petroleum

technologies group LLC

4665 Broadmoor Ave SE Ste# 150
Grand Rapids MI 49512
customerservice@oil-lab.com
P (616) 698-9399

TABLE OF CONTENTS

Testing Solutions For The Future

BASICS OF FLUID ANALYSIS

INTRODUCTION

For many years, fluid inspection and testing has been used to help diagnose the internal condition of components and to provide valuable information about the components serviceability. The first test methods used for this purpose included such simple procedures as smelling used fluids for the sour odor of excess acid, checking visually for obvious signs of contamination or placing a small drop of sample on absorbent paper to detect contaminates and monitor additive effectiveness.

Modern day analysis is built on these early efforts. The importance of using a combination of physical and spectrochemical tests to monitor fluid and component conditions is not universally accepted. Fluid analysis test procedures are established and reviewed by such agencies as the International Standards Organization, the American Society of Testing Materials and the Society of Automotive Engineers. Today, little doubt remains that a comprehensive fluid analysis program is a very valuable tool.

WHY USE FLUID ANALYSIS?

Fluid analysis makes it possible to literally look inside an engine, transmission or hydraulic system. By monitoring the fluid, its condition and the presence of contaminates, an fluid analysis user can anticipate problems, monitor system wear and repair problems before they become catastrophic.

Some of the specific uses of oil analysis include:

- Noting progressive wear in order to repair damaged parts before they become emergency break-downs
- Detection of corrosive acids, coolant, fuel dilution and other oil conditions which are caused by engine problems that could become major failures
- Planning of needed repairs based upon the noted progression of an abnormal wear pattern, which can lead to more effective equipment utilization and fewer emergency repairs
- Oil Analysis provides useful records when handling warranty problems, resale of equipment, detection of abuse and evaluation of new oils, oil filters and air filters

WHAT DOES FLUID ANALYSIS MEASURE?

Fluid analysis tests a sample taken from your equipment after shut down and three different types of testing are done on the sample:

- Physical and chemical testing, which measures problems such as carbon build up or silica dirt
- Elemental analysis, which measures the presence of even the most microscopic particles of metals, can determine whether component wear rates are taking place at an abnormal rate
- Infra-Red or IC testing is performed on the sample to determine the condition of the advanced properties. This test can help to determine if the service intervals are at the proper length for the equipment and conditions of usage

FLUID ANALYSIS PROGRAM

A superior program of fluid analysis is a vital part of today's good maintenance. Analysis programs detect internal engine parts that are wearing at abnormal rates, whether additive packages are breaking down and finally they measure the physical condition of the fluid and the levels of contamination. Fluid analysis programs are vital to a strong preventative maintenance program.

TREND FLUID ANALYSIS

All fluid analysis programs are designed to be performed as a trend analysis. This is a regularly scheduled set of samples over a span of time. A trend is a unique history of what is happening to a unit within its specific application. To establish a trend, at least three samples are needed. With waiting until there is an indication of a problem to use fluid analysis the true value and purpose has been lost. Establishing a trend will give an early alert so that corrective action can be taken to prevent a major failure.

HOW TO:

Establish and maintain a successful fluid analysis program

1. Establish goals and metrics
2. Obtain management commitment
3. Train and educate personnel
4. Identify equipment and sample frequencies.
5. Implement the program
6. Respond to analysis results
7. Measure program results versus goals and metrics
8. Review and modify program
9. Document savings

WHAT & WHEN TO TEST?

Determine WHAT to sample - Consider these 4 general factors listed below when selecting equipment for the program, and refer to your OEM manual for guidance on recommended sample frequency.

Operating Environment	Fluid & Equipment Age Factor	Target Sample Results	Economic Impact of Failure
* High dirt/dust enviroment	* Hours/miles/kilometers since last change	* Above control limits	* Safety risk
* High loads/pressures/speeds	* Hours/miles/kilometers on unit	* Within control limits	* Operational criticality
* High temperatures	* Oxidation, contamination		* Repair cost
* Low temperatures	* Synthetic, premium, mineral		* Downtime cost
* Chemical contamination	* Rated life expectancy		* Spare unit
* Wet environment	* Make and model number		

Determine WHEN to sample - A regular pattern of sampling will establish a credible historical trend of equipment performance. If you don't have OEM-recommended smaple interval guidelines, refer to the table below for general guidance in establishing intial sample frequency.

Lubricating Oils

Industrial/ Plant Equipment		Off-Highway Equipment		On-Highway Equipment	
* Landfill Gas Engine	250 Hours	* Diesel Engine	250 Hours	* Diesel Engine	25,000km or 15,000mi
* Generator Engine	500 Hours	* Wheel Motor	250 Hours	* Transmission	500hrs, 40,000km or 25,000mi
* Natural Gas Engine	500 Hours	* Differential/Gear	500 Hours	* Hydraulic Systems	500hrs, 40,000km or 25,000mi
* Paper Machine Systems	Monthly	* Hydraulic Systems	500 Hours		
* Turbine	Monthly	* Transmission	500 Hours		
* Compressor	3 Months	* Final Drive	1,000 Hours		
* Gear Drive	3 Months				
* Hydraulic Systems	3 Months				

Coolants/Antifreezes

Conventional Coolants	Extended Life Coolants	Hybrid Coolants
* 120,500 Km or 75,000 Mi	* 475,500 Km or 300,000 Mi	* 240,500 Km or 150,000 Mi
* 2500 Hrs	* 4000 Hrs	* 3000 Hrs
* Quarterly	* Yearly	* Bi-Yearly

HOW TO TEST: REFERENCE SAMPLE

Ensuring Health and Safety conditions

Always observe safety rules. Take particular care with high-pressure piping and thermal systems and any sampling close to electrical equipment or when sampling from a drain line. If in doubt, please contact your Supervisor.

Drawing a sample with a sample pump

1. Using a sample bottle; remove the cap and screw into the pump body.
2. Using a new length of tube for each sample, push the tube through the top of the pump until it appears half way down the sample bottle. Please make sure to tighten the thumbscrew to secure the tube.
3. Place the end of the tube into the sampling point.
4. Ensure that the sample bottle is vertical throughout the sampling operation and that it is not overfilled.
5. Unscrew the bottle and immediately screw on the cap to avoid any contamination.
6. Complete the sample information card and send the sample and sample information card to the laboratory.

Sampling from circulation systems

For circulating systems one of the best sampling locations is a live zone upstream of filters where contaminants and wear debris are the most concentrated. Usually, this means sampling from fluid return lines or drain lines. For systems where oil drains back to a sump without being directed through a line (such as engines), draw from the pressure line down-stream of the pump (before the filter). Permanent sampling points should be at elbows in pipe runs in preference to straight sections. This will help to ensure that the flow regime at the sample point is turbulent and that wear and contaminant particles do not 'drop out' of suspension.

Sampling from reservoirs, sumps and tanks

Avoid sampling from dead zones of static tanks and reservoirs. In particular, sampling from the bottoms of sumps should be avoided because the wear debris and contaminants collected are likely to be the results of build up over time and may not represent current operating conditions. The sample point should be near the mid-point between the surface of the oil and the floor of the tank/sump and away from walls.

Why correct oil sampling is important

Most lubricant condition monitoring services use an oil sample of only 100ml(3 oz) to represent a system that may hold hundreds or thousands of liters of oil. The importance of taking a representative sample cannot be over-emphasized. From the very first sample you begin investing in a valuable condition monitoring program. But this will only be achieved if every sample contributes to building an accurate history from which trends in wear, contamination, and degradation can be determined.

Ensuring the quality of the sample

We recommend a consistent method of taking a sample. Always take the sample at the same point, in the same way and after the same amount of time. For example, if you previously took the sample half an hour after the machine has been started, please make sure that the next sample is taken half an hour after the start of the machine as well. We recommend that you sample a component while it is running (if it is safe to do so) or within 30 minutes after shutdown. Always keep in mind to refrain from sampling right after a large volume of lubricant has been added. Always be sure to draw sufficient of the sample to fill the bottle. 80% full is a good level to aim for as this will ensure that there is adequate sample to complete all tests.

Avoiding contamination of the sample

Areas where lubricant flow is restricted or where contaminants and wear products tend to settle/collect should be avoided as sampling points. Always take the sample in the most hygienic of conditions. In this way, you can avoid contaminating the sample, which could lead to an incorrect analysis. Always use the right sampling equipment and the bottles supplied and make sure that they are unopened, unused and clean. Always clean the sampling kit immediately after use. After taking the samples, check to make sure that the bottles are tightly closed. It is important that the gun/bottle assembly is kept upright while in use to prevent oil entering the gun. Should this occur, disassemble it immediately and flush thoroughly with mineral spirit or kerosene. Dry before reassembling. DO NOT FLUSH GUN WITH DIESEL FUEL OR DEGREASING FLUID.

Eng-001: Basic Lubrication Test

Viscosity @ 40°C or 100°C	ASTM D445
Trace Elements (18)	ASTM D5185
Water content	FTIR E2412
Glycol	FTIR E2412
Fuel Dilution	FTIR E2412
Soot content	FTIR E2412
Oxidation / Nitration	FTIR E2412

NGas-002: Gas Engine Oils Test

Viscosity @ 40°C or 100°C	ASTM D445
Trace Elements (18)	ASTM D5185
Water content	FTIR E2412
Glycol	FTIR E2412
Fuel Dilution	FTIR E2412
Soot content	FTIR E2412
Oxidation / Nitration	FTIR E2412
Acid Number	ASTM D664

IndPC-004: Advanced Industrial Oil Test

Viscosity @ 40°C or 100°C	ASTM D445
Trace Elements (18)	ASTM D5185
Water content	Karl Fischer
Oxidation / Nitration	FTIR E2412
Acid Number	ASTM D664
Particle Count	ISO 4406/ ISO 11500

Cool-002: Advanced Coolant Test

Trace Elements (14)	ASTM D6130
Freeze/Boil Point	Internal Meth.
Glycol %	Internal Meth.
Ion Chrom (Acids & Chloride)	ASTM D5827
SCA Number	Field Kit
Visuals (Color, Oil, Fuel)	Internal Meth.
Total Solids	Meter Meas.
Specific Conductance	Meter Meas.
pH Waters	ASTM D5827

***** Kits Listed Above are Frequently Ordered *****

Specific testing is available - Consult an Agent to find whats right for you!

HOW TO:

Obtain sample kits

1. By Phone - 1.800.262.3817
2. By Email - customerservice@oil-lab.com
3. Website - www.oil-lab.com/contact

Petroleum Technologies

NITRATION
This reading indicates the nitrate acids building up in the system. The condemning limit for nitration, as expressed on our report is at 75% of allowable. This is converted directly from the FTIR scan. Maximum is generally set at 35 a/cm

OXIDATION
The condemning limit for oxidation, as expressed on our report is at 75% of allowable. The is converted directly from the FTIR scan. Maximum is generally set at 35 a/cm.

SULFATION
This reading indicates the sulfur acids building up in the system. The condemning limit for sulfation, as expressed on our report is at 75% of allowable. This is converted directly from the FTIR scan. Maximum is generally set at 35 a/cm.

WATER
The general limitation for water is .3%.

ANTIFREEZE
The limit for antifreeze is any trace amount. There should never be any amount of antifreeze present in the oil.

VISCOSITY
The limit for viscosity is an increase or decrease of one grade.

FUEL DILUTION
The limit for excessive fuel in the oil is 3.0%. Inter-city trucks or equipment that idle more may reach higher than 3% and would be based on trend. This limit can be different depending on the EPA emission year of the engine and OEM guidelines.

SOOT
The limit for soot is 5% by volume generally. These are combustion products in the sample. This limit can be different depending on the EPA emission year of the engine and OEM guidelines.

WEAR METALS
Limits are established by trend over a number of samples. There are general guidelines that OEM's have made public but will change depending on application. See table below.

General Engine Wear Rates

EQUIPMENT TYPE	Silicon (Si)	Iron (Fe)	Chromium (Cr)	Nickel (Ni)	Aluminum (Al)	Tin (Sn)	Copper (Cu)	Lead (Pb)
GENERAL	>15	>125	>10	>10	>15	>15	>35	>35
INTERNATIONAL	>15	>100	>15	>10	>15	>10	>40	>30
CATERPILLER	>15	>100	>10	>10	>15	>10	>30	>30
DETROIT	>15	>150	>10	>10	>15	>10	>30	>30
CUMMINS	>15	>80	>5	>10	>15	>10	>30	>30
MACK, PERKINS	>15	>150	>10	>10	>15	>10	>30	>30
GMC	>15	>150	>20	>10	>30	>20	>50	>50

NOTE: All of the information above is typical for diesel engines described above. These are only guidelines and the wear rates for a particular engine should be determined by a trend established from a number of samples on that engine or the OEM.

NITRATION / SULFATION / OXIDATION
This reading indicates the acids building up in the system. The condemning limit for nitration, as expressed on our report is at 75% of allowable. This is converted directly from the FTIR scan. Maximum is generally set at 20 a/cm.

ANTIFREEZE
The limit for antifreeze is any trace amount. There should never be any amount of antifreeze present in the oil with the exception of Glycol based oils.

WATER
The general limitation for water is .3%. Exception: Turbine limit is .1%

PARTICLE COUNT
The limit is determined by the manufacturer of the system or equipment and usually will be determined by the type of pump, valves and pressures in the system.

ADDITIVE METALS
These metals are usually Zinc, Calcium, phosphorus, etc. The limits are determined by knowing the new oils starting point and using a 25% drop in levels as condemning limits.

WEAR METALS
Limits are established by trend over a number of samples. There are general guidelines that OEM's have made public but will change depending on application. See table below.

General Hydraulic Wear Rates

EQUIPMENT TYPE	Silicon (Si)	Iron (Fe)	Chromium (Cr)	Nickel (Ni)	Aluminum (Al)	Tin (Sn)	Copper (Cu)	Lead (Pb)
GEAR BOX	>50	>500	>20	>10	>25	>20	>50	>50
HYDRAULICS	>15	>30	>5	>10	>15	>10	>25	>15

Typical Hydraulic Component Requirements

TARGET CLASS	EQUIPMENT TYPE
ISO 15/14/11	Servo Control Valves
ISO 17/16/13	Vane and Piston Pumps
ISO 17/16/13	Directional and Pressure Control Valves
ISO 18/17/14	Gear Pumps
ISO 19/18/15	Flow Control Valves and Cylinders

Suggested Contamination Levels for Various Hydraulic Systems

TARGET CLASS	SENSITIVITY	SYSTEM
14/13/9	Very Critical	Silt sensitive control systems. Laboratory or Aerospace.
16/15/11	Critical	High performance servo and high pressure systems.
17/16/13	Very Important	High quality systems. General machine requirements
19/18/14	Important	General machinery and mobile systems. Medium pressure and medium capacity.
20/19/15	Average	Low pressure industrial systems.
22/21/17	Main Protection	Low pressure with large clearances.

NOTE: All of the information above is typical for hydraulic systems described above. These are only guidelines and the wear rates for a particular application should be determined by a trend established from a number of samples on that system or OEM standards.

TYPICAL CORROSION
Corrosion occurs when the buffers are no longer able to balance out the acid formation due to thermal degradation. (Iron, aluminum, copper, lead)

CORROSION INHIBITORS
Inhibitors are present in coolants for metal protection and pH control. Inhibitors presents are dependant upon the formulation for the product.

CONTAMINATION
Calcium and Magnesium are contaminates that are found in most coolants causing scale build up. This causes localized heating.

NITRITES
This is present in most formulations of coolants. Some include a combination of nitrite and molybdenum. The maximum acceptable level by itself or in combination is 3200 ppm. Higher levels can lead to solder corrosion.

pH LEVELS
An adequate pH range should remain between 8.0-11.0 for conventional coolants. 7.0-9.5 for extended life coolants. Proper pH levels are necessary for optimum corrosion inhibitor performance.

WEAR METALS
Limits are established by trend over a number of samples. There are general guidelines that OEM's have made public but will change depending on application. See table below.

General Coolant Wear Limits

EQUIPMENT TYPE	Aluminum (Al)	Copper (Cu)	Iron (Fe)	Lead (Pb)	Tin (Sn)	Zinc (Zn)
General	>14	>14	>24	>24	>24	>24

Typical Inhibitor & Glycol Limits

Element	Minimum	Maximum	Normal Range	Ideal
pH	8.0	11.0	8.0 - 11.0	9.5
Glycol %	45%	65%	45 - 65%	50%
Conductivity	0	7,000	<6,000	4,500
Nitrite **	1,000	3,200	1,200 - 2,600	2,000
Nitrite ***	350	3200 (comb)	1,200 - 2,600 (comb)	2000 (comb)
Molybdenum ***	430			
Silicate	50	250	100 - 250	150

** Applies to coolants containing only Nitrite formulation.
*** Applies to coolants containing Nitrate and Molybdenum in the formulation.

NOTE: All of the information above is typical for hydraulic systems described above. These are only guidelines and the wear rates for a particular application should be determined by a trend established from a number of samples on that system or OEM standards.

Testing Solutions For The Future

Petroleum Technologies Group LLC
4665 Broadmoor Ave SE Ste# 150
Grand Rapids MI 49512
customerservice@oil-lab.com
P (616) 698-9399