



Document title: Fault Diagnosis of rotary machines by Wear Debris Analysis (WDA) of lubricating oil

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Confidentiality Statement

The information in the document mentioned is not confidential and have been taken references from various sources as specified.

Abstract

Wear debris analysis is a technique used to monitor the condition of machines and may help to improve the overall equipment effectiveness value of a factory in a significant manner. Worm gears are used in various production machines, and their breakdowns may cause significant production losses. Wearing of these gears is relatively difficult to monitor with vibration analysis. Analysis of two indicator metals, copper and iron, may reveal wearing phenomena of worm gears effectively, and savings can be significant.

WDA and oil analysis is helpful in understanding how fast a system is wearing. It is also helpful in understanding contaminants and even the performance ingredient levels in oils

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Intended Readers

Maintenance and reliability personnel.

Introduction

Wear Debris analysis similar to visiting your doctor for an annual blood test. The doctor can determine your overall health and well-being from a very small sample of your blood. The same can be done with oil lubricated equipment such as engines, gearboxes, hydraulics, air compressors, and turbines. It has been estimated that many maintenance technicians change oil too early or too late. Changing oil too early wastes money on oil, filters and labor. Changing oil too late can lead to deposit build-up and costly equipment repairs. The best way to determine when to accurately change oil is through WDA.

- Industrial plants regularly document that comprehensive oil analysis has decreased their overall maintenance cost up to 28%.
- WDA and oil analysis is helpful in understanding how fast a system is wearing. It is also helpful in understanding contaminants and even the performance ingredient levels in oils

Description

WDA provides the following:

- **Elemental Analysis** - detects the amount and type of elements in the oil from component wear, contamination and various ingredients found in oil.
- **Contamination Analysis** - detects the physical presence of unwanted fluids (water, fuel, antifreeze) or particles (dirt, metal, etc...) in the oil and identifies oil by-products such as soot, nitration and sulfur.
- **Oil Condition Analysis** - tests viscosity and an oils ability to neutralize acids (TBN for engines or TAN for non-engines).

The WDA results will be broken down into wear metal concentration, oil condition and contaminants. Each analysis normally has past results included.

Elemental Analysis

When oil lubricated component begins to wear, small amounts of metal become suspended in the oil. These trace amounts of metal are the first indicators of component wear. If left unattended, the wear will increase and potential part failure will occur. In extreme cases, metal shavings from worn gear teeth can be found in the oil. If the wear is severe, metal shavings can be seen during the oil change. The shavings will contribute to more wear. This situation can occur in gearboxes, hydraulics, engines, and air compressors. Many components and parts are made-up of several different metals. WDA results can determine which component is beginning to show signs of wear just by the type of metal and the concentration found in the test sample.

The following table gives an idea on the source of specific wear metal for a given piece of equipment

Iron (Fe): Most common of the wear material	
Equipment	Source of Iron (Fe) as wear metal
Engines	Cylinder Liners, Piston Rings, Valve train, Crankshaft, rocker arms, spring gears, lock washers, nuts, pins, connecting rods, engine Blocks, oil pump,
Bearings	Rolling element Bearings: rollers (tungsten alloyed steel), raceways and cages, journal Bearings: journal shaft, bearing Shoe backing, locking keys
Gears	Bull gears, pinions, case hardened teeth, locking pins
Transmissions	Gears, bearings, Brake bands, clutch, shift spools, pumps, power take off (PTO)
Hydraulic systems	vanes, pump housing, cylinder bores and rods, servo valves, pistons
Compressors	Rotary Screw, lobes, vanes, connecting rods, rocker arm, bearings, cylinders, housing, shafts, roller bearings (see above) oil pump, piston rings
Turbines	Reduction gear, shaft, bearings, piping, case

Copper (Cu): Widely used as alloying element. It is heavily used in bearing systems, as well as heat exchangers.

Equipment	Source of Copper (Cu) as wear metal
Engines	Valve train bushing, Wrist pin bushing, Cam bushings, Oil Cooler core, Thrust washers, governor, connecting rods bearings, valve gear train thrust buttons,
Bearings	Rolling element Bearings: alloyed element in cages, Journal Bearings: journal bearing pads, slinger rings, Locking keys
Gears	Bushings, thrust washers
Transmissions	Clutches, steering discs, bearings
Hydraulic systems	Pump thrust plates, bushings, cylinder gland guides, pump pistons, oil coolers
Heat exchangers	Cooler tubes, baffles, plates.
compressors	Bearings, cylinder guides, wear plates, thrust washers, bearings (see above) oil pump, oil coolers, thermostats, separator filters
Turbines	bearings
Tin (Sn): used as alloying element with copper and lead for sacrificial bearing liners	
Equipment	Source of Tin (Sn) as wear metal
Engines	Valve train bushing, Wrist pin bushing, Cam bushings, Oil Cooler core, Thrust washers, governor, connecting rods bearings, valve gear train thrust buttons,
Bearings	Rolling element Bearings: alloyed element in cages, Journal Bearings: journal bearing pads, slinger rings, Locking keys
Gears	Bushings, thrust washers
Transmissions	Clutches, steering discs, bearings
Hydraulic systems	Pump thrust plates, bushings, cylinder gland guides, pump pistons, oil coolers
compressors	Bearings, cylinder guides, wear plates, thrust washers, bearings (see above) oil pump, oil coolers, thermostats, separator filters
Turbines	bearings
Aluminum (Al): Has high strength to weight ratio, an excellent corrosion resistance, Alloyed with other elements improves its wear and temperature resistance	
Equipment	Source of Aluminum (Al) as wear metal

Engines	Engine blocks, pistons, blowers, Oil pump bushings, bearings (some) Cam bushings (some), Oil coolers (some)
Bearings	Rolling element Bearings: alloyed element in cages, Locking keys
Gears	Bushings, thrust washers, grease contamination
Transmissions	Bushings, clutches
Hydraulic systems	Cylinder gland (some) pump, motor pistons, oil coolers. Aluminum complex grease contaminant Heat Exchangers Cooler tubes, baffles, plates
Heat exchangers	Cooler tubes, baffles, plates
Compressors	Housing, bearings, cylinder guides, wear plates, thrust washers, bearings (see above), oil pump, oil coolers
Turbines	Bearings, Residue from synthetic media (alumina) filters

Chrome (Cr):Used as engineering material for its great hardness and corrosion resistance

Equipment	Source of Chrome (Cr) as wear metal
Engines	Rings, Liners, exhaust valves, zinc chromate from cooling system inhibitor
Bearings	Rolling element Bearings: alloyed /coated element in rollers, tapers
Gears	Bearings (some), shaft coatings, some special gears are chrome plated
Transmissions	Bearings
Hydraulic systems	Cylinder liners, rods, spools
Compressors	Housing, bearings, cylinder guides, wear plates, thrust washers, bearings (see above), oil pump, oil coolers
Turbines	Shaft coating (some) bearings

Lead (Pb):Lead based Babbitt bearings are widely used.

Equipment	Source of Lead (Pb) as wear metal
Engines	Main Bearings, connecting rod bearings. Lead can be present as a contaminant fro gasoline (Leaded gas) (Octane improver, anti-knock compound)
Bearings	Rolling element Bearings: alloyed element in cages, Journal Bearings: Major alloying element in Babbitt bearings, alloying elements
Gears	Bearings, can also be red lead paint flakes from gear case walls
Hydraulic	Bearings

systems	
Compressors	Bearings
Turbines	Bearings
Silver (Ag): Has an exceptional thermal conductivity and is an excellent bearing plate material	
Equipment	Source of Silver (Ag) as wear metal
Silicon (Si):Most common contaminant found in lube oil analysis, abundant in all areas, very hard crystalline material and very abrasive to metal components	
Equipment	Source of Silicon (Si)as wear metal
Engines	Engine blocks (alloying element with aluminum parts), ingested dirt from breathers, external sources. Can also be from defoamant additive in lubricant
Bearings	Rolling element Bearings: alloyed element with aluminum in cages
Gears	Bushings, thrust washer, silicone sealant, defoamant additive
Transmissions	Brake shoes, clutch plates, ingested dirt
Hydraulic systems	Elastomeric seals (some) pump, motor pistons, oil coolers
Heat exchangers	Cooler tubes, baffles, plates
Compressors	Ingested dirt, silicone sealant, bearings, cooler (alloyed with aluminum)
Turbines	Ingested dirt, silicone sealant, defoamant additive

Engines	Valves, Valve guides, Cylinder liners, Bearings.
Bearings	Rolling element Bearings: alloyed element in rollers, races
Gears	Alloying element for tool steel gears
Hydraulic systems	Bearings, servo valve plating pumps, pistons
Compressors	Bearings
Turbines	Bearings, shaft, reduction gears

Other metals

Other metals can be found in oil samples due to wear or contamination

Equipment	Possible sources
Titanium	Wear metal for aircraft engines, bearings, Can also be contaminant from paint (titanium dioxide is used as a pigment)
Vanadium	Fuel Contaminant, can also be alloying element for steel
Magnesium	Alloying element in steels
Molybdenum	Solid/liquid antiwear additive, alloy in bearing and piston rings
Zinc	Antiwear, Corrosion inhibitors, Anti-oxidants, alloying element for bearings, thrust washers, galvanized cases

Wear Metal Limits

Wear metal analysis is performed by emission spectroscopy. This test provides the concentration of metals for wear, additive concentration and contamination found in lube oils and is measured in parts per million (1000 p.p.m. = 0.1%). Emission spectroscopy measures metallic particles that are less than 10 microns in size. Many components have different levels of acceptable concentrations of wear metals. A transmission or gearbox can withstand higher levels of wear metals compared to a hydraulic pump or engine. Some systems by their design will produce high levels of wear metals. It is essential that periodic test results are compared in order to establish if any trends are emerging.

The following table is the rule of thumb for metal concentration limits in parts per million (ppm) for different components. It is important to examine past test results in order to identify potential trends or emerging problems.

	Hydraulic	Gear Box	Diesel Engine	Gasoline Engine	Transmission	Differential
Iron	75	300	80	300	300	1000
Chromium	5	N/A	25	40	10	N/A
Lead	20	N/A	50	N/A	50	N/A
Copper	75	250	50	75	400	250
Tin	10	250	25	40	20	250
Aluminum	25	250	30	40	50	250
Nickel	5	N/A	10	15	20	N/A
Silver	5	N/A	5	5	5	N/A
Silicon	75	250	25	50	50	250

Internal and external sources and damage

Contaminants: the source of these contaminants can be internal or external. The only way to insure that the elements can be considered a contaminant is to compare the results against a reference sample of the oil being used.

Contaminant	Source and potential problem
Silicon	1. Silicon Dioxide (sand & dirt) is a common contaminant – may indicate a faulty air filter or seal. May have also entered when top-filling. 2. Polysiloxane (silicone rubber) is commonly used in gaskets and seals – may indicate that a gasket is wearing out and abrading.

Sodium and Potassium	<p>1. Found as additives in anti-freeze – potential cracked block or cross-contaminated from the oil container that may have been used for coolant.</p> <p>2. Sodium Chloride or Potassium Chloride (salt) –road salt or sea salt entered thorough breather, filter or through broken seal.</p>
Boron	Found as additives in anti-freeze – potential cracked block or cross contaminated from an oil container that may have been used for coolant.

Additive Elements found in oil: Many oil use various chemical additives to obtain certain levels of performance. It should be noted that certain elements found in this additives (calcium for instance) may not decrease as the oil begins to wear out, these elements continue to exist but may loose functionality, Keep in mind, the performance additives change into different compounds as they are used up and are not as effective as their original design. In other cases, elements found in certain additives may actually decrease in concentration (zinc and phosphorus), because they are adhering to the surface of the metal and are no longer in the oil. The only way to truly know when the additives are being used up is the sharp rise in wear metal concentrations.


Element	Function
Barium	Detergent or dispersant additive
Boron	Anti wear additive
Calcium	Detergent or dispersant additive
Copper	Anti-wear additive
Magnesium	Detergent or dispersant additive
Molybdenum	Lubricity modifier
Phosphorus	Corrosion inhibitor
Silicon	Anti foaming additive
Sodium	Detergent or dispersant additive
Zinc	Anti-wear or anti-oxidant additive

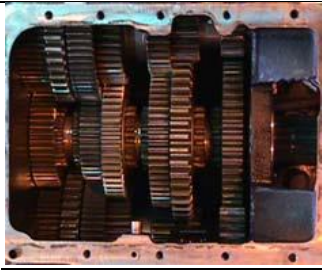

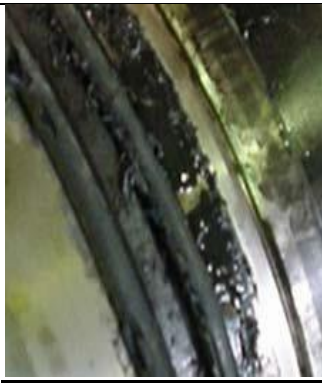

Many gearboxes, hydraulic systems, air compressors and engines can quickly become contaminated with water, particulate and various deposits such as varnish

and sludge that are the products of oil oxidation. These contaminants contribute to the degradation of the lubricant, increased operating temperature, energy demand, component wear and oil usage.

Contaminant	source	Problem
Water	Naturally formed from condensation or during combustion in engines	Leads to heat build-up, foaming, additive depletion, rust and oil oxidation
Particles	Enters sumps and reservoirs through leaking seals, top-filling or inadequate breathers	Leads to premature component wear and facilitates deposit build-up
Oxidation	The chemical breakdown of oil from heat, water, and or dissimilar metal contact.	Results in thickened oil, deposits, acid formation, increased operating temperature and plugged filters.
Soot (in engine oil)	Typically from partially burned fuel.	Leads to poor combustion can lead to excessive wear and increased fuel costs.

When lubricants oxidize, they form reactive materials that can re-constitute into different deposits. Oil analysis can help to identify the degree of oxidation that has occurred. More sophisticated analysis may have to be performed in order to identify the exact contaminant. The following are several of the typical deposits that are formed and the problems that can occur when lubricating oil breaks down.

Deposit Formation	Potential Problem	Example
Varnish: Oil or fuel oxidizes, forming a gummy substance that develops into a coating with highly cross linked molecules that are insoluble in oil. Found on bearings, cylinders, pistons, gears, vanes, pumps, and	Varnish coating can lead to uneven gear wear due to unbalancing, increased drag/energy demand and increased temperatures due to lack of lubrication on metal surface, oil viscosity increase	

<p>Turbines.</p>			
<p>Lacquer: Found on bearings, cylinders, pistons, gears, vanes, pumps, and turbines. When varnish is exposed to excessive temperatures and pressure, it becomes baked on and ironed out, forming lacquer</p>	<p>Lacquer, like varnish, can lead to uneven gear wear, increased drag/energy demand and increased temperatures due to lack of lubrication on metal surface</p>		
<p>Sludge: Found in oil pans, sumps, housings, reservoirs, and bearings. Formation begins when contaminants begin to settle out of the oil. Sludge develops with excessive accumulation of contaminants</p>	<p>Sludge is composed of water, carbon residue, oxidized oil, and acidic compounds, which can lead to further oil decomposition. Sludge can restrict oil flow, leading to increased system pressure, temperature, wear</p>		
<p>Gum: Typically found in the crankcase or combustion area of an engine. Gum develops when oil or fuel hydrocarbons break down due to high temperature and combustion by-products. Gum acts as a binder for contaminants to adhere to pistons, rings and valves</p>	<p>Gum can form on valves, pistons, rings, ring grooves and on the cylinder walls, causing contaminants and residue to adhere and restrict lubrication. Lack of lubrication increases friction and wear and restricts the heat transfer function of Lubricating oil.</p>		
<p>Carbon Deposits: Found in all lubricated systems such as engines, bearings, pumps, gears, and journals. Most common form is soot; can also be a tar-like residue. Soot is considered to be an advanced deposit formation.</p>	<p>Carbon deposits form, additional contaminants adhere, facilitating continued oil Oxidation. The deposits can form a slurry or gelled mass. The deposits restrict lubrication flow and additive functionality</p>		

Oil Analysis Methods

Oil analysis methods can be divided into laboratory-scale (off-line) or continuously

Working (on-line/in-line) methods. On-line and in-line methods can be used to determine, for instance particle quantities in oils, water content and general oil condition, like oil degradation, based on, e.g., IR spectroscopy or electrical conductivity. On the other hand, on-line methods can be used to collect wear particles by means of magnetic chip detectors (MCD). Deeper inspection of the wear particles can then be carried out with microscopic methods. On-line instruments are situated in oil circulation systems and a part of the oil circulates through the measuring device. If the device is assembled in-line, then the whole oil volume will go through the measurement system. Off-line analyses require taking a representative oil sample. Despite the constantly growing significance of the on-line oil condition monitoring methods, in this study, the focus is especially on laboratory-scale, off-line oil analysis methods.

Wear Metal analysis

Spectroscopy

Spectroscopy is a technique for detecting and quantifying the presence of elements in a material. Spectroscopy utilizes the fact that each element has a unique atomic structure. When subjected to the addition of energy, each element emits light of specific wavelengths or colors. Since no two elements have the same pattern of spectral lines, the elements can be differentiated. The intensity of the emitted light is proportional to the quantity of the element present in the sample allowing the concentration of that element to be determined. The light has a specific frequency or wavelength determined by the energy of the electron in transition. Since many transitions of different energy are possible for complicated atoms which have many electrons, light of many different wavelengths is emitted. If this light is dispersed

by using a dispersing element such as a prism, a line spectrum will result. These spectral lines are unique to the atomic structure of only one element. If more than one element is present in the sample, spectral lines of distinctively different wavelengths will appear for each element. These lines must be separated in order to identify and quantify. Techniques used for wear metal analysis are numerous, for

example, atomic absorption spectroscopy (AAS), atomic/optical emission spectroscopy (AES/OES), mass spectrometry (MS), X-ray fluorescence spectroscopy (XRF), ferrography and magnetic chip detectors . Spectroscopic methods usually require pre-treatment of oil samples before analysis, whereas instruments based on magnetism allow analysis to be carried out directly from the oil. Nevertheless, spectroscopic techniques are more versatile than methods based on ferromagnetism. Spectroscopic methods can be used in determinations of most metals and even with some non-metals, depending on the application.

Solid Debris Analysis

Metallic solid debris in oils can originate from machine elements due to wearing. Filters, seals and other non-metallic machine parts can introduce non-metallic solid debris into oil. Severe oxidation of oil can produce solid sludge with carbon deposits. Contamination with process chemicals and environmental dust can increase the amount of solid particles in oils.

Automatic particle counting is a commonly used method for monitoring the Cleanliness of hydraulic oils in particular Automatic particle counters can be divided into three classes, methods based on light extinction, flow decay and mesh obscuration. Methods based on light extinction are commonly used in commercial instruments. Because their measurement range is wider than with Instruments based on the pressure difference before and after the filters of the instrument. Particle counters based on light extinction may have problems with highly viscous and dark-colored oils and with high particle quantities. In addition, air bubbles and water introduce bias to the determined results. Air can be removed in some instruments and water is also harmful to the lubrication system, hence the

detection of water can be seen as a good property, depending on the requirements. Commercial instruments are available as laboratory, portable and on-line devices. Optical microscopy is often used as a supporting technique for automatic particle counters. The quality, morphology, size and color of solid debris can be detected if the oil sample is first filtered through a membrane filter. In some cases particle counting can also be carried out with optical microscopes, but it should be noted that manual counting with a microscope seldom produces the same results as an automatic particle counter. Manual particle counting with microscopes may yet be the only possible method with some oils.

Additive Analysis

Additives are used to improve certain properties of the base oils used. They can be used, for instance, as detergents, dispersants, anti-wear agents, antioxidants, extreme pressure agents (EP), viscosity index improvers, corrosion inhibitors, pour point depressants or defoamants. A wide variety of different types of substances can be used for these purposes and their analysis is often very specific. However, additives are usually organic molecules and can be detected e.g., using infrared spectroscopy (IR), nuclear magnetic resonance spectroscopy (NMR), mass spectrometry (MS) or chromatographic methods. For example, vibration spectroscopy (e.g., IR) is molecule-specific and produces information about functional groups of the molecule without destructing the samples. In IR spectroscopy infrared radiation emitted by the light source is absorbed by the molecules of the sample and the amount of absorption are detected. Fourier transform infrared spectroscopy (FTIR) has been used extensively to analyze additives of lubricating oils as well as to monitor oxidation and contamination of oils. Many sensors developed for rapid on-line controlling of oil condition are based on IR spectroscopy. In these sensors data is collected from spectral areas which are the most significant for oil condition evaluation. For instance, the carbonyl band tells about the oxidation of oil or depletion of an ester additive in some oils. The FTIR instrument produces a molecular spectrum of the oil sample and the amount of additives can be detected by comparing the used oil sample with new oil or against a standard series made of the additives under study. The

FTIR method has been applied, for instance, in the analysis of alcohols, esters, antioxidants (like 2,6-ditertiarybutyl-*p*-cresol), polybutenes and organozincdithiophosphates used as oil additives. Chromatographic methods are often used to separate additives from the base oil. In gas chromatography (GC) separation of the analytes is based on the partition of the molecules between the mobile gas phase and the immobilized liquid phase on a solid support material. In liquid chromatography (LC) the mobile phase is liquid and the stationary phase can be e.g., a liquid on a solid material packed in a column. GC and/or LC as individual methods have been used, for instance, in determining fatty acids, fatty acid esters, di- and triglycerides, organ phosphorus compounds or polar emulsifiers in oils

On the other hand, chromatographic methods can be used only for separation of analytes and mass spectrometry is used as a detector. Mass spectrometry as such or combined with chromatographic methods can be an effective tool in the analysis of base oils and additives. MS has been used e.g., in determining antioxidants, metal passivators, lubricity improvers or anti-wear agents in lubricating oils.

The basis of NMR spectroscopy is to measure absorption of electromagnetic radiation in the radio frequency region. The sample is in an intense magnetic field, where the nuclei of atoms form energy states suitable for absorption. NMR are the basic methods used for characterization and quantitative analysis of a great deal of different additives, like fatty alcohols, fatty acids, fatty acid esters or antioxidants. NMR is suitable for analyzing organophosphorus additives.

Method of Contaminants measurement

Oxidation, sulfur, soot, fuel, antifreeze, and nitration are measured by an instrument called a Fourier Transform Infrared Spectroscopy (FTIR). The lab must know the type of oil in service to produce accurate results. Engine oils are tested for oxidation, nitration and sulfur content. A base-line reference samples is required in order to compare the test sample against a base-line. The FTIR will scan the sample and look for a build-up.

Water contamination is typically screened using a hot plate technique. The oil sample is dripped onto a hot plate. If the sample crackles, water is present. This method is used to quickly screen samples for further analysis. Positive results are confirmed and quantified using the Karl Fischer Titration Method. Results may be reported in parts per million or by percent by weight. Water can be found in hydraulic and compressor oil samples due to large temperature swings and a large air cavity in the sumps.

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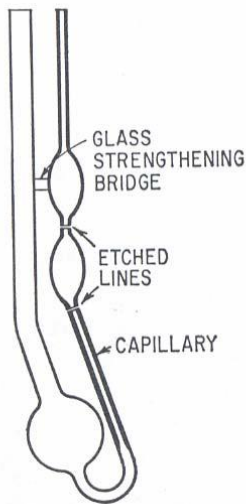
Oil Condition Analysis

Viscosity:

Viscosity is considered the single most important characteristic of lubricating oil. Viscosity is a fluid's resistance to flow with respect to temperature. Oil will thicken in cold temperatures and thin out at high temperatures. Viscosity is measured using a bubble viscometer and kept at 40°C or 100°C, depending on equipment application. Single weight or ISO grade oils such as some gear and hydraulic oils are tested at 40°C (105°F). Multi-grade oils such as SAE transmission and engine oils are tested at 100°C (212°F). Results are reported in centistokes, cSt. Other viscosity tests include Saybolt (SUS) and Brookfield (cPs). Viscosity may increase or thicken due to oil oxidation or excessive particulate. Viscosity may also decrease or thin down due to fuel or contamination from solvents, another lighter oil or thermal breakdown.

One way of measuring viscosity is by a bubble viscometer. The device is filled with oil and kept at a constant temperature. When the viscometer is tipped, an air

bubble in the sample is timed to see how long it takes to travel from one etched line to other. The value is then converted to unit of measures called centistokes (cSt)



As a oil begins to breakdown, various types of acids form which can lead to further oil degradation, metal wear and additive depletion. It is important to establish a starting point in order to compare the oil that is being used. A baseline sample from the oil drum is essential. The TAN or Total Acid Number is used to check the acid neutralization of hydraulic, gear and air compressor oils. The TAN normally increases over time. The TAN of a reference sample should be tested in order to establish an oils initial TAN. If the used oil increases 3 points above the TAN number from the reference sample, the oil should be changed. The TBN or Total Base Number measures the amount of basic (alkaline) materials in engine oil that will neutralize acids. The TBN decreases as it approaches the end of it's useful life. TBN is used to test the acid neutralization ability of engine oils. The lower the value, the less effective the oil will be at neutralizing acids. As acids increase, so do deposits. Deposit build-up will shorten engine life. The TBN is also known as BN or Base Number.

Taking Oil Analysis sample

A) Taking samples using a permanently installed sampling valve

The valve should be mounted in the oil flow circuit prior to the filter. Sample the hot oil after it has left the mechanical system(s) but before it has passed through the filter. Always sample oil from a machine that has been running minimum of 30 minutes for uniform sample.

- 1) Unscrew the dust cap from the valve. Allow a few ounces of oil to drain from the valve.
- 2) Take the sample bottle and place it under the valve discharge opening.
- 3) depress the button on the valve, fill the sample bottle and then cap it tightly. The hand pump is also equipped with a built-in sampling valve which has a rubber cover.
- 4) Screw the dust cap back on to the sampling valve.
- 5) Carefully and completely label the sample and send it to the lab.

B) The drain pan Method

In certain instances the only way to obtain an oil sample is by taking it while the oil is being drained from the sump or the oil pan

Assure that the sample is warm from a system that has been running for at least 30 minutes.

- 2) Wipe the surrounding area clean to reduce cross-contamination.
- 3) Drain at least a quart of oil before passing the sample bottle into the stream of oil. The oil will be hot, wear the appropriate protection or use a pair of pliers or channel-locks to hold the sample bottle under the oil stream.
- 4) Carefully and completely label the sample and send it to the lab.

Sampling frequency

An oil sample should be taken just before the regularly scheduled oil change. If the oil analysis results indicate that the oil is in good shape, extend out the change

interval by 30%. It is recommended to test the oil again prior to the extended change-out.

In certain cases, it may be difficult or impractical to sample every system. If this is the case, it is recommended that sampling be done on:

Critical Systems - systems or equipment that are responsible for production. If a Component on a critical system fails, production is halted. The critical systems are the ones that have been identified as being essential for continuous operation. These systems may require quarterly or semi-annual sampling.

• **Sample Population of Representative Systems** - The sampling of less critical systems may not be necessary but would still improve plant reliability. If, for example a plant had 48 gearboxes that run machines that are essential but not critical. The 48 gearboxes are essentially all the same make, model and year and have the same operating conditions. Oil samples can be taken on 10% of the total and still provide information that could be transferred. Taking samples on 5 of the 48 would provide information that could be transferred to the other system.

Acknowledgement

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