Experiment Instructions

HM 150.40 Vortex Flowmeter

Experiment Instructions

This manual must be kept by the unit.

Before operating the unit:
- Read this manual.
- All participants must be instructed on handling of the unit and, where appropriate, on the necessary safety precautions.

Table of Contents

1 Introduction

The unit is intended for educational and research purposes. It is used for experiments on various methods of measuring volumetric and mass flow rates.

The unit includes the following measuring methods:

- Volumetric volume flow rate measurement
- Gravimetric volume flow rate measurement
- Measurement with
  - Rotameter
  - Vortex flowmeter
- Calibration of flow meters

The measuring instruments are built into a pipe system such that the water supply can be provided from a central point. A number of valves make it possible to be perform measurements at different positions and using different instruments.

The volume flow rate can be adjusted using a fine regulator valve.

A comparison of the measurements using the different methods is possible. In addition, other measuring instruments can be calibrated.

The water supply is provided either by means of the **HM 150 Basic Hydraulics Bench** or from the mains supply in the laboratory.

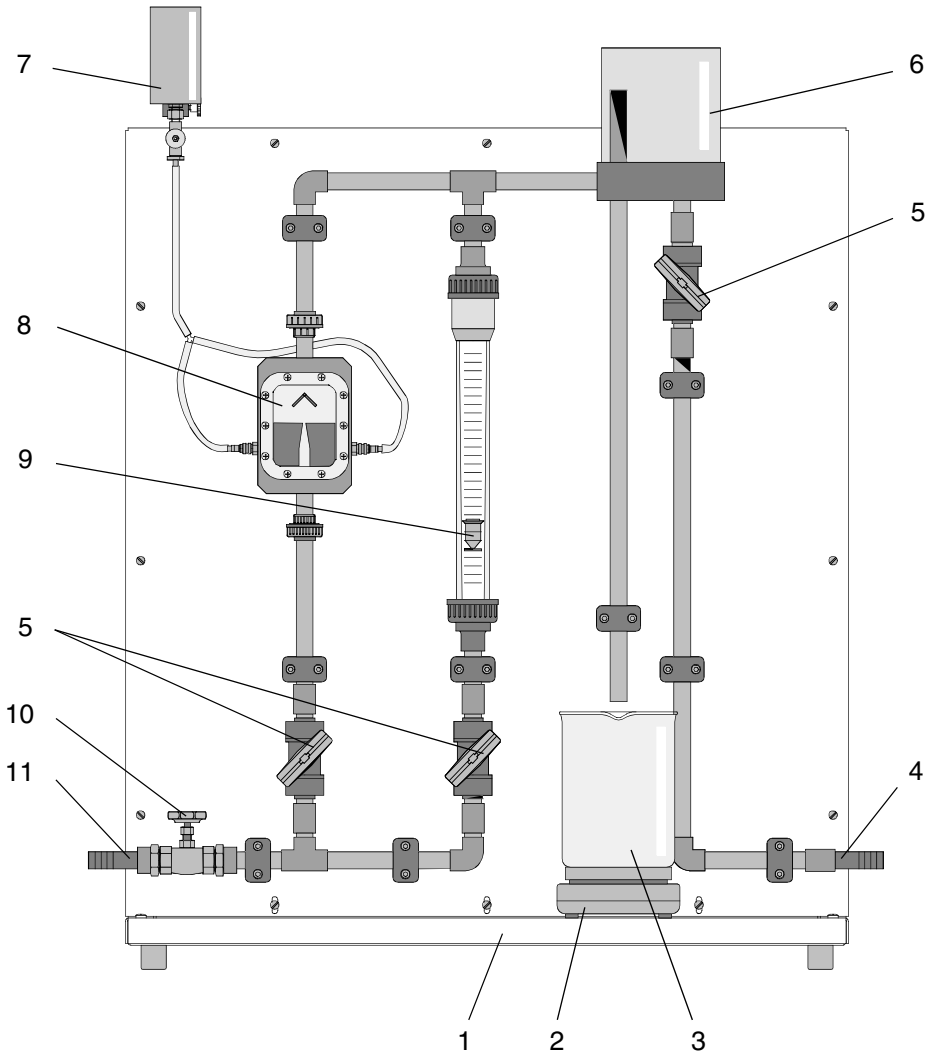
With the **HM 150** a closed water circuit can be set up.

1.1 Intended Use

The unit is to be used only for teaching purposes.

2 Description of the Unit

The unit essentially comprises the following components:



1	Support	7	Ink tank with metering valve
2	Scales	8	Vortex flowmeter
3	Measuring container	9	Rotameter
4	Water outlet	10	Fine regulator valve
5	Ball valve	11	Water feed
6	Collector tank with constant height		

Fig. 2.1

3 Experiments

The selection of experiments makes no claims of completeness but is intended to be used as a stimulus for your own experiments.
The results shown are intended as a guide only. Depending on the construction of the individual components, experimental skills and environmental conditions, deviations may occur in the experiments. Nevertheless, the laws can be clearly demonstrated.

3.1 Preparation of the Experiment

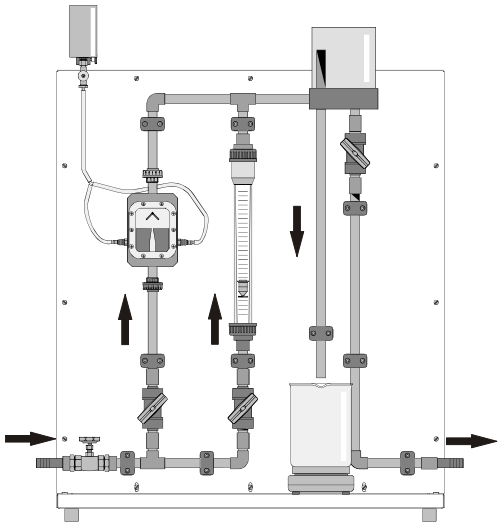


Fig. 3.1

- Place experimental setup on **HM 150**,
- Make hose connection between **HM 150** and the feed on the unit.
- Feed hose from drain on the unit to the volumetric tank on the Basic Hydraulics Bench.
- Open tank drain on **HM 150**.
- Close **HM 150** main cock and switch on **HM 150** pump.
- Open **HM 150** main cock
- Slowly open fine regulator valve for the flow rate measurement.

NOTICE

Do not set volume flow rate so high that the collector tank can overflow.

- During experiments with the vortex flowmeter the ink tank is to be filled with diluted ink and the hoses attached to the side of the vortex flowmeter using quick action couplings. Without the addition of ink the jet change can only be seen with difficulty.

3.2 Performance of the Experiment

3.2.1 Volumetric Volume Flow Rate Measurement

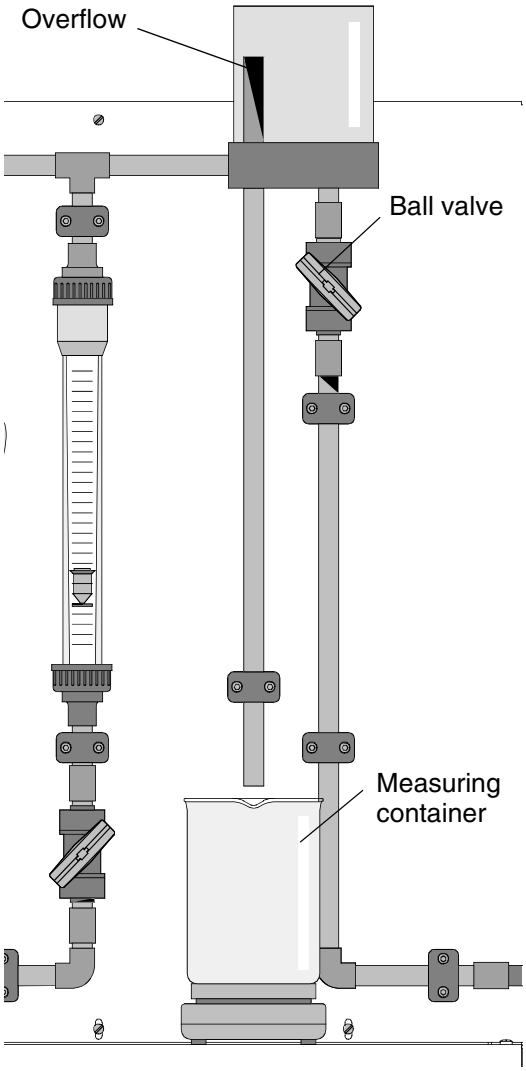


Fig. 3.2

The volumetric volume flow rate measurement is performed using the measuring container and the stopwatch. To ensure that the volume flow rate is not affected by a changing feed height, the level must be kept at a constant height above the overflow in the collector tank. The overflow flows out into the measuring container.

To start the measurement, the ball valve on the outlet of the collector tank is closed. When the overflow is reached and drops of water start to flow into the measuring container, the stopwatch is started. Once a previously defined mark is reached (e.g. 1000ml), the stop button on the stopwatch is pressed. The drain valve must now be opened again so that the measuring container does not overflow. The volume flow rate can now be calculated from the time that has elapsed and the difference between the start and end mark on the measuring container.

$$\dot{V} = \frac{V_2 - V_1}{t_2 - t_1} \qquad (3.1)$$

To compare the calculated value with one of the two measuring instruments built into the pipe system, the ball valve in front of the required comparison measuring point must be opened, while the other is closed.

In this way both the vortex flowmeter and also the rotameter can be calibrated. The volume flow rate can be adjusted using the needle valve at the inlet.

3.2.2 Gravimetric Volume Flow Rate Measurement

For the gravimetric volume flow rate measurement the same operating state is to be set up as for the volumetric volume flow rate measurement. The measuring container is on a digital scales. So that it is not necessary to subtract the weight of the measuring container from the total weight at the end of the experiment, the zero function on the scales can be used prior to the start of the experiment. This means that the scales with the measuring container fitted is set to zero, such that only the actual amount of water is measured.

The start and end of the experiment are to be performed in exactly the same way as for the volumetric measurement.

The formula for determining the volume flow rate is:

$$\dot{V} = \frac{m_2 - m_1}{(t_2 - t_1) \cdot \rho} \tag{3.2}$$

ρ = density in $\frac{\text{kg}}{\text{dm}^3}$

For water at 20 °C the following applies:

$$\rho = 0{,}99826 \frac{\text{kg}}{\text{dm}^3} \tag{3.3}$$

A calibration of the measuring instruments built into the pipe system is only possible if the ball valve in front of the measuring point not being calibrated is closed.

3.2.3 Rotameter

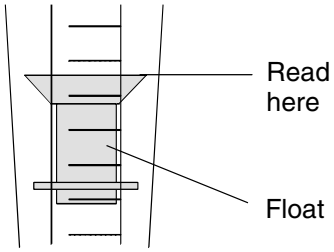


Fig. 3.3

For a measurement of the volume flow rate using the rotameter, the ball valve in front of the rotameter is opened. The ball valve in front of the vortex flowmeter is to be kept closed. With the collector tank drain open, the fine regulator valve is to be adjusted such that the volume flow rate does not cause the tank to overflow. The volume flow rate can, depending on the scale on the rotameter, either be read direct or as a percentage of the end value of the measuring range. The top edge of the float acts as a marker for the readings.

3.2.4 Vortex Flowmeter

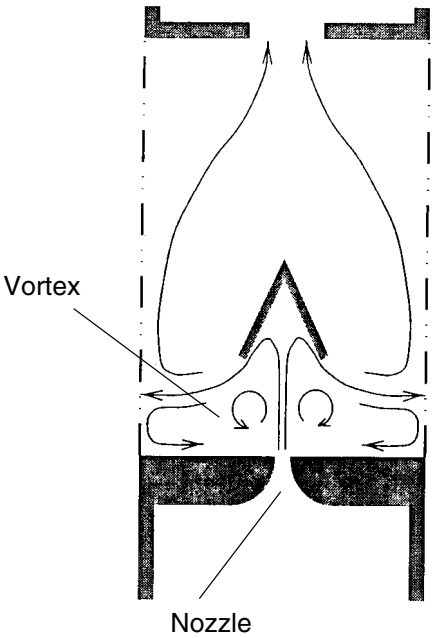


Fig. 3.4

In the vortex flowmeter a flow oscillating back and forward is generated. The frequency of oscillation of the flow is proportional to the flow rate. The oscillation of the flow is caused by vortices that press the flow leaving a nozzle in one or the other direction. To make the oscillation visible, ink is added to the nozzle. The frequency is determined by timing the oscillations using the stopwatch.

$$f = \frac{n}{t_n} \tag{3.4}$$

Here n is the number of oscillations, e.g. 10 and t_n the related time measured using the stopwatch.

The volume flow rate is determined using the frequency *f* as:

$$\dot{V} = k \cdot f \tag{3.5}$$

A calibration curve can be prepared by means of a comparison with the gravimetric measurement. The slope of the calibration curve yields the constant k.

4 Technical Data

Dimensions

Length x width x height	850 mm x 640 mm x 1.150	mm
Weight	25	kg

Connections

Water supply via HM 150 or via laboratory mains

Rotameter

Measuring range	150...1.600	ltr/h
Connection	1 1/2	"
Length	405	mm
Accuracy Class	1,6	%

Measuring container

Capacity	2.000	ml
Graduation	200	ml

Digital scales

Measuring range	0...2.000	g
Graduation	1	g
Power supply unit	230V/12	V

Stop watch

Measuring range	0...9,99	h
Resolution	0,01	s
Battery supply	1,5	V