CSTRs in Series: Conversion for a First-Order Reaction

Conversion of a first-order reaction in N equal stirred tanks in series for a total residence time, compared with one CSTR and a plug flow reactor.

Method: Tanks-in-series; first order: X = 1 − (1 + kτ/N)^(−N) (Levenspiel)

Input parameters

Unit system: SI

Parameter	Value	Unit
First-order rate constant	0.10000	1/min
Total residence time	30.000	min
Number of equal tanks	3.0000	

Calculated results

Parameter	Value	Unit
Conversion with N tanks	87.500	%
One tank of the same total volume	75.000	%
Plug flow reactor	95.021	%

Formula and method

$$X_N = 1 - \left(1 + \frac{k\tau}{N}\right)^{-N}$$

Variables

k	First-order rate constant	1/s
τ	Total residence time	s
N	Number of equal tanks	-
X_N	Conversion with N tanks	-
X_1	One tank of the same total volume	-
X_{PFR}	Plug flow reactor	-

Method and standards

Tanks-in-series.

Assumptions and limits

- Equal tanks, first order.

References

- Tanks-in-series
- first order: X = 1 − (1 + kτ/N)^(−N) (Levenspiel)

Report details

Report reference	FCC-52BB-Z9SD (the same inputs always give the same reference)
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Release checks	3 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/cstrs-in-series

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.