Equipment for Engineering Education

Instruction Manual

HL 111 Fluid Friction Training Panel

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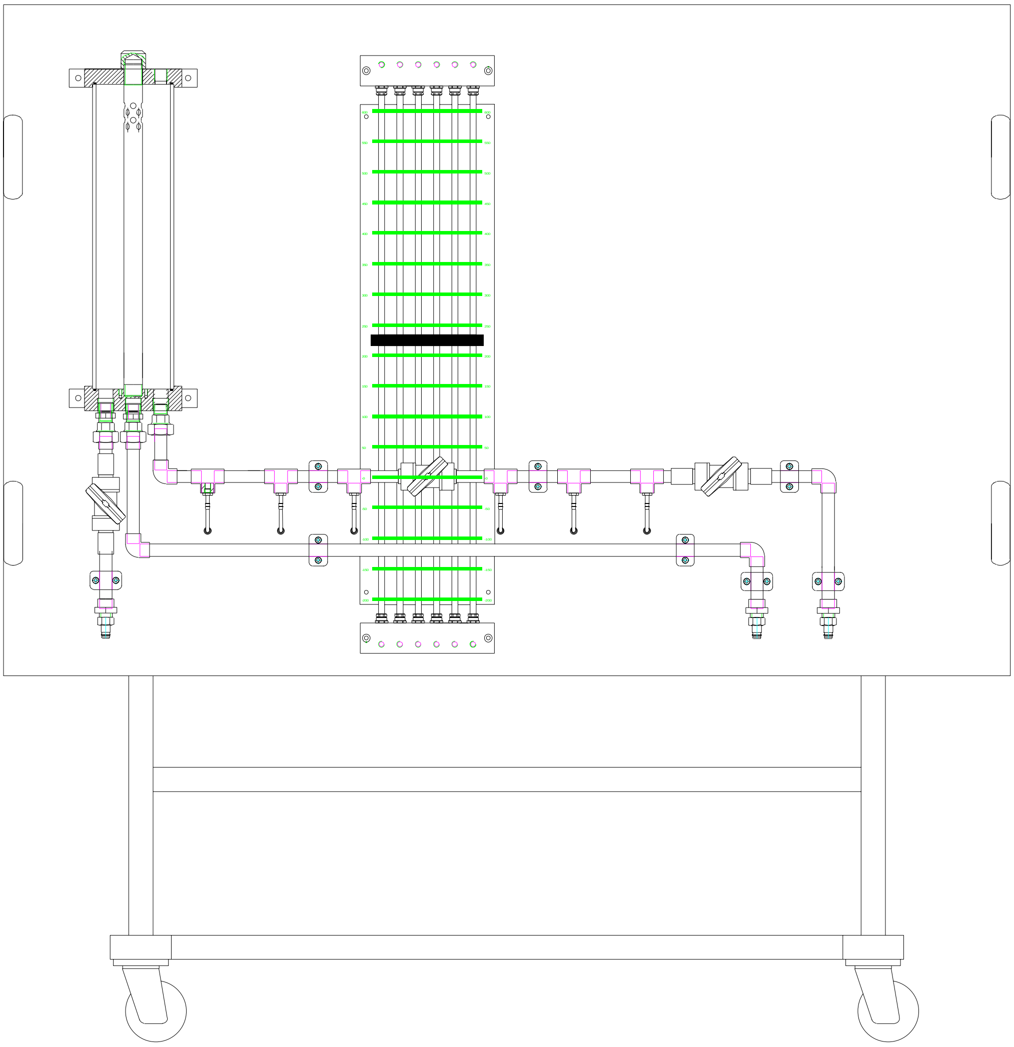
HL 111 Training Panel Fluid Friction



Instructions Manual

Please read and follow the instructions before the first installation!

Publication-No.: 916.000 00F 111 12

5/95

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1 Introduction

The pressure in liquids at rest and in flowing liquids is a recurring topic in domestic installations.

To understand how liquids behave in pipe systems and for which reasons it is necessary to install pumps in these pipe systems, sound knowledge of basic principles is required. This basic knowledge should include an understanding of hydrostatic pressure and how it affects open systems. In addition, the trainee must understand the significance of friction in flowing liquids, particularly at pipe walls and pipe fittings such as pipe bends, valves, mixers, etc.

The **G.U.N.T. HL 111 Training Panel Fluid Friction** demonstrates this behaviour of liquids at rest and liquids that are flowing in an open system in a very simple manner.

It makes the flow losses and the relationships with the flow speed in pipes and pipe fittings very clear.

2 Unit Description

The Training Panel Fluid Friction is a fully equipped experimental unit with a measurement section for flow losses. In conjunction with the HL 100 Universal Stand for Training Panels or the HL 090 Supply Bench for Training Panels, the HL 111 Training Panel offers the following features:

- The complete experimental setup is on a training panel
- The experimental unit can be moved and is easy to manoeuvre due to four castors
- Dimensions are such as to permit passage through normal door openings
- Secure positioning by means of two castors with brakes
- Pressure measurement with liquid at rest
- Pressure measurement with liquid flowing
- Differential pressure measurement
- Differential pressure measurement of two different flow speeds
- Demonstration of the pressure loss along the measured section

2.1 Layout of the Training Panel

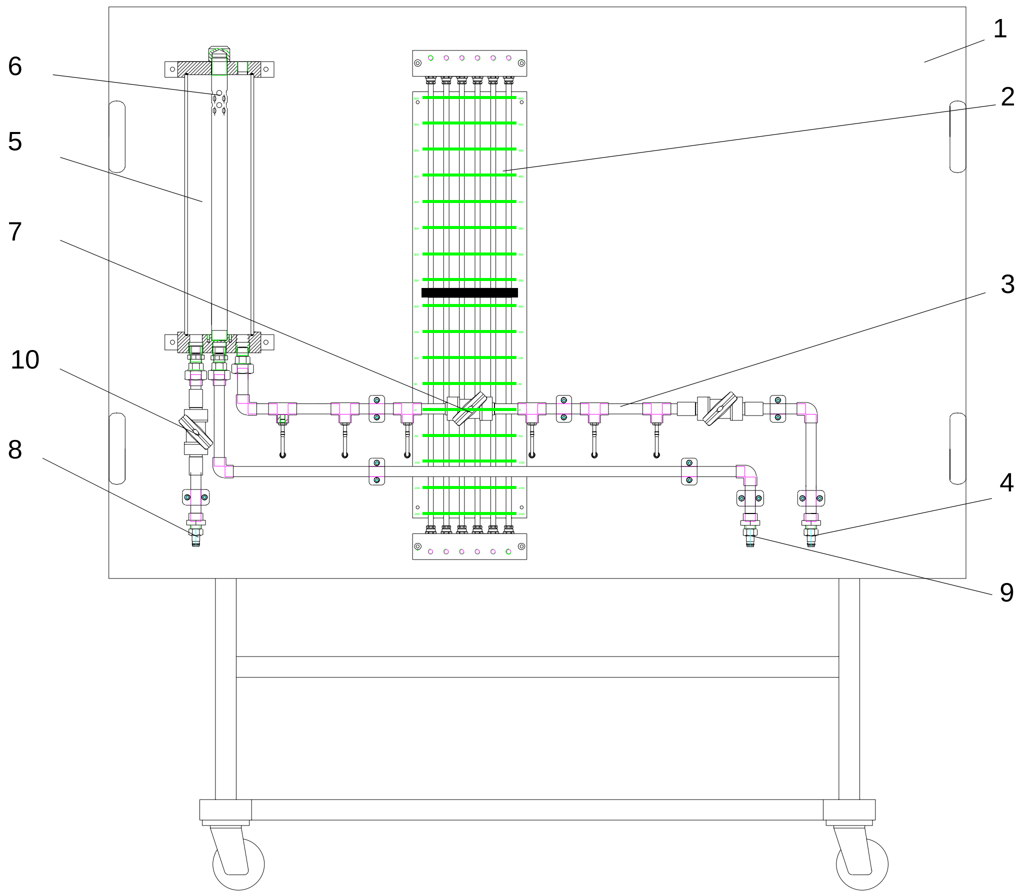

Fig. 2.0: Layout and Identification of the Training Panel

1	Training Panel	6	Overflow in the Tank
2	6-Tube Water Manometer	7	Ball-Cock
3	Measurement Section	8	Feed
4	Measurement Section Drain	9	Overflow Drain
5	Plexiglass Tank	10	Metering Valve

Fig. 2.0 shows the HL 111 Training Panel with the HL 100 Universal Stand for Training Panels, which is not included with the training panel.

2.2 Identification of the Measurement and Connection Points

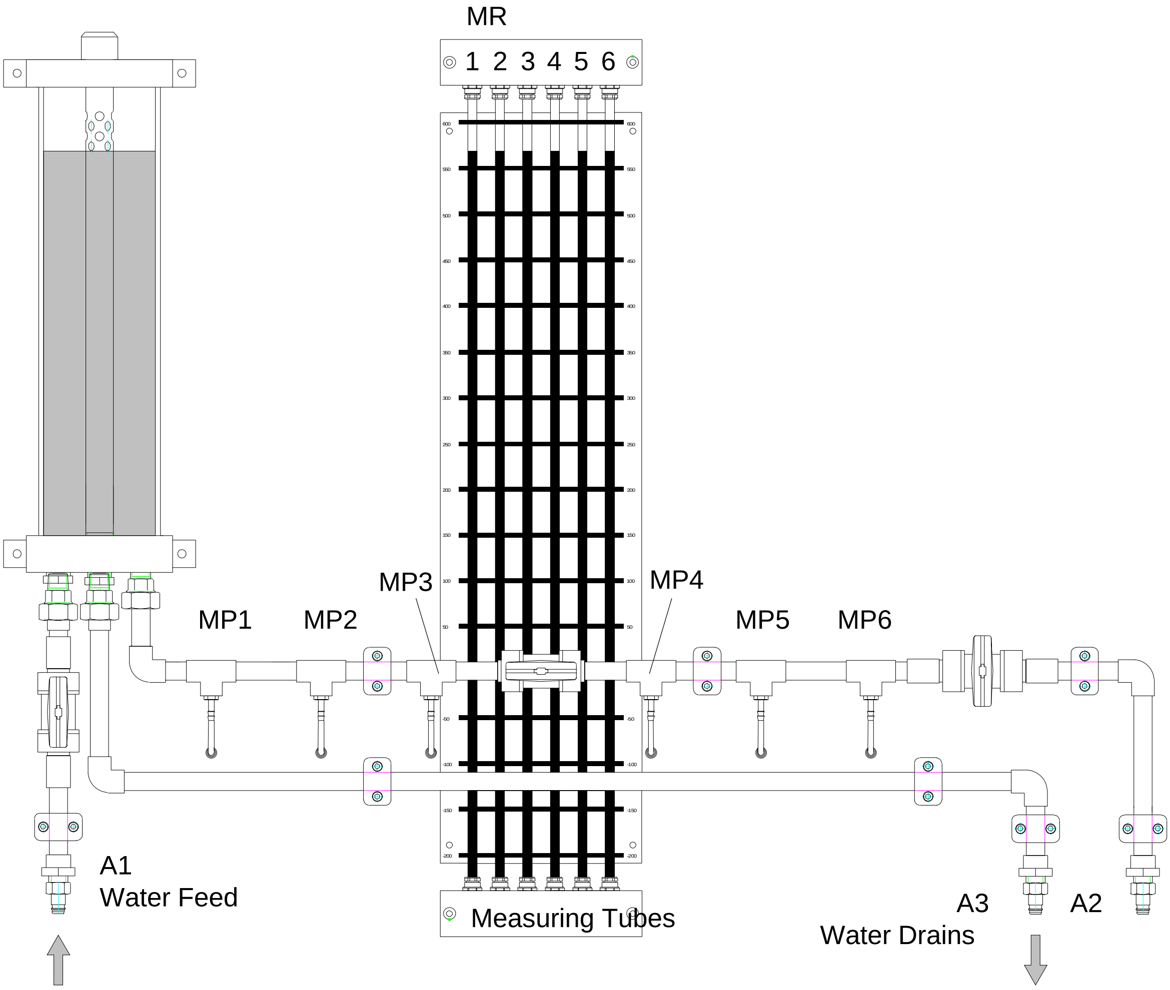

Fig. 2.1: Identification of the Measurement and Connection Points

To be able to describe the training panel consistently and straightforwardly in the following, the abbreviations given below are used:

A1 - A3:	Connections for Water Feed and Drain
MP1 - MP6:	Measuring Points for Static Pressure
MR1 - MR6:	Measuring Tubes for Static Pressure

2.3 Function of the Training Panel

The training panel comprises an open pipe system with water tank. This tank is fitted with an overflow such that a constant water level and thus also a constant flow speed is achieved.

The measurement section through which the water passes on leaving the tank is equipped with 6 measuring glands. The measuring glands are designed such that they measure the static pressure in the measurement section. The 6-tube water manometer is connected to the measuring glands via hoses. A simple cm scale on the 6-tube manometer facilitates the direct reading of pressures.

With the tank full and the drain valve open the hydrostatic pressure, or the pressure with the liquid at rest, can be read on the 6-tube water manometer.

With the drain valve open the flow pressure and the differential pressures between the individual measuring points can be read.

In addition, it is possible to demonstrate the flow loss at a pipe fitting by adjusting the drain valve in the middle.

The flow pressure functions can be displayed either continuously, by continuously filling the tank - excess water then flows out through the overflow, or the tank can be allowed to empty through the measurement section after filling. In the second case it then becomes very clear how the pressure loss reduces with reducing flow speed.

3 Savety

This section is normally used to make the user aware of hazards and their consequences caused by incorrect operation of the training panel.

The **HL 111 Training Panel Fluid Friction** cannot be damaged by incorrect operation if correctly connected to a mains water supply. It is also not possible for any health hazards to be caused by incorrect operation.

Note:

The water tank has a larger opening at the top, from which the water will escape if the overflow can no longer drain away the excess water.

Close the metering valve in feed as appropriate.

4 Operation

In this section the points necessary for the operation of the apparatus are listed so that the experiments can be performed straightforwardly.
This instruction manual is only valid in conjunction with the related manufacturer's documentation for the components connected.

4.1 Setting Up

Suspend apparatus on the HL 100 Universal Stand for Training Panels or in the HL 090 Supply Bench for Training Panels. Secure against rolling away by locking the brakes.

- Choose a flat, water resistant surface for setting up the stand (on connecting, filling and bleeding small amounts of water may escape),
- Connect feed to cold water using LW13 hose
- Make connection to drain using LW13 hose , or use collecting tray on the HL 090 Supply Bench for Training Panels

4.2 Filling and Bleeding the System

- Open metering valve in the feed
- Open shut-off valve and flush system
- When the tank overflows, close valve on the right
- Open and close valve in the middle several times until the measuring tubes are free of air bubbles.

The apparatus is ready for use now.

5 Theoretical Principles

5.1 Hydrostatic Pressure

The **hydrostatic pressure** is the pressure of a liquid at rest. It is based on the action of force due to the gravity. The pressure within a liquid is the same in all directions. The magnitude of the pressure at a point is dependent on the height of the column of liquid above it.

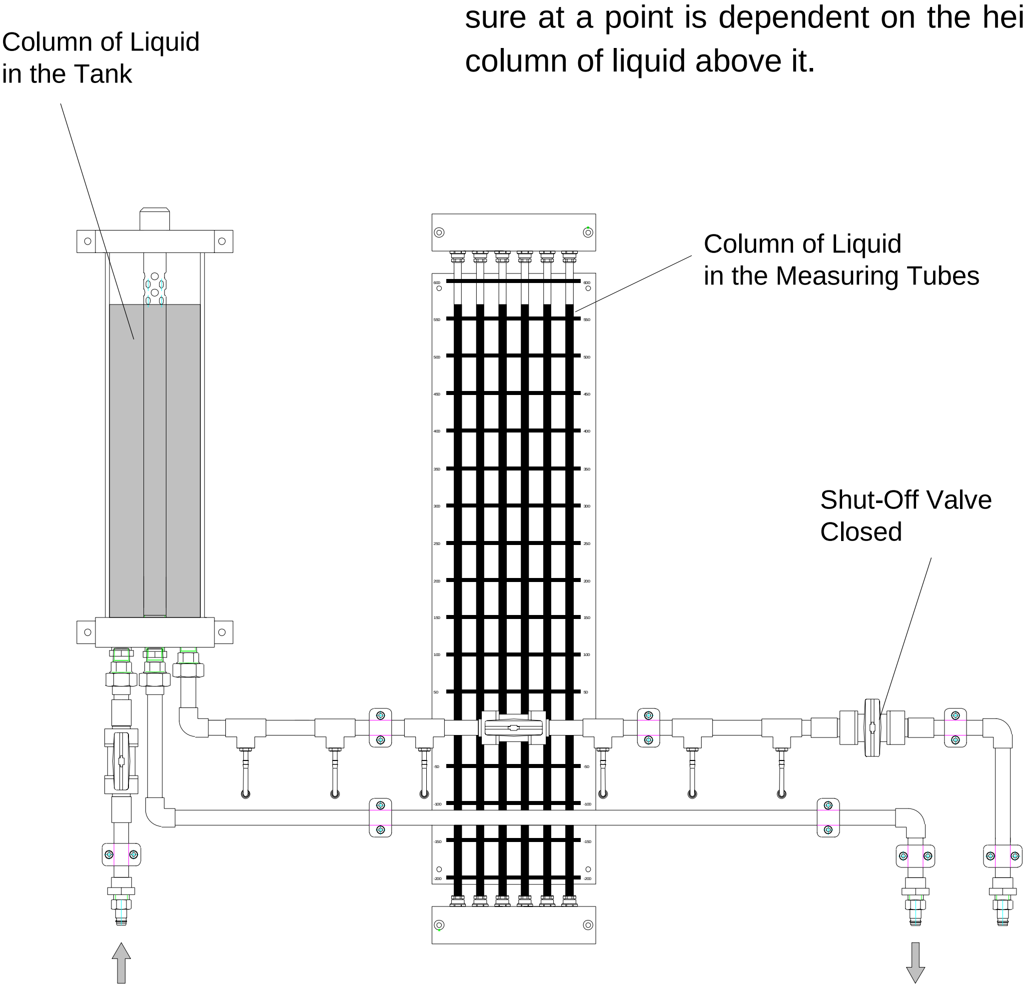

Fig. 5.1: Hydrostatic Pressure

In Fig. 5.1 it can be seen that the columns of liquid in the measuring tubes 1 - 6 are exactly the same height as the column of liquid in the feed tank. Here it does not matter if feed A1 is open and excess water is flowing through the overflow, or whether the feed is closed. Only the height of the liquid is of relevance.

As $p = \frac{F}{A}$ and $F = A \cdot h \cdot \rho \cdot g$,

the following is found:

$$p = \rho \cdot g \cdot h$$

Here it can be seen that the pressure p primarily depends on the height of the liquid h. We are taking the density ρ and the acceleration due to gravity g as constants here.

The now outdated pressure variable ***m WG*** (m Water Gauge) resulted from this relationship.

Here: 10m WG =1bar =10000Pa

for $g = 10\ \frac{m}{s^2}$ and

$$\rho = 1000\ \frac{kg}{m^3}$$

In this way it is now possible to read on the training panel, which has a simple cm scale, the **hydrostatic pressure** present or simply the static pressure $\boldsymbol{p_{st}}$ in the tank.

5.2 Flow Pressure

On a draining tank the pressure reduces in the direction of the drain (Fig. 5.2). This pressure drop, or also pressure loss, is produced in flowing liquids due to resistances in the pipework. These resistances are the friction of the liquid at the pipe and fitting walls, as well as the friction between the liquid particles. This means that the longer the pipework, the larger must be the initial pressure or the pump rating.

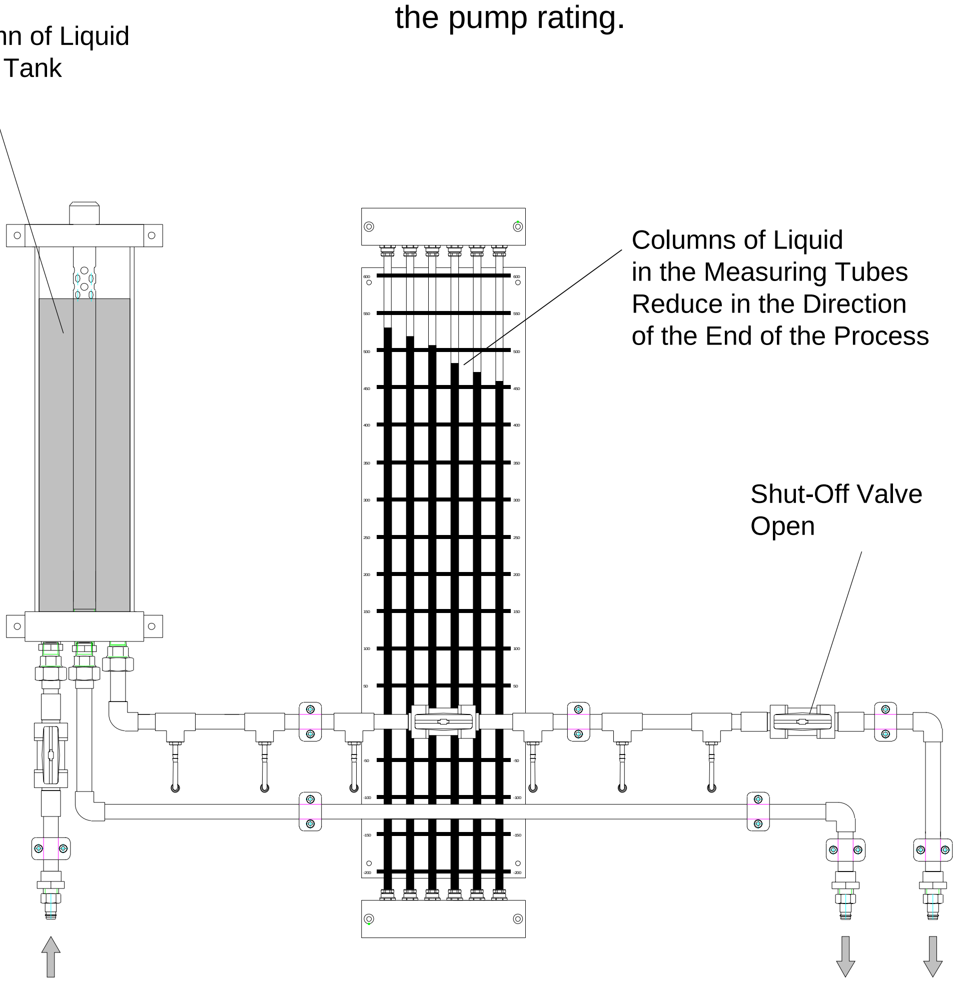

Fig. 5.2: Flow Pressure

If the static pressure p_{st} in a flowing liquid is now measured, this pressure will be lower than the pressure at the same point with the liquid at rest (cf. Fig. 5.1). The static pressure in a flowing liquid is termed the **flow pressure.**

The **static pressure** is thus the pressure that is acts on the pipe wall,
in the case of a liquids at rest = pressure at rest
in the case of flowing liquids = flow pressure.

5.3 Pressure Loss

The pressure loss produced in a flowing liquid results from the pipe and particle friction in the liquid already described (cf. 5.2 Flow Pressure). It is also called **flow loss**. This pressure loss, or flow loss, is dependent on the wall roughness in the pipe section and the type of pipe fittings. Pipe fittings have relatively large flow resistances due to their deflection, regulation, and mixing tasks; these are reflected in corresponding pressure losses. The pressure loss is thus to be seen as fractional for a specific pipe length of a specific pipe fitting. The pressure loss is thus a pressure difference over the section or the fitting.

Pressure loss Δp :

$$\Delta p = \lambda \cdot \frac{l}{d} \cdot \frac{\rho}{2} \cdot \overline{w}^2 \text{ for pipes}$$

$$\Delta p = \zeta \cdot \frac{\rho}{2} \cdot \overline{w}^2 \qquad \text{for pipe fittings}$$

In the equation for the pressure loss, the flow speed $\overline{w}$ is entered as a quadratic term. This means that if the flow speed increases by a factor of 2, the pressure loss Δp increases by a factor of $2^2 = 4$, or the other way around, if the flow speed drops, the pressure loss also drops. From this statement it can also be determined that no pressure loss can occur in liquids at rest.

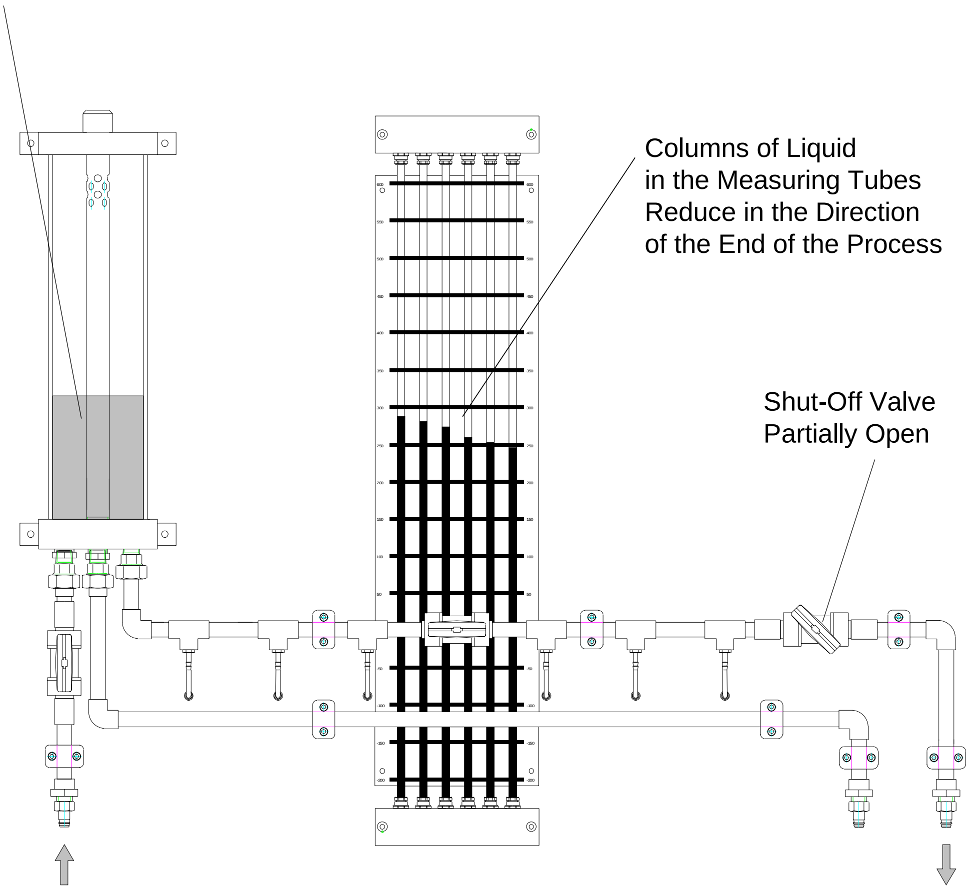

Fig. 5.3: Flow Rate Reduced

Fig. 5.3 shows that at reduced flow rate, that is at a lower flow speed, the pressure loss reduces. The difference between the individual measuring points becomes smaller (cf. 5.2).

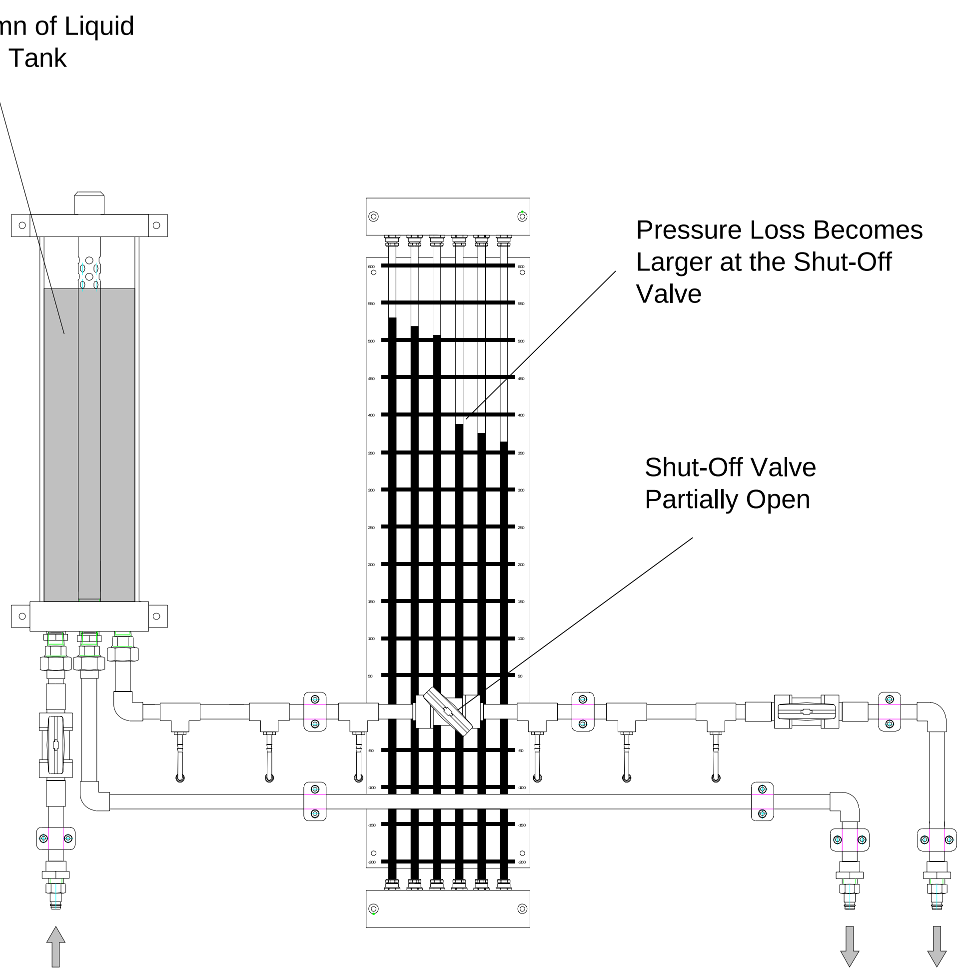

Fig. 5.4: Pipe Fitting with Resistance

Fig. 5.4 shows that a larger pressure loss is produced at a shut-off valve that is not fully open, that is the pressure loss is at the shut-off valve. The pressure losses at the individual measuring points remain the same as per their flow speeds.

Fig. 5.5 shows, in comparison to Fig. 5.4, that on reducing the flow speed, the pressure loss at the shut-off valve also reduces again.

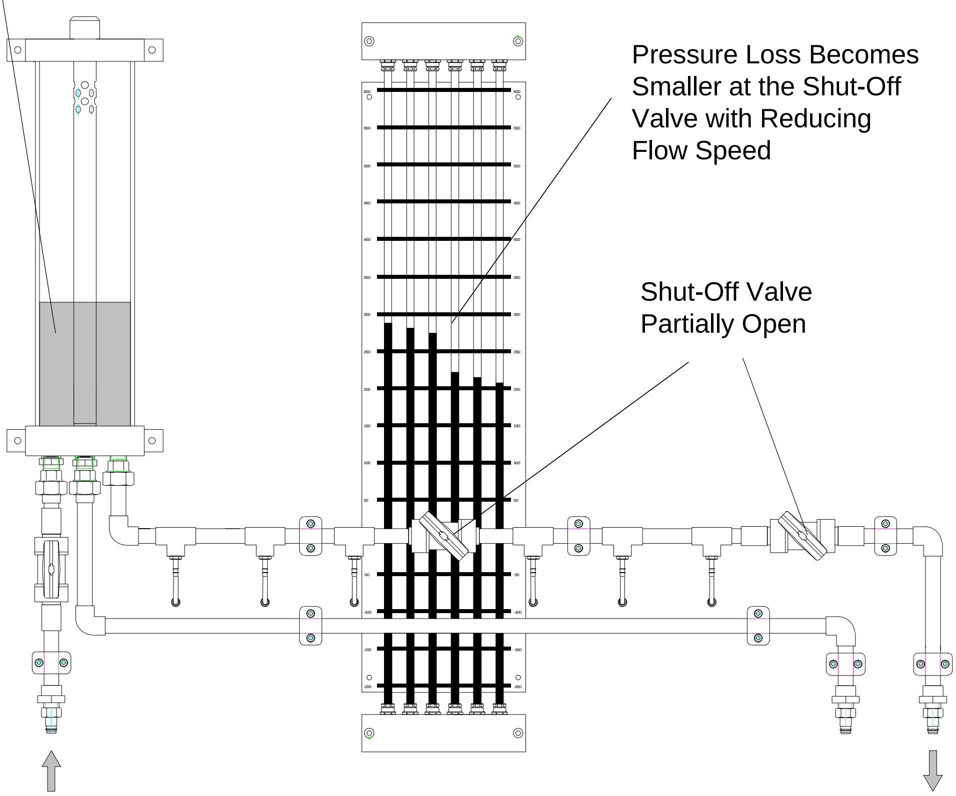

Fig. 5.5: Pipe Fitting with Resistance

Note:

The equations given for the pressure loss cannot be simply applied to the measurement section on the HL 111 Training Panel without further consideration. The measurement section is so short that a measurement cannot be compared with a calculation. Heavy interference in the pipe feed and drain, as well as problems with the measuring points will produce incorrect results for such a check measurement.

6 Appendix

6.1 Technical Data

Sheet Steel Panel:

Powder coated, colour grey-white
Overall Dimensions of the Training Panel:

Length:	1650	mm
Depth:	200	mm
Height:	1100	mm
Weight:	55	kg

Supply:

Cold Water Connection:
Quick-action coupling with LW13 hose connection

Drain:
Quick-action coupling with LW13 hose connection

Plexiglass Tank:

Capacity:	approx. 8	Ltr

Water Manometer:

Filling	Water

Absolute and Differential Pressure Measurement

	6-Tube	
Measuring Range	600	mm

6.2 Symbols and Units

A	*Area*	m^2
d	*Tube Diameter*	*m*
F	*Compression Force*	*N*
g	*Acceleration Due to Gravity*	$\approx 10 \frac{m}{s^2}$
h	*Height*	*m*
l	*Pipe Length*	*m*
p	*Pressure*	*Pa: bar*
$\overline{w}$	*Mean Flow Speed*	$\frac{m}{s}$
Δp	*Pressure Loss*	*Pa: bar*
ζ	*Coefficient of Resistance*	
λ	*Coefficient of Pipe Friction*	
ρ	*Density*	$\frac{kg}{m^3}$

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