LUBRICANTS

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Webinar Executive Summary

Contaminants in August 6, 2021
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Lubricants can contain various types of contaminants. Those contaminants can include solids, liquids, gases, and other contaminants. This webinar will look at the various types of contaminants, their sources, and ways to control contamination.

Solid contaminants include dirt, metal particles, soft insolubles, and soot. Dirt can be of environmental origin, comprising dust, sand, etc. It is characterized by the presence of silicon, aluminum, calcium, sodium, potassium, magnesium, and iron. Dirt can also be of industrial origin, including concrete dust, clinker, coal or coke fines, and cellulose fiber.

Metal particles are typically produced in wear processes. Each type of wear produced particles with characteristic shape or appearance. Wear metals include iron, aluminum, chromium, nickel, molybdenum, copper, tin, lead, manganese, zinc, and silver.

Soft insoluble materials include sludge, varnish, lacquer, etc. This type of material is primarily produced by oxidation processes. Additive degradation and oil oxidation can result in significant formation and deposition of deposits on surfaces and in the oil. Over time, the materials become insoluble. Varnish can decrease bearing clearances, leading to premature failures. It also causes valve sticking in spool valves.

Soot is typically formed during combustion in diesel engines. Individual soot particles are very small, averaging 0.078 microns. When soot particles agglomerate in oil, the size becomes large enough the cause problems. Soot is very hard, and soot agglomerations can cause severe engine wear.

Liquid contaminants include water, other lubricants, fuel, coolant, and wash-down chemicals

Water is the single most common contaminants. It is pervasive, being found virtually everywhere, including new lubricants. A small amount of dissolved water is common, and does not affect lubricant performance in most cases. Water in in-service lubricants can range from single-digit parts per million (ppm) to 30% or more in grossly contaminated oil. Water can have multiple negative effects on lubricant performance.

Most new oils contain trace amounts of dissolved water, typically less than 100 ppm. Transformer oils and high dielectric strength hydraulic fluids are specially treated to reduce water to less than 30 ppm.

Water can enter a lubricated system in several ways: the atmosphere (humidity, precipitation), improper or ineffective vent or breather, improper lubricant storage, cooling system leaks, condensation, and equipment wash-down.

Water can exist in lubricants in three forms: dissolved, emulsified, and free water. New oil should <u>never</u> contain emulsified or free water. A small amount of water can dissolve in oil, causing no change in appearance, and no decrease in performance. The amount of dissolved water in in-service lubricants can vary, depending on the type of lubricant, its age, and the temperature. The lubricant typically becomes hazy when the concentration becomes saturated with water. That point varies based on the type of oil.

Emulsified water forms at a concentration above the saturation point. It can appear as haze, which if mixed by churning results in a stable emulsion. Additives such as the detergents in engine oils can ruin the water separation properties of industrial oils. Free water forms when droplets of water merge to form a layer of free water.

Free and emulsified water can have multiple negative effects on lubricants: lubricating film degradation, viscosity increase, increased rate of oxidation, hydrolysis, additive degradation, additive loss, hydrogen embrittlement, and reduced filter performance.

Cross-contamination with a different lubricant can be the source of some unique problems. Even a quart of engine oil can ruin the water separation properties of thousands of gallons of turbine oil. Addition of a hydraulic fluid of a different viscosity grade can cause a reduction in system performance. Mixing products from different manufacturers can lead to incompatibility issues.

Fuel dilution is a serious issue for many vehicle fleets. It can reach 20% or more in vehicles with high idle times. The major result of fuel dilution is reduced oil viscosity, which can be reduced by nearly 50%. Low oil viscosity can be the cause of excessive wear and premature engine failure. Other fuel dilution effects include reduced additive concentration, increased oil volume, low oil pressure, lower oil flow rate, increased oil volatility, and loss of oil film on the cylinder walls. Causes of fuel dilution include stop-and-go driving (long idle times), cold weather start-ups, fuel injector issues, and poor combustion.

The effects of coolant contamination include oil thickening, formation of organic acids that cause corrosion, additive degradation, oil filter plugging, formation of abrasive oil balls. Evidence of coolant contamination includes the presence of sodium, potassium, boron, and silicon in the oil.

Wash-down chemicals are used widely in the food and beverage industry. Lubricants in those industries can be contaminated with aggressive wash-down and disinfection chemicals. Frequent relubrication of food and beverage processing equipment may be necessary.

Gases that contaminate lubricants include air, natural gas, and refrigerant gases. New oil typically contains up to 5% dissolved air, which does not affect performance. Air can take the form of dissolved air, entrained air, free air, and foam. Air in oil can lead to accelerated depletion of antioxidant additives, and oil oxidation. Other effects include microdieseling, viscosity increase, foaming, rust, corrosion, sludge and varnish formation, and cavitation.

Natural gas can be absorbed into the lubricant used to lubricate natural gas compressors. Mineral oil can absorb more gas and suffer significant dilution. Higher molecular weight hydrocarbons have a greater dilution effect than methane. Polyalkylene glycol (PAG) fluids are diluted to a lesser extent than mineral oils or polyalphaolefin (PAO) fluids.

The lubricants used in refrigeration compressors must be compatible and to a certain degree miscible with the refrigerant. Different lubricant types are recommended based on the type of refrigerant gas.

Other types of contamination in lubricants are heat and radiation. Heat is one of the worst enemies of lubricants. The higher the temperature, the higher the rate of oxidation. For every 10°C (18°F) rise in oil temperature above 60°C (140°F), the rate of oxidation doubles, cutting the oil life in half. An increase in temperature also causes the oil viscosity to decrease. The proper viscosity for lubrication of the application may not be maintained if the temperature is too high. Radiation is typically only a consideration in nuclear power applications. Lubricants used in nuclear power plants must have proven resistance in the case of radiation exposure.

Contamination can come from various sources. Solid contaminants can be introduced from new oil, an unsealed tank or drum, oil transfer containers, transfer lines/hoses, funnels, vents and breathers, poor seals, machine wear, and service or manufacturing debris. Water can come from the environment (headspace condensation, rain and snow, and the hygroscopic tendency of oil), hose sprays (high-pressure wash-down or fire suppression), a steam heating system, process water, heat exchanger leaks, and combustion condensate in engines. Contamination with a different lubricant is often the result of an error or the need to add oil to a system when the in-service product is not available. Coolant leaks are also a common source of liquid contamination. Contamination with air can be caused by a leak on the suction side of a pump that draws air into the lubrication system. Human error is often the cause of contamination in lubricants.

Contamination control involves excluding contamination as well as removing contaminants. It is estimated that the cost of keeping dirt out of oil is about 10% that of removing dirt from oil. Ways to exclude contaminants from a lubricated system include filtering new oil, using proper breathers, especially desiccant filter breathers, proper seal maintenance, cleaning out service or manufacturing debris, and changing filters before the differential pressure gets too high and they start to by-pass. Strategies for removing contaminants include using proper system filters, adding off-line filters for systems that are splash or bath lubricated. Adding filter carts to provide kidney-loop filtration on machine sumps, proper sump/reservoir design and management to remove contaminants, and timely servicing of system filters. The cost of using high-performance filters over a machine's life will generally be much less expensive than using cheap, low-efficiency filters.