Practicing Oil Analysis
The Magazine for the Analysis and Management of Lubricants

Establishing Effective Sampling Frequencies

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Establishing an oil analysis strategy is a fundamentally identical process whatever the industry. However, this leads to the perception that the implementation is a straightforward, paint-by-numbers exercise using default values. But this is simply not the case. Every machine is unique in its intended performance, locality, environment and maintenance schedules, and this uniqueness should be reflected in the oil analysis program design process. Therefore, sampling frequencies should be set specifically for a particular machine. Each frequency is assigned not a fixed value that can be cross-referenced to similar machines in similar industries, but is based on a critical assessment of those parameters that affect a specific machine on a case-by-case basis.

One of the most prominent questions in a person's mind when discussing an oil analysis program design is, "How often should I sample this machine?" While it may not be the simple answer they are seeking, the correct response is, "How reliable a system do you require?" One simply cannot offer an opinion without understanding a number of factors, such as the age of the oil or the machine, the specific targets for each parameter, the environment and duty, and more importantly, the value of the machine to the business, and the safety risks associated with failure.

Predictive vs. Proactive

When selecting sampling frequencies, it is important to consider whether a predictive or proactive strategy is to be used. With a predictive approach, the program is geared toward looking for signs of impending failure. As such, no warning sign is too soon, suggesting that a predictive oil analysis strategy may mean more frequent sampling.

With a proactive approach, the key focus should be monitoring root cause parameters, such as contamination or lubricant degradation. In this case, the sampling frequency will depend on the criticality of the unit, the application and environment severity, the age of the lubricant and machine, and how tightly goal-based proactive targets have been set. The upside to a proactive strategy is that the occurrence of abnormal conditions will be far less frequent than under a predictive maintenance regime, because proactivity essentially equates to healthier machines plant-wide. Although proactive oil analysis usually means higher cost due to the inclusion of more sophisticated tests, in the long term, it usually reduces overall sampling cost with more time spent solving root cause problems and less time recovering from failures.

Where to Begin

The first step in setting up an oil analysis program is to select the systems to be monitored, and then establish the sampling frequency. This will dictate the tools and services required to achieve oil analysis success.

For example, assume that for a specific machine, safety, process criticality and economic penalty of failure dictate that sampling should be online, and in real-time. These factors suggest the need to procure an online instrument. Conversely, if the sample frequency analysis reveals a three-month interval is appropriate, then a commercial laboratory service may be the answer. In this case, sample frequency influences not only how often an oil sample is taken, but also the entire approach to oil analysis program design (Figure 1).

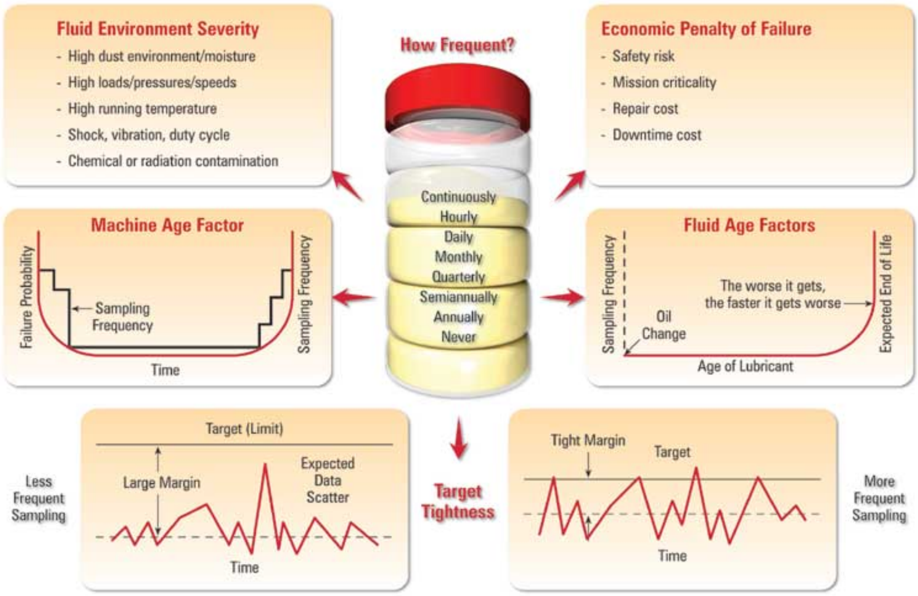
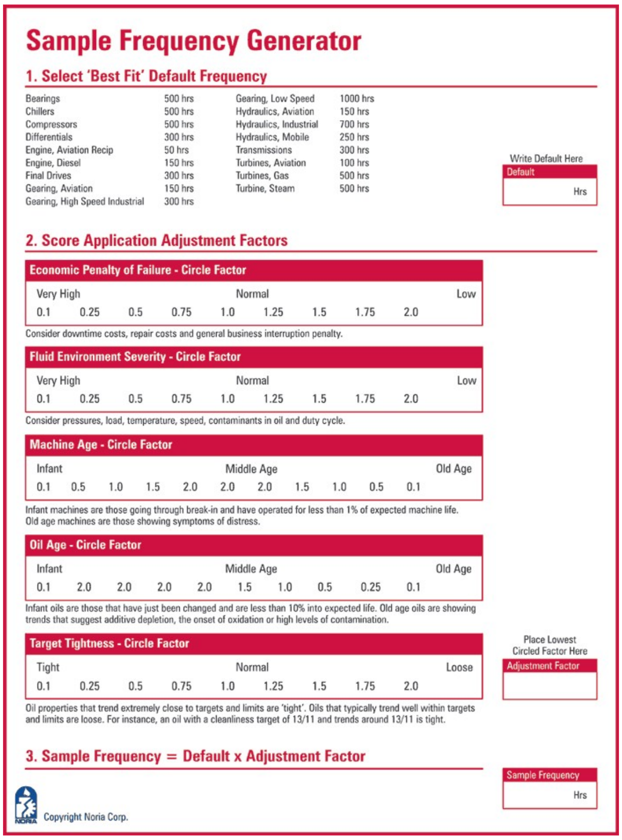


Figure 1. Frequency Variables and Results

Optimizing with the Sample Frequency Generator

The Sample Frequency Generator (Figure 2) provides a systematic method with which to estimate the optimized sampling frequency, taking into account economic penalty of failure, fluid environment severity, machine age, oil age and the tightness of goal-based target like contamination control. These factors are discussed below. To use the tool, select the best-fit default frequency identified in Step 1 of Figure 2. Then, score the application-related factors identified in Step 2. Finally, multiply the best-fit default frequency by the lowest application score to arrive at the adjusted sampling interval. As a caveat, step two should be considered pseudo-quantitative, meaning that one selects a number to represent his or her opinion. Because opinions vary, each machine type should be scored as a group consensus. This approach has proven to be more effective with this type of tool.



Sample Frequency Generator

1. Select 'Best Fit' Default Frequency

Bearings	500 hrs	Gearing, Low Speed	1000 hrs
Chillers	500 hrs	Hydraulics, Aviation	150 hrs
Compressors	500 hrs	Hydraulics, Industrial	700 hrs
Differentials	300 hrs	Hydraulics, Mobile	250 hrs
Engine, Aviation Recip	50 hrs	Transmissions	300 hrs
Engine, Diesel	150 hrs	Turbines, Aviation	100 hrs
Final Drives	300 hrs	Turbines, Gas	500 hrs
Gearing, Aviation	150 hrs	Turbine, Steam	500 hrs
Gearing, High Speed Industrial	300 hrs		

Write Default Here
Default
Hrs

2. Score Application Adjustment Factors

Economic Penalty of Failure - Circle Factor

Very High — Normal — Low
0.1 0.25 0.5 0.75 1.0 1.25 1.5 1.75 2.0

Consider downtime costs, repair costs and general business interruption penalty.

Fluid Environment Severity - Circle Factor

Very High — Normal — Low
0.1 0.25 0.5 0.75 1.0 1.25 1.5 1.75 2.0

Consider pressures, load, temperature, speed, contaminants in oil and duty cycle.

Machine Age - Circle Factor

Infant — Middle Age — Old Age
0.1 0.5 1.0 1.5 2.0 2.0 2.0 1.5 1.0 0.5 0.1

Infant machines are those going through break-in and have operated for less than 1% of expected machine life.
Old age machines are those showing symptoms of distress.

Oil Age - Circle Factor

Infant — Middle Age — Old Age
0.1 2.0 2.0 2.0 2.0 1.5 1.0 0.5 0.25 0.1

Infant oils are those that have just been changed and are less than 10% into expected life. Old age oils are showing trends that suggest additive depletion, the onset of oxidation or high levels of contamination.

Target Tightness - Circle Factor

Tight — Normal — Loose
0.1 0.25 0.5 0.75 1.0 1.25 1.5 1.75 2.0

Oil properties that trend extremely close to targets and limits are 'tight'. Oils that typically trend well within targets and limits are loose. For instance, an oil with a cleanliness target of 13/11 and trends around 13/11 is tight.

Place Lowest Circled Factor Here
Adjustment Factor

3. Sample Frequency = Default x Adjustment Factor

Sample Frequency
Hrs

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Figure 2 .Sample Frequency Generator

Economic Penalty of Failure

As expected, the economic penalty of failure adjusts the factor according to the cost of failure, that is, it would double the sampling frequency if it were very low, but would increase ten fold if it were high. The penalty of failure must take into account the cost of downtime, the cost of repair or rebuild, the overall interruption to business and the impact on product quality, or output where applicable.

Fluid Environment Severity

Fluid environment severity includes more than just the opportunity for particulate, process chemical and moisture contamination, but also takes into account the demands placed on the lubricant by the machine. This includes the pressure, speed and load, as well as the duty cycle. The greater the risk of lubricant damage, the more frequent the sampling.

Machine Age

Geriatrics has an impact on establishing sampling frequencies. Sampling frequencies must be modified according to the classic 'bathtub' curve used to explain the probability of equipment failure (Figure 3). In general, component failure is most likely during break-in, due to infant mortality, and of course as a component reaches the end of its natural life. For this reason, sampling frequencies must be increased during these periods of higher failure probability, particularly when analysis results indicate impending machine mortality.

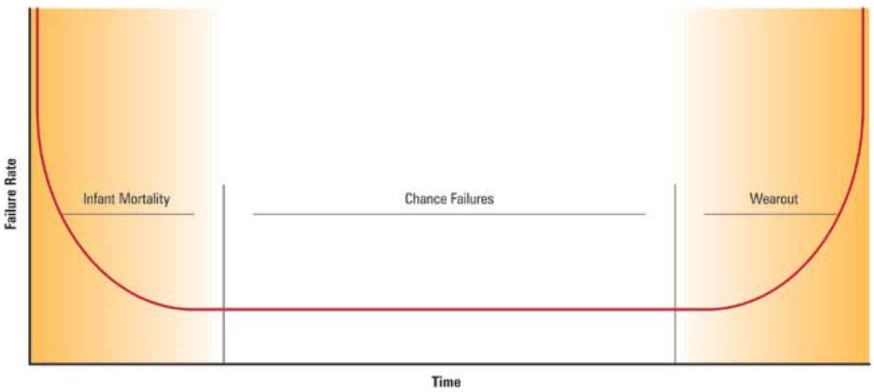

Figure 3. Bathtub-Type Failure Rate Curve

Oil Age

This geriatric rule applies to the lubricant, too. Aside from the obvious new oil sample for baseline purposes, the lubricant needs a frequent recheck in the first 10 percent of its expected life to ensure that it is bedding in correctly. This is particularly true when a new oil type or manufacturer is used. Notice how the adjustment factor is somewhat different between the age of the machine and the age of the oil. A lubricant is more likely to suffer a mid-life crisis than a machine when impacted by accidental ingress conditions and is thus less recoverable than a machine at that point.

Target Tightness

The final consideration is the tightness of any goal-based limits. For example, if a fluid cleanliness target of ISO 15/13/10 is set, and the average fluid cleanliness is normally around ISO 14/12/9, then this is considered tight, while if it typically trends at ISO 11/9/6, then this is considered loose. Tight targets require more frequent sampling because the possibility of exceeding the target will occur more readily than targets that are relatively loose.

Putting Sampling Intervals to Work

One consideration when applying this strategy is to understand that the machine and oil age are moving targets, so readjustment will be required as the machine and oil ages. However, if the target tightness, fluid environment severity or economic penalties scored high and dictated a factor of 0.1, then an adjustment to the age of the machine or oil may not apply because the single lowest factor overrides that.

In the worst-case scenario, an adjustment factor of 0.1 would indicate a daily sampling frequency. In this case, the use of online sensors is likely the most cost-effective strategy because the initial cost would soon be recovered in the savings on laboratory expenses, or even the manpower costs of doing this onsite. However, an online portable unit might also be considered if a number of systems require daily sampling because one unit can be applied to a number of machines. Again, the sampling frequency will have a major influence on oil analysis program design considerations

The frequencies calculated using the Sample Frequency Generator might seem ridiculously tight compared to historical programs, so forget historical approaches. This approach is designed for a proactive strategy, which requires frequent analysis to check for root cause conditions. However, even predictive programs designed to look for signs of impending failure require more frequent sampling, because a filter failure or a coolant leak can happen instantly, and if left unnoticed over a three-month period, will cause significant damage and severely reduce the useful life of the machine. However, when spotted immediately with frequent sampling whether your strategy is predictive or proactive, the problem can be rectified immediately so that minimal damage is likely to occur.

Please reference this article as:
Martin Williamson, Noria UK Ltd., "Establishing Effective Sampling Frequencies". *Practicing Oil Analysis* Magazine. January 2001

Issue Number: 200101
Practicing Oil Analysis
Best Practices