Pipe Insulation Heat Loss and Surface Temperature

Heat loss and outer surface temperature of an insulated horizontal pipe in still air by ISO 12241, compared with the bare pipe.

Method: ISO 12241:2008 (horizontal pipes, still air); CODATA 2018 (Stefan–Boltzmann constant)

Input parameters

Unit system: SI

Parameter	Value	Unit
Pipe outer diameter DN150 = 168.3 mm, DN100 = 114.3 mm, DN50 = 60.3 mm (ASME B36.10).	168.30	mm
Insulation thickness (0 = bare pipe)	75.000	mm
Insulation thermal conductivity at its mean temperature From the insulation maker's data at the mean of the inner and outer temperatures; mineral wool is about 0.04–0.07 W/(m·K) at 50–250 °C.	0.045000	W/(m·K)
Medium (pipe) temperature	180.00	°C
Ambient air temperature	25.000	°C
Emissivity of the outer surface Bright aluminium cladding about 0.05–0.1, galvanised steel 0.25, painted or plastic surfaces about 0.9.	0.10000	
Emissivity of the bare pipe (for comparison)	0.90000	
Pipe length	100.00	m

Calculated results

Parameter	Value	Unit
Heat loss per metre	61.841	W/m
Heat loss of the length	6.1841	kW
Outer surface temperature	40.622	°C
Bare pipe heat loss per metre	1,488.9	W/m
Heat loss saved by the insulation	95.846	%
Outer surface coefficient	3.9586	W/(m²·K)
Convection part	3.3086	W/(m²·K)
Radiation part	0.65006	W/(m²·K)
Outer diameter of the insulation	318.30	mm

Formula and method

$$q' = \frac{2\pi\lambda\,(T_i - T_s)}{\ln(D/D_o)} = h_{se}\,\pi D\,(T_s - T_a) \qquad D = D_o + 2t \qquad Q = q'\,L$$

$$h_{se} = h_{cv} + h_r \qquad h_r = \varepsilon\,\sigma\,\frac{T_s^4 - T_a^4}{T_s - T_a}$$

$$h_{cv} = 1.25\left(\frac{\Delta T}{D}\right)^{1/4} \quad (D^3\Delta T \le 10\ \mathrm{m^3K}) \qquad h_{cv} = 1.21\,\Delta T^{1/3} \quad (D^3\Delta T > 10\ \mathrm{m^3K})$$

Variables

D_o	pipe outer diameter	m

t	insulation thickness	m
λ	insulation conductivity at its mean temperature	W/(m·K)
T_i	medium (pipe) temperature	K
T_a	ambient air temperature	K
ε	emissivity of the outer surface	–
ε_b	emissivity of the bare pipe	–
L	pipe length	m
q'	heat loss per metre	W/m
Q	heat loss of the length	W
T_s	outer surface temperature	K
q'_b	bare pipe heat loss per metre	W/m
S	share of the bare loss saved	–
h_{se}	outer surface coefficient	W/(m²·K)
h_{cv}	convection coefficient	W/(m²·K)
h_r	radiation coefficient	W/(m²·K)
D	outer diameter of the insulation	m
σ	Stefan–Boltzmann constant, 5.670 374 419 × 10^{-8}	W/(m²·K⁴)

Method and standards

ISO 12241:2008 (thermal insulation for building equipment and industrial installations): steady conduction through a cylindrical layer, and an outer surface coefficient made of the standard's natural-convection equations for horizontal pipes in still air plus linearised radiation to surroundings at the air temperature. The surface temperature is found by a bracketed root solver. Stefan–Boltzmann constant from CODATA 2018.

Assumptions and limits

- Horizontal pipe, still indoor air, surroundings at the air temperature. Wind outdoors raises h_se and lowers the surface temperature; the heat loss changes little for well-insulated pipes.
- Inner film and pipe wall resistances neglected: the inner insulation surface is at the medium temperature.
- One insulation layer with a constant conductivity; for two layers, or a conductivity that varies strongly with temperature, the result is approximate.
- No allowance for supports, flanges, valves or damaged insulation; add them as equivalent lengths.

References

• ISO 12241:2008 (horizontal pipes, still air)
• CODATA 2018 (Stefan–Boltzmann constant)

Report details

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Release checks	4 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

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Reopens the calculator with the inputs of this report.