

Flow Measurement Formulas



Quick reference for instrumentation and control engineers

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Basic relations

Volume flow $Q = A \times v$

Pipe area $A = \pi \times D^2 \div 4$

Mass flow $q_m = \rho \times Q$

Velocity $v \text{ (m/s)} = Q \text{ (m}^3\text{/h)} \div (2827 \times D^2 \text{ (m)})$

Reynolds number

Definition $Re = \rho \times v \times D \div \mu$
 $= v \times D \div \nu$

Laminar $Re < 2300$

Transitional $2300 \text{ to } 4000$

Turbulent $Re > 4000$ (most meters need this)

Orifice plate (ISO 5167-2)

Mass flow $q_m = C \div \sqrt{(1 - \beta^4) \times \epsilon \times (\pi \div 4) \times d^2 \times \sqrt{(2 \times \Delta P \times \rho)}}$

Beta ratio $\beta = d \div D$, usually $0.2 \text{ to } 0.75$

Square law $Q \propto \sqrt{\Delta P}$, so 50% flow = 25% DP

Typical C about 0.6 for a sharp edged orifice

Permanent pressure loss about $(1 - \beta^{1.9}) \times \Delta P$, roughly 40% to 95% of the DP

Gas: actual to standard flow

Ideal gas $Q_{std} = Q_{act} \times (P \div P_{std}) \times (T_{std} \div T) \times (Z_{std} \div Z)$

Rule Use absolute pressure (bar a) and absolute temperature (K)

Normal conditions Nm^3 : $0^\circ C$, 1.01325 bar a

Standard (often) Sm^3 : $15^\circ C$, 1.01325 bar a (check your contract)

Meter selection rules

Meter	Key rule
Magnetic	Conductive liquid, typically $\geq 5 \mu S/cm$; full pipe
Coriolis	Mass flow and density direct; check pressure drop
Vortex	Needs Re above about 10,000 to 20,000; no low flow
Ultrasonic	Clean liquids or gas; long straight runs
Turbine	Clean, low viscosity fluids; K factor in pulses per litre
DP (orifice)	Turndown about 3:1 to 4:1 per DP range

Straight pipe runs (guide)

- Typical: 10 D upstream and 5 D downstream
- Orifice after two bends out of plane: up to 30 to 40 D upstream (ISO 5167-2 tables)
- A flow conditioner shortens the requirement
- Always use the meter data sheet for the final value

Velocity guidelines

Service	Typical velocity
Water, pump discharge	1.5 to 3 m/s
Water, pump suction	0.6 to 1.5 m/s
Steam (saturated)	20 to 35 m/s
Compressed air	6 to 10 m/s
Magmeter best accuracy	1 to 3 m/s

Conversions

From	To
1 m ³ /h	16.667 L/min
1 m ³ /h	4.4029 US gpm
1 US gallon	3.7854 L
1 kg/s	3.6 t/h
1 ft ³ /min (CFM)	1.699 m ³ /h

K factor and totals

Flow from $Q = f \div K$ pulses

Total $V = \text{pulse count} \div K$
K factor pulses per unit volume (for example per litre)