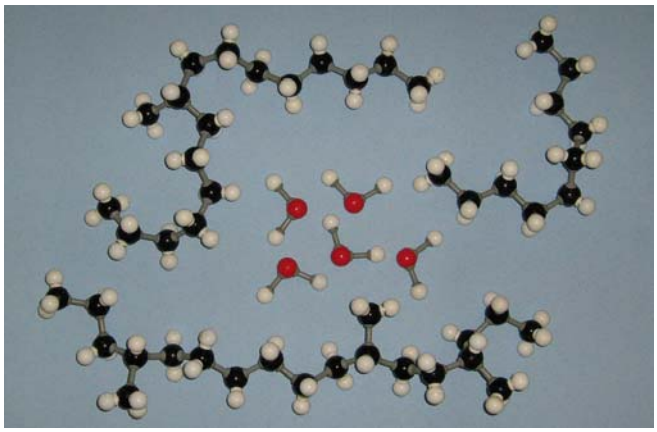
Technical Bulletin

Effects of water in EcoSafe Hydraulic Fluids

EcoSafe hydraulic fluids and EcoGear gear oils are manufactured from polyalkylene glycol (PAG) base stocks as anhydrous synthetic lubricants. Synthetic lubricants made from PAG base stocks differentiate themselves from mineral oil and vegetable oil base stocks with their tolerance of water.

The reason for this difference is due to the chemical structure of the PAG base stock and the way water interacts with it. See Figure 1.

Mineral Oil and water



PAG and water

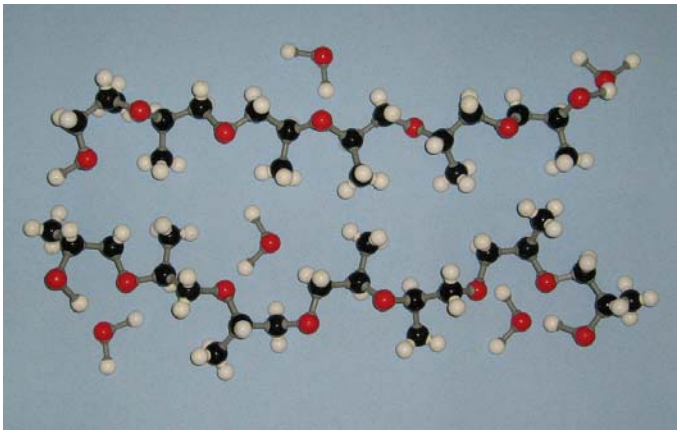


Figure 1: Model of water in a Mineral Oil and water in a PAG base stock. Carbon is black; oxygen is red; hydrogen is white. The diagram shows the expected interaction of five (5) water molecules to the respective base stock.

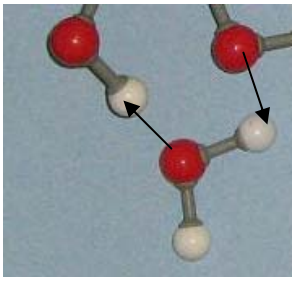


Figure 2 : Hydrogen bonding of water

Water seeks out places where it can share its hydrogen as shown in Figure 2. The connection must be oxygen-hydrogen-oxygen (RED-WHITE-RED). In a mineral oil, there are few sites for water to interact with the base oil. The result is that in mineral oil the water locates other water molecules and becomes “free water.” This Free Water can be separated by physical means, is a poor lubricant, and can carry ions that catalyze corrosion. Therefore, the upper acceptable limit for water in mineral oil fluids is legitimately very low.

In a PAG based hydraulic fluid, there are multiple sites for hydrogen bonding. Therefore, water is evenly dispersed throughout the fluid. The water cannot be separated by physical filtration. The water does not negatively impact the lubricating properties. With no Free Water in a PAG lubricant, the water cannot carry ions. Therefore, corrosion is not an issue and the upper acceptable limit for water content can be significantly higher.

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The oxygen in the PAG base oil binds up to 7500 ppm of water before a saturation point is reached. However, water in mineral oils start to form Free Water at approximately 200 ppm water.

American Chemical Technologies manufactures and supplies EcoSafe and EcoGear with between 200 and 900 ppm water. This is directly tied to the purchase specifications of the PAG base stock. As the fluid is used in service, significantly larger amount of water can be contained in the system without any negative impact upon the performance characteristics of the hydraulic fluid.

Ambient humidity conditions cause the water content of a PAG-based lubricating fluid to oscillate between 1000 and 4000 ppm of water in a seasonal cycle. There is over 10 years of field experience with PAG based lubricating fluids showing no long-term issues with water contents far in excess of what is recommended for mineral oil-based hydraulic fluids.

The following tests have been performed with PAG lubricating fluids where water is either part of the test or excessive amounts of water have been added:

ASTM D-665 – Standard Test Method for Rust-Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water

HF2 Denison Pump Test – TP-30283 T6C cartridge for 300 hr at 250 bar with 1% water

ASTM D-943 – Standard Test Method for Oxidation Characteristics of Inhibited Mineral Oils (TOST test)

ASTM D-4172 – Standard Test method for Wear Preventative Characteristics of Lubricating Fluid (Four-Ball Method)

Results found in the standard technical brochures for EcoSafe and EcoGear products are independent of changes in water content below the saturation point. Above the saturation point, only small decreases in the lubricating properties of the fluids have been observed.