# Filtration in the brewery (Part 4): membrane filtration

**MAXIMUM PRODUCT SAFETY** | Filtration is an integral part of all process steps in the brewery. No matter how the beer is brewed, final microbiological stabilization is always carried out before the beer is bottled. This is normally done using flash pasteurization, but many breweries are now using cold-sterile membrane filtration too. This final filtration step offers brewery operators numerous advantages – as you will see in part 4 of this five-part series about filtration in breweries.

**FILTRATION STAGES,** such as fine filtration, play a vital role in defining the taste and shaping the character of each beer a brewery produces. But before a finished beer can be poured into barrels, bottles or cans, its quality must be assured one last time, which means that final microbiological stabilization must take place first. The aim of this process is not to change the taste or appearance of the beer; rather, it is needed to ensure the necessary shelf life and maintain consistent high product quality.

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## One goal, two methods

Nowadays, there are two established methods for ensuring that beer is sterile: flash pasteurization (HTST) and membrane filtration. During HTST, the beer is heated to a temperature of 162 to 167 °F (72 to 75 °C) for a defined period to kill harmful microorganisms. The simple process engineering behind HTST offers key advantages. First and foremost, it irons out any fluctuations in quality created during previous stages of the brewing process, such as fine filtration. The poor environmental and carbon footprint of heating and cooling the beer is a major drawback, however, since this requires a lot of energy, which is typically obtained from fossil fuels.

Membrane filtration offers an alternative to the energy-intensive process of HTST. This process has not been used in beer production for as long as HTST has, but it constitutes a higher-quality alternative that offers significant advantages, such as cost-effective operation and a smaller carbon footprint due to lower energy consumption.

HTST and membrane filtration both have the same clearly defined goal: to reduce beer-spoiling microorganisms to the extent necessary to ensure that sterility, shelf life and quality of the finished beer are beyond any doubt. In concrete terms, eliminating all the beer-spoiling germs means killing malolactic bacteria, acetic acid bacteria and yeasts, which without appropriate treatment can multiply and affect the beer's flavor. The process not only improves the beer's shelf life but also makes it easier to handle, because logistics partners and food retailers demand sterility to allow the beer to be transported unrefrigerated and to reduce returns.

## Keeping germs out

Membrane filtration works in the same way as the prior filtration stages: The unfiltered beer flows through a filter cartridge with a defined pore size. This cartridge retains yeasts and bacteria and guarantees flawless quality and shelf life.

The filter membrane can be made of one of four materials:

**Fig. 1 Example of PES membrane filter cartridges for high mechanical, thermal and chemical stability, and a long service life**

- Hydrophilic polyethersulfone (PES);
- hydrophilic polyvinylidene fluoride (PVDF);
- single-layer or double-layer nylon 66 (polyamide 66);
- single-layer or double-layer cellulose acetate (CA).

The first membrane filter cartridges to be launched on the market were made of nylon 66 and CA. PVDF was also used for a time, but the material did not become a popular filtration medium because its symmetrical pore structure means that its service life is relatively short and its ability to chemically regenerate is limited. The trend is now clearly toward filter cartridges made of PES and for good reason, because the asymmetrical pore structure of the membrane enables a high flow rate and ensures microbiological stability. Attempts have been made to offset the disadvantages of nylon 66 and CA compared to PES by creating double-layer versions, but these have not been successful in practice. Although this puts them on par with PES at a microbiological level, their use is still hampered by them having a shorter service life and higher costs.

## Filters ensure safety and reliability

Membrane filter cartridges offer a key advantage over HTST in that their microbiological retention can be clearly determined by the defined pore size. Membrane filtration therefore significantly increases product safety. Membrane filter cartridges have several properties that can be used to clearly check their performance and whether they meet defined quality standards. They

- can be tested for integrity;
- enable validated microbiological retention (titer reduction or LRV = log reduction value);
- ensure high mechanical and thermal stability, for example through guaranteed steaming cycles;
- offer high chemical stability.

In terms of ensuring a defined and consistently high level of product quality, the ability to test the integrity of membrane filter cartridges particularly stands out among their positive properties. There are two common test methods: destructive and non-destructive. Destructive tests are carried out by manufacturers to determine the bacteria retention rate (titer reduction). This sees 10 million ($10^7$) germs applied per cm² of the filter›s surface area. The sterile filtrate must then contain only one test germ or none at all. This corresponds to an LRV value of 7 or >7. Table 1 lists common test organisms for destructive testing of membrane filter cartridges.

### TEST ORGANISMS USED TO CHECK THE RETENTION RATE WITH REGARD TO VARIOUS GERMS

| Pore size | Test organism | Titer reduction |
|---|---|---|
| 0.2 µm | *Brevundimonas diminuta* | > $10^7$ per cm² (LRV > 7) |
| 0.45 µm | *Serratia marcescens* | > $10^7$ per cm² (LRV > 7) |
| 0.65 µm | *Saccharomyces cerevisiae* | > $10^7$ per cm² (LRV > 7) |
| 1.0 µm | *Saccharomyces cerevisiae* | > $10^6$ per cm² (LRV > 6) |

*Table 1*

Non-destructive tests are carried out by both filter cartridge manufacturers and users. Manufacturers determine the air diffusion rate in mL/min. This value denotes the maximum air diffusion from which the membrane filters in a sterile manner and is therefore intact. Users can test the filters using the diffusion or pressure holding test, or the bubble point test.

The diffusion and/or pressure holding test has become the norm for standard filter cartridges offering large filter surface areas of 10 inches (250 mm) or more. This allows users to check whether the membrane is intact. The membrane filter is sterilized, cooled with air and then rinsed with cold water so that the membrane is fully wet. The housing is then pressurized with compressed air or nitrogen at a specified test pressure. After a five-minute stabilization period, the compressed air supply is shut off and the test is timed for 5 or 10 minutes. During this period, only a defined amount of gas should diffuse through the membrane/only a permitted pressure drop should be measured. The permissible values are specified by the manufacturer.

If the filter has a surface area of 5 inches (125 mm) or less, the bubble point test can also produce meaningful results. The pressure in the housing is gradually increased until the water is pressed out of the largest pores. Air flows freely through these open pores, thereby defining the "bubble point." If the bubble point is greater than the size specified by the manufacturer, the membrane is intact.


**Fig. 2 An integrity test unit enables membrane filter cartridges to be measured fully automatically. It can be used to test filter cartridges in both small and large housings**

As membrane filter cartridges are critical to the quality of the finished beer, high standards are applied not only to their functioning but also to their stability, and their mechanical, thermal and chemical stability in particular.

The mechanical stability of membrane filter cartridges is expressed in the form of maximum pressure differences that components such as the cage, adapters, etc. must be able to withstand, e.g., 72.5 psi at 68 °F (5 bar at 20 °C). If this pressure difference is not exceeded, the membrane filter cartridge remains mechanically stable and microorganism retention is guaranteed.

Since membrane filter cartridges can be sterilized multiple times, high requirements are imposed on their thermal stability. Up to 100 steam-

ing cycles are guaranteed depending on the manufacturer. The material is soft after undergoing thermal treatment due to expanding and contracting again during the cooling process. To ensure that the membrane filter cartridges are intact, it is advisable to perform an integrity test after each thermal treatment.

Chemical stability is important if the membrane filter cartridges become clogged following numerous filtration and cleaning cycles with cold and hot water. In such cases, chemical cleaning agents are used too – which are also used for regeneration with the addition of enzymes and which the filter cartridge material must be able to withstand.

**Fig. 3 With an index measuring device such as the Beco LiquiControl$_2$, users can determine filterability to optimize the design of the filtration process and reduce downtimes during bottling**

## Tests ensure filtration performance

The fact that membrane filter cartridges are highly stable and undergo extensive testing ensures that they are suitable for the given application and that they fulfill their disinfection function effectively. Considering how important they are for product quality, it is advisable for breweries to perform integrity tests on the membrane filter cartridges before each product is produced, i.e., after sterilization and before filtration of the next batch. This is the only way users can ensure that the membrane filter cartridges are still intact and able to filter in a sterile manner.

The integrity test must be carried out according to the manufacturer›s specifications. Furthermore, brewery operators must also factor in the quality of the water used for cleaning and testing the membrane filter cartridges. This means the water must be almost the same quality as the filtrate – otherwise clogging substances will put a strain on the filter membrane, which can lead to service life problems.

## Automation facilitates quality testing

To ensure that brewery operators and managers in other areas of beverage production can comply with the highest quality and safety standards by using membrane filter cartridges, the range of procedures and devices for carrying out the tests described above is growing. For example, automation under defined test conditions is playing an increasingly important role. Moreover, easily accessible interfaces enable the test results to be transferred seamlessly into users› existing IT environments.

One example is the Beco Max$_2$ (fig. 2). It checks the integrity of the membrane filter cartridges fully automatically. It offers up to 10 programs and can store up to 40 performance data. The device can be used to carry out pressure holding tests on the membrane filter cartridges in a simple, automated way under defined conditions.

Automated devices such as the Beco LiquiControl$_2$ (fig. 3) are also now available for automatically measuring the filterability of ready-to-bottle beer. The index measuring device is used before starting membrane filtration to filter a sample over a reference membrane under defined conditions and at constant pressure. If the measurement shows that the beer is difficult to filter, additional pre-filtration can be carried out to improve its filterability. Users can utilize the device›s performance data to improve the overall service life of the membrane filter cartridges, reduce downtimes during bottling and optimize the design of the entire filter cartridge system by conducting preliminary tests. They can view all archived measurements and an Ethernet interface makes it easy to download all the performance data.

## Membrane filtration for maximum quality

Membrane filtration was introduced as the final step in the brewing process more than 20 years ago. Since then, the process has become an established method that gives brewers a simple, clear and safe means of ensuring the shelf life, safety and quality of their beer. More and more users are switching to membrane filtration because it offers a high degree of automation, reproducible process conditions and consistently high quality – not to mention low energy consumption, which helps make the brewing process safe and efficient at a time of high energy costs and fluctuating energy availability.

Whether they use bottles, cans or barrels, breweries that rely on membrane filtration as the final step in the process before filling offer consumers uncompromisingly good beer. The method shows that filtration has become an integral part of modern-day brewing processes, whether at the level of a multinational corporation or a regional craft brewery. The fifth and final part of our series of articles about filtration in breweries examines the advantages that filtration processes bring to small breweries in particular. ■

### Comparison of common membrane filter cartridges on the market

Users can assess the differences between the different membrane filter cartridges according to the following criteria:

- The membrane is made of PES, PVDF, nylon 66 or CA;
- the log reduction value (LRV) with different test germs at different pore sizes relates to the filter surface area cm² or a 10-inch element and is defined by the manufacturers for all products;
- the number of guaranteed steaming and cleaning cycles;
- the filter surface area of 6.5 to 13 ft² (0.6 to 1.2 m²) per 10-inch element acts as a reference point for comparing the different products;
- the flow rate is given by the water value as an indicator.