Equipment for engineering education

GSDE s.a.r.l.

Hands-on teaching engineering

Level 3 Level 4 Level 5

Hands-on teaching engineering

In this catalogue, we present a comprehensive overview of our innovative demonstration and experimental units.

This catalogue covers the following engineering courses:

- engineering
- chemical engineering
- civil engineering
- manufacturing engineering
- mechanical engineering
- computer engineering
- mechatronics engineering
- environmental engineering

Imprint

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STEM education

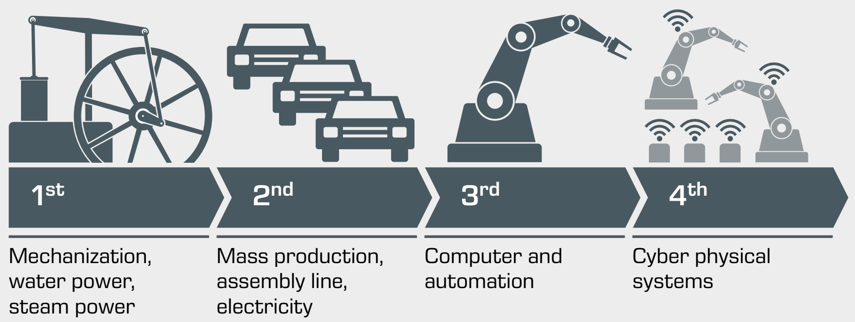
What is engineering?

Engineering is the practical application of science and mathematics to solve problems, and it is everywhere in the world around you. From the start to the end of each day, engineering technologies improve the ways that we communicate, work, travel, stay healthy and entertain ourselves.

Engineers influence every aspect of modern life and it's likely that today you will have already relied on the expertise of one or more engineers. Perhaps you woke to a DAB clock radio, or used a train or a bus? Maybe you have listened to an iPod? Or watched television? Did you wash your hair today? Do you have a mobile phone in your pocket or trainers on your feet? These have all been designed, developed and manufactured by engineers.

Engineers are problem-solvers who want to make things work more efficiently and quickly, and less expensively. From computer chips and satellites to medical devices and renewable energy technologies, engineering makes our modern life possible.

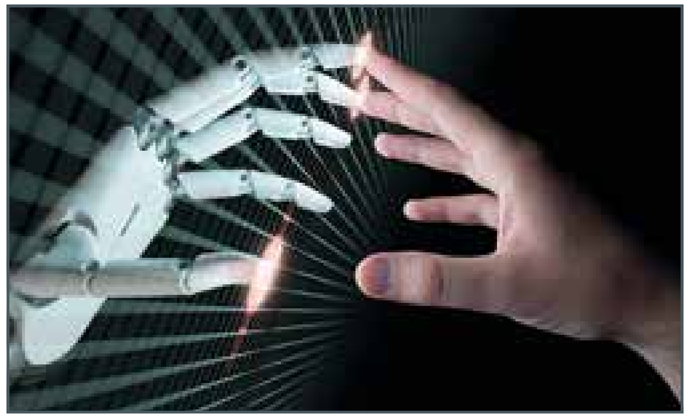
Industry 4.0 <–> Education 4.0



Engineering in the future

We are now going through a third transition in engineering in response to many factors in society and in technology itself. In the larger picture, society went through the agricultural phase, the industrial phase, and now the information phase.

These three phases of civilization created and were created by the most powerful and applicable technologies of the time. Engineering is and will be the creative element in the information age as it has been in preceding ages.



Artificial Intelligence Technology

A cyber-physical system (CPS) is a mechanism that is controlled or monitored by computer-based algorithms, tightly integrated with the Internet and its users.

In cyber-physical systems, physical and software components are deeply intertwined, each operating on different spatial and temporal scales, exhibiting multiple and distinct behavioural modalities, and interacting with each other in a myriad of ways that change with context.

Examples of CPS include

- smart grid
- autonomous automobile systems
- medical monitoring
- process control systems
- robotics systems
- automatic pilot avionics

Education 4.0

Education should pave the way for Industry 4.0 to fully exploit the potential of cyber-physical systems in the future.

What does the industry want of future employees?

Priorities: 1st **attitudes**, 2nd **skills**, 3rd **knowledge**

What capabilities does an engineer need in professional life to meet these priorities?

Technology

Materials science	Mechanics	Thermo dynamics	Electrical engineering	Metrology	Process engineering	Control engineering	Computer sciences	Fluid dynamics

Technical framework

- Design process
- Production process
- Legislation standardization
- Management business operations

Maths and science

- Mathematics
- Physics
- Chemistry
- Biology

Employability skills

- Cognitive skills
- Applied skills
- Transferable skills

How can STEM education support in these needs?

Students need both good qualifications and employability skills to enhance their career prospects and personal development. This catalogue suggests ways to support lecturers of colleges and universities in their STEM education. We have structured this catalogue in accordance with needs of employability. Please find details concerning structure and contents on the following pages.

Engineering education in level 3 - 5
STEM education

Higher education (HE)

Level 8
Doctorates
+ advanced professional diplomas and certificates

Level 7
Master's Degree
Postgraduate Certificate / Diploma
NVQ level 5
BTEC Advanced award, certificate and diploma level 7
+ various other professional diplomas and certificates

Level 6
Bachelor's Degree
Graduate Certificate / Diploma
VQ level 6
BTEC Advanced award, certificate and diploma level 6
+ various other professional diplomas and certificates

Level 5
Second year at University
Foundation Degree
Higher National Diploma (HND)
NVQ level 4
BTEC Professional award, certificate and diploma level 5
+ various other professional diplomas and certificates

Level 4
First year at University
Higher National Certificate (HNC)
VQ level 4
BTEC Professional award, certificate and diploma level 4
+ various other professional diplomas and certificates

Further education (FE)

Level 3
A levels
Apprenticeship
NVQ level 3
BTEC award, certificate and diploma level 3
National Diploma
Extended Diploma
Access to HE Diploma
+ various other diplomas and certificates

State education

Level 2
GCSE (grades A*–C)
Apprenticeships
NVQ level 2
+ various other diplomas and certificates

Level 1 (Foundation)
GCSE (grades D–G)
Key Skills level 1
NVQ level 1
+ various other diplomas and certificates

Entry Level
Pre-Foundation options for students who need support to progress with their learning

This catalogue offers devices covering levels 3–5 in engineering courses:

- engineering
- chemical engineering
- civil engineering
- manufacturing engineering
- mechanical engineering
- computer engineering
- mechatronics engineering
- environmental engineering

This catalogue is based on the information of City & Guilds Level 3 qualifications and BTEC Pearson, the UK's largest awarding body offering academic and vocational qualifications that are globally recognised and benchmarked.

Pearson BTEC

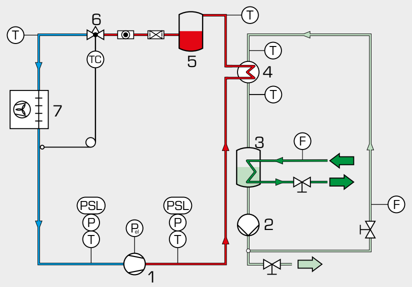
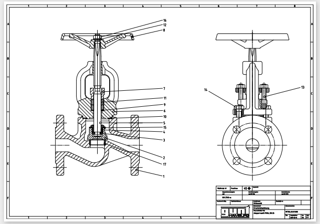
City & Guilds

Hands-on teaching engineering

Table of contents

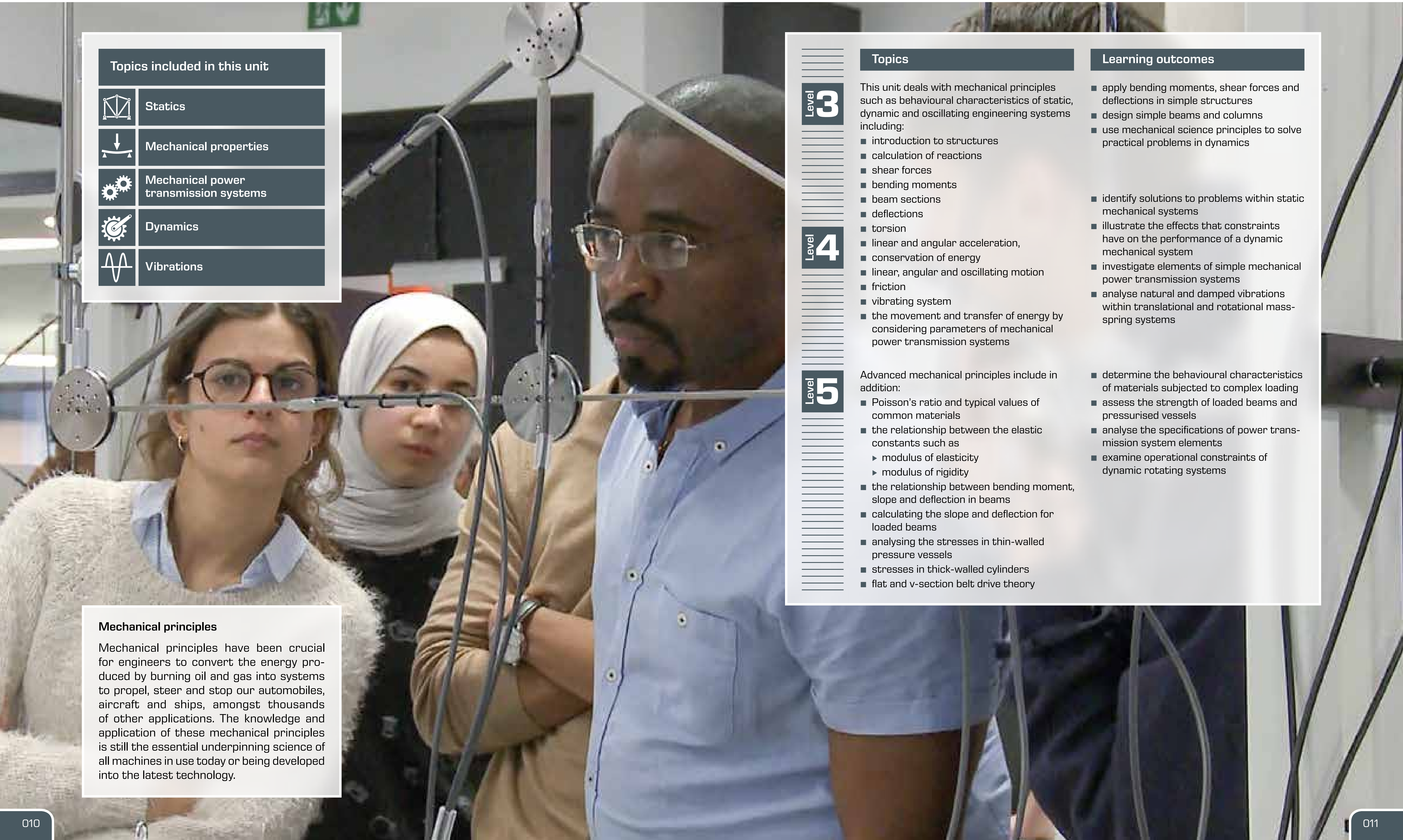
Skills development

Beside the pure knowledge and understanding of the fundamental principles, also skills development can be integrated into the curriculum. Skills can be divided into cognitive, applied and transferable skills. How can GUNT support to implement these skills into the learning process?

Skills	Examples	How can GUNT support to implement these skills
Cognitive skills	**verbal ability**	using the correct terminology, e.g. process schematics, datasheets, manuals and guidelines  
	spatial ability	interpretation of engineering drawings, cut away models, assembly exercises etc.  Additional to practical exercises, materials with focus on reading, understanding and application of technical drawings and parts lists.  HM 700.17 Cutaway model: centrifugal pump
	planning	conducting experiments with GUNT devices: apply project management skills and techniques for reporting, planning, control and problem-solving  
	hand-eye coordination	assembly exercises, conversion of equipment for various tests  Plan assembly steps and procedures; Complete assembly of individual machine elements through to the functional fitting; Familiarisation with machine elements and standard parts
	recognition	GUNT uses industrial components to achieve the recognition effect  Engine test stand CT 400 together with the four-cylinder diesel engine

Skills	Examples	How can GUNT support to implement these skills
Applied skills	**put knowledge to work**	integrate theory and practice through the investigation, evaluation and development of practices and products in the workplace: experiments and data evaluation of GUNT devices 
Transferable skills	**team working**	solve and conduct tests and experiments in a team, interpretation of distribution and delegation of tasks 
	communication skills	presentation of experimental data and experiment evaluation in oral and written manner 
	analytics	use quantitative skills to manipulate, evaluate and verify data 
	problem solving	identifying electrical faults in air conditioning or refrigeration systems from GUNT  ET 170 Electrical faults in simple air conditioning systems

1 Mechanical principles



Topics included in this unit

- Statics
- Mechanical properties
- Mechanical power transmission systems
- Dynamics
- Vibrations

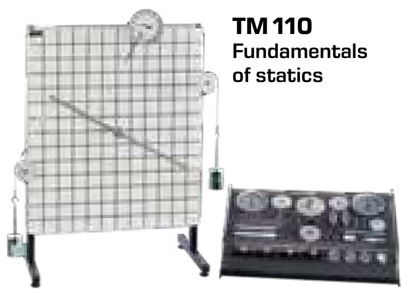
Level	Topics	Learning outcomes
Level 3	This unit deals with mechanical principles such as behavioural characteristics of static, dynamic and oscillating engineering systems including: ■ introduction to structures ■ calculation of reactions ■ shear forces ■ bending moments ■ beam sections ■ deflections ■ torsion	■ apply bending moments, shear forces and deflections in simple structures ■ design simple beams and columns ■ use mechanical science principles to solve practical problems in dynamics
Level 4	■ linear and angular acceleration, ■ conservation of energy ■ linear, angular and oscillating motion ■ friction ■ vibrating system ■ the movement and transfer of energy by considering parameters of mechanical power transmission systems	■ identify solutions to problems within static mechanical systems ■ illustrate the effects that constraints have on the performance of a dynamic mechanical system ■ investigate elements of simple mechanical power transmission systems ■ analyse natural and damped vibrations within translational and rotational mass-spring systems
Level 5	Advanced mechanical principles include in addition: ■ Poisson's ratio and typical values of common materials ■ the relationship between the elastic constants such as ▸ modulus of elasticity ▸ modulus of rigidity ■ the relationship between bending moment, slope and deflection in beams ■ calculating the slope and deflection for loaded beams ■ analysing the stresses in thin-walled pressure vessels ■ stresses in thick-walled cylinders ■ flat and v-section belt drive theory	■ determine the behavioural characteristics of materials subjected to complex loading ■ assess the strength of loaded beams and pressurised vessels ■ analyse the specifications of power trans-mission system elements ■ examine operational constraints of dynamic rotating systems

Mechanical principles

Mechanical principles have been crucial for engineers to convert the energy produced by burning oil and gas into systems to propel, steer and stop our automobiles, aircraft and ships, amongst thousands of other applications. The knowledge and application of these mechanical principles is still the essential underpinning science of all machines in use today or being developed into the latest technology.

Statics

Fundamentals of statics

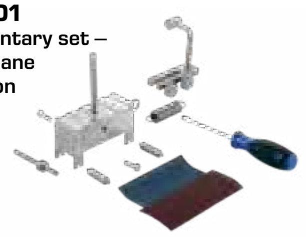


TM 110
Fundamentals of statics

Demonstration of force and moment equilibrium in a static system

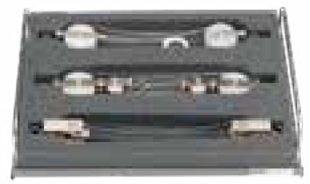
- accumulation and resolution of forces with force parallelogram
- equilibrium of forces
- law of levers, determination of moments and equilibrium of moments
- combined lever systems
- forces in bearings
- deflection and resolution of force by fixed and free pulley

TM 110.01
Supplementary set – inclined plane and friction



- elastic deflection of a helical spring (Hooke's law)
- dynamic friction as a function of the normal force, contact area and surface properties of the friction body
- determination of the friction coefficient
- rolling friction
- forces on the inclined plane

TM 110.02
Supplementary set – pulley blocks



- setup and principle of pulley blocks with 4 pulleys and with 6 pulleys; differential pulley block
- principle of "simple machines": force transmission, lifting work and potential energy

TM 110.03
Supplementary set – gear wheels

- transmission ratio of speed and moment on a single-stage gear
- influence of intermediate wheels on the direction of rotation
- transmission ratio on a two-stage gear
- conversion of rotation into linear motion and vice versa

Forces and moments

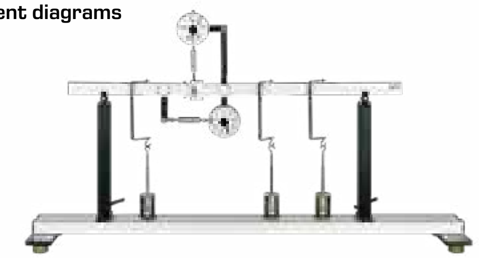
TM 115
Forces in a crane jib

Graphical and experimental determination of forces in a planar central force system

- graphical breakdown of forces by force parallelogram
- determination of the bar forces on various jib forms
- comparison of: measuring result – calculation – graphical method

Internal reactions and methods of section

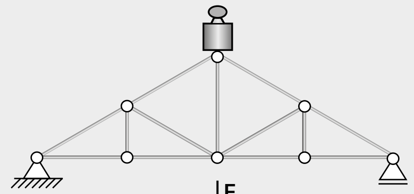
WP 960
Beam on two supports: shear force & bending moment diagrams



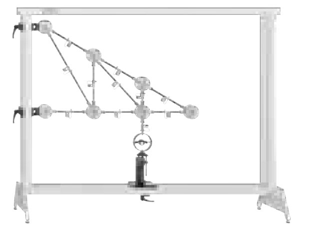
- calculation of the reactions arising from the static conditions of equilibrium
- application of the method of sections to calculate the internal forces and moments
  - under a point load
  - under multiple point loads
- calculation of the shear force diagram
- calculation of the bending moment diagram
- comparison of calculated and measured values for shear force and bending moment

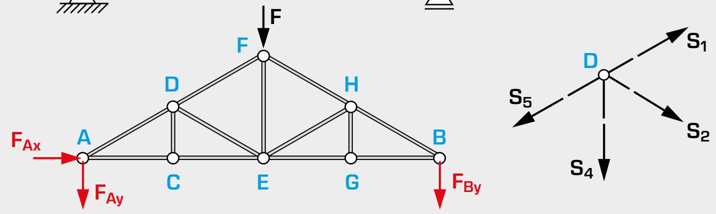
Forces in a truss

- bar forces in statically determinate and indeterminate trusses
- dependence of bar forces on external forces
- method of sections: method of joints and Ritter's method
- graphical method: Cremona diagram



SE 110.21
Forces in various single plane trusses



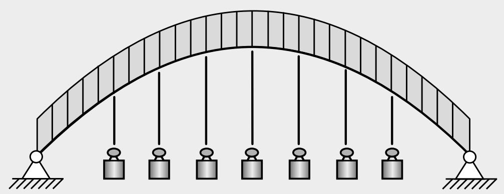


Method of joints to determining the forces on a truss

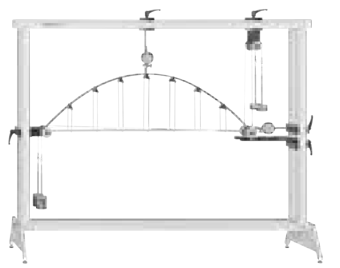
F force, **F_{Ax}**, **F_{Ay}**, **F_{By}** support forces, **S** bar forces, **A-H** joints

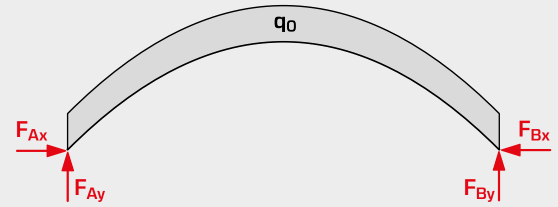
Bridges, beams, arches and cables

- calculation of support forces
- determining internal reactions
- different load cases: point load, line load and moving load



SE 110.16
Parabolic arch





Line load and support reactions on an arch

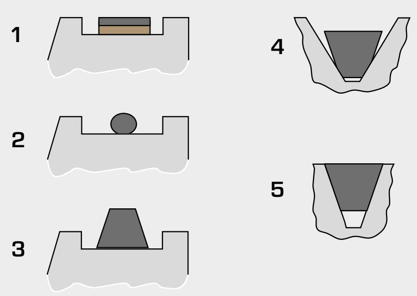
F_{Ax}, **F_{Ay}**, **F_{Bx}**, **F_{By}** support forces, **q_0** line load

Static and kinetic friction

- static and dynamic friction
- demonstration of frictional forces
- determining the coefficients of friction

SE 225
Friction on the inclined plane

TM 220
Belt drive and belt friction



Comparison of different belt types

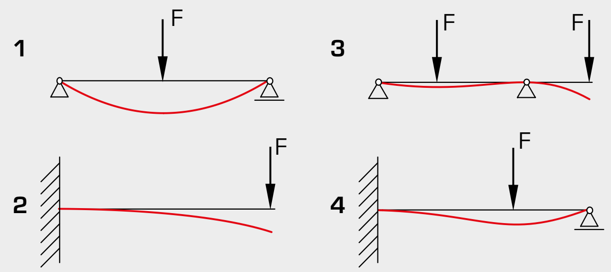
1 flat belt, **2** cable, **3** V-belt, **4** adverse belt seat in the groove, **5** optimum belt seat in the groove

Mechanical properties

Elastic deformations

WP 950
Deformation of straight beams

Elastic lines of statically determinate and indeterminate beams under various clamping conditions

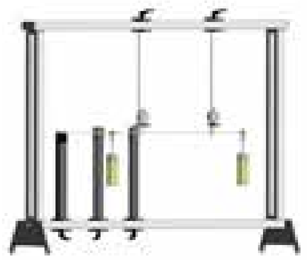


Elastic lines for statically determinate (left) and indeterminate (right) cases

1 single-span beam with fixed and movable support, **2** cantilever, **3** beam with 2 fixed supports, **4** propped cantilever

Part of the SE 110-Series: GUNT-Structure Line

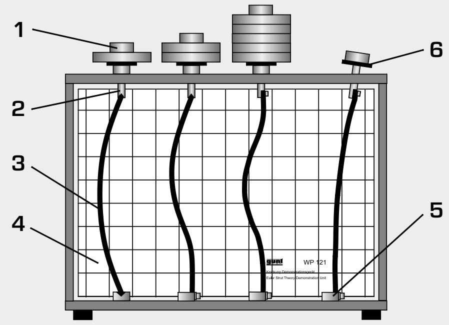
SE 110.14
Elastic line of a beam



SE 110.47
Methods to determine the elastic line

Buckling and stability

WP 121
Demonstration of Euler buckling

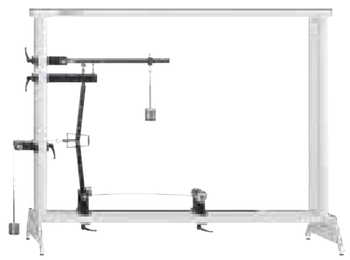


1 weight, **2** pinned support, **3** bar, **4** backing wall with grid pattern, **5** fixed support, **6** mount for weight

Part of the SE 110-Series: GUNT-Structure Line

SE 110.57
Buckling of bars

SE 110.19
Investigation of simple stability problems



Compound stress

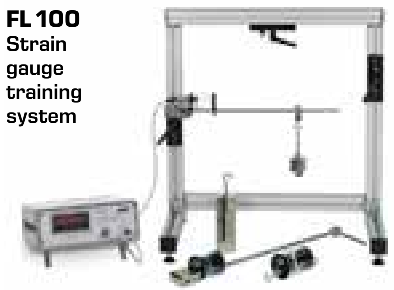
WP 130
Verification of stress hypotheses

Multiaxial loading of samples by bending and torsion

- generation of multi-axial loads on test samples made of ductile metals:
  - steel, copper, brass, aluminium
- generation of various load moments
  - pure bending moment
  - pure twisting moment
  - combined bending moment and twisting moment
- determination of the yield point
- verification of the Rankine yield criterion
- verification of the Tresca yield criterion
- representation in Mohr's circle of stresses and strains

Experimental stress and strain analysis

FL 100
Strain gauge training system



Basic introduction to measurement with strain gauges for tension, bending and torsion

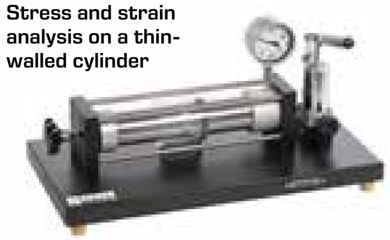
FL 101
Strain gauge application set

Complete equipment for practising manual handling of strain gauge technology

FL 120
Stress and strain analysis on a membrane

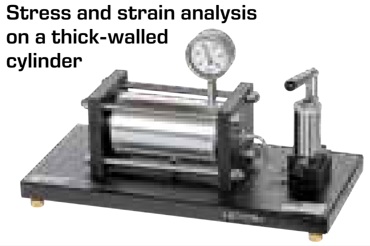
Investigation of deflection and strain of a membrane under internal pressure; membrane with strain gauge application

FL 130
Stress and strain analysis on a thin-walled cylinder



Investigation of axial and circumferential stress in a thin-walled cylinder under internal pressure

FL 140
Stress and strain analysis on a thick-walled cylinder

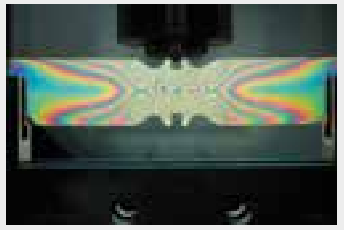


Triaxial stress state in the cylinder wall; cylinder with strain gauge application on surface and in wall

FL 200
Photoelastic experiments with a transmission polariscope

Visualisation of mechanical stresses in models subject to varying loads

Model of a notched bar (FL 200.05) in monochromatic light



Model FL 200.05 in white light

Mechanical power transmission systems

Transmission or conversion elements

Complex machine elements used to alter the motion variables of path, velocity and acceleration are known as conversion elements or gears. In a gear drive, positively locking **gears** transfer the rotary motion from one shaft to another. In a traction drive, the rotary motion is transferred between two shafts by means of a traction gear. Here, a distinction is made between non-positive traction drives **(belt drive)** and positive traction drives **(chain** or **toothed belt drive).**

Fundamentals

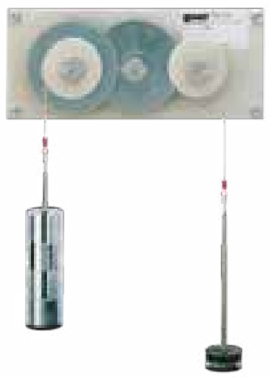
GL 100
Principle of gear units

Fundamental principles of belt drives, wheel and disc drives, and gear trains

GL 110
Cam mechanism

Demonstration and measurement of the displacement curves for cam mechanisms

TM 123
Spur gear unit



Mode of operation and layout of toothed gearing mechanisms

TM 124
Worm gear unit

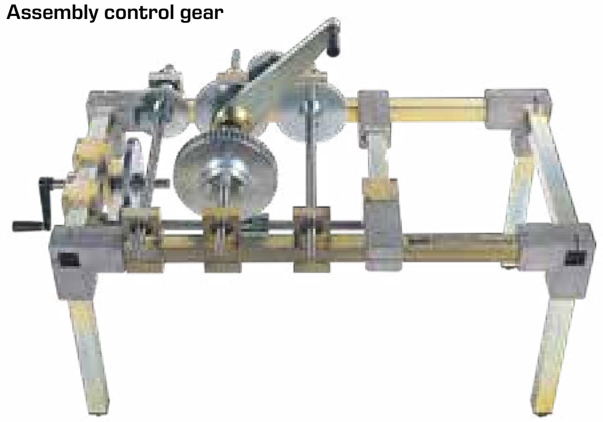
Mode of operation and layout of a worm gear

TM 125
Cable winch

Using force equilibrium considerations to determine load transmission and efficiency

Advanced

GL 430
Assembly control gear



Versatile assembly exercise for various step and gear units

- familiarisation with main components and forms of mechanical gear engineering
  - step pulley gear
  - sliding gear drive
  - Norton gear
  - tumbler gear
  - change gear
  - cam box (tripping device for lathe)
- calculations on mechanical gears
- practical setup of different gears, associated with setup and configuration exercises
- read and understand engineering drawings, familiarisation with technical terms

GL 200
Lathe gear

Safe and clear demonstration of function of the gears on a conventional lathe

- investigation of all essential gear functions of a lathe
- main gear
- change gear
- tumbler gear
- feed gear (Norton gear)

AT 200
Determination of gear efficiency

Level 5+

Test system for determining mechanical drive and braking efficiency for spur and worm gears

- determination of the mechanical efficiency of gears by comparing the mechanical driving and braking power for
  - spur gear, two-stage
  - worm gear
- plot the torque/current characteristic curve for a magnetic particle brake
- drive and control engineering

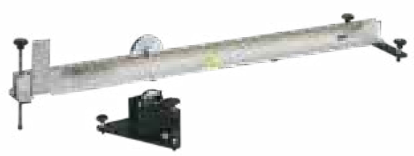
Dynamics and vibrations

Kinetics

TM 610
Rotational inertia

Moments of inertia of different mass arrangements and bodies

TM 611
Rolling disk on inclined plane



Determining moment of inertia on rotating masses by rolling down an inclined plane and by performing a pendulum test

TM 612
Kinetic model: flywheel

Experimental determination of the moment of mass inertia of a flywheel

TM 600
Centrifugal force

Laws on the behaviour of centrifugal forces on rotating masses

TM 630
Gyroscope

Experimental verification of the laws of gyroscopes

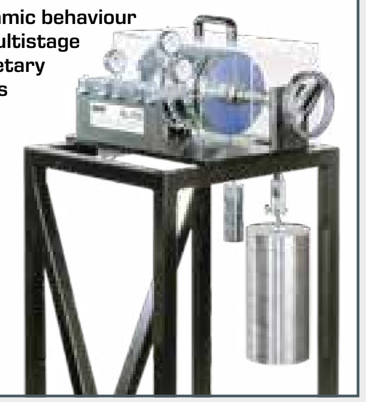
TM 632
Centrifugal governor

Characteristic curves of different centrifugal force governors

GL 210
Dynamic behaviour of multistage spur gears

Investigation of the dynamics of rotation of one-, two- and three-stage spur gear units

GL 212
Dynamic behaviour of multistage planetary gears



Investigation of rotational dynamics of a two-stage epicyclic gear with three planetary gears each

TM 605
Coriolis force

Demonstration of the Coriolis force in rotating reference system

Kinematics

KI 110
Kinematic model: crank mechanism

Conversion of rotary motion into oscillating motion

KI 120
Kinematic model: crank slider

Conversion of a uniform rotary motion into a pure harmonic reciprocating motion

KI 130
Kinematic model: four-joint link

Conversion of rotary motion into oscillating motion

KI 140
Kinematic model: Whitworth quick return mechanism

Uneven reciprocating motion with slow feed and quick return

KI 150
Kinematic model: Hooke's coupling

Phenomenon of the gimbal error in Hooke's couplings and how to avoid it

KI 160
Kinematic model: Ackermann steering mechanism

Determining the lead angle of a steering trapezoid

GL 105
Kinematic model: gear drive

Investigation of transmission ratios on spur gear units

Vibrations

TM 161
Rod and gravity pendulum

Comparison of physical and mathematical pendulum

TM 162
Bifilar/trifilar suspension of pendulums

Moments of inertia of different bodies in a rotary pendulum experiment

TM 163
Torsional vibrations

Determination of the oscillation period depending on torsion wire length, diameter and rotating mass

TM 164
Coil spring vibrations

Investigation of vibrations on a spiral spring rotating mass system

Vibrations: TM 150 Vibration trainer

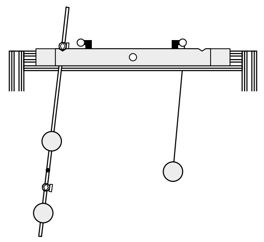
Vibration theory requires a good understanding of mathematical and physical relations. In technical professions, knowledge of vibration theory is essential. Illustrative experiments are offered to make it easier for students to understand the principles.

The TM 150 vibration trainer developed especially for this demanding field allows conducting experiments on a variety of vibration-related topics.

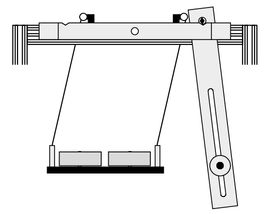
- pendulum swings
- spring-mass systems
- free and forced vibration
- damped vibrations
- beam vibrations
- dual-mass systems and dynamic vibration absorbing effects

TM 150
Vibration trainer

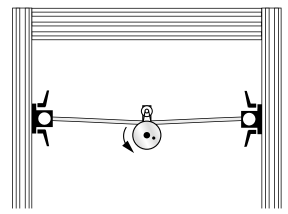
To study **pendulums**, the trainer includes different pendulum versions and a pendulum bearing:



- **2 gravity pendulums** with steel and wooden ball
- **2 rod pendulums** with adjustable masses and knife-edge bearings

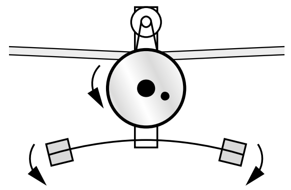


- **1 wooden physical pendulum** with adjustable masses and knife-edge bearing
- **1 pendulum with bifilar suspension** and different masses

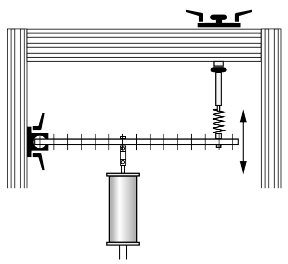


Investigation of **forced vibration** by an imbalance exciter; controllable frequency and imbalance exciter amplitude

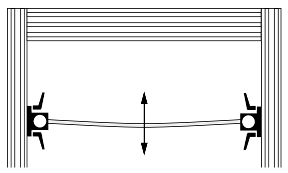
Tunable vibration absorber for investigating **vibration-absorbing effects**



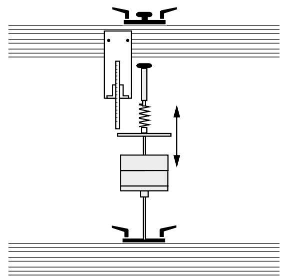
Two bar types available in the **bar-type oscillator:**



Rigid bar as discrete rotational oscillator, fixed support, suspension on a helical spring. A breadboard allows the attachment of springs, exciters and absorbers in a wide variety of reproducible configurations.



Elastic bar as oscillating continuum, either fixed or movable support, ball-bearing-mounted for minimal system damping



Investigation of a **spring-mass system** with

- height-adjustable spring holder
- bracket for holding different masses
- helical springs with varying spring stiffness
- vernier calliper to measure deflection

Damped vibration via an adjustable viscous damper with very low Coulomb friction

TM 150.20 System for data acquisition

- analysis of vibration signals on a PC
- frequency and phase response curves
- all principal functions of a digital storage oscilloscope
- frequency spectra of the signals
- comprising software, a displacement sensor, a reference sensor and an interface box
- the interface box supplies up to three sensors, prepares their measuring signals for the PC and offers them to three analogue outputs for display

TM 150.02 Free and damped torsional vibrations

Torsional vibrations play a key role in drive systems and must be controlled to avoid damage. The TM 150.02 accessories set can be used to produce **free and damped torsional vibrations** and to study the effects of torsional stiffness, mass and damping on frequency and amplitude.

The range of experiments includes

- torsional stiffness
- mass moment of inertia
- free torsional vibrations
- damped torsional vibrations
- oscillator with several masses

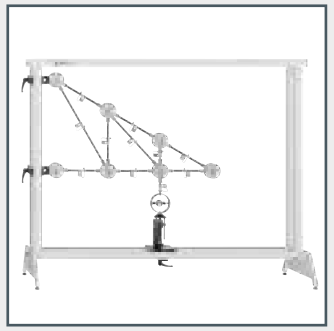
All parts of the system are ready at hand and securely housed in a storage system.

Course: mechanical principles

GUNT-Structure Line

A course on engineering mechanics





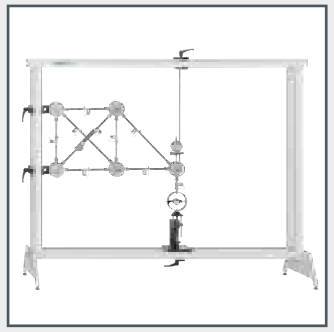












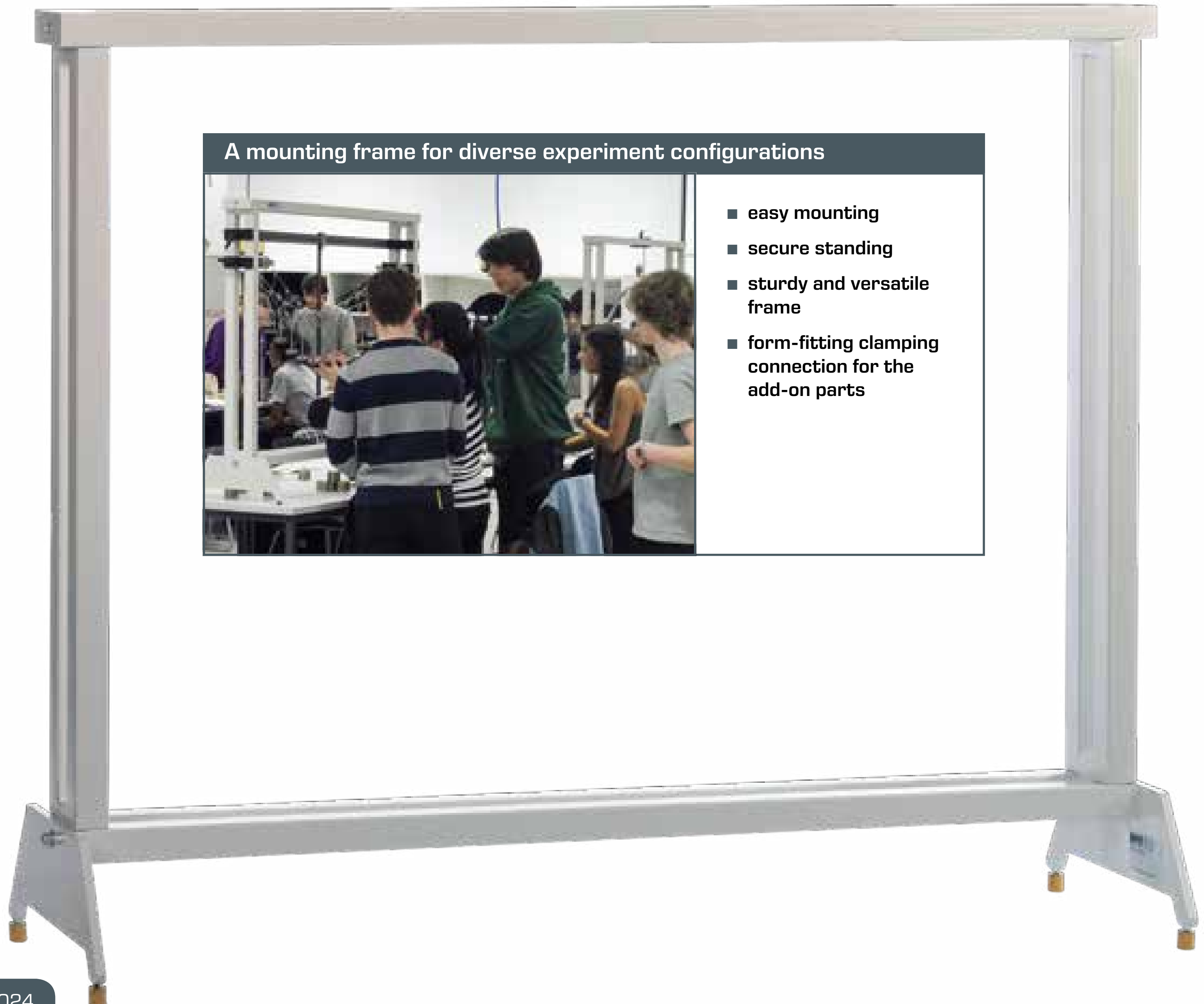
Course: mechanical principles

In GUNT, the term “structure” refers to a supporting structure or a building structure. The term “line” refers to a GUNT series of units. The GUNT-Structure Line is a series of units that has been specially developed by GUNT to support teaching basic engineering principles with practical exercises.

The series of units offers a variety of opportunities to learn about common topics such as equilibrium conditions, forces and deformations or stability and buckling and to develop a more in-depth understanding.

The GUNT-Structure Line offers the following advantages:

- meaningful compilation of experiment subjects
- wide range of experiments: one frame is combined with different add-on parts
- easy to transport and space-saving storage of the add-on parts thanks to stackable storage systems
- orderliness when conducting experiments, thanks to individual parts being stored in clear foam inserts
- safe storage of small parts such as screws, adapters, or tools in transparent boxes
- stable mounting frame, easy to assemble and disassemble, with rubber feet for secure standing
- easy-to-install add-on parts can be fitted at any point on the frame using adjustable clamping levers

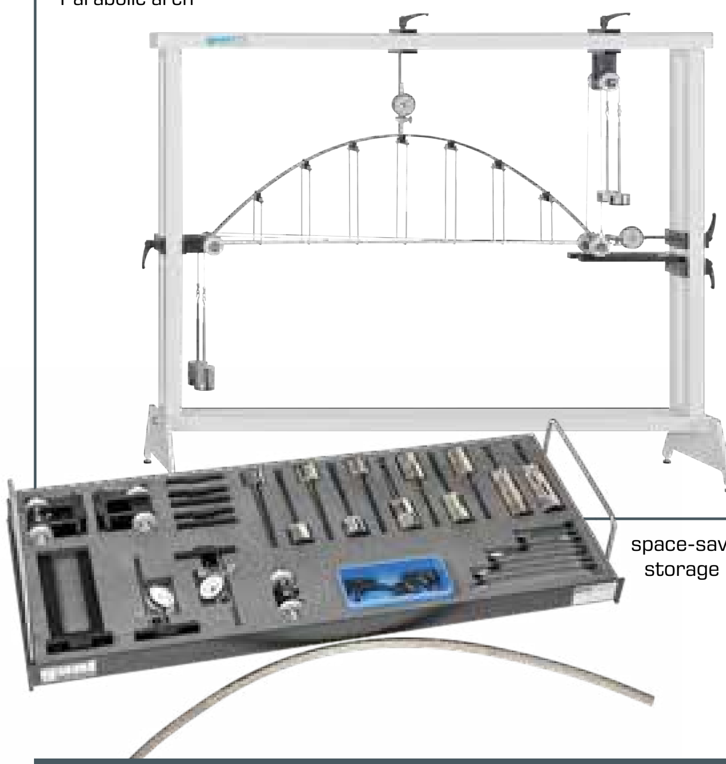


A mounting frame for diverse experiment configurations

- **easy mounting**
- **secure standing**
- **sturdy and versatile frame**
- **form-fitting clamping connection for the add-on parts**

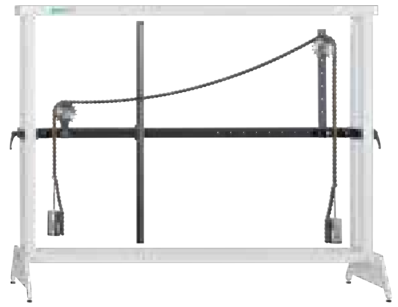
Experiments on statics

SE 110.16
Parabolic arch

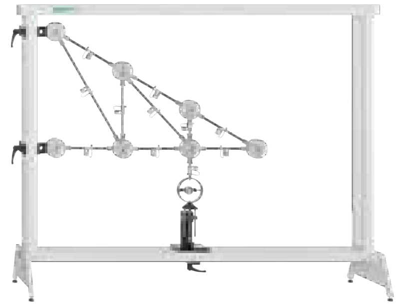


space-saving storage

SE 110.50
Cable under dead-weight



SE 110.21
Forces in various single plane trusses



Experiments on strength of materials

SE 110.44
Deformation of trusses

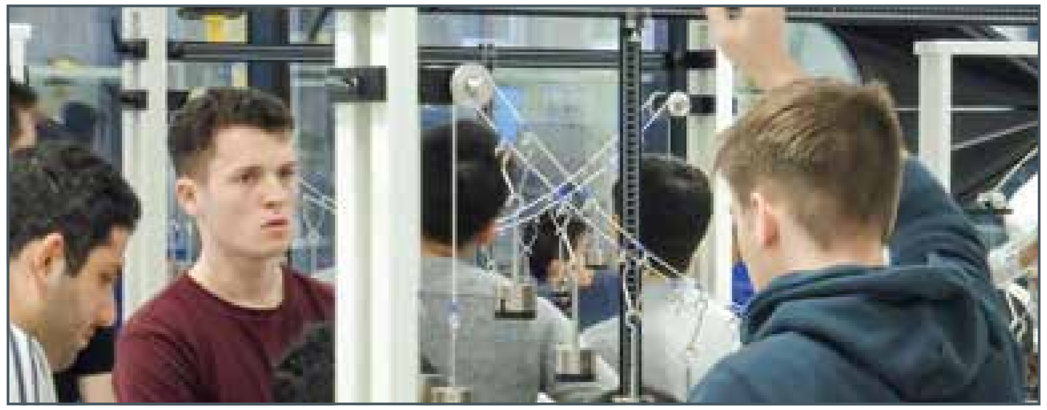
SE 110.47
Methods to determine the elastic line

SE 110.19
Investigation of simple stability problems

space-saving storage

Didactic concept of the GUNT-Structure Line

The GUNT-Structure Line allows you to build an extensive laboratory on the fundamentals of engineering. In this way, the rather abstract contents of the lecture can be practically simulated and clearly represented through small-group experiments. This promotes students' long-term learning success. Meanwhile, group participants' social skills are encouraged in addition to their more technical skills.



Manual experimentation promotes the following capabilities:	**How does manual experimentation promote skills?**
■ planning experimental series ■ setup of experiments ■ encouraging abstraction skills ■ encouraging manual work and technical ability ■ encouraging effective teamwork	■ The abstract structural diagram must be implemented in a real experimental setup. This requires imagination, judgement and manual dexterity. Students learn how to technically realise abstract concepts such as clamping or flexible supports. The limits of idealisation are also made clear.
■ implementing theoretical teaching subjects in the experiment ■ developing an understanding of forces and stresses	■ Terms such as stability and balance of a system are illustrated by the manual application of the load. ■ The load on the experimental setups, mainly from weights, gives students a feeling for masses and forces.
■ evaluating results ■ estimating errors	■ Measuring the deformation using dial gauges provides direct feedback of the load. The factors of slack, friction and the resulting hysteresis – which are almost always present in real systems – can be experienced.

Frame, components and connecting elements are combined into a functioning experimental setup. The points of action for loads, their effect on the support structures and structural elements and the use of fixed and movable supports are tested.

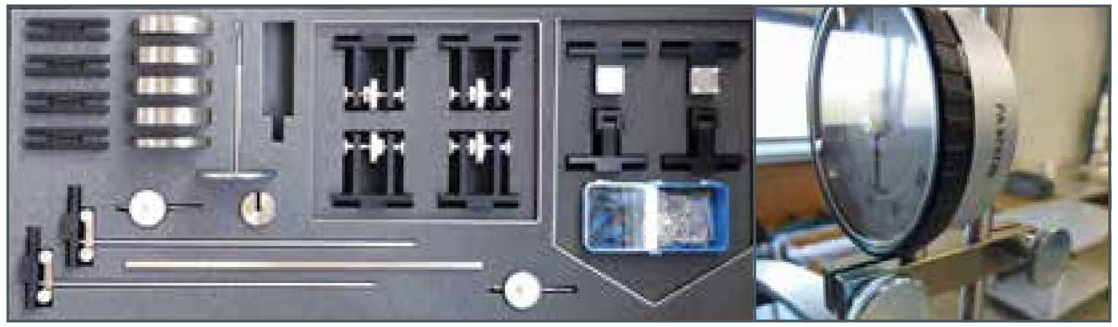
This makes the function and the processes in support systems easy to observe and understand and it ensures a lasting learning experience.

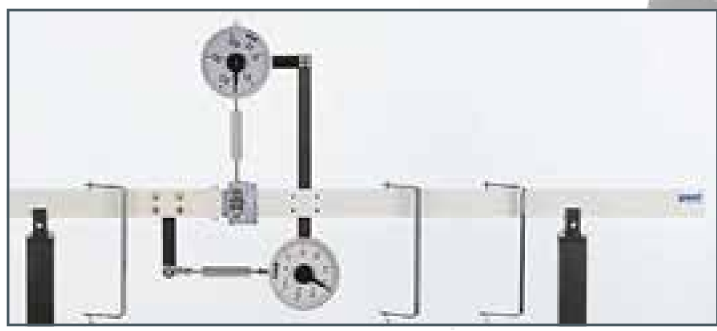
A fundamental section with the relevant theory and model-based experiment instructions allow an intensive preparation for the experiment. Sample experiment results allow a qualified assessment of the students' own results.

Our didactic materials offer excellent support when preparing lessons, when conducting the experiments and when reviewing the experiment.

The software forms a bridge between the mechanical model and the didactic material in paper form.

Trusses can be simulated and configured in the software. Similarly, the behaviour of truss systems is reflected in concrete measured values and the bar forces are graphically displayed (SE 110.21, SE 110.22).





Contents of the GUNT-Structure Line

A wide range of experiments with a variety of options

The series of units covers topics such equilibrium conditions, forces and deformations or stability and buckling.

The units represent self-contained learning units, complementing the experimental units from a topic in terms of the learning objectives.

For a complete experimental setup, the components of an experimental unit are assembled in the SE 112 mounting frame.

Equilibrium conditions

SE 110.50
Cable under dead-weight

- determine catenary of a free-hanging cable
- measure sag
- compare calculated and measured values

SE 110.53
Equilibrium in a single plane, statically determinate system

- the main principle of the practical experimentation: free-body diagrams in statics
- calculation of support forces
- application of the 1st and 2nd equilibrium conditions of statics

Bridges, beams and arches

SE 110.12
Lines of influence on the Gerber beam

- application of the method of sections and the equilibrium conditions of statics to calculate the support forces
- determine the internal reactions under static load

SE 110.16
Parabolic arch

- mechanical fundamentals of the parabolic arch
- differences between statically determinate and statically indeterminate arches
- influence of load on the support forces and deformation of the arch

SE 110.17
Three-hinged arch

- investigation of how the load affects the horizontal thrust in the supports
- determine the influence lines for the supports under a moving load

SE 110.18
Forces on a suspension bridge

- calculate supporting cable force
- observe the effect of internal moments in the carriageway under uneven load

Forces and deformations in a truss

SE 110.21
Forces in various single plane trusses

- dependence of bar forces on external forces
- comparison of measuring results with mathematical solutions using: the method of joints and Ritter's method of sections

SE 110.22
Forces in an overdeterminate truss

- distribution of forces in a plane truss, depending on the use of a redundant bar
- dependence of bar forces on an external force

SE 110.44
Deformation of trusses

- work-energy theorem and deformation energy
- application of Castigliano's first theorem for calculating deformation at a defined point
- comparison of the deformations of different trusses under the same load

Elastic and permanent deformations

SE 110.14
Elastic line of a beam

- elastic line under different loads / support conditions
- demonstration of Maxwell-Betti's theorem

SE 110.47
Methods to determine the elastic line

- principle of virtual work (calculation), Mohr's analogy (Mohr's method on an area of moments; graphical approach)
- applying the superposition principle of engineering

SE 110.20
Deformation of frames

- interaction between stress and strain on the frame
- first-order law of elasticity for statically determinate and indeterminate systems

SE 110.29
Torsion of bars

- shear modulus and polar second moment of area
- angle of twist as a function of the clamping length / twisting moment
- influence of torsional stiffness on twist

SE 110.48
Bending test plastic deformation

- load of a bending beam with a point load
- create a force-path diagram

Stability and buckling

SE 110.19
Investigation of simple stability problems

- determine the buckling force
- investigate buckling behaviour under the influence of additional shear forces or pre-deformation

SE 110.57
Buckling of bars

- investigate buckling behaviour under the influence of different supports, clamps, cross-sections, materials, or additional transverse stress
- test Euler's theory: buckling on elastic bars
- calculate the expected buckling force with Euler's formula
- graphical analysis of the deflection and the force

Vibrations in a bending beam

SE 110.58
Free vibrations in a bending beam

- free vibration in a vertical and horizontal bending beam
- determine the natural Rayleigh frequency
- how do clamping length and mass affect the natural frequency

2 Materials, properties and testing

Topics included in this unit

Materials, properties and testing

Materials, properties and testing

The world we live in would be a very different place without the sophisticated engineering materials currently available. Many of the things we take for granted, such as telecommunications, air travel, safe and low-cost energy, or modern homes, rely on advanced materials development for their very existence. Successful engineering application and innovation is dependent upon the appropriate use of these materials, and the understanding of their properties.

Level 3

Level 4

Topics

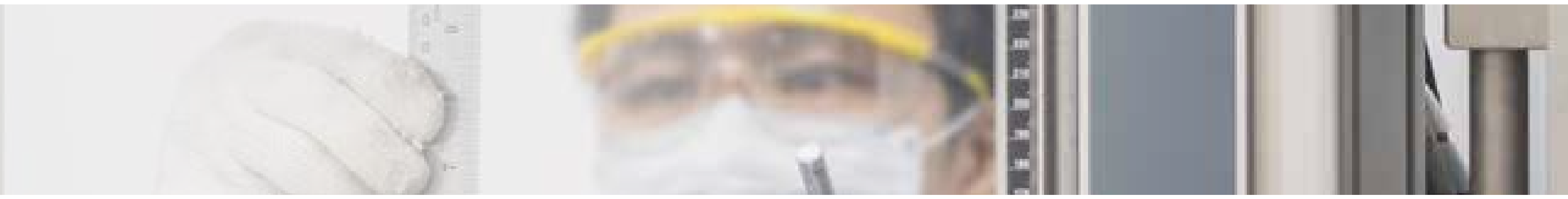
This unit introduces students to

- the atomic structure of materials and the way it affects the properties
- physical nature and performance characteristics of common manufacturing materials
- how these properties are tested
- modification by various processing treatments
- problems that occur which can cause materials to fail in service

Learning outcomes

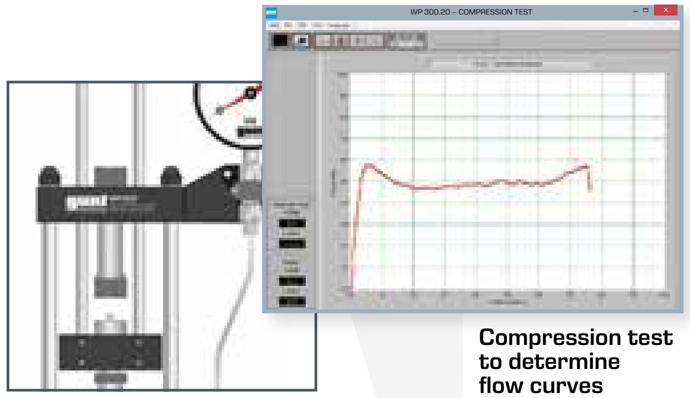
- identify properties and characteristics of engineering materials
- determine the suitability of engineering materials for use in a specified role
- understand and explore the testing methods used to determine physical properties of an engineering material
- test materials to meet given specifications
- recognise and categorise the causes of in-service material failure

Materials, properties and testing: WP 300



WP 300
Materials testing, 20 kN

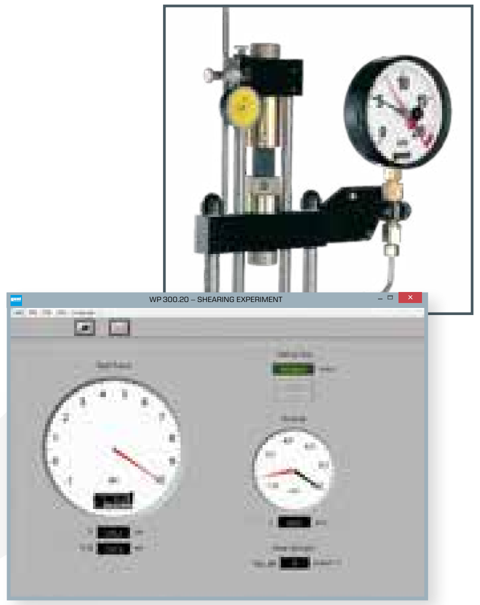
A solid understanding of the properties of materials is essential for technical and scientific professions. This knowledge helps select the suitable material, monitor production and processing and ensure the requirements in terms of a component. The materials test provides the necessary data in a reproducible and precisely quantified manner. The tensile test, bending test and hardness test are all part of classic destructive materials testing.



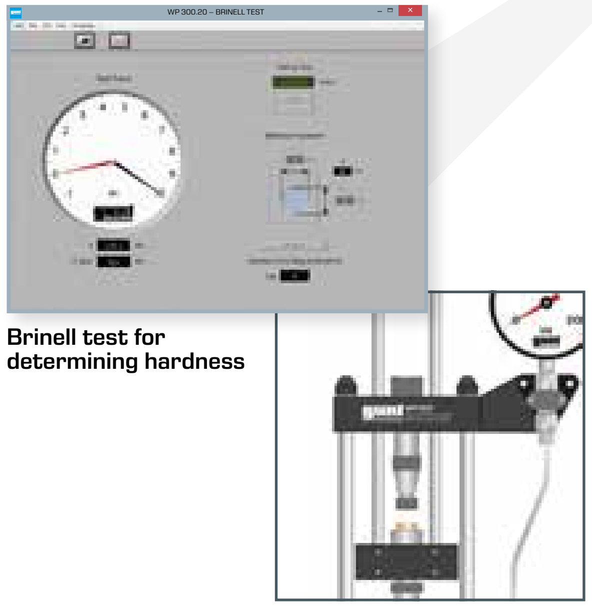
Compression test to determine flow curves

Tensile test to determine the tensile strength and elongation at fracture

WP 300.20
System for data acquisition



Shearing experiment to study the load capacity against shearing

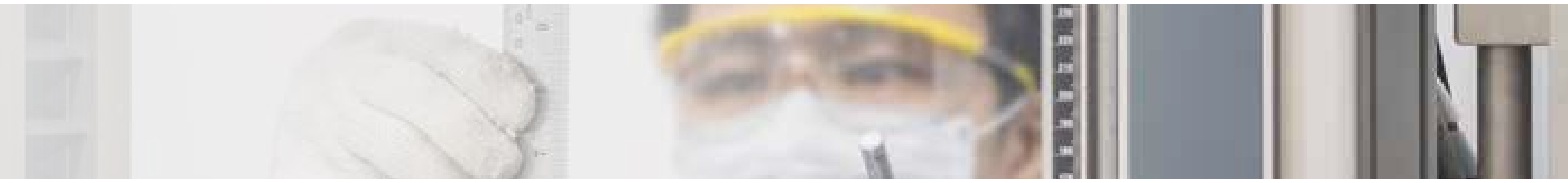


Brinell test for determining hardness

Bending tests for the study of deformation behaviour

The compact WP 300 experimental unit generates a 20 kN test load

- classic experiments in destructive materials testing
- observation of the experiment in all details and phases
- clear demonstration of relationships between rising forces and change in various materials
- mobile use thanks to compact and lightweight design
- preparation display and storage of data with the WP 300.20 system for data acquisition



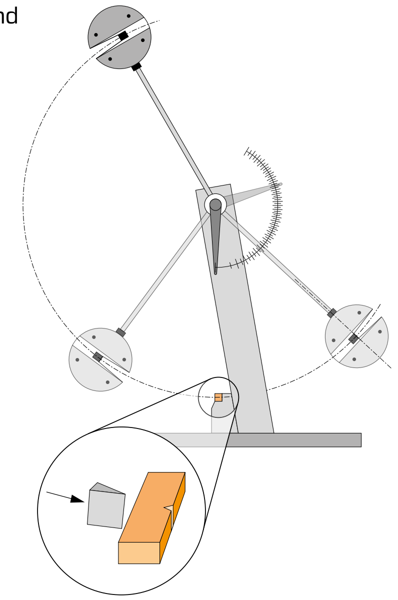
Materials, properties and testing

WP 400
Impact test, 25 Nm

Classic Charpy notched-bar impact test; specimens with different cross-sections and materials

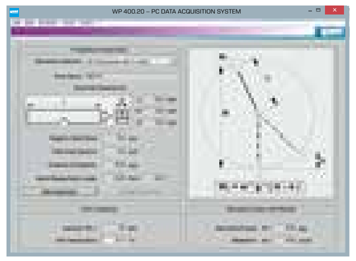
The compact WP 400 experimental unit generates a 25 Nm work capacity

- Charpy notched-bar impact test for quality control and analysis of the fracture behaviour in metallic materials
- pendulum impact tester based on DIN EN ISO 148-1
- various safety devices for conducting experiments, e.g. WP 400.50 protective cover for the operating area
- preparation display and storage with the WP 400.20 system for data acquisition



Principle of the Charpy notched-bar impact test

WP 400.50 Safety cage for pendulum impact tester



WP 400.20 System for data acquisition

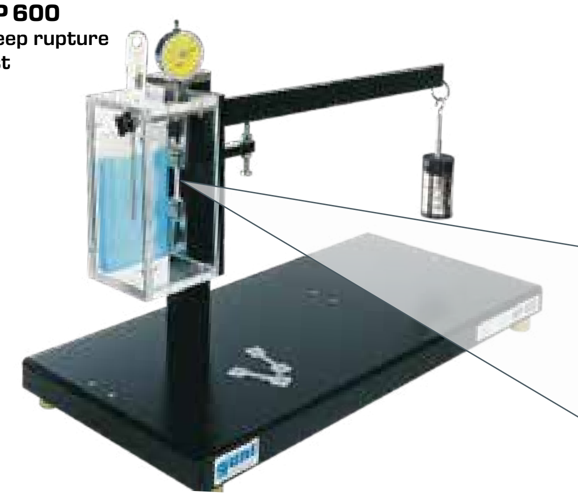
WP 140
Fatigue strength test

Fatigue strength of bars subject to cyclic bending load; stress-number (S-N) diagram

- fatigue strength of bars under reverse bending stress
- digital counter displays load cycles
- automatically shuts down when the test bar fractures
- preparation display and storage with the WP 140.20 system for data acquisition

Analysis of the fracture surface following the fatigue strength test

WP 600
Creep rupture test

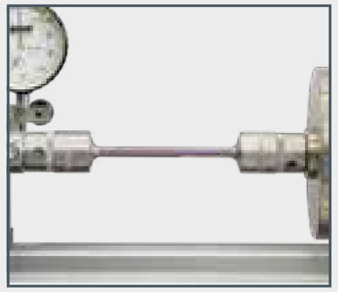


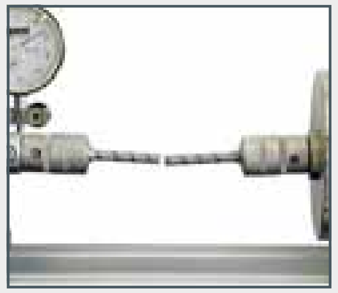
Demonstration of typical creep phenomena in various materials

- simple creep rupture tests with lead and plastic specimens
- experiments can be conducted at room temperature
- cooling elements allow experiments to be conducted below room temperature
- experiments last from a few minutes to an hour

Manual torsion testing of different materials to fracture

- generates the twisting moment by means of a worm gear
- measure the twisting moment with strain-gauge measuring shaft and encoder for measuring the twisting angle
- the scope of delivery includes GUNT software for analysing the measured values





In the torsion test, a specimen is clamped at one end and subjected to the load of a steadily increasing moment, known as the twisting moment or torsional moment.

Left: specimen before the load
Right: The twisting moment causes shear stresses in the crosssection of the specimen and a stress state that leads to deformation and ultimately to fracture.
The marked red line on the surface indicates the number of revolutions.

3 Engineering design

Topics included in this unit

- Engineering drawing
- Cutaway models
- Machine elements
- Assembly exercises

Engineering design

The tremendous possibilities of the techniques and processes developed by engineers can only be realised by great design. Design turns an idea into a useful artefact, the problem into a solution, or something ugly and inefficient into an elegant, desirable and cost effective everyday object. Without a sound understanding of the design process the engineer works in isolation without the links between theory and the needs of the end user.

Topics

Level 3

For the design of engineering components such as car engine parts, aircraft undercarriages or train brake units, performance and reliability are key. In this unit students will be able to look at that process and see how a customer's product specification is developed and turned into a final design for manufacture. Students will learn the meaning of the phrases 'fit, form and function', and 'fit for purpose' and learn to use them when deciding if a particular design is finished.

Level 4

This unit introduces students to the methodical steps that engineers use in creating functional products and processes; from a design brief to the work, and the stages involved in identifying and justifying a solution to a given engineering need.

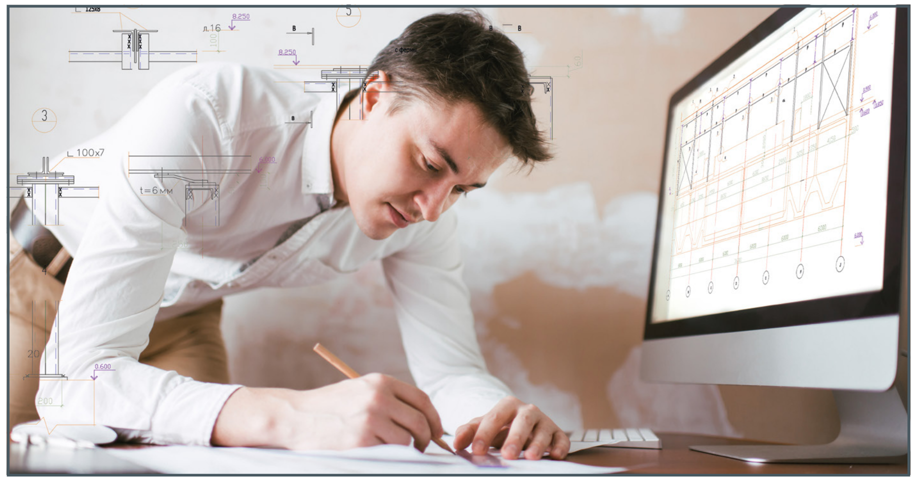
Learning outcomes

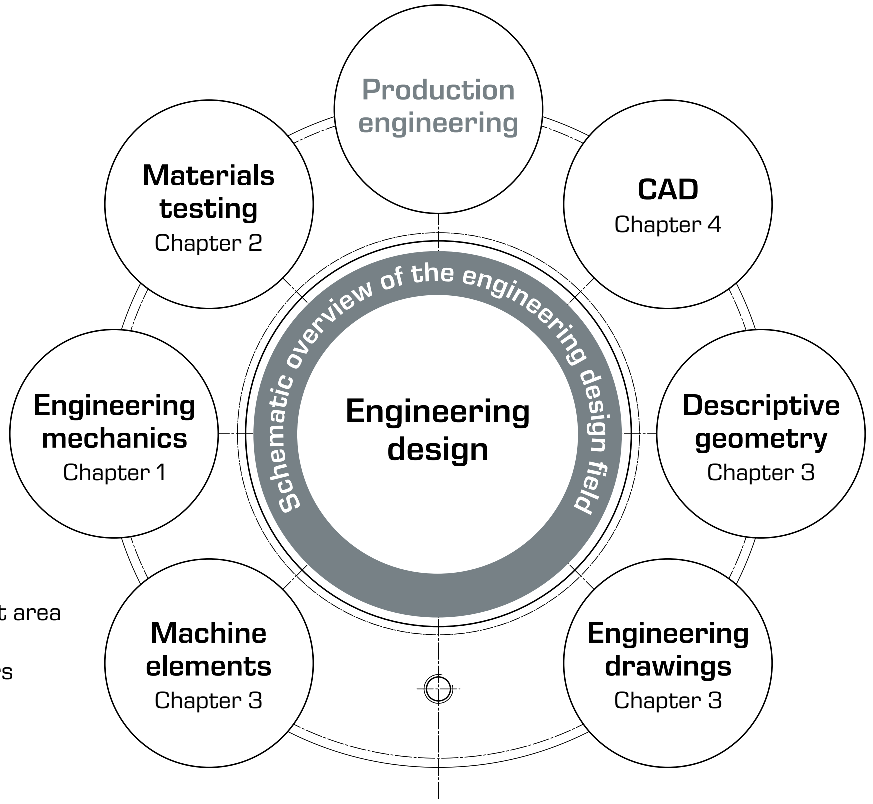
- understand the process of developing a product design specification
- understand how engineering design solutions meet product design specifications
- introduction to technical terms and technical language
- read and understand technical documentation
- familiarisation with machine elements and standard parts
- develop broad knowledge of assembly technology as a basis for the design of assemblies
- recognise assemblies, understand functions, describe systems
- plan and execute assembly steps and sequences
- familiarisation with typical tools and devices
- check and evaluate work results

Engineering design and drawing

Engineering design means describing technical products in full, thereby enabling their manufacture. This includes observations and concepts with sketches, calculations and initial drafts, all the way up to lists of parts and drawings with specifications for materials, machining, dimensions and tolerances. The applied principles of engineering design are taught in the engineering design discipline. Engineering design is a central and challenging area of learning within engineering education.

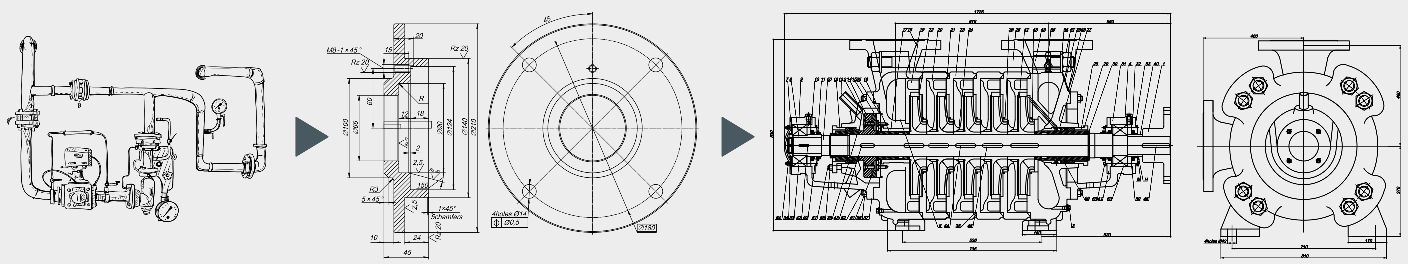
By carefully developing fundamental topics such as statics, strength of materials and dynamics, machine elements, materials testing, descriptive geometry and engineering drawings, students are prepared for subsequent professional activities.





Division of the subject area “Engineering design” into different chapters of this catalogue

From the idea for a product to its illustration in the form of a production-oriented engineering drawing



Idea as a sketch

Single-part drawings

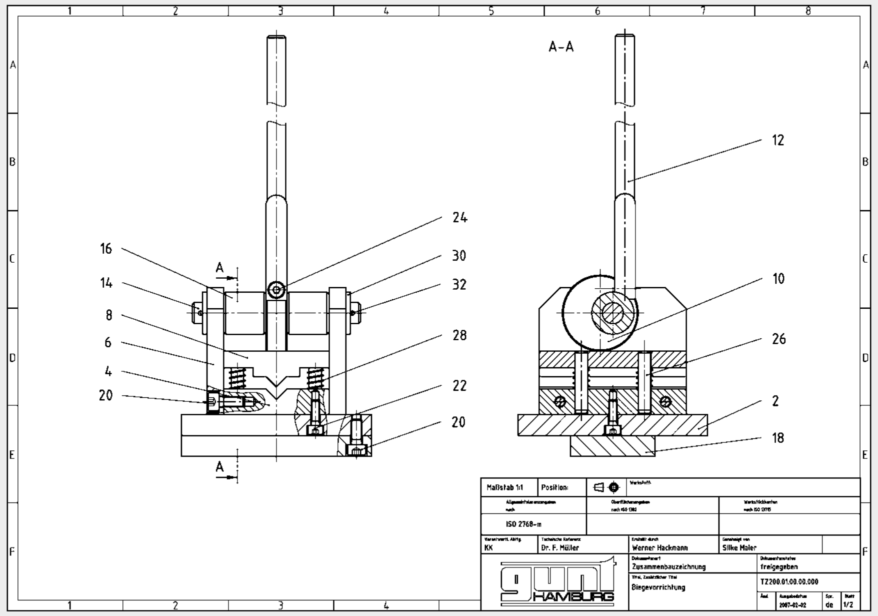
General arrangement drawing

Engineering drawing

Engineering drawings present a very abstract image of the components or devices with precise specifications. Using geometric and graphical features such as lines and symbols, as well as alphanumeric characters such as digits and letters, a three-dimensional object is described in two dimensions.

Reading and understanding engineering drawings is a fundamental element in the development of professional competence in all engineering disciplines.

General arrangement drawing of the bending device TZ 200.01



Bending device TZ 200.01

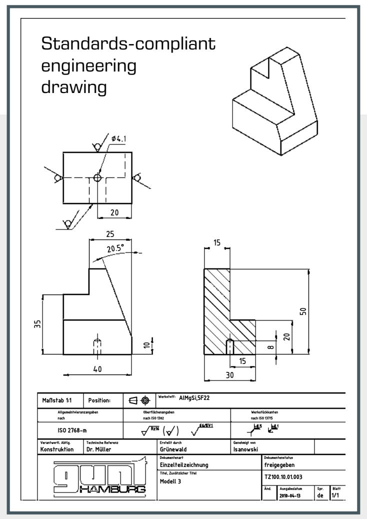
The components and assembly exercises of GUNT teach:

- the standards-compliant execution of engineering drawings
- the recognition of standardised representations
- the understanding of contexts of individual components

The reading of drawings is illustrated in:

- general arrangement drawings and exploded drawings
- raw casting drawing, production drawings

The types of drawings and their role and content in terms of standardisation are precisely explained.



Regulations and standards in engineering communication

The creation of an engineering drawing, whether manually or computer assisted, follows binding rules – the drafting standards – that do not permit any ambiguity. Drafting standards take account of the standards and recommendations of the ISO (International Organization for Standardization) and are therefore applicable internationally. They include, for example:

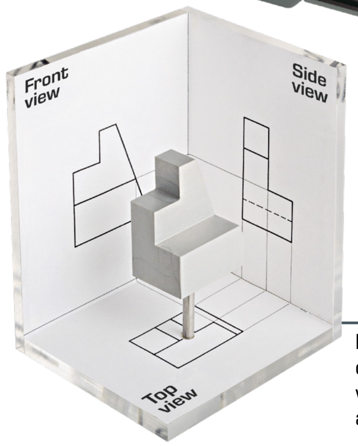
- precise identification and use of line styles, hatches and colours as well as the representation of views and sections
- isometric and diametric representation; simplified representation
- dimension inscriptions, tolerance abbreviations
- drawing-sheet formats, title blocks, standard font
- fits; basic terms of tolerances and fits

Engineering design and drawing

Geometric models

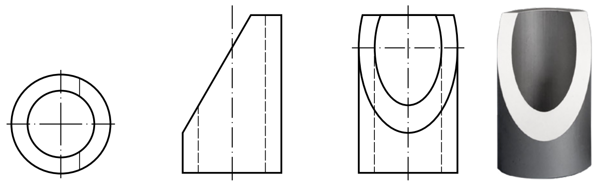
Geometric models support the learning process by providing an introduction to technical drawings: from the solid model to the more abstract representation of the three views in a technical drawing. Different solid models are available.

TZ 100
Engineering drawing: three-dimensional display



Room corner made of three Plexiglas planes with inlaid drawing and a prismatic model

TZ 120
Cylindrical work samples with slanted cut-outs

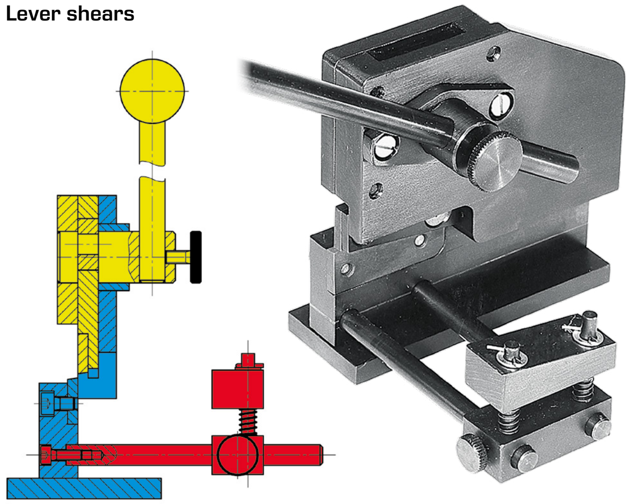


Top view | Side view | Front view

Practice models

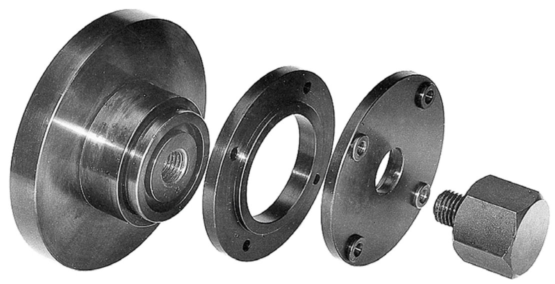
Core didactic aspects are reading and understanding technical drawings, and standardised and production-oriented dimensioning of parts.

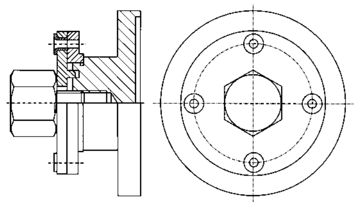
TZ 200.07
Lever shears



Function groups of a lever shears:
main body, shear body, stop

TZ 200.06
Drilling jig for an annular disc



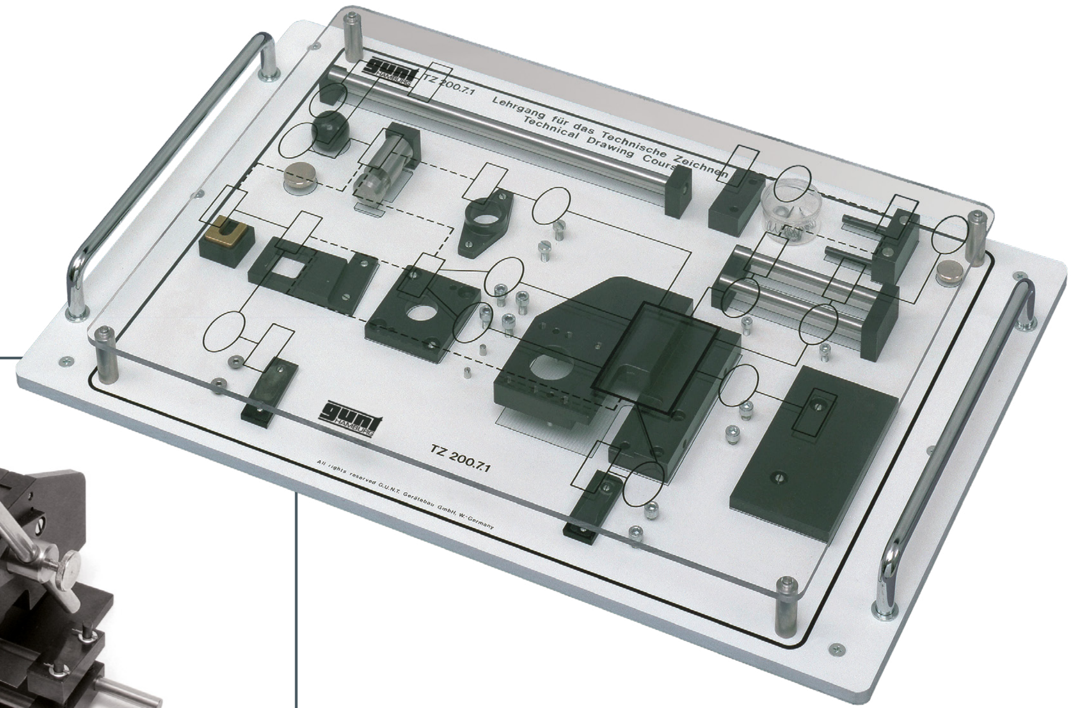


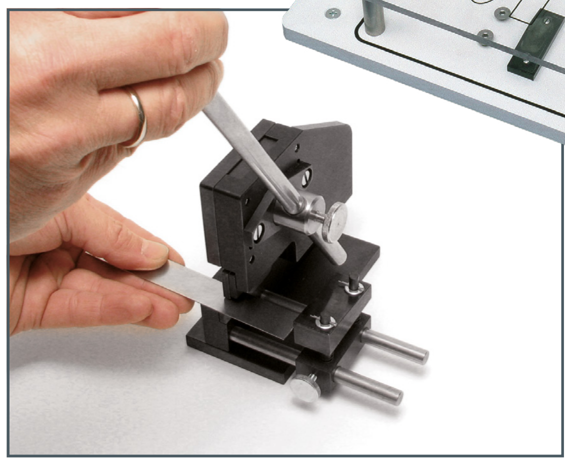
Sectional view

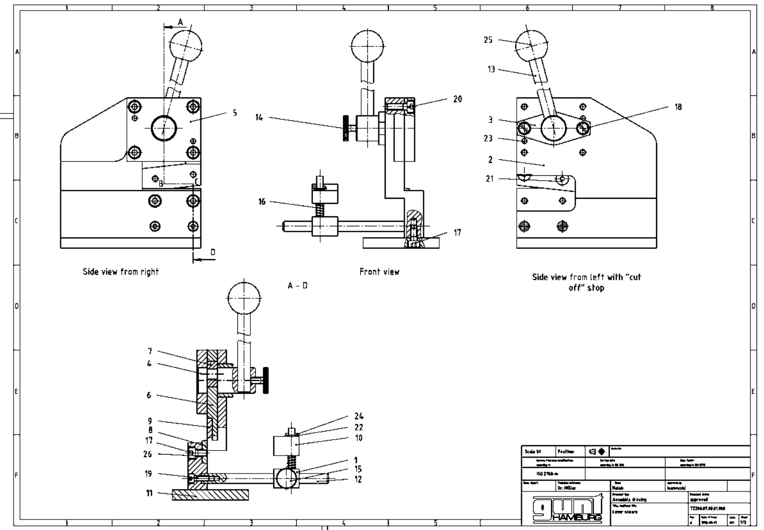
Training panels and assembly sets

In addition to the primary learning area of "engineering drawing", it is also possible to deal with topics such as assembly planning and execution as well as measuring exercises.

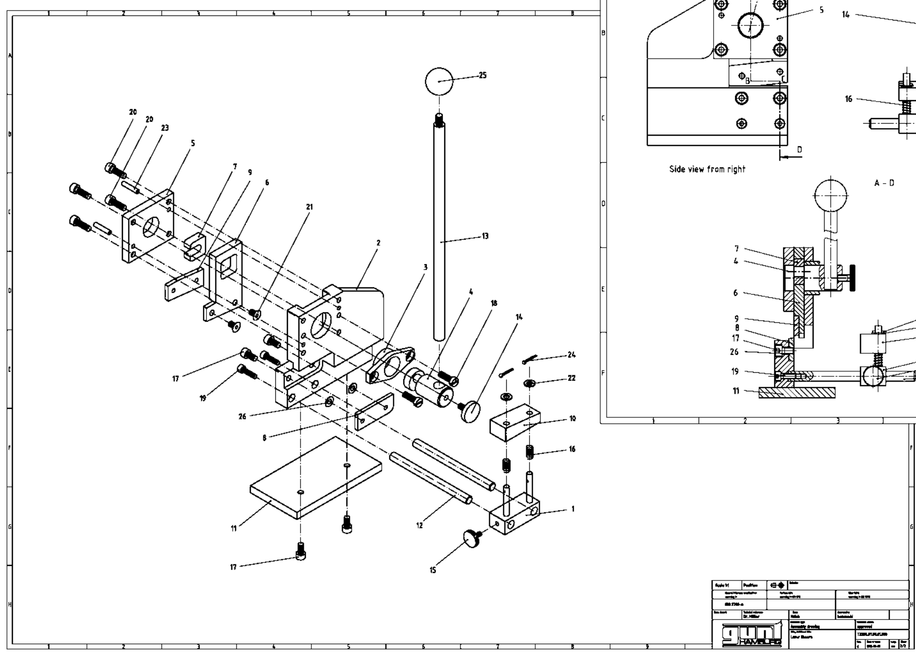
TZ 200.71
Assembly of lever shears







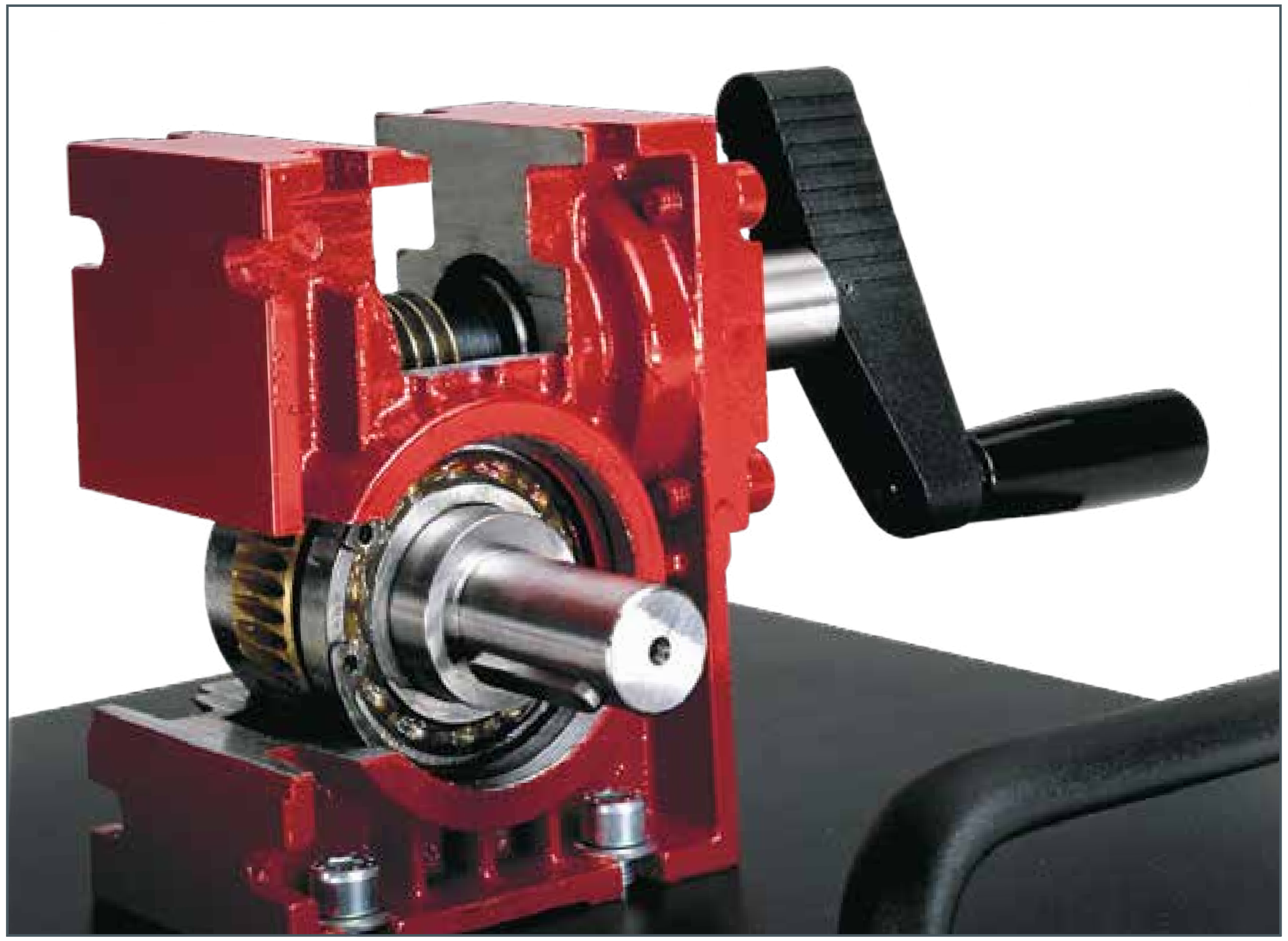
General arrangement drawing

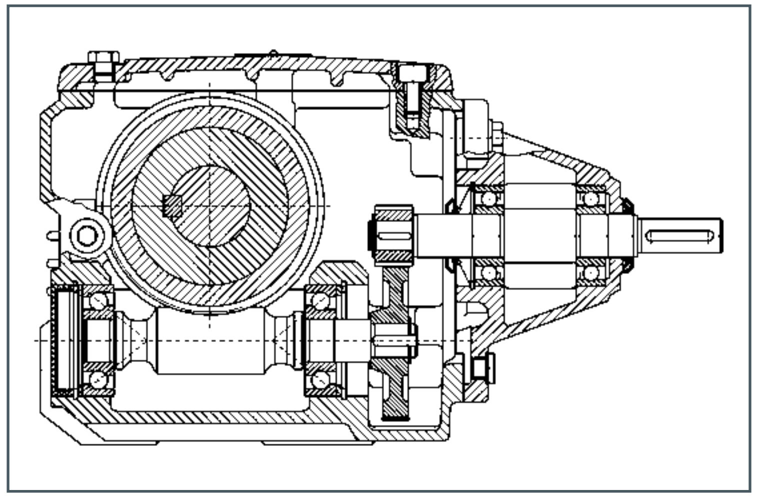


Exploded view

Cutaway models

GL 300.01
Cutaway model: worm gear





The technical drawings are part of the instructional material.

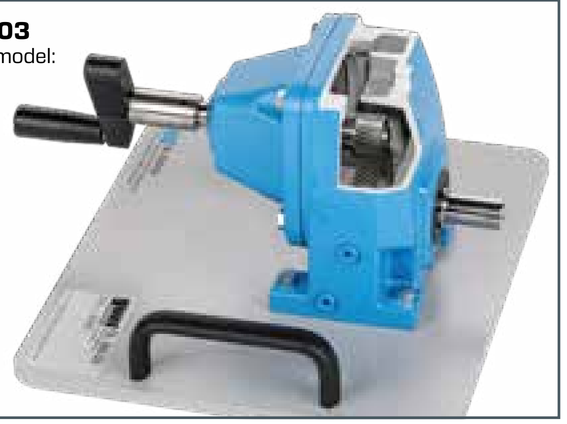
Manually operated open samples of various drive components and elements

- view of the details and function of the components
- despite the cut outs the movement functions are completely retained
- operation using a hand crank

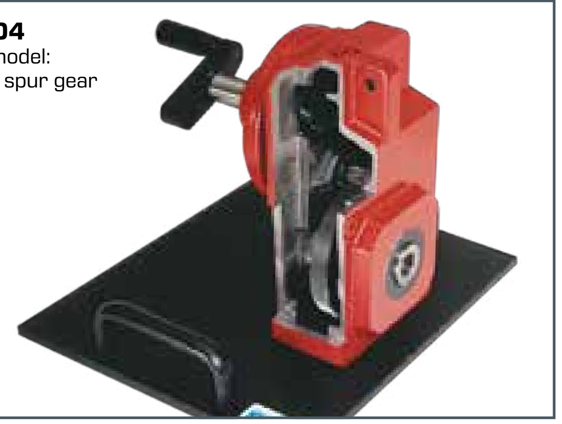
These models are fitted to sturdy metal base plates. Lifting handles make the models easier to carry. Technical descriptions and sectional drawings are included so that calculations and design aspects can be used as an educational topic.

GL 300.02
Cutaway model:
mitre gear

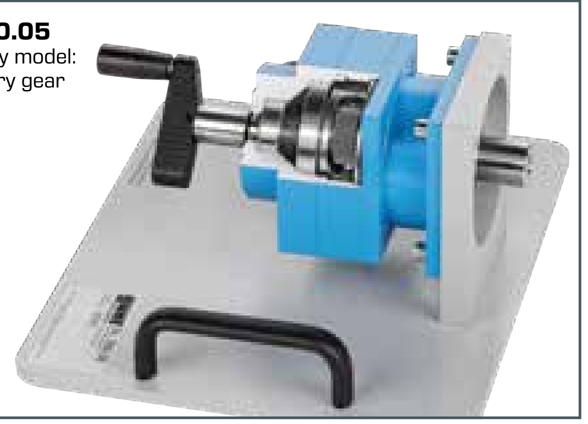
GL 300.03
Cutaway model:
spur gear



GL 300.04
Cutaway model:
two-stage spur gear

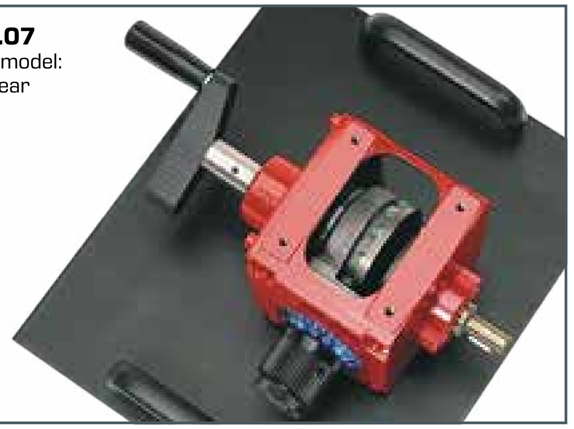


GL 300.05
Cutaway model:
planetary gear



GL 300.06
Cutaway model:
variable speed
belt drive

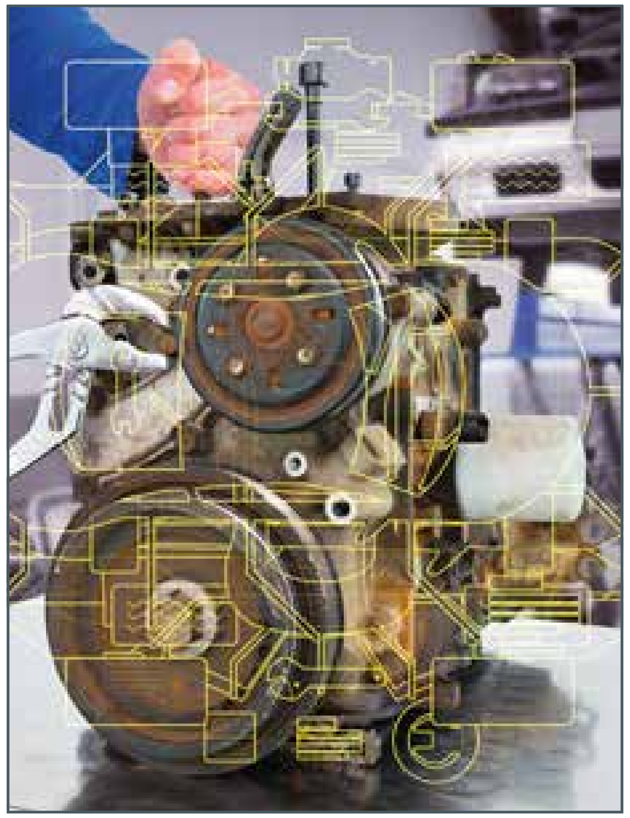
GL 300.07
Cutaway model:
control gear



GL 300.08
Cutaway model:
multiple-disk
clutch

GL 300.12
Cutaway model:
pedestal bearing

Machine elements



Components of a technical application that fulfil certain functions in structures are known as machine elements. Machine elements can be both single components and assemblies:

- individual parts such as screws, bolts or gears
- assemblies consisting of individual machine elements, such as couplings, ball bearings, transmissions or valves

An individual machine element always performs the same function, even though it is used in very different structures.

Simple machine elements such as screws, cylinder pins, feather keys or seals are defined according to standards and therefore can be exchanged without difficulty. More complex machine elements such as bearings, couplings, gears or shafts are standardised in only certain important properties, such as main dimensions or flanges, and as such are not fully interchangeable.

TZ 200.06
Drilling jig for an annular disc

Introduction to technical drawing: turned parts, threads

MT 110.02
Assembly spur wheel / worm gear mechanism

Assembly of an industrial gear unit, using simple tools and jigs

TM 123
Spur gear unit

Mode of operation and layout of toothed gearing mechanisms

MT 171
Assembly hydrodynamic journal bearing

Understanding components and function; assembly and maintenance

Machine elements

Connecting elements

Non-detachable connections
- riveted
- soldered
- welded
- glued

Detachable connections
- fastening screw
- motion screw
- bolt and pin connections

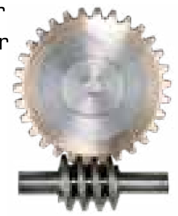
Elements for storing energy

- springs
- flywheels

Transmission or conversion elements

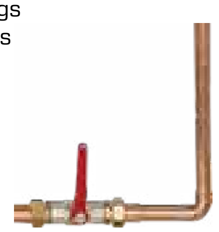
Gears and gear drives
- spur gear
- bevel gear
- worm gear
- helical gear

Traction gears
- chain gear
- belt drive



Elements for transporting fluids

- pipes
- hoses
- fittings
- valves



Lubricants

- oils
- grease
- solid lubricants

Resting elements

- couplings
- brakes

Sealing elements

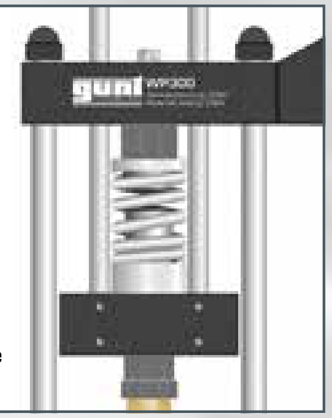
Resting seals
- flat seals
- gaskets
- liquid sealing materials

Motion seals
- lip seals
- radial shaft seals
- labyrinth seals

Bearing elements

- roller bearing
- slide bearing
- shafts and axles

WP 300.06
Experimental setup for spring test, helical spring, 2 sets



Easy to install test device for spring tests

HL 960
Assembly station pipes and valves and fittings

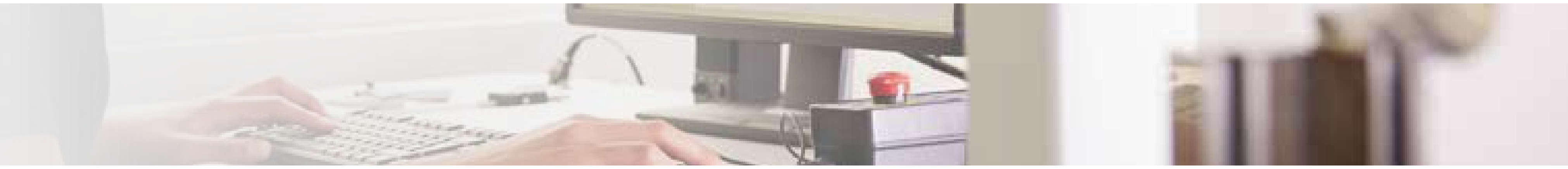
Assembly of real piping and plant installations; together with HL 960.01: operational testing on a pipe network

PT 500.13
Couplings kit

Vibration analysis of couplings

MT 170
Assembly shaft with journal bearings

Design and function of a simple journal bearing



Assembly exercises

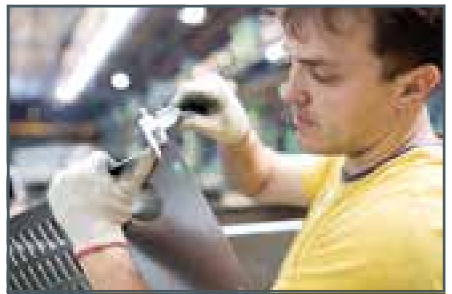
Assembly process

In industrial manufacturing, the repeated fashioning of individual prefabricated components and assemblies into a finished product, unit or device is called assembly.

The entire assembly process comprises the assembly operations:

Joining (DIN 8593)

- joining together
- filling
- pressing on and impressing
- joining by moulding
- joining by forming
- welding
- soldering
- bonding
- textile joining



Handling (VDI 2860)

- retaining
- changing quantities
  - dividing
  - merging
- moving
  - turning
  - positioning
- securing
  - holding
  - detaching
- inspecting
  - checking

Special operations

- cleaning
- aligning
- marking
- lubricating
- ...

Assembly exercises from GUNT

The assembly exercises from GUNT are part of the GUNT-Practice Line. This series of units has been designed specifically for the areas of assembly, maintenance and repair. Together with cutaway models, these units represent a practical addition to the field of engineering design.

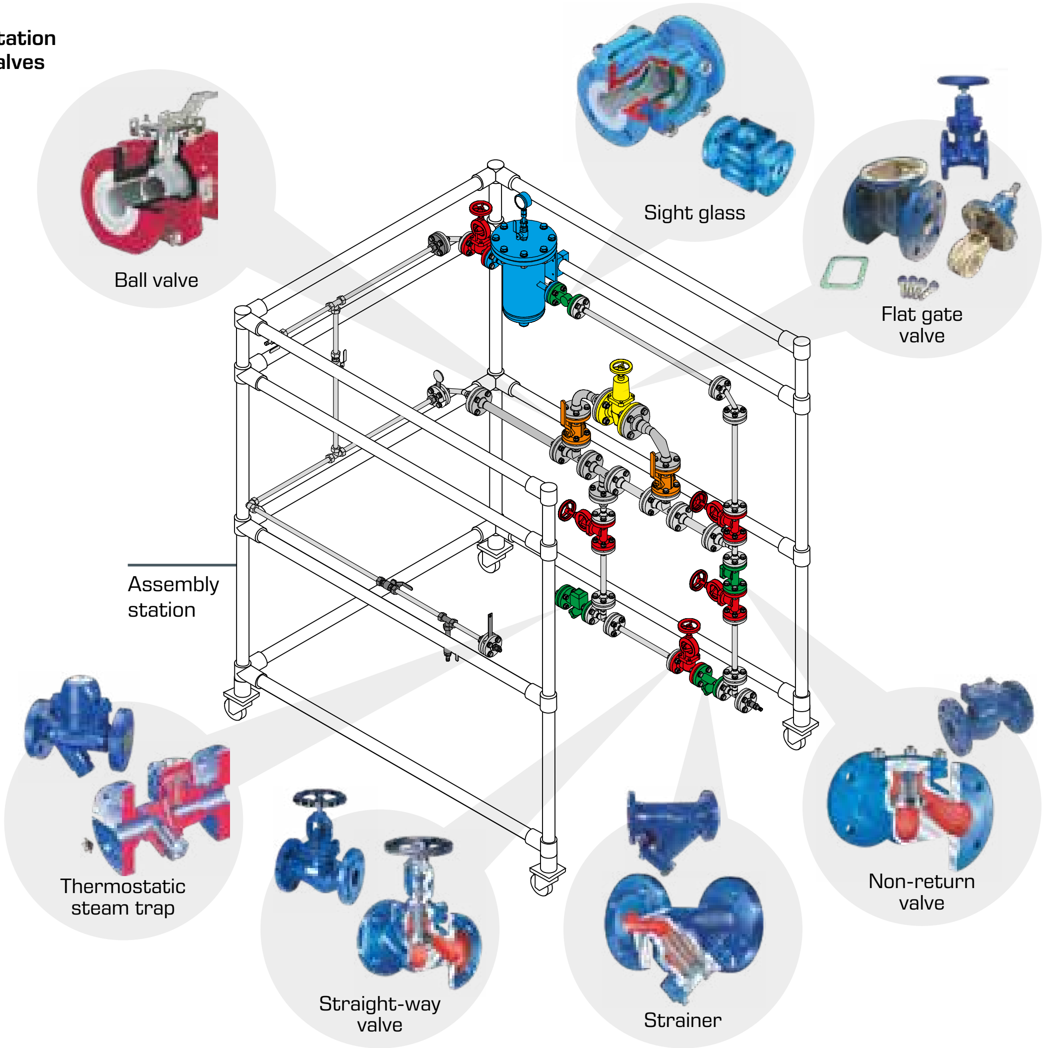
Drive elements and gears

MT 110
Assembly station: spur wheel / worm gear mechanism

MT 110.02
Assembly spur wheel / worm gear mechanism

Piping assembly, valves and fittings

HL 960
Assembly station pipes and valves and fittings



Pumps and compressors

MT 181
Assembly & maintenance exercise: multistage centrifugal pump

MT 140.02
Assembly exercise: piston compressor

Selected kits of the GUNT Practice Line

Next generation assembly exercises

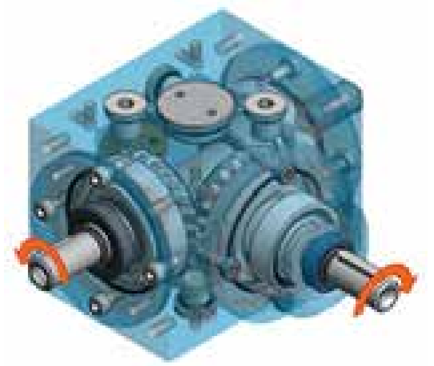
Variable handling and processing of digital data is the access of understanding Industry 4.0

The GUNT Practice Line is a equipment series for assembly, maintenance and repair, which has been designed for technical colleges and company training centres. The close link between theory and practice-based learning content is evident.

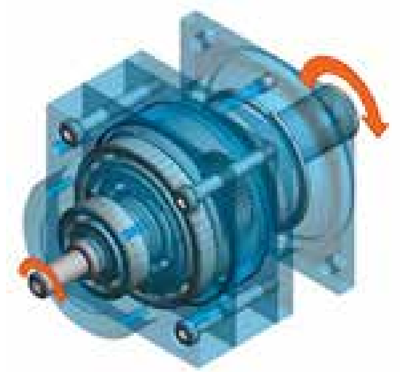
The contemporary multimedia instructional materials provide extensive technical information that provides the basis for lesson design. The core element of the teaching materials is a complete set of drawings as files with lists of parts, single-part drawings, exploded views, assembly drawings and 3D drawings. All drawings are to standard and are dimensioned in accordance with production requirements. The set of drawings consists of CAD files, STEP files and PDF files. Assembly videos support the learning process.

MT 120
Assembly exercise:
spur gear

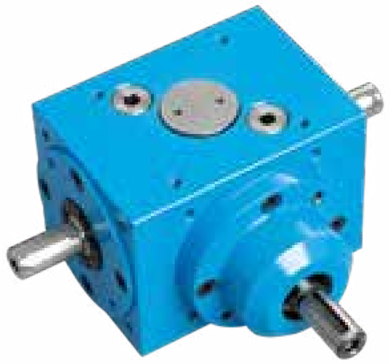
MT 121
Assembly exercise:
mitre gear

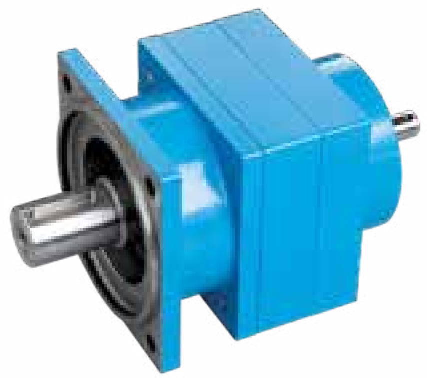


MT 122
Assembly exercise:
planetary gear



Transparent sectional view of the assembled gears





Assembled gear units

Learning content

- assembly and disassembly of various industrial gear units
- planning of the assembly process
- familiarization of machine elements and their function
- reading and understanding of technical drawings
- calculation of transmission characteristics and learning about different types of materials
- dealing with digital data:
  CAD files, 3D PDF, exploded views
- creating production
  programs for 3D printing and CNC machining

Advantages

- comprehensive technical information and didactic material on USB stick and as printed manual
- surcharge- or accessories policy: you will receive everything you need for your successful lessons with one order number
- at GUNT you speak with experts: we are a mechanical engineering company, this distinguishes us from dealers or publishers
  You benefit from it

Storage system with foam inlay open: all components have their place, the foam is labelled

Set of small parts

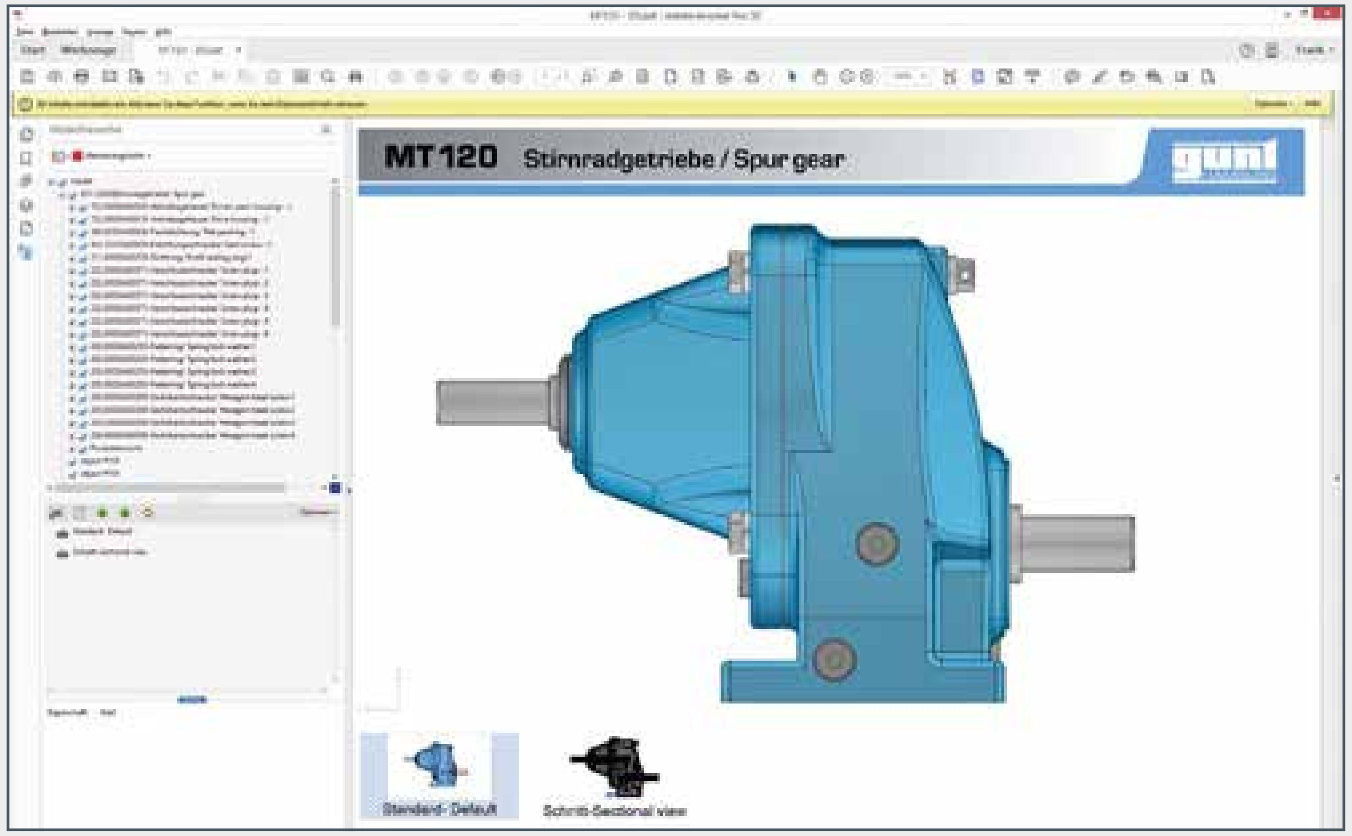
Storage system + set of small parts (on top)

Multimedia instructional materials for GUNT assembly exercises

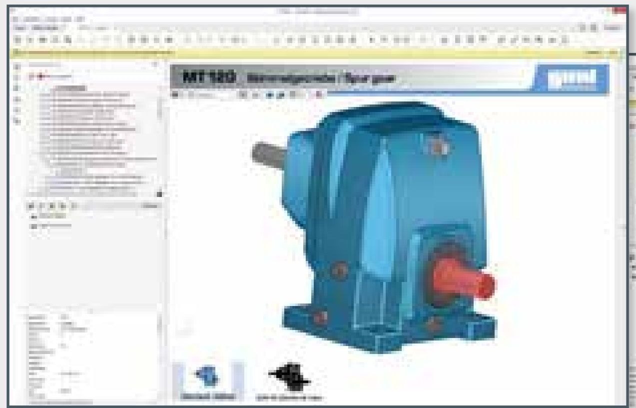
Interactive 3D PDF

The 3D PDF contains the assembly drawing of the assembly exercise. GUNT has defined two default views that can be opened by clicking on the respective icon: “Standard-Default” and “Schnitt-Sectional view”. Many effects are available to take a closer look at the fully assembled unit or at individual parts, among other things:

- rotate the entire object to any position
- mark a component: by clicking on the component, it is highlighted in the drawing and in the model tree. The click can be done both in the model tree and in the drawing.
- hide and show components
- representation as wireframe
- transparent representation of the object
- cut through the selected view



The illustration above shows the default view that opens after clicking on “Standard-Default”.

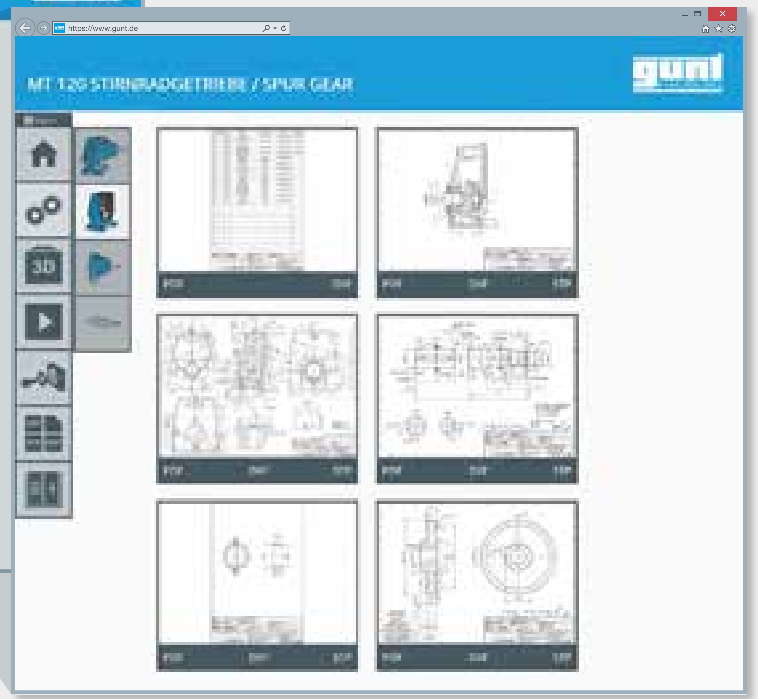


The gear unit is rotated. The driven shaft is selected and displayed in red (top). On the right, the same perspective is shown as shaded wireframe.

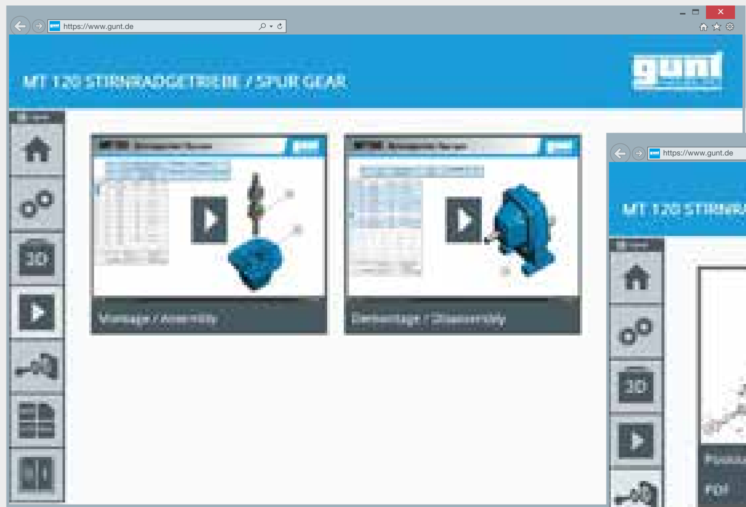
GUNT Media Center

The GUNT Media Center is a new platform that provides digital data via internet. Customers have the possibility to access data files and product information of selected products independent of time and place. This data include CAD-files as STP-files or DXF-files as well as PDF-files and videos.

After selection of the device the customer can choose to view and/or download the overall drawing, or the component groups or the single part drawings. Videos of assembly or disassembly as well as parts lists and manuals are available.



The product consists of various component groups, which are themselves assembled from individual parts. Parts lists as well as overall and single part drawings are provided.



Videos of assembly or disassembly

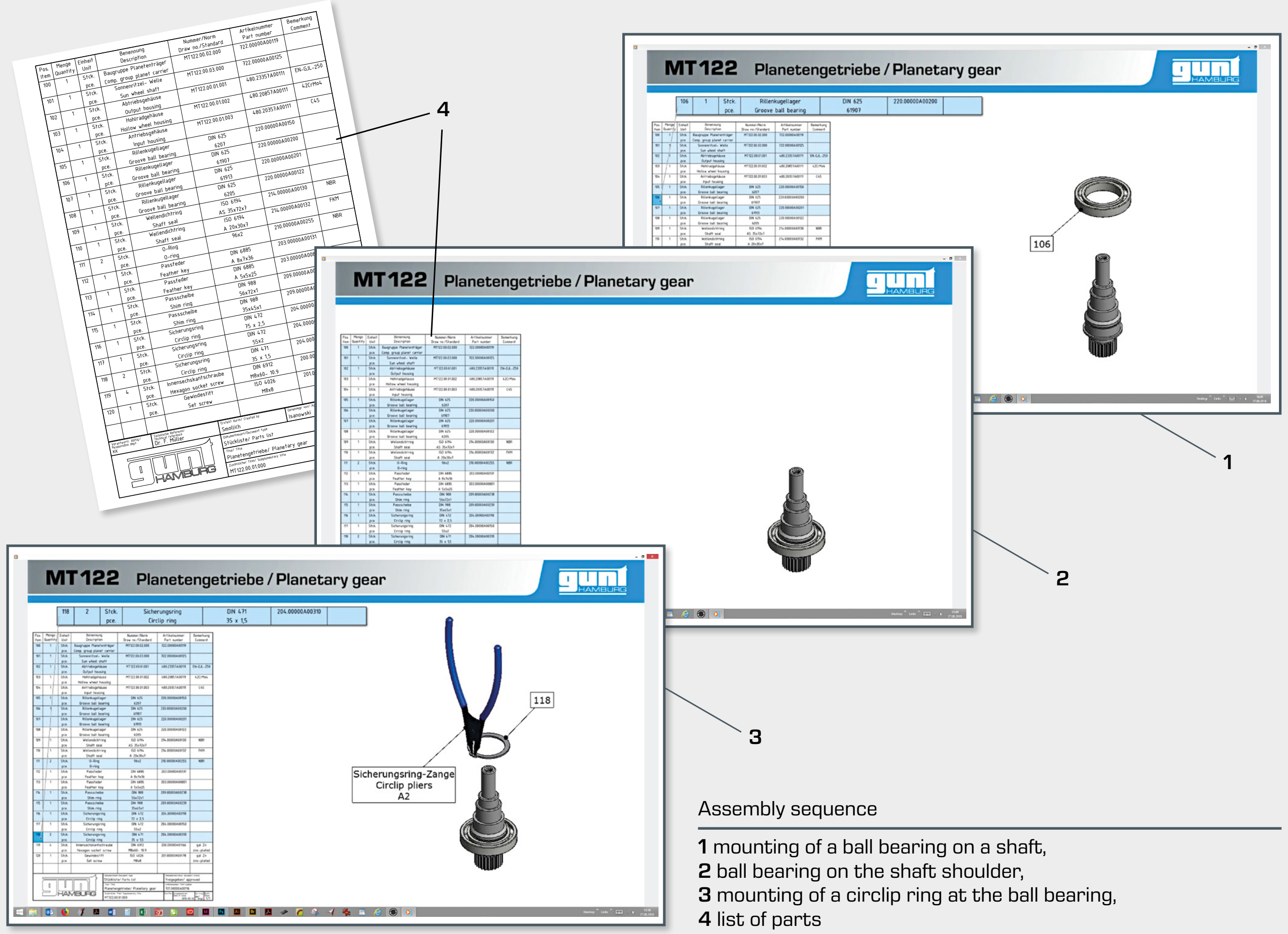
Exploded view

Multimedia instructional materials for GUNT assembly exercises

Videos

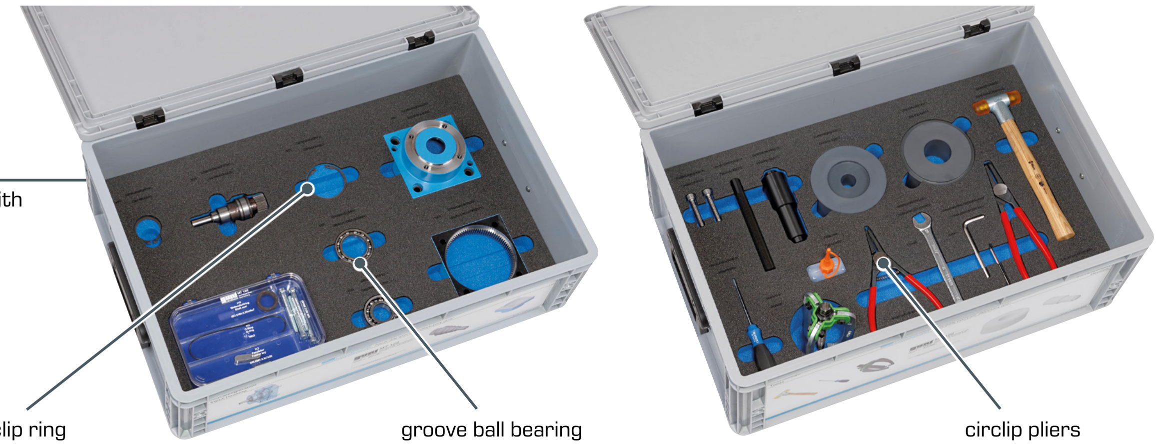
The assembly video shows the assembly step by step, including tools and devices. The individual part to be assembled is described using the displayed list of parts. A short animation at the end of the assembly video shows the assembled unit in action. Another video supports the disassembly.

All component names (parts and tools) are used in the lists of parts, videos, and storage boxes. This makes it easy to identify and find every component.



Assembly sequence

1 mounting of a ball bearing on a shaft,
2 ball bearing on the shaft shoulder,
3 mounting of a circlip ring at the ball bearing,
4 list of parts

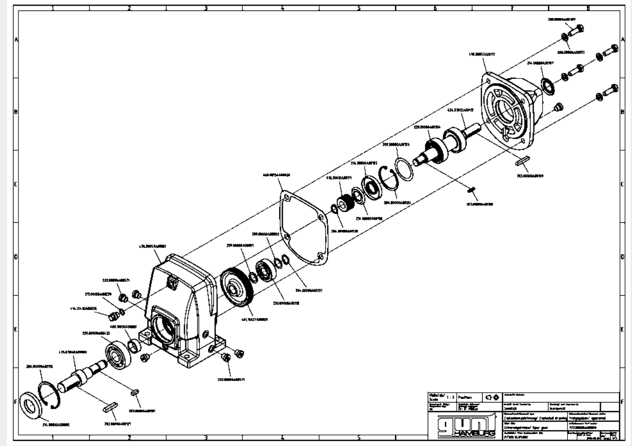


Storage system with labelled foam inlay

Instructional material

Along with the printed manual customers get a USB stick that contains the videos, the set of drawings as files with lists of parts, individual part designations, exploded views, assembly drawings and 3D drawings. The set of drawings consists of CAD files, STEP files and PDF files.

Printed manual with USB stick



Exploded view

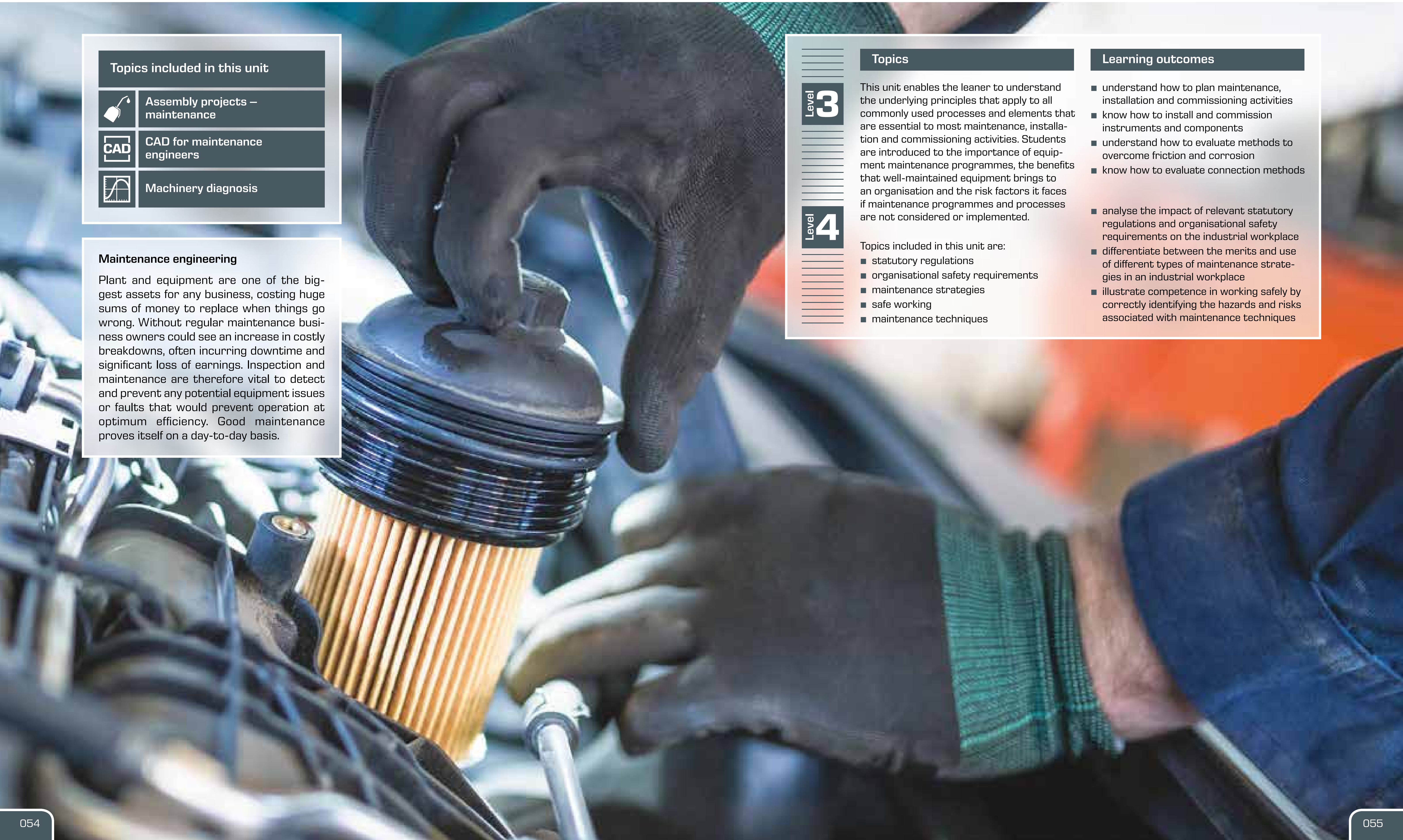
Storage

The storage system consists of boxes with labelled foam inlays. All components are stored neatly, carefully, and easily to find (see illustration on the bottom of the left page). The boxes are clearly labelled and stackable.

The optional accessories MT 120.01 Trolley or MT 120.02 Transport roller are available for convenient transport of the kits.

MT 120.02 Transport roller with MT 120

MT 120.01 Trolley with MT 122



4 Maintenance engineering

Topics included in this unit

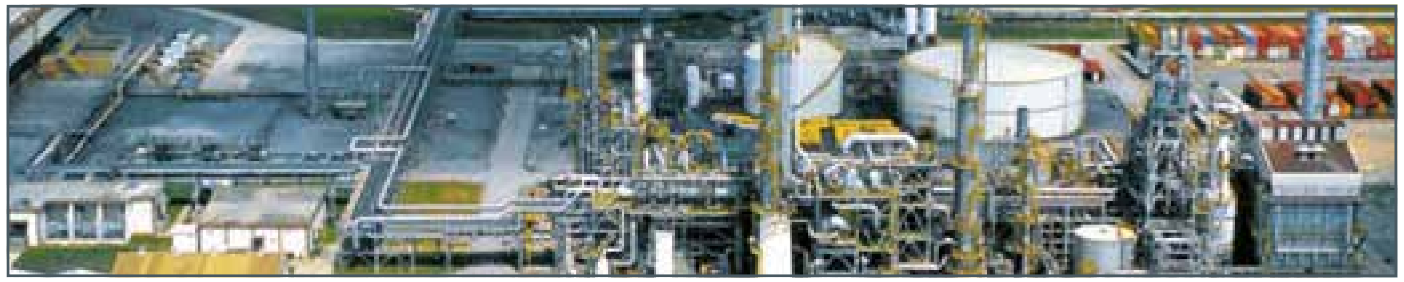
- Assembly projects – maintenance
- CAD for maintenance engineers
- Machinery diagnosis

Maintenance engineering

Plant and equipment are one of the biggest assets for any business, costing huge sums of money to replace when things go wrong. Without regular maintenance business owners could see an increase in costly breakdowns, often incurring downtime and significant loss of earnings. Inspection and maintenance are therefore vital to detect and prevent any potential equipment issues or faults that would prevent operation at optimum efficiency. Good maintenance proves itself on a day-to-day basis.

Level	Topics	Learning outcomes
Level 3	This unit enables the leaner to understand the underlying principles that apply to all commonly used processes and elements that are essential to most maintenance, installation and commissioning activities. Students are introduced to the importance of equipment maintenance programmes, the benefits that well-maintained equipment brings to an organisation and the risk factors it faces if maintenance programmes and processes are not considered or implemented.	■ understand how to plan maintenance, installation and commissioning activities ■ know how to install and commission instruments and components ■ understand how to evaluate methods to overcome friction and corrosion ■ know how to evaluate connection methods
Level 4	Topics included in this unit are: ■ statutory regulations ■ organisational safety requirements ■ maintenance strategies ■ safe working ■ maintenance techniques	■ analyse the impact of relevant statutory regulations and organisational safety requirements on the industrial workplace ■ differentiate between the merits and use of different types of maintenance strategies in an industrial workplace ■ illustrate competence in working safely by correctly identifying the hazards and risks associated with maintenance techniques

Maintenance is a key area in apprentice training



Plant and machinery should be operational...

Therefore maintenance is an essential part of production and machine management.

...not sitting idle.

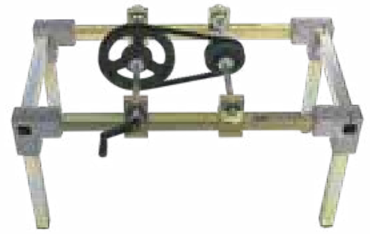
You must have

- strategies and methods in place
- qualified and trained staff

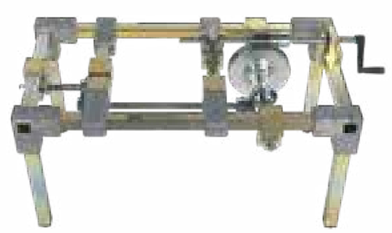
GUNT supports you with our proven teaching systems regarding assembly projects and maintenance.
Our service will help you to make the education of your staff much more practice-oriented. This is hands-on tuition in practice.

A selection of assembly exercises

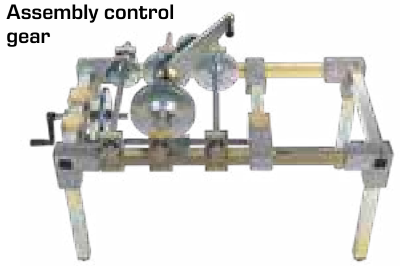
GL 410
Assembly simple gears



GL 420
Assembly combined gears



GL 430
Assembly control gear



MT 156
Assembly exercise: wedge gate valve and angle seat valve

MT 157
Assembly exercise: butterfly valve and non-return valve

MT 158
Assembly exercise: ball valve and shut-off valve

MT 140.02
Assembly exercise: piston compressor

MT 140.01
Assembly exercise piston compressor: functional test

MT 110.02
Assembly spur wheel / worm gear mechanism

MT 180
Assembly & maintenance exercise: centrifugal pump

MT 181
Assembly & maintenance exercise: multistage centrifugal pump

MT 182
Assembly & maintenance exercise: screw pump

MT 183
Assembly & maintenance exercise: diaphragm pump

MT 184
Assembly & maintenance exercise: piston pump

MT 185
Assembly & maintenance exercise: in-line centrifugal pump

There is much more at GUNT. On the following pages we show you some detailed examples.

Learning concepts relating to industrial maintenance

The maintenance

of industrial plant and machinery is a key field of activity for technicians and skilled tradesmen working in mechanical and electrical engineering.

Key area in technical training

The level of attention devoted to the subject of maintenance by the curricula is therefore high.

Teaching and learning systems relating to maintenance

GUNT offers a wide range of wholly practice-oriented teaching and training systems relating to technical maintenance with which you can cover essential learning content:

Use of specific manufacturer's documentation for maintenance, inspection and repair	Planning and assessing maintenance sequences and steps
Reading and understanding engineering drawings	Practical execution and documentation of maintenance operations
Familiarisation with machine and system components	Testing and commissioning of repaired systems
Understanding maintenance as the interaction between inspection, maintenance and repair	Assessment of malfunctions, detection of faults

The GUNT training systems are ideally suitable for students' group working, and of course for project-oriented working methods.

Things don't have to get this bad

It's possible to do something in time

What is maintenance?

'Maintenance' as defined by industry standard DIN 31051 is a complex field, so the range of teaching and training systems we offer in this area is very diverse.

Maintenance according to DIN 31051

Maintenance	Inspection	Repair	Improvement / overhaul
Preservation of the target state	Detection and assessment of the actual state	Restore the target state	Elimination of weak points
Cleaning, lubricating, adjusting	Measuring, testing, diagnosing	Replacing or refitting	Combination of all steps to rise security of function in a unit without changing the basic functions themselves
Only according to maintenance instructions during plant downtime	On operational plant and during plant downtime in accordance with inspection requirements	Only during plant downtime in accordance with job order and careful preparation	Permanent improvement independent of operating status

Learning through practice…

Assembly projects

This chapter deals with the process of familiarisation with components and their functions, reading and understanding engineering drawings or operating instructions, and familiarisation with technical terminology and language. The assembly exercises can be conducted in relatively short periods of time (within lesson units) and do not as yet require any particular technical experience. Fault diagnosis and maintenance measures are not yet central to the training systems.

Maintenance

The real, industrial nature of the exercises is higher than in the Assembly Projects. Typical maintenance methods and testing procedures are offered as learning content. Some of the exercises take a lot of time to complete and amount to substantial project work. Demands are made on technical skills.

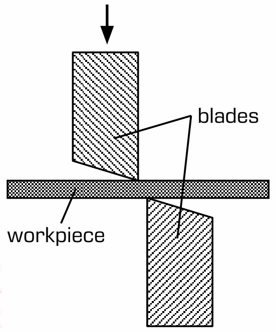
Machinery diagnosis

The teaching systems familiarise trainees with the specific methods of monitoring plant/machinery condition, such as the early detection of bearing or gear damage. We work primarily with vibration analysis methods which constitute diagnostic steps for preventive maintenance or targeted repair.

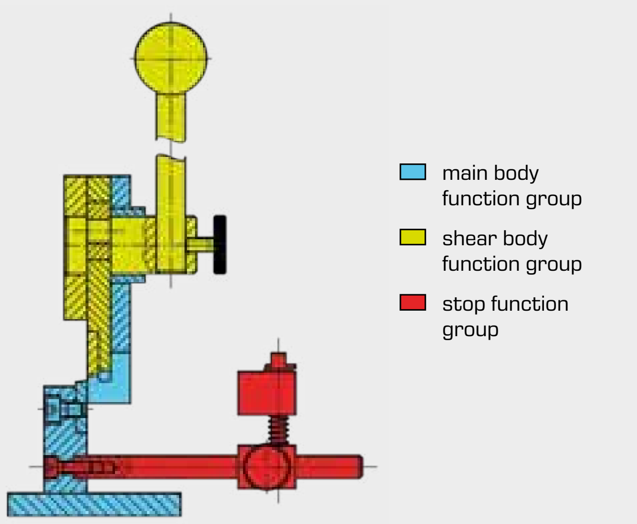
…so the theory is easy!

TZ 200.71
Assembly of lever shears

Coverage of the fundamentals: an assembly kit for introducing a course



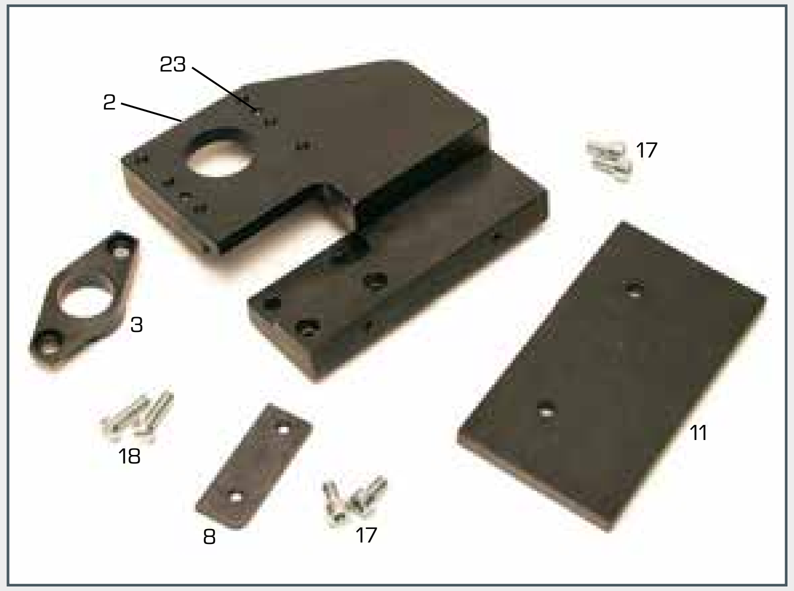
Operating principle of lever shears



Lever shears function groups

Function group	Partial function	Movement
main body	carries, supports and guides all other parts	none
stop	sets the length to be cut off	none
shear body	transmits the shearing force to the workpiece	rotary & linear motion

- interdisciplinary teaching possibilities
- learning in a small team is an effective learning format
- excellent instructional materials, including digital files, for printing and presentation



Assembly step 1 (main body) – parts required for assembly

Pos.	Name	Pos.	Name
2	main body	17	socket head cap screw
3	bearing flange	18	cheese head screw
8	lower blade	23	parallel pin
11	base plate		

Learning objectives / experiments

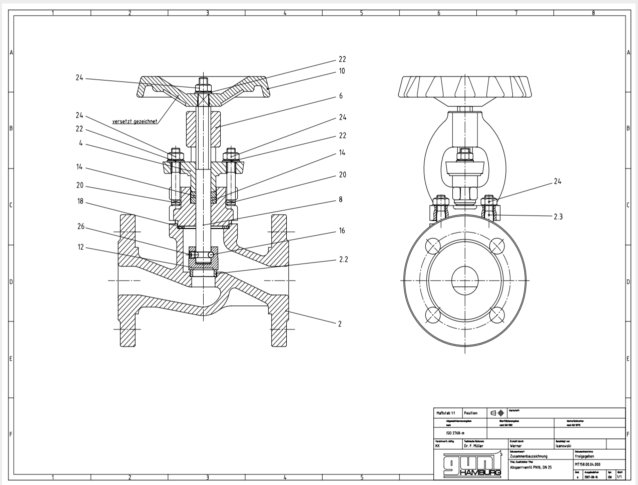
- introduction to technical drawing:
  - reading and understanding technical drawings
  - three-plane views
  - sectional views
  - drawing types
  - 3D views
  - parts lists
  - dimensioning
  - surface finish and tolerance specifications
  - differentiation between standard and production parts
  - material specifications
- planning and execution of simple assembly operations:
  - planning and describing work sequences
  - assessing results
- measurement exercises:
  - length measurements
  - angle measurements
- manufacturing methods:
  - operational examples of handmade production and production on machine tools

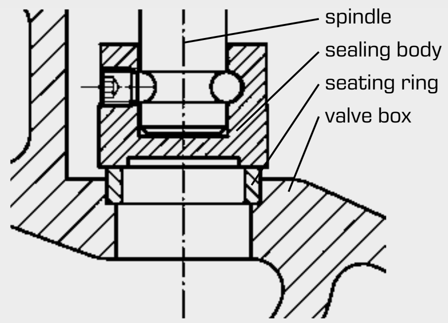
MT 158
Assembly exercise: ball valve and shut-off valve

Two different valves and fittings in one assembly kit. Parts are clearly and perfectly arranged.


The assembly kit

- exercises can be conducted in a classroom – no workshop environment necessary
- assembly exercises can be conducted in relatively short periods of time (within lesson units)
- comprehensive and well structured instructional material will impress you


Replacement parts available according to part lists and drawings

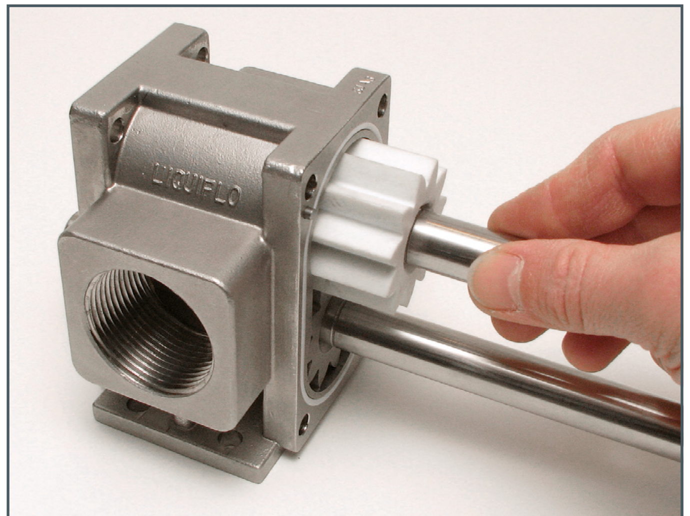


Grinding of the seat of a flatseat valve

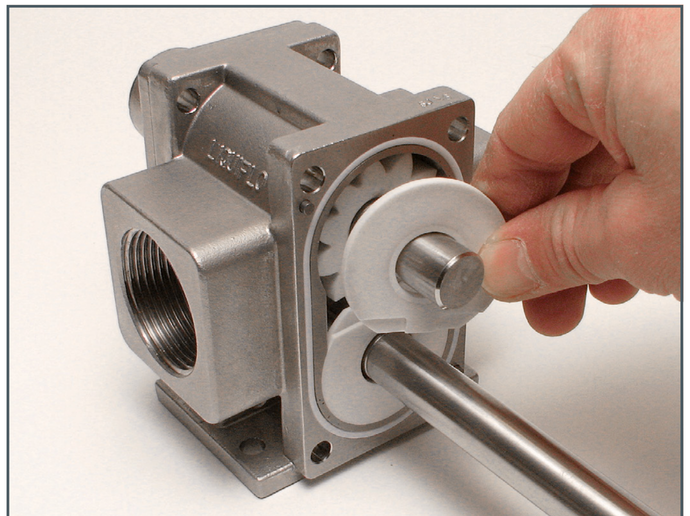
Learning objectives / experiments

- design and function of a ball valve
- design and function of a valve
- assembly and disassembly, including for the purposes of maintenance and repair
- replacing components (e. g. seal)
- comparison of two different valves and fittings
- reading and understanding engineering drawings and operating instructions
- leak testing (together with hydraulic valves and fittings test stand MT 162)

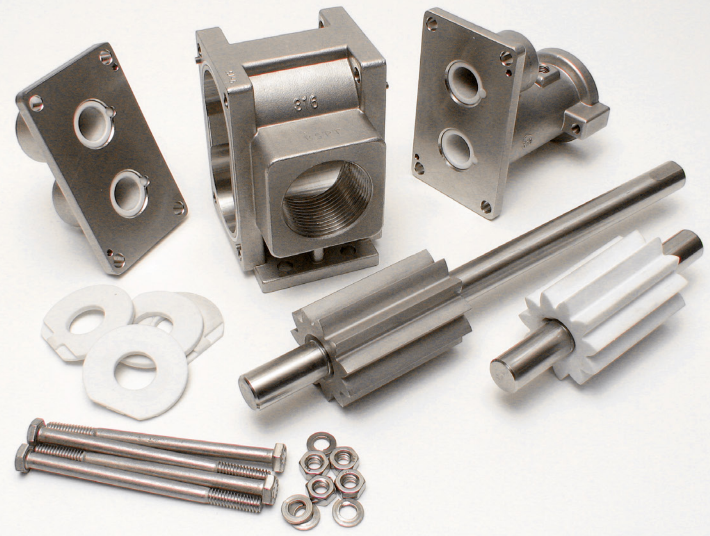
MT 186
Assembly & maintenance exercise: gear pump



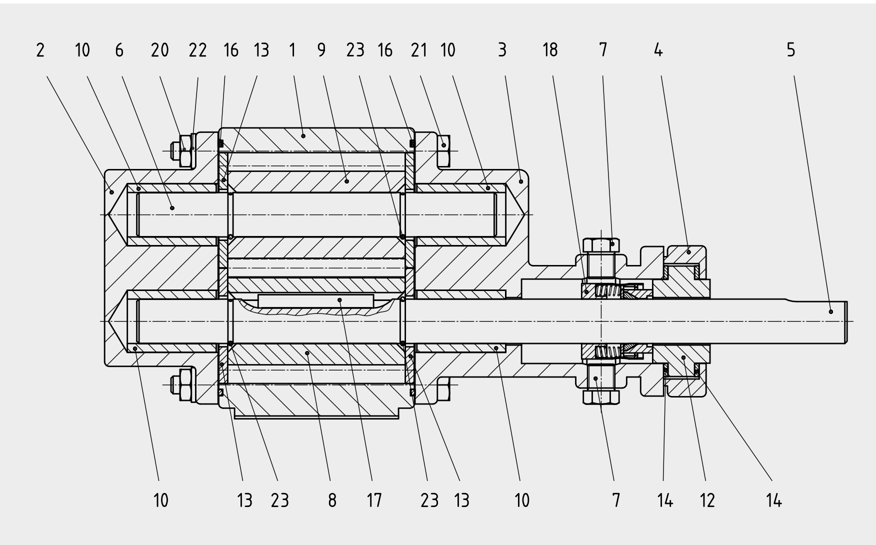
Installing the driven shaft



Mounting the wearing discs



Components included
in the assembly kit

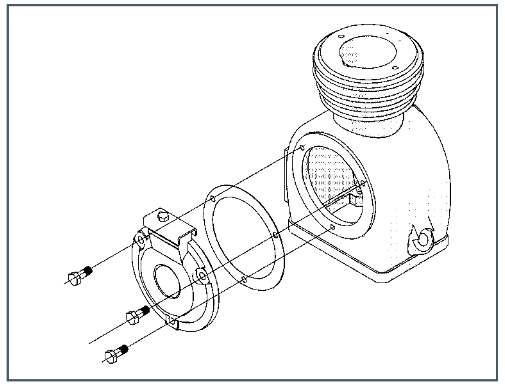


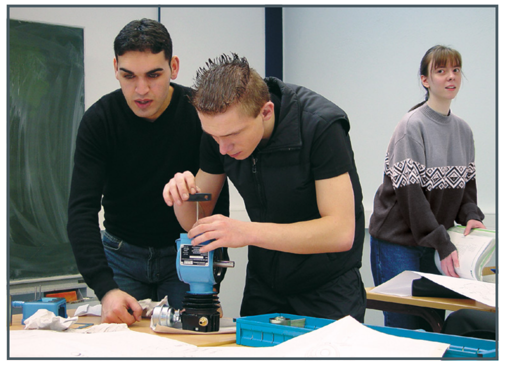
Learning objectives / experiments

- design and function of a gear pump and its components
- assembly and disassembly for maintenance and repair purposes
- replacing components (e. g. seals)
- troubleshooting, fault assessment
- planning and assessment of maintenance and repair operations
- reading and understanding engineering drawings and operating instructions

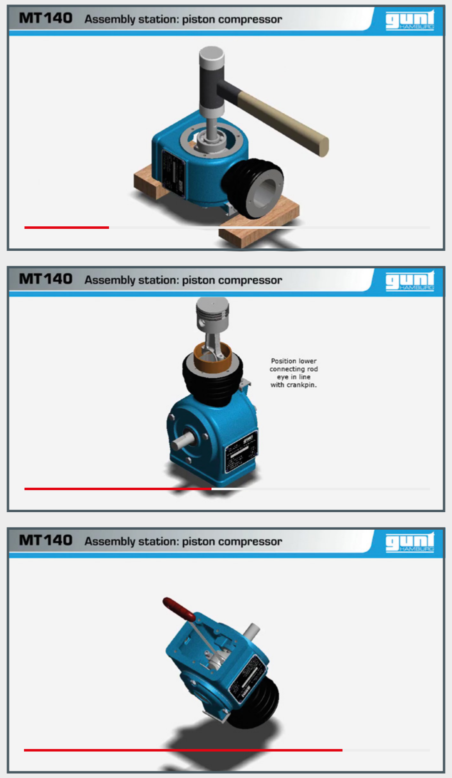
MT 140.02
Assembly exercise: piston compressor

The classic assembly project





Students studying the assembly



Along with the devices comes a video that shows clearly and easy to understand the individual steps for the assembly of a piston compressor.

An assembled compressor, to the left individual parts, exploded view in the background

Learning objectives / experiments

- design and function of a compressor
- reading and understanding engineering drawings
- familiarisation with components and assemblies, their design features and functions
- dimensioning exercises, gauging of parts
- work planning, particularly planning and presentation of the assembly process
- familiarisation with assembly aids and jigs
- assembly exercises: component and complete unit assembly
- analysis of faults and damage, in conjunction with maintenance and repair steps
- material selection criteria

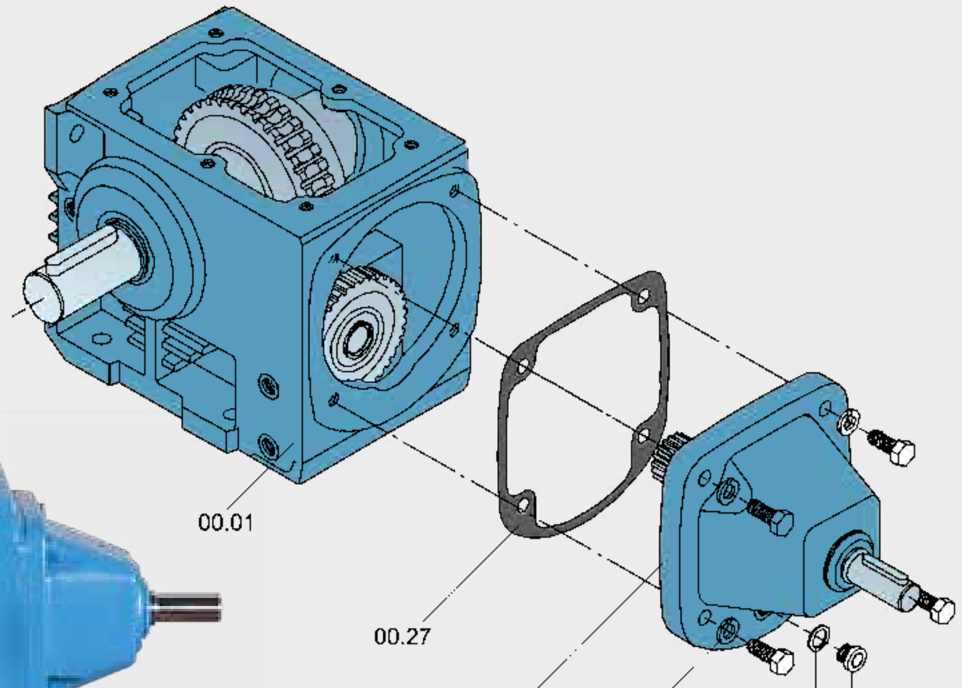
In conjunction with MT 140.01

- functional testing of the assembled compressor

MT 110.02
Assembly spur wheel / worm gear mechanism

A totally hands-on assembly exercise

Fully assembled multistage gear



An example of assembly section

- practical assembly of an industrial gear unit, using simple tools and devices
- broad scope of learning with interdisciplinary problems
- comprehensive and well-structured instructional material

Learning objectives / experiments

- design and function of a multistage gear combination
- reading and understanding engineering drawings
- familiarisation with component and assemblies, their design features and functions
- dimensioning exercises, gauging of parts
- work planning, particularly planning and presentation of the assembly process
- familiarisation with assembly aids and jigs
- assembly exercises: component and complete unit assembly
- analysis of faults and damage, in conjunction with maintenance and repair steps
- material selection criteria

In conjunction with MT 172:

- functional testing of the assembled gear unit

MT 190
Assembly materials tester

Build your own materials tester

This is the assembly kit...

...and this is the result

Learning objectives / experiments

- read and understand technical documentation
- plan and execute assembly steps and sequences
- familiarisation with machine elements and components
- commission and inspect materials tester after successful assembly
- plan, implement and evaluate maintenance operations
- fault analysis: troubleshooting, fault analysis and remedy
- after successful assembly
  - tensile test on metallic specimens
  - plot load-extension diagrams
  - Brinell hardness test

MT 210
Assembly & maintenance exercise: refrigeration

Maintenance, repair, troubleshooting of a refrigeration system – totally practice-oriented

Fully assembled system:

1 fully hermetic compressor, **2** filter drier, **3** sight glass with humidity indicator, **4** delivery side manometer, **5** HP (high pressure) pressure switch, **6** LP (low pressure) pressure switch, **7** intake side manometer, **8** cooling chamber with evaporator and fan 2, **9** thermostat, **10** expansion valve, **11** assembly panel, **12** solenoid valve, **13** condenser with fan 1, **14** service valves, **15** electrical switch box

Leak testing at expansion valve

Learning objectives / experiments

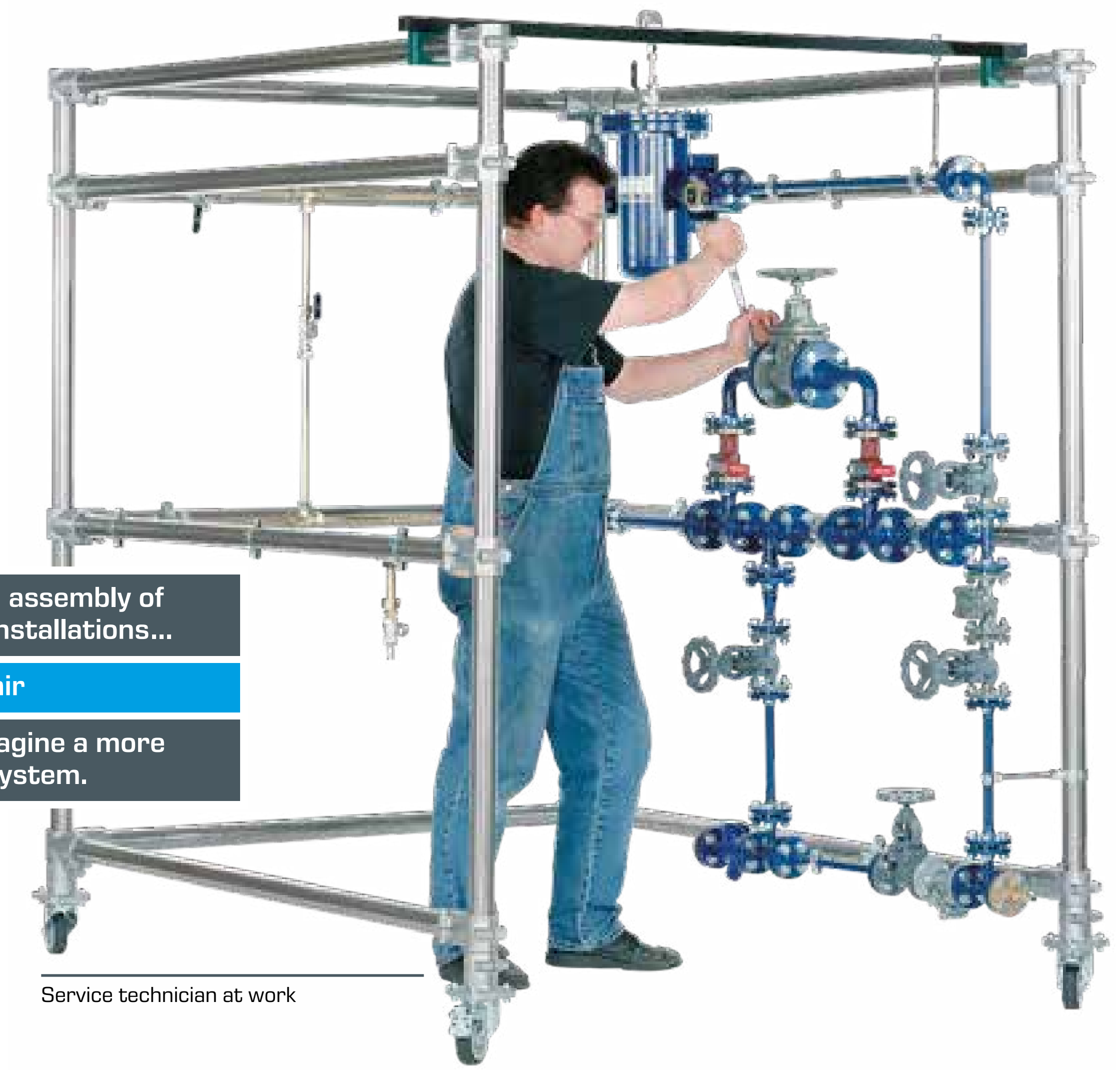
- reading and understanding technical documentation
- in conjunction with ET 150.02
  - planning and executing assembly steps and processes
  - making pipe joints in accordance with a system diagram
  - carrying out electrical installation in accordance with a circuit diagram
- in conjunction with ET 150.01
  - filling and evacuating of the refrigeration system
  - commissioning and checking the refrigeration system after successful assembly
  - familiarisation with the function of a refrigeration system as a system and its components as system components
  - fault analysis: fault finding, fault evaluation and repair
  - planning, executing and evaluating maintenance processes

HL 960
Assembly station pipes and valves and fittings

Practically oriented assembly of piping and system installations...

Maintenance – repair

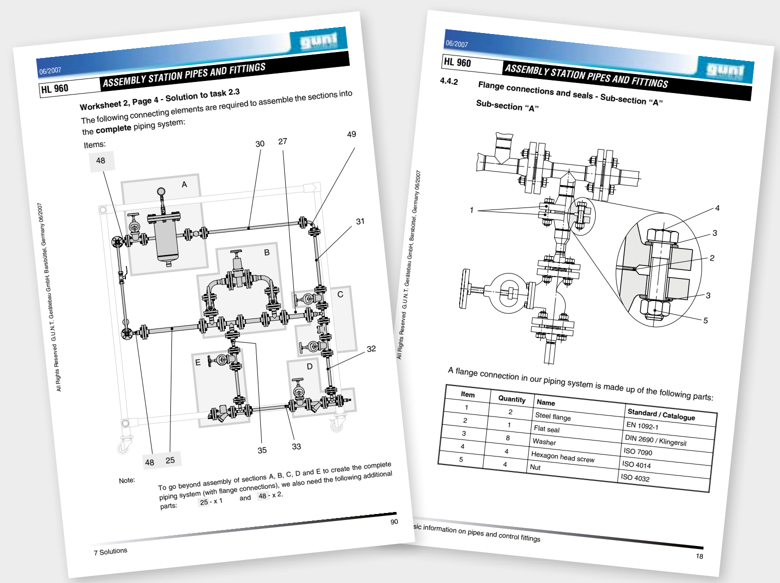
...it is difficult to imagine a more hands-on training system.



Service technician at work

Learning objectives / experiments

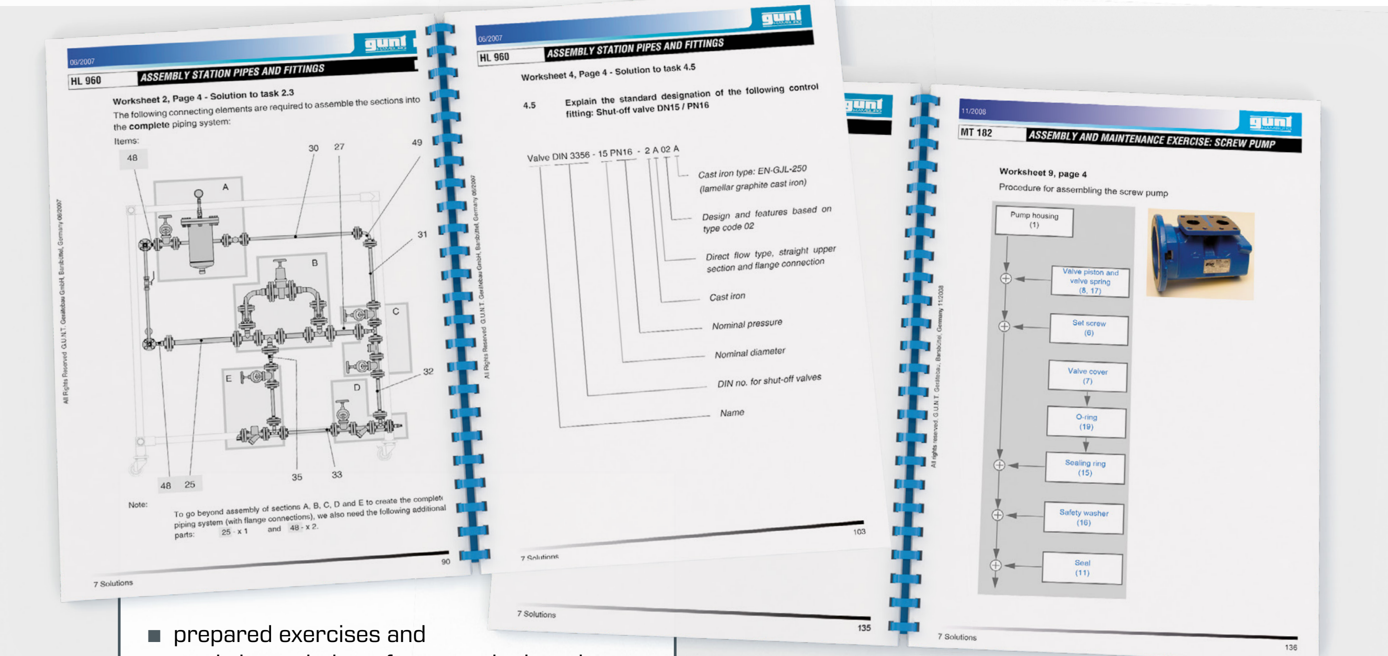
- design and function of valves and fittings, piping elements and system components
- planning of piping and system installations according to specification, e.g. a process schematic
- selection of components and drafting of requirement lists
- technically correct preparation and execution of system assembly
- reading and understanding engineering drawings and technical documentation
- operational testing of the constructed systems (in conjunction with suitable water supply and disposal)



Two examples from our comprehensive training documentation

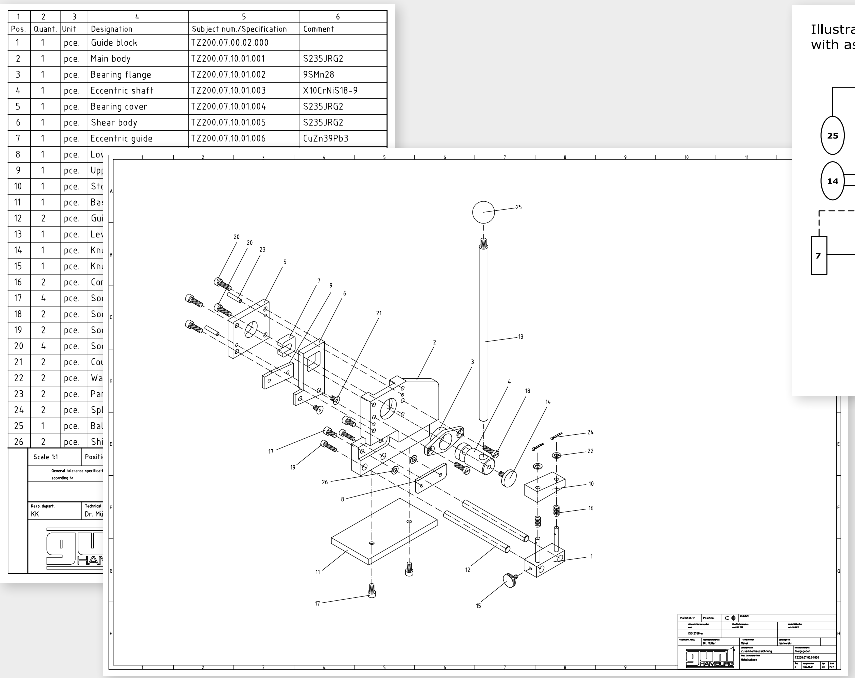
Our instructional material will impress you

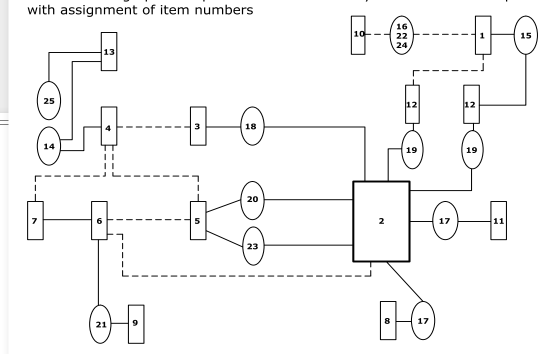
Tasks and solutions



- prepared exercises and worksheets help to focus on the learning task so the students work efficiently
- of course there is a recommended solution for every exercise

Complete set of drawings





The core of the teaching material is a complete set of drawings conforming to standards. In addition to the assembly drawing with parts list, you will find all manufacturing drawings of the individual parts. So you are able to produce your own parts, or have them manufactured for you.

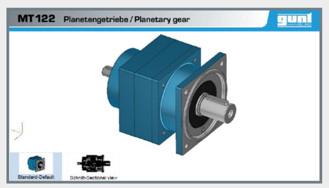
GUNT attaches great importance to innovative, state-of-the-art solutions and modern ways of imparting knowledge in the preparation of instructional material.

Selected devices have:

- interactive 3D PDFs and CAD drawings
- videos with detailed step-by-step assembly instructions
- interactive parts list
- convenient transport systems

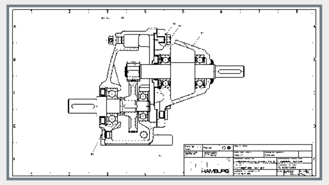
Platform-independent: computer, tablet or mobile phone

Special features



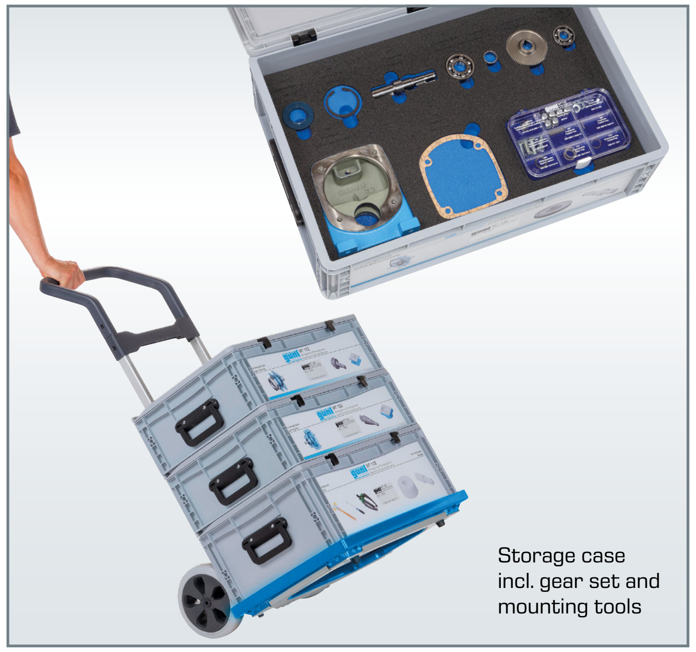
Interactive 3D PDFs „Exploring“ of all details

Videos with detailed step-by-step assembly instructions with interactive parts list function



All CAD files and sets of drawings already included

Thought out storage and transport system



Storage case incl. gear set and mounting tools

CAD for maintenance engineers

Multimedia instructional materials for GUNT assembly exercises

There is a growing trend, in part due to the popularity of three-dimensional (3D) **C**omputer **A**ided **D**esign (**CAD**) systems, for students to generate two-dimensional (2D) drawings from three-dimensional (3D) solid models. 3D models do look impressive and whilst they clearly serve an important function in CAD design, in reality the vast majority of CAD drawings used in the industry are 2D based and, of those, a significant number are schematic drawings utilised by maintenance engineers, which cannot be produced using a 3D system.

Therefore offers GUNT a new product series of assembly exercises that include multimedia instructional materials in different formats:

- 3D PDF files to view 3D sections, single parts, component groups as well as the solid body as overview
- 2D and 3D CAD drawings as **DXF**- (Drawing Interchange Format) and **STEP**-files (**ST**andard for the **E**xchange of **P**roduct model data)

The aim of these multimedia instructional materials is to enable students to produce 2D CAD drawings (using industry standard CAD software), and to modify and construct drawings.

This material will support the development of the students' CAD abilities and build upon those skills to introduce the more advanced techniques that are used to create and modify schematic drawings quickly and efficiently.

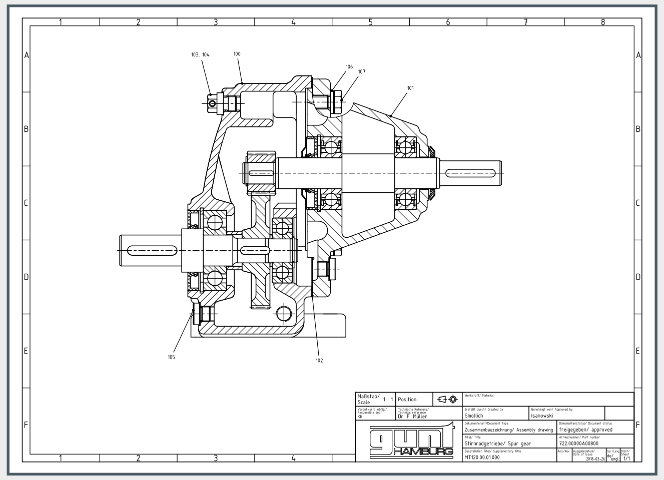
For certain devices GUNT offers a web-based platform, that provides customers online with all multimedia instructional materials. Beside the set of drawings, this platform includes manuals and videos, e.g. of assembly or disassembly.

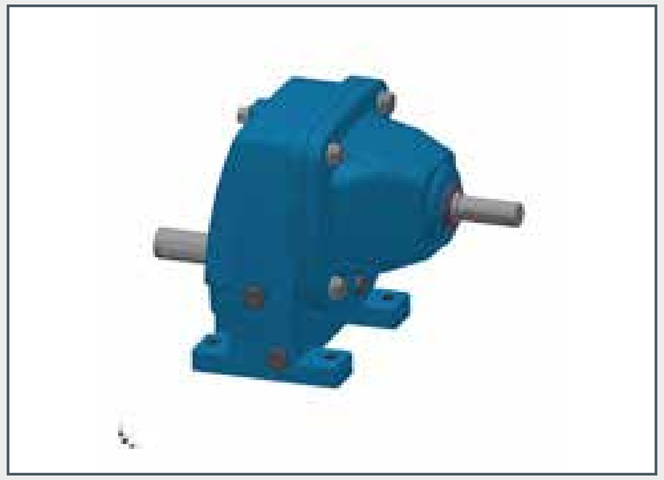
MT 120 serves as an example of a series of GUNT devices offering multimedia instructional materials

All files may be downloaded by the client so that the data can be used individually in order to:

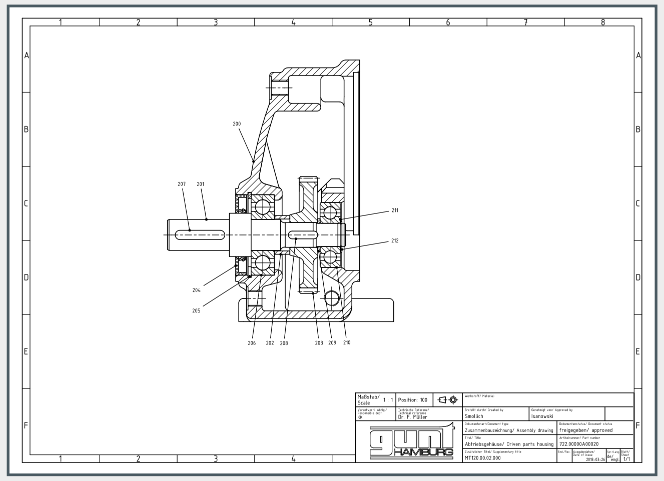
- create and modify CAD drawings
- construct, insert and export blocks with textual attributes
- produce complex schematic drawing
- transfer information to external sources, e.g. a 3D printer

Overview drawing

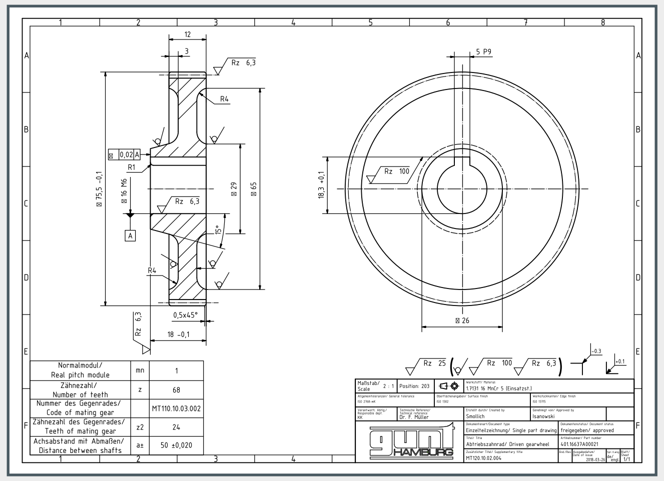




Component group drawing



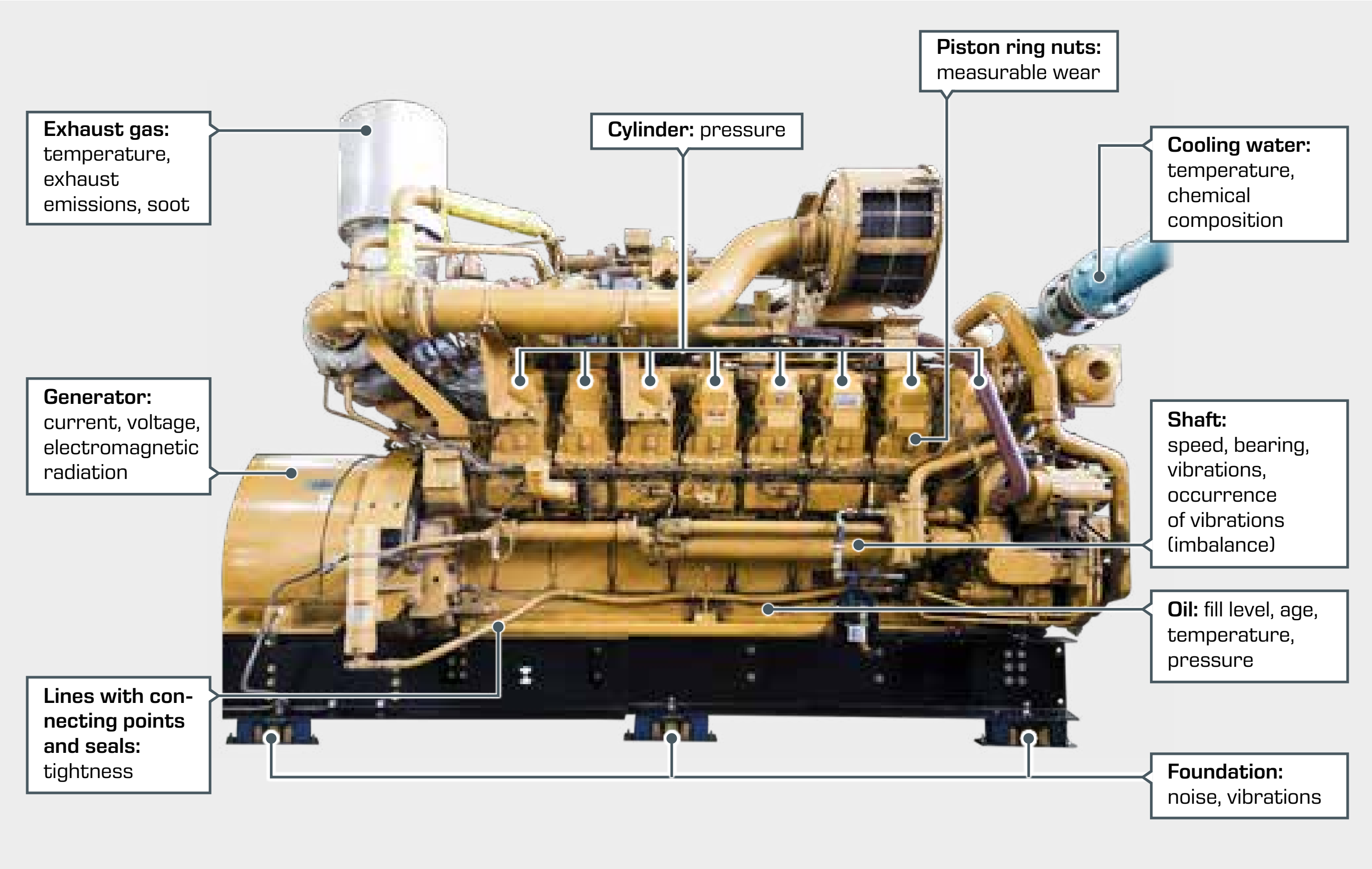
Single-part drawing



Machinery diagnosis

The aim of machinery diagnosis, also known as machinery status monitoring or condition monitoring system (CMS), is to conduct needs-based maintenance or repair and therefore to minimise the repair and downtimes of a machine. Damage should be detected when it occurs. This increases the overall equipment effectiveness (OEE), a measure of the added value of a plant, and optimises the cost structure.

What characterises the condition of a machine? The following are some measurable state variables using the example of a diesel generator:



Machinery diagnosis is used for

- weak-point analysis to optimise a process or to detect expected errors in good time
- condition-based maintenance, e.g. the use of car tyres when these fail to meet the prescribed minimum tread depth
- avoid or minimise failures thanks to pre-determined maintenance, e.g. oil change in motor vehicle at a fixed interval or after a certain mileage

Machinery diagnosis leads to

- increased and optimum use of the lifecycle of plant and machinery
- improved operational safety
- increased plant reliability
- optimised operating processes
- reduced disturbances
- reduced costs

Machinery diagnosis is conducted on

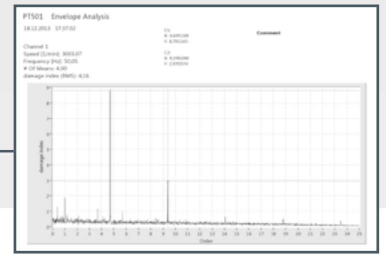
machines at standstill by:

- disassembly and visual inspection
- wear measurement
- crack testing (X-rays, ultrasound, magnetic penetration, natural frequency measurement)

running machines by:

- measuring the state variables, e.g. vibration measurement
- acoustic measurement
- extension of the shaft
- lubricant analysis

PT 501 Roller bearing faults

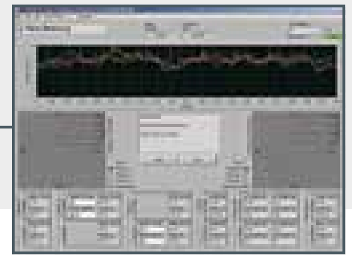


Envelope analysis of the bearing with damage on outer ring

Learning objectives / experiments

- vibrational spectrum of the running noise of roller bearings
- familiarisation with the envelope analysis
- influence of damage to outer race, inner race or roller body, on the spectrum
- estimating service lives of roller bearings
- influence of the lubricant on the vibration spectrum
- detection of faulty roller bearings
- use of a computerised vibration analyser

PT 502 Field balancing



Two-plane balancing using the GUNT software for vibration analysis

Learning objectives / experiments

- measure and assess machine vibrations
- occurrence of imbalance vibrations
- static, dynamic or general imbalance
- dependence of imbalance vibration on position and magnitude of the imbalance
- basic principles of balancing
- field balancing in one plane
- field balancing in two planes
- assessment of balancing quality
- using a computerised vibration analyser

5 Thermodynamics, heat engines and thermofluids

Topics included in this unit

- Fundamentals of thermo-dynamics
- Heat transfer
- Refrigeration systems
- Heat pumps
- Heat engines and thermofluids

Thermodynamics, heat engines and thermofluids

Thermodynamics is one of the most common applications of science in our lives, and it is so much a part of our daily life that it is often taken for granted. For example, when driving your car you know that the fuel you put into the tank is converted into energy to propel the vehicle, and the heat produced by burning gas when cooking will produce steam which can lift the lid of the pan. These are examples of thermodynamics, which is the study of the dynamics and behaviour of energy and its manifestations.

The significance that thermodynamics plays in the 21st century cannot be underestimated.

This unit helps to prepare students for an engineering apprenticeship, for progression to higher education and for employment in a technician-level role, such as an aircraft maintenance technician, or as a technician with design responsibilities for improving the efficiency of power plants.

Level	Topics	Learning outcomes
Level 3	This unit introduces students to the principles of thermodynamics that apply to gases and consider the process parameters that apply to thermodynamic systems, and how these affect the expansion and compression of gases. Students learn how these thermodynamic parameters influence the operation of a range of open- and closed-loop thermodynamic systems.	■ investigate thermodynamic principles related to the expansion and compression of gases that are applied in mechanical systems ■ investigate energy transfer in thermodynamic systems and applications of open and closed-loop systems ■ explore the combustion and sustainability of fuels that are used to produce work in mechanical systems
Level 4	Experimental investigation of the combustion process for different types of fuel and the performance of internal combustion engines are part of this unit.	■ investigate fundamental thermodynamic systems and their properties ■ apply the Steady Flow Energy Equation to plant equipment ■ examine the principles of heat transfer to industrial applications ■ determine the performance of internal combustion engines
Level 5	Further on students examine the principles of heat transfer to industrial applications. Among the topics included in this unit are heat pumps and refrigeration, performance of air compressors, steam power plant and gas turbines.	■ evaluate the performance and operation of heat pumps and refrigeration systems ■ review the applications and efficiency of different compressors ■ determine steam plant parameters and characteristics ■ examine the operation of gas turbines and assess their efficiency

Fundamentals of thermodynamics

Thermodynamic systems and their properties

WL 202
Fundamentals of temperature measurement

Experimental introduction to temperature measurement: methods, areas of application, characteristics

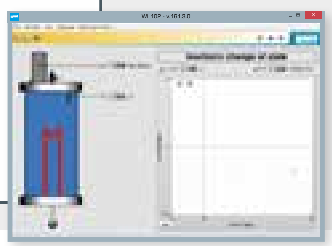
- experimental introduction to temperature measurement: methods, areas of application, characteristics
- clearly laid out unit primarily for laboratory experiments, also suitable for demonstration purposes

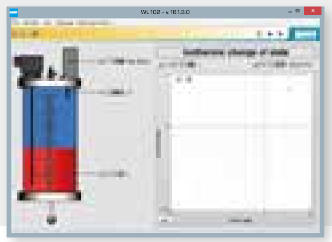
WL 203
Fundamentals of pressure measurement

Measurement of positive and negative pressure with different measuring devices

- comparison of different pressure measurement methods
- measuring positive and negative pressure
- calibration device with Bourdon tube pressure gauge for calibrating mechanical manometers

WL 102
Change of state of gases

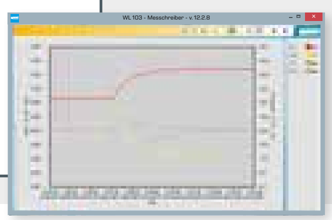


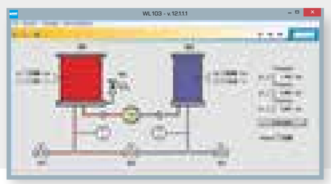


Isothermal and isochoric change of state of air

- demonstrating the laws of state changes in gases experimentally
- isothermal change of state, Boyle-Mariotte law
- isochoric change of state, Gay-Lussac's 2nd law

WL 103
Expansion of ideal gases





Determination of the adiabatic exponent according to Clément-Desormes

- determination of the adiabatic exponent according to Clément-Desormes
- adiabatic change of state of air
- isochoric change of state of air

Evaporation process

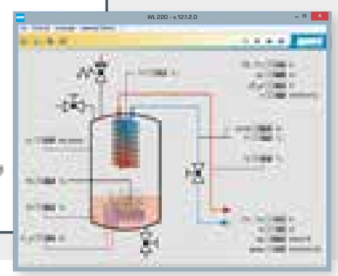
Steam is used for a variety of processes in engineering. The most common applications are heating processes as well as steam turbines in power plants. Other typical applications include: propulsion, propellant, atomization, cleaning, product moistening and air humidification.

WL 210
Evaporation process

Different forms of evaporation in an externally heated pipe

- observation of typical forms of evaporation
  - single phase liquid flow
  - sub-cooled boiling
  - slug flow
  - annular flow
  - film boiling
  - dispersed flow
  - single phase vapour flow
  - wet steam
- effect on the evaporation process by
  - flow rate
  - temperature
  - pressure

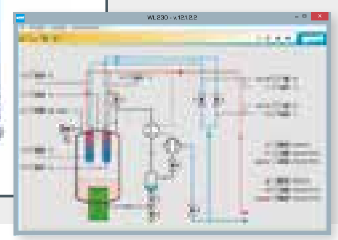
WL 220
Boiling process



Visualisation of different forms of evaporation in a transparent pressure vessel

- visualisation of different forms of evaporation
  - free convection boiling
  - nucleate boiling
  - film boiling
- heat transfer
- effect of temperature and pressure on the evaporation process

WL 230
Condensation process



Measurement of heat transfer in dropwise and film condensation

- dropwise and film condensation
- determination of the heat transfer coefficient
- effect of pressure, temperature and non-condensable gases on the heat transfer coefficient

Material-bound/non-material-bound heat transport

Material-bound heat transport

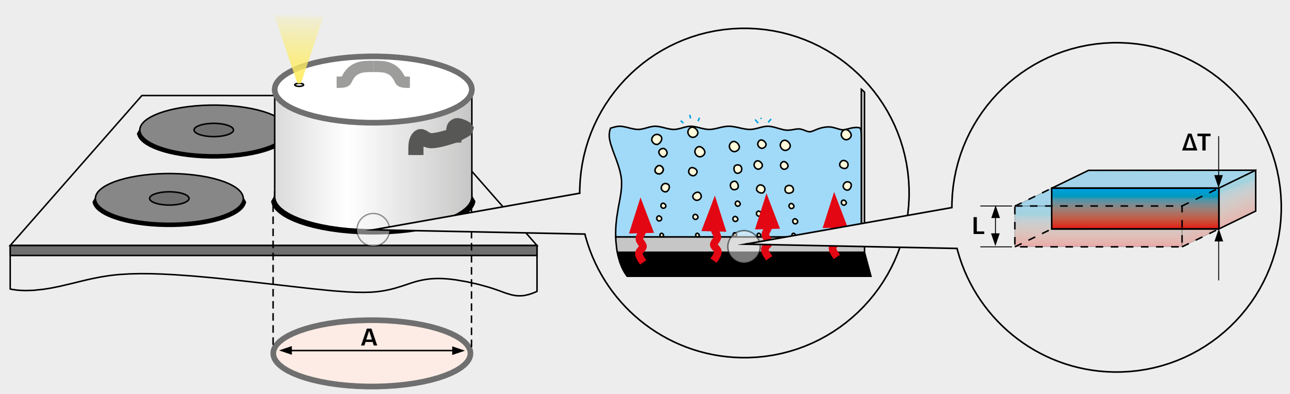
by conduction and convection

Conduction

In the case of thermal conduction, heat transport takes place through direct interaction between the molecules (e.g. molecule collisions) within a solid or a fluid at rest. A prerequisite for this is that there is a temperature difference within the substance or that substances of different temperatures come into direct contact with each other. All aggregate states allow this transfer mechanism.

The amount of heat transported depends on:

- the thermal conductivity **λ** of the material,
- the heat conducting length **L**,
- the heat transferring area **A**,
- the dwell time **t** and
- the temperature difference **ΔT** between the beginning and end of the thermal conductor



The hot stove transfers the heat to the water through the bottom of the saucepan with the cross-sectional area **A**.

The red arrows indicate the direction of the heat flux.

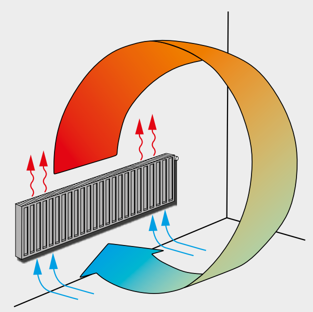
The heat is transferred from the hot to the cold material along the heat-conducting length **L** due to the interaction of the molecules via the temperature difference **ΔT**.

Convection

Heat transport takes place in flowing liquids or gases by means of material movement, i.e. material transport. Where **forced convection** occurs, the flow is forced by external forces. Examples: a pump in a warm water heater, fans in a power pack or PC.

If the flow is caused by differences in density due to different temperatures within the fluid this is called **free or natural convection.** Examples: water movement when heated in a pot, by a foehn wind, the gulf stream, or a vent in a chimney.

Cold air is sucked in by the fan, cools the internal components and flows out again as heated air.



The air molecules warmed by the heater rise due to differences in density.

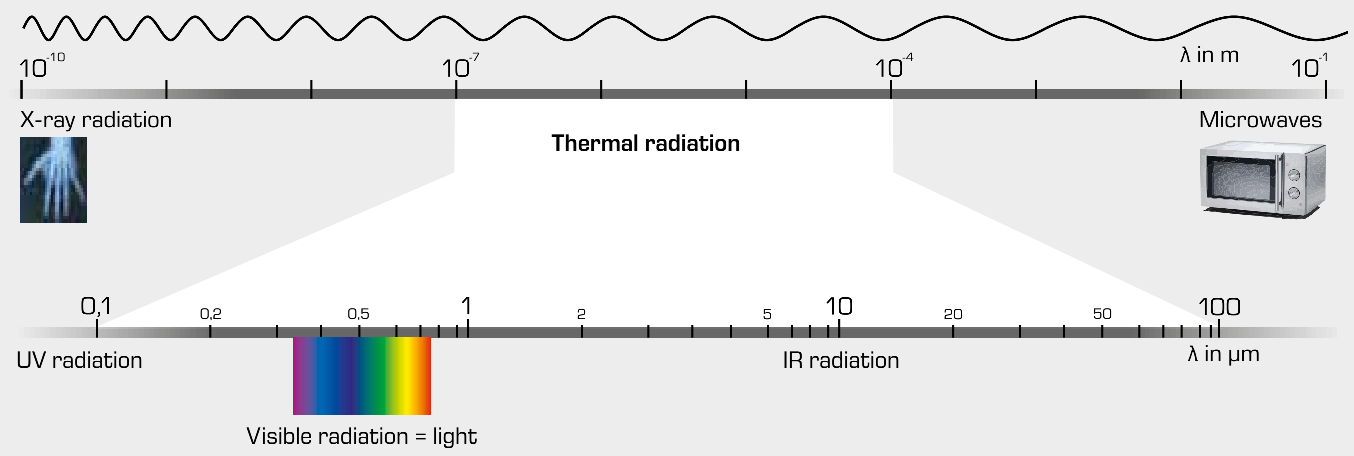
Non-material-bound heat transport

by thermal radiation

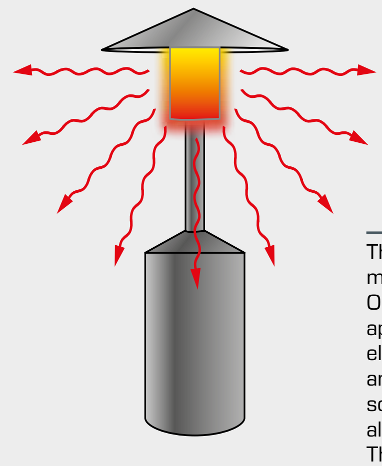
Radiation

Energy transport through electromagnetic oscillation in a specific wavelength range. Any body with a temperature above zero Kelvin emits radiation known as thermal radiation.

Thermal radiation includes UV radiation, light radiation and infrared radiation. Light radiation covers the wavelength range visible to the human eye.



Using a thermal imaging camera, it is possible to make thermal radiation visible: the thermal camera converts long-wave infrared radiation into visible radiation.



The best example of thermal radiation is the sun.
One example of a technical application is a patio heater: electromagnetic oscillations are emitted by the heat source as thermal radiation in all directions.
The portion of the thermal radiation directed upwards is reflected by the canopy.

Material characteristics

Heat transfer coefficient α: a measure of how much heat is transferred from a solid to a fluid or vice versa (convection)

Thermal conductivity λ: a measure of how well heat is transferred into a solid (conduction)

Overall heat transfer coefficient k: describes the overall heat transfer between fluids separated by solids (convection and conduction)

Reflectance, absorbance and transmittance: a measure of the proportion of thermal radiation reflected, absorbed or transmitted to a body (radiation)

GUNT-Thermoline
Fundamentals of heat transfer

Overall didactic concept for targeted teaching on the fundamentals of heat transfer.

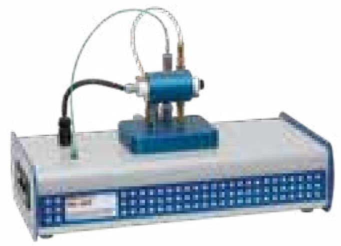
- accurate measurements
- software-controlled
- tutorial software

WL 420
Heat conduction in metals

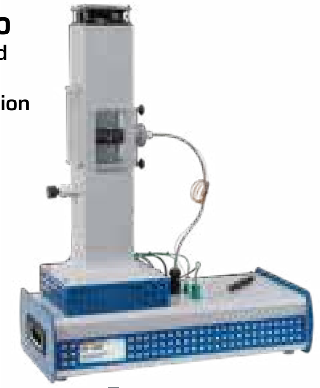
WL 430
Heat conduction and convection

WL 460
Heat transfer by radiation

WL 422
Heat conduction in fluids



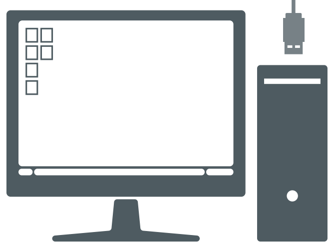
WL 440
Free and forced convection



USB connection

Network capability

- full network access to ongoing experiments by any number of external workstations
- experiments can be independently followed and evaluated by students at all workstations when using a single training system

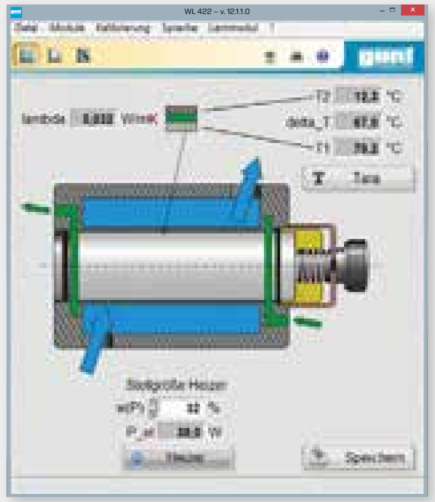


One computer for control and operation of the experimental unit

LAN/WLAN connection

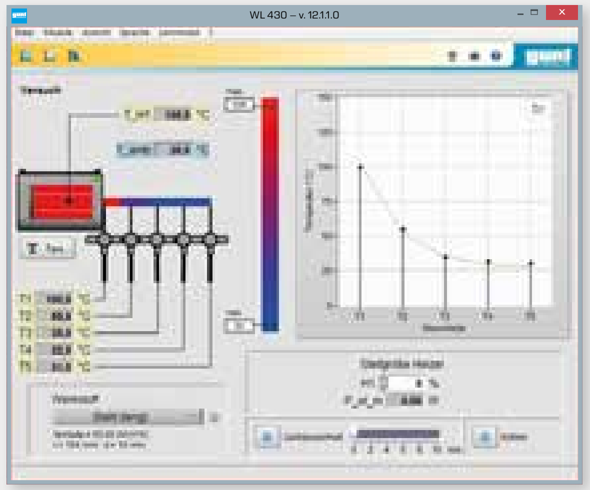
...any number of workstations with GUNT software with just a single licence

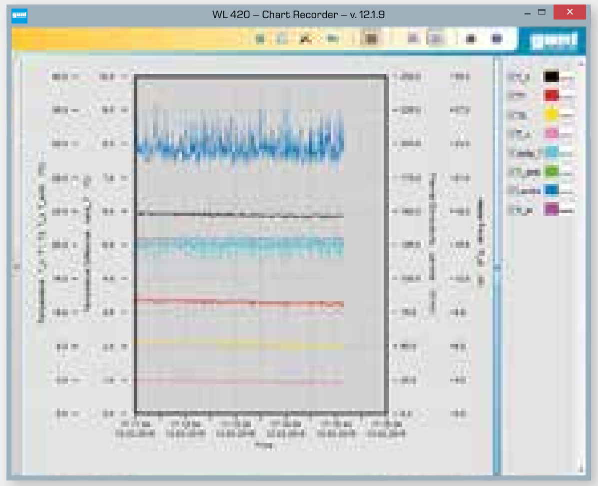
Operation and data acquisition



Operation

- simple operation of the system via the software
- adjust operating parameters via respective button icons
- check and read off measured values





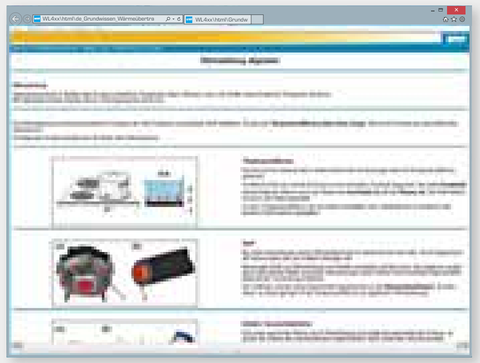
Time dependency

- representation of the measured values as a function of time
- plot and log your own characteristics
- freely selectable form of presentation of the measured values
  - measured values selection
  - resolution
  - colour
  - time intervals

Geometric temperature curve

- representations of the temperature curves make it easier to understand the respective heat transfer mechanisms

Tutorial software



Course in the fundamentals

Educationally thought-out and media-rich learning content in the field of heat transfer

Detailed thematic courses

- the various forms of heat transfer are explained using concrete examples
- independent preparation for handling the equipment

Targeted review of the learning content

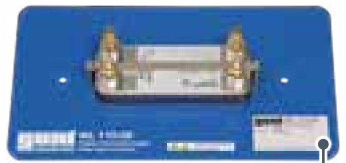
- allows learning progress to be checked discreetly and automatically
- detect weaknesses and provide targeted support

For further information, please refer also to the Thermoline-brochure.

WL 110-Series
Heat exchanger with supply unit

WL 110.01
Tubular heat exchanger

WL 110.03
Shell & tube heat exchanger



WL 110.02
Plate heat exchanger

WL 110.04
Stirred tank with double jacket and coil

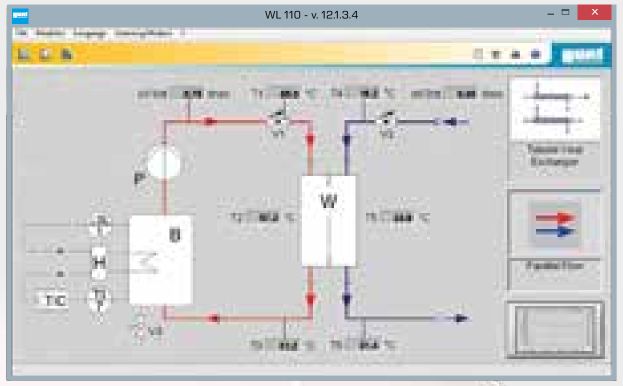
WL 110
Heat Exchanger Supply Unit

The supply unit produces hot water. All measured values can be displayed on the device and transferred via a USB connection.

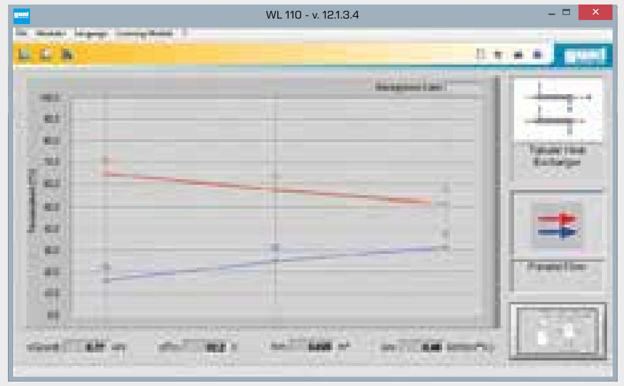
WL 110.20
Water Chiller

The water chiller can be used to operate the heat exchangers under suitable experimental conditions.

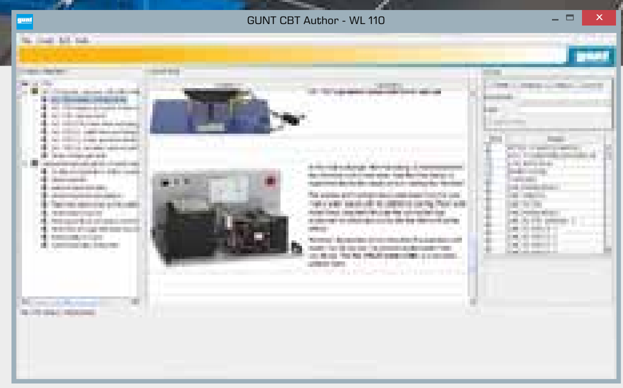
Operation and data acquisition

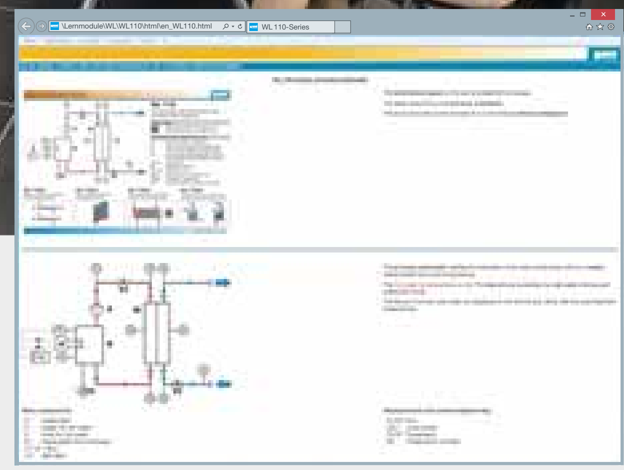


Process schematic



Data acquisition: temperature profile





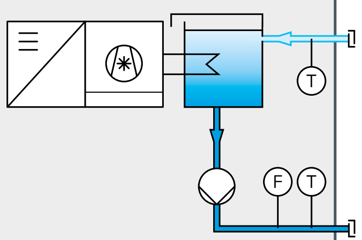
Tutorial software

WL 315C
Comparison of various heat exchangers

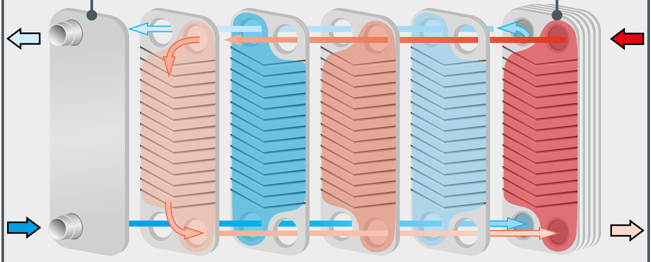
WL 315C
Comparison of various heat exchangers

WL 312.11
Water chiller

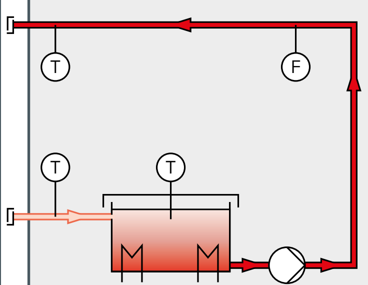
WL 312.10
Hot water generator



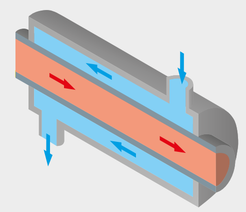
WL 312.11 Water chiller



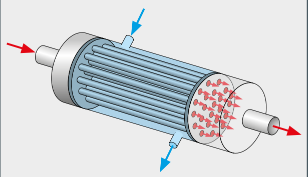
WL 315C Trainer with five different heat exchangers. The plate heat exchanger is shown as an example.



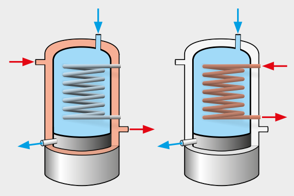
WL 312.10 Hot water generator



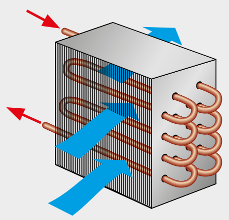
Tubular heat exchanger



Shell & tube heat exchanger



Stirred tank with double jacket and coiled tube



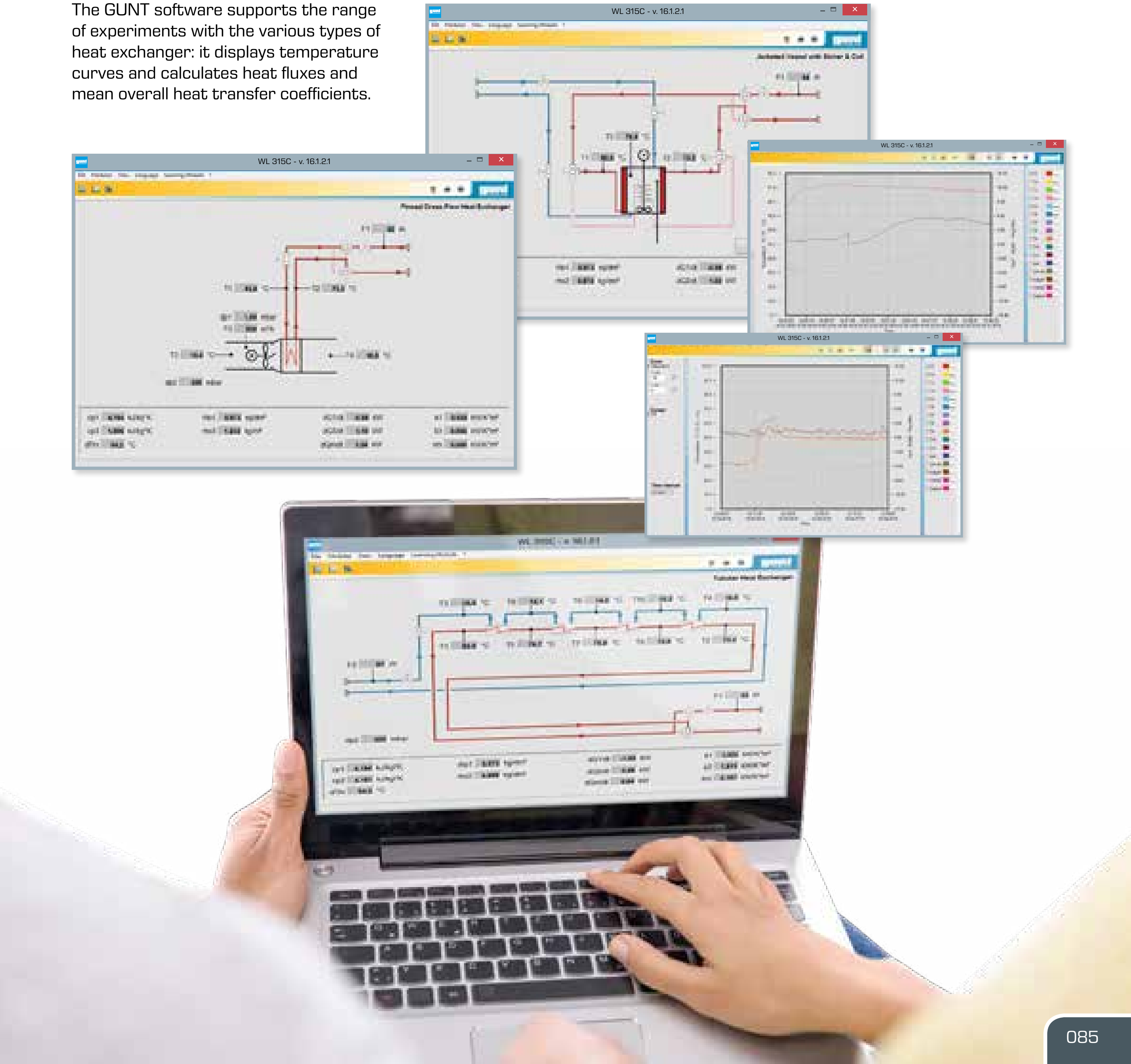
Finned tube heat exchanger

The WL 315C trainer is used to study and compare different types of heat exchanger under experimental conditions. The most widespread design is the shell & tube heat exchanger, which is included here as double-tube and shell & tube heat exchangers. The plate heat exchanger is an equally frequently used design. One special design is the stirred tank with double jacket and coiled tube. In the model used here, hot water can flow through either the outer jacket or the inner coiled tube. The finned tube heat exchanger is a typical example of heat transfer between a liquid and a gaseous medium.

The types presented here are indirect heat exchangers, in which the material flows are conducted in parallel flow, counterflow or, in the case of the finned tube heat exchanger, in cross flow.

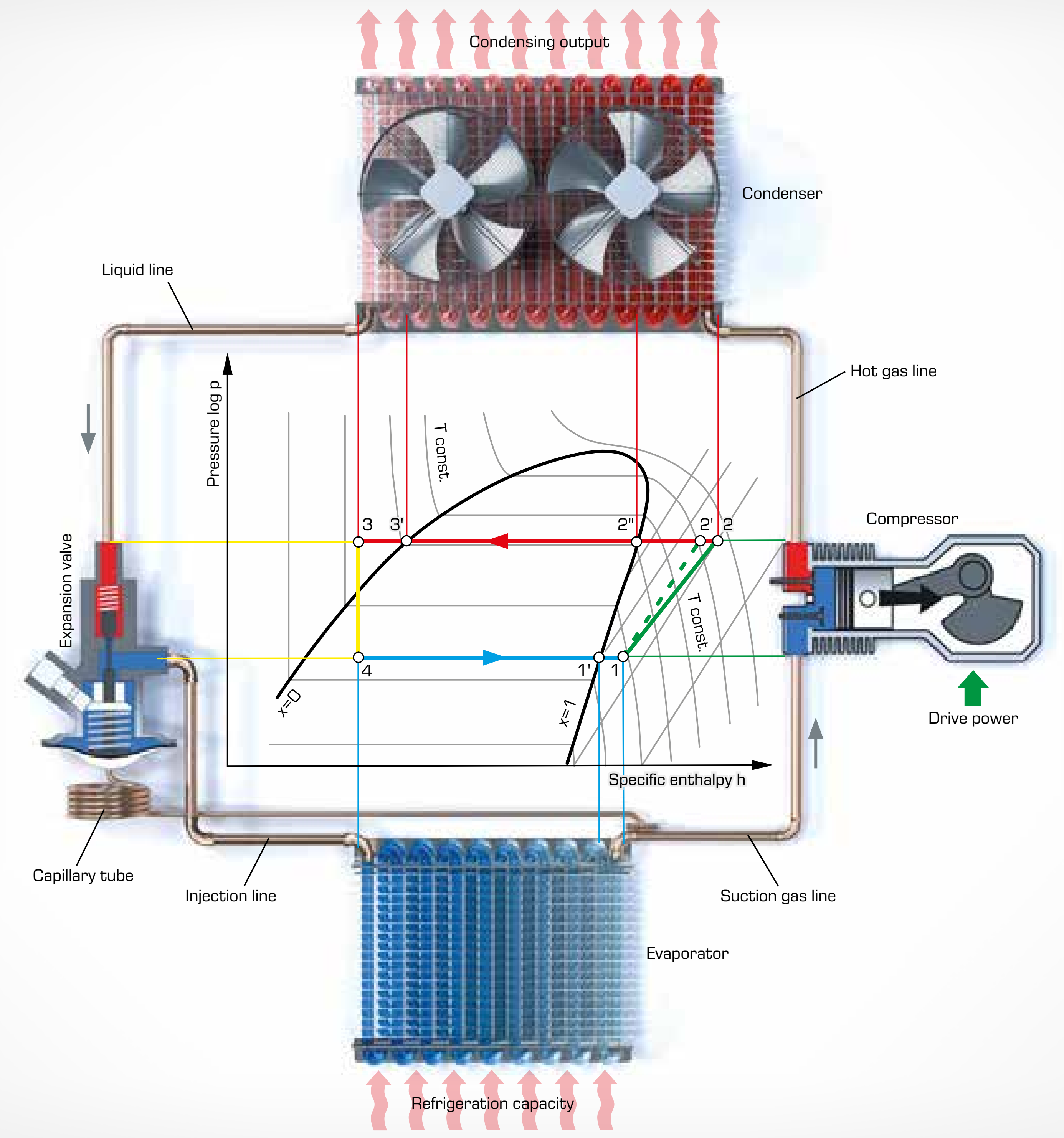
GUNT software for data aquisition

The GUNT software supports the range of experiments with the various types of heat exchanger: it displays temperature curves and calculates heat fluxes and mean overall heat transfer coefficients.



Components of refrigeration systems

Components of refrigeration systems



1 – 2	2 – 2''	2'' – 3'	3' – 3	3 – 4	4 – 1'	1' – 1
polytropic compression to the condensing pressure (for comparison 1 – 2' isentropic compression)	isobaric cooling, deheating of the superheated vapour	isobaric condensation	isobaric cooling, supercooling of the liquid	isenthalpic expansion to the evaporation pressure	isobaric evaporation	isobaric heating, superheating of the vapour

Experimental units from GUNT show the function of the components in the refrigerant circuit and their interaction with each other. Different types of main components such as compressors, evaporators and condensers as well as primary and secondary controllers are investigated and typical parameters are determined.

ET 180
Pressure switches in refrigeration

ET 460
Oil return in refrigeration systems

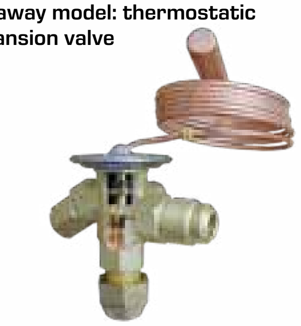
ET 432
Behaviour of a piston compressor

Cutaway models are ideal for displaying details and functions. GUNT uses industrial components for the section models. Movement and switching functions are retained. The sections are arranged in such a way that the constructive details are easily recognized. A short description and a sectional drawing are included in the scope of delivery.

ET 499.01
Cutaway model: hermetic refrigerant compressor

ET 499.03
Cutaway model: open refrigerant compressor, 2-cylinder

ET 499.18
Cutaway model: thermostatic expansion valve



Assembly exercises, troubleshooting and **maintenance** provide trainees with a particularly high level of practical relevance and support them with an overall didactic concept in learning manual work on refrigeration systems. This involves the planning, execution and checking of processes.

ET 192
Replacement of refrigeration components

ET 150.01
Refrigerant filling and evacuation equipment

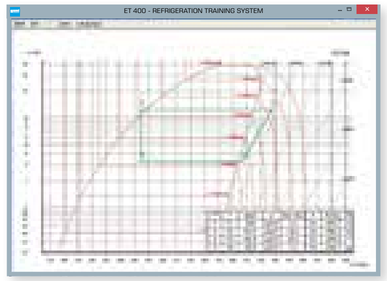
Refrigeration systems

ET 400
Refrigeration circuit with variable load

Compression refrigeration system with water-cooled evaporator

Learning objectives / experiments

- design and components of a refrigeration system
  - compressor
  - condenser
  - thermostatic expansion valve
  - evaporator
  - pressure switch
- representation of the thermodynamic cycle in the log p-h diagram
- determination of important characteristic variables
  - coefficient of performance
  - refrigeration capacity
  - compressor work
- operating behaviour under load



ET 350
Changes of state in the refrigeration circuit

Energetic analyses of the refrigeration cycle; transparent components offer insights into the changes of state

Learning objectives / experiments

- design and operation of a compression refrigeration system
- observe the evaporation and condensation of the refrigerant
- represent and understand the refrigeration cycle in the log p-h diagram
- energy balances
- calculation of the coefficient of performance

Solar cooling

With the increasing demand for refrigeration worldwide, the interest in processes of cold production which can be supplied from renewable energy sources is also growing. The use of solar power offers particular advantages for mobile and very remote applications.

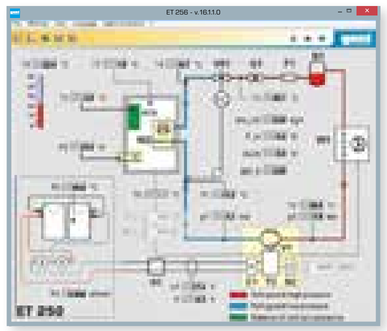
ET 256 contains a typical compression refrigeration system with refrigeration chamber. It is possible to supply the refrigerant compressor directly with current from photovoltaic modules. To do this, the photovoltaic modules from ET 250 are connected to ET 256.

ET 256
Cooling with solar electricity

Compression refrigeration system for operation with solar current from ET 250

Learning objectives / experiments

- supply a compression refrigeration system with current from photovoltaic modules
- components of a photovoltaic refrigerating plant
- operation of the compressor with changing power available and cooling demand
- charge and discharge cold accumulators
- coefficient of performance of the refrigerating plant dependent on operating conditions
- refrigeration cycle in the log p-h diagram
- energy flow balance



ET 915 HSI training system refrigeration and air conditioning technology

The ET 915 HSI Training system refrigeration and air conditioning technology, base unit provides basic experiments for the different areas of refrigeration and air conditioning technology.

The term HSI refers to our overall didactic concept: **H**ardware – **S**oftware – **I**ntegrated.

Refrigeration

ET 915.01
Refrigerator model

ET 915.02
Model of a refrigeration system with refrigeration and freezing stage

Air conditioning

ET 915.06
Model of a simple air conditioning system

ET 915.07
Air conditioning model

All attachments contain expansion elements and evaporators

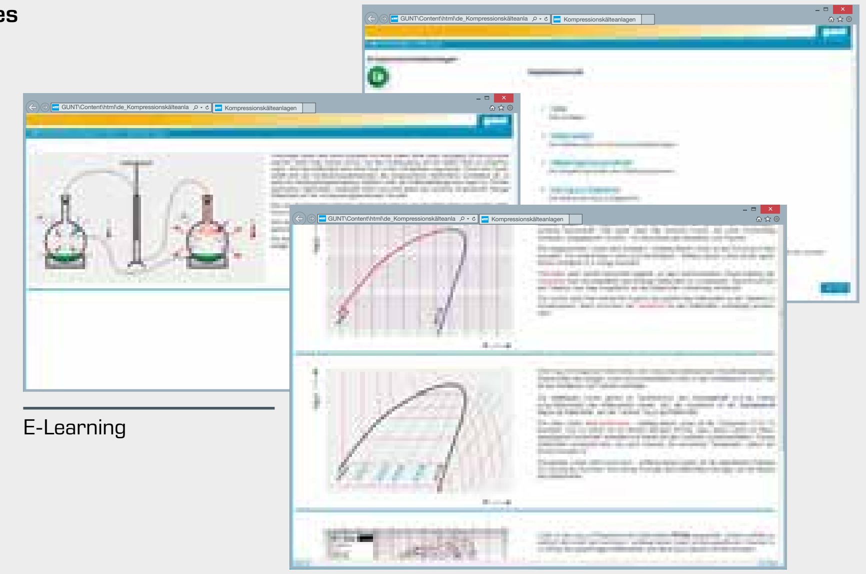
The ET 915 base unit contains the main compressor and condenser components

Modular system with extensive teaching possibilities

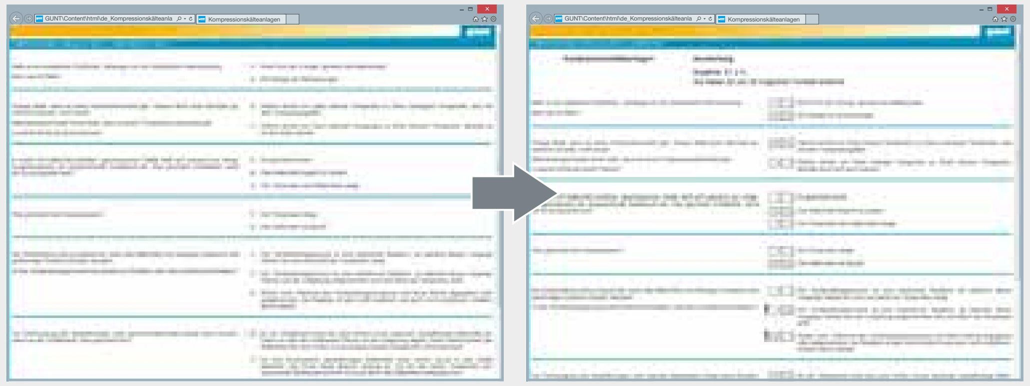
Tutorial software

...with didactically valuable course of studies

- use the tutorial software on the students' own PCs
- complete course of studies for refrigeration and air-conditioning technology including quiz
- very flexible thanks to the structure of own learning modules and tests
- intuitive user interface



E-Learning



Quiz with detailed evaluation

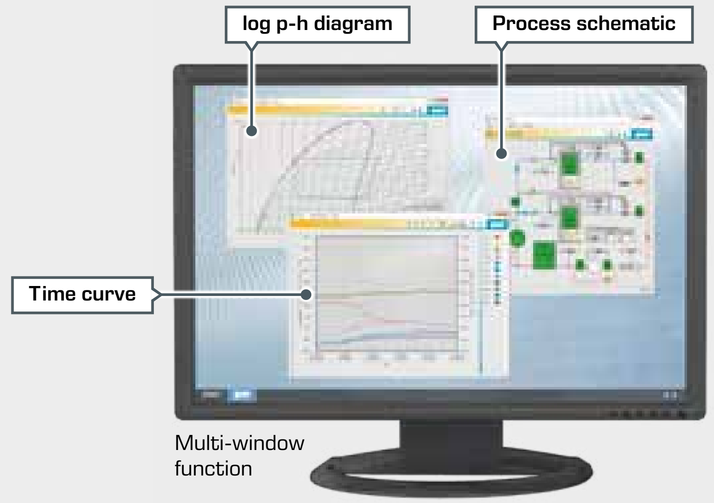
Targeted review of the learning content

- learning progress can be monitored discretely and automatically
- detect weaknesses and provide targeted support

Data acquisition

...with unlimited networking capability

- interactive experiments for students via network connection
- real-time display of the processes in the log p-h diagram and h-x diagram
- plug & play system via USB connection



Multi-window function

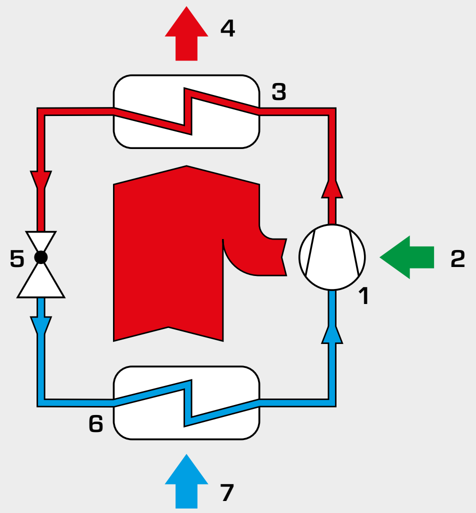
Heat pumps

What is a heat pump?

A heat pump transports heat from a low temperature level to a higher temperature level. To do this, the heat pump requires drive power. This can be mechanical, electrical or thermal. Usually heat pumps which operate according to the principle of a compression refrigeration system are used. Less often, heat pumps running on the absorption process are used.

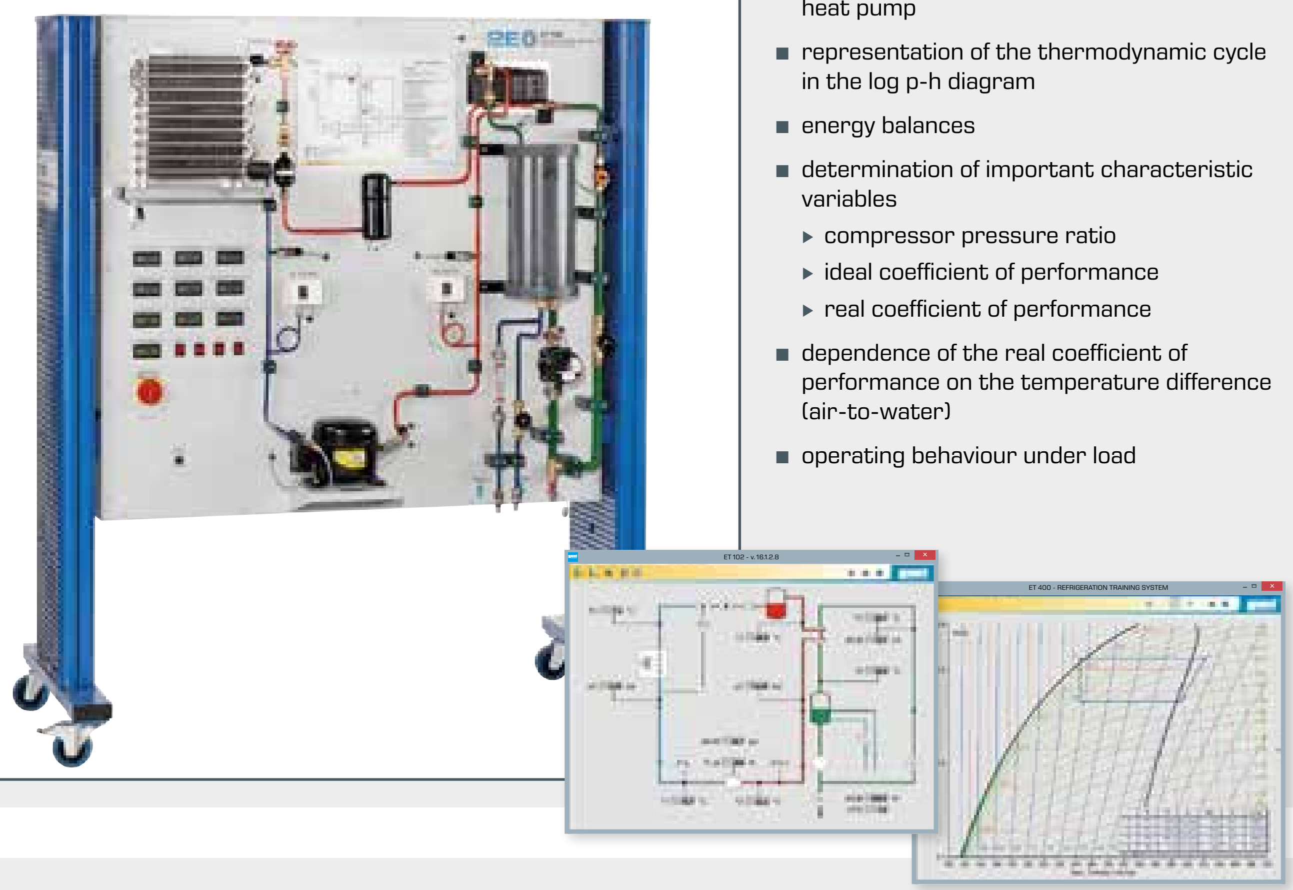
The COP is an important indicator for the operation of heat pumps. COP stands for "Coefficient of Performance". The COP indicates how efficiently a heat pump works. The COP indicates the ratio of heat capacity and the required drive power. This value allows an easy comparison between different heat pumps.

The COP is directly dependent on the temperature of the heat source and the heating temperature in the building. Therefore, the COP changes at each operating point of the heat pump. The larger the COP, the more effective the heat pump.



1 compressor,
2 mechanical work,
3 condenser,
4 heat dissipation,
5 expansion valve,
6 evaporator,
7 heat absorption

ET 102
Heat pump

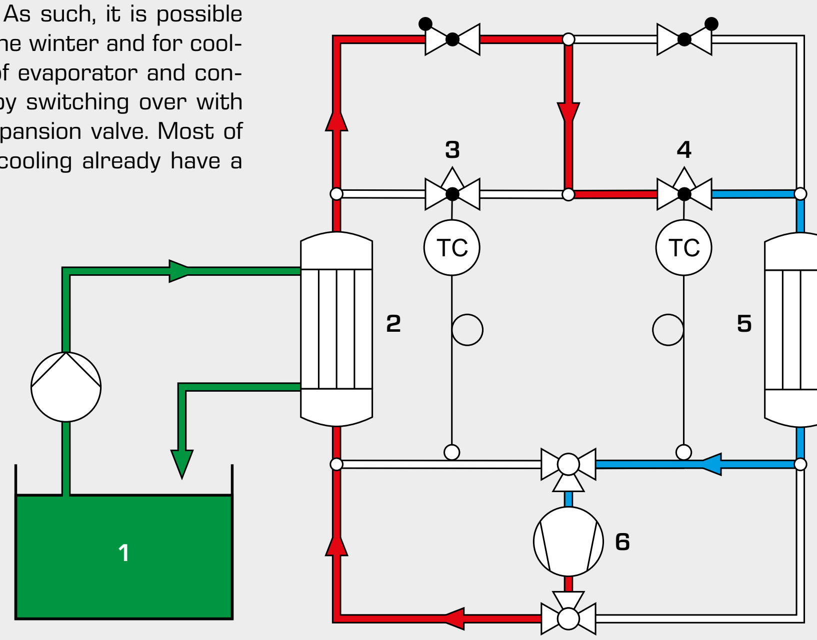


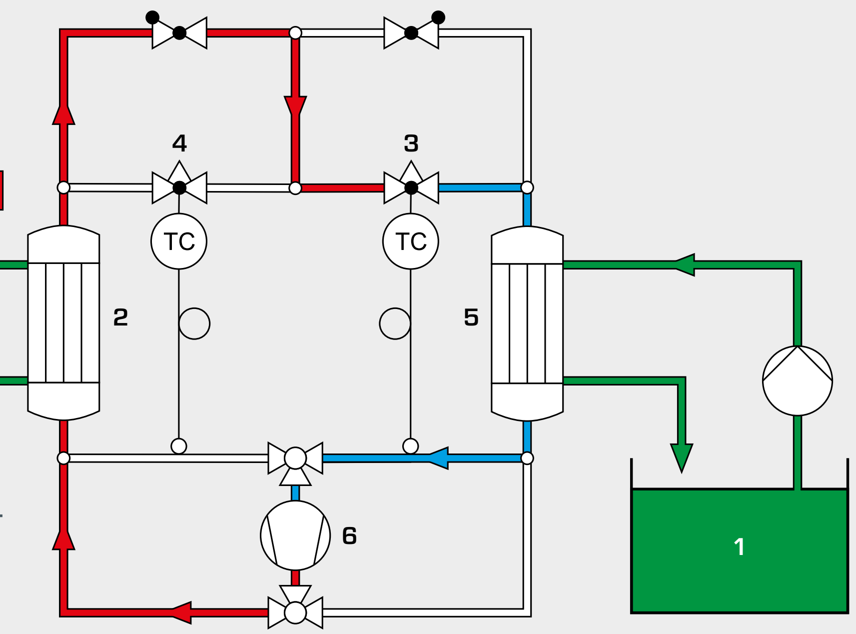
Utilisation of ambient heat for water heating

- design and operation of an air-to-water heat pump
- representation of the thermodynamic cycle in the log p-h diagram
- energy balances
- determination of important characteristic variables
  - compressor pressure ratio
  - ideal coefficient of performance
  - real coefficient of performance
- dependence of the real coefficient of performance on the temperature difference (air-to-water)
- operating behaviour under load

A heat pump can be used for cooling or heating

Because they have the same principle of operation, a heat pump can function as a refrigeration system. As such, it is possible to use the same system for heating in the winter and for cooling in the summer. Only the functions of evaporator and condenser are swapped. This takes place by switching over with two non-return valves and a second expansion valve. Most of these so-called split devices for room cooling already have a heater function included.





Summer

1 heat sink, **2** condenser, **3** expansion valve 1, **4** expansion valve 2, **5** evaporator, **6** compressor, water/solar circuit, refrigerant (low pressure), refrigerant (high pressure)

Winter

1 heat source, **2** condenser, **3** expansion valve 1, **4** expansion valve 2, **5** evaporator, **6** compressor, water/solar circuit, refrigerant (low pressure), refrigerant (high pressure)

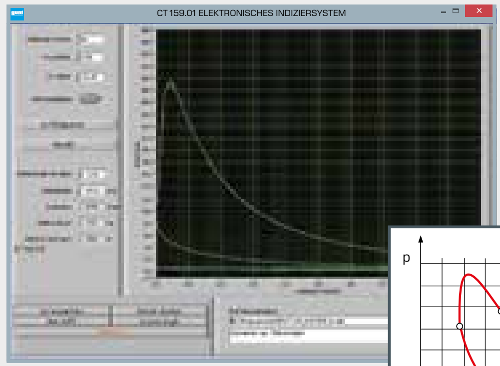
Test stands for internal combustion engines

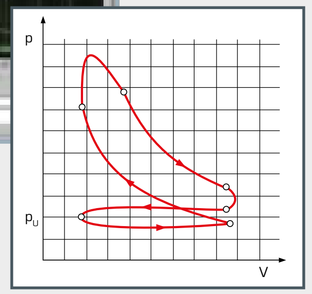
GUNT offers four different test stands for internal combustion engines in the **2,2 kW to 75 kW** power range. The engines include four-stroke diesel and petrol engines, petrol engines with variable compression ratios and two-stroke petrol engines.

The engines are supplied with fuel and air via the test stands. The exhaust gases can be studied using an exhaust gas analyser.

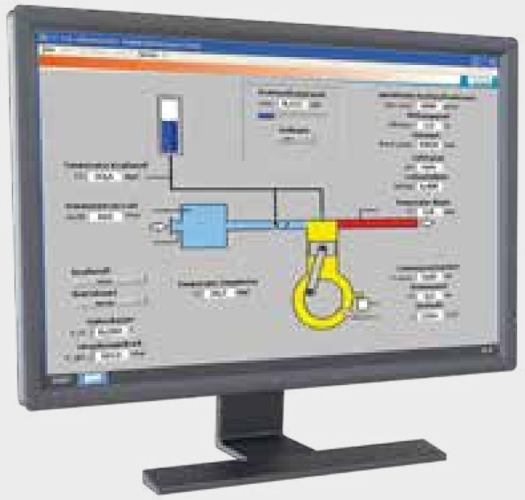
The **electronic indicating system** is a good way to gain an in-depth understanding of how an engine works. Special pressure sensors record the pressure in the cylinder chamber. These data provide important information on the combustion process in the engine. In industrial applications, indicating systems are used to optimise the combustion process. The data are used to create the **indicator diagram**.

The indicating system helps identify the individual strokes of the engine. The process of **ignition** or an **ignition attempt**, and the **gas exchange** can be examined. Cranking without ignition can be simulated while examining the processes inside the cylinder chamber. The **idling behaviour** of diesel and petrol engines can be compared. The indicating system can be used to carry out a thermodynamic analysis of the engine.





Indicator diagram of a 4-stroke engine



Modern GUNT software for Windows with comprehensive visualisation functions:

- process schematic for all engines with real-time display of all measured and calculated variables
- display of up to four characteristics at the same time
- representation of characteristics: select any assignment for the axes of the diagram
- storage of measuring data
- selection between four preset languages
- easy connection to a PC via USB
- calculated variables
  - specific fuel consumption
  - intake air volumetric flow rate
  - mechanical power
  - efficiency
  - volumetric efficiency
  - fuel-air ratio **λ**

CT 159
Modular test stand for single-cylinder engines, 2,2 kW

CT 150
Four-stroke petrol engine for CT 159

CT 152 Four-stroke petrol engine with variable compression for CT 159

CT 151
Four-stroke diesel engine for CT 159

CT 153
Two-stroke petrol engine for CT 159

CT 110
Test stand for single-cylinder engines, 7,5 kW

CT 100.21
Two-stroke petrol engine for CT 110

CT 100.20
Four-stroke petrol engine for CT 110

CT 100.22
Four-stroke diesel engine for CT 110

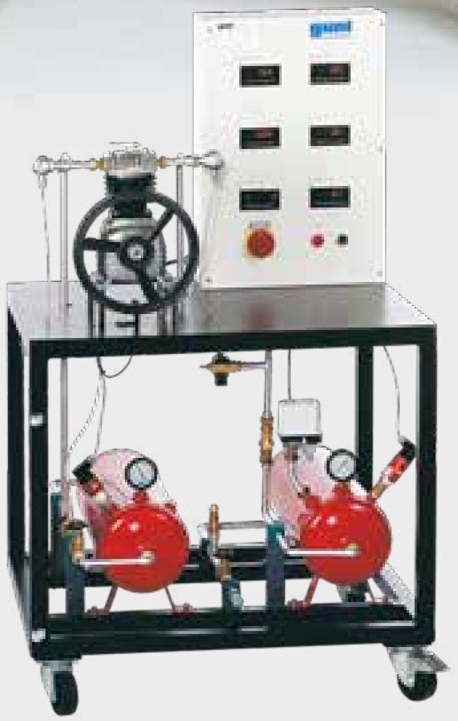
CT 100.23
Water-cooled four-stroke diesel engine for CT 110

ET 513
Single-stage piston compressor with drive unit HM 365

Learning objectives / experiments

- operating principle of a piston compressor
- measurement of volumetric flow rate and pressures
- power measurement
- determination of efficiency
- plotting of compressor characteristic
- determination of intake and volumetric efficiency

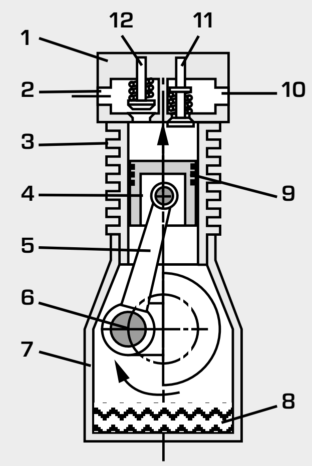
HM 365 Universal drive and brake unit



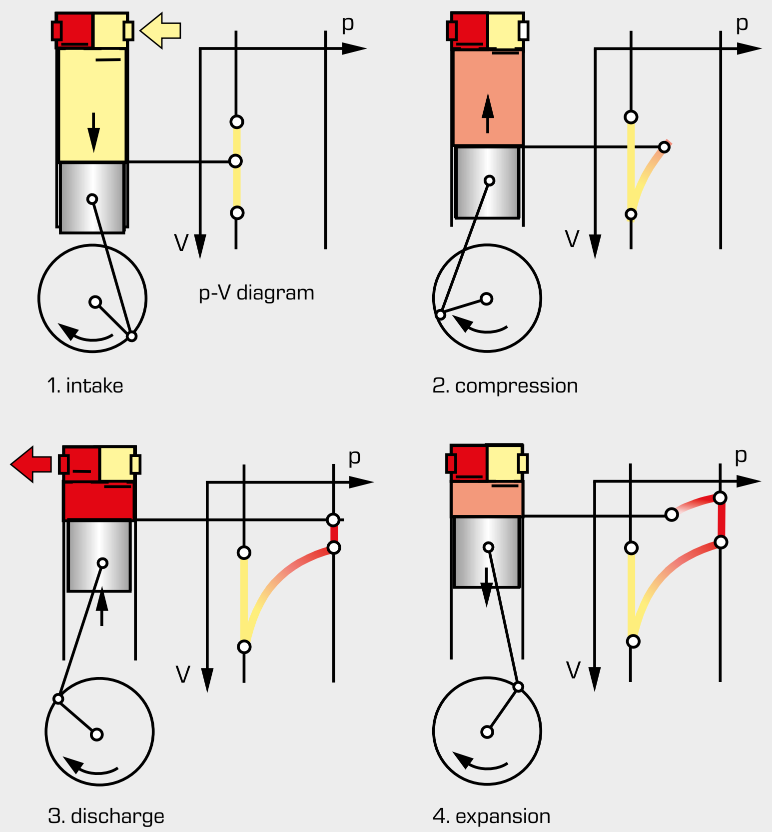
ET 513 Single-stage piston compressor

Piston compressors deliver compressible media such as gas or air.

Piston compressors are positive displacement machines. The piston (displacement element) forms a space with variable volume together with cylinder and cylinder cover. A crank mechanism generates the periodic reciprocating movement of the piston inside the cylinder. The self-acting valves in the cylinder cover control the inflow and the outflow of the delivered medium.



1 cylinder head,
2 air outlet,
3 cylinder with cooling fins,
4 piston,
5 connecting rod,
6 crank shaft,
7 crank case,
8 oil sump,
9 piston rings,
10 air intake,
11 intake valve,
12 discharge valve



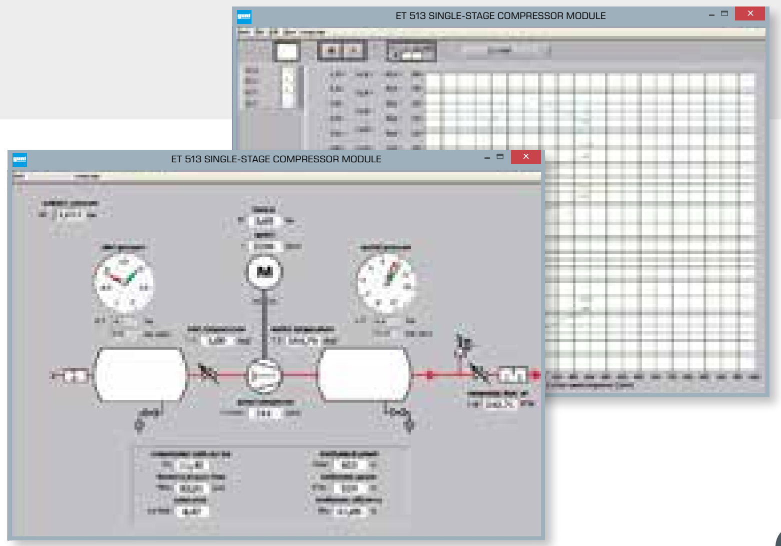
The process of delivery is divided into four steps

1. intake
The piston moves downwards and the delivery medium (air) is sucked into the cylinder via the opened intake valve.

2. compression
The piston moves upwards, the intake valve is closed and the pressure in the cylinder increases.

3. discharge
Once the pressure in the cylinder exceeds the pressure inside the outlet line, the discharge valve opens and the piston pushes the compressed medium into the outlet line.

4. expansion
The cylinder volume is not emptied completely into the outlet line. A small part remains inside the cylinder. This part expands during the downward movement of the piston until the pressure inside the intake line is reached. The first step (intake) follows.



The software enables display of measured values on a PC. Recording and saving of data history is possible.

With the help of spreadsheet programmes (e.g. MS Excel) saved data can be evaluated. The measured values are directly transmitted to the PC via USB.

GUNT steam power plants

Steam power plants play a key role in supplying electrical energy. This is why the Rankine steam cycle is still one of the most important industrially used cyclic processes today. Thanks to optimised processes, the efficiency of electrical energy generation has improved continuously over the past years. Today, a total efficiency of almost 45% has been achieved. The steam cycle process therefore plays an important role in the training of future engineers. GUNT steam power plants for laboratory and experimental applications offer a practical approach to teaching this important subject area in technical fields of study. They are particularly well suited for investigating and understanding the behaviour of steam power plants under different operating conditions. The plants are built with real, industrial components, and can also be used to teach aspects such as maintenance, repair, measurement technology, and control engineering.

ET 810
Steam power plant with steam engine (5W)

ET 813 Two-cylinder steam engine (500W) together with **HM 365** Universal drive and brake unit and **ET 813.01** Electrical steam generator

ET 850 Steam generator and **ET 851** Axial steam turbine (50W)

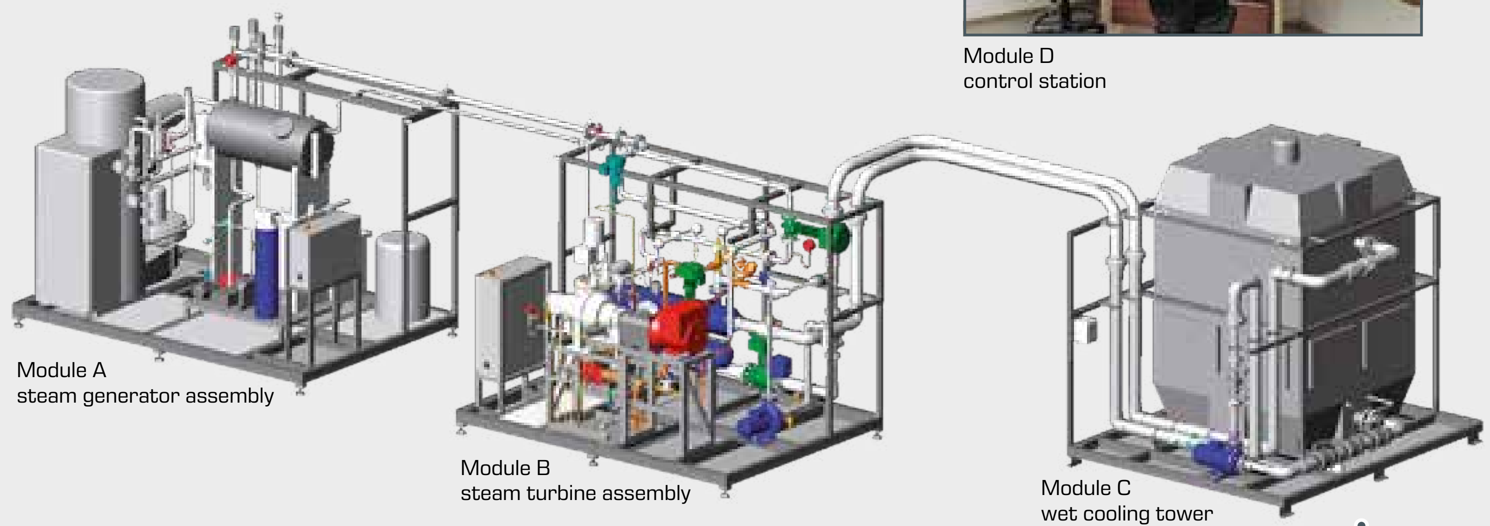
GUNT offers a wide range of steam power plants

The GUNT steam power plant product range encompasses everything from simple demonstration facilities with a power output of just a few watts, to modular systems in the medium power range, and a complex steam power plant with a process control system and an output power of 20kW (ET 805).

Due to the size and complexity of ET 805, many aspects of its operating behaviour correspond to those of real large-scale plants, allowing for hands-on training. ET 805 consists of three separate modules and a control station.

ET 805 Steam power plant 20kW with process control system

Module D
control station



Module A
steam generator assembly

Module B
steam turbine assembly

Module C
wet cooling tower

ET 830
Steam power plant, 1,5kW

or

ET 833
Steam power plant 1,5kW
with process control system

5W | 50W | 500W | 1.500W | 20.000W

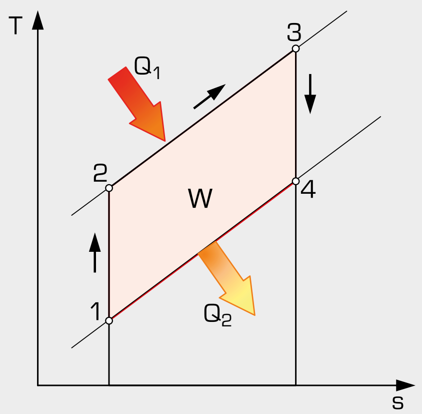
Gas turbines for experiments and demonstration

ET 792
Gas turbine

Operation with power turbine or as
jet engine with propelling nozzle using liquid gas

Learning objectives / experiments

- familiarisation with the function and typical behaviour during operation of a gas turbine
- operation as jet engine
- operation as power turbine
- determining effective power
- thrust measurement
- determining specific fuel consumption
- recording the characteristic of the power turbine
- determining the system efficiency

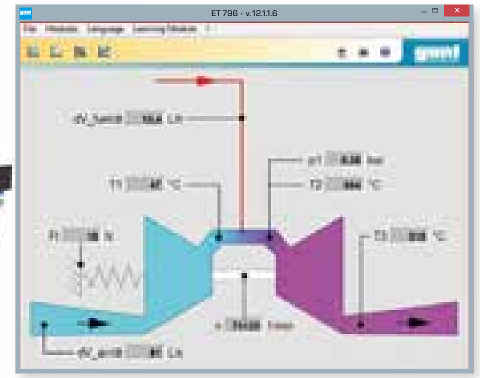


T-s diagram of open gas turbine process:

1 – 2 compression, **2 – 3** heat addition,
3 – 4 expansion; $\mathbf{Q_1}$ heat input, $\mathbf{Q_2}$ heat output, **W** useful work

A real jet engine in laboratory scale is used as the gas turbine for the trainer ET 796. The jet engine is a single-shaft engine with radial compressor, annular combustion chamber and axial turbine. As in reality the turbine is operated with kerosene. An electronic control unit (ECU) facilitates automated start-up and monitors turbine functions.

A protective hood ensures safe operation and prevents burns from the hot turbine.

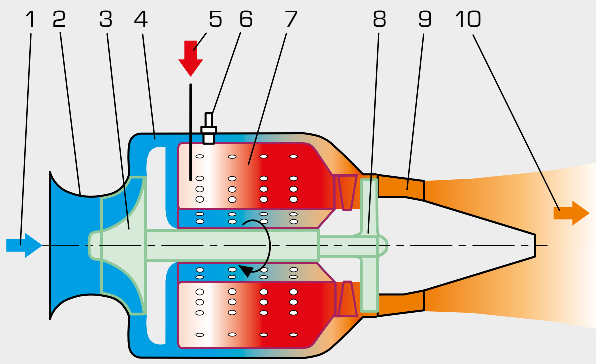


ET 796
Gas turbine jet engine

Small single-shaft gas turbine with thrust measurement using either kerosene or petroleum

Learning objectives / experiments

- behaviour during operation of a jet engine including start-up procedure
- determination of the specific thrust
- determination of the specific fuel consumption
- determination of lambda (fuel-air ratio)



Process schematic: open gas turbine process

1 cold air, **2** housing, **3** compressor, **4** diffuser, **5** fuel, **6** spark plug, **7** annular combustion chamber, **8** turbine, **9** propelling nozzle, **10** exhaust gas

6 Heating, ventilation and air conditioning (HVAC)

Topics included in this unit

- Ventilation systems
- Air conditioning systems
- Heating systems

Heating, ventilation and air conditioning (HVAC)

The buildings we use in everyday life to live, work, study and socialise are becoming increasingly more complex in their design. As well as being subject to more stringent environmental emission targets, within these buildings the heating, ventilation and air conditioning (HVAC) systems play a vital role in maintaining the comfort of the occupants within the built environment.

Level 5

Topics

This unit will introduce students to some of the most important HVAC systems and their supporting elements, and the underpinning science that is currently used in many different buildings around the world.

Subjects covered include:

Ventilation systems
- requirements
- ventilation rates
- ventilation strategies
- fans, fan types and operational characteristics

Air conditioning systems
- requirements
- air conditioning strategies
- cooling loads
- psychrometrics

Heating systems
- fuels
- combustion
- boiler efficiency

Learning outcomes

- explain the operating principles of ventilation systems
- explore the range of air conditioning systems
- investigate the operational characteristics of heating systems

Ventilation systems

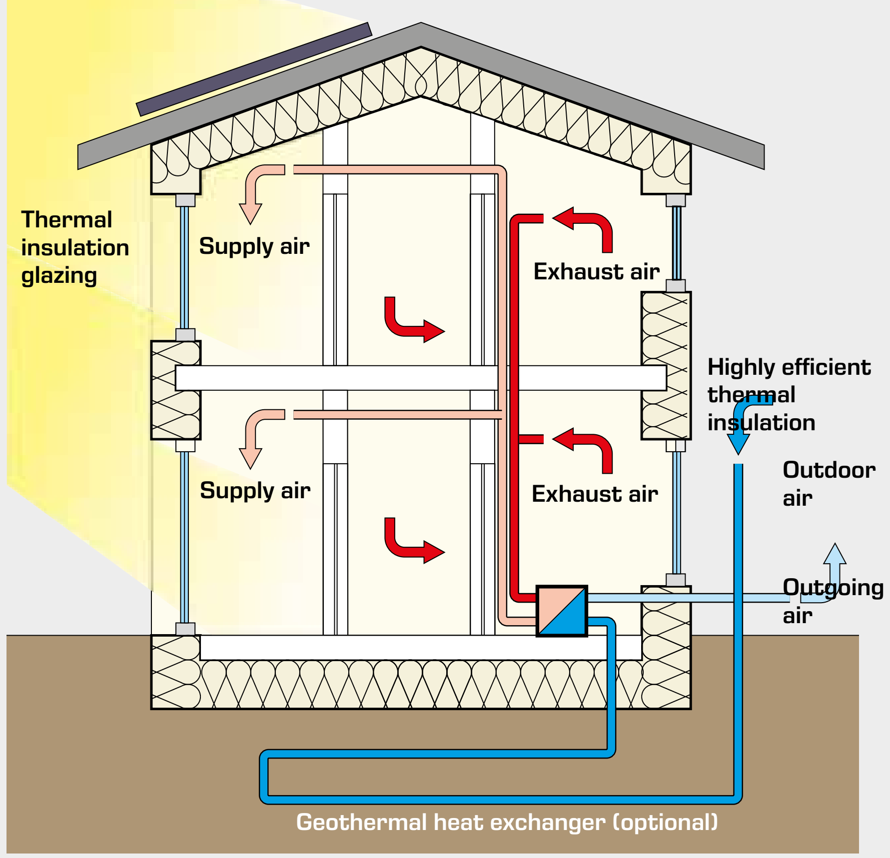
Ventilation systems ensure the change of air in residential, office and equipment rooms.

Ventilation systems are not only concerned with air supply and exhaust, but also with the consideration of **thermal energy:** sophisticated ventilation systems can transfer the heat of the outflowing air to the incoming air, so that hardly any thermal energy leaves the system.

There are basically three types of system:

1. exhaust air system: the "used" air from the building is expelled to the outside (outgoing air)
2. ventilation system: in addition to the exhaust air system, a supply system supplies fresh air to the living areas
3. different techniques that target the saving of heating energy, e.g. via heat recovery or geothermal heat exchangers

These systems are grouped together under the term controlled residential ventilation. Non-controlled ventilation of living space, on the other hand, is the free ventilation of living space by means of window ventilation, joint ventilation or shaft ventilation.

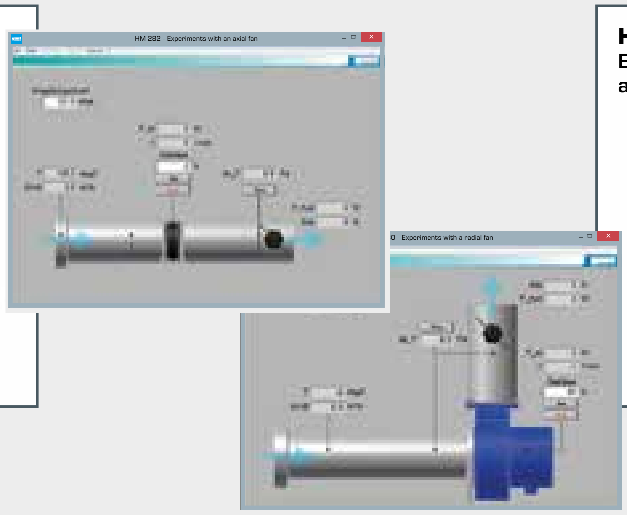


Ventilation with heat recovery

- **outside air:** air drawn in from the environment,
- **outgoing air:** air released into the environment,
- **supply air:** air entering a room or facility after it has been treated, e.g. by filtering or heating
- **exhaust air:** air leaving a room

Fans, fan types and operational characteristics

HM 282
Experiments with an axial fan

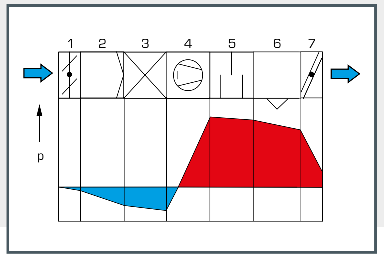


HM 280
Experiments with a radial fan

HL 720 Ventilation system

Learning objectives / experiments

- design and operation of a ventilation system
- pressure measurements in the air duct
- determine the electric drive power of the fan
- determine the flow rate
- design and operation of components such as
  - protective grating
  - multi-leaf damper
  - filter
  - heat exchanger (no operation)
  - fan
  - inspection cover
  - sound insulation link
  - ventilation grill with adjustable flow rate
  - fire protection flap
  - ceiling vents



Pressure curve within the ventilation system: **1** multi-leaf damper, **2** filter, **3** heat exchanger, **4** fan, **5** sound insulation link, **6** wall vent, **7** fire protection flap; overpressure, vacuum

HL 710 Air duct systems

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

Air conditioning systems

ET 915 HSI training system refrigeration and air conditioning technology

ET 915.06
Model of a simple air conditioning system

- air conditioning system for room cooling and its main components
- principle of operation of an evaporator as air cooler

ET 915.07
Air conditioning model

- complete model of a full air conditioning system
- heating, cooling, humidifying and dehumidifying
- outer air and recirculation operation possible

Component operation and fault simulation via the GUNT software

ET 600 Conditioning of room air

- air conditioning system with steam humidifier
- wide experimental program for conditioning of room air
- representation of the thermodynamic principles in the log p-h and h-x diagram

ET 605 Air conditioning system model

ET 605.01 **Software controller with data acquisition**

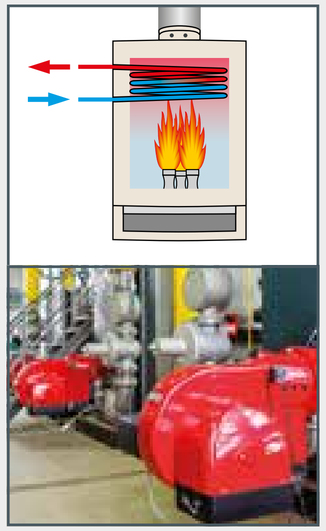
ET 605.02 **Air conditioning controller**

ET 605.03
I/O connection box

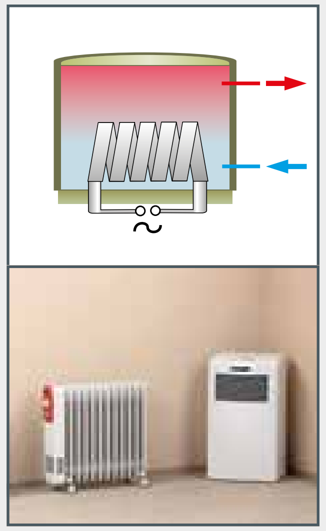
- climatic chamber with latent and sensitive heat source as cooling load
- recirculating and outer air operation
- connection options for the use of different automation solutions

Heating systems

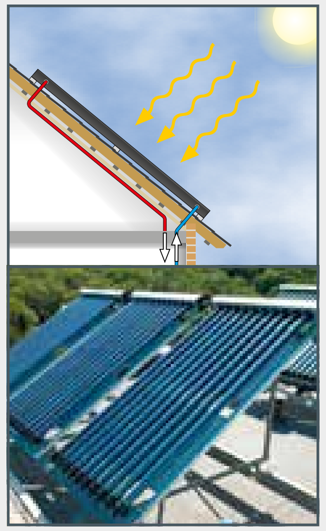
Generation of hot water



Oil, gas or wood-fired boiler



Electric resistance heating



Solar thermal energy

Heat pump

Hot water

Water as a heat transfer medium

Advantages

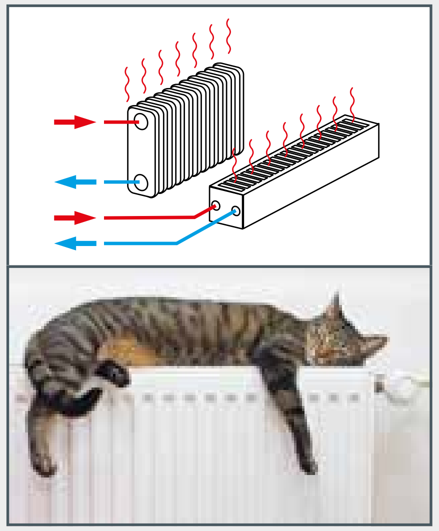
- high heat capacity
- inexpensive and easily obtainable
- non-toxic and environmentally friendly

Disadvantages

- temperature range only 0...100°C at ambient pressure
- corrosive in the presence of oxygen

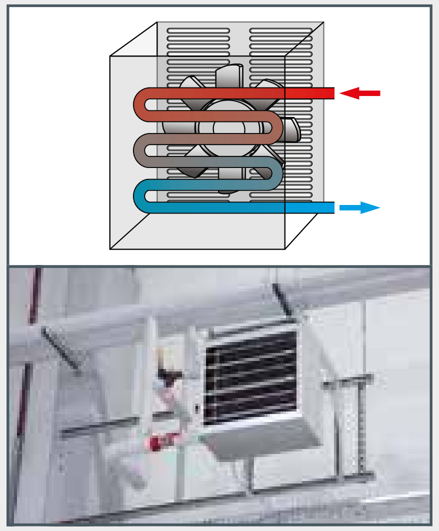
Cold water

Heat transfer to rooms



Radiator with natural convection

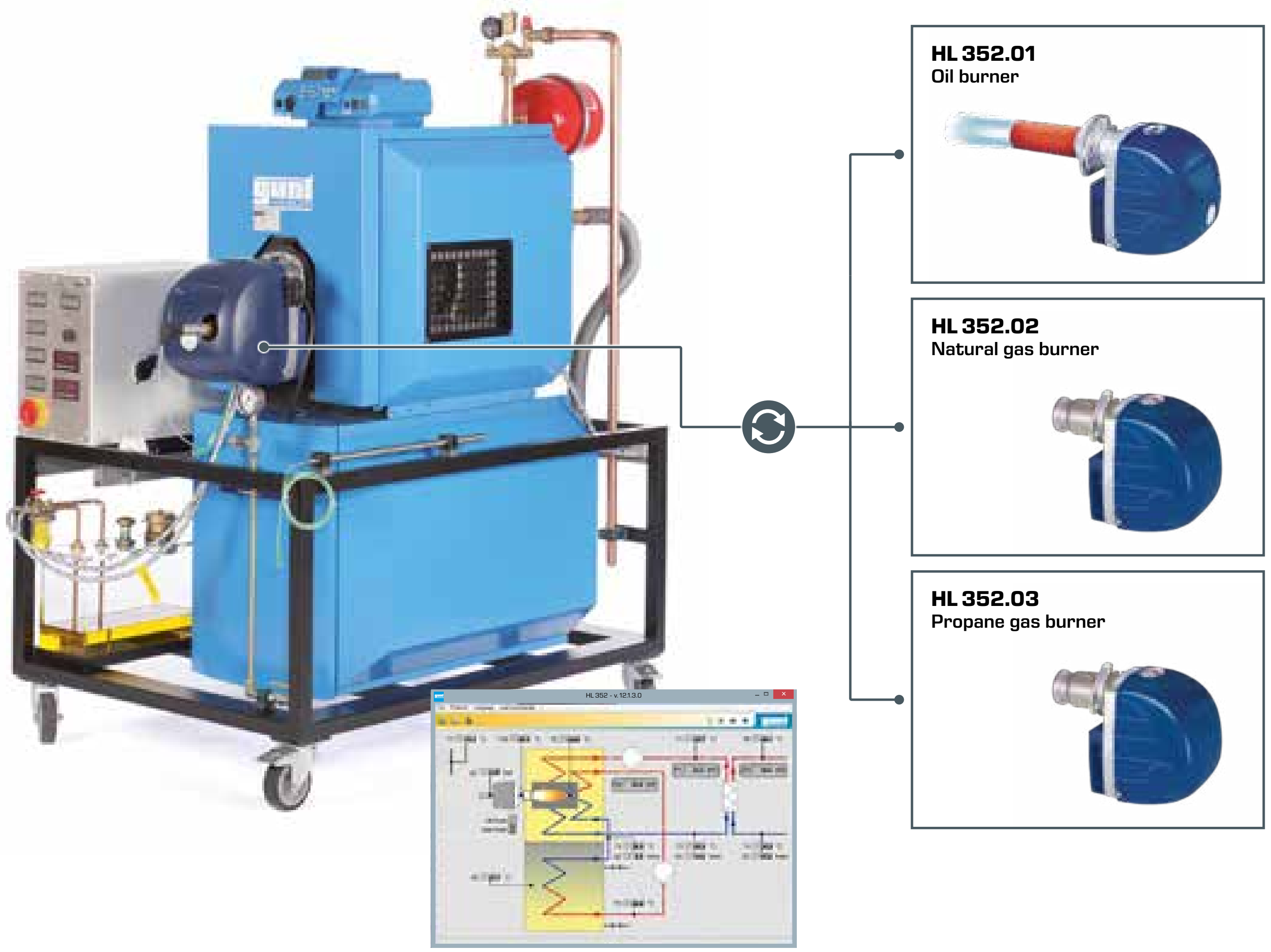
Underfloor or wall heating with natural convection



Air heater with forced convection

HL 352 Test stand for oil, natural gas and propane gas burners

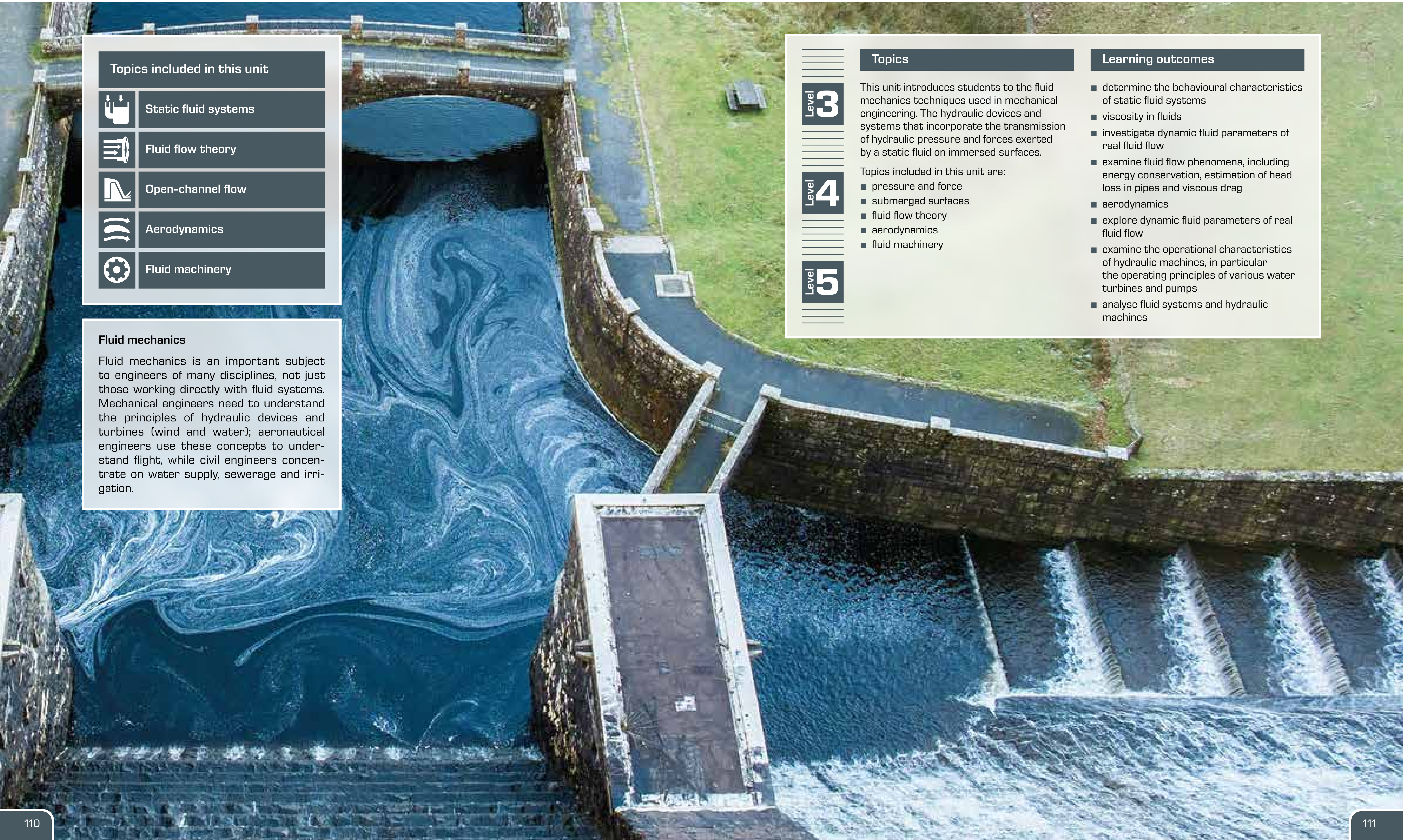
Gas and oil burners can be used to generate heat for central hot water heating systems. Burners convert the chemically stored energy of the fuels into thermal energy. There are different types of burners that differ mainly in their design. Oil burners are distinguished as yellow flame or atomizing burners and blue flame burners. Gas burners can be built in the form of gas fan burners, which are optimised for different gases depending on the heating medium.



Learning objectives / experiments

- design and operating behaviour of a heating boiler
- comparison of burners (3 different burners available as accessories)
- changes in settings during operation with observation of the effects on the flame pattern
- temperature measurements in different areas of the combustion chamber
- oil pressure measurements on the burner with observation of the effect on the flame pattern
- thermal balance
- calculation of the thermal output of a heating boiler

7 Fluid mechanics



Topics included in this unit

- Static fluid systems
- Fluid flow theory
- Open-channel flow
- Aerodynamics
- Fluid machinery

Fluid mechanics

Fluid mechanics is an important subject to engineers of many disciplines, not just those working directly with fluid systems. Mechanical engineers need to understand the principles of hydraulic devices and turbines (wind and water); aeronautical engineers use these concepts to understand flight, while civil engineers concentrate on water supply, sewerage and irrigation.

Level 3 Level 4 Level 5

Topics

This unit introduces students to the fluid mechanics techniques used in mechanical engineering. The hydraulic devices and systems that incorporate the transmission of hydraulic pressure and forces exerted by a static fluid on immersed surfaces.

Topics included in this unit are:

- pressure and force
- submerged surfaces
- fluid flow theory
- aerodynamics
- fluid machinery

Learning outcomes

- determine the behavioural characteristics of static fluid systems
- viscosity in fluids
- investigate dynamic fluid parameters of real fluid flow
- examine fluid flow phenomena, including energy conservation, estimation of head loss in pipes and viscous drag
- aerodynamics
- explore dynamic fluid parameters of real fluid flow
- examine the operational characteristics of hydraulic machines, in particular the operating principles of various water turbines and pumps
- analyse fluid systems and hydraulic machines

Static fluid systems

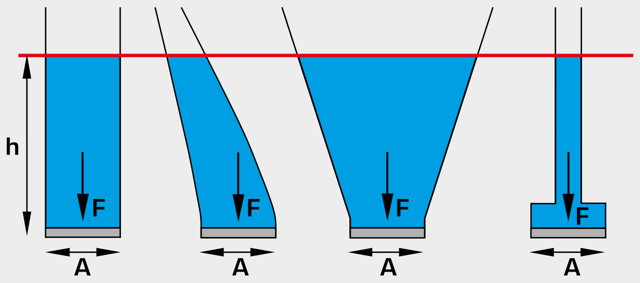
HM 115
Hydrostatics trainer

Learning objectives / experiments

- study of buoyancy on a variety of bodies
- study of the density of liquids
- hydrostatic pressure, Pascal's law
- communicating vessels
- determination of the centre of pressure
- study of surface tensions
- demonstration of capillarity
- Boyle's law
- study of static and dynamic pressure component in flowing fluid
- familiarisation with various methods of pressure measurement

Hydrostatic paradox

The hydrostatic pressure generates a force **F** on the area **A**. If these areas are equal, this force only depends on the level **h**; the shape of the vessel is irrelevant.

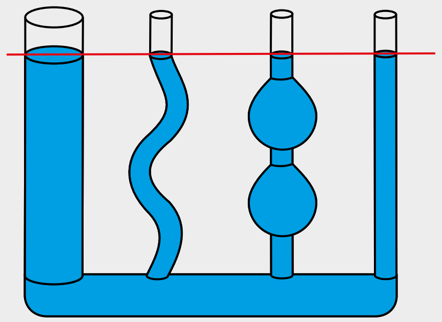


h level, **F** force, **A** area, **red line** level

Communicating vessels

Communicating vessels are tubes that are open at the top and interconnected at the bottom. Regardless of the shape and size of the tubes, the level of the fluid in them is the same.

Applications include water levels, locks and drain traps in sewers.



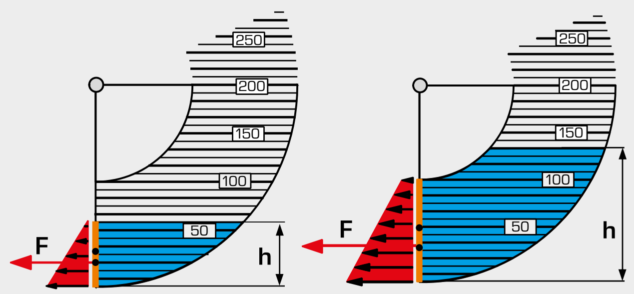
HM 150.05
Hydrostatic pressure in liquids

Learning objectives / experiments

- pressure distribution along an effective area in a liquid at rest
- lateral force of the hydrostatic pressure
- determination of the centre of pressure and centre of area
- determination of the resulting compressive force

Hydrostatic pressure on walls

In addition to the ground pressure of a fluid, it is often important to also know the hydrostatic pressure on boundary surfaces, for example in order to calculate the forces acting on the side walls (channel, aquarium etc.) or on weirs.



h level, **F** resultant force, **A** effective area, pressure profile, water level

Viscosity

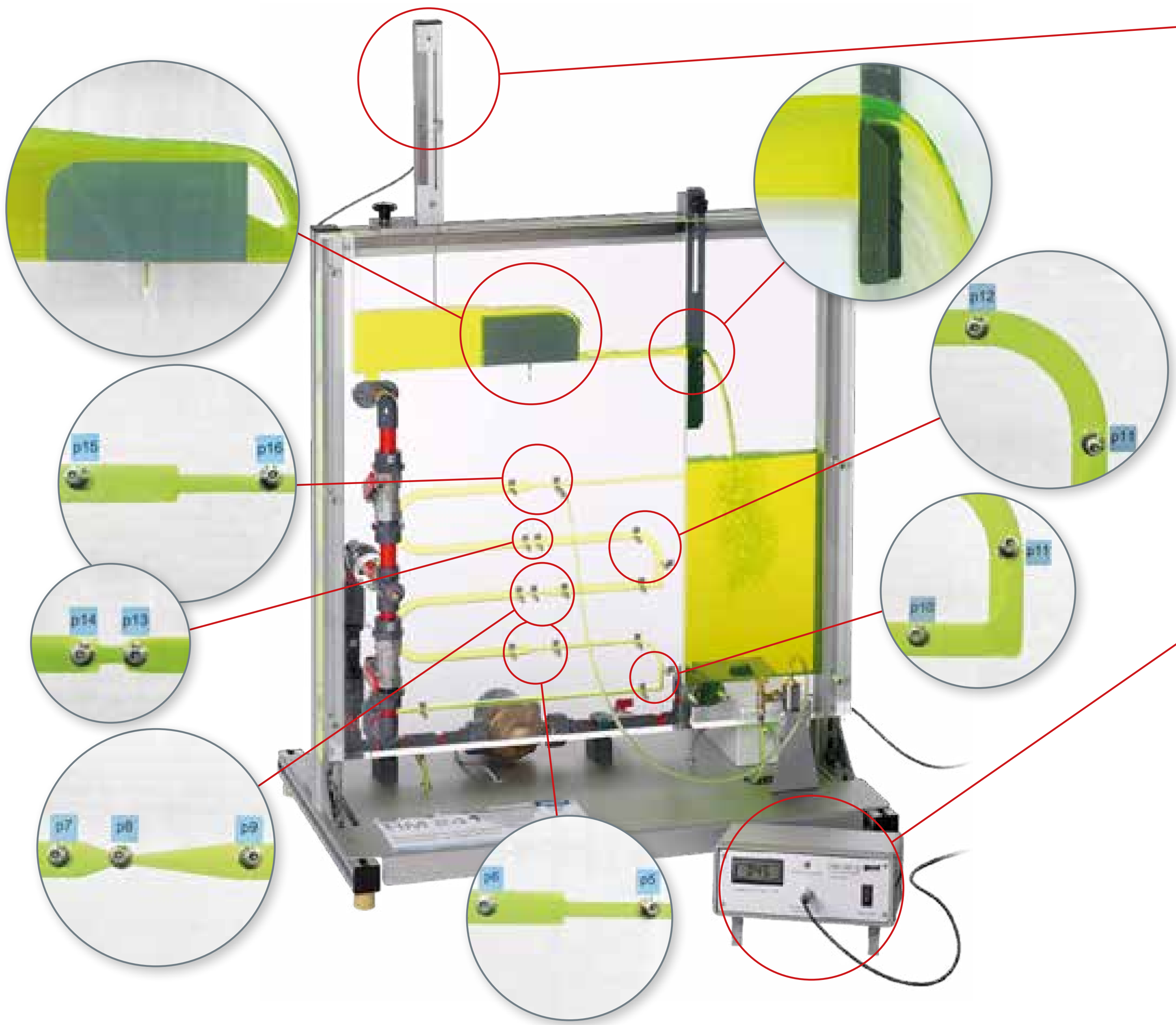
HM 135
Determination of the settling velocity

Influence of the following parameters on the settling velocity of spheres:

- diameter of the sphere
- density of the sphere
- density of the fluid
- viscosity of the fluid

HM 241 Fundamentals of water flow

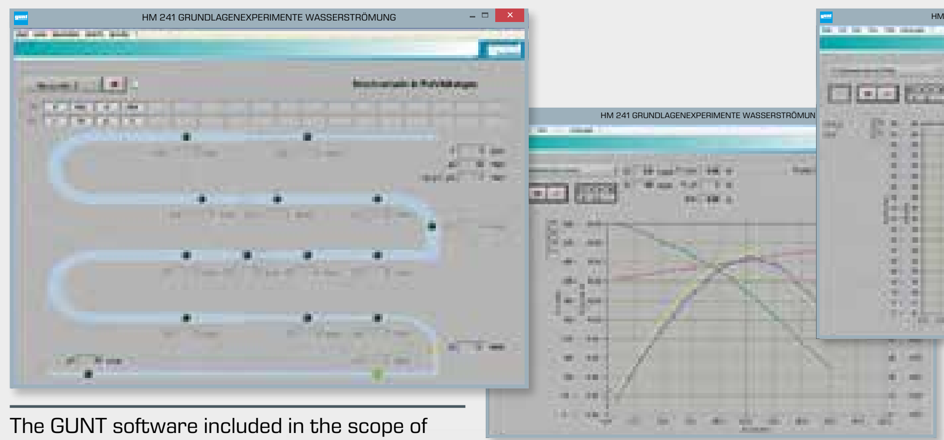
HM 241 is suitable for conducting basic experiments in the field of incompressible flow. This tabletop demonstrator only requires a small amount of space, is simple to use and offers particularly illustrative experiments thanks to the transparent design. The measured values are displayed on a PC. The experimental unit does not require a water connection.



The water level in the open channel is measured with the electronic level gauge. The level gauge can be attached at any point on the side wall of the duct. The water level is determined by means of a sliding probe. The position of the probe can either be read directly from the scale on the level gauge or displayed digitally on the main unit.

The power meter HM 240.02 measures the power consumption of the pump and allows the calculation of the pump characteristic. The power is determined by real-time-multiplication of current and voltage. The power determination does not depend on the waveform of the plot.

Software for data acquisition



The GUNT software included in the scope of delivery displays the measurement results and assists in the evaluation of the experiments.

The instructional material includes a detailed introduction to the fundamental principles of fluid mechanics.

The series includes extensive experiments on the subject of pipe flow and open-channel flow.

All major pipe elements such as:

- straight pipe sections, pipes with different cross-sections
- pipe bends, pipe angles
- enlargements, contractions
- nozzles, orifices

are clearly displayed in a compact space.

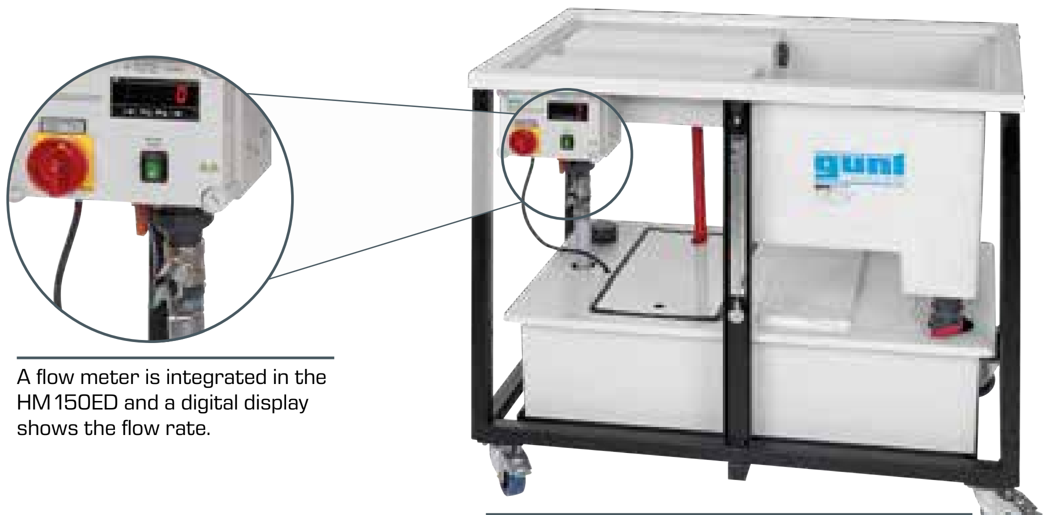
Open-channel flow and its main effects such as:

- overfall over the weir
- supercritical flow

can be seen especially well in the transparent open channel.

HM 150-Series
Introduction into the fundamentals of fluid mechanics

The HM 150 base module provides a closed water circuit to supply the separate experimental units. The experimental unit is connected to the base module for the water supply via a hose. With HM 150 the flow rate is measured volumetrically.

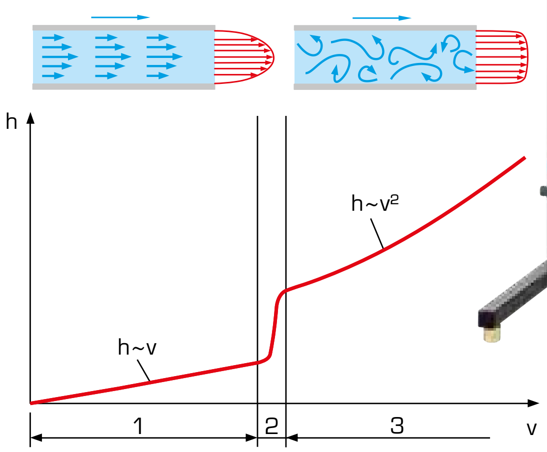


A flow meter is integrated in the HM 150ED and a digital display shows the flow rate.

Base module for experiments in fluid mechanics HM 150ED, with integrated flow meter

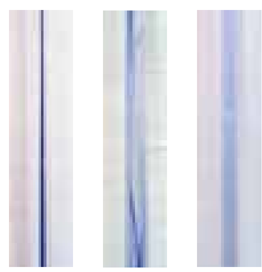
Laminar and turbulent flow

HM 150.01
Pipe friction for laminar/turbulent flow



Pressure losses as a function of velocity in pipe flow
1 laminar flow, **2** transition from laminar to turbulent, **3** turbulent flow; **h** pressure loss, **v** velocity

HM 150.18
Osborne Reynolds experiment

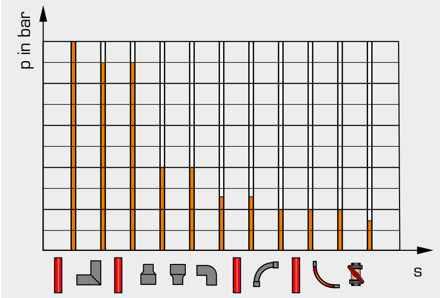


Re Reynolds number

Energy losses in piping systems

HM 150.11
Losses in a pipe system

HM 150.29
Energy losses in piping elements

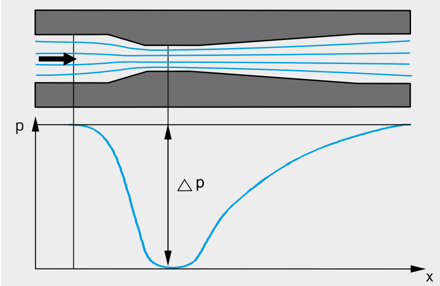


Sample measurement of the pressures between the various pipe elements

Flow measurement

HM 150.07
Bernoulli's principle

HM 150.13
Methods of flow measurement



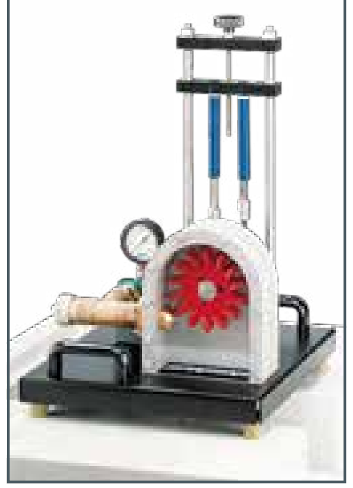
Pressure curve in a Venturi nozzle
p pressure, **x** section

Turbomachines

HM 150.04
Centrifugal pump

HM 150.16
Series and parallel configuration of pumps

HM 150.19
Operating principle of a Pelton turbine



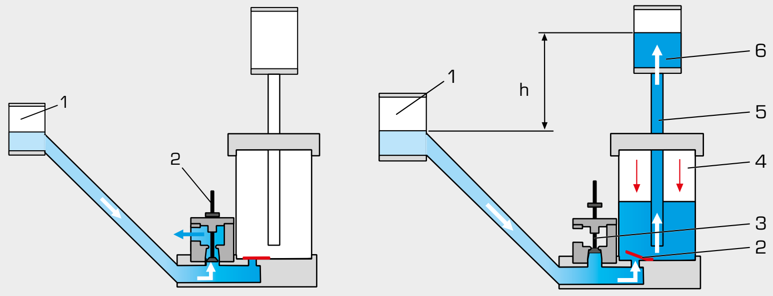
HM 150.20
Operating principle of a Francis turbine

HM 150-Series
Introduction into the fundamentals of fluid mechanics

Transient flow

HM 150.15
Hydraulic ram – pumping using water hammer

Principle of operation of a hydraulic ram

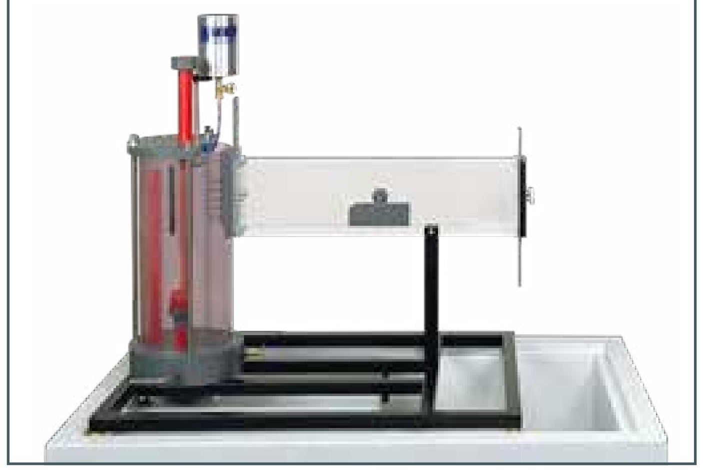


Waste valve open, check valve closed, water outlet through waste valve; **1** inlet tank, **2** waste valve

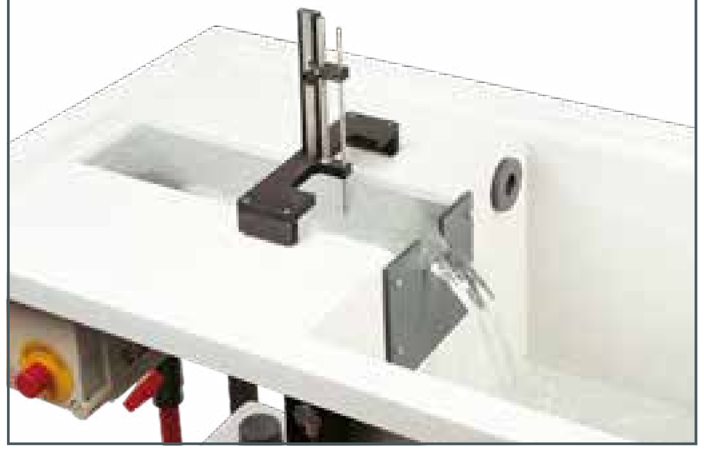
Waste valve closed, check valve open, water inlet to air vessel and elevated tank; **1** inlet tank, **2** check valve, **3** waste valve, **4** air vessel with air volume, **5** riser, **6** elevated tank; **h** head

Steady open-channel flow

HM 150.21
Visualisation of streamlines in an open channel



HM 150.03
Plate weirs for HM 150



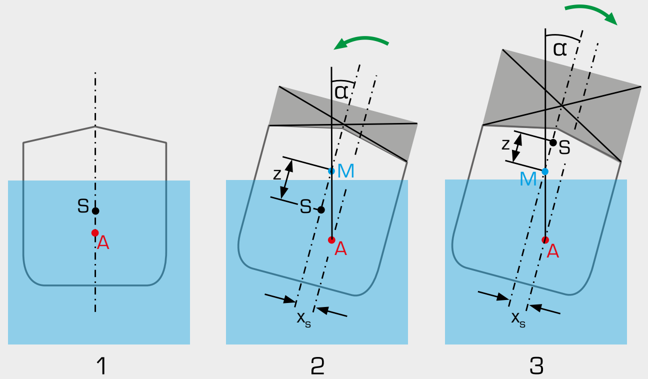
Flow around bodies

HM 150.10
Visualisation of streamlines

Various models included:

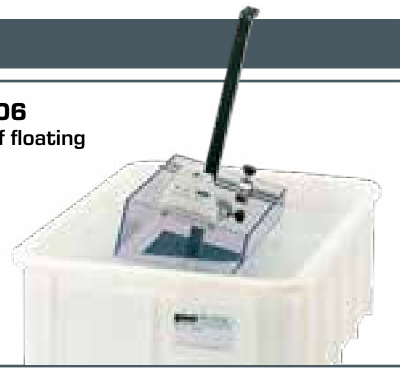
- drag bodies and changes in cross-section
- sources and sinks, individually or in combination

Determining the metacentre



1 stable position, **2** stable position despite load, metacentre above the centre of gravity, **3** unstable position due to load, metacentre under the centre of gravity; green arrow: restoring moment, **M** metacentre, **S** centre of gravity, **A** centre of buoyancy, **z** metacentric height, **α** angle of heel

HM 150.06
Stability of floating bodies

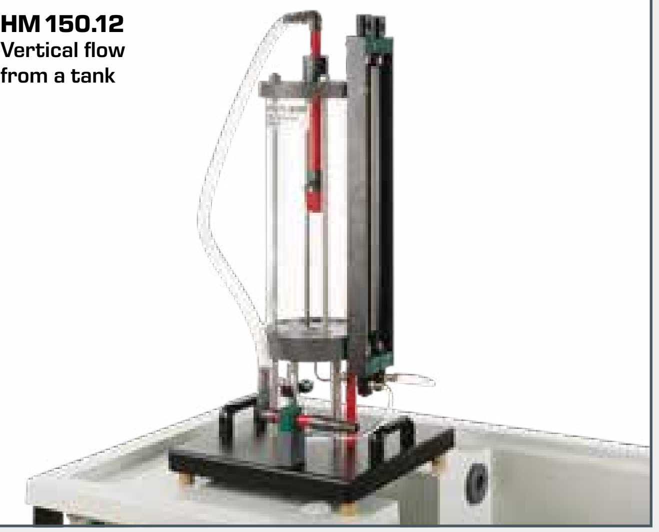


HM 150.39
Floating bodies for HM 150.06

Flow from tanks

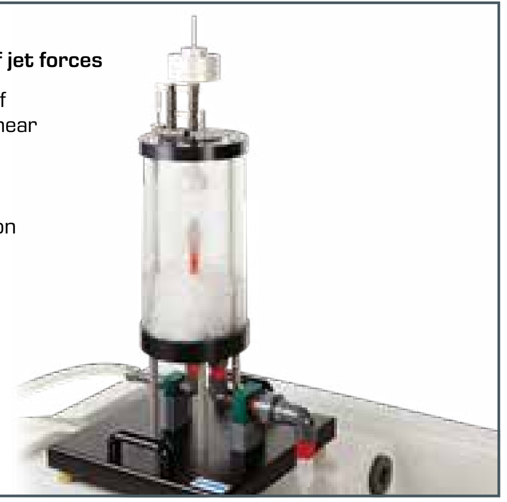
HM 150.09
Horizontal flow from a tank

HM 150.12
Vertical flow from a tank



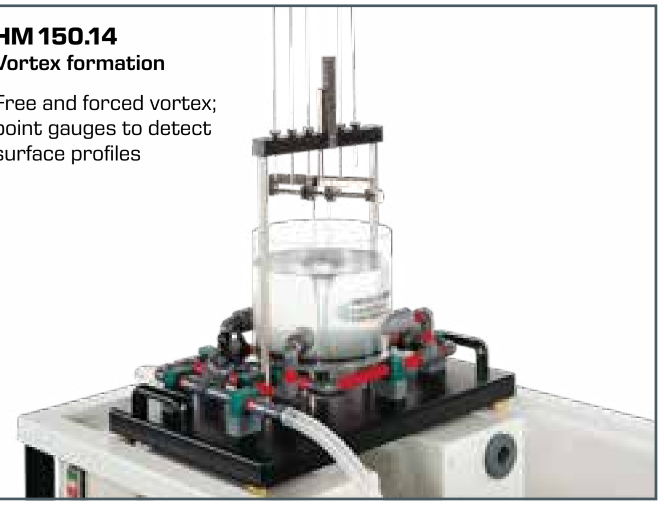
HM 150.08
Measurement of jet forces

Demonstration of the principle of linear momentum; interchangeable deflectors with different deflection angles



HM 150.14
Vortex formation

Free and forced vortex; point gauges to detect surface profiles

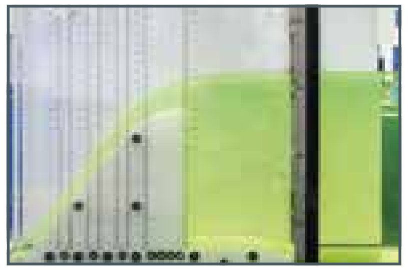


HM 160 Experimental flume 86 x 300 mm

HM 160 is the smallest experimental flume in the GUNT range that can be used to give excellent demonstrations of all open-channel flow phenomena. Thanks to its small size and the closed water circuit, HM 160 can easily be set up and used in classrooms.

Used together with the comprehensive selection of additional accessories a wide range of topics within the field of open-channel flow can be demonstrated and investigated. These accessories include control structures, discharge measurement, losses due to changes in cross-section, waves and sediment transport. Additional accessories allow measuring the discharge depth and flow velocity.

The experimental flume HM 160 is available with two experimental sections of different lengths: 2,5 m or 5 m with an additional extension element HM 160.10 – see diagram.

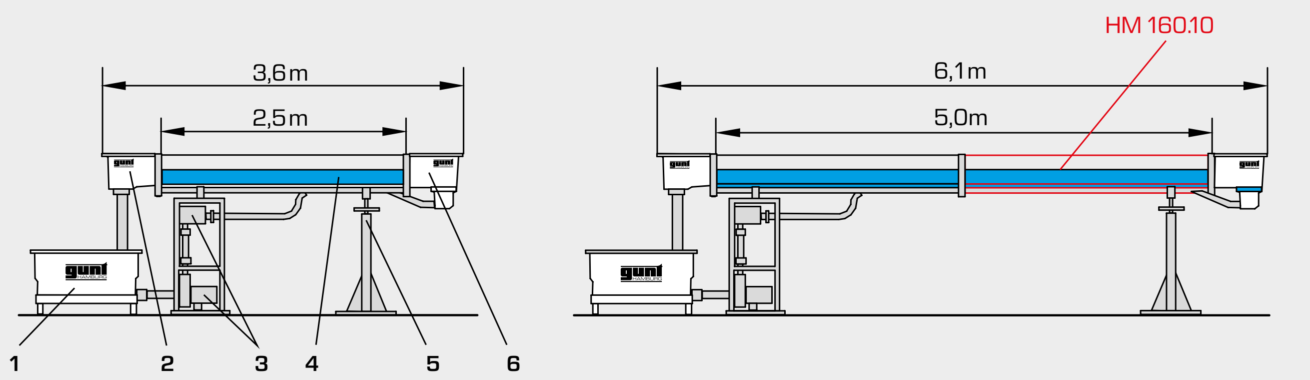


Ogee-crested weir with pressure measurement HM 160.34

Ogee-crested weir HM 160.32 and elements for energy dissipation HM 160.35

Siphon weir HM 160.36

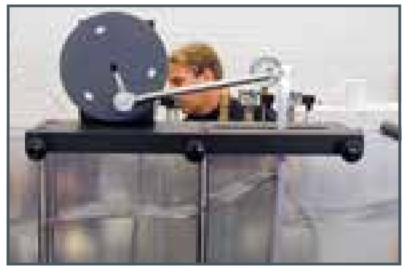
Venturi flume HM 160.51



1 water tank, **2** outlet element, **3** pump with switch box, **4** experimental section,
5 height-adjustable support incl. flume inclination adjustment, **6** inlet element

Waves in the experimental flume

Sediment feeder HM 160.73



Wave generator HM 160.41

Plain beach HM 160.42

Models available as accessories

Control structures	**HM 160.29** Sluice gate
	HM 160.40 Radial gate
	HM 160.30 Set of plate weirs, four types
	HM 160.31 Broad-crested weir
	HM 160.33 Crump weir
	HM 160.34 Ogee-crested weir with pressure measurement
	HM 160.36 Siphon weir
	HM 160.32 Ogee-crested weir with two weir outlets (expandable with **HM 160.35** Elements for energy dissipation)
Discharge measurement	**HM 160.51** Venturi flume
Change in cross-section	**HM 160.77** Flume bottom with pebble stones
	HM 160.44 Sill
	HM 160.45 Culvert
	HM 160.46 Set of piers, seven profiles
Other	**HM 160.41** Wave generator
	HM 160.42 Plain beach
	HM 160.72 Sediment trap
	HM 160.73 Sediment feeder
	HM 160.61 Vibrating piles

Measuring instruments available as accessories

- **HM 160.52** Level gauge / **HM 160.91** Digital level gauge
- **HM 160.53** Ten tube manometers
- **HM 160.50** Pitotstatic tube
- **HM 160.64** Velocity meter

Training in Algeria

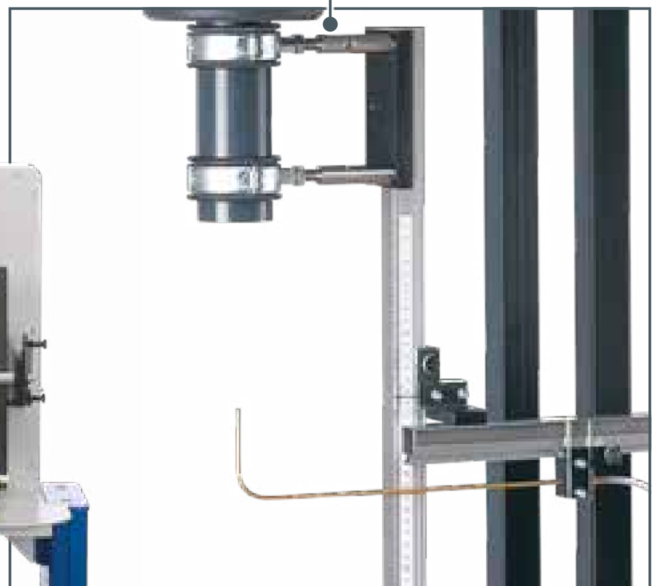
Training in Malaysia

HM 225
Aerodynamics trainer

Experiments from the field: steady flow

HM 225.03
Bernoulli's principle

HM 225.05
Flow in a pipe elbow



HM 225.07
Free jet

Experiments from the field: flow around bodies

HM 225.02
Boundary layers

HM 225.04
Drag forces

HM 225.06
Coanda effect

HM 225.08
Visualisation of streamlines

HM 170 Open wind tunnel

GUNT offers an “Eiffel” type open wind tunnel as a classic experimental plant in the field of flow around bodies.

The flow medium of air is brought up to the desired velocity by a fan and flows around the model being studied in a measuring section. Additional experiments, such as investigation of the boundary layer or pressure distribution of drag bodies immersed in a flow are available as options.

The new design of the open wind tunnel HM 170

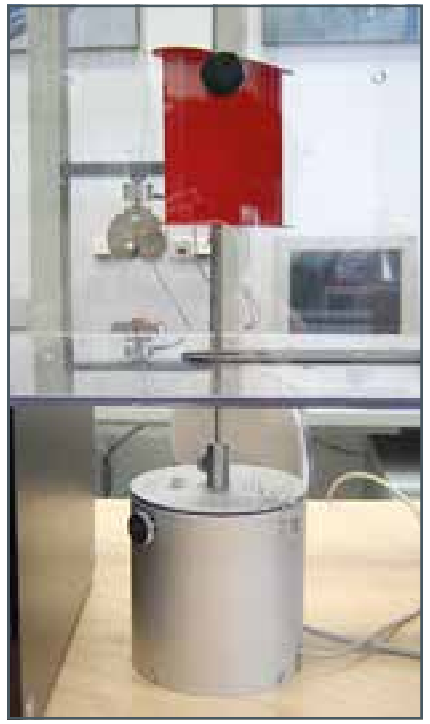
HM 170 with optional accessories: different drag bodies and HM 170.50 16 tube manometers

Training at the HM 170 Open wind tunnel at the Technical College for Aeronautical Engineering in Hamburg (Germany)

Measuring lift and drag forces as a function of the angle of attack of an aerofoil with flap and slot

Measuring lift and drag forces on the streamlined body with the two-component force sensor

Pressure distribution on an aerofoil immersed in a flow

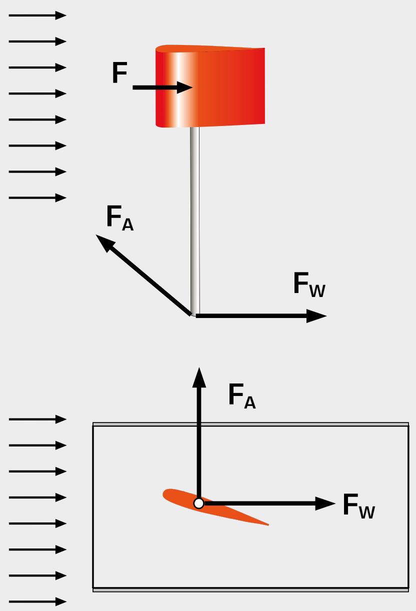


Measuring lift and drag forces and moment on the aerofoil drag body with the three-component force sensor HM 170.40

HM 170
Selected experiments

Flow around various drag and lift bodies HM 170.01 – HM 170.14

- determining drag and lift coefficients
- two-component force sensor for measuring drag and lift forces included in HM 170
- visualisation of streamlines by using fog



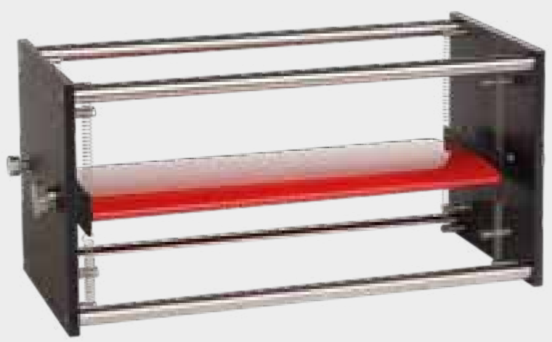
Force measurement on the drag body

F_A lift force, F_W drag

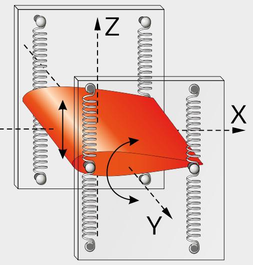
Demonstration of flutter

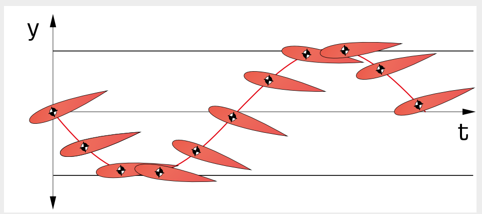
HM 170.20 Airfoil, spring-mounted

- demonstrate flutter (self-excited vibrations)
- natural oscillation behaviour can be influenced by different spring settings



Air flows along an elastic system. Motion-controlled flow forces can cause vibrations with significant amplitudes in the elastic system. This instability phenomenon is called flutter. Flutter is crucial in the design of aircraft, bridges, chimneys and high-voltage power lines. This model is used to demonstrate the aerodynamic excitation of vibrations and instability. By using a stroboscope it is possible to observe the natural oscillation of the wing.



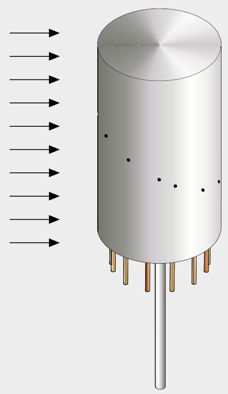


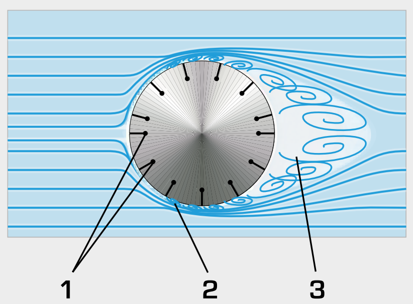
Flutter shown over time

Pressure distribution at the perimeter of a cylinder immersed in a flow

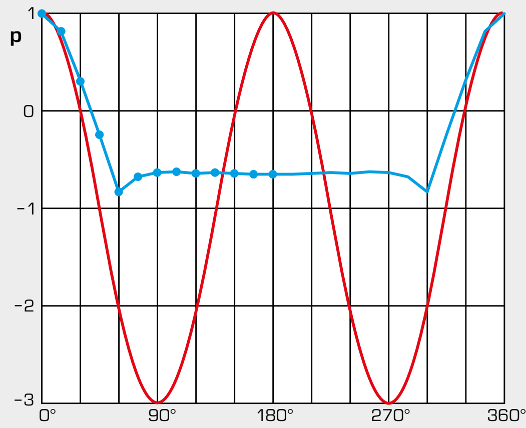
HM 170.23 Pressure distribution on a cylinder

- record pressure distribution on the perimeter of the cylinder
- measuring the static pressure
- each pressure measuring point is equipped with a hose connection



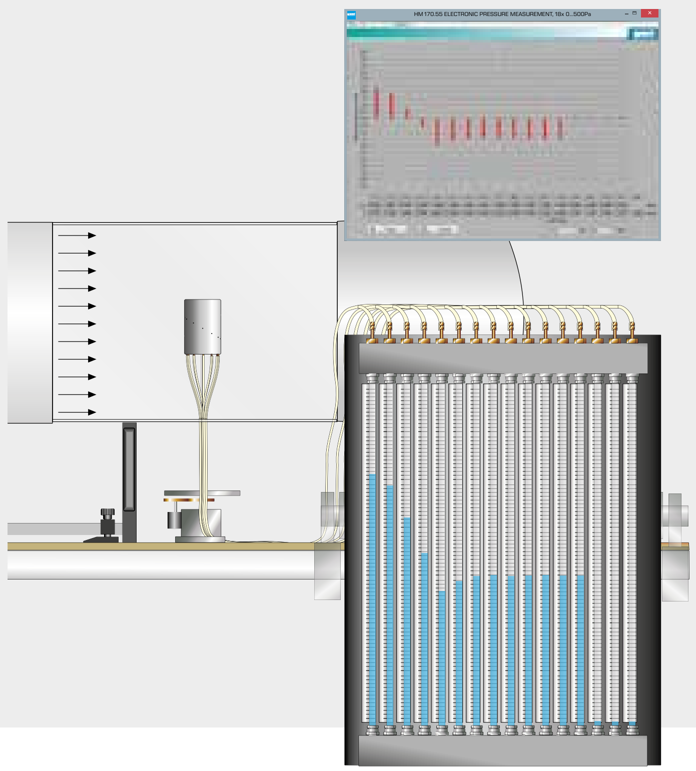


1 measuring point, **2** flow separation, **3** turbulence



Comparison between measured and ideal pressure distribution when flowing around a cylinder

ideal pressure distribution (frictionless),
measured pressure distribution



In conjunction with the electronic pressure measurement HM 170.55:

- recording and display of the pressure distribution on a PC
- saving of measured values

In conjunction with the HM 170.50 16 tube manometers:

- recording the pressure distribution
- particularly clear display of the pressure distribution by the simultaneous measurement of all pressure measuring points with the tube manometers HM 170.50

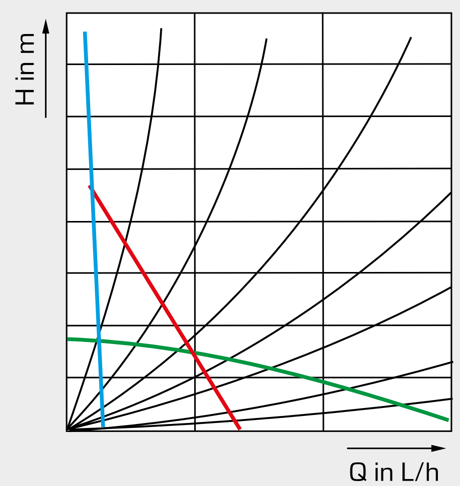
HM 362 Comparison of pumps

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.

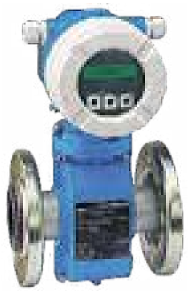


Compare operating behaviour of different types of pumps

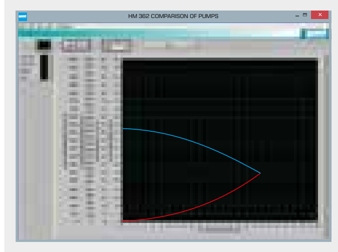
centrifugal pump (green), side channel pump (red),
piston pump (blue), system characteristics (black);
Q flow, **H** head

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

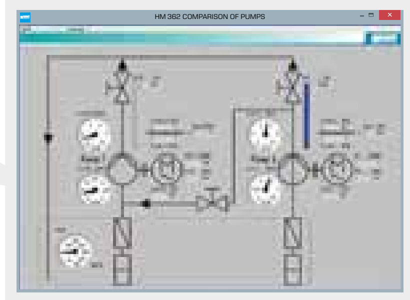
Each pump has an inlet and outlet above pressure sensors



Sensors for flow measurement

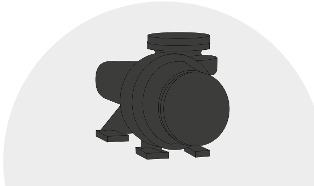


Record characteristic curves

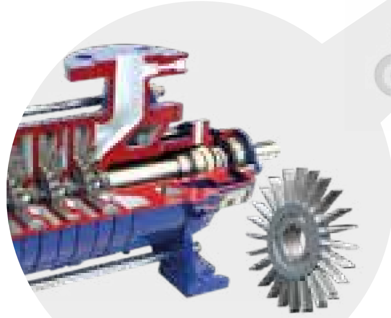


Display of measured data on displays on the trainer and in the GUNT software on a PC

Piston pump

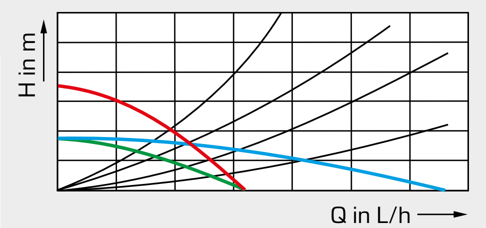


Free space for investigation of additional pumps



Side channel pump

Two centrifugal pumps



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

GUNT-Labline
Complete course on fluid machinery

The GUNT-Labline “Fluid Energy Machines” allows an easy introduction to a complex subject. The experimental units offer basic experiments to familiarise students with the function, the operating behaviour and the most important characteristics of positive displacement and turbomachines. Transparent housings allow observation during operation. The GUNT-Labline comes with microprocessor-based metrology and a device-specific GUNT software for control and data acquisition via USB.

Advantages of the device conception:

- the compact design enables mobile use of the experimental units
- easy transport thanks to handles on the tabletop devices and rollers on the frame
- the same device can be used for demonstration purposes in the lecture hall or the classroom or to conduct experiments in the laboratory
- only a power connection is required for operation of the equipment
- no external water supply required thanks to closed water circuits
- despite complex metrology and software analysis, the devices do not require any complicated wiring: a USB connection to the computer is sufficient
- transparent housing and clear arrangement provide an excellent insight on the functions of the components and on the procedures for operation of the equipment
- damage caused by incorrect operation is very rare thanks to the way in which the devices are designed
- the compact size of the experimental units and the low price make it easy to fit out a classroom or laboratory with a larger number of experiment workstations

Ideas in the didactic concept:

- a self-contained course on the topic of fluid energy machines
- the experimental units of one sub-field complement each other in terms of learning objectives
- each experimental unit forms a self-contained learning unit
- effective learning in small groups (2-3 people)
- the direct proximity to the experimental unit encourages inquisitive exploration of the technology
- development of characteristic properties of various types of machines
- comparison and evaluation of different types of machines

In addition, the common fundamentals of the experimental techniques can be practised, for example:

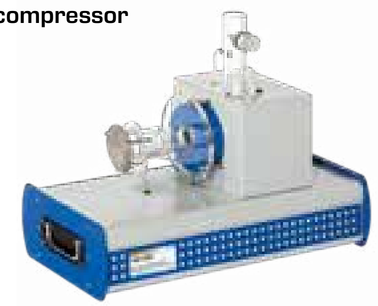
- selecting the chart axes
- selecting the increment when varying parameters
- waiting for the steady state
- averaging over time with fluctuating readings, etc.

Experiments for different fans and a radial compressor

HM 280
Experiments with a radial fan

HM 282
Experiments with an axial fan

HM 292
Experiments with a radial compressor



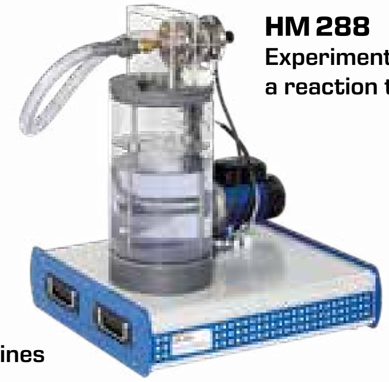
Experiments for different water turbines

HM 289
Experiments with a Pelton turbine

HM 291
Experiments with an action turbine

HM 287
Experiments with an axial turbine

HM 288
Experiments with a reaction turbine



HM 290
Base unit for turbines

Experiments for centrifugal and positive displacement pumps

HM 283
Experiments with a centrifugal pump

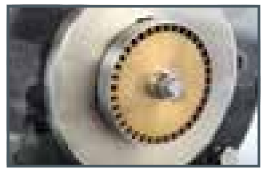
HM 285
Experiments with a piston pump

HM 284
Series and parallel connected pumps

HM 286
Experiments with a gear pump

Learning concept of the GUNT-Labline range









Advantages of the learning concept

In order to enable optimal teaching in the demanding field of fluid energy machines, we have developed a learning concept that perfectly combines the various advantages of mechanical models, device-specific software and the instructional material.

Simple and clear mechanical models of the machines are connected to the PC via USB. Operation, measurement, display and analysis of measurement data are all carried out on the PC. To this end, the electronic data acquisition and control components are fully integrated into the models. The PC is therefore an integral part of the system. We call this the Hardware-Software Integration approach, or HSI for short.

The experimental units represent self-contained learning units, complementing the experimental units from a sub-field in terms of the learning objectives. During the experiments, importance is placed on the development of characteristic properties of the various types of machine. This allows the students to perform an evaluative comparison of the machine types and to assimilate criteria for later work in practice. The advantages and disadvantages of different types of machines can be demonstrated and discussed.

Mechanical model

Housing, pipes and tanks are transparent and provide a view of the key components and flow processes during operation (vortex, air bubbles, cavitation). Operating and flow noise and vibrations produce a realistic impression.

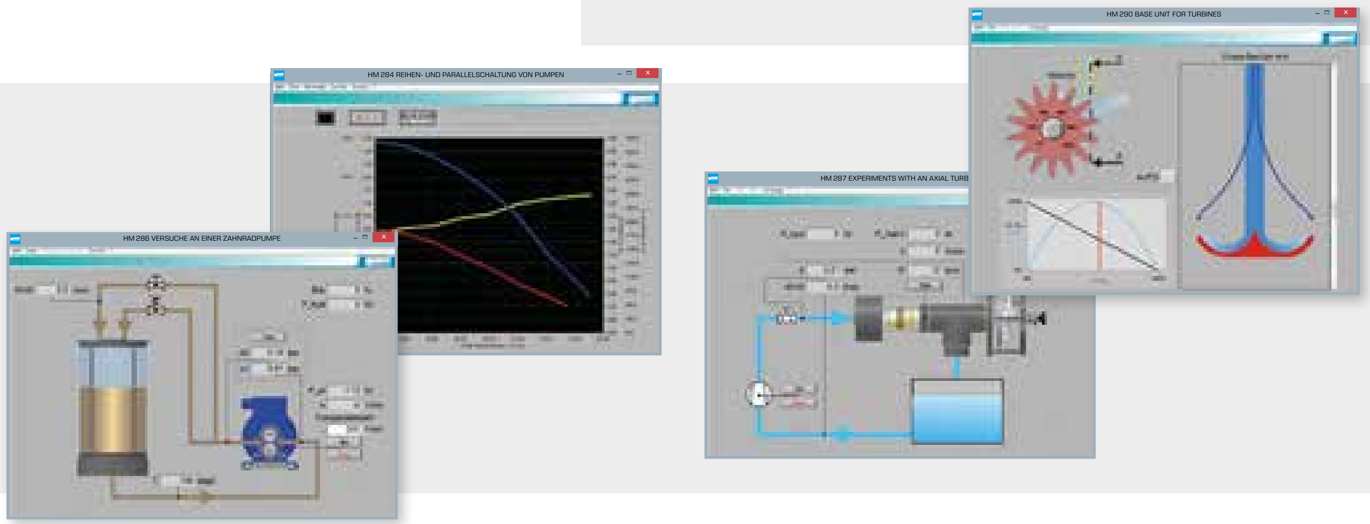
All this makes the function and processes in a machine understandable and guarantees a sustainable learning experience.

Water jet in the reaction turbine HM 288

Instructional material in paper form

A fundamental section with the relevant theory and model-based experiment instructions allow an intensive preparation for the experiment. Sample experiment results allow a qualified assessment of the students' own results.

Our didactic materials offer excellent support when preparing lessons, when conducting the experiments and when reviewing the experiment.



Device-specific GUNT software

The software forms a bridge between the mechanical model and the instructional material in paper form.

The software reflects the behaviour of the machine in specific measurements. The machine's behaviour can be studied and discussed in form of characteristic curves. Through simulation, the software provides the ability to visualise flow processes that cannot be seen and to show them in slow motion.

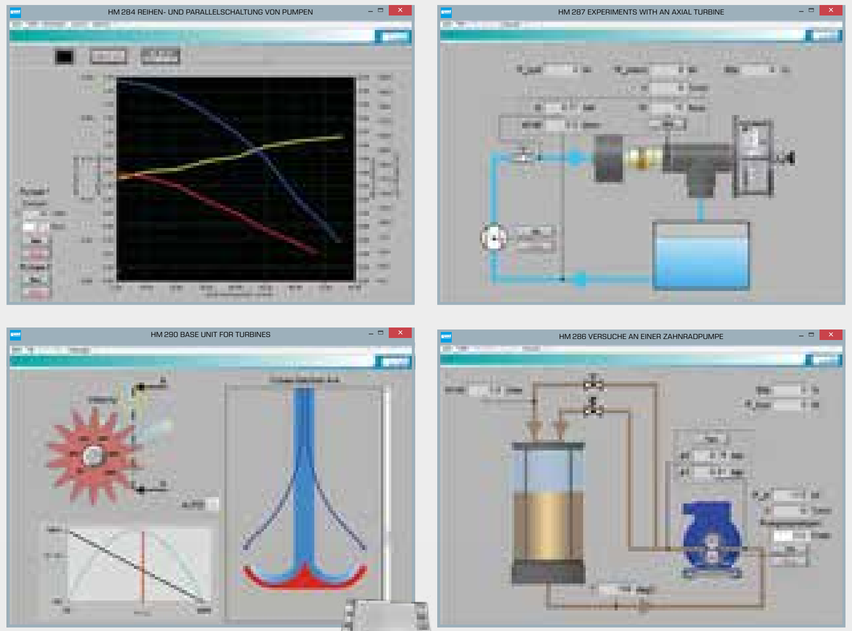
In particular the energy conversion between a mechanical component and a fluid in a fluid energy machine is easily understood.

Learning concept of the GUNT-Labline range

A wide range of experiments with a variety of options

Device-specific GUNT software, together with the microprocessor, provides software-based experiment execution and assessment

- record typical characteristic curves
- measurement of the mechanical, electrical and hydraulic power as well as power consumption
- determine the efficiency
- effect of speed on pressure and flow rate
- advantages and disadvantages of various fluid energy machines
- how the impeller shape affects the characteristic and efficiency
- occurrence of cavitation
- function of an air vessel



Overview of the topics

Fans, compressors

- typical dependence of pressure on speed
- typical dependence of flow rate on speed
- hydraulic power output and efficiency

HM 280
Experiments with a radial fan

- characteristic of a radial fan
- effect of the impeller shape

HM 282
Experiments with an axial fan

- characteristic of an axial fan
- stall

HM 292
Experiments with a radial compressor

- characteristic of a 2-stage radial compressor
- stage pressure ratio
- temperature increase

Pumps

- power and efficiency

HM 283
Experiments with a centrifugal pump

- typical dependence of pressure and flow rate on the speed
- characteristic of a centrifugal pump
- effect of direction of rotation
- cavitation

HM 284
Series and parallel connected pumps

- individual and overall characteristics
- advantages and disadvantages of series and parallel connections
- efficiency considerations and areas of application

HM 285
Experiments with a piston pump

- typical characteristic of a displacement pump
- cyclical pump process over time
- p,V diagram and internal power
- pulsation and air vessel
- mechanical drive power

HM 286
Experiments with a gear pump

- typical dependence of pressure and flow rate on the speed
- pressure limitation
- characteristic of a displacement pump

Turbines

- torque/speed characteristic curve
- hydraulic input power, mechanical output power
- efficiency

HM 287
Experiments with an axial turbine

- power regulation

HM 288
Experiments with a reaction turbine

- partial load behaviour

HM 289
Experiments with a Pelton turbine

- partial load behaviour with needle adjustment compared to a throttle control

HM 291
Experiments with an action turbine

- partial load behaviour with regulation via number of nozzles compared to a throttle control

8 Industrial services and systems

Topics included in this unit

- Industrial training systems
- Industrial components
- Steam power plants
- Heat pumps and refrigeration

Industrial services and systems

Behind the scenes in many modern-day manufacturing facilities there lies a complex system of services that powers production, both day and night. The underlying aim of this unit is to enhance the students' understanding of the electrical supply systems, industrial air compressors, steam services, refrigeration systems and heat pumps that are used in an array of industrial engineering environments. This broad-based methodology reflects the fact that operations engineering encompasses many disciplines and, as such, engineers must be conversant in the wide scope of service provision. The intention is to encourage students to develop a holistic approach to the design, operation, installation and maintenance of both industrial services and operating equipment.

Level 3 | Level 4 | Level 5

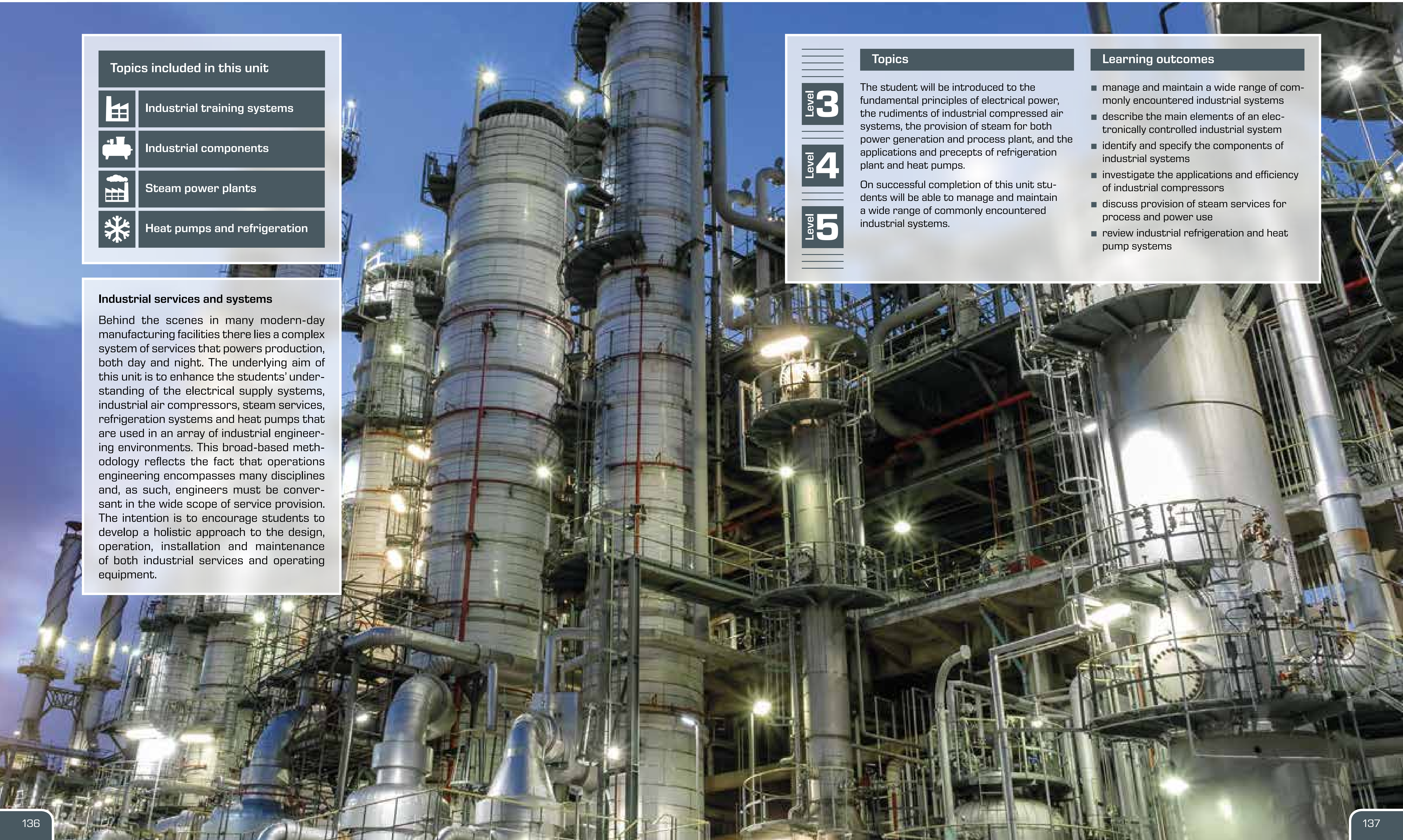
Topics

The student will be introduced to the fundamental principles of electrical power, the rudiments of industrial compressed air systems, the provision of steam for both power generation and process plant, and the applications and precepts of refrigeration plant and heat pumps.

On successful completion of this unit students will be able to manage and maintain a wide range of commonly encountered industrial systems.

Learning outcomes

- manage and maintain a wide range of commonly encountered industrial systems
- describe the main elements of an electronically controlled industrial system
- identify and specify the components of industrial systems
- investigate the applications and efficiency of industrial compressors
- discuss provision of steam services for process and power use
- review industrial refrigeration and heat pump systems

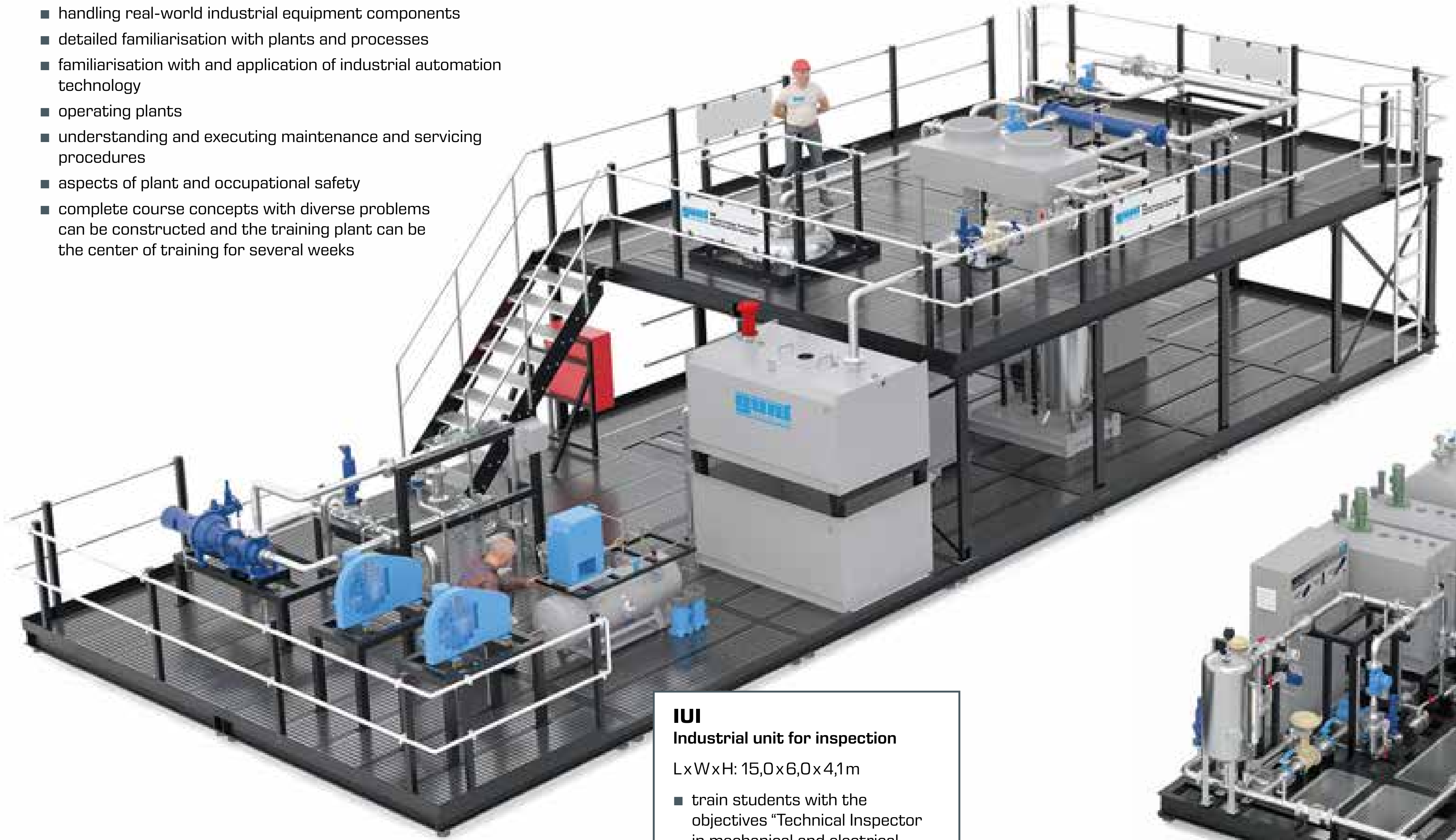


Industrial training systems

GUNT has been known for decades as the leading manufacturer of educational systems, famous in engineering departments of universities and colleges.
An other field of GUNT's activities are Industrial Training Plants to cater for the specific training needs of the industry.

GUNT training systems for industry are absolutely authentic:

- handling real-world industrial equipment components
- detailed familiarisation with plants and processes
- familiarisation with and application of industrial automation technology
- operating plants
- understanding and executing maintenance and servicing procedures
- aspects of plant and occupational safety
- complete course concepts with diverse problems can be constructed and the training plant can be the center of training for several weeks



IUI
Industrial unit for inspection

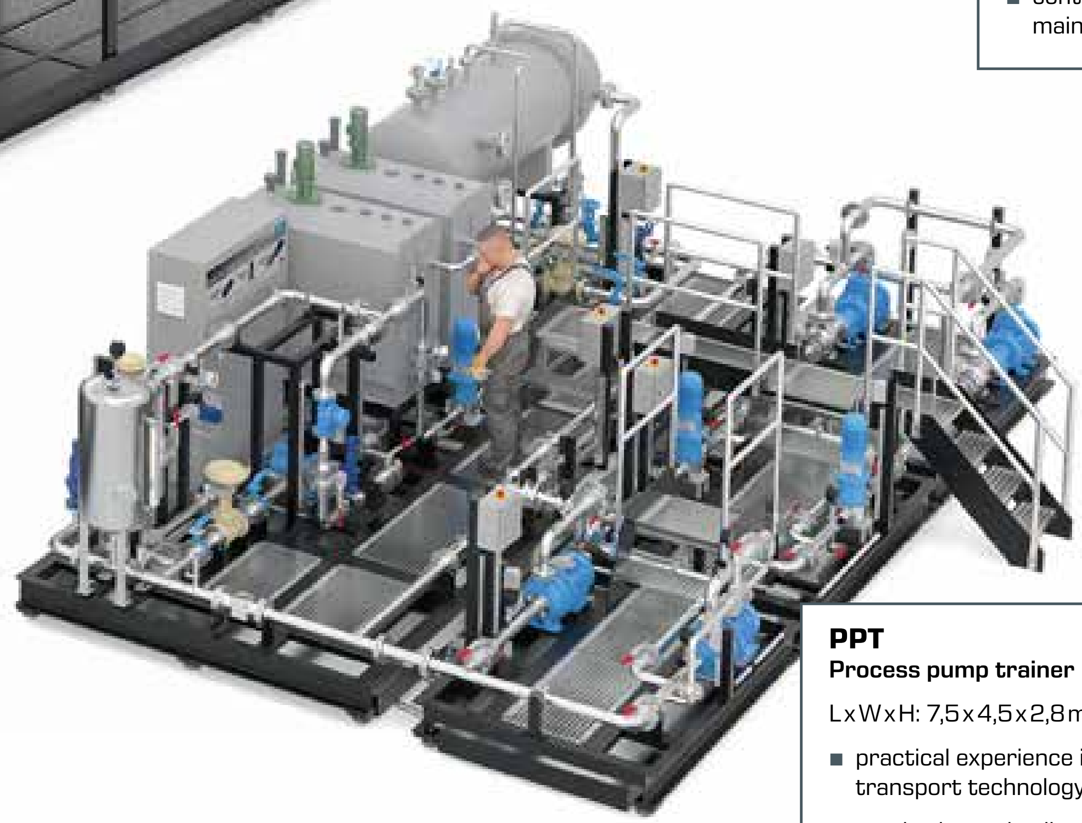
LxWxH: 15,0x6,0x4,1m

- train students with the objectives "Technical Inspector in mechanical and electrical engineering sector"
- quality management and maintenance operations

PST
Phase separation trainer

LxWxH: 5,0x2,5x2,5m

- practical experience in separation technology
- separate synthetic crude oil to fractions: oil, water, gas
- control, operation and maintenance methods



PPT
Process pump trainer

LxWxH: 7,5x4,5x2,8m

- practical experience in fluid transport technology
- synthetic crude oil as medium. Three different pump sets in comparison. Phase separation.
- control, operation and maintenance methods

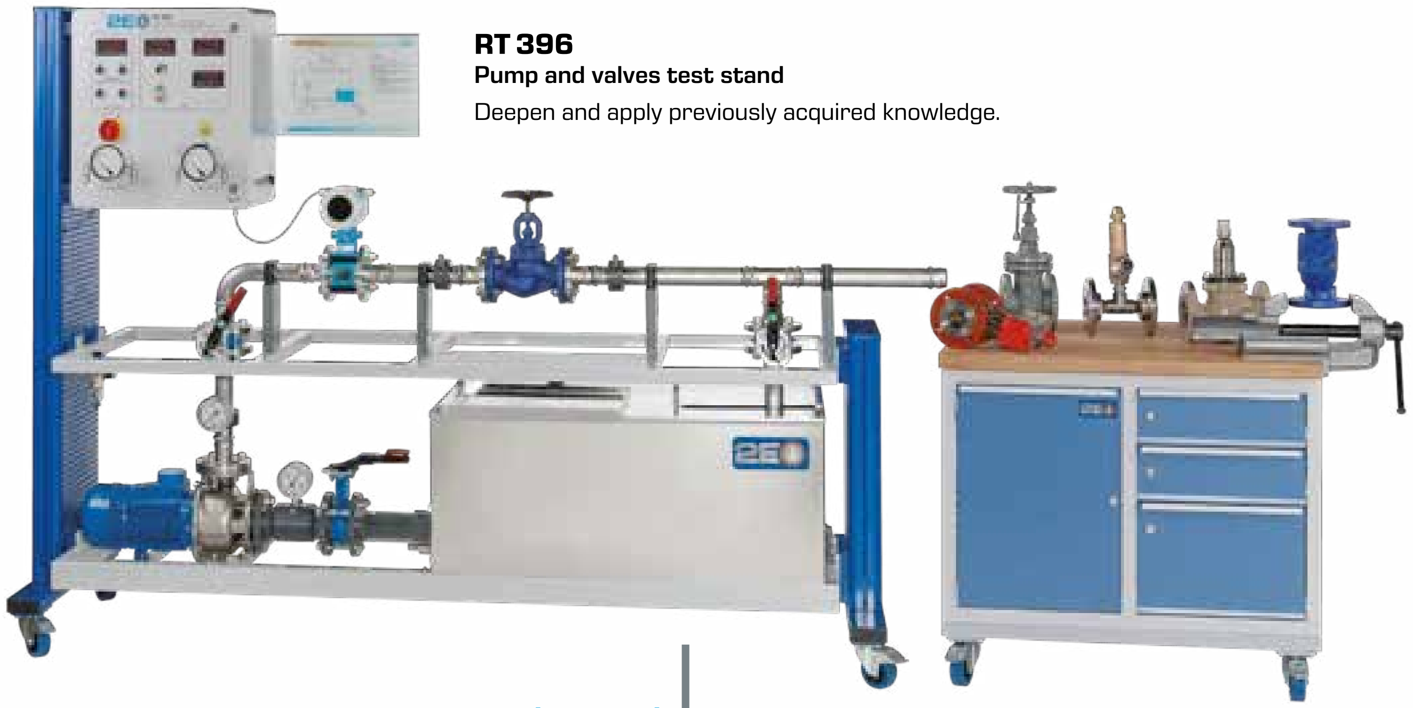
Industrial training systems

Everything from basic to advanced

basic

intermediate

MT 140
Assembly station: piston compressor
Ideal entry-level device for demonstration, installation, maintenance and repair.



RT 396
Pump and valves test stand
Deepen and apply previously acquired knowledge.

advanced

GUNT trainings plants help you to reach excellence in your instructional practice

Areas, where GUNT is active:

- chemical plant operations
- power plant operations
- natural gas plant operations
- oil refinery operations
- wastewater treatment operations
- drilling for oil & gas
- biofuel operations
- wind energy
- electrician training
- hvac training
- plumbing training

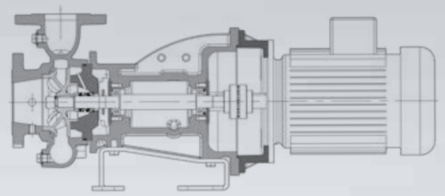
...and many other

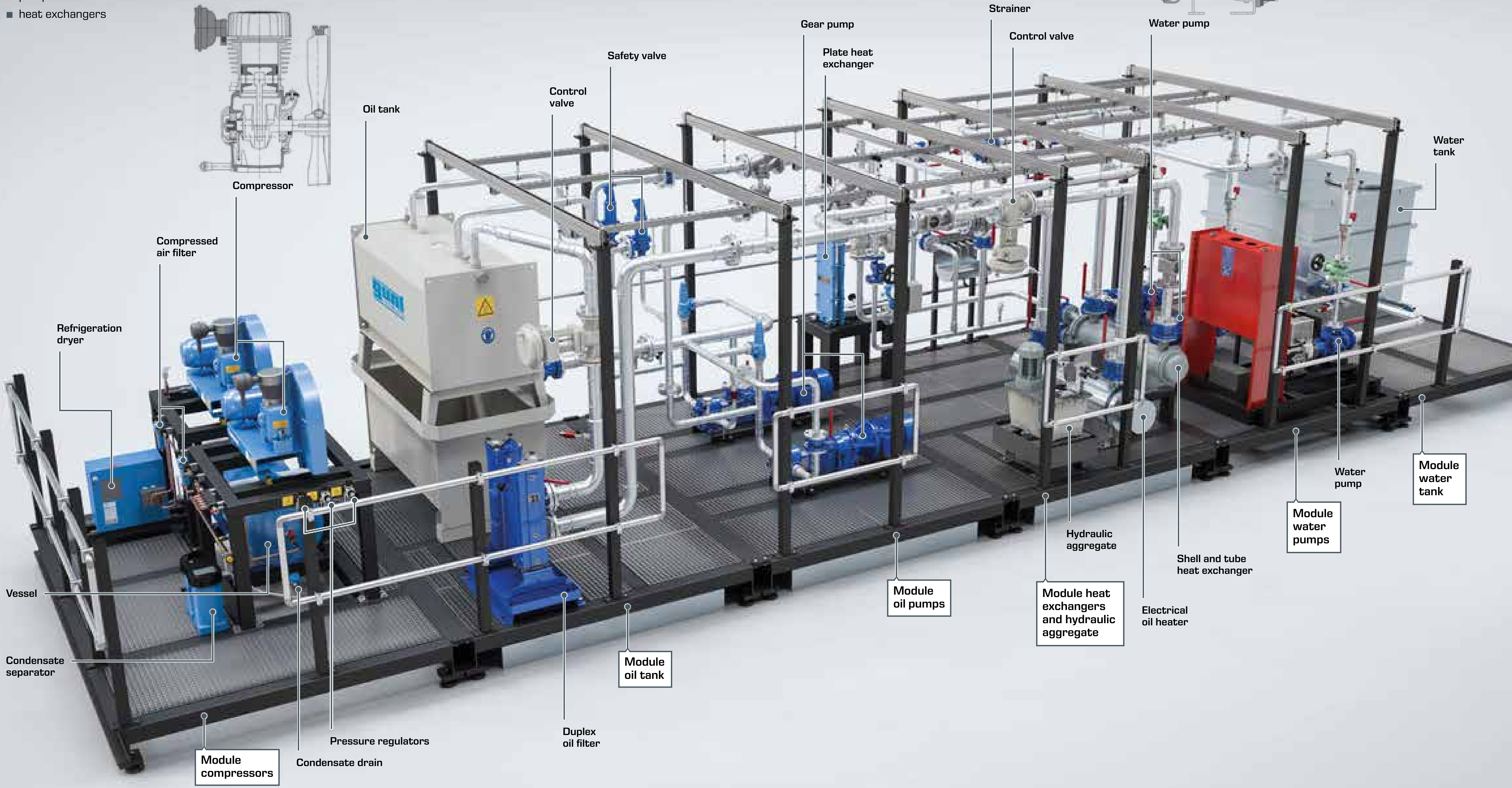
IUI
Industrial unit for inspection
All previously acquired knowledge is implemented in this complex plant.

MMTS – Mechanical Maintenance Training System

Training plant for maintenance and operation with **distributed control system** and with fully functioning real-world components such as:

- compressors
- pumps
- heat exchangers

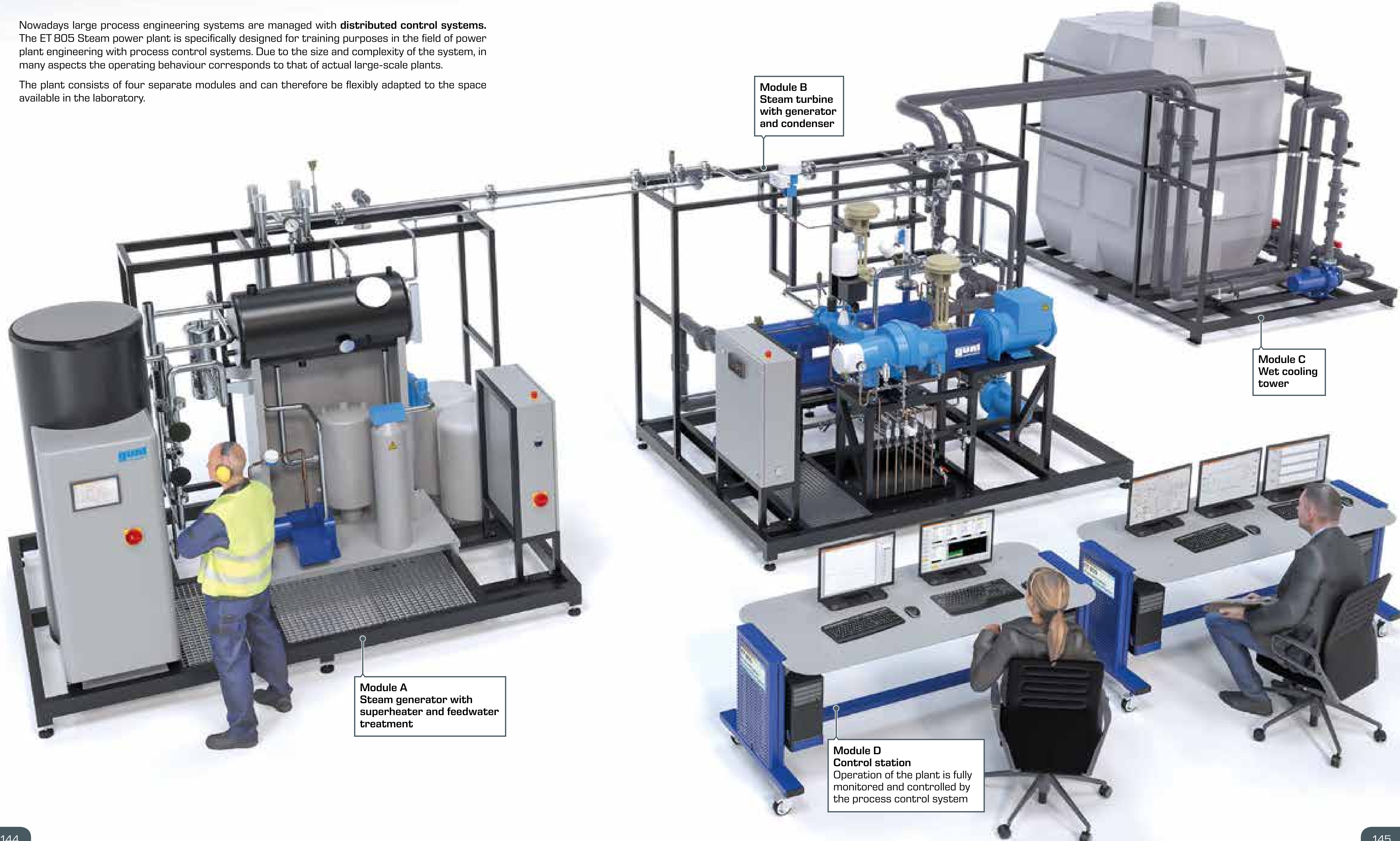




ET 805
Steam power plant 20kW with process control system

Nowadays large process engineering systems are managed with **distributed control systems.** The ET 805 Steam power plant is specifically designed for training purposes in the field of power plant engineering with process control systems. Due to the size and complexity of the system, in many aspects the operating behaviour corresponds to that of actual large-scale plants.

The plant consists of four separate modules and can therefore be flexibly adapted to the space available in the laboratory.



ET 405 Heat pump for cooling and heating operation

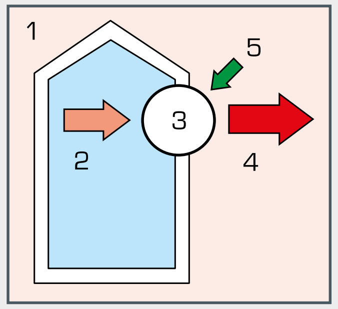
With suitable arrangement of compressor, condenser and evaporator, the same heat pump can be used for heating and for cooling. In the air conditioning of buildings this has the advantage that the rooms are heated in the winter and cooled in the summer. The provision of hot water is also possible. The heat source is always of central importance in heat pump technology. The design of the heat pump is particularly important in order to be able to use the existing heat sources effectively at a low temperature level.

ET 405 enables the investigation of a multitude of component arrangement options. A compressor, a condenser (heat exchanger with fan) and two evaporators with fan (refrigeration stage and freezing stage) are available. A coaxial coil heat exchanger can optionally be operated as an evaporator or a condenser. It connects the heat pump circuit to another circuit filled with a glycol-water mixture.

Level 5+

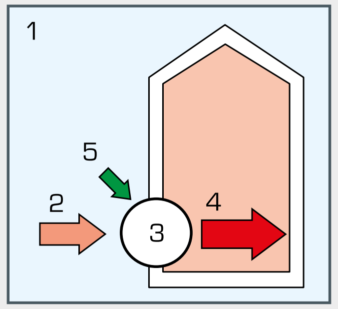
Cooling and heating using the heat pump

Gain: cooling



During cooling the absorbed heat at the heat pump provides the gain. It is absorbed from a room and discharged into the environment. Electrical energy to operate the compressor of the heat pump is required for this purpose.

Gain: heating



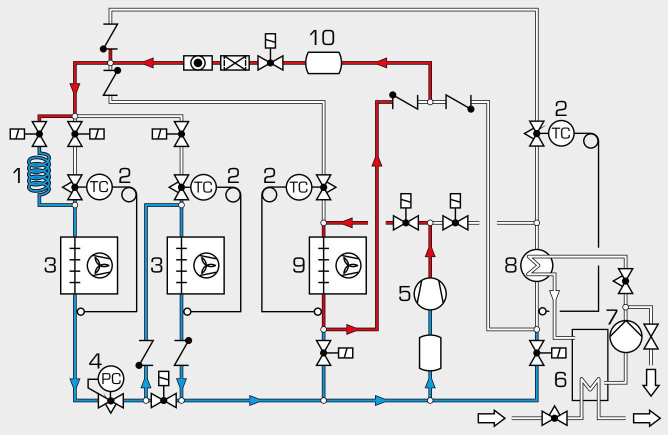
During heating the heat discharged by the heat pump is the gain. The heat pump absorbs heat from the environment and discharges it to the room.

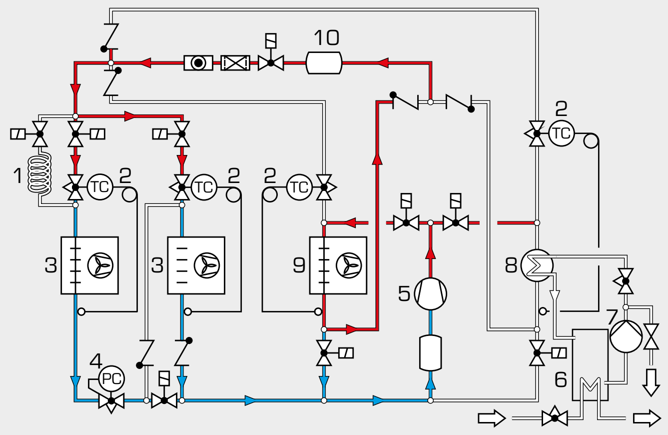
1 environment, **2** absorbed heat, **3** heat pump, **4** discharged heat, **5** electric energy

Different operating modes for typical applications

Two evaporators connected in series or parallel

The two evaporators can optionally be connected parallel or in series. It is also possible to operate only one evaporator. The condenser **9** operates as an air heater. At both evaporators **3** the heat is absorbed from the environment.





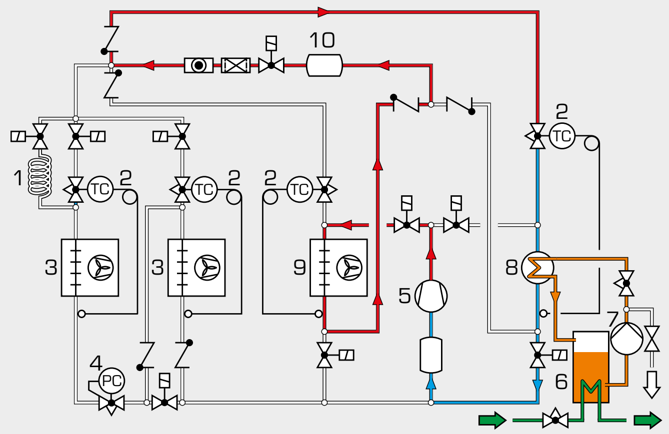
1 capillary tube, **2** expansion valve, **3** evaporator, **4** evaporation pressure controller, **5** compressor, **6** tank for glycol-water mixture, **7** pump, **8** coaxial coil heat exchanger, **9** heat exchanger with fan, **10** receiver

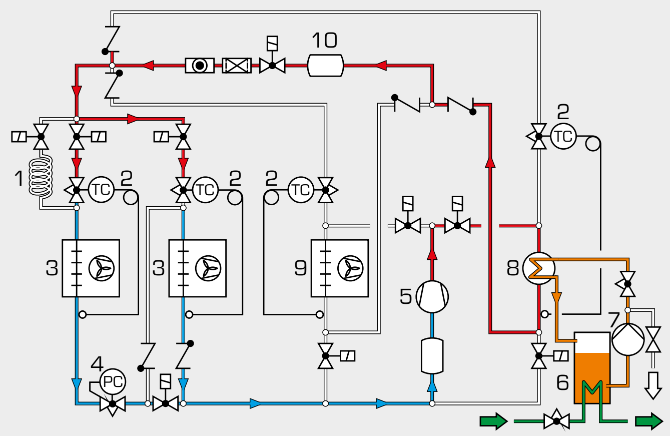
Coaxial coil heat exchanger as evaporator (cooling)

The liquid refrigerant is expanded using a thermostatic expansion valve **2** and evaporated in the coaxial coil heat exchanger **8**. This cools the glycol-water mixture. The condensation of the refrigerant takes place in the air-cooled finned tube heat exchanger **9**. In the tank **6** the glycol-water mixture absorbs heat from the pipe coil through which water flows.

Coaxial coil heat exchanger as condenser (heating)

The refrigerant steam flows through the coaxial coil heat exchanger **8**. Here the refrigerant is condensed and heats the glycol-water mixture. The refrigerant then flows through two evaporators **3** which can optionally be connected in parallel or in series. The glycol-water mixture discharges its heat in the tank **6** to a water-cooled pipe coil.





9 Renewable energy

Renewable energy

With the increasing concerns regarding climate change arising from increasing carbon dioxide levels and other adverse environmental impacts of industrial processes, there are widespread economic, ethical, legislative and social pressures on engineers to develop technologies and processes that have reduced carbon and environmental impact.

Topics included in this unit

- Wind power
- Hydropower
- Solar energy
- Biomass
- Geothermal energy
- Energy storage systems

Level 3 · Level 4 · Level 5

Topics

The aim of this unit is to introduce students to renewable energy resources and technologies, including current storage and generation technologies, and explore their advantages and limitations.

On successful completion of this unit students will be able to determine the optimum combination of renewable energy technologies and evaluate their efficiencies.

Students will also be able to describe how to conduct a cost-benefit analysis to determine the most viable option between renewable and conventional energy sources.

Learning outcomes

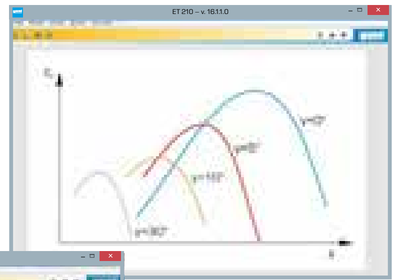
- explore potential renewable energy resources, including current generation technologies
- correct use of photovoltaic solar modules and modern flat collectors
- technological fundamentals of solar cells
- parameters affecting solar thermal heat
- energy conversion in water turbines
- comparing turbine types and characteristics
- how does the real wind supply and electricity demand affect the yield from wind power plants
- chemical-electrical energy conversion
- shallow geothermal energy
- bioethanol, biogas, biodiesel

Wind power

ET 210
Fundamentals of wind power plants

Wind power plant with rotor blade adjustment and yaw angle adjustment

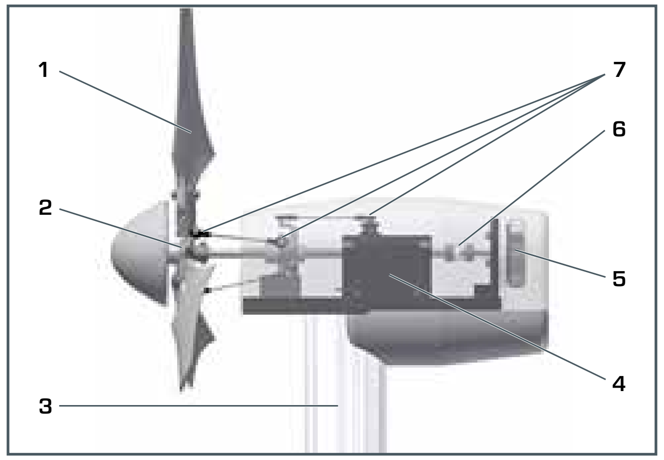
- conversion of kinetic energy into electrical energy
- power adjustment by means of speed adjustment
- power adjustment by means of rotor blade adjustment
- behaviour in the case of oblique flow
- comparison of different rotor blade shapes
- recording of characteristic diagrams
  - determination of the power coefficient as a function of the tip-speed ratio and rotor blade adjustment angle
  - determination of the power coefficient as a function of the tip-speed ratio and yaw angle



Analysis of measurement data with GUNT software: Power coefficient vs. tip speed ratio at different rotor blade pitch angles

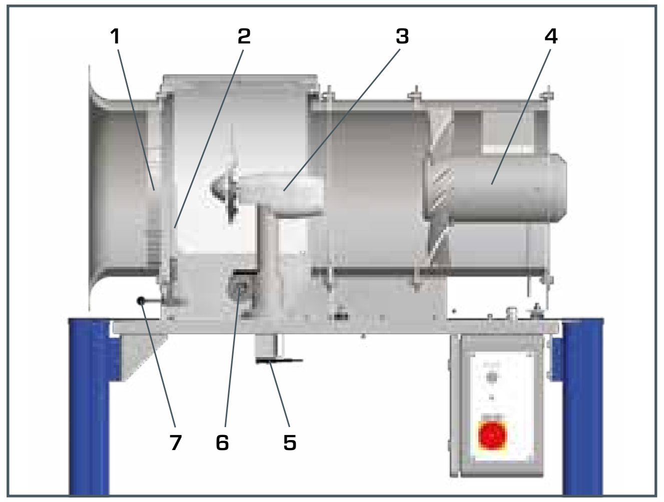
Replaceable rotor blades:
Measurement on different blade profiles (production by means of 3D printing)

GUNT software for device control and measurement data acquisition via PC



Setup of the wind power plant

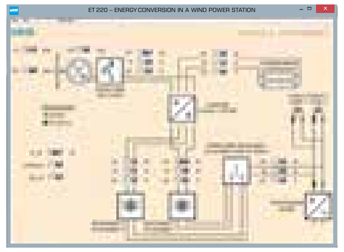
1 rotor blade, **2** hub, **3** tower, **4** servomotor, **5** generator, **6** coupling, **7** rotor blade adjustment



1 flow straightener, **2** wind velocity sensor, **3** wind power plant, **4** fan, **5** yaw angle sensor, **6** handwheel, **7** lever

ET 220
Energy conversion in a wind power plant

- conversion of kinetic wind energy into electrical energy
- function and design of an stand-alone system with a wind power plant
- determining the power coefficient as a function of tip speed ratio
- energy balance in a wind power plant
- determining the efficiency of a wind power plant



ET 220.01
Wind power plant

Connection to ET 220 or ET 200.10; outdoor installation allows practically relevant investigations

- conversion of kinetic wind energy into electrical energy
- design and function of a wind power plant in stand-alone operation
- energy balance of a wind power plant under real wind conditions

Hydropower

HM 450C
Characteristic variables of hydraulic turbomachines

The trainer HM 450C is able to operate pump and turbine at the same time. Relevant measured values are recorded contemporaneously at both turbomachines. Thus the trainer can be used as a **pumped storage plant**.


Needle nozzle and impeller of the Pelton turbine


Adjusting knob for the needle nozzle

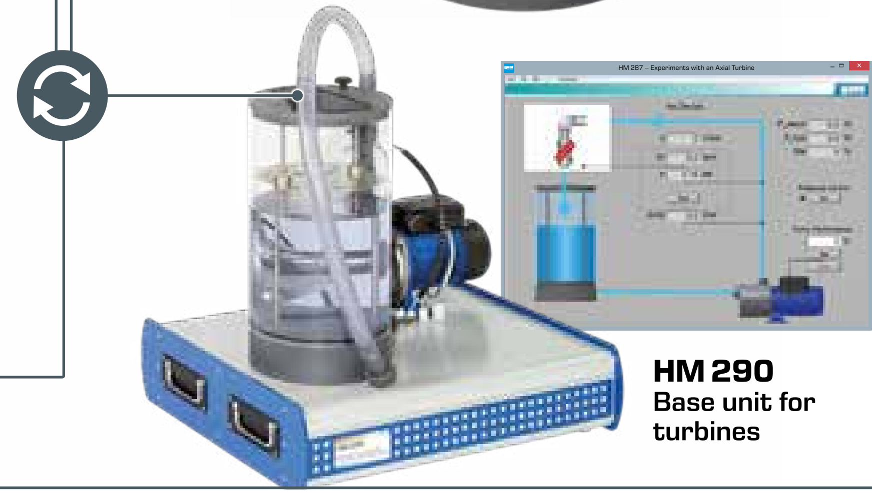
Position of the guide vanes in the Francis turbine


Vanes and impeller of the Francis turbine

HM 288
Experiments with a reaction turbine

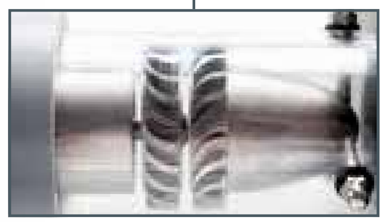
HM 289
Experiments with a Pelton turbine

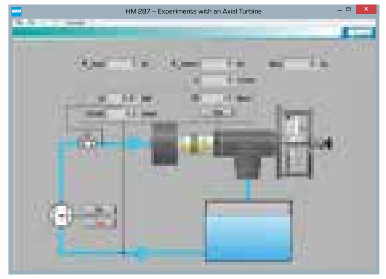
HM 291
Experiments with an action turbine



HM 290
Base unit for turbines

HM 287
Experiments with an axial turbine





Solar energy: photovoltaics

Using photovoltaics in an experimental setup

The photovoltaic DC current from ET 250 is either fed to the input of **ET 255** or **ET 250.01** or **ET 250.02**

The trainer **ET 255** can either be run with actual solar modules or with the built-in photovoltaic simulator.

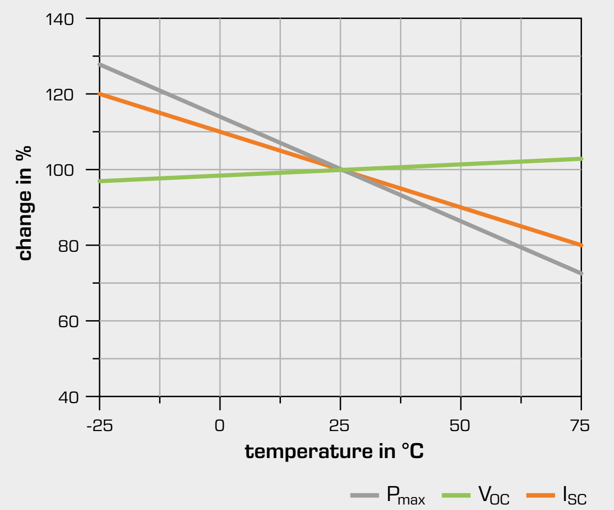
ET 250.01
Photovoltaic in grid-connected operation

ET 250.02
Stand alone operation of photovoltaic modules

ET 252
Solar cell measurements

Investigation of the properties of solar cells; objective measurements by extensive temperature control of solar cells

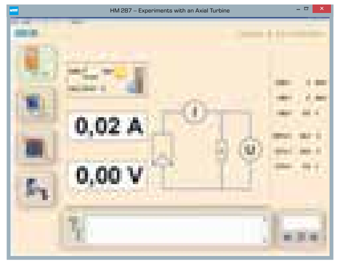
Patch panel for different connection possibilities: the four solar cells can be interconnected in a number of ways, e.g. individual cells can be bridged by bypass diodes in order to examine differences in power loss such as caused by shaded cells



ET 252 allows you to investigate the specific effect of temperature on the solar cell.

Learning objectives / experiments

- physical behaviour of solar cells under varying illuminance and temperature
- recording of current-voltage curves
- calculating current strength and achievable output based on the single diode model
- how illuminance and temperature affect the curves
- interconnecting solar cells in parallel and series connection
- effect of bypass diodes
- power degradation due to shading



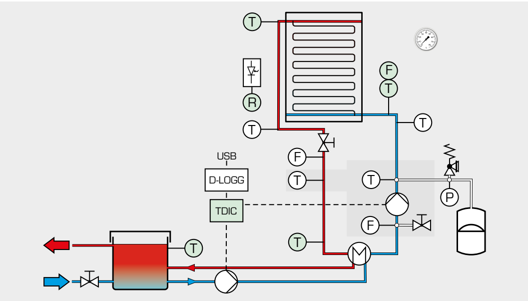
Solar energy: solar thermal energy

HL 313
Domestic water heating with flat collector

Demonstration of the conversion of the sun's radiation energy into heat and the storing of that heat

Learning objectives / experiments

- familiarisation with the functions of the flat collector and the solar circuit
- determining the net power
- relationship between flow and net power
- determining the collector efficiency
- relationship between temperature difference (collector/environment) and collector efficiency

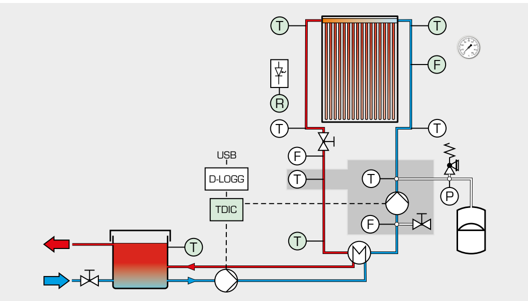


HL 314
Domestic water heating with tube collector

Conversion of solar energy into heat in the evacuated tube collector

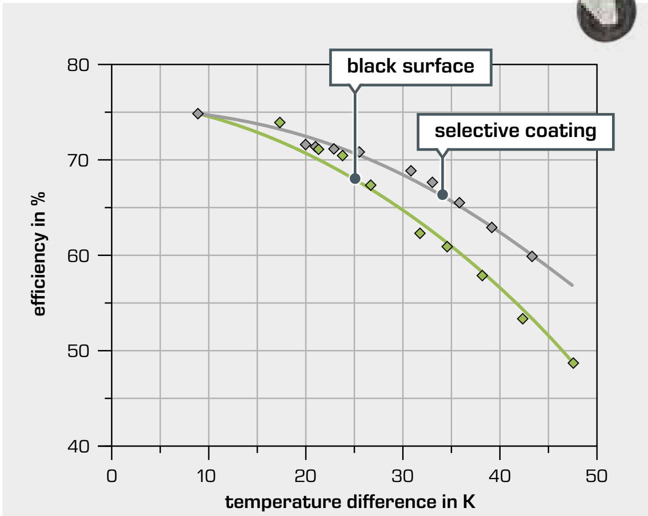
Learning objectives / experiments

- familiarisation with the functions of the tube collector and the solar circuit
- determining the net power
- relationship between flow and net power
- determining the collector efficiency
- relationship between temperature difference (collector/environment) and collector efficiency



ET 202
Principles of solar thermal energy

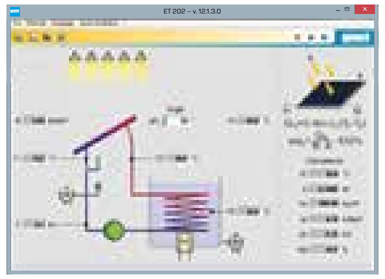
Determining characteristic parameters of a solar thermal system; model fitted with artificial radiation source



The illustration shows measured values for the efficiency as a function of the collector temperature. A special coating on the absorber allows higher efficiencies.

Learning objectives / experiments

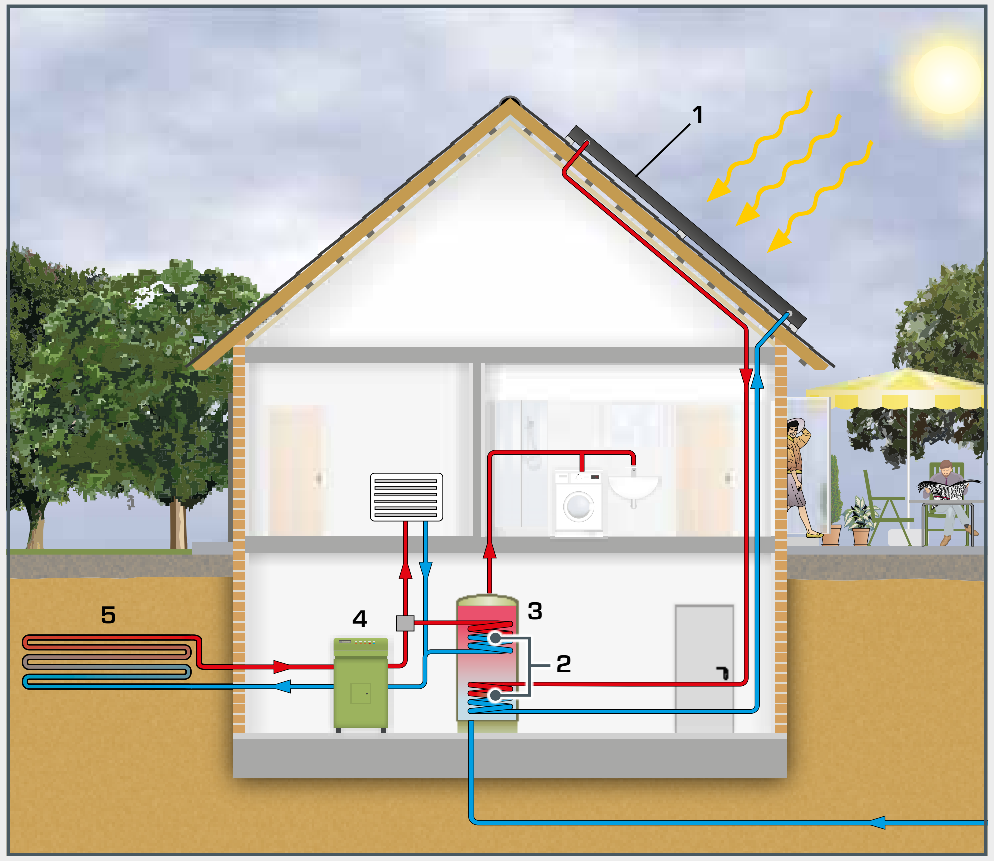
- design and operation of a simple solar thermal system
- determining the net power
- energy balance on the solar collector
- influence of illuminance, angle of incidence and flow rate
- determining efficiency curves
- influence of various absorbing surfaces



Green building

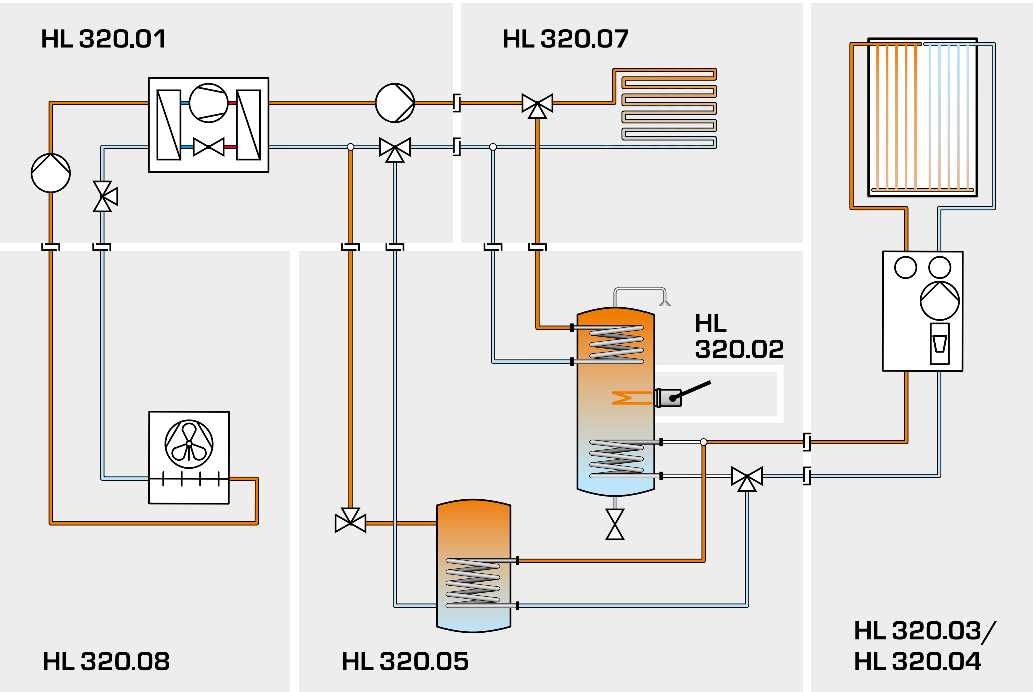
The HL 320 modular system allows you to investigate heating systems with various renewable and traditional energy sources. Solar thermal energy can be combined with heat generation from heat pumps.

The modular design of the HL 320 system makes it possible to achieve different combinations and configurations.



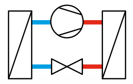
Components for the combined use of renewable heat sources in the domestic supply

1 flat collector, **2** heat exchanger, **3** hot water storage tank, **4** heat pump, **5** geothermal absorber;
hot heat transfer fluid, cold heat transfer fluid

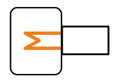


Example for a system diagram for complementary heating and domestic water heating with a solar thermal collector and a heat pump (combination 5).

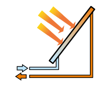
HL 320.01
Heat pump



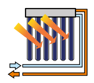

HL 320.02
Conventional heating



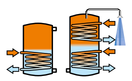

HL 320.03
Flat collector




HL 320.04
Evacuated tube collector

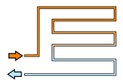



HL 320.05
Central storage module with controller

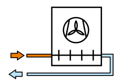



The storage module provides bivalent storage and buffer storage. The controller can be used to log measured values over longer periods for analysis of the system behaviour.

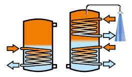
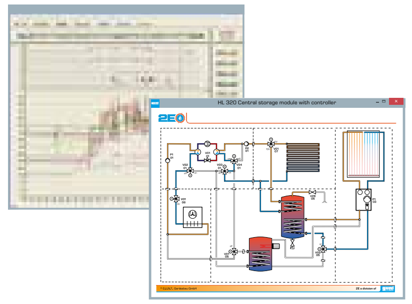
HL 320.07
Underfloor heating/ geothermal energy absorber




HL 320.08
Fan heater/ air heat exchanger



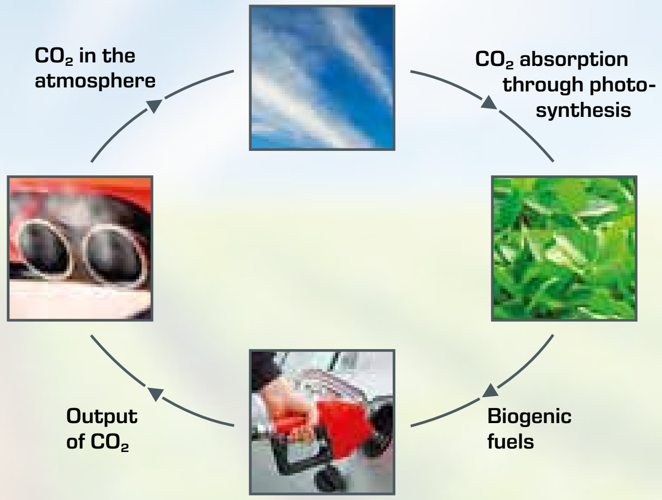

Freely programmable controller with extensive software


Biomass

The CO_2 cycle

Photosynthesis, with the aid of sunlight, enables plant growth. In this process CO_2 from the atmosphere, as well as water and inorganic substances from the plants, are absorbed and converted into energy-rich organic compounds. This biomass can be regarded as the product of a biochemical process, in which a portion of the absorbed sunlight is stored in the form of chemical energy. Being able to use the biomass as an energy source in various technical processes requires special treatment processes. These include simple physical processes as well as more complex thermochemical and biological processes.



Bioethanol

CE 640
Biotechnical production of ethanol

Discontinuous conversion of starch-containing bio-resources into ethanol

- familiarization with the necessary individual steps and system components for production of ethanol:
  - gelatinisation by steam injection
  - liquefaction by use of alpha-amylase
  - saccharification by use of gluco-amylase
  - fermentation: conversion of sugar into ethanol by yeast cultures under anaerobic conditions
  - distillation: separation of ethanol from the mash

Biogas

CE 642
Biogas plant

Two-stage continuous degradation of organic substances. First stage: hydrolysis and acidification, second stage: anaerobic degradation

- achieving a stable operating state
- influence of the following parameters on the biogas generation
  - temperature
  - substrate
  - volumetric loading
  - pH value
- influence of the operation mode on the biogas yield
  - single stage or dual stage
  - with and without post-fermentation
  - continuous and discontinuous
- determining the following parameters depending on the operating conditions
  - biogas yield
  - biogas flow rate
  - biogas quality

Biodiesel

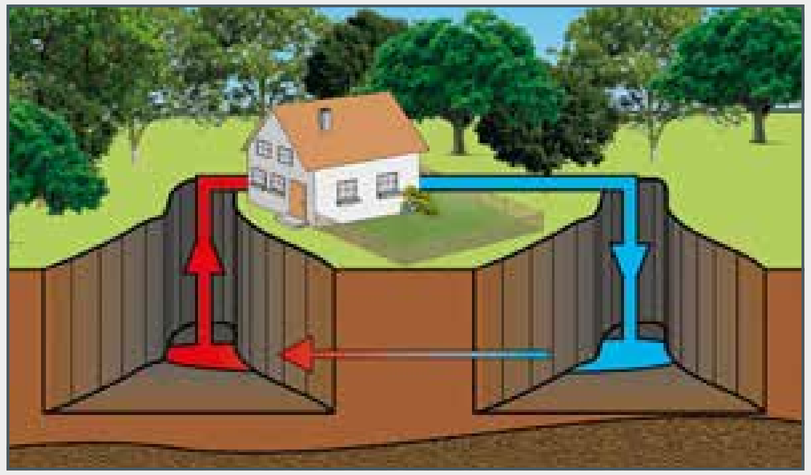
CE 650
Biodiesel plant

Chemical transesterification of vegetable oils

- production of biodiesel from vegetable oil
  - influence of dwell time
  - influence of temperature
- chemical transesterification
- phase separation in the gravity field
- distillation
- liquid-liquid extraction
- approach of a continuous process consisting of several basic operations

Geothermal energy

Dual well system



Groundwater is pumped from a well to the surface. After thermal use the ground-water is returned to the soil via a discharge well to conserve the groundwater reservoir. A sufficient distance between the well and discharge well prevents a hydraulic short cut.

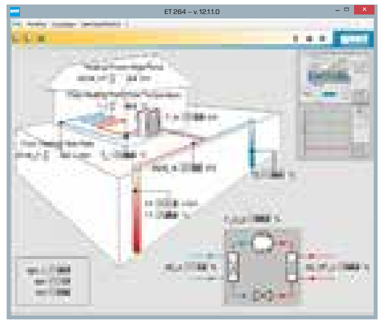
The dual well system is an open geothermal system without thermal retroaction on the heat source. It can be used for heating or cooling purposes, where groundwater serves as a geothermal heat source or heat sink. These systems require sufficient groundwater to be present at the site in layers near the surface.

ET 264

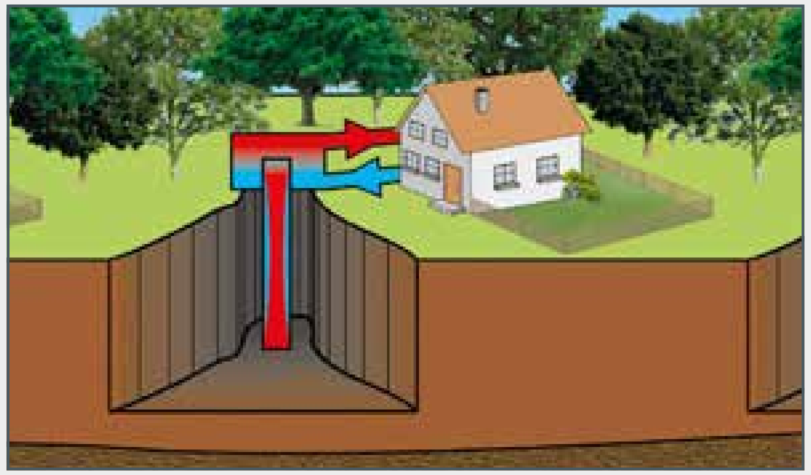
Geothermal energy with two-well system

Use of geothermal energy in an open system without thermal repercussion

- fundamentals of geothermal use
- operating behaviour of a two-well system
- hydraulic and thermal properties of the ground
- determination of the usable heat capacity
- fundamentals and energy balance of a heat pump



Geothermal probes



Probe with heat pipe principle

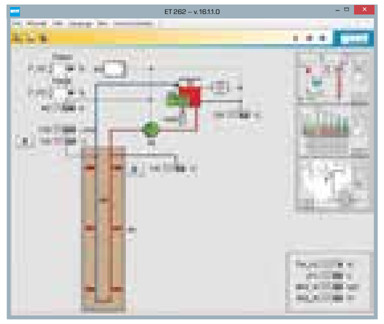
Geothermal probes are heat exchangers that are inserted vertically or at an angle into the ground. In most cases, these consist of plastic pipes inserted into boreholes. The probes can be designed in different ways. Geothermal probes are a closed geothermal system with thermal retroaction on the ground.

ET 262

Geothermal probe with heat pipe principle

Transparent components allow observing how the state of the heat transfer medium changes

- operating behaviour of a geothermal probe with heat pipe principle
- fundamentals of geothermal energy
- determination of the amount of heat that can be dissipated in the heat pipe with variation of the thermal load
- variation of the filling level of the heat transfer medium contained
- examination of the radial temperature profile in a sand sample and determination of the thermal conductivity
- determination of the sand's thermal conductivity by means of a thermal response test
- fundamentals and energy balance of a heat pump



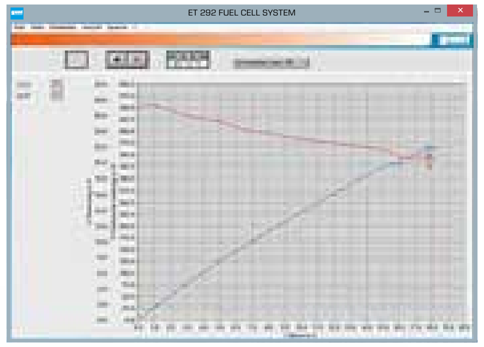
Energy storage systems

Energy conversion

ET 292
Fuel cell system

Water-cooled polymer-membrane fuel cell combined heat and power

- conversion of chemical energy into electrical and thermal energy
- function and design of a fuel cell system
- relationships of fuel cell operating parameters
- effects on the electrical performance of fuel cells
- recording and visualisation of all relevant voltage/current characteristics
- calculation of relevant variables



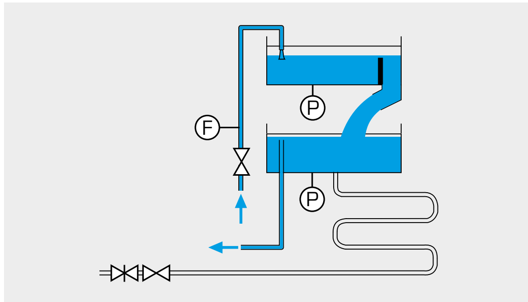
GUNT software screenshot: characteristic of the fuel cell

Energy storage

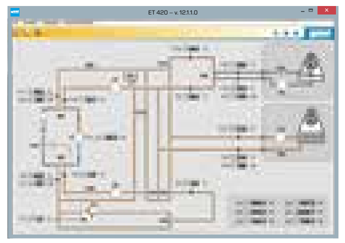
HM 143
Transient drainage processes in storage reservoirs

Demonstration of the function of a rainwater retention basin and a storage lake

- demonstrating transient drainage processes in two rainwater retention basins located one behind the other
- demonstrating transient drainage processes in two storage lakes located one behind the other
- recording oscillations of the water level in a surge chamber after water hammer
- recording and displaying water level fluctuations



ET 420
Ice stores in refrigeration

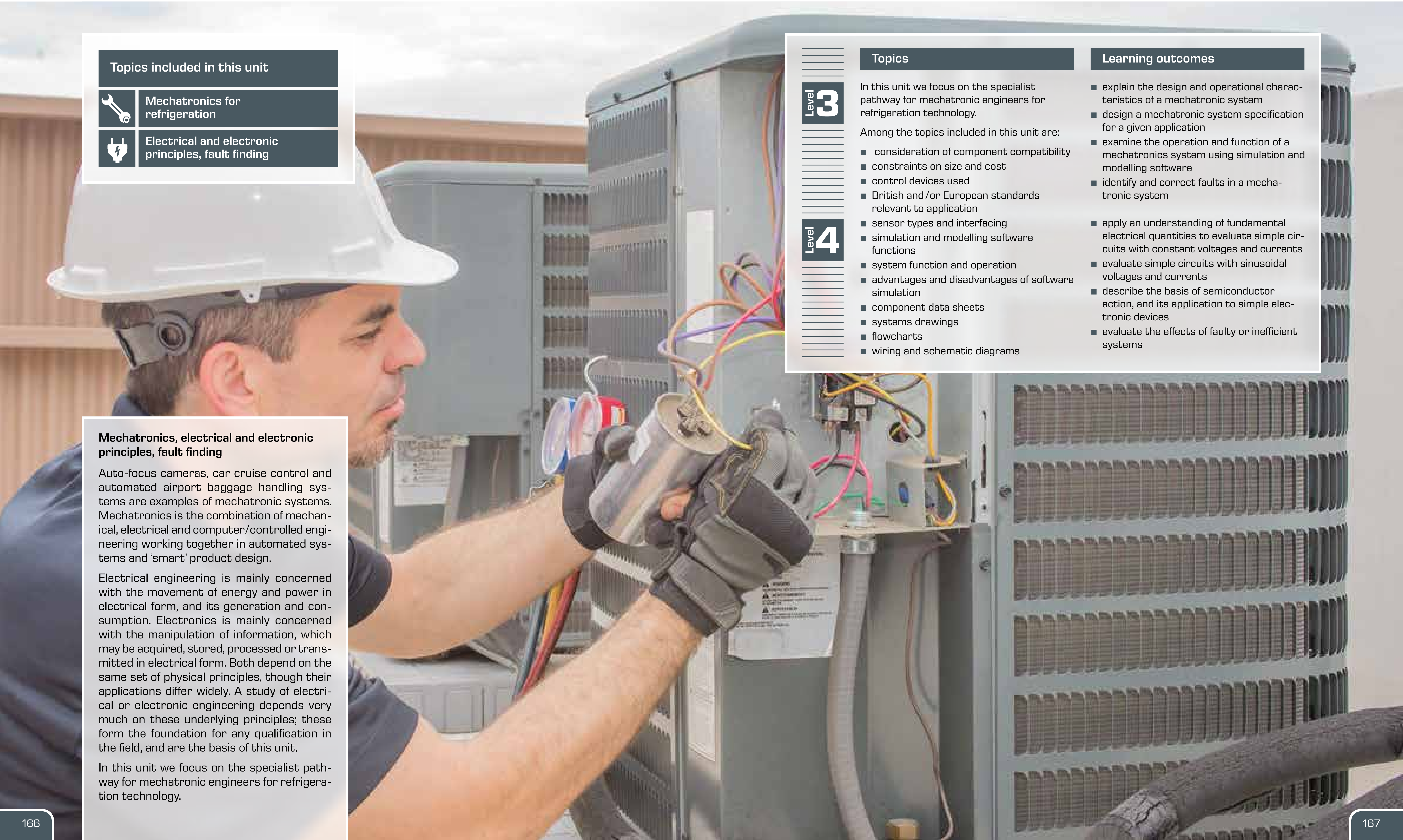


Learning objectives / experiments

- design and operation of an energy-efficient refrigeration system
- function and operation of an ice store
  - charge
  - discharge
- energy flow balance
- energy transport via different media
- compression refrigeration cycle in the log p-h diagram
- function and operation of a wet cooling tower
- function and operation of a dry cooling tower

Level 5+

10 Mechatronics, electrical and electronic principles, fault finding



Topics included in this unit

- Mechatronics for refrigeration
- Electrical and electronic principles, fault finding

Mechatronics, electrical and electronic principles, fault finding

Auto-focus cameras, car cruise control and automated airport baggage handling systems are examples of mechatronic systems. Mechatronics is the combination of mechanical, electrical and computer/controlled engineering working together in automated systems and 'smart' product design.

Electrical engineering is mainly concerned with the movement of energy and power in electrical form, and its generation and consumption. Electronics is mainly concerned with the manipulation of information, which may be acquired, stored, processed or transmitted in electrical form. Both depend on the same set of physical principles, though their applications differ widely. A study of electrical or electronic engineering depends very much on these underlying principles; these form the foundation for any qualification in the field, and are the basis of this unit.

In this unit we focus on the specialist pathway for mechatronic engineers for refrigeration technology.

Level 3 / Level 4

Topics

In this unit we focus on the specialist pathway for mechatronic engineers for refrigeration technology.

Among the topics included in this unit are:

- consideration of component compatibility
- constraints on size and cost
- control devices used
- British and / or European standards relevant to application
- sensor types and interfacing
- simulation and modelling software functions
- system function and operation
- advantages and disadvantages of software simulation
- component data sheets
- systems drawings
- flowcharts
- wiring and schematic diagrams

Learning outcomes

- explain the design and operational characteristics of a mechatronic system
- design a mechatronic system specification for a given application
- examine the operation and function of a mechatronics system using simulation and modelling software
- identify and correct faults in a mechatronic system
- apply an understanding of fundamental electrical quantities to evaluate simple circuits with constant voltages and currents
- evaluate simple circuits with sinusoidal voltages and currents
- describe the basis of semiconductor action, and its application to simple electronic devices
- evaluate the effects of faulty or inefficient systems

Mechatronics
ET 910 Refrigeration training system

Modular system for experiments in the field of refrigeration engineering

ET 910 base unit with components for basic experiments and advanced experiments

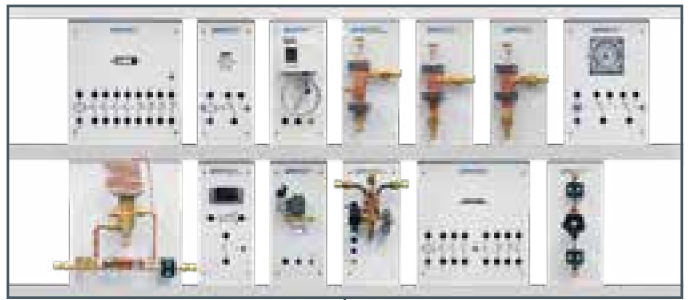
A functional workplace includes:

- ET 910.05 Refrigeration laboratory workplace
- ET 910.10 Refrigeration components for basic experiments
- ET 910.11 Refrigeration components for advanced experiments
- ET 910.12 Accessories
- ET 910.13 Maintenance set

By using modular plates the experiments can be set-up flexibly and clearly. The use of lockable hoses minimises

ET 910.10
Refrigeration components for basic experiments

ET 910.11
Refrigeration components for advanced experiments



ET 910
Refrigeration training system, base unit

ET 910.05
Refrigeration laboratory workplace

ET 910.12
Set of accessories

ET 910.13
Maintenance set

Practice project for a comprehensive understanding

Preparation

- read and understand refrigeration system flow diagrams and simple electric circuit diagrams

Experimental setup

- familiarisation with the real refrigeration components corresponding to the flow diagrams

Commissioning

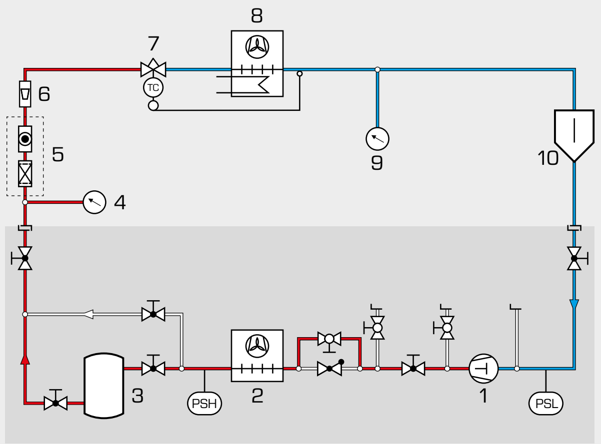
- practical tasks, such as evacuating, filling and leak tests in accordance with relevant regulations and guidelines

Experimental procedure

- grasp the function of the system
- optimisation of controllers and expansion elements by the adjustment

Evaluation

- temperature and pressure measurements
- measured value acquisition and graphical representation in a log p,h-diagramm
- comprehend the change of state

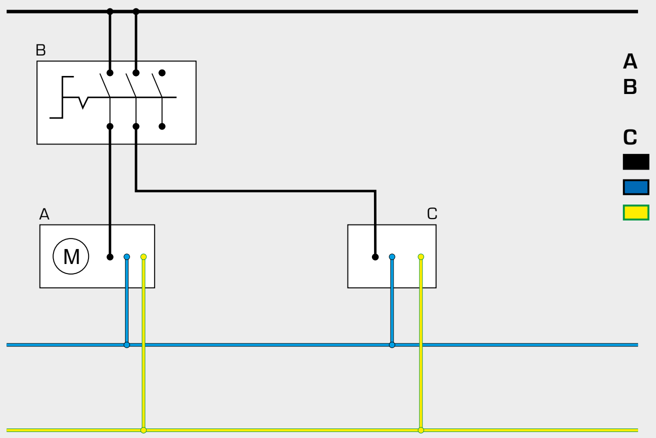


Components

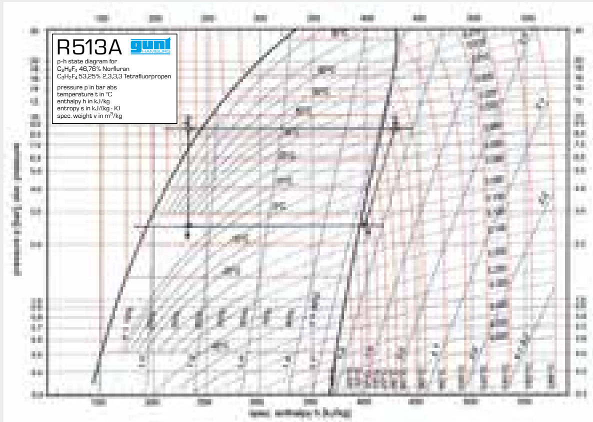
ET 910
- **3** collector
- **2** condenser
- **1** compressor
- **8** evaporator

ET 910.10
- **7** thermostatic expansion valve
- **6** flow meter
- **5** sight glass with filter/drier
- **4** intake side manometer
- **9** delivery side manometer
- **10** liquid separator

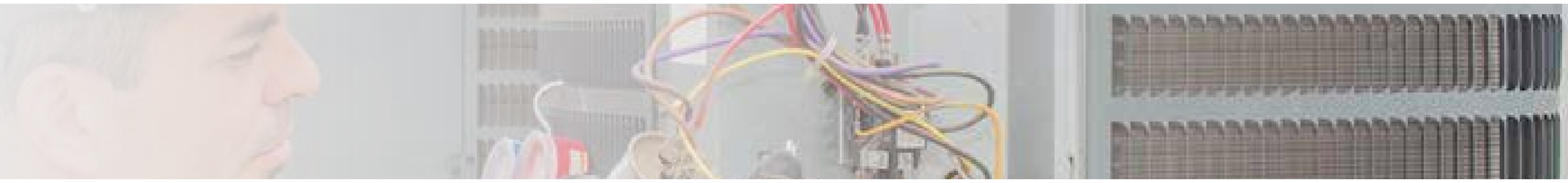
Set of accessories ET 910.12 with cables, hoses etc.



- **A** condensing unit,
- **B** refrigeration chamber heater/fan,
- **C** off switch 3 pole,
- phase (L),
- neutral conductor (N),
- protective conductor (PE)



Enter measured values in the log p-h diagram and draw the cyclic process

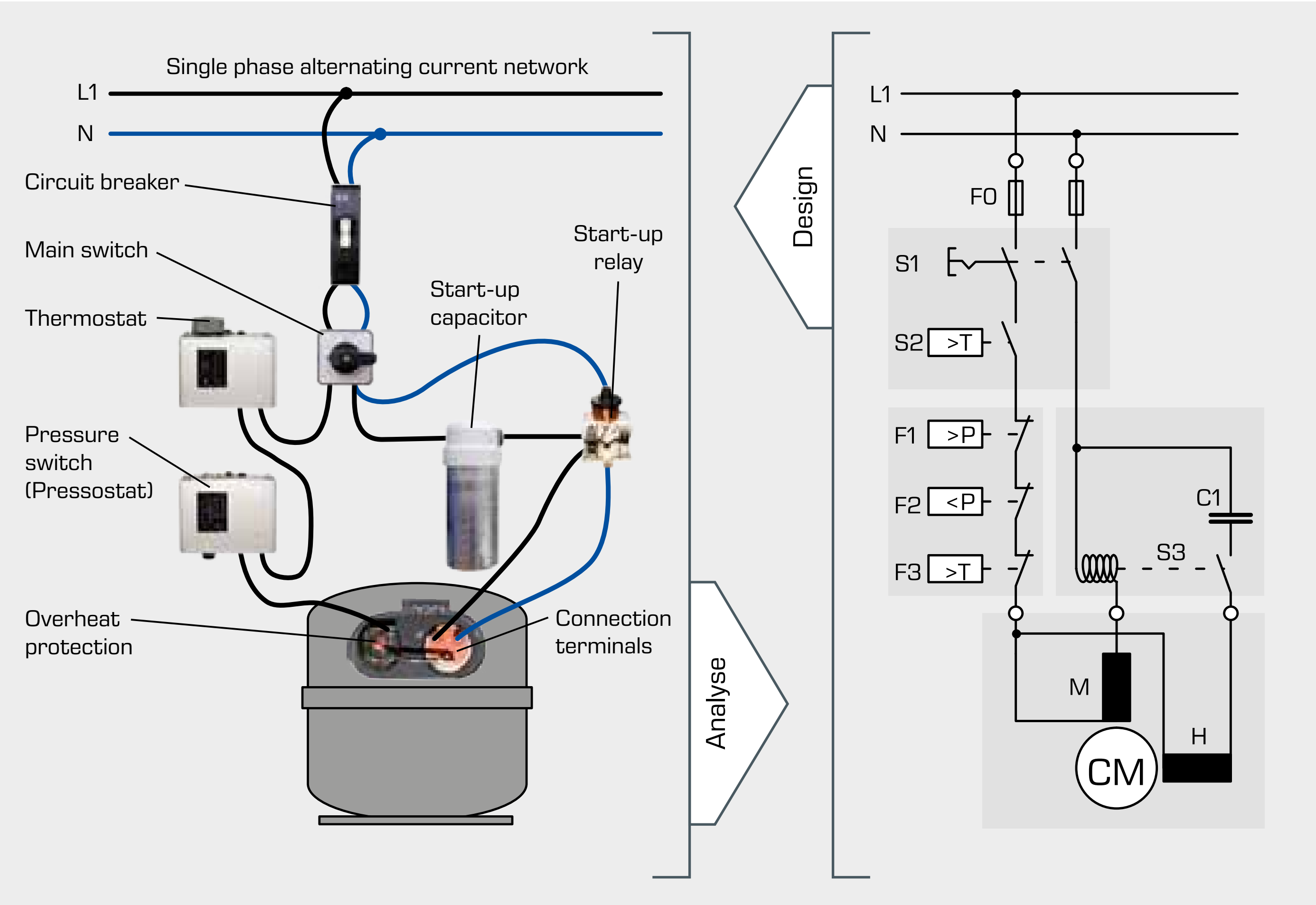


Electrical engineering in refrigeration

Refrigeration systems contain many electrical components, such as compressors, pressure switches, thermostats, fans, solenoid valves or controls. Therefore, electrical engineering is an important field in refrigeration. This is reflected in the high share of electrical engineering content in the training of the mechatronics engineer for refrigeration. The mechatronics engineer for refrigeration should be capable of planning, designing and commissioning electrical systems.

In the service field the testing, fault finding and repair of electrical systems is also an important item. During service you are often confronted with incomplete documentation, which is why the mechatronics engineer for refrigeration must be able to analyse the system and comprehend its operation. This requires a good basic knowledge of electrical engineering.

Electric connection of a refrigerant compressor to the alternating current network



The connection of a refrigerant compressor and its protective elements to the single phase alternating current network is part of the standard activities of the mechatronics engineer for refrigeration. This task requires the correct preparation of an electric circuit diagram (flow diagram) and the practical wiring of the electrical components in the refrigeration system.

The wiring of the compressor **CM** consists of three functional groups:

- controller, consisting of main switch **S1** and thermostat **S2**
- safety module, consisting of pressure switches (Pressostat) **F1, F2** and overheat protection of the compressor **F3**
- start-up circuit, consisting of the start-up relay **S3** and start-up capacitor **C1**

Start-up circuits for single phase compressor motors

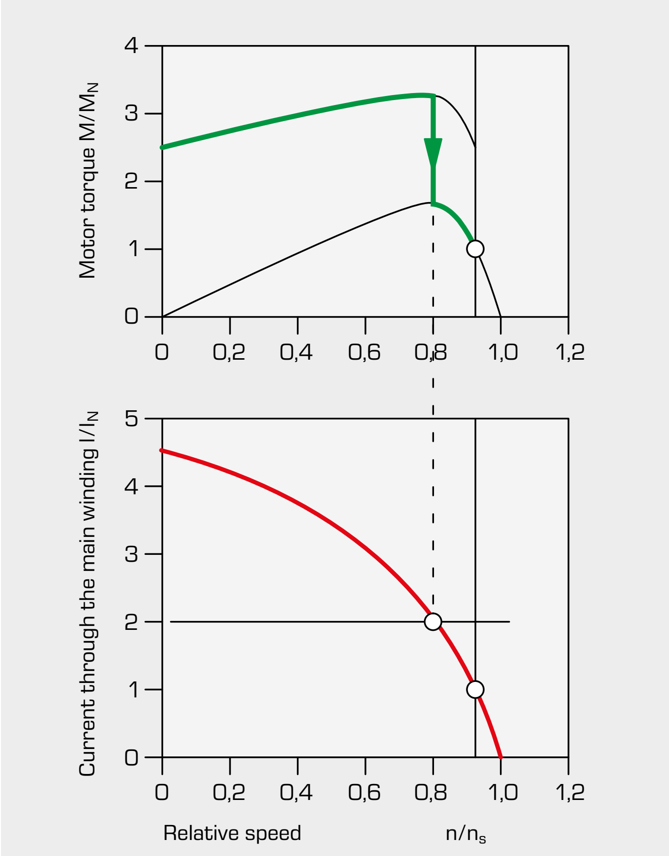
Drive motors for refrigerant compressors require a high start-up torque. For low compressor capacities single phase alternating current motors are used as drive motors. These are of simple design, maintenance-free, cheap and can run inside the refrigerant (hermetic compressor).

Due to their principle of operation these motors do not have any or only a low torque at rest. To increase the torque the motors must be equipped with a start-up circuit. Here an auxiliary winding is additionally supplied with current via a capacitor until the operating speed is reached. The automatic switching on and off of the auxiliary winding can be implemented via different options.

The most common is a start-up relay whose winding is connected in series to the main winding. When starting the motor a very high current first flows through the main winding, the start-up relay responds and activates the auxiliary winding via the capacitor. Once the motor has reached its speed, the current through the main winding drops. If the current falls below a certain value, the relay is released and the auxiliary winding is disabled.

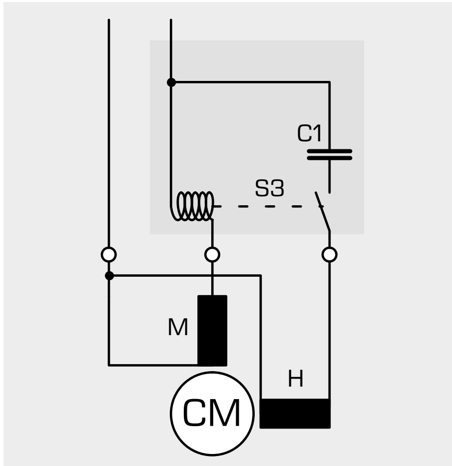
The switching of the auxiliary winding can also take place via a centrifugal force switch directly dependent on the speed. In some motors the auxiliary winding is permanently activated via an operating capacitor. Here a second start-up capacitor is connected in parallel during start-up to increase the torque.

Another particularly wear-free method is the use of a PTC element. This heats due to the current flowing in the auxiliary winding and increases its resistance. This reduces the current through the auxiliary winding after a brief period of time.

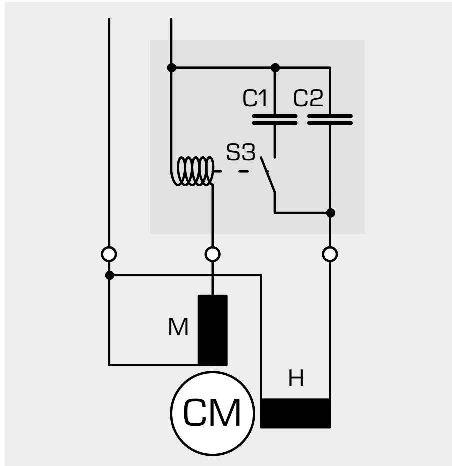


Start of a single phase alternating current motor with auxiliary winding: auxiliary winding is switched off at $I = 2\,I_N$

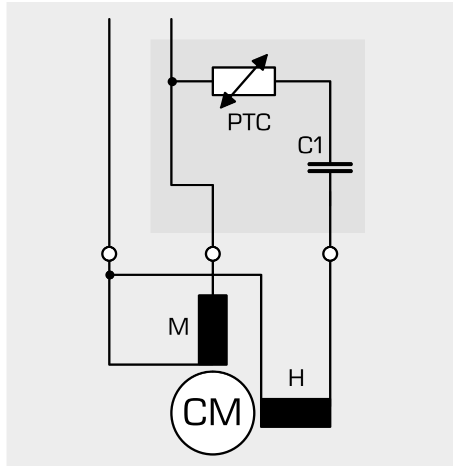
M_N nominal torque, **I_N** nominal current, **n_s** synchronous torque, **A** switching point, **B** operating point, **C** n_N/n_s = nominal speed



Start-up capacitor **C1** via start-up relay **S3**



Operating capacitor **C2** and start-up capacitor **C1** via start-up relay **S3**



Start-up capacitor **C1** via **PTC**

Electrical and electronic principles, fault finding

Electrical and electronic principles

ET 144
Electrical installation in refrigeration systems

Set-up and wiring of typical electrical circuits for refrigeration circuits

- read, understand, wire and test electric circuit diagrams
- design and operation of electrical components from refrigeration
  - start-up capacitor
  - operating capacitor
  - start-up relay
  - time relay
  - timer
  - circuit breaker
  - start-up current limiter
  - contactors
  - pressure switch
  - thermostat
  - solenoid valve
- design and testing of a safety chain
- star/delta connection
- change of direction of rotation in an alternating current circuit
- safety aspects when handling mains voltage

ET 171
Electrical connection of refrigerant compressors

Use of a real refrigerant compressor

- read, understand, wire and test electric circuit diagrams for refrigerant compressors
- design and operation of electrical components of refrigerant compressors
  - start-up capacitor
  - start-up relay
  - overheat protection
  - automatic fuse
  - pressure switch
  - thermostat
- design and testing of a safety chain
- representation methods in electrical engineering
  - symbols
  - circuit diagrams
- safety aspects when handling mains voltage

ET 930
Evaporator control with electronic expansion valve

Practical programming of a modern refrigeration controller

- modern refrigeration controller with electronic expansion valve
- functional principle of the controller
  - thermostat function
  - daytime and night-time operation
  - operation with open and closed freezer
  - defrost functions
  - safety functions
  - alarm functions
  - monitoring of the components
- controller programming
- fault finding

Fault finding

ET 172
Electrical faults in refrigerant compressors

Investigation of important electrical components from refrigeration

- electrical connection of refrigerant compressors
- read and understand electrical circuit diagrams
- design and operation of the electrical components of a refrigerant compressor
  - start-up capacitor
  - start-up relay
  - operating capacitor
  - overheat protection
  - main contactor
  - automatic fuse
- fault finding in electrical components
  - in idle state
  - under mains voltage

ET 170
Electrical faults in simple air conditioning systems

Design and operation of electrical components in a simulated air conditioning system

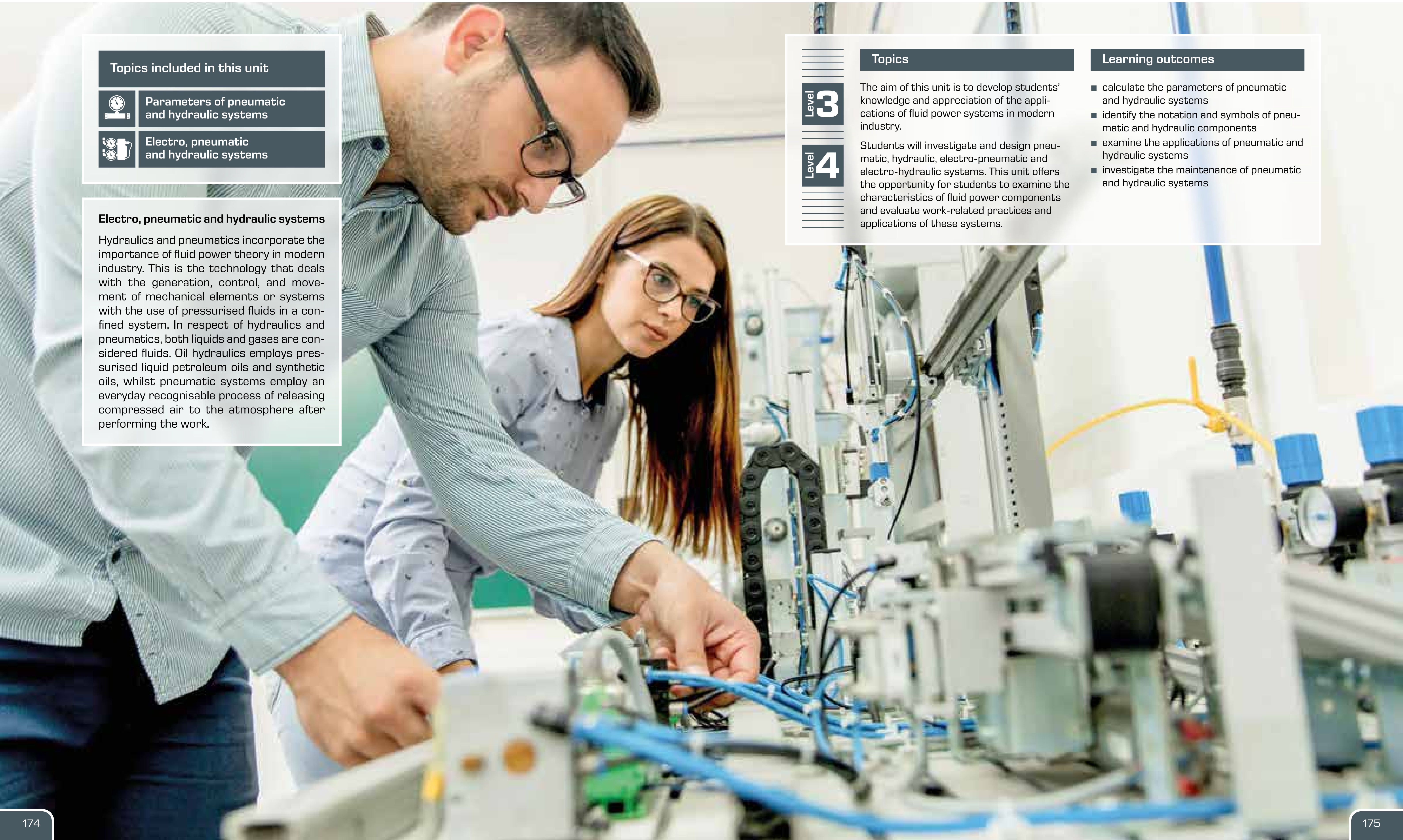
- electrical design and principle of operation of simple air conditioning systems
- read and understand electrical circuit diagrams
- design and operation of electrical components in an air conditioning system
  - start-up capacitor
  - start-up relay
  - overheat protection
  - main contactor
  - automatic fuse
  - on/off switch
  - speed switch
  - thermostat
- fault finding in electrical components
  - in idle state
  - under mains voltage

ET 174
Electrical faults in full air conditioning systems

Design and operation of electrical components in a complex simulated air conditioning system

- electrical design and operation of full conditioning systems
- reading and understanding electrical circuit diagrams
- design and operation of electrical components in an air conditioning system
  - start-up capacitor
  - start-up relay
  - operating capacitor
  - overheat protection
  - Heinemann circuit breaker
  - solenoid valve
  - defrost timer
  - float switch
  - thermostat
  - hygrostat
  - frost protection monitor
- fault finding in electrical components
  - in idle state
  - under mains voltage

11 Electro, pneumatic and hydraulic systems



Topics included in this unit

- Parameters of pneumatic and hydraulic systems
- Electro, pneumatic and hydraulic systems

Electro, pneumatic and hydraulic systems

Hydraulics and pneumatics incorporate the importance of fluid power theory in modern industry. This is the technology that deals with the generation, control, and movement of mechanical elements or systems with the use of pressurised fluids in a confined system. In respect of hydraulics and pneumatics, both liquids and gases are considered fluids. Oil hydraulics employs pressurised liquid petroleum oils and synthetic oils, whilst pneumatic systems employ an everyday recognisable process of releasing compressed air to the atmosphere after performing the work.

Level 3

Level 4

Topics

The aim of this unit is to develop students' knowledge and appreciation of the applications of fluid power systems in modern industry.

Students will investigate and design pneumatic, hydraulic, electro-pneumatic and electro-hydraulic systems. This unit offers the opportunity for students to examine the characteristics of fluid power components and evaluate work-related practices and applications of these systems.

Learning outcomes

- calculate the parameters of pneumatic and hydraulic systems
- identify the notation and symbols of pneumatic and hydraulic components
- examine the applications of pneumatic and hydraulic systems
- investigate the maintenance of pneumatic and hydraulic systems

Parameters of pneumatic and hydraulic systems

Knowledge foundation prior to industrial application

WL 102
Change of state of gases

Isothermal and isochoric change of state of air

- demonstrating the laws of state changes in gases experimentally
- isothermal change of state, Boyle-Mariotte law
- isochoric change of state, Gay-Lussac's 2nd law

WL 103
Expansion of ideal gases

Determination of the adiabatic exponent according to Clément-Desormes

- determination of the adiabatic exponent according to Clément-Desormes
- adiabatic change of state of air
- isochoric change of state of air

HM 150.07
Bernoulli's principle

Static pressure and total pressure distribution along the Venturi nozzle

- energy conversion in divergent/convergent pipe flow
- recording the pressure curve in a Venturi nozzle
- recording the velocity curve in a Venturi nozzle
- determining the flow coefficient
- recognising friction effects

HM 240
Principles of air flow

Determining the fan characteristic curve

- recording a fan characteristic
- in conjunction with the power meter HM 240.02
  - determining the fan efficiency
- in conjunction with corresponding accessories
  - velocity distribution in the pipe
  - velocity distribution behind a cylinder subject to transverse incident flow
  - pressure distribution around a cylinder subject to transverse incident flow
  - friction losses in pipes, pipe bends and pipe angles
  - recording the cooling curve of a copper cylinder subject to incident flow
  - determining the heat transfer coefficients from the cooling curve

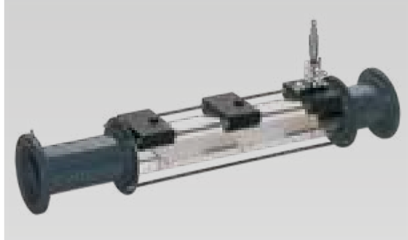
The HM 220 experimental plant allows an extensive range of experiments with the varied accessories:

Measuring and investigating the air flow via a Pitot tube

in a free jet

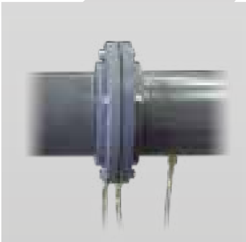
within a pipe

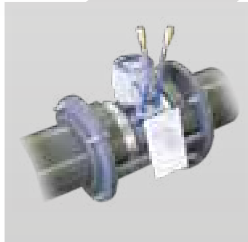
Boundary layer measurements on a flat plate in longitudinal flow via a Pitot tube (HM 220.02 accessory)

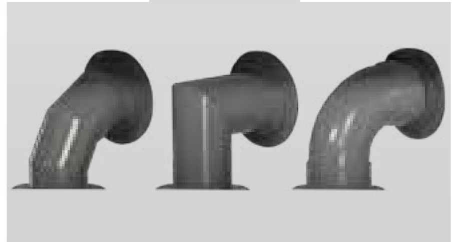


- use of various pipe elements
- adjustment of the air flow through a frequency converter
- up to 20 pressure measuring points
- calculation of the volumetric flow rate and the flow velocity from the measurement results
- representation of system characteristics
- recording the different velocity profiles in both the free jet and the pipe cross-section
- representation of the increase in pressure loss due to pipe friction at different pipe elements
- optimal formation of the air flow due to a low-loss inlet and the large length of the pipe section

HM 220
Air flow experimental plant







Change in volumetric flow rate

- in an orifice plate or nozzle
- in an iris diaphragm

Measurement and investigation of air flow

- via a Venturi tube (accessory HM 220.01)
- in different pipe fittings

Electro, pneumatic and hydraulic systems

RT 700
Training system: fundamentals of hydraulics

Complete training system providing an experimental introduction to the fundamentals of hydraulics

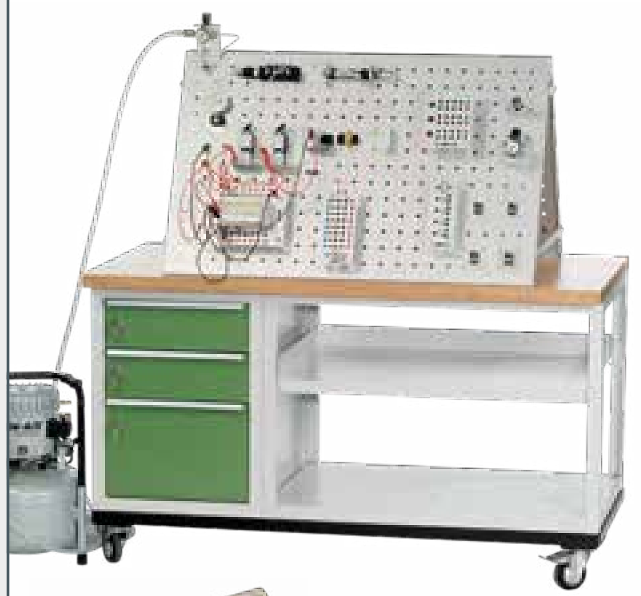
- comprehensive experimental introduction to the fundamentals of hydraulic drive and control engineering
- familiarisation with terms and symbols
- representation of hydraulic circuits
- drive unit
- multi-way valves and drives
- shut-off and flow control valves
- pressure valves and pressure switches
- hydraulic accumulators
- application circuits
- commissioning and maintenance

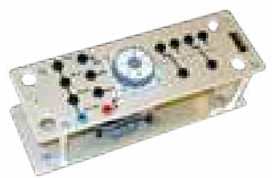
RT 701
Components set electrohydraulics

Set of electrohydraulics components for hydraulics trainer RT 700

- together with RT 700, the following experiments are possible (among others)
  - locking
  - sequence control
  - hold a load
- experimental components
  - 1 plate with electric switching elements, 2 electric limit switches
  - 2 relays, 1 adjustable time relay
  - 2 4/2-way valves with spring return
  - 1 4/3-way valve, spring-centered, A, B, P, T closed in centre position
  - 1 4/3-way valve, spring-centered, A and B closed

RT 770
Training system: pneumatics, electro-pneumatics and PLC





Relay board

Complete training system providing an experimental introduction to the fundamentals of pneumatics and electro-pneumatics, also with PLC

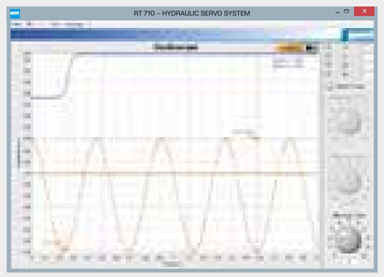
- physical principles of pneumatics and electro-pneumatics
- fundamentals of, and terms used in, process control
- design and function of pneumatic components
- logic elements, logic diagram
- multi-way valves, pressure, shut-off and flow control valves
- controls with starting and setup conditions (automatic/manual/jog mode)
- controls with boundary conditions
- routing and time controls (process and time controlled sequencers)
- position-dependent controls
- troubleshooting and commissioning

RT 710
Hydraulic servo system

Level 5+

Hydraulic position control circuit with adjustable load conditions

- familiarisation with the mode of operation of a hydraulic position control loop with adjustable load conditions
- reading and understanding circuit diagrams
- replacing springs and adjusting the damper
- influence of load and system pressure on control accuracy
- influence of the amplifier constants on the stability of the closed control loop
- recording the frequency response



12 Instrumentation, control systems, automation, and distributed control systems

Topics included in this unit

- Instrumentation systems
- Control systems
- Automation
- Distributed control systems

Instrumentation, control systems, automation, and distributed control systems

Instrumentation and control can also be described as measurement automation, which is a very important area of engineering and manufacturing. It is responsible for the safe control of a wide range of processes from power stations to manufacturing facilities and even the cruise control in cars.

Control engineering is usually found at the top level of large projects in determining the engineering system performance specifications, the required interfaces, and hardware and software requirements. In most industries, stricter requirements for product quality, energy efficiency, pollution level controls and the general drive for improved performance, place tighter limits on control systems.

With increased complexity and greater emphasis on cost control and environmental issues, the efficient control of manufacture and processing plant becomes ever more important. While small and medium scale industries require Programmable Logic Controller (PLC) and Supervisory Control and Data Acquisition (SCADA) technologies, large scale applications require Distributed Control Systems (DCS).

Level	Topics	Learning outcomes
Level 3	This unit introduces students to the important principles, components and practices of instrumentation in the controlling of a process system, together with the terminology, techniques and components that are used in such a system.	■ understand microcontrollers and their applications ■ apply open and closed loop control ■ use sensors and transducers in control and robotic systems ■ understand the basic principles of industrial instrumentation
Level 4	Among the topics included in this unit are: ■ instrumentation systems, ■ instrumentation signal terminology, ■ signal conversion and conditioning, ■ process control systems, ■ process controller terminology ■ system terminology and concepts ■ system tuning techniques and application of predicted values to a control system	■ identify the instrumentation systems and devices used in process control ■ investigate the industrial process control systems ■ analyse the control concepts and technologies used within an industrial process ■ apply predicted values to ensure stability within a control system
Level 5	The topic distributed control systems introduces students to: ■ the applications in industrial measurements and control engineering ■ different types of industrial networking used in control and instrumentation ■ the analysis of the performance of a given control system	■ discuss the basic concepts of control systems and their contemporary applications ■ analyse the elements of a typical, high-level control system and its model development ■ analyse the structure and behaviour of typical control systems ■ explore the impact of automated systems in modern control processes ■ evaluate the basic concepts, architecture, operation and communication of Distributed Control Systems

Instrumentation systems: measuring methods

With the aid of automation and process control engineering, processes are monitored and influenced as they happen. This is enabled by the measurement and control of variables such as flow rate, pressure, temperature, and concentration.

To control processes, first of all it is necessary to record the process variables. The different properties of the process variables, but also of the substances used and the respective aggregate states, make different measuring methods necessary.

IA 120
Principles of industrial sensors

- mode of operation and application of different sensors
  - one-way photoelectric barrier
  - reflex photoelectric barrier
  - inductive proximity switch
  - capacitive proximity switch
  - reflex photoelectric proximity switch, infrared
  - reflex photoelectric proximity switch, red light
  - limit switch
  - reed contact

IA 110
Calibrating a pressure sensor

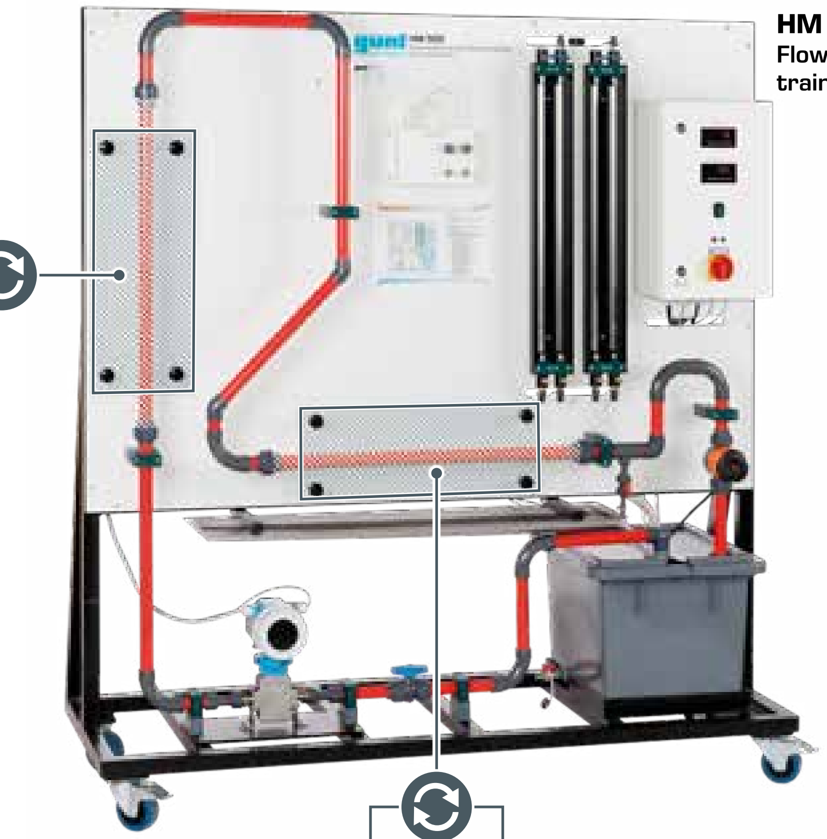
Interior layout of an electronic pressure sensor

- familiarisation with, and carrying out of the calibration of an electronic pressure sensor
- plotting the sensor output signal dependent on the pressure applied
- familiarisation with the design and operation of a piezo-resistive electronic pressure sensor
- familiarisation with the installation and connection of the pressure sensor
- information on applications, measuring ranges and accuracies of typical electronic pressure sensors

Flow rate measurement

HM 500.03
Rotameter with transducer

For some of the flow meters the position is important for correct operation. The rotameter can only be used vertically:
upright mounting

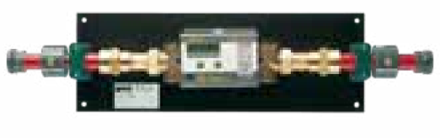


HM 500
Flow meter trainer

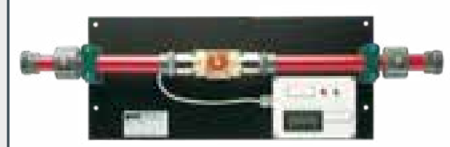
Learning objectives / experiments

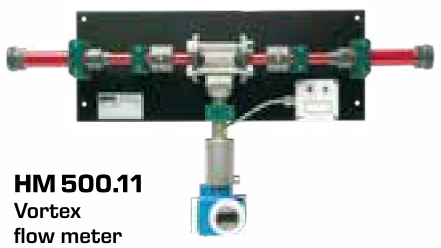
- **HM 500 Flow meter trainer** together with the flow meters **HM 500.1 – HM 500.16**
  - different flow meters and their principles of operation
  - calibration of different flow meters
  - position dependency of flow meters
  - plotting and comparison of pressure loss curves

HM 500.05
Ultrasonic flow meter



HM 500.10
Paddle wheel flow meter

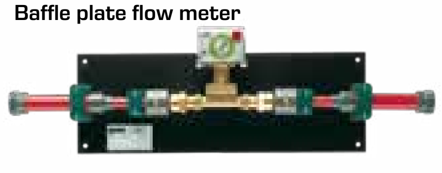




HM 500.11
Vortex flow meter

HM 500.04
Electromagnetic flow meter

HM 500.16
Baffle plate flow meter



The flow meters shown on this page transmit the information about the flow rate as an electrical signal. The eletrical signal can be processed via digital controller.

Control systems: teaching the fundamentals

Process control is a key area in any study of automation.

With this model series, GUNT offers six systems providing an introduction to the fundamentals of process control through the use of experimentation. Software plays a key role as an integral component of the equipment concept, in the sense of hardware/software integration (HSI). It relieves students from routine activities and supports intera ctive action when they are experimenting with new approaches.

The effects of changes to control parameters or disturbance variables on the system behaviour can be investigated quickly and easily. In contrast to purely computer-based simulation, these actual models of controlled systems provide a closer link to the real world, and so aid understanding.

The network capability of the software enables teacher/student systems to be established.

RT 020
Training system: flow control, HSI

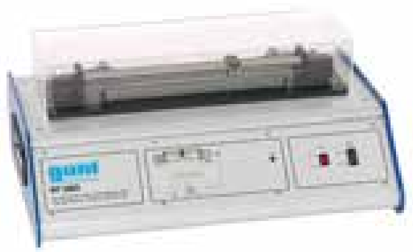
RT 030
Training system: pressure control, HSI

RT 040
Training system: temperature control, HSI

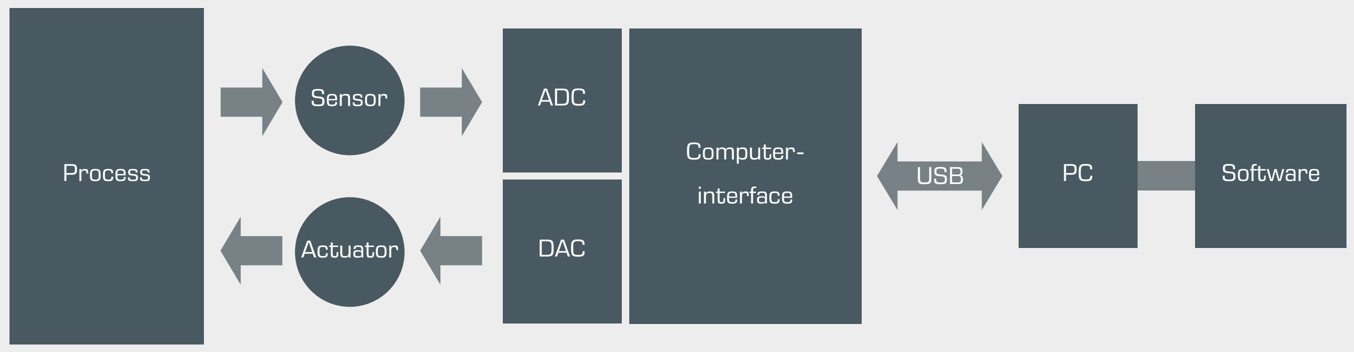
RT 010
Training system: level control, HSI

RT 050
Training system: speed control, HSI

RT 060
Training system: position control, HSI



Cooperation of hardware and software – hardware/software integration (HSI)



Advantages

- compact benchtop models
- ideally suited to multi-user applications
- typical control systems from the field of process control such as flow, level, pressure, temperature, speed and position
- high level of observability of processes based on transparent elements (covers, containers, lines)
- richly featured software
- computer interface with USB port

Comprehensive experiment programme for each trainer:

- control loop analysis
- influence of controller parameters on control action and disturbance response
- stability of the open and closed loop
- controller optimisation

Comprehensive instruction material sets out the fundamentals and provides a step-by-step guide through the experiments.

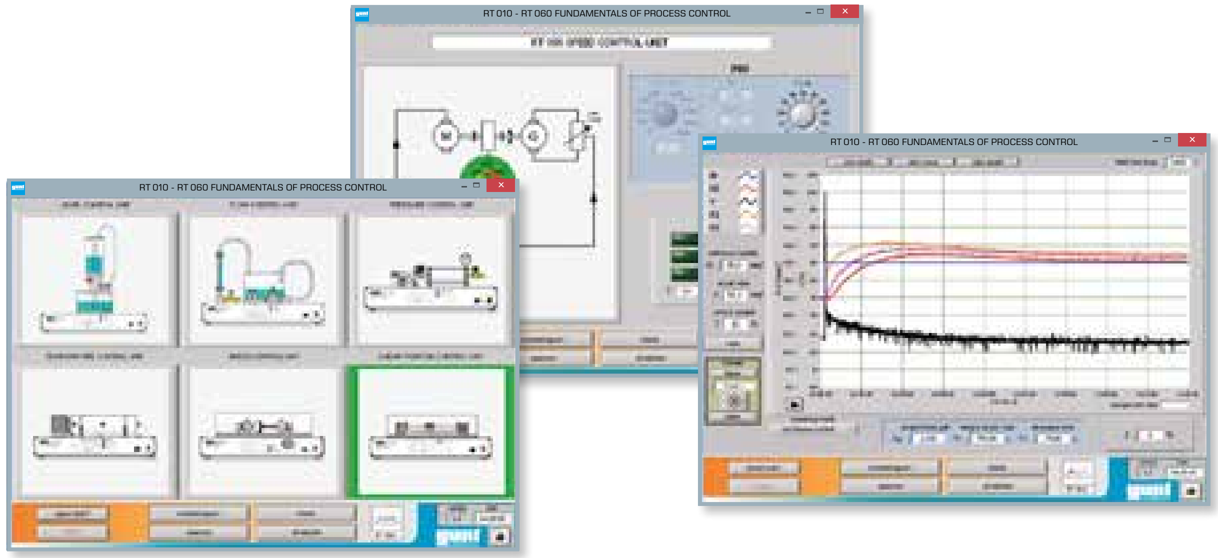
Software

State-of-the-art control and measurement data acquisition software based on LabVIEW for Windows

- software controller in real time, possible with real controlled system or simulation options
- setpoint profiles (programme controller)
- display and storage of all process variables
- network capability
- language switching

Software functionality

- process schematics with online display of all process variables
- user control and parameter setting of the software controllers
- manual control of actuators and disturbance feedforward control
- recording of step responses for system identification
- manual and automatic controller optimisation
- stability tests
- controlled system simulations for simplified system models



Control systems: digital industrial controllers

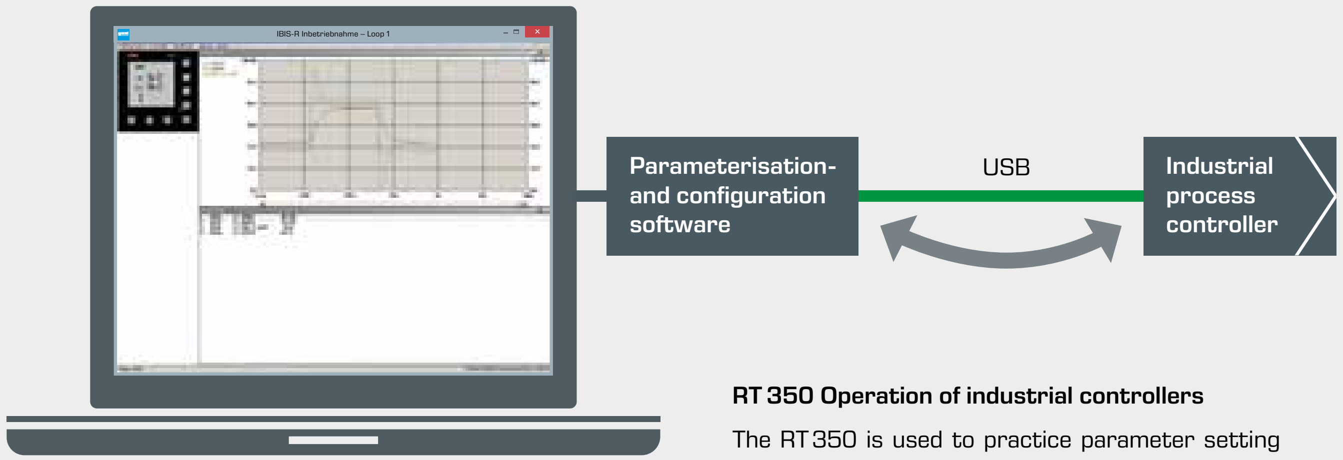
Nowadays most industrial processes are automated. Process controllers are at the heart of the automation of process applications. State-of-the-art digital process controllers offer a level of functionality which would have been inconceivable some years ago. Alongside extensive configuration and parameter setting functions to adapt to the control task, they also permit interconnected networking. Thus, process automation by way of centralised process control systems or distributed control systems (DCS) is possible. The range of equipment on the following pages provides a step-by-step introduction to process automation and process control engineering.

RT 350

Operation of industrial controllers

Simulation of controlled systems; digital controller with freely selectable parameters

- basic concept of an industrial controller
  - operator control levels
  - parameter level
  - configuration level
- learning about basic terminology and methods of process control
  - static and dynamic transfer function
  - step response
  - reference variable step
  - closed control loop
- setting controller parameters
  - setting input and output channels
  - scaling displays
  - using PC-based configuration tools



RT 350 Operation of industrial controllers

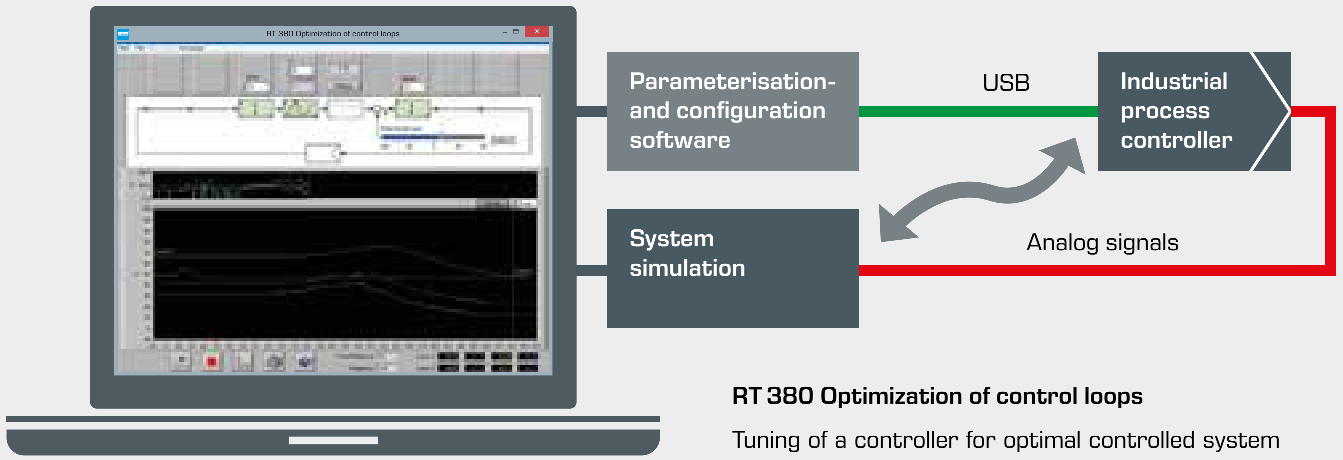
The RT 350 is used to practice parameter setting and configuration of a state-of-the-art process controller. This can be carried out either manually by way of the front panel buttons or from a PC by means of a special software programme via an interface. In this case the controller is linked to the PC by a serial port.

RT 380

Optimization of control loops

Tuning the controller to the controlled system; software simulation of the most common controlled systems

- learning basic terminology and methods involved in process control
  - control loop comprising controller and controlled system
  - difference between open and closed loop control
- adapting the controller to different controlled systems
  - determining the controlled system parameters
  - choosing optimum controller parameters
  - using commonly applied tuning rules
  - investigating control and disturbance response
  - investigating the stability of the closed control loop



RT 380 Optimization of control loops

Tuning of a controller for optimal controlled system performance can be practised with the RT 380. The controller works together with a simulated system model. The simulation is created on a PC using a special software programme. A wide variety of controlled system models is available. A configuration programme enables user-friendly, intuitive parameter setting of the controller from the PC.

RT 450 The modular process automation training system: closed-loop and open-loop control

RT 450 offers you a flexible and versatile learning platform to provide students with a practical introduction to a wide range of topics and issues in the field of process automation. The close interlinking of practical skills with theoretical/analytical aspects promotes thorough learning.

Level control

RT 450.10
Continuous controller module

- functional range of a digital process controller
- configuration, parameterisation and operation via keyboard
- familiarisation with an industry-standard configuration software (RT 450.14, available as an option)
- signal links and standard current signals
- Profibus communication (RT 450.41, available as an option)

RT 450.14
Software for controller configuration

All the functions which can be realized by way of the keyboard of the process controller can also be realized using the IBIS-R+ configuration software.

RT 450.20
Control valve, pneumatically driven, Kvs 0,4

Different control valves are available

- functional range of an electro-pneumatically operated control valve
- recording of the flow rate characteristic during the experiment (flow rate dependent on degree of opening)
- standard current signals and correct electrical wiring and interconnection

RT 450.01
Controlled system module: level

- setting up a level control loop
- comparison of different sensors for level measurement
- level control against trapped-air cushion
- level / flow cascade control (with RT 450.02)

Level sensor, capacitive

RT 450.02
Controlled system module: flow

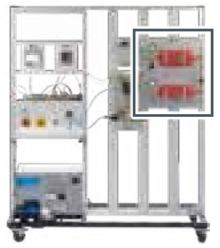
- setting up of a flow control loop
- comparison of different sensors for flow measurement
- level / flow cascade control (with RT 450.01)

Different types of flow rate sensors are available, e. g. electromagnetic

RT 450.03
Controlled system module: pressure

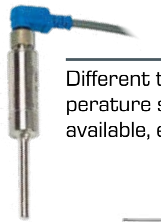
- planning, setting up, testing, optimising and assessing pressure control loops with different objectives and components
  - constructing a 1st order pressure control system
  - constructing a 2nd order pressure control system
- design and function of different instrumentation and control components
- technical terminology and symbols in industrial control engineering
- practical exercises: Implementing process and signal lines
- commissioning and troubleshooting of process engineering systems

Different types of pressure sensors are available



RT 450.04
Controlled system module: temperature

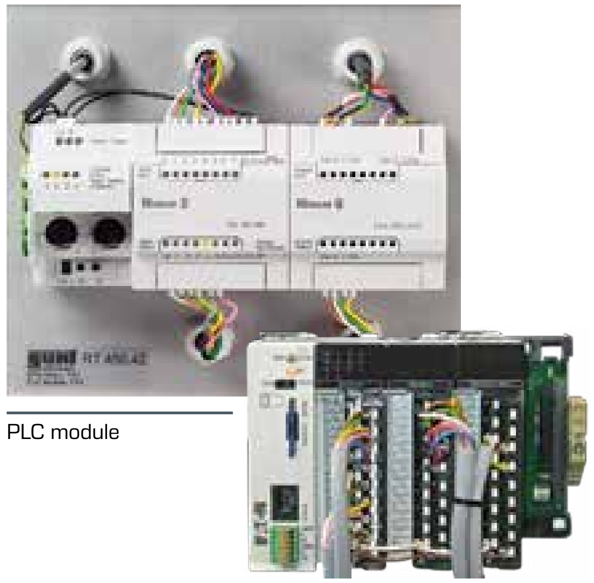
- planning, setting up, testing, optimising and assessing temperature control loops with different objectives and components
- design and function of different instrumentation and control components
- technical terminology and symbols in industrial control engineering
- practical exercises: implementing process and signal lines
- commissioning and troubleshooting of process engineering systems



Different types of temperature sensors are available, e. g. PT 100

RT 450 The modular process automation training system: closed-loop and open-loop control

RT 450.42
PLC module with software



PLC module

- module for exercises using a programmable logic controller (PLC)
- expansion of analog inputs and outputs
- USB interface for programming on computer
- PLC programming software
- programming languages: Statement List (STL), Ladder Diagram (LD), Structured Text (ST), Function Block Diagram (FBD)
- Profibus module (RT 450.43) for communication with network available as an option

Input and output module

- functional range of a PLC
- programming a PLC using included programming software
- electrical connections and signal links
- Profibus communication

RT 450.40
Visualisation software

Computer-assisted communication between automation components over a field bus is a standard approach in industrial control systems.

The RT 450 training system works with Profibus DP. A Profibus card performs the function of the field bus master and serves as the communications interface (CIF). The field bus slaves – in this case the controller module and the PLC module – must likewise be field bus-compatible. The components must be equipped with a Profibus module to facilitate this operation.

Profibus connections on RT 450

Master
Station address 1
FMS/DP CIF50-PB

RT 450.10
Station address 10
DP Slave Protronic/Digitric

RT 450.11
Station address 11
DP Slave Protronic/Digitric

RT 450.42
Station address 20
DP Slave LE4-504-BT1

- principles of communication when using computerised automation over field bus
- familiarisation with the hardware components and wiring
- installation and configuration routines
- using an application
  - closed-loop and open-loop control visualisation software
- familiarisation with the system elements
- Profibus card as communications interface
  - OPC server
  - system configurator

GUNT visualisation software: start menu

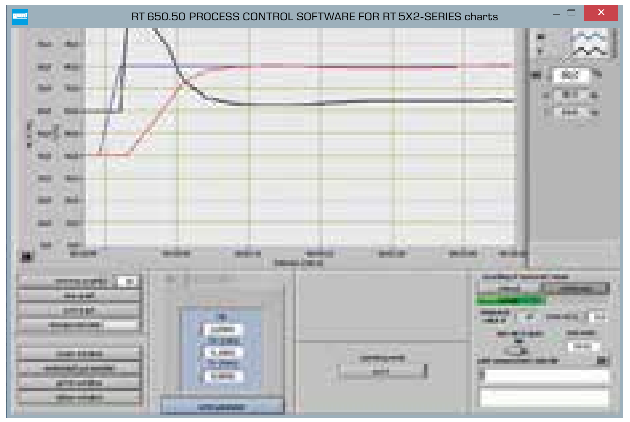


Chart feature to represent time functions in a control system

RT 578
Control of four variables from process engineering

RT 578 Control of four variables from process engineering

The RT 578 facilitates practical learning in the control of four controlled variables which are commonplace in process engineering.

- familiarisation with industrial control loop components
- setup, parameterisation and configuration on the controller
- optimisation of controller settings
- flow rate control
- level control in closed tank with or without counter pressure
- pressure control
- temperature control
- cascade control, level – flow rate
- cascade control, temperature – flow rate
- two-point control, temperature
- plotting step responses

Digital controller

The trainer uses an industrial compact controller for the instrumentation of single control loops. Internally, it has a total of four individual controllers, which can be used independently from each other.

Digital recorder

Three-channel paperless recorder to record the control processes.

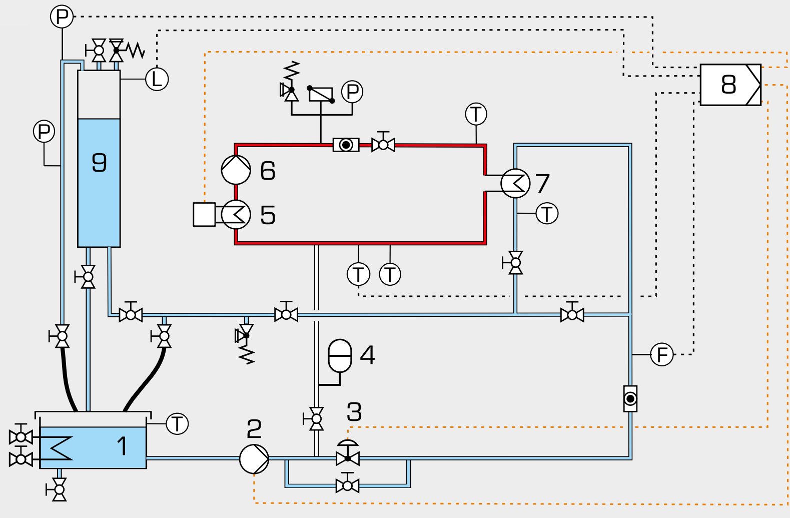
The trainer has three different actuators:

Heater	Pump	Control valve
electrical screw-in cartridge for direct heating of water with a thermostat for temperature limitation	a multiple stage centrifugal pump, speed adjustable with frequency converter	electrically controlled, with pneumatic actuator drive, characteristic: equal percentage

In all control loops, two different actuators are available for solving control engineering tasks.

Data acquisition

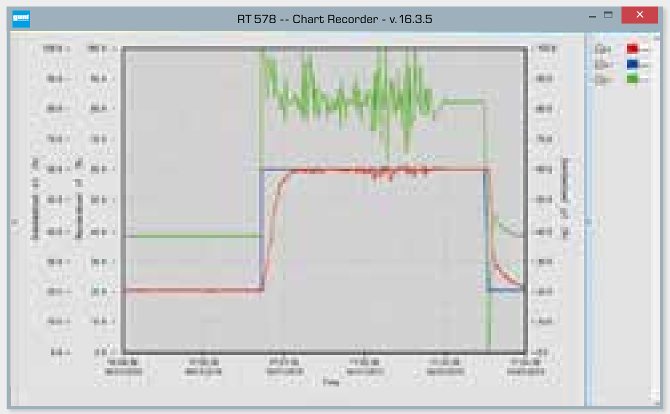
Process schematic



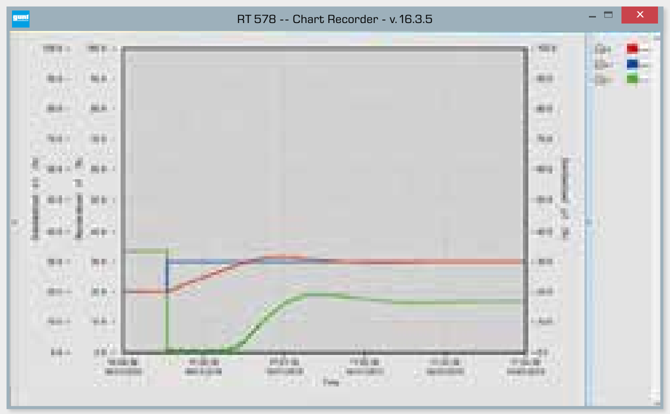
1 collecting tank, **2** pump, **3** control valve, **4** expansion vessel, **5** heater, **6** heating circuit pump, **7** heat exchanger, **8** controller, **9** graduated tank; **F** flow rate, **P** pressure, **L** level, **T** temperature

Experiment 1: Level control in the tank

Experiment 2: Flow rate control



Experiment 3: Pressure control in a closed tank



Experiment 4: Temperature control in a heating circuit

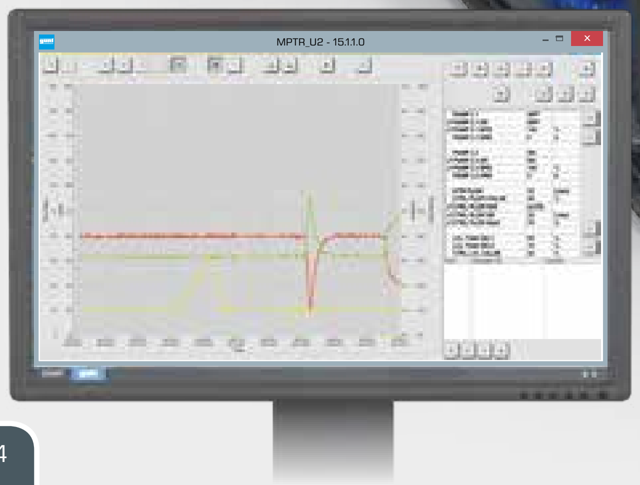
Distributed control systems

MPTR
Main Process Training Rig

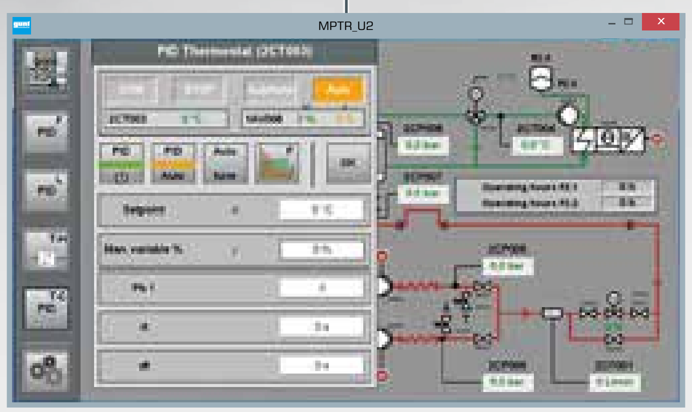
Training plant for pipeline and pump systems, with **distributed control system**

L x W x H: 8,0 x 3,5 x 2,5 m

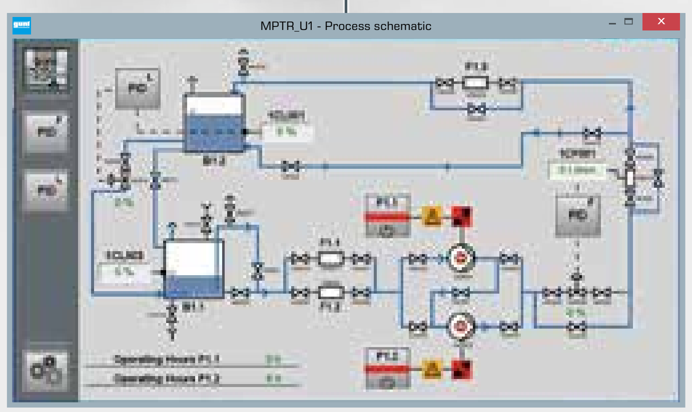
- two different water circuits
- complex process control system
- plant operation and maintenance



Data acquisition via software: time curve



Operation via touchscreen



Process schematic

13 Digitisation Industry 4.0 <–> Education 4.0

Digitisation
Industry 4.0 <–> Education 4.0

Industry 4.0 is the term that has been adopted to describe the 'fourth' industrial revolution currently underway, at present, in the manufacturing and commercial sectors of our society. It optimizes the computerization of industry 3.0 by successfully combining high performance computing, the internet and the development of advanced manufacturing technologies.

Key factors are:

- internet of things and the cloud
- autonomous equipment and vehicles
- robots
- additive manufacturing (3D printing)

Industry 4.0 is changing the way the world's most successful companies produce the products that their global customers demand.

These same companies are also concerned with how to upskill their current workforce to take on new tasks made possible by Internet 4.0 and to recruit new employees with the right skills.

Education should pave the way for Industry 4.0 to fully exploit the potential of cyber-physical systems in the future.

Topics included in this unit

- Remote laboratories
- Industry 4.0 in the process industry
- CAD Virtual engineering and CAD/CAM

Level 3
Level 4
Level 5

How can GUNT help?

Different from other chapters in this catalogue, we cannot offer concrete learning outcomes on the topic digitisation. Therefore we cannot simply advise by offering certain experimental units. Rather is this topic digitisation part of the GUNT development philosophy and you can find digitisation in many elements and aspects throughout the entire GUNT programme.

GUNT as a company with its own R&D facilities and ultra-modern manufacturing production is on the Industry 4.0 track already for many years. Please use this particular chapter to discover the GUNT Industry / Education 4.0 philosophy. We would like to help you to develop ideas and support your teaching preparation by giving examples and ideas on the following pages.

Topics

- advanced manufacturing technology
- virtual engineering
- CAD/CAM

Learning outcomes

- recognise a range of advanced manufacturing processes and cite examples of where they are most effective
- evaluate the concept of the next industrial revolution to determine the impact on both manufacturers and the consumer

Modern digitisation techniques help to enhance your teaching process

Remote laboratories

Remote laboratories allow students to perform experiments on laboratory units over the internet without being near the actual equipment.

In a traditional proximal laboratory, the user interacts directly with the equipment by peforming physical actions (e. g. manipulating with the hands, pressing buttons, turning knobs) and receiving sensory feedback (visual, audio and tactile). In a remote laboratory, this same interaction takes place at a distance with the assistance of the remote infrastructure that is responsible for conveying user actions and receiving sensory information from the equipment.

On the user's side, the remote infrastructure provides a user interface that allows the experimental unit to be monitored and operated, while it also ensures that only one user can use an experiment at a time.

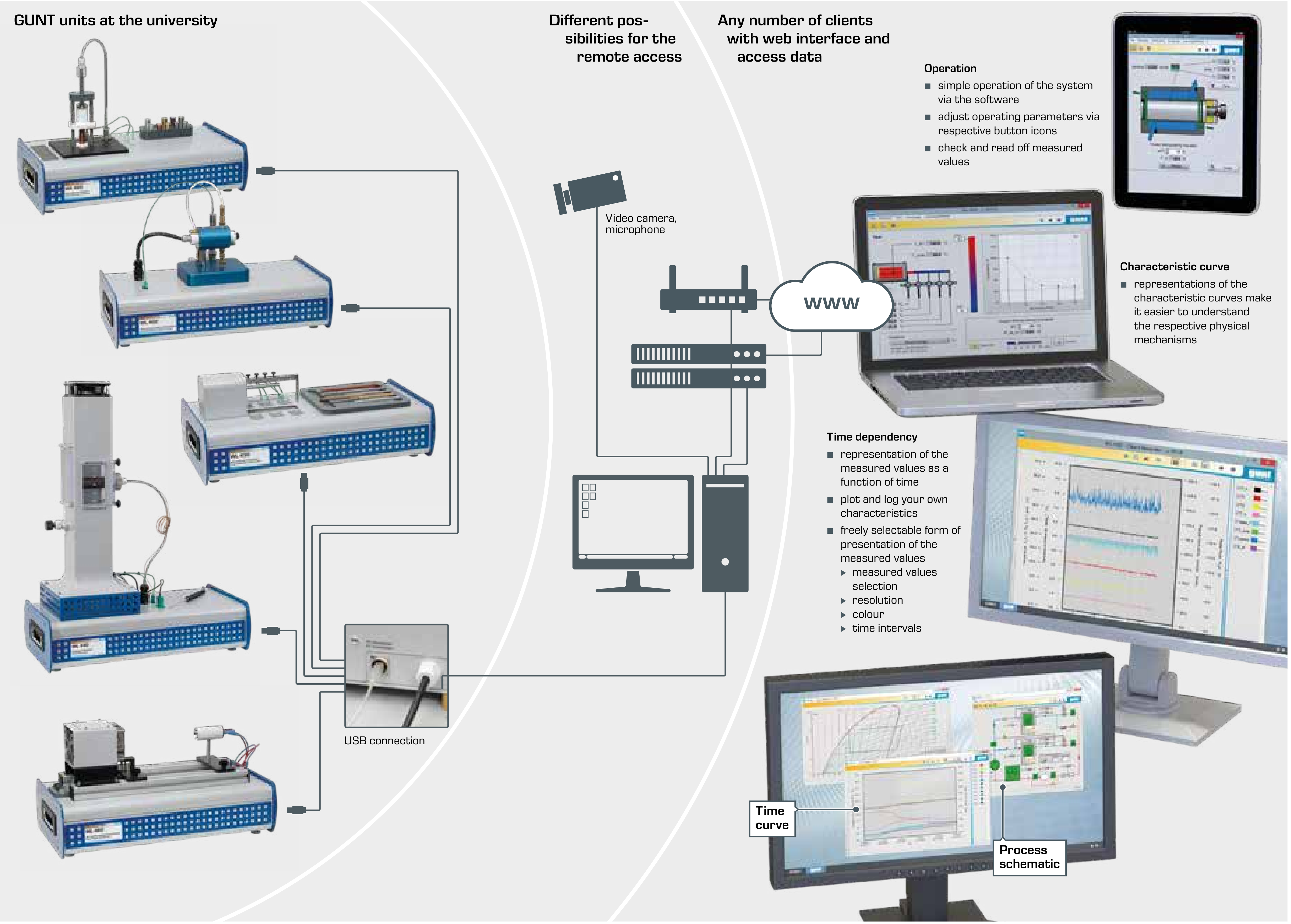
On the equipment side, the remote infrastructure:

- monitors the experimental unit, e. g. through the use of video cameras, microphones and other sensors
- controls the experimental unit, e.g. through the use of I/O interfaces, motors or other actuators
- ensures that the system is 'cleaned up' at the end of a user's session by automatically resetting the experimental unit or putting it into a stable state.

Core of a remote infrastructure is the remote access, e. g. a remote desktop, which ensures the connection to access your work computer from anywhere. There are several possiblities how to set up the remote access. The customer decides which way he prefers and is responsible for the remote infrastructure of his laboratory.

GUNT teaching units form the backbone of a remote lab. These teaching units are for example:

- ET 915-Series: training system for refrigeration and air conditioning technology
- WL 110-Series: thermal processes in heat exchangers
- GUNT-Thermoline: fundamentals of heat transfer
- GUNT-Labline: fluid machinery



Digitisation on industrial level

GUNT teaching and training units – with latest real world automation and communication systems

Our devices reproduce industrial reality: in doing so the reduced scale is the crucial factor The larger the scale of a device, the more realistic the results of the experiment. The smaller the scale, the more flexible the handling of the device. GUNT supplies devices for both cases. Please find two examples on this page: one table-top unit, small, didactically orientated. The second one a shop-floor unit, totally focused on Industry 4.0 elements, professional orientated.

CE 704 Sequencing Batch Reactor (SBR) Process

The unit is equipped with a modern, digital process controller, with multiple HMI layers and touch panel use. That introduces you to the real word in process automation, getting a closer idea about what digitization means.

The process controller performs the following functions:

Representation of the process variables as a time curve

Displaying process variables

Operation of the aeration

Display and calibration of the pH sensor

The digital process controller operates via touchscreen and displays continuously the measured values and the speed of the stirring machine.

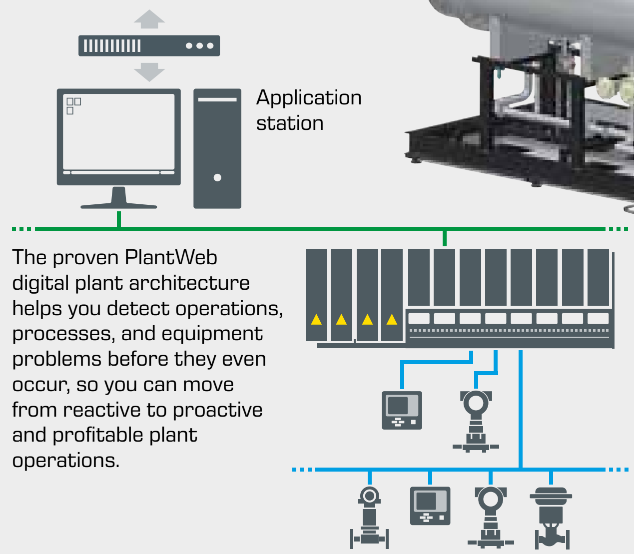
Table-top unit

WaXTOT Wellhead & Xmas-Tree Operation Trainer

This training plant serves for operation and maintenance training for professional staff in an oil/gas industrial working environment. All details of the plant are on latest industrial level, fully authentic to modern field systems. The control system used is Emerson Delta V, very common in process and energy industry. Such a plant control system is a master piece of connecting the world of process automation in any modern aspect, talking on Ind. 4.0 and Digitisation: **Leading the digital transformation.**

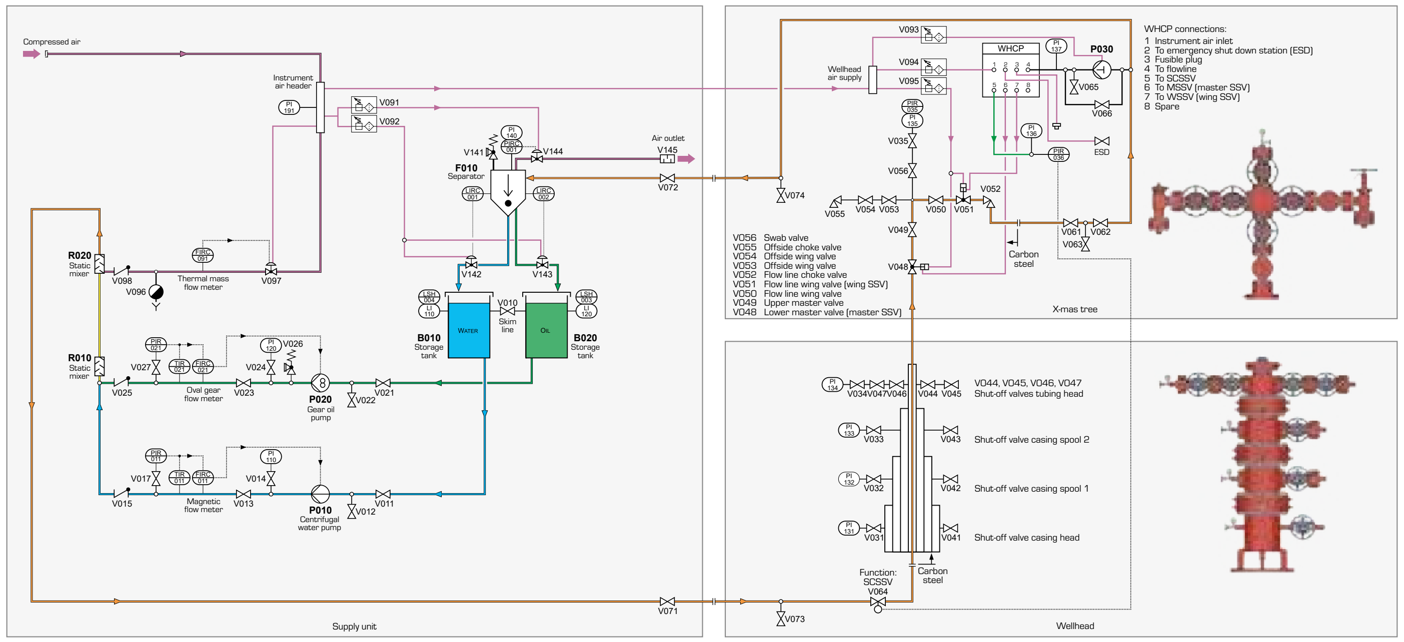
Shop-floor unit

The DeltaV Architecture
Improve plant performance with PlantWeb



The proven PlantWeb digital plant architecture helps you detect operations, processes, and equipment problems before they even occur, so you can move from reactive to proactive and profitable plant operations.

The entire trainer is controlled by a PLC / HMI control system.



Modern digitisation techniques help to enhance your teaching process

Virtual engineering and CAD/CAM

The work of an engineer increasingly involves the use of powerful software modelling tools (virtual modelling). These tools allow us to predict potential manufacturing difficulties, suggest how a product or component is likely to behave in service, and undertake rapid and low cost design iteration and optimisation, to reduce costs, pre-empt failure and enhance performance.

The GUNT Media Center

A platform providing digital information on products in different formats and files

- access via internet
- password protected

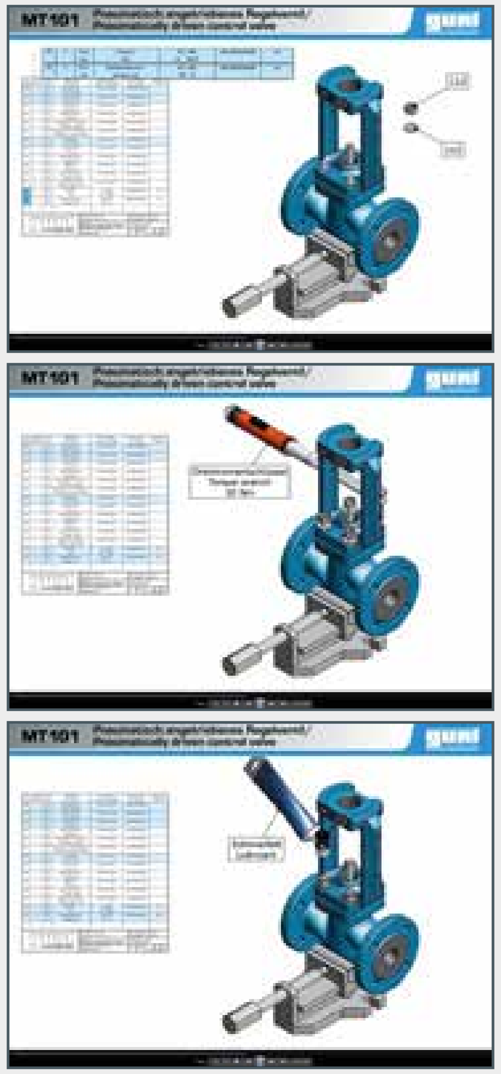
Design files

- 2D and 3D CAD files in addition to the hardware in different formats
- solid modelling
- 3D printing

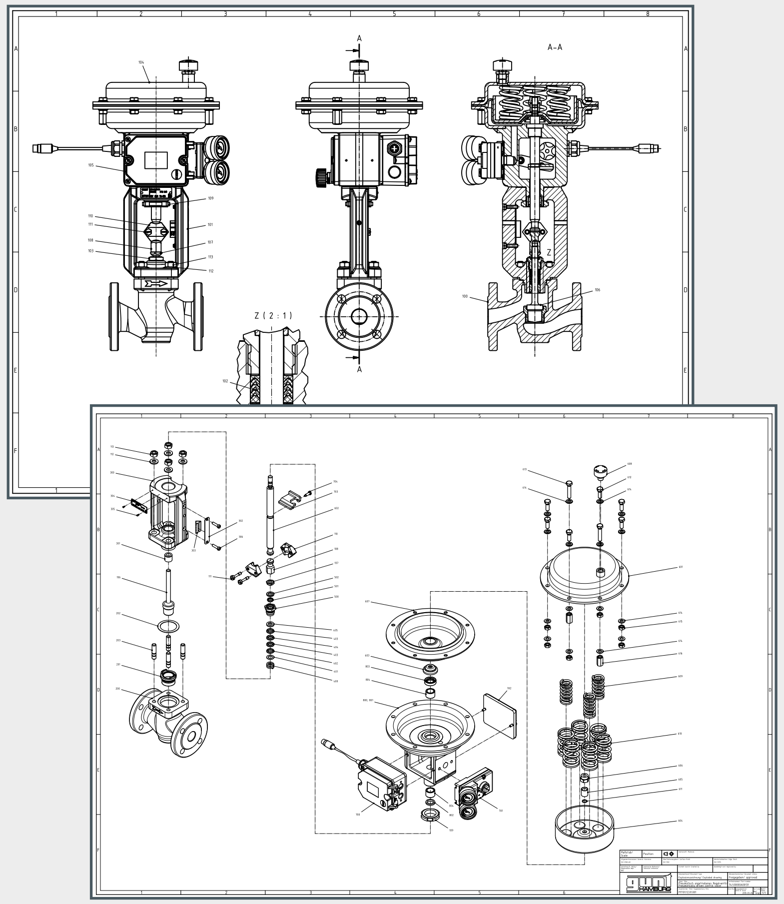
Digital information on the pneumatically driven control valve MT 101

3D CAD files directly via internet browser

Videos of assembly and disassembly

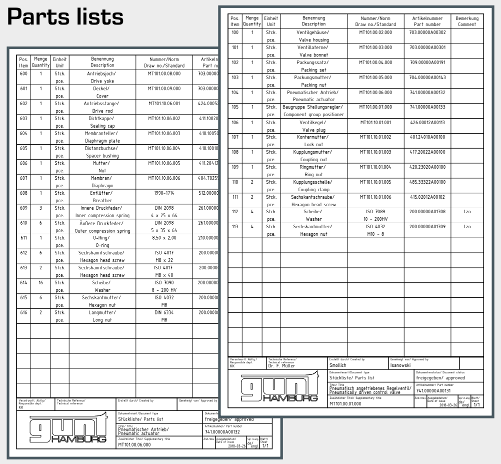


2D drawings



exploded drawings

Parts lists



The complete GUNT programme – equipment for engineering education

Engineering mechanics and engineering design

- statics
- strength of materials
- dynamics
- machine dynamics
- engineering design
- materials testing

Mechatronics

- engineering drawing
- cutaway models
- dimensional metrology
- fasteners and machine parts
- manufacturing engineering
- assembly projects
- maintenance
- machinery diagnosis
- automation and process control engineering

Thermal engineering

- fundamentals of thermodynamics
- thermodynamic applications in HVAC
- renewable energies
- thermal fluid energy machines
- refrigeration and air conditioning technology

Fluid mechanics

- steady flow
- transient flow
- flow around bodies
- fluid machinery
- components in piping systems and plant design
- hydraulic engineering

Process engineering

- mechanical process engineering
- thermal process engineering
- chemical process engineering
- biological process engineering
- water treatment

2E Energy & environment

Energy

- solar energy
- hydropower and ocean energy
- wind power
- biomass
- geothermal energy
- energy systems
- energy efficiency in building service engineering

Environment

- water
- air
- soil
- waste

Planning and consulting · Technical service
Commissioning and training

Allocation of exemplary units to the corresponding chapter of this catalogue

Chapter	Level 3 based on information of BTEC Level 3 Nationals in Engineering	Level 4 based on information of BTEC Level 4 Higher National Certificate in Engineering	Level 5 based on information of BTEC Level 5 Higher National Diploma in Engineering
1 **Mechanical Principles**	Unit 5: Mechanical Principles and Applications Unit 11: Further Mechanical Principles and Applications Unit 12: Applications of Mechanical Systems in Engineering Unit 18: Advanced Mechanical Principles and Applications	Unit 8: Mechanical Principles	Unit 36: Advanced Mechanical Principles Unit 62: Strength of Materials
2 **Materials, Properties and Testing**	Unit 10: Properties and Applications of Engineering Materials Unit 37: Structure and Properties of Metals	Unit 7: Machining and Processing of Engineering Materials Unit 9: Materials, Properties and Testing Unit 10: Mechanical Workshop Practices	
3 **Engineering design**	Unit 3: Engineering Design Unit 16: Engineering Drawing for Technicians	Unit 1: Engineering Design	
4 **Maintenance engineering**	Unit 17: Computer Aided Drafting in Engineering Unit 19: Mechanical Measurement and Inspection Techniques Unit 44: Engineering Maintenance Procedures Unit 49: Installing and Commissioning Engineering Equipment	Unit 18: Maintenance Engineering Unit 32: CAD for Maintenance Engineers	
5 **Thermodynamics, heat engines and thermofluids**	Unit 14: Principles and Applications of Thermodynamics	Unit 13: Fundamentals of Thermodynamics and Heat Engines Unit 30: Operations and Plant Management	Unit 38: Further Thermodynamics Unit 64: Thermofluids
6 **Heating, ventilation and air conditioning (HVAC)**	Unit 35: Ventilation and Air Conditioning Design in Building Services Engineering Unit (6188): Heating and Ventilating	Unit 9: Principles of Heating System Design & Installation Unit 10: Principles of Ventilation & Air conditioning Design & Installation	Unit 62: Heating, Ventilation and Air Conditioning (HVAC)
7 **Fluid mechanics**	Unit 13: Principles and Applications of Fluid Mechanics	Unit 11: Fluid Mechanics Unit 30: Operations and Plant Management	Unit 64: Thermofluids
8 **Industrial services and systems**	Unit 24: Industrial Process Measurement Unit 47: Industrial Plant and Process Control Unit 49: Installing and Commissioning Engineering Equipment	Unit 30: Operations and Plant Management	Unit 45: Industrial Systems Unit 53: Utilisation of Electrical Power Unit 63: Industrial Services
9 **Renewable energy**	Unit 51: Electrical Technology	Unit 5: Renewable Energy	Unit 44: Industrial Power, Electronics and Storage Unit 51: Sustainability Unit 53: Utilisation of Electrical Power
10 **Mechatronics, electrical and electronic principles, fault finding**	Unit 6: Electrical and Electronic Principles Unit 45: Monitoring and Fault Diagnosis of Engineering Systems Unit 60: Electronic Fault-finding	Unit 6: Mechatronics Unit 19: Electrical and Electronic Principles Unit 31: Electrical Systems and Fault Finding	Unit 52: Further Electrical, Electronic and Digital Principles
11 **Electro, pneumatic and hydraulic systems**	Unit 15: Electro, Pneumatic and Hydraulic Systems and Devices	Unit 29: Electro, Pneumatic and Hydraulic Systems	
12 **Instrumentation, control systems, automation, and distributed control systems**	Unit 24: Industrial Process Measurement Unit 25: Selecting and Using Programmable Controllers Unit 47: Industrial Plant and Process Control Unit 50: Industrial Process Controllers	Unit 15: Automation, Robotics and Programmable Logic Controllers (PLCs) Unit 16: Instrumentation and Control Systems Unit 20: Digital Principles	Unit 41: Distributed Control Systems Unit 42: Further Programmable Logic Controllers (PLCs) Unit 45: Industrial Systems Unit 54: Further Control Systems Engineering
13 **Digitisation**		Unit 23: Computer Aided Design and Manufacture (CAD/CAM)	Unit 37: Virtual Engineering Unit 50: Advanced Manufacturing Technology

Product overview

Product overview

Equipment for engineering education

G. Systemes Didactiques E. s.a.r.l.

Equipement pour l'enseignement expérimental, scientifique et technique

www.systemes-didactiques.fr

GSDE 181 rue Franz Liszt
F 73000 CHAMBERY
Tél : 04 56 42 80 70   Fax : 04 56 42 80 71
xavier.granjon@systemes-didactiques.fr

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