Evaluation of System Performance

The following are general guidelines for troubleshooting Membrania® elements and evaluating initial system performance in water purification applications.

INITIAL PERFORMANCE EVALUATION

To gain an understanding of a potential change in a systems's performance, it is most useful to evaluate and compare its normalized operating data to the system's data at start-up. Normalization is a technique that allows the user to compare operation at a specific set of conditions to a reference set of conditions. This allows the user to determine whether changes in flow or rejection are caused by fouling, damage to the membrane or due to different operating conditions. DC Solutions offers a Normalization Spreadsheet, which can be downloaded from the website.

If the initial performance at start-up for RO systems has never been satisfactory, a comparison of the actual system performance to the TROI projected system performance under actual conditions may be used to evaluate how a system is operating. Note that TROI's calculations are estimated to be accurate within ± 10%.

TROUBLESHOOTING CHECKLIST

If the normalized performance is unsatisfactory, it is important to check the following:

- *Ensure meters, sensors and pressure gauges are calibrated and functioning.* Uncalibrated or nonfunctional meters can lead to unintended changes in system performance. Operating at elevated flow rates can result in membrane damage, and operating at flow rates which are too low (or operating above the design recovery rates) can lead to scaling and fouling. Use the general mass balance equations below to confirm the accuracy of flow and conductivity meters. (Note: all equations below should be accurate up to ± 5%). If the accuracy of one of the meters has been compromised, it is recommended to recalibrate or replace it.

    - For Flow Meters:

$$FF = PF + CF$$

where FF, PF and CF are the feed, permeate and concentrate flows.

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- For Conductivity Meters:

$$(FF)(FC) = (PF)(PC) + (CF)(CC)$$

where FC, PC and CC are the feed, permeate and concentrate conductivities.

- *Determine that the system's performance has stabilized.* Performance typically stabilizes after 24 to 72 hours of continuous operation. Normalized data for systems that have been in operation for an extended time should be investigated for any deviations in performance.

- *Consult process and instrumentation diagram (P&ID) and account for system specifics.*

Permeate Backpressure

- Depending on the system design, there may be additional permeate backpressure that has not been accounted for. This added pressure can cause the feed pressure to be higher than projected.

Pressure Losses

- Check restrictions in feed or concentrate lines (particularly valves) that may be contributing to higher than expected pressure losses.
- Location of the feed and concentrate pressure sensors should be as close to the pressure vessel as possible to gather accurate readings and to avoid close proximity to valves and other places of high turbulence.

- *Review start - up and shutdown procedures.* Procedures should be safe with respect to hydraulic shock, permeate backpressure and permeate back-flow when starting up or shutting down the system.

- *Review chemical compatibility and cleaning regimen.*

Cleaning Chemical Compatibility, Effectiveness & Frequency

- Cleaning chemicals should be approved for membrane compatibility.
- Consult DC Solutions Cleaning Guides to ensure cleaning effectiveness.
- Cleaning frequency will vary by application. For water applications, two to six chemical cleanings per year is generally considered acceptable. A high cleaning frequency may indicate inefficient pretreatment or less than optimal system design and operation.
- Higher cleaning frequency may result in higher chemical consumption and lower membrane life. To lower cleaning frequency, it may be economical to invest in pretreatment.

- *Check upstream processes/equipment.*

Prefilters: Prefilters should be regularly monitored and routinely replaced. A high replacement rate may indicate an issue with fouling.

Chlorine & other Oxidizing Chemicals: If chlorination or dechlorination is involved upstream of the system, oxidation reduction potential (ORP) should be monitored. Temperature, pH and the presence of transition metals should be scrutinized as they can promote membrane oxidation with the presence of an oxidant.

Antiscalants: Antiscalant dosages should be between 2 5 ppm. Exceedingly high dosages may result in membrane fouling.

• *Perform a water analysis.*

Transition Metals: Transition metals can catalyze membrane degradation in the presence of an oxidant.

Carbon Dioxide (CO2): CO2 passes freely through the membrane. However, in a lower pH environment of the permeate, CO2 can convert into carbonic acid and increase the permeate conductivity.

Silt Density Index (SDI): SDI in the feed should consistently be <5 (maximum, depending on the system design). Exceeding this value may cause fouling.

If all the above topics have been considered and the system performance is still unsatisfactory, on-site diagnosis tests should be performed. Please see DC Solutions guide on **Troubleshooting – On-Site Diagnostic Testing** (TSG-T-003) for more information.