Earth–Air Heat Exchanger (Earth Tube) Outlet Temperature

Outlet air temperature, effectiveness and heat exchanged by a buried pipe of given length and diameter, from the air speed and the undisturbed soil temperature.

Method: Constant wall temperature pipe flow (ε–NTU) with Dittus–Boelter

Input parameters

Unit system: SI

Parameter	Value	Unit
Pipe inner diameter	200.00	mm
Pipe length	40.000	m
Air velocity in the pipe	3.0000	m/s
Inlet (outdoor) air temperature	40.000	°C
Pipe wall (soil) temperature	26.000	°C

Calculated results

Parameter	Value	Unit
Reynolds number	39,578	
Convective coefficient	12.298	W/(m²·K)
Effectiveness 1 − e^(−NTU)	93.330	%
Outlet air temperature	26.934	°C
Heat exchanged with the soil	1.4916	kW
Air flow	339.29	m³/h

Notes for this case

• Air flowing through a pipe whose wall stays at the soil temperature approaches it exponentially: T_out = T_soil + (T_in − T_soil)e^(−NTU) with NTU = hπDL/(ṁc_p). The convective coefficient uses the Dittus–Boelter correlation (Nu = 0.023Re^0.8Pr^0.4) for turbulent flow and Nu = 3.66 for laminar flow, with air properties near 20 °C. In long operation the soil around the pipe warms (or cools), so real effectiveness falls over a season; space pipes about 3–5 diameters apart and bury them 2–3 m deep.

Formula and method

$$T_{out} = T_{soil} + (T_{in} - T_{soil})e^{-NTU}, \quad NTU = \frac{h\pi DL}{\dot{m}c_p}, \quad Nu = 0.023Re^{0.8}Pr^{0.4}$$

Variables

D	Pipe inner diameter	m
L	Pipe length	m
u	Air velocity in the pipe	m/s
T_{in}	Inlet (outdoor) air temperature	K
T_{soil}	Pipe wall (soil) temperature	K
Re	Reynolds number	-
h	Convective coefficient	W/(m²·K)
ε	Effectiveness 1 − e^(−NTU)	-
T_{out}	Outlet air temperature	K
$\dot{Q}$	Heat exchanged with the soil	W
$\dot{V}$	Air flow	m³/s

Method and standards

Earth tube.

Assumptions and limits

- Constant wall temperature; smooth pipe; dry air properties.

References

Constant wall temperature pipe flow (ε–NTU) with Dittus–Boelter

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/hvac/loads/earth-air-tunnel

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Reopens the calculator with the inputs of this report.