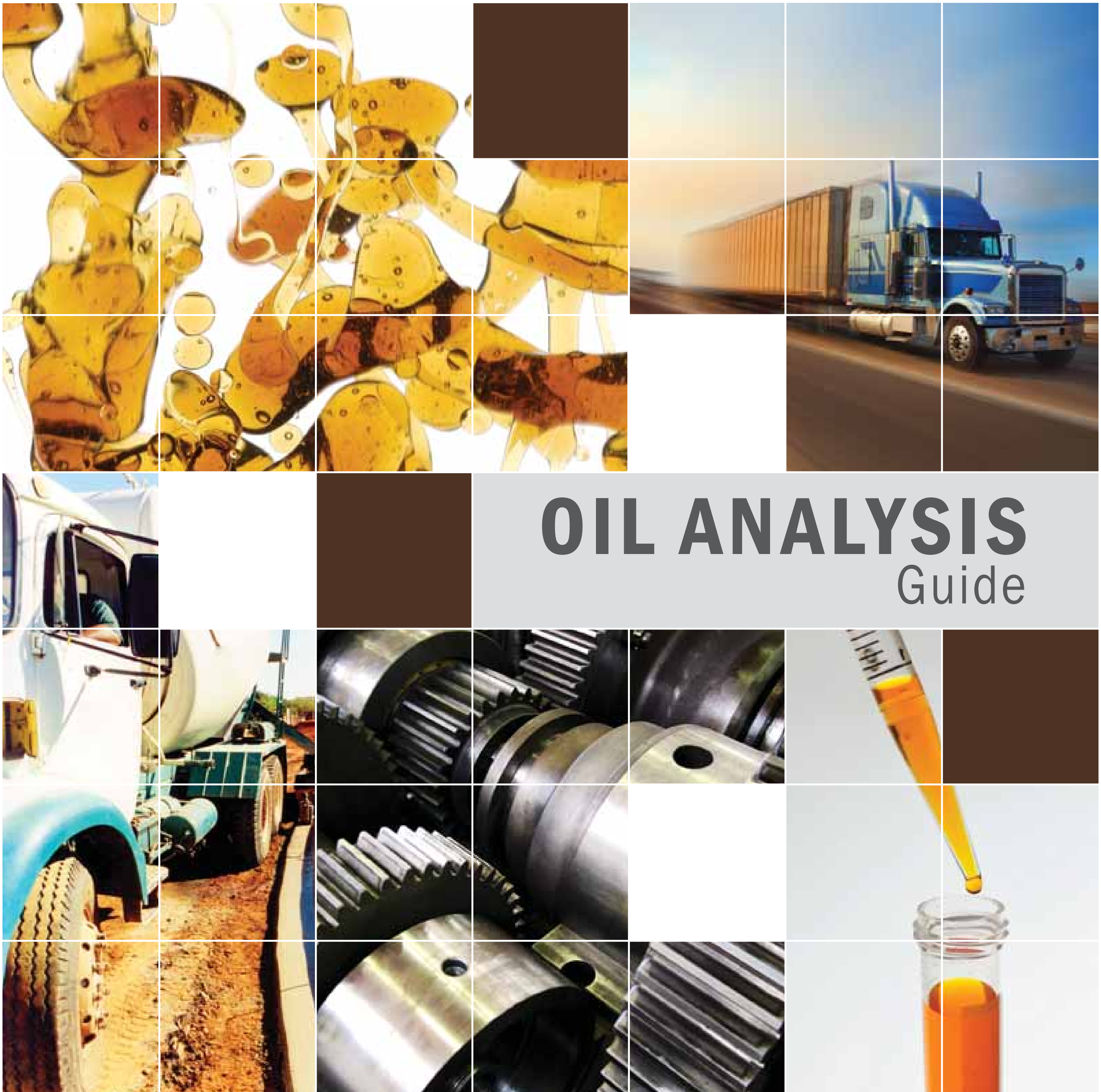


OIL ANALYSIS
Guide

AGAT Laboratories

Service Beyond Analysis ■ www.agatlabs.com

Analytical solutions for the **Environmental, Energy, Mining, Transportation, Industrial, Agri-food** and **Life Sciences** sectors.

Interpreting Oil Analysis Test Reports

AGAT Laboratories' maintenance professionals provide clients with pre-planned monitoring packages or if required, custom-designed packages to suit their individual project needs. With flexible options made available, we ensure that equipment remains operational and efficient at all times. Our experts are experienced and up-to-date on all analytical procedures for lubricated equipment. Their focus on maintaining the highest standards of quality in their analytical results will ensure that your maintenance program is a success.

Why Test Lubrication Oils?

Testing lubrication oils can determine when the oil's lubrication properties have been depleted and can provide insight on the condition of the mechanical operating equipment. These tests provide the advantage of scouting out early warning signals that could signify problems later on. By catching an issue early, the problem can be caught and resolved before permanent or costly damage occurs.

Return on Investment

Loss of production is often the most expensive result of equipment down-time. A good preventive maintenance program can reduce these costs and improve production. Through an *Oil Analysis Program*, premature failures can be reduced maximizing equipment life and reducing capital costs for new equipment. AGAT Laboratories' *Oil Analysis Program* will allow the development of efficient maintenance schedules to reduce necessary repairs and lubrication costs.

Why Establish a Testing Program?

Oil testing programs are the most effective when sampling is conducted on a regular basis. For consistent testing, a program is required to determine the normal wear from the abnormal wear, as every unit will wear differently. Monitoring through analysis can allow for warning signals to be identified prior to the occurrence of damage.

Engine Oil Contamination

The most common engine oil contaminants are silicon (dirt), fuel dilution and antifreeze coolant. Silicon (dirt) contamination is the most common form of contamination and causes serious engine wear due to its abrasive actions against all moving parts within the engine. If the silicon levels surpass 25 ppm, the air intake system should be inspected to locate the source of entry for the dirt and other airborne debris.

Coolant is another very common oil contaminant and probably the most serious. Water from the coolant reduces the lubricity causing severe bearing problems, while the glycol degrades at high temperatures and forms into sludge. Monitoring water contamination levels is unreliable, as normal engine temperatures are high enough to evaporate water over time, keeping detectable levels as low as 0.05 per cent. Coolant levels can be detected by chemical analysis and through monitoring the levels of boron, sodium and potassium in the oil.

Evidence of Contamination

Signs	Possible Causes	Effects
Viscosity Increase	Soot, lead, water contamination or high temperature operation.	Wear rate increase.
Viscosity Decrease	Fuel dilution or excessive high speed operation.	Wear rate increase.
Additive Depletion	High operating temperatures, long drain intervals or improper make-up oil.	Reduce lubricating properties, increases wear rate.
High Solids Content	Dirt, dust, soot, engine metals or high temperature operation.	Increases wear rates, reduces life of equipment.
Water Contamination	Coolant leak, low temperature operation or poor mechanical conditions.	Reduces lubricating properties of the oil, causes corrosion formation.
Glycol Contamination	Cooling system leak.	Reduces lubricating properties of the oil, causes corrosion formation.
High Wear Metals	Accelerated normal wear.	Reduces the life component.

Contaminants Found in Oil

Contaminant	Possible Causes	Effects
Fuel Combustion Products	Soot, sulphur compounds, water, lead compounds or partially oxidized fuel.	Increased viscosity, deposit formation and can cause corrosion.
Liquid Fuel	Fuel in the oil.	Reduced viscosity, increased wear rates and deposit formation.
Solid Particles	Dirt and airborne dirt, wear metals, rust, corrosion or fuel soot.	Wears vital engine parts and can increase oil viscosity.
Water Contamination	Combustion, the cooling system or other mechanical problems.	Rusting and corrosion, forms sludge and acids and reduces lubrication properties of oil.
Coolant Contamination	Coolant leaks can react with oil additives.	Sludge deposits and reduced lubrication properties of the oil.

Spectrochemical Analysis on Wear Metals and Additives

This type of analysis determines the level of wear metals, additives and contaminants in new and used oil. Done on all types of samples, rates of wear, additives and contaminants are trended to identify problems.

Please note: This analysis measures only soluble particles (<10 μm).

Wear metal analysis can indicate which engine components are wearing and if the wear is becoming significant. This information can make the difference between minor component inspections and repairs versus major overhauls.

Wear metal analysis requires more than simply plotting data on a graph. Wear metals can be generated from as many as a dozen different engine parts and locations making it difficult to identify the specific part that is wearing excessively.

Wear Metals/Additives

Metal	Common Sources	General Purpose	Required Action
Aluminum *(Al)*	Bushings, shims, washers, pistons, bearing cage surfaces (thrust/turbo) or blowers.	Strong, lightweight material (smaller mass) which dissipates heat well and aids in thermal transfer.	Higher than expected *Al* level. May represent wear or be a component of silicon dirt. Identify and evaluate source of *Al*.
Chromium *(Cr)*	Plating material, seals, bearing cages, piston rings, liners, shafts or chromate corrosion inhibitor from coolant system.	Because of its strength and hardness, is used to plate rings and shafts that are usually mated with steel (softer).	Higher than expected *Cr* level. May represent component of water inhibitor or engine wear. Identify and evaluate source of *Cr*.
Copper *(Cu)*	Bearings, bushings (wrist pin), oil coolers, radiators, camshaft thrust washers, gears, valves, clutch plate or sealing compounds.	Utilized to wear first in order to protect other components. Conforms well so is used to seat bearings to the crank-shaft. **Remember:** *Cu* + *Zn* = Brass *Cu* + *Sn* = Bronze	Higher than expected *Cu* level. May represent wear, cooling water leaks or scaling compounds. Identify and evaluate source of *Cu*.
Iron *(Fe)*	Gears, blocks, cylinder wall/ head liners, valve guides, piston rings, ball and roller bearings, oil pump or rust.	Is used as the base metal of steel in many components due to its strength. Since Iron will rust, it is alloyed with other metals (i.e. *Cr*, *Al*, *Ni*), making steel.	Higher than expected *Fe* level. May represent wear of rust/ scale contamination in case of water leaks. May be critical wear due to break-in. Identify and evaluate source of *Fe*.
Tin *(Sn)*	Bearings, bushings, wrist and piston pins, rings, piston overlay seals or solder.	Is a conforming material used to plate and protect surfaces to facilitate break-in. Surface coating on components such as the pistons.	Higher than expected *Sn* level. May represent bearing wear. Identify and evaluate source of *Sn*.

Metal	Common Sources	General Purpose	Required Action
Lead *(Pb)*	Overlay on bearing surfaces, seals, clutch, solder, oil additive in gear lubes, antiseize/grease compounds or gasoline contamination.	Is a conforming material used to plate bearings. Appears in new engines while the bearings are melding and conforming.	Higher than expected *Pb* level. May represent normal flashing wear after overhaul or problem wear. If appears later, misalignment may be indicated. Identify and evaluate source of *Pb*.
Silicon *(Si)*	External dirt/dust, grease additive, antifoam additive or gasket sealants.	Can be an antifoam additive in the form of silicone. Can be primary indicator of dirt/dust contamination.	Higher than expected *Si* level. May represent dirt/dust contamination. Identify and evaluate source of *Si*.
Molybdenum *(Mo)*	Surface coating on some piston rings or oil additive (antiwear).	An alloy used in some piston rings in place of *Cr*. Also used as a friction modifier (reducer) in some oils.	Unexpected *Mo* level. May represent wear or mixing with another product. Identify and evaluate source of *Mo*.
Nickel *(Ni)*	Bearing metals, valve stems/guides, ring inserts on pistons, turbo charger blades or stainless steel components.	Alloyed with iron in high strength steel, used to make valve stems and guides.	Higher than expected *Ni* level. May represent initial stages of bearing wear. Identify and evaluate source of *Ni*.
Silver *(Ag)*	Bearing cages or silver soldered joints.	Is used to plate components because it conforms well, dissipates heat and reduces coefficients of friction.	Higher than expected *Ag* level. May represent bearing wear or initial stages of cooling system degeneration. Identify and evaluate source of *Ag*.
Potassium *(K)*	Coolant additive.	Presence in oil may represent coolant contamination.	Higher than expected *K* level. May represent a coolant leak into engine crankcase. Identify and evaluate source of *K*.
Sodium *(Na)*	Coolant additive, grease additive, road salt or ingested dirt.	Not a wear metal. Presence in oil may represent coolant contamination.	Higher than expected *Na* level. May represent coolant leak into engine crankcase. Identify and evaluate source of *Na*.
Boron *(B)*	Water inhibitor, limited EP additive, coolant additive (borate) or grease additive.	May represent mixing with another product, water inhibitor or glycol.	Unexpected *B* level. May represent mixing with another product, water inhibitor or glycol. Identify and evaluate source of *B*.
Barium *(Ba)*	Detergent additive or grease additive.	Toxic additive but advantageous because it does not leave excessive ash residue.	Unexpected *Ba* level. May represent mixing with another product. Identify and evaluate source of *Ba*.

Metal	Common Sources	General Purpose	Required Action
Calcium *(Ca)*	"Hard" water, alkaline based additive or road salt.	Used as an oxidation inhibitor and is used to neutralize acids formed in combustion engines (detergent additive).	Unexpected *Ca* level. May represent mixing with another product. Identify and evaluate source of *Ca*.
Magnesium *(Mg)*	Component housing, a constituent in some *Al* alloys or detergent additive.	Oxidation inhibitor (detergent additive).	Unexpected *Mg* level. May represent mixing with another product or gasoline. Possible indication of hard water. Identify and evaluate source of *Mg*.
Manganese *(Mn)*	Valves, blowers, exhaust and intake systems or detergent additive (unleaded gas).	Unleaded gasoline additive.	Unexpected *Mn* level. May represent mixing with another product or gasoline. Identify and evaluate source of *Mn*.
Phosphorus *(P)*	Anti-wear/extreme pressure (EP) additive or coolant additive.	Used to provide a protective film in high-pressure areas. Coolant additive in conjunction with high *Na* and/or *K*.	Unexpected *P* level. May represent mixing with another product or coolant leak into engine crankcase. Identify and evaluate source of *P*.
Vanadium *(V)*	Surface coating, turbine impeller blades or valves.	Fuel contaminant, can also be alloying element for steel.	Higher than expected *V* level. May represent component wear. Identify and evaluate source of *V*.
Zinc *(Zn)*	Anti-wear additive, oxidation and corrosion inhibitor or brass alloy.	Used to provide a protective antiwear film.	Unexpected *Zn* level. May represent mixing with another product. Identify and evaluate source of *Zn*.

Viscosity

Viscosity is one of the most important properties of lubricating oil. It is a measurement of the resistance to flow at a specific temperature in relation to time and can indicate engine degradation. Normally, a viscosity increase from one grade to the next is a warning that the oil has reached the end of its useful life.

The two most common temperatures for lubrication oil viscosity are 40 °C and 100 °C. Viscosity is normally evaluated with a kinematic method and reported in centistokes (cSt.). In used oil analysis, the used oil's viscosity is compared to that of the new oil to determine whether excessive thinning or thickening has occurred.

Viscosity Break-down

High Viscosity Sources

- Contamination of soot/solids
- Incomplete combustion (A-F ratio)
- Oxidation degradation
- Leaking head gaskets
- Extended oil drain
- High operating temperature

Effects

- Increased operating costs
- Engine overheating
- Restricted oil flow
- Oil filter by-pass
- Harmful deposits or sludge

Viscosity Break-down Solutions

- Check air-to-fuel ratio
- Check for incorrect oil grade
- Inspect internal seals
- Check operating temperature
- Check for leaking injectors
- Change oil and filter
- Check for loose fuel crossover lines

Low Viscosity Sources

- Additive shear
- Fuel dilution
- Improper oil grade

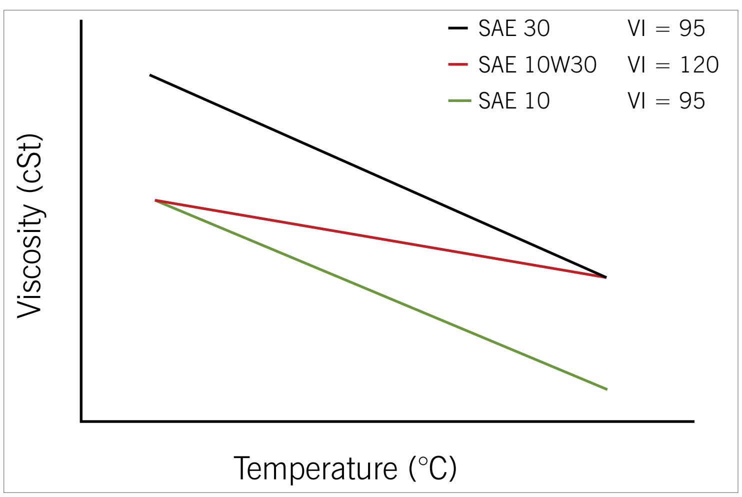
Effects

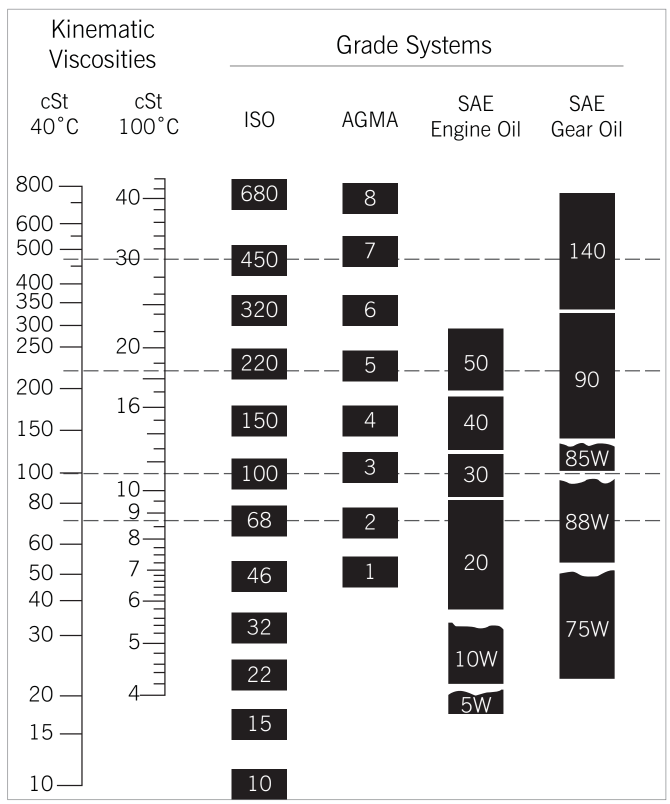
- Increased operating costs
- Engine overheating
- Poor lubrication
- Metal to metal contact

Viscosity Grades

SAE Viscosity Grade	Low Temperature Viscosities		High-Temperature Viscosities		
	Cranking (cP) max at temp °C	Pumping (cP) max with no yield stress at temp °C	Low Shear Rate Kinematic (cSt) at 100°C		High Shear Rate (cP) at 150°C min
			Min.	Max.	
0W	3250 at (-30)	60,000 at (-40)	3.8	-	-
5W	3500 at (-25)	60,000 at (-35)	3.8	-	-
10W	3500 at (-20)	60,000 at (-30)	4.1	-	-
15W	3500 at (-15)	60,000 at (-25)	5.6	-	-
20W	4500 at (-10)	60,000 at (-20)	5.6	-	-
25W	6000 at (-5)	60,000 at (-15)	9.3	-	-
20	-	-	5.6	<9.3	2.6
30	-	-	9.3	<12.5	2.9
40	-	-	12.5	<16.3	2.9 (0W-40, 5W-40, 10W-40 grades)
40	-	-	12.5	<16.3	3.7 (15W-40, 20W-40, 25W-40, 40 grades)
50	-	-	16.3	<21.9	3.7
60	-	-	21.9	<26.1	3.7

Viscosity Equivalents





Acid Number (AN)

The Acid Number (AN) is the quantity of acid or acid-like derivatives in the lubricant and serves as an indicator of oil serviceability. The AN of a new oil is not necessarily zero as oil additives can be acidic in nature. If an increase in AN is found in a new lubricant, it should be monitored as these increases usually indicate lubrication oxidation or contamination with an acidic product.

Sources of Increase

- High sulphur fuel
- Overheating
- Excessive blow-by
- Extended oil drain intervals
- Improper oil type

Effects

- Decreased base number (BN)
- Corrosion of metallic components
- Promotes oxidation
- Oil degradation
- Oil thickening
- Additive depletion

Solutions

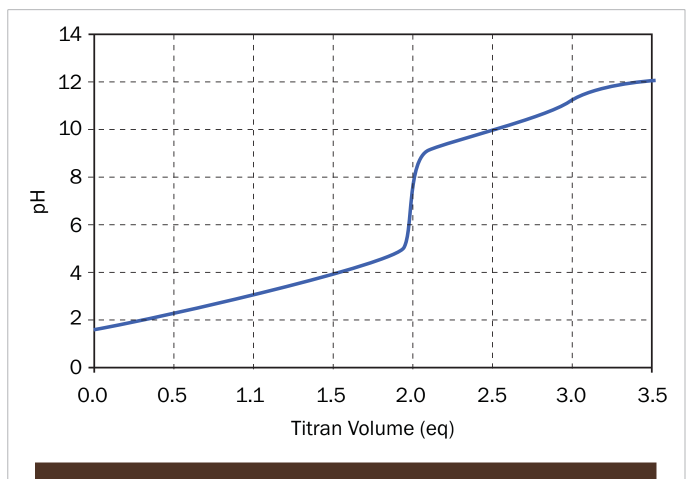
- Drain oil
- Reduce oil drain intervals
- Confirm oil type being used
- Check for overheating
- Check fuel quality

Base Number (BN)

The Base Number (BN) represents the amount of alkaline additives in the lubricant, which neutralizes the acidic products of combustion and combats the acid formation of in-service oils. The BN is an indication of oil degradation or contamination and can help to determine the oil life in diesel and gasoline engines.

Most engine oils are formulated with a variety of additives which enhance lubricity, inhibit oxidation and corrosion, and reduce the tendency for sludge and deposit formations. The levels of these additives can be determined by monitoring the BN.

For Example: The reduction of a BN below 4.0 is a warning that the additives have been depleted and an oil change should be scheduled.



Rule of Thumb
When the AN doubles, it is time to drain the oil.
When the BN is reduced by half, drain the oil.

Sources of Low BN

- High sulphur fuel
- Overheating
- Extended oil drain
- Improper oil type

Effects

- Increased acid number (AN)
- Oil degradation
- Increased wear rate
- Acid build-up in oil

Solutions

- Use low sulphur diesel fuel
- Re-evaluate oil drain intervals
- Verify base number of new oil being used
- Verify oil type being used
- Change oil
- Test fuel quality

Fuel Dilution

The fuel dilution of crankcase oil by unburned fuel reduces the effectiveness of the lubricant. Fuel dilution is serious as it can significantly reduce oil viscosity and lubricity thus causing engine wear. The thinning of lubricants can then lead to the decreased lube film strength, adding to the risk of abnormal wear. Fuel dilution can initially be detected by a lowering of the flash point of the oil, accompanied by a noticeable viscosity reduction and a heavy fuel odor. Fuel dilution is measured by both gas chromatography and fuel dilution meters. Depending on certain variables, when fuel dilution exceeds two and a half to five per cent, corrective action should be taken.

Sources of Dilution

- Incorrect air/fuel ratio
- Extended idling
- Stop and go driving
- Defective injectors
- Leaking fuel pumps or lines
- Incomplete combustion
- Incorrect timing

Effects

- Metal to metal contact
- Poor lubrication
- Cylinder ring wear
- Depleted additives
- Decreased oil pressure
- Reduced fuel mileage (mpg)
- Reduced engine performance
- Shortened engine life

Solutions

- Check fuel lines, worn rings, leaking injectors, seals and pumps
- Examine driving or operating conditions
- Check timing
- Avoid prolonged idling
- Change oil and filters
- Check quality of fuel
- Repair or replace worn parts

FlashPoint

Flashpoint is done on fuels, engine oils and large bath application oils. It is used to determine fuel contamination or the flammability hazard of a sample. It is measured in degrees Celsius (°C) and can be taken as absolute or correlated against the sample viscosity, to determine the percentage of fuel in the sample.

Please note: Water and glycol can bias this test.

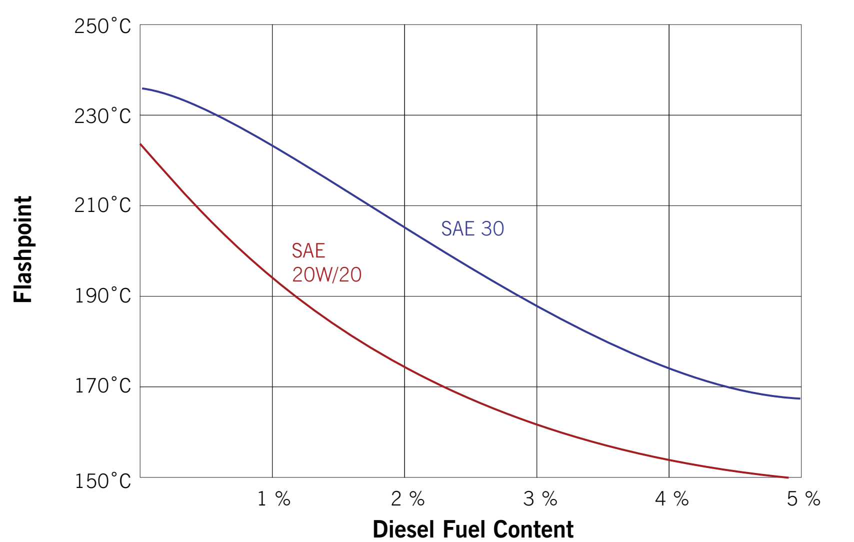


Figure 3. Diesel Fuel Content and FlashPoint in Motor Oils (by Volume)

Solids

Solids represent a measurement of all solid and solid-like material contained in a lubricant. The composition of solids depends on the system. In diesel engines, fuel soot is usually the major component measured. In non-diesel engines, wear debris and oil oxidation products are usually measured.

Causes

- Extended oil drain intervals
- Environmental debris
- Wear debris
- Oxidation by-products
- Leaking or dirty filters
- Fuel soot

Effects

- Shorter engine life
- Filter plugging
- Poor lubrication
- Engine deposits
- Formation of sludge
- Accelerated wear
- Decreased oil flow

Solutions

- Drain oil
- Flush system
- Change operating environment
- Reduce oil drain intervals
- Change filters

Fuel Soot

Fuel Soot is composed of carbon and is always found in diesel engine oil. Laboratory testing is used to determine the quantity of fuel soot in used oil samples. The fuel soot level is a good indicator of engine combustion efficiency and should be monitored on a regular basis.

Please note: EPA Emissions Regulations place significant importance on fuel soot levels.

Causes

- Improper air/fuel ratio
- Improper injector adjustment
- Defective spray pattern
- Poor fuel quality
- Incomplete combustion
- Low compression
- Worn engine parts/rings

Effects

- Poor engine performance
- Poor fuel economy
- Harmful deposits or sludge
- Increased wear
- Carbon deposits
- Clogged filters/ reduced filter life

Solutions

- Ensure injectors are working properly
- Check air induction/ filters
- Change oil
- Assess oil drain intervals
- Check compression
- Avoid excessive idling
- Inspect driving and operating conditions
- Check fuel quality

Oxidation

During oxidation, certain conditions will cause lubricating oil in engines and other components to combine with available oxygen, forming a wide variety of harmful by-products. These by-products can cause lacquer deposits to form which will corrode metal parts and thicken oil so it will not lubricate. Most lubricants contain additives that inhibit or retard the oxidation processes however heat, pressure and catalyst materials can accelerate the oxidation process. The method used to measure levels of oxidation in used oil is referred to as *Differential Infrared Analysis*.

Causes

- Overheating
- Extended oil drain intervals
- Improper oil type/inhibitor additives
- Combustion by-products/blow by

Effects

- Shortened equipment life
- Oil filter plugging
- Increased viscosity
- Corrosion of metal parts
- Increased operating expenses
- Increases wear rate
- Decreased engine performance

Solutions

- Use oil with oxidation inhibitor additives
- Shorten oil drain intervals
- Check operating temperatures
- Check quality of fuel

Nitration

Nitration products are formed during the fuel combustion process in which combustion by-products enter the engine oil during normal operation or as a result of abnormal blow-by past the compression rings. These by-products are highly acidic and can create deposits and accelerate oil oxidation. Infrared analysis is the only method to accurately measure nitration products in used oil.

Causes

- Improper scavenge
- Low operating temperatures
- Defective seals
- Improper air/fuel ratio
- Abnormal blow-by

Effects

- Accelerated oxidation
- Nitrous oxides introduced into the system
- Acidic by-products
- Increased cylinder wear
- Oil thickening
- Combustion deposits
- Increased acid number (AN)

Solutions

- Increase operating temperature
- Check crankcase venting hoses and valves
- Ensure proper air/fuel mixture
- Perform compression check

Particle Count

Particle count testing measures the quantity and micron size of various solid contaminants in a fluid. It is primarily used for hydraulic and turbine systems to evaluate the effectiveness of the filters. The instrument that is normally used is the HIAC/ROYKO Particle Counter, which measures the total population of particles in various ranges. It has been proven that reducing the particulate debris in the fluid can greatly increase the life of these systems.

Source of Contamination

- Water contamination
- Oil oxidation
- Worn seals
- Ineffective filtration
- Dirty makeup oil

Effects

- Increased wear
- Equipment/System failure
- Plugging and/or leakage
- Pressure pulsing
- Sluggish valves or actuators

Solutions

- Change filter
- Change oil
- Use higher quality filters
- Ensure integrity of seals

Important: After an analysis is completed, ISO Cleanliness Codes are determined from the results.

DID YOU KNOW?

Created by the International Organization for Standardization, ISO Cleanliness Codes are used as a standard for measuring and reporting particulate contamination levels in fluids. These codes are assigned based on the number of particles per unit volume greater than 4, 6 and 14 microns.

Data Acquisition

In order to assign an ISO Cleanliness Rating to represent the contamination level of a fluid, the number of particles greater that 5 micron and 15 micron unit volume must be available. Furthermore, the particle population must be obtained from a particle counting system which has been calibrated per ISO/DIS 4406 or an ISO approved equivalent method in order to assign a valid cleanliness rating. The actual counting system is irrelevant as long as the acceptable calibration certification is available.

Why is Compliance so Important?

ISO Cleanliness Codes reveal if the levels of particulate contamination in oil are high or not. These codes can be used in conjunction with preventative maintenance to achieve increased efficiency and reduced equipment downtime.

ISO Cleanliness Rating Reference Chart

International Standard ISO 4406

Particle Concentration (number of particles per)			ISO Range Number
# per ml		# per 100 ML	
More than	Up to and including		
5,000,000	10,000,000	500M - 1,000M	30
2,000,000	5,000,000	200M - 500M	29
1,300,000	2,000,000	130M - 200M	28
640,000	1,300,000	64M - 130M	27
320,000	640,000	32M - 64M	26
160,000	320,000	16M - 32M	25
80,000	160,000	8M - 16M	24
40,000	80,000	4M - 8M	23
20,000	40,000	2M - 4M	22
10,000	20,000	1M - 2M	21
5,000	10,000	500K - 1M	20
2,500	5,000	250K - 500K	19
1,300	2,500	130K - 250K	18
640	1,300	64K - 130K	17
320	640	32K - 64K	16
160	320	16K - 32K	15
80	160	8K - 16K	14
40	80	4,000 - 8,000	13
20	40	2,000 - 4,000	12
10	20	1,000 - 2,000	11
5	10	500 - 1,000	10
2.5	5	250 - 500	9
1.3	2.5	130 - 250	8
0.64	1.3	64 - 130	7
0.32	0.64	32 - 64	6
0.16	0.32	16 - 32	5
0.08	0.16	8 - 16	4
0.04	0.08	4 - 8	3
0.02	0.04	2 - 4	2
0.01	0.02	1 - 2	1
0.005	0.01	0.5 - 1	0.9
0.0025	0.005	0.25 - 0.5	0.8

Glycol Analysis

Coolant Analysis: Is an important part of AGAT Laboratories' *Preventative Maintenance Program*. This analysis involves testing to determine the quality and suitability of a coolant for its intended application. Poor quality coolant will corrode significantly more metal surface on liners, coolers, heat exchangers, radiators and other affected components in a given time period. As a result, it is extremely important that coolant analysis is performed at least once a year, or when a coolant problem is suspected.

Parameter	Acceptable Range	Possible Sources (when out of range)
pH	7 - 11	Depletion of additives.
Reserve Alkalinity	7 or greater	Depletion of corrosion inhibitors.
T.S.S.	> 1200 ppm	Poor water quality, scale or corrosion build-up, poor filters, reservoir open to atmosphere or component wear.
Freeze Point	> (-30°C)	Glycol to water ratio too low.
Glycol Strength	50 - 60%	Glycol to water ratio too low.
Soluble Iron	> 2 ppm	Improper coolant, pump wear, defective pressure caps, air leaks, cavitations or hoses.
Soluble Copper	> 1 ppm	Improper coolant, pump wear, defective pressure caps, air leaks or hoses.
Soluble Lead	> 3 ppm	Improper coolant, pump wear, defective pressure caps, air leaks or hoses.
Total Aluminum	> 2 ppm	Improper coolant, pump wear, defective pressure caps, air leaks or hoses.
Total Phosphorus	300 - 500 ppm	Coolant additive.
Total Silicon	50 - 250 ppm	Coolant additive, dust entry or silicon sealant.
Sulfate	> 100 ppm	Poor water quality, SO_4, cleaner or gas leak into the system.
Nitrate	800 - 2,400 ppm	Defective pressure caps, gas leak into the system, water pump drowning air or insufficient chemicals.
Chlorides	> 40 ppm	HCl cleaners or poor water quality.
Sodium	> 200 ppm	Coolant additive.
Salt as NaC1	> 200 ppm	Poor water quality, defective pressure caps, old coolant or HCl cleaners.
Free CO2	> 1,000 - 2,000 ppm	Water pump drowning air, defective pressure caps, old coolant or HCl cleaners. Transportation of sample.
Conductance	> 6,000 ppm	Poor water quality or gas leak into the system.
Total Hardness	> 170 ppm	Poor water quality.
Specific Gravity	1.050 - 1.14	Glycol to water ratio.

Interpreting the Results/Tests/Reports
and Taking Corrective Action

An evaluation will result in a statement that the unit is normal or a statement that general maintenance recommendations are needed.

Recommendation Categories

Normal

It is important to know that a unit is normal as it can save an unnecessary tear-down.

Abnormal (Reportable)

This category is followed by specific maintenance recommendations, or a notation that component wear is abnormal and reportable.

Example: Recommended to change oil and filters with a comment noting that abnormal bearing wear is present. Recommend to complete suggested maintenance. A second sample (re-sample) may be suggested at this time.

We do not recommend that you go into a unit on an abnormal recommendation unless you have thoroughly discussed the report with the appropriate laboratory personnel (if required) or if you have indications that the unit has a more serious problem than is apparent in the report. Judgement should be based on all tools at your disposal including your report, personal knowledge of the unit and the manufacturer's guidelines and recommendations.

Critical

This category indicates potential failure and that a serious condition exists. The suspected nature of the problem will be indicated and a general recommendation made for maintenance action.

Important: Critical units generally require immediate attention.

If the wear increases, you will be advised of the suspected nature of the problem. Re-sampling may be recommended as a way to verify improper sampling techniques or contamination through the sampling procedure.

Re-sampling: In the event of a critical unit where there is no previous history of a critical result, additional samples are recommended to establish a trend.

In some cases, the data will identify an obvious problem. For example, a high level of water contamination along with high levels of sodium, potassium and boron is a good indication of antifreeze contamination. A high particle count and high levels of silicon usually indicate dirt or dust contamination and air filters or breathers. Oil storage and handling procedures will need to be reviewed.

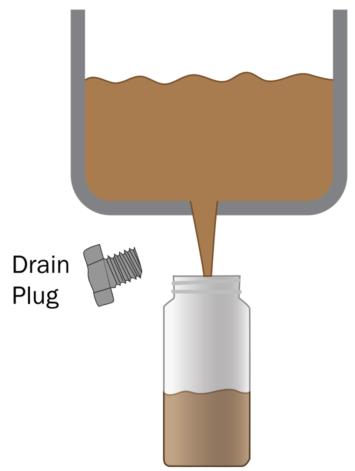
In other cases however, the analytical data from an individual sample does not provide enough information to make subtle judgments about oil or equipment condition. In these situations, it is necessary to monitor the trends in the analytical data over a series of samples to establish a wear-trend pattern. By monitoring wear metals such as iron, lead, copper and tin, it is possible to detect the early stages of possible bearing failure. In most cases, problems will be detected far enough in advance to allow for scheduling of bearing inspections at a convenient time. This can reduce or eliminate expensive equipment down-time and repairs.

Unit Type or System	Component Type	Frequency
Mining Equipment		
Electric Haul Truck	Diesel Engines	250 Hours
Electric Haul Truck	Hydraulic	250 hours
Electric Haul Truck	Gearbox	250 Hours
Electric Haul Truck	Wheel Motors	250 Hours
Electric Haul Truck	Coolant	Quarterly
Mechanical Haul Truck	Diesel Engine	250 Hours
Mechanical Haul Truck	Transmission	500 Hours
Mechanical Haul Truck	Hydraulic	500 Hours
Mechanical Haul Truck	Differential	500 Hours
Mechanical Haul Truck	Final Drive	500 Hours
Mechanical Haul Truck	Wheel Hub	500 Hours
Mechanical Haul Truck	Coolant	Quarterly
Dozers	Engine	250 Hours
Cranes	Transmission	500 Hours
Hoists	Hydraulic	500 Hours
Graders	Differential	500 Hours
Loaders	Final Drive	500 Hours
Scrapers	Steering	500 Hours
Shovels	Coolant	Quarterly
Water Trucks	Engine	250 Hours
Water Trucks	Transmission	500 Hours
Water Trucks	Hydraulic	500 Hours
Water Trucks	Differential	1,000 Hours
Water Trucks	Coolant	Quarterly
Flatbeds	Engine	Quarterly
Forklifts	Transmission	6 Months
Forklifts	Hydraulic	6 Months
Pickups	Engine	6 Months
Compressor	Engine	Monthly
Compressor	Sump	Monthly
Air Compressor	Reciprocating/Centrifugal	Monthly
Misc. Handling Equipment	Agitators, Conveyors, ect.	2 Months
Electrical	Hydraulic	500 Hours
Fans and Blowers	Gearbox	Monthly
Generators	Engine	500 Hours
Pumps	Gears, Bearings, Sump	2 Months
Transformers	Transformer	Annually

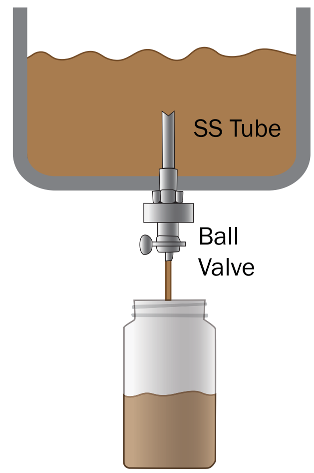
Sampling Guidelines

Fluid Type or System	Regular Use	Intermittent
Stationary Industrial Equipment		
Gear Drives	500 hours or monthly	Quarterly
Compressors	500 hours or monthly	Quarterly
Hydraulic Systems	500 hours or monthly	Quarterly
Turbines	250 hours or monthly	Quarterly
Transformers	Quarterly	Annually
Hot Oil Systems/Oil Baths	500 hours or monthly	Quarterly
HVAC Compressors	250 hours or monthly	Quarterly
HVAC Refrigerants	Quarterly	Annually
Diesel Engines	500 hours or monthly	Quarterly
Natural Gas Engines	500 hours or monthly	Quarterly
Coolants	500 hours or monthly	Quarterly
Vehicle Fuel Tanks	As required	As required
New Diesel Fuel Loads	Every new shipment	Every new shipment
Diesel Fuel Storage Tanks	Quarterly	Quarterly
Aviation Equipment		
Turbine Engines	150 hours	100 hour inspection and annually
Piston Engines	50 hours	100 hour inspection and annually
Gear Drives	100 hours	100 hour inspection and annually
Hydraulic Systems	250 hours	100 hour inspection and annually
New Aircraft Fuel Loads	Every new shipment	Every new shipment
Storage Tanks (Bottom)	Quarterly	Quarterly
Storage Tanks (Center)	Annually	Annually
Marine Equipment		
Main Engine	250 hours	Quarterly
Non Engine	500 hours	Quarterly
Hydraulic Systems	500 hours	Quarterly
Coolants	500 hours	Quarterly
Support Engine Systems	150 hours	Quarterly
Vehicle Fuel Tanks	As needed for troubleshooting	As needed for troubleshooting
New Marine Fuel Loads	Every new shipment	Every new shipment
Storage Tanks (Bottom)	Quarterly	Quarterly
Storage Tanks (Center)	Annually	Annually
Highway Equipment		
Diesel Engines	10,000 miles or 250 hours	Quarterly
Gearboxes	20,000 miles or 500 hours	Quarterly
Hydraulic Systems	20,000 miles or 500 hours	Quarterly
Coolants	20,000 miles or 500 hours	Quarterly
Gasoline or LPG Engines	3,000 miles or 150 hours	Quarterly
Vehicle Fuel Tanks	As needed	As needed
New Diesel Fuel Loads	Every new shipment	Every new shipment
Storage Tanks (Bottom)	Quarterly	Quarterly
Storage Tanks (Center)	Annually	Annually

Drain Port Sampling

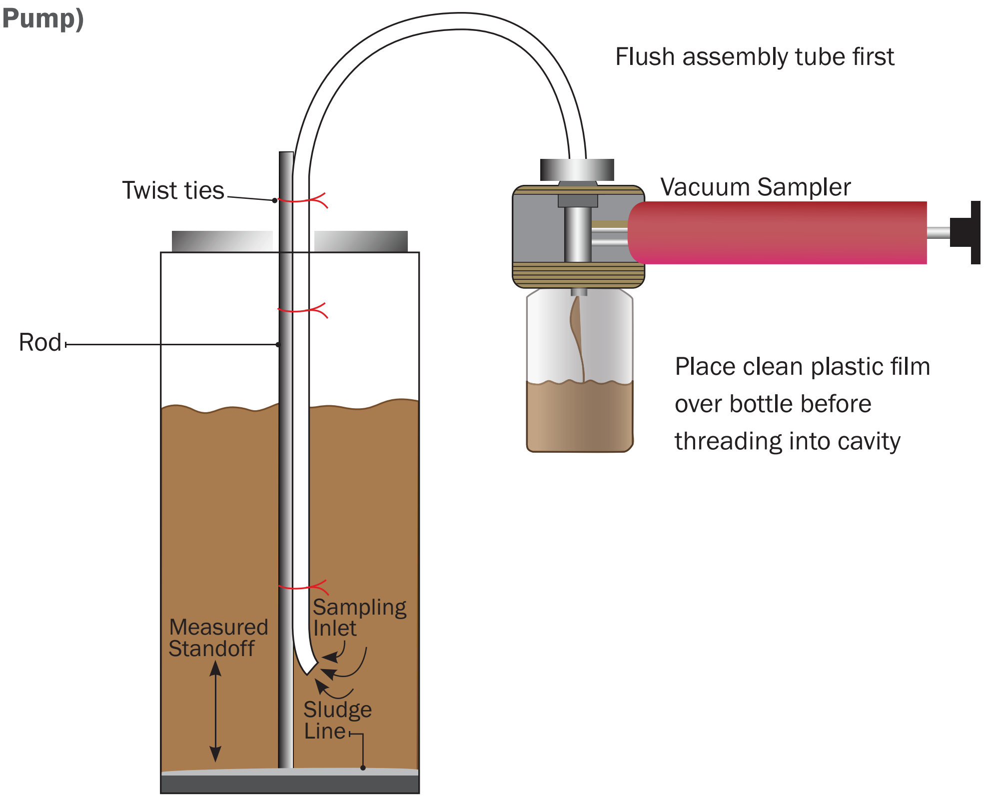


Drain-Port Sampling

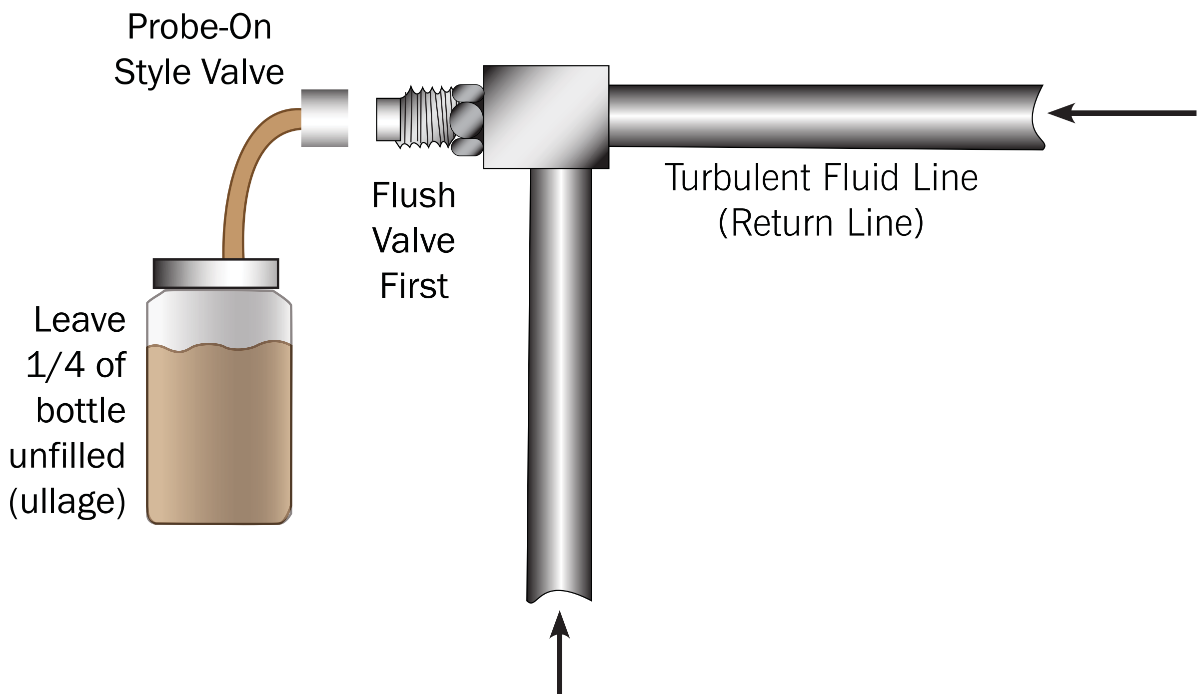


Drain-Port Tap Sampling

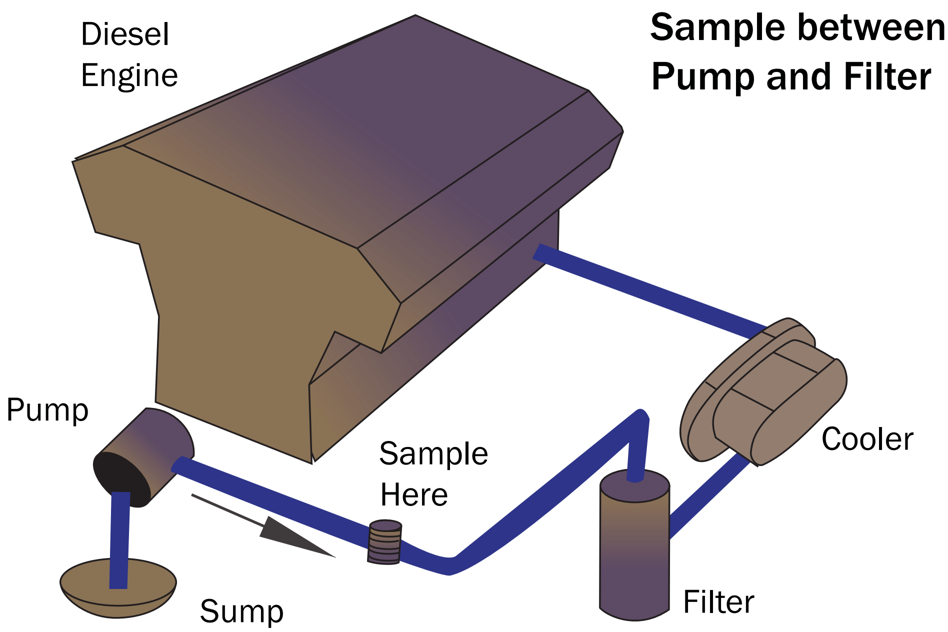
Drop-Tube Vacuum Sampling (Vampire Pump)



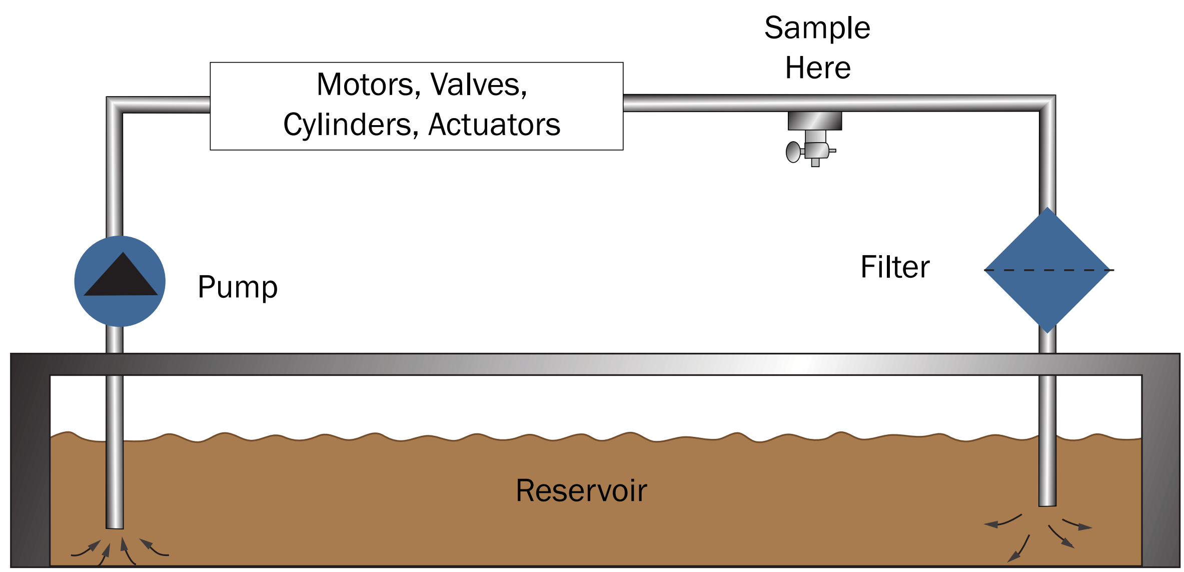
Sample from a Live Zone



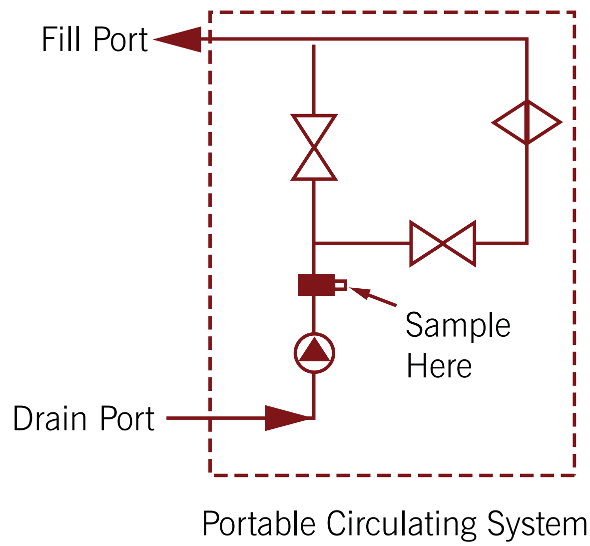
Sampling Engines



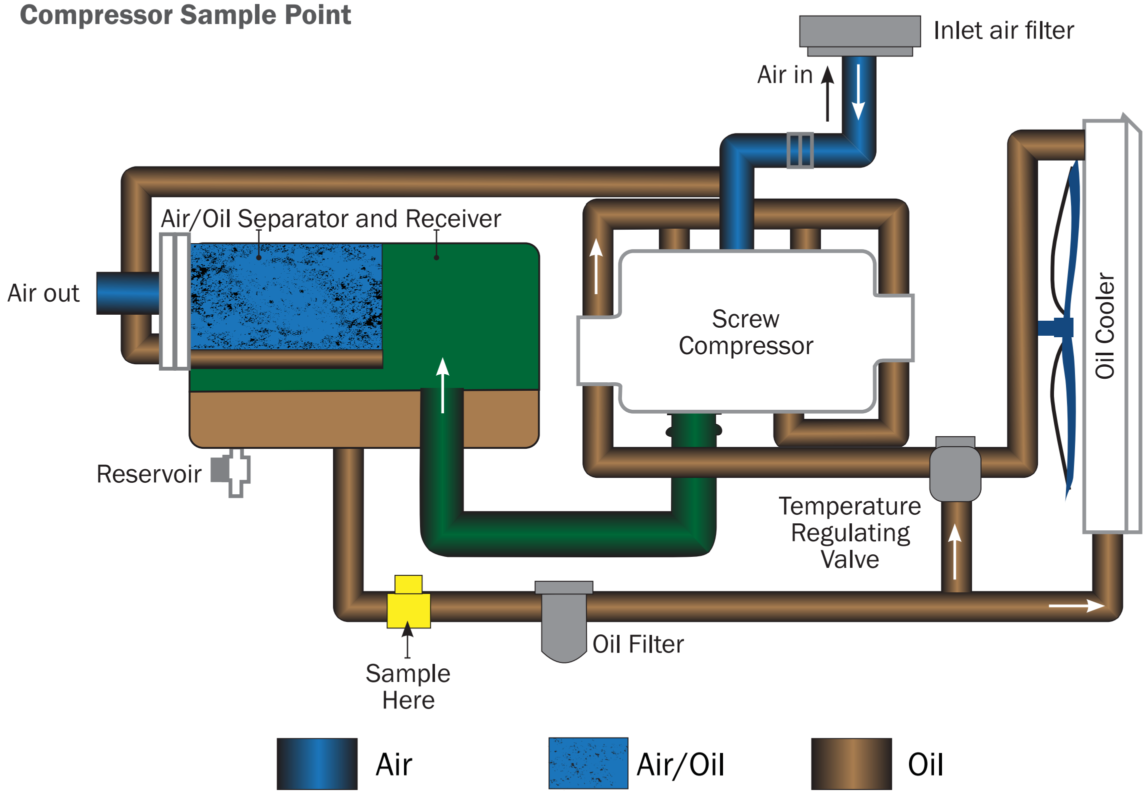
Hydraulic Sample Point



Gear Box Sample Point

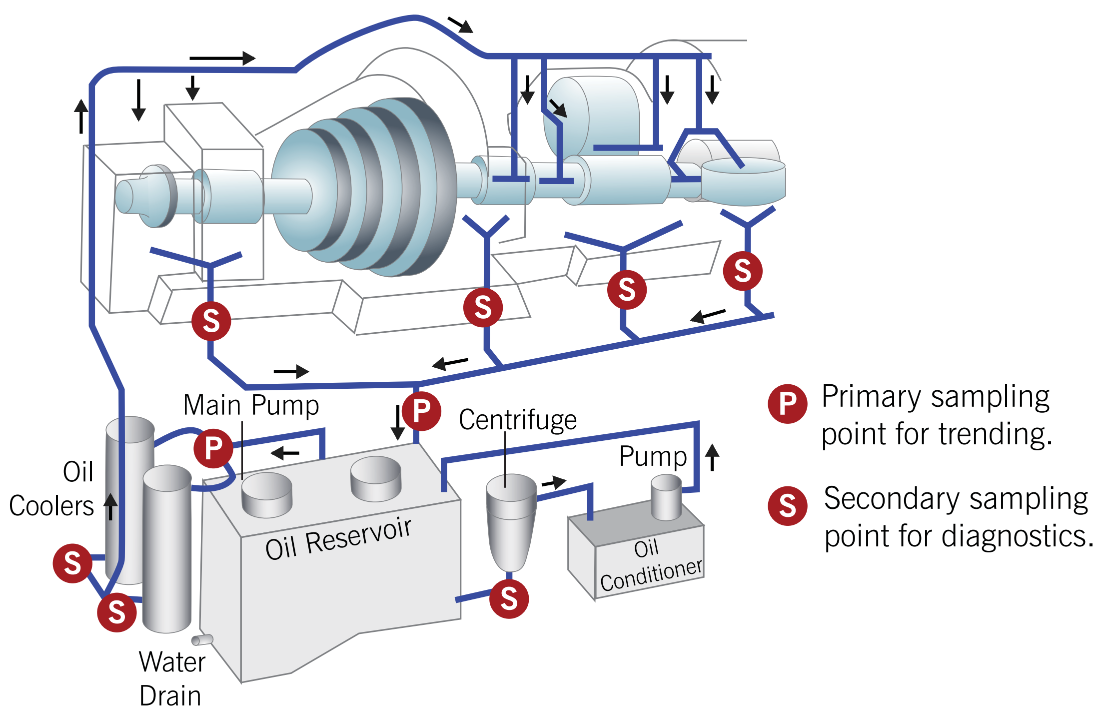


Compressor Sample Point



- Sample on circulating system before filter.
- Sample air compressor more frequently than gas compressors.
- Sample oil flooded compressors more frequently than reciprocating and centrifugal compressors.

Turbine Sample Point



Laboratory Locations

AGAT Laboratories has full-service locations across Canada that house the most modern state-of-the-art technology available in the laboratory industry. Our long-standing relationships with hundreds of depot locations ensures that sample pick-up and shipment is never an issue for our clients. For a complete list of all of our locations, please visit our website at **www.agatlabs.com**.

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