Natural Convection from a Horizontal Pipe (Churchill–Chu)

Natural convection coefficient and heat loss per metre from a horizontal pipe or cylinder in air or water by the Churchill–Chu correlation.

Method: S.W. Churchill and H.H.S. Chu; Int. J. Heat Mass Transfer 18 (1975) 1049; …

Input parameters

Unit system: SI

Parameter	Value	Unit
Fluid	Air (dry)	
Surface temperature	150.00	°C
Fluid temperature	20.000	°C
Outside diameter	114.30	mm
Pressure (absolute)	1.0132	bar

Calculated results

Parameter	Value	Unit
Rayleigh number	8,562,243	
Nusselt number	27.133	
Convection coefficient	6.8481	W/(m²·K)
Heat loss per metre	319.68	W/m

Notes for this case

- Convection only; radiation adds as much again for painted pipes in air.

Formula and method

$$Ra_D = \frac{g\beta|T_s - T_\infty| D^3}{\nu\alpha}, \quad \overline{Nu}_D = \left\{0.60 + \frac{0.387 Ra_D^{1/6}}{\left[1 + (0.559/Pr)^{9/16}\right]^{8/27}}\right\}^2, \quad h = \frac{Nu\, k}{D}, \quad q' = h\pi D(T_s - T_\infty)$$

Variables

fluid	Fluid	-
T_s	Surface temperature	K
T_∞	Fluid temperature	K
D	Outside diameter	m
p	Pressure (absolute)	Pa
Ra	Rayleigh number	-
Nu	Nusselt number	-
h	Convection coefficient	W/(m²·K)
q'	Heat loss per metre	W/m

Method and standards

Churchill–Chu for horizontal cylinders.

Assumptions and limits

- Isothermal cylinder in still fluid; properties at the film temperature (T_s + T_∞)/2. β = 1/T for air (ideal gas); for water β from the IF97 density 0.5 K either side of the film temperature.
- Ra up to 10^{12} (a note is shown above it). Water at or above its boiling point is rejected (boiling is not covered).

References

- S.W. Churchill and H.H.S. Chu
- Int. J. Heat Mass Transfer 18 (1975) 1049

- Incropera
- DeWitt
- Bergman and Lavine
- Fundamentals of Heat and Mass Transfer
- ch. 9
- Air from NIST Shomate
- Sutherland and Eucken (engine); water from IAPWS-IF97 and the IAPWS 2008/2011 transport releases

Report details

Report reference	FCC-H4WR-NHNA (the same inputs always give the same reference)
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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/heat-transfer/natural-convection-horizontal-cylinder

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.