of HVLP and environmentally friendly fluids is less temperature dependent i.e. the curve is less steep.

The following points should be checked in the manufacturer's specification before selecting a fluid:

- Viscosity at 40°C
- Viscosity at the lowest (estimated or demanded) temperature
- Viscosity at the highest (estimated or demanded) temperature (to ensure sufficient service life of the seals not above 80°C!)

Temperature / viscosity curve



Guide lines for selection

- VG10, VG15
  Systems intended for short time operation or use in the open or for clamping devices.
  Systems intended for continuous operation (for use in the open, operation in winter)
- VG22, VG32
  General application
  (for use in the open, operation in summer only)
- VG46, VG68
  Systems in tropical conditions at ambient temperatures up to 40°C or closed rooms (temperature during start not lower than 20°C)

Filtration

Major malfunctions of a hydraulic system can be caused by contamination like fine wear particles and dust or bigger particles e.g. swarf, rubber from tubing or seals. Therefore the following filtration is recommended (after a thorough initial flushing):

Permissible contamination of the pressure fluid			Recommended	Devices
ISO 4406 : 1999	**NAS 1638**	**SAE T 490**	**Filter separation**	
21/18/15...19/17/13	12 ... 8	≧ 6	$\beta_{16...25} \geqq 75$	Radial piston and gear pumps, valves, cylinders (use in general mechanical engineering)
20/17/14...18/15/12	11 ... 6	5 ... 3	$\beta_{6...16} \geqq 75$	Prop. pressure and flow control valves

Lower limits must be applied for pressure above 250 bar

The purity degree of the pressure fluid is especially important for the repeatability accuracy with proportional valves.
It is important to be aware that fresh fluid from the barrel does not always fulfill the highest standards of cleanliness.

Service life

The aging of pressure fluids is caused by shearing processes, cracking induced by high temperatures (gumming), mixing with (condensed) water or reaction with other materials (e.g. metal) in the system (sludging).
A major factor for the service life of the fluid is beside the anti-shear additives of the fluid the lay-out of the system e.g. tank size, operation temperature, number and design of throttling sections.
The following points should be observed:

- Service temperature in the tank < 80°C
  (mineral oils, pressure fluids with low water content)
  Avoid higher temperatures - Service life reduction -
  (+10K ≙ half service life)
- Circulation ratio of the pressure fluid $\frac{Q_{pump}\,[lpm]}{V_{circuit}\,[l]}$ (guideline)
  - approx. 0.2...0.4/min for conventional hydraulic power packs
  - approx. ...1/min for mobile hydraulics
  - approx. ...4/min for hydraulic power packs operated on/off or with idle circulation
- Control of the pressure fluid on a regular base (fluid level, contamination, coloring index, neutralization value etc.)
- Change of the pressure fluid on a regular base (depending on fluid type and application conditions)
  Guideline: - approx. 4000 ... 8000 h (mineral oil)
  - approx. 2000 h (other pressure fluids)
  - or at least annually
  Take into account notes of the fluid manufacturer !

Change of the pressure fluid

Mixing different kinds of pressure fluid sometimes can cause unintended chemical reactions such as sludging, gumming etc.
The respective manufacturers should therefore always be consulted when changing from one to another pressure fluid. The complete hydraulic system should be thoroughly flushed anyway.

Seals

Any question about the compatibility with seal material should be settled with the fluid manufacturer always before using a certain pressure fluid (except mineral oil and synthetic esters). A rough overview is given in the table at the start of this section. HAWE utilizes seals made of the following materials as standard:

- NBR (acrylonitrile rubber, e.g. Bunan, Perbunan) or HNBR (hydrated NBR).

Some devices are available on request with seals made of:

- FPM (also FKM, fluor rubber, e.g. Viton)
  e.g. for fluids type HFD
- The coding ...-PYD should be added to the coding for HAWE devices, e.g. WN1H-G24-PYD
- EPDM (ethylen propylen rubber) or SBR (styrene-butadiene rubber)
- The coding ...-AT should be added to the coding for HAWE devices, e.g. WN1H-G24-AT (for brake fluid)
- Coding for HAWE devices: Suffix ...-SKY, e.g. GR2-1-G24-SKY (for SKYDROL)

Storage of hydraulics components

The storing conditions for hydraulic components mainly depend on the used seal material and the test rig fluid which is on all internal parts.
The storability of rubber materials is generally influenced by the following factors: - Warmth, light, humidity, oxygen, ozone. Any storage additionally should be, when possible, without any stress and deformation on the seal material. A storing temperature in the range of 15 to 20°C has proved as optimal. The relative atmospheric humidity should be kept at approx. 65% (±10%). Any direct sunlight or another light source with strong UV quota has to be avoided. Ozone producing facilities (electric motors, high tension facilities) mustn't be apparent in the storeroom. If seals are packed in plastic bags, these should not contain any softeners and be impermeable for UV light if necessary. Details on the storage of sealing components can be found also in the following standards: DIN 7716/BS3F68:1977, MIL-HDBK-695C, MIL-STD-1523A, DIN 9088.
Hydraulic fluids can be stored usually in containers sealed by the manufacturer for prolonged periods. In connection with oxygen from the air, dust and humidity more or less fast oxidation and gumming can occur depending on fluid brand and utilized additives.
It is recommended to store hydraulic components in a dark room where the suggested temperature and atmospheric humidity are roughly constant. The parts should be kept in plastic bags to protect them from dust and permanent air exchange. It is recommended to make a function test once per year to ensure proper function for the case that the part is required.
A half-yearly function test on-site as well as a routine inspection with seal replacement every two year should be undertaken at our facilities for all safety relevant components. The danger of corrosion can be neglected when the components are properly stored (see above). Extra protection is ensured by the galvanized/nitrided surface and the residuals of the test fluid.