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NF95-225 Oil Analysis

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Oil Analysis[1]

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A detailed analysis of a sample of engine, transmission and hydraulic oils is a valuable preventive maintenance tool for an agricultural producer. In many cases it enables identification of potential problems before a major repair is necessary, has the potential to reduce the frequencies of oil changes, and increases the resale value of used equipment.

What is Oil Analysis?

Oil analysis involves sampling and analyzing oil for various properties and materials to monitor wear and contamination in an engine, transmission or hydraulic system. Sampling and analyzing on a regular basis establishes a baseline of normal wear and can help indicate when abnormal wear or contamination is occurring.

Oil analysis works like this. Oil that has been inside any moving mechanical apparatus for a period of time reflects the exact condition of that assembly. Oil is in contact with engine or mechanical components as wear metallic trace particles enter the oil. These particles are so small they remain in suspension. Many products of the combustion process also will become trapped in the circulating oil. The oil becomes a working history of the machine.

Particles caused by normal wear and operation will mix with the oil. Any externally caused contamination also enters the oil. By identifying and measuring these impurities, you get an indication of the rate of wear and of any excessive contamination. An oil analysis also will suggest methods to reduce accelerated wear and contamination.

The typical oil analysis tests for the presence of a number of different materials to determine sources of wear, find dirt and other contamination, and even check for the use of appropriate lubricants.

Oil analysis can detect:

- Fuel dilution of lubrication oil
- Dirt contamination in the oil
- Antifreeze in the oil
- Excessive bearing wear
- Misapplication of lubricants

Some wear is normal, but abnormal levels of a particular material can give an early warning of impending problems and possibly prevent a major breakdown.

Early detection can:

- Reduce repair bills
- Reduce catastrophic failures
- Increase machinery life
- Reduce non-scheduled downtime

Early detection with oil analysis can allow for corrective action such as repairing an air intake leak before major damage occurs. Probably one of the major advantages of an oil analysis program is being able to anticipate problems and schedule repair work to avoid downtime during a critical time of use.

Looking Inside

One purpose of oil analysis is to provide a means of predicting possible impending failure without dismantling the equipment. A person can "look inside" an engine, transmission or hydraulic systems without taking it apart.

Evaluating Used Equipment

A complete record of oil analysis may be a great tool for selling a used piece of equipment. It shows the potential buyers how the equipment has been maintained and how adjustments were made during its life. The history is a good indicator of potential future repairs and overhaul requirements.

One potential use of oil analysis is in the evaluation of used equipment being considered for purchase. Without knowing the amount of operation of the oil being analyzed, this test should be considered conclusive only if it indicates a problem. A good report could result from either no problems or a short length of service of the oil.

Physical Tests

Some of the physical properties tested for and usually included in analysis of an oil sample are:

- **Antifreeze** forms a gummy substance that may reduce oil flow. It leads to high oxidation, oil thickening, high acidity, and engine failure if not corrected.
- **Fuel dilution** thins oil, lowers lubricating ability, and might drop oil pressure. This usually causes higher wear.
- **Oxidation** measures gums, varnishes and oxidation products. High oxidation from oil used too hot or too long can leave sludge and varnish deposits and thicken the oil.
- **Total base number** generally indicates the acid-neutralizing capacity still in the lubricant.
- **Total solids** include ash, carbon, lead salts from gasoline engines, and oil oxidation.
- **Viscosity** is a measure of an oil's resistance to flow. Oil may thin due to shear in multi-viscosity oils or by dilution with fuel. Oil may thicken from oxidation when run too long or too hot. Oil also may thicken from contamination by antifreeze, sugar and other materials

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Metal Tests

Some of the metals tested for and usually included in analysis of an oil sample and their potential sources are:

- **Aluminum (Al):** Thrust washers, bearings and pistons are made of this metal. High readings can be from piston skirt scuffing, excessive ring groove wear, broken thrust washers, etc.
- **Boron, Magnesium, Calcium, Barium, Phosphorous, and Zinc:** These metals are normally from the lubricating oil additive package. They involve detergents, dispersants, extreme-pressure additives, etc.
- **Chromium (CR):** Normally associated with piston rings. High levels can be caused by dirt coming through the air intake or broken rings.
- **Copper (CU), Tin:** These metals are normally from bearings or bushings and valve guides. Oil coolers also can contribute to copper readings along with some oil additives. In a new engine these results will normally be high during break-in, but will decline in a few hundred hours.
- **Iron (Fe):** This can come from many places in the engine such as liners, camshafts, crankshaft, valve train, timing gears, etc.
- **Lead (Pb):** Use of regular gasoline will cause very high test results. Also associated with bearing wear, but fuel source (leaded gasoline) and sampling contamination (use of galvanized containers for sampling) are critical in interpreting this metal.
- **Silicon (Si):** High readings generally indicate dirt or fine sand contamination from a leaking air intake system. This would act as an abrasive, causing excessive wear.
- **Sodium (Na):** High readings of this metal normally are associated with a coolant leak, but can be from an oil additive package.

Taking an Oil Sample

It is important to get an oil sample that is representative of all of the oil in the machine. Remember, your analysis will be based only on the sample that you send in for analysis. **Always** have the oil hot and thoroughly mixed before sampling. Handle hot drained oil with care — it could cause serious burns.

The easiest way to obtain a sample may be when the oil is being drained for an oil change. Sampling at this time usually involves letting some of the oil drain and then catching a sample in an appropriate container.

Samples also can be obtained without draining oil by suctioning out through plastic tubing routed down into the oil reservoir.

In any case, it is important to have an appropriate container and follow sampling directions thoroughly. Remember, many of the tests are for measuring materials on a parts per million basis, so safe, effective sampling is needed.

Cost and Convenience

Cost of oil analysis will vary according to the laboratory and extent of the analysis. Typical charges are $10 to $30 per analysis. The expense easily can be justified if it alerts the owner of a major problem that can be corrected in the off-season and will prevent downtime when the machine is needed.

Several companies have developed oil analysis kits that make oil analysis convenient. These kits include the sample bottles, suction pump and tubing, and possibly a pre-addressed, postage-paid mailing container.

The reasonable cost and convenience of oil analysis for on-farm use makes it another management tool that should be considered by farmers.

Locating a Source

Your local fuel and oil supplier or machinery dealer may be the most convenient and economical source for oil analysis, although not all fuel and oil suppliers or machinery dealers are involved with oil analysis. Independent laboratories are another source and probably can best be located by looking in the yellow pages of telephone directories of larger cities under the classification of "Laboratories."

Results

Results of the laboratory analysis are typically returned in two to four days after the lab receives the sample. Results are returned to the owner for review. The laboratory may note when the analysis shows an abnormal condition and issue a caution or recommendation accordingly *(Figure 1)*.

A typical analysis report is included in Table I. It shows how detection can predict engine problems. Other typical recommendations might be:

- **Example 1:** Bearing metals indicate wear Inspect all bearing areas for wear Resample at 1/2 interval
- **Example 2:** Unit is in satisfactory condition Resample at normal interval
- **Example 3:** Abrasion indicated Inspect air filtration system Upper cylinder wear indicated Excessive fuel dilution Resample at 1/2 interval

Optimum Maintenance Interval

Most maintenance experts realize the oil change intervals for both engines and transmissions are decided by the "average need." No two pieces of equipment have the same preventive maintenance needs. Each machine has different imperfections and is used under different conditions. Operators doing smaller or lighter jobs can cause different conditions on engines and transmission wear than those that occur during more extended use. When using oil analysis to determine maintenance intervals, there is little guesswork. Records show that some equipment can safely run two or three times longer than recommended intervals. The oil analysis may show that you are changing the oil more often than necessary — or not often enough.

By eliminating too frequent oil changes, you reduce the cost for oil and servicing and also reduce the amount of used oil to deal with. This is an important pollution prevention method — reducing the source!

Oil sample analysis saves you repair and maintenance dollars, has the potential to reduce used oil and increases resale value of equipment.

Table I. Engine problems predicted with oil analysis.

Indicator	*Acceptable Levels*	*Engine Problem*	*What to Check*
Silicon (Si) and **Aluminum** (Al)	10 to 30 ppm	Dirt ingestion	Air intake system, oil filter plugging, oil filler cap and breather, valve covers, oil supply
Iron (Fe)	100 to 200 ppm	Wear of cylinder liner, valve and gear train, oil pump, rust in system	Excessive oil consumption, abnormal engine noise,performance problems, oil pressure, abnormal operating temperatures, stuck/broken piston rings
Chromium (CR)	10 to 30 ppm	Piston ring wear	Excessive oil blow-by and oil consumption, oil degradation
Copper (CU)	10 to 50 ppm	Bearings and bushings wear, oil	Coolant in engine oil, abnormal noise when operating

		cooler passivating,radiator corrosion	at near stall speed
Lead (Pb)*	40 to 100 ppm	Bearing corrosion	Extended oil change intervals
Copper (CU) and **Lead** (Pb)*	10 to 50 ppm	Bearing lining wear	Oil pressure, abnormal engine noise, dirt being ingested in air intake, fuel dilution, extended oil drain intervals
Aluminum (Al)	10 to 30 ppm	Piston and piston thrust bearing wear	Blow-by gases, oil consumption, power loss, abnormal engine noise
Silver and **Tin**	2 to 5 ppm 10 to 30 ppm	Wear of bearings	Excessive oil consumption, abnormal engine noise, loss in oil pressure
Viscosity Change		Lack of lubrication	Fuel dilution, blow-by gases, oil oxidation, carburetor choke, ignition timing, injectors, injector pump, oil pressure
Water/Anti-freeze		Coolant leak or condensation	Coolant supply, gasket sealed, hose connection, oil filler cap and breather

* Significant as wear metal, only for engines using unleaded and diesel fuel.

Figure 1. Example of oil analysis report.

OIL TEST RESULTS

UNIT SERIAL NO:639P830280 OIL USED:DOUBLE CIRCLE SAE GRADE:20 COMPONENT:ENGINE COOLANT:GLYCOL
MAKE:TT MODEL:C-60 ENGINE MANUF:CHEVROLET HORSE POWER:427 FUEL TYPE:GASOLINE

RECOMMENDATIONS FOR LAST SAMPLE ANALYSIS
EXCESSIVE FUEL DILUTION
OIL IN SAE 10W GRADE RANGE
CHECK BLOW-BY (COMPRESSION)
DRAIN OIL
RESAMPLE AT NORMAL INTERVAL
CHECK FUEL PUMP

MAINTENANCE RECORD:

SAMPLE NUMBER	DATE SAMPLE	DATE RECEIVED	MI/HR OIL	MI/HR FILTER	MI/HR NEW	MI/HR OVHL	QTS OIL ADDED	VIS @ 100 C	FUEL DILUTE	WATER	ANTI-FREEZE	TOTAL SOLIDS	OXIDA-TION	TOTAL ACID NO.
18	011693	011993	02100	02100	122826	012000	0	8.8	<1.0	NIL	NEG	1.8	0.1	4.2
36	021893	022193	01800	01800	124626	013800	1	8.7	2.0	NIL	NEG	1.6	0.1	4.6
57	030593	030893	02200	02200	126826	016000	1	8.9	<1.0	NIL	NEG	1.9	0.1	4.4
71	040593	040793	02000	02000	128826	018000		5.6	11.0	NIL	NEG	3.2	0.1	4.7

CONTAMINANTS:

IRON	CHROMIUM	ALUMI-NUM	COPPER	LEAD	TIN	SILVER	NICKEL	SILI-CON	SODIUM	BORON	MAG-NESIUM	CALCIUM	BARIUM	PHOSPHO-RUS	ZINC
75	2	0	7	998	0	0	0	12	31	0	1090	770	0	1310	1570
60	1	0	10	998	0	0	0	15	35	0	1110	790	0	1320	1560
68	1	0	8	998	0	0	0	8	39	0	1080	760	0	1300	1520
169	18	15	8	998	0	0	0	23	24	2	820	480	0	730	1190

RECOMMENDATION:

As a result of the excessive fuel dilution, the oil has been lowered one SAE grade, and we are seeing upper cylinder wear.

[1]Modified from: Pacey, D.A. 1986. Oil Analysis, AgFacts, AF-149, Kansas State University, Cooperative Extension Service, Manhattan, KS.

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