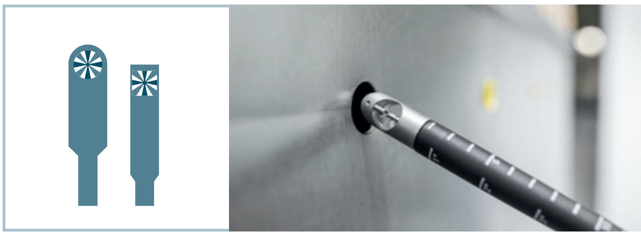
Tips and tricks for air velocity measurements in ducts.

- The most important probes for every application
- Perform acceptance test measurements correctly to DIN EN 12599
- Identify and avoid measurement errors

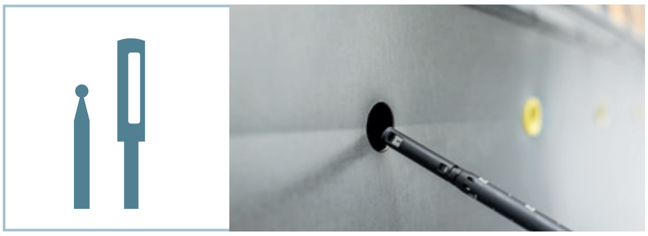
The optimum probe for your application

High air velocities from 20 m/s or measurement of heavily contaminated flows with a high particle content: Pitot tubes

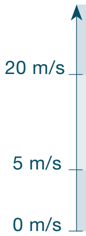
Mean air velocities 5 m/s to 20 m/s: Vane probes with minimal diameters



Low air velocities up to 5 m/s: thermal probes



The accuracy champion from Testo for any flow range:

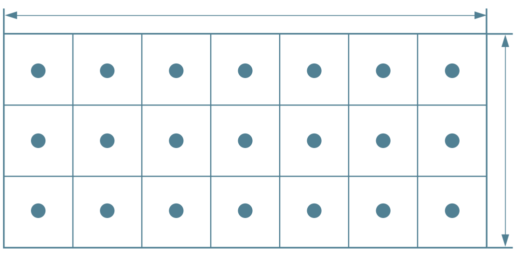


From 20 m/s	All Pitot tubes from Testo e.g. 0635 2243 or 0635 2240	
20 m/s – 5 m/s	5 … 20 m/s	16 mm vanes – e.g. 0635 9542 (testo 480), 0635 9571 (testo 440)
5 m/s – 0 m/s	0 … 5 m/s	Thermal probes – e.g. 0635 1543 (testo 480), 0635 1571 (testo 440)

Acceptance test measurement to DIN EN 12599

Trivial method for grid measurements in rectangular cross-sections

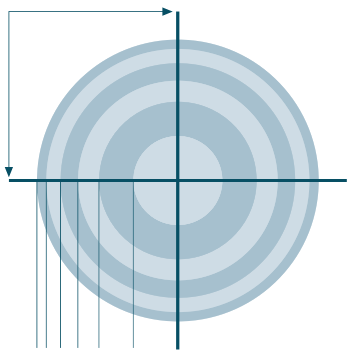
First, the velocity field inside the rectangular duct cross-section is divided into equally sized measurement areas. The measuring point is located in the centre of each. Where there is an even velocity profile, a representative result is achieved even with a small number of measuring points. However, if large differences in the air velocity are ascertained over the cross-section, the number of measuring points is to be increased.



Method of centroidal axis for grid measurements in circular cross-sections

The circular duct cross-section is divided into rings of equal area, with the measuring point located on the ring's centroidal axis. The measurement is evaluated via arithmetic averaging of the individual measuring values.

Centroidal axes



The individual velocity measuring values are used to derive the mean air velocity, from which the volumetric air velocity is then calculated.

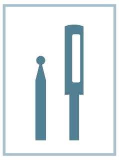
$$\dot{V} = A \cdot \bar{v} \cdot 3600$$

$\dot{V}$ = volume flow in m^3/h
$\bar{v}$ = mean air velocity in m/s
A = flow cross-section in m^2

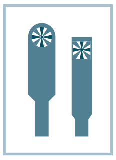
Example: a cross-section A of 0.5 m2 and a measured mean speed of 4 m/s results in a volume flow of 7200 m^3/h

Identifying and avoiding measurement errors

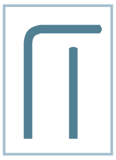
Measurement uncertainties



Thermal flow probes have an extremely small intrinsic error of ±(2 to 5 cm/s), to which a sensitivity error of 2.5 to 5% of measured value should be added.
The measurement uncertainty rises as the air velocity increases. This makes these probes suitable for measuring low air velocities up to 5 m/s.



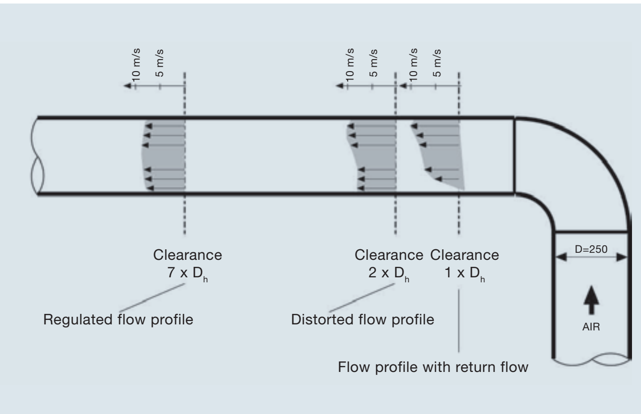
Vanes have an intrinsic error of approx. ±(0.1 to 0.2 m/s) and a sensitivity error of 1 to 2% of measured value. Optimum application range: air velocities above 5 m/s.



With Pitot tubes, the measurement error decreases significantly as the air velocity increases. This makes them suitable for high air velocities.

Influence of interference points

From points of discontinuity upstream of the flow, observe a clearance of at least six times the hydraulic diameter $D_h = 4A/U$ (A: duct cross-section, U: duct circumference). From points of discontinuity downstream of the flow, a clearance of $2 \times D_h$ is sufficient.



Reduction of irregularity in the flow profile as the clearance from the point of discontinuity increases. Horizontal speed profiles were measured with a Prandtl Pitot tube.

Blockage of the flow cross-section by the measurement probe

The ideal vane probe for measurements in larger duct cross-sections is a combined flow/temperature probe with Ø 16 mm (testo 440 16 mm vane anemometer kit). For measurements in small duct cross-sections, the influence of the vane cross-section on the accuracy of the measurement increases as the duct cross-section decreases. As a result, excessively high velocities are measured.

The testo 480 helps you to adjust HVAC systems norm-compliantly according to EN 12599. It guides you through the grid measurement step by step, thus reliably avoiding incorrect measurements.

Be sure. testo

Incorrect evaluation of the measurement results when using Pitot tubes

Tip: Below 5 m/s, use of Pitot tubes is limited. Measurement using thermal probes or vane sensors is recommended here.

In the mean flow range, it is important to ensure the accuracy of the pressure sensor, as this significantly influences the accuracy of the Pitot tube measurement.

Basic formula for calculating the accuracy of the Pitot tube measurement:

Accuracy of Pitot tube measurement =
1/v *77.38 * pressure error

Where: Accuracy of Pitot tube measurement in m/s
v = air velocity in m/s
Pressure error in hPa

Formula for calculating the air velocity in m/s

$$v = s \cdot \sqrt{\frac{2 \cdot \Delta P}{rho}}$$

ΔP = dynamic pressure in Pa
s = Pitot tube factor
= 1.000 for Prandtl Pitot tubes
v = air velocity in m/s
rho = air density in kg/m³
= 1.199 kg/m³
(at 20 °C, 50 %RH, 1013 hPa)

The air velocity is calculated from the Pitot tube factor, dynamic pressure (differential pressure) and air density.

testo 440, testo 480, testo 510 and testo 510i measuring instruments convert the Pitot tube pressure automatically into the air velocity. testo 440 and testo 480 have menus for volume flow measurement with k-factor. Multi-point mean calculation can then be carried out directly in m/s values. A typical error during Pitot tube measurement often occurs if a mean density of 1200 g/m³ is expected. When measuring outside air flows, the actual air density can deviate from the above mean value by up to ±10%. The air flow measurement thus has an uncertainty factor of up to ±5%. Which is why it is important, when using a Pitot tube for measurements, to enter the correct air density in the measuring instrument. This can be determined via tables or is calculated automatically by the measuring instruments once the temperature, relative humidity and absolute pressure have been entered. A prerequisite for this is knowledge of the local absolute pressure, temperature and, if applicable, relative humidity values.

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Air velocity & IAQ measuring instrument

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- User-optimized menus for all air velocity & IAQ measurements
- Wireless probes for all applications
- Clearly arranged display for set-up, measuring values and results at a glance

testo 480
Multifunction measuring instrument

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Differential pressure measuring instrument

testo 510i
Differential pressure measuring instrument

An extensive selection of measuring instruments and probes for measuring flow, air velocity & IAQ and comfort level can be found on our website: **www.testo.com**