Isothermal Gas Flow in a Long Pipeline

Mass flow of a gas through a long pipeline from the inlet and outlet pressures by the isothermal flow equation with its kinetic-energy term.

Method: Isothermal compressible flow: $p_1^2 - p_2^2 = (G^2\ R\ T)[f\ L/d + 2\ \ln(p_1/p_2)]$ (Coulson and Richardson, Chemical Engineering vol. 1)

Input parameters

Unit system: SI

Parameter	Value	Unit
Inlet pressure (absolute)	8.0000	bar
Outlet pressure (absolute)	6.0000	bar
Pipe length	2,000.0	m
Inside diameter	102.30	mm
Darcy friction factor	0.017000	
Gas temperature	15.000	°C
Molar mass of the gas Natural gas is about 16–19; air 28.96.	17.400	kg/kmol

Calculated results

Parameter	Value	Unit
Mass flow	2,312.6	kg/h
Flow at 0 °C and 101.325 kPa	2,978.9	Nm³/h
Velocity at the inlet	13.451	m/s
Velocity at the outlet	17.935	m/s

Notes for this case

- Ideal gas at constant temperature and friction factor; check that the outlet velocity stays well below sonic.

Formula and method

$$p_1^2 - p_2^2 = \left(\frac{\dot{m}}{A}\right)^2 RT\left[f\frac{L}{d} + 2\ln\frac{p_1}{p_2}\right]$$

Variables

p_1	Inlet pressure (absolute)	Pa
p_2	Outlet pressure (absolute)	Pa
L	Pipe length	m
d	Inside diameter	m
f	Darcy friction factor	-
T	Gas temperature	K
M	Molar mass of the gas	kg/kmol
$\dot{m}$	Mass flow	kg/s
Q_N	Flow at 0 °C and 101.325 kPa	Nm³/s
v_1	Velocity at the inlet	m/s
v_2	Velocity at the outlet	m/s

Method and standards

Momentum equation integrated at constant temperature.

Assumptions and limits

- Isothermal, ideal gas.
- The outlet velocity must stay below the isothermal limit √(RT) (Mach 1/√γ); an outlet pressure that would exceed it is rejected.

References

- Isothermal compressible flow: $p_1^2 - p_2^2 = (G^2 R T)[f L/d + 2 \ln(p_1/p_2)]$ (Coulson and Richardson, Chemical Engineering vol. 1)

Report details

Report reference	FCC-KH91-GR8K (the same inputs always give the same reference)
Generated	17 November 2026, 19:36 UTC
Calculator	Isothermal Gas Flow in a Long Pipeline
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.

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