SAMPLING OVERVIEW:

A preventive maintenance program using lube oil analysis is beneficial in many ways. With scheduled oil analysis, wear products can be identified and corrective action taken before equipment failure can occur. Oil analysis can indicate when an oil change is required, point out shortcomings in maintenance and keep repair cost to a minimum. Using oil analysis can create a "window of opportunity", allowing the user to schedule re-fittings or overhauls, maintenance or repairs, thus saving money on equipment repairs and downtime.

SOME OTHER BENEFITS DERIVED FROM LUBE OIL ANALYSIS ARE:

1. The correction and the extension of oil drain intervals.
2. Prevent unscheduled downtime.
3. Increase the equipment life.
4. Identify correct lubricants for use.
5. The quality control of lubricant used.

It is said that all oil problems stem from, or are the results of, about three things: *THE WRONG OIL USED IN THE EQUIPMENT*, *POOR ENGINE OPERATION, and THE COOLING SYSTEM*. If the oil wasn't contaminated during engine operation, the oil would last indefinitely. Lube oil analysis points out the particular operation of the engine that is contaminating the oil and causing it to prematurely deterioration. This could be water, coolant, and dirt or fuel contamination. This information gives the customer an inside look at what is going on.

ESTABLISHING AN OIL ANALYSIS PROGRAM

Once you have decided to start a PM Program using oil analysis, there are a few things to know before getting started.

1. **BASELINE SAMPLES**: All new oils that are used should be sampled in order to establish baseline data. This data will be used to set limits that will alert us of a potential problem.

2. **UNIT INFORMATION**: The Laboratory should be provided with specific information for each unit to be sampled. This information would include make, model, serial numbers, specific unit numbers, oil type, and fuel type. All this information is important in making specific recommendations.

3. **ESTABLISH REGULAR SAMPLING FREQUENCY**: A regular sampling frequency should be established. After 3 to 5 samples, a trend will have been established and abnormalities will become easy to pinpoint.

4. **TAKING REPRESENTATIVE SAMPLES**: Samples should be taken in the same manner each time. Using different sample points or technique's can affect the trend patterns. Engines should be sampled while the oil is still warm. Sample points in order of preference:
    1. A valve in-line before filtration.
    2. Samples Via Dipstick tube using a sample pump.
    3. Drain or sump samples. Other equipment (gearbox, transmission, hydraulic reservoir, etc.) should be sampled at or near the center of the sump or reservoir using a sample gun. It is important to remember, while samples are being taken,
    THE ANALYSIS RESULTS WILL ONLY BE AS GOOD AS THE SAMPLE TAKEN.

5. **THE LAB REPORT:** The lab report is the key to any lube oil analysis program. The report indicates the condition of the unit and oil. It has enough space to view 4 analyses at once, with the last being the most recent. Any abnormal findings will be noted in an interpretation under the results.

6. **COMMUNICATION**: Laboratory and customer communication is extremely essential to making any oil analysis program a success. Key personnel should be well informed on the basics of lube oil analysis.

UNDERSTANDING AND INTERPRETING PHYSICAL PROPERTIES:

VISCOSITY:
Is one of the most important of all the analyses. It is a direct reference to the physical condition of the oil. A change in the trend patterns can be an indicator that the oil has become contaminated.

LOW VISCOSITY:
Can reduce oil film strength and allow rapid wear in the engine. Possible causes for low viscosity are fuel dilution or the inaccurate reporting of the grade of oil being used.

HIGH VISCOSITY:
Can restrict the oil flow causing oil starvation and rapid parts wear. It will also reduce the cooling of parts, which is one of the functions of the oil. Excessive viscosity can be caused by high operating temperatures, critical SOOT levels, considerable nitration, oil oxidation due to excessive service, oil contamination with glycol, sludge and insoluble byproducts.

WATER:
In any amount can be considered abnormal. It can cause scuffing, sludge and emulsion deposits. Water can appear from cooling system leaks, low operating temperatures, outside water contamination, poor crankcase ventilation, and frequent unit shutdowns.

GLYCOL:
In any measurable amount is extremely thermally unstable. It can cause oil starvation, engine seizure and/or failure if not caught in its early stages. All of these will effectively shorten oil and filter life. Glycol may enter oil through cooling system leaks due to failures of o-rings and gaskets, cracks in engine heads, liners and water jackets. These leaks can occur during engine operation or when the engine cools after shutdown. Glycol rapidly attacks copper, most commonly found in bearings, causing premature bearing failure. Sodium borate and Sodium chromate are used as coolant additives in standard SCA coolants, the addition of Potassium in ELC coolants. In the event of a coolant leak, these trace elements will remain in the lubricant even if the water has evaporated due to operating temperatures.

OXIDATION:
Is when oil is being saturated with soluble and/or insoluble oxidation products. This is indicated by a light brown to black varnish. It will then cause ring sticking, excessive or high oil consumption, oil blow-by, overheating and abnormal engine wear. Causes of oxidation are insufficient oil flow, normal build-up due to length of oil service, high oil and/or water temperatures, scale build-up in water jackets and localized engine hot spots.

GUIDELINES USED TO INTERPRET THE PHYSICAL PROPERTIES ANALYSES:

VISCOSITY – is the flow rate of oil in relation to time. This test shows oil grade classification, oxidation and contamination. An increase or decrease of 3 Centistokes in either direction may indicate fuel dilution, wrong oil type, or agglomerated soot and is considered abnormal.

WATER – Any amount of water is considered abnormal. It may indicate a coolant problem or possibly condensation from cool-down.

SOOT – The total amount of solid contamination, both suspended and non-suspended, that is present in the lube oil. 6% by weight or higher is considered abnormal. Abnormal solid content may cause oil to thicken and breakdown prematurely this will promote engine wear. A high solid content may indicate that filters have reached the end of their service. It may also indicate a problem with sample point or technique.
FUEL DILUTION is the amount of unburned fuel oil (like diesel) present in the lubricant. A 10% or more drop in viscosity may indicate a fuel dilution problem. The test indicates such problems as fuel line, injector, and fuel pump leaks.

GLYCOL – Any amount of glycol present in engine oil is considered abnormal and will be reported as critical condition. Even a small amount of glycol will begin to breakdown oil; cause oil starvation and serious engine wear if not caught in its early stages (especially bearings).

OXIDATION – High oil oxidation will indicate that the lubricant has reached the end of its service life. Extended service and/or high operating temperatures can also cause oxidation.

NITRATION – A chemical attack of the lubricant by nitrogen oxides in combustion. Nitration will thicken viscosity and cause sludge deposits.

UNDERSTANDING AND INTERPRETING THE ELEMENT ANALYSIS

ELEMENT ANALYSIS: Twenty metallic elements are measured and identified on the simultaneous reading spectrometer. This element analysis provides a positive means of identifying the critical parts that are beginning to wear. These elements, either singularly or in combination as an alloy, indicate the part that is wearing. These elements are found in microscopic trace amounts long before there are any outward indication of their presence. The interrelation of metals (**copper/lead, Chrome/iron, tin/lead, etc..)** is often key to engine wear and finding the cause of it. The interrelation of metals with **silicon** is key to determining the source and location of abrasive dirt and/or sand.

WEAR METALS and their significance varies with engine model and the oil product in use. They are dependent on engine speed, air charging and oil lubrication systems. Values should not be evaluated by their level only. They should be evaluated for and by the trends (increasing or decreasing, a sudden change or a gradual change). They should be evaluated by engine conditions (idling, overloading, break-in, age of unit and oil service, etc..).

WEAR METALS:

IRON: in increasing levels, may indicate wear from liners, valve trains, shafts, pistons rings, pistons (in some engines) and gears. This may be critical due to break-in. In the case of a cooling system leak, it may represent cooling jacket scale or rust particles.

ALUMINUM: in increasing levels, may be caused by scuffing, scoring or burning of aluminum pistons, aluminum bearing wear, or abrasive dirt contamination to aluminum parts.

COPPER can be from bearing wear, especially when excessive lead amounts are present or when coolant leaks appear. Bearing wear sometimes in conjunction with lead can be from main bearings, and connecting rods, piston pins, camshaft or gear support bearings and bushings and oil cooler leaks. Glycol present during water leaks will attack copper components. Combined with tin, copper may indicate excessive compressor rod packing wear.

LEAD may represent normal flashing wear after overhaul and it can represent problem wear. It may be caused by Babbitt and copper/lead bearings, wear of lead flashing on bearings, contamination with leaded fuel, anti-seize grease compounds and lead based paints.

TIN will normally represent problems with Babbitt bearings, tin flashing on bearings and bushings, tin plating of pistons, or thrust washers and certain bushings.

CHROMIUM can represent engine wear or a component of cooling water inhibitor. Chromium may show up during a cooling water leak even without the evidence of water. It can also come form chrome plated piston rings, liners or valves. Usually chromium indicates scoring and scuffing of liner and rings.

BORON at low levels can represent an additive component used in some lubricants. Most generally represents cooling water (borate inhibitors, glycol's, softeners, etc…). It can present without the evidence of water.

NICKEL normally indicates wear from crankshafts, some gears, some piston rings, and some turbine components.

TITANIUM alloy in high quality gears and bearings

ANTIMONY Bearing overlay alloy or oil additive

SILVER normally indicates wear from bearings.

ADDITIVES: (Zinc, Phosphorus, Barium, Calcium, Magnesium, Molybdenum, and Silicon) these are additive elements blended into the various lubricants by manufacturers. The amount of additives present in oil is one of the best means available to identify a type of oil. Zinc and Phosphorus are anti-wear elements and help reduce friction and wear. Calcium, Barium and Magnesium are the detergents and dispersant. Their function is to flow through the system picking up wear and contaminant particles, then carry them off to the filter for removal from the engine.

OTHER ELEMENTS

1. **SILICON** can represent abrasive dirt in the engine. At normal levels it may represent a defoamant additive in the oil. High levels may indicate insufficient air intake filters, leaks in the intake filters or piping, clogged or low oil level in oil bath air filtration systems or contamination while engine is open during overhaul or repair work, or dirty oil sample container.
2. **SODIUM** can represent oil additives in some oils, cooling water inhibitors (even without the presence of water), road salts and ingested dirt.
3. **POTASSIUM** Coolant water inhibitor found in Extended Life Coolants
4. **BRASS** is a combination of Copper and Zinc.
5. **BRONZE** is a combination of Copper and Tin.
6. **BABBITT** is a soft silvery anti-friction alloy composed of Tin and small amounts of Copper and Antimony.
7. **LEAD FLASHING** is used on some parts to help during break-in wear.

APPENDIX #1

WHAT IS A NORMAL GUIDELINE FOR WEAR METAL ANALYSIS?

It takes years of experience to convert the analysis data into accurate and specific maintenance recommendations. An increase in one or more of the wear metals is an indication of a developing problem. It is important to realize that each unit is unique and will develop its own trend patterns. The chart below gives an example of two engines, each sampled 3 times. Let's look at Iron and assume that 50 PPM is a warning limit.

ENGINE #1 (250 hours on oil)

SAMPLE #1 - 49 PPM, Sample #2 - 50 PPM, Sample #3 51 PPM

ENGINE #2 (250 hours on oil)

SAMPLE #1 - 9 PPM, Sample #2 - 10 PPM, Sample #3 **48** PPM

Utilizing the 50 PPM warning limit would, in the above example, result in an **incorrect** interpretation of the actual conditions. Engine #1 exhibits a steady wear trend, while on Engine #2, Sample #3 shows a 38 PPM increase over the previous sample. This large increase is an indicator that an abnormal condition may exist on Engine #2.

A few other things that are involved in arriving at an accurate interpretation:

1. Oil consumption and the amount of oil added.
2. Operating conditions. (Dusty, wet, heavy load, operating temps, etc.)
3. Component hours. (total unit Hours since new or overhauled)
4. Hours oil has been in service. (since last oil change)
5. Previous history. (Overhauls, oil and filter changers, repairs, etc.)
6. Specific operating difficulties that are reported.
7. Method with which the sample was obtained.

APPENDIX #2

TAKING A PROPER OIL SAMPLE

1. Take the sample while the unit is running (if possible) or right after shutdown. Samples should be taken "**HOT**" whenever possible.
2. **ALWAYS** take the sample from the same point each time. Samples taken different sample points may affect trend patterns.
3. SAMPLE POINTS IN ORDER OF PREFERENCE:
    - A. A valve installed in-line before the oil filters.
    - B. The dipstick when using the sample pump and PVC tubing.
    - C. The drain plug or sump. (Note: when taking sample from the drain plug, it is best to allow oil to flow for a few seconds to allow any contaminates to pass through.)
    - D. Cold samples should be taken by drawing equal amounts from top, middle, and bottom of component.

1. Be sure to keep any dirt, rust water, etc., from accidentally contaminating the sample bottle.
2. Sample at regular intervals to allow a good history to develop. Each unit is unique and will develop its own wear trends.
3. **NEVER** sample a unit immediately after an oil change or large oil addition.
4. When taking dipstick samples, take the sample from the middle of the sump or reservoir.
5. Send samples of all new oils being used to form a baseline for comparison to the used oil.
6. Labels should be filled out as completely as possible.
7. Samples should be sent in for analysis as soon as possible.

APPENDIX #3

SAMPLING FREQUENCY GUIDELINES

SUGGESTED SAMPLING FREQUENCY

HEAVY USE - Diesel Engines 5,000 to 10,000 miles / 250 to 500 hours
REGULAR USE - 2,500 to 5,000 miles / 125 to 250 hours

HEAVY USE - Gasoline Engine 2,500 to 5,000 miles / 125 to 250 hours
REGULAR USE - 1500 to 2500 miles / 75 to 125 hours

Reciprocating Gas Engines & Compressors
HEAVY USE - 500 to 750 hours
REGULAR USE - 250 to 500 hours

Gas Turbines
HEAVY USE - 500 to 750 hours
REGULAR USE - 250 to 500 hours

Gears, Transmission, Final Drive, Gear Reductions, etc..
HEAVY USE - 15,000 to 20,000 miles / 500 to 750 hours

REGULAR USE - 7,500 to 15,000 miles / 250 to 500 hours

NOTE: The sampling intervals listed above are **guidelines**. The sample intervals should be tailored to the operation. Do not change normal maintenance procedures. Take samples prior to or at oil change.

Thank you,
Fred Stauffer
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