Yield Strength from Grain Size (Hall–Petch)

Yield strength of a metal from its grain size by the Hall–Petch relation with your friction stress and locking constant, and the grain size for a target strength.

Method: Hall (1951) and Petch (1953): σ_y = σ₀ + k_y d^(−½)

Input parameters

Unit system: SI

Parameter	Value	Unit
Friction stress From data for the alloy.	70.000	MPa
Locking parameter (MPa·m^½)	0.74000	
Mean grain diameter	20.000	µm
Target yield strength	300.00	MPa

Calculated results

Parameter	Value	Unit
Yield strength	235.47	MPa
Grain size for the target	10.352	µm

Notes for this case

- Holds down to about 10–20 nm; constants depend on the alloy and its condition.

Formula and method

$$\sigma_y = \sigma_0 + \frac{k_y}{\sqrt{d}}, \quad d_t = \left(\frac{k_y}{\sigma_t - \sigma_0}\right)^2$$

Variables

σ_0	Friction stress	Pa
k_y	Locking parameter (MPa·m^½)	-
d	Mean grain diameter	m
σ_t	Target yield strength	Pa
σ_y	Yield strength	Pa
d_t	Grain size for the target	m

Method and standards

Hall–Petch.

Assumptions and limits

- Room temperature, single-phase.
- When the target is at or below σ₀ any grain size reaches it, and the grain size for the target is not shown.

References

- Hall (1951) and Petch (1953): σ_y = σ₀ + k_y d^(−½)

Report details

Report reference	FCC-1J3Q-08DB (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/materials/properties/hall-petch-strength

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.