

# Cat<sup>®</sup> S·O·S<sup>SM</sup> Services

## Understanding Your Results



### Understanding Your:

- S·O·S Oil Reports
- S·O·S Oil Results
- S·O·S Coolant Reports
- S·O·S Coolant Results



**CATERPILLAR<sup>®</sup>**

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# Committed to keeping your equipment moving

Like all Cat® Dealer services, the S-O-S<sup>SM</sup> Services program is a mutual commitment to protect the performance and value built into your Cat equipment. The S-O-S Services program offers you valuable resources for better equipment management. Working together with your Cat® Dealer, you can take the simple process of fluid sampling and combine it with state-of-the-art analysis and clear, easy-to-understand reporting to create not only optimized machine performance, but also improved cost control.

As your local Cat Dealer, we back up our fluid analysis with our reputation for excellence and the expertise of trained Analysts. Enrolling in the S-O-S Services program is your assurance that you'll get accurate analysis. Only your Cat Dealer S-O-S Analysts have access to the expertise of Caterpillar design specifications and engineers. The S-O-S lab completes testing quickly and provides comprehensive maintenance advice in easy to understand feedback. Make the commitment and get the benefits of working with the people who know your Cat equipment best.



# Overview of S·O·S Oil Reports

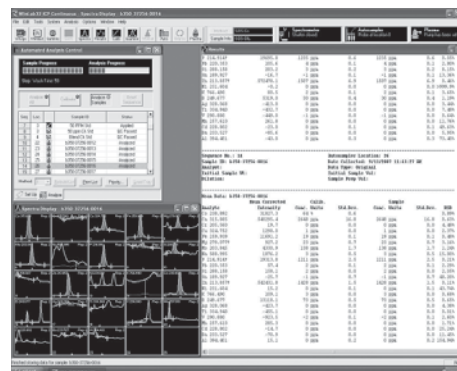
Know what the numbers mean and how to maximize your investment.



S·O·S<sup>SM</sup> Services are valuable management tools that can maximize your equipment life and productivity. At the same time operating costs and downtime can be reduced. During oil analysis four types of tests are performed on engine, hydraulic and drive train oils:

- Component Wear Rate
- Oil Condition
- Oil Contamination
- Oil Identification

Sample at consistent intervals to detect potential problems early.



## Sections of an S·O·S oil report:

### Label information

Label information is the data supplied by you, either by pre-registration or on the sample label. This type of information may include but is not limited to:

- Company name
- Serial number of equipment and compartment
- Equipment and component model
- Equipment manufacturer and component manufacturer
- Equipment hours and component hours
- Equipment number
- Compartment
- Oil hours
- Oil brand
- Oil weight
- Job site
- Notes and miscellaneous information

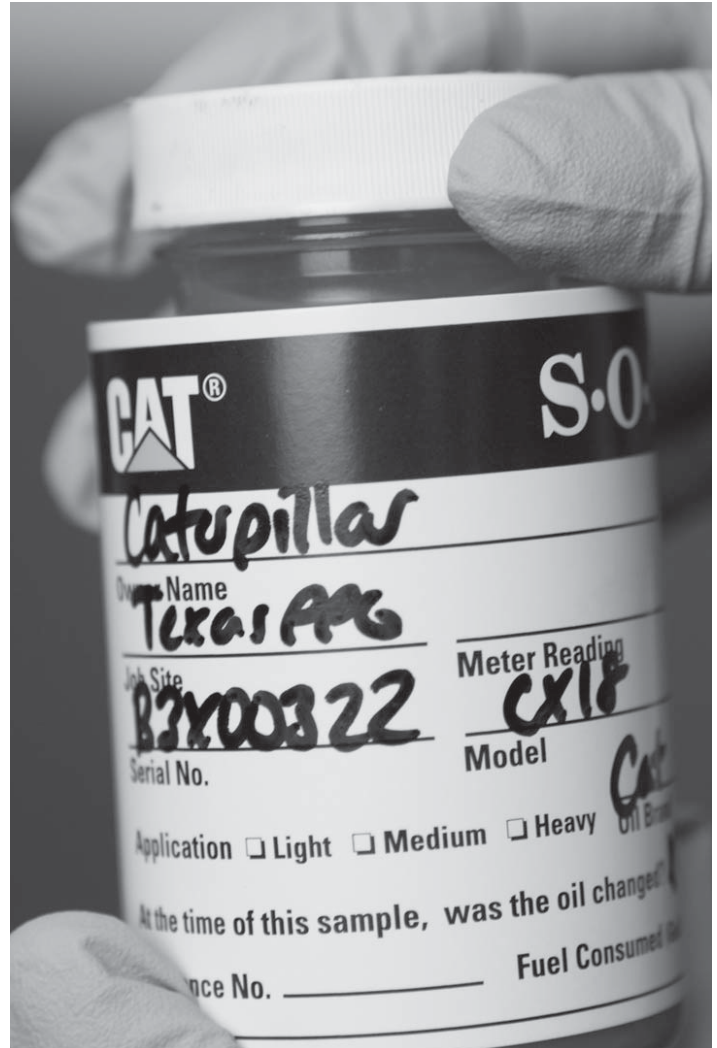
Label information is used to register your sample into a database. This allows the S·O·S sample history to be displayed on the report. Label information also provides key data needed by our interpreters to make the best recommendations and evaluations of your S·O·S sample.

### Lab Control Number

The Lab Control Number is a unique number the lab assigns to your sample. This number helps the lab track the sample through all of the analyses. Sample information in the database may be found using the lab control number or other label information.

### Overall Evaluation

The overall evaluation is a color code indicating the urgency of any needed actions. This allows you to manage the S·O·S reports by exception. Review the red coded reports first since these are the most urgent. Next, review yellow coded reports. Review the green coded reports last.



### Interpretation

The interpretation summarizes the findings of the S·O·S results and provides recommendations. Suggested actions may be to resample at a shortened time frame to verify findings or to monitor wear more closely.

### S·O·S Results

The S·O·S results are listed in this section of the report. The test name and results will be listed individually. Elemental analysis will list each element individually and display the result. The test results will be explained in more detail in the next section of this guide.

### Explanation of Abbreviations

The abbreviations used on the S·O·S report are explained at the bottom of the report.

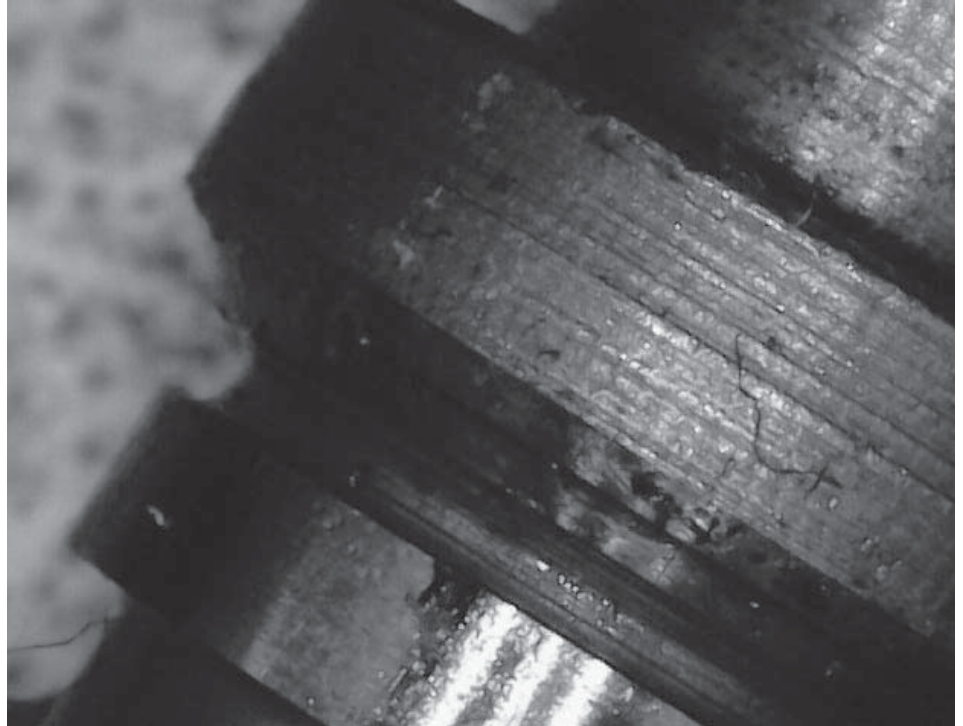
# Overview of S·O·S Oil Results

## Component Wear Rate

Component wear rate analysis evaluates the wear taking place inside the lubricated compartment. Your S·O·S Analyst uses the results of elemental analysis and particle count tests to evaluate the wear. Trend analysis and proprietary wear tables are then used to determine if wear rates are normal or abnormal.

### Elemental Analysis

Elemental Analysis detects wear elements, oil additive package elements, and the elemental constituents of some contaminants. This analysis can detect particles up to about 10 microns in size. The Elemental Analysis results are reported in parts per million, ppm.



## What is ppm?

Parts per million, or ppm, is used to express concentration of elements in oil or coolant. One particle of iron in 99,999,999 particles of oil or coolant is one ppm. Approximate examples of ppm:

**1 minute in 11.5 days**

**1 drop of ink in 150 L (40 Gallons) of water**

## Silicon and Aluminum in Dirt

The primary constituents of dirt are minerals containing silicon and aluminum. The ratio of these two elements vary widely from place to place. Clay soils contain nearly as much aluminum as silicon. Skilled dealer interpreters know your local soil and have the best understanding of the combinations of elements in your samples.

|                                         | Elevated Test Results                               | Possible Sources                                     |
|-----------------------------------------|-----------------------------------------------------|------------------------------------------------------|
| <b>Diesel Engines</b>                   | Iron, chrome                                        | Cylinder liners, piston rings                        |
|                                         | Iron, chrome, aluminum                              | Cylinder liners, piston rings, aluminum piston skirt |
|                                         | Lead, aluminum, iron                                | Lower rod and main bearings, crankshaft              |
|                                         | Sodium, potassium, copper                           | Coolant contamination                                |
|                                         | Silicon greater than aluminum, iron, lead           | Dirt, cylinder liners, piston rings, bearing overlay |
|                                         | Soot, iron, lead, chrome                            | Soot wear on cylinder liners, piston rings, bearings |
| <b>Powershift Transmissions</b>         | Silicon, iron                                       | Wet clutch friction material and separator plates    |
|                                         | Aluminum, copper, iron                              | Torque converter                                     |
|                                         | Copper greater than lead or tin                     | Bronze bushing or thrust washer                      |
| <b>Hydraulic &amp; Steering Systems</b> | Iron, chrome                                        | Cylinder & rod wear                                  |
|                                         | Silicon greater than aluminum, iron, chrome         | Dirt entry, pump wear, cylinder & rod wear           |
| <b>Differentials &amp; Final Drives</b> | Silicon greater than aluminum, iron, chrome, nickel | Dirt entry, gear wear, bearing wear                  |
|                                         | Copper greater than lead or tin                     | Bronze bushing or thrust washer                      |

## Particle Count

Particle Count analysis is used to evaluate particles larger than 10 microns and non-metallic particles. Particle Count results are listed as an ISO code and a channel count. The Particle Count channel counts are reported in counts per milliliter of sample (counts/mL). The ISO code is a summarization of the channel count results. An increase in ISO code values could indicate an increase in wear or the presence of contaminants. For more information about particle counts and ISO codes refer to PEGJ0045.

## Oil Condition

Oil Condition analysis is used to determine if the oil has degraded. Tests are done to look at the viscosity, oxidation, sulfation and nitration of the oil. All lubricated systems risk oxidation damage of the oil. Therefore, it is recommended that oil samples from all compartments be analyzed for oil condition. Your S·O·S Analyst uses established guidelines or trend analysis to determine if the oil has reached the end of its useful life.





## Viscosity

Viscosity is a temperature-dependent characteristic of lubricants that describes how the oil will flow. Viscosity is usually measured at 100 degrees Celsius. At high operating temperatures, a lubricant must be able to maintain appropriate film thickness. If the viscosity becomes too low, wear will occur within the compartment. If viscosity is too high, the oil will not flow to areas needing lubrication.

Many diesel engine oils are designed with multi-grade viscosity characteristics. At low ambient temperatures, multi-grade oils have a lower viscosity to provide start up protection. Appropriate oil viscosity is needed at low temperatures, or the oil will not flow quickly enough to parts needing lubrication. At normal operating temperatures, the multi-grade oils have a higher viscosity to protect moving parts.

## Oxidation

Oxidation occurs in transmission, hydraulic, final drive and engine oils when oxygen molecules chemically join with the oil molecules. Oxidation causes:

- Increased viscosity
- Acid formation
- Deposit formation

In diesel engines, an oxidized lubricant will lose the ability to protect components; as a result, piston rings may stick, cylinder bore polishing may occur and valves may scuff or stick.

In hydraulic systems, oxidized lubricants will increase pump wear and damage control valves. Powershift transmissions will experience clutch slippage, and abnormal wear if the oil is oxidized.

## Sulfation

Sulfur is present in diesel fuel. During combustion, fuel sulfur combines with water to form sulfuric acid. Modern diesel engine lubricants are designed to neutralize this acid. However, if these acids reach unacceptable levels, the lubricant will be degraded and corrosion will occur. This corrosion can attack:

- Valves
- Valve guides
- Piston rings
- Cylinder liners

## Nitration

Nitration occurs in all engine oils, but is generally a problem only in natural gas engines. Nitrogen compounds from the combustion process increase oil viscosity and reduce lubricating ability. Nitration may result in:

- Oil filter plugging
- Piston deposits
- Valve deposits
- Crankcase deposits



## Oil Contamination

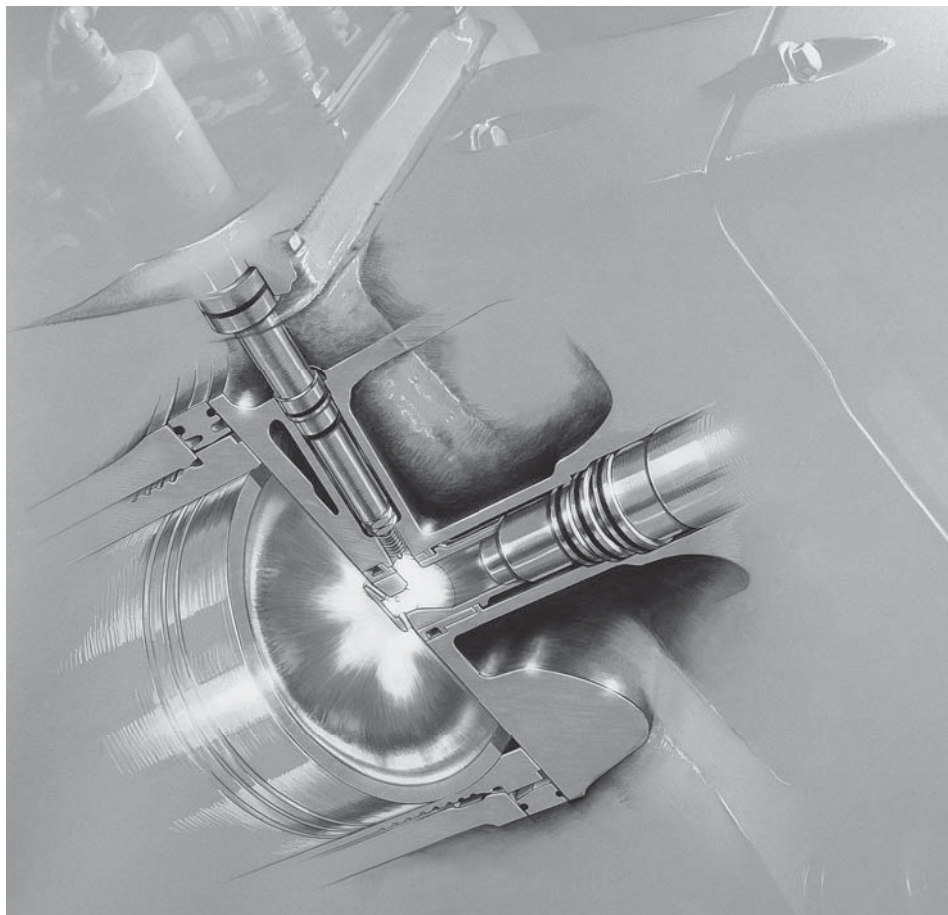
Oil Contamination tests are performed to determine if anything harmful has entered the oil. This analysis relies on the results from the following tests: elemental analysis, soot, particle count, fuel dilution, water, and coolant. The S·O·S Services program has guidelines for the level of contamination allowed in the various compartments of a Cat machine. Elemental Analysis and Particle Count were discussed earlier in this guide please refer back if needed.

### Soot

Soot is the insoluble residue of partially burned fuel. It is held in suspension by oil additives and causes engine oil to turn black. The soot particles are abrasive and cause engine wear.

Excessive soot levels will eventually overpower the engine oil additives. When this occurs, the soot particles will drop out of suspension and form larger particles. These larger soot particles will plug oil filters, form deposits, and increase oil viscosity. Eventually, engine wear will become abnormally high.





## Fuel Dilution

Small amounts of fuel are detected in engine lubricants because of the combustion process and blow-by. The most significant problem associated with fuel dilution is low viscosity. Low viscosity and high operating temperatures can cause oil films to become dangerously thin. If the oil film does not have adequate thickness, moving parts may experience direct contact. This contact could result in scuffing or seizure of the moving parts,

and eventually a failure. If fuel dilution exceeds recommended levels, it is generally because of:

- Internal fuel line leaks
- Worn fuel injectors
- Failed fuel injector
- Extended idling
- Incorrect timing

S·O·S Services uses the viscosity test results and the fuel dilution test results to determine if fuel dilution is excessive.

## Water

Water may condense or leak into a compartment. Water can also be a result of pressure washing equipment. Equipment that operates in wet conditions may experience water in final drives and axles.

Water can cause corrosive wear and rusting in any compartment. Corrosive wear occurs when the water combines with compounds in the oil to form acids. Rusting can occur in areas above the oil level in sumps, where an oil film does not protect the metal. If large quantities of water enter a compartment, the oil and water mixture could create a thick sludge.

## Coolant

Engine oil may become contaminated with coolant due to leaks from: oil cooler cores, internal coolant passages, and cylinder head gaskets. Hydraulic systems or transmissions, using oil-to-water coolers, may become contaminated with coolant. Coolant contamination will increase wear. High levels of coolant in the oil will produce sludge and total oil deterioration.

Your S·O·S Analyst uses elemental analysis to identify coolant leaks. This technique looks for traces of the coolant additives in the oil. In some cases, a separate test for glycol is used to further identify coolant entry.

## Oil Identification

Oil Identification is another very important part of the S·O·S oil analysis program. The wrong oil in a compartment can severely damage major components. Your S·O·S Analyst uses elemental analysis and viscosity results to identify key characteristics of the oils.

# Overview of S·O·S Interpretation

## Trend

Trend analysis will provide the best indication of compartment health. Trend analysis uses the historical oil sample results as the basis for normal test results. A trend is established by repeated oil sample results from the same compartment. Three to five oil samples are needed to establish a compartment trend. Oil hours and equipment hours must be correct for effective trend analysis. Therefore, all efforts should be made to correctly fill out the sample label. Sample results that deviate from the established trend may indicate a problem.

## Communication

### Additional Samples

Occasionally, an additional sample may be requested for several reasons:

- To more closely monitor a Yellow Alert condition
- To verify a concerning result from the previous sample
- To develop a trend
- To check for possible oil transfer between two compartments
- To measure carryover from oil changes
- If the scheduled sample did not contain enough oil to perform S·O·S analysis



### Follow-up Questions

Sometimes more information is needed to clarify the S·O·S results. You may see some of the following questions:

- Did you change to a different oil brand and/or viscosity?
- Did you change operators or maintenance personnel?
- Was there a recent field repair made to the machine?
- Have you changed maintenance procedures?
- Were there any changes in the overall job or machine application?

Your S·O·S Analyst will use your feedback to these types of questions, along with sample label information to improve the quality of the S·O·S report.

### Recommendations

S·O·S report recommendations are specifically tailored to the compartment under analysis. Your S·O·S Analyst will evaluate all of the test results and look for correlation between these results. If an area of concern is discovered, your S·O·S Analyst will explain how the test results relate to each other and identify abnormalities. Your S·O·S Analyst may also suggest areas of the compartment to inspect. These inspections will often reveal an early problem, before it becomes a major failure.

# Overview of S·O·S Coolant Report



Diesel engines are designed to operate at higher temperatures and higher energy levels than in the past. Today's heavy-duty diesels produce a tremendous amount of power from a small package. Cooling systems have to absorb more heat with smaller cooling systems and less coolant. A cooling system may also be transferring heat away from turbochargers, transmissions, hydraulic systems and other equipment components. In addition, used coolant disposal requirements have become more stringent and expensive. You may be extending coolant drain intervals, recycling coolants or reconditioning coolants to reduce the disposal costs. For all of these reasons, S·O·S coolant analysis is highly recommended to achieve optimum performance and the full life designed into today's machines and engines. Four types of analysis are performed during coolant testing:

- Coolant Type
- Boil and Freeze Protection
- Coolant Condition
- Coolant Contamination

## Sections of a S·O·S Coolant report:

### Label information

Label information is the data you supply, either by pre-registration or on the sample label. This type of information may include but is not limited to:

- Company name
- Serial number of equipment and compartment
- Equipment and component model
- Equipment manufacturer and component manufacturer
- Equipment hours and component hours
- Equipment number
- Compartment
- Oil hours
- Oil brand
- Oil weight
- Job site
- Notes and miscellaneous information

Label information is used to register your sample into a database. This allows the S·O·S sample history to be displayed on the report. Label information also provides key data needed by our interpreters to make the best recommendations and evaluations of your S·O·S sample.

### Lab Control Number

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### Interpretation

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### S·O·S Results

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### Explanation of Abbreviations

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# Overview of Level 1 S·O·S Coolant Results

## Coolant Type

There are many different coolant choices on the market today. These coolants provide cooling system protection using different chemistries. Your S·O·S Analyst uses label information and color to determine type of coolant. This is one reason it is important to provide as much information on the coolant sample label as possible.

## Boil and Freeze Protection

Ensuring the correct boiling and freezing point is important, no matter what climate the engine or equipment operates. Your S·O·S Analysts use Percent Glycol, Boiling Point and Freezing Point to monitor the ability of the coolant to provide adequate protection.

### Percent Glycol

Glycol is the active ingredient of most engine coolants. Glycol solutions provide these benefits when used in a cooling system:

- Increases the boiling point of the coolant
- Decreases the freezing point of the coolant
- Reduces ability of coolant to cause corrosion wear



Too much or too little glycol will reduce the coolant's ability to provide protection to the cooling system. Heat transfer is affected by glycol concentration. Excessive levels of glycol will reduce heat transfer. Freezing Point and Boiling Point are calculated from Percent Glycol.

## Coolant Condition

Coolant Condition tests consider the health of the coolant. Tests are performed to look at pH, conductivity, nitrite, solids, odor, color and appearance.

### pH

pH is a description of the coolant's acidity or alkalinity. When the coolant pH becomes too acidic (too low), the coolant system may experience increased wear. If the coolant pH is too alkaline (too high), possible coolant contamination has occurred.

### Conductivity

Conductivity is the ability of the coolant to conduct an electrical current. Improper grounding and some marine applications make this an important characteristic to monitor. In addition, conductivity is used to monitor contamination levels of the cooling system.

### Nitrite

Nitrite is a coolant additive that protects piston liners from cavitation erosion and corrosion. Nitrite is destroyed during the process of protection and is an especially key component to monitor for conventional coolants.

### Physical Inspection

Tests like odor, appearance, color, and precipitate are all physical descriptions of the sample. These physical inspections provide information about the general condition of the coolant, and may provide information on contamination.

## Coolant Contamination

Coolant Contamination tests are performed to determine if anything harmful has entered the coolant. This analysis relies on the results from the following tests: pH, conductivity, foam, odor, oil or fuel presence. The S·O·S Services program has guidelines for the level of contamination allowed. Please refer to the earlier description of pH, conductivity and odor.

### Foam

The Foam test evaluates the coolants ability to entrain air. Entrained air reduces the heat transfer ability of coolant. Formation of foam may indicate the coolant has been contaminated or may indicate the defoamants have degraded.

### Oil or Fuel Presence

The presence of oil or fuel will greatly interfere with heat transfer. These contaminants are difficult to clean from cooling system passages. Your S·O·S Analyst may question sampling technique if oil or fuel is detected. Using the same vacuum pump for oil sampling and coolant sampling will contaminate the samples. Oil compartments may indicate coolant contamination and coolant samples will indicate oil contamination. It is important to follow good sampling techniques. See PEGJ0047.

## Level 2 Coolant

Level 2 Coolant Analysis is a more extensive chemical evaluation of the coolant and the overall condition of the cooling system. Level 2 includes Level 1 tests and has additional categories of results like coolant chemistry, cooling system health and water quality.

## S·O·S Services Web

With S·O·S Services Web, it's fast and easy to monitor the effectiveness of your equipment maintenance program. From the opening screen you can view your current sample information by exception or by performing an advanced search by exception, job site, serial number, unit number, status, manufacturer, family, model, or compartment.



Once the information is pulled up, a detailed description of the specific sample is available along with a history of previous samples from that engine or piece of equipment. This data can be used to create graphs for easy trend analysis of one compartment or even across models.

S·O·S Services Web also allows users to create and print out labels by pulling compartment information directly from the database and provides a built in messaging system and actions taken feature that keeps track of activities associated with each sample.

For more information, see your Cat Dealer today or visit [www.CAT.com/sos](http://www.CAT.com/sos).

### View and analyze fluid sample information online – anytime and anywhere

- Access information with an internet browser on your Cat Dealer's website – no additional software required.
- View current data— no waiting for uploads
- Access to oil, coolant, and fuel sample data
- Minimize paper filing and storage, while maintaining the ability to generate and print reports and graphs when needed.

# Working together with the same goal

S-O-S Services are one element of a condition monitoring philosophy that you can put into place with your equipment to monitor the impact of your maintenance program. The S-O-S program combined with regular inspections, analysis of your equipment's site conditions, electronic data, and service history will enable you to evaluate your equipment's health. You can perform a maintenance program on your own, or you can enlist the assistance of your Caterpillar Dealer to perform any level of preventive maintenance that will keep your equipment running at peak performance.

## **CAT® DEALERS DEFINE WORLD-CLASS PRODUCT SUPPORT.**

We offer you the right parts and service solutions, when and where you need them.

The Cat Dealer network of highly trained experts can help you maximize your equipment investment.



PEGJ0046

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TODAY'S WORK. TOMORROW'S WORLD.™