Monitoring & Cleaning of Diffusers for
MICRODYN BIO-CEL® MBR

Introduction

Proper operation of diffusers is mandatory for safe and reliable operation of MICRODYN BIO-CEL® MBR modules, since the diffusers provide the required crossflow aeration which mitigates cake-layer build up on the membrane surface. In addition, the membrane diffusers have major benefits such as excellent oxygen transfer efficiency characteristics and are widely used in wastewater treatment. However, membrane diffusers also have maintenance requirements dependent on the characteristics of the wastewater.

Safety Precautions

Please consider your local safety requirements.

When using the chemicals indicated below, please follow these accepted safety practices:

1. Always wear eye protection. In the case of handling corrosive chemicals, wear full-face masks and protective clothing. Consult the chemical manufacturer for detailed information about safety, handling and disposal.
2. When preparing cleaning solutions, ensure that all chemicals are dissolved and well mixed before circulating the solutions to the membranes.

Influent Properties Effect on Diffuser Lifetime

The lifetime of diffusers is highly influenced by the influent properties such as foulants and scales, and also by operation. The expected lifetime is 5 to 10 years, but may be less or more dependent on various factors. For some industrial or very aggressive wastewater applications, the lifetime may be reduced. Also, if no improvement is gained after applying the cleaning strategy discussed in this document, the economics of replacement should be considered since operation at high pressure decreases the economic efficiency of the diffusers.

The presence and concentration of certain dissolved substances in wastewater increases the risk of formation of deposits inside and on the outside of the diffuser membranes. The risk of clogging (scaling or biofouling) is strongly dependent on the pH conditions in the biology, which are a result of buffer capacity (carbonate hardness), microbial activity and physical properties of the activated sludge (i.e. temperature, turbulence). At pH 7 or lower the sludge is CO_2-saturated and the air passing the diffuser membrane is nearly free of CO_2. This results in a pH increase in the sludge on the pore sidewalls and a decrease in $CaCO_3$ solubility, which can lead to clogging due to limescale formation. Another common source of clogging is silicic acid. At a lower pH most of the potentially precipitating inorganics are kept in solution, whereas silicic acid, present in natural water, is transformed into a colloidal species or even precipitated.

Other Common Causes of Diffuser Clogging

Two other common causes of diffuser clogging are poor air filtering at the blower and biofouling within the air piping.

It is highly recommended to use a paper inlet filter for the blower with removal of >93% of 10 micron particles or larger to prevent clogging of the diffuser membrane from inside. Although the amount of particles in the air normally is low, the high flow rate of the blower will cause an accumulation of particles if there is no filter. Also consider local air-quality conditions (i.e. sandy or salty air), as these may have an impact on blower performance.

Ensure that there is no biofouling inside the air piping to prevent the MICRODYN BIO-CEL® MBR diffuser from becoming fouled from the inside. If there is an indication of biofouling, the entire piping needs to be disinfected and the diffusers need to be disconnected to avoid contamination by accumulating biofoulants.

Diffuser Monitoring

The performance of the diffusers should be monitored via pressure loss, temperature and air flow rate measurements.

Pressure Loss

The pressure loss of the diffusers is a good monitoring parameter because an increase usually indicates scaling or fouling issues. There are two methods to measure diffuser pressure loss. The first method is measuring the pressure inside the air piping. This measurement does not measure the actual pressure loss of the diffusers very accurately, since it is also dependent on the system pressure. However, this measurement may give an indication of the pressure loss. To account for system pressure, the head pressure at the diffusers is subtracted from the measured pressure inside the air piping. This calculated pressure loss should be in the range of the expected pressure loss according to Table 1. It is critical that the pressure gauge is installed near the membrane modules to avoid significant pressure loss due to the air piping.

The second and preferred method to measure pressure loss is a differential pressure measurement. This method measures the pressure difference between the diffuser and a water bubble aeration tube which is measuring the system pressure (see Figure 1). The water bubble aeration tube is installed at the same level as the diffusers and the needle valve is adjusted so that bubbles are slowly released into the system. Due to a typical pressure loss being in the range of 60 to 85 mbar (0.87 to 1.23 psi- see Table 1), the differential pressure transmitters should be sensitive to small pressure changes and is recommended to have a maximum range of 500 mbar (7.25 psi). A valve for dosing chemicals into the system is also required.

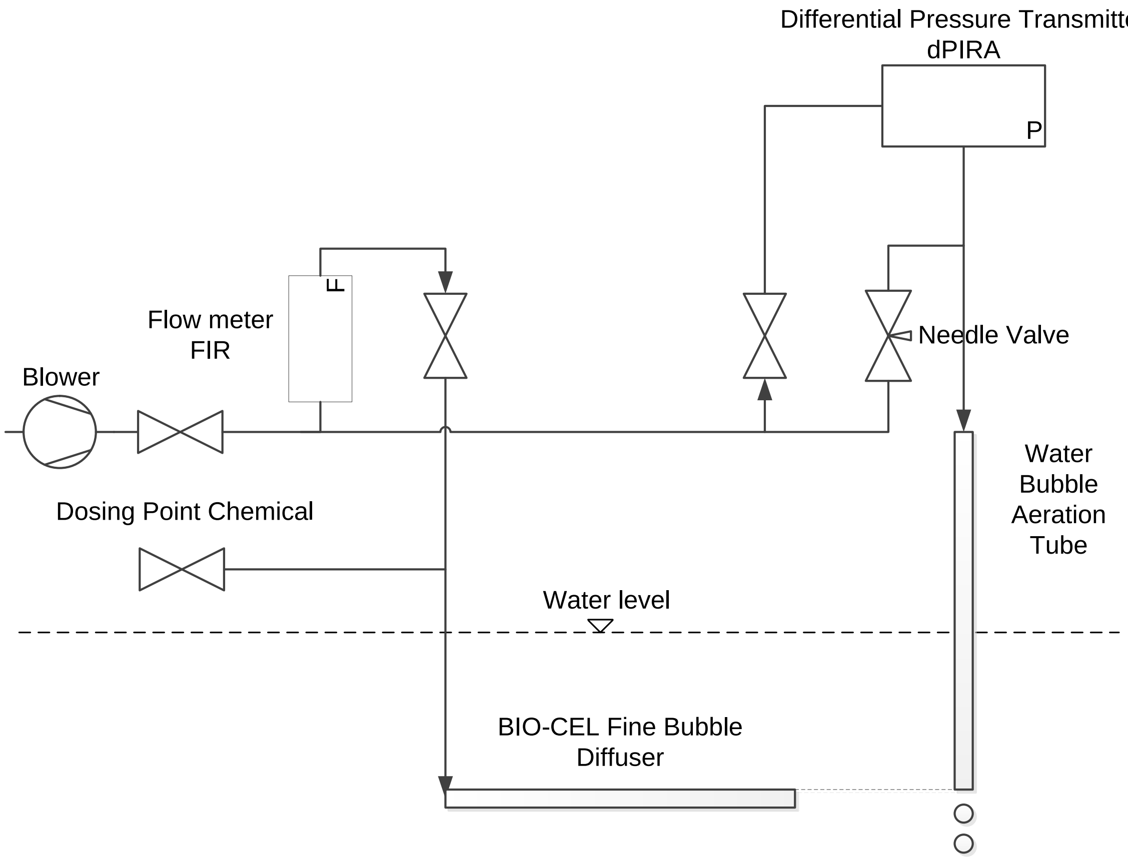


Figure 1. Differential pressure measurement for monitoring of pressure loss MICRODYN BIO-CEL® diffuser

Table 1 provides an overview of the pressure losses of each MICRODYN BIO-CEL® MBR module type. This pressure loss is an estimate and is dependent on various design factors. Therefore, MICRODYN-NADIR recommends monitoring the pressure in relation to the initial pressure measured during start-up of the membranes.

Temperature & Air Flow

Temperature and air flow should also be measured. See Table 1 for appropriate values.

Visual Inspection

MICRODYN-NADIR recommends regular visual inspections of the diffusers for inhomogeneous aeration. A typical inspection is made by lowering the sludge level 5 cm (2 inch) above the membranes, aerating them at 70% of standard air flow and looking for inhomogeneous distribution. A detailed inspection can be combined with the cleaning of the tank and/or cleaning of the BIO-CEL membrane modules.

Table 1. Aeration design parameters for MICRODYN BIO-CEL® MBR modules

Parameter	Unit	BIO-CEL XL-1	BIO-CEL L-1	BIO-CEL 416	BIO-CEL 104	BIO-CEL 52	BIO-CEL XS-1
# of diffusers		30	7	7	4	4	1
Temperature	°C	5 to 90	5 to 90	5 to 90	5 to 90	5 to 90	5 to 60
	°F	41 to 194	41 to 194	41 to 194	41 to 194	41 to 194	41 to 140
Typical diffuser pressure loss @ recommended air flow rate	mbar	80	85	70	70	70	60
	psi	1.16	1.23	1.02	1.02	1.02	0.87
Diffuser submergence depth @ minimum water level (standard dimensions)	mm	2750	2740	2950	1500	1500	1465
	Inches	108.3	107.9	116.1	59.1	59.1	57.7
Total pressure loss at minimum water level	mbar	355	359	365	220	220	206
	psi	5.15	5.21	5.29	3.19	3.19	2.99
Maximum aeration rate in operation	m^3/h	460	115	105	60	30	6
	GPM	2025	506	462	264	132	26

Cleaning Methods for MICRODYN BIO-CEL® MBR Diffusers

MICRODYN BIO-CEL® MBR diffusers need to be cleaned if:

- Clogging (dewatering, sludging) of modules has occurred due to improper aeration.
- Pressure loss of diffuser is higher than the initially measured pressure loss. Clean when the pressure increase is higher than 10 mbar (0.15 psi).
- The bubble pattern of the membrane module appears irregular and inhomogeneous. Check if this is caused by dewatered modules which may be an independent issue from the diffusers.
- Visual inspection of the diffusers show that they are scaled or fouled.

The entire MBR system should be operated continuously, and down-time should be minimal. Therefore, MICRODYN-NADIR recommends to first apply the Clean In Place (CIP) approach. Cleaning intervals may vary from hours to months depending on the media.

When a cleaning is required, first start with air purging and continue with the CIP approach. If the CIP approach doesn´t help, try the recovery cleaning and/or mechanical cleaning approach. A chemical cleaning with citric acid is conducted for scaling issues, while a sodium hypochlorite cleaning removes organic foulants. If it is unclear what type of cleaning should be performed, both cleaning should be performed. Begin with a citric acid clean since scaling is more likely for diffusers.

Always check the monitoring parameter to evaluate the success of each cleaning approach.

Cleaning Via Purging Air

Intermittent operation with air purging is recommended to mechanically clean the diffusers. To do this, stop the permeate pump so that filtration is stopped and turn the air on for 5 minutes and then off for 5 minutes. Resume normal operation after completing the purge. This strategy can be repeated three times a day. Purging should be integrated in the blower controller. Additionally, purging should occur at regular intervals based on actual pressure loss measurements and the bubble pattern.

Chemical Cleaning Parameter

Table 2. Chemical cleaning data for diffusers

Parameter	Range
Target sodium hypochlorite concentration	1000 mg/l (ppm) @ pH < 11
Target citric acid concentration	1 wt% @ pH 2-3
Target temperature	< 50 °C (122 °F)
Target pH	2 to 11
Soaking time	4 to 12 hours

Cleaning in Place (CIP)

The CIP approach is done with diffusers (and the whole module) submerged in activated sludge. The module line which diffusers have to be cleaned needs to be taken out of operation (stop production and aeration). Please make sure not to overload other module lines which are still in operation.

The steps of the CIP are detailed below.

Table 3. CIP cleaning steps

Steps	Procedure
1	Check and note the diffuser pressure loss before starting the cleaning procedure
2	Isolate the module line from operation (close permeate and air valve)
3	Disconnect the air pipe of the line you would like to clean above the water level.
4	Prepare a batch of citric acid solution (or sodium hypochlorite solution). The required volume per module is depending on the size and amount of diffusers installed (see Table 4 below), air pipe dimensions and its length. Prepare twice the volume you calculated. On the one hand you have to make sure, that the level of solution in the pipe is higher compared to the water level in the tank to force the solution passing the diffuser membrane. On the other hand you have to make sure that there will be a complete exchange of the water (which might be in the air pipe) by cleaning solution.
5	Add the cleaning solution slowly (without applying pressure) into the disconnected air pipe. The solution will displace the water through the diffuser membrane by gravity flow. Depending on the level of scaling, this process may take some time. The higher the disconnection point is, the better. Once half of the prepared amount of cleaning solution is poured in, the diffusers outer layer will now get in contact with the cleaning solution. Add the rest of the prepared volume into the pipe.
6	Leave the diffuser for at least 4 hours (refer to Table 2).
7	Repeat step 4 with water and without any chemical for a complete exchange of the cleaning solution by water. You should now see that the exchange process goes much faster. If this is not the case, repeat steps 3-5 with cleaning solution.
8	Once the cleaning procedure is done, connect again the air pipe and put the module back in operation.
9	Check and note diffuser pressure loss after cleaning to evaluate the cleaning efficiency. The diffuser pressure loss should now be again in a normal range. Please document all cleaning approaches in the plants log book.

Caution

IN CASE OF CLEANING WITH BOTH CLEANING SOLUTIONS, MAKE SURE THAT THE SYSTEM IS COMPLETELY PURGED WITH WATER AFTER USING THE FIRST SOLUTION AND BEFORE ADDING THE SECOND SOLUTION. CHECK PH AND/OR CHLORINE CONCENTRATION BEFORE ADDING THE SECOND SOLUTION.

Table 4. Aeration design parameters for MICRODYN BIO-CEL® MBR modules

	Unit	BIO-CEL XL-1	BIO-CEL L-1	BIO-CEL 416	BIO-CEL 104	BIO-CEL 52	BIO-CEL XS-1
# of diffuser		30	7	7	4	4	1
Volume added to fill diffusers	L	170	60	60	30	30	4
	gal	45	17	17	15	10	2

Recovery Cleaning

The recovery cleaning of the diffusers can be combined with a recovery cleaning of the filtration tank. In some cases, it can be directly combined with a recovery cleaning of the membrane modules when the tank is completely filled with the cleaning solution. Otherwise, it is recommended to first clean the diffusers and then perform the recovery cleaning by chemical backwash for the membrane modules.

The steps of the recovery cleaning are detailed in Table 5.

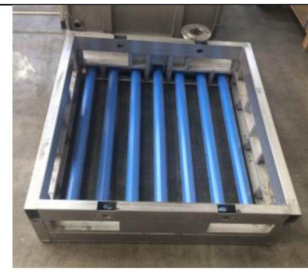
Table 5. Recovery cleaning steps

Step	Procedure
1	Drain the tank completely.
2	Cover the diffusers to the top (5 cm or 2 inches above perforation) with a citric acid solution or sodium hypochlorite solution (Table 2).
3	Check the pressure loss at very low aeration (10-20%) of standard air flow.
4	Soak the diffusers and aerate them at very low aeration in between every hour (e.g. 5 min). Check the pressure loss of the diffusers. If it decreases, this indicates that fouling or scaling was efficiently removed. If possible, it would be best to recover the diffusers to the initial pressure loss measured during start-up.
5	Drain the tank again and proceed with further cleaning steps.
6	If there is no significant decline of pressure loss, a manual cleaning is recommended as detailed below.

Manual Cleaning Method

If the previous methods are not working, then a manual cleaning will be necessary.

Table 6. Manual cleaning method

Steps	Procedure
1	• Please consider the assembly guides for each MICRODYN BIO-CEL® product type. • Lift the membrane unit out of the diffuser base frame. • The diffusers can be either disassembled and cleaned outside or cleaned inside the diffuser frame. 
2	**Manual Method- Water Hose** The nozzle should be at least 50 cm (~20 in) away from the diffuser.  **Caution** DO NOT USE A HIGH PRESSURE NOZZLE SUCH AS A DIRT BLASTER TO CLEAN THE DIFFUSERS. THEY MAY DAMAGE THE DIFFUSER MEMBRANE SURFACE.
3	**Manual Method- Wiping with Cloth, Soft Brush or Sponge** Deposits may also be removed by carefully wiping the surface with a cloth or soft brush.  **Caution** ENSURE THAT THE MEMBRANE SURFACE IS WETTED WITH WATER.
4	Prepare a chemical cleaning bath according to recommendations given in Table 2 with sodium hypochlorite or citric acid and place the diffusers into this bath. If the diffusers are still mounted in the diffuser base frame, perform a recovery cleaning. A maintenance cleaning may be performed at the same time so that the inside and outside of the diffusers are cleaned.
5	Let the diffuser soak according toTable 2.
6	Repeat Steps 0 and 0.
7	Reinstall the diffusers.
8	Fill up the basin and check the pressure loss. Compare to the initial pressure loss.

Diffuser Replacement

The diffusers should be replaced if one of the following conditions is met:

- Diffusers are damaged during transport onsite.
- The pressure loss is significantly higher than the initial pressure loss and the cleaning methods described in this document are not successful. In addition, if the membrane module performance suffers significantly due to diffusers (for instance inhomogeneous aeration or clogging of membrane module).
- Dewatering of modules occurs due to improper aeration and is confirmed by visual inspection.
- Sludge intrusion into diffuser as shown in the picture below. This may be caused by product imperfections (loose clamps, incorrectly mounted) or process-related issues such as sludge intrusion into piping, leaking flange connection, etc.

Figure 2. Sludge intrusion into diffuser

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