

**INSTALLATION
&
MAINTENANCE
GUIDE**

INTRODUCTION

MRL HYDRAULICS LLC has provided this Care and Maintenance Manual to assist you the owner/operator in the installation and maintenance of synthetic lubricants supplied by us. The information contained within comes from a number of different sources including professional experts from both the Fluid Power Industry and Lubrication Industry. The information content is derived from experience and best practices. It should be used as a guide and not as the only and definitive source of information. In most cases there should be no significant contradictions between this document and the OEM's maintenance and operational procedures manual. However, if in the case that there is, the owner/operator must decide and carefully choose that which would provide the greatest benefit to equipment operation.

There are many ways to define performance. For our purposes we define fluid performance in comparison to comparable petroleum based lubricants. The lubricants that MRL HYDRAULICS LLC blends and markets meet or exceed the performance of comparable petroleum or vegetable based lubricants.

The performance of the non-petroleum based fluid is dependent on a number of variables. Since hydraulic component OEMs design their products for the use of petroleum based lubricants, there may be circumstances and conditions where synthetic fluids, especially water based lubricants, have limitations. This could include system design, allowable component materials, component construction, maximum working pressures, actuator speeds, and ambient working temperatures. It is the responsibility of you the owner/operator to predetermine the suitability of the lubricant and its possible limitations prior to fluid installation. In some cases not adhering to the OEM's prohibitions and/or limitations will result in the voidance of warranties or less than optimal performance, or both.

Performance is also directly dependent on other variables such as: the length of time the equipment has been in service; past and present operating conditions; past maintenance; the level of expertise of the maintenance personnel; and the owner/operator's commitment to maintaining the equipment and the lubricant health. Since this is beyond our control we cannot make specific claims as to how the fluid will perform in each specific application. General performance claims are based on accumulated experience by a large number of users, from single owner/operators to large multi-national corporations.

Procedures concerning the proper disposal of spent fluid are beyond the scope of this manual. It is determined by a variety of regulatory agencies; nationally, state or province, and locally. For the most part, spent fluid must be disposed of as if it were like any other industrial lubricant, packaged and disposed of by a qualified waste recycler. However, leaks and small spills can be usually cleaned up with soap and water. This is due to the nature of the lubricant's biodegradability. Small quantities, although not recommended, that find its way into the effluent will not cause damage and should quickly degrade.

This manual is divided into sections covering a variety of pertinent information. Although we have attempted to cover most contingencies, there may still be areas not directly addressed or remain unclear. Therefore, we can be contacted directly through the use of our Toll Free Number @ (877) 223-2822 in order to provide assistance. It is recommended that the owner/user read through the manual prior to beginning the conversion process of their equipment. Whether the owner/operator is doing the conversion and maintenance or contracting it to be done, it is recommended that a relationship with a fluid power professional be made.

SYSTEM CONVERSIONS & INSTALLATIONS

SUGGESTED INSTALLTION & MAINTENANCE EQUIPMENT LIST

ITEM	QUANTITY	COST	COMMENTS
CARE & MAINTENANCE MANUAL	1	\$20.00	Everything that is needed to know to convert and maintain water based hydraulic fluid systems.
Wet/Dry Vacuum	1	< \$50.00	The Wet/Dry Vacuum is needed to skim the oil from the top of the reservoir.
Fluid Transfer Pump or Hydraulic Filter Cart	1	\$100.00 to \$200.00	Although the fluid transfer pump is much less expensive, it does not have the added feature of filtering fluid prior to placing into the reservoir. Also, the hydraulic filter cart can work as a side loop filter for cleaning of the system if it should become contaminated.
		\$1000.00 to \$3000.00	
Viscometer or Refractometer	1	\$400.00 to \$1200.00	One or the other device is needed to accurately measure fluid viscosity. The refractometer is lower in cost and easier to use,
		\$200.00 to \$800.00	
Litmus Test Paper or Ph Meter	1	< \$20.00	The litmus paper requires subject judgement and is limited in reading from about 4.5 to 8.3 pH. Whereas the pH meter is higher accurate from 1 to 14 pH.
		\$150.00 to \$500.00	
Battery Powered UV Lamp	1	<\$30.00	A hand held UV Lamp is only necessary if the fluid contains a fluorescing leak detector. The leak detector can only be seen under UV light.
2L to 4L Graduated Beaker or Pitcher	1	<\$20.00	A graduated beaker of 2 to 4 liters will be required to make viscosity adjustments when needed. The container should be graduate in ml.
Return Filters	1 case	<\$50.00	Filters will have to be changed several times during the installation phase. Also filters will periodically need to be changed when full or whenever components are changed in the system. It is recommended that filters with fiberglass or polypropylene be used.
Various supplies of absorbent dry, spill dams, and drip pans	As needed	Should be a part of facilities equipment	These would be used to control leaks or spills during the conversion process and during routine maintenance.
Fluid Sample Kits	2	\$50.00 to \$75.00 each	This includes the cost of processing the sample, but does not include postage.

A Guide to Converting Hydraulic Systems from Petroleum Based Mineral Oil or Vegetable Based Oil to Synthetic Hydraulic Fluid

Introduction

After careful thought and consideration you have decided to convert your hydraulic system over to a synthetic hydraulic fluid. It is not a simple matter of draining the old oil out and replacing it with the new fluid. The change out process requires considerable preparation including some basic research. Your system was probably designed to run on standard mineral oil based hydraulic fluid. The Original Equipment Manufacturer's (OEM) Manual of Operating and Maintenance Procedures were, most likely written, based on the use of mineral oil. Therefore, with the use of a synthetic fluid some of the recommended maintenance procedures will most likely have to be modified or expanded. This guide is as a result of nearly three decades in the fluid power and process control industry. I will be recommending what I have come to consider as the best practice and procedures, but it is always prudent to refer to your Operating and Maintenance Procedures Manual provided by the OEM.

Step Number One

Research:

Before changing out the system to the synthetic fluid it is wise to contact the OEM and ask for their recommendations regarding synthetic fluids. Based on the construction materials of the system there may be fluids that cannot be used in the equipment. The use of fluids that are either unknown fluids or not recommended by the OEM may void any limited warranties that are in force. Always seek approval from the OEM and get an affirmation, if possible, in writing. If the OEM cannot guide you in the fluid selection then it is best to contact the various hydraulic component OEMs and fluid suppliers prior to changing the fluids. Most reputable fluid suppliers will be able to advise you as to whether or not the fluid is compatible with your system construction. For example: some fluids react with non-anodized aluminum or galvanized components. Still again, there are some fluids that cannot be used with certain seal materials. If your system contains questionable materials, then you should proceed with caution and do further research by contacting fluid power and hydraulic fluid professionals. From the fluid supplier always ask for a reference list of other similar applications that you can contact to confirm the claims made by the fluid supplier, and make sure that you contact them. Do not purchase any fluid prior to completing your research.

Get to know the characteristics and properties of the fluid that you are converting to. There are a number of important things that must be understood. Your fluid supplier should be able to provide you with the information and also should be able to explain the information in terms that you can understand. If they can't, then find another supplier.

- 1. What is the basic chemistry of the fluid?**
- 2. What third party approvals does the fluid carry?**
- 3. Is the fluid water soluble or is it anhydrous.**
- 4. Ask if the fluid is biodegradable in your operating area?**
- 5. How will the fluid operate at your system pressure?**
- 6. What is the normal pH level?**
- 7. What is the normal viscosity and VI (Viscosity Index)?**

8. What is the fluid's bulk modulus?
9. What is the pour point?
10. What are the temperature limitations?
11. What is the expected life time of the fluid?
12. How often should the filters be changed?
13. How often should the fluid be sampled?
14. How often should the fluid be changed?
15. What type of filter media is recommended?
16. What type of fire resistance does the fluid offer?
17. What are the proper disposal procedures of the fluid?
18. What affect does the fluid have on worker contact?
19. Does the fluid require special handling?
20. What is the recommended shelf life of the fluid?
21. Does the fluid supplier have a fluid power professional on staff to provide assistance?

Step Number Two

Draining the System:

Equipment needed:

- Fluid transfer pump electric or manual
 - Waste containers to put used oil in, 55 USG drums or 275 USG totes
 - Splash pans to contain any spillage
 - Absorbent media for spillage
 - Lint free shop towels
 - Fluid dams in case of large uncontrolled spills (optional)
1. Select a time when the hydraulic system can be shut down for at least an 8 hour period. This will give you plenty of cushion time in case problems develop.
 2. Prior to shutting the hydraulic system down, record the pressure and temperature readings of the system. Make sure the system has run long enough that the fluid in the system is warm. Also make a mental note of what the system sounds like before shutting down. Once the conversion has taken place you will want to compare the sound of what the system sounded like before the fluid conversion to what it sounds like after the conversion.
 3. Turn off all power to the hydraulic system. If the prime mover is an electric motor, lockout with paddle locks the main power or disconnect switch. Place a placard on the disconnect alerting of the maintenance status and **Do Not Turn On**.
 4. Place the appropriate size splash pan on a level floor surface in close proximity of the reservoir to be drained. Make sure the discharge hose of the transfer pump will reach. If it will require more than one waste container to completely drain the system then have another waste container already set up on another transfer pallet for easy transfer.
 5. Place a transfer pallet on the drip pan and place the waste oil container on the pallet.

6. Remove the oil filler cap on the reservoir and place the fluid transfer pump pick up tube within ½ inch of the bottom of the reservoir.
7. Place the transfer pump discharge hose into the waste container.
8. Prior to pumping insure that all sources of ignition are extinguished, especially smoking materials.
9. Begin pumping and monitor the discharge flow and insure that the pump does not start to cavitate.
10. To remove all fluid, when the fluid level in the reservoir gets to within 1 inch from the bottom, move the transfer pump inlet tube to within a 1/8 of inch from the bottom.
11. When the waste container is full shut the discharge pump off and carefully remove the transfer pump discharge hose. Replace the container if necessary.
12. Once the fluid has been fully pumped out of the reservoir and into the waste container/s; seal off the waste container and mark it clearly as used oil and do not use. Remove the waste container to a safe storage area and clean up any spillage.
13. Disconnect lines and hoses at low points and drain fluid into appropriate waste containers.
14. Reinstall lines and hoses, replace those that are worn.

Step Number Three

Cleaning the System:

- Equipment needed:
 - Steam cleaner (optional)
 - Wet/dry shop vacuum
 - Splash pans to contain any spillage
 - Absorbent media for spillage
 - Lint free shop towels
 - New filters
1. Carefully remove the reservoir clean out access cover.
 2. Vacuum out any fluid left in the bottom of the reservoir.
 3. Inspect the interior of the reservoir for any obvious signs of damage, excessive wear and corrosion. Also look for evidence of foreign particles that are metallic. This may be an indication that some of the components in the system are about to fail. This can be easily done by running a small hand held permanent magnet around the surface of the bottom of the reservoir. If metallic particles are found it can also be an indication that the rating on your return filters is not correct and the return filters are not catching enough of the contaminants.
 4. If the system has a suction strainer, remove it and clean it and if it cannot be cleaned then replace it. Most new systems usually no longer use suction strainers especially if the system utilizes cavitation sensitive pumps. If your system has such a pump and also has a suction strainer then you may want to ask your OEM if the strainer can be removed.
 5. Wipe out the interior of the reservoir with lint free shop towels until all traces of old fluid and dirt is removed.
 6. At this point you may want to steam clean the interior of the reservoir. This is especially wise in old systems that have been operating for long periods of time with mineral based oil hydraulic fluid. The steam will soften and remove the build up of oil oxidation varnishes.

7. It is possible to use certain approved solvents to clean with instead of steam cleaning, but make sure to check with the fluid supplier before using any solvents for compatibility with the synthetic fluid.
8. Thoroughly wipe out the interior of the reservoir with clean lint free shop towels.
9. Inspect the seal on the clean out access panel for obvious signs of aging or damage. Thoroughly clean the clean out access panel and reinstall on the reservoir.
10. Close off the oil filler access and thoroughly clean the exterior of the reservoir.
11. Inspect the rest of the hydraulic system for leaks or damage. Steam clean the rest of the hydraulic system if possible.
12. Remove all filters in the system and replace with fluid supplier recommended filters.
13. Replace the reservoir breather cap with a new unit.

Step Number Four

Repair or replace damaged components:

1. This is the perfect time to repair or replace worn components in the system. If pumps or motors are beginning to lose efficiency or if cylinders are not operating correctly; then go ahead and repair or replace them. Make sure to repair all leaks. Also replace all damaged and worn tubes and hoses at this time. When replacing hoses the new hose or tube should be thoroughly cleaned with solvent and then "pigged out". (Pigging out of a hose is a small absorbent plug that is pushed through the hose with air pressure. It will remove the solvent and any particle contamination that accumulated during the hose construction.) Make sure that whatever components are replaced that they are replaced with like components.
2. If there are upgrades that you want to make to the system, this is the time to do so. Whatever upgrades are made; make sure that the upgrade components will be compatible with the new synthetic fluid. If the upgrades are particularly complicated it may be wise to have a fluid power professional do the upgrades.

Step Number Five

Filling the System:

- Equipment needed:
 - Viscometer or refractometer
 - Fluid filler cart
 - Wet/dry shop vacuum
 - Splash pans to contain any spillage
 - Absorbent media for spillage
 - Lint free shop towels
 - Fluid dams in case of large uncontrolled spills (optional)
1. Before filling the reservoir it is recommended to take a synthetic fluid sample and check the viscosity using the viscometer or refractometer. This is to assure that you didn't receive the

wrong fluid from the supplier. If there is a certain color that the fluid should be this should also be checked. Also check the fluid pH with either a pH meter or litmus paper. If litmus paper is used, retain the test strip for future reference. Once these observations have been made and satisfied then proceed with filling the reservoir.

2. Again place the appropriate size splash pan on the level floor surface. Place the drum or tote and pallet on the drip pan.
3. Place the fluid filler cart discharge hose into the reservoir and the inlet hose into the drum or tote. Begin pumping until the reservoir is $\frac{3}{4}$ full by the fluid site gauge. It is not necessary to fully fill the reservoir yet. Stop the fluid transfer and remove the discharge hose from the reservoir and replace the reservoir filler cap.
4. Energize the system assuring that it is safe to do so. If there is a system unloading (dump) valve make sure that it is in the open mode. You want to make sure that you don't initially run the pump in a loaded condition. Start the electric motor and pump and run for 15 seconds. After 15 seconds shut the system off for 45 seconds. This procedure should fill the pump case and avoid excess cavitation of the pump (running a dry pump for prolonged periods can cause severe pump damage). You will know when the pump case is full and the pump fully primed by the sound. After 45 seconds at rest again start the electric motor and pump and run for a maximum of one minute. Shut the motor and pump off and let it set for 1 minute. After 1 minute start the electric motor and pump still in the unloaded condition. Remove accumulated mineral oil from the reservoir using the transfer pump or wet/dry vacuum. Close the dump valve and load the pump. Run for five minutes charging the system and forcing fluid over the safety relief valve. Do not begin to cycle the actuators. Shut down and remove accumulated mineral oil from the reservoir using the transfer pump or wet/dry vacuum. After 5 minutes again start the unit and this time begin actuating each of the actuators one by one, thus forcing fluid through the actuators and back to the tank. After actuating the final actuator, shut the system down and check the fluid level in the reservoir. Remove accumulated mineral oil from the reservoir using the transfer pump or wet/dry vacuum. Caution: If at any time the reservoir drops to below $\frac{1}{2}$ full, shut the system down and fill to $\frac{3}{4}$ full to resume the system charging.
5. By this time the reservoir should be relatively free of mineral oil but any mineral oil left will remain on top. If the volume is sufficient, then pump it off using the transfer pump. If there isn't enough volume to use the transfer pump then use the wet/dry vacuum to remove the oil.
6. Fill the reservoir up to the $\frac{3}{4}$ level again.
7. Start the unit again and run for an additional 5 minutes and then shut it down and bleed the air out of the system until fully bled. Also, remove any mineral oil that has accumulated in the reservoir. If necessary fill the reservoir to the $\frac{3}{4}$ level again. Start again and listen for noises of air and cavitation in the system. A properly bled system should sound very much like it did when it was running on mineral oil based fluid.
8. Shut the system down and inspect for fluid leaks and tighten any leaks.
9. Once leaks are corrected then start the system and run for 30 minutes monitoring system pressure and temperature.
10. After 30 minutes shut the system down and replace the return filters.
11. Allow the unit to set for 30 minutes and then open the reservoir and check the level of mineral oil that should have accumulated on the top of the synthetic fluid. If there is $\frac{1}{4}$ inch to one inch, carefully remove the surface layer of fluid with a wet/dry vacuum. If there is more than 1 inch then the system should be run for an additional 15 minutes, mineral oil removed, and the reservoir replenished and run again for 15 minutes. The procedure must be repeated until all mineral oil is out of the system.

12. Finish filling the reservoir to the OEM recommended level.
13. The transfer of fluids is now complete.
14. After running the system 6 hours, during normal operations, shut down the system and replace the system return filters and take a fluid sample.
15. Carefully monitor the system for the next 5 to 10 days and check the accumulation of old mineral oil on the top of the fluid in the reservoir. If it becomes excessive, a ¼ inch or more, then skim off the oil using the wet/dry vacuum.

Step Number Six

Maintaining the System:

No matter what the fluid is it must be properly maintained to enjoy its full benefits. The fluid will not correct past bad maintenance practices nor will it operate to its full potential unless properly maintained. The best source for proper maintenance practices and procedures is the OEM and the fluid supplier.

Even though the fluid will probably help to extend the life of the hydraulic system components, don't expect components not to fail, especially the components that were in place prior to the time of fluid conversion. Where the real benefits come in is when new components are installed. The properly maintained system will then most assuredly provide the extended life times that come with your synthetic fluid selection.

A Planned Maintenance Program is the best practice and procedure for operating your system. Listed are some more of the important practices to perform:

1. Carefully monitor the system and fluid. Take regular fluid samples and have them analyzed. This alone will help extend the life of the system. It will also tell you when the fluid is "worn out". Even the best and most robust fluids have a useful lifetime and should be changed when they are no longer able to properly provide the benefits and characteristics expected of the hydraulic fluid. Additionally, fluid samples tell you the overall health of the hydraulic system. It is like in medicine, a blood sample tells a great deal about the health of the individual. Fluid samples can indicate whether or not components are wearing excessively and if filtration is adequate. It is recommended that fluid samples be done at least on a semi-annual basis.
2. If the fluid is a water glycol; viscosity and pH must be monitored on a regular basis. Viscosity can be determined by the use of a viscometer or refractometer. pH levels can be determined with either litmus paper or the use of a pH meter. Viscosity monitoring should be done monthly except during the hottest part of the year where it should be done weekly. Water glycol is prone to the evaporation of water out of the fluid, thus changing the viscosity. Repeated viscosity corrections will eventually lead to a change in the fluid pH to below 8.0. When this does occur, the fluid needs to be replaced with fresh fluid since pH cannot be replenished in the field.
3. Fix leaks. It is estimated that 10% to 20% of all hydraulic fluid is lost through leakage. This provides a hazard to the work space and the environment.
4. Change the system filters regularly before they become fully clogged and the system must be shut down. Dirty and worn fluid accelerates the wear process on system components.

5. Keep good maintenance records of the system. Maintenance records will show over time the overall system health and indicate when components are beginning to be excessively worn. Good maintenance records also provide documentation to equipment and component OEMs when warranty questions come up.

The final comment is to stay in close contact with fluid power professionals and hydraulic fluid professionals. Together they can assist in helping you get the most out of your hydraulic system. A good attitude toward maintenance will also keep the system operating at the desired level. A few pennies spent will reap dollars in return.

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Converting New Systems to Synthetic Hydraulics Fluids

The conversion of a new hydraulic system to take advantage of the benefits of synthetic hydraulic fluids is much simpler than converting a system from mineral based or vegetable based fluids. The main advantage is that the system is not full of mineral based fluids that must be drained and cleaned before proceeding with the full conversion.

If the equipment OEM is aware that the system will be using synthetic hydraulic lubricants; the system can be tested with the appropriate fluid prior to leaving the fabrication facility, if requested in advance. This facilitates the conversion process since trace amounts of mineral oil will not be left in the system. Most manufacturers utilize mineral oil in their systems and subsequently test the systems with mineral oil, leaving trace amounts in the system. Systems are normally shipped without fluid in the reservoir but do contain fluids in the actuators and trace amounts in the lines. Although the trace fluids must be purged from the system it can easily be done by the following procedures.

Step #1:

System set up

After the equipment has been installed, drain the pump and actuators of left over mineral or vegetable oil. Disconnect hoses and lines at low points to drain any residual fluid. After draining hoses and lines reconnect and prime the pump with new fluid if possible. Note: New systems that have had their actuators drained will have to bled of air before placing into service. Follow equipment OEM's setup and startup procedures.

Step #2:

Fluid installation

When the OEM Setup Procedure calls for filling the system with hydraulic fluid, fill with synthetic fluid. After the system air bleeding is complete and system has run for a minimum of 30 minutes; shut the system down and skim any residual oil from the top of the reservoir. Replace the return filters at this time and begin normal system operation.

Step #3:

System Check

1. After 100 hours of operation check the reservoir for accumulation of residual oils. Remove any residual oil. Record action in Fluid Maintenance Record.
2. After 150 hours change return filters. Record action in Fluid Maintenance Record.
3. After 200 hours sample system fluid, check pH level, and take viscosity reading. Record action in Fluid Maintenance Record.

Step #4:

Routine Service

Place the system into normal service adhering to a routine maintenance schedule.

CARE & MAINTENANCE OF WATER GLYCOL HYDRAULIC FLUIDS

CARE & MAINTENANCE OF WATER GLYCOL HYDRAULIC FLUIDS

If you are reading this document, then you're probably already using water based (water glycol) hydraulic fluid or giving it serious consideration. Fluid providers are continuously questioned about maintaining water glycol hydraulic fluid. This is not surprising, in light of the vast majority of users unfamiliarity with water glycol hydraulic systems and fluid maintenance requirements. There is also a plethora of rumors, myths and misinformation circulating about the care and maintenance of water based hydraulic fluids. Much of the misinformation is promoted by those who either don't fully understand water glycol fluids or see water glycol fluids as a threat to their own interests. One source for the misinformation comes directly from hydraulic component OEMs.

For the most part, hydraulic components are manufactured to use petroleum based hydraulic fluids. Since the introduction of water into any petroleum based system results in dire consequences, there has been an avoidance of fluids containing water. This is not to say that component OEMs haven't tested water and water based fluids for use with their components, but much of the testing was done quite some time ago and may no longer be relevant. There remains a general lack of knowledge by the OEMs concerning the use of the newer water based fluids. For those that do allow the use of water based hydraulic fluids in their equipment they normally recommend de-rating the component by as much as 60%. Since it is not likely, in the near future, that any hydraulic component manufacturer will develop and build components designed specifically for water glycol use, it remains incumbent on the fluid manufacturers to design fluids that are compatible with the components designed for petroleum based fluids. There rests the challenge. Before going on let's look at the function of hydraulic fluid.

Hydraulic Fluid Functions

Hydraulic fluid provides four primary functions in a hydraulic system; lubrication, force transmission, contaminant removal, and heat exchange. Lubrication is needed to maintain a boundary layer between moving surfaces, thus eliminating friction, which result in wear and losses in efficiency. The properties of petroleum based fluids provide excellent lubrication and maintain boundary layers between moving surfaces very well. The second primary function of hydraulic fluids is as a force transmitter. Due to the nature of fluid's resistance to compression, force is easily transmitted over distance resulting in work being done. Petroleum based fluids have an excellent bulk modulus (< 8.0% compression) resulting in good force transmission. The third function of a hydraulic fluid is to carry away the contaminants produced from wear. Those contaminants can then be captured by some type of filtration system, thus extending the life of the components. Again petroleum based fluids provide an excellent media to capture and transport contaminants. The final primary function of the fluid is to work as a heat exchanger. The fluid picks up the heat produced by the functioning component and carries it away. Keeping the heat under control allows for optimal functioning of the component by maintaining alignments, tolerances, and sealing properties. Petroleum based fluids are not very efficient in heat transference. They pick heat up fairly well but also tend to hold onto it. Now that it has been established what the primary functions of a hydraulic fluid are, we need to look at specific fluids.

Water

Water was the original hydraulic fluid. Historical records establish water being used as a force transmitter as far back as 500 B.C.E. by Archimedes. With the collapse of the Roman Empire much of that knowledge was lost until sometime in the 18th century C.E. at which time water was again put to

work as a force transmitter. Although water satisfies three of the primary functions of a hydraulic fluid; water is a poor lubricant and has some other less desirable properties. It has a low viscosity, thus making it very difficult to seal for leaks. It has a high vapor pressure resulting in easy cavitation and damage. Due to its extremely high bulk modulus it easily creates “water hammering”. Static water freezes at 0° C (32° F), thus limiting its application uses. Finally, water is extremely erosive and corrosive. From an environmental standpoint water would be the ideal hydraulic fluid since it has no negative impact on the environment if properly treated.

Petroleum Based

Petroleum based fluids were first introduced as hydraulic fluids in the 19th century as an alternative to water. Over the course of the 20th century they became the dominant fluid for use in hydraulic systems. Most petroleum based hydraulic fluids are blended mineral based oil with an additive package. The additives are blended into the fluid to provide rust inhibitors, wear inhibitors, emulsification inhibitors, and corrosion inhibitors. Over time heat breaks the oils down and results in oxidation and the production of varnishes and sludge. Also, since petroleum based fluid is a hydrocarbon it easily supports combustion resulting in a significant fire hazard. Finally petroleum based hydraulic fluids are polluting and toxic. Although an excellent lubricant, petroleum based fluids may not be the best modern solution as hydraulic fluids since they are flammable, toxic and polluting.

Water Glycol

Water glycol represents a compromise alternative solution to both water and petroleum based fluids. Water glycol provides the lubricity of oil and the heat transfer characteristics, fire resistance, and positive environmental impact of water. In addition, water glycols have the added advantage of having a broad operational temperature range, broader than both oil and water.

The composition of water glycol fluid is comprised of a polyglycol thickener, glycol (ethylene, diethylene, propylene, etc.), water and additives. As stated in an interview with Roscoe McDowell of Houghton International, Inc. (now retired and working as a private consultant); he states that a less known fact about water glycol is that water glycol hydraulic fluids are the closest thing to a permanent hydraulic fluid. He further states that if the hydraulic system’s reservoir was pressurized and all leaks eliminated, that the water glycol fluid would never need to be changed. Unlike oil, water glycol is not degraded by heat. However, water glycol is subject to water evaporation, which creates a need to regularly monitor the viscosity and pH of the fluid. Other properties of water glycol is that it has a very low pour point allowing the hydraulic system to be started and run at very low temperatures, thus eliminating the need for preheating the fluid. Operating water glycol at temperatures over 50° C (122°F) may change the lubrication characteristics and the ability to maintain an adequate lubrication boundary layer. High temperatures also promote evaporation of the water out of the blend. Many water glycol blends are also limited in their upper pressure limits of operation. Since viscosity is minimally affected in water glycols by high temperatures; water glycol, which is more viscous than oil, may not be able to maintain the lubrication boundary layer at higher pressures. Normally the water glycols are separated into two categories; those that operate at pressures < 210 bar (3000 psi) and those that operate at > 210 bar (3000 psi) and as high as 520 bar (≅7500 psi). It is incumbent on the user to determine the pressure rating of the fluid since operating a lower pressure rated fluid in a high pressure system could lead to premature wear and component failure.

As previously mentioned water glycol blends are comprised of 4 parts; polyglycol thickener, glycol, water and an additive package. The additive package makes up from 5% to 10% of the total blend. The additives are amines which provide corrosion inhibitors for the liquid and vapor phase, lubrication, metal passivators; such as copper, brass, and bronze and dye. The water makes up normally 35% to 45% of the blend. The water is used to control viscosity, provide fire resistance,

provide greater and better force transmission, and to provide better heat exchange. The remainder of the blend is made up of the polyglycol thickener and glycol. Maintaining the correct balance between the four parts of the water glycol blend is critical to maintaining the desired characteristics and function of the fluid.

Equipment Design

Since water glycol hydraulic fluids have higher viscosities and contain water that has a high vapor pressure, it is imperative that the system be designed in such a manner as to compensate for these fluid characteristics. Prior to running the hydraulic system on water glycol some modifications may be needed.

Special consideration should be made of system pump placement, the use of suction line strainers, and filtration. Because of the higher viscosity, pumps should be placed where they are able to maintain a “positive head”. In other words, it is important to the pump operation to not allow cavitation to occur. This can be accomplished by maintaining a positive inlet flow and pressure. This is normally accomplished by placing the pump lower in elevation than the reservoir. However, this can also be accomplished by submerging the pump in the tank or having a very short inlet from tank to pump where the pump does not have to exert too great a negative pressure to pull fluid into the inlet side of the pump.

In many older systems it was routine to place an inlet strainer in the pump inlet line. However, it was found that if these strainers became clogged that it would easily cause the pump to become starved of fluid and create cavitation. It is recommended to not use an inlet strainer in water glycol systems. However, if one is used it should be between 60 μm mesh and 100 μm mesh.

Another area that must be considered in the operation of water glycol systems is the filtration system. Filters and filter media must be compatible with alkaline water solutions. This may eliminate the use of paper media filters since alkaline water solutions dissolve the paper. Water glycol blends are normally not adversely affected by extremely fine elements. Ratings of 3 μm absolute can be used.

Water glycol hydraulic fluids should not be used in hydraulic systems that contain components constructed of non-anodized aluminum. The fluid will react with the aluminum causing the aluminum to oxidize and contaminate the fluid. The fluid’s appearance will be a white soapy substance. Where this has occurred the fluid must be drained and disposed of. The system must be corrected by changing the non-anodized aluminum component or water glycol cannot be utilized in this system. Most often the non-anodized component is an aluminum reservoir without proper interior surface treatment. It is also questionable whether or not water glycol hydraulic fluids can be used with galvanized components. In general, they should be avoided. Lead and alloys containing lead > 15%, should also be avoided.

Another design consideration is that of temperature. Water glycols provide the best operation when temperatures are at or below 50° C. Most hydraulic systems depend on the heat exchange that occurs from the reservoir. Fluid temperature is reduced by the heat transfer from the fluid through the tank walls. The effectiveness and efficiency of the heat transfer is dependent on the ΔT between the fluid temperature and the ambient temperature. In this situation air movement and ventilation is also highly important. In applications where the ambient temperature is high and/or there is a lack of air ventilation, it is particularly difficult to gain sufficient ΔT and cooling of the temperature is difficult at best. In those conditions it is recommended to add a heat exchanger to the system. The least expensive solution is to go with a radiator type air over fluid heat exchanger. For more severe

conditions it is recommended to use a tube and shell heat exchanger. This heat exchanger uses flowing water in a shell surrounding tubes filled with fluid to effectively transfer the heat. Although more expensive than the radiator type it is also more effective and is well worth the extra investment in the long run. To select and properly size the heat exchanger, assistance can be gained from your local fluid power distributor or call heat exchange manufacturers. In regards to temperature, it is always wise when using water glycol hydraulic fluids to install a temperature gauge in the reservoir. If temperatures can be held below the 50° C threshold, it will dramatically reduce the evaporation of the water out of solution and extend the lifetime of the fluid.

A final consideration in system design is that of elastomers used in the hydraulic system. There are some elastomers used in seals, gaskets and hoses that are not compatible with water glycols. The fluid manufacturer should be able to provide that information. It is always wise to talk to the component OEM about chemical compatibility with water glycols.

Fluid Maintenance

There are three important measurements to maintaining fluid health; contaminants, viscosity and pH. Viscosity can be field corrected whereas pH and contaminants cannot.

Viscosity for the most part is controlled by water content. The lower the water content the higher the viscosity. Verses, the higher the water content the lower the viscosity. In the case of low water content, which usually occurs through the process of water evaporation; when the viscosity reaches 50 SUS @ 100° F above the viscosity of new fluid measured on a viscometer or refractometer, then water adjustments must be made. Only water that is distilled, soft, deionized or boiler concentrate can be used. Water hardness should not exceed 5 ppm. Zero hardness as calcium carbonate is preferred for making water adjustments. Water is added until the viscosity returns to the level of new fluid SUS @ 100° F. This means that water should be added in a slow measured process. Add water & measure; add water and measure; until the correct viscosity is achieved. If potable or cooling tower water should find its way into the system the calcium and magnesium ions present in the water will react with the lubricant additive in the water glycol fluid. The reaction product is a white, soapy solid that can be filtered out of the fluid. Hard water permanently damages water glycol fluids and those systems that have been contaminated in this manner should have the fluid removed and disposed of properly. Adding too much water will result in the second condition which will require adjustment.

If the viscosity is too low, then an adjustment must be made by draining half of the low viscosity fluid and adding new water glycol fluid in make up. Continue the process of draining and making up until the correct viscosity is achieved. The low viscosity fluid does not need be discarded but can be used as make up fluid in the future when the viscosity needs to be adjusted downward.

Examination of pH is the determination of the corrosion inhibiting properties of the fluid. The pH is defined as the inverse logarithm of the hydrogen ion concentration. In order to inhibit rust in a hydraulic system, the pH of water based fluids must be maintained at 8.0 or above. This is an alkaline or base pH, with a neutral pH at 7.0 on a scale of values ranging from 1 to 14. Due to heat and evaporative water losses, the pH of a fluid will most likely drift downward. This downward movement of pH is due to the loss of the vapor phase corrosion inhibitor. As water adjustments are made to reduce viscosity, amines, the base materials that contribute to pH are not being replenished. Fluids with a pH of less than 8.0 should be removed from the hydraulic system and disposed of properly. Measurements of pH can be accomplished by using either a pH meter or pH paper. In food grade water glycol fluids, the additive package is not as robust and concentrated as in general water glycol fluids, resulting in more frequent changes of the fluid.

Fluid contamination can only be done through fluid sampling. Fluid samples are sent to a certified laboratory for analysis. Contamination is a “snap shot” of the hydraulic system’s health. High concentrations of metal contaminants are an indication of wear and subsequent component failure. Multipoint sampling also can determine filtration effectiveness. Fluids that have been contaminated after catastrophic component failure can be cleaned by using an external closed loop filtration cart. Fluid samples should be part of routine planned maintenance programs. Whenever a catastrophic event has occurred, a fluid sample should be taken after the replacement of the failed component and the fluid filtered.

A properly designed system filled with water glycol hydraulic fluid, that is well maintained and monitored, will provide the user with benefits that only water glycols can provide.

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VISCOSITY ADJUSTMENT PROCEDURE

MEASURING VISCOSITY

To maintain the proper chemical balance is critical to the satisfactory performance of water based hydraulic lubricants. Beside the pH level, viscosity is important to maintaining the lubricity and flow characteristics of the fluid. Viscosity of water based fluids remains largely unaffected by low temperatures resulting in very low temperature pour points. This is an excellent characteristic when a system is required to operate in cold temperatures. However, higher fluid temperature operation will result in the natural process of water evaporation out of the fluid resulting in higher fluid viscosity. High viscosity fluids have difficulty maintaining the lubrication boundary layer between mating surfaces. This can have the net affect of creating abnormal wear within the components reducing their lifetimes. Therefore it is important to monitor and adjust viscosities as they change over time. Rarely does the viscosity become too low. When this occurs it is usually as a result of viscosity adjustments reducing high viscosities to lower viscosities and too much water has been added.

The measurement of viscosity is accomplished by one of two methods. The first method is through the use of a viscometer. This scientific instrument can be of two types; drop ball or vibrating probe. In both means of measurement, it requires carefully controlled conditions. The fluid must be at the proper temperature of 100° F and in the drop ball test the ball is timed during its decent. Although accurate when properly done, it requires a certain level of experience and expertise of the person performing the test. A good viscometer can begin around \$500.00 US on up. The second method is through the use of a refractometer. This is the easiest to use and gives excellent accuracy without a great deal of preparation for the testing or a high level of expertise of the person taking the reading.. Essentially it works by measuring the light refraction through the fluid. Costs start at around \$200.00 US. Which ever method is used; if the SUS is > 50 over the standard SUS @ 100° F, then the viscosity must be adjusted downward to the standard SUS. Contrarily; if the level falls below the standard SUS @ 100° F, then the viscosity must be adjusted upward.

Viscosity measurement should be made periodically and be part of the standard maintenance procedures for the equipment. Determining how often the procedure should be accomplished will be dependent on the application type and the ambient operating conditions. Equipment operating in high heat ambient conditions, especially without the benefit of an additional heat exchanger, must be measured more frequently. Note: if viscosity adjustments exceed two or three per year, then it would be wise to consider adding a heat exchanger device.

LOWERING VISCOSITY

Lowering of the viscosity is done through the addition of purified water. The water should be deionized, softened, or boiler concentrates. In all cases; water hardness should not exceed 5 ppm. Zero hardness as calcium carbonate is preferred for making water adjustments.

Equipment needed:

- Viscometer or refractometer
- Measuring beaker, metric units in liters and mille-liters preferred, minimum volume 2.0 liters
- Supply of purified water

Procedure:

1. Measure out liter of water
2. Open reservoir and pour water in
3. Close reservoir and run system for 1 minute
4. Take viscosity measurement
5. Repeat steps 1 through 4 until viscosity closely approaches the standard SUS, within 10 SUS above the standard reading
6. Make the final adjustments using 500 ml or less until the standard SUS is achieved

INCREASING VISCOSITY

Increases in viscosity are usually needed because too much water was added during the lowering viscosity procedure. Increasing the viscosity is accomplished by removing the diluted fluid and replacing it with new fluid. This is less labor intensive than lowering the viscosity.

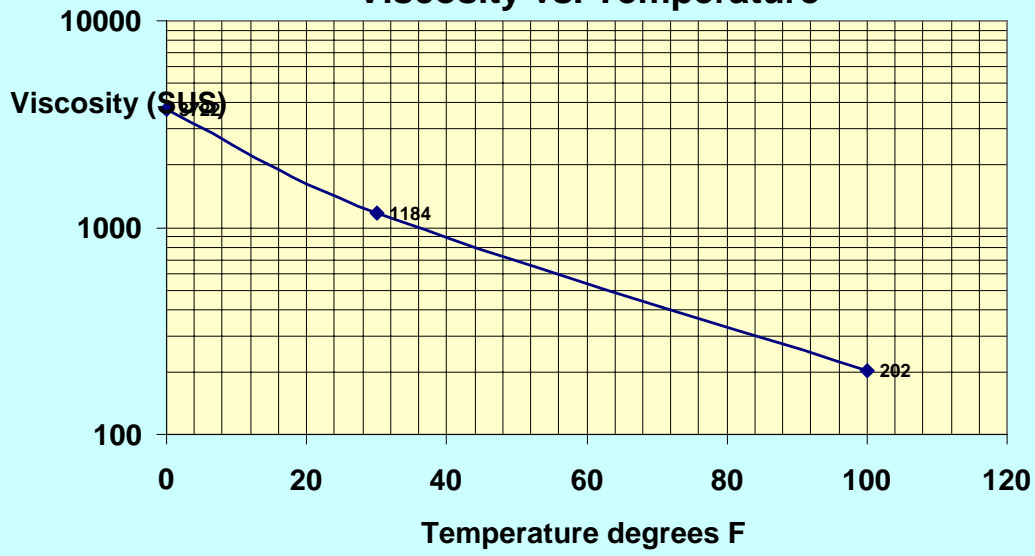
Equipment needed:

1. New fluid equal to $\frac{1}{2}$ the reservoir capacity
2. Fluid transfer pump, normally a filtration cart
3. Clean sealable storage containers
4. Drip pans
5. Spill dams
6. Absorbent material for large spills

Procedure:

1. Transfer diluted fluid from the system reservoir equaling $\frac{1}{2}$ the reservoir capacity into the clean sealable storage containers
2. Replace the diluted fluid with the new fluid
3. Run the system for 5 minutes
4. Measure the viscosity and record
5. Store the diluted fluid which can be used in the future instead of water for lowering the viscosity
6. Clean up and properly dispose of any spills

**DIETHYLENE WATER GLYCOL
HYDRAULIC FLUID
Viscosity vs. Temperature**



TEST	TEST RESULTS	ACTION
<p>Ph</p> <p>Litmus Meter or Litmus Paper</p>	<p>8.0 to 10.0</p> <p>< 8.0</p> <p>> 10.0</p>	<p>SATISFACTORY/USE</p> <p>pH IS TOO LOW/DRAIN Remove ½ of the fluid and replace with fresh WATER GLYCOL FLUID.</p> <p>pH IS TOO HIGH CHECK For Alkaline Contaminant. Drain all WATER GLYCOL FLUID™ From the Hydraulic System. Fill the System with Fresh WATER GLYCOL FLUID.</p>
<p>CONTAMINATION WITH OIL</p> <p>Visual Observation</p>	<p>< 2.0%</p> <p>> 5.0%</p>	<p>REMOVE OIL By Suction or by Skimming From the Top of WATER GLYCOL FLUID.</p> <p>DRAIN WATER GLYCOL FLUID™ From the Hydraulic System and put it into Clean Drums. Allow the Fluids to Separate. Use the WATER GLYCOL FLUID Layer as Make-Up Fluid if the Fluid Properties are Satisfactory.</p>
<p>VISUAL APPEARANCE</p>	<p>CLEAR TO TURBID LIQUID</p> <p>BURNT APPERANCE, RED OR RUSTY</p> <p>VISIBLE PARTICLES OR CONTAMINANTS</p>	<p>SATISFACTORY/USE</p> <p>DRAIN WATER GLYCOL FLUID Take Fluid Sample and Drain WATER GLYCOL FLUID From the Hydraulic System and Dispose. Replace Return Filters. Replace with Fresh WATER GLYCOL FLUID™</p> <p>DRAIN WATER GLYCOL FLUID Take Fluid Sample and Drain WATER GLYCOL FLUID™ From the Hydraulic System and Dispose. Replace Return Filters. Replace with Fresh WATER GLYCOL FLUID.</p>

TROUBLE SHOOTING GUIDE

TROUBLE SHOOTING GUIDE

CONDITION	COMMENTS
<p>Water glycol fluid appears as a white soapy substance.</p>	<ul style="list-style-type: none"> • There can be several explanations for this condition. There are two common causes: <ol style="list-style-type: none"> 1. The water glycol is reacting with the material in components. This is a condition where the component is constructed of non-anodized aluminum, zinc or has a high lead content. Check with hydraulic component OEMs to determine materials used. This condition is generally noticed shortly after converting the system over to water glycol lubricants. Corrective action - requires replacement of the component with an anodized aluminum component. The fluid must be replaced in the system with new fluid since the fluid is contaminated and cannot be reclaimed. If the component cannot be replaced, water glycol cannot be used in the system and must be replaced with another type of fluid. 2. Although it is uncommon, the condition can be as a result of potable water in the system. If for some reason viscosity adjustment was made with potable water, or potable water is finding its way into the system from some other source such as a heat exchanger leak, then the calcium carbonate and magnesium in the water is reacting with the water glycol. Corrective action - requires finding the source of water contamination. In the case of a heat exchanger leak, the leak must be repaired. What ever the source of water contamination the water glycol fluid must be replaced with new fluid.
<p>The system components are acting sluggish. Motors and cylinders appear to be having difficulty achieving the required speed.</p>	<ul style="list-style-type: none"> • There are two primary causes for this condition. <ol style="list-style-type: none"> 1. Flow controls have been adjusted reducing flow to the actuators. Corrective action – requires checking the system flow to the components and adjusting the flow control as necessary. 2. Water has evaporated out of the system leaving the viscosity of the water glycol too high. The higher viscosity fluid moves slower in the system. Corrective action – Using a refractometer or viscometer check the fluid viscosity. The viscosity should not exceed 50 SUS over the SUS value @ 100° F found in the fluid specifications. If the viscosity is above the specification limit then the viscosity can be lowered by using the viscosity adjustment procedures.

CONDITION	COMMENTS
<p>When the pump is running its sounds as if it is struggling and sounds as if it is under load even when it isn't.</p>	<ul style="list-style-type: none"> • Clearly conditions as described would lead to an assumption of a problem with the fluid viscosity. This is a condition that would develop over time and wouldn't represent an acute condition. The changes in fluid viscosity happen slowly over time and may not be recognized until the viscosity had changed significantly. Changes of this nature usually are caused by water evaporation. • Corrective action - requires checking the viscosity of the fluid. If it exceeds the viscosity limits, then the viscosity adjustment procedure should be informed. If the viscosity is within normal limits, then contact a fluid power professional to ascertain the pump problem.
<p>When the pump is running it occasionally sounds as if it is experiencing cavitation.</p>	<ul style="list-style-type: none"> • This normally is not a fluid problem but usually indicates that the pump intake is blocked or is being starved. Two common conditions that may cause this condition is blockage of the intake or a collapsing of the intake hose. Blockage is the normal cause. Whenever this condition is observed the system should be immediately shut down and investigated. Running the pump in this condition will cause serious pump degradation and failure. • Corrective action – requires examining the pump intake. If the reservoir has a suction strainer the fluid will have to be drained from the tank and the strainer checked. If the strainer is clogged it should be cleaned, replaced or removed. If the pump is submerged directly in the reservoir the pump inlet should be checked for blockage. Intake hose collapse is easily observed and should be replaced. Other possible causes may be that the pump is failing and the internal damage is sufficient to cause the cavitation. Other than blocked intakes, strainers or collapsing inlet hose; a fluid power professional should be contacted.

<p>The pump is making popping sounds.</p>	<ul style="list-style-type: none"> • The popping sound indicates a serious condition. The popping sound comes from entrained bubbles. Although rare in occurrence, there is usually only one of two ways in which this is experienced: It is a faulty system design where the pressure relief valve discharge is plumbed into the inlet line of the pump. Or, the fluid viscosity is too low making the fluid very thin. This is more common for fluids that have a high vapor pressure close to water or the viscosity is close to that of water. The pump shouldn't be operated until this condition is corrected. The popping sound is an indication that the bubbles are compressed to the extent that they are exploding. These small explosions literally remove parts of the pump's material surface. • Corrective action – requires a check of the fluid viscosity. If the viscosity is too low then the fluid viscosity should be adjusted using the viscosity adjustment procedures. If it turns out to be an improperly designed system, then a qualified fluid power professional needs to be called in to correct the design issues. It may be the case that if the condition has been going on long enough, the pump will probably have to be changed.
<p>System cylinders are moving in jerky motions when activated.</p>	<ul style="list-style-type: none"> • Cylinders should move in and out in a smooth motion. When cylinders are moving in a jerky motion the cause is normally air in the hydraulic system. Other causes can be cylinder directional control valves that are searching between the open and closed positions. This is an extremely rare condition. • Corrective action – requires bleeding the air out of the system. If it is a valve problem or something else, then a fluid power professional should be contacted to correct the problem.
<p>System cylinders will not hold a load.</p>	<ul style="list-style-type: none"> • This is not a fluid issue. This is a mechanical issue with the cylinder piston seals or a load holding valve. • Corrective action – requires replacement of the cylinder. If the problem persists, contact a fluid power professional to analyze and correct the problem. In some cases water glycol fluids can react with the cylinder piston seals if the elastomer is a non-compatible material, but only a fluid power professional can make that determination.
<p>Pumps and motors are not achieving their expected lifetimes.</p>	<ul style="list-style-type: none"> • This can be attributed to a number of variables. Overtime pumps and motors lose efficiency from wear. Industry expectations are that pumps should last between 8,000 to 10,000 hours of operation. However this represents an average and other factors do contribute to wear. Common issues that effect pump wear are fluid particle contamination, operating pressures, and the lubricity and ability of the fluid to maintain the lubrication boundary layer between the metal mating surfaces.

<p>Pumps and motors are not achieving their expected lifetimes. (continued)</p>	<ul style="list-style-type: none"> • Corrective action – requires an extensive analysis of the situation. In water based fluids the lubricity is controlled by the pH level of the fluid. Fluid pH must be 8.0 or higher. The 1st test to perform is to test the pH of the fluid. If the pH is lower than 8.0, then the fluid must be replaced. It is expected that repeated adjustments to the viscosity of the fluid will eventually delude the amine additives and the pH will drop. In addition to perform pH tests a fluid sample should be taken to determine if the fluid is contaminated. Contaminated fluid will cause excessive wear and is usually associated with too infrequent changing of return filters. Routine maintenance and filter changes are critical to maintaining fluid cleanliness. System pressures also should be checked. If the system is continually required to operate at the maximum operating pressure, then the system pressure should be reduced. If the pressure must be maintained at the high levels, then a fluid power professional should be contacted to assist in determining whether a different pump may be more suitable.
<p>The fluid requires frequent viscosity adjustments.</p>	<ul style="list-style-type: none"> • Since water glycols have between 35% to 45% water content, it is susceptible to evaporation. This is usually the reason for adding purified water to return the viscosity to normal levels. • Corrective action – requires a check of fluid temperatures. The higher the fluid temperature, the higher the evaporation rate. In water glycol fluids the operating temperatures should be kept below 50° C (122° F). If the fluid temperature is consistently higher, then the evaporation will be high. Also, operation at higher temperatures can cause a reduction in boundary layer lubrication, thus accelerating pump and motor wear. Evaporation rates will be higher during warmer seasonal periods and it is common to make more viscosity adjustments during the warm weather. Corrective action – requires monitoring the fluid temperature. If the fluid is operating at temperatures higher than recommended and fluid system levels are normal, the addition of a heat exchanger will provide the best solution. Contact a fluid power professional or heat transfer professional to assist in selecting the best solution.
<p>It is difficult to determine when the system return filters need to be replaced.</p>	<ul style="list-style-type: none"> • This is a common problem. Maintaining fluid cleanliness is one of the easiest and most cost effective means for maintaining system health and achieving desired lifetimes. Filter lifetimes are affected by several variables. These include filter media type, filtration rating, and filter size. There can be some system design issues that also affect filter lifetimes. • Corrective action – requires the addition of some type of filter dirt indicator when the filter is full. These dirt indicators can be mechanical, electronic, or both. Also, filters can be upgraded

<p>It is difficult to determine when the system return filters need to be replaced. (continued)</p>	<p>in size and dirt holding capacity. However, the additional capacity may not be cost effective. In the long run the addition of dirt indicators will save on unnecessary filter changes and filter costs can be more closely controlled. In some cases the filter rating is too fine for the application. However, only a fluid power professional or filtration professional can make that determination.</p>
<p>Recently the system was changed to a water glycol and when the filter was changed the filter media appeared to be dissolved.</p>	<ul style="list-style-type: none"> • This occurs when the filter type is a paper media filter and the filter type was not changed at the time the water glycol was installed. If the system is not corrected, component failures will occur. • Correction action – requires changing to filters that have something other than paper media. Normally fiberglass filter media is the best choice since it doesn't react with the fluid. The fluid must be cleaned prior to being put back into service. This can be accomplished by running the fluid through a side loop filtration system (filter cart). Once the reservoir is cleaned the system can be started and run the system through the side loop filtration until fluid is cleaned. It can be expected that filters will have to be changed, since they will fill with paper contaminants, much more frequently until the system is clear.
<p>After changing the system to water glycol and following the installation procedures, oil is still accumulating in a layer on top of the reservoir.</p>	<ul style="list-style-type: none"> • This is to be expected as the water based fluid continues to push trace amounts of oil out of the system. Since the specific gravity of oil is less than the specific gravity of the water based fluid, the oils will float on the top of the fluid in the reservoir, creating a layer of oil. This is generally not a concern to the health or performance of the system. • Corrective action – requires the vacuuming off, with a wet vacuum, of the oil layer and suitable disposal. Layer amounts of less than a cm do not require any corrective action.

For conditions, questions or clarifications; please contact MRL HYDRAULICS LLC by calling Toll Free (877) 223-2822 or e-mail: LyleRMRLHYD@aol.com.