Governments around the world have enacted regulations aimed at protecting the environment, and they usually carry significant fines and remediation costs for violators. That’s become increasingly important to designers and users of hydraulically powered equipment, especially when operating in wetlands and other environmentally sensitive areas.

While hydraulic hose and connectors perform better than ever, they still have the potential to leak or rupture and spill fluid. Fluid suppliers have responded by introducing eco-friendly biodegradable and nontoxic fluids based on a variety of chemistries. Unfortunately, none of these fluids is a direct replacement for petroleum-based hydraulic fluid.

Here’s a look at commonly available bio fluids, and some engineering considerations when making the switch.

**BIODEGRADABLE FLUIDS**

Four basic types of environmentally friendly hydraulic fluids are commonly used. Each is derived from different base stocks and is best applied to a specific range of applications and operating conditions. And because they have different chemistries, interactions with seal materials and other system components vary from fluid to fluid. Engineers must account for these interactions when weighing whether or not one will be a suitable replacement for petroleum-based fluids in a specific hydraulic system.

**HETG fluids** (hydraulic environmental triglyceride) are water insoluble triglycerides derived from vegetable or animal oils — with soybean, sunflower, and rapeseed (Canola) being the most common sources. They frequently contain soluble thickeners to increase their natural viscosity, which is approximately 35 mm²/sec at 40°C.

Triglycerides are long-chain fatty acids combined with alcohol in the form of glycerin. Natural triglycerides have excellent lubricity but poor thermal and hydrolytic stability. They also oxidize rapidly. Additives, chemical modification, and even genetic modification of the seeds used to produce the base stock can improve hydrolytic stability and oxidation resistance.

HETG fluids offer many advantages. For one, they are highly biodegradable and nontoxic. They offer excellent lubricity and anticorrosion properties. And because they are made from natural, renewable resources, they are readily available. In addition, they have a high viscosity index and high flash point.

Mobile equipment operating in environmentally sensitive areas increasingly relies on biodegradable hydraulic fluids. While not harmless, they are less toxic than petroleum-based fluids and cause less damage in the event of a spill.
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But HETG fluids also have drawbacks. High-temperature operation can cause quick aging, rapid oxidation, and extreme thickening and gumming. In addition, they are susceptible to water contamination, which causes hydrolysis and increases total acid number (TAN). They tend to thicken at high temperatures, which harms machine performance. And because they are miscible with mineral oil, this can lower biodegradability in circuits that aren’t properly flushed. Finally, they are double the cost of mineral oils.

**HEES fluids** (hydraulic environmental ester synthetic) are water-insoluble synthetic esters derived from either petroleum (traditionally rapeseed) oil feedstocks. Petroleum-sourced HEES fluids combine an organic acid and alcohol, whereas vegetable sourced fluids combine a fatty acid and alcohol.

HEES fluids are available and can be used in most circumstances such as they are unsaturated, partially saturated, and fully saturated products. Of these, fully saturated versions generally offer the best performance and command the highest price.

HEES fluids offer long service life due to high thermal and oxidative stability and good resistance to low temperatures. They are also available in a wide viscosity range (ISO VG 32/46/68). However, they have more disadvantages than advantages. For example, they’re expensive and, like HETG fluids, require special system-design requirements. They also hydrolyze in the presence of water, as do HETG fluids. However, because they are miscible with mineral oil, this can hurt biodegradability.

**HEPG fluids** (hydraulic environmental poly glycol) are water-soluble polyglycolyle glycols (PAG), polymers made from reacting alkylene oxide monomers such as ethylene oxide, propylene glycol, or propylene oxide with glycol. Those with 50 to 100% ethylene oxide are water soluble, while those with 100% propylene oxide are water insoluble. Both types are inherently fire resistant.

The biodegradability of HEPG fluids depends on the ratio of propylene oxide to ethylene oxide. The higher the molecular weight, the lower the biodegradability of the fluid. HEPG fluids come in a broad viscosity range and have an operating temperature range of –20 to 80°C. In addition, water-soluble polyglycols can be used as anhydrous lubricants.

Hydraulic fluid of choice is a special system design. For instance, they are incompatible with polyurethane seals, and pumps and motors may need to be derated when used with HEPG fluids.

**HEP fluids** (hydraulic environmental polyphosphate esters) have a higher specific gravity than traditional petroleum-based fluids. This may require adjusting pump intake conditions, say with overhead reservoirs to ensure positive inlet pressure, maintain adequate suction, and avoid cavitation.

Bio fluids also differ from standard petroleum-based hydraulic fluids in terms of properties like oxidation stability, biodegradability, water compatibility, filterability, and so on, and this can require special design and maintenance considerations. Engineers and equipment users must keep in mind that engine oil additives are not compat-ible with environmentally friendly fluids. Equipment that has operated with engine oil as a hydraulic fluid requires an exceptionally thorough cleaning before environmentally friendly fluid is installed.

**ADDITIONAL RECOMMENDATIONS**

Engineers and equipment users must keep in mind that environmentally friendly hydraulic fluids are not substitutes for regular maintenance and good operating practices. Preventing leaks is much more cost effective than remediation when it comes to the environmental impact of any operation. Spills of environmentally friendly fluids are still reportable incidents, but many environmental regulatory agencies treat them differently from petroleum-based fluid spills. Because the fluids are less toxic and more biodegradable, cleanup and reclamation costs may be lower. For example, the affected soil often does not have to be dug up and autoclaved, as is the case in most petroleum-based spills. And operations are frequently allowed to continue for a short period of time.

Eco fluids offer a less-toxic alternative to petroleum-based fluids that are more easily assimilated by the environment when properly disposed of, and cause less damage should they spill. The price for these benefits is often measured in higher initial cost, potentially shorter service life, lower efficiency, and additional maintenance requirements.