

FLUID ANALYSIS PROGRAM USER GUIDE

LUBEWATCH®



LubeWatch®



Quality Fluid Analysis Can Help Extend Equipment Life

The LubeWatch® Fluid Analysis Program is a diagnostic, preventive maintenance tool that uses fluid analysis to monitor and evaluate lubricant and equipment condition in all types of mobile and industrial applications.

Lubricants are the “lifeblood” of machines and equipment. Routine testing and analysis can show you how the condition of the lubricant can affect equipment performance and reliability. Imagine being able to see exactly what’s happening inside an engine, a gearbox or hydraulic system. Problems can be found before they become failures, and less unscheduled downtime means increased production and profitability.

What the LubeWatch Fluid Analysis Program Can Do For You

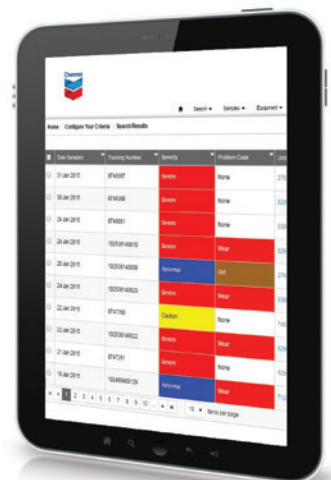
- **Identify minor problems before they become major failures** by monitoring trends in wear and contamination to prevent catastrophic failure
- **Reduce labor costs** by only performing fluid changes when test results require it
- **Extend equipment life** by monitoring system cleanliness helps reduce repair and replacement costs and helps enable you to keep equipment longer
- **Maximize asset reliability** by scheduling downtime according to your schedule to eliminate unforeseen decreased production



LUBEWATCH CAN HELP EXTEND THE LIFE OF YOUR EQUIPMENT

Reach a new level of reliability with the LubeWatch Fluid Analysis Program User Guide. The combination of using LubeWatch with our targeted services, allows our Chevron specialists to design a lubrication plan that works in sync to help your equipment continue to operate under demanding conditions.

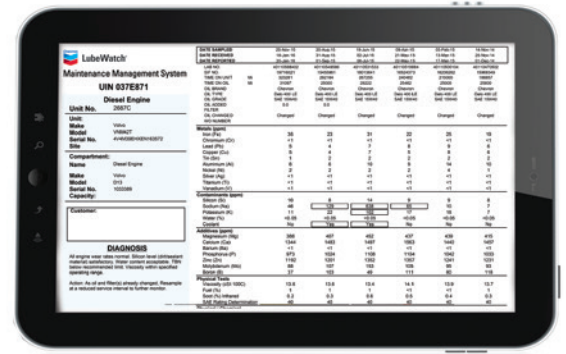
To learn more, contact your marketer.



LubeWatch® Fluid Analysis Program Services

ALS has provided oil, engine coolant, fuel and metalworking fluids testing services to the LubeWatch Fluid Analysis Program since August 1994. ALS offers a full slate of testing capabilities and standardized packages designed for the specific needs of Chevron customers.

In addition to the LubeWatch packages listed below, ALS provides fluid analysis packages designed to meet or exceed customer expectations and over 150 different specialized ASTM methodologies that cover any combination of conditions, fluids and applications.



Customer Service

Kits and other supplies can be ordered for approved Chevron Marketers and Direct Accounts through the LubeWatch designated customer service phone number (800-LUBE-808), or by contacting customer service at any of our North American laboratories listed below.

Atlanta, Georgia

5300 Oakbrook Pkwy #245,
Norcross, GA 30093
T +1 800 394 3669
csr.atlanta@alstribology.com

Cleveland, Ohio

6180 Halle Dr., Suite D
Valley View, OH 44125
800.726.5400
csr.cleveland@alstribology.com

Kansas City, Kansas

935 Sunshine Rd.
Kansas City, KS 66115
800.332.8055
csr.kansascity@alstribology.com

Phoenix, Arizona

3319 West Earll Dr.
Phoenix, AZ 85017
800.445.7930
csr.phoenix@alstribology.com

Portland, Oregon

4943 NW Front Ave.
Portland, OR 97210
800.770.4128
csr.portland@alstribology.com

Burlington, Ontario (Canada)

5036 South Service Rd.
Burlington, ON L7L 5Y7
Canada
877.732.9559
csr.burlington@alstribology.com

Edmonton, Alberta (Canada)

9450 17th Ave. NW
Edmonton, AB T6N 1M9
Canada
888.489.0057
csr.edmonton@alstribology.com

ALS offers a unique combination of testing and analytical solutions. Tribology operations in North America provide comprehensive oil, fuel, engine coolant and metalworking fluids testing services. With the largest independent laboratory network in North America, ALS has a customer base of over 14,000 throughout the United States, Canada and Mexico, including many Fortune 500 corporations. Our dedication to the highest levels of customer service and excellence is unmatched in the industry.

ALS has over 15,000 staff, operates over 350 laboratories in 65 countries and is one of the largest independent analytical groups in the world providing fluids analysis, minerals, coal, environmental and nondestructive testing services. As one of the world's most diversified testing services providers, ALS has sites strategically located to provide accurate and timely services. The company has teams of experts around the world available to provide specialized business solutions that align with client needs. Major hub facilities are located in Australia, Asia, North America, South America, Europe, the Middle East and Africa.



BASIC & DIESEL ENGINE TEST PACKAGES

Test Description	Test Method	C1 Basic Lubrication	C2 Diesel Crankcase	C2AN Diesel Crankcase	Delo 600 ADF Diesel Crankcase
Viscosity @ 40 C or 100 C	D445	• 40 C or 100 C	• 100 C	• 100 C	• 100 C Plus VI
Elemental Metals by ICP	D5185	•	•	•	•
% Water by Crackle	Crackle Test	•	•	•	•
Water by Karl Fischer	D6304C				
% Fuel Dilution	D7593/D3524		•	•	•
% Fuel Soot	E2412		•	•	•
Oxidation	E2412		•	•	•
Nitration	E2412		•	•	•
Acid Number (AN)	D664			•	•
Base Number (BN)	D4739		•		
Particle Count w/ ISO Rating	ISO4406/11171	Optional Add-On	Opt Add-On Unused	Opt Add-On Unused	Opt Add-On Unused
Initial pH	D7946				•
Water Separability	D1401	Optional Add-On			
Foam (Seq I, II, III)	D892	Optional Add-On	Optional Add-On	Optional Add-On	Optional Add-On
Oxidation Stability by Rotating Pressure Vessel (RPVOT)	D2272	Optional Add-On			
Micro Patch Photo		Optional Add-On	Optional Add-On	Optional Add-On	Optional Add-On
Membrane Patch Colorimetry	D7843	Optional Add-On			
Analytical Ferrography	D7690	Optional Add-On	Optional Add-On	Optional Add-On	Optional Add-On
Particle Quantifier		Optional Add-On	Optional Add-On	Optional Add-On	Optional Add-On
Applications & Notes		Not recommended for engine applications or critical industrial systems. Limited data for trending analysis	Diesel, Dual Fuel & Gasoline Engines. Not recommended for drive train components, hydraulics or industrial applications. Particle count only available on new lubricant	Diesel, Dual Fuel & Gasoline Engines using CK-4/ FA4 Oils. Not recommended for drive train components, hydraulics or industrial applications. Particle count only available on new lubricant	Diesel Engines on Delo 600 ADF Only . Not recommended for drive train components, hydraulics or industrial applications. Particle count only available on new lubricant

ADVANCED NATURAL GAS ENGINE FLUID AND INDUSTRIAL FLUID PACKAGES

Test Description	Test Method	C3 Natural Gas Engines & Comp	C4 & C4PC Industrial & Drive Trains	C5 Metal Working	C6 Turbines
Viscosity @ 40 C or 100 C	D445	• 40 C or 100 C	• 40 C	• 40 C	• 40 C
Elemental Metals by ICP	D5185	•	•	•	•
% Water by Crackle	Crackle Test	•	•		
Water by Karl Fischer	D6304C	If H2O Detected	If H2O Detected	•	•
% Fuel Dilution	D7593/D3524				
% Fuel Soot	E2412				
Oxidation	E2412	•	•		•
Nitration	E2412	•			•
Acid Number (AN)	D664	•	•		•
Base Number (BN)	D4739				
Particle Count w/ ISO Rating	ISO4406/ 11171	Optional Add-On	Included on C4PC		•
Initial pH	D7946	•			
Water Separability	D1401		Optional Add-On		•
Foam (Seq I, II, III)	D892		Optional Add-On		Optional Add-On
Oxidation Stability by Rotating Pressure Vessel (RPVOT)	D2272		Optional Add-On		•
Micro Patch Photo		Optional Add-On	Optional Add-On		Optional Add-On
Membrane Patch Colorimetry	D7843		Optional Add-On		Optional Add-On
Analytical Ferrography	D7690	Optional Add-On	Optional Add-On		Optional Add-On
Particle Quantifier		Optional Add-On	Optional Add-On		Optional Add-On
Chlorine	D5384			•	
Sulfur	D4951			•	
Fat%				•	
Applications & Notes		Natural Gas Engines and Associated Compressors	Industrial applications including hydraulics, gearboxes, circulating systems, compressors, pumps and drive train components, transmis- sions, axles, differentials	Metal Working Only	Steam and Gas Turbines

ENGINE COOLANT ANALYSIS TEST PACKAGES

Test Description	Test Method	C7 Coolant Basic Conventional	C8 Coolant Basic Extended Life	C9 Coolant Advanced Extended Life
pH	D1287	•	•	•
Freeze Point	D3321	•	•	•
% Glycol	D3321	•	•	•
Boiling Point	In-house		•	•
Total Dissolve Solids (TDS)	D1125	•		
% Nitrite	D5827	•	•	•
Carboxylate Acid	Test Kit		•	•
Chloride, Sulfate, Nitrate, Glycolate, Acetate, Formate, Oxylate	D5827			•
Elemental Metals (Corrosive, Contaminant & Additive by ICP)	D6130			•
Applications & Notes		Diesel or Gasoline Engines with conventional coolant	Diesel Engine Cooling systems with Extended Life Coolant. Basic Test	Diesel Engine Cooling systems with Extended Life Coolant. Recommend testing once per year

GREASE AND OTHER TEST PACKAGES

Test Description	Test Method	C10 Basic Grease	C11 Advanced Grease	C12 Filter Debris Analysis	C13 Photo Patch Test
Elemental Metals by ICP or RDE Spectroscopy*	D5185 or D6595	•	•	•	
FTIR Scan	D7418	•	•		
Ferrous Debris	D7918	•	•		
Grease Colorimeter	D7918	•	•		
Water (Crackle/Karl Fisher)*	Varies	•	•		
Consistency/Die Extrusion	D7918		•		
Ruler	D6971		•		
Analytical Ferrography*	D7690		•	•	
Micro Patch Photo					•
Applications & Notes		Testing of in-service grease. Recommend using grease thief to pull proper sample. *Test procedures can vary by lab	Testing of in-service grease. Recommend using grease thief to pull proper sample. *Test procedures can vary by lab	Analysis of component filter element. Recommend also sending in sample of lubricant for separate analysis	Provides a visual of the cleanliness and particles in a lubricants. Standard patch test which includes a photo of the patch on the report

DIESEL FUEL TEST PACKAGES

Test Description	Test Method	C14 Diesel Fuel Basic	C15 Diesel Fuel Advanced	C16 - Diesel Fuel Cleanliness
Viscosity @ 40 C or 100 C	D445		• 40 C	
Elemental Metals by ICP	D5185		•	•
Water by Karl Fischer	D6304C	•	•	•
Appearance	Visual	•	•	
Particulate Contamination/Count*	D6217/5452 ISO4406/11171	•		•
Cloud Point	D7689		•	
Flash Point	D3828		•	
Pour Point	D7346		•	
API Gravity	D7777		•	
Cetane Index	D4737/D976		•	
Distillation	D7345		•	
Sulfur	D5453/D7220		•	
Stability	D6468		•	
Microbial Growth	In-house	•	•	
Water & Sediment	D2709	•	•	
Applications & Notes		Use for basic properties of diesel fuel. *Test procedures can vary by lab	Comprehensive package for advanced storage as well performance properties of diesel fuel	Measurement of diesel fuel cleanliness level, water content, and metals



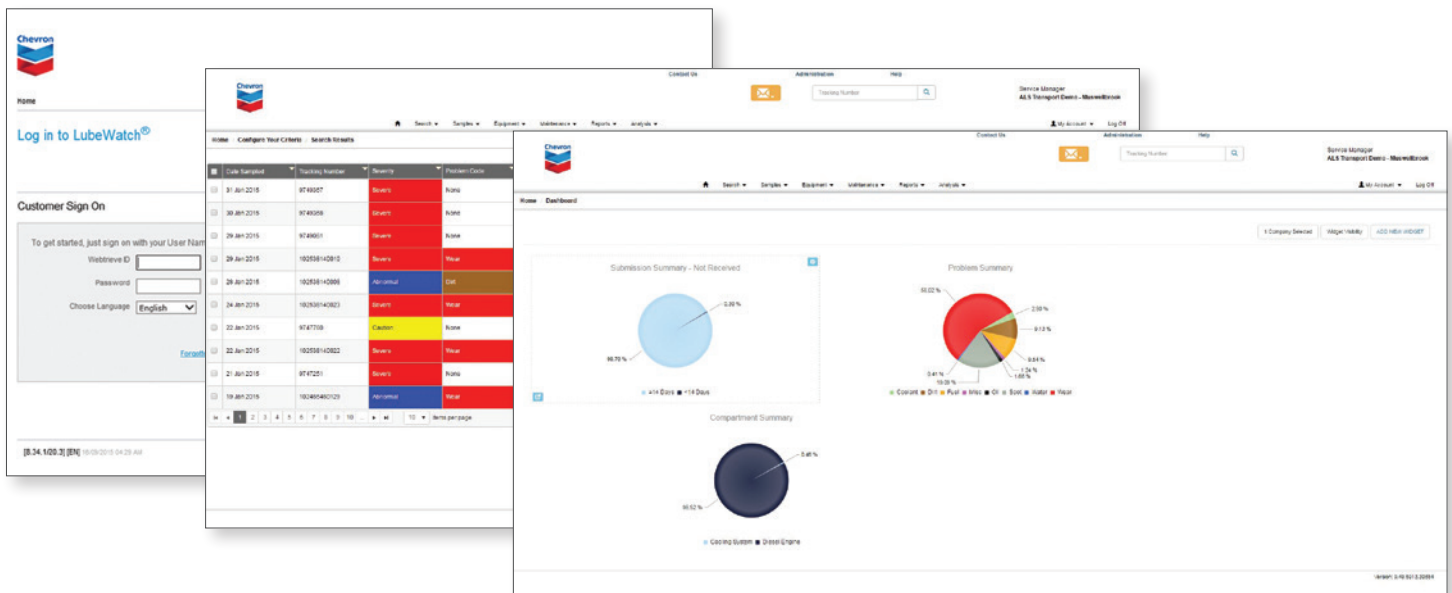
SAMPLING SUPPLIES

Part	Part No.	Description
	C-VB14	1/4" B series sampling valve—recommended for pressurized systems (5 to 3000 psi), maximum sample pressure 750 psi. Suitable for general industrial, plant, and utility.
	C-PROBEB14	Probe adapter for use with B Series Valve. Designed to transfer between valves/remove after sampling. Tubing also requires for use with adapter.
	C-VKP14	1/4" KP Pushbutton Sampling Valve recommended for pressurized systems (5 to 3000 psi), maximum sample pressure 750 psi. Suitable for engines, transmissions, compressors, and in-line hydraulics.
	C-VKP18	1/8" KP Pushbutton Sampling Valve recommended for pressurized systems (5 to 3000 psi), maximum sample pressure 750 psi. Suitable for engines, transmissions, compressors, and in-line hydraulics.
	VK18	1/8" KST Series Valve recommended for vacuum systems, pressurized systems (5 to 3000 psi) maximum sample pressure 750 psi. Suitable for general off-highway, mobile and marine applications.
	VLT14NT12	LT Series High Flow Tube Extend 1/4" OD high flow tube extend with 12" tube (0 to 100 psi).
	VADAPT14L	LT Series Probe Adapter 1/4" OD Probe Adapter for L/LT valve.
	C8-CAPPROBE	Needle Probe Sampler for use with needle port valves and required with KST valve.
	C5-PUMP-RED	Suction Dual Pump.
	C6-TUBROL1/4 C6-TUBROL3/16	100' Roll Suction Pump plastic tubing (pre-cut also available) in 1/4" or 3/16" OD.

Data Management & LubeWatch®

ALS and the Chevron LubeWatch Fluid Analysis Program offer a great deal of flexibility in managing fluid analysis data. The laboratory can transmit reports via email, provide access to a website to view/manage data or send a data file that can be imported into third party software programs.

The LubeWatch system provides flexibility in managing and querying test data and is easy to use. Because it is a secure, Internet-based program, it allows clients access to data from anywhere in the world. With LubeWatch, customers have direct entry into our real-time global database of all samples processed by ALS regardless of laboratory location.



Key Features

- Modern look and design
- Dashboards that display key statistics at a glance
- Additional query capability for higher level hierarchies
- Tag items to build custom groups
- Flag favorite pages for easy access to frequently used functionality
- Ability to print test reports in batches
- Internet-based application, so data is available from wherever you are—review, email and print sample reports at your convenience
- Online sample submission featuring a bar-coded label wizard for error-free lab sample entry, assurance of data integrity, and turnaround time transparency
- Real time tracking of sample progression at the click of a button—when samples have reached the lab, are being processed, are complete
- Ability to build and store custom reports
- Variety of test report formats available, and data is easily imported into other software programs—such as Excel
- Simple, one-step search function to quickly find sample data and statistics
- Multiple levels of security; authorization of access level confirmed before registration approved
- Powerful management reports for managing asset health

The Chevron LubeWatch® website has a full suite of management reports and data mining capabilities to assist with improving and managing the program. Searching for information based on a compartment type and/or other variables is easy and quick. Users have the ability to assess compartments by problem and testing thresholds to quickly identify the equipment for which maintenance action is needed. This application allows clients to review, email, print reports, print labels and produce management reports. The system is easy to use and allows for numerous levels of access and data viewing permissions that are defined by the customer.

ALS will aid in the importing of equipment information and/or historical data. Additional value is obtained by ensuring that the equipment makes, models and other information are correctly entered into the system. Once equipment is pre-entered into the system, labels can be printed for submission, thereby reducing the effort and possibility for errors when submitting first-time samples. The LubeWatch generated label allows users to track their samples from the point of receipt to testing completion. It also simplifies the data entry process and significantly diminishes the possibility for errors in the data entry process, as all information is downloaded from the bar code scan. LubeWatch is a powerful tool, yet easy to use. Training is provided on system navigation and label printing so as to familiarize you and your staff with the functions of this system.

To access the site, go to chevron.alstribology.com.

LubeWatch Mobile Application

LubeWatch Mobile is a simple to use app, for both iOS and Android, that allows users to receive immediate sample alerts in the palm of their hand. Designed for maintenance professionals in the field, the app sends Instant alerts to users based on sample condition. Basic information such as unit ID, equipment type, and diagnostic commentary are displayed for rapid maintenance response and facilitating assessment to meet a client's operational needs. Notifications can be set for all results or just for abnormalities.

Key Features

- Mobile app is designed for immediate sample alerts
- App is available for iOS and Android
- Alerts are sent to users based on sample condition
- App provides full reporting capability
- Allows for sample submission and barcode scanning

LubeWatch Mobile significantly improves response time for clients who are out in the field or in remote locations. To download LubeWatch Mobile, visit the Apple or Android store and search for ALS Tribology.



SAMPLING INSTRUCTIONS

Scheduled Intervals

Ideally, fluid samples should be taken in a manner that is easily repeatable and effectively represents the actual condition of the fluid in the equipment. Good sampling procedures ensure consistency and reliability of data. Fluid samples must be taken on a regular preventive maintenance schedule. Do not take samples soon after a fluid change, filter change or after makeup fluid has been added. Adding new fluid dilutes the levels of contaminants and wear metals found, which may result in conditions appearing better than they actually are.

General Guidelines for Taking a Quality Sample

Each sample drawn must be taken regularly from a single location in a system. Take samples during normal operating conditions, downstream of pumps, cylinders, bearings, and gearboxes and upstream from the filter. When obtaining a sample from a lubricated system, always have the fluid hot and thoroughly mixed before sampling. When possible and safe, always take the sample while the machine is running.

- Make sure that the sample bottle is clean and free of any moisture before obtaining sample.
- When utilizing the vacuum pump method, make sure that sample is not obtained from the bottom of the fluid compartment where sludge accumulates. Aim for the midpoint of the reservoir.
- Obtain samples during normal equipment operation or at least within 30 minutes after equipment is shut down. This is the best way to obtain a truly representative sample of conditions within a lubricated compartment or a machine compartment.
- Make sure that sample bottle and container are properly sealed before shipping.
- Enter sample information correctly and completely.
- Ship sample to laboratory promptly to receive analysis results as soon as possible.

Sample Valve Method

Install valves upstream of any filter in order to capture wear particles. Make sure the valve is clean and adequately flushed. Using a sample valve, such as the 1/8" NPT Push Button Valve, helps in producing reliable test results. Install valve properly on a pressurized fluid line or fluid galley. Avoid areas where fluid does not circulate as freely, such as the bottom of a sump.



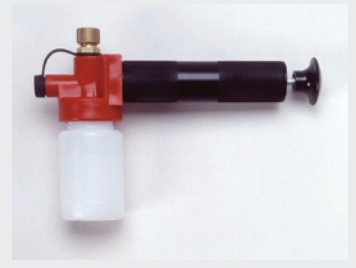
Taking a Fluid Sample Using the Valve Method

1. Unscrew dust cap from sample valve.
2. Depress the button on the sample valve.
3. Flush the fluid line allowing several ounces to drain before taking the sample.
4. Place the empty sample bottle under the sample valve discharge opening.
5. Fill the sample bottle 3/4 full and release the sample valve.
6. Tighten the cap on the sample bottle to secure a tight seal.
7. Screw the dust cap back on the valve. Prepare for shipment.



Sample Pump Method

If taking a fluid sample using the pump method, operate the equipment long enough to mix the fluid thoroughly; bringing the fluid to operating temperature is a good indication that the fluid is adequately mixed. It is important that vacuum pumps are used with appropriate tubing. Make sure that new tubing is used for each sample in order to avoid cross contamination. Cut the tubing to the same length each time you sample. Avoid scraping the tubing along the sides or bottom of the tank or reservoir. Use this method with systems not equipped with sampling valves.



Taking a Fluid Sample Using the Pump Method

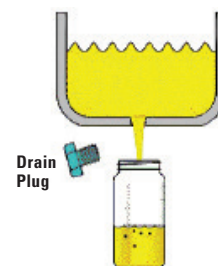
1. Estimate the length of a piece of new tubing to reach half way into the depth of the fluid or midpoint of the reservoir (use dipstick, if available), and cut the end at a 45° angle.
2. Insert the tubing through the head of the vacuum pump and tighten the retaining nut. The tubing should extend about 1/2 inch beyond the base of the vacuum pump head.
3. Install a new sampling bottle onto the vacuum pump and insert the end of the tubing into the fluid – do not allow the tubing to touch the bottom of the compartment.
4. Pump the vacuum pump handle to create a vacuum. Hold the pump upright to avoid fluid from contaminating the pump. If fluid enters the pump, disassemble and clean it before taking the sample. Fill the fluid sample bottle at least 3/4 full.
5. Remove the tubing from the compartment and dispose of it correctly. Do not reuse tubing. Remove the bottle from the vacuum pump and secure the cap on the bottle. Prepare for shipment.

Drain Line Method

The drain line method is considered the least preferred method of sampling. If used, make sure that an ample amount of fluid is drained before collecting a sample. The sludge, particles and water that settle to the bottom of a tank or reservoir, provides poor and sometimes unreliable results.

Taking a Fluid Sample Using the Drain Method

1. Clean area around the drain plug to avoid sample contamination.
2. Allow ample amount of fluid to flush through the fluid pan drain hole.
3. Fill sample bottle 3/4 full.
4. Screw bottle cap on tightly. Wipe bottle clean and prepare for shipment.
5. Proper identification from each unit sample is crucial for tracking critical reports and unusual wear.



SAMPLING INSTRUCTIONS

Sample Submission – Online via Website

Samples can easily be submitted on-line using the LubeWatch® interactive website via computer login for accounts. This is the preferred approach. Equipment can be easily searched and listed for sample submission, entering sample information, and creating barcoded labels to print for sample identification.

A sample submission list is created that allows the user to manage all sample submission from creation to when samples reach the laboratory.

New units and components can be created on-line which notifies the laboratory to create the equipment under a customer's account. This feature is only available to the "Equipment Administrator."

Barcoded sample identification labels are printed with online submissions for sending to the laboratory. ALS Tribology can assist with setting up barcode printers, which are relatively inexpensive.

Sample Submission – Mobile App

Samples can also be submitted by end-users through the LubeWatch mobile app using a smart phone which works in conjunction with the website. This is useful for individuals in the field who service equipment and submit samples.

Equipment can be looked up for sample submission or scanned using a barcode reader to identify the equipment.

Once a sample has been submitted successfully via the mobile app, barcode labels can be printed later at a computer or just include a blank sample information form (SIF) with the samples to be shipped that provides a tracking number. The labels become available in the LubeWatch website and can be printed from there. When using the Sample Information Forms (SIFs) to submit the sample, it can be scanned at the lab with the sample details when included with the sample shipped.

Shipping Instructions

ALS Tribology does provide prepaid USPS postage mailing labels at an additional cost. Though this may add some convenience it is not the most cost effective option for sending samples. USPS sample delivery to the laboratories can be spotty and not always the most reliable.

It is recommended that a commercial courier such as UPS, FedEx, or DHL be utilized. This provides the most cost effective option for shipping samples and allows for delivery tracking to the laboratory. A courier that allows tracking delivery to the laboratory is recommended.

It is recommend that samples are shipped as soon as possible after taking a sample so the data is provided is current.

Once samples are delivered to the laboratory, samples can be tracked via the ALS Website for all samples that have yet to be evaluated/ diagnosed and their current status.

Sample Information Forms (SIFs) also provide a tracking number for reference when tracking a sample. The forms provide a perforated section with the tracking number for retention by the sender.



Reference Guides

Wear Metal Reference Guide

Many times, users that test their in-service lubricants will look at reports and ask “what do these tests mean?” Most routine analysis reports display similar test parameters for monitoring the condition of the operating equipment and the lubricant in service. This simple guideline will help explain the use and meaning behind the routine tests you are likely to see on an analysis report. Please note that this serves only as a guideline; the elements listed do not purport to include all possible resources.

When trace elements are detected, the following areas could be responsible:	Aluminum (Al)	Chromium (Cr)	Copper (Cu)	Iron (Fe)	Lead (Pb)	Nickel (Ni)	Tin (Sn)	Silver (Ag)	Titanium (Ti)	Vanadium (V)
Bearings	•	•	•	•	•	•	•	•		
Bushings	•		•	•	•		•	•		
Compressor Piston	•			•			•			
Cylinder /Liners	•	•		•						
Clutch Discs			•		•			•		
EGR	•									
Gears		•		•		•			•	
Housing/Blocks	•			•		•				
Hydraulic Cylinders	•	•	•	•	•		•			
Hydraulic Pumps	•		•	•	•	•	•			
Oil Cooler	•		•				•	•		
Pistons	•			•						
Piston Skirt Overlay							•			
Rings	•	•		•		•				
Rust				•						
Shafts		•		•		•			•	
Thrust Plates	•		•		•		•			
Thrust Washers	•		•		•		•			
Turbine Blades									•	•
Valve Guides/Stem	•	•		•		•				
Valve Trains		•				•			•	
Washers	•		•	•	•					

LUBRICANT REFERENCE GUIDE

Purpose of Lubricant Additive	Antimony (Sb)	Barium (Ba)	Boron (B)	Calcium (Ca)	Magnesium (Mg)	Molybdenum (Mo)	Phosphorus (P)	Sodium (Na)	Silicon (Si)	Titanium (Ti)	Zinc (Zn)
Alkalinity Reserve				•	•						
Anti-foam									•		
Anti-wear	•						•			•	•
Antioxidant	•										•
Corrosion Inhibitor								•			
Detergency			•	•	•						
Extreme Pressure	•		•			•	•				
Friction Modifier							•				
Lubricity						•					
Rust Inhibitor		•									
Water Separability		•									

CONTAMINANT REFERENCE GUIDE

When contaminants are detected, the following could be the source:	Aluminum (Al)	Boron (B)	Magnesium (Mg)	Potassium (K)	Silicon (Si)	Sodium (Na)
After cooler Brazing Flux	•			•		
Coolant		•		•	•	•
Dirt	•				•	
Gasket/Seal Material					•	
Natural Gas (Wet Gas) Transferring						•
Seawater			•			•

Physical and Chemical Tests for Lubricant Condition and Service Life

Improper **Viscosity** can affect a lubricant's performance. Too low of a viscosity will not create sufficient surface film to keep moving parts separated and prevent rubbing on opposing metal surfaces. Too high of a viscosity will create excessive heat and reduced fluid flow within circulating systems. A change in viscosity will indicate a change in the fluid performance integrity. A drop in viscosity generally indicates contamination with a lighter product, addition of an incorrect viscosity grade, and in some cases thermal cracking. An increase in viscosity can indicate oxidation and reduced service life due to age, addition of an incorrect viscosity grade, or excessive soot or insoluble content.

Base Number represents the level of alkalinity reserve available for neutralizing acids formed during the combustion process and may be introduced through recirculated exhaust gases. As the lubricant ages and the additive package depletes, the base number will decrease from its initial fresh fluid value.

Acid Number in a new lubricant represents a certain level of additive compounding. This can come from anti-rust, anti-wear or other additives. The acid number can drop a bit after a lubricant has been in service for a certain period, which indicates some initial additive depletion. After a time the acid number will start to increase, which indicates the creation of acidic degradation products related to oxidation. The acid number is a means of monitoring fluid service life.

The **Oxidation Number** is a relative number that monitors increase in the overall oxidation of the lubricant by infrared spectroscopy. This test parameter generally complements other tests for fluid service life, such as viscosity and acid number. Generally this test is not used as a primary indicator when all other tests are within normal limits. Accurate fluid information is required to get the most valid test results.

The **Nitration Number** is a form of oxidation that relates to chemical reaction with nitrogen, forming nitrogenous compounds also. Nitration is a relative number that monitors increase in the overall fluid degradation due to reaction with nitrogen and oxygen by infrared spectroscopy. This test parameter generally complements other tests for fluid service life, such as viscosity and acid number. Accurate fluid information is required to get the most valid test results. Contributors to increased nitration can come from exhaust gas blow-by or reaction with natural gas products with the lubricant and heat. It is also an indicator of electrostatic discharge across filter surfaces in turbine fluid.

Physical and Chemical Tests for Lubricant Contaminants

Water as a contaminant will generally lead to increased corrosion, depletion of proper lubricating film, decreased lubricant performance life and increased acid formation.

Coolant contamination will degrade lubricant service life and performance, create sludge and block lubricant passageways.

Fuel Dilution will decrease fluids viscosity, therefore affecting its lubricity properties. Fuel dilution also promotes degradation of lubricant service life and additive properties.

Excessive **Soot** increases viscosity, creates excessive wear, and will tie up active additives needed for lubricant performance.

“Clean Systems” require a minimum level of cleanliness in order to operate reliably. This is especially true for circulating systems with high pressure and close tolerance components. The ISO Cleanliness Rating is a convenient way to communicate the level of particulate contamination within a system based on the **Particle Count** for micron sizes greater than 4, 6 and 14.

Tests for Wear Debris

Particle Quantification Index (PQI) is a valuable trending tool for monitoring the relative level of ferrous wear material within a lubricant sample.

Filter Patch inspection provides a visual assessment of wear particle and other solid debris present in a sample after collection on a 0.8 micron to 5.0 micron filter membrane and examined by a microscope.

Microscopic Particle Examination (Analytical Ferrography) provides detailed information on different wear particles present in a sample.

This is generally an exception test that provides information on the type of metal makeup of the wear particles present and how they were formed.

- Additional information and resources are available through the ALS eSource, our electronic newsletter. Visit www.alsglobal.com/en-us/news/channel/esource to view past issues of eSource or to register to receive this free electronic newsletter via email.



Engine Coolant Reference Guide

Engine coolants are a mixture of glycol, inhibitors, and water. Each formula is designed for specific protection and engine requirements. Mixing different coolants is not recommended and can compromise the coolant's general overall protective capability, resulting in decreased coolant life and damage to the cooling system and/or engine. The following is a reference guide to assist in understanding the engine coolant data.

COOLANT REFERENCE GUIDE

Appearance Assessment	Target	Observation	Possible Result	Corrective Action
Clarity	Clear	Appear hazy or opaque	Degraded or contaminated engine coolants or a mixture of incompatible coolant types	Check shelf life of the coolant; check coolant handling practices
Color	Clear, bright, and representative of the original engine coolant color	Brown could indicate improper mixing of different coolants	Decreased coolant protection	Verify original coolant color of product in use; if brown was reported, check coolant handling practices
Visible Sediment	None	Presence of sediment is typically indicative of additive fallout, corrosion, rust, scale buildup, or other contaminants	Water pump and seal deterioration, liner pitting, copper and aluminum corrosion, plugged fluid cooler and radiator; poor sampling technique	Add a non-SCA filter for ELC coolants; add an SCA filter to conventional coolant systems
Visible Petroleum Layer	None	Indication of fuel or fluid contamination will be observed usually in the form of a separated layer	Combustion gas blowby into the coolant, leaking fluid cooler; poor sampling technique	Check for any seal failures and system integrity

pH

Appearance Assessment	Target	Observation Low pH	Observation High pH	Corrective Action
ELC Engine Coolant and Conventional Engine Coolant	Extended Life 7.5 – 9.5 pH Conventional 8.5 – 11.0 pH	ELC Low pH (<7.5) Conventional Low pH (<8.5) Low pH can lead to metal corrosion Air leaks will lower pH Improper coolant volume Shelf life of coolant, age will lower the pH Under additized SCA concentration (conventional coolant)	ELC High pH (>9.5) Conventional High pH (>11.0) Mixed coolant types Over additized SCA concentration	Check coolant volume Check for air leaks Pressure check radiator cap Check SCA filter and replace if needed (conventional coolant only) Electrical grounding issues (if coolant has a burnt smell) Combustion gas leak if pH is below 7.0 Remove SCA filter when ELC coolants are in use, this will add pH buffer and raise the pH Drain, flush, refill then resample

NITRITES

Nitrites	Target	Observation Low Nitrites	Observation High Nitrites	Corrective Action
Nitrite	<p>Initial coolant concentration typically >1200 PPM</p> <p>Nitrite only formulas >300 PPM for nitrite/molybdate formulas < 25 for nitrite free</p>	<p>Verify coolant type in use</p> <p>Under concentrated with glycol</p> <p>Improper coolant mixing</p> <p>Under concentration of SCAs for conventional coolants</p>	<p>Verify coolant type in use</p> <p>Over concentration of glycol</p> <p>Improper coolant mixing</p> <p>Over concentration of SCAs for conventional coolants</p>	<p>Check the coolant mixture, if under or over concentrated, this will impact the nitrite level when present</p> <p>If low, look at nitrate level; if pH has dropped, check for head gasket leaks, low coolant volumes, and pressure check radiator cap</p> <p>Rapid depletion could indicate overheating of the cooling system and localized hot spots, check; this will occur along with an increase in glycolates</p> <p>Rapid depletion could also indicate electrical shorts; check grounding, coolant will have a burnt smell</p> <p>If using ELC, check for a precharged SCA filter and replace with a non-precharged filter</p> <p>If nitrites are low, but carboxylate acid inhibitor passed, resample at next service interval</p> <p>Drain 50% of system and add 50/50 coolant, resample</p>

CARBOXYLATE ACID TECHNOLOGY

Carboxylate Acid	Target	Observation Low OAI	Observation High OAI	Corrective Action
OAI	<p>Passing level depends on the initial extended life coolant's inhibitor level formula</p> <p>Under concentrated with glycol</p> <p>Improper coolant mixing</p> <p>Coolant is brown – possible improper conversion from conventional to extended life</p>	<p>Verify coolant type in use</p> <p>Under concentrated with glycol</p> <p>Improper coolant mixing</p> <p>Coolant is brown – possible improper conversion from conventional to extended life</p>	<p>Verify coolant type in use</p> <p>Over concentrated with glycol</p> <p>Improper coolant mixing</p>	<p>Adjust coolant concentration; if over concentrated, add proper source water; if under concentrated, add glycol concentrate; check freeze point and resample at next service interval</p> <p>>25 % diluted, add FleetFix Maintenance, allowed two times over the life of the equipment; resample to confirm inhibitor level</p> <p>If coolant was improperly mixed with conventional and extended life coolant, apply FleetFix Conversion following Chevron's instruction; resample to confirm inhibitor level</p>

OTHER ION CHROMATOGRAPHY DATA

Ion Chromatography Results	Source
Chlorides	Outside contaminants and can come from improper source water or air leaks. It has the potential to form acids and cause corrosion. It can also come from coolant degradation due to aging.
Glycolates	Is among a group of acids that form as coolant degrades. This will also increase when overheating or hot spots are occurring. As this acid increases, iron corrosion is at risk.
Molybates	Provides protection of cast iron corrosion and cavitations.
Nitrates	Provides protection of light alloys also provides aluminum and solder protection. If nitrites are being exposed to air, they will chemically transform to nitrate – when this occurs look for air leaks.
Phosphates	pH buffer utilized in some coolant brands and provides iron corrosion protection. Over treating the cooling system can lead to sediment detection resulting in possible plugged fluid cooler or radiator. Some engines that are aluminum must be phosphate free, check OEM requirements before using a phosphate coolant.
Sulfates	This contaminant can combine with calcium to create scale. This can also indicate coolant degradation due to aging or improper source water is being used.

COOLANT SPECTROCHEMICAL DATA

Purpose of Lubricant Additive	Aluminum (Al)	Boron (B)	Calcium (Ca)	Copper (Cu)	Iron (Fe)	Lead (Pb)	Magnesium (Mg)	Molybdenum (Mo)	Phosphorus (P)	Potassium (K)	Silicon (Si)	Sodium (Na)	Silver (Ag)	Tin (Sn)	Zinc (Zn)
Additive Elements		•						•	•	•	•	•			
Corrosion Elements	•			•	•	•							•	•	•
Water Elements			•				•								

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