

## Water Filtration in Bottled Water

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Water entering a bottled water facility contains bacteria, no matter the source (even spring water). While these organisms are generally not harmful to humans, they can cause off-flavor or even haze in the final product if allowed to enter the final packages and grow.

Bottlers use several technologies to either remove bacteria from the bottling process or prevent bacteria from growing. Filtration is an important part of the effort to remove bacteria and produce a safe, clean product for consumers.

Most processes for production of spring water, purified water, distilled water, even deionized water, are operated to be “bacteria-free”. Keeping a system free of bacteria is not necessarily a regulatory requirement, even pharmaceutical water for injection is not required to be bacteria-free, but bacteria free operation is still the goal of most operators.

Several methods may be used to keep bacteria and other airborne microorganisms from entering the system, including filtration of the air that enters storage tanks as they are emptied. This document looks at how tank vent filters fit into the array of tools used to prevent contamination of bottled water by bacteria and mold.

There are many forms of waterborne organisms. Harmful bacteria such as *E. coli* and *Pseudomonas* strains are common in natural sources of water. A well-known illness outbreak caused by waterborne *Cryptosporidium* oocysts led to the industry taking steps to assure the microbiological safety of its products. Numerous other non-pathogenic bacteria are also common in water.

Figure 1 shows some simplified processes for multiple types of water that may be produced in a facility. Most bottled water products are actually treated municipal water that has been filtered, processed through a reverse osmosis system and bottled.

At the bottom of Figure 1 is the spring water process, which is the least complex of all. This process preserves the mineral content of the spring water as it comes from the ground while protecting the consumer from bacteria that may enter the process. Other processes may be added by the bottler, but the filtration steps are shown where they are normally located in the processes.

Waterborne organisms are often very small, and those that can survive in treated water are often smaller than those of the same type living in natural waters. For that reason, the final filters used to remove waterborne bacteria have very small pore sizes – usually  $0.10\mu\text{m}$  to  $0.22\mu\text{m}$ . Because there may be a large number of particles and bacteria in high volume processes, the final filters are almost always protected by “bioburden” reduction or particle reduction filters. These reduce the number of particles and bacteria that the critical final filters must remove, preventing premature fouling (clogging) of the final filters.



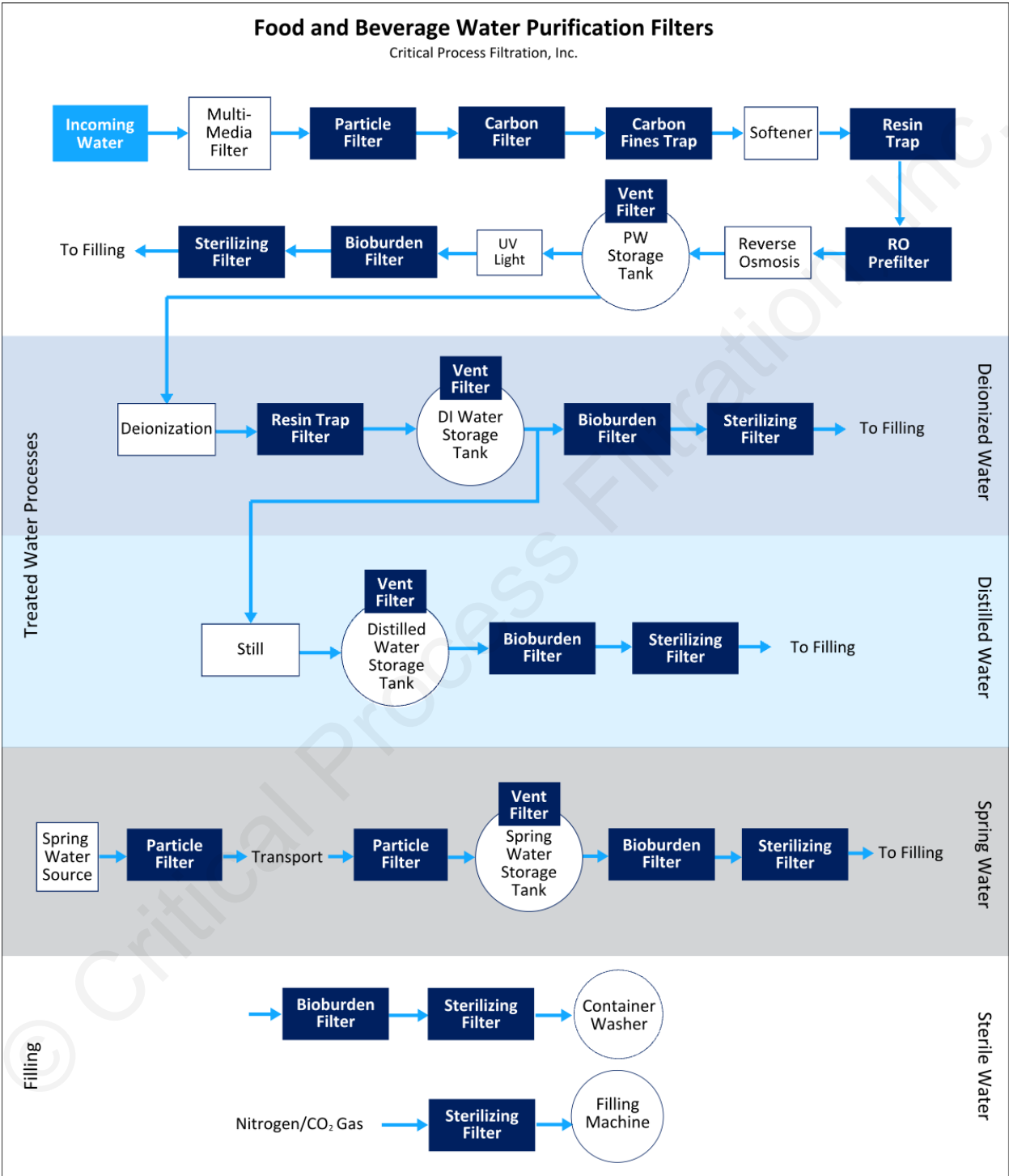


Figure 1

## Prevention and Remediation

Most of the time, the old saying “an ounce of prevention is worth a pound of cure” is true. Preventing an unwanted event is usually easier than repairing whatever damage is done if the event occurs. However, in virtually all water systems, including bottled water systems, it is safe to assume that BOTH prevention and remediation are needed to control microorganisms.

For our purposes, we will define prevention as not allowing bacteria to enter the system. The best way to do that is to design the system using components that are operated with a minimum of maintenance and create barriers wherever there is the potential for bacteria or other organisms to enter from outside sources. Keeping the system components sealed and barriers in place is usually very effective. Unfortunately, almost any maintenance activity requires opening system components, exposing the interior of the system to the atmosphere and letting bacteria and other airborne organisms enter.

Since it is almost impossible to totally prevent bacteria from entering a system, remediation steps are needed to prevent the growth of microorganisms. Those steps can take three basic forms: 1) inhibiting organism growth with high temperatures or high flows, 2) killing microorganisms using system sanitizing/disinfection with heat or chemicals, and 3) physically removing organisms (liquid filtration).

Using both prevention and remediation places multiple obstacles in the way of bacteria and mold that might affect product quality and potentially harm consumers and your brand.

## Why Tank Vent & Process Gas Filters?

Whenever a tank is emptied, the volume of liquid removed has to be replaced by an equal volume of air or process gas. Otherwise the tank will experience a vacuum condition and implode. As discussed above, outside air contains bacteria and other organisms which have to be removed before the air enters the tank. If used, process gas can also contain particles and microorganisms.

Figure 1 on the previous page shows multiple filters to control particles and bacteria in a process water system. The filters on the tops of tanks are used to filter the air directly in contact with water in the tanks. These filters protect the water from particulates and microorganisms in surrounding air. The filter attached to the Filling Machine stream is used to filter process gases that might be used to displace air during filling. This gas, usually nitrogen or carbon dioxide, may be used to limit the oxygen in bottles for product quality reasons.

The tanks used in bottled water systems, even tanks made of stainless steel, do not tolerate excessive pressure or vacuum. Both conditions can cause structural bulging or tank implosion. Therefore, as a tank is filled or emptied, the air inside is allowed to escape or is replaced by outside air or process gas. The vent filter removes possible particle and microorganism contamination.

## Filters for Air vs Liquid

Filters used for liquid applications are made of materials that attract water – are “hydrophilic” – and allow the flow of water with low resistance. For air filtration, it is critical that the media remain dry. If the media becomes wet, and the pores are filled with water, then the air flow is restricted and the pressure or vacuum inside the tank can reach critical levels and cause tank failure. The various media used for air filters are made using materials that repel water – are “hydrophobic” – and resist wetting from water vapor or water droplets.

## Choosing Final Filters

The most critical filters in Figure 1 are the final, “Sterilizing” filters. Sterilizing filtration is defined as removing all bacteria in a fluid stream. Filters claiming to be sterilizing must be supplied with proof that they can remove organisms the size of those targeted in the user’s system. The pharmaceutical industry has accepted successful removal of surrogate organisms by specific filter membranes as proof that a filter can remove organisms of similar size. The organisms are defined for each pore size rating. The testing is according to an ASTM standard (ASTM F838-05, rev 2013) that requires COMPLETE removal of all test

bacteria when a filter is challenged with at least 107 organisms per cm<sup>2</sup> of membrane surface area. This level of challenge is extremely unlikely in actual applications.

Critical Process Filtration provides filters tested using the ASTM standard, with 0.10µm filters challenged with *Acholeplasma laidlawii* and 0.22µm challenged with *Brevundimonas diminuta*. The sterilizing filters are supplied with a certificate of compliance stating that the filter has passed the required quality control tests.

Critical Process Filtration's PTFE membrane and high capacity hydrophobic PVDF membrane-based cartridges and capsules are utilized for ambient temperature storage tanks. If the storage tanks are maintained at elevated temperatures, or frequently sanitized using heat, then the operator should use specially designed PTFE membrane cartridges made for continuous high heat applications (70°C to 80°C).

If sterilizing filtration is required for the tank vent and process gas filters, then it is important to remember that sterilizing filtration is defined as removing all bacteria. Filters claiming to be sterilizing must be supplied with proof that they can remove organisms the size of those targeted in the user's system. The pharmaceutical industry has accepted successful removal of surrogate organisms by specific filter membranes as proof that a filter can remove organisms of similar size. The organisms are defined for each pore size rating. The testing is according to an ASTM standard (ASTM F838-05, rev 2013) that requires COMPLETE removal of all test bacteria when a filter is challenged with at least 107 organisms per cm<sup>2</sup> of membrane surface area. This level of challenge is extremely unlikely in actual applications.

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## Protecting Sterilizing (Final) Filters

Bioburden reduction filters remove particles and reduce the amount of organic content before the water reaches the critical final filters. These are often membrane filters designed to capture most, but not all bacteria. The filters are chosen based on the particle and organic content that must be removed.

## Preventing Contamination of Stored Water

Tank vent filters are also critical to the quality of the water. These hydrophobic membrane filters keep airborne bacteria in the environment from entering tanks as they are emptied. The air in bottled water facilities may contain mold and other microorganisms, so preventing them from entering the tanks further protects product quality.

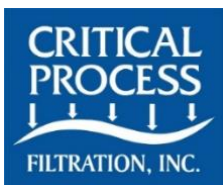
## Safeguard Filling Operations

Filters shown on the right side of Figure 1 are not used to filter product water. They prevent contamination of the packaging by wash and rinse water during the container washing process and keep any bacteria that may be carried by process gases (like nitrogen or CO<sub>2</sub>) from being introduced.

## Support for Designing Your System

If your operation is purchasing purified water the expense alone may have you consider a water purification system onsite. A risk analysis by your team will determine the feasibility of that project.

If you are considering ways to improve efficiency and lower overall costs of your existing system with filtration, we can help. Critical Process Filtration's application engineers can evaluate your current system and make recommendations that lower your risks and assure your water purification goals are met.



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