Nitto

HYDRANAUTICS
Nitto Group Company

Technical Service Bulletin

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Integrity Testing Procedure for HYDRAsub®-MBR Systems

The purpose of this document is to provide details on how to monitor and maintain integrity of the HYDRAsub®-MBR system. System integrity is maintained through the following main steps:

1) Verification of integrity begins at the manufacturing facility. The bubble point of the hollow fiber membrane is measured after production of membranes.
2) After the hollow fiber membranes are potted in elements, 100% of elements must pass pressure hold tests before shipment to customer.
3) After the modules are installed but before sludge is fed to the system, total system integrity, including filtrate piping and module connections, is confirmed by pressure hold test.
4) Membrane permeability is verified (refer to TSB405)
5) Operation begins. During operation, measurement of filtrate turbidity is used to confirm system integrity.
6) In the event that filtrate turbidity exceeds predetermined limits, the filtrate turbidity of each train and module is used to identify the problem train(s) and module(s).
7) In case the problem module(s) can not be identified by checking the filtrate turbidity, system pressure hold tests are used.
8) In the event that filtrate piping connections are not responsible for integrity problems, individual modules are removed from the system and pressure hold tested to identify the problem areas.
9) In the event that permeate adapter connections are not responsible for integrity problems, individual elements are removed from the module and pressure hold tested to identify the problem fiber(s).
10) Damaged fiber(s) are repaired according to TSB402. Dried fiber(s) are rewetted according to TSB401.

1. Safety Notices

All safety precautions must be taken when operating equipment, working in enclosed spaces, working on or near ladders, floor openings or exposed openings, working at elevated levels, etc. in accordance with local rules and regulations. The servicing of HYDRAsub®-MBR modules may entail the use of a crane or hoist, working 8 ft (2.4 m) or higher above the ground, and working near an exposed opening, such as an open tank, where proper harnessing may be needed for operators. Safety boots and hardhats are also recommended. Personal protective equipment (PPE) should be used properly when working with or near chemicals, hazardous waste or corrosive materials. The use of PPE and good hygiene (washing hands with soap and water frequently, keeping equipment clean, etc.) will help prevent contamination and disease. Additionally, required immunizations, per local regulations, should be administered for operators working around sewage or wastewater.

2. Materials and Tools

Configure a system as shown in Figure 1 to apply the specified pressure to the unit. Multiple module trains can be tested, but each module must be tested individually.

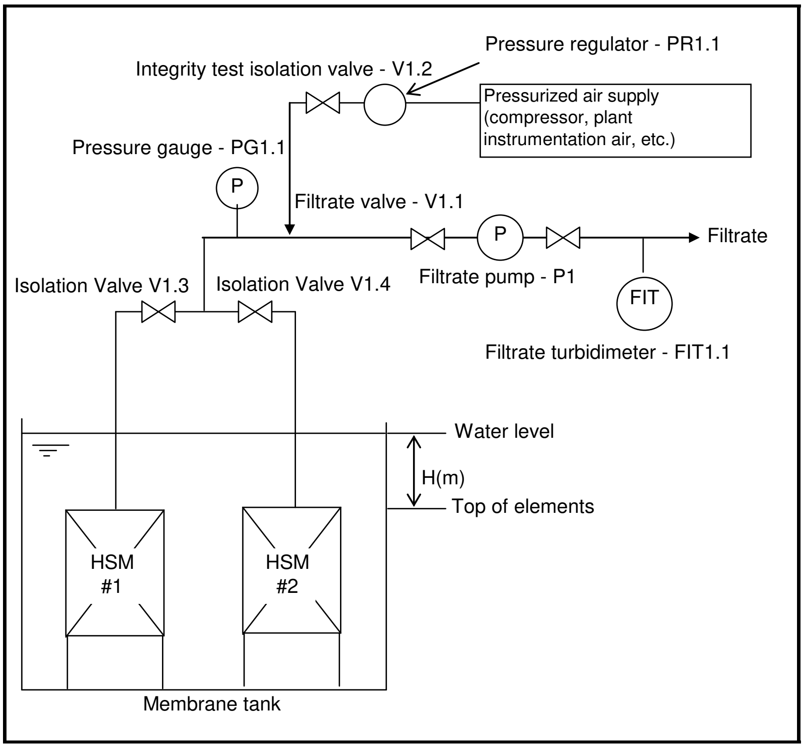

Figure 1: Simplified system schematic for pressure hold test

Quantity	Tool	Size	Notes
1	Pressurized air supply – Either a oil free compressor or plant instrumentation air	Supply enough air to displace the inner volume of the filtrate piping from injection point and membrane elements.	Calculate the inner volume of the membrane elements using a volume of approx. 0.5 l/m² membrane area
2	Pressure Regulator (PR1.1 and 2.1)	0 to 100 kPa	Must be capable of accurately controlling outlet pressure within +/- 1 kPa.
2	Pressure Gauge (PG1.1 and 2.1)	0 to 100 kPa	-Minimum scale value of 1 kPA or less - Digital pressure gauge is recommended
2	Integrity test isolation valve (V1.2 and 2.2)	Depends on system size	Gate valve recommended
1	Individual module testing tank	Depends on module size	With cover

3. Startup System Pressure Hold Integrity Test Procedure

Perform this procedure after initial installation of new or previously stored HYDRAsub®-MBR modules into a system. Follow TSB411 for detailed instructions on installation and start up. This procedure should be done prior to performing a clean water permeability test (TSB405) on the membranes.

1) Fill the membrane tank with clean water (tap water or water filtered through a 500 micron sieve). Perform the integrity test on only one module at a time. Ensure that the membrane air scour blower and filtrate pump are off.
2) Close the train filtrate valve (V1.1 in Figure 1) and other module isolation valves in the test train (V1.4 in Figure 1). With the pressure regulator (PR1.1 in Figure 1) closed, open the integrity test isolation valve (V1.2 in Figure 1).
3) Slowly open the pressure regulator (PR1.1) until the pressure is 22 kPa + the water head (H) above the top of the elements ((h (m) × 10) kPa). Record the pressure, P_o.
   a) H = Water head above the elements. For example: When h (m) = 0.5, H (kPa) = 0.5 m x 10 kPa/m= 5 kPa. Therefore, P_o = 22 kPa + 5 kPa = 27 kPa.
4) To remove the water from the piping and all parts of the module, increase the pressure to P_o and maintain for 30 minutes.
   a) While increasing the pressure, do not exceed a rate greater than 10 kPa/min.
   b) Carefully, adjust PR1.1 as needed to maintain P_o.
   c) **Do not allow the pressure to exceed P_o.**
   d) **Do not leave the site.**
   e) As air is injected in the membrane fibers, visually check for air leakage (bubbling) from the piping, joints, module connections, and from within the module itself. It is normal to see small bubbles coming from the elements, however significant bubbling should be noted.
      i)Note any locations which are bubbling for further examination/repair.
5) After removing all water from the module and filtrate piping, check that the pressure is correctly set to P_o and close the integrity test isolation valve (V1.2). Measure and record the pressure after five minutes, P_5. The pressure will gradually decrease during the five minute test period.
   a) During the test period, continue to visually check for significant bubbling from any piping, joints, module connections, and from within the module itself.
      i)Mark any locations which are bubbling for further examination/repair.
   b) Ensure that the water level does not change during this time. If the water level changes, a measurement error may occur.
   c) If the pressure drop after five minutes is less than 7 kPa ($P_0 - P_5 < 7$ kPa), then integrity is confirmed for the test module (HSM #1 in Figure 1) piping and connections. Repeat procedure for all other modules, one module at a time.
      i)If integrity of all other modules is confirmed, proceed to the clean water

permeability test according to TSB405.

6) If the pressure drop exceeds 7 kPa ($P_0 - P_5 > 7$ kPa), the module integrity is not confirmed. It is possible that there may still be water remaining in the elements.
   a) To ensure that all water is out of the elements, reopen the integrity test isolation valve (V1.2), and increase the pressure to P_o again.
   b) Keep the module at P_0 for at least 10 minutes.
   c) Repeat Step (5).
   d) If the pressure drop is still greater than 7 kPa, but is smaller than the first pressure drop, there is still a possibility that all of the water has not been completely pushed out of the elements. Again increase the pressure to P_0 and repeat step 5).
   e) If the pressure drop is equal to or larger than the first pressure drop, a module integrity problem exists. Proceed to Section 6.

4. Monitoring System Integrity During Operation

Each HYDRAsub®-MBR system is divided into trains, which consist of sets of modules connected to a common header. Each train in a system should have a dedicated online turbidimeter (FIT1.1 in Figure 1) installed or provisions to divert filtrate from each train to a common turbidimeter. If the filtrate turbidity is above the maximum value allowed, then it would be necessary to isolate the train for further testing. Please note that sufficient time should be allowed to flush the turbidimeter if a common turbidimeter is used for multiple trains so as to displace filtrate in the lines from other trains. This is especially important if other trains have undergone cleaning (chemically enhanced backwash (CEB) or clean-in-place (CIP)) before the train being checked is tested. The PLC should be programmed so that the alarm set point for high-turbidity is raised for the train under study for a buffer period of 1 hour following CEB or CIP cleaning. For example, if the high-turbidity alarm set point is 0.5 NTU for regular operation, the set point can be increased to 2 NTU during a buffer period following CEB and CIP or the alarm can be disabled. These set points may vary for each system and will be specified by Hydranautics in the product and performance warranties for each project. As long as the filtrate turbidity remains below these set points, then system integrity is confirmed, **DO NOT PERFORM PRESSURE HOLD INTEGRITY TESTING**.

After identify the problem train, the filtrate turbidity from each module should be checked to determine the problem module. Please note that sufficient time should be allowed to flush the turbidimeter if a common turbidimeter is used for multiple modules so as to displace filtrate in the lines from other modules.

After identifying the problem module(s), proceed to Section 6.

5. Identification of the module(s) with an integrity problem

In case the problem module(s) can not be identified by monitoring filtrate turbidity, perform a pressure hold test on each module of the problem train, one module at a time, as follows:

1) Ensure that the membrane air scour blower and filtrate pump are off.
2) Close the train filtrate valve (V1.1 in Figure 1) and all other module isolation valves in the test train (V1.4 in Figure 1). With the pressure regulator (PR1.1 in Figure 1) closed, open the integrity test isolation valve (V1.2 in Figure 1).
3) Slowly open the pressure regulator (PR1.1) until the pressure is 22 kPa + the water head (H) above the top of the elements ((h (m) × 10) kPa). Record the pressure, P_o.
   a) H = Water head above the elements. For example: When h (m) = 0.5, H (kPa) = 0.5 m x 10 kPa/m= 5 kPa. Therefore, P_o = 22 kPa + 5 kPa = 27 kPa.
4) To remove the water from the piping and all parts of the module, increase the pressure to P_o and maintain for 30 minutes.
   a) While increasing the pressure, do not exceed a rate greater than 10 kPa/min.
   b) Carefully, adjust PR1.1 as needed to maintain P_o.
   c) **Do not allow the pressure to exceed P_o.**
   d) **Do not leave the site.**
   e) As air is injected in the membrane fibers, visually check for air leakage (bubbling) from the piping, joints, module connections, and from within the module itself. It is normal to see small bubbles coming from the elements, however significant bubbling should be noted.
      i)Note any locations which are bubbling for further examination/repair.
5) After removing all water from the module and filtrate piping, check that the pressure is correctly set to P_o and close the integrity test isolation valve (V1.2). Measure and record the pressure after five minutes, P_5. The pressure will gradually decrease during the five minute test period.
   a) During the test period, continue to visually check for significant bubbling from any piping, joints, module connections, and from within the module itself.
      i)Mark any locations which are bubbling for further examination/repair.
   b) Ensure that the water level does not change during this time. If the water level changes, a measurement error may occur.
   c) If the pressure drop after five minutes is less than 7 kPa ($P_0 - P_5 < 7$ kPa), then integrity is confirmed for the test module piping and connections.
      i) Repeat procedure for all other modules in the problem train, one module at a time.
      ii) If integrity of all other modules in the train is confirmed, then the cause of the high turbidity readings may be due to something other than a leak in the

system. The possible causes are 1) the filtrate line is contaminated and needs disinfection cleaning, 2) the tank and/or lines used to deliver the CEB/CIP solution is contaminated and needs to be cleaned, 3) there are air bubbles that are causing erroneous turbidity readings, or 4) the calibration on the turbidimeter needs to be redone to ensure the accuracy of the readings. Determine the cause of the turbidity increase before putting the module(s) back into service.

6) If the pressure drop exceeds 7 kPa ($P_0 - P_5 > 7$ kPa), the module integrity is not confirmed. It is possible that there may still be water remaining in the elements.
   a) To ensure that all water is out of the elements, reopen the integrity test isolation valve (V1.2), and increase the pressure to P_o again.
   b) Keep the module at P_0 for at least 10 minutes.
   c) Repeat Step (5)
   d) If the pressure drop is still greater than 7 kPa, but is smaller than the first pressure drop, there is still a possibility that all of the water has not been completely pushed out of the elements. Again increase the pressure to P_0 and repeat step 5).
   e) If the pressure drop is equal to or larger than the first pressure drop, a module integrity problem exists. Proceed to Section 6.

6. Out of system Module Integrity Testing and Repair

After identifying the module(s) with the suspected integrity problem, remove the module(s) from the membrane tank according to TSB411 for further inspection. During removal, care should be taken to ensure that the filtrate hoses do not submerge into the mix liquor and get contaminated. Prior to removal, the filtrate isolation valve (V1.3 for HSM #1 and V1.4 for HSM #2 in Figure 1) for that particular module should be closed.

After removing the suspect module(s) from the membrane tank and before submerging it in the testing tank, carefully remove the filtrate adapter retainer plates. After removing the filtrate adapter retainer plates, all modules removed from the membrane tank should be immediately submerged in a clean water testing tank in order to prevent drying of the membranes. If the testing tank is only large enough to hold one module at a time, close the isolation valves of the other suspected modules and leave them submerged in the membrane tank. The tank dimensions will depend on the module type (HSM250, HSM500, HSM1000 or HSM1500). Provisions should be taken so that an operator can climb to the top of the tank and observe pressure hold testing as described below. Ensure that there are no sharp objects such as PVC or metal shavings in the tank which can damage the membrane surface. The tank should be cleaned and drained and filled with tap water or water filtered though a 500 micron strainer. When not in use, the tank should be kept covered to keep out dust and particles or cleaned prior to use.

If required, the train under study can be brought back into service without the suspect module(s) in operation or after installing spare module(s) in place of the suspect module(s). It is advisable to put used spare modules (instead of brand new spare modules) in a train with other used modules so as to avoid a situation of flow imbalance whereby the new module tends to produce a lot more filtrate than the used modules and thus also gets fouled faster. If the train is brought back into service without the suspect module(s) in operation, then the flow set point for that train in the PLC control should be decreased in proportion to the reduced number of operational modules in the train.

After the module is in the testing tank, connect one of the filtrate headers to an air line with an isolation valve, pressure reducing valve, and pressure relief valve as shown in Figure 2. Block the other filtrate header with a blind flange.

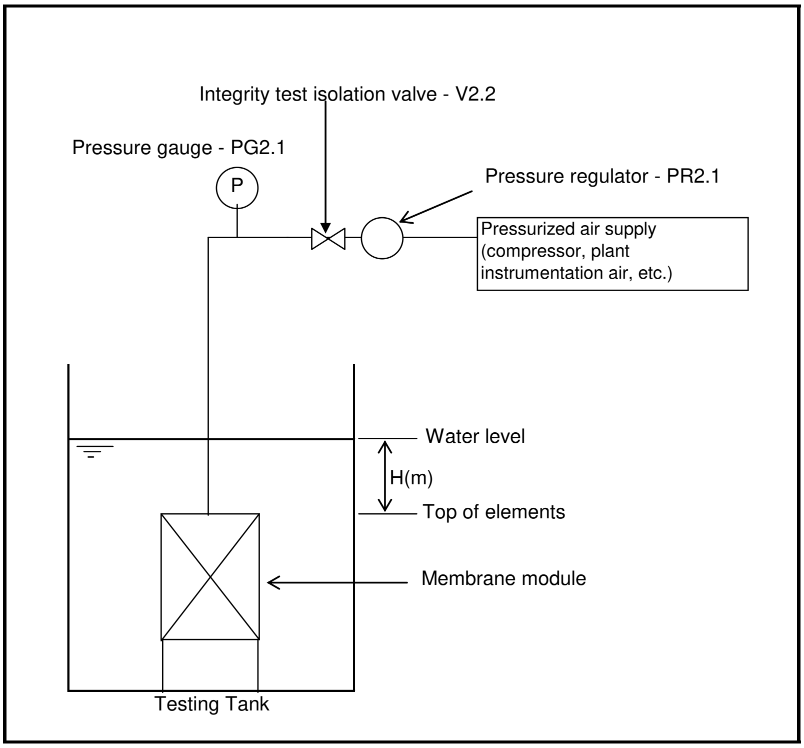

Figure 2: Simplified system schematic for out of tank pressure hold test

After configuring the test system as shown in Figure 2, identify the problem area of the module as follows:

1) With the Pressure regulator (PR2.1) completely closed, open the integrity test isolation valve (V2.2).
2) Slowly open the pressure regulator (PR2.1) until the pressure is 22 kPa + the water head (H) above the top of the elements ((H (m) × 10) kPa). Record the pressure, P_o.
   a) H = Head pressure of water from water level to top of the element. For example: When H (m) = 1.5, H (kPa) = 1.5 m x 10 kPa/m= 15 kPa. Therefore, P_o = 22 kPa + 15 kPa = 37 kPa.
3) To remove the water from the piping and all parts of the module, increase the pressure to P_0 and maintain for 30 minutes.
   a) While increasing the pressure, do not exceed a rate greater than 10 kPa/min.
   b) Carefully, adjust PR2.1 as needed to maintain P_o.
   c) **Do not allow the pressure to exceed P_o.**
   d) **Do not leave the site.**
   e) As air is injected in the membrane fibers, visually check for air leakage (bubbling) from the piping, joints, module connections, and from within the module itself. Small bubbles from the membrane elements are normal, but streams of larger bubbles should be noted.
   f) Mark any locations which are bubbling for further examination/repair.

4) If the bubbling appears to be coming from the filtrate header flange connection, remove the flange and inspect the gasket. If there is any damage to the gasket, replace it with a new gasket and repeat steps 1) through 3) of this section. If no bubbling appears to be coming from the flange connections, proceed to Step 5).
5) If the bubbling appears to be coming from a filtrate adapter(s), remove the suspect adapter(s) and inspect for damage.
   a) Damage to the o-rings on the filtrate adapter is most likely. Carefully inspect the o-rings to make sure that they have not been cut, misshapen, or damaged in any way. If the o-rings are cut, misshapen or damaged in any way, replace them.
   b) Although unlikely, it is possible that the filtrate adapter(s) may have also been cracked during operation, installation, or removal. If the filtrate adapter(s) is cracked, replace it with a spare. After inspecting the filtrate adapter(s), carefully reinstall it.
   c) Take extra caution during installation of the filtrate adapter(s) to ensure that no o-rings are cut, rolled, or pinched.
   d) After repairing/replacing all suspect filtrate adapters, repeat Steps 1) through 3) of this section. If no bubbling appears to be coming from the filtrate adapters, proceed to Step 6) of this section.
6) Make sure that the pressure is correctly set to P_o, close the integrity test isolation valve (V2.2). Measure and record the pressure after 5 minutes, P_5. The pressure should gradually decrease during the 5 minute test period.
   a) If the pressure drop after 5 minutes is less than 7 kPa ($P_0 - P_5 < 7$ kPa), then module integrity is confirmed. The cause of any high turbidity readings may be due to something other than a leak in the system. The possible causes are 1) the filtrate line is contaminated and needs disinfection cleaning, 2) the tank and/or lines used to deliver the CEB/CIP solution is contaminated and needs to be cleaned, 3) there are air bubbles that are causing erroneous turbidity readings, or 4) the calibration on the turbidimeter needs to be redone to ensure the accuracy of the readings. Determine the cause of the turbidity increase before putting the module(s) back into service.
7) If the pressure drop exceeds 7 kPa ($P_0 - P_5 > 7$ kPa), the module integrity is not confirmed. There may be water remaining in the elements.
   a) To ensure that all water is out of the elements, reopen the integrity test isolation valve (V2.2), and increase the pressure to P_o again.
   b) Keep the module at P_o for about 10 minutes.
   c) Repeat Step 6).
   d) If the pressure drop is less than 7 kPa, then the module integrity is confirmed.
   e) If the second pressure drop is more than 7 kPa and is smaller than the first pressure drop, there is still a possibility that water has not been completely pushed out of the elements. Again increase the pressure to P_0 for 10 minutes

and repeat Steps 6).

f) If the pressure drop exceeds 7 kPa (P_0 - P_5 > 7 kPa) and significant bubbling appears to be coming from the elements, proceed to Section 7.

7. Element testing and fiber repair

The suspect elements should be laid flat in a shallow tank with minimum dimensions of 2.1 m (L) x 1.35 m (W) x 0.5 m (H), with a minimum water level of 0.3 m. Ensure that the shallow tank is thoroughly cleaned before use and then filled with tap water filtered through a 500 micron sieve. One of the filtrate ports should be plugged with an adapter (part # HSAP25) while the other filtrate port should be connected to an isolation valve through another adapter (part # HSAIT25). This isolation valve is connected to an air supply with an in-line pressure regulator that maintains pressure at P_o, as calculated above. There should be provision to hold down the elements in the tank to prevent them from floating to the surface when pressurized with air. When the setup is ready, open the air isolation valve to remove the water in the fibers and headers. Allow pressure to stabilize to P_0. Record $P_{0.}$ Close the isolation valve and allow the pressure to decay for 5 minutes. Record the pressure after five minutes, P_5. If the pressure drop after 5 minutes is less than 5 kPa ($P_0 - P_5 < 5$ kPa), element integrity is confirmed. Test the next suspected element.

If the pressure drop exceeds 5 kPa ($P_0 - P_5 > 5$ kPa), locate the defective fibers (cracked or broken) by the position of the air leaks. After marking the location of the fiber defects, remove the element from the test trough and perform the fiber repair procedure according to TSB402. After repairing the affected fiber(s) according to TSB402, retest the element to ensure that fiber(s) have been properly repaired and that no other fiber(s) are damaged.

If the pressure drop exceeds 5 kPa ($P_0 - P_5 > 5$ kPa), but the exact location of the air leaks can not be determined, then the membrane elements may need rewetting. Please refer to TSB401 for the rewetting procedure.

After all suspected elements have been tested and repaired and/or rewetted, reassemble and reinstall the module according to TSB411.

For answers to any questions about this document please contact Hydranautics Customer Service. For assistance with other issues that have not been covered in this document, please contact Hydranautics Customer Service before taking action to resolve the issue.

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