Heat Loss Through a Pipe with Two Insulation Layers

Heat loss per metre and layer temperatures of a pipe with up to two layers of insulation, with inside and outside coefficients, by cylindrical resistances in series.

Method: Cylindrical conduction resistances in series (Incropera, DeWitt, Bergman and Lavine, Fundamentals of Heat and Mass Transfer, ch. 3)

Input parameters

Unit system: SI

Parameter	Value	Unit
Fluid temperature inside	400.00	°C
Ambient temperature	30.000	°C
Inside coefficient	1,000.0	W/(m²·K)
Outside coefficient (convection + radiation)	10.000	W/(m²·K)
Pipe inside radius	77.100	mm
Pipe outside radius	84.150	mm
Pipe wall conductivity	45.000	W/(m·K)
Insulation layer A thickness (inner)	50.000	mm
Layer A conductivity	0.060000	W/(m·K)
Insulation layer B thickness (outer)	50.000	mm
Layer B conductivity	0.040000	W/(m·K)

Calculated results

Parameter	Value	Unit
Heat loss per metre	143.06	W/m
Pipe outer wall temperature	399.66	°C
Interface between layers A and B	222.69	°C
Outer surface temperature	42.364	°C
Outer radius	184.15	mm

Formula and method

$$q' = \frac{T_i - T_a}{\frac{1}{2\pi r_1 h_i} + \sum \frac{\ln(r_{j+1}/r_j)}{2\pi k_j} + \frac{1}{2\pi r_o h_o}}$$

Variables

T_i	Fluid temperature inside	K
T_a	Ambient temperature	K
h_i	Inside coefficient	W/(m²·K)
h_o	Outside coefficient (convection + radiation)	W/(m²·K)
r_1	Pipe inside radius	m
r_2	Pipe outside radius	m
k_p	Pipe wall conductivity	W/(m·K)
t_a	Insulation layer A thickness (inner)	m
k_a	Layer A conductivity	W/(m·K)
t_b	Insulation layer B thickness (outer)	m

k_b	Layer B conductivity	W/(m·K)
q'	Heat loss per metre	W/m
T_w	Pipe outer wall temperature	K
T_{ab}	Interface between layers A and B	K
T_s	Outer surface temperature	K
r_o	Outer radius	m

Method and standards

Steady radial conduction.

Assumptions and limits

- Steady, uniform layers; fixed h_o.
- Interface and surface temperatures are not compared with the service limits of the layers: check T_ab against the inner layer's limit and the outer layer's rating.

References

• Cylindrical conduction resistances in series (Incropera, DeWitt, Bergman and Lavine, Fundamentals of Heat and Mass Transfer, ch. 3)

Report details

Report reference	FCC-5356-K6CP (the same inputs always give the same reference)
Generated	17 November 2026, 19:49 UTC
Calculator	Heat Loss Through a Pipe with Two Insulation Layers
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/multilayer-cylinder-conduction

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Reopens the calculator with the inputs of this report.