Natural Convection Between Inclined Parallel Plates (Hollands)

Rayleigh number, Nusselt number and convection coefficient across the air gap between an absorber and cover, or two covers, by the Hollands correlation.

Input parameters

Unit system: SI

Parameter	Value	Unit
Hotter (lower) plate temperature	90.000	°C
Colder (upper) plate temperature	40.000	°C
Plate spacing	40.000	mm
Tilt from horizontal (0–75°)	0	°
Air conductivity at the mean temperature	0.029300	W/(m·K)
Air kinematic viscosity at the mean temperature	1.9400e-05	m²/s
Air thermal diffusivity at the mean temperature	2.7600e-05	m²/s

Calculated results

Parameter	Value	Unit
Rayleigh number	173,321	
Nusselt number	4.5237	
Convection coefficient	3.3136	W/(m²·K)
Convective flux across the gap	165.68	W/m²

Notes for this case

• Hollands et al. (1976) for air between plates heated from below, tilts 0–75°; use 75° for vertical gaps. Below Ra cos β = 1,708 there is no convection and Nu = 1 (conduction).

Formula and method

$$Nu = 1 + 1.44\left[1 - \frac{1708(\sin 1.8\beta)^{1.6}}{Ra\cos\beta}\right]\left[1 - \frac{1708}{Ra\cos\beta}\right]^{+} + \left[\left(\frac{Ra\cos\beta}{5830}\right)^{1/3} - 1\right]^{+}$$

One further formula is shown on the calculator page: https://calc.firecad.com/environmental/solar-thermal/parallel-plate-natural-convection

Variables

T_1	Hotter (lower) plate temperature	K
T_2	Colder (upper) plate temperature	K
L	Plate spacing	m
β	Tilt from horizontal (0–75°)	rad
k	Air conductivity at the mean temperature	W/(m·K)
ν	Air kinematic viscosity at the mean temperature	m²/s
α	Air thermal diffusivity at the mean temperature	m²/s
Ra	Rayleigh number	-
Nu	Nusselt number	-
h	Convection coefficient	W/(m²·K)
q	Convective flux across the gap	W/m²

Method and standards

Hollands' correlation for inclined air layers heated from below.

Assumptions and limits

- Air, tilt 0–75°, heated from below.

Report details

Report reference	FCC-DW8A-QQTM (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/environmental/solar-thermal/parallel-plate-natural-convection

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.