Ethanol Carried Off in Fermenter CO_2

Ethanol and water vapour in the CO_2 leaving a fermenter saturated at beer temperature, and the ethanol lost as a share of production (Wilson VLE, 1 CO_2 per ethanol).

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; Stoichiometry: one mole of CO_2 per mole of ethanol (Gay-Lussac)

Input parameters

Unit system: SI

Parameter	Value	Unit
Beer strength % vol at 20 °C.	10.000	%
Beer temperature	32.000	°C
Pressure in the fermenter head space	101.33	kPa
Ethanol production at 20 °C	4.1667	m³/h

Calculated results

Parameter	Value	Unit
Ethanol mole fraction in the gas	2.3563	%
Water vapour mole fraction	4.5657	%
Ethanol lost as a share of production	2.5315	%
Ethanol lost at 20 °C	0.10548	m³/h

Notes for this case

- A CO_2 scrubber recovers most of this ethanol; the loss share rises with beer strength and temperature.

Formula and method

$$y_e = \frac{x_e \gamma_e p_e^s(T)}{P}, \quad y_w = \frac{x_w \gamma_w p_w^s(T)}{P}, \quad \varepsilon = \frac{y_e}{1 - y_e - y_w}$$

Variables

q	Beer strength	-
T	Beer temperature	K
P	Pressure in the fermenter head space	Pa
$\dot{V}_e$	Ethanol production at 20 °C	m³/s
y_e	Ethanol mole fraction in the gas	-
y_w	Water vapour mole fraction	-
$\mathcal{E}$	Ethanol lost as a share of production	-
$\dot{V}_L$	Ethanol lost at 20 °C	m³/s

Method and standards

Saturated off-gas with Wilson activity coefficients; CO_2 moles equal ethanol moles produced.

Assumptions and limits

- Gas saturated at beer temperature; dissolved CO_2 and solids ignored; Wilson model fitted near 78–100 °C, extrapolated to fermenter temperatures.
- The loss is proportional to the activity coefficient of ethanol, which is extrapolated here and has not been compared with measured values at 10–40 °C; if it is overstated, so is the loss.

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
• Stoichiometry: one mole of CO_2 per mole of ethanol (Gay-Lussac)

Report details

Report reference	FCC-36WS-MTF2 (the same inputs always give the same reference)
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Method last reviewed	13 November 2026
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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/fermenter-co2-ethanol-loss

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.