Gas Membrane Separation: Complete-Mixing Model

Permeate and retentate compositions of a binary gas membrane stage from feed, stage cut, selectivity and pressure ratio (complete-mixing model).

Method: Weller and Steiner (1950) complete-mixing model; as given in Geankoplis; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Fast gas mole fraction in the feed	20.900	%
Stage cut (permeate/feed)	30.000	%
Selectivity (fast/slow permeability)	5.0000	
Pressure ratio (permeate/feed side)	10.000	%

Calculated results

Parameter	Value	Unit
Fast gas in the permeate	37.938	%
Fast gas in the retentate	13.598	%
Recovery of the fast gas to the permeate	54.456	%

Notes for this case

- Complete mixing on both sides is the most conservative flow pattern; cross-flow and counter-current modules do better at the same stage cut.

Formula and method

$$\frac{y_p}{1-y_p} = \alpha \frac{x_o - (p_L/p_H)y_p}{(1-x_o) - (p_L/p_H)(1-y_p)}, \quad x_f = \theta y_p + (1-\theta)x_o$$

Variables

x_f	Fast gas mole fraction in the feed	-
θ	Stage cut (permeate/feed)	-
α	Selectivity (fast/slow permeability)	-
p_L/p_H	Pressure ratio (permeate/feed side)	-
y_p	Fast gas in the permeate	-
x_o	Fast gas in the retentate	-
R	Recovery of the fast gas to the permeate	-

Method and standards

Complete-mixing model.

Assumptions and limits

- Binary; complete mixing; constant permeabilities.
- The two nested solutions are checked against both equations; if they do not close, the calculation stops with a message instead of returning a bracket end point.

References

- Weller and Steiner (1950) complete-mixing model
- as given in Geankoplis
- Transport Processes and Separation Process Principles
- and Perry's Chemical Engineers' Handbook
- 9th ed. (McGraw-Hill, 2019)
- sec. 20

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/chemical/unit-operations/gas-membrane-complete-mixing

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.