Hindered Settling Velocity (Richardson–Zaki)

Settling velocity of a suspension from the Stokes velocity and voidage, u = u_t ε^n, with the Richardson–Zaki exponent from the particle Reynolds number.

Method: Perry's Chemical Engineers' Handbook; 9th ed. (McGraw-Hill, 2019); ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Particle diameter	0.10000	mm
Particle density	2,650.0	kg/m³
Fluid density	998.00	kg/m³
Fluid viscosity	1.0000	cP
Solids volume fraction	20.000	%
Single-particle terminal velocity, if known (0 = Stokes) Leave 0 to use Stokes' law. Above the Stokes range enter u_t from the particle terminal velocity calculator.	0	m/s

Calculated results

Parameter	Value	Unit
Single-particle (Stokes) velocity	0.009000	m/s
Particle Reynolds number	0.89823	
Richardson–Zaki exponent	4.4142	
Hindered settling velocity	0.003361	m/s

Notes for this case

- Re above the Stokes range: the single-particle velocity is overstated; use a drag correlation for u_t.

Formula and method

$$u_t = \frac{(\rho_p - \rho_f) g d_p^2}{18\mu} \text{ (or } u_{t,in} \text{ if entered)}, \quad Re_t = \frac{\rho_f u_t d_p}{\mu}, \quad u = u_t(1-\phi)^n$$

Variables

d_p	Particle diameter	m
ρ_p	Particle density	kg/m³
ρ_f	Fluid density	kg/m³
μ	Fluid viscosity	Pa·s
ϕ	Solids volume fraction	-
u_t	Single-particle (Stokes) velocity	m/s
Re_t	Particle Reynolds number	-
n	Richardson–Zaki exponent	-
u	Hindered settling velocity	m/s
$u_{t,in}$	Single-particle terminal velocity, if known (0 = Stokes)	m/s
g	Standard gravity, 9.806 65	m/s²

Method and standards

Stokes' law with the Richardson–Zaki correction.

Assumptions and limits

- Uniform spheres.
- Stokes' law is used only while Re_t stays below 1; beyond that the calculation stops unless you enter the single-particle terminal velocity from a drag correlation (for example the particle terminal velocity calculator). The exponent n is then taken at the Re of that velocity.

References

• Perry's Chemical Engineers' Handbook
• 9th ed. (McGraw-Hill, 2019)
• sec. 17: Richardson and Zaki
• $U/U_i = \varepsilon^n$ [Trans. Inst. Chem. Eng. 32: 35 (1954)]
• Richardson–Zaki exponent: 4.65 (Re < 0.2)
• 4.4 Re^−0.03 (0.2–1)
• 4.4 Re^−0.1 (1–500)
• 2.4 (> 500)

Report details

Report reference	FCC-D63Y-V59Y (the same inputs always give the same reference)
Generated	17 November 2026, 19:50 UTC
Calculator	Hindered Settling Velocity (Richardson–Zaki)
Method last reviewed	13 November 2026
Software release	FireCAD Calc, release of 17 November 2026
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/unit-operations/hindered-settling-richardson-zaki

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.