

Machinery Lubrication

November - December 2014

machinerylubrication.com

MAINTENANCE AND RELIABILITY

Preventing Premature Engine Failure with Coolant Analysis



Preventing Premature Engine Failure with Coolant Analysis

By ELIZABETH NELSON, ANALYSTS INC.



Almost everyone knows 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.

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.

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 ingress, 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

Analysis Report
 Status: **CRITICAL** on Jan 15 2013

Analysts, Inc. | ISO 17025 Accredited | 3401 Jack Northrop Ave, Hawthorne, CA, 90250
 Phone: 800-424-0999

Acme Company
 Michael Smith
 1250 Hightower Road
 Mobile Alabama

Referencing the Lab Number will expedite resolving any question when contacting the lab concerning a sample.

Unit ID: S/N 6GF00492
 Component Type: COOLANT
 Unit Manufacturer and Model: Please provide
 Component Manufacturer and Model: Please provide
 Maintenance Recommendations for Lab No. 201301170384
 From: Acme Company - Coolant Analysis

Unit Worksite: 121130-0403
 Component: COOLANT
 Coolant Type: Please Provide
 Component Serial Number: 6GF00492
 Reported On: Jan 17 2013
 Comp. Ref. NO.: 5614288

Data analysts provide you with Maintenance Recommendations based on in-depth analysis, taking the guesswork out of interpreting coolant analysis results.

ANALYSIS INDICATES CRITICAL COOLANT CONDITIONS! Iron, copper, lead, tin and zinc are extremely elevated to a critical level. Solder bloom from lead corrosion could be plugging the cooling system passages and restricting flow of the coolant and cavitating. This coolant could be boiling internally due to the lack of glycol present. The pH level is low and the coolant will become acidic under heat due to the lack of supplemental coolant inhibitor. The reserve alkalinity level is extremely low due to the lack of coolant maintenance. Recommend correcting the solder corrosion. Clean this system with a cleaner designed to remove heavy metals then flush 3 - 5 times to completely remove cleaner. Install new recommended coolant containing 50% glycol and proper supplemental coolant inhibitors. Resample this system in 30 days to be sure metals are coming under control and the coolant maintenance levels are adequate.

Corrosion occurs when buffers are no longer able to counter acid formation due to thermal degradation.
Typical Corrosion Product Sources:
Iron — liner, water pump, cylinder block/head
Aluminum — radiator tanks, coolant elbows, piping, spacer plates, thermostat housings
Copper — radiator, oil cooler, aftercooler, heater core
Lead — radiator solder, oil cooler, aftercooler, heater core

Silicon, Boron, Molybdenum and Phosphorous are inhibitors present in coolants for metal protection and pH control. Inhibitors present are dependent upon the coolant formulation.

Calcium and Magnesium Contaminants present in an engine coolant will form scale on hot metal surfaces. Scale is an insufficient insulator and can cause localized engine overheating which can result in component failure. OEM and ASTM specifications are set on Total Hardness levels as CaCO.

SPECTROCHEMICAL ANALYSIS IN PARTS PER MILLION

LAB NO.	Fe	Cu	Al	Mn	Pb	Zn	Sn	Ca	Mg	Si	B	Mo	P	Ni	As	Se	Ag	Au	Co	Cr	Other	Sample Drawn
0384	1131	<1	<1	130	16	86	<0.1	1	25	32	918	990	<5	991	57	<10	<10	4	<30	1	01/15/13	

Complete and accurate Sample Information – number of hours on both unit and coolants and filter and fluid change information – is critical for a data analyst to make a proper maintenance recommendation.

SAMPLE INFORMATION

LAB NO.	HR/HR Unit	Spills/Gasoline	Coolant Add	FLTR CHG	COOLANT CHG	Nitrite ppm	Color	pH	R.A. ml	Visual Appear	Antifreeze %	Freeze Pt. °F
0384	570	0	N	N	600	Brown	7.70	2.8	Opaque	25	5	

Adequate glycol levels must be maintained to ensure proper Freeze and Boil Point protection. High glycol can cause additive dropout and decrease coolant life. A glycol range of 45% to 60% is recommended.

Nitrite is present in heavy duty, fully formulated conventional coolants, nitrite OAT and hybrid coolant formulations. Some are a combination of nitrite and molybdenum. The maximum acceptable level of nitrite or nitrite and molybdenum combined is 3200 ppm (parts per million). Excessive nitrite levels can lead to solder corrosion.

An adequate pH range should remain between 8.0 – 11.0 for conventional coolants and 7.0 – 9.5 for ELCs. Proper pH levels are necessary for optimum corrosion inhibitor performance.

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. ■

About the Author



She can be reached at enelson@analystsinc.com.

Elizabeth Nelson is the coolant program manager for Analysts, Inc. She has more than 30 years of experience working with OEMs and coolant manufacturers and training field and reliability engineers and maintenance personnel on the importance of coolant analysis.

ABOUT US

Since 1960, Analysts, Inc. has established a trusted reputation as a world class oil analysis laboratory. As the pioneering force in oil analysis, Analysts is recognized worldwide as the leading provider of diagnostic evaluations and maintenance solutions. Today's top corporations rely on Analysts for ASTM and other industry-accepted test methods and advanced instrumentation.

As an independent analytical testing organization, Analysts operates five regional laboratories in the U.S. and three abroad – in Tokyo, Japan, Monterrey, Mexico, and Zhenjiang (Jiangsu) China. Our services cover an entire spectrum of industries, including production machinery, manufacturing equipment, power generation, marine, heavy construction, mining, trucking, transit and aircraft industries.

Our oil analysis programs help equipment managers understand the “what, when, where and why” of events happening inside any lubricated component. Armed with quality testing, expert data analysis and easy-to-follow maintenance recommendations, these managers can more effectively assess equipment condition and plan maintenance schedules to minimize breakdowns and maximize uptime.



ANALYSTS, INC.

3401 Jack Northrop Ave., Hawthorne, CA 90250
TEL 800.655.4473 • analystsinc.com