CSTR Volume for a Conversion (First or Second Order)

Residence time and volume of a continuous stirred tank reactor (CSTR) for a target conversion with first- or second-order kinetics.

Method: CSTR design equation V = F_A0 X/(−r_A) at outlet conditions (Fogler; Levenspiel)

Input parameters

Unit system: SI

Parameter	Value	Unit
Feed volumetric flow	10.000	m³/h
Target conversion	80.000	%
Reaction order	First order	
Rate constant k·C_A0^(n−1) For first order k itself; for second order k × C_A0.	0.20000	1/min

Calculated results

Parameter	Value	Unit
Residence time	20.000	min
Reactor volume	3.3333	m³
Damköhler number k'τ	4.0000	

Notes for this case

• Constant density, perfect mixing, isothermal. A CSTR works at the outlet concentration, so it needs more volume than a plug flow reactor.

Formula and method

$$\tau = \frac{X}{k(1-X)} \ (n=1), \quad \tau = \frac{X}{kC_{A0}(1-X)^2} \ (n=2), \quad V = \dot{V}\tau$$

Variables

$\dot{V}$	Feed volumetric flow	m³/s
X	Target conversion	-
n	Reaction order	-
k'	Rate constant k·C_A0^(n−1)	1/s
τ	Residence time	s
V	Reactor volume	m³
Da	Damköhler number k'τ	-

Method and standards

CSTR design equation.

Assumptions and limits

- Isothermal, constant density.

References

• CSTR design equation V = F_A0 X/(−r_A) at outlet conditions (Fogler; Levenspiel)

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/reactors/cstr-volume

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.