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MEMBRANE SYSTEMS
A Koch Chemical Technology Group, LLC Company

Membrane Filtration Technology: Meeting Today's Water Treatment Challenges

Growing global demand for clean water and increasing environmental concerns make membrane filtration the technology of choice for industries seeking to reuse their wastewater and reduce their water footprint. Knowing which membrane system solution is best for your water treatment challenge can help you increase plant efficiency, while reducing operating and chemical costs, and complying with increasingly stringent discharge regulations. Membrane filtration also offers solutions for large-scale municipal applications that produce potable water from a variety of source waters. This paper will present and define the wide range of membrane filtration technologies available from Koch Membrane Systems, highlighting a number of important issues to consider when evaluating an effective and efficient membrane filtration system.

Membrane Filtration: The Technology of Choice

Widely recognized as the technology of choice for superior water and wastewater treatment, membranes provide a physical barrier that effectively removes solids, viruses, bacteria and other unwanted molecules. Different types of membranes are used for softening, disinfection, organic removal, and desalination of water and wastewater and can be installed in compact, automated, modular units. Membrane filtration units can also be installed in relatively small facilities that blend into the surrounding area and can be fully automated to significantly reduce the required amount of operator attention.

Recent advances in technology have significantly reduced the cost of membrane-based systems. Installation costs are lower because membrane systems don't require large buildings or as much land as conventional systems. Operating costs are reduced since today's membranes produce more water and remove more impurities while using less energy.

In the United States, regulations such as the Safe Drinking Water Act and the Long Term 2 Enhanced Surface Water Treatment Rule have had a significant impact on municipal water treatment. This, in addition to increasingly stringent wastewater discharge regulations, has promoted dramatic growth in the implementation of membrane technology.

Membrane Separation Technology: An Overview

Membranes provide physical barriers that permit the passage of materials only up to a certain size, shape or character. There are four crossflow, pressure-driven membrane separation processes currently employed for liquid/liquid and liquid/solid separation: ultrafiltration (UF), reverse osmosis (RO), nanofiltration (NF), and microfiltration (MF). Membranes are manufactured in a variety of configurations including hollow fiber, spiral, and tubular shapes. Each configuration offers varying degrees of separation.

Ultrafiltration: Ultrafiltration (UF) is a pressure-driven process that removes emulsified oils, metal hydroxides, colloids, emulsions, dispersed material, suspended solids, and other large molecular weight materials from water. UF membranes are characterized by their molecular weight cut-off.

The major opportunities for UF involve clarification of solutions containing suspended solids, removal of viruses and bacteria or high concentrations of macromolecules. These include oil/water separation, fruit juice clarification, milk and whey production and processing, automotive electrocoat paint filtration, purification of pharmaceuticals, poly-vinyl alcohol and indigo recovery, potable water production, and secondary or tertiary wastewater reuse.

Reverse Osmosis: The membrane with the smallest pores is reverse osmosis (RO), which involves reversal of the osmotic process of a solution in order to drive water away from dissolved molecules. RO depends on ionic diffusion to effect the separation.

A common application of RO is seawater and brackish water desalination. RO is also used in many industrial processes including cheese whey concentration, fruit juice concentration, ice-making, and car wash water reclamation, and wastewater volume reduction. In each of these examples, the goal is either to produce a pure filtrate (typically water), reduce the volume of the wastewater for disposal or retain the components of the feed stream as the product.

Nanofiltration: Nanofiltration (NF) functions similarly to RO, but is generally targeted to remove only divalent and larger ions. Monovalent ions such as sodium and chloride will pass through an NF membrane, thus many of the uses of NF involve de-salting of the process stream. An example is the production of lactose from cheese whey; the NF process is designed to concentrate the lactose molecules while passing salts – a procedure that purifies – and concentrates – the lactose stream.

In water treatment, NF membranes are used for hardness removal (in place of water softeners), pesticide elimination and color reduction. Nanofiltration can also be used to reclaim spent NaOH solutions. In this case, the permeate (filtrate) stream is purified NaOH, allowing reuse many times over.

Microfiltration: Microfiltration (MF) has significant applications in simple dead-end filtration for water filtration, sterile bottling of fruit juices and wine, and aseptic uses in the pharmaceutical industry.

A large portion of the MF market has been captured by crossflow. The most common of these are clarification of whole cell broths and purification processes in which macromolecules must be separated from other large molecules, proteins and/or cell debris. Clarification of dextrose and highly-colored fruit juices employ MF extensively as well. There are also large markets for MF crossflow filtration in wine production, milk/whey de-fatting, and brewing. MF systems operate at relatively low pressures and are configured based upon the application.

A Range of Solutions

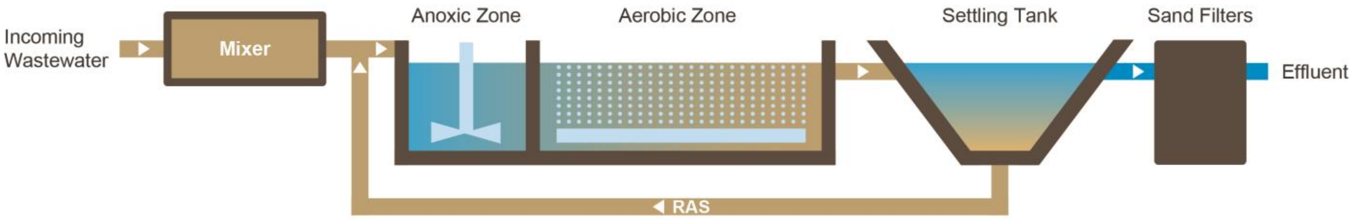
There are a variety of membrane technologies and configurations available in the marketplace, each of which provides certain advantages for specific process needs. The key to a successful membrane filtration system is to carefully evaluate the physical characteristics of the process fluid.

Membrane Bioreactor (MBR)

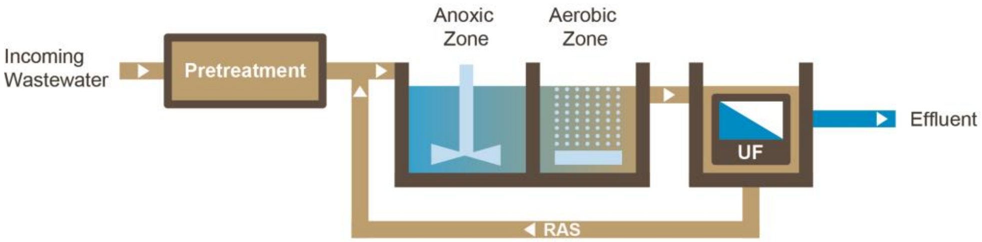
A membrane bioreactor is a biological process that combines secondary and tertiary treatment using a membrane filtration process. MBR systems are growing in popularity for virtually all wastewater treatment applications because they offer many advantages over conventional wastewater treatment plants such as consistently high quality effluent with low turbidity, low bacterial counts, low TSS and NTU, while using fewer chemicals than conventional wastewater treatment plants. The filtrate quality, in many instances, is suitable for feeding directly into an RO process. An additional advantage of an MBR system is its compact footprint.

Conventional Wastewater Treatment vs. MBR Technology

Conventional Activated Sludge System



Membrane Bioreactor (MBR)



Here are a few key points to consider when evaluating an MBR system:

Increased Effluent Quality: In an MBR, UF membrane modules are submerged in the activated sludge to combine the biological step and the solid-liquid separation into a single process.
The membrane acts as a barrier, which improves the effluent quality. An MBR system eliminates the secondary clarifier and allows the activated sludge to be more concentrated.

Reduced System Footprint: In an MBR system, the volume requirement for biological tanks is reduced, saving space and construction costs. Overall, the MBR process reduces footprint significantly, by as much as 50 percent, compared to the combination of conventional wastewater treatment followed by sand filtration or ultrafiltration.

Flexibility: MBR systems feature flexible layout options, are easily expandable, have a compact footprint, and can be configured to meet the unique effluent requirements of each site.

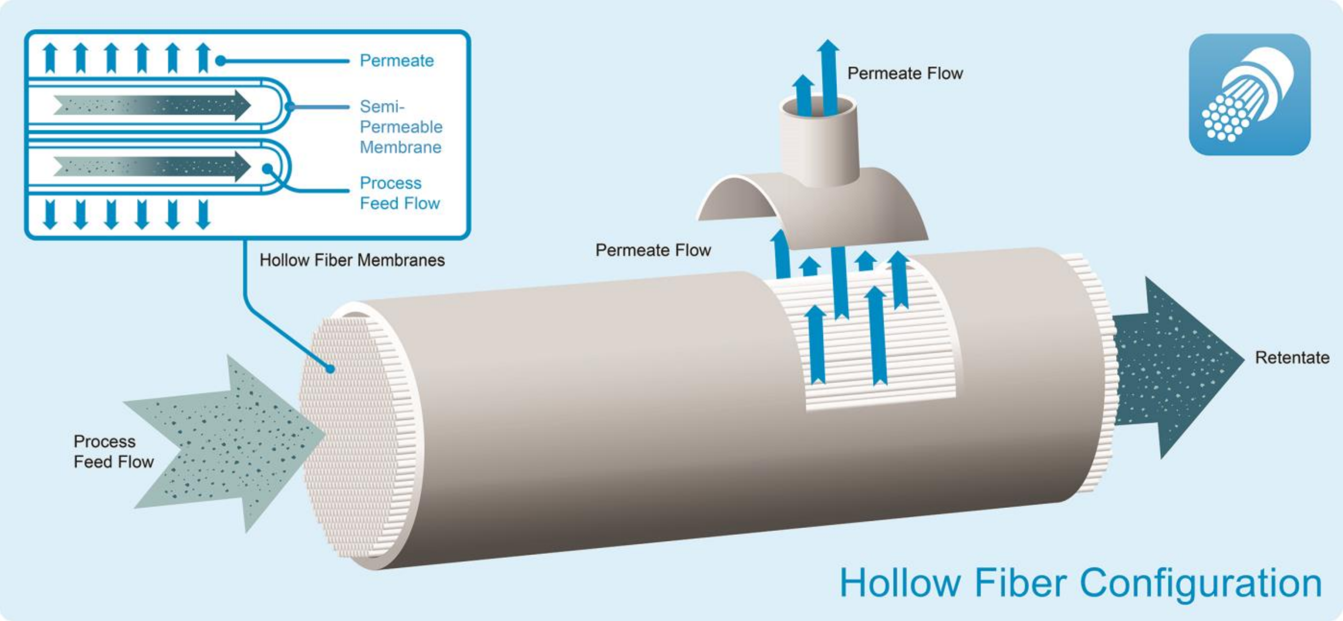
Range of Applications: MBR systems are increasingly used for locations where water resources are scarce, reusable-quality effluent is desirable, space availability is limited, and/or stringent discharge standards are in effect. These locations include small communities, housing developments, commercial developments, mining camps, resorts, hotels, malls, schools, and golf courses, among others.
The MBR is also employed for industrial applications to recycle process water to reduce wastewater disposal costs.

Hollow Fiber

Hollow fiber membranes are also based on UF technology. Depending on the application, hollow fiber membranes can be highly practical and cost effective alternatives to conventional chemical and physical separation processes.

Here are a few key points to consider:

Mode of Operation: Hollow fiber cartridges operate with flows from outside-to-inside, or inside-to- outside with fluid flowing through the center and permeate passing through the fiber wall to the outside of the membrane, a design that is highly flexible and easily handles large volumes for circulation, dead- end, and single-pass operations. Other operating techniques that can be employed with hollow fiber membrane systems include back flushing with permeate and retentate reverse flow.



Durable Construction: Due to their structural integrity and construction, hollow fiber membranes can withstand permeate back pressure, thus allowing flexibility in system design and operation.

High Efficiency: Hollow fiber membranes have a physical membrane barrier provides consistent permeate quality. They offer a compact, cost-effective solution for filtering large volumes of liquids utilizing minimal space and energy. Hollow fiber membranes can be backflushed to remove solids from the membrane inside surface, thus extending the time between chemical cleaning cycles.

Flexibility: Hollow Fiber membranes are available in UF and MF technologies and come in an array of diameters. Hollow Fiber membranes feature a high membrane packing density resulting in systems with a small footprint. Systems can be configured to a range of flow capacities.

Range of Applications: Hollow fiber membranes have been successfully employed in a wide variety of applications including municipal water and wastewater treatment, industrial biotechnology, and in the food, beverage, dairy, and wine industries.

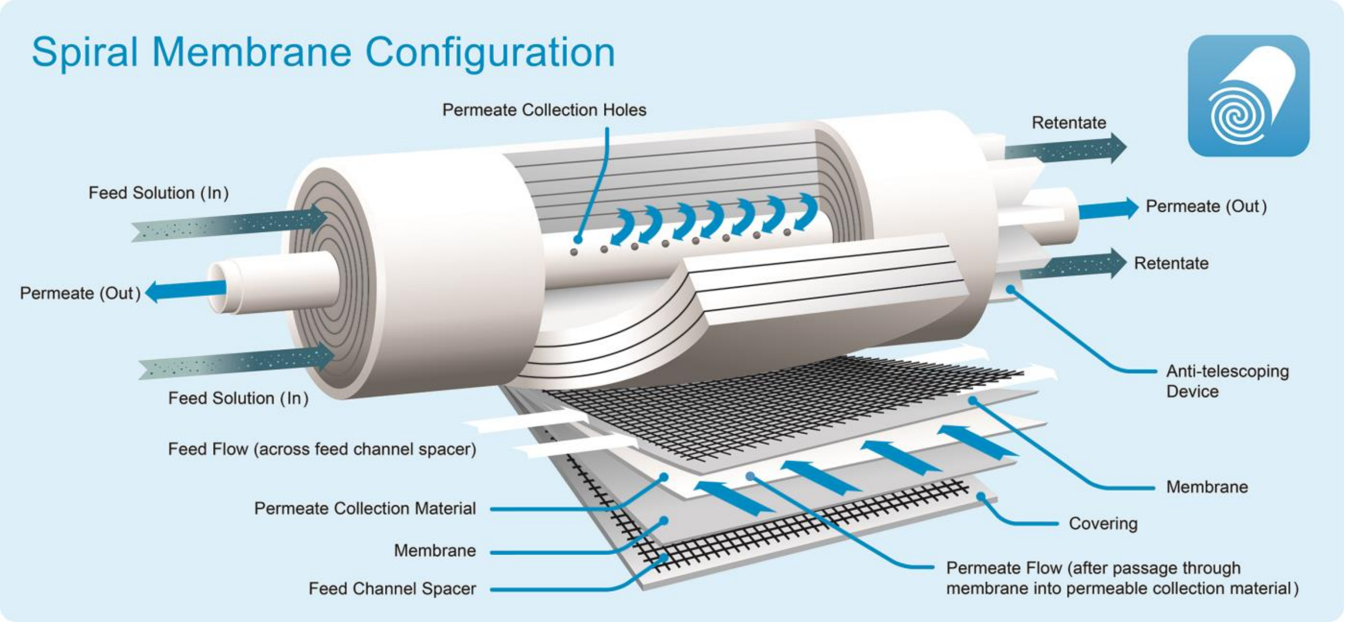
Spirals

For feed waters with a high concentration of dissolved solids, such as seawater, membranes in the spiral-wound configuration are the optimal solution. Spiral membranes commonly employ RO or NF technology.

Here are a few key points to consider:

Mode of Operation: Feed solutions enter one end of the element, flowing under pressure through the membrane into permeate channels, spiral to the central core, and exit as permeate.

High Efficiency: Spiral elements are made from layers of flat sheet membranes and feed separators wrapped around a hollow core. This configuration offers the highest membrane packing area capability with the smallest footprint. Spiral elements are robust, energy efficient, and economical to operate.



Flexibility: Spiral membranes are available in a variety of materials, diameters and lengths. Spiral membranes reliably remove dissolved solids from a variety of source waters; generally reverse osmosis and nanofiltration spiral membranes serve the water and wastewater market, while ultrafiltration and microfiltration spiral membranes are used in the industrial and life sciences markets.

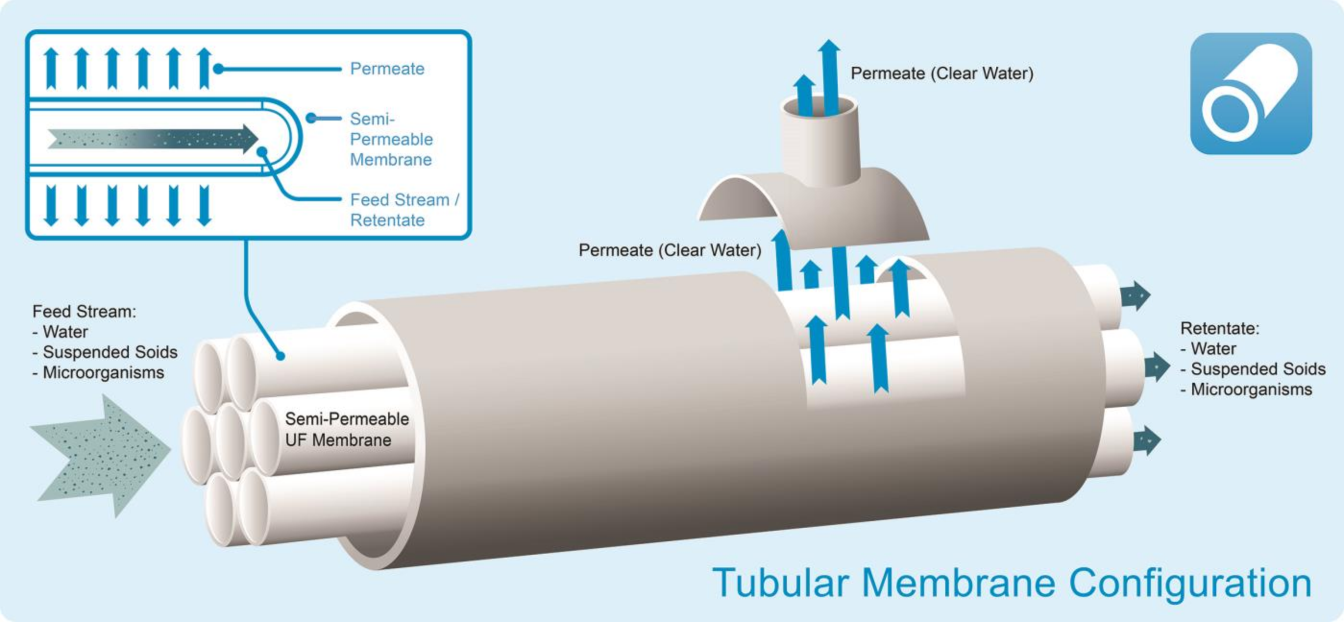
Range of Applications: Spiral wound membranes have quickly become the most prevalent of all the available membrane configurations. They excel at seawater desalination, brackish water treatment, water softening, and organics removal. Sanitary spirals are widely used in dairy, food, and pharmaceutical applications, allowing for high rejection without compromising yield.

Tubular

While virtually any membrane design can be applied to water-like liquids with low concentrations of suspended solids, viscous streams and fluids with large amounts of solids are best handled with tubular membranes, which are specifically designed for this purpose.

Here are a few key points to consider:

Mode of Operation: Tubular membranes operate in tangential, or crossflow, design where process fluid is pumped along the membrane surface in a sweeping action. This design maintains stable filtration rates for process streams with high concentrations of particles or macromolecules such as cells, proteins and precipitates.



Durable Construction: Tubular membranes have a rugged construction made of sturdy polymeric materials, so they can easily process high suspended solids and concentrate product proficiently and repeatedly to high end-point concentration levels without plugging.

High Efficiency: Durable and long-lasting, low-energy tubular membrane configurations are easy to operate, run in continuous, reproducible processing cycles, and offer optimal productivity, high flux, and high recovery.

Flexibility: Tubular membranes are available in UF and MF technologies and come in an array of diameters. They can be purchased as individual elements or in compact systems covering a range of capacities.

Range of Applications: Tubular membranes are well suited for juice clarification, easily removing suspended solids, colloidal haze particles, microorganisms, and undesirable proteins without the need for diatomaceous earth. In tough industrial environments, tubular membranes are ideal for difficult to treat wastewater contaminated with oil, grease, heavy metals, and suspended solids. Tubular membranes operate successfully within a wide pH and temperature range without plugging.

Choose an Experienced Membrane Supplier

Koch Membrane Systems (KMS) can help you evaluate your specific application requirements and determine which membrane product is the best solution for your fluid separation needs. KMS can also help existing membrane users enhance the performance and extend the life of their membranes by improving system operating, cleaning and maintenance procedures. For more information about designing a system to meet your needs, please visit KMS online at www.kochmembrane.com.