REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
04-24-98

3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE
LOGISTICS OF INDUSTRIAL LUBRICATION OIL RECLAMATION

5. FUNDING NUMBERS

6. AUTHORS
VICHAI SRIMONGKOLKUL

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

VICHAI SRIMONGKOLKUL OIL PURE
TECHNOLOGIES INC
KANSAS CITY, MISSOURI 64120

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
PAPER FROM 1998 TECHNOLOGY SHOWCASE JOAP INTERNATIONAL CONDITION MONITORING CONFERENCE

12a. DISTRIBUTION / AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

12b. DISTRIBUTION CODE

13. ABSTRACT ***(Maximum 200 Words)***

19980624 040

14. SUBJECT TERMS
JOAP-TSC, JOINT OIL ANALYSIS PROGRAM, CONDITION BASED MONITORING, NOAP,AOAP, SOAP *THE ABOVE TERMS SHOULD BE INC. WITH THE BOOK AS A WHOLE IN ADDITION TO EACH INDIVIDUAL PAPER

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	
UNCLASSIFIED	UNCLASIFIED	UNCLASSIFIED	UNLIMITED

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

Logistics of Industrial Lubrication Oil Reclamation

Vichai Srimongkolkul
OilPure Technologies, Inc.
6114 Connecticut Avenue
Kansas City, Missouri 64120

Abstract: American industries tend to overlook the alternative of oil reclamation because of our relative affluence, and because it's just been easy to throw oil out. But many factors are changing this situation. And technology now exists to produce reclaimed oil that is equivalent to new oil. Specialists in oil technology say, with only mild exaggeration, that really clean oil can be used and re-used indefinitely. Thus the key to gaining all the benefits of an oil recycling program is the recovery of oil at the source of its use, and closing the recycle loop. And the closer the loop, the less it costs. What are these benefits? Cost savings on buying new oil. Better product quality and production efficiency. Savings in downtime of equipment and in repair and replacement of component parts. Reduction of waste oil disposal, its costs and liabilities.

Key Words: Industrial oil; reclamation; macro analysis; micro analysis; clean oil; recycling; indefinite re-use; savings.

Introduction: America uses roughly two billion gallons of lubricating oil each year. Only about 20 percent of these oils is recycled by American industries. By way of contrast, the Japanese recycle 80 percent of their oils.

Our industries tend to overlook the alternative of oil reclamation because of our relative affluence - and because it's been easy to just throw oil out. But many factors are changing this situation. And technology now exists to produce reclaimed oil, oil which is equivalent to new oil.

Much of this process, this new look at the problems of waste oil disposal and at the benefits of reclamation, involves education of management and of plant maintenance people and machine operators. And it involves a new discipline to eliminate the wasteful habits that often seem second nature to us.

Waste Oil Disposal: Disposing of regular, large quantities of waste oil is a real problem - and will be more of a problem. One of the prime reasons for being concerned about waste oil is the environmental damage that can result from waste disposal. These environmental damages are not part of the cost accounting or record keeping procedures of a firm and don't come to light as a cost of doing business.

Thus, to put a dollar cost figure on these damages is not easy to do.

Here are three ways, among a number of others, in which used oil is an environmental threat - and why federal and state governments are cracking down.

Oils find their way into watercourses. Some of this results from individuals dumping oil into sewers. An undetermined but sizeable amount comes from collectors dumping oil illegally.

Another use of waste oil is for dust control on highways. While these findings are not completely verified, it seems that about 70 percent of this oil apparently leaves the roadway either in dust particles or in water runoff, with a major part of the metal contaminants in the waste oil entering the environment.

Thirdly, airborne pollution. When waste oil is burned, heavy metals in the waste oil, such as lead, are brought into the atmosphere as micro-small particles which are a potential danger to health and the environment.

An industrial plant must confront both the EPA and state regulations in its disposal of oil. If a plant buys 1,000 gallons of new oil each month, the EPA often pokes and prods - "how are you using that oil - where is the waste hauler taking it?"

States have their own regulations, and many of them want to be at least minimum in their codes.

A typical industrial lubricant and its additives will start to deteriorate after being in use in the lubricating process. The dirty oil can cause substantial equipment damage, deterioration in plant equipment, and considerable added cost if maintenance staff do not replace with new oil on the scheduled basis. Unfortunately, there will be the pending waste oil disposal problems facing industries for oil replacement in the equipment. This dilemma has been and is a common problem.

The Outer Loop (Macro Analysis): There are two ways to view this condition of oil use in the industrial plant. We call it Macro Analysis, or the Outer Loop, and Micro Analysis, the Inner Loop.

In Macro Analysis, the whole picture of oil usage in a plant is taken. It goes like this:

Crude oil.
The crude oil goes to a refinery.
From the refinery to an oil distributor who.....
..... Sells to the industrial plant as the end user.
At the plant, the oil first goes into new oil storage, then....
Leaked oil, used oil, in the pit goes to mixed waste oil storage.
From there it is pumped into the tank of the waste hauler truck.

At this point, the waste oil can take one of two courses. One is to an oil re-refining plant in conjunction with an oil additive repackage process. The oil is re-refined, is resold to an oil distributor and makes its way back to further industrial use. Or, the waste disposal company plans the oil for disposal, which offers two options. If the oil is "On-Spec" oil, non-hazardous waste, it is burned and as such can provide both fuel energy, but also potential air pollution by-products. If the oil is "Off-Spec" hazardous waste, it requires special incineration, special waste handling, and deposit in a landfill for residuals.

This movement of used oil is an outer loop. It leaves the plant and moves in a cycle to the re-refiner and back to industrial use. Or it leaves the plant with the waste hauler as custodian and moves through the incineration and landfill route.

So what is happening? The buyer of the new oil uses it once, until it is dirty, then discards it and must buy new oil. But potential problems don't cease as the waste oil moves out the back door.

The Inner Loop (Micro Analysis): It's hard to think of an environmental problem whose solution represents all of these: (1) improve the quality of water, land and air; (2) conserve energy resources; (3) make obvious economic sense to the user; (4) and be so easy to do.

In our Micro-Analysis, we start again with the oil distributor bringing oil to the end user. But after its use in the machinery or equipment, its path changes. Instead of being considered a waste substance, the oil is recovered on-site, goes through a filtration and purification process, is returned to new oil storage and then back to the equipment.

Specialists in oil technology say, with only some exaggeration, that really clean oil can be used and reused forever. Thus the key to gaining all of the aforementioned user benefits is recovery of oil at the source of use, closing the recycle loop. And the closer the loop, the less it costs.

There are two additional means of reducing waste disposal of oil.

The first is employment of an on-site oil cleaning service. This contractor brings to the plant a truck which can include various equipment to meet particular needs. This includes oil purification unit, vacuum distillation, high speed centrifuge, bag filters, cotton filters, a filter cart for different micron ranges.

As we said, this program helps reduce the waste oil disposal problem. But it has some negatives:

Most of the time, this service does not test for additives, thus cannot report on what additives may be missing.
It can bring in cross-contamination with other oils.

It can't segregate oils - for example, cutting oil from hydraulic oil.
It doesn't promote a pro-active maintenance policy for lubricants.

A second service that brings assistance to the plant is a contractor who provides a Total Chemical Reduction and Management Program. By "chemical" here, we mean oils, solvents, soaps - anything that contributes to the waste stream. This service helps the customer use all these types of chemicals efficiently, helps him manage his oil usage. It assists the customer in maintaining a proper inventory of these products and will, if requested, do the purchasing of new oil and other needed chemicals. This contractor does not filter or purify oil, but aids the customer in prudent management of his inventory of chemicals. With the normal maintenance and supervisory personnel not equipped with skills in these areas, he provides a professional approach which can fill a gap in plant operations.

Many industrial oil users follow pro-active practices in maintaining high quality recycled oil. Instead of using the oil until hydraulic problems develop and operating efficiency begins to wane, they have a program of regular testing and analysis of the oil. Many progressive companies use on-line monitoring of their oil with monitoring devices for particle counting positioned within the lubrication plumbing.

Caution must be used in selecting an outside laboratory for oil testing purposes. Some of the problems that can be encountered here:

The lab can accept a sample for which the customer maintenance personnel have not taken from the right sample location, have not monitored the cleanliness of the sample container or possible cross-contamination of the sample itself.

Testing equipment settings and frequency of equipment calibration may vary from lab to lab, even though all are under the same ASTM standards.

The lab technician cannot understand customer's oil problems, namely, oil application, equipment application, oil cleanliness target, the plant environment, and cannot communicate solutions for these problems to the customer.

In recent years, there has been more emphasis on testing of industrial oil because of equipment failure. But a valued side effect of this testing has been the realization that such testing is also important for ensuring production continuity and savings in labor and material costs. Regular testing and analysis of oil makes sense as a pro-active maintenance policy. However, customer is bombarded by test reports that he cannot interpret. So this oil analysis program is of no use and may be a burden, which leads to additional production expense.

Clean Oil - Why Is It Good?: Discussions on the role of industrial oil have been as numerous as the applications of the oils themselves. But not discussed as often is the subject of really clean oil. We have mentioned the responsibilities of the user regarding disposal of waste oil and its ultimate effect on the environment. But what we also are talking about is the conversion, the transformation, of waste oil scheduled to be disposed of, to recycled oil, cleaned and ready to contribute again to a plant's quality production.

Not every application requires fine filtration of its oil. And thus "clean oil" takes on a different definition according to where it's being used. But, in referring to clean oil, plant managers and engineers have been lowering the threshold of contaminants in their oil. Clean oil today means more than what it did 20 and even 10 years ago.

New oil is accepted as clean oil. But, again, it's a matter of definition. New oil....at what point? As it leaves the refinery, oil is clean. But in its journey to the user's plant equipment, the oil has passed through delivery to the distributor; it's piped from his tanks to his truck tank and then through those hoses to the end user's storage tank. In this process it has picked up contamination, and many plant people who are quality-conscious about their oil have it filtered before it enters the work process.

The values of clean oil, their benefits to the user, are becoming recognized and appreciated by more industrial operations each year. However, the understanding of clean oil and the steps needed to maintain it have not quite kept pace. If a manufacturer wants to run really clean oil, it's a help to him to be aware of all the factors that can raise the level of contaminants in the oil. And there are a number of such factors.

Here's one example:

A plant engineer may say confidently, "We are filtering out particulate of about 3 micron and larger, and we periodically bring in a full supply of new oil." What's really happening is this:

When the oil distribution system is new and is started up with a supply of new, finely filtered oil, oil contamination can be said to be at zero level. At the three month mark, contamination has soared past that acceptable level. The old oil is drained, new oil introduced, but the contamination level of the oil doesn't return to zero because some contamination remains in the equipment oil reservoir.

After another three months, new oil is again brought in, but as its use begins, its contamination level is higher than when the new oil was introduced three months previously, because even more particulate has built up in the reservoir and in the plumbing system. This cycle continues, because the deposit of particulate continues to build up.

When fines of 1 micron and up are filtered out in this situation, the level of contamination rises more slowly. As new oil is brought in, there is still some contamination build-up but it continues at a proportionately lower level with 1-micron substance continuing to be filtered out. A build-up will occur, but at a pace far slower than at the above rate.

A plant engineer, as said above, may refer to "filtering out 3 micron particulate." Actually, this is a deceptive way to refer to particulate contamination problems - by using micron size rating as a benchmark for a better filter.

The particulate condition of oil is actually measured by ISO code cleanliness standard. This standard uses laser light to count particle in different size at 5 and 15 micron in 100 cc volume. And what we mean by the quality of the filtration is actually the efficiency of the filtration. Filter efficiency is determined by the ratio of the number of particle downstream measurement to number of particle upstream measurement. The quality of the filtration is determined by what is being taken out, and the effectiveness of this activity will vary - for example, cutting oil to hydraulic oil. The same filter efficiency rating will vary upon filtering different types of oil and different oil condition.

We are saying "clean oil - why is it good?" We have stressed the value of recycling and fine filtration of oil at the work place to get away from constant disposal of waste oil, and the problems and responsibilities this incurs. But there is another side to this coin: the positive benefits that constantly clean oil bestows on a quality production process. In a word, clean oil minimizes, usually eliminates, the problem caused in machinery operations by impurities in the oil. We will cite three applications where impurities in the oil affect operations negatively - and how constant maintenance of clean oil handles these problems. The "closed loop," that is, exhibits one of its other major assets: supporting a higher level of production quality.

Hydraulic Oil: Contamination of the fluid used in hydraulic systems is said to contribute wholly or in part to 80 percent of all hydraulic system failures.

Larger contaminant particles, between 5 and 15 micron size, present the more obvious ill effects. But the smaller particulate has the more insidious effect: sluggishness in machine performance and gradual wear on components. Larger particles can block an opening but so can the very small ones in the frequent situations where clearances themselves are small, namely sub-micron to 1 to 5 micron in tolerance.

An example would be these typical critical clearances in fluid system components: gear pump, gear to side plate; 0.5 to 5 microns; piston pump, valve plate to cylinder, 0.5 to 5 microns; servo valve, spool sleeve, 1 to 4 microns; control valve, spool sleeve, 1 to 23 microns; anti-friction bearings, 0.5 micron and up. Clearances in many hydraulic components are very close, 0.5 micron and less.

Another troublesome capability of this ultra-small size particulate is its capacity for gathering, accumulating, or "silting," and its capacity for oxidation, which cannot be filtered out by mechanical means. Silt is the accumulation and bonding of very fine particles, less than 5 micron in size. Combination of silt, oxidation by-products, and heat in the process in hydraulic oil will cause waxy and gummy residue on valve surface which will cause erratic valve performance. When the gap, for example, between components separated by an oil film is bridged by contaminants, abrasion and wear can take place. Further particles result, and these, by means of silting, can bring about failures.

Manufacturers of precision machine tools continue to tighten their requirements on maintaining of clean hydraulic oil. In the past, it was noted that, though components were made with greater care and quality control, these components often operated erratically or failed. Studies on these conditions indicated that finer filtration was needed. Just as important were the initial and operating levels of contamination.

It is the hidden part of the iceberg that trips up ocean liners, and it's the invisible-to-the-eye contamination that often wrecks fine metalworking systems. A large amount of extremely small particles can lap or sludge precision parts. And, regarding hydraulic oil, they can form the nucleus for joining of non-metallic materials to increase particle size and clog small orifices.

Cutting Oil: Shop people are realizing that longer tool life and higher productivity can result from providing better filtration than what's necessary just to keep chips from passing through to the coolant pump.

The negative effect of fine contamination in cutting oil has a marked bearing on tool performance. Since the separation of the metal takes place just ahead of the cutting edge of the tool, there is a cavity at this point. The liquid coolant applied to the job enters this cavity as well as flooding over the part and the tools, and it performs an essential function here in carrying away the heat generated.

The cutting oil entering this cavity can be contaminated with particles of metal separated from both the chip and the body metal during the cutting action. These particles, mostly only a few microns in size, are coated with cutting oil. Some of them become trapped either between the tool and the work or between the tool and the chip, where they are subjected to extremely heavy loading. The resulting friction causes a rapid temperature rise in the particle, which can become white hot and weld to the tool tip. This is a major cause of cutting edge breakdown. When tests have been carried out on this problem, the removal of these fine particles from the coolant has proved to increase the life of the cutting edge.

One test, for example, was with a multi-spindle machine using various tools and recorded with and without fine filtration of the cutting oil. Tools such as drills, reamers and boring tools were involved in the test. Using fine filtration, the average tool life of drills increased by 209 percent, with increases of 44 to 87 percent on the other tools. These tests were carried out on nine different types of steel components with varying specifications. In a continuation of the procedure, results noted under actual working conditions were found to be as good, and sometimes better, than in the tests.

On machines that use an abrasive method of removing metal, such as grinding, honing and lapping machines, failure to remove the swarf and abrasive wheel debris will cause a rapid deterioration in surface finish on components. What is not normally realized is the degree to which coolants must be filtered to achieve a given surface finish.

Quenching Oil: At what point does contamination build-up in the oil affect the quenching process?

Filtration has long been accepted as a necessity. But the efficiency of the quenching process, and its maintenance costs, may be affected by a lenient attitude toward the quality of the oil in use. How does minute particulate affect quenching results?

Carbon fines of 1 micron in size and less begin accumulating with the heat build-up in the oil. The initial accumulation of these fines first acts as a speed improver in quenching action. But as the contamination continues to increase, the oil slows down. This occurs for two reasons: (1) the growing amount of contaminants reduces the cooling characteristics of the oil (quench curve); (2) oxidation by-product starts to build up in the oil. The oxidation moves chemically to the carbon fines, the oil grows in viscosity and its quenching speed drops more rapidly. The hardness value from this heat treated process become effective on just the part surface, rather than the piece. Metal becomes brittle and can fail prematurely during use.

Another way of stating this contamination build-up: the high temperature of the oil draws condensation from the air. With this higher moisture, plus the heat, the emulsified water and carbon fines exchange molecules - the so-called "Hydrolysis" effect. The carbon metal fines oxidize and become acid.

The loss of quench capability, though it's a gradual, step-by-step process, proceeds at a different pace depending on shop practices, the working environment, the application, heat, and the maintenance of the oil. One factor that is often overlooked and doesn't get deserved credit - or blame - is the entrance of water from the plant environment into the oil.

Water molecules in the oil expand under heat faster than the oil. In molecular terms, this can be a violent activity. The water, in effect, kicks the oil out and actually can create an unsafe working environment, especially, for example, if this is taking place in a 3,000-gal. reservoir. When the carbon content of the oil is high, the resulting oxidation gradually takes its effect in corrosion of the part, the surface becomes brittle and changes color, and deterioration continues until, as said, specs are altered.

The question for the heat treating engineer has to be "How clean must this fluid be for the process to be done right?" And a second question could be "What will be the direct effects, and side effects, of quenching oil that is not kept really clean?"

Good Filtration - What Should It Do?: There are, of course, many different types of filtration techniques, and each one has its own place, its own application. To mention just a few: the paper filter; vacuum dehydration - low heat for dehydration, high heat for distillation; the electrostatic filter; the centrifuge, both low and high speed; a filter using combinations of chemical compounds.

But regardless of the technique used, the good filter should have these capabilities:

Capacity for achieving low-micron, even sub-micron filtration, depending on the application and still maintain high dirt holding capacity.
Ability to remove dissolved water.
Will lower acidity (Total Acid Number - TAN) and remove oxidation by-products.
Will not affect additives.
Will meet the filtration demands of the particular job. This should include analysis of the problems encountered on the job so that a customized filtration solution can be provided. It has become recognized that tests originally conducted for environmental reasons now are just as important for ensuring production continuity and quality and cost savings.

Oil Dialysis: Oil dialysis is a new method of off-line filtration which balances oil contamination, oil additives, and based oil in an effort to keep the lubricant in the equipment at its best performance during production. It is an oil purification process, rather than oil filtration process, which is capable of completely removing all types of oil contamination incurred during the manufacturing process.

The oil dialysis unit will continuously flush out and purify the lubricant with multiple passes while equipment is running during production. With this oil dialysis method, contamination has no chance to chemically interact with lubricant and has no effect on equipment performance because contaminants are removed from the lubricating system as they are generated. It pro-actively stops the contamination ingression at the original source. The lubricant in the oil reservoir is never contaminated and never will become waste oil for disposal.

This true oil dialysis or oil purification requires that the system must completely remove three major types of oil contamination at a single pass:

Remove sub-micron particulate with at least 98 percent efficiency during oil purification process. In other words, the system can maintain ISO cleanliness code 12/9 to ISO code 13/10 or NAS class 3 to class 4.
Remove emulsified water down to less than 100 ppm.
Remove oxidation by-products which cause high acidity in Total Acid Number (TAN)
Retain original oil additives that protect equipment.

Typical conventional filtration techniques, such as filter cart, vacuum distillation, centrifuge cannot be claimed as oil dialysis. They require separate filtration processes. True oil dialysis and oil purification require high levels of filtration technology and professional problem solving technique.

The Need: A Change In Attitude And Discipline: As in all plant procedures and improvements, a change in attitude on the importance of clean oil is required from management to gain these very benefits. The machine operator generally is content if his machine is running and he is not being chastised for being out of spec. He does not consider the oil leaking into the drip pan as being a matter of concern. It is always "thrown out," anyway.

Oddly enough, two outside entities have brought the plant manager to a greater awareness of the importance of clean oil and the minimizing of waste oil disposal. Machine tool manufacturers increasingly are requiring effective filtration of hydraulic oil and, in some cases, are building filtration systems into their machines.

Government, also, usually considered a thorn in the side of industrial operations, is forcing plant management to take a new look at dirty oil and its disposal. Government can't say "do this or that" regarding what is done with waste oil but it can call down penalties for disposal violations. It can be said that government at all levels is demanding that industry re-examine this situation and is forcing us to be efficient.

Management must stress to its personnel a "good housekeeping" attitude, a common sense working attitude. And this is a process of education. With machines working at higher speeds and with quality production being stressed more by customers - and their customers - workers must learn that slowdowns, machine sluggishness, shortened tool life can be caused also by accumulations of fine and silt-sized particles, and that this contamination must be monitored on a sustained basis.

Maintenance personnel must be made aware of the many causes of contamination, air-based and moisture-based as well as solid particulate. They must be instructed and encouraged to practice pre-emptive tactics to ensure a continual supply of clean oil and the minimizing of waste oil.

The plant has options for reclaiming and cleaning used oil: shipping waste oil to re-refining services; on-site reclamation provided by an outside source; and in-house recycling of the oil.

The latter offers an additional two options. Individual filtering and purifying units can service one machine and then be moved to another. Or centralized systems can be installed to service a number of machines at the same time. The Japanese have been using this centralized oil purification system for some time, with quality thus being built into the manufacturing process. A number of machines using the same oil are connected by piping to a central reservoir and purifying system, continually recirculating the oil. This process recovers oil at the source, thus shortening the cycle of contaminated oil and providing a closed loop.

Top management must be convinced of the importance of reducing waste disposal of oil and of the benefits to themselves of reclaiming and cleaning this oil for reuse. For years, American industry had run on a principle of "if it's running, don't fix it." We must, however, inject some important new disciplines into plant management, go back to fundamentals, keep oil clean, use preventive disciplines, pro-active maintenance.

We have been conditioned to look just a bit beyond the end of our nose at short term benefits instead of at the "big picture," where the benefits come in larger sizes.

Yes, that drip pan has a real message. Hopefully, we will see, take note, and act.