Establishing Proper Lubricant Service Intervals For Fleet Applications

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Abstract

Management has decided to pursue cost savings by extending oil drain intervals and you've been assigned responsibility. Where do you start? What needs to be reviewed and considered? What are the options? What testing is required? Do I have correct or sufficient sampling information and histories? These topics are addressed as well as tips on documenting your cost savings.

Introduction

Everyone's primary goal within equipment operations and maintenance is to improve equipment reliability and longevity. This is accomplished through a comprehensive PdM program that includes routine oil sampling. Secondary goals typically include: lubricant selection and quality assurance, filtration evaluations, monitoring the effectiveness of service procedures, establishing service intervals, and possibly inventory control assistance.

The common factor for objectives at all levels is to save operating costs – preferably not at the expense of the primary goals. Extending lubricant service intervals can yield a high return on the time and cost investments when properly qualified and administered. However, inappropriate or mismanaged extended service intervals can have dire negative consequences.

Where To Begin

The cornerstone of establishing proper lubricant service intervals is through your oil analysis program. Regularly scheduled and representative oil samples with the proper testing and adequate equipment information is essential to evaluating current conditions and the effectiveness of your maintenance and lubricants.

The next step is to review the historical test data to identify the qualifications of the equipment at current operating and service cycles. It is not uncommon at this point to find that in some cases equipment service intervals are over-extended. Drain interval reductions or alternate lubricants may be required to assure safe and reliable operations.

Following your determination that all or some of your equipment is qualified for extending fluid service, you must then determine which type of service evaluation is appropriate for your fleet: (1) Fleet / Class based intervals or (2) Individual vehicle assessments.

We're going to break a golden rule and make the following assumptions: your personnel are properly trained in sampling procedures and consistent representative samples have been submitted for analysis. Based upon this foundation, we'll review the necessary testing upon which your evaluations and considerations will be based.

Sample Testing Requirements

There are minimum requirements for testing necessary to safely determine and extend oil service intervals. Although the specific testing methods may vary from laboratory to laboratory certain indicators and properties must be monitored by one means or another. There may also be alternate methods within a laboratory based upon program cost considerations. Figure 1 lists the appropriate and necessary testing for engine and non-engine compartments. Additional testing for ferrous specific monitoring and fine particulate controls will not be addressed in this forum.

REQUIRED TESTING	METHODS	ENGINES	XMSN / DIFF
Spectrochemical	ICP / RDE	X	X
Fuel Dilution	FTIR / Sniffer	X	
Fuel Soot	FTIR / LEM®	X	
Insolubles / Oxidation	Blotter / FTIR		X
Water	Crackle / IR	X	X
Viscosity	Kinematic	X	X
Neutralization Number	Titration	X	X

Figure 1. Required testing for establishing lubricant serviceability.

Spectrochemical Analysis. This is the measurement of specific chemical elements within your lubricating oil. The various elements are provided to monitor wear and corrosion levels, airborne contaminants, the presence of coolant inhibitors, and oil additives to monitor for mixtures and ensure the proper lubricant is in service.

The wear metals are evaluated in relation to operating time and monitored for increases from baseline (trend analysis) for each compartment or the averages within a defined group of like equipment. This is where complete and accurate equipment and sample data is required for interpretations and analysis. We will address the information requirements a little further on in this discussion. Components that historically generate high levels of wear metals during their current drain cycles should not be considered for extended service. High levels of wear metals can be a catalyst for increased wear rates and oxidation levels. Likewise, lubricants containing silica (dirt) or coolant additives should not be considered for extended service until the source or problem has been identified and corrected.

WEAR	CONTAMINANTS	ADDITIVES
Iron	Silicon	Phosphorus
Chromium	Sodium	Zinc
Nickel	Boron	Calcium
Molybdenum	Potassium	Magnesium
Aluminum		Molybdenum
Lead		
Copper		
Tin		

Figure 2. Applications of typical spectrochemical elements.

Many equipment manufacturers (OEM's) have established guidelines and limits relative to allowable levels of wear and contaminant metals permitted for continued oil service. These can typically be found in service bulletins or specific publications. Additive levels must be compared to the levels present in your new (unused) products to ensure the proper levels are present. The levels of these additives do not typically diminish through normal operations. They will deplete or become inert through use, but this is measured by other testing methods.

Fuel Dilution. This is the measure of unburned diesel fuel present within the crankcase. Whereas fuel dilution is generally associated with defects and leaks within the fuel delivery system levels that affect lubricant serviceability can also be caused by operating modes and equipment applications. Excessive idling, stop & go services, and short-term unloaded operations can produce accumulating levels of fuel dilution that may preclude some vehicles from extended oil service consideration.

As a general rule, a five percent fuel dilution will decrease the viscosity approximately one SAE grade. Most OEM's have published lubricant serviceability limits that range from 2 to 5 percent maximum. Consistent levels of fuel dilution of 2 percent and higher should be investigated and corrected before extending oil service intervals.

Fuel Soot. Fuel soot typically accounts for approximately 98 percent of the solid contaminants in diesel engine oils. Directly or indirectly, controlling fuel soot is the foremost factor toward extending oil drains in today's engines. The generation of soot is relative to engine designs, air-to-fuel ratios, and combustion or exhaust efficiency. When not controlled by lubricant dispersants and removed by the oil filtration, soot forms gels, creating crankcase sludge and hard carbon deposits. The hard deposits that form on the upper pistons and in ring grooves can break away and, as 'carbon stone' particles, become an internal source of abrasive wear.

Soot gels are allowed to form when the oil's dispersants are "tied up" and will thicken the oil and increase the viscosity. Moisture will also tie up dispersants and diminish the oil's ability to combat soot formations. The rate of dispersant depletion cannot be plotted or predicted. It is essential to closely monitor the viscosity for increases along with accurate and absolute soot levels. In many cases extending oil drains may require additional filtration capacity, retention of current filter service intervals, or possibly selection of a different lubricant.

Most OEM's have published preferred methods and allowable limits for soot or insoluble (solids) levels. Generally, when your soot levels are typically at least 25% below the OEM maximum and viscosity is within SAE grade of the lubricant in service, extended service can be considered.

Insolubles / Oxidation. Heat and degradation by oxidation are major factors affecting the serviceability of transmission and differential lubricants. When the oil degrades, acids are formed, oxidation occurs resulting in varnish formations, and eventually the viscosity increases.

Monitoring insoluble (solids) or oxidation levels can be accomplished by various methods. Some OEM's have published preferred methods and acceptability limits. In the absence of OEM specifics, close consideration should be aligned to the viscosity and acid number test results. Oils that typically reflect high levels of solids or oxidation product should not be considered for extended service intervals.

Water: You've undoubtedly heard the expression *"it's just normal condensation"*. It may be *'typical'* condensation, but it is not *'normal'* relative to operating acceptance. When water is detected in an oil sample, the type and source of the water must be identified. The most typical sources include coolant leaks, condensate, rain, or wash-down spray. Coolant leaks can be determined by accompanying tests for glycol and identification of coolant inhibitors (metallic additives) present in the oil sample.

Water due to condensation is seldom found in diesel engine oils samples from fleet applications. Normal operating temperatures and filtration will remove slight levels of condensation. Non-engine compartments may build up accumulated moisture and preclude extending oil service if not controlled or corrected. Most OEM's have published allowable limits for water presence. A good general application of 0.2% by vol. maximum can be applied to assess oil serviceability.

Viscosity. Viscosity is the most important single property of lubricating oils and is affected by more factors than any other property. The most widely applied and accepted method for testing viscosity is the kinematic method as it conforms to ASTM D 445. Engine oils are typically measured at 100º C and compared to SAE Engine Oil viscosity grades. Non-engine oils are typically measured at 40º C and compared to ISO or SAE Gear Oil grades.

New oils are formulated to comply with acceptability within defined ranges for grade requirements. Some of these grades have wide ranges of acceptability and although 'typical viscosity' is usually projected near mid-range, actual blends and finished products could actually be near minimum or maximum for the given grade. Properly evaluating viscosity changes requires submitting samples and knowing where your new oil measures within grade.

APPLICATION	VISCOSITY DECREASES	VISCOSITY INCREASES
Engines	Fuel contamination.	Soot loading.
	Oil migration from transmission.	
Engine & Non-engines	Additive shear.	Oxidation.
	Improper oil installed or added.	Water / Glycol contamination.
		Improper oil installed or added.

Figure 3. Typical causes for viscosity changes.

Most OEM's provide serviceability limits for viscosity. Some are based upon percentage changes from the new oil and others are specific minimum and maximum measurements (cSt or mm^2/s). As a general rule, where viscosity is still within 10% of the new oil viscosity, acceptance

for safe extended service can be considered. Greater variations should be individually considered relative to the lubricant and application.

Base Number (BN). The Base Number is a measure of the remaining alkaline reserve additives. An alkaline reserve is necessary to neutralize the acids that a formed during the combustion processes, chemical changes, and reactions within the lube oil. There are several methods for determining BN and the results will vary as to the method employed. The serviceability of engine oils is governed by the level of BN depletion (reduction) from the level of your new oil. It is important that the analysis histories are from a consistent test method and that the starting reference point (new oil) is tested by the same method as the used oils.

Most of today's fleet engine oils will have BN levels in the range of 7 to11. Depletion rates are not linear and will vary relative to many factors. As a general rule, if you have at least 50% BN remaining the lubricant can be considered for extended service.

Acid Number (AN). An Acid Number is a measure of the weak, and if present, strong acids within the lube oil. The most common method for determining AN is by titration as prescribed in ASTM D 664. The serviceability of transmission and differential lubes is governed by the level of AN increase above the level of your new oil. New oils will have an initial level of weak acids present variable to the types and levels of additives present. It is essential to sample each product for baseline data.

Most OEM's recommend changing lubricants (mineral oils) when the acid number has increased by 2.0 to 2.5 above the new oil. Where AN levels have typically increased less than a 1.5 above baseline, the lubricant can be considered for extended service.

Providing Equipment Information

Providing complete and accurate component and operating information is obviously essential to the evaluation and interpretations of the individual analyses. It is also going to play a major role in your data review for fluid extensions. It is important to provide as much qualifying information as possible when filling out sample forms or equipment lists. As appropriate for your equipment, distinctions and definitions should be provided at the unit and component levels.

Unit Information. This is the overall vehicle information where you identify the manufacturer (Freightliner, International, Mack, etc.). If you have several models from one manufacturer, you may need to also include a specific model designation.

Component Information: This information is specific to the component being sampled. Identical units may have different engines or transmissions. The information should be specific as to the manufacturer and model of the sampled compartment and consistent for like equipment. The more specific the description: the easier it will be to qualify, review, and compare your data.

Operating Data: Each sample submitted must include the operating times for how long the oil has been in service and the total operating time since new or overhaul. You will not be able to extend services without an accurate record of current cycles and conditions. Total operating time may become relative if you find oil conditions change at varying points through the life of the equipment. For example: You have reviewed the data for a given engine model and application and have identified this engine has a tendency to shear multi-grade oils. As you review the data relative to age, you may find the increased oil consumption is replacing the additives and preventing the shearing. You can now qualify this application for extension once it has reached a specified age or mileage.

Sampling Intervals: Sampling intervals should be as consistent as possible, typically aligned to a service or maintenance schedule. This provides for easier trending of results and grouping data for comparison and evaluation.

Reviewing Your Data

Reviewing your analysis histories will require several considerations variable to the size and types of equipment within your fleet. This is where providing the laboratory with complete equipment and operating data as previously discussed becomes crucial. It may be easiest to export your analysis records from your oil analysis management software into a spreadsheet format for sorting and review. If you do not have your data in oil analysis management software, your laboratory should be able to provide you with a generic extraction file.

You'll first want to sort your data by equipment manufacturer, model, and possibly class, route or application (long-haul, local, stop & go, etc). The next step is to determine the percentage of analyses that were 'Normal' and qualified for service extension as discussed previously. Your oil analysis supplier may be able to assist with this step by providing you with condition summary reports generated for each specific manufacturer and model. Such a summary could provide you with (1) Total samples, (2) Number and percentage of samples by condition (normal, abnormal, critical), and (3) A breakdown of the types and counts of problems detected.

Extending Service Intervals

Fleet Intervals: Where your summary reports or data reviews reflect a high percent of 'Normal' analyses, and all properties qualify for extended service, the service intervals can be increased as deemed appropriate by fleet or defined sub-group. When extending large numbers of vehicles by fleet or class, it is generally recommended that increasing intervals be limited to 25 percent increments. In this case, oil samples should still be submitted at the original interval to check for contaminants and assure serviceability. Additional samples should be monitored at the extended intervals to assure against over-extension and provide the data for additional extensions.

Individual Vehicle Intervals: An alternative to extending entire fleets or groups is to leave the oil in service until the laboratory results indicate a drain is necessary. This may best be applied when vehicles can be readily brought in for service in reaction to analysis results. This method

may also be appropriate for smaller operations with highly mixed fleets. In this case, extension can be accomplished by submitting oil samples at the original interval and at each 50 percent increased intervals. For example, if current drain intervals are at 6,000 miles, a sample should be submitted at the 6,000 mile service and every 3,000 additional miles until the oil is changed.

Using Representative Data. In cases where you may not have analysis histories or all the required properties were not being monitored, an option would be to develop a representative 'snapshot' of conditions for each group of vehicle classifications. The minimum recommended representation would be five vehicles per group with the preferred number being 15. Baseline samples should be taken at the current standard interval and at each 25 percent increase until the laboratory results indicate the necessity to change oil.

When all the vehicles have reached the drain point for reasons other than contamination (soot, viscosity, or BN), the mileages should be recorded and averaged for each group. Set the fleet's drain interval at the shortest averaged interval from among the groups.

Cost and Benefit Calculations

The following parameters in figure 4 may be used to document current and projected costs of labor, parts, materials, legal disposal, and oil analysis, for any given oil drain interval. Actual costs and figures will need to be provided for your operations and applications. Where there are large variances in types of equipment and the associated costs, separate calculations will be required.

PARAMETER	EXAMPLE
A. Crankcase & filter oil capacity	48 qt.
B. Drain interval	15,000 mi.
C. Oil cost	$0.75 qt
D. Oil filter cost	$10 ea.
E. Disposal/recycle costs:	
- E1. Oil	$0.04 qt.
- E2. Filter	$0.65 ea.
F. Burdened labor rate	$40 hr.
G. Time required	40 min. = 0.66 hr.
H. Annual mileage utilization	100,000
I. Oil Analysis cost	$10 sample
J. Frequency of oil analysis	6 yr.

Figure 4. Formulae parameters.

Utilizing the above parameters, costs per mile can be calculated as shown in figure 5.

FORMULAE	COST per CHANGE	COST per MILE
Oil cost	A x C	/B
Filter cost	D	/B
Disposal/recycle	(E1 x A) + E2	/B
Labor	F x G	/B
Oil analysis	(I x J) / (H/B)	/B
Total	Sum All	Sum All

Figure 5. Formulae calculations.

The calculation for a 15,000 mile drain interval would be as shown in figure 6.

FORMULAE	COST per CHANGE	COST per MILE
Oil cost	A x C = $36	$0.0024
Filter cost	D = $10	$0.0007
Disposal/recycle	(E1 x A) + E2 = $2.57	$0.0002
Labor	F x G = $26.40	$0.0018
Oil analysis	(I x J) / (H/B) = $8.99	$0.0006
Total	**$83.96**	**$0.0057**

Figure 6. Formulae calculations example.

Compiling these figures for various intervals, comparing the potential cost savings to the involvement required and any associated risks, will give management assistance with their decisions and provide a means to document savings achievements. This simple format can be adjusted to include any other costs of materials (and labor) that may be extended to reflect interval savings. Such items could include air filters, by-pass filters, breathers, etc.

Summary.

In review, the recommended practices for extending oil drain intervals include:

- Ensure your oil analysis program is providing appropriate testing and your laboratory has accurate and sufficient vehicle and operating data to evaluate, group, and compare your historical data.
- Components that historically generate high levels of wear metals, or those containing silica (dirt) or coolant additives, should not be considered for extended service.
- Consistent levels of fuel dilution of 2 percent and higher should be investigated and corrected before extending oil service intervals.
- Generally, soot levels at least 25% below the OEM maximum (and viscosity is within SAE grade of the lubricant in service) extended service can be considered.
- Oils that typically reflect high levels of solids or oxidation product should not be considered for extended service intervals.
- Most OEM's have published allowable limits for water presence. A good general application of 0.2% by vol. maximum can be applied to assess oil serviceability.

- As a general rule, where viscosity is still within 10% of the new oil viscosity, acceptance for safe extended service can be considered.
- As a general rule, if you have at least 50% BN remaining the lubricant can be considered for extended service.
- As a general rule, where AN levels have typically increased less than a 1.5 above baseline, the lubricant can be considered for extended service.
- When extending large numbers of vehicles by fleet or class, it is generally recommended that increasing intervals be limited to 25 percent increments.
- When extending intervals by monitoring individual vehicles, it is generally recommended that increasing intervals be limited to 50 percent increments.

The extension of oil drain intervals can provide opportunities for true maintenance cost savings. The ease or simplicity of evaluating and implementing extension programs will vary relative to the complexity of your fleet, variations in maintenance schedules, availability of vehicles for reactive service, and overall conditions. Fleets, groups or classes of equipment should be historically achieving at least 90% normal oil analysis results at current intervals before being considered for extension unless an 'individual' monitoring and extension program is applied.

Equipment still under OEM warranty is not recommended for extended oil drains unless the practice is approved and supported by the OEM. Unauthorized extension of oils drains could negate warranty qualification. Some OEM's have authorized extension programs with defined lubricant and monitoring requirements.

Define your goals and work with your oil analysis provider to assess your current conditions and qualifications. Measure the projected savings and weight the gains against the possible risks. Be patient, keep informed through oil analysis, and enjoy successful savings.