

# Biodegradable hydraulic fluids

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## Introduction

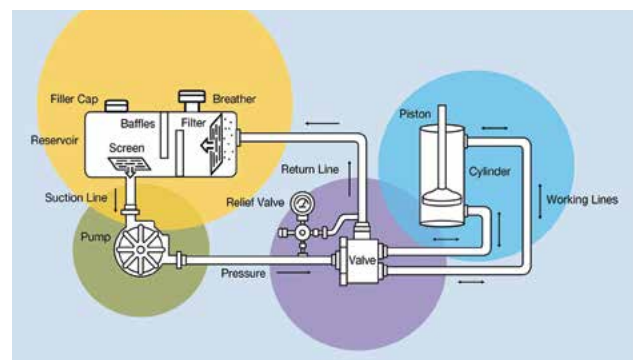
In the hydraulic system, the fluid which transfers power from the pump to various parts of the system is called hydraulic fluid [1]. This is not the only thing this fluid does but it also lubricates the system, acts as a heat-transfer medium, and prevents wear and corrosion [1]. Every component which is part of a hydraulic system, comes in contact with this fluid and because of this, hydraulic fluid must be compatible with the materials which are part of a hydraulic system, ensuring that the surfaces, seals and other components are not at risk of being altered [1]. A good ability to deal with water and air must be one of the main characteristic of hydraulic fluid, otherwise severe problems in hydraulic systems can occur [1].



**Figure 1:** Hydraulic pump [3]

Like every lubricant, hydraulic fluid is made by blending a base oil and different kind of additives. The additives help to enhance or improve particular properties in the fluid and can take various forms. Viscosity, friction, temperature or pressure, to wear, corrosion, filterability or the fluid's ability to separate water and air are some of the particular properties with which additives can help [1]. The additives improve the fluid's performance for specific applications, and it is the additives that determine in which product the lubricant should be used [1].

Hydraulic fluids can be used in hydraulic brakes, refuse trucks, excavators and backhoes, power steering systems, automatic transmissions, aircraft flight control systems, lifts, and industrial machinery [2].



**Figure 2:** Hydraulic System [3]

Without the proper fluids, the hydraulic system is at risk of costly damages that can ultimately hinder effective operation or cause an overall system failure [3]. Below will be discussed the various types of hydraulic fluids available to ensure that you can meet the needs of your equipment.

## Petroleum-based hydraulic fluids

These are among the most reliable hydraulic lubricants; significantly increasing the performance of your machinery and product outcomes [4]. The exact benefits of petroleum-base fluids can vary based on their composition, but typically you can expect to improve rust resistance, decreased foaming, and enhanced lubrication [4]. The biggest problem with this kind of fluid is that they have a significant impact on the environment, as they are not biodegradable and can contaminate soil and water if leaked or spilled. These kinds of fluids are also highly combustible, which makes safety a top priority when handling this flammable material [4].

## Water-based hydraulic fluids

Two types of water-based hydraulic fluids exist:

water-oil emulsion and water glycols. A water-oil emulsion type is the most affordable fire-resistant fluid and is roughly 35% water and 65% oil [4]. This ratio creates an oil-continuous cycle and, when combined with other additives, stabilises and emulsifies the liquids [4].

A water glycol hydraulic fluid is glycol mixed with water. It is about 40% water-glycol, leaving the other 60% to additives that provide superior viscosity and corrosion prevention. Because of the presence of water, this fluid is also used for cooling and it is fire-resistant [4].

### Synthetic blend hydraulic fluids

In high-temperature scenarios, synthetic blend hydraulic fluids are mostly used [4]. The chemical composition of these fluids is fire-resistant and offers extremely smooth viscosity levels for maximum lubrication [4].

### Biodegradable hydraulic fluids

These fluids represent industry-leading lubricants which and a significant decrease in pollution [4]. This type of hydraulic fluid is an eco-friendly alternative that runs off soybean, rapeseed, canola or sunflower oil. So, in the event of oil leaks or hose failures, biodegradable hydraulic fluids pose less risk while performing similarly to a mineral blend fluid [4]. General information about biodegradable lubricants can be reviewed in the table below.

### Ecolabel certification system

The EU Ecolabel [6] system represents a voluntary labelling system that promotes and identifies

environmentally friendly products. Based on EC No. 66/2010[7] of the European Parliament and of the Council of 25 November 2009 the EU Ecolabel can be used on products and services as well as their associated promotional material, exclusively during the validity period of the EU Ecolabel awarded licence.

Current criteria for awarding EU Ecolabel licence to lubricants is defined by COMMISSION DECISION (EU) 2018/1702 of 8 November 2018. The product group 'lubricants' shall comprise any lubricant falling within one of the following sub-groups [7]:

- The Total Loss Lubricants (TLL)
- The Partial Loss Lubricants (PLL)
- The Accidental Loss Lubricants (ALL)

Lubricants that are awarded with the EU Ecolabel license can put EU Ecolabel logo and licence number.



Figure 4: The EU Ecolabel "Flower" [8]

Besides EU Ecolabel other popular ecolabels in EU are Blue Angel and Nordic Swan.

QUICK FACTS			
	Bio-Based Lubricants are at least partially derived from biological material. Also known as <b>Bio-lubes</b> .		Not the same as <b>Food Grade (H1, H3)</b> , but may be considered this if composed of ingredients defined by CFR 21, Sec. 178.3570.5
	The <b>USDA BioPreferred Standards</b> provides certification for bio-based lubricants, even when blended with other base oils like synthetics.		Not the same as <b>Green Oils (Eco Friendly)</b> , but may be considered as such if it falls into one of these "green" categories: biodegradable, low eco-toxicity, low bio accumulation, or renewable.
	Can be used as part of a <b>Bio-Synthetic</b> if at least 25% bio-based (renewable) oil and a synthetic oil.		Can be <b>Environmentally Acceptable Lubricants (EAL)</b> , lubricants that are biodegradable and minimally toxic.
	Are considered <b>Renewable</b> as these are oils produced from renewable sources.		Can be called <b>Natural Esters</b> (fats and oils are esters), or sometimes called <b>Natural Oils</b> .
	May be <b>Biodegradable</b> , as most bio-based lubricants naturally break down over time. (Ref: ASTM D6064)		

Figure 3: Biodegradable lubricants – General Information [5]

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## Blue Angel

The Blue Angel has been introduced in 1978 by federal government of Germany and it represents the first ecolabel in EU [9]. It is an independent and credible label that sets stringent standards for environmentally friendly products and services.



Figure 5: Blue Angel – The German Ecolabel [9]

## Nordic Swan

Nordic Swan was established in 1989 as the official ecolabel of the Nordic countries[10]. Each country has its ecolabelling secretariat, which is responsible for its activities. The secretariat handles license applications, inspection visits and marketing in their respective countries. Each country is also responsible for its position in product groups and criteria issues.



Figure 6: Nordic Swan Ecolabel [10]

## Vegetable biodegradable hydraulic oil

Vegetable hydraulic oils are produced mainly from Canola oil. Their chemical structure is similar to that of polyol esters. Vegetable hydraulic oils possess very good lubrication properties and high viscosity index (low temperature sensitivity of viscosity). They are non-toxic and biodegradable. The main disadvantage of vegetable hydraulic oils is their poor performance when working at high temperature and pressure[11].

Below a list of vegetable biodegradable hydraulic oils which are produced from main lubricants companies:

- Castrol Performance BIO HE 32 TG
- Fuchs Plantohyd 40 N
- Total Biohydran RS 38 B

## Castrol Performance BIO HE 32 TG

Biodegradable hydraulic fluid produced by Castrol is formulated using vegetable ester oil and additives to prevent oxidation, wear and corrosion[12]. This biodegradable hydraulic fluid is called Castrol Performance™ Bio HE 32 TG (previously called Castrol Carelube™ HTG 32). Below are given typical characteristics of this product from which it can be seen that Castrol Performance™ Bio HE 32 TG is 99% biodegradable according to CEC-L-33-A-93 and 75% biodegradable according to OECD 301B.

Name	Method	Units	Performance Bio HE 32 TG
Density @ 15°C	ISO 12185 / ASTM D4052	kg/m³	921
Kinematic Viscosity @ 40°C	ISO 3104 / ASTM D445	mm²/s	36
Kinematic Viscosity @ 100°C	ISO 3104 / ASTM D445	mm²/s	8.2
Viscosity Index	ISO 2909 / ASTM D2270	-	>200
Biodegradability	OECD 301B	%	75
Biodegradability	CEC-L-33-A-93	%	99
Flash Point - open cup method	ISO 2592 / ASTM D92	°C	>270
Pour Point	ISO 3016 / ASTM D97	°C	-33
Water Separation @ 54°C (40/37/3)	ISO 6614 / ASTM D1401	min	15
Foam Sequence I - tendency / stability	ISO 6247 / ASTM D892	ml/ml	30/0
Rust test - synthetic seawater (24 hrs)	ISO 7120 / ASTM D665B	-	Pass
FZG Gear Scuffing test - A/8.3/90	ISO 14635-1	Failure Load Stage	>12
Eaton-Vickers 35VQ/25 Vane Pump test (3000 psi, 2400 rpm, 100 hrs, 95°C)	-	wt loss (ring & vane) mg	<5

Table 1: Typical characteristics - Castrol Performance™ Bio HE 32 TG [12]

## Fuchs Plantohyd N

According to ISO15380 which specifies the requirements for environmentally acceptable hydraulic fluids, Fuchs Plantohyd N is defined as type HETG (triglycerides)[13] and according to OECD 301 B it is more than 60% biodegradable. This lubricant is awarded with European Eco Label.

Product name	32 N	40 N	
Properties	Unit		Test method
ISO VG	32	46	DIN 51 519
Kinematic viscosity at -20°C	mm²/s	898	1444
at 0°C	mm²/s	280	430
at 40°C	mm²/s	31.4	44
at 100°C	mm²/s	7.4	9.6
Viscosity index	-	213	211
Density at 15°C	kg/m³	922	922
Colour	ASTM	1.0	1.0
Flashpoint (COC)	°C	274	306
Pourpoint	°C	-39	-36
Neutralisation number	mgKOH/g	0.7	0.4
FZG A/8.3/90	Failure load stage	> 12	> 12
Effect on FPM AK 6 sealing material, 1000 h, 100°C			DIN ISO 1817
relative volume change	%		0.5
change of Shore-A-hardness	Shore		-2

Table 2: Typical characteristics - Fuchs Plantohyd N [13]



## Total Biohydran RS 38 B

Total BIOHYDRAN RS 38 B is a vegetable oil based biodegradable hydraulic fluid, which is applied as a replacement of hydraulic mineral oils in activities such as civil engineering, construction, quarrying and gravel plies [14]. This hydraulic lubricant is particularly recommended when there is a possibility of contaminating water such as forestry operations, off-shore, river dredging, winter sport, etc.

According to CEC-L-33-A-93 this lubricant is more than 95% biodegradable and it can replace mineral oils after a complete drain of the circuit followed by a replacement of the filter. Below are given typical characteristics [14] of this lubricant.

TYPICAL CHARACTERISTICS	METHODS	UNITS	BIOHYDRAN RS 38 B
Appearance	Visual	-	clear
Density at 15°C	ISO 3675	kg/m <sup>3</sup>	920
Viscosity at 40°C	ISO 3104	mm <sup>2</sup> /s	38
Viscosity at 100°C	ISO 3104	mm <sup>2</sup> /s	8.6
Viscosity index	ISO 2909	-	217
Cleveland flash point	ISO 2592	°C	290
Pour point	ISO 3016	°C	- 36
Biodegradability test- rate after 21 days	CEC-L-33-A-93	%	> 95
FZS A/B 3/90	DIN 51354	Stage	> 12
Operating temperature	-	°C	- 10 to 70

Table 3: Typical characteristics - Total Biohydran RS 38 B [14]

## Conclusion

In 2011 a Commission Decision 2011/381/EU was introduced by which the ecological criteria and the related assessment and verification requirements for lubricants were defined. This Commission Decision was valid until 31 December 2018, when Commission Decision (EU) 2018/1702 establishing the EU Ecolabel criteria for lubricants was introduced.

From 2011 until now much was done on development of biodegradable lubricants, especially in the field of biodegradable additives by which producing of biodegradable lubricants was made possible.

Regarding the base oils, usually soybean, rapeseed, canola or sunflower oil are used as a base oil for producing of biodegradable lubricant. Main problem with this kind of base oils is that all of them have poor performance when working at high temperature and pressure, which represents a big problem while using biodegradable hydraulic fluid.

There are now companies present which have managed to produce sustainable synthetic base oil (SSBO); a 100% renewable, plant-derived, synthetic base oil which has great performance when working at high temperature and pressure. This

kind of biodegradable base oils introduces new set of biodegradable lubricants which will replace the mineral ones in much bigger aspect.

Regarding the biodegradable hydraulic oils, with using SSBO as base oil for their production a biodegradable hydraulic lubricant with higher performance would be produced, which would maintain good performance when working at high temperature and pressure.

And, of course, the main advantage of all biodegradable lubricants is the very fact that they are biodegradable which makes them environmentally friendly.

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