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The Purpose, Use and Care of Pressure Leaf Filters.

Training For Operators, Maintainers, Technicians and Engineers.

Training Objective

This training teaches users and maintainers of pressure leaf filters why they are used, how they work, what causes them to go wrong and what to do 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.
- Most likely failure modes, their causes and what to do about them.
- On-Site, workshop or test bench observations of an equipment installation.
- 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 pressure leaf 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

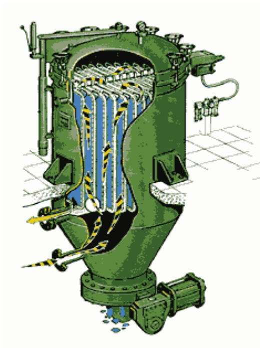
The training takes one hour to complete for able people with some industry experience.

Training in the Purpose, Use and Care of Pressure Leaf Filters

Purpose of Equipment

Pressure leaf filters are used to remove small particles of solid or soft matter from liquid streams. Typically a fine metal or plastic mesh screen, or a woven fabric, is used to retain the particles while letting the liquid through. The particles layer on the screen and coat it. The coating thickens into an intertwined ‘filter cake’ (see Figure 4) which filters out even finer particles. The screen acts as the support mechanism and the ‘cake’ does the filtration. For removal of very fine material or slimy material a cake is purposely formed on the screen by first ‘precoating’ the screen.

Figure 1 shows several types of pressure leaf filters.



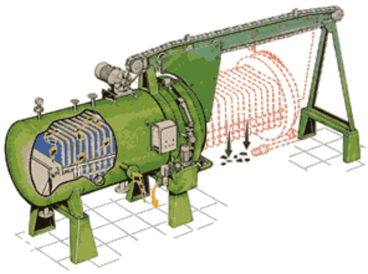


Figure 1 Vertical Leaf Pressure Filter Horizontal Vessel Leaf Pressure Filter Horizontal Plate Pressure Filter

Leaf filters consisted of flat, circular or rectangular filter elements spaced apart inside a pressure vessel. Circular designs are clamped together on a centre shaft while vertical designs are positioned side by side on a manifold. A coffee plunger is a leaf filter.

How the Equipment Works

The mesh or fabric used as a filter screen has fine holes in it. The mesh is drawn tight across a frame and supported underneath by a strong, courser mesh or structural ribs. The screen holes are sized to stop particles of a larger size. The contaminant is retained on the upstream side of the screen and the cleaned liquid passes through. The trapped material builds up the screen’s surface. As the contamination material thickens it becomes a filtering screen itself and acts to remove the contaminants in the liquid.

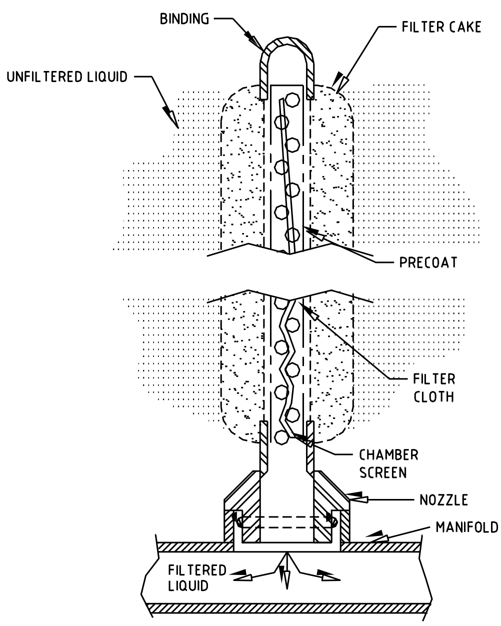


Figure 2 Wire Leaf Filter Screens Cross-section of a Precoated Wire Leaf Screen

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 build-up, the harder it becomes to push the plunger.

Figure 2 shows a picture of a leaf filter screen and a drawing of the cross-section through such a screen when in use.

Use of Precoat and Body Feed

When particularly fine filtration is required and the screen hole size is not sufficiently small a precoat is first layered onto the screen as a bed on which the filtered material can form and not be flushed through the screen (se Figure 3). If the filtered material rapidly causes back-pressure it is possible to use the filter aid as a body feed continuously injected into the liquid stream. In this case the body feed settles onto the screen along with the material to be filtered and creates cavities and openings through the cake which become fine passages for the liquid to pass but are too small for the contaminant.

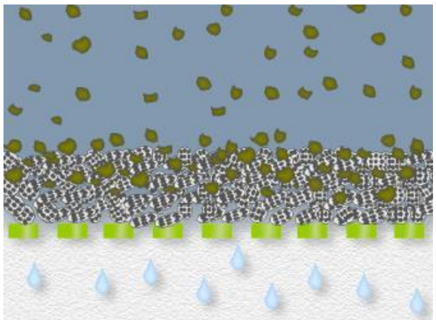


Figure 3 Precoat on the Screen

The first filtered particles are held back by the screen or precoat. They begin to bridge over the holes and voids. Soon the bridged material becomes the actual filtering media and the screen only acts as the supporting structure.

Precoat is not used unless it is necessary. Long, streaky or flat contaminants intertwine and will form a weave mat across the screen. Round or chunky contaminants tumble together filling up the gaps between their neighbours and themselves to form a sediment bed across the supporting screen.

Figure 4 Filter Cake

During operation the unwanted material in the liquid flow builds-up and thickens on the screen or precoat surface. As the operation progresses, the contaminating material comes to rest against itself intertwined and compacted. Very small liquid flow paths or channels develop in the spaces between and beside each particle. When the liquid flows through these channels the contaminants get caught in the winding passage and are trapped.

Over time, the build-up thickens and grows and the flow channels and passages through it gradually start to block and disappear. To maintain the same flow through the gradually thickening 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 5 is a diagram of what happens to the liquid pressure and flow as the contaminant material builds-up on the filter screen. In this case a precoat has been applied.

At the start, with a clean filter screen and precoat, there is a rush of filtered liquid (the light blue area in the figure). The surface of the membrane starts to build-up cake of contaminant matter (the yellow area in the figure). Gradually, with continued use, the cake thickens and becomes interwoven and compacted on the membrane. The finer matter may even find its way into the inner passages 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 the figure).

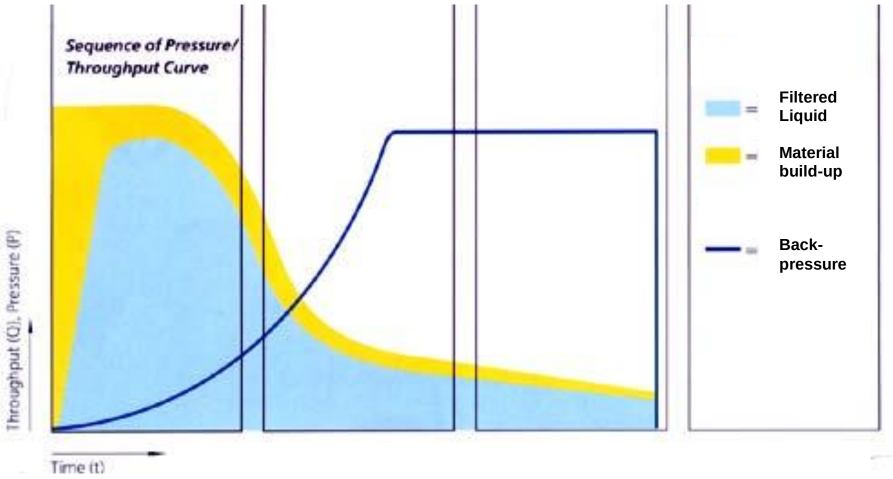


Figure 5 Effects of Material Build-up on Back Pressure and Liquid Flow through a Leaf Filter

The built-up sediment cake can be removed by a number of methods. Shaking, spinning and blown-off by water or air are common. Automatic cleaning sprays starting at the top and working their way down can be installed and used to wash down the screens. Shaft mounted screens are spun clean by rotating the screens at high speed after emptying the filter. Non-automated designs of filters require them to be opened up and the screens manually hosed down or shaken.

<u>Important Parts and Assemblies</u>

The pressure housing, manifolds, shafts, the filter screen and its frame, and the seal between the filter screen outlet and manifold need to be corrosion resistant to the liquid and its impurities. The seal between manifold and screen must be impassable to the liquid being filtered, otherwise the fine particles in the liquid are not removed and by-pass into the clean filtrate. If this happens the filtered liquid becomes contaminated. Figure 6 shows the major components in a horizontal leaf filter.

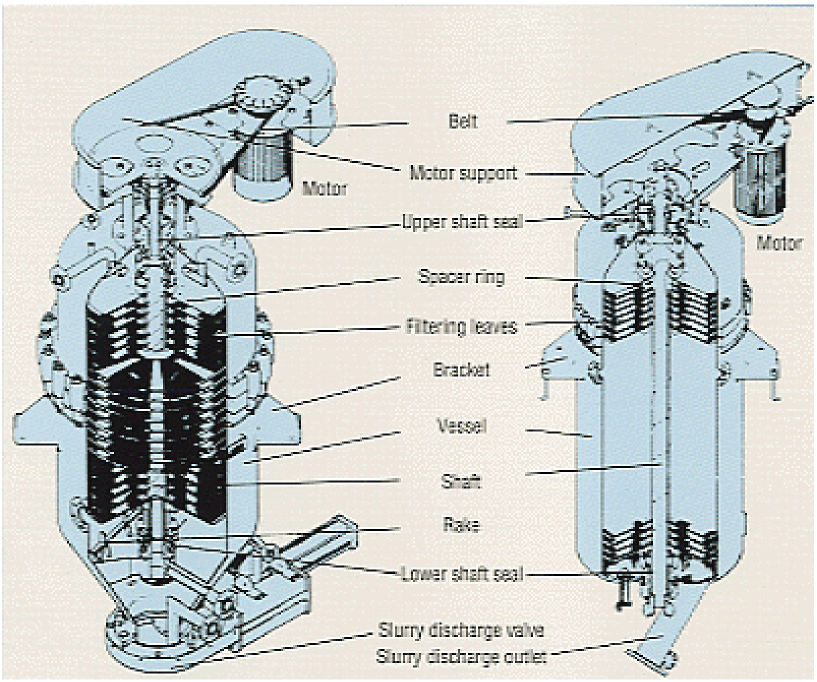


Figure 6 Sectional Views of Vertical Pressure Leaf Filter Showing Components

The filter leaf is the most important component of the pressure filter. Each leaf has its own filtrate discharge outlet. For a vertical screen (Figure 7) the discharge nozzle is placed into a horizontally mounted manifold. For a horizontal screen the discharge is through a central shaft. Every leaf can be taken out individually. As the leaves filter on both sides, a large filtration area can be obtained in a relatively small vessel.

Figure 7 Vertical Leaf Screen Outlet Port

In-Service Design and Operation

Figure 8 shows how a vertical pressure leaf filter is set-up in a process circuit.

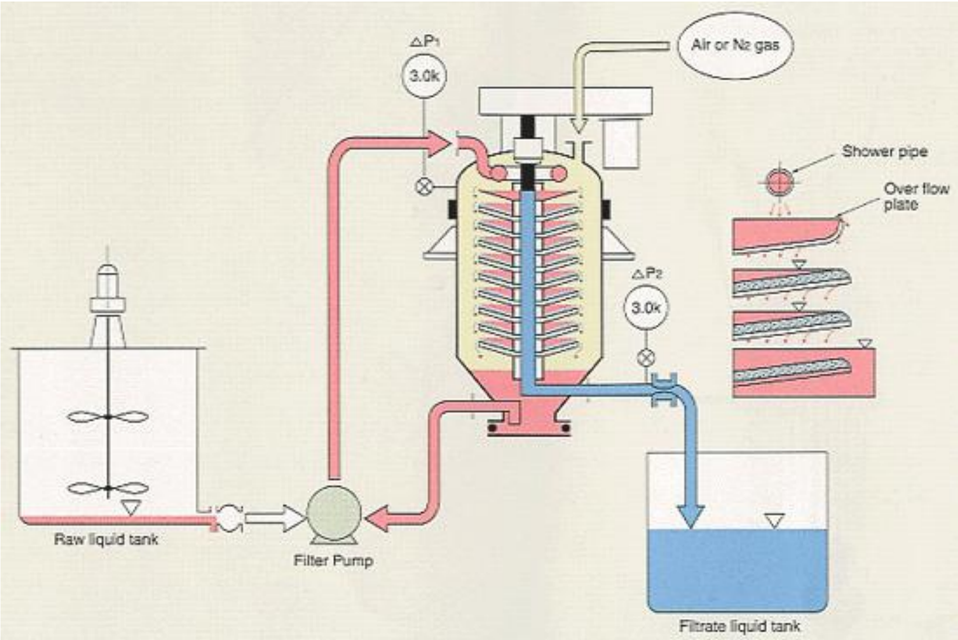


Figure 8 Liquid Flow Through a Vertical Pressure Leaf Filter and Screens

The liquid to be filtered is pumped into the filter. As if flows it carries the contaminant material with it. The screen traps the material and it becomes covered in matter. Where the material settles it acts to shield the liquid flow from the screen. The liquid then flows to where there are fewer blockages. As it flows through the unblocked areas the contaminant now covers those areas and flow through the area again slows. The liquid then finds the next area of least blockage. In this way the liquid covers the filter screen evenly with material and the cake builds equally in thickness.

The supply pressure from the pump forces the liquid through the thickening cake and past the screen. The filtered liquid, or filtrate, flows through the centre chamber on the screen and out the outlet ports to continue through to the next step of the process.

When in a process stream it is necessary to know if the filter is blocking. Since the material building on the screens 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 screens must be cleaned or replaced.

The upstream pressure gauge shows the 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 harder to push the liquid through the built-up material and screen.

If a precoat is needed it is feed into the suction side of the Filter Pump and the liquid is circulated until the screens become coated. Once the filter screens become too blocked the filter run is ended. The screens are cleared of the build-up and the material is removed from the filter so it can be brought back to a clean condition ready for the next filter run.

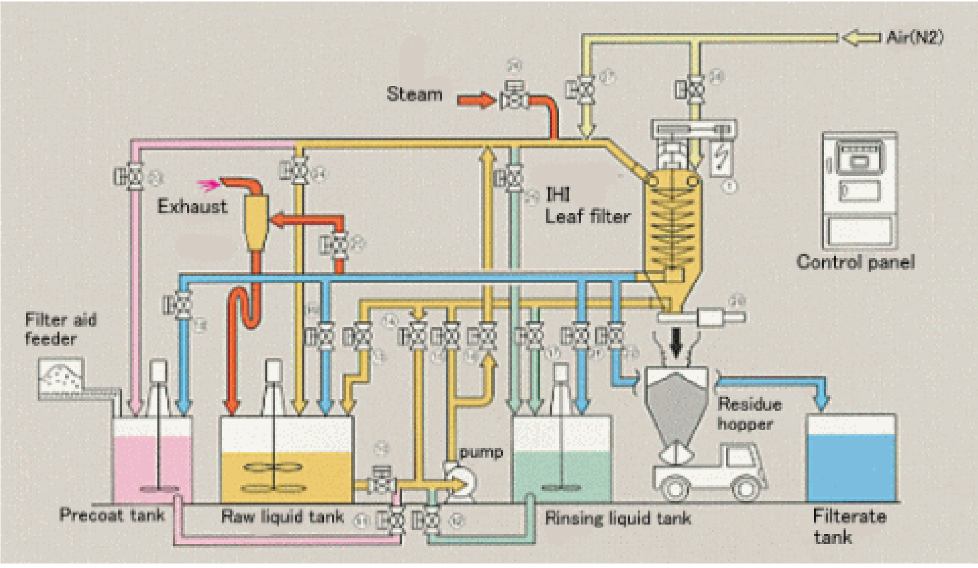


Figure 9 Simplified Pressure Filtration Process

Figure 9 shows a simplified pressure leaf filter system design. Liquid and contaminating particles flow under pressure to the filter to be cleaned. At the filter screens the liquid passes through but the contaminants are trapped on the screens and removed from the flow. The clean filtrate exits the filter to the next part of the process. The captured contaminants are removed from the screens when they no longer pass a sufficient flow of liquid.

The precoat and cleaning processes are also shown. Compresses air is used to blow the last of the liquid out of the filter before cleaning the screens. Steam is often used to sterilise the filter internals in a food process, or to boil-up the filter and soften the captured sediment in an industrial process before its removal

Factors Affecting Pressure Leaf Filter Operation

There are several key factors that must be confirmed to insure successful leaf filter operation.

- **Screen hole size** determines the size of particles that will pass through and those which will not. The holes in the screen must not be so large that the sediment bed, the 'cake', cannot develop.

- **Filter cake thickness** must 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.

Figure 10 Filter cake edge-on

- **Preferential tracking through the cake** occurs wherever the sediment bed is not of equal consistency or thickness. If the contaminant or body feed changes it properties or characteristics during the filter run for short periods of time the screens will not be seen by the liquid as equal all over and it will flow through the locations of least resistance. Sometimes large material and foreign matter can also settle on the screens and produce an uneven filter bed.

- **Low flow velocity through the filter** is needed so as to not disturb the filter cake and move it off the screen. This requires a sufficient surface area of screen 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 annoyingly require frequent cleaning.

- **Process chemical attack of the screen material** is prevented by proper selection of screen 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 screen. 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.

- **The right size distribution in the cake** is necessary for good flow with good filtering results. The filter bed material size distribution must form channels for the liquid to flow through while still capturing the contaminants. Take a sample of a good performing filter bed and get the material size distribution tested so that you know and have a record of the correct proportions of material size in its make-up.

Possible Failure Modes Causes, Prevention and Corrective Actions

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

- **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 screen onto the frame. Do not cut or damage the filter screens when installing them in the housing. A crease or scratch in a mesh screen becomes a stress raiser and a tear will develop at a stress point before it happens anywhere else. Replace damaged screens. The screen must seal onto the support frame so that the flow will only pass through the screen. The outlet from the screen must seal into the manifold so that no bypass is possible.

- **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 for the screen material 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. Take regular samples during the filter run and check them for clarity. You might save a disaster if you catch a damaged screen or break-through early enough.

- **Polishing 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 screens fail, or the filter will be incorrectly assembled, and contaminants will get past.

- **Filter body seals must close leak-free** to stop escape of product. Elastomeric (rubber) and plastic seals can become compressed and not retain their shape after long periods of use. The seal material may deteriorate with time and use and start to leak. The seal can be accidentally damaged. Inspect seals and replace them with new at regular intervals before leaks start. Insure the seal sits snugly in its required position when reassembling the filter and that it does not move during the tightening down process.

- **Rotary shaft seals will fail quickly** if they are not kept clean. The seals on horizontal filter shafts need to be supported against the shaft to seal properly. Usually a pressurised flush is injected into the seals to 'balloon' them out against the shaft and hold the sealing lip against the shaft. If the 'balloon pressure' is too low or it is turned off or lost, the liquid and particulate in the filter will leak past the seals and damage them.

- **Allow no vibration of a horizontal filter body during cleaning** or the shaft seals will fail from hammering by the shaft as it is shaken from side to side.

- **A too small particle size distribution in the cake** will cause the flow to fall. Smaller than average size particles act to seal the pathways for the liquid to flow around the larger particles. If you have uncharacteristic low flows check that the particles size distribution in the liquid is normal. If there are too many small particles they pack together closely and block the flow. Find out why the particles size distribution has changed. Where an agitator is used upstream in the process to keep material suspended check that its paddles or blades have not worn away. If the heavier material falls out of suspension, leaving only the finer material, it will not allow sufficient or large enough passages for the liquid to flow.

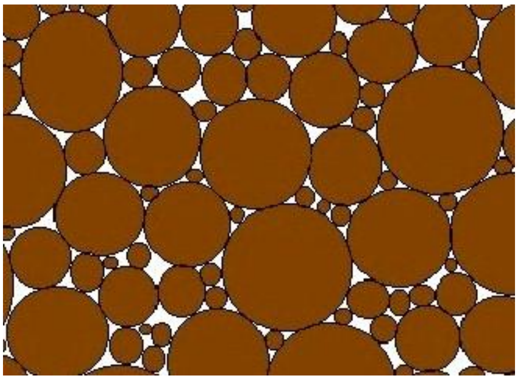


Figure 11 Particles Size Distribution

- **Leaf spacing must allow the cake to build** and still have a long filter run. If the filter leaves are too close the cake can build and grow till it touches the neighbouring screen or a growing filter cake. When the cakes get close the edge-on area available for the liquid to wash across the screen reduces and velocities increase at the edges. The higher velocity can rip the cake off the screen. In some cases with reducing edge gap between screens less liquid can enter and the flow drops quickly.

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 a 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 and see how it behaves. 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 filtering process 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.

3.2. Inspect a screen and write a short description of its surface condition, its component parts and how it is built.

3.3. Describe how to install the filter screen into the housing and get a perfect, no-leak seal in your installation. Describe how to insure the filter housing is sealed 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 Screen, 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 thickening 'cake' build-up on the filter membrane or screen will do to the upstream pressure? You can mimic the effect by gradually closing the outlet valve or observing what happens during a filter run.

4.3. Pressure Difference with Cake Build-up.

If there was a cake build-up on a particular filter at your workplace, note below at what pressure difference you have to act to clean 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 a Pressure Leaf Filter Works to Provide Clean Filtrate.

6. Possible Modes of Failure

6.1. List the Ways That Leaf 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.

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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 ☐