Characteristics of fire-resistant hydraulic fluids

Consideration	Water glycol	Invert emulsion	Phosphate ester	Polyol ester	Consideration
Cost	$3 to $9 per gal: Cost is function of water content and performance enhancing additives.	$1.50 to $3.00 per gal. Cost is a function of water content, anti-freeze, and performance-enhancing additives.	$7.00 to $15.00 per gal: Cost is a function of specific chemistry and end-use requirements (i.e., special cleanliness standards). Aircraft and military requirements increase the cost over the range stated.	$7.00 to $12.00 per gal: Cost varies according to overall quality and tailoring to special applications.	Cost
Fire resistance	FMRC approval: yes Spray: excellent Hot metal (manifold): excellent Pool: fair — as product loses water, it can burn and sustain combustion.	FMRC Approval: yes Spray: fair to good Hot metal (manifold): excellent Pool: fair — as product loses water, it will burn and sustain combustion. Generally, will lose water at a slower rate than water glycol.	FMRC Approval: yes Spray: good to excellent Hot metal (manifold): excellent Pool: fair to good	FMRC Approval: yes Spray: good Hot metal (manifold): fair Pool: good	Fire resistance
Environmental	If fluid is lost from hydraulic system, it cannot readily be recovered. In waste treatment systems it readily disperses in water and can only be treated biologically or digested chemically. This may contribute to high BOD & COD costs. Some water glycol products may contain phenols and other ingredients.	In waste collection systems an invert emulsion will float on water and can be removed by skimming for subsequent treatment. Spills or leaks will be readily visible. Collected waste can be treated as an oily waste (incinerated, biological, chemical treatment). In the event of fires, products of combustion are non-toxic and relatively clean.	The fluid is immiscible in water and because of its high specific gravity will settle at the bottom of the containment system, which precludes recovery by skimming. It is biodegradable but products generated by hydrolysis may be toxic. Certain forms of phosphate esters are also toxic. The products are very fire resistant but when burned or thermally degraded, generate dark smoke that should be considered noxious.	The fluid is immiscible in water and can be readily skimmed and treated as an oily waste. It is biodegradable and non-toxic. Hydrolysis products are non-toxic. The products are fire resistant, and when burned or thermally degraded, they generate non-noxious compounds. These products are generally regarded as non-hazardous.	Environmental
Operation and design	Lubrication varies among products from fair to good. Has excellent low-temperature properties and good viscosity-temperature behavior. Operating temperature is limited to 120°F. Its high specific gravity may cause pump suction problems. In operation, the water content of the fluid must be maintained to ensure proper viscosity (and fire resistance). Corrosion protection may become depleted over time; fluid must be monitored on a regular basis in close-tolerance systems.	Invert emulsion has somewhat poor low-temperature properties because a dispersed water phase can freeze and, in some products, irreversibly destroy the emulsion stability. Premium products contain anti-freeze additives. The viscosity-temperature behavior is reasonable over the recommended operating temperature range, which should be restricted to 120°F. Its relatively high viscosity and high water partial-pressure may cause pump suction problems. In operation, the water content of the fluid must be maintained to ensure proper fire resistance. Under certain circumstance, the product may split into its oil and water phases and lose all important properties.	Low-temperature products are available, but their high viscosity indexes contribute to poor viscosity-temperature behavior. When the fluid is maintained properly there are few operational problems. Acid number beyond the recommended level can lead to corrosion problems, particularly with servovalves. Spills must be treated with care because the chemical activity of the product can be aggressive with regard to skin, gloves, shoes, etc.	Most products have an operational temperature limit of 175°F, although some specialty versions reportedly can be used above 200°F. The fluid should be monitored for total acid number and viscosity. Any excursions beyond recommended levels should be corrected through replacement or conditioning.	Operation and design
Conversion from oil-based systems	For many applications, a hydraulic system designed for oil use can be readily adapted to water glycol, particularly with regard to seals, hoses, and packing. Water glycol is immiscible in oil-based fluids, and performance considerations exist that may require derating the pump's maximum allowable pressure, speed, and operating temperature. Every effort should be made to remove as much of the old fluid as possible (>95%); with time, the residual oil will float in the reservoir and can be skimmed off. If the system has seen extended service, filter elements must be changed and obvious leaks repaired. In any conversion program, the new fluid may loosen or clean residual dirt and debris; the reservoir and filters should be monitored for increased dirt loads for several months after the conversion.	For many applications, a hydraulic system designed for oil use can be readily adapted to an invert emulsion. There may be performance considerations that require derating the pump's maximum pressure and speed; in some cases changing the type of pump.	The conversion process to phosphate ester requires special care. To accommodate phosphate ester fluids, a hydraulic system designed to use oil-based fluids requires retrofitting all elastomers with materials such as Viton, butyl, or EPR. Phosphate esters are excellent lubricants and generally require no derating of component performance. Phosphate esters are not miscible with oil, and any residual product must be removed. Fluid condition should be monitored for TAN and moisture level. In any conversion program, the new fluid may loosen or clean residual dirt and debris; the reservoir and filters should be monitored for increased dirt loads for several months after conversion.	The conversion process is simple because these fluids readily adapt to hydraulic systems designed originally for oil-based fluid. Pump derating is not required, and lubrication is comparable to oil-based fluid. Temperature-viscosity behavior is not compromised. They are generally compatible and miscible with oil based fluids. To maximize fire resistance, the conversion efficiency should be at least 95%. In any conversion program, the new fluid may loosen or clear residual dirt and debris; the system's reservoir and filters should be monitored for increased dirt loads for several months after conversion.	Conversion from oil-based systems