Best Practices for Using Oil Analysis in Lubrication Management

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There is no question that an effective oil analysis program lowers maintenance costs on rotating equipment. The trick is knowing how to run an effective oil analysis program. Organizations must be proactive so the solution to an oil-related problem is not always an oil change. The real benefit of oil analysis is using the data to steer you toward solutions to eliminate lubricant issues. This article will describe the best practices for using oil analysis to monitor your lubrication management program.

Getting Started

Are you waiting until you have implemented basic lubrication management strategies before taking those first oil samples because you know the results will be bad? Don't hesitate to start your program. You likely will see many problematic oil samples, but that is no reason to delay sampling. Oil-related problems are opportunities for your lubrication program. The worse the problem is, the better the opportunity for a cost-effective solution that will translate into big savings for your maintenance budget's bottom line.

Start sampling before you begin making improvements in order to establish baselines on the condition of your lubricants and lubricated equipment within the plant. Additionally, the initial oil analysis results will provide you with direction in terms of the solutions that should be implemented and on which machinery.

What to Look for

When you receive your first oil sample results, you most likely will see a number of abnormal or critical sample reports. The main issues to watch for are water contamination, high levels of oil particulate, improper oil top-ups and poor oil condition.

It is also possible that you will have results showing abnormal or severe wear in some machines. The purpose of establishing a lube program is to maintain proper lubrication and avoid unnecessary wear, so let's assume your reliability team is assessing these reports and has the situation in hand. Instead, we will focus on the oil-related problems, beginning with dirt and water contamination.

Water will show up on your sample report as "water" or "H_2O." Are these results abnormal or severe? At this point, you have not set any alarm levels for water contamination, so it is acceptable to use the laboratory defaults for your industry and type of machine. With most rotating equipment, the contamination limit for water will be 0.1 percent. Limits will range as low as 0.03 percent for turbines and as high as 0.2 percent for gearboxes. Some compressors using synthetic oils may go as high as several percent water.

Dirt will appear on a sample report under silicon (Si), along with the other elemental data for wear and additives. If you are sampling machines with oil filtration, the laboratory should perform particle count testing. Ensure that you are purchasing the correct test kits for this type of machinery. Pay attention to the ISO cleanliness code as well as the particle counts by micron size. Abnormal or severe silicon levels and/or particle count results indicate a problem with contamination. Again, the laboratory will be using typical industry limits for silicon and oil cleanliness, which is fine when you are starting your oil analysis program. Standard silicon alarm levels for most equipment are approximately 25 parts per million (ppm). ISO cleanliness codes for filtered systems are generally around 19/17/14.

Improper oil top-ups are a bit more difficult to detect, but look for comments about changes in the elemental additive levels (phosphorus, zinc, magnesium, boron, barium, sulfur, etc.) and monitor any changes in oil viscosity that are plus or minus 10 percent from the oil specification. Elemental additive levels can fluctuate as much as 25 percent, so a laboratory will look for other elements that shouldn't be present or the lack of an element that should be present in the oil. Some labs have very sophisticated algorithms that not only compare the used oil to the new baseline but can also determine the fluid type and compare it to the generic fluid type for the oil you have specified. They can then alert you when a different type of fluid is being used. You may want to inquire whether your laboratory has the ability to perform this level of comparison.

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The most blatant types of improper oil top-ups or incorrect oil usage are when the viscosity varies drastically from the specification. This would include when you believe you are using an ISO 320 gear oil, but the viscosity is actually 100 centistokes (cSt), indicating a possible top-up with hydraulic, compressor or circulating oil.

For most lubricated plant machinery, the oil condition is monitored using the oil's acid number (AN). When oil oxidizes, it forms acidic degradation products. An increasing AN signifies oil degradation. Once the AN is over the limit for the oil, it is time to schedule an oil change. Large systems like turbines require more advanced testing, such as rotating pressure vessel oxidation testing (RPVOT), water

1 WATER CONTAMINATION	2 HIGH LEVELS OF OIL PARTICULATE	3 IMPROPER OIL TOP-UP	4 POOR OIL CONDITION
Water (H20): >0.1% Free Water: >0.5% Ferrography: Ferrous Red Oxides (FRo)	Silicon (Si): > 25 ppm ISO Code +2 above target cleanliness code	Viscosity: +/- 10% One or more of boron (B), barium (Ba), molybdenum (Mo), magnesium (Mg), phosphorus (P), zinc (Zn): +/- 25%	AN: +1.0 mg/KOH from base RPVOT: <25% of New Oxidation: >0.20 Abs/0.1 mm

The most common oil-related issues uncovered by oil analysis and their associated general warning limits separability, rust properties, foaming characteristics and air release, to determine if the oil is suitable for continued use.

How to Correct Problems

So oil analysis found some issues. Now what? Realize these oil-related problems are opportunities for improvement in your lubrication program. Most of the suggestions here are low cost and provide a high rate of return on investment. Many of these recommendations can be implemented within a short amount of time and don't require a huge capital investment. The sooner you get started, the sooner you will improve your maintenance budget's bottom line.

Rated desiccant air breathers are the first place to start. Air breathers are an easy-to-implement, low-cost solution for preventing water and particulate from entering lubricated machinery. Air breathers can reduce moisture levels in lubricants even when oil analysis results show 0.2 percent or less water contamination. Desiccant air breathers dry the air that enters the machinery during operation and also dry the headspace in reservoirs, moving moisture out of the oil. The result is drier oil. In addition, these air breathers have a rated micron filter that cleans the air, which leads to cleaner oil.

For very large systems, dry gas blanketing may be an effective option, especially when there is a readily available source of inert gas present (such as in refineries). For instance, feeding dry nitrogen into a turbine reservoir can create a positive pressure that prevents the introduction of contaminants. The dry gas causes moisture to move out of the oil and into the headspace, where it is exhausted externally.

For systems with major water contamination issues (0.5 percent or more water in the oil), a more involved solution will be required. Start by ensuring that all machine hatches and inspection ports are properly sealed. Upgrading the seals may be necessary. To remove water contamination between 0.3 and 2.0 percent on smaller systems (less than 15 gallons of oil), consider using an offline filtration cart outfitted with water adsorption filter media. If there is too much water, you run the risk of spending a lot of money on filter elements. A bit of consultation with your filter cart provider can help you assess the

situation. If the water contamination issues are chronic (e.g., leaking cooler) and you have large systems (more than 100 gallons), you will need some serious equipment, such as a vacuum dehydrator or bypass centrifugal filtration system. In this case, you will be investing $25,000 to $100,000.

Particulate contamination can be easily managed with proper lubrication, drain ports and offline filtration. Purchase an offline filtration cart that best suits your application. Hydraulic filter carts are fairly straightforward and inexpensive. Gearbox applications require heavy-duty equipment and time spent to ensure that the filter cart has the proper specifications for the application.

The addition of lubrication and drain ports to machinery that will be part of your offline filtration program is essential, as these ports feature quick connections to allow maintenance technicians to easily hook up a filter cart and perform oil top-ups and changes without having to remove fill and drain ports. Additionally, a desiccant breather can be affixed to the lubrication port, further reducing particulate ingression.

Controlling oil top-ups can be managed easily. Start by installing lubrication porting on equipment to make top-ups easier and provide the right kind of dispensing equipment to empower your lubrication technicians to do the job correctly. If you give your maintenance staff the right tools, they will do the job the way you intended.

Oil identification tags should be attached to the lubrication ports. Use colors and/or symbols to identify the lubricant to be used. Dispensing equipment is available in a variety of colors to match. With some basic lubrication education, your lube crew will be armed with the tools and knowledge to do the job right.

If the sample report indicates a poor oil condition (not contamination), you should schedule an oil change when it is convenient. If this will be an expensive oil change (more than $5,000), it may be prudent to invest in advanced oil testing to determine if an oil change is required immediately or whether the task can be put off for three months or more. Unlike contamination, in 99 percent of cases when the oil condition is a problem, you need to change the oil. For a better indication of what is happening with the oil, request membrane patch colorimetry (MPC) testing for varnish potential and linear sweep voltammetry (LSV) tests to determine the exact amounts of antioxidants remaining in the oil.

Monitoring Your Lubrication Program

After implementing these solutions, what should you watch for on your oil sample reports? The moisture and particulate levels should start to come down once you have properly sealed your reservoirs from contamination. Over about six months, these levels will reach their minimum. It is worth noting the change from the baseline samples and to set reasonable targets going forward.

For example, let's say the water level in your gearbox was initially 0.15 percent and the

ISO cleanliness code was 22/20/18. Six months after adding desiccant air breathers and an offline filtration cart program, your moisture levels are 0.03 percent and the ISO cleanliness code is 20/18/16. You should inform your laboratory that you want to establish new alarm limits on these gearboxes. Set the ISO cleanliness abnormal alarm at 22/20/18 (two codes above the new average), and the critical alarm at 23/21/19 (three codes above the new target). For moisture, set the abnormal alarm at 0.05 percent and the critical alarm at 0.10 percent. Now when you receive abnormal or critical sample reports based on the water or particulate level, you will know what corrective action to take – change the desiccant air breather and/or run the offline filter cart for several days and resample.

If you implemented oil identification procedures and invested in appropriate dispensing equipment, you should no longer see significant additive changes (more than plus or minus 25 percent) or viscosity changes (more than plus or minus 10 percent) unless the oil condition is also suspect. When you see a dramatic change, ensure any new maintenance personnel are educated about preventing oil mixing and have been trained regarding the use of dispensing equipment. If training is not the issue, you may have an improperly identified oil delivery and should take samples from the suspected totes or barrels.

Gauging Success

If you have been using oil analysis data to track oil-related issues in your plant, subsequent management reports should show a decreasing trend in the water, particulate and incorrect oil usage statistics.

If you have reduced the moisture and particulate levels, then you have increased the mean time between failures (MTBF) for those machines. In the previous example, the gearbox should see an increase of approximately 1.25 times, based on the moisture reduction, and 1.25 times for the particulate reduction, which means more than a 50-percent increase in MTBF. That is significant.

Regarding lubricant mixing, not all incorrect oil top-ups result in lubrication issues. However, in several instances, serious damage can occur. Adding less than 1 percent of an emulsifying oil, which is designed to hold water in suspension, will destroy the demulsibility of an oil formulated to separate from water, i.e., bearing circulating oil, turbine oil, etc. Machines with bronze components should not use common extreme-pressure (EP) additives. Topping up such a machine with an EP gear oil will not only increase the viscosity but also lead to corrosion of any bronze components long after the problem has been detected and the oil has been changed.

An investment in fluid identification, proper dispensing equipment, and most importantly in training and education will drastically reduce the incidence of incorrect oil top-ups. It is more difficult to put numbers on the savings, but any averted catastrophe warrants the improvement.

Next Steps

With these upgrades, you no doubt will have dramatically improved your lubrication program. Typical internal rates of return and net present value over five years are about 150 percent and $500,000 for a program in a medium-sized plant.

The next steps will require putting in a plan for capital expenditure. Invest in a world-class lube room complete with an advanced oil storage system, cabinets and lubrication handling carts. Replace the offline filter cart program with permanently mounted filtration systems on critical equipment. Augment your stawndard oil analysis program with an advanced oil monitoring program for critical machines and those with large oil sumps (in excess of 250 gallons).

As you continue to improve the condition of your lubricants, revisit your wear, oil condition and contamination alarm levels and adjust them accordingly. Your initial investment in lubrication management has likely eliminated 80 percent of your oil-related problems. The next 20 percent will take more continuous efforts.

The subsequent steps involve looking for incremental improvement throughout the plant. It will be essential that you continue to educate yourself on lubrication best practices and seek opportunities to enhance your lubrication program. Remember, world class is a moving target, so my advice is to get started now.