Medium Sterilisation: Del Factor, Holding Time and Holding-Tube Length

Del factor for a target contamination risk, spore death rate by an Arrhenius law, holding time at temperature and continuous holding-tube length.

Method: Doran; Bioprocess Engineering Principles; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Spores per litre of raw medium	1.0000e+09	
Medium volume per batch	40.000	m³
Acceptable surviving spores per batch (e.g. 0.001)	0.001000	
$\log_{10}$ of the Arrhenius constant A (1/s)	36.200	
Activation energy for spore death	283.00	kJ/mol
Holding temperature	140.00	°C
Velocity in the holding tube	0.50000	m/s

Calculated results

Parameter	Value	Unit
Del factor ln(N_0/N)	38.228	
Specific death rate at T	158.16	1/min
Holding time	0.24170	min
Holding-tube length (plug flow at the mean velocity)	7.2510	m
Decimal reduction time at T	0.014558	min

Notes for this case

- Holding phase only: in a batch, heating and cooling contribute part of the Del factor. Axial dispersion in a real holding tube needs a longer tube than plug flow, and in laminar flow the fastest fluid moves at about twice the mean velocity. Defaults are Deindoerfer–Humphrey constants for Bacillus stearothermophilus spores.

Formula and method

$$N_0 = n_0 V \times 1000\ \mathrm{L/m^3}, \quad \nabla = \ln\frac{N_0}{N}, \quad k_d = A e^{-E_d/RT}, \quad t_h = \frac{\nabla}{k_d}, \quad L = u t_h, \quad D_T = \frac{\ln 10}{k_d}$$

Variables

n_0	Spores per litre of raw medium	-
V	Medium volume per batch	m³
N	Acceptable surviving spores per batch (e.g. 0.001)	-
$\log_{10} A$	$\log_{10}$ of the Arrhenius constant A (1/s)	-
E_d	Activation energy for spore death	J/mol
T	Holding temperature	K
u	Velocity in the holding tube	m/s
∇	Del factor ln(N_0/N)	-
k_d	Specific death rate at T	1/s
t_h	Holding time	s
L	Holding-tube length (plug flow at the mean velocity)	m

D_T	Decimal reduction time at T	s
N_0	Spores in the batch before sterilisation	-

Method and standards

Del factor with Arrhenius death kinetics.

Assumptions and limits

- First-order death; plug flow in the tube at the mean velocity. Real tubes need a margin for axial dispersion, and laminar flow (fastest fluid at about twice the mean velocity) needs a longer tube.
- N_0 is the total spores in the batch: n_0 per litre times the volume in litres.

References

- Doran
- Bioprocess Engineering Principles
- 2nd ed. (Academic Press, 2013)
- ch. 14 (sterilisation: Del factor, Arrhenius death kinetics; Deindoerfer and Humphrey constants for B. stearothermophilus)

Report details

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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/sterilisation-del-factor

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.