Removing Harmful Water Contamination from Oil

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Water contamination is often called the scourge of the machine. An ongoing battle ensues between lubrication technicians in the wet process industries like pulp and paper, in outdoor machinery applications like construction and mining, and where frequent machine wash downs occur such as food processing. Its effects are not limited to these industries, however. Water contamination rears its ugly head in almost every plant and industry.

Water affects both the oil and the machine. It promotes oxidation of the lubricant's base oil and washes out some additives which are attracted to water. Later, water will typically separate to the bottom of the sump. It hydrolyzes (chemically attacks) additives, which compromise their performance, and in some cases, produces highly corrosive by-products. A water-degraded lubricant cannot fully lubricate and protect the machine, which leads to excessive wear and failure. Water also attacks the machine directly. The following is a summary of common water-induced wear mechanisms:

Rust and Corrosion - Water directly attacks iron and steel surfaces to produce iron oxides. Water teams up with acid in the oil to increase the corrosive potential in the attack of ferrous and nonferrous metals. Rust and corrosion lead to rapid surface deterioration when abrasive particles are present. Rust particles are also abrasive. Abrasion also exposes fresh nascent base metal which is more easily corroded in the presence of water and acid.

Vaporous Cavitation - If the vapor pressure of water is reached in the low-pressure regions of a machine, such as the suction line of a pump, the pre-load region of a journal bearing, etc., the vapor bubbles expand. Should the vapor bubble be subsequently exposed to sudden high pressure, such as in a pump or the load zone of a journal bearing, the water vapor bubbles quickly contract (implode) and simultaneously condense back to the liquid phase. The water droplet impacts a small area of the machine's surface with great force in the form of a needle-like micro-jet, which causes localized surface fatigue and erosion. Water contamination also increases the oil's ability to entrain air, thus increasing gaseous cavitation.

Film Strength Loss - With elastohydrodynamic (EHD) contacts such as rolling element bearings and the pitch line of a gear tooth, the great strength of the lubricating film occurs because the oil's viscosity increases as pressure increases. 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) caused by surface-to-surface rolling contact. In these high-pressure zones, hydrogen-induced wear, a complex tribo-chemical reaction, also occurs, causing embrittlement and blistering.

Managing Water Contamination

The best way to manage water contamination is to keep water out of the oil in the first place. Water enters the sump or reservoir at those points where the machine interfaces with its environment. Following are tips for water exclusion:

- Manage new oil properly.
- Use desiccant breathers or other tank headspace protection.

- Use and maintain high quality shaft and wiper seals.
- Avoid shafts, fill ports and breathers when washing down machines. Avoid high-pressure sprays in the areas of seals if possible.
- Maintain steam and heating/cooling water system seals.

Despite even the best efforts to exclude water contamination, for many machines, some ingestion will likely occur. Following is a description of the most common water decontamination techniques. Table 1 provides a general rating of the ability of each technology to remove free (unstable suspension), emulsified (stable suspension) and dissolved (incorporated into the oil's molecular chemistry) water.

Separator Type	**Water Type Removed**		
	Free	**Emulsified**	**Dissolved**
Gravity	Yes	Some	No
Centrifuge	Yes	Some	No
Coalescing	Yes	Some	No
Absorbent Polymer	Yes	Yes	No
Vacuum Distillation	Yes	Yes	Yes
Headspace Dehumidification	Yes	Yes	Yes

Table 1. Water Removal Techniques

Gravity Separation - Because water generally has a higher specific gravity than hydraulic fluid (exceptions do exist), water tends to settle at the bottom of the reservoir, given sufficient resident time in a still environment. Increasing the fluid's temperature and employing a cone-shaped separating tank improve the effectiveness of gravity separation. High fluid viscosity, oxidation by-products and polar additives and impurities inhibit the effective separation of oil and water. Gravity separation alone does not remove tightly emulsified or dissolved water.

Centrifugal Separation - By spinning the fluid, the difference in specific gravity between the fluid and the water is magnified. Centrifugal separators remove free water faster than gravity separators. They also remove some emulsified water depending upon the relative strength of the emulsion vs. the centrifugal force of the separator. Centrifugal separators do not remove dissolved water. They are an excellent option for continuous decontamination of fluids with excellent demulsibility (water separating characteristics).

Coalescing Separation - Coalescing separators help small droplets of water combine to form large ones so they will drop out of the oil more easily. This is achieved because large droplets have less surface contact with the fluid than an equal volume of water dispersed as tiny droplets. Coalescing separators are more effective when the oil's viscosity is low, making them an ideal solution for removing water from fuel. For instance, coalescing separators do not remove dissolved water.

Absorbent Polymer Separation - Free and emulsified water is collected by super absorbent polymers impregnated in the media of certain filters. These look like conventional spin-on or cartridge type filters. The water causes the polymer to swell and remain trapped in the filter's media. Superabsorbent filters can remove only a limited volume of water before causing the filter to go into pressure-drop induced bypass. They are not well-suited for removing large volumes of water, but they are a convenient way to maintain dry conditions in systems that don't normally ingest a lot of water. These filters do not remove dissolved water.

Vacuum Distillation - This technique effectively removes free, emulsified and dissolved water. Vacuum distillation units operate by distributing oil over a large surface area and effectively boiling the water by increasing the temperature to approximately 150°F to 160°F (66°C to 71°C) and creating a vacuum of about 28 inches Hg. At 25 inches Hg, water boils at approximately 133°F (56°C). These devices effectively remove water at a temperature that does not cause much damage to the base oil or additives. Vacuum distillation will also remove other high vapor pressure contaminants like refrigerants, solvents and fuels. There is some risk of additive vaporization with this technique. See reference at end of article for more information on vacuum distillation.

Headspace Dehumidification - These units operate by removing air from the headspace of a sump, dehumidifying it then sending an equal volume (or a boosted volume, in some cases) of air back to the reservoir to maintain pressure. If the oil contains water contamination, it will migrate to the dry air, which is eventually sent to the dehumidifier for removal. The great advantage of this technique is that it never contacts the oil. This technique will remove free, emulsified and dissolved water.

How much water should you tolerate? A good rule of thumb is to control water to the lowest levels you can reasonably achieve, preferably well below the oil's saturation point at operating temperature. Once you get water under control, don't leave it to chance. Monitor stored and in-service oils frequently to ensure water is kept in-check. Numerous easy-to-use field techniques exist for routine water monitoring (see "The Lubrication Field Test and Inspection Guide" by Jim Fitch and Drew Troyer). Also, your oil analysis laboratory can provide precision water contamination measurement using Karl Fischer titration (ASTM D6304).

Conclusion

Controlling water is like controlling cholesterol: it is not something you can attempt occasionally and expect good results. It requires a change in lifestyle, which may require some major procedural revisions and some minor machine modifications. However, given the damage water can cause, the change is well worth the effort.

References

Fitch, J. (2001, March-April). Vacuum Distillation for the Removal of Water and Other Volatile Contaminants. Practicing Oil Analysis magazine.

About Hy-Pro Filtration

Hy-Pro is a total solutions provider for hydraulic and lubrication fluid contamination challenges. Hy-Pro Vac-U-Dry vacuum dehydrators rapidly remove free and dissolved water to < 20 ppm while controlling particulate contamination to achieve target ISO Fluid Cleanliness Codes. Vac-U-Dry is suitable for a wide range of fluids including hydraulic oils and high viscosity lubricating oils plus bio-diesel. Intelligent equipment allows for 24/7 unattended operation with automatic condensate water drain. Extend the useful life of fluids by conditioning the oil while in use or use Vac-U-Dry to reclaim and recondition used oils to servo quality.

Hy-Pro coalesce water removal skids are ideal for turbine oils and diesel fuels, which have a low saturation point. High single pass water and particulate removal efficiency makes the Hy-Pro coalesce skid ideal for maintaining low water levels in turbine lube reservoirs under normal operation and rapidly removing free water from a continuous heat exchanger leak. Ideal for meeting new cleanliness requirements for diesel fuels where high pressure injectors require clean and dry fuels for reliable operation. Hydraulic and lubricating fluids are the lifeblood of any system, and when properly managed, asset reliability and cost of ownership can be optimized.

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