CO_2 Scrubber Ethanol Recovery (Kremser)

Fraction of ethanol recovered from fermenter CO_2 by a water scrubber with N theoretical stages, by Kremser with the infinite-dilution K-value of ethanol in water.

Method: Ethanol–water VLE at about 1 atm: Wilson equation (Perry's Chemical Engineers' Handbook, 9th ed., sec. 4) with energies 399 and 933 cal/mol fitted to FireCAD ethanol–water x–y–T data at 101.325 kPa; ethanol vapour pressure Perry's 9th ed. Table 2-8; water IAPWS-IF97; Kremser equation for absorbers (Perry's 9th ed. sec. 13)

Input parameters

Unit system: SI

Parameter	Value	Unit
Scrubber water temperature	20.000	°C
Scrubber pressure (absolute)	101.33	kPa
Water per kg of CO_2	0.50000	kg/kg
Theoretical stages	4.0000	
Ethanol in the gas entering	0.50000	%

Calculated results

Parameter	Value	Unit
Equilibrium slope y/x at infinite dilution	0.52970	
Absorption factor L/(mG)	2.3059	
Ethanol recovered	97.966	%
Ethanol in the gas leaving	0.010171	%

Notes for this case

- Return the scrubber water to the fermenter or the beer well so the ethanol is distilled.
- The infinite-dilution activity coefficient comes from Wilson energies fitted near the boiling point and is extrapolated to scrubber temperatures; treat the recovery as an estimate.

Formula and method

$$m = \frac{\gamma_1^{\infty} p_1^s(T)}{P}, \quad A = \frac{L}{mG}, \quad \phi = \frac{A^{N+1} - A}{A^{N+1} - 1}$$

Variables

T	Scrubber water temperature	K
P	Scrubber pressure (absolute)	Pa
$\dot{m}_w/\dot{m}_{CO_2}$	Water per kg of CO_2	kg/kg
N	Theoretical stages	-
y_{in}	Ethanol in the gas entering	-
m	Equilibrium slope y/x at infinite dilution	-
A	Absorption factor L/(mG)	-
ϕ	Ethanol recovered	-
y_{out}	Ethanol in the gas leaving	-

Method and standards

Kremser recovery with the Wilson infinite-dilution activity coefficient.

Assumptions and limits

- Dilute; isothermal; fresh water entering; Wilson model extrapolated below 78 °C.
- The Wilson energies were fitted to boiling data at about 1 atm and are taken as independent of temperature, so the infinite-

dilution activity coefficient at 5–40 °C is an extrapolation and has not been compared with measured values. A higher coefficient gives a larger m and a lower recovery.

References

• Ethanol–water VLE at about 1 atm: Wilson equation (Perry's Chemical Engineers' Handbook, 9th ed., sec. 4) with energies 399 and 933 cal/mol fitted to FireCAD ethanol–water x–y–T data at 101.325 kPa; ethanol vapour pressure Perry's 9th ed. Table 2-8; water IAPWS-IF97
• Kremser equation for absorbers (Perry's 9th ed. sec. 13)

Report details

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Release checks	2 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/sugar-ethanol/ethanol/co2-scrubber-ethanol-recovery

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.