Technical Information

How can Oil purification improve your equipment reliability and extend oil life ?

Oils in use, what happens to them and how can "Oil Reclaiming" help?

How do oils get dirty and wet? How do they degrade?

Any oil when exposed to normal conditions in a plant will start to pick up moisture immediately it is exposed to the air. Oil is very hygroscopic and picks up moisture easily. Moisture levels in an oil will normally increase to a maximum of about 300 PPM. and then stabilize. These levels are normal and will cause no damage.

If the oil is used in a "total loss" application, such as a drip feed, pick up of moisture and dirt is not a factor as the oil is used once then discarded.

Most oils however are used in enclosed reservoir's and re-circulate through the operating system. As the oil re-circulates, it lubricates, cools and flushes away debris from normal wear particles. This debris, depending on the size of the particle, may settle out by gravity in the oil reservoir, be removed by the filters, or simply be recirculated if it is too small to be removed. This recirculated particle is able to cause more damage by abrasive wear, each time it is re-circulated. Information developed in the last few years shows that particles as small as 5 microns, if present in large quantities will cause severe pump and valve wear by acting as a "lapping compound".

A lot of dirt is also introduced into the oil reservoir by airborne dirt. Very few oil reservoirs have efficient air filters on them. Dirt particles light enough to float in the air as dust, are drawn into the reservoir every time the oil level in the tank goes down. When this happens some of the dust particles settle out into the oil. Oil reservoirs where the level changes frequently can pump many times their volume of air every hour. This exposes the oil in the tank to very large potential amounts of dirt. This mechanism is how the new oil delivered from most oil companies becomes contaminated with dirt.

The additives present in most oils contain various chemicals to give long life to the oil. These consist mainly of antioxidants, rust preventatives, anti-foam agents, de-emulsifiers etc.

Water, heat and oxygen are the materials that separately or together will cause damage to both the base oil and the additive system. Water will react with many oil additives and hydrolyze them. When this happens the water reacts and fractures the additive into two or more other chemical fragments. These reaction products may or may not be oil soluble. They may also act as catalysts for the further decomposition of the oil or additive.

Oxygen will react with both the additives and the oil to form oxidation by-products. These by-products will generally be of a acidic nature initially and may also act as catalysts for further oxidation.

The antioxidant protects against oxidation only so long as it is present in sufficient quantity. When it falls below a certain value it will become less effective. As it is further reduced it will become completely ineffective.

Antioxidant is used up slowly under normal conditions. It protects by actually being consumed as it reacts with and neutralizes the initial oxidation products. Heat and the presence of moisture will both accelerate the consumption of the antioxidant.

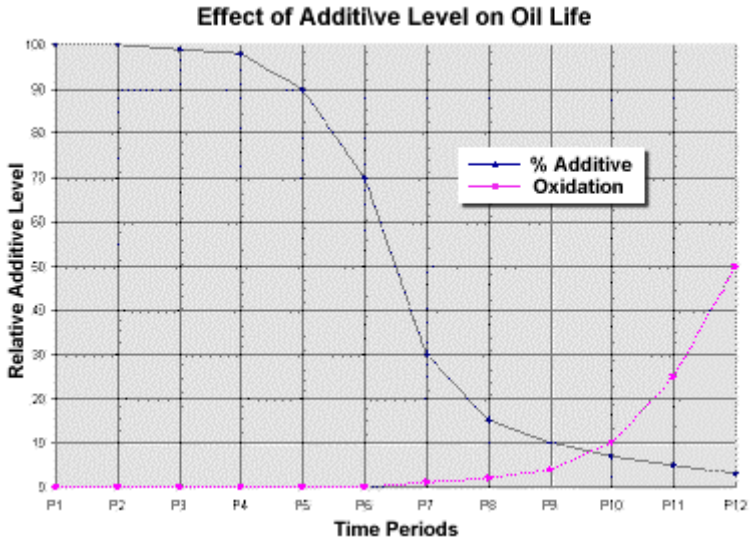
The effect of this is shown in Chart # 1, which is a generalization (not actual figures) of what will typically happen in real life.

CHART 1

The top line represents the additive level and starts at 100%. After a period of time, the level drops slowly until it reaches a point where it will start to drop rapidly.

At about this point, the first signs of oxidation will appear, they may be measured by TAN increase or some other function.

As the additive level falls below some critical number (depends on specifics) the rate of oxidation will increase. Oxidation by products will self catalyze more oxidation, so the more of them there are present, the faster oxidation will occur.

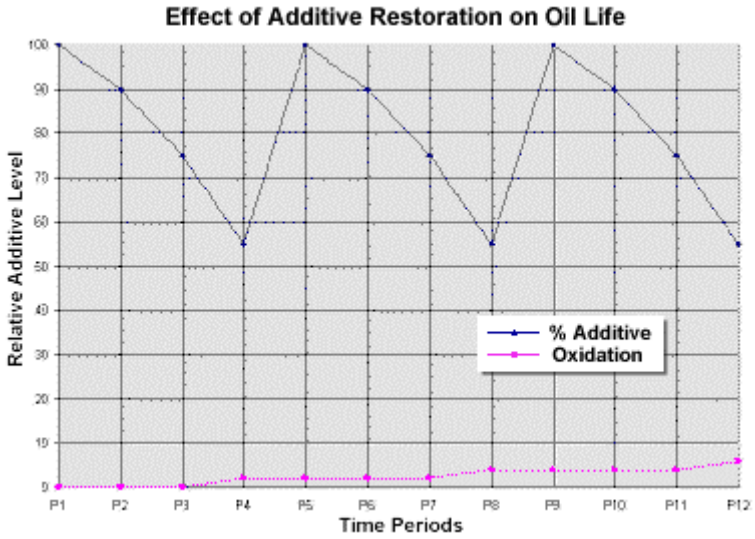


Eventually the degree of oxidation will reach the point where the lubricant must be removed and replaced with new oil. Reclamation at this point is not recommended.

CHART 2

Chart # 2 attempts to show graphically what can happen if the oil is reclaimed properly at regular intervals. Reclaiming is not a valid solution once the oil has severely degraded, as at the end of the example above, but used properly, before severe damage has occurred it can give great benefits.

The top line again represents the additive level. As in the previous scenario, it drops slowly due to consumption. A very small amount of oxidation takes place. Instead of doing nothing and letting nature take it's course, **the oil is Reclaimed and THE ADDITIVES RESTORED TO THEIR ORIGINAL LEVELS.**



The additives start the next cycle from a very high level and the same scenario takes place. Again a very small amount of oxidation takes place. The oil is reclaimed again and the additives restored. **The net effect is that oxidation is controlled at very low levels, water and contaminants never build up to troublesome levels, Oil Life can be extended MANY TIMES!**

We have demonstrated at many customers over the last twenty two years, that this system works.

The financial benefits in extending oil life in machines is actually threefold. The two more obvious ones are;

1. **The cost savings in buying new oil because of longer oil life and**
2. **The cost savings from disposal.**

The major saving comes out of the process where you extend the life of the oil by improving the system. If you improve the preventive maintenance and keep the oil system cleaner, the system will operate better and longer than it would without the improvements. **Maintenance costs will be lower and productivity will be higher.**

Filtration Improvements

The best type of filtration is full flow filtration after the supply pump. Unfortunately this will be the most expensive option. In some machines is just not possible to easily find a point where the system can be split to put this in.

Make sure that there is a suction strainer in the supply line to the pump.

If you can't put full flow in, then at least put in "Kidney Loop Filtration". This can usually be added to the reservoir, even if you have to cut in new access points for the filter/pump unit. Filter the reservoir capacity typically every hour. Remember you will be adding to the total flow through the reservoir so the retention time for settling and air separation will be reduced.

Use as fine a filter as possible. Start with a large capacity "nominal" filter and follow it with an "absolute" filter. Most machines will see a big difference going to even a 10 micron absolute filter. Finer is better. New equipment using a lot of servo valves will **REQUIRE** at least 3 micron absolute filters.

Leave the filtration loop running all the time, even when the machine is shut down. This gives the filters a chance to catch up with the normal debris generated and clean the system up while it idles.

If you are getting moisture in the oil DO SOMETHING ABOUT IT! Don't ignore it. **Moisture is the single most damaging item in oil maintenance.**

Remember you will be using additives up. While continual filtration will keep the oil clean, you will be depleting additives and these need to be checked by your oil supplier.

Reclaiming is NOT a panacea, it won't solve all problems or give indefinite life to all oil systems. But used properly it can save a lot of money and extend the life of a lot of oils and oil systems SIGNIFICANTLY.

I'd like to define some terms at this point, some of these are ours, some are in general use.

Definitions & Comments

Reclaiming

Reclaiming is removing contamination, either solid, liquid, or dissolved and returning the material to a state **where it can be re-used for it's original purpose**.

Recycling

This is the re-use of the product **for any other purpose than the original use** and covers such things as conversion to fuel programs.

Re-Refining

Re-Refining uses severe physical and chemical process's, or separation of the oil fraction by distillation. The old, now obsolete technology, was to contact the oil with Sulphuric acid, separate the acid sludge, then clay contact the oil at high temperature. This produced a relatively low grade basestock of some average viscosity that was generally only suited to making low grade industrial oils, such as lubes and cutting oils. Nowadays the preferred process is demetalization followed by vacuum distillation of the various oil fractions. Distillation is followed by Hydrotreating, which further purifies the basestock fraction. There are other process's based on Solvent Extraction which are presently being commercialized

Oils produced by distillation and Hydrotreating are typically pure enough to be used in high quality products and **are indistinguishable in performance from virgin oils** produced by the major oil companies. Two or three viscosity grades are typically produced.

Waste Oil

Used oils are of either industrial origin or from automotive crankcase oils. No attempt is made to separate or segregate any part of the sources. These wastes may contain almost any organic liquid not deemed "Hazardous Waste" and large amounts of aqueous wastes.

Waste oils generally are disposed of by burning as fuel in waste heat generation, cement kilns or by re-refining to produce industrial oil Basestocks. None is presently used for dust control on roads. **At present only a relatively small percentage is sent for re-refining.**

Industrial Oils

Industrial oils are described by some of the following general classes:

Lubricating,
Hydraulic,
Gear,
Cutting,
Soluble,
Drawing,
Phosphate ester fluids

Segregation

The process of separating various wastes from others, by containing the different waste streams as close as possible to the source of the waste. Each waste should be identified and stored separately from all others.

Filtration

The removal of solid particles by passing the fluid through a "Filter" where the solid particles are removed from the fluid stream by collection on a "Filter Media". The filter media may be paper, fibrous material (felts etc.), filter aid, diatomaceous earth, or man made materials.

The filter may be a cartridge, belt, or filter press.

Centrifuge

A Centrifuge removes insoluble materials by spinning the fluid at high speed. The high 'G' forces generated have the effect of increasing the effects of specific gravity differences of the impurities. In an oil, water being generally heavier flows to the outside of the spinning bowl. Dirt particles heavier than the water, collect at the bottom of the water layer. Centrifuges will not give complete separation of either water or dirt, but can be useful for preliminary treatments to remove gross contamination. Centrifuges are generally only useful for low viscosity fluids, **the higher the viscosity and the specific gravity of the oil, the less effective they are.**

Vacuum Dehydration

Water boils at 100 deg C at atmospheric pressure. **Many additives present in industrial oils will be degraded relatively rapidly if heated to 100 deg C in the presence of water**. When removing water it is very important to find ways to lower the process temperature as much as possible.
As the pressure is reduced, the boiling point is also reduced. A high vacuum of about 25 millibars allows the water to be distilled off at a temperature of about 50 deg C. This reduces the "Stress" on the oils and additives, so that there is **no degradation of either during this process**.

Distillation

Distillation is a process where a fluid is heated above it's boiling point and turned to a vapour. The vapour passes into a condenser and is turned back into a liquid. Impurities present in the original fluid remain behind, allowing the distilled fluid to be purified. **Distilled oil will usually require further treatment before it can be re-used as a useful lubricant.**

Oxidation

In simple terms, oxidation is the reaction of Oxygen with oil components. The higher the temperature of an oil, the faster oxidation reactions will take place. They can never be completely eliminated, but can be slowed down tremendously by the use of the proper "Antioxidant additive" and also controlling temperatures and contamination that the oil is exposed to in use.

The first effect of oxidation is generally an increase in "Total Acid Number" (TAN), then as a second stage a rise in viscosity. Along with these effects there will probably be sludge's and

varnishes formed which may separate out in the oil reservoirs, or coat the surfaces of metal components and cause all kinds of mechanical problems.

Additive Degradation

Additives in industrial oils are very often compounds that will react with water, oxygen or system metals to form reaction, or hydrolysis products which may not be completely soluble in the oil phase. The presence of water together with high temperatures will accelerate this process. These reaction products quite often are responsible for deposits, sludge's and the formation of varnish like deposits and the accelerated wear of components. Deposits and varnishes are commonly associated with oxidation by-products when in fact the deposits MAY be from degraded additives.

The reduction of additive concentration will also reduce the antiwear, or EP properties of the oil.

Filter Aid

Filter Aids are normally a "Diatomaceous Earth" or "Pearlite Mineral" which are mined, heated to remove organic materials then ground and classified into various size ranges.

Filter Aids are very useful for removal of extremely fine materials suspended in liquids, they are used for clarifying many liquids, water, beer and wine among many.

The small chambers present in the ground material allows very small particles to become trapped in them, filtration of the relatively large particle also removes all the very small particles trapped within it.

Filter Aids are generally non absorbing to oil additives, **although some specific additives can be extracted and removed.**

Clay Treatment

Many people become confused when talking about filter aids and various clays such as Fullers Earth used for oil treatment. They are two completely different types of materials. Filter Aids are described above.

Activated Clays and Fullers Earth are a kind of "Bentonite Clay". This type of material when properly pre-treated becomes very attracted to "polar" materials and will actually attract and chemically attach to many impurities, thus removing them from the oil.

The clays are particularly reactive to acidic materials. During the process of oil oxidation, many acidic by-products are formed, these further oxidize to give the sludge's and varnishes typical of severely oxidized oils. It is well known in oil chemistry that these acidic materials are first formed in the oxidation process and themselves act as catalysts for the further oxidation of the oil.

Removal of these materials while they are present in small amounts and as they form, **will enhance the oxidation stability of the oil and extend it's life.**

Clay Treatment is normally accomplished by mixing a known amount of SELECTED ACTIVATED CLAY with the oil in a specially equipped reactor. The oil/clay mixture is heated to a pre-determined temperature, for a very specific time period. The oil is cooled and filtered to remove all traces of the clay. Contact at too high, or too low a temperature will not remove the impurities efficiently. Contact for too long can degrade the oil quality as well as severely degrade some oil additives.

Clay treatment is particularly effective for removing very small particles of degraded oil

additives. These particles are semi-plastic and have been proved to pass through even a 0.45 micron absolute filter.

▲Colour Degradation

Oil companies have put much effort into producing light coloured base stocks. Removal of unstable compounds during the refining process usually removes the materials that are highly coloured as well. We have been conditioned by the oil companies to think that a light coloured oil is required for oils to have "Good Quality". As a general rule, when dealing with virgin oils, this may be so, but colour is actually a minor characteristic. The materials that give the colour are present in parts per million levels and are difficult, if not impossible to analyze for specifically.

Oils that are "Reclaimed" will always be slightly darker in colour than new oil. The more times an oil is put through the "Reclaiming Process" the darker the colour will become. **THIS IS NOT NECESSARILY A SIGN THAT THE OIL IS OXIDIZING!** It only means that these "colour components" are building up slightly in the oil. Analysis of the oil is the **ONLY** way to determine if the oil is starting to oxidize. **If the analysis indicates oxidation is NOT occurring and the oil is clean and the additives are present, the colour is irrelevant!**

How bad can it get? One of our first customer's has been recycling the oil from it's presses for over twenty years now. They pick up and reclaim about 80% of the oil, so there is a 20% make up rate. The oil has been a very dark brown for a long time. Every reclaimed batch is analyzed by the major oil company that supplied the new oil. **NOT ONE BATCH HAS BEEN REJECTED BY THE OIL COMPANY!**

▲Total Acid Number (TAN)

This is a measure of the acidity in an oil. **The number by itself does not relate to oxidation.** Many additives used in oils have a significant acid number to start with. It is very important that the TAN be recorded over time, as it is this trend that indicates whether or nor an oil is oxidizing, or degrading.

▲I.S.O. Particle Counts (Cleanliness Rating)

In the past there have been many systems developed to measure how clean an oil is. Many of these were very time consuming and difficult. Different labs would often give non uniform results of the same sample.

The whole world is now using one measurement system. One milliliter of oil is filtered through an absolute filter and the particles counted. Only five micron and 15 micron particles are counted, all others are ignored. A typical clean hydraulic system will have an ISO rating of better than 16/14. The numbers of particles are broken into groups for each rating class, numbers falling on the line between groups moves the rating up towards the next higher group. The first number reported is the rating for five micron particles and is referred to the SILT level. The silts will cause wear by acting like an abrasive lapping compound". The second number refers to the 15 micron group rating, these are generally considered to cause abrasive wear.

▲Filter Ratings

Industrial filters have traditionally been rated at an arbitrary number which was supposed to be the largest size particle that would pass through the filter. In effect this rating was only achieved when the filter was loaded with particles and about ready to be thrown away.

A better way to rate filters uses the BETA RATIO. The ratio is the number of particles per ml. in the dirty stream divided by the number of particles actually passing through the filter. The number is based on particles of a particular size. A filter that passes 5000 particles of the 10,000 entering the filter of size 5 microns has a $Beta_5$ ratio of 2. A filter passing only 100

particles of the 10,000 entering has a $Beta_5$ ratio of 100 and is obviously a better filter. A filter can have a number of Beta ratios depending on it's construction.