Guidelines for
Water Flux and Standard Compound Test of
AMS NanoPro™ Elements

1. Storage of new elements

1.1. Store new elements in their original package.

1.2. Store or transport elements in a place that has:

- Protection from direct sunlight;
- Ambient temperature from 4 °C to 30 °C (39 °F to 86 °F);
- Ambient temperature short-term fluctuations within the range from 0 °C to 45 °C (32 °F to 113 °F);
- Humidity less than 60-70%.

1.3. Inspect elements visually for biological growth every month.

1.4. Every 5-6weeks, or when preservation solution is not clear, or when biological growth was spotted:

- Remove the element from its package;
- Drain the old preserving solution from the element;
- Rinse the element with demineralized (RO) water;
- Soak the element for 2 hour in fresh preservation solution of 1.5% sodium metabisulphite;
- Allow the preservation solution to drip;
- Repack the element in a new package; select the package bag by low air permeability type (eg. Aluminum foil bag).
- Vacuum seal the package hermetically.

1.5. In case of short-term storage or transportation at low temperature from –15 °C to 5 °C, (from 5 °F to 41 °F):

- Remove the element from its package;
- Drain the old preserving solution from the element;
- Rinse the element with demineralized (RO) water;
- Soak the element for 2 hour in fresh preservation solution of 1.5% sodium metabisulphite and 20% v/v% glycerin;
- Allow the preservation solution to drip;
- Repack the element in a new package; and select the package bag by low air permeability type (eg. Aluminum foil bag).
- Vacuum seal the package hermetically.

2. Installation

2.1 Membrane modules are packaged with a small amount of biocide to prevent biological growth.

⚠ Provide adequate ventilation. Always use protective gloves and wear eye protection.

2.2 Remove the element bag from the shipping box.

2.3 Remove the element from the element bag.
Remove the foam protectors from each end of the element.
Ensure that element was not damaged during transportation.
Verify that the V-cup brine seal seats properly in the end-cap groove of the anti telescoping device (ATD) and faces the flow direction, so that the brine seal opens in the upstream direction.
⚠ Do NOT put V-cup brine seals on both ends of an element.

2.4 Lubricate the O-ring seals inside the end-cap permeate adaptor and V-cup brine seal with a small amount of glycerin (very thin layer of silicone lubricant DOW Corning 111 or Parker Super O-Lube may be used).
⚠ Do NOT use oil, grease, or petroleum based compounds to lubricate O-rings and V-cup brine seals.

2.5 Drain the preserving solution from the element into suitable container or drain.
Lightly rinse the element with demineralized (RO) water to remove any foreign material and remaining of the preservation solution.

2.6 Verify that all parts of high-pressure membrane housing (pressure vessel, PV) are clean and free from dust and dirt.
Examine the O-rings for nicks or cuts, discard if damaged.

2.7 Remove the upstream (feed) and downstream end caps from the membrane housing.
Determine the direction of feed flow in the membrane housing (see Fig. 1).

2.8 Load the element into the membrane housing in the direction of the feed flow following arrow direction on the element (see Fig. 2). In case you cannot see the arrow, install the element with the side without a brine seal first.
Apply smooth and constant motion into the pressure vessel. Take special care when handling the surfaces near the O-rings contact points. Damage to this area may adversely affect the performance of the element.
⚠ Do NOT load element in the direction contrary to the feed flow.

2.9 Install the end caps.

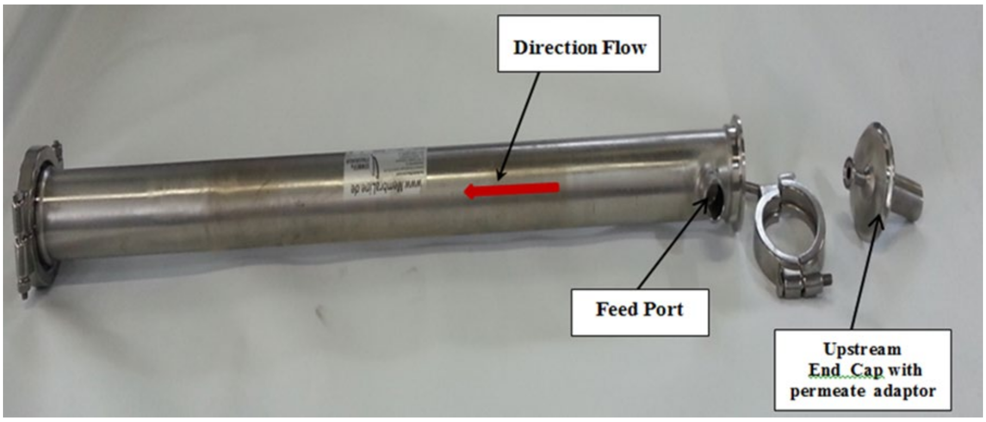

Fig. 1 NF high-pressure membrane housing

Fig. 2 NF 2540 element

3. System start-up

3.1 Proper start-up of the membrane system is essential to prepare element for operations and to prevent damage from excessive pressure, flow volume or hydraulic shock. Schematic diagram of the NF membrane system is presented in Fig. 3.

3.2 Fill up the feed tank with soft / demineralized / RO water.

3.3 Verify that all outlet, retentate and permeate valves are open.
Verify that sampling and drain valves are closed.

3.4 Operate the system with soft / demineralized / RO water with a recirculation flow of:

- For 2540 element: 13 liter/min; or
- For 4040 element 42 liter/min.

Maintain pressure of 4 bar (58 psi) for 30 minutes, directing retentate and permeate to drain.

3.5 Slowly fill the system with water at low pressure to prevent hydraulic shock (water hammer) at start-up.

3.6 Watch the concentrate flow meter for air to insure that it has all been purged.

3.7 During the flushing operation, check all pipe connections and valves for leaks. Tighten connections where necessary.

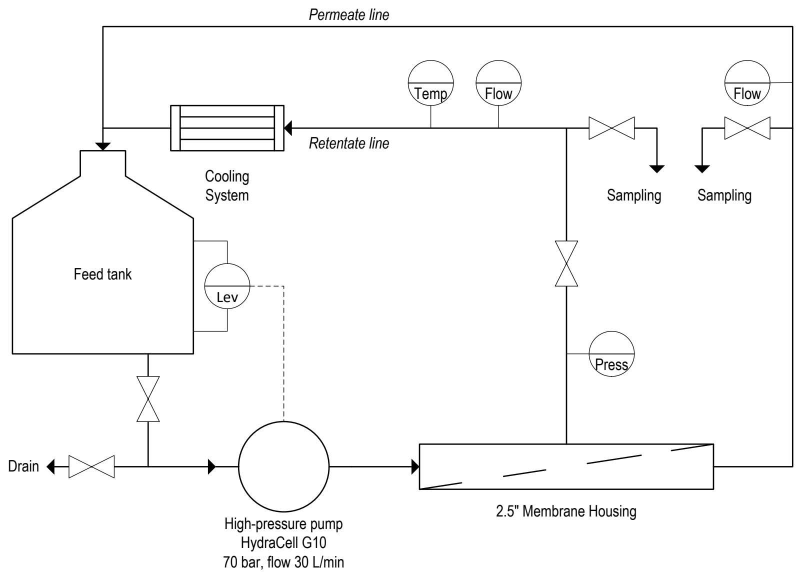

Fig. 3 Schematic diagram of NF system

4. Clean water flux measurement

4.1 Fill the feed tank with soft / demineralized / RO water.

4.2 Run the system with a recirculation flow of:

- For 2540 element: 13 liter/min; or
- For 4040 element 42 liter/min.

Maintain pressure of 40 bar (580 psi) and temperature of 30 °C (86 °F), directing retentate and permeate to the feed tank.

- ⚠ Do NOT abruptly change pressure or flow rate—residual air may cause air hammer.
- ⚠ Do NOT use tap or chlorinated water—instantaneous irreversible damage will occur.
- ⚠ Pressurization & Depressurization rate should be less than 0.7bar/second.
- ⚠ Heating & Cooling down rate should be less than 5°C/minute.

4.3 Operate for 60 minutes, filling the feed tank with soft / demineralized / RO water if necessary.

4.4 Take permeate flow measurement.

4.5 Drain the system.

5. Standard Compound Test

5.1. Prepare 2’000 mg/liter MgSO4 feed solution, take sample. Account for any water present in the $MgSO_4$ powder.

5.2. Fill the feed tank with the prepared solution.

5.3. Run the system with a recirculation flow of:

- For 2540 element: 13 liter/min; or
- For 4040 element 42 liter/min.

Maintain pressure of 40 bar (580 psi) and temperature of 30 °C (86 °F), directing retentate and permeate to the feed tank.

5.4. Operate for 60 minutes, filling the feed tank with $MgSO_4$ solution if necessary.

5.5. Take permeate and retentate samples.

5.6. Measure the electroconductivity or concentration of $MgSO_4$ of:

- Feed sample;
- Permeate sample; and
- Retentate sample.

5.7. Drain MgSO4 solution from the system and fill the feed tank with soft / demineralized / RO water.

5.8. Run the system with a recirculation flow of:

- For 2540 element: 13 liter/min; or
- For 4040 element 42 liter/min.

Maintain pressure of 4 bar (58 psi), directing retentate and permeate to the drain.

5.9. Operate for 15 minutes, filling the feed tank with soft / demineralized / RO water if necessary.

5.10. Run the system with a recirculation flow of:

- For 2540 element: 13 liter/min; or
- For 4040 element 42 liter/min.

Maintain pressure of 40 bar (580 psi), directing retentate and permeate to the feed tank.

5.11. Operate for another 30 minutes; filling the feed tank with soft / demineralized / RO water if necessary.

5.12. Drain the system.

- ⚠ Do NOT abruptly change pressure or flow rate—residual air may cause air hammer.
- ⚠ Pressurization & Depressurization rate should be less than 0.7bar/second.
- ⚠ Heating & Cooling down rate should be less than 5°C/minute.

Appendix: Calculations

Permeate flux calculation

To calculate the membrane flux, determine the permeate volume collected in a given time (e.g. milliliters per minute).

The permeate flux, F, can be calculated by:

$$F = \frac{\text{Permeate Volume}}{\text{Time} \times \text{Membrane Area}}$$

Consult element datasheet for the membrane area.

Make necessary unit conversions to achieve standard permeate flux units.

Standard permeate flux units include:

- LMD: liter per meter-squared per day:

$$F(\text{LMD}) = \frac{\text{Permeate Volume[liter]}}{\text{Time[day]} \times \text{Membrane Area}[\text{m}^2]}$$

- LMH: liter per meter-squared per hour:

$$F(\text{LMH}) = \frac{\text{Permeate Volume[liter]}}{\text{Time[hour]} \times \text{Membrane Area}[\text{m}^2]}$$

Mass balance retention

Mass balance retention, MBR, in permeate or retentate determines the fraction of component's mass that is recovered in permeate or retentate correspondingly to that in the feed. Calculation relies on the facts that Mass=Concentration × Volume and the mass is preserved during the process.

$$\text{MBR(Permeate)} = \frac{C(\text{Permeate}) \times V(\text{Permeate})}{C(\text{Feed}) \times V(\text{Feed})}$$

$$\text{MBR(Retentate)} = \frac{C(\text{Retentate}) \times V(\text{Retentate})}{C(\text{Feed}) \times V(\text{Feed})}$$

Volumetric concentration factor

Volumetric concentration factor (VCF) expresses the extent of volumetric concentration and is determined ratio of feed volume to retentate volume. The higher the VCF, the higher is the permeate volume and the lower is that of retentate

$$\text{VCF} = \frac{V(\text{Feed})}{V(\text{Retentate})}$$

Rejection calculation for Standard Compound Test

Rejection of a component can be thought of as the chance for a membrane to stop the component from

permeating. It is defined as one minus the ratio of component's concentration in permeate to component's concentration in the average feed.
In case of electro conductivity, EC, measurement, use the formula:

$$R = \left(1 - \frac{EC(\text{Permeate})}{\text{Avg}[EC(\text{Feed})]}\right) = \left(1 - \frac{EC(\text{Permeate})}{\big(EC(\text{Feed}) + EC(\text{Retentate})\big)/2}\right)$$

In case of concentration, C, measurement, use the formula:

$$R = \left(1 - \frac{C(\text{Permeate})}{\text{Avg}[C(\text{Feed})]}\right) = \left(1 - \frac{C(\text{Permeate})}{\big(C(\text{Feed}) + C(\text{Retentate})\big)/2}\right)$$

Rejection calculation for Application

When high degree of concentration is achieved, i.e. permeate volume represents substantial part of feed volume, use the adapted formula for rejection:

$$R = 1 + \frac{\log \text{MBR}(\text{Retentate})}{\log \text{VCF}},$$

Where MBR is the mass balance retention of the component, VCF is the volumetric concentration factor and log is either natural (base e=2.71828…) or common (base 10) logarithm.