PAUL GOTHE BOCHUM

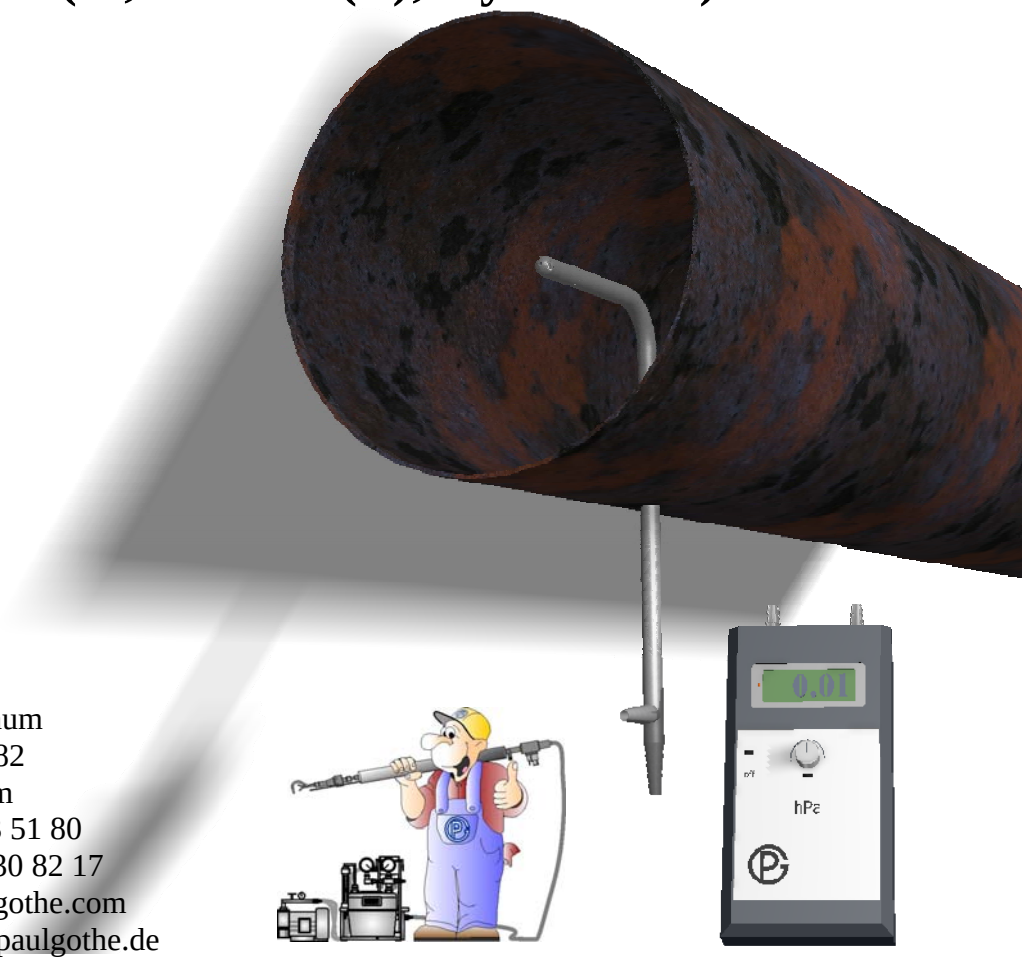
PAUL GOTHE – GMBH

Bedienungsanleitung Staurohre

(S-; Prandtl, Zylinder)

Manual for Pitot Tubes

(S-, Prandtl (L); Cylindrical)



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Measurement of the Gas Velocity

The Pitot-Tube

By Pitot Tubes you have always two pressure tubes. One against the gas flow, which measure the total pressure (sum of dynamic and static pressure) and one to measure the static pressure. The difference between this pressures (dynamic pressure) can use to calculate the gas velocity. This dynamic pressure are depends of the density, temperature and barometric pressure. If you know the density, you can calculate the gas velocity by measure of the difference pressure.
So that the gas velocty can be measured right, certain conditions must be kept.

- If you use a Prandtl-pitot tube be sure that no heavy vortex are in the channel. A suitable inlet and outlet section must be at the measuring position.
- The probe must be against the gas flow (< 15° angel to the gas stream).
- If you don't use a Prandtl-pitot tube, you must use a correction factor.

Measurement section

The flow in the measurement sections shall be as undisturbed as possible. Changes of the direction, shut off devices or other installations, changes of the cross section etc. affect the flow conditions and lead to irregular distribution of gas. The measurement cross section shall, therefore be placed within a straight measuring section of the constant size and shape of cross section and having inlet and outlet free of any interference. The lengths of the inlet and outlet sections shall be at least three times the "hydraulic diameter" of the measuring cross section. If this condition can not be satisfied the length of the inlet section has to be greater than the outlet section. You get more information's in the German guideline VDI 2080/EN 12599, VDI 4200, VDI 2066 or the european standards EN 13284-1.

Formula to calculate the density:

$$\delta_B = \delta_N \bullet \frac{(b \pm p) \bullet T}{p_N \bullet (T + t)}$$

δ_B: density operating condition [kg/m³]
δ_N: density in standard state [kg/m³]
b: Barometric pressure [mbar]
p: pressure [mbar]
p_N: standard state (1013 mbar)
T: standard state (273 K)
t: operating temperature [°C]

Formula to calculate the gas volume:

$$V = v \bullet A \bullet 3600$$

A: cross section in m²

To calculate the density of a gas:

The standard-density of a known gas mixture can be calculate itself from the single components in dependence to the respective volume percentage in each case.

For example: Gas with 20 Vol-% Carbon dioxide, 72 Vol-% Nitrogen, 6,5 Vol-% Oxygen and 1,5 Vol-% Carbon-mono-oxide:

Compounds	%-Volume	standard density [kg/m³] at 100 %	factor (%-/100)	F-Standard-Density
CO_2	20	1,9770	0,2	0,3954
N_2	72	1,2505	0,72	0,9004
O_2	6,5	1,4290	0,065	0,0929
CO	1,5	1,2505	0,015	0,0188
			Standard density of the gas in kg/m³ (sum):	**1,4075**

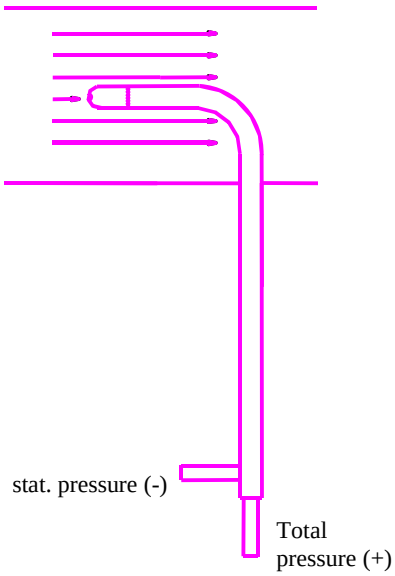
Example for the calculation:

Parameter at the measurement:

Temperature:	30°C
Stat. pressure:	+3 mbar
Barometrc pressure:	1000 mbar
Standard density:	1,4075 kg/m³

$$\delta_B = \delta_N \bullet \frac{(b \pm p) \bullet T}{p_N \bullet (T + t)} = 1{,}4074 \bullet \frac{(1000 + 3) \bullet 273}{1013 \bullet (273 + 30)} = 1{,}256 [kg / m^3]$$

Prandtl-Pitot-Tube



Long leg against the gas flow.
Find the maximum value at the measure point
through easy movements of the pitot tube.

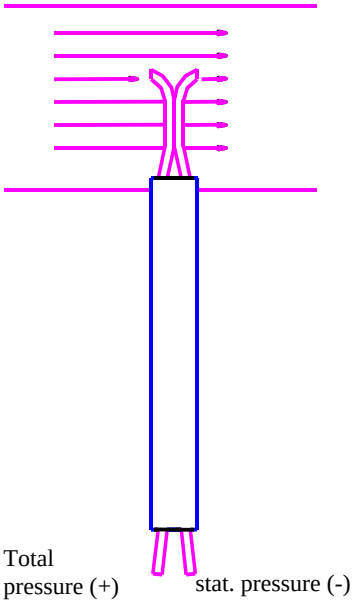
Formula to calculate the gas velocity:

$$v = \sqrt{\frac{200 \bullet \Delta p}{\delta}}$$

with p: difference pressure in mbar,

δ: operating density of the gas

S-Pitot-Tube



Factor ~ 0,84

One leg against the gas flow.
Find the maximum value at the measure point
through easy movements of the pitot tube.
To determine the flow direction turned the ptitot tube 90°.
When the difference pressure is zero, then is the gas flow
vertically to it.

Formula to calculate the gas velocity:

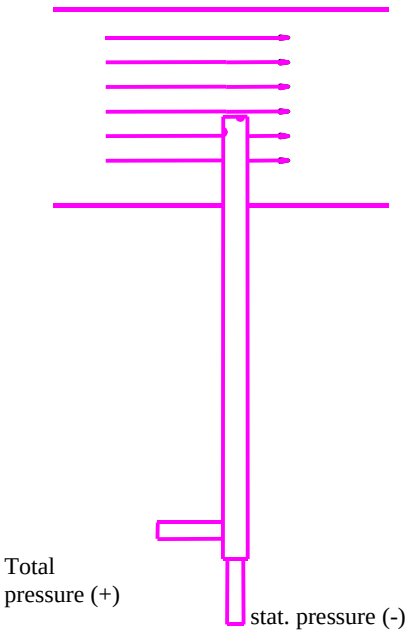
$$v = K \bullet \sqrt{\frac{200 \bullet \Delta p}{\delta}}$$

with p: difference pressure in mbar,

δ: operating density of the gas

K: Correction factor
(see calibration certificate [K ~ 0,84])

Cylindrical Pitot Tube



Factor ~ 0,79 .. 0,83 (see calibration certificate)

One opening against the gas flow.

Formula to calculate the gas velocity:

$$v = K \bullet \sqrt{\frac{200 \bullet \Delta p}{\delta}}$$

with p: difference pressure in mbar,

δ: operating density of the gas
K: Correction factor