Duct Pressure Drop (Air and Flue Gas)

Pressure drop of a round or rectangular air or flue gas duct by Darcy–Weisbach with the Colebrook friction factor on the hydraulic diameter, plus fittings.

Method: Darcy–Weisbach equation; Colebrook (1939); ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Duct shape	Rectangular	
Inside diameter (round)	800.00	mm
Inside width (rectangular)	1,600.0	mm
Inside height (rectangular)	1,000.0	mm
Duct length	40.000	m
Volume flow (actual)	72,000	m^3/h
Gas density	1.1500	kg/m^3
Dynamic viscosity Air 1.85 × 10^{-5} Pa·s at 30 °C; flue gas about 2.3 × 10^{-5} at 140 °C (gas properties calculator).	1.8500e-05	Pa·s
Wall roughness Galvanised sheet about 0.15 mm (ASHRAE); plain steel plate with some scale 0.5 mm or more.	0.15000	mm
Sum of fitting loss coefficients Bends, dampers, transitions, entry and exit, each on the duct velocity pressure.	2.0000	

Calculated results

Parameter	Value	Unit
Total pressure drop	22.430	mmWC
Friction in straight duct	4.1068	mmWC
Loss in fittings	18.323	mmWC
Velocity	12.500	m/s
Velocity pressure	9.1615	mmWC
Reynolds number	956,341	
Darcy friction factor	0.013793	
Hydraulic diameter	1,230.8	mm

Formula and method

$$D_h = D \text{ (round)}, \quad \frac{2ab}{a+b} \text{ (rectangular)} \qquad v = \frac{\dot{V}}{A} \qquad Re = \frac{\rho\, v\, D_h}{\mu} \qquad p_d = \frac{\rho v^2}{2}$$

$$\frac{1}{\sqrt{f}} = -2\log_{10}\left(\frac{\varepsilon/D_h}{3.7} + \frac{2.51}{Re\sqrt{f}}\right) \qquad \Delta p_f = f\,\frac{L}{D_h}\,p_d \qquad \Delta p_K = \Sigma K\, p_d \qquad \Delta p = \Delta p_f + \Delta p_K$$

Variables

shape	round or rectangular	–
D	inside diameter, round duct	m
a	inside width, rectangular duct	m

b	inside height, rectangular duct	m
L	duct length	m
$\dot{V}$	actual volume flow	m³/s
ρ	gas density	kg/m³
μ	dynamic viscosity	Pa·s
ε	wall roughness	m
ΣK	sum of fitting loss coefficients	–
Δp	total pressure drop	Pa
Δp_f	friction in straight duct	Pa
Δp_K	loss in fittings	Pa
v	velocity	m/s
p_d	velocity pressure	Pa
Re	Reynolds number	–
f	Darcy friction factor	–
D_h	hydraulic diameter	m
A	flow area	m²

Method and standards

Darcy–Weisbach with the Colebrook–White friction factor (laminar 64/Re), on the hydraulic diameter, as in the Duct Design chapter of the ASHRAE Handbook—Fundamentals. Fittings by loss coefficients on the duct velocity pressure.

Assumptions and limits

- Constant density along the duct (pressure changes small against absolute pressure).
- Fully developed turbulent flow; loss coefficients of fittings close together interact and are approximate.
- Laminar 64/Re below Re 2 300, Colebrook above; the transitional range 2 300–4 000 (Colebrook, conservative) is flagged.
- For flat ducts (aspect ratio above about 4) the hydraulic-diameter method slightly underestimates friction.

References

• Darcy–Weisbach equation
• Colebrook (1939)
• ASHRAE Handbook—Fundamentals (2017)
• ch. 21 (Duct Design)

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

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