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Hydraulic Fluid and Hydraulic System Compatibility with Bio-Ultimax™ & Hydro Safe®Technology

STABILIZED™ by Renewable Lubricants

"Biobased Lubricants that Perform Like Synthetics"

Bio-Ultimax™ - Hydro Safe® Hydraulic Fluids, (1000, 1200, 1500, and 2000 ISO Grade Series), including Bio-Fleet™ & Hydro Safe® Select, Bio-HVO™, Bio-HVO2™ & Hydro Safe® FR, Bio-Hydra FR, Bio-Air Compressor Fluid, Bio SynXtra EP and Bio EP Gear Oils and Bio-AW turbine R&O Hydraulic Fluids (listed herein as Bio-Ultimax™ Technology Fluids) are compatible with the same system materials and components that are designed to operate on mineral oil based and most synthetic based fluids. In addition, they have been tested and have shown to be compatible with conventional mineral oil based and most synthetic PAO based hydraulic fluids or in the case of BIO EP Gear Oils and BioSynXtra EP Gear Oils they are compatible with straight ISO grade petroleum and synthetic PAO EP gear oils. Conversion procedures are much easier and No engineering design changes are necessary. They are designed to be compatible with the same filters, seals, hoses, accumulator bladders, cylinders and valves designed for petroleum, petroleum semi-synthetic, petroleum synthetic, and synthetic ester formulations. They can operate in static, mid-dynamic, and dynamic areas of hydraulic systems that contain plastic nylon composite (Nylatron GS, GSM, NSM), bearing composite (Iglide), fluorocarbon (Viton), polytetrafluoroethylene (Teflon), fluorosilicone, polyurethane, polysulfide, low Nitrile Buna-N, medium Nitrile Buna-N, high Nitrile Buna-N, Hydrogenated Nitrile Buna Rubber (HNBR), and include the following elastomers and description trade names:

Elastomer Compatibility

Including **ISO/DIN 1629**	DESCRIPTION (Trade Names)
• NBR	Low nitrile rubber NBR-L, NBR1 (Buna N, <30% acrylonitrile)
• NBR	Medium to high nitrile rubber (Buna N, >30% acrylonitrile)
• HNBR	Hydrogenated or Highly Saturated Nitrile Rubber
• FPM, FKM	Fluoroelastomer (Viton) Type 1 or A, Type 2 or B, (Dyneon, Flurel)
• FFKM	Perfluoroelastomer (Kalrez, Chemraz, Isolast, and Perlast)
• TFE/P, FEPM	Tetrafluoroethelene propylene (Aflas) non-conventional FKM Fluoroelastomer
• AU, EU	Polyurethane, (Adiprene, Millathane, Desmopan) Polysulfide, (Thiokol)
• PTFE, FEP	Polytetrafluoroethylene (Teflon, Armalon, Fiberglide)
• ECO, CO	ECH Epichlorhydrin
• CR	Polychloroprene (Neoprene)
• FVMQ	Fluorosilicone, (FSE, Silastic, Sylon), generally used for static seals
• VMQ, Si	Vinyl-methyl-silicone, silicone, generally used for static seals

In addition to the elastomer compatibility list above, Bio-HVO2™ Hydraulic ISO 46 and 68 FR Fluids have also performed in hydraulic system containing EPDM elastomers and contain specific biodegradable, biobased oils that provide compatibility with EPDM. (See TDS on Bio-HVO2™ Hydraulic Fluids ISO 46, and 68 FR Fluids, ISO 32 Grade is not compatible with EPDM).

Petroleum-Mineral Oil Based Fluid Compatibility

Bio-Ultimax™ Technology Fluids are formulated with natural esters and other synthetic base oils (BioSynthetic) The majority of the formulations are >50% natural esters (rape, canola, soy, or sunflower) plant base oils, that are known to the industry to be compatible with petroleum/mineral and synthetic/PAO base oils. Because of the patented antioxidants (Stabilized*) and they are biosynthetic they provide improved performance in compatibility, oxidation stability, and cold temperature over the competitive plant-vegetable/HETG and unsaturated synthetic esters HEES type Fluids. If there are compatibility problems, it is generally with certain VI improver additives and/or saturated complex esters provided in other formulations. Bio-Ultimax™ Technology Fluids and BIO-Gear Oils (BIO EP Gear Oils and BioSynXtra EP Gear Oil) formulations have been designed and tested to directly replace conventional mineral oil based hydraulic fluids or gear oil formulations that contain Group I, Group II, Group III, and synthetic PAO base oil formulations, (without VI improver additives). NBR is one of the most widely used seal elastomers in the industry for mineral oil based hydraulic systems. Because of more synthetic formulation entering the market, HNBR and FKM elastomers are gaining market in newer equipment and are listed above with other elastomers that are recommended. **System Conversion regardless of the base oil:** if the present system is using a non-multigrade fluid (conventional fluid without viscosity index (VI) improvers), simply drain and recharge to convert a system. In addition, RLI has Bio-Ultimax™ Technology Fluids that were designed specifically

to be compatible with fluids that contain certain VI improvers. If the existing fluid contains a VI improver or if there are any questions on compatibility, contact Renewable Lubricants Inc., (RLI) for the recommended replacement fluid. RLI's lab can do your compatibility studies. For reason of maintaining the best biodegradability, at least 90% of the mineral oil based fluid should be removed from the system. Most of the fluid can be removed by draining the reservoir and lines. Flushing fluids are not necessary with compatible fluids, but if you choose to flush because of dirty fluid, or you don't know the past maintenance care of the system only Bio-Ultimax™ Technology Fluids should be used for flushing. (RLI recommends that only the fluid that you're converting to should be used to flush the system.) Bio-Ultimax™ Technology Fluids may also be used as a top fill (with compatible fluids) until the existing fluid is converted in the maintenance schedule. This simplifies the change-over procedure. In addition, **Monitoring the fluids in use with scheduled Universal Oil Analysis (UOA) Program, and complying with scheduled filter inspection and oil change intervals are most important regardless if you flush or not flush.** It is a standard maintenance procedure of most OEMs' to check and change oil filter more frequently after change over to reduce contaminates that are loosened during servicing new equipment and servicing/replacement of parts, or fluids. RLI also recommends complying with these OEM standard maintenance procedures to control contaminates in the system. The question is To Flush or not to Flush? this should be determined by first knowing the condition and past maintenance care of the system and prior fluid, and this can only be determined by reviewing the past history of UOA records or performing a UOA on the prior used fluid that is in the system before the change-over. Guessing, or not checking the condition of the system with an UOA on the fluids can lead to long term problems and cost. UOA on the systems fluid is the start of a responsible predictive maintenance program that can extend the life of the system and the system's fluid, simplifies the change-over procedure, and save long term system problems and money for your customers.

Synthetic Based Fluid Compatibility

PAOs

Bio-Ultimax™ Technology Fluids are compatible with synthetic Polyalphaolefins (PAOs) and semi-synthetic PAO and mineral oil blends. PAOs are widely used in the synthetic lubricant market and generally formulated to meet the same hydraulic systems compatibility requirements as mineral oil fluids. Converting a system would require the same procedure as petroleum oil based above.

Synthetic Esters

Bio-Ultimax™ Technology Fluids are compatible with most synthetic esters based fluids and depending on selection of esters they may be considered biodegradable. RLI's compatibility studies show polyolesters and diesters to be very compatible however there can be compatibility problems when blending some complex ester fluids and different VI improvers used in multigrade fluids. Most synthetic ester based fluids have excessive seal swell on butyl and low nitrile rubber and more chemically resistant seals and components (NBR medium to high nitrile, HNBR, FPM, FKM and PTFE) are usually recommended. Bio-Ultimax™ Technology Fluids are highly compatible with systems designed to use synthetic esters. Converting a system would require the same procedure as petroleum oil based above.

Polyalkalene Glycol (PAG), and Polyethylene Glycol (PEG),
Water glycol (HFC) and invert emulsions (HFA / HFB)

Bio-Ultimax™ Technology Fluids are **NOT** compatible with most PAG, PEG, and water based fluids. However, there are some oil based PAGs that could be compatible, but compatibility studies would need to be conducted for verification. If they are water based fluids, they must be removed from the system by draining the reservoir and lines. Density and emulsification with water is the main problem with these Glycol / water based type Formulations. Refill with Bio-Ultimax Fluid as a flush. Remove residual fluid by circulating and draining. Flush and repeat flushing until the residual is removed from the system. Standard practice for flush and purification of hydraulic systems may be found in ASTM D 4174-89. Seal and system compatibility should also be considered before changing the system over, because EPDM seals may be used in systems designed with water glycol, PAG and PEG fluids. Water contamination can not be drained at the reservoir with water based fluids,

Phosphate Esters

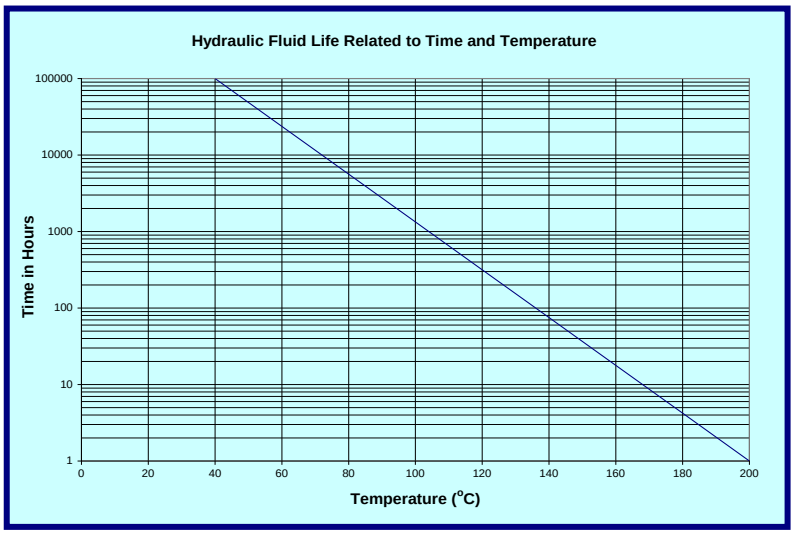
Bio-Ultimax™ Technology Fluids are compatible with some, but not all phosphate ester fluids. Testing is recommended before conversion. Seal compatibility should also be considered because Butyl rubber and EPDM are the most compatible elastomer with phosphate esters. Conventional Butyl rubber and EPDM has poor compatibility with mineral/petroleum hydraulic oils.

Professional Technical Services (Protecting and Improving the Life of you equipment)

RLI's technical services include hydraulic fluid system analysis and conversion recommendations. RLI recommends a program of regular hydraulic fluid analysis every 6 months or less depending on the application and system. Contact RLI for these services. RLI's goal is to provide a high performance hydraulic fluid that is safe, cost effective, and extends the life of your equipment. ***It is recommended by RLI that if there are any questions about material and fluid compatibility to contact RLI's technical service. If professional high velocity oil flushing, cleaning, and filtration are required, RLI can provide compatible flushing fluids for high velocity system flushing. For additional information on high velocity flushing services contact PWS Motion Control, Inc. www.pwsdirect.com or contact RLI.***

Life Expectancy of Hydraulic Fluids

The logarithmic chart to the right shows the life expectancy of hydraulic fluids related to time and temperature. Bio-Ultimax Technology Fluids are designed to meet OEM oil change requirements that are recommend for mineral oil (HLP) based fluids. Although this chart is a good reference, it does not take into consideration other variables that can affect the life of the fluid as in moisture, dusty conditions, system design, etc. We, therefore, recommend that the fluid and filters be changed at least as frequently as mineral oil (HLP) formulations. Most OEMs' recommend that you maintain constant, close contact with lubricant manufacturers to support you in the selection, maintenance, care and analyses of your fluids.



With the proper maintenance and RLI's fluid analysis program, equipment and/or fluid life can be extended with Bio-Ultimax Patented Technology Fluids. **Our experience up to the present time with many different pump systems indicates that RLI's fluids have the same or better aging characteristics as HLP mineral oil type formulations.**

Filtration is highly important to RLI and OEMs:

All hydraulic filter elements must be inspected and changed when required by the OEM maintenance manual or when necessary during regular maintenance Inspection of filters. When commissioning a system, please note that the required minimum cleanliness class can frequently be attained only by flushing the system This is Due to past oil contamination, severe start-up and change-over contamination, it may be possible by monitoring UOA, that an oil and/or filter replacement becomes necessary after a short operating period (<50 operating hours), According to the present state of knowledge, all hydraulic fluids, regardless of additivation, can be filtered with all customary filter materials in all known filtration ratings (<0.8 µm), without filtering out effective additives at the same time. RLI's environmentally friendly, zinc-free additive system has also been developed that has shown to 1) provides excellent system filterability even with the addition of .2% water, (although the system should never be operated if the water in the fluid is >1%) 2) additives not to be filtered out of the formulation after years of use, and 3) meets or exceeds high pressure system and pump requirements for antiwear. If the fluid in system before change-out is PAG, PEG, or water based type fluids, because of compatibility the system must always be drained and flushed with RLI's recommended fluid. RLI recommends flushing the system with the same formulation that was chosen as best to service the system. **Excellent demulsification:** RLI's Technology fluids provide excellent demulsification, they are not soluble in water. RLI's Technology fluids are designed to rapidly deposit any accumulated water in the tank bottom during system shut down and water can be easily separated from the fluids. Therefore, it is advantageous if the tank has a sloping base and a drain fit for draining water from the system.

Green and Clean;

Look for our new ISO Green logo to be found on our products that are readily biodegradable, Eco-nontoxic, and meet stringent ISO cleanliness standards.

ISOGREEN™ CERTIFIED LUBRICANTS

Solid particle contamination and cleanliness classes: Solid particle contamination is a problem in hydraulic fluids in the system, RLI can provide the particle count on the new Fluid provided on the C of A, **and the ISO Green logo on our labels (on the top of the drum), provides our customer the insurance that the stringent ISO cleanliness standards have been met on the new fluid before use**, and should be monitored before, or during change over through RLI's UOA. Contaminates may lead to a number of effects in the hydraulic system. Firstly, single large solid particles may lead directly to a system malfunction, and secondly small particles cause continuous elevated component and seal wear. The indication of the cleanliness class for environmentally acceptable hydraulic fluids is given, similar to mineral oils and includes synthetic fluids, in form of a three digt numerical code in accordance with ISO 4406. This numerical code denotes the number of particles present in a hydraulic fluid for a defined quantity. Furthermore, foreign particles must not exceed a mass of 50 mg/kg. In general, compliance with a minimum cleanliness class of 20/18/15 in accordance with ISO 4406 or better is to be maintained in operation. Special servo valves demand improved cleanliness classes of at least 18/16/13. A reduction in cleanliness class by one level means half of the quantity of particles and thus greater cleanliness. Lower numbers in ISO cleanliness classes should always be striven for to extend the service life of hydraulic fluid and system components. The component with the highest cleanliness requirements determines the required cleanliness of the overall system. Please also observe the specifications: "Cleanliness classes to ISO 4406"and in the respective data sheets of the various OEM hydraulic components. In addition, the typical physical and performance properties of the Biobased fluids should be compared to HLP and

HVLP fluids on the OEM respective data sheets and manuals. The viscosity and the viscosity/temperature coefficient are of primary importance, as are the density and the pour point for pump and system performance. RLI's Formulations are specifically formulated to provide the proper viscosity and density to meet and exceed mineral based formulas (HLP and HVLP) physical and performance properties (see performance properties in RLI's TDSs and SDS.

Most competitive Hydraulic fluids frequently fail to meet these cleanliness requirements on delivery. Careful filtering of the fluid is therefore required during operation and in particular, during filling in order to ensure the required cleanliness classes. Renewable Lubricants as your lubricant manufacturer will provide you the ISO cleanliness class of RLI's hydraulic fluids as delivered, to insure your ISO required cleanliness and help simplify the hydraulic system change-over. In addition, regardless of the type fluid (Petroleum or Biobased) you must always make sure your lubricant transfer system is not contaminated, before servicing your hydraulic system with the new Hydraulic Fluid. To maintain the required cleanliness class over the system's operating period, you must use a clean tank breather filter and clean the top of the reservoir lid, fill cap, and breather filter before filling. If the environment is humid, take appropriate measures, such as a breather filter with air drying elements. If the hydraulic fluid is a PAG, PEG, or water based formulation, additional special equipment may be required to separate condensate, foreign accumulated water, and contaminates from the fluid.

Viscosity

The optimum operating viscosity is an important property of hydraulic fluids and should be monitored during operation by ASTM D445 in RLI oil Universal oil analysis (UOA) program. The permitted viscosity range of complete systems needs to be determined taking account of the permitted viscosity of all OEM equipment and it is to be reviewed for each individual OEM component. The viscosity at operating temperature determines the response characteristics of closed control loops, stability and damping of systems, the efficiency factor and the degree of wear. We recommend that the optimum operating viscosity range of each component be kept within the permitted temperature range required by the OEM. An overview of viscosity limitations is provided in OEM equipment component data sheets and manuals. "Viscosity limitations and required cleanliness classes of hydraulic components", with additional specifications are also in the respective OEM component data sheets, or manuals. If the viscosity of a hydraulic fluid used is above the permitted operating viscosity, this will result in increased hydraulic-mechanical losses, (energy loss). In return, there will be lower internal leakage losses. If the pressure level is lower, lubrication gaps may not be filled up, which can lead to increased wear. For hydraulic pumps, the permitted suction pressure may not be reached, which may lead to foam and cavitation damage. If the viscosity of a hydraulic fluid is below the permitted operating viscosity, increased leakage, wear, susceptibility to contamination and shorter equipment life will result. RLI's can help in supplying the proper ISO viscosity Fluids and most fluids have a viscosity index of more than >150 VI and therefore provide improved lubrication fluid film during higher and wider temperature ranges for both stationary and mobile applications. In equipment operating outside, wear from poor cold temperature pumpability, surge loads, moisture, and dusty environments are more prominent. RLI has a broad range of many different types of Hydraulic fluids to recommend and properly service the industry with the best designed product for the application. The Bio-Ultimax™ Technology Hydraulic Fluids are provided in many different formulation series and viscosities to improve performance in equipment that requires excellent filtration, compatibility, anti-wear, antifoam, corrosion protection, rapid water separation, and RLI's Technology provides formulation that can provide cold temperature pumpability as low as -50C (see Bio Ultimax 1200LT series TDSs). They are compatible with the same seals, filters, materials and components that are designed to operate on petroleum oil based HP and HLP formulations.

Density

Moisture and Density problems with PEG, PAGs/Glycols are a problem because they are susceptible to hydrolysis, emulsify water, they are higher in density, and may require OEM system design change: Due to the higher density of the polyglycol **PAG/HEPG >1g/ml** in comparison to mineral based HP and HLP formulas @ <.90 density, lower suction pressures are to be anticipated for pumps. To prevent system problems OEM's recommend reducing the maximum speed as required and optimize suction conditions if density (Specific Gravity @ 15.6°C is **>1.0**) **Checking the drive speed of the pumps: Due to the high density of water based fluid, Fluids >1 g/ml it is recommended by a major pump OEM that the maximum permissible speed of self-aspirating pumps is reduced by 20%**. RLI BioUltimax and Bio-Fleet formulations density are **<1g/ml** thus do not have the problem on the suction side, and no design changes are required. With PAGs the emulsification and ingress of water must be highly avoided. Water changes the physical characteristics and reduces the chemical structure of the PAG and with water based fluids, and water can only be removed in these fluids by addition of vaporization equipment or permanent off-line water separation. This is just some of the reason why PEG, PAG, water based fluids should not be blended with RLIs Product.

Respectfully Submitted,

William Garmier V.P Technology