

Energy Efficiency in Building Services Engineering

1.7

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Basic Knowledge Energy Efficiency in Building Services Engineering



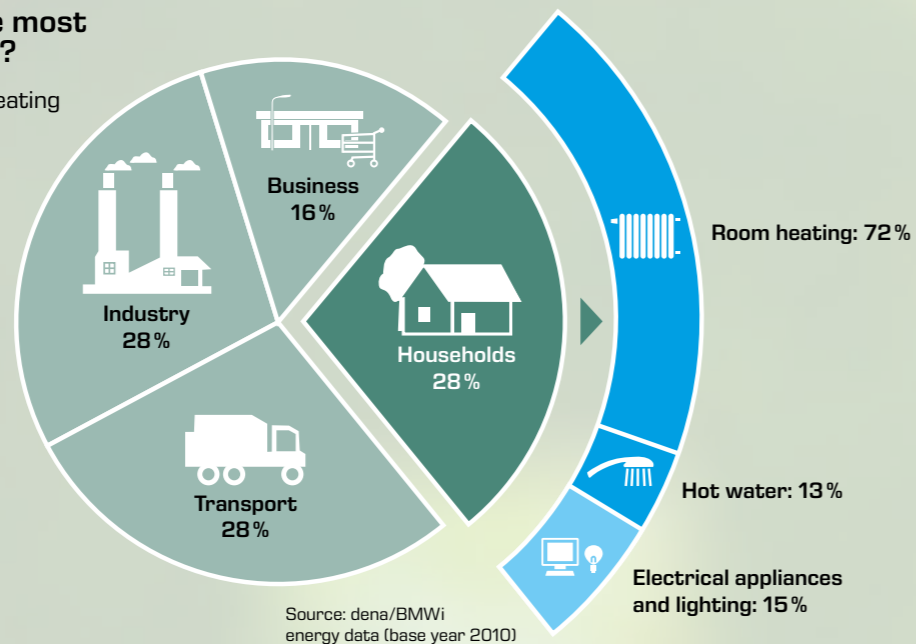
Climate protection through increased energy efficiency in building services engineering

Efforts to encourage climate protection through the use of renewable energies can only be successful if, at the same time, all measures to increase energy efficiency are consistently used. Since the main proportion of globally-consumed energy relates to the supply of buildings, this area offers enormous potential for delivering a significant contribution in reducing the use of primary energy through energy efficiency increases. Measures

which result in a building using energy more efficiently involve nearly all the areas of modern building services engineering. In addition to consumption by electronic equipment, lighting and water heating, these include in particular consumption by heating, ventilation and air conditioning. As can be seen from the diagram using Germany as an example, the field of heat supply for buildings represents a major energy consumer.

Who consumes the most energy in Germany?

Energy consumption of heating often underestimated



Based on our 2E curriculum, we offer you teaching equipment from the following subject areas to allow you to focus on energy efficiency in building services engineering:

Heat supply
and air conditioning

Inclusion of
renewable energies

Energy efficiency
in business and industry

We believe that knowledge in these subject areas is indispensable for engineering students and professionals in the field of building services engineering in order to create sustainable and energy-efficient buildings, and to convert existing buildings to be more energy-efficient.



Structural and technical techniques for resource conservation

Structural and technical measures are needed in order to reduce the primary energy demand in buildings. Heat insulation and the use of transparent façades, for example, are some of the possible structural measures. This area is becoming increasingly important in the training of architects, urban planners and construction engineers.

Efficient components and systems, controlled by means of modern building services engineering, are at the forefront of technical measures for heating optimisation. Taking modern concepts for combined heat and power, distributed power grids and energy storage into account, it is possible to achieve energy production and distribution which is optimally adapted to demand.

Standards for energy efficiency in building services engineering

Directives have been passed by the European Parliament on energy efficiency in buildings. Below is an excerpt from Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings:

[...] (3) Buildings account for 40% of total energy consumption in the Union. The sector is expanding, which is bound to increase its energy consumption. Therefore, reduction of energy consumption and the use of energy from renewable sources in the buildings sector constitute important measures needed to reduce the Union's energy dependency and greenhouse gas emissions. Together with an increased use of energy from renewable sources, measures taken to reduce energy consumption in the Union would allow the Union to comply with the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC). [...]

To implement the EU Directive in Germany, the energy efficiency of buildings is categorised in the energy efficiency classes A to G in an energy certificate in accordance with the German Energy Efficiency Act. Buildings are classified according to the specific primary and final energy demand. For highly-efficient passive houses, the annual energy demand is well below 50kWh/m².



Subject Areas Heat Supply and Air Conditioning



Subject Areas

2E0 Products

Significant savings can often be achieved just through simple measures and the more conscious use of energy. In the field of building heating, the necessary energy can be reduced by more than 80% through a combination of measures in some cases. These include improved insulation materials, optimised hydronic balancing of radiators and the use of more modern, controlled circulation pumps.

Since the energy consumption required to cool buildings is becoming an increasingly important factor in warmer regions of the world, and due to generally rising average temperatures, our building services engineering teaching equipment also covers this area. Further efficiency improvements in air conditioning are possible, for example, with new materials and the intelligent control of combined systems for heating and cooling.

Thermal insulation and heat recovery

- WL 376**
Thermal Conductivity of Building Materials
- WL 110**
Heat Exchanger Supply Unit

Efficient heating technology

- HL 305**
Hydronic Balancing of Radiators
- HM 283**
Experiments with a Centrifugal Pump
- HL 630**
Efficiency in Heating Technology

Air conditioning

- ET 340**
Building Automation in Heating and Air Conditioning Systems
- ET 630**
Split System Air Conditioner

Basic Knowledge

Thermal Insulation and Heat Recovery



Improving the thermal insulation of walls and roofs is only one possible measure towards energy savings in buildings. An economic assessment requires an analysis of the savings to be expected through reduced heat losses in each individual case.

Heat transport

Temperature differences result in the transport of thermal energy. Transport takes place in the direction of the lower temperature. There are three different heat transport processes:

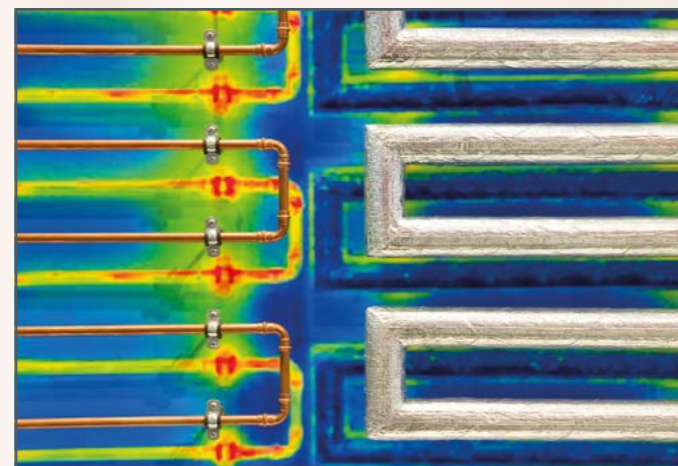
- heat conduction
- convection
- heat radiation

Enabling heat transport with as little obstruction as possible, or suppressing heat transport, are crucial in providing an efficient heat supply for buildings.

If a heat transfer medium is used for transporting heat (forced convection), then an unimpeded intake at the heat source and an unimpeded heat dissipation at the place of use are the ideal. However, heat dissipation should be suppressed as much possible during the actual transport.

In the case of heating for rooms, heat dissipation out of the room being used and into adjacent areas should be prevented. Besides the heat transfer surface, the heat conduction properties of the heat transfer material are a key factor for heat transfer which is as unobstructed as possible. Heat conduction is typically expressed as a coefficient of thermal conductivity.

In contrast, construction materials for suppressing heat dissipation are usually described by the overall heat transfer coefficient. This also includes the thermal resistance of the adjacent air layers.



The insulation of heat transfer conduits also provides a significant contribution to energy efficiency.

Heat recovery

Processes in which the residual heat of a mass flow is used after its primary use are referred to as heat recovery. The heat gained in this way would otherwise be wasted without heat recovery.

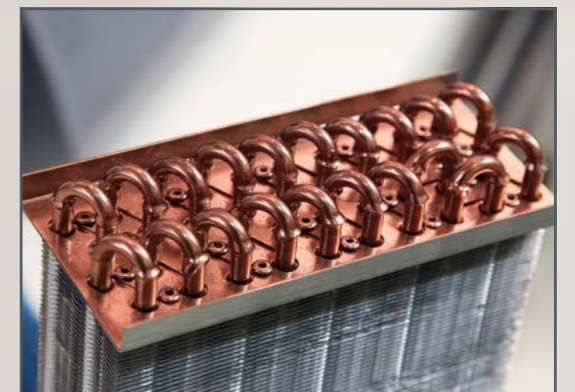
The greatest energy savings potential from heat recovery comes from heating and ventilation systems. In addition, heat recovery systems are conceivable in principle in many other supply and disposal processes in building services engineering.

Heat demand of a passive house

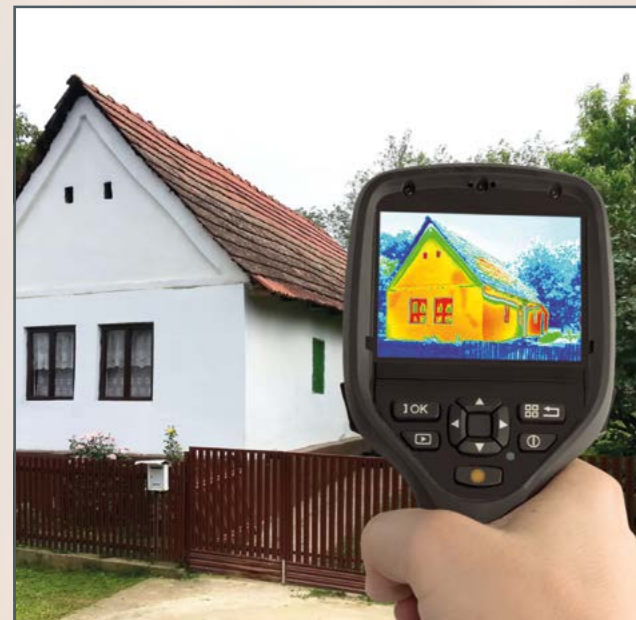
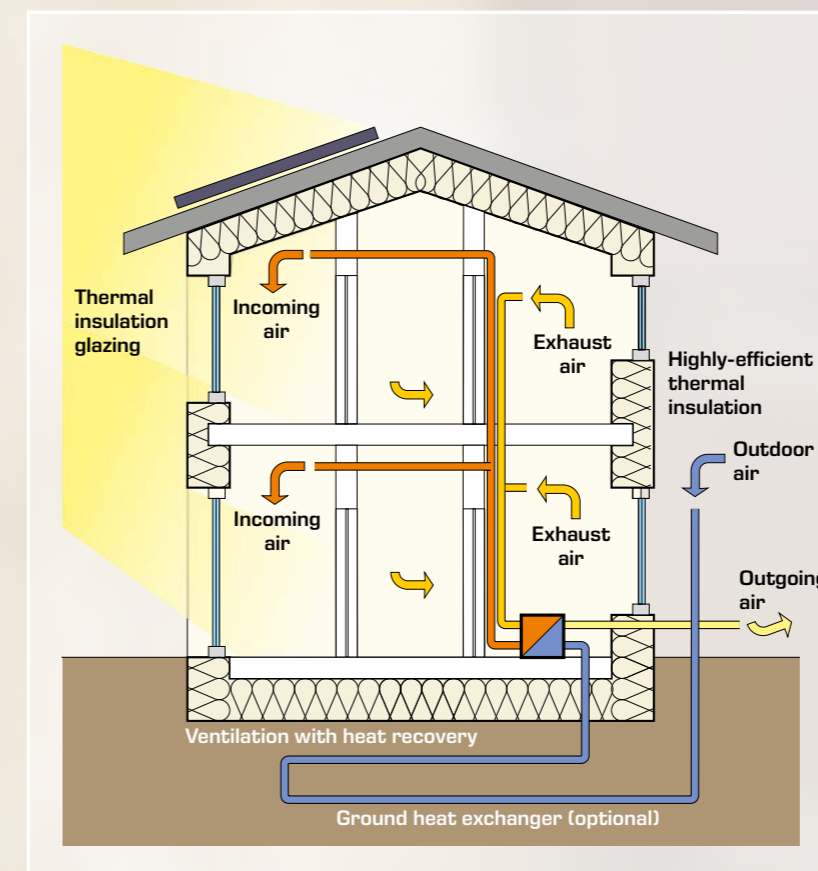
In buildings known as passive houses, the heat demand is reduced by up to 90% by thermal insulation and heat recovery compared to typical houses in existing building stock. Highly effective insulating materials and triple glazing are used in passive houses. One particularly efficient measure is heat recovery from the ventilation system's exhaust air.



In larger buildings in particular, the optimisation of ventilation technology often results in huge savings opportunities in the year-round energy demand for heating and air conditioning.



In so-called circuit compound systems, two separate air-to-water heat exchangers are employed in order to use the heat contained in the exhaust air to heat the incoming air.



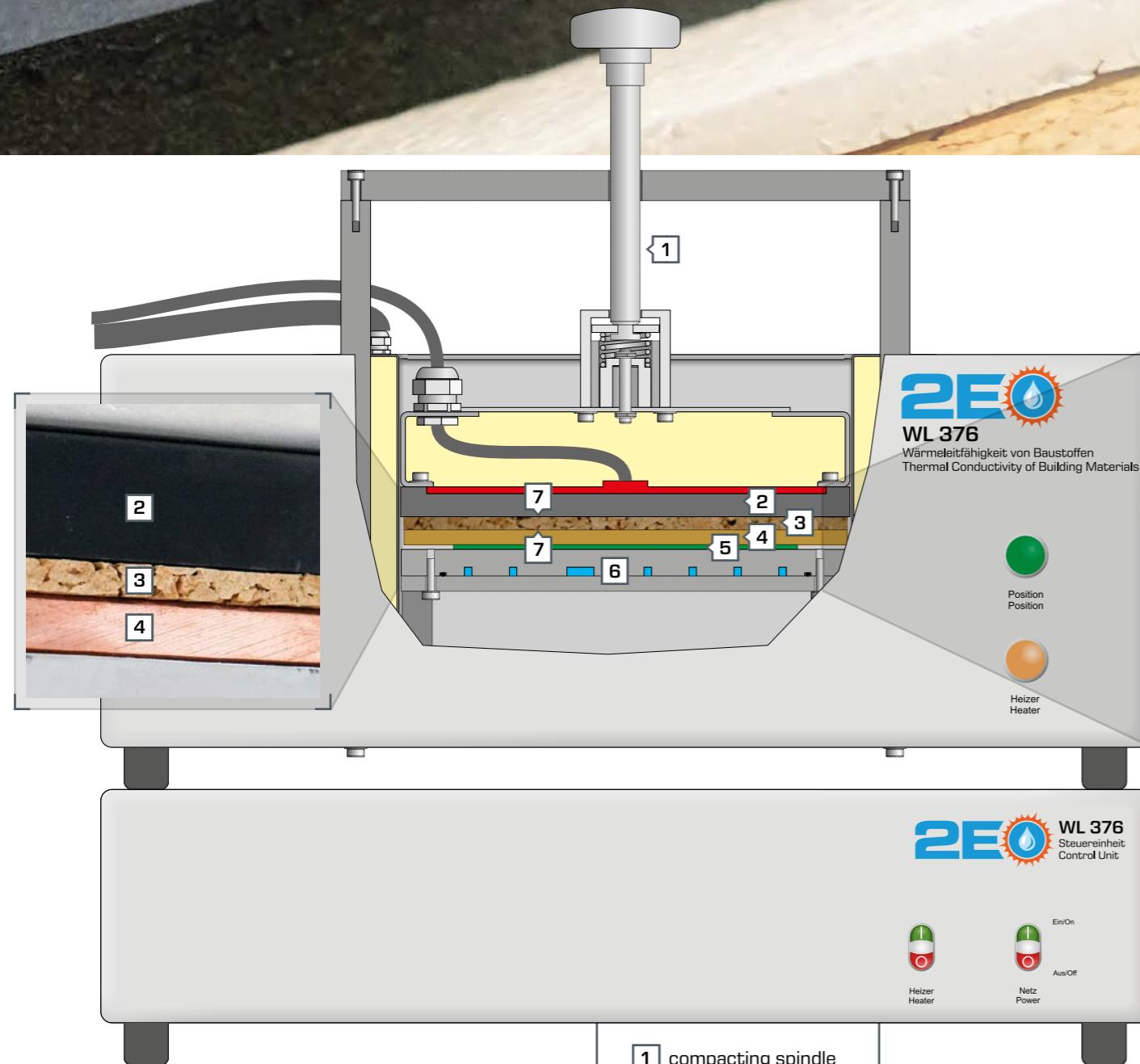
A lack of insulation in old buildings can lead to heat leakages. These problem areas can be detected by means of sensitive infrared cameras based on the emitted heat radiation. It is not just the heat conduction of materials, but also how they are fabricated that determine the effectiveness of insulation in walls and heat transfer conduits.



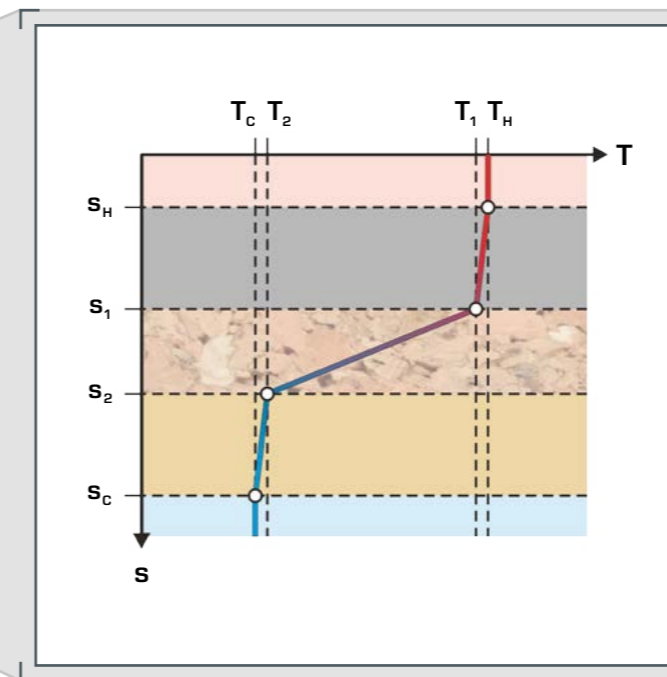
WL 376 Thermal Conductivity of Building Materials

This experimental device allows you to conduct experiments on steady-state heat conduction in non-metallic materials such as polystyrene, PMMA, cork or plaster according to DIN 52612. You can place flat samples between a hot plate and a water-cooled plate, apply a

reproducible clamping force with the compacting spindle and adjust the heat contacts. The special heat flux sensor is used to measure the actual heat flux and to regulate the temperatures of the hot and cold plate by means of the integrated software controller.



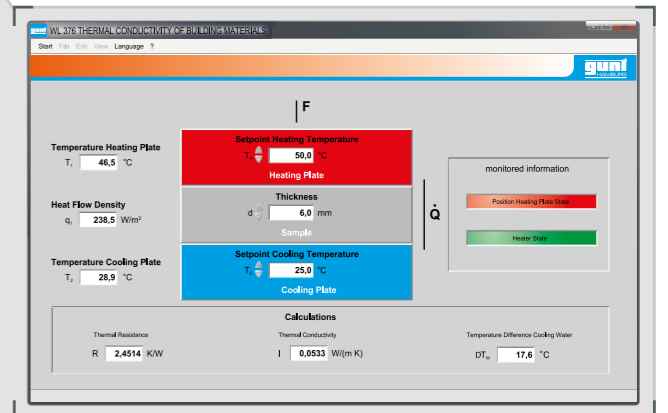
- 1 compacting spindle
- 2 hot plate
- 3 sample
- 4 clamping plate
- 5 heat flux sensor
- 6 cold plate
- 7 temperature sensor



The analysis of the experimental data clearly shows the temperature gradients across the cork material. The hot plate, clamping plate and cold plate only show very small temperature gradients due to the much higher thermal conductivity of copper.

Software

The GUNT software for WL376 detects the measurement data via USB and offers extensive options for analysing and displaying the results.



Learning objectives

- determination of the thermal conductivity k of different materials
- determination of the thermal resistance
- thermal conductivity k of several specimens connected in series (up to a thickness of 50 mm)



WL 110-Series Modular Heat Exchangers



Experiments on the fundamentals of heat transfer

Clear, simple, reliable, learning progress monitoring



Didactic advantages

Ideally suited for student-led experiments

A small group of 2-3 students can easily and independently conduct a variety of experiments. The lecturer can present characteristic aspects of the heat exchanger using software for data acquisition and a projector connected to the computer. The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

Supply unit for heat exchangers WL 110 with WL 110.03 Shell and Tube Heat Exchanger



WL 110.04 Jacketed Vessel with Stirrer & Coil



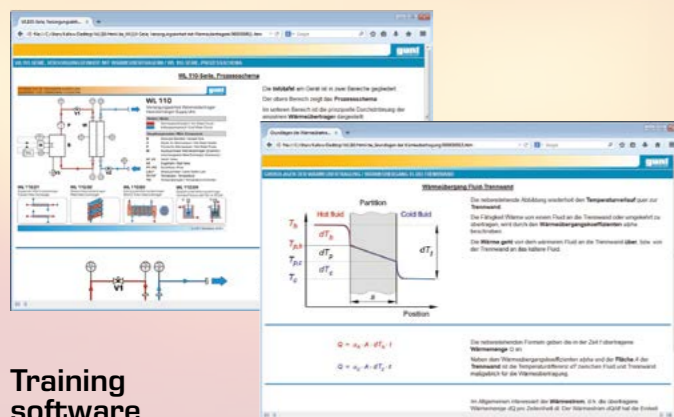
WL 110.03 Shell & Tube Heat Exchanger



WL 110.02 Plate Heat Exchanger



WL 110.01 Tubular Heat Exchanger



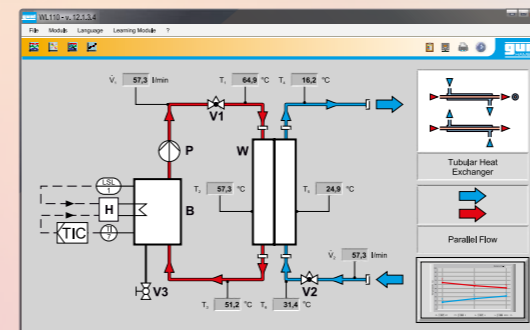
Training software

Our training software, specially developed for this equipment series, provides a multimedia-based and interactive course of study on the fundamentals of heat transfer and on operating the WL 110 series. Didactically thought-out test questions at the end of the course allow you to review students' learning progress directly on the PC.



WL 110.20 Water Chiller for WL 110

The cold water required for all experiments is usually provided by the laboratory supply. If the ambient temperature of the laboratory is too high, we recommend using the water chiller to obtain meaningful experimental conditions. Hot water is also needed for the experiments. It is provided by the WL 110 supply unit.



Software

The software for WL 110 has the following main features:

- measurement of temperatures and flow rates
- operation in parallel flow or counterflow
- calculation of the mean heat transfer coefficient
- calculation of the heat fluxes

Learning objectives

- function and operational behaviour and different heat exchangers
- plotting temperature curves
 - ▶ in parallel flow mode
 - ▶ in counterflow mode
- calculation of the mean heat transfer coefficient
- comparison of different heat exchanger types

Basic Knowledge Efficient Heating Technology



Considerable savings possibilities, without any reduction in comfort, are often possible in modern heating systems through more efficient components and a demand-based supply of heat.

Significant efficiency gains can be achieved in heating technology using modern circulation pumps or by hydronic balancing of installed heating systems, for example. Our educational equipment on heating technology helps you to teach the detailed knowledge necessary to achieve significant energy savings through a suitable combination of various measures.

Energy-efficient circulation pumps

A heating pump ensures that each radiator is supplied with hot water. Standard pumps with an electrical output of 45 to 90 watts are often still being used even in newer buildings. These circulation pumps are preconfigured according to the amount of water in the heating system – regardless of the actual heating demand. This is very inefficient and consumes a lot of electricity unnecessarily. Modern circulation pumps on the other hand, are adjusted to demand by means of the differential pressure, thereby saving up to 80% of electricity costs for heating alone.



High-efficiency heating circulation pumps provide the same capacity as conventional pumps while consuming up to 80% less power.

Optimisation through hydronic balancing

Hydronic balancing adjusts the flow rates of the hot water through all radiators or heating circuits of a surface heater to a certain value. As a result, each room is supplied with the amount of heat required to achieve the desired room temperature at a certain feed flow temperature at the heating system operating point. Hydronic balancing also ensures that the return feeds on all radiators have the same temperature.

Thermostatic valves for demand-based room heating

Before the widespread introduction of thermostatic valves, the only option for adjusting individual room temperatures was often to open the windows. This approach was naturally associated with considerable energy losses. Nowadays, however, thermostatic valves are widely used and allow the heat supply to be adjusted according to demand.

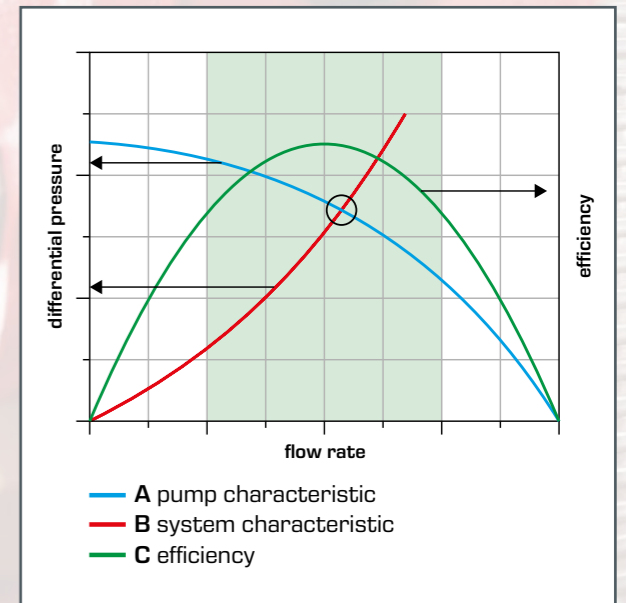
Thermostatic valves are mechanical temperature controllers which permit the flow of a heat transfer fluid depending on the ambient temperature. A valve ensures a lower or higher flow rate in order to keep the temperature of the surrounding space constant.

Design of the heating system

When designing heating systems, it is important to make sure that the components used are well matched to each other. Typical characteristics of the pump and the piping system help with this. This is shown in the diagram by way of example. The efficiency of the pump (C) is also plotted. The operating point of a system is determined by the intersection of the pump characteristic (A) and the system characteristic (B). The operating point should be as close to the central region of the pump characteristic as possible to ensure good efficiency.

Heating system operation under varying heat demand

Naturally, the performance capacity of a heating system should cover the maximum heat demand from room heating and hot water supply in winter. Nevertheless, in order to keep year-round energy demand to a minimum, it is essential to create adaptive heating systems for a highly fluctuating energy demand. In addition to an intelligent control system, factors such as adequate storage and an appropriate mix of renewable heat sources where possible are important.



Ideal operating point of a heating system

Heating controller

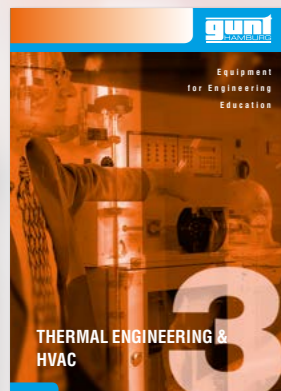
The central element of modern heating systems is the heating controller. The heating controller measures the outdoor temperature and the room temperature, and from these it calculates the house's heat demand by means of the heating curve. The feed flow temperature needed to cover the heat demand is adjusted by the flow rate of the circulation pump and/or the position of the mixing valve.

In most cases, hot water is also supplied with heating energy via the boiler. In this regard, the controller switches the charging pump on as required.

In addition to using efficient components and optimising systems, a key element for the long-term reduction of energy demand is regular monitoring of the proper functioning of the system. Nowadays, modern and inter-linkable heating controllers greatly facilitate system monitoring.



Checking the system components



Many of the fundamental themes of heating technology are also covered by a wide selection of educational systems from our catalogue 3.

Catalogue 3
Thermal Engineering and HVAC

HL 305 Hydronic Balancing of Radiators

Typical heating problems, most of which are based on an insufficient hydronic balancing, are sometimes incorrectly dealt with even by professionals. The widely-adopted but usually ineffective measures include:

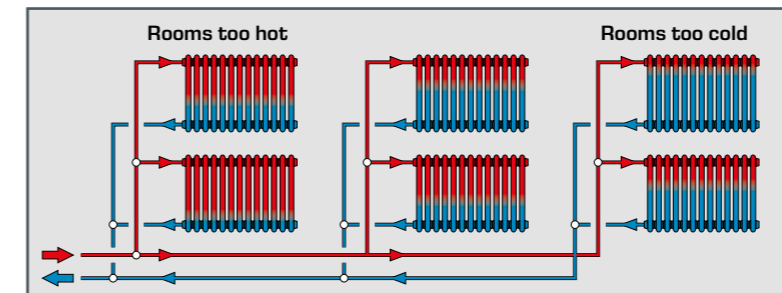
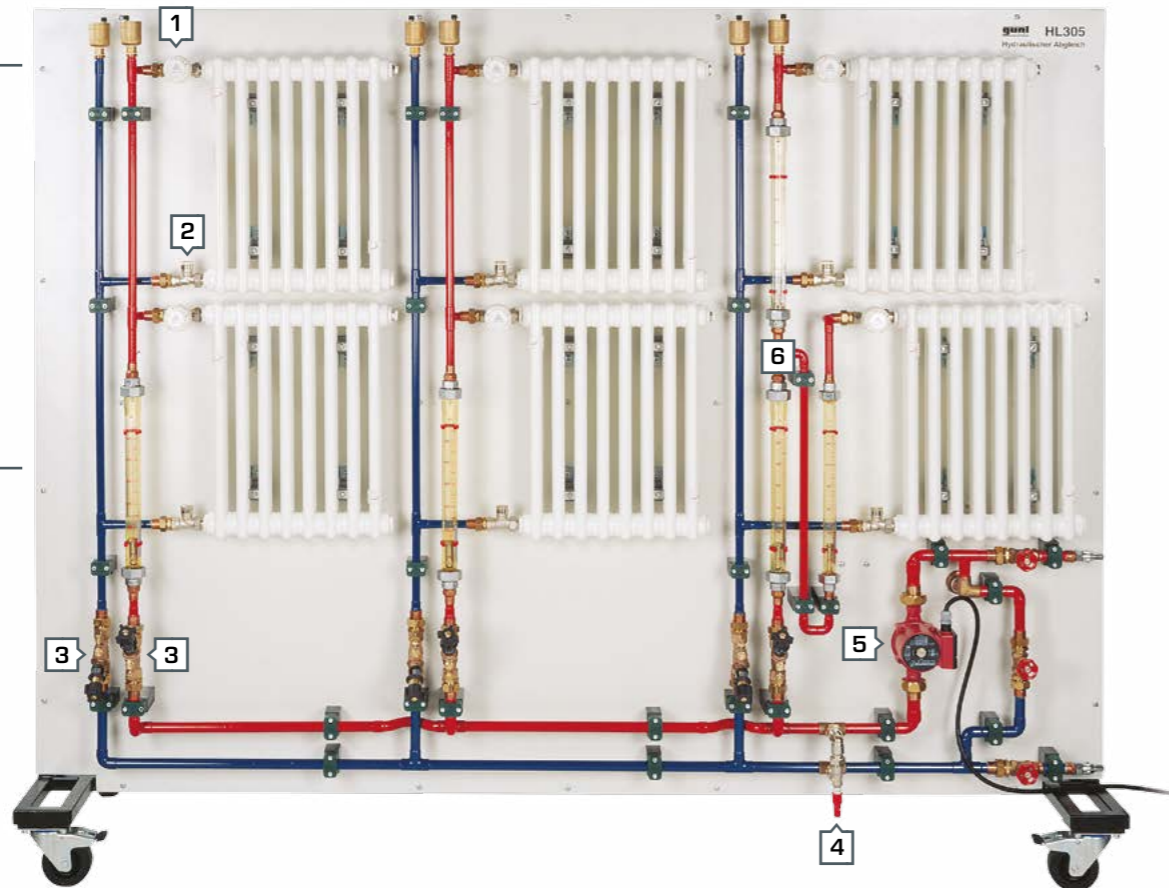
- increasing the feed flow temperature
- increasing the pump power
- bringing the reheating time forward

These measures are associated with additional energy losses and thus impair the efficiency of the heating system to a considerable extent. It is estimated that, in Germany, the hydronic balancing of heating systems is inadequate in up to 90% of all cases. The resultant potential for improving energy efficiency is therefore considerable.

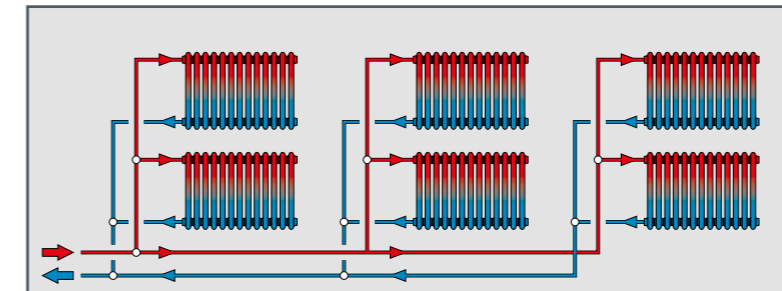
This demonstration unit allows you to teach the essential fundamentals of heating technology for energy-efficient room heating. The demonstration unit contains commercially available components and consists of three heating sections with radiators, thermostatic valves and a circulation pump. The flow rates in all three sections can be adjusted separately. As a result, hydronic balancing of the sub-sections amongst themselves is possible. Within a section, lockshield valves enable separate radiators to be balanced. A differential pressure relief valve is integrated in the circuit parallel to the circulation pump. This valve limits the pressure drop across the piping system to a predetermined range.

Hydronic balancing is used to limit the amount of water which is available within a heating system for each radiator. The aim is to ensure that, at a specific operating point of the heating system, each room is supplied with exactly the amount of heat needed to achieve the desired room temperature. The figure below shows the distribution of heat in a heating system before and after hydronic balancing.

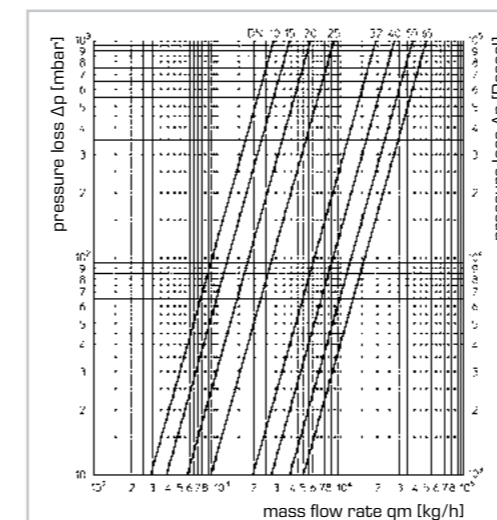
- 1 thermostatic valve
- 2 lockshield valve
- 3 balancing valve
- 4 differential pressure relief valve
- 5 pump
- 6 flow meter



Temperature distribution in radiators without hydronic balancing



Temperature distribution in radiators with hydronic balancing leads to uniform room temperatures



Our instructional material contains all the relevant information about the HL 305 demonstration unit. Using the valve capacity diagrams included it is possible to determine and carry out the required settings for hydronic balancing.

Learning objectives

- optimisation of heat distribution in heating systems
- effects from changing pipe network resistances
- use of:
 - ▶ balancing valves
 - ▶ programmable thermostatic valves
 - ▶ differential pressure relief valves

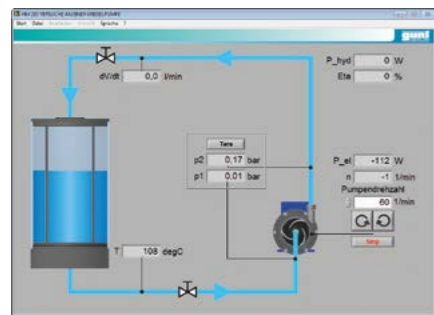
Product No.
065.30500
More details and technical data:
gunt.de/static/s3416_1.php



HM 283

Experiments with a Centrifugal Pump

Centrifugal pumps are used in many modern heating systems as circulation pumps and can therefore make a significant contribution to energy savings. The efficiency of a centrifugal pump is defined by the ratio of the hydraulic power generated in the respective operating point to the electrical power used. With HM 283, you can investigate the underlying factors affecting operation of a centrifugal pump. The experiments focus on both the operating behaviour under varying flow rates and pressure differences, and the power balance.



Software

The clear software included with HM 283 displays the key measured variables continuously. The logged measured values can be saved for analysis. This supports you while carrying out experiments.

Learning objectives

- principle of operation of a centrifugal pump
- relationships between head, flow rate and speed
- recording pump characteristics and determining the pump efficiency

Product No.
070.28300

More details and technical data:
gunt.de/static/s3556_1.php



HL 630

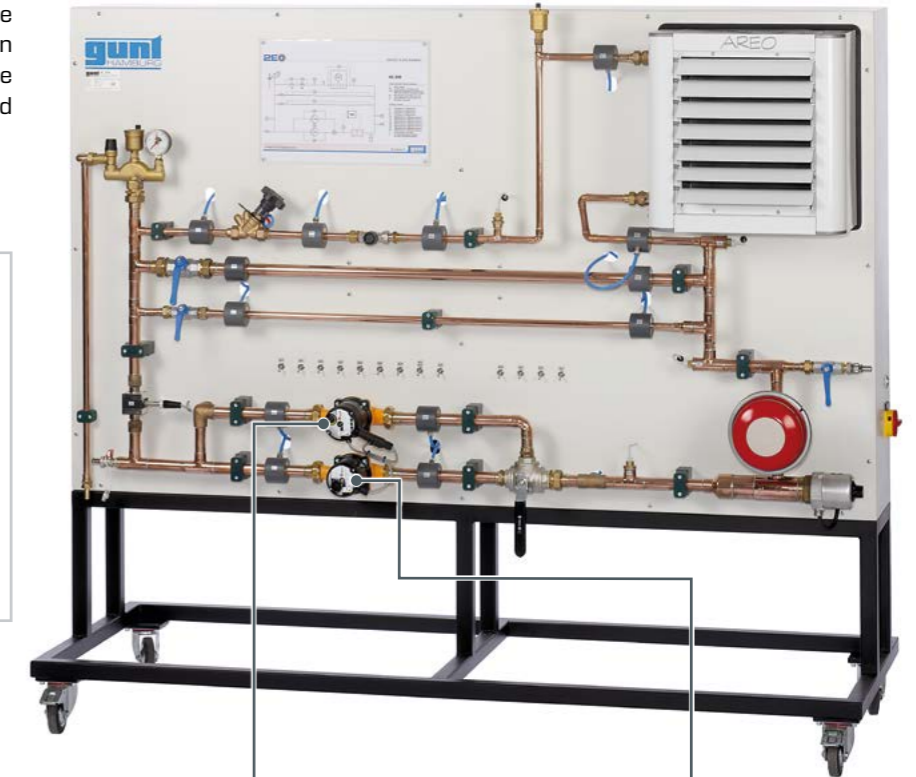
Efficiency in Heating Technology

HL 630 allows further experiments on energy efficiency in heating technology. The HL 630 unit provides you with a trainer including a complete heating circuit. In addition to the circulation pump, a heat source and a heat sink, the device also includes various pipe sections, valves and fittings and safety elements.

Software

The software included with HL 630 displays the temperatures, pressure differences and the electrical power consumption of the pumps in the process schematic.

As such, it is possible to clearly teach both the influence of modern, high-efficiency pumps and the drawbacks of incorrectly-sized pipe sections.

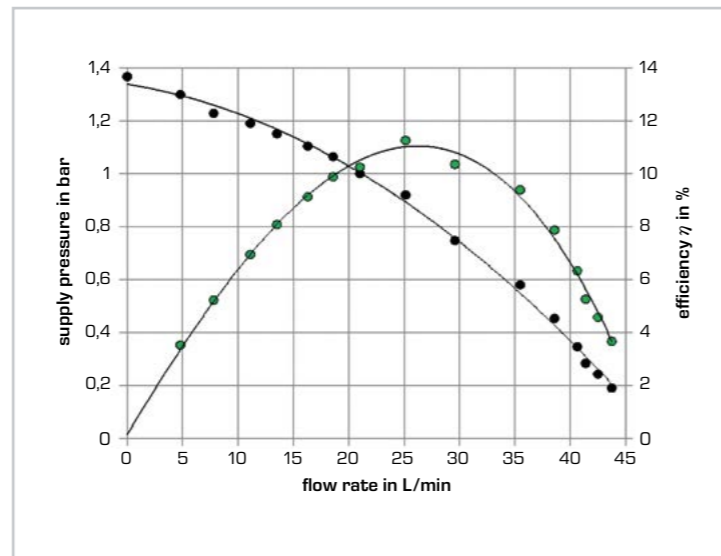


Learning objectives

- comparison of conventional and differential pressure controlled circulation pumps
- determining pump efficiency
- recording of system and pump characteristics
- pressure losses at various pipe diameters, valves and fittings

Product No.
065.63000

More details and technical data:
gunt.de/static/s3597_1.php



In the case shown here, the energy balance results in maximum efficiency at a flow rate of 25L/min.



Non-controlled circulation pump with selectable speed (efficiency class C)

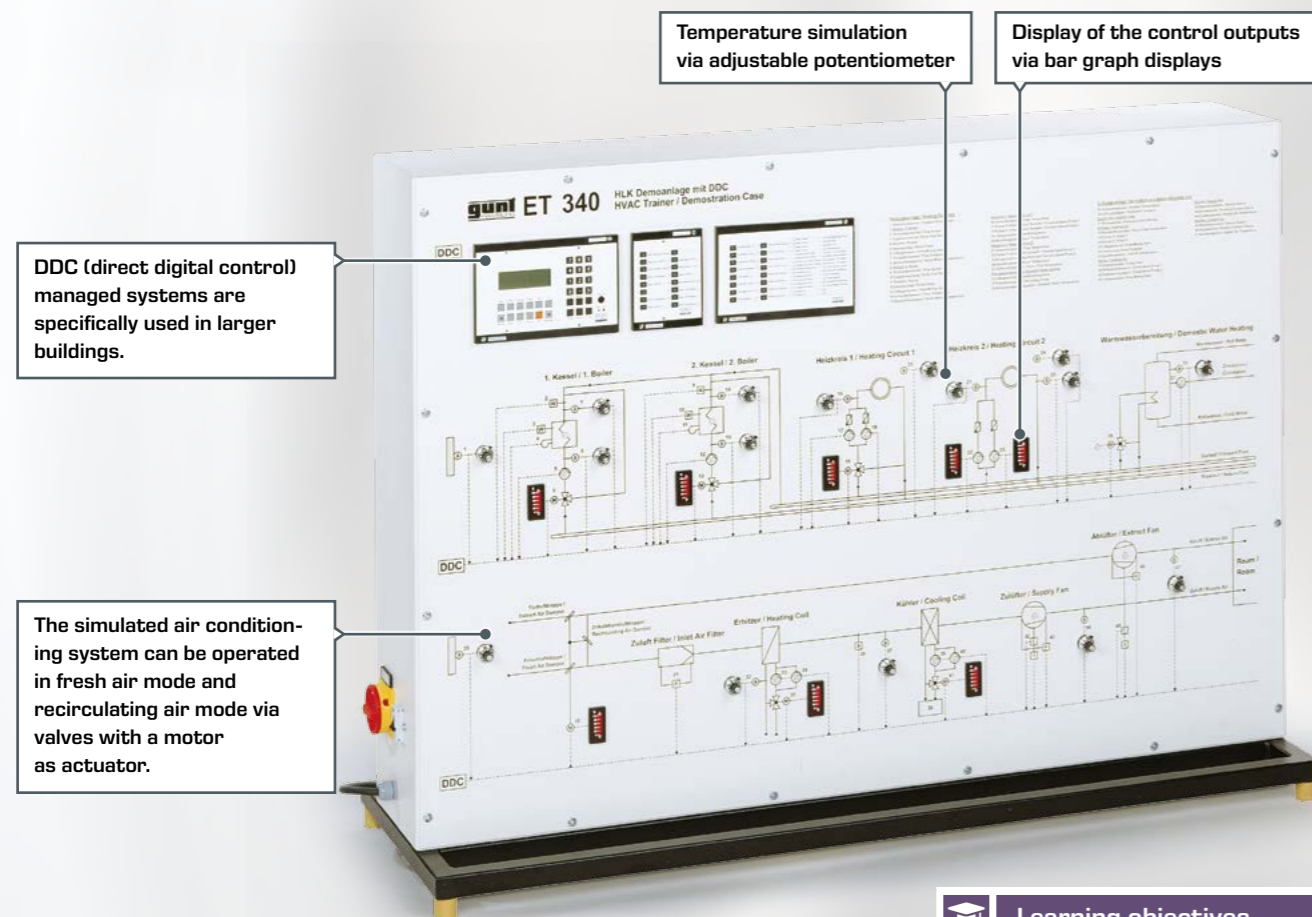


Energy-efficient circulation pump with adjustable differential pressure control (efficiency class A)

ET 340 Building Automation in Heating and Air Conditioning Systems

The ET 340 unit allows you to teach the programming of DDC-controlled (Direct Digital Control) heating and ventilation systems. To this end, this trainer simulates a heating circuit with domestic water heating and a ventilation/air conditioning

system with mixed air control. Different operating conditions and control systems can be simulated. Furthermore, it is possible to simulate faults in the system and to observe the system's resulting behaviour.



Software

In addition to manually operating the controller, the DDC's configuration software allows you to create and save modified or new controller programs.

Product No.
061.34000
More details and technical data:
gunt.de/static/s3237_1.php



Learning objectives

- operation and programming of a DDC
- effects of temperature changes on the operating behaviour of a
 - heating system
 - air conditioning system
- fault finding in a
 - heating system
 - air conditioning system
- safety devices

ET 630 Split System Air Conditioner

Energy consumption for room air conditioning has risen sharply in recent years. ET 630 contains all the necessary components to enable you to teach the design and function of air conditioning units in as practical a way as possible.

The device consists of an inner unit and an outer unit. The inner unit includes a heat exchanger with fan, which acts as an evaporator in the refrigeration circuit in cooling mode. In heating mode, on the other hand, the heat exchanger operates as a condenser. The outer unit includes a compressor, an additional heat exchanger, an expansion valve and a changeover switch for the operating mode (cool/heat).



Heat flux in cooling mode

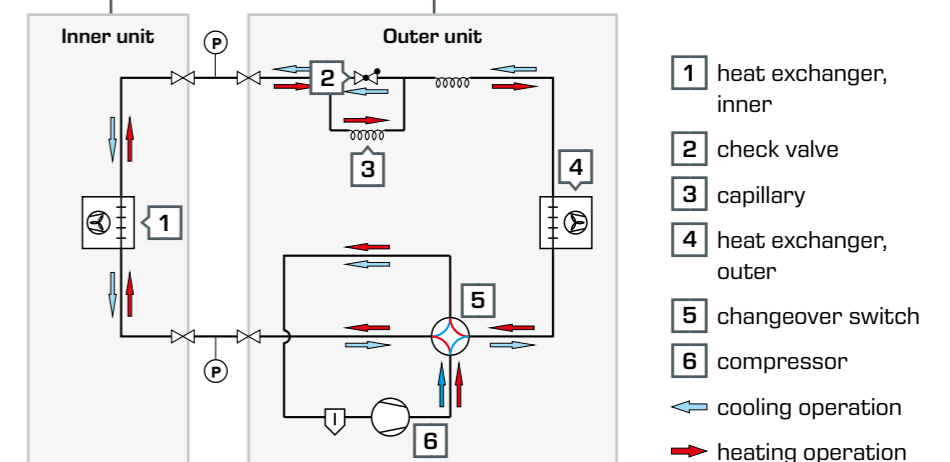
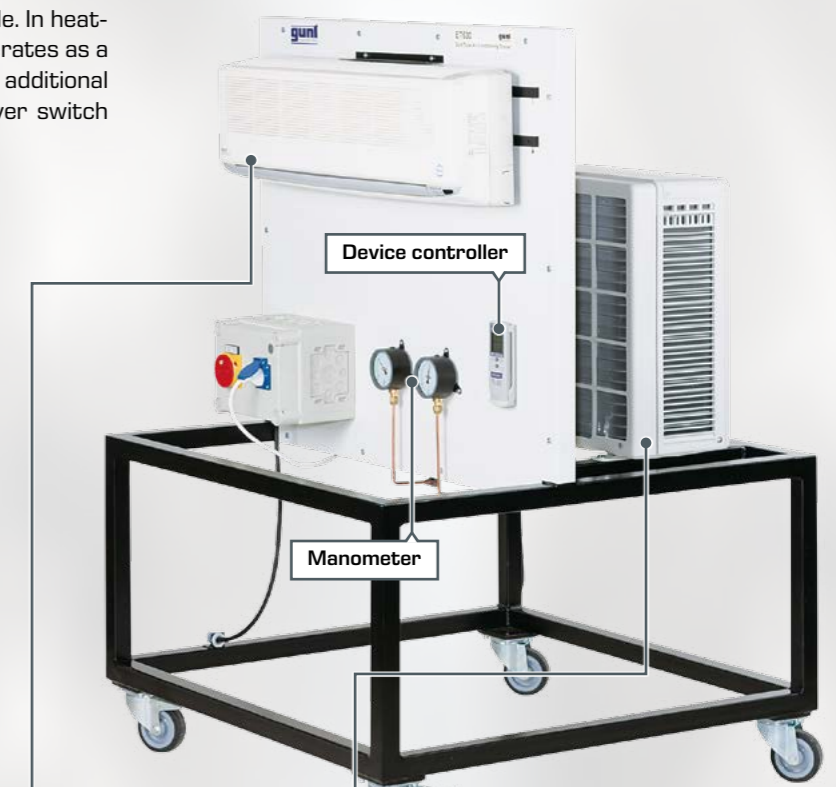
Learning objectives

- design and function of a split unit air conditioner
- basic operating modes:
 - cooling, dehumidification, heating, ventilation, automatic
- additional functions:
 - shutdown after a few hours, slat position at the air outlet, timer for switching on and off
- system control by remote control

Product No.
061.63000
More details and technical data:
gunt.de/static/s3469_1.php



Operating mode, fan stage of the inner unit and desired room temperature are all selected by remote control via the device controller. During automatic operation the actual room temperature is measured and an operating mode automatically selected to achieve the specified room temperature.



Schematic representation of the ET 630

Subject Areas Inclusion of Renewable Energies

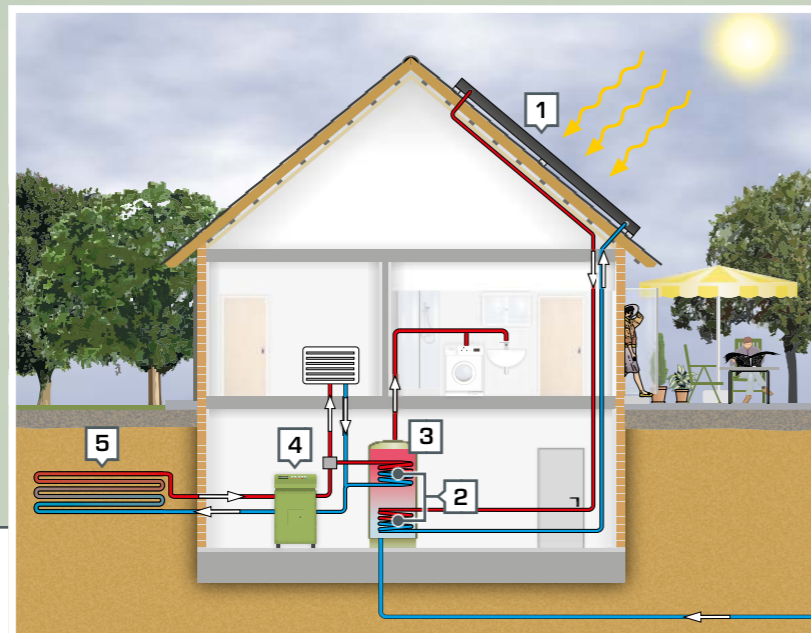


Subject Areas

Products

HL 320 Solar Thermal Energy and Heat Pump Modular System

Our HL 320 modular system covers essential Subject Areas from the field of renewable energy usage in building services engineering. 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 concept of the HL 320 system allows you to create a variety of configurations.



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

- 1 flat collector
- 2 heat exchanger
- 3 bivalent storage
- 4 heat pump
- 5 geothermal energy absorber

Possible applications of modern heat pumps

HL 320.01
Heat Pump

Combination of regenerative and conventional heat sources

HL 320.02
Conventional Heating

Solar thermal heat generation

HL 320.03
Flat Plate Collector

HL 320.04
Evacuated Tube Collector

Storage in regenerative heating systems

HL 320.05
Central Storage Module with Controller

Heat sources and heat sinks

HL 320.07
Underfloor Heating / Geothermal Energy Absorber

HL 320.08
Fan Heater / Air Heat Exchanger

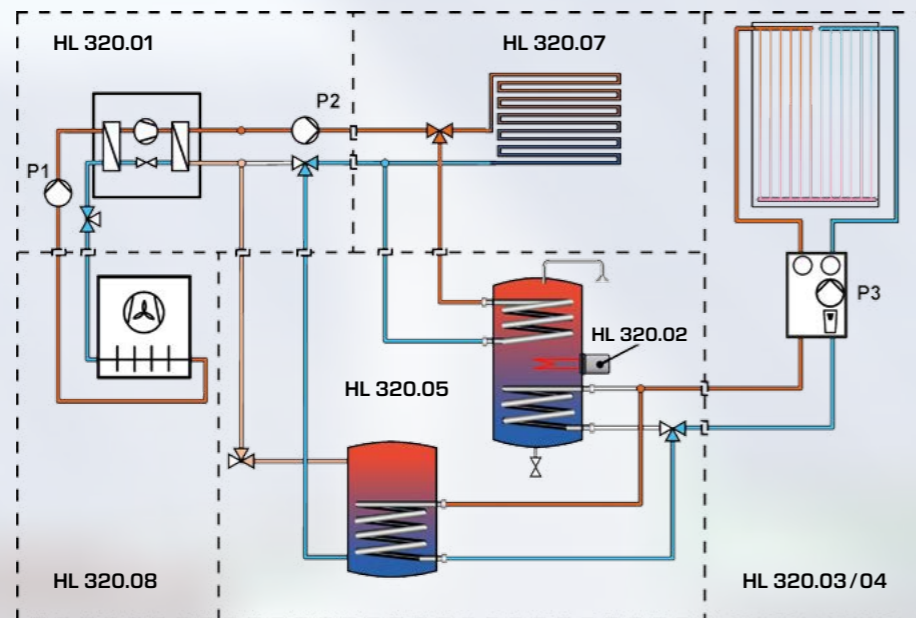
HL 320

Solar Thermal Energy and Heat Pump Modular System



The right configuration for every application

In heating technology, both correct composition of necessary components and optimisation of cabling and controller settings depend on the local conditions. We have developed experiments for a selection of relevant module combinations in order to be able to teach the corresponding learning content in balanced steps. In addition, you may of course create your own system configurations to investigate further issues from the field of regenerative heating technology.



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



Recommended combinations for the HL 320 modular system

Combination ▶	1	2	3	4	5
HL 320.01 Heat Pump					
HL 320.02 Conventional Heating					
HL 320.03 Flat Plate Collector					
HL 320.04 Evacuated Tube Collector					
HL 320.05 Central Storage Module with Controller					
HL 320.07 Underfloor Heating / Geothermal Energy Absorber					
HL 320.08 Fan Heater / Air Heat Exchanger					

Learning objectives and experiments

Combination 1

- function of a solar thermal heating system
- commissioning
- collector efficiency and losses

Combination 2

- combined use of traditional and solar thermal energy
- efficient indoor heating with underfloor heating

Combination 3

- function and design of a heat pump
- parameterisation of a heat pump controller
- factors influencing the COP (Coefficient of Performance)

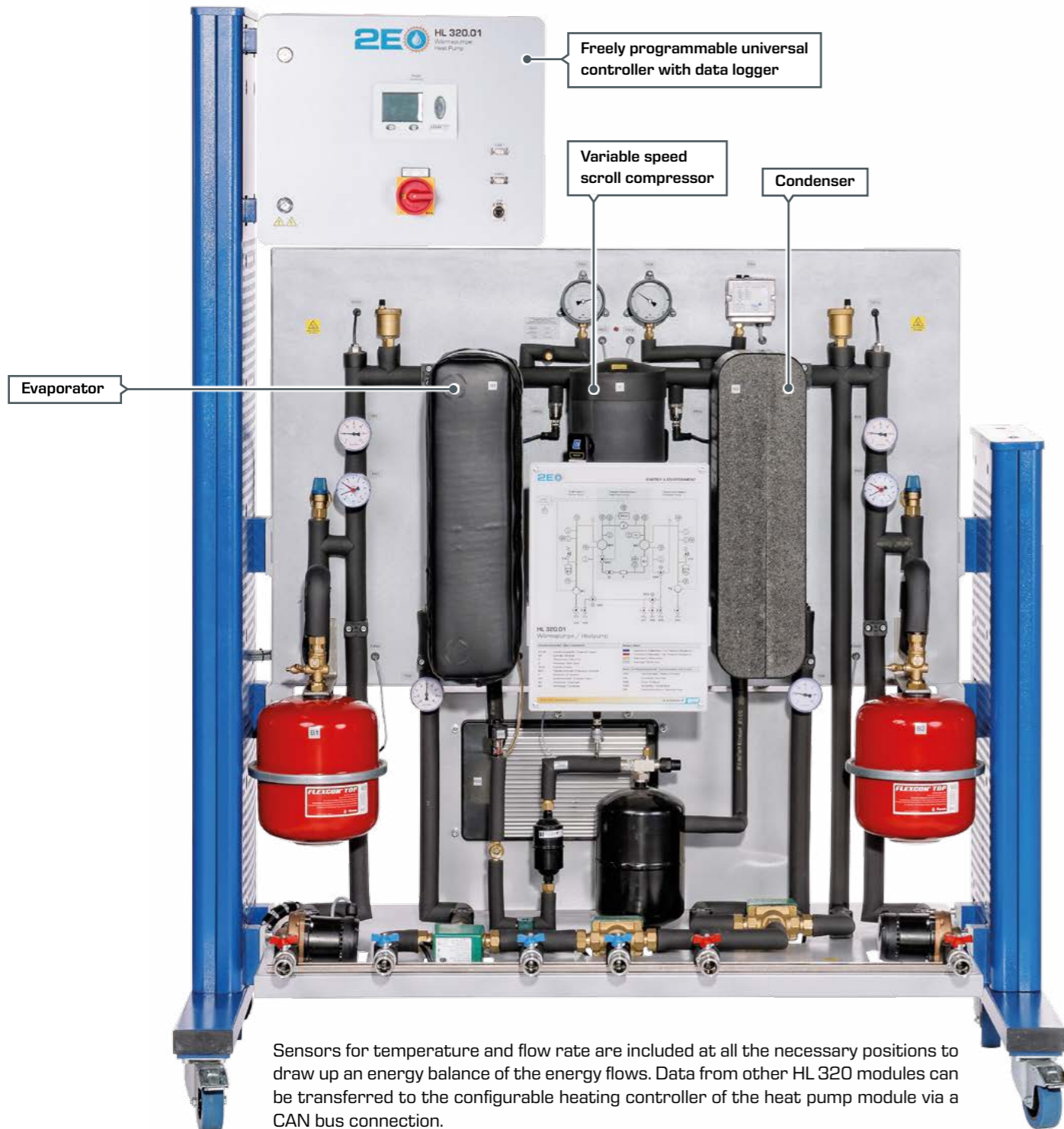
Combination 4

- efficient use of solar thermal and geothermal energy
- strategies for heat supply in various consumption profiles

Combination 5

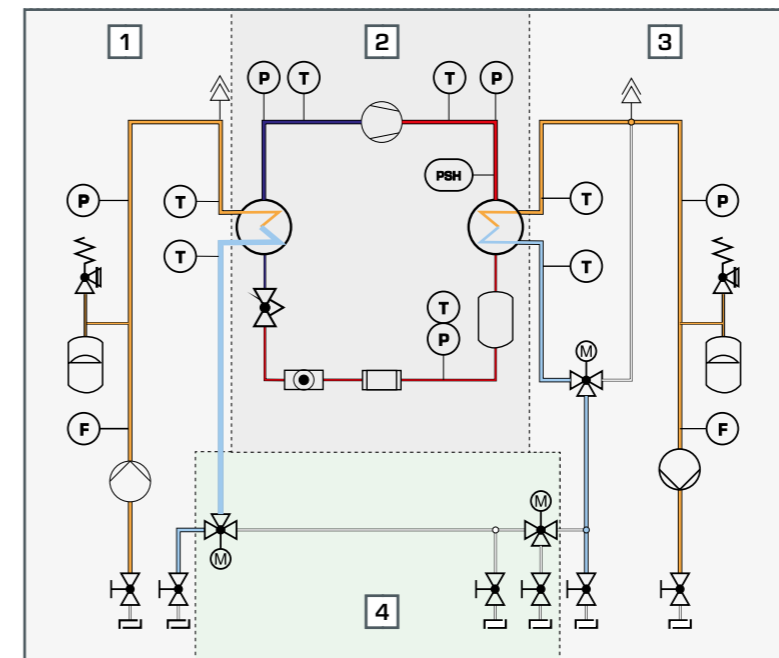
- use of renewable and fossil fuels for heating and hot water
- bivalent parallel and bivalent alternative heat pump mode

HL 320.01 Heat Pump



Sensors for temperature and flow rate are included at all the necessary positions to draw up an energy balance of the energy flows. Data from other HL 320 modules can be transferred to the configurable heating controller of the heat pump module via a CAN bus connection.

The HL 320.01 Heat Pump is part of the HL 320 modular system and provides you with a variety of combination options from geothermal and solar thermal energy in a modern heating system. The heat pump is driven by a variable speed scroll compressor. This means it is possible to adapt the heating power of the heat pump to the current heating system demand.



Process schematic of the HL 320.01 Heat Pump Module

- 1 source circuit connections
- 2 refrigeration circuit
- 3 heating circuit connections
- 4 additional options for including HL 320 modules

In combination 3 of the HL 320 system, the following modules are combined to create one system:

- HL 320.01 Heat Pump
- HL 320.07 Underfloor Heating / Geothermal Energy Absorber
- HL 320.08 Fan Heater / Air Heat Exchanger

This combination allows fundamental experiments on the operating behaviour of the heat pump. For more detailed experiments a storage module (HL 320.05) and a thermal solar collector, for example, can be connected.



Fixed and movable spirals of a scroll compressor

Learning objectives

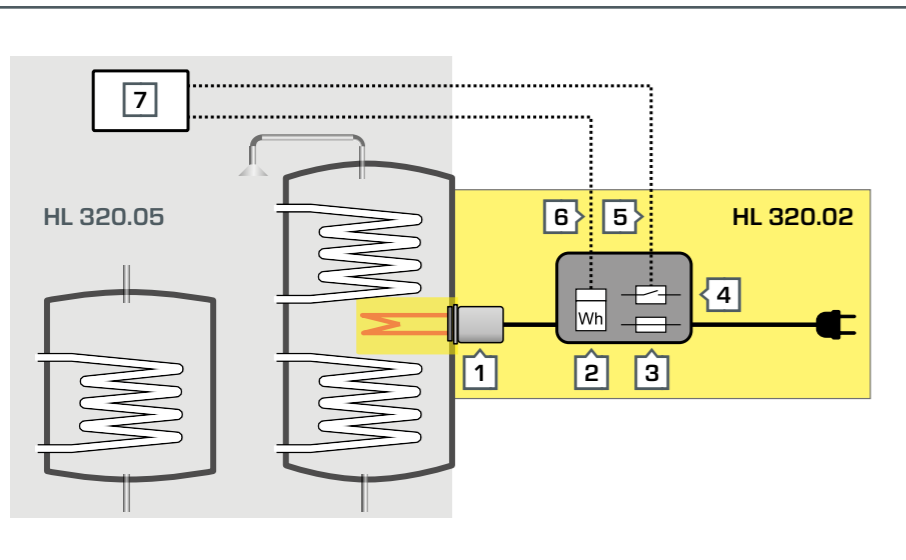
- function and design of a heat pump
- distinguishing different operating conditions
- factors influencing the COP (coefficient of performance)
- parameterisation of a heat pump controller



HL 320.02 Conventional Heating

In heating systems using different renewable heat sources, it may be economically feasible to cover the peak demand by means of a conventional heater. In order to be able to investigate this aspect in the HL 320 modular system, the HL 320.02 module provides an additional heater that can easily be integrated into different system configurations.

The practical cost of operating this heater for your experiments remains low because an electrically operated heating element is used. The heating element is inserted into the storage tank of the HL 320.05 Central Storage Module and can be controlled by the storage module's controller via CAN bus. An integrated meter records the amount of electricity consumed. The data from this meter can be sent to the controller of the HL 320.05 Central Storage Module via the CAN bus connection for capture by a data logger.



- 1 heating element
- 2 energy meter
- 3 fuse
- 4 switch box
- 5 connection between contactor and controller output
- 6 connection between energy meter and controller input
- 7 HL 320.05 module's controller

Product No.
065.32002
More details and technical data:
gunt.de/static/s5364_1.php



Learning objectives

- complementary heating and/or domestic water heating by conventional additional heater
- bivalence point and heating load
- control strategies for complementary heating



The storage tank is emptied in preparation for the experiment. The auxiliary heater can easily be inserted subsequently in just a few steps.

HL 320.03 Flat Plate Collector

In conjunction with other HL 320 modules, you can conduct experiments on solar thermal energy domestic water heating with the HL 320.03 Flat Plate Collector. The control engineering for the combined production of domestic hot water and heating is of particular practical relevance. Here, the system is controlled and data captured via CAN bus via the HL 320.05 Central Storage Module.

Modules are easily connected via hoses and quick-release couplings. Different combinations for renewable heat sources can be tested and optimised in conjunction with other modules from the HL 320 system.



Product No.
065.32003
More details and technical data:
gunt.de/static/s5285_1.php



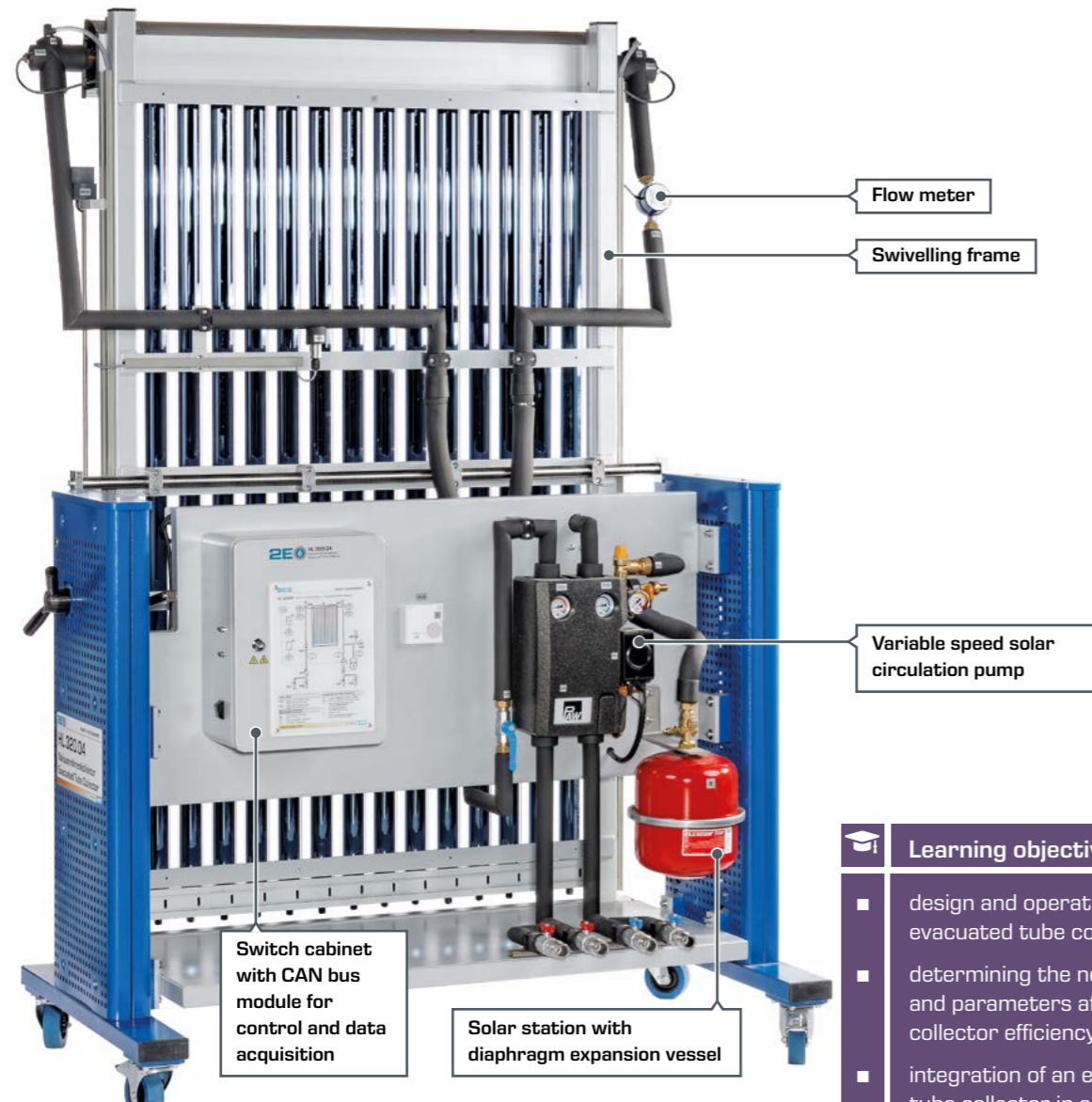
Learning objectives

- determining the net power
- how temperature, illuminance and angle of incidence affect the collector efficiency
- integration of a flat collector in a modern heating system
- hydraulic and control engineering operating conditions
- energy balances
- optimisation of operating conditions for different types of use

HL 320.04 Evacuated Tube Collector

The HL 320.04 unit provides you with an evacuated tube collector in a modern design. Evacuated tube collectors reach much higher operating temperatures compared to simple flat plate collectors due to the lower thermal losses. In practice, evacuated tube collectors are used where there is limited floor space, for example. In the year-round heating operation, evacuated tube collectors enable the reduction of the seasonal demand on a conventional auxiliary heater. HL 320.04 is one of

the modules from the HL 320 Solar Thermal Energy and Heat Pump Modular System. The experiment module can be incorporated into the modular system in a variety of different ways. The module can be used both for generating heated domestic water and for the combined production of domestic hot water and for heating rooms. Pipe connections for the heat transfer fluid are easy to create and alter thanks to the quick-release couplings.



Product No.
065.32004
More details and technical data:
gunt.de/static/s5287_1.php



Learning objectives

- design and operation of an evacuated tube collector
- determining the net power and parameters affecting collector efficiency
- integration of an evacuated tube collector in a modern heating system

HL 320.05 Central Storage Module with Controller

The HL 320.05 Central Storage Module with Controller has been developed for your experiments as a central component of the HL 320 modular system. HL 320.05 contains two different heat storage systems, pipes, a pump, two motorised 3-way valves and safety devices. Quick-release couplings on the front of the module enable hydraulic connections to other modules in the modular system. In addition, HL 320.05 contains a freely-programmable heating controller, which is connected to the respective modules via control and data lines (CAN bus). This controller allows you to operate and study all intended module combinations.



Product No.
065.32005
More details and technical data:
gunt.de/static/s5289_1.php



Learning objectives

- fundamentals and commissioning of heating systems with solar thermal energy and heat pump
- properties of various heat storage methods
- electrical, hydraulic and control engineering operating conditions
- energy balances for different system configurations
- optimisation of control strategies for solar station with different operating modes

HL 320.05 Central Storage Module with Controller

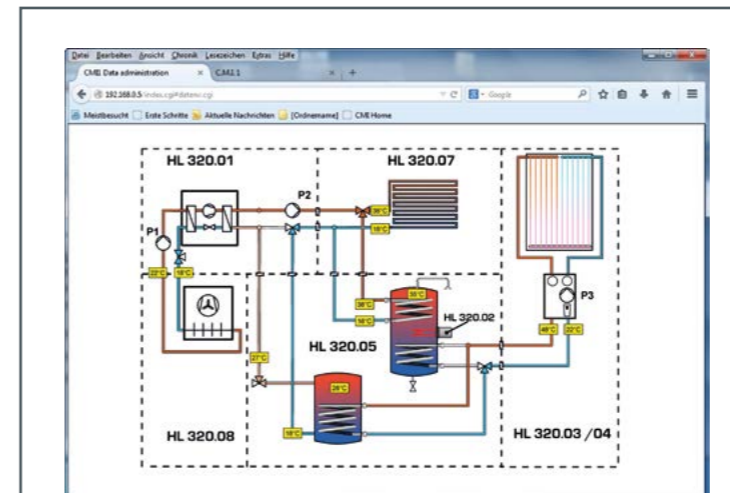


- 1 freely programmable heating controller with data logger
- 2 ports for CAN bus and network
- 3 process schematic
- 4 buffer storage
- 5 heat exchanger
- 6 3-way change-over valve
- 7 circulation pump
- 8 bivalent storage

Product No.
065.32005
More details and technical data:
gunt.de/static/s5289_1.php



The HL 320.05 Central Storage Module with Controller can be connected to the HL 320 modular system in a variety of ways using individually accessible inputs and outputs. Schematics and controller configurations are provided for five pre-defined combinations. First of all, the labelled pipe connections are established in preparation for the experiment. Then a controller connection and a data connection (CAN bus) are made to each module. The experiment can begin once the prepared controller configuration has been activated. Different PC programs are available for the controller and data logger, which allow individual adaptation of the configuration or the desired data logging options as required.



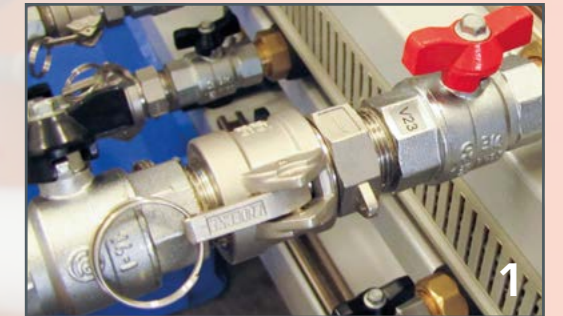
Visualisation in the web browser

The controller is controlled and data acquired via a network module to a PC. Current system data can be represented in a diagram, for example. This representation can be called up on any current web browser.

Hochschule für
Wirtschaft und Recht Berlin
Berlin School of Economics and Law

At the Berlin School of Economics and Law, HL 320.05 is used in conjunction with HL 320.03 and HL 313.01 for experiments in the field of renewable energies.

Preparation for the experiment



Secured cable connections (1, 2) allow safe modification of the cable routing. Current system data can be visualised both on the controller (3) and via a network connection (4).

HL 320.07 Underfloor Heating/ Geothermal Energy Absorber

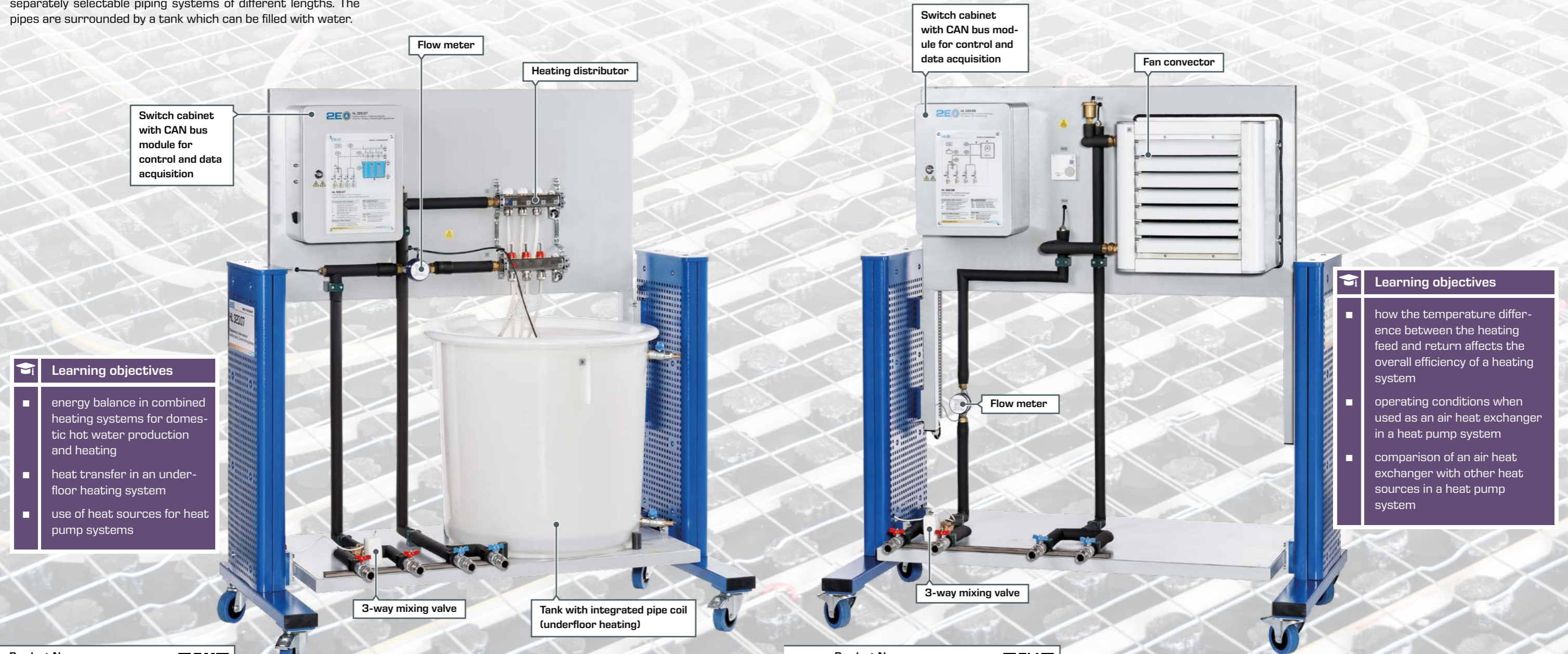
Underfloor heating systems transfer heat through piping systems arranged in a spiral or winding pattern underneath the floor covering. Underfloor heating requires much lower feed flow temperature than conventional radiators. Besides its function as a heat sink when used as an underfloor heating system, HL 320.07 can also be used as a heat source for a heat pump in the HL 320 modular system. In this case, the direction of the heat transport is reversed. HL 320.07 is equipped with three separately selectable piping systems of different lengths. The pipes are surrounded by a tank which can be filled with water.

Sensors are mounted on the piping system to detect the temperatures in the feed and return. Heat quantities and energy balances can be calculated using these temperatures together with the measurement data from the integrated flow meter. Data is transferred to the controller of each main module (HL 320.01 or HL 320.05) via the CAN bus connection. The integrated 3-way mixing valve can also be controlled by the controller via the CAN bus connection.

HL 320.08 Fan Heater/ Air Heat Exchanger

When heating rooms, fan heaters offer the possibility of achieving a comparatively good transfer of heat to the room air compared to traditional heating radiators, even at small dimensions. When combined with a heat pump, the fan heater often represents a beneficial application both economically and in terms of energy, especially when renovating heating systems

in old buildings. The HL 320.08 experiment module completes your HL 320 modular system. This module can also be operated as either a heat sink or a heat source for a heat pump. Sensors for temperature and flow rate are available to create energy balances. Data is transferred to the controller of each main module (HL 320.01 or HL 320.05) via the CAN bus connection.



Learning objectives

- energy balance in combined heating systems for domestic hot water production and heating
- heat transfer in an underfloor heating system
- use of heat sources for heat pump systems

Learning objectives

- how the temperature difference between the heating feed and return affects the overall efficiency of a heating system
- operating conditions when used as an air heat exchanger in a heat pump system
- comparison of an air heat exchanger with other heat sources in a heat pump system

Product No. 065.32007
More details and technical data:
gunt.de/static/s5291_1.php

Product No. 065.32008
More details and technical data:
gunt.de/static/s5362_1.php

Subject Areas

Energy Efficiency in Business and Industry



Subject Areas

2E0 Products

In business and industry, measures to improve energy efficiency are connected to both the optimisation of building services engineering and to the relevant value creation processes. Close integration of these two areas often results in novel approaches to improving energy efficiency. For example, waste heat from cooling equipment can be used in the food trade for air conditioning in the showrooms. In industrial environments, the use of process engineering waste heat is a good example of a more efficient measure.

On these pages we have compiled only a very small selection of devices on this topic. The basic approach to analysing energy flows in given application environments in order to achieve a reduction of primary energy use can also be demonstrated by many devices from our standard product range, in addition to our 2E devices.

Energy efficiency in refrigeration technology

ET 420
Ice Stores in Refrigeration

ET 428
Energy Efficiency in Refrigeration Systems

Outlook: energy efficiency in process engineering

RT 682
Multivariable Control: Stirred Tank

RT 396
Pump and Valves and Fittings Test Stand

Basic Knowledge Energy Efficiency in Refrigeration Technology



Typical application for refrigeration systems:
sales counters in supermarkets operating in the standard cooling range.

Refrigerating plants in building services engineering

Refrigerating plants consist of various components, in which energy is transferred. All of these components are associated with different efficiencies, and can therefore be regarded as potential adjusting points for optimisation. Building services engineering in particular provides the option of significantly increasing the efficiency and cost-effectiveness of the overall system by, for example, utilising the waste heat from a refrigerating plant to heat the building. Another interesting concept for interlinked operation of heat sources and heat sinks consists of the use of waste heat for cold production in absorption refrigeration systems, for example.

Measures to improve energy efficiency

In refrigeration technology the implementation of energy-efficient concepts for refrigerating plants is often associated with increased investment costs. In contrast, achievable savings and economic benefits for some solutions are only significant when viewed over the entire life of the system. Therefore, it may be useful to create economic incentives for specific applications or technologies to reduce the risks for new systems, especially in the initial phase.

In Germany, refrigeration plants and air conditioning units consume about 15% of electrical energy. Under EU rules, the German government has set up special support programmes to increase efficiency in this area in order to achieve the planned savings targets by 2020.



Individual production steps in food production often require very precise preset temperatures. One particular challenge when planning production facilities is the energy efficient integration of the required refrigerating plants into the rest of the building supply.



Condenser in a refrigerant network

Refrigerant networks for building supply

In larger refrigerating plants, cold generators and refrigeration points are often physically separated from each other. Sometimes several refrigeration points at different locations are supplied by a central plant. There is often not enough space at the refrigeration points (e.g. the sales counter) to install a cooling unit. It is also crucial for the system design whether the waste heat is to be released to the outside air or into the building supply. In principle, it is the task of refrigerant networks to transport refrigerant from the cooling unit to the refrigeration point and back.

Energy efficiency under varying cooling demand

Naturally, the performance of a refrigerating plant should cover the maximum demand of all refrigeration consumers at peak times. Adaptive refrigeration systems can be used to keep the energy demand as low as possible when cooling demand varies widely. These systems include, for example, variable speed or multi-stage compressors and electronic expansion valves. Efficient plant control avoids frequent switching on and off. However, it also requires sufficient cold storage. Integration into the energy management system of the entire building should also be considered alongside an intelligent control system.



Goods often have to be stored in refrigeration for a long time, and not only in the food sector. Substantial savings in energy consumption are also possible even with low efficiency gains, due to the required continuous operation of refrigerating plants.

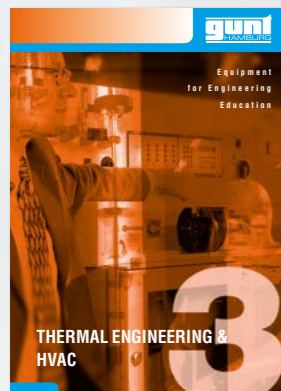
Temperature ranges in refrigeration technology

The integration of refrigeration technology into building services engineering first requires consideration of the temperature range of the application. Typically, the following ranges are identified:

- air conditioning +25°C ... +15°C
- standard cooling +10°C ... -5°C
- deep freeze -15°C ... -30°C
- shock freezing -35°C ... -50°C

System monitoring by energy management systems

In addition to the implementation of efficient system concepts and the use of optimised components, regular monitoring of all operating parameters is crucial for the long-term reduction of energy demand. Interlinkable refrigeration controllers, whose data is collected by a modern energy management system for the entire building, are becoming increasingly important for system monitoring.



Many of the fundamental themes of refrigeration technology are also covered by a wide selection of educational systems from our catalogue 3.

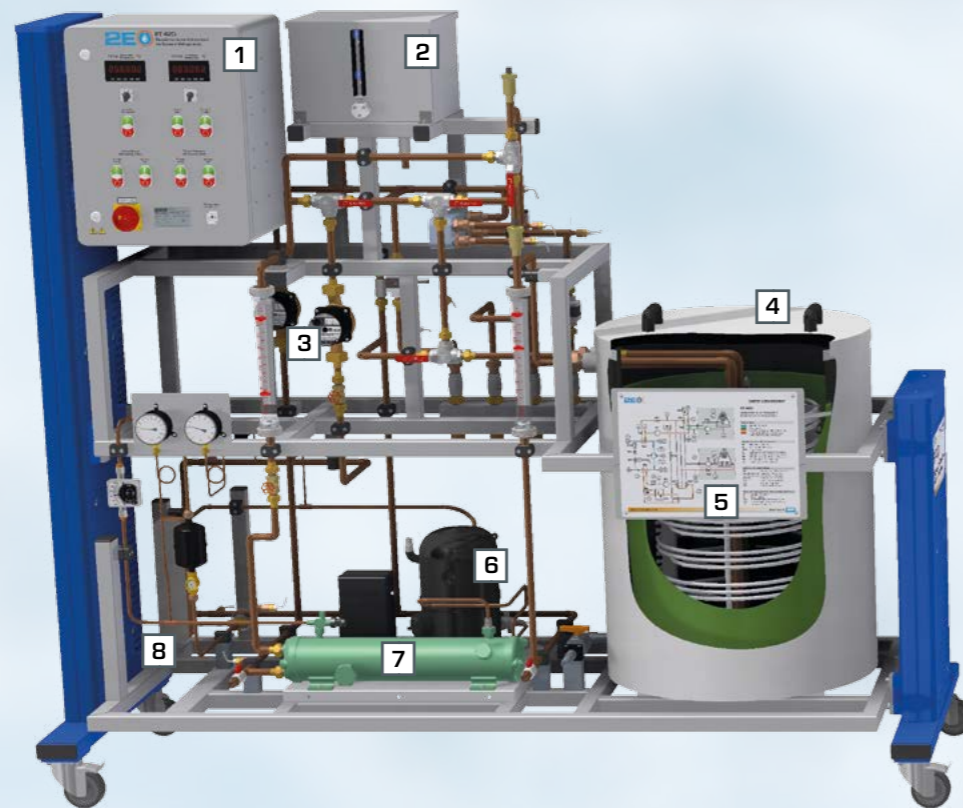
Catalogue 3
Thermal Engineering and HVAC

ET 420 Ice Stores in Refrigeration

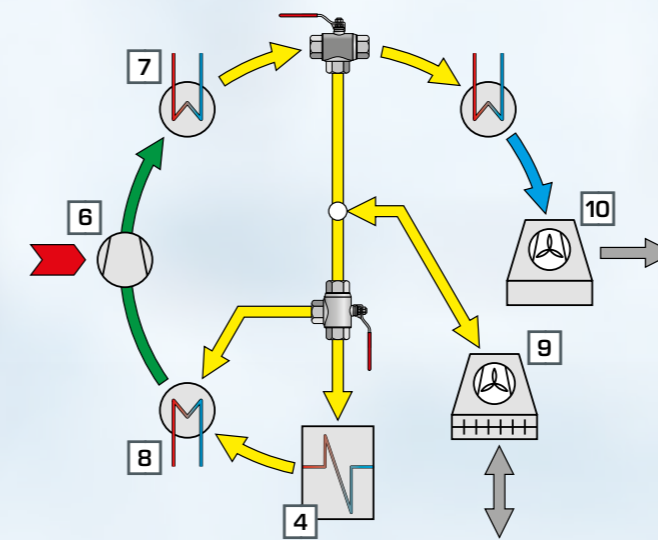
The ET 420 experimental unit provides you with a refrigerating plant with two cooling towers and an ice store. The advantage of this ice store is the higher peak load, without the need for a larger refrigerating plant. The refrigerating plant may also be operated at the optimal operating point all the time. The

ice store is charged during the night when cooling demand is lower, and discharged during the day as additional refrigeration capacity. You can adjust the different operating modes with the experimental unit and demonstrate the direct increase in efficiency with ice stores.

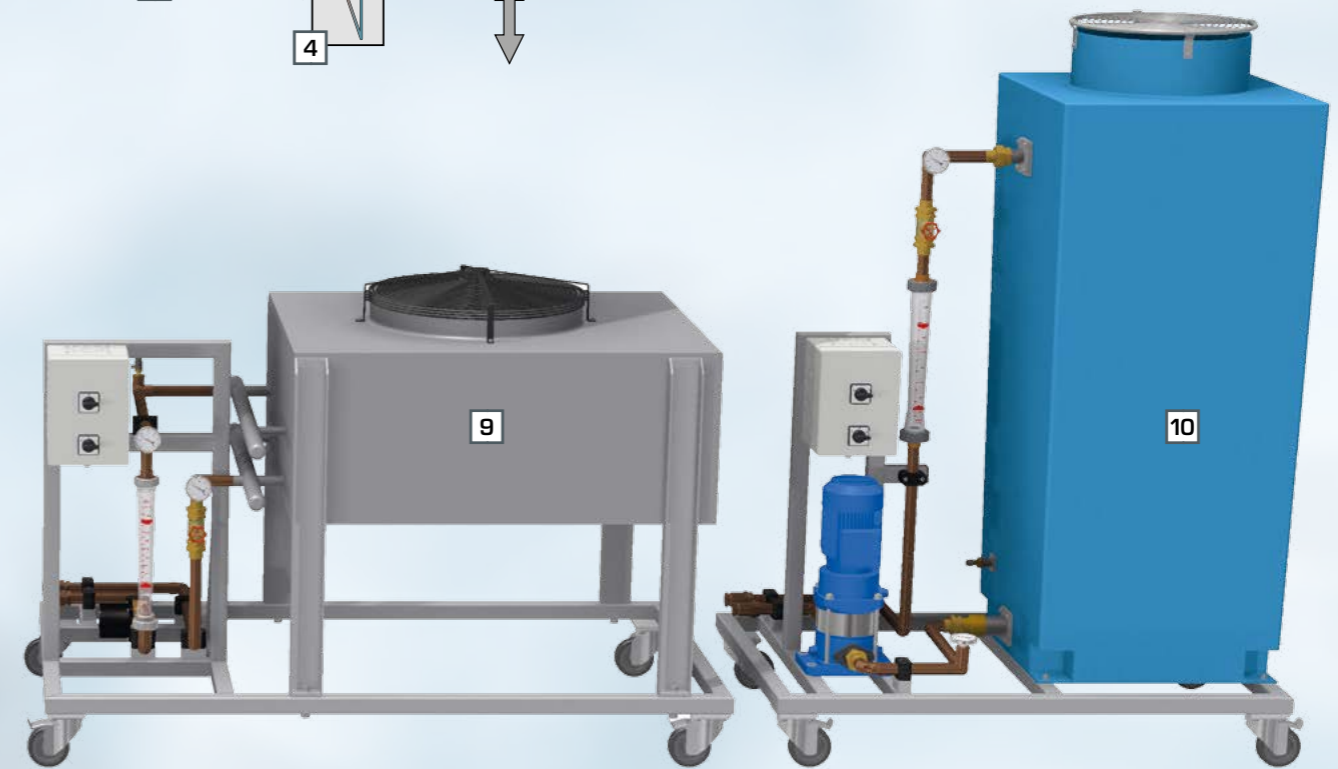
Learning objectives	
■	design and operation of an energy-efficient refrigeration system
■	function and operation of an ice store <ul style="list-style-type: none"> ▶ charge ▶ discharge
■	energy flow balance
■	energy transport via different media
■	compression refrigeration cycle in the log p-h diagram
■	function and operation of a wet cooling tower
■	function and operation of a dry cooling tower



System components with efficiency gain



1	switch cabinet	■	glycol-water mixture
2	storage tank	■	water
3	circulation pumps	■	refrigerant
4	ice store	■	air
5	process schematic	■	electrical power
6	refrigerant compressor		
7	refrigerant condenser		
8	refrigerant evaporator		
9	dry cooling tower		
10	wet cooling tower		

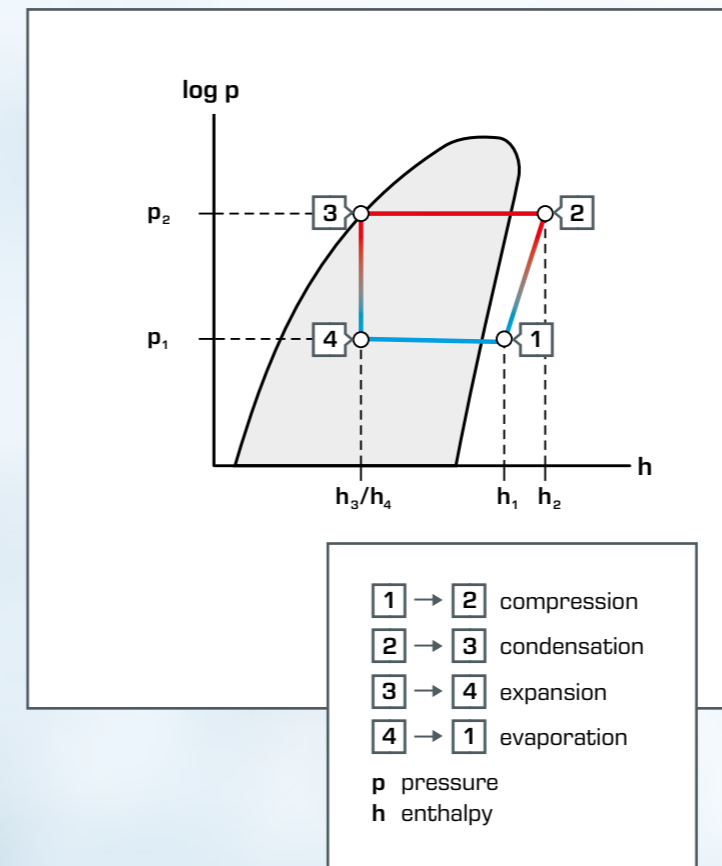


ET 428 Energy Efficiency in Refrigeration Systems

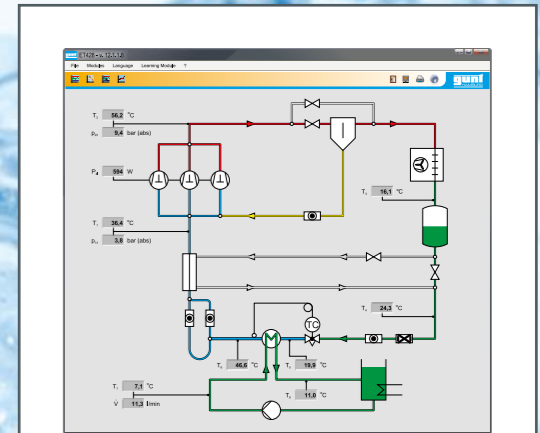
The efficient use of energy in refrigeration technology is an important contribution to a sustainable energy supply. In order to ensure energy-efficient operation even when power demand is high, small compressors are connected in parallel in industry. The optimal adaptation to the power demand is achieved by switching the compressors on and off. The ET 428 trainer includes three compressors connected in parallel, which can be switched on or off via a controller. The components of the

refrigeration circuit with the three compressors are clearly arranged on the trainer. The glycol-water circuit with pump and tank with heater serves as cooling load at the evaporator. An internal heat exchanger in the refrigeration circuit allows you to study how refrigerant supercooling affects process efficiency. You can undertake a quantitative analysis of the efficiency using an energy balance in the glycol-water circuit and by measuring the electrical output of the compressors.

To protect the three compressors, the refrigeration cycle is equipped with a combined pressure switch for the pressure and intake sides. To ensure a reliable oil supply to the three compressors, an oil separator is provided on the pressure side of the compressors. The separated oil is returned to the compressors on the intake side.



The representation of the process in the log p-h diagram is a standard for illustrating the cyclic process in refrigerating plants. ET 428 also provides you with an online view of the cyclic process with the current measured values.



Software

The GUNT software for ET 428 enables the acquisition, storage and display of all relevant measured values.

Learning objectives

- variables affecting energy efficiency
 - ▶ controller parameters
 - ▶ refrigerant supercooling
- interconnected operation of compressors
- operation of a multicompressor controller
- methods for returning oil in a multicompressor refrigeration system
- representation of the thermodynamic cycle in the log p-h diagram



Basic Knowledge

Process Engineering and Building Services Engineering



The implementation of energy-efficient concepts is much easier if they can be incorporated into the planning of production at an early stage.

Resource-efficient production plants

Nowadays an interdisciplinary approach is needed, as indicated in the example of a resource-efficient supply of raw materials and energy. Various aspects from the fields of energy engineering, building services engineering and process engineering must be taken into consideration. The combination of the otherwise mostly independent subject areas of building services engineering and process engineering is based on this knowledge. Any future-oriented education must include this combination of these two subject areas. This ensures that the challenges of designing energy-efficient production plants will be met in the future.

Joining sub-systems

The joint approach of building services engineering and process engineering has been successfully implemented in the construction of new industrial or commercial buildings or the modernisation of old ones. A significant increase can be noted in this regard. The willingness to accept the associated higher expense has increased significantly due to the positive experience gained from projects implemented to date. This trend is supported by government funding. The valuable lessons learned from the operation of coupled systems flow into the further development of individual components and energy-efficient control systems.

Energy-optimised plant control

For the energetic optimisation of process engineering plants, it is first necessary to consider which sub-processes or components are affected by energy losses. In existing plants, additional components and measuring equipment often have to be installed for this purpose. It should then be possible to measure all relevant energy flows of the plant. In order to identify potential savings, the measurement data must first be analysed and the individual process steps accounted for. These savings can then be exploited by optimising the plant control system. However extensive experiments are usually required in order to simultaneously maintain the same product quality.

Heat recovery in food production

Lots of energy is used during the production of food, in the form of hot water, process heat, cooling and heating. An example of process engineering from this field is the use of a temperature-controlled stirred tank. Typical requirements for such a system are:

- rapid heating of the components to be treated prior to entry into the tank
- constant temperature during treatment in the tank
- rapid cooling of the products produced by the treatment
- energy-efficient operation of the plant

Efficient control systems are needed in order to meet all the requirements, alongside a possibility for heat recovery. What effects are possible, such as changes in the control parameters, can be studied using our RT 682 trainer.



Large-scale stirred tanks



Detecting and measuring the energy flows is a prerequisite for the optimisation of existing plants.

Valves and fittings in process engineering

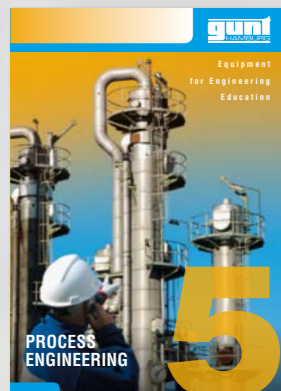
Adjustable valves and fittings are used in process engineering when materials with fluid properties have to be transported in piping systems. They are responsible for limiting the flow rate to a certain value.

Naturally, limiting a given flow rate through a valve or fitting is associated with a pressure drop and thus with a loss of hydraulic power. If the only aim is to adjust the flow rate through a main pipe, it is for example more energy efficient to use a pump with an adjustable flow rate. In branched piping systems however, this is not always possible or economically viable. In this case, adjustable valves and fittings are often used.

When selecting suitable valves and fittings, besides the specific requirements of the intended application, basic design questions must be taken into account in order to ensure a low-loss operation. For experiments in this field of process engineering, we recommend our RT 396 pumps, valves and fittings test stand.



Valves and fittings of a large-scale distribution station

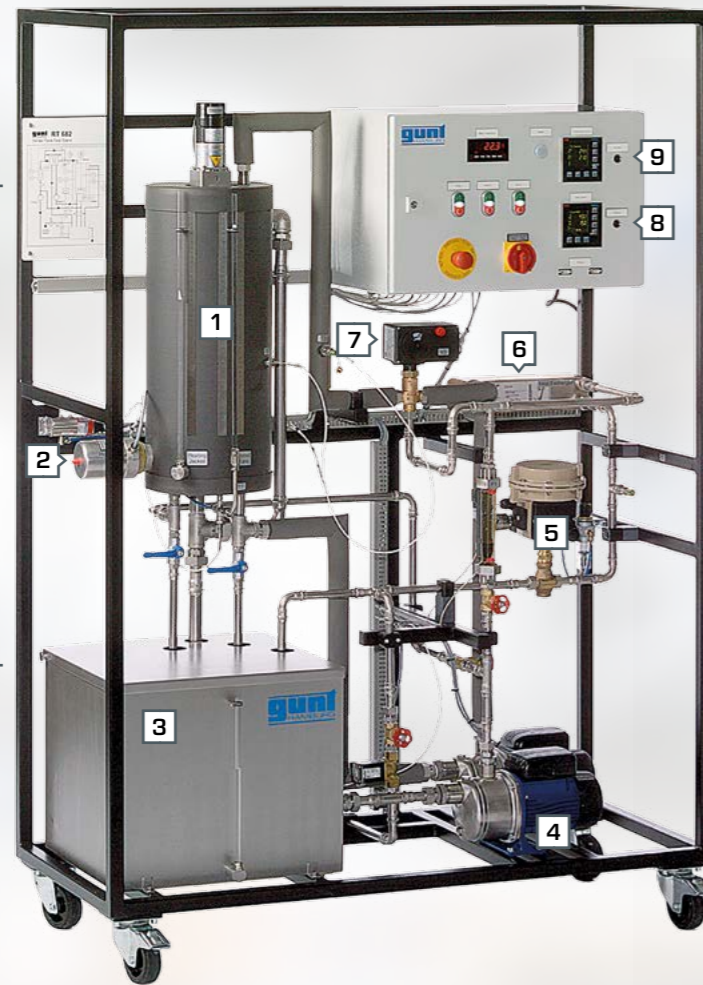


Many of the fundamental themes of process engineering are also covered by a wide selection of educational systems from our catalogue 5.

Catalogue 5
Process Engineering

RT 682 Multivariable Control: Stirred Tank

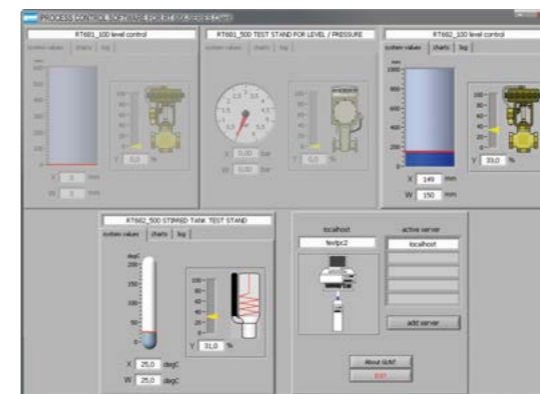
- 1 stirred tank
- 2 heater
- 3 collection tank
- 4 pumps
- 5 level control valve
- 6 heat exchanger
- 7 3-way motorised valve
- 8 level controller
- 9 temperature controller



In process engineering, energy-efficient operation of the individual components is also of great importance. The less energy required to manufacture the products, the more cost-effective the production process, so that the products can be offered more cheaply. In this case, the cost of maintenance of the production building, the control room and the office building must be considered. The waste heat occurring during production can be used, for example to heat buildings, which can reduce operating costs. Automation and monitoring of individual flows and temperatures are required for this purpose.

Another measure for increasing energy efficiency is in-process heat recovery. For example, this could be implemented by using the still-warm products to preheat the input materials. The modified plant behaviour has to be adapted for the production process using the control parameters.

With RT 682 you can teach the complex relationships of a multivariable control system in a practical way, and display and compare the system behaviour with heat recovery.



Software

The process control software specially developed for RT 681 and RT 682 allows you to connect, monitor and control both trainers simultaneously. The software offers the following options:

- process schematics and display of all measured values
- warning function with logging
- parameterisation of the controller
- controller manual or automatic mode
- how a programmer works
- networking with server/client
- control panel function with both trainers connected

If you require a Profibus card, this can be ordered using product number 080.65012.

Product No.
080.68200
More details and technical data:
gunt.de/static/s3335_1.php



Product No.
080.65060
More details and technical data:
gunt.de/static/s4589_1.php

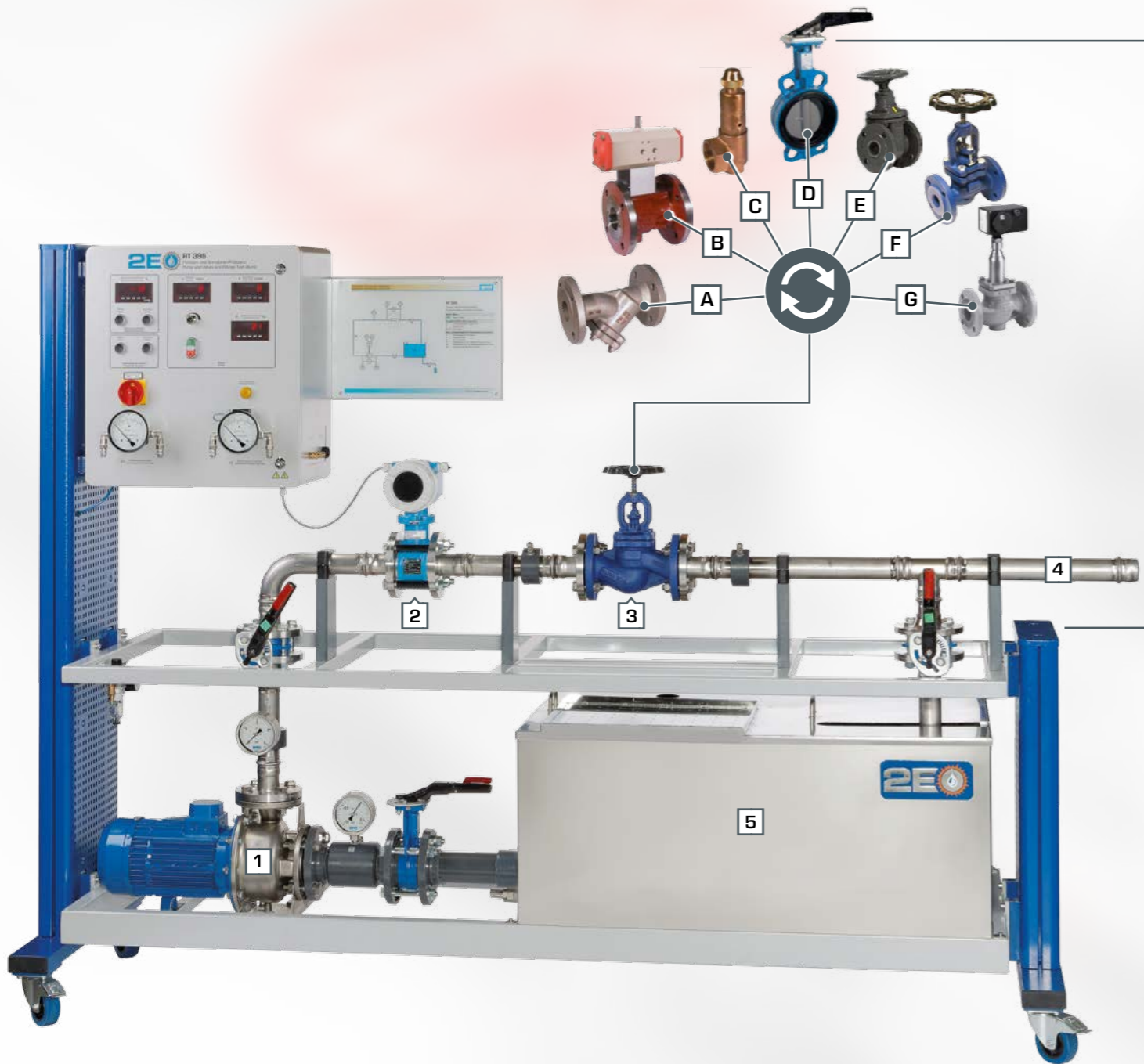


Learning objectives

- coupled level and temperature control
- level control with
 - ▶ PI controller
 - ▶ disturbance feedforward control
- temperature control
 - ▶ with two-point controller
 - ▶ with three-point controller (split range)
 - ▶ with override control
 - ▶ via motorised valve with position feedback
- plotting step responses

RT 396

Pump and Valves and Fittings Test Stand

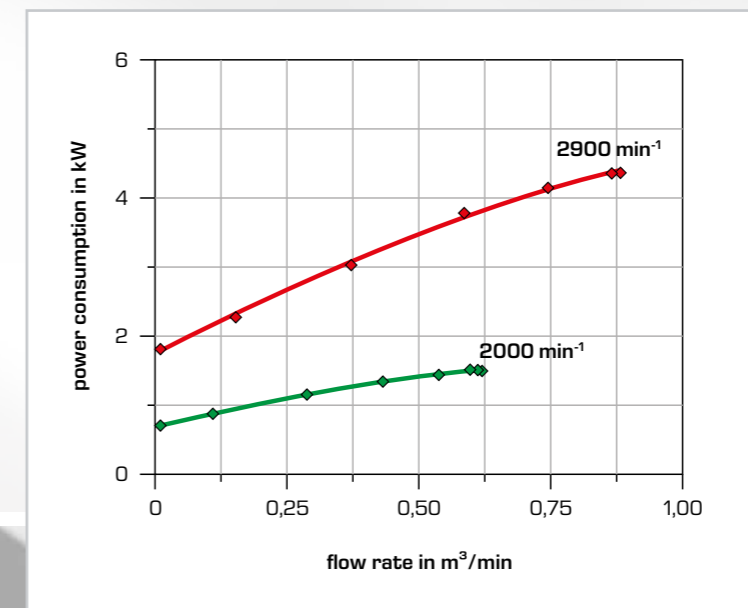


- A** dirt trap
- B** ball valve
- C** safety valve
- D** butterfly valve
- E** wedge gate valve
- F** shut-off valve
- G** control valve

- 1** pump
- 2** flow rate sensor
- 3** interchangeable valve or fitting
- 4** pipe section
- 5** storage tank

The RT 396 trainer provides you with a test bench for pumps, valves and fittings. The test bench can be used to investigate a total of seven valves and fittings with regard to their functional principle and characteristic. You can also plot the pump characteristic and the power demand of the installed centrifugal pump, as well as determining the power demand of the series-connected centrifugal pump and valves and fittings for various flow rates. Comparing the power demand without valves and fittings and the pressures occurring also allows you to determine the flow coefficients of the various valves and fittings.

- Learning objectives**
- behaviour during operation and function of
 - ▶ ball valve
 - ▶ butterfly valve
 - ▶ shut-off valve
 - ▶ wedge gate valve
 - ▶ control valve
 - ▶ safety valve
 - ▶ dirt trap
 - determining the Kvs value of the control valve
 - pressure losses at the dirt trap depending on the filter and its load
 - reading and understanding engineering drawings and operating instructions



Power consumption of the centrifugal pump at different speeds

Product No.
080.39600
More details and technical data:
gunt.de/static/s4720_1.php



Energy

Energy systems:
conversion in energy systems

ET 292
Fuel cell system
Water-cooled polymer-membrane fuel cell combined heat and power



Order No.: 061.29200



ET 102
Heat pump
Utilisation of ambient heat for water heating



Order No.: 061.10200



ET 794
Gas turbine with power turbine
Two-shaft arrangement with high-pressure turbine and power turbine using liquid gas



Order No.: 061.79400

HL 320.01
Heat pump
Heat pump for operation with different sources



Order No.: 065.32001

HL 320.07
Underfloor heating / geothermal energy absorber
Can be used as heat sink or heat source



Order No.: 065.32007

HL 320.08
Fan heater / air heat exchanger
Can be used as heat sink or heat source



Order No.: 065.32008

Energy

Energy efficiency in building service engineering:
energy efficiency in business and industry

ET 420
Ice stores in refrigeration
Industrial refrigeration system with ice store, dry cooling tower and wet cooling tower



Order No.: 061.42000



ET 428
Energy efficiency in refrigeration systems
Investigation of a refrigeration system in multi-compressor operation

Order No.: 061.42800



RT 682
Multivariable control: stirred tank
Heated stirrer tank with heat recovery as model: coupled level and temperature control

Order No.: 080.68200



RT 396
Pump and valves and fittings test stand
Recording characteristic curves of industrial fittings and a centrifugal pump



Order No.: 080.39600

Energy

 Energy efficiency in building service engineering:
heat supply and air conditioning

WL 376
Thermal conductivity of building materials

Investigation of the insulation properties of typical materials from the building materials sector



Order No.: 060.37600


WL 110
Heat exchanger supply unit

Measuring the transfer characteristics of four different heat exchanger models



Order No.: 060.11000


WL 110.01
Tubular heat exchanger

Transparent heat exchanger with additional temperature measuring point after half of the transfer section; parallel flow and counterflow operation



Order No.: 060.11001

WL 110.02
Plate heat exchanger

Typical plate heat exchanger in parallel flow and counterflow operation



Order No.: 060.11002

WL 110.03
Shell & tube heat exchanger

Transparent shell and tube heat exchanger in cross parallel flow and cross counterflow operation



Order No.: 060.11003

WL 110.04
Stirred tank with double jacket and coil

Heating using jacket or coiled tube; stirrer for improved mixing of medium

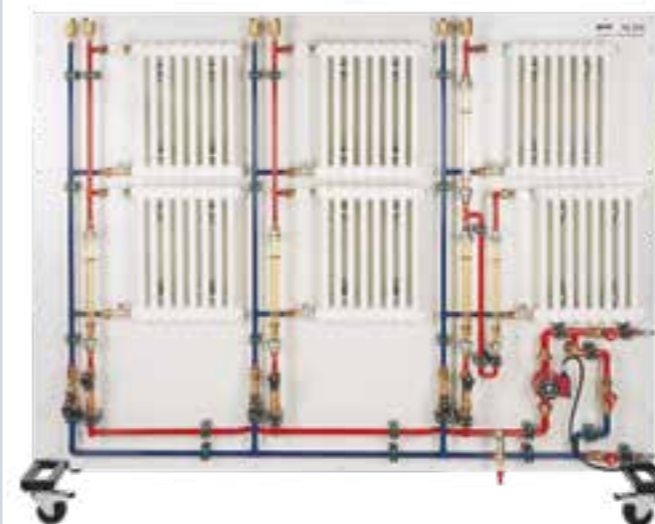


Order No.: 060.11004

HL 305
Hydronic balancing of radiators

Hydronic balancing of a heating system: three heating subcircuits with radiators, thermostatic valves and circulation pump

Order No.: 065.30500


HL 630
Efficiency in heating technology

Basic principles of energy efficient heating technology with a computer-supported learning process

Order No.: 065.63000


ET 630
Split system air conditioner

Modern air conditioning unit with heat pump function: cooling or heating

Order No.: 061.63000


HM 283
Experiments with a centrifugal pump

Determination of the characteristics of a centrifugal pump

Order No.: 070.28300



Energy


Energy efficiency in building service engineering:
inclusion of renewable energies

HL 320.01
Heat pump

Heat pump for operation with different sources



Order No.:
065.32001

HL 320.02
Conventional heating

Electric complementary heater for the module system HL 320



Order No.:
065.32002

HL 320.03
Flat plate collector

Pivotable flat plate collector for converting solar energy into heat



Order No.:
065.32003

HL 320.04
Evacuated tube collector

Conversion of solar energy into heat in the evacuated tube collector



Order No.:
065.32004

HL 320.05
Central storage module with controller

Module with buffer storage and bivalent storage for heating systems with renewable energies

Order No.: 065.32005


HL 320.07
Underfloor heating / geothermal energy absorber

Can be used as heat sink or heat source



Order No.:
065.32007

HL 320.08
Fan heater / air heat exchanger

Can be used as heat sink or heat source



Order No.:
065.32008

Environment


Air:
mechanical processes

CE 235
Gas cyclone

Solid separation from gases using a cyclone

Order No.: 083.23500


Environment


Air:
thermal processes

CE 400
Gas absorption

Separating a CO₂/air mixture by absorption in a solvent using counterflow

Order No.:
083.40000


CE 540
Adsorptive air drying

Basic principle of adsorption and desorption

Order No.: 083.54000

