Like Water for Oil: Secrets of Fluids Unveiled

The next time you hear that engine running, think of all the secrets held within the fluids it contains.

By Preston Ingalls and Michael D. Holloway

Two things are always with us at all times—when we shop at the mall, work out at the gym, or just walk down the street, we always have our cell phone and a bottle of water in hand. At first glance, these deceptively plain bottles are just that—uninteresting. But those innocuous bottles of water shield considerable secrets, unknown to the average person. For instance:

• Bottled water is not monitored or controlled compared to tap water (except well water), which is regulated by the EPA.

• We drink more bottled water than milk and beer combined. In fact, we consume 12.8 billion gallons annually. That is a whopping 39 gallons per person in the U.S. alone.

• We spend about $1.22 per gallon on bottle water, which is about 300 times more than the cost to produce one gallon of tap water.

• Americans are the largest consumers of bottled water in the world, followed by China. Americans spend nearly $12 billion on bottled water each year—more than 10 percent of the global total.

• More than 25 percent of bottled water is simply tap water that a company has filtered and packaged in a bottle. That's right; it does not come from a sparkling spring in the south of France. Surprised?

• It takes more water to create the bottle of water than the water itself—1.40 liters to produce 1 liter of water.

• According to *National Geographic* magazine, only one in six bottles are recycled, with Americans emptying 2.5 million plastic water bottles an hour with each bottle taking 500 million years to decompose.

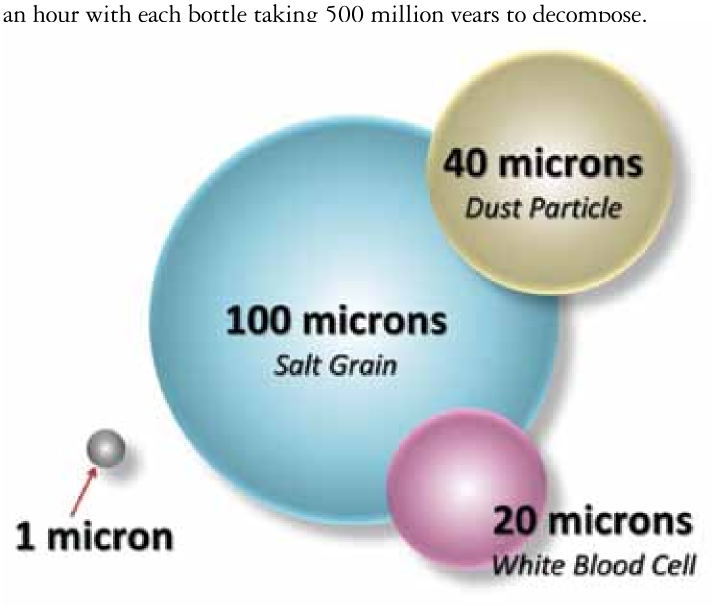

Figure 1:
Although contamination particles are small and minuscule, they pose considerable risks in closed fluid systems.
Images courtesy of TBR Strategies.

• Two-thirds of people surveyed could not tell the difference between tap and bottled water taste.

• When it comes down to it, any water with a pH level of less than 7.0 is considered acidic, or harmful to the body. However, some of the most popular brands have a pH level of less than 5.5—meaning it can dissolve tooth enamel, which is the hardest substance in the body. These include Perrier, Function, Dasani and Penta.

• Many plastic water bottles contain chemicals called phthalates, which can leach into bottled water and disrupt testosterone and other hormones.

• There are no requirements for bottled water to be tested for parasites or disinfectants. Bottled water companies are also not required to notify their customers if elevated levels of contaminants are found as they are not regulated by the EPA.

• The production of plastic water bottles in the U.S. alone creates 2.5 million tons of carbon dioxide, a key greenhouse gas responsible for global warming.

I share this because little do we know about that simple bottle of water unless we investigate. Nowhere on that bottle would these facts appear. It is the same logic as to why we go into the doctor's office a week or so ahead of our annual physical exam and have our blood drawn and leave a urine sample. Nowhere on our body is it posted what the results are of the conditions of that blood or urine. Those samples make up essential elements of the annual physical that will be reported later by the doctor. In addition to the visual exam of the head eyes, chest, abdomen, musculoskeletal system, prostrate, blood pressure, heart rate, reflexes, etc., the results of the lab test are examined for at risk elements.

When we think of both water and oil, we think of substances that are vastly different in makeup. However, water and oil have more in common than you might know.

The Lifeblood of Equipment

Like our body and the bottled water examples, our equipment is subject to contamination from impurities. We attempt to filter them out, but filters get clogged, components degrade and shed particles, fluid leakages occur, soot is emitted and all of these cause issues in closed fluid systems.

As **Figure** 1 shows, contamination particles are small and minuscule. However, they pose considerable risks in closed fluid systems. The human eye is only effective down to 40 microns, which is about the size of a dust particle or a speck of ginger; most fluid system (hydraulic, fuel, oil) damage is in the 2- to 20-micron range, which is not visible to the human eye. Therefore, pulling a 'blood sample' (oil analysis) of the engine makes perfect sense to analyze the characteristics.

The bottle of secrets.

Lubrication is the lifeblood of mechanical equipment. Just as our blood can become anemic or experience an imbalance of white or red blood cells or platelets that signal biological issues, the equipment's 'blood' can show signs of wear and contamination. Of course, where hematology is the science of blood, tribology is the science of lubrication, wear and friction control.

Consequently, oil analysis can provide valuable information in engines. Just as the doctor is looking for certain characteristics in the blood sample, we need to understand what we are examining. Early detection leads to early correction. Let's examine some of these technical features.

Oil Analysis Basics

Spectrochemical Analysis for Additives

The spectrochemical analysis measures different metals in parts per million (ppm), which represent lubricant additives, as well as system contaminants and equipment wear:

- Anitmony (Sb): Antiwear and Extreme Pressure, Antioxidant, Corrosion Inhibitor
- Barium (Ba): Rust inhibitor, Water separability
- Boron (B): Extreme Pressure Additive, Detergency Calcium (Ca): Detergency, Alkalinity Reserve (contributes to base number)
- Magnesium (Mg): Detergency, Alkalinity Reserve (contributes to base number)
- Molybdenum (Mo): Extreme Pressure Additive, Lubricity Additive
- Phosphorus (P): Antiwear when present with Zinc, Extreme Pressure Additive, Friction modifier Potassium (K): Extreme Pressure Additive in some gear lubricants
- Sodium (Na): Corrosion Inhibitor.
- Silicon (Si): Anti-Foam Additive
- Zinc (Zn): Antiwear when present with Phosphorus, Antioxidant, and Anticorrosive.

Viscosity

Viscosity is considered the most important property of a lubricant. Improper viscosity can affect a lubricants performance. Too low of a viscosity will not create sufficient surface film to keep moving parts separated and prevent rubbing on opposing metal surfaces. Too high of a viscosity will create excessive heat and reduced fluid flow within circulating systems.

A change in viscosity will indicate a change in the fluid performance integrity. A drop in viscosity generally indicates contamination with a lighter product, addition of an incorrect viscosity grade, shearing down of a viscosity index improver found in multi-grade oils, and, in some cases, thermal cracking. An increase in viscosity can indicate oxidation and reduced service life due to age, addition of an incorrect viscosity grade, or excessive soot or insolubles content.

Base Number

Base number represents the level of alkalinity reserve available for neutralizing acids formed during the combustion process and may be introduced through recirculated exhaust gases. As the lubricant ages and the additive package depletes, the base number will decrease from its initial fresh oil value.

Acid Number

Acid number in a new lubricant represents a certain level of additive compounding. This can come from antirust, anti-wear or other additives. The acid number can drop a bit after a lubricant has been in service for a certain period, which indicates some initial additive depletion. After a time, the acid number will start to increase, which indicates the creation of acidic degradation products related to oxidation. The acid number is a means of monitoring fluid service life.

Oxidation Number

The oxidation number is a relative number that monitors increase in the overall oxidation of the lubricant by infrared spectroscopy. This test parameter generally compliments other tests for fluid service life, such as viscosity and acid number. Generally, this test is not used as a primary indicator when all other tests are within normal limits. Accurate oil information is required to get the most valid test results.

Nitration Number

The nitration number is a form of oxidation that relates to chemical reaction with nitrogen, forming nitrogenous compounds also. Nitration is a relative number that monitors increase in the overall fluid degradation due to reaction with nitrogen and oxygen by infrared spectroscopy. This test parameter generally compliments other tests for fluid service life, such as viscosity and acid number. Generally, this test is not used as a primary indicator when all other tests are within normal limits. Accurate oil information is required to get the most valid test results. Contributors to increased nitration can come from exhaust gas blow-by or reaction with natural gas products with the lubricant and heat. It is also an indicator of electrostatic discharge across filter surfaces in turbine oil.

Sulfation Number

The sulfation number is a form of oxidation that relates to chemical reaction with sulfur compounds also. Sulfation is a relative number that monitors increase in the overall fluid degradation due to reaction with sulfur compounds and oxygen by infrared spectroscopy. This test parameter generally compliments other tests for fluid service life, such as viscosity and base number. Generally, this test is not used as a primary indicator when all other tests are within normal limits. Accurate oil information is required to get the most valid test results. Increase in sulphation generally correlates to a decrease in base number.

Contamination

Spectrochemical Analysis for Contaminants

The spectrochemical analysis measures different metals in parts per million (ppm), which represent contaminants, as well as equipment wear and lubricant additives:

- Aluminum/Aluminum (Al): After-cooler Brazing Flux, Dirt if in combination with Silicon
- Magnesium (Mg): Seawater if present with sodium
- Potassium (K): Engine Coolant, After-cooler Brazing Flux
- Silicon (Si): Dirt (especially in combination with aluminium/ aluminum and/or sodium), Gasket/Sealant Material, Engine Coolant
- Sodium (Na): Engine Coolant, Seawater, by product from Natural gas (wet gas) transferring, Dirt in combination with silicon

Water

Water as a contaminant will generally lead to increased corrosion, depletion of proper lubricating film, decreased lubricant performance life and increased acid formation.

Coolant

Coolant contamination will degrade lubricant service life and performance, create sludge and block lubricant passageways.

Fuel Dilation

Fuel dilution will decrease a fluid's viscosity, therefore affecting its lubricity properties. Fuel dilution also promotes degradation of lubricant service life and additive properties.

Soot

Excessive soot increases viscosity, creates excessive wear, and will tie up active additives needed for lubricant performance.

Particle Count

"Clean Systems" require a minimum level of cleanliness in order to operate reliably. This is especially true for circulating systems with high pressure and close tolerance components. The ISO Cleanliness Rating is a convenient way to communicate the level of particulate contamination within a system based on the particle count for micron sizes greater than 4, 6 and 14.

Wear Metals and Wear Debris

Spectrochemical Analysis for Wear Metals

The spectrochemical analysis measures different metals in parts per million (ppm), which represent equipment wear, as well as system contaminants and lubricant additives.

Note: The listing below illustrates some major sources of wear metals, but does not indicate all possible secondary sources. Abnormal wear is commonly indicated by a combination of metals:

- Iron (Fe): Major component material in equipment manufacturing. Housing/Blocks, Cylinders, Pistons, Gears, Bushings, Bearing, Shafts, Valves, Rings, Rust
- Chromium (Cr): Cylinders Liners and Guides, Bushings, Bearing, Shafts, Valve, Rods, Rings, Hydraulic Cylinders
- Lead (Pb): Bearings/Bushings, Thrust Plates, Washers
- Copper (Cu): Bearings/Bushings, Thrust Plates, Washers, Oil Cooler, Pumps, Disc/Disc Lining
- Tin (Sn): Bearings/Bushings, Pumps, Motors, Compressor Piston, and Piston skirt overlay
- Aluminum/Aluminum (Al): Pistons, Bearings/Bushings, Thrust Washers, Rings, Housing/Blocks, Oil Cooler, Cylinders and Cylinders Guides, Engine After-cooler
- Nickel (Ni): Gears, Shafts, Rings, Valve Trains, Bearings/Bushings, Pumps
- Silver (Ag): Bearings/Bushings, Oil Cooler, Some Gears and Shafts, Disc/Disc Lining
- Titanium (Ti): Bearings/Bushings, Some Gears and Shafts, Turbine Blades, Valve Trains, Gear Trains, Some Shafts (additive in some HDMO's)
- Vanadium (V): Turbine Blades, Some Bearings and Bushings

PQI

PQI is a valuable trending tool for monitoring the relative level of ferrous wear material within a lubricant sample.

Filter Patch

Filter patch inspection provides a visual assessment of wear particle and other solid debris present in a sample after collection on a 0.8 micron to 5.0 micron filter membrane and examined by a microscope.

Analytical Ferrography

Analytical Ferrography provides detailed information on different wear particles present in a sample. This is generally an exception test that provides information on the type of metal makeup of the wear particles present and how they were formed.

Think of the Facts

So, the next time you pick up that bottle of water, think of all the facts held within those fluids. Similarly, the next time you hear that engine running, think of all the secrets held within the fluids it contains. **WA**

For more than 48 years, ***Preston Ingalls****, President and CEO of TBR Strategies (Raleigh, NC) has led maintenance and reliability improvement efforts across 30 countries for Toyota, Royal Dutch Shell, Exxon, Occidental Petroleum, Hess, Skanska, Bayer, Baxter Healthcare, Lockheed Martin, Unilever, Monsanto, Pillsbury, Corning and Texas Instruments. He consults extensively with heavy equipment fleets, heavy construction industry, and the oil and gas industry in the areas of equipment uptime and cost reduction. Preston is a contributing writer to seven trade publications, holds three degrees, has written more than 80 articles and published two e-books on lubrication. For more information, visit www.tbr-strategies.com.*

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