RO Performance & Design Calculation:

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There are numerous calculation that are used for the judgement of performance of RO system & for its design considerations. RO system has instruments that are link for quality, flow rate, pressure. In some case's temperature, operating hour is also take into consideration. To measure concisely, the following operational parameters are taken into consideration...

Operational parameter for Feed Water	Operational parameter for Permeate Water	Operational parameter for Reject Water
- Feed Water Flow Rate - Feed Water Pressure - Feed Water pH - Feed Water Temperature - Feed Water TDS - Feed Water Hardness - Feed Water Conductivity - Feed Water Turbidity	- Permeate Flow Rate - Permeate Pressure - Permeate pH - Permeate TDS - Permeate Hardness - Permeate Conductivity	- Reject Water Flow Rate - Reject Water Pressure - Reject Water TDS - Reject Water Hardness - Reject Water Conductivity

Salt Rejection%:

Salt Rejection% is the indicator for RO effectiveness. Salt Rejection% indicates how effective the RO membranes are removing contaminants. It generally shows, how the overall system is performing, rather than individual performing. If an RO system is well designed & functioning properly, the rejection rate will be 95% - 99% of the feed water contaminants. By using the below equation, anyone can determine the "Effectiveness of RO Membrane".

$$\text{Salt Rejection\%} = \frac{\text{Conductivity of Feed Water} - \text{Conductivity of Permeate Water}}{\text{Conductivity of Feed Water}} \times 100$$

High Salt Rejection% = Membrane is performing well
Low Salt Rejection% = Membrane needs cleaning or replacement

Salt Passage%:

Salt Passage% is a simple inverse of Salt Rejection%. It is the salt amount expressed as a percentage that are generally passing through the RO system.

Salt Passage% = [1 – Salt Rejection%]

High Salt Passage% = Membrane needs cleaning or replacement
Low Salt Passage% = Membrane is performing well

Recovery%:

Recovery% is termed as the water recovered as Permeate Water. On the other hand, it can be said that, the recovery% is the amount of water which is not sent to drain as concentrate or reject. The recovery% of RO system depends of feed water chemistry and RO pretreatment. Calculation for recovery% is as follows.

$$\text{Recovery\%} = \frac{\text{Permeate Flow Rate [gpm]}}{\text{Feed Flow Rate [gpm]}} \times 100$$

High Recovery% = Sending Less amount of Water to Drain/Reject/Concentrate
High Recovery% = Can lead to Larger Problems due to Scaling & Fouling
Low Recovery% = Sending High amount of Water to Drain/Reject/Concentrate

65% Recovery Rate = Feed Water 100 gpm, Permeate Water 65 gpm, Reject Water 35 gpm
75% Recovery Rate = Feed Water 100 gpm, Permeate Water 75 gpm, Reject Water 25 gpm
85% Recovery Rate = Feed Water 100 gpm, Permeate Water 85 gpm, Reject Water 15 gpm

Concentration Factor:

The more water can be recovered as permeate [the higher recovery%], the more concentrated salts and contaminants can be collected in the concentrate stream. High Concentration Factor will lead the higher potential for scaling on surface of the RO membrane.

$$\text{Concentration Factor} = \frac{1}{1 - \text{Recovery\%}}$$

High Concentration Factor = High potential of scaling on the surface of RO membrane.

Example:
Suppose that, Feed Water is 100 gpm and permeate flow is 75 gpm. Then the recovery% is [75/100]x100 = 75%.

In that situation, the concentration factor is [1/[1-75%] = 4

A concentration factor 4 means, the water going to the concentrate system will be 4 times more concentrated than feed water. If the feed water feed water is 300 ppm, then the concentration will be 300 x 4 = 1200 ppm.

Mass Balance:

To determine the flow and quality instrumentation, the Mass Balance equation is required. It provides signal that, the system is working well or the system requires calibration.

The needed items for Mass Balance Check:

- Feed Water Flow [gpm]
- Permeate Water Flow [gpm]
- Concentrate Flow [gpm]
- Feed Water Conductivity [µS]
- Permeate Water Conductivity [µS]
- Concentrate Water Conductivity [µS]

Mass Balance Formula:

[Feed Flow X Feed Conductivity] = [Permeate Flow X Permeate Conductivity] + [Conc. Flow X Conc. Conductivity]

Problem:

Feed Water Flow …….. ??? gpm
Feed Water Conductivity …… 500 µS
Permeate Water Flow …….. 5 gpm
Permeate Conductivity …….. 10 µS
Concentrate Flow …….. 2 gpm
Concentrate Conductivity …….. 1200 µS

In this situation, what will be the Mass Balance?

Answer:

Feed Water Flow …… 5 + 2 = 7 gpm

[Feed Flow X Feed Conductivity] = 7 x 500 = 3500

[Permeate Flow x Permeate Conductivity] + [Conc. Flow x Conc. Conductivity]
= [5 x 10] + [2 x 1200]
= 50 + 2400
= 2450

Difference% = [3500 – 2450]/[3500 + 2450] = 18%

Good Result = < 5%+/-
Adequate Result = 5% - 10% +/-
Unacceptable = > 10%+/- [in that situation, Calibration of RO Instrumentation is required]