Reverse Osmosis Flux and Salt Passage (Solution–Diffusion)

Water flux, permeate concentration and salt rejection of a reverse osmosis membrane from permeabilities A and B, pressure and osmotic pressures.

Method: Perry's Chemical Engineers' Handbook; 9th ed. (McGraw-Hill, 2019); ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Water permeability (L/(m²·h·bar))	3.0000	
Salt permeability (L/(m²·h))	0.15000	
Applied transmembrane pressure	15.000	bar
Feed-side salt concentration at the membrane	2.0000	g/L
van 't Hoff factor	2.0000	
Salt molar mass	58.440	kg/kmol
Temperature	25.000	°C

Calculated results

Parameter	Value	Unit
Feed osmotic pressure	1.6968	bar
Water flux (L/(m²·h))	39.929	
Permeate concentration	7.4853	mg/L
Salt rejection	99.626	%

Notes for this case

• Concentration at the membrane surface is above the bulk because of polarisation (often 10–20 % in spiral elements). Osmotic pressure by van 't Hoff, adequate below about 35 g/L of NaCl.

Formula and method

$$J_w = A(\Delta p - \Delta\pi), \quad J_s = B(C_f - C_p), \quad C_p = \frac{BC_f}{J_w + B}, \quad \pi = \frac{iC}{M}RT$$

Variables

A	Water permeability (L/(m²·h·bar))	-
B	Salt permeability (L/(m²·h))	-
Δp	Applied transmembrane pressure	Pa
C_f	Feed-side salt concentration at the membrane	kg/m³
i	van 't Hoff factor	-
M	Salt molar mass	kg/kmol
T	Temperature	K
π_f	Feed osmotic pressure	Pa
J_w	Water flux (L/(m²·h))	-
C_p	Permeate concentration	kg/m³
R	Salt rejection	-

Method and standards

Solution–diffusion model.

Assumptions and limits

- Dilute solutions; van 't Hoff osmotic pressure, adequate below about 35 g/L; above that it is flagged as an extrapolation.
- A, B and J_w are plain numbers in L/(m²·h·bar) and L/(m²·h) in every unit system: 1 L/(m²·h) = 0.589 gal/(ft²·d) (GFD), and 1 L/(m²·h·bar) = 0.0406 GFD/psi.

References

- Perry's Chemical Engineers' Handbook
- 9th ed. (McGraw-Hill, 2019)
- sec. 20 (reverse osmosis: J_w = A(Δp − Δπ), J_s = BΔC)
- van 't Hoff osmotic pressure

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/chemical/unit-operations/ro-flux-solution-diffusion

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Reopens the calculator with the inputs of this report.