Water Contamination In Hydraulic & Lubrication Oils, A General Discussion

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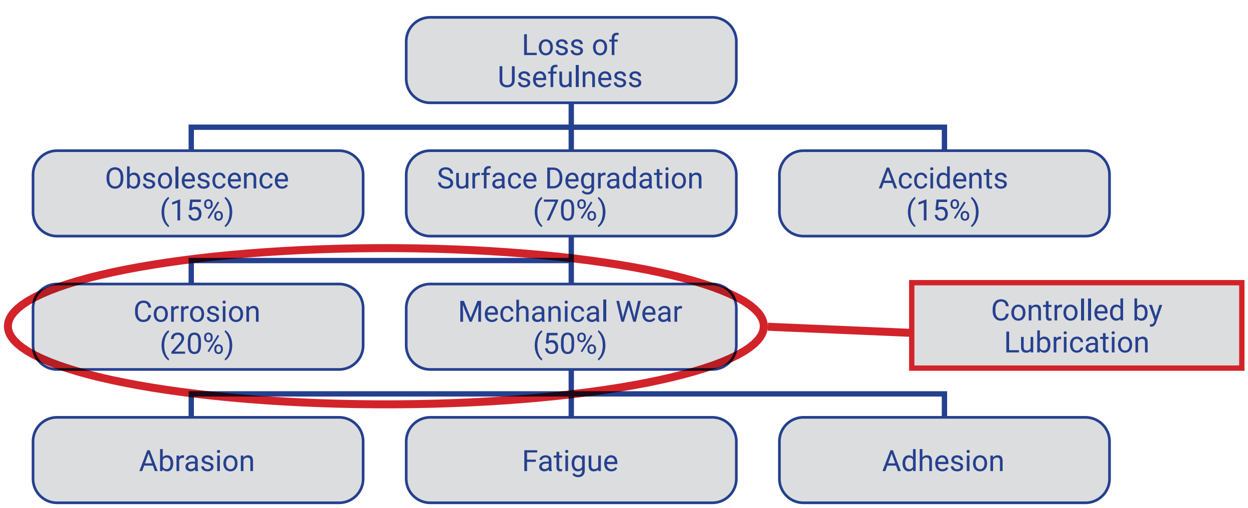
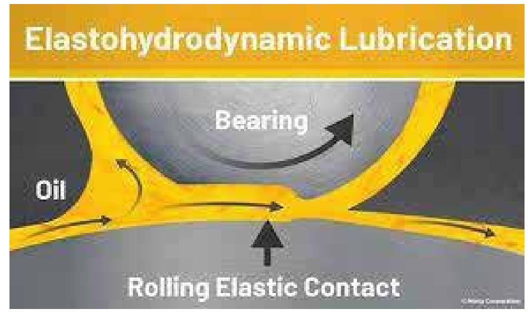
There are several different types of contamination in hydraulic and lubrication oils which cause problems for reliable operations in industrial plants around the world, including particulate, entrained gases, acids, and varnish. One of the biggest problems is water contamination.

It has been estimated that over $1 trillion of the gross national product here in the USA is spent every year to repair the damage caused by mechanical wear on rotating equipment, and water contamination in hydraulic and lubrication oils is a major contributing factor to that number.



The main purpose of a lubricating oil is to provide a good protective film between moving metal surfaces (bearings, for instance), and great care is taken in the industry to make sure that an oil with the proper characteristics is used for specific applications. Water contamination in the oil can change those important characteristics, leading to poor hydrodynamic and elastohydrodynamic lubrication performance in rotating equipment, as follows:



Viscosity – Water contamination can significantly lower the oil's viscosity, reducing the film thickness and strength, thereby allowing the moving metal surfaces to come in contact with one another. This can lead to premature abrasive wear on the components themselves.

Oxidation – Water contamination in the oil can cause oxidation, rust, and corrosion on metal surfaces.

Additive Depletion – Water can react with an oil's additive package, altering its chemical composition, impairing its demulsibility, and promoting the breakdown of the oil itself.

Sludge & Varnish – Water contamination can act as a catalyst for the formation of sludge and varnish within the oil.

Acid Formation – Water contamination can act as a catalyst for the formation of acids in the oil (hydrolysis).

Foaming – Water contamination can cause excessive foaming within the oil, which can significantly reduce the film strength.

Microbial Growth – Water can promote microbial growth within lube oils and fuels, particularly at the oil/air interface within bulk tanks and reservoirs.

All of these harmful effects of water contamination in hydraulic and lubrication oils impact the efficient operation and profitability of industrial plants by:

- Shortening the useful life of the hydraulic and lubrication oil itself
- Leading to premature wear and failure of rotating equipment
- Requiring costly down-time and equipment repair

Several studies have been conducted to create life extension charts based on the amount of water contamination in the oil, and although the numbers are not hard and fast, it has been estimated that the life of rotating equipment can be extended by as much as 4x by lowering the overall water content from 1000 PPM to <100 PPM.

Water exists in oil in 3 phases – free, emulsified, and dissolved.

Free water – Readily separates from the oil and settles to the bottom of the reservoir

Emulsified water – Becomes mixed with the oil and forms an emulsion (milky in appearance)

Dissolved water – Dissolved within the oil itself, usually a very small amount which differs from oil to oil.

Free water and emulsified water are the main culprits causing all of the problems – dissolved water is usually a negligible concentration that does not cause any of the harmful effects noted above.

Therefore, it is good practice to keep your hydraulic and lubrication oils absolutely clean and dry, removing all free and emulsified water down to the water saturation point.

HOW DRY DOES YOUR OIL NEED TO BE?

The water saturation point of various viscosity grades and types of oils is different (depending on additive packages, etc.), but various OEMs of rotating equipment have set the following general guidelines for water content in oil:

ISO 32 Turbine Oil < 100 PPM
Hydraulic Oils < 100 PPM
Gear Oils < 300 PPM
Ester Based Oils < 800 PPM

There are several different ways that overall water content in oil is measured and displayed, and it is important to understand exactly what each one means.

Many oil analysis labs use a Karl Fischer Titrator to measure water content in PPM (parts per million).

Many labs also give you a number of “% by volume”, which is a straight forward calculation that relates to PPM as follows:

1.00% (by volume) = 10,000 PPM
0.1% (by volume) = 1,000 PPM
0.01% (by volume) = 100 PPM

There are a number of inline and bottle sampling devices on the market today which utilize moisture/ humidity sensors to measure overall water content in oil, and the number that they display is typically “Relative Humidity (rH)” or “% Saturation”.

When there is free water in the oil, it is considered fully saturated, and the device reading will be 1.00 or greater. When there is no free water in the oil, only dissolved, then the device reading will be <1.00, and this should be the target for keeping your oil absolutely clean and dry.

The way this translates to PPM is as follows:

Assuming you are working with an ISO 32 Turbine Oil (which typically has a water saturation point of 150 PPM), a reading of rH = 0.70 translates to 105 PPM.

(150 PPM x 0.70 % saturation = 105 PPM)

COMMON CAUSES OF WATER CONTAMINATION IN OIL

Atmospheric – Heating and cooling cycles cause condensation of water within a reservoir, and reservoirs that are vented to atmosphere tend to “breath” moist air, particularly in humid environments. Also, manways and fill caps do not always form perfect seals, and often allow the ingression of rain water into the oil when outdoors.

Process – An even worse situation with continuous active water ingression into the oil can be created by a leaking steam seal, gas seal, or by a leaking cooling water tube bundle within a lube oil system.

WAYS TO PREVENT INGRESSION OF WATER CONTAMINATION

The golden rule "An ounce of prevention is worth a pound of cure" has no better application than in the maintenance of rotating equipment.

There are some fairly simple, intuitive, and inexpensive things that maintenance personnel can do to minimize the amount of moisture ingression into their lube oil:

- Good housekeeping and implementing best practices for storing new drums and totes of oil in clean, dry, indoor environments.
- Properly maintaining manways and fill ports on outdoor tanks and reservoirs.
- Installing and maintaining high quality desiccant air breathers on all reservoirs
- Consider implementing a "positive pressure' device on the head space of critical reservoirs (where applicable).
- Proper maintenance of all steam seals, gas seals, and cooling water tube bundles in lube oil systems.

WAYS TO REMOVE WATER CONTAMINATION FROM HYDRAULIC AND LUBRICATION OILS

Despite all of your best efforts to prevent the ingression of water contamination into your lube oil, you may still encounter a situation where the overall water content exceeds the set limits, and you have an alarm condition with high water content. When that happens, you essentially have two options:

1. Dump the oil and replace it with new
2. Use a "kidney loop" filtration system to recirculate the oil in the reservoir and remove the water

The big disadvantage to the first choice above (other than the high cost of new oil, disposal of used oil, and the labor and downtime associated with oil change-out) is that some residual moisture usually remains in the piping, and a new fill of oil is typically re-contaminated by the water that remained in the lube oil system after draining.

A more thorough and cost effective solution is usually the second choice referenced above. Kidney-loop filtration is a proven method to achieve target cleanliness specifications in your oil, and it can be safely implemented while the lube oil system is in operation or during shut-downs.

A summary of the most common technologies used to remove water contamination from hydraulic and lube oils is as follows:

Water Removal Filter Elements (Depth Media) – typically made of cellulose or similar material which absorbs free water (much like a baby's diaper). The advantage of this technology is that it is relatively inexpensive, but unfortunately, it has multiple disadvantages. First of all, water removal filter elements can only absorb free water, and they will not break an emulsion or remove dissolved water. For this reason, they <u>cannot</u> achieve very low overall water content in oil (< 100 PPM). When used on oils with high water content, they tend to plug quickly and require frequent change-out, but measurable results are rarely achieved.

Centrifuges – utilize centrifugal force to mechanically separate water from oil due to its different specific gravity. The advantage of this technology is that it can rapidly remove large amounts of free water from oil, but it cannot break an emulsion or remove dissolved water from oil. For this reason, centrifuges <u>cannot</u> achieve very low overall water content in oil (< 100 PPM). Furthermore, centrifuges have a lot of intricate moving parts, and they tend to leak and require a lot of maintenance as they become older.

Lube Oil Coalescers – utilize coalescing technology for the mechanical separation of water from oil. Like centrifuges, the advantage of coalescers is that they can rapidly remove large amounts of free water from oil, but they cannot break an emulsion or remove dissolved water from oil. For this reason, coalescers <u>cannot</u> achieve very low overall water content in oil (< 100 PPM). Furthermore, they cannot be cost-effectively used on high viscosity gear oils, and if the oil has any detergents or surfactants in it, the coalescers can be rendered totally ineffective.

Vacuum Dehydrators – utilize vacuum distillation to remove all water (free, emulsified, and dissolved) from hydraulic and lube oils. By raising the oil temperature to around 150 degrees F, dispersing it through media to create a large amount of surface area, and putting it under 22" of vacuum, water essentially "boils" out of the oil and is effectively removed. Advantages are that vacuum dehydrators can break an emulsion and remove dissolved water to very low levels (< 100 PPM), and they can work effectively on high viscosity gear oils as well. Disadvantages are that some designs require plant water to operate (which can be very costly over time), and some designs utilize rotary vane vacuum pumps which are prone to premature failure in "wet oil" applications.

In conclusion, water contamination in hydraulic and lubrication oils contributes to the premature wear and failure of critical machinery components and rotating equipment in industrial plants around the world.

Plant maintenance and reliability personnel should pull regular oil samples and have them analyzed for overall water content (as well as other key contamination measurements).

Plant maintenance and reliability personnel should establish and enforce "best practices" in terms of housekeeping, reservoir design, and seal maintenance to prevent the ingression of water contamination into their hydraulic and lube oil systems.

When necessary, an effective "kidney loop" filtration system should be used (either temporarily or permanently) to remove water contamination from the oil and maintain very low overall water content.

The drier the better!