Aquaporin Inside® Flat Sheet Reverse Osmosis Membrane Manual

Coupon Performance Test Guide

Materials and Equipment Checklist

- Coupon cutting device
- Deionized or RO water (electrical conductivity < 25 µS/cm)
- NaCl (technical grade or higher)
- Containers for soaking of membranes (min. volume 1 liter)
- Permeate sample containers (100 ml)
- Stopwatch
- Thermometer
- Electrical conductivity or TDS meter for permeate measurement; calibrated against 100 µS/cm standard (or similar range)
- Electrical conductivity or TDS meter for feed measurement; calibrated against 1314 µS/cm standard (or similar range)
- pH meter, calibrated against pH 4 and pH 7 standard (or similar)
- Weighing balance for flux calculation
- Cross-flow coupon test station (see Figure 1)
    - Feed pump
    - Feed water tank
    - Feed water temperature control
    - Feed water temperature sensor
        - *Measure as close as possible to the inlet or outlet of the test cell or test cell array*
        - *Target temperature is 25.0 ± 0.5 °C for the entire test duration*
    - Feed and Brine Pressure Sensor
        - *Regularly check/calibrate pressure sensors to calibrated reference pressure sensor*
        - *Measure feed pressure as close as possible to the inlet of the test cell*
        - *Measure brine pressure as close as possible to the outlet of the test cell*
        - *Large pressure drops (> 0.5 bar) across the test cell array are to be avoided if possible*
    - Brine Flowmeter

Note: A well-maintained test station is a must. Many factors can contribute to feed water contamination, resulting in effects such as unexpected low flux results. Here are some common examples:

1. Positive displacement piston pump leaking oil into the feed water (potential for membrane fouling)
2. Poorly flushed filters (particle filter, activated carbon filter, etc.) can have manufacturing chemicals that leach into the feed water if they are not properly flushed (potential for membrane fouling and brine pH shift)
3. Exhausted filters (particle filter, activated carbon filter, etc.) can contaminate the recirculated brine solution due to biological growth or exhaustion of filtration/adsorption capacities (potential for membrane fouling)

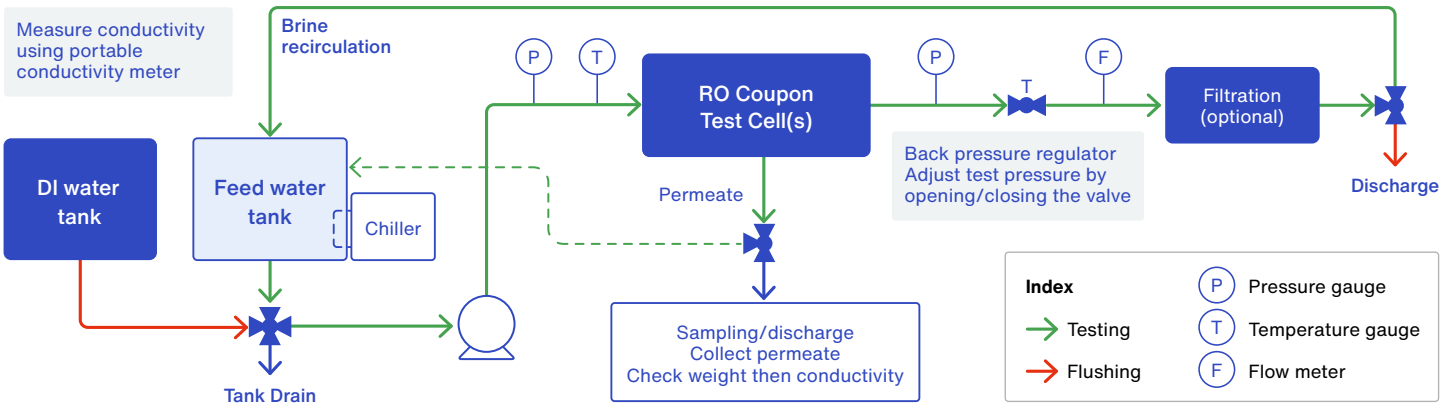

Figure 1. Cross-flow coupon test station flow diagram

Recommended Testing Protocol

1. **Flatsheet membrane coupon preparation**
   a. Cut coupons. Handle the membrane with care. Do not touch the intended active area of the membrane during cutting/preparation.
   b. Pre-soak the coupons 30 minutes at ambient conditions (~25°C) in individual containers with excess DI or RO water (min. 1 L per coupon).

   Note: This step assists to stabilize membrane performance earlier, avoid coupon damage, and minimize leaching membrane preservatives into the recirculated brine solution. Always use fresh DI or RO water for soaking a new coupon.

2. **Prepare the test station and feed water solution**
   a. Clean the test station and flush with DI or RO water until electrical conductivity or TDS measurement in the brine reaches that of the DI water supply.
   b. Preparing fresh feed water solution (with 250 ± 5 ppm NaCl, 0.21 bar osmotic pressure) for each membrane test to be executed.
   c. Prior to each test, drain the test station and fill with a fresh feed water solution to avoid any buildup of membrane preservatives in the recirculated brine solution over the course of multiple tests.

   Note: Preservative buildup in the recirculated brine solution can result in membrane fouling and performing at lower-than-expected fluxes. In real world applications, membranes only see fresh water, and the quick 30 min test must be executed in a way that mimics this fresh water supply to get the most accurate results. Adding a filtration unit (e.g. carbon filter) after the RO coupon test cells can help to reduce the contaminant build-up.

3. **Conduct test at controlled conditions**
   a. Maintain high enough feed water flow rate, which should increase membrane surface flow velocity above 20 cm/s. Feed water flow rate is dependent on test setup and cell design.

   Example: Aquaporin test station configuration: 2 parallel trains of 3 cells in series (6 test cell array) with 42 sq cm active area per test cell; Brine flow rate = 3.7 L/min.

   Note: Recovery in most cross-flow coupon test stations is likely significantly less than 1%. In this situation, from inlet to outlet, feed water flow is negligibly decreased, and feed water solute concentration is negligibly increased.

   b. Target pH: 6.5–7

   Note: Regularly calibrate pH meter to in-date standard solutions.

   c. Maintain feed water temperature at 25.0 ± 0.5 °C.
   d. Maintain feed pressure at 4.5 bar.
   e. Test stabilization time: 30 min (i.e., sampling is started after exactly 30 min of operation at above operating conditions).
   f. Collect the permeate sample in the clean and weighed permeate collection container. Permeate collection time: Precisely 10 min is typical but depends on permeate flow rate.

   Notes:
   1. Longer collection time may be required to collect enough volume (min. 10 grams) for both permeate conductivity and permeate weight measurements.
   2. Measure the permeate collection time precisely.
   3. Make sure that permeate collection beaker is clean and dry before sample collection. Contaminated containers affect permeate electrical conductivity/TDS measurement.

   g. Measure permeate weight first to avoid disrupting the weight measurement with the permeate electrical conductivity / TDS probe or device.
   h. Measure permeate electrical conductivity / TDS

   Note: Have a designated conductivity meter for the feed solution conductivity measurement and a separate conductivity meter calibrated for measuring the permeate sample conductivities. This will help generate more consistent and reliable feed and permeate conductivity results.

Calculations

$$\% \text{ Rejection} = 1 - \frac{\text{Permeate Conductivity}}{\text{Feed Conductivity}}$$

$$\text{Water Permeability} = \frac{\text{Water Flux}}{(\text{Applied Pressure} - \text{Osmotic Pressure})}$$

a. *Water Flux = Permeate Volume / Membrane Active Area / Collection Time*

Note: All active membrane area should have adequate feed water mixing and unrestricted permeate flow. Significant active membrane located in feed water dead zones or with restricted permeate channels can produce lower membrane flux and rejection during testing. Incorporation of feed spacer mesh into the feed channels is possible if done carefully with the proper sizing, but is not necessary.

b. *Osmotic Pressure* is calculated as 0.21 bar for the 250 ± 5 ppm NaCl feed water.

c. Applied Pressure is the average of the inlet pressure and the outlet pressure for the individual coupon cell.

Note: Measure the coupon cell inlet and outlet pressures if possible, but if unable, then estimate the individual cell Applied Pressure based on the Feed and Brine pressures.

d. Aquaporin's Certificates of Analysis (CoA) report *Water Flux* in GFD (gallons/ft^2/day), and the *Water Flux* is normalized to the *Standard Net Driving Pressure* (4.29 bar).

Note: The CoA reported Water Flux = measured Water Flux * (4.29 bar / Actual Net Driving Pressure). Actual Net Driving Pressure = Applied Pressure – Osmotic Pressure of feed

Recommendation on how to Assess a Representative Average Membrane Sample Performance

- 3 coupons minimum tested in the same membrane machine direction lane is recommended to get a representative average performance for that lane.
- 9 coupons total is recommended for the entire cross-web performance measurement (3 coupons in left lane, 3 coupons in center lane, 3 coupons in right lane) (refer to Figure 2).

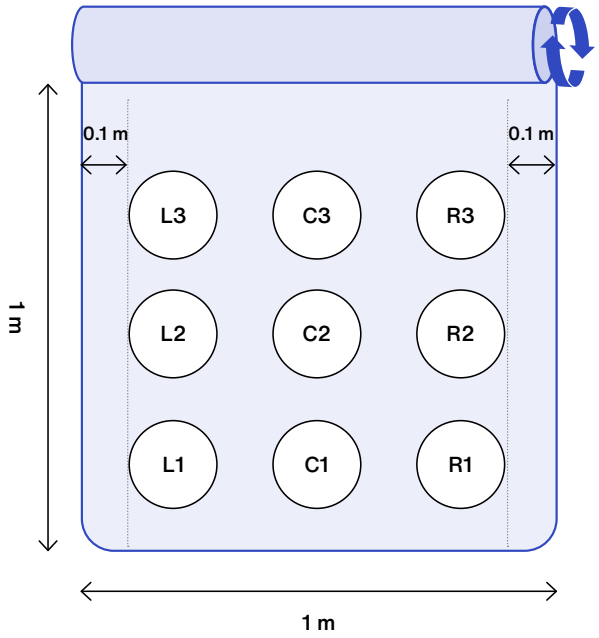

Figure 2. Recommended locations of coupon extraction from a 1-meter wide roll (L: Left, R: Right, C: Center).

Aquaporin A/S
Nymøllevej 78
2800 Kongens Lyngby
Denmark

Phone: +45 8230 3082
sales@aquaporin.com
aquaporin.com