



Cleaning oil systems - Are you buying a solution or a product?

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When you invest in an oil filtration system it is really worth knowing what you are buying and what you are really acquiring for your money. If a product or service does not add value to a business then why buy it? The problem in the oil filtration sector is that end-users' knowledge regarding filtration alternatives and their impact on the bottom line is still limited - one thing is what the salesman would have you to believe, and the other is the reality.

An independent study, undertaken by Tampere University of Technology in Finland, showed that 10 leading brands of surface filters failed to live up to the filtration ratio printed on the product. Quite frankly you do not want to be paying for a 12 μ m filter that only filters effectively at 25 μ m.

It is now an established fact that 80% of all failures in oil systems are due to contamination of the oil. Lack of effective oil filtration causes the gradual erosion of the mechanical parts that are being lubricated. Eventually components like bearings will lose efficiency, dynamic tolerances will increase, and wear and tear will accelerate until the machine breaks down. At this point expensive downtime and maintenance will be necessary. Typically, a bearing failure may have occurred prematurely, if this is the case then one may ask why they failed so early cheating you out of the rest of the normal expected remaining service life and costing you money in terms of repair and downtime. The obvious question to ask is why had they deteriorated so rapidly and what can be done about it.

Unfortunately, in the filtration sector, selling methods have remained aggressive rather than consultative, and often sales are made on the basis of a list of dubious benefits rather than quantifiable facts. Then when things go wrong, the client sits with the problem of proving that it was inadequate filtration caused by low filter efficiency that was the root cause of his problem and of trying to recover some of the costs.

Below you will find some recommendations and discussions that may help you buy and evaluate oil filtration, more effectively so that you can avoid sitting with your hands in your hair when insufficient filtration causes or at least assists with premature failure.

1. Buy the cleanliness and not the filter.

When determining the required filtration ratio for an oil system it is usually based upon the smallest, dynamic tolerance in the system. The dynamic tolerance in for example a turbine journal bearing is typically 20 μ m during normal operation, but at turning speed these film clearances can be as small as 1.5 μ m. Considering the extremely high flow rate of the main pump and the demand for reliable operation, manufacturers agree that a filtration finer than 10 μ m absolute is advisable.

Using a 10 μ m absolute filter on oil with a normal particle distribution will reduce the number of particles by only 10%. By using a 3 μ m fine filter the particle removal increases to 65%, and the wear on machinery parts is correspondingly dramatically reduced. The graph in fig 1 indicates the normal particle distribution in an oil. An increasing number of machine manufacturers do not accept warranty claims if the cleanliness level of the oil exceeds the recommended ISO classes. (Thus regularly monitor cleanliness levels). On turbines the general recommendation is ISO 15/12 or better. (Sources: VGB, ABB, ALSTOM, Ansaldo Energia). (See Table 1 below for explanation of ISO Norm 4406 Cleanliness Codes)



The ISO organisation has developed a “method for stating codes of the contamination level of solid particles in oil”. ISO norm 4406 forms the basis of standardisation of cleanliness codes for oils.

In a particle count, automatic or manual, the number of particles in 100 ml of oil larger than respectively 2, 5, and 15 μm is recorded. The result can be plotted into the diagram below and the ISO code is found.

Max. number of particles per 100 ml hydraulic fluid after their size ranges		
More than	Till	Class
8,000,000	16,000,000	24
4,000,000	8,000,000	23
2,000,000	4,000,000	22
1,000,000	2,000,000	21
500,000	1,000,000	20
250,000	500,000	19
130,000	250,000	18
64,000	130,000	17
32,000	64,000	16
16,000	32,000	15
8,000	16,000	14
4,000	8,000	13
2,000	4,000	12
1,000	2,000	11
500	1,000	10
250	500	9
130	250	8
64	130	7
32	64	6

Table 1 : ISO Norm 4406 Codes

Example:

100 ml of oil is tested and the result is as follows:

Number of particles per 100 ml	> 2 μm	1,801,000
	> 5 μm	270,000
	> 15 μm	54,000

Using the table on the previous page these results are transported into ISO codes.

1,801,000 particles > 2 μm equivalent to an ISO code 21

270,642 particles > 5 μm equivalent to an ISO code 19

10,261 particles > 15 μm equivalent to an ISO code 16

The ISO code according to ISO 4406 is in this case ISO 21/19/16.



The codes are built up logarithmically; an increase of only one class is a doubling in the number of particles. A one-class increase is therefore of dramatic importance.

N.B. If an ISO code only contains 2 figures these correspond to 5 and 15 μm .

ISO codes are used by producers of machinery to determine the maximum contamination levels acceptable to system components.

Using a diagram similar to the one below:

RECOMMEND CONTAMINATION LEVELS FOR HYDRAULIC SYSTEMS.

ISO 14 / 12 / 9	Silt sensitive systems aerospace or laboratory.
ISO 16 / 14 / 10	Critical systems general servo systems.
ISO 17 / 15 / 11	High quality general proportional valves.
ISO 18 / 16 / 13	Medium pressure systems.
ISO 20 / 18 / 14	Low pressure systems with large clearances.
ISO > 21 / 19 / 15	Not suitable for hydraulic systems.

It must be remembered that system cleanliness is not only as a result of solid dirt ingress, contamination can also be as a result of operating conditions and of gas and vapour entry. Wear particles, soot particles, resins, varnishes, air and water also are contaminants that can also be a problem and they too should be removed or their entry retarded. When high temperatures, air-, particle-, and water contamination are present they compound many smaller problems and degradation processes which can have a synergistic bad effect on the system and lubricant. For instance, typically every 7°C increase in temperature of an in-service oil will lead to its rate of oxidation doubling and subsequently halving the remnant service life! By-products of the oxidation process are among others “resin”-like substances in the oil system. If these oxidation products are not removed they will lead to system malfunctioning by increasing the wear rates and clogging oil passages, valves and orifices. In almost all lubricants and hydraulic fluids oxidation of the fluid occurs with use and the longer the service period or the more arduous the operating conditions the sooner it becomes evident and can be the cause of a lubricity problem. In laymans terms the word oxidation indicates that parts of oil’s hydrocarbon molecules are chemically altered often by an aggressive chemical (such as oxygen or an acid). This in turn causes this altered hydrocarbon to degrade further forming acids and soots and to loose its lubricating ability. Thus it is important to remove or at least reduce the substances that cause oxidation

Oxidation is an increasingly recognised problem in industrial applications. However, many problems are wrongly diagnosed as being of a mechanical nature when in fact it is instead caused by oxidation of the fluid. Oxidation of the lubricant often takes place as a chain of events with many intermediate products (such as peroxides and acids) being produced that in themselves can also be detrimental to the lubricant and the system. Compounds formed in this chain of reactions often include soot and a group of compounds classified as resins and varnishes. These particular groups of contaminants are worth mentioning as if an oil is operated under oxidation conditions, they may cause problems such as oil starvation by blocking valves, oil orifices and passages. A filter system should safeguard a system by removing the particles formed so that the subsequent problems are alleviated.

Resins are a group of high- molecular weight organic molecules of very varying composition. The general feature is that it contains acidic groups. The molecular weight is very high. Resins are not soluble in water but dissolves without problems in alcohols, ketons and some fractions of



hydrocarbons.

The term varnish is sometimes used because the deposits formed often have the appearance of varnish. The reason for this is that all varnishes contain resin type binding agents. So what appears as a varnish is really a resin that has been "polymerized" i.e.chemically bonded other resin molecules to form longer chain and often harder "polymers"

Resins contain the element oxygen which makes them polar and makes it easier for them to adsorb to metal(oxide)- surfaces and other polar compounds. This is often evident inside engine cylinders that has been operating for extensive times under high temperature and pressures when the inner walls become coated by a shining "varnish)

Oxidation products once formed in lubricant, are difficult to remove due to their high solubility in hydrocarbons. This solubility is temperature dependant which makes chilling the lubricant a possible but highly impractical removal method as the lubricant will still have to be filtered but now at the lower temperature. A better removal method makes use of the polar action of oxidized hydrocarbons.

In filter media, the higher the polarity of the adsorbent, the greater the chance of entrapping the polarised oxidation products and holding them tightly within the media. High specific surface area is also advantageous as each molecule occupies a certain surface area and thus a high specific area means high capacity to adsorb. Cellulose materials contain large amounts of oxygen and are thus polar. They have been shown to adsorb oxidation products. Cellulosic filters cannot be used to purify transformer oils since the transformer itself contains large amounts of cellulosic insulation. Fuller's Earth and other mineral clays also have a good service record in purifying oils and they too can be used.

Adsorption characteristics are temperature dependant and a variation in the temperature will effect the amount of oxidised dirt collected.

One can significantly reduce the rate of oxidation that a lubricant is subjected to by changing the lubricant to a more resistant base oil etc. Such a lubricant is a full synthetic oil that can be utilised. This, however, also requires maintenance.

In many lubricant systems, water contamination is a serious problem. The water not only acts as a catalyst decreasing the remnant service life of the oil in use and thereby creating oxidation deposits but water levels above 200 - 300 ppm in the oil decrease bearing lifetimes by up to 50%. All oil systems will experience slight water contamination as temperature fluctuations along with relative humidity levels which will result in condensation inside the system which is detrimental to the system and to the oil. Major water problems will often occur by coolers, cleaning of the equipment etc.

As your most important task is to keep your oil system clean it is therefore important to determine the contamination limits for particles, water and oxidation in the oil. This can be done by combining recommendations from the manufacturer of the machine, oil companies, independent oil laboratories and filter manufacturers, but remember that everybody gains something from their recommendations whether this is sale of spare parts, oil, analysis or filters.

2. Installation and Operating Cost of the Filtering Equipment

It is important to maintain operating costs of filtration equipment to be cost effective. A Filtration system must provide the end-user with a secure and reliable system to protect the filtered systems components in case of an unplanned failure. Under these conditions it must protect the systems



sensitive components.

The traditional solution has been the use of in-line pressure or return line filters. These filters work in extreme operating conditions with widely varying flow rates and pressures. Because of this they are expensive and are only able to handle small dirt loads before requiring frequent replacement as they cannot handle the high dirt load experienced in many industrial operations. Thus the operating cost of such a system is prohibitively high and in cases where they are placed in return lines after the sensitive components of a system they are not able to offer the protection sought.

The more cost-effective alternative is to use the pressure filters as so-called “police filters” that only enable reliable filtration before the system’s sensitive components thus protecting it from catastrophic failure owing to large sized contamination throughput. The next step is to find reliable high capacity equipment to handle the high dirt load i.e. to “control the contamination in the oil system” itself and to remove the dirt load from the pressure filters thus prolonging their life and reducing the cost of replacing them. Such a contamination control filtration system must be able to deliver the required cleanliness level and in fact guarantee the achievement and maintenance of these required levels.

As already mentioned above water and oxidation also causes problems and thus they too should be removed. Thus the contamination control filter system should also be able to take care of these contaminants and then deliver a dries lubricant capable of producing a guaranteed cleanliness level. Thus both solid (ingress and internally produced) and water removal should be achieved.

World-wide experience has shown that to achieve maximum dirt holding capacity and low operating costs an off-line filtration system constantly cleaning the oil in the oil reservoir is recommended. In this case the filter system incorporates its own pump and can operate independently of the rest of a lubricated system. The advantage of such a system is that it’s flows and pressures can be independently controlled and the filtration process can be optimised for contamination control.

Experience has taught that in off-line filtration it is good comparative practice to calculate the dirt and water capacity in litres and the amount of oxidation product that each filter can remove per cost of the filter so that the most cost effective filter system can be chosen in terms of life-cycle costing.

3. Filtration Performance.

After installing a filtration system it’s performance should be regularly monitored. Regular independent oil tests between oil changes looking at particularly particle counts, water content and varnishing type particulate levels as well as the amount of acid present (TBN) should be performed. If these do not correlate with the specific filter’s OEM operating specifications the matter should be taken up with them.

If the matter is not resolved to your satisfaction you may have to review your filtration method, type or the filtration supplier.

It is important that the oil analysis is performed by an independent reputable laboratory capable of presenting credible results. It is a good idea to get the filter supplier/manufacturer in on the act so that they can assist you in or advise you on all aspects of the filters operation. In particular they should be able to advise you on the best method of drawing a lubricant sample and they may even be able to provide you with specially designed sampling systems or kits. In Europe to analyse an oil sample costs around € 60.00, fortunately here in the RSA it can vary from only R85.00 per sample upwards. Such sample monitoring practice enables one to measure the performance of a filter and to compare the results obtained to the manufacturers claimed specification. Typically analytical results can be obtained within 10 working days (often far shorter) and the cost, effort and time spent waiting for the results is a small price to pay for peace of mind knowing that a system is being adequately protected. The frequency of sampling is not a rigid requirement and it will vary according to the type of filtration



system installed and the contaminant load on the lubricant and filter. Typically in correctly matched filtration systems with sufficiently large contaminant holding capacity, sampling every 6 months should suffice. Sampling frequency per system should be recorded in the specific system logbook.

4. Meet the Locally Appointed Manufacturers Representatives

When you have to choose between different types of filtration systems make sure that your information gathered is correct by communications with the official representatives of the manufacturers. To confirm the claimed filtration performance parameters in writing is also a good idea. Remember it is your process that must be protected and it is your system that will fail prematurely if sufficient cleanliness levels are not achieved. Remember too, that cheap solutions without adequate written guarantees, however attractive they may look, could escalate into devastatingly expensive costs if machines are damaged through inadequate filter performance. But even a written guarantee can be misleading unless it takes filtration tolerances into account (bear in mind the Tampere University study.) Therefore as mentioned earlier, confirm the filter tolerances and the achievable level of ISO code and under what conditions this can be achieved, and ask for it in writing!

Helping potential clients towards an educated and balanced decision on their filtration requirements and method is a responsibility of the filtration sector, and we hope that this article will help to guide some of its readers towards better evaluation and higher expectations.

We who earn our livings from the filtration sector should give some thought to the philosophy that perhaps we should focus on selling solutions rather than purely products. We could then use this to create a more positive and fruitful exchange of ideas with our clients, identify viable and longer-term solutions to their filtration requirements, and be persons motivated by more than just the potential for volume of filter element sales.