Tank Level Process Dynamics: Integrating Rate and Residence Time

Integrating rate of a tank level loop from valve capacity, tank area and level span, with the residence time and the time to sweep the span.

Method: Mass balance of a tank (Seborg, Edgar, Mellichamp and Doyle, Process Dynamics and Control, 4th ed. (Wiley, 2016), ch. 2)

Input parameters

Unit system: SI

Parameter	Value	Unit
Inflow change for 100 % valve	20.000	m³/h
Tank cross-section	3.0000	m²
Level transmitter span	2.0000	m
Working volume (for residence time)	6.0000	m³
Normal throughput	10.000	m³/h

Calculated results

Parameter	Value	Unit
Integrating rate (%/s per % of valve)	9.2593e-04	1/s
Time to change the span at full valve imbalance	18.000	min
Residence time at normal throughput	36.000	min

Notes for this case

- k' = Q_max/(A·L_s): with level and valve in %, 100 % valve imbalance moves the level 100 % in 1/k' seconds.

Formula and method

$$k' = \frac{Q_{max}}{A L_s}, \quad t_{fill} = \frac{1}{k'}, \quad \tau_r = \frac{V}{Q_n}$$

Variables

Q_{max}	Inflow change for 100 % valve	m³/s
A	Tank cross-section	m²
L_s	Level transmitter span	m
V	Working volume (for residence time)	m³
Q_n	Normal throughput	m³/s
k'	Integrating rate (%/s per % of valve)	1/s
t_{fill}	Time to change the span at full valve imbalance	s
τ_r	Residence time at normal throughput	s

Method and standards

Tank mass balance.

Assumptions and limits

- Constant cross-section.

References

- Mass balance of a tank (Seborg, Edgar, Mellichamp and Doyle, Process Dynamics and Control, 4th ed. (Wiley, 2016), ch. 2)

Report details

Report reference	FCC-ZEMB-JP0V (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/instrumentation/control-loops/tank-level-process-gain

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.