Sampling Methods for Used Oil Analysis©

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Sampling is arguably the most important step in the oil analysis process. If the sample in the bottle fails to effectively represent the lubricant and the condition of the machine from which it was drawn, no meaningful conclusions can be from the oil analysis data. This article presents a comprehensive methodology for designing the sampling system and for obtaining a sample from equipment commonly found in the industrial or fleet environment. Useful hints and tips are provided to ensure that oil analysis is on-target to meet the expectations of the condition monitoring organization in pursuit of optimized asset reliability.

KEY WORDS

Oil Analysis; Machine Condition Monitoring; Reliability; Particles; Contamination Monitoring; Wear Debris Analysis; Sampling Valve; Sampling Bottle; Sampling Location; Sampling Procedure

INTRODUCTION

Oil sampling is the most critical aspect of oil analysis. Failure to obtain a representative sample impairs all further oil analysis efforts. There are two primary goals in obtaining a representative oil sample.

Maximize Data Density

Simply stated, samples should be taken in such a way that there is the most information per milliliter of oil possible. This information relates to such criteria as cleanliness and dryness of the oil, depletion of additives, and the presence of wear particles being generated by the machine.

Minimize Data Disturbance

Samples should be extracted in such a way that the concentration of information is uniform, consistent and representative. It is important to make sure that the sample does not become contaminated during the sampling process. This can distort and disturb the data, making it difficult to distinguish what was originally in the oil from what has come into the oil during the sampling process.

To ensure good data density and minimum data disturbance in oil sampling, one should consider the following factors, each of which is discussed in detail later in the chapter:

Sampling Location

Not all locations in the machine will produce the same data. Some are far richer in information than others. Some machines require multiple sampling locations to answer specific questions related to the machine's condition, usually on an exception basis.

Sampling Procedure

The procedure by which a sample is drawn is critical to the success of oil analysis. Sampling procedures should be documented and followed uniformly by all members of the oil analysis team. This ensures consistency in oil analysis data and helps to institutionalize oil analysis within the organization. It also provides a recipe for success to new members of the team.

of sliding track of the eutectic Al-Si alloy plane with time are shown in Fig. 8. It is confirmed that the wear amount of Al-Si alloy was larger in nitrogen than in HFC134a, although the reduction in viscosity hardly occurred in nitrogen unlike in HFC134a because nitrogen has poor mutual solubility with PAG. The fluoride formed on Al-Si alloy was credited with the ability to prevent wear.

CONCLUSIONS

The influence of lubricants on wear of aluminum-silicon alloy was investigated under a reciprocating sliding condition in alternative refrigerant HFC134a. The results of this investigation are as follows:

1. With a eutectic Al-Si alloy, whose microstructure consisted of uniform distributed small silicon particles of about 5 μm in diameter in an aluminum matrix and for polar lubricants of PAG and POE, adhesion between the Al-Si alloy and the mated steel ball occurred. Consequently, transfer of the Al-Si alloy to the steel ball was promoted. In contrast, with a hypereutectic Al-Si alloy containing large silicon particles of about 30 μm, the Al-Si alloy subjected the mated steel ball to abrasive wear.
2. The extent of the adhesion and the formation of deposits of the Al-Si alloy on the mated steel ball were considerably low with nonpolar mineral oils compared to polar oils.
3. In HFC134a fluorides were formed on Al-Si alloy surfaces. The fluorides had an ability to prevent wear.

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Sampling Device

The hardware used to extract the sample should not disturb sample quality. It should be easy to use, clean, rugged and cost-effective.

Sample Bottle

The type of bottle and cleanliness of bottle both help assure that a representative sample is achieved.

It is always advised to spend the time and money to make sure machinery is properly fit with the sampling hardware to ensure these goals in oil sampling are achieved.

Sampling Locations on System Returns

There are several rules for properly locating oil sampling ports on circulating systems. These rules cannot always be precisely followed because of various constraints in the machine's design, application, and plant environment. However, the importance of proper oil sampling cannot be overstated as a priority in oil analysis. As closely as possible follow the several rules outlined below. These rules will be expanded and further discussed later in this section.

Turbulence

The best sampling locations are highly turbulent. This means that the oil is not flowing in a straight line but is turning and rolling in the pipe. Sampling valves located at right angles to the flow path in long straight sections of pipe can result in "particle fly-by". Basically, this leads to a substantial reduction of the particle concentration entering the sample bottle. This can be avoided by locating sampling valves at elbows and sharp bends in the flow line.

Ingression Points

Where possible, locate sampling ports downstream of the components that wear and ingress particles and moisture. These return lines and drain lines heading back to tank offer the most representative levels of wear debris and contaminants. Once the fluid reaches the tank, the information becomes diluted.

Filtration

Filters and separators are contaminant removers, therefore they can remove valuable data from the oil sample. Always locate sampling valves upstream of filters, separators, dehydrators, and settling tanks unless the performance of the filter is being specifically evaluated.

Drain Lines

In drain lines where fluids are mixed with air, locate sampling valves where oil will travel and collect. On horizontal piping this will be on the underside of the pipe. Sometimes oil traps must be installed, like a goose-neck, to concentrate the oil in the area of the sampling port.

Look first at circulating systems where there are specific return lines or drain lines back to a reservoir. These systems include pressurized returns and drains such as those in hydraulic systems or forced circulating lubrication systems where there is a scavenger pump returning the oil back to the tank. There are also drain-line applications where the oil returns to the tank by the force of gravity. Sometimes these drains are vented like those commonly seen on steam turbines, paper machines, etc.

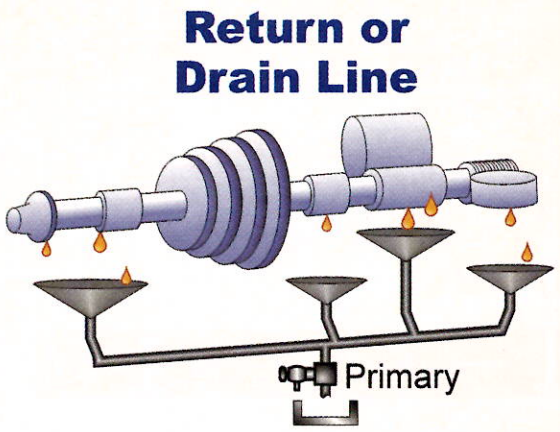

Fig. 1.

In the case of the circulating system, the ideal location for sampling is on the drain and return lines (see Fig. 1). They allow you to catch a sample of the oil before it returns to the tank and always before the oil goes through a filter. If the oil is permitted to return to the tank, then the information in the sample becomes diluted, potentially by thousands of gallons of fluid in large lubricating and hydraulic systems. Return line sampling helps identify active debris generation while debris in the reservoir tends to accumulate over weeks and months and may not accurately represent the current condition of the machine.

Figure 2 is an example of a large lubrication system with oil being supplied to a set of bearings. The oil flows down from these bearings by gravity through a manifold or header, then back to tank. Here, a number of optional sampling locations are identified. Some locations are labeled with an "S" meaning they are secondary sampling locations.

The primary sampling location, labeled "P" is on the header of this drain line just before the oil is returned to the tank. By sampling at this location many potential problems can be detected. For example, if the bearings are experiencing abnormal wear, or if there are high levels of moisture, particles, process debris or chemicals being pulled into the oil from seals or vents, you will get an indication of this from the drain-line sampling port. Likewise, you can verify that the oil meets the required levels of cleanliness and dryness. It also verifies that the viscosity and all other physical properties of the oil are within the target range. This is considered the primary sampling location because it is representative of the oil that is being delivered to the bearings and also picks up any debris that the bearings might be adding to the oil.

When an abnormal machine condition is detected from the primary sampling point, the next step is usually to sample from secondary points to isolate the problem. In this case, on Fig. 2, there is 32 ppm represented at the primary sampling point (for this example, assume that this number represents the amount of iron in the oil). This high reading leads you to use the secondary sampling points to identify the source of the increased iron concentration. In this example 17 ppm is being generated in

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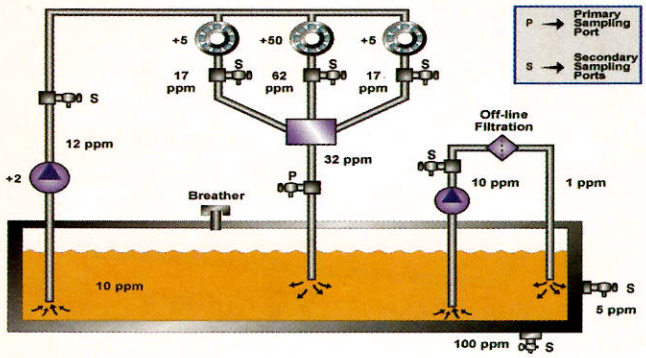


Fig. 2.

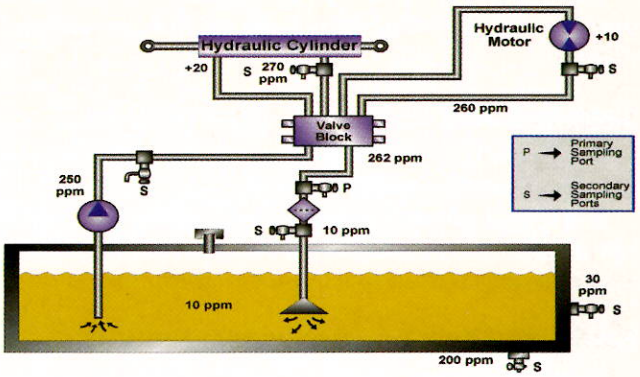


Fig. 3.

each of the outside bearings while the center bearing is producing 62 ppm. The supply fluid of this system shows just 12 ppm. It is obvious in this example that the middle bearing is producing the wear debris. Diagnostic efforts can now be focused upon that component.

In this example, had the authors relied entirely upon oil sampled from the tank, the authors would have observed only 10 ppm because of dilution by the large volume of oil, particle settling and the presence of the off-line filter that removes much of wear debris from the oil. Likewise, if we were to sample the bottom of the tank we would see a very high concentration of sludge and water and, in this case, there is a 100 ppm of iron. This, of course, is historic information and probably has nothing to do with the current condition of the bearings.

In summary, the drain-line provides the primary sampling point. If there is an abnormal reading or an over-limit alarm, samples should be taken from the individual bearing drains. A sample on the supply fluid should also be obtained. By comparing these samples, a good estimation of what the problem is and from where it is being generated can be determined.

Figure 3 illustrates a hydraulic system with fluid that is pressurized on all the lines. Again the primary sampling location is the return line. But, in this case, because there is a return line filter, the primary sample should be taken just upstream of this filter. If the filter is doing its job, it is a data remover. If a sample is taken on the downstream side of the filter, the filter can capture critical information about the condition of the machine before it has a chance to reach the sample bottle. If the filter itself is a problem, and is in bypass, or has collapsed, or is defective, the sample upstream of the filter will ultimately be contaminated just like the sample on the downstream side.

In this case, the sampling port on the return line upstream of the filter is showing 262 ppm of wear metal or contaminant. If a sample is taken at both of the secondary locations it is seen that there is 260 ppm coming downstream of the hydraulic motor and 270 ppm coming downstream of the cylinder. This suggests that the material entering the fluid is shared by both of these two actuators. By following the flow upstream and sampling downstream of the pump, it is clear that the 250 ppm is coming from the pump. This means that there is either a problem with the pump, or that dirty oil is being supplied to the pump from the tank. A sample drawn from the tank reveals the low reading of 10 ppm confirming that the pump is the problem. With the problem localized, diagnostic and corrective actions can now be focused entirely upon the hydraulic pump.

Live Zone Sampling From Circulating Systems

When a sample is taken from a line in a circulating system it is referred to as a live zone sample. There are things that can be done during the sampling process that improve the quality and effectiveness of the live zone sample. The following is a summary of do's and don'ts.

Do

Sample from the system's turbulent zones where the fluid is moving and the oil is well mixed.

Sample downstream of the equipment after it has completed its primary functions such as lubricating a bearing or a gear or has passed through a hydraulic pump or actuator.

Sample systems during typical working conditions, on the run, and under normal applications. Try not to sample after an oil change, filter change or at some time when the fluid wouldn't represent typical conditions.

Where required, employ secondary sampling locations to localize problems.

Don't

Sample from dead pipe legs, hose ends, and standing pipes where the fluid isn't moving or circulating.

Sample after filters or separators.

Sample when the machine is cold and hasn't been operating or has been idling.

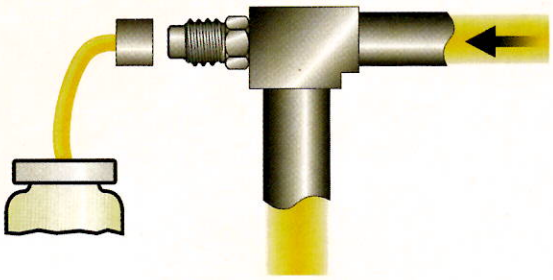
Sample from laminar flow zones (lack of fluid turbulence). The best way to insure the fluids are turbulent and mixed during the sampling process is to sample from elbows instead of straight lengths of pipe (see Fig. 4).

Sampling from Pressurized Lines

When samples need to be taken from pressurized feed lines leading to bearings, gears, compressors, pistons, etc. the sampling method is somewhat simplified. Figure 5 shows four different configurations.

Portable High-Pressure Tap Sampling

The upper most configuration on Fig. 5 is a high pressure zone where a ball valve or needle valve is installed and the outlet is fitted with a piece of stainless steel helical tubing. The purpose of the tubing is to reduce the pressure of the fluid to a safe level before it enters the sampling bottle.



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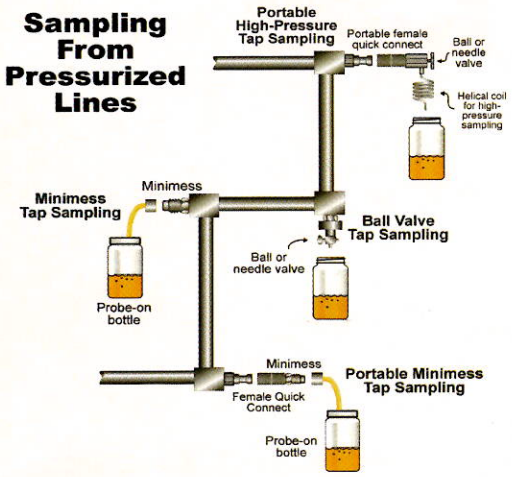

Fig. 5.

Minimess Tap Sampling

This alternative requires that a minimess valve be installed, preferably on an elbow. The sampling bottle has a tube fitted with a probe protruding from its cap. The probe attaches to the minimess port allowing the oil to flow into the bottle. There is a vent hole on the cap of the sample bottle so that when the fluid enters the bottle the air can expel or exhaust from the vent hole. This particular sampling method requires lower pressures (less than 500 psi) for safety.

Ball Valve Tap Sampling

This configuration requires the installation of a ball valve on an elbow. When sampling, the valve should be opened and adequately flushed. Extra flushing is required if the exit extension from the valve is uncapped. Once flushed, the sampling bottle's cap is removed and a sample is collected from the flow stream before closing the valve. Care should be taken when removing the bottle cap to avoid the entry of contamination. This technique is not suitable for high pressure applications.

Portable Minimess Tap Sampling

This option requires installing a minimess onto the female half of a standard quick-connect coupling. This assembly is portable. The male half of a quick-connect is permanently fitted to the pressure line of the machine at the desired sampling location. To sample, the portable female half of the quick-connect is snapped onto the male piece affixed to the machine. To sample, the bottle's probe tip is pressed onto the minimess valve to induce fluid flow into the bottle. In many cases these male quick-connect couplings are preexisting on the equipment. A helical coil, previously described, on high pressure lines should always be used.

Fig. 6.

Figure 6 shows a minimess valve installed on hydraulic machinery. This valve is properly equipped with a dust cover so that the internal opening of the sampling port is protected from debris. The cap, when fitted with an o-ring also serves as a secondary seal in the unlikely event the minimess valve should fail.

Sampling From Low Pressure Circulating Lines

Occasionally a drain line, feed line, or return line is not sufficiently pressurized to take a sample. In such cases sampling requires assistance from a vacuum pump equipped with a special adapter allowing it to attach momentarily to a valve, such as a minimess valve, commonly used in sampling. A minimess valve has a mechanical check that is actuated by a probe. With the adapter threaded onto the minimess valve, fluid can be drawn by vacuum into the bottle (see Fig. 7).

Sampling Wet-Sumps

Frequently, there are applications where a drain line or a return line can't be accessed or no such line exists. Basically these are wet sump applications where the sump within the casing serves as the reservoir. Examples of wet sump systems include: diesel engines; circulating gearboxes; circulating compressors.

In these applications, because there is no return line, fluid must be sampled from the pressurized supply line leading to the gearing and the bearings (see Fig. 8). The sample should be collected before the filter, if one exists.

The best place to sample engine crankcase oil is just before the filter (see Fig. 9). Install the sampling valve between the pump and filter. This sample location is highly preferred over sampling from a drain port or using a vacuum pump and tube inserted down the dipstick port.

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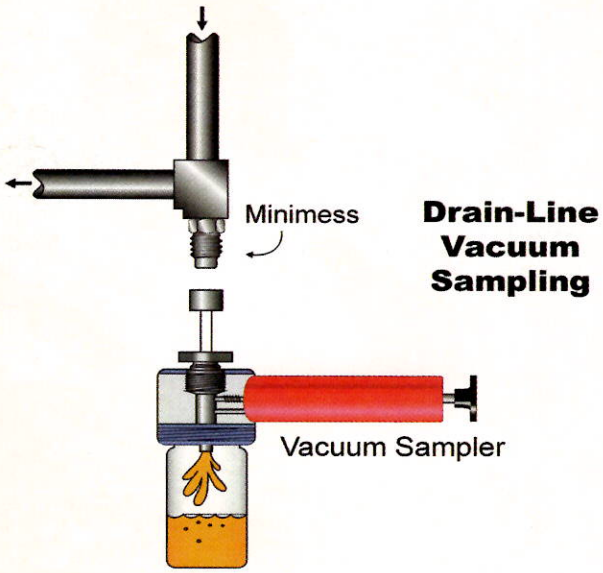

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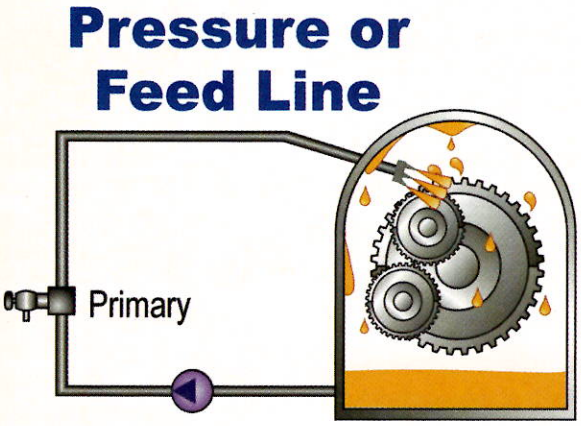

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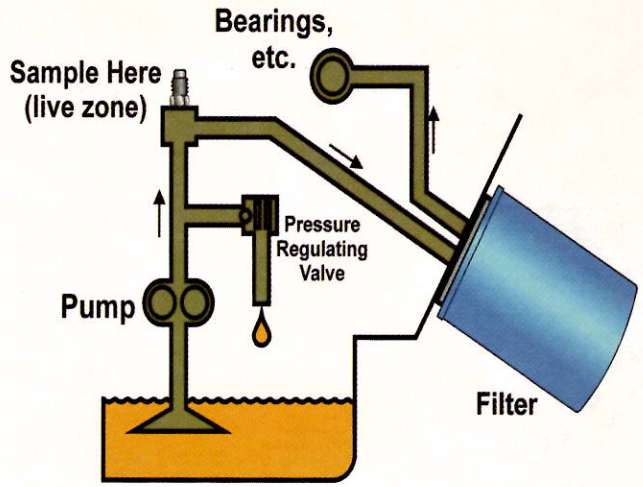

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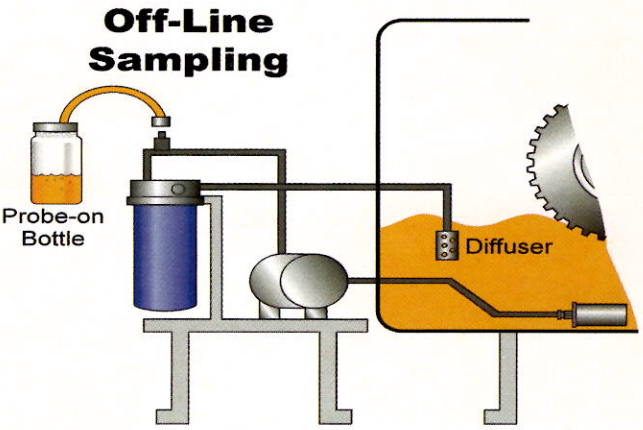


Fig. 10.

Another example of a wet sump involving circulation is shown in Fig. 10 where there is a side loop that is often referred to as a kidney loop filter. This off-line circulating system provides an ideal location to install a sampling valve between the pump and filter. A ball valve or a minimess valve can be used so that the fluid under pressure flows easily into the sample bottle without disturbing the operating system or filtration system.

Sampling Non-Circulating Systems

There are numerous examples where no forced circulation is provided and a sample must be taken from a system's sump or casing. This often must be done with "in-service" equipment on the run. Ring or collar bath-lubricated bearings and splash lubricated gearboxes are common examples of these systems. All of these situations increase the challenge of obtaining a representative sample.

The most basic method for sampling such sumps is to remove the drain plug from the bottom of the sump allowing an amount of fluid to flow into the sample bottle. For many reasons this is not an ideal sampling method or location. Most important is the fact that bottom sediment, debris and particles (including water) enter the bottle in concentrations that are not representative of what is experienced near or around where the oil lubricates the machine. The drain plug sampling method should be avoided if at all possible.

Drain port sampling can be greatly improved by using a short length of tubing, extending inward and up into the active moving zone of the sump (see Fig. 11). This ball valve and tube assembly can, in many cases, be threaded into the drain port and can be easily removed to facilitate draining of the oil.

A third option is called drain port vacuum sampling. With this method a minimess valve is installed as previously described, but instead of fluid passing into a sample bottle by gravity, it is assisted by a vacuum sampler (see Fig. 12). This is particularly helpful where the oil is viscous and difficult to sample through a narrow tube. During the sampling process the connector on the end of the plastic tube of the vacuum pump is threaded onto the minimess valve. Vacuum is produced by the pump pulling oil downward from the case into the sample bottle.

Still another method for sampling a gearbox or bearing housing is to use a portable oil circulating system such as a filter cart. In this case the filter cart is attached to the sump (see Fig.

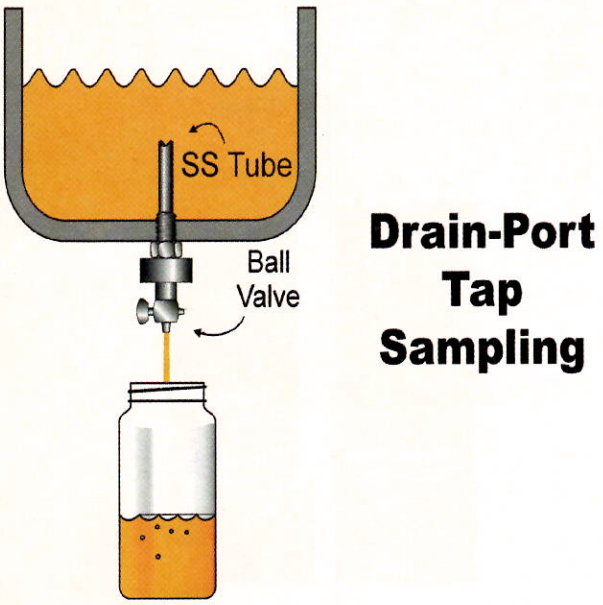


Fig. 11.

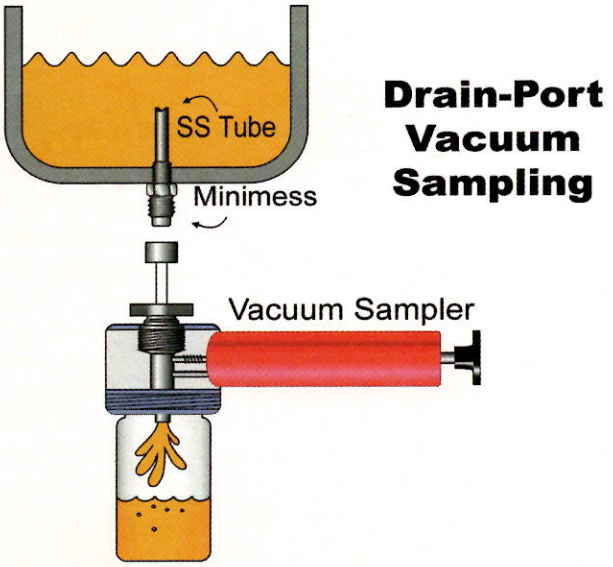
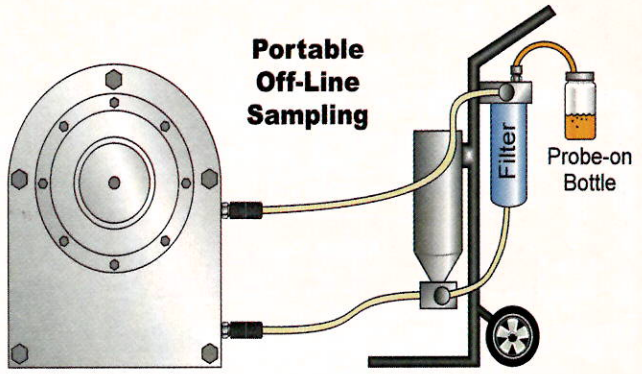


Fig. 12.

13). Here the cart circulates the fluid off the bottom of the sump and back into the sump. In order to keep from cleaning the oil before sampling, the filters must be by-passed using a directional valve. Allow the fluid to become homogenous by circulating the fluid for about 5 to 15 minutes, depending on the size of the unit, the amount of fluid in the unit, and the flow rate of the filter cart. Once sufficient mixing has occurred, a sample can be taken from the sampling valve (installed between the pump and the filter). With the sample drawn, the filters can be engaged to clean the fluid.

Drop-Tube Vacuum Sampling

One of the most common methods for sampling a bath or splash-lubricated wet sump is to use the drop-tube vacuum



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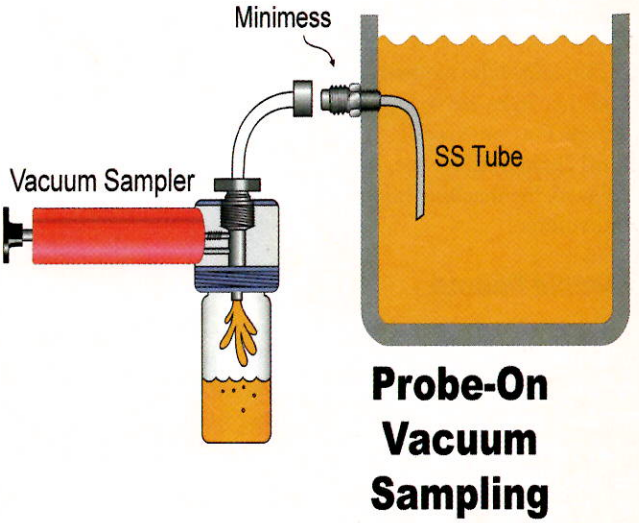

Fig. 14.

sample method. A tube is inserted through a fill port or dip stick port and lowered into the sump cavity—usually about midway into the oil level (see Fig. 14). This sampling method has a number of drawbacks and should be avoided if other sampling methods, as previously described, can be used instead. Below is a summary of the risks and problems associated with drop-tube vacuum sampling.

Tube Location

A tube that is directed into the fill or dipstick port is extremely difficult to control. The tube's final resting-place is hard to predict, resulting in samples being taken from different locations each time. There is always a risk of the tube actually going all the way to the bottom of the sump where debris and sediment is picked up.

Drop Tube Contamination

There is considerable concern that the tube will scoop up debris from the sides of the casing as it is being inserted. Also, the tube itself may be contaminated due to poor cleanliness control when it was produced or while it was stored.

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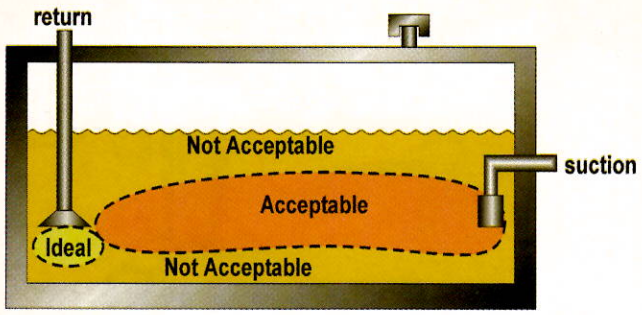

Fig. 15.

Large Flush Volume

The drop-tube method substantially increases the volume of fluid that must be flushed in order to obtain a representative sample. For some small sump systems this practically results in an oil change. Likewise, if the removed volume of fluid is not replaced, the machine might be restarted with inadequate lubricant volume.

Particle Fallout

For most systems, a shutdown is required to deploy the drop-tube method. This means that production must be disturbed for the sake of oil sampling, or sampling frequency must suffer because of production priorities. Neither situation is ideal. Likewise, particles begin to settle and stratify according to size and density immediately upon shutdown, compromising the quality of oil analysis.

Machine Intrusion

The drop-tube method is intrusive. The machine must be entered to draw a sample. This intrusion introduces the risk of contamination, and there is always the concern that the machine might not be properly restored to run-ready condition before start-up.

Whenever drop-tube sampling is used it should be considered a sampling method of last resort. However, there are situations where no other practical method of sampling is available.

In the case where drop tube vacuum sampling must be used on circulating systems, the best location to get the sample is between the return line and the suction line (Fig. 15). This is known as the short circuit. Even in cases where there is baffling in the tank, the sample needs to be taken from the most direct flow zone between this return line and suction line. And, ideally this will be as close to the return port as possible. If there is baffling, it should be on the return side of the baffle.

In order to insure that the plastic tube is lowered to the same place each time, it can be fitted with a weight, attached to the end of the tube, where a specific length of tube is lowered into the tank. An easier way is to attach the tube to a metal or plastic rod using wire or twist-ties (Fig. 16). Then, measure a stand-off on the bottom of the rod so that the rod is lowered to the tank floor and the end of the tube is a fixed distance above. This "measured stand off" is to be consistently used each time a sample is taken.

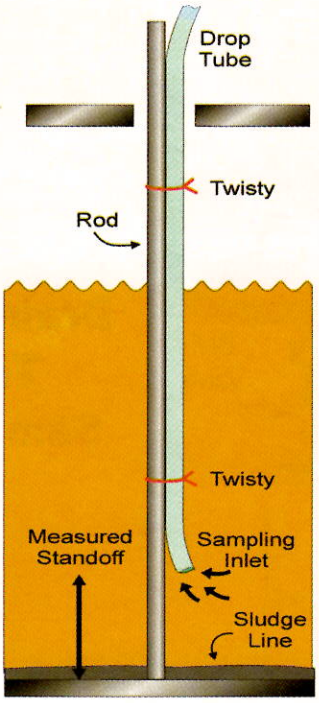

Fig. 16.

Sampling Bottles and Hardware

An important factor in obtaining a representative sample is to make sure the sampling hardware is completely flushed prior to obtaining the sample. This is usually accomplished using a spare bottle to catch the purged fluid. It is important to flush 5-10 times the dead space volume before obtaining the sample. All hardware that the oil comes into contact with is considered dead space and must be flushed, including: system dead-legs; sampling ports, valves and adapters; probe on sampling devices; adapters for using vacuum sample extraction pumps; plastic tubing used for vacuum pumps (this tubing should not be reused to avoid cross contamination between oils)

There is an assortment of sampling bottles that are commonly used in oil analysis. An appropriate bottle needs to be selected for the application and the test that is planned. Consider the following features when selecting sample bottles.

Size

There are a number of different sizes of sample bottles that are available. They vary from 50 ml (or about two ounces of fluid) to a more common 100 to 120 ml bottle. The larger bottle is preferred when tests such as particle count and viscosity analysis are required. Where a considerable number of different tests are required a 200 ml bottle (or two 100 ml bottles) may be required. Coordinate with the laboratory to select the bottle size that will provide a sufficient volume to conduct all the required tests and leave some extra for storage in case a re-run is necessary. Another consideration in selecting the bottle size is that the entire volume of the bottle should not be filled with fluid during the sampling process. Only a portion of the sample bottle should be filled. The unfilled portion, called the ullage, is needed to allow proper fluid agitation by the laboratory to restore even distribution of suspended particles and water in the sample.

Below is a general guideline for filling bottles.

1. Low viscosity (ISO VG 32 or less) - Fill to about 3/4 of the total volume.
2. Medium Viscosity (ISO VG 32 to ISO VG 100) - Fill to about 2/3 of the total volume.
3. High Viscosity (over ISO VG 100) - Fill to about 1/2 of the total volume.
4. Material - Bottles are available in several materials. Below is a review of the most common bottle materials:
5. Plastic polyethylene - One of the most common bottle materials, this is an opaque material similar to a plastic milk jug. This type of sampling bottle presents a drawback because the oil can't be visually examined after the sample is obtained. Important properties of the oil can be immediately learned from a visual inspection such as sediment, darkness, brightness, clarity and color.

PET Plastic

This is a completely clear, glass-like, material and it is available in standard sizes. This plastic is found to be compatible with most types of lubricating oils and hydraulic fluids, including synthetics.

Glass Bottles

These bottles tend to be more expensive, are heavier, and there is the risk of breakage during the sampling process. One advantage with glass bottles is that they can be cleaned and used over and over. The cleanliness of glass bottles often exceeds that of plastic bottles.

Cleanliness

One of the most important considerations in selecting a sample bottle is to make sure it is sufficiently clean. The bottle's required cleanliness level should be determined in advance. The bottle supplier should provide, with each bottle order (or upon request), a certificate of cleanliness that is based upon random testing of the bottles per ISO 3722. The report should identify the mean and standard deviation for the lot from which the shipped bottles were taken. Bottles can be classified according to their contribution to the particle count into the following cleanliness categories.

1. Clean - Fewer than 100 particles greater than 10 microns per ml of fluid.
2. Super Clean - Fewer than 10 particles greater than 10 microns per ml of fluid.
3. Ultra Clean - Less than 1 particle greater than 10 microns per ml of fluid.

Important Tips for Effective Oil Sampling

To achieve "bull's eye" oil analysis data, where oil sampling and analysis produces the most representative and trendable information, follow these basic sampling tactics.

Machines should be running in application during sampling. That means sampling when machines are at normal operating temperatures, loads, pressures and speeds on a typical day. If that is achieved, the data will be typical as well, which is exactly what is desired.

Always sample upstream of filters and downstream of machine components such as bearings, gears, pistons, cams, etc. This will ensure the data is rich in information. It also ensures that no data (such as particles) is being removed by filters or separators.

Create specific written procedures for each system sampled. This ensures that each sample is extracted in a consistent manner. Written procedures also help new team members quickly learn the program.

Ensure that sampling valves and sampling devices are thoroughly flushed prior to taking the sample. Vacuum samplers and probe-on samplers should be flushed too, and if there are any questions about the cleanliness of the bottle itself it should also be flushed.

Make sure that samples are taken at proper frequencies and that the frequency is sufficient to identify common and important problems (more on this below). Where possible, especially with crankcase and drivetrain samples, record the hours on the oil. This can be a meter reading or some other record identifying the amount of time that the oil has been in the machine. If there has been any makeup fluid added or any change to the oil such as the addition of additives, a partial drain, or anything similar, communicate this information to the lab.

Forward samples immediately to the oil analysis lab after sampling. The properties of the oil in the bottle and the oil in the machine begin to drift apart the moment after the sample is drawn. Quickly analyzing the sample ensures the highest quality and timely decisions.

Oil Sampling Frequency

The objective of oil analysis, like condition monitoring in general, is to find bad news. The objective of proactive maintenance is to manage bad news away. The machine and oil will generally give off silent alarms when problems first occur. In time, as the severity increases, these alarms are no longer silent and even the most rudimentary condition monitoring methods can reveal the problem. Of course, at this point, a great deal of damage has probably occurred. And, it is likely too late to arrest the problem on the run; the machine may have to be torn down and repaired.

Machine Type	Hours
Diesel engines - off highway	150
Transmission, differentials, final drives	300
Hydraulics - mobile equipment	200
Gas turbines - industrial	500
Steam turbines	500
Air/gas compressors	500
Chillers	500
Gear boxes - high speed/duty	300
Gear boxes - low speed/duty	1000

Section 4
PLANT LUBRICATION PROGRAM

LUBRICANT HANDLING AND STORAGE

A Plant Lubrication Program must, of necessity, include measures for handling and storage of lubricants. Section 1 raised important considerations for proper handling and storage. This Section focuses on the responsibilities of the Lubrication Engineer in that area. He should recommend appropriate facilities and procedures for handling lubricants. He should concern himself with plant procedures that promote good housekeeping and worker safety. He should provide for the efficient transfer and dispensing of uncontaminated lubricant at the point of use. And he should provide proper indoor and outdoor storage for lubricants held in inventory. Avoid outdoor storage to prevent moisture from entering or being drawn into the bung hole due to rain, snow or condensation.

Both the central storage area and storage at the consumption site should be equipped with hoists and other equipment for lifting heavy drums. Where bulk grease systems are employed at the mill unit, the Lubrication Engineer should oversee and advise mill personnel on the equipment and procedures for operating and maintaining them.

The Lubrication Engineer gives due consideration to consolidating the number of lubricants used, to take advantage of the lower prices when lubricants are bought in bulk quantities. With bulk purchase, the central storage facilities require large receiving tanks, from which smaller quantities may be parceled out to the consumption sites. Bulk grease can be purchased in portable 4000-lb bins or from 40,000 lb trailers that are unloaded into stationary plant containers of varying sizes.

No matter how the lubricant is received, each container must be labeled with the brand name or plant code, together with the supplier's own batch number and any other identification deemed necessary. This information should be stenciled on both the lid and side of each container. Complete identification reduces the chance of error in application and can be used for preparing inventory reports.

Disposing of nearly empty grease and oil containers, without incurring spills throughout the plant, is a concern involving collaboration with the plant Environmental Engineer. Using returnable drums diminishes, but does not eliminate, this problem because oil companies and drum reconditioning companies are often reluctant to accept residual or drums that have been damaged. Some companies clean, crush and melt down used oil drums as scrap. Because grease drums are so hard to clean, using plastic drum liners or pump elevators that sweep the sides has become popular. In view of these factors, conversion to bulk is rapidly becoming the best method of handling drums. If conversion to bulk is difficult, one might consider using totes — portable containers of 250 to 500-gal capacity.

NEW LUBRICANT EVALUATION

This element of a Plant Lubrication Program is extremely important. Changes in operating conditions, such as speed, load or plant environment, may demand new products. Even under consistent operating conditions, when the same lubricant has been used for a particular application, the Lubrication Engineer should consider new or improved products from time to time: this year's new offering may surpass last year's product. Occasionally, price becomes a consideration; however, it is always desirable to have alternate sources of supply because every lubricant supplier sometimes encounters difficulties with manufacture or delivery. Moreover, new testing methods may prompt studies that discover new products that represent improvements over those in service, even from the same supplier.

When a new lubricant is being considered, several important factors come into play. First, do the laboratory test results reported by the supplier equal or exceed those of the product in service? Can the supplier provide evidence of satisfactory performance in similar equipment? Does the equipment builder know anything about the new product? Substantiated data from field service studies are exceptionally valuable.

Cost is another consideration in the selection of a new lubricant. If using a low-priced lubricant causes unsatisfactory performance, the lubricant becomes an expensive item.