Oil Analysis Troubleshooting Guide

SPECTROCHEMICAL ANALYSIS

WEAR METALS

Iron (Fe)

Origin: Engine Block, Gears, Rings, Bearings, Cylinder Heads, Rust

Purpose: Because of its strength, iron is the base metal of steel in many engine parts. Since iron will rust, it is alloyed with other metals (ie: chromium, aluminum, nickel, making steel)

Chromium (Cr)

Origin: Shafts, rings, Chromate from cooling system

Purpose: Because of its strength and hardness, Chromium is used to plate rings and shafts that are usually mated with steel (softer). Chromium is also alloyed with iron (steel) for strength

Aluminum (Al)

Origin: Bushings, some Bearings, Pistons, Turbo Charger, Compressor Wheels

Purpose: Aluminum is a strong, lightweight metal (lower mass) which dissipates heat well and aids in thermal transfer

Copper (Cu)

Origins: Bearings, Bushings, Oil Coolers, Radiators, Camshaft Thrust Washers, Connecting Rods,

Bushings, Oil Additives for Anti-wear/anti-oxidant

Purpose: Copper is utilized to wear first in order to protect other components. Copper conforms well so it is used to seat bearings to the crankshaft

Nickel (Ni)

Origin: Valve stems, Valve Guides, Ring inserts on Pistons

Purpose: Nickel is alloyed with Iron in high strength steel

Silver (Ag)

Origin: Bearing Cages (low friction bearings), Silver solder, Turbo-charger bearings and wrist pin bushings.

Purpose: Silver is used to plate some components because it conforms well, dissipates heat and reduces coefficient of friction

Tin (Sn)

Origins: Bearings, Pistons

Purpose: Tin is conforming metal used to plate and protect surfaces to facilitate break-in

Molybdenum (Mo)

Origin: Piston rings, oil additives

Purpose: Silver is used as an alloy in some piston rings in the place of Chromium. Molybdenum is also used as a friction-reducing additive in some oils. Soluble Molybdenum can be used as anti-oxidant additive.

Additive Elements

Zinc (Zn)

Purpose: Anti-wear additive, which provides a protective film.

Phosphorus (P)

Purpose: Anti-wear, Extreme pressure additive that provides a protective film in high-pressure areas, Antioxidant Phosphorus is added to extreme pressure oils to provide a protective film. Extreme pressure oils are characterized by high phosphorus.

Barium (Ba)

Purpose: Detergent. Barium is toxic and expensive but it is advantageous because it leaves minimal ash residue

Calcium (Ca) and Magnesium (Mg)

Purpose: Calcium and Magnesium are alkaline-based additives used to neutralize acids formed by products of combustion in engine oils. Calcium and Magnesium also have some detergent qualities.

Boron (B)

Purpose: Inhibitor. Boron is also found as an additive in coolant as borate

Copper (Cu)

Purpose: Antioxidant. Copper is added to oils to prevent oxidation.

Contaminants

Potassium (K)

Origin: Potassium is a coolant additive. Its presence in oil is indicative of coolant contamination

Sodium (Na)

Origin: External contamination, additive, or coolant. Sodium is not a wear metal. Its source is from coolant, the environment (salt).

Silicon (Si)

Origin: External (dirt), additive, sealants. Silicon can be an anti-foam additive in the form of silicone.

Fuel Dilution

Fuel dilution of crankcase oil by unburned fuel reduces lubricant effectiveness. The thinning of lubricant can lead to decreased lube film strength adding the risk of abnormal wear. Depending on certain variables, when fuel dilution exceeds 2-5%, corrective action should be taken. Fuel dilution is measured by both gas chromatography and fuel dilution meters.

Source:

Incorrect Air to fuel ratio

Extended idling

Stop and go driving

Defective injectors

Leaking fuel pump/lines

Incomplete combustion

Incorrect timing

Solution:

Repair fuel leaks

Change Oil/Filter

Result:

Metal to metal contact/ Shortened Engine Life

Poor lubrication

Cylinder ring wear

Depleted additives

Decreased Oil Pressure

Reduced MPG/Reduced Engine Performance

Viscosity

Viscosity is one of the most important properties of lubricating oil. Viscosity is a measurement of resistance to flow and a specific temperature in relation to time. The two most common temperatures for lubricating oil viscosity are 40C and 100C. Viscosity is normally evaluated with a kinematic method and reported in centistokes (cSt). In used oil analysis, the used oil's viscosity is compared to that of the new oil to determine whether excessive thinning or thickening has occurred.

Source:

High Viscosity (thicker oil)

Contamination soot/solids

Incomplete combustion

Oxidation degradation

Leaking head gaskets

High temperature

Improper oil grade

Low Viscosity (thinner oil)

Additive Shear

Fuel Dilution

Improper oil grade

Result: High Viscosity

Increased operating costs/fuel consumption

Engine overheat

Restricted oil flow

Oil filter bypass

Harmful deposits/sludge

Solution:

Check air/fuel ratio

Incorrect oil grade

Result: Low Viscosity

Engine Overheating

Inspect Internal Seals

Leaking injectors

Change oil/Filter

Poor lubrication

Metal to metal contact

Increased operation costs

Water/Coolant Contamination

Water presence in engines indicates contamination from outside sources. These sources may be condensation of moisture from the atmosphere, or internal water leaks. Water is normally evaporated by engines at normal working temperatures. However, water may remain in the oil when engine temperatures are too low for evaporation to occur. Other types of equipment, when operated at satisfactory temperatures, also have a tendency to evaporate water contamination.

Oil analysis can identify water/coolant contamination before problem occurs. ASTM D-1744, the Karl Fischer method is used to measure water in systems, which are sensitive to low moisture content.

Source:	**Result:**
Low operating temperatures	High Viscosity
Defective seals	Engine wear
Coolant leak	Corrosion
Improper use/storage	Acid formation
Weather/humidity	Weld spots
Cracked head	Engine failure
Combustion byproduct	Reduced additive properties

Solids

Solids represents a measurement of all solid and solid-like material in a lubricant. The makeup of solids depends on the system. In diesel engines fuel soot is usually the major component measured. In non-diesel engines, components wear debris and oil oxidation products are measured.

Source:	**Result:**
Extending drain intervals	Shorter engine life
Environmental debris	Filter plugging
Wear debris	Poor lubrication/wear
Oxidation by-products	Engine deposits
Weather/humidity	Sludge
Leaking/dirty filters	Decreased oil flow
Fuel Soot	Reduced additive properties

Solution:

Bypass Filter

Flush system

Change operating environment

Change oil and Filter

Total Base Number

Total base number (**TBN**) represents the amount of alkaline additives in the lubricant which neutralizes the acidic products of combustion.

Source of low (TBN)

High sulfur fuel

Overheating

Improper oil type

Result:

Increased total acid number

Oil degradation

Increased engine wear

Acid build-up in oil

Solution:

Use low sulfur diesel fuel

Re-evaluate oil drain intervals

Verify TBN of oil used

Test fuel quality

Total Acid Number

Total acid number (**TAN**) is the quantity of acid or acid-like derivatives in the lubricant. An increased TAN from that of the new lubricant should be monitored. The TAN of a new oil is not necessarily nil since oil additives can be acidic in nature. Increase in TAN usually indicate lubrication oxidation or contamination with and acidic product. TAN is an indicator of oil serviceability.

Source

High sulfur fuel

Overheating

Excessive blow-by

Extended oil drain intervals

Improper oil type

Result:

Corrosion of metallic components

Oil degradation

Oil thickening

Increased engine wear

Additive depletion

Solution:

Replace oil

Re-evaluate oil drain intervals

Check for overheating

Check fuel quality

Check oil type

Fuel Soot

Fuel soot is formed of carbon and is always found in diesel engine oil. Laboratory testing is used to determine the quantity of fuel soot in used oil samples. Recent EPA emission regulations have placed a great importance on fuel soot levels. The fuel soot level is a good indicator of combustion efficiency and should be monitored on a regular basis.

Source of low (TBN)

Poor fuel quality

Improper air/fuel ratio

Improper injector timing

Incomplete combustion

Low compression

Worn engine.

Result:

Poor engine performance

Poor fuel economy

Harmful deposits and sludge

Increased engine wear

Carbon deposits

Clogged filters

DPF plugging

Solution:

Healthy injectors

Healthy air filter

Change oil

Assess drain intervals

Check compression

Avoid excessive idling

Check fuel quality

Assess Driving conditions

Oxidation

Lubricating oil in engines and other components will combine with available oxygen under certain conditions to form a wide variety of harmful by-products. Heat, pressure, and catalyst materials like water accelerate the oxidation process. By-products of oxidation form lacquer deposits, corrode metal parts, and thicken oil beyond its ability to lubricate. Most lubricants contain additives which inhibit or retard the oxidation process. Differential infrared analysis is the method to measure the level of oxidation in used oil.

Source:

Overheating

Combustion byproducts/blow-by

Assess oil change intervals

Improper oil/inhibitor additive type

Result:

Plugs oil filters

Increased viscosity

Increased engine wear

Corrosion of metal parts

Solution:

Assess oil drain intervals

Use better oil

Check operating temperatures

Check fuel quality

Nitration

Nitration products are formed during the fuel combustion process when combustion by-products enter the engine oil during normal operation or as a result of abnormal blow-by past the compression rings. These products are highly acidic, create deposits and accelerate oil oxidation. Infrared analysis represents the only method of accurately measuring nitration products in used oil.

Source:

Improper scavenge

Low operating temperatures

Defective seals

Improper air/fuel ratio

Abnormal blow-by

Result:

Accelerated oxidation

Nitrous oxides introduced into the system

Acidic by-products

Increased cylinder wear

Oil thickening

Combustion deposits

Increased total acid number

Solution:

Increase operating temps

Check crankcase ventilation

Ensure proper air/fuel mixture

Compression check

Particle Count

Particle Count testing basically measures the relative cleanliness of a given fluid. It is primarily used for hydraulic and turbine systems to evaluate the effectiveness of the filters. It has been proven that reducing the particulate debris in the fluid can greatly increase the life of these systems.

The instrument that is normally used is a HIAC/ROYKO Particle Counter that measures the total population of particles in different size ranges. High levels of water can produce erroneously high readings. After the analysis is completed, an ISO Cleanliness Rating is determined from the results. The ISO Cleanliness Rating consists of two numbers and is a convenient method to communicate the sometimes unwieldy particle count results. The first number represents 5 micron (silt) particles. The second number represents 15 Micron (abrasives) particles.

Source:

Water contamination

Oil oxidation

Worn seals

Ineffective filtration

Result:

Plugging and/or leakage

Engine wear

Engine failure

Pressure pulsing

Sluggish valves/actuators

Solution:

Change oil

Change Filter

Use higher quality filters

Verify Seal integrity

Interpreting the results test reports and taking corrective action

Once all the tests are complete, the results are evaluated by a highly trained Data Evaluator. The evaluation will result in (1) a statement that unit is normal or (2) specific maintenance recommendations will be made. Report recommendations are only one tool that can assist you in making your maintenance decisions.

Recommendation Categories

Normal:

No explanation is needed for this category. Keep in mind that it is important to know that a unit is normal. This can save you unnecessary teardown.

This category is followed by specific maintenance recommendations, or a notation that component wear is abnormal: there might, for example, be a recommendation to change oil and filters, and a comment noting that abnormal bearing wear his present. We are not telling you that it is time to tear down the unit. We are suggesting that you perform the maintenance suggested, and advising you that bearing wear is present. A second sample in a shorter time span might be requested. We do not recommend that you go into a unit on an abnormal recommendation unless you have discussed the report with the appropriate laboratory Data Evaluator or you had indications that the unit has a more serious problem than is apparent in the report. Again your judgment must be based on all of the tools at your disposal, including our report, your knowledge of the unit and your experience.

Critical:

This is the category we use to indicate potential failure and a serious condition exists. We will indicate the suspected nature of the problem and make a recommendation for maintenance action. Critical units require immediate attention.

A serious problem could be developing the unit should be closely monitored.

Re-samples: We will request the second sample to establish a trend whenever we have a potential “critical” unit with no previous history. If the wear increases, you'll be advised on the suspected nature of the problem.

In some cases the data will identify an obvious problem. For example, a high level of water contamination along with high levels of boron and sodium is a good indication of anti-freeze contamination. A high particle count and high levels of silicone usually indicate dirt or dust contamination, and the need to check air filters or breathers, reservoir access covers, or oil storage and handling procedures.

Sometimes however, the analytical data from individual sample does not provide enough information to make more subtle judgments about oil or equipment condition. In these situations it is necessary to monitor the trends in analytical data over a series of samples to establish aware trend pattern. By monitoring where metals such as iron, lead, copper, and tin it is possible to detect the early stages of possible bearing failure. In most cases it detect problems far enough in advance that it will allow for scheduling bearing inspection at a convenient time, reducing or eliminating expensive equipment downtime and repairs.

One measure of the degradation of an engine is an increase in viscosity. Normally, a viscosity increase from one grade to the next is a warning that oil has reached the end of its useful life.

Most engine oils are formulated with a variety of additives which enhance lubricity, inhibit oxidation and corrosion, and reduce the tendency for sludge and deposit formations. The levels of these additives can't be determined by monitoring the total base number (TBN), the reduction of the TBN below 4.0 is a warning that the additives have been depleted and oil change should be scheduled. Some additive levels can be measured with spectrographic metals analysis. This test will detect the levels of zinc, phosphorus, calcium, and magnesium… Which are common elements in most additive packages.

The most common engine oil contaminants are silicone (dirt), fuel dilution, and antifreeze coolant. Silicone (dirt) contamination is the most common form of contamination causes serious engine where due to its abrasive action against all moving parts within the engine. Silicone levels above 25 ppm should be considered cost for inspection of the air intake system to locate the source of entry for the dirt and other airborne debris.

Fuel dilution is serious since it can significantly reduce oil viscosity and lubricity thus causing engine wear. Fuel dilution can initially be detected by a lowering of the flashpoint of the oil, accompanied by a noticeable viscosity reduction, and heavy fuel order.

Coolant is another very common oil contaminant and probably the most serious. Water from the coolant reduces the lubricity, which causes severe bearing problems, while the glycol degrades at high temperatures and forms of sludge. Monitoring water contamination levels is not reliable, since normal engine temperatures are high enough to evaporate the water overtime and keep detectable levels as low as 0.05%. Coolant levels can be detected by chemical analysis and by monitoring the levels of boron, phosphorus, sodium, and potassium and oil.

Wear metal analysis can indicate which engine components are wearing and if the wear is becoming significant. This information to make the difference between minor component inspections in repairs and major overhauls. Wear metals levels are provided by spectrographic analysis of the oil sample, indicate the element level in parts per million (ppm), of each of the common metals found in the engine: iron, aluminum, chromium, lead, copper, tin, nickel, and silver.

Wear metal analysis requires more than simply plotting data on a graph. Wear metals can be generated from as many as a dozen different engine parts and locations making it difficult to identify the specific part of that is wearing excessively. It is knowledge acquired through years of experience in analytical training that the analyst can draw upon, to provide the most accurate analysis possible for customers.