Shanghai Morui Environmental Technology Co., Ltd.

Morui MBR Manual

【THE MBR HANDBOOK】

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1. Notes of Terminology

I. **MBR** - Short for Membrane Bio-Reactor, is a new type of wastewater treatment process that organically combines membrane separation technology and biological treatment technology. It consists of a biochemical reaction system and a membrane module. It uses membrane modules to trap activated sludge and macromolecular organic substances in the aerobic biological reaction tank to increase the concentration of activated sludge. The hydraulic retention time (HRT) and sludge retention time (SRT) can be controlled separately, while the hard-to-degrade substances are continuously biodegraded in the reactor.

II. **SMBR** - Submerged Membrane Bio-Reactor, that is, the membrane module is directly immersed in the biochemical membrane tank, and the membrane module directly filters the water by suction.

III. **HRT** - The hydraulic residence time refers to the average residence time of the sewage to be treated in the reactor, that is, the average reaction time of the interaction of sewage with microorganisms in the bio-reactor.

IV. **SRT** - Sludge residence time refers to the average residence time of microorganisms in the reaction system from its generation to the discharge system, that is, the time required for all microorganisms to be updated once in the reaction system

V. **Flux** - The flow of produced water through the membrane is usually expressed as the amount of water produced per unit of membrane area per unit time (L/m2·h).

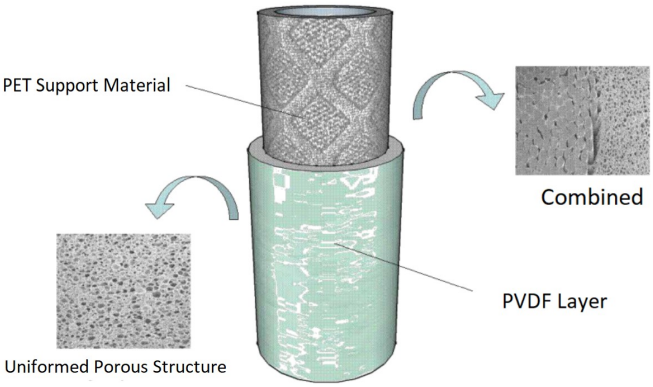
VI. **TMP** - Trans Membrane Pressure difference refers the difference between the average pressure of the water production side and the water inlet side, that is, the average pressure difference between the two sides of the membrane.

VII. **Fouling** - Fouling refers to the large-scale solutes such as microparticles, colloidal particles, organic matter, and microorganisms in the water being treated that cause physical, chemical, or mechanical effects on the membrane and cause adsorption and precipitation on the membrane surface or membrane pores to make the membrane pores smaller or clogged. A phenomenon in which the water permeability or separation ability of a membrane decreases.

2. Morui MBR Material Introduction

2.1 Fiber Introduction

Morui hollow fiber MBR membrane is the made of Reinforced PVDF. After years of research and development, we successfully developed this high performance hydrophilic PVDF product. This fiber is produced in terms of Thermally Induced Phase Separation(TIPS). With the PET inner-support material, it has a higher intensity (the tensile strength is ≥ 20.0MPa), stronger anti-peeling condition (peeling strength ≥ 1.0MPa), higher porosity (≥60%) and larger flux (≥200L/m2·h-0.01MPa).



2.2 Fiber Feature

I. **Higher flux and higher production water quality** - this high performance hydrophilic PVDF product can ensure a larger flux, and the water turbidity is <0.3NTU.

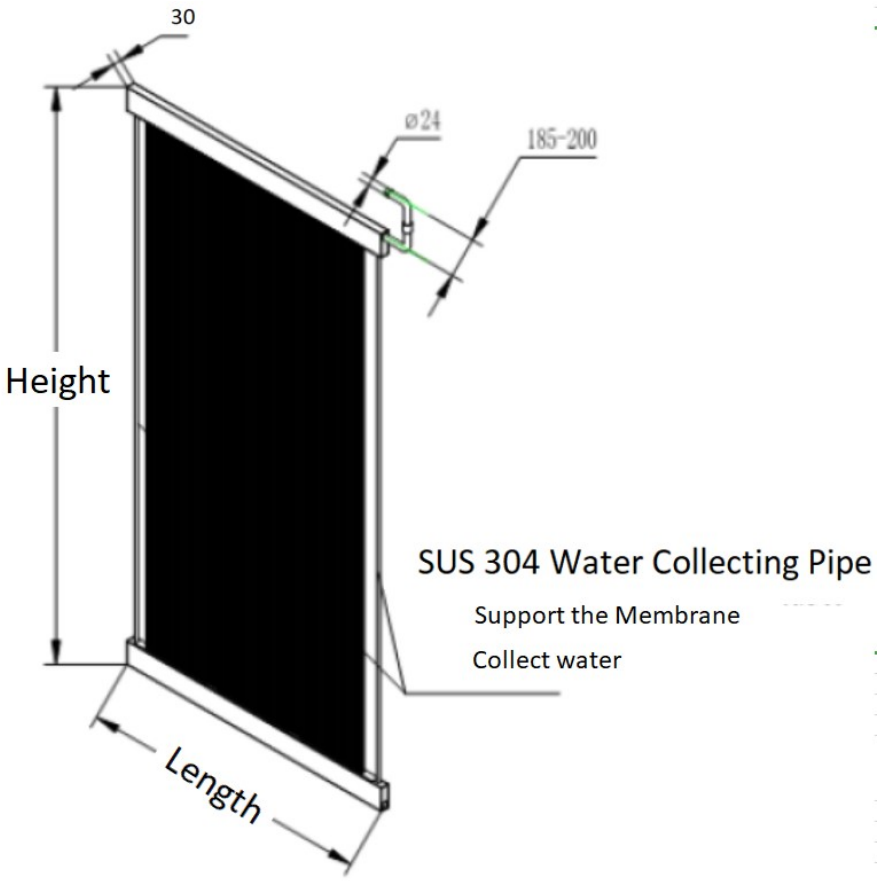
II. The peeling strength is higher, with good hydrophile, more resistant to pollution, and supports instantaneous high pressure back washing.

3. Morui MBR Introduction

3.1 MBR Unit Parameters

Applications- municipal sewage treatment, integrated sewage treatment equipment, industrial waste water deeply treatment and reuse, the pre-treatment of seawater desalination or brackish water desalination, printing and dyeing wastewater and even treat the wastewater from rubbish landfill.

The size of MBR element is followed.



Model	MR-313	MR-227	MR-193	MR113	MR097	MR057
Effective membrane area	31.3	227	193	113	097	057
Fiber Material	RPVDF	RPVDF	RPVDF	RPVDF	RPVDF	RPVDF
OD/ID of fiber (mm)	2.5/1.4	2.5/1.4	2.5/1.4	2.5/1.4	2.5/1.4	2.5/1.4
Pore size(um)	0.2	0.2	0.2	0.2	0.2	0.2
Height(mm)	2000	1500	1300	1500	1300	1125
Length(mm)	1250	1250	1250	680	680	480
Width(mm)	30	30	30	30	30	30
Connect Pipe D(mm)	24	24	24	24	24	24
Connect Pipe E(mm)	180~200	180~200	180~200	180~200	180~200	180~200
SUS 304 material water collecting pipes at both side of the unit						

3.2 MBR Module Parameters

The module is made up of membrane frame (normal SUS304 material, but in special situation,using 316L), collecting pipe(material:ABS).

An example of the MBR module - The module is assemble of 32 pcs membrane element, the effective area of module is 1000m2 (31.3m2/pc x 32pc). The chart is followed.

The specification of the standard MBR

Quantity of membrane element(PC)	32 PC MR313
The effective membrane area(m2)	1000
Size of membrane element(mm)	1600×1500×2700
Weight (Dry)	605 kg
Weight (Wet)	908 kg

For sure, we could put up the different pieces element into the frame like the photo shows below.

The MBR Module

3.3 MBR Module Features

I. The structure is not only simple and compact, reduces leakage points, improves sealing, but also makes the design more flexible and easier to install and remove.

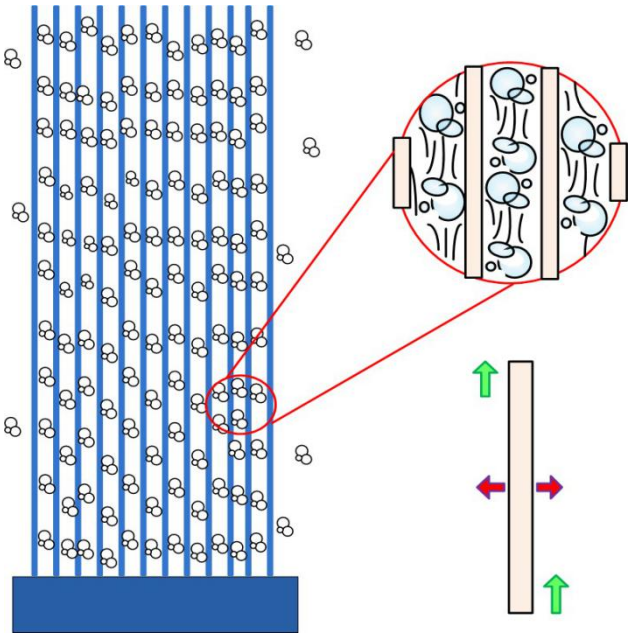
II. More resistant to pollution and low operating costs - the structure of the membrane unit is more reasonable and compact, the space between the membrane elements is exactly the same. The aeration method with pulsing agitation continuous is used to not only effectively increase the vibration of the membrane fibers, but also more uniform and effective, in operation, reducing the scrubbing gas volume, reducing the energy consumption of the system, ensuring the elimination of dead corners. Single-point intermittent aeration further reduces system energy consumption.

III. Small amount of residual sludge and high degree of automation-the built-in sludge return is built in the membrane tank, and the sludge reduction is obvious, reducing the sludge treatment cost by 50%.

IV. There are various types of back washing of the membrane module. Due to the high peeling strength of the membrane fiber, it supports instantaneous single-point high-pressure back washing.

V. The whole system has a high degree of automation and control, and the running backwash cycle is continuously performed.

VI. In addition, the membrane module can adjust the length of the membrane fiber, according to the actual needs of the user. The user can also design the MBR membrane module into a single-layer structure or a double-layer structure. Also, users can design single or double rows, flexible combination, and multiple membrane frames can form a large module to meet the needs of large projects, which is convenient for overall installation, operation and maintenance.



4. Morui MBR installation

4.1 Preparation

I. Before installation, the MBR tank shall be cleaned and the garbage (concrete block, chip particles, fragments, etc) shall not be left in the tank, to avoid fiber damaged in further operation.

II. According to the actual situation on site, confirm the transport and the route to the tank for membrane installation, and make a record. Mechanical equipment (e.g. forklift, crane, trailer, etc.) may required for larger size MBR assembly.

4.2 Installation

Make sure the MBR is in a wet condition when take out from the sealing package.

When carrying the membrane, it should be prevented from being pulled and squeezed.

After the membrane assembly, ensuring the interface of the device is tested for leak detection, through the pressure test.

After confirming that there is no leakage, the membrane module is immersed in the membrane tank, connecting the water pipe and the aeration pipe with the system pipeline.

4.3 Uninstallation

Disconnect the water collecting pipe and the aeration pipe from the MBR frame, then lift the MBR frame out of the tank and rinse the sludge attached on the surface with clean water.

After rinsing, hang the membrane module to a stable flat ground, uninstall the connecting accessories and take out the MBR unit from the frame and storage temporarily in the clean water.

4.4 Setup In The Tank

The membrane module should be kept at an appropriate distance from the wall in the tank. Below the membrane, it is also necessary to arrange an aeration pipe to ensure the required aeration & cleaning. The following distance requirements for the installation is important.

- The recommend spacing between unit to unit is ≥ 40 mm.
- To ensure the MBR can achieve full potential during operation, the length of the fiber is actual 15-30 mm longer than the size of MBR unit.
- The distance from the membrane frame to the side wall spacing ≥500 mm.
- The distance from the top of the membrane to the surface of water is ≥ 500 mm.
- The distance from the bottom of the membrane unit to the bottom of the tank is ≥300 mm.
- The distance of the frame to frame is ≥300 mm.

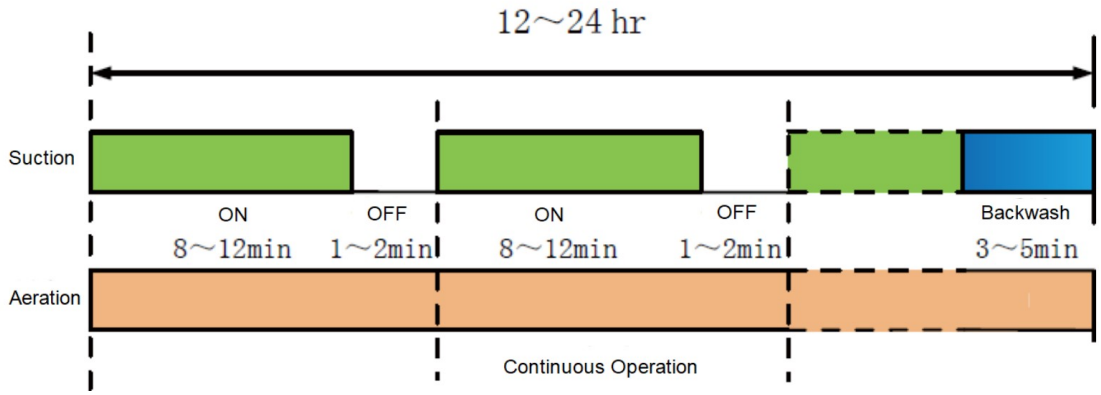
5. Operating And The Conditions

5.1 Operating Schedule

During the operation of the MBR system, the aeration continues when the suction is suspended. The aeration in this duration can clean the surface of MBR effectively.

The recommend intermittent operation setting is: 8 mins on, 2 mins off, as shown at below.

Standard operating time chart



5.2 Operating conditions

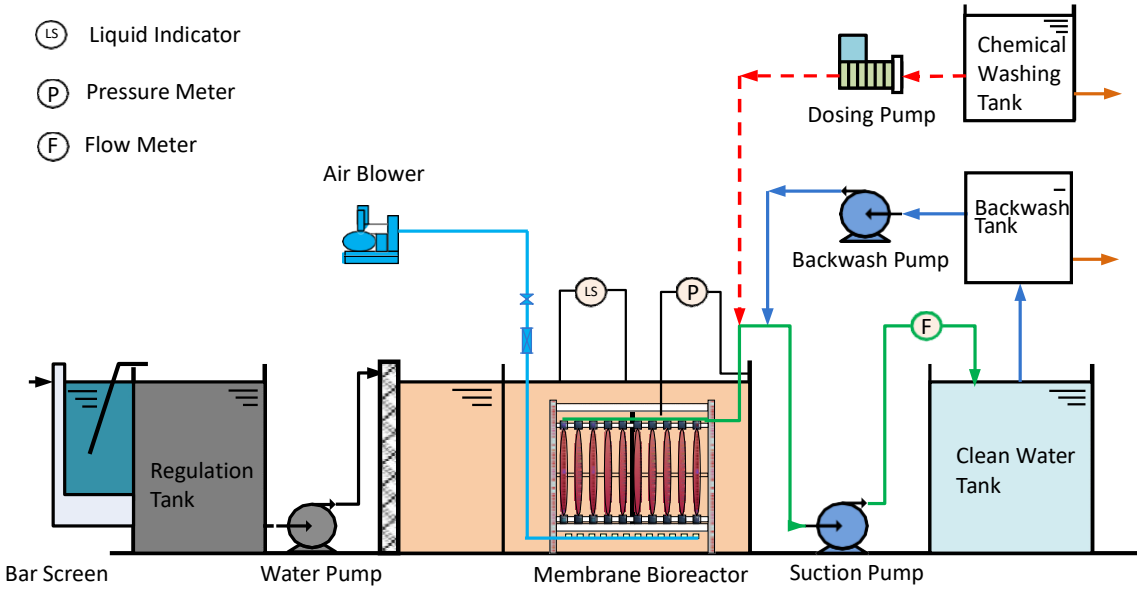
Standard Operating conditions

Operating conditions	Temp（℃）	10-45
	pH	2-12
	MLSS(g/L)	4-12
	Operating pressure(MPa)	-0.01 to -0.03
	Max. TMP(MPa)	0.05
	Design Flux(L/m2*H)	10-30
	Backwash pressure	≧0.1
	Aeration Quantity of module（Nm3/m2·h）	60-120
	Aeration Quantity	Keep 2-3mg/L of DO, at the end of tank

Typical effluent quality of MBR treatment of domestic waste water

BOD	<2 mg/L	TSS	<1mg/L
TN(High Temp)	<3 mg/L	TP	<0.1 mg/L
TN(Low temp)	<10 mg/L	NTU	<0.3 NTU

5.3 Operation Flow Chart



Basic operation flow chart

Equipment:

I. Bar Screen

To prevent large particles and impurities from blocking the membrane module, a fine grid should be set at the front of the MBR (membrane bio-reactor), and the gap between the grids is preferably 1 to 2 mm.

II. Flow control device

A flow control inspection device is installed in the water production pipeline of the membrane device to control and inspect the water production flow. Where multiple sets of membrane module are operating, each module should be equipped with a flow control inspection device.

III. Negative pressure gauge / differential pressure meter

Considering the system running for a long time, detecting the blockage of the membrane, the suction pump inlet is setting to a negative pressure meter to detect the negative pressure of the pump. While recording the negative pressure and the flow rate of the outlet, through the flow meter, monitoring the operation of the membrane module.

In the water production pipe and the membrane bio-reactor module, a differential pressure meter is setting to measure the pressure difference between the membranes. Differential pressure gauges are setting for each module when multiple sets of membrane devices are operating.

IV. Aeration part

According to the conditions of the membrane module, calculating and design the shaking and aeration device of the membrane module to control the aeration volume.

V. Suction pump

According to the design flux, calculating the amount of water pumped by the membrane module, and selecting a suction pump with Head.

VI. Level gauge

According to the operation design considerations, control the high-level start and low-level stop of the membrane tank, ensure that the low-level automatic shutdown alarm of the membrane tank, and the high-level automatic start. The low level must be higher than the membrane module.

VII. Cleaning system

In order to prevent the membrane module from pollution, it is necessary to set up regular back washing and chemical cleaning devices, and design a targeted cleaning scheme to delay membrane pollution and maintain membrane product water quality.

6. Morui MBR Maintenance

6.1 The Requirements for Source Water

The inlet water of Membrane bio-reactor must be treated by the front-end biochemical treatment system, being activated by sludge inoculation / breeding and debugging. After the end water quality has reached the biochemical treatment effect, it is suitable to start entering the membrane bio-reactor for mud-water separation. If the source water is directly separated by the membranes may cause membrane clogging earlier.

In order to maintain the good processing capacity of the membrane bio-reactor, it is necessary to ensure that the processing conditions such as MLSS concentration, viscosity, DO (dissolved oxygen), and pH in the membrane bio-reactor are in a proper range.

If the source water contains many inclusions or coarse SS (suspended matter), and if the specific gravity of the oil component is large, appropriate pre-treatment is needed.

● Oil content — Oil content will cause the surface of the membrane to become clogged. Generally, animal and vegetable oils should be controlled below 50mg /L, and mineral oils should be controlled below 3 mg /L. When the water content exceeds the standard, corresponding treatment equipment should be considered.

●When the membrane bio-reactor is operated in aeration, if a large amount of bubble is generated, the design should consider spraying and defoaming with a defoamer. Please use a high-grade ethanol-based

defoamer. Silicon-based defoamers can easily cause membrane fiber clogging.

●If the BOD load is operated under a high load condition, the fiber will easily cause clogging. Please adjust to a suitable load. The BOD sludge load is 0.05 ～ 0.15 (kg-BOD / kg activated sludge · d) (the standard value is 0.07)

6.2 Operation Management

The operating performance of the membrane tank changes with the quality of the source water and the set operating conditions. In order to maintain stable operation of the membrane tank, it is recommended that the user manage and record various operating data to ensure that the user monitors the changes and characteristics of the operating performance of the membrane tank.

A. The aeration volume of biochemical system

B. The Aeration status and the amount of the membrane

C. Water temperature

D. The pH of MBR Tank

E. DO (dissolved oxygen concentration)

F. Flow rate

G. Trans membrane pressure difference (TMP) during operation

H. Production water quality (BOD, COD, turbidity, etc.)

I. Source water quality (BOD, COD, suspended matter, etc.)

J. The amount of excess sludge discharge

K. Sludge concentration

L. Sludge sedimentation performance (SV30)

M. Sludge viscosity

6.3 Description of the operational monitoring

(1) Transmembrane pressure difference (TMP)

Check the stability of TMP.

The sudden rise of the TMP indicates the occurrence of membrane clogging, which may be caused by abnormal aeration or excessive sludge concentration. It is necessary to investigate the cause in time and take corresponding measures.

(2) Aeration status

Check regularly, to see if the aeration volume of the membrane module is in the required range and whether it is uniformly aerated. When the aeration air volume is abnormal or the aeration is nonuniform, necessary measures need to be taken.

When the aeration is insufficient or the aeration is stopped, the suction operation must not be performed, otherwise the membrane surface will be blocked.

For example, check the installation, check the blower or adjust the aeration.

When the aeration is insufficient or the aeration is stopped, the suction operation must be stopped, otherwise the membrane surface will be clogged.

(3) The flow of the production water

Record the daily production water amount and flow rate changes. The backwash frequency and cleaning scheme of the MBR can be adjusted according to the flow rate decay and the water production rate change.

(4) Sludge concentration

The MLSS of membrane bio-reactor is around 4-15g/L.

Appropriate MLSS concentration can ensure the quality of the effluent water that meets the design requirements.

When the MLSS is too low, the measures such as putting in sludge or stopping sludge return or discharge can be adopted.

when the MLSS is too high, measures such as increasing sludge return or discharge can be taken.

(5) Sludge viscosity

Normal sludge should be below 100 mPa · s. If this condition is not met, the performance may not be achieved, so please adjust to the normal viscosity range. When it is too high, you can take measures such as renewing sludge, increasing sludge return or discharge.

(6) DO (dissolved oxygen concentration)

The normal DO at the end of the membrane bioreactor is 2mg/L ～ 3mg/L. When this condition is not met, measures like adjusting the aeration amount can be taken.

(7) PH

The PH in the membrane bioreactor is 6-8. When this condition is not met, the pH of source water can be adjusted by adding Acid or Alkali.

(8) Water temperature

The normal water temperature is 15-35 ° C. Where this condition is not met, necessary measures such as cooling and thermal insulation can be taken.

(9) Water level

Check the water level of the membrane bio-reactor to ensure that the minimum water level can submerge the membrane module. When an abnormality occurs, please check the followings in time:

A. Check whether the liquid level meter is normal.

B. Whether the membrane water outlet pipe is flowing or leaking.

6.4 Cleaning

6.4.1 Backwash

Reinforced hollow fiber membranes are made of polymer materials and use outside-in pressure filtration. During filtration, the membrane filaments are compressed by pressure from the outside to the inside, and the pore size on the outer surface of the membrane are correspondingly compressed, and the precision of the filtration is becoming higher. When backwashing, the fibers are forced to expand outwards. The pore size on the outer surface of the fibers are expanded, so that the impurities that may enter the membrane pores are washed more thoroughly.

During backwash, use membrane-produced water or higher quality water as the backwash water, and the backwash pressure is controlled at 50 - 100 kPa. Backwash flow: 1 to 2 times the amount of produced

water, backwash time: 1 - 5min, adjust the backwash process per 1-12h according to the quality of product water.

6.4.2 Maintenance chemical cleaning (online chemical cleaning)

When the surface of the membrane is adsorbed by colloidal or dissolved microbial metabolites, the TMP is rising, and it couldn't removed by washing/air blowing.

It is required the maintenance chemical cleaning.

- Type of drug: NaClO, effective chlorine concentration 100~500ppm, 0.1 - 0.2% HCl, citric acid, oxalic acid.
- Maintenance chemical cleaning time: 5 ~ 10 min.
- Cleaning frequency: TMP increases by more than 30 kPa or per 1 to 12 weeks after operating.

Record the actual operation, when the TMP at the initial stabilization is increased by 30 kPa. The duration can be set to one cycle. Regularizing the cleaning can effectively extend the life-span of the membrane.

6.4.3 Restorative chemical cleaning(offline chemical cleaning)

When the membrane is operated for a long time, it produces an irreversible and strong pollution layer. When blowing, backwash or maintenance online cleaning methods have no significant effect. And the TMP couldn't be reduced. The membrane needs restorative chemical cleaning. Submerge the membrane in the relevant chemical. With a longer chemical cleaning, the membrane can get a better cleaning effect. Use restorative chemical cleaning to achieve recovery membrane flux.

- Before offline chemical cleaning, the membrane module is stopped operation, and the cleaning process could be carried out in a separated membrane tank. Another option is lifting out the membrane module into a medical tank.

● Offline chemical cleaning is considered only when the online cleaning operation couldn't restore the TMP. It may be considered per 3 months to a year or more.

● After the restorative chemical cleaning, rinse it with water before it can be used.

●After offline chemical cleaning, rinse thoroughly with water before putting it into use. When cleaning with multiple medicals, it is necessary to rinse with clean water before switch the medicines.

The chemicals used in restorative chemical cleaning are shown in below chart

Main pollutant	Detergent	Use Conditions	Cleaning time
Metal oxide, calcium-containing scale	Citric acid 0.5%.	pH=2	4～8h
	Hydrochloric acid 0.2%		
Fatty acids, proteins, polysaccharides	Alkali (0.5mol/L NaOH) and oxidizing agent 200 mg/L	pH=10	4～8h
Bacteria, biomacromolecule	Alkali （0.1mol/L-0.5mol/L，NaOH and oxidizing agent 200mg/L	pH=10	4～8h
	Enzyme preparation, surfactant （0.1%-2%）		
	NaCLO 1000-2000mg/L, Alkali 1%-3%		

7. Common problems and solutions

According to the summary of long-term MBR operation, the failure is generally: aeration abnormality, the TMP rising / the flux reduced, the NTU rising.

The common problems and solutions are shown in below chart

Failure	Problems	Solutions
Aeration Abnormal	Blower failure	Check blower
	Aeration pipe clogged	Cleaning and dredging the aeration pipe
The TMP rising / the flux reduced	The membrane is polluted and clogged	Chemical cleaning
	Abnormal aeration cause the flushing is not effective on the MBR	Improve aeration condition
	Outlet water quality changes	a. Prevent abnormal component influx (oil) b. Adjustment of BOD loading c. Adjustment of raw water
	Sludge concentration is too high	Adjust the amount of sludge discharge
NTU rising	MBR fiber or connecting pipe broken	Closing the water produced by the damaged membrane module unit valve, replace, repair damaged parts
	Water supply piping leaks	
	Bacteria growth on the outlet water pipe	Backwash with NaClO

8. Morui MBR transport and storage

8.1 Packaging and transportation

A. Morui MBR unit is packed individually, and covered with a polyethylene film bag. Put in a thick cardboard/wooden box with anti-shock and stable measures after sealing. Please avoid extra force to the package when handling.

B. During the transportation, it should be laid flat on the transport carrier, and the maximum number of floors in allowable stacking is 8 layers. At the same time, it is necessary to consider sheltering from sun, rain and frost, and the transportation environment temperature should be higher than 0 ° C.

C. Each MBR unit is coated with storage protection solutions.

8.2 Installation & Storage

A. When installing Morui MBR, please note that the membrane should not be used as a support material. And do not hit with heavy or hard objects. Please avoid installation under the exposure of the sun.

B. If the membrane is stocking temporarily, please coat with the protective liquid before sealing and stack under a good environment - flat & clean area with no corrosion & pollutants. Please keep away from cold and hot area. Storage temperature is controlled between 5 and 40 °C.

C. The protection liquid is a 1% aqueous solution of NaSO4.

The pH value of the protection liquid should be tested every other month. When its pH is ≤3, the protection liquid should be replaced in time

D. The maintenance during shut-down period

If the membrane is not scheduled to work for a short period of time (2 or 3 days), the advised operation time during this period is 30 to 60 minutes per day, to prevent bacterial growth and pollution.
If the membrane is not scheduled to work for a long period of time (more than 7 days), the advised action is to aerate 30 to 60 minutes per day, to prevent sludge adsorbing on the surface of the membrane

8.3 Services:

I. Overall design and technical consultation of MBR project.

II. MBR processing equipment manufacturing.

III. Engineering construction, equipment installation and after-sales service.