# Technical Service Bulletin

October 2013 TSB400.06

## Startup and Usage Guidelines for HYDRAsub®-MBR

The following precautions should be taken when using the HYDRAsub®-MBR membranes:

1. The concentration of mixed liquor suspended solids in the membrane tank shall be kept below 12000 mg/l.
2. The temperature in the membrane tank shall never exceed 104°F (40 °C).
3. The pretreated feed water entering the system shall not contain more than 50 mg/l of animal or vegetable oil/fat and not more than 3 mg/L mineral oil and/or grease. The animal or vegetable oil/fat can be measured using n-hexane extraction.
4. Silicone-based anti-foaming agents should not be used for foam control in the system (aeration tank or membrane tank).
5. The feed water shall not contain chemicals which can chemically degrade or damage the membrane (please see HYDRAsub®-MBR Operating Manual for chemical compatibility chart).
6. The feed water to the membrane tank shall be filtered with a 0.5 - 1 mm screen. Certain types of screens with up to 2 mm openings may be allowable contingent upon approval by Hydranautics technical department. The screen specifications should be such that there is no passage of any particle or fiber with a dimension (diameter or length) of more than 1 mm, through the screen or through the joints, seams or any other portion of the screen mechanism.
7. Transmembrane pressure (vacuum) across the membranes shall not exceed 6 psig (0.41 bar).
8. Backwash pressure inside the membrane shall not exceed 2 psig (0.14 bar).
9. During air integrity tests on membrane elements, air pressure inside the membrane elements shall not exceed 5 psig (0.34 bar), while typical integrity tests should be done at 4 psig (0.28 bar).
10. Backwash water to the HYDRAsub®-MBR membranes should contain no particles larger than 0.1 mm in any dimension before being sent to the membranes. Backwash water holding tank should be covered and protect against algal and bacteria growth.
11. The feed water pH shall be between six (6) and eight (8), the cleaning solution pH shall be between one (1) and eleven (11).
12. The maximum continuous concentration of free chlorine during cleaning shall not exceed 5000 ppm and the maximum duration of chlorine exposure shall not exceed 2 hours.

13. HYDRAsub®-MBR membranes filled with water shall not be exposed to freezing conditions.
14. HYDRAsub®-MBR membranes shall not experience water hammer or severe and rapid changes in pressure during filtration or backwash.
15. Instructions in HYDRAsub®-MBR Technical Manual and Technical Service Bulletins must be followed at all times when handling HYDRAsub®-MBR membranes, during module commissioning, and any subsequent operations after plant startup.

## MEMBRANE INTEGRITY TESTING

Buyer acknowledges that the following provisions shall apply in connection with the Membrane Integrity Testing:

a) The membrane modules integrity is indirectly monitored (by monitoring filtrate turbidity). Air pressure decay test should not be used regularly for integrity testing the membrane modules after they are operational.
b) Please refer to TSB410 for the detailed integrity testing procedure.

## STARTUP GUIDELINES

For the purposes of this document, the MBR “Startup” is defined as the process of reaching a steady state for the biological and membrane systems. This process begins after the system operating sequence, controls, interlocks, etc. have been confirmed, after the membrane modules have been properly assembled and installed according to TSB411, and after the system integrity has been confirmed according to TSB410.

The first step in MBR startup is to ensure that the membranes have the correct permeability. Please refer to TSB405 for detailed instructions about permeability testing.

If the permeability is not in the correct range, it could possibly be due to loss of hydrophilicity of the membranes. When the HYDRAsub®-MBR membranes are shipped, they are rendered temporarily hydrophilic by coating a hydrophilic substance onto the membrane surface. If this substance gets washed away or removed for any reason, the membranes need to be wetted with a surfactant. Please refer to TSB401 “Hydrophilic Treatment Procedure for HYDRAsub®-MBR” for details on the hydrophilization procedure.

Once the permeability of the new membrane is in the correct range, the membranes can be used with activated sludge. When the membranes are first introduced and operated in an activated sludge environment, it is important that the flux is increased gradually. The ramp-up procedure for the flux increase depends on the type of wastewater used. The following three scenarios are outlined.

**Case 1: Startup with aged sludge with MLSS in the range of 5000-10000 mg/L in the aerobic tank**

For such a sludge, it is recommended to start at a flux of 4 gfd (6.8 lmh) and increase it in increments of 4 gfd (6.8 lmh) until it reaches the target flux, which for municipal applications should typically not exceed 18 gfd (31 lmh). If the transmembrane pressure increases rapidly during transition to the next higher flux value in the ramp-up, then it is recommended that the flux be lowered to the previous (lower) value until the TMP is stabilized and then the next higher flux value should be tried.

An example of such a flux ramp up with aged sludge is shown in Table 1.

**Table 1. Flux Ramp Up With Aged Sludge**

| Day | Flux (gfd) | Flux (lmh) |
|---|---|---|
| 1 | 4 | 6.8 |
| 3 | 8 | 13.6 |
| 5 | 12 | 20 |
| 7 | 16 | 27 |
| 9 | 18 | 31 |

**Case 2: MBR startup using primary effluent feed and with seed sludge**

Following is an example of a system that was started up by using primary effluent as feed and with seed sludge from a municipal wastewater plant.

**Table 2. Biological and Membrane Process Design for MBR Start Up with Primary Effluent and Seed Sludge**

| Parameter | Value |
|---|---|
| **Flow rate** | 5 m3/day |
| **Anoxic tank** | 0.72 m3 |
| **Anoxic tank HRT** | 3 hrs |
| **Aerobic tank** | 0.72 m3 |
| **Aerobic tank HRT** | 3 hrs |
| **Design F/M ratio** | 0.1 kg BOD/kg MLSS/day |
| **Recirculation ratio** | 2 |
| **Membrane area** | 6.3 m2 |
| **Operating flux** | 0.8 m/d |
| **Filtration time** | 7 minutes |
| **Relaxation time** | 1 minute |
| **CEB frequency** | Weekly |

| | |
|---|---|
| **Cl2 concentration for CEB** | 300-500 ppm |
| **Backwash flux during CEB** | 0.1 m/d |
| **Cl2 concentration for CIP** | 3000 mg/L |
| **Backwash flux during CIP** | 0.1 m/d |
| **Membrane aeration** | 100-150 Nm3/hr/m2 of projection area of membrane module |

This study was meant to simulate the startup procedure for an MBR by seeding it with sludge from a conventional activated sludge plant followed by the growth phase to achieve the target concentration of 10000 mg/L in the membrane tank.

The system was filled with sludge at a concentration of ~ 10000 mg/L which was obtained from a parallel MBR study that was being conducted. Approximately 90% of the system volume was removed and replaced by primary effluent. This brought down the sludge concentration in the system to ~ 1000 mg/L.

The startup operation over a 66-day period is depicted Table 3.

**Table 3. Parameters for MBR Startup with Primary Effluent and Seed Sludge**

| Day | Flux | HRT | Recirculation ratio | Sludge removal | Aeration (linear velocity) | Volumetric ratio of air flow to feed flow | MLSS | F/M ratio |
|---|---|---|---|---|---|---|---|---|
| | (m/d) | (hrs) | | (%/day) | m/hr | | (mg/L) | (kg BOD/kg MLSS/d) |
| 0 | 0.10 | 54.9 | 6.3 | 0 | 100 | 229 | 1100 | 0.067 |
| 7 | 0.20 | 27.4 | 2.6 | 0 | 100 | 114 | 1200 | 0.123 |
| 17 | 0.30 | 18.3 | 2 | 0 | 100 | 76 | 2000 | 0.111 |
| 25 | 0.53 | 10.4 | 2 | 0 | 100 | 43 | 3760 | 0.104 |
| 27 | 0.60 | 9.1 | 2 | 0 | 100 | 38 | 4400 | 0.101 |
| 32 | 0.80 | 6.9 | 2 | 1.8 | 100 | 29 | 5810 | 0.101 |
| 35 | 0.80 | 6.9 | 2 | 3.6 | 100 | 29 | 6440 | 0.091 |
| 49 | 0.80 | 6.9 | 2 | 3.6 | 150 | 43 | 9240 | 0.063 |
| 66 | 0.80 | 6.9 | 2 | 4.4 | 150 | 43 | 11510 | 0.051 |

The feed entering the system was approximately equal to the filtrate drawn out of the system (after considering the volume discharged as waste sludge). F/M ratio was calculated assuming average feed BOD of 140 mg/L. As shown in Table 3, the F/M (food to microorganism) ratio was maintained as stable as possible during the course of the startup. This was achieved by adjusting the filtrate flux accordingly with the increase in biosolids so that the F value (BOD entering the system) would increase

accordingly with the M value (mass of biosolids in the system). The target flux of 0.8 m/d was achieved on the 32nd day of the startup.

No sludge was wasted until the MLSS reached 5000 mg/L. Until the 7th day after startup, filtration was carried out such that filtration period was 7 minutes and soak period was 7 minutes. After the 7th day, filtration/soak times were adjusted to the regular values of 7 min/1 min, respectively. Linear aeration velocity was maintained at 100 m/hr until the 35th day. After the 35th day, it was raised to 150 m/hr. The volumetric ratio of feed flow (m3/day) to air flow (m3/d) reduced gradually with the progress of the test due to increase in the feed flow.

Maintaining the system at a relatively constant F/M ratio of ~ 0.1 kg of BOD/kg of MLSS/day helped degrade the soluble organic matter and reduce the membrane fouling rate.

The MLSS was 7000 mg/L on the 40th day and that is when the startup was considered to be completed. The TMP had started to increase on the 40th day of the testing. This was primarily attributed to the winter season and the consequent low feed water temperature. To counter the higher rate of TMP increase, the linear air velocity was increased from 100 to 150 m/hr and the weekly CEB cleaning with 300 ppm Cl2 was started on the 44th day. CEB cleaning was not conducted when the MLSS concentration was lower than the target MLSS. Conducting CEB cleaning with chlorine at low MLSS concentration could have reduced the microbe population and upset the biological system. The aeration velocity was initially maintained at a low value of 100 m/hr so as to prevent the breakup of microbial floc due to the high shear rate associated with high aeration velocity.

With respect to the effluent (filtrate) quality, the NO3-N reached the target value after the 20th day from startup. This was due to the low MLSS concentration and also due to the higher recirculation ratio in the initial phase of the startup due to the low filtrate flow. The high recirculation ratio resulted in high DO (dissolved oxygen) liquor from the nitrification (aerobic) tank being recirculated into the denitrification tank thus reducing the anoxic environment in the denitrification tank. The PO4 value in the filtrate dropped after the 40th day from startup.

**Case 3: MBR startup by concentration of secondary wastewater from a conventional wastewater plant**

This procedure is used if a continuous stream of activated sludge from a conventional wastewater plant is readily available. This activated sludge is concentrated with the membranes until the target value of 8000-10000 mg/L in the aerobic tank is reached. Then primary effluent is introduced as feed to the system. This procedure significantly reduces the time required to reach the target concentration.

The activated sludge from a conventional wastewater plant operates at a high F/M (Food to microorganism) ratio. This may result in higher rate of membranes fouling. So, it is particularly important to monitor rate of increase of TMP and adjust the flux or

soak time between filtration cycles. An example of ramp up for such a procedure for a module with a membrane area of 3 m2 is shown below. However, it should be noted that the ramp up protocol with respect to increments and duration of flux increase may change depending on the specific characteristics of the activated sludge. The following table is just a suggested protocol.

**MBR startup by concentration of secondary wastewater from a conventional wastewater plant**

| | | |
|---|---|---|
| Membrane area | 3 | m2 |
| MLSS in secondary WW | 1400 | mg/L |
| Total system volume | 170 | gal |
| Module cross-sectional area | 0.038 | m2 |
| Measured air pressure | 3.00 | psig |
| Sludge bleed fraction | 2 | % |

| Day | Calculated MLSS | Operating flux | Operating flux | Operating flow | Filtration time | Soak time | Net flux | Net flux | Net flow | Total HRT | Recirc flow | Recirc ratio | Sludge bleed | Aeration velocity | Air flow required |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (m/d) | (lmh) | gpm | (min) | (min) | (m/d) | (lmh) | gpm | (hrs) | (gpm) | | (gpd) | (m3/hr/m2 of projection area) | cfm@3psig |
| | Begin test with secondary wastewater feed | | | | | | | | | | | | | | |
| 1 | 1400 | 0.1 | 4.2 | 0.06 | 7 | 7 | 0.05 | 2.1 | 0.03 | 102.7 | 2.0 | 72 | 0.000 | 100 | 2.0 |
| 2 | 1727 | 0.1 | 4.2 | 0.06 | 7 | 7 | 0.05 | 2.1 | 0.03 | 102.7 | 2.0 | 72 | 0.000 | 100 | 2.0 |
| 3 | 2054 | 0.2 | 8.4 | 0.11 | 7 | 7 | 0.1 | 4.2 | 0.06 | 51.4 | 1.9 | 35 | 0.000 | 100 | 2.0 |
| 4 | 2708 | 0.2 | 8.4 | 0.11 | 7 | 7 | 0.1 | 4.2 | 0.06 | 51.4 | 1.9 | 35 | 0.000 | 100 | 2.0 |
| 5 | 3362 | 0.4 | 16.7 | 0.22 | 7 | 7 | 0.2 | 8.4 | 0.11 | 25.7 | 1.9 | 17 | 0.000 | 100 | 2.0 |
| 6 | 4670 | 0.4 | 16.7 | 0.22 | 7 | 7 | 0.2 | 8.4 | 0.11 | 25.7 | 1.9 | 17 | 3.2 | 100 | 2.0 |
| 7 | 5889 | 0.6 | 25.1 | 0.33 | 7 | 7 | 0.3 | 12.5 | 0.17 | 17.1 | 1.8 | 11 | 4.9 | 100 | 2.0 |
| 8 | 7683 | 0.6 | 25.1 | 0.33 | 7 | 4 | 0.382 | 16.0 | 0.21 | 13.5 | 1.8 | 9 | 6.2 | 100 | 2.0 |
| 9 | 9901 | 0.72 | 30.1 | 0.40 | 7 | 1 | 0.63 | 26.3 | 0.35 | 8.2 | 1.7 | 5 | 10.2 | 100 | 2.0 |
| | Switch to primary effluent feed after target MLSS is reached. Bleed sludge to maintain MLSS concentration | | | | | | | | | | | | | | |

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