New Membrane Point of Entry Filtration System Certified as Microbiological Purifier

Innovative, efficient and convenient POE water disinfection solution for all water sources

By Ron Ing and Andrew Warnes

Introduction

In both developed and developing countries throughout the world, the need for small, self-contained point of entry (POE) water purifying systems is acute. One of the most recognized manufacturers of municipal membrane water and wastewater treatment systems has focused on the development of a new solution that addresses these needs by bringing cutting-edge commercial water treatment technology to homes and small industries throughout the world.

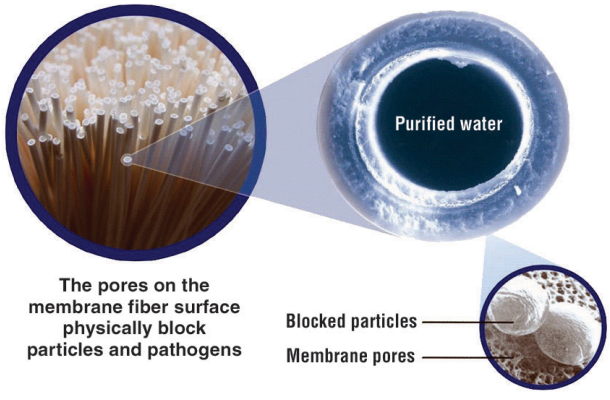
Background

In developed countries, the exodus of millions of people into rural areas has created the need for purified water in new parts of the countryside. In municipalities, bottled water sales continue to grow at double-digit rates due to concerns over the quality and taste of the municipal water supply. In developing countries, simple and effective solutions are being sought to achieve purified water for daily drinking and hygiene needs.

Various technologies are currently being utilized to disinfect/purify water by killing, inactivating or removing bacteria, viruses and cysts. Most current technologies have limitations: they may generate disinfection by-products (DBPs); some require electricity to disinfect; some are only effective on certain pathogens or leave inactivated pathogens in the drinking water; others are highly inefficient due to the ratio of water wasted versus the amount of usable water produced or cannot be used on hard water without pretreatment. Also, most disinfection systems available today require a complex combination of multiple technologies to achieve the required turbidity and disinfection levels to meet safe drinking water standards.

Hollow fiber membrane filtration technology

Hollow fiber membrane technology for treating water provides one of the simplest and most effective ways to both clarify and disinfect water. Hollow fiber membranes, which resemble strands of spaghetti that are hollow inside, utilize physical exclusion to filter water. The polymeric walls of the membrane strands have billions of pores that act as a strainer to filter out particles, turbidity and pathogens while allowing water to flow through with virtually no pressure drop.



The pores on the membrane fiber surface physically block particles and pathogens

Hollow fiber membranes are available in either microfiltration (MF) or ultrafiltration (UF) levels. Microfiltration membranes filter down to approximately 0.2-0.1 microns nominal. Ultrafiltration membranes filter down to approximately 0.05-0.02 microns nominal.

Hollow fiber UF membrane effectiveness and performance is based on pore size, pore size distribution, permeability, surface area, fouling characteristics and membrane consistency. The nominal pore size is the primary determinant of the particle/pathogen rejection characteristics of the membrane. If many of the pores are larger than the nominal pore size, or if there are a few pores that are significantly larger than the nominal pore size, the membrane will have poor rejection characteristics against small pathogens such as viruses. Pore size distribution is controlled by having good base membrane chemistry and a tightly controlled manufacturing process. For UF membranes to be capable of virus rejection, the membrane pore distribution must be very tight.

Permeability is the measure of the flux rate of the membrane. It represents the pressure necessary to achieve a specified flow rate. The higher the permeability of a membrane, the more efficient the membrane is. Surface area represents the amount of available membrane area for the water to pass through. A larger surface area, combined with higher permeability, will result in larger product water throughput.

Both outside-in and inside-out flow directions through the membrane walls are employed in the water treatment industry today. Having a flow passage from the outside-in provides a significantly higher filtration surface area due to the larger outside circumference of the membrane. Also, an outside-in flow prevents large particles from being lodged in the membrane bore, which can occur with an inside-out flow. This can result in a stress riser, leading to fiber weakening and breakage over time as the membrane fibers flex during normal operation.

Fouling characteristics and a cleaning regime are crucial to the life performance of the membrane fiber. The design of the membrane skin and the chemical composition of the membrane affect the fouling characteristics. Non-disposable membranes are cleaned on a regular basis using either linear membrane flow for inside-out membranes or a combination of linear flow combined with 'through the membrane' wall flushing for outside-in membrane flows. Generally, 'through the membrane' wall flushing using pre-filtered water in the opposite direction of normal flow is the most effective methodology, as it both pushes away debris/pathogens that have collected on the membrane skin and dislodges any particles that have become stuck in the pores during normal filtration.

There are numerous companies throughout the world working on hollow fiber membranes. Many have been able to produce a satisfactory membrane on a limited laboratory production basis. The challenge for most companies is leaping from laboratory development to actual mass production—to manufacturing millions of miles of consistently high quality hollow fiber membrane and keeping the process under control. ZENON's ZeeWeed® hollow fiber UF membranes are an unprecedented success in industrial and municipal markets and are now being used to solve residential and small commercial purification needs worldwide.

A new system

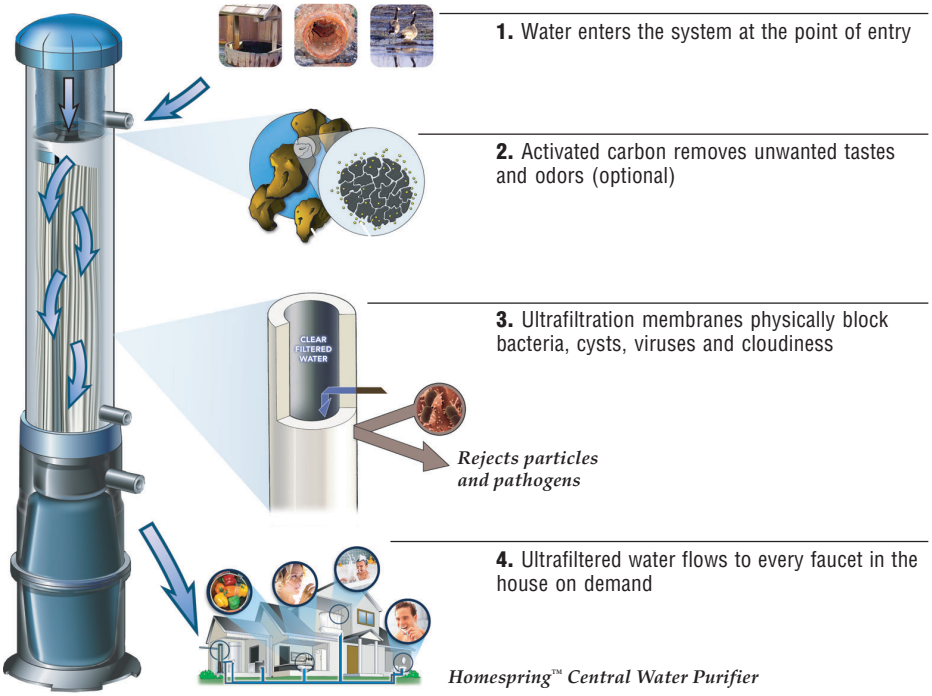
The same industrial grade membranes that have been proven in water treatment plants around the globe have been incorporated into the firm's Homespring™ Central Water Purifier, developed for residential point of entry (POE) and small commercial/industrial applications. It incorporates a two-stage filtration process that addresses both taste and odor issues while purifying water for whole home or commercial applications.

The first stage uses granulated activated carbon (GAC) to pre-filter the water and remove unwanted taste and odors, such as chlorine. The second stage uses thousands of strands of proprietary hollow fiber membranes. The water flows through pores that are 0.02 microns (nominal) from the outside-in; the membranes physically remove turbidity, bacteria, viruses and cysts from the water. The systems do not require electrical power to filter the water. Using only the inlet water pressure, the systems can filter up to 11 gallons (42 liters) of water per minute. The unit uses electricity *only* to operate a programmable controller for scheduling backwashes. During power failures, the systems can continue to supply purified water as long as there is water line pressure. When electricity returns, the systems resume their normal backwashing schedule.

Because the membranes are extremely efficient, the system has a minimal pressure drop (~2.5 psi per 3 gpm/0.17 bar per 12 lpm). The purifier has a built-in daily backwashing system that performs a 'through the wall' membrane flush with pre-filtered water every 24 hours, and is typically maintenance-free for an entire year. The systems come in a range of sizes and are up to 64 inches (165 cm) tall, have an 18-inch (46 cm) footprint and weigh only 100 pounds (45.5 kg) when empty.

There are considerable differences between the hollow fiber membrane used in the new system and other, more common, flat sheet membrane systems. Unlike typical home point of use (POU) reverse osmosis (RO) systems, there is no mineral removal. The membrane is chlorine tolerant and will work directly on hard water. No under-sink storage tanks are required, because this is a flow-through system. The membranes are highly efficient (up to 97 percent) when compared to typical RO systems, which can reject 50 percent or more of the incoming water to the drain.

To provide the ability to validate the performance of the system on the spot, an on-site, handheld integrity tester has been developed (patent pending), which can immediately determine whether all the membrane strands are intact and functioning. This test can be performed in minutes and assures customers and regulators that the units are delivering purified water upon start-up and at any other time during their use—including during boil water advisories, should municipal emergencies arise.

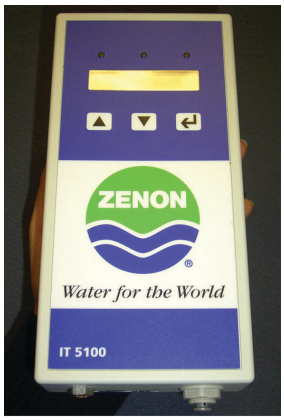


Homespring™ Central Water Purifier

U.S. EPA testing and certification

The U.S. Environmental Protection Agency (U.S. EPA) *Guide Standard and Protocol for Testing Microbiological Water*

Purifiers was developed in 1987. The protocol outlines the testing and performance expectations for a microbiological water purifier on potentially contaminated water sources, such as wells and springs. It is used as a guide to the acceptance of water treatment units for compliance with Safe Drinking Water Act requirements where the device may be used temporarily to treat potentially contaminated water supplies during emergency situations like boil water alerts and natural disasters. The stringent protocol involves testing multiple systems over a number of days with microbiologically contaminated water that includes bacteria, viruses and cysts.



Handheld on-site membrane integrity tester

The protocols for testing the systems were developed and performed by BioVir Laboratories (a NELAP and California Department of Health Services approved laboratory) and the systems were certified under the Water Quality Association's Gold Seal Certification program. The procedure involved testing three systems concurrently over a 12-day period with various feed test waters that contained, on average, concentrations of 3.9 x 10^7 bacteria and 3.7 x 10^5 of viruses while varying the pHs from 6.5 to 9, turbidities from 0 to greater than 30 NTU and a water temperature varying from 20°C to 4°C (68°F to 39°F). The test was to simulate a variety of worse-case scenarios under different water environments.

Upon completion of the testing, no bacteria or viruses were detected from any of the water samplings. These are the first POE water filtration systems certified as a Microbiological Water Purifier by the WQA.

The systems are also certified by NSF and WQA to NSF/ANSI Standard 42 (Aesthetic Effects) and NSF/ANSI Standard 53 (Health Effects). In Australia and New Zealand, the same systems have been certified to AS/NZS 4348 Standard *Water Treatment-Domestic Type Water Treatment Devices-Performance Requirements* to achieve greater than 99.99999 percent bacteria reduction, greater than 99.999 percent virus reduction and greater than 99.95 percent cyst reduction.

Applications

The new central purifier can be used on treated municipal water, untreated well supplies and lake water sources. For people on city water systems, it eliminates the need for bottled water as the taste and odor of chlorine are removed. It also provides additional peace of mind in case of a water main break or boil water alert. On well, surface or rainwater sources, the unit provides crystal clear purified water for all household needs. The system can also be used in small commercial/industrial applications and a number of systems can be combined to deliver up to 30,000 gallons (114 cubic meters) of purified water a day. The systems have been effectively deployed to supply water in disaster relief areas as they require no electricity to supply purified water. In small communities (less than 250 homes), the units can be used for decentralized water treatment. By installing one at each house, developers can provide a more cost effective solution than building a conventional water distribution line infrastructure and centralized water treatment plant. (Editor's note: Arizona has already endorsed individual units as a viable alternative to more traditional centralized infrastructure improvements).

Conclusion

The challenge for the water treatment industry, particularly for disinfection systems on waters of unknown quality, has centered upon being able to provide consistent, reliable and verifiable disinfection for the entire home—not just at a single POU. Designed to address these concerns and satisfy the needs of both consumers and regulators, new systems utilizing proven membrane technology provide high flows with minimal pressure drops using existing water line pressures. Their effectiveness can be verified on-site with a simple, immediate test and they do not require electricity to provide purified water. The patented system design enables these units to automatically self-clean usually resulting in maintenance-free operation for an entire year.

These advances have generated interest outside of the water treatment industry. In 2004, the the Homespring™ Central Water Purifier was handed the "Best of What's New" award in the Home Tech category by *Popular Science* magazine. Literally thousands of products were considered and the winners are those judged to be one of the products that "represented a significant step forward."

About the authors

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About ZENON Environmental

♦ *ZENON Environmental Inc., based in Oakville, Ontario, Canada, has been a global leader in membrane-based water filtration technology since the 1980s. ZENON has hundreds of patents for membrane developments and membrane system designs worldwide. Each day, ZENON's ZeeWeed® patented hollow fiber UF membranes are used in over 500 large scale municipal and industrial water treatment plants throughout the world that treat anywhere from 1,000 to 100 million gallons (3.79 to 379,000 cubic meters) of water. Over a billion gallons (3.79 million cubic meters) of water is filtered through ZeeWeed® membranes daily.*