Convection from a Cylinder in Cross Flow (Churchill–Bernstein)

Average convection coefficient of a cylinder or pipe in cross flow of air or water by the Churchill–Bernstein correlation, with the heat loss per metre.

Method: S.W. Churchill and M. Bernstein; J. Heat Transfer 99 (1977) 300; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Fluid	Air (dry)	
Approach velocity	5.0000	m/s
Outside diameter	50.000	mm
Surface temperature	100.00	°C
Fluid temperature	20.000	°C
Pressure (absolute)	1.0132	bar

Calculated results

Parameter	Value	Unit
Reynolds number	13,258	
Average Nusselt number	63.701	
Average convection coefficient	34.763	W/(m²·K)
Heat flow per metre	436.84	W/m

Notes for this case

- Properties at the film temperature; single cylinder (tube banks have their own correlations).

Formula and method

$$\overline{Nu}_D = 0.3 + \frac{0.62 Re_D^{1/2} Pr^{1/3}}{\left[1 + (0.4/Pr)^{2/3}\right]^{1/4}} \left[1 + \left(\frac{Re_D}{282\,000}\right)^{5/8}\right]^{4/5}$$

Variables

fluid	Fluid	-
V	Approach velocity	m/s
D	Outside diameter	m
T_s	Surface temperature	K
T_∞	Fluid temperature	K
p	Pressure (absolute)	Pa
Re_D	Reynolds number	-
Nu_D	Average Nusselt number	-
$\bar{h}$	Average convection coefficient	W/(m²·K)
q'	Heat flow per metre	W/m

Method and standards

Churchill–Bernstein correlation.

Assumptions and limits

- Single cylinder, uniform approach flow.
- Single-phase: for water a surface at or above the saturation temperature (boiling) is flagged.

References

- S.W. Churchill and M. Bernstein
- J. Heat Transfer 99 (1977) 300
- Incropera
- DeWitt
- Bergman and Lavine
- Fundamentals of Heat and Mass Transfer
- ch. 7
- Air from NIST Shomate
- Sutherland and Eucken (engine); water from IAPWS-IF97 and the IAPWS 2008/2011 transport releases

Report details

Report reference	FCC-BND9-SENQ (the same inputs always give the same reference)
Generated	17 November 2026, 19:50 UTC
Calculator	Convection from a Cylinder in Cross Flow (Churchill–Bernstein)
Method last reviewed	12 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/mechanical/heat-transfer/cross-flow-cylinder-convection

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.