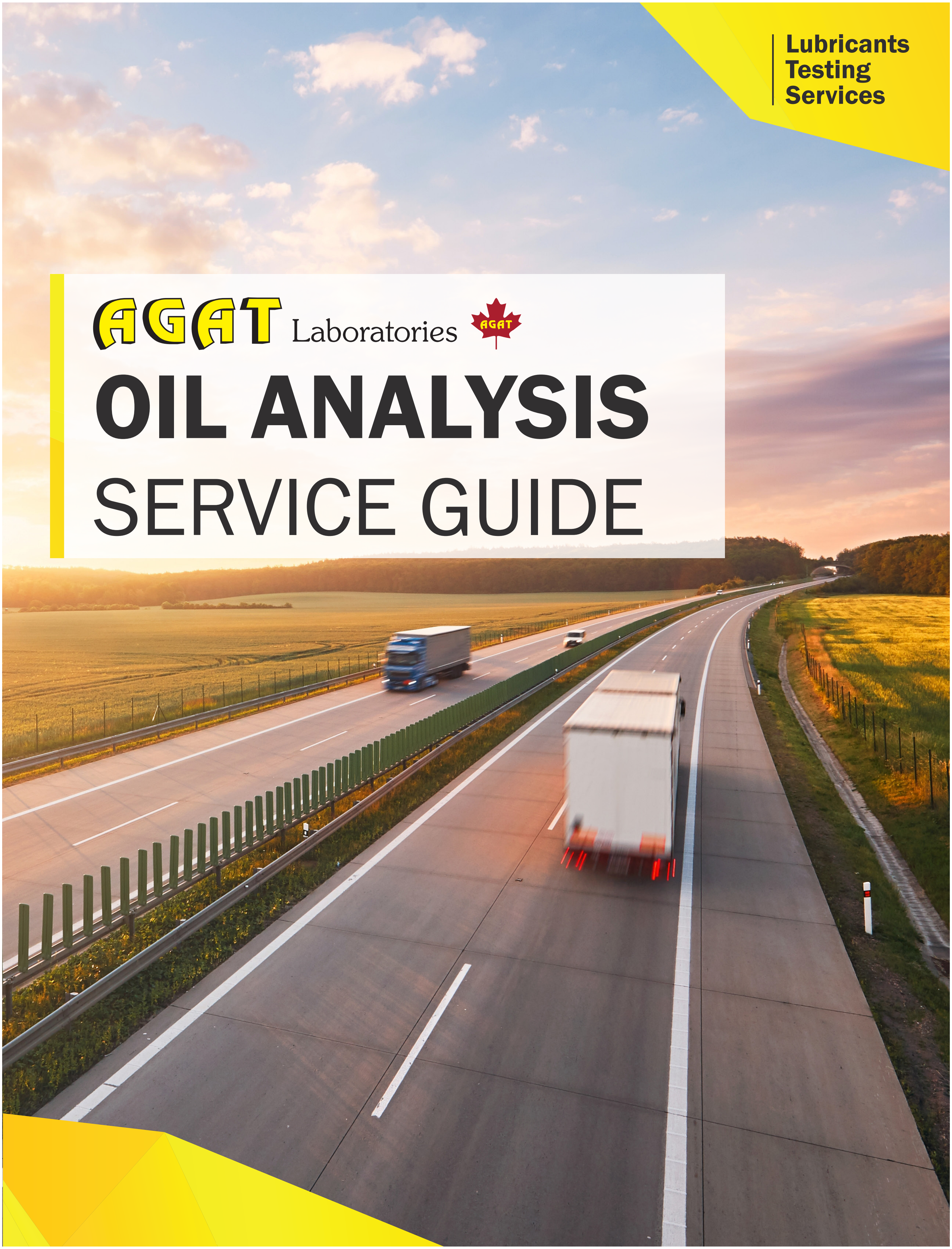
Lubricants Testing Services

AGAT Laboratories

OIL ANALYSIS
SERVICE GUIDE



About AGAT Laboratories

AGAT Laboratories is a highly specialized Canadian company providing analytical solutions worldwide. As Canada's sole privately-owned laboratory network, AGAT Laboratories is renowned for providing accurate, timely and defensible solutions to complex analytical requests with a constant focus on ensuring "Service Beyond Analysis" to its national and international clients. With 43 locations and 1,200 employees coast to coast, AGAT Laboratories is comprised of 12 scientific divisions that service a wide spectrum of industries, namely, Environmental Chemistry, Mining Geochemistry, Petroleum Testing, Oil Sands Analysis, Rock Properties, Reservoir Characterization, Lubricant Testing, Air Quality Monitoring, Forensic Chemistry, Ultra-Trace and Toxicology, Food Testing, and Agricultural Analysis.

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AGAT Laboratories

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 crankshaft. **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*.
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*.

Metal	Common Sources	General Purpose	Required Action
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*.
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 oil 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

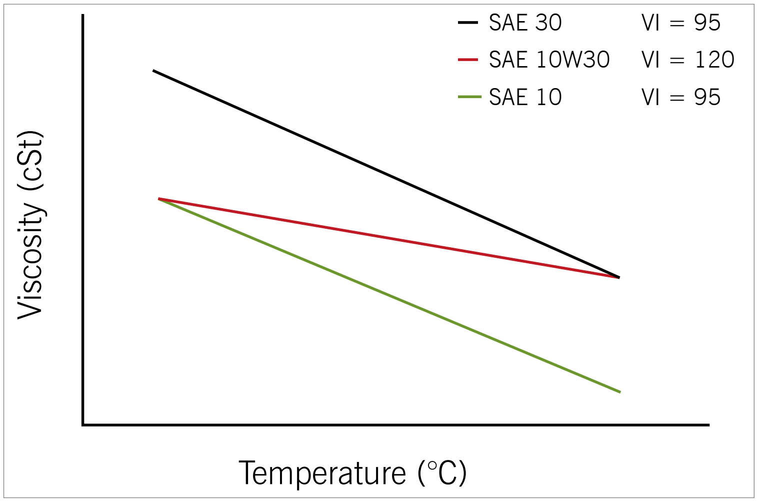
Effects

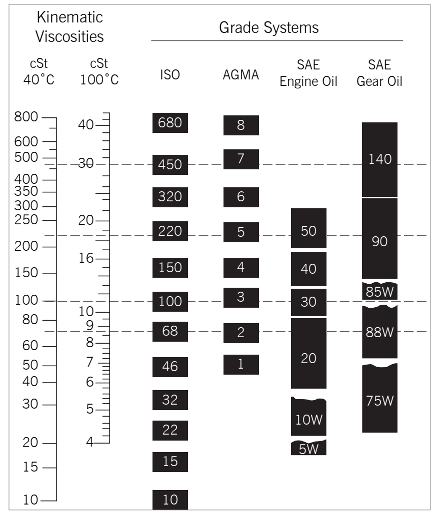
- Increased operating costs
- Engine overheating
- Poor lubrication
- Metal to metal contact

Viscosity Grades

	Low Temperature Viscosities		High-Temperature Viscosities		
SAE	Cranking (cP) max at temp °C	Pumping (cP) max with no yield stress at temp °C	Low Shear Rate Kinematic (cSt) at 100°C Min.	Low Shear Rate Kinematic (cSt) at 100°C Max.	High Shear Rate (cP) at 150°C min
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	Effects	Solutions
▪ High sulphur fuel ▪ Overheating ▪ Excessive blow-by ▪ Extended oil drain intervals ▪ Improper oil type	▪ Decreased base number (BN) ▪ Corrosion of metallic components ▪ Promotes oxidation ▪ Oil degradation ▪ Oil thickening ▪ Additive depletion	▪ Drain oil ▪ Reduce oil drain intervals ▪ Confirm oil type being used ▪ Check for overheating ▪ Check fuel quality

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.

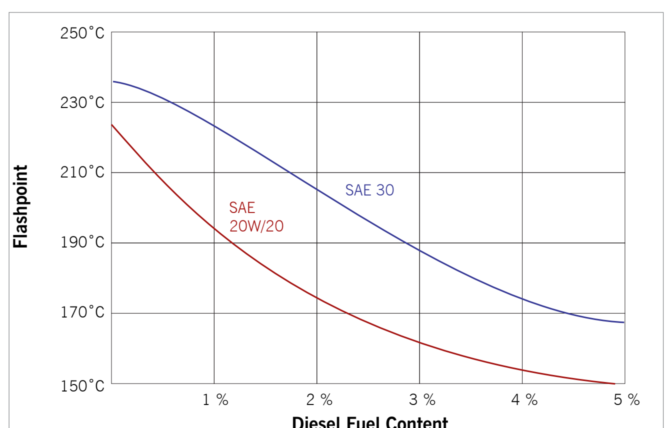


Figure 3. Diesel Fuel Content and FlashPoint in Motor Oils (by Volume)

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.

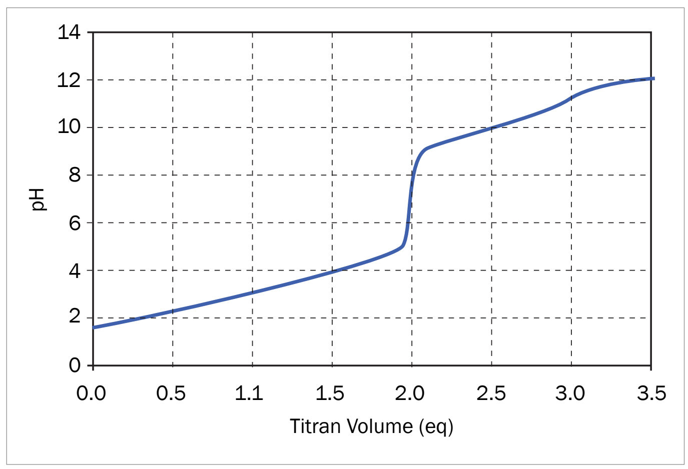
Sources of Dilution	Effects	Solutions
▪ Incorrect air/fuel ratio ▪ Extended idling ▪ Stop and go driving ▪ Defective injectors ▪ Leaking fuel pumps or lines ▪ Incomplete combustion ▪ Incorrect timing	▪ Metal to metal contact ▪ Poor lubrication ▪ Cylinder ring wear ▪ Depleted additives ▪ Decreased oil pressure ▪ Reduced fuel mileage (mpg) ▪ Reduced engine performance ▪ Shortened engine life	▪ 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

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

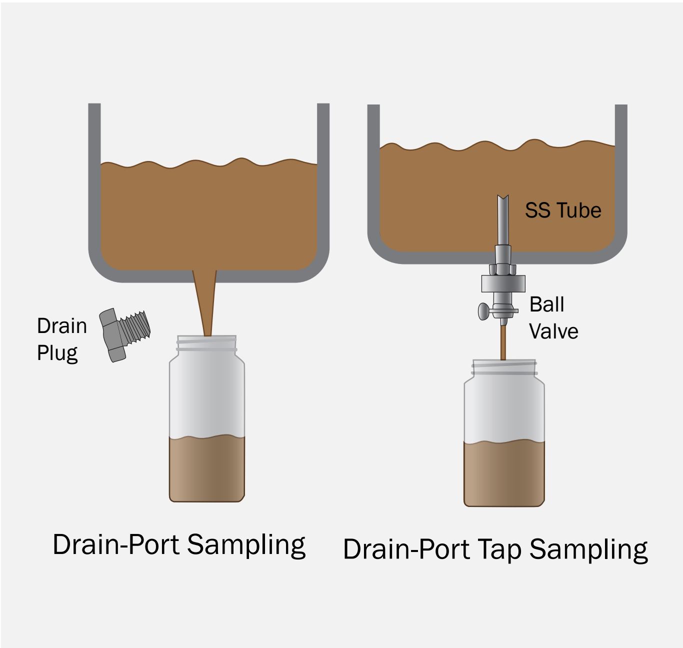
When the AN doubles, it is time to drain the oil.

When the BN is reduced by half, drain the oil.

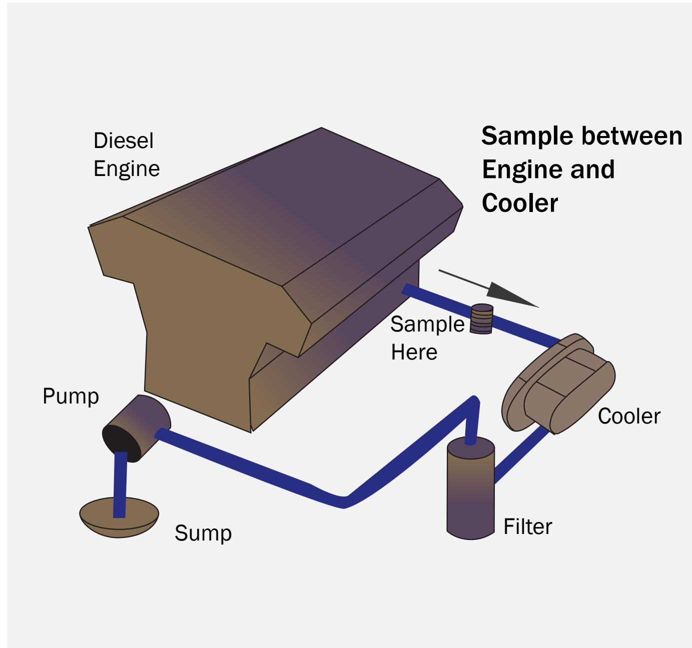
Sources of Dilution	Effects	Solutions
▪ High sulphur fuel ▪ Overheating ▪ Extended oil drain ▪ Improper oil type	▪ Increased acid number (AN) ▪ Oil degradation ▪ Increased wear rate ▪ Acid build-up in oil	▪ Use low sulphur diesel fuel ▪ Re-evaluate oil drain intervals ▪ Verify base number of new oil being used ▪ Verify oil type being used ▪ Change oil ▪ Test fuel quality

Oil Sampling Techniques

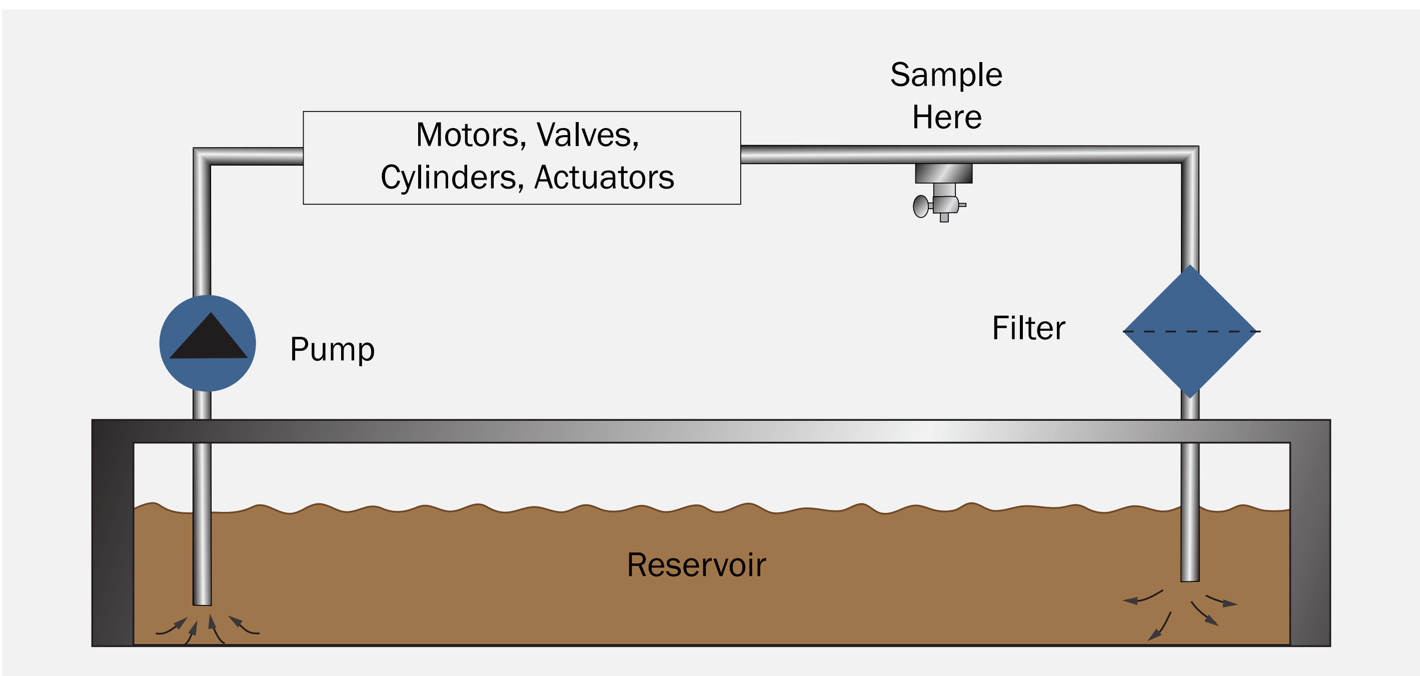
Drain Port Sampling



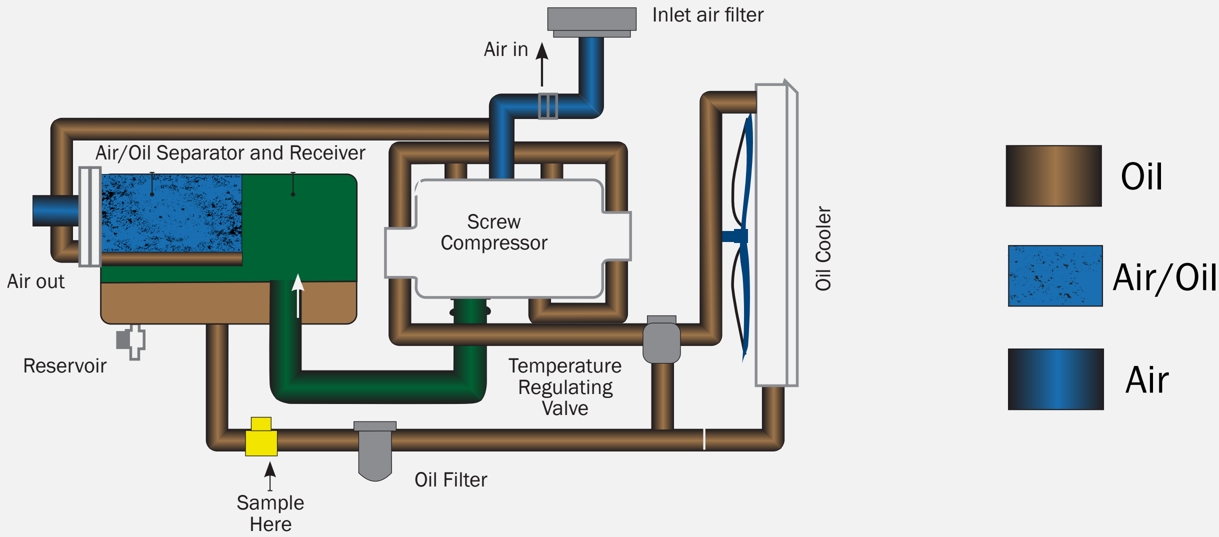
Sampling Engines



Hydraulic sample point

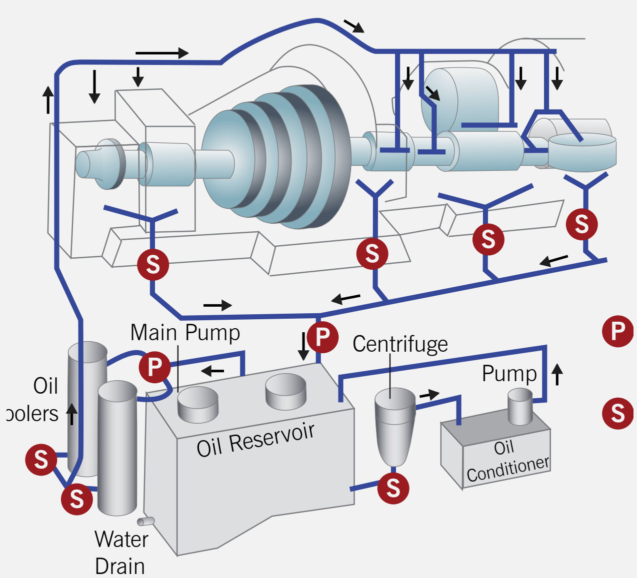


Compressor Sample Point



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

Turbine Sample Point



P Primary sampling point for trending.

S Secondary sampling point for diagnostics.

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