Membrane Filtration Processes
Dead-End vs. Cross-Flow

Membrane systems can operate either through dead-end filtration or through cross-flow filtration. This bulletin explains the differences between the two processes.

INTRODUCTION

Many filtration processes use a dead-end technique, where the feed stream is directed perpendicular to the filter surface. A common example of dead-end filtration is a coffee filter. The coffee flows through the filter, but the coffee grounds remain on top of the filter's surface.

Municipal and industrial wastewater treatment plants, as well as other applications, use screens as a means of pretreatment to remove large solids, preventing possible equipment damage downstream. Like coffee filters, screens remove solids using dead-end filtration. Furthermore, wastewater screens are classified into two categories: coarse and fine screens. In some wastewater plants, a coarse screen (screen openings generally ranging from 0.25 to 6 inches) is used to remove the larger solids and is followed by a fine screen (screen openings typically range from 0.06 to 0.25 inches) to remove smaller solids.

Contrastingly, many process streams with high concentrations of small particles and molecules may rapidly coat the filter surface when operated in a dead-end mode. In doing so, the flow of liquid drops quickly as it has difficulties navigating through the build-up of particles. In these applications, a cross-flow membrane system provides a means of stable flow rates. Cross-flow membranes may be provided in tubular, flat sheet, hollow fiber and spiral wound configurations, each of which provides certain advantages for specific processes.

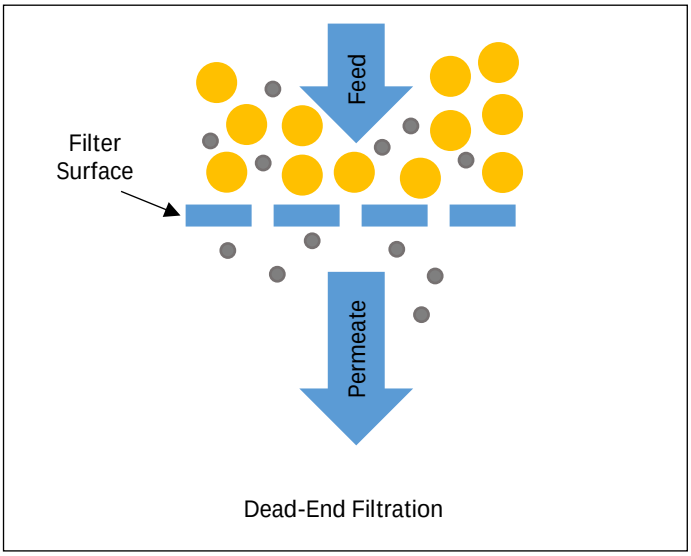

Figure 1. Dead-end filtration is a batch process in which the feed water is forced through the membrane. Retained particles stay behind on the membrane surface while water flows through. Accumulated particles on the membrane surface must be cleaned to maintain membrane performance.

DEAD-END FILTRATION

The most basic form of filtration is dead-end filtration. In dead-end filtration, the feed water is forced through the filter surface via an applied pressure. Retained particles stay behind on the filter surface while water flows

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through (Figure 1). The retained particles accumulate on the filter surface and consequently, the water experiences a greater resistance to passing through the filter. This may result in a decrease in flux.

Because the removed solids accumulate on the surface of the filter, filters and/or screens require cleaning to restore performance. For this reason, larger and newer treatment facilities tend to install mechanically, self-cleaning screens whereas smaller and older treatment facilities tend to install manually-cleaned screens. Self-cleaning screens come in a variety of configurations that allow for regular cleanings and solids removal from the screen's openings.

Dead-end filtration is a batch process and can be a very useful technique for concentrating compounds. It has two streams: the feed (raw water going through the filter or screen) and permeate (treated water free of solids).

CROSS-FLOW FILTRATION

Cross-flow filtration (also known as tangential-flow filtration) is a filtration technique in which the feed solution passes along the surface of the membrane (Figure 2). The constant turbulent flow along the membrane surface prevents the accumulation of matter on the membrane surface. A pressure difference across the element drives water through the membrane (permeate) while particles that are retained (concentrate) by the membrane continue to pass along the membrane surface. The process is referred to as "cross-flow" because the feed (and concentrate) flow(s) and permeate flow are perpendicular (90°) to one another.

Whereas dead-end flow has two streams, cross-flow filtration has three streams: feed (raw water going through the element), permeate (treated water) and concentrate (water with retained particles).

Cross-flow filtration is an excellent way to filter liquids with a high concentration of filterable matter. The feed and concentrate flows help keep the membrane surface clean and free of accumulated matter so the membrane may continue to perform with less frequent cleanings.

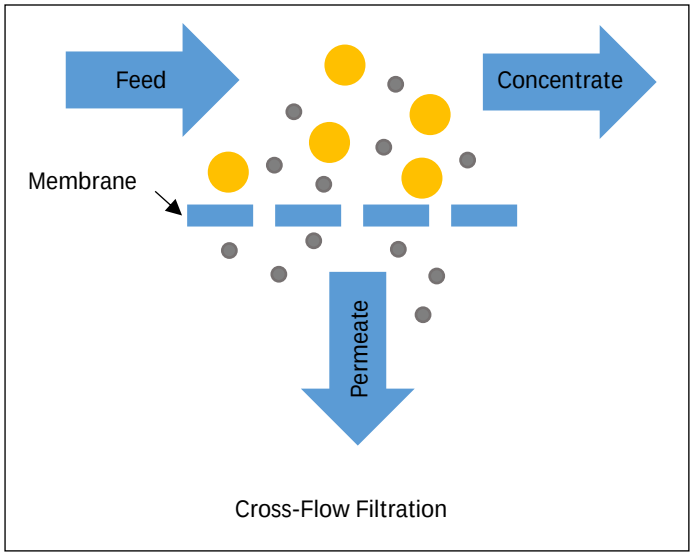

Figure 2. Cross-flow filtration is a process where the feed stream passes along the surface of a membrane. A pressure difference across the element drives water perpendicularly through the membrane while rejected particles continue to pass along the membrane surface.

In cross-flow filtration, it is important to maintain a high cross-flow velocity (or concentrate flow) to keep the membrane surface free of accumulated matter. For 4-inch diameter spiral-wound reverse osmosis (RO) and nanofiltration (NF) elements, it is recommended to keep the concentrate flow at 1.0 m^3/hr (5 gpm) or higher per pressure vessel. For 8-inch diameter spiral-wound RO and NF elements, it is recommended to maintain a concentrate flow of at least 4.5 m^3/hr (20 gpm) per pressure vessel.

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