FLUID POWER
TUTORIAL 7
HYDRAULIC FILTERS AND RESERVOIRS

This tutorial is set at QCF level 4 and was originally written to cover the HNC module Unit 24. It covers the principles and applications of ***hydraulic and pneumatic*** power systems. It introduces you to the concepts of fluid power and describes the principles, applications and types of hydraulic and pneumatic filters.

On completion of this tutorial you should be able to do the following.

- Explain the purpose of filters.
- Explain the principles of surface filters.
- Explain the principles of depth filters.
- Explain the methods used to identify filter size and efficiency.
- List common contaminants in hydraulic fluids.
- Describe the materials used to make filters.
- Describe the various safety features on filters.
- Explain why and where filters are fitted to a system.
- Explain the main design features of hydraulic reservoirs.
- Explain the various safety features built into reservoirs.

Contents

1. *Introduction*

Filtration is a vital part of safeguarding hydraulic equipment and maintaining the condition of the fluid. Contamination of the fluid may result in wear, corrosion, poor performance and ultimately failure of the equipment. Filtration is about the removal of solid contaminants from the fluid.

Most filters work on the principle of trapping the particles in small holes or pores. The fluid may pass through but particles above a certain size become trapped. There are two main types of filter elements, surface and depth.

2. *Surface Filters*

Surface filters are normally constructed from thin sheets of material folded into many sections and then turned into a multi pointed star shape as shown. This allows a large surface area to be used in a small space. The filter fits inside a bowl. They may be in the form of a replaceable cartridge or permanently fitted inside a throw away bowl. The thin sheet s full of pores which trap the solid particles as the fluid passes through them.

Figure 1

Typical materials are

- Cellulose (paper)
- Woven steel fibres
- Woven nylon fibres

Paper filter elements are ruined by water which makes them become soggy and the pores close. Another design is the use of a single filament of metal wound into a cylinder.

3. *Depth Filters*

Depth filters are constructed with a thick layer of material with small passages through which the fluid must pass (like a bed of sand for example). The particles become trapped in the passages. The passages may be formed from granules compacted into a thick cylindrical layer or fibres compacted into a tube.

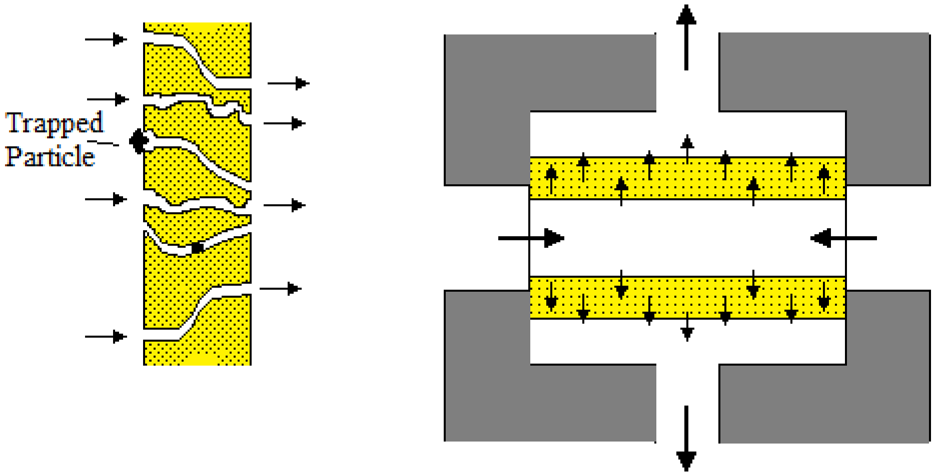

Figure 2

Typical materials are

- Cellulose (paper)
- Synthetic fibres
- Metal fibres
- Glass fibres
- Sintered metal granules

4. *Contaminants*

The main contaminants are

- Welding scale and beads
- Sealing tape shreds
- Shards of screw threads
- Bits of seal material
- Grinding chips
- Wear particles
- Sludge and varnish from oxides oil
- Rust
- Water
- Dirt from the atmosphere
- Biological material such as hair, skin scales, flies and so on

Solid contaminants get into the clearance spaces between moving parts such as piston and valve spools. They cause wear and damage and may jam the component. Solid particles are removed in the filter by trapping them in tiny passages in the filter element. Particles down to 5 microns (0.005 mm) may be trapped. A typical general purpose filter traps particles of 25 microns.

Water damages paper filters and causes corrosion and lack of lubrication. Water should be removed by settling the fluid in the tank and draining it off. It may also be removed by a centrifuge.

5. *Filter Size and Efficiency*

Filters do not have uniform holes and passages so it cannot be guaranteed that all the particles larger than the nominal size are trapped. The efficiency of the filter determines how much of the contaminant is removed. The level of contamination in a fluid is covered in standards ISO 4406 (BS5540). Two range numbers must be stated. The first number is the range of particles in 1 milli-litre larger than 5 microns and the second the range for particles larger than 15 microns. For example code 18/13 means the sample contains 1300 to 2500 particles larger than 5 microns and 40 to 80 particles larger than 15 microns.

Scale No.	21	20	19	18	17	16	15	14	13	12	11	10	9	8
Min	10000	5000	2500	1300	640	320	160	80	40	20	10	5	2.5	1.3
Max	20 000	10000	5000	2500	1300	640	320	16	80	40	20	10	5	2.5

Beta Rating (β)
The Beta rating is the percentage of particles of a stated size trapped by a filter in a multi-pass test. For example a β_{15} of 80% means that 80% of particles larger than 15 microns are trapped. The absolute rating is widely based on 98% of particles larger than the stated size being trapped by the filter. This is more likely to be given for surface filters because the size of the pores is more consistent.

6. *Location*

A full flow filter is designed to filter the full output from a pump. It may be placed before the pump (suction filter) or after the pump in which case it must be capable of withstanding the full pressure of the system. It may also be placed in the return line to the tank in which case it does not have to withstand high pressure. Sometimes a separate pump is used solely for the purpose of circulating the fluid through a filter with no great pressure on it. The system in which the fluid may be pumped through a filter at any time independent of the main system is called ***Off Line Filtering.***

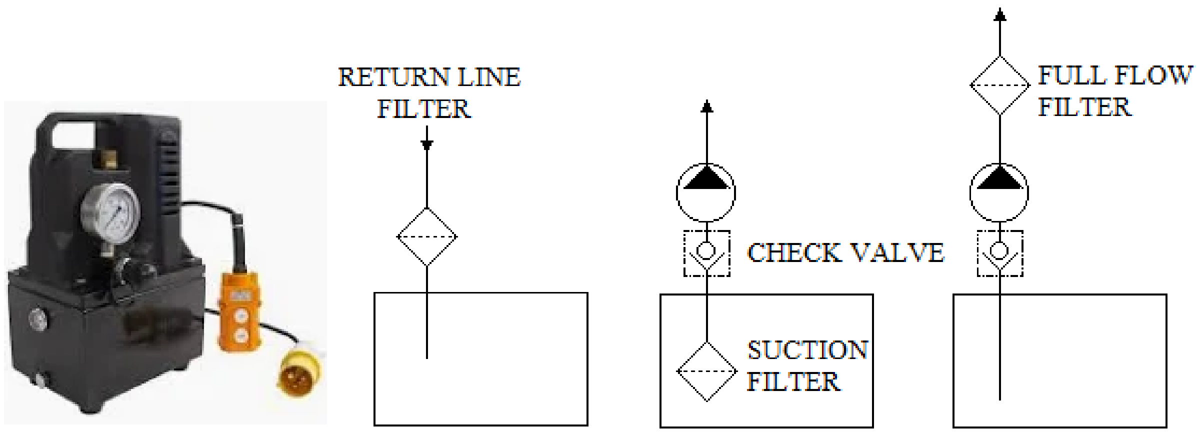

Figure 3

The check valve prevents reverse flow and draining of the filter and pump. High precision components such as spool valves are sometimes protected by using a filter adjacent to or part of the component. These would be high quality filters of 5 or 10 microns.

7. *Clogging*

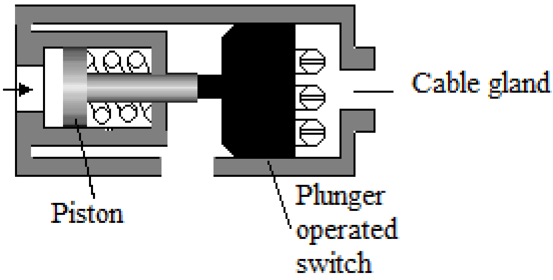

Figure 4

A clogged filter will cause excess suction and cavitation which will damage the pump. The state of a filter is often indicated either on the filter or on a control panel. The indicator may be a small pressure gauge showing the build up of pressure. It might also be a pressure switch as shown for setting off an alarm.

The full flow filter shown below has a spring loaded element which moves as it clogs and pressure builds up. The movement moves a pointer on the outside which indicates the state.

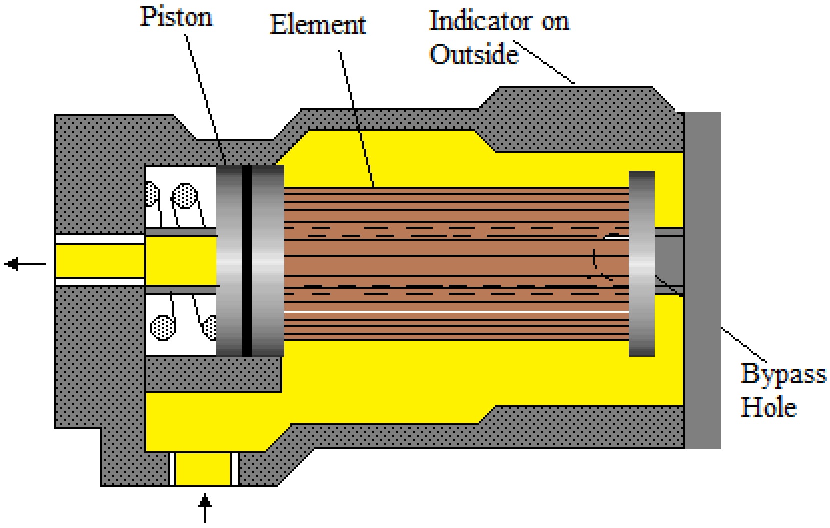

Figure 5

Bypass

If a filter is not changed when clogged, it is better to allow unfiltered oil through the system than to run with it clogged. In this emergency situation, the oil automatically bypasses the filter element. This may be done with a simple spring loaded valve which is opened by the back pressure. In the diagram of the full flow filter above, the filter element moves against the spring as back pressure builds up and uncovers a bypass hole in the central stem. The symbol below shows a filter with bypass and clogging indicator.

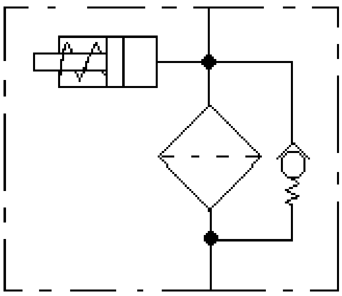

Figure 6

The full flow filter shown below has a bowl which screws into a head fitting. This contains a bypass valve which opens automatically when pressure builds up due to clogging.

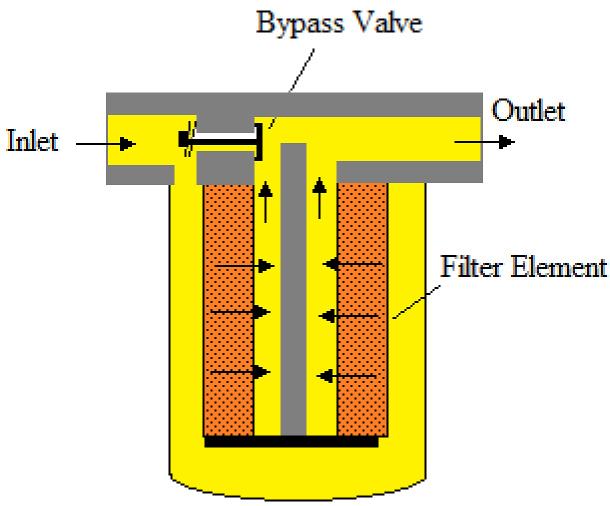

Figure 7

8. Reservoir Design

The main design features of a reservoir are shown below.

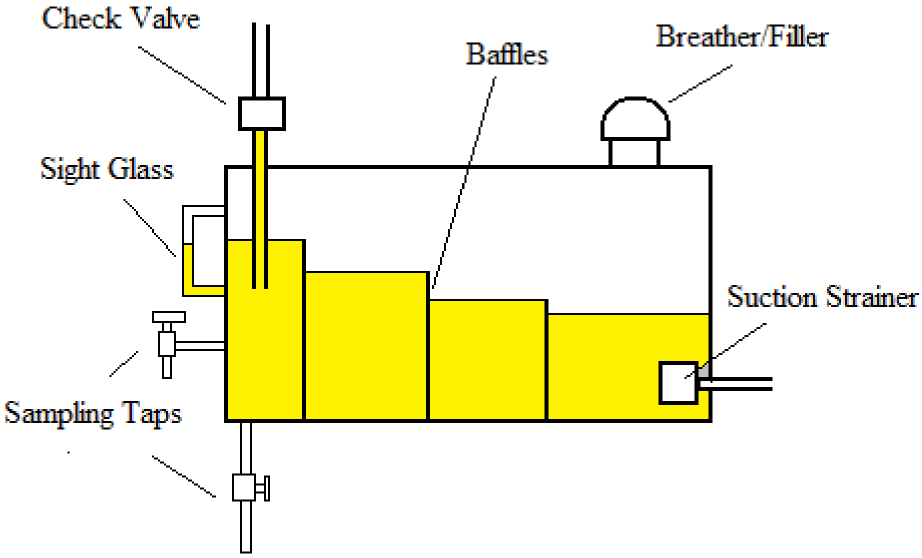

Figure 8

1 A baffle to reduce foaming.

2 Air filter to prevent dirt entering as air is drawn in through the breather when the oil level falls.

3 The inlet and outlet are not close together to prevent hot oil being re-circulated. The tank can be an effective cooler.

4 The return pipe is below the oil surface so that cascading does not occur; if it does, air will be mixed with the oil and foam will form.

5 A check valve in the return pipe to prevent back flow.

6 A sight glass to see that the level is between maximum and minimum.

9. System Protection

Avoid restrictions which produce a vacuum on the suction side of the pump. If the suction is restricted, air may be drawn in and the oil may form vapour pockets. This will lead to pump damage and oxidation of the oil.

A typical power pack might have on it a thermostat for detecting the fluid temperature. In the event of the fluid overheating, the thermostat might do the following.

Set off an alarm.
Switch off the pump
Switch on a cooling system.

The system might use a separate pump to circulate the oil through a filter and also a cooler. The cooler typically is a heat exchanger with the surrounding air. The thermostat would switch on the cooling fan to boost the cooling rate.

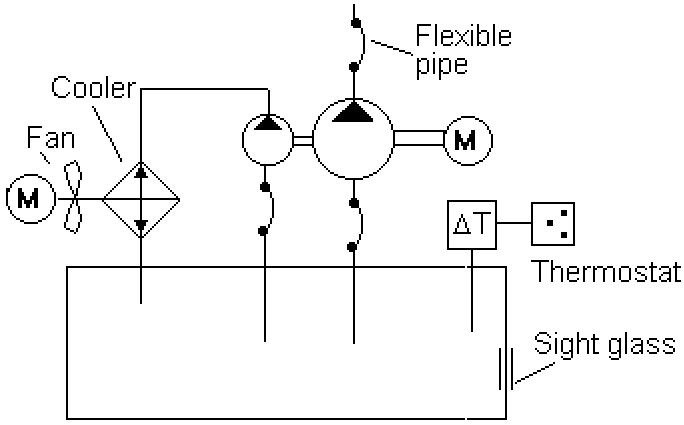

Figure 9

Vibration

It is normal to connect the suction side of the pump to the reservoir with a flexible hose and also the pressure side to the main system with a flexible hose so that vibrations produced by the pump are not transmitted to the tank or the system.

This is a good point to do the Work Sheet as part of your assessment. Tutors should modify the material to suit their situation and those just testing themselves should do what they can without having access to the hardware.

WORKSHEET

FILTERS AND POWER PACKS

Name ________________________________ Date ________________________________

On completion of these training exercises you should be able to do the following:

- Explain the purpose of filtration in a hydraulic system.
- Explain the types and construction of filters.
- Explain filter size and efficiency.
- Change a hydraulic filter.
- Explain the purpose of hydraulic fluids.
- Explain a typical power pack with reference to a circuit diagram.

PART 1

You must read the notes supplied on filters and fluids. When you have done this answer the following questions.

1. List 6 typical contaminants found in hydraulic fluids.

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2. An oil sample has an ISO4406 contamination rating of 20/14. How many particles are there larger than 5 microns in a millilitre sample?

____

3. How much contaminant should be removed by a 30 micron filter using absolute rating?

____

4. List the materials commonly used for surface and depth filters.

SURFACE TYPE	DEPTH TYPES

5. Draw the symbol for a full flow hydraulic filter with an automatic bypass.

6. State an important consequence of letting a filter become clogged.

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7. Describe two methods of indicating the state of a filter to the plant operator.

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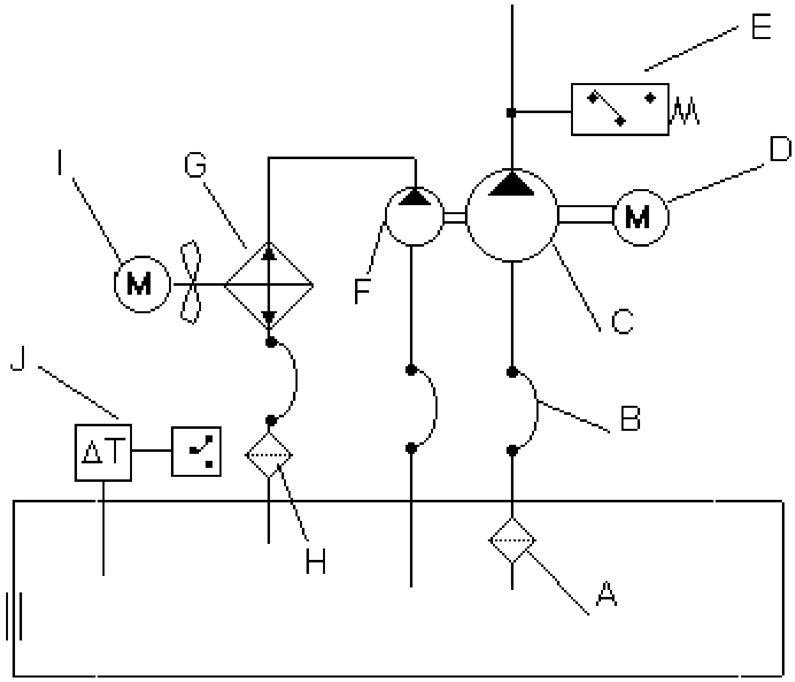
PART 2

Study the circuit diagram for a hydraulic power pack below. Study the features and answer the following.



How is the oil cooled? ____

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What are the thermostats on the oil tank for? ____

____

How is a clogged filter indicated? ____

What features are incorporated in the filler cap? ____

____

How is the level of oil in the tank indicated? ____

PART 3

Identify the items labelled A to J and state its purpose. The first answer is already completed to show you what to do.

A

<u>Suction filter or strainer to remove course dirt at suction to the main pump.</u>

B

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C

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D

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H

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I____

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J____

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