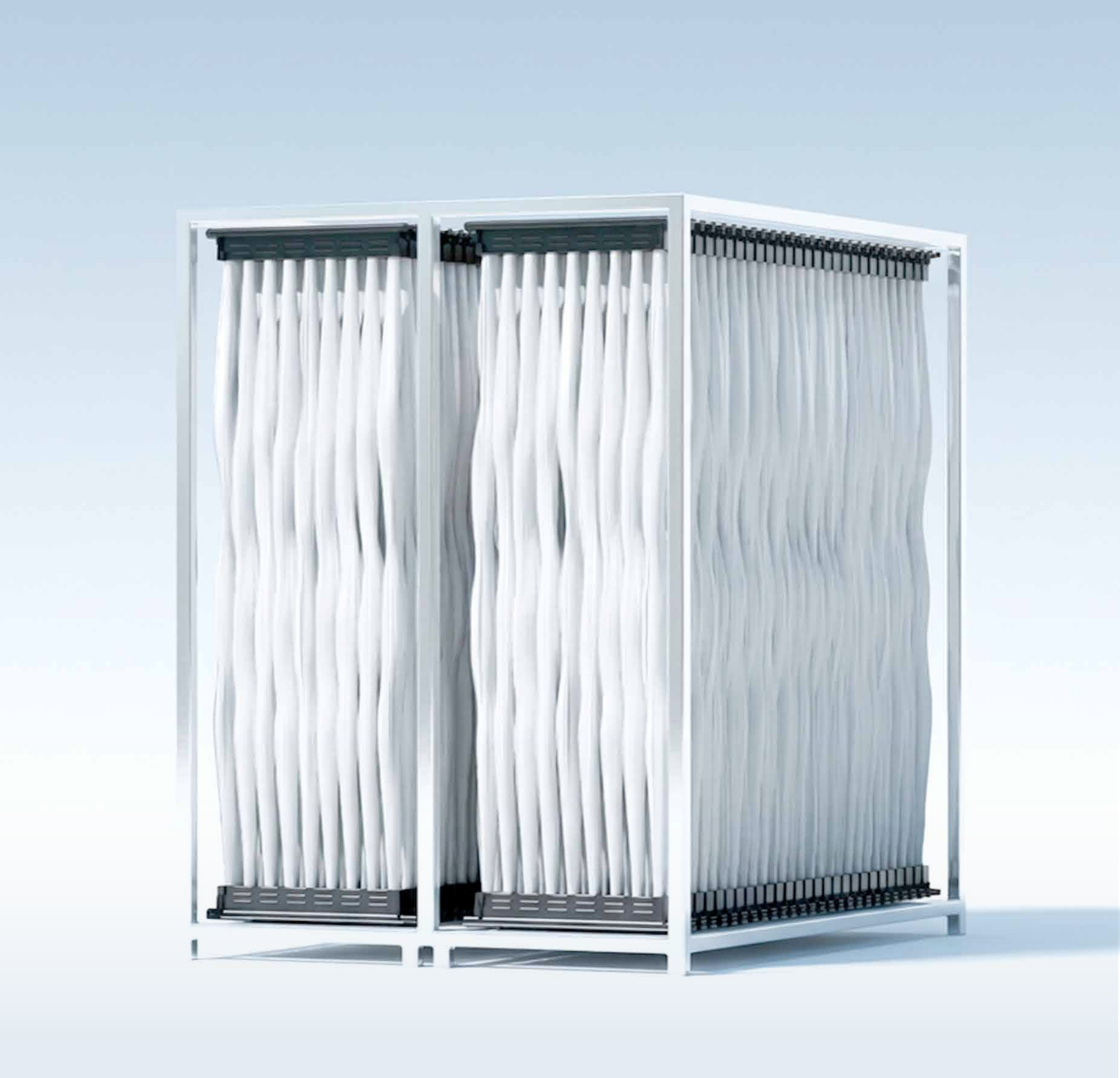
Version 1.0.0

# QuantumFlux™
# MBR/Submerged UF Membrane

The Choice for High-Performance MBR Membranes



NANOH2O

Technical
Service
Bulletin

NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin

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NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

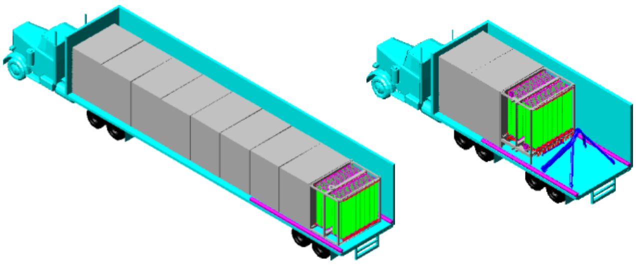
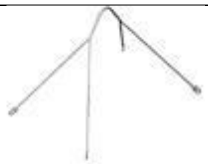
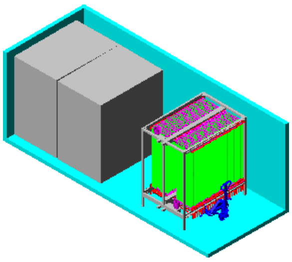
# Technical Service Bulletin 801

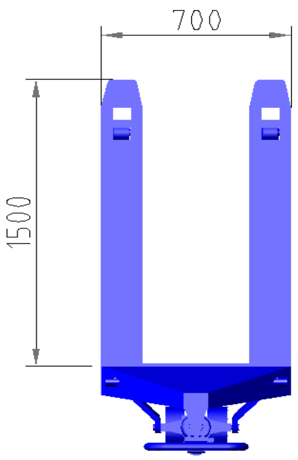
MBR & Submerged UF Transportation, Receiving, Storage, and Disposal of Used Modules

### Membrane Device Transportation

When transported by sea, the membrane device and accessories are loaded into containers for transportation; when transported by land, the membrane devices and accessories are loaded onto flatbed trucks for transportation.

**Table 1 : Membrane Device Transportation**

| Process | Figure | Notes |
|---|---|---|
| 1 |  | When shipped by sea, membrane devices and accessories are transported in 40-foot or 20-foot containers. Use high cube containers where possible.<br><br>When transported by land, the membrane device and accessories are transported on flatbed trucks. |
| 2 |  | When loading, the spreader and accessories are put together for transportation. |
| 3 |  | **Unloading:**<br>The membrane device can be unloaded using a crane or forklift. Before installing the membrane device, keep it in a secure area sheltered from sun and rain.<br><br>**Note: Do not open the outer packaging of the membrane skid.** |

| | | |
|---|---|---|
| 4 |  | **Precautions:**<br>When using a forklift to unload or transfer the membrane device, the forklift arm should be slowly extended under the membrane skid to avoid damaging the aeration box and membrane modules.<br>The dimensions of the forklift used are that the opening of the two fork arms is not greater than 800MM and the length is not less than 1500MM.<br>The distance between the front and rear of the skid frame bracket is 1280MM. |

**Receiving Inspection**

After a shipment arrives, conduct a visual inspection of all packages to confirm that:

1. Shipment arrived without damaging the packaging or its contents.
2. All packages listed on the packing list arrived in good order.

CAUTION

To avoid damage to the membrane module, the module should not be subjected to impact, drops, and excessive vibration.

CAUTION

Take caution when opening the shipping container. Do not damage the membrane with the tools used to open the box.

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## MBR & Submerged UF Transportation, Receiving, Storage, and Disposal of Used Modules

**CAUTION**

Two people are recommended to lift the module at all times.

MBR & Submerged UF membrane modules are shipped in cardboard boxes. NANOH2O strongly recommends inspecting the product for any visible damage or defects immediately upon receipt. If any issues are encountered, please contact an NANOH2O Customer Service representative before accepting the delivery to ensure that your rights are protected. In such cases, NANOH2O will promptly identify possible causes of the damage and determine whether it occurred during transit.

Please notify your carrier or freight forwarder and a NANOH2O Customer Service Representative IMMEDIATELY of any damaged merchandise or product shortages.

**Storage**

Modules are shipped in cardboard boxes, typically containing 5 modules. Do not stack module boxes more than 5 layers: excessive stacking will damage the membrane or membrane modules. Keep the membrane module boxes dry during storage and prevent moisture from entering the boxes, as the integrity of the box will be compromised if wet.

Before use, the module(s) should be stored, in their original packing, in an area between 5-40˚C (41-104˚F), with good ventilation, no direct sunlight, and no corrosive substances.

Allowing the module to freeze by reaching temperatures below 0˚C (32˚F), may cause serious damage to the membrane.

After factory performance testing, membranes are preserved in a protective solution of 30% Calcium Chloride ($CaCl_2$) and water. This prevents damage to the membrane, along with bacterial growth. Do not open the membrane module bags until ready to assemble the module(s).

NANOH2O MBR & Submerged UF modules should NOT be stored in areas exposed to direct sunlight.

NANOH2O MBR & Submerged UF modules should NOT be stored in areas where damage can occur from moving equipment such as forklifts and pallet jacks.

For long-term storage (greater than 60 days), periodically re-inspect the shipping containers to ensure that there is no physical damage or leakage. Any leakage may indicate a loss of the membrane preservative.

Please contact NANOH2O Technical Services for instructions and supplies for re-preserving the modules.

Modules stored per the conditions listed in this bulletin, with original factory packaging and vacuum seal intact, are likely to meet expected performance for storage periods up to 12 months and possibly longer.

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MBR & Submerged UF Transportation, Receiving, Storage, and Disposal of Used Modules

### Disposal of Used Module

Used NANOH2O membrane modules should be disposed of in accordance with all local and federal regulations. Used membrane modules can be disposed of as municipal waste provided that no preservation solution or other hazardous liquids remain within the module and no deposition of hazardous substances on the membranes at concentrations exceeding regulatory standards.

If the user wants to recycle the module, the material components by weight of an unused module can be found below:

| Material | Weight (%) |
|---|---|
| Nitrile Rubber | 0.1 – 0.2 |
| ABS (Acrylonitrile-Butadiene-Styrene) | 15 - 30 |
| PVDF | 60 - 80 |
| Epoxy (2Part) | 2 - 6 |
| Polyurethane | 2 - 6 |
| Silica Gel | 0.1 - 0.5 |

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## MBR & Submerged UF System Pre-Startup Considerations and Checklist

Successful system performance, both short term and long term, depends on handling, operation, and maintenance in accordance with all published guidelines and limits. Specific guidelines and limits can be found in:

- Performance Projection Software
- Membrane Specification Sheets
- Standard and Custom Warranties
- Technical Service Bulletins

Please refer to all appropriate documents to become familiar with the guidelines and limits for a specific project. As a membrane supplier, NANOH2O's scope of supply and liability is limited. The considerations and items presented below are intended as a general reference and are not to be considered all-inclusive for any specific project.

### Feedwater Source

- Analyze the feedwater source for contaminants, inorganic and organic matter, and suspended solids to ensure they are within the limits considered for the system design.
- Ensure pretreatment processes and associated equipment, especially coarse and fine screening, is installed and working properly.
- Ensure a stable and sufficient flow rate for the MBR or Submerged UF system.

### Instrumentation, Sampling, and Monitoring

Each train requiring monitoring and performance tracking contains, as a minimum, provisions for reporting:

- Feed water flow rate ($m^3/h$) (gpm)
- Pressure gauges/transmitters, positioned to measure transmembrane pressure (kPa) (psi)
- Feed water temperature (°C) (°F)
- pH sensors installed in the biological reactor and filtrate lines for MBR
- Filtrate water turbidity (NTU) to monitor filtrate quality

Ensure that:

- Instruments are properly located and installed.
- Instruments are calibrated to the manufacturer's specifications.
- SCADA (Supervisory Control and Data Acquisition), if provided, is functioning and available for retrieval of historic operating data.
- Data collection routine for startup and long-term operation has been established.
- Arrangements have been made to use NANOH2O's data acquisition program or direct transmission of data (in spreadsheet form) to NANOH2O for review.
- Sample points are established for influent, mixed liquor, and filtrate.

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## MBR & Submerged UF System Pre-Startup Considerations and Checklist

**Key Parameters to Monitor:**

- Mixed Liquor Suspended Solids (MLSS)
- Chemical Oxygen Demand (COD) for MBR
- Biochemical Oxygen Demand (BOD) for MBR
- Total Nitrogen (TN) for MBR
- Total Phosphorus (TP) for MBR
- Ammonia for MBR
- Nitrate
- Periodic microbial analysis for assessment of microbial community health
- Transmembrane pressure
- Feed water temperature
- Feed water flow rate
- Filtrate flow rate
- Product water turbidity

**Pre-Startup Checklist**

Before loading cassettes into the tanks, confirm that the system is ready for commissioning and subsequent operation.

- Verify that all tanks and piping have been cleaned and are free of debris.
- Verify all mechanical installations are complete and secure.
- Confirm electrical connections and control systems are operational.
- Check that all valves are in the correct position.
- Verify that aeration systems are working properly.
- Test all pumps for proper operation.
- Confirm chemical dosing systems are ready (if applicable).
- Ensure all instrumentation is calibrated and functioning.
- The feed water quality is satisfactory, within design expectations.
- The drain system is ready.
- Auto control system is ready.
- Biological process equipment and controls have been checked and are ready to receive sludge (MBR).

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MBR & Submerged UF System Pre-Startup Considerations and Checklist

### Prohibited Chemicals

In general, NANOH2O S-series modules have very high chemical tolerance. However, generally speaking, chemicals commonly known to be incompatible with PVDF, PVC, ABS, polyurethane, and EPDM should be avoided. The following is a non-exhaustive list of chemicals that should not come into contact with the UF modules:

| Class | Examples |
|---|---|
| Non-Polar Solvents | Pentane, Heptane, Hexane, Toluene, Benzene, Chloroform, Cyclohexane |
| Slightly Polar Solvents | Chlorobenzene, Cyclohexanone, Acetaldehyde, etc. |
| Polar Aprotic Solvents | Acetone, Acetonitrile, Dimethylformamide (DMF), Dimethylacetamide (DMAC), Dimethyl sulfoxide (DMSO), N methyl-2-Pyrolidone (NMP), Methyl ethyl ketone (MEK), Methyl Butyl Ketone (MBK), Methyl Isobutyl Ketone, Methyl Acetone etc. |
| Alcohols | High concentrations (E.g. >50%) of Methanol, Ethanol, Diacetone alcohol |
| Paint Thinners | Turpentine, Naphtha, Kerosene, Xylene, etc. |
| Ethers | Diethyl ether, Tetrahydrofuran, Isopropyl Ether, etc. |
| Esters | Ethyl acetate, Butyl acetate, Isopropyl Acetate, Cellulose acetate, Ethyl Benzoate etc. |
| Selected Strong Alkalis | 50% NaOH |
| Chlorinated Compounds | Chlorinated solvents |
| Selected Acids | Chlorosulfonic Acid, Phosphoric Acid (molten and anhydride) |

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## MBR & Submerged UF System Pre-Startup Considerations and Checklist

**Confirmation Checklist Before MBR System Commissioning**

1. Project Name:

2. Project process

3. Tasks to be commissioned (scope of work and responsibilities)

4. Overall commissioning plan (Table 1)

| Work Content | Plan Start and Finish Time | Remarks |
|---|---|---|
| Official Electricity Connection | | |
| Commissioning Water Connection | | |
| Stand-alone Commissioning | | |
| Clearwater Linkage Test Run | | |
| Sewage Test Run | | |
| Commissioning and Training Complete | | |

5. List of documents to be provided before commissioning (Table 2)

| Document | Submission time | Remarks |
|---|---|---|
| Design | When requesting commissioning services | Final version |
| Design Notes | When requesting commissioning services | |
| Process Control Instructions | When requesting commissioning services | |
| PID | When requesting commissioning services | Final version |
| Process Construction Drawing | When requesting commissioning services | Final version |
| Change of Drawings | When requesting commissioning services | |

6. Confirmation of completion of works prior to commissioning (Form 3)

| Categories | Content of Work | Completion | Remarks |
|---|---|---|---|
| **1. Pre-treatment System** | Are the installation and commissioning of the Coarse grid and lift pump house complete? | Y □<br>N □ | |
| | Is the installation and commissioning of the fine grid complete? | Y □<br>N □ | |
| | Is the installation and commissioning of the grit tank complete? | Y □<br>N □ | |
| | Installation and commissioning of the membrane grid is complete (including grid body, filter press, flushing, automatic control, etc.)? | Y □<br>N □ | |
| **2. Bio-system** | Is the installation of agitators, propellers, return pumps, biochemical blowers, aerators, and instrumentation complete? | Y □<br>N □ | |
| | Is the stand-alone commissioning complete? | Y □<br>N □ | |
| | Is the pipeline and valve installation complete? | Y □<br>N □ | |
| | Is pipeline purging, pressure testing completed? | Y □<br>N □ | |
| | Is biochemical dosing pumps, storage tanks, pipework installation completed? | Y □<br>N □ | |
| | Is the commissioning of the dosing pumps completed? | Y □<br>N □ | |
| | Is the pressure test and leak test completed for each dosing line? | Y □<br>N □ | |
| **3. Membrane System** | **3.1 Membrane tanks and their facilities** | | |
| | Is the installation of the membrane tank inlet and outlet gates complete? | Y □<br>N □ | |
| | Completion of closed water test on inlet and outlet gates of membrane tanks. | Y □<br>N □ | |

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MBR & Submerged UF System Pre-Startup Considerations and Checklist

| Categories | Content of Work | Completion | Remarks |
|---|---|---|---|
| 3. Membrane System | Is the membrane tank inlet baffle installed? | Y ☐<br>N ☐ | |
| | Is the membrane tank corrosion protection complete? | Y ☐<br>N ☐ | |
| | Is the membrane tank cleaned of debris? | Y ☐<br>N ☐ | |
| | Membrane skid guide rails installed in accordance with requirements. | Y ☐<br>N ☐ | The distance between the two points on the inside and the top of the guide rail is required to be controlled at L+25, with an error of no more than ±5mm. |
| | Is the membrane skid levelling complete? | Y ☐<br>N ☐ | The height difference between the 4 fixed feet of the membrane skid placed on the bottom of the same membrane tank should be controlled within ±5mm in the length direction, ±3mm in the width direction, and ±5mm in the bottom of each membrane tank. |
| | Is the membrane skid inside the membrane tank and filled with water? | Y ☐<br>N ☐ | |
| | Is the installation and calibration of the membrane tank level gauge complete? | Y ☐<br>N ☐ | |
| | Is the installation and calibration of the membrane tank inlet channel level gauge complete? | Y ☐<br>N ☐ | |
| | Is the installation and calibration of the membrane tank return channel level gauge complete? | Y ☐<br>N ☐ | |
| | Is the installation and calibration of the membrane tank return channel level gauge complete? | Y ☐<br>N ☐ | |
| | Is the installation of the membrane tank return pump complete? | Y ☐<br>N ☐ | |
| | Completion of stand-alone commissioning of membrane tank return pumps. | Y ☐<br>N ☐ | |

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## MBR & Submerged UF System Pre-Startup Considerations and Checklist

| Categories | Content of work | Completion | Remarks |
|---|---|---|---|
| | Is the membrane tank crane installation complete? | Y ☐<br>N ☐ | |
| | Is the crane quality control test completed? | Y ☐<br>N ☐ | |
| | Is the commissioning of the membrane tank crane complete? | Y ☐<br>N ☐ | |
| | **3.2 Membrane permeate facilities** | | |
| | Is the installation of the permeate pump complete? | Y ☐<br>N ☐ | |
| | Is stand-alone commissioning of permeate pumps complete? | Y ☐<br>N ☐ | |
| | Is the installation and purging of the permeate pipeline complete? | Y ☐<br>N ☐ | |
| | Is the pressure test of the permeate pipeline completed? | Y ☐<br>N ☐ | |
| **3. Membrane System** | Is the installation of the permeate control valve complete? | Y ☐<br>N ☐ | |
| | Is the installation of electromagnetic flow meters for permeate pipelines complete? | Y ☐<br>N ☐ | Guaranteed full pipes and easy maintenance |
| | Is the installation of the pressure transmitter for the permeate pipeline complete? | Y ☐<br>N ☐ | |
| | Is the installation of the turbidity meter in the permeate pipeline complete? | Y ☐<br>N ☐ | It is recommended that water is taken from the side of the pipe and not at the top. |
| | Is the blowing and pressure testing of the permeate pipeline completed? | Y ☐<br>N ☐ | |
| | **3.3 Vacuum facilities** | | |
| | Suction pump/kit installation and commissioning completed (if designed). | Y ☐<br>N ☐ | |
| | Vacuum pipeline airtightness test completed (if designed to do so). | Y ☐<br>N ☐ | |

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## MBR & Submerged UF System Pre-Startup Considerations and Checklist

| Categories | Content of work | Completion | Remarks |
|---|---|---|---|
| 3. Membrane System | **3.4 Membrane aeration facilities** | | |
| | Is the installation and commissioning of the membrane blower complete? | Y ☐<br>N ☐ | |
| | Is the installation of the membrane aeration pipe valves and purging completed? | Y ☐<br>N ☐ | |
| | Is the installation of membrane aeration flow meter, pressure monitor and other instruments complete? | Y ☐<br>N ☐ | |
| | **3.5 MC facilities** | | |
| | Is the backwash pump installation complete? | Y ☐<br>N ☐ | No taking water at the top of the permeate pipeline |
| | Is the backwash pump stand-alone commissioning complete? | Y ☐<br>N ☐ | |
| | Backwash pipe installation and purging completed. | Y ☐<br>N ☐ | |
| | Is the backwash flow control valve installation complete? | Y ☐<br>N ☐ | |
| | Backwash pipeline pressure test/leak test completed. | Y ☐<br>N ☐ | |
| | Is the backwash flowmeter installed? | Y ☐<br>N ☐ | |
| | Is the MC dosing pump installation complete? | Y ☐<br>N ☐ | |
| | Are the other MC dosing pump installation complete, if more than one? | Y ☐<br>N ☐ | |
| | Is the stand-alone commissioning of the MC dosing pump(s) complete? | Y ☐<br>N ☐ | |
| | Is the MC chemical storage tank installed in position? | Y ☐<br>N ☐ | |
| | Is the MC dosing pipeline installed? | Y ☐<br>N ☐ | |
| | Leak testing and pressure testing of MC dosing pipes completed. | Y ☐<br>N ☐ | |
| | MC chemicals in place. | Y ☐<br>N ☐ | |

| Categories | Content of work | Completion | Remarks |
|---|---|---|---|
| **5. Instrument air system** | Is the installation of air cleaners and air compressors complete? | Y □<br>N □ | |
| | Is the stand-alone commissioning of air cleaners and air compressors completed? | Y □<br>N □ | |
| | Is the installation of the air storage tank complete? | Y □<br>N □ | |
| | Completion of quality inspection of air storage tanks. | Y □<br>N □ | |
| | Installation and purging of instrument air system pipeline completed. | Y □<br>N □ | |
| | Is the instrument air system pipeline pressure test complete? | Y □<br>N □ | |
| **6. Electro-instrumental systems** | Completion of automatic control programming. | Y □<br>N □ | This part should be completed before the automatic control equipment leaves the factory |
| | Completion of the automatic program simulation. | Y □<br>N □ | |
| | Is the PLC cabinet screen complete? | Y □<br>N □ | |
| | Is the host computer screen complete? | Y □<br>N □ | |
| | Is the communication between the PLC cabinet and the host computer complete? | Y □<br>N □ | |
| | Is the communication between each machine, pump and instrument and the PLC cabinet complete? | Y □<br>N □ | |
| | Power supply and distribution system installation and power-on testing completed? | Y □<br>N □ | |

7. **Others**

7.1 Are the required operational and management personnel in place during commissioning, experienced in the commissioning or operation of similar processes, and trained in the operation and management of similar process wastewater treatment plants?

7.2 Are the necessary chemicals available for commissioning?

7.3 Are sludge transport and final disposal outlets coordinated? Are contracts commissioned.

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# Technical Service Bulletin 803

MBR & Submerged UF Skid & Module Assembly

## Skid Assembly

**WARNING**

The protective solution, 30% Calcium Chloride ($CaCl_2$), can cause serious eye irritation. Wear protective gloves, appropriate skin protection, and eye protection when handling. IF IN EYES: Rinse cautiously with water for several minutes.

**CAUTION**

The protective solution, 30% Calcium Chloride ($CaCl_2$), can corrode metals. Should the metal pipes or skids come into contact with the protective solution, water should be used to clean the affected area immediately to prevent corrosion. Protective solution should be discharged according to local requirements.

**CAUTION**

After removing the protective solution, skid installation should be completed as soon as possible to prevent the membrane fibers from drying out. Once the membrane fibers become dry, the filtration performance of the module may deteriorate or even be totally lost.

**CAUTION**

Use scissors or paper cutter to open the adhesive tape and open the outer carton and individual boxes.

**CAUTION**

When cutting the module bags with a tool, only cut near the plastic filtrate pipe end. Do not use any sharp objects near the membrane fibers.

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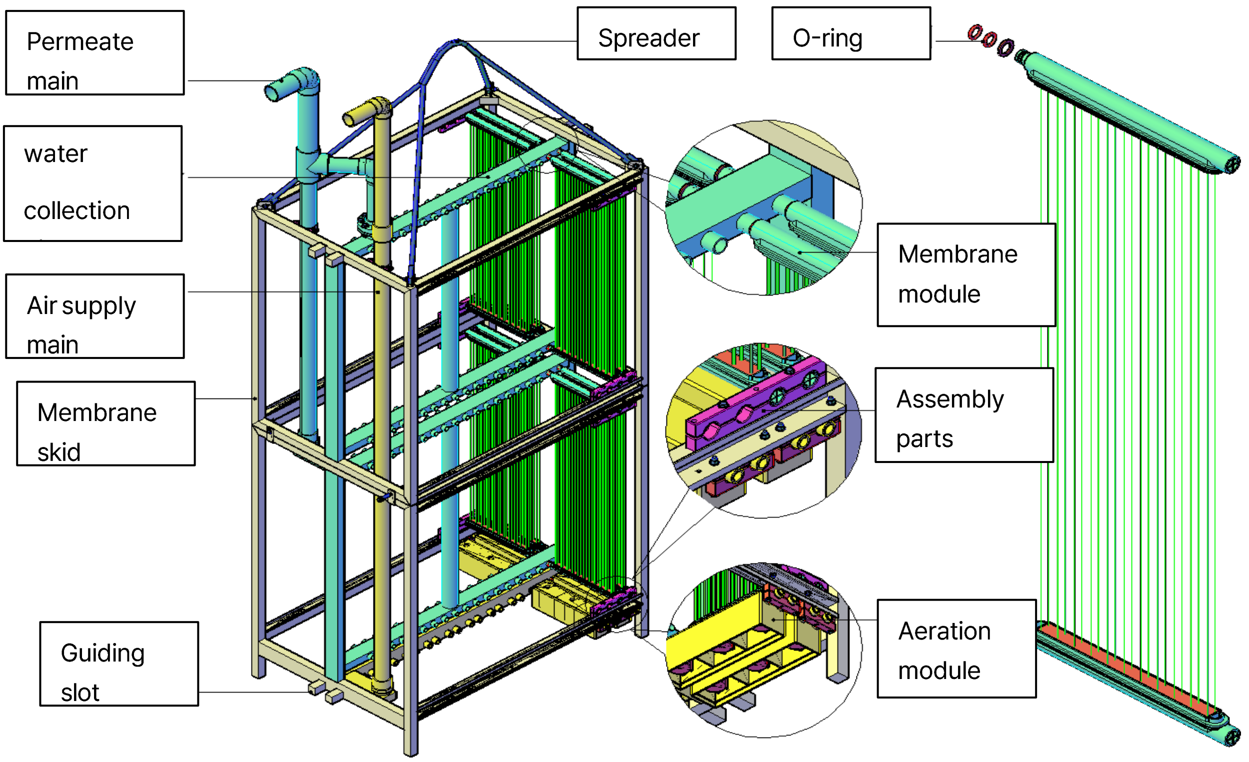
MBR & Submerged UF Skid & Module Assembly

### S-Series Skid Components

- Submerged membrane modules: including membrane hollow fibers, water collection pipes, seals etc.
- Water collection system: including permeate mains, water collection pipes, etc.
- Aeration system: including air supply mains, Air box or Air pipes, etc.
- Membrane skid: single or double layer.
- Spreader: could be multiple structures such as double hook spreader and tie rod spreader.
- Guiding Slot: U-shaped guiding and positioning slot at both ends of the membrane device.
- Assembly parts: including various plastic assembly parts, splints and bolt fasteners.

**Figure 1: S Series Skid components**



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MBR & Submerged UF Skid & Module Assembly

### Membrane Device Assembly and Testing

Corresponding preparations must be made before assembling the membrane device, including passing the air tightness test of the membrane skid frame, preparing the site, trained personnel, and complete accessories and tools.

### Site Preparation

- Assemble the module indoors to avoid direct sunlight, keep the room ventilated and clean.
- Indoor headroom height and door size should meet the requirements.
- Stabilized power supply available.
- Having a crane for easy loading and unloading is recommended.
- The installation site is divided into module storage area, accessories storage area, module installation area and membrane device inspection area.

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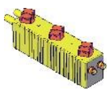
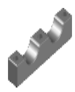
MBR & Submerged UF Skid & Module Assembly

### Preparation of Accessories and Tools

The accessories required when assembling the membrane device are shown in Table 1. For specific quantities, refer to the project specific membrane drawings and BOM table

**Table 1 : List of Accessories**

| S/N | Item | Spec (mm) (L*W*H) | MOC | Legend | Remarks |
|---|---|---|---|---|---|
| 1 | Module (with accessories) | 571×45×**** | PVDF | 1.  2.  | Height of module depends on model |
| 2 | Flat Seal | D38×φ27×3.0 | Nitrile rubber | | Already mounted on the membrane module |
| 3 | O-Ring | D28×φ4 | Silicon rubber | 3  4  | Already mounted on the membrane module |
| 4 | Module Splint (type D) (4 module position & 5 bolt holes) | 296×33×25 | ABS | | For Membrane Module Fixing |
| 5 | Air Scouring Box/aeration module | 180×30×30 | ABS | 5.  6.  | |
| 6 | Module Splint (type B) 2 module position & 3 bolt holes) | 150×33×25 | ABS | | For Air Scouring Box Fixing |
| 7 | Hex Bolt, Nut, Flat Washer, Lock Washer | M8×90 | SS304/SS316 |  | For splint and Air Scouring Box |
| 8 | Hex Bolt, Nut, (2) Flat Washer, Lock Washer | M12×60 | SS304/SS316 | | For skid |
| 9 | Hex Bolt, Nut, (2) Flat Washer, Lock Washer | M12×80 | SS304/SS316 | | For spreader |
| 10 | Skid | | SS304/SS316 | | |

The tools required when assembling the membrane device are shown in Table 2.

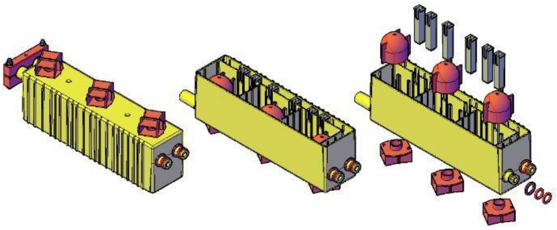
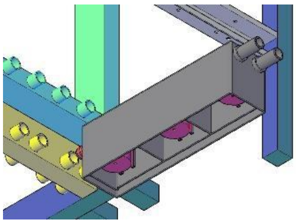
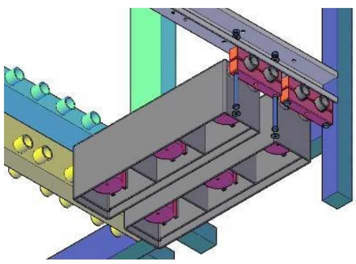
**Table 2 : List of Tools**

| paper cutter | Scissors | Open-end and Flat Wrenches | Adjustable Wrenches |
|---|---|---|---|
|  |  |  |  |
| **Rubber Mallet** | **Ladder** | **mobile scaffolding** | **spirit level** |
|  |  |  |  |
| **Thread Locker** | | | |
|  | | | |

### Air Box Installation (where applicable)

The installation procedure of the air box is as shown in Table 3.

**Table 3 : Air Box Installation Process Table**

| Process | Figure | Notes |
|---|---|---|
| 1 |  | Air box inspection:<br><br>Check whether the flat washer and O-ring on the air box are installed in place;<br><br>Check whether the internal plug-in and water sealing box have been bonded well. |
| 2 |  | Air box insert:<br><br>Insert the air inlet end of the air box parallel to the joint of the air pipe and insert evenly with a rubber hammer. Water can be applied to the sealing ring of the air box to lubricate it, if needed.<br><br>The other end of the air box must be temporarily lifted before the splint is attached. Do not leave the other end in a suspended state, which will result in breaking the air inlet of the aeration box. |
| 3 |  | Air box fixed:<br><br>Use a two-position splint to fix the air box, and use a wrench to tighten the bolts, being careful not to overtighten, which may cause the splint to be significantly deformed.<br><br>Bolts to be tightened properly with flat and spring washers. Below are options generally used to seal bolts.<br><br>Option 1 - The bolts should be coated with thread lock compound.<br><br>Option 2 – Self-Locking bolts can be used to prevent loosening and will be in client scope.<br><br>Each bolt is equipped with two flat washers, one spring washer and one nut.<br><br>Each aeration box is required to be installed horizontally and at the same height. |

### Membrane Module Installation

The membrane module installation procedures are shown below.

**Table 4：Membrane Module Installation Process Table**

| Process | Figure | Notes |
|---|---|---|
| 1 |   | Open the outer carton:<br>Use scissors or a paper cutter to cut the tape and open the outer carton. Be careful not to scratch the membrane fiber.<br>Then open the carton of the membrane module. |
| 2 |   | Take out the membrane module:<br>After opening the outer carton, lay the membrane module flat on a flat workbench.<br>Use scissors or a paper cutter to open the plastic packaging bag from one end of the membrane module.<br>Note: When using a knife, it is required to cut at the membrane water collecting pipe end. It is strictly prohibited to use sharp tools such as knives near to the membrane fibers, which may cause membrane fiber damage. |
| 3 |   | Check the accessories:<br>Open and remove the plastic wrap (one person holds the collection pipe while the other person removes the plastic wrap). Check the number of seals on the filtrate outlet, it should include membrane modules, O-rings, flat seals. |

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MBR & Submerged UF Skid & Module Assembly

| | | |
|---|---|---|
| 4 |   | Transporting membrane components:<br><br>When transporting the membrane modules, two people should hold both ends of the membrane module and let the membrane fibers hang down naturally.<br><br>Note: Do not tighten or touch the membrane fiber. |

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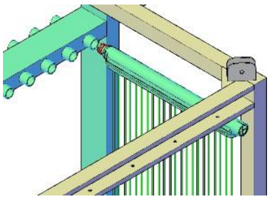
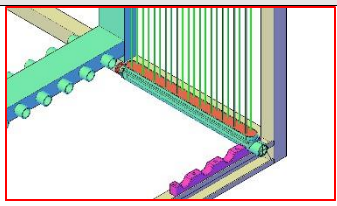
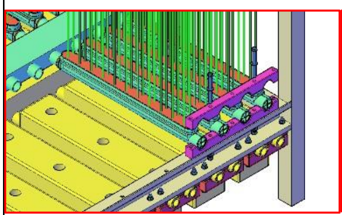
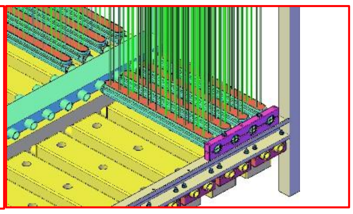
| Process | Figure | Notes |
|---|---|---|
| 5 |    | Insert membrane module:<br><br>Insert the filtrate outlets at the upper and lower ends into the water collecting pipe interface of the membrane skid respectively. (Insert the upper interface first, then the lower interface.)<br><br>The upper water collection pipe of the membrane module must be temporarily lifted before being fixed by the splint. It cannot be left in a suspended state to avoid breaking the outlet of the membrane module.<br><br>Note: Do not tighten or touch the membrane fiber. Add water to the opening of the tube to lubricate it for assembly and rotate it for insertion. |
| 6 |       | Fixed membrane modules:<br><br>Straighten the membrane module, then tap one end of the membrane module with a rubber mallet to insert it into place, and finally tighten the splint with bolts.<br><br>Bolts to be tightened properly with proper flat and spring washers. Below are options generally used to seal bolts.<br><br>Option 1 - The bolts should be coated with thread lock compound.<br><br>Option 2 – Self-Locking bolts can be used to prevent loosening and will be in client scope.<br><br>Each bolt is equipped with two flat washers, one spring washer and one nut.<br><br>Notice: When tightening the bolts, be careful not to over-tighten the bolts, which may deform the splint or break the water collection box of the membrane module. |

Repeat steps 1-6 until all the modules are installed in the skid.
Note the module serial number engraved on the module pipe & location of the modules in the skid.

**On-site Assembly of Membrane Skids**

CAUTION

Only qualified personnel should operate machinery required to lift skids into the membrane tank.

CAUTION

Use Personal Protective Equipment (PPE), including but not limited to a hard hat, safety vest, etc.

Double-layer membrane skids are divided into integrated and split types. The upper and lower layers of the integrated double-layer membrane skid are connected together and do not require on-site assembly. The upper and lower layers of the split double-layer membrane skid are separated during transportation and then assembled on site.

**Site Requirements**

A spacious site must be prepared for the assembly of the double-layer membrane skid, with sufficient space around the membrane skid to set up an operating platform. The ground of the venue should be flat and solid.

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MBR & Submerged UF Skid & Module Assembly

### Membrane Skid Assembly Materials and Tools

The materials required for membrane skid assembly are shown in Table 5.

**Table 5 : Materials Required for Membrane Skid**

| S/N | Item | Spec（mm）(L*W*H) | MOC | Legend | Remarks |
|---|---|---|---|---|---|
| 1 | Pipe gasket | Refer to drawings or BOM | ABS | 1  | On-site procurement and installation |
| 2 | Male straight joint | | UPVC | 2  | |
| 3 | Straight pipe | | UPVC | 3  | |
| 4 | Elbow | | UPVC | 4  | |
| 5 | Flange | | UPVC | 5  | |
| 6 | Gasket | | Nitrile rubber | 6  | |
| 7 | DN100 pipe | | UPVC | 7  | |
| 8 | DN100 elbow | | UPVC | 8  | |
| 9 | DN100 tee | | UPVC | 9  | |
| 10 | DN80-100 core filling | | UPVC | 10  | |
| 11 | Hexagon bolt set | M12×60 | SS304/SS316 | 11-13  | Connect the upper and lower skid |
| 12 | Hexagon bolt set | M12×80 | SS304/SS316 | | For lifting lugs |
| 13 | Hexagon bolt set | M16×80 | SS304/SS316 | | For flange |
| 14 | Pipe connector | Refer to drawings or BOM | SS304 | 14  | |

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The tools required for membrane skid assembly are shown in Table 6.

**Table 6 : Membrane Skid Assembly Tool List**

| Ladder or platform | Adjustable wrench | Socket wrench | Cutter |
|---|---|---|---|
|  |  |  |  |
| **Sandpaper** | **Rag** | **PVC glue (PVC711)** | **Crane** |
|  |  |  |  |

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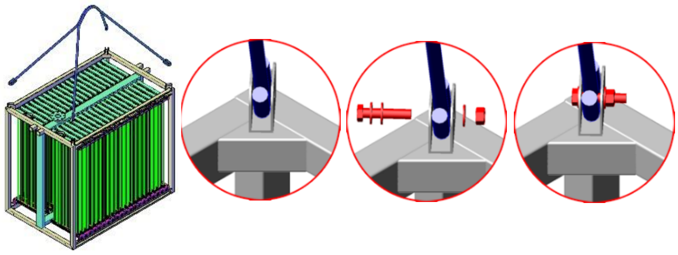
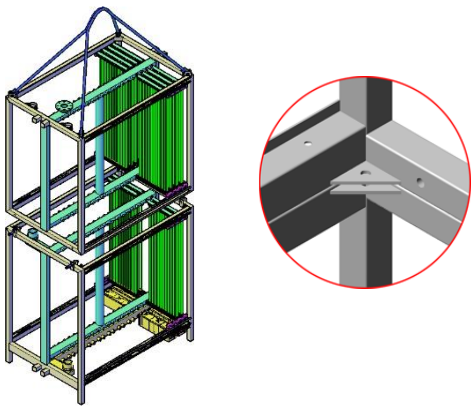
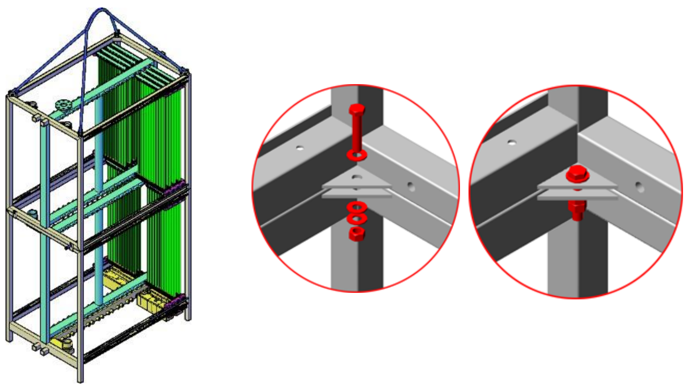
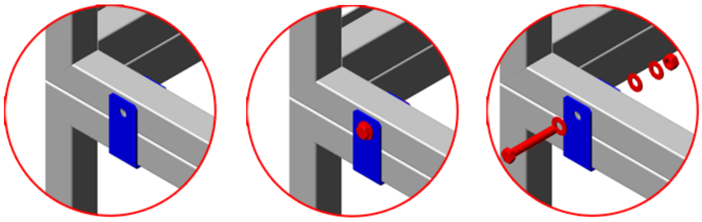
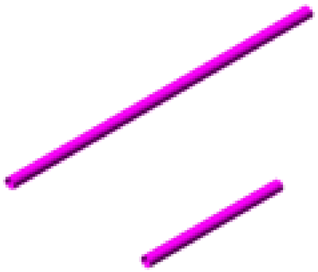
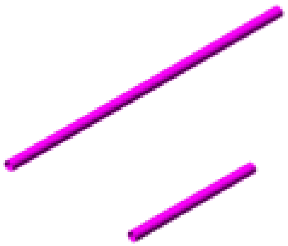
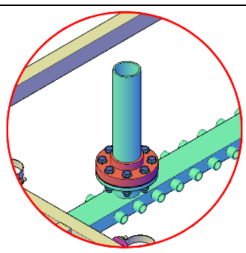
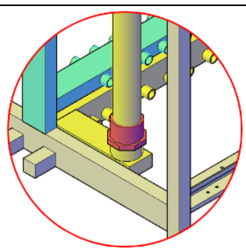
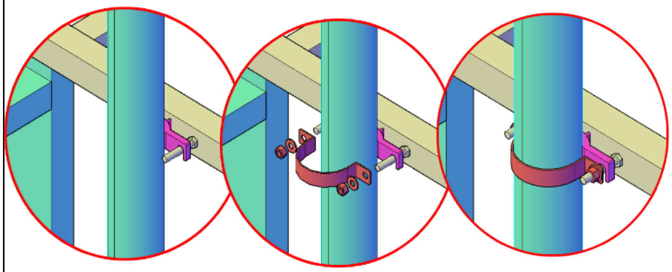
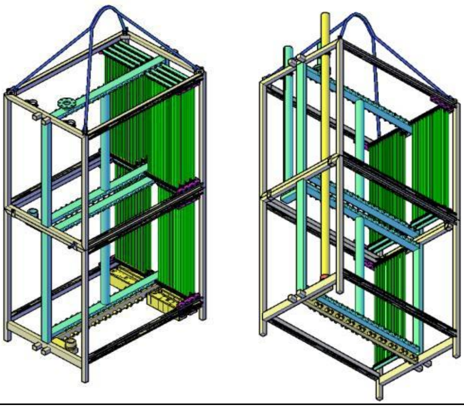
## MBR & Submerged UF Skid & Module Assembly

### Membrane Skid Assembly Steps

**Table 7 : Membrane Skid Assembly Steps**

| | | |
|---|---|---|
| **1** |  | Spreader installation:<br>Place the lifting sling in the four lifting lugs of the upper membrane skid and fix it with M12×60 bolts. 1 bolt with 1 nut, 2 flat washers and 1 spring washer, a total of four sets.<br>Bolts to be tightened properly with proper flat and spring washers. Below are options generally used to seal bolts.<br>Option 1 - The bolts should be coated with thread lock compound.<br>Option 2 – Self-locking bolts can be used to prevent loosening and will be in client scope. |
| **2** |  | Alignment of upper and lower membrane skid:<br>Before aligning the upper and lower membrane skids, first check whether the numbers of the upper and lower membrane skids correspond.<br>Use a crane to place the upper membrane skids on the lower membrane skids and align the holes. At this time, be careful not to touch the DN100 male straight joint on the lower membrane skids directly and protect the membrane. |
| **3** |  | Fix the upper and lower membrane skid 1:<br>Use M12×60 bolts to fasten the membrane skid through the fixing pieces of the upper and lower membrane skid.<br>1 bolt with 1 nut, 2 flat washers and 1 spring washer, 4 sets in total.<br>Bolts to be tightened properly with proper flat and spring washers. Below are options generally used to seal bolts.<br>Option 1 - The bolts should be coated with thread lock compound.<br>Option 2 – Self-locking bolts can be used to prevent loosening and will be in client scope. |

| | | |
|---|---|---|
| 4 |  | Fix the upper and lower film frames 2:<br>Put the lifting lugs into the lower membrane skid and use M12×80 bolts to pass through the holes of the lifting lugs and the upper membrane skid to fix it.<br>1 bolt with 1 nut, 2 flat washers and 1 spring washer, 4 sets in total.<br>Bolts to be tightened properly with proper flat and spring washers. Below are options generally used to seal bolts.<br>Option 1 - The bolts should be coated with thread lock compound.<br>Option 2 – Self-locking bolts can be used to prevent loosening and will be in client scope. |
| 5 |   | Cut the pipe:<br><br>Use a cutting machine to cut the pipe to the appropriate length, and chamfer each end to facilitate assembly to the fittings. |
| 6 |   | Grinding pipes:<br><br>Use sandpaper to polish the outer surfaces of both ends of the pipe to ensure a firm bond. The length is about 50-80MM. |
| 7 |   | Pipe bonding:<br>Use PVC cement to directly bond the PVC pipe to the flange and male straight coupling. Wipe off excess glue with a rag.<br>Do not touch the membrane fibers during this operation! |

| | | |
|---|---|---|
| 8 |  | Fixed pipe:<br><br>Install the pipe gasket. Use a wrench to secure the stainless-steel pipe clamp with an M10 nut. |
| 9 |  | Examine:<br><br>After the pipeline installation is completed, check the bolt assembly again, and finally use a crane to lift the membrane device into the membrane tank. |

NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 803

MBR & Submerged UF Skid & Module Assembly

**Membrane Skid Installation**

Before installing the membrane skid, it is necessary to determine whether the conditions are met. The prerequisites for the installation of the membrane device include: the membrane tank has been cleaned, the anti-corrosion lining of the membrane tank has been completed, the leveling brackets and guide rails in the membrane tank have been installed, the filtrate pipes and air pipes in the membrane tank pipe gallery have been installed, and the front and rear gates of the membrane tank have been installed. After the installation is completed, there must be a clean water source that can enter the membrane tank for purposes of commissioning.

The membrane device installation steps are shown in Table 8.

**Table 8 : Membrane Skid Installation Steps**

| S/N | Figure | Notes |
|---|---|---|
| 1 |  | Move the membrane device into the membrane tank:<br>The outer packaging of the membrane device must be removed before being placed in the membrane tank. Use a forklift or crane to move the membrane device to a lifting position near the membrane tank. Use a crane to lift the membrane skid into the membrane tank along the guide rails.<br>Note: Make sure the forklift does not touch the aeration box. |
| 2 |   | Pipe connection:<br>After the membrane device is in place in the membrane tank, measure the length of the required connecting pipes, and then cut and connect them.<br>Notice: Construction workers cannot step directly on the water collecting pipe of the membrane module.<br>A hard plate can be placed above the membrane skid, and construction workers can step on the hard plate for construction purposes to prevent the membrane module from being stepped on.<br>Do not carry out welding, metal cutting and other work in or above the membrane tank to avoid damage to the membrane fiber by flying sparks. If not preventable, the membrane within the scope of construction influence must be shielded and protected. |

| | | |
|---|---|---|
| 3 |   | Membrane tank water filling:<br><br>After the membrane device connecting pipe is installed, any fallen debris in the membrane tank must be cleaned again. After cleaning, the membrane tank will be immediately filled with water.<br><br>Note: After installation, keeping the membranes dry for an extended period may lead to irreversible loss of performance. |

**Guide Rail System (not supplied by NANOH2O)**

Guide rails make it possible to lift the MBR skid in and out of the MBR tank without draining the tank contents. Prior to removal of the skid, it is necessary to:

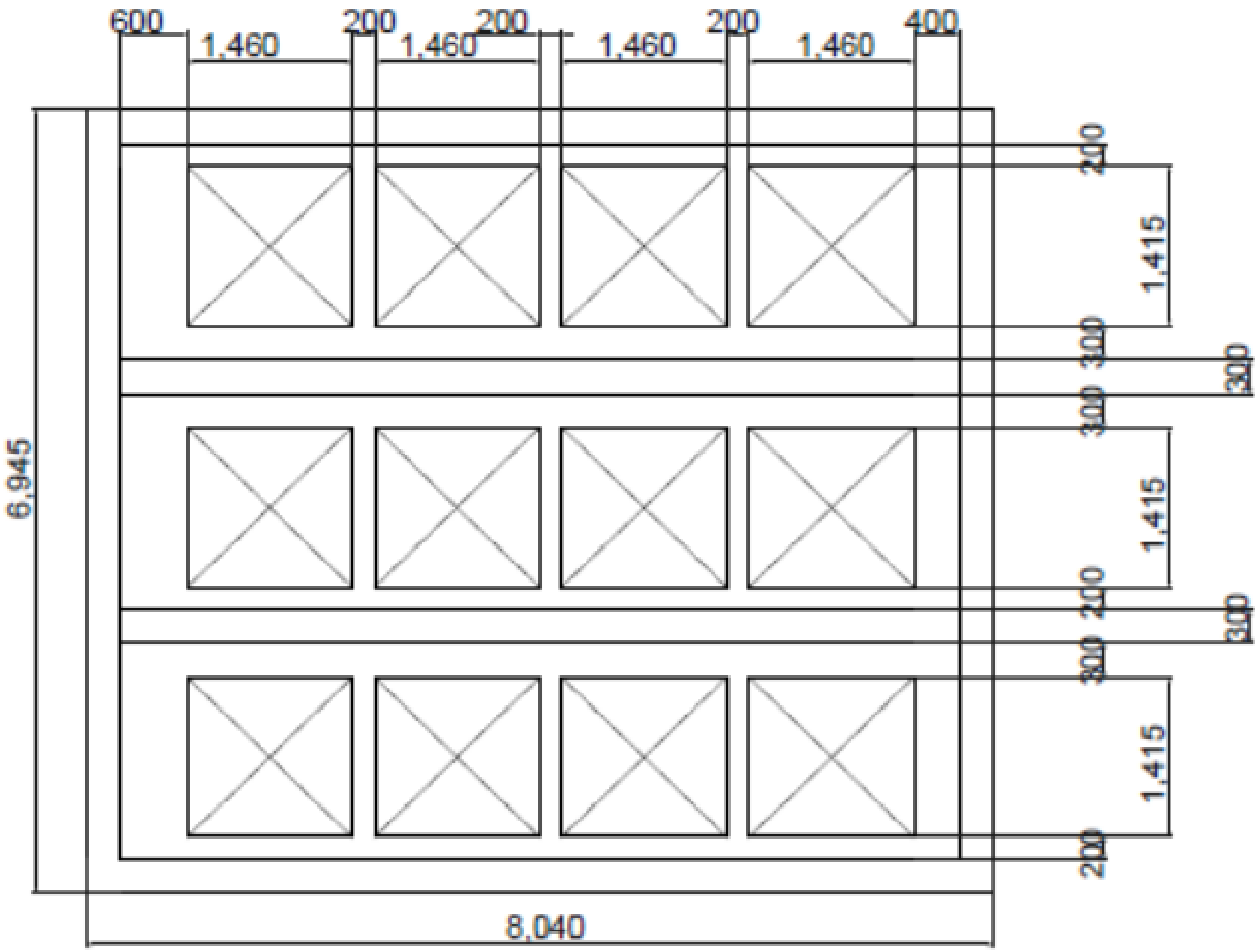
1. Isolate the air supply line to the skid and disconnect the section of pipe connecting the air pipe to the skid.
2. Isolate the filtrate line of the skid from the filtrate manifold and disconnect the section of pipe/hose connecting the filtrate manifold to the skid.

NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 803

## MBR & Submerged UF Skid & Module Assembly

### Skid to Wall Spacing Recommendations




### System Integrity Testing

After the assembly of the membrane device is completed, gas tightness testing should be carried out to check whether the installation of the membrane module is tight and whether the membrane module is complete. The testing process is shown in TSB 806.

NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

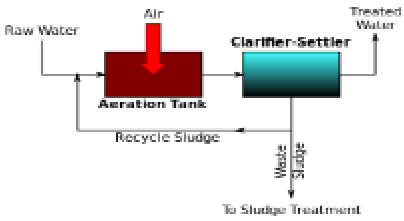
# Technical Service Bulletin 804

## MBR & Submerged UF System Start-up & Operating Procedures

MBR or Submerged UF System commissioning should not occur until the plant is ready to start normal operations. If not, it is better to leave the modules in their shipping containers, stored according to TSB 801. Once the plant is ready to start normal operations, proceed in the following order:

1. Conduct pre-startup checks
2. System Integrity Test
3. Install modules on skid(s)
4. Operating Sequence Test
5. Switch to auto mode

### Terms, Abbreviations, and Definitions

| Terms | Definitions |
|---|---|
| **Submerged Membrane Modules (S-SERIES)** | NANOH2O modules designed for use in submerged applications |
| **Air Scouring** | A physical cleaning method for removing suspended solids fouling from the membrane surface |
| **Bubble Point** | The pressure (at a given temperature) at which the first bubble of gas is formed |
| **Clean Water** | Filtrate, or tap water |
| **Conventional Activated Sludge (CAS) Process** | A wastewater treatment process which relies on well mixed, suspended microorganisms for the degradation of wastewater constituents, and a clarifier which relies on gravity for separation of suspended solids from the treated water   |
| **Feed** | The flowrate of water into the membrane bioreactor system |
| **Filtrate** | Water that has been filtered |
| **Fouling** | Deposits of inorganic or organic substances on the membrane surface, leading to reduction in membrane permeability |
| **Maintenance Cleaning (MC)** | Regular chemical cleaning during normal operation |
| **Membrane** | A physical barrier used for the filtration process |
| **Membrane Bioreactor (MBR)** | A wastewater treatment process that combines biological treatment through activated sludge processes and solids separation through membrane filtration |
| **NTU** | Nephelometric Turbidity Unit, a measure of turbidity |

| Terms | Definitions |
|---|---|
| **P&ID** | Piping and instrumentation diagram |
| **Permeability** | The rate at which water passes through the membrane under defined pressure |
| **Programmable Logic Controller (PLC)** | Controls the membrane system pumps and valves based on stored logic of process sequences and inputs from instrumentation |
| **Return Activated Sludge (RAS)** | Sludge which is pumped from one zone in the treatment process back to an earlier zone In MBRs, typically, from the end of the membrane tank to the front of the aerobic tank, and from the end of the aerobic tank to the front of the anoxic tank |
| **Skid** | A group of UF modules mounted on a frame, connected in parallel to a set of header pipes |
| **Train** | A skid or skids operated in unison |
| **Turbidity** | A measure of cloudiness or haziness of a fluid; the degree to which a transparent liquid scatters light, usually a measure of the amount of suspended material in the liquid |
| **UF** | Ultrafiltration |
| **S-Series Module** | A single, distinct component comprised of hollow fiber ultrafiltration membranes fixed in plastic headers, that is ready for connection to a skid |
| **Waste Activated Sludge (WAS)** | Sludge disposed of from the system to control the MLSS concentration |

NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 804

MBR & Submerged UF System Start-up & Operating Procedures

## Key Operating Parameter Definitions

### Filtrate Flow Rate

Filtrate flow rate is the rate of the water that passes through the membrane from the feed side to the filtrate side. It is a function of the pressure, and the quality of the feed water. The filtrate flow rate should be set according to NANOH2O's recommended membrane flux.

### Filtrate Flux

Filtrate flux is the volume of filtered water passing through a unit of membrane surface area in a specified period of time. It is commonly expressed as lmh (Liters of filtered water/$m^2$ of surface area/hour of filtration time), gfd (gallons of filtered water/$ft^2$ of surface area/day of filtration time), or m/d ($m^3$ of filtered water/$m^2$ of surface area/day of filtration time). Appropriate flux selection is one of the most important design and operating considerations. The filtrate flux should be set according to NANOH2O's recommendation for your specific application. The flux may be increased or decreased during operation to account for changes in feed water quality, temperature, or product water demand.

### Transmembrane Pressure

Transmembrane Pressure (TMP) is the pressure difference between the feed and filtrate sides of the membrane. It is commonly measured in units of bar, psi, or kPa. TMP is the driving force for filtration. Most ultrafiltration/MBR systems operate at a constant flow rate during filtration. As filtration occurs, solids deposited on the membrane surface will create resistance to filtration causing the TMP to increase. Proper design filtrate flux is necessary to control the rate of TMP increase. Physical and chemical cleaning are required to remove accumulated fouling and reduce TMP.

### Normalized Permeability

Normalized permeability, or specific flux, is defined as filtrate flux per applied transmembrane pressure (differential pressure) corrected to a specified temperature, typically 20 or 25 degrees Celsius. It is commonly measured in units of lmh/bar or gfd/psi @20°C. Normalized permeability is one of the most important parameters used to measure the performance of the membrane system. In a properly designed and operated system, the normalized permeability will decrease slowly between cleanings and will return to previous levels after cleaning such that it remains essentially constant over long-term operation.

### Filtration Cycle Duration

The filtration cycle duration is dependent on the quality of the feed water. An appropriate design value should be selected per NANOH2O's recommendation. The actual time should be set by testing at site and adjusted according to the changes of the feed water quality during the operation. Typical filtration cycle duration is 20 - 60 minutes.

# Technical Service Bulletin 804

MBR & Submerged UF System Start-up & Operating Procedures

**Mixed Liquor Suspended Solids (MLSS)**

The Mixed Liquor Suspended Solids (MLSS) is a measure of the concentration of solids suspended in solution in an activated sludge process. It is commonly measured in units of mg/L or g/L. The MLSS is an important design and operating parameter that affects both the biological process and the membrane process. Generally speaking, MBRs operate at higher MLSS concentrations than conventional activated sludge (CAS) processes due to the suspended solids retention capability of the membranes. Higher bacteria density in the MBR system translates to higher removal efficiency of BOD and nutrients in the incoming wastewater. Higher removal efficiency allows hydraulic treatment times, and resulting tank volumes, to be significantly reduced compared to CAS systems. The MLSS concentration impacts the membrane performance by affecting the viscosity of the sludge and the concentration of solids to be filtered. Typically, the viscosity of the sludge increases linearly with increasing MLSS concentration, until the MLSS concentration reaches about 12-15 g/L, at which there is an inflection point and the viscosity increases at a steeper rate with increasing MLSS.

**Associated Documents**

The following documents will be referred to frequently throughout this document. Have them available for quick reference.

- NANOH2O Typical S-Series P&ID (MBR-I-PID-ETS-60001-003)
- NANOH2O Technical Service Bulletins
- Project Specific Design Calculation Output

**Initial System Start**

Once all pre-startup checks have been concluded, the system is ready for module loading and process startup.

Ensure that cassettes and membranes are assembled and installed in accordance with TSB 803.

Fill the system with clean water. Proceed as follows for each skid or train:

- Start the air blower, feeding air to the skid(s) and check that the air diffusion at the membrane skid is evenly distributed. Foaming may occur during clean water operation but does not affect system performance.
- Allow the air blower to operate for 5 – 10 minutes and discard the water in the tank to get rid of any residual membrane preservative.
- Start the filtration process and allow enough time for displacement of air and establishing of a vacuum in the filtrate manifold.
- Make sure that any leaks are identified and repaired prior to introducing the process influent source.
- Conduct a membrane integrity test (MIT) to ensure that there is no membrane damage or installation errors.

- MIT tests the performance level by injecting air into the Membrane filtrate water lines where the Cassette is installed. It is important to check if there is any leak on any and all joints, including filtrate water lines and valves prior to implementation of MIT.
- In case any large air bubbles are observed, contact NANOH2O for recommendations.
- Discontinue clean water tests and stop the air supply after these tests are completed.
- For MBR system, prepare and add initial mixed liquor or seed sludge in to the aerobic tank.
- Restart the air blower system(s).
- Start with a low percentage of actual wastewater mixed with clean water.
- Gradually increase the proportion of wastewater over time.
- For MBR, monitor biomass health and activity through microscopic examination and respirometry tests.
- Adjust feed water feed rate to design capacity. For MBR, this is also based on biomass response and effluent quality.
- Maintain close observation on MLSS, F/M ratio (MBR only), and effluent quality during this period.

**Unit Operation Control Recommendations**

NANOH2O's scope of supply is usually limited to the membrane modules or skids. However, other unit operations, such as pre-treatment, feed pumping, fine screening, biological treatment, recirculation, and sludge wasting will impact NANOH2O's S-Series product performance. Therefore, a general description of the controls around these unit operations is included. However, NANOH2O takes no responsibility beyond what is explicitly stated in any applicable warranty (separate document).

**Pretreatment**

Pretreatment should be provided and operated, as necessary, to bring feed water quality within NANOH2O feed water quality requirements. For example, coarse screening is usually provided to remove large debris and grit. An oil skimmer(s), dissolved air flotation (DAF), or other treatment process(es) may be utilized for removal/reduction of fats, oil, and grease. Pretreatment processes should remain in proper functioning order and should transmit operational status to the membrane control system. In case of pretreatment failure, a shutdown alarm will be initiated and all affected membrane trains should enter STANDBY mode.

**Feed Pumping**

Feed pumps used to send wastewater to the UF/MBR are normally triggered based on demand. The demand is not determined by NANOH2O. For systems which are discharging treated water, the demand is usually triggered by the water level in the upstream collection or equalization tank. For UF/MBR systems which are designed to produce filtrate for direct reuse or for additional treatment (e.g. reverse osmosis), the demand for the feed pumps to operate is determined by the water level in the downstream filtrate collection tank.

Feed pumps can be designed with Variable Frequency Drives (VFDs) intended to match the feeding flow rate with the filtrate production flow rate to minimize cycling the pumps on and off, or without VFDs and are cycled on/off.

In case of a feed pump failure, a shutdown alarm will be initiated and all affected membrane train(s) should enter STANDBY mode. In case a feed pump failure does not send an alarm to the PLC, the water level in the membrane tank will decrease as filtration occurs until a low-low level is reached, causing a shutdown alarm for the affected train(s). The PLC will move the affected train(s) to STANDBY mode.

Flow meters, pressure switches, and pressure transmitters on the feed pump discharge can all be used to communicate feed pump failure to the PLC. The feed pump supplier should be contacted for additional information about failure mode prevention, detection, resolution, and communication to the PLC.

**Fine Screening**

Fine screening of particles larger than 2 mm in any dimension is critical to membrane performance and longevity. NANOH2O recommends punched hole, drum screens, specifically designed for UF/MBR applications. Use of bar or wedge-wire screens is not allowed.

Fine screens should not be bypassed at any time. In case of a fine screen failure, a shutdown alarm will be initiated and all affected membrane train(s) should enter OFF mode. Only after the cause of failure is resolved, the operator should manually put the affected membrane train(s) back into AUTO or MANUAL mode.

The fine screen supplier should be contacted for information about failure mode prevention, detection, resolution, and communication to the PLC.

**Activated Sludge Treatment**

There are a wide variety of activated sludge treatment processes that can be applied to achieve the treatment goals of a project. NANOH2O does not require any particular process. However, proper process selection, design, and operation are key to stable membrane performance. For MBR, the activated sludge process serves to degrade pollutants in the incoming feed water which can accelerate fouling on the membranes.

While there are many factors that can impact membrane fouling, three common parameters to control in MBR operation are:

1. Dissolved oxygen concentration at the end of the aerobic tank
2. MLSS Concentration in the biological treatment tanks
3. Recirculation rate(s)
4. Sludge wasting

**Aerobic Tank DO Concentration**

A common rule of thumb for reducing organic fouling on the membranes is to ensure that the dissolved oxygen (DO) concentration at the end of the aerobic tank is always greater than or equal to 2 mg/L. Maintaining this DO level will also serve as an indicator of complete BOD removal.

The aerobic tank(s) should be equipped with DO meter(s). The biological air blowers should be equipped with VFDs. The PLC should control the air blower speed by comparing the DO measurement to the HMI adjustable setpoint.

**Recirculation**

Recirculation, or return activated sludge (RAS), pumping from the end of the membrane tank(s) to the beginning of the aerobic tank(s) (or other prescribed location) is required to control the ratio of MLSS in the aerobic tank to that of the membrane tank. The MLSS in the membrane tank should be kept at less than 12,000 mg/L to prevent accelerated sludge accumulation in the membrane skids. The design MLSS range for the membrane tank is selected during the design stage. Refer to the project specific design calculation.

The recirculation or RAS pump(s) should be equipped with VFDs and the recirculation line(s) should have mag meter type flow meter/transmitter(s). The membrane tank or end of the aerobic tank should be equipped with an online TSS meter. The PLC should control the RAS pump flowrate by comparing the RAS flow rate measurement to the HMI adjustable RAS flow rate setpoint.

In case the system is not equipped with an online TSS meter, the RAS flowrate should be adjusted manually by the operator using a manual measurement of the MLSS in the aerobic tank and the membrane tank.

**Wasting**

Wasting sludge (referred to as Waste Activated Sludge, WAS) is required to control the overall biomass and the MLSS concentration in the membrane tank. WAS can be removed from the system through use of a pump and valve or with a line and automatic valve teed off the pumped RAS line. In either case, the RAS line should be equipped with a RAS flowmeter.

The WAS pump and/or valve should operate automatically based on the online TSS reading compared to the HMI adjustable TSS setpoint, i.e. when the TSS reading hits a certain value, waste for X (timer set by operational experience) seconds. In case the system is not equipped with an online TSS meter, the WAS equipment should be activated manually by the operator based on a manual measurement of the MLSS in the membrane tank.

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MBR & Submerged UF System Start-up & Operating Procedures

### NANOH2O S-Series Trains

A membrane train is defined as a skid or group of skids and associated equipment required to automatically operate said skid(s) in unison.

### Operating Modes

Each membrane train can be placed into one of the following operating MODES. Each membrane train can be in only one operating MODE at any given time. Operating MODES will be written in all CAPS and bold in this document

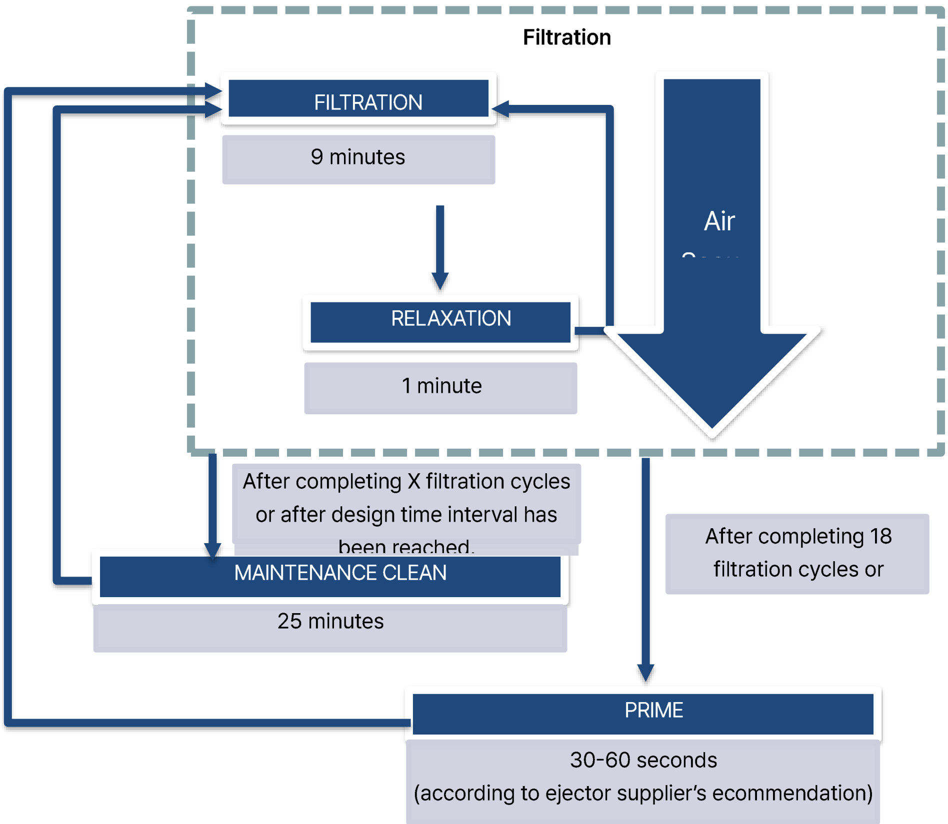
| Mode | Definition |
|---|---|
| **AUTO** | When the membrane train and all necessary equipment are in AUTO, the membrane train proceeds through its normal operating sequences according to the CSTs. Operator cannot manually control any membrane train equipment. Operator can manually stop AUTO, putting the membrane train into STANDBY. |
| **MANUAL** | In MANUAL, operators can manually control membrane train equipment (e.g. open/close valves, turn pumps on/off, etc.). Operator can manually place the membrane train into an operating STATE, such as FILTRATION, RELAXATION, MC, RC, etc. |
| **OFF** | In OFF mode, all equipment for the membrane train is de-energized. Operator cannot manually control membrane train or equipment. Operator must switch the state to AUTO or MANUAL mode in order to operate train or equipment. |

**AUTO Mode**

When in AUTO, the train proceeds through the following STATES automatically:

1. FILTRATION;
2. RELAXATION;
3. MAINTENANCE CLEAN;
4. PRIME

Durations are indicative and vary from site to site. Refer to the project specific CSTs for recommended durations of the steps within each STATE, which may be adjusted at site.



NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

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MBR & Submerged UF System Start-up & Operating Procedures

### Operating States

Each membrane train will be in only one operating MODE and only one operating STATE at any given time. Not all operating STATES are available in each operating MODE. Operating STATES will be written in all CAPS in this document.

Refer to the CSTs for step-by-step details on the valves and equipment status for each of the following STATES.

| STATE | Definition |
|---|---|
| **STANDBY** | Applicable membrane train exits its current sequence and de-energizes any active valves or pumps. If in AUTO and FILTRATION, the membrane train will automatically resume FILTRATION once the conditions which moved the train to STANDBY clears.<br>If in MANUAL when the train enters STANDBY, the operator must manually put the system back into the desired state, once the conditions which moved the train to STANDBY clears. |
| **FILTRATION** | Membrane train is producing filtrate. Filtrate is sent to downstream collection tank/process. |
| **RELAXATION** | Membrane train is being air scoured but is not producing filtrate. |
| **PRIME** | Membrane train is proceeding through priming sequence automatically by operating air removal equipment. |
| **MAINTENANCE CLEAN 1 (MC1) (OXIDANT)** | Membrane train is proceeding through MC1 sequence automatically. Operator cannot manually control any membrane train equipment. Operator can manually stop MC1 mode, putting the membrane train into MC EXIT. |
| **MAINTENANCE CLEAN 2 (MC2) (CAUSTIC)** | Membrane train is proceeding through MC2 sequence automatically. Operator cannot manually control any membrane train equipment. Operator can manually stop MC2 mode, putting the membrane train into MC EXIT. |
| **MAINTENANCE CLEAN 3 (MC3) (ACID)** | Membrane train is proceeding through MC3 sequence automatically. Operator cannot manually control any membrane train equipment. Operator can manually stop MC3 mode, putting the membrane train into MC EXIT. |
| **MAINTENANCE CLEAN (MC) EXIT** | Membrane train has been forced by operator or by shutdown alarm to exit MC1, MC2, OR MC3. Membrane train proceeds automatically through MC EXIT sequence, then enters STANDBY. |
| **RECOVERY CLEAN 1 (RC1) (OXIDANT)** | Membrane train is proceeding through RC1 sequence automatically. Operator cannot manually control any membrane train equipment. Operator can manually stop RC1 mode, putting the membrane train into RC EXIT. |

| STATE | Definition |
|---|---|
| **RECOVERY CLEAN 2 (RC2) (CAUSTIC)** | Membrane train is proceeding through RC2 sequence automatically. Operator cannot manually control any membrane train equipment. Operator can manually stop RC2 mode, putting the membrane train into RC EXIT. |
| **RECOVERY CLEAN 3 (RC3) (ACID)** | Membrane train is proceeding through RC3 sequence automatically. Operator cannot manually control any membrane train equipment. Operator can manually stop RC3 mode, putting the membrane train into RC EXIT. |
| **RECOVERY CLEAN (RC) EXIT** | Membrane train has been forced by operator or by shutdown alarm to exit RC1, RC2, OR RC3. Membrane train proceeds automatically through RC EXIT sequence, then enters STANDBY. |
| **MEMBRANE TANK DRAIN DOWN** | Membrane train is proceeding through membrane tank drain down sequence automatically. |
| **INTEGRITY TEST** | Membrane train is proceeding through integrity test sequence automatically. |
| **SHORT-TERM SHUTDOWN** | Membrane train is proceeding through short-term shutdown sequence automatically. |

### Filtration State

During filtration, the filtrate pump (P-03) is on, the filtrate valve (AV-05) is open, the air scour blower (B-01) is on, and the air scour supply valve (AV-04) is open. The feed water pump (P-01), feed water valve (AV-01), and recirculation pump (P-02) are all on/off, depending on the tank level controls.

The filtration step lasts for 7-12 min, usually 9 minutes. Filtration step timing should be adjustable by the operator through the HMI.

During filtration, the filtrate flow rate is controlled by a VFD on the filtrate pump. The speed of the filtrate pump is controlled by a PID loop comparing the filtrate flow rate measured by the filtrate flowmeter reading (FIT-03) to the filtrate flow rate setpoint, which is HMI adjustable.

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**Transmembrane Pressure (TMP) Measurement**

During filtration, solids will accumulate on the membrane fibers. As the filtrate pump typically operates on a constant flow rate setpoint, this means that the TMP will increase during filtration. TMP is the primary measure of membrane fouling, and is therefore very important to measure correctly. There are two ways to measure the TMP.

TMP = Feed Pressure – Filtrate Pressure

Method 1:

TMP = Pressure measured by PIT-03/N during RELAXATION of filtration cycle X –

Pressure continuously measured by PIT-03/N during FILTRATION of filtration cycle X

Method 1 automatically accounts for the position of PIT-03/N relative to the water level and module.

Method 2:

TMP = [Hw (as measured continuously by LT-03/N) – Hs (Fixed height of the skid to the top of the fibers)] –

[Pressure continuously measured by PIT-03/N during FILTRATION –

Hp (Fixed height of the pressure transmitter above the top of the membrane fiber)]

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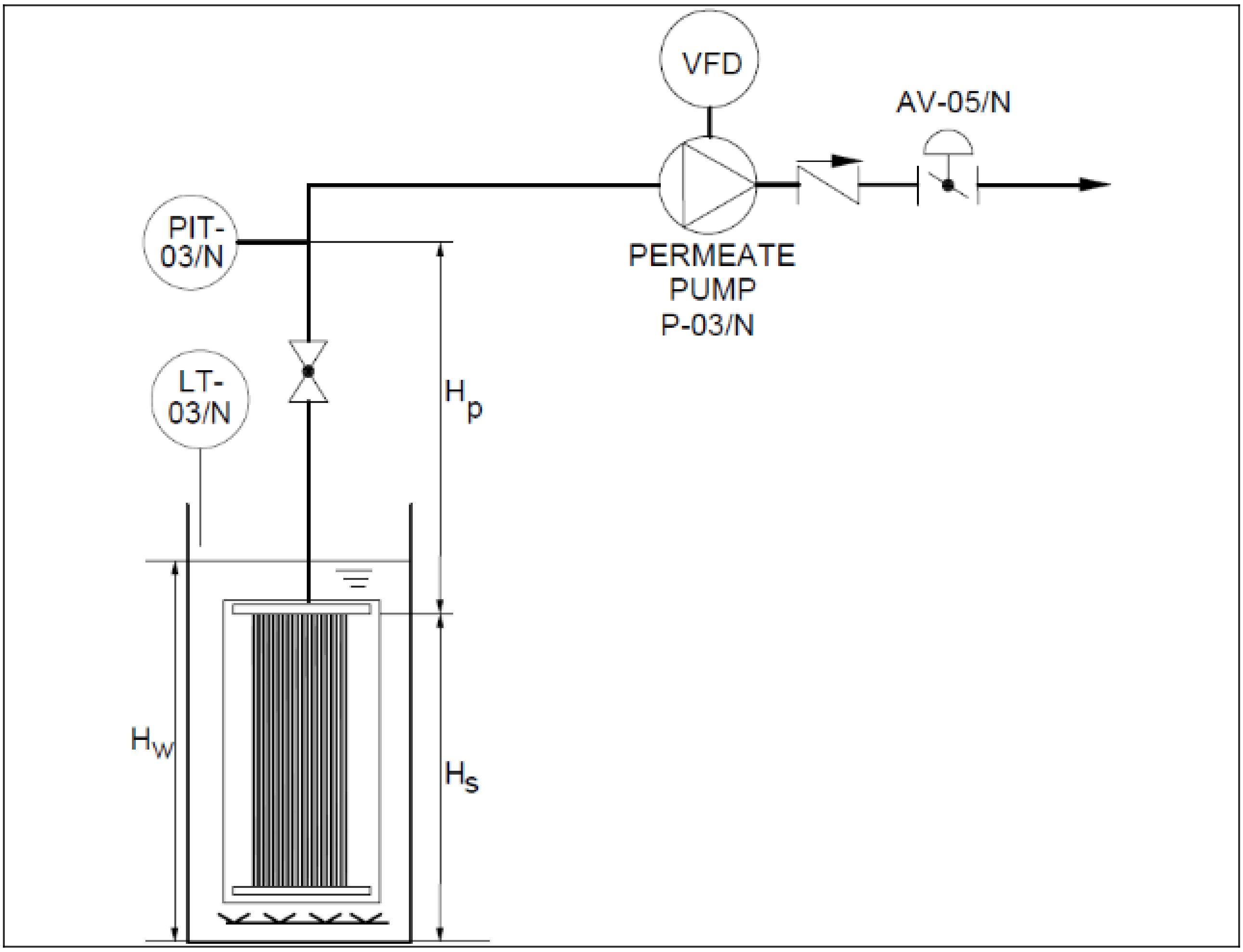
**Figure 1: TMP Measurement Graphic**




**Note**

Make sure that there is no air lock in the filtrate pipes, as the system is running under vacuum. Air lock can create false pressure readings and prevent filtration from occurring.

**Note**

Do not exceed the maximum TMP of 0.05 MPa (7.5 psi). .

**Note**

Ensure that air scouring is taking place while FILTRATION is occurring.

### Relaxation State

RELAXATION occurs at the end of every filtration step. During RELAXATION, the air blower (B-01) and the air scour supply valve (AV-04) is open, the filtrate pump (P-03) is stopped, the filtrate valve (AV-05) is closed. The feed water pump (P-01), feed water valve (AV-01), and recirculation pump (P-02) are all on/off, depending on the tank level controls.

During RELAXATION, the thickness of the layer of suspended solids on the outer surface of the membrane fibers will decrease.

**Note**

Ensure that air scouring is taking place while RELAXATION is occurring.

### Air Scouring

Air scouring is conducted continuously during FILTRATION, RELAXATION, and during sections of MCs and RCs to control accumulation of contaminants on the membrane surface. NANOH2O has two types of patented air scouring – big bubble and variable intensity.

The air scouring method used in a particular project is selected during the design stage. The PLC should be programmed for the selected air scouring method and should have two settings for air scouring: NORMAL AIR SCOURING and HIGH MLSS AIR SCOURING.

For trains using big bubble air scouring, the air flow rate during NORMAL AIR SCOURING is 2 $m^3$/hr/module, continuously. Under HIGH MLSS AIR SCOURING, when the MLSS exceeds 8,000 mg/L, the required air flow rate is 2.5 $m^3$/hr/module.

For skids using variable intensity air scouring, the required air flow rate during NORMAL AIR SCOURING is 2.5 $m^3$/hr/module during filtration and 5 $m^3$/hr/module during relaxation. When the MLSS exceeds 8,000 mg/L, the required air flow rate during HIGH MLSS AIR SCOURING is continuously 5 $m^3$/hr/module.

The PLC should be programmed to automatically switch from NORMAL AIR SCOURING to HIGH MLSS AIR SCOURING when the MLSS in the membrane tank increases above 8,000 mg/L, based on on-line TSS meter measurement. If the system is not equipped with an online TSS meter, the operator must switch from NORMAL AIR SCOURING to HIGH MLSS AIR SCOURING, based on MLSS measurement.

**Note**

Ensure that air scouring is taking place while FILTRATION is occurring.

**Note**

Air scouring flow rates are given as actual volumetric values at the site conditions (air pressure and temperature at the delivery location).

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**Prime State**

There are two situations in which air or oxygen(g) will be present in the filtrate piping. First, during installation or reinstallation. In this case, the entire filtrate piping will be full of air from the water level up to the highest point in the piping. Second, due to changes in partial pressure, there will be gradual accumulation of dissolved oxygen coming out of solution. To avoid potentially cavitating the filtrate pump and to ensure accurate pressure reading from the filtrate pressure gauge, gases in the filtrate line should be removed on a regular basis.

Every 3 hours of operation (18 filtration cycles), after the 1-minute RELAXATION step of the operating process, the PLC should move the train into PRIME and the air removal equipment will turn on for approximately 30-60 seconds.

An air ejector system is recommended for air removal. However, a vacuum pump may also be used. The air ejector or vacuum pump supplier should be contacted for equipment sizing and operation assistance.

**Maintenance Clean 1, 2, 3 States**

> **Note**
> The chemicals used should not damage the membrane module or create secondary pollution.

Chemical cleanings are used to remove fouling that is not removed by air scouring. The 3 types of MAINTENANCE CLEAN are based on the chemicals used. Chemicals should be selected based on the type of foulants present. Refer to the project design calculation for the details for the MCs recommended for a particular project.

MAINTENANCE CLEAN 1: An oxidant chemical, typically sodium hypochlorite, is used to control organic and biological fouling.

MAINTENANCE CLEAN 2: A basic chemical solution, typically sodium hydroxide, is used to control organic and biological fouling, as well as fats, oil, and grease fouling.

MAINTENANCE CLEAN 3: An acidic chemical solution, typically hydrochloric acid, is used to control inorganic fouling.

MC1 and MC2 may be combined into one cleaning.

The procedure for MC1, MC2, and MC3 is the same in all cases. The MAINTENANCE CLEAN is a shorter clean designed to maintain the membrane permeability. In general, a chemical solution is pumped into the membrane trains from the filtrate side of the membranes with the NORMAL AIR SCOUR off. The chemical solution is then allowed to soak in and on the membrane fibers. After a set soaking time is reached, NORMAL AIR SCOUR is resumed. Soaking and NORMAL AIR SCOUR steps may be repeated up to three times. After completing the soaking and NORMAL AIR SCOUR steps, filtration resumes. After MC, the TMP should be at least partially recovered. Refer to the project CSTs for a step-by-step description.

All MC1, MC2, and MC3 sequences should be programmed in the PLC. The PLC should put the membrane train in MC, MC2, or MC3 based on the HMI adjustable time or filtration cycle interval.

**Recovery Clean 1, 2, 3 States**

DANGER

If sodium hypochlorite and acid are mixed, poisonous chlorine gas will be formed. The PLC should be programmed such that trains are thoroughly rinsed between chemical cleanings so that the chemicals do not mix.

Like MCs, the 3 types of RECOVERY CLEAN are based on the chemicals used – RC1 – Oxidant; RC2 – Basic; RC3

- Acidic. RC1 and RC2 may be combined into one cleaning. Chemicals should be selected based on the type of foulants present. Refer to the project design calculation for the details for the RCs recommended for a particular project.

The RECOVERY CLEAN is designed to recover membrane permeability to the original value. The RECOVERY CLEAN is similar to the MAINTENANCE CLEAN but uses a higher concentration of the chemical and longer soak times. The steps of the RC are very similar to the MC, but the membrane tank is drained prior to filling with chemical cleaning solution. Additionally, the RC always includes at least oxidant and acidic solutions. A RECOVERY CLEAN may be triggered by time (every 30-90 days), or when MC fails to restore membrane permeability and the TMP continues to rise a certain amount about the initial value. For example, more than 50KPa (7.3 psi) above the initial value.

The recovery clean procedure should be programmed into the control system. It should be manually initiated whenever an established number of days has passed (commonly, 30-90 days), or the TMP reaches 0.7 bar (10 psi). The procedure should be repeated for each chemical. Ensure rinsing is complete before introducing a new chemical. Typically, sodium hypochlorite is first, followed by sodium hydroxide. Finally, citric, hydrochloric, or sulfuric acid is used.

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**Integrity Test State**

Pressurized air is applied to one side of the wetted membrane fibers. If the membrane integrity is intact, and the air pressure is lower than the bubbling point, there will be no observable air flow from the membrane pores. However, if there are damaged membrane fibers, air flow can be easily observed at pressure far below the bubbling point. Therefore, the integrity of a membrane module can be tested by observing bubble flow or the pressure change on one side of the membrane fibers.

Membrane Integrity is confirmed by the PLC through online filtrate turbidity readings. The Integrity Test procedure should be programmed in the PLC and triggered manually by the operator, only when required.

> Caution
>
> The compressed air used for integrity testing must be oil free. Dirty air will contaminate the membrane.
> The maximum air pressure allowed during testing is 50kPa (7 psi).

The following procedure is used to confirm system integrity and identify any integrity breach in need of repair.

1. Stop filtration of the train to be tested by closing the filtrate valve (AV-05) or stopping the filtrate pump (P-03).
2. Stop air scouring of the train to be tested by closing the air scour supply valve (AV-04).
3. Make sure the membrane modules are completely submerged.
4. Slowly open the integrity test (IT) valve (AV-08). Compressed air applied through the integrity test valve will drive the water from the filtrate side of the membrane to the feed side. As water evacuates and air fills the filtrate side, the pressure will slowly increase until the it reaches a regulated set point, which should be less than 50 kPa (7 psi).
5. Allow the pressure to stabilize at the set point, typically ~2 minutes. This will occur once all the water on the feed side of the membrane has been evacuated.
6. After the pressure has stabilized, close the IT valve. Note the pressure.
7. Hold the pressure for 5 minutes.
8. Typically, if the pressure drop is less than 17KPa (2.5 psi) in 5 minutes, the system integrity is intact. If the pressure drops rapidly, it indicates that there is a leak in the system.
9. Look for and mark areas of vigorous bubbles to be removed for further testing and repair.

### Membrane Train HMI Adjustable Operating Setpoints

The following setpoints are key operating parameters for the membrane trains. NANOH2O suggests that the membrane system operating parameters in the following table are adjustable by the operator in the HMI.

**Table 1 : Adjustable Operating Parameters – Membrane System**

| Item | Description | Default Setpoint Value |
|---|---|---|
| 1 | Feed flow rate | Project Specific |
| 2 | Filtrate flow rate | Project Specific |
| 3 | Recirculation flow rate | Project Specific; 3 – 6 x Filtrate flow rate |
| 4 | Air scouring flow rate | 2.0-2.5 $m^3$/hr /module (Big Bubble Aeration) or<br>2.5-5 $m^3$/hr /module (Variable Intensity Aeration) |
| 5 | Chemical Cleaning Solution Pump flow rate | Project Specific |
| 6 | NaOCl Dosing Pump flow rate | Project Specific |
| 7 | NaOH Dosing Pump flow rate | Project Specific |
| 8 | Acid Dosing Pump flow rate | Project Specific |
| 9 | Filtration cycle time | 9 Min. |
| 10 | Relaxation time | 1 Min. |
| 11 | MC interval | Project Specific - 3 to 7 days; Adjusted on-site |
| 12 | MC chemical solution injection time | Adjusted on-site to achieve target cleaning solution |
| 13 | MC chemical soak 1 time | 300 Sec. |
| 14 | MC chemical air scour 1 time | 300 Sec. |
| 15 | MC chemical soak 2 time | 300 Sec. |
| 16 | MC chemical air scour 2 time | 300 Sec. |
| 17 | MC chemical soak 3 time | 0 Sec. |
| 18 | MC chemical air scour 3 time | 0 Sec. |
| 19 | RC interval | Project Specific - 30 to 180 days; Adjusted on-site |
| 20 | Membrane tank drain time | 600 Sec. |
| 21 | Oxidant RC chemical solution injection time | Adjusted on-site to achieve target cleaning solution |
| 22 | Oxidant RC chemical soak 1 time | 3600 Sec. |
| 23 | Oxidant RC chemical air scour 1 time | 300 Sec. |
| 24 | Oxidant RC chemical soak 2 time | 2400 Sec. |

| | | |
|---|---|---|
| 25 | Oxidant RC chemical air scour 2 time | 300 Sec. |
| 26 | Oxidant RC chemical soak 3 time | 300 Sec. |
| 27 | Oxidant RC chemical air scour 3 time | 300 Sec. |
| 28 | Membrane tank chemical drain time | Adjusted on-site to reach empty tank |
| 29 | Membrane tank chemical flush time | Adjusted on-site to reach target residual |
| 30 | Membrane tank drain time | Adjusted on-site to reach empty tank |
| 31 | Acid RC chemical solution injection time | Adjusted on-site to achieve target cleaning solution |
| 32 | Acid RC chemical soak 1 time | 2700 Sec. |
| 33 | Acid RC chemical air scour 1 time | 300 Sec. |
| 34 | Acid RC chemical soak 2 time | 1800 Sec. |
| 35 | Acid RC chemical air scour 2 time | 300 Sec. |
| 36 | Acid RC chemical soak 3 time | 1800 Sec. |
| 37 | Acid RC chemical air scour 3 time | 300 Sec. |
| 38 | Membrane tank chemical drain time | Adjusted on-site to reach empty tank |
| 39 | Membrane tank chemical flush time | Adjusted on-site to reach target residual |
| 40 | Membrane tank drain time | Adjusted on-site to reach empty tank |
| 41 | Membrane tank refill time | Adjusted on-site to reach target tank level |
| 42 | Air removal system operation interval | Once every 12 to 18 filtration cycles |
| 43 | Air removal system operation duration | Per Supplier's recommendation |

Default values listed in Table 1 are for reference only. The initial set points for these parameters should be according to the system design recommendations provided by NANOH2O. Adjustments will likely be made over time depending on the actual feed water quality and the observed system performance.

**Membrane Train Power Outage**

If a power outage occurs, the membrane train will enter OFF status. When the power returns, the system will remain in OFF. The operator will need to switch the system back to AUTO or MANUAL. Depending on the duration of the shutdown, it may be necessary to conduct MCs or RCs. If the shutdown was long enough for the sludge to die, a complete drain down and re-seed may be required.

**Membrane Train Alarms**

There should be two types of alarms – Shutdown and Operator Alert. Shutdown alarms move the system to STANDBY or OFF, depending on the alarm type. Operator Alert alarms notify the operator visually and/or audibly at the HMI.

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| Alarm | Response |
|---|---|
| Low filtrate flow | Operator Alert; Operator to assess situation. |
| High filtrate flow | Operator Alert; Operator to assess situation. |
| High-High filtrate flow | Shutdown; Enter STANDBY; Operator to assess situation. |
| Low filtrate pump Pressure | Operator Alert; Operator to assess situation. |
| High TMP | Operator Alert; Operator to assess situation. MC or RC may be required. |
| High-high TMP | Shutdown; Enter STANDBY; Operator to assess situation. MC or RC may be required. |
| Low-low air scour flow | Shutdown; Enter STANDBY; Operator to assess situation. |
| Low air scour flow | Operator Alert; Operator to assess situation. |
| High air scour flow | Operator Alert; Operator to assess situation. |
| High-high water level | Shutdown; Enter STANDBY; Resume previous MODE once the alarm is cleared and the level drops below the high setpoint in the membrane tank. |
| Low-Low water level | Shutdown; Enter STANDBY; Resume previous MODE once the alarm is cleared and the level hits the high setpoint in the membrane tank. |
| High turbidity | Operator Alert; Operator to assess situation. Check turbidimeter. INTEGRITY TEST may be initiated by the operator. |
| High-high turbidity | Shutdown; Enter STANDBY; Operator to assess situation. Check turbidimeter. INTEGRITY TEST may be initiated by the operator. |
| Low turbidimeter flow | Operator Alert; Operator to assess situation. |
| High-high temperature | Shutdown; Enter STANDBY; Operator to assess situation. |
| High filtrate Pressure | Shutdown; Enter STANDBY; Relieve pressure on filtrate line. |

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**Membrane Train Performance Monitoring**

**Membrane System**

It is very important to record the operating data of the system accurately and completely. At minimum, the following variables should be recorded automatically and stored in an exportable format on the SCADA system or other data logging equipment. Recommended minimum frequency is once every 15 minutes.

Each train:

- Membrane tank level (m) (ft)
- Filtrate pressure (kPa) (psi)
- Filtrate flow rate ($m^3$/h) (gpm)
- Air scour flow rate (delivery $m^3$/h) (acfm)
- Product water turbidity (NTU)

Minimum one per membrane system:

- Membrane tank sludge temperature (°C) (°F)
- Membrane Tank MLSS (mg/L)
- Membrane Tank DO (mg/L)
- Filtrate Soluble BOD5 (mg/L)

NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 805

## MBR & Submerged UF Membrane Cleaning

Air scouring will remove most fouling from the membranes, but not all. Over time, fouling will accumulate. Chemical cleanings are used to remove fouling that is not removed by air scouring. Chemicals should be selected based on the type of foulants present. The chemicals used should not damage the membrane module or create secondary pollution. NANOH2O utilizes two methods of chemical cleaning to recover membrane performance.

DANGER

If sodium hypochlorite and acid are mixed, poisonous chlorine gas will be formed.
The skids should be thoroughly rinsed between chemical cleanings so that the chemicals do not mix.

Caution

Maintain cleaning solutions within allowable pH ranges and only use approved chemicals.

### Maintenance Clean (MC)

The maintenance clean is a shorter clean designed to maintain the membrane permeability. In general, a chemical solution is pumped into the skids from the filtrate side of the membranes with the air scour off. The chemical solution is then allowed to soak in and on the membrane fibers. After a set soaking time is reached, air scouring is resumed. Soaking and Air Scouring steps may be repeated up to three times. After completing the soaking and air scouring steps, filtration resumes. After maintenance cleaning, the TMP should be at least partially recovered.

### Recovery Clean (RC)

The recovery clean is similar to the maintenance clean but uses a higher concentration of the chemical and longer soak times. The recovery clean is designed to recover the membrane permeability to the original value. The steps of the RC are very similar to the MC, but the membrane tank is drained prior to filling with chemical cleaning solution. Additionally, the RC always includes at least oxidant and acidic solutions. A recovery clean may be triggered by time (every 30-90 days), or when MC fails to restore membrane permeability and the TMP continues to rise a certain amount about the initial value. For example, more than 50KPa (7.3 psi) above the initial value.

### Chemical Cleaning Regime Design

The chemical cleaning regime (chemicals, frequencies, durations, and concentrations) should be uniquely selected for each site-specific condition. Contact NANOH2O for assistance selecting the cleaning regime for your system. The following table is an indicative guide for various water types with typical quality. Variation from this table due to site-specific water quality is common.

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## MBR & Submerged UF Membrane Cleaning

**Table 1: Chemical Cleaning Parameters**

| | Oxidant MC Frequency (# per skid/week) | Basic MC Frequency (# per skid/day) | Acid MC Frequency (# per skid/day) | Oxidant RC Frequency (Days between clean) | Basic RC Frequency (Days between clean) | Acid RC Frequency (Days between clean) |
|---|---|---|---|---|---|---|
| Chemical & Concentration[1] | 200 ppm NaOCl | 3500 ppm NaOH | 1500 ppm $H_2SO_4$ | 1000 ppm NaOCl | 3500 ppm NaOH | 5000 ppm $H_2SO_4$ |
| Sewage/Municipal Wastewater | 1-2 | - | - | 180 | - | 180 |
| Industrial Wastewater | 2-4 | 0-1 (TIPS products only) | 0-1 | 60 | 60 (TIPS products only) | 60 |

1) Please contact NANOH2O for the cleaning formulation for special contaminants.

### Method to Verify the Effectiveness of the Cleaning

Please record the following parameters before and after the cleaning:

1. Feed and filtrate flow rate
2. Feed, concentrate, and filtrate pressure
3. Water temperature

Compare the data. If the filtrate flow rate, or TMP could not be recovered it means the cleaning is not effective, please contact an NANOH2O engineer to find a solution for this issue.

NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 805

MBR & Submerged UF Membrane Cleaning

### Cleaning Process Procedures

The cleaning process for both maintenance clean and recovery clean have been outlined. On the following pages, you can find detailed sequence tables.

The maintenance clean and recovery clean procedures should be programmed into the control system. Maintenance cleans should occur automatically based on time or number of completed filtration cycles. Recovery Cleans should be manually initiated when an established number of days have passed (commonly 30-90 days), or the TMP reaches 0.5 bar (7.5 psi). The procedure should be repeated for each chemical. Ensure rinsing is complete before introducing a new chemical. Typically, sodium hypochlorite is first, followed by sodium hydroxide. Finally, citric, hydrochloric, or sulfuric acid is used.

**Caution**

Ensure top drain valve is open during chemical soak step.

**Caution**

Check for potential exothermic reactions between cleaning solutions.

**Table 2: Control Sequence Table – Maintenance Clean**

| | | | | Valve Position | | | | | | | | Pump Status | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Step Number | Step Description | Typical Step Duration (s) | Typical Cumulativ e Sequence Duration (s) | Feed Valve | MC Solution Supply, Value | RC Solution Supply Valve | Air Scour Supply Valve | Filtrate Discharge Valve | Membrane Tank Drain Valve | Vacuum Pump/Air Ejector Valve | Integrity Test Valve | Feed Pump | Membrane Tank Recirculation Pump | Filtrate Pump with VFD | Chemical Solution Pump | Membrane Tank Drain Down pump | Sludge Discharge Pump (or Valve) | Air Blower | NaOCl (Cleanin g) Dosing Pump | Acid (Cleanin g) Dosing Pump |
| | | | | AV-01 | AV-02 | AV-03 | AV-04 | AV-05 | AV-06 | AV-07 | AV-08 | P-01 | P-02 | P-03 | P-04 | P-05 | P-06 | AB-01 | DP-01 | DP-02 |
| 1 | Stop Filtration | 0 | 0 | O | X | X | O | O | X | X | X | R or S (on level, control) | R or S (on level, control) | R | S | S | S or R (on TSS meter, control) | R | S | S |
| | Step Transition - Valve positioning, and pump and blower speed adjustment | 10 | 10 | O→X | X→O | X | O→X | O→X | X | X | X | R or S (on level, control) | R or S (on level, control) | R→S | S→R | S | S or R (on TSS meter, control) | R→S | S→R | S |
| 2 | Inject Chemical Solution | | 310 | X | O | X | X | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | R | S | S or R (on TSS meter, control) | S | R | S |
| | Step Transition - Valve positioning and pump speed adjustment | 10 | 320 | X | O→X | X | X | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | R→S | S | S or R (on TSS meter, control) | S | R→S | S |
| 3 | Chemical Soak 1 | | 620 | X | X | X | X | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | S | S | S |
| | Step Transition - Valve positioning and blower speed adjustment | 10 | 630 | X | X | X | X→O | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | S→R | S | S |
| 4 | Chemical Air Scour 1 | | 930 | X | X | X | O | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | R | S | S |
| | Step Transition - Valve positioning and pump speed adjustment | 10 | 940 | X | X | X | O→X | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | R→S | S | S |
| 5 | Chemical Soak 2 | | 1240 | X | X | X | X | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | S | S | S |
| | Step Transition - Valve positioning and blower speed adjustment | 10 | 1250 | X | X | X | X→O | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | S→R | S | S |
| 6 | Chemical Air Scour 2 | | 1550 | X | X | X | O | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | R | S | S |
| | Step Transition - Valve positioning and pump speed adjustment | 10 | 1560 | X | X | X | O→X | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | R→S | S | S |
| 7 | Chemical Soak 3 | | 1560 | X | X | X | X | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | S | S | S |
| | Step Transition - Valve positioning and blower speed adjustment | 10 | 1570 | X | X | X | X→O | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | S→R | S | S |
| 8 | Chemical Air Scour 3 | | 1570 | X | X | X | O | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | R | S | S |
| | Step Transition - Valve positioning, and pump and blower speed adjustment | 10 | 1580 | X→O | X | X | O | X→O | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | R | S | S |
| 9 | Resume Filtration | 0 | 1580 | O | X | X | O | O | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | R | S | S |
| | Sequence duration (s) | | 1580 | Notes: O=open valve | | | | | | | | | R=run pump | | | | | | | |
| | Sequence duration (min) | | 26 | X=closed valve | | | | | | | | | S=stop pump | | | | | | | |

### Table 3: Control Sequence Table – Recovery Clean (Sheet 1 of 2)

| | | | | Valve Position | | | | | | | | Pump Status | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Step Number | Step Description | Typical Step Duration (s) | Typical Cumulativ e Sequence Duration (s) | Feed Valve | MC Solution Supply, Value | RC Solution Supply Valve | Air Scour Supply Valve | Filtrate Discharge Valve | Membrane Tank Drain Valve | Vacuum Pump/Air Ejector Valve | Integrity Test Valve | Feed Pump | Membrane Tank Recirculation Pump | Filtrate Pump with VFD | Chemical Solution Pump | Membra ne Tank Drain Down pump | Sludge Discharge Pump (or Valve) | Air Blower | NaOCl (Cleanin g) Dosing Pump | Acid (Cleanin g) Dosing Pump |
| | | | | AV-01 | AV-02 | AV-03 | AV-04 | AV-05 | AV-06 | AV-07 | AV-08 | P-01 | P-02 | P-03 | P-04 | P-05 | P-06 | AB-01 | DP-01 | DP-02 |
| 1 | Stop Filtration | 0 | 0 | O | X | X | O | O | X | X | X | R or S (on level, control) | R or S (on level, control) | R | S | S | S or R (on TSS meter, control) | R | S | S |
| | Step Transition - Valve positioning, and pump speed adjustment | 10 | 10 | O→X | X | X | O | O→X | X→O | X | X | R or S (on level, control) | R or S (on level, control) | R→S | S | S→R | S or R (on TSS meter, control) | R | S | S |
| 2 | Membrane tank drain | 600 | 610 | X | X | X | O | X | O | X | X | R or S (on level, control) | R or S (on level, control) | S | S | R | S or R (on TSS meter, control) | R | S | S |
| | Step Transition - Valve positioning and pump and blower speed adjustment | 10 | 620 | X | X→O | X | O→X | X | O→X | X | X | R or S (on level, control) | R or S (on level, control) | S | S→R | R→S | S or R (on TSS meter, control) | R→S | S→R | S |
| 3 | Oxidant RC Chemical Soln Injection | 600 | 1220 | X | O | X | X | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | R | S | S or R (on TSS meter, control) | S | R | S |
| | Step Transition - Valve positioning and pump and blower speed adjustment | 10 | 1230 | X | O→X | X | X | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | R→S | S | S or R (on TSS meter, control) | S | R→S | S |
| 4 | Oxidant RC chemical soak 1 | 3600 | 4830 | X | X | X | X | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | S | S | S |
| | Step Transition - Valve positioning and blower speed adjustment | 10 | 4840 | X | X | X | X→O | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | S→R | S | S |
| 5 | Oxidant RC chemical air scour 1 | 300 | 5140 | X | X | X | O | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | R | S | S |
| | Step Transition - Valve positioning and blower speed adjustment | 10 | 5150 | X | X | X | O→X | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | R→S | S | S |
| 6 | Oxidant RC chemical soak 2 | 2400 | 7550 | X | X | X | X | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | S | S | S |
| | Step Transition - Valve positioning and blower speed adjustment | 10 | 7560 | X | X | X | X→O | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | S→R | S | S |
| 7 | Oxidant RC chemical air scour 2 | 300 | 7860 | X | X | X | O | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | R | S | S |
| | Step Transition - Valve positioning and blower speed adjustment | 10 | 7870 | X | X | X | O→X | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | R→S | S | S |
| 8 | Oxidant RC chemical soak 3 | 300 | 8170 | X | X | X | X | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | S | S | S |
| | Step Transition - Valve positioning and blower speed adjustment | 10 | 8180 | X | X | X | X→O | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | S→R | S | S |
| 9 | Oxidant RC chemical air scour 3 | 300 | 8480 | X | X | X | O | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | R | S | S |
| | Step Transition - Valve positioning and pump speed adjustment | 10 | 8490 | X | X | X | O | X | X→O | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S→R | S or R (on TSS meter, control) | R | S | S |
| 10 | Membrane tank chemical drain | 600 | 9090 | X | X | X | O | X | O | X | X | R or S (on level, control) | R or S (on level, control) | S | S | R | S or R (on TSS meter, control) | R | S | S |
| | Step Transition - Valve positioning and pump speed adjustment | 10 | 9100 | X | X→O | X | O | X | O→X | X | X | R or S (on level, control) | R or S (on level, control) | S | S→R | R→S | S or R (on TSS meter, control) | R | S | S |
| 11 | Membrane tank chemical flush | 300 | 9400 | X | O | X | O | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | R | S | S or R (on TSS meter, control) | R | S | S |
| | Step Transition - Valve positioning and pump speed adjustment | 10 | 9410 | X | O→X | X | O | X | X→O | X | X | R or S (on level, control) | R or S (on level, control) | S | R→S | S→R | S or R (on TSS meter, control) | R | S | S |
| 12 | Membrane tank drain | 600 | 10010 | X | X | X | O | X | O | X | x | R or S (on level, control) | R or S (on level, control) | S | S | R | S or R (on TSS meter, control) | R | S | S |
| | Step Transition - Valve positioning and pump and blower speed adjustment | 10 | 10020 | X | X→O | X | O→X | X | O→X | X | X | R or S (on level, control) | R or S (on level, control) | S | S→R | R→S | S or R (on TSS meter, control) | R→S | S | S→R |

### Table 3: Control Sequence Table – Recovery Clean (Sheet 2 of 2)

| Step Number | Step Description | Typical Step Duration (s) | Typical Cumulativ e Sequence Duration (s) | Feed Valve | MC Solution Supply, Value | RC Solution Supply Valve | Air Scour Supply Valve | Filtrate Discharge Valve | Membrane Tank Drain Valve | Vacuum Pump/Air Ejector Valve | Integrity Test Valve | Feed Pump | Membrane Tank Recirculation Pump | Filtrate Pump with VFD | Chemical Solution Pump | Membra ne Tank Drain Down pump | Sludge Discharge Pump (or Valve) | Air Blower | NaOCl (Cleanin g) Dosing Pump | Acid (Cleanin g) Dosing Pump |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | AV-01 | AV-02 | AV-03 | AV-04 | AV-05 | AV-06 | AV-07 | AV-08 | P-01 | P-02 | P-03 | P-04 | P-05 | P-06 | AB-01 | DP-01 | DP-02 |
| 13 | Acid RC Chemical Soln Injection | 600 | 10620 | X | O | X | X | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | R | S | S or R (on TSS meter, control) | S | S | R |
| | Step Transition - Valve positioning and pump speed adjustment | 10 | 10630 | X | O→X | X | X | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | R→S | S | S or R (on TSS meter, control) | S | S | R→S |
| 14 | Acid RC chemical soak 1 | 2700 | 13330 | X | X | X | X | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | S | S | S |
| | Step Transition - Valve positioning and blower speed adjustment | 10 | 13340 | X | X | X | X→O | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | S→R | S | S |
| 15 | Acid RC chemical air scour 1 | 300 | 13640 | X | X | X | O | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | R | S | S |
| | Step Transition - Valve positioning and blower speed adjustment | 10 | 13650 | X | X | X | O→X | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | R→S | S | S |
| 16 | Acid RC chemical soak 2 | 1800 | 15450 | X | X | X | X | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | S | S | S |
| | Step Transition - Valve positioning and blower speed adjustment | 10 | 15460 | X | X | X | X→O | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | S→R | S | S |
| 17 | Acid RC chemical air scour 2 | 300 | 15760 | X | X | X | O | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | R | S | S |
| | Step Transition - Valve positioning and blower speed adjustment | 10 | 15770 | X | X | X | O→X | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | R→S | S | S |
| 18 | Acid RC chemical soak 3 | 1800 | 17570 | X | X | X | X | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | S | S | S |
| | Step Transition - Valve positioning and blower speed adjustment | 10 | 17580 | X | X | X | X→O | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | S→R | S | S |
| 19 | Acid RC chemical air scour 3 | 300 | 17880 | X | X | X | O | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | R | S | S |
| | Step Transition - Valve positioning and pump speed adjustment | 10 | 17890 | X | X | X | O | X | X→O | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S→R | S or R (on TSS meter, control) | R | S | S |
| 20 | Membrane tank chemical drain | 600 | 18490 | X | X | X | O | X | O | X | X | R or S (on level, control) | R or S (on level, control) | S | S | R | S or R (on TSS meter, control) | R | S | S |
| | Step Transition - Valve positioning and pump speed adjustment | 10 | 18500 | X | X→O | X | O | X | O→X | X | X | R or S (on level, control) | R or S (on level, control) | S | S→R | R→S | S or R (on TSS meter, control) | R | S | S |
| 21 | Membrane tank chemical flush | 300 | 18800 | X | O | X | O | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | R | S | S or R (on TSS meter, control) | R | S | S |
| | Step Transition - Valve positioning and pump speed adjustment | 10 | 18810 | X | O→X | X | O | X | X→O | X | X | R or S (on level, control) | R or S (on level, control) | S | R→S | S→R | S or R (on TSS meter, control) | R | S | S |
| 22 | Membrane tank drain | 600 | 19410 | X | X | X | O | X | O | X | X | R or S (on level, control) | R or S (on level, control) | S | S | R | S or R (on TSS meter, control) | R | S | S |
| | Step Transition - Valve positioning and pump speed adjustment | 10 | 19420 | X→O | X | X | O | X | O→X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | R→S | S or R (on TSS meter, control) | R | S | S |
| 23 | Membrane tank refill | 600 | 20020 | O | X | X | O | X | X | X | X | R or S (on level, control) | R or S (on level, control) | S | S | S | S or R (on TSS meter, control) | R | S | S |
| | Step Transition - Valve positioning and pump speed adjustment | 10 | 20030 | O | X | X | O | X→O | X | X→O | X | R or S (on level, control) | R or S (on level, control) | S→R | S | S | S or R (on TSS meter, control) | R | S | S |
| 24 | Prime and Resume Filtration | 60 | 20090 | O | X | X | O | O | X | O | X | R or S (on level, control) | R or S (on level, control) | R | S | S | S or R (on TSS meter, control) | R | S | S |
| | Sequence duration (s) | | 20090 | Notes: O=open valve | | | | | | | | | R=run pump | | | | | | | |
| | Sequence duration (min) | | 335 | X=closed valve | | | | | | | | | S=stop pump | | | | | | | |

NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 806

## MBR & Submerged UF Membrane Integrity Testing and Repair

After the assembly of the membrane device is completed, gas tightness testing should be carried out to check whether the installation of the membrane module is tight and whether the membrane module assembly is complete. The testing process is shown in Table 1.

**Table 1 : Integrity Testing Process**

| S/N | Figure | Notes |
|---|---|---|
| 1 |   | **Testing standards:** After the membrane module is installed, connect the water collection pipe interface to the air source. Feed in compressed air and pressurize slowly. The membrane module is pressurized to 0.05Mpa, and the pressure is maintained for 60secs. If the air pressure drops no more than 0.01Mpa, it is qualified. |
| 2 |   | **Membrane leak detection method:** If the air pressure drops by more than 0.01Mpa, use a spray bottle to spray a small amount of detergent/water solution on the adhesive joints of the pipe fittings and the water outlet of the membrane module. If there are continuous bubbles emerging, it indicates a leak, which must be repaired or dealt with separately. |
| 3 | | **Membrane repair:** If a leak is found, wipe it clean with a damp cloth. After it dries, apply the prepared epoxy resin glue evenly three times and let it cure for 2 hours. Prepare the epoxy resin according to the instructions on the package. |

NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 807

## MBR & Submerged UF System Troubleshooting

The MBR & Submerged UF System troubleshooting are covered in this TSB under the following sections:

**General Membrane Troubleshooting**

**Submerged UF System Troubleshooting**

**MBR System Troubleshooting**

**Emergency Response Procedures**

**Performance Recovery Strategies**

**Preventive Measures**

If the operating problems are not addressed here, contact NANOH2O for support.

**General Membrane Module Troubleshooting**

The following are critical to maintain stable operation and produce high quality water over the long term:

1. Properly pre-treated feed water
    a. Pretreatment equipment should remain in proper working condition.
    b. Feedwater should be within the ranges provided in Table 1. The purpose of controlling these parameters is to minimize the risk of membrane damage and/or fouling. These ranges apply to all systems using NANOH2O Submerged UF and MBR modules. Selection of operating parameters depends on the specific project.
2. Appropriate filtrate flux
3. Suitable filtration cycle time
4. Sufficient air scour flow rate
5. Targeted chemical cleaning regime

Membrane tank water quality should be monitored closely. Changes in feed water quality may require adjustment of operational settings. Careful attention to how the membrane performance is affected by changing feed water quality is required to make necessary system adjustments.

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NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 807

## MBR & Submerged UF System Troubleshooting

### Table 1 : Allowable Membrane Tank Sludge Quality

| Parameter | Allowed Range | Comments |
|---|---|---|
| pH in membrane tank | 1 – 10 (TIPS) | 1—14 allowed during cleaning (TIPS) |
| Particle Size[1] | ≤ 2.0 mm | ≤ 2 mm by automatic screening<br>Perforated plate or punched hole type is recommended |
| Mixed Liquor temperature ºC (ºF) | 5 – 45 (41 – 113) | |
| MLSS in membrane tank, mg/L (MBR only) | 5,000 – 12,000 | Normal range 6,000 – 8,000<br>Check with NANOH2O if higher MLSS higher |
| Oil | < 2 mg/L (TIPS) | To prevent membrane fouling |
| Dissolve Oxygen (mg/L) | > 2 | For MBR |
| Total hardness (mg/L as $CaCO_3$) | Non-scaling | Dependent on pH and scaling Scaling to be removed by acid cleaning |
| Soluble BOD5 Concentration (mg/L) | < 3 | |
| $NH_3$-N concentration in mixed liquor entering membrane tanks (mg/L) | ≤ 1.0 | |
| Colloidal TOC (cTOC) concentration in mixed liquor entering membrane tanks (mg/L) | ≤ 10 | |
| Soluble alkalinity of mixed liquor entering membrane tanks (mg/L as $CaCO_3$) | 50 – 150 | |

[1] Primarily concerned with the entry of sharp objects into the treatment system such as branches, plastic pieces, sand etc., and fibrous material, such as hair.

* This is not an extensive list and does not constitute the only conditions for a valid warranty claim. Refer to your project specific warranty document for all conditions that apply to your warranty.

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NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 807

MBR & Submerged UF System Troubleshooting

### Submerged UF System Troubleshooting Basics

| Symptom | Possible Causes | Solutions |
|---|---|---|
| High TMP | Fouling of the membrane<br>Low air scour flow rate<br>Faulty instrument readings | Undergo suitable cleaning; Adjust filtration flux; Adjust filtration cycle time; Adjust air scour rate; Verify automated cleanings are occurring correctly |
| Rapid rise in TMP over 24-48 hours | Sudden feed water quality deterioration | Review recent feed water quality data |
| | Chemical cleaning system failure | Verify chemical dosing systems |
| | Air scouring system malfunction | Check air scouring equipment and distribution |
| Low air scouring flow rate | Blower fault | Check the blower |
| | Valve closed | Check the piping and valve |
| Low filtrate flow | Membrane fouling | Review cleaning protocol effectiveness |
| | Loss of filtrate pump prime | Air removal system not operating properly or frequently enough |
| | Control system failure | Check filtrate pump PID and flow meter |
| | Pressure meter fault | Calibrate the flow meter |
| Low membrane tank level | Feed/RAS pump failure | Check feed and RAS pump and piping |
| | Valve failure | Check feed and RAS valves; Check drain valve |
| Motor failure | No electricity | Check power supply |
| | VFD failure | Check the VFD unit |
| | Motor Overload | Check the setting of overload for the motor; If the value is exceeded, contact the supplier |
| Uneven Air Distribution | Air header damage or<br>Improper leveling of modules or<br>Blocked air pathways | Clean or replace diffusers<br>Inspect air distribution system<br>Level module racks<br>Clear air flow channels |
| Valve failure | No open or close action | Check the compressed air; Check the solenoid valve. |
| | Switch fault | Check the switch and the 24V power supply |
| High TSS or turbidity of product water | Air in the turbidimeter | Check the water pipe and eliminate the air |
| | Membrane skid or module integrity breach | Perform integrity test and repair |
| | O-ring failures or module sealing issues | Check module connections and seals |

NANOH2O

NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 807

MBR & Submerged UF System Troubleshooting

### MBR System Troubleshooting Basics

| Symptom | Possible Causes | Possible Solutions |
|---|---|---|
| High TMP | Membrane fouling | Confirm filtrate flowrate; Initiate suitable cleaning |
| | | Verify automated cleanings are occurring correctly |
| | Low air scouring flow rate | Check the blower; Check the piping and valve |
| | | Adjust air scour flow rate; Confirm aeration is even |
| | High MLSS | Waste sludge to bring into correct range; Increase RAS pumping rate |
| | | Confirm WAS system is functioning properly |
| | Biological system performance | Verify DO concentration; Verify filtrate BOD concentration |
| | Faulty reading | Check for presence of air in filtrate line; Operate air removal system, as needed |
| High filtrate TSS or turbidity | Membrane skid or module integrity breach | Perform integrity test and repair |
| | Air in the turbidimeter | Check the water pipe and eliminate the air. |
| Low filtrate flow | Membrane fouling | See above |
| | Loss of filtrate pump prime | Air removal system not operating properly or frequently enough |
| | Control system failure | Check filtrate pump PID and flow meter |
| | Pressure meter fault | Calibrate the flow meter |
| Low membrane tank level | Feed/RAS pump failure | Check feed and RAS pump and piping |
| | Valve failure | Check feed and RAS valves;<br>Check drain valve |
| Motor failure | No electricity | Check power supply |
| | VFD failure | Check the VFD unit |
| | Motor Over load | Check the setting of overload for the motor; If the value is exceeded, contact the supplier |
| Valve failure | Will not open or close | Check the compressed air supply pressure; Check the solenoid valve |
| | Switch fault | Check the switch and the 24V power supply |

NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 807

MBR & Submerged UF System Troubleshooting

### Response Procedures

#### Critical Failure Response

1. Implement immediate system shutdown if:

- TMP exceeds maximum allowable limit
- Multiple fiber breaks detected
- Chemical leak identified
- Major mechanical failure occurs

2. Documentation Requirements:

- Record all alarm conditions
- Log operator actions taken
- Document system parameters at time of failure
- Photograph any visible issues

3. Recovery Steps:

- Isolate affected modules
- Implement temporary bypass if possible
- Contact technical support
- Prepare incident reports

### Performance Recovery Strategies

#### Short-term Recovery

- Implement extended chemical cleaning
- Increase air scouring frequency
- Reduce flux temporarily
- Enhance pretreatment chemical dosing

#### Long-term Solutions

- Evaluate membrane replacement criteria
- Assess operating protocols
- Review maintenance procedures
- Consider system modifications

### Preventive Measures

#### Early Warning Signs

- Gradual increase in TMP
- Minor permeate quality fluctuations
- Unusual noise or vibration
- Changes in chemical consumption

#### Risk Mitigation

- Implement regular integrity testing
- Monitor critical spare parts inventory
- Maintain detailed operational logs
- Conduct regular operator training
- Perform preventive maintenance according to schedule

NANOH2O

NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 808

MBR & Submerged UF System Design

This technical manual provides comprehensive guidance for engineers and system designers working on Membrane Bioreactor (MBR) & submerged ultrafiltration (UF) Systems. The information contained within addresses fundamental design considerations, operational parameters, and best practices for implementing successful UF & MBR installations in water and wastewater treatment applications.

**Key Operating Parameter Definitions**

**Filtrate flow rate**
Filtrate flow rate is the rate of the water that passes through the membrane from the feed side to the filtrate side. It is a function of the pressure, and the quality of the feed water. The filtrate flow rate should be set in according to NANOH2O's recommended membrane flux.

**Filtrate flux**
Filtrate flux is the volume of filtered water passing through a unit of membrane surface area in a specified period of time. It is commonly expressed as lmh (Liters of filtered water/$m^2$ of surface area/hour of filtration time), gfd (gallons of filtered water/$ft^2$ of surface area/day of filtration time), or m/d ($m^3$ of filtered water/$m^2$ of surface area/day of filtration time). Appropriate flux selection is one of the most important design and operating considerations. The filtrate flux should be set according to NANOH2O's recommendation for your specific application. The flux may be increased or decreased during operation to account for changes in feed water quality, temperature or product water demand.

**Transmembrane Pressure**
Transmembrane Pressure (TMP) is the pressure difference between the feed and filtrate sides of the membrane. It is commonly measured in units of bar, psi, or kPa. TMP is the driving force for filtration. Most ultrafiltration systems operate at a constant flow rate during filtration. As filtration occurs, solids deposited on the membrane surface will create resistance to filtration causing the TMP to increase. Proper design filtrate flux is necessary to control the rate of TMP increase. Physical and chemical cleaning are required to remove accumulated fouling and reduce TMP. The maximum allowable TMP is 0.05 MPa (7.2 psi).

**Normalized permeability**
Normalized permeability, or specific flux, is defined as filtrate flux per applied transmembrane pressure (differential pressure) corrected to a specified temperature, typically 20 or 25 degrees Celsius. It is commonly measured in units of lmh/bar or gfd/psi @20°C. Normalized permeability is one of the most important parameters used to measure the performance of the membrane system. In a properly designed and operated UF system, the normalized permeability will decrease slowly between cleanings and will return to previous levels after cleaning such that it remains essentially constant over long-term operation.

**Filtration cycle duration**
The filtration cycle duration is dependent on the quality of the feed water. An appropriate design value should be selected per NANOH2O's recommendation. The actual time should be set by testing at site and adjusted according to the changes of the feed water quality during the operation. Typical filtration cycle duration is 20-60 minutes for submerged UF and 7-12 minutes for MBR applications.

NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 808

MBR & Submerged UF System Design

## Membrane Tank Sludge Limiting Conditions

### Table 1: Allowable Membrane Tank Sludge Quality

| Parameter | Allowed Range | Comments |
|---|---|---|
| pH in membrane tank | 1 – 10 (TIPS) | 1—14 allowed during cleaning (TIPS) |
| Particle Size[1] | ≤ 2.0 mm | ≤ 2 mm by automatic screening Perforated plate or punched hole |
| Mixed Liquor temperature ºC (ºF) | 5 – 45 (41 – 113) | |
| MLSS in membrane tank, mg/L MBR only | 5,000 – 12,000 | Normal range 6,000 – 8,000 |
| Oil | <2 mg/L (TIPS) | To prevent membrane fouling |
| Dissolved Oxygen, mg/L | > 2 | For MBR only |
| Total hardness (mg/L as $CaCO_3$) | Non-scaling | Dependent on pH and scaling |
| Soluble $BOD_5$ Concentration (mg/L) | < 3 | |
| $NH_3$-N concentration in mixed liquor entering | ≤ 1.0 | |
| Colloidal TOC (cTOC) concentration in mixed liquor entering membrane tanks (mg/L) | ≤ 10 | |
| Soluble alkalinity of mixed liquor entering membrane tanks (mg/L as $CaCO_3$) | 50 – 150 | |

[1] Primarily concerned with the entry of sharp objects into the treatment system such as branches, plastic pieces, sand etc., and fibrous material, such as hair.

* This is not an extensive list and does not constitute the only conditions for a valid warranty claim. Refer to your project specific warranty document for all conditions that apply to your warranty.

NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 808

MBR & Submerged UF System Design

### Design Fundamentals

**Membrane Selection**
The selection of appropriate membrane materials and configurations forms the foundation of successful UF system design. Polymeric membranes, typically fabricated from PVDF (polyvinylidene fluoride), offer excellent chemical resistance and mechanical strength. The nominal pore size typically ranges from 0.01 to 0.04 micrometers, enabling effective removal of suspended solids, bacteria, and other particulates while allowing dissolved constituents to pass through.

**Hydraulic Design Parameters**
The hydraulic design of submerged UF/MBR systems must account for several critical parameters. The specific flux, typically expressed in liters per square meter per hour (LMH), determines the membrane area required. Design flux rates for submerged UF generally range from 40-70 LMH for drinking water applications and 30-50 LMH for wastewater applications, depending on feed water quality and operational conditions. For MBR, the typical flux rate is 10-25 LMH depending on the application.

Transmembrane pressure (TMP) must be carefully controlled, typically 0.5 bar, to maintain stable operation while preventing membrane damage. The relationship between flux and TMP should be evaluated during the design phase to ensure optimal performance throughout the system's lifecycle.

**Module Configuration**
Membrane modules must be arranged to facilitate effective air scouring and maintain uniform flow distribution. Typical configurations include vertical arrays with modules resting on the tank bottom. Adequate spacing between modules (typically 55-85mm) ensures proper air distribution and prevents localized fouling.

**Air Scouring System Design**
The air scouring system represents a crucial component in submerged UF/MBR design. Coarse bubble aeration provides mechanical cleaning action to control fouling and maintain membrane permeability. Air flow rates are provided in the NANOH2O projection software output.

The air distribution system should incorporate the following design modules:

Header pipes must be sized to maintain uniform air distribution across all modules. Manifold design should account for pressure losses and ensure balanced flow.

**Chemical Cleaning Systems**
Effective chemical cleaning capabilities must be integrated into the system design. Both maintenance cleaning (MC) and recovery cleaning (RC) should be incorporated. The chemical cleaning system should include:

- Storage tanks sized for cleaning solution volumes based on module requirements
- Chemical metering pumps with appropriate materials of construction
- Distribution piping with proper chemical resistance
- Neutralization capabilities for spent cleaning solutions

Typical cleaning chemicals include sodium hypochlorite for organic fouling and citric acid for inorganic fouling. The appropriate cleaning chemicals, dosage rates and MC/RC frequencies are provided in the NANOH2O design projection and are typically fine-tuned during startup and operation.

**Instrumentation and Control**

Robust instrumentation and control systems are essential for monitoring and optimizing UF system performance. Key parameters requiring continuous monitoring include:

- Flow rates (feed, permeate, and air scour)
- Transmembrane pressure
- Turbidity (feed and permeate)
- Temperature
- pH
- Pressure at various points in the system
- DO & MLSS for MBR applications only

The control system should automate critical processes including filtration cycles, backwashing sequences, and chemical cleaning operations. Integration with SCADA systems enables remote monitoring and data collection for performance optimization.

**Pretreatment Requirements**

Proper pretreatment design extends membrane life and optimizes system performance. Essential pretreatment steps may include:

- Screening to remove large particles and debris (typically 100-500 microns)
- Grit removal for applications with high suspended solids
- Chlorination for biological fouling control
- Coagulation/flocculation for enhanced particle removal

The pretreatment system should be designed based on detailed feed water analysis and anticipated variations in water quality.

**Operational Considerations**

**Filtration Cycle Design**

Filtration cycles must be optimized to balance productivity with membrane fouling control. Typical cycle times will be provided in the NANOH2O design output and may be optimized based on operational experience and data. The specific duration of cycle times may also be determined based on pilot testing.

# Technical Service Bulletin 808

## MBR & Submerged UF System Design

**Energy Efficiency**

Energy consumption represents a significant operational cost for Submerged UF/MBR systems. Design considerations for energy efficiency include:

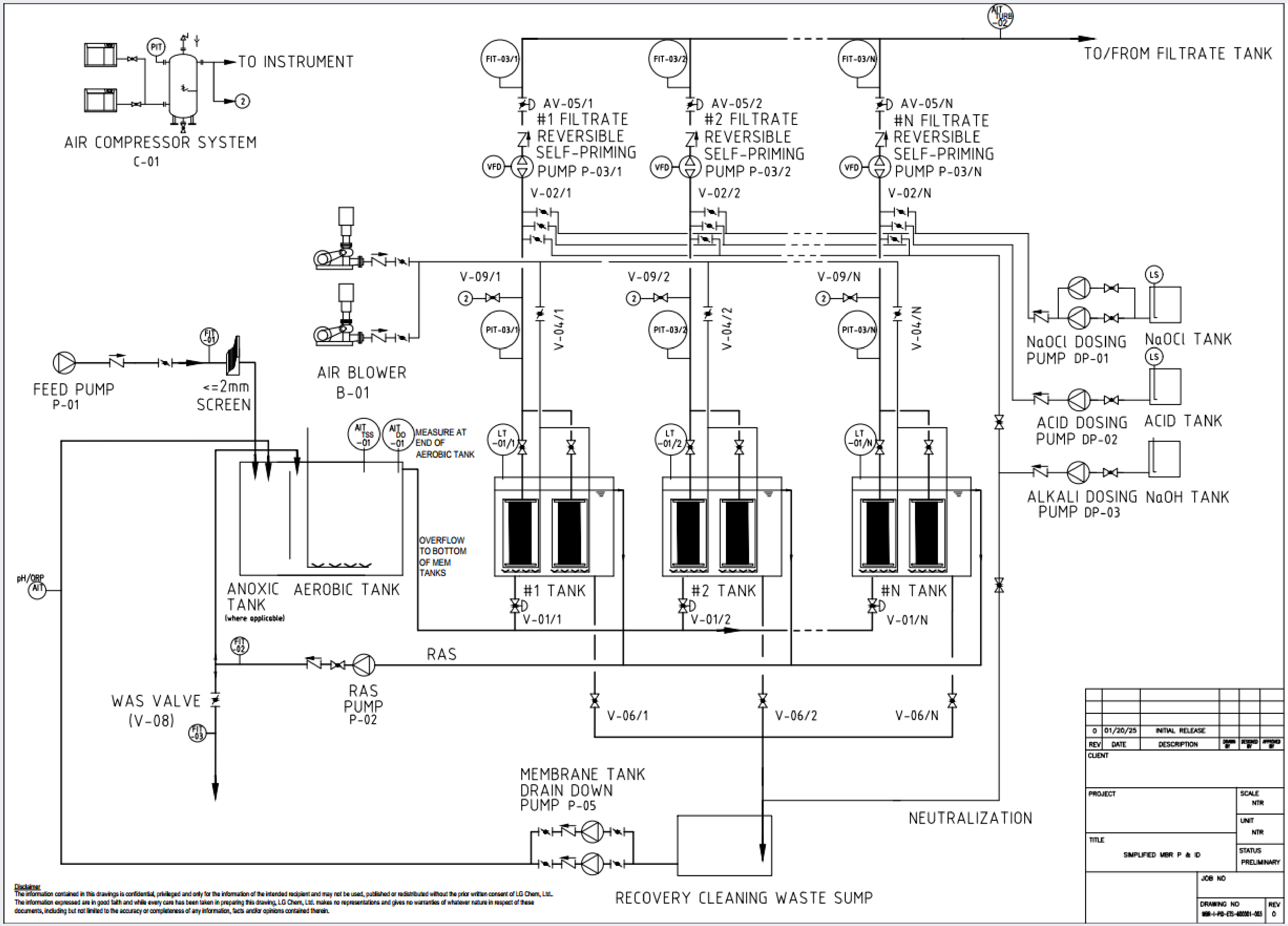
- Selection of energy-efficient pumps and blowers
- Optimization of air scour rates
- Implementation of energy recovery devices where applicable
- Use of variable frequency drives for equipment

**Safety Considerations**

System design must incorporate appropriate safety measures including:

- Chemical containment and handling systems
- Emergency shower and eyewash stations
- Proper ventilation for chemical storage areas
- Access platforms and railings for maintenance
- Lock-out/tag-out capabilities for all equipment

**The following Simplified PFD refers to QuantumFlux S series modules For MBR Application**


AIR COMPRESSOR SYSTEM
C-01
PIT
TO INSTRUMENT
AIT TURB -02
TO/FROM FILTRATE TANK
FIT-03/1
FIT-03/2
FIT-03/N
AV-05/1
AV-05/2
AV-05/N
#1 FILTRATE REVERSIBLE SELF-PRIMING PUMP P-03/1
#2 FILTRATE REVERSIBLE SELF-PRIMING PUMP P-03/2
#N FILTRATE REVERSIBLE SELF-PRIMING PUMP P-03/N
VFD
V-02/1
V-02/2
V-02/N
V-09/1
V-09/2
V-09/N
PIT-03/1
PIT-03/2
PIT-03/N
V-04/1
V-04/2
V-04/N
AIR BLOWER
B-01
FEED PUMP
P-01
FIT -01
<=2mm
SCREEN
NaOCl DOSING PUMP DP-01
NaOCl TANK
LS
ACID DOSING PUMP DP-02
ACID TANK
ALKALI DOSING PUMP DP-03
NaOH TANK
AIT TSS -01
AIT DO -01
MEASURE AT END OF AEROBIC TANK
LT -01/1
LT -01/2
LT -01/N
OVERFLOW TO BOTTOM OF MEM TANKS
pH/ORP
AIT
ANOXIC TANK
(where applicable)
AEROBIC TANK
#1 TANK
#2 TANK
#N TANK
V-01/1
V-01/2
V-01/N
FIT -02
RAS
RAS PUMP
P-02
WAS VALVE
(V-08)
FIT -03
V-06/1
V-06/2
V-06/N
MEMBRANE TANK DRAIN DOWN PUMP P-05
NEUTRALIZATION
RECOVERY CLEANING WASTE SUMP
0 01/20/25 INITIAL RELEASE
REV DATE DESCRIPTION
CLIENT
PROJECT
SCALE NTR
UNIT NTR
TITLE SIMPLIFIED MBR P & ID
STATUS PRELIMINARY
JOB NO
DRAWING NO
REV 0
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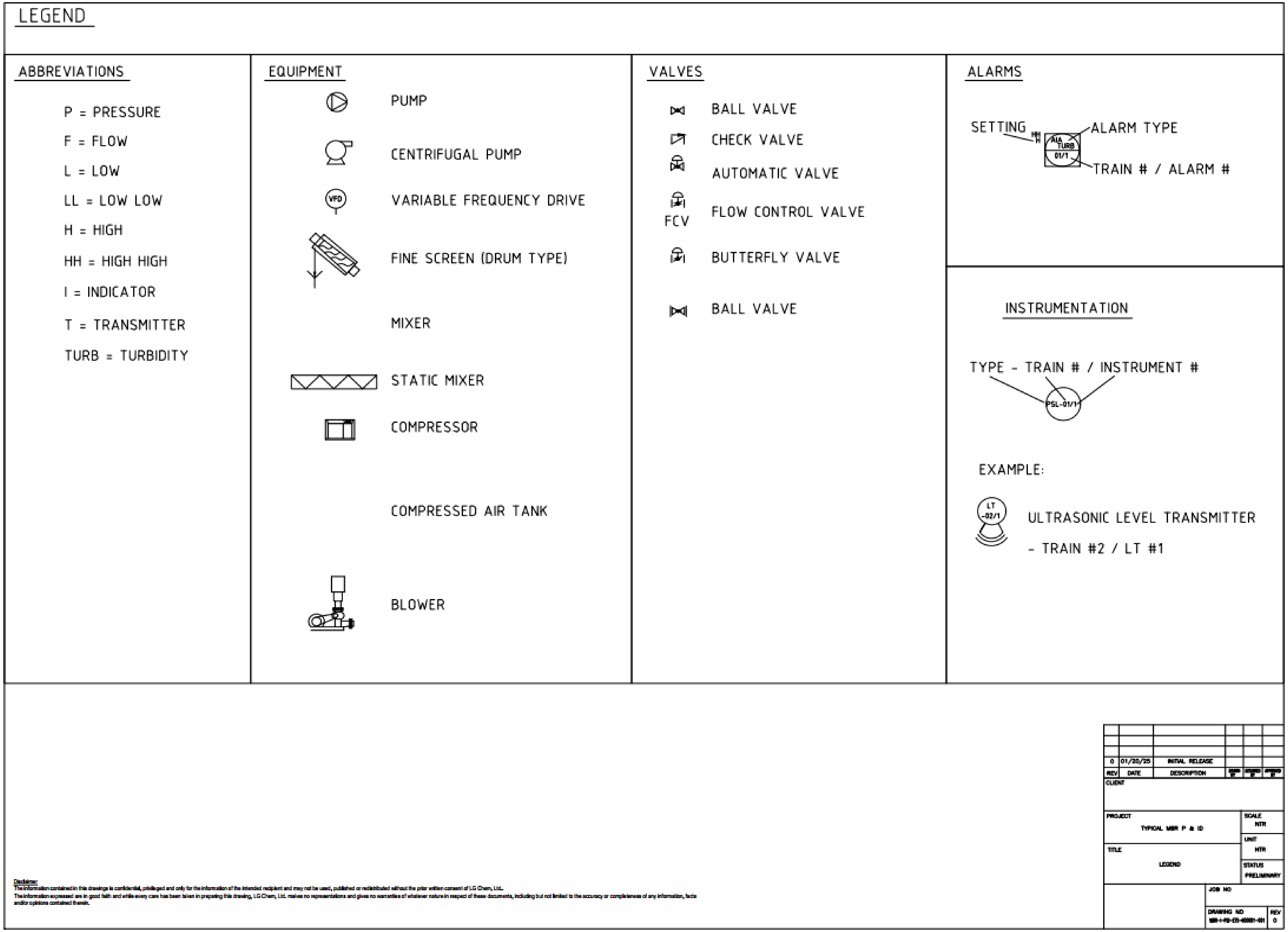
**The following P&I Diagrams refer to QuantumFlux S Series modules**
**For MBR Applications**


LEGEND
ABBREVIATIONS
P = PRESSURE
F = FLOW
L = LOW
LL = LOW LOW
H = HIGH
HH = HIGH HIGH
I = INDICATOR
T = TRANSMITTER
TURB = TURBIDITY
EQUIPMENT
PUMP
CENTRIFUGAL PUMP
VFD
VARIABLE FREQUENCY DRIVE
FINE SCREEN (DRUM TYPE)
MIXER
STATIC MIXER
COMPRESSOR
COMPRESSED AIR TANK
BLOWER
VALVES
BALL VALVE
CHECK VALVE
AUTOMATIC VALVE
FCV
FLOW CONTROL VALVE
BUTTERFLY VALVE
BALL VALVE
ALARMS
SETTING
ALARM TYPE
TRAIN # / ALARM #
TURB
01/1
INSTRUMENTATION
TYPE - TRAIN # / INSTRUMENT #
PSL-01/1
EXAMPLE:
LT
-02/1
ULTRASONIC LEVEL TRANSMITTER
- TRAIN #2 / LT #1
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DATE
DESCRIPTION
CLIENT
PROJECT
TYPICAL MBR P & ID
SCALE
NTR
UNIT
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TITLE
LEGEND
STATUS
PRELIMINARY
JOB NO
DRAWING NO
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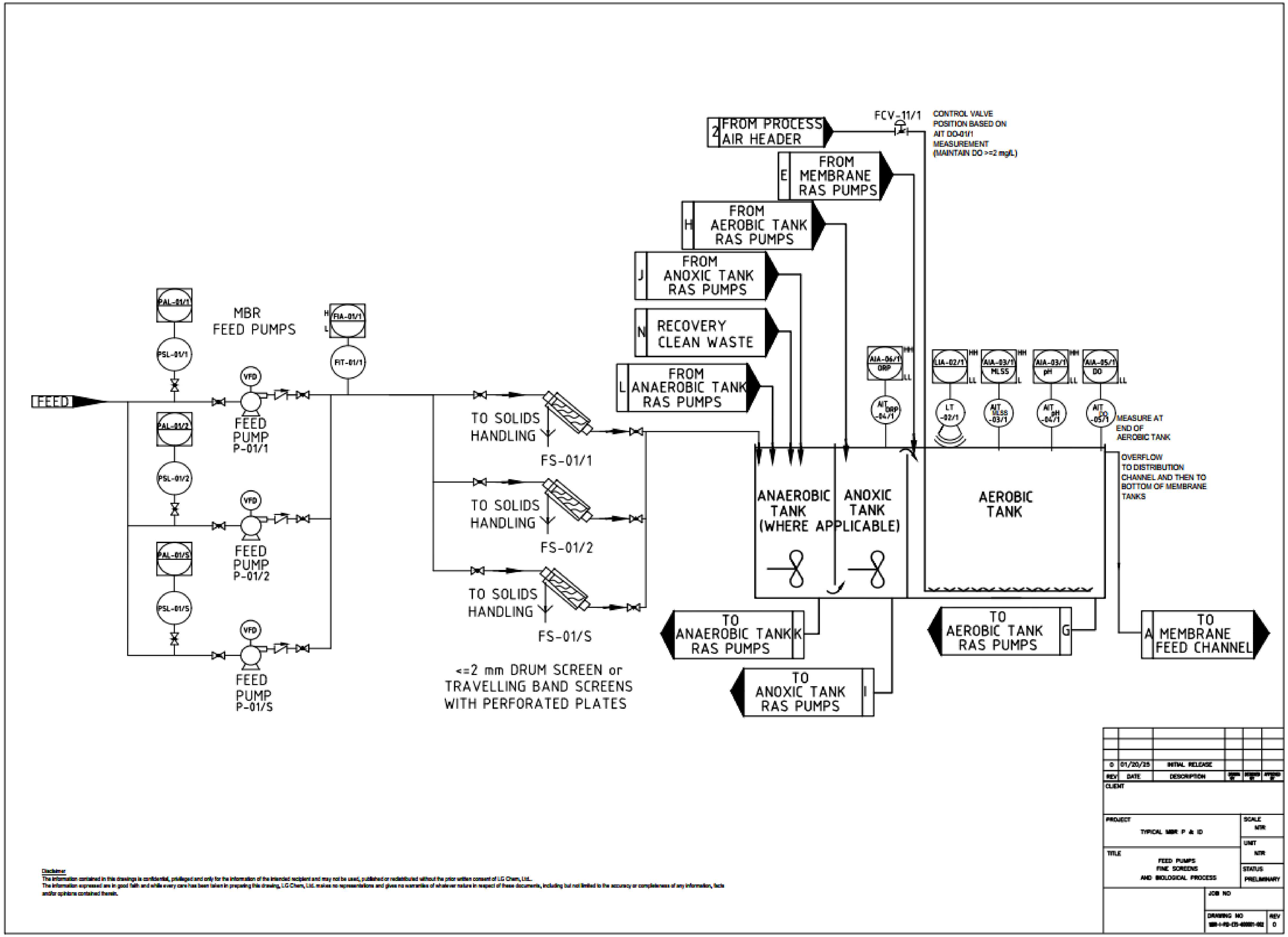

FROM PROCESS AIR HEADER
2
FCV-11/1
CONTROL VALVE POSITION BASED ON AIT DO-01/1 MEASUREMENT (MAINTAIN DO >=2 mg/L)
E
FROM MEMBRANE RAS PUMPS
H
FROM AEROBIC TANK RAS PUMPS
J
FROM ANOXIC TANK RAS PUMPS
N
RECOVERY CLEAN WASTE
L
FROM ANAEROBIC TANK RAS PUMPS
PAL-01/1
PSL-01/1
MBR FEED PUMPS
FIA-01/1
FIT-01/1
FEED
VFD
FEED PUMP P-01/1
PAL-01/2
PSL-01/2
FEED PUMP P-01/2
PAL-01/S
PSL-01/S
FEED PUMP P-01/S
TO SOLIDS HANDLING
FS-01/1
TO SOLIDS HANDLING
FS-01/2
TO SOLIDS HANDLING
FS-01/S
<=2 mm DRUM SCREEN or TRAVELLING BAND SCREENS WITH PERFORATED PLATES
AIA-06/1 ORP
AIT ORP -04/1
LIA-02/1
LT -02/1
AIA-03/1 MLSS
AIT MLSS -03/1
AIA-03/1 pH
AIT pH -04/1
AIA-05/1 DO
AIT DO -05/1
HH
LL
L
MEASURE AT END OF AEROBIC TANK
OVERFLOW TO DISTRIBUTION CHANNEL AND THEN TO BOTTOM OF MEMBRANE TANKS
ANAEROBIC TANK (WHERE APPLICABLE)
ANOXIC TANK
AEROBIC TANK
TO ANAEROBIC TANK RAS PUMPS
K
TO ANOXIC TANK RAS PUMPS
I
TO AEROBIC TANK RAS PUMPS
G
A
TO MEMBRANE FEED CHANNEL
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0 01/20/25 INITIAL RELEASE
REV DATE DESCRIPTION
CLIENT
PROJECT
TYPICAL MBR P & ID
SCALE
NTR
UNIT
NTR
TITLE
FEED PUMPS
FINE SCREENS
AND BIOLOGICAL PROCESS
STATUS
PRELIMINARY
JOB NO
DRAWING NO
REV
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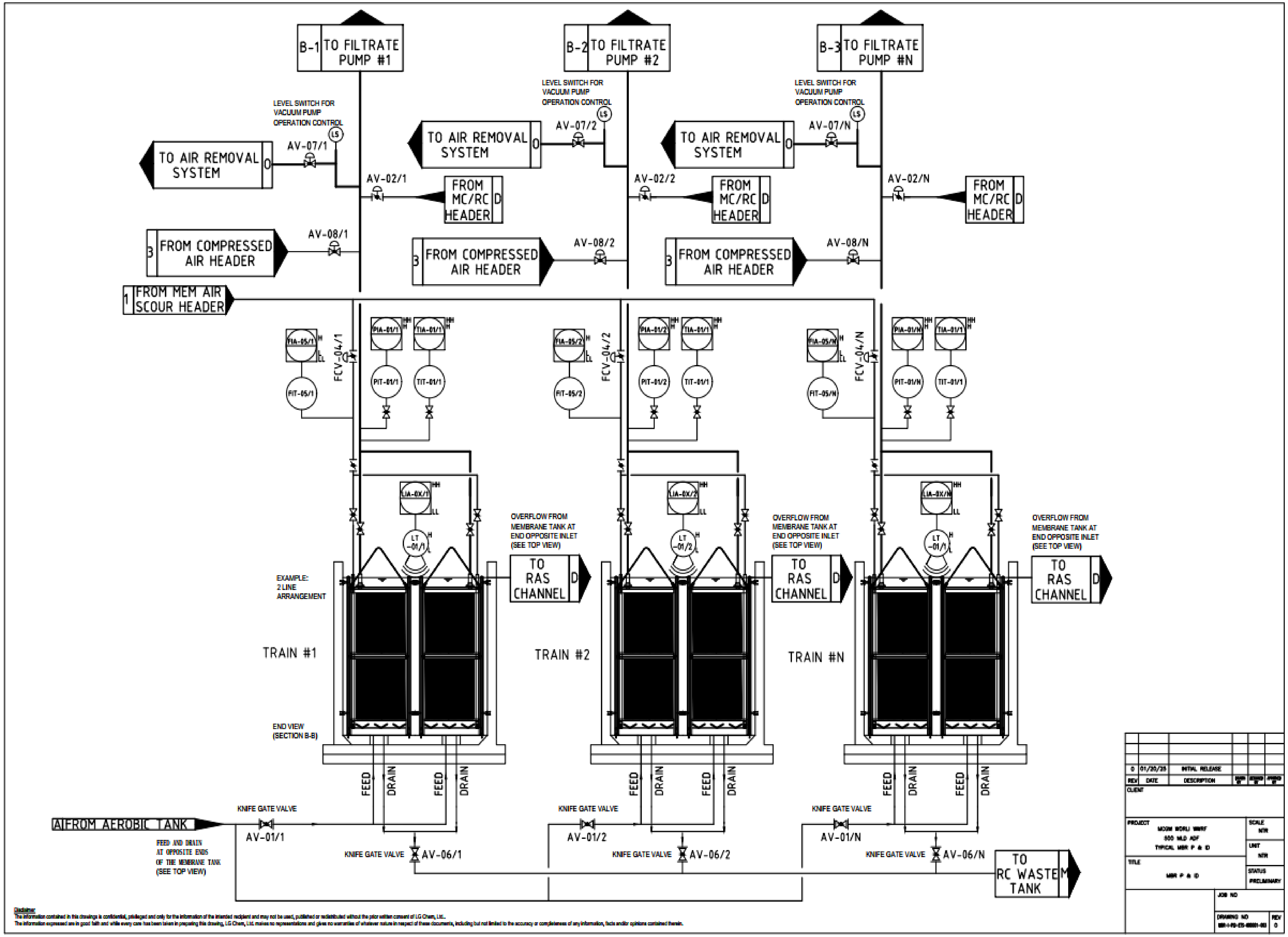
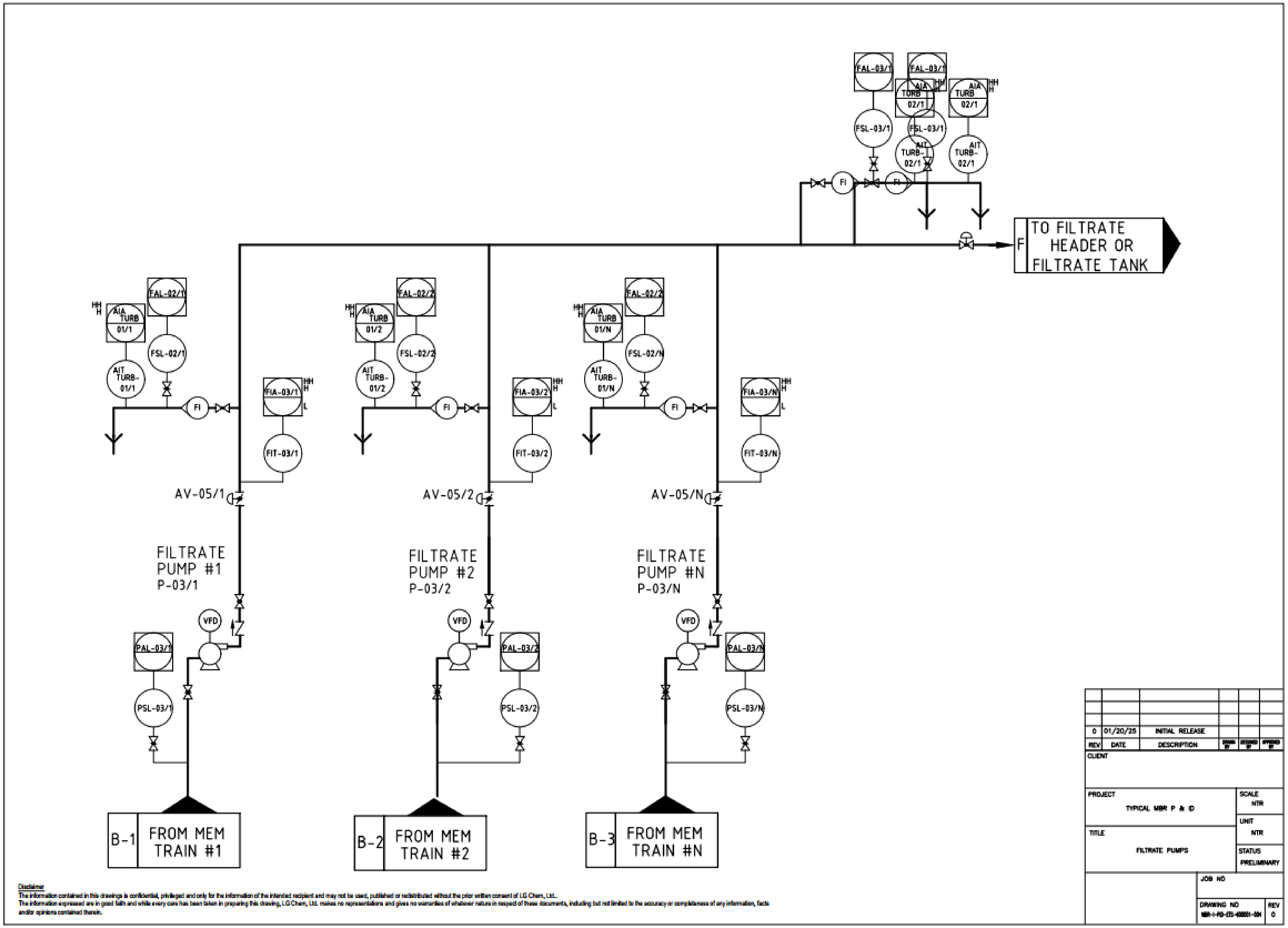

B-1 TO FILTRATE PUMP #1
B-2 TO FILTRATE PUMP #2
B-3 TO FILTRATE PUMP #N
LEVEL SWITCH FOR VACUUM PUMP OPERATION CONTROL
LS
TO AIR REMOVAL SYSTEM 0
AV-07/1
AV-07/2
AV-07/N
AV-02/1
AV-02/2
AV-02/N
FROM MC/RC HEADER D
FROM COMPRESSED AIR HEADER
AV-08/1
AV-08/2
AV-08/N
1 FROM MEM AIR SCOUR HEADER
FCV-04/1
FCV-04/2
FCV-04/N
FIT-05/1
FIT-05/2
FIT-05/N
PIT-01/1
PIT-01/2
PIT-01/N
TIT-01/1
OVERFLOW FROM MEMBRANE TANK AT END OPPOSITE INLET (SEE TOP VIEW)
TO RAS CHANNEL D
EXAMPLE: 2 LINE ARRANGEMENT
TRAIN #1
TRAIN #2
TRAIN #N
END VIEW (SECTION B-B)
FEED
DRAIN
KNIFE GATE VALVE
A FROM AEROBIC TANK
AV-01/1
AV-01/2
AV-01/N
FEED AND DRAIN AT OPPOSITE ENDS OF THE MEMBRANE TANK (SEE TOP VIEW)
AV-06/1
AV-06/2
AV-06/N
TO RC WASTE TANK M
INITIAL RELEASE
REV
DATE
DESCRIPTION
CLIENT
PROJECT
SCALE
NTS
UNIT
TITLE
MBR P & ID
STATUS
PRELIMINARY
JOB NO
DRAWING NO
Disclaimer:


TO FILTRATE HEADER OR FILTRATE TANK
F
FAL-03/1
AIA TURB 02/1
HH
H
FSL-03/1
AIT TURB-02/1
FI
AIA TURB 01/1
FAL-02/1
FSL-02/1
AIT TURB-01/1
FIA-03/1
FIT-03/1
AV-05/1
FILTRATE PUMP #1 P-03/1
VFD
PAL-03/1
PSL-03/1
B-1
FROM MEM TRAIN #1
AIA TURB 01/2
FAL-02/2
FSL-02/2
AIT TURB-01/2
FIA-03/2
FIT-03/2
AV-05/2
FILTRATE PUMP #2 P-03/2
PAL-03/2
PSL-03/2
B-2
FROM MEM TRAIN #2
AIA TURB 01/N
FAL-02/N
FSL-02/N
AIT TURB-01/N
FIA-03/N
FIT-03/N
AV-05/N
FILTRATE PUMP #N P-03/N
PAL-03/N
PSL-03/N
B-3
FROM MEM TRAIN #N
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0 01/20/25 INITIAL RELEASE
REV DATE DESCRIPTION
CLIENT
PROJECT
TYPICAL MBR P & ID
SCALE
NTR
UNIT
NTR
TITLE
FILTRATE PUMPS
STATUS
PRELIMINARY
JOB NO
DRAWING NO
REV
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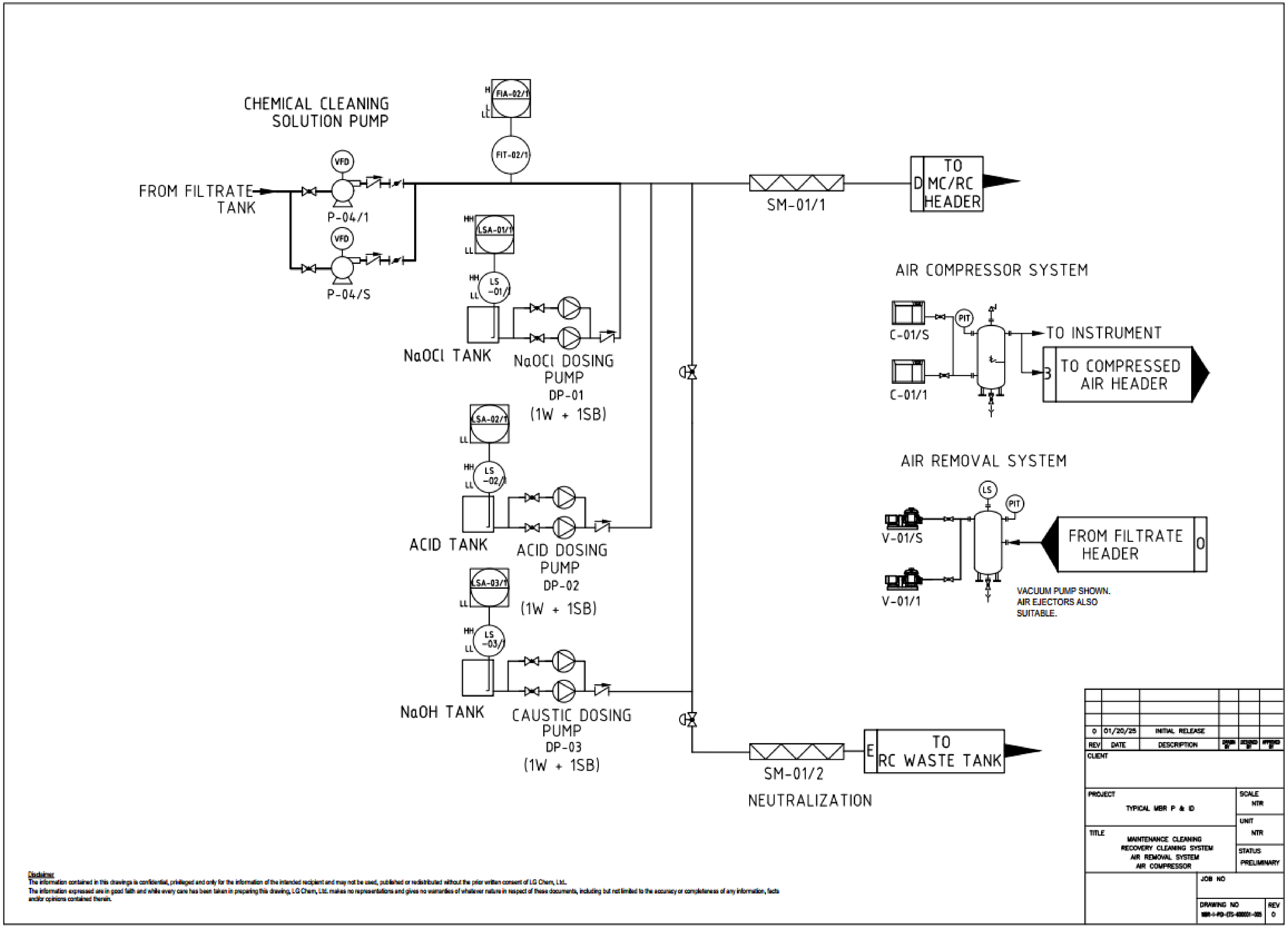

CHEMICAL CLEANING SOLUTION PUMP
FIA-02/1
FIT-02/1
FROM FILTRATE TANK
VFD
P-04/1
VFD
P-04/S
LSA-01/1
LS -01/1
NaOCl TANK
NaOCl DOSING PUMP
DP-01
(1W + 1SB)
LSA-02/1
LS -02/1
ACID TANK
ACID DOSING PUMP
DP-02
(1W + 1SB)
LSA-03/1
LS -03/1
NaOH TANK
CAUSTIC DOSING PUMP
DP-03
(1W + 1SB)
SM-01/1
D
TO MC/RC HEADER
AIR COMPRESSOR SYSTEM
C-01/S
C-01/1
PIT
TO INSTRUMENT
3
TO COMPRESSED AIR HEADER
AIR REMOVAL SYSTEM
LS
PIT
V-01/S
V-01/1
FROM FILTRATE HEADER
O
VACUUM PUMP SHOWN. AIR EJECTORS ALSO SUITABLE.
SM-01/2
NEUTRALIZATION
E
TO RC WASTE TANK
0 01/20/25 INITIAL RELEASE
REV DATE DESCRIPTION
CLIENT
PROJECT
TYPICAL MBR P & ID
SCALE
NTR
UNIT
NTR
TITLE
MAINTENANCE CLEANING
RECOVERY CLEANING SYSTEM
AIR REMOVAL SYSTEM
AIR COMPRESSOR
STATUS
PRELIMINARY
JOB NO
DRAWING NO
REV
0
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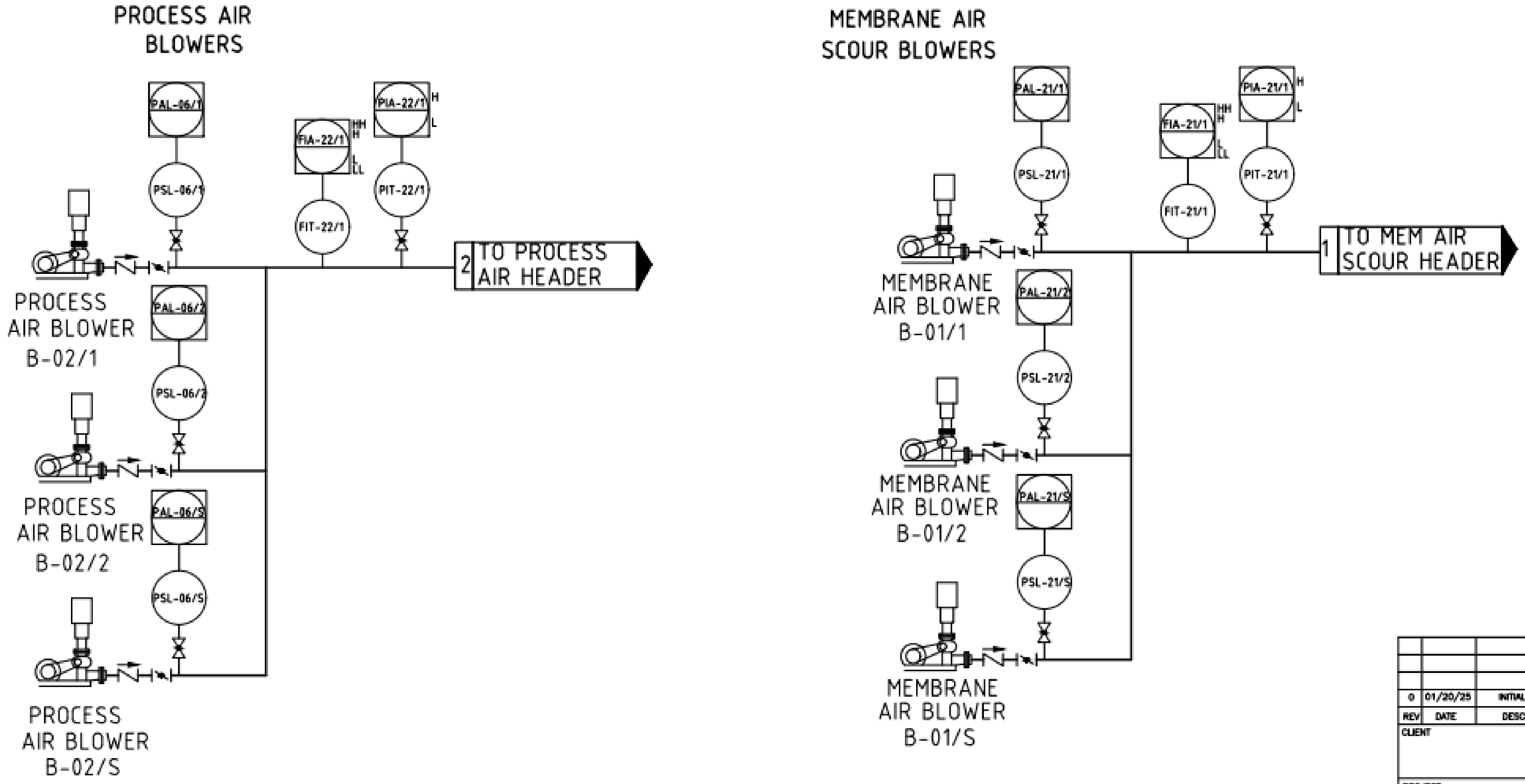


| REV | DATE | DESCRIPTION | DRAWN BY | DESIGNED BY | APPROVED BY |
|---|---|---|---|---|---|
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| 0 | 01/20/25 | INITIAL RELEASE | | | |

CLIENT

PROJECT
TYPICAL MBR P & ID

SCALE
NTR

UNIT
NTR

TITLE
MEMBRANE AIR SCOUR BLOWERS
BIOLOGICAL PROCESS AIR BLOWERS

STATUS
PRELIMINARY

JOB NO

DRAWING NO
MBR-I-PID-EES-400001-006

REV
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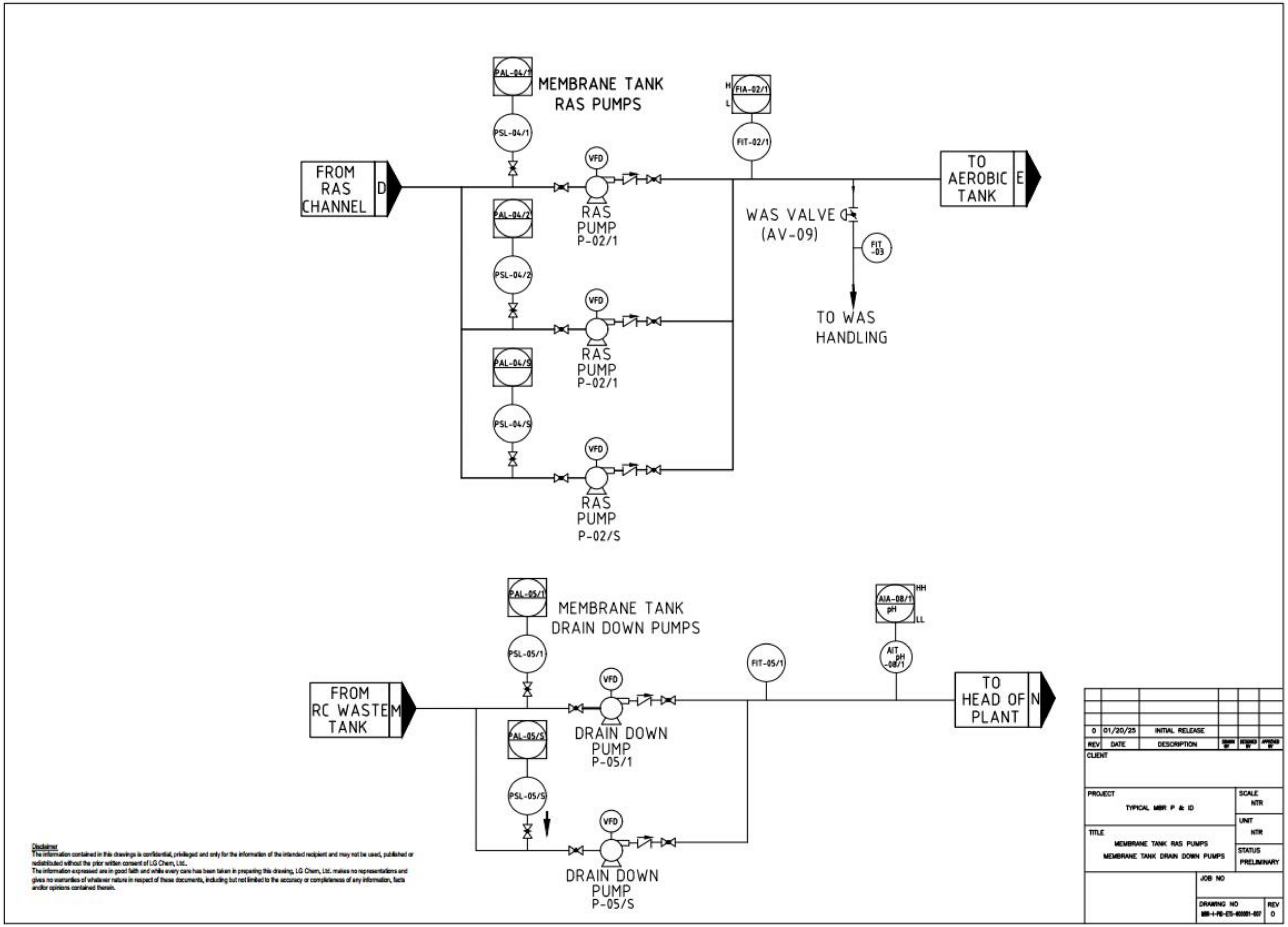
MEMBRANE TANK
RAS PUMPS
PAL-04/1
PSL-04/1
FIA-02/1
H
L
FIT-02/1
VFD
FROM
RAS
CHANNEL
D
TO
AEROBIC
TANK
E
RAS
PUMP
P-02/1
WAS VALVE
(AV-09)
FIT
-03
PAL-04/2
PSL-04/2
TO WAS
HANDLING
RAS
PUMP
P-02/1
PAL-04/S
PSL-04/S
RAS
PUMP
P-02/S
PAL-05/1
MEMBRANE TANK
DRAIN DOWN PUMPS
AIA-08/1
pH
HH
LL
PSL-05/1
FIT-05/1
AIT
pH
-08/1
FROM
RC WASTE
TANK
M
TO
HEAD OF
PLANT
N
DRAIN DOWN
PUMP
P-05/1
PAL-05/S
PSL-05/S
DRAIN DOWN
PUMP
P-05/S
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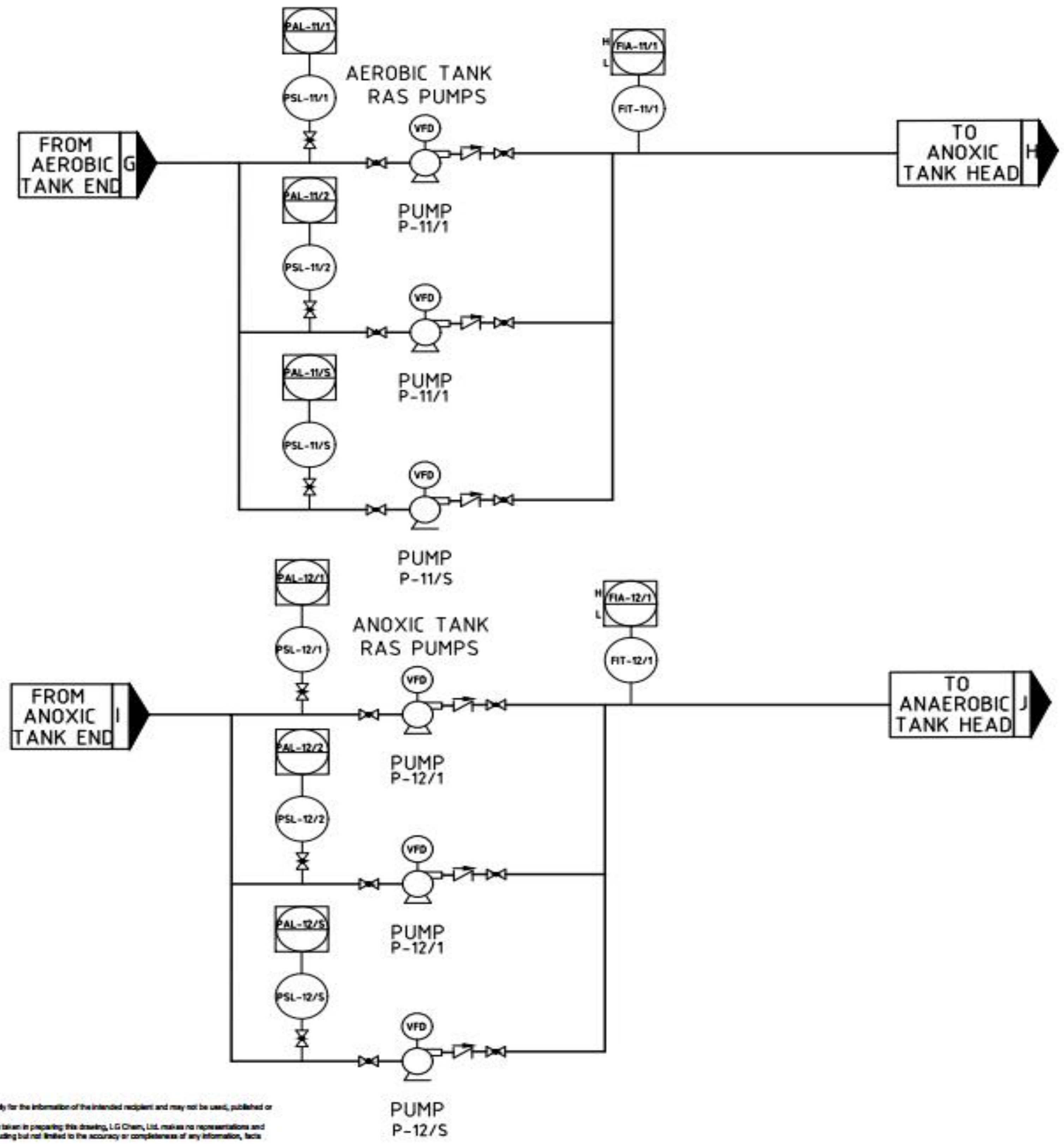
0
01/20/25
INITIAL RELEASE
REV
DATE
DESCRIPTION
CLIENT
PROJECT
TYPICAL MBR P & ID
SCALE
NTR
UNIT
NTR
TITLE
MEMBRANE TANK RAS PUMPS
MEMBRANE TANK DRAIN DOWN PUMPS
STATUS
PRELIMINARY
JOB NO
DRAWING NO
REV
0

NANOH2O

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| REV | DATE | DESCRIPTION | | | |
|---|---|---|---|---|---|
| 0 | 01/20/25 | INITIAL RELEASE | | | |

CLIENT

PROJECT: TYPICAL MBR P & ID

SCALE: NTR

TITLE: BIOLOGICAL PROCESS RAS PUMPS

UNIT: NTR

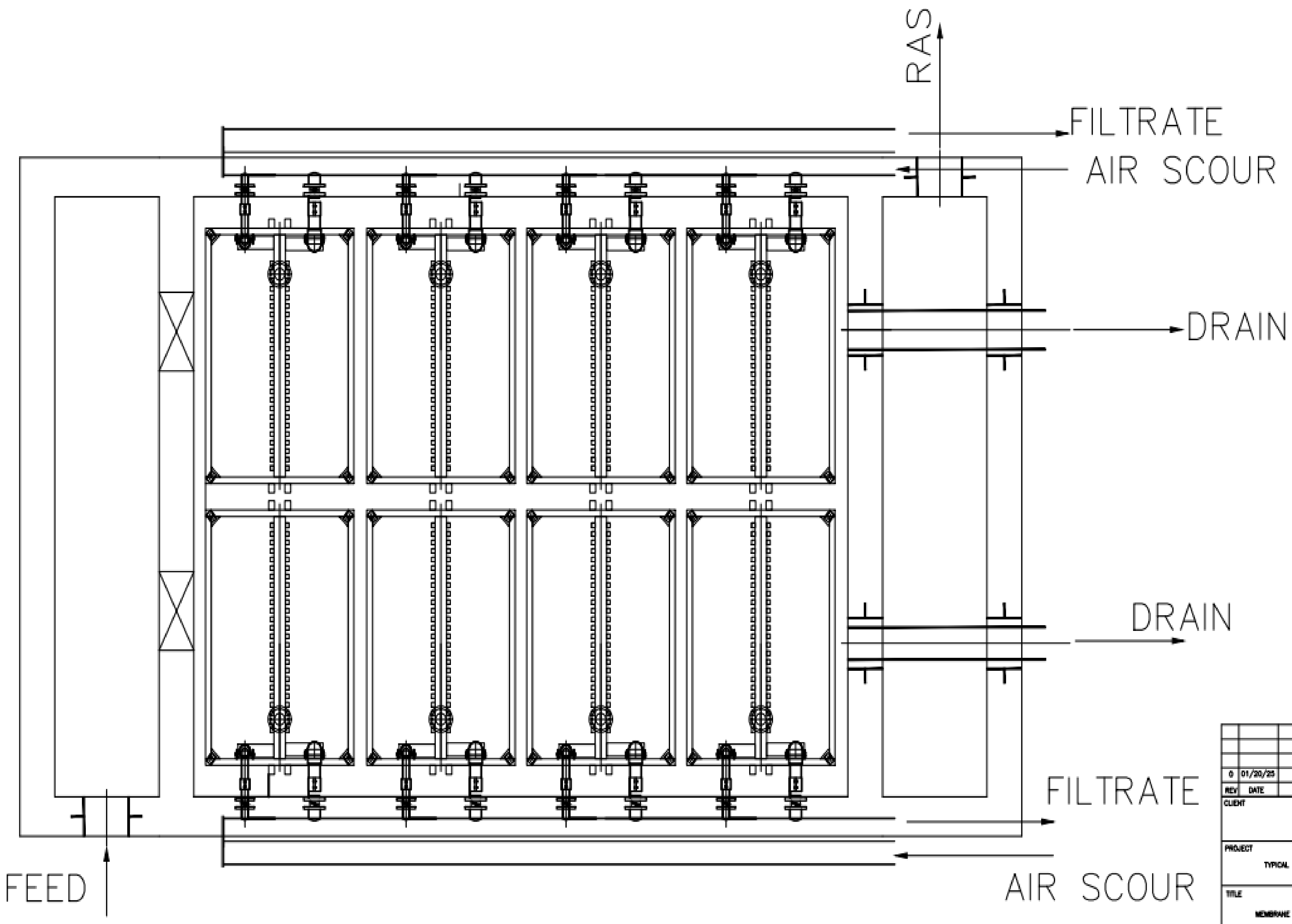
STATUS: PRELIMINARY

JOB NO

DRAWING NO: [illegible]

REV: 0

## MEMBRANE TANK TOP VIEW
## (2-LINE ARRANGEMENT)




| | | | | | |
|---|---|---|---|---|---|
| 0 | 01/20/25 | INITIAL RELEASE | | | |
| REV | DATE | DESCRIPTION | | | |

| | |
|---|---|
| CLIENT | |
| PROJECT: TYPICAL MBR P & ID | SCALE: NTR |
| | UNIT: NTR |
| TITLE: MEMBRANE TANK TOP VIEW | STATUS: PRELIMINARY |
| | JOB NO |
| | DRAWING NO: [illegible] — REV: 0 |

NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 809

Data Logging and Performance Monitoring

In order to properly troubleshoot MBR & Submerged UF module performance issues, identify system operational issues, develop cleaning and maintenance procedures, and ensure the validity of the product/system warranty, it is critical that feedwater quality and system performance data be recorded and logged on a regular basis such that information is readily available for review in the event of a performance problem or a warranty claim.

**Why is Data Collection Important?**

UF/MBR membrane performance can be affected by a variety of factors, such as a change in feedwater quality or a change in operating conditions; the only way to determine whether your membranes are performing as expected is through regular collection and routine analysis of feedwater quality and system performance data. This information can then be evaluated over time to determine whether membrane performance is tracking as expected or if adverse trends develop which then require corrective action. All data collected should be systematically logged for future access to allow analysis of longer-term performance trends that may require troubleshooting or support a warranty claim.

CAUTION

Failure to maintain the minimum data logging requirements identified herein or to make such data available to NANOH2O upon request may result in voiding your product/system warranty.

**Data Storage Requirements**

All monitored parameters require secure storage in a database system including the following:

- Operational data
- Integrity test results
- Calibration records

**Trend Analysis**

Automated trend analysis should be configured to identify:

- Gradual TMP increases indicating fouling
- Sudden permeability changes suggesting membrane damage
- Deviations from normal operating patterns
- Long-term performance degradation

**Quality Control**

Data validation protocols must include automated range checking and error flagging. Systems should incorporate redundant sensors for critical parameters and automatic notification of sensor disagreement exceeding 5% variation.

NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 809

## Data Logging and Performance Monitoring

### Calibration and Maintenance

- Sensor Calibration
- Establish regular calibration schedules
- Pressure transmitters: Quarterly verification
- Flow meters: Semi-annual calibration
- DO sensors: Weekly calibration
- MLSS sensors: Monthly calibration
- Turbidity meters: Weekly calibration

### Data Collection Procedures

The following tables identify the data to be regularly collected and the frequency of collection.

### NANOH2O Submerged UF/MBR Membrane Minimum Logging Requirements

Membrane Tank Fluid Characteristics - Required Data:

| Parameter | Frequency of Collection | Comment or Unit of Measure |
|---|---|---|
| Sludge Temperature, °C (°F) | Every 15 mins | Via SCADA System |
| Membrane Tank MLSS, mg/L | Every 15 mins | Via SCADA System |
| Membrane Tank DO, mg/L | Every 15 mins | Via SCADA System |
| Filtrate Soluble BOD5, mg/L | Every 15 mins | Via SCADA System |

UF/MBR Each Train – Required Data:

| Parameter | Frequency of Collection | Comment or Unit of Measure |
|---|---|---|
| Membrane Tank Level, m (ft) | Every 15 mins | Via SCADA System |
| Filtrate pressure, kPa (psi) | Every 15 mins | Via SCADA System |
| Filtrate Flow, $m^3/h$ (GPM) | Every 15 mins | Via SCADA System |
| Air flow rate delivery, $m^3/h$ (acfm) | Every 15 mins | Via SCADA System |
| Filtrate turbidity, NTU | Every 15 mins | Via SCADA System |

NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 809

## Data Logging and Performance Monitoring

Operating or Maintenance Events for UF System or Each Train:

| Parameter | Frequency of Collection | Comment or Unit of Measure |
|---|---|---|
| System or Train Start-up | As applicable | Record date and time |
| System or Train Shutdown | As applicable | Record reason for shutdown, date, and time |
| Membrane Recovery Clean (RC) | As applicable | Record reason for cleaning, chemical(s) used, method or procedure, concentration, date and time. Record results following cleaning. |

NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 809

Data Logging and Performance Monitoring

**Sludge Quality Testing for MBR**

The performance of the membranes in a MBR system depends heavily on the performance of the biological system. Analytical tests do not capture the whole picture and may or may not be very useful for troubleshooting. The following tests are useful for qualitatively checking the sludge quality, as it relates to membrane fouling potential. These tests are qualitative. Performing these tests daily from plant start-up will eventually generate a data set which reveals trends between the test results and membrane performance. Comparing the trends alongside associated analytical test results (e.g. feed and filtrate BOD, COD, etc.), biological system operating data (DO concentration, temperature, MLSS, etc.), and membrane system operating data (TMP, flux, air scour flowrate, etc.) will enable easier troubleshooting.

**Filterability Test**

Prepare the following supplies:

- 100 mL graduated cylinder (2)
- Circular 1 micron rated filter paper large enough for 100 mL funnel
- 100 mL funnel
- Stopwatch

Use the following procedure:

1. Prepare a filter paper rated at 1 micron by folding 6 times into a conical shape with accordion style bends. There should be 12 bends, with each neighboring bend alternating up, then down.
    a. It is critical to use the same type of filter paper and bend it the same way every time. Otherwise, the results may not be relatable.
    b. Place the filter paper in the funnel.
    c. Pour 50 mL of tap water through the filter paper, then allow filter and funnel to dry for 30 minutes.
    d. Place the funnel outlet over the 100 mL graduated cylinder. Support, as needed, to prevent the funnel from falling over.
    e. Collect >50 mL representative sample of mixed liquor (sludge) from the membrane tank.
    f. Pour 50 mL of the solution into the other 100 mL graduated cylinders.
    g. From the 100 mL graduated cylinder, slowly pour the solution into the funnel with the filter paper collecting the filtrate in the other 100 mL graduated cylinder.
        a. Start the stopwatch when you start pouring.
    h. Stop pouring the solution after 5 minutes and remove the funnel outlet from the graduated cylinder. During this period, you will have to repeatedly top off the solution in the funnel.
    i. Measure and record the volume of filtrate collected, as "Filterability Test – Filtrate Volume (5 mins)".

Changes in filterability test filtrate volume from one day to another would indicate a possible lowering of flow through the MBR membranes.

NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 809

Data Logging and Performance Monitoring

**Sludge Volume – 30 minutes (SV30) Test**

Prepare the following supplies:

- 1000 mL graduated cylinder
- Stopwatch
- 10 mL pipet
- Handheld turbidimeter

Use the following procedure:

1. Collect 250 mL of sludge from the membrane tank in a graduated cylinder. (Use the same sludge volume every time.)
2. Dilute with filtrate until the volume reaches 1000 mL.
3. Mix the solution. This results in a 4:1 dilution ratio
4. Place the graduated cylinder on a level surface.
   a. Start the stopwatch.
5. After 30 minutes, observe and record the volume, in ml, of sludge settled in the graduated cylinder, as "SV30 – Sludge Volume" in ml/L.
6. Use the pipet to extract the clearest supernatant present.
7. Measure and record the turbidity of the supernatant, as "SV30 – Supernatant Turbidity".

The SV30 sludge volume should be in the range of 150 – 300 ml/L.

A higher SV30 turbidity from one day to another may be the result of less flocculation and hence increase in membrane fouling.

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NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 809

Data Logging and Performance Monitoring

**Analytic Measurements**

There are many parameters to monitor in the biological system which are beyond the scope of this manual.

| Location | | Feed to MBR | Filtrate | Membrane Tank | Frequency |
|---|---|---|---|---|---|
| Biochemical Oxygen Demand (BOD) | mg/L | X | X | | Once per day |
| Chemical Oxygen Demand (COD) | mg/L | X | X | | Once per day |
| Total Kjeldahl Nitrogen (TKN) | mg/L | X | X | | Once per day |
| Ammonium-Nitrogen ($NH_4$-N) | mg/L | X | X | | Once per day |
| Total Nitrogen (TN) | mg/L | X | X | | Once per day |
| Total Suspended Solids (TSS) | mg/L | X | X | | Once per day |
| Volatile Suspended Solids (VSS) | mg/L | X | | | Once per day |
| Total Phosphorus | mg/L | X | X | | Once per day |
| Alkalinity (as $CaCO_3$) | mg/L | X | X | | Once per day |
| Total Dissolved Solids (TDS) | mg/L | X | | | Once per day |
| Hardness | mg/L | X | X | | Once per day |
| pH | S.U. | X | X | | Once per day |
| Oil and Grease | mg/L | X | | X | Twice a week |

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NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 810

## Customer Claim and Complaint Procedure

This procedure is for customers whom NANOH2O Water Solutions ("Manufacturer") have advised to return their purchased product for evaluation in support of a warranty claim ("Return Merchandise").

Before returning the Return Merchandise, customers are required to complete the 'Request for Return Merchandise Authorization Form' (see a copy at the end of this bulletin, or download from our website www.NANOH2Owatersolutions.com). and email the completed form to the email corresponding to your region listed below:

| Region | E-mail |
|---|---|
| Americas | nasales@Nanoh2owater.com |
| Europe, Africa | eumanasales@Nanoh2owater.com |
| Middle East, Egypt | mesales@Nanoh2owater.com |
| Korea | krsales@Nanoh2owater.com |
| China | cnsales@Nanoh2owater.com |
| India | insales@Nanoh2owater.com |
| Southeast Asia | seasales@Nanoh2owater.com |

Customers will receive a Return Merchandise Authorization (RMA) number by email within 48 hours after submitting the Request for Return Merchandise Authorization form. The RMA number MUST appear on all shipping documents accompanying Return Merchandise to ensure that Return Merchandise is identified, accepted, and routed to the proper department for processing and evaluation. Any Return Merchandise received without an identifiable RMA number will be refused at the expense of delivery charges to the sender.

Please ship all Return Merchandise corresponding to the RMA claim to the Manufacturer immediately upon confirmation of your RMA number by the Manufacturer. Immediate shipping allows for a more accurate analysis of Return Merchandise claims. The Manufacturer must receive the Return Merchandise within 30 days for domestic shipments and 60 days for international shipments from when the RMA number is issued. Failure to comply with this requirement may void your warranty claim, and the Manufacturer will not be liable for any incurred costs (i.e., shipping).

Shipping of Return Merchandise to Manufacturer does not mean that the Manufacturer accepts all responsibility of a warranty claim. The sole purpose of returning the Return Merchandise to the Manufacturer is to carefully inspect the Return Merchandise to determine whether it falls within or outside of the warranty terms. Before any conclusions are determined through analysis of the Return Merchandise, all expenses will be the customer's responsibility.

Merchandise should be prepared for shipment and packaged per the Packing and Shipping Requirements detailed below:

**NOTE**

DO NOT RETURN MERCHANDISE UNTIL YOU HAVE RECEIVED A WRITTEN AUTHORIZATION AND A VALID RMA NUMBER FROM NANOH2O WATER SOLUTIONS.

NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 810

Customer Claim and Complaint Procedure

**Packing and Shipping Requirements:**

- Flush membrane modules with UF Filtrate for a minimum of 30-minutes at pH 6-8 to ensure that any hazardous liquids contained in the Return Merchandise are flushed out and for safe handling of the Return Merchandise.

  **LIQUIDS CONTAINING A STRONG ACID OR AN ALKALI CLEANING SOLUTION ARE CONSIDERED TO BE HAZARDOUS FOR TRANSPORT AND MUST BE FLUSHED OUT BEFORE SHIPMENT.**

- Before shipping, the Return Merchandise ports must be sealed with rubber caps, packaged in a leak-proof polyethylene bag, and securely packaged in wooden crate to keep the module hydrated and protect it from physical damage during shipment.

  **DURING SHIPMENT, TAKE PRECAUTIONS TO ENSURE THAT MEMBRANE MODULES ARE PROTECTED FROM FREEZING OR PROLONGED EXPOSURE TO TEMPERATURES EXCEEDING 40°C.**

  Please ship Return Merchandise to the following address:

| |
|---|
| Contact NANOH2O Technical<br>Service representative for return<br>merchandise shipping instructions |

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NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 810

Customer Claim and Complaint Procedure

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**Warranty Claim Validation Procedure**

1. The return of membrane modules will only be necessary when both the customer and the manufacturer agree.
2. Before any membrane modules are returned, the requester must submit a request and seek approval from the manufacturer.
3. The cost of shipment will be solely borne by the requester.
4. The manufacturer will bear the cost of the membrane autopsy and will be responsible for delivering the autopsy reports, which will typically include visual inspection, permeability testing, cleaning testing, contaminant analysis, fiber analysis, and potting layer analysis, unless otherwise specified.
5. Determination
   a. Return Merchandise found to comply with warranted performance values will be returned to the customer at the customer's expense ("freight collect").
   b. Return Merchandise found to be defective based on the Material and Workmanship Warranty will be replaced or credited to the customer according to the applicable warranty terms and conditions.
   c. Return Merchandise performing below warranted performance values regarding filtrate flow, or turbidity removal, will be replaced or credited to the customer according to the applicable warranty terms and conditions.

NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 810

## Customer Claim and Complaint Procedure

**General Conditions**

The customer is responsible for prepaying the shipping charges of the Return Merchandise. The Manufacturer will not accept any Return Merchandise unless it is prepaid. The Manufacturer may request that the customer issue a valid purchase order covering all work related to the warranty inspection, such as analytical work.

When inspection of the Return Merchandise by the Manufacturer concludes that a defect did not cause the warranty claim in material and workmanship:

- The Return Merchandise shall be returned to the customer at the expense of the customer (freight collect); and
- The customer will be billed for the Return Merchandise evaluated including autopsy and house analysis.

When inspection of the Return Merchandise by the Manufacturer concludes that a defect caused the warranty claim in material and workmanship:

- The Return Merchandise will be shipped to the customer free of charge. Please review your warranty for the terms and conditions applicable to your purchase order.

All terms, conditions, and specific remedies outlined in the customer's applicable warranty shall apply in processing all warranty claims. Please contact NANOH2O Water Solutions through the email address corresponding to your region listed above for further questions.

The customer is responsible for returning the Return Merchandise to the Manufacturer for membrane analysis. The warranty claim will not be accepted unless the membrane analysis is complete.

The Manufacturer advises the customer to complete the Request for Return Merchandise Authorization Form, including "The option for prior compensation request" on the form if replacement UF membrane modules are required to prevent the shutdown of the system while the Manufacturer conducts the warranty claim inspection.

When the customer receives replacement membrane modules by prior compensation request, the Return Merchandise must be shipped immediately to the Manufacturer following membrane module replacement. If the Return Merchandise is not returned within two months, the customer is responsible for the compensation membrane modules at current pricing plus shipping charges.

The membrane modules delivered under prior compensation will be billed to the customer at their recent purchase price if the conclusion of the analysis of the used membrane elements is that the problem has not been caused by the membrane supplier.

NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 810

## Customer Claim and Complaint Procedure

**MBR / Submerged UF RMA Request Form**

**New or Used Modules Removed from Original Packaging**

| | | | |
|---|---|---|---|
| **Section 1** | | | |
| **TO BE FILLED OUT BY REQUESTOR** | | | |
| Name of Requestor | | Date of Request | |
| **CUSTOMER INFORMATION** | | | |
| Company Name | | | |
| Address/ Region | | | |
| Contact Person | | | |
| Phone/ Mobile | | Email | |
| Purchase Order No. | | Ship Date | |
| **REPORTED PROBLEM** | | | |
| ☐ Low Flow (High Feed Pressure) | | ☐ High Filtrate Turbidity | |
| ☐ High Differential Pressure | | ☐ Visual Product Defect | |
| ☐ Other: | | | |
| **TIME WHEN PROBLEM FIRST OCCURRED** | | | |
| ☐ Before Membrane Module Installation | | | |
| ☐ At Startup (Less than 24 hours of continuous operation) | | | |
| ☐ After Startup (2 to 14 days) | | | |
| ☐ XXX Months After Startup | | | |
| ☐ Describe failure mode and attach pictures | | | |
| **SYSTEM INFORMATION** | | | |
| Feed Water Type<br>Surface water, seawater, tertiary wastewater etc. | | | |
| Filtrate Application<br>RO pretreatment, drinking, discharge etc. | | | |
| Upstream treatment<br>e.g. Primary clarification, aerobic system, secondary clarifier, media filter, bag filter etc. | | | |
| Downstream treatment | e.g. RO | | |
| **SKID/MODULE INFORMATION** | | | |
| Total No. of skids | | No. of modules per skid | |
| No. of skids per train | | Total modules per system | |
| Serial numbers of affected modules<br>(attach separate file if necessary) | | | |
| Have the modules been exposed to | ☐ Yes ☐ No | | |

| | |
|---|---|
| hazardous materials? | If **Yes**, provide details (attach to this document) and advise customer that MSDS sheets for all hazardous materials have to be submitted along with this RMA request. |

**FEED AND FILTRATE WATER QUALITY INFORMATION**

For performance warranty claims, please provide historical trend data in addition to the following.

| | | Feed | | | Filtrate | | |
|---|---|---|---|---|---|---|---|
| **Parameter** | **Units** | Design | Actual | | Design | Actual | |
| Water Temp | ºC | | | | | | |
| Total suspended solids | mg/L | | | | | | |
| Turbidity | NTU | | | | | | |
| TOC | mg/L | | | | | | |
| $BOD_5$ | mg/L | | | | | | |
| COD | mg/L | | | | | | |
| Iron | mg/L as ion | | | | | | |
| Manganese | mg/L as ion | | | | | | |
| Aluminum | mg/L as ion | | | | | | |
| Calcium | mg/L as ion | | | | | | |
| Alkalinity | mg/L as $CaCO_3$ | | | | | | |
| Total Hardness | mg/L as $CaCO_3$ | | | | | | |
| Total dissolved solids | mg/L | | | | | | |
| pH | S.U | | | | | | |
| O&G | mg/L | | | | | | |
| Chlorine | mg/L as $Cl_2$ | | | | | | |
| $SDI_{15}$ | | | | | | | |
| Other (specify) | | | | | | | |

# Technical Service Bulletin 810

## Customer Claim and Complaint Procedure

**OPERATING PARAMETERS AND PERFORMANCE**

Provide historical trends in addition to the following. Trend files in raw data form to be attached in a separate file

| Process Fluid | Parameter | Position | Units | Design | Actual |
|---|---|---|---|---|---|
| Filtration | Feed Flow Rate | All skids (total) | $m^3/h$ | | |
| | | Single skid | $m^3/h$ | | |
| | Pressure (single skid) | Feed | Bar | | |
| | | Filtrate | Bar | | |
| | | Concentrate | Bar | | |
| | | TMP | Bar | | |
| | | Pressurization Rate | Bar/second | | |
| Air Scour (per skid) | Air Scour Flow Rate | | $m^3/h$ | | |
| | Air Scour Pressure | | Bar | | |
| | Air Scour Duration | | minutes | | |
| | BW Flow (if used) | | seconds | | |
| | BW Frequency (if used) | | $m^3/h$ / GPM | | |
| | BW Duration (if used) | | Bar / kPa / psi | | |
| | Air Scour/Backwash process (if applicable)<br>Describe steps | | | | |

**PROCESS SEQUENCES**

| Process | Sequence | | Units | Design | Actual |
|---|---|---|---|---|---|
| Maintenance Cleaning (MC) / Chemically Enhanced Backwash (CEB) / Enhanced Flux Maintenance (EFM) | MC1 | 1. Recipe | | | |
| | | 2. Cleaning Frequency | | | |
| | | 3. Wash Orientation | | | |
| | | 4. Backwash flow rate (if used) | | | |
| | | 5. MC 1 duration | | | |
| | | 6. MC1 protocol | | | |
| | MC2 | 1. Recipe | | | |
| | | 2. Cleaning Frequency | | | |
| | | 3. Wash Orientation | | | |
| | | 4. Backwash flow rate (if used) | | | |
| | | 5. MC 2 duration | | | |
| | | 6. MC2 protocol | | | |

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NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 810

Customer Claim and Complaint Procedure

| | | | | | |
|---|---|---|---|---|---|
| Recovery Cleaning (RC) / Clean-In-Place (CIP) | RC1 | 1. Recipe | | | |
| | | 2. Cleaning Frequency | | | |
| | | 3. Duration | | | |
| | | 4. Protocol | | | |
| | RC2 | 1. Recipe | | | |
| | | 2. Cleaning Frequency | | | |
| | | 3. Duration | | | |
| | | 4. Protocol | | | |

| | | | | |
|---|---|---|---|---|
| Integrity Test | Air pressure applied to inside or outside of fibers? | | | |
| | Starting Pressure | Bar / kPa / psi | | |
| | Frequency | days | | |
| | Duration | mins | | |

| | |
|---|---|
| Other process sequences e.g. Forward flush (describe) | |

| COMMERCIAL CLASSIFICATION | |
|---|---|
| ☐ Warranty Claim | ☐ Non-Warranty Replacement |
| ☐ Non-Warranty Credit | ☐ Billable Technical Service Evaluation |
| ☐ No Charge Technical Service Evaluation | ☐ Application Engineering |

NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 810

## Customer Claim and Complaint Procedure

| Section 2 |
|---|
| **TO BE FILLED OUT** |
| **REQUIRED TEST** |
| ☐ As Received Visual Inspection |
| ☐ Autopsy including permeability test, cleaning test, contaminant analysis, fiber analysis and potting layer analysis |
| ☐ Other: |
| ☐ Other: |
| ☐ |

| Section 3 | | |
|---|---|---|
| **INFORMATION FOR CUSTOMER SERVICE** | | |
| No of Modules to be Returned: | | |
| Serial Numbers and Customer PO: | | |
| Commercial Classification: | ☐ Credit | ☐ Replacement |
| Further Instructions: | | |
| **RMA NUMBER** | | |

# Technical Service Bulletin 810

## Customer Claim and Complaint Procedure

### Commercial Invoice

| | |
|---|---|
| Sender :<br><br>Email Address : Phone Number : | Recipient :<br>Contact NANOH2O Technical Service representative for return merchandise shipping information |
| Invoice Date : | Invoice Number : |
| Waybill Number : | Sender's Reference : |
| Carrier : | Recipient's Reference : |

| Quantity | Country of Origin | Description of Contents | Harmonized Code | Unit Weight | Unit Value | Sub Total |
|---|---|---|---|---|---|---|
| | | | | | | |

| | | | |
|---|---|---|---|
| Total Net Weight: | | Total Declared Value: (USD) | |
| Total Gross Weight | | Freight & Insurance Charges: (USD) | |
| Total Shipment Pieces: | | Other Charges: (USD) | |
| Currency Code: | | Total Invoice Amount: (USD) | |
| Type of Export : | | Terms of Trade : | |
| Reason for Export : | | | |
| General Notes : | | | |

NANOH2O QuantumFlux™ MBR/Submerged UF Membrane

# Technical Service Bulletin 810

## Customer Claim and Complaint Procedure

I/We hereby certify that the information on this invoice is true and correct and that the contents of this shipment are as stated above.

| | |
|---|---|
| Name :<br><br>Position in Company:<br><br>Signature:<br><br>________________________________. | Company Stamp |