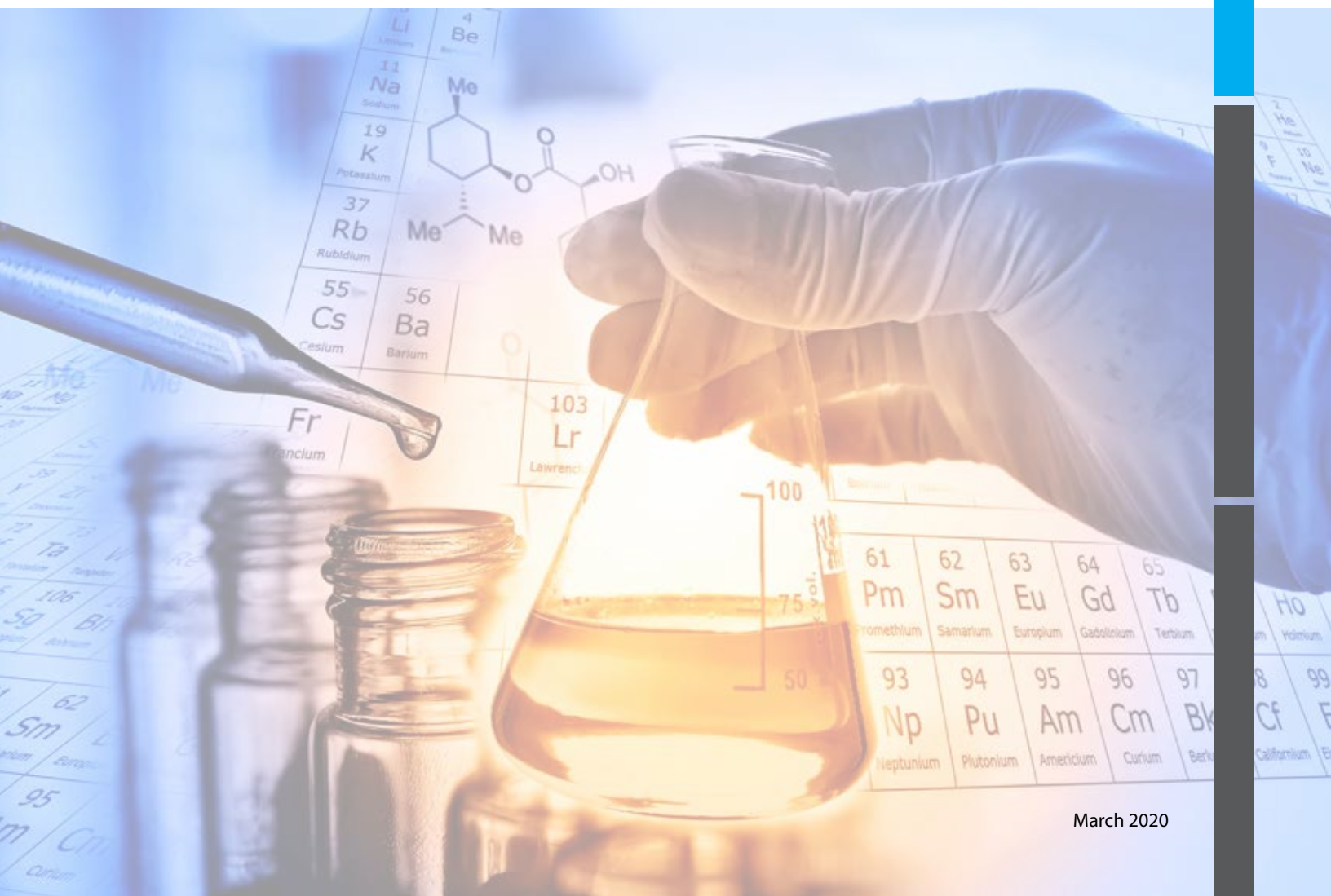
petroleum

technologies group L.L.C.

Additives, Metals, Contaminates

Basics of Oil



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Introduction

Wear metals analysis using Inductively Coupled Plasma Spectrometers (ICP-OES) has been an important component of predictive maintenance programs for many years. Used oil-based materials, such as engine oils, transmission oils, and many others, are regularly monitored for the presence of particles deposited from the components that they are designed to protect. These particles gradually build up in the oil due to normal wear of the component. For this reason, the analysis of used oils is often referred to as “wear metals analysis” or “fluids analysis”. This technique can be used to accurately identify and predict component failure, based on the composition of the metals and the speed at which they accumulate overtime. [i]

By analyzing the various metals in the fluids and applying trend analysis, expensive breakdowns can be prevented and service life increased. Fluid analysis can also be used to maximize the usable life of oils by monitoring the health of any additive packages by determining the depletion of particular elements. Among the most widely used additive types are those used for anti-wear. These additives typically contain high concentrations of calcium, phosphorus, and zinc, and are used to reduce premature wear. The additives in the oil bond to metal surfaces in the components and help reduce friction between the moving parts.

Additives are chemical agents added to oils, fuels, and coolants to impart specifics beneficial properties to the finished products. Additives create new fluid properties, enhance properties already present and reduce the rate at which undesirable changes take place in a fluid during service. The percentage of additives can range from as little as 1-2% in some general-purpose industrial lubricants to over 30% in cylinder oils used in engines burning heavy fuels. Some additives have a somewhat competitive nature and an overtreatment of one additive can have a negative effect on the performance of other additives in the lubricant formulation. Additives can be classified into one of three main types or functions: Surface protection, Fluid Protection, or performance improvement. Some additives have a multi-functional property to them.[ii]

I. Wear Metals Detected in Oil

a. Common Contaminate Metals

i. **COPPER (Cu):** Copper is almost always found in the form of an alloy, usually brass (copper and zinc) or bronze (copper and tin). These high copper alloys are referred to as 'Yellow Metals'. Some AW and EP additives can leach and/or corrode copper from these metals. Copper is also used in some cooler exchangers and can leach into the lubricant. A few, mostly gear lubricants, contain copper as an anti-wear additive.

ii. **IRON (Fe):** Iron is the most commonly use material of construction and the most commonly found wear metal in used lubricants. Elemental iron is usually found in the form of cast iron, carbon steel, and high alloy steels such as is used in shafts, cams, and valves. Most machinery cases are manufactured from cast iron. Most roller bearing rolling elements and races are manufactured from carbonized steel. Most gears are also manufactured from carbonized steel. Most machinery shafts, cams, and valves are manufactured from high alloy or stainless steels. These high alloy steels contain trace amounts of nickel, chromium, and sometimes, titanium.

iii. **CHROMIUM (Cr):** Chromium is most often used as an alloying metal in high alloy and stainless steels. Chromium is also used as a plating metal such as chrome plated rings. Trace amounts of chromium with higher amounts of iron usually indicate shaft wear.

iv. **ALUMINUM (Al):** Aluminum is often used as a primary material of construction for cases and engine blocks. Aluminum can also be an alloying metal as in aluminum bronze. Many sleeve bearings and bushings are overlaid with aluminum. Aluminum is also found in some sealing compounds

v. **LEAD (Pb):** Lead is also an alloying metal used in Babbitt sleeve bearing overlays. Most Babbitt metal is Tin based, however, in electric motors and engines, most Babbitt metal is lead based, IE, lead will be the major alloy component. Other sources of lead include leaching from solder joints, corrosion resistant paints used on the inside of cases (older equipment), and sealing compounds.

vi. **TIN (Sn):** Tin is a common alloying metal used in Babbitt sleeve bearing overlays. Most Babbitt alloys used in industry are tin based, IE, tin will be the major alloy component. Another source of tin can be leaching from solder joints.

i. **NICKEL (Ni):** Nickel is also an alloying metal in high alloy and stainless steels. Trace amounts of nickel with higher amounts of iron usually indicate shaft wear.
ii. **SILVER (Ag):** Silver is only used in some EMD drives as a bearing overlay.

b. Contaminate Metals

i. **SILICON (Si):** Silicon is the most common metal on earth. Sources of silicon as a contaminant include airborne dirt and dust, sand, grease, sealant, cooling water, coatings, and many others. It can be found in very rare situations as an anti-foam additive but generally in those situations it is found below 20 PPM.
ii. **BORON (B):** Boron is most often found as a contaminant from cooling water incursion. Boron is an anti-corrosion and detergent found as an additive in most coolant corrosion inhibitor packages. It is primarily water-borne. When found as a contaminant, it almost always indicates coolant incursion. Some gear and engine oils use boron to provide both anti-wear and detergent properties too. When found as an additive, it is generally found less than 300 ppm
iii. **SODIUM (Na):** Sodium is usually considered a contaminant, however, sodium is also found as an incidental additive as a result of the metallic salt additives. In some AW and EP lubricants, sodium may be found as high as 100 ppm.
iv. **POTASSIUM (K):** With very few exceptions, potassium present in lubricants indicate cooling water. A few gear lubricants, however, use potassium as an anti-corrosion additive. When found as an additive, it will generally be in the 150-ppm range.

c. Common Additive Metals:

i. **CALCIUM (Ca):** Calcium is an anti-corrosion additive. It is found in high concentrations in engine oils, and never found in R&O (Rust and Oxidation) lubricants. It is the primary additive in most engine oils that provides acid neutralization. Generally, the higher the calcium amount in a new engine lubricant, the higher the Total Base Number, or level of protection against corrosive acid build-up. Calcium can be found as high as 4000 or 5000 parts per million (ppm) range in some high-base diesel engine oils, but generally found in the 500 - 3000 ppm range in today's oils.

i. **MAGNESIUM (Mg):** Magnesium, like calcium, is an anti-corrosion additive. It neutralizes acids. Magnesium also provides some anti-wear properties. It is never found in R&O oils. In industrial Anti-Wear (AW) and Extreme Pressure (EP) industrial lubricants, magnesium is usually found below 150 ppm in new lubricants. In Engine oils, magnesium may be 300 ppm or higher, depending on the formulation and base number.

ii. **BARIUM (Ba):** Barium provides tremendous anti-wear (AW) and some extreme-pressure (EP) properties, but is found in only a few specialty lubricants. When found, it is usually below 300 ppm in new lubricants.

iii. **PHOSPHORUS (P**): Phosphorus is an anti-wear, anti-corrosion additive. It can be found alone, or with zinc as part of a ZDDP additive package. Phosphorus can be found over 1200 ppm in some diesel engine oils. In industrial AW and EP lubricants, it is usually under 500 ppm.

iv. **ZINC (Zn):** Zinc provides anti-wear properties. It is also part of the ZDDP additive package with phosphorus, where it is generally found at or near the same level as phosphorus. When found without phosphorus, it is generally found below 200 ppm. Zinc can also be found as an alloying metal in brass and some bronze metals. Trace amounts of zinc may be seen spectrographically in severe brass or bronze wear situations.

v. **MOLYBDENUM (Mo):** Molybdenum, or 'moly', is an anti-wear and extreme pressure additive. It is generally found in gear oils and some engine oils. It can also be found as molybdenum di-sulfide, a solid lubricant additive. It can be found as high as 5000 ppm in some specialty gear oils, but is usually in the 100 ppm range