

Static pressure
in a reduced cross section
– Measuring the pressure with the
precision manometer

Objects of the experiment

- To measure the relative static pressure in a Venturi tube.
- To determine the relative static pressure in a Venturi tube depending on its cross-sectional area.

Principles

The total pressure p_{tot} is determined by the static pressure p_s and the dynamic pressure p_d :

$$p_{\text{tot}} = p_s + p_d = \text{const.} \quad (\text{I})$$

For non-turbulent flows the Bernoulli equation of ideal fluids leads to:

$$p_{s1} + \frac{\rho}{2} v_1^2 = p_{s2} + \frac{\rho}{2} v_2^2 \quad (\text{II})$$

ρ : density of the flow medium

Combined with the continuity equation

$$v_1 \cdot A_1 = v_2 \cdot A_2 \quad (\text{III})$$

v : flow velocity

it approximates the flow of air through a tube with changing cross-sectional area A .

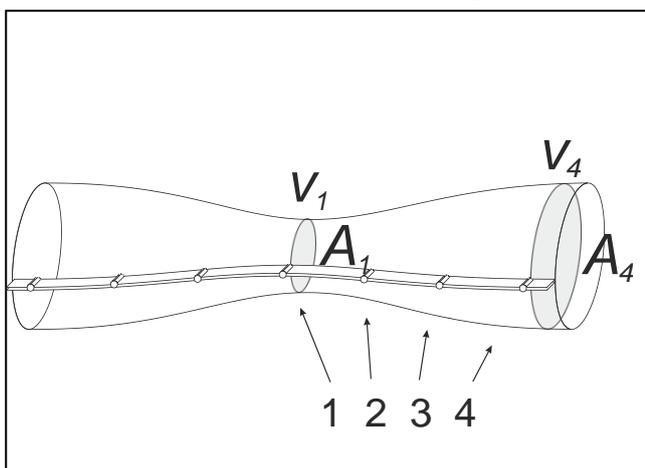
In this experiment the relative static pressure Δp is measured at cross sections A_1 to A_4 of a Venturi tube (see Fig. 1).

$$\Delta p = p_s - p_{\text{tot}} \quad (\text{IV})$$

Δp : relative static pressure

Remark: The experiment is closely related to P1.8.5.2 where the volume flow through a Venturi tube is determined.

Fig. 1: Venturi tube: cross-sectional areas A_0 and A_4 , flow velocities v_0 and v_4 . The numbers 1 to 4 denote the measuring points for the static pressure p_s .



Apparatus

1 Suction and pressure fan	373 041
1 Venturi tube with multimanoscope	373 091
1 Precision manometer	373 10
2 Stand base, V-shaped, small	300 02
1 Stand rod, 25 cm, 12 mm Ø	300 41
1 Stand rod, 47 cm, 12 mm Ø	300 42
1 Leybold multiclamp	301 01

Optional:

1 CASSY Lab 2	524 220
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Additionally required: 1 PC with Windows XP or higher

Setup

Equip the suction and pressure fan with the small nozzle (100 mm) and the Venturi tube on the pressure side. Set up these devices horizontally on the base as shown in Fig. 2. Additionally, support the Venturi tube using the stand base, stand rod and Leybold multiclamp. Put the small metal plate between the Leybold multiclamp and the Venturi tube. Do not overtighten the screw of the Leybold multiclamp!

- Align the precision manometer exactly horizontal. If needed, refill the reservoir for manometer fluid.
- Connect the hose of the precision manometer to the precision manometer's tube attachment nipple for low-pressure (right).
- Connect the other end of the hose to the hose nipple and plug it into measuring point 1 of the Venturi tube (see Fig. 2).
- The precision manometer's tube attachment nipple for high-pressure (left) remains open for measuring the difference to the atmospheric pressure p_0 .

Remark: The left measuring points are not used for didactic reasons. Since air is not an ideal gas, it results in a positive pressure on the left side – due to friction.

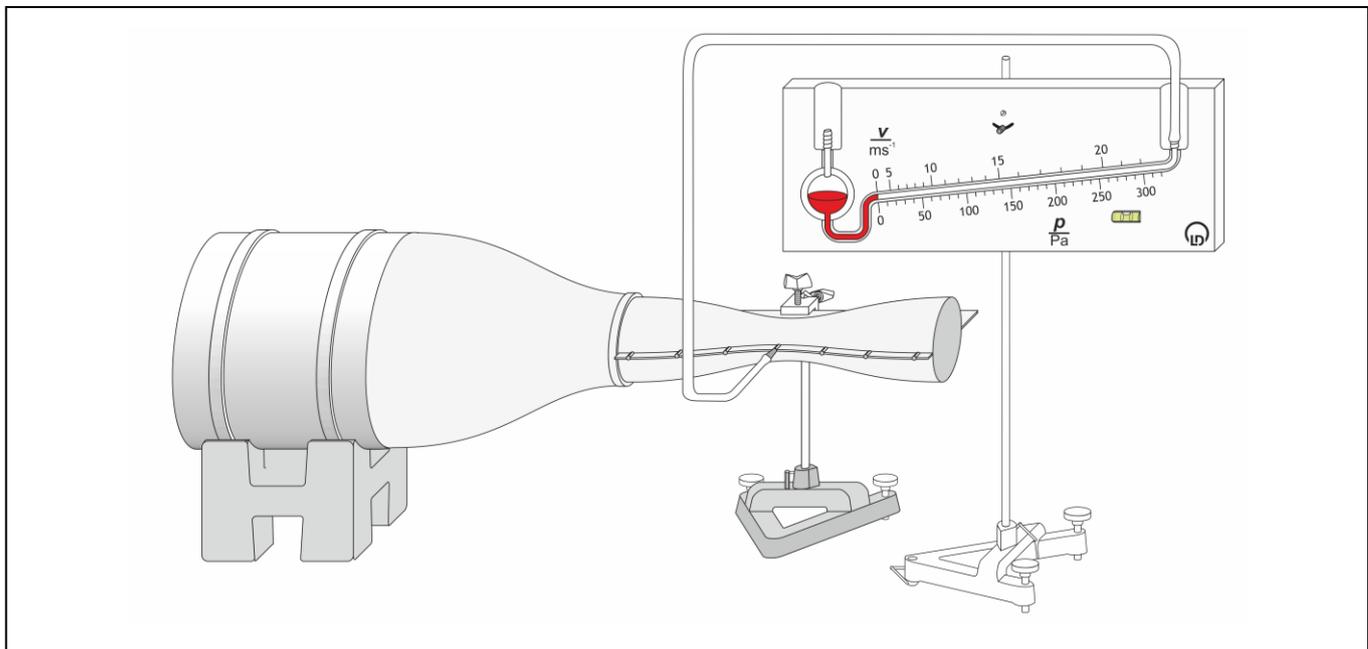
Safety notes

Mind the safety notes in the instruction sheet of the suction and pressure fan.

Before removing the protective grid or the nozzle:

- Pull out the mains plug and
- wait for at least 30 seconds until the suction and pressure fan comes to a complete stop.

Fig. 2: Experimental setup with the precision manometer.



Carrying out the experiment

Remark: Repeat one measurement several times for estimating measuring errors.

a) Measuring without CASSY Lab 2

- Set the suction and pressure fan to its minimum speed (i.e. left limit position of fan control) and only then switch it on.
- Slowly increase the speed of the suction and pressure fan until the relative static pressure Δp reaches approx. -200 Pa at measuring point 1 (middle of the Venturi tube).
- Read off the relative static pressure Δp and note the value in a table together with the belonging cross-sectional area A :

$\frac{A_1}{\text{cm}^2}$	$\frac{A_2}{\text{cm}^2}$	$\frac{A_3}{\text{cm}^2}$	$\frac{A_4}{\text{cm}^2}$
19.6	36.3	72.4	78.5

- Change the measuring points one by one and read off the relative static pressure Δp for each cross-sectional area A_2 to A_4 .

b) Measuring with CASSY Lab 2

- If not yet installed, install the software CASSY Lab 2 and open the software.
- Set the suction and pressure fan to its minimum speed (i.e. left limit position of fan control) and only then switch it on.
- Slowly increase the speed of the suction and pressure fan until the relative static pressure Δp reaches approx. -200 Pa at measuring point 1 (middle of the Venturi tube).
- Read off the relative static pressure.
- [Load the settings in CASSY Lab 2](#) and type in the pressure values in table " $\Delta p(A)$ [manu.]".
- Change the measuring points one by one and read off the relative static pressure Δp for each cross-sectional area A_2 to A_4 :

$\frac{A_1}{\text{cm}^2}$	$\frac{A_2}{\text{cm}^2}$	$\frac{A_3}{\text{cm}^2}$	$\frac{A_4}{\text{cm}^2}$
19.6	36.3	72.4	78.5

Remark: To record more than the prepared measurement series open "Measurement" in the menu bar and select  "Append new Measurement Series". Select table " $\Delta p(A)$ [manu.]" and click  once. Open the  "Settings" pane and mark " $\Delta p(A)$ " in the submenu "Displays". Push the button "Add new Curve" and select " $\Delta p\#2$ " in the drop down menu for "y-axis".

Measuring example

Tab. 1: Relative static pressure Δp at measuring points 1 to 4 and at cross sections A_1 to A_4 in the Venturi tube (see Fig. 1).

MP	1	2	3	4
$\frac{A}{\text{cm}^2}$	19.6	36.3	72.4	78.5
$\frac{\Delta p}{\text{Pa}}$	-222	-33	-28	-13

Evaluation and result

The relative static pressure decreases in the reduced cross section of the Venturi tube:

$$\Delta p \propto -\frac{1}{A^2}$$

Fig. 3: Relative static pressure Δp as function of the cross-sectional area A .

