KNOW HOW!

Avoiding and eliminating filter cartridge clogs in wine and sparkling wine filtration

Careful consideration of filtration solutions yields decisive advantages in many processes: Improvement of product quality, minimization of down-time, and a reduction in maintenance and disposal costs. It's not only the filter itself that contributes to efficient filtration but also proper handling of the filter media, the associated processes as well as experience and detailed knowledge. The goal, with the help of optimal coordination of all of these aspects, is to exploit the full potential of the filter's service life, especially avoiding early clogging.

Wine and sparkling wine filtration use depth and membrane filter cartridges. Proper use and handling of filter cartridges may eliminate the causes of clogging. Vinification and filtration parameters can be reasons for early clogging.

Differences between membrane and depth filter cartridges

Filter cartridges not only differ in their retention ratings, but also differ in other features. The following table compares filter cartridges to help facilitate selection in wine and sparkling wine production.

Membrane filter cartridges are always pleated because they require a large surface area. With absolute retention ratings of 0.45 µm and 0.65 µm, they are used as the "police filter" for microbiological stabilization during filtration for bottling.

Depth filter cartridges are either wrapped or pleated. Wrapped depth filter cartridges are preferred for wine and sparkling wine filtration. The fleece is wrapped from coarse to fine around the core. The filter material gets tighter and tighter towards the inside. This graded wrapping allows fractionated depth filtration and increases the cleaning effect in the regeneration phase when the filter cartridges are freely rinsed backwards. The structure of the fleece can collect and retain a broad spectrum of particles. The graded wrapping allows for easy removal of the collected particles in the regeneration phase and reuse, therefore leading to longer service life of the depth filter cartridge. The wrapping increases the mechanical stability and allows it to regenerate at higher pressures compared to pleated filter cartridges. With a nominal retention rating of 0.2 µm or 0.3 µm, depth filter cartridges are especially suitable for fine filtration because they largely retain filter-clogging substances to protect downstream membrane filter cartridges.

	Membrane filter cartridges	Depth filter cartridges
Material	Pleated hydrophilic polyethersulfone (PES) or polyvinylidene fluoride (PVDF)	Wrapped or pleated, hydrophobic polypropylene (PP)
Application	Sterile filtration	Clarifying, fine filtration and protection of the membrane filter cartridge
Mode of action	Separation of clogging substances on the surface	Separation of clogging substances in the fleece matrix through the sieving effect
Retention rating	Absolute retention rating: LRV (log reduction value), determination with test bacteria	Nominal retention rating: ß-ratio or efficiency of retention, determination with defined particles; by definition, these filter cartridges have an absolute retention rating at a ≥ 5000 ß-ratio or a ≥ 99.98% efficiency of retention
Economical service life per 30" filter cartridge	Approximately 150,000 – 400,000 liters	Approximately 150,000 – 800,000 liters

Table 1: Different features of membrane and depth filter cartridges

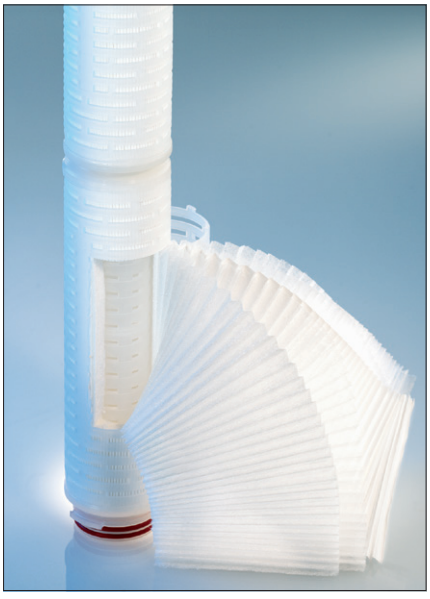

Figure 1: Membrane filter cartridge

Clogging substances

The wine to be filtered contains substances of different particle sizes like diatomaceous earth, yeasts, bacteria, proteins, glucans, pectins, and polyphenols that can cause clogs.

During pre-filtration, particles like diatomaceous earth and yeast are reliably retained in the graded fleece matrix of the depth filter cartridges while bacteria and glucans are reduced. The volume of pectins, proteins and polyphenols is slightly reduced in this filtration phase.

Causes of clogs

The results of internal cartridge analyses show that filter cartridges become clogged in very different ways.

Membrane filter cartridge clogs are found on the surface and in the matrix often due to fine colloids and bacteria. Further evaluations are possible using special analytical devices.

Depth filter cartridge clogs can obstruct the internal, middle or external fleece and are most often caused by particles. Iron testing, copper testing, erosion of coatings and microscopy allow the particle load to be analyzed easily.

The test results often provide the basis for solving the clogging issues.

Table 3 summarizes frequent triggers and causes of clogged filter cartridge and recommendations on how to avoid them.

If filtration for bottling does not go smoothly, the cause typically lies in the poor filterability of the wines and the service media like rinse water and steam condensate. For an optimal filtration process, determine the filterability of the wine and, if applicable, the quality of the service media before starting filtration.

Determination of filterability using index measuring

The BECO LiquiControl2 index measuring device from Eaton can be used to determine the filterability of wines and sparkling wines ready for bottling as well as service media.

This determination allows:

- Timely introduction of measures to improve filterability and reduction of downtime
- Best possible calculation of regeneration intervals
- Check of service media
- Optimal design of filter cartridge systems

To measure the filterability, the operator fills 2.2 l or 3.2 l (0.58 gal or 0.85 gal) of wine ready for bottling into the reservoir of the index measuring device and inserts a 0.45 µm flat filter membrane into the filter holder. The operator vents the system after it starts. The index measuring device automatically applies a preset overpressure of 1 bar (14.5 psi) and filters the wine through the inserted membrane. If the flux (flow rate) is 50 ml/min. (0.01 gal/min.), the membrane is considered clogged, and the device stops filtering automatically.

The filterability is determined based on the targeted filter volume (see Table 4). In a two-layer mode, the end flux of 3 liters (0.79 gal) is also significant. This value should be > 200 ml/min. (0.05 gal/min.). In wines that are difficult to filter, an additional tight pre-filtration improves filterability by reducing microorganisms and fine colloids.

The filtration of service media is essential because particles and contaminants can considerably reduce the success of cleaning the filter cartridges or damage them. The test membrane discs from the index measuring device are also visually inspected in addition to the test results and analyzed in the lab if necessary.

Filter sizing taking flow rates and differential pressure into account

Clogging can arise early in wine filtration. Depending on the wine's particle load, the respective filter steps can become clogged or blocked.

The proper sizing of the membrane and depth filter steps is a precondition for a good and efficient filtration outcome. Determine the following factors before layout:

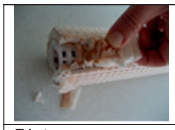	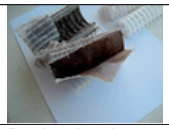	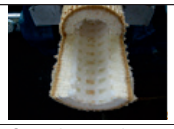		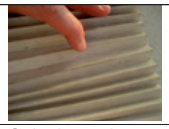
Diatomaceous earth blockage, leakage at the diatomaceous earth sieves	Particle blockage on the external fleece in the filtration direction and filtrate-side blockage on the inner fleece by desolved particles from chemical cleaning	Clogging on the external fleece because of coarse product contaminants	Filter fleeces are heavily coated with soil and iron from the rinse water	Soiled membrane surfaces

Table 2: Actual clogging examples

– Filtration requirements and targets
– Flow rate
– Filterability of the wine to be bottled

The initial differential pressure is understood to be the differential pressure (resistance in the filter cartridge) at the start of filtration at a constant flow rate. For a new filter cartridge, it should be under 0.2 bar (2.9 psi) to help ensure long service life and timely initiation of the cleaning process (at maximum 0.5 bar/7.25 psi). This is achieved with the appropriate flow rates. They are between 400 and 700 liters per hour (106 – 185 gal/hour) for 30-inch BECO filter cartridges for the filter cartridge types mentioned above.

Triggers	Causes	Recommendations
Product	Addition of fining and stabilization agents, e.g., metatartaric acid, CMC, gum arabic, tannin, etc.	Observe additional time according to manufacturer specifications, tight pre-filtration
	Fine colloids (mash heating, grape rot, long storage on its own yeast)	Use enzymes in wine processing, like the SIHA® Panzym® Fino G enzyme
	Filter clogging due to fine colloids, size < 0.5 µm, aggregation of the finest particles after approximately 4 hours	Allow 2 to 3 hours between pre-filtration and bottling (ensured through index measurement)
	Wine quality and vintage issues	Tight pre-filtration when germ count is large and pH value > 3.7
Service Media	No cold and hot water filtration	Water filtration through 1.0 – 0.5 µm BECO® PROTECT® PG depth filter cartridges (also two-step filtration)
	No steam filtration	Steam filtration through 10 µm BECO PROTECT KM stainless steel cartridges
Filter (Regeneration)	Hot water temperature < 70 °C (158 °F), inadequate hot water volume	Hot water temperature > 75 °C (167 °F), ideal 80 – 85 °C (176 – 185 °F), minimum 30 l/30" cartridge, "early regeneration at Δp < 0.5 bar/7.25 psi"
	Residual clogging (example: 0.4 bar/5.8 psi differential pressure, i.e. approx. 50% of the filter surface area is blocked!)	Influence of hot water overnight or chemical cleaning
Filter (Design)	Too high flow rate	Flow rate of membrane 0.45 µm: 400 l/h/30" cartridge: Wine difficult to filter Up to 700 l/h/30" cartridge: Wine easy to filter Flow rate of depth filter cartridge 0.3 µm: 400 l/h/30" cartridge: Wine difficult to filter Up to 500 l/h/30" cartridge: Wine easy to filter
Filter (Combination)	Insufficient pre-filtration	Process options for pre-filtration prior to 0.45 µm membrane filter cartridges: • BECO Steril S or BECOPAD 115C depth filter sheets • BECO PROTECT PG (0.3 µm), FS (0.2 µm) or BECO PROTECT CS 115 depth filter cartridges Process options for pre-filtration prior to 0.65 µm membrane filter cartridges: • BECO Steril S or BECOPAD 115C, 170 depth filter sheets • BECO PROTECT PG (0.6 µm, 0.3 µm) or BECO PROTECT CS 115, 170 depth filter cartridges

Table 3: Triggers and causes of filter cartridge cloggings and recommendations for avoidance

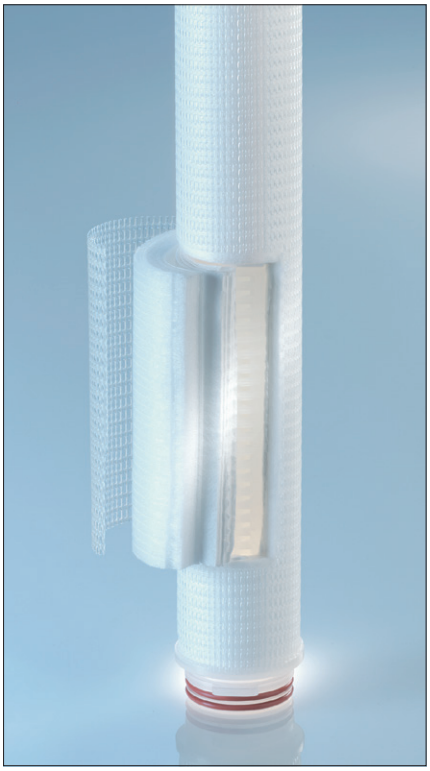

Figure 2: Depth filter cartridge

High differential pressures (large resistance in the filter cartridge) lead to earlier clogging. The pressure gradient is then no longer linear but rather exponential and has to be regularly monitored on the manometers of the filter cartridge housing. The differential pressure (△p) gives the difference between the inlet pressure (pI) and the outflow pressure (pO) and is stated in bar or mbar (1 bar = 1000 mbar/14.5 psi).

The maximum permitted differential pressure during filtration, regeneration or sterilization depends on the temperature. It must always be observed to prevent damage or destruction of the filter cartridges.

The end differential pressure is the differential pressure from the end of filtration upon termination of filtration in the case of early clogging. For simple and successful cleaning of the filter cartridges, it should be ≤ 0.5 bar/7.25 psi. The rule of thumb is: If the end pressure differential is twice as much as the starting pressure differential (at the same flow rate), the filter surface area is already clogged approximately 50 percent. The earlier cleaning is performed, the more effective it is. At differential pressures above 1 bar/14.5 psi, the filter cartridges can barely be rinsed clear with hot and cold water.

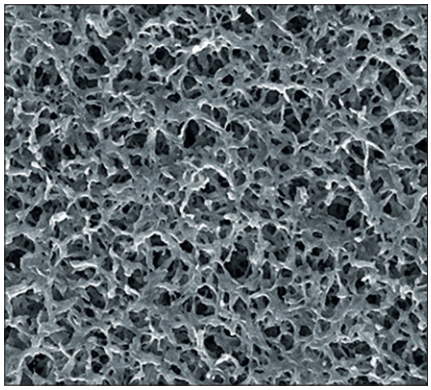

Figure 3: Matrix membrane filter cartridge

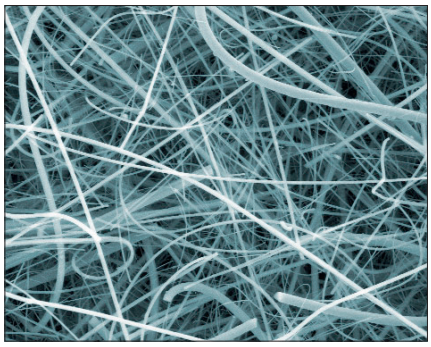

Figure 4: Matrix depth filter cartridge

Regeneration recommendations with cold and hot water

Eaton recommends regenerating filter cartridges with a differential pressure of ≤ 0.5 bar (≤ 500 mbar/7.25 psi, see Figure 7) in every case, yet after each filtration. In the process, the membrane filter cartridges are rinsed in the direction of flow and wrapped depth filter cartridges are rinsed against the direction of flow. The flow rate for cold and hot water depends on the flow rate that will be used for wine filtration.

The procedure for the regeneration process is as follows:

– Rinsing the filter cartridges with cold water at 1 to 1.5 times the flow rate and 0.5 bar/7.25 psi counter pressure until clear water flows (2 to 5 minutes)
– Rinsing the filter cartridges with hot water (80 °C/176 °F) at 1 to 1.5 times the flow rate and approx. 40 liters (10.6 gal) per 30-inch filter cartridge until clear water flows (10 to 50 minutes)
– To improve the regeneration effect: Allow hot water to stand in the filter housing overnight, then empty and rinse with cold water

Single-shift operation	**Two-shift operation**	**Notes**
Sample volume: 2,200 ml (0.58 gal)	Sample volume: 3,200 ml (0.85 gal)	
Wine/sparkling wine (ml/gal)	**Wine/sparkling wine (ml/gal)**	
> 2,000/0.53	> 3,000/0.79	Easy to filter
1,700 – 2,000/0.45 – 0.53	2,500 – 3,000/0.66 – 0.79	Average filterability
< 1,700/0.45	< 2,500/0.66	Difficult to filter
Cold/hot water		
Sample volume: 5,200 ml (1.37 gal)		
> 5,000 ml (end flux > 350 ml/minute)/ > 1.32 gal (end flux > 0.09 gal/minute)		Optimal water quality
Steam condensate		
Sample volume: 2,200 ml (0.58 gal)		
> 2,000 ml (end flux > 350 ml/minute)/ > 0.53 gal (end flux > 0.09 gal/minute)		Optimal steam quality

Table 4: Empirical values for classification of filterability through the 0.45 µm PVDF/PES membrane with a 47 mm (1.85 in) diameter (test membrane disc)

A chemical cleaning is required if hot water rinsing is no longer sufficient, for example, if the differential pressure at the start of filtration is higher than 0.5 bar/7.25 psi.

After regenerating the filter cartridges, the housing is often sterilized with steam or hot water.

Summary

Membrane filter cartridges primarily clog on the surface due to bacteria or fine colloids that can form during vinification or appear in the wine through filtration additives. Internal, middle or external fleece of depth

	
Film from city water	Film from steam condensate

Table 5: Practical examples of coatings on test membrane discs from soil of piping systems, for example

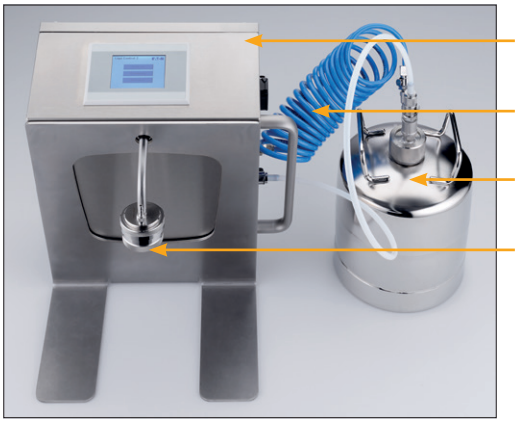

Figure 5: BECO LiquiControl2 index measuring device from Eaton with connected reservoir

filter cartridges become clogged by particles like diatomaceous earth, yeasts, etc.

Helpful recommendations for avoiding filter cartridge cloggings include:

- Observe time intervals when adding metatartaric acid, CMC, gum arabic, tannin, etc., according to manufacturer specifications
- Use enzymes for clarification of wines
- Ensure filterability of wine ready for bottling by index measurement
- Filtration of service media
- Allow ≤ 0.5 bar/7.25 psi filter cloggings (differential pressure), then initiate immediate regeneration
- Hot water temperature of 80 to 85 °C (176 to 185 °F) for regeneration of filter cartridges as well as sufficient hot water volume
- Allow hot water to work overnight to increase the regeneration effect
- Observe the recommended flow rate
- Use proven filter cartridge combinations

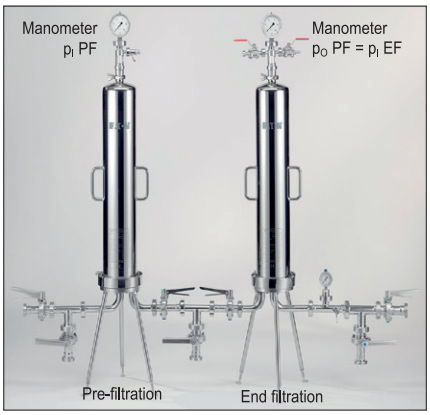

Figure 6: Explanations of filter steps

$\Delta p = p_I - p_O$
Further definitions: Differential pressure of pre-filter: Δp PF = p_I PF – p_O PF Differential pressure end filter: Δp EF = p_I EF – p_O EF
p_I PF = Inlet pressure pre-filter p_O PF = Outlet pressure pre-filter = p_I EF = Inlet pressure end filter p_O EF = Outlet pressure end filter

Table 6: Explanations of differential pressure

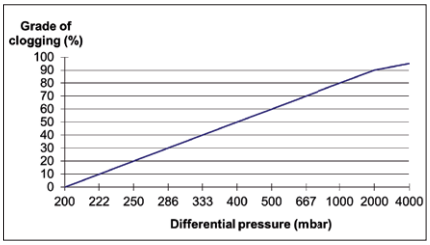

Figure 7: Clogging curve. The higher the differential pressure is, the stronger the filter surface is blocked with the clogging substances.

In summary, when filter cartridges clog early in the process, causes can be the wine to be filtered, filter cartridge handling and the filtration parameters. There are often multiple sources of error.

Only a standardized process leads to an efficient filtration outcome. In addition to the filterability of the wines, sparkling wines and service media, the sizing of the filtration steps, filter combinations (pre-filter and end filter), flow rates and regeneration processes have to be tailored to the individual operation.

Filter cartridges facilitate the proper method of operation and, taking the aspects and details mentioned into account, result in the most effective, economical, modern and safe filtration. Often, appropriate support and services are needed to optimize coordination of all parameters. Eaton's many years of practical experience as an expert partner developing customized solutions with clients on-site significantly contributes to achieving the filtration goals: excellent service life, greater economic efficiency and exceptional wine and sparkling wine quality. □

Elke Brandscheid

Team Leader Product Management Filtration & Technical Service, ElkeBrandscheid@eaton.com

Dieter Speh

Application Engineer, DieterSpeh@eaton.com, Eaton Technologies GmbH, Langenlonsheim, Germany