RO Limiting Salt: Maximum Recovery Before Scaling

Maximum reverse osmosis recovery before a sparingly soluble salt such as calcium, barium or strontium sulfate reaches saturation at the membrane surface.

Input parameters

Unit system: SI

Parameter	Value	Unit
Cation in the feed (Ca, Ba or Sr)	2.0000	mg/L
Cation molar mass (Ca 40.08, Ba 137.33, Sr 87.62)	87.620	kg/kmol
Anion in the feed (sulfate)	400.00	mg/L
Anion molar mass (SO4 96.06)	96.060	kg/kmol
Log of the solubility product (CaSO4 −4.6, BaSO4 −9.97, SrSO4 −6.5)	-6.5000	
Concentration polarisation factor	1.2000	

Calculated results

Parameter	Value	Unit
Cation in the feed	2.2826e-05	mol/L
Anion in the feed	0.004164	mol/L
Concentrate fraction at saturation	65.789	%
Maximum recovery	34.211	%
Concentration factor at the limit	1.5200	

Notes for this case

- 100 % rejection and activities equal to concentrations, in common practice; activity coefficients below 1 allow somewhat higher recovery. Antiscalants let plants exceed the saturation limit by a margin set by the supplier.

Formula and method

$$K_{sp} = [M^{2+}]_M [A^{2-}]_M = \frac{\beta^2 [M^{2+}]_F [A^{2-}]_F}{y^2}$$

$$y = 1 - r = \beta \sqrt{\frac{[M^{2+}]_F [A^{2-}]_F}{K_{sp}}}$$

Variables

C_{cat}	Cation in the feed (Ca, Ba or Sr)	kg/m³
M_{cat}	Cation molar mass (Ca 40.08, Ba 137.33, Sr 87.62)	kg/kmol
C_{an}	Anion in the feed (sulfate)	kg/m³
M_{an}	Anion molar mass (SO4 96.06)	kg/kmol
$\log K_{sp}$	Log of the solubility product (CaSO4 −4.6, BaSO4 −9.97, SrSO4 −6.5)	-
β	Concentration polarisation factor	-
$[M^{2+}]_F$	Cation in the feed	mol/m³
$[A^{2-}]_F$	Anion in the feed	mol/m³
$y = 1 - r$	Concentrate fraction at saturation	-
r_{max}	Maximum recovery	-

CF	Concentration factor at the limit	-

Method and standards

Solubility product at the membrane surface with full rejection.

Assumptions and limits

- 1:1 divalent salts, full rejection, activity = concentration.

Report details

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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

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

This calculator online

https://calc.firecad.com/environmental/drinking-water/ro-limiting-salt-recovery

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.