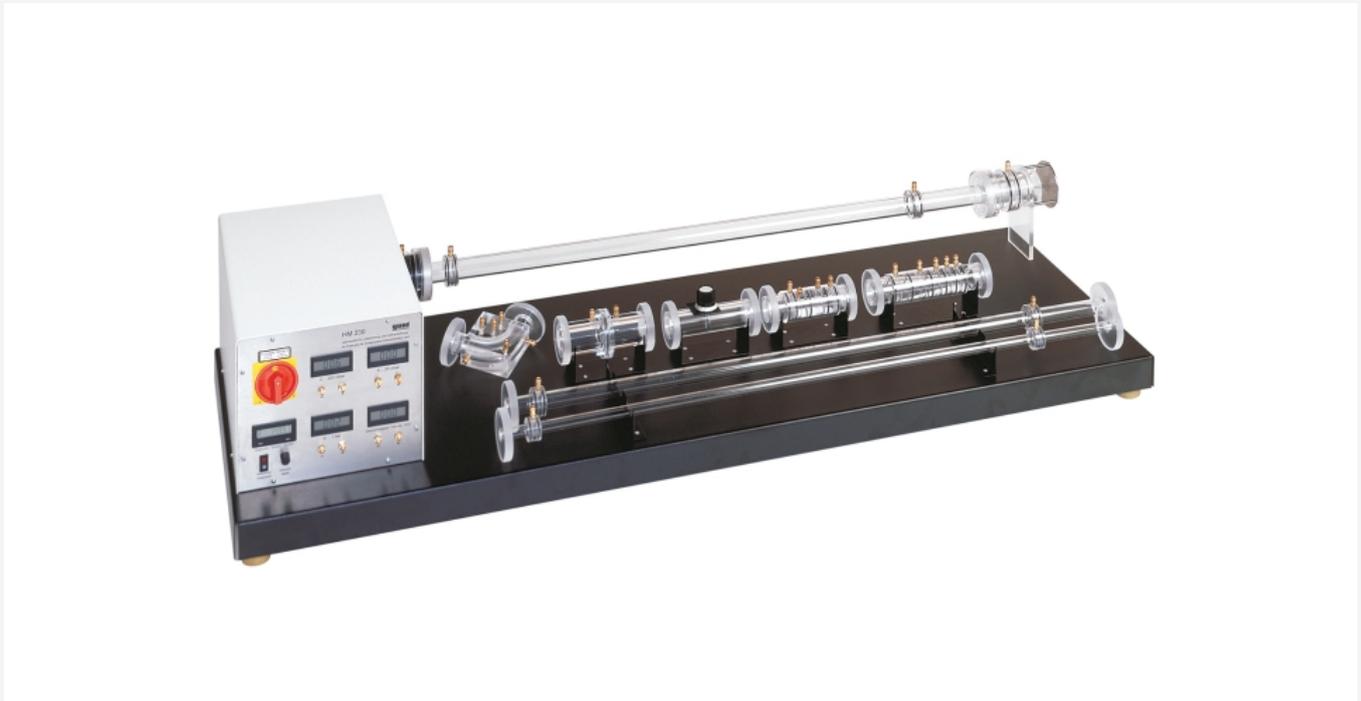


# HM 230

## Flow of compressible fluids



### Description

- investigation of flow in compressible fluids
- varied range of experiments for studying subsonic and sonic flow
- de Laval nozzle generates velocities up to  $Ma\ 1$

Compressible fluids change their density due to pressure change in the flow. Flows with velocities less than  $Ma\ 0,3$  are regarded as incompressible and the change in density is negligible. At higher velocities, the density has to be included in calculations. These conditions must be taken into consideration when designing e.g. turbo compressors, jets and fast planes.

The HM 230 experimental unit is used to investigate air flow in various ranges of velocity.

A radial fan with infinitely variable speed control draws in air from the environment. At the intake the air flow is accelerated in a measuring nozzle. Further down the measuring section the air

flows through interchangeable measuring objects. Drawing in the air and the arrangement of the measuring objects on the intake side of the fan minimise turbulence when flowing into the measuring objects. All measuring objects are made of transparent material and provide excellent insight into the inner structure.

Pressure losses are studied in a pipe elbow, various pipe sections and a nozzle with sudden enlargement. The nozzle with gradual enlargement (de Laval nozzle) provides an introduction to the topic of sonic flow. The volumetric flow rate is measured in an orifice using a differential pressure manometer. The orifice is fitted with four interchangeable orifice disks for different measurement ranges. The fan's characteristic curve can also be recorded by using a throttle valve.

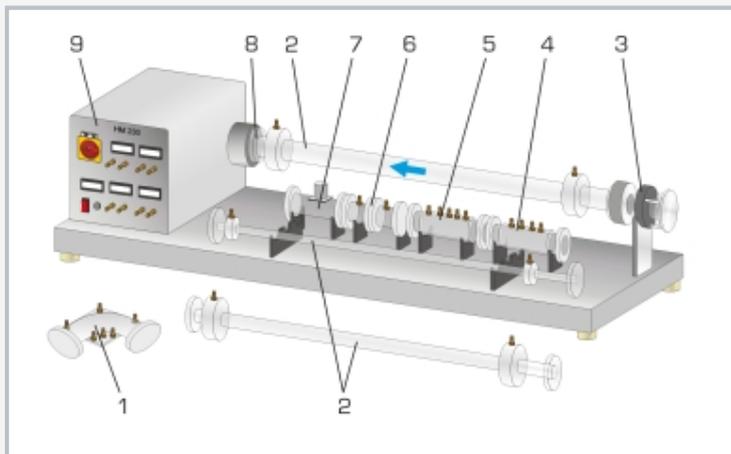
The measured values for volumetric flow rate, pressure and speed are displayed digitally.

### Learning objectives/experiments

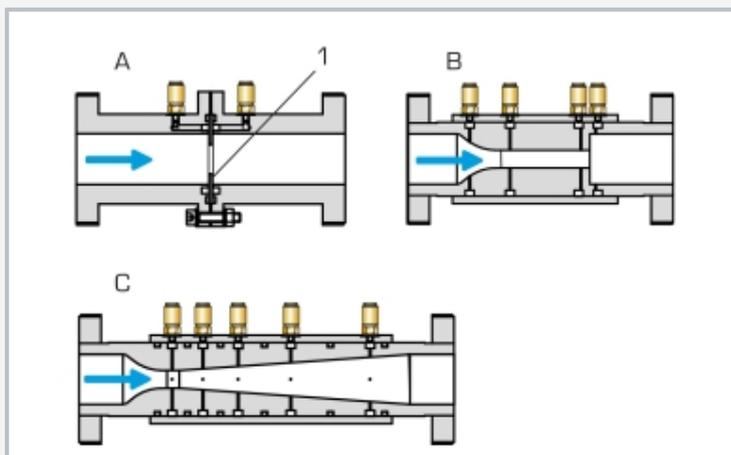
- pressure losses in pipes and pipe elbows
- flow in convergent/divergent nozzles
- determine the speed of sound in air
- compare calculation methods for incompressible and compressible flow
- use complete continuity equation
- determine mass flow rate using orifice and volumetric flow rate using orifice
- record calibration curve for orifice
- record fan characteristic curve at different mass flow rates and speeds

# HM 230

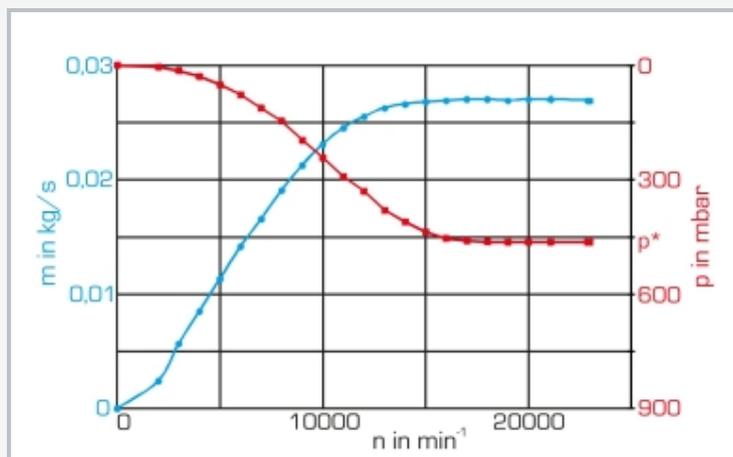
## Flow of compressible fluids



1 pipe elbow, 2 pipe section, 3 measuring nozzle, 4 nozzle with sudden enlargement, 5 nozzle with gradual enlargement (de Laval nozzle), 6 orifice, 7 throttle valve, 8 suction opening fan, 9 switch cabinet with display and control elements (integrated radial fan)



Measuring objects  
A orifice, 1 interchangeable orifice disks, B nozzle with sudden enlargement, C nozzle with gradual enlargement (de Laval nozzle)



Experimental result "nozzle flow and critical pressure ratio", de Laval nozzle: blue: mass flow rate, red: negative pressure, black: speed;  $p^*$  critical pressure

### Specification

- [1] investigate flow of compressible fluids
- [2] subsonic and sonic air flow
- [3] variable speed on the radial fan for adjusting the mass flow rate
- [4] minimised turbulence by drawing in air and optimum arrangement of the measuring objects
- [5] transparent measuring objects with connectors for pressure measurement provide insight into the internal structure
- [6] measuring nozzle for determining the mass flow rate
- [7] pressure losses in subsonic flow in pipe elbows and various pipe sections
- [8] pressure curve at subsonic and sonic nozzle flow
- [9] orifice for determining volumetric flow rate by differential pressure measurement
- [10] record fan characteristic curve using a throttle valve
- [11] digital displays for pressures, velocity and speed

### Technical data

#### Radial fan

- max. speed:  $31000 \text{ min}^{-1}$
- max. volumetric flow rate:  $226 \text{ m}^3/\text{h}$
- max. head: 318mbar
- max. power consumption: 1,8kW

#### Measuring objects

- pipe section: 1m
  - ▶  $\varnothing$  16, 24, 34mm
- 90° pipe elbow
- 2 nozzles, inner diameter: 12...34mm
  - ▶ with sudden enlargement
  - ▶ with gradual enlargement (de Laval nozzle)
- orifice with orifice disks
  - ▶  $\varnothing$  12, 19, 25, 32mm
- throttle valve:  $\varnothing$  34mm

#### Measuring ranges

- speed:  $0 \dots 99999 \text{ min}^{-1}$
- pressure:
  - ▶ 1x  $0 \dots 25 \text{ mbar}$
  - ▶ 1x  $0 \dots 600 \text{ mbar}$
  - ▶ 1x  $0 \dots 1000 \text{ mbar}$
- velocity:  $0 \dots 65 \text{ m/s}$

230V, 50Hz, 1 phase  
 120V, 60Hz, 1 phase, 230V, 60Hz, 1 phase  
 UL/CSA optional  
 LxWxH: 1750x600x390mm  
 Weight: approx. 58kg

### Scope of delivery

- 1 experimental unit
- 1 set of measuring objects
- 1 set of tools
- 1 set of instructional material