Feb. 19, 2013

Filtration with Offline Oil Filters

By Steffen D. Nyman, Corporate Trainer & Consultant, CleanOilCon

Fine filtration of Oil

The requirements for production optimisation are constantly increasing, along with those for precision, speed, reliability, longer lifecycles and lower consumption. Meanwhile, design and construction focus on reducing production costs, reducing the weight of products etc. All these aspects point in the direction of higher oil maintenance requirements, as studies show that **80% of oil-related machinery breakdowns are due to contaminated oils.**

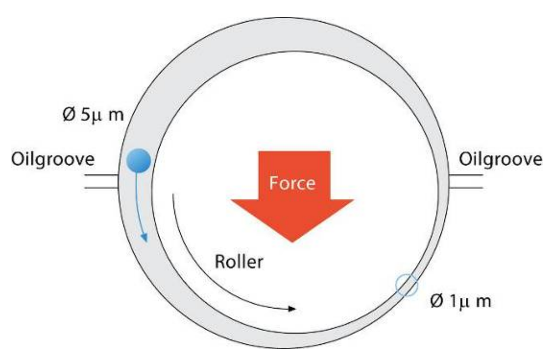
Any machine which uses oil for power transfer, lubrication or combustion is dependent on the condition of the oil. Oil comes into contact with all system components, and should be regarded just as important as the blood in our bodies. Maintaining oil performance and machine components at their best is therefore vital.

The primary objective of keeping oil clean in a hydraulic or lubrication system is therefore **optimum protection of machine components, such that reliability and function are protected**, as the consequential costs of breakdown and loss of production are often very high - e.g. a malfunctioning servo valve in a hydraulic system can stop an entire production line.

The secondary objective is to reduce running costs by extending the lifecycle of all system components - and the oil itself. This ensures optimum economical performance in relation to the system's production performance.

The same applies to the combustion of diesel or gas oil, where impurities in the form of particles and water accelerate wear and tear on the fuel pump, needle valves, injectors etc. Modern common rail engines, in where the injection pressure is high, have very fine tolerances - typically less than 10 µm (1 micron meter equals 1/1000 of a millimeter).

In most oil systems you'll find silt particles of between 2-7 µm. These are highly abrasive as they get trapped in clearances in between valve plunger and housing in servo valves for example, or between the piston and cylinder in a piston pump. The result is abrasive wear – known as seizing or grinding - which can give rates of wear a thousand times greater than anticipated by the machine manufacturer.



Such particles are invisible to the naked eye, but can enter the oil system in large numbers via shaft seals, piston and other gaskets, plus inadequate oil tank breather filters.

Oil maintenance must therefore reduce the amount of particles able to lodge in clearances, to minimise the risk of abrasive wear.

The dynamic oil film thickness for typical machine components:

Components	Dynamic oil film (microns)
Journal bearings and bushings	0.5 – 100 µm
Hydraulic cylinders	5 – 50 µm
Engines, piston rings/cylinder lining	0.3 – 7 µm
Piston and gear pumps	0.5 – 5 µm
Servo and proportional valves	1 – 3 µm
Roller and ball bearings	0.1 – 3 µm
Gears	0.1 – 1 µm
Dynamic seals (shaft seals etc.)	0.05 – 0.5 µm

Source: Noria Corporation

What needs to be removed from the oil?

Optimum reliability and protection of oil systems can only be achieved if the oil maintenance equipment deployed can remove all types of relevant contaminants, such as:

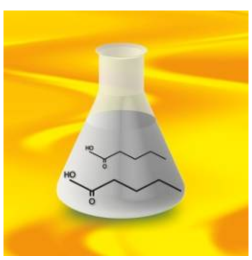
***Solid particles*, especially those of the same size as the clearance/oil film, are extremely damaging, as they accelerate wear on pumps, valves, bearings and gears. Such particles are usually less than 10 µm. Wear metals being in the oil will act as catalysts to speed up the oil degradation process.

***Water*, because water in oil can cause such damage as micro-pitting and hydrogen embrittlement in pumps, gears and bearings, and is a catalyst for rust and oil degradation (varnish). Water can also cause bacteria growth and sludge (particularly in diesel oil, known as diesel-pest).

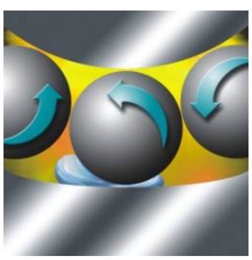
Oxidation/varnish is caused by oil degradation and reduces the oil lifecycle considerably plus generates acids. The degradation process forms soft contaminants which falls out as varnish and sludge in cold areas of the oil system, and will result in sticking valves, blocked heat-exchangers and accelerated wear due to the "sandpaper effect".

Acid can be generated during degradation of oils, by the hydrolytic deterioration (hydrolysis) of ester-based fluids or as residues from the combustion of diesel or gas oil.

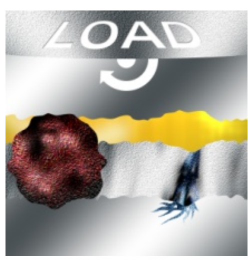
Four types of oil contamination:



Acid



Water



Particles

Varnish

Offline Oil Filtration

Inline pressure filters are primarily fitted between the main pump and sensitive machine components as the last line of defence, but are not conducive to achieving optimum oil cleanliness, as pressure shocks caused by stop/start of the main pump will result in the release of a large amount of the particles already retained by the filter insert. However, pressure filters are still important as last chance inline filters.

Offline oil filtration is ideal for ensuring the lowest possible degree of contamination in the system, e.g. to achieve a specific level of oil cleanliness.
In principle, an offline oil filter installation can be compared with the way a kidney and a dialysis machine work. The filter is fitted with its own circulation pump and works continually on a separate filter circuit from the system's oil tank.
Offline installation is the only way to ensure optimum, uniform operating conditions for an oil filter. Because the flow is governed by the offline pump - which is set according to the filter density - it can be kept low. This makes it possible to use a very fine filter insert, such as 3 µm, which combines high dirt holding capacity with fine particle filtration and removal of water through absorption, or continuous water separation using coalescence, if this is required.
The offline filter will furthermore be operating continuously, so risk of pressure shocks are avoided.

Because an offline filter circuit works independently of the hydraulic or lubrication oil system, its level of efficiency remains constant – even in periods when main system pumps are not in operation.
During such downtime periods, offline oil filtration is ideal, as the oil cleanliness in the system and the tank can reach very low levels, ensuring smooth start-up with totally clean, water-free oil. This will prevent any so-called “Monday morning syndrome” to occur.

Avoid Monday morning syndrome on plastic moulding machines

When is offline oil filtration recommended?

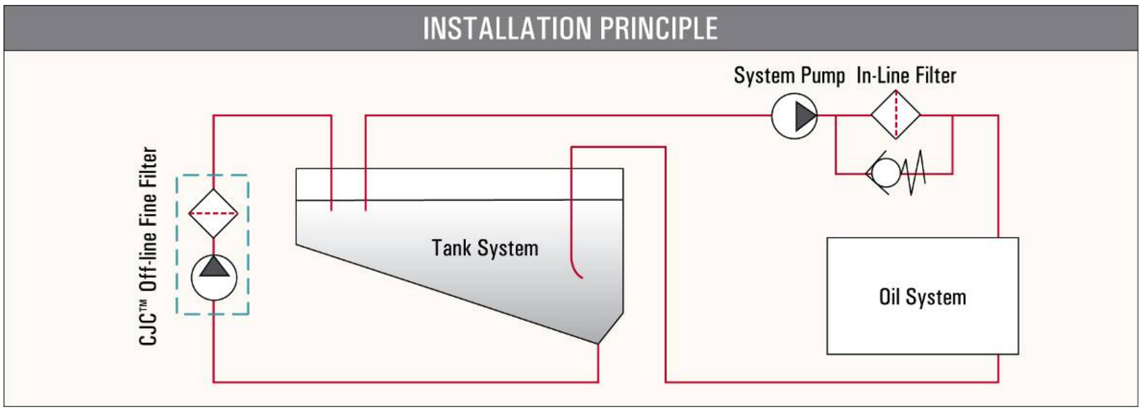
Offline oil filtering should be used when the cost of not having optimum oil cleanliness becomes high, e.g. for the hydraulic oil in a steam turbine regulation system, when a sticking valve could cause turbine trip-out costing tens of thousands of dollars.
Utilizing offline oil filtration the following can be achieved:

- Optimum protection of all components in an oil system, by improving and maintaining the desired level of cleanliness in the system
- It will keep all the components and the oil tank clean, avoiding flushing and manual cleaning
- It will reduce the load on inline pressure filters, making them last longer (relieving stress)
- It can remove all four types of oil contamination (particles, water, varnish, acid), if specialised filters are used

In regards to operation optimisation the benefits of offline oil filtration will be:

- Greater availability and operational reliability (less downtime)
- Greater machine precision and repeatability
- Lower costs for service and maintenance due to extended component and oil lifecycle
- Best oil cleanliness at the lowest possible cost, due to consistent operating conditions for the offline oil filter

How to install offline filters



Schematic diagram of an offline oil filter installed on an oil system
Source: C.C.JENSEN

An offline oil filter consists of the following components as a minimum: pump, filter insert, by-pass valve (safety device in the event of a blocked filter) and an oil pressure gauge, as increasing differential pressure over the filter indicates when the insert needs changing.
The filter insert can be a traditional pleated pressure filter made of glass fibre or metal, or a dept filter insert usually made of cellulose.

To achieve the maximum benefit, the suction line for an offline oil filter is connected at the lowest point of the tank (bottom drain). This ensures that all contaminants, particles, water etc. settling in the tank are also removed from the oil. A T-piece can be fitted to the tank bottom accommodating drain and suction line to the offline filter. Another T-piece with an isolating valve and a quick-connect coupling can be fitted to the suction line before the offline pump. This allows topping-up or filling oil via the offline filter, so that the new oil is filtered before it comes into contact with vital system components.

The return line from the offline filter is connected to bring clean oil into the system tank as far as possible away from the drain, and below the oil level in the tank.

Oil is sucked from the system tank via the pump into the filter housing, and forced through the filter insert from the outside and towards the centre. On its way through the filter insert, particles in the oil will be trapped, water and acid absorbed and oxidation residues/varnish retained. The clean oil will be pumped back to the system tank, where the oil and additives can start a complete cleaning process of the oil system.

Continuous water separation can be achieved by using coalescence for low viscosity oils or diesel, in which high water content is a problem. Coalescence forces the normal water settlement which occurs when oil is mixed with water.
The working principle is the same as that described above, although a type of filter insert is used which does not absorb water, but repels it. Microscopic drops of water form into larger drops in the filter insert, which run down from the centre of the filter into a fine mesh or stack of discs in the coalescer element. At this point, the velocity of the water drops is so low that they have more time to settle to the bottom, from where the water can be drained. Please see drawing below.
The dehydrated oil is pumped out of the filter through the coalescer element and returned to the oil system.

Typical applications for which offline oil filtration is recommended

Offline oil filtration can be installed on almost any oil system for which optimum oil cleanliness is required, and where the consequences of contaminated oil are high.
A few examples follow:

Lubrication oil in wind turbine gear box
Reason for offline oil filtration: Breakdown will result in high costs, as the repair or replacement of bearings and gears is expensive, and requires special cranes, as wind turbines are often sited in remote places. Furthermore, lost energy production is a factor.
Problem: Very high energy/torque transfer and a complex gear design (planetary gears) place heavy demands on oil quality and cleanliness. Particles and water reduce oil and component lifecycles. Contaminated oil can cause gear or bearing failure within 12 months. An offline oil filter must be able to remove fine particles (3 µm), oxidation/varnish and water (condensation) from high viscosity gear oils, typical ISO VG 320.

Hydraulic control fluids in turbine regulation systems (gas or steam turbines)
Reason for offline oil filtration: Functional failure in the regulation system can cause turbine trip-out, which can cost tens of thousands of dollars in lost production. Components and the control fluid are very expensive.
Phosphate ester-based fluids are usually used, as they are fire-resistant (HFD-fluid). Unfortunately, ester-based fluids break down into acids when they come in contact with water.
Problem: Higher concentration of acid results in shorter intervals between oil changes, and causes component damage. Particles, varnish and water cause wear and control valve failure.
An offline oil filter must be able to remove fine particles (3 µm), oxidation/varnish, water and acid.

Lubrication oil in steam and gas turbines

Reason for offline oil filtration:
High costs linked to turbine trip-out due to loss of revenue. Can result in fines levied by the customer.
The large volume of oil is expensive to replace.
Problem: High bearing temperatures generate varnish and lacquer coatings, which settle in the pressure filters and bearing clearances. If the turbine regulation system and lubrication circuit share the same oil, varnish can block the regulation valves causing a turbine stoppage. Particles settle in the varnish layer, causing an abrasive "sandpaper effect". Heat exchangers are insulated with varnish layer and can be clogged.
Steam turbines can be subject to continuous steam/water ingress through labyrinth seals. Water creates rust and is a catalyst for accelerated oil degradation. An offline oil filter should be able to continuously remove fine particles (3 µm) and oxidation/varnish. For steam turbine lube oil water separation is required as well.

Oil in cooling tower gear boxes

Reason for offline oil filtration: The cooling tower fan gear has to be stopped to change gear oil, which is hazardous and difficult. The cost of repairing or replacing worn gears is very high.
Problem: Water and particles in the oil shorten the intervals between oil changes and reduce gear lifecycles. Offline filter can be used to top up oil levels without having to stop the gear box.
An offline oil filter must be able to remove fine particles (3 µm), oxidation/varnish and water from high viscosity gear oils.

Engine lubrication oil in diesel engines (e.g. marine engines)

Reason for offline oil filtration: The high cost of oil changes due to large oil volumes and short oil lifecycle. Engine overhauls are very expensive.
Problem: Very hot oil, metal wear and combustion blow by’s (soot, acid etc.) result in short oil lifecycle. Oxidation/varnish can block filters, oil pipes and glaze cylinder linings with lacquer. The level of soot will reduce the TBN value (the oil's alkaline properties).
An offline oil filter must be able to remove oxidation/varnish, abrasive particles and soot (approx. 1 µm), to stabilise the TBN value. Doing so will extend oil and component lifecycles.

Diesel oil filtration

Reason for offline oil filtration: If parts of the injection system do not function optimally due to wear or blockages, the engine will lose efficiency, and in the worst scenario, can even stop. Overhauling the injection system is very expensive.

Problem: High pressure and very fine tolerances, particularly in common rail systems. Fuel pump, needle valves and injectors are all subject to wear by water and particles. Diesel and gas oil are hygroscopic - they absorb water from their surroundings, and condensation in the fuel tank(s) can result in high water content. Bacteria growth causes sludge/pest built-up in tanks. Large amounts of dust and sand particles are often present.

An offline oil filter must be able to continuously remove fine particles (3 µm), bacteria and water. Coalescence filters are very efficient for removing water from diesel (MGO).

Hydraulic winch on fishing boats

Reason for offline oil filtration: The high cost of winch breakdowns, as net and catch cannot be winched onboard, plus the hydraulic components are expensive. High risk of particles and water in the oil due to the harsh environment and intensive use followed by periods of non-activity. High pressure and fine tolerances in valves and pumps require clean oil.

Problem: Oxidation/varnish and rust caused by water in the oil cause valves to stick. Particles cause wear on hydraulic pumps and valves, reducing precision, performance and lifecycle.

An offline oil filter must be able to remove fine particles (3 µm), oxidation/varnish and water.

About the author

Steffen Nyman earned his Mechanical Engineering degree in 1996 with specialty in power generation. He was in technical sales for three and a half years before he realized that training was his calling. For more than 12 years, he has been responsible for developing and conducting technical training and documentation for sales, service and technical staff at Alfa Laval, Grundfos and C.C.JENSEN.

Steffen Nyman is a certified ICML Machinery Lubrication Technician (I+II) and Lubrication Analyst (I) as well as 4-MAT trainer in adult teaching skills. He has conducted hundreds of customized seminars in understanding oil maintenance, analysis and oil filtration technologies for the Marine, Mining, Power, Off-Shore and Wind industries.

Steffen has been a license partner for Noria Corporation since December 2012.