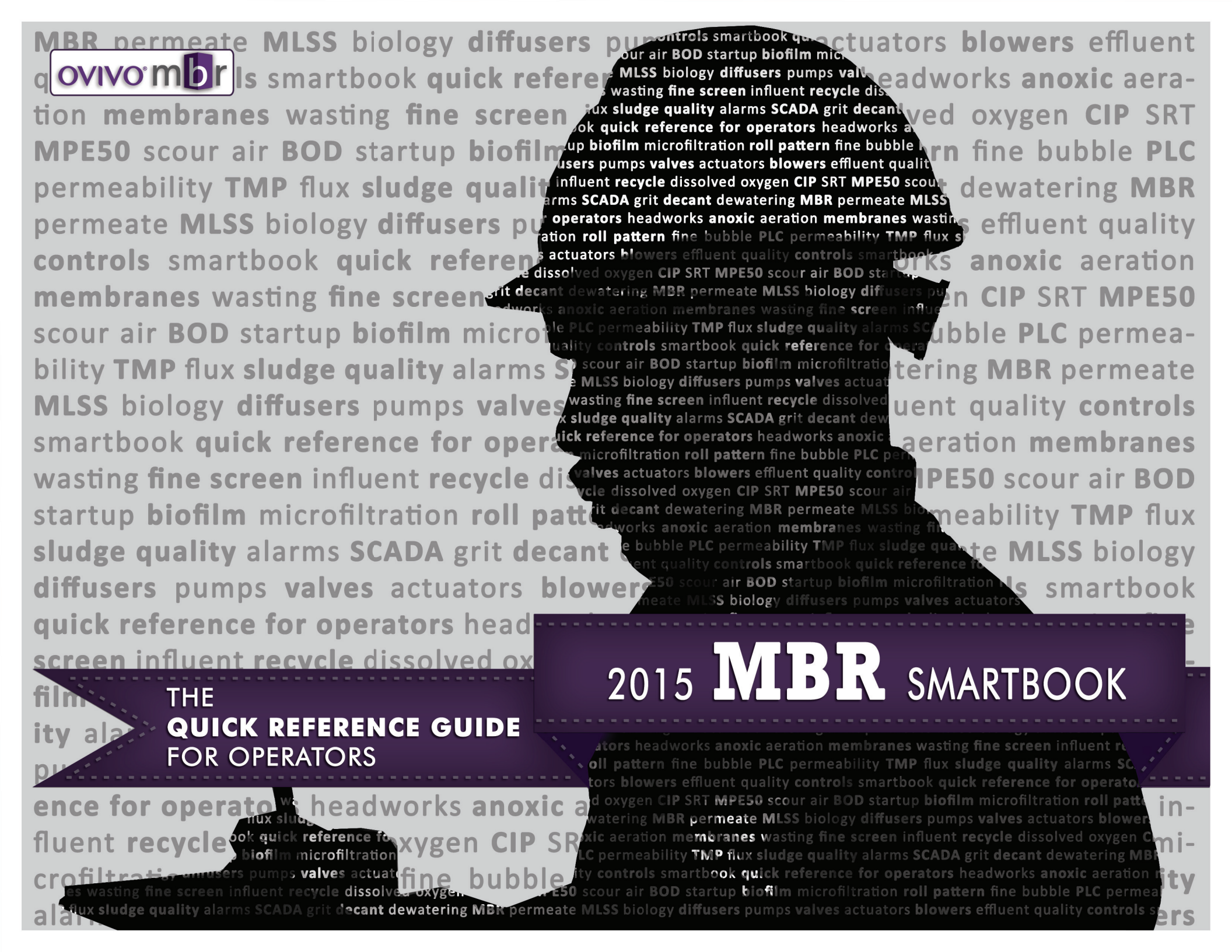
OVIVO mbr

2015 MBR SMARTBOOK

THE
QUICK REFERENCE GUIDE
FOR OPERATORS



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INTRO-DUCTION

At its most basic level, MBR is very simple: filter clean water out of mixed liquor. However when you start adding in the different parts that make the overall system work, things start to get complicated. Biology, controls, diffusers, pumps, valves, blowers—how do all these parts interact with each other to produce high quality effluent?

It's easy to be overwhelmed by a full scale MBR facility, so this Smartbook takes the approach of walking through all the major things that an operator would want to know on Day One, having never touched an MBR before.

We think that if you have a quick reference guide to your MBR, you'll be able to become an expert much faster than if you only had O&M and startup manuals to read.

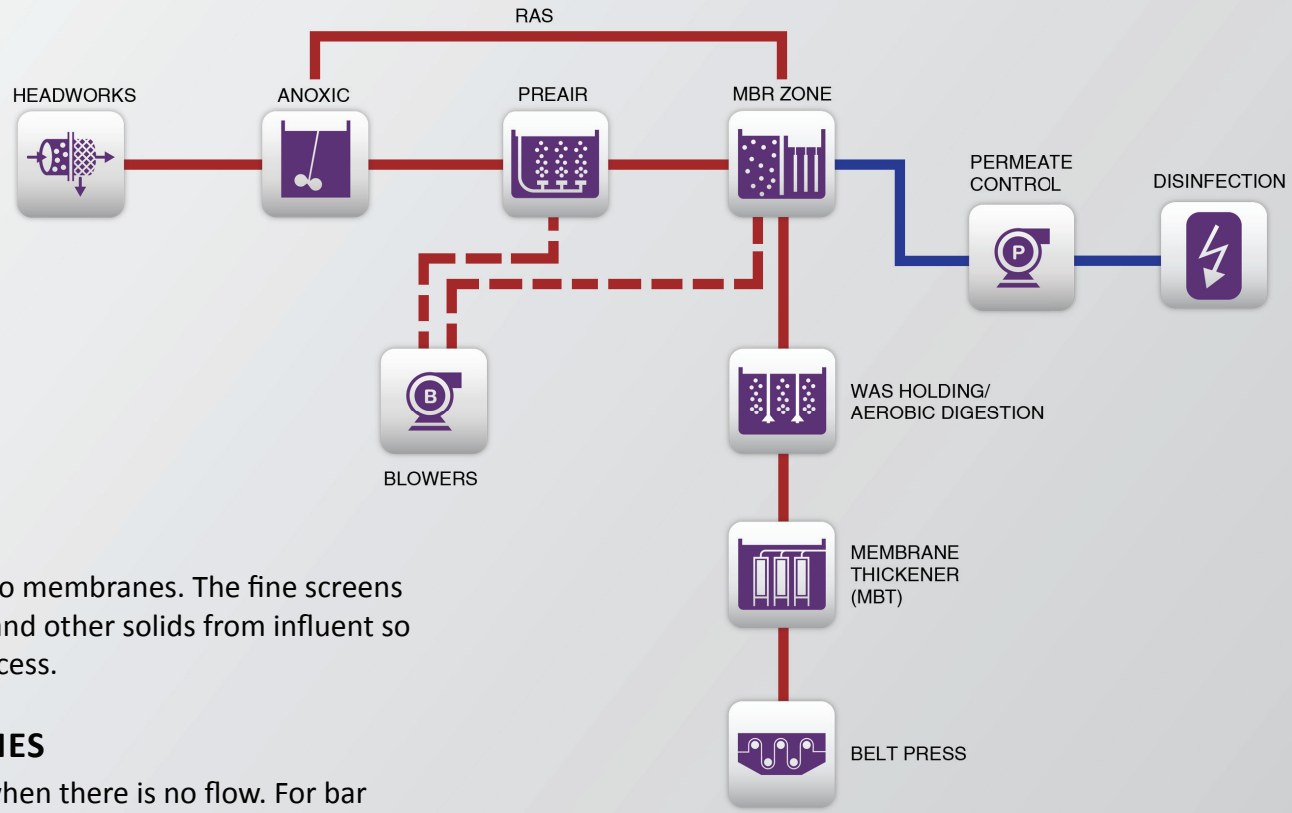
While this Smartbook is aimed at the **Day One operator** who is just getting to know his or her MBR, we also hope that the hundreds of experienced operators from established MBRs around the world will read it and give us feedback on how we can improve this book.

"What do we do?
Cultivate biology and then filter it"
– Josh Phillips,
MBR startup technician

HEAD WORKS

INFLUENT FLOW METER

Measures influent flow entering the MBR from the lift station. In flow control mode, the system attempts to match permeate flow to influent.



FINE SCREENS

Debris and grit can cause damage to membranes. The fine screens remove food particles, trash, hair, and other solids from influent so that it does not reach the MBR process.

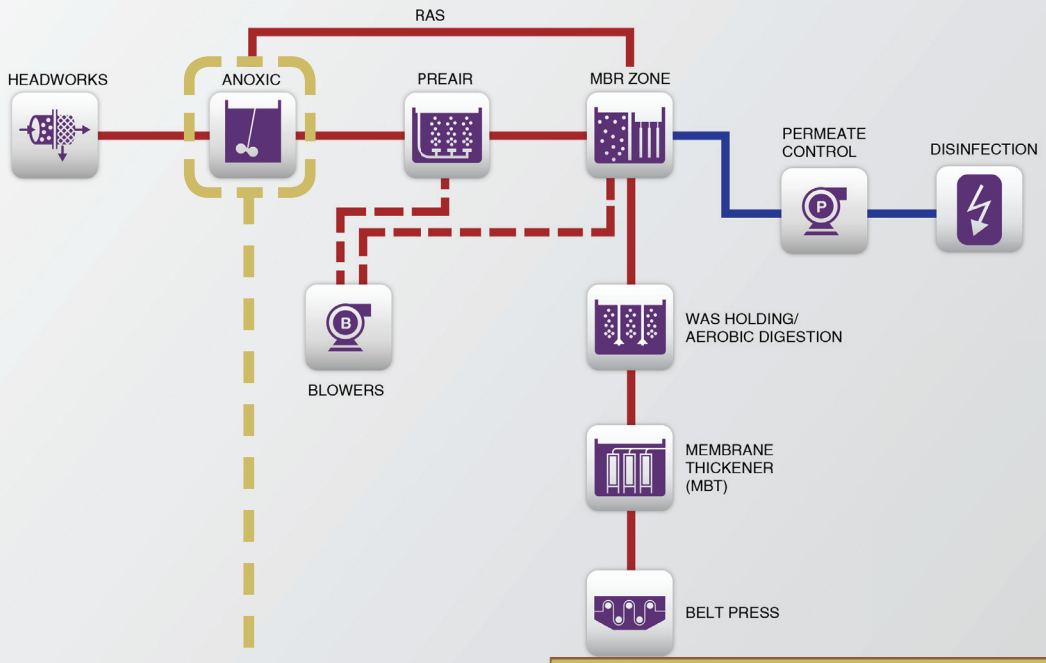
FINE SCREEN FLOAT SWITCHES

The fine screen does not operate when there is no flow. For bar screens to activate, there must be enough water in the fine screen box to float the high level switch. To shut off, the water level must recede far enough that the low level switch hangs straight down.

MBR
WALK-THROUGH

ANOXIC (AX) ZONE

VISIT **BLOG.MBRCENTRAL.COM/ANOXIC** AND LEAVE YOUR QUESTION OR COMMENT



BIOLOGICAL PURPOSE

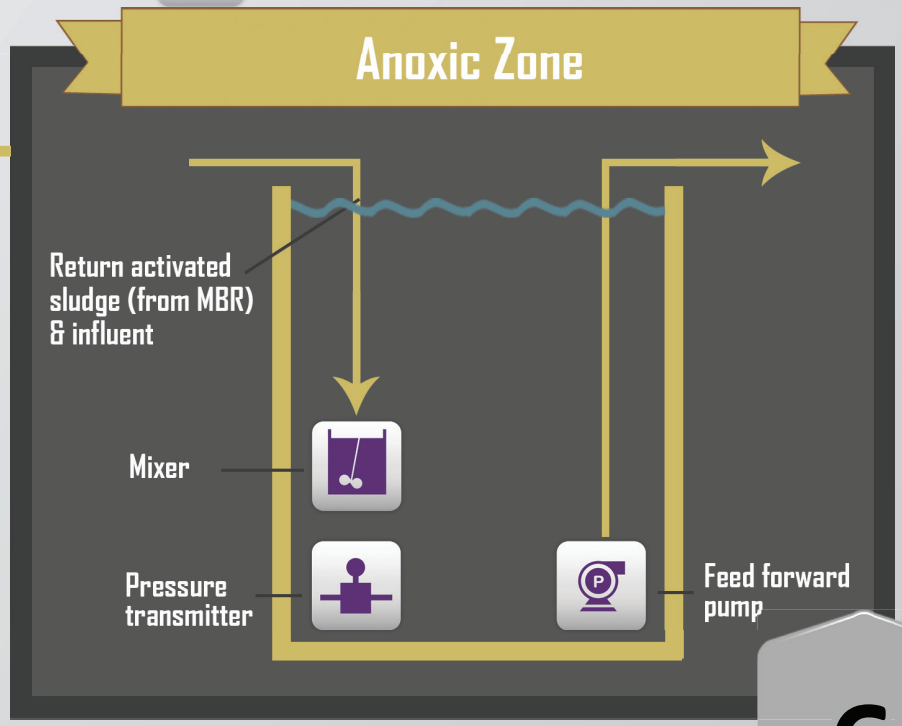
Remove nitrates (NO_3) by converting to N_2 gas.

ANOXIC MIXER

The anoxic basin requires a mixer to prevent settling.

PRESSURE TRANSMITTER

In Level Control Mode, the system determines the permeate flow rate based on the water depth in the anoxic basin. The level sensor/transmitter sends this data to the SCADA system.



RECYCLE (AKA RAS OR FEED FORWARD) PUMPS

RAS pumps circulate mixed liquor between basins. Typically, the thickest sludge in the plant is located in the MBR zone, so it's very important to circulate it back to the front of the plant to mix with lower MLSS (mixed liquor suspended solids) sludge. The MLSS in the various basins is never going to be equal but the pumps keep it moving and keep the MBR sludge from getting too thick.

The purpose of recycle pumps is to –

- Help equalize the MLSS (mixed liquor suspended solids) between the basins
- Move mixed liquor through the various process zones (anoxic, aeration, etc.) to allow biological nutrient removal to take place

Recycle pumps are sometimes referred to as "feed forward" pumps. Generally, if the pumps are located in the anoxic zone they are feed forward pumps while if they are located at the end of the plant (MBR zone) they are called recycle pumps.

RAS CHECK VALVES

Check valves prevent backwards flow. In this case, if the RAS pumps were to stop, two undesirable things would happen--

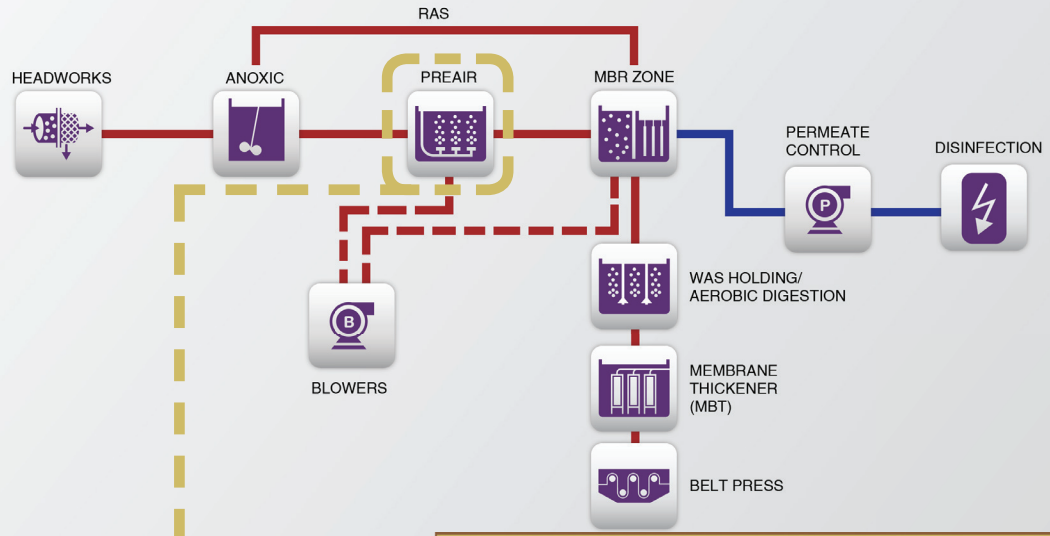
- Sludge would flow backwards through the pumps, causing them to rotate backwards
- Sludge would flow back to the anoxic basin from the preair zone

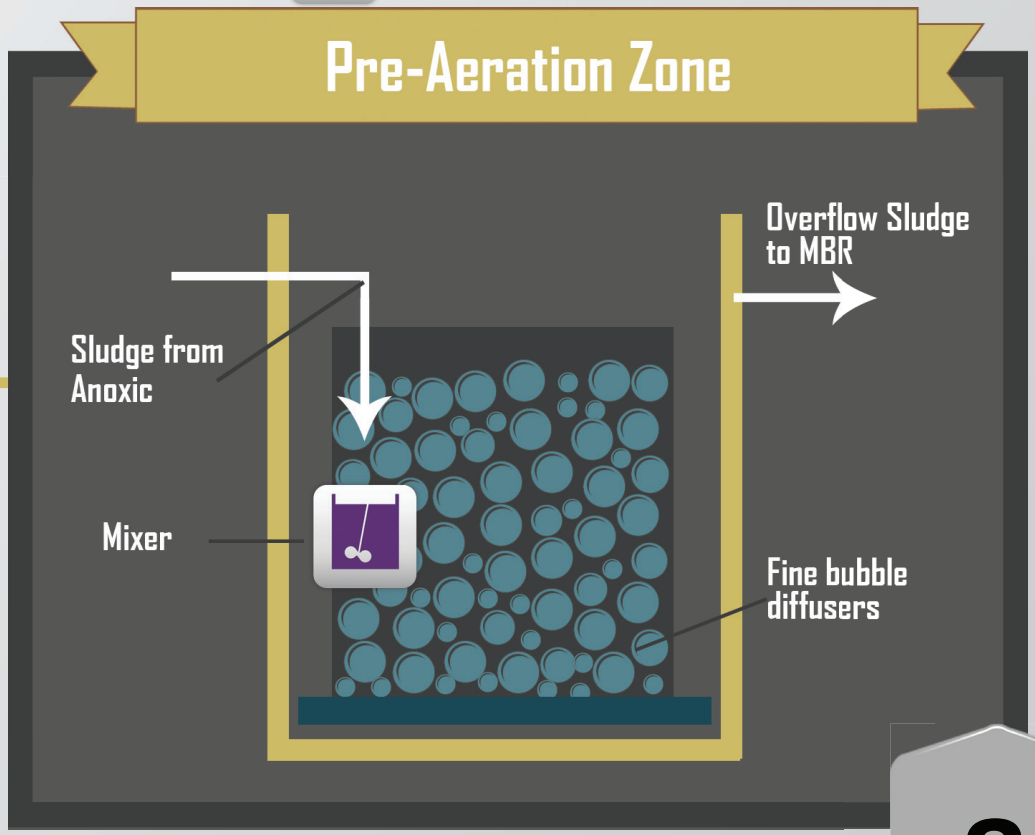
RAS FLOW METER

The RAS flow meter measures how much flow the pumps are generating. Desired flow is normally 4-5 times the plant's design influent flow (4-5Q). The SCADA is programmed so that flow that does not meet the set point results in an alarm. Recycle flow below 3Q will result in excess thickening in the membrane zone.

MBR
WALK-THROUGH

PRE-AERATION
(PA) ZONE





PA MIXER

In some systems, the pre-air basin acts as a “swing” basin. That is, aeration can be shut off for extended periods of time. In this case, a mixer is needed to prevent solids from settling.

FINE BUBBLE DIFFUSERS

For nitrification, which primarily takes place in the pre-air basin, it is desirable to have the most efficient diffusers possible. In general, smaller (finer) bubbles are more desirable than larger (coarse) bubbles, because small bubbles transfer oxygen into water more efficiently.

DO/TEMPERATURE SENSOR

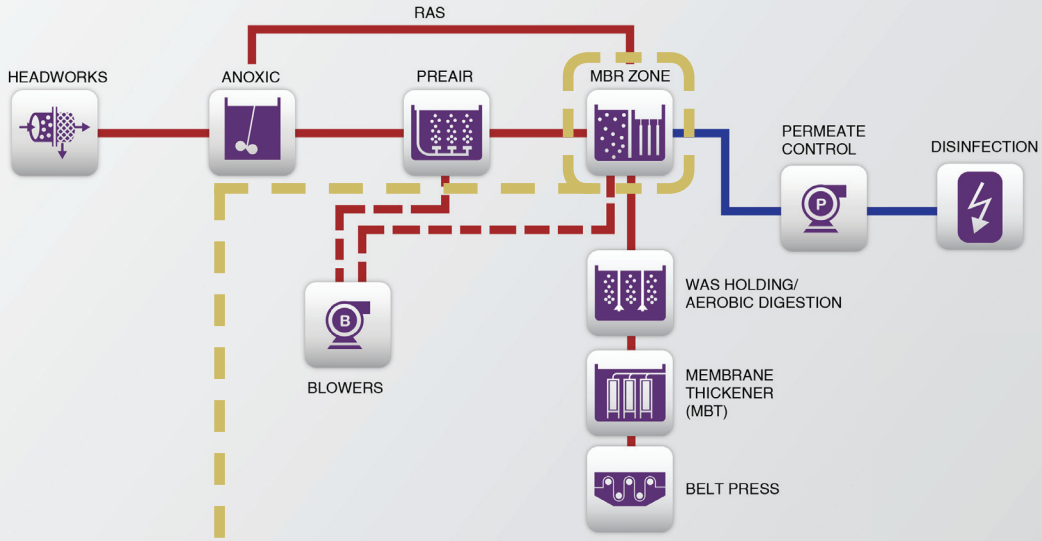
Dissolved oxygen level in the pre-air basin is commonly used to control the airflow into the basin. When DO reaches its set point (usually 1-2mg/L), the blower can be temporarily shut off or reduced until DO falls.

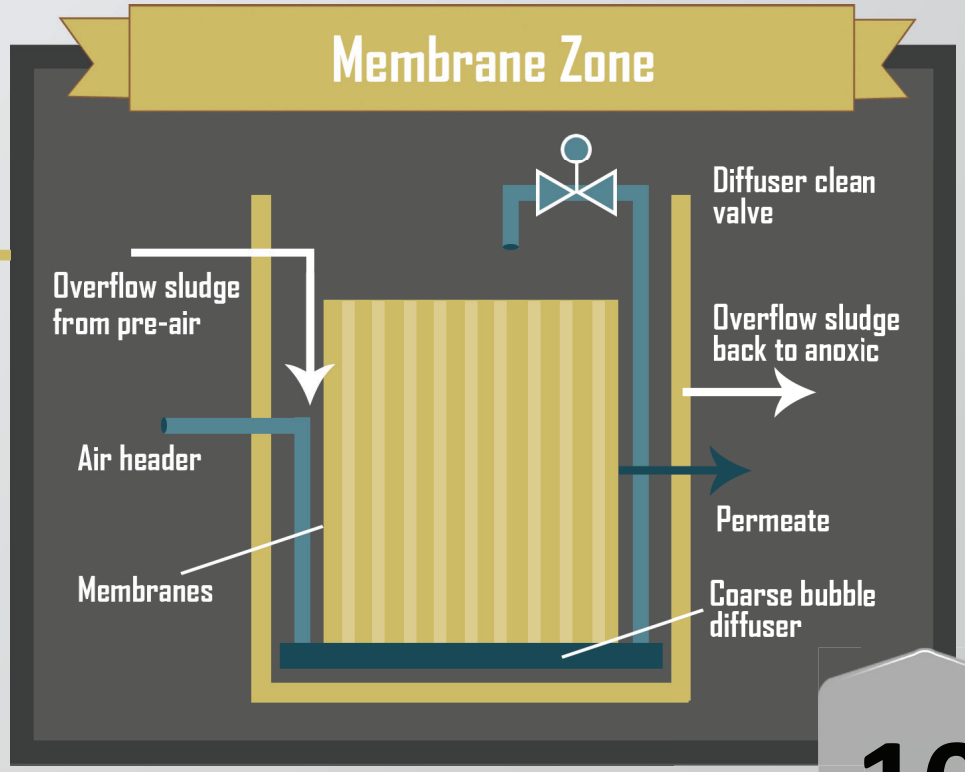
SC100/SC200 TRANSMITTER

The transmitter is located at the basin and the DO/temperature and other sensors are connected to it. The sensors can be calibrated and configured at the SC200. The SC200 sends a signal back to the PLC with the DO and temperature reading.

MBR
WALK-THROUGH

MBR | MEMBRANE ZONE





MEMBRANE CASSETTES

Sometimes called submerged membrane units (SMU) in the case of flat plate systems, this is the central piece of equipment in the MBR. A membrane cassette (or unit) is the container for anywhere from 75 to 200 plates, sheets, or hollow fibers.

SCOUR AIR DIFFUSERS

Diffusers are located below the membranes. In the case of flat plate membranes, these are coarse bubble diffusers; for flat sheet systems, fine or medium bubbles are used. Air flow is supplied to drive mixed liquor up through the membrane cassette. It also serves to “scour” the membrane surface, which reduces the fouling rate.

DIFFUSER CLEAN VALVE

Applies to systems with Kubota (flat plate) membranes. Coarse bubble diffusers can become clogged when debris or rags buildup on them. Diffuser cleaning is the process where mixed liquor is sucked into and through the diffuser to flush it out. When the diffuser clean valve is open, that is a “Diffuser Clean” cycle. When it is closed, that is normal operation.

CHEMICAL CLEAN PIPING

Clean-In-Place (CIP) is performed by backfilling the membranes with dilute bleach or acid solution and allowing them to soak for anywhere between 2-12 hours.

SCOUR AIR FLOW METER

Air flow is varied depending on the amount of permeate flow. Higher permeate generally requires more scour air to prevent fouling rate from increasing. The flow meter allows the SCADA system (and operator) to monitor the air scour rate and ensure that it meets the desired set point.

PERME-ATE | CONTROL

PERMEATE PUMPS

Pumps create suction to draw water through the membranes. Pumps are required when the permeate discharge is located above the membrane basin. Pumps are not required when there is sufficient head in the MBR basin to drive water through the membrane surface, such as when the MBR basin is located above ground.

PRESSURE TRANSDUCERS

These measure the amount of pressure after water passes through the membranes. This allows the PLC to perform a calculation to find the TMP (transmembrane pressure).

FLOW CONTROL VALVES

In systems with flow control valves, they are used to throttle the permeate lines, controlling the flow rate. These are automated valves that are controlled by the PLC; they work in conjunction with the permeate flow meter and adjust to meet the set point.

PERMEATE FLOW METER

Measures the flow of water being filtered by the membranes.

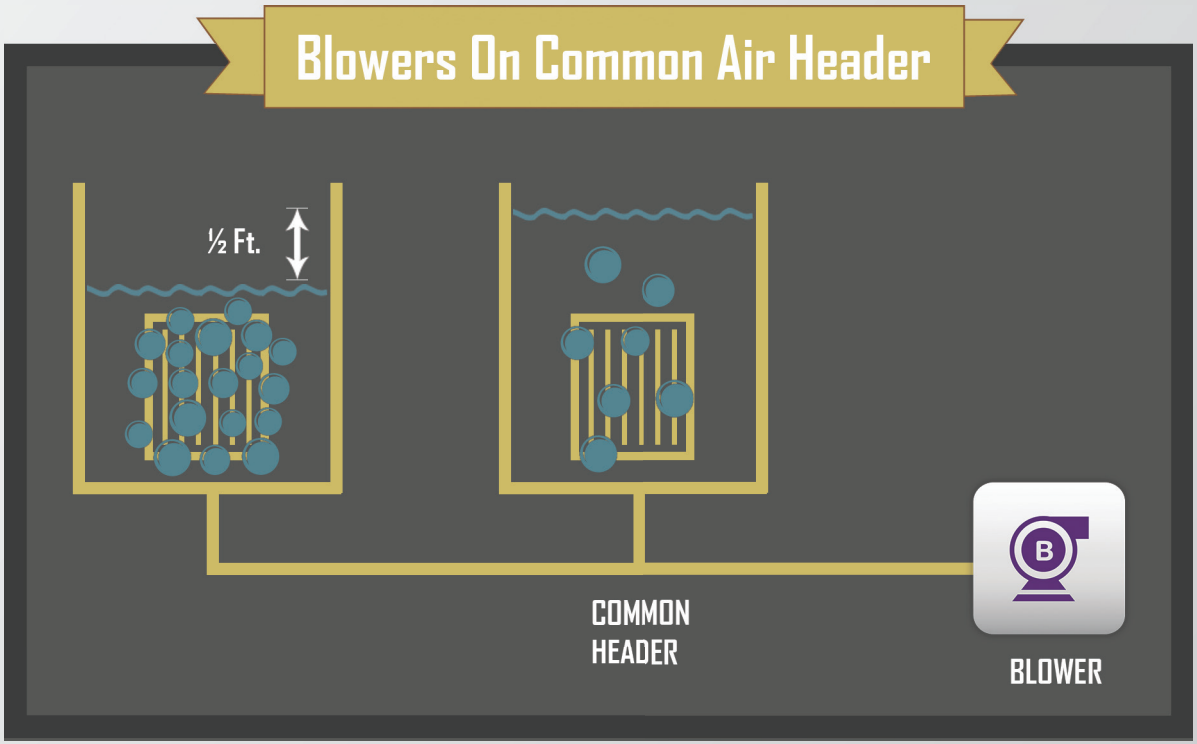
BLOWERS

MEMBRANE BLOWER

Supplies air to the scour air diffusers. One type of piping design for MBR or preair blowers uses a common header for multiple basins. This design depends on each basin having the same side water depth at all times. Even a slight different in water level (as little as six inches) can cause an imbalance in flow due to air following the path of lease resistance.

COMMON STANDBY BLOWER

In case the primary MBR or pre-air blower fails, the standby takes over.

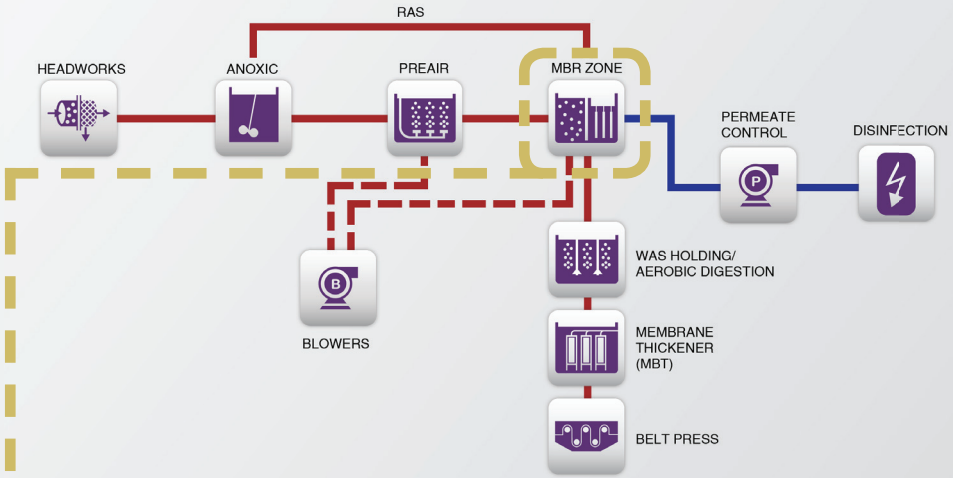


PRE-AIR BLOWER

Supplies air to the fine bubble diffusers.

MBR
WALK-THROUGH

CHEMICAL CLEAN-IN-PLACE | **(CIP)**



MAZZEI INJECTOR

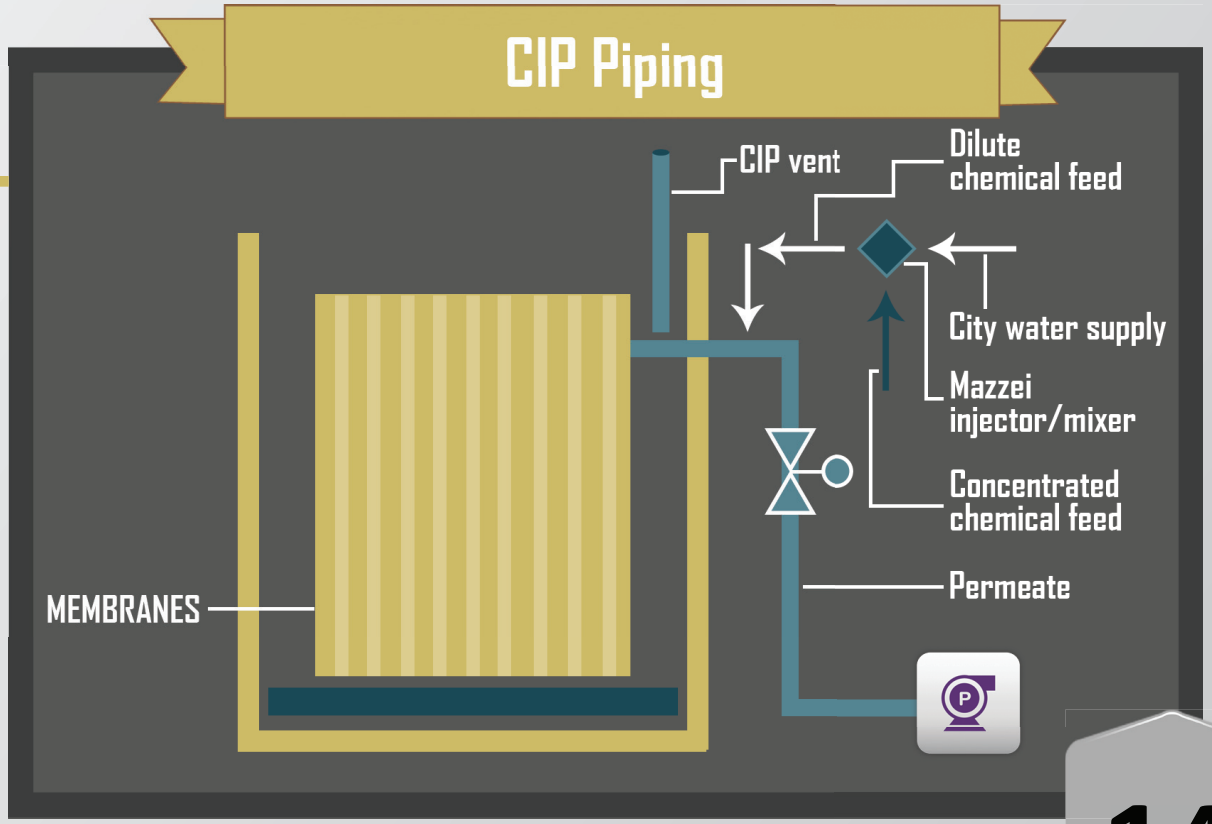
Continuously mixes concentrated chemical with water to produce a dilute chemical solution.

FLOW METER

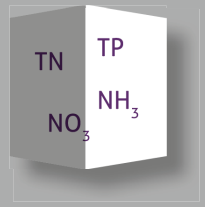
Measures the flow of dilute chemical solution going to the membranes.

CIP VENT

Allows gases to escape during the chemical soak; regulates backpressure at the membrane surface by allowing water to escape if it reaches 7 ft. above the membrane cassette.



BIOLOGY AND SLUDGE

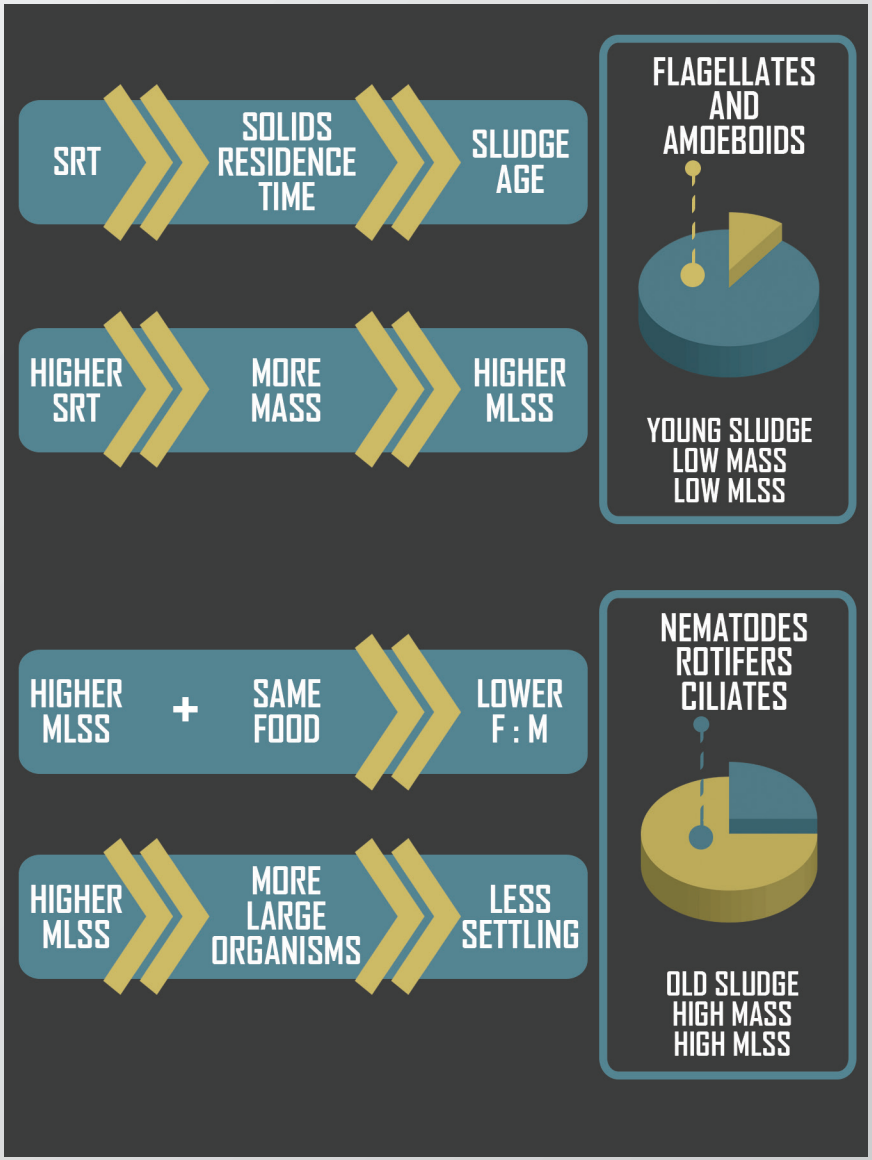


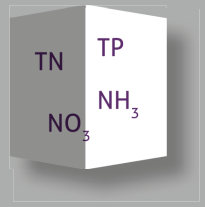
WHAT IS

MIXED LIQUOR?

There are a number of differences between conventional activated sludge and MBR sludge, but it all starts with the amount (or mass) of the sludge itself. To get more mass takes more time. Greater sludge age means more of the larger types of organisms (nematodes, rotifers, ciliates) will be present, and there will be fewer of the small organisms like flagellates and amoeboids (as a percentage). Since the small organisms tend to floc together and cause settling, MBR sludge doesn't tend to settle very much.

There are a few other correlations. One that is commonly talked about is food to mass ratio (F:M). Realize that a conventional plant and an MBR with the same influent will have different F:M ratios. The MBR has more mass, but the same amount of food; this means it has a smaller F:M.



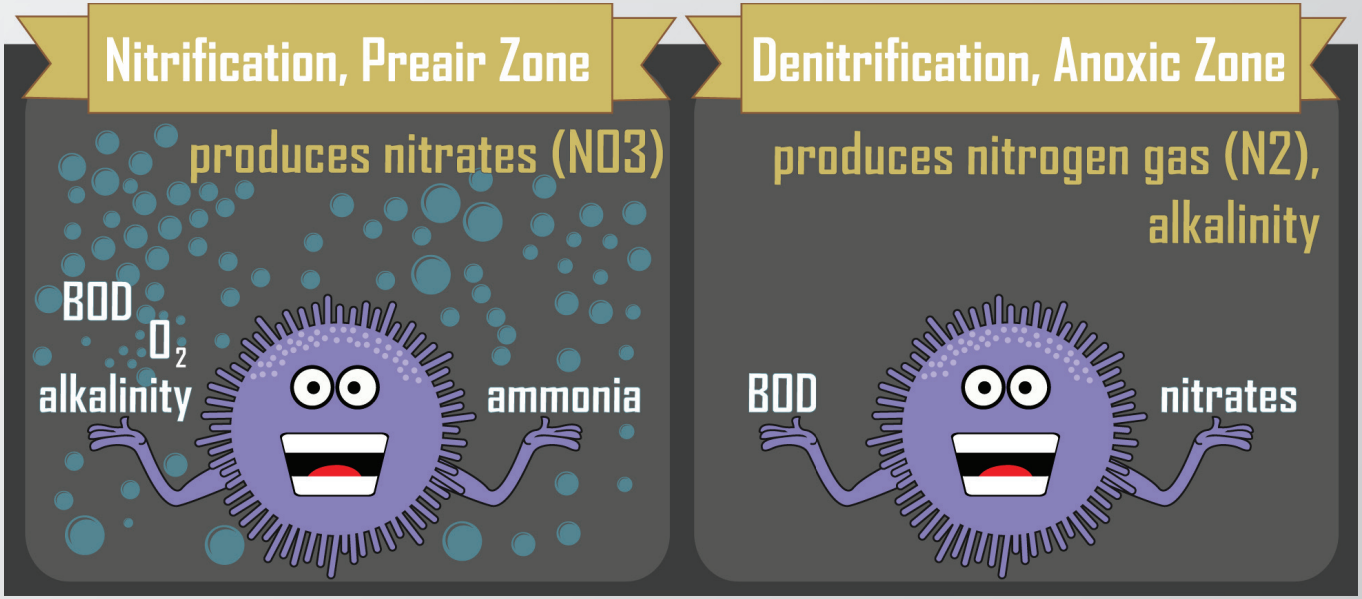


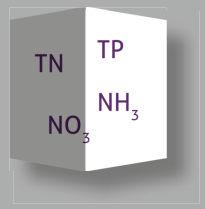
NIT-DENIT

NITRIFICATION / DENITRIFICATION

Ask a wastewater operator about his permit and in most places you'll be talking about ammonia (NH_3); and nothing gets rid of ammonia like bacteria and oxygen. But what happens to it? As you probably know this process is called nitrification. Essentially, bacteria use ammonia (NH_3), oxygen (O_2), and carbon (BOD), and produce nitrates (NO_3). This occurs mainly in the preair zone, where there is dissolved oxygen (DO).

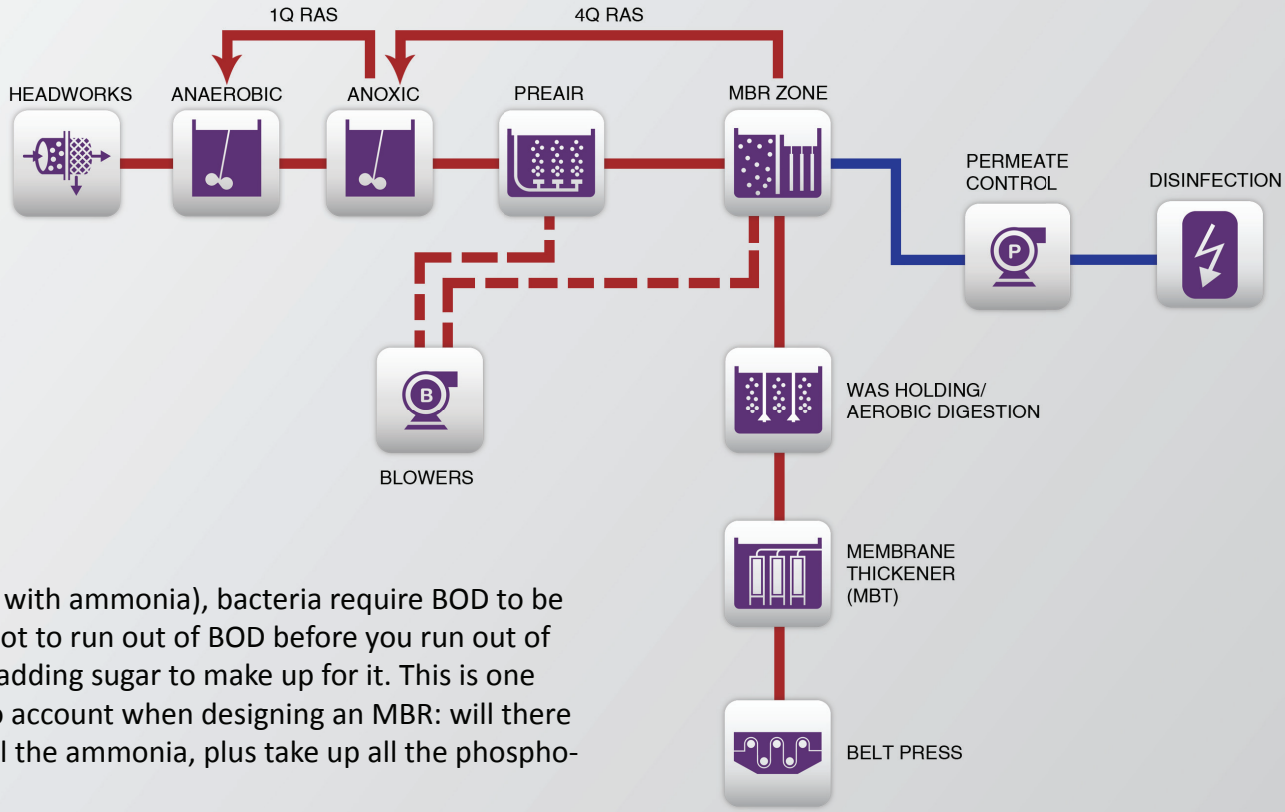
Next, the question becomes what to do with all the nitrates (NO_3) produced in the preair zone? Assuming the permit requires it, you may need to get rid of all but 1-2 mg/L of NO_3. This is where the anoxic zone becomes important. Those same bacteria, which in the preair were gobbling DO find themselves in need of oxygen; and the place they find it is on an NO_3 molecule! Taking two NO_3 molecules and stripping the oxygen off will give you one N_2 nitrogen gas molecule. This is very convenient for the environment, since the earth's atmosphere is almost 80% nitrogen gas.





BNR
BIOLOGICAL NUTRIENT REMOVAL

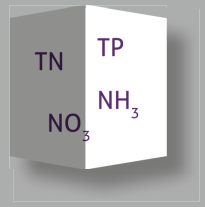
What other nutrients besides nitrogen (ammonia and nitrates) do we need to remove? Mostly we're concerned with carbon (BOD) and phosphorous (TP). Since biology will consume BOD no matter what, that part is easy. Phosphorous is a little trickier though.



For phosphorous uptake (as well as with ammonia), bacteria require BOD to be present. That's why it's important not to run out of BOD before you run out of phosphorous, or else you'll end up adding sugar to make up for it. This is one thing that Ovivo engineers take into account when designing an MBR: will there be enough BOD present to nitrify all the ammonia, plus take up all the phosphorous?

Phosphorous uptake has to happen in a zero DO environment, so there will generally be an anaerobic zone added to the plant for this to happen. The other way to remove phosphorous is to use a chemical such as alum (aluminium sulfate).

BIOLOGY AND SLUDGE



MLSS

FOR DIFFERENT TYPES OF MEMBRANES

There are three basic types of membranes for wastewater treatment: hollow fiber, flat plate, and flat sheet. They each have their advantages and disadvantages. From an engineering perspective, the most important factor is packing density (how much membrane you can fit into a basin); but if you have too high of a packing density, things start to get tricky from the operator's point of view.

One of the advantages of hollow fiber (HF) is that engineers can pack a very large amount of membranes into a small space. HF probably has the highest packing density of the three technologies. On the other hand, when you pack membranes too tightly, it restricts the ability of sludge to move around, which means the operator may have to operate at a lower MLSS: thinner sludge can move more easily between membranes. Flat plate membranes on the other hand do not pack the membranes as close together. They generally have rigid plates which are a fixed 8mm distance from each other. This leaves lots of room for sludge to move around between membranes, so the MLSS can be much higher without losing performance.

Flat sheet is a sort of hybrid between the two other technologies. It still maintains the fixed 8mm distance between sheets, which allows for operation at higher MLSS. The difference is that the sheets are much thinner than plates are. This means that engineers can fit more sheets into the same space compared with plates (packing density again).

Pore size is another consideration. Flat plate membranes have a large pore size which becomes smaller as it is covered with biofilm when submerged in mixed liquor. This allows for high quality permeate after the biofilm grows up, but the MLSS has to be a minimum of 8,000mg/L for this to happen. With HF and flat sheet membranes, pores are small to begin with, so it is not as important to keep MLSS above 8,000mg/L. Some MBRs are so underloaded that running at very low MLSS can be an advantage.

The Ovivo startup technician's main goal during training is to make the operator comfortable running the new system. However, it is always good to have something to refer back to. Your IOM is a wealth of detailed information, but this Smartbook is your quick, easy-to-use reference. Some other areas that require your attention post-startup are—

MIXED LIQUOR MATURITY

After seeding at 3,000mg/L the process is acclimating itself as it grows to 8,000mg/L. At that point it's time to increase the permeate flow rates to full design because the biofilm will have established itself on the membranes.

ROUTINE CHECKS

Establish your daily and weekly routine checks as soon as possible. Use the forms included here as a guide.

BLOWER OIL

Most blowers require the oil to be changed within the first 100 to 500 hours because the original factory oil picks up any metal shavings left over from manufacturing.

MLSS TESTING

Make sure to decide what method will be used to test mixed liquor suspended solids (MLSS): hand-held probe, lab testing in house, or outside lab testing.

LAB TEST KITS

Order any needed chemical tests from Chemetrics, Blue Book, or other sources.

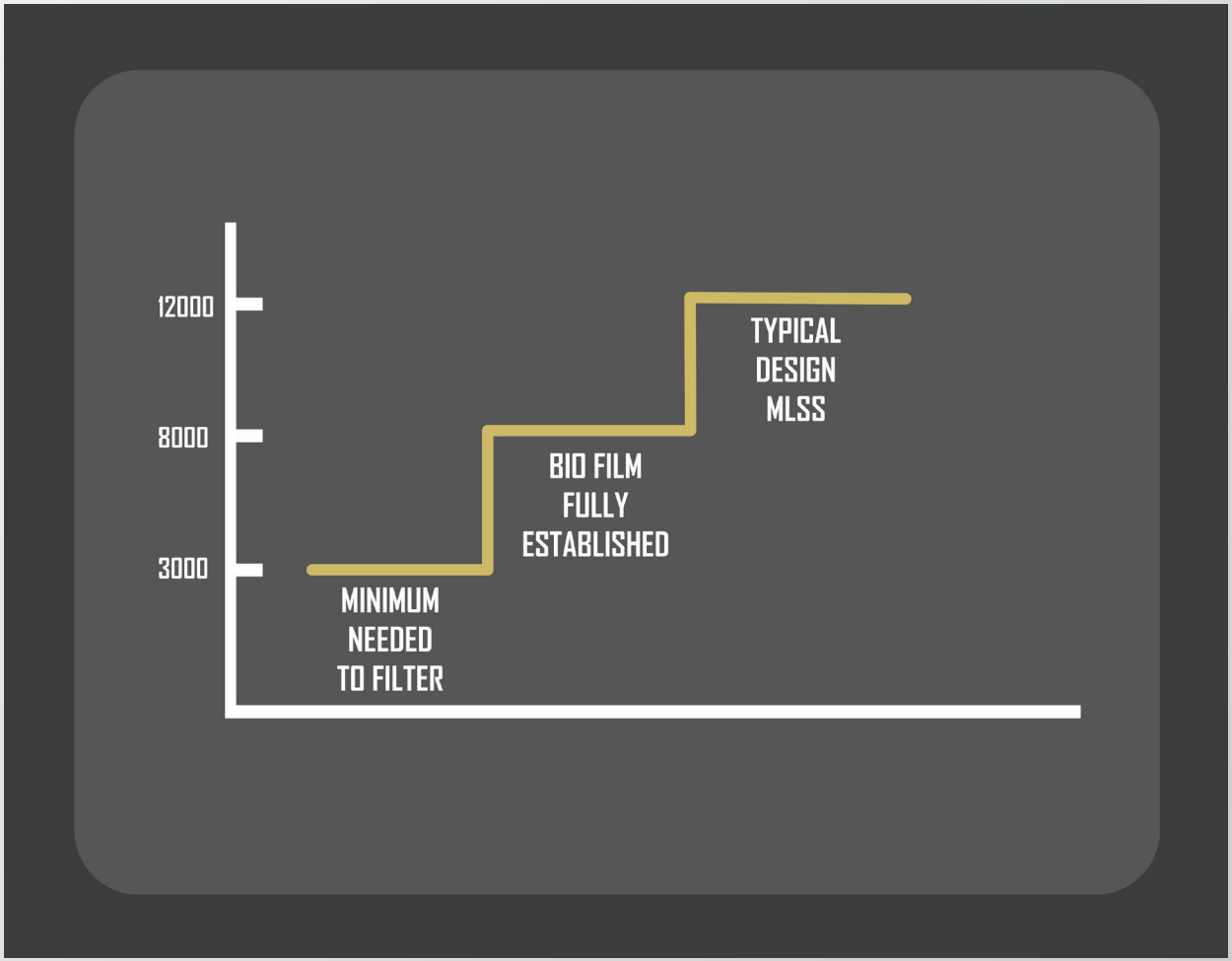
CARING FOR

MIXED LIQUOR

POST-STARTUP

VISIT **BLOG.MBRCENTRAL.COM/CARING_MIXED_LIQUOR**
AND LEAVE YOUR QUESTION OR COMMENT

When the Ovivo technician is onsite during startup, there are a few things that happen: equipment checking, clean water testing, seeding, entering set points, etc. Most of the time the seed sludge has a MLSS of 3,000mg/L which is the minimum concentration needed for the membranes to build up a biofilm.



CARING FOR
MIXED LIQUOR
POST-STARTUP

After commissioning, the biology will grow as influent comes into the plant and feeds it. The major transition point is when MLSS reaches 8,000 mg/L. This allows a biofilm to establish itself on the membrane surface. At this point it's recommended to begin permeating at the normal design flow rate.

The time it takes to reach 8,000 mg/L can be days, weeks, or months. The factors affecting the time are influent flow and loading (primarily BOD and ammonia). There are a few things that every MBR operator should have right after commissioning--

FILTERABILITY TEST KIT

Usually the very first sign that something is going wrong with the plant's mixed liquor is the filterability. It's best to have a filterability test kit and perform the test every couple of days for the first few weeks after startup. A drop in filterability can alert the operator to problems such as low BOD loading long before lab test results come back.

MLSS TEST EQUIPMENT

Knowing your MLSS (mixed liquor suspended solids) is important. Some plants have a handheld probe on-site, some send samples to a lab, still others have the vacuum pump, oven, and scale to test in their lab.

INFLUENT LOADING DATA

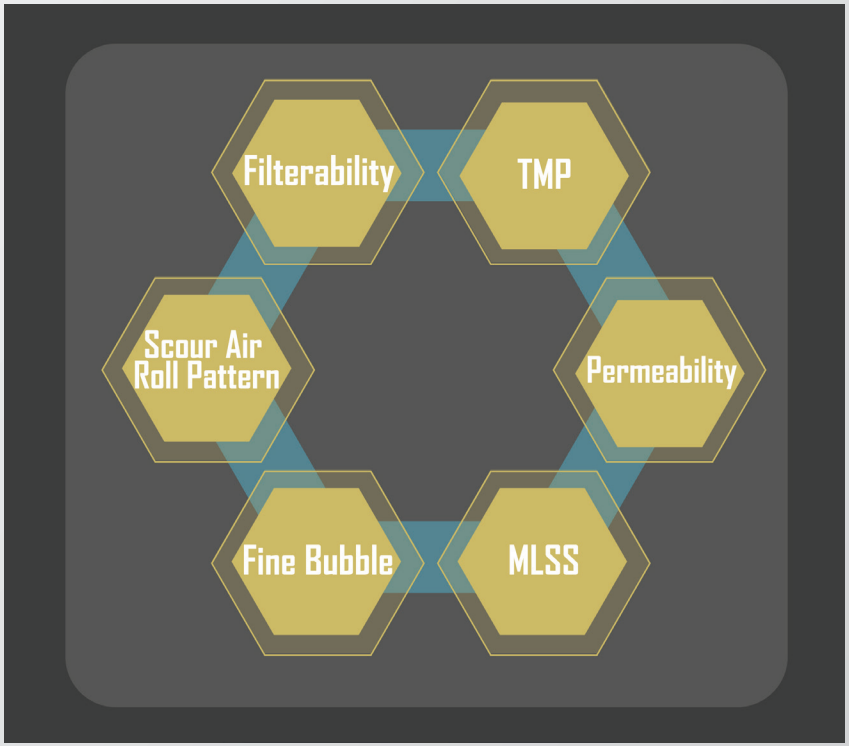
Immediately following startup, it's important to frequently test influent for BOD loading. This is how you know if the plant's biology is getting enough food to grow.

CARBON DOSING PLAN

For the case of low BOD loading, it might be necessary to add supplemental carbon to help the biology grow. Sugar, dried molasses, and methanol are some good sources. Don't use dog food as it contains a lot of fats, oils, and grease (FOG).

TOP 5 OPERATOR CHECKS

Initially the MBR process can seem complicated to someone who has not operated one before. It's actually possible to make it simple by keeping an eye on a few key things.



1. FILTERABILITY

Filterability testing simulates water passing through a membrane. A volume of at least 10mL filtered in 5 minutes tells you that you have healthy sludge. See the article later in this book for more details.

2. TMP & PERMEABILITY

Found on the overview or the permeate screen of your HMI computer. Monitor these frequently. A permeability value dropping towards 10gfd/psi or a rapid TMP increase of 1.0psi should be the trigger to perform a CIP (clean-in-place).

3. MLSS

Good membrane performance starts with healthy biology (sludge) and MLSS (mixed liquor suspended solids) represents both the amount of biology and its age. The normal operating range in a flat plate or flat sheet MBR is 8,000-12,000 mg/L.

4. SCOUR AIR ROLL PATTERN

The most important aeration in the plant is MBR scour air, which moves mixed liquor through the membrane cassette and controls fouling. As air and sludge move up and out of the cassette they form a "roll pattern" that can be observed by the operator. Dead zones are a sign that dewatering may be present.

5. FINE BUBBLE PATTERN

In the preair zone, oxygen transfer efficiency is key. Monitor the basin to ensure that fine bubbles are present. Best efficiency is reached with fine bubbles, higher side water depth, and MLSS below 15,000mg/L.

PREVENTATIVE
BLOWER
MAINTENANCE AFTER STARTUP

VISIT **BLOG.MBRCENTRAL.COM/BLOWER_MAINTENANCE**
AND LEAVE YOUR QUESTION OR COMMENT

Blowers keep the biology alive in your MBR; they also help to keep sludge mixed and suspended. Most importantly, MBR blowers move mixed liquor through the membrane cassettes which allows them to filter water. The most critical maintenance is probably right after plant commissioning. Most manufacturers recommend an oil change in the first few hundred hours of operation.

ROOTS BLOWERS PREVENTATIVE MAINTENANCE (SELECTED POINTS FROM THE ROOTS IOM)

- First oil change after 100 hours
- Synthetic oil of correct viscosity
- Fill the reservoir up to the overflow hole. DO NOT OVERFILL. Place the breather and the overflow plug back into their respective holes.
- No automotive oil
- Oil change interval based on temperature? Roots Synthetic Oil is rated for 6,000 hours and decreases by half for each 15°F increase in temperature.
- Type of grease specified: NLGI #2 premium grade aluminium complex grease p/n T20019001

AERZEN BLOWERS (SELECTED POINTS FROM THE AERZEN IOM)

- Have Aerzen inspect after 3 years or 20,000 hours
- Replace oil after the first 500 hours
- Replace oil every 4,000 hours or six months (Temperature over 140°C or 280°F)
- SO VG 150 fully synthetic (PAO) Poly-Alpha-Olefin, gearbox oil or compressor oil. Example: MOBIL SHC 629.
- Grease schedule is the same as oil schedule

KAESER BLOWERS (SELECTED POINTS FROM THE KAESER IOM)

- First oil change after 500 hours
- 6,000 hour oil change for 110°C
- 3,000 hour oil change for 130°C

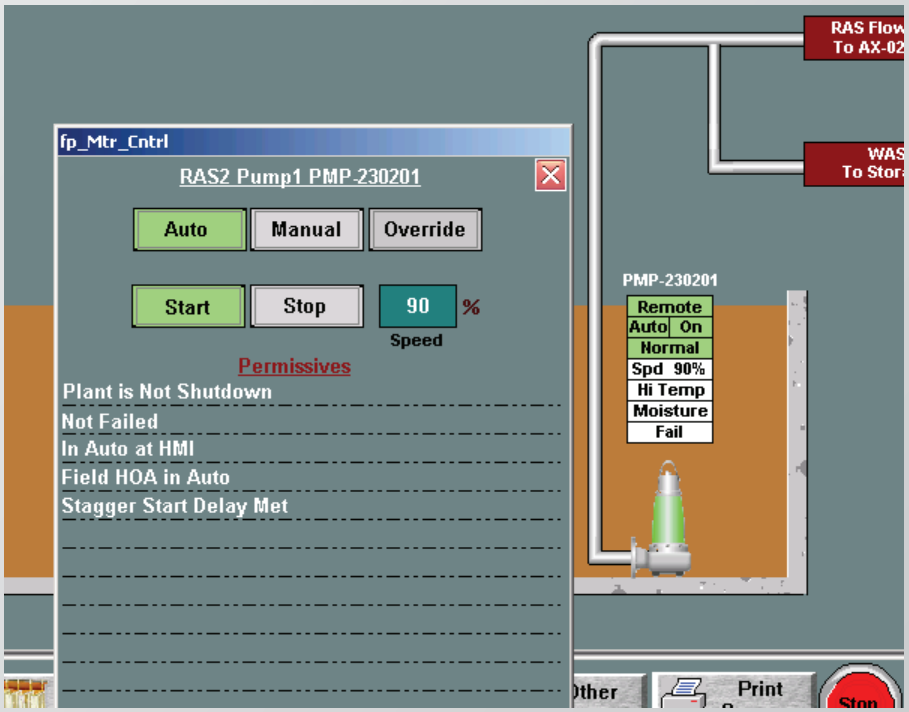
RUNNING THE MBR IN AUTO,
MANUAL,
AND HAND

RUNNING IN AUTO

In auto operation the PLC runs the plant based on operator set points. Set points can be changed at the HMI, and process data is displayed on the HMI screen. If the HMI computer goes down, the plant continues to run because the PLC still has all the set points.

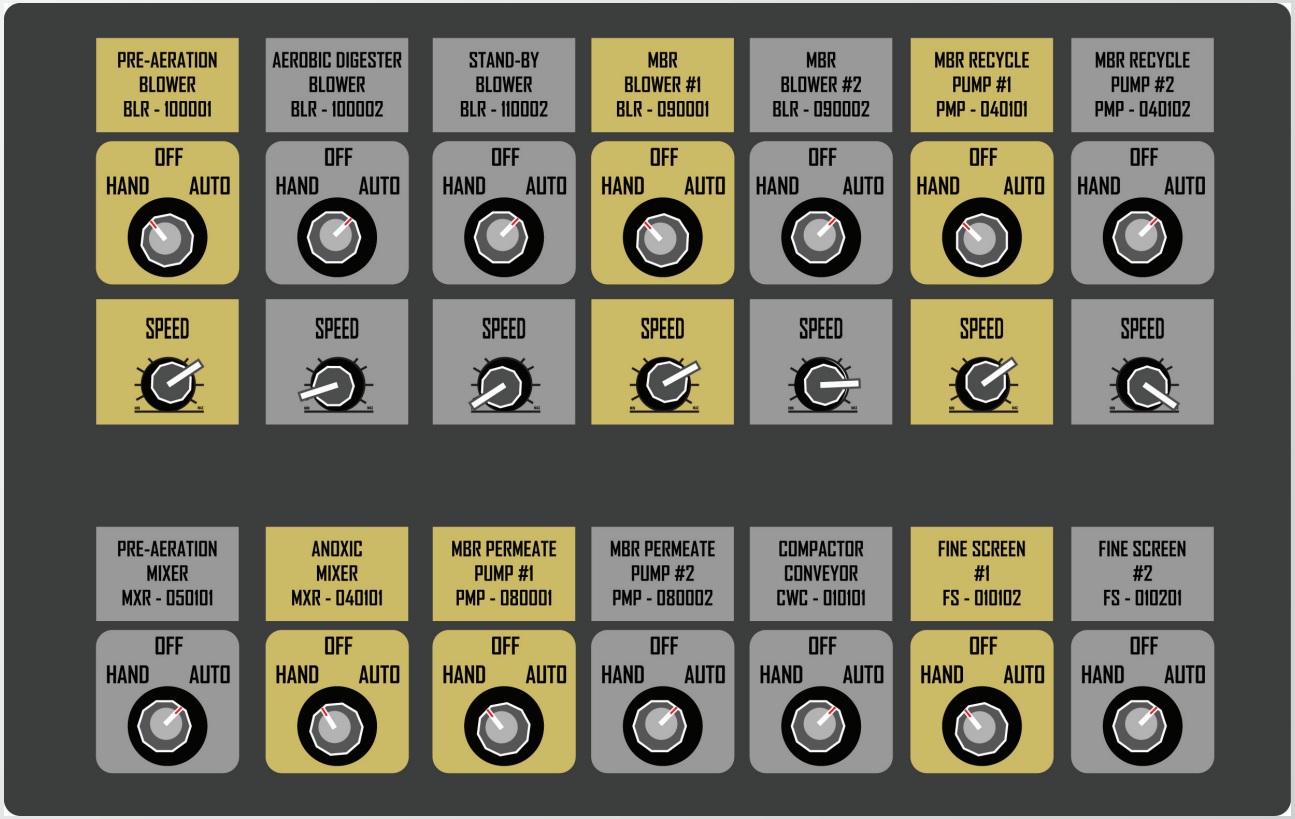
RUNNING IN MANUAL

The operator can click “manual” on almost any piece of equipment on the HMI to turn it on or off and set the operating speed. The rest of the MBR continues to run in auto, except for the specific piece of equipment that was put into manual. The most common time this is necessary is in preparation for a CIP (clean-in-place) when the MBR basin is taken offline and the RAS pump is placed in manual-off.



RUNNING IN HAND

If the PLC ever were to fail, the MBR can still be operated in “hand.” The HOA (hand-off-auto) switches can run each piece of equipment independently of the control system. Turn on the preair blower, anoxic mixer, MBR blower, recycle pump, and fine screen. Generally speaking, 50-75%



speed will be enough. Check the air and RAS flow meters to make sure they are in the desired range. Finally, the permeate flow control valve may need to be opened manually. Running in hand can also be excellent training to gain familiarity with the hydraulics of the MBR.

WHAT IS A

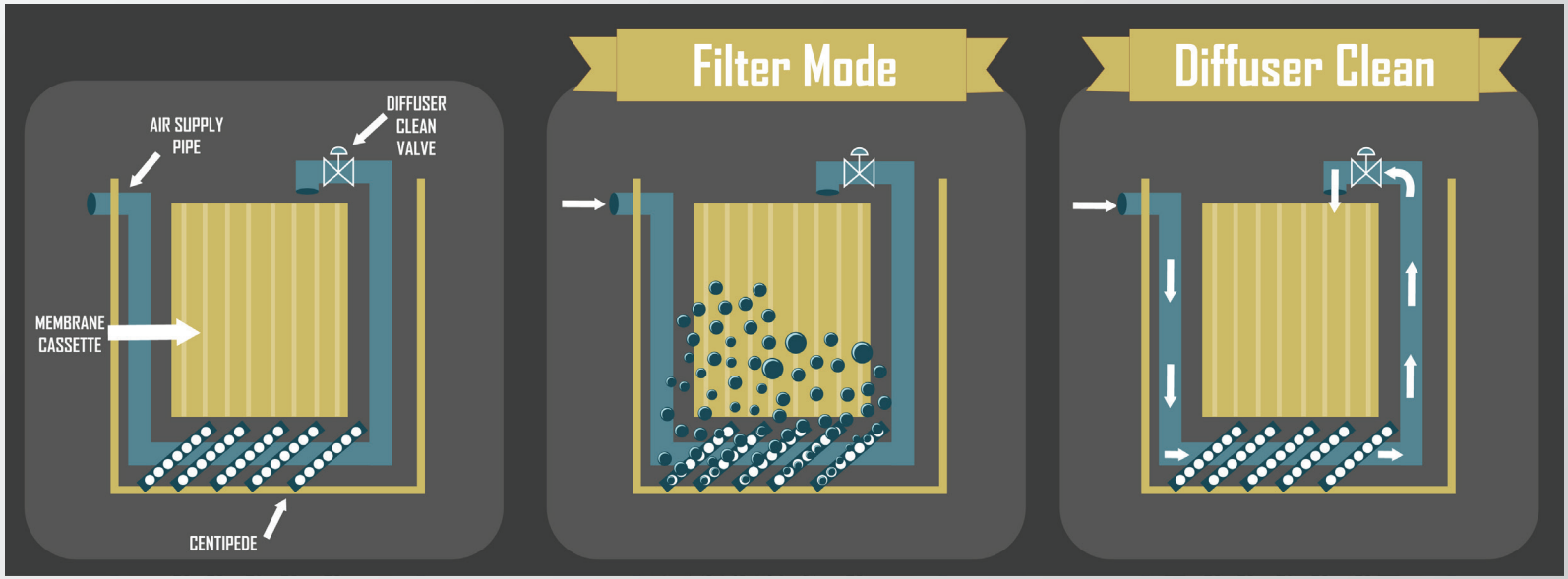
DIFFUSER CLEAN?

Scour air is probably the most important air fed to the entire MBR. Without it, mixed liquor stops moving past the membranes and filtration eventually stops. In flat plate systems, this can also mean sludge is dewatered (thickened to about 20%), which has to be cleaned by hand.

Flat plate systems use a type of coarse bubble diffuser with air pores that are large enough that they can sometimes become clogged with debris from mixed liquor during normal operation. The diffuser clean cycle is designed to unclog the pores and keep scour air flowing to all the membrane plates. Typically this will be a 10-minute cycle twice per day.

When the diffuser clean valve is open, the air is no longer forced up through the membrane cassette; instead it is given a path of lower resistance up and out the valve. This creates a venturi effect which sucks liquid into the air pipe and hopefully dislodges any clogs in the process.

In a flat plate MBR, diffuser cleans are key to preventing dewatering events. Flat sheet systems use fine bubble diffusers, which are not susceptible to clogging by large debris, so the diffuser clean cycle is eliminated.



CRITICAL
ALARM
CALLOUTS AND
RESETTING THE ALARM

There are 12 critical alarms that cause callouts in an Ovivo system. They are--

1. Permeability control failure
2. No permeate pumps available or flow control valve failure
3. Low MBR water level
4. High TMP
5. Diffuser clean valve fail to close
6. No or too few MBR blowers available
7. Low MBR air flow
8. Feed forward pump failure
9. PLC-HMI communications failure
10. PLC not running
11. High level in any basin / imminent overflow
12. Facility power loss

Inevitably, the callout comes when you least expect it. In the middle of the night your phone rings and as you try to wake up, the SCADAlarm software is telling you the alarm in its computerized, hard-to-understand voice. Frustration begins to set in.

That's why it's so important to do a trial run to make sure you are familiar with the SCADAlarm procedure.

When we train operators at startup we have them run through the following procedure so that they are prepared for an alarm callout when it eventually does happen.

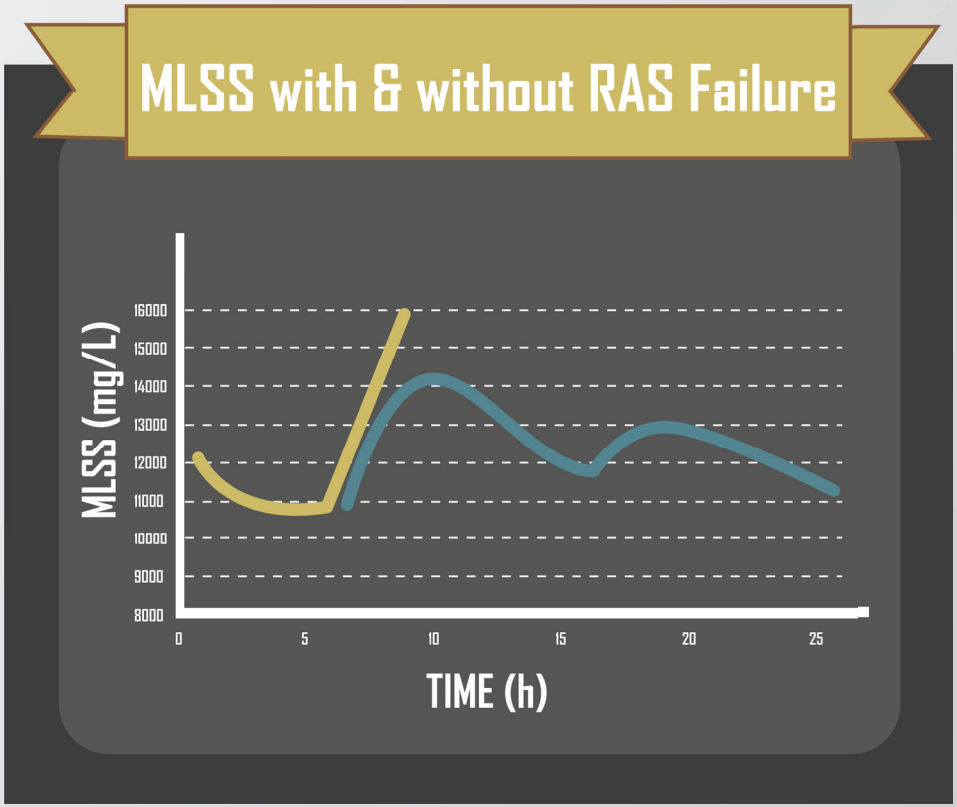
PROCEDURE FOR TESTING CALLOUT ALARMS

1. Make sure the SCADAlarm has the operator's cell phone number programmed into it
2. Conduct this test when the plant is running normally and the MBR is "online" at the HMI
3. The easiest alarm to cause manually is an anoxic high level
4. Go to the anoxic basin and locate the high level float switch
5. Take the anoxic high level switch and hang it upside-down to simulate it floating
6. Do not use zip ties to keep the float in place as these are easy to drop into the basin when you cut them off and they'll eventually damage the membranes
7. Go to the HMI screen and watch the alarms to make sure it causes the high level alarm
8. After the alarm appears, go outside the building to make sure you have cell service
9. You will get the callout a few minutes after the alarm occurs
10. Answer the phone
11. Enter your PIN (The standard PIN is 9999) followed by the # sign
12. SCADAlarm will then tell you the alarm and ask you to enter your PIN to acknowledge the alarm
13. If the alarm does not continue (for example if the anoxic level goes back down), you won't receive another call
14. If the alarm does continue (if you don't put the float switch back), SCADAlarm will call you again and again
15. Go put the float back to its normal position

CRITICAL ALARM
EXAMPLE:
FEED
FORWARD PUMP FAILURE

What happens if the feed forward (recycle) pump fails? This pump is critical to the operation of the MBR. Without it, the membrane zone becomes a thickener.

RAS is usually set to a flow rate that is 4-5 times the permeate flow (4-5Q). One of the reasons for recycle flow is to maintain MLSS levels throughout the plant. Remember that the membranes thicken sludge by filtering water out of it, and without recycle flow, MLSS will increase very rapidly.



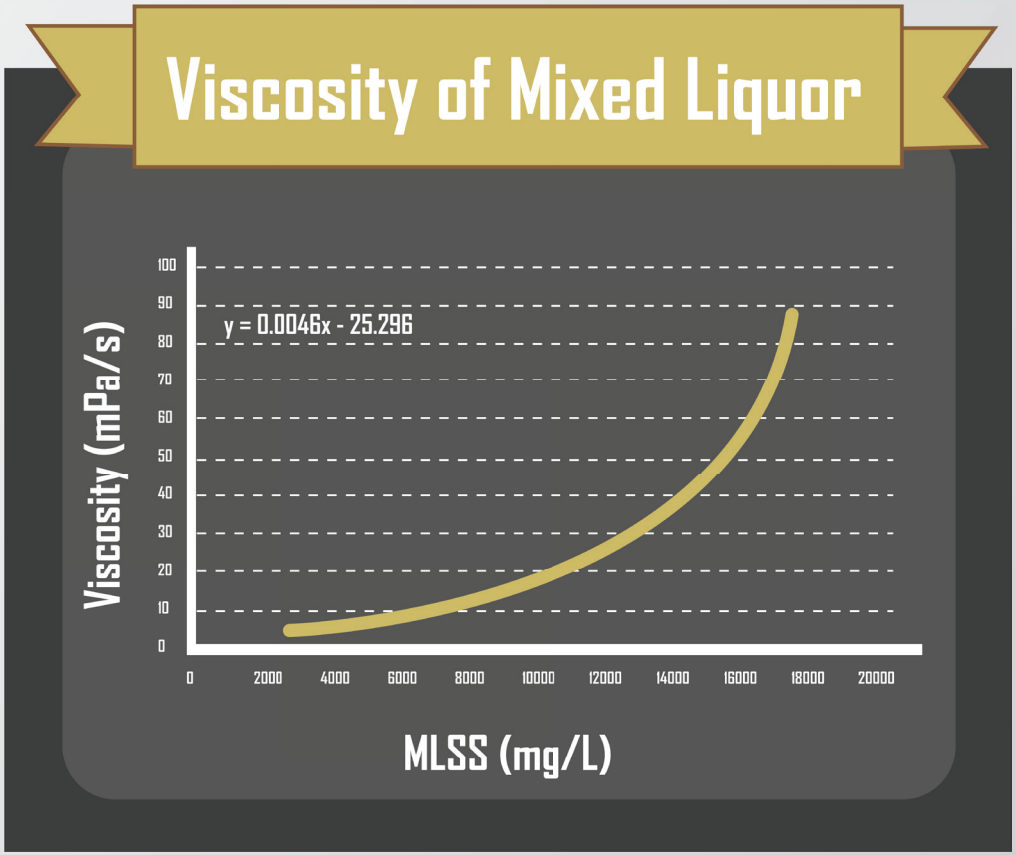
The graph here shows the variation of MLSS in the membrane zone basin throughout a typical day. It increases and decreases with the diurnal pattern of flow entering the plant. Superimposed is the graph of MLSS if the recycle pump were to fail. MLSS can shoot up very fast and this can lead to dewatered sludge buildup between the membranes.

Keeping MLSS within the design range is important because if it gets too high, you might get faster membrane fouling, pump problems, or dewatering. Solids too low might cause problems with biological nutrient removal. The typical design MLSS is between 10,000 and 12,000mg/L. This can vary from plant to plant so it is good to know what your MBR's design MLSS is.

MLSS can have an impact on many aspects of the MBR. Three examples are--

1. PUMPS

When MLSS is 15,000mg/L or greater, viscosity begins to increase rapidly. Pumps have to work harder, and sometimes solids can accumulate in the volute, leading to pump damage.



2. FILTERABILITY

High MLSS usually means old sludge. This can have a negative effect on filterability and permeability.

3. MEMBRANE BIOFILM

MLSS that is too low prevents biofilm from growing on the membrane surface. Avoid going below 8,000mg/L or you may have to reduce permeate flow rates.

TIPS ON WASTING

As a general rule of thumb, waste no more than 10% of the total plant volume at one time. If your MBR contains 40,000gal of sludge, try to only waste a maximum of 4,000gal at any given time. Decide on a predetermined level, such as 15,000 mg/L and use this as the trigger to waste sludge.

DECANTING

Perform a jar test to see how the sludge settles (or doesn't) when it's sitting in a container. Many MBRs have sludge that actually all floats to the top. If your solids accumulate all at the top or the bottom, you can potentially save on hauling costs by sucking out the clear water from your holding basin.

MPE50 is a non-toxic chemical coagulant for activated sludge systems. According to the manufacturer it can allow plants to operate up to twice as long before they see a significant decrease in permeability. If your MBR experiences periods of peak flow from rainstorms, snowmelts, infiltration, or peak holiday occupancy, it is recommended to have a barrel on site. Ovivo stocks MPE50 in Austin, TX.

Running an MBR at peak flow for extended periods tends to make the membranes foul faster and so the need for a CIP can come along sooner. MPE50 can help the plant get through peak events by extending the time between CIPs.

Dosing can be a little tricky because only small amounts are usually needed and dosing too much can have a negative effect. MPE50 also tends to stay in the system for a while so you have to be careful about any subsequent dosing. Try the following procedure to determine how much to dose.

LAB TESTING

Test the MPE50 on a series of one-liter sludge samples from the MBR. Ideally, you will be able to take six one-liter samples.

In each sample, add a different amount of MPE50 so that they each have a different concentration: 50ppm, 100ppm, 200ppm, 300ppm, 400ppm, and 500ppm. The best way to measure out the MPE50 is with a lab pipette. If you don't have one you can use an eye dropper; It's less accurate, but it will get the job done. See the table below for how much to put in each sample.

Next, mix the samples, run the filterability tests, record the results, and select the concentration that results in the highest filterability.

How much MPE50 to add to each sample		
MPE50 conc. (ppm)	Volume MPE50 (mL)	Number of drops of MPE50 (roughly)
50	0.05	1
100	0.1	2
200	0.2	4
300	0.3	6
400	0.4	8
500	0.5	10

DOSING MPE50 TO THE MBR

Now that you did the lab scale testing and found the concentration of MPE50 which gave you the best results, you have to calculate how much to dose to the plant. Let's say the 100ppm concentration gave the best results in the lab and you have 100,000 gallons of sludge in your plant—

100ppm * 100,000gal / 3,785,000 = 2.64gal MPE50

So the only thing you have to do is plug in the actual volume from your MBR and your own lab test result.

WHAT CAN

TRIGGER DISASTER

There are three basic worst case scenarios for MBR plants. They are—

DEWATERED SLUDGE

Description

This is where the sludge in between the membrane plates has water filtered out of it until it reaches about 20% solids (normal MLSS is less than 2% solids). A dewatering event can be extremely difficult to recover from. It usually involves draining the MBR basin, removing and disassembling all the membrane cassettes, and cleaning all the solid sludge from the membrane plates by hand with a hose. This can take several days at small plant and weeks at larger facilities.

Potential Causes

Failure of the MBR blower & backup blower
Clogged MBR diffuser which blocks scour air flow

Prevention

Make sure to perform all needed blower preventative maintenance
Perform two diffuser cleans per day for 10 minutes each
Keep MLSS with in design range
Never permeate without scour air

SEPTIC SLUDGE

Description	This is basically the die off of the biology in a basin.
Potential Causes	Failure of the RAS pumps and/or failure of the preair blower. Basically anything that would allow sludge to sit and stagnate without aeration.
Prevention	Blower preventative maintenance. Also – have spare RAS pumps and anoxic mixers on hand.

MEMBRANE DAMAGE

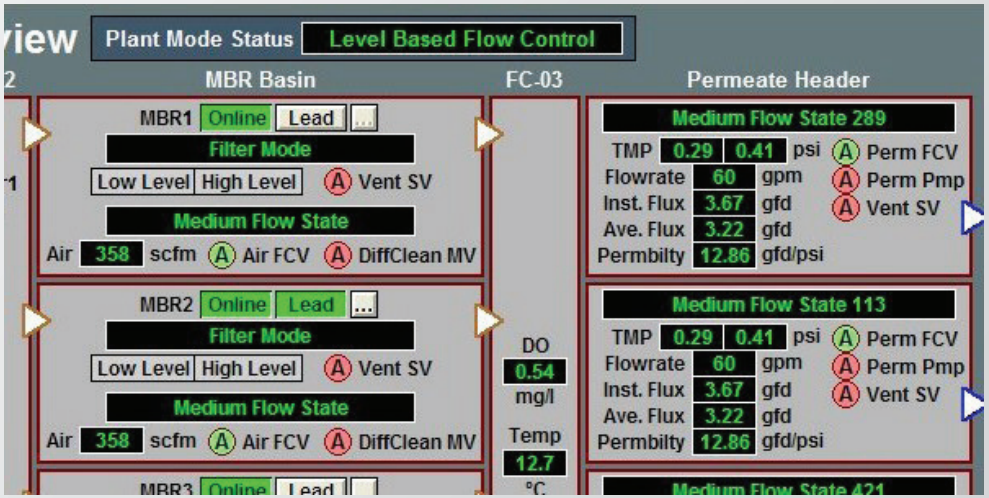
Description	Membranes can become torn by plastic debris (plastic floats) in the basin, can be torn from the membrane plate by scour air without permeate, and can be torn by excessive backpressure from the CIP feed line.
Potential Causes	Fine screen bypass Scour air without permeating for greater than 5 minutes Excessive pressure (greater than 1.5psi) when feeding CIP solution to the membranes
Prevention	Never allow a fine screen bypass to occur Never run the MBR blower longer than 5 minutes without permeating Always monitor the pressure in the CIP line when feeding cleaning solution

WHAT'S ALL THIS STUFF ON THE

HMI SCREEN?

FILTER MODE

The MBR has filter mode, relax mode, and intermittent mode. Filter is when the MBR is permeating, relax is no permeate but with scour air, and intermittent is no permeate and air scour only once every 30 minutes.



FLOW LEVEL

The MBR has three different flow levels (low, medium, and high); this is usually controlled by the side water depth in the anoxic zone (occasionally it's controlled by the depth in the MBR, the RAS channel, or even the influent flow rate).

TMP (TRANS-MEMBRANE PRESSURE)

One of the most important measures of membrane performance. TMP is the amount of energy (pressure) it takes to move water from one side of the membrane to the other. TMP is not measured directly, but it is calculated by the system using the actual pressure reading.

PERMEABILITY

In contrast to TMP, higher permeability means better membrane performance. It is a way of monitoring how well the membranes are performing independent of the flow rate. When you increase flow, TMP goes up, but that's only because you're pulling more water through the membrane. What you really want to know is this: is the TMP only going up because of higher flow, or is it going up because of fouling? When you watch permeability go down, it is telling you that the membranes are fouling (independent of the flow rate).

INSTANTANEOUS FLUX AND AVERAGE FLUX

How much water is flowing through the average square foot of membrane right now (this instant), and how much has flowed through the average square foot over the past 24-hours.

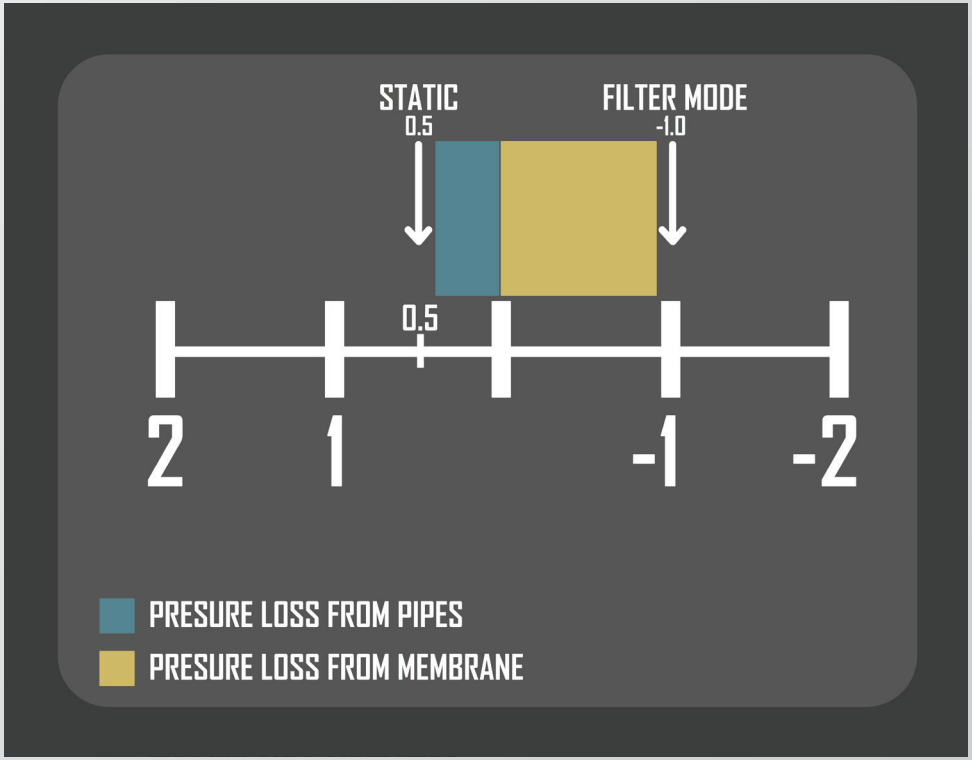
IF YOU DON'T HAVE
TMP
ON YOUR SCREEN

What about older MBRs that don't have a TMP reading? An operator still needs to know how the membranes are performing.

What you will see in this situation is a pressure reading on the screen. This is not TMP, but it is a simple measurement of pressure in the pipe. You can use it to figure out a rough estimate of what the TMP is. Here's how--

1. Note the pressure reading when the system is not permeating. This is the "static" pressure.
2. Note the pressure when the system is permeating (filter pressure).
3. Find the difference of the two numbers, and then subtract 1.0 psi.

Why subtract 1.0psi? This is a rough estimate of how much pressure (or head) the water loses as it flows through all the pipes (pipe loss). It is different for every MBR, but 1.0psi is a common value.



Sometimes the static pressure is positive while the filter pressure is negative. This can be confusing, so what you will find is that it is easier to calculate the TMP if you draw a diagram like the figure below. This will remind you that you are finding the absolute value, which is the distance from one point to the other.

FLUX
EXPLAINED

Imagine that you have two MBRs, one in Seattle and the other in Spokane. You want to compare how the membranes are performing. The Seattle plant is complaining because the TMP keeps going up to 1.5psi, while the Spokane plant (using the same type of membranes), has a TMP of 0.5psi.

The Seattle operator explains that he has 1,000gpm of influent, while the Spokane plant is getting 500gpm, but unfortunately this information doesn't help you very much. It's fine to know how much water is flowing through the plant, but you want to know how much membrane space that water has to fit through.

You don't want to compare the flow going through the two MBRs. You want to compare the flow going through an average square foot of membrane in each of the MBRs.

This is why we talk about flux. Flux is simply the amount of water going through one square foot of membrane in a given day. Take the gallons per minute flowing through one square foot of membrane right this instant, and then multiply by the number of minutes in a day. This will give you the flux (gallons per square foot per day, or gfd).

The nice thing about flux is-- a square foot of membrane in Seattle is identical to a square foot of membrane in Spokane! So if Seattle has a higher flux than Spokane, you will naturally assume that it will also have a higher TMP. This won't be a surprise.

On the other hand, if Seattle has a higher flux, but Spokane has the higher TMP, you know something is wrong!

Another term you might hear is "sustainable flux." Imagine you are permeating at a flux of 10gfd. How long can you push water through at this flux before TMP begins to rise quickly? Probably a long time. What about 18gfd? If you tried to run at 18gfd and the TMP suddenly increased a lot, then you know you've pushed it a little bit too far. You found out that 10gfd was sustainable, but 18gfd was not.

FILTER-ABILITY
EXPLAINED

Filterability testing allows you to keep tabs on mixed liquor health, which impacts membrane performance. The reverse is true as well; if your MBR has a permeability problem, a filterability test will help you determine if the problem has sludge health as a root cause.

1. Use one of the pieces of 5C filter paper from Advantec MFS (boxes can be obtained through Ovivo). Note: using a different type of filter paper will provide different results than the standard 10mL baseline.

2. Fold it in 16ths so it will form a cone as the photo shows

3. Place it in a funnel which sits atop a 50mL graduated cylinder

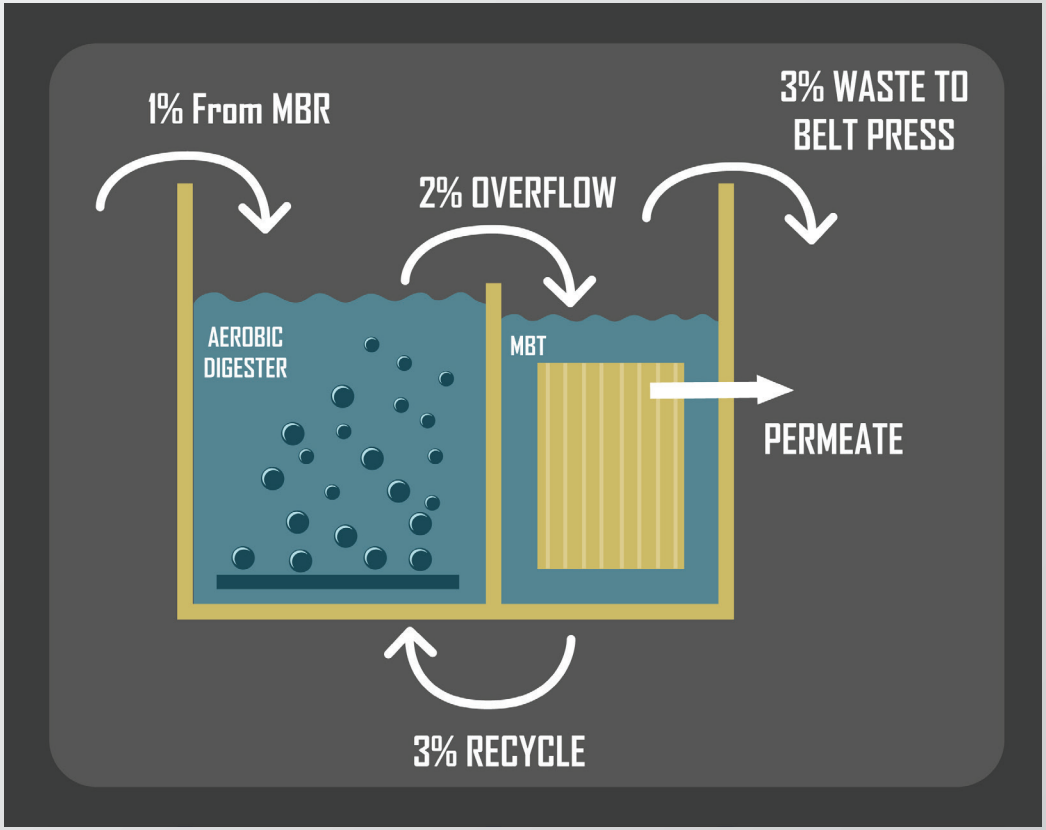
4. Take 50mL of sludge and pour it into the filter paper

5. Set a timer for five minutes and then note the amount of clear water in the graduated cylinder. If the final filtrate is more than 10mL, your sludge is happy. If not, sludge health may be the problem causing low permeability.

MBT:
MEMBRANE THICKENER OPERATIONS

Membrane thickeners (MBTs) simply remove water from sludge very slowly until it gets to about 30,000mg/L (or 3%). What for? This either reduces the amount of sludge that an operator must haul away, or reduces the number of hours he has to run his belt press.

Sludge becomes much harder to move around when it reaches 1.6%. That's why we operate MBTs at a flux of 4gfd of less (see the article Flux explained). This is the central idea in MBT operation.

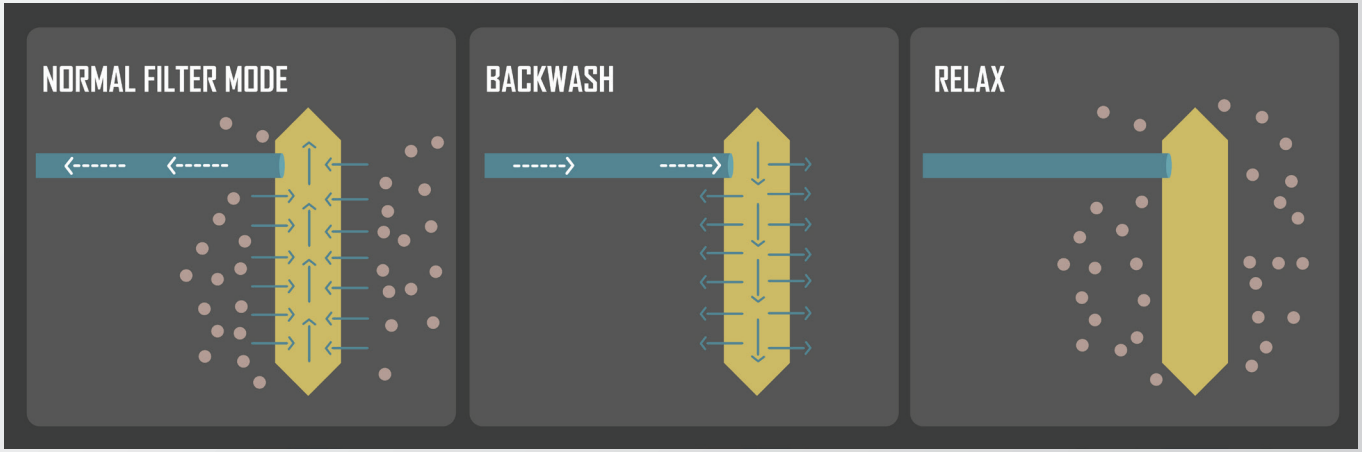


The other main idea is the digester. Typically, there will be an aerated digestion basin next to the MBT. The process of digestion is simply supplying air to microbes but no food; they feed on themselves and some of the mass is in turn converted to gas. This helps reduce hauling costs too.

Imagine the MBT and the digester as one system but with a wall separating the two sides. The system should operate at a constant MLSS (say 3%). To keep it constant, the operator removes thick sludge from the MBT and adds thinner waste sludge to the digester every day. Sludge circulates from one side to the other while the membranes remove water by permeating.

BACKWASH VS. RELAX

Backwash and relax are two strategies to control membrane fouling. The idea is that without using one or the other, TMP would gradually creep up over the course of the day and filtration would eventually shut down. Typically, filtration will run for a set period of time (e.g. ten minutes), then the system will either backwash or relax for one minute before going back to filtration. This keeps fouling in check and controls TMP, allowing for long periods (weeks or months) between chemical cleans.



Backwash: reverse permeate flow. Water (no bleach or acid, just water) is fed back into the membranes.

Relax: permeate flow is shut down, but scour air is kept on.

The decision to use one or the other depends on how the membranes themselves are built. Flat plate membranes are not structurally able to withstand much backpressure, so backwashing is not a good option. On the other hand, hollow fiber membranes are not fixed in place, so relax is not as effective. Flat sheet membranes, being structurally able to withstand backpressure but also fixed in place, allow for either strategy to be used.

The other consideration is the permeate pumps themselves. Running in reverse requires a particular type of pump, additional controls, and a permeate holding tank to store water for backwash. This adds cost and complexity to the MBR design. A good rule of thumb in engineering is to make things as simple as possible while still accomplishing the main purpose. So when designing MBRs with flat sheet membranes, Ovivo tends to favor relax over backwash.

MBR OPERATIONS

SAMPLE DAILY AND WEEKLY

OPERATOR CHECK-LIST

This is only a sample, and we suggest creating your own custom checklists based on your own requirements.

	TRAIN 1	TRAIN 2	TRAIN 3	TRAIN 4
Date				
TMP				
Permeability				
Filterability				
MLSS				
MBR basin roll pattern				
Preair fine bubble pattern				
Preair DO (mg/L)				
Effluent turbidity				
Effluent COD				
Effluent ammonia				
Effluent nitrates				
Effluent phosphorous				
MBR blower discharge temperature				
Preair blower discharge temperature				
Turbidimeter clean?				
DO meter cap clean?				
Yesterday's total flow				
Yesterday's waste sludge volume				

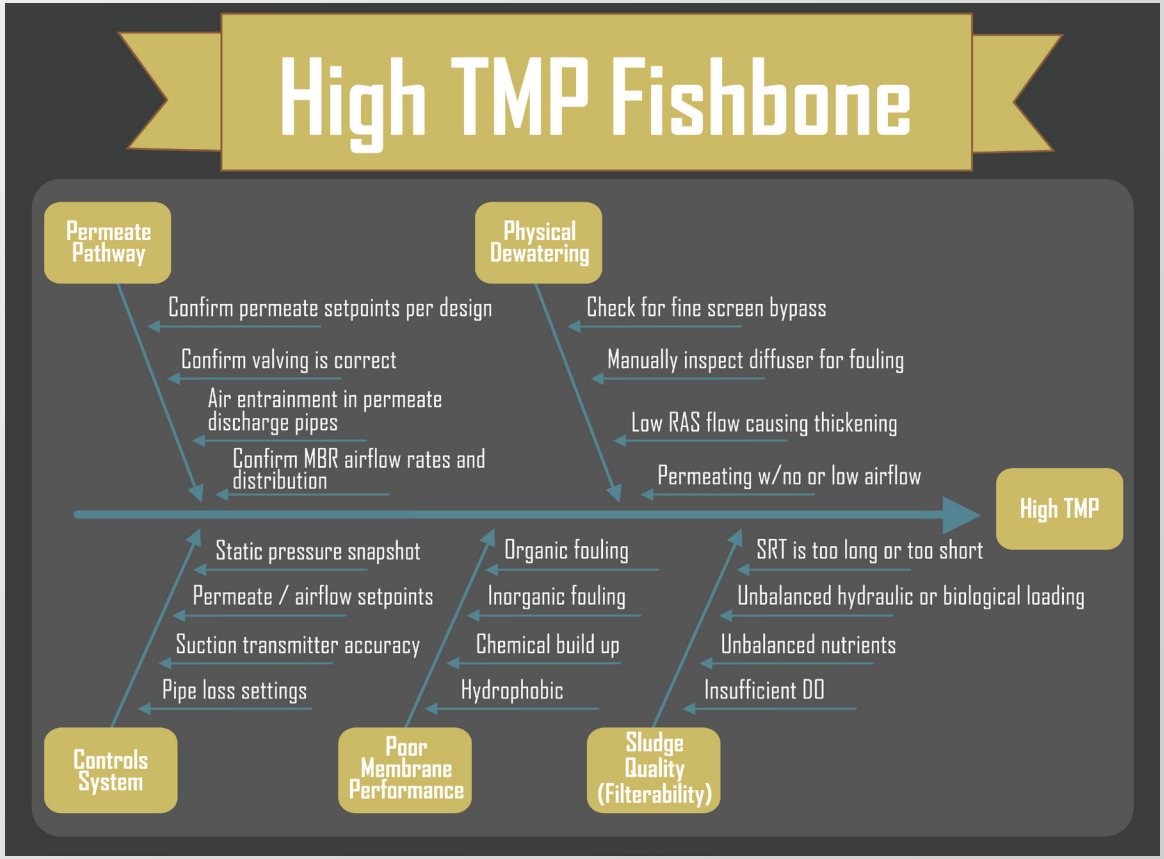
MBR TROUBLESHOOTING

FIGURING OUT LOW

PERMEABILITY

When an MBR has low permeability, many times the first response will be to do a chemical clean (CIP). This might help temporarily, but what if the problem persists?

Low permeability doesn't always mean membrane problems. There might be a deeper cause which has to do with influent, sludge, aeration, or even a combination of things. The fishbone approach allows us to attack the problem in an organized way. We can work on finding its root cause by eliminating one possibility at a time. For permeability, there are a few different possibilites to consider.



FIGURING OUT LOW

PERMEA-BILITY

FOULING

The classic “membranes are fouled” problem which is usually treated by chemical cleaning.

TEMPERATURE

Large infiltration flows can decrease the sludge temperature, leading to EPS secretion, which leads to fouling and low permeability. Chemical cleaning can help but probably just temporarily.

DEWATERING

Large amounts of caked sludge make it harder to filter water. In flat plate systems, this can only be fixed by cleaning dewatered sludge by hand or with specialized machinery. In either case, the membranes have to be removed from the basin to be taken apart and cleaned. Chemical cleaning might provide some temporary improvement, but will not last long.

SLUDGE HEALTH

Filterability tests should give 10mL of filtrate (in five minutes) and volatile suspended solids (VSS) lab tests should be at least 80%. Chemically cleaning membranes with poor sludge health will generally not help.

AIR LOCKING

Bubbles form in permeate lines which effectively reduces the diameter of the pipe. This leads to higher pressure and shows up as low permeability.

MBR TROUBLESHOOTING

CAUSES OF

AIR LOCKING

AND AIR ENTRAINMENT

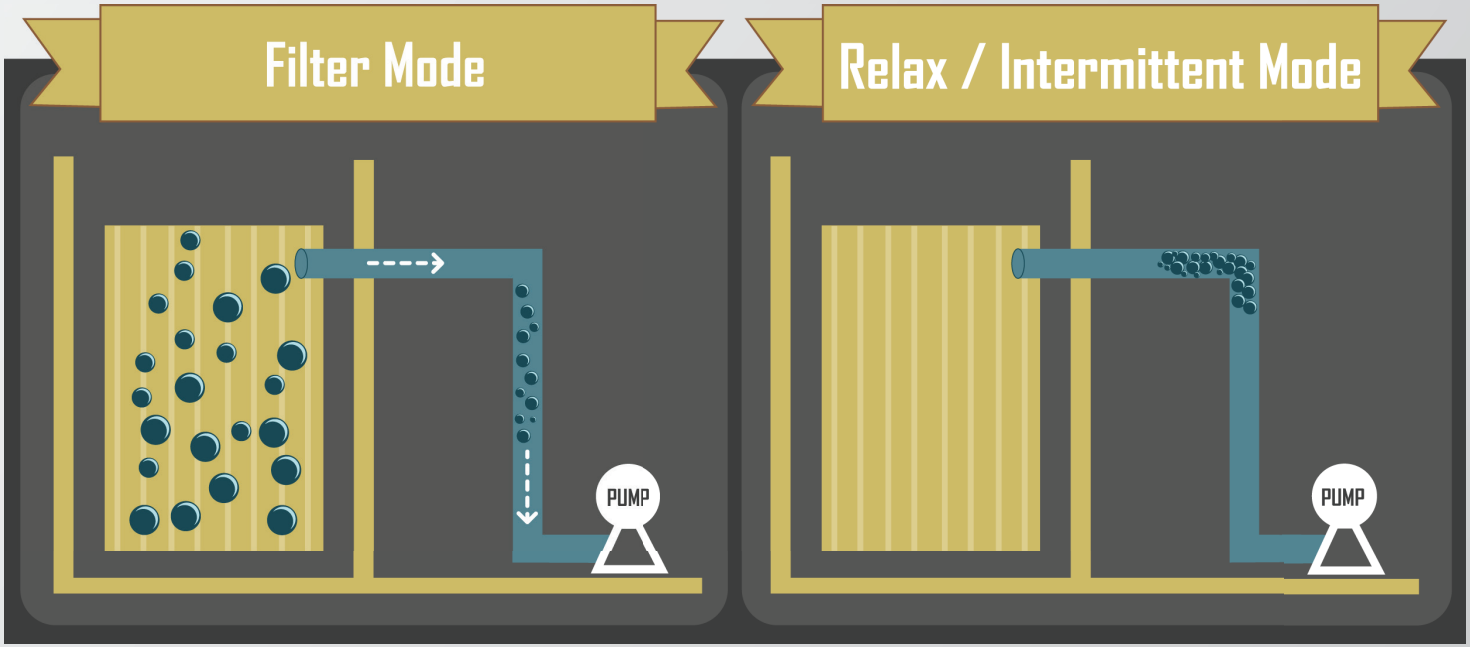
Air in permeate lines reduces the amount of space that water has to flow through. This means that either the pressure will rise or the flow will drop. Sometimes it's temporary, and increasing the pump speed to 100% for a minute will clear out all the bubbles; but sometimes there is so much air that it becomes a bigger problem. Why does this happen?

PIPE LEAKS

Any leaks in the permeate lines or loose fittings can let in air. Remember that the lines are under negative pressure, so air will be sucked into any leak. This is especially likely to happen at a new MBR during the startup phase.

SCOUR AIR

Essential to an MBR is the scour air which keeps sludge moving through the membrane cassette. Without it, the membranes would foul, dewater, and stop permeating. However some of this air always dissolves and enters the permeate lines where pressure is lower (remember that there is suction from the pump). At this point, the air may come out of solution and form bubbles.



Most of the time if this happens during filter mode, it's not a problem because the flow of permeate doesn't allow bubbles to accumulate. But during relax, when there is only air and no permeate flow, bubbles can accumulate at the highest points. That's why you are most likely to notice high TMP and low permeability from air locking right after a relax cycle.

MBR TROUBLESHOOTING

FIBER AND
RAGS

VISIT **BLOG.MBRCENTRAL.COM/RAGS** AND LEAVE YOUR QUESTION OR COMMENT

Research has shown that the rags operators see in wastewater plants are mainly made up of cotton fibers. This material tends to agglomerate in MBR basins where it can become problematic by blocking scour air. It's particularly bad for flat plate membranes because the rags will build up on the bottom of the membrane cassette and block air flow between membrane plates. They can also attach themselves to coarse bubble diffusers, blocking airflow there. Lack of air flow can cause dewatered sludge to buildup which is very time consuming and expensive to remove.

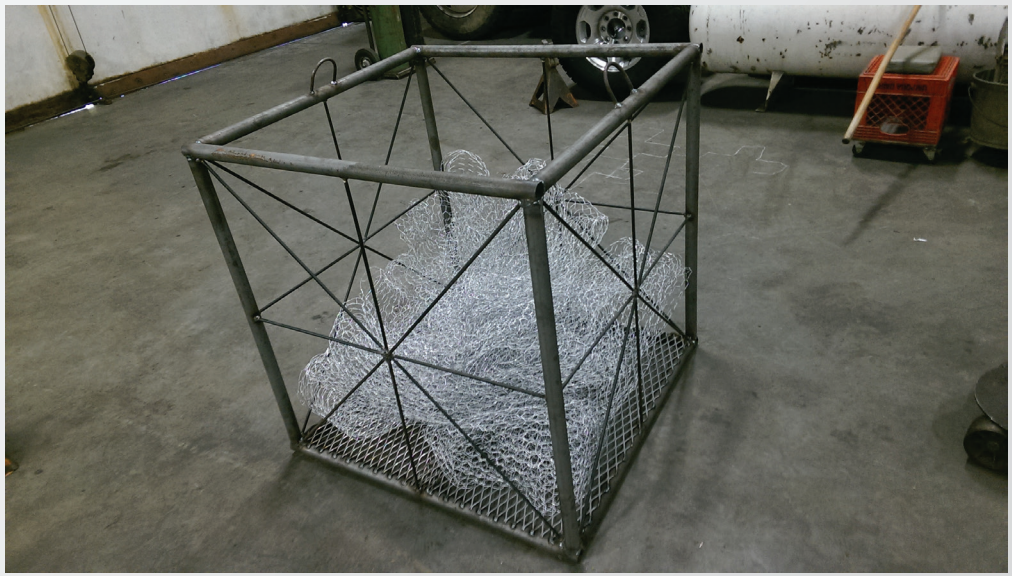
Fiber accumulation can be addressed with short term stop-gap solutions or in a more long term way.

STOP-GAP

Fiber traps can be simple metal boxes containing chicken wire and placed in the influent channel. The example shown here is a three foot cube which was able to contain two full rolls of wire. While it didn't catch everything, there was a significant amount of material caught on the wire after about a month in the channel.

LONG TERM

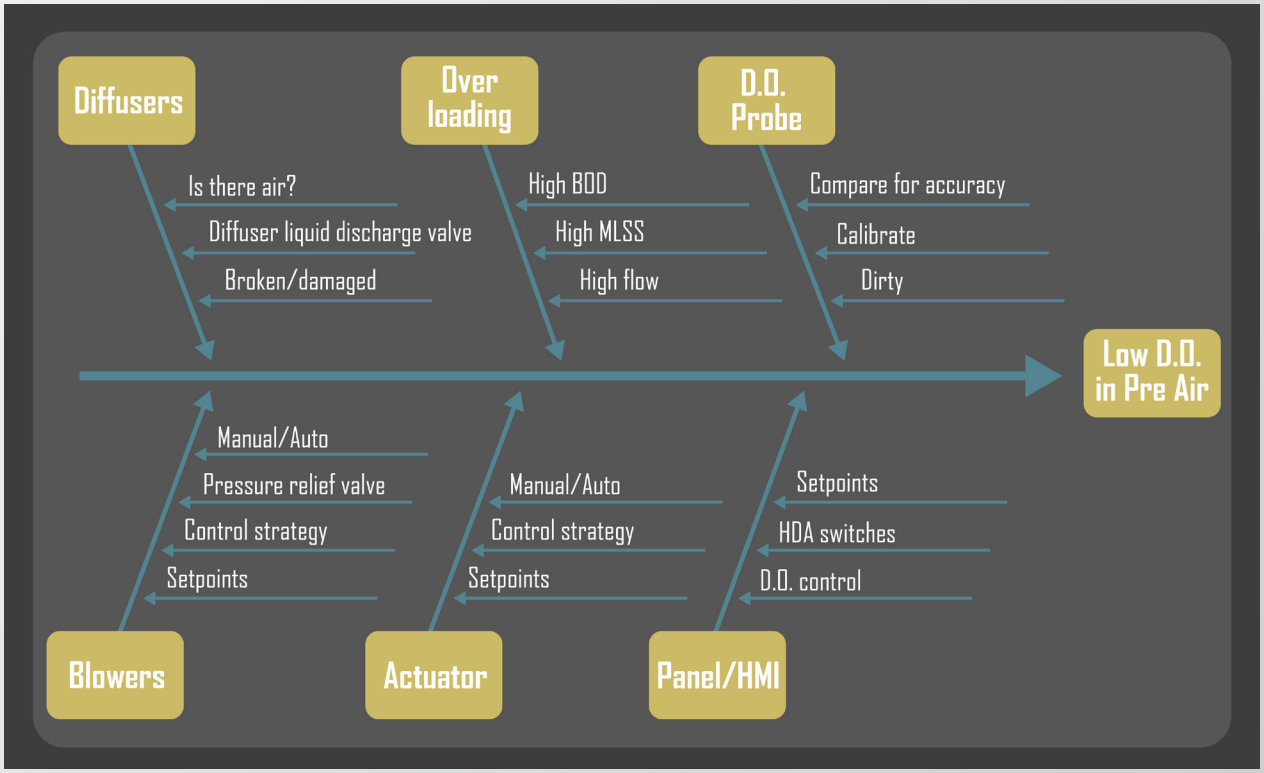
Better fine screens. Certain types of drum screens capture more material than bar screens. Flow is not perpendicular to the screen, so there is less chance of fiber passing through. This means that a 2mm bar screen is not necessarily equal to a 2mm drum screen.



FISHBONES

FOR TROUBLESHOOTING
THE ROOT CAUSE

Wastewater treatment plants are complicated systems. On one hand, they are biological systems, and on the other hand they are factories, containing lots of heavy equipment. MBR adds an additional layer of complexity. Membranes prefer to operate continuously at a steady flow, but wastewater flows are not steady. Diurnal flow patterns, changes in temperature, and varying nutrient loads all have to be dealt with.



When problems crop up, all these different layers (biology, equipment, membranes, and controls) interact with each other, so it becomes important to have a systematic approach to troubleshooting. That's where the fishbone diagram comes in. Also known as the Ishikawa drawing after its creator, the fishbone is a cause and effect diagram. The intent of the drawing is to identify all the possible contributors to a problem and display them in a manner that supports logical troubleshooting.

First identify the problem or defect. From there, work through all the possible contributors until identifying the root cause (or causes).

CAUSES OF

DEWATERING

AND HOW TO RECOGNIZE IT

In the absence of scour air, membranes will continue to filter water, but sludge will be immobile. Sludge becomes thicker and thicker until it reaches about 20% solids. At this point, the suction pressure required to continue filtering water will be too great and in the extreme case, permeate flow will simply stop. Flat plate membranes are particularly susceptible because the membranes are rigid, in fixed positions so that removing the dewatered sludge can be a major undertaking. Flat sheets can also be dewatered, however the sheets themselves are not rigid, so sludge is not permanently trapped in one place. Turning on scour air is generally enough to break up the dewatered sludge and get it moving.

The extreme case of zero permeate flow is very unusual. Most cases of dewatering don't involve a total lack of scour air. More likely, air will be blocked to a few regions within a membrane cassette. If your MBR is a flat plate system (or certain types of hollow fiber), and you suspect that a dewatering event has occured, it helps to know what signs to look for.

1. PERMEABILITY

At first, indications of dewatering are the same as normal fouling. TMP will rise and permeability will drop. Often, operators will perform a chemical clean at this point.

2. RECOVERY AFTER CHEMICAL CLEAN

Chemical cleans will reverse the fouling on membranes but won't do anything to break up dewatered sludge. After CIP in a system with dewatering you might see TMP drop and permeability rise, but these will be temporary; they will return to their previous levels within a day or two at most.

3. DEAD ZONES

When observing the MBR basin in filter mode, you might see areas without scour air (dead zones), while other areas might have too much air.

4. VISUAL INSPECTION

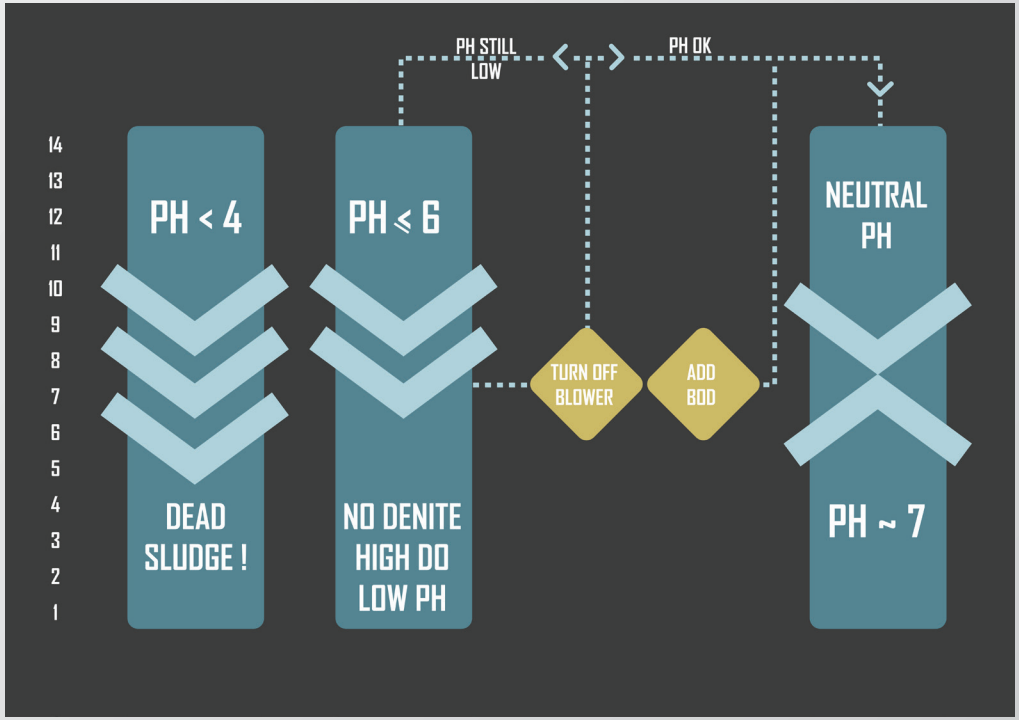
With flat plate systems, it is usually possible to walk on top of the membrane cassette after drawing the water level down far enough. This is the last step to determine if the plates are dewatered. You will actually see the sludge buildup in between the plates.

LOW pH IN AN MBR

Low pH can kill off mixed liquor and ruin a plant's ability to accomplish BNR (biological nutrient removal). This might happen because of chemical dumps, especially for a smaller MBR; but that is an extreme case. More commonly, pH hovering around six is an indicator of lack of de-nitrification; lack of denit caused by excess DO or shortage of BOD.

As nitrification occurs, microbes also consume alkalinity; this tends to drive pH down towards six. As denitrification occurs, microbes release alkalinity, driving pH back towards seven.

High DO can sometimes inhibit denitrification; a high residual (e.g. 5mg/L) can carry over and "poison" the anoxic zone. If a plant is fully nitrifying, but not de-nitrifying, chances are that pH will hover just below six.



However, excess DO might not be the only problem. Lack of BOD can lead to a similar situation. Underloaded MBRs can see this happen. Keep in mind that BOD is consumed fastest, and ammonia is second fastest. You might see that by the time all the ammonia is converted to nitrates, there is no BOD left. In that case, biology will not denitrify, and will not release alkalinity. The result is the same as above: low pH and high nitrates.

Take for example an MBR that was underloaded because its only source of sewage was septic tank effluent. With low BOD (120mg/L) but normal ammonia (60mg/L) it was able to fully nitrify (effluent ammonia was 0.4mg/L), but its effluent nitrates were 38mg/L. DO hovered around 20mg/L and pH was just under 6. Turning the blower off eliminated excess DO, but low pH and high nitrates persisted. The next step, dosing carbon to simulate normal levels of BOD (the equivalent of 300mg/L) allowed the plant to denitrify, and pH rose to about 6.9.

ACTUATOR

HUNTING

Hunting is when an actuator continuously adjusts position, shortening the life expectancy of the device. There are different causes for this, and thus different solutions.

CLOSED POSITION ADJUSTMENTS

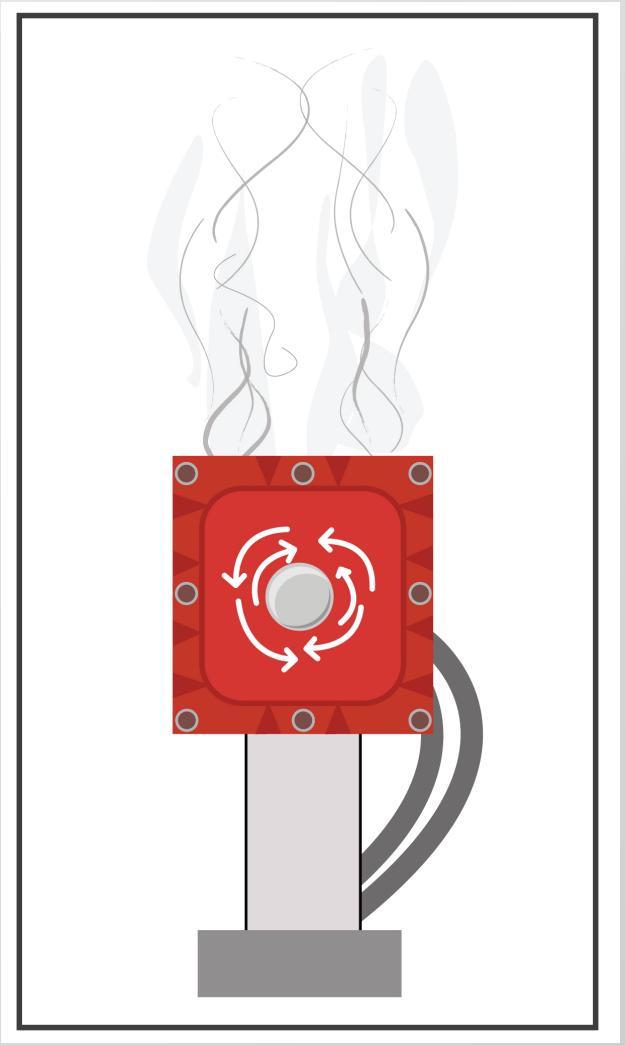
When the actuator should be in the closed position, it should stay there. The closed limit cam (on a Bettis actuator) should be properly met, which opens the switch and kills power to the motor.

SENSITIVITY TOO HIGH (TINY ADJUSTMENTS NEAR SET POINT)

Most actuators have a sensitivity setting (or dead band) that can be decreased to prevent unnecessary movement. A dead band basically says “if we are within x% of our mark, don’t move.”

SENSITIVITY SET TOO LOW

As discussed above, sometimes an actuator is “desensitized” to prevent unnecessary small movements. However, this can cause it to move in larger steps that overshoot and undershoot the intended set point all day long. Increasing the sensitivity (or resolution) of movements can allow it to hit its mark, and stay there. Increasing sensitivity is the same as decreasing deadband. Different actuator brands use different terminology.

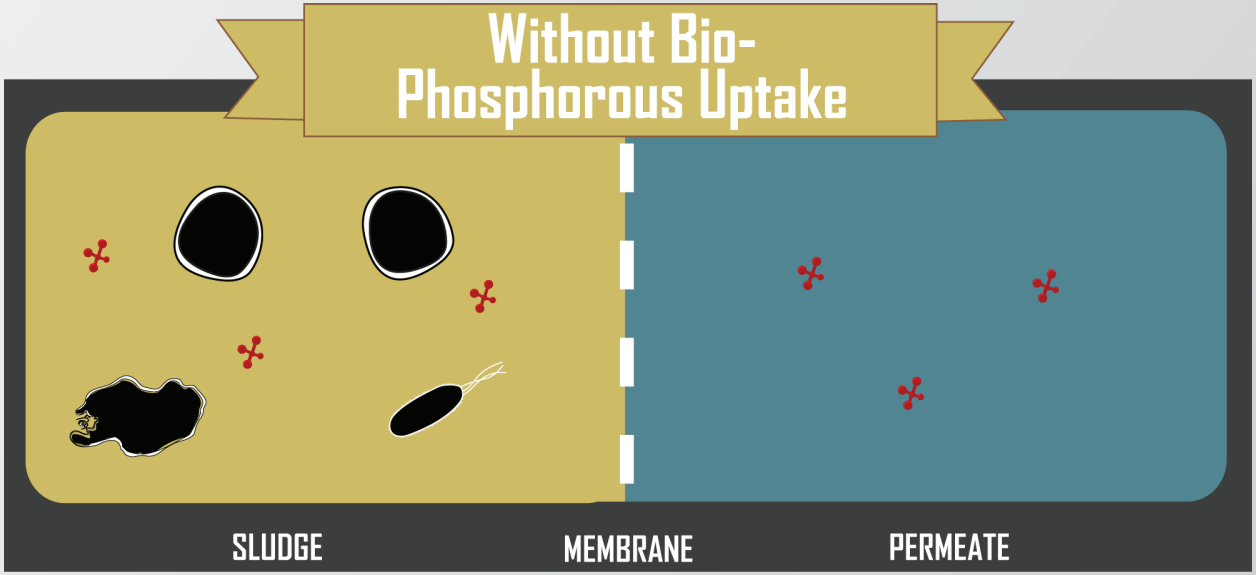


EFFLUENT

PHOSPHO-ROUS

(TP) CONTROL

Many times, the primary reason for building an MBR instead of some other type of waste-water plant is because of tight phosphorous permit limits. The idea is that suspended solids containing phosphorous can't get through the membrane barrier and make it into the effluent; but that's only the second half of the battle. First you have to figure out how to take phosphorous, which comes to the plant in the form of a dissolved solid (which can easily pass through membranes), and get it to go into a suspended solid state.



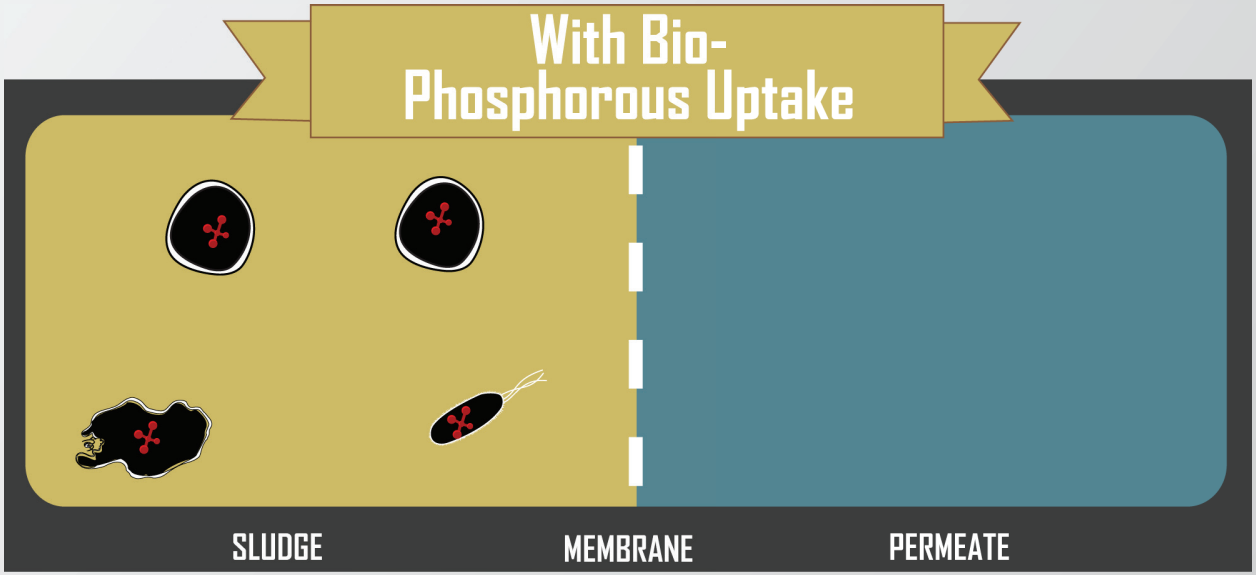
There are two ways of doing this: chemical and biological. In the first, operators dose chemicals such as alum (aluminium sulfate), which binds with phosphorous and forms a solid which is not soluble in water.

EFFLUENT

PHOSPHO-ROUS

(TP) CONTROL

Biological phosphorous removal is alot like ammonia, BOD, and nitrate removal. It uses the microbes in sludge to get rid of phosphorous. The thing is, phosphorous uptake only happens in anaerobic conditions. In other words, DO has to be less than 0.1mg/L (or better yet, zero).

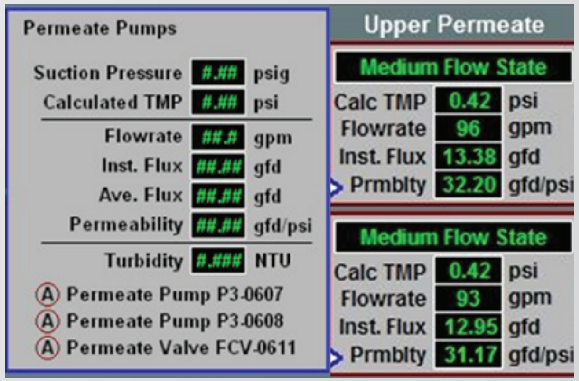


Other things have to happen too. Your sludge needs BOD to be able to take up phosphorous. If you run out of BOD before you run out of TP, you'll have phosphorous in your effluent. The same thing happens with alkalinity. If the sludge pH is too low, the microbes won't take up phosphorous either. If this happens you may end up dosing alkalinity.

Making sure there is the right amount of DO, BOD, and alkalinity are some of the things that Ovivo engineers take into account when designing an MBR that will be subject to tight TP limits.

WHEN NUMBERS DON'T SHOW UP ON THE HMI

The HMI and PLC communicate via an Ethernet cable. A simple network drawing is below. When everything is working correctly the HMI displays the data you expect: levels, flow rates, TMP, flux, etc. If something interrupts the communication then your values will likely be replaced with different symbols such as #, &, **, etc. It is important to remember that the PLC controls the system, so just because you can't see the data on the HMI doesn't necessarily mean your plant is not being properly controlled.

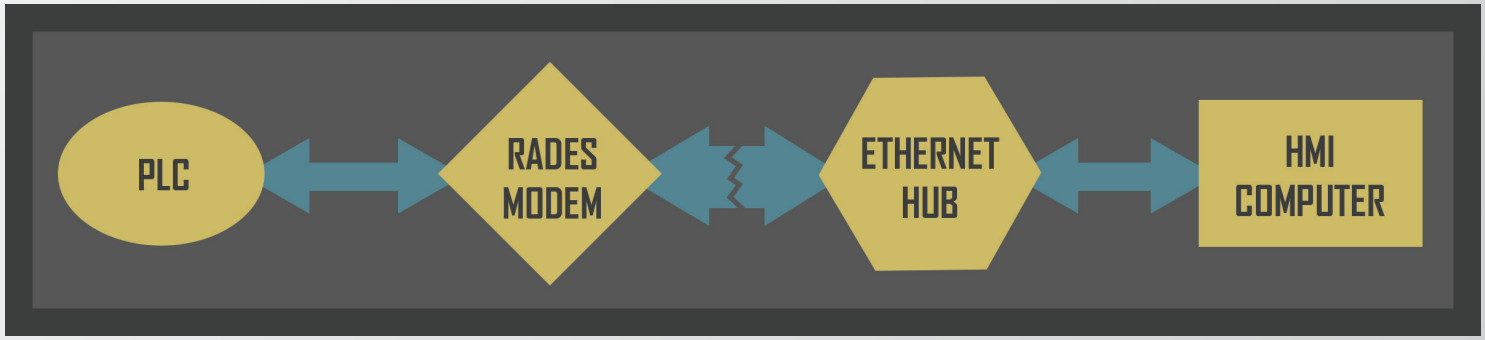


If you are experiencing this situation then something in the communication path has failed. Your challenge is to find the failed component. Typically the problem is related to either the cable itself, or the hub/switch that connects the network.

Try these things before calling for help.

- Check your connections. Look for error lights, pinched cables, loose connections, etc.
- Reboot your HMI computer
- Cycle power to the switch

Call for help before you consider cycling power to the PLC.

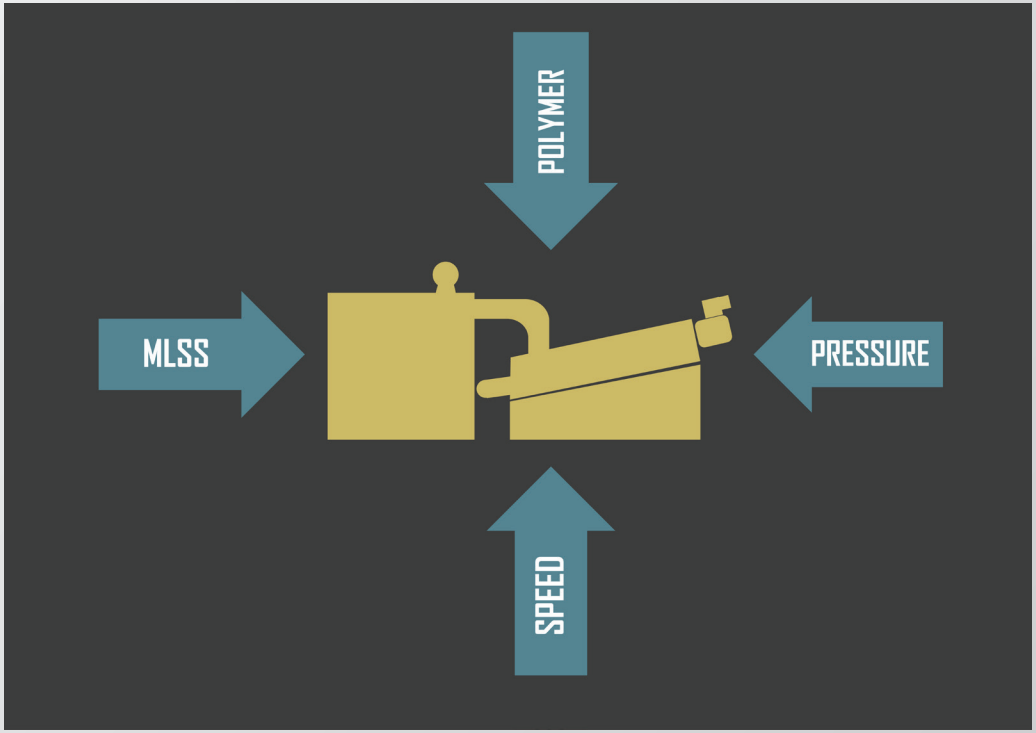


MBT AND FILTER PRESS

BALANCING ACT

The belt filter press can take MBR waste sludge from about 1% to 24% or even higher. They are great for cutting down sludge hauling, but they do require babysitting. Some MBRs produce enough waste sludge that the belt press has to run 8-hours per day, essentially taking up the attention of a full time operator.

Membrane thickeners (MBTs) are one way to help to reduce the amount of time you need to run the belt press. In theory, taking MBR sludge at 1% and thickening to 3% will cut your belt press run time by three. Of course, it's not always that simple. Belt presses can be finicky. A polymer flocculant is added to waste sludge before it enters the belt press. This makes it easier to separate solids from water. Polymer, speed, and pressure are the three variables that need to be tuned to optimize belt press efficiency. Thicker sludge might require a different speed setting, or more polymer. There's a point where adding too much will hurt, not help, the final dewatered sludge product coming out of the press.

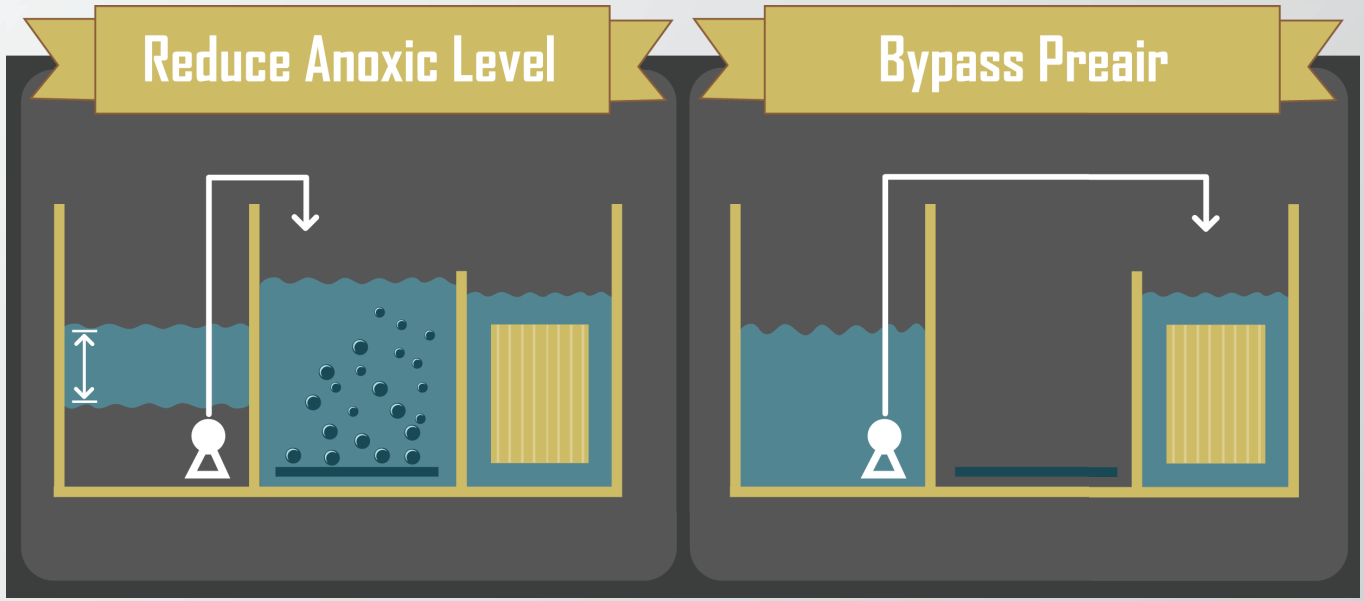


It's a balancing act. Every plant has slightly different sludge, so there are no hard and fast rules. Operators have to experiment a little bit to find out what works best: the thickest sludge you can feed and just the right amount of polymer to get the best dewatered sludge product at the end.

REASONS TO TURN

PREAIR ON OR OFF

Many MBRs are under loaded: hydraulically, biologically, or both. For example, sometimes a plant was designed for a certain number of connections to new homes, but the planned developments were postponed for several years.



In some cases such as campgrounds and ski resorts seasonal variations can leave a plant so under loaded that in the off season biology can't survive without supplemental carbon dosing. Mixed liquor is a living organism. It needs food, air, and other nutrients like any living organism. The more of it you have, the more you have to care for it. Reducing the overall mass of sludge can be a way of dealing with the situation. There are three ways to reduce overall mass--

1. Reduce operating levels in the anoxic zone
2. Reduce sludge thickness (MLSS)
3. Empty and bypass the preair zone

Number three is the most drastic but also allows for the biggest reduction in biological mass.

MBR TROUBLESHOOTING

VFD, LIFTSTATION PUMPS, AND LEVEL CONTROL

VISIT **BLOG.MBRCENTRAL.COM/VFD_LIFTSTATION**
AND LEAVE YOUR QUESTION OR COMMENT

The combination of fine screens, liftstation pumps, and the VFD (variable frequency drive) that runs them is a complicated system. It can be a source of alarms (read: operator headaches) if pumps tend to overwhelm the screens under certain conditions. This might only happen occasionally, like once a week in the middle of the night. This article will oversimplify the system a little bit to make it clear how to troubleshoot a situation like this.

Let's look at the stages of the lift station-fine screen cycle:

1. Lift station fills with sewage until the level reaches the high level float
2. Pumps activate, fine screen box begins to fill
3. Steady state: fine screen has activated and influent flows through the screens at the same rate that it enters the box
4. Lift station reaches low level and pumps deactivate; fine screen box empties
5. Repeat

Stage 3 is where the problem might occur. If pumps are flowing too fast, the fine screens become overwhelmed and may trigger a high level alarm. We'll call this non-steady-state, or... overflow!

Now let's take a look at the requirements for the lift station pumps:

1. Fast enough flow so that solids don't settle in the pipe
2. When the pump comes on, there must be enough head (water level) so that it can operate properly
3. Low level shut off must be low enough to prevent the pump from cavitating
4. Low enough flow not to overwhelm the fine screens and cause an alarm

No doubt the design engineer took all this into account back when the plant was being designed. However, the difference between steady state and overflow might only be 10gpm! That's a rounding error to an engineer; the real world has many unexpected variables that can throw a system off. The pump might be a little more powerful than expected; maybe someone replaced the impeller with a bigger one and didn't think about the effects; maybe there is less head loss in the piping than anticipated, leading to higher flow; maybe somebody moved a float switch.

The result is that in the real world, we look for ways to compensate for these kinds of things.

Some easy options might be:

1. Reduce the flow set point on the HMI (if there is one)
2. Reduce the maximum speed (hz) on the VFD (if the pump is not constant speed)

These can be a little bit tricky so it is a good idea to call the product support hotline for help.

MBR TROUBLESHOOTING

IS YOUR

BIOLOGY

UNDERLOADED OR OVERLOADED?

VISIT **BLOG.MBRCENTRAL.COM/UNDERLOADED** AND LEAVE YOUR QUESTION OR COMMENT

Conventional wastewater operators cultivate sludge so that it will settle. MBR operators cultivate sludge so that it will filter. When influent flow and loading are just about exactly what the design engineer originally planned for, operation is fairly easy. That's when the MBR just hums along in its sweet spot. However in the real world, things can change.

UNDERLOADED

One extreme is the MBR that was built for a housing development, but only five of the one hundred planned homes are built. It is severely underloaded, but the MBR still has to service the existing homes. Some signs that this is having an effect on mixed liquor health would be a lack of wasting and low filterability. Consider thinning out the sludge so that it requires less food (BOD) to survive. MLSS below 8,000mg/L might be a good idea in this situation, but it is usually recommended to reduce permeate set points as well. Keep a close eye on effluent BOD and ammonia to make sure the plant stays within permit.

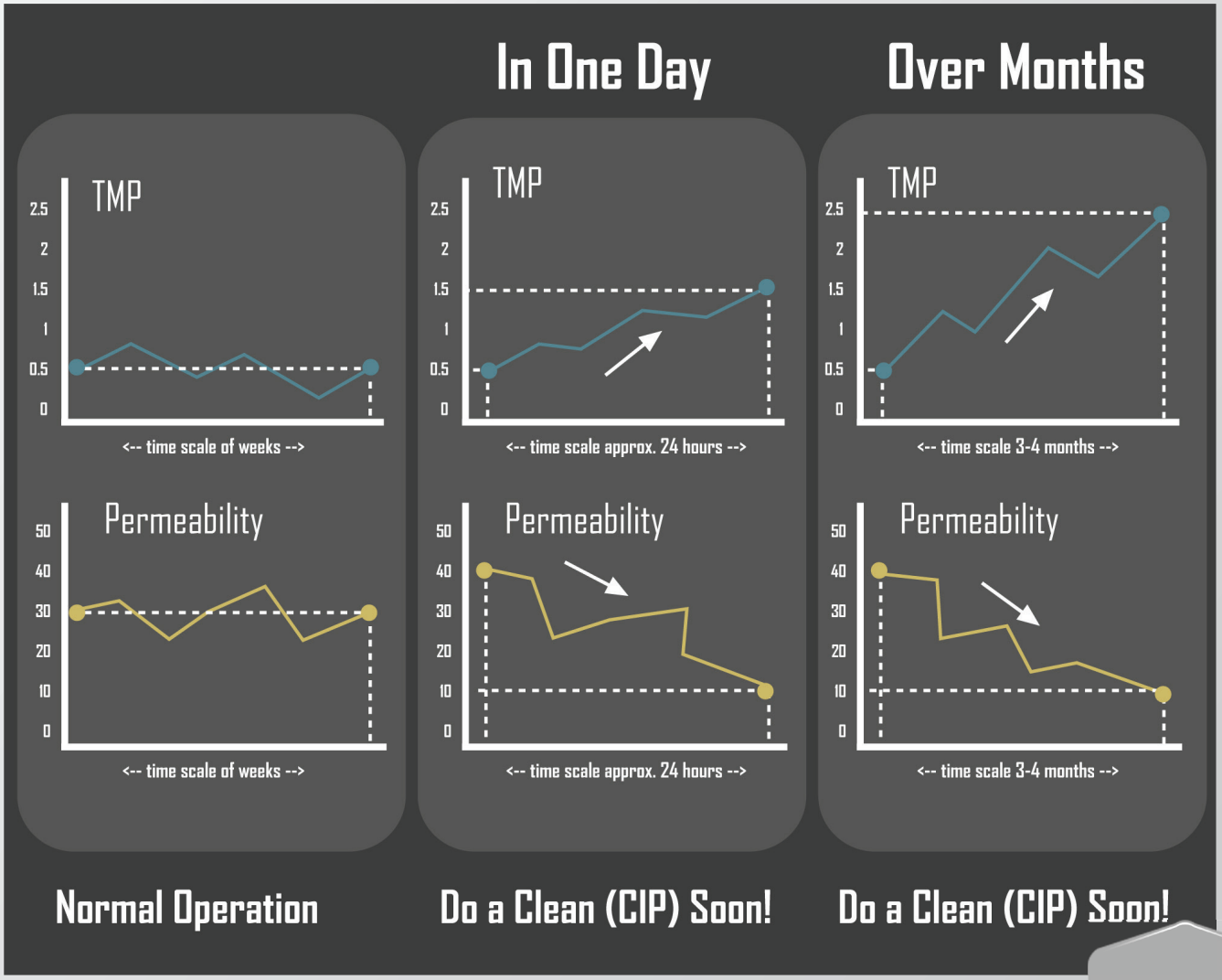
OVERLOADED

The other end of the spectrum is an MBR that receives much more nutrient loading than it was originally designed for. Imagine that a nearby school installs low flow toilets and because it's a small plant, ammonia and BOD go up 50% as a result. The most immediate sign of overloading would probably be preair blowers running continuously without meeting the DO set point. Later on, the operator might notice he is wasting much more frequently, and might even see permit violations.

This is the kind of problem that many people look at and decide that the answer is to build more tankage, add more fine bubble diffusers, and increase the size of the plant. Other options do exist and are worth considering. Adding a concentrated oxygen system combined with increasing MLSS is one approach. Think of it as intensifying the process instead of expanding the process.

WHEN
AND HOW TO CLEAN IN PLACE
(CIP)

Permeability starts to drop when fouling builds up on the membrane surface. The operator can differentiate this from a problem with unhealthy sludge by performing a filterability test. If the permeability drops close to 10, TMP rises by 1.0psi, and filterability is still over 10mL/5min this indicates fouling.



WHEN
AND HOW TO CLEAN IN PLACE
(CIP)

CIP is most commonly performed with a 0.5% bleach solution and 2 hour soak time. Acid can be used in the case of inorganic fouling. It's important to plan prior to expected high flow events. Calculate the amount of bleach needed and have it on-hand. Contact the Equiptech hotline for help with this calculation.

The following is a generic CIP procedure. It's important to develop a custom procedure tailored to your specific MBR. This will prevent any missed steps and help to train new operators in the future. Ovivo can also provide a custom procedure as part of an on-site training visit to your plant.

GENERIC CIP PROCEDURE

1. Call the support hotline at (512) 652-5848
2. Make sure there is enough equalization volume available for the train to stop filtering for two hours
3. Calculate amount of bleach required
4. Mix CIP solution
5. Take the MBR basin offline
6. Shut off the RAS (liquid in MBR basin needs to be quiescent)
7. Open the CIP vent
8. Feed the CIP solution to the membranes (it should take 10 minutes to fill)
9. Soak (rule of thumb—2 hour soak for 0.5%, more for higher concentration)
10. Close the CIP vent
11. Put the MBR basin back online, turn RAS back on
12. Prime the permeate pump if necessary
13. Flush out air entrainment if necessary
14. Monitor performance

MEMBRANE MAINTENANCE

HOW OFTEN

DOES YOUR PLANT NEED A MAINTENANCE CLEAN

(CIP)

VISIT **BLOG.MBRCENTRAL.COM/CIP_FREQENCY** AND LEAVE YOUR QUESTION OR COMMENT

We at MBR Product Support are often asked the question "Why am I having to clean my membranes more often than X times per year?" Where X could be 2, 3, 5 or more times per year. The fact is that CIP maintenance cleans are based on operating conditions and while plant A might need one per year, plant B might need six per year.

There are still things you can do to reduce the number of CIPs you need to perform. Some of the factors affecting fouling, and thus chemical cleaning frequency are--

1. FLUX RATE

Flux is the flow of permeate per square foot of membrane surface. The rule of thumb is that a higher flux will lead to faster fouling and more frequent need for CIP. For example, running at a flux of 25gfd (gallons per square foot per day) will cause you to have to clean sooner than running at 20gfd. The flux at which you can run the plant without a steep drop in permeability is going to be different for every MBR.

2. SLUDGE QUALITY

Always try to perform your filterability test at least once a week. The minimum filterability you want is 10mL in 5 minutes. If you're not familiar with this test, we have a kit that makes it easy to perform. If you have any doubts about your mixed liquor quality, contact the hotline for some recommendations on how to get it healthy. It could potentially save you a lot of headaches in the future.

3. SCOUR AIR

The primary purpose of aeration in the membrane zone is to move sludge past the membrane surface. If it's moving too slowly, some of it can build up on the membranes, contributing to fouling and more frequent CIP. Ovivo startup technicians set the MBR air flow set points to the optimal levels to scour, protect the membranes, and for efficient energy usage. If you have any doubt about your set points, contact the hotline.

4. INFLUENT CONSTITUENTS

Things like water hardness, inorganic dissolved solids such as iron, and FOG (fat, oil and grease) can affect the fouling rate. A plant with significant hardness in its influent might have to clean more often than a plant without it.

MEMBRANE MAINTENANCE

CLEANING

FOR DIFFERENT MEMBRANE TYPES

VISIT **BLOG.MBRCENTRAL.COM/CIP_DIFFERENCES**
AND LEAVE YOUR QUESTION OR COMMENT

MBRs are very dependent on automation. They have to be. The system has to increase or decrease permeate to match influent, and it has to cycle from filter to relax several times an hour. It would be impractical to have a person running around adjusting valves 24 hours a day.

When it comes to membrane cleaning, the automation is a little bit less and there is more operator involvement. That's probably why a very large chunk of tech support questions and calls from operators have to do with membrane cleaning: when, how, how often. There are two schools of thought when it comes to this part of MBR operations--

1. MINIMIZE CHEMICAL USE AND CLEANING FREQUENCY (CONDITIONS BASED)

Flat plate and flat sheet MBRs usually take this approach. Conditions based means keeping an eye on TMP and permeability and reacting by cleaning the membranes only when you have to. When the time comes, the operator will perform a clean-in-place (CIP) by taking the permeate offline, feeding dilute chemical into the membranes using a separate pump, and letting them soak for a time (usually between two and twelve hours). We call this a maintenance clean.

2. MINIMIZE OPERATOR DECISION MAKING (SCHEDULE BASED)

This is the approach that more hollow fiber MBRs take. This is because permeate pumps on a hollow fiber system typically are reversible. They are set to backpulse every cycle (flat plate and flat sheet use relax instead). On a set schedule (once a week), they will backpulse with dilute chemical to clean the membranes. This is the maintenance clean. The idea is that you clean every week whether you need it or not. This approach adds a requirement; one to two times per year the membranes have to be soaked in a basin that is completely filled with bleach, usually for 24 hours. This is known as a recovery clean. It usually involves removing the membranes from their basin and placing them in a separate soak tank.

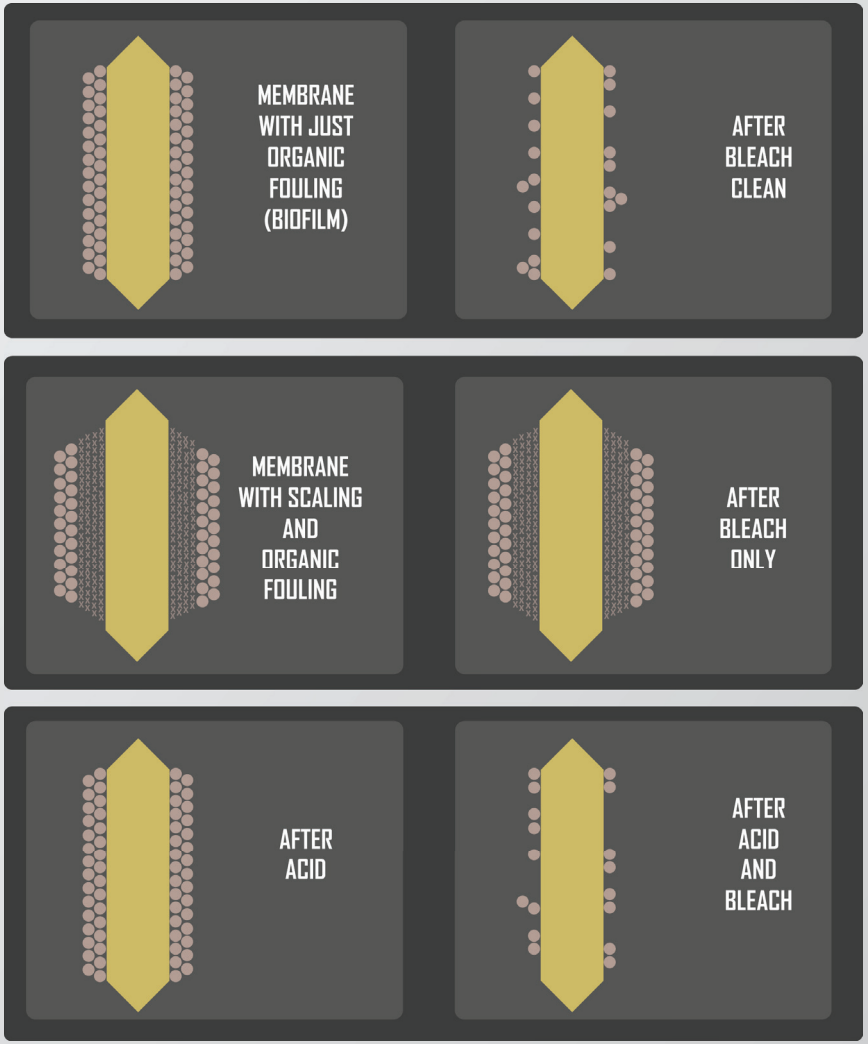
SELECTING

WHICH CHEMICAL

TO USE FOR CLEANING

How to select the chemical to use to clean membranes is probably the second most common question we get, coming in a close second to operators asking for training on how to perform a CIP (clean-in-place). It's actually not very complicated, but just as with the frequency of CIPs, you choose which chemical to use based on conditions: the results you see by watching TMP.

The default is to use dilute bleach. This is because the primary cause of fouling in an MBR is organic material. Bleach cleans this up nicely and it's easier to get and safer to handle than some acids.



If bleach cleans are not producing the desired long term recovery in TMP and permeability, then it becomes time to think about acid. Inorganic fouling may be a source of the problem here. At this point, if it is possible to remove three or four membranes (applies to flat plates) from the system you can test different chemicals on individual plates to see what works best (we call this barrel testing).

Inorganic fouling, or scaling can be controlled by performing an acid clean. Commonly, operators will use citric acid, oxalic acid, or hydrochloric (muriatic) acid. It's important to remember that if your area has hard water, oxalic should not be used. Perform an acid CIP one day, then thoroughly rinse all the storage tanks and piping-- anything that came into contact with acid. Observe the TMP and permeability for awhile to note any recovery. The next day, perform a bleach clean to take care of any remaining organic fouling. The idea is that the acid will wash away scaling so that bleach will be able to come into contact with organic biofilm.

HOW MUCH CHEMICAL TO USE FOR CIP

Figuring out how much chemical to use for a membrane clean is all about how many membranes you have, how much volume they hold, and what chemical concentration you want to use. The examples below show how we perform the calculations to figure out how much chemical to buy and use.

Let's start with flat plate membranes. Calculate how much chemcial to use based on how many plates you are going to clean. Kubota has two basic models of membrane plates: the 510 and the 515. RW and RM cassettes use model 515 plates which each hold 1.35 gal per plate. The older ES and EK cassettes use model 510 plates which hold 0.85 gal per plate. The first thing to do is multiply how many plates you have times the gallons per plate. This equals how much **dilute** cleaning solution you will need. For bleach cleans, dilute solution is normally 0.25% concentration, but when you buy bleach it comes as 12.5%. Let's say you need 1350 gallons of dilute. This is the calculation to use--

X = 1350 * 0.25 / 12.5

X = 27 gal of concentrated bleach

Flat sheet membranes are similar, except that you need to know how many membrane units you are going to clean instead of the number of plates. For example, say you have six OV-400 in one basin. They take 160 gallons of **dilute** per unit (for example, per OV-400). That's a total of 950 gallons dilute chemical. Use this calculation for 12.5% concentrated bleach:

X = 950 * 0.25 / 12.5

X = 19 gal concentrated bleach

MEMBRANE MAINTENANCE

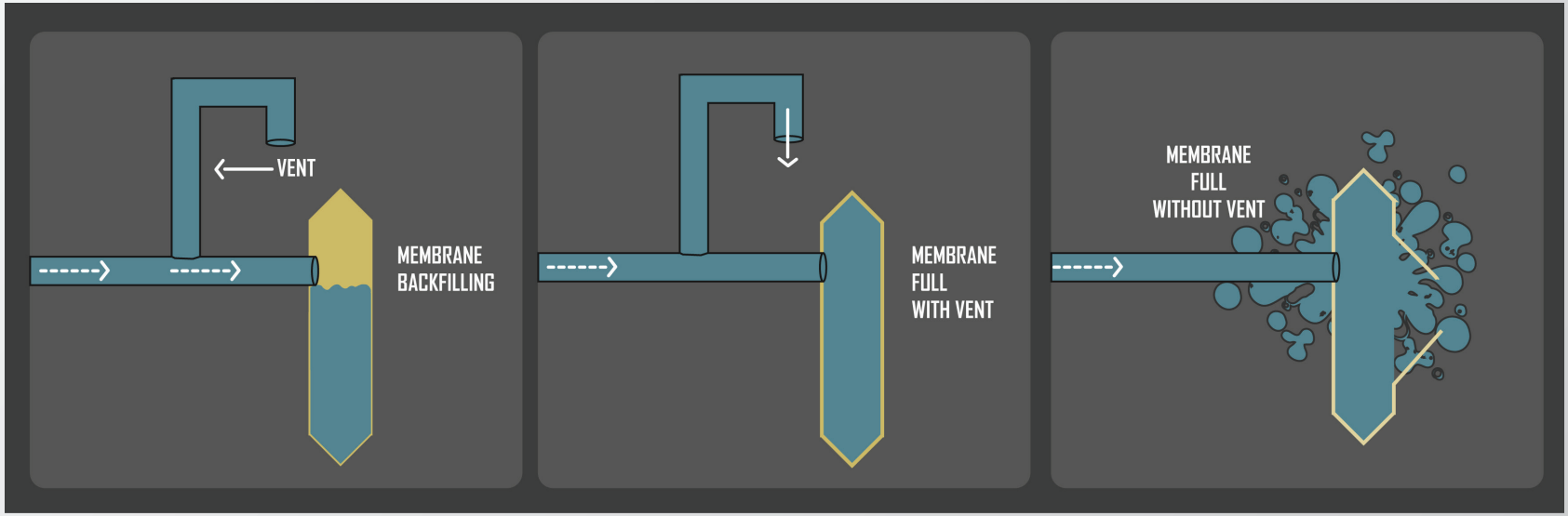
WHAT IS THE CIP VENT THERE FOR?

VISIT **BLOG.MBRCENTRAL.COM/CIP_VENT** AND LEAVE YOUR QUESTION OR COMMENT

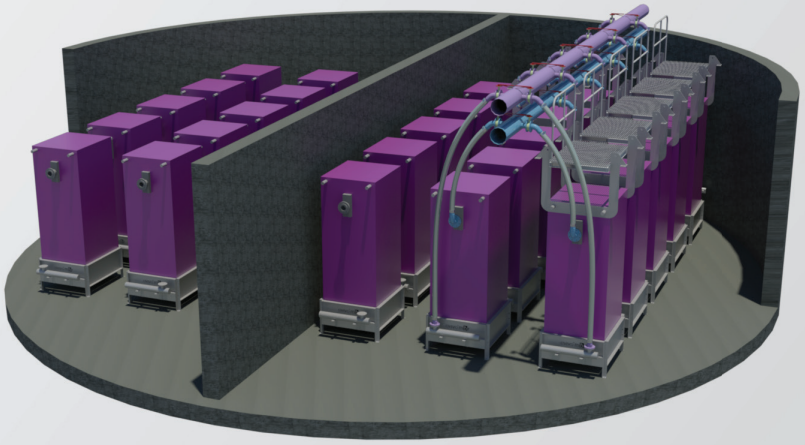
Filling a membrane is kind of like filling a balloon. When you backfill a membrane with dilute chemical cleaning solution, it expands. But what happens if you fill it too fast or overfill it? At some point, if the water has nowhere to go, pressure increases and the membrane has to give out. Different types of membranes are more or less resistant to back pressure. Flat plates are rated to about 3 psi; flat sheets, 2.2 psi; and hollow fiber, 9 psi.

The CIP vent is there to make sure that if pressure reaches the cut off point, water has somewhere to go. It is the simplest way to make sure that back pressure doesn't get too high: an open pipe with a precise height over the top of the membrane cassette based on the backpressure cutoff. For example, flat plate membranes will require the vent to be seven feet above the top of the membranes (1psi = 2.31ft of water).

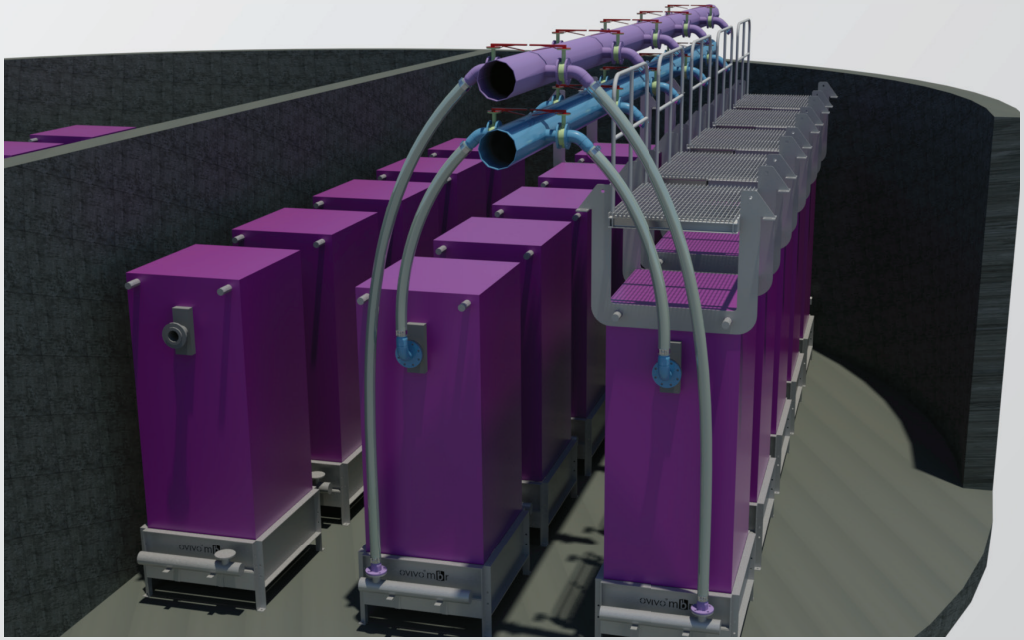
The vent has an additional purpose. During a CIP soak, when the membranes are filled with chemical, the reaction of bleach with biofilm causes gases to form. That's why the vent is left open during the soak, and why it is normally located next to the membrane basin instead of further upstream.



HOW A CLARIFIER CAN BE RETROFITTED WITH MBR TECHNOLOGY



Many wastewater plants are nearing their capacity due to population growth or industrial flows. In the past, wastewater plants that wanted to expand had to build new tankage; but it has become possible in recent years to add membranes to old basins without significant modifications. In the figure below, a 50ft clarifier is shown with twenty-five OV-400 membrane units. These units would be suspended from beams (not shown) running across the top of the concrete walls. Depending on the arrangement, a membrane retrofit could provide up to 1.5mgd capacity, and run at an MLSS of 12,000mg/L.



MBR
PRODUCT DESIGN

HOW
MEM-BRANES
DIFFER FROM EACH OTHER

VISIT **BLOG.MBRCENTRAL.COM/MEMBRANES_DIFFER**
AND LEAVE YOUR QUESTION OR COMMENT

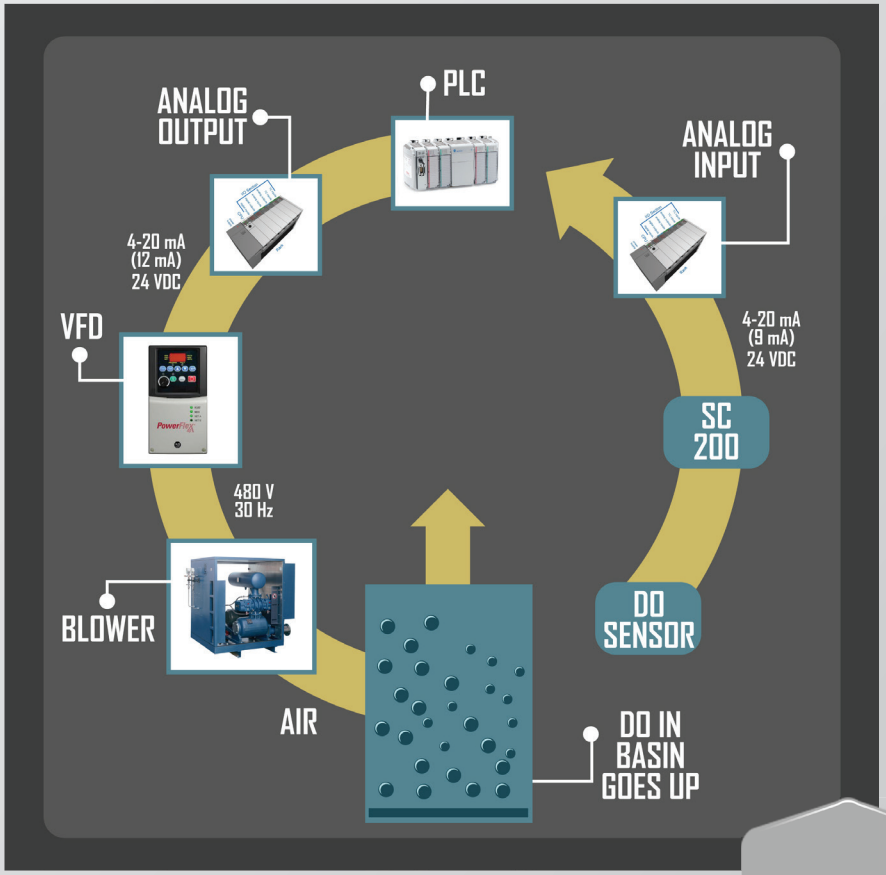
	HOLLOW FIBER	FLAT PLATE	FLAT SHEET
Predominant U.S. vendor	General Electric	Kubota	Ovivo
AKA	Spaghetti, noodles	Plates, cartridges	OMU (Ovivo membrane unit)
Pore size	0.04 micron	0.4 micron (nomimal) 0.04 micron (operational)	0.04 micron
Disassembly	Individual fibers are not replacable	Individual cartridges can be removed and replaced	Contains four modules which can be replaced individually
Dewatering	Susceptible to dewatering primarily at the "potted" sections at the top and bottom of a cassette	Susceptible to thickening and dewatering between plates if scour air is blocked	Dewatering can occur if scour air is shut off during filter mode
Dewatering recovery	Dewatering and debris must be washed out and picked out by hand from between fibers	Cassettes must be completely disassembled and individual cartridges cleaned by hand	Majority of dewatered sludge will slide out by gravity without any disassembly
Damage to membrane material	Can be cut or torn by sharp debris (e.g. plastic razor covers)	Can be cut or torn by sharp debris (e.g. plastic razor covers)	Not easily torn or cut by plastic debris
Turbidity from tears	Can result in turbidity spikes	Can result in turbidity spikes	Fibers within sheet will self-clog, resulting in little turbidity spike
Recovery from membrane tears	Operators tie off individual torn fibers to block turbidity	Replace individual damaged plates	No action required: self clogging

CONTROLS

OVERVIEW: PLC, I/O, VFD, INSTRUMENTS

The PLC (programmable logic controller) is a small computer about the size of two packs of cards which contains a program that tells it how to run the entire plant. Let's say it wants to change the speed of a blower. It instructs the analog output card sitting next to it to send a 4-20mA signal to the VFD. Imagine that 4mA means full stop and 20mA means full speed. In this case the signal is 12mA which equates to telling the blower to run at 50%. The VFD translates this signal to send the actual 480V power to the blower. In this stage, the VFD doesn't change the amperage, it actually adjusts the frequency of the power which is sent to the blower. Since alternating current in the U.S. is normally 60hz, the VFD in this case sends 30hz power to the blower, causing it to run at 50% speed. Next, the blower ramps up and delivers more air to the preair basin, which causes the DO to rise from 0.1mg/L to 1.5mg/L.

The DO sensor in the preair now sends a signal back saying there is now 1.5mg/L dissolved oxygen. The analog input card receives this 9mA signal (on the 4-20mA scale), and tells the PLC that the preair now has 1.5mg/L DO. The PLC compares this reading to the set point in its program and realizes the DO is too high! It then turns around and sends a signal to reduce the blower speed.



CONCENTRATED
OXYGEN:
HOW IT WORKS

VISIT **BLOG.MBRCENTRAL.COM/CONCENTRATED_O2**
AND LEAVE YOUR QUESTION OR COMMENT

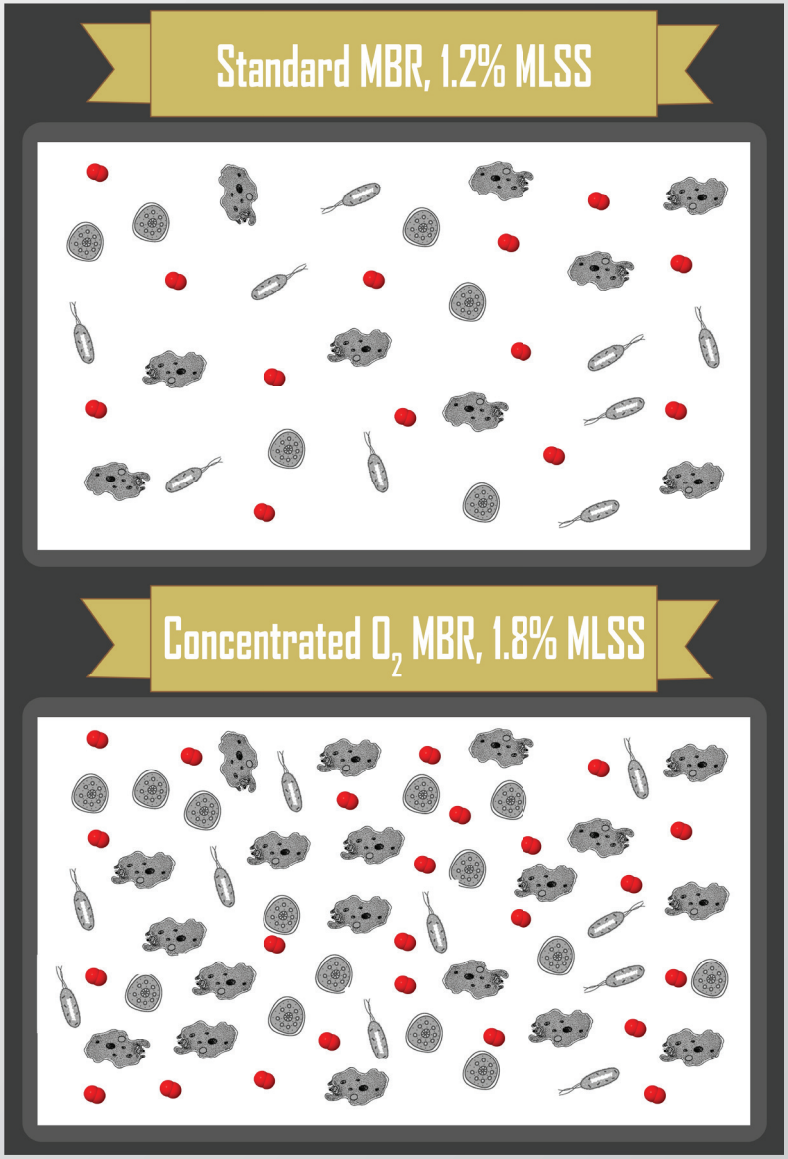
The problem: an MBR that is overloaded and cannot fully denitrify or remove BOD due to industrial waste streams and the recent switch to low flow plumbing fixtures in a nearby school.

The plant: a standard MBR with 12,000mg/L MLSS and fine bubble diffusers.

The conventional solution: increase capacity by adding tankage for additional diffusers (more mixed liquor plus more diffusers equates to more capacity).

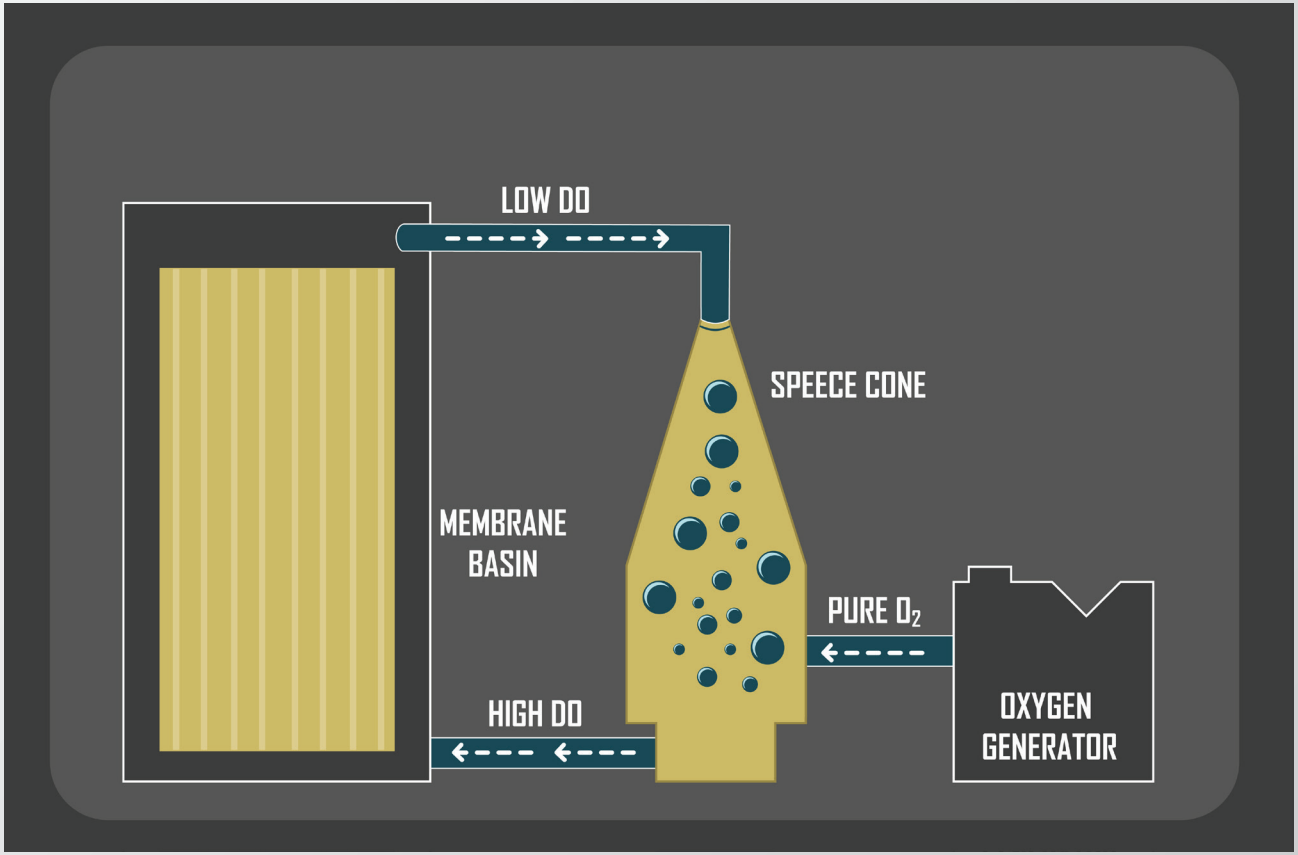
The alternative solution: add a concentrated oxygen loop to avoid building new tankage.

Concentrated oxygen operates on the principal that water at high pressure can dissolve more oxygen. In fact, increasing pressure to 20psig more than doubles solubility compared with atmospheric pressure.



CONCENTRATED
OXYGEN:
HOW IT WORKS

The ability of sludge to use all this additional O_2 partially depends on its MLSS. Fine bubble diffusers don't operate efficiently over 15,000mg/L, but since concentrated oxygen systems don't use diffusers, the MLSS can be increased to 18,000mg/L or more. Finally, the system is also more effective because we can feed pure O_2 instead of air.



MBR TECHNICAL SERVICES

MBR PRODUCT SUPPORT

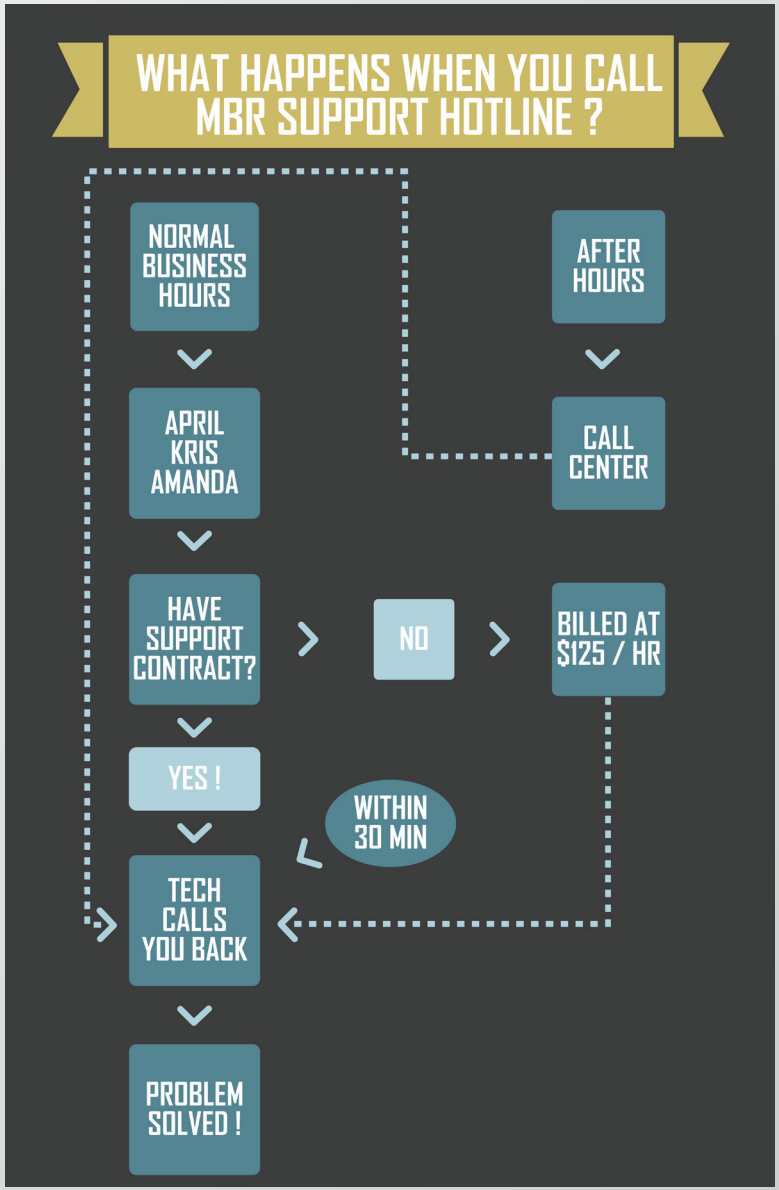
HOTLINE

The MBR support hotline: it's a tool for contacting the right people. Use it for getting a parts quote, or for help resolving an operations problem. The hotline is (512) 652-5848. For submitting tech support cases online, check out the article on page 73.

How it works: During normal business hours (M-F 9am-5pm Central): your call is routed directly to our customer service representatives in Austin: April, Kris, and Amanda. If they are talking with another customer and you go to voicemail make sure to leave your name, plant name and your call back number! We'll call you back within 30 minutes.

After hours: we always have someone on call 24/7/365. Your first call will go to a call center who will ask for some basic info. Then the on-call technician will get back to you within 30 minutes.

If your plant is still under warranty or has an annual support agreement there is no additional charge. If not, that's ok too. We might just bill you though; it's $125/hour. Support contracts start at $3,000/year for unlimited calls. Depending on your problem, we might be able to solve it right away! Other problems might take multiple calls, recommendations, and trouble-shooting. But whatever it is, we're here to help.



MBR TECHNICAL SERVICES

ANNUAL OPERATOR'S

WORK-SHOP

Each year since 2005, Ovivo hosts its annual MBR workshop in downtown Austin, TX. Attendance consists of about 150 MBR operators from across the U.S., some consulting engineers, and some prospective plant owners. The two-day event consists of 80% operations talks and 20% engineering presentations. Sales presentations are left out of the mix. We want the conference to be primarily a learning experience for every attendee.

While the content itself is very jam packed with useful information, one of the biggest features of the conference is the opportunity to meet and network with over 100 other MBR operators from around the country. The workshop is offered at no cost.

In 2014, four presentations were given by head operators from La Center, WA; Shelton, WA; Ruidoso, NM; and Piedmont, SC. One talk was from the professor of membrane technology from Cranfield University in the UK, Simon Judd; and fourteen operations presentations were given by members of our MBR field service and technical support group. Operators in attendance were eligible for continuing education credits.

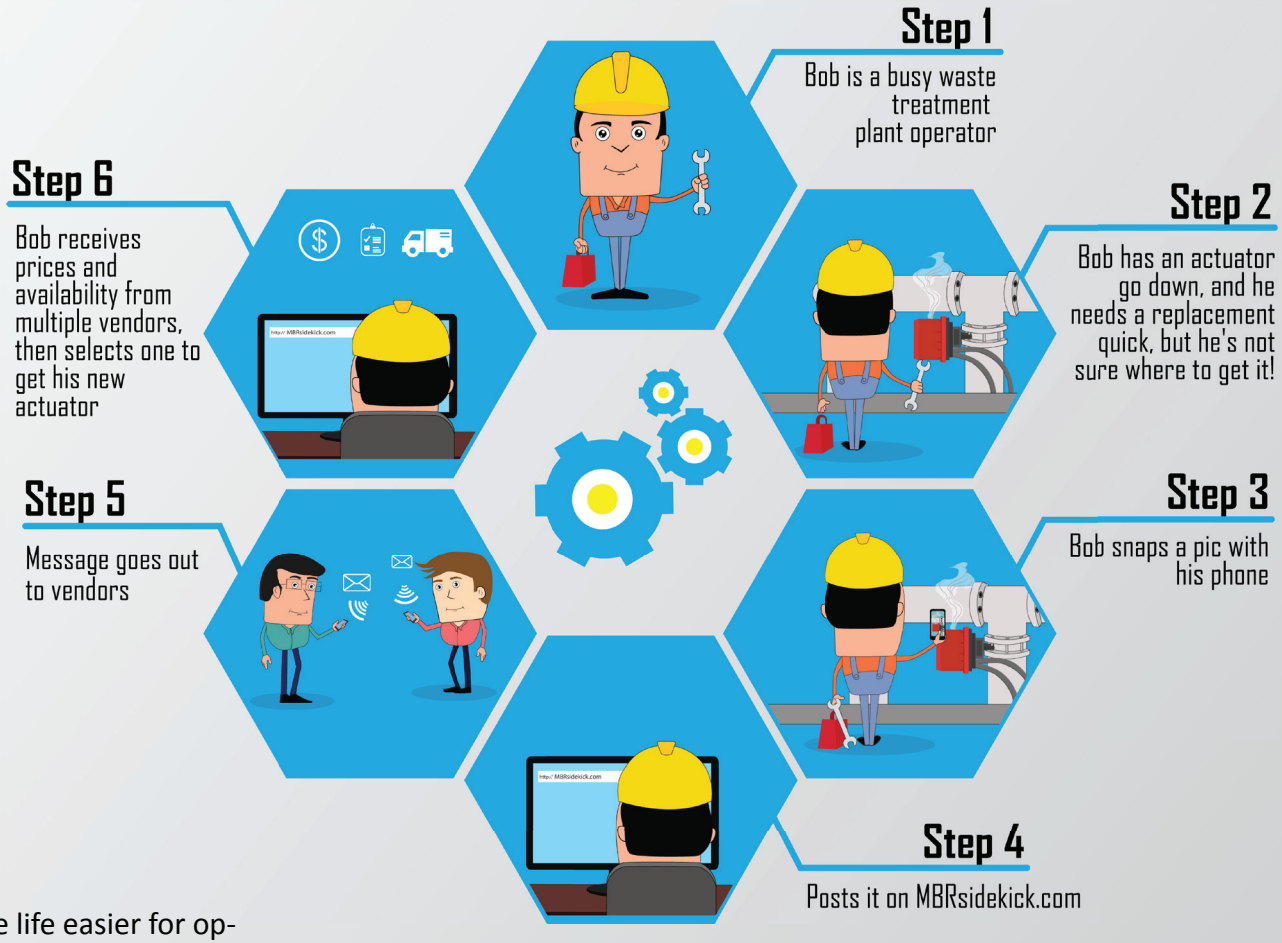
MAY 2015 DAY-1 AGENDA

- Innovation - More in the Next 20 Years than in the Last 100
- What We've Learned Since the First Operator Workshop
- MBR Fundamentals with a Look to the Future
- Finally…An Engineer's Perspective: 10 MBR Systems & Counting
- Ovivo MBR #3 Out of 247: 10+ Years at Running Springs
- MBR vs. SBR: The Path to Lower OPEX
- EQuipTech: The Year in Review
- Options for Extending Membrane Service Life & Maximizing Value
- It Doesn't Count Unless it's Monitored
- Wisdom Never Lost: Advances in Training & Record Keeping
- When Things Appear Unfixable Try a DISRUPTION
- Driving MBR Performance Based on OPEX
- Servicing Multiple MBRs…A Day in the Life
- So What Did We Learn Again?

MAY 2015 DAY-2 AGENDA

- Day 1 Recap and Day 2 Goals
- MBR Optimization is Not for the Faint of Heart
- Understanding Fine Screen Performance
- Managing Solids The Membrane Way
- Making of the Most of Digital Tools
- Improving Record Keeping and Reporting
- Turning Lessons Learned into Innovations
- Understanding Fine Bubble Diffusers
- Extending Membrane Life and Saving $$$

GETTING REPLACEMENT
PARTS
AND EQUIPMENT



MBRSIDEKICK.COM

MBRsidekick is designed to make life easier for operators. If you have a tech support problem or need replacement parts you can just upload a photo of the problem equipment and click submit. Tech support requests go straight to our MBR support group, while parts requests go to Ovivo plus all the vendors you already know and buy from.

MBR
TECHNICAL SERVICES

FILTERABILITY & MPE50

TEST KIT

Busy wastewater operators have a lot of things on their plate without having to shop around for all the various supplies needed for filterability testing. We'd like to save you the time of searching through catalogs and calling different vendors. This kit contains everything needed to begin filterabilty testing immediately after plant commissioning. Later, if filterability is low, the kit has what you need to do the lab scale test for MPE50. To purchase this kit, call the product support hotline at (512) 652-5848.

The kit contains--

- 100 sheets Advantec filter paper
- Two 50mL graduated cylinders
- Funnel
- Timer
- Syringe (for measuring MPE50)
- 50mL bottle of MPE50
- 25mL beaker

WHO IS
OVIVO MBR?

Ovivo MBR

TECHNICAL
SERVICES

VISIT **BLOG.MBRCENTRAL.COM/WHO_IS** AND LEAVE YOUR QUESTION OR COMMENT

AMANDA BAGRICH

Amanda is often the first person to respond to a new MBR technical support case. She has been with Ovivo in a customer service role since 2012.

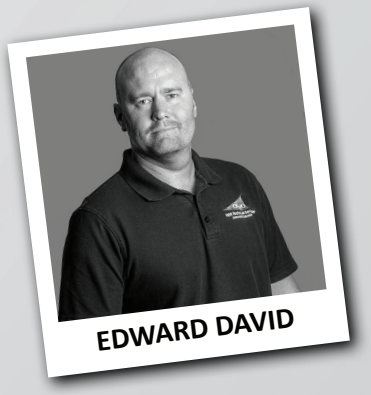
APRIL REYES

April leads the Customer Service Group and is responsible for the annual MBR Operator's Workshop. She has been with Ovivo since 2005.

Kris has been with Ovivo for 19 years and MBR customer service since 2010. She coordinates many customers and parts orders in the western US.

KRIS ARMSTRONG

Eddie has unmatched expertise in plant startup, operator training, and troubleshooting MBR systems. He is currently the manager of the Product Support Group.



EDWARD DAVID

JEFF MAIS

Jeff performs integration and controls tasks for MBR and microBlox projects. He also designs controls strategies, conducts factory acceptance tests, and configures PLCs and SCADA systems.

JOSH PHILLIPS

Josh has been with the support team since 2012. He works out of the Canton, OH office and holds an Ohio Class 3 Wastewater Operator and a Wastewater Laboratory Analyst license.

WHO IS
OVIVO MBR?

Ovivo MBR

TECHNICAL
SERVICES

VISIT **BLOG.MBRCENTRAL.COM/WHO_IS** AND LEAVE YOUR QUESTION OR COMMENT

JESSE PHILLIPS

Jesse is a highly skilled MBR troubleshooter and has published many technical documents on the EQVue webpage. He has been with the MBR support group since 2008.

KEVIN HAMMLER

Kevin has been with the MBR field service group since 2012 and performs troubleshooting and on-site support throughout the US.

Mark headed the MBR technical support group from 2005-2013 and oversaw the startup of over 180 plants. He now manages the aftermarket parts and services group.

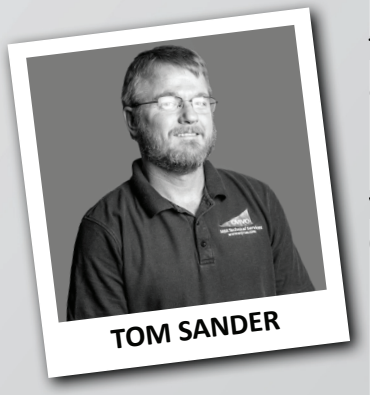
MARK PARLI

Russell is a Control System Specialist with 18+ years' experience. His areas of expertise are in programming, configuring HMI, and troubleshooting electrical issues.

RUSSELL REED

TAIT STAHL

Tait is a Senior Field Service Technician and is in charge of MBR startups—he has also performed 37 startups himself since joining Ovivo in 2010.



TOM SANDER

Tom is the Case Management Supervisor for MBR systems. He has been an MBR field service and startup technician since 2005.