Understanding S·O·S℠ Services Tests

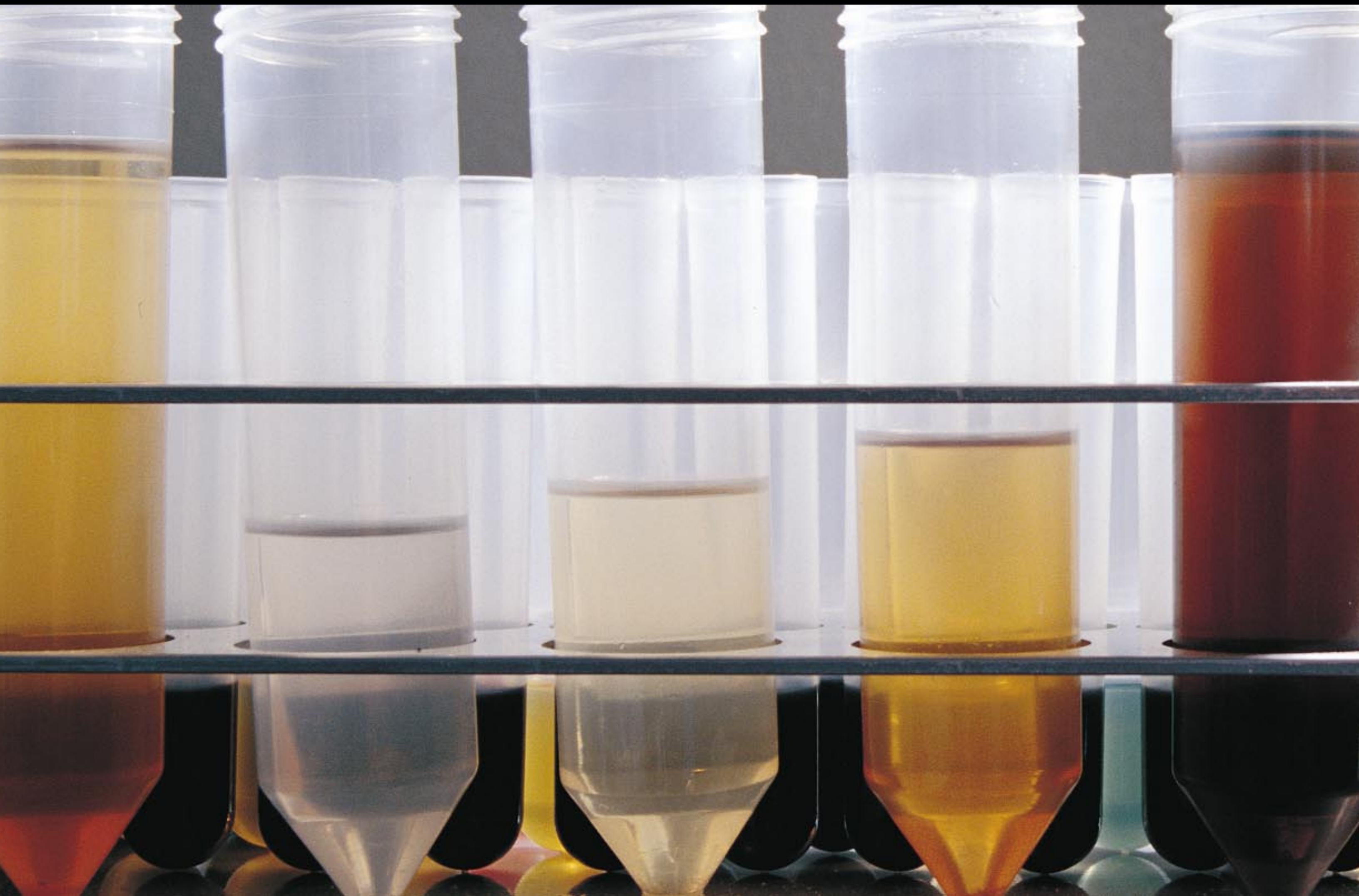
You'll get greater benefits from your S·O·S Services program when you understand the tests chosen by Caterpillar® engineers to monitor oil condition and contaminants.

Know what the numbers mean and maximize your investment

S·O·S Services are valuable management tools that can maximize equipment life and productivity, and minimize operating costs and downtime. Four types of analysis are performed on engine, hydraulics and drivetrain oil.

- **Wear Rate** monitors and tracks metal wear particles, contaminants and oil additive package elements
- **Oil Condition** compares used oil to new oil to see if it is providing adequate lubrication and protection
- **Oil Cleanliness** determines if abrasive contaminants are causing accelerated wear
- **Additional Tests** detect water, glycol or fuel in oil

Take oil samples at consistent intervals to detect potential problems early, reduce repair costs and lessen the impact of downtime.



CATERPILLAR®

S·O·S Wear Rate Analysis

Prevent problems and reduce costs by knowing wear rates

Wear Rate Analysis is an integral part of our S·O·S Services program that helps you maintain equipment performance and maximize availability. Through regularly scheduled testing of oil samples from your engine, hydraulics and powertrain systems, Wear Rate Analysis detects tiny metal particles caused by component wear. By monitoring trends in the type and quantity of particles, you can get early warning of problems before major damage occurs.

Understanding wear metals

Every oil-washed system—engines, hydraulics, transmissions, and final drives—produces wear metals in everyday operation. If wear accelerates, the concentration of wear metal particles increases, signaling a problem. Wear Rate Analysis allows you to find problems before they result in major repairs or machine failure.

Wear Rate Analysis can detect particles that range up to about 10 microns in size. Wear metal concentrations are expressed in parts-per-million (or ppm). The S·O·S Services program tests for at least nine different substances: copper, iron, chromium, lead, tin, aluminum, molybdenum, silicon and sodium. All are wear metals found in Caterpillar machines and engines except silicon (which generally indicates dirt) and sodium (which indicates water or coolant). Certain elements in a sample may be from the oil additive package rather than from wear within the system. Skilled dealer interpreters can tell the difference between normal elements and those that indicate abnormal wear.

Trending wear metals in your equipment

Two identical machines under identical conditions may generate wear particles at different rates. Our S·O·S interpreters have access to a large database of samples for comparison with samples from your equipment. However, your own machines provide the best guidelines for appropriate levels of wear metals in each compartment. That's why trending is an essential part of Wear Rate Analysis. After three samples have been taken from a particular compartment, a trend for each wear metal is established. Our interpreters then compare subsequent samples to this trend line to quickly spot deviations as well as monitor gradual changes in concentration levels. This attention to trends also assists with life cycle analysis, helping you optimize productivity.

The technology behind Wear Rate Analysis

We use an emission spectrometer to perform Wear Rate Analysis. The spectrometer determines wear elements and silicon in a sample by subjecting the oil to very high temperatures. At these temperatures, the elements in the sample are "atomized," with each emitting a different wavelength of light energy. An optical system measures and records the light energy and calculates the results in parts-per-million for each element.

Combinations of Classic Wear Elements

	Primary Element	Secondary Element	Potential Wear	Probable Problem Area/Causes
Engines–Top End	Silicon (dirt)	Iron, Chrome, Aluminum	Liners, Rings, Pistons	Air Induction System/Filter Dirt Contamination
	Iron	Chrome, Aluminum	Liners, Rings, Pistons	Abnormal Operating Temps., Oil Degradation, Fuel and/or Coolant Contamination, Stuck/Broken Rings
	Chrome	Molybdenum, Aluminum	Rings, Pistons	Blowby, Oil Consumption, Oil Degradation
	Iron	———	Liners, Gears, Valve Train, Crankshaft	Abnormal Operating Temps., Lack of Lubrication, Contamination, Storage (Rust)
Engines–Bottom End	Silicon (Dirt)	Lead, Aluminum	Bearings	Dirt Contamination
	Lead	Aluminum	Bearings	Lack of Lubrication, Coolant Contamination, Fuel Contamination
Hydraulics	Silicon (Dirt)	Molybdenum, Aluminum	Cylinders, Rods	Dirt Contamination
	Copper	Iron	Hydraulic Pumps	Oil Degradation, Contamination
Transmissions	Iron	Aluminum, Chrome	Roller or needle bearings	Bearing fatigue/failure
	Aluminum	Iron, Copper	Torque Converter	Bearing wear/failure allowing contact
Final Drives	Silicon (Dirt)	Iron, Aluminum	Gears	Dirt Contamination, Clay Soils Contamination
	Iron	Sodium, Chrome	Gears, Bearings	Water Entry, Preload Loss

Pinpointing the causes and effects of component wear

By comparing infrared (Oil Condition) test results with wear metal buildup, we can pinpoint probable causes of elevated wear metals. The chart above illustrates some of the most common wear metals, their source(s), and the potential problems they indicate in oil-lubricated systems.

Spectrometry detects dirt contamination, as well as wear metals. Silicon is the most common element indicating dirt entry, although some clay soils also produce increased aluminum readings.

Monitoring your components

When S·O·S oil analysis identifies an increase in the concentration of one or more metals, it can point to the wearing component most likely causing the increase and, often, the probable cause. For example, a sudden increase in copper and iron in a hydraulic oil sample would probably indicate a problem with the hydraulic pump caused by either oil degradation or contamination (see chart, above).

Silicon/aluminum ratio in dirt varies by location

The primary constituents of dirt are minerals containing silicon and aluminum. The ratio of these two elements varies widely from place to place. Clay soils contain nearly as much aluminum as silicon. This is one reason why local interpretation of your sample results is important. We are familiar with the soils in your area, giving us the best understanding of the combinations of elements in your samples.

S·O·S Oil Condition Analysis

Maximize performance by knowing your oil condition

Oxygen exposure, heat and contaminants cause all oils to degrade. Engine oil is particularly susceptible to degradation by sulfur, nitration, by-products of combustion, high temperatures, and water from the combustion process or condensation. Oil Condition Analysis, part of the comprehensive S·O·S Services program, helps prevent component damage by monitoring your oil and keeping track of its degradation. Oil Condition Analysis also allows you to correct problems that affect oil performance. The bottom-line benefit: maximum oil performance, optimum oil change intervals and reduced repair costs.

Understanding Oil Condition Analysis

Oil Condition Analysis is similar to Wear Rate Analysis with one important exception: It evaluates chemical compounds in the oil rather than wear element particles.

Oil Condition Analysis is important for oil from all systems: transmissions and hydraulics, as well as engines.

It works like this:

1. You submit a sample of new oil, called "reference oil," when you enroll in the S·O·S Services program and when you get new shipments of bulk oil. Reference oil samples are processed at no cost to you. If you are using Cat oil, new oil samples may not be necessary. Advise your S·O·S analyst of the viscosity of the Cat oil you use in each system; it has its own Cat oil reference samples.
2. The new oil is scanned by a special instrument using infrared light. Information is stored in the instrument's memory.
3. At each scheduled interval, you submit a sample of used oil.
4. The Oil Condition Analysis instrument focuses a beam of light through a film of used oil and records the data.
5. The instrument uses a mathematical formula to compare the used and new oils and quantify any differences.

Fourier Transform Infrared Analysis

S·O·S Oil Condition Analysis includes an infrared instrument that uses a mathematical method to convert raw instrument data into meaningful terms. This test, often called FT-IR (Fourier Transform Infrared Analysis), identifies and quantifies organic compound groups by measuring their infrared absorption at the specific wavelength of each group. Besides identifying oxidation, soot, sulfur products and nitration, the test is also used to scan for oil contamination by fuel, water or glycol (engine coolant).

Identifying contaminants before they cause problems

Oil Condition Analysis detects soot, oxidation, nitration products and sulfur products/acids. This test can also detect contamination by water, fuel and glycol from coolant. If detected, specific contaminant tests are used to confirm findings. Oil Condition Analysis focuses on:

Soot

Soot is found only in engine oil. It is the insoluble residue of partially burned fuel. It is held in suspension by the oil additive package and causes engine oil to turn black. When soot drops out of suspension in the oil, it contributes to additive depletion and eventually increases oil viscosity. Heavy concentrations of soot can cause bearing damage by starving contact surfaces of lubrication.

Oxidation

Oxidation occurs in transmission, hydraulic and engine oils when oxygen molecules chemically join with oil molecules. This chemical reaction is accelerated by high oil temperatures, glycol contamination from engine coolant, the presence of copper, and from extended oil change intervals. Oxidation causes the oil to thicken, form acids, and lose lubrication qualities, which threatens the life of your components. Oxidized oil will cause deposits on engine pistons and valves, stuck rings, and bore polishing. In hydraulic systems and transmissions, it can cause valve scuffing and sticking.

Nitration Products

Nitration occurs in all engine oils, but is generally only a problem in natural gas engines. Nitrogen compounds from the combustion process thicken the oil and reduce its lubricating ability. If nitration continues unchecked, it can result in filter plugging, heavy piston deposits, lacquering of valves and pistons, and eventual failure.

Sulfur Products/Acids

Sulfur is present in all fuels and affects all engines. During combustion, fuel sulfur oxidizes, then combines with water to form acid. Acid corrodes all engine parts, but is most dangerous to valves and valve guides, piston rings and liners.

Optimizing your equipment with the S·O·S Services program

Oil degradation may be the result of a number of factors and conditions, including extended oil change intervals, abnormal temperatures, or contamination by fuel, water or coolant. Lower quality oils will degrade more rapidly than a premium quality lubricant.

With Oil Condition Analysis, you can determine the extent to which oil has deteriorated during use and verify whether it is performing up to specification during the entire oil change period. Oil Condition Analysis is just one part of the S·O·S Services program that provides information to reduce downtime and save you money by preventing major equipment problems.

Glycol, Water and Fuel Detection

Fluid Contaminants

When present in your engine oil or fluid power system, water, glycol (coolant) or fuel can indicate a number of problems, from incorrect engine timing (fuel) to cooling system leaks. By detecting these problems before they cause component failure, we can work with you to schedule downtime and maximize productivity.

Glycol (Coolant)

Glycol causes rapid oxidation of the oil and usually indicates a cooling system leak. Severely oxidized oil becomes sticky and forms sludge that plugs the filter. Any amount of glycol contamination in the oil is unacceptable. Engines, hydraulics or transmissions using water-to-oil coolers may become contaminated with coolant if a leak develops in a cooler tube or seal.

Water

If infrared analysis indicates the presence of water, the approximate amount is determined by placing a drop of oil on a plate heated to between 230˚ and 250˚ F. If water is present the oil will bubble and sputter. By comparing the amount of bubbling to laboratory control samples, experienced laboratory technicians can determine the quantity of water in the sample. Any amount over 0.5 percent is considered excessive.

Water can contaminate a system by leaking in from the outside or condensing in the engine's crankcase or compartment. When water combines with oil, it reduces the oil's ability to lubricate and forms a sludge that plugs filters. Water passing between very close components can create "hot spots." If the water gets hot enough, it causes tiny steam explosions that can fracture metal.

Fuel

Fuel contamination is confirmed using a flash test in which the used oil is heated to a prescribed temperature in a closed cup, then subjected to a flame. Fuel vapors driven off by the heat will flash if the dilution exceeds four percent.

Fuel in the engine oil reduces its lubricating properties. Small amounts of fuel are common as a result of the combustion process. But if fuel levels exceed recommended levels, we will suggest a check for defective fuel injection nozzles and other sources of leakage. Fuel dilution is generally the result of extended idling, incorrect timing, or a problem with the fuel injectors, pumps or lines.

CATERPILLAR®

S·O·S Oil Cleanliness Analysis

Clean oil keeps equipment running right

Counting the tiny particles in an oil sample identifies harmful contaminants that shorten component life. It can also pinpoint larger particles that signal imminent equipment failure. Our S·O·SServices program finds these particles through a combination of tests that includes Particle Count.

Fighting an unseen enemy

Even particles far too small to see can cause damage. In fact, oil that looks clean may contain particles that cause abrasive wear. Particle contamination:

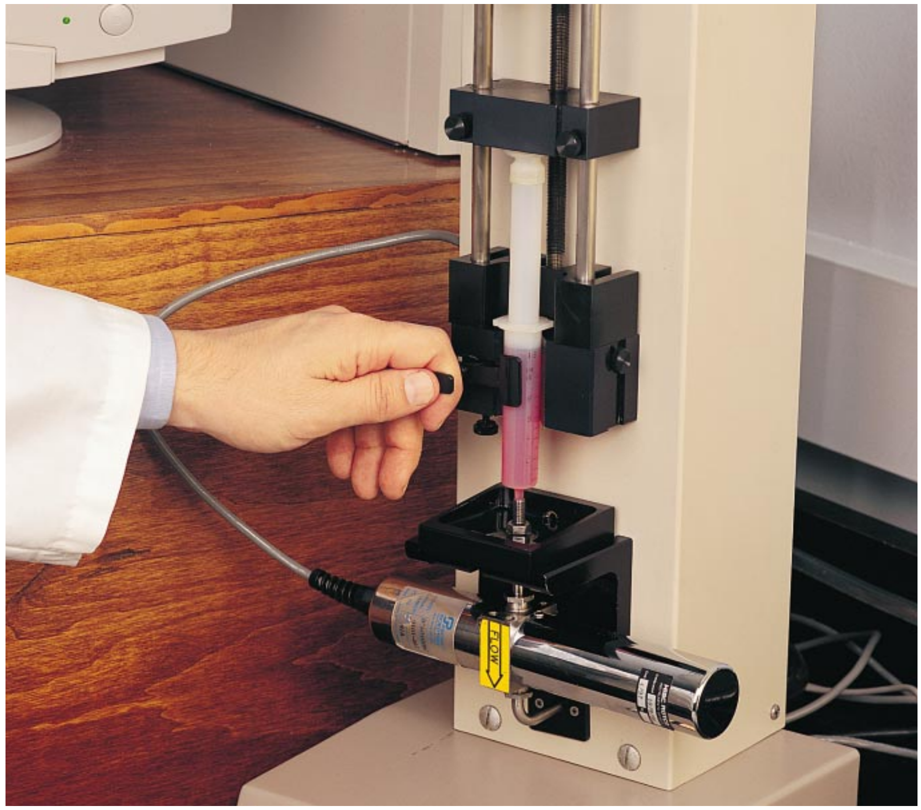
- Accelerates component wear
- Reduces system efficiency
- Diminishes equipment performance

Learn About ISO Cleanliness Codes

The International Standards Organization (ISO) has developed a code system for convenience in discussing the cleanliness level of a fluid. The system reports on particles at two important size catagories (>5 micron and >15 micron). You may wish to learn more about this system of reporting oil cleanliness to better manage the life of your hydraulic and transmission components. If you are interested ask us for Form No. PEJT5025 *Reporting Particle Count by ISO Code.*

The technology behind Particle Count

S·O·S labs use a technique called light extinction to “count” the particles. The sample is passed through a beam from a special light source. When a particle in the oil passes through the beam, a sensor monitors changes in the light, counts the particles and records their sizes. This test detects particle contaminants that can lead to accelerated wear and other costly problems.



Going beyond Wear Rate Analysis

Particle Count, which is used for transmission and hydraulic system oil samples, is one of two tests in the S·O·S Services program that look at particles. The other is Wear Rate Analysis, which uses spectrometry to identify metal particles from 8 to 10 microns in size. Unlike Wear Rate Analysis, Particle Count detects metallic and non-metallic particles from 2 to 100 microns. However, Particle Count only reports the size and number of particles, not their composition.

Particle Count is the most efficient way to identify non-metallic particles in oil. These may include silicon from dirt or synthetic friction materials that signal deterioration in transmissions, steering clutches and brakes. Gasket, seal, filter and hose material can also be detected.

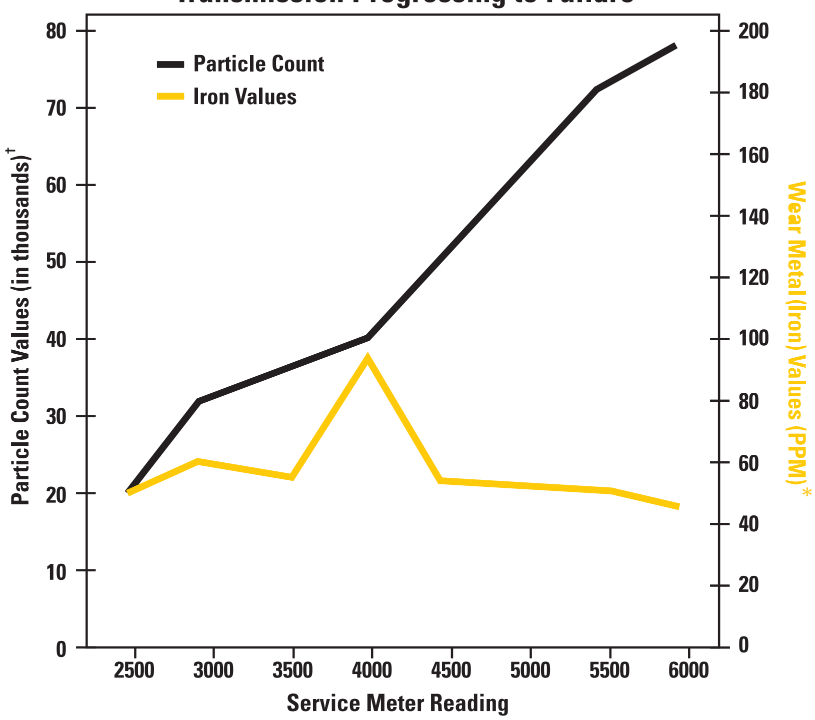
Another benefit of Particle Count is its ability to detect particles larger than 10 microns that cannot be seen by Wear Rate Analysis or any other oil analysis test. These larger particles are a sign of imminent failure if the problem is not corrected.

Particle Count is only used for non-engine oil samples because engine oil contains soot that cannot be distinguished from metal particles or debris.

A partnership of tests identifying trends

Particle Count works with Wear Rate Analysis to give you a more accurate picture of what's going on in your machine. Wear Rate Analysis may indicate a sharp rise in the concentration of a certain wear metal. This concentration may then level off, indicating normal wear. But Wear Rate Analysis can only detect particles up to about 10 microns. A Particle Count run on the same sample could show a sharp rise in particles over 15 microns. The two trends together may show a failure in progress, or an intrusion of external contaminants.

Actual Oil Analysis Results from Transmission Progressing to Failure



*Wear metals are calculated as parts per million, or PPM.

†Particle count values are those sized >15μ per ml.

Count on our experts.

The S·O·S Services program is just one of many maintenance products and services we offer to help you maximize productivity and reduce operating costs. For example, you may wish to check into our maintenance software programs. Trend Analysis Module (TAM) permits you to receive your S·O·S results electronically. Maintenance Control System (MCS) is a Windows®-based system for maintenance and repair scheduling. Preventive Maintenance Planner (PMP) provides convenient checklists for maintenance personnel at each service interval. Talk to our experts or stop in for a demonstration.

For more information, see us today
or visit our Web site at www.CAT.com