Hydraulic Cylinder Rod Buckling (Euler, by Mounting)

Euler buckling load of a hydraulic cylinder piston rod from diameter, extended length, mounting and modulus, with the safety factor at working force.

Method: Euler column buckling with effective length factors (definitions)

Input parameters

Unit system: SI

Parameter	Value	Unit
Rod diameter	50.000	mm
Fully extended length (mounting to load)	1.5000	m
Effective length factor	Fixed–free (2.0)	
Elastic modulus	207.00	GPa
Rod yield strength (0 = Euler only) With a yield strength, short rods (KL/r below the transition) use the Johnson parabola instead of Euler.	0	MPa
Working force	80.000	kN

Calculated results

Parameter	Value	Unit
Second moment of area	306,796	mm^4
Buckling load (Euler; Johnson for a short rod when σ_y is given)	69.643	kN
Safety factor	0.87054	
Slenderness ratio	240.00	

Notes for this case

- The safety factor is below 1: the rod buckles at the working force.
- Rod only, as commonly used for quick checks; the cylinder tube adds stiffness. Use a safety factor of at least 3–4.

Formula and method

$$P_{cr} = \frac{\pi^2 E I}{(KL)^2}, \quad I = \frac{\pi d^4}{64}, \quad SF = \frac{P_{cr}}{F}$$

$$P_{cr} = A\sigma_y \left[1 - \frac{\sigma_y}{4\pi^2 E}\left(\frac{KL}{r}\right)^2\right] \quad (\text{Johnson, when } \frac{KL}{r} < \sqrt{\frac{2\pi^2 E}{\sigma_y}}), \quad A = \frac{\pi d^2}{4}, \quad r = \frac{d}{4}$$

Variables

d	Rod diameter	m
L	Fully extended length (mounting to load)	m
K	Effective length factor	-
E	Elastic modulus	Pa
σ_y	Rod yield strength (0 = Euler only)	Pa
F	Working force	N
I	Second moment of area	m^4
P_{cr}	Buckling load (Euler; Johnson for a short rod when σ_y is given)	N
SF	Safety factor	-
KL/r	Slenderness ratio	-

Method and standards

Euler buckling.

Assumptions and limits

- Rod only. With no yield strength Euler is used for any slenderness (an overestimate for short rods, flagged below KL/r 100); with σ_y the Johnson parabola applies below the transition slenderness.
- Theoretical K (0.5, 0.7, 1, 2). Design practice often uses larger values for imperfect fixity (for example 0.65 and 0.8 for the fixed–fixed and fixed–pinned cases).
- A safety factor below 1 (buckles) or below 3 is flagged.

References

- Euler column buckling with effective length factors (definitions)

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

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