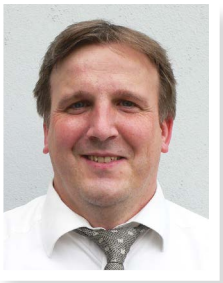
Fluid Rating

Validated hydraulic fluids increase the service life of the hydraulic system



Karl-Heinz Blum,
Fluid Validation,
Bosch Rexroth AG

Dipl.-Ing. Klaus Ellenrieder,
Head of Department Testing,
Elchingen, Bosch Rexroth AG

Over the past few years, the efficiency of hydraulic systems has again risen considerably. This also increases the demands that are made on the hydraulic fluids that are used, since they can have a crucial effect on the wear properties of hydraulic components. Relevant standards only define the minimum requirements of hydraulic fluids. They do not reflect further technical developments and do not make it possible to differentiate between the fluids. Bosch Rexroth offers the manufacturers of lubricants and additives a standardised assessment procedure based on scientific knowledge, which takes these aspects into account and tests the hydraulic fluids for suitability under realistic application conditions.

Due to increasing operating pressures, speeds, oil circulation and temperatures, the power density has risen considerably over the last few years. This means that the power-to-weight ratio for axial piston pumps and motors has more than doubled over the last few decades. These increases in performance place demands on the hydraulic fluids used more than ever before, therefore the quality requirements must increase.

Hydraulic fluids themselves have also been further developed technically. Both further developments with hydraulic systems and with hydraulic fluids are not adequately reflected in the relevant standards. In connection with these changes the hydraulic fluids combined with the operating conditions have a crucial effect on the wear properties and consequently the service lives and availability of hydraulic components.

The standard requirements for hydraulic fluids like DIN 51524 or ISO 11158 for mineral oils; ISO 15380 for environmentally compatible hydraulic fluids and ISO 12922 for fire-resistant ones only describe the minimum requirements that hydraulic fluids must have in the a new unused condition or in a container prior to filling complying with (Fig. 1). These requirements do not allow for differentiation of the fluids. The test standards for assessing the wear properties that are incorporated in them are often not adequate to assess fluids in practice with regard to their wear performance in the heavy-duty mixed friction area. The standard requirements do not take into account the chemicals used by lubricant manufacturers in the base oil and additives. Depending on the application

and operating conditions, however, this aspect can be highly relevant.

This is why there are component tests, which are defined in in-house standards, in addition to mechanical testing in a vane pump according to ISO 20763 and mechanical testing in an FZG (Institute of Machine Elements) gear wheel test rig A/8.3/90. They are intended to assess the suitability of the hydraulic fluid under real conditions on a product-specific basis.

Breaking down and using hydraulic fluids

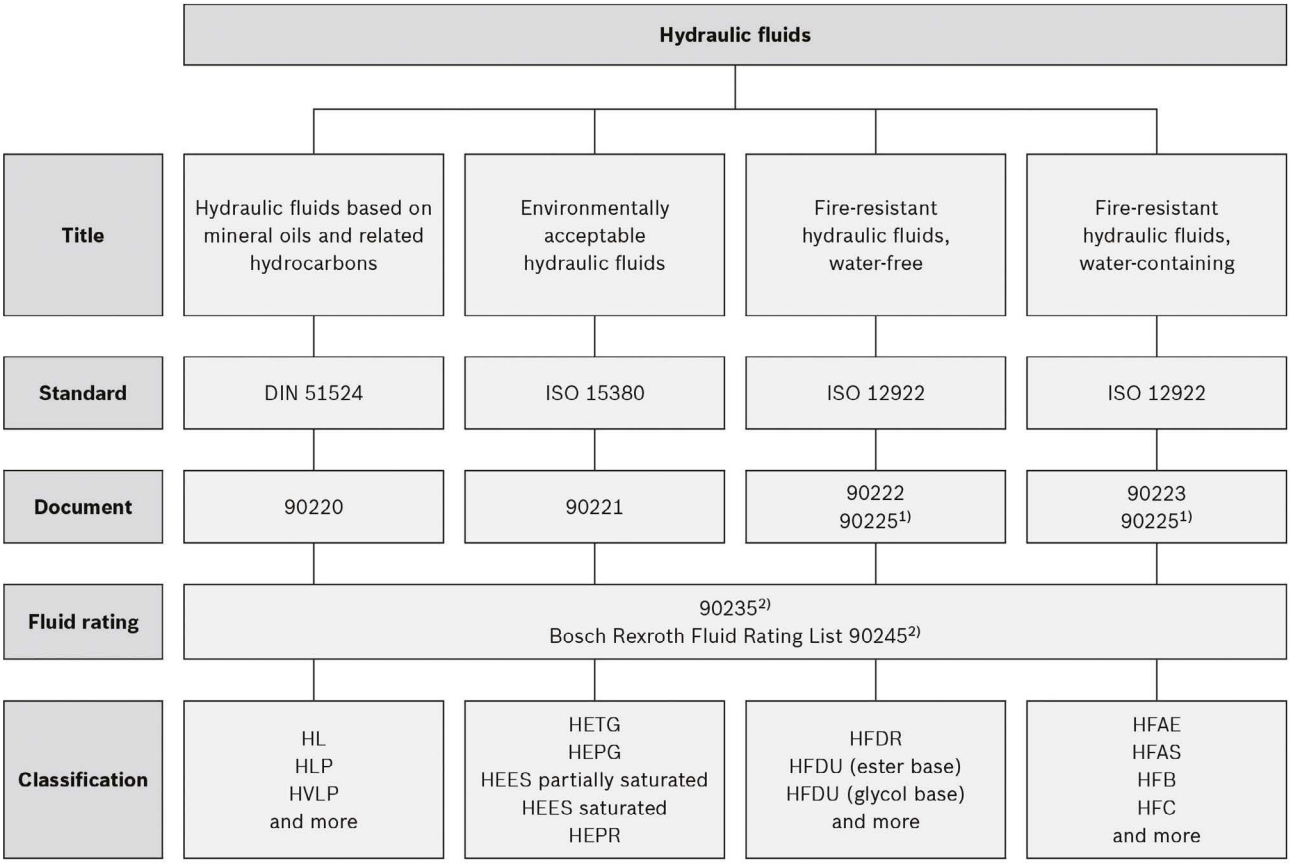
In the case of hydraulic fluids, a differentiation is made between fluids for hydrostatic applications and fluids for hydrokinetic ones. Based on the CETOP and ISO classification and taking into account domestic standards, it is possible to divide hydraulic fluids for hydrostatic applications into mineral oils, universal oils, food-safe, environmentally friendly and fire-resistant hydraulic fluids.

The most frequently used group of hydraulic fluids are the mineral oil-based, which account for about 88 percent of the market. The remaining 12 percent of the market share is occupied by synthetic base oils, such as esthers, polyalphaolefins (PAO) and polyglycols (PAG). With mineral oil base oils the trend is moving away from paraffinic API Group I oils (with a current market share in the group of 48 percent) and towards hydrated paraffins of API Group II (market share of 30 percent) and Group III (market share of 12 percent).

The DIN 51524 standard

DIN 51524 Part 3, Point 5 states: "In the heavy-duty mixed friction area in particular, it is possible in individual cases to agree on additional bench tests from the multitude of mechanical-dynamic tests that are not generally included in the catalogue of a requirements standard. Standardised test procedures and component tests have been proven for this purpose"[1].

Since the structures, combinations of materials used and the environmental conditions can place different stresses on the hydraulic fluid, it is preferable to use practice-relevant materials (e.g. SRE-NBR 28/PX with the seal test) that are specified in DIN 51524. Equally, practical conditions at testing, such as the operating time, temperature and pressure, for example, would make possible a much more application orientated



1) Valid for Bosch Rexroth axial piston units
2) Valid for Bosch Rexroth Business Unit "Mobile Applications" – pumps and motors

Figure 1. *Classification of hydraulic fluids (Copyright: Bosch Rexroth AG)*

assessment. Previous experience has shown that the wear test that is incorporated in DIN 51524 should be adapted to reflect much more closely current operating conditions and requirements. The trends with the hydraulic fluids and additives that are used must also be included to a greater extent in catalogues of requirements[2].

Bosch Rexroth has gathered a wide range of experience in numerous tests with fluids. Some of the hydraulic fluids that were tested demonstrated very different wear properties after a relatively short operating time in modern motor and pump applications: For example, a fluid that complied with the minimum requirements of the standard led to significant wear in pumps and motors after fewer than 100 operating hours. On the other hand, when using alternative, selected hydraulic fluids that also comply with the standard, it was not possible to detect a deterioration in the status of the components even after 510 operating hours with identical pumps and motors. The causes of failure due to fluid can be in the form of wear, cavitation, deposits or inadequate material resistance.

Figure 2. *Causes of failure due to fluid (Copyright: Bosch Rexroth AG)*

In spite of everything, machine manufacturers were only able to rely on the information provided by the fluid manufacturers when choosing fluids and to select suitable ones on the basis of trial and error. If the wrong choice is made here, it will result in machine standstills and expensive warranty claims.

To meet the aim of minimising the risk of damage due to fluids and to increase operating safety for machine manufacturers and operators, Bosch Rexroth has developed a neutral rating procedure based on existing DIN or ISO minimum requirements. This means that the company tests the behaviour of fluids in a practical way and the reciprocal effects on the core components of the pump and motor. It is suitable for all mineral oil-based hydraulic media, related hydrocarbons, environmentally acceptable media as well as fire-resistant anhydrous hydraulic fluids. Manufacturers of lubricants and additives can register at **www.boschrexroth.com/fluidrating** to have the effectiveness of their hydraulic fluids rated on an independent basis. The rating procedure is described in detail in Rexroth data sheet 90235.

All of the information in the technical data sheets of the manufacturers with regard to compliance with the appropriate requirement standard currently correspond to Bosch Rexroth's information in the respective component data sheets (minimum requirements). The machine manufacturer or fluid user does not carry out audits for the correctness of the characteristic fluid values.

Within the scope of the Rexroth Fluid Rating, Bosch Rexroth requests the technical characteristic values of the hydraulic fluid to be tested from the manufacturer, checks them for plausibility and has them confirmed for compliance with the standard. The additional requirements include stricter standard characteristic values, motor and pump tests as well as a specified, static seal test that evaluates the suitability of the hydraulic fluid with defined Rexroth components and conditions. Depending on the fluid category and the Rexroth components that are used, the fluid test must have been passed before commissioning the fluid rating. In addition, retention samples of the base oils that are used and the hydraulic fluid that is to be tested are stored for future reference.

If the hydraulic fluid meets all the requirements of RDE 90235, it is included in Bosch Rexroth Fluid Rating List 90245. The Fluid Rating List replaces current market overviews RD 90220-01 (mineral oils) and RD 90221-01 (environmentally acceptable hydraulic fluids).

In addition to this, the manufacturers of the hydraulic fluids that are listed in RD 90245 are issued with a quality label (Fig. 3). This means that users can recognise immediately that the hydraulic fluid in question is a tested, high-quality one.

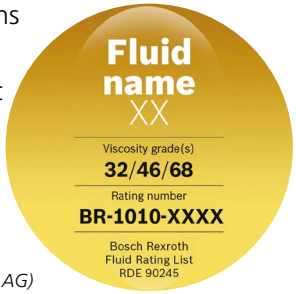


Figure 3. *Label (Copyright: Bosch Rexroth AG)*

The fluid test

Bosch Rexroth currently offers one fluid test each for closed loops and open loops. Rexroth's "Fluid Test Axial Piston Unit Closed Loop" (RFT-APU-CL) (Fig. 4) represents the current requirements of a hydrostatic drive. It uses a combined unit consisting of a swashplate hydraulic pump (A4VG045EP) and a swashplate hydraulic motor (A6VM060EP) (Fig. 5).

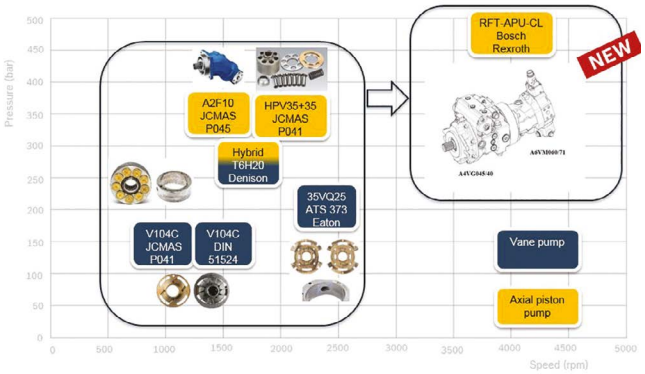


Figure 4. *Comparison of test conditions for pump tests (Copyright: Bosch Rexroth AG)*

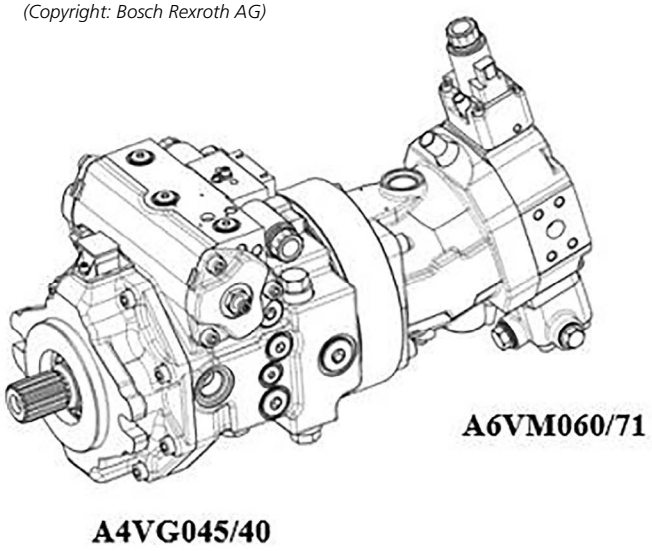


Figure 5. *RFT-APU-CL test samples (Copyright: Bosch Rexroth AG)*

Under real-world conditions the hydraulic fluid goes through a break-in, a cyclic phase and a full speed and pressure phase. At high loading levels, the unit runs for several hundred operating hours at 4000 RPM during the test and at an operating pressure of up to 500 bar.

Following the test the combined unit is disassembled and the combination of effects between the hydraulic fluid and the components are examined. While doing this, changes in the weight of the components or in their dimensions are measured and a visual inspection is carried out of the component's surfaces. From this, Bosch Rexroth specialists derive material compatibilities and wear properties. In addition to this, they analyse the condition of the hydraulic fluid before, during and after the test. This allows them to draw valid conclusions about continuous operation or wear properties. Depending on the pump/motor combination and the hydraulic fluid used, we envisage further tests in future, including cavitation and ageing properties for example.

Figure 6 shows an example of a visual assessment of pump components that have been operated using hydraulic fluids that are normally available on the market. Fluid A did not pass the fluid test due to the wear properties that occurred. Fluid B demonstrates wear properties after 510 hours, which successfully passed the fluid test.

Figure 6a+b. *On the one hand, Bosch Rexroth tests show fluids that have led to significant damage after fewer than 100 operating hours. Other hydraulic fluids cause no wear whatsoever after 510 hours. (Copyright: Bosch Rexroth AG)*[3].

Rexroth's "Fluid Test Axial Piston Unit Open Loop-HFC" (RFT-APU-OL-HFC) for hydraulic fluids in an open loop represents the requirements for applications specifically with fire-resistant, aqueous hydraulic fluids of Category HFC. The fluid test consists of a constant conditions phase and a swivel cycle test. The test consists of a high-pressure (A4VSO125) swashplate combined unit and a medium-pressure (EA-10VSO18) swashplate unit. Here too, the combined unit is disassembled after the test and the components and hydraulic fluid are inspected for their relative effects according to similar rating criteria as with the "RFT-APU-CL" fluid test.

Conclusion

As Karl-Heinz Blum, the manager responsible for fluid validation at Bosch Rexroth, emphasises, "Our results from fluid ratings demonstrate enormous differences between the hydraulic fluids that are available on the market, even though they all meet the minimum requirements of the standards. "Machine manufacturers who use the Bosch Rexroth Fluid Rating List to orient themselves when selecting hydraulic fluids improve operational safety, reduce the probability of pump and motor failure and lower downtime and maintenance costs". If desired, Bosch Rexroth also offers a fluid test bench (RFT-APU-CL) that the manufacturers of lubricants and additives can use in test laboratories for their own development work, for example (Fig. 7).

Figure 7. *Abb. 7: If desired, Bosch Rexroth also offers an RFT-APU-CL fluid test bench that the manufacturers of lubricants and additives can use in test laboratories for their own development work, for example. (Copyright: Bosch Rexroth AG)*

List of references

Source: Geimer, M.; Synek, P.-M.: 9th Mobile Hydraulics Colloquium. Karlsruhe: Karlsruher Schriftenreihe Fahrzeugsystemtechnik, Institut für Fahrzeugsystemtechnik, 49, 2016 [Karlsruhe Vehicle System Technology Publication Series, Institute for Vehicle System Technology]

1 DIN 51524-3: 2006-04, Pressure fluids - Hydraulic oils - Part 3: HVLP hydraulic oils; Minimum requirements

2 Wilfried J. Bartz and 18 co-authors: Hydraulikflüssigkeiten, Eigenschaften, Normung und Prüfung. Renningen: Expert Verlag, 1995 [Hydraulic fluids, characteristics, standardization and testing. Renningen: Expert Verlag publishers]

3 Bosch Rexroth AG: rating of hydraulic fluids flyer, RD 98129

LINK:
www.boschrexroth.com