Ultrasonic Transit-Time Flowmeter Velocity and Flow

Flow velocity and volume flow from the upstream and downstream transit times of an ultrasonic flowmeter, the path length and the path angle.

Method: Transit-time principle v = L (t_up − t_dn)/(2 cos θ t_up t_dn)

Input parameters

Unit system: SI

Parameter	Value	Unit
Transit time upstream (against the flow)	1.5200e-04	s
Transit time downstream (with the flow)	1.5160e-04	s
Acoustic path length	226.30	mm
Angle of the path to the pipe axis	45.000	°
Pipe inside diameter	160.00	mm
Profile factor (mean / path velocity) Depends on Reynolds number: 0.75 for laminar flow, about 0.93–0.96 for turbulent flow in a straight pipe.	0.94000	

Calculated results

Parameter	Value	Unit
Velocity along the path axis	2.7777	m/s
Speed of sound in the fluid	1,490.8	m/s
Mean velocity in the pipe	2.6110	m/s
Volume flow	188.99	m³/h

Notes for this case

- The speed of sound cancels out of the velocity, so the result does not depend on fluid temperature.

Formula and method

$$v_L = \frac{L}{2\cos\theta}\,\frac{t_{up}-t_{dn}}{t_{up}\,t_{dn}}, \quad c = \frac{L}{2}\,\frac{t_{up}+t_{dn}}{t_{up}\,t_{dn}}, \quad Q = k_h v_L \frac{\pi D^2}{4}$$

Variables

t_{up}	Transit time upstream (against the flow)	s
t_{dn}	Transit time downstream (with the flow)	s
L	Acoustic path length	m
θ	Angle of the path to the pipe axis	rad
D	Pipe inside diameter	m
k_h	Profile factor (mean / path velocity)	-
v_L	Velocity along the path axis	m/s
c	Speed of sound in the fluid	m/s
v_m	Mean velocity in the pipe	m/s
Q	Volume flow	m³/s

Method and standards

Sound travels faster with the flow than against it.

Assumptions and limits

- The profile factor k_h is entered, not computed. For a diametral single path it is 0.75 in laminar flow and rises to about 0.93–0.96 in turbulent flow as the Reynolds number increases; meters compute it from Re internally.

- Single path, fully developed flow.

References

- Transit-time principle v = L (t_up − t_dn)/(2 cos θ t_up t_dn)

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/instrumentation/flow/ultrasonic-transit-time-flow

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.