NanoH_2O

Data Logging and Performance Normalization - TB 111

In order to properly troubleshoot membrane performance issues, identify system operational issues, develop cleaning and maintenance procedures and ensure the validity of the product/system warranty, it is critical that feedwater quality and system performance data be recorded and filed on a regular basis so that such information is readily available for review in the event of a performance problem or a warranty claim.

Why is Data Collection Important?

Because RO membrane performance can be affected by a variety of factors, such as a change in feedwater quality or a change in operating conditions, the only way to determine whether your membranes are performing as expected is through regular collection and routine analysis of feedwater quality and system performance data. This information can then be evaluated over time to determine whether membrane performance is tracking as expected or if adverse trends develop which then require corrective action. All data collected should be systematically logged and filed for future access to allow analysis of longer-term performance trends that may require troubleshooting or support a warranty claim.

Regular systematic data collection is required to confirm that your membrane products are being operated under their design conditions, to aid in proper maintenance and to enable troubleshooting in the event of a performance issue or problem.

CAUTION

Failure to maintain the minimum data logging requirements identified herein or to make such data available to NanoH_2O upon request may result in voiding your product/system warranty.

Why Normalize Data?

RO membrane performance will vary depending on feedwater characteristics, feedwater composition and operating conditions. Parameters such as feedwater temperature, feedwater TDS, membrane fouling, or system recovery will change key membrane performance characteristics such as feed pressure, permeate flow and permeate quality.

To determine whether changed performance is the result of changed feedwater or operating conditions, or whether it is due to a change in actual membrane performance, operating data must be taken at regular intervals and then “normalized” to baseline reference conditions. Whether changed performance is apparent or actual can only be determined by comparing “normalized” performance over time with baseline performance. To ensure optimized membrane performance and a long service life, it is important that any changes in membrane performance be identified and corrective action be taken as quickly as possible. A complete record of normalized data is therefore essential for users to realize the best performance and longest operating life of Qfx RO membrane elements.

Causes for Changes in Apparent Membrane Performance

Certain changes in the operating parameters of the RO system or train will result in changes in RO membrane performance. Such changes can result in an apparent or actual change in permeate flow or quality. Below is a list of the changed conditions that typically affect RO membrane performance.

Conditions Resulting in Reduced Permeate Flow:

1. A reduction in feedwater temperature will result in a reduction in permeate flow if there is no corresponding increase in the feed pressure. An increase in the feedwater temperature will likewise result in an increase in permeate flow if there is no corresponding decrease in the feed pressure.

Notice: The use of this product in and of itself does not necessarily guarantee the removal of cysts and pathogens from water. Effective cyst and pathogen reduction is dependent on the complete system design and on the operation and maintenance of the system.

2. Decreasing the RO feed pressure will result in a reduction in permeate flow as a consequence of reducing the net driving pressure (NDP) across the membrane elements. NDP is the available effective pressure required to drive permeate through RO membranes. NDP is a function of the applied feed pressure, pressure losses, feed/concentrate osmotic pressure and permeate pressure.

3. Increasing the permeate backpressure will result in a reduction in permeate flow, due to a reduction in the available NDP.

4. An increase in the feedwater TDS will increase the osmotic pressure and result in a loss of permeate flow due to a reduction in the available NDP, unless the feed pressure is also increased.

5. Increasing the system recovery (the ratio of permeate flow to feed flow) will result in an increase in osmotic pressure, which will reduce the NDP, thus a reduction in permeate flow.

6. Membrane surface fouling will cause a decrease in membrane permeability and a subsequent reduction in permeate flow.

7. Fouling of the membrane element's feed/brine spacer will increase the feed/concentrate pressure drop across the membrane elements operating in series, causing a decrease in NDP for the elements at the end of the system and resulting in a reduction in permeate flow.

Conditions Resulting in Increased Permeate Salinity:

8. An increase in the feedwater temperature without a corresponding change in permeate flow will result in an increase in permeate salinity.

9. A reduction in the plant/train permeate flow reduces the rate of water flux through the membrane, causing an increase in permeate salinity because there is less permeate to dilute the salts that have passed through the membrane.

10. An increase in the feedwater salinity will result in an increase in permeate salinity because an RO membrane rejects a fixed percent of the total salts.

11. An increase in the system recovery (the ratio of permeate to feed) will increase permeate salinity because this has the effect of increasing the average salinity of the feed/brine in the system.

12. Membrane surface fouling results in less permeate flow and thereby less permeate to dilute the salts that have passed through the membrane.

13. Mechanical leaks caused by O-ring leaks or failure can allow high TDS feed/brine to leak into the permeate without passing through the membrane or allow feed to bypass an element's brine seal.

14. Membrane surface damage can be caused by exposure to free chlorine.

By normalizing plant data, the reviewer can determine if changes in membrane performance (in either permeate flow or quality) result from operating under different feed pressure, salinity or temperature conditions and, therefore, conclude if changes in performance are only apparent or actual. Actual changes require corrective action to remove surface foulants, locate and correct O-ring leaks, or prevent further membrane damage due to oxidation.

Graphing normalized data over time provides a useful picture of RO system performance and will identify how and when performance may have changed. Adverse changes in performance trends can then be reviewed in light of other data and plant operation logs to determine what happened, when it happened, and what can be done to correct the problem.

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Data Collection Procedures

The following tables identify the data to be regularly collected and the frequency of collection.

NanoH$_2$O RO Membrane Minimum Logging Requirements

RO Feedwater Characteristics - Required Data

Parameter	Frequency of Collection	Comment or Unit of Measure
Silt Density Index (SDI)	Once per day (every 24 hours)	Please refer to “SDI Procedure TB 107”
Turbidity (NTU)	Once per shift (every 8 hours)	Nephelometric Turbidity Units
Temperature	Once per day (every 24 hours)	°C or °F
Conductivity (µS)	Once per day (every 24 hours)	
Feedwater Chemical Analysis	Once per month	

RO Permeate System or Each Train - Required Data

Parameter	Frequency of Collection	Comment
Conductivity (µS)	Once per day (every 24 hours)	
Flow	Once per shift (every 8 hours)	
Pressure	Once per shift (every 8 hours)	

RO Concentrate System or Each Train - Required Data

Parameter	Frequency of Collection	Comment
Conductivity	Once per day (every 24 hours)	
Flow	Once per shift (every 8 hours)	
Pressure	Once per shift (every 8 hours)	

Operating Conditions for RO System or Each Train

Parameter	Frequency of Collection	Comment
Pressure Differential	Once per day (every 24 hours)	
Cumulative Hours of Operation	Once per day (every 24 hours)	

Operating or Maintenance Events for RO System or Each Train

Event	Frequency of Collection	Comment
System or Train Start-up	As applicable	Record date and time
System or Train Shutdown	As applicable	Record reason for shutdown, date and time
Membrane Cleaning or Flushing	As applicable	Record reason for cleaning, chemical(s) used, method or procedure, concentration, date and time. Record results following cleaning.

Data Normalization Equations

- To obtain normalized permeate flow, use the following equation:

$$Q_n = Q_a * (NDP_n / NDP_a) * (TCF_n / TCF_a)$$

Q_n	Rate of permeate flow (vol/t) normalized to standard conditions
Q_a	Actual flow rate (vol/t)
NDP_n	Net Driving Pressure at standard conditions (expressed as units of pressure)
NDP_a	Actual Net Driving Pressure (expressed as units of pressure)
TCF_n	Temperature Correction Factor for temperature at standard conditions
TCF_a	Temperature Correction Factor for temperature at the actual conditions

- To obtain the Net Driving Pressure, use the following equation:

$$NDP = P_f - ½ \Delta P_{fb} - P_{osm} - P_p$$

P_f	Feed pressure
ΔP_{fb}	Pressure drop between the feed and brine systems
P_{osm}	Osmotic pressure - weighted average
P_p	Permeate pressure

- To obtain the Osmotic Pressure, use the following equation:

$$P_{osm} = CF_{lm} * C_f * 11/1000 * K_{p\text{-}cond}$$

CF_{lm}	Log mean concentration factor
C_f	Feed conductivity (μS-cm)
$K_{p\text{-}cond}$	Conductivity to Pressure conversion factor (this constant is a function of the TDS of the sample)

- To obtain the Log Mean Concentration Factor, use the following equation:

$$CF_{lm} = \ln [1 / (1-R)] / R$$

R	Water recovery, expressed as a decimal
R	Permeate flow divided by feed flow (Q_p / Q_f)

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- To obtain the Temperature Correction Factor (TCF), use the following equation:

$$TCF = \exp \{ K * [1 / (273 + t) - 1 / 298] \}$$

t	degrees Celsius
K	3070 for composite RO membranes

- To obtain normalized Salt Passage, use the following equation:

$$\%SP_n = (EPF_a / EPF_n) * (STCF_n / STCF_a) * \%SP_a$$

$\%SP_n$	Percent Salt Passage normalized to standard conditions
SP_a	Percent Salt Passage at actual conditions
EPF_n	Element Permeate Flow rate at standard test conditions
EPF_a	Element Permeate Flow rate at actual conditions
$STCF_n$	Salt Transport Temperature Correction Factor at standard conditions
$STCF_a$	Salt Transport Temperature Correction Factor at actual conditions

- To obtain the actual Salt Passage, use the following equation:

$$\%SP_a = C_p / C_{fb}$$

C_p	Permeate concentration (expressed in ppm)
C_{fb}	Feed/brine concentration (expressed in ppm) which = the feed concentration (expressed in ppm) multiplied by the log mean

- To obtain the Salt Transport Temperature Correction Factor, use the following equation:

$$STCF = \exp \{ K * [1 / (273 + t) - 1 / 298] \}$$

t	degrees Celsius
K	5030 for composite RO membranes

Notes:

1. Membrane element permeate flow is unique to each model number. Please refer to the Qfx™ product data sheet for the specified flow.

2. Please contact NanoH_2O to obtain the temperature correction factor for salt transport. Alternatively, use the TCF provided in the temperature correction equation provided above.

3. The equations described above are simplified versions of the actual expressions. As a result, some variation (~10%) can be expected in the normalized flow or salt passage. Better normalization can be accomplished using NanoH_2O's Q^+ Projection Software .