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Considerations for a Mine Maintenance Program

By making the best use of the available tools, decisions can be made quickly improving availability and keeping costs low

By Steve Fiscor, Editor-in-Chief

Take care of the equipment and the equipment will work as it should for many years to come. To do this, the mine must develop and administer maintenance programs for stationary and mobile equipment. Many modern programs rely on data from monitoring systems, such as oil and vibration analysis, to keep tabs on the health and performance of various components. Even better tools are being developed and tested.

Training is one of the building blocks in the foundation of a modern maintenance program. Maintenance personnel need to know which lubricant is used where and why. This is especially true in the mining business where components encounter high pressures and stress daily. They also need to understand the importance of cleanliness and proper sampling.

Similarly, the engineers and executives overseeing these maintenance programs need to know the same things. They must also invest time in reading the reports and they must do so with a critical eye, not necessarily looking at the numbers, but looking at the trends. The era of the intelligent mine is here and the maintenance department of the future will use insight (or information) to improve its decision-making ability based on data.

Getting the Full Benefits of Maintenance Program

Phillips 66 supplies about 70% of the lubricants used in the mines in the western U.S. by volume. When it comes to maintenance programs at a large mining operations, Steven Strollo, industrial lubricants engineer for Phillips 66, highlighted several steps to improving performance: identifying the correct oil for the application and using it consistently, understanding oil analysis and being able to interpret the data, and reinforcing the importance of cleanliness and understanding the errors associated with the automatic particle counting methods used by nearly all oil analysis labs.

The demands placed upon a lubricant and the operating conditions vary greatly with different components. To protect the equipment and address the demands placed upon the oil, lubricants have significantly different physical and chemical characteristics. Original equipment manufacturers (OEMs) stipulate the specifications for the lubricant, which are needed to minimize wear, maximize the performance and ensure the safe operation of their equipment. This information is normally found in the service manual. Mine operators need to review the service manuals for new equipment and work with his or her lubricant manufacturer to determine the appropriate oil. Quite likely, a lubricant meeting the OEM requirements may already exist on the property. This information needs to be conveyed to the maintenance staff to ensure its use in a component.

Strollo stressed the importance of consistently using the correct oil to maximize the life and performance of equipment and not topping off with an incorrect oil for convenience. Consistent use of the correct oil can be promoted by a variety of means including lubrication surveys, work orders identifying the proper lubricant, or permanent tags mounted near the filler port, which state the lubricant. He also stressed permanent, legible, and proper labeling of hose reels and oil storage and conveyance containers. Regardless of the method used, training should exist that reinforces the differences in lubricants and the need to use the appropriate oil.

Any maintenance program can be greatly enhanced through the use of condition monitoring tools. Oil analysis is one such tool, which, if properly implemented, provides multiple benefits. Some of the most powerful benefits include the detection of abnormal wear, projecting the time to failure, determine the suitability of the oil for further use, and detecting operating problems earlier in the failure cycle.

These benefits and others cannot be realized without a comprehensive oil

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analysis program, which addresses all aspects of the program from the shop floor collection of representative samples taken at an appropriate interval to the office interpretation of the laboratory report by a trained individual who understands the information and trends provided on an oil analysis report. "Too many customers do not have personnel with the time or training to make oil analysis maintenance decisions," Strollo said. "Out of necessity, many customers depend exclusively upon the warnings and comments provided by their laboratory. This information is very important and should not be ignored, but full value of oil analysis is achieved by spotting subtle changes early and knowing which changes are important, knowing where and how a component is operating, understanding equipment, as well as an awareness of recent maintenance. This knowledge only exists at the mine level."

To gain the full benefit of oil analysis, Strollo suggested that mine owners invest in software to assist with trending the laboratory data. This greatly simplifies and improves the accuracy of the maintenance decisions, which are derived from the oil analyses.

A maintenance program should include training, procedures and equipment, which promotes proper oil handling and storage practices to minimize the ingression of airborne dirt and water. These contaminates and others will shorten the life of equipment and hinder the efficient operation of equipment.

Most mining industry maintenance managers are aware of the ISO cleanliness levels, which are suggested by many OEMs for the oil used in their equipment, but many managers may not be aware of the various problems that are associated with the various automated methods used by nearly all of the laboratories to determine the cleanliness of new and in-service oils.

These problems very often lead to elevated particle counts, which do not accurately reflect upon the cleanliness of the oil. These problems include sample preparation errors, which do not remove air bubbles or moisture from the sample or oil additive interference. To eliminate them, the filter patch method should be used to accurately determine the cleanliness of a lubricant. "In this process, lab analysts draw a set volume of oil through a patch using a vacuum," Strollo said. "Higher viscosity oils may need to be diluted with a clean solvent. The residue that accumulates on the patch is examined under a microscope and analysts physically count the particles or they compare it to a template of photos of other patches that are representative of different cleanliness codes. It's labor intensive and therefore seldomly used."

Strollo said he has to often address inaccurate cleanliness analyses with a customer. The issue is normally resolved by the collection of additional samples, which are split and sent to both the customer's normally used laboratory and a laboratory capable of performing the filter patch method. Nearly always, the results provided by the patch method will be lower. This is a problem not only for lubricant manufacturers, but also for filter companies. One of the large filtration suppliers, Donaldson, has a YouTube video discussing this topic in-depth.

Establish Baseline and Implement Training

David Kupiec, mining manager for Total Lubrifiants, agreed and believes that maintenance programs at mines should focus on contamination control. To be successful in its application, lubricants must be used properly and contamination degrades the product's ability to perform, Kupiec explained. "Most lubricant suppliers have good products and the problems are not due to oxidation or performance related, it is usually related to contamination," Kupiec said. He believes that a lot of the lubricant-related problems are connected to contamination.

For every new mining customer, Total conducts an audit and tracks the lubricant flow from the storage system to the warehouse and on to the machines, taking samples at different stages. A pinch of dirt could divide by two the life of components, Kupiec said.

Filtration also plays a vital role. The filtration system needs to be installed in the right location and maintenance crews need to make sure it works. "Oftentimes, mines will invest in an efficient and expensive system and, when it becomes clogged, the miners just bypass it," Kupiec said. "That is why communications and setting a baseline correctly are so important."

Kupiec agreed that oil analysis is important, especially for mining operations. In addition to looking at the reports page-by-page, Kupiec said maintenance planners should be looking at the fleet and the equipment from a macroscopic level.

Total operates a state-of-the-art oil analysis laboratory, ANAC, in Belgium. This ANAC laboratory ensures maximum efficiency and quality by operating a unique level of automation and the implementation of the most advanced oil testing techniques. This ANAC center also hosts a unique database with several million analysis samples on all types of equipment. It also hosts a customer website used by the company's worldwide network of Weblink ANAC laboratories. This enables Total to give specialized diagnosis and miners to access its algorithms globally even in very remote locations.

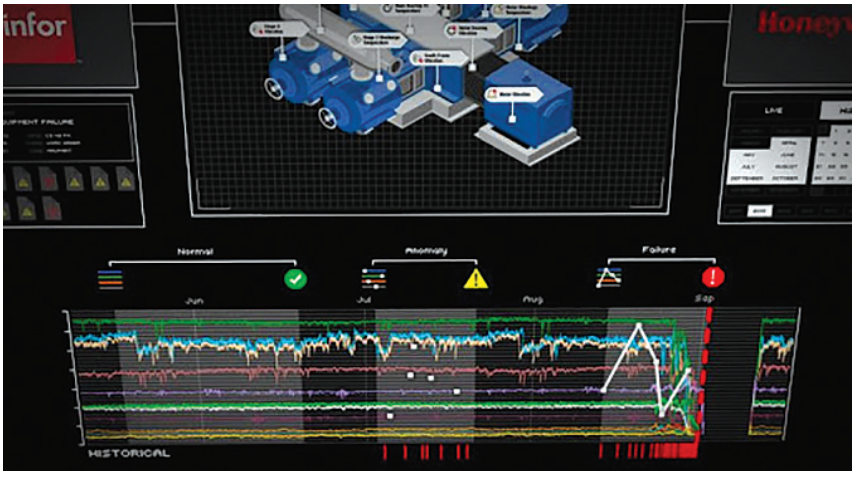
"Very regularly, we perform routine checks to make sure the values delivered from any ANAC Weblink lab in the world follow our standards and do not deviate," Kupiec said. "It is more than being ISO certified. It's making sure results are consistent from one year to the next and from one lab to another.

Total has a network of 20 oil analysis labs worldwide and mining customers simply send samples to the closest lab. For some of the larger mines, the company builds labs on-site. They recently installed and now operate a lab at a gold mine in Ghana and they are working on other projects around the globe.

Having Total people on-site also benefits the mine in other ways as they can readily assist with training and maintenance planning. "We have different levels of training based on the maturity level of the lubricant knowledge base," Kupiec said. "As we move step-by-step from the baseline, we focus on best practices and experience sharing to build an reliable lubrication culture at the mine sites."

Total also offers the TIG 6 maintenance software package, the sixth version of a digital tool that helps maintenance planners and mine engineers build programs matching oil analysis with machines and greasing schedules. Technicians can access it with devices, such as smart phones, and the system sends alerts automatically.

Total made two major product announcements recently. The first, with the recent acquisition of LUBRILOG, a leader in specialty lubricants such as open gears, the company now offers Lubriclean EP, which reduces downtime for continuously operating machines with open gears, like the ones found on grinding mills. "When



The Aspen Mtell sotfware looks for multivariant signal patterns.

it comes to open gears in the processing plant, there's always incoming dust and other pollutants with limited ways to prevent it from sticking to the gears," Kupiec said. "Cleaning an open gear usually takes more than 48 hours. The plant stops the mill and operators manually remove the abrasive mixture of grease and particles, sludge, etc. from the open gear. We have created a new product that enables cleaning of the open gearing while its running. It's a special solvent boosted with performance additives. Technicians spray the gearing for an hour. It removes the build-up and they can inspect the gears. It shortens the inspection time to a fraction of the traditional method and eliminates all contaminants from the gear. We have already used it on more than 100 open gear units worldwide. This will be a game changer when you realize the costs involved in stopping these large mills for long periods of time."

Total has also developed a water-based, biodegradable hydraulic oil. This hydraulic oil has been designed specifically for large pieces of mining machinery with high hydraulic pressures. The benefits are twofold: it's fire resistant and eco-friendly. When fires occur on mining equipment, it's usually the hydraulic oil that fuels the fire as the hydraulic lines burst or burn. Kupiec said he is looking forward to introducing this to the mines.

Predictive Analytics

What if a mine wanted to take the process one step further and predict failures even faster? Aspen Technology believes it has the answer. The company's Aspen Mtell system is an analytical tool that makes decisions based on data and they said it is already helping mine operators predict and prevent failures faster and earlier than traditional systems.

Aspen Mtell represents a paradigm shift, when compared to traditional programs that are focused on monitoring equipment with oil or vibration analysis, which trigger alarms at certain thresholds, explained Eduardo Gonzalez, senior account engagement consultant for Aspen Technology's APM Metals & Mining Group.

"Aspen Mtell differs from other systems as it looks for multivariant signal patterns," Gonzalez said. "Based on those patterns, we can identify pending failures well before the signals trigger an alarm from vibrations or changes in oil lab analysis. The system is easy to use. It's meant to be used by personnel who are familiar with equipment, not data scientists. It's equipment agnostic."

More importantly, Gonzalez said it has a low time-to-value proposition. "Not long after it's installed, it will begin to pay for itself," Gonzalez said. "Many solutions require significant development work to identify the analytics to detect changes in behavior in the assets. In this case, all the data science work is done by the tool and it facilitates the creation of pattern recognition. We're talking hours compared to other solutions that take days, weeks or even months."

To reliably predict problems, Aspen Mtell uses data. "One of the barriers we see with mining is collecting data from geographically dispersed assets and large mobile assets," Gonzalez said. "The system needs data. Data collection technology is readily available and many mines are already collecting lots of data. Other mines will need to make an investment for data collection. Once the data is collected, the tool can be deployed and it will generate insight from that data."

When Aspen Technology started deploying this at the mines, they started with fixed equipment, such as grinding mills, because the data is readily available through the plant's control system. Those mines have now started using the tool on haul trucks and shovels.

A barrier to widespread use in mining is psychological or the perception of not being ready to use this type of tool. By perception, Gonzalez means a customer who feels they need to invest more money on sensors to collect more data. "We usually tell them they're more ready than they think," Gonzalez said. "They could leverage this tool on existing data and convert it to insight. This is a tool that can be deployed across the entire site."

The various types of failures have different occurrence periods. "Our objective is not to predict lightning strikes," Gonzalez said. "We are looking at degradation that occurs over time and we detect failures days, weeks and even months in advance of the occurrence. The system that the mines are currently using detects the failure while it's occurring. We aim to detect it before it starts."

Aspen Mtell runs on a set of data that the mine provides. Using two types of agents, an anomaly and failure agent, the system uses machine learning to constantly improve. The anomaly agent is trained to recognize normal behavior. When behavior deviates from normal, it generates an alarm. If the deviation is confirmed, the software creates a failure agent to more precisely identify that action when it occurs again and it sounds the alarm earlier. If it's a normal operation, the pattern is learned by the anomaly agent and it will no longer alert on this pattern.

"The anomaly agent learns not to report on false positives," Gonzalez said. "The algorithms are already written and embedded in the software. The agents are trained on seasonal data by looking at a year's worth of data at a time."

Some mines have already saved significant sums of money in as little as 45 days, which pays for years of use of the software system. More than a dozen tier one mining sites are currently using the system.