Is This the Right Oil Lab for My Business: Considerations and Steps to Make That Determination

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Selecting an oil analysis laboratory can be a stressful process. It is important to make sure that you get the most bang for your buck, as well as ensure that your needs are met. There are several factors to consider from an economical, logistical, and scientific standpoint. Once you determine the factors that are most important to you, a sound decision can be made. This session will introduce different factors for consideration in addition to steps in choosing the best commercial laboratory for your reliability needs.

When selecting an oil laboratory, it is important to start with a list of expectations. Key expectations may include a 24 hour turn around on a sample, the format in which oil analysis data is submitted, and the general pricing of performing the sample analysis. We can start at these three points and expand out to ensure that the oil laboratories in question are meeting your needs and also delivering what they promise.

LABORATORY LOCATION AND VISITATION

Before any hardcore, determination begins it is necessary to visit the oil laboratories in question. How many locations do I have to plan for? How many locations does the oil laboratory have? Where are the oil laboratories in relation to my location or locations? The nature of your business will dictate your requirements, but be aware that sampled equipment should always be analyzed at the same laboratory on the same equipment and if possible by the same technician. If your equipment is not mobile, and is located at several locations, you may choose several laboratory locations. For example, a laboratory in Houston for a plant in Houston, or a laboratory in Dallas for a plant in Fort Worth. If your equipment is mobile, and is required to move from one location to the next over a large distance and it moves often, one laboratory for all locations may be required, for example, a backhoe in Dallas will have its samples sent to Atlanta and a loader in Kansas City will have its samples sent to Atlanta. The following month the sample backhoe and loader maybe in Jacksonville, FL and thus their samples will continue to go to Atlanta. This increases the consistency for the analysis being performed since the laboratory equipment will more than likely be calibrated the same way each time.

Once you visit the laboratory, it is important to observe what you see from a scientific stand point, and make sure you speak with the staff. Does the staff seem knowledgeable and enthusiastic about what they are doing? What are the training requirements for laboratory personnel? Are there procedures in place for preparing and performing the sample analysis? Are these procedures available at the work stations? Are calibration and quality control records readily available and current? Are sample bottles left open and exposed to the environment before testing? Is all the analysis testing done in house?

Is the laboratory clean and well maintained? If the spectrometer is held together with duct tape it is a sure bet the calibration may be off, and honestly equipment held together with duct tape does not inspire faith with regard to the maintenance being done onsite.

LABORATORY ANALYSIS SERVICES

Oil laboratories offer a variety of analyses that have different costs associated with them. The types of tests performed are related to the type of fluid being analyzed, as well as the end results the customer is looking for with regard to the needs and goals of their maintenance program. Engine oils are typically the least expensive samples to analyze when only a basic analysis is required, but if the customer wishes to extend oil drains a Total Base Number or Oxidation test may be added. The addition of this test adds to the cost of the sample. Hydraulic fluids tend to be the most expensive samples to process as they require the basic spectrographic analysis along with a particle count, water contamination, and TAN. In most cases, an oil laboratory will offer a flat rate for sample processing based on a weighted average of sample types submitted over a certain period.

WEIGHTED AVERAGE SAMPLE PRICING

A weighted average is an average that is calculated by allowing for extra weight to be given to one or more elements of a sample of data. In the case, our sample of data is the number of samples(w) and sample cost by type(x). We want the number of samples to weight the overall cost per month. If we average the cost per sample without weighting it, our cost per sample would be $12.00. Subsequently, the Overall Cost per Month based on Number of Samples would be $48,000. However, by using the formula for the following data set, we can determine that the average weighted cost per sample is $9.88 per sample, the Total Cost per Month divided by the Total Number of Samples per Month.

$$\text{Weighted Average} = \frac{w_1x_1 + w_2x_2 + w_3x_3 + w_4x_4 + w_5x_5 + \ldots + w_nx_n}{w_1 + w_2 + w_3 + w_4 + w_5 + \ldots + w_n}$$

Sample Type	# of Samples/Month	$/Sample	Cost/Month
Hydraulics	500	$18.00	$9,000.00
Gearboxes	1000	$7.00	$7,000.00
Diesel Engine	2000	$8.00	$16,000.00
Bearings	500	$15.00	$7,500.00
Total Per Month	4000		$39,500

BILLING METHODS

Laboratories have different methods for billing for their services, we will focus on the general concepts of Pre-Paid and Post-Paid billing practices where weighted average pricing is utilized.

Pre-Paid

We will define Pre-Paid as the billing method where the cost of performing a sample analysis is included in the cost of ordering the bottle. Essentially, a sample bottle that costs around $1.00 is ordered for $10.00, the other $9.00 would be the cost of burning the sample.

Post-Paid

Post-paid sampling allows for the purchase of sample bottles up front, and billing for the number samples burned on a monthly or weekly basis. Samples bottles are ordered for roughly $1.00 per bottle, and at the end of the billing increment you are billed for the number of samples burned. If 1,000 bottles are ordered for the month with only 900 samples analyzed, billing would include only those 900 samples. If the cost is $9.00 per sample, the total would be $8,100.00 plus the cost of the bottles.

Bottle Shrinkage

With both billing methods it is important to consider bottle shrinkage and determine what the in house rate of shrinkage is. Industry estimates put the average rates of bottle shrinkage between 10-15% over time. Bottle Shrinkage is the loss of sample bottles to activities other than oil sampling. It encompasses the count of sample bottles that are purchased but are never sent in for oil analysis. Bottles could be used for storing screws, bolts, nuts, or a lost box is disposed of.

The costs associated with bottle shrinkage vary based on pre-paid and post-paid sampling. With prepaid sampling, oil sample bottles cost between $10-15.00, and a lost or misappropriated bottle equals a $10-15 lost. If a company purchases 1,000 bottles per month and losses 15%, the shrinkage loss is $1,000-2,250 per month. Under post-paid sampling agreement, bottle shrinkage costs would be equivalent to $100-150 per month.

BREAKEVEN

Pre-paid sampling normally has a cheaper upfront cost which makes it look more attractive when compared to post-paid. However, bottle shrinkage problems make it necessary to look further at the pricing. The following will discuss a basic formula for comparing prepaid and post-paid pricing that will aid in determining the breakeven number of samples required on a monthly basis.

The general formulas for determining and charting the costs for the breakeven points for pre-paid and post-paid sampling cost are as follows:

Pre-Paid:

Sample Cost = N * $ * (1 + S)

Where:

N = Number of Samples

$ = Cost per Sample

S = Rate of Shrinkage (in decimal form)

Post-Paid:

Sample Cost = (N * B * (1 + S)) + (N * $)

Where:

N = Number of Samples

B = Cost per Bottle

$ = Cost per Sample

S = Rate of Shrinkage (in decimal form)

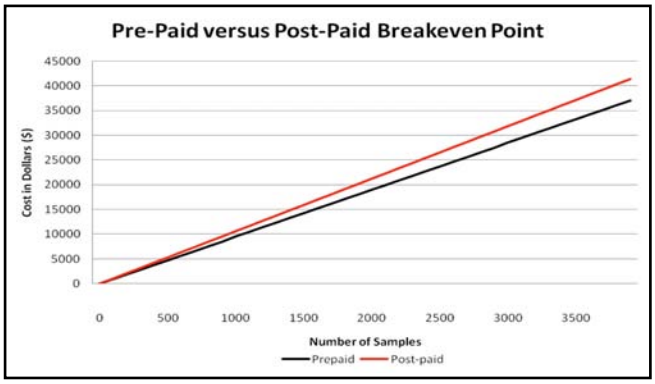

Chart 1- Pre-paid versus Post-Paid Breakeven Point where Prepaid sample cost is $8.25 and Post-paid sample cost is $9.75.

In Chart 1, the breakeven point is essentially zero. In this example, the prepaid billing would be economically beneficial based on the pricing and rate of shrinkage.

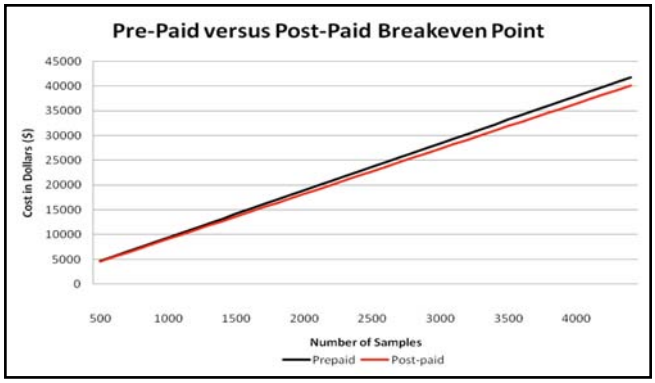

Chart 2- Pre-paid versus Post-Paid Breakeven Point where Prepaid sample cost is $8.25 and Post-paid sample cost is $8.25.

In Chart 2, the breakeven point is approximately 500 samples. If the anticipated number of monthly samples is greater than 500, then Post-paid billing would be economically beneficial. If less than 500, Pre-paid billing would be the economical choice.

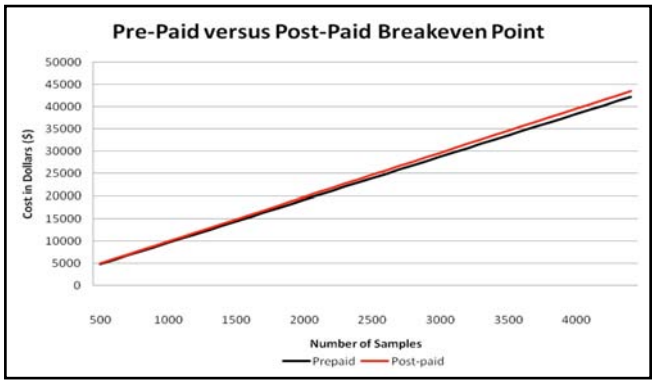

Chart 3- Pre-paid versus Post-Paid Breakeven Point where Prepaid sample cost is $8.00 and Post-paid sample cost is $9.00.

In Chart 3, the breakeven point is approximately 500 samples, as well. However, if the anticipated number of monthly samples is greater than 500, then Pre-paid billing would be economically beneficial.

The above examples were calculated utilizing fifteen percent as a rate of shrinkage. To do more accurate calculations, it is necessary to determine the in house rate of shrinkage associated with your business. Calculating rate of shrinkage can be done at a basic level by counting the sample inventory at the beginning of the month and the inventory at the end of the month. Sample bottles purchased during the month must be accounted for, as well as the number of samples that are analyzed for the month. Sample bottles that are not accounted for are used to calculate the shrinkage rate.

Example-Rate of Shrinkage Calculation

Inventory Count	
Beginning (ICB)	1000
Ending (ICE)	900
Bottles Purchased (BP)	500
Samples Burned (SP)	500
Calculated Inventory (CI)	
= (ICB-ICE) + BP	
= (1000-900) + 500	
= 600	

Bottles Unaccounted For (BU)
= (ICB – ICE) + BP – SB
= (1000 – 900) + 500 – 500
= 100
Rate of Shrinkage
= BU / CI
=100 / 600
= 0.166667 or 16.7 %

Increasing the period of time for calculating the rate of shrinkage will increase the accuracy of an overall rate of shrinkage as one month may have a lower number of samples analyzed and bottles purchased compared to the next month which may have unusually higher numbers.

SHIPPING EXPENSES

Similar to oil sampling analysis expenses, shipping expenses have pre-paid and post-paid billing practices. In addition, shipping expenses have an additional dimension: multiple or single return shipping. The number of samples pulled per day will dictate whether shipping should be priced for multiple or single packaging. If one sample is pulled per day, then single packaging should be utilized. Under no circumstance should samples be collected over days or weeks for multiple sample shipping. After all, oil analysis results should be available as soon as possible. Delaying the results renders them outdated and useless.

Establishing a shipping time is critical when choosing a laboratory. Dealing with a shipping company adds a new dimension to consider and quoted shipping time can be misleading. Your location versus the oil laboratory location will affect shipping time for each shipping company to a different degree. Additional factors that affect shipping time include the day of the week the item is shipped, the time of day items are picked up, and the size of the package. To determine an effectual shipping time, test the proposed shipping companies whether it is the United States Postal Service or Federal Express.

To begin the shipping time determination, package up samples for shipping that are neither urgent nor necessary. It is helpful to pull several of the same samples for this purpose which will be discussed later. The samples should be packaged appropriately for shipping whether using laboratory provided shipping materials or in house materials. However, be sure to utilize materials that will become the standard once a laboratory and shipping method is selected. The more samples used for the experiment that more accurate the shipping time.

Sample ID	Day of Week Sent	Date/Time Sent	Day of Week Received	Date/Time Received	Days Elapsed
1	Monday	2/4/08-8:00am	Tuesday	2/5/08-12:00pm	1 day (28 hrs)
2	Monday	2/4/08-1:00pm	Wednesday	2/6/08-12:00pm	2 days (47 hrs)
3	Tuesday	2/5/08-10:00am	Thursday	2/7/08-8:00am	2 days (46 hrs)
4	Tuesday	2/5/08-3:00pm	Friday	2/8/08-8:00am	3 days (65 hrs)
5	Wednesday	2/6/08-9:00am	Monday	2/11/08-8:00am	4 days (95 hrs)
6	Wednesday	2/6/08-2:00pm	Monday	2/11/08-8:00am	4 days (90 hrs)
7	Thursday	2/7/08-8:00am	Friday	2/8/08-12:00pm	1 day (28 hrs)
8	Thursday	2/7/08-12:00pm	Friday	2/8/08-12:00pm	1 day (24 hrs)
9	Friday	2/8/08-11:00am	Tuesday	2/12/08-12:00pm	3 days (71 hrs)
10	Friday	2/8/08-3:00pm	Tuesday	2/12/08-12:00pm	3 days (68 hrs)

Once samples are pulled and packaged for shipping, it is important to document what is shipped out and when. Samples should be sent out at various times of the day over a span of several days. The dates should be compared with the date and time the oil laboratory records receiving them.

Based on the above documentation, it is determined that the average shipping time to this oil laboratory is 2.4 days, or 56.2 hours. For time frames that include a Sunday, the Sunday is not included as most shipping companies do not deliver on Sundays.

Once the samples are received for processing, the oil laboratories turn-around time can be measured to verify their proposed turn-around times. The laboratory turn-around time is based on the time the oil laboratory receives the sample and the time the customer is sent the analysis results.

Sample ID	Day of Week Received	Date/Time Received	Day of Week Results Available	Date/Time Results Available	Days Elapsed
1	Tuesday	2/5/08-12:00pm	Wednesday	2/6/08-4:00pm	1 day (28 hrs)
2	Wednesday	2/6/08-12:00pm	Thursday	2/7/08-12:00pm	1 day (24 hrs)
3	Thursday	2/7/08-8:00am	Thursday	2/7/08-4:00pm	1 day (8 hrs)
4	Friday	2/8/08-8:00am	Friday	2/8/08-4:00pm	1 day (8 hrs)
5	Monday	2/11/08-8:00am	Monday	2/11/08-4:00pm	1 day (8 hrs)
6	Monday	2/11/08-8:00am	Tuesday	2/12/08-12:00pm	1 day (28 hrs)
7	Friday	2/8/08-12:00pm	Monday	2/11/08-4:00pm	1 day (28 hrs)
8	Friday	2/8/08-12:00pm	Monday	2/11/08-12:00pm	1 day (24 hrs)
9	Tuesday	2/12/08-12:00pm	Thursday	2/14/08-4:00pm	2 days (52 hrs)
10	Tuesday	2/12/08-12:00pm	Thursday	2/14/08-4:00pm	2 days (52 hrs)

The Days elapsed are calculated on the assumption that the oil laboratory does not run a weekend shift. When comparing across the board with laboratories that do have a weekend shift, including that time on the non-weekend shift laboratory maybe helpful.

Based on the data available, this oil laboratory has an average 1.2 day, or 26 hour, turn-around time frame. Using the information that has been gathered for shipping time and laboratory turn-around time, overall turn-around time from the ship date to the analysis received date can be determined. This is done simply by subtracting the date results are available from the date the sample was sent.

Sample ID	Day of Week Sent	Date/Time Sent	Day of Week Results Available	Date/Time Results Available	Days Elapsed
1	Monday	2/4/08-8:00am	Wednesday	2/6/08-4:00pm	2 days (56 hrs)
2	Monday	2/4/08-1:00pm	Thursday	2/7/08-12:00pm	3 days (71 hrs)
3	Tuesday	2/5/08-10:00am	Thursday	2/7/08-4:00pm	2 days (54 hrs)
4	Tuesday	2/5/08-3:00pm	Friday	2/8/08-4:00pm	3 days (73 hrs)
5	Wednesday	2/6/08-9:00am	Monday	2/11/08-4:00pm	5 days (127 hrs)
6	Wednesday	2/6/08-2:00pm	Tuesday	2/12/08-12:00pm	6 days (142 hrs)
7	Thursday	2/7/08-8:00am	Monday	2/11/08-4:00pm	4 days (104 hrs)
8	Thursday	2/7/08-12:00pm	Monday	2/11/08-12:00pm	4 days (96 hrs)
9	Friday	2/8/08-11:00am	Thursday	2/14/08-4:00pm	6 days (149 hrs)
10	Friday	2/8/08-3:00pm	Thursday	2/14/08-4:00pm	6 days (145 hrs)

With these ten samples, it is calculated that the average turn-around time from ship date to analysis results received is 4.1 days, or 101.7 hours. This type of test should be done for each proposed laboratory.

Timing is everything, but how are the oil analysis results presented? Easy to understand reports enhance the turn-around time. If reports are difficult to understand or are not structured well, turn-around time will essentially increase. If it takes hours or days to make sense of the report, then the data is not available for use when it arrives from the laboratory. Who decides if the report is well structured and easy to understand? The person who will be reading them on a regular basis, and making decisions based on the reports.

It is important to determine the end use of the oil analysis reports, and honest evaluation needs to be done. Will the report be read? Will it be read once and a maintenance decision made? Will the report information be used later for more advanced maintenance calculations? Does the information need to be in an electronic format? Will the data need to be in a format that can be modified or exported into other software for further manipulation? Reporting methods run the gamut between faxed copies, emailed .pdf files, and internet accessible databases. A laboratory that provides flexible data reporting that can be extracted and used in other software would be ideal regardless of current practices for handling oil analysis data. As a maintenance program evolves, a flexible history of data can be modified and evolved as well.

Once the results are available, how do they compare? When you submit samples for the turn-around time calculation, these samples should be a variety of sample types. If you send in twenty samples, have five of the samples be hydraulic fluids, which require particle count, have five of the samples be engine oil, which requires flash point testing and total base number, etc. The purpose of mixing up the fluid types is to ensure that all possible testing is performed for review. Reviewing the results among the different laboratories provides insight into the ability to repeat results, a look at which laboratories provide results within a standard deviation and which provide outlier results. It is essential to understand that this is a small number of samples to make concrete scientific decisions on, but will provide a guide for where the laboratory stands with comparison to others that are being considered.

Laboratories normally participate in sample testing that is sometimes referred to as a "round robin." The purpose is to ensure that their techniques and results are in line with other laboratories, as well as ensuring results are accurate. It is possible for all participating laboratories to have similar results that are considered repeatable; however, repeatable does not equal accurate. "Round robins" fall into two different categories that evaluate the laboratory's ability to perform specific analysis or perform a range of analyses competently. These two categories can be broken down into subcategories that relate to the sample utilized for testing. Samples are described as:

1. Randomly selected subsamples from a bulk homogenous supply of material are distributed simultaneously to participating laboratories.[1]
2. Samples of a product or material are divided into two or more parts with each participating laboratory testing a subsample of each part. Referred to as "split sample" testing.[1]
3. Sample to be tested is circulated successively from one laboratory to the next. Samples may be returned to a central laboratory before being passed on to the next testing laboratory in order to determine whether any changes to the sample have taken place.[1]

Of these three subcategories, randomly selected subsamples are most common. Each type of testing has items to consider with how it affects the overall results. For your purposes, the randomly selected subsamples are recommended.

Comparing results among laboratories and within the laboratory follows similar procedures for calculating a mean and standard deviation. Because accurate results are not available, utilizing a standard deviation that is calculated in house is an acceptable practice. The following table displays a partial list of spectrometric results from three different laboratories for a randomly selected sample. The standard deviation is calculated for roughly a twenty-five percent.

Element	Lab 1	Lab 2	Lab 3	Average	Lower Limit	Upper Limit
Iron	5	***10***	6	7	5	9
Lead	***9***	5	5	6	5	8
Tin	***10***	1	0	4	0	8

According to the above data, we can determine that Laboratory 1 has results for two elements that fall outside of the standard deviation. It was later determined that this laboratory reported higher results for these two elements across the board. From this example, Laboratory 1 may be discounted as an appropriate laboratory.

Following the same format, we will look at the same sample repeated at the same laboratory. For this example, we will use Laboratory 2. Using a smaller standard deviation is critical when calculating the laboratory's ability to repeat its own results. The standard deviation will need to be static between different elements. By having a fluctuating standard deviation percentage, the percentage can be adjusted to reflect the amounts being measured. Additives tend to register higher amounts, sometimes in the hundreds or thousands parts per million, whereas wear metals tend to be under 100 parts per million barring any mechanical failures.

Element	Sample 1	Sample 2	Sample 3	Average	Lower Limit	Upper Limit
Iron	5	***70***	16	30	27	33
Lead	9	15	12	12	9	15
Tin	10	***7***	10	9	8	10

Based on the information reported, Sample 2 has an iron level that may be questionable when compared with Sample 1 and Sample 2. Otherwise, the samples fall into a fairly repeated pattern, but close attention should be paid to other tests and element results for any additional repeatability issues.

SUMMING IT UP

When choosing an oil analysis laboratory to handle your analysis needs, performing an in house assessment of each laboratory establishes a scientific view of the services provided. Assessing a laboratory begins with selecting and visiting a location and developing a test slate, followed by an evaluation of pricing structure in correlation to the amount and type of anticipated samples. Monitoring sample bottle inventory for accurate shrinkage percentage should be taken into account for establishing a breakeven point for prepaid and post-paid billing methods. The average number of samples collected per day provides a guideline for shipping methods. Once a shipping method (single or bulk) is confirmed, prepaid and post-paid is determined.

Once economic factors are evaluated, the logistical concerns should be appraised. By utilizing a set of randomly selected duplicated samples, shipping time, laboratory time, and overall turn-around time is determined. When results are returned, precision, accuracy, and repeatability are evaluated based on desired results.

Bibliography

Prichard, F. Elizabeth, et al. Quality in the Analytical Chemistry Laboratory. West Sussex: John Wiley & Sons Ltd., 1995.