

Keeping things fluid - a guide to best practice in:

# Hydraulic fluid selection and management



# Introduction

**When, in 1795, British mechanic Joseph Bramah applied the principle of Pascal's law to patent the first hydraulic press, he can have had no idea of the extent to which hydraulic systems would develop and proliferate over the next 200 years.**

Today, hydraulic systems drive everything from small items of manufacturing equipment to massive steel fabrication processes, lifts and the braking systems of cars. They are fundamental to many of the manufacturing, distribution and transport systems that we all rely on so heavily.

Pascal's law, upon which hydraulic systems are based, states that pressure applied at any point to an enclosed fluid is transmitted undiminished throughout that fluid and acts upon every part of the structure or object within which it is contained. In other words, the pressure of a fluid within an enclosed space is constant throughout. The fluid within a hydraulic system is that system's fundamental driving force: in an effective hydraulic system, the forces exerted by the fluid are sufficient to get the job done with minimal need for mechanical intervention. So, hydraulic systems can achieve extremes of strength and productivity, based on the performance of their hydraulic fluid.

Not all hydraulic fluids, however, perform to the same standards, and many of the tests used to assess minimum requirements are inconclusive. Of two seemingly similar

fluids, both in theory meeting these minimum requirements, one could cause significant damage to equipment after as few as 100 operating hours, while the other could create no ill-effects at all, even after 500 hours of operation.



Bosch Rexroth ABPAC modular power unit

“The results show that suitable fluids substantially lengthen the service life of hydraulic components and therefore significantly lower the probability of failure.”

“Faced with evolving technology and tougher operating conditions, modern manufacturing companies are placing greater emphasis on improving equipment efficiency and driving down total cost of ownership (TCO).”

The condition and quality of the hydraulic oil has a direct impact on the performance of the system. ... Indeed, many surveys conducted by hydraulic equipment manufacturers and other industry bodies have shown that 50% to 70% of equipment failures are related to ‘improper hydraulic fluid condition’..... “Every part of your machine or process has been meticulously engineered, so you want to be sure that you choose a lubricant that has been designed to ensure that your equipment is well protected and works efficiently.”

**Ulf Rieper, OEM Approvals Manager, Shell Lubricants**

# Introduction

“Numerous hydraulic pump tests are conducted to ensure high performance additives, used to formulate hydraulic fluids around the world, not only meet the latest specifications but also provide superior performance and proven durability for hydraulic operators in a variety of end uses and all climatic conditions.

While there have been significant changes in hydraulic equipment over many years, with power densities increasing and sump sizes getting smaller, surprisingly, hydraulic fluid specifications have remained relatively unchanged.

However when Bosch Rexroth introduced the new RE90235 specification, the testing regime finally reflected the performance demands of modern hydraulic systems. This has been the most significant step change seen in the world of hydraulics in many years. It is fair to say that up to this point, increases in pressures and pump speeds with respect to hydraulic fluid testing were small. However, to reflect the huge increases in power densities seen in modern hydraulic systems, testing is conducted at 4,000 rpm, with variable flow and a pressure of up to 500 bar. The increases in testing conditions represent a huge increase in performance and place enormous stress on hydraulic components and the fluids that are required to protect them.

A system that is running at higher temperatures, under higher pressures and at higher speeds needs a fluid that is capable of withstanding the high thermal stress whilst delivering enhanced wear protection. These are all parameters that can cause failure of hydraulic system components and lead to catastrophic failure and costly downtime. Given the arduous conditions of this new testing regime it is not surprising to learn that a large number of hydraulic fluids on the market today will simply not meet these requirements.

Bosch Rexroth have set a new standard for hydraulic fluids, a standard that meets the requirements of today’s modern hydraulic systems and the challenges of tomorrow.”

**David Lancaster, Global Marketing Manager, Lubrizol Ltd.**

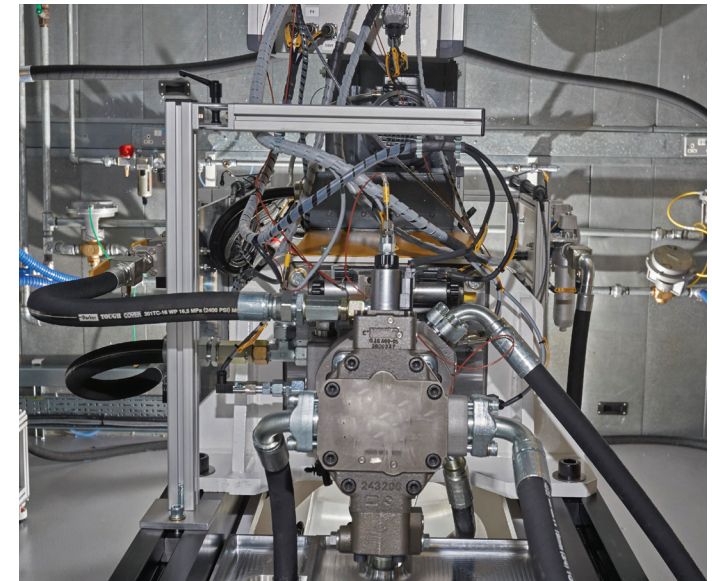


Image courtesy of Lubrizol Ltd. Test rig incorporating Bosch Rexroth pump and motor

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# Why is hydraulic fluid needed?

Of course, the demands placed upon hydraulic systems have come a long way since Bramah's day. The need for ever greater volumes of power, for example in modern industries such as aviation and mechanised farming, has revolutionised the use and design of hydraulic systems. In a similar way, other sectors, particularly electronics and computer technologies, are increasingly evolving their design, allowing the production of ever more compact, precise, efficient and targeted hydraulic equipment, often integrated with computerised or electronic controls.

All of this means now that hydraulics manufacturers often use smaller components but these work at much higher pressures: this increases power density, but it can affect other parts of the system such as heat distribution and temperature control. As a result, hydraulic fluid comes under much greater stress now than in the past and fluids that have not evolved to cope with these demands may compromise equipment and outputs. Specifying the right fluid can save users a great deal of time (including costly downtime) and money, as it can optimise performance and equipment life cycles while minimising the dangers of equipment damage and failure.

Fluid choice is important because hydraulic fluid does many things within a hydraulic system. While its primary purpose is to transmit power, it fulfils many other duties depending on the system in which it is used. For example, hydraulic fluid can transfer heat to and away from parts of the

system, helping to maintain optimal temperature and thereby protecting the machine and its components from damage. Hydraulic fluid lubricates and cools bearings and moving parts and also removes contaminants, taking particles and other unwanted elements away from critical areas to the nearest filter or conditioning device. This too protects the system and its outputs: if contaminants are not removed, they may accumulate and cause damage over time. Hydraulic fluid may also act to form a seal (particularly within internal components of pumps, valves and motors) and to lubricate.

In short, hydraulic fluid not only powers a hydraulic system, but also protects and sustains it – but the extent to which it achieves these may vary hugely according to fluid choice, as we shall see. With hydraulic machinery operating within increasingly demanding specifications and environments, choosing the right hydraulic fluid is perhaps more important now than ever. In this white paper we will find out why that is, and examine the factors involved in choosing the best hydraulic fluid.



Example of hydraulics in harsh environments; Steelworks hot rolling mill

# Why is correct fluid selection so important?

As we have seen, hydraulic fluid is effectively the lifeblood of any hydraulic system, fulfilling a range of duties. Every part of every component in a hydraulic system relies on the fluid to maintain its temperature and lubricate it. The hydraulic system as a whole relies on hydraulic fluid to maintain optimal temperature – without which hydraulic equipment cannot function efficiently and may ultimately fail – as well as to remove water, maintain pH and de-aerate.

To achieve these objectives, a hydraulic fluid must be suited to its environment. With the requirements of hydraulic equipment becoming ever more demanding, with higher pressures, tighter tolerances, smaller reservoirs and wider temperature ranges, hydraulic fluids have had to evolve. Manufacturers are now producing fluids that are more targeted and tailored to those environments than ever before.

Simultaneously, improved systems for rating and assessing those fluids have also developed; for as we have seen, some of the standards previously used to rate fluids are no longer sufficient. Truly effective and specific rating systems allow users to ascertain a fluid's performance in real operating conditions and in key areas, such as viscosity (and specifically, the ability to maintain a specific viscosity in use, given the parameters of the desired application), environmental concerns and materials compatibility, when looking for the best fluid to meet their own specific needs.

Most hydraulic fluids are oils; usually they are based on mineral oil, although some are synthetic, and can be monograde, multigrade, environmentally acceptable and/or fire resistant, according to need. Fully synthetic oils, for example, may be used to help machinery cope with large swings in temperature and/or pressure. There are now biodegradable hydraulic oils on the market, with more in development. Water-based hydraulic fluids are also available, and often used where fire resistance is important, but these often require specific engineering parameters in the equipment where they are used and offer much lower protection against wear than their more conventional counterparts. Most hydraulic systems use hydraulic fluids based on mineral oil. The precise nature of each hydraulic fluid is determined largely by the additives incorporated into the base oil; for example some are blended to minimise corrosion and damage by wear, some to optimise fire resistance, and so on.

The choice of hydraulic fluid will depend largely on the qualities that the end user seeks, operating conditions such as temperature range and the application involved. Environmental concerns may also play a part. Yet while many end users will have a good idea of the qualities they want in a hydraulic fluid, there may be other concerns of which they are less aware. For example, is their fluid of choice compatible with the materials used in their system, and if so for how long? If it is compatible, are there other qualities in the oil that may conflict with and be potentially damaging to their equipment or productivity rates?

And of course, as the nature of hydraulic equipment changes in line with technological advances, and the capability of fluids increases, a fluid which has suited a user in the past may not be able to keep up with more modern applications, and a different fluid may generate far better outcomes. For example, older hydraulic fluids may have required changing every 1000 hours or less, but some of the leading modern fluids not only perform better in operation, but have much extended drain intervals - in some cases around 6000 hours. The potential benefits here are obvious.



Image courtesy of Finning Fluid Analysis

# How can users assess fluids?

The key international standards which govern hydraulic fluids are ISO6743-4, ISO4406, ISO 15380, ISO12922 and DIN 51524. However, some feel these specifications are no longer sufficient, because they fail to reflect the more demanding requirements of modern hydraulic systems. Pump tests have revealed that some standardised fluids can quickly generate signs of wear in hydraulic components, while others leave the same components in pristine condition over many hundreds of hours. In short, not all hydraulic fluids are equal, and there is a great deal to be gained by users of hydraulic equipment if they can specify the fluid that gets the best from their system. To do this they need accurate, validated data that goes well beyond the minimum specifications.

Bosch Rexroth has, in response to this need, developed a validating procedure that is scientifically sound, standardised and independent. All manufacturers are invited to submit their oils for this validation, the results of which are published in the Bosch Rexroth Fluid Rating List (RE 90245). Bosch Rexroth subjects each hydraulic fluid to a range of tests at high loads over hundreds of operating hours, the results of which correlate with field tests. This reveals the behaviour of each fluid and its interaction with core component pumps and motors under realistic operating conditions. As Karl-Heinz Blum, Basic Development Fluids at Bosch Rexroth, puts it: „The results show that suitable fluids substantially lengthen the service life of hydraulic components and therefore significantly lower the probability of failure.“

The Bosch Rexroth evaluation procedure, which is described in Rexroth datasheet 90235, is suitable for all mineral-oil-based hydraulic media, environmentally acceptable media and fire-resistant, water-free hydraulic fluids. While other ratings systems do exist (such as the Eaton and Denison specifications), the assessment specified in datasheet 90235, the results of which are published in the Bosch Rexroth Fluid Rating List (RE 90245), is now the most demanding and comprehensive in the world.

Manufacturers, conscious of the ever-increasing demands of hydraulic systems, have been quick to submit their products for assessment, which means Bosch Rexroth is compiling a steadily growing database of hydraulic fluid properties under real conditions. This helps manufacturers and users of hydraulic equipment to choose the fluid best suited to their application, and in doing so, optimise their operations.

The Drive & Control Company **Rexroth**  
Bosch Group

**Bosch Rexroth Fluid Rating List**  
für Rexroth-Hydraulikkomponenten (Pumpen und Motoren)  
*for Rexroth hydraulic components (pumps and motors)*

**RDE 90245**  
Edition: 08.2016

Die unten genannten Hydraulikflüssigkeiten sind von der Bosch Rexroth AG positiv bewertet. Sie erfüllen die Bedingungen nach RD 90235 für eine Listung in der Bosch Rexroth Fluid Rating List 90245.

*Hydraulic fluids mentioned below have been rated favourably by Bosch Rexroth AG. The requirements for listing according to RE 90235 on the Bosch Rexroth Fluid Rating List 90245 are fulfilled.*

Klassifizierung von Hydraulikflüssigkeiten / Hydraulic Fluids Classification					
Hydraulikflüssigkeiten auf Basis von Mineralölen und artverwandten Kohlenwasserstoffen / <i>Hydraulic fluids based on mineral oil and related hydrocarbons</i>	HL (HL), HLP (HM), HVL (HV) und weitere / and other				
Umweltverträgliche Hydraulikflüssigkeiten / <i>Environmentally acceptable hydraulic fluids</i>	HETG, HEPG, HEES, HEPR				
Schwerentflammbare Hydraulikflüssigkeiten – wasserfrei / <i>Fire-resistant, water-free hydraulic fluids</i>	HFDR, HFDU und weitere / and other				
Schwerentflammbare Hydraulikflüssigkeiten – wasserhaltig / <i>Fire-resistant, water-containing hydraulic fluids</i>	HFAE, HFAS, HFB, HFC und weitere / and other				

**Hydraulikflüssigkeiten auf Basis von Mineralölen und artverwandten Kohlenwasserstoffen / Hydraulic fluids based on mineral oil and related hydrocarbons**

Hersteller / Manufacturer	Fluidname / fluid brand name	Legend	ISO VG	Kategorie / Category	Gültigkeitsdatum bis (YYYY/MM) / Valid until (yyyy/mm)
Fuchs Schmierstoffe GmbH	Renolin B HP	1 ● ● ●	32 46 68	HLP (HM)	2021/03
Fuchs Schmierstoffe GmbH	Renolin B HP Plus	1 ● ● ●		HLP (HM)	2021/01
Liqui Moly GmbH	Liqui Moly Hydrauliköl HYPER SG1	1 ● ● ●		HLP (HM)	2021/01
Shell International Petroleum Company	Shell Tellus S2MX	1 ● ● ●		HLP (HM)	2021/03
SRS Schmierstoff Vertrieb GmbH	Wiolan HB	1 ● ● ●		HLP (HM)	2021/03

**Legende / Legend**  
1 Zinkhaltig / with zinc  
2 Zinkfrei / without zinc

Von der Bosch Rexroth AG positiv bewertete Hydraulikflüssigkeiten dürfen von den Schmierstoffherstellern in deren Datenblättern oder sonstigen Publikationen mit folgendem Vermerk geführt werden:  
Erfüllt die Anforderungen gemäß Bosch Rexroth RDE 90235 oder Bosch Rexroth Fluid Rating List RDE 90245.  
Nicht oder negativ bewertete Hydraulikflüssigkeiten dürfen diesen Vermerk nicht führen.

*Hydraulic fluids rated favourably by Bosch Rexroth AG may be listed by the lubricant manufacturers in their data sheets or other publications with the following note:  
Meets the requirements of Bosch Rexroth RDE 90235 or Bosch Rexroth Fluid Rating List RDE 90245.  
Hydraulic fluids that have not been rated or that have been rated negatively may not carry this note.*

RDE 90245/08.2016, Bosch Rexroth AG

**Bosch Rexroth Fluid Rating List RDE 90245, August 2016**

# What should users look for in a hydraulic fluid?

Some qualities are valued by almost all users of hydraulic fluid – for example, most would like their oil to have an extended lifespan (saving costs in terms of oil purchase and maintenance), to contribute to extending the lifespan of their equipment (saving costs in terms of maintenance and replacement), and to optimise efficiency. As we have seen, modern fluids are having to do this in the face of increasing pressures and temperatures. Thus, to function well in the modern world a hydraulic fluid must:

- Protect the system from damage, such as wear and corrosion.
- Promote thermal stability.
- Promote air release.
- Resist oxidation.
- Operate at optimal viscosity throughout the process.
- Have good properties in terms of foaming and filterability.

Modern hydraulic fluids can have all of these properties, but not all fluids on the market perform as well as each other, so operators and manufacturers need to look beyond the information on the packaging and delve more deeply into product qualities.



Image courtesy of Lubrizol Ltd. Test engineer on fluid test rig incorporating Bosch Rexroth pump and motor.

# How should the specification/selection process be carried out?

In order to choose the best possible fluid, the operator or person specifying should gather all of the relevant information. This is likely to include, but not be limited to, the following:

- The manufacturer's specifications and/or recommendations regarding hydraulic fluids.
- The compatibility of the oil and materials involved.
- The application for which the hydraulic system is to be used. Critical and finely-tuned applications may merit the highest grade of hydraulic fluid that is available for that environment; less sophisticated applications and machinery may not justify the extra cost involved and thus a lower grade of fluid may be deemed sufficient. There may be considerations around temperature and pressure levels and variations, the dangers of fire or a need to minimise the impact of contamination on people or the local environment.
- The pump design type and viscosity requirements – the manufacturer's information will be important here, along with information about the pump's operating environment, e.g. temperatures. Having fluid of incorrect viscosity can seriously limit the performance and lifespan of the system, and in particular the pump, so it is important to get this right. It is also important to determine the viscosity index (VI) of any potential hydraulic fluid, because this indicates how the fluid flows across the range of temperatures within which it operates.
- The final destination of the equipment – for example, if equipment is to be taken overseas, are there regulatory or legal requirements to be considered? What would be the result of any accidental fluid spill or drain in any final destination? Are there environmental concerns to bear in mind? Some settings, such as maritime and forestry applications, demand oils that will not threaten wild or marine life.
- Any data concerning real-life operation of the fluid is extremely helpful. Information on the label may indicate that a fluid meets standardised levels at the point of sale, but this does not, necessarily, say anything at all about its performance in the field.

In other words, the selection of hydraulic fluid depends on many interdependent variables, of which viscosity, and the way in which viscosity is influenced by temperatures during operation, is the most crucial.

When all relevant information has been gathered, it is a question of narrowing down the options (i.e. which fluids are suitable for this equipment and application?) and then of assessing the pros and cons of each. This is the point at which field-based testing data becomes invaluable. In some

cases, more than one fluid may be suitable but using a fluid other than in accordance with the manufacturer's recommendations may affect warranties. In such cases, it is sensible to consult the manufacturer and a technical specialist before making a decision.



Example of hydraulics in a harsh environment; mining excavator and haul truck



# Maintaining oil inside – and outside – the hydraulic system

Once the choice of hydraulic fluid has been made, the operator must ensure the oil is properly maintained. This is largely because hydraulic fluid that becomes degraded or contaminated in situ can cause severe damage to the pump and other components, sometimes to the point of system failure. Incorrect viscosity can affect system performance, generating leaks, pressure loss, cavitation and other issues.

Hydraulic oil has a finite life span. As soon as the oil enters the system, the additives within it begin to be used up and the ability of the oil to lubricate and protect the system starts to decrease. Any oxidation and contamination that occurs during use, including water contamination, will have a similar effect. These changes are generally reflected in the colour and smell of the fluid: it darkens over time and may develop a stronger odour.

Consequently, oil analysis is an important part of monitoring any hydraulic system. Oil can be assessed by an external laboratory, or in-house, depending on the expertise available. In any case, oil analysis can identify contamination and degradation of the oil, and its likely remaining life. It is important to remember that many contaminants are abrasive and thus damaging to equipment, while oxidised oil can form a 'sludge' which sticks to valves and compromises equipment performance. Keeping an eye on hydraulic oil, even

when it is in the machinery, is critical.

When the oil becomes too dirty and/or has too much water suspended in it, it must be treated with additional offline filtration or a dewatering unit and the source of the problem located and dealt with. An oil only needs changing when the additives cease to be effective and no longer provide the protection they were intended for. When this is done the system must be clean, the oil must be clean from initial fill, the (clean) products correctly assembled and a proper start-up procedure must be followed. Oil has a finite life, but its length is largely dependent upon the way the machine is maintained and looked after.

In a similar way, oil awaiting use must be stored correctly to avoid contamination and loss of quality. If water is allowed to contaminate the oil, it can reduce the oil's life and performance – the same is true of other contaminants, including air, so oil in storage must be protected, and sampled regularly to make sure it has not been inadvertently damaged.



Image courtesy of Finning Fluid Analysis. Oil analysis laboratory.

# In summary

Choosing the correct hydraulic fluid may seem daunting, but as long as sufficient data is gathered and assessed, it need not be so. Operators and manufacturers must recognise the changing nature of hydraulic systems, and in particular the dramatically increased stresses that modern hydraulic systems put upon hydraulic fluids. Not all fluids can cope and the dangers of choosing an inappropriate fluid – for hydraulic equipment of any age and application are considerable. They include compromised equipment performance and reduced productivity, damage to equipment and the related costs including maintenance, downtime and replacement, and the danger of injury to operatives, especially if failure occurs without warning. Conversely, the benefits of choosing a highly appropriate, high performance fluid are also considerable, and can include longer equipment life, better productivity and outputs and cost savings in terms of maintenance, replacement and downtime.

As we have seen, choosing the 'best fit' hydraulic fluid is not merely a matter of deciding which fluid will work with which machine. Just because a hydraulic system can run on a given fluid, that doesn't make it necessarily the best fluid for the job. So some research and consideration of the variables involved is required.

However, the benefits of creating a perfect fit between hydraulic system and hydraulic fluid make the effort well worthwhile. As long as it is accompanied by a best practice storage and maintenance regime, and regular inspection of the oil both in

the machine and in storage, and correct use of the system, choosing the best hydraulic fluid and caring for it correctly are the most important things that any operator can do to ensure the performance and longevity of their hydraulic equipment.



Example of hydraulics in harsh environment; Large 2 stroke marine engine with hydraulics valve actuation and fuel injection

If you would like to

## Find out more

then give us a call on

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@boschrexroth.co.uk**

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# In summary

“As a leading partner to companies involved in hydraulic applications across a broad spectrum of industrial sectors, our aim is always to fully understand individual customer requirements then match the most appropriate solution from our portfolio.

Best practice in fluid selection and management is a vital driver in ensuring safe, legal and high-quality operation, and extracting the very best performance and service life from a company’s capital investment.

Bosch Rexroth’s prowess as a supplier of hydraulic equipment is matched by the company’s commitment to working with suppliers of consumables to deliver optimum performance for customers. Nowhere is this better illustrated than by Bosch Rexroth’s Fluid Ratings List, drawing on many hours of painstaking research to recommend the very best fluid solutions for individual application types.

This work goes way beyond simply assessing fluids against international standards, and encompasses deeper, extended tests in the most demanding operating conditions – in short, providing as strong a guarantee as possible of how a fluid will perform in service. Testing of this rigorous nature will become even more important as the demands on hydraulic systems intensify in the face of increased pressure on productivity,

efficiency and sustainability, making the Bosch Rexroth Fluid Ratings List the ‘go to’ document for more and more specifiers worldwide.

**Clemens Pieper, Product Manager AS / IS, SRS  
Schmierstoff Vertrieb GmbH**

