# Elastic Buckling of a Cylinder under External Pressure

Elastic collapse pressure of a thin cylinder under external pressure, as a long tube and between stiffeners (Windenburg–Trilling), and the safety factor.

**Method:** Bresse long-tube and Windenburg–Trilling short-cylinder formulas

## Input parameters

Unit system: SI

| Parameter | Value | Unit |
|---|---|---|
| Outside diameter | 2.0000 | m |
| Shell thickness | 8.0000 | mm |
| Length between stiffeners or heads | 3.0000 | m |
| Elastic modulus | 200.00 | GPa |
| Poisson's ratio | 0.30000 | |
| External pressure (or vacuum) | 101.33 | kPa |

## Calculated results

| Parameter | Value | Unit |
|---|---|---|
| Collapse pressure, long cylinder | 28.132 | kPa |
| Collapse pressure between stiffeners | 357.23 | kPa |
| Governing elastic collapse pressure | 357.23 | kPa |
| Factor of safety at the pressure | 3.5255 | |

**Notes for this case**

• Long cylinder (Bresse): p = 2E/(1 − ν²)(t/D)³. Between stiffeners, Windenburg–Trilling: p = 2.42E(t/D)^2.5/[(1 − ν²)^0.75(L/D − 0.45√(t/D))]; the governing value is the larger, since short spacing stiffens the shell. These are elastic values for perfect shells: real shells with out-of-roundness collapse much lower, which is why codes apply large factors (often 3 or more) and plastic limits.

## Formula and method

$$p_{long} = \frac{2E}{1-\nu^2}\left(\frac{t}{D}\right)^3, \quad p_{WT} = \frac{2.42E(t/D)^{2.5}}{(1-\nu^2)^{0.75}\left(\frac{L}{D}-0.45\sqrt{t/D}\right)}$$

### Variables

| | | |
|---|---|---|
| $D_o$ | Outside diameter | m |
| $t$ | Shell thickness | m |
| $L$ | Length between stiffeners or heads | m |
| $E$ | Elastic modulus | Pa |
| $\nu$ | Poisson's ratio | - |
| $p$ | External pressure (or vacuum) | Pa |
| $p_{long}$ | Collapse pressure, long cylinder | Pa |
| $p_{WT}$ | Collapse pressure between stiffeners | Pa |
| $p_c$ | Governing elastic collapse pressure | Pa |
| $p_c/p$ | Factor of safety at the pressure | - |

### Method and standards

Shell buckling.

### Assumptions and limits

- Elastic, perfectly round, simply supported ends.

### References

Bresse long-tube and Windenburg–Trilling short-cylinder formulas

## Report details

| | |
|---|---|
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| 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/mechanical/vessels/cylinder-external-pressure-buckling

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.