Instruction Manual

HL 113 Valve Loss Training Panel

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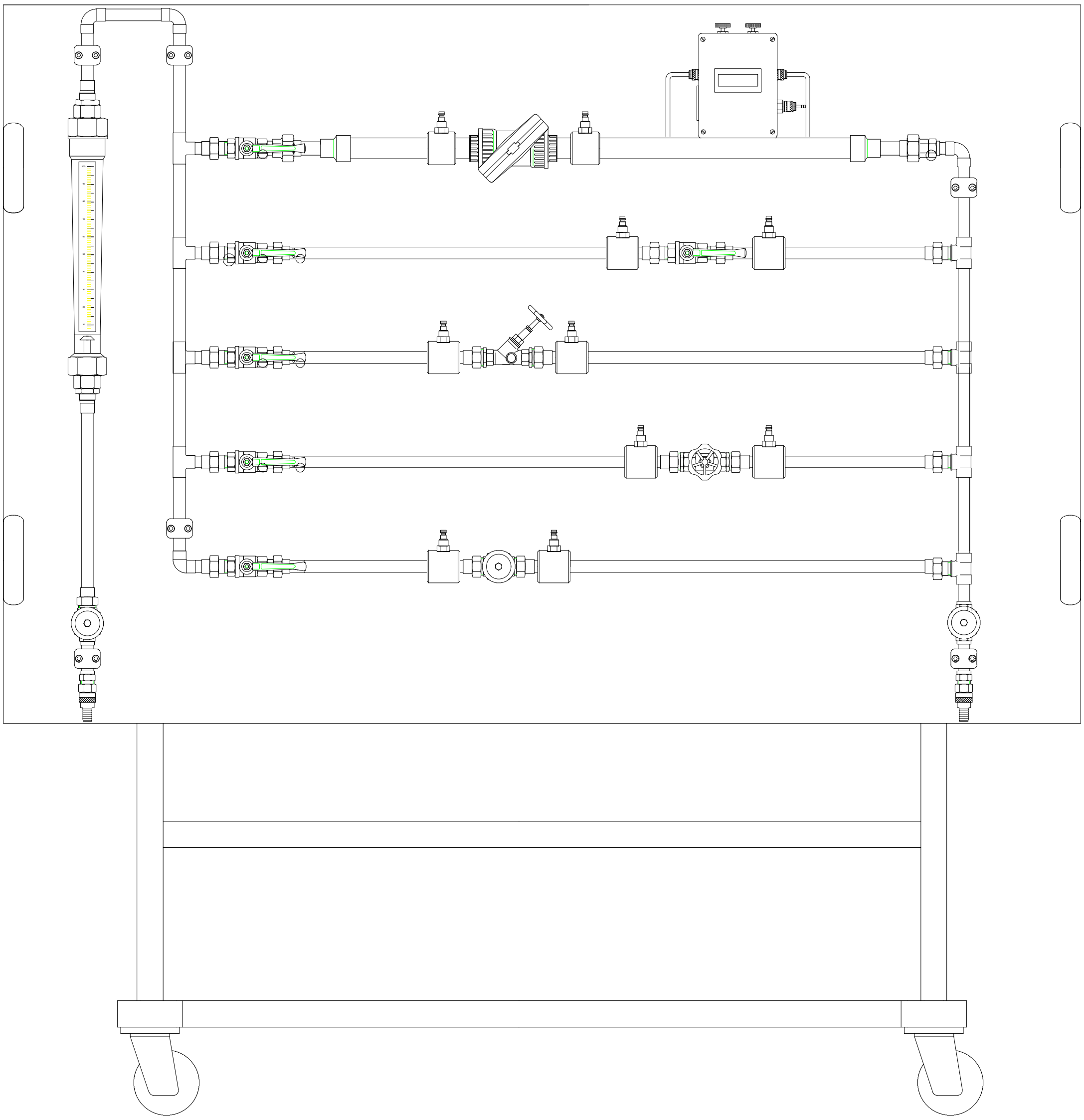

Instruction Manual

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1 Introduction

All sorts of shut-off and regulating fixtures for regulating the flow volume are built into the pipe system. Flows are subjected to strong directional restrictions and cross-sectional restrictions in these fixtures, which lead to the respective friction losses.

The G.U.N.T. training panel for Losses on standard fixtures HL 113 for investigating pressure losses allows the experimental investigation of flow losses on standard shut-off fixtures. The following topics can be investigated individually on the training panel:

- The influence of different fixtures such as:
  - Ball valve, PVC
  - Ball valve, galvanized brass
  - Slanted-seat in-line valve
  - Straight-seat valve
  - Socket shut-off gate valve
- Influence of different materials and surface characteristics with the standard valves above
- Influence of the flow speed
- Measureing of characteristic valves-curves
- Determining differential pressures
- Comparing experiments and calculations

The ball valve of PVC is mounted with its entire path of flow being transparent, so that flow-ratios and the individual components of the ball valve can be very clearly seen.

The trainees acquire general skills in the preparation and performance of series testing and the knowledge required for handling pressure and flow-measurement devices.

The measurement of pressures is done using a digital differential pressure gauge.

Pressure samples are taken via annular chambers. Rapid-action couplings are used for making the connection between differential pressure gauges and annular chambers.

The five measurement sections are exchangeable by using threaded connections. The user can insert a different valve into the measuring system for testing at any time.

The flow rate is read with a variable flow-meter.

Handles make it easier to transport the training panel.

2 Unit Description

The HL 113 training panel is a completely equipped experimental unit for loss measurements on standard isolation valves. The training panel has the following features:

- The entire experimental setup is on a single training panel
- Flow measurement with float flow meters
- One digital pressure measuring system for measuring differential pressure
- Fault-free Pressure measurements via annular chambers
- Simple and quick connection between measuring points and pressure gauge via hoses with rapid action couplings
- Five different measurement sections permanently installed
- Fixtures are exchangeable, enabling the use of other measurement objects
- Simple measurement section selection with ball valves

2.1 Test stand construction

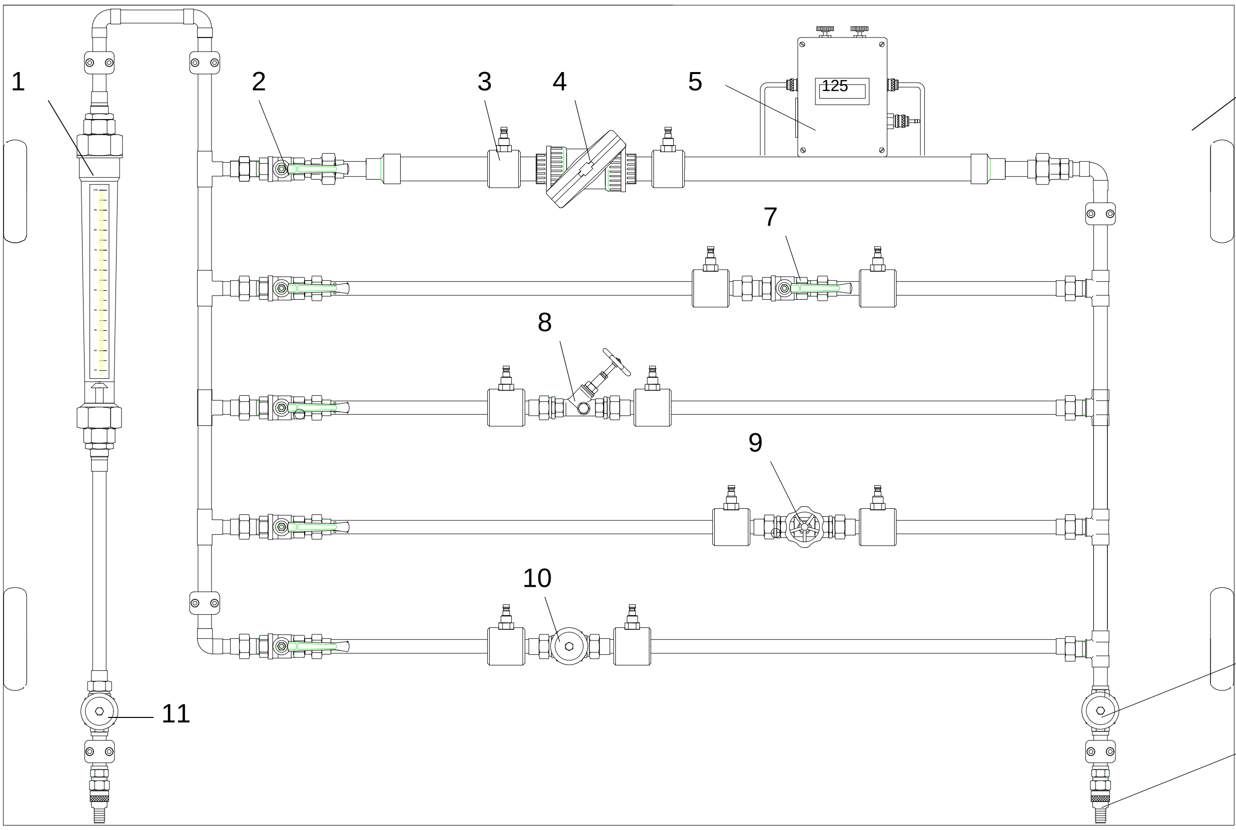


Fig. 2.0: Training panel construction HL 113

1	Float flow meter	7	Measuring object Ball valve Steel, DN15
2	Stop valve measurement section	8	Measuring object Slanted-seat In-line valve, DN15
3	Annular chamber with rapid-action coupling	9	Measuring object Straight-seat In-line valve, DN15
		10	Measuring object Socket shut-off valve, DN15
4	Measuring object ball valve PVC, DN32	11	Regulator valve Water inlet
		12	Regulator valve Water outlet
5	Digital differential pressure gauge	13	Water outlet with rapid-action coupling
6	Training panel with handles		

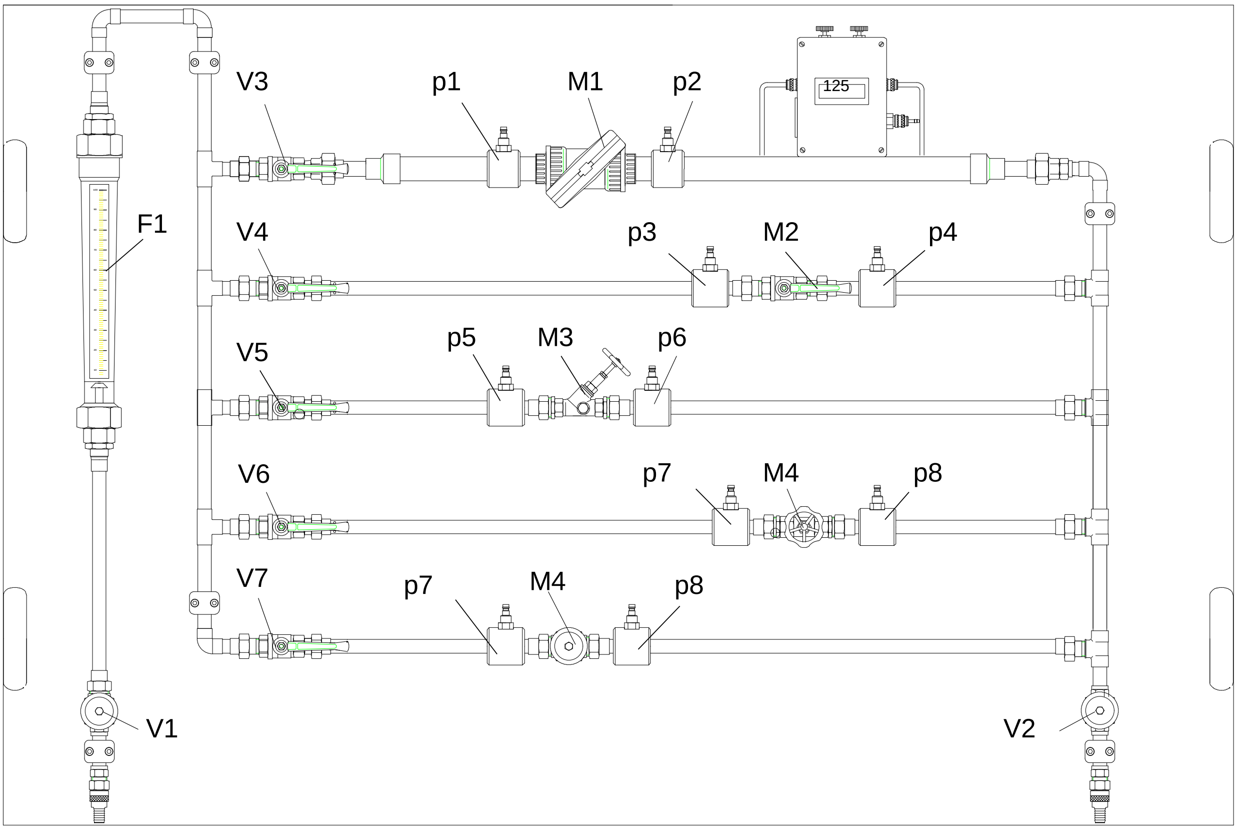


Fig. 2.1: Identification of the measuring and shut-off points

In order to describe circuitry for the following testing simply and uniform, the following codes are used:

- V1 - V7 Shut-off and regulating valves
- p1 - p8 Pressure measuring points
- M1 - M5 Measurement section
- RS1 - RS4 Pipe sections
- F1 Flow measurement

2.2 Training panel functionality

After the feed, the water flows through the flow rate measurement.

After the flow rate measurement, the water is fed through ball valves on the measurement section to be tested or the fixture to be tested.

The pressure is taken at the beginning and the end of the measurement section via annular chambers and is output as a differential pressure via the digital differential pressure gauge.

The flow can be regulated with socket shut-ff gate valves 10 and 11 in the inlet and outlet of the pipe system.

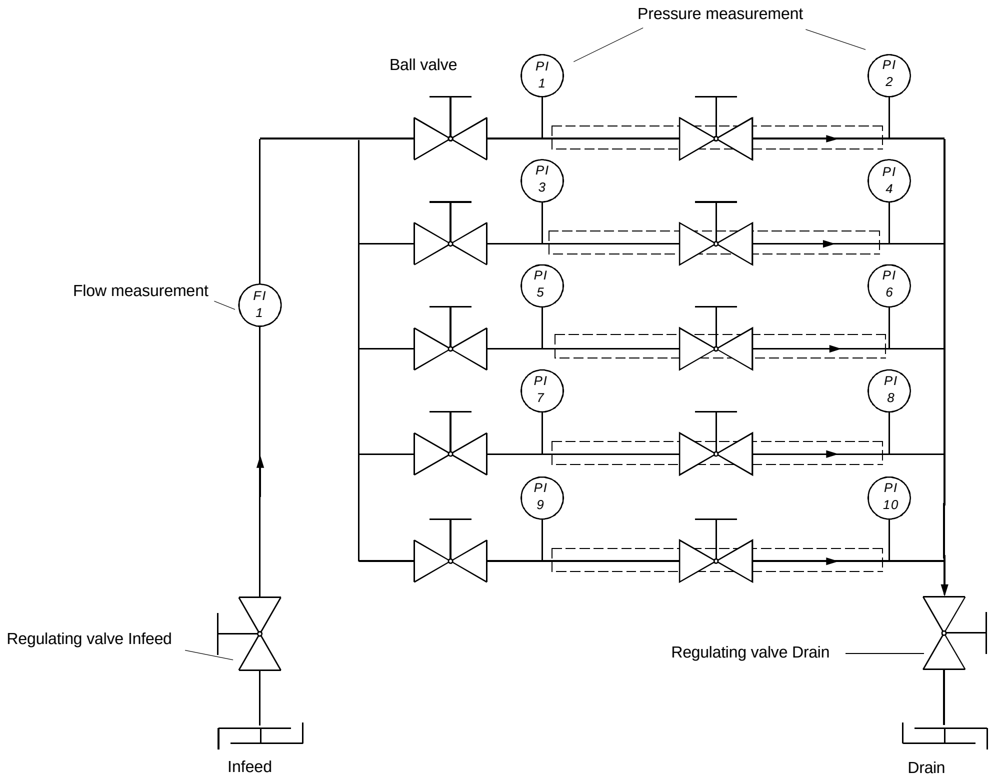


Fig. 2.2: Process diagram for experimental setup

2.3 Commissioning

Hang the training panel in the universal frame for training panels HL 100 or the supply table for HL 090 training panels and secure it from rolling by applying the brakes.

- Select a level, waterproof support surface (when changing the measuring lines, small quantities of water can escape)
- Connect the water supply on the socket shut-off gate V1 with the rapid action coupling (V1 closed)
- Attach water drain on socket shut-off gate V2 with rapid action coupling

Check the test stand for leaks:

- Open the outlet valve
- Activate the water flow
- Slowly open all ball valves one after the other and flush the pipe lines.
- Close the outlet valve. This ensures that the piping system is completely under pressure (this depends on the chosen water supply)
- Rinsing the experimental unit must be carried out until no more air bubbles rise up through the float flow meter after briefly closing and opening all valves
- ATTENTION!! Rapid-action couplings of the differential pressure measuring instrument are not to be connected with annular chambers, so that the sensors of the measuring instrument are not damaged by pressure surges

Check all lines and connections for leaks.

2.3.1 Connecting the differential pressure measuring instrument

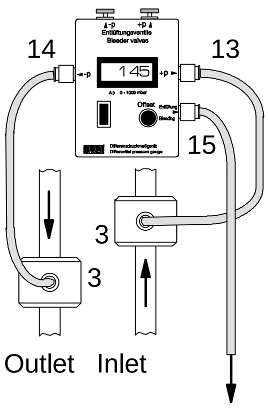


Fig. 2.3: Connections Pressure gauge

- The training panel must be free of pressure:
  Closed regulating valve (11),
  socket shut-off gate valve open in drain
- Connect the ventilation hose (15) to the pressure measuring instrument.
- Connect the +P connection (13) with the annular chamber (3) at the inlet of the measuring section.
- Connect the -P connection (14) with the annular chamber (3) at the outlet of the measuring section.

2.3.2 Flushing the measuring lines and the measuring instrument

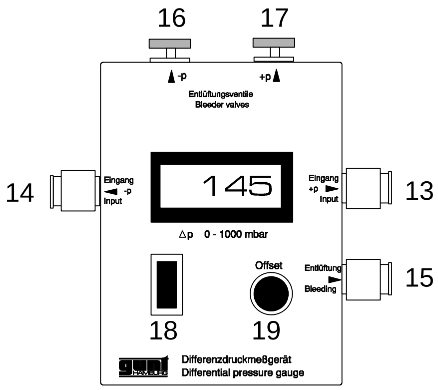


Fig. 2.4: Ventilation Pressure gauge

- Open the bleed valves (16, 17) on the pressure measuring instrument.
- Slowly open the regulating valve (11) flush the pipe section or measuring lines, until no air bubbles appear in the measuring lines.
- Close the bleed valve +P (17) and then close the bleed valve -P (16) (prevents negative differential pressure).
- Close the infeed again with the regulating valve (12).
- Switch the measuring instrument (4) on.
- If there is no more flow, set the dispaly to zero with the offset adjuster (19).

The differential pressure gauge is now ready for operation. If air bubbles can be seen in the measuring lines, the bleeding process should be repeated.

2.3.3 Operating the differential pressure gauge

The differential pressure gauge is equipped with a sensitive piezo-resistive pressure sensor. This pressure sensor is only suitable for positive pressure differences. For measuring pressure differences, the connections are to be swapped. The following rules are to be followed so that the sensitive sensors will not be damaged:

- **The +P connection** is always on the measuring point with the **higher pressure** (Measuring section inlet).
- **The -P connection** is always on the measuring point with the **lower pressure** (Measuring section outlet).

ATTENTION! Absolute limit values.

- **Maximum permitted differential pressure** (Exceeding this leads to the destruction of the sensor)
  - Positive: **7000 mbar**
  - Negative: **-3000 mbar**
- **Measuring range: 0 - 2000 mbar**
- In order to avoid overloading with excessive differential pressure, both inputs should always be connected to the pipe system.
- Avoid pressure surges. Slowly open and close valves and taps.
- All connections are equipped with closing rapid-action couplings. Bleeding functions only with the connected hose.

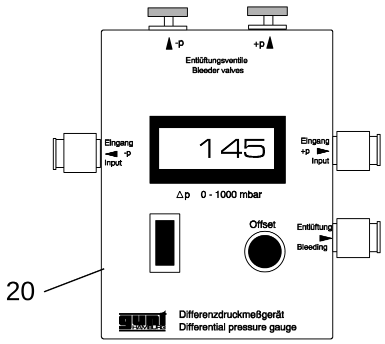


Fig. 2.5: Battery change

- If no measuring hoses are connected, an internal pressure equalization can be performed for the zero setting by opening the bleed valves.
- The measuring gauge is equipped with a battery voltage indicator. At less than 7 V, a battery symbol appears on the display. The operating period is about 40 hours of uninterrupted operation. The 9V battery is mounted on the left-hand side of the device (20).
-

2.3.4 Flow measurement

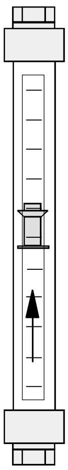


Fig. 2.6: Float-flow meter

To measure the flow, a float flow meter with the following features is used.

- Precision measurement tube of Trogamid
- Exchangeable float of stainless steel
- Clear legible scale
- Max. flow 1600 l/h
- Precision class 2.5

The flow can be read in the upper edge of the tapered lip.

Air bubbles or particles of contamination on the float can influence the measuring precision.

In order to rinse it away, operate the test stand with maximum flow. Open all taps completely for this.

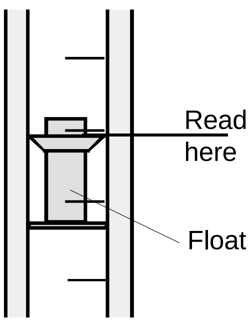
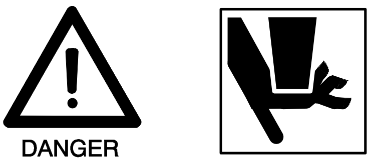


Fig. 2.7: Flow measurement

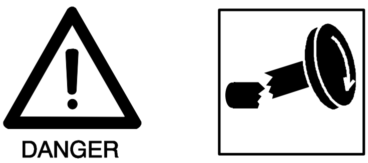
3 Safety

This chapter contains lists of the possible outcomes, that can be produced by improper operation of the training panel.

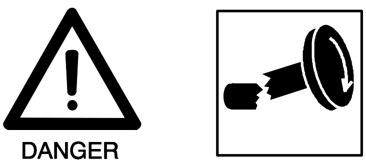
As a matter of principle, all applicable safety regulations are to be observed for all work, in particular the accident prevention regulations of the the government safety organization.



- **DANGER! Take care when changing the training panel.**
  There is a danger of crushing hands and feed when hanging the training panel in place.



- **ATTENTION! Take care during transport.**
  There is a danger of damaging the training panel on door edges, etc. while transporting. It can lead to damages to the measuring devices and valves.



- **ATTENTION! Take care during commissioning.**
  The differential pressure measuring instrument is not to be connected with the annular chambers when filling and flushing, since strong pressure surges can lead to a zero point shift in the sensor

4 Experiments

This section describes examples of experiments that can be performed with this device. The choice of experiments makes no claims of completeness and is intended to serve as a stimulus for your own experiments.

The test description is split into a **basic part** with the most important calculation formulas, the actual **test execution** with the recording of the measurement values and the **comparison between calculation and experiment**.

The measured results listed should not be viewed as reference or calibration values for all conditions. Depending on the design of the individual components used and the individual's experimental skill, greater or smaller variations may occur in your own experiments.

4.1 Pipe flow with friction

In these experiments, the **pressure loss p_V** for a flow subject to friction will be determined experimentally. The measurement values are then compared with the results of the calculation.

With **turbulent pipe flow**, where the flow is considered steady at Reynolds numbers of Re>2320, pressure loss is proportional to the

- Length l of the pipe
- Pipe friction coefficient λ
- Density ρ of flowing medium

Square of the flow speed v.

The pressure loss also increases with diminishing pipe diameter d. It is calculated as follows

$$p_V = \frac{\lambda\, l}{2\, d}\ \rho\, v^2\ .$$

In the case of turbulent pipe flow (Re>2320), the pipe friction coefficient λ depends on the pipe roughness k and the Reynolds coefficient Re. The pipe roughness k defines the height of the unevenness on the wall in mm. The roughness of the sample pipes is listed in the appendix in table 5.1. The relationship between Re, λ and k is shown in the diagram according to Colebrook and **Nikuradse**. The wall roughness k refers to the pipe diameter d.

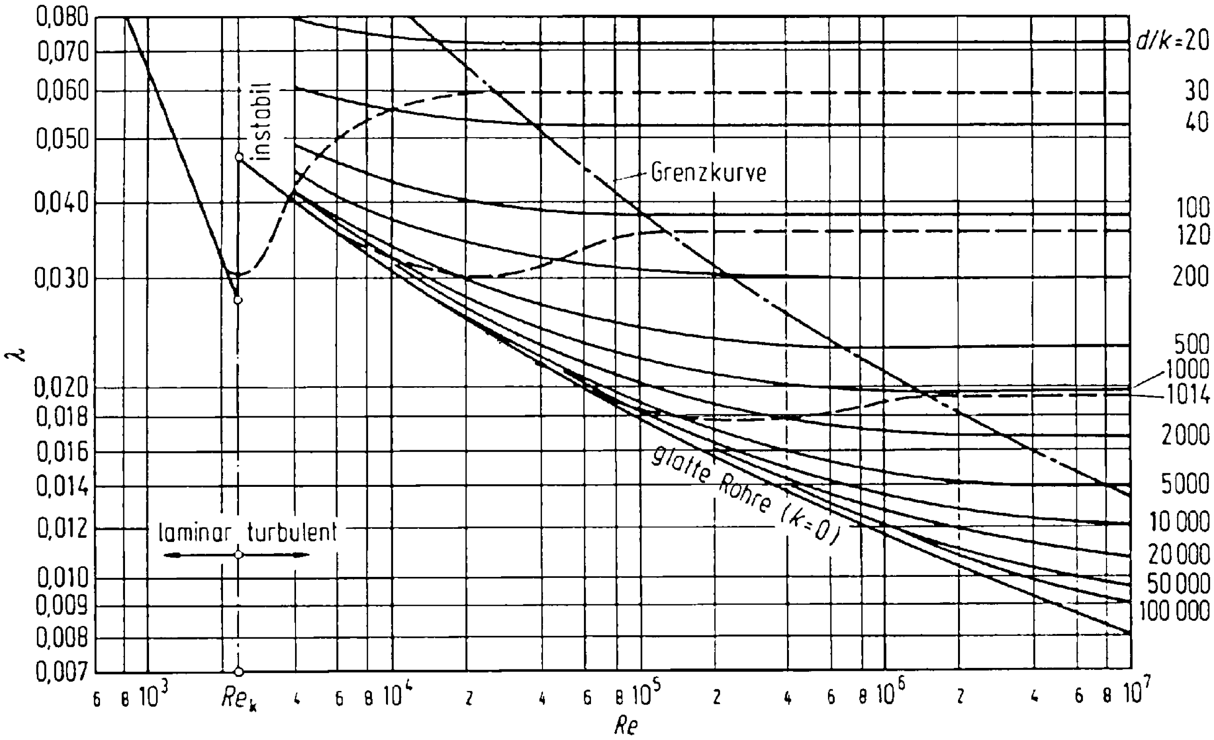


Fig. 4 1: Coefficient of pipe friction λ according to Colebrook and (dotted) according to Nikuradse (from Dubbel: Taschenbuch für den Maschinenbau[Engineering handbook])

The **Reynolds number Re is** calculated from the pipe diameter d, flow speed v and kinematic viscosityν.

$$Re = \frac{v\,d}{\nu}$$

The kinematic viscosity for water can be taken from the table 5.1.2 as a function of the temperature.

The **flow speed v** is calculated from the volumetric flow $\dot{V}$ and the pipe cross-section

$$v = \frac{4\,\dot{V}}{\pi\,d^2}$$

For **hydraulically smooth pipes (Re < 65 d/k)** and a Reynolds number in a range of 2320 < Re < 10^5 , the pipe friction coefficient is calcualted according to the Blasius **formula**

$$\lambda = \frac{0.3164}{\sqrt[4]{Re}} .$$

For **pipes in the transition range to rough pipes (65 d/k 11111 Re < 1300 d/k**, area under the limit trend in the diagram) , the pipe friction coefficient is calculated according to **Colebrook**

$$\lambda = \left[2\,lg\left(\frac{2.51}{Re\,\sqrt{\lambda}} + \frac{0.27}{d/k}\right)\right]^{-2} .$$

It is an implicit formula that must be solved iteratively. First an estimation is made regarding λ to which the formula is applied and a first approximation calculated. This is re-used in the equation to calculate a second approximation. If the estimated value is taken from the diagram according to Colebrook and Nikuradse, the first approximation already generally has a sufficient degree of precision and the values first vary at 3 decimal places.

4.2 Coefficients of resistance for special pipe components

Special pipe components and fittings such as pipe bends or elbows, pipe branches, changes in cross-section or also valves and flaps produce additional pressure losses apart from the wall friction losses.

For changes in cross-section and the associated changes in speed, the proportion of the total pressure loss made up of Bernoulli's pressure loss (dyn. pressure) needs to be taken into account. **Bernoulli's equation** with loss element is

$$\frac{\rho\, v_1^2}{2} + p_1 + \rho\, g\, z_1 = \frac{\rho\, v_2^2}{2} + p_2 + \rho\, g\, z_2 + \Delta p_v \,.$$

Based on the assumption of equal heights z_1 and z_2, this results in the **total pressure loss that can be measured**

$$\Delta p_{ges} = p_1 - p_2 = \frac{\rho}{2}\,(v_2^2 - v_1^2) + \Delta p_v \,.$$

Unlike the wall friction losses investigated in the previous section, apart from a few special cases the additional flow resistance cannot be calculated exactly.

For the various elements, the literature specifies empirically obtained coefficients of resistance ζ. They can be used to easily calculate the additional pressure losses

$$p_{vz} = \zeta\, \rho\, \frac{v^2}{2}$$

This means that for the total head loss, we can state that

$$p_{vges} = \frac{\rho}{2}\left[(v_2^2 - v_1^2) + \frac{\lambda_1\, l_1\, v_1^2}{d_1} + \frac{\lambda_2\, l_2\, v_2^2}{d_2} + \zeta\, v_2^2\right].$$

The pipe friction resistance must be determined separately for the sections before and after the change of cross-section. By contrast, the coefficient of resistance is only related to the speed v_2 after the change of cross-section.

If the speeds are equal, there is no dynamic pressure component and a combined pipe friction component is used.

The measured total head loss and the known pipe friction can be used to determine the coefficient of resistance ζ

$$\zeta = \frac{p_{vges}}{\rho\, v_2^{\,2}} - \left[1 - \left(\frac{d_2}{d_1}\right)^4\right] - \left[\lambda_1 \frac{l_1}{d_1}\left(\frac{d_2}{d_1}\right)^4 + \lambda_2 \frac{l_2}{d_2}\right].$$

Without changing the cross-section ($d_1/d_2 = 1$) the statement is simplified to

$$\zeta = \frac{p_{vges}}{\rho\, v^2} - \lambda \frac{l}{d}\ .$$

4.3 Pressure losses on shut-off fixtures

To regulate the flow volume, shut-off and regulating fixtures of various designs are integrated in pipe lines. Flows are normally subjected to strong directional restrictions and cross-sectional restrictions in these fixtures, which lead to the respective pressure losses. The coefficient of resistance of the shut-off and regulating fixtures is always dependent on the position of the actuator and the rates diameter and can be taken from the respective documentation. The calculations are done according to the formulas from chapter 4.3.2.

The training panel has the following shut-off fixtures to be tested:

- Ball valve PVC, transparent, DN32

- Galvanized brass ball valve, DN15
- Slanted-seat in-line valve, DN15
- Straight-seat in-line valve, DN15
- Socket shut-off gate valve, DN15

When open, the **ball valve** has a completely smooth and free cross-section.

This means that here the lowest pressure losses are to be expected. Drag coefficients right down to $\zeta_R = 0.03$ can be achieved.

Due to its jagged passage cross-section, the **slanted seat in-line valve has a significantly higher coefficient of resistance in the range of** $\zeta_R = 2–3.5$**. However, it is still significantly more favourable in terms of the flow than a standard DIN straight-seat in-line valve**, in which the flow has to be diverted twice by 90. In this case, a coefficient of resistance of around $\zeta_R = 10$ can be expected.

The **socket shut-off gate valve**, in this case a sluice valve, has the same completely free passage cross-section as the ball valve. However, there are side recesses for holding sealing surfaces, resulting in swirling. This means that the coefficient of resistance $\zeta_R = 1–1.5$ is not as good as with the ball valve.

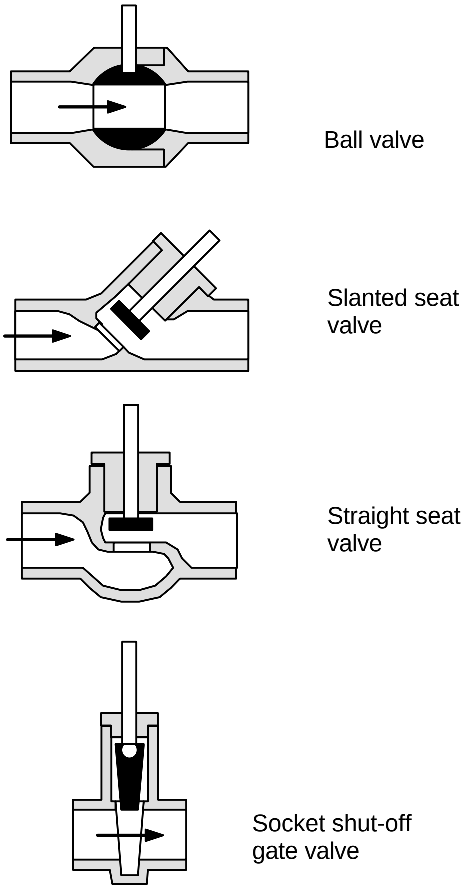


Fig. 4 2: Shut-off fixtures

4.3.1 Performing the experiment

Since only one measuring object is being tested at any given time, the remaining 4 measuring sections are blocked off during the experiments using the shut-off ball valves V3 - V7.

The flow $\dot{V}$ is read directly from the float flow-meter.

The displays of differential pressure gauge and the flow-meter are indicated in tables (Appendix 5.3.1, Worksheet 1).

The pressure gauge is connected and the measurements are carried out as described in section 2.3.

Measured results measuring section 1: Ball valve, PVC transparent, DN32 l= 240 mm	
Volumetric flow $\dot{V}$ in l / h	p_V in mbar
200	0
400	0
600	0
800	0
1000	0
1200	0

Measured results Measuring section 2: Ball valve, Ms offs., DN15 l= 220 mm	
Volumetric flow $\dot{V}$ in l / h	p_V in mbar
200	0
400	0
600	2
800	7
1000	10
1200	16

Measured results Measuring section 3: Slanted-seat In-line valve, DN15 l= 250 mm	
Volumetric flow $\dot{V}$ in l / h	p_V in mbar
200	0
400	3
600	12
800	23
1000	38
1200	57

Measured results Measuring section 4: Straight-seat In-line valve, DN15 l= 220 mm	
Volumetric flow $\dot{V}$ in l / h	p_V in mbar
200	4
400	26
600	61
800	111
1000	185
1200	254

Measured results Measuring section 4: Socket shut-off gate valve, DN15 l= 180 mm	
Volumetric flow $\dot{V}$ in l / h	p_V in mbar
200	0
400	0
600	3
800	7
1000	14
1200	22

The graphic representation of the measurement results shows that, as expected, the slanted-seat in-line valve has the highest loss. The ball valve of measurement section 1 is distinguished with no losses. The shut-off gate valve for measurement section 5 also has very little loss. The ball valve of measurement section 2 on the other hand, shows a higher flow resistance than expected.

This is because of the inner structure of the type used. The ball valve is not designed for a low flow resistance by the manufacturer. It has a passage cross-section that is 15 mm under the pipe diameter and has sharp-edged transition points.

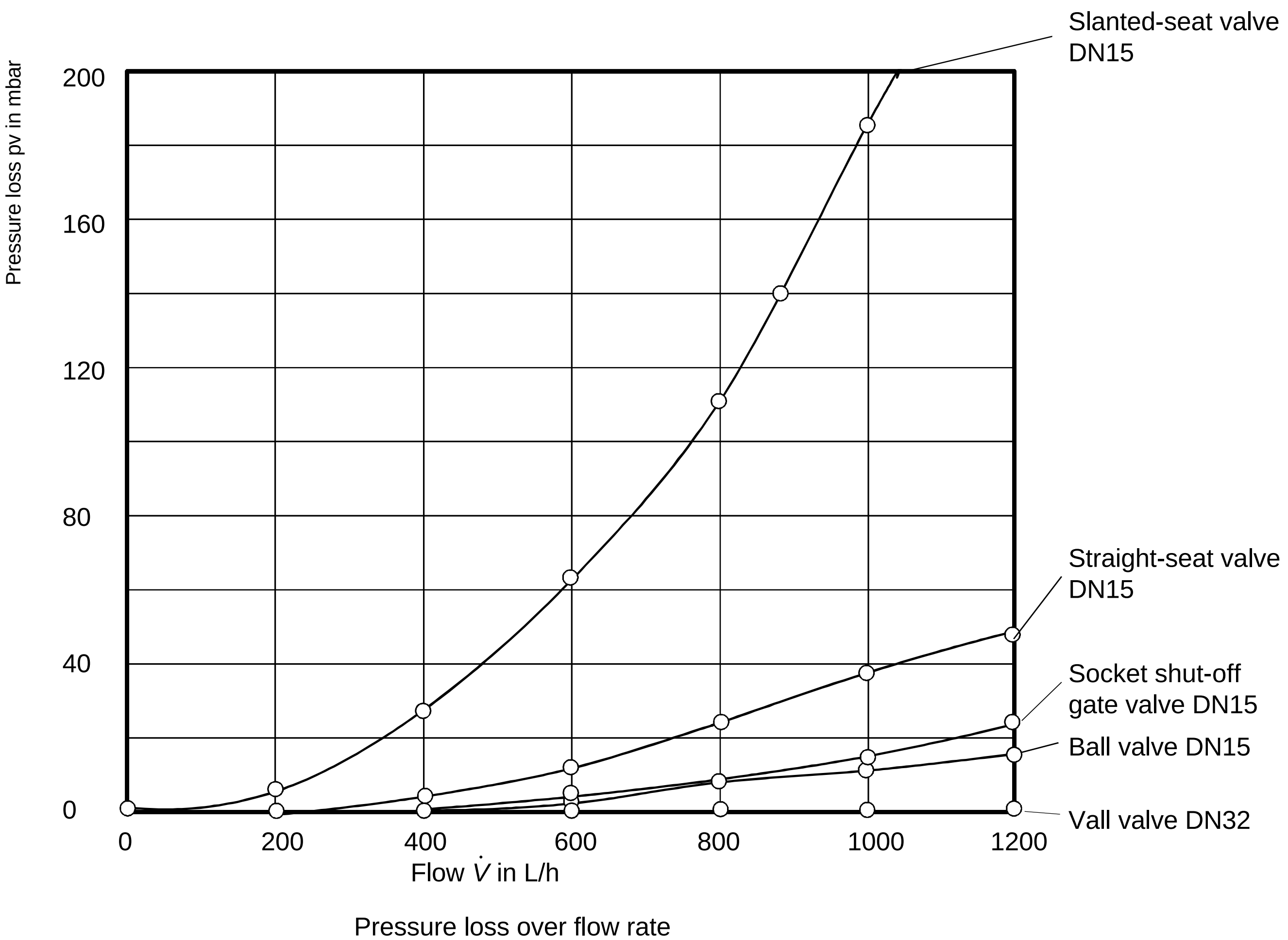


Fig. 4 3: Graphic display of measured results

4.3.2 Calculation of coefficients of resistance

For shut-off fixtures ball valve, slanted-seat valve and gate valve, the coefficient of resistance is determined according to the following formula

$$\zeta_R = \frac{p_{vges}}{\rho\, v^2} - \lambda \frac{l}{d} \ .$$

The distance between the measurement supports is used as length l .

Calculation of coefficient of resistances ζ_R for various ball valves, Valve and gate						
Pipe section	internal diameter d in mm	length in mm	volumetric flow in m$\dot{V}$3/s	flow speed v in m/s	Reynolds No.Re	d/k
1 ball valve DN32	32	240	$33.3 \cdot 10^{-5}$	0.41	12159	32000
2 ball valve DN15	15	220	$33.3 \cdot 10^{-5}$	1.88	26135	15000
3 slanted-seat valve DN15	18	250	$33.3 \cdot 10^{-5}$	1.31	21853	18000
4 straight-seat valve DN15	17	220	$33.3 \cdot 10^{-5}$	1.47	23160	17000
5 socket gate valve DN15	15	180	$33.3 \cdot 10^{-5}$	1.88	30241	15000

Pipe section	λ calculation in accordance with	pipe friction coefficient λ	measured pressure loss p_{vges} in mbar	**coefficient of resistance ζ_R 1 ball valve DN32**
2 ball valve DN15	Blasius	0.0249	17	**0.12**
3 slanted-seat valve DN15	Blasius	0.0260	57	**2.96**
4 straight-seat valve DN15	Blasius	0.0256	254	**11.40**
5 socket gate valve DN15	Blasius	0.0286	25	**0.36**

Overall, the coefficients for resistance values are very similar to those in the documentation.

4.4 Opening characteristics of shut-off fixtures

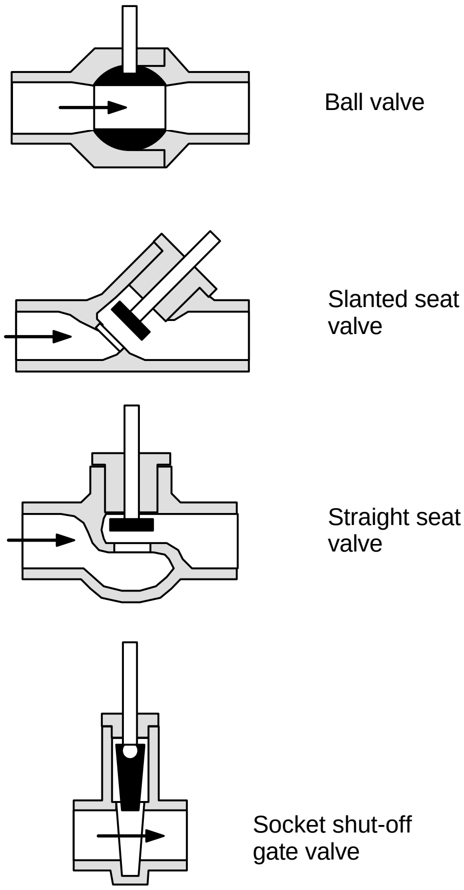


Fig. 4 4: Shut-off fixtures

In these experiments, the throttling behaviour of the ball valve, valve and gate valve shut-off fixtures are investigated.

If shut-off devices are used to set particular volumetric flows in pipe systems, at low opening levels and volumetric flows, considerable attention needs to be paid to good dosing capability.

A progressive characteristic curve is optimal, where the opening level rises slowly at first then increasingly quickly. Adjustment of the shut-off device by a particular absolute amount results in a corresponding percentage change in the volumetric flow.

For example:

If a valve with a maximum opening of 10 revolutions is opened from 1 to 2 revolutions, i.e. by 10% absolute, the volumetric flow will show a relative increase of 10%, e.g. from 1 to 1.1 l/min.

This so-called "equal percentage characteristic curve" is designated as progressive in the adjacent diagram. Plotted next to it are a linear and a degressive characteristic curve, as occur on typical shut-off devices.

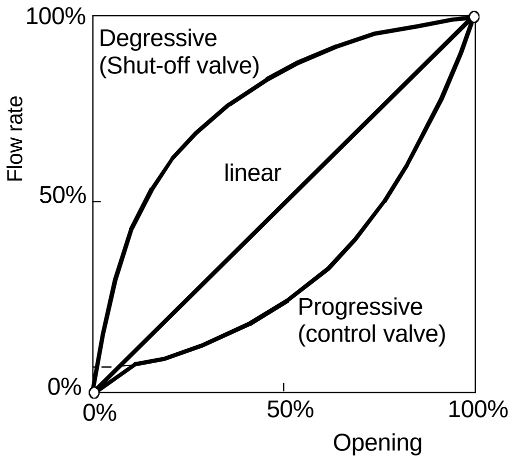


Fig. 4 5: Opening characteristics of valves

4.4.1 Performing the experiment

Only one measuring section is ever supplied at any given time. The ball valves in the feed area of the other 4 measurement segments must be closed off.

In order to meet general uniform tolerances, before every test, the maximum flow is to be set with completely open valve at $\dot{V}$ **= 600 l/ h** on the regulating valve water inlet 10.

Ball valve DN32

- Close ball valve completely
- Open the ball valve by a defined angle e.g. 30 in steps and make a note of the flow-rate

Ball valve DN15

- Close ball valve completely
- Open the ball valve by a defined angle e.g. 30 in steps and make a note of the flow-rate

Slanted-seat in-line valve DN15

- Close the slanted-seat valve completely
- Open the slanted-seat valve by a defined amount of turns in steps and note down the flow-rates.

CAUTION! Since the valve is very sensitive at the beginning, choose very small opening steps of 1/4 turn to start with.

Straight-seat in-line valve DN15

- Close the straight-seat valve completely
- Open the straight-seat valve by a defined amount of turns in steps and note down the flow-rates.

CAUTION! Since the valve is very sensitive at the beginning, choose very small opening steps of 1/4 turn to start with.

Socket shut-off gate valve DN15

- Open pipe section drain
- Open pipe section feed
- Close the gate valve completely
- Open the socket gate valve by a defined amount of turns in steps and note down the flow-rates.

4.4.3 Evaluation of the experiment

The measured values recorded can be plotted graphically against the opening of the shut-off fittings.

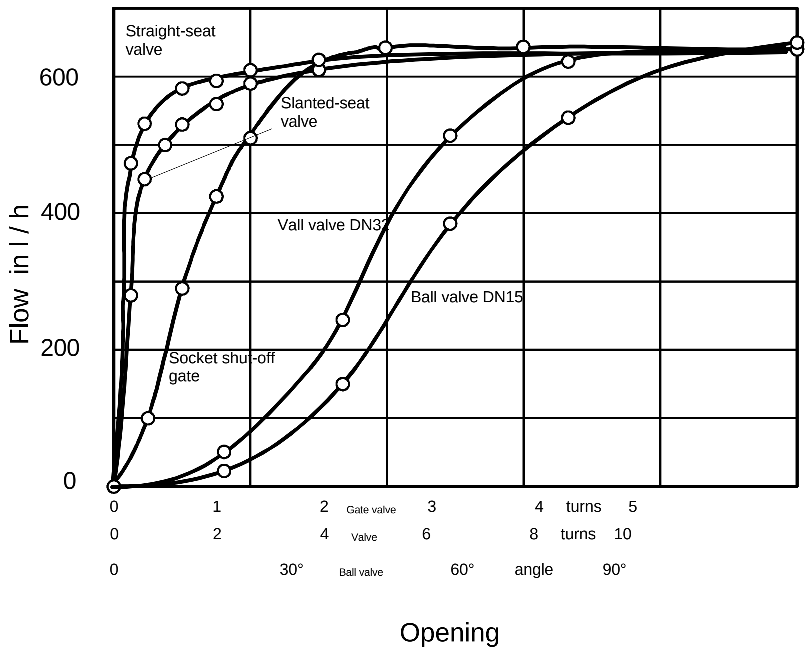


Fig. 4 6: Opening characteristics of the tested valves

The slanted-seat valve and the straight-seat valve open very quickly and are therefore typical shut-off fixtures. To throttle a flow-volume, the valve is just as unsuitable as the gate valve. The ball valves are much more suitable as throttle fixtures on the other hand. However, none of the tested shut-off fixtures has a purely progressive characteristic curve therefore having especially good throttling properties.

5 Appendix

5.1 Technical data

Powder-coated steel plate panel
Color Off-white

Main dimensions:
L x D x H 1650 x 200 x 1100 mm

Weight: 54 kg

Cold water connection: Rapid-action coupling with hose connection

Drainage connection: Rapid-action coupling with hose connection

Electronic differential pressure gauge with bleed unit.

Measuring range	0 - 1000	mbar
Digital display	3 1/2	digit
Burst pressure absolute	7	bar
Max. permitted differential pressure	-1...+4 bar	
Supply	9 V/ 12 mA	

Float flow meter 0 - 1600 l/h

Measuring objects:

Ball valve, PVC transparent:		DN32
Internal diameter:	32	mm
Coefficient of resistance ζ:	0	
Ball valve, Ms galvanized:		DN15
Internal diameter:	15	mm
Coefficient of resistance ζ:	0	
Slanted-seat in-line valve:		DN15
Internal diameter:	18	mm
Coefficient of resistance ζ:	3	
Straight-seat in-line valve:		DN15
Internal diameter:	17	mm
Coefficient of resistance ζ:	10	
Socket shut-off gate valve:		DN15
Internal diameter:	15	mm
Coefficient of resistance ζ:	1	

5.2 Used symbols

A	m^2,mm^2	Surface
d	m, mm	Pipe inner diameter
k	mm	Wall roughness
l	m, mm	Length
p	N/m^2=Pa, mbar	Pressure
p_0	N/m^2=Pa, mbar	Air pressure
p_v	N/m^2=Pa, mbar	Pressure loss
Re	-	Reynolds Number
v	m/s	Speed
$\dot{V}$	m^3/s	Volumetric flow
λ	-	Pipe coefficient of friction
ν	m^2/s	Kinematic viscosity
ρ	kg/m^3	Density
ζ		Coefficient of resistance

5.3 Diagrams and tables

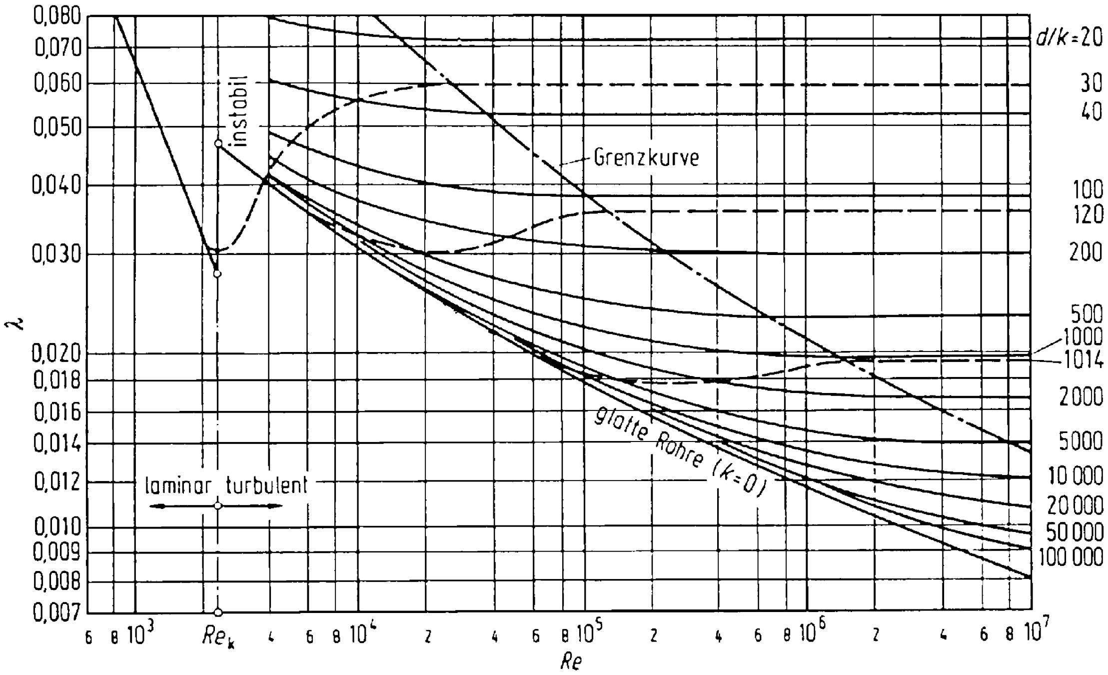


Fig. 4 1: Coefficient of pipe friction λ accordng to Colebrook and (dotted) according to Nikuradse (from Dubbel: Taschenbuch für den Maschinenbau[Engineering handbook])

Kinematic viscosity of water depending on the temperature (based on Kalide: Technische Strömungslehre [Technical fluid mechanics)	
Temperatur in °C	kinem. viscosity ν in 10^{-6} m^2/s
10	1.297
11	1.261
12	1.227
13	1.194
14	1.163
15	1.134
16	1.106
17	1.079
18	1.055
19	1.028
20	1.004
21	0.980
22	0.957
23	0.935
24	0.914
25	0.894
26	0.875
27	0.856
28	0.837
29	0.812
30	0.801

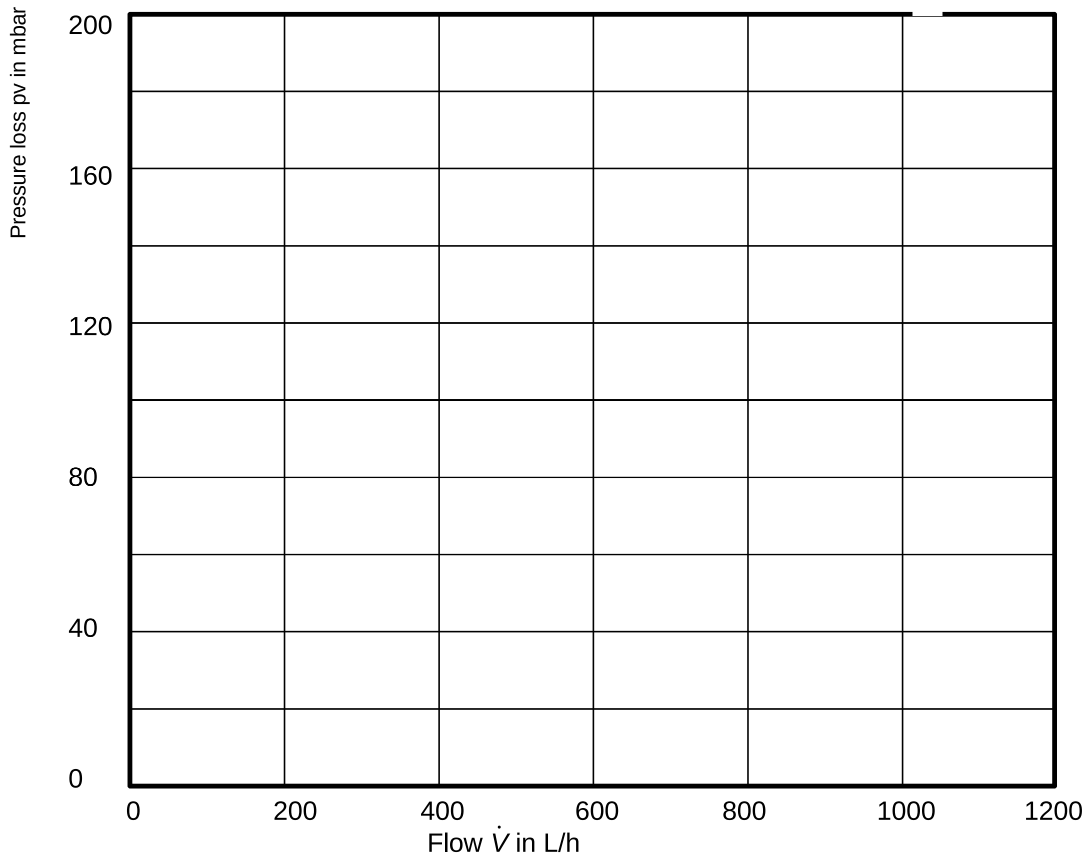
Wall roughness of measuring objects		
Material	Surface	Wall roughness k
Ball valve, PVC transparent	Technical smooth	0.001 mm
Ball valve, Ms galvanized	Technical smooth	0.001 mm
Slanted-seat In-line valve	Technical smooth	0.001 mm
Straight-seat In-line valve	Technical smooth	0.001 mm
Socket shut-off gate valve	Technical smooth	0.001 mm

5.4 Forms

Measured results Measurement section : , DN l= mm	
Volumetric flow $\dot{V}$ in l / h	p_v in mbar

Measured results Measurement section : , DN l= mm	
Volumetric flow $\dot{V}$ in l / h	p_v in mbar

Measured results Measurement section : , DN l= mm	
Volumetric flow $\dot{V}$ in l / h	p_v in mbar



Pressure loss over flow rate

Calculation of coefficient of resistances ζ_R for various ball valves, Valve and gate

Pipe section	internal diameter d in mm	length in mm	volumetric flow $\dot{V}$ in m^3/s	flow speed. v in m/s	Reynolds No. Re	d/k

Pipe section	λ Calculatetin accordance with	Pipe friction coefficient λ	measured pressure loss p_{vges} in mbar	**Drag coefficent** ζ_R

5.5 Index

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