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The Purpose, Use and Care of In-line Liquid Filters.

Training For Operators, Maintainers, Technicians and Engineers.

Objective

This training teaches users and maintainers of in-line process liquid filters why they are used, how they work, what causes them to go wrong and what is necessary to keep them operating properly all the time, every time.

Training Contents

- Purpose of the equipment.
- The principles of how the equipment works.
- Important parts and assemblies.
- In-service design and operation.
- How the equipment achieves its purpose and the necessary operating conditions.
- Most likely failure modes, their causes and what to do about them.
- On-Site, workshop or test bench observations of an equipment installation.
- Compare the installation to the minimum design required.
- Conduct site tests and trails on the equipment operation.
    - Predict effect of changes.
    - Observe actual changes.
    - Identify impact of changes to the equipment operation.
- Learning Assessment
    - Explain purpose and use of equipment.
    - Identify how the equipment achieves its purpose.
    - Specify the required operating conditions for proper performance.
    - List what failures are possible at the workplace and how to fix them.
    - Training Supervisor review.

Outcomes of the Training

This training will make the trainee clear and knowledgeable in the proper use, care and maintenance of in-line liquid filters. It will give them in-depth knowledge of the equipment and the factors that affect its operation. They will use the new know-how to better operate, care-for and maintain such equipment in future.

Time Required

The training takes one hour to complete for able people with some industry experience.

Training in the Purpose, Use and Care of In-line Liquid Filters

Purpose of Equipment

In-line liquid filters are used to trap and remove small particles of solid or soft matter from a liquid stream. Typically a fine porous membrane or filament cartridge catches and holds the material while letting the liquid through.

Figure 1 shows in-line filters and the typical range of filter media or filter elements placed inside them to trap and remove fine particles from the liquid.





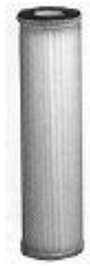


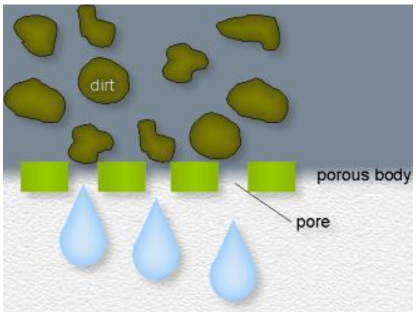
Figure 1 In-line Filter Housings   Filter Bags   Filter Cartridges Types

How the Equipment Works

The fabric or cartridges used in the filter have fine perforations, holes or channels in them. The holes or channels are sized to stop particles of a larger size. The dirt or contaminant is retained on the upstream side of the fibre or fabric element and the cleaned liquid passes through. The trapped material builds up the surface. As the contamination material thickens it becomes a filtering screen itself and acts to remove more and more finer material.

The method is known as 'surface filtration'. It is the way a coffee plunger works to separate the fine coffee grounds from the coffee liquid. The plunger screen is coated by the first grounds that contact it. As the plunger moves further more grounds layer over the first layer. The thicker the layer, the harder it becomes to push the plunger.

Figure 2 shows a filter membrane collecting material on the upstream side of the fabric while letting cleaned product through the pores. Figure 3 shows a magnified image of a filter membrane. Notice the passage ways through the membrane twist and turn to catch and trap material.



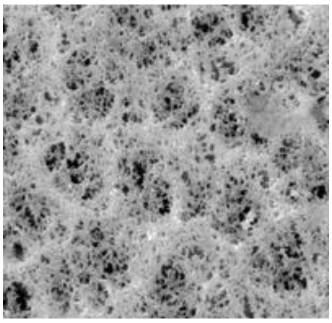


Figure 2 Porous Filter Medium   Figure 3   Filter Membrane Pores

With continued use the unwanted material in the liquid flow builds-up and thickens on the membrane surface. As the build-up gets thicker it gradually blocks-off the flow channels for the liquid and less liquid passes through. To maintain the same flow through the gradually thickening material build-up or 'cake' requires more supply pressure. Eventually the cake becomes so thick and dense that no matter how high the supply pressure, little flow occurs across the cake and element.

The material build-up or 'cake' must eventually be cleaned off so that the filter surface is again clean. Figure 4 is a diagram of what happens to the liquid pressure and flow as the contaminant material builds-up on the filter.

At the start, with a clean filter membrane, there is a rush of filtered liquid (the light blue area in Figure 4). The surface of the membrane starts to build-up cake of contaminant matter (the yellow area in Figure 4). Gradually, with continued use, the cake thickens and becomes interwoven and compacted on the membrane. Some matter may even find its way into the membrane pores and block them. Eventually the cake 'chokes' the liquid flow off and a back-pressure will develop up-stream of the filter (the dark blue line in Figure 4).

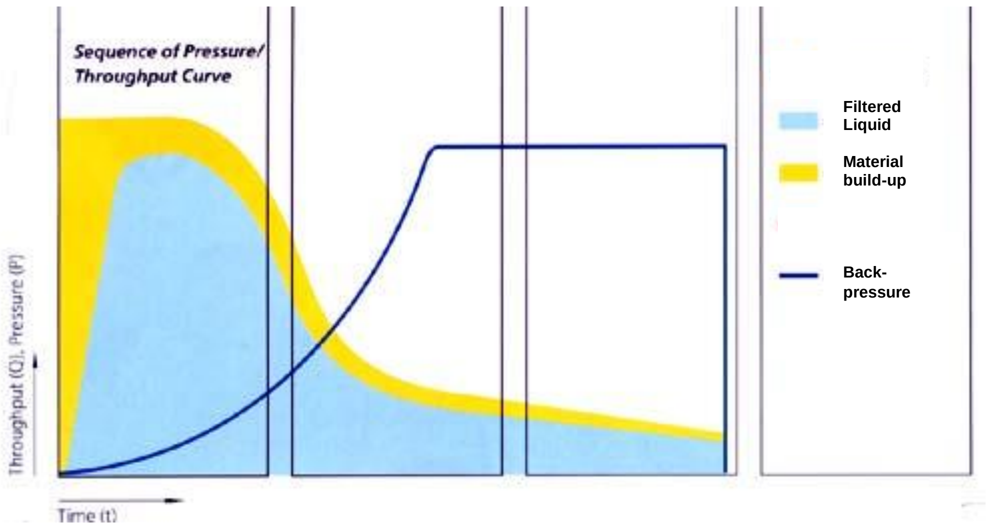


Figure 4 Effects of Material Build-up on Back Pressure and Liquid Flow Through a Filter

When placed into a pipeline or process stream it is necessary to know if the filter is blocking. Since the material blocking the pores causes a back-pressure in the liquid we can monitor the pressure and 'see' the effectiveness of the filter. By measuring the pressure change from clean to blocked surface it is possible to 'watch' the material build-up. Once the back-pressure is too much the filter must be opened and cleaned or replaced.

Important Parts and Assemblies

For a filter the important parts are the housing, filter media and the seal between the filter element and housing. The housing, seal and the filter medium need to be corrosion resistant to the liquid and its impurities. The seal between housing and filter must to be impassable to the liquid being filtered, otherwise the fine particles in the liquid by-pass and are not removed. If this happens the filtered liquid becomes contaminated. Figure 5 shows the construction and fine pores in typical filter membranes and cartridges.

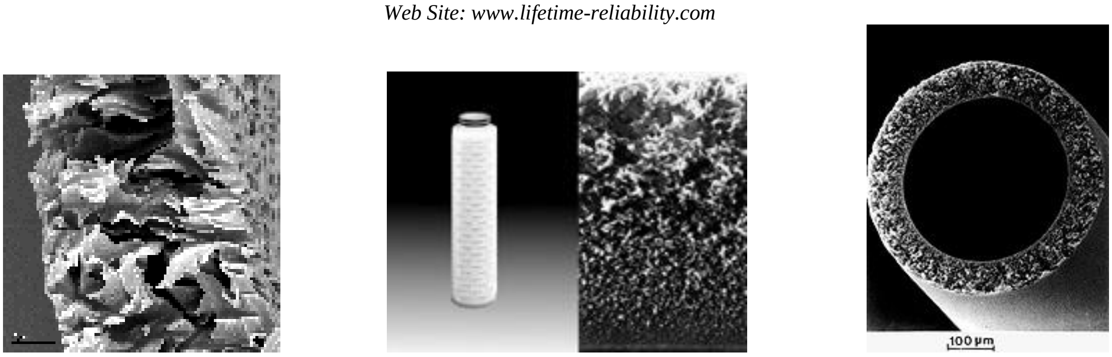


Figure 5 Filter Membrane Element Section Cross-Sections

In-Service Design and Operation

Figure 6 shows how a filter is set-up in a process circuit. Included is all the necessary equipment to insure the filter operates correctly and to permit its operation to be monitored.

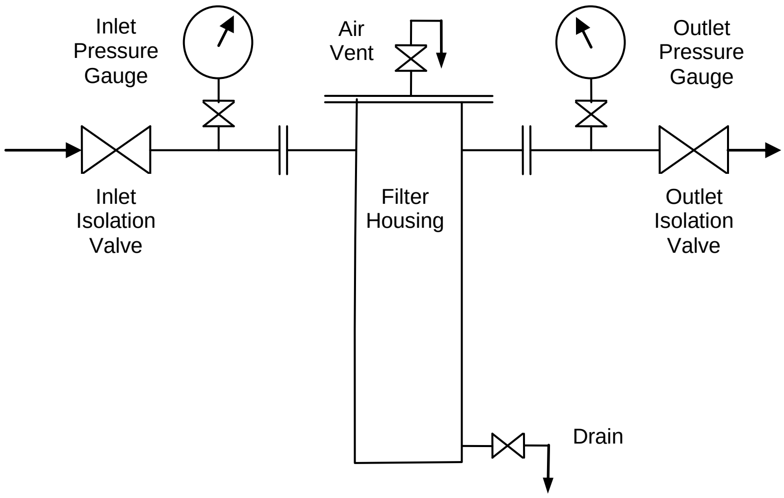


Figure 6 Minimum Filter Station and Strainer Design

Liquid enters from up-stream through the inlet valve. The upstream pressure is shown on the inlet pressure gauge. In situations where air, gas or vapour can be trapped at the top of the filter housing they are vented to a safe place. The liquid enters the housing and flows through the filter media. The media traps contamination larger than the rated pore size. The clean liquid continues through to the outlet. The outlet pressure is registered on the outlet pressure gauge.

Figure 7 show the two possible flow directions through a depending on purpose and design.

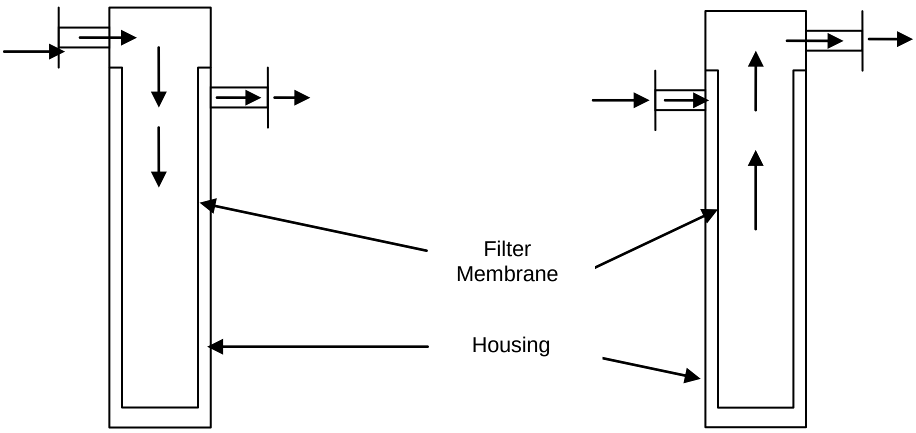


Figure 7 Liquid Flow Down Through Screen Liquid Flow Up Through Screen

How The Equipment Achieves Its Purpose And The Necessary Operating Conditions.

Look at first the filter station design. Liquid and contaminating particles flow under pressure to the filter. The inlet pressure gauge shows the upstream, in-coming pressure. The outlet pressure gauge shows the liquid pressure after passing through the filter. The outlet pressure is less than the inlet pressure because the filter screen traps the contaminating particles and builds a 'cake'. The presence of the thickening cake blocks flow and creates a back-pressure. The rising back-pressure acts to push the liquid through the built-up material and screen.

Look at the filter station drawing in Figure 8 below. Notice that the upstream pressure has risen and the downstream pressure has fallen. The screen build-up is becoming very thick and blocking flow. It needs to be cleaned away. It is time to de-pressurise and drain the filter. It will be necessary to remove and clean, or replace, the membrane element to return the filter back to a clean operating condition.

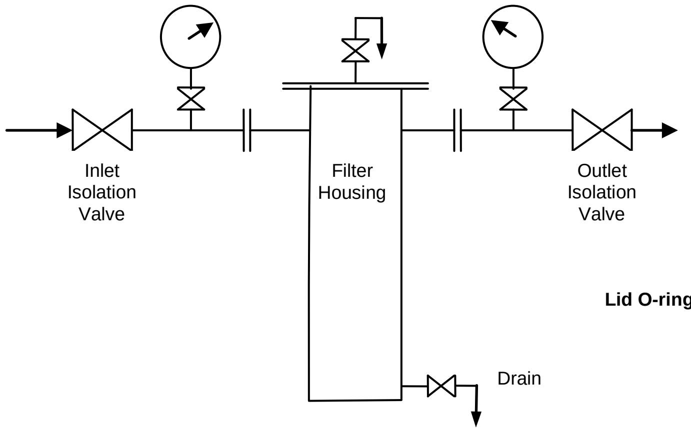


Figure 8 Filter After Use

Figure 9 Filter Lid and Seal

Factors Affecting In-Line Filter Operation

There are several key factors that must be confirmed to insure successful in-line filter operation.

- **Pore hole size** determines the size of particles that will pass through the screen and those which will not. The pores in the filter fabric must not be so large that the filter weave prevents the sediment bed, the 'cake', developing.

- **Filter cake thickness** should develop evenly across the screen. Fortunately the nature of creating a cake means that any preferential flow in one area builds the bed up with particulate until the pressure is even with the rest of the bed. Provided the contaminant size is evenly distributed in the flow stream the cake should filter equally everywhere.

- **Low flow velocity through the filter** is needed so as to not disturb the filter cake and move it off the membrane. This requires sufficient surface area of membrane to create the right liquid velocities. It also means that the filter should be sized to permit a long run between cleans, else it will require frequent, annoying cleaning.

- **Process chemical attack of the screen material** is prevented by proper selection of fabric of sufficient thickness to also provide the necessary mechanical strength to take the forces that develop as the back-pressure increases during the filtration run.

- **Sufficient pressure is needed** to force the material against the membrane and still push the liquid through the cake and membrane. That means as the cake thickens the upstream pressure must rise to push the liquid through the cake bed. Usually the pump speed is increased to boost the supply pressure.

- **Small particulate size in the cake** blocks liquid flow. Smaller than average size particle act to seal the pathways for the liquid to flow around the larger particles.

Possible Failure Modes Causes, Prevention and Corrective Actions

Problems with Filter Membranes, Elements and Housings

- **Screen or fabric blinding** occurs when the smaller particles to be filtered get caught in the screen itself and block the pores. This introduces a solid obstruction to the flow. If enough pores are blocked the flow falls and back-pressure builds quickly. If this occurs it may be necessary to change screen or membrane design, or the shape of the pores.

- **Screen or fabric rupture** can be a result of fair wear-and-tear over a long period of time. It could also be the result of high local velocities across the screen; large solids impacting the screen, ‘water hammer’ pressure surges, excessively high differential pressure across the membrane or chemical attack.

- **Poor fabrication or assembly** of the membrane onto the frame. Do not cut or damage the filter membranes when installing them in the housing. Replace damaged cartridges or membranes. They must seal into the housing so that the flow cannot pass between the seal between element and frame.

- **Improper cleaning of the screen** due to blinding or old sediment build-up. If necessary repeat the cleaning sequence to try and dislodge the cake. Chemical cleaning can be used if safe to do so or use hot liquid flushing in an attempt to soften the built-up. Mechanical cleaning with water jetting may remove surface build-up. Ultrasonic cleaning may remove deeply imbedded materials.

- **Silted filtrate from the filter** can be a sign of element rupture or contaminant break-through. If sediment has got past the filter it will end up downstream and possibly ruin the product. Monitor the pressure gauges at the filter station and change or clean the filter when the upstream backpressure gets high. If the down stream pressure is unexpectedly near to the up-stream pressure it a good sign that the screen has failed and needs to be replaced.

- **Secondary filters** should be used downstream of the primary filter if it absolutely critical that the product is not contaminated. Without a second filter there will be occasional times that the membrane fails, or the filter will be incorrectly assembled, and contaminants will get past.

- **Filter lids seals must close leak-free** to stop escape of product. The lid seal can become compressed and not retain its shape with constant use. The seal material may deteriorate with time and use and start to leak. The seal can be accidentally damaged. Inspect the seal and replace it with a new one at regular intervals before it starts to leak. Insure the seal sits snugly in its required position when closing the lid and does not move during the tightening down process.

On-Site Test, Workshop or Lab Test of an Installation and Learning Assessment

It is now time to do some 'hands-on' training in the field, or with a spare, or on the test-bench. To thoroughly understand this topic it is best to see what happens in a working situation and practice by making and controlling changes. You will better understand what the equipment does, and how to run it well, if you can operate it. Locate suitable equipment in your plant that you will be allowed to adjust and inspect.

1. Locate the manufacture's operating manual if available or find it on-line over the Internet. Take the time to read it. Tag anything you don't understand and come back to it at the end of the training to see if you come to know what they mean.

2. Hand-sketch below the equipment installation at your workplace and write the name of the individual equipment items on the sketch.

3. Internal Inspection

3.1. Once it is safe to do so, open a filter and look inside. Name and describe below each equipment part of the filter. The manufacturer's manual and parts list can help you.

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3.2. Remove a membrane or cartridge element and write a short description of its surface condition, its component parts and how it is built.

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3.3. Describe how to install the filter element into the housing and get a perfect, no-leak seal in your installation. Describe how to insure the lid seals liquid tight on your equipment.

4. If at all possible, and once you have supervisor permission, operate the equipment to see what effects happen as the operating conditions change. If you cannot operate a real item of equipment then describe as best you can what will happen to the process due to the change.

4.1. Clean Membrane, Start-Up Conditions.

Starting with a clean filter, record the pressures upstream and downstream of the filter and calculate the difference.

4.2. Effect of Cake Build-up.

Describe what increasing 'cake' build-up on the filter membrane or cartridge will do to the upstream pressure? You can mimic the effect by gradually closing the outlet valve.

4.3. Pressure Difference with Cake Build-up.

If there was a cake build-up on a particular in-line filter at your workplace, note below at what pressure difference you would have to act to clean to replace the filter. How much is the change in backpressure values between the clean condition and the blocked condition? If necessary ask an experienced operator or see the operating manual.

5. Describe Below How an In-Line Filter Works to Provide Clean Filtrate.

6. Possible Modes of Failure

6.1. List the Ways That In-line Filters Have Failed to Perform Properly at Your Workplace. Talk to the experienced operators and maintainers if necessary.

6.2. Getting the Equipment Back to Proper Operation.

For each failure mode listed above, describe in detail what needs to be done to correct them.

This is the end of this training. Please record the following details and hand your answers back to the supervisor in charge of this training.

Trainee ________________________________ **Signature** ______________________________
(Print Name) (Trainee)

Supervisor ______________________________ **Signature** _____________________________
(Print Name) (Supervisor)

Assessment Result: ☐ Pass

☐ Repeat

Completion Date ___________________ 'Pass' recorded in the Trainee's training records ☐