

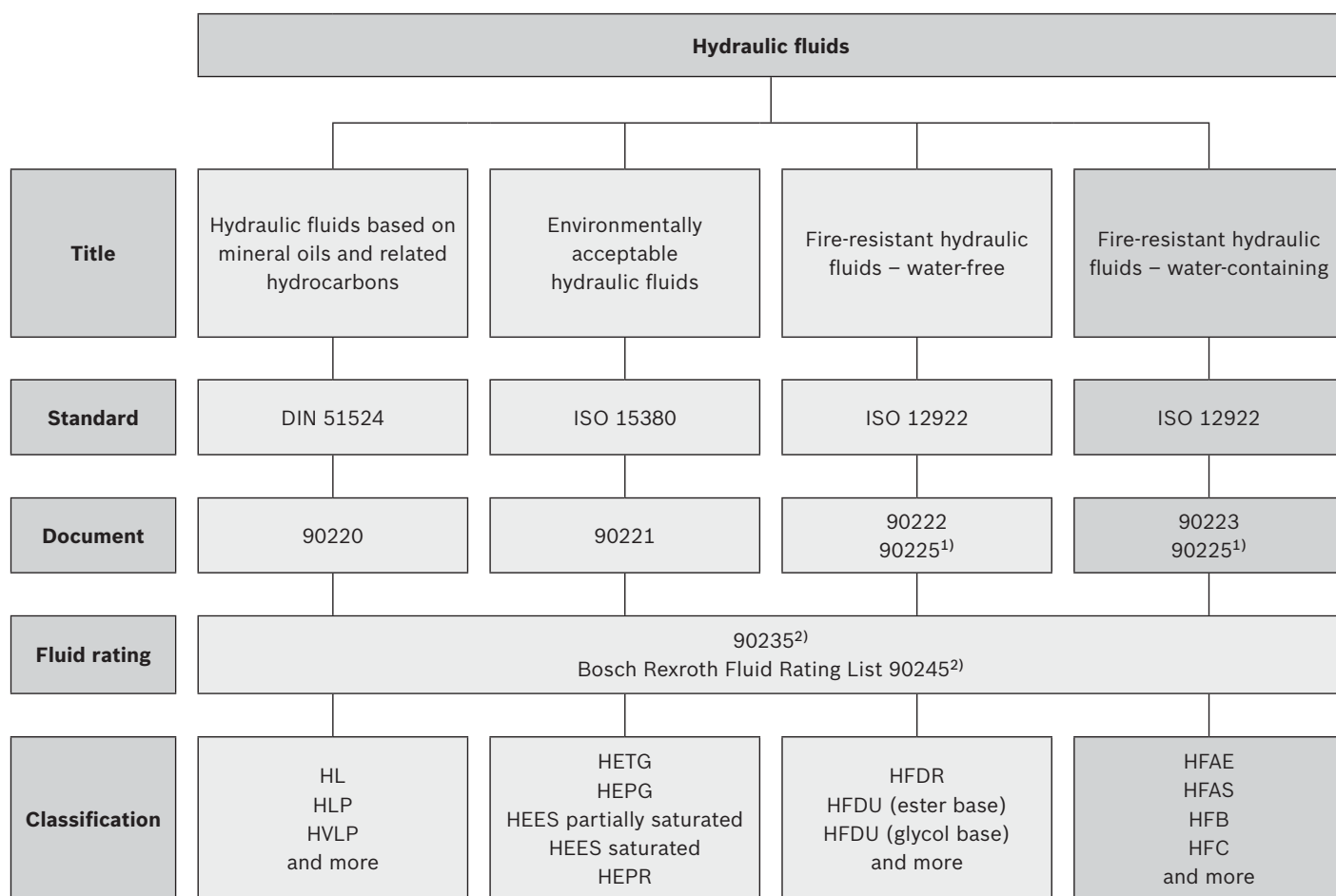
Fire-resistant hydraulic fluids – water-containing (HFAE, HFAS, HFB, HFC)

RE 90223

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Application notes and
requirements for Rexroth
hydraulic components



1) Valid for Bosch Rexroth axial piston units

2) Valid for Bosch Rexroth Business Unit "Mobile Applications" – pumps and motors

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1 Basic information

1.1 General instructions

Hydraulic fluid is the common element in any hydraulic system and must be selected very carefully. Quality and cleanliness of the hydraulic fluid are decisive factors for the operational reliability, efficiency, and life cycle of the system. Hydraulic fluids must conform, be selected and used in accordance with the generally acknowledged rules of technology and safety provisions. Reference is made to the country-specific standards and directives (in Germany the directive of the Employer's Liability Insurance Association BGR 137).

This document includes recommendations and regulations concerning the selection, operation, and disposal of water-containing, fire-resistant hydraulic fluids in the application of Rexroth hydraulic components.

The individual selection of hydraulic fluid or the choice of classification are the responsibility of the operator.

It is also the responsibility of the operator to ensure that appropriate measures are taken for safety and health protection and to ensure compliance with statutory regulations. The recommendations of the lubricant manufacturer and the specifications given in the safety data sheet are to be observed when using hydraulic fluid.

This document does not release the operator from verifying the conformity and suitability of the respective hydraulic fluid for his system. The operator of a hydraulic system must ensure that the hydraulic fluid remains fit for purpose throughout its entire period of use.

The currently valid standard for fire-resistant hydraulic fluids is ISO 12922. In addition, even more detailed documents, guidelines, specifications, and laws (the observance of which the operator shall also be responsible) may be valid. This includes, for instance:

- a. 90235 - Assessment of hydraulic fluids used in Rexroth hydraulic components (pumps and motors)
- b. 7th Luxembourg Report: Luxembourg, April 1994 - Doc. No. 4746/10/91 EN "Requirements and tests applicable to fire-resistant hydraulic fluids used for power transmission and control (hydrostatic and hydrokinetic)"
- c. VDMA 24314 (1981-11): "Change of pressure liquids – Directives"
- d. VDMA 24317 (2005-11): "Fire-resistant hydraulic fluids - Minimum technical requirements"

- e. FM Approval Standard 6930 (2009-04): "Flammability Classification of Industrial Fluids" (only available in English)
- f. DIN Technical Report CEN/TR 14489 (2006-01): "Selection guidelines for protecting safety, health, and the environment"
- g. BGR 137 - Handling hydraulic fluids (1997-04): German trade association rules health and safety at work.
- h. DIN 24320: "Fire-resistant fluids - Hydraulic fluids of categories HFAE and HFAS - Characteristics and requirements"
- i. List of hydraulic fluids in the set of regulations for the mining sector (coal mining): http://www.bezregarnsberg.nrw.de/themen/s/schwerentflammbare_hydraulikfluessigkeiten/index.php
- j. RAG N 762010 (2012-10): "Fire-resistant hydraulic fluids HFC-E, requirements"
- k. RAG N 762011 (2012-09): "Requirements on synthetic, fire-resistant hydraulic fluids (HFA-S and synthetic emulsions)"
- l. Ordinance for all mining sectors - ABergV (1995-10): General Federal Mining Ordinance
- m. Occupational Health and Safety Ordinance for Mines (GesBergV) (1991-07): Mining ordinance for the health protection of mineworkers

We recommend that you maintain constant, close contact with lubricant manufacturers to support you in the selection, maintenance, care, and analyses.

When disposing of used hydraulic fluids, apply the same care as during use.

1.2 Fire resistance

There is no clear legal definition of fire-resistant hydraulic fluids. There are great differences regarding fire resistance. Selection is the sole responsibility of the system operator with respect to requirements (application, construction and design of the system, hottest ignition source in the system, required fire protection).

The most important task in determining the fire resistance of hydraulic fluids is to find a test method that reproduces the situation occurring in a specific application. Different test methods are used to assess the fire resistance according to ISO 12922:

- ▶ Spray ignition characteristics according to ISO 15029-1 (Spray flame persistence – Hollow-cone nozzle method)
- ▶ Spray ignition characteristics according to ISO 15029-2 (Stabilized flame heat release method) Flammability index (RI)
- ▶ Wick flame persistence of fluids according to ISO 14935 (average flame persistence)
- ▶ Flammability on hot surfaces according to ISO 20823 (ignition temperature, spread of flame)

The required minimum values for the ignition temperature differ according to ISO 12922:

HFB: 650 °C, HFC: 600 °C, HFDU: 400 °C, HFDR: 700 °C

In general, fire-resistant hydraulic fluids are distinguished between fire-resistant, **water-free**, and fire-resistant, **water-containing** hydraulic fluids. The fire-resistant, water-free hydraulic fluids are described in Document 90222.

Fire resistant, water-containing hydraulic fluids are normally understood as hydraulic fluids with a proportion greater than 35% by mass of water (according to ISO 12922).

Information

- ▶ Only fire-resistant, water-containing hydraulic fluids can currently receive approval from the mining authorities for use in coal mining below ground.
- ▶ In contrast to water-free fluids, all fire-resistant, water-containing hydraulic fluids do not have a flash point or combustion point.
- ▶ The test conditions for determining the flammability on hot surfaces vary significantly within ISO 12922 between fire-resistant, water-free and fire-resistant, water-containing hydraulic fluids (e.g. different testing temperatures).
- ▶ Just as much care should be taken when working with fire-resistant hydraulic fluids as with other hydraulic fluids, e.g. mineral oils. Leakage in the hydraulic system must be prevented. The best and most cost-effective protection against fire and explosion is to prevent leakage with meticulous servicing, and maintenance and care of the hydraulic system.
- ▶ If possible, the system should be designed such that fires and explosions cannot arise.

1.3 Scope

This document must be applied when using fire-resistant, water-containing hydraulic fluids in Bosch Rexroth hydraulic components. Please note that the specifications in this document may be further defined by the data sheets for the individual components.

The use of the individual fire-resistant, water-containing hydraulic fluids according to the intended purpose can be found in the safety data sheets or other product description documents of the lubricant manufacturers.

Rexroth hydraulic components may only be operated with fire-resistant, water-containing hydraulic fluids according to ISO 12922 if this is specified in the respective component data sheet or if a Rexroth approval for use is furnished.

The manufacturers of hydraulic systems must adjust their systems and operating instructions to the fire-resistant, water-containing hydraulic fluids.

Bosch Rexroth will accept no liability for its components for any damage resulting from failure to comply with the notes below.

1.4 Safety instructions

Hydraulic fluids can constitute a risk for persons and the environment. These risks are described in the hydraulic fluid safety data sheets. The operator is to ensure that a current safety data sheet for the hydraulic fluid used is available and that the measures stipulated therein are complied with.

See also sub-paragraphs 1.1 b., f., g., j., k., and l.

2 Solid particle contamination and cleanliness levels

Solid particle contamination is the major reason for faults occurring in hydraulic systems. It may lead to a number of effects in the hydraulic system. Firstly, single large solid particles may lead directly to a system malfunction, and secondly small particles cause continuous elevated wear. For fire-resistant, water-containing hydraulic fluids, the cleanliness level is given as a three-digit numerical code in accordance with ISO 4406. The determination of this is made pursuant to the microscope method according to ISO 4407. The automatic method cannot be applied for fire-resistant, water-containing hydraulic fluids, since oil droplets could be counted as particles, for instance. This numerical code denotes the number of particles present in a hydraulic fluid for a defined quantity. Only particles $> 5 \mu\text{m}$ and $> 15 \mu\text{m}$ are counted here. The specification of the cleanliness level according to ISO 4406 thus only relates to those two particle sizes; for example: "ISO 4406: - / 18 / 15". The type of measuring method applied must always be specified as well when the cleanliness level is being determined. ISO 4406 is generally preferred in hydraulics. Moreover, foreign solid matter is not to exceed a mass of 50 mg/kg (gravimetric examination according to ISO 4405).

In general, compliance with a minimum cleanliness level of 20/18/15 according to ISO 4406 or better is to be maintained during operation. Special servo valves require better cleanliness levels of at least 18/16/13. An ordinal number lower by one signifies one half of the number of particles, and thus a higher level of cleanliness. Lower numbers in cleanliness levels should always be striven for, and extend the service life of hydraulic components. The component with the highest cleanliness requirements determines the required cleanliness for the overall system. Please also note the information given in Table 1: "Cleanliness levels according to ISO 4406" and in the respective data sheets for the various hydraulic components.

As an option, SAE AS 4059 can be used instead of ISO 4406 if particles above the size of $14 \mu\text{m}$ are going to be identified. The specification of cleanliness levels using cumulative particle counts is indicated by way of a letter/numerical code, although usually the particle size with the highest code is specified.

Hydraulic fluids frequently fail to meet the cleanliness requirements on delivery (basic contamination in containers). Careful filtering is therefore required during operation and, in particular, during filling in order to ensure the required cleanliness levels in the system. Your lubricant manufacturer can tell you the cleanliness levels of hydraulic fluids as delivered. To maintain the required cleanliness level over the operating period, it is recommended that a tank breather filter be used.

Information

Note: the specifications of the lubricant manufacturer relating to cleanliness levels are based on the time at which the container concerned is filled and not on the conditions during transport and storage. Further information about solid matter contamination and cleanliness levels can be found in the Bosch Rexroth oil cleanliness booklet R999000239.

Filter inspections and tests can be ordered at Bosch Rexroth as a service using the number R928037504 - Filter inspection - (inspection of used filter cartridges).

Table 1: Cleanliness levels according to ISO 4406 (determination according to ISO 4407)

| Particles per 100 ml | | Ordinal number |
|----------------------|---------------------|----------------|
| More than | Up to and including | |
| 8,000,000 | 16,000,000 | 24 |
| 4,000,000 | 8,000,000 | 23 |
| 2,000,000 | 4,000,000 | 22 |
| 1,000,000 | 2,000,000 | 21 |
| 500,000 | 1,000,000 | 20 |
| 250,000 | 500,000 | 19 |
| 130,000 | 250,000 | 18 |
| 64000 | 130,000 | 17 |
| 32000 | 64000 | 16 |
| 16000 | 32000 | 15 |
| 8000 | 16000 | 14 |
| 4000 | 8000 | 13 |
| 2000 | 4000 | 12 |
| 1000 | 2000 | 11 |
| 500 | 1000 | 10 |
| 250 | 500 | 9 |
| 130 | 250 | 8 |
| 64 | 130 | 7 |
| 32 | 64 | 6 |

– / 18 / 15

 > 5 µm > 15 µm

3 Selection of the hydraulic fluid

Fire-resistant, water-containing hydraulic fluids for Bosch Rexroth hydraulic components are assessed on the basis of their fulfillment of the minimum requirements according to ISO 12922.

Based on this, hydraulic fluids can be used that were assessed by Bosch Rexroth according to 90235 (fluid rating).

3.1 Selection criteria for the hydraulic fluid

The specified limit values for all components employed in the hydraulic system, for example required viscosities and cleanliness levels, need to be complied with while observing the specified operating conditions with the hydraulic fluid used. Please refer to the data sheet for the respective Rexroth hydraulic component for the permissible viscosity range, the required cleanliness levels, and the approved operating data.

Hydraulic fluid suitability depends, among other things, on the following factors:

3.1.1 Viscosity

Viscosity is a basic property of hydraulic fluids. The permissible viscosity range of complete systems needs to be determined taking account of the permissible viscosity of all components, and it is to be observed for each individual component.

The viscosity at operating temperature determines the response characteristics of closed control loops, stability and damping of systems, the efficiency factor, and the degree of wear.

We recommend that the optimum operating viscosity range of each component be kept within the permissible temperature range.

If the viscosity of a hydraulic fluid used is above the permitted operating viscosity, this will result in increased hydraulic-mechanical losses. However, internal leakage losses will be fewer. If the pressure level is lower, lubrication gaps may not be filled up, which can lead to increased wear. For hydraulic pumps, the permitted suction pressure may not be reached, which could lead to cavitation damage.

If the viscosity of a hydraulic fluid is below the permitted operating viscosity, increased leakage, wear, susceptibility to contamination, and a shorter life cycle in the components will result.

Please ensure that the permissible temperature and viscosity limits are observed for the respective components. This usually requires either cooling or heating, or both.

The viscosity is influenced by the water content. If water loss occurs during operation owing to temperatures > +40 °C, then the viscosity will increase firstly (mainly in

open systems). If the viscosity drops when the water content is reduced or if it remains the same, then the polymers in the water-glycol mixture are either damaged or sheared.

Fig. 1: Example ν - T -diagram HFA, HFAS thickened, HFC compared to HFDR, HFDU (ester based) and HLP (reference values, double-logarithmic presentation)

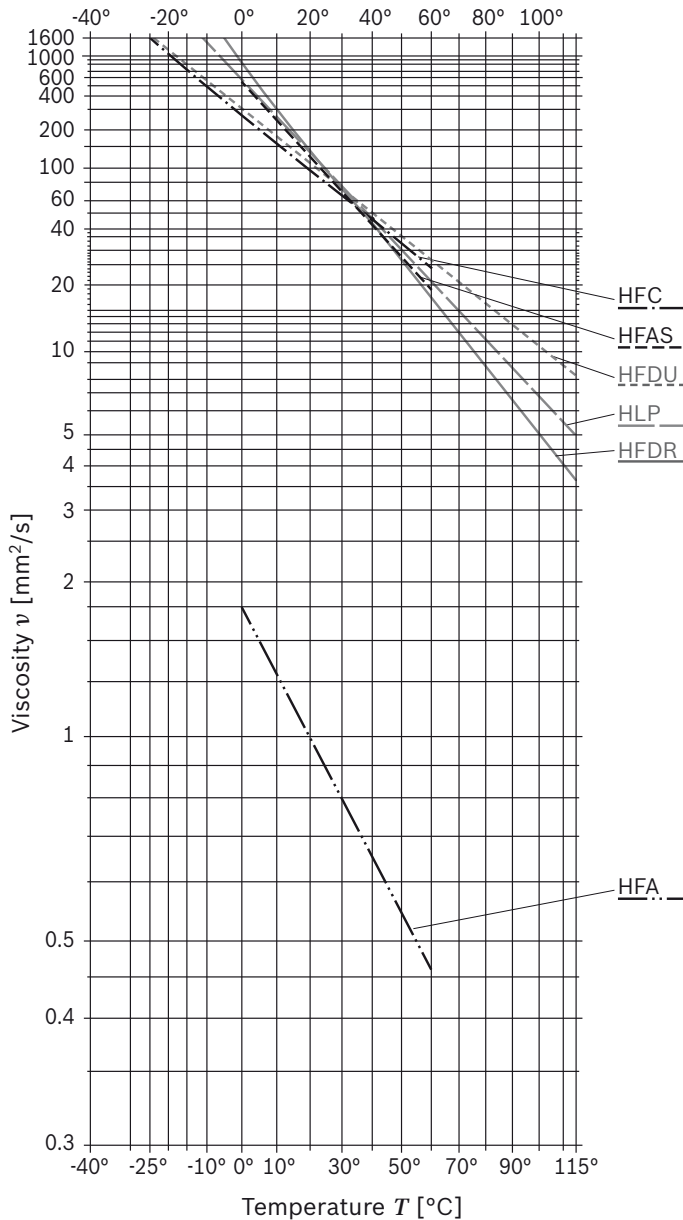


Table 2: Examples of typical viscosity data [mm²/s] in different hydraulic fluids

| Temperature | -20 °C | 0 °C | 40 °C | 60 °C | 100 °C |
|--|-----------------------|------|-------|-------|---------------------|
| HFA | – ¹⁾ | 1.75 | 0.65 | 0.47 | – ²⁾ |
| HFAS thickened | – ¹⁾ | 550 | 42 | 18.7 | – ²⁾ |
| HFC | 1183 | 295 | 46 | 24.3 | – ²⁾ |
| compare HFDR (see 90222) | (14250) ³⁾ | 956 | 43 | 17.1 | (5) ³⁾ |
| compare HFDU (ester based) (see 90222) | 1195 | 310 | 50 | 26.5 | 10.4 |
| compare HLP (see 90220) | (4034) ³⁾ | 547 | 46 | 20.8 | (6.9) ³⁾ |

1) Not applicable (see Pour point)

2) Not applicable (water loss in depressurized reservoir)

3) Observe permissible viscosity range for the respective hydraulic component.

3.1.2 Viscosity temperature behavior

In hydraulic fluids, it is primarily the viscosity temperature behavior (ν - T -behavior) that is of particular importance. In hydraulic fluids, the viscosity is characterized in that it drops when the temperature increases and rises when the temperature drops. The interrelation between viscosity and temperature is described by the viscosity index (VI).

HFC hydraulic fluids have a better viscosity temperature behavior than HLP mineral oil.

In HFA hydraulic fluids, the dependency of the viscosity on the temperature is negligible.

The differing viscosity temperature behavior needs to be taken into consideration when selecting hydraulic fluid for the required temperature range.

Owing to a high vapor pressure in comparison to a similar HLP mineral oil, the maximum operating temperature when working with fire-resistant, water-containing hydraulic fluids must be limited. Reservoir temperatures above +50 °C must be prevented in open systems, because they can lead to serious water loss and accelerate the aging process in the hydraulic fluid. Furthermore, in HFC hydraulic fluids, water losses that are too high can lead to both an increase in viscosity and to a reduction in the fire-resistant properties.

Information

- ▶ The minimum operating temperature for HFA hydraulic fluids is +5 °C.
- ▶ HFC hydraulic fluids respond very well at low temperatures and have a lower pour point when compared to HLP mineral oils.

3.1.3 Wear protection capability

Wear protection capability describes the property of hydraulic fluids to prevent or minimize wear within the components.

This is described in ISO 12922 for HFC hydraulic fluids using the following test methods:

- ▶ Mechanical testing in the vane pump (ISO 20763), method B (reduced temperature and working pressure when compared to HLP mineral oil)
- ▶ Testing in the four-ball apparatus (ISO 20623)
- ▶ Testing in the FZG test machine for mechanical stress in the gears (ISO 14635-1), reduced test temperature when compared with HLP mineral oil: in accordance with the 7th Luxembourg Report or ISO 12922 for HFB and HFC at 60 °C.

These test methods cannot be applied for HFA hydraulic fluids.

The test methods and test conditions for fire-resistant, water-containing hydraulic fluids are not comparable to those used for HLP/HVLP mineral oils. This is why the operating data for Rexroth hydraulic components that were optimized for HLP/HVLP mineral oils are (in part) limited. To some extent, Rexroth hydraulic components specifically developed for fire-resistant, water-containing hydraulic fluids are available without the limitation of operating data (e.g. in 92053, the A4VSO axial piston variable pump for HFC hydraulic fluids).

3.1.4 Material compatibility

The hydraulic fluid must not negatively affect the materials used in the components. Compatibility with coatings, seals, hoses, metals, and plastics is to be observed in particular. The fluid classifications specified in the respective components data sheets are tested by the manufacturer with regard to material compatibility. Parts and components not supplied by us are to be checked by the user.

The material incompatibilities mentioned here do not automatically result in function problems. However the elements of the materials are found in the hydraulic fluid after use. Material incompatibilities may, where applicable, lead to an accelerated aging process in the hydraulic fluid and to increased wear and corrosion of the components.

Table 3: Known incompatibilities of materials

| Classification | Incompatible with |
|--------------------------------|--|
| Water-containing HF... general | <p>Seals/plastics/coatings FKM elastomers are normally not resistant, NBR elastomers are recommended. Seals, plastics, coatings (of control cabinets, too), outer coatings of hydraulic components, and accessory components (connectors, wiring harnesses, control cabinets) are to be tested for stability. Note: hydraulic fluid vapors can also lead to incompatibility!</p> <p>Coatings on the inside of the reservoir Single component lacquer (e.g. zinc dust paint) is unstable; the use of stainless steel reservoirs (rustproof steel) is recommended.</p> <p>Zinc Zinc and zinc coatings exhibit in the static immersion test only a minimal amount of change in weight. If zinc (e.g. Zn die-cast housings for filters etc.) is attacked even to a minimal extent, then voluminous reaction products are formed (e.g. zinc soaps) that may block the filters, solenoids etc.</p> <p>Aluminum Aluminum alloys are not stable in all cases (risk of corrosion with cast aluminum). Above all, it is the simpler properties that get attacked, especially if they come into contact with steel parts. The electrochemical reaction with steel (potential difference approx. 1.23 V) may cause a severe case of aluminum removal. Anodized aluminum is suitable for static loading. Aluminum wrought alloys offer improved stability.</p> <p>Cadmium/magnesium Cadmium and magnesium alloys are not compatible.</p> <p>Lead Pure lead is noticeably attacked already in the static compatibility test.</p> |
| HFB | <p>Seals Polyurethane (AU) not stable</p> |
| HFC | <p>Seals Polyurethane (AU) not stable</p> <p>Tin and zinc Tin and zinc should be avoided in systems using HFC hydraulic fluids. Residual amounts of HLP mineral oils containing zinc and oils used for corrosion protection must be avoided.</p> |

3.1.5 Aging resistance

Fire-resistant, water-containing hydraulic fluids are less subject to thermal load than HLP mineral oils, which is why they are substantially less subject to aging.

In HFAE hydraulic fluids, microbial contamination can cause undesirable aging in the hydraulic fluid. Fungal slime, cakes of fungus, and yeasts can clog filters and lines.

3.1.6 Environmental compatibility

Fire-resistant, water-containing hydraulic fluids are hydraulic fluids that can also be environmentally acceptable at the same time. The main criterion for fire-resistant, water-containing hydraulic fluids is the leak-free, technically problem-free application with the necessary fire resistance. Environmental compatibility is merely a supplementary criterion. You can recognize the environmental compatibility in the technical data sheet for the hydraulic fluid using the reference to:

- ▶ DIN Technical Report CEN/TR 14489
- ▶ BGR 137
- ▶ 7th Luxembourg Report, Part IV “assessment of health hazards” and Part VI “assessment of environmental compatibility”
- ▶ Occupational Health and Safety Ordinance for Mines (GesBergV)

Please refer to the safety data sheet of the respective hydraulic fluids for more information on environmental compatibility.

Information on other environmentally acceptable hydraulic fluids can be found (without reference to fire resistance) in Document 90221.

3.1.7 Air separation ability (ASA)

The air separation ability (ASA) describes the property of a hydraulic fluid to separate undissolved air. Hydraulic fluids always contain dissolved air. During operation, dissolved air may be transformed into undissolved air, leading to cavitation damage.

Furthermore, the system behavior can differ due to the higher proportion of undissolved air when compared with HLP mineral oil. According to ISO 12922, a specific value for the air separation ability is not required for the HFAE and HFAS classifications.

The air separation ability for the HFC classification depends

on the viscosity, the temperature, basic fluid, and aging. It cannot be improved by additives.

Fluid classification, fluid product, reservoir size and design must be coordinated to take into account the dwell time and ASA value of the hydraulic fluid.

According to ISO 12922 for instance, an ASA value of ≤ 25 minutes is required for HFC in viscosity class ISO VG 46, lower values are preferable.

3.2 Classification and fields of application

Table 4: Classification and fields of application

| Classification | Features | Typical field of application | Information |
|--|---|--|---|
| HFAE according to ISO 12922 | Oil-in-water emulsions | Mine support, hydrostatic drives, hydraulic strut extension below ground | Approved for all components that allow "HFAE according to ISO 12922" in the product data sheet for hydraulic fluids. Observe limitations in the operating data for the respective components. |
| Density at 15 °C typically 1.00 kg/dm ³ | Viscosity at 40 °C: max. 5 mm ² /s | | - Water-polluting (WGK 1 to 3) - Reservoir temperature +5 °C to +50 °C - Resistance to aging, see chapter 3.1.5 |
| Normal water content ≥ 95% (m/m) | Appearance: milky to translucent emulsion | | - Owing to the higher density by comparison to HLP, lower intake pressures are to be expected in pumps and, where applicable, the flow must be reduced and the intake conditions optimized (higher cavitation tendency) |
| HFAS according to ISO 12922 | Chemical solutions in water | Mine support, foundry technology, press hydraulics (example: hydroforming) | Approved for all components that allow "HFAS according to ISO 12922" in the product data sheet for hydraulic fluids. Observe limitations in the operating data for the respective components. |
| Density at 15 °C typically 1.00 kg/dm ³ | Viscosity at 40 °C: max. 5 mm ² /s or thickened variants up to ISO VG 68 | | - Mineral-oil free - Water-polluting (WGK 1 to 2) - Reservoir temperature +5 °C to +50 °C |
| Normal water content ≥ 95% (m/m) | Appearance: transparent | | - Owing to the higher density by comparison to HLP, lower intake pressures are to be expected in pumps and, where applicable, the flow must be reduced and the intake conditions optimized (higher cavitation tendency) |
| HFB according to ISO 12922 | Water-in-oil emulsions | Mostly in coal mining below ground, primarily in the U.K. (hydrostatic control systems and drives) | Practical requirements are frequently not fulfilled by hydraulic fluids in this classification. As a result of a high mineral oil content up to 60%, they do not meet the limit values for spray ignition characteristics (fire resistance) prescribed in Germany. Observe limitations in the operating data for the respective components. |
| Density at 15 °C typically 0.92 to 1.05 kg/dm ³ | Viscosity classes: ISO VG 46 up to 100 | | - Water-polluting (WGK 1 to 3) - Reservoir temperature +5 °C to +50 °C |
| Normal water content ≥ 40% (m/m) | | | - Owing to the higher density by comparison to HLP mineral oil, lower intake pressures are to be expected in pumps and, where applicable, the flow must be reduced and the intake conditions optimized (higher cavitation tendency) |
| HFC according to ISO 12922 | Watery polymer solutions | All application areas where water-free hydraulic fluids are not permitted due to the risk of fire. For example: The steel industry, coking plants, foundries, hardening plants, forming presses, injection molding and pressure die casting machines, mining technology (exception: salt mining) | Approved for all components that allow "HFC according to ISO 12922" in the product data sheet for hydraulic fluids. Observe limitations in the operating data for the respective components. |
| Density at 15 °C typically 1.07 to 1.09 kg/dm ³ | Viscosity classes: ISO VG 22 up to 68 Usually ISO VG 46 | | - Categorized as non-/minimally water-polluting (NWG/WGK 1) - Reservoir temperatures -20 °C to +50 °C - Very good viscosity temperature behavior |
| VI: typically > 150 | | | - Owing to the higher density by comparison to HLP mineral oil, lower intake pressures are to be expected in pumps and, where applicable, the flow must be reduced and the intake conditions optimized (higher cavitation tendency). |
| Normal water content ≥ 35% (m/m) | | | - A reservoir with an inspection port above the fill level is recommended in order to remove floating residual oil. |
| HFC-E not standardized according to ISO 12922 | Watery polymer solutions | Mostly in coal mining below ground, primarily in Germany | - Like HFC, but improved protection against wear and extended temperature range up to 70 °C |
| Density at 15 °C typically 1.07 to 1.14 kg/dm ³ | Viscosity classes: ISO VG 46 up to 68 Normally ISO VG 68 | | |
| VI: typically > 135 | | | |
| Normal water content 18 to 20% (m/m) | | | |

4 Hydraulic fluids in operation

4.1 General

The properties of hydraulic fluids can change continually during storage and operation.

Please note that the fluid standard ISO 12922 merely describes minimum requirements for hydraulic fluids in new condition at the time of filling into the delivery containers. The operator of a hydraulic system must ensure that the hydraulic fluid remains fit for purpose throughout its entire period of use.

Deviations from the characteristic values are to be clarified with the lubricant manufacturer, the test labs, or Bosch Rexroth.

Bosch Rexroth will accept no liability for damage to its components within the framework of the applicable liability legislation insofar as the latter is due to non-observance of the following instructions.

Please note the following aspects in operation.

4.2 Storage and handling

Hydraulic fluids must be stored correctly in accordance with the instructions of the lubricant manufacturer. Avoid exposing the containers to lengthy periods of direct heat. A container is to be stored such that the risk of any foreign liquid or solid matter (e.g. water, foreign fluids, or dust) ingress into the inside of the container can be ruled out. After taking hydraulic fluids from the containers, these are to be properly resealed immediately. HFAE and HFAS hydraulic fluids are delivered in a concentrated form. Please observe the hardness (°dH) in order to produce the finished product, lower hardness values should be aimed at (°dH, calcium oxide CaO in ppm).

Recommendation:

- ▶ Store containers in a dry, roofed place
- ▶ Store HFA containers frost-protected
- ▶ Clean reservoir systems and machine reservoirs regularly

Please refer to the respective safety data sheet for the minimum storage duration and storage conditions.

4.3 Filling of new systems

Usually, the cleanliness levels of the hydraulic fluids as delivered do not meet the requirements of our hydraulic components at the company. When filling, hydraulic fluids must be filtered using an appropriate filter system to minimize solid particle contamination in the system.

As early as possible during test operation, new systems should be filled with the selected hydraulic fluid so as to reduce the risk of accidentally mixing the fluids (see chapter 4.5 “Mixing and compatibility of different hydraulic fluids”). Changing the hydraulic medium at a later point represents significant additional costs (see following section).

4.4 Hydraulic fluid changeover

Problems may be encountered in particular when changing over from fire-resistant, water-free hydraulic fluids or mineral oils to fire-resistant, water-containing hydraulic fluids (e.g. incompatibilities in the form of gelling, silting, stable foam, reduced filterability, or filter blockage). This may also happen when changing products within the same classification. In the case of changeovers of the fluid in hydraulic systems, it is important to ensure compatibility and miscibility of the new hydraulic fluid with the remains of the previous hydraulic fluid from the system.

Bosch Rexroth recommends obtaining verification of compatibility and miscibility from the manufacturer or supplier of the new hydraulic fluid. The remainder quantities of the old fluid need to be minimized. Mixing hydraulic fluids should be avoided; see following section.

Information on changing over hydraulic fluids with different classifications can be found in VDMA 24314 and ISO 7745, among others. Beyond that, please observe chapter 3.1.4 “Material compatibility”.

Bosch Rexroth will not accept liability for any damage to its components resulting from inadequate hydraulic fluid changeovers!

4.5 Mixing and compatibility of different hydraulic fluids

If hydraulic fluids from different manufacturers or different types from the same manufacturer are mixed, gelling, silt-ing, and deposits may occur. These, in turn, may cause foaming, impaired air separation ability, malfunctions, and damage to the hydraulic system.

If the fluid contains more than 2% of another fluid then it is considered to be a mixture.

Mixing with other hydraulic fluids is not generally permitted. This includes hydraulic fluids with the same classification. If individual lubricant manufacturers advertise miscibility and/or compatibility, this is entirely the responsibility of the lubricant manufacturer.

Bosch Rexroth customarily tests all components with HLP mineral oil.

Bosch Rexroth will not accept liability for any damage to its components resulting from mixing hydraulic fluids!

4.6 Re-additivation

Additives added at a later point in time such as colors, wear reducers, VI enhancers or anti-foam additives, may negatively affect the performance properties of the hydraulic fluid and the compatibility with our components, and are not approved.

Bosch Rexroth will not accept liability for any damage to its components resulting from re-additivation!

4.7 Foaming behavior

Foam is created by rising air bubbles at the surface of hydraulic fluids in the reservoir. Foam that develops should collapse as quickly as possible.

The foaming behavior of fire-resistant, water-containing hydraulic fluids is normally worse than in HLP mineral oil.

4.8 Corrosion protection

Water generally has corrosive properties.

Corrosion protection is only possible to a limited extent due to the water content in fire-resistant, water-containing hydraulic fluids, despite the available corrosion protection additives.

Materials made of steel, copper, zinc, aluminum, bronze alloys and brass alloys, as well as combinations of these materials have a higher corrosion tendency.

4.9 Dissolved and undissolved air

Under atmospheric conditions, the hydraulic fluid contains dissolved air. In the negative pressure range, for instance in the suction pipe of the pump or downstream of control edges, this dissolved air may transform into undissolved air. The undissolved air content represents a risk of cavitation.

The consequence of this is material erosion on components. With the correct measures, such as suction pipe and reservoir design, and an appropriate hydraulic fluid, air intake and separation can be positively influenced.

See also section 3.1.7 "Air separation ability (ASA)".

4.10 Fluid servicing, fluid analysis, and filtration

To preserve the usage properties and ensure a long service life for hydraulic fluid and components, both the monitoring of the fluid condition and a filtration adapted to the application requirements are indispensable.

The application of hydraulic system filters with a filtration rate > 200 for $10\mu\text{m}$ particles ($\beta_{10(c)} > 200$ according to ISO 16889) is not recommended for fire-resistant, water-containing hydraulic fluids, since finer filters can break down the chemical composition of the fluid. If finer filters are required despite that, then the fluid manufacturer needs to be consulted before they are used.

$\beta_{10(c)} > 75$ according to ISO 16889 is recommended. The effort is higher in the case of unfavorable usage conditions, increased stress on the hydraulic system or high expectations as to availability and service life, see chapter 2 "Solid particle contamination and cleanliness levels".

When commissioning a system, please note that the required minimum cleanliness level can frequently be attained only by flushing the system. Due to severe start-up contamination, it may be possible that a fluid and/or filter replacement becomes necessary after a short operating period (< 50 operating hours).

The hydraulic fluid must be replaced at regular intervals and tested by the lubricant manufacturer or recognized, accredited test labs. A reference inspection is recommended both for the unused hydraulic fluid (casks) and after commissioning.

14 Fire-resistant hydraulic fluids - containing water

Hydraulic fluids in operation

Minimum information in analyses (recommended)

| Property or test conditions | Test method | HFAE | HFAS | HFB | HFC |
|---|---|------|------|-----|-----|
| Appearance | | ● | ● | ● | ● |
| Water content | HFAE, HFB: ISO 3733 HFAS: ISO 6296; HFC: DIN 51777-1 | ● | ● | ● | ● |
| Density at 15 °C | ISO 3675, DIN 51757 incl. supplementary sheet 1 | – | – | ● | ● |
| pH value at 20 °C | ISO 20843 | ● | ● | – | ● |
| Viscosity at 20 °C, 40 °C, and 50 °C | ISO 3104, DIN 51562-1, ASTM D7042 | ● | ● | ● | ● |
| Volume fraction of emulsified concentrate | DIN 51368 in conjunction with DIN 51423-2 | ● | – | ● | – |
| Foreign oil proportion | | ● | ● | ● | ● |
| Cleanliness level | ISO 4406 | ● | ● | ● | ● |
| Content of foreign solid matter | ISO 4405 | ● | ● | ● | ● |
| Microbial stability with details on bacteria, fungi, yeasts, and germ count | | ● | ● | ● | – |
| Elements | DIN 51399-1 | ● | ● | ● | ● |

Optional information

| Property or test conditions | Test method | HFAE | HFAS | HFB | HFC |
|--|-------------|------|------|-----|-----|
| Reserve alkalinity compared with pH values 3.3 and 5.5 | | ● | ● | ● | ● |
| Testing in the four-ball apparatus | ISO 20623 | – | – | – | ● |
| Air separation ability at 50 °C | ISO 9120 | – | – | – | ● |

Information

- ▶ If possible, compare the measurement results with the values of new oil or available trend analyses.
- ▶ The test report should include an evaluation / assessment pertaining to the further use of the hydraulic fluid.

When using fire-resistant, water-containing hydraulic fluids, the same servicing and maintenance requirements as applied for HLP/HVLP mineral oil are necessary. However, the scope of the analysis/analysis methods have to be adapted to the fluid properties.

After changing over hydraulic fluids, it is recommended that the filter be replaced again after 50 operating hours as fluid aging products may have detached themselves ("self-cleaning effect").

Fire-resistant, water-containing hydraulic fluids contain alkaline additives. They are used both for the neutralization of contamination and for corrosion protection in the hydraulic system. If the reserve alkalinity drops significantly below the value for the unused hydraulic fluid, there is a chance that fully developed, acidic reaction products can no longer be fully neutralized. The risk of electrochemical corrosion in the system increases, which is why the proportion of corrosion protection inhibitors have to be checked during operation (reserve alkalinity compared with pH values 3.3 and 5.5).

If the water contained has noticeably vaporized, then distilled water or VE water needs to be replenished in order to set the initial viscosity; tap water must never be used. The addition of larger quantities of water should be done slowly and, if possible, in several positions during ongoing operation, so as to prevent the pump from occasionally sucking in pure water, and thus being damaged by that. It is recommended that the corresponding amount of water prior to the addition be mixed with approximately the same amount of HFC fluid, for example.

Ultimately, the evaluation by the test lab or lubricant manufacturers is authoritative. Their recommendation should be urgently observed.

In case of warranty, liability, or guarantee claims to Bosch Rexroth, service verification and/or the results of fluid analyses are to be provided.

5 Disposal and environmental protection

All fire-resistant, water-containing hydraulic fluids, are, like mineral oil-based hydraulic fluids, subject to special disposal obligations.

The respective lubricant manufacturers provide specifications on environmentally friendly handling and storage. Please ensure that spilled or splashed fluids are absorbed with appropriate adsorbents or by a technique that prevents it contaminating water courses, the ground, or sewerage systems.

It is also not permitted to mix fluids when disposing of hydraulic fluids. Regulations governing the handling of used oils stipulate that used oils are not to be mixed with other products. Non-compliance will increase disposal costs.

Both the national legal or regulatory provisions and the information given in the respective safety data sheets (e.g. waste codes) must be observed for the disposal of the relevant hydraulic fluid.

6 Standardization

The information pertaining to the standards listed in this document relates to the respective standard edition currently valid.

7 Glossary

Additivation

Additives are chemical substances added to base fluids in small quantities to achieve or improve specific properties.

Alkaline additives

Hydraulic fluids can produce acids as a result of various aging processes. The hydraulic fluid contains alkaline additives in order to cushion/remove the acidification. These additives bind the acid residue and then become particles that are (can be) filtered out. A statement in regard of alkaline additives still effective is provided, on the one hand, by pH value, but better still is the statement pertaining to the content of free acids. In the alkaline pH value range, acidic corrosion is not possible, even if acids are present.

Aging

The aging response in a hydraulic fluid describes the chronological sequence of the oxidative, thermal, and (sometimes) hydrolytic change in selected chemical and physical data under test conditions or in practice. (See chapter 3.1.5 "Aging resistance").

Arrhenius equation

The quantitative relation between reaction rate and temperature is described by an exponential function, the Arrhenius equation. This function is usually visualized within the typical temperature range of the hydraulic system.

ICP (optical emission spectrometry)

The ICP procedure can be used to determine various wear metals, contamination types, and additives. Practically all elements in the periodic system can be detected with this method.

Karl Fischer method

Method for determining the proportion of water in water-containing hydraulic fluids: potentiometric method according to DIN 51777-1

Cavitation

Cavitation is the creation of vapor filled cavities (vapor bubbles) in fluids due to insufficient vapor pressure and subsequent implosion when the pressure increases. When the cavities implode, extremely high acceleration, temperatures, and pressures may occur temporarily, which may damage the component surfaces.

Reserve alkalinity

Determining the reserve alkalinity is used for the investigation of the corrosion protection still available. If the determined reserve alkalinity significantly drops below the initial value of the new oil, then acidic contamination can no longer be neutralized, this means that there is a potential threat to the system becoming damaged due to corrosion.

pH value

This is the measurement for the acidic or alkaline character of an aqueous solution or emulsion.

Pour point

This is the lowest temperature at which the fluid still just flows when cooled down under set conditions. The pour point is specified in the lubricant manufacturers' technical data sheets as a reference value for achieving this flow limit.

RFA (energy dispersive or wavelength dispersive X-ray fluorescence analysis)

Is a procedure to determine almost all elements in liquid and solid samples with nearly any composition. This analysis method is suitable for examining additives and contamination, delivering fast results.

VE water

Demineralized water, also known as deionized, fully desalinated water

Viscosity

Viscosity is the measure of the internal friction of a fluid to flow. It is defined as the property of a substance to flow under tension. Viscosity is the most important characteristic for describing the load-bearing capacity of a hydraulic fluid.

Kinematic viscosity is the ratio of the dynamic viscosity and the density of the fluid; the unit is mm²/s. Hydraulic fluids are categorized in ISO viscosity classes by kinematic viscosity. The reference temperature for this is 40 °C.

Viscosity index (VI)

Refers to the viscosity temperature behavior of a fluid. The lower the change of viscosity in relation the temperature, the higher the VI.

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