OIL ANALYSIS PROGRAM USER GUIDE

LUBEWATCH®

CHEVRON SERVICES CAN HELP YOU **RUN BETTER LONGER**

Quality Oil Analysis Can Help Extend Equipment Life

LubeWatch® maintenance management system is a diagnostic, preventive maintenance tool that uses oil 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 engine failures and less unscheduled downtime means increased production and profitability.

What the LubeWatch Maintenance Manage System Can Do For You

- **Identify minor problems before they become major failures** by monitoring trends in wear and contamination to help prevent catastrophic failure
- **Extend drain intervals** by performing oil changes when the condition of the oil requires it, helps reduce unnecessary labor costs
- **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 helps eliminate unforeseen decreased production

LubeWatch®
Oil Analysis Program

LUBEWATCH CAN HELP YOUR EQUIPMENT RUN BETTER LONGER

Reach a new level of reliability with LubeWatch Oil 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.

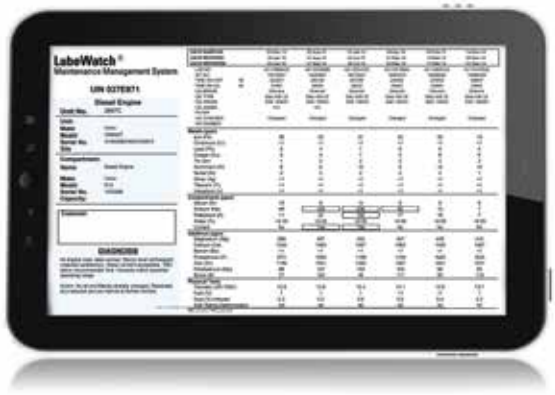
To learn more, contact your marketer.

RBL RUN BETTER LONGER

CHEVRONLUBRICANTS.COM/RBL

LubeWatch® Oil Analysis Program Services

ALS has provided oil, engine coolant, fuel and metalworking fluids testing services to the LubeWatch Maintenance Management System 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

ALS North American laboratories are able to assist LubeWatch customers. Kits and other supplies can be ordered 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. Our customer service organization is also available for new customer set-up, equipment registration and any other general questions.

Atlanta, Georgia
3121 Presidential Dr.
Atlanta, GA 30340
800.394.3669
csr.atlanta@alstribology.com

Burlington, Ontario (Canada)
1240 Burloak Dr., Unit 6
Burlington, ON L7L 6B3
877.732.9559
csr.burlington@alstribology.com

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

Edmonton, Alberta (Canada)
10717-176 Street
Edmonton, AB T5S 1K1
888.489.0057
csr.edmonton@alstribology.com

Kansas City, Kansas
935 Sunshine Road
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

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 13,000 staff, operates over 370 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.

OIL ANALYSIS TEST PACKAGES

Test Parameter	C1 Basic Lubrication	C2 Diesel Crankcase	C3 Natural Gas	C4 Basic Industrial	C4PC Advanced Industrial	C4IND Paper Machine + Turbine Oil	C5 Metal-working Fluids
Elemental Analysis *(Wear, Contaminants, Additive and Multi-Source)*	•	•	•	•	•	•	•
Viscosity @40°C or 100°C	•	•	•	•	•	•	•
Water Content % Vol	•	•	•	•	•		
Water Content PPM						•	•
Engine Coolant Contamination *(if applicable)*	•	•	•	•	•		
Fuel Dilution *(if applicable)*	•	•					
Fuel Soot *(if applicable)*	•	•					
Acid Number			•	•	•	•	
Base Number		•					
Oxidation		•	•	•	•	•	
Nitration			•				
Particle Count with ISO Rating					•	•	
Copper Corrosion							•
Sulfur							•
Solids							•
Initial pH			•				

ENGINE COOLANT ANALYSIS TEST PACKAGES

Test Parameter	C7 CT-AF Basic Conventional	C2 CTELC Basic Extended Life	C3 CTELCA Advanced Extended Life
Visual Assessment	•	•	•
pH	•	•	•
Freeze Point	•	•	•
Percent Glycol	•	•	•
Total Dissolved Solids (TDS)	•		
Nitrite	•	•	•
Nitrate		•	•
Phosphate			•
Chloride			•
Sulfur			•
Glycolate			•
Spectrochemical Analysis			•
Boil Point Calculated		•	•
Carboxylate Acid		•	•

Advanced Turbine Testing

ALS has developed an exclusive test bundle and report. Turbine Oil Suitability adheres to the guidelines established by ASTM D4378, "Standard Practice for In-Service Monitoring of Mineral Turbine Oils for Steam and Gas Turbine." This bundle is structured on a progressive tier of analytical tests based on service time, condition and turbine type (steam or gas).

Advanced Turbine Testing Continued

Turbine Oil Suitability report is issued as an evaluation of the submitted lubricant sample to determine its suitability for continued in-service use as a turbine circulating oil and/or EHC control fluid. The tests performed are selected to provide in-depth analysis of the lubricant's key properties, contamination, and irregular component wear impacting the performance of the turbine and the oil's suitability for continued use. The commentary and other information in this report provide guidance for the turbine operator. Special attention is paid to indicators that the in-service oil exhibits characteristics that will enable continued use and what, if any, corrective action is required to address a specific condition the analysis has identified.

ALS is the exclusive provider of Advanced Turbine Oil Suitability packages for the Chevron LubeWatch program. These packages are identified as TOS-1 through TOS-5.

ADVANCED TURBINE OIL PACKAGES

Test Parameter	C6 Turbine Oil	TOS-1 New Oil/New Oil Charge	TOS-2 Steam + Gas Routine PM	TOS-3 Steam Turbine PM Quarterly	TOS-4 Gas Routine PM Quarterly	TOS-5 Steam + Gas Annual Suitability
Acid Number	•	•	•	•	•	•
Appearance		•	•	•	•	•
Color		•	•	•	•	•
Copper Corrosion		•				•
Elemental Analysis *(Wear, Contaminants, Additive + Multi-Source)*	•	•	•	•	•	•
Foam, Seq 1		•				•
FTIR Baseline		•				
FTIR Oxidation	•		•	•	•	•
Inhibitor Additives, RULER Baseline		•		•		
Particle Count	•	•	•	•	•	
Rotating Pressure Vessel Oxidation Test (RPVOT)	•	•				•
Rust					•	•
Varnish Potential*	•	•	•	•	•	•
Water Content by Karl Fischer PPM	•	•	•	•	•	•
Water Separability	•	•				•
Compatibility Detailed Analytical Report	Optional					

**Varnish Potential Analysis includes: Blotter, Color, Ultracentrifuge, Membrane Patch Colorimetry (MPC), Pentane Insolubles by Weight, ISO Particle Count, Inhibitor Additives, RULER Baseline*

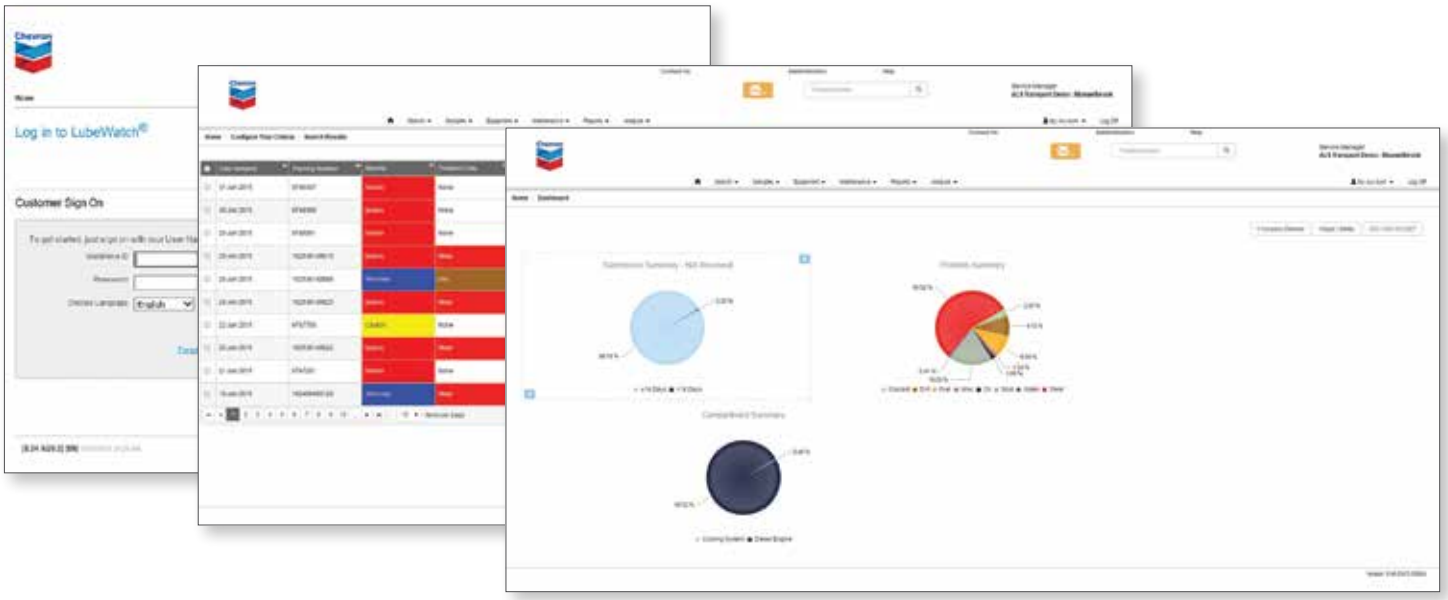
SAMPLING SUPPLIES

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 Samplyzer 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 & WEBTRIEVE™

ALS and the Chevron LubeWatch® Oil 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 Webtrieve™ 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 Webtrieve, 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

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 Webtrieve™ 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. Webtrieve™ 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 http://chevron.alstribology.com/.

WEBTRIEVE™ Mobile Application

Webtrieve™ 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
- Basic information such as unit, type, condition and diagnostic commentary are displayed

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

SAMPLING INSTRUCTIONS

Scheduled Intervals

Ideally, oil samples should be taken in a manner that is easily repeatable and effectively represents the actual condition of the oil in the equipment. Good sampling procedures ensure consistency and reliability of data. Oil samples must be taken on a regular preventive maintenance schedule. Do not take samples soon after an oil change, filter change or after makeup oil has been added. Adding new oil 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 oil 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 oil 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.
- Fill out the sample information form 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 oil line or oil galley. Avoid areas where oil does not circulate as freely, such as the bottom of a sump.

Taking an Oil Sample Using the Valve Method

1. Unscrew dust cap from sample valve.
2. Depress the button on the sample valve.
3. Flush the oil 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 an oil sample using the pump method, operate the equipment long enough to mix the oil thoroughly; bringing the oil to operating temperature is a good indication that the oil 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 an Oil Sample Using the Pump Method

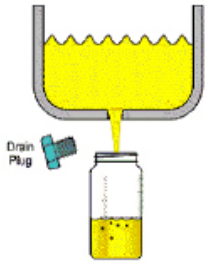
1. Estimate the length of a piece of new tubing to reach half way into the depth of the oil or midpoint of the reservoir (use dipstick, if available), and cut the end at a 45° angle.
2. Insert the tubing through the head of the vacuum pump and tighten the retaining nut. The tubing should extend about 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 oil – 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 oil from contaminating the pump. If oil enters the pump, disassemble and clean it before taking the sample. Fill the oil 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 oil 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 an Oil Sample Using the Drain Method

1. Clean area around the drain plug to avoid sample contamination.
2. Allow ample amount of oil to flush through the oil 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 Information Forms (SIF)

The laboratory requires that SIFs be filled out completely and accurately, and are included with the sample, in order to perform an accurate analysis. The analyst uses the form to determine what is normal, caution, abnormal, or severe for the component and lubricant based on component make and model, lube brand and grade, length of time or miles on the sample and any other information provided by the customer.

Shipping Instructions

Ship all samples to the designated laboratory on the same day that the sample is taken. Be sure that all information is filled out correctly and completely on the SIF. Place the sample bottle and SIF in the shipping container provided, attach the shipping address label and ship to the designated laboratory. It is the shipper's responsibility to follow all applicable regulations related to proper packaging, labeling and offering for shipment of fuel samples which are regulated as hazardous materials. Please consult with the U.S. Department of Transportation and your courier for more information. If you have any questions regarding the fuel packaging, please contact your local ALS customer service representative.

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)	Magne-sium (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 oil 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 oil 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 oil 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 oil.

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 **alsglobal.com/esourcearchive** 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.

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

Carboxylate Acid Technology

Carboxylate Acid	Target	Observation Low OAI	Observation High OAI	Corrective Action
OAI	Passing level depends on the initial extended life coolant's inhibitor level formula Under concentrated with glycol Improper coolant mixing Coolant is brown – possible improper conversion from conventional to extended life	Verify coolant type in use Under concentrated with glycol Improper coolant mixing Coolant is brown – possible improper conversion from conventional to extended life	Verify coolant type in use Over concentrated with glycol Improper coolant mixing	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 >25 % diluted, add FleetFix Maintenance, allowed two times over the life of the equipment; resample to confirm inhibitor level If coolant was improperly mixed with conventional and extended life coolant, apply FleetFix Conversion following Chevron's instruction; resample to confirm inhibitor level

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 oil 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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