

INDEX OF FAQ

1. Why should I use a synthetic fluid rather than standard petroleum mineral oil based hydraulic fluid?
2. What are the different synthetic hydraulic fluids?
3. How do I know which one to use for my application?
4. Are the synthetic fluids more dangerous for personnel to be around and handle?
5. Won't synthetics cut the lifetime of my hydraulic equipment?
6. Will the equipment manufacturer still warranty his product if I use synthetic hydraulic fluids?
7. Are synthetic hydraulic fluids more flammable than mineral oil based hydraulic fluids?
8. What are the important ratings that a synthetic hydraulic fluid must have?
9. I have heard that many of the synthetic fluids are biodegradable, what does that mean?
10. Will synthetic hydraulic fluids provide the same flow characteristics and lubricity as does mineral oil based fluids?
11. Will I get similar lifetimes from the synthetic hydraulic fluids that I now get from my mineral based oils?
12. I have noticed that it seems that every manufacturer of synthetic hydraulic fluid has a different color. Are there color standards and if so what are they?
13. I have been pricing various hydraulic fluids and it seems that the synthetics are much more expensive than the mineral oil based products. Why is this?
14. Are the synthetic hydraulic fluids as price sensitive as the mineral oil based fluids to fluctuations in the petroleum commodities market?
15. Are synthetic lubricants more energy efficient than petroleum based fluids?
16. Does anyone who is currently providing synthetic hydraulic fluids provide application assistance?
17. I understand that many synthetic fluids have a high water content and the manufacturer of my pumps will not warranty their equipment if the fluids I use exceed 40% in water; are there synthetics that are 40% and below in water content?
18. I understand that many synthetic fluids have a high water content and the manufacturer of my pumps will not warranty their equipment if the fluids I use exceed 40% in water; are there synthetics that are 40% and below in water content?
19. If the hydraulic fluid is a water based glycol what prevents it from emulsifying like oil does when it comes in contact with water?
20. If the hydraulic fluid has high water based content, then won't it freeze in cold temperatures or evaporate in extremely warm temperatures?
21. With a high water base won't it cause my equipment to rust?
22. If the fluid is biodegradable does that mean that I can dispose of it just by dumping it down the drain?
23. Can I mix the synthetic fluids with the oil that I am currently using?
24. What do I have to do to convert my system from oil based hydraulics to synthetic based hydraulics?
25. I have heard that you shouldn't use synthetic hydraulic fluids with aluminum and galvanized steel. Is this true and why?
26. The manufacturer of my industrial fryer recommends that I use a food grade water glycol fluid in my equipment. Why should I?
27. Do synthetic hydraulic fluid systems require more maintenance?
28. With synthetic hydraulic fluid systems can I use paper media filters?
29. Currently I am running my hydraulic system at 5000 psi. Can I use a synthetic hydraulic fluid at these high pressures? How high of a pressure will they withstand?
30. Why have the synthetic carwash hydraulic fluids gotten such a bad reputation?

- 31. The fluid manufacturer recommends checking the water content of my fluid on a weekly basis; how can I check the water content of my water glycol system?**
- 32. If synthetic hydraulic fluids are so desirable why don't all manufacturers recommend using them in their equipment?**
- 33. When researching fluids and their properties I have found terminology that I don't really understand. Is there somewhere I can go to find these terms with an easy to understand meanings?**
- 34. I have been told there are a number of seals and hoses that cannot be used with synthetic fluids. If so, why and where can I find out what is compatible and what's not.**
- 35. Do synthetic fluids have to be changed more often than petroleum based fluids?**
- 36. If fluid biodegradability is such a desirable characteristic then why isn't it mandated to be used in all hydraulic systems?**
- 37. My system is operating on a diethylene glycol hydraulic fluid and it is running sluggish in comparison to when I first converted the system. What could cause this condition?**
- 38. I am having problems with my hydraulic system and the evaporation of water from the water glycol fluid that I am using. The ambient temperature ranges from around 40° F in the winter to 110° F in the summer. The power unit is placed in an equipment room without much ventilation. My fluid power professional recommends that I restore my system back to a mineral oil based fluid. What can be done to reduce the evaporation so that I can keep using the water based fluid.**
- 39. How can it be determined if a synthetic fluid would be beneficial for my application?**
- 40. What equipment will I need to convert the mineral oil hydraulic system over to synthetic fluid?**
- 41. Some hydraulic fluids have a leak detector dye. What advantage does this provide?**
- 42. Why do food grade hydraulic fluids need to be replaced so often?**

SYNTHETIC HYDRAULIC FLUIDS - FREQUENTLY ASKED QUESTIONS

1. **Question:** Why should I use a synthetic fluid rather than standard petroleum mineral oil based hydraulic fluid?

Answer: *Synthetic fluids are generally used to obtain greater performance of machinery, to obtain a product that delivers a better film strength for bearings and mating metal surfaces, fire resistance and, in some cases, synthetic fluids are more environmentally acceptable.*

2. **Question:** What are the different synthetic hydraulic fluids?

Answer: *The most common are Water Glycols, Anhydrous Glycols (Polyalkaline Glycols), Polyol Esters, Phosphate Esters, and the Vegetable Oils (Canola, Soybean etc.). Other types of synthetics are Poly Alpha Olefins, Silicone, Fluorocarbons etc... These are not commonly used for hydraulic fluids. Each has been designed to provide specific properties for specific applications.*

3. **Question:** How do I know which one to use for my application?

Answer: *It depends on what you are looking for in your application. If you're looking for fire resistance, then you would choose a water glycol. This would also apply if you are looking for an easily maintained fluid with good biodegradability and a low temperature operation. The esters are generally used where high pressure operations and a need for boundary lubrication are present. Esters are not good in situations where they are subject to attack by moisture. The use of Vegetable Oils is good for environmental concerns such as food plants. They are also subjected to attack by moisture.*

4. **Question:** Are the synthetic fluids more dangerous for personnel to be around and handle?

Answer: *Generally no, but their respective additives could influence that. Phosphate esters are the exception and have more potential to be hard to handle by workers. The MSDS will provide information on personnel safety.*

5. **Question:** Won't synthetics cut the lifetime of my hydraulic equipment?

Answer: *If synthetic fluids are properly maintained they should extend the life of hydraulic equipment. The operating conditions will dictate the type of Synthetic Fluid to use.*

6. **Question:** Will the equipment manufacturer still warranty his product if I use synthetic hydraulic fluids?

Answer: *Yes, if it meets the specifications he has set for Synthetic Hydraulic Fluids. Your best course of action would be to contact the OEM and assure that the fluid is acceptable.*

7. **Question:** Are synthetic hydraulic fluids more flammable than mineral oil based hydraulic fluids?

Answer: *Not necessarily. This is set by Factory Mutual Insurance Engineers which is the approval authority for determining fire resistance in the USA. Synthetic fluids are blended to*

provide desired characteristics and flammability resistance is one of the characteristics that the manufacturer can blend into the fluid. Water based fluids are inherently fire resistant unless the water evaporates completely, then it will support combustion.

8. Question: What are the important ratings that a synthetic hydraulic fluid must have?

Answer: *Ratings on synthetic hydraulic fluids are application specific. This is determined by industry standards. All synthetic hydraulic fluids must have a third party certification for fire resistance. These are normally provided by Factory Mutual International (FM) in the U.S. Other nations have standards that must be accepted and may or may not accept FM. Food Grade fluids must have the appropriate approvals to be used in and around food processing. In the U.S. there is no third party standard to indicate biodegradability. However, there are Canadian Standards and EU Standards for biodegradability and will be suitably labeled.*

9. Question: I have heard that many of the synthetic fluids are biodegradable, what does that mean?

Answer: *Biodegradability is a term used to describe the difficulty of a product to degrade in waste treatment. This is measurable and is generally calculated by waste treatment facilities to determine the effect that a product might have on the ability to treat it when it enters the waste treatment plant. Municipal waste treatment plants will set their standards and may be very different in one municipality than in another. They will usually levy fines to the company responsible for the product being released into their system when BOD/COD exceeds their limits. The waste treatment standard set by the municipal waste plant is for Biological and Chemical Oxygen Demand (BOD & COD) and is a measurement of biodegradability. There are three important thresholds in biodegradable considerations; biodegrades within 7 days or less, biodegrades within 28 days or less, biodegrades in excess of 28 days, and non-biodegradable in most jurisdictions fluids must degrade within 28 days or less to be considered biodegradable. Again this can only be established by local authorities.*

10. Question: Will synthetic hydraulic fluids provide the same flow characteristics and lubricity as does mineral oil based fluids?

Answer: *The Viscosity Index (VI) of the synthetic fluids is generally better than that of petroleum or mineral oils. The oils will generally have a viscosity index of 90 while Synthetics are above 100. A water glycol fluid averages 150 or better. Oils form waxy particles at low temperatures. This inhibits flow unless the oil contains polymers to improve viscosity. Much like you find in multigrade motor oils. For fluids, the higher the VI the better the flow characteristics are at low temperature.*

Lubricity is determined by the character of the additives in each fluid. Some Synthetic Esters are added to oil to improve the oils film strength.

Water based fluids depend on the lubricity of the glycol in use. Unlike oil which provides a lower viscosity at higher temperatures, water glycols have reduced lubricity (inability to provide boundary lubrication) at extremely high temperatures. Therefore, most manufacturers of water glycol lubricants recommend keeping the fluid at or below 50° C or 122° F.

11. Question: Will I get similar lifetimes from the synthetic hydraulic fluids that I now get from my mineral based oils?

Answer: *Yes, but it is dependent on good maintenance procedures. Synthetic Hydraulic Fluids are less forgiving than oil. Oil can be abused and operate satisfactorily but the same is not usually true for synthetic fluids. Synthetic fluids are highly dependent on maintaining a chemical balance.*

12. Question: I have noticed that it seems that every manufacturer of synthetic hydraulic fluid has a different color. Are there color standards and if so what are they?

Answer: *Not every synthetic fluid supplier has different colors for their fluids. These fluids have colors that are usually indicative of an industry standard' i.e. water glycols-red, polyol ester-amber and phosphate ester-green, etc.*

13. Question: I have been pricing various hydraulic fluids and it seems that the synthetics are much more expensive than the mineral oil based products. Why is this?

Answer: *That is generally true and it is partially due to demand. Some products are also more expensive to manufacture than mineral based hydraulic oil.*

14. Question: Are the synthetic hydraulic fluids as price sensitive as the mineral oil based fluids to fluctuations in the petroleum commodities market?

Answer: *Yes, many of the polymers and other additives are petroleum based.*

15. Question: Are synthetic lubricants more energy efficient than petroleum based fluids?

Answer: *In short, no. Energy efficiency is a function of a number of variables. Primarily efficiencies will be determined by the overall system design, component efficiencies, and operating environments. Although synthetic fluids with higher bulk modulus are theoretically more efficient in the transmission of energy it is generally so slight that the impact is only negligible at best.*

16. Question: Does anyone who is currently providing synthetic hydraulic fluids provide application assistance?

Answer: *Yes, fluid manufacturers more so than fluid or fluid power distributors. As the use of the synthetic fluids expands, there will be more and more application assistance available. It is good to check with your supplier and see what kind of assistance that they can provide. If they seem incapable or unwilling, seek outside assistance.*

17. Question: I understand that many synthetic fluids have a high water content and the manufacturer of my pumps will not warranty their equipment if the fluids I use exceed 40% in water; are there synthetics that are 40% and below in water content?

Answer: *Of all the synthetics available, High Water Based Fluid and Water Glycols are the only water based fluids commonly used in industry. The other Synthetic fluids are anhydrous. Each is used under specific conditions set by the manufacture, i.e. HWBF are used in systems that can operate on water while Water Glycol can operate in a number of systems that are designed to use oil. Usually if water based fluids are used in a system the OEM component manufacturer will de-rate the pumps to avoid excessive wear. Also, depending on the fluid, there may be limitations on either system pressures, pump speeds or both.*

18. **Question:** I understand that many synthetic fluids have a high water content and the manufacturer of my pumps will not warranty their equipment if the fluids I use exceed 40% in water; are there synthetics that are 40% and below in water content?

Answer: *Except for High Water Based Fluid and Water Glycols all other commonly used fluids are anhydrous. Anhydrous fluids should be used in systems where the application would be best served with non water based fluids. It is always best to contact the OEM for their recommendations for synthetic fluid use.*

19. **Question:** If the hydraulic fluid is a water based glycol what prevents it from emulsifying like oil does when it comes in contact with water?

Answer: *Water Glycols are water soluble while emulsion fluids are not, therefore they will not emulsify. While water based fluids will not emulsify they will foam. The fluid manufacturer adds an antifoaming agent to prevent this problem.*

20. **Question:** If the hydraulic fluid has high water based content, then won't it freeze in cold temperatures or evaporate in extremely warm temperatures?

Answer: *Yes in extreme circumstances, but most commercial HWBF usually have a pour point that is well below most ambient low temperatures. However, if the pour point of the fluid must be lowered, then it can be lowered by the addition of antifreeze. Antifreeze should be glycol without a standard additive package. Concerning evaporation; continuous operation of systems in high temperatures will promote the possible evaporation of water; therefore systems that are exposed to high temperatures, water content must be monitored on a scheduled basis. However, water glycols, due to the high water content, tend to run cooler than oils and the glycols provide anti-freeze protection. Therefore, additional anti-freeze is usually not necessary in water glycol systems.*

21. **Question:** With a high water base won't it cause my equipment to rust?

Answer: *These fluids, like suitably blended oils, have anti-rust and anti-corrosion packages.*

22. **Question:** If the fluid is biodegradable does that mean that I can dispose of it just by dumping it down the drain?

Answer: *No; biodegradability is the standard set by the local waste water treatment facility and is determined by the Biological Oxygen Demand and the Chemical Oxygen Demand. Most water soluble fluids, that are small in nature and flow into the sewage system, will generally have minimal or no impact on the waste disposal system. The local authorities should be contacted to ascertain what levels and product type is considered acceptable if a spill should occur.*

23. **Question:** Can I mix the synthetic fluids with the oil that I am currently using?

Answer: *Sometimes but compatibility studies should be made in a lab prior to mixing these fluids with oil. Obviously water and oil do not mix and generally the mixing of oil and water glycols should be avoided. A previous oil system, once converted, will purge the trace amounts of oil into the reservoir and can be skimmed off.*

24. **Question:** What do I have to do to convert my system from oil based hydraulics to synthetic based hydraulics?

Answer: *If you do a compatibility study with fluid currently in the hydraulic system you will be able to plot the course of action you need to take. The best way, but not necessarily the most practical way, is to thoroughly drain and flush the hydraulic system prior to introducing the new fluid. Professional fluid suppliers will have procedures that must be followed to convert the system. Before purchasing the synthetic fluid talk to the supplier as to the conversion process. It is a wise choice to also involve a fluid power professional during the conversion process if there is any uncertainty as to the conversion process.*

25. Question: I have heard that you shouldn't use synthetic hydraulic fluids with aluminum and galvanized steel. Is this true and why?

Answer: *Alkaline fluids, which get their lubricity from the alkaline, generally react with alloys of aluminum. Coating the surface of alloys of aluminum by anodizing will reduce the reaction. These coatings can be scratched from the aluminum surface, which will lead back to incompatibility. Galvanized metals should be checked in the fluid for compatibility.*

26. Question: The manufacturer of my industrial fryer recommends that I use a food grade water glycol fluid in my equipment. Why should I?

Answer: *Most fires are made worse by high pressure fluid escaping from hydraulic hose ruptures or leaks at couplings. Oil fluid could contact open flame or high heat sources at the fryer. This would instantly cause violent ignition of petroleum or mineral oil hydraulic fluid. The workers and the plant could suffer grave injury and damage. Further, clean-up is difficult and more time consuming when oil is the hydraulic fluid. In many instances the plant may have to be closed if a fire occurs with oil.*

Today insurance companies realize the need for better safety measures to be implemented in food plants, especially if high heat and/or fryers are involved. Managers of food plants may benefit from lower insurance premiums when better safety measures are initiated. Since wash down procedures are a big part of the work load, water glycol fluids, being water soluble, will wash away with little effort. Oil cannot be removed as effortlessly. Water glycol fluids are currently operating in food plants without need to change hydraulic equipment. The current hydraulic operating conditions in food plants are very suitable for water glycol fluids. Water glycol hydraulic fluids offer the best fire protection.

27. Question: Do synthetic hydraulic fluid systems require more maintenance?

Answer: *In a word, yes. For any hydraulic system to operate efficiently and to achieve the expected lifetimes, quality maintenance must be performed. Synthetic fluids are no different in this respect. However, because of the synthetic fluid's unique characteristics, they do require closer monitoring and maintenance.*

28. Question: With synthetic hydraulic fluid systems can I use paper media filters?

Answer: *Yes, provided you check for filter element compatibility with the synthetic fluids. It is always best to check with manufacturers of filter elements and fluid providers for compatibility with the fluid in question. In general it is probably not wise to use a paper media filter with water based fluids. Water often will react with the paper causing the media to degrade into something like mush. Often it is advisable to use a filter media of fiber glass or polypropylene.*

29. Question: Currently I am running my hydraulic system at 5000 psi. Can I use a synthetic hydraulic fluid at these high pressures? How high of a pressure will they withstand?

Answer: *Usually it depends on the fluid and the hydraulic equipment manufacturer and their specifications. In general synthetic esters are the most compatible with high pressure operations. Most water glycols are limited to 3000 psi (210 bar) continuous and at higher pressures are less able to maintain the lubrication boundary film resulting in more wear. A number of tests that are used for pump wear are for only 2000 psi (140 bar). For most systems requiring higher pressure operation anhydrous fluids and other blend packages for water base must be used. Contact the OEM for additional information concerning pressure limitations.*

30. Question: Why have the synthetic carwash hydraulic fluids gotten such a bad reputation?

Answer: *I am not sure it has acquired a bad name but I will guess that it had more to do with the people involved than the fluid. When the water glycols were introduced into the carwash industry less than two decades ago, a number of people saw it is a good opportunity to sell owner/operators synthetic fluids. The only problem was that the people selling the products were not well versed in system applications and did not have the necessary experience to properly apply the fluids. It is always best to utilize companies that have trained people in the specialty applications. If the synthetic fluid is properly applied to a system that operates on synthetics and is properly maintained, it should provide excellent service and eliminate a number of problems that mineral oil based fluids cause in carwashes.*

31. Question: The fluid manufacturer recommends checking the water content of my fluid on a weekly basis; how can I check the water content of my water glycol system?

Answer: *Most manufacturers of water based synthetic hydraulic fluids make a recommendation for checking the water content. However, depending on the manufacturer the frequency varies from weekly, monthly, biannually or annually. Essentially there are three methods to accomplish this observation.*

- 1. Viscometer*
- 2. Refractometer*
- 3. Fluid sampling*

Viscometer-*This is a scientific instrument for determining the viscosity of a fluid. When the synthetic fluid manufacturer produces the fluid it will be manufactured to a viscosity specification. The percentage of water will cause variation in viscosity. Too much water and the fluid will not be viscous enough and not enough water will make it too viscous. The viscometer is an excellent means for checking water content. However, since it is a scientific instrument it is more costly and many end-users will not have access to it.*

Refractometer- *A refractometer is an optical instrument that is used to determine the refractive index of a substance. This often refers to some physical property of a substance that is directly related to its refractive index. Certain types of refractometers can be used for measuring gases, liquids such as oils or water-based, and even transparent or translucent solids such as gemstones. A refractometer can be used to determine the identity of an unknown substance based on its refractive index, to assess the purity of a particular substance, or to determine the concentration of one substance dissolved in another. Most commonly, refractometers are used for measuring fluid concentrations such as the sugar content (Brix level, for example in carbonated beverages, fruits, juices, and or vegetables, etc), blood protein concentration, salinity and specific gravity of urine. Refractometers are*

also used for measuring fluid concentrations for commercial liquids such as antifreeze, cutting fluids, and industrial fluids.

Fluid sampling- Usually fluid sampling is done on a periodic basis to determine fluid contamination. Although this is the most precise test it is not done on a frequent enough basis to be of much use for routine monitoring of water content.

32. Question: If synthetic hydraulic fluids are so desirable why don't all manufacturers recommend using them in their equipment?

Answer: *There isn't a simple answer to the question. It is more complex. Petroleum based fluids have been used in hydraulic systems for over a century and both component and equipment OEMs know very well the operating characteristics of the fluid and for the most part petroleum based fluids still satisfy the vast majority of applications. As general awareness begins to reflect the deeper understanding of the environmental and safety impacts of using traditional petroleum based hydraulic fluids, OEMs will eventually begin to design components and equipment to accommodate more synthetic fluids. At this point in time it is the fluid manufacturer who must design the fluids to operate in equipment primarily designed for oils. Because the fluid design must meet the OEMs' requirements it adds cost to the formulation of the synthetic fluid contributing to the higher price of synthetics. The higher cost is also the primary obstacle for many to switch from petroleum based fluids to synthetics. One must remember that anytime that a fluid is used in a system that is designed for something else that compromises are in order. One must weigh the benefits gained by the loss of other benefits against cost. There are synthetics available that will perform as well or better than petroleum based fluids but are at such a cost premium that they are limited to unique applications.*

33. Question: When researching fluids and their properties I have found terminology that I don't really understand. Is there somewhere I can go to find these terms with an easy to understand meanings?

Answer: *There are a number of different sources and guides, some better than others. The internet is always a good place to search, but a comprehensive search can be time consuming. To facilitate some of the most common terms, the following should be of some help:*

- **Bulk modulus:** In mechanics this is the value K which represents a substance's uniform resistance to compression when force or pressure is applied. In fluids the higher the bulk modulus values the higher resistance to uniform compression. The practical consequences are that fluids that resist compression transmit the input energy more efficiently. For example water resists compression more than air. Therefore water transmits energy more efficiently than air. When comparing water based fluids to oils, water based fluids have a higher bulk modulus than oils therefore are better transmitters of force resulting in higher theoretical efficiencies.
- **Viscosity:** Viscosity is a measure of a fluid's resistance to deform under sheer stress. It is commonly perceived as fluid "thickness", or resistance to flow. The "thinner" the fluid such as water, the easier it flows. Viscosity is directly affected by temperature. The higher the temperature the less viscous the fluid. Conversely, the lower the temperature the more viscous the fluid. Therefore, it is important when fluid viscosities are compared that it is done so at equal temperatures.

- **Viscosity Index – V.I.:** Viscosity index is a petroleum industry term. It is a lubricating oil quality indicator, an arbitrary measure for the change of kinematic viscosity with temperature. The viscosity of liquids decreases as temperature increases. The viscosity of a lubricant is closely related to its ability to reduce friction. Generally, you want the thinnest liquid which still forces the two moving surfaces apart. If the lubricant is too thick, it will require a lot of energy to move the surfaces (such as in molasses); if it is too thin, the surfaces will rub and friction will increase. The VI scale was set up by the Society of Automotive Engineers (SAE). The temperatures chosen arbitrarily for reference are 100 °F (40 °C) and 210 °F (100 °C). The lower the V.I. the more energy that is required to get lubrication. Most synthetic hydraulic fluids have higher V.I.s than comparable oils, which provides lubrication over a wider range of temperatures. Most non-additive oils have V.I.s lower than 100 and synthetics have V.I.s greater than 100.
- **Centistokes – cSt:** A measure of kinematic viscosity. A measure of resistance to flow based on a fluid's density at a given temperature. The practical use is that hydraulic OEMs designate the range of permissible viscosities of fluid to be used in the equipment based on cSt.
- **Saybolt Universal Seconds – SUS:** A measure of kinematic viscosity. SUS relates to flow resistance within layers within fluids. The fluids may be described SUS or cSt as a measure of kinematic viscosity.
- **Vapor Pressure:** Vapor pressure is the pressure of a vapor in equilibrium with its non-vapor phases. All solids and liquids have a tendency to evaporate to a gaseous form, and all gases have a tendency to condense back. At any given temperature, for a particular substance, there is a partial pressure at which the gas of that substance is in dynamic equilibrium with its liquid or solid forms. This is the vapor pressure of that substance at that temperature. Equilibrium vapor pressure is an indication of a liquid's evaporation rate. It relates to the tendency of molecules and atoms to escape from a liquid or a solid. A substance with a high vapor pressure at normal temperatures is often referred to as volatile. The higher the vapor pressure of a material at a given temperature, the lower the boiling point. The vapor pressure of any substance increases non-linearly with temperature according to the Clausius - Clapeyron relation. The boiling point of a liquid is the temperature where the vapor pressure equals the ambient atmospheric pressure. At the boiling temperature, the vapor pressure becomes sufficient to overcome atmospheric pressure and lift the liquid to form bubbles inside the bulk of the substance. From a practical standpoint the higher the vapor pressure the easier it is for evaporation to occur. With water based fluids higher vapor pressures, do to the water content, the easier it is for the water to evaporate causing a key change in the fluid chemistry and fluid performance.
- **Pour Point:** The pour point of a liquid is the lowest temperature at which it will pour or flow under prescribed conditions. It is a rough indication of the lowest temperature at which a fluid is readily pumpable. Also, the pour point can be defined as the minimum temperature of a liquid, particularly a lubricant, after which, on decreasing the temperature, the liquid ceases to flow.
- **Ignition Temperature:** The minimum temperature that a substance must be heated to before it will spontaneously burn independent of the source of heat.
- **Flash Point:** The flash point of a flammable liquid is the lowest temperature at which it can form an ignitable mixture in air. At this temperature the vapor may cease to burn when the source of ignition is removed. A slightly higher temperature, the fire point, is defined as the temperature at which the vapor continues to burn after being ignited. Neither of these parameters are related to the temperatures of the ignition source or of the burning liquid, which are much higher. The flash point is often used as one

descriptive characteristic of liquid fuel, but it is also used to describe liquids that are not used intentionally as fuels.

- **Laminar Flow:** Laminar flow, sometimes known as streamline flow, occurs when a fluid flows in parallel layers, with no disruption between the layers. In fluid dynamics, laminar flow is a flow regime characterized by high momentum diffusion, low momentum convection, pressure and velocity independent from time. It is the opposite of turbulent flow. In nonscientific terms laminar flow is "smooth," while turbulent flow is "rough". The (dimensionless) Reynolds number is an important parameter in the equations that describe whether flow conditions lead to laminar or turbulent flow. In a pipe with laminar flow, the Reynolds number is less than 2100. Creeping motion or Stokes flow an extreme case of laminar flow where viscous (friction) effects are much greater than inertial forces, occurs when the Reynolds number is much less than 1.
- **Turbulent Flow:** In fluid dynamics, turbulence or turbulent flow is a flow regime characterized by chaotic, stochastic property changes. This includes low diffusion, high momentum convection, and rapid variation of pressure and velocity in space and time. Flow that is not turbulent is called laminar flow. The (dimensionless) Reynolds number characterizes whether flow conditions lead to laminar or turbulent flow; e.g. for pipe flow, a Reynolds number above about 2300 will be turbulent.
- **Cavitation:** Cavitation is a general term used to describe the behavior of voids or bubbles in a liquid. Cavitation is usually divided into two classes of behavior: inertial (or transient) cavitation and non-inertial cavitation. Inertial cavitation is the process where a void or bubble in a liquid rapidly collapses, producing a shock wave. Non-inertial cavitation is the process where a bubble in a fluid is forced to oscillate in size or shape due to some form of energy input. Inertial cavitation can be quite damaging to pumps by removing material and cause pitting or cracking. Inertial cavitation is particularly problematic of low viscous fluids and fluids with high vapor pressures, i.e. water. Non-inertial cavitation creates instability within the system and can also lead to energy waste if allowed to persist.
- **Anti-Oxidation Additives:** These are chemical additives that either inhibit or block the process of oxidation. Oxidation occurs when oxygen molecules come into contact with a material and bonds with the material's free radicals. In fluids that are subject to oxidation the anti-oxidation additives inhibit the oxidation process for a period of time. Once oxidation begins to occur, the chemical nature of the fluids change and in oils it can produce varnish and sludge.
- **De-Emulsification Additives:** These are agents that are added to prevent emulsification. Emulsification is a suspension of small globules of one liquid within another with which the first will not mix, i.e. oil and water. In most non water soluble fluids, such as oil, emulsification affects the ability of the oil to provide its primary benefit, reduction of friction.
- **Non-flammability Additives:** These are chemical agents or additives which are added to fluids to change the flammability characteristics. Non-flammability additives can render a fluid completely non-flammable or inflammable only under certain conditions. For example aircraft hydraulic fluids are non-flammable under all conditions whereas water glycols are non-flammable only as long as they still contain water.
- **Antiwear Additives:** These are a class of compounds that are added to prevent metal to metal contact. Under certain conditions the natural lubricity of the fluid is affected and the antiwear additive helps to attain and maintain lubricity under a wider range of conditions.
- **Anti-corrosion Additives:** These are a class of compounds that inhibit galvanic corrosion or electrolysis.
- **Standards Organizations:**

AMSE	American Society of Mechanical Engineers
ANSI	American National Standards Institute
ASTM	American Society for Testing & Materials
BSI	British Standards
DIN	Deutsches Institut für Normung, German Institute for Standardization
EPA	Environmental Protection Agency
FM	Factory Mutual International
IEC	International Electrical Code
ISO	International Standards Organization
NEC	National Electrical Code
NFPA	National Fluid Power Association
NFPA	National Fire Protection Agency
NSF	National Sanitation Foundation
OSHA	Occupation Safety and Health Agency
SAE	Society of Automotive Engineers

34. Question: *I have been told there are a number of seals and hoses that cannot be used with synthetic fluids. If so, why and where can I find out what is compatible and what's not.*

Answer: *There are some fluids that react with certain elastomers and hose materials. When hydraulic components OEMs design equipment, they design it to meet certain performance specifications. Seals, which are critical to operational performance, are carefully selected and tested to match the equipment and environment in which they will function.*

The materials science and engineering of seals is extremely complex. Chemical reactivity, although important, is just one of the critical considerations of seal design. Formulations must incorporate specific characteristics such as elasticity, memory, deformation characteristics, thermal performance, and lubricity. Even though a seal may fall into the same general chemical family, it can differ based on other chemical design properties selected by the seal manufacturer. Therefore, an OEM that incorporates a certain seal into their component will thoroughly test it to assure desired component performance. Often times seal manufacturers will change seal chemical composition, for the same product, requiring the component OEM to retest for performance compliance.

Since most hydraulic component OEMs design their systems to be used with mineral oil based hydraulic fluids, the seal elastomers will have properties consistent with use in mineral oils. Therefore, elastomers, which were designed for mineral oil, may encounter problems when operated with synthetic fluids. Because of the commonality of glycols, they usually experience the most problems with seal compatibility.

Diethylene Glycol is the most widely used of the water based fluids. In comparison with other synthetic fluids it is by far the least expensive. A wide number of chemical companies manufacture this product. Therefore due to its commonality included is a compatibility table with the most common elastomer materials.

General Seal Material Compatibility with Diethylene Glycols*

Material	General Compatibility
Buna N, acrylonitrile-butadiene rubber, Nitrile, NBR	C
Buna S, styrene-butadiene rubber, SBR	NC
Butyl Rubber, isobutylene/isoprene	C
EPDM, ethylene-propylene diene terpolymer	C
Epichlorohydrin	NC
Ethylene-Propylene	C
FTEP, fluorocarbon, Viton, Teflon	C
Fluorosilicone	C
Natural Rubber, polyisoprene	C
Neoprene Rubber, chloroprene	C
PNF, phosphonitrilic fluoroelastomer	C
Polyurethane	NC
Silicone, Silastic	C
Cork	NC
Leather	NC
Hemp or Cord	NC

C **Compatible** **NC** **Not Compatible**

* Common Water Based Glycols use diethylene, which is an alkaline, as a base product. Although the seal material listed is generally compatible or not compatible, each seal manufacturer can and will vary the chemical composition slightly; possibly rendering the seal incompatible with the fluid.

There is usually not the same concern and problems with hydraulic hoses as there are with seals. Generally hoses that are compatible for petroleum based fluids will also handle most synthetics. Just as polyurethane is not a compatible seal material to be used with diethylene glycol; neither would a low pressure hose of polyurethane be acceptable. Hose manufacturers are an excellent resource to ascertain fluid compatibility with their hydraulic hose.

35. Question: Do synthetic fluids have to be changed more often than petroleum based fluids?

Answer: *In some cases this is true. However, this is usually synthetic fluids that are used around applications that are processing food or drugs. All hydraulic fluids and lubricants will eventually wear and will need to be changed. A worn out fluid will not provide the desired characteristics and will lose some of its critical properties.*

All lubricants whether petroleum based or not have additive packages that enhance their performance and longevity. In fluids designed for use with food, the manufacturer blends an additive package that is not as robust as an additive package that is used in non food applications. This is usually due to the possible toxicity of the additives and avoidance of food contamination. Therefore, fluids designed for food wear out more quickly.

Except for food grade fluids, synthetic fluids, properly maintained, will generally outlast petroleum based fluids. Another advantage of synthetic fluid is as it degrades, unlike petroleum based fluids; does not deposit oxides, varnishes and sludge. Because of this property, worn synthetic fluids may be more difficult to identify. Therefore, routine fluid sampling becomes critical to hydraulic system maintenance with synthetic fluids.

36. Question: If fluid biodegradability is such a desirable characteristic then why isn't it mandated to be used in all hydraulic systems?

Answer: *In a perfect world that might be the case. However, there are so many more considerations that must be addressed. In the first place the cost to convert millions of existing systems to biodegradable fluids would be prohibitive. In addition, there isn't yet a biodegradable fluid that could completely and universally replace mineral oil based fluids.*

Another detractor to a universal mandate is that there is not a universal regulatory standard which can be followed. Much of the regulatory control rests at the local level and it differs from jurisdiction to jurisdiction. What is driving local control over universal control is that fluid use is application specific and industries already set their own general standards, which would be very difficult to translate into regulation. Therefore, regulation has been directed to waste disposal and spills, worker safety, and transportation.

Until hydraulic equipment OEMs begin to manufacture components specifically for use with synthetic fluids a universal mandate will be difficult to achieve. Unlike the U.S., one must look to the EU and other large markets to drive change. The EU and Sweden specifically is on the leading edge of product innovation to solve environmental issues.

37. Question: My system is operating on a diethylene glycol hydraulic fluid and it is running sluggish in comparison to when I first converted the system. What could cause this condition?

Answer: *There are a number of conditions which might result in this type of performance. The most common problem is that the fluid is out of chemical balance. In water based systems, depending on the fluid type and manufacturer, water content should be from between 35% to 60%. It is natural for the water to evaporate with extended use. If water is lost do to evaporation, the fluid viscosity, friction, the operating temperature of the fluid will increase, causing it to be sluggish and increase energy consumption. On the other hand, if fluid viscosity is permitted to drop do to excessive water, internal leakage at the actuators will increase causing sluggish operation. A thin fluid is also prone to turbulent flow which will increase the potential for erosion of the components and cavitation.*

Under normal use, the fluid pH can be expected to drop due to water evaporation, heat, and loss of corrosion inhibitors. The fluid pH should be slightly alkaline, pH above 8, to prevent rust. However, do to their volatility and toxicity, handling the amine additives that stabilize the pH is not recommended. Therefore, fluids with pH levels that drop below 8.0 should be removed and properly discarded.

Make-up water added to the system must be distilled or soft de-ionized. The calcium and magnesium present in potable water will react with lubricant additives causing them to floc or come out of solution and compromise the fluid's performance. When this condition occurs the fluid is permanently damaged and should be replaced. To prolong the fluid and component life, water added to the system should have a maximum hardness of 5 parts per million (ppm).

If adding make-up water to the system it is essential to measure the pH with wither a viscometer or refractometer. The refractometer is probably the best instrument to use. Measuring the fluid pH will indicate when the water content is correct.

A common practice, although not recommended, is for systems with excessive water a process of draining part of the system and replenishing with fresh fluid and running it for five minutes. The process is repeated until the water is reduced and chemical balance returned. This is only done with system fluids that are relatively new and an error was made when making-up water. If the water is too excessive and has been operated under those conditions for some time, adding fresh fluid may be unfruitful and the whole system should be completely removed and replaced with fresh fluid.

38. Question: I am having problems with my hydraulic system and the evaporation of water from the water glycol fluid that I am using. The ambient temperature ranges from around 40° F in the winter to 110° F in the summer. The power unit is placed in an equipment room without much ventilation. My fluid power professional recommends that I restore my system back to a mineral oil based fluid. What can be done to reduce the evaporation so that I can keep using the water based fluid.

Answer: *It is assumed that other than the increased maintenance, that you are satisfied with the benefits that the water based fluid provides. It is possible to reduce the evaporation without too much effort. Since the system experiences rather high ambient temperatures during the summer season it will be necessary to cool the fluid to below system temperatures of < 122° F. Assuming that you are not already using a system cooler, it is recommended that you have your fluid power professional add a cooler.*

There are two basic add on coolers that are normally used; air cooled and water cooled. In the air cooled system air is moved over the fluid to remove the heat. Water cooled systems run the hot fluid through some type of water device to take out the heat.

Air cooled systems are much like the radiator used in an internal combustion engine. When the fluid reaches a preset temperature, a valve opens allowing the hot fluid to flow through the radiator coils, thus cooling the fluid. This is the most common system for controlling system temperatures in hydraulic systems. A fluid power professional can assist in determining the size and type of cooler.

A less common method but more effective is the water cooled device. This system is usually of a tube and shell design. Flowing water within a shell surrounds the fluid flowing through tubes. Due to the excellent heat transfer characteristics of water the heat is quickly transferred from the fluid to water. Another advantage to this type is that it doesn't require air moving fans and relies on normal water system pressure.

Prior to adding a cooler it should be determined if the hydraulic system has a "dump valve". In some systems the design relies on a pressure relief valve to return the fluid to the reservoir when the pump is running but the actuators are not loaded for work. This has the effect of passing pressurized fluid over a direct acting valve which generates heat. Prolonged periods of fluid passing over the pressure relief valve are the main issue. If this is the case then installing an inexpensive dump valve will eliminate the heating problem. The dump valve will allow non-pressurized fluid to return to the reservoir. The heat is avoided by not passing it over the system pressure relief valve.

Keeping the fluid cool will not only reduce the evaporation problem but will extend the overall life of the fluid and increase system component lifetimes.

39. Question: How can it be determined if a synthetic fluid would be beneficial for my application?

Answer: Before investigating different fluids, a system analysis needs to be performed. The system specifications should be reviewed with a fluid power professional. Important to the analysis are the following:

- 1. Current hydraulic fluid**
- 2. Mobile or fixed location**
- 3. System location and placement**
- 4. Ambient conditions, ambient temperature range, relative humidity, ventilation**
- 5. System age**
- 6. System pressure requirements**
- 7. System flow requirements**
- 8. System capacity**
- 9. Pump make, style, model number, volumetric displacement, desired rpm, and placement within the system**
- 10. Open or closed system**
- 11. Number and types of actuators**
- 12. Valve types, placement, and functions**
- 13. Reservoir type and construction**
- 14. Filtration requirements**
- 15. Maintenance capabilities**

Another service the fluid power professional should provide is recommendations and restrictions of the hydraulic component OEMs and system OEM; primarily focusing on fluid

compatibilities and fluid restrictions. Also it should be determined if there would be any impacts on warranties.

After analyzing the current system, then meet with a trusted fluid provider. Review with the provider the desired benefits from the fluid along with the system analysis, including OEM recommendations and restrictions. A competent fluid provider will review the application, the desired benefits, analysis of conversion needs, and waste and reclamation issues prior to making a recommendation. Based on the fluid price and conversion costs; a final decision can thus be based on a cost benefit analysis.

40. Question: What equipment will I need to convert the mineral oil hydraulic system over to synthetic fluid?

Answer: *Although it is impossible to render an equipment list that would be required for all types of synthetic fluids, since some might require specialized equipment; the following items are universal to most conversions:*

- *Wet Dry vacuum*
- *Filter cart (buggy) with two stage filtration*
- *Or Low pressure fluid transfer pump, electric or manual*
- *Refractometer or viscometer*
- *Lockouts for locking out electric power while working on the system*
- *A sufficient number of empty clean waste drums for the waste oil*
- *Waste spill containment floor pans*
- *UV flashlight if the synthetic fluid comes with a fluorescing dye for leak checking*
- *At least two sets of system return filters*
- *A sufficient quantity of clean dry lint free clothe rags to clean up leaks and minor spills*

41. Question: Some hydraulic fluids have a leak detector dye. What advantage does this provide?

Answer: *This is a nice feature if it's available. Although large leaks are fairly easy to identify the leak detector allows detection of small leaks before they become large. The quicker a leak can be detected the easier it is to fix and avoids the loss and clean up of expensive fluid. Many leak detectors are additives that fluoresce when exposed to UV light. This allows better monitoring of shaft seals and fittings.*

42. Question: Why do food grade hydraulic fluids need to be replaced so often?

Answer: *Since the fluids are to be around food and food processing the fluids must be fairly benign. The fluids are of usually two types; vegetable oils and poly propylene glycols. Both easily degrade and additives are added to stabilize oxidation, reduce emulsification, and enhance corrosion resistance and lubricity. Vegetable oils have more trouble than PPGs. In either case the additive packages are not as robust and long lasting as non food grade fluid additive packages. Therefore the food grade fluids wear out much quicker and require replacement.*