# Extending Oil Change Intervals on Heavy Mining Equipment

Piet Hoffman, Kumba Iron Ore

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Extending oil drain intervals in off-highway engines and machines can be challenging. Dirt ingress and coolant leaks occur more frequently, and at times oil drain intervals are established to minimize damage from such problems. The cost reduction associated with longer oil and filter change intervals must be balanced against the risk of shortened engine life and the cost associated with less reliability if oil drain intervals are extended too far.

## Possible Benefits

There are many hidden costs of an oil and filter change that have influenced companies to find a more efficient approach to keep oil healthy and reliable. A recent study found that the true cost of an oil change normally exceeds the oil cost by a factor of 40. These same principles can be applied to filter changes. The following factors contribute to the true cost of an oil change:

- Lost production
- Paperwork (including maintenance schedules, data entry, manpower planning, inventory management, work orders, documentation, etc.)

- Labor and supervision
- Storage and handling costs, purchasing and quality assurance (additional costs associated with obtaining lubricants must be taken into consideration, such as lubricant storage and handling, filtering new oil to ensure compliance with specifications, analyzing oil samples, transportation, disposal of used oil, environmental issues, etc.)

## If It’s Not Broken, Don’t Fit It

Often a lubricant remains serviceable for long periods of time without draining and recharging (influenced by makeup rates, operating temperature, fluid volume, cleanliness, etc.). Draining oil and adding new lubricants into a system presents risks such as:

- Introduction of the wrong oil
- Introduction of contaminants or contaminated oil
- Re-suspension of settled contaminants in the tank/sump floors and inactive zones
- Human agency failures (dead-heading pumps on restart, not opening suction lines, not removing cleaning solvents, loosening machine parts, etc.).

Considering the real cost and the associated risk of an oil change, it is wise to let the conditions of the oil drive the decision.

## Benefits of a Hydraulic System Redesign

The cleanliness of hydraulic oil in the Sishen mine’s haul trucks was found to correspond to ISO 21/19, which is extremely poor. The trucks were fitted with three different-sized, high-pressure hydraulic filters for the hoist pump, steering/brake pump and hydraulic blower pump. After installing bypass pressure switches, it was determined that the filters went into bypass after 135 hours, resulting in the poor cleanliness levels.

The manufacturer installed high-quality filters in their systems with an expected life of at least 500 hours between service intervals, but the dry, dusty conditions at the mine drastically reduced it.

One option was to install return-line filters. However, the cost was prohibitive, so the alternative of resizing the high-pressure filters was chosen instead.

The existing blower filter was replaced by the steering/brake filter, while the existing steering/brake filter was replaced by the hoist filter. The existing hoist filter was then replaced by a large hydraulic filter. This step increased the filter area on all the filters. Larger 10-micron absolute air breathers were also installed on the hydraulic tank. The filters used were high-quality depth filters that are very efficient with good dirt-holding capacity.

The newly designed system was installed. Previously, the hydraulic filter cost was more than $100,000 per year for 36 haul trucks on 500-hour service intervals, achieving 6,600 hours per year. The new system ran for 1,991 hours at a target cleanliness level of ISO 15/12. At these hours, the filters went into bypass. The direct savings on hydraulic filter costs for the fleet of haul trucks were approximately $121,000 per year.

Other benefits were also realized, including:

- Less oil usage
- Fewer disposal costs
- The number of services went down from 475 to 237 per year, resulting in labor savings
- For 36 trucks, 2,376 more hours were now available for production. With the trucks moving on average 400 tons per truck per hour, 950,400 tons of additional production per year is possible.

## Life Factors for In-Service Lubricants

There is an assortment of operating conditions that can reduce the life of lubricants and filters. Obviously, if possible, these are to be avoided. However, very often nothing can be done, as many of the factors are associated with the machine's application and environment.

The timing of an oil and filter change is important, but even more important is the strategy to proactively improve conditions that extend oil life. When applied correctly, proactive maintenance strategies can double or triple lubricant and filter life. This is achieved by reducing the conditions that stress the oil and filter.

The following is a list of factors that influence the life of a lubricant:

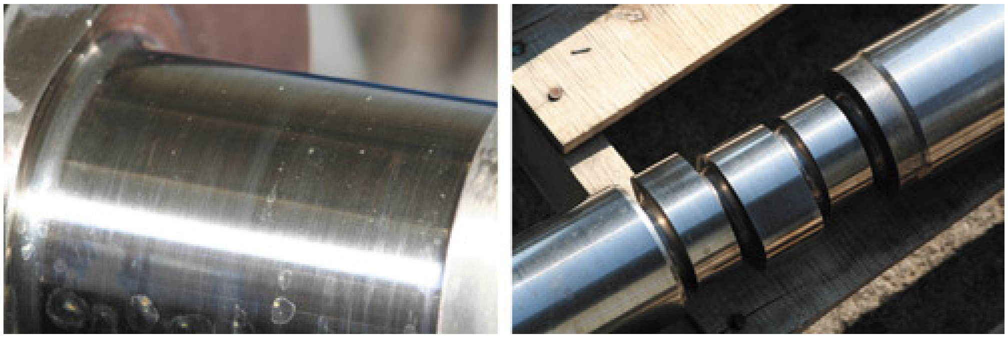
### Contamination

Contamination control is indispensable in preserving the integrity of all material in power and motion systems. Without it, few if any systems could ever achieve their intended purpose, let alone their expected service lives. Contamination control offers the assurance needed to achieve efficient, reliable and economical production of the "necessities" and "amenities" of our modern civilization.

Knowing the potential and probable sources of contaminants helps to establish an effective exclusion program. Generally, three fundamental modes contribute to contamination:

1. Those injected by people (implanted during manufacturing or induced in the field during maintenance, repair or overhaul operations).
2. Those generated by the systems (created tribologically, chemically or by desorption).
3. Those ingested by the machine (introduced by inhalation of dust, air and water; encroachment of energy; and migration of microbes from the environment).

The control of contamination in machinery is pointless if contaminated or below-specification lubricants are used, or if clean lubricant is being handled so carelessly that it enters machines in a contaminated state. Much work should be done in close cooperation with the lubricant suppliers to ensure that clean lubricants of the right specification are used in a particular application.



*After 28,000 hours of operation, this crankshaft (left) and camshaft (right) from a haul truck only needed polishing before being reused.*

### High Fuel Consumption

Inefficient engines contaminate by combustion byproducts including soot, fuel and fuel residuals, sulfur, acids and water. These contaminants distress the quality of the lubricant, resulting in filters going into bypass very quickly.

### Blow-by

Worn engines, timing/injector problems, lugging, incorrect rack settings, excessive idling, cold operating conditions and high elevations can all contribute to increase blow-by. This adds soot, fuel and other contaminants that distress even the most robust lubricants.

### Coolant Leaks

Glycol and water sharply disrupt dispersancy and contribute to a host of other problems such as corrosion, deposits, filter plugging, etc.

### Fuel Dilution and Fuel Quality

Fuel dilutes additives and introduces sulfur and aromatics into crankcase oils, which will affect viscosity. Lubricant and filter life is influenced by the quality of diesel fuel and natural gas, especially relating to sulfur levels.

### Air Cleaners

Blocked air filters result in the engine being starved. This causes overfuelling, leading to higher levels of soot entering the crankcase oil.

### Running Conditions

Lugging, stop-and-go driving, intermittent service, cold ambient temperatures, idling, etc., all influence the life of the crankcase oil.

### Oil Level

Low oil levels concentrate heat, contaminants and catalytic wear metals, resulting in fewer additives available to resist oxidation and lubricant degradation.

## Abrasives

Dirt and other solid contaminants attract additives and can catalytically advance the rate of oxidation. An even bigger problem is associated with the wear debris that is generated from abrasion and its influence as a pro-oxidant.

## Water Contamination

Water contamination leads to oxidation, additive distress, loss of dispersancy and many other lubricant life-related problems.

## Sludge and Varnish

Oil degradation products often contain high concentrations of carboxylic acids, free radicals and hydro peroxides. When oil is drained from a compartment but sludge and varnish remain, the following oil change could be short lived.

## Makeup Rate

Makeup oil refreshes additives and dilutes contaminants. Lube compartments with low makeup rates, while beneficial in one sense, also require more frequent oil changes.

## Lubricant Quality

The quality of base oils and additives can have a marked influence on oil life. Some lubricant suppliers can design lubricants with specific characteristics suited for a high or low ambient temperature environment. High operating temperature accelerates the rate of additive depletion and oxidation.

## Other Contaminants

The ingress of other contaminants can degrade additives and affect the quality of base oils. Any fluid system, reservoir or gearbox that is open or connected to the atmosphere by means of a breather inhales and expels air. By this action, it ingests moisture and collects water. Humid air exposed to temperature variations in a reservoir constantly condenses water into the system, causing hydrolytic action, corrosion, fluid additive breakdown, etc.

In certain areas, silica gel dryers can be used with synthetic media hydraulic oil filters to remove dirt and moisture from the air. Hydraulic filters are used as breathers. They filter down to at least a 5-micron absolute level.

## Establishing Extended Oil Drain Intervals

To establish extended oil drain intervals:

- Construct a fleet profile.
- Estimate oil drain intervals and potential cost savings associated with the optimum oil drain intervals.
- Assess the risk associated with the optimum oil drain intervals.

- Develop a testing plan for a small segment of your equipment to determine if the estimated oil drain intervals are acceptable.
- Implement the optimized oil drain interval after testing.

Fleet profiles describe the equipment, service severity, operating conditions and maintenance practices. Different engine models contaminate engine oil at different rates. The same engine may have a different oil volume in different equipment. Fuel and oil consumption rates vary for different equipment and service severities.

The capability of the oil and the engines must be considered to properly estimate oil drain intervals. Studies show that a liter of fleet oil possesses the ability to neutralize and suspend the contamination generated by burning 300 liters of fuel. High-quality premium oils have the ability to neutralize and suspend the contamination generated by burning 500 liters of fuel.

## Case Study: Sishen Mine

Situated in the Northern Cape of South Africa, the Sishen iron-ore mine is an open-pit operation with the deepest area of the mine about 492 feet deep.

The hematite iron ore at Sishen is extremely abrasive, and repairing and circumventing wear is the major cost component of maintenance.

Tests were run on the mine’s haul trucks to extend service intervals, reduce maintenance costs through high-efficiency filtration and increase production by better availability. The goal was to increase the service intervals from 500 hours to 1,000 hours. The biggest barrier to overcome was the life of the hydraulic oil and filters.

To achieve the target of 1,000-hour service intervals, the mine considered the factors that have an influence on the life of lubricants and filters, as well as reliability and safety risks.

Oil analysis was used to determine the oil condition. Samples were taken and analyzed weekly by the in-house lab. The 500-hour wear limits were taken as the target for 1,000-hour service intervals. As could be expected, Figure 1 shows iron exceeding the limit of 28 ppm at about 600 hours.

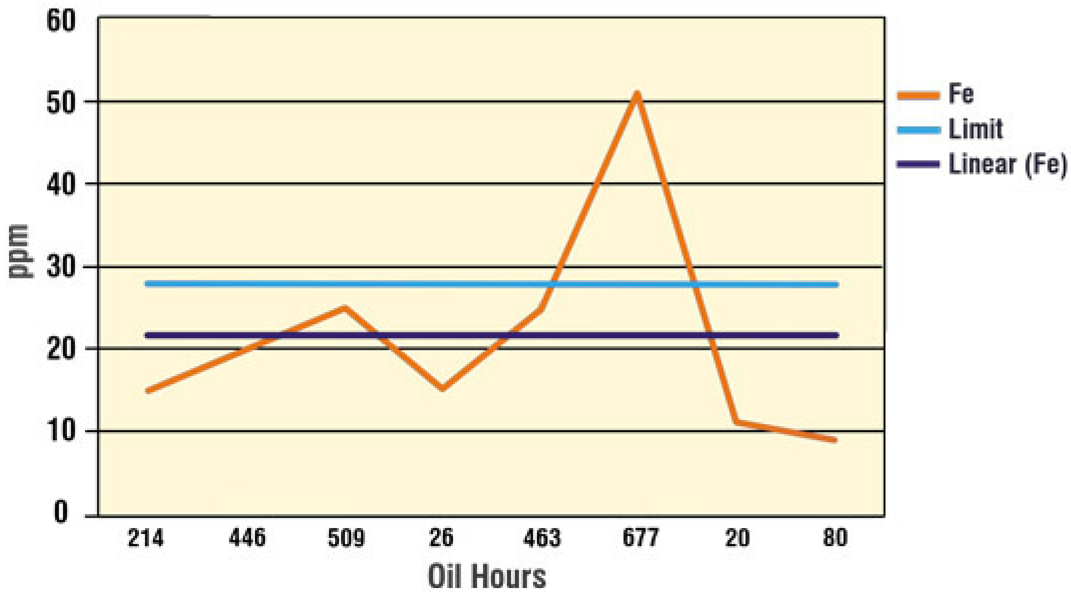



*Figure 1. Analysis of increasing wear metals in mineral oils before installing bypass filters*

Test results showed that the mineral oil was still fit for use after 1,000 hours. The main problem was the increasing of wear metals after about 650 hours.

Full-flow filters in the engines were replaced with advanced Venturi combo full-flow bypass filters. The bypass media was developed for organic contamination (oil sludge) separation.

An additional depth-style bypass filter was also added. It allowed a certain amount of oil to flow from the main gallery of the engine oil line, and by means of the element depth, filter out the impurities to 1-micron size.

*Installing bypass filters was key in extending the service intervals on the haul trucks at the Sishen mine.*

The cartridge used was made of densely wound, pure coniferous, long-fiber wood pulp paper. It works both by absorption and adsorption in a continuously recycling process. The long fibers of the paper absorb water formed by either the combustion process or by condensation. As the oil passes through the cartridge, minute carbon, wear metals and silicon particles are extracted from the oil by adsorption. The removing of water inhibits the production of acids that both degrade the oil and cause excessive wear. The simultaneous removal of minute contaminants as they occur enables the oil life to be extended.

After the filter modification, a test was run on the same haul truck. The 1,000-hour target was achieved within the set wear limits of 28 ppm iron. Figure 2 shows results from a second test in which the iron limit was exceeded after 1,195 hours. Several tests were performed on three other haul trucks, and the same results were achieved.

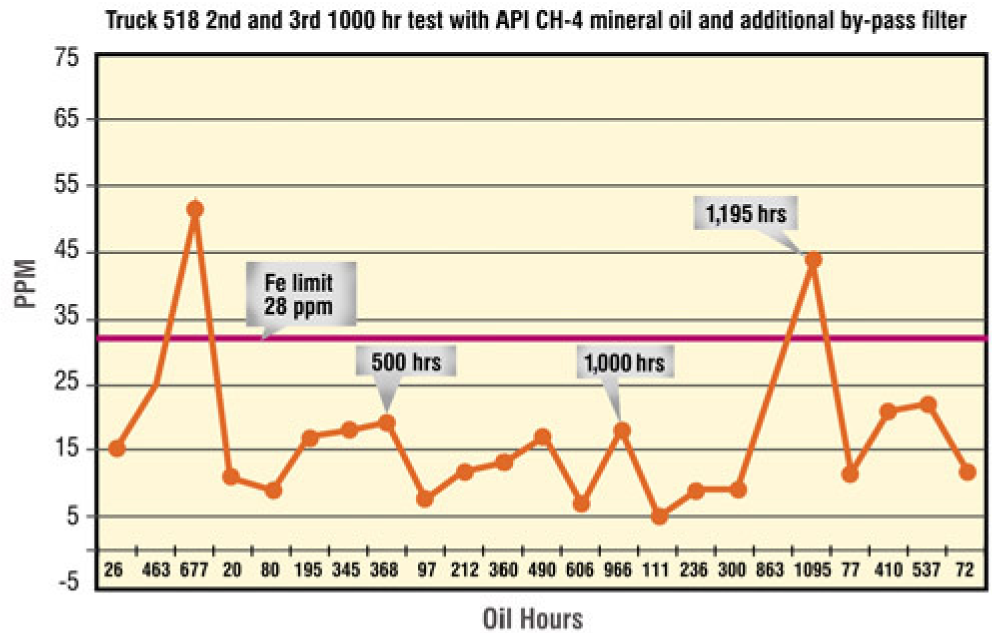



*Figure 2. Analysis of wear limits in mineral oil after bypass filter installation*

In October 2007, the haul truck fleet's service intervals were increased to 750 hours, and every truck was monitored closely by using oil analysis. No problems have been experienced so far, but the haul truck availability immediately increased by 4 percent.

In conclusion, it has been shown how extended service intervals can lead to enormous savings. By using oil analysis and setting target cleanliness levels along with proactive maintenance, a significant downward trend in lubricant consumption and maintenance costs can be achieved. The availability of equipment also will increase, allowing for more production, higher revenue and increased utilization of equipment.

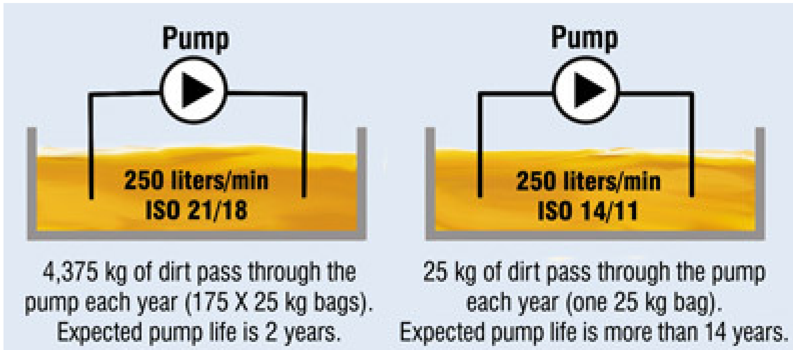
## Effects of Particle Size on Roller Bearing and Pump Life

In a recent case study, contaminant particle size was controlled by the use of filtration. The study concluded that there was a dramatic increase in bearing and pump life when the majority of particles of 3 to 5 microns and larger were removed from the lubricating oil.

While several factors cause rapid deterioration in service life, two of the main reasons are:

- Abrasion caused by particles greater than 3 microns bridging the dynamic clearances provided by the oil film.

- Large concentrations of small particles rolling through the oil film under pressure. This eventually leads to surface fatigue of the metal, causing pitting and ultimately bearing and pump failure.




*Number of particles per 100 ml of sample fluid*

| | ISO 21/18 | ISO 14/11 |
|---|---|---|
| Particles larger than 5 μm | 1,000,000 - 2,000,000 | 8,000 - 16,000 |
| Particles larger than 15 μm | 13,000 - 250,000 | 1,000 - 2,000 |

The study showed that bearing and pump life should increase significantly with lower particle concentration.