Hydro Safe® ISO VG-46(FR) and ISO VG-68(FR)

Fire Resistive Hydraulic Oils Without Sacrificing Performance

The increasingly important issues of environmental acceptance and biodegradability are the drivers behind the quest for alternatives to mineral oil as a base stock for hydraulic fluids. This search for replacements has led in several directions. Currently there are three commercially available biodegradable base stocks. They are polyglycols, polyol esters and naturally occurring triglycerides or vegetable oils.

Polyglycols were the first base stocks to be formulated into biodegradable fluids. They offer excellent oxidation stability but are the highest priced biodegradable fluids. Polyglycols are also used widely in the food processing industry. Synthetic polyol esters are the reaction product of a fatty ~i4 derived from either animal or plant sources and a synthetic polyol. The polyol ester resulting from this condensation reaction can be blended with various additives to produce a hydraulic fluid. Synthetic polyol esters represent the current industry standard, especially in high pressure, high performance applications. Naturally occurring triglycerides or vegetable oils are in the same chemical family as polyol esters. While favored for their inherent biodegradability and low environmental impact, they have traditionally exhibited low oxidative stability, which is a crucial shortcoming that has limited their widespread acceptance and use as a cost effective replacement for synthetic polyol ester fire resistant hydraulic fluids. Improved base stocks and additive technology have now overcome this deficiency.

Where fire resistance is a primary concern, synthetic polyol esters have performed well in extreme operations for over 25 years. Polyol esters have emerged as the fluid of choice, despite costs ranging up to six times more than mineral-based oils. An industry goal has been to develop a vegetable oil based (naturally occurring ester) fire resistant fluid equaling the performance properties found in synthetic esters while reducing fluid costs in the process. This goal can be achieved. By optimizing additive packages and using selected base stocks, naturally occurring ester fluids have oxidation stability and lubricity performance on par with synthetic polyol ester fluids.

Over the past four decades, two general types of products have competed in the fire-resistant fluids marketplace: water based and anhydrous fluids. It is important to note that the term “Fire-Resistant” as defined by Factory Mutual Research Corporation means 1) sprayed fluid that contacts an ignition source will not propagate flame and 2) that if the source of ignition is removed from a fluid spray, any flames will self extinguish. “Specification Tested” as defined by Factory Mutual Research Corporation means 1) the fluid is less flammable and harder to ignite in a spray area and 2) has a reduced heat release rate. Wherever fire is a possibility from a spark or heat source, a fire-resistant hydraulic fluid should be considered.

Anhydrous or non-water containing technology, on the other hand, provides lubrication much like mineral oil. Synthetic polyol esters (formed by the reaction of a fatty acid with an alcohol, diol or other polyol) have been regarded as one of the best performing of the biodegradable and fire-resistant hydraulic fluids. Their properties have been well-documented.

For synthetic polyol esters, biodegradability ranges up to 90 percent; lubrication is excellent, as is liquidity and aging stability at low and high temperatures. Polyol esters feature a high viscosity index (over 150); flash point at 530-550 degrees F; and fire point at 600-615 degrees F. As an anhydrous fire-resistant fluid, synthetic polyol esters have proven ideal for applications such as high-pressure mill equipment operating at pressures above 3000 psi and as high as 5000 psi.

Fully compounded vegetable oil fluids (vegetable oils or naturally occurring triglycerides are in the same chemical family as polyol esters) are over 90% percent biodegradable and offer good chemical and thermal stability. Their low total acid numbers contribute to their overall stability and longer system life. Corrosion protection is also excellent. While these fluids are good lubricants, performance concerns have typically arisen over their tendency toward rapid oxidation at elevated temperatures.

The oxidation instabilities normally associated with vegetable derived fluids are due to a high content of linoleic and linolenic fatty acids. Research has shown that the oleic acid ester distribution in a naturally occurring ester base stock is critical to fluid performance. These acids are characterized by two and three double bonds, respectively. A greater number of double bonds results in a material more sensitive to and prone to rapid oxidation. The high degree of unsaturation, in fact, leads to increases in viscosity, increases in the total acid number, and fluid aggressiveness toward copper and copper alloys. Taking these deficiencies into account, specially formulated additive packages and selected base stocks have allowed Hydro Safe Oil Division's chemists to produce a product that overcomes the shortcomings normally associated with vegetable oil based fluids. Tests have now demonstrated that additive technology can further be applied to enable vegetable oils to perform like polyol esters. This is because, with the exception of the ester base stock, the formulations for finished synthetic polyol ester and naturally occurring triglyceride fluids are identical. Both contain viscosity index modifiers, rust and oxidation inhibitors, EP additives, copper passivators, and defoamers.

To determine whether additive packages could be used to fortify vegetable oils to greatly improve their oxidation stability and thus equal the desired characteristics of synthetic polyol esters, key laboratory comparison tests were conducted.

The process began with canola oil as the base stock. This was then formulated with additives for benchmark comparison against a commercial, premium synthetic polyol ester fluid. When testing was completed, the canola oil with optimized additive package was found to provide overall comparable performance to the synthetic fluid, including in these areas:

Lubrication. When properly formulated, both passed FZG stage 12; Shell 4-Ball results (1,800 rpm, 40 kg., 1 hr., RT) were 0.30 mm.

Pump Testing. The Vickers 35VQ Vane Pump Test was utilized. This is a severe, mobile equipment wear test based on the Vickers 35VQ25 vane pump. The standard test procedure requires that the same charge of fluid be tested with satisfactory results in three successive 50-hour test runs (total ring and vanes wear must be below 90 mg in each of the three tests. A commercially available vegetable oil based fluid has passed the Vickers 35VQ pump test. Pump Wear (ASTM D2882) is also exceptional. Ring and vane loss was less than 12 mg for both the synthetic polyol ester and properly formulated canola oil. These results equal high performance hydraulic oil.

Oxidative Stability. The Rotating Bomb Oxidation Test (RBOT) was applied with these results: bomb life ranged from 55 minutes to 180 minutes for several synthetic polyol esters that were evaluated. The result for canola oil featuring an optimized additive package in a oleic acid ester base stock was 165 minutes.

The conclusion from these and other tests is that a fire resistant fluid based on naturally occurring triglycerides can be formulated to perform as an equal with synthetic polyol ester fire-resistant fluids in terms of lubricity and oxidation stability.

Based on the test results and proven optimized formulation, Hydro Safe Oil Division, Inc., has developed two hydraulic fluids which are vegetable oils derived fire-resistant hydraulic fluids with additives to enhance corrosion protection, metal passivation, and oxidative inhibition. Hydro Safe® ISO VG-68 is Factory Mutual approved as a less hazardous fluid. Hydro Safe® ISO VG-46 FR is Factory Mutual "Specification Tested".

Among the physical properties of Hydro Safe® ISO VG-46(FR) are a Viscosity Index of 197, ASTM Flash Point of 580 degrees F, and ASTM Fire Point of 660 degrees F. Hydro Safe ISO VG-68(FR) provides a Viscosity Index of 214, ASTM Flash Point of 500 degrees F, and ASTM Fire Point of 653 degrees F. These fluids passed Corrosion Test (ASTM D-665A).

The combination of a growing desire for biodegradability and for renewable, less-costly alternatives suggests that this new canola oil-based product offers potential as a practical replacement for synthetic polyol esters, especially in applications where fire resistance is a paramount concern.

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