Oxygen Uptake Rate and Aeration Needed for a Fermenter

Oxygen uptake rate of a culture from biomass and specific uptake, the kLa needed above a critical dissolved oxygen, and the air flow (vvm) required.

Method: Doran; Bioprocess Engineering Principles; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Biomass concentration (dry cell weight)	30.000	g/L
Specific oxygen uptake (mmol O_2 per g dry cells per hour)	8.0000	
Broth volume	50.000	m³
Saturation dissolved oxygen	7.2000	mg/L
Dissolved oxygen to hold (above critical)	1.5000	mg/L
Oxygen absorbed from the air	20.000	%

Calculated results

Parameter	Value	Unit
Oxygen uptake rate	7.6795	kg/(m³·h)
Oxygen demand of the broth	383.98	kg/h
kLa needed	1,347.3	1/h
Air flow at 0 °C, 1 atm	6,419.3	Nm³/h
Air flow per broth volume per minute (air at 0 °C, 1 atm)	2.1398	

Notes for this case

- High-density aerobic cultures often need kLa of several hundred per hour; above that, oxygen-enriched air or pressure is used.

Formula and method

$$OUR = q_{O_2} X, \quad k_L a_{req} = \frac{OUR}{C^* - C_{crit}}, \quad Q_{air} = \frac{OUR \cdot V}{0.2095\,\eta_{O_2}} \cdot 22.414\ \mathrm{L/mol}$$

Variables

X	Biomass concentration (dry cell weight)	kg/m³
q_{O_2}	Specific oxygen uptake (mmol O_2 per g dry cells per hour)	-
V	Broth volume	m³
C^*	Saturation dissolved oxygen	kg/m³
C_{crit}	Dissolved oxygen to hold (above critical)	kg/m³
η_{O_2}	Oxygen absorbed from the air	-
OUR	Oxygen uptake rate	kg/(m³·s)
$\dot{m}_{O_2}$	Oxygen demand of the broth	kg/s
$k_L a_{req}$	kLa needed	1/s
Q_{air}	Air flow at 0 °C, 1 atm	Nm³/s
VVM	Air flow per broth volume per minute (air at 0 °C, 1 atm)	-

Method and standards

Oxygen balance.

Assumptions and limits

- Steady state; ideal gas at 0 °C, 1 atm.
- vvm is on normal air (0 °C, 1 atm); vvm quoted at inlet or actual conditions is larger by the temperature and pressure ratio.
- X is dry cell weight and q_{O_2} is per gram of dry cells; q_{O_2} is entered as a plain number in mmol/(g·h).

References

• Doran
• Bioprocess Engineering Principles
• 2nd ed. (Academic Press, 2013)
• ch. 10 (oxygen demand and transfer)

Report details

Report reference	FCC-5W8H-CKHA (the same inputs always give the same reference)
Generated	17 November 2026, 19:46 UTC
Calculator	Oxygen Uptake Rate and Aeration Needed for a Fermenter
Method last reviewed	13 November 2026
Software release	FireCAD Calc, release of 17 November 2026
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/chemical/bioprocess/oxygen-uptake-aeration

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.