Engine Lube and Hydraulic Oil Analysis Program

The Donaldson oil analysis service provides the quality testing necessary for effective preventive maintenance. Operated by an independent laboratory, Donaldson provides fast, low cost and extremely accurate information about the status of your equipment. The program is based on proven laboratory techniques and covers a wide range of systems and applications.
How Donaldson Oil Analysis Works

The Donaldson oil analysis service includes evaluating the results of the tests we perform and providing detailed reports, including specific maintenance recommendations. You can use our data and recommendations to improve your preventive maintenance, reduce equipment downtime, and reduce your overall cost of lubricants by extending your oil drain intervals.

There are 5 processing steps to the Donaldson oil analysis service:

1. Collect the Sample (Page 5)
   A portion of oil is removed from a machine and sent to our lab. Sampling devices are ordered through your local Donaldson distribution outlet.

2. Complete the Sample Processing Form (Page 6)
   For each piece of equipment to be sampled, a sample processing form must be completed. It is vitally important to inform us of any mechanical work or operating problems with the sampled system. This feedback influences our future recommendations and interpretations. Communication between you and the laboratory is essential for an effective oil analysis program.

3. Label the Sample (Page 7)
   The label on the sampling container should always be filled out completely to assist in our correct identification and analysis of the sample.

4. Send the Sample to Lab (Page 7)
   Always use First Class Mail, UPS, FEDEX, or other commercial delivery service for quick transport of samples. We strongly recommend you do not “hold” samples before mailing them.

5. Review the Results (Page 4)

The Laboratory Report

This is the heart of the program. Each computerized report indicates the results of the current and up to 5 previous samples for a given sampling point—making trending simple—plus comments and maintenance recommendations provided by our trained Data Analysts.

Data Analyst Recommendations

After testing is complete, our experienced Data Analysts evaluate the results and make specific comments about the results, their significance, and recommended maintenance actions.

In all cases, the final decision to follow the recommendations is yours. We have provided you with test results and recommendations, which you can use as a tool to make more accurate maintenance decisions. The effectiveness of this tool is related to the quality of the sample, the information you provide the lab, and your desire to use our service.

Oil Analysis Kits

<table>
<thead>
<tr>
<th>Kit</th>
<th>Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lube</td>
<td>X007374</td>
</tr>
<tr>
<td>OEM Drain</td>
<td>E0A7375</td>
</tr>
<tr>
<td>Extended Drain</td>
<td>E0A7376</td>
</tr>
<tr>
<td>Hydraulic Drain</td>
<td></td>
</tr>
<tr>
<td>Drain Development</td>
<td>E0A7376</td>
</tr>
<tr>
<td>Correct Drain &amp; ISO</td>
<td>X007377</td>
</tr>
</tbody>
</table>

Total Base Number (TBN) determination.
4 Key Report Recommendations

NORMAL
Physical properties are within acceptable limits, and no signs of excessive contamination or wear are present. Keep in mind that it is important to know that component/lubricant conditions are “normal.” This can save you unnecessary maintenance and inspections.

MONITOR
Specific test results are outside acceptable ranges, but are not yet serious enough to justify an “abnormal” status. Caution is advised; the beginning stages of a problem often show the same pattern of results as temporary conditions such as extended usage or high load.

ABNORMAL
Lubricant physical properties, contamination, and/or component wear is clearly unsatisfactory, but not yet critical. A confirming resample should be submitted. Additional diagnostic procedures may be needed to verify each condition. Corrective actions are necessary to prevent reduced service life or overall loss of performance.

CRITICAL
Lubricant physical properties, contamination and/or component wear is clearly serious enough to require immediate diagnostic and corrective maintenance to prevent major long-term loss of performance or failure in service. Increases in operating hazard may occur. Short-term loss of performance may already be present. Large-scale inspections (including physical teardown) and repairs will probably be required. It may be necessary to remove the unit/component from service until a confirming resample is tested and/or diagnostics confirm that inspection/repair is justified.

These assessments are relative and are assigned using both trend analysis and condemning limits.

Lab Contact
There are many reasons for directly contacting the lab. Phone and fax numbers are found on the top of each report.

The lab can quickly access your sample results from your component reference number. This number can be found on the upper right of each report for quick access to your sample results!

Our laboratories divide work into departments, and you can best get information or answers by contacting the lab Data Analyst or Data Entry personnel:

Donaldson’s Independent Test Lab
Analysts, Inc.
2450 Hassell Road
Hoffman Estates, Illinois 60195
(800) 222-0071
FAX (847) 884-8098
www.analystsinc.com

To order kits/sampling supplies, check on the status of an order, inquire about invoicing or billing, or to obtain price quotes or general information on pricing contact your Donaldson sales representative (800-374-1374).

Ways to Improve the Accuracy of your Oil Evaluations

The accuracy of our evaluations is verified by comparing the lab test result-based predictions with actual conditions confirmed by inspection. In this way, our interpretations are continually refined by practical experience.

When any of these situations occur, notifying the lab will improve your analysis report. These items may be noted on the sample processing form, in the block marked “Comments.”

• Lubricant or component conditions that you suspect are present;
• The findings of any inspection, especially those performed as a result of oil analysis program recommendations;
• Lubricant or component conditions discovered that were not previously indicated by oil analysis;
• Notification of servicing and maintenance performed.

If you have specific questions about evaluations, the significance of tests, and overall technical aspects of your oil analysis program ask to speak to a Data Analyst.

If you have questions about the status of a sample you have sent, want to update/change report distribution or clerical info such as unit ID’s, makes and models, or to obtain reprints of analysis reports ask for a Data Entry person.
Reviewing the Lab Report

The summary below shows the basic layout of our routine oil analysis report. As each report is printed, the address/phone number for that particular lab is also printed at the top center of the form.

**SECTION A**
In Section A you will see the date when the oil sample was drawn and its status. You will also find the unit ID number along with the name of the component being sampled. The Component Reference Number is assigned by our system for quick access to your results. Just below the Component Reference Number is your purchase order or accounting number.

**SECTION B**
Section B lists specific information about the unit and component sampled; the worksite or location, and the oil type in service.

**SECTION C**
This portion of the report is where our Data Analysts make their evaluations and recommendations. This evaluation is based on the specific tests performed on the individual samples and the information provided by you about the sample and the sampled system.

**SECTION D**
The Spectrochemical Analysis section identifies and reports 21 metallic elements from the atomic emission spectrometer. These elements provide a positive means of identifying wear, contamination and additive content. This section also documents the date when each sample was drawn, and shows the lab ID number we assigned to each sample.

**SECTION E**
Section E consists of unit operating information provided by you.

**SECTION F**
Section F lists the Physical Test Results, a series of related tests run to determine the classification, contamination and degradation of a lubricant.

**Features of the Report:**
- Up to 6 sets of test results (current and 5 previous) displayed
- Spectrochemical and Physical results underlined where applicable
- Full headings for all results
- Guide to tests and their meaning on back of the report

This form is also used for Donaldson Endurance® oil analysis.
Collecting the Sample

Obtaining a representative sample is the most important part of a scheduled oil analysis program. If a sample does not represent the true condition of the lubricant and component at the time of sampling, the reliability of the test results and their interpretation is dramatically affected.

General comments on sampling

- **Areas where lube flow is restricted or where contaminants and wear products tend to settle/collect should be avoided as sampling points.**
- **We recommend that you sample a component while it is running (if it is safe to do so) or within 30 minutes after shutdown.**
- **Both of these practices ensure that wear products and lubricant contaminants are thoroughly mixed with the lubricant and that the heavier wear particles have not settled out.**

Recommended sampling points:

- **A QSS™ (Quick Sampling System) sampling valve or petcock installed PRIOR to the oil filter.** To insure safety, the QSS valve must not be installed in an area of the oil system that is exposed to pressures greater than 35 psi/241 kPa.
- **The sump or reservoir drain**

NOTE: Once a proper sampling point and method is chosen for a particular component, oil samples from that component should always be taken from the same point with the same method.

Vacuum pump sampling

Recommended Sampling Frequency

<table>
<thead>
<tr>
<th>Unit Type</th>
<th>Regular Use</th>
<th>Intermittent Use</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mobile Equipment On-Road</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diesel Engines</td>
<td>10,000 miles / oil change</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Gasoline / LPG Engines</td>
<td>3,000 miles / oil change</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Non-Engines</td>
<td>20,000 miles / 500 hours</td>
<td>Quarterly</td>
</tr>
<tr>
<td><strong>Mobile Equipment Off-Road</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diesel Engines</td>
<td>250 hours / oil change</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Gasoline / LPG Engines</td>
<td>150 hours / oil change</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Non-Engines</td>
<td>500 hours / monthly</td>
<td>Quarterly</td>
</tr>
<tr>
<td><strong>Marine</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main Engines</td>
<td>250 hours / monthly</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Support Engines</td>
<td>150 hours / oil change</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Non-Engines</td>
<td>500 hours / monthly</td>
<td>Quarterly</td>
</tr>
<tr>
<td><strong>Industrial / Stationary</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diesel / Nat Gas Engines</td>
<td>500 hours / monthly</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Gas Turbines</td>
<td>250 hours / monthly</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Compressors, Steam Turbines</td>
<td>250 hours / monthly</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Geared Drives, Bearings</td>
<td>500 hours / monthly</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Hydraulics</td>
<td>500 hours / monthly</td>
<td>Quarterly</td>
</tr>
</tbody>
</table>

QSS™ and Bellows® are registered trademarks for Analysts, Inc. sampling devices
Complete the Sample Processing Form

The sample processing form follows the general layout shown below. Please refer to the instructions for each area. One original form should be sent in with each sample. We use the form for proof of payment (prepaid analysis), to obtain important information from you, and to track each sample throughout the lab.

Area 1: Sample Submitted by (Return Address)
This is the MAIN address/person who will receive the report and phone/fax contact for critical results or questions. If this information is incomplete, there may be difficulty returning your results or contacting you. In this area, please fill out the complete return mailing address for the analysis report, including attention name, and phone number for that person.

Area 2: Comments
This area is reserved for you to write any information you want us to make note of or add to the data returned on your analysis report. Examples of “Comments” include maintenance/servicing feedback, abnormal performance, abnormal conditions suspected or found, etc.

Area 3: Unit/Component ID
In this area, you must provide two unique reference identifications for us to file your results under:
1 - UNIT NUMBER -- your ID for an entire functional machine
2 - COMPONENT SAMPLED -- the ID for the oil-wetted system from which the sample was drawn (engine, transmission, etc.)

Each sampled component may have its own unit number (industrial applications), or several components may fall under one unit number (engine, transmission, etc. from one vehicle/unit).

Once this ID is established (at the first sample), you must provide it exactly the same way for any future samples from that sampling point.

Area 4: Operating Data
Please record here the machine operating data we need to accurately evaluate your results. This information includes:
1 - Hours or miles of component use between the time the oil was last changed and when the sample was taken;
2 - Hours or miles of use since the sampled component was first used, or since the last major rebuild/overhaul;
3 - The calendar date on which the sample was taken;
4 - The amount of oil added to maintain a correct oil fill level;
5 - What oil/filter servicing was done at sampling.

Area 5: Unit/Component Supporting Data
This information is essential to an accurate analysis. Please complete:
1 - Machine manufacturer and model information;
2 - The manufacturer, product name, and SAE or ISO viscosity grade for the oil that was sampled;
3 - Other descriptions that help us reference specific engineering data supporting your analysis.

Please note that Area 5 should only be completed for new units/components or if the data is incomplete/incorrect.
Label Sample

The sample label is used to help you identify samples immediately after you take them, and to help us identify samples in the lab. If the sample processing form is missing or incorrect, or if the sample is separated from the form, a fully completed label is essential. The label is found on the top of the sampling bottle.

NOTE: Please make sure you print legibly, and use a pen with indelible ink.

Send the Sample

You should send your sample(s) as soon as possible after they are taken. The oil samples do not “break down,” but any long delay between sampling and analysis can be crucial if a unit is failing. Once the sample reaches the lab, we will process it within 24 hours. You will be notified by phone or fax if critical conditions are present.

If you take several samples within a short time, use the cardboard 10 Pak shipping container the mailers came in to send the samples back to the lab. This will save postage, but you should always consider the impact of the turnaround delay if you wait to ship in units of 10.

First Class (and lower) U.S. Mail may be too slow (up to 4 days in some parts of the country) for the best turnaround. Use FedEx, UPS, or other rapid mail system for the fastest receipt and tracking in case of lost or misrouted samples.

Mark the form “RUSH” and write “RUSH” on the outer mailing label if immediate attention is needed. There may be an extra charge for rush handling; consult your local lab for details.

Spectrochemical Analysis

Selected metallic elements present in the form of microscopic particles are identified and reported as parts per million (ppm) by weight on an atomic emission spectrometer. These elements provide the means for monitoring wear elements, corrosion, debris, airborne contaminants, coolant additives, and metallic oil additives. Interpretation of results should be made by a trained and qualified Data Analyst.

Wear Particles

The source of these elements, either individually or in combination, as in an alloy, will vary with the manufacturer and type of system analyzed. Wear analysis is most effectively applied when a series of samples from a component are evaluated on a routine basis for “trend analysis.”

Airborne Contaminants

Silicon, present as silica dioxide (sand) is the most common and dominant element within airborne contaminants. New oil reference samples are required for effective evaluations since silicon may also be present due to oil or coolant additives, sealants, and/or other sources.

Coolant Indicators

Antifreezes and coolants are formulated with many different combinations of additives and inhibitors. In the event of a coolant leak, these trace elements will remain present in the lubricant even when the water has been evaporated by operating temperatures. Coolant reference samples are required to identify each specific formulation.

Metallic Additives

Lubricating oils are formulated with many different types of “additive packages” to fulfill the operational requirements of equipment and the manufacturer’s specifications. These packages may include metallic compounds such as anti-oxidants, anti-foaming agents, dispersants, detergents, and/or solid film lubricants.
**Glossary of Terms**

The following is furnished as an aide for understanding the terminology and application of routine oil analysis as provided by our independent lab: Analysts, Inc.

**Fuel Dilution (% by volume)**
The amount of unburned fuel present in a sample of crankcase oil. High fuel dilution is generally caused by excessive idling, improper adjustment, and/or faulty components within the fuel delivery system.

**Fuel Soot (% mass)**
An accurate measurement of the dispersed fuel soot present. Performed by Light Extinction Measurement (LEM) and reported as % mass, soot levels are indicative of air/fuel ratios, fuel delivery and valve settings, and combustion/exhaust efficiency. The state of the fuel soot depicts dispersant additive effectiveness.

**Infrared Analysis**
Organic compounds present in lubricating oils will absorb infrared light at specific frequencies. The most common frequencies measured in oil analysis indicate fuel soot, oxidation, nitration, water and glycol. Reference (new oil) samples are required for effective determination and interpretation.
- Fuel Soot is a relative measure of the insoluble carbon present in the lubricant which is applied to evaluating combustion efficiency.
- Oxidation is the degradation of oil when molecules chemically combine with oxygen. Oxidation is part of the normal aging process which can be accelerated by increased temperature and the presence of acids. Oxidation increases viscosity and contributes to sludge and varnish deposits.
- Nitration, in the form of nitrogen oxides, is formed during the combustion process and when combined with moisture forms nitrous acid. Nitration is indicative of ring blow-by, can be corrosive, and contributes to oxidation and increased viscosity.
- Water is measured and reported as percent by volume.
- Glycol. Appraised for the presence of glycol based coolant and reported as Positive or Negative.

**Water (% by volume)**
The amount of water suspended in a lubricant can be detected at levels as low as 0.05% by volume. This test is performed by the hot plate “crackle” method. Water content is evaluated in conjunction with other related tests for identification (fresh, salt, coolant, etc.) as well as probable source.

**Water (parts per million by weight)**
The amount of water suspended in a lubricant as measured by the Karl Fischer titration method and expressed in parts per million (ppm) by weight. This method measures water levels down to 1 ppm and is generally applied to fluids from systems which have a low water tolerance or low water requirements (refrigeration compressors, hydraulic systems, turbine oils, etc.).

**Viscosity**
The measurement of a fluid’s resistance to flow at a given temperature in relation to time. Viscosity measurements are used to determine a fluid’s classification by grade, and may indicate level of dilution, shearing, oxidation, and/or product contamination.

**Neutralization Number**
A number expressed in milligrams of reagent required to neutralize one gram of lubricant. The neutralization number is measured and reported as either a Total Acid Number (TAN) or Total Base Number (TBN), depending on the lubricant and application.
- Total Acid Number (TAN) is a measure of the total amount of acid products present in the lubricant. Generally, an increase in TAN above that of the new product is an indication of contamination by an acidic product or the result of oil oxidation.
- Total Base Number (TBN) is a measure of the alkalinity remaining in a lubricant. A relatively low TBN, or a decrease in TBN compared to the new product, indicates low acid neutralizing characteristics or a depleted additive package.

**Particle Count**
A numerical count of particles present in a lubricant which are measured within specific particle size ranges. This test is generally associated with fluids which require the controlled filtration of particles 50 microns or less in size (e.g. hydraulic systems).