Cylinder Sizing

Sample document with complete example values. It shows the report the purchased export produces for YOUR input - it is not itself a report for any part.

Project: Sample project | Part/Position: no real part | Prepared by: Sample, not released

Pneumatics (ISO 15552) - D 63/d 20 mm, p = 6 bar - overall verdict OK

Overall assessment: OK - buckling check and load reserve meet the requirements.

Inputs

Medium	Pneumatics (ISO 15552)
Piston diameter D	63 mm
Rod diameter d	20 mm
Operating pressure p (gauge)	6 bar
Efficiency η	0.9
Mounting type (Euler case)	Case 2 (β = 1)
Piston rod material	E335 (R_e = 335 N/mm², λ_g = 89)
Free length l	500 mm
Required buckling safety S_req	3.5
Stroke s	100 mm
Cycle rate	10 double strokes/min
Clearance volume factor	1.05

Areas and forces

Piston area A_K	3,117 mm²
Annulus area A_R	2,803 mm²
Area ratio φ = A_K/A_R	1.11
Theoretical compressive force F_D,th	1,870 N
Theoretical tensile force F_Z,th	1,682 N
Effective compressive force F_D,eff	1,683 N
Effective tensile force F_Z,eff	1,514 N

Verifications

Criterion	Value	Limit	Status
Buckling safety S = F_K/F_D,th	34.81	3.5	● OK
Rod compression check S_d = R_e/σ_d	56.27	1.5	● OK

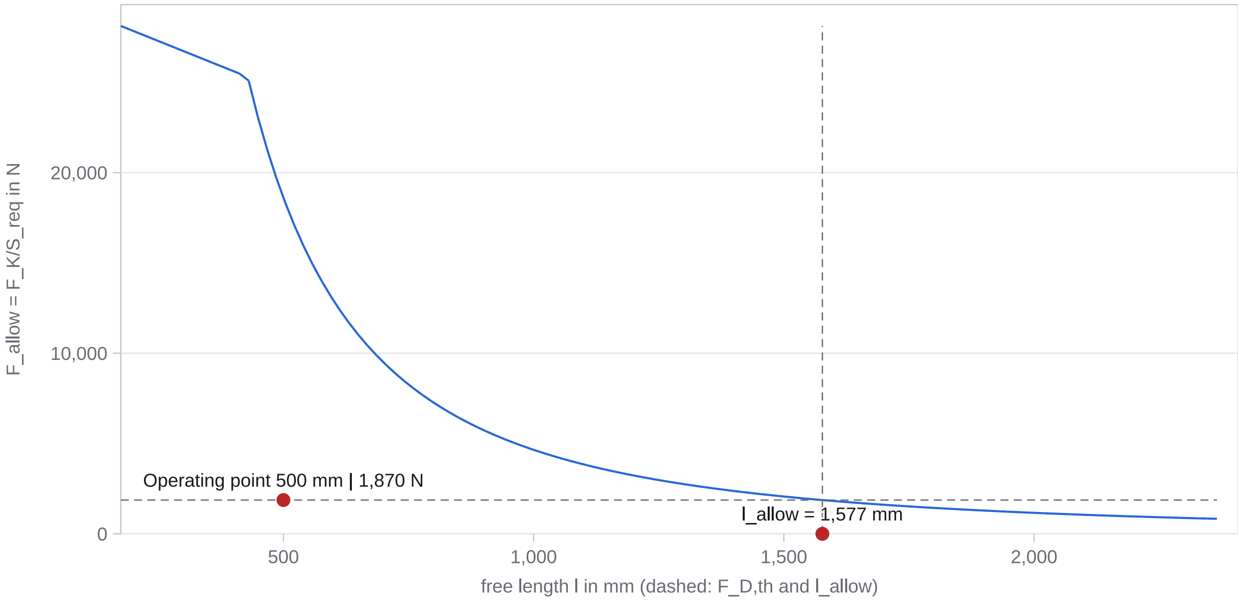
Buckling verification of the piston rod (Euler/Tetmajer)

Buckling length L_k = β·l	500 mm
Rod cross-section A = π/4·d²	314 mm²
Second moment of area I = π·d⁴/64	7,854 mm⁴
Slenderness ratio λ	100
Limiting slenderness λ_g of the material	89
Formula applied	Euler (elastic)
Buckling stress σ_k	207.3 N/mm²
Buckling force F_K = σ_k·A	65,113 N
Allowable force F_allow = F_K/S_req	18,604 N
Compressive stress σ_d = F_D,th/A	6 N/mm²
Allowable free length l_allow at S_req	1,577 mm

Air consumption (double-acting)

Compression ratio ε	6.92
Displaced volume per double stroke V_DH	0.592 L
Air consumption per double stroke q_DH	4.099 Nl
Air consumption Q (incl. clearance volume)	43 Nl/min

Allowable compressive force over free length



Calculation basis

Forces: the piston diameter gives the piston area $A_K = \pi/4 \cdot D^2$; when retracting, the pressure acts only on the annulus area $A_R = \pi/4 \cdot (D^2 - d^2)$. The theoretical force is pressure times area (1 bar = 0.1 N/mm²), the effective force accounts for the efficiency: $F_{eff} = F_{th} \cdot \eta$. The pressure required for a target force follows by rearranging: $p_{req} = F_{target}/(A_K \cdot \eta)$.

Buckling verification: the piston rod is conservatively treated as a rod with the rod diameter over the full free length. The mounting type gives the buckling length $L_k = \beta \cdot l$ and, with $i = d/4$, the slenderness ratio $\lambda = L_k/i$. In the elastic range Euler applies with $\sigma_k = \pi^2 \cdot E/\lambda^2$, in the inelastic range the Tetmajer line $\sigma_k = a - b \cdot \lambda$ from the material table. The switch is made at the INTERSECTION of the two curves, not at the tabulated λ_g: for the line $335 - 0.62 \cdot \lambda$ it lies at 85.8 while the sources state λ_g as 85, 88 or 89. Between 85.8 and 89 the line would sit up to 6.9 % above the Euler hyperbola, and no buckling stress exceeds it: in the inelastic range $\sigma_k = \pi^2 \cdot T_K/\lambda^2$ applies with the buckling modulus $T_K < E$ (Dubbel, 22nd ed., printed page C 40, eq. (8)). In both cases σ_k is capped at the yield strength R_e - there the rod squashes instead of buckling. The buckling force is $F_K = \sigma_k \cdot A$ with $A = \pi/4 \cdot d^2$; the safety factor $S = F_K/F$ is checked against the theoretical compressive force without efficiency, required is S_{req} (typically 3.5 to 5). The second criterion is the rod compression check: $\sigma_d = F_{D,th}/A$ against R_e with the standard safety factor 1.5. It is needed because a stocky rod yields long before buckling governs. The allowable free length l_{allow} does not follow from an inverse formula but from a search on the same curve: a closed-form solution would exist only in the Euler branch. If even the shortest rod misses the required safety, there is no l_{allow} - the compression check is then governing. Model limits: a straight, centrically loaded rod without initial deflection, without guidance forces from the cylinder tube and without bending from self-weight in long horizontal cylinders.

Air consumption (pneumatics, double-acting): per double stroke, the volume $(A_K + A_R) \cdot s$ is displaced; referred to standard conditions via the absolute pressure ratio $\varepsilon = (p + 1.013)/1.013$ (isothermal, Boyle-Mariotte). The consumption per minute is $q_{DH} \cdot n$ plus the clearance volume allowance.

About this sample

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