7 Fluidic experimental plants

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Industrial scale fluidic experimental plants

Industrial systems consist of various components that are often in separate locations. The individual modules are made up of various components in which the various work processes run. Here, one process may influence both the following and the preceding operations.

Interactions between the individual work processes affect the overall system. This effect occurs in all real, industrial plants. Studying the individual components alone does not reflect reality. Measuring results are not representative of an entire plant if the aspect of the interplay between the individual components and their interaction is not considered.

GUNT offers a range of large-scale equipment. GUNT's development team has paid attention to the mutual impact and influence of the processes on individual components when planning and designing the equipment. This means that the GUNT equipment can be used to conduct practical investigations and experiments with realistic measuring results.

Practical relevance is further enhanced by the use of industrial components and measurement techniques.

Advantages of large-scale equipment

- highly relevant to practice thanks to the use of industrial components and measurement techniques
- large experimental plants allow precise measurements with realistic values: small model plants often give contradictory results that have to be corrected due to disproportionately increasing losses

Complex technical systems from industry

Complex technical systems from the GUNT range

Air duct system in an office complex

HL 710 Air duct systems

Pump station in Achau, Germany

HL 962 Assembly stand for pumps

Axial-flow turbomachine by Sulzer Innotec

HM 405 Axial-flow turbomachines

Wastewater engineering in a large building

ST 510 Full-scale sewerage system

GUNT offers a range of large-scale equipment. The didactic concept of the experimental plants covers the following topics in order to offer practical training:

Familiarisation with complex plant systems

- interaction of the individual components in the overall system
- consequences of interactions between the individual work processes

Design of complex plant systems

- learn about planning, design and assembly of a large technical plant
- plan and practise maintenance
- functional tests and operational measurements
- apply technical competence and basic knowledge

Application of metrology

- recording measured values for a comparison of theory and practice
- all sensors are components from industry

HM 124 Fluid mechanics experimental plant

HM 124 experimental plant in laboratory with optional pressure controlled system via a pressure vessel

Experiments and learning objectives

- experiments on pumps, valves and fittings and pipes
- operating behaviour of centrifugal pumps in stand-alone or parallel operation
- recording pump characteristics
- determining pump efficiencies
- influence of system characteristic on flow rate and operating point of the pumps
- measurements of pressure losses in pipe bends and in pipes of different roughness
- measurements of the velocity distribution in pipes
- visualization of the pipe flow
- determination of loss coefficients in fittings
- recording of opening characteristics and K_v values
- adjustment and maintenance on valves
- experiments on flow and pressure control loops

This complex experimental plant consists of several modules: a pump station, two measuring sections, a control station, a tank system and an optional pressure controlled system. The modules themselves include a number of components: centrifugal pumps in different sizes, various valves, level and pressure controllers, pipes of different diameters and surface roughness, control valves and fittings, pipe fittings and various tanks to name a few.

The interaction of the various components determines the fluidic behaviour of the overall system. The individual processes interact with each other, resulting in interactions that affect the entire system. This effect occurs in all real, industrial plants. Studying the individual components does not reflect reality. In order to obtain comparable, objective measuring results on individual components, certain conditions must be met. For example, certain inlet and outlet sections are required for the measurement of valve characteristics.

This aspect has been taken into consideration when planning and designing the HM 124 experimental plant, so that objective measuring results can be achieved. The components are matched to each other to largely minimise the mutual interaction and influence of the processes on the individual components. This means rigorous experiments from the field of fluid mechanics can be performed. The system is also ideally suited for scientific investigations.

The use of industrial components and measurement techniques teaches great practical relevance

Industrial metrology

Industrial components

The individual design of the measuring section offers the user a wide range of experiments.

There are two different sized centrifugal pumps available for investigations on pumps.

The experimental plant HM 124 requires a high degree of professionalism during the planning stage, since the system must be carefully matched to the laboratory space due to its size. GUNT engineers are available for planning an individual arrangement and design of the experimental plant.

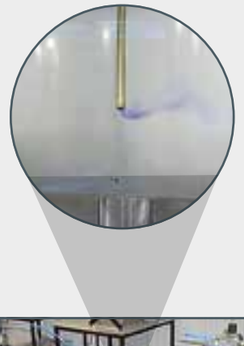
If there is sufficient space available, a second intake tank may be added on the floor below the experimental plant. The resulting greater suction head makes it easier to conduct series of experiments on the operating behaviour of a pump in relation to the NPSH and cavitation.

The industrial scale control console ensures a clear and convenient operation.

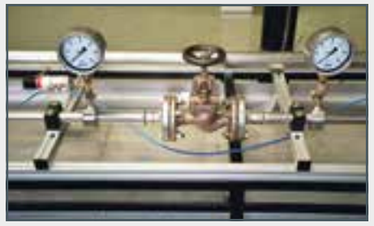
HM 124 Fluid mechanics experimental plant

HM 124 measuring section components

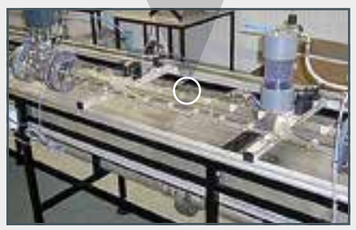
HM 124
measuring section



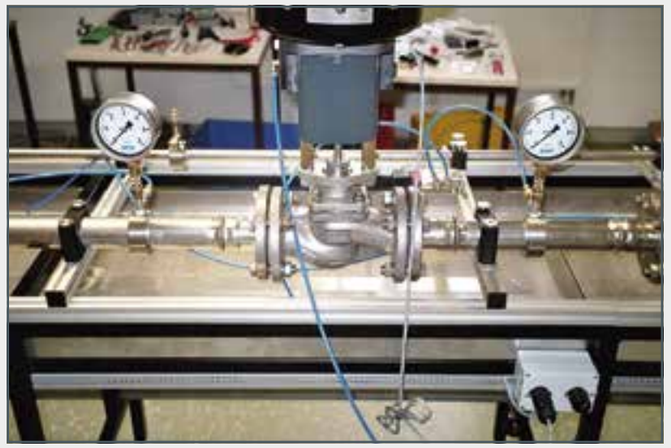
Measurement of pressure losses at 45° and 90° pipe bends.



A corresponding measurement station has been incorporated into the measuring section to record a valve characteristic.



A transparent measuring section and a contrast agent means flows can be visualised.

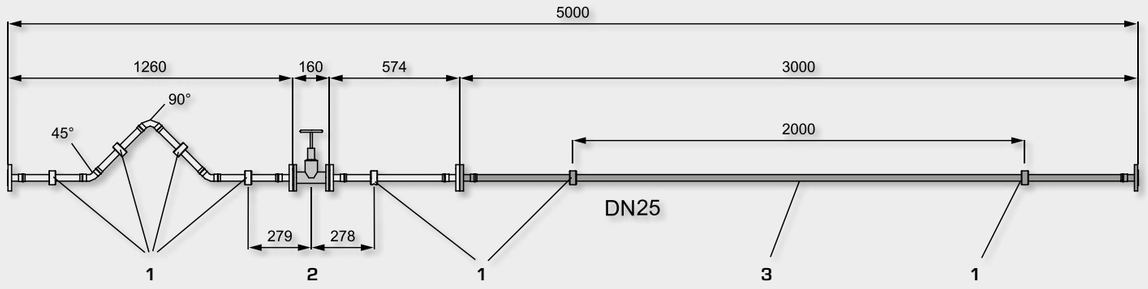


Pipe sections with different diameters and made from different materials are available for measuring pressure losses. In addition to hydraulically smooth pipe sections there is also a pipe section with a defined roughness.

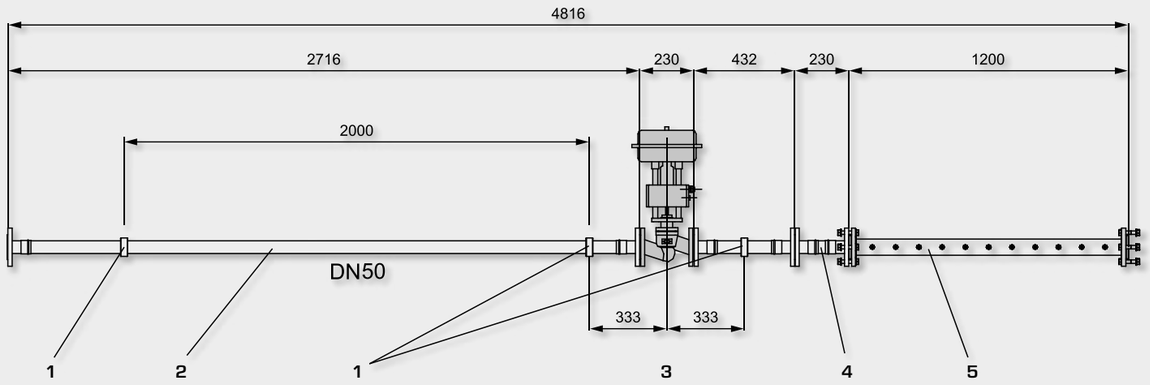
Measurements for determining the K_v value are conducted on an industrial control valve. Other valves with standard flanges (not included) can be installed and studied.

The experimental plant has two parallel measuring sections with nominal diameters of DN25 and DN50.

The individual pipe elements can easily be removed and installed by means of flanges. This means it is possible to construct individual pipe section configurations. Each measuring section is fitted with a valve at the inlet and outlet. When redesigning the plant, any water that escapes is collected in a pan below the measuring section.



1 measuring points for pressure losses in pipe elements, **2** measuring range for shut-off element,
3 defined pipe section with DN25 for measuring pipe friction coefficients



1 pressure measuring points, **2** defined pipe section with DN50 for measuring pipe friction coefficients, **3** measuring range for K_v value valve test,
4 pipe element or flow straightener, **5** transparent pipe used for observing the reduction of vortices after disturbances

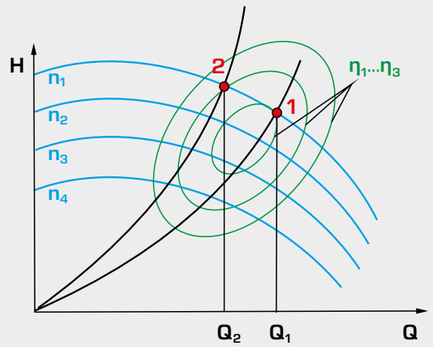
HM 124 Fluid mechanics experimental plant

Pump station of HM 124

The two pumps in the pump station are operated from the control station. The speed can either be adjusted manually or automatically controlled.

The operating behaviour of pumps is studied. In conjunction with the software, it is possible to record characteristics at a constant speed and fixed efficiency. The collected data is used to determine characteristic fields for the pumps. The diagram below shows an example of system characteristic of a pump station with the operating points 1 and 2. The pump characteristics at different speeds are highlighted in blue, the efficiency in green.

HM 124 pump station



H head, **Q** flow rate, **η** efficiency, **n** speed, **1** + **2** operating points; pump characteristics, efficiency

Control station of HM 124

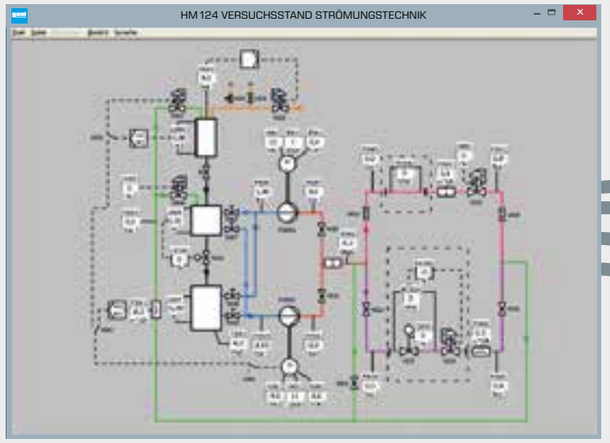
Transfer of measured data to a PC

HM 124 control station

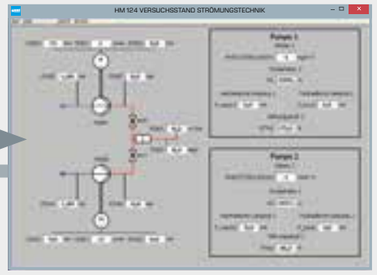
All electronic displays and controls are housed in the control station. The experiments can be conducted manually or automatically. The measured values are displayed on digital displays on the control console. Data acquisition and the related GUNT software can be used to clearly display the measured data on a PC. Upon request, all measurement data is available as standard electrical signals (0 - 10 V, 4 - 20 mA).

Data acquisition of HM 124

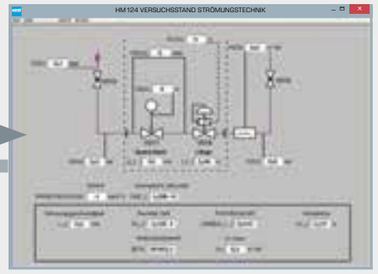
The software has its own sub-schematics available for the various experiment options.



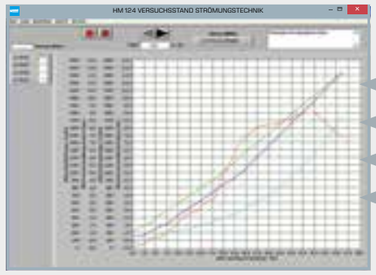
All of the measured values from the experimental plant HM 124 are shown in an overview schematic on the PC, giving a quick summary.



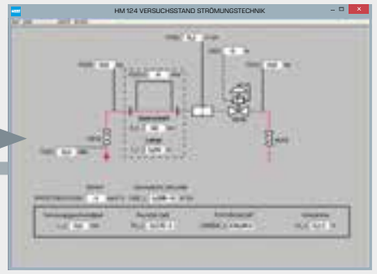
Record operating behaviour of pumps



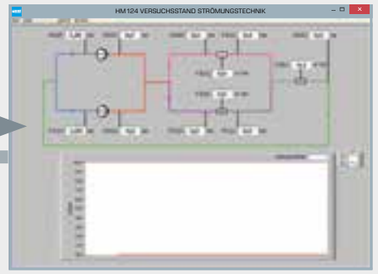
Determine opening characteristic and K_v values at valves and fittings and control valves



Measurement data can be evaluated quickly and clearly via the software and displayed graphically.



Measure pressure losses in pipe sections and pipe elements



Record system characteristics

HM 124
Fluid mechanics experimental plant

Description

- **large scale to ensure realistic measuring results**
- **operating behaviour of centrifugal pumps**
- **pressure losses in piping elements**
- **K_v value determination of control valves**
- **flow rate and pressure control**

HM 124 allows precise investigations of different fluidic problems. The large scale of the experimental plant and the use of industrial components deliver results close to reality. The dimensions of the experimental plant allow sufficient inlet and outlet sections for the flow formation.

HM 124 consists of several assemblies: a pump station with two differently sized centrifugal pumps, a priming tank, two measuring sections – each of five meter length – one with a nominal diameter of 50mm (DN50), the other one with 25mm nominal diameter (DN25), and a control room consisting of a control console and data acquisition. Optionally the experimental plant may be operated with an additional tank on a lower level for higher suction heads. The complex system may be adjusted in a flexible way to the local facilities.

Many interchangeable piping elements allow an extensive experimental range. Using the measuring section DN50, the K_v values of different control valves can be determined conforming to standards, e.g. an electropneumatic control valve. A transparent pipe section with ink injection allows to observe the flow in the wake of a fitting or a valve. To measure pipe resistances, pipe sections with different surface roughness are inserted in the measuring section DN25.

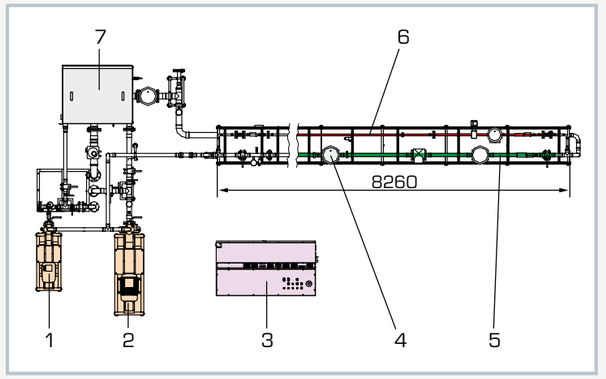
A pressure controlled system controls the system pressure, the flow rate is controlled by a flow controller and the speed of the pumps. The pumps are operated by the control console. Thus the mapping of pump characteristics is comfortably done.

The experimental plant is equipped with numerous sensors for pressure, flow rate, temperature, speed and torque. The measured values can be read on digital displays. At the same time, the measured values can also be transmitted directly to a PC via USB. The data acquisition software is included.

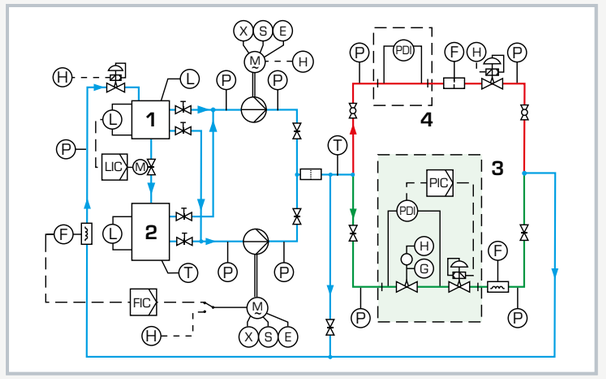
Learning objectives/experiments

- experiments with pumps, valves and fittings and pipe sections
- operating behaviour of centrifugal pumps in individual or parallel operation
- measurement of the NPSH value of pumps
- pressure losses in pipe sections with different surface roughness
- pressure losses in pipe fittings
- K_v value determination of control valves and fittings
- visual investigation of turbulent pipe flow
- experiments on flow rate and pressure controlled systems

HM 124
Fluid mechanics experimental plant



Flexible setup of the experimental plant: 1 pump 32/160, 2 pump 40/250, 3 control console, 4 measuring location for control valves, 5 measuring section DN50, 6 measuring section DN20/25, 7 upper priming tank



Complex process schematic: 1 upper priming tank, 2 additional tank in lower level, 3 measuring location for control valves, 4 measuring location for pipe sections; green: measuring section DN50, red: measuring section DN20/25, blue: pipes

Control station consisting of control console and data acquisition for convenient recording and analysis of the experiments

Specification

[1] experimental plant in laboratory scale
[2] 2 measuring sections, each of 5m length
[3] 2 centrifugal pumps including electrical and mechanical measurement, variable speed via frequency converter
[4] measuring location DN50 conforming to standards to determine K_v values in control valves
[5] interchangeable piping elements
[6] flow controlled system
[7] separate control station with control console and data acquisition
[8] electronic measurement and digital display of all important measured values at the control console
[9] differential pressure control at determination of K_v value
[10] GUNT software for data acquisition via USB under Windows 7, 8.1, 10

Technical data

Pipe system
- nominal diameters: DN25, DN50, DN80, DN100
- pressure stage: PN10
- priming tank: 500L (optional tank 1200L)
- control valves: 1x K_{vs}10, 2x K_{vs}40, 1x K_{vs}100

Pumps, speed: 300...3000min^{-1}
- norm pump 32/160, 20m^3/h, 34,7m, 4kW
- norm pump 40/250, 40m^3/h, 66,5m, 11kW

Pipe sections
- 1: length: 3m, smooth/rough, DN25/DN20
- 2: length: 3m, smooth, DN50
- 3: length: 1,2m, 10 measuring connections, transparent, DN50

Measuring ranges
- pressure: 8x 10bar, 2x -1...0,6bar
- differential pressure: 2x 0...1,6bar
- flow rate: 1x 0...50m^3/h, 1x 0...100m^3/h
- orifice plate flow meter: DN25, 0...0,6bar

400V, 50Hz, 3 phases
LxWxH: 11450x4500x2400mm
Weight: approx. 1000kg

Required for operation

water connection: 1,5m^3/h
PC with Windows recommended

Scope of delivery

1 pump station
2 measuring sections
2 priming tanks
1 control console
1 set of accessories
1 GUNT software CD + USB cable
1 set of instructional material

Assembly and maintenance excercises pipes, valves, fittings and pumps

HL 962
Assembly stand for pumps

HL 962.01
Standard chemical pump

HL 962.02
Canned motor pump

HL 962.03
Side channel pump

HL 962.04
Standard chemicals pump with magnetic clutch

HL 962.32 **Pipe systems and fittings**
Set of pipes, valves and fittings and connecting elements, adapted to the respective order configuration.

HL 962.30
Tank system

Learning objectives

Familiarisation with plant components:
- different pumps and their drives
- elements of pipeline construction
- valves and fittings, fastening and sealing elements, measuring instruments

Electrical connections of a pump drive plus displays and controls

Alignment of pump and drive motor

Operational measurements in piping and pumping systems

Repair and maintenance tasks and procedures

Reading and understanding technical documents such as: drawings, schematics or original operating instructions

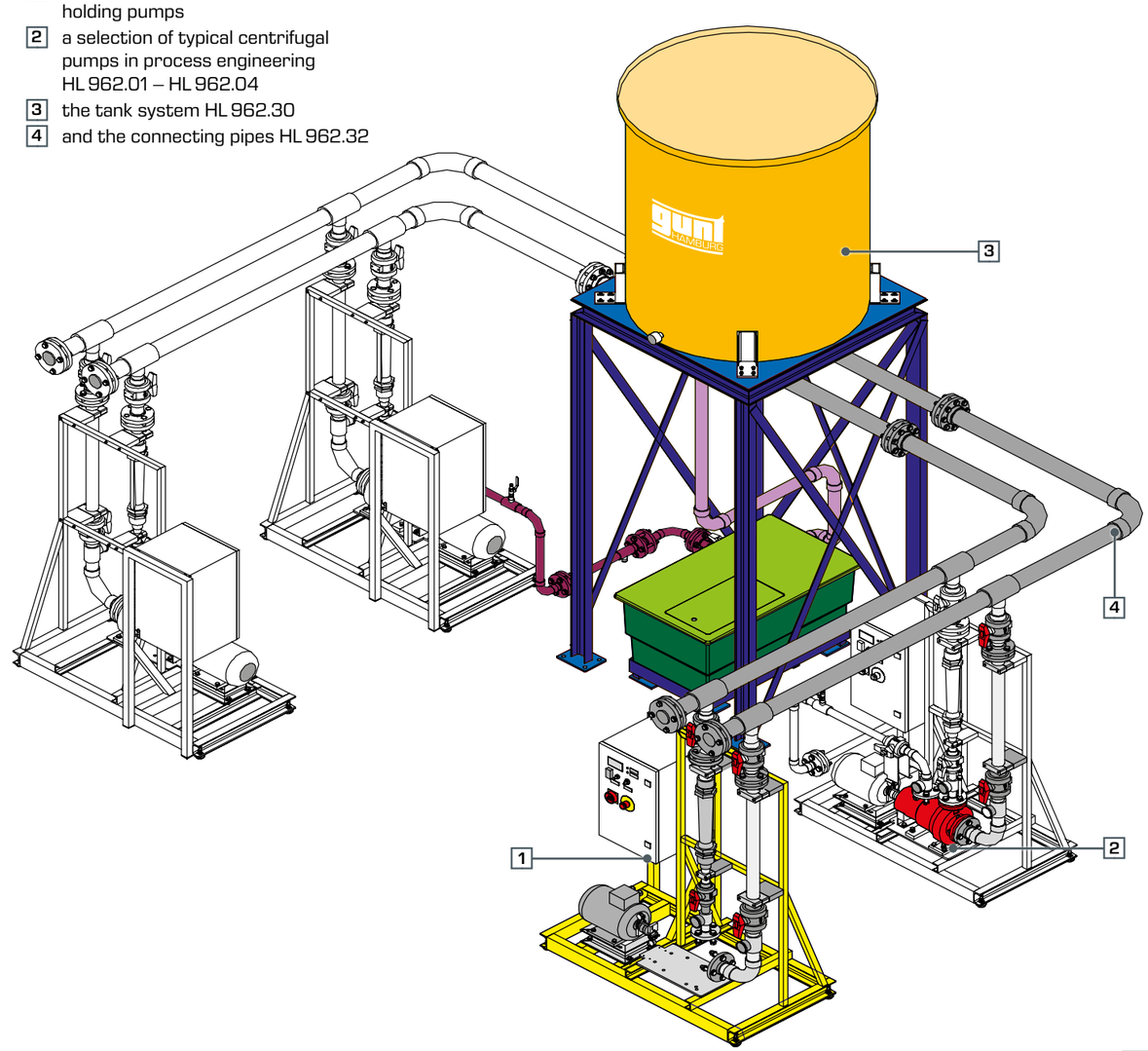
Familiarisation with the procedures for commissioning

Repairing machines such as pumps, piping systems and valves and fittings is an important part of the work of maintenance technicians. In particular, the steps are divided into:
- the removal and installation of pumps for inspection, repair or replacement
- aligning the drive
- commissioning and testing the pump, e.g. for leaks

The complete exercise system that allows the individual steps to be practised consists of the following components:
1. the assembly stand HL 962 for holding pumps
2. a selection of typical centrifugal pumps in process engineering HL 962.01 – HL 962.04
3. the tank system HL 962.30
4. and the connecting pipes HL 962.32

Several assembly stands with identical or different pumps can be integrated into the training system and expanded to create a network.
The main component of the training system is the assembly stand, which holds the pumps. This assembly stand is prepared for the installation of different centrifugal pumps and provides the drive. Used in conjunction with the tank system and the connecting lines results in a complete system with a closed water circuit.

The training system represents complex project work for training pipeline and plant fitters as well as for service and maintenance mechanics. Several students can cooperate in a small study group. The planning and exercise instruction manuals can take several days to complete. The detailed technical documents provided, in conjunction with the teacher's notes, effectively support the learning process.



HL 962
Assembly stand for pumps

The illustration shows a similar unit.

Learning objectives/experiments

- in conjunction with an accessory pump (standard chemicals pump HL 962.01, canned motor pump HL 962.02, side channel pump HL 962.03, standard chemicals pump with magnetic clutch HL 962.04) and a suitable water supply, e.g. HL 962.30 with HL 962.32
  - mounting of the pump and alignment of the electric motor
  - familiarisation with various methods of aligning the motor and pump
  - commissioning and leak testing
  - recording a pump characteristic
  - comparison of various pump types (only if multiple pumps are available)

Description

- **mounting of different pumps (available as accessories)**
- **alignment of motor and pump by different methods**
- **base unit when constructing a complex piping system**

The individual steps for repairing driven machines such as pumps are: removal and installation of pumps for inspection, repair or replacement; aligning the drive and commissioning and checking the pump, e.g. for leaks.

In conjunction with the HL 962.30 tank system, the HL 962.32 connecting pipes and one of the four HL 962.01 – HL 962.04 pumps, the HL 962 assembly stand forms a complete training system for complex piping and plant systems. The training system forms a closed water circuit.

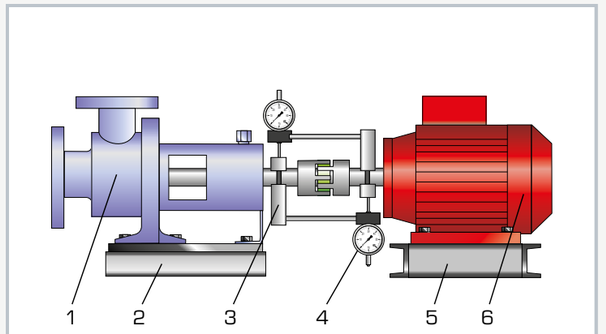
The assembly stand HL 962 includes a three-phase asynchronous motor with frequency converter as the drive and pipes with valves to adjust the pressure. A pump from the accessory equipment is attached to the base plate of the assembly stand and connected to the drive and the pipes. The pumps that are available as accessories are typical centrifugal pumps used in process engineering.

The position of the asynchronous motor can be adjusted in three directions for alignment purposes. The alignment can either be checked in a conventional manner with a straight edge or with the reverse alignment method using two dial gauges. Non-contact, microprocessor-aided methods can also optionally be used (specific alignment systems are not included in the scope of delivery).

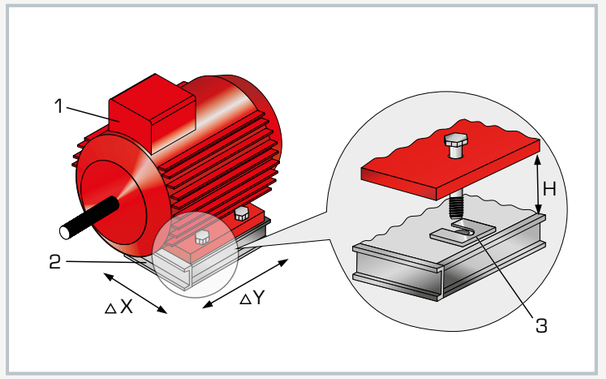
Manometers indicate the pressures upstream and downstream of the pump. The flow rate is measured with a rotameter. Speed and power output of the motor are indicated on digital displays.

HL 962
Assembly stand for pumps

1 flange connections to connect HL 962 to HL 962.30, 2 switch box with displays and controls, 3 electric motor, 4 mounting plate for test pump, 5 flange connections for test pump, 6 manometer, 7 valve, 8 flow meter



1 HL 962.01 pump, 2 pump base plate, 3 bracket for dial gauge, 4 dial gauge, 5 motor base plate, 6 electric motor



Aligning the electric motor (height, x and y direction): 1 electric motor, 2 base plate, 3 fitting plates to adjust the height H

Specification

[1] stand for mounting of various pumps
[2] asynchronous motor with variable speed via frequency converter
[3] electric motor with positioning frame and fit plates for alignment
[4] base plate prepared for mounting of various pumps
[5] alignment of motor and pump with straight-edge or by dial gauges
[6] switch box with speed adjuster and digital display of speed and power output
[7] frame with adjustable feet for levelling
[8] PVC piping
[9] water supply from tank system HL 962.30
[10] the system forms part of the GUNT assembly, maintenance and repair practice line

Technical data

Three-phase AC asynchronous motor
- power output: 4kW, speed range: 0...1450min^{-1}

Connecting flanges for water supply
- intake side: DN50
- delivery side: DN50
- intake side channel pump: DN32

Fit plates as motor chocks
- 43x43mm
- 4 different thicknesses: 0,1 – 0,2 – 0,5 – 1,0mm, 20 of each

Measuring ranges
- pressure (inlet): ±1bar
- pressure (outlet): 0...16bar
- flow rate: 0...11m^3/h
- speed: 0...3000min^{-1}
- power: 0...4kW
- travel: 0...3mm, resolution: 0,01mm

400V, 50Hz, 3 phases
400V, 60Hz, 3 phases; 230V, 60Hz, 3 phases
LxWxH: 1300x750x1800mm
Weight: approx. 220kg

Scope of delivery

1 assembly stand
1 set of tools
1 set of measuring aids: 2 dial gauges with attachment, 1 straight-edge
80 fit plates, differing thicknesses
1 set of instructional material

HL 962.01
Standard chemicals pump

Learning objectives/experiments

- in conjunction with HL 962, HL 962.30 and HL 962.32
  - operation of a standard pump
  - recording the pump characteristic
  - leak testing
  - alignment of pump and drive motor

Specification

[1] centrifugal pump as accessory for installation in HL 962
[2] drive and water supply provided by HL 962
[3] process configuration permits easy exchange of wearing parts
[4] pump hydraulic design according to ISO 2858
[5] pump technical requirements according to ISO 5199

Technical data

Centrifugal pump (at nominal speed: 1450min^{-1})
- max. flow rate: 9,5m^3/h
- max. head: 9,5m
- power consumption: 0,5kW

Connecting flange
- delivery side: DN32
- intake side: DN50

Materials
- housing, impeller: grey cast iron
- shaft: stainless steel

LxWxH: 570x240x300mm
Weight: approx. 43kg

Scope of delivery

1 pump
1 manual

Description

- **centrifugal pump according to ISO 5199 as accessory for installation in assembly stand HL 962**

The standard pump used here is a centrifugal pump commonly used in the chemical and process engineering industries. The media being carried are often corrosive, toxic, explosive or volatile, or are carried at very high or very low temperatures. This places extreme stress on the pump.

The standard pump is a single-stage spiral casing pump in process configuration. The process configuration ensures quick and easy exchanging of wearing parts. The spiral housing is the most common design for single-stage pumps. Its design is precisely adapted to the flow of the pump. This enables the optimum efficiency levels to be attained. The hydraulic design and connecting dimensions of the pump conform to ISO 2858; the technical requirements are to ISO 5199.

HL 962.02
Canned motor pump

Learning objectives/experiments

- in conjunction with HL 962, HL 962.30 and HL 962.32
  - operation of a canned motor pump
  - recording the pump characteristic
  - leak testing

Specification

[1] hermetic pump for aggressive liquids
[2] accessory for installation in HL 962
[3] drive: three-phase squirrel-cage motor
[4] water supply provided by HL 962
[5] maintenance-free pump

Technical data

Canned motor pump
- max. flow rate: 12m^3/h
- max. head: 39m
- power consumption: 3kW
- nominal speed: 2900min^{-1}

Connecting flange
- delivery side (radial): DN32
- intake side (axial): DN50

400V, 50Hz, 3 phases
LxWxH: 510x240x305mm
Weight: approx. 62kg

Scope of delivery

1 pump
1 manual

Description

- **hermetic centrifugal pump, particularly suitable for pumping liquid gases**
- **accessory for installation in assembly stand HL 962**

Canned motor pumps are used primarily in process engineering to pump aggressive, toxic, fire-hazard, explosive, delicate or volatile liquids (such as liquid gases). They are also suitable for pumping extremely hot or cold products, and liquids under high system pressure or under vacuum.

The pump is a fully self-contained centrifugal pump with no shaft seal, the drive is provided electro-magnetically via the canned motor. Its design means it is completely leak-tight and largely maintenance-free. Part of the primary flow is branched off by way of a self-cleaning filter to cool the motor and lubricate the journal bearings, and to provide hydraulic compensation for the axial thrust. After passing through the hollow shaft and the rotor chamber, the cooling medium is returned to the primary flow on the delivery side.

HL 962.03
Side channel pump

The illustration shows the pump with a fitting from HL 962.30 on the intake (grey elbow + manometer).

Learning objectives/experiments

- in conjunction with HL 962, HL 962.30 and HL 962.32
  - operation of a side channel pump
  - recording the pump characteristic
  - leak testing
  - alignment of pump and drive

Specification

[1] three-stage self-priming pump for installation in HL 962
[2] drive and water supply provided by HL 962
[3] pump can intake and deliver air/water mixture
[4] relatively high head at low flow rate

Technical data

Side channel pump
- 3 stages
- max. flow rate: 4,5m^3/h
- max. head: 122m
- power consumption: 3kW
- nominal speed: 1450min^{-1}
- max. speed: 1800min^{-1}

Connecting flange
- delivery side: DN32
- intake side: DN50

Materials
- housing: grey cast iron
- shaft: stainless steel

LxWxH: 470x220x240mm
Weight: approx. 30kg

Scope of delivery

1 pump
1 manual

Description

- **self-priming three-stage centrifugal pump**
- **accessory for installation in assembly stand HL 962**

Side channel pumps are self-priming centrifugal pumps, and are in widespread use. They can attain relatively high pressures at low flow rates. They are able to intake and deliver liquids containing gases. The pump can be started even when there is no head of liquid in the intake pipe. The side channel stage removes the air from the intake pipe and generates the necessary suction to intake the liquid.

The pump used here is three-stage. Drive and water supply are provided by the assembly stand HL 962.

HL 962.04
Standard chemicals pump with magnetic clutch

Learning objectives/experiments

- in conjunction with HL 962, HL 962.30 and HL 962.32
  - operation of a standard chemicals pump with magnetic clutch
  - recording the pump characteristic
  - leak testing
  - alignment of pump and drive

Specification

[1] single-stage centrifugal pump with magnetic clutch as accessory for installation in HL 962
[2] drive and water supply provided by HL 962
[3] permanent-magnetic synchronous drive inside pump
[4] pump technical requirements according to ISO 5199

Technical data

Pump (at nominal speed: 2900min^{-1})
- max. flow rate: 12m^3/h
- max. head: 39m
- power consumption: 3,7kW

Connecting flange
- delivery side: DN32
- intake side: DN50

LxWxH: 625x240x300mm
Weight: approx. 60kg

Scope of delivery

1 pump
1 manual

Description

- **hermetic centrifugal pump according to ISO 5199**
- **accessory for installation in assembly stand HL 962**

Magnetic drive pumps are used primarily in process engineering to pump aggressive, toxic and flammable liquids. Leakage of such liquids could result in major problems. Its design means it is completely leak-tight, even at continuous operation and under difficult usage conditions.

The viscosity of the delivered liquid is a key criterion in selecting a pump, as it determines the coupling torque to be transmitted. The torques transmitted by magnetic couplings are limited. As a result, magnetic drive pumps are not suitable for all operating conditions and media.

The pump is a fully self-contained centrifugal pump with no shaft seal. It is fitted with a permanent-magnetic synchronous drive complete with clutch. Drive and water supply are provided by the assembly stand HL 962.

HL 962.30
Tank system

The illustration shows the complete layout of a pump system, comprising four HL 962 assembly stands, each with one pump (HL 962.01 – HL 962.04), the piping system HL 962.32 and the tank system HL 962.30.

Description

- **water supply for a complex piping and pump system**
- **large high-level tank for normally primed pumps**
- **low-level tank for self-priming pumps**

The HL 962 assembly stands are connected with piping elements from HL 962.32 to form a complex piping and pump system. The tank system HL 962.30 is required so that the system can operate as a closed process.

The tank system consists of a large high-level tank with a mounting frame, a low-level tank and connections with shut-off devices to the PVC piping system HL 962.32.

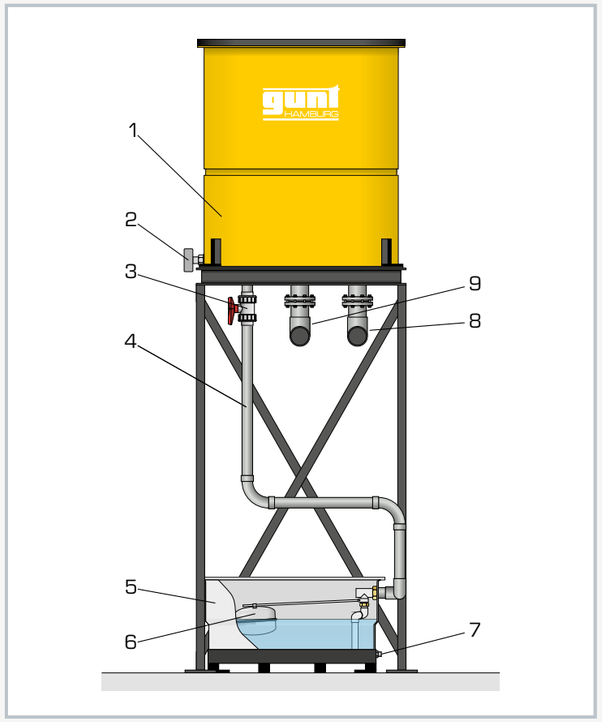
The high-level tank has a capacity of approximately 1,5m³ of water. A manometer close to the base of the tank measures the base pressure, thereby indicating the fill level. The high-level tank supplies the intake pipes of normally primed centrifugal pumps, and ensures an adequate inflow head. Its inlet and outlet distribution points are located at a height of about 2m.

The low-level tank is also supplied with water from the high-level tank. It is used for the self-priming side channel pump. A float valve ensures an adequate water level. All pumps transfer the water back to the high-level tank via the piping system.

All materials in the tank system are fully corrosion-proof, as they are all manufactured from plastic.

The assembly stand (HL 962), tank system (HL 962.30) and piping system (HL 962.32) are interconnected by way of flanges. It is possible to expand the system and connect more assembly stands.

HL 962.30
Tank system



1 high-level tank, 2 manometer, 3 ball valve, 4 pipe to low-level tank, 5 low-level tank, 6 float valve, 7 connection for side channel pump, 8 distributor tank outlet, 9 distributor tank inlet

Specification

[1] water supply for a complex piping and pump system
[2] high-level tank with cover and manometer on solid frame for supply to normally primed pumps
[3] low-level tank with cover and float valve to supply the self-priming side channel pump HL 962.03
[4] PVC piping to supply the low-level tank from the high-level tank
[5] connection between the HL 962.30, HL 962.32 and HL 962 elements via flanges
[6] high-level tank with frame

Technical data

High-level tank with cover
- capacity: 1500L
- material: polyethylene
- distributor to pipes in base
- height of delivery side distributor: approx. 2m
- 1 manometer on supply tank: 0...1,6mWC

Low-level tank with cover
- capacity: 280L
- material: glass fibre-reinforced plastic

2 manometers to check the pressure at inlet of the side channel pump HL 962.03: -1...1,5bar

PVC pipes from HL 962.32
- tank inlet and outlet: DN80
- connection to side channel pump: DN32

LxWxH: 1350x1350x3860mm
Weight: approx. 350kg

Scope of delivery

1 mounting frame
1 high-level tank with cover
1 low-level tank with cover
1 PVC pipe to interconnect the two tanks
1 set of assembly drawings

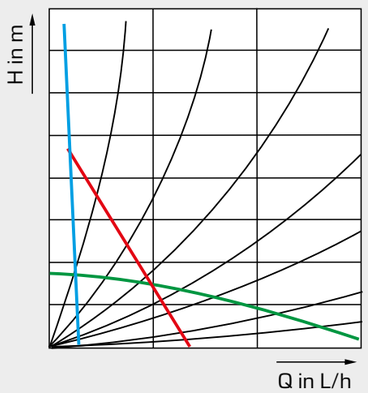
HM 362 Comparison of pumps

In order to properly use a pump, it is important to know the pump's operating behaviour. The HM 362 trainer offers students the opportunity to compare the operating behaviour of three different types of pumps. The trainer includes two centrifugal pumps, a piston pump as positive displacement pump and a self-priming side channel pump. The side channel pump primarily works as a centrifugal pump and, depending on the fill level, may also act as a positive displacement pump. This means a special feature of the side channel pump is the ability to convey gases.

Investigations on series and parallel configurations can be conducted with the two identical centrifugal pumps.

The trainer provides a ready-prepared place for experiments with its own pump. This space is fitted with a variable speed three-phase motor, whose direction of rotation is reversible.

The measurements are supported and visualised by the GUNT data acquisition software.



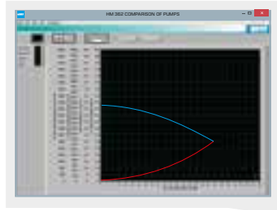
Compare operating behaviour of different types of pumps

green centrifugal pump, red side channel pump, blue piston pump, black system characteristics; **Q** flow, **H** head

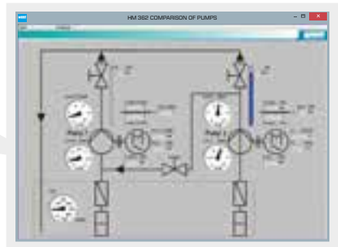
Each pump testing station has a measuring device for detecting the drive torque

Each pump has an inlet and outlet above pressure sensors

Sensors for flow measurement



Record characteristic curves



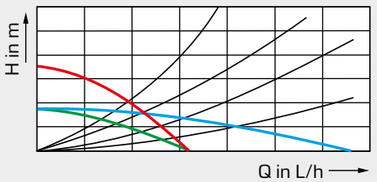
Display of measured data on displays on the trainer and in the GUNT software on a PC

Piston pump

Free space for investigation of additional pumps

Side channel pump

Two centrifugal pumps



green single pump, red series configuration, blue parallel configuration, black system characteristics; **Q** flow, **H** head

HM 362
Comparison of pumps

Description

- **investigation of the operating behaviour of centrifugal, piston and side-channel pumps**
- **all pumps driven separately by three-phase AC motors**
- **centrifugal pumps can be operated in series or parallel configuration**

The experiments familiarise students with various pump types, such as centrifugal and positive-displacement pumps.

The HM 362 trainer includes two centrifugal pumps, one piston pump as a positive-displacement pump and a self-priming side-channel pump. The side-channel pump works primarily as a centrifugal pump and, depending on liquid level, can also act as a positive-displacement pump. This means, as a special feature, the side-channel pump also permits gases to be pumped.

The pump being investigated pumps water in a closed circuit. In the process, the performance data of the pump and pressure losses in the pipeline are recorded. The centrifugal pumps can also be operated in parallel or in series configuration. Each pump is driven by a separate three-phase AC motor. The speed of the motors for the centrifugal pumps is variably adjustable by a frequency converter. All motors are mounted on swivel bearings, so the torque can be measured by way of a force sensor, enabling the mechanical drive power output to be determined.

One free position is likewise equipped with a reversible three-phase AC motor with variable speed. This position can be used for mounting of any pump.

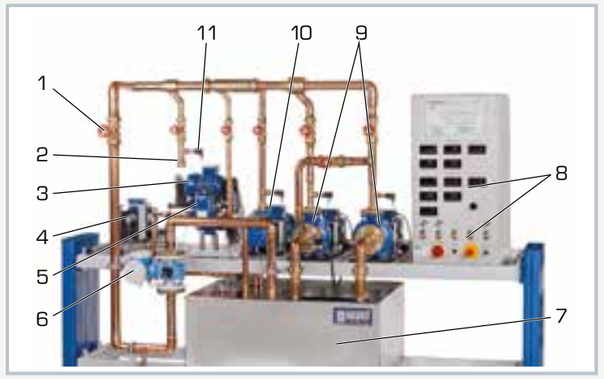
Experiments demonstrate the basic operating behaviour of various pump types.

Relevant measured values can be read on digital displays. At the same time, the measured values can also be transmitted directly to a PC via USB. The data acquisition software is included. The performance data of the pump and losses in the pipeline are calculated by the software and represented by characteristic curves. The operating point of the pump can be determined from these characteristics.

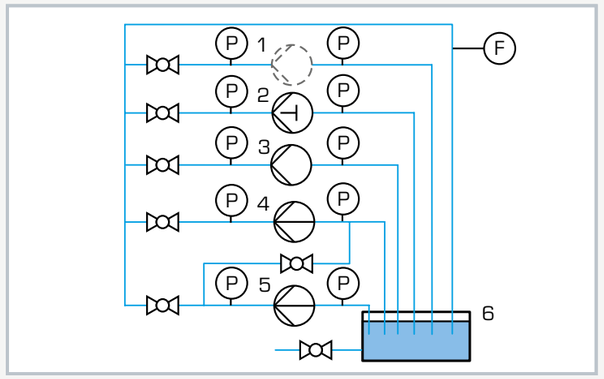
Learning objectives/experiments

- investigation and comparison of the operating behaviour of various pump types:
  - centrifugal pumps
  - piston pump (positive-displacement pump)
  - side-channel pump
- recording a pump characteristic curve
- recording a system characteristic curve
- determining efficiency
- investigation and comparison of parallel and series configuration of centrifugal pumps
- comparison of pump types

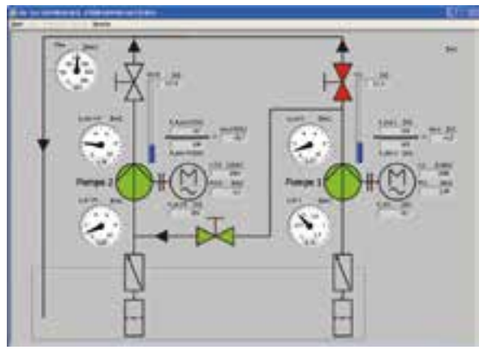
HM 362
Comparison of pumps



1 flow control valve (at outlet), 2 connection for additional pump, 3 piston pump motor, 4 motor for additional pump, 5 piston pump, 6 flow rate sensor, 7 storage tank, 8 switch cabinet with displays and controls, 9 centrifugal pump, 10 side-channel pump, 11 pressure sensor



Process schematic of the trainer
1 free place for additional pump (provided by user), 2 piston pump, 3 side-channel pump, 4+5 centrifugal pump, 6 storage tank; F flow rate, P pressure



Software screenshot: series configuration of centrifugal pumps

Specification

[1] experiments relating to key issues in pump engineering
[2] comparison of various pump types: centrifugal pump, piston pump, side-channel pump
[3] operation of centrifugal pumps in parallel or series configuration
[4] free position for additional pump
[5] three-phase AC motors for centrifugal pumps and additional motor with variable speed by frequency converter
[6] GUNT software for data acquisition via USB under Windows 7, 8.1, 10

Technical data

Centrifugal pump 2x
- max. flow rate (Q): 300L/min
- max. head (H): 16,9m
- nominal speed: 2900min^{-1}

Three-phase AC motor 2x, for centrifugal pump
- power output: 1,1kW

Side-channel pump, self-priming, one-stage
- Q: 83,3L/min, H: 50m
- nominal speed: 1450min^{-1}

Three-phase AC motor for side-channel pump
- power output: 1,1kW

Piston pump
- Q: 17L/min, H: 60m
- nominal speed: 405min^{-1}

Three-phase AC motor for piston pump
- power output: 0,55kW

Three-phase AC motor, additional motor, reversible
- power output: 0,75kW
- speed range: 750...3000min^{-1}

Measuring ranges
- flow rate: 0...500L/min
- pressure (inlet): -1...1,5bar
- pressure (outlet): 0...10bar
- torque: 0...15Nm
- speed: 0...3000min^{-1}
- pump electrical power consumption: 0...2kW

400V, 50Hz, 3 phases
400V, 60Hz, 3 phases
230V, 60Hz, 3 phases
LxWxH: 2860x1200x1960mm
Weight: approx. 430kg

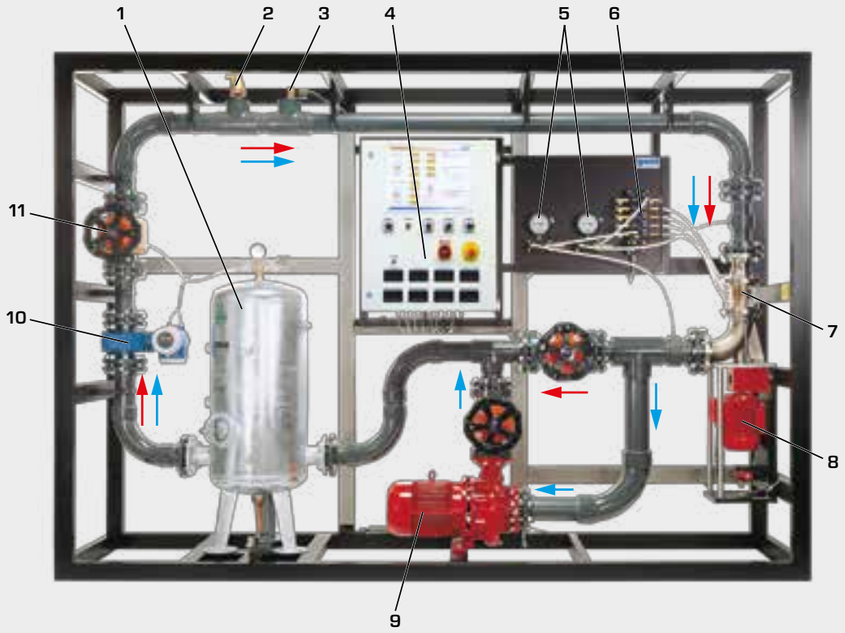
Required for operation

PC with Windows recommended

Scope of delivery

trainer, 1 GUNT software CD + USB cable, 1 set of instructional material

HM 405
Axial-flow turbomachines



1 water tank with air cushion,
2 bleed valve,
3 solenoid valve for venting,
4 switch cabinet with displays and controls,
5 manometer for inlet and outlet pressure,
6 differential pressure sensor,
7 axial turbomachine,
8 motor/generator with torque measurement,
9 centrifugal pump for turbine operation,
10 electromagnetic flow meter,
11 valve for flow adjustment;

red arrows pump operation,
blue arrows turbine operation

The experimental plant HM 405 illustrates the function of an axial turbine with interchangeable rotors and stators. By replacing these, the turbomachine can be operated as a turbine or pump. Different rotors and stators respectively impellers and guide vane systems are provided so that their influence on the power characteristics can be investigated.

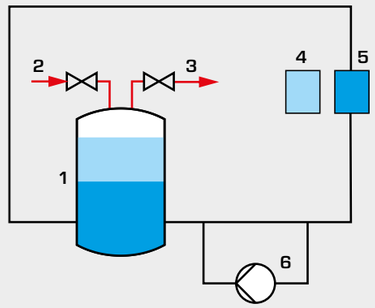
The housing is made of transparent material in order to provide insight into the flow processes upstream, between and downstream of rotor and stator respectively impeller and guide vane system.

In turbine mode the electric motor operates as a generator to generate electricity. In pump mode it operates as a drive for the pump. The electricity produced from the generator is fed into the centrifugal pump for turbine operation.

Practical experiments and calculations on the following topics can be performed depending on the operating mode:

- record characteristics
- determine dimensionless characteristic variables
- velocity triangles and pressure curves
- investigation of energy conversion within the turbomachine
- how blade / vane shape affects power and efficiency
- determine the outlet angular momentum and its effect on the power
- cavitation effects

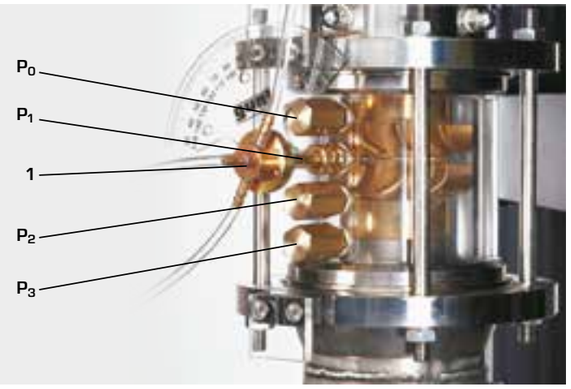
The system can be depressurised in order to attach the guide vanes and blades. In this way the pump is emptied with no loss of water. The water runs back into the tank. Admitting compressed air to the tank refills the system. The compressed air is also used to adjust the upstream pressure. An automatic bleed valve removes the remaining air from the pipe system.



1 water tank with air cushion, **2** compressed air, **3** bleeding,
4 empty turbomachine, **5** filled turbomachine, **6** centrifugal pump;
refill system,
drain system

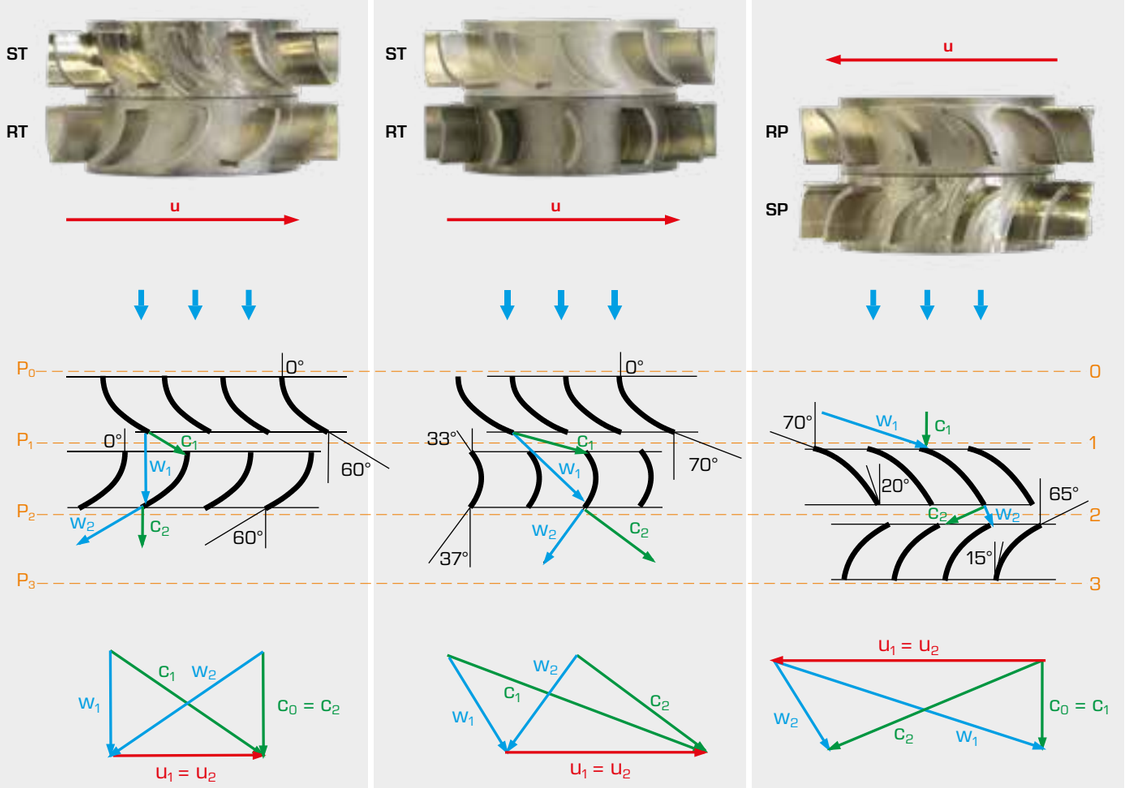
The 3-hole probe (1) can be used to measure the direction and velocity in the flow field directly upstream of, between and downstream of rotor and stator respectively impeller and guide vane system. These values are used to record the velocity triangles for the blade / vane shapes.

Varying load, speed and flow rate offers a wide range of experiments.



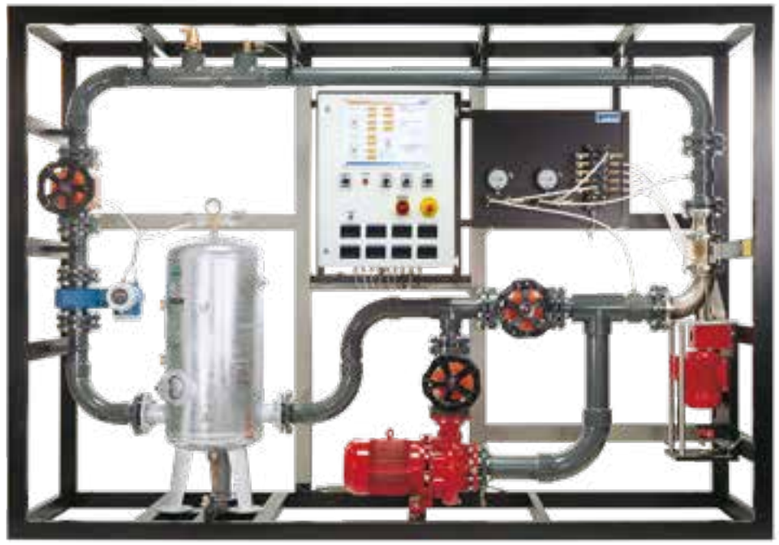
Velocity triangles on turbines or pumps

Reaction turbine	Action turbine	Pump



ST turbine stator, **SP** pump guide vane system, **RT** turbine rotor, **RP** pump impeller, **w** relative water velocity, **c** absolute water velocity, **u** circumferential velocity, **P_0...P_3** pressure measuring points

HM 405
Axial-flow turbomachines



Description

- **investigation of a single-stage axial turbomachine**
- **can be operated as pump or turbine by changing rotor, impeller and stator, guide vane system**
- **probe to determine flow conditions at inlet and outlet of rotor, impeller and stator, guide vane system**
- **transparent working area**

The core piece of the experimental plant is the axial turbomachine with attached asynchronous motor. It can be operated either as a pump or turbine. To this end, different rotors, impellers and stators, guide vane systems are used. Included in the scope of delivery are four rotors, impellers and four stators, guide vane systems supplied with different blade, vane angles. The experimental plant contains a closed water circuit with expansion tank and centrifugal pump. The compressed-air powered expansion tank allows the turbomachine to be converted without loss of water.

The asynchronous motor functions during turbine operation as a generator, and during pump operation as a drive. A powerful pump generates flow and pressure during turbine operation. The power that is generated by the turbine is fed into this pump.

The transparent housing allows a full view of the rotor, impeller and stator, guide vane system and flow processes. The 3-hole probe can be used to measure the direction and velocity in the flow field directly upstream of, between, and downstream of rotor, impeller and stator, guide vane system. These values are used to record the velocity triangles for the blade, vane shapes.

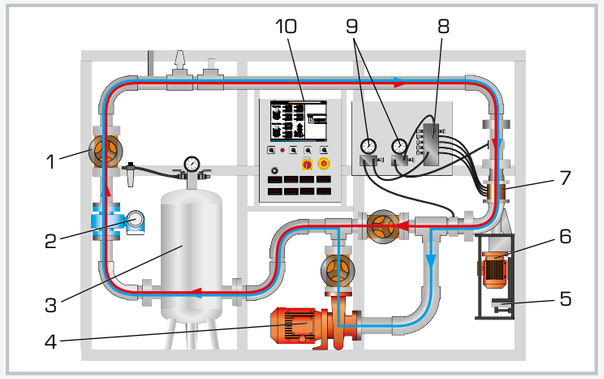
Operation under different pressure levels is possible in order to study cavitation.

The speed is detected contact-free by means of an inductive displacement sensor on the motor shaft. To determine the drive power, the asynchronous motor is mounted on swivel bearings and equipped with a force sensor to measure the drive torque. Manometers measure the pressures at inlet and outlet. Pressure sensors measure the differential pressures at rotor, impeller and stator, guide vane system. The flow rate is measured by an electromagnetic flow meter. The measured values are read from digital displays.

Learning objectives/experiments

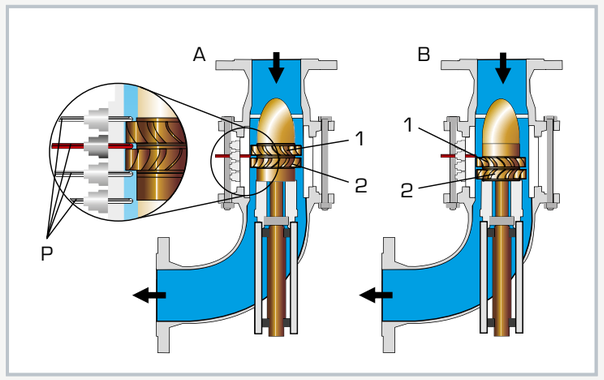
- recording characteristic curves
- determining dimensionless characteristics
- velocity triangles and pressure curves
- investigation of energy conversion within the turbomachine
- how blade, vane shape affects power and efficiency
- determining the outlet angular momentum and its effect on the power
- cavitation effects

HM 405
Axial-flow turbomachines



1 valve for adjusting the flow, 2 flow meter, 3 expansion tank with air cushion, 4 centrifugal pump for turbine mode, 5 force sensor for measuring the torque, 6 asynchronous motor, 7 axial-flow turbomachine, 8 differential pressure sensor, 9 manometer, 10 switch cabinet; red: pump mode, blue: turbine mode

The illustration shows cavitation effects in the working area of the axial flow turbomachine



A: axial flow turbomachine as a turbine, 1 stator, 2 rotor;
B: axial flow turbomachine as a pump, 1 impeller, 2 guide vane system;
P pressure sensor

Specification

[1] investigation of an axial flow turbomachine
[2] closed water circuit with expansion tank and centrifugal pump
[3] turbomachine may be operated as a turbine and as a pump
[4] two sets of impellers and guide vane systems for pump mode and two sets of rotors and stators for turbine mode with different inlet and outlet angles
[5] asynchronous motor with 4-quadrant operation via frequency converter
[6] recovery of the brake energy
[7] motor with pendulum bearing, torque measurement via lever arm and force sensor
[8] inductive speed sensor on the motor
[9] manometers for measuring the inlet and outlet pressures
[10] measuring probe and differential pressure sensor for recording the pressure curve in the turbomachine
[11] electromagnetic flow meter
[12] display of power consumption, torque, speed, pressure, differential pressure and flow rate

Technical data

Centrifugal pump
- power: 5,5kW
- max. flow rate: 150m^3/h
- max. head: 10m

Asynchronous motor
- power: 1,5kW
- torque: 0...5Nm
- speed: 0...3000min^{-1}

Expansion tank: 150L

Measuring ranges
- pressure (manometer): 2x -1...5bar
- differential pressure: 5x 0...500mbar
- flow rate: 0...100m^3/h
- speed: 0...3000min^{-1}
- torque: 0...9,81Nm

400V, 50Hz, 3 phases
LxWxH: 3300x750x2300mm
Weight: approx. 620kg

Required for operation

Compressed air connection: 3...10bar

Scope of delivery

1 experimental plant
4 rotors
4 distributors / guide vanes
1 set of accessories
1 set of instructional material

HM 215 Two-stage axial fan

Axial fans are often used in practice in building services engineering for air conditioning and ventilation systems. In order to increase the supply pressure axial fans can be connected in series. In this case they are known as two-stage fans.

With HM 215 GUNT offers experiments on a two-stage axial fan. In addition, the trainer allows the investigation of a fan in stand-alone operation. Theory and practice can be compared in a simple way.

The device is equipped with sensors for temperature and differential pressure. The flow rate is determined by differential pressure in the inlet nozzle.

Learning objectives

- determining the fan characteristic
- stand-alone or series configuration of axial fans
- determining the energy balance
- determining the pressure and velocity distribution on rotor and guide vane by means of a probe
- effect of rotating blade position

Measuring device with 3-hole probe for determining the differential pressure on rotor and guide vane

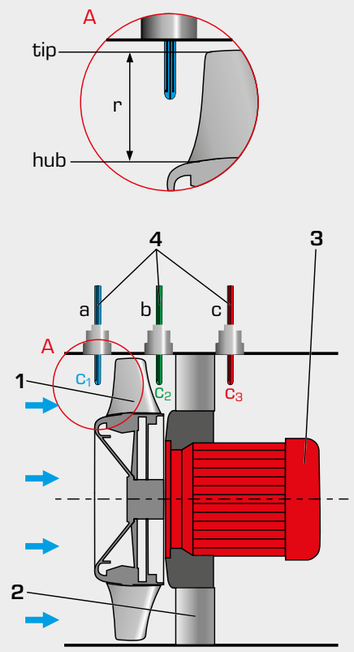
A carefully designed nozzle contour and a flow straightener at the air inlet ensure turbulence-free flow of the blades

The experimental unit is equipped with two high-power axial fans

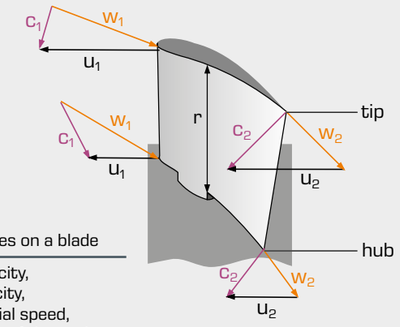
Throttle valve at the end of the measuring section for adjusting the volumetric flow rate

Adjustable blade on the rotor hub

The angle of attack and exit angle, as well as the pressure of the air can be measured with an adjustable measuring probe along the blade radius. Adjusting the blades alters the angle of attack. The GUNT software simplifies measurements with the measuring device and enables the processing and visualisation of measured data.

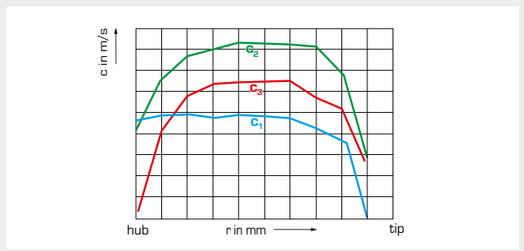


1 adjustable blade on the rotor hub, **2** guide vane, **3** motor, **4** measuring points a-c with 3-hole probe (radial adjustable);



Velocity triangles on a blade

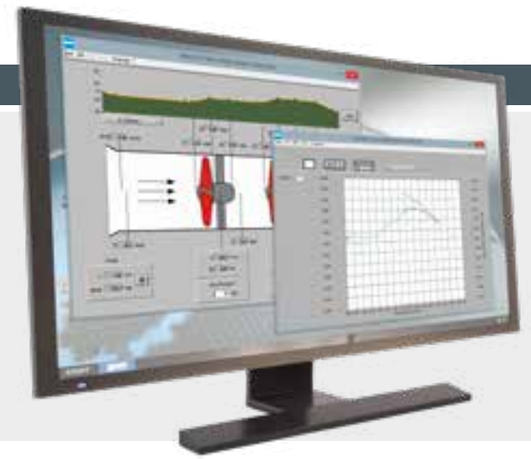
c absolute velocity,
w relative velocity,
u circumferential speed,
r radial position of the probe;



Velocity distribution

pos. a upstream of rotor, c_1,
pos. b downstream of rotor, c_2,
pos. c downstream of guide vane, c_3

Software



The GUNT software clearly displays the measurements on the PC and allows easy analysis of the measuring results. For example, the pressure curve in the measuring section can be clearly shown for different operating states.

HM 215
Two-stage axial fan

Description

- **two axial fans in series configuration or in individual operation**
- **three-hole probe for determining pressure and velocity profile**

Axial fans are connected in series in plants to increase the pressure. In theory, connecting two fans in series doubles the pressure increase.

The HM 215 trainer allows the investigation of a two-stage axial fan. A measuring device is used to determine the pressure and velocity distribution.

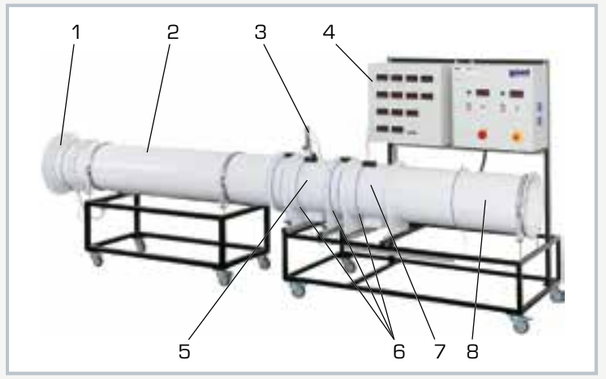
The trainer includes a measuring section with two identical axial fans. The carefully designed nozzle contour and a flow straightener at the air inlet ensure a uniform velocity distribution with little turbulence in the measuring section. The rotors are equipped with individually adjustable blades to change the angle of attack. The fans are equipped with outlet guide vane systems. These guide mechanisms redirect the angular momentum of the outflow in the axial direction and allow an increase in pressure. A pipe bend may optionally be installed to rotate the flow at the outlet of the measuring section. One of the fans can be removed from the measuring section so that the remaining fan can be studied in individual operation.

In the measuring section there are measuring connections to detect the differential pressures and temperatures. The flow rate is measured via an inlet nozzle. The differential pressure and the angle of attack are detected radially at rotors and guide vane systems by means of the 3-hole probe. This enables the display of different pressure and velocity profiles. The measured values are read from digital displays and can at the same time be transmitted via USB directly to a PC where they can be analysed using the software included.

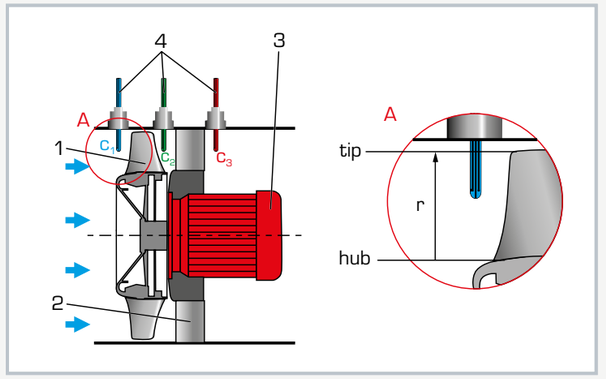
Learning objectives/experiments

- determining the fan characteristic
- series configuration or individual operation of axial fans
- determining the energy balance
- determining the radial pressure and velocity distribution on rotor and guide vane system by means of a probe
- effect of the blade position

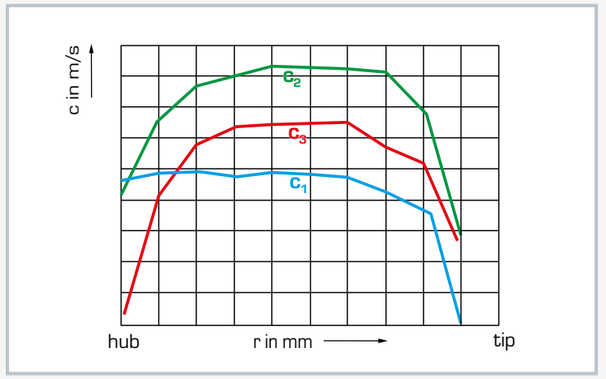
HM 215
Two-stage axial fan



1 nozzle with flow straightener, 2 intake pipe, 3 measuring device, 4 switch box, 5 fan no. 1, 6 pressure measuring points, 7 fan no. 2, 8 throttle valve



Fan with measuring device
1 adjustable blade on the rotor hub, 2 guide vane system, 3 motor, 4 measuring points with 3-probe hole; c_1 to c_3 absolute velocities, r radial position of the probe



Velocity distribution along the blade in radial direction
blue: c_1 upstream of the rotor, green: c_2 downstream of the rotor, red: c_3 downstream of the guide vane system; v velocity, r radial position of the probe along the blade from hub to tip

Specification

[1] investigate two-stage axial fan
[2] 2 identical single-stage fans in series configuration or individual operation
[3] individually adjustable blades
[4] fans both with variable speed via frequency converter
[5] flow-optimised nozzle and flow straightener for smooth, low-turbulence flow
[6] air flow in the pipe section can be adjusted via throttle valve
[7] optional pipe bend at the outlet for flow deflection
[8] measuring device with three-hole probe for determining the differential pressure on rotor and guide vane system
[9] sensors for pressure and temperature upstream and downstream of each fan
[10] volumetric flow rate measured via inlet nozzle
[11] GUNT software for data acquisition via USB under Windows 7, 8.1, 10

Technical data

2 fans
- drive motor rated output: 3,45kW
- max. pressure difference: 798Pa
- speed: 0...2850min^{-1}
- blade angle adjustable up to 39°

Measuring section inner diameter: 400mm

Measuring ranges
- temperature: 0...100°C
- differential pressure: ±25mbar
- radial position of the probe: 100...200mm

400V, 50Hz, 3 phases
400V, 60Hz, 3 phases
LxWxH without pipe outlet: 4325x970x1800mm
Length with pipe outlet: 5225mm
Weight: approx. 250kg

Required for operation

PC with Windows recommended

Scope of delivery

1 trainer with 2 fans
1 pipe bend
1 measuring device
1 set of measuring hose with quick-release couplings
1 CD with GUNT software + USB cable
1 set of instructional material

HL 710
Planning and set-up of air duct systems

System at original scale, individual set-up

Air duct systems with typical components from ventilation technology: set-up and experiments

The components


Pipe bends


Reduction (left) and connection elements


Branches


Throttle valve (left) and iris diaphragm (right)


Disc valve (left) and slotted vent (right)

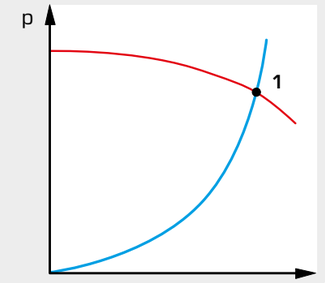

Filter

The experiments

In the air duct system several components with measuring points for pressure measurements are installed. With an inclined tube and a digital manometer the static and dynamic pressure can be measured at these points. This allows a determination of the pressure losses of the individual components in the whole air duct system.

With the anemometer the air velocities and air flows are measured at the outlets of the system. The measured values are used to generate the system and fan characteristics. From the characteristics the operating point is determined.

1 digital manometer, **2** inclined tube manometer, **3** anemometer



air duct system,
fan characteristic;
1 operating point,
p pressure, **Q** flow rate


Measuring points for static and dynamic pressure

HL 710
Air duct systems

Description

- **planning and setup of simple and complex air duct systems**
- **measurement of the dynamic and static pressures in air duct systems**
- **measurement of the air velocity and volumetric flow rate under different conditions**

Ventilation systems are used in many areas. They are used to ventilate offices, sports halls, production halls, conference halls etc. These systems consist of an air duct system and often other facilities for the conditioning of room air. There may also be elements for air purification or sound insulation, e.g. filters.

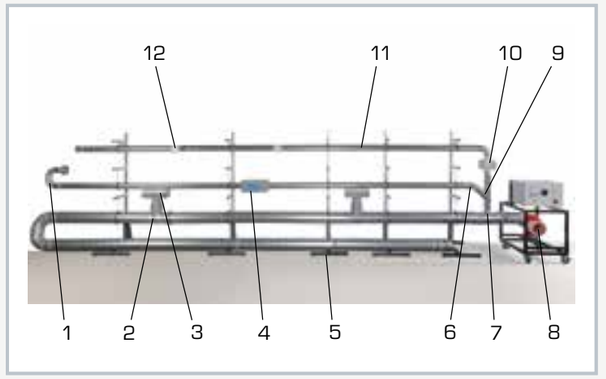
The trainer HL 710 examines how the air can be distributed in a building. The air duct system is supplied via a speed-controlled fan. The trainee constructs variable air duct systems from commercial components, such as pipes, pipe bends, branches, filters and disk valves. Connections for pressure measurements can be installed at any position.

The effects of the individual components on the pressure loss and thus on the velocity and flow rate of the air are examined. For this purpose there are two manometers with different measuring ranges and a manual device for measuring the air velocity. The fan characteristic is also determined and the power consumption of the fan is measured.

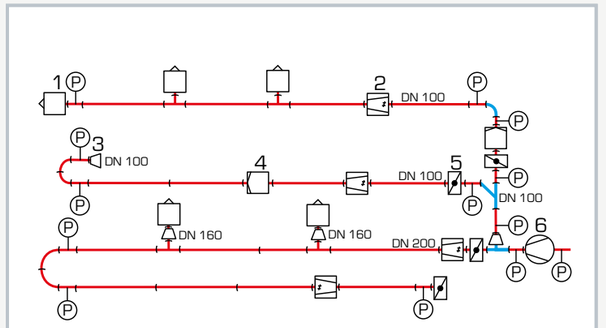
Learning objectives/experiments

- plan, setup and test air duct systems
- typical components of ventilation technology
- measure the flow rate and velocity of the air
- measure dynamic and static pressures
- determination of the pressure loss via different components: pipe bends, angles, distributors etc.
- recording of system characteristics
- recording of the fan characteristic
- determination of the operating point
- calculate the electric capacity of the fan motor with regard to current and voltage
- calculate the fan efficiency

HL 710
Air duct systems



1 90° pipe bend, 2 reducer, 3 slotted outlet, 4 pocket filter, 5 assembly stand, 6 45° pipe bend, 7 T piece, 8 fan, 9 branch, 10 filter cartridge, 11 iris diaphragm, 12 disk valve



Pipe routing diagram: 1 inlet air or disk valve, 2 iris diaphragm, 3 reducer, 4 filter, 5 throttle valve, 6 fan; P pressure measuring point; blue: pipe bends and joints

1 fan speed adjustment, 2 fan on/off switch, 3 main switch, 4 power meter

Specification

[1] experimental setup for training in ventilation engineering
[2] radial fan, on mobile frame, to connect air ducts
[3] air ducts from galvanised folded spiral-seam pipe with pipe bends, joints and components
[4] pressure measuring connections with variable locations
[5] 6 assembly stands to attach the air ducts
[6] inclined tube manometer and digital manometer for 2 different measuring ranges
[7] measuring of the air velocity by anemometer
[8] switch cabinet with display of power consumption

Technical data

Fan
- power consumption: 900W
- max. volumetric flow rate: 1680m^3/h
- max. pressure difference: 1000Pa
- speed: 0...2840min^{-1}

Pipes
- length: 1600mm
- diameter: 8x DN200, 8x DN100

Pipe bends and connections, each DN100 and DN200
- 90° pipe bend, 45° pipe bend
- 45° branch
- T piece, T piece with reducer
- reducer, plug-in connection, pipe coupling

Flow restriction elements, each DN100 and DN200
- throttle valve
- iris diaphragm

Filters, each DN100 and DN200
- pocket filter
- filter cartridge

Measuring ranges
- pressure: 0...200Pa / 0...2000Pa
- velocity: 0,25...30m/s
- power: 0...5,75kW

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase; 120V, 60Hz, 1 phase
LxWxH: 800x810x1250mm (fan)
Weight: approx. 180kg (total)

Scope of delivery

1 radial fan on mobile frame
6 assembly stands
1 set of pipes, pipe bends, connections, components (outlets, filters etc.)
1 inclined tube manometer
1 digital manometer
1 anemometer
1 set of instructional material

ST 510 Sanitation fittings training panel

Sewerage technology at a glance with ST 510 by GUNT

- transparent components made of glass and PMMA for perfect observation of flow conditions
- direct comparison of correct and false arrangement of pipes
- ventilation and deairing adjustable with solenoid valves
- convenient flushing by remote control
- pressure distribution in pipework
- closed water circuit with storage tank and pump

Installation of system at customer's site

Observing the flow

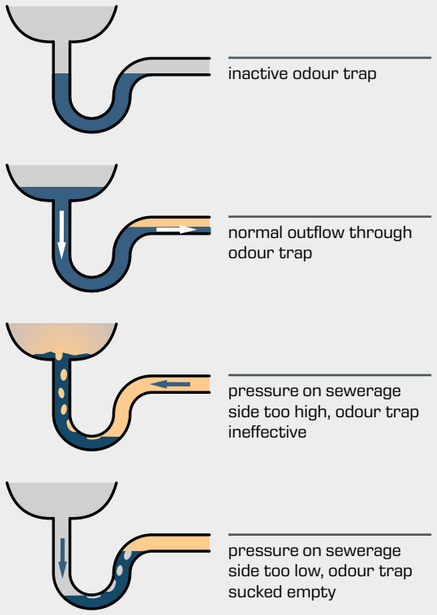
Correct installation of waste water pipes in buildings is important for trouble-free operation of the sewerage system.

Poor pipe arrangement and incorrect selection of pipe diameters can cause pressure extremes, which may complicate or prevent waste water flow.

In addition, blockages and annoying odours and noise may occur.

Adequate ventilation of the piping under all flow conditions is essential for correct functioning.

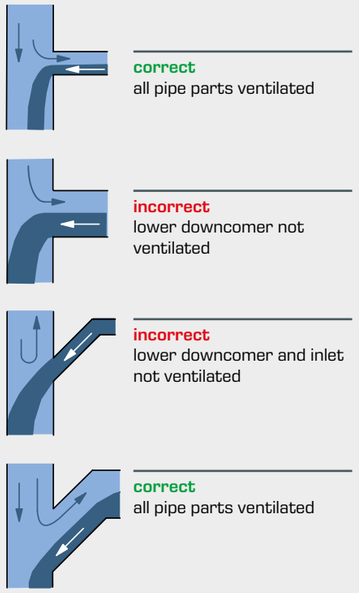
Functions of odour traps



Flushing tanks and odour traps

Flow conditions at different junctions at downcomers

Pipes and valves and fittings made of glass



ST 510
Full-scale sewerage system

Description

- **transparent pipes and tanks for observation of flow processes**
- **closed water circuit**

The routing of sewers is particularly important in wastewater engineering. Pipe inclinations, pipe inlets and outlet, reducers and cross-sections must be considered when designing systems, taking into account interactions between the components. In particular, the pressure distribution in complex pipe systems places high demands on design engineers. Design errors lead to noise, empty drain traps and clogged pipes.

ST 510 allows a variety of experiments in the field of wastewater engineering and enables the visualisation of flow processes in sewers.

The experimental plant includes an extensive drainage pipe system based on common real-world elements.

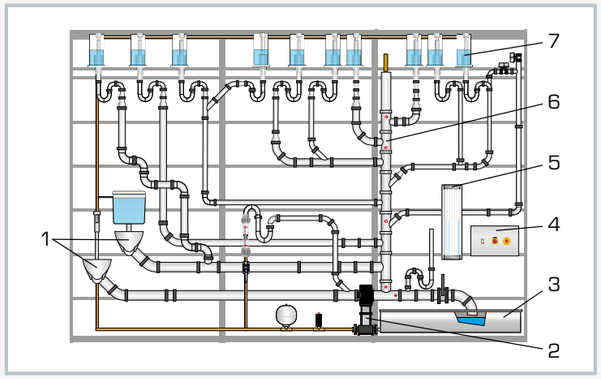
The pipes are transparent to allow visualisation of the flow processes. The cisterns are located in the top part of the experimental plant. These are opened or closed individually via solenoid valves. In addition, the bypass, ventilation pipe and pressure flushing are equipped with solenoid valves. The solenoid valves are triggered via a remote control. The system can be used to study the flow and pressure curve at different types of junctions, pipe offsets, cross-sectional changes and drain traps under different ventilation and evacuation conditions. The system contains a closed water circuit with collection tank and pump.

There are pressure measuring points located along the downcomer to measure the pressure conditions in the wastewater system. The measuring points are connected to a tube manometer via hose connections. The flow rate is determined via a rotameter.

Learning objectives/experiments

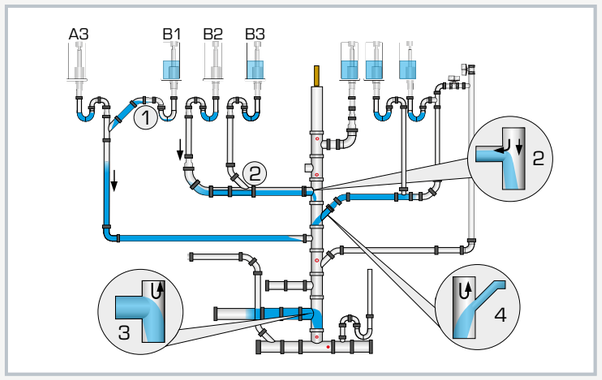
- pressure curve in the downcomer
- bypass
- incorrect flow behaviour with defective ventilation of the pipes
- incorrect flow behaviour with incorrect pipe sizing
- flow at pipe offset
- suction effect at junctions
- behaviour of sanitary valves and fittings
- function of various drainage pipes

ST 510
Full-scale sewerage system



1 toilet bowl, 2 pump, 3 tank, 4 switch cabinet, 5 tube manometer, 6 downcomer with pressure measuring points, 7 cistern

1 toilet bowl pressure flush, 2 toilet bowl with cistern, 3 transparent pipes



1 incorrect: drain trap B1 emptied through Y-piece when flushing A3, 2 correct: drain trap B3 not emptied by cross-sectional expansion and good ventilation when flushing B2, 3 ventilation failure due to equal pipe cross-sections, 4 ventilation failure due to high flow velocity

Specification

[1] experimental plant for demonstration of wastewater technology
[2] transparent glass pipes and tanks
[3] 10 cisterns with remotely-operated solenoid valves
[4] 1 toilet with cistern
[5] 1 toilet with pressure flush
[6] contains downcomer, collection pipe, ventilation pipe and bypasses
[7] 6 tube manometers to indicate the pressure curve in the downcomer
[8] measurement of flow rate via rotameter

Technical data

Pump
- power consumption: 550W
- max. flow rate: 4,5m^3/h
- max. head: 42,6m

Collection tank
- volume: approx. 300L

Transparent cisterns
- 4x 20L
- 6x 10L

Cistern
- 1x 9L

Flush for toilet: max. 9L

Measuring ranges
- flow rate: 0,4...4L/h
- pressure: 6x 1500mmWC

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase
120V, 60Hz, 1 phase
UL/CSA optional
LxWxH: 5700x800x3900mm
Weight: approx. 1100kg

Required for operation

compressed air connection: 6...10bar

Scope of delivery

1 experimental plant
1 set of hoses
2 remote controls
1 set of instructional material