

Environmentally safe hydraulic oils

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As the mining industry continues in efforts to minimise the environmental impacts of its activities, Glenn Johnston takes a look at 'environmentally friendly' options available for hydraulic oils. What should industry be considering when selecting a 'greener' option for its hydraulic oils?



Spills of standard, petroleum-based hydraulic fluids are known to kill marine life and contaminate soil. Environmentally safe hydraulic fluids are formulated to avoid these undesirable results.

To be classified as 'environmentally safe', a fluid must be readily biodegradable, which means that more than 80% of the fluid must break down into innocuous products when exposed to the atmosphere over a 28-day period. They must also be virtually non-toxic. These fluids reduce the cost of spill clean-ups, and the fluid is unlikely to harm plant life, fish, animals or humans that come into contact with it.

Renewable, biodegradable hydraulic oils based on vegetable oil base stock easily meet the environmental requirements, but they must also be a useful hydraulic fluid and meet or outperform other forms of hydraulic fluid if they are to gain widespread adoption.

Selecting the right hydraulic fluid for an application means balancing various fluid characteristics to achieve the desired overall properties. An ideal hydraulic fluid would have the following characteristics:

- Constant viscosity, regardless of temperature;
- High anti-wear characteristics;
- Thermal stability;
- Hydrolytic stability;
- Low chemical corrosiveness;
- Low tendency to cavitate;
- Long life;
- Fire resistance;
- Readily biodegradable;
- Low toxicity;
- Low cost.

No single fluid has all these ideal properties, so selection of the best compromise involves understanding the basic characteristics of the system in which the fluid will be used. The main influential factors other than toxicity and biodegradability are:

- **Viscosity** — Maximum and minimum operating temperatures, along with the load, determine the system's viscosity requirements. A minimum viscosity must be maintained at higher temperatures,

and the fluid must not be so viscous at low temperatures that it cannot be poured. Vegetable oil hydraulic fluids have viscosity indexes comparable with petroleum-based fluids.

- **Wear** — Wear caused by metal-to-metal contact can be prevented by using a fluid with additives that create a thin protective film between moving metal parts. The most common anti-wear additive used to date in petrochemical hydraulic oils has been zinc dithiophosphate (ZDP), but this heavy metal is water soluble and highly toxic to marine environments, and these types of fluids are being replaced by 'ashless' anti-wear fluids. Vegetable oils provide natural anti-wear characteristics to a certain extent, but are still supported by anti-wear additives, especially for higher temperature operation.
- **Corrosion and oxidation** — System rusting is caused by water carried within the fluid attacking ferrous metal parts, so rust inhibitors are normally added. Ideally, the oil should exhibit good stability in the presence of water (hydrolytic stability). Other additives are often also used to prevent chemical corrosion as fluids age, creating acids sludge and varnish as they oxidise. These problems can be mitigated by changing the fluid regularly, and by not allowing it to be used at high temperatures, which accelerates decomposition.
- **Flammability** — Even though petroleum-based fluids have a relatively high flash



point ($>150^{\circ}\text{C}$) they can be a significant hazard if hydraulic machinery is operating in an environment with potential ignition sources — open flames, sparks or hot metal. In these environments, a leak spraying from a high-pressure hydraulic system could cause a serious fire and result in major property damage, personnel injury or death. Vegetable oils are inherently more resistant to fire than petroleum-based fluids.

The types of non-petroleum base oils

Three different types of base oils have been tried for use as environmentally safe hydraulic fluids — synthetic esters, polyglycols and vegetable oils.

- Synthetic esters have superior lubrication performance, but at a high cost, which has limited their usage.
- Polyglycols are less costly than synthetic esters, but they lack the required level of biodegradability and are potentially toxic when mixed with lubricating additives.
- Vegetable oils have excellent natural biodegradability and are in plentiful supply.

The base fluids used for biodegradable hydraulic fluids are usually vegetable oils, selected synthetic esters, or a blend of the two. They usually contain ashless (no zinc dithiophosphate or ZDP) corrosion and wear inhibitors and performance-enhancing additives, and can provide wear resistance similar to anti-wear petroleum fluids.

Vegetable oils contain unsaturated hydro-

carbons and are naturally occurring esters. The downside of them being biodegradable in this way, however, is that the unsaturation means that the fluid has poor low-temperature flow properties and is more susceptible to oxidation, especially at higher operating temperatures. They also have less water resistance. The use of a blend of vegetable oil with a synthetic ester is therefore often used to improve these characteristics, and low toxicity additives can help with some performance aspects, but oxidation stability has remained an issue.

Since vegetable oils generally have the same range of operating temperatures as petroleum-based oils, they are still not suitable for extreme cold or heat — they are best used between temperatures of -15 and 80°C . Synthetic ester-based hydraulic fluids are best used outside this temperature range.

On the positive side, vegetable oils offer excellent lubricity and have a high intrinsic viscosity and extreme-pressure properties. Well-formulated vegetable oil-based hydraulic fluids can pass the demanding Vickers 35VQ25 or Denison T5D-42 vane pump wear tests. They can perform satisfactorily for years under mild climate and operating conditions, provided they are kept free of water contamination.

And unlike petroleum-based hydraulic oils, they come from renewable feedstock.

Vegetable oil feedstock

Vegetable oil hydraulic fluids are mainly made from rapeseed (or canola), sunflower or soybean oil. Each have their respective differences in properties, but with different processing and additive formulations, there is little significant difference between them. Historically, rapeseed has been the most commonly used, particularly in Europe. Soybean oil has been researched and tested in more depth in the United States where it is a more prevalent crop.

Because of the inherent poor oxidation behaviour, as mentioned previously, makers of vegetable oil-based hydraulic fluids have had to use chemical additives or combine them with synthetic ester base stock to improve their life and high-temperature characteristics.

But now we live in the age of genetically modified crops and hybrid breeding. Recent advances in hybrid breeding technology have made it possible to alter the physical properties of vegetable oils by changing their fatty acid profiles. This has allowed some researchers to improve oxidation stability by increasing the oleic content of the oil. The resulting high-oleic base stock (HOBS) oils with additional antioxidants have been shown to be as good or better than petroleum oils in oxidation stability trials. For example, US-based Renewable Lubricants Inc has produced a hydraulic fluid that outperformed petroleum oils, synthetics, synthetic blends and commercial vegetable oil formulations in independent third-party tests.

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Cost

Cost varies with specific application, but in general, plant-based oils are 2–2.5 times more expensive than mineral oils, and half as much as synthetic formulations. The price differential between plant-based and mineral oil lubricants is attributable both to the higher raw material cost of vegetable base oils and to more costly additives.

Purchase price, however, is not an accurate measure of overall cost. Because vegetable oil-based lubricants evaporate less quickly and adhere better to metal surfaces, end users often use less product per application. Other cost benefits associated with vegetable oils may include reductions in environmental and safety penalties in the case of spills, parts wear and maintenance costs and disposal fees. As is the case with many plant-based products, once factors such as these are considered, plant-based lubricants are competitive in cost with petroleum oils.