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The changing economics of fire-resistant hydraulic fluids

Japanese die casters find polyol esters give a productivity edge.

Globally, two dominant hydraulic fluids are used in die casting – water glycols and polyol ester (HFD-U) based fluids. Despite their many benefits and inherent safety, if water glycols were introduced as a new type of fire-resistant fluid today, manufacturers might have a hard time getting them into service due to heightened environmental awareness and regulatory changes. The relative benefits of these fluids are shifting as die casters respond to the demands of a weak economy and more-stringent environmental requirements.

Recent studies conducted in Japan show there is a strong case for converting from water glycols to polyol-ester fluids – and not just because of environmental benefits. Although polyol esters are often 1.5 to 2 times the cost of water-glycol fluids, they can outperform conventional water-glycol fluids based on fluid cost per part produced. In fact, after converting to polyol-ester fluids to meet environmental demands, Japanese automakers realized savings – from higher efficiency and greater productivity – that made their die casting operations a stronger contributor to the bottom line.

Fire-resistant hydraulic fluids

Water glycols — For decades, some experts have heralded the merits of water-glycol hydraulic fluids. These assertions are based on the fact that the components of a water-glycol fluid have good thermal and hydrolytic stability. These properties are essential to

Comparing features and benefits

Properties	Water-glycol fluid (HFC)	Polyol-ester fluid (HFD-U)
Formulation	Water, glycol, polymeric thickener, and additives – for viscosity, corrosion protection, and anti-wear properties	Polyol ester base stock (synthetic or natural ester) and additives for oxidation and corrosion protection and anti-wear and extreme pressure lubrication
Environmental	• Possible wastewater surcharges for BOD (biological oxygen demand) and COD (chemical oxygen demand) • Some additives can cause a false positive in EPA phenol testing	• Biodegradable, low aquatic toxicity • Floats on water, specific gravity of <1.0; can be removed with standard emulsion-breaking technology
Fire resistance	Excellent due to high water content	Very good
Stability	Exceptional thermal and hydrolytic stability	Exceptional thermal and hydrolytic stability
Lubricating film strength	Generally good but poor under high pressure	Excellent even under high pressures
Vapor pressure	More prone to captivation due to water content	No vapor pressure concerns

Despite a price premium, polyol esters offer a number of environmental and performance advantages.

the fluid's performance (as water is the key fire-resistant component), and fire-resistant hydraulic fluids are typically exposed to heat. Some manufacturers even claim that water-glycol fluids, because they contain water, provide the greatest safety per fluid dollar spent. In reality, the technology behind water-glycol fluids hasn't changed much since the early 1960s, but the economics have.

As with any system component, water glycol fluids have drawbacks. Water glycols do not have the film strength characteristics of a non-water-based fluid. Under heavy loads, the hydrodynamic film can break down, causing excessive pump and seal wear that contributes to premature failure and equipment downtime. The fluids also require continuous maintenance to monitor water content and levels of corrosion inhibitors.

Because of their water solubility, when they mix with plant effluent, they form a solution that cannot be removed with standard waste water treatment methods. They contribute to BOD (biological oxygen demand) and COD (chemical oxygen demand) of the effluent. As a result, die casters are often subject to treatment surcharges from their local wastewater treatment plant for high organic loads in the effluent.

Early ester-based fluids — Early anhydrous, fire-resistant hydraulic fluids were based on phosphate-ester chemistry. These fluids used a phosphorus-centered molecule with three organic "tails" as their base stock. The phosphorus-containing portion of the molecule gave the fluid its fire resistance, with the overall molecular structure providing excellent lubrication in both hydrodynamic (thick film) and boundary (thin film or extreme pressure) modes.

Unfortunately, phosphate esters are not particularly waste treatable. They have a specific gravity greater than 1.0, so they sink in water. Their degradation byproducts are phenols and, when burned, generate an acrid, heavy smoke. Phosphate ester fluids also require special seals and hoses. In short, phosphate-ester technology had numerous shortcomings, so users pressed manufacturers to find alternative anhydrous fire-resistant fluids.

Organic ester-based fluids. The major breakthrough that was a true alternative to phosphate-ester fluids was polyol esters. These fluids, based on organic esters, avoided the shortcomings of phosphate esters. Polyol esters are, in themselves, excellent lubricants. Additives impart fire resistance by giving the synthetic esters self-extinguishing properties that stop flame propagation. Corrosion resistance additives and an ashless extreme-pressure additive give these synthetic fluids lubrication performance on par with mineral oil.

Polyol-ester fluids are also lighter than water, so they can be removed from wastewater streams by skimming. Should the fluid become emulsified with water, normal wastewater treatment techniques remove the emulsion. Polyol-ester fluids do not degrade into phenolic com-

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How fluids affect pump seals

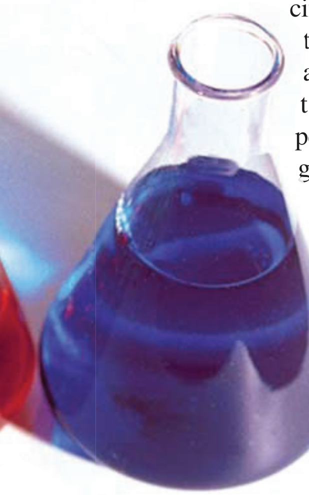
Seal properties	Water-glycol fluid(HFC)	Polyol-ester fluid (HFD-U)
Hardness	+7%	+2.2%
Volume	+11.4%	+5.7
Weight	+16.2%	+4.2

Machine testing with 70-durometer Buna N seals showed polyol esters have a smaller impact on a seal's physical characteristics.

pounds, and they don't require special seals; Buna N or nitrile elastomers are compatible with these fluids.

Changing economics

The traits that made polyol-ester fluids the preferred replacement for phosphate ester fluids for the most part went unnoticed by water-glycol fluid users in general, and die casters specifically, until waste treatment became an issue. The relatively low price per gallon of water-glycol fluids and a lack of perceived benefits from anhydrous fluid technology kept polyol esters from breaking into the die-casting industry. But that's changing.



Pressures to reduce wastewater treatment costs and surcharges led some die casters to take a second look at polyol-ester fluids. What they found was surprising – not only could they reduce costs associated with wastewater, they could gain a competitive advantage through higher productivity.

Today, die casters must push harder for efficiency and productivity in a tough economy. As a result, die-casting machinery has become larger, as has the amount of metal being injected. Hydraulic pressures have increased and cycle times decreased. All of these changes have contributed to process improvements.

However, these demands for performance and productivity are putting strains on equipment, as evidenced by excessive pump and seal wear and poor component life. Many die casters are finding the resulting downtime is hurting profitability.

Lessons from Japan

Several years ago, the Japanese government began to evaluate the organic waste that manufacturing facilities generate, and was especially interested in the organic load in wastewater streams. Die casters, and especially die casters for the largest Japanese automakers, began to take a critical look at the performance of polyol-ester fluids versus water-glycol fluids. Their findings make the case for switching to polyol-ester fluids.

The environmental component was easily solved. Again, because polyol-ester fluids are lighter than water, they can be removed from wastewater streams by skimming. If they become emulsified with water, they can be removed using normal water-treatment techniques. Therefore, die casters were able to reduce or eliminate government surcharges.

Machine tests on die-casting equipment at Japanese automakers showed that converting to polyol-ester fluids offered other advantages that similarly hit the bottom line.

One example involves seal life. Performance studies showed that seals operating with polyol-ester fluid had less wear. Further investigation of hydraulic cylinder seals indicated that the water-glycol fluid, being more volatile than polyol ester, was more prone to evaporation. Retracting cylinder rods could be dry, depending on the ambient temperature. Highly efficient rod wipers also had a negative effect on the performance of cylinders using water-glycol fluid, whereas polyol-ester fluids showed a constant film thickness regardless of the rod wiper.

And, as the accompanying table shows, other tests gauged the effects of hydraulic fluids on pump seals. Results indicate polyol esters have a much smaller impact on the seals' physical properties, as compared with water glycols.

The conclusion was that polyol esters could extend seal life, resulting in fewer cylinder replacements and rebuilds while also reducing fluid leakage. The net result was more machine up time and greater productivity.

Improved lubricity and reduced pump wear also translated into reductions in power consumption. As the "Energy consumption" table shows, switching to polyol esters cut power requirements by 5% to 15%, depending on motor size. In machines running around the clock, overall savings can be substantial.

In summary, the government regulations in Japan for organic loading in wastewater – instead of being damaging to profits – turned auto manufacturers to new fluid technologies that gave them a financial advantage. Reductions in energy consumption, elastomer wear, and fluid leakage, along with a significant reduction in waste-treatment costs, made a strong case for converting from water-glycol fluids to polyol-ester fluids. On a cost-per-part-produced basis, polyol esters consistently outperformed conventional water-glycol fluids.

Polyol ester fluid compared to water glycol

Motor size	Energy reduction with polyol ester
18 kW	5.6%
18.5 kW	9.4%
22 kW	11.2%
45 kW	15.1%

Better lubricity means polyol ester fluids reduce energy consumption on die-casting equipment.