Oil Analysis

Introduction

Oil analysis was originally used by the military and the railroad as a preventative maintenance program. It has expanded today to the field of study called Tribology. Oil analysis is used by industries from automobile shops to nuclear power plants. Each industry has its own specific needs and criteria for testing. It is important to understand that each industry has many different methods for testing and reporting. Industry is moving towards consolidation of methods, but there are still many differences that must be understood to be able to use the data presented.

It is the purpose of this course to give a clear understanding of the following:

- How to take a representative oil sample
- How the tests are performed
- How to interpret the data once you receive the report
- How to cross reference data from one type of test specification to another
- Other services are available to help solve your maintenance problems

Sampling Procedures

Sampling technique is key to oil analysis. The sampling procedure can bias a sample to make it cleaner or dirtier depending on where or how the sample is taken. It is the goal of oil analysis to provide a representative insight into the actual condition of the oil and the condition of the piece of equipment.

It is important that the sampling be done in the following manner:

1. When selecting a sampling point it is important to sample in several locations in the system to determine where the most representative sample can be taken. Some of the most common sampling ports are as follows:
   - Reservoir (using a vacuum gun and tubing from the center of the reservoir)
   - In-line sampling port
   - Before the filter
   - After the filter
2. Take the sample while the system is operating if possible. If not, take it just after shut down.
3. Be aware of airborne dust and particles.
4. Always close bottle as soon as possible, and be very careful where you place the lid when taking the sample.
5. Make sure the system is warm when you take the sample.

Oil Analysis

A. Testing Procedures

Oil analysis is the evaluation of the oil itself and any contamination that is present. The information derived from the following tests looks for different types of wear and contamination. Each test looks at a different aspect of the oil. This is the reason for the different tests. The tests are as follows:

B. Physical Testing:

Viscosity

The viscosity test measures the thickness of the oil. The oil is heated and run through the viscosity bath. The results are then compared to the new oil specification. This test is valuable in determining the condition of the oil and is an indicator of water contamination and oxidation.

Water Content (greater than1%)

Water content above 1% is detected in the basic oil analysis.

C. Spectrochemical Analysis:

Spectrochemical analysis is the analysis of the metal content and additive package. This test checks 19 elements of the chemical spectrum and reports them in parts per million. These numbers represent the elements less than 5 microns in size. The spectrometers design limits its detection level to 5 microns and below. To evaluate the particulate larger than 5 microns, other test methods must be implemented.

The spectrochemical analysis is used to look for bearing or bushing wear in the form of copper, lead or tin. The spectrochemical analysis also looks at dirt levels in the form of silicon. Wear in pumps, housings and other points of contact can be evaluated using this information. It is important to remember that these are small particulate and even if there are large particles of metals in the oil, larger than 5 microns, the spectrochemical analysis will not detect them. The larger particulate will be detected in the particle count and or the filter analysis, if the particulate are large enough.

The additive package of the oil can be identified and evaluated using the spectrochemical analysis.

D. Particle Analysis

The particle count is the single most important part of the report to measure the efficiency of system filtration. The particle count measures all particulate in the oil larger than 5 microns. Particulate include: dirt, carbon, metals, fiber, bug parts, etc.

The particle count can be done using either laser or optical methods. The laser method reports the quantity, size and distribution of particulate but not what they are. The optical method gives a quantity, size, distribution and identification. A combination of these two methods is used in ServoCon Alpha's particle analysis. Through the use of the two methods, we can provide the most representative analysis available.

The color photograph that is taken of the .8 micron filter patch gives a visual identification of the contamination. This is one of the most effective tools for showing system cleanliness.

A more complete discussion of this test procedure is outlined in the next section.

E. Other Tests

Other tests are needed in some situations. For example, some systems have a low tolerance to water content or acidity levels. Additional testing is required in these situations. The following is a brief description of additional tests and the information they provide:

1. **Water By Karl Fisher — ASTM-D1744**
   This test measures water content down to 50 parts per million and is 0.005%. It is used in turbine system analysis, servo systems and any other system that has low tolerance for water.
2. **Total Acid Number — ASTM D-644**
   This test measures the acidity level of a system. Over time the acidity level of the

system increases. This can be detected with this test. In addition, some forms of contamination can also increase the acidity levels.

3. **Foam Test — ASTM D-892**
   In some systems high amounts of carbonization of oil occurs and pump cavitation is a problem. In these cases the oil could be foaming and causing these characteristics. This test measures the ability of the oil to resist foaming when air is injected into the oil in a controlled environment. In many instances the problem once identified can be corrected by changing to a different type of oil.
4. **Flash Point — ASTM D-3828**
   Each oil type has a known flash point when it is produced at the refinery. In some situations, contamination such as solvents, fuels or other flammable substances are present in the system. This test is an indicator of this type of contamination. The procedure uses the new oil flash point as a base line, for example 525 degrees F. If the sample in question has a flash point of 250 degrees, then the oil could be contaminated with a flammable substance.
5. **Infrared Analysis**
   In many situations the customer is looking for the source of external contamination. This is initially discovered by a high particle count or short filter life. In some cases the contamination is due to a cross contamination of fluids. In this case we can run a footprint of the new oil and overlay it with the foot print of the oil in question to determine if there is cross contamination. In addition to cross contamination situations, this test also can give information on oxidation, nitration, water content and sulfur levels.

Particle Analysis

Particle analysis is the second phase of oil analysis. This test evaluates the particulate from 5–100+ microns. A particle count is a totally separate test from a spectroanalysis. In many cases there are no correlations between a particle count and the spectroanalysis. Particle Analysis is one of the most misunderstood procedures in oil analysis.

It is the purpose of this section to give a clear understanding of what particle tests are available, different formats of information and how to interpret the data.

Two of the most common methods of particle counting are:

- Automated Mechanical Method
- Manual Optical Method

A. Automated Mechanical Method

The most common method is the automated mechanical method. This method employs a particle counting machine that uses some form of laser beam or light source to count the particulate.

Advantages:

- Easy to perform
- Requires limited technician training time
- Provides automatic graphing capabilities
- Fast

Disadvantages

- Cannot count samples with high water content
- Some use high dilution factors that decrease accuracy
- No identification of particulate composition (What type of particle is it?)
- Photograph of contamination is not possible.

B. Manual Optical Method

This method is a manual method that follows Aerospace Recommended Practice ARP 598. In this method 50—100 mls of fluid is filtered through a .8 micron grided millipore patch. The particulate are then counted and identified using a high power microscope.

Advantages

- Can count samples with high water content
- Uses little or no dilution factor to increase accuracy
- Identifies the type of particulate
- Photographs of contamination are possible

Disadvantages

- Requires highly trained staff
- No automated graphing system
- Time consuming

C. Data Reporting Formats

Three of the most common forms of data formats are:

1. ISO—International Standards Organization
2. NAS—National Aerospace Standards
3. SAE—Society of automotive Engineers

These methods group the actual particulate levels into classes.

ServoCon Alpha utilizes a combination of the laser and optical methods in our particle testing. The laser method is run to give particle size and distribution and then a filter patch is made and an optical correlation is performed to confirm or dispute the laser test. If the laser is confirmed, a photograph is taken and the results reported. If there is a conflict between the two methods, the tests are rerun. If there is still a difference the customer is called and the conditions are reviewed to get a better understanding of the situation.

It is important to understand that though there are correlations between these two methods, the exact numbers should not be considered identical. Once a trend is developed using one type of test method, it is important not to cross methods, using one method one time and the other the next.

A cleanliness level correlation table can be helpful in some cases.

It is important that the method of testing, optical or laser, is known when comparing test results. If there is a big discrepancy between two test results, call the laboratory and see if they can help you find out why.

D. About The Servocon Alpha Lab

ServoCon Alpha utilizes one of the most advanced particulate analysis laboratories in the industry.

Methodologies and highly trained staff provide the most accurate and repeatable particle analysis available.

Two methods—laser and optical, provide the most comprehensive analysis available. No method is perfect, but through the use of these two methods we can give the customer an actual representation of the particulates in the system.

In addition to the numeric count we can provide a color photograph or a VHS video of the particulates at 25, 40 or 100 times magnification.

35mm photography will give you the best photograph available.

E. Methodologies

Optical Method — ARP 598-B

Laser Method — SAE, ISO, NAS

With the use of these two methods we can provide not only a numeric but a visual description of the contamination in the system.

F. What is Particle Count

A particle count is a scientific analysis of particulates in fluid. It evaluates the size and distribution of particulates from 5 to 100 microns in size.

All particulates are included in this analysis. Examples include: dirt, metal, carbon, fiber, bugs, and many other types of material.

A particle count evaluates the cleanliness of a system and measures the efficiency of the filtration system.

Many equipment manufacturers have specifications on the operating cleanliness of their systems. If they do, we evaluate your sample compared to their requirements. If they have no specifications we call on our extensive data base to determine if your system is normal or abnormal.

A particle count differs from a spectrochemical analysis in that it evaluates particles 5 microns and larger.

The spectrochemical analysis evaluates metals and additives less than 5 microns in size. It is important to use both methods to determine the overall cleanliness and condition of the system.

Filter Analysis

A. System Insight

A filter analysis is used to gain even more insight into the system. The filter collects data with every gallon of oil filtered. By evaluating the residue the filter collects we can:

1. Determine system cleanliness
2. Predict failure of components
3. Determine source of contamination from inside or outside the system.

B. Filter Analysis Used In The Following:

1. System is experiencing short filter life
2. Vibration monitoring system is picking up abnormal vibrations
3. High pressure differential across the filter
4. Large metal particulate present in the system
5. Highly contaminated particle count
6. Failure analysis investigation

The filter analysis picks up where the particle count leaves off. When some components fail they fail in large chunks. These particles are not circulating in the oil, but are picked up by the filter. Take a roller bearing for example. When it fails the particulate that are generated are too large to be picked up in a spectroanalysis and are usually from 25 to 100 microns in size. These are picked up in the filter and can be evaluated using filter analysis.

C. The Process

The residue is washed from the filter, dried and weighed. It is then evaluated for metal content, organic matter (such as wood fiber) and foreign contamination. The percent of each form of contamination is evaluated and reported.

Major — 40% or more
Minor — 20% to 30%
Trace — 10% or less

The residue is then photographed at 25, 40 and 100 times magnification. This allows the customer to see exactly what is in the filter. This method of filter analysis was first used on aircraft applications. ServoCon ALPHA found it so effective that we started performing the evaluation on industrial filters.

Through the use of spectroanalysis, particle count and filter analysis we are evaluating all the particulate from sub micron on up.

Computer Data Management

A. Data Base Reporting/Plotting

ServoCon Alpha has developed a computer database program for its customers. It was developed to provide the customer a tool to better manage the oil analysis data generated. It has the capability to store, display and print up to four histories for each unit. The trend graphing feature will graph up to four unit histories. The program also generates the following reports:

1. Units to be tested within the next 7 days
2. Units with critical schedule dates within the next 30 days
3. Units with critical hours
4. Notes for selected units
5. All notes for all units
6. Summary report and plots for all units.

B. The System

This is a stand alone system that will run on any IBM compatible PC with a printer. The data can be down loaded through the internet or disk.

Additonal Services

ServoCon ALPHA also offers these additional services:

Predictive Maintenance

- Filter Analysis
- Particle Counts — laser and optical
- Photography of contamination or failure
- Total acid number
- Total base number
- Water by Karl Fisher
- Infrared analysis

Environmental Testing

- Waste oil testing
- Total petroleum hydrocarbons
- Heavy metal analysis
- Water and soil testing

Fuel Testing/Quality Assurance

- Diesel
- Gasoline
- Jet A

Contact us for more information and prices.

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