Eaton Hydraulics Newsletter

July 2013 | Issue 1

The Eaton Lubricator

Water in Mineral Base Anti-Wear (AW) Hydraulic Oils

Introduction

It is generally believed that water and oil don't mix, hence water is not considered as a critical contaminant. This document briefly explains how water contamination can be problematic, how can water be measured, how it can be controlled, and how it can be removed. Unlike other contaminants, water exists in different states as its entry to hydraulic systems is relatively easy. Because of its unique properties, water is required for cooling, cleaning etc. which creates further possibilities of water entering the system in addition to the contamination from the environment.

Water in hydraulic oil

Water can exist in hydraulic oils in three forms: dissolved, emulsified and free water. New and clean oils are usually clear, bright yellow in appearance.

Dissolved water : Dissolved water does not make any distinct difference in the appearance of the oil. Normally petroleum-based hydraulic oils contain very small amounts of dissolved water and they are not harmful for the hydraulic system and the oil.

Emulsified water : Emulsified water gives a distinct appearance to the oil, depending on the amount of water the oil may turn hazy or milky. The water content in the emulsion is relatively high but will not separate easily from the oil. Emulsified water poses the greatest risk to the hydraulic system and the oil.

Free water : When excessive amount of water is present in the oil, the oil turns cloudy, milky and may separate at the bottom of the reservoir. Free water that settles at the bottom of the reservoir can be drained.

Any moisture entering a hydraulic system may emulsify under violent churning conditions if those exist in the system. The emulsion formed can be thin and watery, thick and pasty, or heavy and gummy. Emulsified and free water promote the collection of dust, grit and dirt, and they can adversely affect the proper function of valves, increase wear and corrosion, promote oil oxidation, cause additive depletion, and plug fine filters. Because of these adverse effects, most hydraulic equipment manufacturers specify the use of hydraulic oils that separate water rapidly. Also, many hydraulic systems are designed with drains located at a low point to allow for periodic removal of water. Otherwise the use of oils that emulsify a limited amount of water without degrading the performance characteristic of the oil is recommended.

Water will dissolve in oil until it reaches the saturation point. Once the saturation point is reached, water will be in emulsified or free form or both. The saturation point varies with different factors including temperature, base stock, additives, oxidation state/deterioration, and contaminants. At higher temperatures, the water saturation point of oils increases and the oil may hold more water in dissolved form; as oil cools, the reaction reverses and free water appears. Emulsifier and detergent additives enhance the emulsion formation and provide greater stability.

Most oils have good demulsibility characteristic. Usually water rapidly separates from these types of oils. However, some hydraulic oils have poor demulsibility and water will not separate out easily. These oils can tolerate only trace amounts of water.

Excessive amount of water adversely affects the performance of oils and the machines in which they are used, hence water content should be carefully monitored and controlled.

Water Contamination Limits

New anti-wear (AW) hydraulic oil usually contains around 200 – 300 ppm (0.02 – 0.03% wt) of dissolved water. This small quantity of water will not cause any harm to the hydraulic system and to the oil. Experience indicates water contamination up to 700 ppm

Water Content in AW Hydraulic Oils	Oil Appearance	Action
200 – 300 ppm	Normal (clear appearance)	No action to be taken
500 ppm	Cloudy, hazy	Check source to eliminate
700 ppm	Maximum allowable limit. hazy, cloudy	Check source and take action to eliminate
1000 ppm	Cloudy or separate layer	Immediate action to eliminate source

(0.07%wt) can be tolerated in the field, without extensive damage.

Please note, the appearance may vary with saturation point of the hydraulic oil.

Sources of water in hydraulic oil

(a) System environment
(b) Moisture condensing in reservoirs
(c) Improper storage and handling of oils

The Effects of Water on Hydraulic System and Hydraulic Oil

Water contamination damages the oil and hydraulic components and system performance. The major effects are as follows:

Lubricity: Small amounts of water can significantly reduce the load carrying capability and lubricity of the oil.

Additive degradation : Water can destroy additives especially anti-wear additives (ZDDP) and forms acidic byproducts.

Rust and corrosion: Rust is a chemical reaction of oxygen with iron containing metals. Water is the primary catalyst in the rusting process by adhering to the components and provide the oxygen required. Rust can degrade component performance by altering surface finish, can add contaminants to the system and can cause component to seize.

Hydrogen Embrittlement is a chemical change that occurs on the ferrous metal surface when exposed to hydrogen rich atmosphere. It can occur when the hydrogen in water is absorbed by the metal resulting in change of the metallic structure, losing its ductility and becomes very brittle and may crack.

Viscosity: Small quantities of water evenly dispersed as microscopic droplets will have little effect on viscosity.

Ways to Measure Water Content in Oil

Water contamination is easy to identify, although a quantitative determination usually requires laboratory analysis. Frequently, that step is not required: hazy or milky oil appearance indicates the presence of excessive amount of water, in that case a simple “crackle” test can be performed in the field to confirm the presence of water in the oil. There are a number of ways to measure the presence of water in oil but most of them are complicated /expensive/difficult to use in the field. Portable water sensors are available to measure water content in the field.

Several laboratory methods are available to determine water contamination level in oils. Current methods for determining absolute water concentrations in lubricating oils include Karl Fischer (columetric) titration, dielectric measurements, FTIR, calcium hydride test kits and Dean and Stark method. No one method can be identified as ideal for all water contamination levels.

Excluding and Removing Water

It is important to prevent water from entering the system and be prepared to remove any that might find its way in.

Water enters the system through the points where the machine interfaces with its environment. The following are tips for water exclusion.

- Proper handling and storage of new oil
- Use breathers for water control
- Use and maintain good quality shaft and wiper seals
- Avoid water sprays in the areas of seals, fill ports, breathers etc.
- Maintain the seals/gaskets of heating/cooling systems in good condition

The following are the most common techniques for water removal from lubricating oils.

1. Gravity separation
2. Centrifugal separation
3. Absorbent polymer separation
4. Coalescers
5. Vacuum dehydration and
6. Dehydration by air stripping

Conclusion

In general, good quality mineral base anti-wear hydraulic oils separate water rapidly. However, care must be taken to ensure the additives that are used in the formulation of the oil do not have an adverse effect on the water separation properties.

Failure to properly maintain the oil free of excessive water contamination often results in less than optimum performance, and can lead to component or system to malfunction and eventually failures.

Key Words

Demulsibility: Ability of an oil to separate from water

Emulsion: Mixture of oil and water, usually of a cloudy or milky appearance

Emulsifier: Additive that promotes the formation of a stable emulsion.

AW: Anti-wear

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