David Dise | Noria Corporation

Factor: C3M

Why Gearboxes **Hate Water Contamination**

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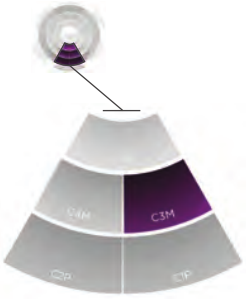

Factor:
C3M – Contamination Control Objectives

Level:
Management and Training(M)

Stage:
Contamination Control & Lubricant Reconditioning

About:
Implementing contamination control objectives and goals increases machine reliability. More stringent objectives should be set for machines with high criticality.

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Water is the second most destructive contaminant and is often ignored as the primary root cause of gearbox failure. The metal parts inside the gearbox will always be susceptible to rusting and varnish when water is present. When you add a slight amount of heat, air and water together, you will have oxidation, acid numbers will rise and rust will start forming, causing a plethora of other problems. As the additives in the oil start working in overdrive to combat the water contamination, they get consumed or used up. Additive polarity is defined as the natural directional attraction of additive molecules to other polar materials in contact with the oil. These polar materials include water, sponges, glass, dirt, metal surfaces and wood pulp. In effect, additives hitch a ride on particles or water droplets. Over time the oil loses its ability to protect metal surfaces, viscosity changes and eventually failure will occur.

Let's talk about the three different states, or phases, of water contamination you might see inside a gear-box oil reservoir. You can have dissolved water, free water or emulsified water. It is important to know the different states of water contamination and what they look like to not only determine how bad a problem is, but to identify what action needs to be taken to fix it. When talking about gearbox reservoirs, all three states of water can cause serious damage. Free water and emulsified water specifically are the most harmful states in any lubricated system.

Dissolved Water

Dissolved water is like humidity in the air. The water or moisture is present but dispersed throughout the oil, molecule by molecule, making it almost impossible to detect with the human eye. You can have a high concentration of dissolved water without being able to see it with the naked eye. With a high concentration of dissolved water, you might see condensation start to build. Having a high concentration of water and adding heat will make it react like when you leave a water bottle almost empty in the sun. The heat pulls the moisture out of the oil in a fog or cloud and sticks the moisture to the inside walls of the reservoir not being splashed with oil. As the saturation level goes up, condensation builds and eventually forms into a condensation droplet waiting to become heavy enough to slide or drip

into the oil. Dissolved water is what causes any part not coated in oil to start rusting, promoting further oxidation and contamination down the road. As the concentration or saturation of dissolved water builds, it will turn into free water or emulsify with the oil. You can have both free and emulsified water in the same sump.

Free Water

We all know water and oil do not mix well together. Water is usually heavier than oil and will sometimes settle out in the bottom of the sump. This is what we refer to as free water. Free water is usually in high concentration because of a shaft seal leak or some other source of outside water ingression. Free water is also hard to identify in small concentrations unless we have a window or some way to see the oil inside the sump.

If caught early enough, free water is the easiest form to remove from a sump or reservoir. Installing a bottom sediment and water bowl or column sight glass on the drain port is a good way to keep a constant eye on water contamination. Free water buildup can cause serious problems, with oil levels eventually filling up and either overflowing or causing the gears to now operate with water and oil causing emulsification. If water is allowed to mix around in the oil, it can cause foam and become suspended within the oil, emulsifying and causing serious viscosity changes which then results in boundary conditions and eventual machine failure.

Emulsified Water

Water/oil emulsification occurs when free water and hot oil are agitated together. The oil and water become mixed, leading to increased viscosity, loss of film strength, additive washout and lubricant failure. Viscosity is the most important physical characteristic of an oil. When free water is allowed to become emulsified, the viscosity will go up and machines will start working harder, become hotter and machine parts will fail.

Emulsified water is almost impossible to fight with filtration. It is important to catch the problem during the free state to prevent emulsification. Failure due to water contamination may be catastrophic, but it may not be immediate. Many failures blamed on lubrication are truly caused by excess water contamination.

Some of the effects of water on gearboxes:

- Shorter component life due to rust and corrosion (gears and bearings).
- Water etching caused by the generation of hydrogen sulfide and sulfuric acid from water.
- Erosion caused by free water flashing onto hot metal surfaces and causing pitting.
- Hydrogen embrittlement happens when water invades microscopic cracks in the metal surfaces. Under extreme pressure, water decomposes into its components and releases hydrogen. This explosion forces the crack to become wider and deeper, leading to spalling.
- Film strength loss — the pitch line of a gear tooth is protected because oil viscosity increases as pressure increases due to the oil's pressure/viscosity coefficient. Water does not possess this property. Its viscosity remains constant (or drops slightly) as pressure increases. As a result, water contamination increases the likelihood of contact fatigue (spalling failure).

Some of the effects of water on gearbox oil:

- Water accelerates oxidation of the oil.
- Water depletes additives like oxidation inhibitors and demulsifiers.
- Water causes ZDDP anti-wear additives to destabilize over 180°F.
- Competes with polar additives for metal surfaces.

Water can lead to soot agglomeration, wax curd and even sludge by mopping polar impurities. Chemically, it can cause additive depletion and oxidation of the lubricant while also forming acid and rust. Physically, it can alter the viscosity of the lubricant. Now that we know all about how water affects gearboxes and the damage it can cause, let's talk about how to solve the problem and keep it from happening again.

The most common cause of water ingression or contamination is through open ports/hatches, shaft seals, flange fittings and cooling systems. Water is used in every industry and is therefore the leading cause of machine failures. Water contamination is a silent killer. It can take a long time to cause noticeable damage, but when the signs do appear, it is usually too late.

However, all oils will have a traceable amount of water in them. It is important to test new oil coming in, so you have a baseline or starting point — something to use as a reference if a problem does arise.

Some of the ways to monitor water in oil are:

- The use of sight glasses (column sight glass & BS&W bowl) for a quick visual indication. Moisture sensors attached to the oil reservoir.
- Moisture sensors can be installed to measure the moisture in the headspace of the reservoir as well as moisture in the oil.
- Oil analysis is another way to monitor the amount of water in the oil. For the most accurate results, I recommend using an oil analysis lab.
- A convenient way to determine water concentration in the field is by using a calcium hydride test kit. Water reacts with solid calcium hydride to produce hydrogen gas, which is directly proportional to the amount of water present in the sample. The water content of the sample is measured by the increase in pressure in a sealed container. These test kits are reported to be accurate down to 50 ppm free or emulsified water. The calcium hydride test is a great starting point, letting you know immediately that a water problem exists.
- Another way to monitor for water contamination is by suspending a metal rod inside the reser-voir's headspace. Over time, if water is present, the metal rod starting to rust will let you know that water contamination is an issue.

Controlling water contamination can be accomplished in a variety of different ways:

- A simple desiccant breather mounted on the headspace. Desiccant breathers allow the air entering equipment to flow through the desiccant media, stripping out any moisture and trapping it in the desiccant media before entering equipment.
- On medium size reservoirs, you can attach

filters with water capturing capabilities. On large reservoirs, I would recommend using a vacuum dehydrator for removing and monitoring water.

- You can utilize heat to flash off any water in the oil. I personally avoid recommending such methods because I do not like taking the risk of adding unnecessary heat to a system.

The cheapest and most effective method of controlling water is simply stopping water from entering machines or making contact with machine surfaces. Invest in splash guards around equipment, making sure ports and hatches are sealed tight and training people on how to carefully spray down and clean equipment with high pressure. It is also helpful to inspect shaft seals for damage and replace damaged seals as needed. If equipment is outside, building rain covers or redirecting the drain water away from equipment can also help mitigate water contamination problems. It will be much cheaper and easier to protect equipment from water ingression than to remove water after it's inside the system.

Gearboxes are expensive but built to last — if maintained correctly. Controlling contamination is a full-time job. Not only are we fighting against something we cannot see most of the time, but we are also dealing with a problem that could fluctuate by the hour. Water is something we cannot ever completely get rid of, but it is something we can control. Start a "No Water Contact" initiative at your plant. Work on training people on the proper ways of spraying down machine parts without causing damage. Modify and safeguard equipment against water contact in any way you can. By taking the right steps and thinking through the problem carefully, we can help control water and reduce how much of it is entering our equipment. ***ML***

About the Author

David Dise is an to Associate Technical Consultant for Noria Corporation. He works closely with plant managers and reliability engineers to develop lubrication and reliability programs. His goal is to help plants become world class. David has been certified as a Level II Machine Lubricant Analyst and a Level I Machine Lubrication Technician by the International Council for Machinery Lubrication. Before joining Noria, he worked as a flowback operator at 1st Rate Energy Services, traveling to several different locations around the United States.