FIRE-RESISTANT HYDRAULIC FLUIDS

A GUIDE TO SELECTION AND APPLICATION

Monsanto

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GREATER SAFETY PLUS OPERATING EFFICIENCY

Fire-resistant hydraulic fluids have been commercially available for over twenty years. However, in the past ten years their adoption in preference to petroleum oil has grown dramatically. Millions of gallons of fire-resistant fluids are specified each year, reflecting industry's increasing concern for maximum safety. Fire-resistant fluid in high pressure operations not only protects the lives of employes, it insures equipment utility, safeguards premises, and eliminates a source of extensive damage and costly down-time.

Despite the widespread use, it is estimated that as yet only about 5% of all hydraulic fluids in use today are the fire-resistant type. Petroleum oil is still the standard for most fluid-powered industrial equipment. However, good hydraulic performance is equally assured with fire-resistant fluids when the differences between these fluids and petroleum oil are recognized. It is extremely important that the differences are understood by anyone who uses or is considering conversions to fire-resistant fluids. Safer operating practices with fire-resistant fluids are here to stay. Conversion to chemically made lubricants will grow. The following pages will serve as a guide in the selection and use of these fluids in industrial hydraulic equipment.

SELECTING THE FLUID

When considering the use of fire-resistant fluids, a number of questions should be considered:

* What constitutes a fire hazard near hydraulic equipment?
* In what industries do these hazards exist?
* What types of fire-resistant hydraulic fluids are available?
* What are the properties of the different types?
* What equipment changes are needed to accommodate their use?

In every operation these questions must be considered and decisions reached. Each of them bring up important factors to weigh when choosing a fire-resistant hydraulic fluid.

Fire Hazards

Petroleum type hydraulic fluids constitute a potential fire hazard wherever sources of ignition are present in the operating vicinity. Ignition sources may be open flames, electrical contacts discharge, sparks from metalworking, high temperature surfaces, even light bulbs. As long as the fluid is confined in the hydraulic system there is no danger. However, high pressure hose and line breaks, leaking joints or accidental spillage that puts hydraulic fluid in contact with these kinds of ignition sources can result in burning oil and a fire that can spread to other equipment, buildings and people.

Table 1 shows some common ignition sources, physical states of hydraulic fluid and environmental conditions. The concurrence of various combinations of these conditions can be helpful in estimating the degree of fire hazard. Where multiple dangers exist, it is safer to use fire-resistant hydraulic fluids.

(Note: Fire resistance of fluids and how it is measured is covered, starting Page 9.)

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TABLE 1

FIRE HAZARD CONDITIONS

Source of Ignition

Flames
Sparks
Hot Metal Surfaces
Electrical Contacts

Fluid Condition

Pools and Puddles
Sprays – stream and highly atomized
Vaporized
Wicking – saturating insulation, packaging

Environment

Air Temperature
Draft
Equipment and building spacing

Hazardous Industrial Applications

Table 2 lists typical industrial applications where fire-resistant fluids are highly desirable and where they are predominantly used. The concentration of use in primary metal production and metalworking industries is a result of the power usage and high temperatures involved in refining ores, in the producing and forming of steel, aluminum, copper, brass, zinc, magnesium and rare metals such as titanium, tantalum and beryllium.

Hydraulic power is used extensively in the basic steel and aluminum industries, in foundries and it is the primary means of transmitting large forces in die casting, forging and extrusion. Metal temperatures in or near hydraulic equipment range from 800°F to 3000°F and the fire hazard is severe.

Hydraulics are also used extensively in coal mining and plastic injection molding. Electrical arcs and easily-ignited flammable gases are the fire hazards in mining; the electrical heaters for the high-temperature melting plastics are the ignition dangers in injection molding. Recent legislation will require greater use of fire-resistant fluids in coal mines in the future, particularly in unattended hydraulic equipment.

Fire-resistant fluids should also be considered for lubricating air compressors and as bearing lubricants in rotating equipment such as steam and gas turbines. These uses will not be covered here. They are a separate technology that requires its own detail. However, it should be noted that synthetic fire-resistant fluids have been used as air compressor lubricants for many years. Any compressor can be hazardous when lubricated with petroleum oil. In reciprocating compressors, oils

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oxidize and build up carbon deposits on valves, cylinders and in air lines. High temperature compressed air can cause the carbon deposits to become hot enough to ignite fine mists of oil present in the system. The result is an explosive blast that can ignite the lubricant in the receiver reservoir. In centrifugal compressors, where fire-resistant fluids are available as bearing lubricants, seal failures often spray fluid onto high temperature surfaces of the compressor. In both types of compressors, synthetic fire-resistant lubricants greatly reduce the hazard since they resist ignition and possess much higher thermal and oxidative resistance than petroleum oils. These properties prevent carbon deposit formation.

TABLE 2

INDUSTRIES & EQUIPMENT WHERE FIRE-RESISTANT HYDRAULIC FLUIDS ARE NEEDED

Primary Metals
(Steel, Aluminum, Copper)

- Continuous Casters
- Rolling Mills
- Furnace Controls
- Stripper Cranes
- Automatic Welders
- Charging Equipment
- Mobile Equipment
- Hydraulic Shears

Forging and Extrusion

- Forging Presses
- Extrusion Presses
- Mobile Equipment

Coal Mining

- Continuous Miners
- Shuttle Cars
- Conveyors
- Car Spotters

Chemical-Petroleum-Power

- Valve Operators and Controls
  For High Temperature Equipment
- Air Compressors
- Steam and Gas Turbines

Die Casting

- Die Casting Machines
- Trim Presses
- Mobile Equipment

Foundries

- Core Machines
- Molding Machines
- Furnace Controls

Fabrication

- Forming Presses
- Automatic Welders
- Furnace Controls
- Conveyors

Injection Molding

- Molding Machines

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TYPES OF FIRE-RESISTANT HYDRAULIC FLUIDS

There are three major types of fire-resistant fluids which are being used today:

Synthetic Fluids
Water Glycol Fluids
Water-Oil Emulsion Fluids (Invert emulsions; more oil than water)

A rarely encountered fourth type are fluids made with soluble oils. They are water-oil solutions with corrosion inhibitors and lubricant additives added. This type fluid finds use in large central systems that feed low-speed hydraulic equipment and need not be treated here.

Synthetic Fluids

Synthetic fluids divide into two categories, straight synthetic and synthetic base fluids. The "straight synthetics" are pure phosphate esters. "Synthetic base" fluids are compounded products containing primary phosphate ester plus hydrocarbon fraction. This type has been commercially available for about seven years. They are solutions of straight synthetic fluid in selected high-viscosity, low-volatility hydrocarbons.

Both types of synthetic fluids are inherently fire resistant due to their phosphorus content. They have high film strength and the lubrication performance is equivalent to the best petroleum oils. Synthetic fluids have excellent thermal stability and can operate at temperatures up to 225°F depending on system design. However, non-metal components of hydraulic systems such as seals, hoses and paints commonly used in petroleum oil systems, generally speaking, are not compatible with synthetic fluids. Synthetic fluids are compatible with and non-corrosive to common metals of construction.

Water Glycols

Water glycol fluids are true solutions of water, glycols and high molecular weight thickeners to increase viscosity. They derive their fire resistance from water (usually 40-50% of volume), which acts as a snuffer and inhibits ignition of the flammable glycol content. Because of their water content, the film strength is lower than that of either petroleum oil or synthetics and lubrication performance is poorer. This limits their use in high pressure applications (above 1500 psi). Water glycol fluids, however, are compatible with the kinds of seals, hoses and paints commonly used in petroleum oil systems. This is an advantage when converting existing equipment.

Water-Oil Emulsions

The water-in-oil emulsions (commonly called invert emulsions) are mixtures of tiny water droplets dispersed in a continuous phase of petroleum oil. Like the water glycols, these emulsions also derive their fire resistance from their water content. Again, due to the water, the film strength of emulsions is relatively low and this limits their use in high pressure applications.

One of the primary use problems with water-oil emulsions is separation or "breaking" of the emulsion. This separation of components can be caused by long periods of standing, by extreme temperatures or from contamination. If separation occurs, the circulation of unemulsified water phase alone can cause serious pump damage and premature equipment failures.

The primary advantage of water-oil emulsions is that they are compatible with the same non-metal system components that are used with petroleum oil. This includes the kinds of elastomers used for seals and hoses as well as paints and common metals of construction (except magnesium).

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COMPARISON OF PROPERTIES

The many properties most important to good hydraulic fluid performance are shown in Table 3 and Table 4. Petroleum oil is included as a reference fluid. The differences between each type of fire-resistant fluid can be readily seen. The tables are a general classification; there are various differences within each category, but these general properties are representative of each type. When specifying a fire-resistant fluid, the supplier should always be consulted for his product's specific recommendation for the application.

Physical Properties

As Table 3 shows, all fire-resistant fluids are heavier than petroleum oil. The degree of difference is shown by their density. Because of this, a fluid starvation can occur at the pump inlet if the system was not designed for a fire-resistant fluid. It is easily avoided. Increasing the line size on the pump suction or refitting with a flooded suction will usually prevent pump starvation from a heavier fluid. If an extreme "high lift" condition cannot be avoided, supercharging the pump may be necessary. Filtration of fluid in the suction line should always be avoided and a 50 to 60 mesh strainer (no finer) should be used to protect the pump.

The "VI" (viscosity index) of fire-resistant fluids varies according to type. Straight synthetic fluids have a low VI; synthetic base fluids are intermediate viscosity; the VI of water glycols is quite high. (Emulsions are non-Newtonian liquids; they show a different viscosity in motion than at rest; viscosity index cannot be measured.)

The VI of a fluid is usually not critical unless the system temperatures range from very low (<40°F) to very high (>175°F). Within each category of fluids, a range of viscosity index is available. Depending on operating conditions, it may be necessary to select a grade with lower or higher viscosity to ensure satisfactory low temperature pumpability and/or adequate high-temperature viscosity for good pump lubrication.

Vapor pressure, the measure of volatility, is very important from the standpoint of pump performance as well as fluid maintenance. Operating temperatures above 150°F with the water-base fluids cause excessive water evaporation. This creates a tendency to vaporize at the pump inlet, resulting in pump cavitation. This water make-up control is covered later in the fluid maintenance section.

All fluid types offer corrosion protection in their liquid phase, but with water-containing fluids there is still a need for better vapor phase corrosion inhibitors. Vapor phase rusting usually occurs in the reservoirs and the rust particulates falling into a system can damage pumps and cause erractic valve operation. Maintaining adequate fluid level in the reservoir is the best way to avoid vapor phase corrosion; proper filtration can help to prevent rust particle damage.

The storage stability of all these types of fluids is good except for emulsions. Emulsions will separate into three phases (oil, emulsion, water) upon standing. The degree of separation and the time lapse before separation starts, depends upon the particular formulation or brand. Even when emulsions are stored at room temperature, most suppliers recommend drum rolling before the fluid is put into a system. If the emulsion has been stored at low temperatures, high speed stirring is recommended before the fluid is used.

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TABLE 3

PHYSICAL PROPERTIES

	Petroleum Oils	Synthetic Fluids	Synthetic Base Fluids	Water Glycol Fluids	Water-Oil Emulsions
Density	0.85-0.9	1.09-1.2	1.02-1.07	~ 1.05	~ 0.95
Viscosity Index	High	Low	Intermediate	High	Non-Newtonian
Vapor Pressure	Low	Low	Low	High	High
Corrosion Resistance					
Liquid Phase	Good	Good	Good	Good	Good
Vapor Phase	Fair	Fair	Fair	Fair to Poor	Fair to Poor
Storage Stability					
Room Temperature	Good	Good	Good	Good	Requires Care
Low Temperature	Good	Good	Good	Good	Poor

Functional Properties

Lubrication characteristics vary markedly between synthetic fluids (and petroleum oils) and water-base fluids. The significance of this difference depends on the type of pump used, the pressure and the temperature. As shown in Table 4, water-base fluids are generally not recommended above 1800 psi and in many cases 1500 psi is the practical limit. Operating temperatures with water-base fluids should be controlled in the range of 120°to 130°F for best performance. A high of 150°F is the maximum since heat leads to excessive water evaporation and aggravates the tendency to vaporize at the pump inlet. Synthetic fluids may be used at pressures up to 5000 psi with no sacrifice in pump life when compared to petroleum oil. The ceiling of 225°F set as the maximum fluid temperature for synthetics is only because at this temperature the viscosity of most fluids is reduced to a point where film strength approaches what is marginal for good pump lubrication. The synthetic fluids have thermal stability well in excess of 225°F so pump life, not temperature, is the factor to consider.

The type of pump used in a hydraulic system may also limit the choice of fire-resistant fluid used. Though all types of fluids can be used in vane and gear pumps, the outlet pressure of axial piston pumps must be derated 30-40% when used with water-base fluids; radial piston pumps should not be operated with water-base fluids at all. Synthetic fluids, however, may be used with both these types of piston pumps.

Most common metals of construction are compatible with all types of fire-resistant fluids. Aluminum should not be used for load bearing surfaces with any of the fire-resistant fluids. Other exceptions are shown in Table 4.

Compatibility with Seals, Packings, Hose Materials: The most common elastomers used for seals and hoses are neoprene and buna N since these two synthetic rubbers are compatible with petroleum oil. Both water-glycol and water-oil emulsion fluids are compatible with these elastomers and this is a significant advantage when converting an operating hydraulic system to a fire-resistant fluid. Synthetic fluids soften and swell both neoprene and buna N and these elastomers are particularly unsuitable for dynamic seals (cylinder packing, pump shaft seals) when these types of fluids are to be used. When converting an oil-operated system to an all synthetic or synthetic base fluid, it is highly advisable to replace dynamic seals with seals made of swell resistant elastomer. Viton is the most common. Seals of Viton (or other compatible elastomers) will prevent premature failure of the seals and forestall excessive fluid leakage. Static seals generally need not be changed,

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since swelling tightens them and serves to prevent leakage. However, static seals should also be replaced with seals of a compatible elastomer when components are disassembled for maintenance.

For hydraulic hoses, buna N and neoprene are the most common hose liner materials; they are satisfactory for use with water glycols and water-oil emulsions. Synthetic and synthetic base fluids require hose linings of Butyl, EPR or nylon.

Paints commonly used in the reservoirs of petroleum oil systems are not compatible with synthetic, synthetic base or water glycol fluids. These types of fluid cause peeling of oil-resistant paint and contact results in fluid contamination and erratic valve performance. When converting a system, reservoirs should be stripped of paint before contact with any synthetic or water-glycol fluid. Reservoir repainting is not necessary but if this is done, an epoxy-base paint should be used.

When converting from petroleum oil to a fire-resistant fluid, or from one type of fire-resistant fluid to another, the fluid supplier should be consulted for recommendations on proper procedures. USA Standard B 93.5, 1966 also gives complete details on conversion procedures. Copies can be obtained from the National Fluid Power Association, Thiensville, Wisconsin 53092.

Filtration of hydraulic fluids is extremely important and can dramatically affect pump life. Synthetic, synthetic base and water glycol fluids tend to be more detergent than petroleum oil or emulsions; they will carry dirt and wear particles in suspension rather than sinking them to the bottom of the reservoir. Therefore, good filtration is important to maintain long component life. All of the hydraulic fluids are easily filtered and a pressure side filter of 10 micron or smaller is advisable for any industrial hydraulic system regardless of the fluid used. The only precaution in the filtering is that absorption-type filters that operate with active earths or clay should not be used with water-base fluids since their corrosion inhibitors and wear additives may be removed.

General costs for the various types of fluids are given in Table 4 and cover a wide range. Fire-resistant fluids are in the higher range as can be expected. It is usually necessary to pay a premium for safety since fire prevention in any form costs money. Fire-resistant hydraulic fluids, while more expensive than petroleum oil, can save many times their cost when a hydraulic line breaks and sprays fluid on an ignition source. Nearly all insurance companies recognize this and adjust their rates accordingly. If fire-resistant fluids are not being used in a hazardous area, a check with the insurance company may reveal the price paid for petroleum oil is higher than its cost per gallon.

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TABLE 4

FUNCTIONAL PROPERTIES

	Petroleum Oil	Synthetic Fluid	Synthetic Base Fluid	Water Glycol	Water-Oil Emulsions
Lubrication					
Max. Pressure	Up to 5000 psi	Up to 5000 psi	Up to 5000 psi	Moderate	Moderate
Recommended Operating Temperature	200°	175°-225°F	150°-200°F	150°F (max.)	150°F (max.)
Compatibility					
Common Metals	Good	Good*	Good*	Exclude Zn,* Cd, Mg	Exclude Mg*
Common Seals	Neoprene Buna N	Viton[1] Silicone Teflon[1] Fluorel[3] Butyl EPR	Viton Silicone Teflon Fluorel Butyl** EPR**	Neoprene Buna N Butyl[2]	Neoprene Buna N
Common Hoses	Neoprene Buna N	Butyl EPR Nylon	Butyl EPR Nylon	Neoprene Buna N Butyl	Neoprene Buna N
Paints	Oil Resistant	Special (epoxy base)	Special (epoxy base)	Special (epoxy base)	Oil Resistant
Filtration, Min. Size, microns	<10	<10	<10	<10	<10

* Aluminum is not recommended for load bearing surfaces with any fire-resistant fluid.
** Satisfactory under certain use conditions – fluid supplier should be consulted.
[1] Trademark of DuPont de Nemours & Co.
[2] Trademark of Enjay Chemical Co.
[3] Trademark of Three-M Co.

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FIRE RESISTANCE

The safety of any fluid is directly related to its relative fire resistance. This leads to the question: What is fire resistance and how is it measured?

The term fire-resistant is used to describe these fluids rather than non-flammable or fire proof. All commercial fire-resistant fluids can be made to burn under highly artificial or unusual conditions. The key points to consider when evaluating fire resistance are ease of ignition and propagation. These are practical measures of a fluid's safety in use.

Fire-resistant fluids are more difficult to ignite and once ignited, flames have much less tendency to spread from the ignition source. This is not the case with petroleum oils.

There are many tests used to measure fire resistance. Private organizations, industrial companies, military branches, government departments, insurance underwriters and cooperating combinations of these groups have done much work to measure fire resistance and to standardize the tests.

Although many individual tests exist, they may be classified into the following small number of groups:

Flash and Fire Points
Autogenous and Spontaneous Ignition Temperature
Ignition of Spray and Flame Propagation
Hot Metal Surfaces and Molten Metal
Wick Flammability
Special and Combined

The fire resistance of hydraulic fluids is a difficult property to define and measure. Several facets must be considered and all factors weighed to assess their relative importance in a given application. The fire resistance of a given fluid is then a considered judgment in the light of all these factors. Generally fire resistance tests are empirical simulative tests which compare known and unknown fluids. Each test is designed to bear some relationship to an actual hazard. Most ratings therefore are arrived at by qualitative visual observations.

Typical fire resistance values for commercial types of industrial fire resistant fluids are compared with petroleum oil in Table 5.

Except for large operations that can justify their own fire test facilities, a fluid user usually looks for guidance from the supplier's fire tests. Insurance underwriters will approve or rate fire-resistant fluids and may require they be used in certain installations.

FLUID MAINTENANCE

In normal use, fire-resistant fluids can be divided into two groups for maintenance considerations. As with petroleum oil, straight synthetic and synthetic base fluids are relatively stable and require only simple filtration at the machine to remove solid contaminants. Water-base fluids usually need periodic water make-up and some types require replenishment of additives.

In cases of severe service or accidental contamination, more elaborate maintenance and monitoring programs may be justified if the fluid renewal procedures will allow long-continued use of the fluid and minimum make-up or replacement. Such programs usually require a portable recovery unit that can be moved to each machine or ways to collect fluid and move it to a central processing point. Such programs can be carried out by the user or by a contract reclaimer.

The specific points to observe on maintenance of each type of fluid are as follows:

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TABLE 5

FIRE RESISTANCE PERFORMANCE

	Petroleum Oil	**Straight Synthetic**	*Synthetic Base*	*Water Glycol*	**Water-In-Oil Emulsion**
Flash Point	300-400°F	400-500°F	400-500°F	No ignition until water is evaporated	No ignition until water is evaporated
Fire Point	350-450°F	650-700°F	450-550°F	No ignition until water is evaporated	No ignition until water is evaporated
Spontaneous Ignition Temperature (ASTM D2155)	500-650°F	900-1000°F	750-850°F	800-850°F	650-700°F
Temperature for Ignition on Open Metal Surface	500-900°F	1300-1600°F	1000-1300°F	1000-1200°F	650-1000°F
Wick Type Ignition	Ignites readily, spreads along wick	Difficult to ignite. Does not spread.	Moderately difficult to ignite, does *not spread or* spreads slowly	No ignition until water evaporates *then burns* and spreads	No ignition until water evaporates then burns and spreads
Sprays and Streams	Ignites readily, large flame carried along stream and usually continuous burning	Difficult to ignite, local flame by ignition source, self-extinguishing when ignition removed	Moderately difficult to ignite, medium size flame may flash along stream, self-extinguishing when ignition removed	When water present — difficult to ignite, small flame, non-spreading and self-extinguishing. When water content low, burns readily with large flame which spreads.	Similar to water glycol with and without water

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Straight Synthetic Fluids

Filtration at the machine is all that is necessary for long fluid life in most installations. Small amounts of moisture can be removed by paper or active earth filters. Active earth filters may be used with straight synthetic fluids since either they contain no additives or the additives are stable. Appearance, acidity, viscosity, specific gravity and moisture content are used to judge fluid condition. Yearly sampling and testing is sufficient unless system malfunctions occur which appear to be fluid related.

If fluid degradation occurs it is usually caused by severe local overheating. Earth filtration will remove small amounts of acidic decomposition products. However, if fluid has been severely degraded, contains large amounts of water or has become contaminated, the fluid should be removed from the system for more extensive reclamation. The extent of damage and the problem of reclamation will vary and the supplier or a competent fluid reclaimer will recommend the most economical reclaiming procedure.

A common contaminant is petroleum oil. This will greatly decrease the fluid's fire resistance. Most straight synthetic fluids can tolerate some oil contamination without complete loss of fire resistance, depending upon the grade of oil and its viscosity. The fluid's supplier will be the best source of information for reclamation of such fluids.

Synthetic Base

Maintenance of the synthetic base fluids is similar to that with straight synthetics. Since these usually contain selected hydrocarbons, their margin of toleration for oil contamination is smaller. For this reason, greater care must be exercised to prevent oil contamination.

As with straight synthetics – appearance, viscosity, acidity, specific gravity and moisture content are used to judge the fluid's condition. These should be tested on a yearly basis or as required to check any system malfunction.

Water Glycol

Normal wear debris and solid contaminants can be removed by suitable water-resistant filters. Earth or active clay type filters should not be used with this type fluid since these tend to remove additives.

Water-glycol fluids should be checked at appropriate intervals for water content. The proper proportion of water is necessary both to insure adequate fire resistance and maintain the viscosity. Alkalinity and pH changes may require replenishing of part of the original additives to insure against rust and lubrication problems.

Water content can be determined by direct measurement or on the basis of viscosity. As water evaporates, viscosity will increase. The fluid supplier will furnish charts or tables that show the amount of water to be added to restore the fluid to its original viscosity.

Only distilled, deionized, steam condensate, or air conditioner condensate water should be used for make-up. Hard or impure water may cause inhibitor separation and lubrication problems. Operating the hydraulic system at the lowest practical temperature will decrease the need for water make-up.

If alkalinity must be adjusted, the fluid supplier should be consulted for the type and amount of additive to be used. The relatively low cost of water-glycol fluids makes reclamation of badly contaminated or degraded fluid uneconomical. In these cases disposal by incineration or other acceptable means is recommended.

Water-In-Oil Emulsions

Measuring the water content at appropriate intervals is the primary maintenance check

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necessary with water-in-oil emulsions. The amount of water to be added is determined by referring to tables or charts that are furnished by the fluid supplier. As with water-glycol fluids, only high purity water should be used. Hard water can precipitate additive separation and emulsion breaking. Operating the fluid at the lowest practical temperatures will decrease need for water replacement.

Solid contaminants can be removed by filtration; however, absorptive filters such as clay, cotton, felt, paper, or resin impregnated paper types should not be used since they may absorb additives and cause emulsion separation.

As indicated earlier, emulsion type fluids have a tendency to separate into layers and should be remixed thoroughly before addition to or make-up in the hydraulic system.

The low cost of emulsion fluids makes any reclamation of badly contaminated fluid impractical. It can be incinerated or disposed of by any acceptable method.

POLLUTION

All industries are becoming increasingly aware of the problems and feeling the pressures to minimize pollution from manufacturing operations. The question arises: will the use of fire-resistant fluids cause more problems relative to pollution and plant effluent purification? The answer, of course, depends both on the type of fluid used and the operating practices of particular companies.

Legislation and its enforcement is increasingly prohibitive of the kinds and amounts of materials – even petroleum oil – allowable in plant effluent streams. This means that no matter what type of fluid is used it must be removed from effluent streams unless it is readily decomposed to harmless materials without environmental changes.

This need to re-claim or process can be turned to advantage: better plant maintenance practices reduce fluid use. The stable straight synthetic and synthetic base fluids can usually be recovered, cleaned and reconstituted as needed and recycled. This practice eliminates disposal problems and will reduce overall fluid costs.

Straight synthetic and synthetic base fluids are also usually readily removed from effluent streams. Water-in-oil emulsions, however, may first require oil separation before the water portion can be further treated to remove remaining pollutants. Water-glycol fluids present a problem since the glycol components cannot be separated inexpensively. If large quantities of these solutions are discarded in water streams, the area's biological oxygen demand limits may be exceeded. In some areas, the maximum daily quantity of discard will be a restriction.

When the various fire-resistant fluids cannot be reused, the best means of disposal is high temperature incineration. By this means, the fluid is decomposed to relatively harmless materials. Where questions of proper disposal arise, the fluid supplier should be consulted.

CONCLUSION

Since many factors enter into the use of the various types of fire-resistant fluids, it is helpful to summarize the advantages and disadvantages of each type of fluid in a concise manner. Table 6 lists the various types, shows the relationship between cost and performance. Without questions, straight synthetic type fluids are the best performing and they are followed in order by synthetic base fluids, water glycols and water-oil emulsions. Likewise, synthetic fluids are the most costly and the other types follow in the same order.

Under the diverse conditions of use, there is a need for each of the types. The selection of a fluid for a particular application depends on which of the advantages and disadvantages cited in Table 6 are most critical; degree of fire resistance, overall cost (including maintenance or reclamation ease), lubrication characteristics, stability, seals and hoses required. Only when the critical factors are determined for a particular application can fire resistant fluids be evaluated on a cost/performance basis and the most satisfactory fluid selected.

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TABLE 6

Fluid Type	Advantages	Disadvantages
Synthetic Fluids	Excellent Fire Resistance Excellent Lubricant Excellent Stability Minimum Maintenance Readily Reclaimed	Higher Cost Special Seals, Hoses Required
Synthetic Base Fluids	Good Fire Resistance Excellent Lubricant Excellent Stability Minimum Fluid Maintenance Readily Reclaimed	Moderate Cost Special Seals, Hoses Required
Water Glycols	Low Cost Excellent Fire Resistance* Compatible with standard seals and hoses Good Stability	Fair Lubricant High Fluid Maintenance Not Readily Reclaimed System Pressure Limitations
Water-Oil Emulsions	Very Low Cost Compatible with standard seals and hoses	Fair Fire Resistance Fair Lubricant High Fluid Maintenance Poor Stability Not Readily Reclaimed System Pressure Limitations

*Provided proper water concentration is maintained.

Monsanto manufactures a full line of pure phosphate ester, phosphate ester blend and water glycol fire-resistant hydraulic fluids under the trade names Pydraul® and Santosafe®.

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