Filtration of Oil and Related Benefits

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ABSTRACT

This article contains information about the negative influence oil contamination will have on machine component life time and the oil life time. It is also mentioning some of the existing oil filter types/principles available and the positive influence a good filtration system will have on any oil system.

The purpose of this article is to give an illustrative introduction to what can be done if a company is having problems with contamination causing machinery to break down. It also gives an idea to what can be done to prevent these problems occurring in the first place.

Keywords: Oil contamination, life of components and oil, removal of contamination, filter principles.

1. INTRODUCTION

One of the major problems in today's oil systems is the effect which particles, water and oxidation deposits (broken down additives) have on the lifetime of oil system components and the fluid itself. These factors are the cause of 80% of breakdowns, and can be avoided with improved oil management techniques. This test will mainly focus on particle influence on an oil system.

Figure 1. Bearing Wear

Figure 2. Water in Oil

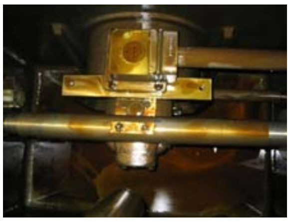


Figure 3. Oxidation, Steering Gear

The key is to optimize oil "house keeping" – this should be delivered by installing efficient oil filtration systems in conjunction with an increased effort to limit contamination ingress and generation.

Figure 4. An example of a CJC Filter total solution,
which removes particles (3µm), water and oxidation from oil.

If oil is kept clean and "dry" the optimal conditions for the oil additives are created and "the benefits are clear". Good oil environment will, in fact, offer savings in maintenance costs, production down time, component replacement and oil changes.

2. OIL CONTAMINATION AND GENERATION

As mentioned in the introduction we see one of the major problems in today's oil systems as the effect particles, water and oxidation deposits (broken down additives) have on the lifetime of oil system components and the fluid itself. The Danish Maintenance Association stated a few years ago that these factors are the cause of 80% of machinery breakdowns, and can be avoided with improved oil management solutions.

Concisely, the contamination of lube oil systems will therefore create much higher running costs for production equipment than is necessary.

If you take a look at the below mentioned illustration you will see an example of a lube oil system. On the right hand side of this illustration some of the common potential contamination sources are mentioned.

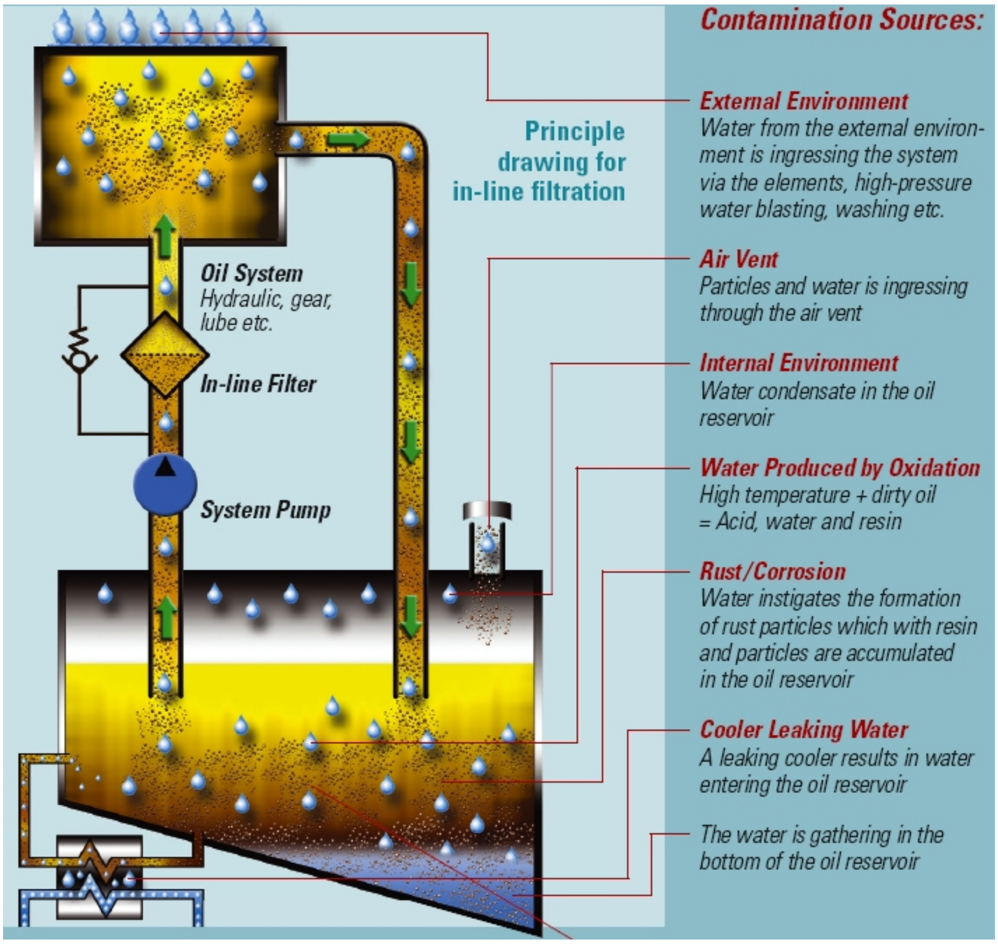


Figure 5. Contamination Sources

Additionally, to the above-mentioned contamination sources, contamination can be delivered with new machinery (built in). Also, new oil can be the source if it is not cleaned before it is poured into a lube oil system.

No matter how the fluid has been contaminated, a particle generation of will take place. Figure 6 shows some of the ways particle generation occurs.

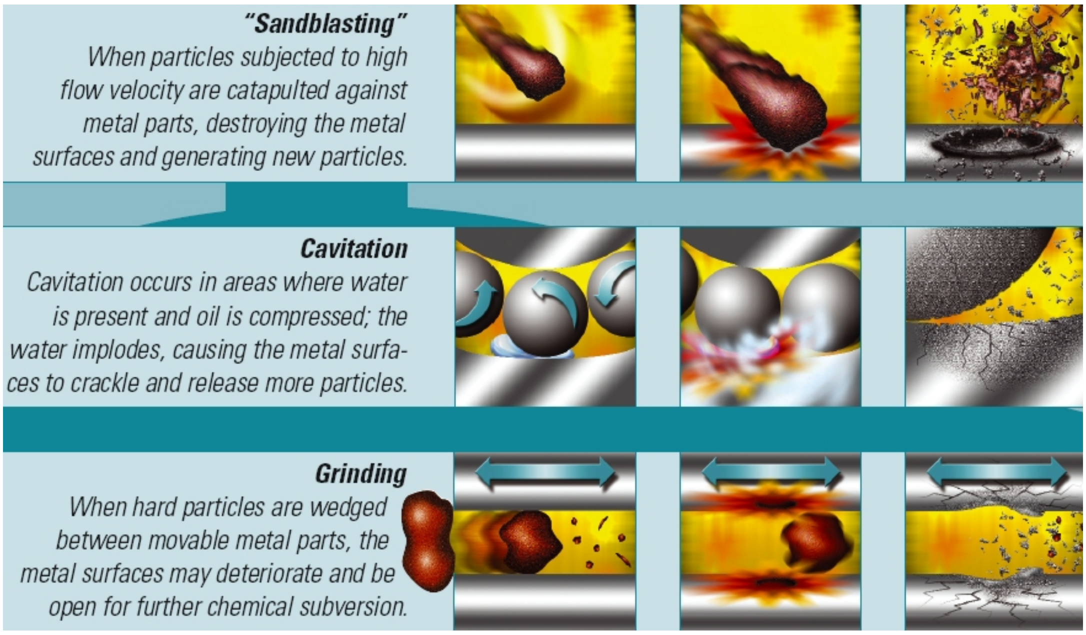


Figure 6. Wear caused by contamination

In lube oil systems the negative effect on lubricity is caused by particles, water and heat.

In an oil system there is always a level of particles present, however, the number should always be as low as possible. Figure 7 shows an observed particle average in a medium charged hydraulic oil system. The number of small particles is higher than the number of large particles.

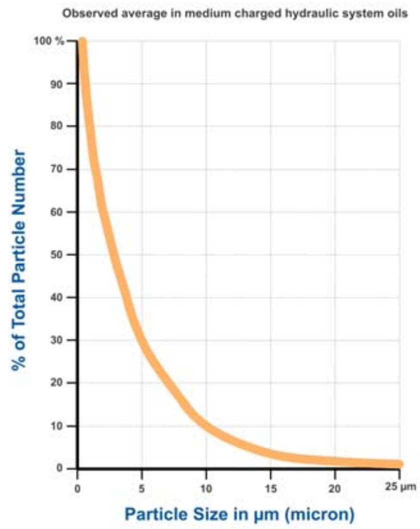


Figure 7. Particle size distribution

Looking at the above graph it can be concluded that 70% of the particles are smaller than 5µm and looking at component tolerances in oil systems they are often between 1 and 5µm. With this knowledge we can conclude that it will be beneficial to remove the very small particles from the oil system.

This conclusion has also been made by MacPherson who discovered the importance of small particles. The MacPherson Graph (Figure 8) [1] is based on an accelerated test of 10 roller bearings. The lubricating oil used was contaminated with dirt from gearboxes.

The MacPherson Graph indicates that the real component life time improvement is achieved when filtering below 10µm. Why is that?

Firstly, 90% of all particles in gear oil are smaller that 10µm i.e. a 10µm filter will leave 90% of the particles in the oil, only offering a very limited filtration.

Secondly, the dynamic tolerance in, for example, a wind turbine bearing is between 1-5µm, which indicates that only particles smaller than 5µm are able to enter and damage the bearing.

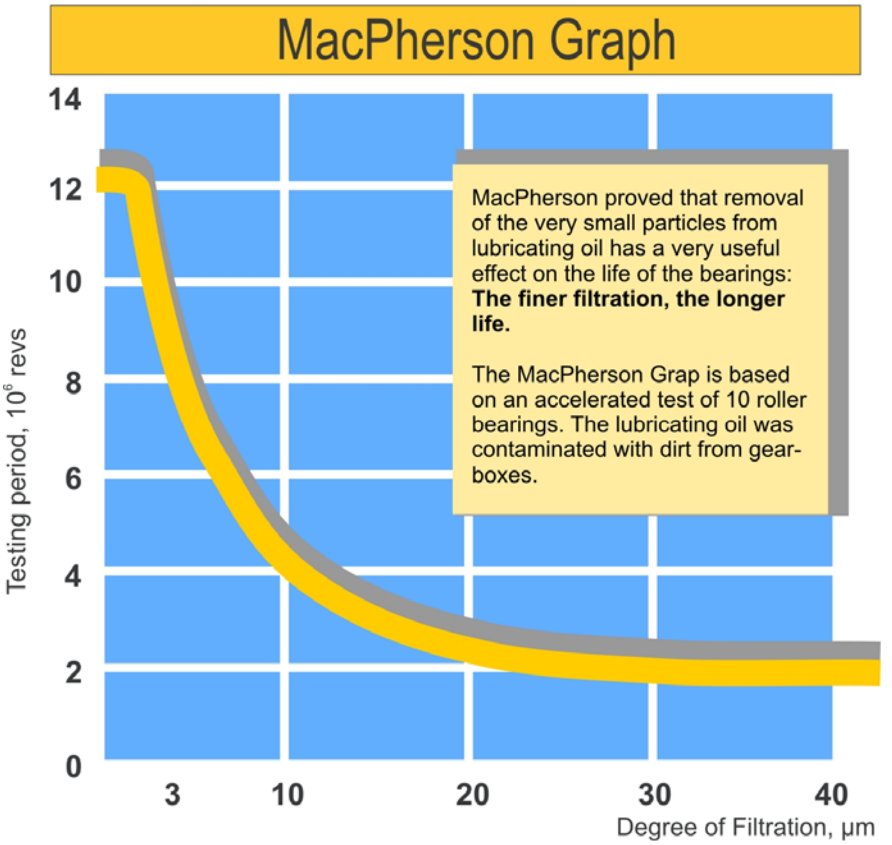
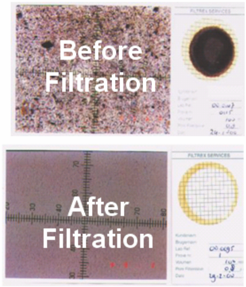


Figure 8. MacPherson Graph [1]

Looking at the graph you will find that increasing the filtration ratio from 30µm to 3µm will increase the component life 3 to 4 times.

3. INFLUENCE ON COMPONENT LIFE

CJC Off-line Oil Filter Application	
Application:	Wind Turbine 600 kW
Oil type:	Tribol 1710/320
Oil volume:	220 litres



Filtration time	0 hours	48 hours	1 month
Particles 2 µm	1,443,178	29,975	6,774
Particles 5 µm	298,681	14,652	2,204
Particles 15 µm	17,893	1,549	356
ISO 4406 Code	21/19/15	15/14/11	13/12/9
Water content	1,240	109	76
Colour of membrane filter disc	Black	Light	White

Figure 9. Results from a CJC Fine Filter mounted on a wind turbine gearbox

The above mentioned results shows what difference a good and efficient filtration system makes – in this case – to a gear oil contamination level.

Before filtration (0 hours) you can see the number of particles is high, which equates to an ISO code of 21/19/15. A month later (after filtration) the particle contamination has dropped dramatically (e.g.: 2µm particles have dropped from 1,443,178 to 6,774) which equals an ISO code of 13/12/9.

To quantify this in relation to prolongation of the component life, we can plot the two above-mentioned ISO Codes into the following Figure 10 which is a diagram concerning life extension of element bearings [2].

Life Extension Method (LEM)
Rolling Element Bearings

Life Extension Faktor (LEF)

	2	3	4	5	6	7	8	9	10
28/26/23	24/22/19	22/20/17	20/18/15	19/17/14	18/16/13	17/15/12	17/15/12	16/14/11	16/14/11
27/25/22	23/21/18	21/19/16	19/17/14	18/16/13	17/15/12	16/14/11	16/14/11	15/13/10	15/13/10
26/24/21	22/20/17	20/18/15	19/17/14	18/16/13	17/15/12	16/14/11	15/13/10	15/13/10	14/12/9
25/23/20	21/19/16	19/17/14	17/15/12	16/14/11	15/13/10	15/13/10	14/12/9	13/11/8	13/11/8
24/22/19	20/18/15	18/16/13	16/14/11	15/13/10	14/12/9	13/11/8	13/11/8		
23/21/18	19/17/14	17/15/12	15/13/10	14/12/9	13/11/8	13/11/8			
22/20/17	18/16/13	16/14/11	15/13/10	13/11/8					
21/19/16 →	17/15/12	15/13/10	13/11/8	←					
20/18/15	16/14/11	14/12/9							
19/17/14	15/13/10	13/11/8							
18/16/13	14/12/9								
17/15/12	13/11/8								
16/14/11	13/11/8[1]								
15/13/10	13/11/8[2]								
14/12/9	13/11/8[3]								

(1) LEF = 1.8 • **(2)** LEF= 1.5 • **(3)** LEF = 1.3

Figure 10. Diagram on rolling element bearing lifetime [2]

The exact ISO Code is not in this diagram; however the above-mentioned 21/19/15 and 13/11/8 are very close. This is why we can conclude that the filter on the wind turbine gear oil will prolong the bearing life approximately 4 times.

4. DIFFERENT TYPES OF OIL FILTERS

To obtain good clean oil you need to choose a good and reliable filtration system. There are a lot of different filters and filtration equipment on the market, and to mention the most common filter types - please take a look at Figure 11.

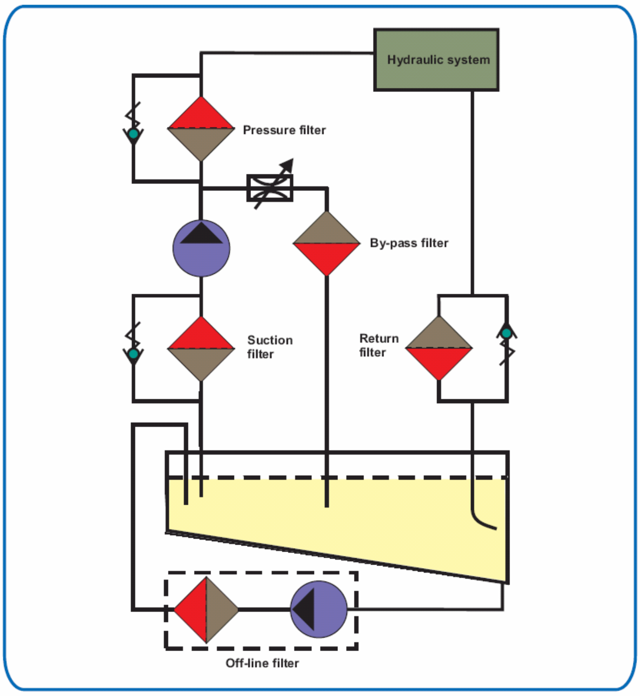


Figure 11. Filter types

The filters types: Suction, Pressure and Return filters are all **Inline surface** filters working with the full flow of, in this case, a hydraulic system. Please take a look at the illustration below regarding inline filter inserts.

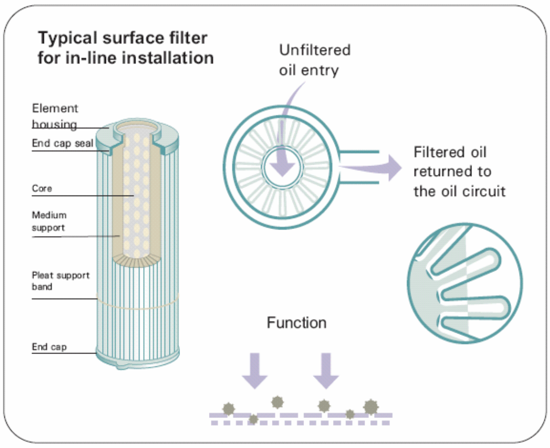


Figure 12. Inline surface filter

By-pass filters operate by drawing a limited stream of oil from the main oil circuit. The oil flows through the filter and returns to the sump/tank.

Offline filters are sucking the oil i.e. the bottom from the oil reservoir, with a dedicated pump which presses the oil through a cellulose **depth** filter insert (not a surface inline insert). The clean oil is returned to the oil reservoir below the oil surface. Please see the illustration below which shows the function of a true offline filter insert function.

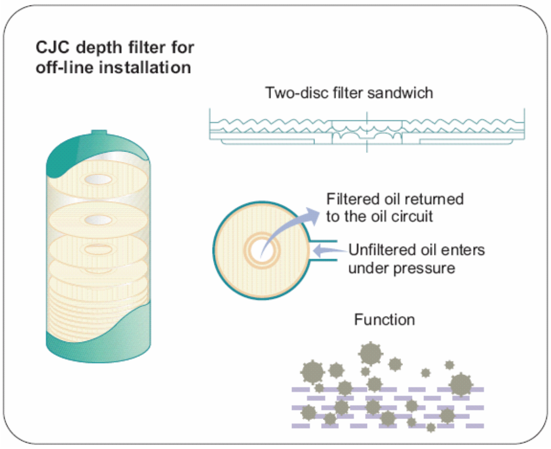


Figure 13. Offline Depth Filter

Offline filters are very important to oil systems as they are the only ones that can keep the oil reservoir clean. The reason being that the offline filters suck the dirty oil out from the bottom of the reservoir and thereby always take out particles, the settled sludge, water (some filter systems) and oxidation (some filter systems).

To illustrate the importance of offline filtration, please look at the photograph shown below. It shows the bottom of a tank in a hydraulic system where the oil system is equipped with a 3µm (beta value 200) inline filter, however, there is still a good deal of contamination in the tank.

Figure 14. The bottom of a tank in a hydraulic system,
equipped with a 3µm (beta value 200) inline filter.

5. BENEFITS OBTAINED WHEN MAINTAINING CLEAN OIL

The key is to optimize oil “house keeping” – this should be achieved by installing efficient oil filtration, systems in conjunction with an increased effort to limit contamination ingress and generation in the first place.

If oil is kept clean and “dry” the optimal conditions for the oil additives are created and “the benefits are clear”. Good oil environment will, in fact, offer you the following benefits:

- Prolonged life time of components
- Prolonged life time of oil
- Less unplanned production stops
- Longer machine service intervals
- Less man hours needed to keep machinery running

AT THE END OF THE DAY OPTIMIZING YOUR OIL SYSTEM IS A GOOD WAY OF EARNING MONEY FOR YOUR COMPANY!

REFERENCES

[1] MacPherson
[2] NORIA