What every operator needs to know about membrane bioreactor activated sludge

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Knowledge	Principle	Practical considerations
Influent flow	Type of wastewater	A membrane bioreactor (MBR) activated sludge facility can treat most types of wastewater: ■ typical residential/domestic wastes, ■ hauled septage waste, and ■ high-strength wastes from industries. Limitations are similar to those of a conventional activated sludge treatment process and more associated with the ability to treat the wastewater biologically.
	Influent pumping and hydraulic profile	The influent configuration is the same as those found in conventional treatment facilities.
Preliminary treatment	Coarse screening	Most common is 20-mm (0.75-in.) or larger screen openings to protect downstream equipment and to remove larger materials that would inhibit, hinder, or be detrimental to the fine screen process performance.
	Grit/grease removal	Grit/grease removal is preferred, but not absolutely necessary depending on the characteristics of the influent wastewater. The membranes make the MBR process more sensitive to coarse debris and grease accumulation. Grit/grease removal will enhance MBR process performance and likely increase the life expectancy of the membranes.
	Fine screening	MBRs require 1- to 3-mm fine screens. Removal of particulate matter larger than these sizes protects the membranes from damage, deterioration, and sludging/ratting/sludge build-up. Two-dimensional screening is preferred. One-dimensional screening will not prevent passage of long thin objects, such as razor blades, thin rods, ropes, springs, or hair. Membrane manufacturers dictate screen size based on testing and experience. Screenings carry-over and/or pass-through is prohibited. (Pass-through refers to design or construction of the screen allowing unacceptable materials to pass either because the screen construction is poor or extreme conditions require it. The key is that pass-through occurs through the mechanical device and not around the unit.) Many screens are not designed for membrane application. It is recommended that materials removed by the screen be washed to capture and return the organics to the MBR activated sludge process.

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Equalization	Peak flow retention	Equalization is common and often preferred to reduce peak flow capacity through membranes and/or stabilize diurnal flows through the MBR process.
Primary treatment	Settling tanks	Most MBR facilities do not need primary tanks. A successful preliminary treatment process may eliminate the need for primary settling. Conveyance of organics, typically captured in the primary process, to MBR activated sludge can be preferred, especially in more advanced selector processes.
MBR activated sludge process configuration	Activated sludge process	Design is based on biological treatment of wastewater. Selector-based design is common and necessary for biological nutrient reduction. Process hydraulics operate either via gravity flow with traditional return pumping or forward pumping with gravity return flow. Membranes perform the critical solids separation process.
	Process design parameters	Mixed liquor suspended solids (MLSS) concentrations typically are between 8000 and 16,000 mg/L depending on the membrane used. Solids retention time should be 10 to 20 days. Hydraulic residence time should be 4.5 to 16 hours. Maintaining minimum wastewater temperature is a key parameter for membrane sizing and must be identified to size the membrane area properly. When properly sized, the membrane design-average and peak-daily flow rates likely will differ from the respective biological process flow rates. Membranes typically have no more than a 2- to 1-peak factor. Total tank volume should be 25% to 40% of a conventional facility and side water depth should be similar to a traditional process: 2.5 to 5.0 m (8 to 16 ft).
	Physical configuration	Total activated sludge tank volumes are within 10% when compared among various membrane types. Basin sizes for the installed membranes and remaining process volumes will vary greatly when comparing membrane types.
	Recirculation systems	MBRs use traditional return activated sludge (RAS) rates for biological process and mixing; the recycle flow is 4 to 6 times the influent flow. Internal recycle(s) for biological process should be between 1 and 2 times influent flow.
	Membranes	MBRs can use microfiltration or ultrafiltration membranes configured as flat sheets, plates, or hollow fibers. Quantity of membranes (required surface area) will be based on flow-through capacity of the membrane type. Membranes are hydraulically limiting. Membrane characteristics – flux rates, physical configuration, transmembrane pressure (TMP), and maintenance practices – vary widely among manufacturers.
	Air systems	Process air systems in basins other than those with membranes usually use fine bubble diffusers. Scour air system diffuser types may vary and provide air to the membranes for flux maintenance and the biological process. Air flow for each system and/or basin is quantified (metered) and controlled automatically.

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MBR activated sludge process configuration *(continued)*	Permeate system	Permeate can leave the system by gravity or pumping depending on the membrane used and site-specific conditions. The typical permeate cycle takes 10 minutes, which includes 8 to 9 minutes of filtration and 1 to 2 minutes of relaxation. Pumps and/or control valves and meters continuously control and monitor permeate flow. TMP is monitored and controlled through permeate header pressure. Turbidity is monitored to measure the permeate quality.
	Flux maintenance	Flux maintenance is achieved through the following techniques. ■ Continuous air scour during permeating. ■ Permeate relax cycle with scour air and no permeating. ■ Daily relax with no scour air and no permeating. ■ Flow back-pulse during permeate relax. ■ Chemical back-pulse during permeate relax. ■ Daily maintenance chemical clean. ■ Periodic *in situ* recovery clean with chemical. ■ Periodic soak recovery-clean with chemical.
	Control system	Microprocessor controls – often programmable logic controllers (PLCs) – handle automatic control of all systems associated with the membrane performance. Human–machine interfaces (HMIs) are provided for operators to monitor and interact with the process.
	Ancillary equipment	This equipment includes ■ mixers in the process basin without aeration; ■ basin-level indicators; ■ oxidation–reduction potential, MLSS, temperature, and dissolved oxygen probes; ■ permeate storage tank(s) for back-pulsing depending on the membrane type; ■ supply chemical storage and pumping; and/or ■ flow systems for maintenance cleaning. These facilities vary widely depending on the membrane being used.
Effluent clarification	Secondary and tertiary clarifiers	These components are unnecessary because the membranes separate the solids from the MLSS and effluent (permeate).
Post-treatment processes	Aeration system	Adding air to maintain a dissolved oxygen level is common.
	Disinfection system	Chemical dosage or an open/closed channel ultraviolet systems are common. A study in Ohio of five facilities found that disinfection following MBR activated sludge treatment provided no additional reduction in *Escherichia coli,* fecal coliforms, and viruses. In these cases, the process permeate before disinfection also exceeded post-disinfection quality of conventional effluent.
Effluent quality	Biochemical oxygen demand (BOD) and turbidity	BOD and total suspended solids typically should be less than 5 mg/L following MBR treatment. Non-detect results are common. Turbidity concentration should range between 0.05 and 0.4 NTU.
	Ammonia and total nitrogen	MBR activated sludge processes can be used to achieve total nitrogen concentrations as low as 2 to 3 mg/L.
	Phosphorus	MBRs can achieve less than 1.0 mg/L phosphorus biologically. Most designs include a chemical addition system to aid in the biological removal of phosphorus.

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