What every operator should know about membrane bioreactors

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Knowledge	Principle	A practical consideration
Membrane bioreactor (MBR)	This process is a combination of biological treatment (activated sludge) and membrane filtration (instead of a clarifier).	An MBR can satisfy the needs of activated sludge treatment, including biological nutrient removal, without worrying about settling issues.
Membrane	A thin sheet of porous material. The porous medium is configured to provide highly efficient filtration of mixed liquor.	The pore size on this "filter" for most MBRs is 0.04 to 0.2 µm (microns).
Membrane configurations	Membranes may be configured in several ways, including • hollow fiber (looks like spaghetti), • flat plate (membrane sheets), and • disk (new).	Fibers and plates generally hang suspended in the mixed liquor, and the air scour causes movement of the media and cleaning. Disks are semirigid and may not require as much air for cleaning.
Micron (µm)	1/1,000,000 of a meter or 1/1000 of a millimeter	The pore size for the filters used in bacteriological analyses is 0.45 µm. (Most membranes will prevent the passage of bacteria.)
Pore size	Pore size is the average opening (pore) in the membrane. Most MBRs are in the range of ultrafiltration.	Ranges of relative pore sizes for filtration area include • sand filtration – 1 to 10 µm; • microfiltration – 0.1 µm; • ultrafiltration – 0.01 µm; • nanofiltration – 0.001 µm; and • reverse osmosis – 0.0001 µm.
Flux	Flux is the throughput of the membrane. It is based on rate of flow per unit of surface area, per unit time.	The typical range for flux rate may be 370 to 775 L/m^2•d (9 to 19 gal/ft^2•d). The effective surface area varies based on the membrane configuration.
Transmembrane pressure (TMP)	TMP expresses the pressure differential between the outside and inside of the membrane, similar to head loss.	A rise in TMP indicates an increase in fouling (clogging pores) or an increase in flux rate (throughput).
Basics of operation	To ensure best operation of the MBR system, some unique operations will be needed, including • using 1- to 3-mm fine screening; • maintaining 8- to 20-day sludge age; • operating at high mixed liquor suspended solids (MLSS) concentrations (8000 to 15,000 mg/L); and • sustaining a high return activated sludge (RAS) flow, about 2 to 4 Q.	• Good screening will remove materials that could harm the membranes. • Membrane filtration enables the use of higher sludge age and MLSS needed for nutrient reduction without the risk of high effluent total suspended solids. • The membrane tank is, in effect, a dead end for solids; therefore, the RAS rate will be higher than for a normal activated sludge process.

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Membrane cleaning	Just as filters must be backwashed to remove solids from the media, membranes require similar actions, including • air scour, • resting mode (or back-pulse), • clean-in-place, and • chemical cleaning.	All membranes require one or more of the cleaning methods. Cleaning methods vary with configuration and membrane type.
Typical results	Parameter performance BOD: <2 mg/L TSS: <0.5 mg/L NH_3–N: <0.5 mg/L TN: <3 mg/L TP: <0.05 mg/L Turbidity: <0.2 NTU Fecal coliform: <10 CFU per 100 mL	Note that reduction of nitrogen and phosphorus will depend on proper operation of specific nutrient removal processes. Even though most membranes will filter out fecal coliform, disinfection is required by regulatory authorities.
Motive force	Some MBR systems will require a reduction in the downstream pressure to achieve the necessary flux rate. This force can be from • pump suction, • vacuum assist, or • gravity.	MBR systems may require pumps, vacuum systems, or gravity to force the liquid to flow through the tiny pores. The amount of force needed will vary with configuration and system type.
Associated operational issues and limitations	Operators should consider the following issues when working with MBRs: • stormwater flow control, • membrane monitoring and cleaning, and • equipment maintenance.	• High flows will require flow leveling, equalization, or a scalping operation. • Membranes will age and require various cleaning methods and eventual replacement. • An MBR's support systems will require additional monitoring and maintenance.

BOD = biochemical oxygen demand.
TSS = total suspended solids.
NH_3–N = ammonia–nitrogen.
TN = total nitrogen.
TP = total phosphorus.

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