Bureau Veritas
Oil Analysis

Coolant Analysis - Whitepaper

Preventing Premature Engine Failure with Coolant Analysis

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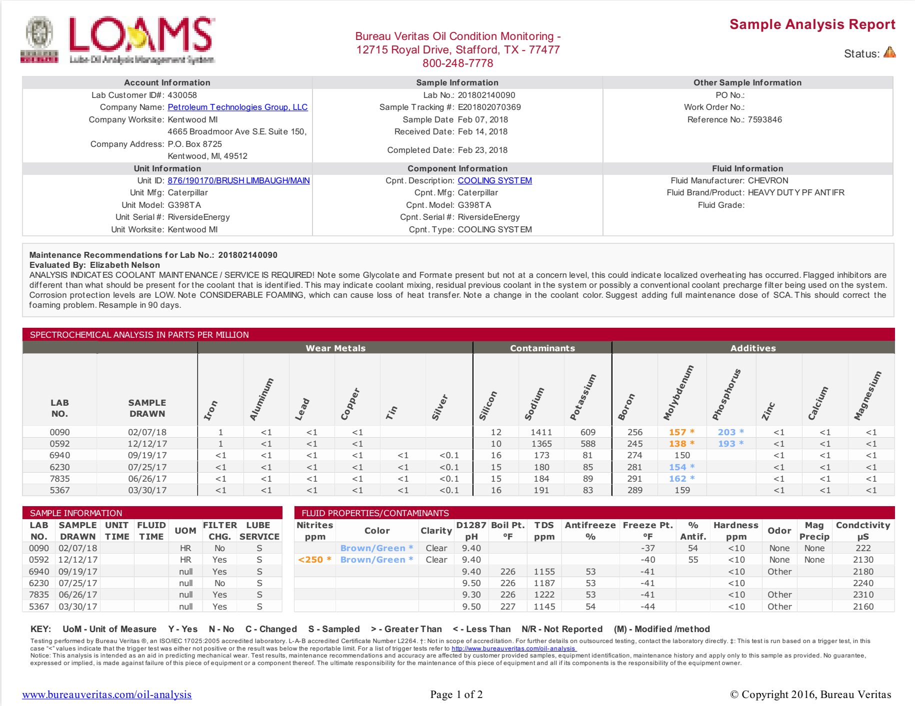
Introduction

Almost everyone understands how important a properly maintained lubrication system is to optimum engine health, but what most people don't understand is that engine coolant and the cooling system are just as critical to engine design, maintenance and optimum performance.

The demands of today's Tier-4 engines have dramatically changed cooling system design and coolant formulation. These heavy-duty diesel engines produce a tremendous amount of power from a relatively small package, placing greater demands on the cooling system to absorb heat transferred from the engine, transmission and hydraulic fluids. At the same time, cooling systems have become smaller and operate at higher temperatures, pressures and flow rates, making efficient heat removal and adequate metal protection even more challenging.

While oil analysis is an invaluable condition monitoring tool, it tells you very little about what is happening inside the cooling system. Coolant analysis provides the rest of the story by pinpointing coolant and cooling system issues that can lead to premature engine failure.



LOAMS Lube-Oil Analysis Management System

Bureau Veritas Oil Condition Monitoring -
12715 Royal Drive, Stafford, TX - 77477
800-248-7778

Sample Analysis Report

Status:

Account Information	Sample Information	Other Sample Information
Lab Customer ID#: 430058	Lab No.: 201802140090	PO No.:
Company Name: Petroleum Technologies Group, LLC	Sample Tracking #: E201802070369	Work Order No.:
Company Worksite: Kentwood MI	Sample Date Feb 07, 2018	Reference No.: 7593846
4665 Broadmoor Ave S.E. Suite 150,	Received Date: Feb 14, 2018	
Company Address: P.O. Box 8725		
Kentwood, MI, 49512	Completed Date: Feb 23, 2018	
Unit Information	**Component Information**	**Fluid Information**
Unit ID: 876/190170/BRUSH LIMBAUGH/MAIN	Cpnt. Description: COOLING SYSTEM	Fluid Manufacturer: CHEVRON
Unit Mfg: Caterpillar	Cpnt. Mfg: Caterpillar	Fluid Brand/Product: HEAVY DUTY PF ANTIFR
Unit Model: G398TA	Cpnt. Model: G398TA	Fluid Grade:
Unit Serial #: RiversideEnergy	Cpnt. Serial #: RiversideEnergy	
Unit Worksite: Kentwood MI	Cpnt. Type: COOLING SYSTEM	

Maintenance Recommendations for Lab No.: 201802140090
Evaluated By: Elizabeth Nelson
ANALYSIS INDICATES COOLANT MAINTENANCE / SERVICE IS REQUIRED! Note some Glycolate and Formate present but not at a concern level, this could indicate localized overheating has occurred. Flagged inhibitors are different than what should be present for the coolant that is identified. This may indicate coolant mixing, residual previous coolant in the system or possibly a conventional coolant precharge filter being used on the system. Corrosion protection levels are LOW. Note CONSIDERABLE FOAMING, which can cause loss of heat transfer. Note a change in the coolant color. Suggest adding full maintenance dose of SCA. This should correct the foaming problem. Resample in 90 days.

SPECTROCHEMICAL ANALYSIS IN PARTS PER MILLION

		Wear Metals						Contaminants			Additives					
LAB NO.	SAMPLE DRAWN	Iron	Aluminum	Lead	Copper	Tin	Silver	Silicon	Sodium	Potassium	Boron	Molybdenum	Phosphorus	Zinc	Calcium	Magnesium
0090	02/07/18	1	<1	<1	<1			12	1411	609	256	157 *	203 *	<1	<1	<1
0592	12/12/17	1	<1	<1	<1			10	1365	588	245	138 *	193 *	<1	<1	<1
6940	09/19/17	<1	<1	<1	<1	<1	<0.1	16	173	81	274	150		<1	<1	<1
6230	07/25/17	<1	<1	<1	<1	<1	<0.1	15	180	85	281	154 *		<1	<1	<1
7835	06/26/17	<1	<1	<1	<1	<1	<0.1	15	184	89	291	162 *		<1	<1	<1
5367	03/30/17	<1	<1	<1	<1	<1	<0.1	16	191	83	289	159		<1	<1	<1

SAMPLE INFORMATION

LAB NO.	SAMPLE DRAWN	UNIT TIME	FLUID TIME	UOM	FILTER CHG.	LUBE SERVICE
0090	02/07/18			HR	No	S
0592	12/12/17			HR	Yes	S
6940	09/19/17			null	Yes	S
6230	07/25/17			null	No	S
7835	06/26/17			null	Yes	S
5367	03/30/17			null	Yes	S

FLUID PROPERTIES/CONTAMINANTS

Nitrites ppm	Color	Clarity	D1287 pH	Boil Pt. °F	TDS ppm	Antifreeze %	Freeze Pt. °F	% Antif.	Hardness ppm	Odor	Mag Precip	Condctivity µS
	Brown/Green *	Clear	9.40				-37	54	<10	None	None	222
<250 *	Brown/Green *	Clear	9.40				-40	55	<10	None	None	2130
			9.40	226	1155	53	-41		<10	Other		2180
			9.50	226	1187	53	-41		<10			2240
			9.30	226	1222	53	-41		<10	Other		2310
			9.50	227	1145	54	-44		<10	Other		2160

KEY: UoM - Unit of Measure Y - Yes N - No C - Changed S - Sampled > - Greater Than < - Less Than N/R - Not Reported (M) - Modified /method

Testing performed by Bureau Veritas ®, an ISO/IEC 17025:2005 accredited laboratory. L-A-B accredited Certificate Number L2264. †: Not in scope of accreditation. For further details on outsourced testing, contact the laboratory directly. ‡: This test is run based on a trigger test, in this case "<" values indicate that the trigger test was either not positive or the result was below the reportable limit. For a list of trigger tests refer to http://www.bureauveritas.com/oil-analysis
Notice: This analysis is intended as an aid in predicting mechanical wear. Test results, maintenance recommendations and accuracy are affected by customer provided samples, equipment identification, maintenance history and apply only to this sample as provided. No guarantee, expressed or implied, is made against failure of this piece of equipment or a component thereof. The ultimate responsibility for the maintenance of this piece of equipment and all if its components is the responsibility of the equipment owner.

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A coolant analysis report should be easy to read with detailed recommendations that will enable you to reduce major repairs and increase equipment uptime, productivity and safety.

Cooling System Criticality

An estimated 50 percent of all engine failures are associated with problems in the cooling system. Once initiated, these problems can spread through the lubrication, hydraulic and transmission systems, damaging components, causing scale, clogging passages and forming deposits. Yet the cooling system is the least understood and most neglected of these systems.

Cooling system problems can potentially reduce the life of components within all machinery, which makes maintenance of these systems essential for achieving optimum machine performance and longevity. Coolant analysis takes the guesswork out of maintaining these systems. Implementing a predictive maintenance program that includes analyzing the in-service coolant has proven to optimize reliability, decrease unscheduled downtime, reduce in-service failures and field repairs, establish proper coolant drain intervals, increase component lifespans and control equipment costs.

Conventional vs. Extended-life Coolants

Coolant analysis is recommended for both conventional and extended-life coolants. Fluid design cannot prevent or correct the mechanical issues or chemical reactions that impact cooling system performance. Air and combustion gas leaks, localized overheating, hot spots or electrolysis can chemically alter or destroy the coolant and its inhibitors. Changes in coolant composition may cause chemical reactions that can damage metals and result in premature component failure. Mechanical problems and chemical reactions affect conventional and extended-life coolants equally, and neither fluid formulation can correct the root cause of a mechanical problem.

Inhibitor and glycol levels should be analyzed regularly not only to ensure adequate system protection but also to identify any mechanical issue or chemical reaction that could result in catastrophic engine or component failure.

The Importance of Proper Coolant Formulations

One of the biggest issues facing our industry today is coolant formulation mixing. Maintenance personnel often refer to the coolant by its color. This can be a huge issue if coolant mixing has taken place or the shop has more than one type of coolant for their bulk fluid. Think about it, you may have a John Deere that has yellow coolant, a Komatsu with blue coolant and a Caterpillar with red coolant. What really does that mean to your maintenance personnel? Do they know how to properly maintain the fluid that is in the system? Do they know which bulk fluid to use for top off if you have more than one type of bulk fluid? Think about this… who is the one person in your fleet that sees every piece of equipment? How well is he trained to know what coolant type goes into the various equipment?

There are a couple of problems with this type of coolant maintenance practices:

1. It is very easy for improper top off to occur, leaving the systems vulnerable to corrosion and cavitation.

2. Money is being wasted keeping different coolant formulations in-house. This leads to coolant formulation mixing and the systems vulnerable to corrosion and premature failures.

Today there are more coolant formulations on the market to choose from. The coolant you choose must meet engine OEM specifications for use in their engines. Engine manufacturers have become very specific about what type of coolant is recommended for use in their engines. This has to do with the fluid compatibility with the materials used to manufacture the components in the system, i.e., hoses, seals, metallurgy, etc… Cooling system components and the engine are manufactured globally and the resources available to manufacture the components are different for each region.

Another reason for the changes to coolant formulations has to do with the increase in temperature and flow rates that have taken place over the years. Engines today output a lot of heat and the fluid used in the cooling system must be able to hold up to the additional heat and load put on the system.

Many people have been told that they do not have to test their cooling system if they are using Extended Life coolant. That the only thing they need to do is check the glycol level and keep the system topped off. This couldn't be farther from the truth and can leave your fleet vulnerable to expensive downtime.

There is a big disconnect on why testing your coolant is so important even if Extended Life coolant is being used. A few facts about ELC coolants need to be addressed first:

- ELC coolants are more stable
- You don't have to continually add supplemental coolant inhibitors or additives to the fluid, therefore eliminating overtreatment
- Longer service life can be achieved with ELC

If the above is true then why is it necessary to test these fluids?

1. Mechanical issues take place with-in the cooling system. These mechanical issues such as combustion gas leaks, air leaks, localized over-heating or hotspots or stray electrical ground issues can chemically affect and destroy the coolant and its inhibitors. In turn the chemically changed coolant can attack the metals and components in the system causing premature failure. A fluid cannot correct a mechanical issue but the mechanical issue can destroy the coolant making it unsuitable for continued use. The key to a coolant analysis predictive maintenance program is to predict and prevent premature failure of the system and the fluid.

2. The coolant can become contaminated due to poor maintenance practices or contaminants entering the system such as from and air leak. Contaminants are either going to form scale or acid depending on the pH. The effects of acid formation can be corrosive wear or pitting of cooling system components, degradation of hoses and seals and inhibitor/additive depletion or dropout.

If the fluid is alkaline the contaminants can form scale which can lead to cracked heads, ring/cylinder wear which increases oil consumption or oil degradation which increases bearing wear. Notice these issues affect the oil side as well as the cooling system side. Again, a fluid cannot correct excessive contaminants that find their way into the system whether it is due to maintenance practices or a mechanical issue allowing them to be drawn into the system.

3. Regular scheduled coolant analysis can determine coolant mixing. If mixing has occurred more than 25% the inhibitors will be too diluted to protect the system and serious corrosion can occur. Many fleets of mixed brands have different coolants used in them.

Loss of revenue from unscheduled maintenance is the largest drain for a company. Analyzing your coolant helps to eliminate the un-known. Education, regular scheduled coolant analysis and program assessments can eliminate these losses in revenue issues.

No matter what coolant formulation in use mechanical issues and contaminants can reduce the life of your engine and fluids. Only laboratory coolant analysis can pinpoint the issues before damage has occurred.

An effective fluid analysis program should address the four primary goals of coolant analysis: preventive maintenance, predictive maintenance, root cause analysis and life-cycle management.

Preventive Maintenance

Small problems with the coolant or cooling system can become catastrophic component or system failures if left unchecked. Regular coolant testing and analysis can determine:

- If the coolant is suitable for continued use or needs to be replenished or replaced (a laboratory can identify proper fluid change recommendations).
- If coolant mixing has occurred.
- If contaminants are present that can cause the formation of scale or acids.
- If additive depletion is compromising metal protection.

Predictive Maintenance

Coolant analysis can help in predicting impending failures by noting abnormalities and trends in test results. Trends can pinpoint mechanical and formulation concerns that may jeopardize the life and longevity of the system and its components. These issues often involve the formation of acids and scale, contamination ingression, electrical ground problems and localized overheating or hot spots.

Root Cause Analysis

When an engine or cooling system component failure does occur, coolant analysis at the proper intervals can identify the root cause of the problem, such as a blown head gasket, electrolysis, a blocked coolant line or an exhaust gas recirculation (EGR) system failure. Once the root cause has been determined, an experienced data analyst can make informed recommendations for correcting the problem and assist in establishing fluid maintenance procedures for preventing a recurrence.

Life-Cycle Management

Coolant analysis not only can detect deficient maintenance practices, but it can also assist you in implementing corrective actions to ward off issues within the cooling and lubrication systems, as well as provide indications of shortcomings in equipment operational practices and maintenance procedures.

Combining Coolant Analysis and Oil Analysis

When reviewing a coolant analysis report, it is important to evaluate it in concert with the oil analysis performed at the same maintenance interval. The effects of engine overheating may be evident in both oil and coolant samples. Remember, cooling system deficiencies affect all systems, including the engine, transmission and hydraulics.

Engines

High coolant temperatures can cause high oil temperatures, reducing the oil's operating viscosity and thereby its hydrodynamic lubricity. This leads to oil oxidation and eventual engine wear. This could be evident in ring sticking, piston glazing or varnishing, and valve wear, which often masks the fact that a cooling system problem was a contributing factor.

Transmissions

An overheated cooling system can also shorten transmission life. Transmission disc slippage may occur as a result of reduced oil viscosity at elevated temperatures. Transmission slippage creates more heat, which causes oil oxidation, and a vicious cycle is established.

Hydraulics

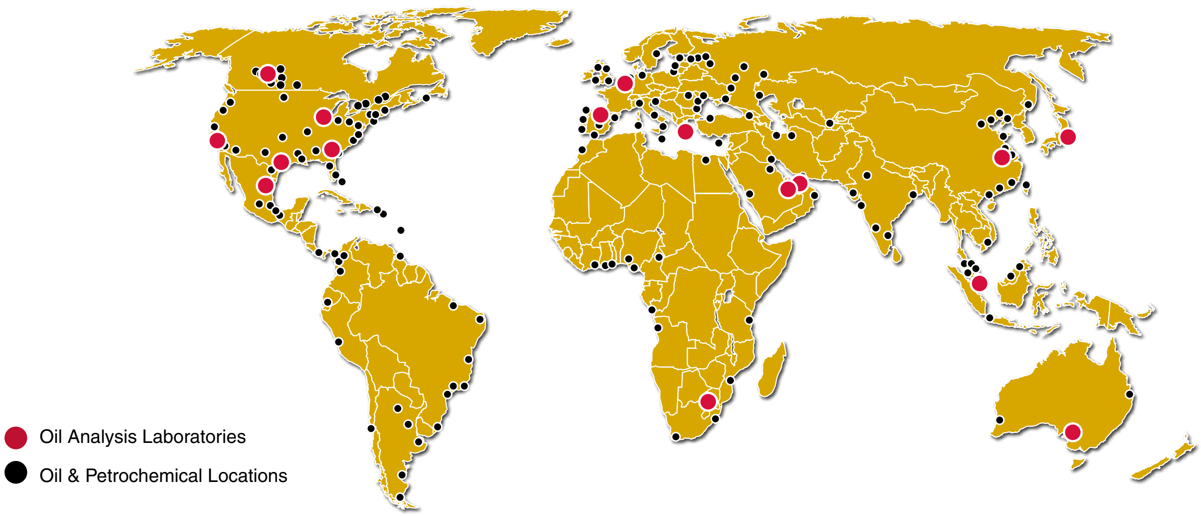
Hydraulic pumps and motors become less efficient at elevated temperatures and may reduce the life of valves, pump slippers, barrels, plungers and seals due to reduced oil viscosity and oil oxidation.

Engines, transmissions and hydraulics are often repaired with no consideration given to the possibility that a serious cooling system problem may have precipitated the issue. As a result, the same failures happen again and again.

Coolant analysis can dramatically improve machine performance, reduce unnecessary repair and replacement costs, and extend the life of equipment by optimizing the condition of the mechanical systems involved and the fluids that keep them running.

Bureau Veritas

Oil Analysis Global Network



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