McCabe–Thiele Stages with Constant Relative Volatility

Theoretical stages, optimum feed stage and minimum reflux of a binary distillation with constant relative volatility, by stepping off McCabe–Thiele stages.

Method: Perry's Chemical Engineers' Handbook; 9th ed. (McGraw-Hill, 2019); ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Relative volatility	2.5000	
Light component in the feed (mole fraction)	40.000	%
Light component in the distillate	95.000	%
Light component in the bottoms	5.0000	%
Feed condition q	1.0000	
Reflux as a multiple of the minimum	1.5000	

Calculated results

Parameter	Value	Unit
Minimum reflux ratio	1.4444	
Reflux ratio	2.1667	
Theoretical stages (reboiler = 1)	11.722	
Optimum feed stage from the top	6.0000	

Notes for this case

- The last stage counted as a fraction is the share of a stage needed to reach x_B; the reboiler is the last stage.

Formula and method

$$y^{*} = \frac{\alpha x}{1 + (\alpha - 1)x}, \quad y = \frac{R}{R+1}x + \frac{x_D}{R+1}, \quad R_{min} = \frac{x_D - y_p}{y_p - x_p}$$

Variables

α	Relative volatility	-
x_F	Light component in the feed (mole fraction)	-
x_D	Light component in the distillate	-
x_B	Light component in the bottoms	-
q	Feed condition q	-
R/R_{min}	Reflux as a multiple of the minimum	-
R_{min}	Minimum reflux ratio	-
R	Reflux ratio	-
N	Theoretical stages (reboiler = 1)	-
N_F	Optimum feed stage from the top	-

Method and standards

Stage-by-stage stepping from the top with constant molar overflow.

Assumptions and limits

- Constant α and molar overflow; total condenser.
- If the stepping reaches x_B without crossing the operating-line intersection, the feed stage is not shown and a note says so.

References

- Perry's Chemical Engineers' Handbook
- 9th ed. (McGraw-Hill, 2019)
- sec. 13 (distillation)
- McCabe–Thiele method
- Mass Transfer Tutorial: Distillation (McCabe–Thiele example)

Report details

Report reference	FCC-7GNP-PZAT (the same inputs always give the same reference)
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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/separation/mccabe-thiele-constant-alpha

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.