COMMUNITY WASTEWATER TREATMENT SYSTEM

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FACULTATIVE MEMBRANE BIOREACTOR SYSTEM

In collaboration with JDL Environmental Protection Company, NextGen Septic is marketing the Facultative Membrane Bioreactor (FMBR) system for communities with wastewater flowrates greater than 1,000 gallons per day up to 100,000 gallons per day. The facultative membrane bioreactor (FMBR) is a low-energy membrane biological wastewater treatment process that removes carbon, nitrogen, and phosphorus in a single reactor under a low DO facultative environment. It encourages natural microbial competition, maximizes the activity of the mixed biomass consortium, saves energy, and meets nutrient discharge limits with simple controls.

The key to the core technology of the FMBR is that it can operate under a low DO condition to accomplish biological treatment while preventing the membrane from biofouling. Under a facultative environment, FMBR has a low sludge yield rate, just like most anaerobic systems. Still, it is not sensitive to the impact of its toxicity and pH change treatment performance. It replaces the complex reactors in a series of traditional BNR processes with a single reactor. FMBR is a pre-designed compact engineering system. It can be installed on-site without a dewatering system and the investment in a long sewer pipeline.

The first FMBR full-scale demonstration project in North America was at the Plymouth Municipal Airport (PMA). The existing PMA plant was an SBR system with an average flow of 5,000 gpd with a solid raw influent and high O&G. The average Influent COD, BOD, TSS, NH3-N, were 570, 376, 109, and 53 mg/l, respectively. The influent organic load was unstable. It fluctuated 2-3 times higher than average influent strength in BOD, NH_3-N, and O&G. Therefore, the plant was often upset, and sludge was washed out several times yearly in 2019. Since the SBR aeration device was rated at 25 HP (33.5KW) with an aerator, mixer, and decanter in one unit, it could not shut down the aeration during anoxic fill. Therefore, the energy consumption was high. The SBR system could not maintain the necessary biomass and DO control to accomplish nitrification/denitrification effectively and had difficulty facing unstable influent shock load.

An FMBR full-scale 5000 gpd pilot demonstration project was installed and has been running at the Plymouth Municipal Airport plant since November 2019. It has converted the full SBR flow to the FMBR system since inception and is now in the process of approval by the Massachusetts Department of Environmental Protection. The installed aeration device is a 2.2 KW diaphragm air compressor. The system started with seeded sludge from other FMBR systems that had acclimated to a low DO condition. The energy consumption was measured at about 44 kwh/d vs. the SBR consumption of 367 kwh/d. The overall energy and cost savings are about 77 % and 73%, respectively, compared to the existing SBR plant. Effluent BOD and TSS are under detectable limits (Table 1). TN is between 3-6 mg/l without adding external carbon.

Effluent TP is less than 1.0 mg/l even though the plant permit doesn't require phosphorus removal. In addition, it also saves 90% on chemical costs and 50% on sludge disposal costs compared to that of SBR's 25,000 gal/year (refer to Figure 1)

The FMBR system is robust. The high MLSS concentration (12,00020,000 ppm) and a consortium of diverse nitrifiers and novel facultative ammonia-oxidizing organisms make the FMBR system more robust to loading changes. It can recover from upset quickly. The longer the system runs, the better the microorganisms acclimate to the facultative environment. The result shows that the FMBR system can tolerate influent organic shock loads much better than the SBR system.

FMBR started on November 22, 2019, with an 60^{o}F cold temperature and the worst condition of high influent of BOD 470 mg/l, NH_3-N 68.6 mg/l, and O&G of 158 mg/l, respectively. However, one week after start-up, TN reduced to < 5 mg/l and stayed at that level for the rest of the startup period (refer to Tables 2, 3, and 4 and Figures 2, 4, and 5). Although FMBR has been impacted by decayed sludge with high NH_3-N settling in the SBR tank, the system can recover quickly in 2-3 days. The effluent TN is always under ten mg/l at shock load impact. After the FMBR equipment arrived at the PMA site, it only took 1.5 months to complete the installation and startup operation. It was 4.5 months ahead of the project schedule. FMBR can quickly be brought online to deal with an emergency, especially when a plant upgrade expansion is under construction.

Principle of FMBR

Cell decay is the principal mechanism of sludge reduction and the elimination of external carbon addition. Due to the high biomass concentration, long SRT, and low DO conditions, the diverse nitrifiers, novel ammonia-oxidizing organisms (including AOA, anammox), PAOs, and denitrifying PAOs can coexist in the same facultative environment and compete with each other to form a microbial food web and remove C, N and P simultaneously. The FMBR system is robust. The high MLSS concentration (12,000~20,000 ppm) and a consortium of diverse nitrifiers and novel facultative ammonia-oxidizing organisms make the FMBR system more robust to loading changes. It can recover from upset quickly. The longer the system runs, the better the microorganisms acclimate to the facultative environment.

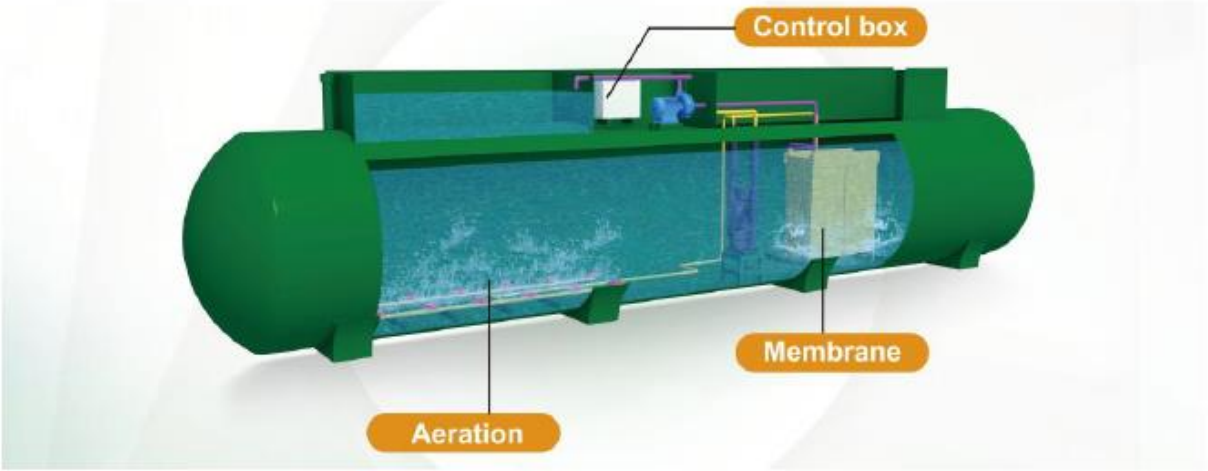
Footprint and Power Consumption

Model Number	Flowrate (GPD)	Inlet/Outlet Pipe Size (inches)	Container Size (ft)	Power Consumption (kW/h)	Power Capacity (kW/h)
FMBR-2K	2000	1.25	20 ft x 6.6 ft	0.9	1.6
FMBR-5K	5000	1.25	20 ft x 8.2 ft	1.2	2.0
FMBR-10K	10,000	1.50	38 ft x 8.2 ft	2.0	3.0
FMBR-20K	20,000	2.5	50 ft x 11.5 ft	4.0	6.0

Applications

FMBR has been installed in over 3000 projects in 19 countries for various client applications except the US. FMBR has won the IWA project innovation award in 2014 and recently won the 2018 R&D 100 Award as a special recognition corporation. It has been highly praised by URS, the authority on international standards, as having “the potential to be the ground-breaking & leading technology in the 21st century's wastewater treatment industry”.

FMBR applications include domestic sewage, industrial wastewater, and brewery wastewater. The longer the FMBR operates, the better performance it achieves because microbial activities have been cultivated and acclimated in a low DO environment. The most important feature is the simple process control. Most small plants can operate unattended, and a mobile service station can take care of a plant's routine maintenance.



FMBR system process sketch

Performance Data

Table 1. SBR operation summary 2017-2019

Date	Flow	Influent mg/l				Effluent mg/l								
	gpd	BOD	TSS	NH3-N	O&G	BOD	TSS	TKN	NH_3-N	NO_3	NO_2	TN	TP	O&G
2017	4735	420	950	75	86	16.4	20.0	3.5	0.12	5.3	0.13	8.9	5.7	1.3
2018	5225	317	229	51	37	8.9	13.7	3.3		1.7	0.1	5.0	8.1	0.8
2019	5931	350	239	72	72	11.3	14.1	4.1		0.4	ND	4.5	4.6	1.5

SBR upset more often (4 months) in 2019, Sludge was washed out. When effluent was pumped to pre-EQ tank, it caused raw influent high BOD & TSS at 2188 mg/l and 5190 mg/l respectively by certified Lab.

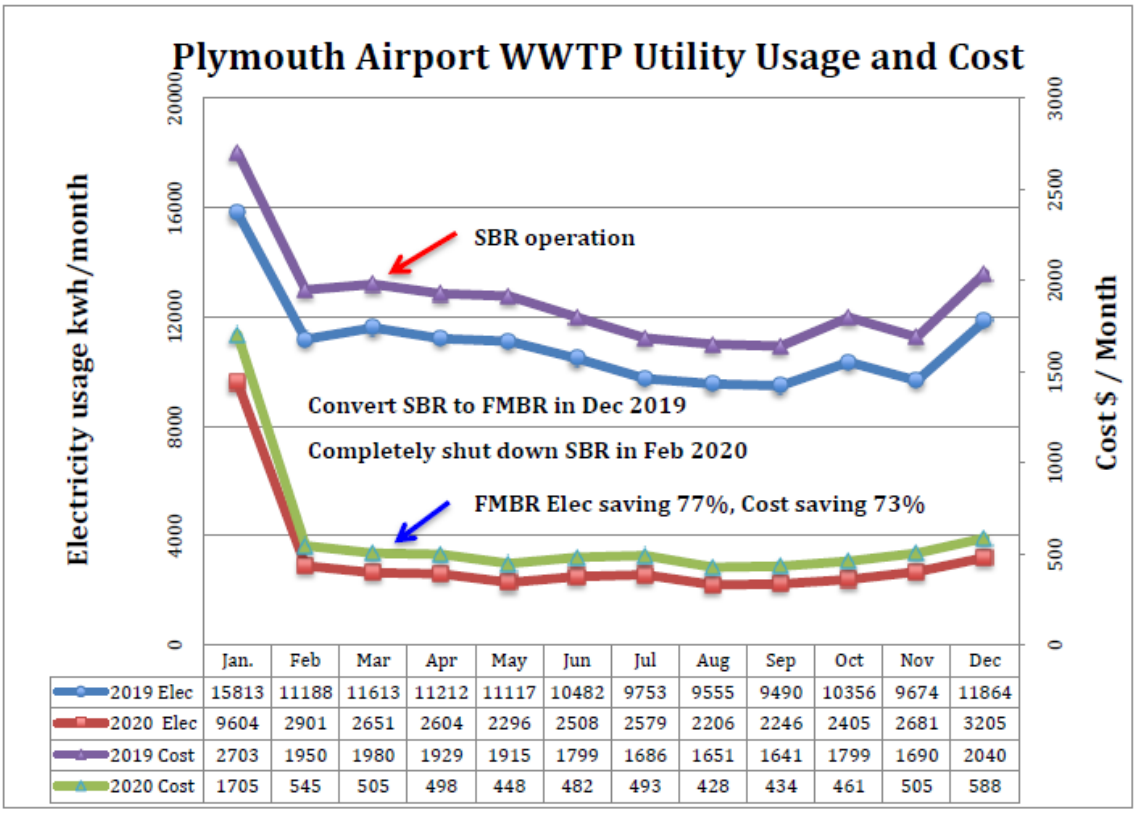


Figure 1 PMA wastewater treatment plant electricity usage and cost comparison

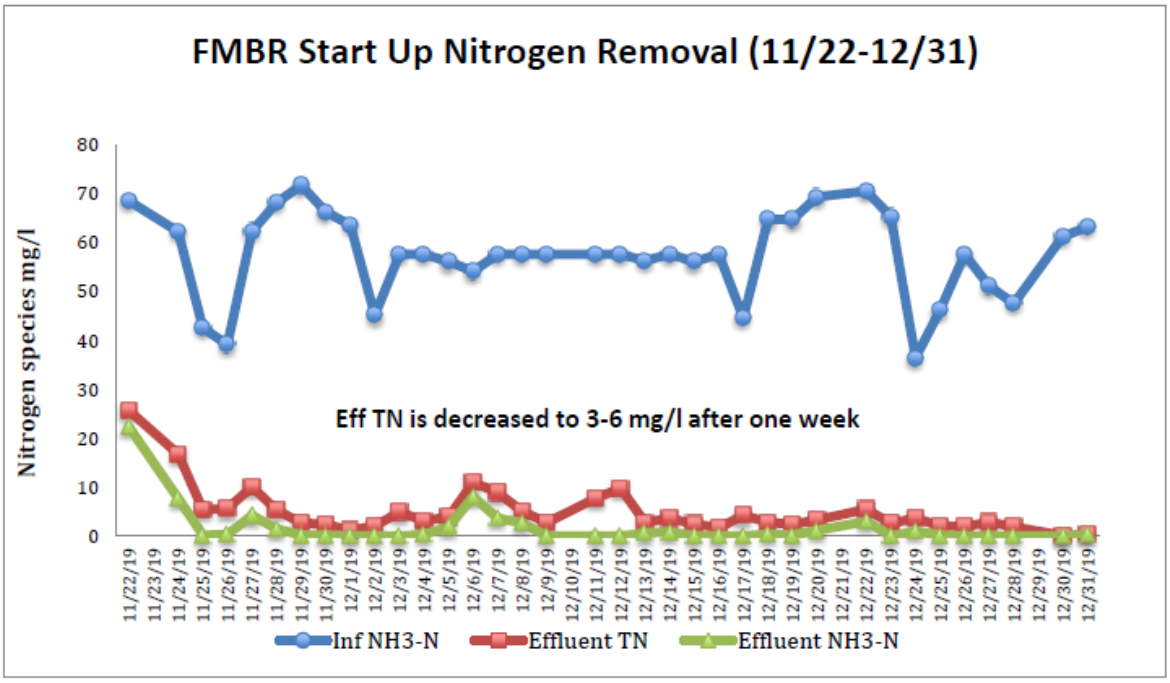


Figure 2. FMBR nitrogen removal during start up operation

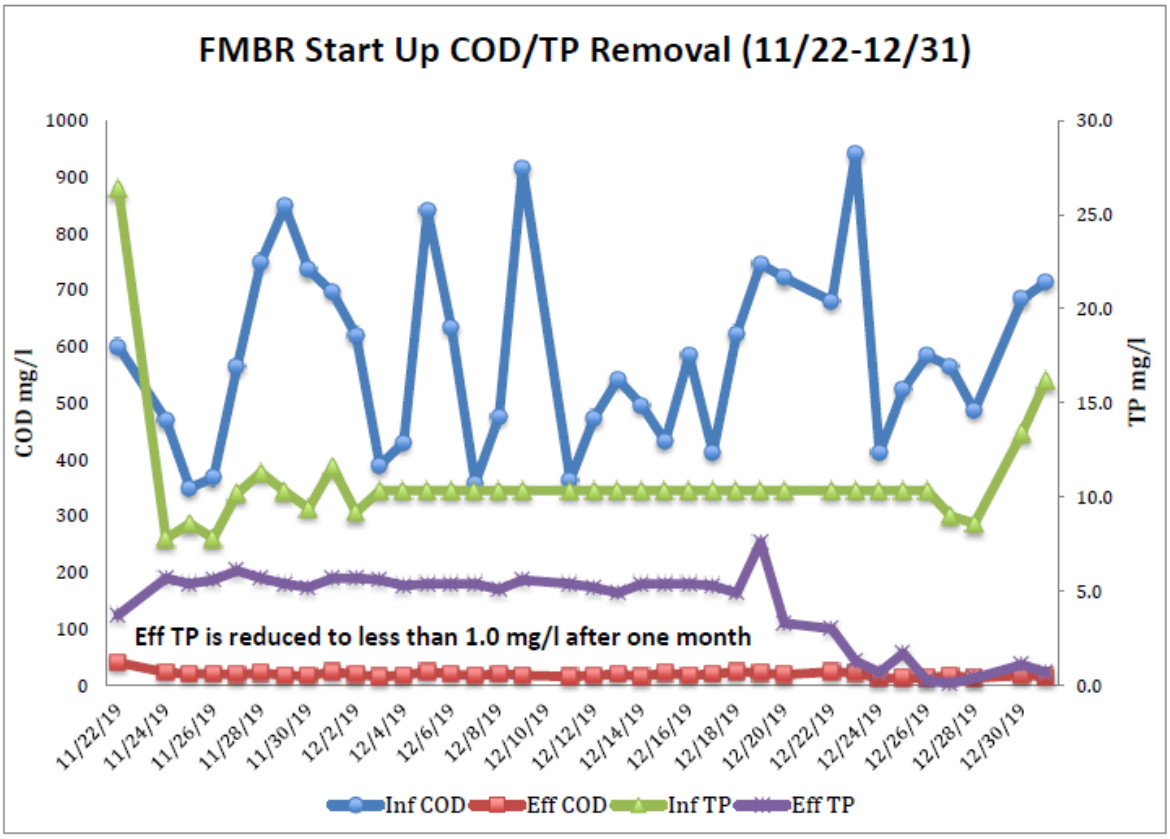
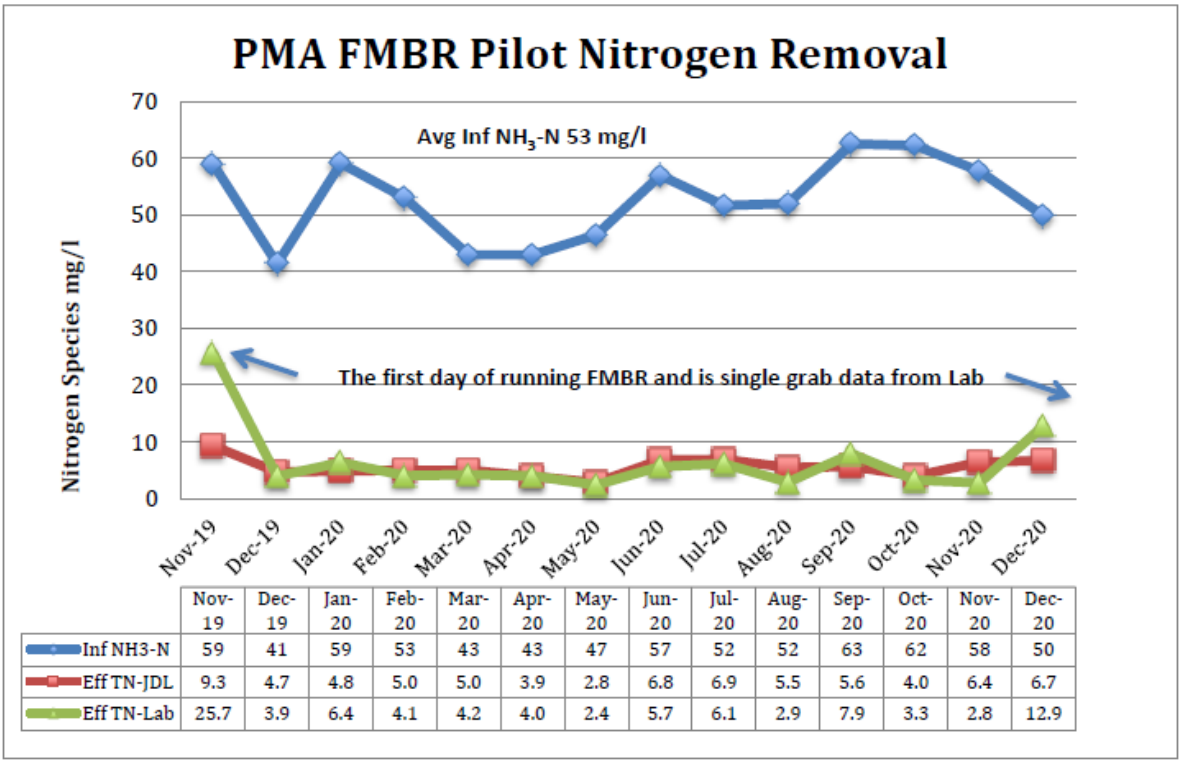
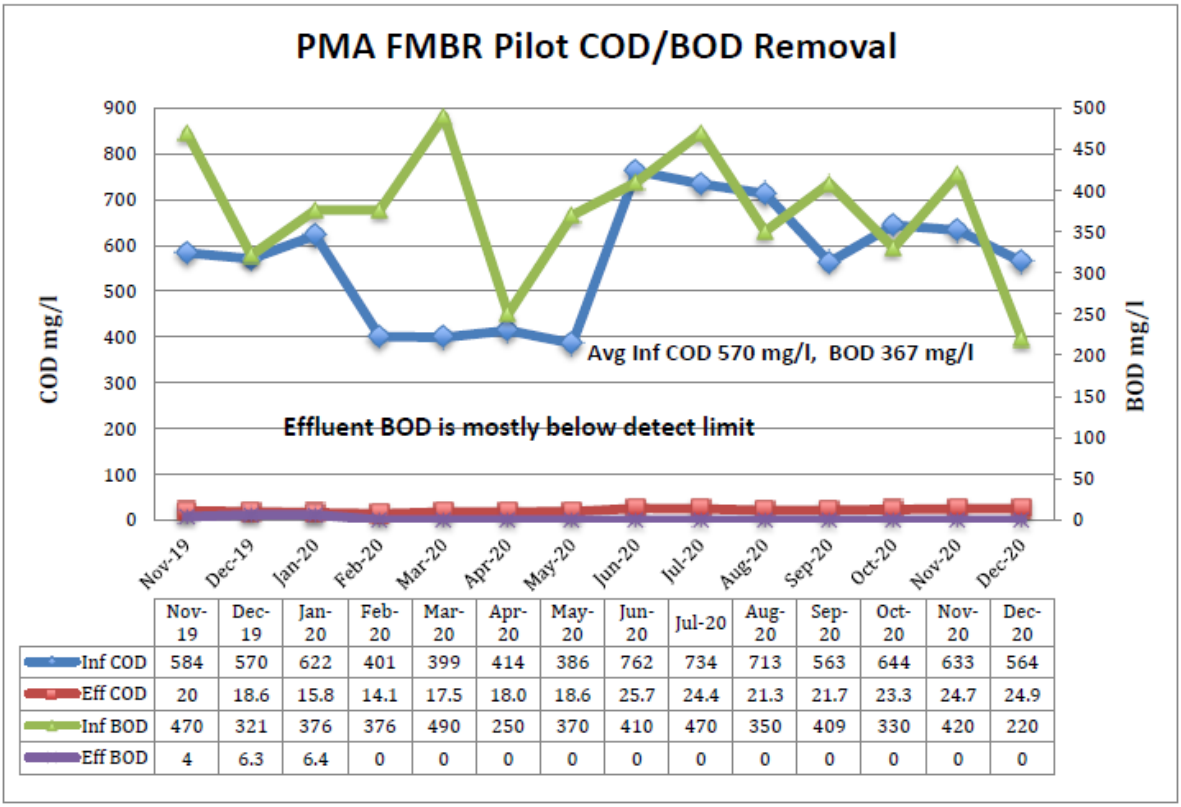


Figure 3. FMBR COD and phosphorus removal during start up operation



	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20
Inf NH3-N	59	41	59	53	43	43	47	57	52	52	63	62	58	50
Eff TN-JDL	9.3	4.7	4.8	5.0	5.0	3.9	2.8	6.8	6.9	5.5	5.6	4.0	6.4	6.7
Eff TN-Lab	25.7	3.9	6.4	4.1	4.2	4.0	2.4	5.7	6.1	2.9	7.9	3.3	2.8	12.9

Figure 4. Plymouth Airport FMBR pilot and lab nitrogen removal comparison



	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20
Inf COD	584	570	622	401	399	414	386	762	734	713	563	644	633	564
Eff COD	20	18.6	15.8	14.1	17.5	18.0	18.6	25.7	24.4	21.3	21.7	23.3	24.7	24.9
Inf BOD	470	321	376	376	490	250	370	410	470	350	409	330	420	220
Eff BOD	4	6.3	6.4	0	0	0	0	0	0	0	0	0	0	0

Figure 5. Plymouth Airport FMBR pilot and lab COD and BOD removal comparison

Table 2. PMA FMBR pilot start up data operation

Date	Flow	Influent mg/l				Effluent mg/l					
	gpd	COD	TN	NH3-N	TP	COD	NH3-N	NO3	NO2	TN	TP
2019.11.22	3657						18.8	1.2		20	3.4
2019.11.24	10962	470	67	62.3	7.8	23	7.7	6.9	2.2	16.8	5.7
2019.11.25	10962	350	47	42.6	8.6	20	0.2	4.0	1.2	5.4	5.4
2019.11.26	6695	367	45	39.2	7.8	21	0.3	4.2	1.1	5.6	5.6
2019.11.27	4267	564	69	62.4	10.2	19	4.2	4.7	1.2	10.1	6.1
2019.11.28	3379	750	72	68.2	11.3	22	1.5	2.7	1.1	5.3	5.7
2019.11.29	3379	848	78	71.8	10.3	18	0.2	1.7	0.8	2.7	5.4
2019.11.30	4287	736	70	66.4	9.4	17	0.2	1.5	0.7	2.4	5.2
2019.12.01	3858	696	68	63.6		24	0	0.8	0.4	1.2	5.7
2019.12.02	4090	620	52	45.2		19	0	1.7	0.4	2.1	5.7
2019.12.03	6929	390	55	46.3		16	0	3.6	1.3	4.9	5.6
2019.12.04	2796	430	63	58.3		18	0.3	2.1	0.7	3.1	5.3
2019.12.05	5263	840	67	56.2		24	1.9	1.4	0.6	3.9	5.4
2019.12.06	12044	634	65	54.2	8.9	20	8.1	2.0	0.9	11	5.4
2019.12.07	4356	358	66	51.4		17	3.7	3.8	1.4	8.9	5.4
2019.12.08	4356	476	69	62.3		21	2.7	1.7	0.7	5.1	5.1
2019.12.09	4356					18	0	3.9	0.4	4.3	5.6
2019.12.11	4587	364	56	44.6		16	0	6.88	0.9	7.78	5.4
2019.12.12	3809	473	61	46.7		18	0	9.4	0.4	9.8	5.2
2019.12.13	7684	542	66	56.4	8.6	20	0.6	1.6	0.6	2.8	4.9
2019.12.14	5627	496	64	54.3		16	0.9	2.0	0.7	3.6	5.4
2019.12.15	5627	432	63	56.2	8.6	22	0	2.1	0.4	2.5	5.4
2019.12.16	5627	477				18	0	2.2	0.3	2.5	5.4
2019.12.17	7947	412	53	44.6	8.6	20	0.0	4.2	0.1	4.31	5.3
2019.12.18	3564	623	73	64.8		24	0.4	2.3	0.1	2.8	4.9
2019.12.19	5103	746	84	64.8		22	0.2	2.1	0.1	2.4	
2019.12.20	5473	722	78	69.4	9.8	19	1.2	2.0	0.1	3.3	3.3
2019.12.22	6680	680	81	70.6		24	3.0	2.4	0.1	5.5	3.0
2019.12.23	6680	942	78	65.4		22	0	2.5	0.1	2.6	1.3
2019.12.24	5253	412	52	36.5		13	1	2.6	0.1	3.7	0.7
2019.12.25	7710	524	58	46.2		13	0.2	1.8	0.1	2.1	1.7
2019.12.26	7710					13	0	1.8	0.1	1.9	0.3
2019.12.27	7301	564	60	51.2	9	18	0	2.8	0.1	2.9	0.1
2019.12.28	3719	486	56	47.6	8.6	13	0	1.8	0.1	1.9	0.4
2019.12.30	3719	684	72	61.4	13.4	18	0.1	1.6	0.1	1.8	1.1
2019.12.31	6434	714	78	63.2	16.2	16	0.3	1.8	0.1	2.2	0.7

Table 3. FMBR pilot JDL data (Avg monthly)

Date	Avg Flow	Influent mg/l				Effluent mg/l						
	gpd	COD	TN	NH3-N	TP	COD	NH3-N	NO3	NO2	TN*	TP	DO
Dec-19	7525	570	65.5	55.3	10.3	18.6	0.86	2.6	0.4	4.7	0.78	
Jan-20	5597	622	67.3	56.6	11.4	15.8	1.04	3.0	0.1	5.1	0.2	
Feb-20	2391	401	55.3	51.4	5.2	14.1	0.11	4.1	0.0	5.0	0.4	
Mar-20	6545	399	53.2	42.7	6.5	17.5	0.60	3.6	0.0	5.0	0.2	
Apr-20	5018	414	52.3	42.5	10.4	18.0	0.52	2.6	0.0	3.9	0.27	
May-20	5464	386	61.1	46.5	10.2	18.6	0.56	1.4	0.0	2.8	0.28	
Jun-20	3548	762	70.1	56.7	15.7	25.7	2.03	4.0		6.8	0.6	0.5
Jul-20	4430	734	70	51.7	15.3	24.4	1.68	4.5		6.9	0.6	0.9
Aug-20	5155	713	70	52.0	18.2	21.3	0.80	3.8		5.5	1.8	0.6
Sep-20	5605	563	74.8	62.5	17.8	21.7	0.80	4.0		5.6	2.2	0.5
Oct-20	5862	644	63.2	62.2	18.1	23.3	1.01	2.5		4.0	2.8	0.8
Nov-20	4890	633	63.0	57.2	16.6	24.7	2.85	3.1	0.1	6.4	1.1	1.1
Dec-20	5564	564	54.7	49.9	16.3	24.9	3.28	3.4	0.1	6.7	0.10	0.8

TN* = data add 0.82 value without measure TKN

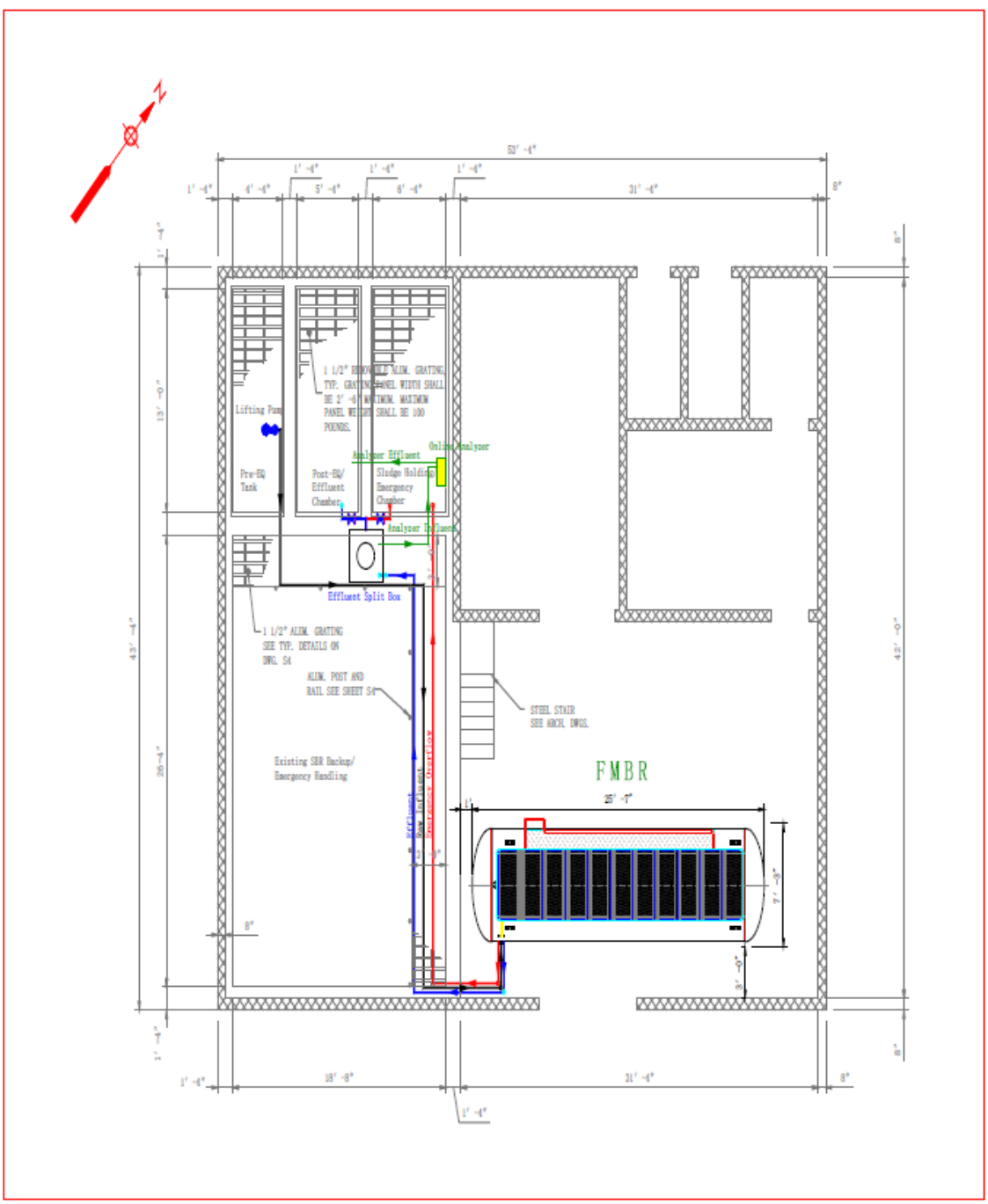
2/25/2020, 7/8 202 and 11/6/202 Membrane maintenance

Dec 2020 several power failure

Table 4. FMBR pilot Lab data (Avg monthly)

	Influent mg/l						Effluent mg/l									
	COD	BOD	TSS	NH3-N	TP	O&G	COD	BOD	TSS	TKN	NH3-N	NO_3	NO_2	TN	TP	O&G
Nov-19	600	470	190	68.6	26	158	40.3	4	<4.0	25.1	22.3	0	0.57	25.7	3.75	
Dec-19	489	321	79	27.6	9.5		18.7	6.3	<4.0	2.3	0.28	1.02	0.56	3.93	5.34	<1.2
Jan-20								6.4	<4.0	4.0	1.9	2.4	ND	6.4	0.1	
Feb-20											ND	4.05	ND	4.05		
Mar-20	876	490	90	48.4	11		36.5	<4.0	<4.0	4.21	2.04	ND	ND	4.21	4.29	
Apr-20		250	60	34.7		13.3		<4.0	<4.0	1.66	0.64	1.11	ND	3.98	0.66	<1.2
May-20		370	68	43.9				<4.0	<4.0	1.61		0.77	ND	2.38		1.2
Jun-20		410	51	60.3				<4.0	<4.0	1.54		4.03	0.09	5.66		4.6
Jul-20	995	470	80	58.1		40.1	92.6	<4.0	<4.0	1.28	0.32	4.45	ND	5.73	ND	1.6
Aug-20		350	124	50.2				<4.0	<4.0	1.99		0.88	ND	2.87		<1.2
Sep-20		392	111	62	11			<4.0	<4.0	2.77		5.14	ND	7.91	7.24	2.05
Oct-20		330	256	71				<4.0	<4.0	2.13		1.14	ND	3.27	0.87	<1.2
Nov-20		420	80	57.4				<4.0	<4.0	1.28		1.47	ND	2.75		<1.2
Dec-20		220	204	66.4				<4.0	<4.0	1.65		11.2	ND	12.9		<1.2

Yellow is for lab single grab data during power failure period


Lifting Pump
Pre-EQ Tank
Post-EQ/ Effluent Chamber
Sludge Holding/ Emergency Chamber
Online Analyzer
Effluent Split Box
STEEL STAIR SEE ARCH. DWGS.
Existing SBR Backup/ Emergency Handling
FMBR

The site installation of FMBR equipment

Installed FMBR pilot system and start up completion

FMBR Installation Guide

I. Preparation- Check the conditions of the project site

(1) If installing underground, check whether it has been backfilled and compacted;

Whether the regulating pool is built and construction waste is removed;

Has the trench for the installation pipe been dug?;

(2) Verify if the equipment area is connected to a three-phase circuit. The equipment operates on three-phase electricity, including neutral and ground wires. Install the wiring cabinet within 15 meters of the equipment's inlet pipe. The wiring cabinet must be equipped with a circuit breaker, and the meter should be selected based on the required capacity.;

(3) Determine whether the inflow can reach the site area or enter the regulating tank.;

2、Prepare the basic tools needed for installation.

Select the tools as needed to ensure the fastest and best completion of the on-site equipment installation. The required installation tools are listed in Table 1 below.:

Table 1

#	Name	Count	Pic	#	Name	Count	Pic
1	Impact Drill	1		11	Phillips screwdriver	1	
2	Grinder	1		12	flathead screwdriver	1	
3	adjustable wrench	2		13	wire stripper.	1	
4	chain pipe wrench	1		14	needle-nose pliers	1	
5	Saw	1		15	Paper Cutter	1	
6	Leveler	1		16	power strip	1	
7	Measuring Tape	1		17	voltage tester	1	
8	angle wrench (#22)	1		18	wire puller	1	
9	Y-shaped socket wrench	1		19	Lineman's pliers	1	
10	Towel	1		20	multimeter.	1	

2. Equipment Installation

I. Above Ground

1) The pipe installation should use the PVC positioning plate as a reference, first connecting the emergency pipe (No. 1), followed by the inlet pipe (No. 2), and then the outlet pipe (No. 3), with the lower end reaching the ground. The pipe installation must be horizontally and vertically aligned, ensuring no pipe crossings occur. After completing this, install the conduit (No. 4), as shown in Figure 1.

2) The conduit should be installed close to the outlet pipe and secured with zip ties.

4-3-2-1

Figure 1: Installation Sequence Diagram for Pipes

3) The flow meter and inlet valve should be installed 5 centimeters above and below the PVC positioning plate, respectively. (As shown in Figure 2.)

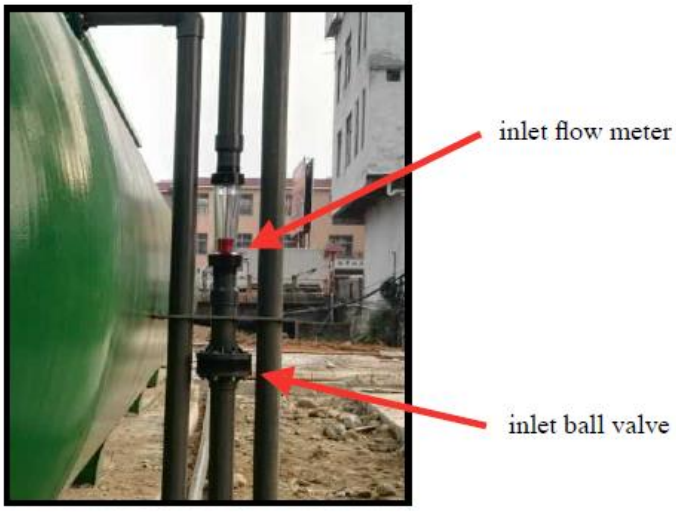


Figure 2: Installation Position Diagram for Flow Meter and Inlet Valve

4) On the concrete ground, a pipe clamp must be installed every 3 meters along the pipeline. For sections with an elbow, an additional pipe clamp should be secured 10 centimeters from the elbow.。

2、Underground

1) The emergency pipeline should be installed with a 10-centimeter gap from the tank. The emergency pipe, inlet pipe, and outlet pipe should each have a 10-centimeter gap between them. The conduit should be installed close to the outlet pipe and secured with zip ties. The pipes must be horizontally and vertically aligned, as shown in Figure 3.

Figure 3: Pipeline Installation Standards Diagram

2) The inlet ball valve for the equipment should be installed 5 centimeters from the outlet of the inlet PVC flange. The inlet PVC butterfly valve should be directly connected to the inlet iron flange of the equipment, as shown in Figure 4.

Figure 4: Inlet Valve Installation Standards Diagram

3) No inlet flow meter installation is required for all underground equipment.。

4) Appropriate measures must be taken (such as placing bricks or stones under the pipe elbows and compacting them) to prevent the pipes from sinking after backfilling.

5) In cold regions, proper insulation of the tank must be ensured. Pipes that are exposed or within the permafrost layer should be insulated using heating cables, insulation cotton, or other insulating materials, as shown in Figure 5.

spray insulation coating foam insulation

Figure 5: Application Methods for Insulation Coating and Insulation Cotton

3、Regulating Tank Section (Including Inlet Pump and Emergency Pipe)" would be the English translation for

(1) An union joint must be installed on the inlet pump pipeline, with a 5-centimeter horizontal distance between the union joint and the elbow for bonding.

(2) The extra power cables from the inlet pump and the float switch must be secured with zip ties and attached to the side clamp on the edge of the tank. The inlet pump chain should also be fixed to the side clamp on the edge of the tank in the same manner.

4、Circuit Section

(1) The main power cable, inlet pump power cable, and module signal cable must be routed through conduits and the appropriate corrugated tubing, ensuring no wires are exposed.

(2) When adding wiring to the electrical components inside the control cabinet, the wires must be routed through the cable duct and not laid out randomly, as shown in Figure 6.

(3) For above-ground system, the inlet pump control box should be fixed next to the vertical pipeline on the ground. For underground equipment, the inlet pump control box should be fixed next to the inlet pump inspection port of the regulating tank, as shown in Figure 7.

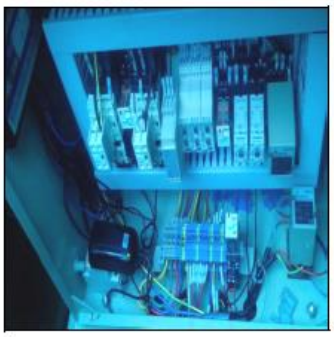
messy wiring   Organized wiring

Figure 6: Wiring Layout Comparison Diagram Inside the Control Cabinet

Figure 7: Installation Standards Diagram for Lift Pump Control

(4) Module Wire Installation:

First, route the wires properly. Inside the main control cabinet, connect the yellow wire to the GND terminal, the green wire to the D15 terminal, the red wire to the D12 terminal, the black wire to the X10 terminal, and the blue wire to the X13 terminal, as shown in Figure 8. The signal wires for the lift pump control box should be connected according to the color of the signal wires in the main control cabinet, matching them one by one, as shown in Figure 9.

Figure 8: Terminal Connection Diagram Inside the Main Control Cabinet

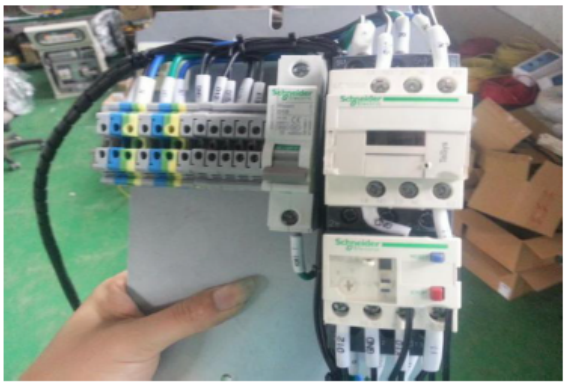


Figure 9: Signal Wire Connection Method for Lift Pump Control Box

5、Important Notes

1. **Pipeline Layout:** The overall layout and routing of the pipelines must be reasonable and aesthetically pleasing. Optimize the layout to minimize the use of pipe fittings. Photos of the key points of the pipeline layout must be taken and sent to the installation supervisor for approval before leaving the site.
2. **Gluing Pipes:** When applying glue during pipe installation, it should be evenly brushed. Use a cloth to wipe off any excess glue to prevent it from overflowing onto the pipe surface.
3. **Float Switch Installation:** If installing a float switch in the regulating tank, first apply glue to all sealing areas before placing it into the tank. Wait for the glue to dry before placing the float switch inside the tank.
4. **Power Cable Ends:** After stripping the outer insulation of the power cable, the exposed ends must be wrapped with electrical tape.
5. **Zip Tie Consistency:** Ensure that zip ties are oriented consistently, and trim the protruding ends to maintain a neat and tidy appearance.
6. **Site Clean-Up:** Before leaving the site, clean the area, the equipment room, and the exterior of the equipment. Hand over any excess pipes to the client for future maintenance and replacement.
7. **Documentation:** After all installation work is completed, take photos of the site installation (including pipeline layout, wiring layout, and overall photos) and send them to the area manager.
8. **Completion Confirmation:** After the installation is confirmed on-site by the client, sign the "Equipment Installation and Commissioning Completion Confirmation" form. Return the signed and stamped form to the company for archiving.

OPERATION AND MAINTENANCE MANUAL

Safety Guidelines

In order to use the FMBR correctly and safely, please be sure to follow the matters needing attention in this O&M Manual.

Please understand that we are not responsible for any damage caused by accidents due to non-compliance with the contents of this O&M Manual.

Warning **If you ignore this instruction and operate the FMBR incorrectly, it may cause personal injury or death.**
Do not operate this equipment without training or instruction
Do not touch the body of the pump or blower while it is in operation
Turn off the power during maintenance and repair
Do not step on the cover of the equipment
Please pay attention to the safety during chemical washing and maintenance of the membrane component, and it is strictly forbidden to mix and use different chemicals.

FMBR is a biological wastewater treatment process developed by Jiangxi JDL Environmental Protection Co., Ltd, it can remove carbon, nitrogen and phosphorous simultaneously in a single reactor. It encourages a nature microbial competition, maximizes activity of the mixed biomass consortium, saves energy, and meets nutrient discharge requirement with simple controls.

FMBR has the characteristics of small footprint, low energy consumption, environmentally friendly and wastewater reuse, etc. It is a packaged wastewater treatment system which is suitable for the treatment of domestic wastewater, urban black odor water, new district wastewater and other organic wastewater, and can achieve the stable treatment of wastewater.

Save Labor

Recovery Fast

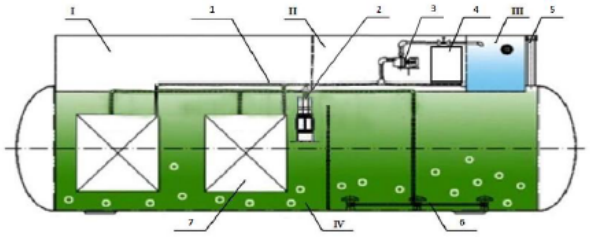
Low Operation Cost

Influent FMBR Effluent

Features of FMBR:

Save:	**Save Energy**	**Save Footprint**	**Save Labor**
Fast:	**Start Fast**	**Effect Fast**	**Recovery Fast**
Low:	**Low Effluent COD**	**Low Investment**	**Low Operation Cost**

Specification and Component Description of the FMBR:



（This is a diagram, please refer to actual product）

I--Inspection Chamber 1--Effluent Pipe 5--Ventilation Port

II--Equipment Room 2--Blower 6--Aeration Pipeline

III--Clear Water Chamber 3--Effluent Pump 7--Membrane Module

IV--Treatment Area 4--Control Cabinet

Power Requirements of FMBR （Grounding Protection）： Incoming Power - 3-phase 4-wire system, AC 460-480V, 60HZ.

Normal Start-up Operation Procedure:

1. Press the power switch.
2. Test the equipment according to the "Test-run Instructions".
3. Turn the knobs to automatic.
   Enter the automatic operation.

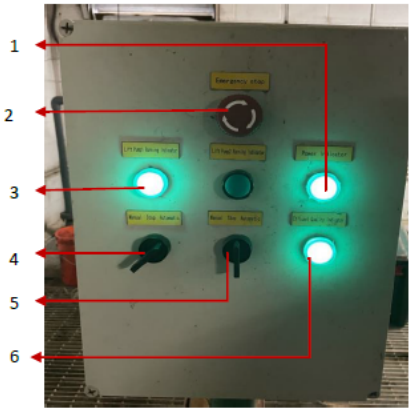
1. Test Run of FMBR

Test Run Procedure:

1. Turn on the lift pump and fill the equipment with wastewater until the membrane module is submerged.
2. Turn on the vacuum pump and aeration pump manually, check whether the rotation direction is correct, if reversing occurred, the circuit should be adjusted.
3. Fill the vacuum pump with water and start to discharge the water, check the whole pipeline

2. Control Panel of Lift Pump

No.	Name	Note
1	Power Indicator	The light is on when there is power.
2	Emergency Stop	To turn off the lift pump in emergency situation.
3	Lift Pump 1 Running Indicator	The light is on when the lift pump 1 is running.
4	Lift Pump 1 Knob	To control the lift pump, it shall be turn to Automatic during daily operation.
5	Lift Pump 2 Knob	Lift pump 2 is not installed. (Optional)
6	Effluent Quality Indicator	To connect with the online analyzer. The light is on when the effluent index exceeds the permit limitation. (Optional)

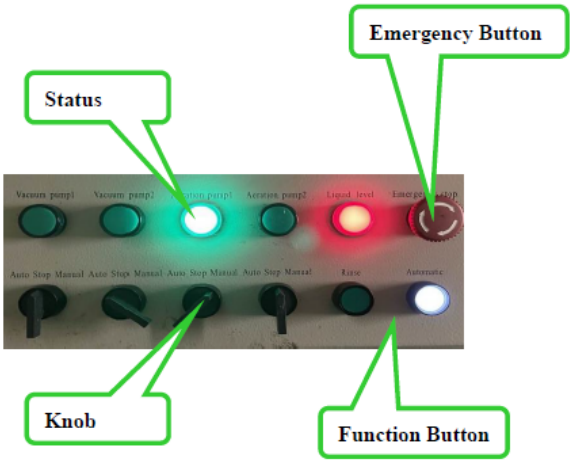


3. Control Panel of FMBR Equipment

Emergency Stop Button: Used as an emergency shutdown or restart of the equipment.
Vacuum Pump Status Light: The light is on when the equipment is running normally and goes off when it stops.
Aeration Pump Status Light: The light is on when the equipment is running normally, and goes off when it stops.
Liquid Level Indicator: The light is on when the liquid level reaches the water discharge level and effluent can be discharged.
Power Switch Button: The power master control of the system, press to turn on the equipment.
Rinse Button: Cleaning program control, press to clean the membrane module.

Knob:
Automatic – the corresponding system will run automatically according to the program (normal operation)
Stop - the corresponding system will stop running
Manual - the corresponding system will run manually (for debugging and maintenance)

During Normal Operation:
The power switch is pressed, each knob is in automatic status; the rinse button is in floating status.



4. Equipment Chamber of FMBR Tank

Vacuum Pump 1
To discharge the effluent

Vacuum Pump 2
To discharge the effluent (Backup)

Control Panel
To control the operation of the vacuum pumps and aeration pumps

Effluent Flow Control Valve
To control the effluent flow

Membrane Pressure Sensor
To monitor the pollution situation of the membrane

Aeration Pump 1 (four pumps)
To aerate
Note: The model and number of the aeration pump will vary based on specific project

Chapter 3 Proper Use and Maintenance of Main Components of FMBR

Section 1 Proper Use and Maintenance of Control Cabinets

A. Use: Operate the system through the buttons on the control panel

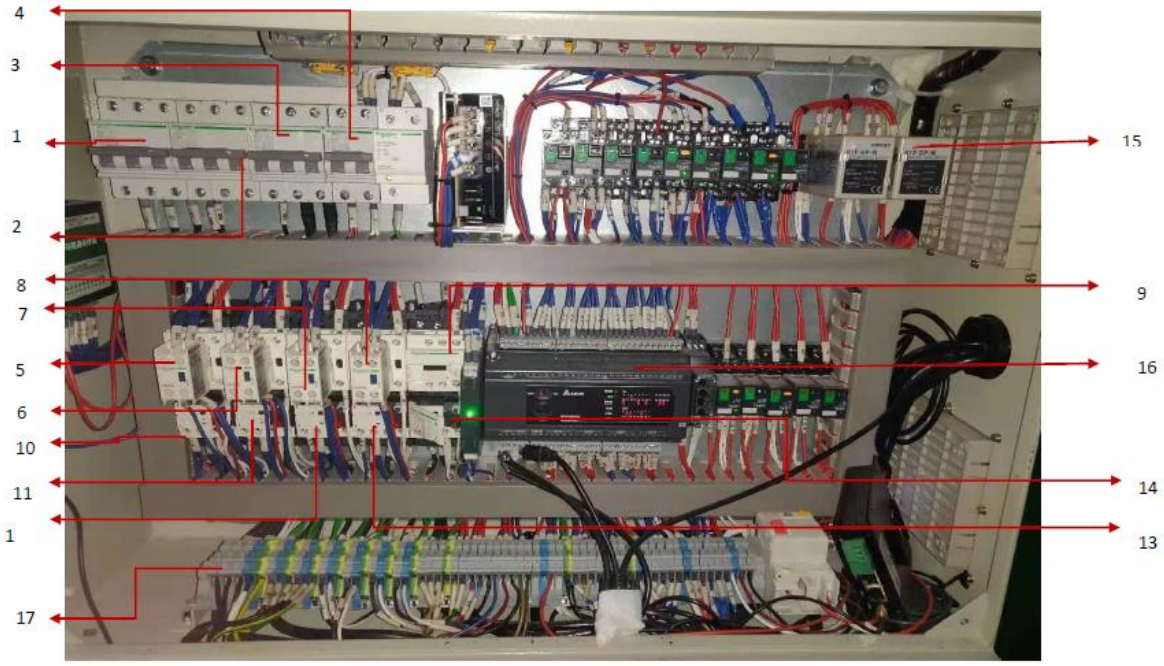
B. **Maintenance:** Inspect the system daily. If problem is found, it should be solved timely (circuit protection, pay attention to safety)

Control Power: AC 220V，60HZ

Components: the power can be reset after tripping, and the equipment can also be reset in the control cabinet after overload tripping.

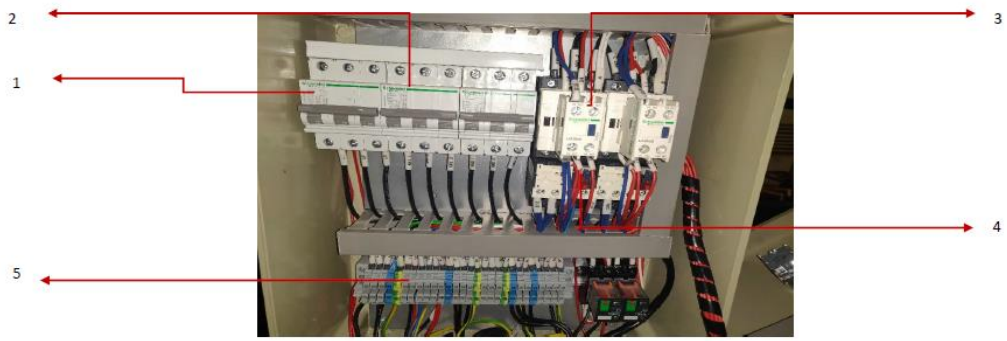
Others: check whether the buttons and equipment operation is normal, if the components are damaged, the system shall be turned off for maintenance.

C. Electrical Cabinet Main Components Diagram

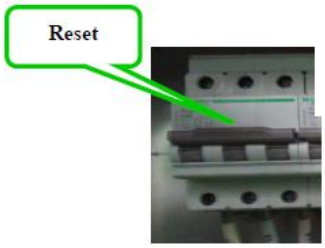


No.	Component	Fault	Reason	Treatment
1	**Main Air Switch**	Vacuum pumps and Aeration pumps do not operate	Tripped or damaged	Reset or replace
2	**Vacuum Pump Air Switch**	Vacuum pumps do not operate	Tripped or damaged	Reset or replace
3	**Aeration Pump Air Switch**	Aeration pumps do not operate	Tripped or damaged	Reset or replace
4	**PLC Signal Air Switch**	Cannot run automatically	Tripped or damaged	Reset or replace
5	**Vacuum Pump 1 Contactor**	Vacuum pump 1 cannot operate	Contactor damaged	Replace contactor
6	**Vacuum Pump 2 Contactor**	Vacuum pump 2 cannot operate	Contactor damaged	Replace contactor
7	**Aeration Pump 1 Contactor**	Aeration pump 1 cannot operate	Contactor damaged	Replace contactor
8	**Aeration Pump 2 Contactor**	Aeration pump 2 cannot operate	Contactor damaged	Replace contactor
9	**Sludge Pump Contactor**	Emergency pump cannot operate	Contactor damaged	Replace contactor
10	**Vacuum Pump 1 Thermal Protection Relay**	Vacuum pump 1 cannot operate	Tripped or damaged	Reset or replace
11	**Vacuum Pump 2 Thermal Protection Relay**	Vacuum pump 2 cannot operate	Tripped or damaged	Reset or replace
12	**Aeration Pump 1 Thermal Protection Relay**	Aeration pump 1 cannot operate	Tripped or damaged	Reset or replace
13	**Aeration Pump 2 Thermal Protection Relay**	Aeration pump 2 cannot operate	Tripped or damaged	Reset or replace
14	**Sludge Pump Thermal Protection Relay**	Emergency pump cannot operate	Tripped or damaged	Reset or replace
15	**Liquid Level Meter**	The high liquid level cannot be displayed. The vacuum pump cannot run automatically, and the lift pump cannot run automatically, but they can run manually.	Liquid level meter damaged	Replace liquid level meter
16	**PLC**	Water pump and blower cannot run automatically, but can run manually	PLC damaged	Replace PLC
17	**Electronic Connector**	Wire U1, N1, PE, and U2, N2, PE are respectively connected to vacuum pump 1, pump 2; V1, N3 and W1, N4 are respectively connected to aeration pump 1, pump 2; N indicates zero wire, PE indicates ground, U, V, W indicates fire wire		

D. Lift Pump Cabinet Main Components Diagram



No.	Component	Fault	Reason	Treatment
1	**Lift Pump Cabinet Main Air Switch**	Lift pump 1 cannot operate	Tripped or damaged	Reset or replace
2	**Lift Pump 1 Air Switch**	Lift pump 1 cannot operate	Tripped or damaged	Reset or replace
3	**Lift Pump 1 Contactor**	Lift pump 1 cannot operate	Contactor damaged	Replace contactor
4	**Lift Pump 1 Thermal Protection Relay**	Lift pump 1 cannot operate	Tripped or damaged	Reset or replace
5	**Electronic Connector**	Wire U1、V1、W1、PE is the wire of lift pump 1		



E. Maintenance Method of Main Components

a) Air switch maintenance method

1) Observe if the air switch is tripped, if it is tripped, reset;
2) Measure the voltage and compare with normal condition, if the voltage is normal, it indicates the air switch is intact, if abnormal, it indicates the air switch is damaged.
3)

b) Contactor maintenance method

1) Check if the above air switch is normal;
2) Measure the voltage at each point of the contactor and compare it with the normal condition, if abnormal, it means the contactor is damaged.

c) Thermal Protection Relay maintenance method

1) Check if the thermal protection relay is tripped, if it is tripped, reset;
2) Check if the front components are normal, then measure the thermal protection relay voltage and compare it with normal condition, if abnormal, it means there is damage.

d) Liquid level meter

1) When two lights on, it means high liquid level and the equipment produces water normally.
2) When two lights off, the automatic operation of the lift pump is carried out and the water pump cannot run automatically.

F. Cautions

1. All electrical work must be performed by authorized electricians in compliance with local electric equipment standards and internal wiring regulations, and non-authorized personnel is strictly forbidden to perform electrical works, as it is not only illegal but may be extremely dangerous.
2. Ensure that the power is disconnected when replacing components and maintaining circuits.
3. Ensure the use of intact components which specifically provided for this equipment, and take pictures before replace the line connections, and check the circuit connections after replacement.
4. Must wear insulated gloves when measuring the voltage and resetting the air switch and thermal protection relay.
5. When replacing electrical components, do not use broken cables, and do not leave the wire ports connecting components exposed.
6. When climbing the stairs of the equipment, grab the handrails and do not carry objects in your hands.
7. Do not lean on the railing of the equipment.

Section 2 Proper Use and Maintenance of Aeration Pump, Vacuum Pump and Lift Pump

A. **Use:** By using the control panel knobs, turn to the required function

Before starting, it should be noted that: the liquid level in the equipment reaches the effluent discharge level.

B. **Maintenance: Maintenance:** Inspect the system daily. If problem is found, it should be solved timely (circuit protection, pay attention to safety)

Make sure the rotation direction of the aeration pump, vacuum pump and lift pump is correct, and reverse rotation is strictly prohibited.

1) **Aeration Pump:** Check the inlet filter and clean it frequently to avoid clogging; keep the pump running for at least 15 minutes a day when the equipment shutdowns for a long time. Clean the dust off the air filter every 6 months. The replacement of the diaphragm once a year is recommended.
2) **Vacuum Pump:** It is strictly forbidden to run the pump without water; check if there is water leakage and if the noise is too loud and the temperature is too high during operation.

3) If the ambient temperature is below 0℃, the pump should be emptied to avoid freezing and cracking.

4) **Lift pump:** Manual operation is strictly prohibited, normal operation must be automatic.

C. Safety precautions

1) Lift pump must be run with water.
2) Do not put cable connector into the water when replacing the aeration pump, vacuum pump and lift pump.
3) The power must be disconnected when checking or replacing the aeration pump, vacuum pump and lift pump.
4) The cable connector of aeration pump, vacuum pump and lift pump must be completely put into the electronic connection port, the wire should not be exposed.
5) Make sure the fire wire, zero wire and ground wire of the aeration pump, vacuum pump and lift pump are correctly connected.
6) Do not turn on the power directly after replacing the aeration pump, vacuum pump and lift pump, check the circuit carefully firstly, then turn on if there are no problems.
7) Lift pump piping should be installed vertically against the wall.

Section 3 Proper Use and Maintenance of Membrane Module

A. Use: By using vacuum pump to do suction filtration for membrane module

Cautions:

1) Membrane modules must be used after complete submersion, dry membrane will cause a decrease in water permeability;
2) Suction filtration should be stopped immediately after the aeration volume drops or aeration stops;
3) Avoid fiber impurities, polymer flocculants, mineral oil, etc. flowing into the raw water, which will cause membrane clogging (Pretreatment with grids or grease separator).
4) If defoam is required, please use senior ethanol type defoamer, silicon type defoamer is strictly prohibited to avoid film clogging;
5) Regular cleaning of inorganic sediment is required according to the operation of the equipment;

B. Maintenance: Cleaning Preparation of FMBR Membrane

1) Prepare the ventilation equipment and connect the power supply in advance.
2) Remove the top cover of the membrane tank to leave the working space.
3) Prepare high-pressure water gun at the membrane tank location in advance.
4) Prepare U-tubes, O-rings, and other easily depleted materials.

5) Safety and waterproof items, such as raincoats, rain pants, rain shoes, life jackets, helmets, safety ropes and etc, shall be prepared in advance.

6) Gas measuring instruments is required during the maintenance (for toxic and hazardous gases such as H_2S).

7) Required items, tools and materials:

Item	Requirement
Sodium Hypochlorite	Concentration＞10%
Citric Acid	Purity >99%
Ventilation Fam	/
Tools	Such as movable wrenches, rubber hammers, hook and rope, etc.

C. Cleaning Procedure

Pumping and disassembling - Rinsing - Soaking - Installing - Operation recovery.

Procedure	Details
Pumping and disassembling	Turn off the lift pump, vacuum pump, and then discharge the wastewater in the FMBR equipment, and the membrane box can be disassembled when the membrane U-tube, water pipe and other fixed parts are exposed.
Rinsing	After disassembling the membrane sheet fixings, separate the single membrane sheet in the membrane module to leave a workable space, and rinse the membrane surface with a water gun.
Soaking	Lift the rinsed membrane sheet to the dipping tank for soaking with 0.3% sodium hypochlorite or 2% citric acid solution. After rinsing, the membrane sheet can be soaked for 6 hours and then rinsed on the surface with a water gun.
Installing	Lift the membrane sheet back to installation.
Operation recovery	After the installation and inspection, start to feed water and turn on the aeration after the membrane module is submerged until the liquid level reaches the normal level and then resume automatic operation.

D. Cautions:

1) Pay attention to the safety of the personnel during maintenance, wear safety ropes, and rule-breaking operation is strictly prohibited.
2) Ensure that the tank is well ventilated, before starting work in tank, the tank should be detected by using simple gas measuring instrument, and the personnel is only allowed to enter the tank after the detection meets the requirements.
3) The required labor protection supplies, materials, accessories, tools, etc. should be sufficient to avoid the lack of materials during maintenance and affect the maintenance time.
4) After maintenance, the sodium hypochlorite solution can be gradually pumped into the SBR tank for dilution and aeration; citric acid solution can be neutralized by caustic soda and then pumped into the SBR tank for treatment.
5) When the water gun is found to be connected to high pressure water, the gun head is not allowed to be pointed at people.
6) The water flow should not be pointed to the people, electrical appliances and instruments directly to avoid damage during the

cleaning operation.

7) When the water gun is connected with high pressure water, it should not be flushed for a long time close to one part of the membrane to avoid the rupture of the membrane filament.

8) Cleaning and sanitation of the site after maintenance.

E. Membrane Storage

1) If the plastic sealing bag of the membrane module is intact, the membrane module can be stored for up to 3 months under the above storage conditions.

2) Membrane modules can be stored for up to 7 days if the plastic sealing bag has been removed and the module is not exposed to water.

3) If the protective fluid has been leaked or the membrane module has been in contact with water, the membrane module must not be left dry under any circumstances, but must be stored temporarily by soaking in water for no longer than 15 days.

4) If the storage time longer than 15 days, it can be submerged in 3mg / L sodium hypochlorite aqueous solution, and sodium hypochlorite concentration needs to be measured weekly ("pool chlorine test kit" can be adopted), to ensure that the residual chlorine > 0.2mg / L.

5) Membrane modules can be exposed to air for up to 6 hours in a humid (non-fire hose or high-pressure washer sprayed) environment and at a temperature of 5°C to 30°C.

6) If the environment is dry, the membrane module can be left in the air for a maximum of 50min under the condition of avoiding direct sunlight and no wind, after which it needs to be re-submerged in water, only sprinkling water on the membrane module is not enough to keep it moist and does not prolong the exposure time of the membrane parts in the air.

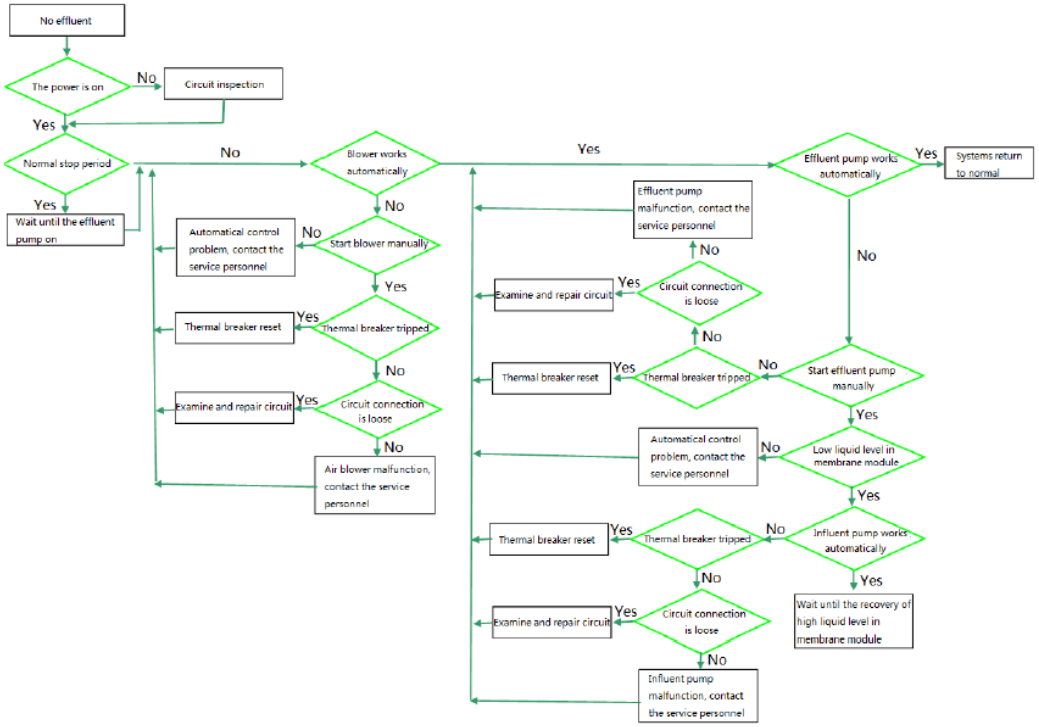
Chapter 4 Handling of Common Faults

Fault	Reason and Judgment	Handling Method
Abnormal equipment shutdown	Sudden program error	Press the power button to reboot
No water inlet	The water level of EQ tank does not reach the inlet level	Replenish influent
	Left pump clogged	Cleaning plugs
	Power trip or equipment overload trip	Reset
Turbid effluent	Influent quality exceeds influent requirements	Stop water inflow and adjust water quality
	The microbial environment in the system is destroyed	Re-culture sludge
	Pipe leakage	Maintain the pipe
	Membrane module damaged	Overhaul or replacement of membrane modules
Low effluent flow	Pipe damaged or clogged	Repairing pipes or clearing plugs
	Vacuum pump fault	Inspection or replace pump
	Membrane clogged	Improve aeration or start online cleaning
Automatic shutdown of vacuum pump	Pipe or valve clogged	Inspection and repair
	Membrane clogging, excessive resistance	Online cleaning
	Liquid level sensor fault	Check the level sensor of membrane tank first, then clean the level sensor probe
Unstable aeration status	Aeration pump fault	Inspection or repair the aeration pump
	Aeration pipe clogged	Cleaning aeration pipe
Lift pump always	Liquid level sensor fault	Check the level sensor of membrane tank first, then clean the

Fault	Reason and Judgment	Handling Method
running		level sensor probe

Note: If the equipment has been used and then not used for a long time, please make sure to turn on the equipment and run it for 2h per week.

Troubleshooting



Chapter 5 Handling of Abnormal Water Quality

Attention: If the effluent NH_3-N exceeds 5mg/L, or the effluent NO_3-N exceeds 8mg/L, or the effluent TN exceeds 10mg/L, please find the reason for the abnormal situation timely, and the corresponding adjustment shall be done.

Fault	Reason and Judgment	Handling Method
Abnormal Effluent NH_3-N	Influent pH is abnormal	Adjust the pH.
	The influent NH_3-N load is too high	Keep equipment running in normal condition, give the system a certain time to adapt. If NH_3-N is constantly abnormal, aeration pump 2 can be turn on.
	Sludge concentration is too high	Dispose the sludge. The normal MLSS is less than 15,000mg/L.
Abnormal Effluent NO_3-N	The influent NO_3-N load is too high	Keep equipment running in normal condition, give the system a certain time to adapt. If NO_3-N is constantly abnormal, add carbon source according to the situation.
	Influent COD is too low	Add carbon source according to the situation.

Chapter 6 Spare Parts List

No.	Spare Part Name	Qty
1	PLC	1
2	Signal Isolator	4
3	Power Supply	2
4	Miniature Relay	8
5	Thermal Protection Relay	4
6	Air Switch	7
7	Indicator Light	3
8	Control Bottom	4
9	Liquid Meter	2
10	Contactor	2
11	Membrane Pressure Senor	1

Chapter 7 Schedule of Daily Inspection and Maintenance

No.	Inspection or Maintenance Items	Frequency	Inspection or Maintenance Contents	Labor Hours
1	Influent and effluent Control panel	Every day	Daily influent and effluent test, equipment operation status inspection	0.5 hour
2	Lift pump, dosing pump	Every 1 or 2 weeks	Check whether the pump is blocked, and whether it is necessary to replenish chemicals (based on the quality of the influent)	1 hour
3	Circuit system, valve, effluent system, blower, dosing pump, equipment appearance	Every 3 months	Check: (1) whether the electrical components are oxidized or loose, whether the voltage and current are normal. (2) whether the valve can be operate and closed normally. (3) whether there is abnormal noise in the effluent system. (4) whether the blower's external fan, fan guard and motor radiating fin are dirty, and whether the filter cotton is clogged. (5) replace the pump head assembly of the dosing pump. (6) whether the appearance of the equipment is clean and tidy	4 hours
4	Membrane in-place clean	Every 2 weeks	Prepare cleaning solution in the clean water chamber and use the automatic program to back wash the membrane	2 hours
5	Membrane off-place clean	Every 3 to 6 months	Take out the membrane and use chemicals to wash and soak the membrane (according to the actual operating conditions on site, the frequency of membrane off-place washing can be extended to 6-12 months)	24 hours
6	Sludge disposal	Every 3 to 6 months	Discharge sludge through emergency pipe using automatic program or use vaccum pump to empty the tank	3 hours

Chapter 8 Schedule of Long-term Routine Maintenance and Replacement

No.	Items	Frequency	Contents	Labor Hours
1	Lift pump, effluent pump	Every 1 year	(1) Check whether there are scratches and hardening on the O-ring surface, check the degree of wear of the machine seal and whether the rubber is hardened. If there is any deformation, replace it. (2) Check whether the lubricating oil has deterioration, if there is moisture, replace the mechanical shaft seal.	4 hours
2	Lift pump, effluent pump	Every 2 years	(1) Check the grease sealing condition, whether the raceway and ball surface are peeled off. If there is any deformation, replace it. (2) Check whether the cable is cracked and whether the surface rubber is hardened.	4 hours
3	Blower	Every 3.5 years	(1) Replace the ball bearing; (2) Clean and re-lubricate the bearing auxiliary chamber when the ball bearing is open; (3) Replace and lubricate the transverse bearing seal ring.	4 hours
4	Lift pump, effluent pump, blower, electrical components	Every 10 years	Routine replacement period. The replacement period will vary depending on the operating condition.	4 hours
5	Membrane module	Every 8-12 years	Replace the membrane (the normal service life of the membrane is 8-12 years, and it can last longer if used according to the design requirements and maintenance requirements)	12 hours