PRECISE Lubrication

Oil Analysis & Industrial Lubrication Management

The Effectiveness of a Quality Filtration Program

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In the current global economic market companies are trying to find new and innovative ways to reinvent themselves to run more efficiently and increase production while minimizing equipment downtime. Now more than ever, plant managers, maintenance and reliability leaders are looking for ways to improve equipment reliability, optimize maintenance and reduce energy consumption. Many are doing so by challenging current methods and experimenting with new ideas. While many focus on the obvious lubrication techniques (5 R's), many are missing key opportunities when it comes to the quality of their plant filtration program.

Prior to tackling any kind of filtration opportunities you must first develop a plant filtration standard that addresses the individual needs of your equipment and ultimately tie into your plant reliability strategy. Many plants fail to address the need for a plant filtration strategy and take a one size fits all approach when it comes to filtration.

Fluid Cleanliness

As we start discussing the effectiveness of a quality filtration program we need to start with what is "Fluid Cleanliness". Fluid cleanliness or lubricant cleanliness refers to the absences of contamination. Microscopic particles are the most harmful form of contamination in lubricants. They can irreversibly damage bearing surfaces, shorten life of equipment and cause early unexpected equipment failure. The saying "New Oil is not Clean Oil" is correct in most cases. The concentration of particles in "new drums" and in bulk deliveries can be extremely high and if not monitored and addressed will ultimately lead to premature equipment failure.

Understanding how equipment fails is the first step in establishing a quality filtration program as part of the overall plant lubrication program. Internal surface degradation is the cause of over 70% of equipment failures (Figure 1), according to one study conducted by Rabinowicz of M.I.T. and published in 1981.

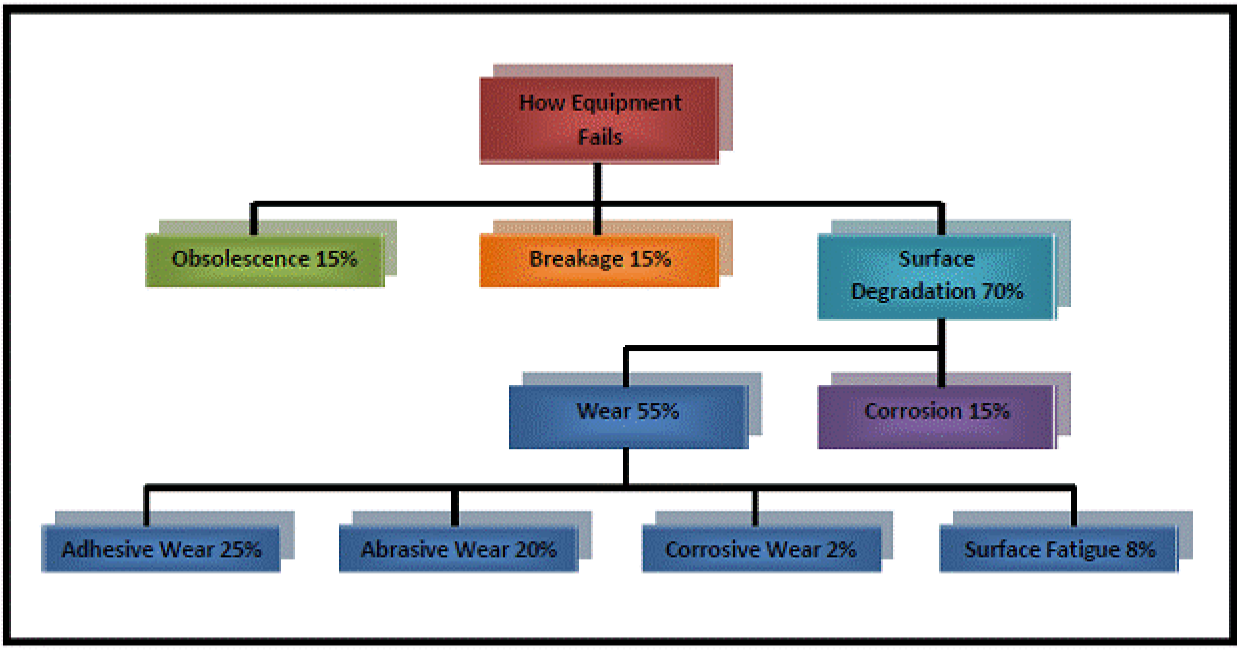

Figure 1. How Equipment Fails Flow Chart, Rabinowicz, 1981.

There are four basic types of wear: adhesive, abrasive, corrosive, and surface-fatigue.
The most common type, adhesive wear, arises from the strong adhesive forces that are generated at the interface of two solid materials. When solid surfaces are pressed together, intimate contact is made over a number of small patches or junctions. During sliding, these junctions continue to be made and broken, and, if a junction does not break along the original interface, a wear particle is formed. These particles eventually break away. Adhesive wear is undesirable for two reasons: first, the loss of material will eventually lead to deterioration in the performance of the mechanism; and second, the formation of large wear particles in closely fitted sliding members may cause the mechanism to seize at an early stage in its productive life. Adhesive wear is many times greater for un-lubricated than for effectively lubricated metal surfaces (Fig 2 and Fig 3).

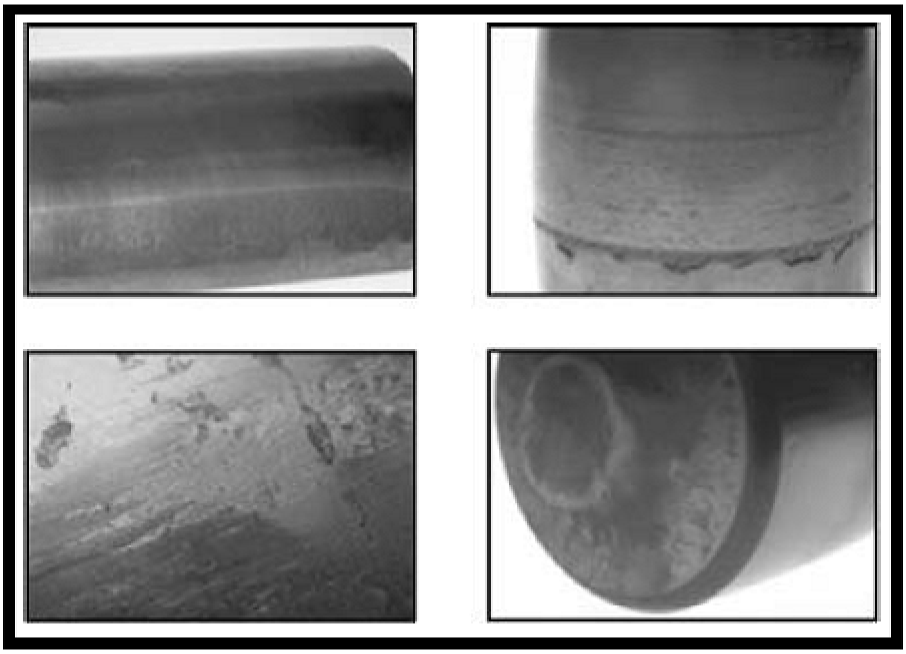

Figure 2. Damage to bearings due to adhesive wear.

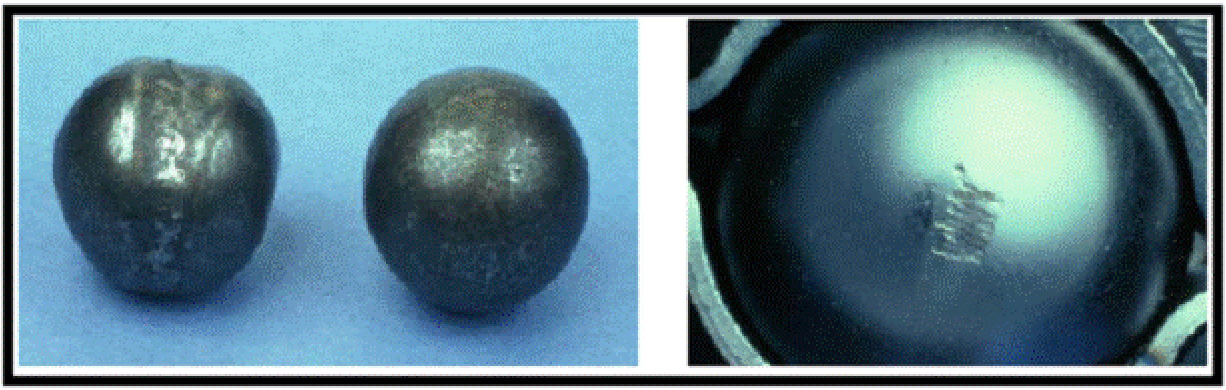

Figure 3. Damage to bearings due to particulate within lubricating oil.

Abrasive wear occurs when a hard, rough surface slides over a softer one, producing grooves on the latter. It also can be caused by loose, abrasive particles rolling between two soft sliding surfaces or by particles embedded in one of the opposing surfaces. Abrasive fragments borne by a stream of liquid or gas may wear down a surface if they strike the surface at high speeds. Since abrasive wear takes place when the abrading material is rough and harder than the surface to be abraded, it can be prevented either by eliminating the hard, rough constituent or by making the surface to be protected harder still (Figure 4).

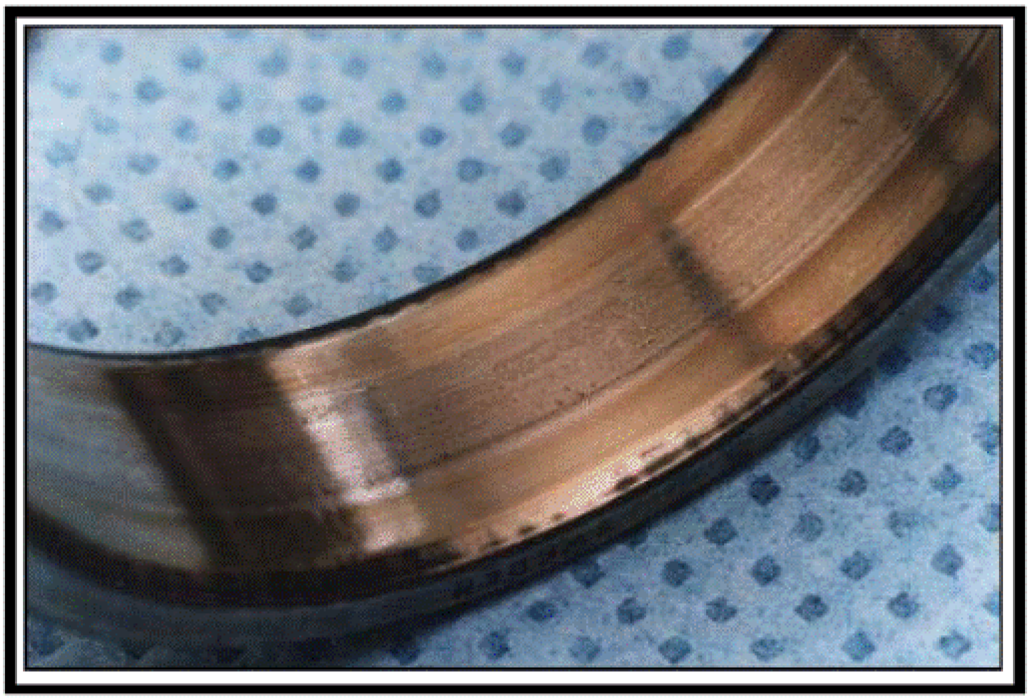

Figure 4. Damage to bearings due to Abrasive wear

Corrosive wear occurs whenever a gas or liquid chemically attacks a surface left exposed by the sliding process. Normally, when a surface corrodes, the products of corrosion (such as patina) tend to stay on the surface, thus slowing down further corrosion. But, if continuous sliding takes place, the sliding action removes the surface deposits that would otherwise protect against further corrosion, which thus takes place more rapidly. A surface that has experienced corrosive wear generally has a matte, relatively smooth appearance (Figure 5A).

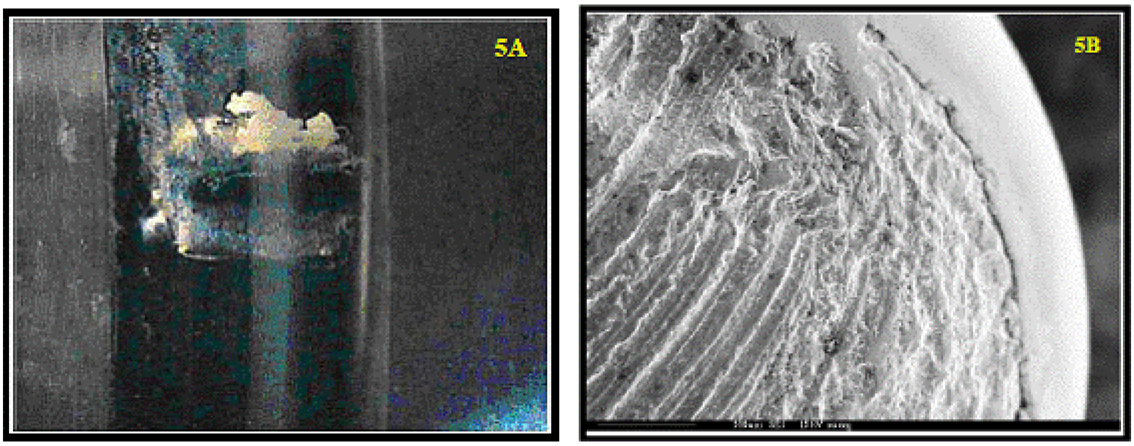

Figure 5. Damage to bearing due to Corrosive wear (5A) and Surface Fatigue (5B).

Surface-fatigue wear is produced by repeated high stress attendant on a rolling motion, such as that of metal wheels on tracks or a ball bearing rolling in a machine. The stress causes subsurface cracks to form in either the moving or the stationary component. As these cracks grow, large particles separate from the surface and pitting ensues. Surface-fatigue wear is the most common form of wear affecting rolling elements such as bearings or gears. For sliding surfaces, adhesive wear usually proceeds sufficiently rapidly that there is no time for surface-fatigue wear to occur (Figure 5B).

By understanding what the four basic types of wear are and how they originate, we can then start to address the proper filtration requirements needed to maintain proper equipment life. If we address new oil delivery, proper storage and handling practices, ventilation and breathers, sealing issues, service and built-in debris and clean reservoirs before filling with new oil we can combat contamination ingression. Understanding that the cost of excluding a gram of dirt is approximately 10% of what it will cost to remove it once it gets into the oil.

Examples of Fluid Cleanliness
As part of your plant reliability program you must address the proper fluid cleanliness targets for each family of equipment such as pumps, gears, hydraulic systems, turbines, etc. Hydraulic fluid is normally cleaner than gear oil since the dynamic clearances in hydraulic system components are much tighter than those in a gear case (Figure 6).

Component	Clearance
Roller Element Bearings	0.1 to 3 microns
Journal Bearings	0.5 to 100 microns
Gears	0.1 to 1 micron
Engines	
Ring / Cylinder	0.3 to 7 microns
Rod Bearing	0.5 to 20 microns
Main Bearings	0.8 to 50 microns
Piston Pin Bushing	0.5 to 15 microns
Valve Train	0.0 to 1 micron
Gearing	0.0 to 1.5 microns
Pump, Gear	
Tooth to Side Plate	0.5 to 5 microns
Tooth Tip to Case	0.5 to 5 microns
Pump, Vane	
Vane Sides	5 to 13 microns
Vane Tip	0.5 to 1 micron
Pump Piston	
Piston to Bore	5 to 40 microns
Valve Plate to Cylinder	0.5 to 5 microns
Servo Valves	
Orifice	130 to 450 microns
Flapper Wall	18 to 63 microns
Spool to Sleeve	1 to 4 microns

Figure 6. Dynamic Clearances in Design of Components

The ISO (Solids Contamination) cleanliness code test ISO 4406:99, targets the particle size of 4µm, 6µm, and 14µm micron. This is usually presented as a three part series of numbers like 18/16/14. The lower this number the cleaner the overall oil is. A typical cleanliness code for new oil delivered to a facility can range from as high as 19/17/15 or higher down to 16/14/12 depending on the manufacturer. Based on the dynamic clearances of your equipment this “New Oil” being delivered to the plant, although it may meet the test criteria to be called the specific oil in most cases will it not meet the cleanliness criteria based on the dynamic clearances of your equipment. The best way to identify the initial cleanliness of your “New Oil” is to pull a sample of oil from one drum of each brand of oil when it comes into the plant. You don't have to sample every drum of oil, but you should pull random samples from each family type of oil you use. By understanding this you can now start to identify the proper filtration level you want to attain per family of equipment.

Bearing Life and the Effects of Contamination

Like we already know, bearing life is greatly reduced in the presence of contaminated lubricants. We must however, if we want to improve bearing life and equipment reliability understand the relationship between lubricant contamination and bearing life. Many factors can impact the overall life of a bearing for example: speed, load, and contaminated lubricant. The basic life or L10 life as defined in ISO and ABMA standards which is typically given in years, is the life expectancy of the bearing with a probability of 90 percent under given stressing conditions (load, speed, etc.), before the bearing fails due to fatigue. In other words, out of a population of 100 bearings, at least 90 of those bearings should reach their L10 life.

Let's address how one of the most common contaminants, water, affects bearing life. Many studies have been conducted over the years to address how water contamination has a drastic impact on the life of a lubricant. First, where does the water come from? The majority of moisture that enters the oil comes from the following:

- Pressure differential between the equipment housing and surrounding environment
    - Housing temperature fluctuations
        - Frequent on/off conditions
        - Process fluid temperature changes
        - Outdoor use
        - Air flow over the equipment/reservoir
- Through system vents and breathers
- From coolers and heat exchangers
- Precipitation
- Introduction of contaminated top up fluids
- Rain entering outside storage reservoirs
- Rain entering into barrels stored incorrectly

Water effects on the life of a bearing are as follows. Many bearing manufacturers recognize that if you have 100 ppm water concentration in your oil that you're bearing life is 1%. If you increase you water concentration to 400 ppm you then reduced the bearing life to .52%, cutting the life of the bearing in half. On the other hand if your water concentration is 25 ppm your bearing life is approximately 2.59%, increasing the bearing life to over 2 ½ times (Figure 7)

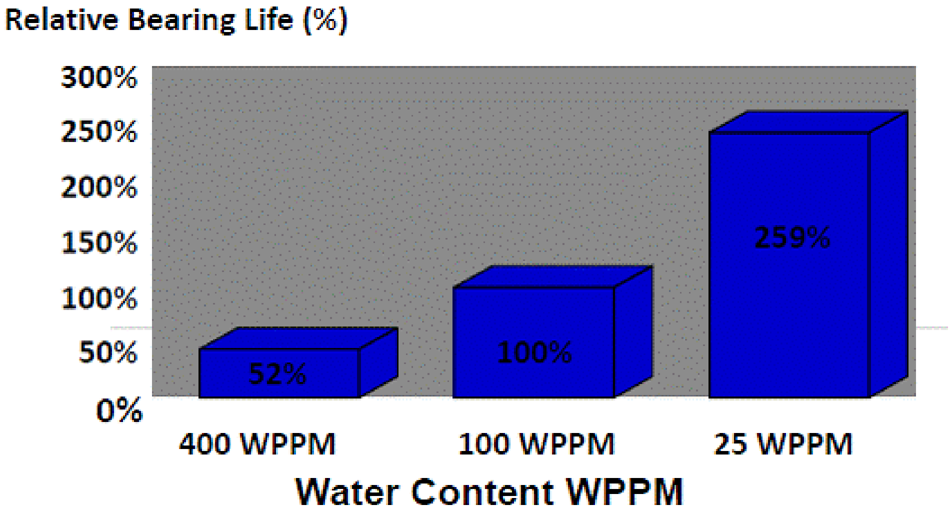

Figure 7. Relative Bearing Life vs. Water Content

By understanding how water contamination happens and the effects it can have on your equipment, strategies can be developed and implemented to combat these issues. By using proper storage & handling techniques, sound filtration principles and standards you can keep your oil in pristine condition. By doing this you will not only reduce equipment failure but also increase your equipment uptime. Remember if you keep your oil clean, cool and dry it will last for a longer period of time.

Implementing a Filtration Program

As you start to develop your plant filtration program you must decide first what level of filtration you want to achieve and then develop your plant filtration standard operating procedure (SOP). The reason for this is you need a roadmap for success for your plant filtration program. In most plants there are a variety of both low and high viscosity fluids, depending on the type of fluid and the application will determine what filtration standards and practices are necessary.

The first thing in your program should be the identification of your major family types and to what level of filtration you want to pre-filter the oil to and to what level of filtration you want to maintain on your system. In developing this you must go back to the dynamic clearance chart for your equipment. Once you have identified the dynamic clearances for that family of equipment you can then look for the correct filter for that application.

The next item in developing your program is to identify the necessary equipment needed to execute your program. The main item needed in your program is a filtration unit. The most common type is a portable filter cart (Figure 8). The versatility of these units is second to none, but there down fall is they too are a piece of equipment that must be maintained. All too often they are a forgotten part of the program and only thought once an issue has been identified. These units are available for filtering low viscosity oils as well as high viscosity oils. The key is to pick the correct unit for your specific application. By doing this, provides your greatest opportunity to remove contamination particulate (Silica, Water, Metal Catalysts, etc.) before it gets into your equipment. The cost per gram removal is approximately 10% the cost before it gets into your system. Once the contamination ingression has occurred the cost for removal can be staggering. Filtration units also provide the ability to filter lubricants that have been stored for extended periods of time.

Figure 8. Example of Different Style Portable Filtration Units

These units may also be used on oil that is already in service. By using portable filtration you can easily address your In-Situ filtration requirements. These are usually identified from an oil analysis report, system issues, etc. By using a portable filter unit you can address your lubrication filtration needs and continue to operate your equipment. This will also allow you to take proactive measures to maintain lubricant health.

The next item you must address is the ability to minimize the potential for cross contamination. This happens when there is only one unit that is available and improper flushing procedures are followed. The optimum is to have a low viscosity unit available for each family type of lubricant you maintain in your facility. Understanding that we all do not operate in a an optimum environment and we all have budget constraints, but still have the desire and drive to improve the lubrication program you can purchase a filtration unit that will meet all your needs. However, you must then have very detailed flushing procedures that are followed.

Once you have developed your program based on the needs of your equipment and identified and purchased the equipment necessary to implement your program. The final piece is training your lubrication technicians. Not only should the training be on the equipment in your program but also on your standards and practices; for it is these documents that are the foundation for your program.

The Move to Proactive Maintenance
Now that you have your filtration equipment in place and your plant personnel trained. The last step is your move to a Proactive Maintenance Strategy. By applying oil analysis technology in your program, sampling new oils, sampling lubricants already in use, etc. you now have the ability to let your oil analysis direct your future maintenance activities. Once you have qualified your equipment into your oil analysis program based on criticality of assets and identified the correct test slates per family of equipment you can start the move to the proactive approach. Ensure you identify upper caution and critical limits for trending as well as lower caution and critical limits.

Do not fall into the trap of having a poor strategy when it comes to oil analysis. Do not wait until you have a problem with a machine and then decide you need to get oil analysis involved. Ensure you avoid the following:

- Too infrequent analysis intervals
- Improper sampling techniques
- Poor data sent to the lab
- Delay in getting samples to the lab
- Incorrect test slates per family of equipment
- Lack of knowledge reviewing oil sample reports
- Failure to integrate oil analysis with other PdM technologies

By doing this you can grow your program into a “Best Class” lubrication program. Although this is one pillar of the program, it is critical that you get this right if you want to have success in your overall program.

Conclusion

By understanding how your equipment fails by the four common wear modes it is easy to understand the importance of having a plant filtration program. Ensuring you lay the ground work by developing your standards and procedures is the first step in developing your filtration program. Identifying the necessary equipment needed for your program and making the investment will help you achieve world class lubrication. By following a solid training program not only on the equipment but on the standards and procedures your lubrication technicians will have the tools, training and the confidence to go out and execute solid lubrication fundamentals that you can build your program on. Your ultimate goal should be to move to a Proactive Maintenance posture within your plant. Following these simple steps will help you along the way.

References

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