Contaminants in Lubricants

The webinar will begin in less than 10 minutes.

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- NLGI Certified
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- Active in STLE, NLGI, and ASTM

Agenda

- Types of Contaminants
    - Solids
    - Liquids
    - Gases
    - Other Contaminants

- Sources of Contamination

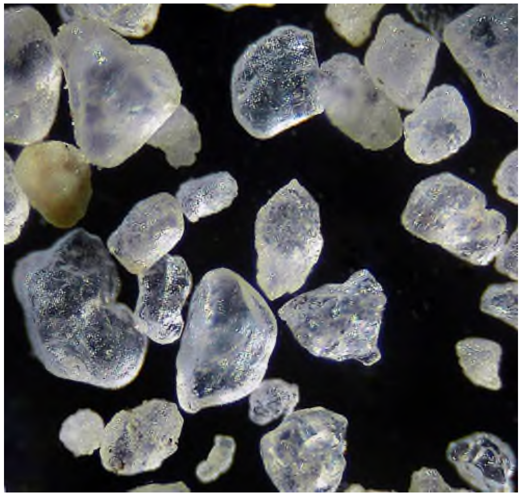
- Controlling Contamination

Solid Contaminants

- Dirt
  - Environmental
  - Industrial
- Metal Particles
- Soft Insolubles
- Soot

Solids – Dirt

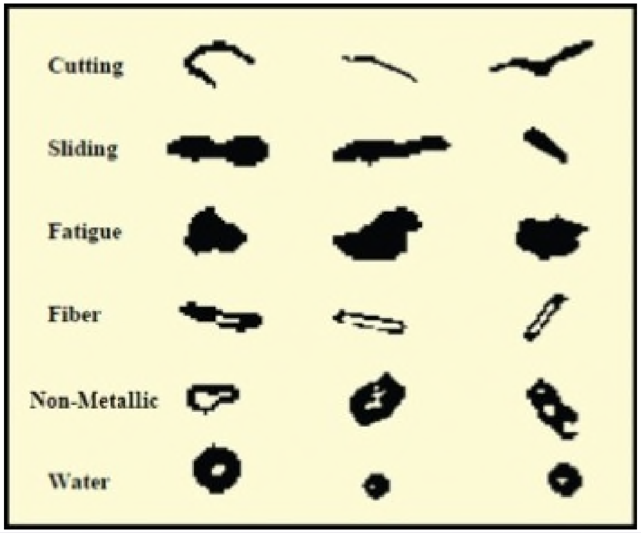
- Environmental
  - Dirt from the environment includes dust, sand, etc. Typical elements include silicon, aluminum, calcium, sodium, potassium, magnesium, and iron.

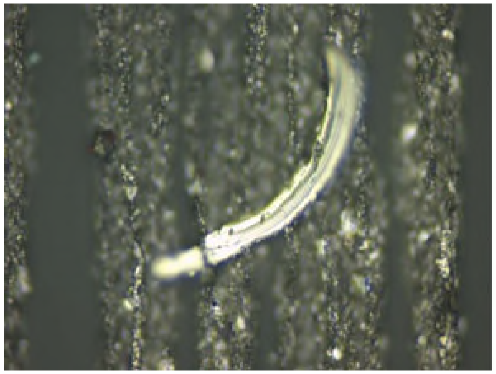


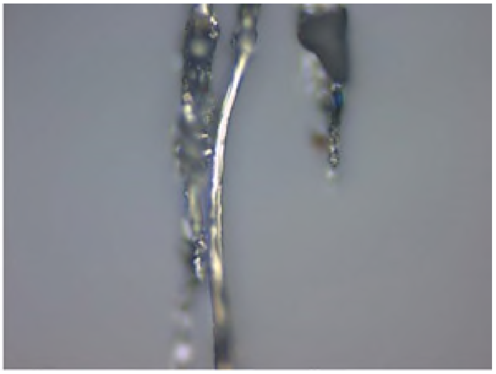
- Industrial
  - Industrial solid contaminants include anything that is produced at an industrial site. Examples include concrete dust, clinker, coal or coke fines, and cellulose fiber.

Solids – Metal Particles

- Metal particles are typically produced in wear processes. Wear modes include adhesive (rubbing/sliding), abrasive (cutting), fatigue, erosive, corrosive, cavitation, polishing, fretting, and electrical discharge. Each produces a characteristic particle shape. Elements include iron, aluminum, chromium, nickel, molybdenum, copper, tin, lead, manganese, zinc, and silver.

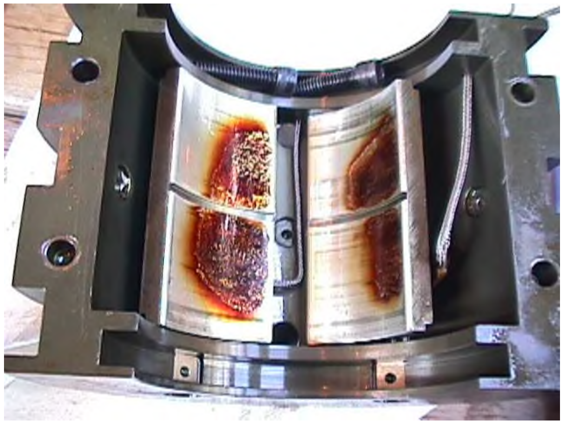






Solids – Soft Insolubles

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



Solids – Soot

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

Liquid Contaminants

- Water
- Other Lubricant
- Fuel
- Coolant (Glycol)
- Wash-down Chemicals

Liquids – Water

- Water is pervasive. It is found almost everywhere, including in new lubricants. A small amount of dissolved water in a new lubricant is very common, and does not affect the performance of the product.

- Water in in-service lubricants can range in concentration from low ppms in well-maintained oil (e.g. transformer oil) to 30% or more in a grossly contaminated system.

- Water can have multiple negative effects on the performance of a lubricant.

How Much Water is Typically in Oil?

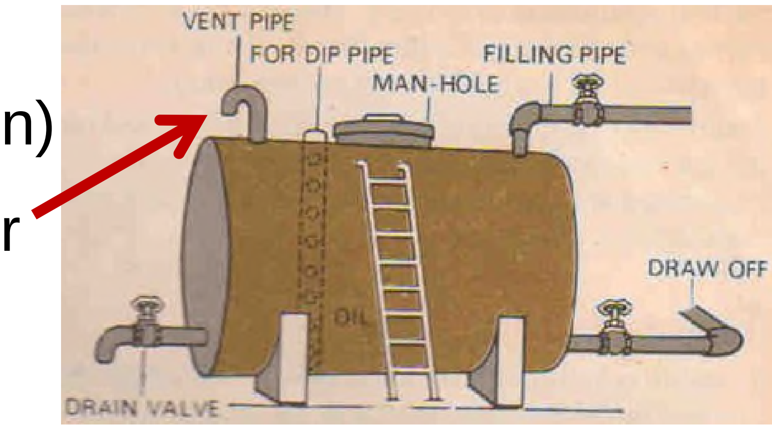
- Most new lubricating oils contain trace amounts of dissolved water
  - Typically less than 100 ppm (0.01 %)

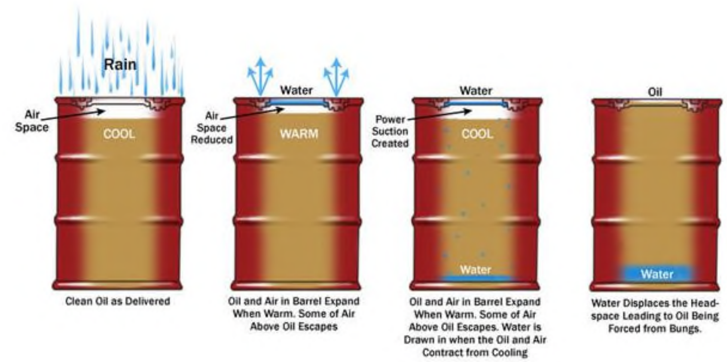
- Transformer oils and high dielectric strength hydraulic oils are specially treated to reduce water concentration (<30 ppm, 0.003 %)

Where Does the Water Come From?

Water can enter a mechanical system in several ways:

- The atmosphere (humidity, precipitation)
- Improper or ineffective vent or breather
- Improper lubricant storage
- Cooling system leaks
- Condensation
- Equipment wash-down





Courtesy: Machinery Lubrication

The Three Forms of Water in Lubricants

- Water in both new and in-service oils is found in three forms:
  - Dissolved water
  - Emulsified water
  - Free water

- New oil should <u>never</u> contain emulsified or free water!

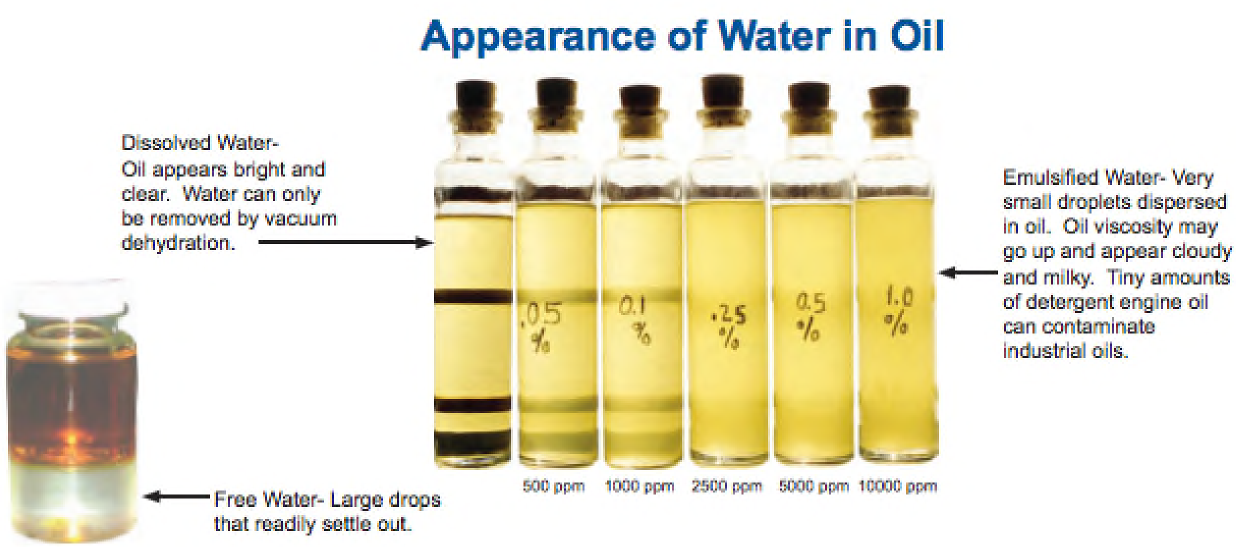
The Three Forms of Water in Lubricants

- Dissolved water – a small amount of water dissolves in oil, causing no change in appearance, and no decrease in performance.
- The amount of dissolved water in in-service lubricants varies depending on the type of lubricant, its age, and the temperature. The lubricant typically begins to become hazy at the following water concentrations:

• Turbine oils, bearing and circulating oils	~100 to 150 ppm
• Hydraulic oils	~150 to 200 ppm
• Industrial gear oils	~200 ppm
• Engine oils	~400 ppm
• Synthetic fluids	
• PAO	~300 ppm
• Diester	~2000 ppm
• PAG	~3000 ppm

The Three Forms of Water in Lubricants

- Emulsified water – When the saturation point of the oil is exceeded, water molecules begin to coalesce in the oil to form tiny droplets – haze. As the oil is churned in service, the water forms a stable emulsion.
  - Additives such as detergents found in engine oils can ruin the water separation properties of industrial oils.
- Free water – Water droplets in the oil merge to form a layer of free water.



Effects of Water on Lubricant Performance

Free and emulsified water contamination in oil can have multiple negative effects on the oil:

- Lubricating film degradation – Loss of hydrodynamic film in journal bearings, flash vaporization leading to erosive wear in rolling element bearings.
- Viscosity increase – The presence of water in oil can cause the viscosity to increase, potentially reducing oil flow or increasing the pressure required to pump the oil. Viscosity increase due to water can mask other issues, such as fuel dilution.
- Oxidation – the rate of oxidation of the oil is increased in the presence of water. The presence of catalytic metals (copper, tin, lead) also contribute to an increase in oxidation rate.

Effects of Water on Lubricant Performance

- Hydrolysis – Certain synthetic fluids (diesters, phosphate esters) can react with water, breaking down into organic acids and alcohols. Hydrolytic degradation destroys the base fluid in the lubricant, and the formation of the organic acids can cause corrosion on metal surfaces.
- Additive degradation – Certain antiwear, extreme pressure, and oxidation inhibitor additives can also undergo hydrolysis, causing their effect to be diminished or removed completely from the lubricant, and acidic by-products to be formed.
- Additive loss – Other additives, such as detergents, dispersants, rust inhibitors, and demulsifiers, can be dissolved in the water phase, effectively removing them from the lubricant, along with their positive effects on lubricant performance.

Effects of Water on Lubricant Performance

- Hydrogen embrittlement – Water can be decomposed into hydrogen and oxygen; the hydrogen ions then cause metallurgical changes in bearing surfaces that lead to subsurface cracking and eventually pitting and spalling.

- Filter performance – Water in a lubricant can quickly degrade the performance of filters. In particular, paper (cellulose) filters that perform very well with dry oil can disintegrate when exposed to water and release fibrous material into the oil.

Liquids – Other Lubricant

- Cross-contamination with a different lubricant can be the cause of some unique problems. Contamination of thousands of gallons of turbine oil by as little as one quart of engine oil can ruin the air release, foam resistance, and water separation properties of the turbine oil.
- To a less dramatic extent, the addition of a different viscosity grade of hydraulic oil into a hydraulic system can cause degradation of the system performance.
- Mixing of competitive products in an industrial system can have serious effects. Additive packages, and even base oils, can be incompatible.

Liquids – Fuel

- Fuel dilution is a serious issue for many vehicle fleets. Fuel dilution can reach greater than 20% in vehicles with high idle times.

- Reduced Oil Viscosity – Fuel dilution causes the viscosity of engine oil to decrease sharply.

In one study, the effect of fuel dilution on oil viscosity was determined:

- At 5% fuel dilution, the viscosity was reduced 20%
- At 10% fuel dilution, the viscosity was reduced 35%
- At 15% fuel dilution, the viscosity was reduced 48%

The dilution effect is greater with higher viscosity oils.

Liquids – Fuel

- Additive dilution effects
  - Reduced detergency
  - Reduced wear protection
  - Reduced oxidation inhibition
  - Reduced resistance to acid formation - corrosion
- Increased oil volume – If the added fuel does not evaporate, the volume in the crankcase can increase, causing additive dilution, as discussed above.
- The oil coating can be washed off the cylinder or liner walls, allowing the piston rings to come into direct contact.
- Low oil pressure and lower oil flow rate. This can lead to a variety of operational issues.
- Increased oil volatility – In extreme cases, this can lead to an explosion in the oil pan.

Liquids – Fuel

Causes of fuel dilution

- Stop-and-go driving (long idle times)
  - Incomplete fuel combustion
- Cold weather start-up
  - Lower than optimum combustion temperature
- Fuel injector issues
  - Fuel not atomized adequately
- Poor combustion
  - Fuel not burned completely

Liquids – Coolant (Glycol)

Effects of Coolant Contamination

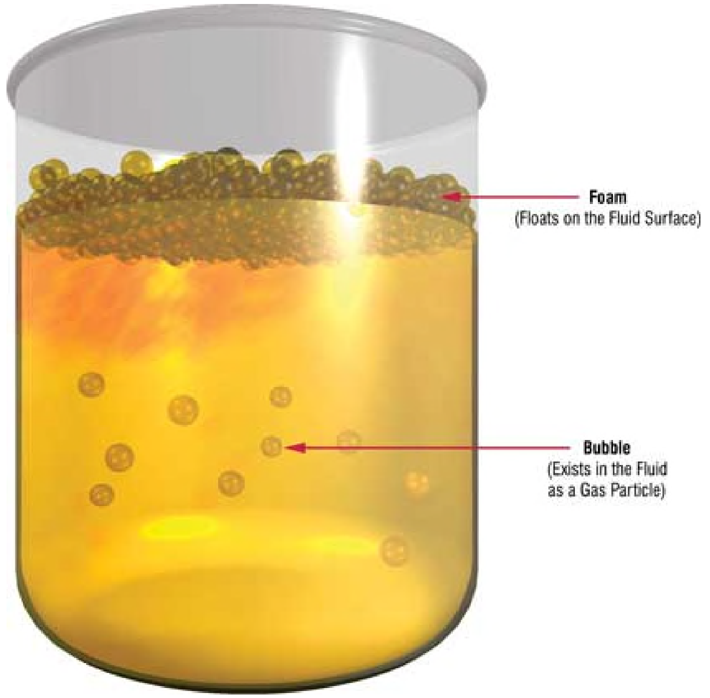
- Oil thickening – reduced oil flow
- Formation of organic acids – increased corrosion, especially of copper based parts
- Additive degradation – reduction of protection by the oil
- Oil filter plugging and eventual by-pass
- Formation of abrasive oil balls – erosive wear on engine surfaces
- Elemental evidence of coolant contamination includes sodium, potassium, boron, and silicon

Liquids – Wash-down Chemicals

In the food and beverage industry, equipment and facilities are washed down on a regular schedule, often with aggressive wash-down chemicals. Those chemicals can degrade additives and wash grease out of equipment. Frequent relubrication of food and beverage processing equipment may be necessary.

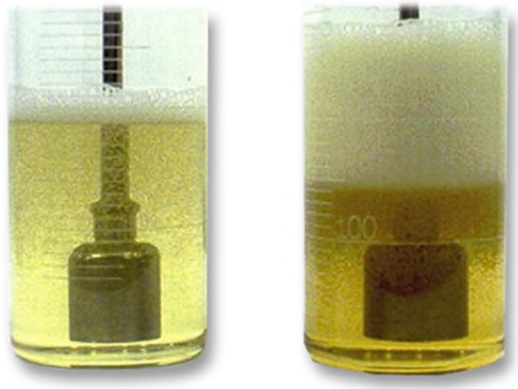
Gas Contamination

- Air
- Natural Gas
- Refrigerant Gases



Gases - Air

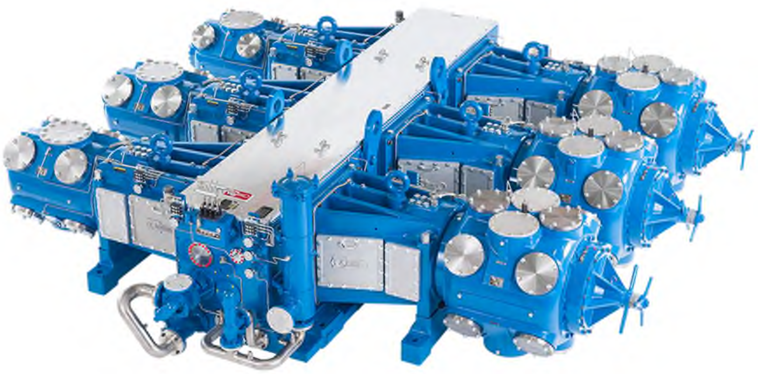
- New oil typically contains up to 5% dissolved air
- Forms of air in oil
  - Dissolved Air
  - Entrained Air
  - Free Air
  - Foam



- Air in oil can result in accelerated depletion of antioxidant additives and possible oil oxidation. Other effects include microdieseling, viscosity increase, foaming, rust, corrosion, sludge and varnish formation, and cavitation.

Gases – Natural Gas

- The lubricants used in natural gas compressors can absorb a significant portion of the gas.
- Mineral oils can absorb more gas, and suffer significant dilution. Higher molecular weight hydrocarbons have a greater dilution effect than does methane.
- Polyalkylene glycol (PAG) based fluids have greater resistance to gas dilution.



Gases – Refrigerant Gases

- 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:

Refrigerant		Recommended Lubricant
CFC	R-12	Min Oil, POE, AB
HCFC	R-22	Min Oil, POE, AB
HFC	R-134a	POE
Ammonia	R-717	Min Oil, AB
Propane	R-290	Min Oil, AB
CO_2	R-744	AB

Other Contaminants

- Two more types of contaminants are found in lubricants, but are often overlooked, include:
  - Heat
  - Radiation

Heat

Heat is one of the worst enemies of lubricants. The higher the oil 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 oxidation life of the product in half.

An increase in temperature causes the viscosity of oil to decrease. The proper viscosity for the lubrication of the application may not be maintained at too high a temperature.

Radiation

Only a consideration in nuclear power applications.

Lubricants used in nuclear power plants must have proven resistance in the case of radiation exposure.

Sources of Contamination

- Solids
  - New Oil
  - Unsealed tank or drum
  - Oil transfer containers
  - Funnels
  - Ventilation and breathers
  - Seals
  - Wear
  - Service and manufacturing debris

Sources of Contamination

Water

- Environmental
  - Headspace condensation
  - Rain and snow
  - Hygroscopic tendency
- Hose Sprays
  - High-pressure wash
  - Fire suppression
- Steam system
- Process water
- Heat exchangers
- Combustion condensate

Sources of Contamination

- Transfer lines
- Transfer containers
- Human error

Controlling Contamination

Exclusion – Keep contaminants from getting in

- New oil
- Ventilation and breathers
- Seals
- Wear generation
- Service and manufacturing debris
- Filter dumping

The cost of keeping dirt out of oil is probably only about 10 percent of what it will cost to remove it from the oil.

Controlling Contamination

Removal – Get contaminants out quickly

- Proper filters for circulating systems
- Off-line filters for some splash/bath-lubricated machines
- Filter carts for other machines
- Proper sump and reservoir design and management
- Timely filter servicing

The cost of using high-performance filters over a machine’s life will generally be much less expensive than using cheap, low-efficiency filters.

Questions

- Please post your questions using the Q&A function.

How to Contact Us

- Lubes Answer Line
- 800-248-4684
  - 8:00 AM - 12:00 PM, 1:00 PM – 5:00 PM CT
  - Monday through Friday
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