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
- 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 unexpectedly low flux results. Here are some common effects of a poorly-maintained test station:

1. Positive displacement piston pump may leak oil into the feed water (potential for membrane fouling).
2. Poorly flushed filters (particle filters, activated carbon filters, etc.) may contain manufacturing chemicals that can leach into the feed water (potential for membrane fouling and brine pH shift).
3. Exhausted filters (particle filters, activated carbon filters, etc.) may contaminate the recirculated brine solution due to biological growth or due to exhaustion of filtration/adsorption capacities. A contaminated brine solution is a potential for membrane fouling.

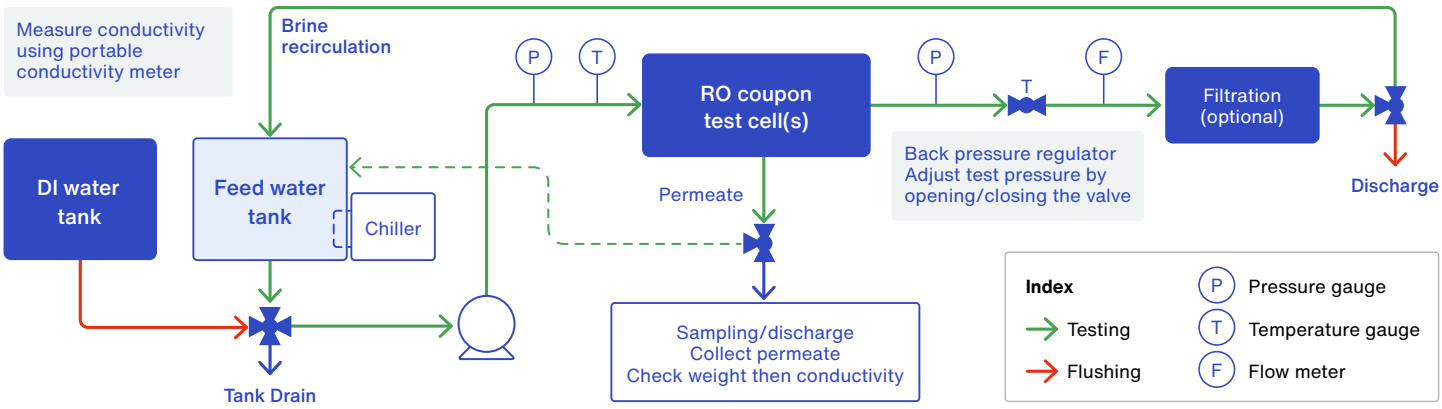

Figure 1. Cross-flow coupon test station flow diagram

Recommended Testing Protocol

1. Flat sheet 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 for 30 minutes at ambient conditions (~25 °C) in individual containers with excess DI or RO water (min. 0.004 L per square centimeter of coupon).

Note: This step helps to stabilize membrane performance, avoid coupon damage, and minimize the leaching of membrane preservatives into the recirculated brine solution. Always use fresh DI or RO water when 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. Prepare fresh feed water solution (with 500 ± 15 ppm NaCl, 0.36 bar osmotic pressure) for each membrane test to be executed.

c. Prior to each test, drain the test station and fill with 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 the membrane performing at lower-than-expected fluxes. In real world applications, membranes only see fresh water. 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 contaminant buildup.

3. Conduct test at controlled conditions

a. Maintain a sufficiently high feed water flow rate, which should increase membrane surface flow velocity above 20 cm/s. Feed water flow rate is dependent on each 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: 7–7.5

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 4.9 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 a 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 (minimum 10 grams) for both permeate conductivity and permeate weight measurements.
2. Measure the permeate collection time precisely.
3. Ensure that the permeate collection beaker is clean and dry before sample collection. Contaminated containers affect permeate electrical conductivity/TDS measurement.

g. Measure the 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

a.

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

b.

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

c.

$$\text{Temperature Corrected Water Flux} = \frac{\text{Permeate Volume} \cdot \text{TCF}}{\text{Membrane Active Area} \cdot \text{Collection Time}}$$

Note: Please refer to the Appendix for full details of the TCF for the Aquaporin Inside® Flat Sheet RO Membrane.

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.

d. Osmotic Pressure is calculated as 0.36 bar for the 500 ± 15 ppm NaCl feed water.

e. 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 this is not possible, estimate the individual cell Applied Pressure based on the feed and brine pressures.

Recommendation on How to Assess a Representative Average Membrane Sample Performance

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

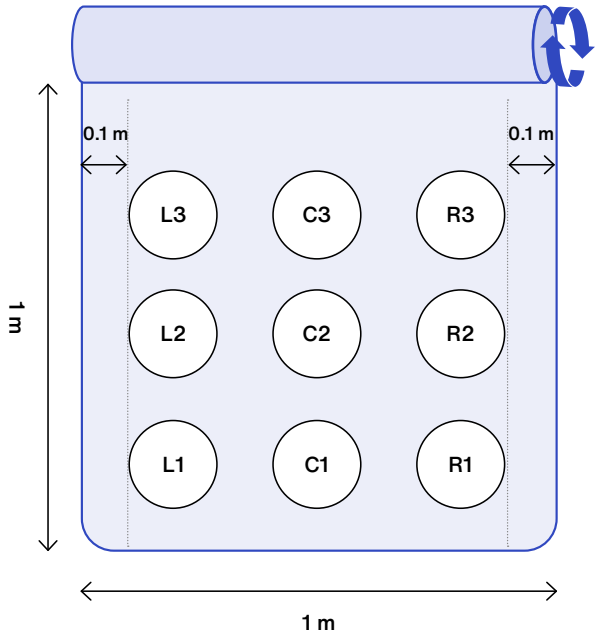

Figure 2. Recommended locations of coupon extraction from a 1-meter wide roll (L: Left, R: Right, C: Center).

Aquaporin A/S
Nymøllevej 78
2800 Kongens Lyngby
Denmark

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

Aquaporin Inside®

Appendix

Shown below are the full details for the Temperature Correction Factors (TCF) for the Aquaporin Inside® Flat Sheet RO Membrane.

T (°C)	TCF	T (°C)	TCF	T (°C)	TCF	T (°C)	TCF	T (°C)	TCF	T (°C)	TCF	T (°C)	TCF	T (°C)	TCF	T (°C)	TCF
5.0	2.070	9.0	1.755	13.0	1.514	17.0	1.276	21.0	1.140	25.0	1.000	29.0	0.900	33.0	0.809	37.0	0.696
5.1	2.059	9.1	1.749	13.1	1.505	17.1	1.271	21.1	1.136	25.1	0.998	29.1	0.898	33.1	0.806	37.1	0.692
5.2	2.051	9.2	1.741	13.2	1.500	17.2	1.266	21.2	1.133	25.2	0.994	29.2	0.895	33.2	0.804	37.2	0.690
5.3	2.044	9.3	1.734	13.3	1.495	17.3	1.263	21.3	1.131	25.3	0.991	29.3	0.893	33.3	0.801	37.3	0.688
5.4	2.035	9.4	1.727	13.4	1.486	17.4	1.261	21.4	1.129	25.4	0.988	29.4	0.891	33.4	0.798	37.4	0.686
5.5	2.028	9.5	1.720	13.5	1.483	17.5	1.259	21.5	1.126	25.5	0.986	29.5	0.888	33.5	0.795	37.5	0.681
5.6	2.020	9.6	1.714	13.6	1.477	17.6	1.255	21.6	1.123	25.6	0.983	29.6	0.886	33.6	0.793	37.6	0.678
5.7	2.011	9.7	1.707	13.7	1.469	17.7	1.250	21.7	1.120	25.7	0.981	29.7	0.883	33.7	0.790	37.7	0.676
5.8	2.003	9.8	1.700	13.8	1.460	17.8	1.246	21.8	1.115	25.8	0.979	29.8	0.880	33.8	0.787	37.8	0.674
5.9	1.996	9.9	1.693	13.9	1.454	17.9	1.241	21.9	1.111	25.9	0.976	29.9	0.878	33.9	0.785	37.9	0.670
6.0	1.989	10.0	1.686	14.0	1.448	18.0	1.237	22.0	1.109	26.0	0.974	30.0	0.875	34.0	0.782	38.0	0.677
6.1	1.980	10.1	1.678	14.1	1.440	18.1	1.235	22.1	1.104	26.1	0.971	30.1	0.873	34.1	0.780	38.1	0.675
6.2	1.974	10.2	1.671	14.2	1.435	18.2	1.232	22.2	1.100	26.2	0.968	30.2	0.871	34.2	0.777	38.2	0.671
6.3	1.966	10.3	1.666	14.3	1.430	18.3	1.228	22.3	1.095	26.3	0.966	30.3	0.869	34.3	0.775	38.3	0.667
6.4	1.955	10.4	1.662	14.4	1.422	18.4	1.225	22.4	1.091	26.4	0.962	30.4	0.867	34.4	0.772	38.4	0.663
6.5	1.949	10.5	1.658	14.5	1.416	18.5	1.223	22.5	1.089	26.5	0.961	30.5	0.865	34.5	0.770	38.5	0.660
6.6	1.942	10.6	1.650	14.6	1.411	18.6	1.220	22.6	1.086	26.6	0.958	30.6	0.863	34.6	0.767	38.6	0.658
6.7	1.935	10.7	1.644	14.7	1.406	18.7	1.215	22.7	1.082	26.7	0.955	30.7	0.860	34.7	0.765	38.7	0.655
6.8	1.927	10.8	1.639	14.8	1.402	18.8	1.213	22.8	1.078	26.8	0.953	30.8	0.859	34.8	0.762	38.8	0.653
6.9	1.919	10.9	1.709	14.9	1.396	18.9	1.211	22.9	1.074	26.9	0.951	30.9	0.856	34.9	0.758	38.9	0.650
7.0	1.910	11.0	1.633	15.0	1.392	19.0	1.207	23.0	1.071	27.0	0.948	31.0	0.854	35.0	0.756	39.0	0.648
7.1	1.902	11.1	1.625	15.1	1.388	19.1	1.202	23.1	1.069	27.1	0.945	31.1	0.851	35.1	0.754	39.1	0.646
7.2	1.896	11.2	1.619	15.2	1.381	19.2	1.200	23.2	1.066	27.2	0.943	31.2	0.849	35.2	0.751	39.2	0.643
7.3	1.889	11.3	1.612	15.3	1.375	19.3	1.195	23.3	1.062	27.3	0.941	31.3	0.846	35.3	0.749	39.3	0.641
7.4	1.878	11.4	1.605	15.4	1.371	19.4	1.191	23.4	1.059	27.4	0.939	31.4	0.844	35.4	0.744	39.4	0.637
7.5	1.869	11.5	1.599	15.5	1.366	19.5	1.189	23.5	1.054	27.5	0.936	31.5	0.842	35.5	0.742	39.5	0.635
7.6	1.862	11.6	1.593	15.6	1.359	19.6	1.186	23.6	1.051	27.6	0.934	31.6	0.840	35.6	0.740	39.6	0.631
7.7	1.855	11.7	1.589	15.7	1.351	19.7	1.184	23.7	1.047	27.7	0.931	31.7	0.838	35.7	0.737	39.7	0.628
7.8	1.849	11.8	1.583	15.8	1.345	19.8	1.180	23.8	1.044	27.8	0.928	31.8	0.836	35.8	0.733	39.8	0.625
7.9	1.841	11.9	1.578	15.9	1.338	19.9	1.175	23.9	1.040	27.9	0.926	31.9	0.834	35.9	0.730	39.9	0.622
8.0	1.835	12.0	1.574	16.0	1.332	20.0	1.173	24.0	1.036	28.0	0.924	32.0	0.832	36.0	0.728	40.0	0.618
8.1	1.827	12.1	1.566	16.1	1.328	20.1	1.171	24.1	1.033	28.1	0.921	32.1	0.829	36.1	0.725	40.1	0.616
8.2	1.819	12.2	1.559	16.2	1.320	20.2	1.168	24.2	1.029	28.2	0.918	32.2	0.827	36.2	0.722	40.2	0.613
8.3	1.813	12.3	1.553	16.3	1.314	20.3	1.163	24.3	1.025	28.3	0.915	32.3	0.824	36.3	0.718	40.3	0.609
8.4	1.806	12.4	1.548	16.4	1.308	20.4	1.160	24.4	1.022	28.4	0.913	32.4	0.822	36.4	0.714	40.4	0.605
8.5	1.800	12.5	1.543	16.5	1.302	20.5	1.157	24.5	1.018	28.5	0.910	32.5	0.820	36.5	0.712	40.5	0.601
8.6	1.794	12.6	1.539	16.6	1.297	20.6	1.153	24.6	1.015	28.6	0.908	32.6	0.817	36.6	0.710	40.6	0.599
8.7	1.788	12.7	1.531	16.7	1.291	20.7	1.151	24.7	1.011	28.7	0.907	32.7	0.815	36.7	0.706	40.7	0.596
8.8	1.769	12.8	1.525	16.8	1.386	20.8	1.147	24.8	1.007	28.8	0.904	32.8	0.813	36.8	0.704	40.8	0.592
8.9	1.761	12.9	1.520	16.9	1.281	20.9	1.143	24.9	1.003	28.9	0.902	32.9	0.811	36.9	0.700	40.9	0.587