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## Service Bulletin

# Oil Analysis Techniques for High Horsepower Diesel Engines

## INTRODUCTION

This service bulletin outlines the proper use of oil analysis techniques to collect an oil sample, to set oil analysis flag limits, and to identify and take appropriate corrective action based on oil analysis results. This document applies to the following high horsepower engines: K19, QSK19, QSK23, V28, QST30, K38, QSK38, QSK45, K50, QSK50, QSK60, and QSK78.

Used oil analysis can be employed to monitor engine oil contaminant levels, which can provide evidence of system weaknesses or malfunctions, such as faulty air filtration, coolant leaks, fuel dilution, and wear metals that can suggest engine damage or unusual wear. Oil analysis can be used to proactively identify and address these issues.

Standard oil analysis has limitations, which include the inability to detect large particles and the inability to identify rapidly developing failures. Because of the method used to detect wear metals for standard oil analysis, particles greater than 5 microns ( $\mu\text{m}$ ) in size can **not** be detected. However, if large particles are suspected, oil analysis labs can perform a ferrographic analysis to quantify individual particles in the sample. Properties like magnetism, heat treatment, shape, and size can be identified to help determine the source of the particles and the associated wear mechanism.

The second limitation to oil analysis is the inability to detect rapidly developing failures. In order to identify a potential problem, a failure would have had to be in progress at the time the last oil sample was taken. Some failure modes progress so quickly that they will **not** be identified in oil analysis.

The guidelines outlined in this bulletin are **not** to be used to establish oil drain intervals. The use of these guidelines for the purpose of extending oil drain intervals may result in the continued use of oil that no longer provides the intended protection. Oil analysis trends can

be charted over a period of time and can provide significant information concerning oil change intervals. For more information on this topic, refer to [Cummins® Engine Oil and Oil Analysis Recommendations, Bulletin 3810340](#), or the Operation and Maintenance manual for the specific engine model for other oil related information.

Table 1 lists those wear metals, oil contaminants, and oil properties that provide the most reliable indicators to detect a potential problem. This list provides both a minimum set of items that should be checked during oil analysis and a list of recommended items to monitor for extended testing. Extended testing is recommended when a problem with the oil condition is suspected, either from the results of the minimum testing or some other indicator in engine operation.

<b>Oil Property</b>	<b>Abbreviation</b>	<b>Minimum Testing</b>	<b>Extended Testing</b>
Aluminum	Al	X	X
Copper	Cu	X	X
Fuel dilution	Fuel	X	X
Iron	Fe	X	X
Lead	Pb	X	X
Potassium	K	X	X
Silicon	Si	X	X
Sodium	Na	X	X
Viscosity at 100°C [212°F]	Visc	X	X
Total base number (ASTM D4739)	TBN		X
Total acid number (ASTM D664)	TAN		X
Soot	Soot		X
Nitration	Nit		X
Oxidation	Ox		X

ISO 17025 is an international standard for testing and calibration laboratories that covers both the methodology and testing equipment of a lab. This standard uses an accreditation body to test if the lab consistently produces valid results. Choosing an oil analysis lab that meets the ISO 17025 certification for the particular oil analysis tests listed above is recommended.

## OIL SAMPLE COLLECTION

Oil sample collection intervals **must** be set in such a manner that trend comparisons can be made. As oil circulates in an engine during normal operation, wear metals and contaminants accumulate at a steady rate. The amount of contaminants in the oil at the time of sampling generally depends on the length of time since the last oil change. In order to be able to detect changes in the wear pattern of an engine, the sample **must** be collected in consistent hour intervals. Background data is required if oil analysis is to be used correctly. Such data **must** include:

Information to provide with each sample:

- Engine model/serial number
- Miles/hours of oil use
- Miles/hours on engine since new or rebuild
- Oil used (brand name, performance category and viscosity grade)
- Date sample was collected
- Engine application
- Amount of new oil added since previous oil change.

Information to investigate potential issues:

- Any recent engine maintenance
- Analysis of new (unused) oil.

It is important to conduct oil analysis on new (unused) oil to establish a baseline. New (unused) oil analysis samples should be taken each time the oil type or oil supplier is changed or, at a minimum, twice a year. Samples should be taken from the bulk supply tanks to determine the makeup of the oil and also to confirm that no contaminants are being introduced by the storage system.

The sample to be used for analysis **must** be representative of the oil in the engine. Use the following guidelines when collecting oil samples:

- Bring the engine to operating temperature prior to sampling. This will make sure representative contaminant levels are in the sampled increment.
- Successive samples **must** be taken in the same manner and from the same location.
- Take the oil sample before adding any new oil to the engine.
- **Always** collect oil in a clean, dry container.
- Collect a minimum of 118 ml [4 oz] of oil.

Two methods can be used to collect oil samples:

The recommended method for collecting an oil sample is to take the sample from a pressurized port while the engine is idling and warm. This method will make sure the oil sample is **not** stagnant and represents the actual homogeneous oil mixture that is flowing through the engine.

1. Clean the outside of the valve by wiping with a clean, dry rag.
2. Idle the engine and bring to warm temperature.
3. Purge the sample fitting by allowing a small amount of oil to flow through the valve.
4. Collect the sample into a clean, dry bottle from the oil stream being pumped by the idling engine.

**NOTE: A recommended location for sampling is a port that allows oil to be collected before the oil is filtered. Reference the Operation and Maintenance Manual for component locations.**

In cases where the engine is **not** operational, an alternative method may be used. This method uses a vacuum to draw oil out of the sump. The sample should be obtained as soon after stopping the engine as possible so the oil is still warm and stratification has **not** occurred.

1. Use the dipstick to determine the oil level in the pan.
2. Hold a new, clean piece of tubing against the dipstick and mark, on the tube, the location where the dipstick seats.

3. Cut the tubing so it reaches 25 to 50 mm (1 to 2 inches) below the oil level in the pan.
4. Insert the tubing into the dipstick tube so that the mark previously made on the tubing is aligned with the top of the opening for the dipstick tube.
5. Use a hand operated vacuum pump to pump the sample into a clean dry bottle.

**NOTE: Do not allow the tube to draw oil from the bottom of the oil pan, because excess debris will be included that could bias the sampling results. Do not reuse the sampling tube.**

## SETTING OIL ANALYSIS FLAG LIMITS

Understanding the oil system is crucial to identifying when an oil sample is indicating a problem. Large oil system capacity, use of Centinel™ oil replenishment systems, and use of eliminator or centrifuge filtration systems will result in overall lower contamination levels, compared to an engine that has a standard sump capacity, no replenishment system, and standard oil filters.

System capacity can be determined by knowing the volume of the oil required to touch the high-level mark on the dipstick and the volume of any remote oil tanks on the machine in which oil is continuously circulated. Oil sump capacities are listed in the operation and maintenance manuals for all Cummins® engines. If the machine is equipped with an oil reserve system with a reservoir remote from the engine oil sump, the reservoir volume **must** be added to the engine sump volume to determine the total system capacity. This is **only** true for remote tanks in which the oil is continuously circulated. The Centinel™ make-up tank volume does **not** add to system capacity, since the engine oil is **not** continuously circulated through this tank.

The addition of new oil will also decrease the overall level of contaminants. In all cases, oil consumption should be documented by the amount of oil added prior to each service interval. Trending oil consumption is important, as any rising trend or step change in oil consumption can indicate possible power cylinder wear, system leaks, or other system malfunction.

One way to compensate for the differences in oil systems between units is to look at the normal wear rates for each engine individually. This method establishes a baseline specific to that particular engine. Provided the oil usage remains fairly constant and other systems are functioning consistently, the trends in wear metals should remain consistent.

For example, setting up statistical flag limits based on a large group will normalize the data. If an engine historically had very low rates of wear, but suddenly jumps to a higher wear rate that is consistent with the average wear rate for the group of engines being analyzed, no flag would be triggered. In comparison, looking at historical readings on a particular unit may cause action to be taken at a lower contaminant level.

Cummins Inc. recommends that customers work directly with their oil analysis labs to establish appropriate limits for their engines using statistical methods. As a guideline, labs should group engines with Centinel™ and without Centinel™ into separate groups. Labs should also group engines with Eliminator™ or Centrifuge type filtration separately from engines with standard filter configurations. Engines should also be grouped together by common oil system capacities. If all engines are grouped together regardless of oil systems, the engines with Centinel™, Eliminator™/Centrifuge type filtration, and higher oil system capacities will experience a higher degree of engine wear before the flag limit is reached.

If the oil analysis lab can **not** provide flag levels based on statistical analysis of previous results, then the fixed flag levels in Table 2 can be used as a reference.

**NOTE: The table published below is to be used only as a reference, keeping in mind the items mentioned above that will affect the concentration of wear metals and contaminants in the oil.**

Table 2: Flag Limits for High Horsepower Engine Oil Analysis				
Oil Property	Abbreviation	Units	Caution Flag Limit	Critical Flag Limit
Aluminum	Al	parts per million (ppm)	15	30
Copper	Cu	parts per million (ppm)	60	180
Fuel dilution	Fuel	percent (%)	5%	
Iron	Fe	parts per million (ppm)	50	130
Lead	Pb	parts per million (ppm)	20	50
Potassium	K	parts per million (ppm)	40	110
Silicon	Si	parts per million (ppm)	40	110
Sodium	Na	parts per million (ppm)	40 <sup>1</sup>	110 <sup>1</sup>
Viscosity change at 100°C [212°F]	Visc	centistokes (cSt)	1 Viscosity Grade	
Total base number	TBN	milligrams potassium hydroxide per gram of sample (mg KOH/g)	2.5 number minimum or equal to total acid number (TAN)	
Total acid number	TAN	milligrams potassium hydroxide per gram of sample (mg KOH/g)	2.5 increase over new oil or equal to total base number (TBN)	
Soot	Soot	percent (%)	5% <sup>2</sup>	
Nitration	Nit	absorbance units per centimeter (abs/cm)	25	
Oxidation	Ox	absorbance units per centimeter (abs/cm)	25	