White Paper

Hydraulic filtration, does it improve reliability?

Hydraulic filters have developed over the last 20 years and there are now more companies than ever offering replacement filters. How do the use of filters and the type assist in the long term reliability of hydraulic systems?

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Introduction

The statement that "70% of hydraulic system failures are attributable to contamination" has been around for many years. Is this fact or a "Get Out of Jail Free Card" for manufacturers on the question of warranty on hydraulic components? Alternatively do filters prevent the number one cause of hydraulic system failure?

Hydraulic Filters

Hydraulic filters have been in use for decades. Advances in technology have seen filter housings rated to higher pressures and filters having better efficiencies and larger dirt holding capacities. The filter media has changed from metal, to cellulose and now to synthetic fibers. There is more choice than ever in the market place so there should be filters available to suit every application and every budget.

Sources of Contamination

Contamination can be generated inside the system or can be introduced from outside. Internal contamination is generated from component wear. The rate of wear depends on the usage of the system, the lubricating characteristics of the hydraulic oil, the oil temperature (affects the oil lubricity) and the amount of contamination already is the system. Solid contaminants can generate more contamination through erosion. Contaminants such as water cause corrosion and reduce the lubricating characteristics of the oil causing erosion.

External sources of contamination can come from;

1. **New oil from suppliers** – unless you specifically ask, and pay for filtering, you will not get oil that is clean enough to be poured straight into your system. There will be contaminants in the oil, which will need filtering before being introduced into the system. Pumping the fluid into the reservoir via a filter is strongly advised. Pouring oil in via a jug or a funnel is not advised as they can have contamination on their surfaces.
2. **New pipework** - contaminants can be left in hoses, from cutting and crimping and also in new pipes. Debris from cutting, mill scale and welding will all need to be removed prior to system start up. New pipework and hoses should be cleaned thoroughly by flushing to a good cleanliness standard.
3. **System maintenance –** such as filter element or component changes. Contaminants can enter the system through open ports etc. Good practice is advised where open ports are plugged or covered and surfaces cleaned with clean lint free rags.
4. **Poor maintenance –** for example if breathers are not replaced they can block and the reservoir then breathes through its lid gasket, the breather gasket or any place convenient for it. Also I have seen a lot of breathers left open after filling the reservoir through the filler basket.
5. **Cylinder seals –** contamination can adhere to cylinder rods and if the wiper seal is not good enough then contamination can enter the system. In areas of high airborne

contamination a bellows over the cylinder rod would prevent a lot of contamination of the cylinder. I have seen fine sand get into the system from cylinders and damage pumps.

6. **Water –** can build up due to condensation when the system is cooled after use. Water vapour, in the air, inside reservoirs can condense. The more water vapour, in humid areas, the higher the risk. Water can also enter from cooler problems. I had many old coolers in the plant when I worked at British Steel. One year I had a problem with two systems and had to clean 10,000 litres of oil. After all the coolers were maintained, during a Summer shut down, I never had a problem again. Water vapour in reservoirs can be minimised by fitting desiccant breathers.

Types & Position of Filters

The position of the filter in the system can affect its efficiency and the overall system cleanliness. The possible positions of filters in the hydraulic circuit are:

1. **Pressure filter** – this filter is usually positioned straight after the pump and protects components downstream. The filter housing can have a bypass, to allow fluid through at pressure drops at 6 bar or above. Contamination can block the filter and increase the pressure drop across it and for bypass type filter housings the elements have a collapse rating of 20 bar. Filters do not work very well in varying flows and pressures, which can make contamination retention very difficult. So a pressure filter in a system with varying flows and pressures, over 90% of systems do this, will not be very effective in controlling system cleanliness as the only filter within the circuit. Filter housings which do not have a bypass, must have a high collapse filter element, typically rated at 210 bar. Contamination cannot flow through a bypass so the effectiveness of this type of filter must be greater. The cost of the element however is much higher. These types of filters usually protect high value dirt sensitive components such as servo valves.

2. **Return filter –** this is the most popular filter, found on its own in most systems, because it is relatively inexpensive for elements and the housing. Return filters have a bypass set around 1.5 bar, as they are low pressure filters. Like pressure filters they are not very effective at holding contamination at varying flows or pressures. Hence their effectiveness at contamination control alone is low.

3. **Offline filter –** positioned in a separate pump system, taking oil from the reservoir and returning it back filtered and cooled. This is the most effective filtration as flow and pressure is constant and the fluid in the reservoir is continually filtered. It relies on cleaning contaminated fluid in the reservoir and passing clean fluid to the system. The filters used in this type of system are low pressure, as the circuit pressure is usually below 6 bar. Filters are usually large with a high dirt holding capacity. The Pall HC8300 39 inch series used to be a popular off line filter but is now no longer in production.
4. **Breathers** – very much forgotten in the filtration world, and forgotten when filters are changed. A typical filler breather that costs around £10 has a 10 micron breather inside the cap, which is foam and you question how effective is it going to be. Tanks need to breathe and so a good breather is advisable, especially in a dusty environment. A filter

can with 10 micron media makes a very effective breather as the element has a Beta Ratio of 200. Water removal breathers, such as the Donaldson Trap breather performs two functions; water and solid contaminant removal, and is very good.

Filter Media

As filters have evolved, the accuracy of the media has evolved. The efficiency, which is discussed in the next section, has also improved. A 10 micron filter now will take out more 10 micron particles, and above, than a filter 15 to 20 years ago. Components manufactured over 30 years ago typically had wider internal clearances, except for servo valves, so filters of 25 micron rating or higher were used. Components today have smaller internal clearances and are more efficient than older components. Hence filters of 10 micron rating and lower are required.

The finer the media, the cleaner the system is going to be and the lower the risk of failure due to contamination. The wear rate of components will also be reduced and will have a longer service life. However finer media filters will be changed more often so there is a cost – benefit scenario to calculate. Most typical systems today have 10 micron filters on the return and the on the pressure side. System with servo valves and critical pumps will have finer media filters, either 6 or 3 micron.

Efficiency of Filters

Filters have improved dramatically over the last 20 years with synthetic fibre elements replacing woven wire and latterly cellulose type elements. The industry has moved from surface media; single layer, to depth media; multi-layer. The result has been an increase in the efficiency and larger dirt holding capability. The efficiency of filters is determined by the Beta Ratio. This is determined during the Multipass Test to ISO 16889. A known quantity of fine test dust is introduced into a test rig and the numbers of particles of a certain size are measured before and after the test filter. For example the Beta Ratio of a 10 micron filter could be calculated as follows;

$$B\,(10)\,C = \frac{50{,}000}{250} = 200$$

The Beta Ratio of the 10 micron filter would be 200, or in other words it has a 99.5% efficiency. If a filter had a Beta Ratio of 1000 (called absolute) it would only allow 50 particles past it, as in the example above, and the efficiency would be 99.9%.

Good quality filters would have been tested to ISO 16889 and they quote either a Beta Ratio of 200 or 1000. Poor quality filters have no quoted Beta Ratio or a quoting 2, 50% efficiency. Good quality filters will keep your system clean, have a high dirt holding capacity and prove to be good value for money.

Filter Maintenance

Maintaining filters and understanding system cleanliness is important when maintaining hydraulic systems. In British Steel we had multiple systems working 24/7 with many hydraulic filters. The problem was that various filters over time became clogged or had faulty indicators so we never knew when to change the elements. Also if filters indicated blockage during plant operation, they could not be changed for periods up to 2 weeks. A project of changing filters during maintenance periods, on a frequency basis, was introduced. Failures due to contamination became a thing of the past. Oil cleanliness levels were measured on a monthly basis and systems operated continuously with clean oil. Servo valves lasted 3 years instead of 6 months.

I know operators of construction plant that don't change filter elements until the vehicle slows its hydraulic functions. Imagine how much contamination is in the system and how much has bypassed the filter. These operators are constantly putting their plant at risk of failure.

Bypass or blockage indicators, electrical or visual, are important. They let you know when your filter is about to bypass or block. You can then make an informed decision on when to change the elements. Having them on your filter assemblies is important and maintaining them is even more important. Taking a look inside your filter is also a good idea. The filter below was in a housing that had an indicator. The indicator did not show a blockage but as you can see it has collapsed and completely blocked. This filter was not removing any contaminant from the system and its cleanliness levels were getting worse month by month.

On another system I worked on there was no indicator on the return filter and valves were failing. We removed the element and found it had partially collapsed, because it had not been changed. The filter was made of cellulose and it had a 30 micron Beta Ratio of 200. Not good enough to protect a modern hydraulic system. The filter was changed for a 10 micron absolute element and the oil started to clean immediately. For approximately £20, a system problem was resolved.

Conclusions

In 2015 there are a huge number of filter choices, at different prices, some high quality, some not, but never the less having a filter in the system is a great benefit. The cost of filters has reduced and there are no longer a couple of companies with a monopoly. Therefore there is a great choice of housing and supplier of elements. A simple 10 micron return filter can be effective and elements purchased for under £20. A car oil filter can cost more and many people choose to change their car oil filters, so why not the filters in a hydraulic system that can earn you money!

I have witnessed the results of contamination, which has resulted in system poor performance and failure. Contamination related problems can take time to diagnose as random component failures can occur. I have not had a contamination problem, or rarely any other problem, with a system that had a good level of filtration. It can be sometimes easy for manufacturers to blame early component life failure on contamination. However if you have good filtration and a cleanliness record of the system then you may be able to argue your point.

If your hydraulic system is dirty and it has not broken down then you are quite lucky. If your system is clean, you monitor the cleanliness and change filter elements regularly then you are in control of your hydraulic systems reliability.