

---

# MBR Waste-water Treatment Design Reference

## Chapter 1. MBR waste-treatment introduction

### 1. Brief of MBR

MBR (Membrane Bio-reaction) is a new technology in the waste-water treatment, which combines the traditional activated sludge treatment with the new membrane separation technology. Because of the high separation property of membrane, the activated sludge and large molecular organic matter can be blocked in the MBR tank, and the clean water can be permeated out through membrane. In MBR system, the bio-reaction and water filtration can be processed in the same time. The sludge sediment tank is un-necessary. The concentration of the sludge can be much higher than that in traditional way. Waste-water stay-time in the tank (HRT) and sludge stay-time in the tank (SRT) can be controlled separately. MBR can treat not only the normal sewage, but also some high organic polluted waste-water. By MBR technology most of the waste-water can be treated easily.

MBR enhanced the function of bio-reaction greatly through the membrane separation. Compared with the traditional waste-water treatment, some obvious advantages can be found, such as higher effective bio-reaction, good resistance of impact from the outlet waste-water, high quality outlet water, small size of the waste-water treatment plant, long age of the sludge, and the MBR system can be controlled by PLC automatically. On the other hand, because of the membrane separation, the outlet water has high quality, which can be recycled without problem.

Based on the technology of hollow fiber membrane production and the experience on the membrane application, [Hangzhou H-filtration Membrane Tech. & Eng. Co., Ltd \(H-Filtration\)](#) has developed the MBR waste-water treatment greatly in the past few years. Several big MBR projects have been installed in China and oversea. Meanwhile [H-Filtration](#) has developed a moveable completed MBR set. This invention received warm welcome both in domestic market and international



---

### **3. The advantages of MBR**

- A. Very good separation result. The outlet water from MBR is high quality, which can be recycled directly. (SS<0.5mg/L. NTU<0.2)
- B. Membrane blocks all the Micro organic in the MBR tank, so the stay-time of waste-water in the tank (HRT) can be easily controlled. The MBR will be suitable for various waste-water, with a wide range of COD and BOD.
- C. High concentration sludge in the MBR tank, which can be 2-3 times than that in traditional way. MBR has perfect behavior in the load-impact of waste-water.
- D. MBR can remove the NH<sub>3</sub>-N and P as well.
- E. Long age of sludge (SRT). Complicated organic matter can be de-graded. There is little balance sludge generated.
- F. MBR system can be controlled by PLC. Operation can be automatic.
- G. MBR can be designed as a completed, moveable set, which needs only a very small space area.

### **4. The application areas of MBR**

The MBR is a new technology in the waste-water treatment, which has been developed in some country for a few years. In China, MBR is widely acceptable and with a very good future, because of the good performance. The application areas can be as follows.

- A. All the sewage waste-water can be treated by MBR, for examples, hotels, car-washing plants, toilets. The completed moveable MBR system will be suitable for such applications, because of the small size, completed design, automatic operation, and the outlet water can be recycled.
- B. The areas without the public sewage pipes, for examples, small countryside, tourism sight-seeing park, high-way service station, etc.
- C. The clients look for higher quality on the outlet water, while the traditional treatment can't meet the requirements. The re-construction of the waste-water plant will need the MBR.
- D. High polluted organic waste-water can be treated by MBR, such as food industrial

waste-water, bio-engineering waste-water, Chinese-medicine industrial waste-water, chemical industrial waste-water, etc. The traditional treatment is difficult to treat such kind waste water well, but the MBR have the competitive capability.

E. Small waste-water treating plant by MBR.

F. The garbage plant waste-water treatment by MBR

Although there is only a small amount of waste-water treated by MBR technology now, the MBR become more welcome in various areas. With the carrying out more serious environmental protection policies, MBR will be used wildly certainly. Facing the shortage of water source, the MBR water recycling technology becomes very important.

## Chapter 2 MBR modules and MBR tank

### 1. MBR modules from H-Filtration

Hangzhou H-Filtration Membrane Tech. & Eng. Co., Ltd. (H-Filtration) produces the PP hollow fiber membrane. Because PP membrane has the good mechanical properties and stable chemical behaviors, the PP hollow fiber membrane is the most suitable materials to make the submerged MBR modules.

#### 1.1. Technical Data of the PP Hollow Fiber

|                        |             |                          |   |
|------------------------|-------------|--------------------------|---|
| <b>Raw Material</b>    | PP          | <b>External Shape</b>    | Hollow fiber  |
| <b>Diameter Inside</b> | 320um-350um | <b>Diameter Outside</b>  | 400um-450um   |
| <b>Pore Size</b>       | 0.1um-0.2um | <b>Pore Density</b>      | 40%-50%   |
| <b>X-axis Strength</b> | 120Mpa      | <b>Air Permeate Rate</b> | >7.0x10 <sup>2</sup> cm <sup>3</sup> /cm <sup>2</sup> .s.cmHg |
| <b>Available Temp.</b> | 4 -45       | <b>PH</b>                | 0-14  |

Because the materials of PP has the hydrophobic property, water can't wet the membrane, if the membrane without pre-treatment. H-Filtration has developed a hydrophilic PP membrane. The MBR modules made by such membrane can be used directly. Please note the information about MBR modules before use.

## 1.2. Technical Data of MBR modules

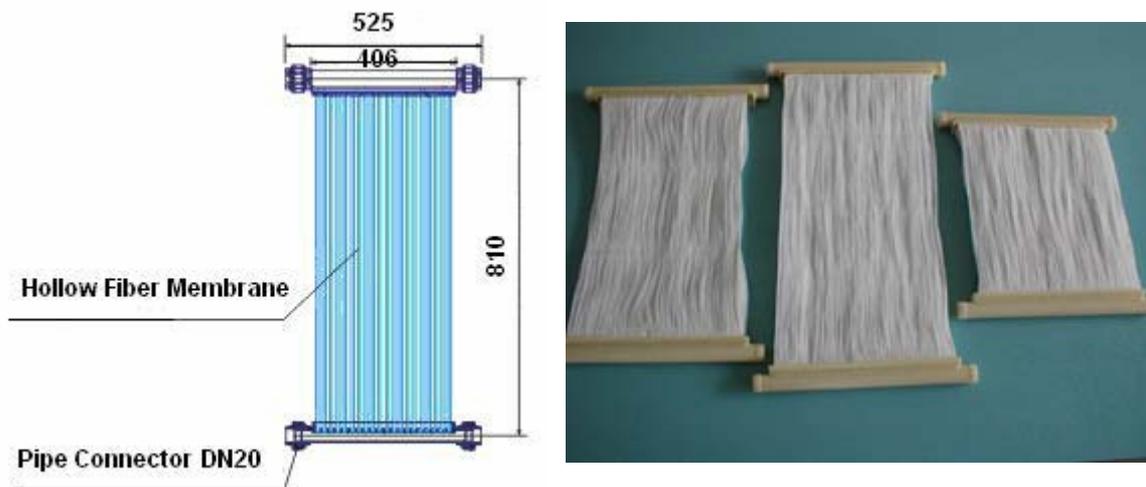
| Type   | Layers | Size (mm)   | Membrane Area(m <sup>2</sup> ) | Pressure Vacuum (Mpa) | Ref. design flux rate (M <sup>3</sup> /day) |
|--------|--------|-------------|--------------------------------|-----------------------|---|
| MR-I   | 1      | 525x810x400 | 4                              | 0.01- 0.03            | 0.5-0.8                                     |
| MR-II  | 2      | 523x810x400 | 8                              | 0.01- 0.03            | 1.0-1.2                                     |
| MR-III | 3      | 523x810x400 | 8                              | 0.01- 0.03            | 1.0-1.2                                     |
| MR-lab | 3      | 380x450x250 | 4                              | 0.01- 0.03            | 0.5-0.8                                     |

Connector pipe: ABS, UPVC or steel piper with the diameter of DN20 or DN15mm.

Ref. design flux rate (-0.015mpa) is for the application on the waste-water treatment

In the MBR waste-water treatment project, the MR-II and MR-III will be used usually.

## 1.3. Diagram of MBR modules



The hollow membrane fibers were woven together to make up single layer. On one membrane layer, there are 5 woven lines to fast the membrane fibers. These woven lines can enhance the strength of the membrane to avoid the breakage of the fiber in the tank.

1, 2 or 3 layers will be sealed in the accessories by PU glue. More layers can obtain more membrane area, and more membrane area can treat more waste-water in the processing. The whole MBR module will be submerged in the waste-water, and the water can permeate through the membrane. From the side pipes, clean water can be taken out by self-priming pump at vacuum pressure.

Usually the MBR modules will be installed in the aeration tank (MBR tank), the upwards water-flow will shake and wash the membrane, which can resist the fouling for long time.

## 2. The Tank of MBR

In the MBR tank, because the clean water is taken out by self-priming pump at vacuum pressure, the MBR modules will be submerged under the water. The tank can be an open or half-open container. MBR frames will be installed in the tank, and the MBR modules will be fixed on the frame. Clean water pipes will be connected together, which will be connected to the self-priming pump.

The volume of the tank can be calculated according to the load of COD or BOD of the waste-water. To treat high COD and BOD waste-water, the volume of MBR tank will be bigger.

The picture of the MBR tank



The size of the MBR tank will be determined according to the size of MBR frame as well.

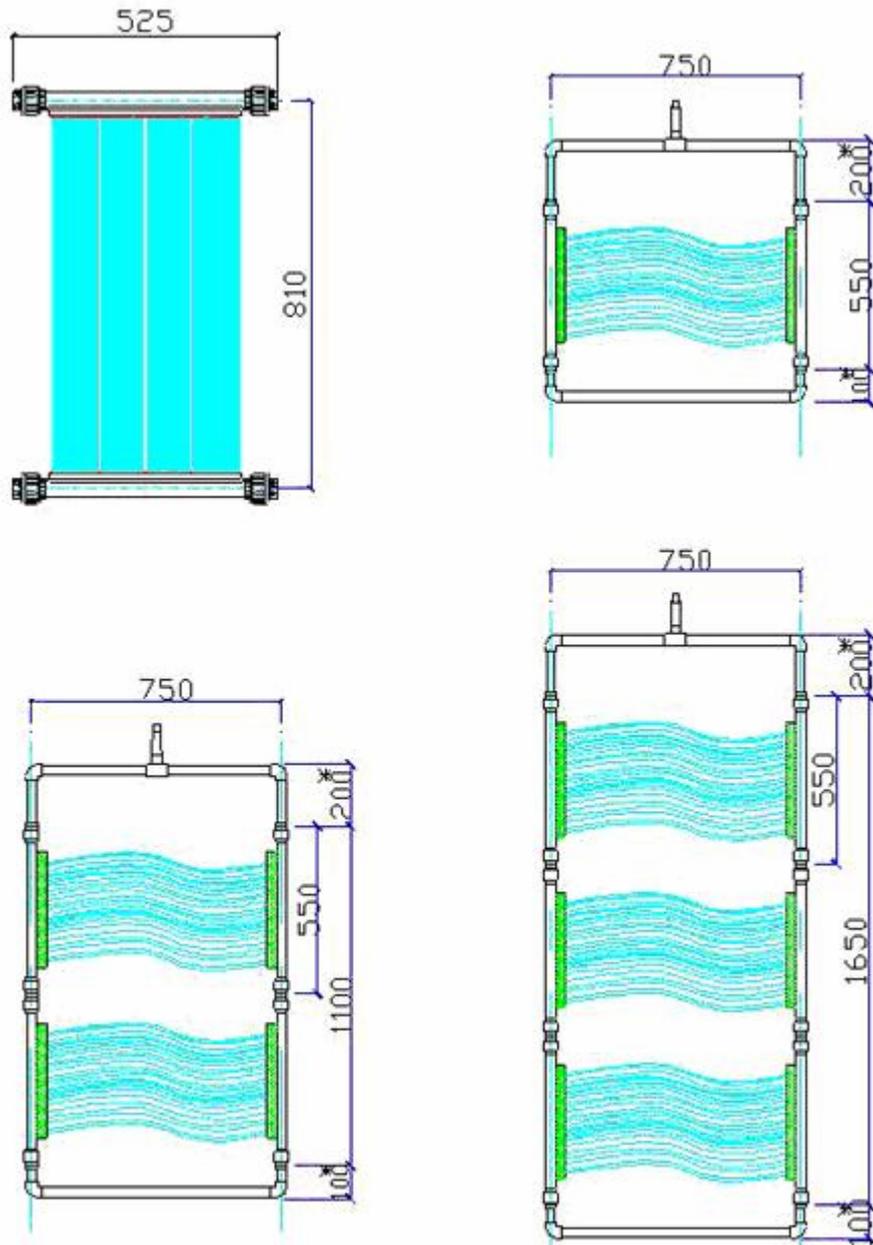
## Chapter 3 The design of the MBR system

The MBR waste-water treatment system include waste-water collection tank, (pre-aeration tank), MBR aeration tank, MBR modules unit, balance sludge collection tank, etc.

The MBR modules unit includes MBR modules, frame, connection pipes, clean water pipe, aeration system, self-priming pumps, vacuum pressure mater, flow rate mater, etc..

### 3.1 The size of the MBR modules and the frame

According to the depth of the MBR tank, the MBR modules can be connected in three shapes. If the depth of the tank will be 1.0m to 1.6m, 1 MBR module can be connected. If the depth of the tank will be 1.6m to 2.2m, 2 MBR modules can be connected together. If the depth of the MBR tank will be more than 2.2m, 3 MBR modules can be connected together. The connection pipe size can be DN15mm or DN20mm pipe. The pipe can be ABS, UPVC and zinc-plate pipe.



1. Size: mm

2. The size with the mark ★ can be modified according to the tank

### 3.2 MBR module frame



---

The volume of the air will be about 1.74 ~ 2.60L/mim for one m<sup>2</sup> membrane area. It can be calculated the rate of air/water = 20:1 to 25: 1.

The air-dispensers can be micro-pore dispenser or air pipe with small holes.

### **3.4 The self-priming pump**

The outlet water will be produced by self-priming pump. The pump connects to the clean water pipe, which reaches to the MBR modules. The absorbing capability of the pump will be more than -5m, with the vacuum pressure of Max. 0.05-0.08Mpa.

The pump will be controlled automatically, working for 11-13mins and stop for 2-3mins. It can resist the fouling of the membrane.

## **Chapter 4 The maintenance of MBR system**

### **4.1 The membrane wetting treatment**

Because of the hydrophobic property of the PP membrane, the MBR modules need to do hydrophilic treating before installation. After such treating, the modules can be used for water filtration. Please wet the membrane by >95% alcohol for 2-3mins. After the alcohol treatment, please wash the membrane by clean water and keep the membrane in wet condition.

[In our company new MBR modules have been developed. The modules have good hydrophilic property, so the modules can be installed directly without alcohol wetting before installation.](#)

### **4.2 The MBR modules cleaning (washing) and the maintenance of flow-rate**

There are three ways used to keep the MBR modules with stable flow rate Firstly, the upwards flow and the air bubble will shake the membrane and wash the membrane. Secondly, the self-priming-pump will work for 11-13mins and stop for 2-3mins. It can keep the membrane with stable flow rate to avoid the block. Thirdly, the MBR modules must be installed after the activated sludge grows well. When you finish the sludge culturing and growing, you can submerge the MBR modules in the tank.

Most of time the vacuum pressure of the self-priming pump will be kept on

---

-0.01 ~ -0.03Mpa. If the vacuum pressure increases to -0.05Mpa, it means that the MBR modules need to be cleaned necessary.

If the membrane is fouled and the flow rate becomes small, the MBR modules need to be washed. The MBR washing treatment can recover the flow rate. Please wash the membrane by the following processing.

Step 1. Take the MBR modules out from the MBR tank, and wash the surface of the membrane by clean water to remove the sludge.

Step 2. Use the chemical of NaClO of 0.5% to wash the membrane for 1 hour. It can remove the micro organic matter completely.

Step 3. Use the chemical of NaOH of 5% to wash the membrane for 2 hours.

Finally step. Use clean water to wash the modules again.

Some time, you can use 2-3% HCl to wash the membrane, if necessary. When doing the washing processing, please be careful to avoid break the membrane fibers.

In some big MBR project, a special MBR module washing tank will be built. The MBR modules together with the frame can be taken out from the MBR tank and remove the washing tank. In the washing tank the MBR modules can be washing by clean water, chemical agent easily. Under the washing tank, the aeration will be built as well.

## **Chapter 5 Transportation and installation of the modules**

During the transportation, please keep the modules in the temperature between 5-40 . Please keep the modules avoiding any direct sunlight. The direct sunlight will degrade the PP membrane fiber.

## **Chapter 6 Examples of the MBR project.**

### **Example 1 Sewage MBR treatment**

Main Processing Steps:

Waste-water → Metal grid filter → MBR system → Clean-water

Results:

| Item         | COD <sub>Cr</sub> ( mg/l ) | BOD <sub>5</sub> ( mg/l ) | SS ( mg/l ) | Color(times) |
|--------------|----------------------------|---------------------------|-------------|--------------|
| Inlet water  | <400                       | <300                      | <50         | <10          |
| Outlet water | <30                        | <5                        | <5          | <1           |

Tech. parameters:

SHT : 6-8 hours

Air: water : 20:1---30:1

DO in MBR Tank : 3-4mg/L

MLSS: 4000-6000mg/L

### Example 2. Food industrial waste-water MBR treatment

#### Main Processing Steps:

Waste-water → Metal grid filter → Collection tank (sediment tank) → Short oxygen tank (Pre-aeration tank) → MBR system → Clean-water

#### Results:

| Item         | COD <sub>Cr</sub> ( mg/l ) | BOD <sub>5</sub> ( mg/l ) | SS ( mg/l ) |
|--------------|----------------------------|---------------------------|-------------|
| Inlet water  | <2500                      | <1200                     | <400        |
| Outlet water | <100                       | <30                       | <50         |

Tech. parameters:

SHT : 25-30 hours

Air: water : 30:1---50:1

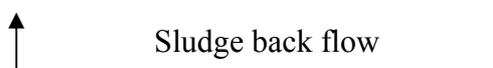
DO in MBR Tank : 3-4mg/L

MLSS: 4000-6000mg/L

### Example 3. Livestock raising industrial waste-water MBR treatment

#### Main Processing Steps:

Waste-water → Metal grid filter → Collection tank (sediment tank)  
 → Short oxygen tank (Pre-aeration tank) → MBR system → Clean-water



#### Results:

| Item | COD <sub>Cr</sub> ( mg/l ) | BOD <sub>5</sub> ( mg/l ) | SS ( mg/l ) | NH <sub>3</sub> -N ( mg/l ) |
|------|----------------------------|---------------------------|-------------|-----------------------------|
|------|----------------------------|---------------------------|-------------|-----------------------------|

|              |       |       |      |      |
|--------------|-------|-------|------|------|
| Inlet water  | <2000 | <1300 | <800 | <300 |
| Outlet water | <150  | <60   | <50  | <25  |

**Tech. parameters:**

SHT : 48-60 hours

Air: water : 50:1---60:1

DO in MBR Tank : 3-4mg/L

MLSS: 6000-8000mg/L

Sludge back-flow rate: 150-200%

**Example 4. Chemical industrial waste-water MBR treatment**

**Main Processing Steps:**

Chemical agent adding



Waste-water → PH adjustment tank → Sediment tank

→ Short oxygen tank (Pre-aeration tank) → MBR system → Clean-water

**Results:**

| Item         | COD <sub>Cr</sub> ( mg/l ) | BOD <sub>5</sub> ( mg/l ) | SS ( mg/l ) | Color(times) |
|--------------|----------------------------|---------------------------|-------------|--------------|
| Inlet water  | <3500                      | <1200                     | <1300       | <10          |
| Outlet water | <150                       | <60                       | <50         | <1           |

**Tech. parameters:**

SHT : 60-72 hours

Air: water : 60:1---80:1

DO in MBR Tank : 3-4mg/L

MLSS: 6000-12000mg/L

**Chapter 7. Technology and cost comparing**

With the development of the MBR technology all over the world, the MBR application areas have been expended from sewage to high polluted organic waste-water and complex industrial waste-water, such as the medicine industrial

waste-water, food industrial waste-water, chemical industrial waste-water, etc. MBR treatment has a good performance on these areas as well.

### 7.1 List of MBR applications in various waste-water

| Waste water<br>From | COD ( mg/L ) |        | BOD ( mg/L ) |        | N3H-N ( mg/L ) |         | SS ( mg/L ) |        |
|---------------------|--------------|--------|--------------|--------|----------------|---------|-------------|--------|
|                     | Inlet        | Outlet | Inlet        | Outlet | Inlet          | Outlet  | Inlet       | Outlet |
| Shower water        | 130-322      | <40    | 99-212       | <5     | 0.59-1         | 0.2-0.4 | 15-50       | 0      |
| Painting<br>making  | 100-1500     | 180    | 500          | 40     |                |         |             |        |
| Hogwash waste       | 900-12000    | <100   | 6805         | <10    | 130-180        | <5      | 4750-5470   | <10    |
| Hospital waste      | 48-278       | <25    | 20           | 0.4    | 10-24          | 1       |             |        |
| Medicine<br>making  | 1500-4900    | <180   | 500-1633     | <10    | 297--354       | <15     | 430-1033    | <10    |
| Building office     | 92-108       | 23     | 27-32        | <8     |                |         | 39-47       | 3.5    |
| Food industrial     | 754          | <80    |              |        |                |         |             |        |

If comparing with the traditional sludge treatment, MBR can insure the good quality of the outlet water, and the system will be more stable. The treatment results will be perfect. From the MBR technology, the removing of NH<sub>3</sub>-N and P is possible.

### 7.2 The Equipment

Main equipments needed in the MBR

| No. | Item                      | Usage   |
|-----|---------------------------|---|
| 1   | Grid filter               | To remove the big solids. The materials can be steel and stainless steel.                       |
| 2   | Raw water<br>feed-in pump | To take the waste-water out from the collection tank to the MBR tank.                           |
| 3   | Sludge back<br>flow pump  | To make the back-flow of the sludge. It can remove the N <sub>3</sub> H-N from the waste-water. |
| 4   | Air blower                | To supply the oxygen to the waste for bio-reaction and to wash the membrane by cross-flow.      |

|           |                          |  |
|-----------|--------------------------|--|
| <b>5</b>  | <b>Flow meter</b>        | <b>To measure the flow rate</b>  |
| <b>6</b>  | <b>Air dispenser</b>     | <b>Pipes with hole or micro-pore dispenser, to diffuse the oxygen to the waste-water, and to wash the membrane</b> |
| <b>7</b>  | <b>MBR module</b>        | <b>To separate the clean water from the waste-water</b>  |
| <b>8</b>  | <b>Frame</b>             | <b>To install the MBR modules in the tank</b>  |
| <b>9</b>  | <b>Self-priming pump</b> | <b>To absorb clean water out from the membrane. It can form the vacuum pressure.</b>                               |
| <b>10</b> | <b>Power panel</b>       | <b>Power supply to all the pumps and air-blower.</b>   |
| <b>11</b> | <b>Pipe &amp; valves</b> | <b>ABS , UPVC or zinc plated pipe , valve</b>  |

The energy cost in the MBR system will a bit higher than tradition way. On one hand, to separate the clean water from the waste-water needs energy. On the other hand, more air-blowing is needed for this system. Firstly, because of the higher MLSS in the MBR tank, more air-blowing is used for the diffusion of oxygen. Secondly, the air/water upwards flow can wash the membrane, which can keep the membrane with a long-term good flow-rate.

Because of the good quality of the outlet water by MBR, and the outlet water can be recycled in some place, the MBR is warm welcome recently..