Mineral oil based pressure fluids for use with vane pumps, radial piston pumps and gear pumps as well as MCR, MR and MKM/MRM motors[1)]

RE 07075/10.05 1/6
Replaces: 02.03

[1)] For axial piston machines see RE 90220

The quality, cleanliness and operating viscosity of the hydraulic medium are decisive factors in the operating reliability, efficiency and service life of a system. The data sheets for the various types of hydraulic components contain specifications regarding the viscosity range and suitable fluids. Furthermore, the ordering details contain details of special models for use with special fluids.

The following points must be taken into account in addition to the specifications stated in the data sheets.

1. Viscosity

The permissible viscosity range of an installation, including combination pumps is always restricted to that of the component with the narrowerst range. (For combination pumps PV7/PR4, for example, the maximum permissible viscosity range of the PR4 pump is limited to that of the PV7 pump). The viscosity range must not be exceeded under any operating conditions.

The viscosity of HV oils falls in operation due to shearing by up to 30%. This has to be taken into account during the design phase. The viscosity is dependent on the temperature. Due to this fact, when determing the viscosity classes, the minimum and maximum oil temperatures in the oil reservoir must be adhered to. As a rule heating or cooling or both is necessary. If, in spite of this, difficulties are still experienced then an operating medium with a different viscosity class (ISO VG class) will probably have to be utilised. In case of doubt, please consult Bosch Rexroth.

1.1 Viscosity range of vane pumps

1.1.1 PV7 pumps:
Max. 800 mm^2/s at start-up when pumping
Max. 200 mm^2/s at start-up at zero stroke
Min. 16 mm^2/s at the max. permissible operating temperature
Permissible operating viscosity range 16 to 160 mm^2/s
(for permissible mediums: see from point 2.1)

1.1.2 PVV, and PVQ pumps:
Permissible viscosity range 13 to 860 mm^2/s
(recommended 13 to 54 mm^2/s)
(for permissible mediums, see from point 2.2)

1.2 Viscosity range for PR4 radial piston pumps:
Permissible viscosity range 10 to 200 mm^2/s
(for permissible mediums, see from point 2.2)

1.3 Viscosity range for external gear pumps and gear motors AZP pumps or AZM motors:
Permissible operating viscosity range 12 to 800 mm^2/s
Permissible start-up viscosity 2000 mm^2/s
(for permissible mediums, see from point 2.1),

1.4 Viscosity range for internal gear pumps

1.4.1 PGF pumps:
Permissible operating viscosity range 10 to 300 mm^2/s
Max. permissible start-up viscosity 2000 mm^2/s
(for permissible mediums, see from point 2.1)

1.4.2 PGH pumps:
Permissible operating viscosity range 10 to 300 mm^2/s
Max. permissible start-up viscosity 2000 mm^2/s
(for permissible mediums, see from point 2.1)

1.5 MCR motor viscosity range:
Permissible operating viscosity range 10 to 2000 mm^2/s
(for permissible mediums, see from point 2.1)

1.6 Viscosity range
MR(E), MRD(E), MRT(E) motors:
Permissible operating viscosity range 18 to 1000 mm^2/s
The recommended operating viscosity is 30 to 50 mm^2/s
(for permissible mediums, see from point 2.2)

1.7 Viscosity range MKM/MRM motors:
Permissible operating viscosity range 20 to 150 mm^2/s
Max. permissible start-up viscosity 1000 mm^2/s
The recommended operating viscosity is 30 to 50 mm^2/s
(for permissible mediums, see from point 2.2)

2. Pressure fluids

This summary is based on many years of experience, it however does not inply that it is complete. The summary relates to the current state of knowledge. It does not release the user from the responsibility that he must be convinced that the fluid is suitable for use by carrying out his own investigations. The fluid specification is always determined by the most sensitive component within the system. All components contained within the system must be compatible with the fluid used.

2.1 HL oils to DIN 51524 part 1

These mediums, mainly only contain anti-oxidation and corrosion protection additives, they do not contain any anti-wear additives for mixed friction (without extreme pressure, anti-wear additives) and are only suitable for use with the following pumps: PGH, PGF, AZP, and PV7 (up to a max. of 80 bar – NS 10, 16, 25 and 40) as well as MCR motors.

Hydraulic mediums which attack lead or bearing materials that contain lead and/or zinc, even when they comply with the specification HL to DIN 51524 part 1 must not be used. They are mainly multi-purpose oils (e.g. bedway oils) that contain fattyacids or fatty acid esters. Fluids that only comply with the classes HL and HR to ISO 11158, without being able to confirm the requirements of DIN 51524-1, may only be used if written authorisation has been obtained from Bosch Rexroth.

2.2 HLP oils to DIN 51524 part 2 (oils with corrosion, oxidation and wear additives)

These fluids are those most commonly used in hydraulics. As long as the viscosity specifications are adhered to, they may be used with all components.

In the viscosity classes VG10, VG15 and VG22, DIN 51524 does not place adequate requirements for wear resistance (DIN 51354-2 and DIN 51389-2). Supplementary to DIN 51524-2 we require a comparible wear protection as provided by the additives contained within the ISO VG classes 32-150 products. The following applies; the water content should be continuously held under 0.05%, as water accelerates the aging of the oils, deteriates the lubrication characteristics, introduces corrosion and cavitation, reduces the seal service life and reduces the filtration characteristics.

The technical values stated within the associated BR data sheets are fulfilled when it is confirmed that the fluid conforms with DIN 51524-2 and complies with the product information fully in the when filled condition and to a large extend in the used condition. The usability of HLP oils and their additives are greatly influenced by many surrounding conditions. The operating time of a particular fluid can, in comparison to other fluids, be limited to a greater degree. The user of the fluid has therefore to comply with the minimum requirements of DIN 51524-2 during the entire time that the fluid is in use. Conformation is normally confirmed by means of oil analysis (after commissioning and at regular intervals during operation).

It is also recommended that well known medium suppliers are selected who can offer support for the selection of maintenance and analysis of the medium. If individual technical properties of the fluid deviate from the standard then this should be clarified with the medium supplier and Bosch Rexroth.

We permit the use of all HLP oils which comply with DIN 51524 part 2, with the exception of those indicated above, but would like to point out that this standard merely lies down the minimum requirements.

As may be seen from the tables contained within DIN 51524 part 2 that there are oils available with regard to aging, wear protection, non-ferrous metal compatibility, thermic loadability and filterability, that far exceed these minimum requirements. The requirements of DIN 51524-2, that are restricted to the as new condition do not permit a general comparison.
Hydraulic mediums which attack lead or bearing materials that contain lead and/or zinc, even when they comply with the specification HLP to DIN 51524 part 2 must not be used. They are mainly multi-purpose oils (e.g. bedway oils) and partly also HLPD oils. Multi-purpose oils type CG to DIN 51502 or HG to ISO 11158, may only be used if written authorisation has been obtained from Bosch Rexroth.

2.3. HVLP oils to DIN 51524 part 3 (oils with an increased viscosity index for the use in systems exposed to a wide temperature range.)

Here the same guidelines and limitations apply that have been stated within point 2.2. for HLP oils. When selecting an HVLP oil the loss in viscosity, due to the effect of shearing, of up to 30% has to be taken into consideration. This means, e.g. when using a PV7 pump with HVLP oils the minimum permissible viscosity of 25 has to be increased to 36 mm^2/s, so that when shearing losses occur during operation the minimum permissible viscosity is not exceeded.

The results of the test for viscosity drop to DIN 51382 is in practise of no consequence, therefore this standard has been withdrawn. At present only the results of tests carried out to DIN 51350 part 6 can be evaluated. Please take into account that in practise there are applications where these fluids are subjected to higher shear factors than those subjected to in this test.

If the low viscosity temperature relationship is obtained by means of additives rather than high value basis oils (VI improver), then it has to be taken into account that the

stated viscosities are only valid when new. VI improvers can additionally have negative effects on the de-emulsifying therefore HVLP oils should only be used where the temperature conditions require their use.

We would again like to emphasis that our temperature and viscosity limits are always to be adhered to in the new and used conditions.

2.4. HLPD oils and HVLPD oils
(oils with detergent and dispensing additives)

These oils can, in some cases, absorb a considerable quantity of water. This can have a negative effect on the wear protection and the oil condition. They should therefore not be used in systems where it is possible or expected that water could enter the system in large quantities. Where synthetic cooling and cutting fluids are used systems will only function correctly if HLPD oils are used. If other oils are used then this leads to the components sticking. In the mobile branch these oils have also proven themselves.

We recommend the use of HLPD oils only in the above mentioned cases. The film strength of these oils is very much dependent on the manufacturer. The statement that these oils are particually good in preventing stick-slip at low cylinder speeds, cannot therefore be accepted as universally true.

In individual cases where heavy contamination from water is to be expected (i.e. in steel works or in damp surroundings), HLPD oils may not be used, as the water emulsified in the fluid is not deposited in the tank, but is turned into steam at highly loaded parts within the system. In these cases the use of HLP hydraulic oils which have particually good water demulsification characteristics is recommended. The water which collects at the bottom of the reservoir has to be drained at regular intervals. When selecting an oil, particular attention has to be taken to ensure that the filterability of the medium, with the increase of water is not excessibly worsened.

When using HLPD oils contamination is not deposited, it is held in suspense and has therefore to be filtered out or removed from the system by means of an oil change. Due to this a larger filtration area is required (filter laid out for a $\Delta p = 0.2$ bar).

Various HLPD oils contain fatty acids or fatty acid esters. Please take into account the comment stated under point 2.2. With the exception of the de-emulsifiying characteristics HLPD oils act the same as HLP oils. Also the air seperation characteristics of brand name products are comparible to those of HLP oils.

3. Additives

We do not specify a special additive system, however one differentiates between zinc-free and zinc containing additives.

Particually with low zinc and zinc-free fluids there are data sheets and papers available that show that with reference to the phyiscal and the technical usage characteristics very large differencies can occur. Please take in particular account point 5.

4. Fluid maintenance and filtering

Generally a minimum cleanliness class of 20/18/15 to ISO 4406:1999 (E) should be maintained. Please take also into account the details stated within the associated data sheets for the hydraulic components.

New oil, as delivered, often does not meet these cleanliness requirements. Careful filtering is therefore necessary when filling. The cleanliness class of the oil, as delivered, can be obtained from the oil supplier. The oils used must have, not only in their new condition but also during their operational life, good filtration characteristics. There are large differences dependent upon the additives used. The required fluid cleanliness grades are the minimum requirements for our components during operation. Electrical devices must be provided so that it is not possible to operate the system with a clogged filter. So that the required cleanliness class can be maintained, careful attention to the air breather filtration is also required. With damp ambient conditions appropriate measures have to be taken, e.g. silica gel absobers.

The service and maintenance requirements increase with an increase in the requirements of the hydraulic systems, deteriarating operating conditions, extending the required fluid service life as well as reducing the probability of breakdowns. The operating medium should be tested by the fluid supplier or by an accredited test laboratory at regular intervals. A reference test is recommended after commissioning. Test laboratories offer the possibility of checking the fluid condition with regard to contamination, aging and additive reserves and from the results are able to make comments regarding the further use of the mediuim. Only in this way is it possible for the user to obtain a quantitive evaluation regarding the actual condition of his hydraulic components and the fluid. These results are to be made available for guarantee, liability and warranty claims.

5. Mixing and the compatibility of differing hydraulic oils

It has to be differentiated between mixability and compatibility. Any mixing with other oils or fluids, even those of the same standard within our area of responsibility is to be avoided. Additives should also not be added.

If individual products are advertised with regard to mixability and compatibility then this lies in the area of responsibility of the medium supplier. When changing over, the new medium supplier must confirm in writing that the old and new fluids are compatible. Only they can confirm and give a functional guarantee, taking residual quantities into account.

If hydraulic oils from a differing manufacturer or different types from the same manufacturer are mixed, then sticking, sedimentation and silting can occur. These can lead to faults or damage to the hydraulic system. All this does not lie within our sphere of influence. **Due to these reasons Bosch Rexroth cannot accept any guarantee claims when fluids are mixed!**

6. Other mineral oil based fluids

Turbine oils to DIN 51515, lubrication oils to DIN 51517 and mineral oil based fluids with an NSF H1 acceptance can be used with the above stated components. Generally these fluids have wear protection that is comparable with HL oils. See point 2.1.

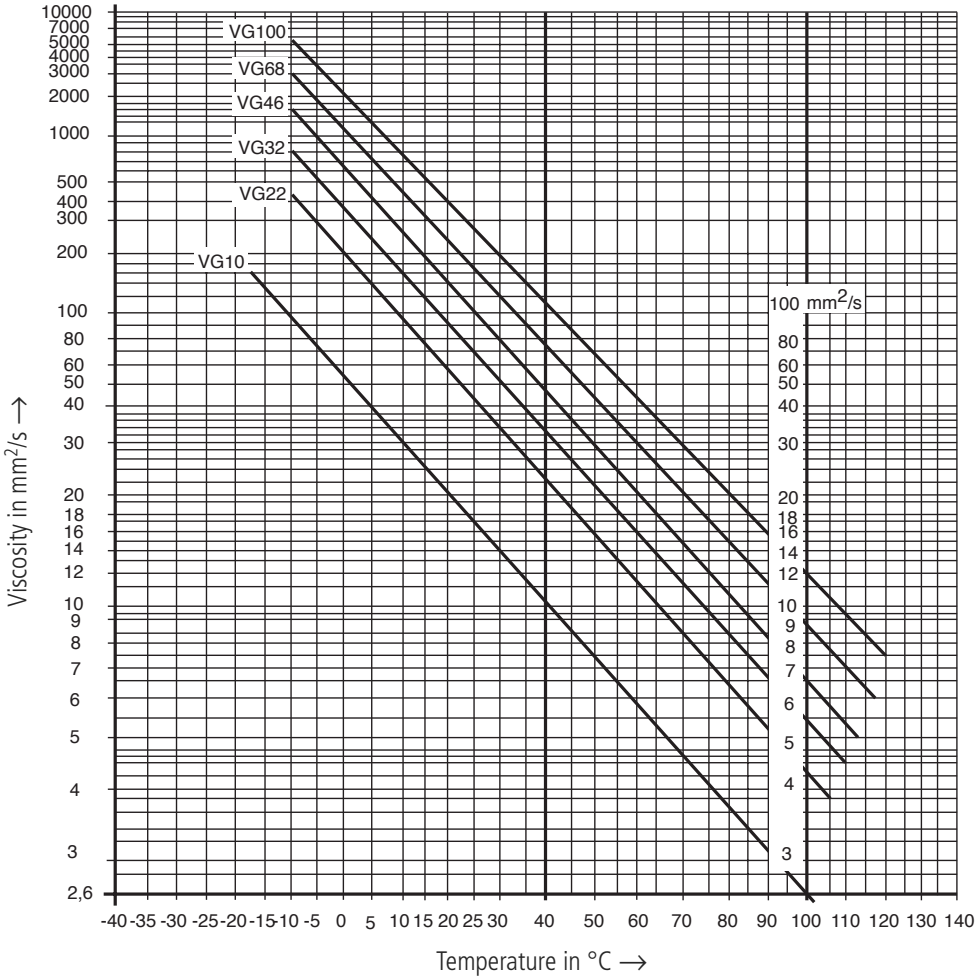
In individual cases idt is possible to find product descriptions with acceptances analogue to the HLP fluid

catagory. For the last mentioned fluid the only limitations are as those stated in point 2.2.

Aviation mediums to MIL-H-5606, MIL H 46170, MIL H 83282 correspond to the wear protection provided by HL oils and can therefore be used within the permissible viscosity ranges of the above stated pumps and motors. Motor (SAE classes) and gearbox oils (ATF Dexron IID and III) have developed with regard to their suitability in hydraulics towards the requirements of hydrualic fluids. Above all multi range motor oils, with their higher proprtion of synthetics are particually noticable.

If the individaul products comply with DIN 51524 then these fluids can automatically be used, dependent on the catagory, with our components. For all other fluids stated within point 6 we can only accept warranty when an application related release has been given.
Functionally these fluids act analogue to the previous description. Due to special secondary requirements, please contact us in individual cases. We have extensive practical experience to take the application specific requirements into account.

Viscosity temperature diagram



Freqently used formulas and standards

Physical formulas

a) Velocity of sound in mineral oil $c = 1320$ m/s

b) Compressibility factor β (compression module)

$$\beta = \frac{\Delta V}{V \cdot \Delta p} = 3 \text{ to } 8 \cdot 10^{-5} \quad \left[\frac{1}{\text{bar}}\right]$$

c) Viscosity temperature function

Gradient $n = \frac{U_1 - U_2}{2{,}303\ (\lg T_2 - \lg T_1)}$ where $U =$ ar sinh $ln\ \nu$

Viscosity index VI (calculated to DIN/ISO 2909)

d) Viscosity pressure relationship (dynamic viscosity η

$\eta_p = \eta_0 \cdot e^{\alpha \cdot p}$ (p in bar) [mPa • s]

$\alpha_{20\,°C} = 0{,}00240$ bar^{-1}
$\alpha_{50\,°C} = 0{,}00205$ bar^{-1}
$\alpha_{100\,°C} = 0{,}00247$ bar^{-1}
(from: "pressure fluids"
by Dpl. Eng. Horst Dietterle, Co. Shell)

e) Specific heat capacity

$c = 1{,}84 \cdot \frac{kJ}{kg \cdot K}$

f) Thermal expansion

$\Delta v = v \cdot 0{,}0007 \cdot \Delta T$ [cm^3] (T in K)

g) Bunsen co-efficient for air in mineral oil ≈ 0,09

$$V_L \approx 0{,}09 \cdot V_{Öl} \cdot \frac{p_2}{p_1}$$

V_L = air dissolved in oil in cm^3
$V_{Öl}$ = oil volume in cm^3
p_1 = start pressure in bar
p_2 = final pressure in bar

h) Co-efficint of circulation (no. of circulations)

$$i = \frac{q_v}{V_{system}} \text{ min}^{-1}$$

this is the reciprocal of the dwell time
q_v in L/min (pump flow)
V in L (oil content of the installation)

Measuring techniques and standards

1 Kinematic viscosity in mm^2/s
Measurement e.g. with a Ubbelohde viscometer
to DIN 51562

2 Density at 15 °C in g/cm^3 with an areometer
to DIN 51757

3 Viscosity index (VI) to DIN/ISO 2909

4 For HL fluids DIN 51524 part 1
For HLP fluids DIN 51524 part 2
For HV fluids DIN 51524 part 3

5 Viscosity classification (to ISO)
to DIN 51519

6 Pour point
(reaching the flow limit is 3° higher than the solidifing point)
to DIN/ISO 3016

7 FZG normal test A/8, 3/90
(gear tooth load test in 12 stages
at 90 °C start temperature and 8,3 m/s
circumferential speed) to DIN 51354 part 2

8 Pressures – terms – pressure ratings to DIN 24312

9 Air separation characteristics to DIN 51381

10 Corrosion protection characteristics
compared to steel (process A) DIN 51585
corrosive effect on copper DIN 51759

11 Demulsification characteristics DIN 51599
Water content DIN/ISO 3733

12 Effect on seal materials
to DIN 53538 part 1
in connection with DIN 53521 and DIN 53505

13 Neutralisation no. in $\frac{\text{mg KOH}}{\text{g}}$ DIN 51558 part 1

14 Determination of carbonised residue according to
Conradson to DIN 51551

15 Mechanical testing of vane pumps
(wear in mg) to DIN 51389 part 2

16 Aging characteristics
Increase in the neutralisation number (NZ)
to 1000 h (mg KOH/g) to DIN 51587

Notes

Bosch Rexroth AG
Hydraulics
Zum Eisengießer 1
97816 Lohr am Main, Germany
Telefon +49 (0) 93 52 / 18-0
Telefax +49 (0) 93 52 / 18-23 58
documentation@boschrexroth.de
www.boschrexroth.de

Notes

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Hydraulics
Zum Eisengießer 1
97816 Lohr am Main, Germany
Telefon +49 (0) 93 52 / 18-0
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www.boschrexroth.de