Continuous Fermentation: Dilution Rate and Train

Dilution rate, residence time, time to steady state and productivity of a continuous fermenter train, with a yeast washout check (Alcohol Textbook ch. 11).

Method: Jacques; Lyons and Kelsall (eds.); ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Mash feed	100.00	m³/h
Working volume of each fermenter	1,000.0	m³
Fermenters in the train The Alcohol Textbook: fuel alcohol plants run trains of four or five fermenters.	5.0000	
Ethanol leaving the last fermenter	110.00	g/L
Maximum specific growth rate of the yeast	0.30000	1/h

Calculated results

Parameter	Value	Unit
Dilution rate F/V	0.10000	1/h
Residence time per fermenter	10.000	h
Total residence time	50.000	h
Time to steady state of one fermenter (three residence times)	30.000	h
Volumetric productivity of the train	2.2000	g/(L·h)
Washout margin (must exceed 1)	3.0000	

Notes for this case

- Steady state needs about three residence times (some studies use six) after any change of feed. That is for one fermenter: later vessels of the train settle later, so allow longer for the last one.

Formula and method

$$D = \frac{F}{V}, \quad T = \frac{1}{D}, \quad Q_P = \frac{PF}{nV}$$

Variables

F	Mash feed	m³/s
V	Working volume of each fermenter	m³
n	Fermenters in the train	-
P	Ethanol leaving the last fermenter	kg/m³
μ_{max}	Maximum specific growth rate of the yeast	1/s
D	Dilution rate F/V	1/s
T	Residence time per fermenter	s
nT	Total residence time	s
$3T$	Time to steady state of one fermenter (three residence times)	s
Q_P	Volumetric productivity of the train	kg/(m³·s)
μ_{max}/D	Washout margin (must exceed 1)	-

Method and standards

Chemostat definitions as given in the Alcohol Textbook.

Assumptions and limits

- Equal volumes; no side feeds after fermenter 1.
- The time to steady state is for a single fermenter; in a train the later vessels settle later, so the last one takes longer than 3T.

References

• Jacques
• Lyons and Kelsall (eds.)
• The Alcohol Textbook
• 4th ed. (Nottingham University Press, 2003)
• ch. 11 (Ingledew)
• single-stage and multistage continuous culture

Report details

Report reference	FCC-QJDV-F7DM (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/sugar-ethanol/ethanol/continuous-fermentation-train

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.