

Equipment
for Engineering
Education

**REFRIGERATION
AND AIR CONDITIONING
TECHNOLOGY**



WELCOME TO GUNT



Your reliable and experienced partner for

- teaching and training systems for innovative technical training
- experimentation and research equipment

GUNT demonstration and experimentation equipment for

- training in technical professions
- training of technical staff in trades and industry
- studies in engineering disciplines



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REFRIGERATION AND AIR CONDITIONING TECHNOLOGY

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*Dr.-Ing. D. Abraham
Head of Development
at GUNT*

I have gone a long way with my development team to design the product range presented in this catalogue in a suitable manner for efficient training in refrigeration and air conditioning technology.

Two aspects were always of importance for us:

- How does the technology actually look like in practice?
- Which subjects matter and which experiments combine into a powerful curriculum?

This program serves both academic interest and the important field of vocational training.

IMPRINT

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THE COMPLETE GUNT PROGRAMME – EQUIPMENT FOR ENGINEERING EDUCATION

ENGINEERING MECHANICS & MACHINE ELEMENTS



- Statics
- Strength of Materials
- Dynamics
- Fundamentals of Engineering Design
- Machinery Diagnosis
- Properties of Materials



FLUID MECHANICS



- Fundamentals of Fluid Mechanics
- Steady Flow
- Steady Flow of Compressible Fluids
- Flow around Bodies
- Examples of Transient Flow
- Hydraulic Fluid Energy Machines
- Components in Piping Systems and Plant Design
- Fluidic Experimental Plants
- Hydraulic Engineering



MECHATRONICS



- Engineering Drawing
- Cutaway Models
- Dimensional Metrology
- Fasteners and Machine Parts
- Manufacturing Engineering
- Assembly Projects
- Maintenance
- Machinery Diagnosis
- Automation



PROCESS ENGINEERING



- Process Control Engineering
 - Fundamentals of Control Engineering
 - Components and Calibration
 - Simple and Complex Control Systems
- Theoretical Fundamentals
- Practical Fundamentals
- Mechanical Process Engineering
- Thermal Process Engineering
- Chemical Process Engineering
- Biological Process Engineering
- Water Treatment



THERMAL ENGINEERING AND HVAC



- Fundamentals of Thermodynamics
- Applied Thermodynamics
- Renewable Energies
- Power Engines and Machines
- Internal Combustion Engines
- Refrigeration and Air Conditioning Technology
- Heating and Ventilation in Buildings
- Sanitary Systems



ENERGY & ENVIRONMENT



- ENERGY**
- Solar Energy
 - Hydropower
 - Wind Power
 - Biomass
 - Geothermal Energy
 - Energy Systems
 - Energy Efficiency in Building Service Engineering

- ENVIRONMENT**
- Water
 - Air
 - Soil
 - Waste



PLANNING & CONSULTING · TECHNICAL SERVICE COMMISSIONING & TRAINING



TRAINING IN REFRIGERATION AND AIR CONDITIONING TECHNOLOGY WITH GUNT TRAINING SYSTEMS

The complete program for all issues in refrigeration and air conditioning technology

Suitable both for vocational education and engineering training

Practical exercises

- Assembly
- Adjustment
- Testing
- Replacement

Scientific investigations

- Thermodynamic interrelationships
- Observations in the cyclic process
- Energy balances and energy efficiency
- Efficiency

With the GUNT training systems you can work successfully in almost all subject areas as a mechatronics engineer for refrigeration.

SUBJECT AREAS FOR TRAINING AS A MECHATRONICS ENGINEER FOR REFRIGERATION

REFRIGERATION	AIR CONDITIONING TECHNOLOGY	ELECTRICAL ENGINEERING, CONTROL AND AUTOMATION
Functional interrelationships in the refrigeration circuit	Investigation of the states of the air	Principles of electrical engineering
Production of mechanical subsystems	Basic interrelationships in ventilation and room air conditioning	Consumers of single phase alternating current
Thermodynamics, log p-h diagram	Construction elements and function of the air conditioning system	Protection against electrical hazards
Refrigerants and lubrication oils	Air conditioning, h-x diagram	Simple refrigeration controls
Primary and secondary controllers	Air circuit in the ductwork	Consumers of three phase alternating current
Heat exchangers	Fire protection measures	Electrical drives and fault finding
Compressors	Energy saving	Control of refrigeration systems
Piping		Building automation
Fault finding, maintenance and disposal		

Extensive allocation of GUNT units to the subject areas can be found on page 222.

■ = covered by GUNT units

Structure of the catalogue Refrigeration and Air Conditioning Technology

The catalogue is divided into the three main chapters refrigeration, air conditioning technology and electrical engineering. Informative pages containing basic knowledge precede the sub-chapters and explain the technical and physical context in an easy to comprehend manner. This allows for an easy introduction to the respective subject matter of the catalogue.

REFRIGERATION	Principles of Cold Production	
	Thermodynamics of the Refrigeration Cycle	
	Components of Refrigeration	
	Assembly, Fault finding, Maintenance	
	Modular Training Systems	
	Heat Pumps and Ice Stores	
AIR CONDITIONING TECHNOLOGY	States of the Air	
	Principles of Air Conditioning Technology	
	Practical Air Conditioning Systems	
	Ventilation Technology	
ELECTRICS IN REFRIGERATION AND AIR CONDITIONING TECHNOLOGY	Refrigeration Controls	
	Control of Refrigeration Systems	
	Fault Finding	

 Mainly with experimental orientation  Mainly with technical orientation

GUNT training systems are complete systems where everything is coordinated and from a single source.

- Experimental unit
- Measuring technology
- Tailored software
- Instructional material
 - ▶ Theoretical background
 - ▶ Detailed experiment instructions
 - ▶ Worksheets for trainees
 - ▶ Solutions and hints for the teacher

This means that GUNT training systems can be used fast and effectively during lessons and study.

REFRIGERATION

PRINCIPLES OF COLD PRODUCTION

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Overview	Basic Knowledge – Principles of Cold Production	10
ET 101	Simple Compression Refrigeration Circuit	12
ET 400	Refrigeration Circuit with Variable Load	14
ET 411C	Compression Refrigeration System	16
ET 352	Vapour Jet Compressor in Refrigeration Engineering	18
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ET 480	Absorption Refrigeration System	24

THERMODYNAMICS OF THE REFRIGERATION CYCLE

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ET 351C	Thermodynamics of the Refrigeration Circuit	32
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COMPONENTS OF REFRIGERATION: COMPRESSORS

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ASSEMBLY, FAULT FINDING, MAINTENANCE

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BASIC KNOWLEDGE

PRINCIPLES OF COLD PRODUCTION

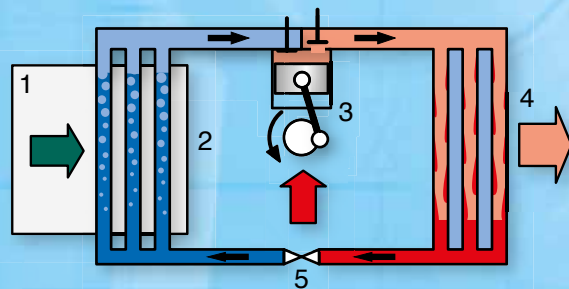
Different types of cold production

- Compression refrigeration system
- Cold gas refrigeration system (Stirling principle)
- Absorption refrigeration system
- Thermoelectric cold production (Peltier element)
- Vortex cold generator

Here we illustrate different basic principles of cold production.

COMPRESSION REFRIGERATION SYSTEM

The compression refrigeration system is used most frequently for cooling. It uses the effect that during evaporation of a liquid a lot of heat is absorbed. When condensing the vapour this heat is discharged again.



With different pressures during evaporation and condensing the temperature levels can be adjusted in such a way that heat is transported from the cold to the hot side.

Because the refrigerant circulates in a closed circuit, this is called the refrigeration cycle. Instead of the piston compressor shown, screw, scroll, turbo or steam jet compressors can also be used.

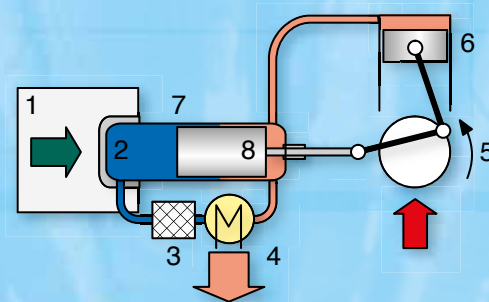
As refrigerant, liquids with a low boiling point, such as fluorinated hydrocarbons (FC), propane, CO₂ or NH₃, are used.

In the most simple case a compression refrigeration system consists of an evaporator 2 in the room to be cooled 1, a compressor 3, a condenser 4 and an expansion element 5.

COLD GAS REFRIGERATION SYSTEM

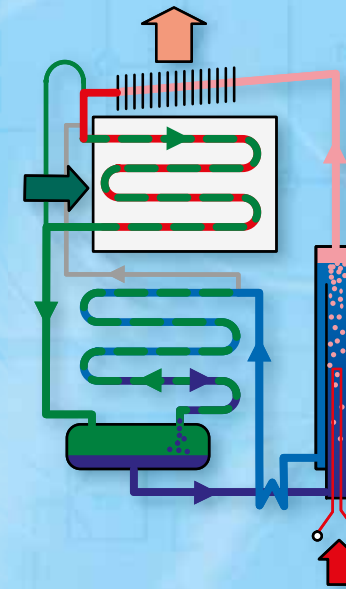
The cold gas refrigeration system based on the Stirling principle is used to generate very low temperatures. Areas of application are the liquefaction of air or the cooling of infrared cameras.

The cold gas refrigeration system corresponds to the familiar Stirling motor, but the direction of rotation is reversed. This reverses the cycle flow and the power generator becomes a work machine operating as a heat pump.



The cold gas refrigeration system consists of an operating cylinder 6 and a displacement cylinder 7. In the operating cylinder the operating gas (usually helium) is alternately compressed and expanded. The compressed hot gas discharges its heat in the heat exchanger 4. During the expansion the gas cools down and absorbs on the cold side 2 of the displacement cylinder heat from the room to be cooled 1. Displacement pistons 8 and operating pistons 6 are moved via a crank drive 5 with offset phases. The recuperator 3 increases the efficiency.

ABSORPTION REFRIGERATION SYSTEM



In an absorption system ammonia (NH₃) is used as refrigerant. As in a compression refrigeration system, liquid ammonia evaporates in an evaporator and thereby absorbs heat. The vaporous ammonia is then dissolved in water in an absorber. The ammonia solution is heated releasing vaporous ammonia. The ammonia vapour is condensed into liquid ammonia again in a condenser.

To ensure a temperature difference between evaporation and condensation, a pressure difference must be present. This difference is created by a pump for the solution or a so-called auxiliary gas (hydrogen H₂). When using the auxiliary gas, a pump can be omitted and the refrigerating machine does not have any moving parts. The supply of the drive energy is purely thermal via a boiler. The boiler can be heated electrically or by gas. The use of waste heat or solar energy is also possible.

ammonia vapour liquid ammonia low concentration ammonia solution high concentration ammonia solution hydrogen hydrogen and ammonia vapour

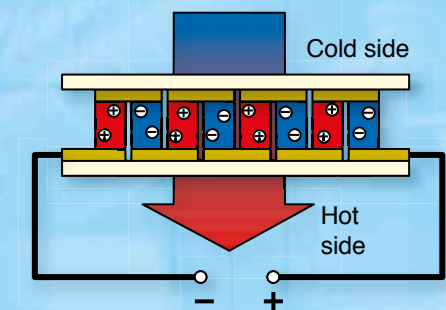
THERMOELECTRIC REFRIGERATION SYSTEM

Thermoelectric refrigeration systems operate using the Peltier effect. The principle of function corresponds to the reversal of the function of the thermocouple known from temperature measurements. A special semiconductor material is used in the Peltier element.

Very low temperatures can be achieved, but the efficiency reduces greatly with increasing temperature difference.

Peltier elements are operated with direct current; the direction of the current determines the direction of the heat transport. Therefore, Peltier elements can cool

and heat, are easy to control and do not have any moving parts or liquid fillings.

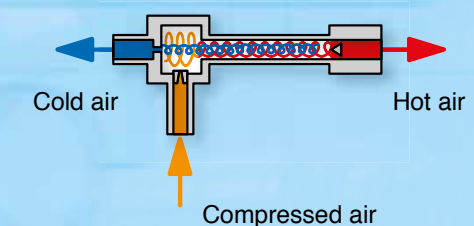


VORTEX COLD GENERATOR

The vortex cold generator is an extraordinary refrigerating machine. Here a cold and a hot air flow is generated from a compressed air flow at room temperature. The compressed air enters a vortex chamber tangentially and is moved into fast rotation. At the centre of the vortex a cold air flow forms, while the outer layer of the vortex heats up. The cold air is extracted at the centre and can be used for cooling.

The benefit of this refrigerating machine is that it is of a very simple design, does not have any moving

parts, no toxic working materials and does not require a power supply. The low efficiency is a disadvantage.



ET 101 Simple Compression Refrigeration Circuit



- * Introduction to refrigeration
- * Model of a compression refrigeration system / heat pump
- * Cooling and heating of the heat exchangers directly tangible

Technical Description

The purpose of a refrigeration system is the cooling of materials and products, e.g. to protect food from spoiling. Cooling can be described as a process in which heat is removed from the environment.

A commonly used refrigeration system is the so-called compression refrigeration system. In this system refrigerant flows through four main elements: compressor, condenser, expansion element and evaporator. The refrigeration system uses the fact that the refrigerant has a low boiling point at low pressure. This means that evaporation takes place on the low pressure side. During the evaporation of the refrigerant heat is removed from the environment and it is cooled. The condensation takes place on the high pressure side after the evaporator. Here the heat is discharged into the environment. If not the cooling effect but the discharged heat is used, this is called a heat pump.

The set-up of ET 101 represents a simple compression refrigeration system. Evaporator and condenser have been designed as a pipe coil with each end immersed in a water-filled tank. The water simulates the environment. A thermostatic expansion valve serves as expansion element. Two manometers indicate the two system pressures on the high and low pressure sides. On an additional scale on the manometer the evaporation temperature of the refrigerant is indicated. Two thermometers measure the temperature of the water in the tanks.

This allows for calculations of the amount of heat removed from the environment (evaporator, cold water) and added to the environment

(condenser, hot water). A sight glass indicates the aggregate state of the refrigerant upstream of the expansion valve.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

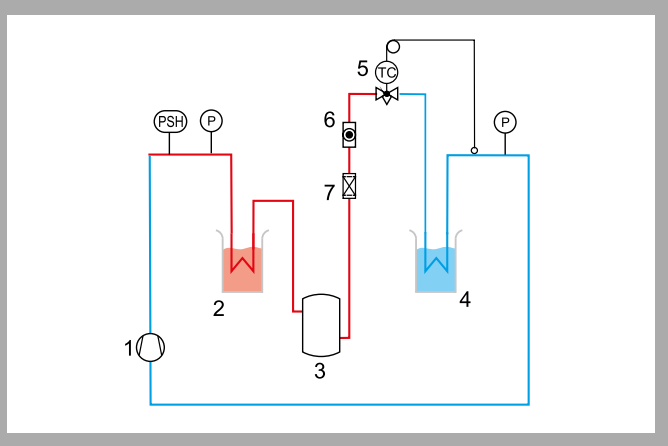
Learning Objectives / Experiments

- fundamentals of a compression refrigeration circuit
- key components of a refrigeration system
- * compressor, evaporator, condenser, expansion element
- relationship between the pressure and boiling point of a liquid
- operation of a refrigeration system / heat pump
- developing a basic understanding of the thermodynamic cycle
- simple energy balance

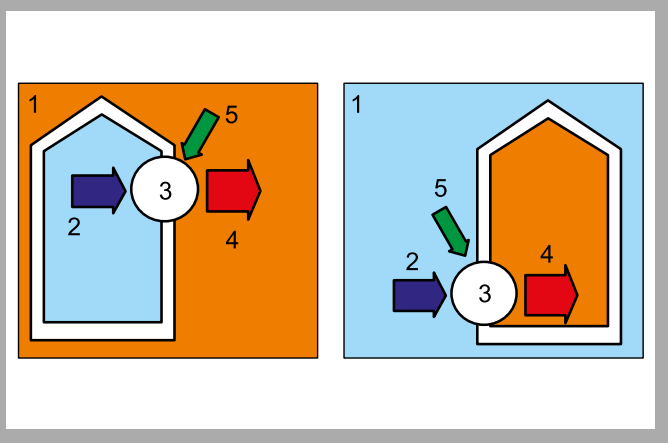
ET 101 Simple Compression Refrigeration Circuit



1 main switch, 2 pressure switch, 3 evaporator with water tank, 4 compressor, 5 receiver, 6 thermometer, 7 condenser, 8 sight glass (refrigerant), 9 manometer, 10 expansion valve



Process schematic of the refrigeration circuit: 1 compressor, 2 evaporator, 3 receiver, 4 condenser, 5 expansion valve, 6 sight glass, 7 filter/drier; PSH pressure switch, P pressure



Cooling and heating using a heat pump
1 environment, 2 absorbed heat, 3 heat pump, 4 discharged heat, 5 electric energy

- Specification**
- [1] fundamentals of refrigeration in a simplified model
 - [2] typical compression refrigeration system with piston compressor, thermostatic expansion valve, evaporator and condenser (each in the shape of a pipe coil)
 - [3] 2 manometers with temperature scale for the refrigerant show the values of the refrigerant on the high and low pressure sides
 - [4] 2 water-filled tanks with thermometer to demonstrate the cooling and heating effect
 - [5] pressure switch to protect the compressor
 - [6] sight glass to monitor the aggregate state of the refrigerant
 - [7] refrigerant R134a, CFC-free

- Technical Data**
- Compressor
- power consumption: 104W at 5/40°C
 - refrigeration capacity: 278W at 5/40°C
 - displaced volume: 2,72cm³
- Manometer with temperature scale for R134a
- intake side (low pressure)
pressure: -1...12,5bar
temperature: -50...40°C
 - delivery side (high pressure)
pressure: -1...25bar
temperature: -40...80°C
- Thermometer: 2x -10...50°C
Tank: 4x 1700mL

- Dimensions and Weight**
- LxWxH: 750x360x690mm
Weight: approx. 30kg

- Required for Operation**
- 230V, 50/60Hz, 1 phase or 120V, 60Hz/CSA, 1 phase

- Scope of Delivery**
- 1 experimental unit, filled with refrigerant
 - 4 water tanks
 - 2 thermometers
 - 2 spoons
 - 1 set of instructional material

- Order Details**
- 061.10100 ET 101 Simple Compression Refrigeration Circuit

ET 400 Refrigeration Circuit with Variable Load



- * Refrigeration circuit with water circuit as load
- * Defined cooling load via controlled water temperature
- * Display of all relevant values at the location of measurement

Technical Description

ET 400 examines a refrigeration circuit under an adjustable load. The refrigeration circuit consists of a compressor, a condenser with fan, a thermostatic expansion valve and a coaxial coil heat exchanger as evaporator. A water circuit serves as load, consisting of a tank with a heater and a pump. The temperature in the tank is adjusted at a controller.

The purpose of this refrigeration circuit is the production of cold water. The water flows through the jacket of the coaxial coil heat exchanger, transfers heat to the refrigerant and thereby cools down.

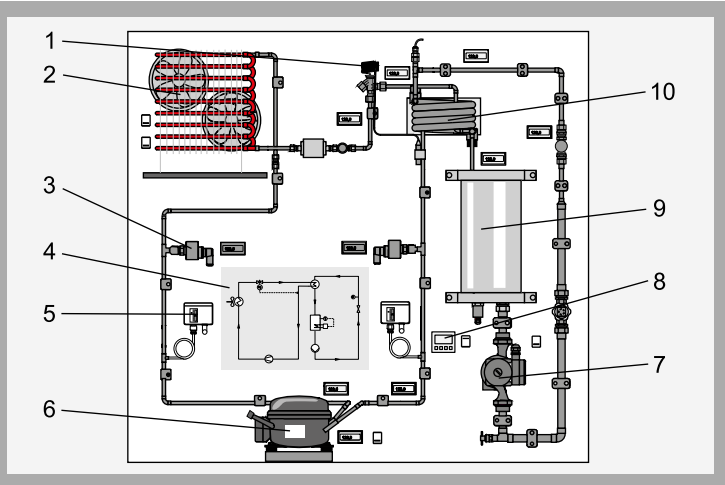
All relevant measured values are recorded by sensors. Displays at the respective locations of measurement indicate the measured values. This makes it easy to assign the measured values to the process. The simultaneous transmission of the measured values to a data recording software enables easy analysis and the representation of the process in the log p-h diagram. The software also displays the key characteristic variables of the process, such as the compressor pressure ratio and the coefficient of performance.

The clearly arranged components aid understanding. The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

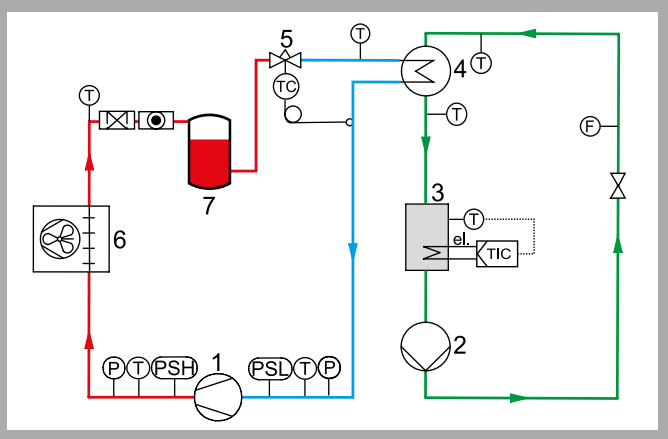
Learning Objectives / Experiments

- 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

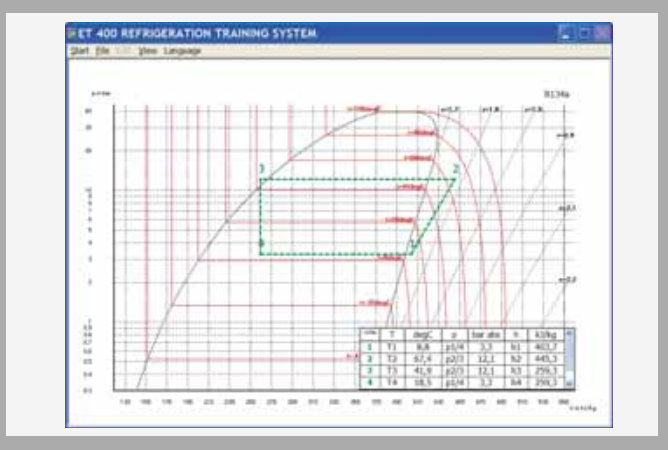
ET 400 Refrigeration Circuit with Variable Load



1 expansion valve, 2 condenser with fan, 3 pressure sensor, 4 process schematic, 5 pressure switch, 6 compressor, 7 pump, 8 heater controller, 9 warm water tank with heater, 10 evaporator



1 compressor, 2 pump, 3 warm water tank with heater, 4 evaporator, 5 expansion valve, 6 condenser; T temperature, P pressure, F flow rate, TIC temperature controller, PSH, PSL pressure switch; blue-red: refrigeration circuit, green: water circuit



Software screenshot: log p-h diagram

Specification

- [1] investigation of a refrigeration circuit with water circuit as load
- [2] refrigeration circuit with compressor, condenser with fan, thermostatic expansion valve and coaxial coil heat exchanger as evaporator
- [3] water circuit with pump, tank with heater as cooling load at the evaporator
- [4] heater with controller to adjust the tank temperature
- [5] record of all relevant measured values and display directly at the location of measurement
- [6] GUNT software for data acquisition via USB under Windows Vista or Windows 7
- [7] refrigerant R134a, CFC-free

Technical Data

- Compressor
 - refrigeration capacity: approx. 380W at 5/40°C
- Evaporator
 - refrigerant volume: 0,4L
 - water volume: 0,8L
- Condenser
 - transfer area: approx. 0,175m²
 - fan power consumption: 2x 29W
- Pump
 - max. flow rate: 1,9m³/h
 - max. head: 1,4m
- Tank
 - volume: approx. 4,5L
 - heater: approx. 450W
- Measuring ranges
 - pressure: 2x -1...15bar
 - compressor power: 1x 0...750W
 - temperature: 6x 0...100°C
 - flow rate (water): 1x 0,05...1,8L/min

Dimensions and Weight

- LxWxH: 1400x560x1800mm
- Weight: approx. 120kg

Required for Operation

- 230V, 50/60Hz, 1 phase or 120V, 60Hz/CSA, 1 phase

Scope of Delivery

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

Order Details

- 061.40000 ET 400 Refrigeration Circuit with Variable Load

ET 411C **Compression Refrigeration System**



- * **Compression refrigeration system with transparent evaporator and transparent condenser**
- * **Compare different expansion elements**
- * **Effect of under/overfilling of the system with refrigerant**

Technical Description

The set-up of ET 411C represents a typical refrigeration circuit consisting of a hermetic compressor, condenser, evaporator and expansion element. Evaporator and condenser are designed as finned tube heat exchangers. The pipes of both heat exchangers are partially transparent to visualise the process of the phase transition during evaporation and condensing. Three capillary tubes of different lengths and a thermostatic expansion valve can be compared as expansion elements.

The trainer is equipped with a receiver for refrigerant. Using the receiver, refrigerant can be added to or removed from the refrigeration circuit. This allows for the effects of overfilling or underfilling of the system to be examined.

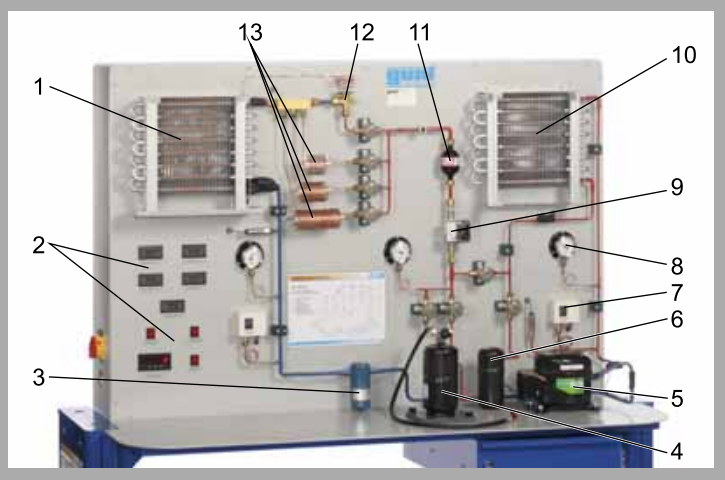
The flow rate of the refrigerant is read from a flow meter. Temperature and pressure in the refrigeration circuit and the electrical power consumption of the compressor are recorded by sensors. The measured values can be read on digital displays. At the same time, the measured values can also be transmitted directly to a PC via USB. The data acquisition software is included. Parameter changes in the refrigeration circuit can be viewed dynamically in the software's log p-h diagram.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

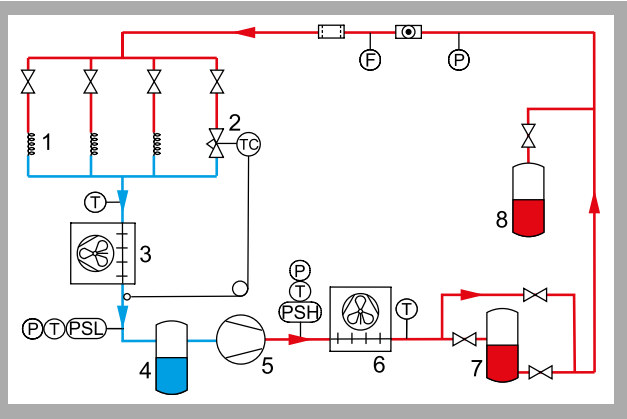
Learning Objectives / Experiments

- function and operational behaviour of the refrigeration circuit components
- operation with expansion valve or with capillary tubes of different lengths
- underfilling or overfilling with refrigerant
- thermodynamic cycle in the log p-h diagram
- from the log p-h diagram and in comparison with the measured values
- * determination of the refrigeration capacity
- * determination of the coefficient of performance
- * determination of the efficiency of the compressor

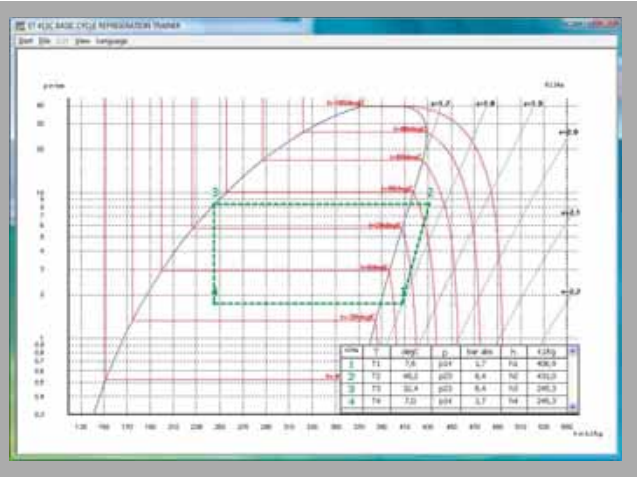
ET 411C **Compression Refrigeration System**



1 evaporator, 2 displays and controls, 3 suction line receiver, 4 reservoir, 5 compressor, 6 receiver, 7 compressor pressure switch, 8 manometer, 9 refrigerant flow meter, 10 condenser, 11 filter/drier, 12 expansion valve, 13 capillary tube



1 capillary tube, 2 expansion valve, 3 evaporator, 4 suction line receiver, 5 compressor, 6 condenser, 7 receiver, 8 reservoir; T temperature, P pressure, F flow rate, PSH, PSL pressure switch



Software screenshot: log p-h diagram

- Specification**
- [1] investigation of a refrigeration system with different expansion elements
 - [2] refrigeration circuit consisting of a hermetic compressor, condenser, evaporator and expansion element
 - [3] transparent finned tube heat exchangers as condenser and evaporator to observe the phase transitions of the refrigerant
 - [4] expansion valve and capillary tubes of different lengths as expansion elements
 - [5] receiver for underfilling/overfilling the system with refrigerant
 - [6] sensors record pressure and temperature
 - [7] compressor equipped with two pressure switches
 - [8] GUNT software for data acquisition via USB under Windows Vista or Windows 7
 - [9] refrigerant R134a, CFC-free

- Technical Data**
- Compressor
- power consumption: 213W at 7,2°/32°C
 - refrigeration capacity: 372W at 7,2/32°C
- Condenser and evaporator with fan
- max. volumetric air flow rate condenser: 300m³/h
 - max. volumetric air flow rate evaporator: 180m³/h
- Capillary tubes: 1,5m, 3m, 6m
- Receiver for refrigerant: 1,3L
- Measuring ranges
- pressure: -1...9bar / -1...24bar
 - temperature: 4x -40...150°C, 1x -100...100°C
 - flow rate: 2...18m³/h
 - electric power consumption: 0...1000W

- Dimensions and Weight**
- LxWxH: 1740x800x1780mm
- Weight: approx. 160kg
- Required for Operation**
- 230V, 50/60Hz, 1 phase or 120V, 60Hz/CSA, 1 phase
- Scope of Delivery**
- 1 trainer
 - 1 GUNT software CD + USB cable
 - 1 set of instructional material

- Order Details**
- 061.411C0 ET 411C Compression Refrigeration System

ET 352 Vapour Jet Compressor in Refrigeration Engineering



- * Refrigeration system with vapour jet compressor
- * Cold production using heat
- * Transparent condenser and evaporator

Technical Description

Unlike standard compression refrigeration systems, vapour jet refrigerating machines do not have a mechanical but a vapour jet compressor. This makes it possible to use different heat sources for cold production. Such sources could e.g. be solar energy or process waste heat.

The system includes two refrigerant circuits: one circuit is used for cold production (refrigeration cycle), the other circuit is used for the generation of motive vapour (vapour cycle).

The vapour jet compressor compresses the refrigerant vapour and transports it to the condenser. A transparent tank with a water-cooled pipe coil serves as condenser.

In the refrigeration cycle some of the condensed refrigerant flows into the evaporator connected to the intake side of the vapour jet compressor. The evaporator is a so-called flooded evaporator where a float valve keeps the filling level constant. The refrigerant absorbs the ambient heat or the heat from the heater and evaporates. The refrigerant vapour is aspirated by the vapour jet compressor and compressed again.

In the vapour cycle a pump transports the other part of the condensate into a vapour generator. An electrically heated tank with water jacket evaporates the refrigerant. The generated refrigerant vapour drives the vapour jet compressor.

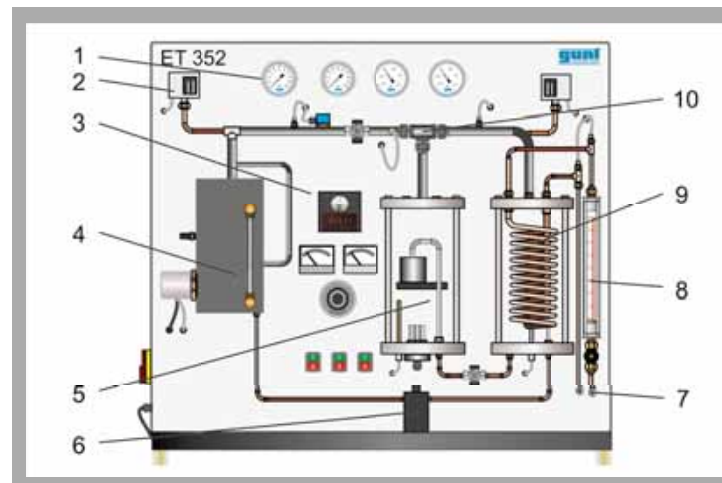
All relevant measured values, such as temperature and pressures, are measured and displayed in the experimental unit. The heater power at the evaporator is adjustable. The cooling water flow rate at the condenser is adjusted using a valve.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

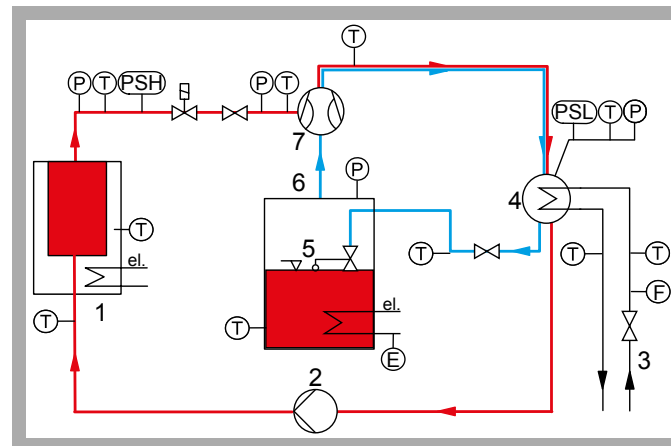
Learning Objectives / Experiments

- understanding compression refrigeration systems based on the vapour jet method
- clockwise and anticlockwise Rankine cycle
- energy balances
- calculation of the coefficient of performance of the refrigeration circuit
- thermodynamic cycle in the log p-h diagram
- operating behaviour under load

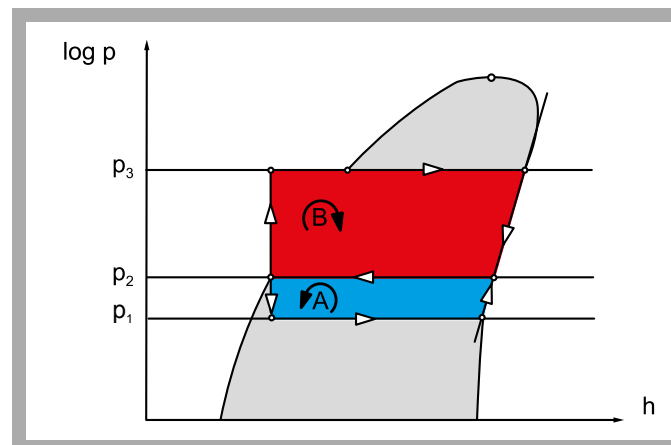
ET 352 Vapour Jet Compressor in Refrigeration Engineering



1 manometer, 2 pressure switch, 3 displays and controls, 4 vapour generator, 5 evaporator, 6 pump, 7 cooling water connections, 8 flow meter, 9 condenser, 10 vapour jet compressor



1 vapour generator, 2 pump, 3 cooling water connections, 4 condenser, 5 float valve, 6 evaporator, 7 vapour jet compressor; T temperature, P pressure, PSL, PSH pressure switch, F flow rate, E voltage and amperage



log p-h diagram: A refrigeration cycle, B vapour cycle, p_1 pressure in the evaporator, p_2 pressure in the condenser, p_3 pressure in the vapour generator

Specification

- [1] investigation of a vapour jet compressor
- [2] refrigeration circuit with condenser, evaporator and vapour jet compressor for refrigerant
- [3] vapour circuit with pump and vapour generator for operating the vapour jet compressor
- [4] transparent tank with water-cooled pipe coil as condenser
- [5] transparent tank with adjustable heater as evaporator
- [6] flooded evaporator with float valve as expansion element
- [7] vapour generator with electrically heated water jacket
- [8] measurement of amperage and voltage to determine the power at the evaporator
- [9] refrigerant Solkatherm SES36, CFC-free

Technical Data

Vapour jet compressor

- d_{min} convergent-divergent nozzle: approx. 1,7mm
- d_{min} mixing jet: approx. 7mm

Condenser

- tank: approx. 3,5L
- pipe coil area: approx. 0,17m²

Evaporator

- tank: approx. 3,5L
- heater power: 4x 125W

Vapour generator

- refrigerant tank: approx. 0,75L
- water jacket: approx. 9L
- heater power: 2kW

Pump

- max. flow rate: approx. 1,7L/min
- max. head: approx. 70mWS

Measuring ranges

- current: 0...2,5A
- voltage: 0...230VAC
- temperature: 10x -20...200°C
- pressure: 2x 0...10bar / 2x -1...1,5bar
- flow rate (cooling water): 6...75g/s

Dimensions and Weight

LxWxH: 1300x460x1200mm
Weight: approx. 170kg

Required for Operation

230V, 50/60Hz, 1 phase
Water connection

Scope of Delivery

1 experimental unit
1 hose
4kg refrigerant Solkatherm SES36
1 funnel
1 set of instructional material

Order Details

061.35200 ET 352 Vapour Jet Compressor in Refrigeration Engineering

ET 120 Cooling Using the Peltier Effect



- * Demonstration of the thermoelectric effect
- * Creation of energy balances

Technical Description

The experimental unit demonstrates cooling using the Peltier effect. Peltier elements utilise the thermoelectric effect of some semiconductors. The thermoelectric effect is the reverse of the known thermopower effect which is e.g. used when measuring temperatures using thermocouples. If current flows through a Peltier element, one end of the semiconductor becomes hot and the other cold. By a suitable connection of p- and n-doped semiconductor materials the refrigeration capacity can be increased sufficiently to be usable.

The benefits of cold production using Peltier elements are: Peltier elements are wear and maintenance-free, noiseless, independent of position and easy to adjust in their refrigeration capacity via the supply voltage. In addition, no refrigerants are required. Peltier elements are used for small capacities in thermography as beverage chillers or in medical engineering. Their low efficiency is a disadvantage.

The experimental set-up is clearly arranged on the front of the experimental unit. The central component of the system is a Peltier element. The heating and refrigeration capacity of the Peltier element are dissipated via water flows. Measuring the respective flow rate and the inlet and outlet temperatures allows for the heat flows to be determined. The supplied electrical power is determined using a current and voltage measurement.

Due to the closed water circuit the experimental unit can also be operated for short periods of time without being connected to the water mains.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

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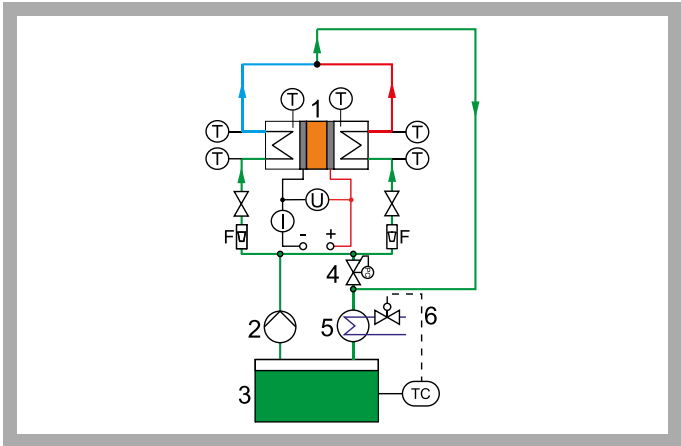
Learning Objectives / Experiments

- function and operation of a Peltier element
 - * for cooling
 - * as heat pump
- determination of the refrigeration and heating capacity
- recording typical characteristics, such as refrigeration capacity, via temperature differences
- energy balance
- calculating the coefficient of performance

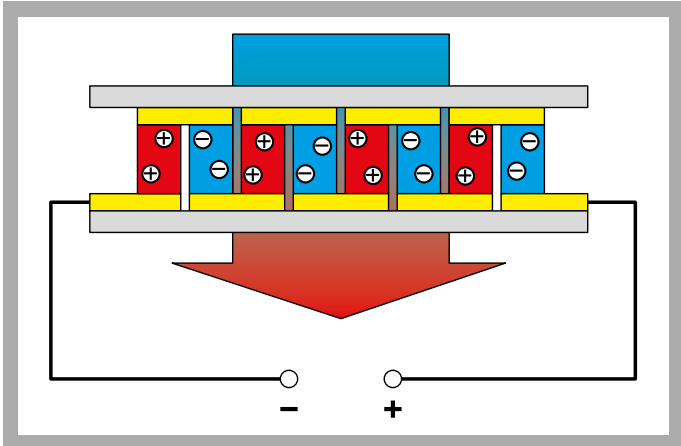
ET 120 Cooling Using the Peltier Effect



1 cold water flow meter, 2 temperature displays cold side, 3 water tank temperature controller, 4 voltage and current displays, 5 adjustment of the electrical power, 6 Peltier element with heat exchangers, 7 hot water flow meter, 8 temperature displays hot side, 9 water tank cover



1 Peltier element, 2 pump, 3 tank, 4 pressure relief valve, 5 heat exchanger, 6 solenoid valve; T temperature, F flow rate; U, I supply voltage and current measurement; blue: water cold side, red: water hot side, green: mixed water



Principle of operation: semiconductors connected electrically in series transport the heat from the cold side (blue) to the hot side (red)

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Specification

- [1] functional model of a Peltier refrigeration system
- [2] experimental unit with clear design of all components at the front
- [3] water-cooled Peltier element
- [4] shared water circuit for heating and cooling with tank, pump and flow meters
- [5] electrical power freely adjustable via potentiometer
- [6] digital displays for temperature, current and voltage
- [7] flow meter measurement of the water flows via rotameters

Technical Data

- Peltier element
- max. refrigeration capacity: 191,4W
 - max. current: 22,6A
 - max. voltage: 16,9V
 - max. temperature difference: 77,8K
 - hot side temperature: 50°C
- Pump
- power consumption: 120W
 - max. flow rate: 1000L/h
 - max. head: 30m
- Water tank
- content: 7L

Measuring ranges

- current: 0...20A
- voltage: 0...200V
- temperature: 2x -30...80°C, 4x 0...100°C
- flow rate: 1x 2...27L/h, 1x 10...105L/h

Dimensions and Weight

- LxWxH: 1000x640x600mm
- Weight: approx. 60kg

Required for Operation

- 230V, 50Hz, 1 phase or 120V, 60Hz/CSA, 1 phase
- Water connection

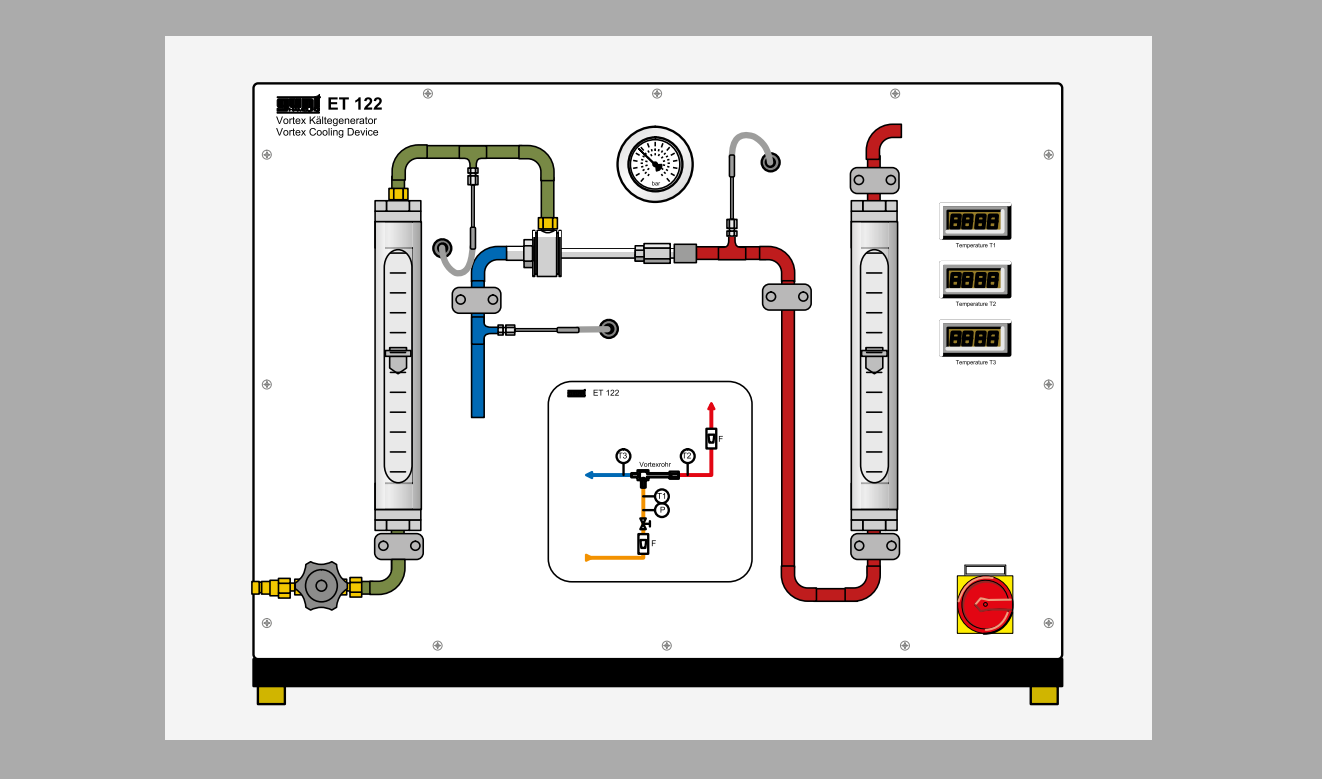
Scope of Delivery

- 1 experimental unit
- 1 set of instructional material

Order Details

- 061.12000 ET 120 Cooling Using the Peltier Effect

ET 122 Vortex Cooling Device



- * Demonstration of the vortex principle
- * Cooling and heating using compressed air

Technical Description

The experimental unit generates cold and hot air with the aid of ordinary compressed air. The central element of the experimental unit is a vortex cooling device also known as a cyclone tube. In the cyclone tube the tangentially incoming compressed air is moved in rapid rotation. This creates a cold and hot air flow in the cyclone tube which leaves the cyclone tube at opposite ends.

A vortex cooling device does not have any moving parts, is maintenance-free and immediately ready for operation.

The vortex cooling device is used for the convective cooling of high-speed tools, the air conditioning of protection suits and the cooling of switch cabinets. It is particularly suited for use in explosive environments. One benefit here is that the vortex device does not require an electric power supply.

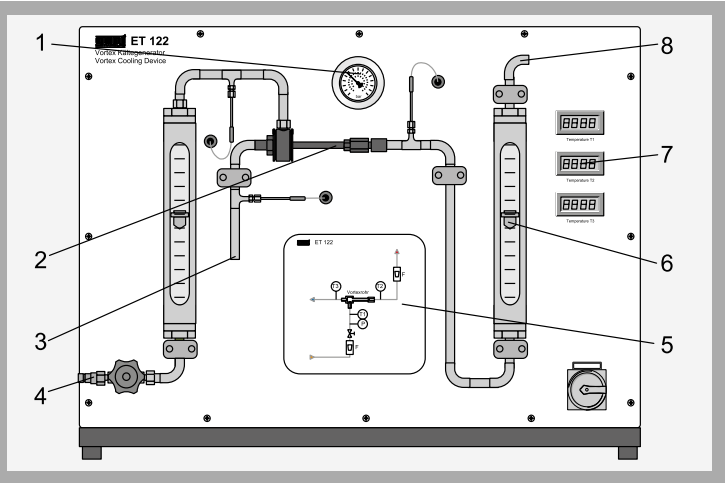
The inlet pressure is measured using a manometer. The compressed air volume and the outlet volume of the hot air flow are each measured using a rotameter. The inlet temperature of the compressed air and the outlet temperatures of the cold and hot air flows are displayed digitally.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

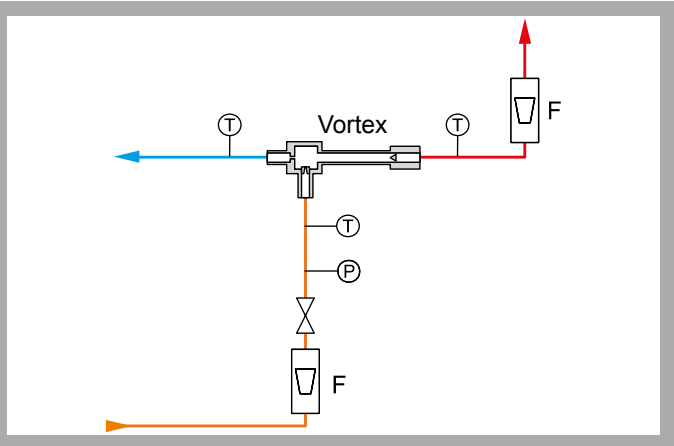
Learning Objectives / Experiments

- function and operation of a vortex cooling device
- air flow distribution dependent on the temperature of the cold air flow
- effect of the inlet pressure on heating and refrigeration capacity

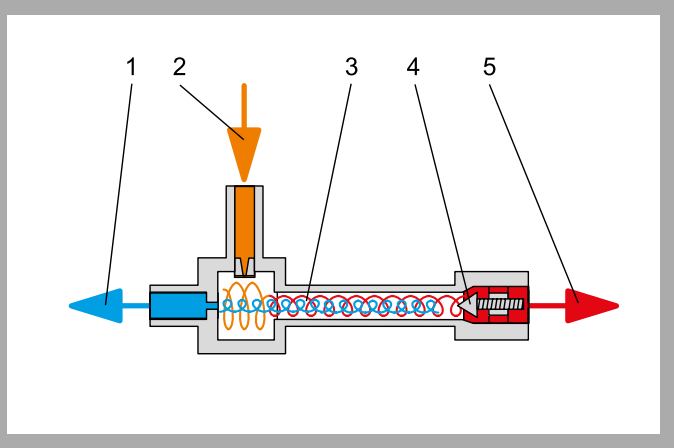
ET 122 Vortex Cooling Device



1 manometer, 2 vortex tube, 3 cold air outlet, 4 compressed air connection, 5 process schematic, 6 flow meter, 7 temperature displays, 8 hot air outlet



T temperature, P pressure, F flow rate;
arrows: blue: cold air, red: hot air, orange: compressed air



Internal structure of the vortex device: 1 cold air outlet, 2 compressed air inlet, 3 cyclone tube, 4 flow control valve in the hot air outlet to adjust the cold air temperature, 5 hot air outlet

Specification

- [1] functional model for cold air generation using a vortex device (cyclone tube) with the aid of compressed air
- [2] experimental unit with clear design of all components at the front
- [3] simple design, no moving components, wear-free
- [4] measuring of the compressed air inlet pressure by manometer
- [5] flow rate measurement of compressed air and exhaust hot air by rotameters
- [6] digital displays for inlet temperature and outlet temperature of cold and hot air

Technical Data

- Vortex cooling device
- inlet pressure: 7bar
- air consumption: max. 280L/min
- refrigeration capacity: max. 175W
- minimum temperature: -47°C
- maximum temperature: 110°C

Measuring ranges

- temperature: 0...150°C / -50...50°C
- pressure: 0...10bar
- flow rate: 30...300L/min

Dimensions and Weight

- LxWxH: 900x400x700mm
- Weight: approx. 60kg

Required for Operation

- 230V, 50Hz, 1 phase or 120V, 60Hz, 1 phase
- Compressed air 10bar

Scope of Delivery

- 1 experimental unit
- 1 set of instructional material

Order Details

061.12200 ET 122 Vortex Cooling Device

ET 480 Absorption Refrigeration System



- * Model of an absorption refrigeration system
- * Boiler operated alternatively by gas or electrically
- * Adjustable heating at the evaporator serves as cooling load

Technical Description

Absorption refrigeration systems operate using thermal energy. They use the principle of liquids evaporating already at low temperatures when pressure is reduced. This basic principle is demonstrated in the experimental unit ET 480 with the example of an ammonia-water solution with the ammonia acting as refrigerant.

In the evaporator the liquid ammonia evaporates and withdraws heat from the environment. To keep the evaporation pressure low, the ammonia steam in the absorber is absorbed by the water. In the next step, ammonia is permanently removed from the high concentration ammonia solution to prevent the absorption process from being halted. For this purpose, the high concentration ammonia solution is heated in a generator until the ammonia evaporates again. In the final step, the ammonia steam is cooled in the condenser to the base level, condenses and is returned to the evaporator. The low concentration ammonia solution flows back to the absorber. To maintain the pressure differences in the system, hydrogen is used as an auxiliary gas.

In process technology systems the resulting waste heat can be used for cooling. In small mobile systems, such as a camping refrigerator or minibar in a hotel, the required heat is generated electrically or by gas burner. Another benefit of absorption refrigeration systems is their silent operation.

ET 480 demonstrates the functional principle of an absorption refrigeration system with its main components: evaporator, absorber, boiler as generator with bubble pump, condenser. The boiler can alternatively be operated with gas or electrically. Another electric heater

at the evaporator generates the cooling load.

Temperatures in the refrigeration circuit and the heating power at the boiler and at the evaporator are recorded and displayed digitally.

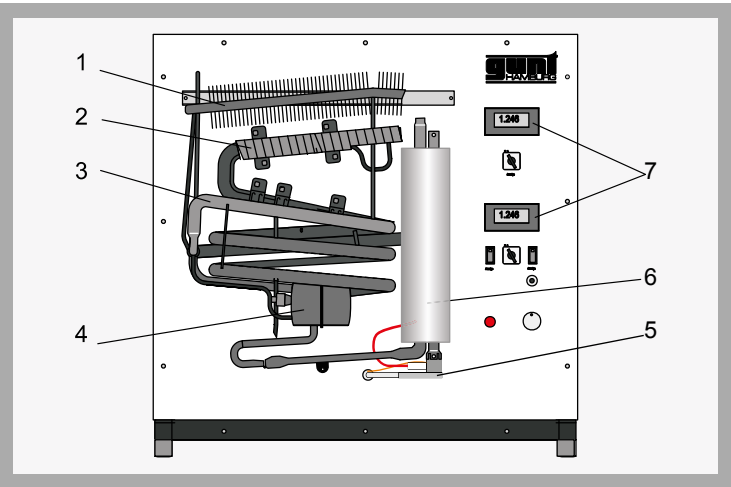
The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

Learning Objectives / Experiments

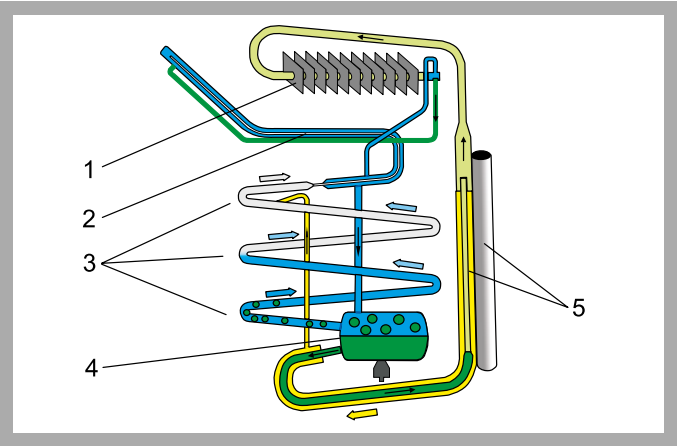
- demonstrate the basic principle of an absorption refrigeration system
- absorption refrigeration system and its main components
- operating behaviour under load

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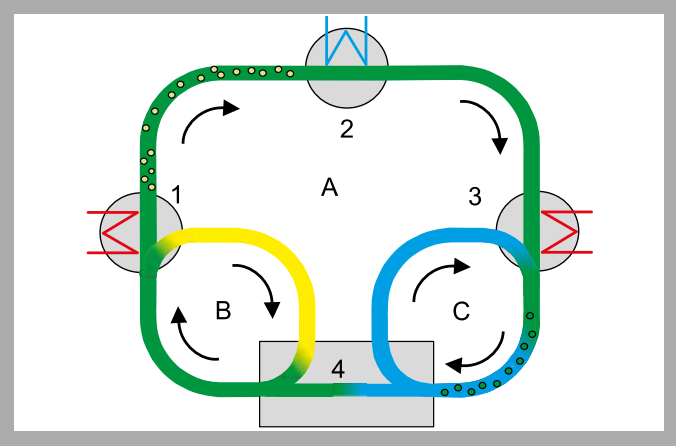
ET 480 Absorption Refrigeration System



1 condenser, 2 evaporator with heater, 3 absorber, 4 tank, 5 gas burner, 6 boiler with bubble pump to separate the ammonia, 7 displays and controls



1 condenser, 2 evaporator, 3 absorber, 4 tank, 5 boiler with bubble pump; green: high concentration ammonia solution, yellow: low concentration ammonia solution, blue: gas mixture ammonia-hydrogen



1 boiler with bubble pump, 2 condenser, 3 evaporator, 4 absorber; A: ammonia circuit, B: water circuit, C: hydrogen circuit

Specification

- [1] operation of an absorption refrigeration system
- [2] main system components: evaporator, absorber, boiler with bubble pump, condenser
- [3] ammonia-water solution as working medium, hydrogen as auxiliary gas
- [4] boiler to separate ammonia
- [5] bubble pump for transportation in the circuit
- [6] adjustable electrical heater at the evaporator serves as cooling load
- [7] boiler is alternatively heated by electrical heater or gas burner
- [8] piezoelectric igniter for gas operation
- [9] digital displays for temperature and power

Technical Data

Working medium: ammonia-water solution
Auxiliary gas: hydrogen
Electric heater: 125W
Gas burner, adjustable: propane gas
Evaporator heater, adjustable: 50W

Measuring ranges
- temperature: 4x -80...180°C
- power: 0...150W

Dimensions and Weight

LxWxH: 750x450x750mm
Weight: approx. 47kg

Required for Operation

230V, 50/60Hz, 1 phase or 120V, 60Hz/CSA, 1 phase;
Propane gas: 30...50mbar

Scope of Delivery

- 1 experimental unit
- 1 hose
- 1 pressure reducer
- 1 set of instructional material

Order Details

061.48000 ET 480 Absorption Refrigeration System

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BASIC KNOWLEDGE

THERMODYNAMICS OF THE REFRIGERATION CYCLE

Set-up and function of a compression refrigeration system

The refrigerant in a compression refrigeration system flows through a closed cycle with the following four stations:

- Evaporation **A**
- Compression **B**
- Condensation **C**
- Expansion **D**

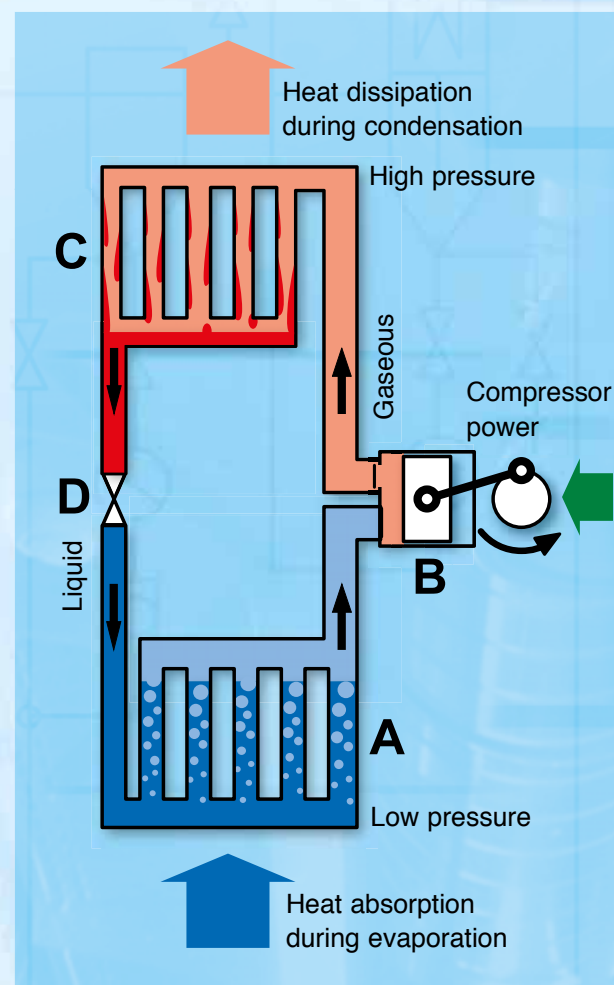
The cooling takes place in the evaporator (**A**). The evaporation takes place at low pressures and temperatures. Here the refrigerant absorbs heat from the environment and thus cools it.

The still cold refrigerant steam is aspirated by a compressor (**B**) and subjected to higher pressure by using mechanical energy. The refrigerant steam heats up due to the compression.

The hot refrigerant steam is cooled down in a condenser (**C**) and condenses while discharging heat to the environment.

The liquid pressurised refrigerant is then expanded to the low evaporation pressure in an expansion element (**D**) and returned to the evaporator.

The refrigerant evaporates again and thus completes the circuit.



Cyclic process of a simple compression refrigeration system

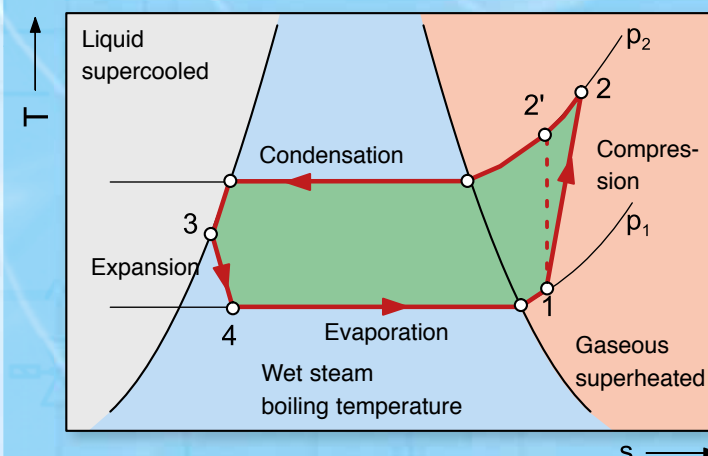
The refrigeration cycle

For operating media which can have different phases, such as water or refrigerant, the T - s diagram looks different.

It has an area on the left (grey), in which the operating medium is liquid and supercooled. In the centre (blue) there is a mixture of steam and liquid, the wet steam. On the right of it (orange) the operating medium is in pure steam form and superheated.

The real refrigeration cycle with its typical phase transitions can also be represented in this T - s diagram. The cycle has many similarities to the familiar steam power cycle. The major difference is that the cycle is anticlockwise. Thus the processes of evaporation and condensation and expansion and compression (pumping) swap places.

The enclosed area (green) corresponds to the compressor work added to the cycle.



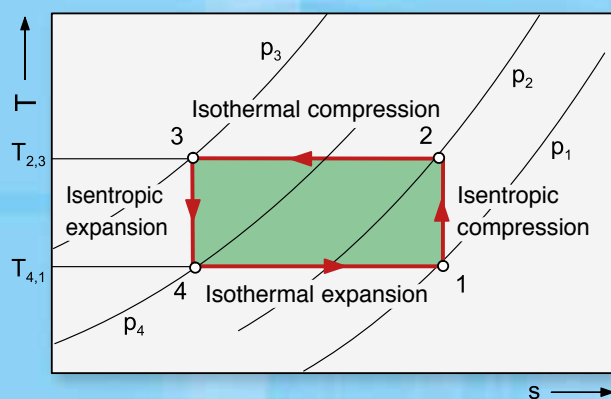
Refrigeration cycle in the T - s diagram

The ideal cyclic process

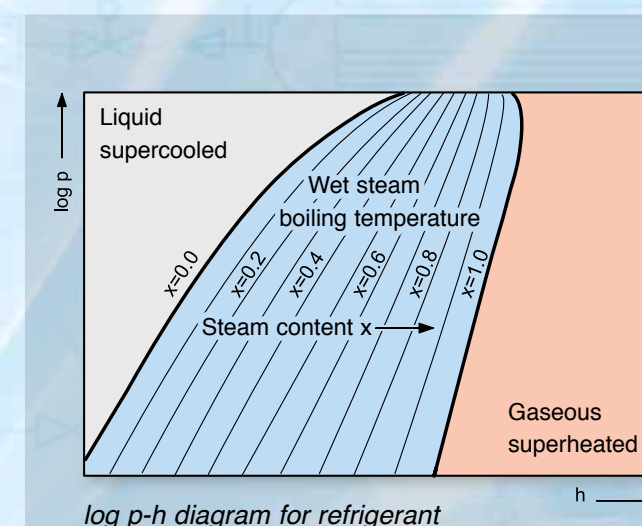
A cyclic process can be represented very clearly in the T - s diagram. Here the temperature T of the operating medium is plotted above the entropy s . The area enclosed by the change of state of the operating medium corresponds to the work realised in the cyclic process.

The cyclic process with the highest possible efficiency is the Carnot cycle, here the enclosed area is a rectangle. This cycle is often used as a comparison cycle to describe the quality of the cyclic process.

The direction of the cyclic process in the T - s diagram determines whether this is a heat pump cycle (refrigeration cycle) or a work machine cycle (steam power cycle). Refrigeration cycles are anticlockwise and the work represented by the green area is added to the cycle.



Ideal cyclic process (Carnot cycle) of a gaseous medium in the T - s diagram



log p - h diagram for refrigerant

The log p - h diagram for refrigerant

In the log p - h diagram the pressure p is plotted above the enthalpy h .

In the centre (blue) is the wet steam area. Here the temperature corresponds to the boiling temperature for the pressure. The wet steam area is surrounded by limit curves with the steam content $x=0.0$ and $x=1.0$.

To the left of it (grey) the refrigerant is liquid. The temperature is below the boiling temperature for the pressure; the refrigerant is supercooled.

On the right (orange) the refrigerant is gaseous and the temperature is above the boiling temperature. The refrigerant is superheated.

Every refrigerant has its own log p - h diagram.

The log p - h diagram is better suited to represent the refrigeration cycle than the T - s diagram and is therefore used predominantly.

Because energies exchanged with the refrigerant modify the enthalpy h of the refrigerant, energy flows can be read directly from the diagram as horizontal lines.

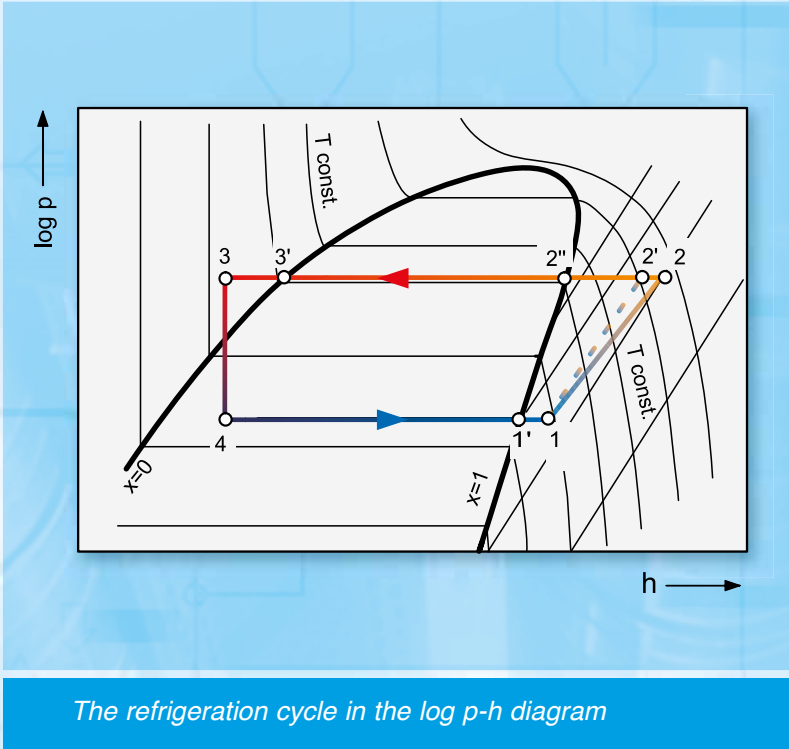
BASIC KNOWLEDGE

THERMODYNAMICS OF THE REFRIGERATION CYCLE

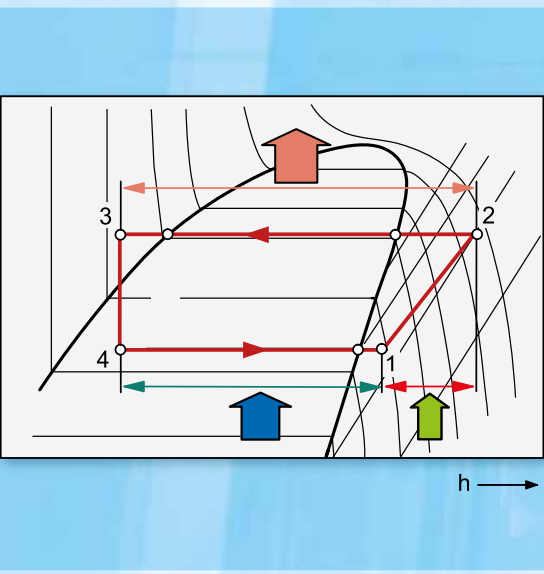
The refrigeration cycle in the log p-h diagram

The real refrigeration cycle consists of the following changes of state:

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



In addition there are also pressure losses in the real refrigeration cycle, which means that evaporation and condensation are not exactly horizontal (isobaric).



Energy flows in the refrigeration cycle

- cooling capacity absorbed
- compressor drive power
- heat capacity discharged

Energy considerations in the log p-h diagram

The horizontal distances of the key cycle points in the log p-h diagram correspond to the enthalpy differences. In the simple refrigeration cycle without branched off mass flows these result in the energy flows or capacities of the ideal system when multiplied with the refrigerant mass flow. The distances in the log p-h diagram are therefore a direct measure for the energy flows exchanged.

The distance 4 – 1 corresponds to the cooling capacity and is the net capacity of the refrigeration system. The distance 1 – 2 is the drive power exerted via the compressor. The distance 2 – 3 corresponds to the heat capacity discharged via the condenser. This is the waste heat of the refrigeration system.

From the ratio of the net capacity and the drive power the coefficient of performance COP can be calculated.

COP = (h1 - h4) / (h2 - h1)

The coefficient of performance can be compared to the efficiency in a work machine.

The refrigerant

Every cyclic process requires an operating medium which in the refrigeration cycle is the refrigerant. In the refrigeration cycle the refrigerant has the purpose of transporting heat. Here the high absorption of energy during evaporation or discharge of energy during the condensation of a liquid is utilised. To achieve this at the temperatures prevailing in a refrigeration system at well manageable pressures, liquids with a low boiling point, such as different fluorocarbons (FC), ammonia (NH3), carbon dioxide (CO2) or hydrocarbons such as butane or propane, are used as operating medium.

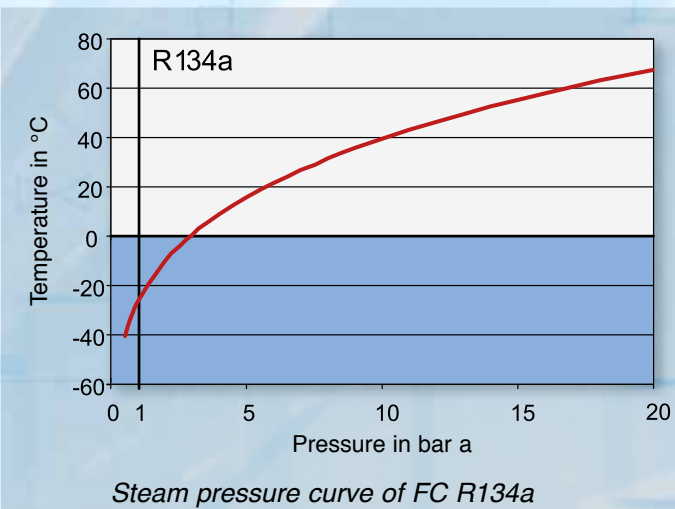
Name		Boiling temperature
FC R134a	Pure substance	Ts = -26°C
FC R404a	Mixture	Ts = -47°C
FC R407a	Mixture	Ts = -39...-45°C
NH3 R717	Pure substance	Ts = -33°C
Isobutane R600a	Pure substance	Ts = -12°C
CO2 R744	Pure substance	Ts = -78°C

The different refrigerants are marked with an R followed by a number.

The water often used in technical cycles is not suitable for the refrigeration cycle. At the low temperatures prevailing in a refrigeration system the evaporation pressure is extremely low and there is a risk of the water freezing.

The use of CO2 is technically demanding. Due to its low boiling temperature a very high pressure level results. This means that common components from refrigeration technology, such as valves, compressors or heat exchangers, cannot be used.

For NH3 there are also special components, because materials containing copper are not resistant against ammonia.



Important for a good operation is the steam pressure curve of the operating medium. It should be gaseous at low pressures and at the desired cooling temperatures and liquid at high pressures and temperatures. The pressure levels should also be easy to manage technically.

The diagram shows the steam pressure curve of the well suited FC R134a. Typical freezing temperatures of -26°C in the evaporator can be implemented with pressures around 1bar while for condensing only a pressure of 17bar at 60°C is required.

While in pure substances, such as NH3, propane and CO2, the steam pressure curve is fixed, it can be adapted in FC within wide boundaries to meet requirements by mixing different base grades.

ET 350 Changes of State in the Refrigeration Circuit



- * Refrigeration circuit demonstrated clearly
- * Transparent components offer insights into the changes of state
- * Energetic analyses of the refrigeration cycle

Technical Description

In a compression refrigeration system a refrigerant flows through the refrigeration circuit and is subject to different changes of state. Here, the physical effect is used that during the transition of the refrigerant from a liquid to a gaseous state energy is required which is removed from the environment (evaporation enthalpy).

The experimental unit ET 350 represents a typical refrigeration circuit consisting of a hermetic piston compressor, condenser, expansion valve and evaporator. The evaporator and condenser are transparent to provide good monitoring of the phase transition process during evaporation and condensation. The operation of the float valve as expansion valve is also easy to observe. Before the entry into the evaporator the aggregate state of the refrigerant can be monitored at a sight glass. A water circuit cools the condenser or supplies the cooling load for the evaporator. Cold and hot water and refrigerant flows are adjustable. The low pressure level of the refrigerant SES36 used permits the use of an evaporator and condenser out of glass. The refrigerant is CFC-free and environmentally friendly.

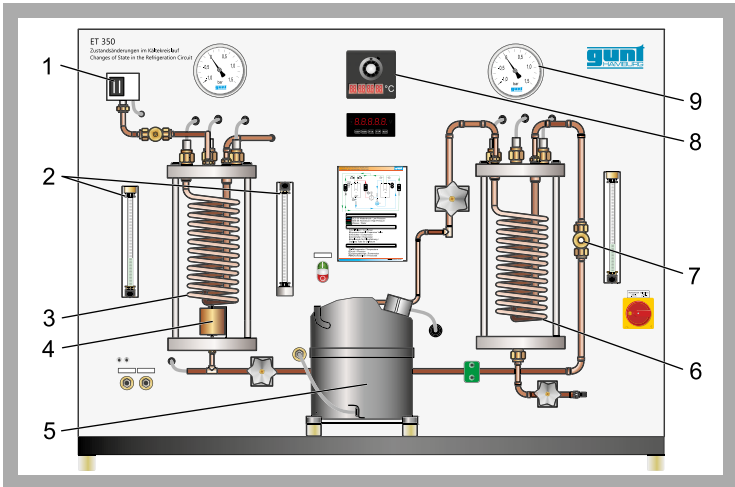
Temperatures and pressures are recorded and displayed. The key points of the cyclic process can be read and entered into a log p-h diagram. The power of the compressor and flow rates of the water flows and the refrigerant are also indicated.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

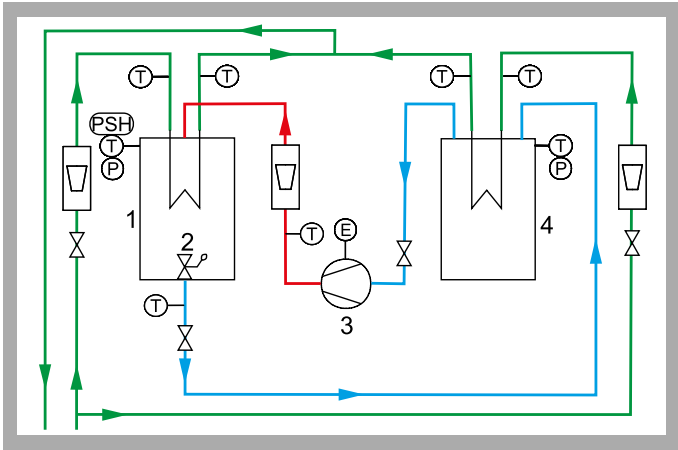
Learning Objectives / Experiments

- 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

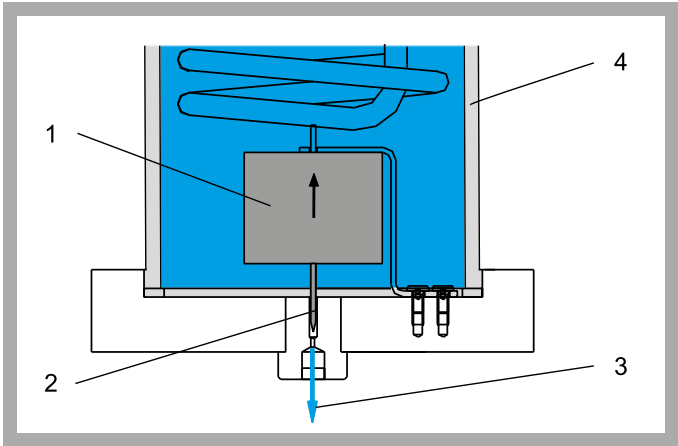
ET 350 Changes of State in the Refrigeration Circuit



1 pressure switch, 2 flow meter, 3 condenser, 4 expansion valve, 5 compressor, 6 evaporator, 7 sight glass, 8 temperature display, 9 manometer



1 condenser, 2 expansion valve, 3 compressor, 4 evaporator; T temperature, P pressure, E electrical power, PSH pressure switch; blue: low pressure, red: high pressure, green: water



Expansion valve in the shape of a float valve: 1 float lifts the needle from the valve seat, 2 needle, 3 refrigerant escapes, 4 tank

Specification

- [1] demonstration of the processes in a refrigeration circuit
- [2] for better process monitoring the evaporator and condenser are of transparent design
- [3] evaporator and condenser with pipe coil
- [4] expansion valve in the shape of a float valve
- [5] pressure switch to protect the compressor
- [6] temperature sensor, power meter, manometer in the refrigeration circuit, flow meter for hot and cold water and refrigerant
- [7] safety valves at the evaporator and condenser
- [8] refrigerant Solkatherm SES36, CFC-free

Technical Data

Hermetic piston compressor
- capacity: 18,3cm³
Evaporator capacity: approx. 2800mL
Condenser capacity: approx. 2800mL

Measuring ranges
- temperature: 8x -20...200°C
- pressure: 2x -1...1,5bar
- flow rate (water): 2x 0...48L/h
- flow rate (refrigerant): 1x 0...700L/h
- power: 0...1200W

Dimensions and Weight

LxWxH: 1200x500x900mm
Weight: approx. 110kg

Required for Operation

230V, 50/60Hz, 1 phase or 120V, 60Hz/CSA, 1 phase
Water connection, drain

Scope of Delivery

1 experimental unit
3,5kg refrigerant Solkatherm SES36
1 set of supply hoses
1 set of instructional material

Order Details

061.35000 ET 350 Changes of State in the Refrigeration Circuit

ET 351C Thermodynamics of the Refrigeration Circuit



- * Compression refrigeration system for thermodynamic investigations
- * Indirectly heated evaporator and water-cooled condenser
- * Open compressor with pendulum bearing drive motor for torque measurement

Technical Description

In this trainer, great care was taken to make the thermodynamic processes in the refrigeration system as transparent as possible. The capacities of compressor, evaporator and condenser can be measured. Pressure and temperature measuring points are provided at all the relevant locations to also allow for the pressure and heat losses in a refrigeration system to be investigated in detail.

The refrigeration circuit of ET 351C contains an open compressor with variable speed, a water-cooled condenser, a thermostatic expansion valve and an evaporator heated by a hot water circuit.

The compressor is driven via a pendulum bearing motor with frequency converter for speed adjustment. A force transducer permits the measuring of the drive torque. Using the speed the mechanical drive power of the compressor can thus be determined. The electrical heating power of the hot water circuit can be freely adjusted and is displayed. The condenser capacity is measured via the cooling water flow.

The measured values can be read on digital displays. At the same time, the measured values can also be transmitted directly to a PC via USB. The data acquisition software is included. The software allows for the process to be represented in the log p-h diagram and displays the key characteristic variables of the process, e.g. compressor pressure ratio and coefficient of performance.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

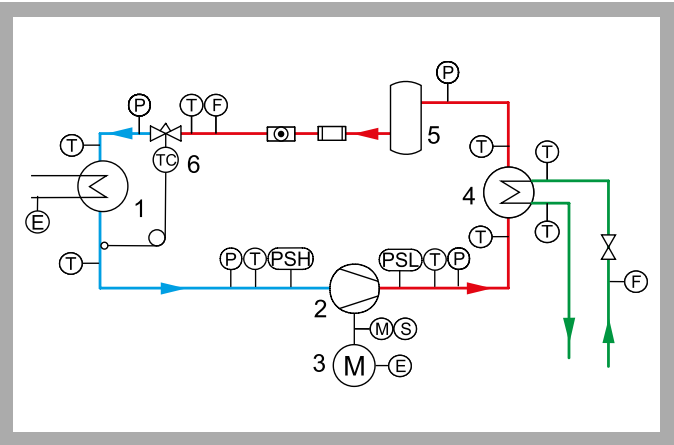
Learning Objectives / Experiments

- cyclic process in the log p-h diagram
- comparison of the real cyclic process and the ideal cyclic process
- energy balances at the evaporator and condenser
- calculation of the motor power via speed and torque
- determination of losses
- calculation of the coefficient of performance
- operating behaviour under load
- non-steady-state operating behaviour

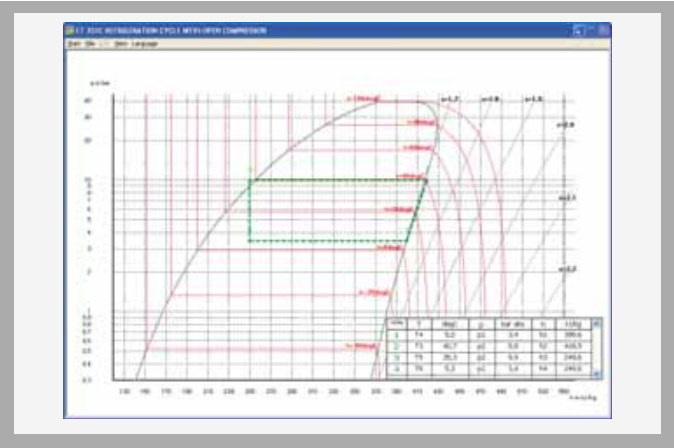
ET 351C Thermodynamics of the Refrigeration Circuit



1 expansion valve, 2 evaporator, 3 refrigerant flow meter, 4 pressure switch, 5 process schematic, 6 receiver, 7 hot water circuit of the evaporator, 8 drive motor, 9 compressor, 10 cooling water flow meter, 11 condenser, 12 displays and controls



1 evaporator, 2 compressor, 3 drive motor, 4 condenser, 5 receiver, 6 expansion valve; P pressure, T temperature, M torque, S speed, E electrical power; PSL, PSH pressure switch; blue: low pressure, red: high pressure, green: cooling water



Software screenshot: log p-h diagram

Specification

- [1] thermodynamic investigation of a refrigeration circuit
- [2] refrigeration circuit with open compressor, water-cooled condenser, thermostatic expansion valve and indirectly heated evaporator
- [3] compressor drive with speed-controlled motor via V-belt
- [4] motor on pendulum bearing for torque measurement
- [5] tube evaporator with hot water circuit as cooling load
- [6] water-cooled coaxial coil heat exchanger as condenser
- [7] displays for temperature, pressure, flow rate, speed, torque and power at the equipment
- [8] GUNT software for data acquisition via USB under Windows Vista or Windows 7
- [9] refrigerant R134a, CFC-free

Technical Data

- Open compressor
 - refrigeration capacity: approx. 550W (at a speed of 500min⁻¹ and -10/20°C)
 - motor: 550W, 1400min⁻¹
- Heater: 1x 1000W
- Condenser
 - capacity: 1300W
- Measuring ranges
 - temperature: 9x -30...100°C, 1x 0...100°C
 - pressure: 1x -1...9bar, 1x -1...24bar, 2x -1...15bar
 - torque (compressor): 0...10Nm
 - speed (compressor): 0...2500min⁻¹
 - power consumption (compressor): 0...1125W
 - power (heater): 0...1125W
 - flow rate (water): 5...70g/s
 - flow rate (refrigerant): 0...0,5L/min

Dimensions and Weight

- LxWxH: 1520x790x1760mm
- Weight: approx. 120kg

Required for Operation

- 230V, 50/60Hz, 1 phase
- Water connection

Scope of Delivery

- 1 trainer
- 1 set of hoses, 1 manual pump
- 1 GUNT software CD + USB cable
- 1 set of instructional material

Order Details

061.351C0 ET 351C Thermodynamics of the Refrigeration Circuit

ET 412C Refrigeration System with Refrigeration and Freezing Chamber



- * Refrigeration system with 2 different evaporation pressures
- * Simulation of 18 faults

Technical Description

Identifying faults in refrigeration systems requires comprehensive knowledge. This knowledge also includes the design and purpose of the individual components. ET 412C helps to acquire this knowledge.

The components of a refrigeration circuit with refrigeration and freezing chambers are arranged clearly in the trainer. Solenoid valves enable the individual or parallel operation of the evaporators in the two chambers. The circuit is equipped with a combined pressure switch for the delivery and intake side of the compressor. The refrigeration chamber features an evaporation pressure controller. The effect of the evaporation pressure controller on the overall process is being examined. An inner heat exchanger in the inlet of the two evaporators is used for supercooling the refrigerant to increase the efficiency of the process. At the same time the intake gas is superheated.

An electric defrost heater is available to defrost the freezing chamber. The simulation of 18 different faults, e.g. faulty solenoid valves or faulty relays, is provided for.

The process schematic at the trainer offers a quick overview. Signal lamps in the process schematic indicate the operating state of selected components.

Relevant measured values are recorded by sensors. The measured values can be read on digital displays. At the same time, the measured values can also be transmitted directly to a PC via USB. The data acquisition software is included.

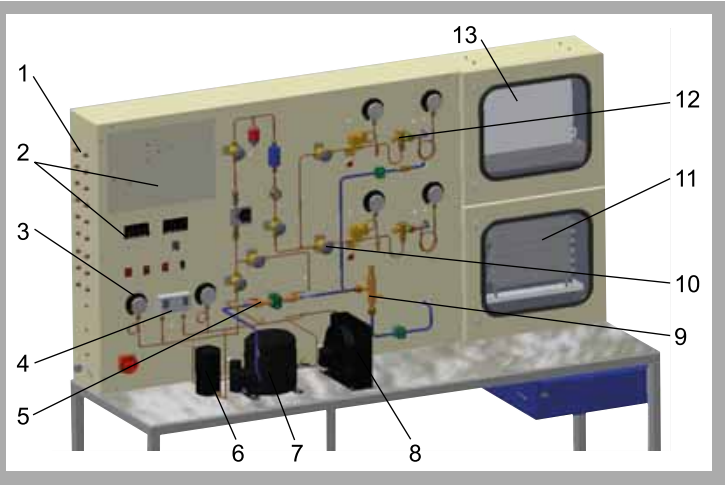
The most important pressures are additionally indicated with manometers directly at the trainer. The software enables the representation of the cyclic process in the log p-h diagram.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

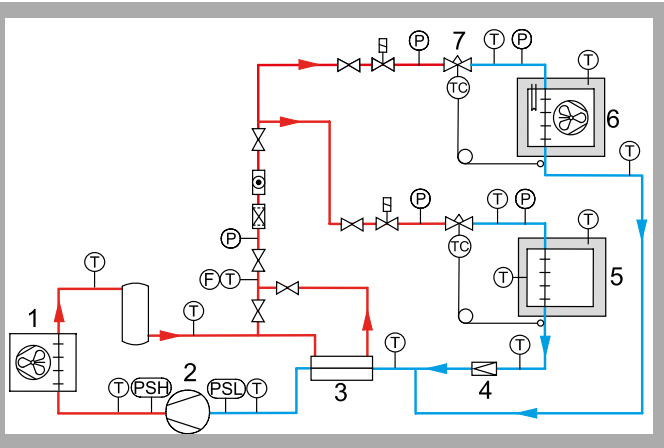
Learning Objectives / Experiments

- design and components of a refrigeration system with 2 evaporators
- components and their functions
 - * compressor, condenser, evaporator
 - * thermostatic expansion valve
 - * evaporation pressure controller
 - * pressure switch
 - * electric defrost heater
- thermodynamics of the refrigeration cycle
 - * effect of refrigerant supercooling
 - * representation of the thermodynamic cycle in the log p-h diagram
 - * determination of important characteristic variables
 - * coefficient of performance
 - * refrigeration capacity
 - * compressor work
- fault finding in refrigeration system components

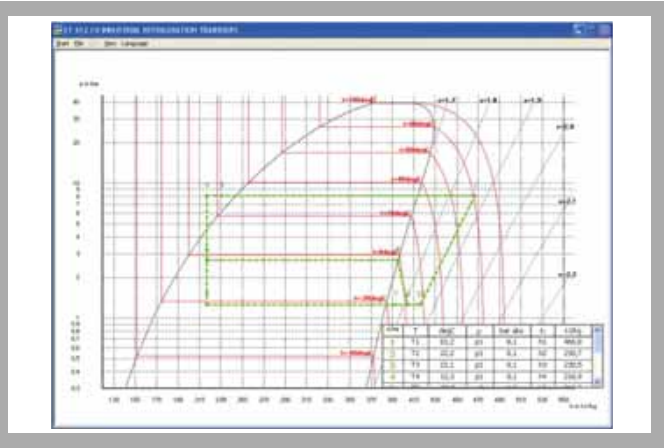
ET 412C Refrigeration System with Refrigeration and Freezing Chamber



1 fault button, 2 displays and controls with process schematic, 3 manometer, 4 pressure switch, 5 heat exchanger, 6 receiver, 7 compressor, 8 condenser with fan, 9 evaporation pressure controller, 10 valve, 11 freezing chamber, 12 expansion valve, 13 refrigeration chamber



1 condenser, 2 compressor, 3 heat exchanger, 4 evaporation pressure controller, 5 refrigeration chamber, 6 freezing chamber with defrost heater, 7 expansion valve; T temperature, P pressure, F flow rate, PSH, PSD pressure switch



Software screenshot: log p-h diagram with 2 different evaporation pressures

Specification

- [1] investigation of a refrigeration system with refrigeration and freezing chambers
- [2] refrigeration circuit with compressor, condenser and 2 evaporators with thermostatic expansion valve and evaporation pressure controller
- [3] insulated freezing chamber with fan and electric defrost heater
- [4] insulated refrigeration chamber with evaporation pressure controller
- [5] heat exchanger for refrigerant supercooling
- [6] individual or parallel operation of the chambers via solenoid valves
- [7] simulation of 18 faults
- [8] GUNT software for data acquisition via USB under Windows Vista or Windows 7
- [9] refrigerant R134a, CFC-free

Technical Data

- Compressor
 - power consumption: 491W at 5/40°C
 - refrigeration capacity: 1104W at 5/40°C
- Condenser with fan
 - volumetric air flow rate: 290m³/h
 - transfer area: 1,5m²
- Refrigeration chamber
 - evaporator transfer area: 1,06m²
- Freezing chamber
 - evaporator transfer area: 2,42m²
 - volumetric air flow rate, fan: 135m³/h
 - electric defrost heater: approx. 150W
- Evaporation pressure controller: 0...5,5bar

Measuring ranges

- temperature: 12x -50...120°C
- pressure: 1x -1...15bar, 3x -1...9bar, 3x -1...24bar
- power: 0...1125W
- flow rate: 1,5...23,5L/h

Dimensions and Weight

- LxWxH: 2000x670x1900mm
- Weight: approx. 285kg

Required for Operation

- 230V, 50/60Hz, 1 phase or 120V, 60Hz/CSA, 1 phase

Scope of Delivery

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

Order Details

- 061.412C0 ET 412C Refrigeration System with Refrigeration and Freezing Chamber

ET 430 Refrigeration System with Two-Stage Compression



- * **Compression refrigeration system with two-stage compression to achieve particularly low temperatures**
- * **Injection intercooler**
- * **Heat exchanger for additional refrigerant supercooling**

Technical Description

Refrigeration systems with two-stage compression are used for the generation of particularly low temperatures. At very low temperatures large pressure differences are required between the evaporator and condenser. In a compressor the volumetric efficiency drops significantly at high pressure ratios. Therefore, two compressors are connected in series, with each compressor only having a relatively low pressure ratio. This makes a more favourable dimensioning of the low pressure stage compressor possible. Due to the large specific volume it requires a larger capacity at lower drive power.

In addition, intercooling between the low pressure compressor (LP) and the high pressure compressor (HP) reduces the outlet temperature of the HP compressor to harmless values and improves the efficiency of the compression.

The trainer ET 430 uses injection intercooling. A small amount of liquid refrigerant is injected from the receiver into the outlet line of the LP compressor. The liquid refrigerant evaporates and thus cools the intake gas for the HP compressor. Via an add-on heat exchanger in the injection cooler the supercooling of the liquid refrigerant can be increased upstream of the expansion valve. This allows for an increase in the evaporator capacity.

Manometers and temperature measuring locations at all relevant circuit points enable the evaluation of the two-stage process. To determine the

compressor capacity, both compressors are equipped with an electrical power measurement. Valves allow for the injection intercooling or the heat exchanger for refrigerant supercooling to be switched off. This can demonstrate their effect on the system.

The online representation of the refrigeration process on the PC makes it easy for the student to understand the processes.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

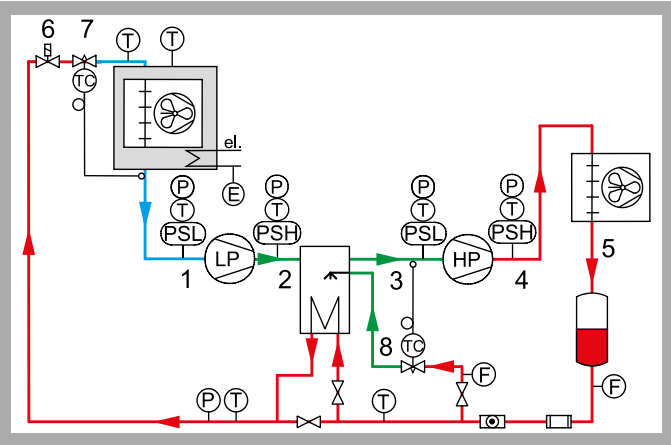
Learning Objectives / Experiments

- design and function of a refrigeration system with two-stage compression and injection intercooling
- effect of the inlet temperature at the HP compressor on the efficiency of the compression
 - * with intercooling
 - * without intercooling
- effect of the additional refrigerant intercooling
- distribution of the compressor pressure ratios
- represent and understand the refrigeration cycle process in the log p-h diagram

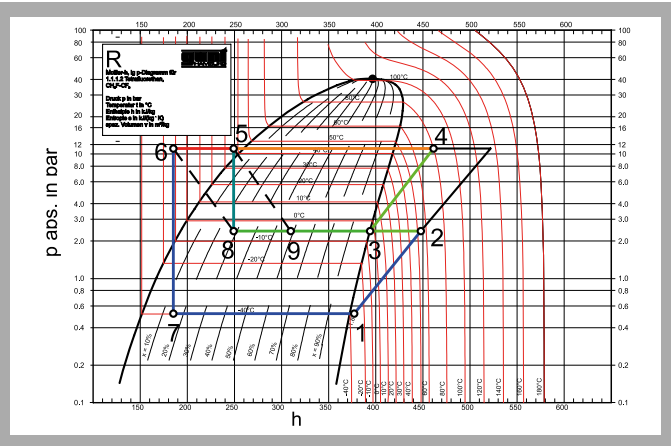
ET 430 Refrigeration System with Two-Stage Compression



1 expansion valve, 2 refrigeration chamber, 3 displays and controls, 4 pressure switch, 5 injection valve, 6 injection cooler, 7 LP compressor, 8 HP compressor, 9 receiver, 10 flow meter, 11 heat exchanger, 12 condenser



1-2 LP compression, 2-3 intercooling, 3-4 HP compression, 4-5 condensation, 5-6 supercooling, 6-7 expansion, 7-1 evaporation; T temperature, P pressure, E electrical power, F flow rate, PSL, PSH pressure switch



log p-h diagram of a two-stage refrigeration system with injection intercooling (for process steps see process schematic)

- Specification**
- [1] refrigeration system with two-stage compression
 - [2] hermetic low and high pressure compressors
 - [3] adjustable intercooling via refrigerant injection
 - [4] heat exchange for additional supercooling of the liquid refrigerant
 - [5] closed refrigeration chamber contains evaporator with fan and adjustable electric heater as cooling load
 - [6] digital display for temperatures, drive power of the compressors and cooling load power
 - [7] GUNT software for data acquisition with USB under Windows Vista or Windows 7 with online display of the log p-h diagram
 - [8] refrigerant R404a, CFC-free

- Technical Data**
- Low pressure compressor (LP)
- displaced volume: 25,93cm³
 - power consumption: 550W
 - refrigeration capacity: 1744W at -10/32°C
- High pressure compressor (HP)
- displaced volume: 8,86cm³
 - power consumption: approx. 375W
 - refrigeration capacity: 583W at -10/32°C

- Measuring ranges**
- flow rate: 1x 2...29L/h, 1x 4...40L/h
 - pressure: 1x -1...15bar, 2x -1...24bar
 - temperature: 8x 75...125°C
 - power: 0...562W, 0...750W, 0...2250W

- Dimensions and Weight**
- LxWxH: 1900x790x1900mm
Weight: approx. 283kg

- Required for Operation**
- 230V, 50/60Hz, 1 phase

- Scope of Delivery**
- 1 trainer
 - 1 GUNT software CD + USB cable
 - 1 set of instructional material

- Order Details**
- 061.43000 ET 430 Refrigeration System with Two-Stage Compression

ET 441 Refrigeration Chamber and Defrosting Methods



- * Combined refrigeration and freezing chamber with temperature and humidity measurement
- * Evaporators of different sizes
- * Different defrosting methods

Technical Description

The climate in the cold storage room has a significant effect on the quality of the products stored there. This climate depends on different influences, such as the surface temperature of the evaporators, cold storage room temperature, degree of evaporator icing, quantity and type of refrigerated goods etc.

The icing of the evaporators depends on the evaporator and room temperatures and the quantity of humidity introduced by the refrigerated goods. Icing of the evaporators significantly reduces the refrigeration capacity and must therefore be prevented as much as possible by periodic defrosting, i.e. heating the evaporator surfaces. In addition to the periodic defrosting at set times, there is defrosting performed as required by measuring the actual ice coating. The evaporator surface can be heated from the outside by electric heating or from the inside by hot gas directly from the refrigerant compressor.

The trainer features a large refrigeration chamber. Two evaporators allow for an investigation of the effect of different evaporator sizes on the cold storage room climate and the icing. An electric defrost heater and hot gas defrosting are available. The defrost process can be performed as required using a defrost controller or at set intervals using a defrost timer.

Two adjustable heat sources in the refrigeration chamber simulate the cooling load. One of these heat sources generates water steam to simulate the introduction of humidity into the refrigeration chamber.

The measured values can be read on digital displays. At the same time, the measured values can also be transmitted directly to a PC via USB.

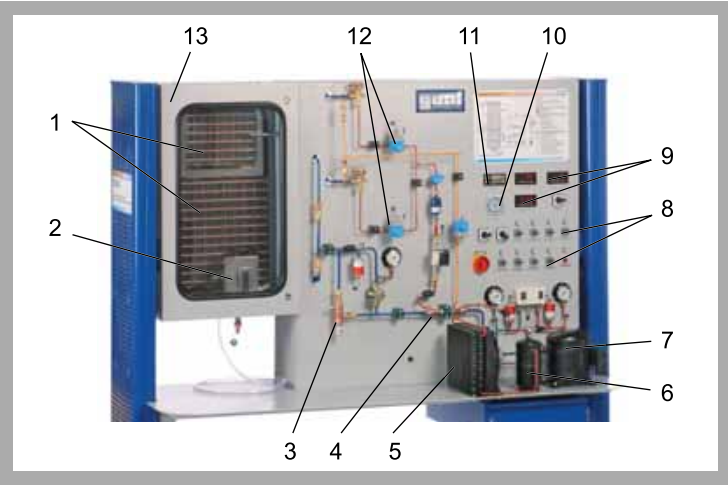
The data acquisition software is included. The data acquisition enables e.g. the recording of the defrosting process over time and the online representation of the climate in the refrigeration chamber in the h-x diagram.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

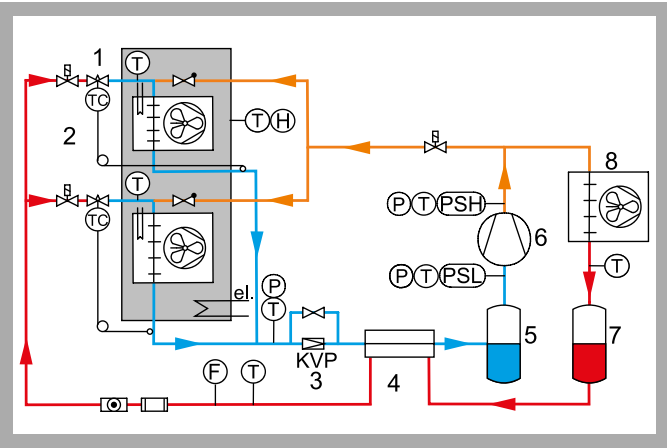
Learning Objectives / Experiments

- effect of the evaporator size and temperature on the climate in the refrigeration chamber
- frosting and icing under different operating conditions
- difference between latent and sensitive cooling load
- different defrosting methods (electric heater, hot gas)
- configuration of defrost controls such as defrost timer or defrost controller

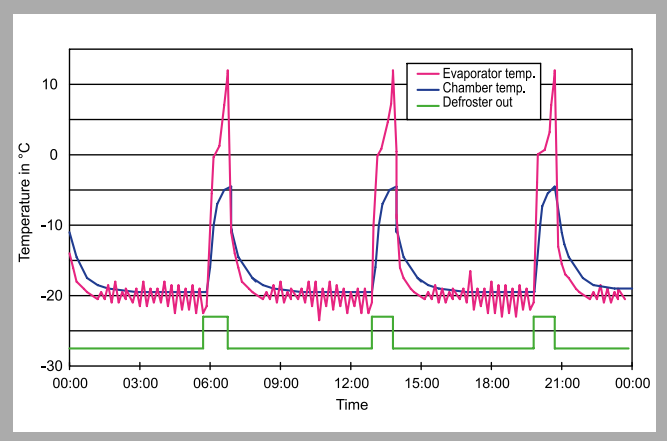
ET 441 Refrigeration Chamber and Defrosting Methods



1 evaporator, 2 humidifier, 3 evaporation pressure controller, 4 heat exchanger, 5 condensing unit, 6 receiver, 7 compressor, 8 controls, 9 temperature and humidity displays, 10 defrost timer, 11 defrost controller, 12 solenoid valves to select the evaporators, 13 refrigeration chamber



Process schematic with hot gas defrosting (orange); 1 expansion valve, 2 refrigeration chamber with 2 heat exchangers of different size, 3 evaporation pressure controller, 4 heat exchanger, 5 suction line receiver, 6 condenser, 7 receiver, 8 condenser; T temperature, P pressure, H humidity, F flow rate, PSH, PSL pressure switch



Time progression of a defrost control (green) with temperature of evaporator (red) and refrigeration chamber (blue)

Specification

- [1] refrigeration system to investigate the climate in the refrigeration chamber and different defrosting methods
- [2] 2 evaporators, separately switchable via solenoid valves
- [3] electric defrost heater
- [4] hot gas defrosting
- [5] defrost controller and defrost timer
- [6] latent and sensitive cooling load
- [7] evaporation pressure and temperature adjustable
- [8] heat exchanger as superheater and for refrigerant supercooling
- [9] digital display for temperature and humidity in the refrigeration chamber
- [10] GUNT software with online representation of the h-x diagram
- [11] GUNT software for data acquisition via USB under Windows Vista or Windows 7
- [12] refrigerant R134a, CFC-free

Technical Data

- Compressor according to CECOMAF
- refrigeration capacity at -5/55°C: 999W
- power consumption: 565W
- Latent cooling load: 2x 0...250W
- Sensitive cooling load: 1x 0...200W, 1x 0...250W
- Receiver: 1,3L

Measuring ranges

- pressure: 2x 0...16bar, 1x 0...25bar
- temperature: 7x -50...150°C, 1x -25...125°C
- humidity: 0...100% r.h.
- flow rate: 2...27L/h

Dimensions and Weight

- LxWxH: 2000x790x1900mm
- Weight: approx. 250kg

Required for Operation

- 230V, 50/60Hz, 1 phase

Scope of Delivery

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

Order Details

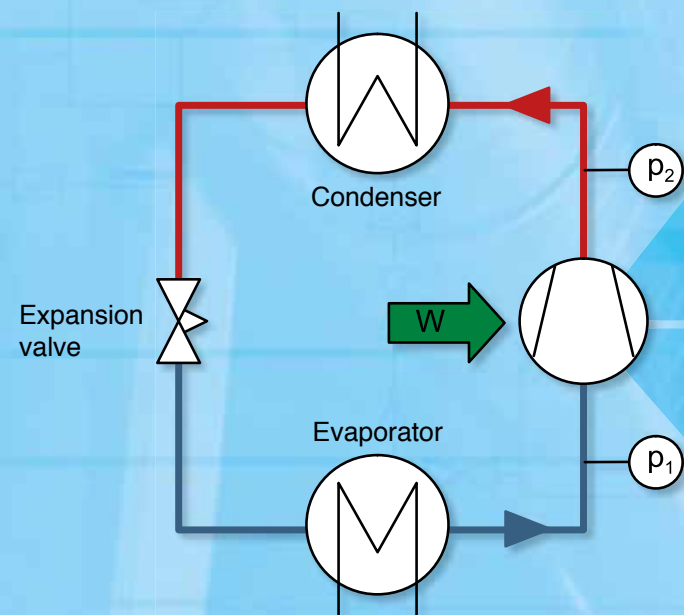
- 061.44100 ET 441 Refrigeration Chamber and Defrosting Methods

BASIC KNOWLEDGE

COMPRESSORS IN REFRIGERATION

Refrigerant compressors have the purpose of moving the vaporised refrigerant from the evaporator pressure level to the condenser pressure level. The supply of the mechanical energy to the refrigeration cycle passes through them. Generally the compressors are driven electrically, but there is also the drive via a standard internal combustion engine (vehicle air conditioning system).

A special case is the steam jet refrigeration system. Here a partial flow of the refrigerant steam is used for the compression itself. Steam jet refrigeration systems are driven thermally and can directly use alternative energy sources such as solar heat or waste heat.



The compressor in the refrigeration circuit



Open 2-cylinder compressor



Hermetic compressor

p-V diagram of the piston compressor

The processes in the cylinder can be clearly demonstrated in the p-V diagram. Here the pressure p in the cylinder is plotted above the cylinder volume V .

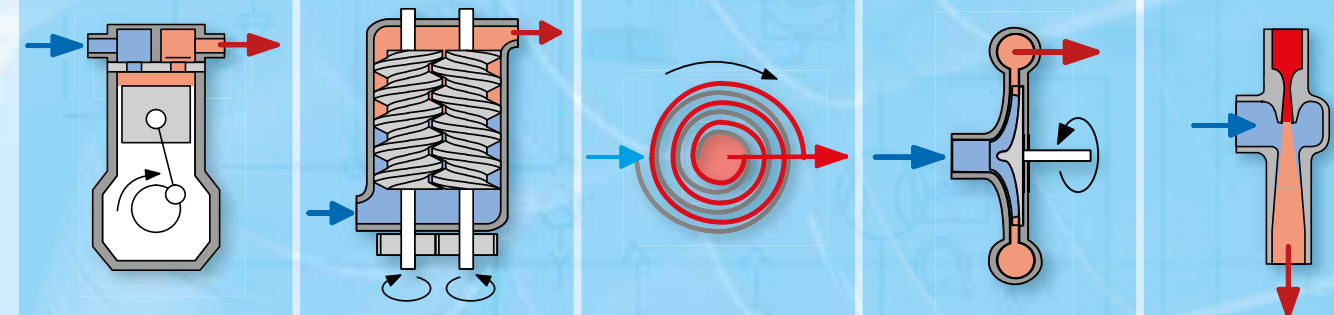
1 – 2 polytropic compression of pressure p_1 to pressure p_2

2 – 3 expelling the compressed gas into the pressure pipe

3 – 4 polytropic re-expansion of the remaining gas to intake pressure p_1

4 – 1 aspiration from the intake pipe

COMPRESSOR DESIGNS IN REFRIGERATION



Piston compressor

Small and medium capacities

Screw compressor

Medium and high capacities

Scroll compressor

Small and medium capacities

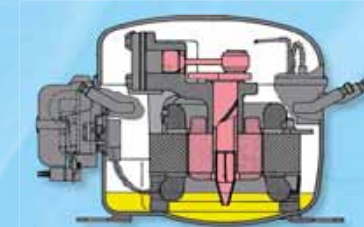
Turbo compressor

Only for very high capacities

Steam jet compressor

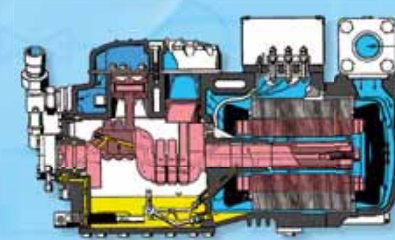
Special applications where motive steam is available

HOUSING DESIGNS



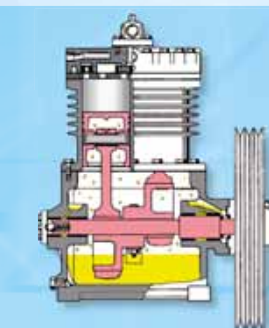
Hermetic compressor

- Drive motor and compressor in a welded housing without seals (capsule)
- Cooling via intake gas
- Maintenance-free, must be replaced in case of a fault



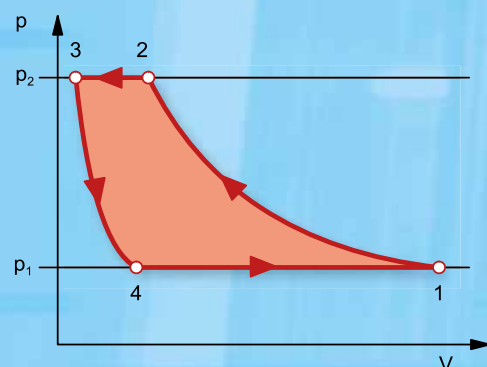
Semi-hermetic compressor

- Drive motor and compressor in a screwed housing
- Cooling via intake gas
- Can be repaired if damaged



Open compressor

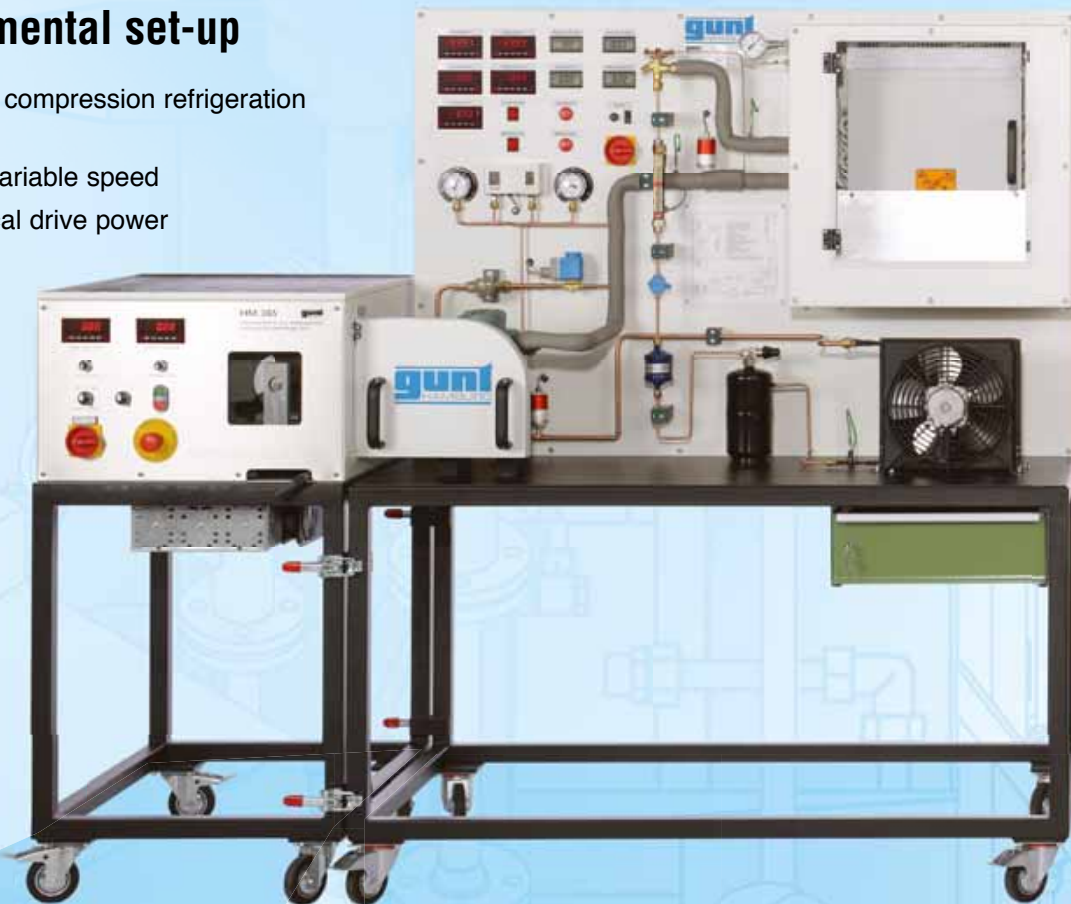
- Compressor in a screwed housing
- Combined intake gas and air cooling
- Drive via an external motor, output can be adjusted via the transmission of the belt drive
- Shaft feedthrough prone to failure
- Can be repaired if damaged



ET 165 COMPRESSION REFRIGERATION SYSTEM WITH DRIVE UNIT HM 365

Complete experimental set-up

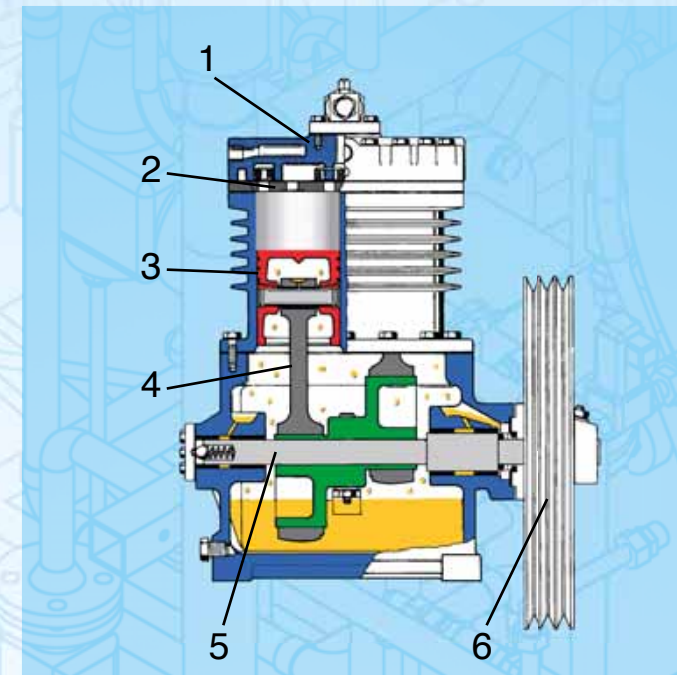
- Principle of function of a compression refrigeration system
- Open compressor with variable speed
- Measuring the mechanical drive power
- Determination of the compressor efficiency
- Effect of the compressor flow rate on the refrigeration circuit
- Drive via the universal drive and brake unit HM 365



HM 365 Universal Drive and Brake Unit

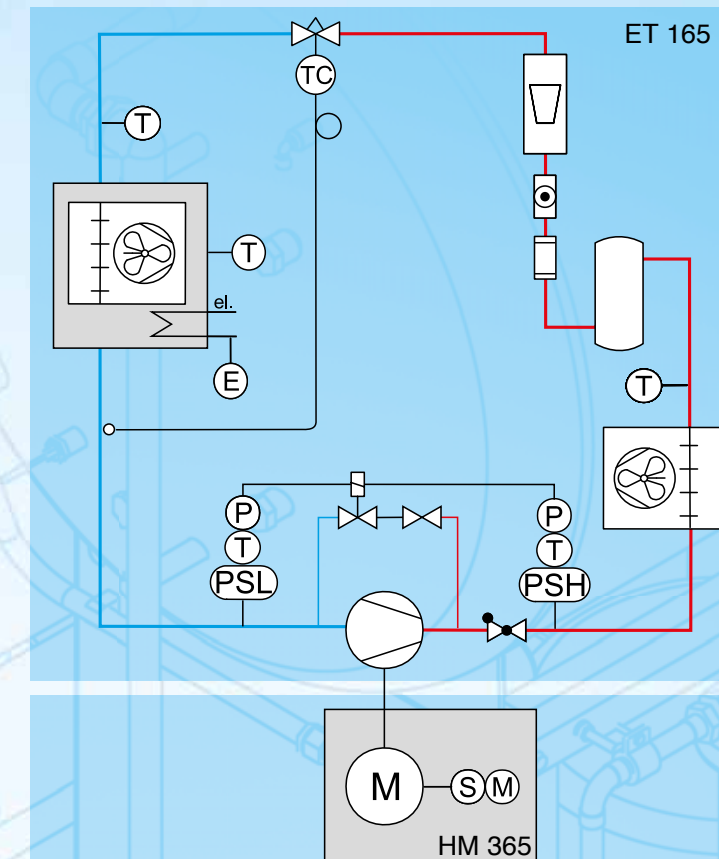


ET 165 Refrigeration System with Open Compressor



Cross-section through an open compressor:
1 cylinder cover, 2 valve plate, 3 piston,
4 piston rod, 5 excenter shaft, 6 pulley

The open compressor of ET 165 is, unlike the hermetic compressor, driven via an external electric motor. Open compressors are used in commercial cooling for medium to high capacities. An advantage is that the flow rate can be easily adjusted via the drive speed. This is done via a speed-controlled electric motor or via different transmissions of the belt drive.

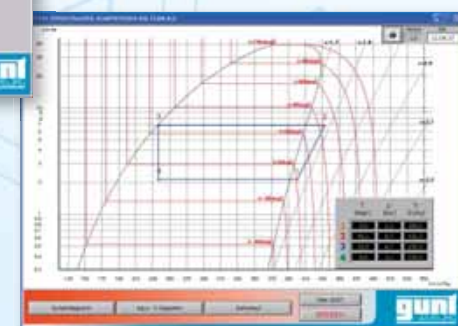


The refrigeration circuit of ET 165 consists of an open compressor, an air-cooled condenser, an expansion valve and an evaporator in a refrigeration chamber. To represent a cooling load, the refrigeration chamber can be heated electrically. Pressure switches protect the compressor against too high or too low pressures by opening a bypass to the compressor.

The drive speed of the compressor is adjustable. This examines the effect of different delivery capacities on the refrigeration system. By measuring the drive speed and drive torque the compressor can be thoroughly examined, e.g. determining the efficiency.



The software enables the clear representation of the measuring data on the PC. Time graphs can be recorded and stored. A very useful property is the display of the cyclic process in the log p-h diagram. Using a spreadsheet program (e.g. MS Excel) the stored data can be analysed. The measured data are transferred to the PC via a USB interface.



ET 165 Refrigeration System with Open Compressor



- * Capacity measurement at the open compressor with variable speed
- * Refrigeration chamber with transparent door and adjustable cooling load
- * Part of equipment series for the investigation of engines and machines

Technical Description

ET 165 enables basic experiments in the field of refrigeration. The trainer includes a closed refrigeration circuit with open compressor, a condenser with fan, a thermostatic expansion valve and an evaporator in a refrigeration chamber with transparent door. A fan in the refrigeration chamber ensures an even temperature distribution. A cooling load is simulated by an adjustable heater in the refrigeration chamber. The drive unit HM 365 drives the compressor via a V-belt. The compressor speed is set at the HM 365. The circuit is equipped with a combined pressure switch for the delivery and intake side of the compressor.

All relevant measured values are recorded by sensors. Digital displays indicate the measured values. The simultaneous transmission of the measured values to a data recording software enables convenient analysis and the representation of the process in the log p-h diagram. The software also displays the important characteristics variables of the process, such as the refrigeration capacity and the coefficient of performance.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

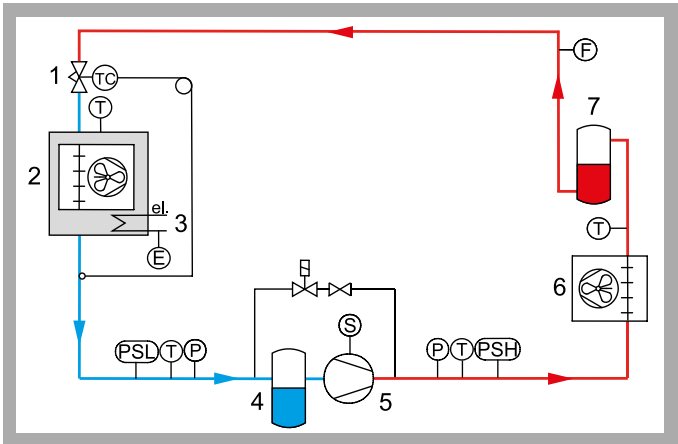
Learning Objectives / Experiments

- fundamentals of refrigeration
- design and components of a refrigeration system
- * open compressor with drive
- * condenser
- * evaporator
- * thermostatic expansion valve
- * pressure switch
- determination of important characteristic variables
- * coefficient of performance
- * compressor capacity
- * refrigeration capacity
- * compression ratio
- * volumetric efficiency
- representation of the thermodynamic cycle in the log p-h diagram
- determination of the compressor efficiency
- effect of the compressor flow rate on the refrigeration circuit

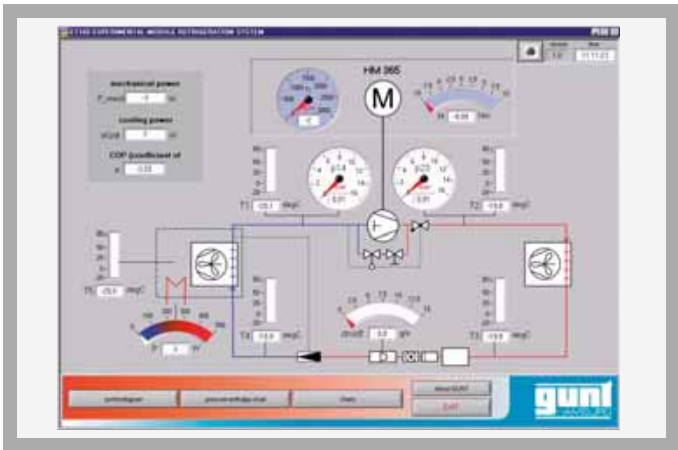
ET 165 Refrigeration System with Open Compressor



1 expansion valve, 2 displays and controls, 3 pressure switch, 4 flow meter, 5 compressor, 6 condenser, 7 receiver, 8 refrigeration chamber



1 expansion valve, 2 refrigeration chamber, 3 heater, 4 suction line receiver, 5 compressor with connection to the HM 365, 6 condenser, 7 receiver; T temperature, P pressure, PSL, PSH pressure switch, F flow rate, S speed, E electric power; blue: low pressure, red: high pressure



Software screenshot: process schematic

Specification

- [1] investigation of a refrigeration circuit with speed-controlled compressor
- [2] refrigeration circuit with open compressor, condenser, thermostatic expansion valve and evaporator in refrigeration chamber
- [3] cooling load in the refrigeration chamber adjustable via heater
- [4] drive and speed adjustment of the open compressor via HM 365
- [5] condenser and evaporator with fan
- [6] digital displays for pressure, temperature, flow rate, power and speed
- [7] GUNT software for data acquisition via USB under Windows Vista or Windows 7
- [8] refrigerant R134a, CFC-free

Technical Data

- Open compressor
- refrigeration capacity: approx. 845W (at speed: 975min⁻¹ and -10/40°C)
- speed: 500...1000min⁻¹
- Condenser with fan transfer area: 2,5m²
- capacity: approx. 1935W at 25°C air temperature (ambient) / Δt=15°C
- Evaporator
- transfer area: 3,62m²
- capacity: 460W at 3°C air temperature (chamber) / Δt=13°C
- Heater power: 500W

Measuring ranges

- temperature: 4x -5...105°C, 1x -50...250°C
- pressure: 2x -1...15bar
- speed: 1x 0...1000min⁻¹
- flow rate R134a: 1x 2...15g/s
- power: 1x 0...500W

Dimensions and Weight

- LxWxH: 1470x800x1850mm
- Weight: approx. 185kg

Required for Operation

- 230V, 50/60Hz, 1 phase or 120V, 60Hz/CSA, 1 phase

Scope of Delivery

- 1 trainer
- 1 v-belt
- 1 GUNT software CD + USB cable
- 1 set of instructional material

Order Details

- 061.16500 ET 165 Refrigeration System with Open Compressor

HM 365 Universal Drive and Brake Unit



- * Core component for experiments on various engines and machines
- * Asynchronous motor with frequency converter and fine adjustment of the drive or brake torque
- * Connection between HM 365 and engine or machine via V-belt drive
- * Set-up of the complete experimental unit together with an engine or machine

Technical Description

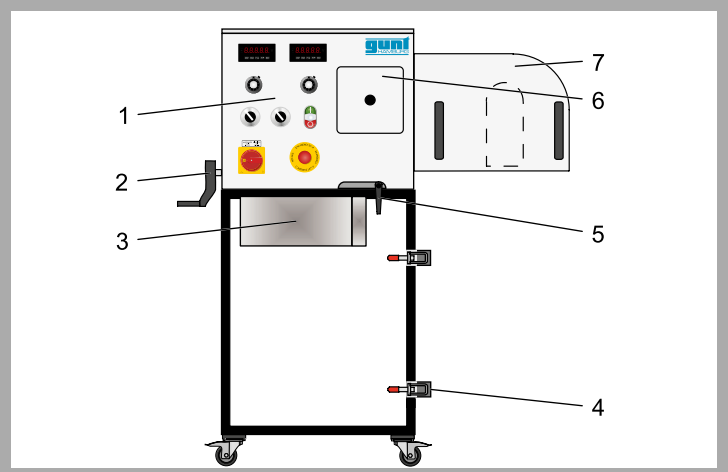
HM 365 is the core element of a modular equipment series enabling experiments at the most varied engines and machines, e.g. pumps, turbines or combustion engines. The machine under investigation is connected to the HM 365 via a belt drive. Fasteners couple the HM 365 and the engine or machine under investigation mechanically.

The main function of the HM 365 is the provision of the required drive or brake power to investigate the selected engines or machines. This power is generated by an air-cooled asynchronous motor with frequency converter. The energy that is generated during generator operation is converted into heat in a load resistor. The drive and brake torque can be finely adjusted. It is measured by a force transducer. For this purpose the asynchronous motor is suspended on a pendulum bearing. To tighten the V-belt, the motor can be moved.

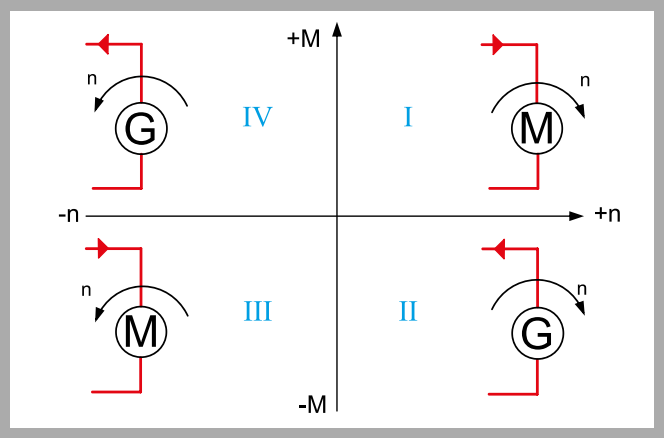
HM 365 includes digital displays for speed and torque. The data transmission between the HM 365 and the investigated engine or machine takes place via a data cable. All measuring signals are available in electronic form and can be saved or further processed using the software for data acquisition from the engine or machine.

- Learning Objectives / Experiments**
- asynchronous motor as drive
- torque measurement
 - speed measurement
- asynchronous motor as brake
- torque measurement
 - speed measurement

HM 365 Universal Drive and Brake Unit



1 displays and controls, 2 clamping device spindle for the asynchronous motor, 3 load resistance, 4 clamping device, 5 fastener for the asynchronous motor, 6 inspection cover, 7 protective cover for V-belt



Representation of 4-quadrant operation in speed/torque diagram: I motor operation, clockwise rotation (drive), II generator operation, clockwise rotation (brake), III motor operation, anticlockwise rotation (drive), IV generator operation, anticlockwise rotation (brake); red line: energy flow, M torque, n speed



This picture shows a complete experimentation set-up: Axial-Flow Pump Module HM 365.45 connected to the Universal Drive and Brake Unit HM 365

- Specification**
- [1] drive and brake unit for connecting to various engines and machines
 - [2] asynchronous motor with frequency converter
 - [3] asynchronous motor with pendulum bearing, torque measurement via lever arm and force transducer
 - [4] speed measurement by reflective light sensor at the motor shaft
 - [5] 4 quadrant operation via frequency converter
 - [6] measurements for speed and torque displayed digitally at the equipment
- Technical Data**
- Asynchronous motor with frequency converter
- power: 2200W
 - max. speed: approx. 3000min⁻¹
 - max. torque: approx. 12Nm
- V-belt drive
- V-belt length: 1157mm, 1180mm, 1250mm
 - V-belt type: SPA
 - V-belt pulley diameter: 125mm
- Load resistor: 72 Ohm, 2400W

- Measuring ranges
- torque: -15...15Nm
 - speed: 0...5000min⁻¹

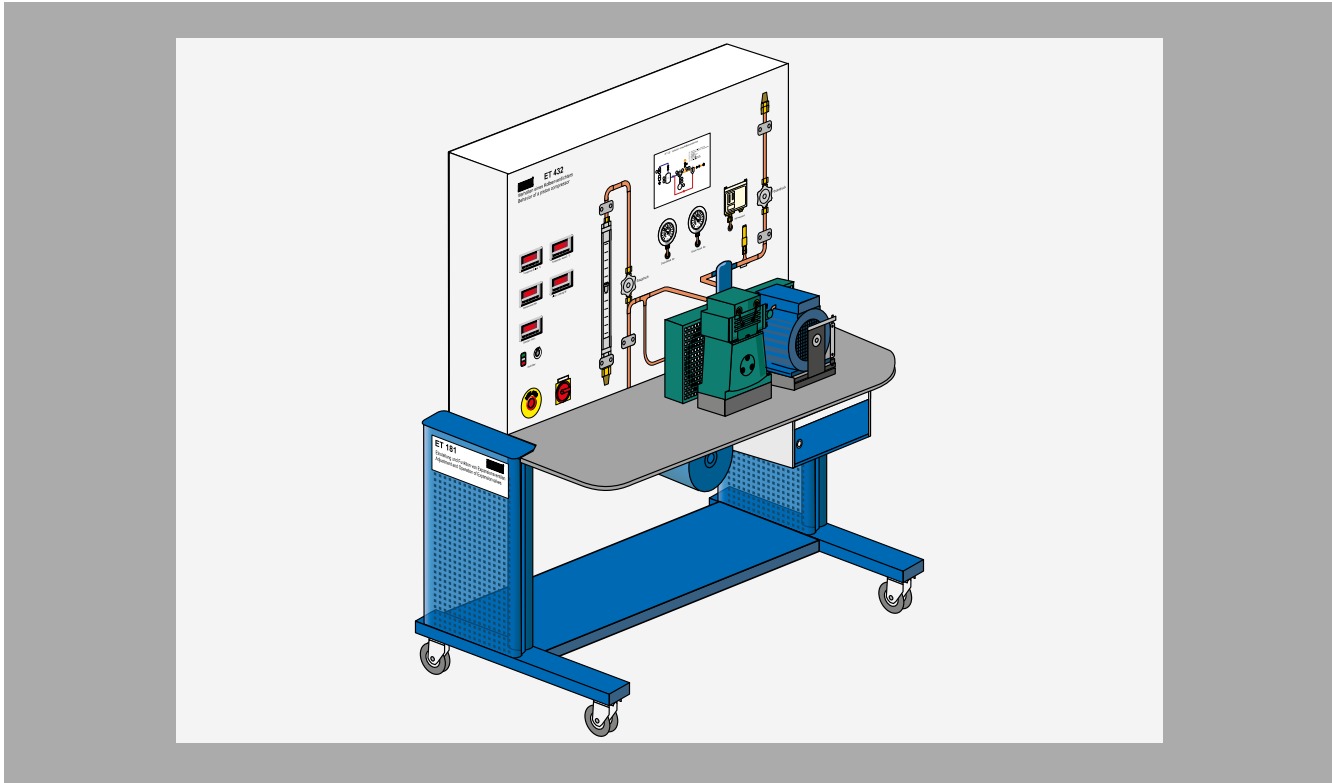
- Dimensions and Weight**
- LxWxH: 1000x800x1250mm
- Weight: approx. 125kg

- Required for Operation**
- 400V, 50/60Hz, 3 phases or 230V, 60Hz/CSA, 3 phases

- Scope of Delivery**
- 1 drive and brake unit
 - 1 set of V-belts
 - 1 data cable
 - 1 manual

- Order Details**
- 070.36500 HM 365 Universal Drive and Brake Unit

ET 432 Behaviour of a Piston Compressor



- * Open 2-cylinder piston compressor from refrigeration
- * Record of the pressure/volumetric flow rate characteristic
- * Measurement of intake volume and pressure ratio
- * Determination of volumetric and mechanical efficiency

Technical Description

Smaller refrigeration systems usually have a piston compressor. Piston compressors are positive displacement machines. These differ in their characteristics decisively from flow equipment which include the turbo compressors that are common in very large systems.

In piston compressors the flow rate is mainly dependent on the displaced volume and speed. Due to the unavoidable dead space the flow rate drops with increasing pressure ratio. Because the flow rate is a measure for the refrigeration capacity of the refrigeration system, the properties of the compressor are important for the capacity of the whole system.

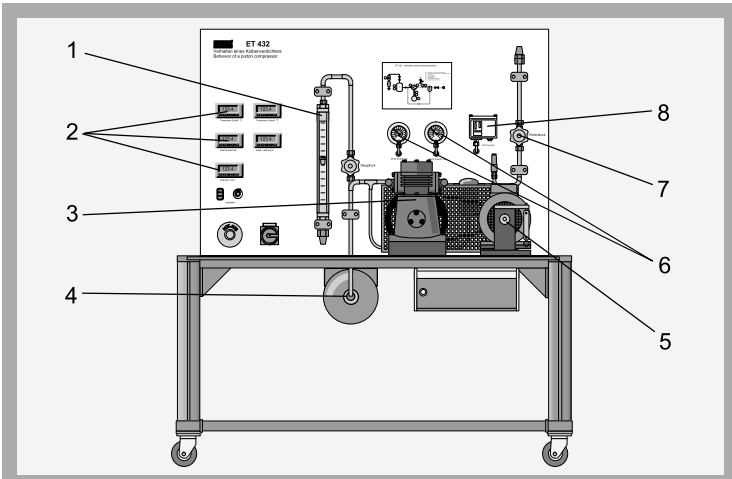
In this trainer a commercial open refrigerant compressor is operated in an open process with air. The inlet and outlet pressures and thus the pressure ratio can be adjusted via valves in wide ranges. The drive via a frequency converter permits variable speeds. Pressures, temperatures, electric power consumption, speed and torque are recorded and displayed at the equipment. The compressor efficiency is calculated from the electrical and mechanical power.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

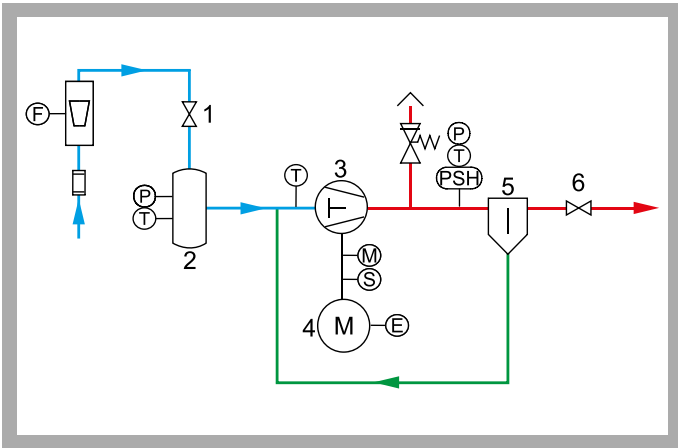
Learning Objectives / Experiments

- determine characteristic variables of a piston compressor during experiments
- record of the pressure/volumetric flow rate characteristic
- determination of the volumetric efficiency at different intake pressures, pressure ratios and speeds
- determination of the isothermal compressor capacity
- measurement of the mechanical and electrical power consumption in dependence of the intake pressure and pressure ratio
- determination of the mechanical efficiency and the overall efficiency

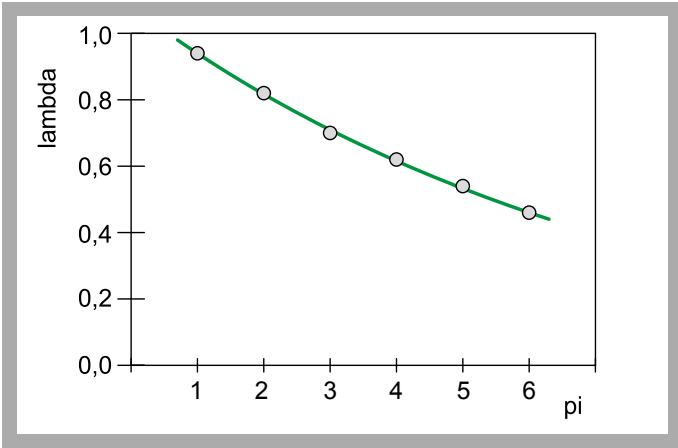
ET 432 Behaviour of a Piston Compressor



1 flow meter, 2 displays and controls, 3 refrigerant compressor, 4 stabilisation tank, 5 drive motor with torque measurement, 6 manometer, 7 valve, 8 pressure switch



1 intake side valve, 2 stabilisation tank, 3 compressor, 4 drive motor, 5 oil separator, 6 delivery side valve; F flow rate, T temperature, P pressure, M torque, S speed, E electric power, PSH pressure switch; blue: low pressure, red: high pressure, green: oil return



Progression of the volumetric efficiency lambda in dependence on the pressure ratio pi

Specification

- [1] experimental unit for piston compressor from refrigeration
- [2] open process with air
- [3] typical open 2-cylinder compressor
- [4] drive via asynchronous motor with frequency converter for speed adjustment
- [5] inlet pressure and outlet pressure (pressure ratio) adjustable via valves
- [6] instruments: manometer, flow meter, temperature sensor, speed, torque (via force), digital power indication

Technical Data

- Compressor
- speed: 480...975min⁻¹
 - number of cylinders: 2
 - stroke: 26mm
 - borehole: 35mm
 - displaced volume: 50cm³
 - max. intake capacity: 49L/min
 - max. pressure: 20bar
- Drive motor power: 370W

Measuring ranges

- torque: 0...5Nm
- speed: 0...3000min⁻¹
- electric power: 0...1000W
- temperature: 0...100°C
- pressure: -1...9bar / -1...24bar
- flow rate: 8...80L/min

Dimensions and Weight

- LxWxH: 1400x790x1750mm
Weight: approx. 150kg

Required for Operation

- 230V, 50Hz, 1 phase

Scope of Delivery

- 1 trainer
- 1 set of instructional material

Order Details

061.43200 ET 432 Behaviour of a Piston Compressor

ET 428 Energy Efficiency in Refrigeration Systems



The illustration shows a similar unit.

- * Refrigeration system with 3 compressors in interconnected operation
- * Ideal adaptation to the capacity requirement by adding and removing individual compressors
- * Industrial multicompressor controller to add and remove the individual compressors
- * Add-on heat exchanger for refrigerant supercooling
- * Monitoring of the lubrication oil transport in the refrigeration circuit

Technical Description

The efficient use of energy in refrigeration is an important topic. A higher capacity requirement is implemented in industry by connecting several small compressors in parallel. This permits the optimum adaptation to the capacity requirement by adding and removing compressors. ET 428 includes three compressors connected in parallel for this purpose which can be switched on or off via a controller.

The components of a refrigeration circuit with three compressors are arranged clearly in the trainer. A 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 for the refrigerant supercooling to be examined for process efficiency. The quantitative analysis of the efficiency takes place using an energy balance in the glycol-water circuit and by measuring the electrical power of the compressors.

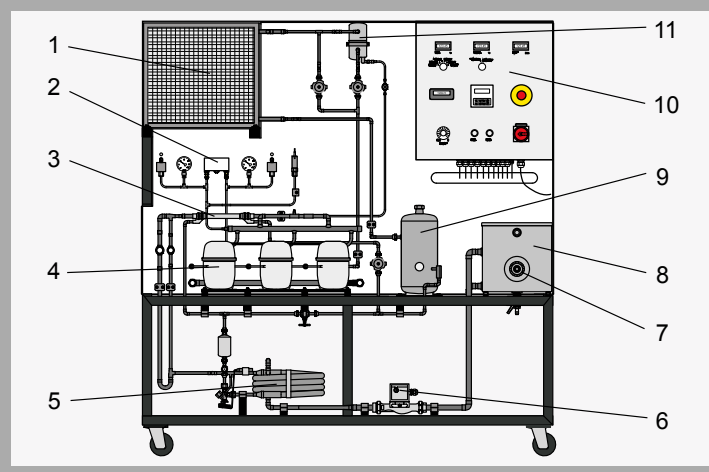
To protect the three compressors, the refrigeration circuit is equipped with a combined pressure switch for the delivery and intake sides. To ensure a secure oil supply to the three compressors, an oil separator is provided on the delivery side of the compressors. The separated oil is returned to the compressors on the intake side. The oil is monitored through sight glasses in the respective lines.

Relevant measured values are recorded by sensors. The measured values can be read on digital displays. At the same time, the measured values can also be transmitted directly to a PC via USB. The data acquisition software is included.

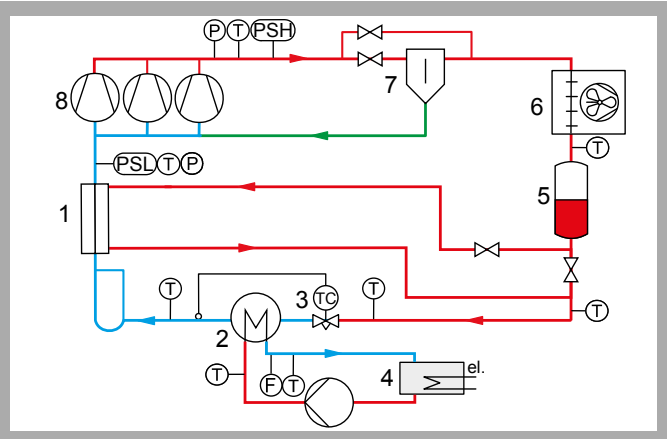
The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

- Learning Objectives / Experiments**
- 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

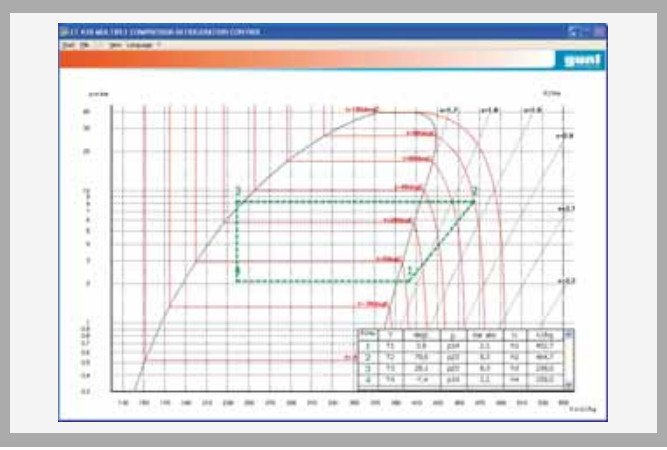
ET 428 Energy Efficiency in Refrigeration Systems



1 condenser, 2 pressure switch, 3 heat exchanger, 4 compressor, 5 evaporator, 6 pump, 7 heater, 8 cooling tank (cooling load), 9 receiver, 10 switch cabinet, 11 oil separator



1 heat exchanger, 2 evaporator, 3 expansion valve, 4 cooling tank with heater (cooling load), 5 receiver, 6 condenser, 7 oil separator, 8 compressor; T temperature, P pressure, F flow rate, PSH, PSL pressure switch; blue: low pressure, red: high pressure, green: oil return



Software screenshot: log p-h diagram

- Specification**
- [1] refrigeration system in multicompressor operation to investigate energy efficiency
 - [2] refrigeration circuit with 3 compressors connected in parallel, condenser, thermostatic expansion valve and coaxial coil heat exchanger as evaporator
 - [3] heat exchanger for refrigerant supercooling can be added via valves
 - [4] glycol-water circuit includes pump and tank with heater serving as cooling load at the evaporator
 - [5] multicompressor controller for the parallel operation of the compressors
 - [6] separation of oil from the refrigerant on the delivery side and return to the intake side of the compressors
 - [7] fan at the condenser with adjustable speed
 - [8] GUNT software for data acquisition via USB under Windows Vista or Windows 7
 - [9] Refrigerant R134a, CFC-free
- Technical Data**
- 3 compressors
 - refrigeration capacity: each 1584W at -10°C/55°C
 - power consumption: each 1156W at -10°C/55°C
 - Condenser with fan
 - capacity: 4100W
 - volumetric air flow rate: 1250m³/h
 - Coaxial coil heat exchanger capacity
 - 4kW at ΔT=9K; 0,6m³/h glycol-water mixture
 - Glycol-water mixture pump
 - max. flow rate: 4,2m³/h
 - max. head: 5,6m
 - Heater power: 3kW
 - Tank
 - glycol-water mixture: 23L
 - refrigeration circuit receiver: 5,8L

- Measuring ranges**
- temperature: 4x 0...100°C, 4x -100°C...100°C
 - pressure: 1x -1...9bar, 1x -1...24bar
 - flow rate: 1x 1...25L/min
 - compressor power: 0...4995W

Dimensions and Weight

LxWxH: 1810x710x1920mm
Weight: approx. 265kg

Required for Operation

400V, 50/60Hz, 3 phases

Scope of Delivery

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

Order Details

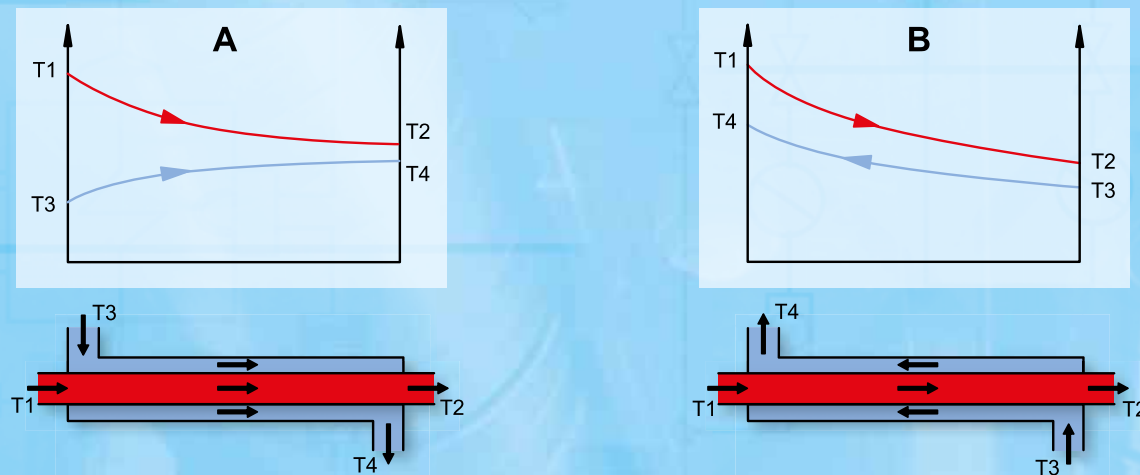
061.42800 ET 428 Energy Efficiency in Refrigeration Systems

BASIC KNOWLEDGE

HEAT EXCHANGERS IN REFRIGERATION

In principle heat exchangers have the purpose to transfer heat from a flowing substance to another flowing substance of a lower original temperature. The substances are gaseous or liquid.

Important for the heat transfer is the temperature difference of the two media as a driving gradient. Dependent on the flow direction (e.g. counterflow, parallel flow) the progression of the temperature difference along the path can be different.



Temperature profile for a tubular heat exchanger:

A parallel flow, B counterflow;

T1 hot medium supply, T2 hot medium discharge, T3 cold medium supply, T4 cold medium discharge

The total transferred heat flow also depends directly on the transfer area. For this reason different wall geometries (e.g. fins) are used to enlarge the transfer area.

The heat transfer is divided into three sections:

- Heat transfer from the hotter medium to the wall
- Heat conduction through the wall
- Heat transfer from the wall to the colder medium

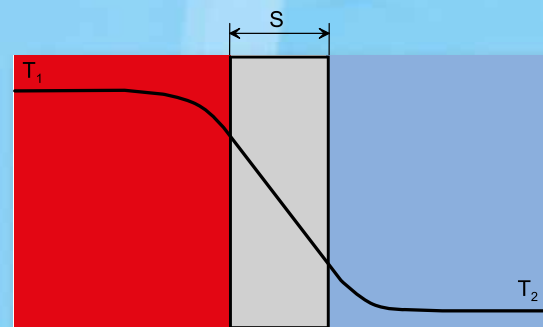
The heat transfer from the medium to the wall or from the wall to the medium depends on the following factors:

- Material type of the media
- Flow velocity of the media
- Aggregate states of the media

For heat exchangers in refrigeration circuits the aggregate state of the refrigerant changes frequently. In evaporators the aggregate state of the refrigerant changes from liquid to gaseous. For this the refrigerant must absorb heat through the wall.

The heat conduction in the wall depends e.g. on the following factors:

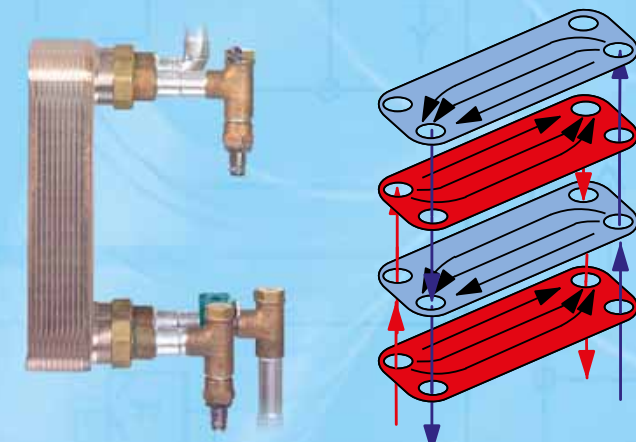
- Wall thickness
- Wall material



Heat exchange at a flat wall:
 T_1 temperature of hot medium
 T_2 temperature of cold medium
 s wall thickness

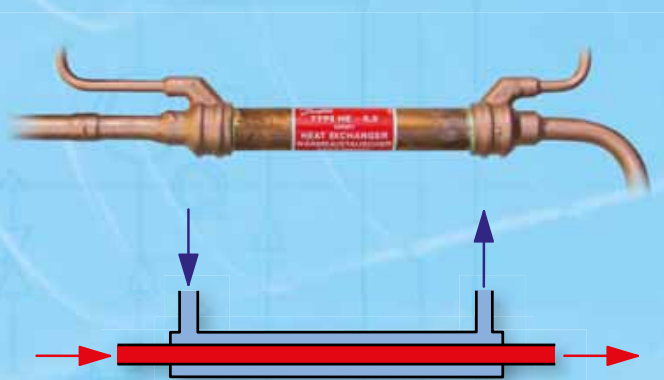
Dependent on the individual application, different types of heat exchangers are used in refrigeration engineering.

PLATE HEAT EXCHANGERS



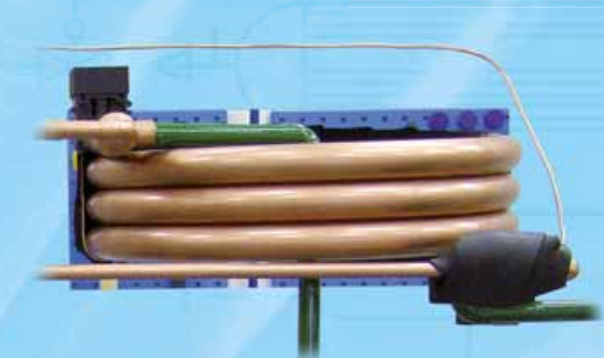
Application: evaporator or oil cooler

TUBULAR HEAT EXCHANGER



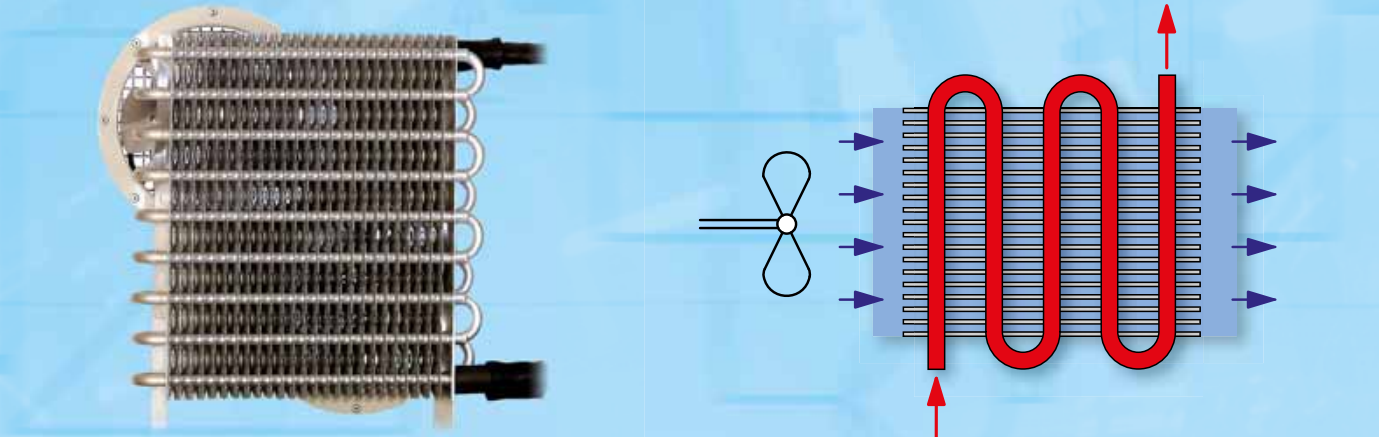
Application: internal heat exchanger for supercooling the refrigerant

COAXIAL COIL HEAT EXCHANGER



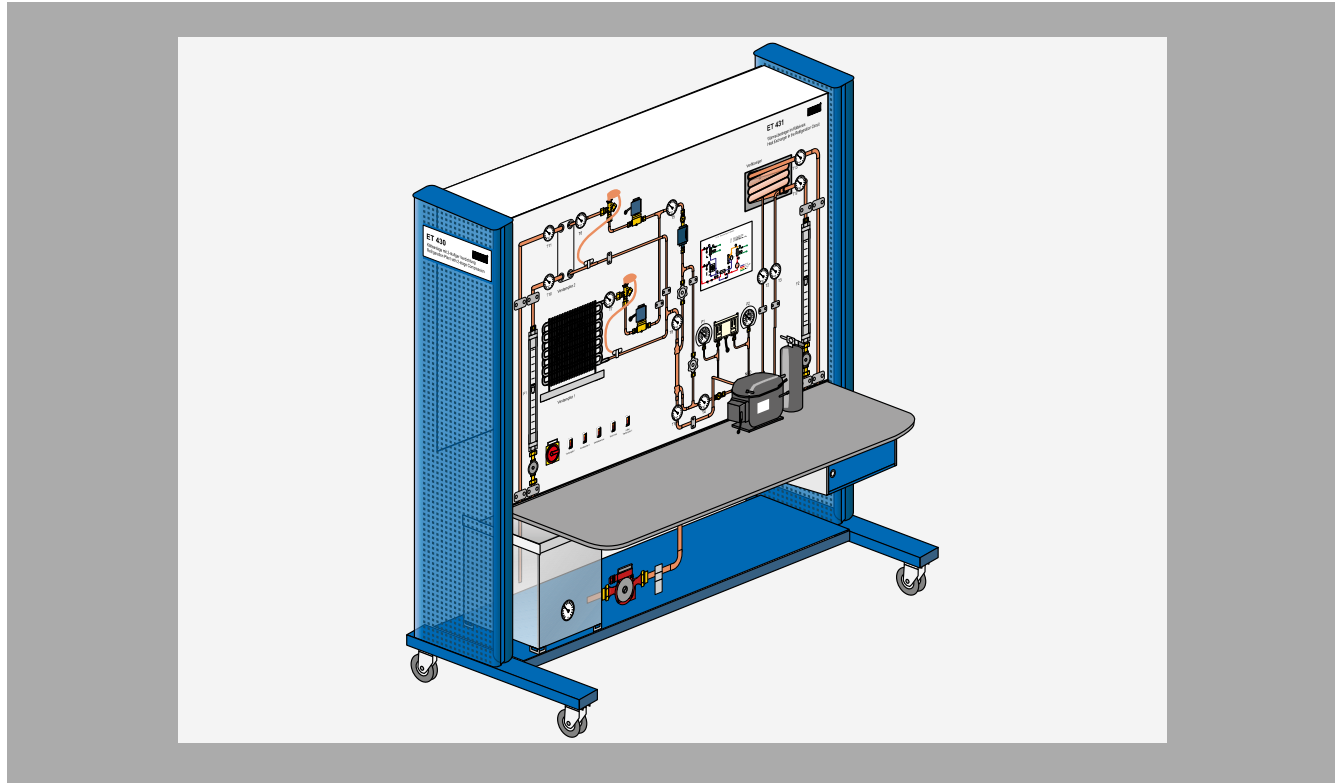
Application: water-cooled condenser or water cooling evaporator

FINNED TUBE HEAT EXCHANGER



Application: air-cooled condenser or air cooling evaporator

ET 431 Heat Exchangers in the Refrigeration Circuit



- * Typical heat exchangers from refrigeration
- * Different media: air/refrigerant, refrigerant/refrigerant and water/refrigerant
- * Effect of superheating and supercooling of the refrigerant on the cyclic process

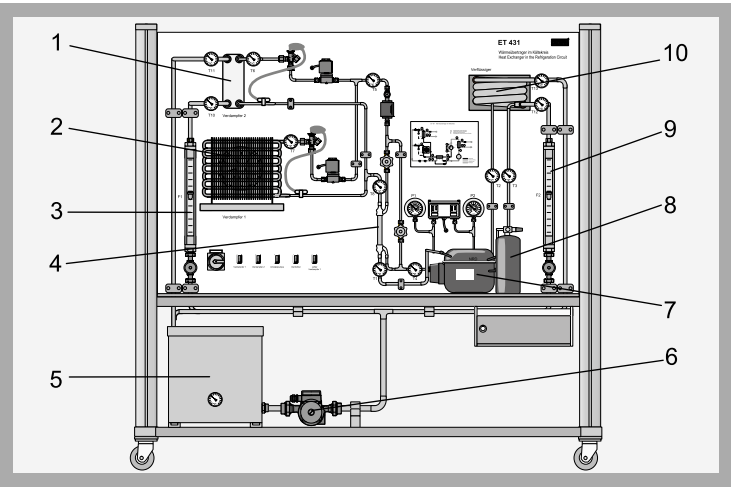
Technical Description

Heat exchangers are an elementary part of refrigeration systems. During cooling they are used to absorb the energy of the refrigerant by evaporation. During heating they discharge the energy set free during the condensation of the refrigerant. They are also used for internal energy transfer during superheating or supercooling of the refrigerant. Dependent on the media, a difference is made between air/refrigerant, water/refrigerant and refrigerant/refrigerant heat exchangers. Dependent on the constructive design, a difference is also made between coaxial, finned tube, plate or shell & tube heat exchangers. The refrigeration circuit of the trainer includes as evaporator an air cooling finned tube heat exchanger and a water-heated plate heat exchanger, as superheater a tubular heat exchanger, and as condenser a water-cooled coaxial coil heat exchanger. These heat exchangers are the ones used most commonly in refrigeration and fulfil different functions dependent on the system type. A finned tube heat exchanger can e.g. also be used as a condenser. By measuring the mass flow rates and the inlet and outlet temperatures the transferred energy fluxes can be determined. The components are arranged clearly at the front. The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

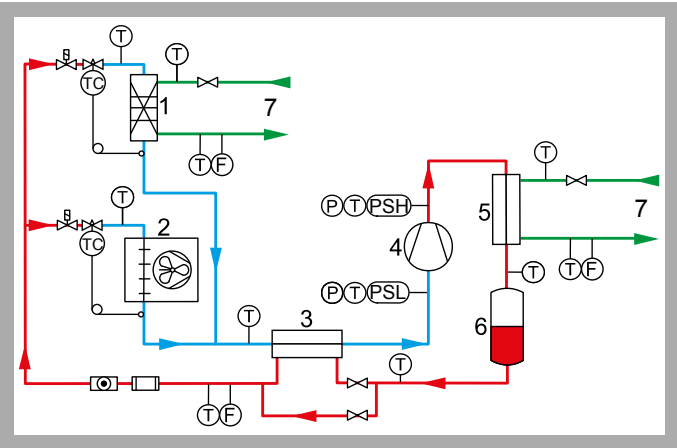
Learning Objectives / Experiments

- different heat exchangers and their use in refrigeration
- * coaxial coil heat exchanger
- * finned tube heat exchanger
- * tubular heat exchanger
- * plate heat exchanger
- find out the correct installation position
- determine energy fluxes
- effect of superheating and supercooling of the refrigerant on the cyclic process
- design of a compression refrigeration system
- representation of the cyclic process in the log p-h diagram

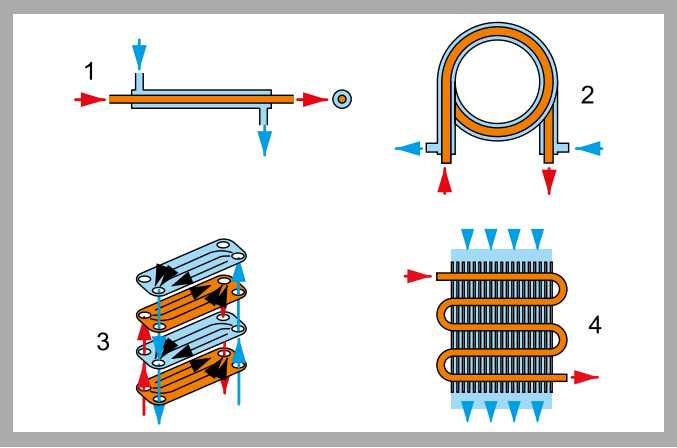
ET 431 Heat Exchangers in the Refrigeration Circuit



- 1 plate heat exchanger as evaporator, 2 finned tube heat exchanger as evaporator, 3 heating water flow meter, 4 tubular heat exchanger as superheater, 5 water tank, 6 water pump, 7 compressor, 8 receiver, 9 cooling water flow meter, 10 coaxial coil heat exchanger as condenser



- 1 plate heat exchanger, 2 finned tube heat exchanger, 3 tubular heat exchanger, 4 compressor, 5 coaxial coil heat exchanger, 6 receiver, 7 water circuit connections; T temperature, P pressure, F flow rate



- 1 tubular heat exchanger, 2 coaxial coil heat exchanger, 3 plate heat exchanger, 4 finned tube heat exchanger

Specification

- [1] Refrigeration system with 4 different heat exchangers: coaxial coil heat exchanger, finned tube heat exchanger, tubular heat exchanger, plate heat exchanger
- [2] combinations of different media: water/refrigerant, refrigerant/refrigerant, air/refrigerant
- [3] water circuit with tank and pump to cool the condenser and heat the evaporator
- [4] superheater can be disabled via bypass
- [5] flow meter and thermometer in the water circuit to determine the exchanged energy fluxes
- [6] thermometers at all relevant points of the system
- [7] refrigerant R134a, CFC-free

Technical Data

- Compressor
- refrigeration capacity: 580W at -5/32°C
- power consumption: 235W at -10/32°C
- Receiver: 1.4L

Measuring ranges

- pressure: -1...9bar / -1...24bar
- temperature: 3x -20...30°C, 9x 0...60°C, 1x 0...100°C
- flow rate: 2x 240L/h

Dimensions and Weight

- LxWxH: 1800x750x1900mm
- Weight: approx. 200kg

Required for Operation

- 230V, 50Hz, 1 phase

Scope of Delivery

- 1 trainer
- 1 set of instructional material

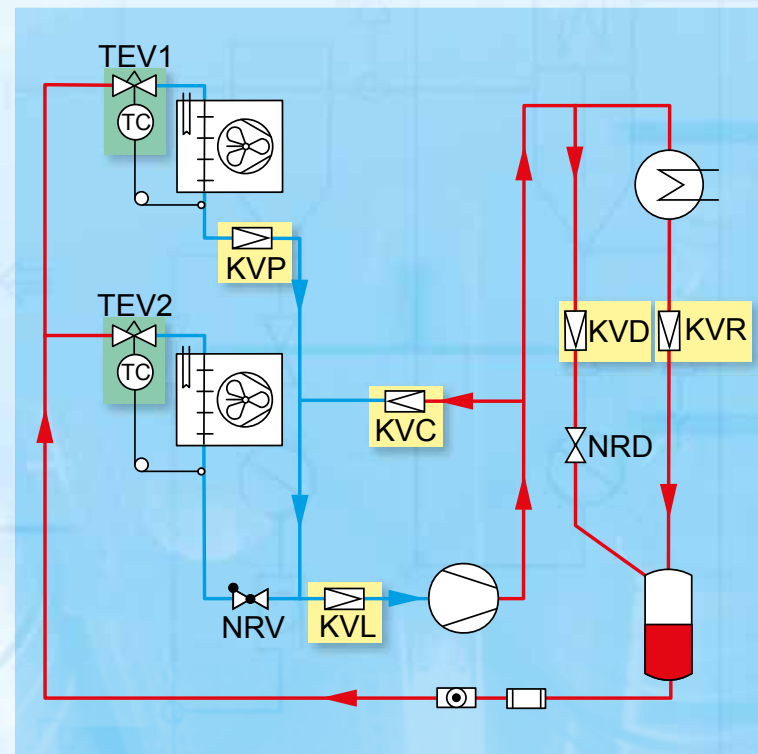
Order Details

- 061.43100 ET 431 Heat Exchangers in the Refrigeration Circuit

BASIC KNOWLEDGE

PRIMARY AND SECONDARY CONTROLLERS

Primary and secondary controllers control the refrigerant flow in the refrigeration circuit. The refrigerant flow must match the capacity demand. I.e. if a higher refrigeration capacity is required because e.g. goods to be cooled are added to the refrigeration chamber, more refrigerant must be evaporated. In addition, controllers are required to ensure that all components of the refrigeration circuit, such as evaporator, condenser and compressor, are operated in their optimum pressure and temperature range. Only this guarantees that a refrigeration system is operated safely and economic.



Refrigeration circuit with primary and secondary controllers

■ primary controller ■ secondary controller

KVP evaporation pressure controller,
KVR condensation pressure controller,
KVL start-up controller,
KVC capacity controller,
KVD collector pressure controller,
NRD, NRV non-return valve,
SGN sight glass,
DN filter / drier,
AEV pressure-controlled expansion valve,
TEV thermostatic expansion valve

Primary controllers

In technical language primary controllers are also called expansion elements. They control the capacity of the evaporator directly via the injected refrigerant flow.

Four different types are differentiated:

- Capillary tube
- Pressure-controlled expansion valve
- Thermostatic expansion valve
- Electronic expansion valve

Capillary tube

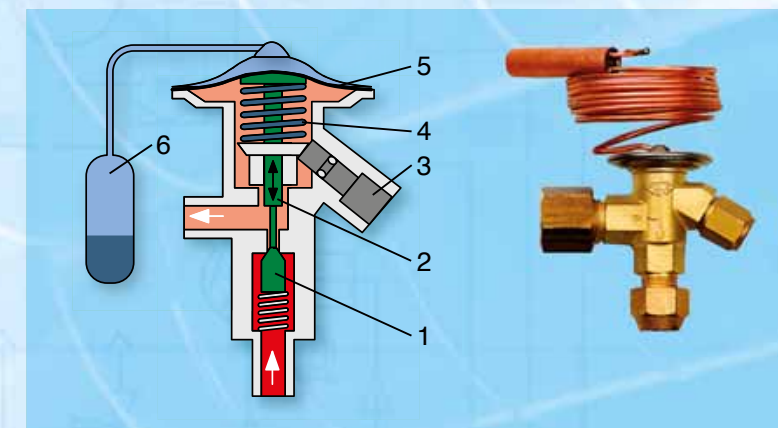
In small systems, such as refrigerators, the capillary tube is favoured. It is a non-adjustable expansion element without control properties. As capillary tube a copper tube with very small inner diameter is used. The expansion element effect is set experimentally via the length of the capillary tube.

Capillary tube systems do not contain a collector and the refrigerant volume is matched exactly to the system.



Thermostatic expansion valve

The thermostatic expansion valve (TEV) is used most frequently. The TEV compares the temperature of the refrigerant at the evaporator outlet with the inlet temperature. Here the TEV tries to maintain a slight overheating of the refrigerant of a few degrees at the outlet. This ensures that the maximum possible refrigerant volume is supplied to the evaporator to be safely evaporated in full. It is important that no liquid refrigerant exits the evaporator, because this could cause major damage to the compressor. The degree of superheating can be adjusted by the pretension of the diaphragm spring.



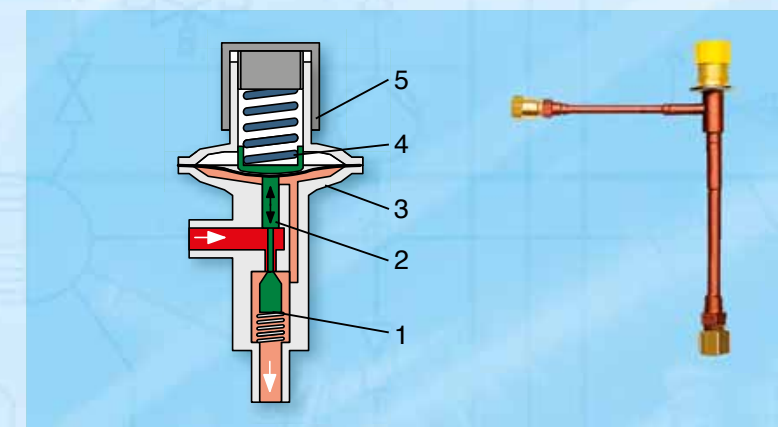
1 nozzle insert with valve cone, 2 tappet, 3 adjustment screw, 4 diaphragm spring, 5 diaphragm, 6 temperature sensor

Pressure-controlled expansion valve

With the pressure-controlled expansion valve (AEV) the pressure in the evaporator and thus the evaporation temperature is kept constant via the refrigerant supply. This is e.g. important if the goods to be cooled come into direct contact with the evaporator surface.

A disadvantage of the pressure-controlled expansion valve is that liquid refrigerant might exit the evaporator. Therefore, it is only used in special applications.

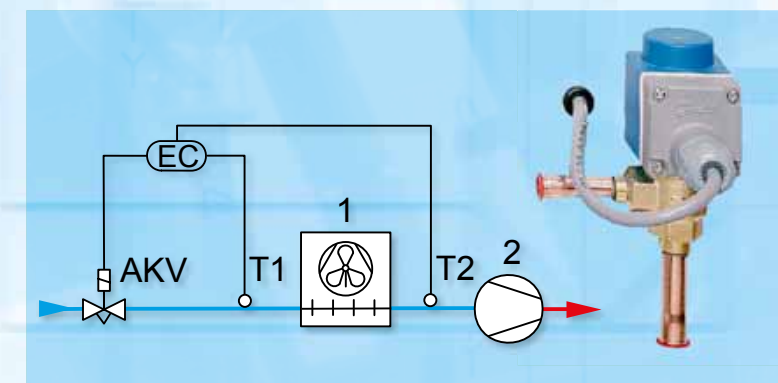
The evaporation pressure is set via the pretension of the diaphragm spring.



1 nozzle insert with valve cone, 2 tappet, 3 diaphragm, 4 diaphragm spring, 5 adjustment cap

Electronic expansion valve

The electronic expansion valve is the most flexible one. Here several effects can control the refrigerant flow simultaneously. However, the electronic expansion valve must be controlled via a complex digital control unit and is due to its high cost only economic for larger systems. In the drive of the valve cone a difference is made between a motorised and electromagnetic drive.



Electronic expansion valve (**AKV**) with control unit (**EC**) and two temperature sensors:
T1 determination of the evaporation pressure and
T2 to measure the superheating

BASIC KNOWLEDGE

PRIMARY AND SECONDARY CONTROLLERS

Secondary controllers

Secondary controllers guarantee the optimum operating conditions for different components of the refrigeration circuit. They are mainly pressure controllers which, dependent on the tasks, keep the inlet, outlet or differential pressure at a desired value. Temperature controllers and electronic capacity controllers are also amongst the secondary controllers.

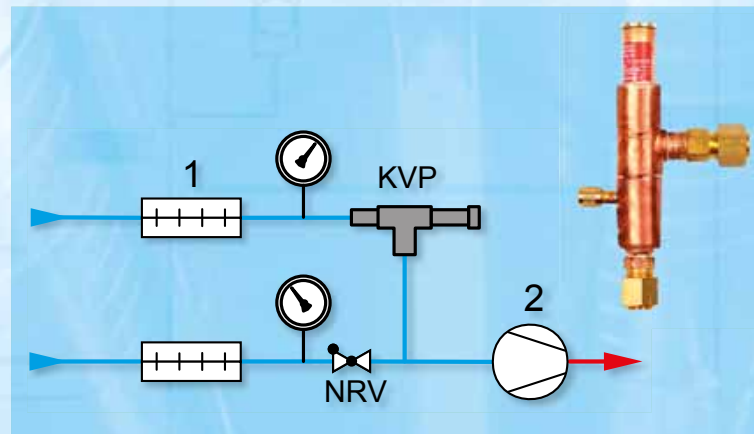
The following types of pressure controllers are differentiated:

- Evaporation pressure controller KVP
- Condensation pressure controller KVR
- Start-up controller KVL
- Capacity controller KVC
- Collector pressure controller KVD

(KVP, KVR, KVL, KVC, KVD, NRV were originally type designations by Danfoss which have become common terms in refrigeration language.)

Evaporation pressure controller

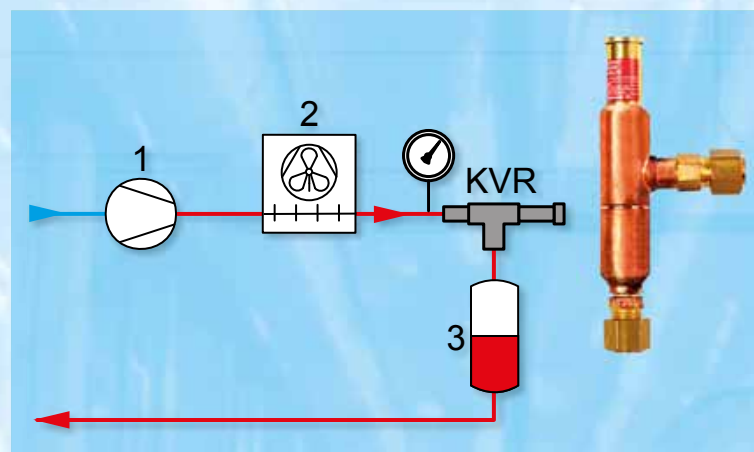
Via the evaporation pressure controller KVP the pressure and thus the temperature of the refrigerant in the evaporator is set. The KVP is often used to set different temperature levels (refrigeration and freezing stage) in a refrigeration system.



1 heat exchanger, 2 compressor, KVP evaporation pressure controller, NRV non-return valve

Condenser pressure controller

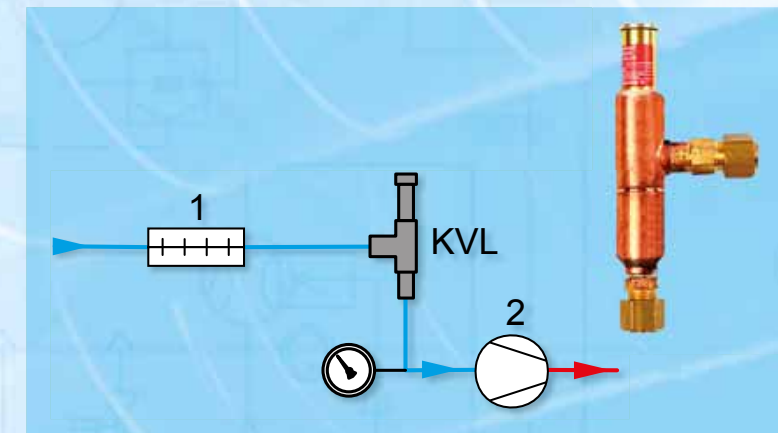
The condensation pressure controller KVR maintains a minimum pressure in the condenser. The KVR is used in air-cooled outdoor condensers. Using accumulated liquid refrigerant, the effective heat transfer area is reduced at low ambient temperatures. This reduces the condenser capacity.



1 compressor, 2 heat exchanger, 3 collector, KVR condensation pressure controller

Start-up control

The start-up controller KVL prevents the compressor start at too high intake pressures. Otherwise the compressor could be overloaded. Therefore the KVL closes if the pressure upstream of the compressor is too high.

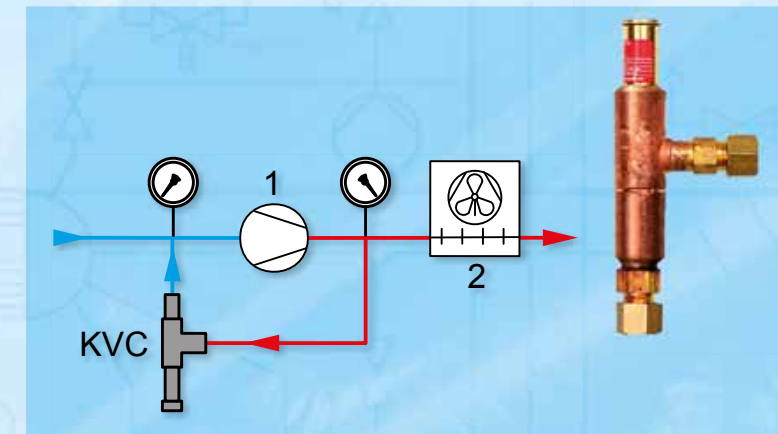


1 heat exchanger, 2 compressor, KVL start-up controller

Capacity controller

The capacity controller KVC reduces the delivery volume of the compressor at low refrigeration capacity. The KVC prevents too low an intake pressure and therefore the unnecessary cycling of the compressor.

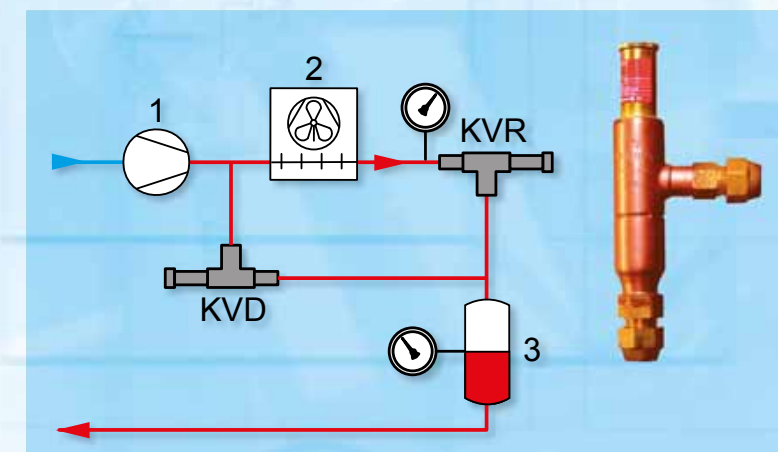
If the intake pressure is too low the KVC returns some of the delivery volume via a bypass to the intake side.



1 compressor, 2 heat exchanger, KVC capacity controller

Collector pressure controller

The collector pressure controller KVD prevents in conjunction with a condensation pressure controller KVR too low a collector pressure which results in a partial evaporation in the liquid pipes of the refrigeration system. For this purpose the KVD directs a small quantity of vaporous refrigerant directly from the compressor outlet to the collector.



1 compressor, 2 heat exchanger, 3 collector, KVD collector pressure controller, KVR condenser pressure controller

ET 426 Capacity Control in Refrigeration Systems



The illustration shows a similar unit.

- * Examination of different capacity control methods
- * Open compressor with variable speed
- * Adjustable cooling load via heater
- * Controlled defrosting with temperature specification

Technical Description

The efficient control of the capacity and temperature in refrigeration systems is an important topic in refrigeration engineering. With ET 426 different methods of capacity control can be investigated. For this purpose a refrigeration circuit with two refrigeration chambers is available in which a cooling load is generated using an adjustable heater. Fans in both refrigeration chambers ensure an even temperature distribution.

In the first refrigeration chamber a thermostat with solenoid valve and an evaporation pressure controller control the pressure of the refrigerant in the evaporator and thereby the temperature.

Sensors record the temperature in the second refrigeration chamber and the temperature of the refrigerant upstream and downstream of the evaporator. A refrigeration controller processes the signals from the sensors. Via a solenoid valve the refrigeration controller changes the refrigerant flow in the evaporator and controls thereby the temperature in the second refrigeration chamber. The temperatures at which the fans and a defrost heater are switched on or off are also set at the refrigeration controller. In addition the refrigeration capacity of the overall refrigeration circuit can be adjusted via the speed of the compressor. There also is the option to adjust the refrigeration capacity at a capacity controller in the compressor bypass.

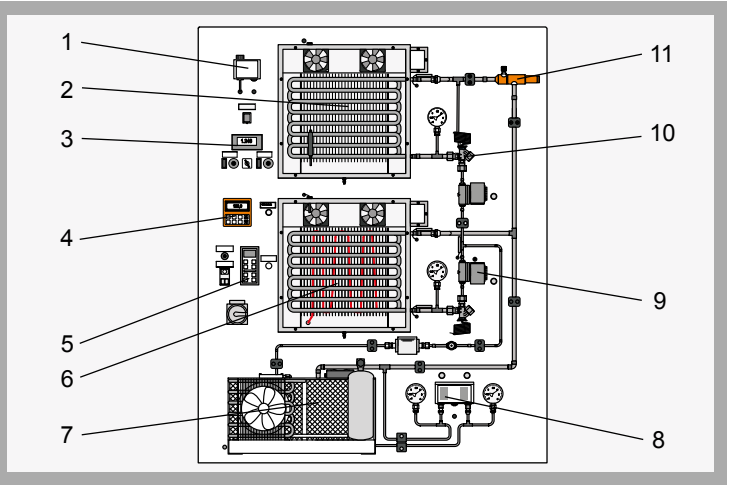
Both refrigeration chambers feature a window to be able to monitor the fan operation and formation of ice. Manometers enable the easy reading of pressures at the relevant points.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

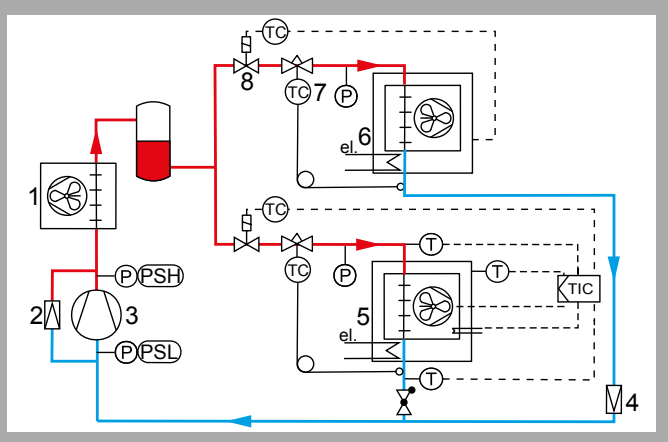
Learning Objectives / Experiments

- key devices for changing the refrigeration capacity
 - * thermostat
 - * evaporation pressure controller
 - * refrigeration controller
 - * capacity controller
 - * compressor with variable speed
- operation of a refrigeration controller with specification of temperatures for
 - * controlling the refrigeration capacity
 - * switching the defrost heater on and off
 - * switching the fans on and off

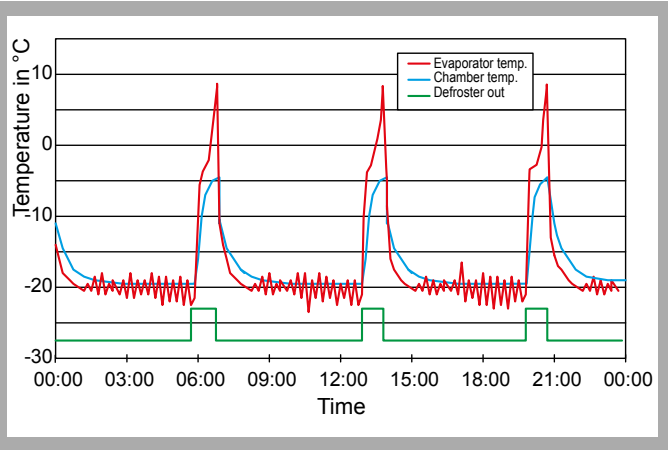
ET 426 Capacity Control in Refrigeration Systems



1 thermostat, 2 refrigeration chamber with heater and fan, 3 heater controls, 4 refrigeration controller, 5 compressor controls, 6 refrigeration chamber with heater, fan and defrost heater, 7 compressor and condenser, 8 combined pressure switch, 9 solenoid valve, 10 expansion valve, 11 evaporation pressure controller



1 condenser, 2 capacity controller, 3 compressor, 4 evaporation pressure controller, 5 refrigeration chamber with heater, fan and defrost heater, 6 refrigeration chamber with heater and fan, 7 expansion valve, 8 solenoid valve with thermostat; T temperature, P pressure; PSH, PSL pressure switch, TIC refrigeration controller



Time progression of a defrost controller (green) with temperature of evaporator (red) and refrigeration chamber (blue)

Specification

- [1] methods for capacity control in refrigeration systems
- [2] refrigeration circuit with compressor, condenser and 2 evaporators in insulated refrigeration chambers
- [3] each refrigeration chamber with adjustable heater to generate a cooling load, thermostatic expansion valve and fan
- [4] 1 refrigeration chamber with refrigeration controller for temperature control; solenoid valve, fan and defrost heater as actuators
- [5] 1 refrigeration chamber with thermostat, solenoid valve and evaporation pressure controller for temperature control
- [6] compressor with variable speed via frequency converter
- [7] capacity controller in the compressor bypass
- [8] refrigerant R134a, CFC-free

Technical Data

- Compressor
 - refrigeration capacity: approx. 560W at -5/25°C and 1450min⁻¹
 - drive motor: 550W
- 2 heaters: approx. 500W
- 4 fans: max. volumetric air flow rate: approx. 36,5m³/h
- 1 defrost heater: approx. 75W
- Refrigeration controller
 - 3 inputs
 - 3 outputs
- Evaporation pressure controller: 0...5,5bar
- Thermostat: -5...20°C
- Capacity controller: 0,2...6bar

Measuring ranges

- compressor speed: 465...975min⁻¹
- temperature: 3x -60...50°C
- heater power: 2x 0...1000W
- pressure: 3x -1...9bar; 1x -1...24bar

Dimensions and Weight

- LxWxH: 1100x750x1900mm
- Weight: approx. 150kg

Required for Operation

- 230V, 50/60Hz, 1 phase

Scope of Delivery

- 1 trainer
- 1 set of instructional material

Order Details

- 061.42600 ET 426 Capacity Control in Refrigeration Systems

ET 180 Pressure Switches in Refrigeration



- * Gain expert knowledge of refrigeration through practical exercises
- * Checking and adjustment of pressure switches in refrigeration
- * Clear arrangement at the front panel
- * Display of switching states via lamps
- * Independent pressure generation via compressor

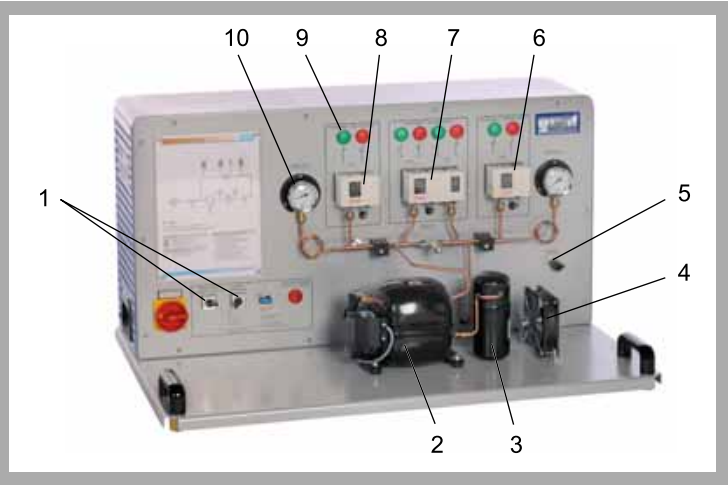
Technical Description

With this experimental unit the operation of the pressure switches, also called pressostats, used in refrigeration can be demonstrated. Pressure switches are used to protect the compressor and system components against too high or too low pressures. They are also used in the so-called pump-down circuits for the controlled shut-down of the compressor. Dependent on the application, individual pressure switches or combined pressure switches are used for high and low pressures. Both the pressure switches for monitoring the delivery pressure and for the intake pressure are available. The switching states are indicated by signal lamps. The switching thresholds and hystereses can be set by the trainee. This allows him to examine and understand the switching behaviour of the pressure switch. A typical refrigerant compressor generates the test pressures. Manometers indicate the pressures. Air is used as a pressure medium. The hazard-free operation of the pressure switches uses 24V. The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the exercises.

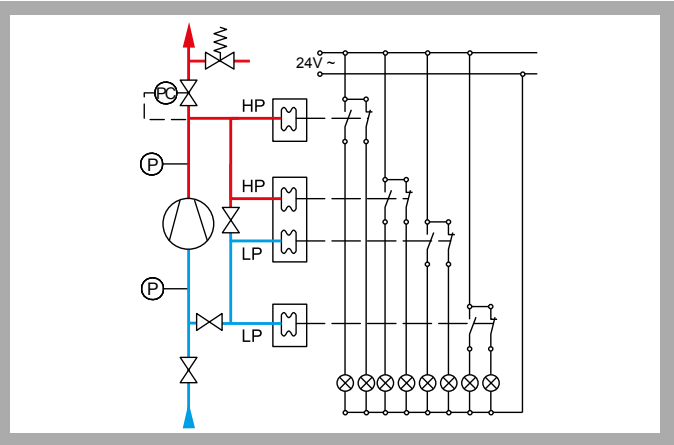
Learning Objectives / Experiments

- gain expert knowledge of refrigeration through practical exercises
- operation of a pressure switch
- difference between low and high pressure switches
- difference between NC and NO contacts of a switch
- setting the switching threshold
- setting the differential gap
- recording the switching behaviour of the pressure switch over pressure

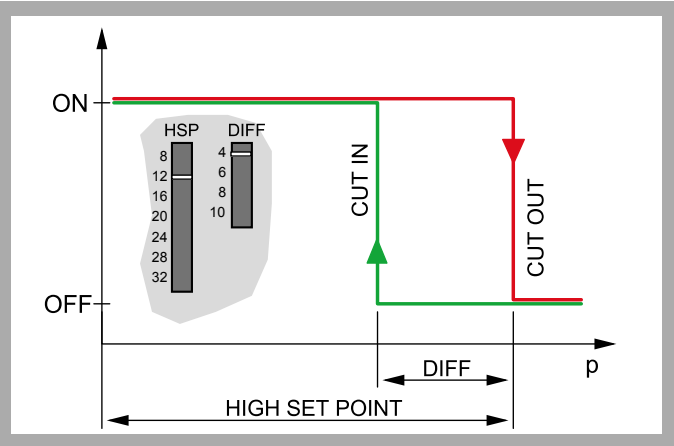
ET 180 Pressure Switches in Refrigeration



1 controls, 2 compressor, 3 receiver, 4 fan, 5 vent valve, 6 high pressure pressure switch, 7 combined pressure switch, 8 low pressure pressure switch, 9 signal lamps for switching state, 10 manometer



P pressure measuring point, PC pressure keeping valve, HP pressure switch, LP pressure switch; blue: low pressure, red: high pressure



Adjustment and operation of a high pressure pressure switch: HSP switch-off pressure, DIFF switch-on difference, CUT IN switch-on, CUT OUT switch-off

Specification

- [1] experimental unit from the GUNT practical series for the training of mechatronics engineers for refrigeration
- [2] operation and adjustment of pressure switches in refrigeration
- [3] low pressure, high pressure and combined pressure switches
- [4] indication of switching states via signal lamps
- [5] pressure generation via independent refrigerant compressor, pressure medium air
- [6] pressure adjustment via pressure keeping valve
- [7] hazard-free operation of the pressure switches at 24V

Technical Data

- Compressor pressure range: -0,9...24bar
- Pressure switches adjustment range
 - low pressure: -0,9...7,0bar
 - hysteresis: 0,7...4,0bar
 - high pressure: 8,0...32,0bar
 - hysteresis: 4...10bar

Manometer measuring range

- low pressure: -1...9bar
- high pressure: -1...24bar

Dimensions and Weight

- LxWxH: 1.000x650x530 mm
- Weight: approx. 60kg

Required for Operation

- 230V, 50/60Hz, 1 phase or 120V, 60Hz, 1 phase

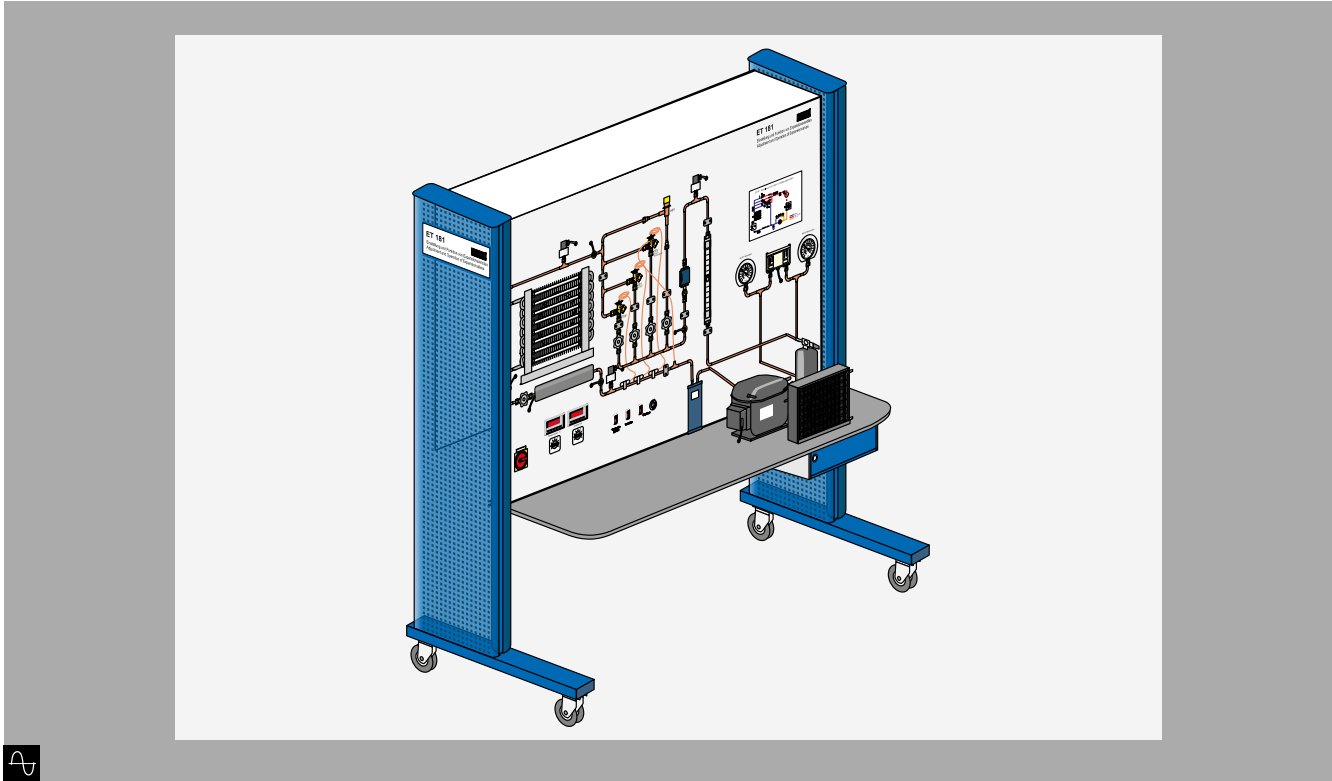
Scope of Delivery

- 1 experimental unit
- 1 set of instructional material

Order Details

- 061.18000 ET 180 Pressure Switches in Refrigeration

ET 181 Adjustment and Operation of Expansion Valves



- * Refrigeration circuit with different expansion valves
- * Adjustable superheating
- * Transparent evaporator to monitor the filling level and evaporation process
- * Recording of the control behaviour in the software

Technical Description

In the refrigeration circuit the expansion valves, also called primary controllers, also play an important role. The correct selection and adjustment decisively affects the capacity of the overall refrigeration system.

The trainer enables the investigation of four different expansion valves: TEV (Thermostatic Expansion Valve) with internal pressure compensation, TEV with external pressure compensation, TEV with MOP function (Maximum Operating Pressure) and AEV (Automatic Expansion Valve). The expansion valves can be selected via valves.

Via an evaporator with glass tubes the correct injection and evaporation of the refrigerant can be monitored. An additional electrically heated superheater at the output of the evaporator enables the investigation of the control behaviour with different refrigerant superheating. The locations of the temperature sensor at the evaporator output can be selected. The control behaviour can be monitored at a flow meter. Pressure and temperature sensors upstream and downstream of the expansion valve and at the evaporator outlet provide information about the state of the refrigerant and the degree of superheating.

A commercial condensing unit completes the refrigeration circuit.

The measured values can be read on digital displays. At the same time, the measured values can also be transmitted directly to a PC via USB. The data acquisition software is included. In the software the control behaviour of the expansion valves is recorded over time. The

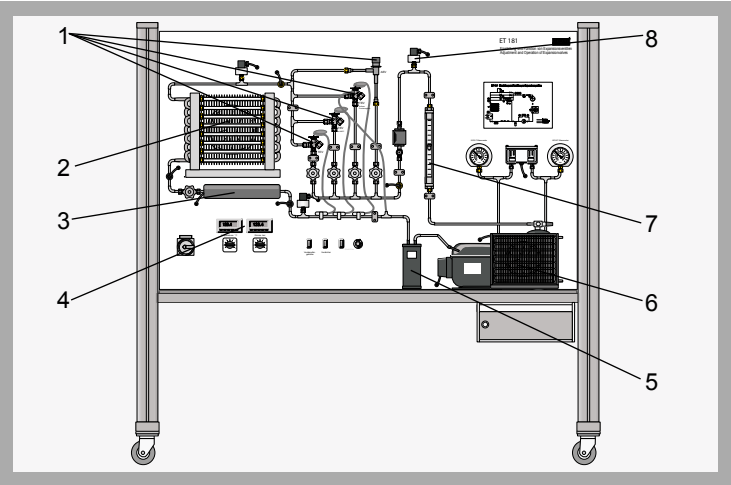
trainee can check the correct adjustment of the expansion valve and investigate effects such as hunting.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the exercises.

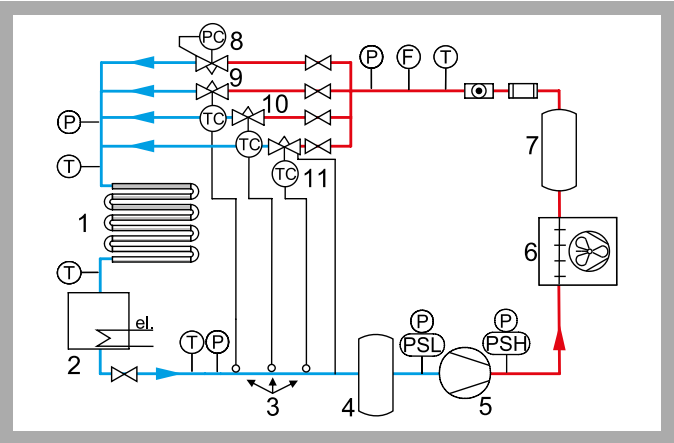
Learning Objectives / Experiments

- operation and properties of the various expansion valves
- investigation of the static control characteristic
- investigation of the dynamic control behaviour
- adjustment of the optimum operating point
- benefits and disadvantages of the different expansion valves
- * thermostatic expansion valve (TEV) with internal pressure compensation
- * TEV with external pressure compensation
- * TEV with MOP function (Max. Operating Pressure)
- * pressure-controlled expansion valve (AEV)
- hunting effect

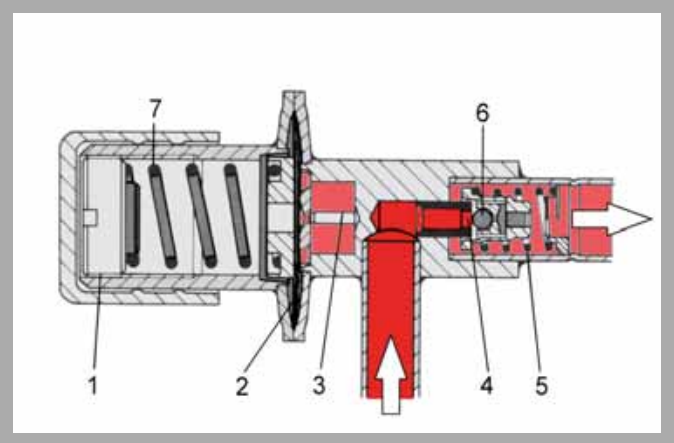
ET 181 Adjustment and Operation of Expansion Valves



1 expansion valves, 2 evaporator with glass tubes, 3 superheater, 4 displays for pressure and temperature, 5 suction line receiver, 6 condensing unit, 7 flow meter, 8 pressure sensor



1 evaporator, 2 superheater, 3 temperature sensor location, 4 suction line receiver, 5 compressor, 6 condenser, 7 receiver, 8 pressure-controlled expansion valve, 9-11 thermostatic expansion valves: 9 with internal pressure compensation, 10 with MOP function, 11 with external pressure compensation; P pressure, T temperature, F flow rate, PSL, PSH pressure switch; blue: low pressure, red: high pressure



Cross-section of a pressure-controlled expansion valve: 1 adjustment screw, 2 diaphragm, 3 pin, 4 nozzle, 5 return spring, 6 needle, 7 adjustment spring

Specification

- [1] trainer from the GUNT practical series for the training of mechatronics engineers for refrigeration
- [2] refrigeration system with different expansion elements: thermostatic expansion valve TEV with internal pressure compensation, thermostatic expansion valve TEV with external pressure compensation, thermostatic expansion valve TEV with MOP function, pressure-controlled expansion valve AEV
- [3] evaporator with glass tubes to monitor injection and evaporation
- [4] valve downstream of the evaporator to simulate different pressure losses
- [5] adjustable electric heater for superheating
- [6] air-cooled condensing unit
- [7] sensors record pressures, temperatures, flow rate
- [8] refrigerant R134a, CFC-free
- [9] GUNT software for data acquisition with USB under Windows Vista or Windows 7

Technical Data

- Air-cooled condensing unit
- power consumption: 485W at -10/32°C
- refrigeration capacity: 675W at -10/32°C
- receiver: 1,4L

Measuring ranges

- pressure: 2x -1...9bar, 1x -1...24bar
- temperature: 4 x -40...150°C
- flow rate: 3...41L/h

Dimensions and Weight

- LxWxH: 1800x750x1900mm
- Weight: approx. 130kg

Required for Operation

- 230V, 50Hz, 1 phase

Scope of Delivery

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

Order Details

- 061.18100 ET 181 Adjustment and Operation of Expansion Valves

ET 182 Secondary Controllers in Refrigeration Systems



- * Familiarisation with common secondary controllers in refrigeration systems
- * Secondary controllers can be decommissioned individually for fault finding
- * Refrigeration and freezing stage with cooling load
- * Different secondary controllers at the water-cooled condenser

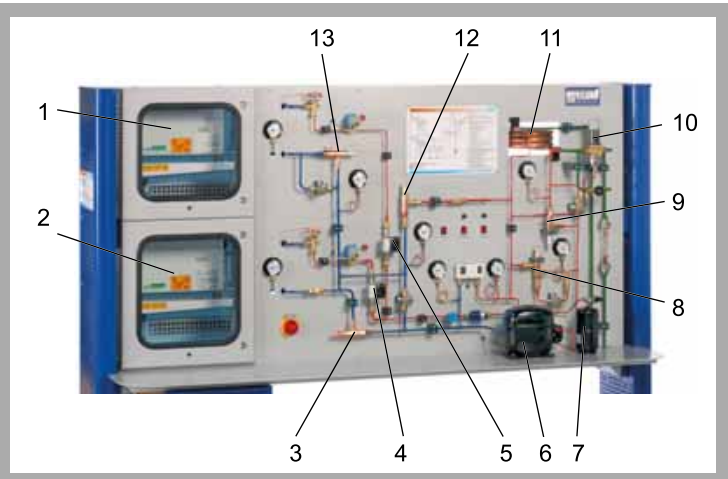
Technical Description

So-called secondary controllers are used to ensure the optimum operation of large, complex refrigeration systems. They control the evaporation pressure (KVP), the intake pressure of the compressor (KVL), the delivery capacity of the compressor (KVC), the condensation pressure (WVFX, KVR) and the receiver pressure (KVD, NRD). With this trainer the student can try out the operation of the different secondary controllers. The secondary controllers can be disabled as required by bypassing or blocking. This option can be used for fault finding. By adjusting the secondary controllers the effect on the overall system can be studied. Manometers at all important locations and a manual thermometer enable the monitoring of the system state. The two evaporators for the cooling and freezing stage can be selected via solenoid valves. With an adjustable electrical heater in the refrigeration chamber the effect of a changing cooling load on the secondary controllers can be examined. The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

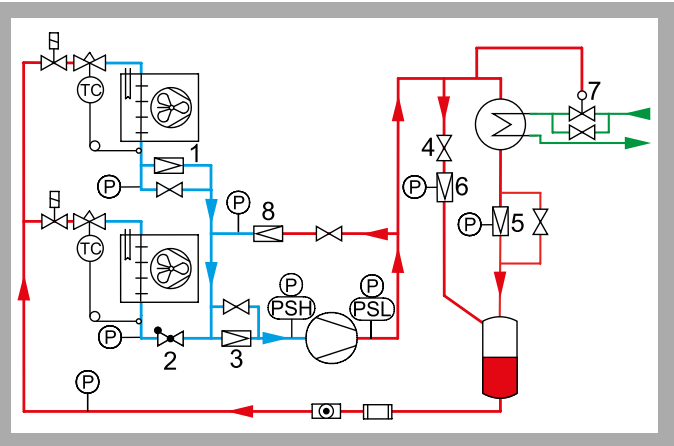
Learning Objectives / Experiments

- properties and application options of different secondary controllers
- * evaporation pressure controller (KVP)
- * start-up controller (compressor intake control; KVL)
- * capacity controller (control of the compressor delivery capacity; KVC)
- * condensation pressure controller (WVFX, KVR)
- * receiver pressure controller (KVD with NRD)
- adjustment of optimum operating points
- fault finding in secondary controllers

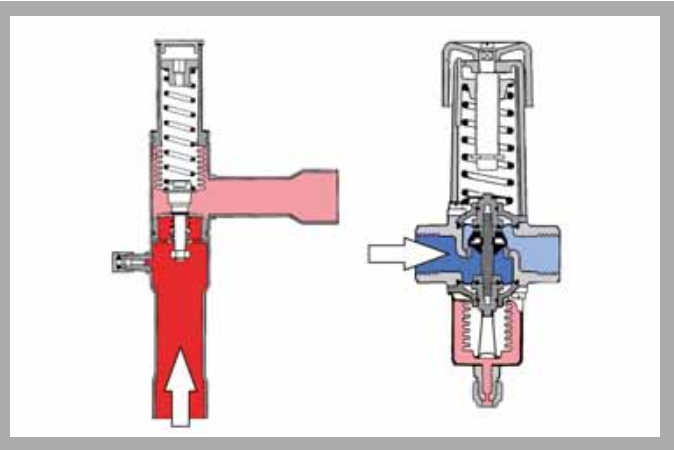
ET 182 Secondary Controllers in Refrigeration Systems



1 refrigeration chamber, 2 freezing chamber, 3 start-up controller, 4+5 flow meter, 6 compressor, 7 receiver, 8 receiver pressure controller, 9 condensation pressure controller, 10 pressure-controlled water valve, 11 water-cooled condenser, 12 capacity controller, 13 evaporation pressure controller



1 evaporation pressure controller KVP, 2 non-return valve NRV, 3 start-up controller KVL, 4 non-return valve, 5 condensation pressure controller KVR, 6 receiver pressure controller KVD, 7 pressure-controlled water valve WVFX, 8 capacity controller KVC; blue: low pressure, red: high pressure, green: cooling water



Condensation pressure control: condensation pressure controller KVR (left) and pressure-controlled water valve WVFX (right)

Specification

- [1] trainer from the GUNT practical series for the training of mechatronics engineers for refrigeration
- [2] refrigeration system with different secondary controllers: evaporation pressure controller KVP, capacity controller KVC, condensation pressure controller KVR, pressure-controlled water valve WVFX as condensation pressure controller, receiver pressure controller KVD, start-up controller KVL
- [3] 2 refrigeration chambers: refrigeration and freezing stage
- [4] evaporator selectable via solenoid valves
- [5] adjustable electric heater in the refrigeration chambers as cooling load
- [6] water-cooled coaxial condenser
- [7] pressure measurement at all relevant points in the system
- [8] refrigerant R134a, CFC-free

Technical Data

Compressor according to CECOMAF
- refrigeration capacity: 990W at -5/55°C
- power consumption: 685W
Cooling load: 0...500W
Receiver: 1,3L

Measuring ranges

- pressure: 5x -1...9bar / 3x -1...24bar
- flow rate water: 20...250L/h
- flow rate refrigerant: 1x 1...11,5L/h; 1x 2...27L/h
- temperature: -50...300°C

Dimensions and Weight

LxWxH: 2.500x790x1.900mm
Weight: approx. 280kg

Required for Operation

230V, 50Hz, 1 phase
Water connection

Scope of Delivery

- 1 trainer
- 1 set of instructional material

Order Details

061.18200 ET 182 Secondary Controllers in Refrigeration Systems

BASIC KNOWLEDGE

PIPING

Piping is an important part of refrigeration systems. The incorrect design and implementation of the refrigerant pipes could result in faulty operation or even damage to the refrigeration system.

Four different types of piping are basically differentiated in the refrigeration system:

Name	connects	Aggregate state	Temperature	Length
Intake pipe	Evaporator – Compressor	Vaporous	Cold	Long
Delivery pipe	Compressor – Condenser	Vaporous	Hot	Short
Condenser pipe	Condenser – Collector	Liquid	Environment	Short
Liquid pipe	Collector – Evaporator	Liquid	Environment / cold	Long

The properties of the different piping types have a direct effect on the constructive design. In long pipelines a low pressure loss must in particular be ensured. In piping with vaporous refrigerant the safe transport of oil must be ensured.

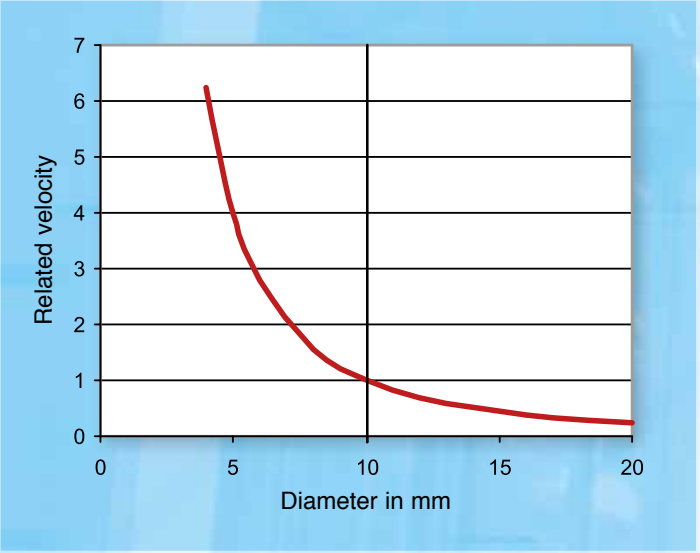
Cold or hot refrigerant pipes must be equipped with insulation to prevent heat loss or condensation on the surface.

Effect of the pipe diameter on the velocity and the pressure loss

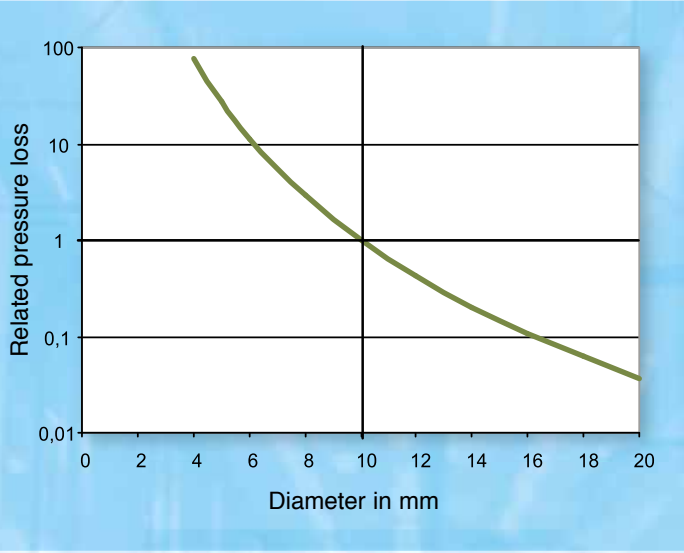
Pressure differences in the refrigerant pipes have an undesired effect on the boiling temperature of the refrigerant and thus on the operation of the system. Pressure differences can be caused by height differences in liquid pipes, or also by pressure losses in the piping. It is therefore important to dimension the piping correctly.

The two diagrams show the effect of the diameter on the velocity and pressure loss in the pipe. Velocity and pres-

sure loss are related to a diameter of 10mm. For example, an increase in the diameter from 10mm to 16mm reduces the velocity by 60%. Conversely the reduction of the pipe diameter from 10mm to 6mm causes a tenfold pressure loss.



Velocity in dependence of the pipe diameter



Pressure loss in dependence of the pipe diameter

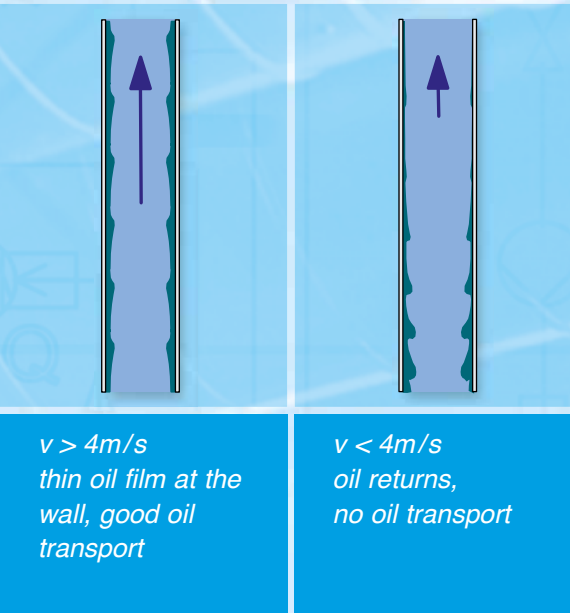
Oil transport in the refrigerant pipes

In refrigerant compressors some lubrication oil is carried along with the compressed refrigeration steam in the system. To prevent a lubrication oil deficiency in the compressor, this lubrication oil must be returned to the compressor and must not remain in the system.

In pipes with liquid refrigerant this is no problem because the lubrication oil is dissolved in the refrigerant. However, in the evaporator the liquid lubrication oil remains back and must be carried by the refrigerant steam along the wall of the intake pipe.

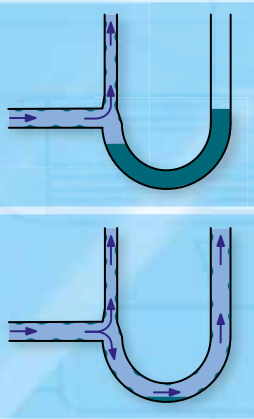
The oil transport is particularly difficult in rising intake pipes. Here a minimum velocity of approx. 4m/s is required to transport the oil towards the compressor.

In intake pipes a compromise between low pressure losses and safe oil transport must therefore be found. It is recommended to maintain a velocity of 4m/s for partial load and 9m/s for full load.



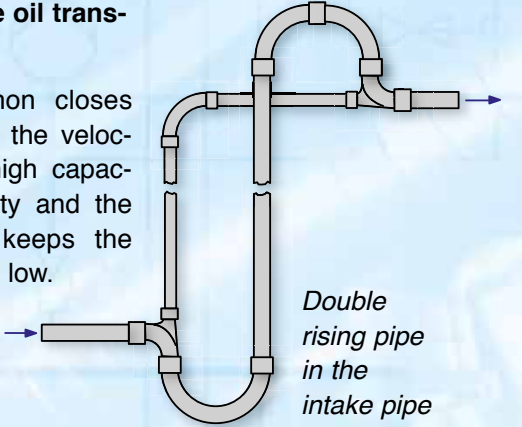
Low capacity:
Siphon filled with oil and only one rising pipe active

High capacity:
Empty siphon and two rising pipes active



Double rising pipe for the safe oil transport at low load

At low load an oil-filled siphon closes one rising pipe. This increases the velocity in the remaining pipe. At high capacity the siphon is pressed empty and the second pipe activated. This keeps the pressure losses at high capacity low.



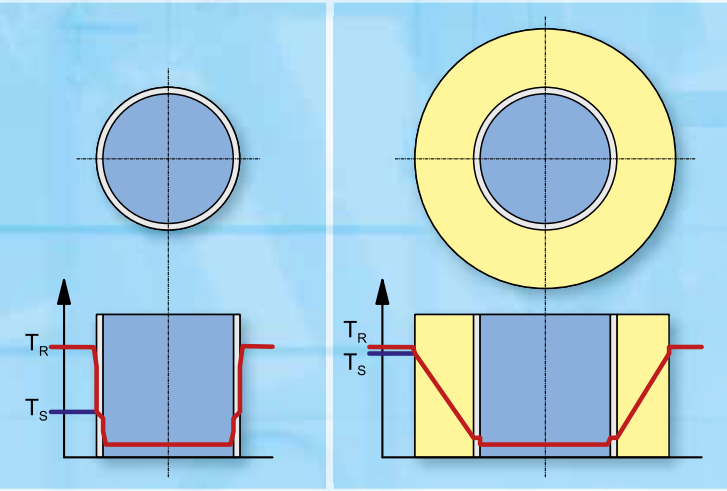
Double rising pipe in the intake pipe

Pipe insulation

The metallic materials used in refrigerant pipes have a high thermal conductivity so that the surface temperature T_s of the pipe matches roughly the refrigerant temperature. This means that plenty of heat can be exchanged with the ambient air (temperature T_R).

By surrounding the pipes with an insulating layer the surface temperature is adapted to the environment and the heat dissipation reduced.

In cold pipes the surface temperature T_s is thus kept above the dewpoint temperature and the condensation or freezing of the humidity in the air prevented. Dripping dew water can cause humidity – and corrosion damage.



Temperature curve in the pipe without insulation

Temperature curve in the pipe with insulation

ET 460 Oil Return in Refrigeration Systems



- * Transport of lubricants soluble in refrigerant in refrigeration systems
- * Transparent material for monitoring the transport states in the rising pipes
- * Monitoring of the processes in a double rising pipe during partial and full load operation
- * Separate or parallel operation of two compressors for partial and full load
- * Well-structured instructional material

Technical Description

The oil return in refrigeration systems is of key importance for the service life of the compressor and thus for a secure constant supply of refrigeration.

In most compressors some lubrication oil is carried along with the compressed refrigerant. In the liquid refrigerant the oil is dissolved in the refrigerant and is transported without problems. In the vaporised refrigerant the oil remains liquid in the lower parts of the system. This can result in lack of oil in the compressor. To return the oil to the compressor, a minimum velocity must be maintained in the pipes. If the velocity in the rising pipe on the intake side of the compressor is too low (partial load), the oil is not returned to the compressor due to its higher density.

The velocity in the rising pipe depends on the pipe diameter and the refrigerant mass flow. A small diameter of the rising pipe results in a high velocity and ensures the return of the oil even under partial load. However, at full load the pressure loss increases due to the small diameter.

To compensate for this disadvantage, double rising pipes are used. During partial load oil gathers in a bend at the bottom of the double pipe. The oil in the bend blocks one of the two pipes so that the refrigerant flows at high velocity through the other pipe and transports the oil to the compressor. At full load the oil in the bend is pressed upwards so that the refrigerant flows through both pipes.

At the front of the ET 460 three transparent rising pipes with different diameters and a double rising pipe have been arranged. The rising pipe selection is via valves. This allows for the oil transport at different velocities to be observed. The other components of the refrigeration circuit are at the back of the trainer. The separate or combined operation of two compressors connected in parallel enables operation at partial or full load.

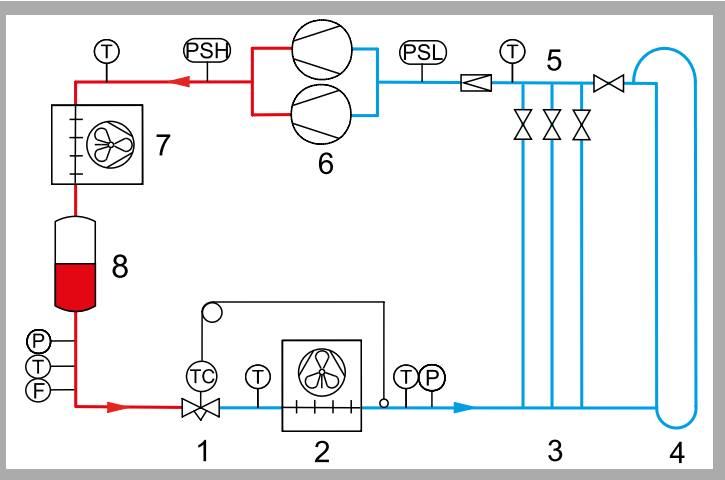
Learning Objectives / Experiments

- fundamentals of the oil return in refrigeration systems
- effect of the rising pipe diameter on the oil transport
- effect of partial and full load operation on the oil transport
- principle of operation of a double rising pipe
- separate or parallel operation of the compressors

ET 460 Oil Return in Refrigeration Systems



1 manometer delivery side, 2 manometer intake side, 3 flow meter, 4 display and control elements, 5 rising pipe d=6mm, 6 rising pipe d=10mm, 7 rising pipe d=14,4mm, 8 double rising pipe, 9 valve for rising pipe selection



1 expansion valve, 2 evaporator, 3 rising pipes, 4 double rising pipe, 5 valves for rising pipe selection, 6 compressor, 7 condenser, 8 receiver; P pressure, F flow rate, T temperature, PSH, PSL pressure switch; blue: low pressure, red: high pressure

Specification

- [1] investigation of the oil return to the compressor in refrigeration circuits with oil soluble in refrigerant
- [2] refrigeration circuit with 2 compressors connected in parallel, condenser with 2 fans, evaporator with fan and thermostatic expansion valve
- [3] 3 single and 1 double rising pipes from glass in the suction pipe of the refrigeration circuit
- [4] rising pipes selectable via valves
- [5] Flow rate in the refrigeration circuit adjustable by single or combined operation of the two compressors
- [6] fan speed adjustable
- [7] thermowells for temperature measurement
- [8] refrigerant R134a, CFC-free

Technical Data

- 2 compressors with condenser
- refrigeration capacity: 1194W at -10/32°C
- volumetric air flow rate fan: 1300m³/h
- Evaporator
- transfer area: 5,7m²
- volumetric air flow rate fan: 720m³/h
- Rising pipes
- d=14,4mm; L=1110mm
- d=10mm; L=1110mm
- d=6mm; L=1110mm
- d=8/10mm (double rising pipe); L approx. 1300mm

Measuring ranges

- pressure: 1x -1...9bar; 1x -1...24bar
- flow rate: 1x 1,5...23,5L/h
- temperature: 5x 0...100°C

Dimensions and Weight

- LxWxH: 1410x800x1900mm
- Weight: approx. 216kg

Required for Operation

- 230V, 50/60Hz, 1 phase

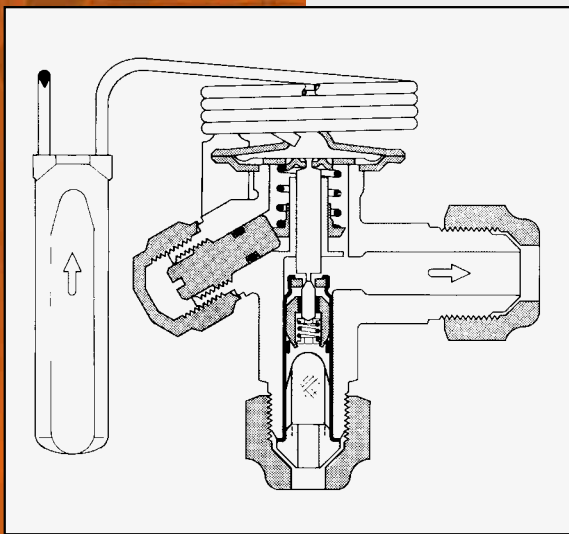
Scope of Delivery

- 1 trainer
- 1 set of instructional material

Order Details

- 061.46000 ET 460 Oil Return in Refrigeration Systems

ET 499.30 *Cutaway Model: Ceiling Air Cooler*



Sectional drawing of a thermostatic expansion valve

Cutaway models from refrigeration engineering

- Become familiar with components and their function
- Gain an insight into component details and understand functional principles
- All movements are fully reproduced

The cutaway models on the following pages show standard commercially available items from the field of refrigeration engineering, such as compressors, valves, driers and liquid separators. Each of the cutaway models come with a short description and a sectional drawing. This enables the didactic application of the models to be extended to exercises in technical drawing. The larger cutaway models are mounted on a solid base. Two handles aid transportation.

For ET 499.30, a commonly used ceiling air cooler, a thermostatic expansion valve and a filter drier are used. The cutaways are arranged to allow design details to be clearly identified.

I x w x h: 750 x 500 x 190 mm
Weight: approx. 20 kg
Item No. 061.49930



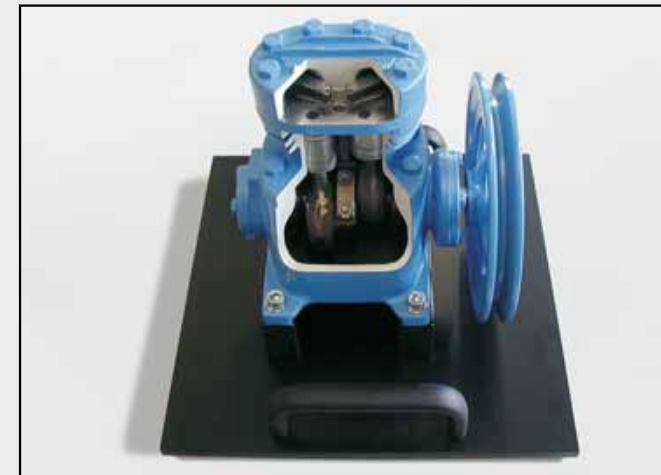
ET 499.01 *Hermetic Refrigerant Compressor*

I x w x h: 300 x 300 x 240 mm, Weight: approx. 12 kg
Item No. 061.49901



ET 499.02 *Semi-Hermetic Refrigerant Compressor*

I x w x h: 365 x 235 x 280 mm, Weight: approx. 41 kg
Item No. 061.49902



ET 499.03 *Open Refrigerant Compressor, 2-Cyl.*

I x w x h: 300 x 300 x 200 mm, Weight: approx. 14 kg
Item No. 061.49903



ET 499.12 *Block Drier*

I x w x h: 250 x 155 x 175 mm, Weight: approx. 5 kg
Item No. 061.49912



ET 499.13 *Oil Separator*

I x w x h: 360 x 110 x 130 mm, Weight: approx. 5 kg
Item No. 061.49913



ET 499.14 *Liquid Separator*

I x w x h: 130 x 65 x 110 mm, Weight: approx. 1 kg
Item No. 061.49914



ET 499.16 Ball Valve

I x w x h: 155 x 30 x 70 mm
Weight: approx. 1 kg
Item No. 061.49916



ET 499.18 Thermostatic Expansion Valve

I x w x h: 120 x 70 x 120 mm, Weight: approx. 1 kg
Item No. 061.49918



ET 499.19 Automatic Expansion Valve

I x w x h: 110 x 35 x 55 mm
Weight: approx. 1 kg
Item No. 061.49919



ET 499.21 Sight Glass with Humidity Indicator

I x w x h: 75 x 35 x 35 mm, Weight: approx. 1 kg
Item No. 061.49921



ET 499.25 4/2-Way Reversing Valve

I x w x h: 110 x 70 x 120 mm
Weight: approx. 1 kg
Item No. 061.49925



ET 499.26 Condensation Pressure Control Valve

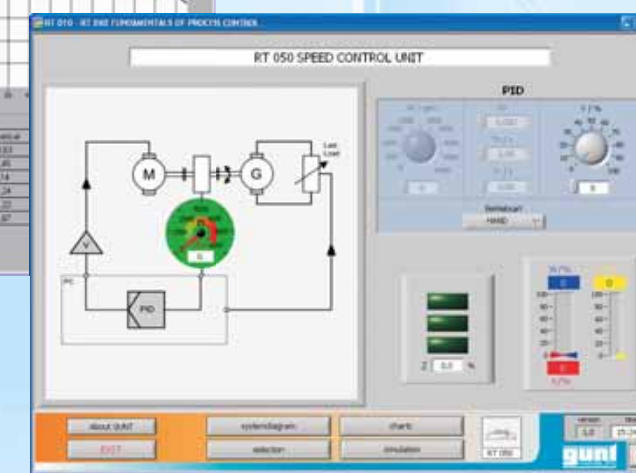
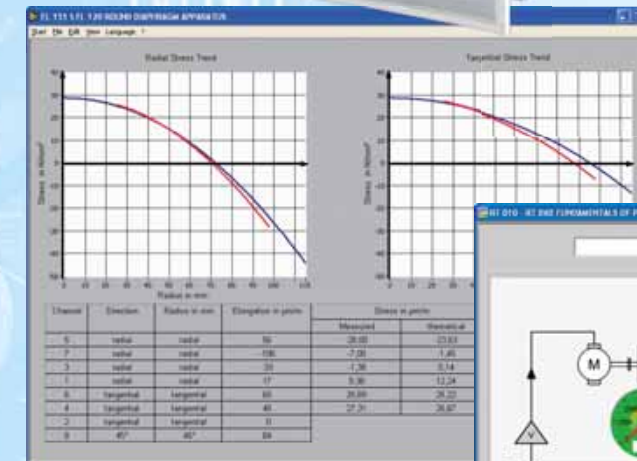
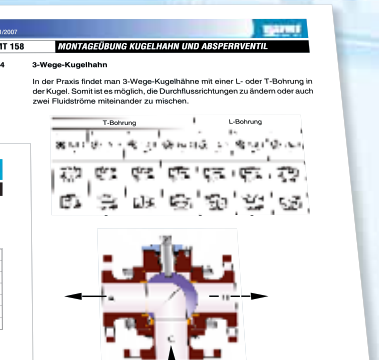
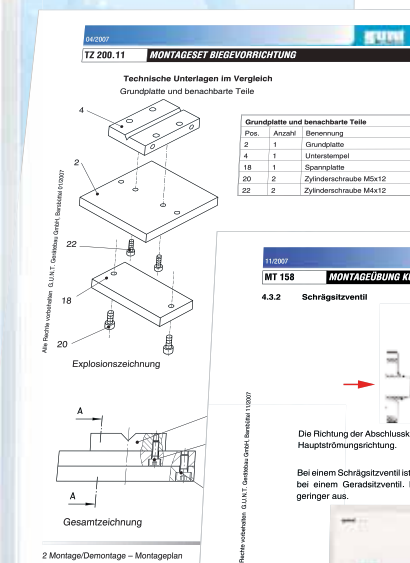
I x w x h: 180 x 30 x 105 mm, Weight: approx. 1 kg
Item No. 061.49926

INSTRUCTIONAL MATERIAL AND SOFTWARE

GUNT's policy is:

High-quality hardware and clearly laid-out instructional materials ensure the teaching and learning success of an experimental unit. The core elements of the instructional material provided to accompany the units are reference experiments conducted by ourselves. The description of the experiment incorporates the detailed set-up, through to interpretation of the results obtained. A group of experienced engineers devise and maintain the accompanying instructional material.

Our software – in our context meaning computerised data acquisition programs – always comes with comprehensive online help to explain the features offered the detailed use of the program. GUNT software is developed and written in-house by another group of experienced engineers.



BASIC KNOWLEDGE

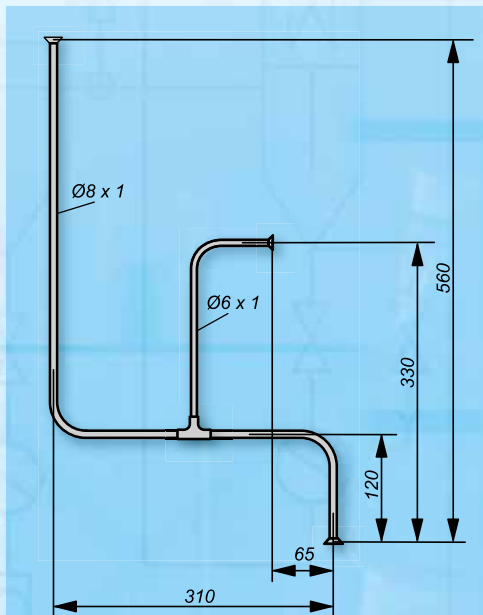
MAKING OF PIPING

Making of piping

In refrigeration systems with FC refrigerant the refrigerant pipes are usually made from copper pipe. Special copper pipe for refrigeration must be used. It meets the specific purity and strength requirements in the refrigeration. To prevent soiling, the pipes are sealed with plastic caps until they are used.

The making of a piping is divided into several steps:

- Determining the required length
- Trimming the pipe and preparing the cutting surfaces
- Bending in accordance with the desired pipe run
- Soldering or flaring to joint the pipe section to other pipe sections or fittings



Sketch for a piping with soldered fittings, pipe ends flanged

BENDING THE PIPE



Inserting the pipe into the bending device



Bend to the desired angle

HARD SOLDERING OF PIPES AND FITTINGS – NON-DETACHABLE JOINT



Heating the workpieces up to the soldering heat and melting of flux material and solder. By capillary effect solder automatically fills the soldering gap.

Due to the high demands on strength, copper pipes and fittings are hard soldered. During hard soldering the metallic materials are joined with the aid of a filler material (solder). The melting point of the hard solder must be at least 450°C. The materials are not melted.

Important when hard soldering

- Metallic pure soldering location
- Suitable with the correct melting point and flux material
- Correct soldering gap between 0.1 and 0.3mm
- Correct workpiece and solder temperature
- Inert gas (e.g. nitrogen) to prevent scaling inside the pipe

TRIMMING THE PIPE AND PREPARING THE CUTTING SURFACES



Determining the length of the pipe section. Here the additions for bends and flanges must be taken into account. Sawing off the pipe.



Filing the saw cut smooth, the cutting surface must be perpendicular to the pipe axis

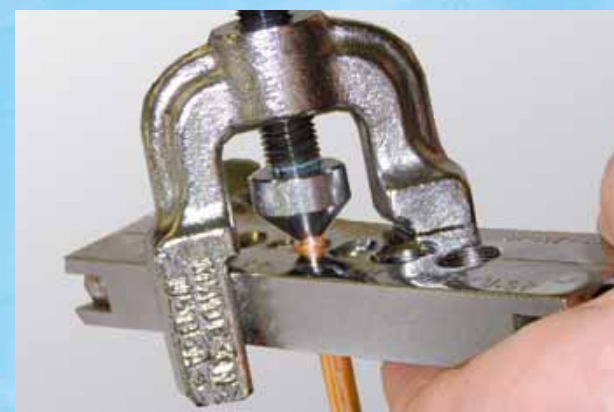


Deburring inside



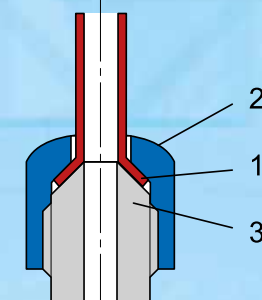
Deburring outside

FLARING OF PIPES – DETACHABLE JOINTS



Flaring of the pipe with the flaring tool

Detachable joints are often made by flared joints. Here the pipe end is widened conically (1) and pressed with a union nut (2) onto the sealing cone (3) of the fitting. When tightening the flared joint the sealing surface must be lightly coated with oil.



Cross-section of a flared joint

MT 210 Assembly & Maintenance Exercise: Refrigeration



- * Study project with high practical relevance
- * Suitable for training in metal and electrical professions
- * Interdisciplinary and covering several subject areas
- * Set-up of a refrigeration system from individual components

Technical Description

Using MT 210 trainees can learn working within a complex project. This involves the planning, implementation and checking of processes related to assembly, commissioning and maintenance. The assembly relates to refrigeration installation: installation of the LP and HP pressure switches, the expansion valve and the pipework of the refrigeration circuit. The pipe joints are not soldered but bolted. The electrotechnical installation includes the wiring and connection of all units and switching elements.

For assembly the tool set ET 150.02, for commissioning the system the filling and evacuation equipment ET 150.01 are required.

The fully assembled system MT 210 represents a fully functional, temperature-controlled refrigeration system with refrigeration chamber and electrical thermostat. Repeated assembly and disassembly are possible.

The experiment is arranged on a workbench with drawers for storing the components and tools. Assembly panel and refrigeration chamber are mounted on a frame. Frame, condensing unit and switch cabinet are bolted permanently to the working surface. The refrigeration and electrical components are attached to the aluminium assembly panel.

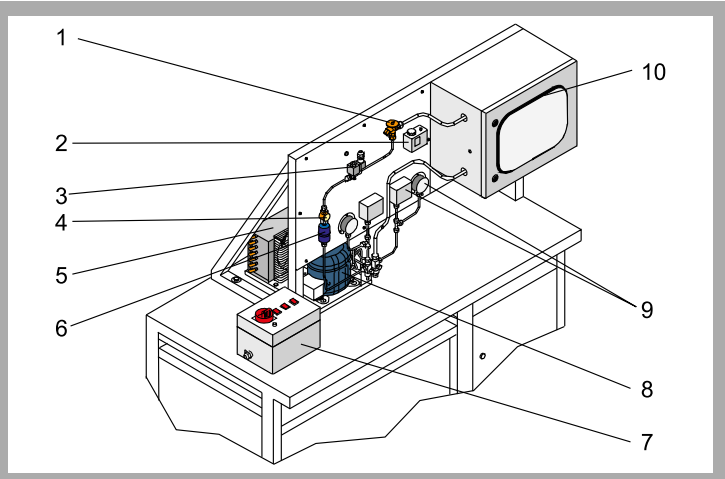
The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the exercises.

Learning Objectives / Experiments

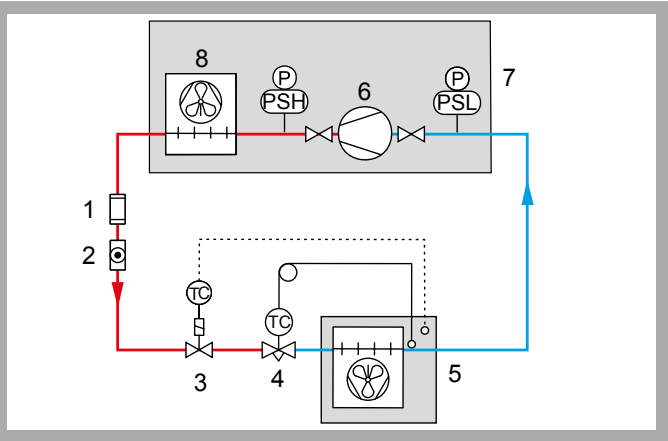
- reading and understanding technical documentation
- planning and executing assembly steps and processes
- making pipe joints in accordance with a system diagram
- carrying out electrical installation in accordance with a circuit diagram
- commissioning and checking the refrigeration system after successful assembly (in conjunction with ET 150.01)
- 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

In conjunction with ET 150.01
- evacuating and filling refrigeration systems

MT 210 Assembly & Maintenance Exercise: Refrigeration



1 expansion valve, 2 thermostat, 3 solenoid valve, 4 sight glass, 5 condenser with fan, 6 filter/drier, 7 switch cabinet, 8 compressor, 9 pressure switch with manometer, 10 refrigeration chamber with sight window and integrated evaporator



1 filter/drier, 2 sight glass, 3 thermostat, 4 expansion valve, 5 refrigeration chamber with evaporator, 6 compressor, 7 condensing unit, 8 condenser; P pressure, PSL, PSH pressure switch; blue: low pressure, red: high pressure



Leak test at the expansion valve of the fully assembled system

Specification

- [1] assembly project for the training of mechatronics engineers for refrigeration
- [2] set-up of a refrigeration system with refrigeration chamber from a complete set of components
- [3] temperature control via thermostat
- [4] air-cooled condensing unit with compressor
- [5] refrigeration chamber with integrated show case evaporator and fan
- [6] refrigeration chamber with large sight window
- [7] assembly panel to mount the refrigeration and electrical components
- [8] electrical assembly in accordance with the circuit diagram
- [9] easy pipeworking of the refrigeration circuit using bolted pipe joints
- [10] workbench with drawers to store the components
- [11] refrigerant R134a, CFC-free
- [12] the training set is part of the GUNT practical series for assembly, service and maintenance

Technical Data

Condensing unit
- power consumption: 190W
- refrigeration capacity: 373W at 5°C evaporation temperature
- receiver: approx. 1L
Show case evaporator
- capacity: 50W at $t_e = -6^\circ\text{C}$, $\Delta T = 8\text{K}$
- transfer area: 1,06m²
Refrigeration chamber with sight window
- LxWxH: 480x280x390mm
Aluminium assembly panel
- LxW: 710x500mm
Thermostatic expansion valve, adjustable
Thermostat, adjustable: -30...15°C

Dimensions and Weight

LxWxH: 1530x750x1670mm
Weight: approx. 155kg

Required for Operation

230V, 50Hz, 1 phase or 120V, 60Hz, 1 Phase

Scope of Delivery

- 1 workbench with drawers, switch cabinet, condensing unit, assembly panel and refrigeration chamber
- 1 kit consisting of all necessary components and installation material
- 1 set of instructional material, consisting of: technical system description, set of drawings with individual components and parts list, description of the assembly, service and maintenance processes

Order Details

051.21000 MT 210 Assembly & Maintenance
Exercise: Refrigeration

ET 150.01 Refrigerant Filling and Evacuation Equipment



* Evacuation and filling of refrigeration systems for refrigerant R134a

Technical Description

The accessory ET 150.01 is used to evacuate and fill refrigeration systems. The refrigeration system is evacuated using a vacuum pump. Evacuation using the vacuum pump removes air and humidity from the refrigeration system to allow subsequent filling with refrigerant. The correct amount of refrigerant is monitored using the filling balance. The equipment is designed for the CFC-free refrigerant R134a.

Learning Objectives / Experiments

- Prepare the filling station
- Evacuate the refrigeration system
- Fill the refrigeration system

Scope of Delivery

- 1 vacuum pump
- 3 filling hoses
- 1 filling balance
- 1 instruction manual

Specification

- [1] Portable equipment
- [2] Vacuum pump and filling balance
- [3] 4-valve assembly aid
- [4] Pulsation-damped manometer for intake pressure, high pressure; vacuum meter
- [5] Manometer for intake and high pressure with temperature scale for refrigerant R134a
- [6] High pressure and intake pressure connections

Technical Data

Vacuum pump: motor power: 0,25kW, intake volume: 66L/min, final vacuum: 0,02mbar

Measuring ranges

- intake pressure: -1...8bar
- high pressure: 0...31bar
- vacuum: 0...1000mbar

Dimensions and Weight

l x w x h: 510x175x485mm
l x w x h: 370x270x60mm (filling balance)
Weight: approx. 15kg

Required for Operation

230V, 50/60Hz, 1 phase or 120V, 60Hz/CSA, 1 phase

Order Details

061.15001 ET 150.01 Refrigerant Filling and Evacuation Equipment

G.U.N.T Gerätebau GmbH, Hanskampring 15-17, D-22885 Barsbüttel, Phone +49 (40) 67 08 54-0, Fax +49 (40) 67 08 54-42, E-mail sales@gunt.de, Web <http://www.gunt.de>
We reserve the right to modify our products without any notifications.

ET 150.02 Tool Set



* Case with tools for the assembly and maintenance of refrigeration systems

Technical Description

One of each of following tools is included in ET 150.02: pipe cutter, adjustable spanner, jointing clamp, flanging tool, manual countersink, side cutter, cable stripping knife, crimping tool, wire strippers, set of Allen keys (7 pieces), set of pipe bending pliers (3 pieces), set of screwdrivers (4x straight, 2x Philips), set of ring spanners (19 pieces), steel ruler, small saw, deburring miller, file. A multimeter is included for electrical fault finding. The leak test in refrigeration systems is carried out using a high quality leak detection device for refrigerant gases. A stable plastic tool case is included.

Scope of Delivery

- 1 tool case with tools
- 1 leak detection device
- 1 digital multimeter

Specification

- [1] Commercial tools for the assembly and servicing of refrigeration systems
- [2] Battery operated leak detection device suitable for refrigerant R134a
- [3] Digital multimeter for direct and alternating current, battery operated

Dimensions and Weight

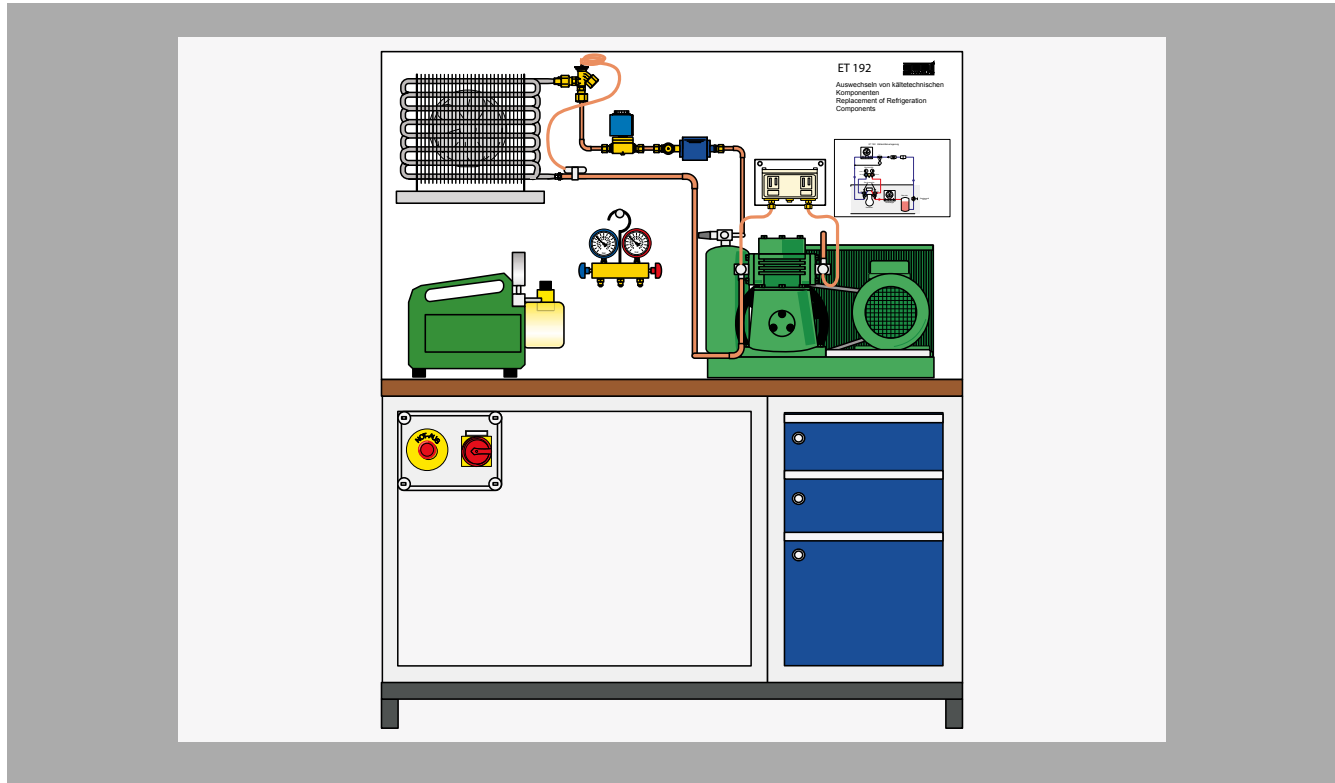
l x w x h: 420 x 210 x 180 mm (case)
Weight: approx. 10 kg

Order Details

061.15002 ET 150.02 Tool Set

G.U.N.T Gerätebau GmbH, Hanskampring 15-17, D-22885 Barsbüttel, Phone +49 (40) 67 08 54-0, Fax +49 (40) 67 08 54-42, E-mail sales@gunt.de, Web <http://www.gunt.de>
We reserve the right to modify our products without any notifications.

ET 192 Replacement of Refrigeration Components



- * **Practical service tasks in refrigeration systems**
- * **Replace typical components of a refrigeration system: compressor, pressure switch, filter/drier, solenoid valve and expansion valve**
- * **Siphoning off, displacing refrigerant, replacement, evacuation, filling and adjustment**

Technical Description

The replacement of a faulty compressor or other components of the refrigeration system are amongst the repeated activities of a mechatronics engineer for refrigeration. ET 192 allows for training in these processes. The consequences of incorrect procedures can be demonstrated.

The components are integrated into an operational refrigeration system. This allows for the practical testing of the functionality of individual components after replacement. The following activities must be carried out e.g. after replacing a compressor:

- Refrigerant displacement (pump-down) into the condenser/receiver (should this not be possible: siphoning off the refrigerant)
- Disconnection of the compressor at the service valves
- Disconnection of electrical connections
- Compressor replacement, correcting oil level, if necessary
- Reconnecting electrical connections
- Reconnecting the compressor with the service valves
- Evacuating the compressor and making the connection to the system
- Compressor test run, checking for leaks and replenish refrigerant, if necessary
- Checking the system pressures

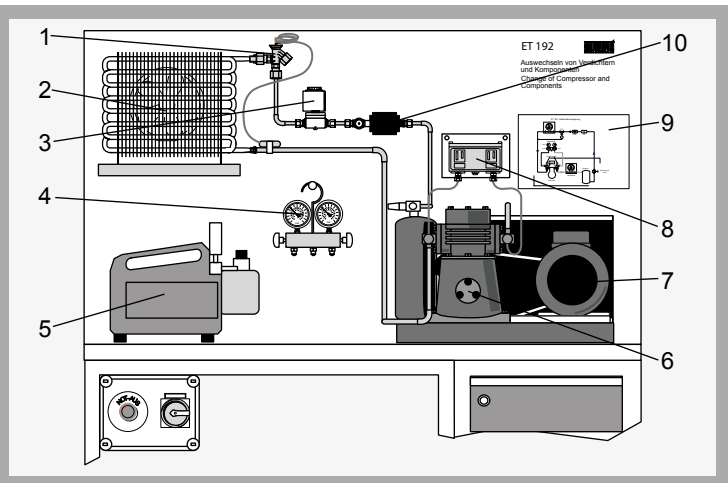
To carry out the service tasks, the tool set ET 150.02 and the filling and evacuation equipment ET 150.01 are required.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the exercises.

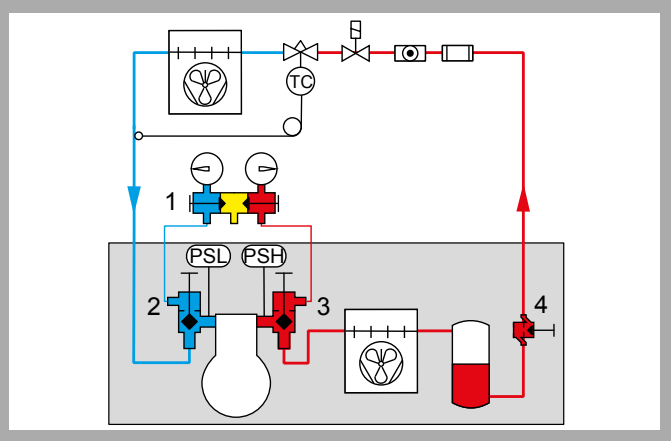
Learning Objectives / Experiments

- Familiarisation with and carry out basic activities for the servicing of refrigeration systems
- Replacement of
 - * compressor
 - * pressure switch
 - * filter/drier
 - * solenoid valve
 - * expansion valve
- Refrigerant displacement (pump-down)
- Mechanical and electrical assembly and disassembly of components
- Replenish refrigerant and compressor oil
- Leak test
- Compressor test run
- Adjustment of expansion valve and pressure switch

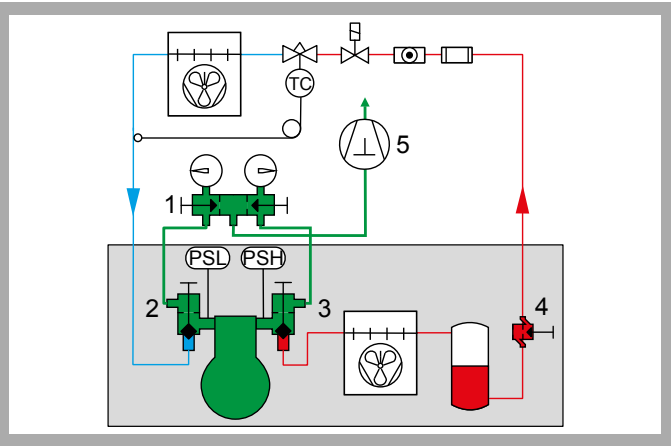
ET 192 Replacement of Refrigeration Components



1 expansion valve, 2 evaporator, 3 solenoid valve, 4 assembly aid, 5 vacuum pump (not included), 6 compressor, 7 condensing unit, 8 pressure switch, 9 process schematic, 10 filter/drier



Example: valve position for normal operation, assembly aid is connected and indicates operating pressures
1 assembly aid, 2 intake side service valve, 3 delivery side service valve, 4 receiver shut-off valve; blue: low pressure, red: high pressure



Example: compressor is evacuated after replacement
1 assembly aid, 2 intake side service valve, 3 delivery side service valve, 4 receiver shut-off valve, 5 vacuum pump; blue: low pressure, red: high pressure, green: evacuated area

Specification

- [1] Trainer from the GUNT practical series for the training of mechatronics engineers for refrigeration
- [2] Service exercises in refrigeration systems
- [3] Complete refrigeration circuit with open compressor, air-cooled condenser, receiver and air cooling evaporator
- [4] Replaceable components: compressor, filter/drier, pressure switch and solenoid valve
- [5] Recommended accessories evacuation equipment ET 150.01 and tool set ET 150.02
- [6] Overall arrangement on robust workbench
- [7] Refrigerant R134a, CFC-free

Technical Data

- Open refrigerant compressor
- drive power: 0,75kW
- refrigeration capacity: 1245W at -5°C/36°C
- maximum system pressure: 18bar

- Pressure switch
- LP: -0.2...7bar
- HP: 10...32bar

Dimensions and Weight

- l x w x h: 1400x750x1650mm
- Weight: approx. 150kg

Required for Operation

- 230V, 50Hz, 1 phase

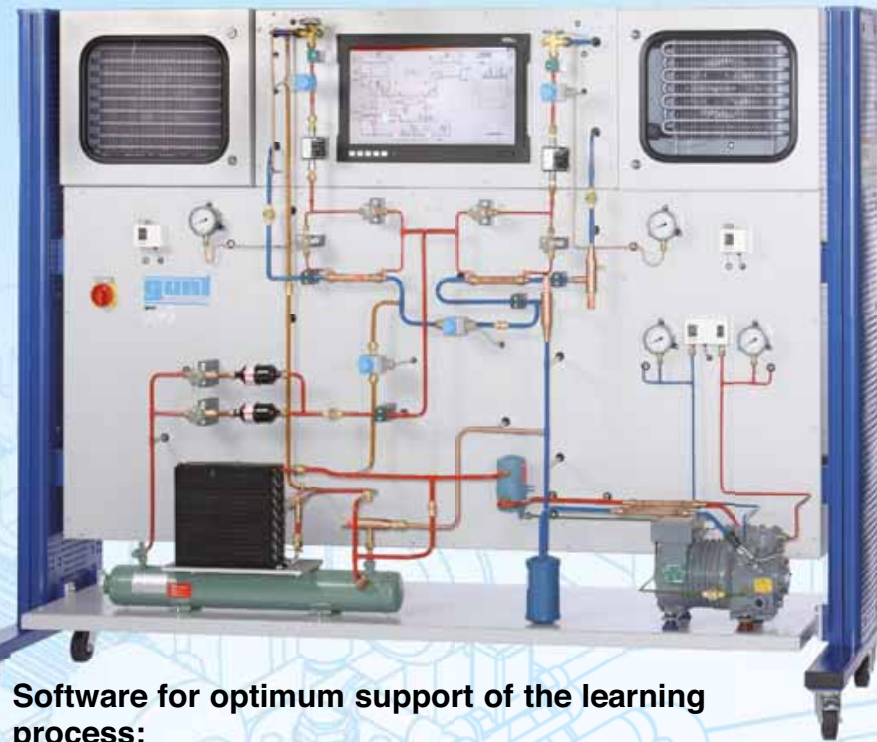
Scope of Delivery

- 1 trainer
- 1 set of instructional material

Order Details

061.19200 ET 192 Replacement of Refrigeration Components

ET 422 CAPACITY CONTROL AND FAULTS IN REFRIGERATION SYSTEMS



Software for optimum support of the learning process:

- Process schematic with display of the measured values
- Recording of time graphs
- Representation of the thermodynamic cycle process in the log p-h diagram

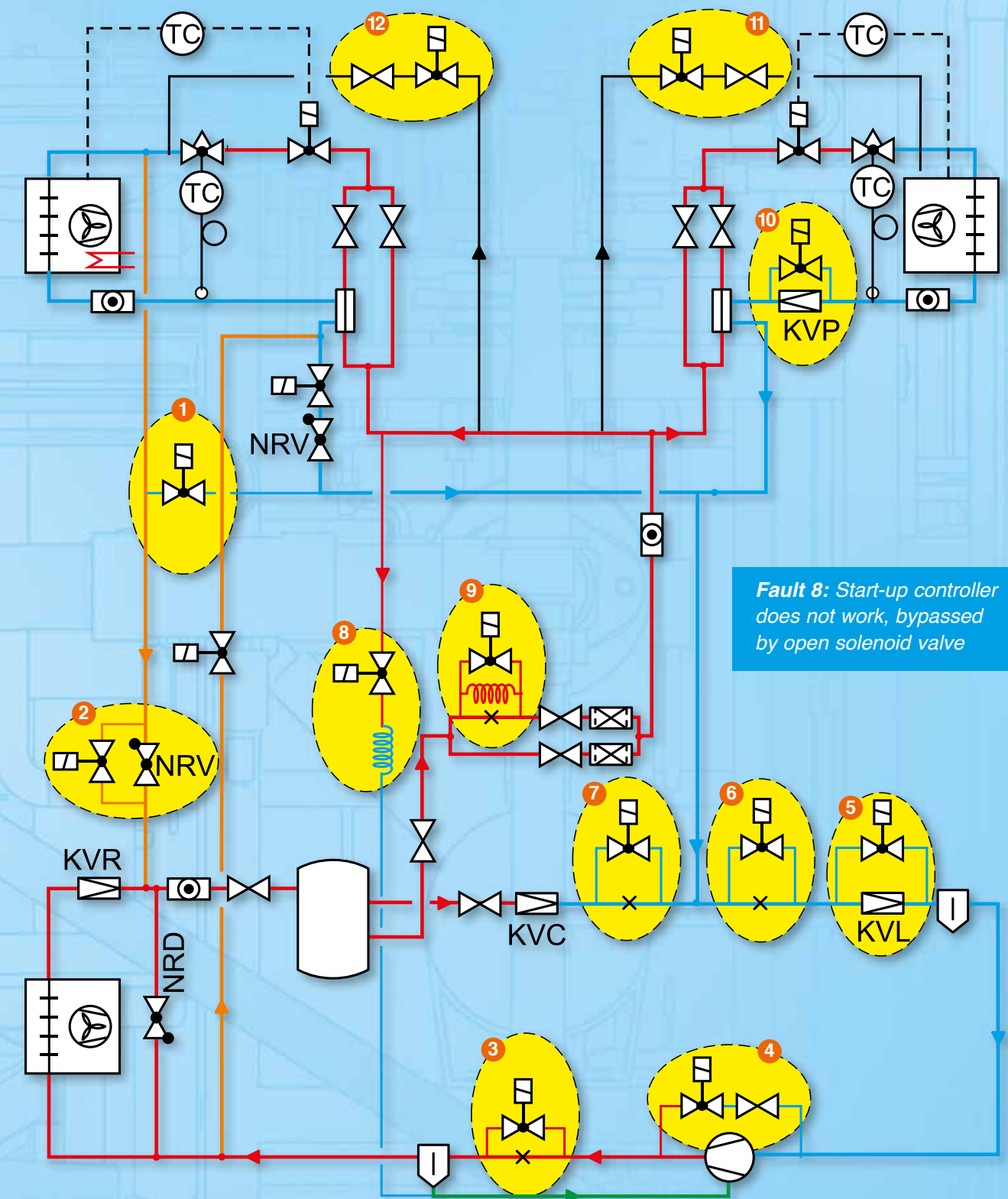
Simulation of typical faults in refrigeration systems



Solenoid valves at the back of the test stand to simulate mechanical faults

Typical mechanical faults

- 1 Non-return valve upstream of the start-up controller faulty
- 2 Non-return valve for hot gas defrosting faulty
- 3 Delivery pipe at the compressor clogged
- 4 Leak at the compressor
- 5 Start-up controller KVL faulty
- 6 Intake pipe at the compressor clogged
- 7 Capacity controller KVC faulty
- 8 Float valve of the oil separator clogged
- 9 Iced-up filter/drier
- 10 Evaporation pressure controller KVP at the refrigeration chamber incorrectly adjusted
- 11 Expansion valve at the refrigeration chamber faulty
- 12 Expansion valve at the freezing chamber faulty



KVP evaporation pressure controller, KVR condensation pressure controller, KVL start-up controller, KVC capacity controller, NRD collector pressure controller, NRV non-return valve;
 ■ hot refrigerant, □ cold refrigerant, ■ pipes for hot gas defrosting, ■ lubrication oil return

ET 422 Capacity Control and Faults in Refrigeration Systems



- * Practice-oriented model of a commercial refrigeration system
- * Refrigeration and freezing chamber to investigate different methods for capacity control
- * Simulation of 12 faults
- * 2 defrosting methods for freezing chamber

Technical Description

The efficient control of the capacity and temperature in refrigeration systems is an important topic in refrigeration technology. With ET 422 different methods of capacity control can be investigated.

The components of a refrigeration circuit with refrigeration and freezing chambers are arranged clearly in the trainer. Solenoid valves enable the separate or parallel operation of the evaporators in the two chambers. The circuit is equipped with a capacity controller, a start-up controller and a combined pressures switch for the delivery and intake sides of the compressor. One heat exchanger each in the inlet of the two evaporators enables the supercooling of the refrigerant to be investigated for the efficiency of the process. The refrigeration capacity of the two individual chambers is controlled by a thermostat. The refrigeration chamber also features an evaporation pressure controller.

There are two defrosting methods for the freezing chamber: an electric defrost heater and a hot gas defrosting where hot refrigerant is fed directly from the compressor in the opposite direction through the evaporator.

The simulation of 12 different faults, such as e.g. faulty valves or clogged pipes, is activated using a touch panel PC.

Relevant measured values are transmitted directly to the touch panel PC and analysed. The software enables e.g. the representation of the cycle in the log p-h diagram.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

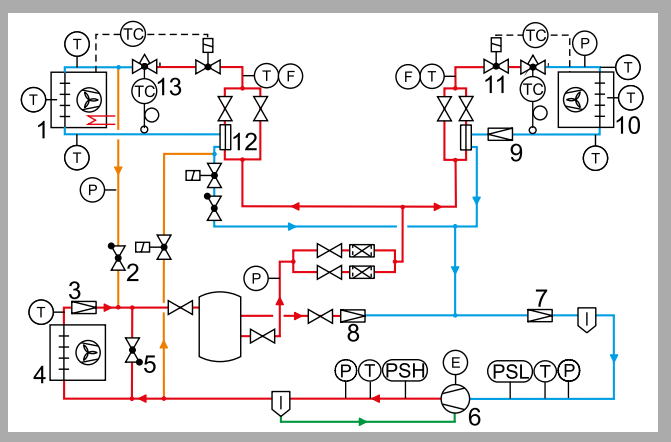
Learning Objectives / Experiments

- familiarisation with the key devices for changing the refrigeration capacity
 - * thermostat
 - * capacity controller
 - * start-up controller
 - * evaporation pressure controller
 - * condensation pressure controller
- fault finding in refrigeration system components
- effect of refrigerant supercooling
- familiarisation with defrosting methods
 - * electric defrost heater
 - * hot gas defrosting
- representation of the thermodynamic cycle in the log p-h diagram

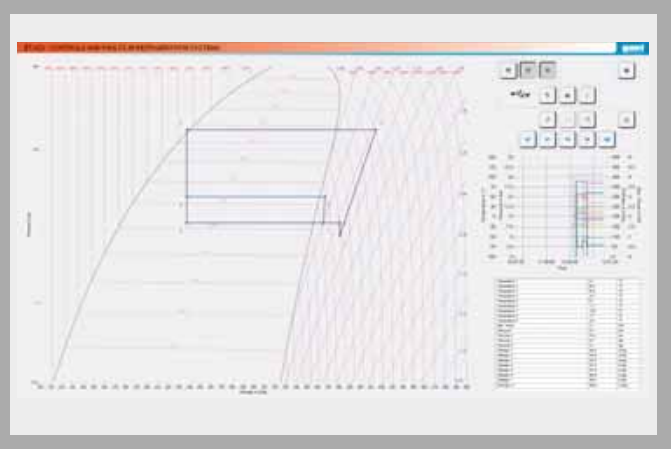
ET 422 Capacity Control and Faults in Refrigeration Systems



1 expansion valve, 2 freezing chamber, 3 thermostat, 4 heat exchanger, 5 solenoid valve, 6 condenser, 7 condensation pressure controller, 8 capacity controller, 9 compressor, 10 start-up controller, 11 pressure switch, 12 evaporation pressure controller, 13 flow meter, 14 refrigeration chamber, 15 touch panel PC



1 freezing chamber, 2 non-return valve hot gas defrosting, 3 condensation pressure controller, 4 condenser, 5 receiver pressure controller, 6 compressor, 7 start-up controller, 8 capacity controller, 9 evaporation pressure controller, 10 refrigeration chamber, 11 solenoid valve (thermostat), 12 heat exchanger, 13 expansion valve; T temperature, P pressure, F flow rate; PSH, PSL pressure switch



Software screenshot: log p-h diagram

- Specification**
- [1] investigation of a refrigeration system with refrigeration and freezing chambers
 - [2] refrigeration circuit with compressor, condenser, capacity controller, start-up controller, combined pressure switch and 2 evaporators in insulated chambers
 - [3] each chamber with solenoid valve, thermostat, thermostatic expansion valve, fan and heat exchanger for refrigerant supercooling
 - [4] refrigeration chamber with evaporation pressure controller
 - [5] freezing chamber with electric defrost heater and hot gas defrosting
 - [6] separate or parallel operation of the chambers via solenoid valves
 - [7] simulation of 12 faults
 - [8] touch panel PC for fault activation, data acquisition, evaluation and representation in the log p-h diagram
 - [9] refrigerant R404a

- Technical Data**
- Compressor
- refrigeration capacity: 2440W at -10/30°C
- Condenser with fan
- volumetric air flow rate: 570m³/h
- Evaporator transfer areas
- refrigeration chamber: 1,12m²
 - freezing chamber: 1,88m²
- Electric defrost heater: approx. 125W
- Capacity controller: 0,2...6bar
- Start-up controller: 0,2...6bar
- Thermostat: 2x -25...15°C
- Evaporation pressure controller: 0...5,5bar
- Measuring ranges
- temperature: 6x -50...50°C; 5x 0...100°C
 - pressure: 3x -1...12,5bar; 2x -1...24bar
 - flow rate: 2x 1,5...22,5L/h
 - compressor power consumption: 0...5kW

- Dimensions and Weight**
- LxWxH: 2420x780x1900mm
- Weight: approx. 280kg
- Required for Operation**
- 400V, 50Hz, 3 phases or 230V, 60Hz/CSA, 3 phases
- Scope of Delivery**
- 1 trainer
 - 1 set of instructional material

- Order Details**
- 061.42200 ET 422 Capacity Control and Faults in Refrigeration Systems

MODULAR SYSTEMS FOR EXPERIMENTS IN THE FIELD OF REFRIGERATION ENGINEERING

The systems deal with simply designed refrigeration circuits

- **ET 900** simple and clear basic experiments related to refrigeration systems and heat pumps
- **ET 915** basic experiments with software support; evaporator connected in series and parallel
- **ET 910** planning, design and testing of different refrigeration systems, primary and secondary controllers in the refrigeration circuit

ET 900 INTRODUCTION TO REFRIGERATION WITH SIMPLE AND CLEAR EXPERIMENTS

- Interchangeable components mounted on plates
- Frame to arrange the components
- Filling and evacuation of refrigerant



Components arranged in a frame and connected with refrigerant hoses

ET 910 BASE UNIT WITH COMPONENTS ET 910.10 AND ET 910.11 FOR BASIC EXPERIMENTS AND ADVANCED EXPERIMENTS

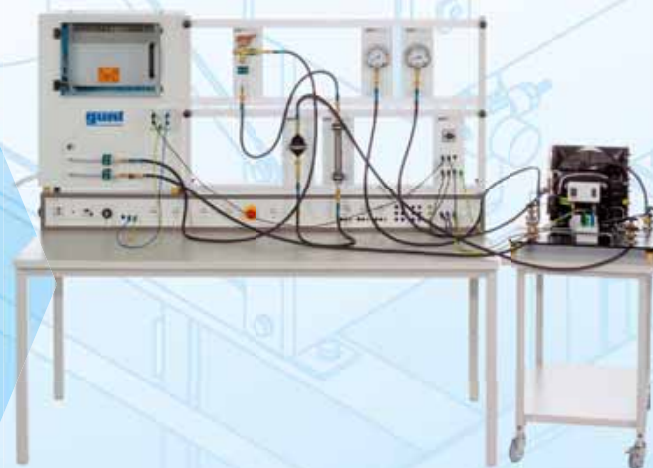
- Real components for the set-up of refrigeration circuits
- Comparison of different capacity controllers
- Assembly and maintenance of refrigeration systems



ET 910.10
Components
for Basic
Experiments



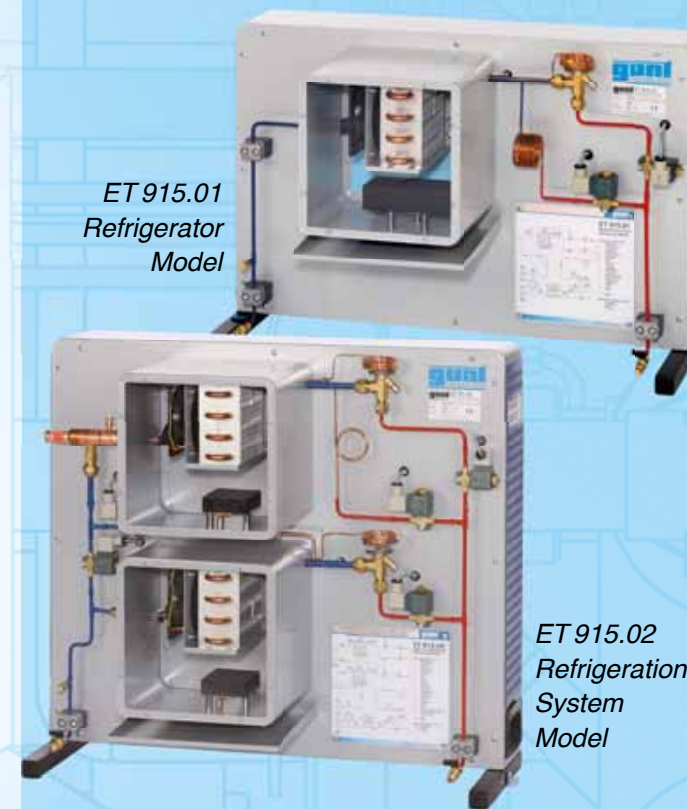
ET 910.11
Components
for Advanced
Experiments



Experimental set-up: ET 910 with components from ET 910.10, laboratory workplace ET 910.05 and accessory set ET 910.12

ET 915 HSI TRAINING SYSTEM WITH THE MODELS REFRIGERATOR ET 915.01 AND REFRIGERATION SYSTEM ET 915.02 EXPLAINS THE OPERATION OF REFRIGERATION SYSTEMS

- Refrigeration systems and their main components
- Operation using several cooling stages
- Interactive learning software with dynamic representation of the measured values and the log p-h diagrams



ET 915.01
Refrigerator
Model

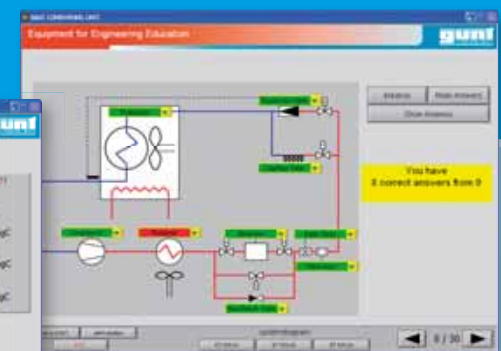
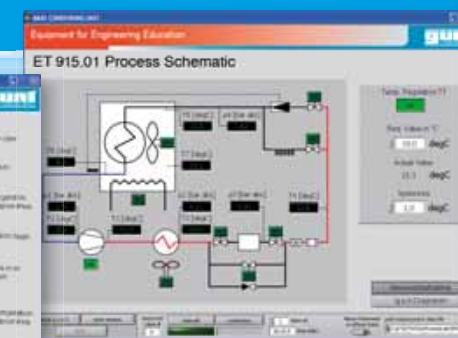
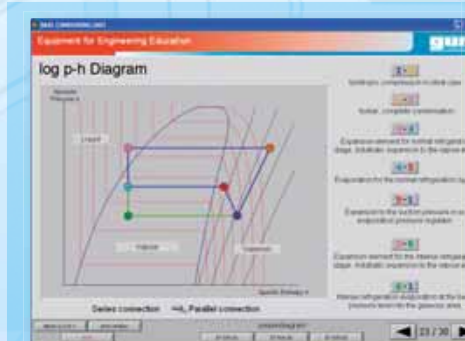
ET 915.02
Refrigeration
System
Model



ET 915
Base Unit

INTERACTIVE LEARNING SOFTWARE

- Guides step by step through the basic learning objectives
- Tracking of learning steps
- Enables the control of the components and simulation of faults

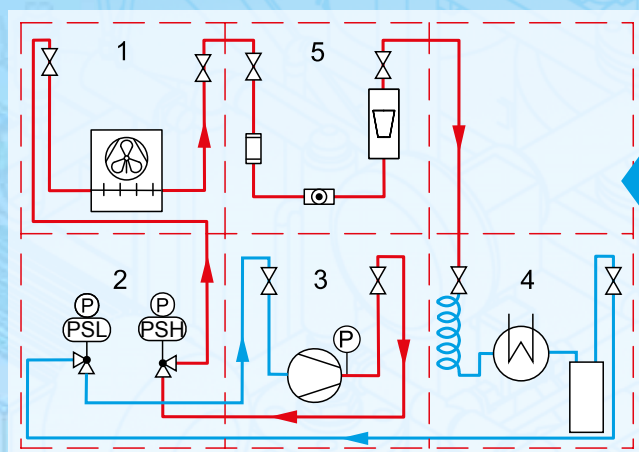


ET 900 INTRODUCTION TO REFRIGERATION: TRAINING SYSTEM WITH MODULAR DESIGN

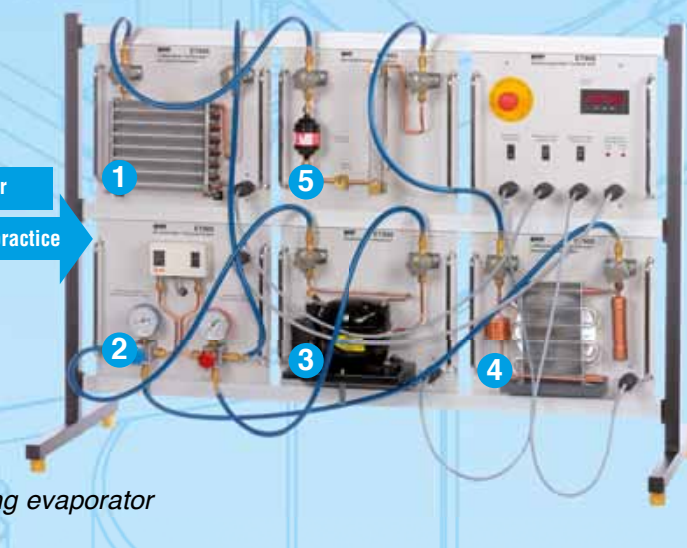
Set-up of simple refrigeration circuits

With the training system ET 900 it is possible to familiarise yourself with the handling and principle of function of refrigeration systems. The training system includes all necessary components for operation, such as compressor, evaporator,

condenser and expansion element. Additional components, such as pressure switches, flow meter, sight glass and filter/drier complement the learning objectives.



On paper
In practice



Refrigeration circuit with air-cooled condenser and air cooling evaporator

Process schematic: 1 condenser, 2 pressure switch, 3 compressor, 4 evaporator, 5 sight glass with filter/drier and flow meter



The connection hoses and couplings included enable the trainee to set up simple compression refrigeration systems quickly and without problems.

Interchangeable modules

The interchangeable modules are mounted ready for installation on plates. The modules condenser and evaporator are available in two designs each. This permits differ-

ent combinations. A set of hoses and cables is included in the scope of delivery.



Sight glass with filter/drier and flow meter



Display and control panel



Pressure switch



Compressor



Water-cooled condenser



Air-cooled condenser



Air cooling evaporator with capillary tube (air cooler)



Water cooling evaporator with capillary tube (water cooler)

- Stationary operation: air-cooled evaporator with an air cooling evaporator
- Mobile operation: water-cooled condenser with a water cooling evaporator
- Cold water generator: air-cooled condenser with a water cooling evaporator
- Heat pump: air cooling evaporator with a water-cooled condenser (water heater)

- Draining and filling a refrigeration system
- Refrigeration system and main components
- Basic principle of a thermodynamic cycle process
- Simple energy balances
- Fault finding

THE TRAINING SYSTEM ET 900 WITH INTERCHANGEABLE COMPONENTS PROVIDES A COMPLETE COURSE OF STUDY IN THE PRINCIPLES OF REFRIGERATION.

ET 900 Introduction to Refrigeration



- * Training system with interchangeable modules
- * Components mounted on plates
- * Rapid connection via hoses

Technical Description

With simple and clear experiments this equipment is intended mainly as a basic introduction to refrigeration.

ET 900 enables familiarisation with the operation and handling of a refrigeration system. The experimental unit includes all the necessary components for a fully operational refrigeration circuit, such as compressor, condenser, evaporator and a capillary tube as expansion element. Other components complement the scope of the equipment: display and control panel, pressure switches and pressure display to protect the compressor against excessive pressure and a flow meter and sight glass with filter/drier. Condenser and evaporator are each present twice: as air/refrigerant heat exchanger and as water/refrigerant heat exchanger. This allows for different component combinations.

The components are mounted on plates and form installation-ready modules. 6 of the 8 modules are positioned in the frame at any one time and connected via hoses and supply cables. This allows for the construction of different simple compression refrigeration systems. For filling the system the refrigerant filling and evacuation equipment ET 150.01 is recommended.

In experiments the processes in the equipment and the changes in the refrigerant state are initially demonstrated. Continued experiments allow the use of the equipment as a refrigeration system and as a heat pump. Pressures, flow rates power consumption of the compressor are displayed as important characteristic variables of refrigeration circuits. The temperature is measured by interlaboratory thermometers.

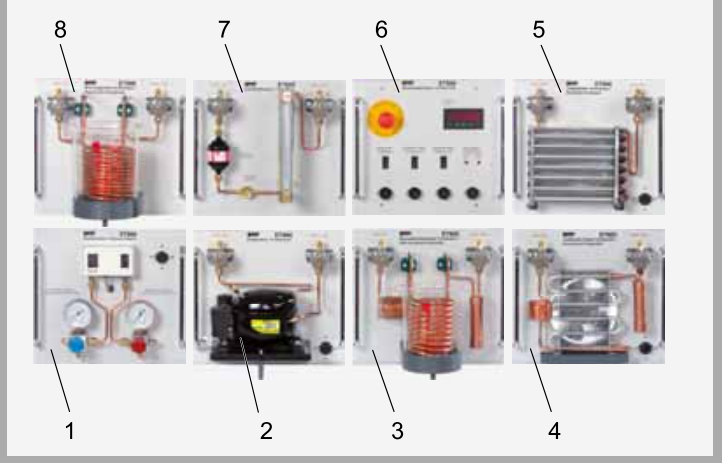
The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

G.U.N.T Gerätebau GmbH, Hanskampring 15-17, D-22885 Barsbüttel, Phone +49 (40) 67 08 54-0, Fax +49 (40) 67 08 54-42, E-mail sales@gunt.de, Web <http://www.gunt.de>
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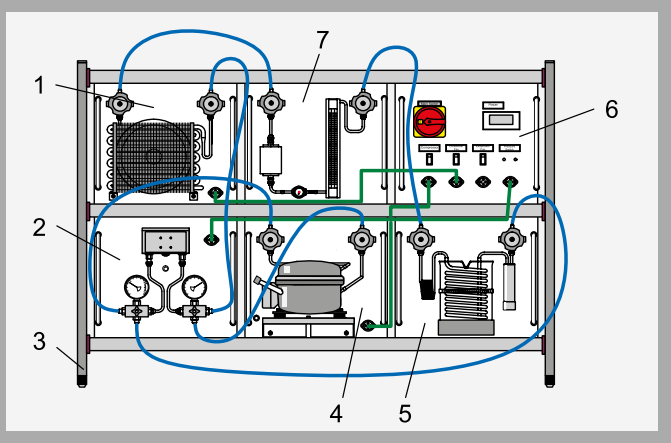
Learning Objectives / Experiments

- Fundamentals of a simple refrigeration circuit
- detection and understanding of the cyclic process
 - changes of state of the refrigerant
 - representation the refrigeration circuit in the process schematic
 - representation of the cyclic process in the log p-h diagram
 - estimating key figures, refrigeration capacity and heat fluxes
- Different operating modes
- air cooling
 - generating cold water
 - heat pump (generate hot water)
- Practical exercises
- draining and filling the refrigeration system (with ET 150.01)
 - fault finding

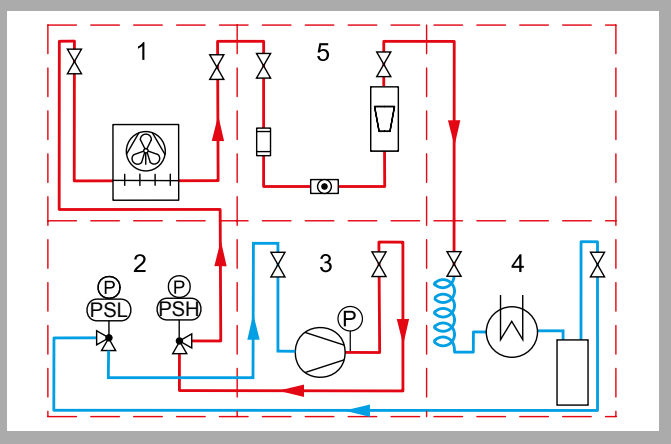
ET 900 Introduction to Refrigeration



1 pressure switch, 2 compressor, 3 water cooling evaporator, 4 air cooling evaporator, 5 air-cooled condenser, 6 display and control panel, 7 sight glass with filter/drier and flow meter, 8 water-cooled condenser



Refrigeration circuit with air-cooled condenser and water cooling evaporator; 1 condenser, 2 pressure switch, 3 frame, 4 compressor, 5 evaporator, 6 displays and controls, 7 sight glass with filter/drier and flow meter; blue: refrigeration circuit hoses, green: power supply cables



1 condenser, 2 pressure switch, 3 compressor, 4 evaporator, 5 sight glass with filter/drier and flow meter

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Specification

- [1] set-up of simple refrigeration circuits with different components
- [2] 8 self-contained operational modules mounted on a plate each
- [3] light-weight aluminium frame to arrange 6 modules
- [4] evaporator and condenser each available as air/refrigerant heat exchanger (finned tube heat exchanger) and as water/refrigerant heat exchanger (with pipe coil)
- [5] modules fitted with manual valves
- [6] components connected via hoses
- [7] CFC-free refrigerant R134a

Technical Data

- Hermetic refrigerant compressor
- power consumption: 67W at -10/32°C
 - refrigeration capacity: 151W at 5/32°C
- Tank content
- water tank, evaporator: 2L
 - water tank, condenser: 3L
- Pressure switch activation pressure
- LP: 1bar
 - HP: 14bar
- Manometer
- intake pressure: 1...10bar
 - delivery pressure: 1...30bar
- Rotameter: 0...7,4L/h

Dimensions and Weight

- LxWxH: 1300x700x900mm
- LxW: 370x340mm (component plates)
- Weight: approx. 30kg

Required for Operation

- 230V, 50/60Hz, 1 phase or 120V, 60Hz/CSA, 1 phase

Scope of Delivery

- 1 frame
- 8 components on plates
- 1 set of hoses
- 1 set of cables
- 1 set of instructional material

Order Details

061.90000 ET 900 Introduction to Refrigeration

ET 910 Refrigeration Training System, Base Unit



- * Set-up of the most varied refrigeration circuits using modular component kits
- * Clear arrangement of components

Technical Description

With this training system practical experiments relating to the operation of a refrigeration system can be implemented by dealing with differently configured compression refrigeration circuits. The components used are common in refrigeration and therefore closely related to practice.

The base unit ET 910 includes the main components of a refrigeration circuit: a condensing unit with compressor, condenser and receiver and a refrigeration chamber with integrated evaporator, fan for forced ventilation and an electric defrost heater. A pressure switch protects the compressor against excessive pressure. The refrigerant flow can be modified via shut-off valves.

Together with the components from ET 910.10, e.g. heat exchanger, flow meter or manometer, simple refrigeration circuits are realised. For continued experiments additional refrigeration components from ET 910.11 are used, e.g. post-injection valve, capacity controller or defrost timer. All components of the training system have ball valves at the connections. Using the required accessory kit ET 910.12 the components are connected into a complete refrigeration system. For the complete experimental set-up, ET 910.05, laboratory workplace with frame for mounting the components and power supply, is required. The CFC-free refrigerant R134a serves as working medium.

With the service set ET 910.13 additional exercises for the filling and evacuation of refrigeration systems are carried out.

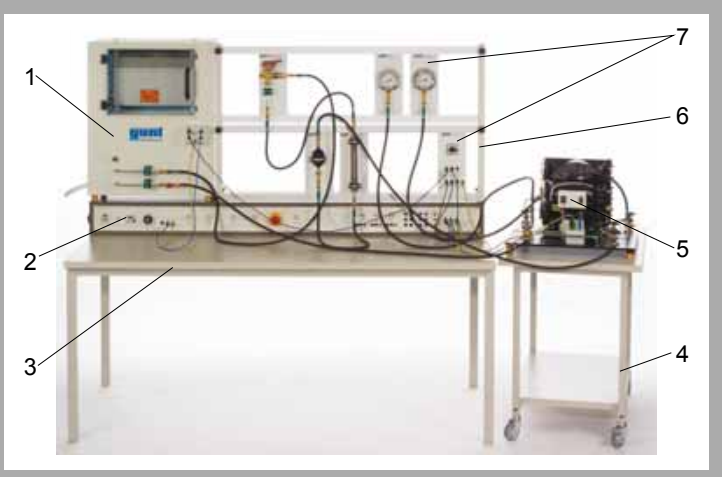
The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

Learning Objectives / Experiments

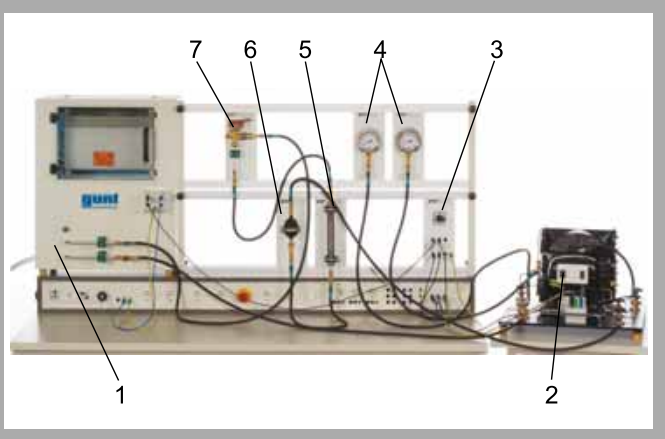
- In conjunction with ET 910.10, ET 910.11, ET 910.13
- design of compression refrigeration circuit
 - draining and filling of refrigeration systems
 - operation of refrigeration components
 - cyclic process of cold production
 - fault finding
 - different operating modes of the receiver
 - * with and without receiver
 - * pump-down
 - * filling the refrigeration circuit
 - compare different expansion elements

A structured curriculum and a detailed representation of the range of experiments is available in our product brochure ET 910.

ET 910 Refrigeration Training System, Base Unit



1 refrigeration chamber, 2 power supply (ET 910.05), 3 table (ET 910.05), 4 base frame (ET 910.05), 5 condensing unit, 6 frame (ET 910.05), 7 components from ET 910.10



1 refrigeration chamber with evaporator and electric defrost heater, 2 condensing unit with condenser and receiver, 3 circuit breaker (ET 910.10), 4 manometer (ET 910.10), 5 flow meter (ET 910.10), 6 sight glass with filter/drier (ET 910.10), 7 expansion valve (ET 910.10)



The illustration shows the accessory set ET 910.12.

Specification

- [1] base unit for the refrigeration training system
- [2] extension with components from ET 910.10 for basic experiments using simple refrigeration circuits
- [3] extension with components from ET 910.11 for advanced experiments in refrigeration systems
- [4] condensing unit, consisting of hermetic compressor, condenser, receiver, pressure switches and shut-off valves
- [5] insulated refrigeration chamber with integrated evaporator, electric defrost heater and condensate drip tray
- [6] refrigeration chamber, condensing unit and power supply equipped with shock-proof lab jacks
- [7] refrigerant R134a, CFC-free

Technical Data

- Air-cooled condensing unit
- power consumption: 367W at -10/32°C
 - refrigeration capacity: 731W at -10/32°C
 - max. volumetric air flow rate: 850m³/h
 - receiver: 1,4L
- Evaporator with fan
- capacity: 190W at t=2°C, ΔT=8K
 - cooling surface: 1,81m²
 - max. volumetric air flow rate: 140m³/h
 - electric defrost heater: 50W/m

Dimensions and Weight

- LxWxH: 600x300x700mm (refrigeration chamber)
- LxWxH: 670x550x380mm (condensing unit)
- Weight: approx. 45kg

Required for Operation

- 230V, 50/60Hz, 1 phase or 120V, 60Hz, 1 phase

Scope of Delivery

- 1 condensing unit
- 1 refrigeration chamber
- 1 set of instructional material

Order Details

- 061.91000 ET 910 Refrigeration Training System, Base Unit

ET 910.10 Refrigeration Components for Basic Experiments



The illustration shows some of the components in the frame of ET 910.05.

* Set-up of simple refrigeration circuits

* Practice-oriented basic experiments using real components from within the industry

Technical Description

ET 910.10 enables in conjunction with ET 910, ET 910.05 and the accessory set ET 910.12 the design and performance of various basic experiments related to refrigeration.

Commercial components are used in practical experiments. These components are mounted on plates ready to be connected and are arranged clearly in the frame of ET 910.05.

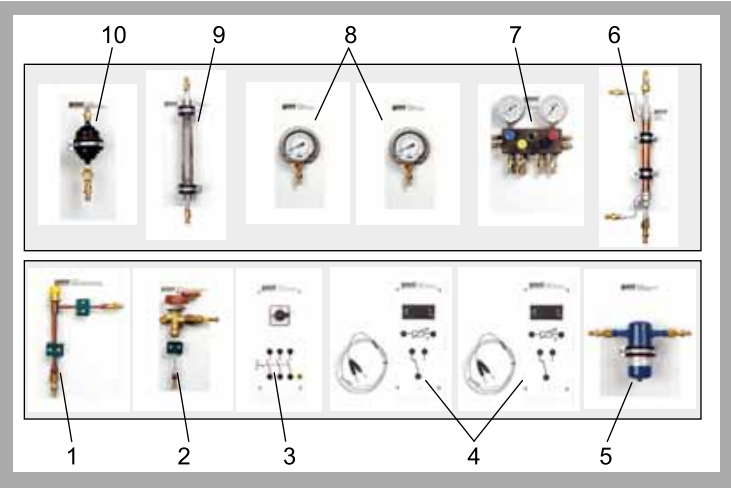
The set includes simple refrigeration components, such as expansion elements and filters, as well as electrical components, e.g. switches and thermostat. The superheater included in the set is a heat exchanger ensuring the complete evaporation of the refrigerant before entering the compressor whilst the liquid refrigerant is supercooled upstream of the expansion element. The control behaviour of the expansion element is monitored at the flow meter. Manometers provide an insight to the pressure ratios in the refrigeration circuit. Via pressure and temperature measurements the change of state of the refrigerant can be tracked and entered into the log p-h diagram. The temperature is measured by interlaboratory thermometers.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

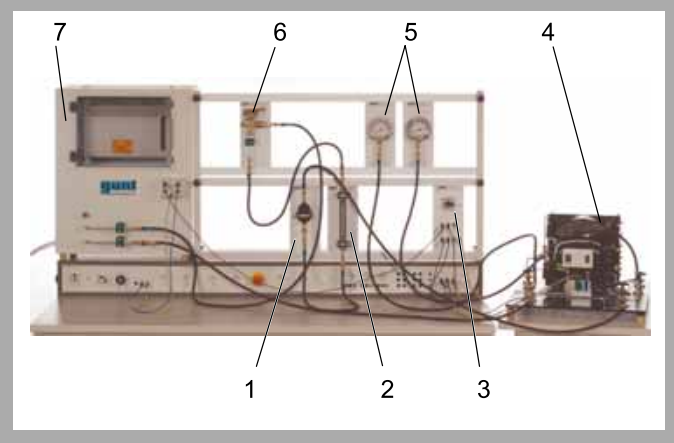
Learning Objectives / Experiments

- Design of different simple refrigeration circuits
- Design, operation and adjustment of components
 - * sight glass with filter/drier
 - * flow meter
 - * delivery and intake manometer
 - * assembly aid
 - * superheater
 - * pressure-controlled expansion valve
 - * thermostatic expansion valve
 - * 3-pin circuit breaker
 - * electric two-point thermostat with switch hysteresis
 - * suction line receiver
- Read and understand technical drawings and operating instructions
- Fault finding

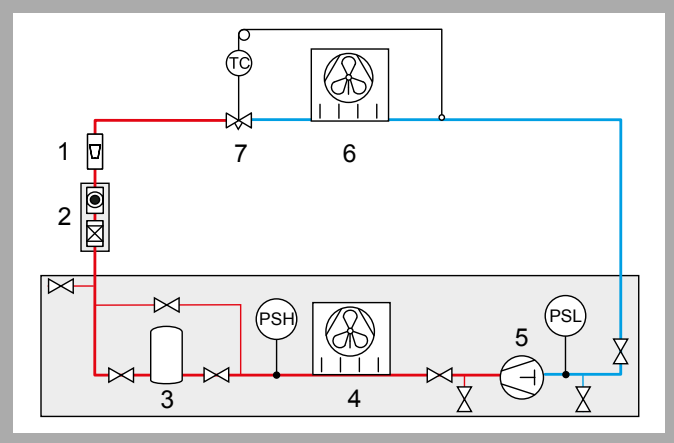
ET 910.10 Refrigeration Components for Basic Experiments



1 pressure-controlled expansion valve, 2 thermostatic expansion valve, 3 circuit breaker, 4 electric thermostat, 5 suction line receiver, 6 heat exchanger as superheater, 7 assembly aid, 8 manometer delivery side/intake side, 9 flow meter, 10 sight glass with filter/drier



Simple refrigeration circuit with thermostatic expansion valve:
1 sight glass with filter/drier, 2 flow meter, 3 circuit breaker, 4 condensing unit (ET 910) with receiver, condenser, compressor, 5 manometer, 6 thermostatic expansion valve, 7 refrigeration chamber (ET 910) with evaporator



1 flow meter, 2 sight glass with filter/drier, 3 receiver, 4 condenser, 5 compressor, 6 evaporator, 7 thermostatic expansion valve; PSH, PSL pressure switch; red: high pressure, blue: low pressure

Specification

- [1] Components for the set-up of simple refrigeration circuits in conjunction with ET 910
- [2] Heat exchanger as superheater
- [3] 3-pin circuit breaker
- [4] Assembly aid: 4-port directional valve with sight glass
- [5] Sight glass with humidity indicator
- [6] Pressure-controlled expansion valve
- [7] Thermostatic expansion valve
- [8] 2 thermostats with different temperature ranges
- [9] Components mounted on plates ready to connect
- [10] Abrasion-proof symbols and labels on plates

Technical Data

- Pressure-controlled expansion valve
 - pressure range: 1...7bar
- Thermostatic expansion valve
 - evaporation temperature: -45°...20°C
 - valve insert rated capacity: 0,3kW
- Circuit breaker, 3-pin: 3kW
- 2 electric thermostats
 - -5...25°C
 - -25...5°C
- Heat exchanger
 - capacity: approx. 2.5kW at -10°C evaporation temperature

Measuring ranges

- pressure, high pressure side: -1...24bar
- pressure, low pressure side: -1...9bar
- flow rate: 3...41kg/h

Dimensions and Weight

- Plate height: 297mm
- Weight: approx. 20kg

Scope of Delivery

- 12 components on plates:
 - 1 pressure-controlled expansion valve
 - 1 thermostatic expansion valve
 - 1 circuit breaker
 - 2 electric thermostats
 - 1 heat exchanger
 - 1 assembly aid
 - 2 manometers
 - 1 flow meter
 - 1 sight glass with filter/drier
 - 1 suction line receiver

Order Details

061.91010 ET 910.10 Refrigeration Components for Basic Experiments

ET 910.11 Refrigeration Components for Advanced Experiments



The illustration shows some of the components in the frame of ET 910.05.

- * Set-up of more complex refrigeration circuits
- * Sophisticated components for advanced experiments

Technical Description

ET 910.11 enables in conjunction with ET 910, ET 910.10, ET 910.05 and the accessory set ET 910.12 the performance of advanced experiments related to refrigeration.

Commercial components are used in practical experiments. These components are mounted on plates ready to be connected and are arranged clearly in the frame of ET 910.05.

The set includes complex refrigeration components, such as capacity controller, start-up controller, defrost timer, 4/2-way reversing valve and refrigeration controller. The 4/2-way reversing valve, for example, is used to reverse the circuit. This allows for the defrosting of an iced-up evaporator by operating it temporarily as condenser. Manometers provide an insight to the pressure ratios in the refrigeration circuit.

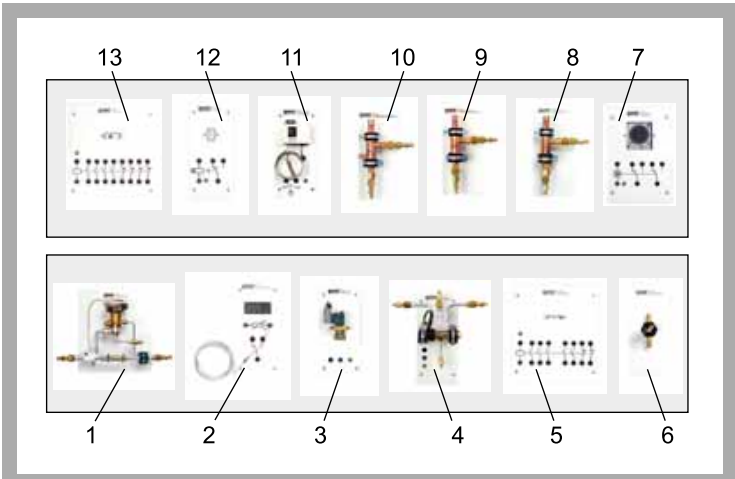
Via pressure and temperature measurements the changes of state of the refrigerant can be tracked and entered into the log p-h diagram. The temperature is measured by interlaboratory thermometers.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

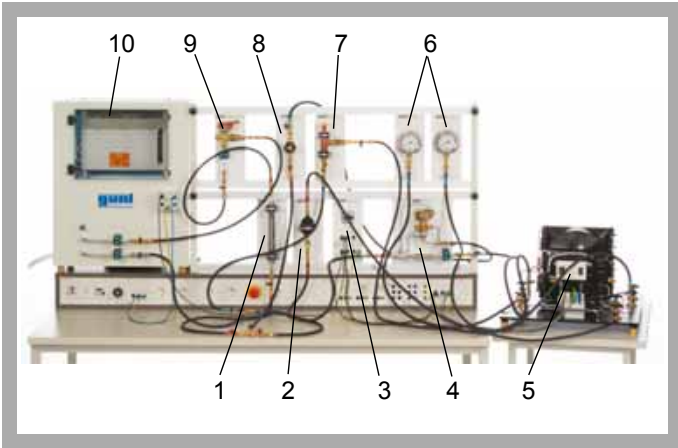
Learning Objectives / Experiments

- Set-up of different refrigeration circuits
- Design, operation and adjustment of components
 - * evaporation pressure, start-up, capacity and refrigeration controllers
 - * electric thermostat
 - * manual valve as expansion element
 - * post-injection valve
 - * solenoid valve with coil
 - * 4/2-way reversing valve
 - * power and auxiliary contactor
 - * time relay
 - * defrost timer
 - * hot gas defrosting
- Read and understand technical drawings and operating instructions
- Fault finding

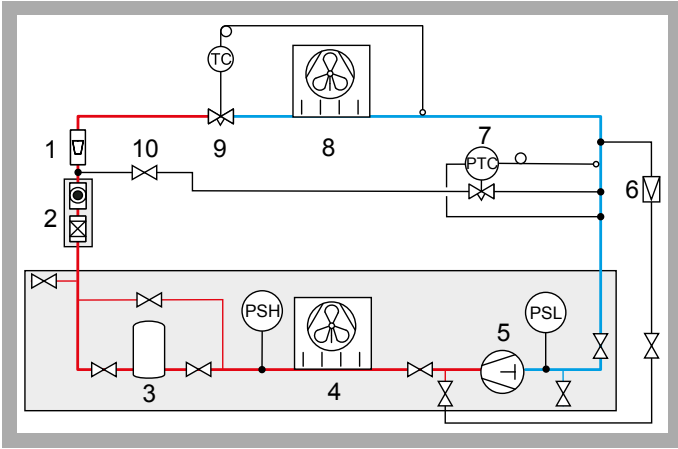
ET 910.11 Refrigeration Components for Advanced Experiments



1 post-injection valve, 2 refrigeration controller, 3 solenoid valve, 4 4/2-way reversing valve, 5 main contactor, 6 valve, 7 defrost timer, 8 capacity controller, 9 start-up controller, 10 evaporation pressure controller, 11 temperature controller, 12 time relay, 13 auxiliary contactor



Capacity control with post-injection; 1 flow meter, 2 sight glass with filter/drier, 3 circuit breaker, 4 post-injection valve, 5 condensing unit (ET 910), 6 manometer, 7 capacity controller, 8 valve, 9 expansion valve, 10 refrigeration chamber (ET 910)



1 flow meter, 2 sight glass with filter/drier, 3 receiver, 4 condenser, 5 compressor, 6 capacity controller, 7 post-injection valve, 8 evaporator, 9 expansion valve, 10 valve; PSL, PSH pressure switch; red: high pressure, blue: low pressure

Specification

- [1] Components for the set-up of complex refrigeration circuits in conjunction with ET 910 and ET 910.10
- [2] Post-injection valve
- [3] Refrigeration controller with PTC sensor
- [4] Defrost timer, timing interval 30min
- [5] Time relay
- [6] 4/2-way reversing valve, solenoid valves
- [7] Electric thermostat as temperature controller
- [8] Power and auxiliary contactor

Technical Data

- Rated controller capacity at $t_0 = -10^\circ\text{C}$, $t_c = 25^\circ\text{C}$
- evaporation pressure: 2,8kW at $\Delta p = 0,2\text{bar}$
- start-up: 5,3kW at $\Delta p = 0,2\text{bar}$
- capacity: 4,8 kW at offset=0,7bar
- Suction line receiver: 0,3L, max. 28bar
- Temperature controller: $-5 \dots 35^\circ\text{C}$
- Refrigeration controller: $-40 \dots 110^\circ\text{C}$
- Post-injection valve: $-45 \dots 35^\circ\text{C}$
- Time relay: response delay: 0,05s...100h

Measuring ranges

- pressure, evaporation: 0...5,5bar
- intake pressure: 0,2...6bar
- pressure, capacity controller: 0,2...6bar

Dimensions and Weight

- Plate height: 297mm
- Weight: approx. 25kg

Scope of Delivery

- 14 components on plates:
- 1 manual valve
- 1 temperature controller
- 1 evaporation pressure controller
- 1 start-up controller
- 1 capacity controller
- 1 4/2-way reversing valve
- 1 post-injection valve
- 1 refrigeration controller
- 2 solenoid valves
- 1 time relay
- 1 power contactor
- 1 auxiliary contactor
- 1 defrost timer

Order Details

- 061.91011 ET 910.11 Refrigeration Components for Advanced Experiments

ET 910.05 Refrigeration Laboratory Workplace



The illustration shows the table with supply strip and frame. Mobile cabinet and movable base frame not shown.

* Laboratory workplace with supply strip

Technical Description

This laboratory workplace enables in conjunction with the base unit ET 910 and the extension sets ET 910.10 and ET 910.11 and the accessory set ET 910.12 the set-up of a complete trainer. The laboratory workplace consists of a table with supply strip, a frame to arrange the components, a mobile cabinet and a movable base frame for the condensing unit.

Scope of Delivery

- 1 table
- 1 mobile cabinet
- 1 movable base frame for the condensing unit

Specification

- [1] Laboratory workplace for the modular training system refrigeration
- [2] Table with supply strip
- [3] Mobile cabinet with drawers
- [4] Movable base frame with 4 steerable castors, brakeable

Technical Data

- Supply strip
- Fault current protection switch: 25A
 - Motor protection switch: 10...16A
 - Key switch, sockets, lab jacks, emergency off switch, main switch

Dimensions and Weight

- l x w x h: 1800 x 900 x 785 mm (table)
- l x w x h: 1800 x 320 x 155 mm (supply strip)
- l x w x h: 1200 x 250 x 685 mm (frame)
- l x w x h: 420 x 600 x 625 mm (mobile cabinet)
- l x w x h: 600 x 900 x 780 mm (base frame)
- Weight: approx. 50 kg

Required for Operation

230V, 50/60Hz, 1 phase or 120V, 60Hz, 1 phase

Order Details

061.91005 ET 910.05 Refrigeration Laboratory Workplace

G.U.N.T Gerätebau GmbH, Hanskampring 15-17, D-22885 Barsbüttel, Phone +49 (40) 67 08 54-0, Fax +49 (40) 67 08 54-42, E-mail sales@gunt.de, Web <http://www.gunt.de>
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ET 910 TRAINING IN REFRIGERATION



*Vocational Training in refrigeration:
Planning, design and testing of different
refrigeration system configurations*

flexible

practice-
oriented

modular

versatile

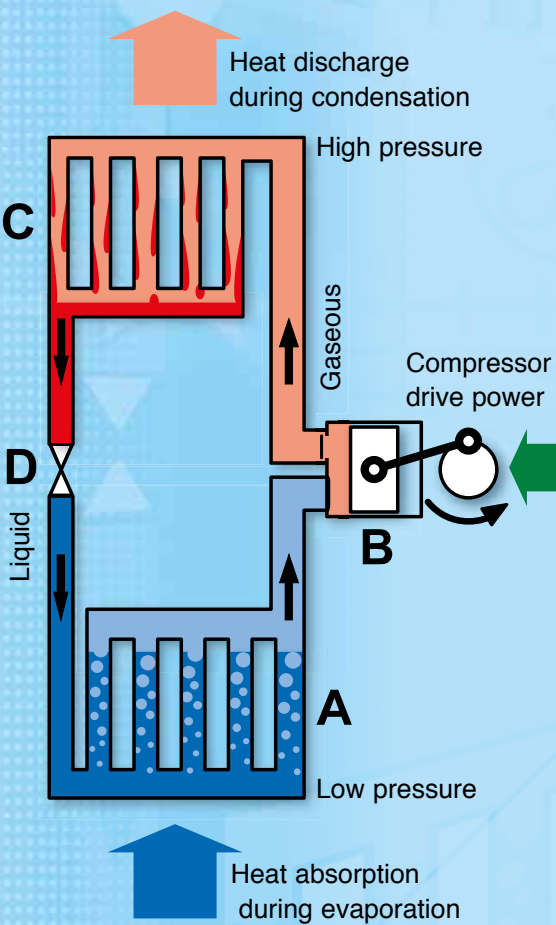
THE IDEAL TRAINING SYSTEM FOR PRACTICE-ORIENTED TEACHING

BASIC KNOWLEDGE

HOW DOES A REFRIGERATION SYSTEM WORK?

A refrigeration system transports heat from a colder location to a warmer location. In other words, the heat is transported “uphill”.

For this reason it is also called a **heat pump**, especially if the gain of the system consists in the discharge of heat.



Compression refrigeration circuit

log p-h diagram
for the simple
compression refrigeration cycle

Compression refrigeration system

The majority of refrigeration systems operate as **compression refrigeration systems**. Here a liquid with a low boiling point, the so-called **refrigerant**, flows through a closed cycle with the following four stations:

- Evaporation **A**
- Condensation **C**
- Compression **B**
- Expansion **D**

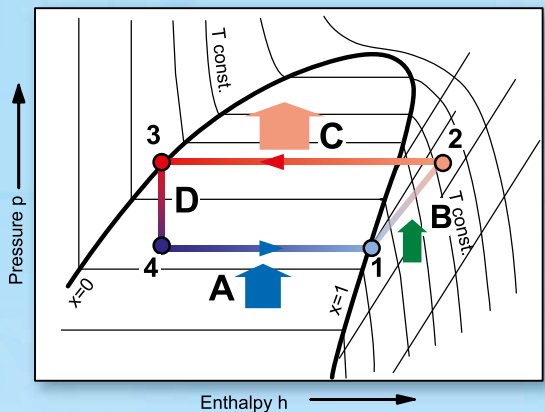
The evaporation **A** takes place at low pressures and temperatures. Here the refrigerant absorbs heat from the environment and cools in this way. The still cold steam is aspirated by a compressor **B** and subjected to higher pressure by using mechanical energy. The hot refrigerant steam is cooled down in a condenser **C** and condenses whilst discharging heat to the environment. The liquid pressurised refrigerant is then expanded to the low evaporation pressure in an expansion element **D** and returned to the evaporator. The refrigerant evaporates again and thus completes the circuit.

As refrigerant fluorinated hydrocarbons (FC) are used, but also hydrocarbons such as butane and propane or the inorganic substances ammonia (NH₃) and carbon dioxide (CO₂).

The log p-h diagram

The refrigeration cycle can be clearly represented in the **log p-h diagram** of the respective refrigerant. In this diagram the pressure is plotted above the enthalpy.

The black limit curve surrounds the wet steam range. In this range steam and liquid are present at the same time. To the left of it (x=0) the refrigerant is fully liquid and to the right of it (x=1) fully gaseous. Evaporation **A** and condensation **C** take place at constant pressures and temperatures. During compression **B** the temperature and pressure rise. The enthalpy differences define the exchanged energies. $h_1 - h_4$ indicates the absorbed heat, the cooling capacity, while $h_2 - h_3$ indicates the heat discharged into the environment. The mechanical work added during compression corresponds to the enthalpy difference $h_2 - h_1$. The expansion **D** of the liquid refrigerant in the expansion element is adiabatic and does not result in a change of enthalpy.

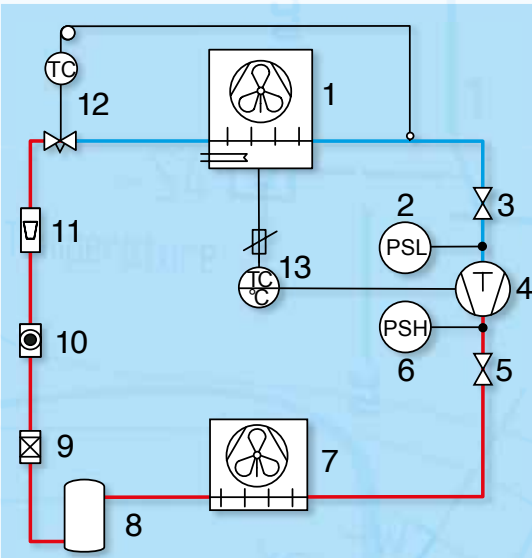


BASIC KNOWLEDGE

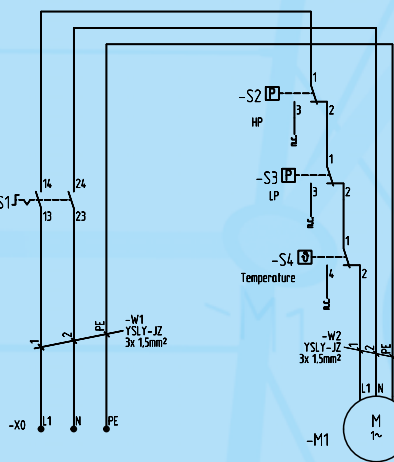
TECHNICAL REPRESENTATION OF A REFRIGERATION SYSTEM

The technical process is illustrated in system flow diagrams. In a system flow diagram the components involved in the technical implementation are represented by standardised symbols.

The system flow diagram forms the basis for the constructive implementation of a system but also for maintenance and repair. Reading and understanding a system flow diagram is therefore an important element in the training of mechatronics engineers for refrigeration.



System flow diagram



Related electrical circuit diagram

The adjacent system flow diagram shows a simple refrigeration system. The refrigerant is evaporated in a ventilated finned tube heat exchanger **1** and aspirated and compressed by a piston compressor **4**. At the compressor inlet and outlet there are shut-down valves **3**, **5** to allow for the compressor to be replaced without loss of refrigerant.

Two pressure switches **2**, **6** protect the system against too high and too low pressures. The hot refrigerant steam is condensed in the second air-cooled finned tube heat exchanger **7** and stored in the collector **8**. From here the liquid refrigerant flows via a filter/drier **9** and a sight glass with humidity indicator **10** to a flow meter **11**.

A thermostatic expansion valve **12** expands the liquid refrigerant and supplies it to the evaporator. The thermostatic expansion valve measures the temperature at the outlet of the evaporator and ensures a slight superheating of the refrigerant upstream of the compressor inlet. This prevents liquid refrigerant being aspirated by the compressor. A thermostat **13** switches the compressor on as required.

Equally important for the mechatronics engineer for refrigeration is the reading and understanding of electrical circuit diagrams.

THE KEY SYMBOLS IN REFRIGERATION TECHNOLOGY

	Piston compressor		Filter/drier
	Shut-off valve		Sight glass with humidity indicator
	Air-cooled finned tube heat exchanger as condenser		Rotameter
	Ventilated finned tube heat exchanger with defrost heater as evaporator		Thermostatic expansion valve
	Collector		Pressure switch

Instructional design and subject areas

The modular training system ET 910 Training in Refrigeration by GUNT has been specifically designed for use in vocational training.

With the modular training system the subject areas in the training as mechatronics engineer for refrigeration are optimally accompanied by practical experiments. The training system ET 910 can also be used most successfully in hands-on experiments in the field of energy technology/refrigeration at universities.

The training system is ideally suited for independent group work with 2–3 trainees or students. Unlike experimental set-ups with permanent piping, changes to the refrigeration circuit can be carried out easily and quickly and their effects experienced directly. This direct feedback guarantees a lasting learning success. With the independ-

ent implementation of the system flow diagram into a real functioning system the trainee makes rapid progress.

The training system ET 910 uses common industrial components from refrigeration. This ensures the necessary high level of practical relevance with high recognition value.

Care was taken during the selection of components to allow the greatest possible number of topics to be covered during the training.

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

Covering subject areas in the training as a mechatronics engineer for refrigeration by experimental work with the training system ET 910

REFRIGERATION	AIR CONDITIONING TECHNOLOGY	ELECTRICAL ENGINEERING, CONTROL AND AUTOMATION
Functional interrelationships in the refrigeration circuit	Investigation of the states of the air	Principles of electrical engineering
Production of mechanical subsystems	Basic interrelationships in ventilation and room air conditioning	Consumers of single phase alternating current
Thermodynamics, log p-h diagram	Construction elements and function of the air conditioning system	Protection against electrical hazards
Refrigerants and lubrication oils	Air conditioning, h-x diagram	Simple refrigeration controls
Primary and secondary controllers	Air circuit in the duct system	Consumers of three phase alternating current
Heat exchangers	Fire protection measures	Electrical drives and fault finding
Compressors	Energy saving	Control of refrigeration systems
Piping		Building automation
Fault finding, maintenance and disposal		

= applications for the ET 910 training system

Experimental range

DIFFERENT EXPANSION ELEMENTS – FUNCTION AND PROPERTIES

- Manually operated expansion valve
- Pressure-controlled expansion valve
- Capillary tube
- Thermostatic expansion valve with internal pressure compensation

DIFFERENT TEMPERATURE CONTROLLERS – FUNCTION AND PROPERTIES

- Control of the evaporation temperature via evaporation pressure controller KVP (normal cooling stage)
- Control of the cold storage temperature via thermostatic switch with compressor control
- Control of the cold storage temperature via electric temperature controller with compressor control

DIFFERENT CAPACITY CONTROLLERS – FUNCTION AND PROPERTIES

- Capacity controller KVC
- Capacity controller KVC with post-injection
- Electrical refrigeration controller with solenoid valve and pump-down control

DIFFERENT DEFROST CIRCUITS IN THE FREEZING STAGE – FUNCTION AND PROPERTIES

- Shut-down of the compressor via defrost timer
- Shut-down of the compressor via evaporator thermostat
- Electric defrost heater via defrost timer
- Hot gas defrosting via reversing valve and defrost timer

DIFFERENT EXTENSIONS OF THE REFRIGERATION CIRCUIT – FUNCTION AND PROPERTIES

- Influence of a heat exchanger - supercooling and superheating
- Pressure-compensated compressor start via time-delayed bypass valve
- Intake pressure control via start-up controller KVL
- Liquid separator in the intake pipe
- Operation with and without collector

DIFFERENT EXTENSIONS OF THE REFRIGERATION CIRCUIT – FAULT FINDING AND MAINTENANCE

- Opening of the refrigeration circuit with refrigerant displacement
- Opening of the refrigeration circuit by extraction off the refrigerant
- Evacuation of the refrigeration circuit
- Filling of the refrigeration circuit
- Leak detection
- Setting of thermostats and controllers
- Check electrical function

This is a selection of the most important experiments.

By way of combination many more refrigeration issues can be dealt with. With the system ET 910 you can design a comprehensive course of study in refrigeration.

The design of our training system

In particular the following topics from the training as a mechatronics engineer for refrigeration can be covered using the basic equipment, extension set and maintenance set.

The basic equipment already covers numerous tasks. If you want to cover the field of refrigeration in more depth, then extend it with ET 910.11 and ET 910.13. Multiple workplace systems can also be designed affordably due to the modular design.

BASIC EQUIPMENT

Fundamentals of the refrigeration circuit

- Simple refrigeration circuit consisting of compressor, condenser, collector, filter/drier, expansion valve, evaporator
- Function of the individual components
- Pressures and temperatures in the cyclic process
- Response to different cooling loads
- Response to different cold storage temperatures
- Response to different mass flows

Extended study of the refrigeration circuit

- Function of evaporator (evaporation pressure, superheating)
- Difference between ventilated / non-ventilated evaporator, frosting in the evaporator
- Function of condenser and collector (condensation pressure)
- Function of heat exchanger, supercooler / superheater
- Function of liquid separator
- Effect of pressure losses in the piping system, simulation via manual valve
- Effects of overfilling / underfilling
- Function of filter/drier and sight glass
- Electrical connection of a consumer



Minimum equipment for a functional workplace, consisting of ET 910 Base Unit, ET 910.10 Set of Components, ET 910.05 Laboratory Workplace and ET 910.12 Accessories. This already enables numerous experiments from the basic field and extended functional contexts.

EXTENSION SET ET 910.11

Primary and secondary controllers in the refrigeration circuit

- Various expansion elements manually operated expansion valve, capillary tube, pressure-controlled expansion valve, thermostatic expansion valve
- Various capacity controllers: evaporation pressure controller KVP, start-up controller KVL, capacity controller KVC with post-injection, electric thermostat with solenoid valve, refrigeration controller with solenoid valve
- Pump-down control of the compressor
- Pressure-compensated compressor start via timedelayed bypass valve
- Electric defrost heater with defrost timer

- Hot gas defrosting with 4/2-way reversing valve and defrost timer

Simple electrical controls from refrigeration

- Master the fundamentals of control technology
- Implement refrigeration tasks: thermostatic control, self-maintenance, alternating operation, delay circuit, electronic refrigeration controller



Enables additional experiments with primary and secondary controllers in the refrigeration circuit. With electrical components tasks from the field of electrical engineering are also possible.

MAINTENANCE SET ET 910.13

Troubleshooting and maintenance

- Drain and evacuate the system
- Fill the system and leak testing
- Open the system with refrigerant displacement/pump-down
- Adjust expansion valves, thermostats, pressure controllers

The maintenance set mainly includes

- Selected tools
- Leak detector
- Multimeter
- Filling and evacuation device

ET 910.13
Maintenance Set



Required to fill and drain the system. A maintenance set ET 910.13 can be used for several workplaces. It also allows tasks from the field of maintenance and troubleshooting to be worked on.

Overview of the modular components

ET 910.10 Set of Components for Basic Experiments



Component 10/01:
Sight glass with filter/drier



Component 10/02:
Flow meter



Component 10/03:
Delivery side manometer



Component 10/04:
Intake side manometer



Component 10/05:
Assembly aid



Component 10/06:
Heat exchanger



Component 10/07: Pressure-
controlled expansion valve



Component 10/08:
Thermostatic expansion valve



Component 10/09:
Circuit breaker, 3 pins



Component 10/10:
Electric thermostat -5...+25°C



Component 10/11:
Electric thermostat -25...+5°C

ET 910.11 Extension Set of Components for Advanced Experiments



Component 11/01: Manually
operated expansion valve



Component 11/02:
Temperature controller



Component 11/03: Evaporation
pressure controller KVP



Component 11/04:
Start-up controller KVL



Component 11/05:
Capacity controller KVC



Component 11/06:
4/2-way reversing valve



Component 11/07:
Post-injection valve



Component 11/08:
Liquid separator



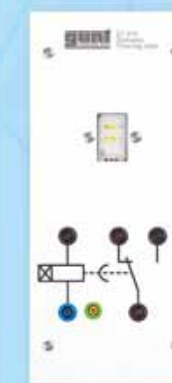
Component 11/09:
Defrost timer



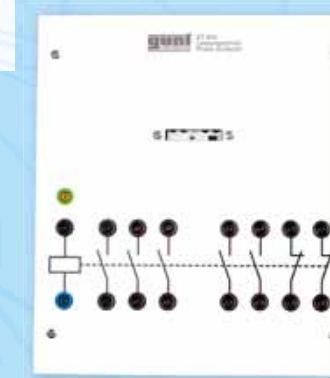
Component 11/10: Refrigeration
controller -5...+25°C



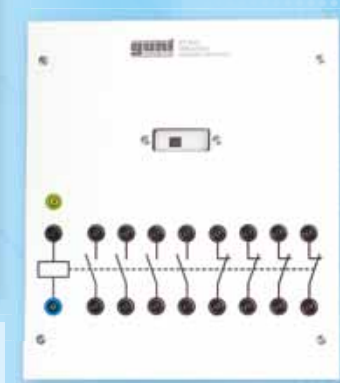
Component 11/11:
Solenoid valve (2x)



Component 11/12:
Time relay, 1x change-over contact



Component 11/13: Main contactor,
3 pins, with auxiliary switch



Component 11/14: Contactor relay,
4 x NO, 4 x NC

Accessory Set ET 910.12



The accessory set ET 910.12 is required for the hydraulic and electrical connection of the modules to each other and to the basic unit. It includes refrigerant hoses of different lengths and diameters (some with shut-off valves), refrigerant filter/driers as replacement, T pieces, couplings and

laboratory cables. Two capillary tubes of different lengths, two distributors and a sufficient length of insulating hose are also included.

Exemplary experimental set-ups

Below some interesting experimental set-ups made possible by the training system are introduced by way of example:

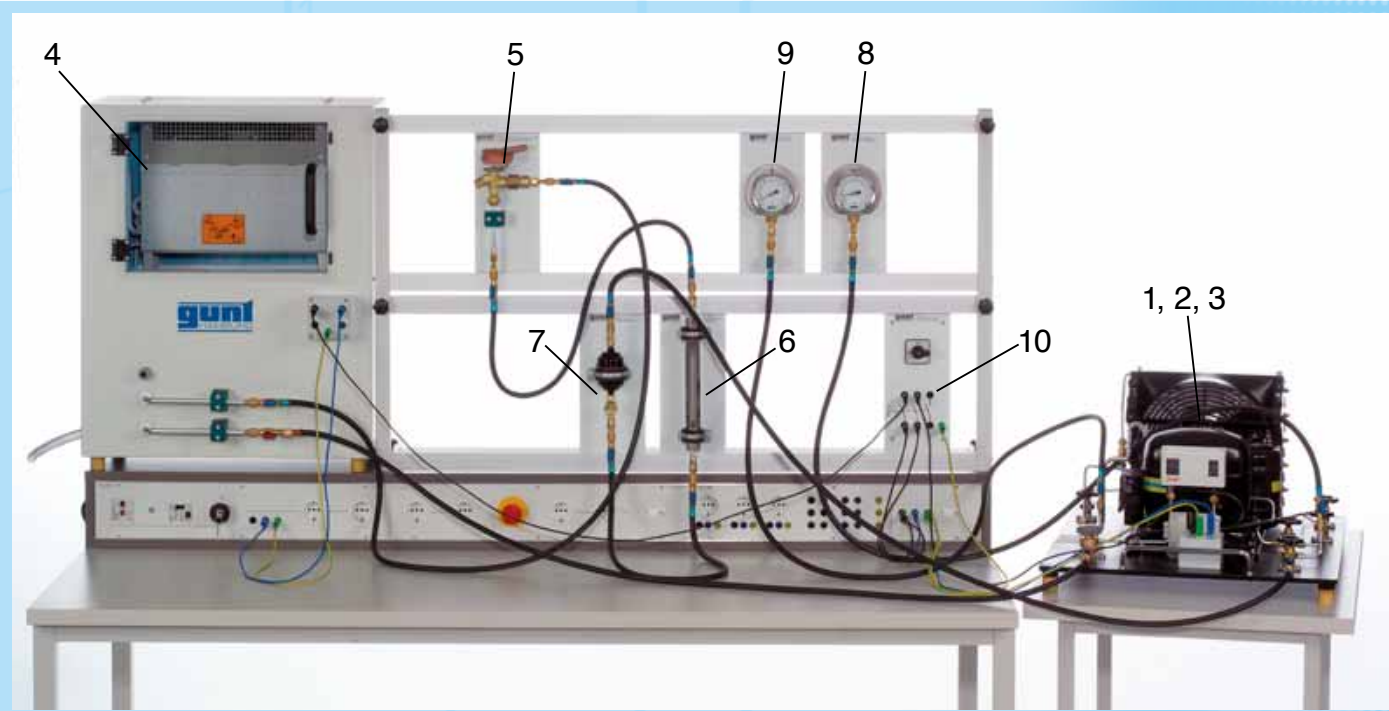
- Simple refrigeration circuit with compressor, condenser, thermostatic expansion valve and evaporator
- Refrigeration circuit with capacity control and post-injection
- Refrigeration circuit with hot gas defrosting of the evaporator

When working with the training system the trainee first learns to read and understand refrigeration system flow diagrams and simple electric circuit diagrams.

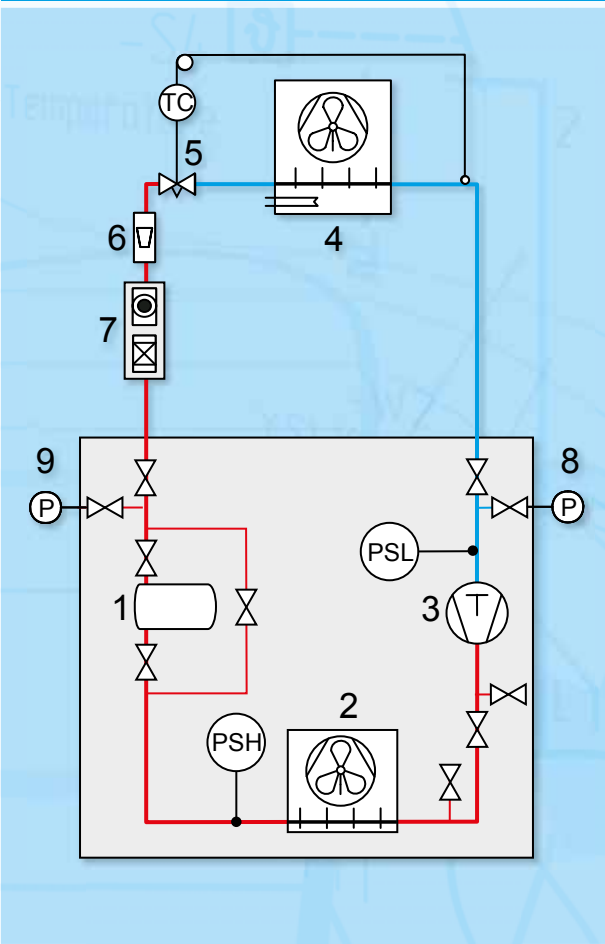
When combining the necessary experimental components he is familiarised with the real refrigeration components corresponding to the flow diagrams.

During commissioning practical tasks, such as evacuating, filling and leak tests, are carried out. The relevant regulations and guidelines can be trained in the process. In the final experiment stage the trainee can literally grasp the function of the system. The function is optimised by the adjustment of controllers and expansion elements. The effects of external influences, e.g the evaporator temperature, on the behaviour and capacity of the refrigeration system can be demonstrated.

Example: Simple refrigeration circuit with thermostatic expansion valve



Experimental set-up with ET 910, ET 910.05, ET 910.10 and ET 910.12



System flow diagram

In this introductory experiment a simple refrigeration circuit consisting of condensing unit (compressor 3, condenser 2, collector 1), refrigeration chamber with evaporator 4, thermostatic expansion valve 5 and sight glass with filter/drier 7 is constructed.

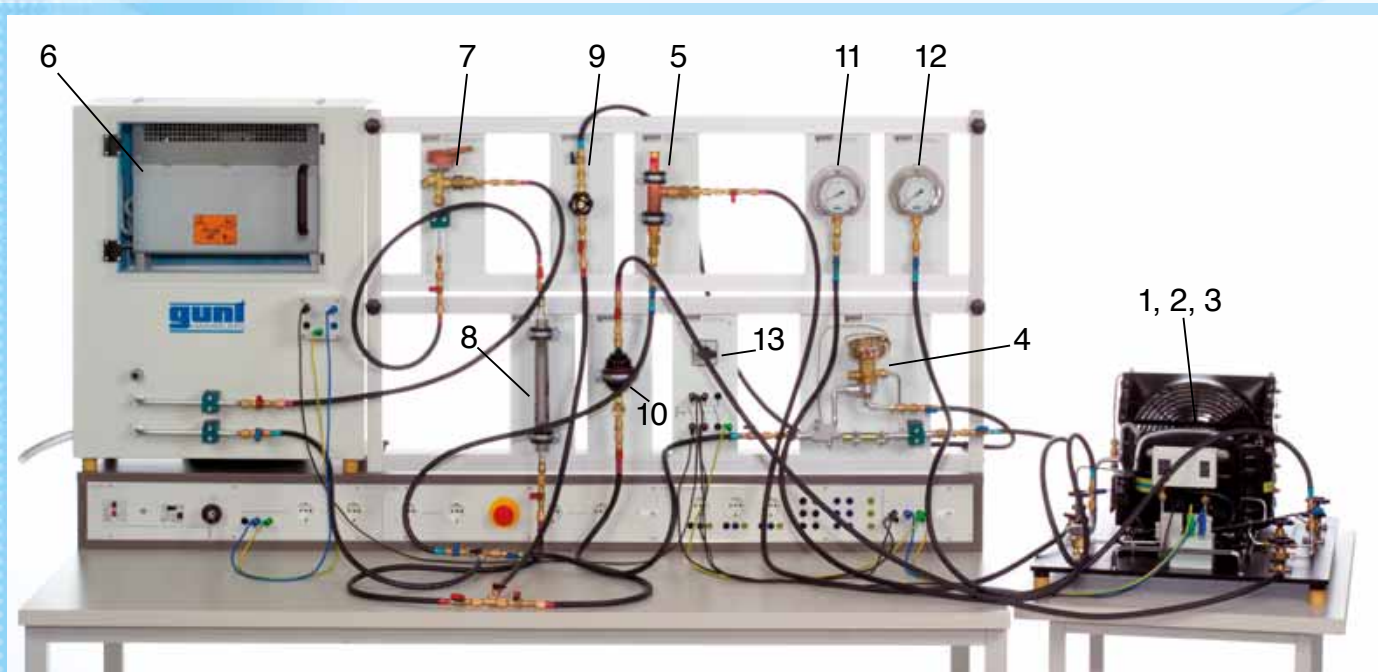
The control behaviour of the expansion valve can be monitored at the flow meter 6. Manometers 8, 9 provide an insight into the pressure states in the circuit. The trainee gets to know the elements and functions in the refrigeration circuit. Via pressure and temperature measurements the change of state of the refrigerant can be tracked and entered into the log p-h diagram. By feeling temperatures manually the understanding of the processes is deepened.

Components

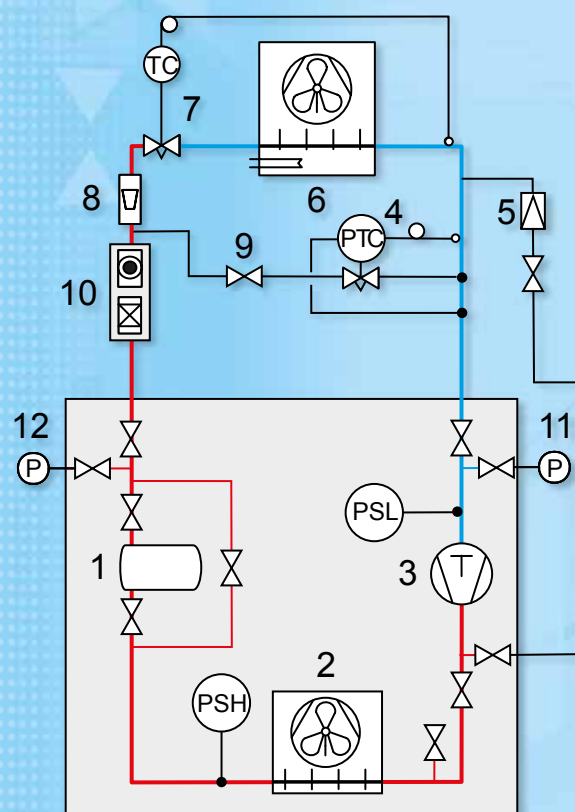
- 1 Collector (condensing unit ET 910)
- 2 Condenser (condensing unit ET 910)
- 3 Compressor (condensing unit ET 910)
- 4 Evaporator (refrigeration chamber ET 910)
- 5 Thermostatic expansion valve (component 08, ET 910.10)
- 6 Flow meter (component 02, ET 910.10)
- 7 Sight glass with filter/drier (component 01, ET 910.10)
- 8 Intake side manometer (component 04, ET 910.10)
- 9 Delivery side manometer (component 03, ET 910.10)
- 10 Circuit breaker, 3 pins (component 09, ET 910.10)

Accessory set ET 910.12 with cables, hoses etc.

Example: Capacity control with post-injection



Experimental set-up with ET 910, ET 910.05, ET 910.10, ET 910.11 and ET 910.12



System flow diagram

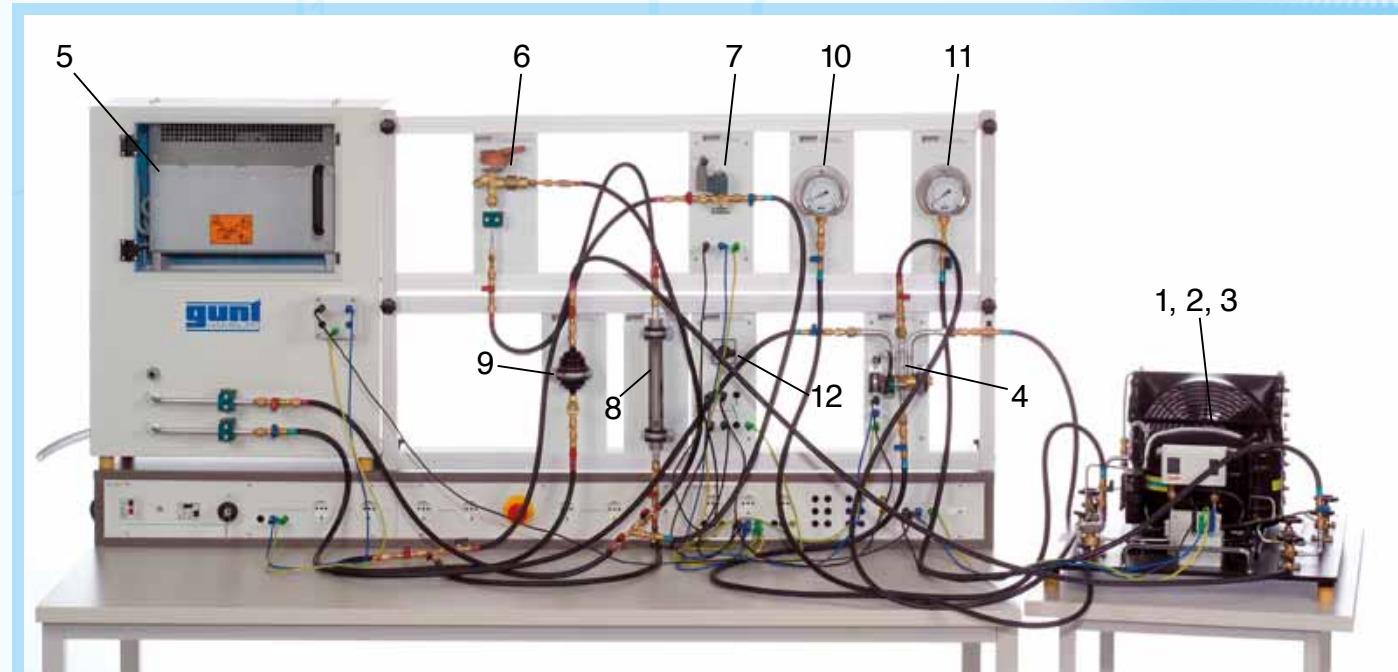
This experiment shows a capacity control type for larger systems. While in small systems the capacity is usually controlled via the on/off operation of the compressor, in larger systems a capacity controller KVC 5 is used. If the pressure differences between the delivery and intake side of the compressor are too high, the KVC allows a partial flow of the compressed gas to return to the intake side. This reduces the effective refrigerant flow. To prevent overheating of the compressor, a small amount of liquid refrigerant is injected directly into the intake pipe via the post-injection valve 4. The refrigerant immediately evaporates and cools down the intake flow as desired. Via the manually valve used as an expansion valve 9 the post-injection can be intentionally disabled to allow the effect to be observed directly.

Components

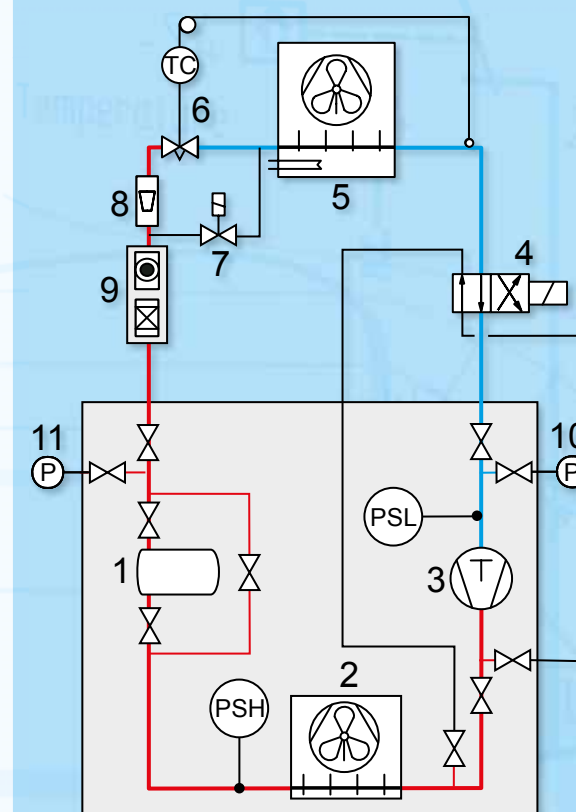
- 1 Collector (condensing unit ET 910)
- 2 Condenser (condensing unit ET 910)
- 3 Compressor (condensing unit ET 910)
- 4 Post-injection valve (component 07, ET 910.11)
- 5 Capacity controller KVC (component 05, ET 910.11)
- 6 Evaporator (refrigeration chamber ET 910)
- 7 Thermostatic expansion valve (component 08, ET 910.10)
- 8 Flow meter (component 02, ET 910.10)
- 9 Manually operated expansion valve (component 01, ET 910.11)
- 10 Sight glass with filter/drier (component 01, ET 910.10)
- 11 Intake side manometer (component 04, ET 910.10)
- 12 Delivery side manometer (component 03, ET 910.10)
- 13 Circuit breaker, 3 pins (component 09, ET 910.10)

Accessory set ET 910.12 with cables, hoses etc.

Example: Hot gas defrosting with 4/2-way reversing valve



Experimental set-up with ET 910, ET 910.05, ET 910.10, ET 910.11 and ET 910.12



System flow diagram

At evaporation temperatures of less than 0°C, e.g. in freezer systems, the usually present humidity in the air freezes and forms frost on the heat exchanger surfaces. This ice layer impedes the heat transfer and reduces the transfer area if the lamellae freeze up. This ice layer is therefore periodically defrosted. In addition to an electric defrost heater (can also be demonstrated with ET 910) there is also the so-called hot gas defrosting.

Here a 4/2-way reversing valve 4 is used to reverse the function of the evaporator 5 and the condenser 2. The frozen evaporator now receives the hot gas directly from the compressor outlet and thus defrosts very effectively. The hot gas defrosting is usually started via a defrost timer.

Components

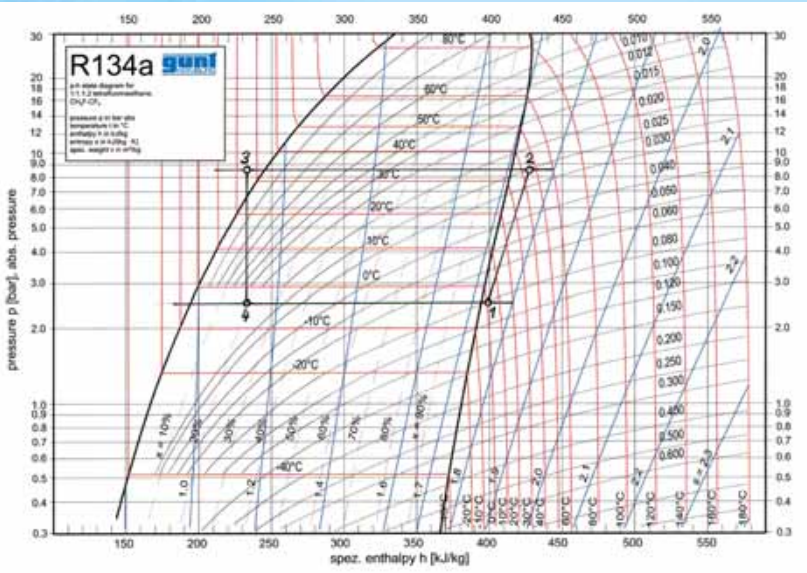
- 1 Collector (condensing unit ET 910)
- 2 Condenser (condensing unit ET 910)
- 3 Compressor (condensing unit ET 910)
- 4 4/2-way reversing valve (component 06, ET 910.11)
- 5 Evaporator (refrigeration chamber ET 910)
- 6 Thermostatic expansion valve (component 08, ET 910.10)
- 7 Solenoid valve (component 11, ET 910.11)
- 8 Flow meter (component 02, ET 910.10)
- 9 Sight glass with filter/drier (component 01, ET 910.10)
- 10 Intake side manometer (component 04, ET 910.10)
- 11 Delivery side manometer (component 03, ET 910.10)
- 12 Circuit breaker, 3 pins (component 09, ET 910.10)
- 13 Defrost timer (component 09, ET 910.11)

Accessory set ET 910.12 with cables, hoses etc.

Insights from the experiments

Measured Values Experiment 2			
Test run	1	2	3
Observation			
Evaporation Pressure P_{1s} in bar	1.5	1.9	2.1
Evaporation Pressure, absolute P_{1a} in bar	2.5	2.9	3.1
Evaporation Temperature in °C (Reading at the manometer)	-4.0	0.0	2.0
Condensation Pressure P_{2s} in bar	7.5	7.2	6.7
Condensation Pressure, absolute P_{2a} in bar	8.5	8.2	7.7
Condensation Temperature in °C (Reading at the manometer)	33.5	32.0	30.0
Temperature T_1 in °C at compressor outlet	45.6	42.3	43.0
Temperature T_2 in °C before expansion valve	24.8	24.0	22.5
Temperature T_3 in °C at evaporator inlet	-2.5	0.5	1.0
Temperature T_4 in °C at evaporator outlet	-1.2	2.5	5.0
Temperature T_5 in °C at compressor inlet	0.4	6.0	8.8
Refrigerant mass flow in kg/h	23	28	30

Record measured values at a refrigeration system



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

Via simple thermodynamic calculations the exchanged energy flows can be determined. Finally, the calculation of the coefficient of performance allows conclusions about the quality and efficiency of the refrigeration system. Here the influence of the pressure ratio or the cold storage temperature on the size of the coefficient of performance and thus also the efficiency of a refrigeration system is of interest.

With temperature and pressure measurements the trainees can trace and understand the changes of state of the refrigerant in the cyclic process. In addition to the training of the practical skill of correct temperature measurements (correct measuring location and good contact of the sensor to the pipe) or correct reading of a manometer, the issue of the stationary condition of the system is also dealt with.

By entering the measured values in the log p-h diagram the cyclic process can be represented graphically. In the very important log p-h diagram for refrigeration the particularities or irregularities of the refrigeration circuit become especially clear and can be discussed in detail.

The abstract term of enthalpy is illustrated via a balance of the exchanged energies. Basic properties of phase mixtures, condensation and evaporation can also be explained using the log p-h diagram.

Calculations Experiment 2			
Test run	1	2	3
Enthalpies (Readings of the log p-h-diagram)			
h_1 in kJ/kg	398	402	405
h_2 in kJ/kg	428	426	428
h_3 in kJ/kg	233	229	228
h_4 in kJ/kg	233	229	228
Enthalpy differences			
$h_1 - h_4$ in kJ/kg	165	173	176
$h_2 - h_3$ in kJ/kg	195	197	200
Mass flow $\dot{m}$ in kg/h	23	28	30
Calculation of Capacity			
Evaporator capacity $P_e = \frac{\dot{m} \cdot (h_1 - h_4)}{3600}$ in kW	1.054	1.345	1.466
Condenser capacity $P_c = \frac{\dot{m} \cdot (h_2 - h_3)}{3600}$ in kW	1.245	1.532	1.666
Theoretical coefficient of performance (COP)			
$\epsilon = \frac{P_e}{P_c - P_e}$	5.49	7.18	7.33

Calculate energy flows and determine the coefficient of performance

The instructional material

We have developed extensive instructional material for the training system ET 910. This makes the use of the system during your lessons easier.

The instructional materials consists in detail of:

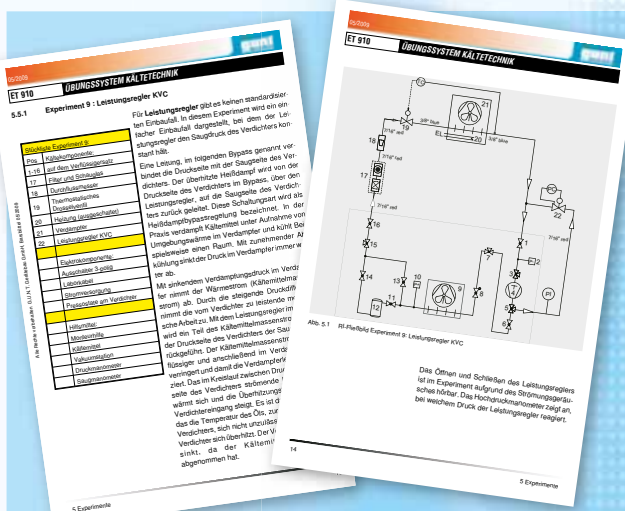
- Comprehensive system description ET 910
- Extensive operating instructions
- Detailed description of the design and function of the components used
- Design instructions with system flow chart, electric circuit diagram and item list
- Worksheets with instructions for the experiments for trainees
- Original manufacturer documentation and assembly instructions for the most important components

Materials as printouts and additionally also as PDF files on CD.

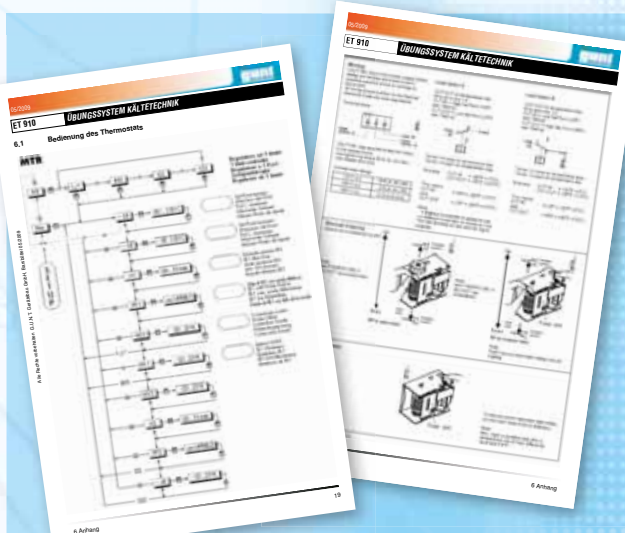
With the purchase of the training system ET 910 you receive a first class documentation and teaching aid.



Detailed description of the components



Experiment and set-up instructions



Original manufacturer documentation

Commissioning and training



Commissioning and training are carried out by competent GUNT employees. In addition to testing the supplied products this includes the training of the customer in the operation of the units. The system options are demonstrated extensively on the basis of comparative experiments. This allows the fast integration of the training system into your lessons.



Hisham Hijjawi College of Technology in Nablus, Palestine



Vocational college for metal technology, Amstetten, Austria

Many customers were happy to utilise our service for carrying out a thorough training.

The content and duration of a training event can be varied as required by the customer: from 1 to 5 days.

Please talk to your local GUNT partner or directly to us.



WE TAKE QUALITY SERIOUSLY



Our quality management system
has been certified since 1998.



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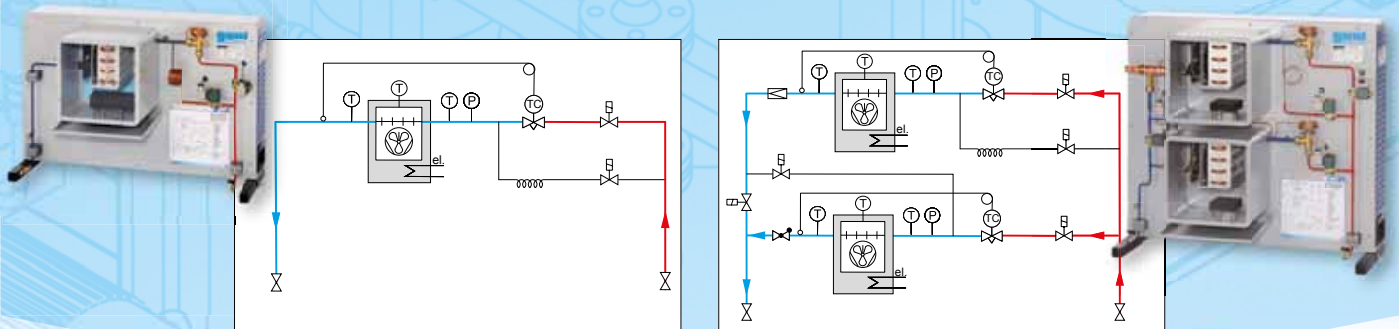
ET 915 HSI TRAINING SYSTEM FOR REFRIGERATION AND AIR CONDITIONING TECHNOLOGY

The experimental units

This series of units provides basic experiments for different areas of the refrigeration and air conditioning technology. The basic unit ET915 provides the components compressor and condenser; the accessory models include expansion elements and evaporator. The air conditioning model

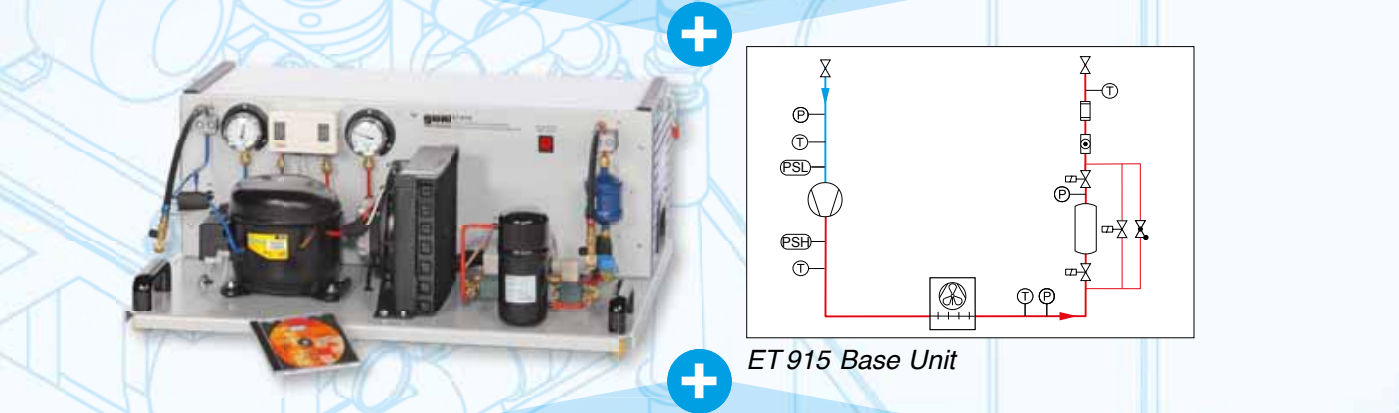
(ET 915.07) additionally includes a device for air humidification. Dependent on the objective of the experiment, the basic unit is combined with one of the accessory models to form a complete refrigeration circuit.

DEVICES FOR EXPERIMENTS FROM THE FIELD OF REFRIGERATION TECHNOLOGY



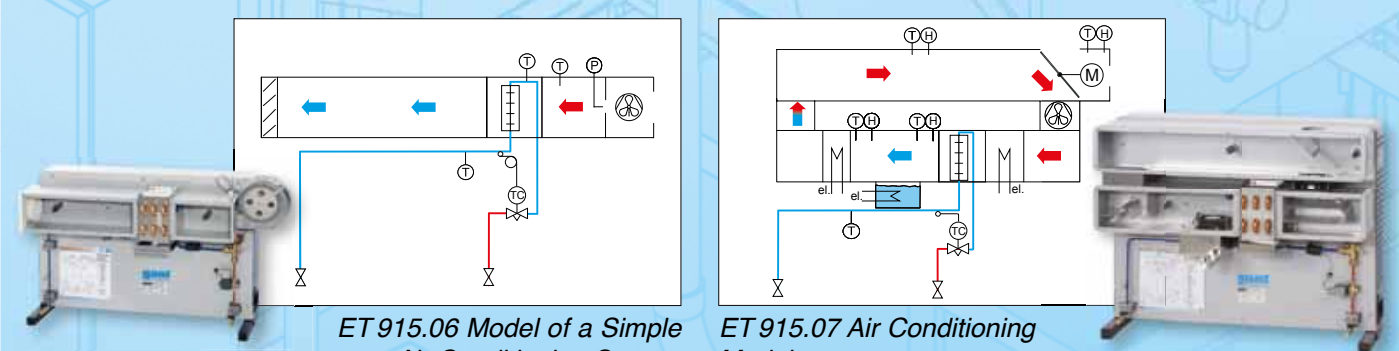
ET 915.01 Refrigerator Model

ET 915.02 Model of a Refrigeration System with Refrigeration and Freezing Stage



ET 915 Base Unit

DEVICES FOR EXPERIMENTS FROM THE FIELD OF AIR CONDITIONING TECHNOLOGY



ET 915.06 Model of a Simple Air Conditioning System

ET 915.07 Air Conditioning Model

The teaching software

GUNT has combined the fundamentals of refrigeration and air conditioning technology in an interactive learning software for you. The modern and powerful software is an integral part of the training system in the form of hardware/software integration (HSI). It enables the comfortable execution and analysis of the experiments.

The experimental unit is connected to the PC via a USB interface. The educational software guides step by step through the experiments. With explanatory texts and illustrations it significantly aids the understanding of the theoretical principles.

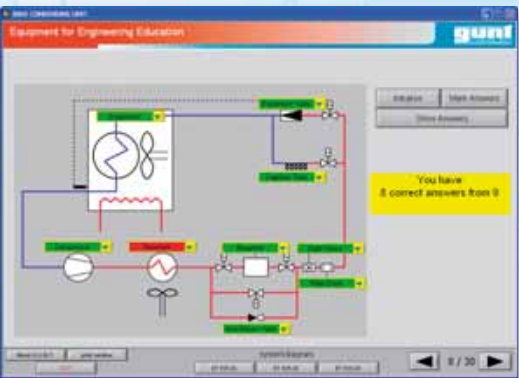
Dependent on the accessory models used and in conjunction with the educational software typical learning objectives are taught:

Refrigeration:

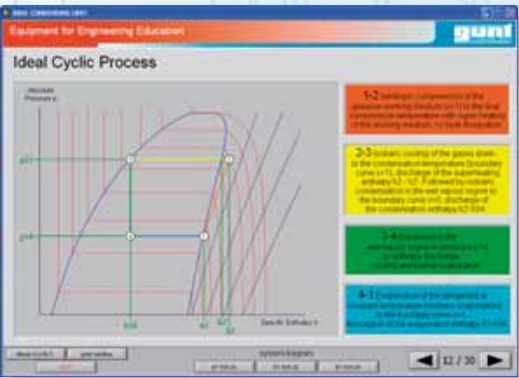
- Fundamentals of a refrigeration cycle
- Refrigeration systems and their main components
- Operation using several cooling stages
- Representation in the log p-h diagram

Air conditioning technology:

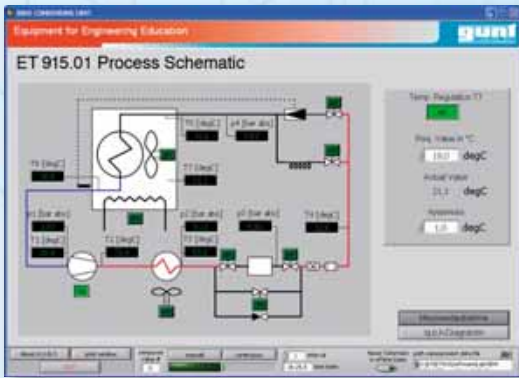
- Fundamentals of air conditioning
- Air conditioning systems and their main components
- Heating, cooling, humidifying and dehumidifying
- Representation in the h-x diagram



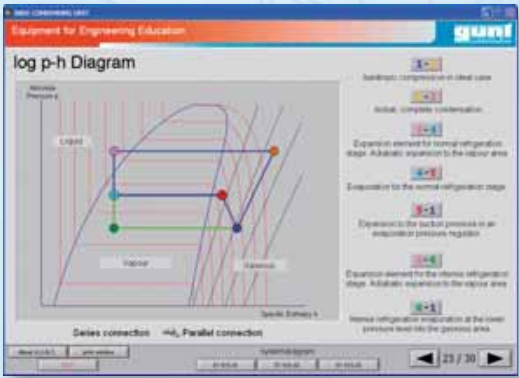
Questions to check the learning success



Representation of the ideal refrigeration cycle in the log p-h diagram and description of the changes of state



Process schematic of ET 915.01



Refrigeration cycle with evaporators connected in parallel

ET 915 HSI Training System Refrigeration and Air Conditioning Technology, Base Unit



- * Base unit for the set-up of basic experiments in refrigeration and air conditioning technology
- * Modern learning environment through hardware/software integration (HSI)
- * Four models on refrigeration and air conditioning technology

Technical Description

The base unit ET 915 is, dependent on the objective of the experiment, extended into complete refrigeration circuit with one of the models available as accessories (ET 915.01 refrigerator, ET 915.02 refrigeration system with refrigeration and freezing stage, ET 915.06 simple air conditioning system, ET 915.07 air conditioning).

The main components of ET 915 are compressor, condenser and receiver plus electrical and communications systems. The models are plugged onto the base unit and connected hydraulically with refrigerant hoses and electrically with cables. Self-sealing couplings reduce the refrigerant loss to a minimum. All components are arranged well visible to allow their operation to be monitored.

The modern and powerful software is an integral part of the training system in the form of hardware/software integration (HSI). It enables the comfortable execution and analysis of the experiments. The experimental unit is connected to the PC via a USB interface.

The educational software guides step by step through the experiments. With explanatory texts and illustrations it significantly aids the understanding of the theoretical principles. Temperatures and pressures in the system are recorded by sensors and displayed dynamically in the educational software. The effect of parameter changes can be tracked in log p-h and h-x diagrams. The system is also controlled via the software.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

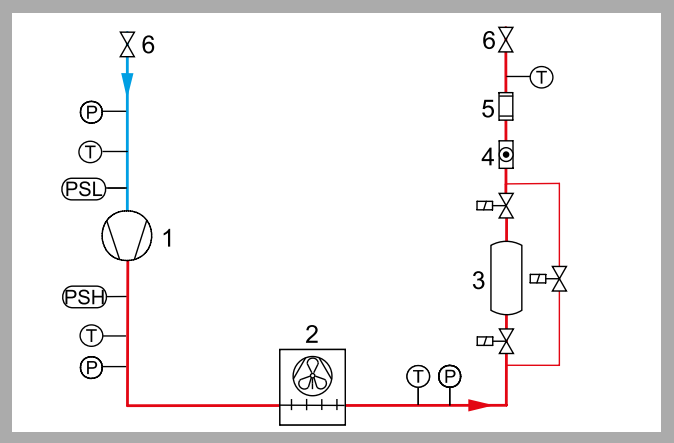
Learning Objectives / Experiments

- In conjunction with ET 915.01, ET 915.02, ET 915.06 and ET 915.07
- fundamentals of the refrigeration cycle
 - fundamentals of air conditioning
 - components in a refrigeration system/air conditioning system
 - system operation
 - fault finding

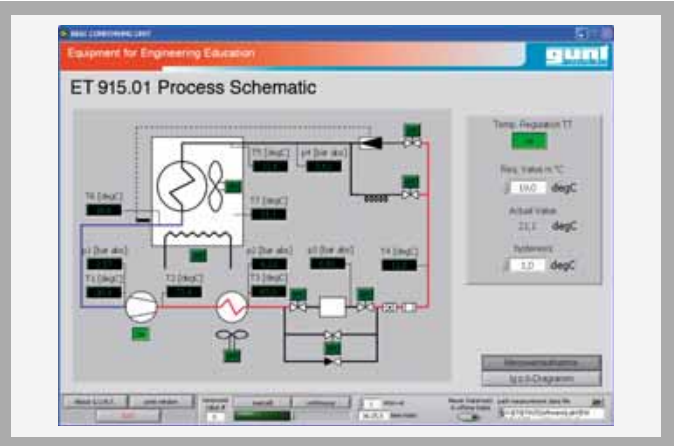
ET 915 HSI Training System Refrigeration and Air Conditioning Technology, Base Unit



1 compressor, 2 condenser with add-on fan, 3 receiver, 4 solenoid valve, 5 frame to mount the models, 6 filter/drier, 7 manometer, 8 pressure switch, 9 refrigerant hose



1 compressor, 2 condenser, 3 receiver, 4 sight glass, 5 filter/drier, 6 refrigerant hose for the models; PSH, PSL pressure switch; T temperature, P pressure; blue: low pressure, red: high pressure



Software screenshot: process schematic of the model ET 915.01. Measured values are displayed "online".

- Specification**
- [1] basic experiments on the operation of refrigeration and air conditioning systems by combining the base unit and models
 - [2] GUNT training system with HSI technology
 - [3] condensing unit consisting of compressor, condenser and receiver
 - [4] connection between condensing unit and model via refrigerant hoses
 - [5] model attached securely on ET 915 with fasteners
 - [6] manometer for refrigerant with temperature scale
 - [7] refrigerant R134a, CFC-free
 - [8] system control via solenoid valves and software
 - [9] functions of the GUNT software: educational software, data acquisition, system control
 - [10] GUNT software for data acquisition via USB under Windows Vista or Windows 7

- Technical Data**
- Condensing unit
- refrigeration capacity: 340W at 0/32°C
- Receiver: 0,9L
- Measuring ranges
- temperature: 1x -50...50°C, 3x 0...100°C
 - pressure
 - 1x intake side: -1...9bar
 - 2x delivery side: -1...15bar

- Dimensions and Weight**
- LxWxH: 830x650x320mm
- Weight: approx. 60kg

- Required for Operation**
- 230V, 50/60Hz, 1 phase or 120V, 60Hz/CSA, 1 phase

- Scope of Delivery**
- 1 condensing unit, filled with refrigerant
 - 1 GUNT software CD + USB cable
 - 1 set of instructional material

- Order Details**
- 061.91500 ET 915 HSI Training System Refrigeration and Air Conditioning Technology, Base Unit

ET 915.01 Refrigerator Model



- * Simple model of a domestic refrigerator for connection to the ET 915
- * Control of components and fault simulation

Technical Description

ET 915.01 is part of the HSI training system for refrigeration and air conditioning technology. In combination with the base unit ET 915 the operational model of a domestic refrigerator is created. The model is plugged onto the base unit, secured using fasteners and connected with refrigerant hoses to become a complete refrigeration circuit.

ET 915.01 consists of a refrigeration chamber with a heater as cooling load, evaporator, fan and various expansion elements. The fan supports the achievement of an even temperature distribution in the chamber. A cooling load can additionally be simulated with the heater. Solenoid valves enable the operation of the system with capillary tube or with expansion valve. All components are clearly arranged on a panel.

The control of individual system components, here the temperature control, fan, heater, compressor and solenoid valves, takes place via the educational software included in the scope of delivery of the base unit ET 915. The software offers the option to simulate faults.

Temperatures and pressures in the system are recorded by sensors and displayed dynamically in the educational software. The effect of parameter changes can be tracked online in the log p-h diagram.

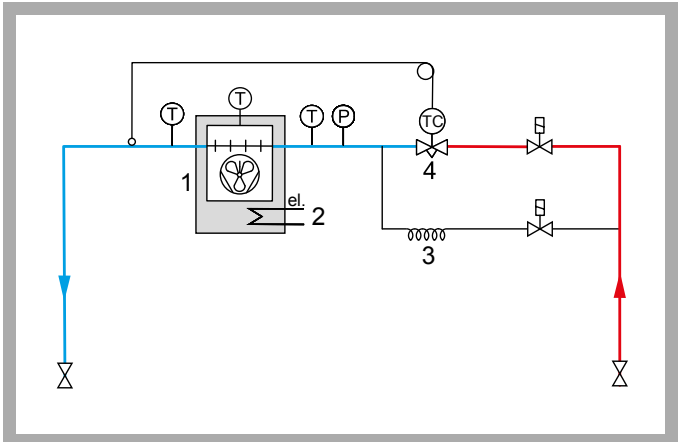
Learning Objectives / Experiments

- Understand and get familiar with the design and operation of a simple refrigeration system
- Familiarisation with the principle of operation of an evaporator
- Different expansion elements
 - * operation with capillary tube
 - * operation with expansion valve
- Operating behaviour under load
- Refrigeration cycle in the log p-h diagram
- Fault simulation

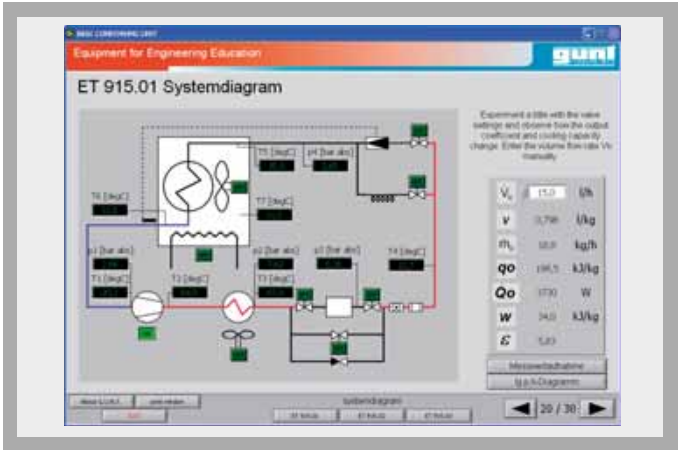
ET 915.01 Refrigerator Model



1 evaporator, 2 fan, 3 refrigeration chamber, 4 heater, 5 connections to ET 915, 6 process schematic, 7 solenoid valve, 8 capillary tube, 9 expansion valve



Process schematic of the refrigerator model: 1 evaporator, 2 heater, 3 capillary tube, 4 expansion valve; T temperature, P pressure; blue: low pressure, red: high pressure



Software screenshot: process schematic

- Specification**
- [1] Model of a refrigerator to plug onto the base unit ET 915
 - [2] GUNT training system with HSI technology
 - [3] Refrigeration chamber with evaporator, fan and cooling load
 - [4] Chamber with transparent front
 - [5] Electric heater to generate the cooling load
 - [6] Expansion elements selectable via solenoid valves: expansion valve or capillary tube
 - [7] Sensors to record temperature and pressure
 - [8] Solenoid valves, fan, heater and fault simulation controlled via the software

- Technical Data**
- Refrigeration chamber: l x w x h: 270x270x220mm
 - Electric PTC heater as cooling load: 210W
 - Capillary tube: length 2m
- Measuring ranges
- temperature: 3x -50...50°C
 - pressure: -1...9bar

- Dimensions and Weight**
- l x w x h: 850 x 380 x 550 mm
 - Weight: approx. 30 kg

- Scope of Delivery**
- 1 refrigerator model, filled with refrigerant

- Order Details**
- 061.91501 ET 915.01 Refrigerator Model

ET 915.02 Model of a Refrigeration System with Refrigeration and Freezing Stage



- * Series and parallel connection of evaporators
- * Control of components and fault simulation

Technical Description

ET 915.02 is part of the HSI training system for refrigeration and air conditioning technology. In combination with the base unit ET 915 the operational model of a refrigeration system with refrigeration and freezing stage results. The model is plugged onto the base unit, secured using fasteners and connected with refrigerant hoses to become a complete refrigeration circuit.

In refrigeration and freezing combinations evaporators are preferably connected in parallel. To increase the refrigeration capacity, evaporators are operated connected in series. Here different pressure levels in the evaporators can be used to obtain different temperature ranges for refrigeration or freezing.

ET 915.02 includes two separate refrigeration chambers with evaporator and expansion elements. The evaporators can be optionally operated connected in series or in parallel. Two fans in the refrigeration chambers support the achievement of an even temperature distribution. With heaters cooling loads can additionally be simulated. One of the refrigeration chambers can optionally be operated with an expansion valve or a capillary tube as expansion element. The various operation modes are set via solenoid valves. An evaporation pressure controller permits in parallel operation the independent adjustment of the temperature level in the upper chamber. All components are clearly arranged on a panel.

The control of individual system components, here temperature control, fan, heater, compressor and solenoid valves, takes place via the educational software included in the scope of the base unit ET 915.

The software offers the option to simulate faults. Temperatures and pressures in the system are recorded by sensors and displayed dynamically in the educational software. The effect of parameter changes can be tracked online in the log p-h diagram.

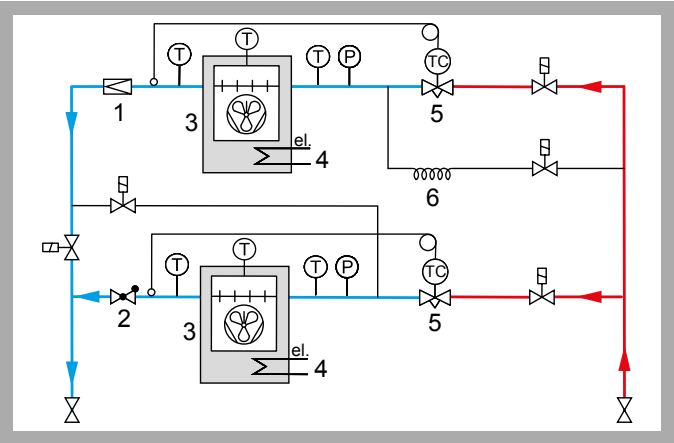
Learning Objectives / Experiments

- design and operation of a refrigeration system with two evaporators
- series and parallel connection of two evaporators
- familiarisation with the different expansion elements
- * operation with capillary tube
- * operation with expansion valve
- operating behaviour under load
- refrigeration cycle in the log p-h diagram
- effect of the evaporation pressure
- fault simulation

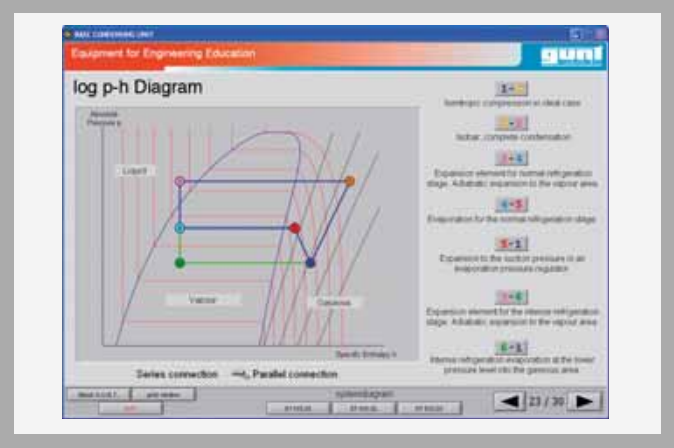
ET 915.02 Model of a Refrigeration System with Refrigeration and Freezing Stage



1 evaporation pressure controller, 2 solenoid valve, 3 fan, 4 evaporator, 5 heater, 6 connections to ET 915, 7 process schematic, 8 expansion valve, 9 capillary tube



Refrigeration system model, evaporators connected in parallel: 1 evaporation pressure controller, 2 non-return valve, 3 evaporator, 4 heater, 5 expansion valve, 6 capillary tube; T temperature, P pressure; blue: low pressure, red: high pressure



Software screenshot: evaporators connected in parallel

Specification

- [1] model of a refrigeration system to plug onto the base unit ET 915
- [2] GUNT training system with HSI technology
- [3] each refrigeration chamber includes: evaporator with fan (to recirculate the air) and heater to generate the cooling load
- [4] refrigeration chambers with transparent front
- [5] adjustable evaporation pressure controller
- [6] selectable expansion elements: expansion valve or capillary tube
- [7] operating modes of the system configurable via 5 solenoid valves
- [8] sensors to record temperature and pressure
- [9] solenoid valves, fan, heater and fault simulation controlled via the software

Technical Data

Refrigeration chamber: LxWxH: 270x270x220mm
Electric PTC heater as cooling load: 210W
Capillary tube: length 2m
Evaporation pressure controller: 0...5,5bar

Measuring ranges

- temperature: 6x -50...50°C
- pressure: 2x -1...9bar

Dimensions and Weight

LxWxH: 850x380x750mm
Weight: approx. 45kg

Scope of Delivery

1 refrigeration system model, filled with refrigerant

Order Details

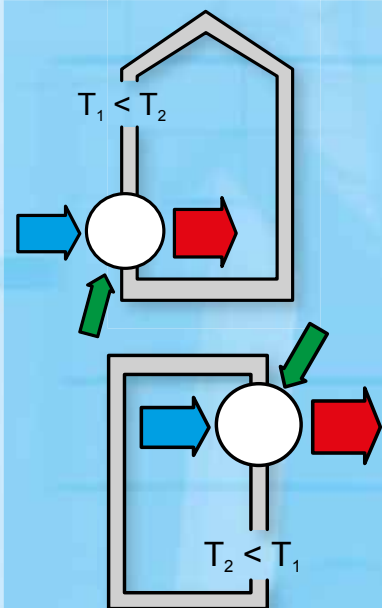
061.91502 ET 915.02 Model of a Refrigeration System with Refrigeration and Freezing Stage

BASIC KNOWLEDGE

HEAT PUMPS

What is a heat pump?

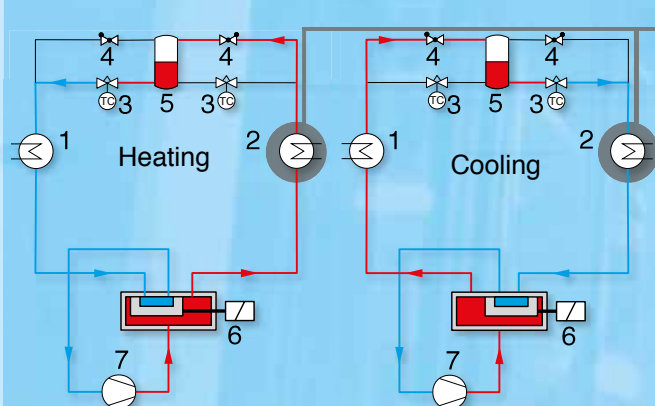
A heat pump transports heat from a low temperature level to a higher temperature level. For this purpose the heat pump requires a drive power. This can be mechanical, electric or thermal. Usually heat pumps working in accordance with the principle of a **compression refrigeration system** are in use. Heat pumps based on the absorption process are used more rarely.



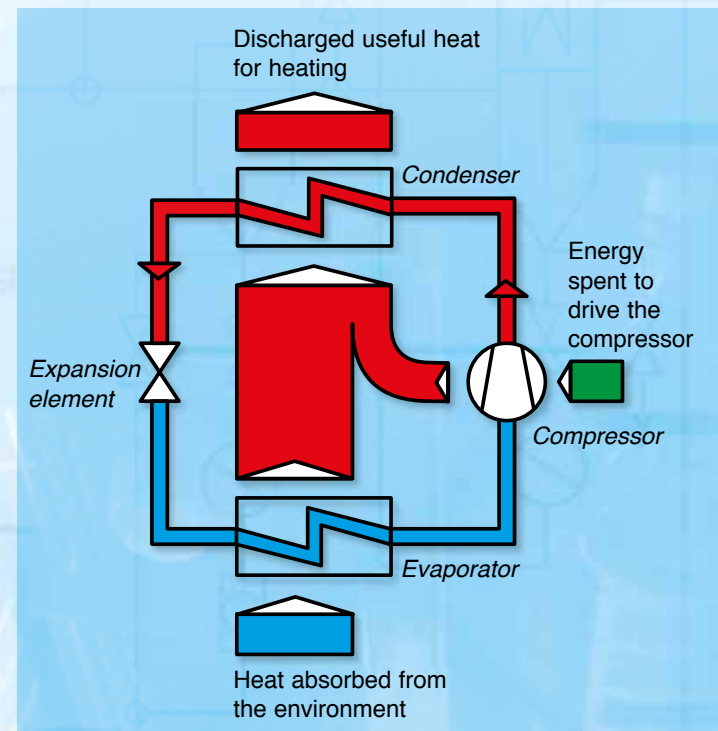
Heat pump:
The gain is the discharged heat (heating)

Refrigerating machine (refrigerator):
The gain is the absorbed heat (cooling)

Comparison of heat pump and refrigerating machine



1, 2 evaporator/condenser, 3 expansion valve, 4 non-return valve, 5 collector, 6 reversing valve, 7 compressor



Energy flows in a compression heat pump

Drive of compression heat pumps by mechanical energy:

- Electric motor
- Internal combustion motor (gas or diesel motor)
- Stirling motor

Drive of absorption heat pumps by thermal energy:

- Combustion
- Solar heat
- Waste heat from processes

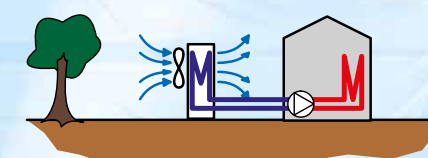
A heat pump can cool or heat

Due to the same principle of operation a heat pump can also operate as a refrigerating machine. It is thus possible to use the same system for heating in winter and cooling in summer. Only the functions of the evaporator and condenser are swapped. This is achieved by a reversing valve, two non-return valves and a second expansion valve. Most so-called split system air conditioners for room cooling already have an integrated heating function.

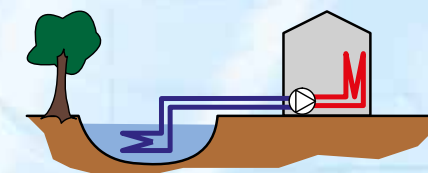
Where does the heat pump get its energy from?

A heat pump withdraws its energy normally from the environment. This is usually air, ground water, soil or river water. If the energy is taken from the ground, it is also called near-surface geothermal energy.

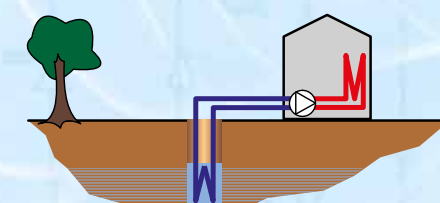
Important for high efficiency is as high and constant as possible a temperature of the energy source. In the winter, when the greatest heating capacity is required, the temperature should not drop too much.



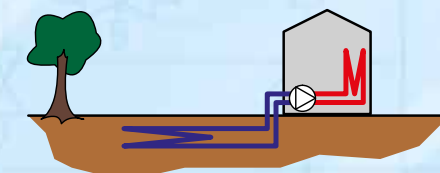
Ambient air
advantage:
low investment
disadvantage:
poor performance in winter



River water
advantage:
low investment
disadvantage:
poor performance in winter

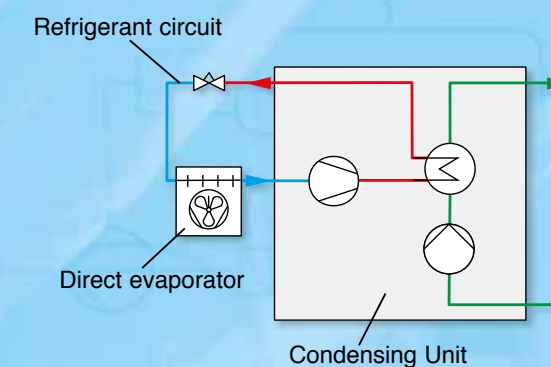


Ground water
advantage:
good performance, independent of seasons
disadvantage:
greater investment, approval



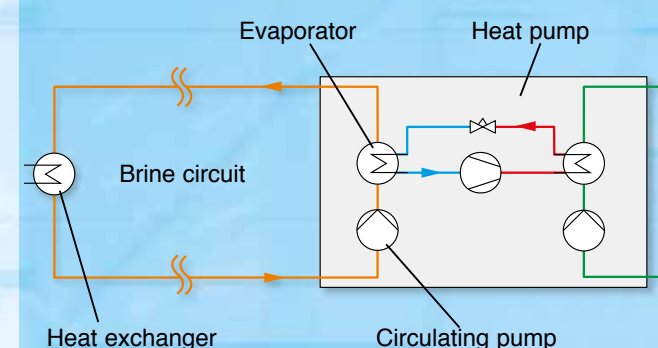
Soil
advantage:
good performance, independent of seasons
disadvantage:
large area required

DIFFERENT EVAPORATOR DESIGNS



Heat pump with direct evaporator

The refrigerant absorbs the heat for evaporation directly from the environment (often ambient air). The principle is used in the air-to-water heat pump. To achieve short refrigerant pipes, the direct evaporator should be close to the condensing unit. The costs are low.



Heat pump with brine circuit

A second circuit, the brine circuit, transports the heat from the heat source to the evaporator. This makes it possible to bridge larger distances between the heat pump and the heat source, preferably ground water, soil or river water. Extensive systems of pipes with low power density can be used as heat exchangers. Due to the second circuit with circulating pump the costs are higher.

ET 102 Heat Pump Trainer



- * Utilisation of ambient heat for water heating
- * Display of all relevant values at the location of measurement

Technical Description

With the air-to-water heat pump ET 102 the ambient heat of the air is used to heat water.

The heat pump circuit consists of a compressor, an evaporator with fan, a thermostatic expansion valve and a coaxial coil heat exchanger as condenser. All components are clearly arranged in the trainer.

The compressed refrigerant steam condenses in the outer pipe of the condenser and thereby discharges heat to the water in the inner pipe. The liquid refrigerant evaporates at low pressure in the finned tube evaporator and thereby absorbs heat from the ambient air.

The hot water circuit consists of a tank, a pump and the condenser as heater. For a continuous operation the generated heat is dissipated via an external cooling water connection. The cooling water flow rate is set via a valve and measured.

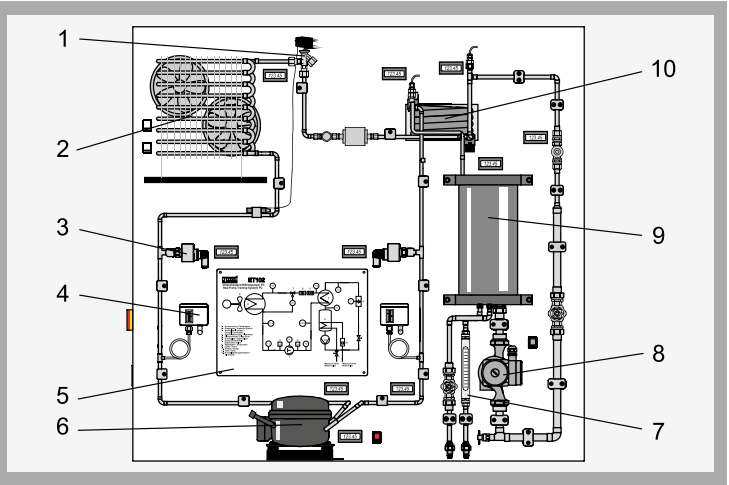
All relevant measured values are recorded by sensors. Displays at the respective locations of measurement indicate the measured values. This makes it easy to assign the measured values to the process. The simultaneous transmission of the measurements to a data recording software enables analysis and the representation of the process in the log p-h diagram. The software also displays the key characteristics variables of the process, such as the compressor pressure ratio and the coefficient of performance.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

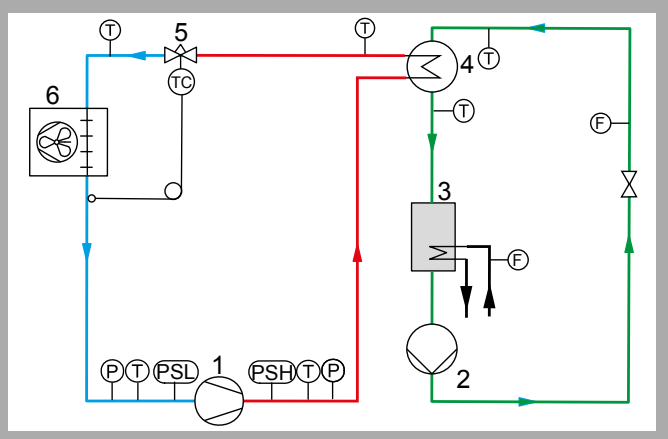
Learning Objectives / Experiments

- 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

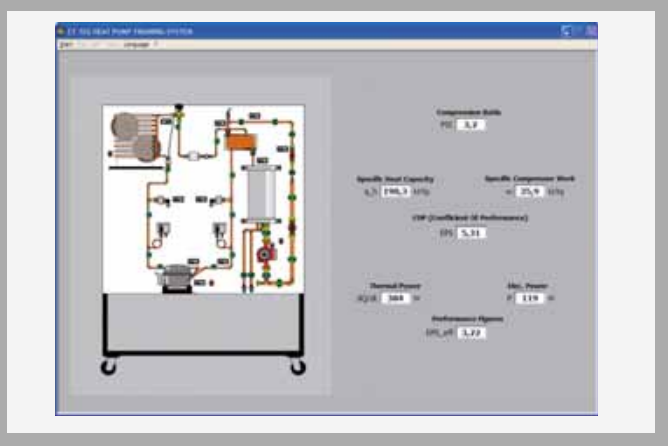
ET 102 Heat Pump Trainer



1 expansion valve, 2 evaporator with fan, 3 pressure sensor, 4 pressure switch, 5 process schematic, 6 compressor, 7 cooling water flow meter, 8 pump, 9 hot water tank, 10 condenser



1 compressor, 2 pump, 3 hot water tank with external cooling water connection, 4 condenser, 5 expansion valve, 6 evaporator with fan; T temperature, P pressure, F flow rate, PSH, PSL pressure switch; blue/red: refrigeration circuit, green: hot water circuit



Software screenshot: calculation and display of important characteristic variables

Specification

- [1] investigation of a heat pump with a water circuit as load
- [2] refrigeration circuit with compressor, evaporator with fan, thermostatic expansion valve and coaxial coil heat exchanger as condenser
- [3] hot water circuit with pump, tank and condenser as heater
- [4] additional cooling via pipe coil in the hot water tank and external cooling water
- [5] record of all relevant measured values and display directly at the location of measurement
- [6] GUNT software for data acquisition via USB under Windows Vista or Windows 7

Technical Data

- Compressor
- capacity: 372W at 7,2/32°C
- Coaxial coil heat exchanger (condenser)
- refrigerant content: 0,55L
 - water content: 0,3L
- Finned tube evaporator
- transfer area: approx. 0,175m²
- Pump
- max. flow rate: 1,9m³/h
 - max. head: 1,4m
- Hot water tank volume: approx. 4,5L

Measuring ranges

- pressure: 2x -1...15bar
- temperature: 6x 0...100°C
- power: 1x 0...1200W
- flow rate (water): 1x 3...108L/h
- flow rate (cooling water): 1x 15...160L/h

Dimensions and Weight

- LxWxH: 1400x550x1880mm
- Weight: approx. 135kg

Required for Operation

- 230V, 50/60Hz, 1 phase or 120V, 60Hz, 1 phase
- Water connection

Scope of Delivery

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

Order Details

- 061.10200 ET 102 Heat Pump Trainer

ET405 HEAT PUMP FOR COOLING AND HEATING OPERATION

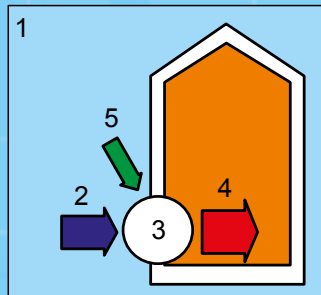
Heat pumps: many areas of application in refrigeration and air conditioning technology

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. Heat pumps can make use of heat sources at a low temperature level. Such heat sources can be the soil or ground water. The heat pump lifts the heat to a temperature level which can be used.

ET 405 enables the investigation of a multitude of component arrangement options. A compressor, a condenser and two evaporators with fan 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.

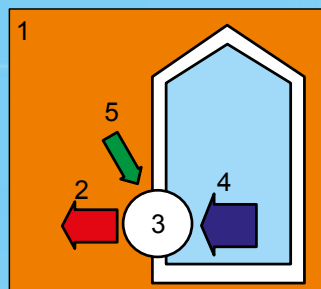


HEATING AND COOLING USING THE HEAT PUMP



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.



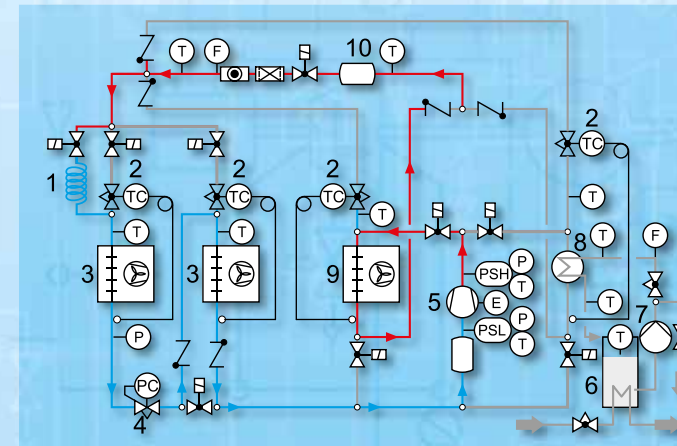
Gain: cooling

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.

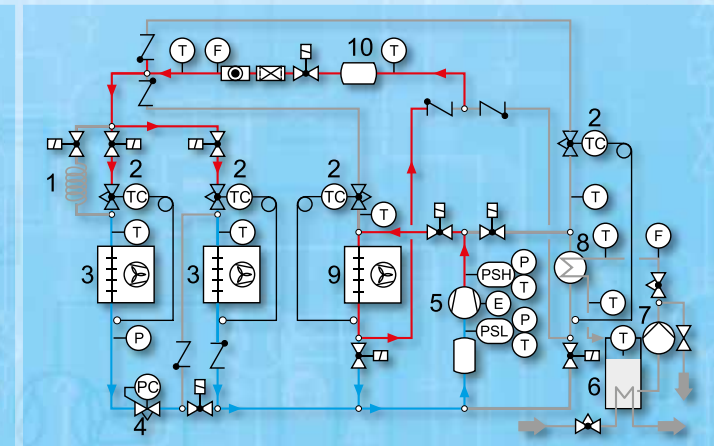
1 environment, 2 absorbed heat, 3 heat pump, 4 discharged heat, 5 electric energy

OVERVIEW OF THE DIFFERENT OPERATING MODES

Two evaporators connected in series



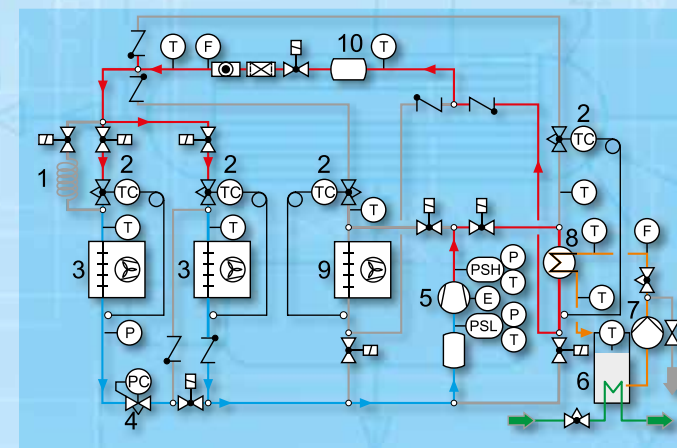
Two evaporators connected in parallel



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; T temperature, P pressure, F flow rate, PSH, PSL pressure switch

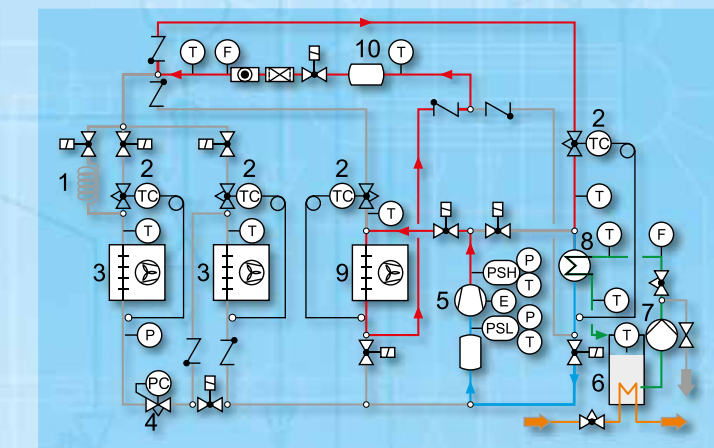
The condenser operates as an air heater. At both evaporators the heat is absorbed from the environment. The two evaporators can optionally be connected parallel or in series. It is also possible to operate only one evaporator.

Coaxial coil heat exchanger as condenser (heating)



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

Coaxial coil heat exchanger as evaporator (cooling)



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

ET 405 Heat Pump for Cooling and Heating Operation



- * Air-to-water heat pump
- * Heating and cooling operation possible
- * High practical relevance by using industrial components from refrigeration
- * Different operating modes can be set via solenoid valves
- * GUNT software for data acquisition

Technical Description

Refrigeration systems and heat pumps only differ in the definition of their use, but can be of the same design. For example, goods can be refrigerated in a supermarket and the store heated with the waste heat. The store can also be cooled with the same system in the summer. With ET 405 the cooling and heating operation can be investigated. Different operating modes can be selected via solenoid valves. The refrigeration circuit with compressor and condenser (heat exchanger with fan) includes two evaporators with fans (refrigeration stage and freezing stage) and thermostatic expansion valves. The two evaporators can be connected in parallel or in series. For the connection in series the capillary tube serves as expansion element for the refrigeration stage evaporator. The refrigerant circuit is connected to a glycol-water circuit via a coaxial coil heat exchanger. Via solenoid valves the coaxial coil heat exchanger can be switched as an evaporator or condenser. Thus the glycol-water mixture in the tank can be heated or cooled. In pure cooling operation (without heating function) the heat exchanger with fan as air-cooled condenser dissipates the heat. This heat exchanger can be also switched as an evaporator. The measured values are read from digital displays and can at the same time be transmitted via USB directly to a PC where they can be

analysed using the software included. The software enables a clear representation of the process. The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

Learning Objectives / Experiments

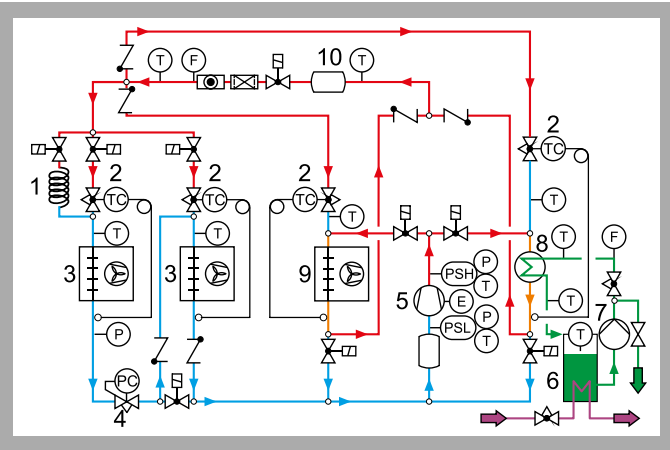
- design, operation and key components of a heat pump or refrigeration system
- representation of the thermodynamic cycle in the log p-h diagram
- comparing different operating modes
- measurement of compressor capacity and heating or cooling capacity in the glycol-water circuit
- determination of
 - * efficiency
 - * coefficient of performance of heat pump and refrigeration system
 - * specific compressor load
 - * compressor pressure ratio
 - * specific cooling capacity
 - * specific refrigeration capacity
- comparing key figures of heat pump and refrigeration system

G.U.N.T. Gerätebau GmbH, Hanskampring 15-17, D-22885 Barsbüttel, Phone +49 (40) 67 08 54-0, Fax +49 (40) 67 08 54-42, E-mail sales@gunt.de, Web http://www.gunt.de We reserve the right to modify our products without any notifications.

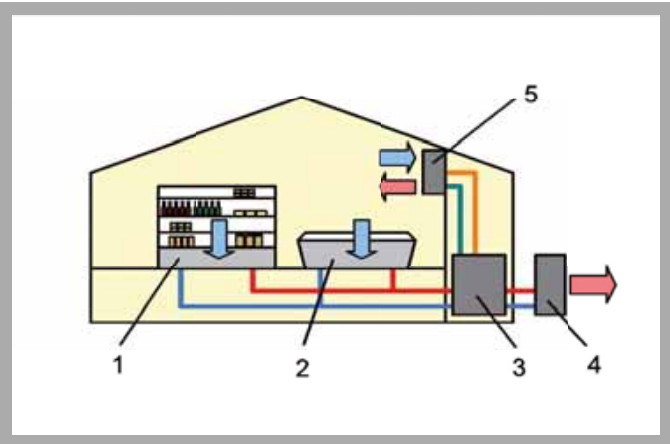
ET 405 Heat Pump for Cooling and Heating Operation



1 evaporator, 2 expansion valve, 3 capillary tube, 4 freezing stage evaporator, 5 evaporation pressure controller, 6 compressor, 7 receiver, 8 heat exchanger with fan, 9 pump, 10 display and control elements, 11 tank for glycol-water mixture, 12 flow meter, 13 solenoid valve, 14 coaxial coil heat exchanger



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; T temperature, P pressure, F flow rate, PSH, PSL pressure switch



Supermarket application: 1 refrigeration units, 2 freezer, 3 heat pump, 4 external condenser, 5 convector to heat or cool the sales room

G.U.N.T. Gerätebau GmbH, Hanskampring 15-17, D-22885 Barsbüttel, Phone +49 (40) 67 08 54-0, Fax +49 (40) 67 08 54-42, E-mail sales@gunt.de, Web http://www.gunt.de We reserve the right to modify our products without any notifications.

Specification

- [1] air-to-water heat pump for cooling or heating operation
- [2] different operating modes selectable via solenoid valves
- [3] refrigeration circuit with compressor, condenser (heat exchanger with fan), 2 evaporators with fan (refrigeration and freezing stage)
- [4] glycol-water circuit with tank, pump and coaxial coil heat exchanger
- [5] coaxial coil heat exchanger and heat exchanger with fan can both be used as condenser or evaporator in the refrigeration circuit
- [6] 1 thermostatic expansion valve each for all heat exchangers and evaporators
- [7] 1 additional evaporation pressure controller and 1 capillary tube for the refrigeration stage evaporator
- [8] displays for temperature, pressure, flow rate and power consumption of the compressor
- [9] GUNT software for data acquisition with USB under Windows Vista or Windows 7
- [10] refrigerant R134a, CFC-free

Technical Data

- Compressor
 - refrigeration capacity: 934W at -6,7/55°C
 - power consumption: 620W at -6,7/55°C
- Heat exchanger with fan
 - transfer area: 1,25m², volumetric air flow rate: 650m³/h, capacity: 1148W at DT=15K
- Evaporators with fan
 - refrigeration stage
 - * transfer area: 1,21m², volumetric air flow rate: 80m³/h, capacity: 140W (t_{L1}=5°C, DT1=10K)
 - freezing stage
 - * transfer area: 3,62m², volumetric air flow rate: 125m³/h, capacity: 330W (t_{L1}=5°C, DT1=10K)
- Coaxial coil heat exchanger
 - capacity: 1,6kW at 0°C; DT=9K
- Measuring ranges
 - temperature: 11x -50...150°C
 - pressure: 2x -1...15bar, 1x -1...24bar
 - flow rate (refrigerant): 1x 4...40L/h
 - flow rate (glycol-water): 1x 2,5...65g/s
 - power: 0...1150W

Dimensions and Weight

- LxWxH: 2210x800x1900mm
- Weight: approx. 330kg

Required for Operation

- 230V, 50/60Hz, 1 phase or 120V, 60Hz/CSA, 1 phase
- Water connection

Scope of Delivery

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

Order Details

- 061.40500 ET 405 Heat Pump for Cooling and Heating Operation

ET 420 ICE STORES IN REFRIGERATION

The cooling demand in buildings, such as shopping centres and hospitals, fluctuates greatly during the course of the day. In the daytime the cooling demand is normally much higher than at night. Refrigeration systems are designed for peak load. At times of low cooling requirement these systems are inefficient and cost intensive. Ice stores are charged with cheap night-time electricity and discharged in the day to cover the peak load. This requires less refrigeration capacity to be installed. This results in lower investment and operating costs. Another advantage is the secure supply of cold supply even during a power failure, e.g. in hospitals.

Ice stores utilise the absorption of energy during the change from the solid to the liquid aggregate state of water. The advantage compared to other stores (e.g. hot water stores) is the relatively large amount of heat per volume at a very low temperature difference. The stored refrigeration energy can be used again almost completely.



Internal view of the ice store

The trainer includes an ice store and refrigeration circuit with compressor to charge the ice store. The waste heat of the refrigeration circuit heats a glycol-water mixture in a tank. This mixture also serves as cooling load.

THE TRAINER



THE COOLING TOWERS

A dry cooling tower, directly operated with the glycol-water mixture, and a wet cooling tower, operated with a secondary circuit with water, are available. This allows e.g. for the dissipation of the waste heat arising during the charging of the ice store at the condenser of the refrigeration circuit.

The investigation of the principle of function and cooling capacity of the two cooling towers is part of the learning objectives in addition to the investigation of the ice store.



Dry cooling tower

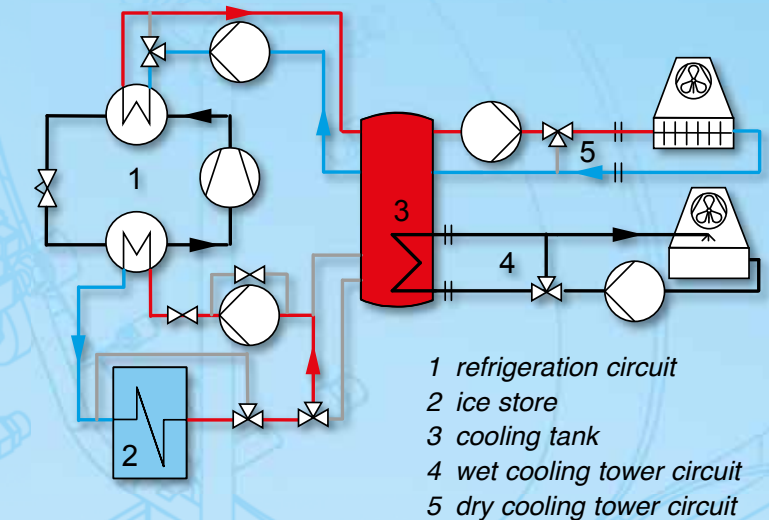


Wet cooling tower

EXAMPLES OF OPTIONAL OPERATING MODES

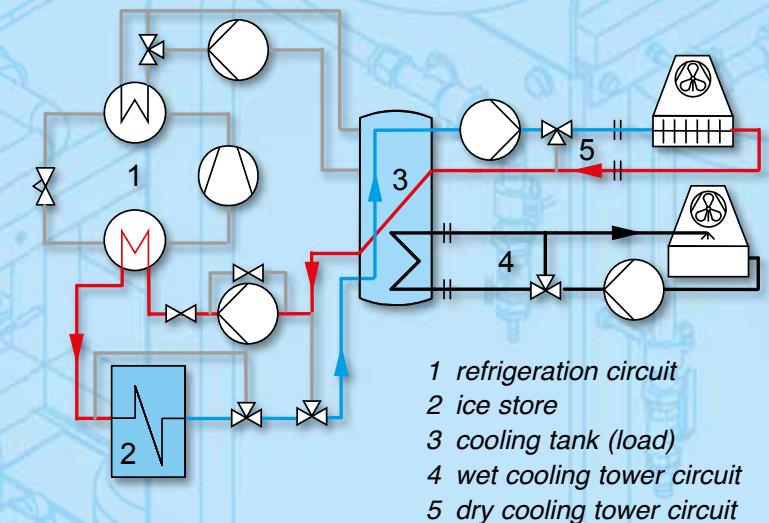
Charging the ice store (night-time operation)

The compressor of the refrigeration circuit is operated using cheap night-time electricity. The evaporator of the refrigeration circuit cools the glycol-water mixture in a second circuit. The glycol-water mixture flows through a pipe coil in the insulated ice store. The glycol-water mixture withdraws energy from the water in the ice store causing it to freeze. The waste heat arising at the condenser of the refrigeration circuit is discharged into a cooling tank filled with a glycol-water mixture. The cooling of the mixture in the cooling tank is achieved by the individual or combined operation of the cooling towers.



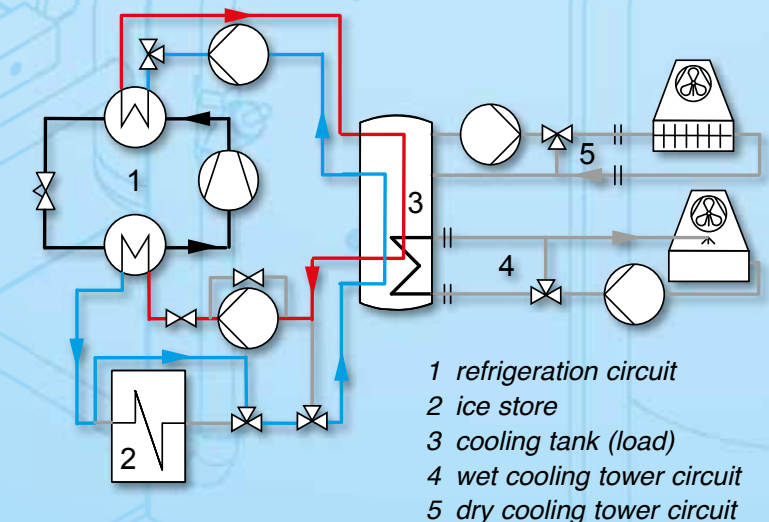
Discharging the ice store (daytime operation)

The compressor of the refrigeration circuit is switched off so that no peak tariff expensive electricity is used. The glycol-water mixture from the cooling tank (cooling load) discharges its energy to the ice in the ice store. The ice melts and its melting energy is available for cooling.



Cooling of the load directly via the refrigeration circuit

Via a bypass of the ice store it is also possible to cool the load (glycol-water mixture in the cooling tank) directly using the refrigeration circuit. The waste heat arising at the condenser of the refrigeration circuit heats the cooling tank. The individual or combined use of the two cooling towers is also possible in this operating mode.



COMMISSIONING IN ROMANIA: ET 420 ICE STORES IN REFRIGERATION



A GUNT service engineer explains the different operating modes to the customer.



The wet cooling tower is connected and can be commissioned.



Universitatea Tehnica
"Gheorghe Asachi" din Iasi
Facultatea de Constructii si Instalatii
Catedra de Instalatii pentru Constructii



Plan view of the wet cooling tower



Positioning of the dry cooling tower



The operation of the ice store is explained.

The Facultatea de Constructii si Instalatii at the Universitatea Tehnica "Gheorghe Asachi" in Iasi (Romania) teaches key areas of refrigeration and air conditioning technology. Our service engineers carry out the commissioning. In addition to testing the supplied products this includes the training of the customer in the operation of the units.

The Universitatea Tehnica "Gheorghe Asachi" uses other units from GUNT in addition to ET 420 for teaching. For air conditioning technology these are ET 605 and ET 611. For experiments in refrigeration, ET 411C and ET 480 are used amongst others.

The GUNT equipment supplied meets all requirements of the university perfectly.

ET 420 Ice Stores in Refrigeration



Trainer (in the background), dry cooling tower (in the foreground) and wet cooling tower (right)

- * Industrial refrigeration system with ice store, dry cooling tower and wet cooling tower
- * Energy efficiency in refrigeration and air conditioning technology

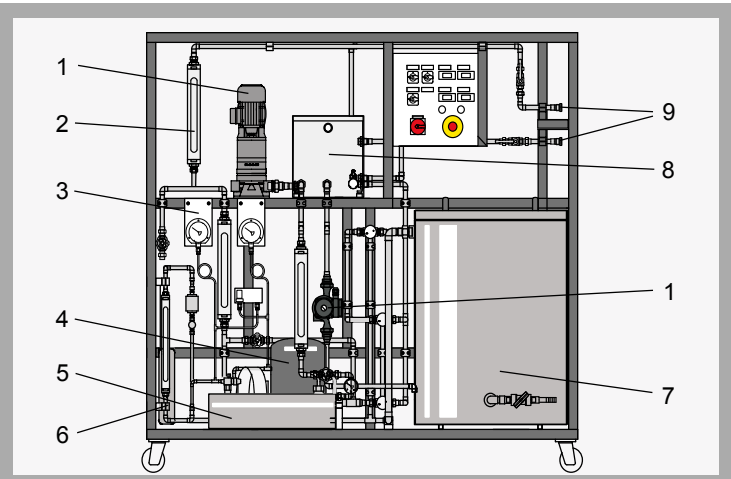
Technical Description

Ice stores are used in refrigeration to cover an increased additional cooling requirement (peak load). The ice stores are usually charged over night when general energy requirements and energy costs are low. To charge and discharge the ice store a circuit with glycol-water mixture is used between the ice store and the compression refrigeration system. When charging the ice store the glycol-water mixture is cooled via a compression refrigeration system to below 0°C and thereby withdraws energy from the water in the ice store, causing the water to freeze. During discharging the melting ice withdraws energy from the glycol-water mixture causing the mixture to cool down. During this cooling process the ice store replaces the compression refrigeration system. ET 420 also includes a tank for the glycol-water mixture and a dry and wet cooling tower. The glycol-water tank is used as a collection point of the different energy flows: during the evaporation of the refrigerant in the compression refrigeration circuit and during discharging of the ice store, energy is withdrawn from the mixture, whereas during the condensing of the refrigerant energy is added. As required the cooling towers add energy to or withdraw energy from the mixture. The record of all required variables enables an energy balance for the individual processes. The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

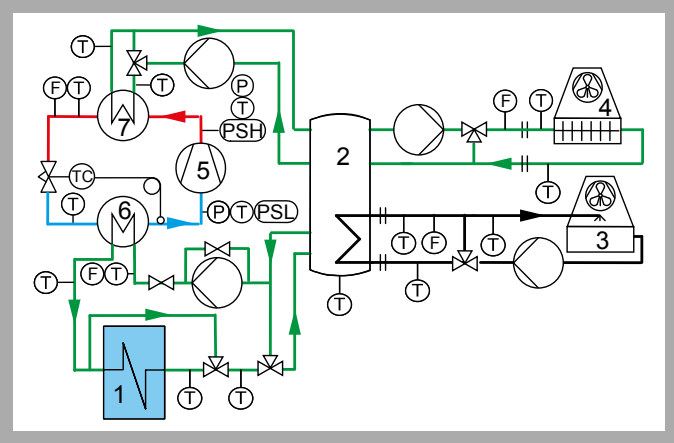
Learning Objectives / Experiments

- 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

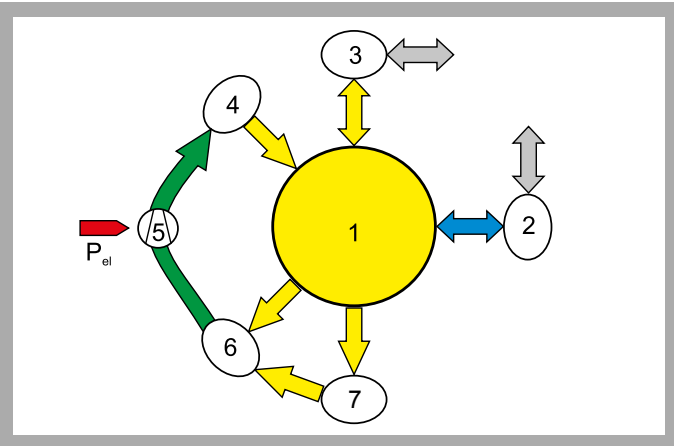
ET 420 Ice Stores in Refrigeration



1 pump, 2 flow meter, 3 manometer for refrigerant circuit, 4 refrigerant compressor, 5 refrigerant condenser, 6 refrigerant evaporator, 7 ice store, 8 glycol-water tank, 9 cooling tower connections



1 ice store, 2 glycol-water tank, 3 wet cooling tower, 4 dry cooling tower, 5 refrigerant compressor, 6 refrigerant evaporator, 7 refrigerant condenser; pipes: black: water, blue/red: refrigerant, green: glycol-water mixture



Energy flows in the system: 1 glycol-water tank, 2 wet cooling tower, 3 dry cooling tower, 4 refrigerant condenser, 5 refrigerant compressor, 6 refrigerant evaporator, 7 ice store; yellow: glycol-water mixture, blue: water, green: refrigerant, grey: air; P_{el} electric power

Specification

- [1] Investigation of the charging and discharging of an ice store
- [2] System with ice store, glycol-water tank, compression refrigeration system, dry and wet cooling towers
- [3] Refrigeration circuit for R134a with compressor, condenser, evaporator and expansion valve
- [4] Glycol-water tank as central receiver and distributor of energy flows
- [5] Glycol-water circuit with pump: cooling of the refrigerant condenser, heating of the refrigerant evaporator, charging/discharging of the ice store, operation of the dry cooling tower
- [6] Water circuit with pump to operate the wet cooling tower
- [7] Thermometer, manometer, flow meter at all relevant measuring points to balance the processes

Technical Data

Compressor, refrigeration capacity: approx. 1,7kW at -15/32°C
Pump, ice store circuit
- max. flow rate: 7m³/h
- max. head: 8m
Pumps, wet/dry cooling tower
- max. flow rate: 3,6m³/h
- max. head: 10m
Pump, condenser cooling
- max. flow rate: 4m³/h
- max. head: 4m
Ice store: 150L
Glycol-water tank: 28L
Wet cooling tower, rated cooling capacity: 12,8kW
Dry cooling tower, rated cooling capacity: 13,8kW
Measuring ranges
- temperature: 4x -20...40°C; 7x 0...60°C; 4x -50...100°C
- pressure: 1x -1...9bar; 1x -1...24bar
- flow rate: 3x 106...1000L/h; 1x 15...105L/h; 1x 395...3995L/h

Dimensions and Weight

l x w x h: 1920x800x1800mm (trainer)
l x w x h: 1350x640x1650mm (wet cooling tower)
l x w x h: 1350x920x1110mm (dry cooling tower)
Weight: approx. 522kg (in total)

Required for Operation

230V, 50/60Hz, 1 phase or 230V, 60Hz, 3 phases
Water connection

Scope of Delivery

1 trainer, 1 wet cooling tower, 1 dry cooling tower, 1 set of hoses, 1 packing unit glycol, 1 set of instructional material

Order Details

061.42000 ET 420 Ice Stores in Refrigeration

AIR CONDITIONING TECHNOLOGY

INTRODUCTION

CODE	PRODUCT	PAGE
Overview	Basic Knowledge – Fundamentals of Air Conditioning	142

STATES OF THE AIR

CODE	PRODUCT	PAGE
WL 201	Fundamentals of Humidity Measurement	144
Overview	WL 320 Wet Cooling Tower	146
WL 320	Wet Cooling Tower	148

PRINCIPLES OF AIR CONDITIONING TECHNOLOGY

CODE	PRODUCT	PAGE
Overview	ET 915 HSI Training System for Refrigeration and Air Conditioning Technology	150
ET 915	HSI Training System Refrigeration and Air Conditioning Technology, Base Unit	152
ET 915.06	Model of a Simple Air Conditioning System	154
ET 915.07	Air Conditioning Model	156
Overview	ET 605 Air Conditioning System Model plus Automation Solutions	158
ET 605	Air Conditioning System Model	160
ET 605.01	Software Controller with Data Acquisition	162
ET 605.02	Air Conditioning Controller	163
ET 605.03	I/O Connection Box	164

VENTILATION TECHNOLOGY

CODE	PRODUCT	PAGE
Overview	Ventilation Systems and their Components	182
HM 280	Experiments with a Radial Fan	184
HM 282	Experiments with an Axial Fan	186
HM 210	Characteristic Variables of a Radial Fan	188
Overview	HM 220 Air Flow Study Unit	190
Overview	HM 240 Principles of Air Flow	192
Overview	WL 312 Multipurpose Air Duct and Heat Transfer Unit	194
Overview	HL 710 Planning and Set-Up of Air Duct Systems	196
HL 710	Air Duct Systems	198
HL 720	Ventilation System	200

PRACTICAL AIR CONDITIONING SYSTEMS

CODE	PRODUCT	PAGE
Overview	Basic Knowledge – Set-Up of an Air Conditioning System	166
ET 600	Conditioning of Room Air	168
Overview	ET 611 Air Conditioning System with Chamber for Comfort Investigations	170
ET 611	Air Conditioning System with Chamber	172
Overview	ET 620 Real Air Conditioning and Ventilation System	174
ET 620	Air Conditioning and Ventilation System	176
ET 450	Vehicle Air Conditioning	178
ET 630	Split System Air Conditioner	180

Explanation of terms:

According to the definitions of DIN 1946-1 the term **ventilation and air conditioning** is the overriding term which includes both **air conditioning technology** and **ventilation technology**.

An air conditioning system does not necessarily have to include all the process steps which can be related to it: cooling, heating, humidifying and dehumidifying. A vehicle air conditioning system e.g. does not feature a humidifying function and is nonetheless called an air conditioning system.

Ventilation systems also have additional functions besides the transportation of air, such as cooling or heating, without already being called air conditioning systems.

The characteristic of air conditioning systems is human comfort. In ventilation systems the main objective is to ensure a certain outer air replacement rate, e.g. in production halls.



BASIC KNOWLEDGE

FUNDAMENTALS OF AIR CONDITIONING

The purpose of air conditioning is to create a room climate comfortable for people. The conditions for describing comfort are standardised in accordance with DIN 1946 and DIN EN 13779. While the temperature should be between 20 and 26°C, a relative humidity between 30 and 65 % is permitted.

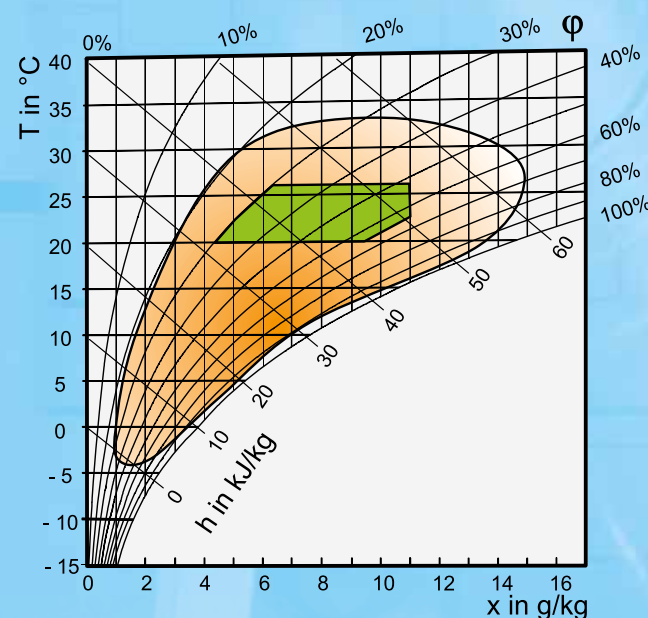
Air conditioning therefore means to affect the room air in such a way that people are comfortable and their productivity is not impeded.

The condition of the air is characterised by temperature, pressure and humidity.

(Normally, the air pressure is not changed. Exception: air conditioning in the aircraft cabin)

Air conditioning also plays an important role in industry, agriculture and research.

COMFORT ZONE IN THE h-x DIAGRAM FOR HUMID AIR BY MOLLIER



In the h-x diagram temperature T , enthalpy h and relative humidity ϕ are plotted above the absolute humidity x .

In the exemplary diagram the comfort zone according to DIN 1946 is drawn in green.

The orange area represents the range of outside temperatures and humidities prevailing in Central Europe. You can see that the outside temperatures and humidities usually do not match the conditions for comfort and that the room air needs to be air conditioned.

In Central Europe this is usually heating and humidification, whereas in the Tropics cooling and dehumidification is required.

In common usage air conditioning is often only understood as the cooling of the air (example: vehicle air conditioning system).

FOR FULL AIR CONDITIONING THERE ARE FOUR PARTIAL FUNCTIONS:

- Heating
- Cooling
- Humidifying
- Dehumidifying

Air humidity

Humid air contains water in a vaporous state. A difference is made between absolute humidity and relative humidity. Absolute humidity is measured in $\text{gH}_2\text{O/kg dry air}$.

For air conditioning the relative humidity is more important. It is perceived by humans. Relative humidity is measured in % of the maximum possible humidity at a given temperature. 100% r.h. means that the air cannot absorb any more humidity, it is saturated. Excessive humidity then remains as a liquid (mist) in the air. The saturation curve is the lower limit curve in the h-x diagram.

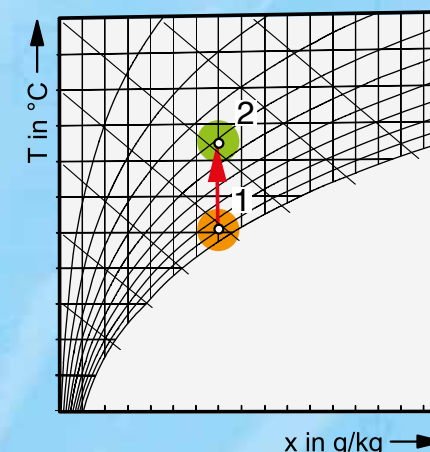
BASIC PROCESSES OF AIR CONDITIONING

The basic processes of air conditioning can be exceptionally well represented in the h-x diagram.

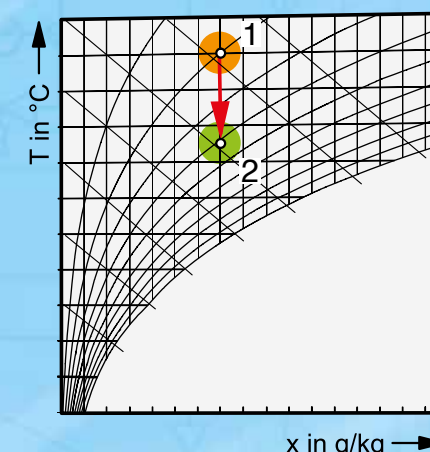
A change of temperature at constant absolute humidity also always results in a change of the relative humidity and enthalpy. The relative humidity and enthalpy also change with a change of the absolute humidity at constant temperature.

Thus temperature and relative humidity cannot be set independently of each other. An increase in the air temperature (heating), for example, always also results in a reduction in the relative humidity. To keep the relative humidity constant, humidification is therefore also required when heating. Conversely, the relative humidity increases during cooling.

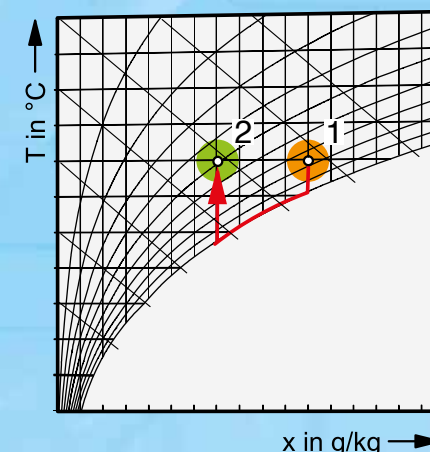
FOUR BASIC PROCESSES OF AIR CONDITIONING IN THE h-x DIAGRAM



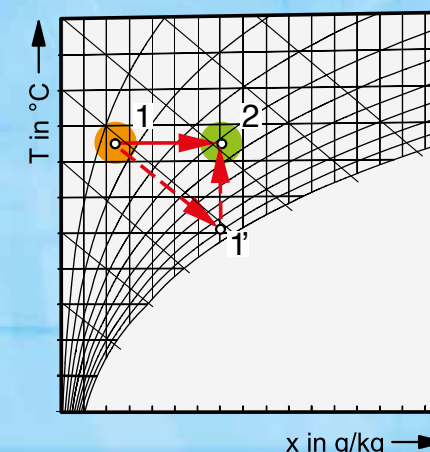
Heating
supply of heat, relative humidity reduces



Cooling
removal of heat, relative humidity increases



Dehumidifying
cooling to 100 % r. h. (saturation), condensation of the humidity on cold surfaces. Followed by heating to the desired temperature.



Humidifying
supply of water steam or water mist (for mist additional heating required to compensate cooling due to vaporisation enthalpy 1-1'-2)

WL 201 Fundamentals of Humidity Measurement



- * Different measuring methods for measuring humidity
- * Climatic chamber with adjustable humidity and transparent door

Technical Description

The measurement of air humidity plays an important role in many branches of industry, e.g. during drying or in the air conditioning of buildings and vehicles. There are different measuring methods to determine humidity.

The trainer WL 201 enables the measurement of air humidity with four different instruments which can be directly compared to each other: two different hygrometers, a capacitive hygrometer and a psychrometer.

Psychrometers operate based on the principle of evaporation cooling and compare the ambient temperature with the wet bulb temperature to determine the humidity. Hygrometers utilise the property of specific fibres, e.g. hair, to expand with increasing air humidity. In the capacitive sensor the dielectricity constant of a layer and with it its capacity changes due to the water molecules absorbed.

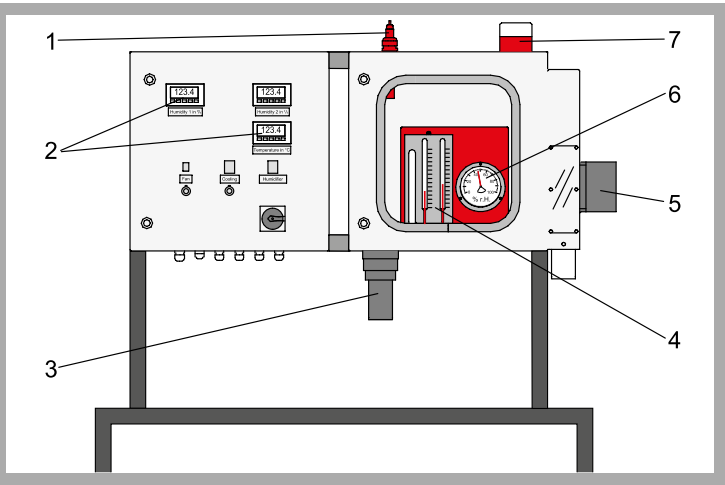
The core element of the trainer is a climatic chamber with transparent door. This chamber can be humidified and dehumidified and contains the four instruments. A Peltier cooling element is used for dehumidification. An ultrasonic atomiser is used for humidification. To circulate the air and ensure good mixing a fan is used.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

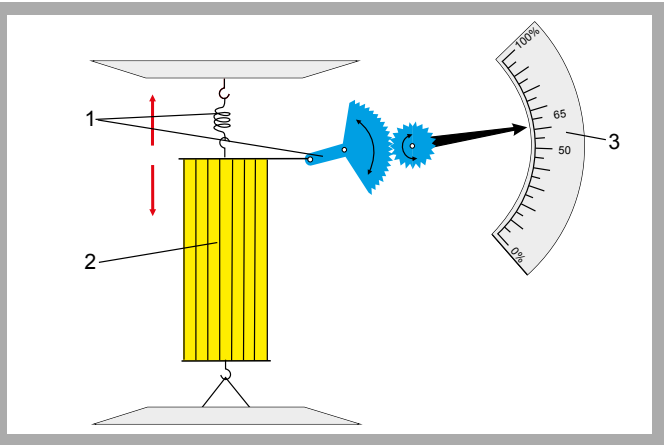
Learning Objectives / Experiments

- measuring methods for air humidity measurement
 - * psychrometric humidity measurement
 - * hygrometric humidity measurement
 - * capacitive humidity measurement
- characteristic variables to describe air humidity
- changes of the state of humid air in the h-x diagram
- determination of the relative air humidity with
 - * psychrometer
 - * hair hygrometer
 - * hygrometer with synthetic fibre
 - * capacitive humidity sensor
- design and operation of the instruments
- comparison of the instruments

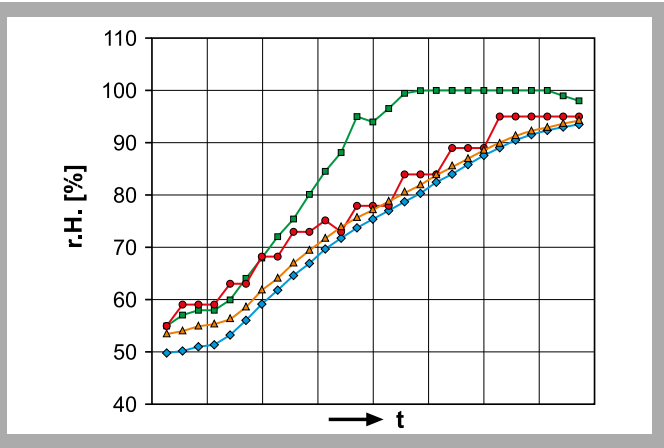
WL 201 Fundamentals of Humidity Measurement



1 capacitive humidity sensor, 2 temperature and humidity displays, 3 humidifier, 4 psychrometer, 5 dehumidifier, 6 hair hygrometer, 7 hygrometer with synthetic fibre and combined temperature sensor



Principle of the hair hygrometer: 1 mechanism to measure the humidity-dependent change in length of the hair bundle, 2 hair bundle, 3 humidity scale



Relative humidity (r. h.) over time (t) with rising content of humidity; blue: capacitive sensor, orange: hygrometer with synthetic fibre, red: psychrometer, green: hair hygrometer

Specification

- [1] different measuring methods for measuring humidity
- [2] climatic chamber with adjustable humidity and transparent door
- [3] humidification via ultrasonic atomiser
- [4] dehumidification via Peltier cooling element
- [5] fan for air recirculation
- [6] 2 mechanical instruments: psychrometer, hair hygrometer
- [7] 2 electronic instruments: capacitive sensor, hygrometer with synthetic fibre and combined temperature sensor

Technical Data

- Humidifier
 - ultrasonic atomiser
 - power consumption: 21,6W
 - low water cut-off
- Dehumidifier
 - Peltier element
 - cooling capacity: 56,6W (50°C ambient temperature)
 - cooling surface: 1600mm²

- Hair hygrometer with deflective needle
 - measuring range: 0...100% r. h.
- Hygrometer with synthetic fibre
 - output voltage: 0...10V
 - measuring ranges: 0...100% r. h. / -30...80°C
- Capacitive sensor with digital display
 - output voltage: 0...10V
 - measuring range: 1...100% r. h.
- Psychrometer with thermometer
 - measuring range: -10...60°C, graduation: 0,5°C

Dimensions and Weight

- LxWxH: 1270x730x1630mm
- Weight: approx. 112kg

Required for Operation

- 230V, 50/60Hz, 1 phase

Scope of Delivery

- 1 trainer
- 1 psychrometer
- 2 hygrometers
- 1 set of instructional material

Order Details

- 060.20100 WL 201 Fundamentals of Humidity Measurement

WL 320 WET COOLING TOWER

With interchangeable cooling columns the wet cooling tower WL 320 is used for basic experiments as well as comparative measurements in different types of cooling columns. Thus the key properties of the wet cooling tower can be traced in the experiment.

Cooling column type 1
medium surface
(included in the scope of
delivery of WL 320)



WL 320 Wet Cooling Tower

ADDITIONAL COOLING COLUMNS FOR COMPARATIVE MEASUREMENTS

WL 320.01
Cooling column
type 2
small
surface



WL 320.02
Cooling column
type 3
large
surface



WL 320.03
Cooling column
type 4,
empty for wet
deck surfaces
of your own
design



WL 320.04
Cooling column
type 5
variable
wet deck
surfaces



Interchangeable cooling columns

Five different cooling columns are available

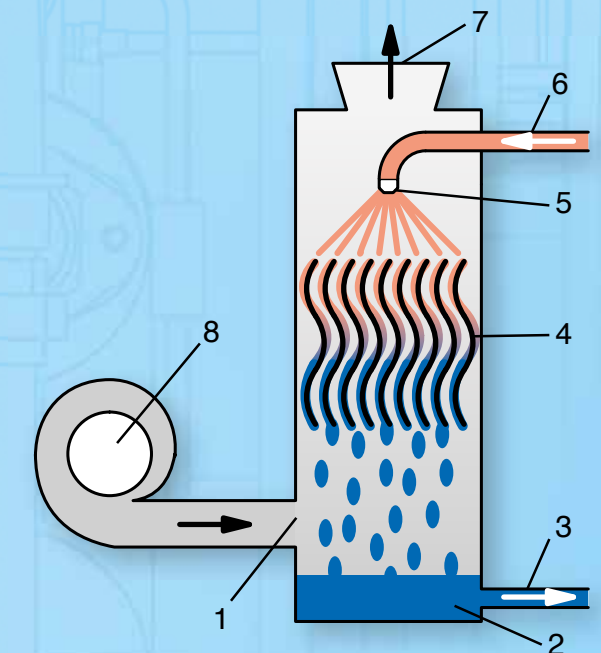
- Three cooling columns with different wet deck surfaces
- One cooling column without wet deck surfaces for investigating the heat transfer in the free water drop or for own wet deck surfaces
- One cooling column with divided wet deck surfaces so that the surface of the wet deck surfaces can be varied and the distribution of the temperature and humidity within the cooling column is measured

How does a cooling tower work?

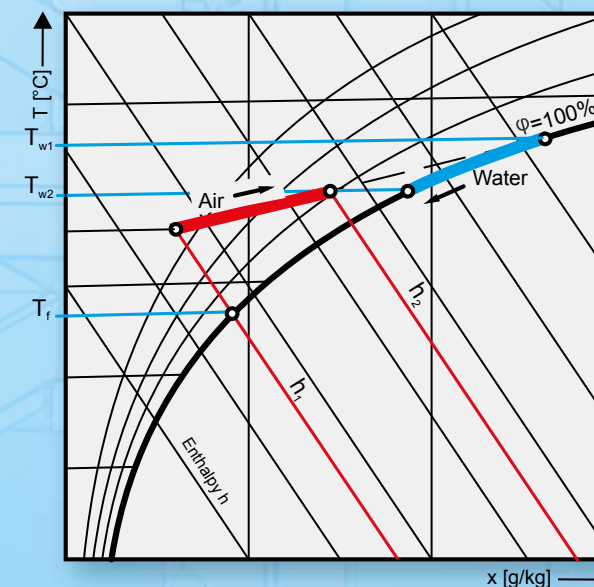
Cooling towers are used to dissipate heat arising during thermal processes, e.g. in steam power plants, air conditioning systems and process chillers. A difference is made between dry and wet cooling towers. Wet cooling towers can be constructed more easily and smaller for the same capacity. However, they feature high water losses in the range of 1–2.5% of the cooling water volume.

WL 320 is a wet cooling tower. The water to be cooled comes into direct contact with the air. The hot water is sprayed at the top of the cooling tower, trickles down the wet deck surface and is cooled in the process. The cooled water is removed at the bottom. The air enters the cooling tower from the bottom, flows upwards in a counterflow along the water trickling down, and exits at the top end.

A difference is made between cooling towers with atmospheric and forced ventilation. Very large cooling towers utilise the principle of atmospheric ventilation. Here the difference in density between the air inside and outside the cooling tower ensures the movement of the air. In small cooling towers the difference in density is insufficient for adequate air movement; they are forcefully ventilated by a fan.



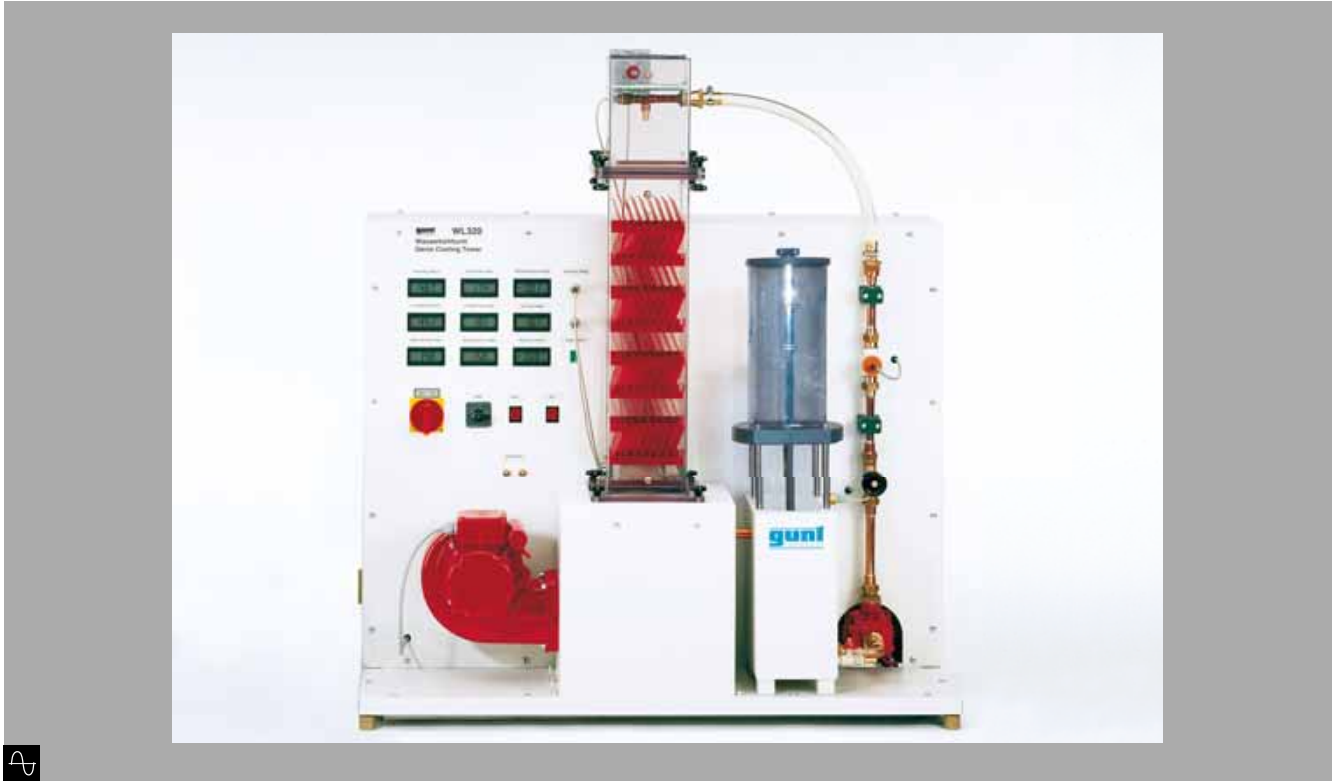
Principle of a wet cooling tower with forced ventilation
1 air inlet, 2 drip pan, 3 cold water outlet,
4 wet deck surface, 5 water distribution nozzle,
6 hot water inlet, 7 air outlet, 8 fan



Representation of the changes of state of air and water in the cooling tower in the h-x diagram

There are two types of heat transfer in a wet cooling tower. First the heat is transferred by convection directly from the water to the air. In addition the water cools by partial evaporation. Decisive for the good operation of a wet cooling tower is that the air does not contain too much humidity. Therefore the water temperature T_{w2} must be clearly above the saturation temperature (wet bulb temperature) T_f of the air.

WL 320 Wet Cooling Tower



- * Principle and characteristic variables of a wet cooling tower with forced ventilation
- * Transparent, easily interchangeable cooling column with wet deck surface
- * 4 additional cooling columns available as accessory

Technical Description

Wet cooling towers are a proven method of closed-circuit cooling and heat dissipation. Typical areas of application are: air conditioning, heavy industry and power stations.

In wet cooling towers the water to be cooled is sprayed over a wet deck surface. Water and air come into direct contact in the counterflow. The water is cooled by convection. Some of the water evaporates and the evaporation heat removed further cools down the water.

WL 320 examines the main components and principle of a wet cooling tower with forced ventilation. Water is heated in a tank and transported by a pump to an atomiser. The atomiser sprays the water to be cooled over the wet deck surface. The water trickles from the top to the bottom along the wet deck surface whilst air flows from the bottom to the top. The heat is transferred directly from the water to the air by convection and evaporation. The evaporated water volume is recorded. The air flow is generated by a fan and adjusted using a throttle valve.

The cooling column is transparent allowing clear observation of the wet deck surface and the trickling water. Interchangeable cooling columns (WL 320.01 - WL 320.04) enable comparative studies.

All important process parameters are recorded (volumetric air flow rate, temperatures of air and water, air humidity, water flow rate). The measured values can be read on digital displays. At the same time, the measured values can also be transmitted directly to a PC via USB. The data acquisition software is included. The changes of state of the air

are represented in an h-x diagram. The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

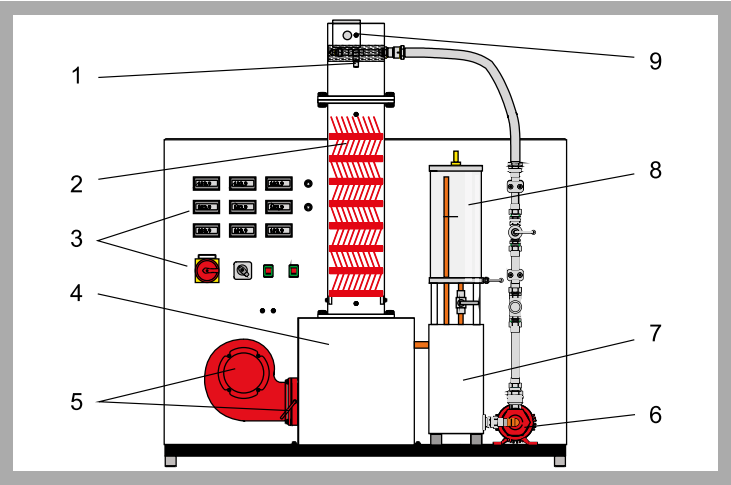
Learning Objectives / Experiments

- thermodynamic principles of the wet cooling tower
- changes of state of the air in the h-x diagram
- determination of the cooling capacity
- energy balances
- calculation of process parameters, such as maximum cooling distance, cooling zone width etc.

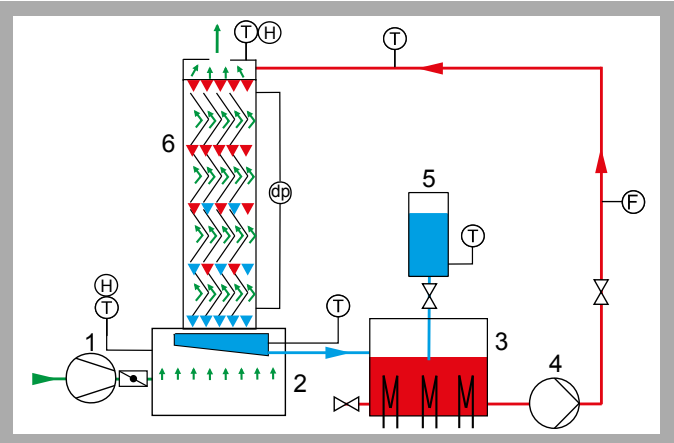
in conjunction with the cooling columns WL 320.01-WL 320.04

- comparison of different wet deck surfaces

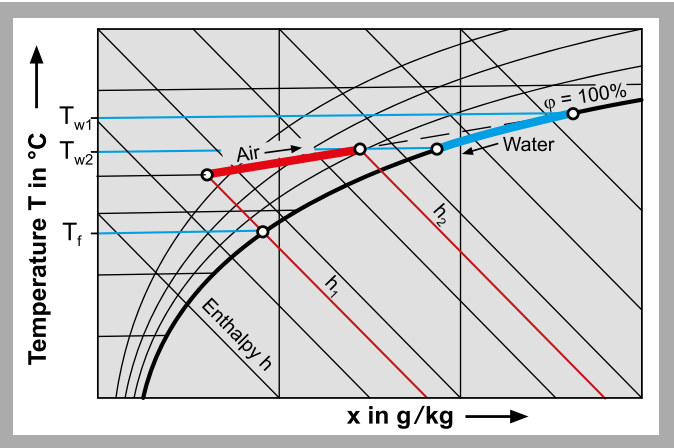
WL 320 Wet Cooling Tower



1 nozzle as atomiser, 2 wet deck surface, 3 displays and controls, 4 air chamber, 5 fan with throttle valve, 6 pump, 7 tank with heating, 8 tank for additional water, 9 combined temperature/humidity sensor



1 fan, 2 air chamber, 3 tank with heater, 4 pump, 5 tank for additional water, 6 cooling column with wet deck surface; T temperature, H humidity, dp differential pressure, F water flow rate



Changes of state of air and water in the h-x diagram as online representation in the software

Specification

- [1] principle of a wet cooling tower with cooling column and forced ventilation
- [2] interchangeable cooling columns with different wet deck surfaces available as accessories
- [3] water circuit with pump, filter, valve and a nozzle as atomiser
- [4] three-stage heater with thermostat for water heating
- [5] radial fan for forced ventilation
- [6] throttle valve to adjust the air flow
- [7] demister unit at the outlet of the cooling columns minimises water loss
- [8] tank for additional water compensates for water loss
- [9] display of temperature, differential pressure, flow rate and humidity
- [10] GUNT software for data acquisition via USB under Windows Vista or Windows 7

Technical Data

- Cooling column
- specific surface of the wet deck surface: 110m²/m³
 - cross-section: 150x150mm
- Volumetric air flow measurement via orifice: D=80mm
- Heater, adjustable in three stages: 500-1000-1500W
- Thermostat: switches off at 50°C
- Fan
- power consumption: 250W
 - max. differential pressure: 430Pa
 - max. flow rate: 13m³/min
- Pump
- max. head: 70m
 - max. flow rate: 100L/h
- Tank for additional water: 4,2L

Measuring ranges

- differential pressure (air): 0...1000Pa
- flow rate (water): 12...360L/h
- temperature: 2x 0...50°C, 3x 0...100°C
- humidity: 10...100% r.h.

Dimensions and Weight

LxWxH: 1110x540x1230mm
Weight: approx. 120kg

Required for Operation

230V, 50/60Hz, 1 phase or 230V, 60Hz/CSA,
3 phases

Scope of Delivery

- 1 trainer
- 1 cooling column type 1
- 1 GUNT software CD + USB cable
- 1 set of instructional material

Order Details

060.32000 WL 320 Wet Cooling Tower

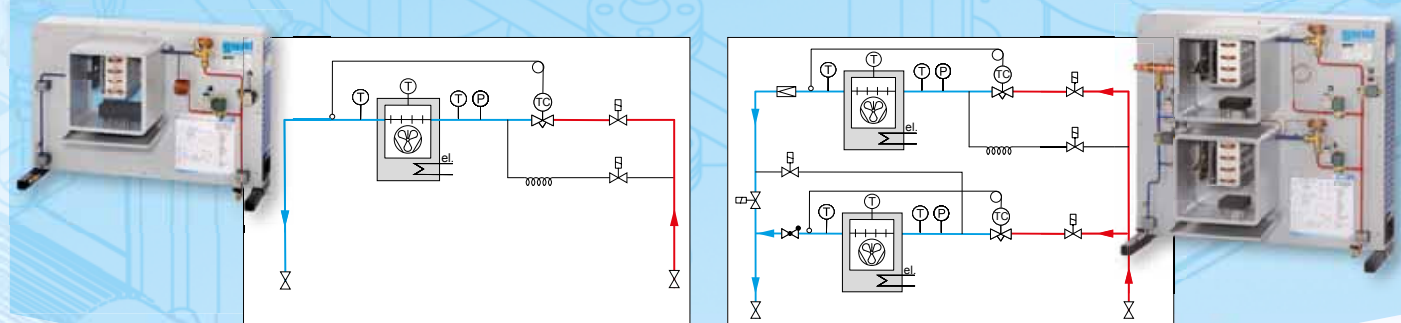
ET 915 HSI TRAINING SYSTEM FOR REFRIGERATION AND AIR CONDITIONING TECHNOLOGY

The experimental units

This series of units provides basic experiments for different areas of the refrigeration and air conditioning technology. The basic unit ET915 provides the components compressor and condenser; the accessory models include expansion elements and evaporator. The air conditioning model

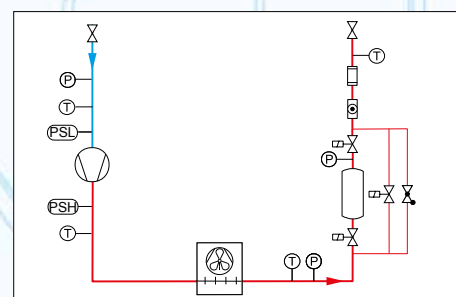
(ET 915.07) additionally includes a device for air humidification. Dependent on the objective of the experiment, the basic unit is combined with one of the accessory models to form a complete refrigeration circuit.

DEVICES FOR EXPERIMENTS FROM THE FIELD OF REFRIGERATION TECHNOLOGY



ET 915.01 Refrigerator Model

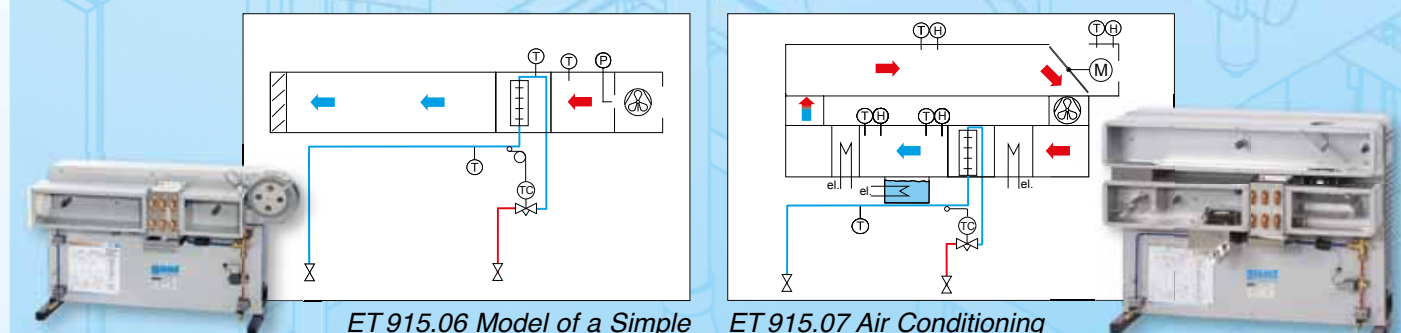
ET 915.02 Model of a Refrigeration System with Refrigeration and Freezing Stage



ET 915 Base Unit



DEVICES FOR EXPERIMENTS FROM THE FIELD OF AIR CONDITIONING TECHNOLOGY



ET 915.06 Model of a Simple Air Conditioning System

ET 915.07 Air Conditioning Model

The teaching software

GUNT has combined the fundamentals of refrigeration and air conditioning technology in an interactive learning software for you. The modern and powerful software is an integral part of the training system in the form of hardware/software integration (HSI). It enables the comfortable execution and analysis of the experiments.

The experimental unit is connected to the PC via a USB interface. The educational software guides step by step through the experiments. With explanatory texts and illustrations it significantly aids the understanding of the theoretical principles.

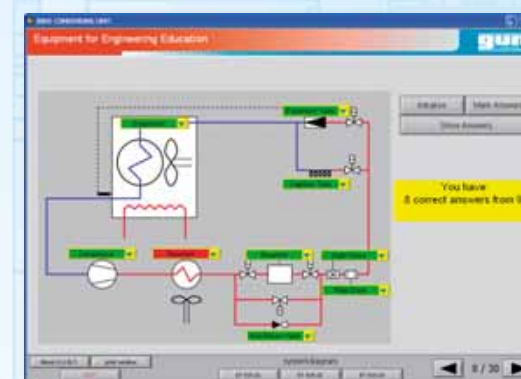
Dependent on the accessory models used and in conjunction with the educational software typical learning objectives are taught:

Refrigeration:

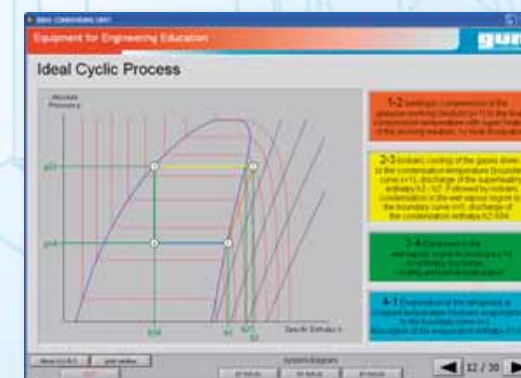
- Fundamentals of a refrigeration cycle
- Refrigeration systems and their main components
- Operation using several cooling stages
- Representation in the log p-h diagram

Air conditioning technology:

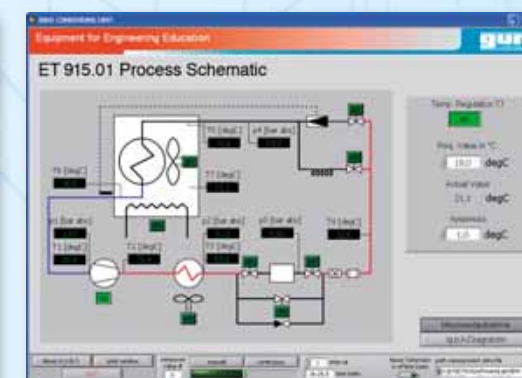
- Fundamentals of air conditioning
- Air conditioning systems and their main components
- Heating, cooling, humidifying and dehumidifying
- Representation in the h-x diagram



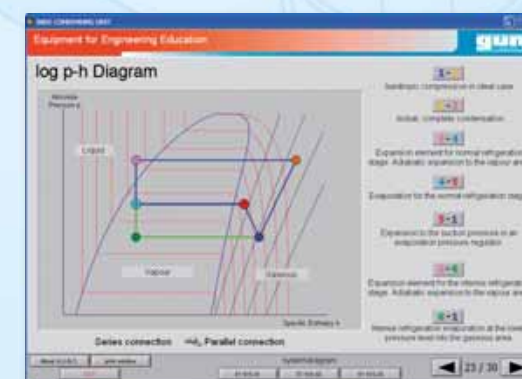
Questions to check the learning success



Representation of the ideal refrigeration cycle in the log p-h diagram and description of the changes of state



Process schematic of ET 915.01



Refrigeration cycle with evaporators connected in parallel

ET 915 HSI Training System Refrigeration and Air Conditioning Technology, Base Unit



- * Base unit for the set-up of basic experiments in refrigeration and air conditioning technology
- * Modern learning environment through hardware/software integration (HSI)
- * Four models on refrigeration and air conditioning technology

Technical Description

The base unit ET 915 is, dependent on the objective of the experiment, extended into complete refrigeration circuit with one of the models available as accessories (ET 915.01 refrigerator, ET 915.02 refrigeration system with refrigeration and freezing stage, ET 915.06 simple air conditioning system, ET 915.07 air conditioning).

The main components of ET 915 are compressor, condenser and receiver plus electrical and communications systems. The models are plugged onto the base unit and connected hydraulically with refrigerant hoses and electrically with cables. Self-sealing couplings reduce the refrigerant loss to a minimum. All components are arranged well visible to allow their operation to be monitored.

The modern and powerful software is an integral part of the training system in the form of hardware/software integration (HSI). It enables the comfortable execution and analysis of the experiments. The experimental unit is connected to the PC via a USB interface.

The educational software guides step by step through the experiments. With explanatory texts and illustrations it significantly aids the understanding of the theoretical principles. Temperatures and pressures in the system are recorded by sensors and displayed dynamically in the educational software. The effect of parameter changes can be tracked in log p-h and h-x diagrams. The system is also controlled via the software.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

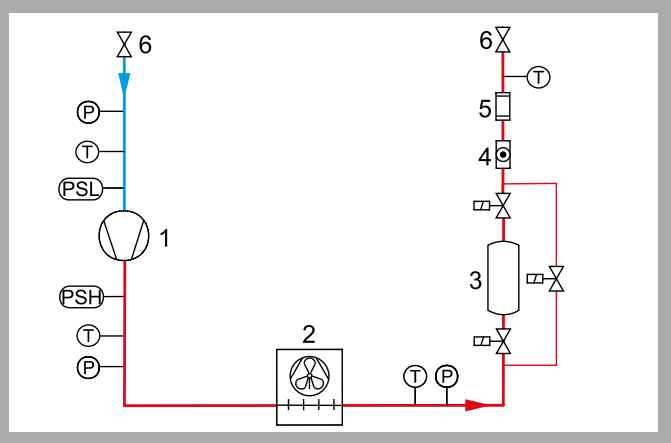
Learning Objectives / Experiments

- In conjunction with ET 915.01, ET 915.02, ET 915.06 and ET 915.07
- fundamentals of the refrigeration cycle
 - fundamentals of air conditioning
 - components in a refrigeration system/air conditioning system
 - system operation
 - fault finding

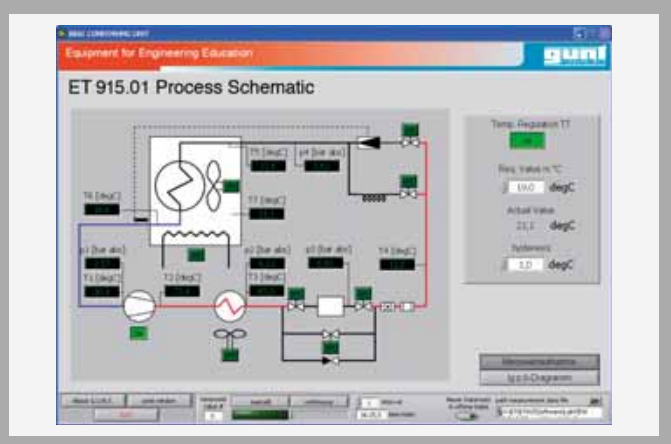
ET 915 HSI Training System Refrigeration and Air Conditioning Technology, Base Unit



1 compressor, 2 condenser with add-on fan, 3 receiver, 4 solenoid valve, 5 frame to mount the models, 6 filter/drier, 7 manometer, 8 pressure switch, 9 refrigerant hose



1 compressor, 2 condenser, 3 receiver, 4 sight glass, 5 filter/drier, 6 refrigerant hose for the models; PSH, PSL pressure switch; T temperature, P pressure; blue: low pressure, red: high pressure



Software screenshot: process schematic of the model ET 915.01. Measured values are displayed "online".

Specification

- [1] basic experiments on the operation of refrigeration and air conditioning systems by combining the base unit and models
- [2] GUNT training system with HSI technology
- [3] condensing unit consisting of compressor, condenser and receiver
- [4] connection between condensing unit and model via refrigerant hoses
- [5] model attached securely on ET 915 with fasteners
- [6] manometer for refrigerant with temperature scale
- [7] refrigerant R134a, CFC-free
- [8] system control via solenoid valves and software
- [9] functions of the GUNT software: educational software, data acquisition, system control
- [10] GUNT software for data acquisition via USB under Windows Vista or Windows 7

Technical Data

- Condensing unit
- refrigeration capacity: 340W at 0/32°C
- Receiver: 0,9L
- Measuring ranges
- temperature: 1x -50...50°C, 3x 0...100°C
 - pressure
 - 1x intake side: -1...9bar
 - 2x delivery side: -1...15bar

Dimensions and Weight

- LxWxH: 830x650x320mm
- Weight: approx. 60kg

Required for Operation

- 230V, 50/60Hz, 1 phase or 120V, 60Hz/CSA, 1 phase

Scope of Delivery

- 1 condensing unit, filled with refrigerant
- 1 GUNT software CD + USB cable
- 1 set of instructional material

Order Details

- 061.91500 ET 915 HSI Training System Refrigeration and Air Conditioning Technology, Base Unit

ET 915.06 Model of a Simple Air Conditioning System



- * Model of a simple air conditioning system for room cooling
- * Component control and fault simulation via the educational software

Technical Description

ET 915.06 is part of the HSI training system for refrigeration and air conditioning technology. In combination with the base unit ET 915 the operational model of a simple air conditioning system is created. The model is plugged onto the base unit, secured using fasteners and connected with refrigerant hoses to become a complete refrigeration circuit for the air cooler.

In systems for room cooling the air to be cooled is aspirated from the room by a fan, cooled and fed back into the room. This model demonstrates the principles of room cooling and the components of an air conditioning system.

The model ET 915.06 includes an air duct with transparent front, fan for air transport, an evaporator as air cooler and an expansion valve. All components are clearly arranged on a panel.

The individual components of the system, here the compressor and the fan, are controlled via the software included in the scope of delivery of ET 915. The software offers the option to simulate faults.

The volumetric air flow rate is determined via a differential pressure measurement. Temperatures before and after the evaporator are recorded by sensors, digitised and dynamically represented in the educational software.

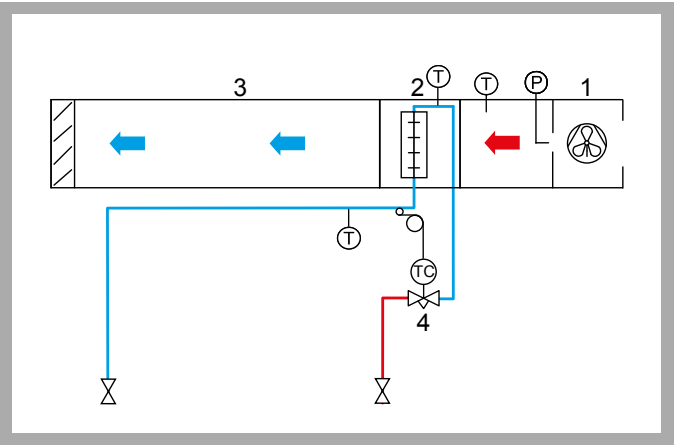
Learning Objectives / Experiments

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

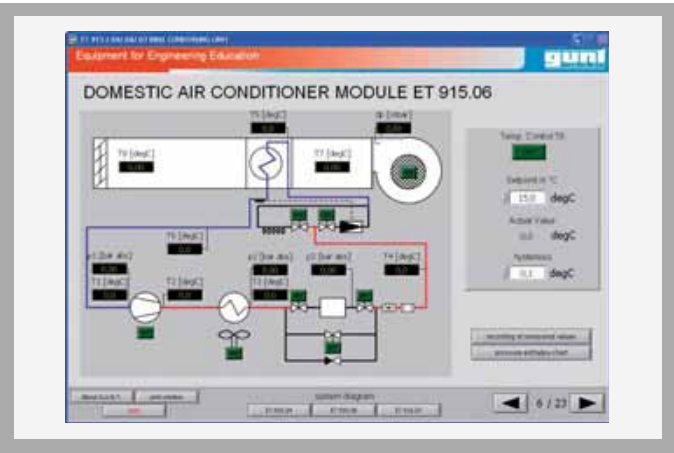
ET 915.06 Model of a Simple Air Conditioning System



1 evaporator as air cooler, 2 air duct, 3 temperature sensor, 4 process schematic, 5 connections for ET 915, 6 solenoid valve, 7 expansion valve, 8 radial fan, 9 differential pressure sensor



Process schematic of the simple air conditioning system model: 1 radial fan, 2 air cooler, 3 air duct, 4 expansion valve; T temperature, P pressure; red arrow: hot, blue arrow: cold; blue: low pressure, red: high pressure



Software screenshot: process schematic of the model ET 915.06

Specification

- [1] model of a simple air conditioning system to plug onto the base unit ET 915
- [2] GUNT training system with HSI technology
- [3] air duct with transparent front
- [4] evaporator as air cooler
- [5] radial fan with throttle valve
- [6] thermostatic expansion valve as expansion element
- [7] sensors to record temperature and differential pressure for determining the volumetric air flow rate
- [8] units and fault simulation controlled via educational software

Technical Data

- Air duct: 136x136x435mm
- Evaporator as air cooler
 - transfer area: approx. 900cm²
- Radial fan
 - max. power consumption: 80W
 - max. flow rate: 255m³/h

Measuring ranges

- temperature: 2x -50...50°C, 2x 0...100°C
- differential pressure: 0...10mbar

Dimensions and Weight

- LxWxH: 970x370x600mm
- Weight: approx. 35kg

Scope of Delivery

- 1 model of a simple air conditioning system, filled with refrigerant

Order Details

- 061.91506 ET 915.06 Model of a Simple Air Conditioning System

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 control and fault simulation via the educational software

Technical Description

ET 915.07 is part of the HSI training system for refrigeration and air conditioning technology. In combination with the base unit ET 915 the operational model of a full air conditioning system is created. The model is plugged onto the base unit, secured using fasteners and connected with refrigerant hoses to become a complete refrigeration circuit for the air cooler.

The room climate is created by the interaction of air temperature, heating temperature and air humidity. The purpose of room air conditioning is to shape the room climate in accordance with the requirements of people or sensitive goods. This model introduces the operation of an air conditioning system and the recirculating air and outer air operating modes.

The model ET 915.07 includes two air ducts with transparent front. The top air duct serves as climatic chamber whilst the bottom air duct contains the air cooler, two electric air heaters and a steam humidifier. A fan between the two air ducts recirculates the air. A motorised butterfly valve in the top air duct allows a change between outer air and recirculating operation. Dependent on the switching of the two air heaters, the air cooler and the humidifier, the air in the duct system can be cooled, heated, humidified or dehumidified.

The individual system components are controlled via the educational software which is included in the scope of delivery of the base unit ET 915. Temperature and humidity before and after the evaporator and

in the climatic chamber are recorded by sensors, digitised and represented dynamically in the educational software. The conditioning of the air can be monitored online in the h-x diagram.

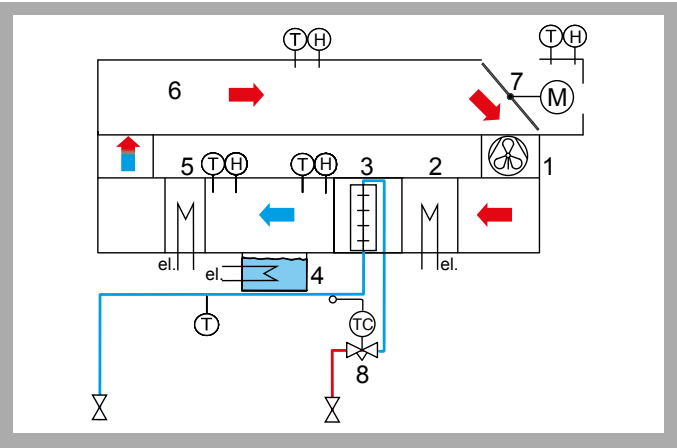
Learning Objectives / Experiments

- Full air conditioning system and its main components
- Heating and cooling in the h-x diagram
- Humidifying and dehumidifying in the h-x diagram
- Outer air and recirculating operation
- Fault simulation

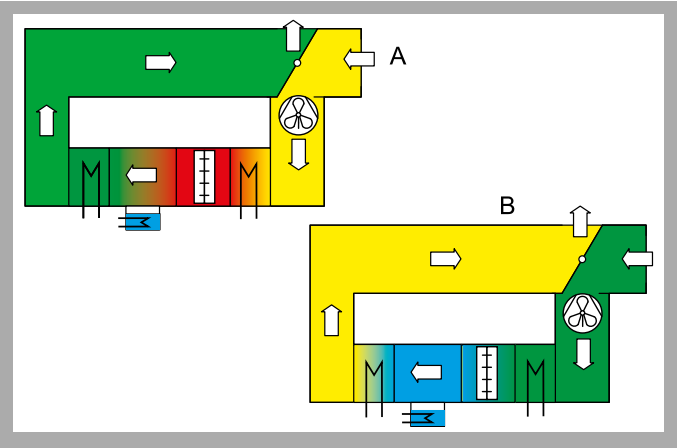
ET 915.07 Air Conditioning Model



1 air duct, 2 air reheater, 3 process schematic, 4 air humidifier, 5 connections for ET 915, 6 evaporator, 7 expansion valve, 8 air preheater, 9 fan, 10 sensors for humidity and temperature, 11 ventilation flap



Air conditioning with recirculating operation: 1 fan, 2 air preheater, 3 air cooler, 4 air humidifier, 5 air reheater, 6 air duct, 7 ventilation flap with servomotor, 8 expansion valve; T temperature, P pressure, H humidity; red arrow: hot, blue arrow: cold; blue: low pressure, red: high pressure



Air conditioning with outer air operation; A: humidification, B: dehumidification; yellow: dry, green: humid, blue: cooling, red: heating

Specification

- [1] Model of an air conditioning system to plug onto the base unit ET 915
- [2] GUNT training system with HSI technology
- [3] Air duct with transparent front and adjustable ventilation flap for recirculating or outer air operation
- [4] Evaporator as air cooler
- [5] 2 heaters as air preheater and reheater
- [6] Air humidifier with float switch, fan, filling level indication
- [7] Thermostatic expansion valve as expansion element
- [8] Sensor to record temperature and combined sensor for humidity and temperature
- [9] Units and fault simulation controlled via educational software

Technical Data

- Air duct, top: 136x136x800mm
- Evaporator as air cooler
- transfer area: approx. 900cm²
- Air heater: 2x 250W
- Axial fan
- max. power consumption: 19W
- max. flow rate: 160m³/h
- Humidifier
- heater: 200W
- Servomotor for ventilation flap: 24VDC

Measuring ranges

- temperature: 2x -50...50°C, 4x 0...50°C
- humidity: 4x 10...100% r.h.

Dimensions and Weight

- LxWxH: 850x400x680mm
- Weight: approx. 51kg

Scope of Delivery

- 1 air conditioning system model, filled with refrigerant

Order Details

- 061.91507 ET 915.07 Air Conditioning Model

ET 605 AIR CONDITIONING SYSTEM MODEL...

A practical air conditioning system model with all elements and functions

The principles of air conditioning technology can be taught optimally with the model ET 605. The air conditioning system consists of an air duct with transparent front and a climatic chamber with two different cooling loads. The overall design of the system is guided by instructional and methodological aspects and thereby supports the learning process.

The main functions of the system – cooling, heating, humidifying, air transport – are activated or deactivated via switches. Recirculating and outer air operation are possible. All relevant measuring data can be read on digital displays.

An important extension of the teaching objectives is provided by the option to extend the system with different additions into a fully automated system.



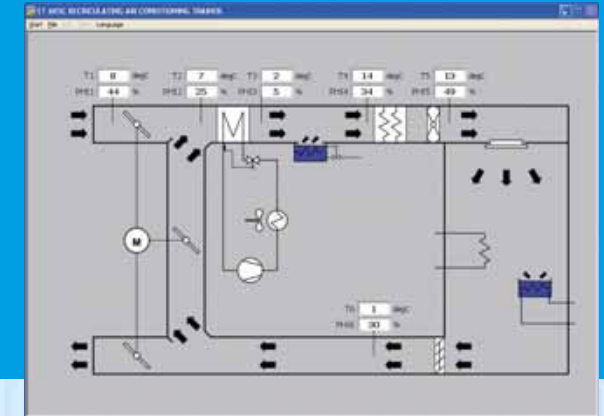
...PLUS AUTOMATION SOLUTIONS

THE SOFTWARE SOLUTION: CLEAR AND VERSATILE

ET 605.01 SOFTWARE CONTROLLER WITH DATA ACQUISITION

Data acquisition and visualisation, control and operation in a single software solution

This solution is recommended if the focus is on instructional and methodological criteria. Compared to an industrial controller the software offers an attractive and very clear representation of the air conditioning process.



THE INDUSTRIAL SOLUTION

ET 605.02 AIR CONDITIONING CONTROLLER

This automation solution is recommended if the training objective focuses on the exact familiarisation with an industrial air conditioning controller. The controller matched to the ET 605 system offers a wide functional spectrum and a graphical display. Dependent on the desired temperature and humidity in the climatic chamber it controls the components.



THE RIGHT TOOL FOR IMPLEMENTING YOUR OWN IDEAS

ET 605.03 I/O CONNECTION BOX

This solution is recommended if the focus is on the topic of automation and own solutions are to be created. The connection box provides all relevant input and output signals which the user can further process according to his own requirements and ideas. The connection of any industrial air conditioning controller or independently written software are possible.



ET 605 Air Conditioning System Model



- * Climatic chamber with latent and sensitive heat source as cooling load
- * Recirculating and outer air operation
- * Optional data acquisition software (ET 605.01)
- * Connection options for the use of different automation solutions

Technical Description

Air conditioning technology is a key topic in building services engineering. For this reason air conditioning technology plays an important role during the training of skilled workers and engineers.

The clear trainer ET 605 represents a complete air conditioning system with an air duct and a climatic chamber. The main components of the air conditioning system are the air cooler with condensing unit, fan, steam humidifier and air heater. Three motorised ventilation flaps control the air distribution in the air conditioning system. The climatic chamber is equipped with two different heat sources (wet and dry). Temperature and relative humidity are measured at relevant points in the air duct and displayed digitally. For the refrigeration circuit two manometers with integrated temperature scale and a flow meter provide all relevant measurements.

ET 605 is operated manually. A key feature of the air conditioning system is that it is fully ready for various automation solutions. The user can thus focus on this important topic during a lesson.

The following solutions are available:

- Software controller ET 605.01
- Industrial air conditioning controller ET 605.02
- Signal connection box ET 605.03 for the integration of an individual user solution.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

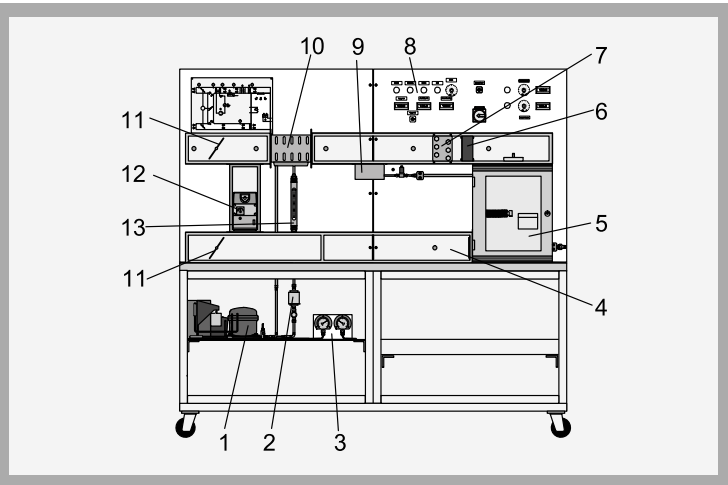
Learning Objectives / Experiments

- air conditioning system and its components
- conditioning room air
- mixing different air flows
- representation in the h-x diagram for humid air
- * humidification and dehumidification
- * heating and cooling
- representation of the circuit in the log p-h diagram
- effect of a cooling load (dry and wet)
- recirculating and outer air operation

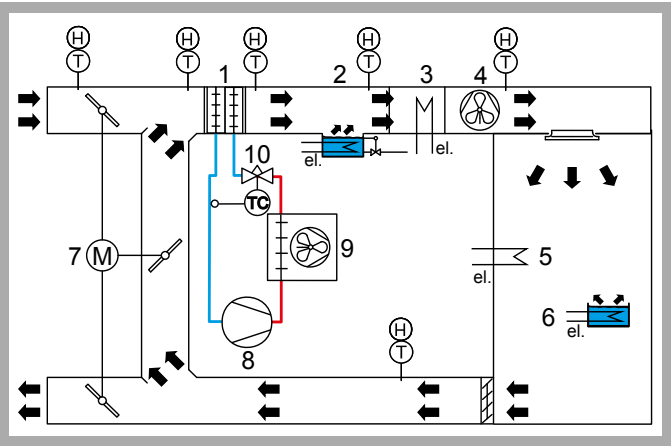
In conjunction with optional accessories

- automation in an air conditioning system

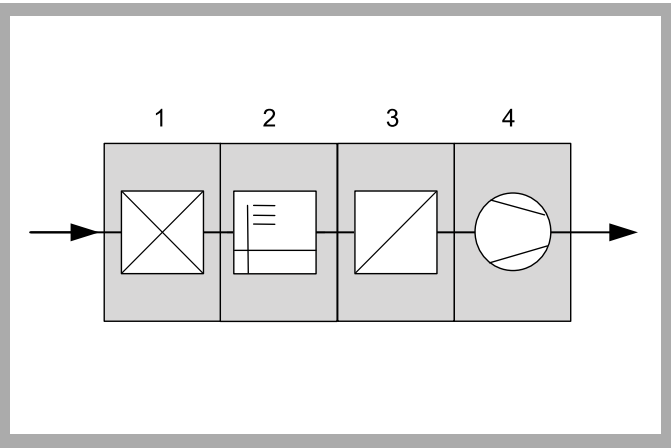
ET 605 Air Conditioning System Model



1 condensing unit, 2 filter/drier (refrigerant), 3 refrigerant manometer, 4 air duct with temperature/humidity sensor, 5 climatic chamber with sensitive and latent heat source, 6 fan, 7 air heater, 8 displays and controls, 9 humidifier, 10 air cooler, 11 ventilation flaps, 12 servomotor, 13 refrigerant flow meter



1 air cooler, 2 humidifier, 3 air heater, 4 fan, 5 sensitive heat source, 6 latent heat source, 7 servomotor for ventilation flaps, 8 compressor, 9 condenser, 10 expansion valve; T temperature, H humidity



Schematic set-up of the air conditioning system in accordance with DIN 1946
1 air cooler, 2 air humidifier, 3 air heater, 4 fan

Specification

- [1] model of an air conditioning system with outer air and recirculating operation
- [2] air duct with transparent front
- [3] air duct with fan, air cooler, humidifier, flaps, air heater and sensors
- [4] chamber with wet (latent) and dry (sensitive) heat source as cooling load
- [5] motorised flaps for recirculating and outer air operation
- [6] process schematic with signal lamps
- [7] air conditioning system ready for different automation solutions: 4 data cable connections to integrate the accessories
- [8] refrigerant R134a, CFC-free

Technical Data

- Air-cooled condensing unit
- power consumption: 140W at -10°C
 - refrigeration capacity: 320W at +5/40°C
- Humidifier
- heating power: 400W
- Air heater
- heating power: 360W
 - 2 heaters in the chamber as cooling load
 - power output: 0...250W each, freely adjustable
- Flow cross-section of the air duct
- WxH: 155x155mm

Measuring ranges

- temperature: 0...50°C
- humidity: 10...90% r.h.
- power: 0...600W (power consumption of the compressor in the condensing unit); 2x 0...300W (cooling loads)
- pressure (refrigerant): -1...9bar / -1...24bar
- flow rate (refrigerant): 1,5...23,5L/h
- air velocity: 0...2,5m/s

Dimensions and Weight

LxWxH: 2010x760x1910mm
Weight: approx. 309kg

Required for Operation

230V, 50/60Hz, 1 phase or 230V, 60Hz, 3 phases
Water connection

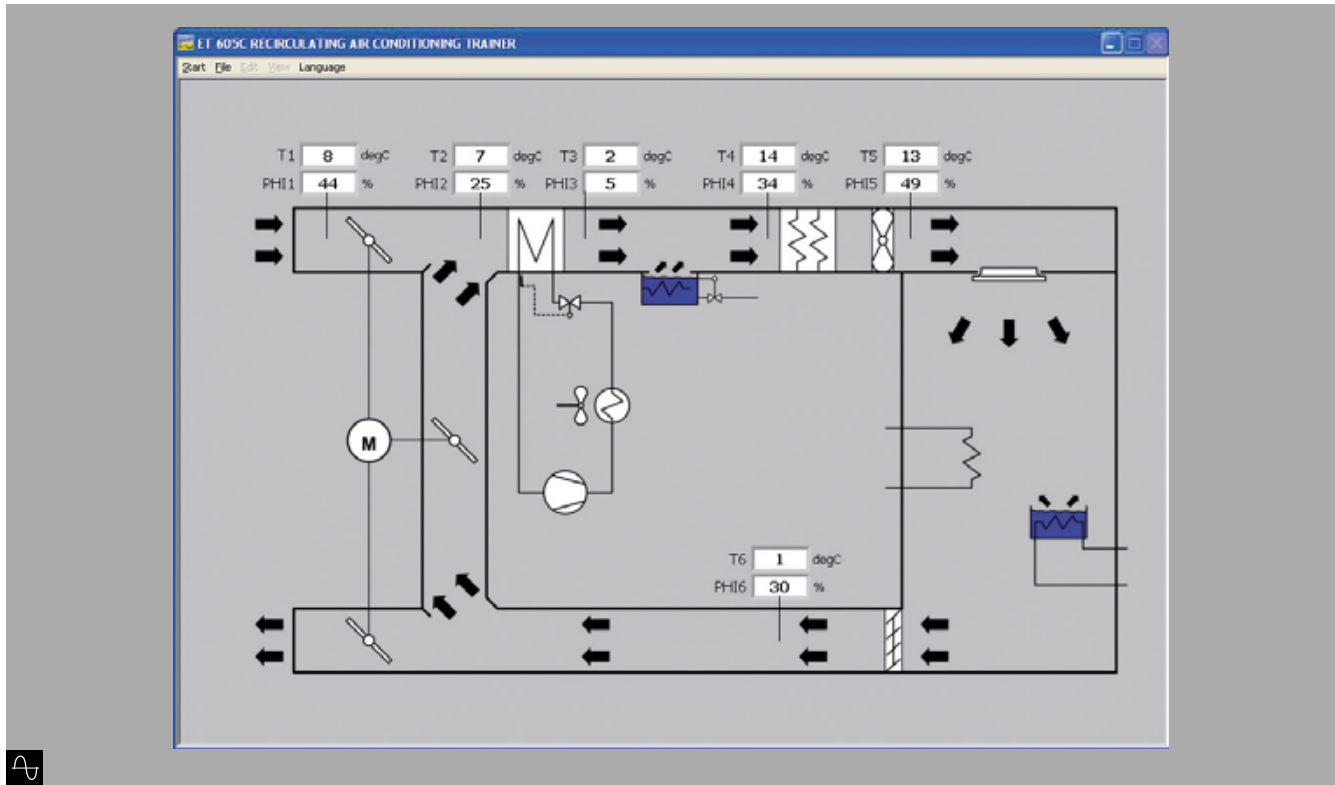
Scope of Delivery

1 trainer, filled with refrigerant
1 set of instructional material

Order Details

061.60500 ET 605 Air Conditioning System Model

ET 605.01 Software Controller with Data Acquisition



- * Automation solution for ET 605 via software
- * Visualise, measure, control
- * Changes of state in the h-x diagram, progression over time

Technical Description

The software includes data acquisition capability and an air conditioning controller enabling the automation of the air conditioning system ET 605. Via the controller components (e.g. air heater, flaps) are controlled to achieve preset temperatures and humidities in the climatic chamber. The periods of use of the air conditioning system can be selected in a time program for each day. All relevant measured values are recorded, analysed and displayed as time progression and in the h-x diagram. The software features better display options than an industrial controller. Therefore this automation solution offers the greatest benefits for instruction purposes.

Learning Objectives / Experiments

- familiarisation with and use of the automation solution via software for the air conditioning system ET 605
- online representation of temperatures, humidities (relative and absolute), air velocity, heating capacity of the heat source (latent and sensitive), position of the ventilation flaps, operating phases of air cooler / air heater / fan / humidifier

Scope of Delivery

1 GUNT software CD + USB cable, 1 manual with description of the software functions and their use

Specification

- [1] menu-guided GUNT software
- [2] data acquisition and evaluation
- [3] control of an air conditioning system using a software controller
- [4] logger function
- [5] process schematic with online data representation
- [6] integrated h-x diagram with representation of the actual measured values
- [7] language freely selectable

Technical Data

Software basis: LabVIEW
System requirements
- PC with Windows Vista or Windows 7

Order Details

061.60501 ET 605.01 Software Controller with Data Acquisition

G.U.N.T. Gerätebau GmbH, Hanskampring 15-17, D-22885 Barsbüttel, Phone +49 (40) 67 08 54-0, Fax +49 (40) 67 08 54-42, E-mail sales@gunt.de, Web http://www.gunt.de
We reserve the right to modify our products without any notifications.

ET 605.02 Air Conditioning Controller



- * Industrial automation solution for ET 605
- * PLC-based controller with comprehensive functions and graphical display

Technical Description

The air conditioning controller ET 605.02 is harmonised with the air conditioning system ET 605. It controls the temperature and humidity in the chamber. In addition there is a time program to define the periods of use, an energy selection circuit and a frost protection monitor. The combined temperature and humidity sensors in ET 605 record the condition of the supply and exhaust air of the chamber. To compensate for the control deviation the controller controls the ventilation flaps, air heater and air cooler. This automation solution is recommended if the training objective focuses on the exact familiarisation with an industrial air conditioning controller.

Learning Objectives / Experiments

- Familiarisation with and use of modern air conditioning controllers
 - * exhaust air temperature cascade control, humidity control
 - * start-up circuit
 - * energy selection circuit (control of the ventilation flaps)
 - * frost protection

Scope of Delivery

1 controller
1 set of data cables
1 instruction manual

Specification

- [1] Air conditioning controller with PLC technology
- [2] Representation of the system schematic with the key process variables in the controller display
- [3] General I & C functions
- [4] Automatic and manual operation possible
- [5] Summer and winter operation, frost protection monitor
- [6] User-friendly design of the menu guidance; language freely selectable

Technical Data

PLC controller
- 17 universal inputs
- 10 binary switching outputs
- 4 analogue outputs
Continuous control of the ventilation flaps
2 point control of
- air heater / air cooler / air humidifier / fan

Dimensions and Weight

l x w x h: 370 x 330 x 150 mm
Weight: approx. 5 kg

Required for Operation

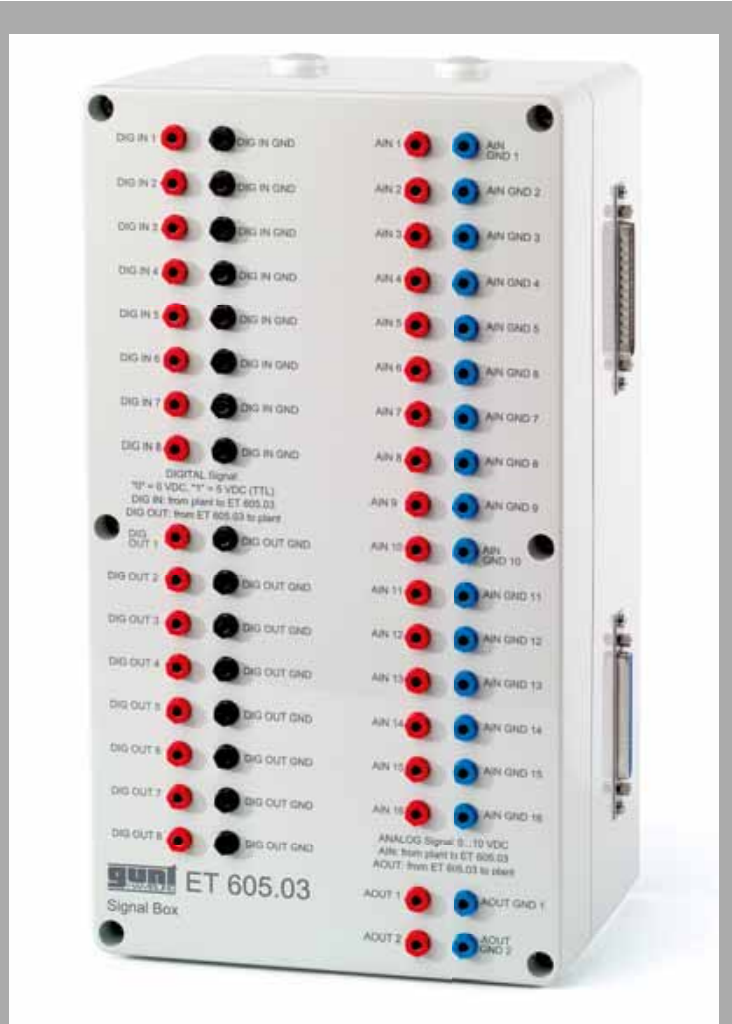
230V, 50/60Hz, 1 phase or 120V, 60Hz/CSA, 1 phase

Order Details

061.60502 ET 605.02 Air Conditioning Controller

G.U.N.T. Gerätebau GmbH, Hanskampring 15-17, D-22885 Barsbüttel, Phone +49 (40) 67 08 54-0, Fax +49 (40) 67 08 54-42, E-mail sales@gunt.de, Web http://www.gunt.de
We reserve the right to modify our products without any notifications.

ET 605.03 I/O Connection Box



Specification

[1] Connection box to connect the external automation solution for ET 605
[2] Lab jacks with defined input and output signals
[3] Parameterisation and configuration of the external solution by the user, e.g. of a controller
[4] Connection between box and ET 605 via 2 included ribbon cables

Technical Data

16 analogue inputs, 0...10VDC
- 6x temperature
- 6x relative humidity
- 2x power: sensitive heat source, latent heat source
- air velocity
- ventilation flap position

2 analogue outputs (1 unused), 0...10VDC
- 1x control of the ventilation flap position

8 digital inputs (3 unused), TTL=0VDC / 5VDC
- 5x message: operating state of the components (air cooler, humidifier, air heater, additional water for humidifier, fan)

8 digital outputs (4 unused), TTL=0VDC / 5VDC
- 4x switch on/off for a component (air cooler, humidifier, air heater, fan)

Dimensions and Weight

l x w x h: 360 x 220 x 170 mm
Weight: approx. 4 kg

Scope of Delivery

1 connection box
2 ribbon cables
1 layout diagram

- * Set-up of an individual automation solution for ET 605
- * Provision of all relevant I/O signals for free further processing

Technical Description

With the connection box ET 605.03 it is possible to connect e.g. a customer's own controller to the air conditioning system ET 605. When appropriately configured and parameterised by the user, this controller then takes care of the control of the air conditioning system. The definitions in the input and output signals must be observed. The controller is connected to the box via lab jacks. The connection to the air conditioning is via two ribbon cables included.

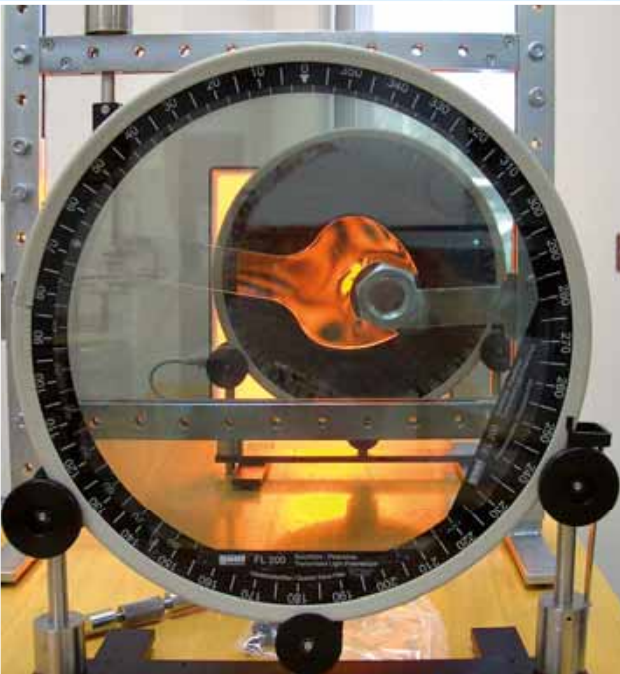
This solution is recommended if the focus is on the topic of automation and own solutions are to be created.

Order Details

061.60503 ET 605.03 I/O Connection Box

G.U.N.T Gerätebau GmbH, Hanskampring 15-17, D-22885 Barsbüttel, Phone +49 (40) 67 08 54-0, Fax +49 (40) 67 08 54-42, E-mail sales@gunt.de, Web <http://www.gunt.de>
We reserve the right to modify our products without any notifications.

A LOOK INSIDE OUR CUSTOMERS' LABORATORIES



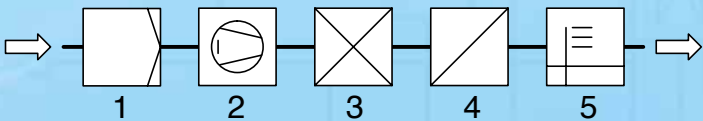
GUNT demonstration and experimentation units have been in use for many years at hundreds of technical education and training centres, and have always proved highly satisfactory to our customers

The very finest design and detailing:
Working with GUNT demonstration and experimentation units teaches students in an engaging, illustrative manner.

BASIC KNOWLEDGE

SET-UP OF AN AIR CONDITIONING SYSTEM

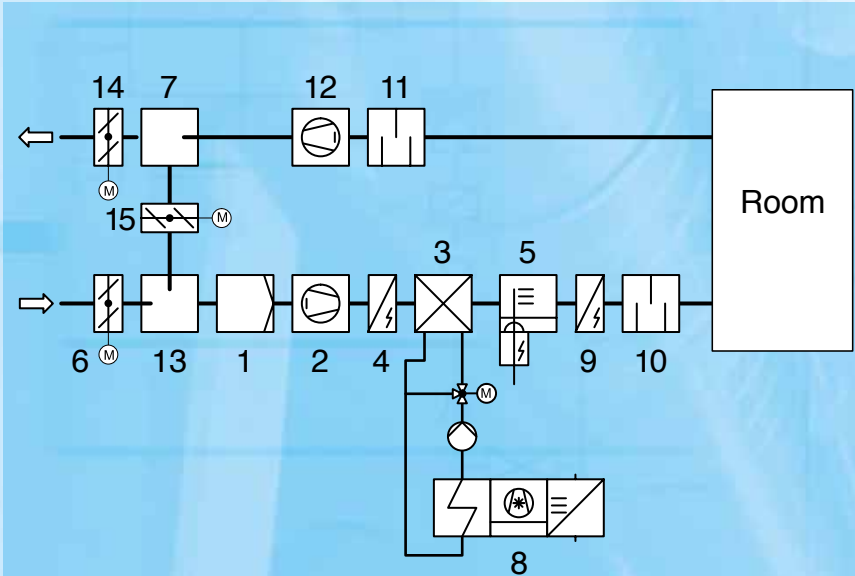
Simple full
air conditioning system



A full air conditioning system consists in its most simple form of the following components:

- 1 air filter: removes dust and dirt from the air
- 2 fan: aspirates the air and transports it through the system
- 3 air cooler: cools and dehumidifies the air
- 4 air heater: heats the air and compensates for the temperature loss during humidification and dehumidification
- 5 air humidifier: adds humidity to the air

Real air conditioning systems are usually more complex in design. To save energy, the waste air from the room can be returned to the room after processing. This is called recirculating operation. The ratio of recirculating air and outer air is controlled by throttle valves or flaps. In the diagram shown below the air cooler is supplied with cold water from a water chiller. Steam humidifier and air heater are heated electrically.



- Complex air conditioning system with recirculating operation**
- 1 air filter
 - 2 air inlet fan
 - 3 air cooler
 - 4 electric air preheater
 - 5 steam humidifier with electrically heated steam generator
 - 6 outer air flap
 - 7 distribution chamber
 - 8 water chiller with compression refrigerating machine in block construction with air-cooled condenser
 - 9 electric air reheater
 - 10 inlet air silencer
 - 11 silencer
 - 12 exhaust air fan
 - 13 mixing chamber
 - 14 exhaust air flap
 - 15 recirculating air flap

AIR COOLER, AIR HEATER, AIR HUMIDIFIER

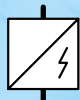


Air cooler

direct evaporator of a compression refrigeration system
Advantage: simple and cheap design

cold water circuit with compression refrigeration system
Advantage: several coolers can be operated via one refrigeration system

Direct evaporator
as air cooler

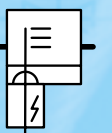


Air heater

electric air heater
Advantage: simple design, easy to control

hot water circuit with boiler
Advantage: all fuels and heat sources possible, several air heaters can be connected to one heat source

Electric air heater



Air humidifier

steam humidifier
Advantage: no cooling by condensation, hygienic

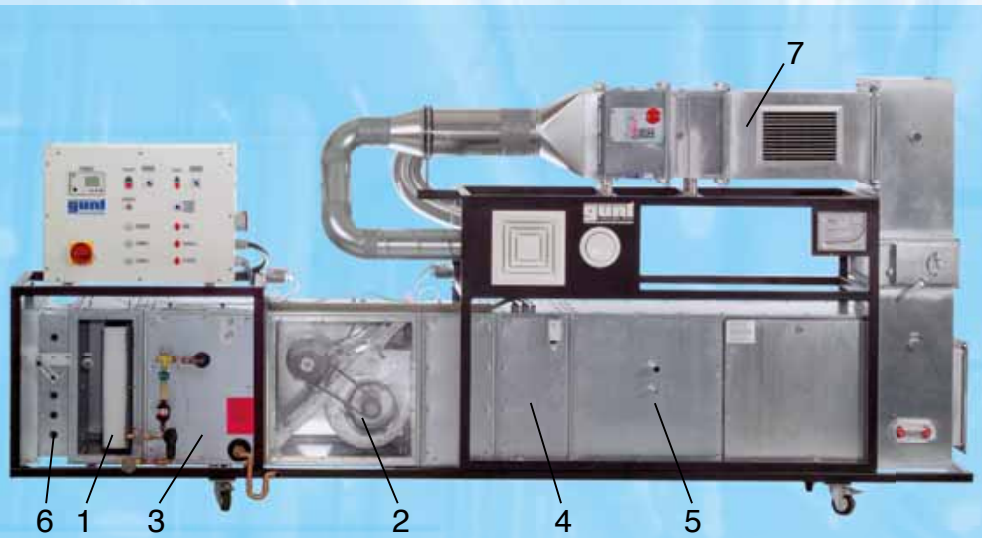
spray humidifier with mist collector
Advantage: can also operate as air cooler

Steam humidifier



ET 620 Air Conditioning
and Ventilation System

- 1 air filter
- 2 fan
- 3 air cooler
- 4 air heater
- 5 humidification chamber
- 6 ventilation flap
- 7 distribution system with flaps and outlets



An example from practice:
industrial air conditioning
system with comprehen-
sive filters for clean room
production

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

Technical Description

In many daily situations the condition of the ambient air does not meet requirements for e.g. a tropical greenhouse, the manufacture of sensitive components or even comfortable offices. The flow velocity, temperature and humidity of the air can be modified by air conditioning systems in accordance with the requirements for the desired room climate.

The trainer ET 600 examines the operation and effect of the individual components of an air conditioning system. ET 600 includes all the components also used in building services engineering. Particular importance was placed on the use of original components.

For air conditioning, air cooler (direct evaporator with condensing unit), steam humidifier, fan, air preheaters and reheaters are arranged in an open air duct. Each of these components can be switched on or off individually. The effect of each individual component on the conditioning of the air is as interesting as the effect of any combination of components.

Sensors record the air temperature and air humidity before and after each stage as well as the pressures and temperatures of the refrigerant. The measured values can be read on digital displays. At the same time, the measured values can also be transmitted directly to a PC via USB. The data acquisition software is included.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

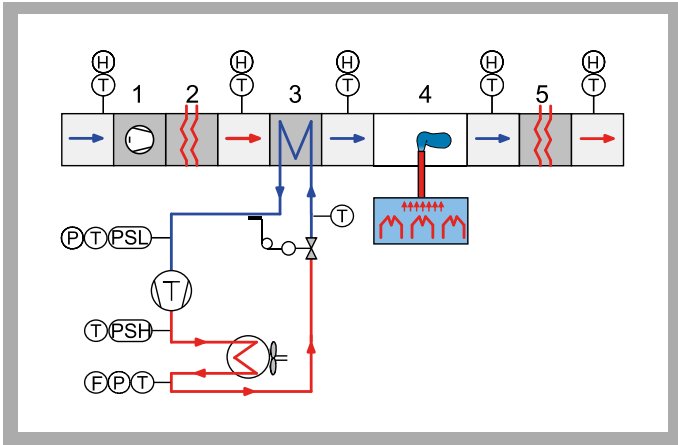
Learning Objectives / Experiments

- air conditioning of room air
 - * set-up of an air conditioning system: main components and their function
 - * variables in air conditioning
 - * measure temperature and air humidity
 - * effect of the air flow
 - * changes of state in the h-x diagram
- set-up of a refrigeration system: main components and their function
- measurements in the refrigeration circuit
 - * cyclic process in the log p-h diagram
 - * determine heating and cooling capacities

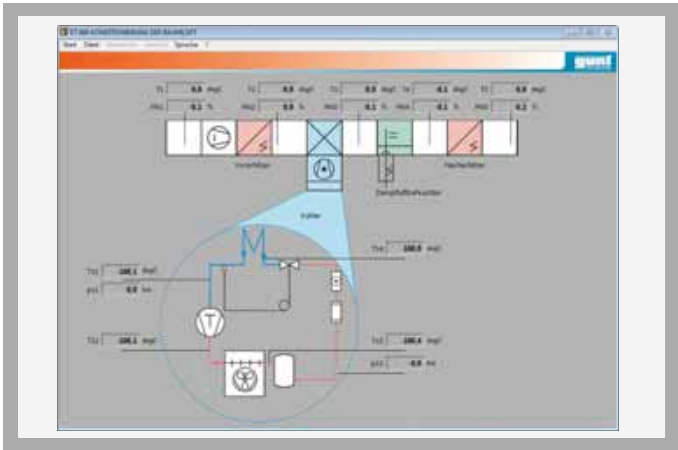
ET 600 Conditioning of Room Air



1 controls, 2 air cooler (direct evaporator), 3 fan, 4 air preheater, 5 temperature sensor, 6 condensing unit, 7 air humidifier, 8 air reheater, 9 air duct, 10 inclined tube manometer, 11 displays



Set-up of the air conditioning system: 1 fan, 2 air preheater, 3 air cooler, 4 air humidifier, 5 air reheater; sensors: H humidity, T temperature, P pression, F flow



Software screenshot: process schematic

Specification

- [1] effect of typical air conditioning system components on the conditioning of room air
- [2] air conditioning system with open air duct
- [3] air conditioning system with air cooler, steam humidifier, fan, air preheaters and reheaters
- [4] all components can be switched on and off individually
- [5] determination of the volumetric air flow rate by differential pressure measurement using an inclined tube manometer
- [6] combined sensors for the air humidity and temperature before and after each stage
- [7] sensor for the pressure and temperature of the refrigerant
- [8] data acquisition with GUNT software under Windows Vista or Windows 7 via USB
- [9] software with representation in the log p-h and h-x diagram
- [10] refrigerant R134a, CFC-free

Technical Data

- Steam humidifier
- power consumption: 4kW
 - steam capacity: 5,5kg/h, switchable in three stages
- Fan
- power consumption: 190W
 - max. volumetric flow rate: 810m³/h
 - speed: 500...1150min⁻¹
 - dp_{max}: 420Pa
- Air preheater: 2kW, switchable in two stages
- Air reheater: 1kW, switchable in two stages
- Air duct, WxH: 300x350mm
- Direct evaporator as air cooler: 6kW
- Condensing unit
- power consumption: 968W at 5/25°C
 - refrigeration capacity: 2,3kW at 5/25°C
- Measuring ranges
- differential pressure (volumetric air flow rate): 0...100Pa
 - temperature: 5x 0...50°C, 4x -100...200°C
 - humidity: 5x 0...100%
 - pressure (refrigerant): 2x 0...16bar
 - flow rate (refrigerant): 8...102L/h

Dimensions and Weight

LxWxH: 2565x790x1750mm
Weight: approx. 180kg

Required for Operation

400V, 50Hz, 3 phases or 230V, 60Hz, 3 phases
Water connection and drainage

Scope of Delivery

- 1 trainer, filled with refrigerant
- 1 GUNT software CD + USB cable
- 1 set of instructional material

Order Details

061.60000 ET 600 Conditioning of Room Air

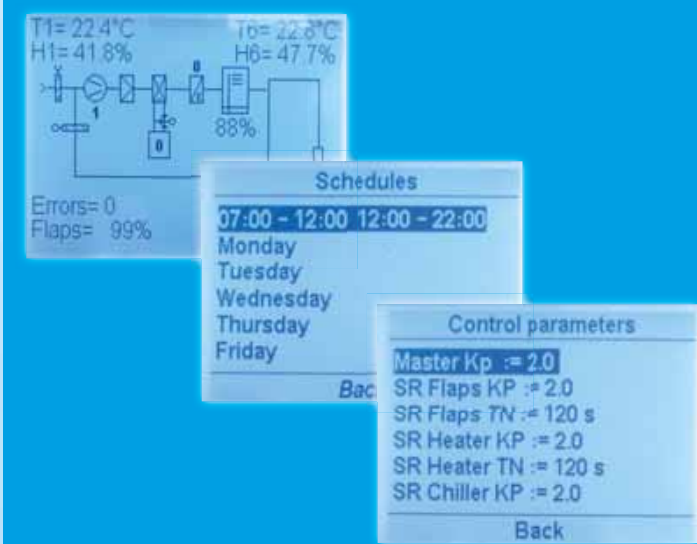
ET 611 AIR CONDITIONING SYSTEM WITH CHAMBER FOR COMFORT INVESTIGATIONS



MORE THAN A QUANTITATIVE INVESTIGATION OF THE ROOM CLIMATE:
EXPERIENCE COMFORT WITH YOUR OWN BODY

The air conditioning of the air takes place in a closed chamber large enough for test persons to be inside. This allows for the effect of the room climate on the personal perception to be investigated. ET 611 is a real system including typical components of larger air conditioning systems: water chiller, PLC controller, filter cartridge. The system operates in outer air and recirculating operation.

CLIMATE CONTROLLER WITH PLC

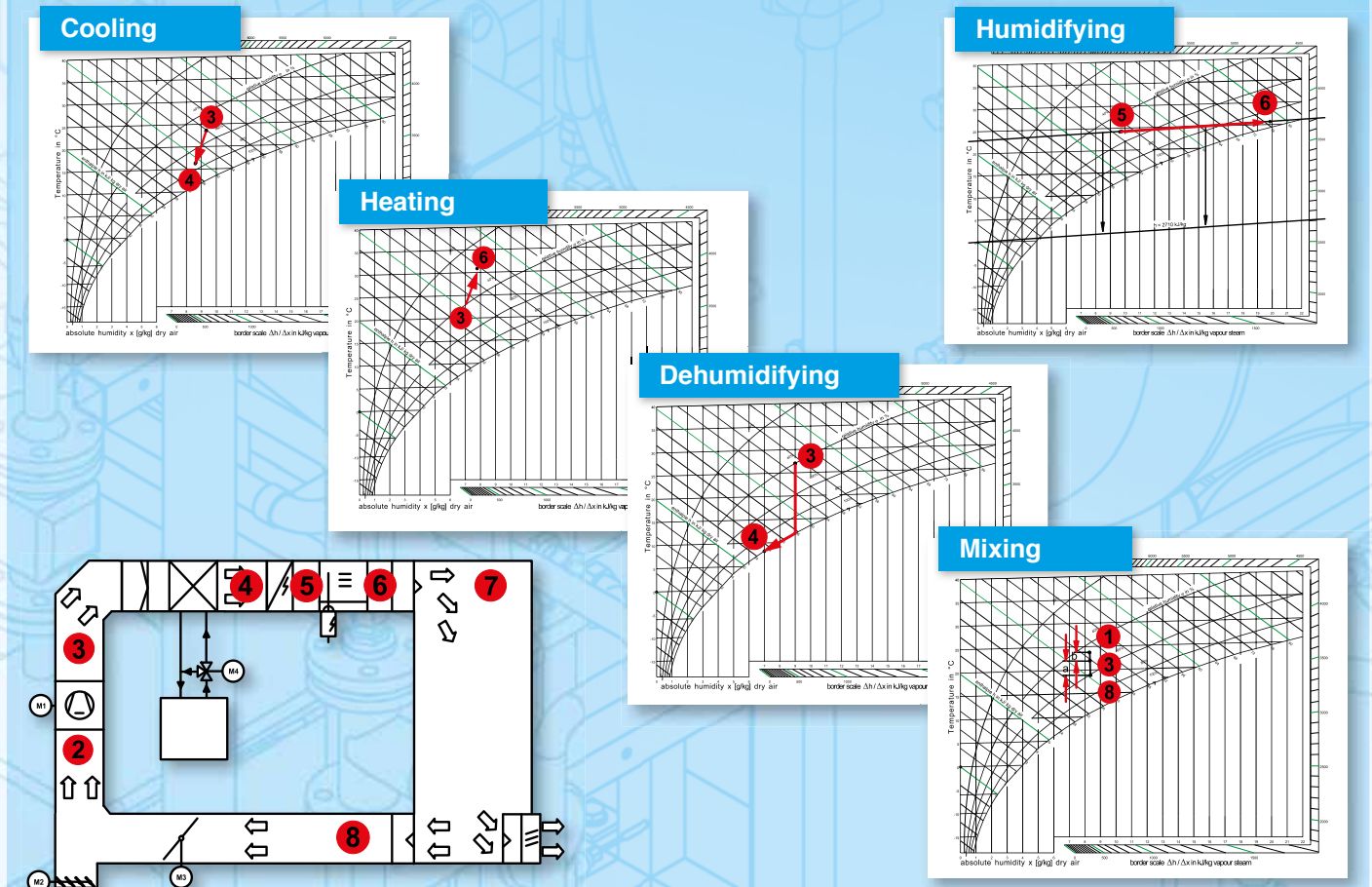


The operation of the air conditioning system is via a PLC. Handling the different PLC functions is learned step by step:

- Display of alarms
- Display of measured values
- Input of reference variables
- Input of control parameters
- Input of limit values

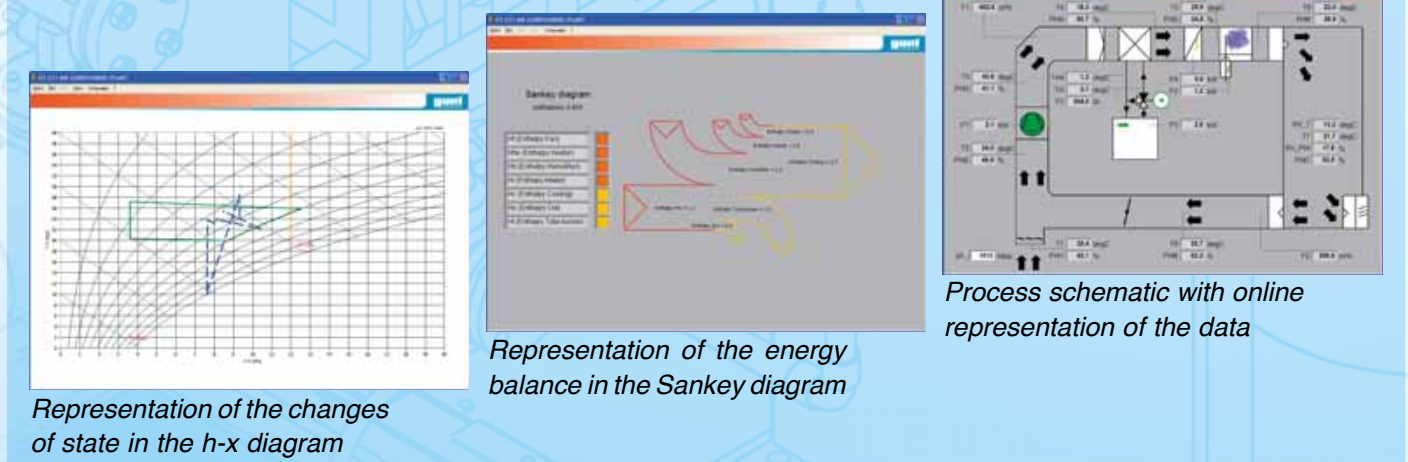
...and much more.

INSTRUCTIONAL MATERIAL AND SOFTWARE:
THE AID FOR FAST LEARNING SUCCESS



The instructional material clearly demonstrates at which locations of the air conditioning system the different changes of the state of the air take place. The manual measurement only indicates the stationary states. In addition to time curves the software enables the dynamic display of the measured

values in the h-x diagram to better monitor transient processes. The task of the trainee is to read the measured values at the relevant locations of the air conditioning system, enter these data correctly into the h-x diagram and analyse them.



ET 611 Air Conditioning System with Chamber



- * Real air conditioning system with water chiller and climatic chamber
- * Chamber for comfort investigations, suitable for test persons to be inside
- * Air conditioning controller with integrated PLC
- * Data acquisition by software

Technical Description

Comfort is of great importance in the air conditioning of rooms and buildings. The comfort depends on the temperature, the relative humidity and the flow velocity of the air. According to DIN 13779 a so-called "comfort zone" has been defined which specifies the values an air conditioning system should achieve.

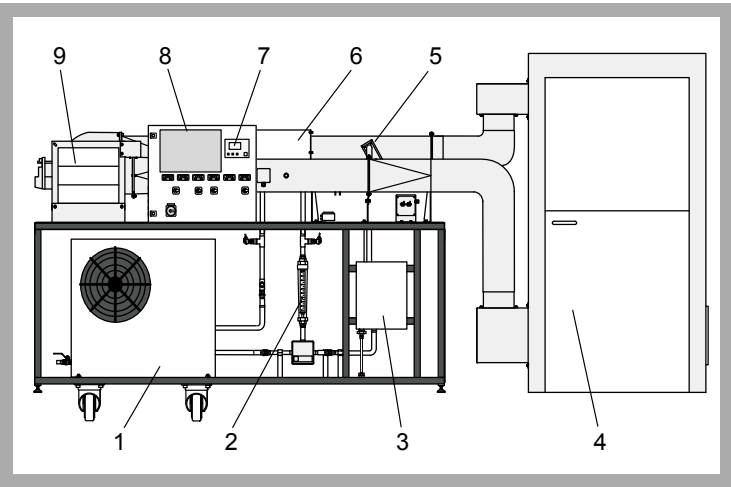
ET 611 is a full air conditioning system with comprehensive test options. The effect of the air humidity and temperature on the comfort is examined. The system has a climatic chamber designed for test persons to be inside. This allows the trainee to study the effect of different system operating states on his own well-being. The components used, such as radial fan, electric air heater, steam humidifier and water chiller are all used in commercial air conditioning and ventilation technology. A PLC air conditioning controller monitors and controls all functions. In addition to the automatic operation it also enables the manual operation of the system.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

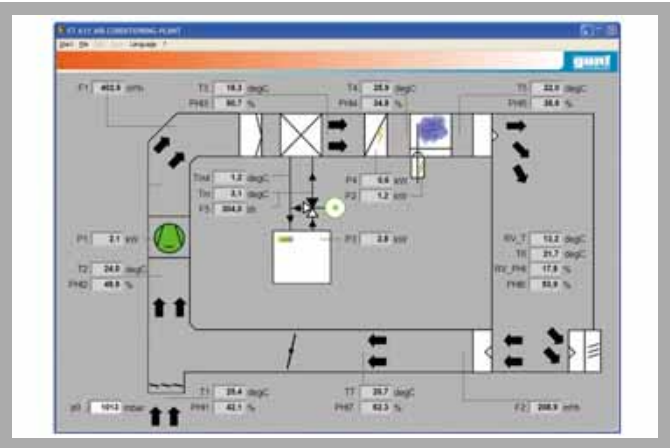
Learning Objectives / Experiments

- design, operation and operating behaviour of a real air conditioning system
- recirculating and outer air operation
- changes of state in the h-x diagram for humid air: heating, cooling, humidifying or dehumidifying, mixing
- application of the mixing line
- comfort studies, limit of comfortable humidity
- energy balance in the Sankey diagram
- PLC air conditioning controller
- * humidity control
- * temperature control
- * manual or automatic operation

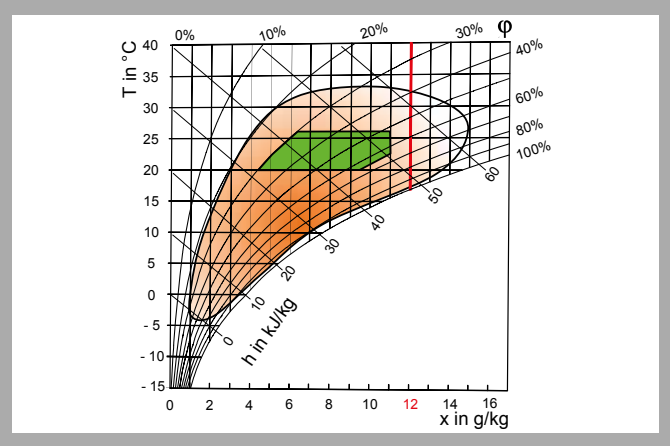
ET 611 Air Conditioning System with Chamber



1 water chiller, 2 flow meter, 3 steam humidifier, 4 climatic chamber, 5 steam distributor (humidifier), 6 air cooler, 7 PLC air conditioning controller, 8 switch cabinet with process schematic, displays and controls, 9 outer air inlet with fan; covered: air heater



Software screenshot: process schematic



h-x diagram with comfort zone (green) and limit of comfortable humidity (red; x=12g/kg); h enthalpy, x absolute air humidity, T temperature, φ relative air humidity

Specification

- [1] air conditioning system with chamber for conditioning and air technology investigations
- [2] chamber suitable for test persons to be inside
- [3] PLC air conditioning controller, manual and automatic operation
- [4] industrial components: fans, air-cooled water chiller, air cooler, air heater, steam humidifier
- [5] digital displays for air temperature, air humidity, air velocity, temperature of the cold water, power
- [6] refrigerant R407C, CFC-free
- [7] GUNT software for data acquisition via USB under Windows Vista or Windows 7

Technical Data

- PLC air conditioning controller
 - 17 universal inputs, 4 analogue outputs, 10 switching outputs
- Radial fan
 - power consumption: 0,75kW
 - max. flow rate: 39m³/min
 - pressure difference: 450Pa
- Air heater: 6x 250W each
- Steam humidifier
 - steam capacity: 6kg/h
 - power consumption: 4,5kW
- Water chiller
 - power consumption: 2,1kW
 - refrigeration capacity: 6,2kW at 32°C, ΔT=5K
- fan, volumetric air flow rate: 3500m³/h
- compressor, power consumption: 2kW
- pump, power consumption: 550W
- Air cooler, capacity: 4,84kW

Measuring ranges

- flow rate (cold water): 0...1600L/h
- temperature: 8x 0...50°C
- humidity: 6x 0...100%
- flow velocity: 2x 0...20m/s
- power: 4x 0...6kW

Dimensions and Weight

- LxWxH: 2700x1480x1900mm (system)
- LxWxH: 1170x1170x2100mm (chamber)
- Weight: approx. 350kg (system); approx. 200kg (chamber)

Required for Operation

- 400V, 50/60Hz, 3 phases

Scope of Delivery

- 1 air conditioning system, filled with refrigerant
- 1 GUNT software CD + USB cable
- 1 set of instructional material

Order Details

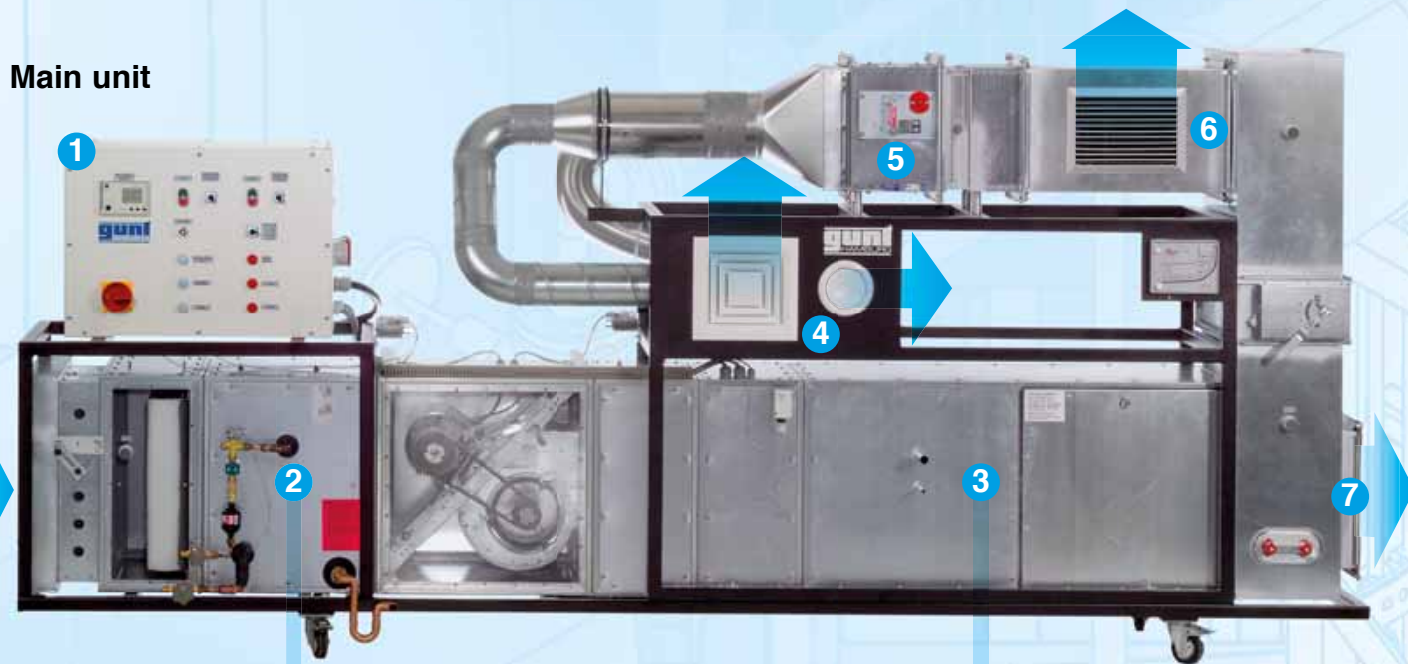
- 061.61100 ET 611 Air Conditioning System with Chamber

ET 620 REAL AIR CONDITIONING AND VENTILATION SYSTEM: THIS IS WHAT THE PRACTICE LOOKS LIKE

ET 620 is a real air conditioning system with connected air duct. The trainer consists of the main unit, a condensing unit and a steam humidifier. The conditioned air flows

through an air duct and exits into the room through air outlets. Alternatively an external ductwork can also be connected.

Main unit



1 switch cabinet with PLC, 2 cooler with connections for the condensing unit, 3 humidification section with connections for steam humidifier, 4+6 outlets for the conditioned room air, 5 fire protection flap, 7 standard connection for external ductwork



Condensing Unit



Steam humidifier

REAL COMPONENTS FROM AIR CONDITIONING TECHNOLOGY

Control via PLC

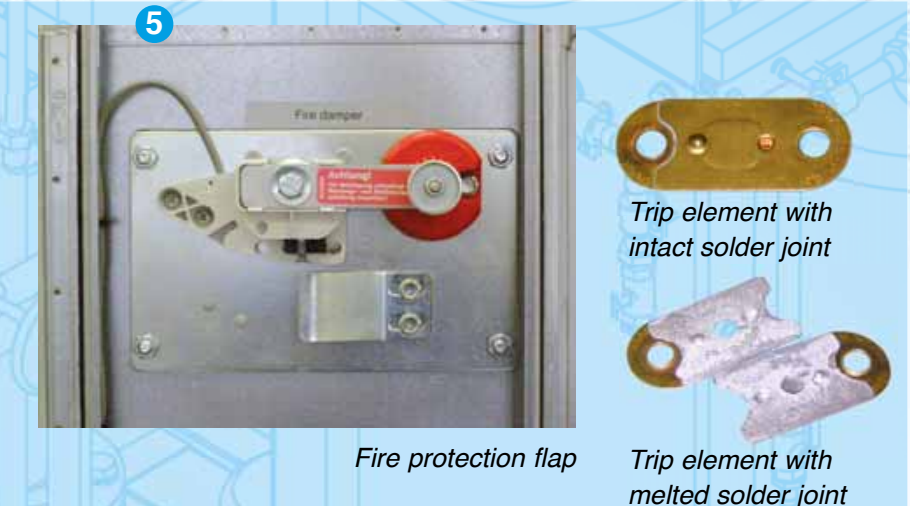
The operation of the air conditioning system is via a PLC. Handling the different PLC functions is learned step by step:

- Display of alarms
- Display of measured values
- Input of reference variables
- Input of control parameters
- Input of limit values
- ...and much more.



Safety in air conditioning technology

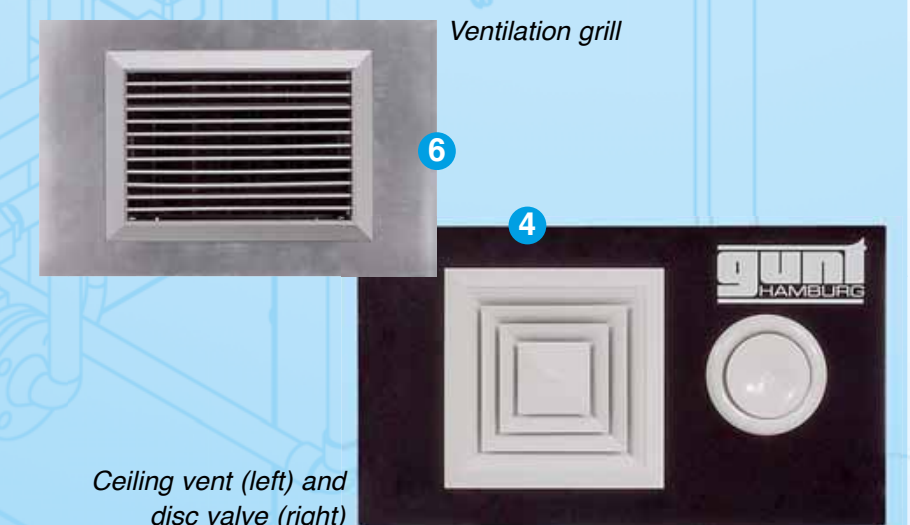
A fire protection flap is fitted in the air duct. Fire protection flaps are used to separate the ventilation network from the source of a fire in an emergency. To trigger and close the fire protection flap a spring and a thermal trip element are used. In case of a fire, the solder melts, the two metal plates are released and the spring shuts the fire protection flap.



Typical air outlets

In order for people to find the room climate comfortable, a strong draught must be avoided.

The air duct of ET 620 features different types of air outlets. The purpose of air outlets is the distribution of the air in the room with a minimum air velocity. Air distribution, air velocity and pressure loss of the different air outlets can be compared.



ET 620 Air Conditioning and Ventilation System



- * Complete air conditioning and ventilation system for laboratory operation
- * High practical relevance due to real dimensions and use of commercial components
- * Manual or automatic operation by PLC air conditioning controller
- * Connection of an external air duct system possible

Technical Description

The experimental set-up represents a real air conditioning and ventilation system. The system capacity is sufficient to climatise a laboratory room.

The air conditioning and ventilation system includes a filter element, a fan with controlled speed, a direct evaporator as air cooler, an electric air heater and humidification by steam humidifier. The following functions are possible: heating / cooling and humidifying / dehumidifying. For this purpose the active components can be run either manually individually or via a central PLC air conditioning controller in automatic operation. The air conditioning controller controls the temperature and air humidity independent of each other. Via time programs, operation is possible dependent on the time of the day or the day of the week, as in reality. Pressure losses can be measured at each section of the duct.

All common components, such as filter, air heater / air cooler, outlets, smoke detector, multi-leaf dampers, inspection and fire protection flaps are available and can be explained. A standard connection piece in the air duct enables the connection to an external air duct system to climatise an existing room.

The air conditioning and ventilation system consists of three independent system components: main unit, steam humidifier and condensing unit. The connection is performed via hoses. Due to the

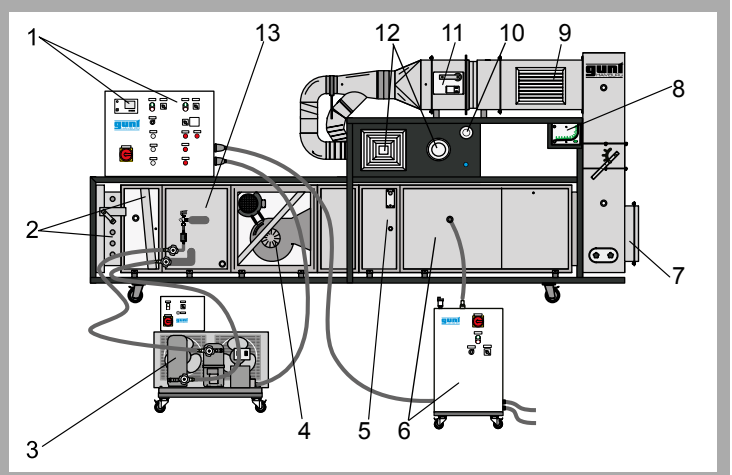
waste heat the condensing unit should not be placed inside the room to be climatized.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

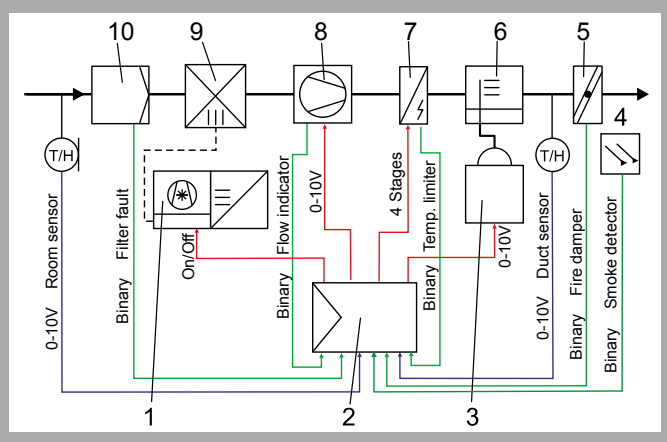
Learning Objectives / Experiments

- practice-oriented principles of air conditioning and ventilation technology
- design and servicing of an air conditioning and ventilation system
- principles of room air conditioning (h-x diagram)
- explanation of components: filter, air heater, air cooler, humidifier, condensing unit, air conditioning controller, flaps, outlets
- operation of safety devices
- measurement of pressure curve and pressure losses
- effect of air cooler, air heater and humidifier on the state of the air at the outlet
- investigation of the control behaviour of an automatic air conditioning controller, determination of limiting factors

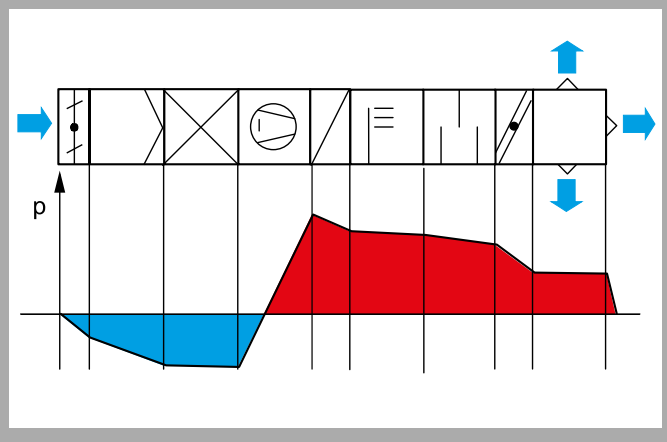
ET 620 Air Conditioning and Ventilation System



1 switch cabinet with controller, 2 air inlet with filter, 3 condensing unit, 4 fan, 5 air heater, 6 steam humidifier, 7 standard connector to connect an external air duct system, 8 inclined tube manometer, 9 ventilation grille with volume adjustment, 10 smoke detector, 11 fire protection flap, 12 ceiling vents, 13 air cooler (direct evaporator)



Control schematic: 1 condensing unit, 2 controller, 3 steam humidifier, 4 smoke detector, 5 fire protection flap, 6 humidification section, 7 electric air heater, 8 fan, 9 air cooler (direct evaporator), 10 filter; T/H temperature/humidity



Pressure curve in the system

Specification

- [1] practice-oriented air conditioning and ventilation system with 3 independent system components: main unit, condensing unit, steam generator
- [2] manual or automatic operation via PLC air conditioning controller
- [3] main unit with air duct, fan, air conditioning system
- [4] air conditioning system with direct evaporator as air cooler, electric air heater, humidification
- [5] hoses connect direct evaporator to condensing unit, humidification to steam humidifier
- [6] air duct from hot galvanised sheet with sight window and pressure measurement connections to record pressure curves
- [7] air duct with filter, multi-leaf damper, ceiling vent, protective grating, ventilation grille, fire protection flap, inspection flap, sound insulation link, smoke detector
- [8] standard connection piece to connect to external ventilation system
- [9] refrigerant R404a, CFC-free

Technical Data

- Fan, speed-controlled 0...1500min⁻¹
- max. volumetric air flow rate: 2500m³/h
- max. pressure level: 715Pa
- drive motor power: 1,1kW
- Air heater, 4 stages: 0-5-10-15-20kW
- Air cooler (direct evaporator), cooling capacity: 27kW
- Condensing unit
- rated cooling capacity: approx. 16,6kW at 7.2/32°C
- power consumption: approx. 7,4kW at 7.2/32°C
- Steam humidifier
- steam capacity: 10kg/h
- power consumption: 7,5kW
- External standard connection piece: 400x400mm
- Duct cross-sections
- bottom: WxH: 630x630mm, top: WxH: 358x358mm
- Inclined tube manometer: 0...750Pa

Dimensions and Weight

- LxWxH: 4000x850x1770mm (air conditioning system)
- LxWxH: 1080x700x1150mm (condenser)
- LxWxH: 450x500x1050mm (steam generator)
- Weight: approx. 590kg

Required for Operation

- 400V, 50/60Hz, 3 phases or 230V, 60Hz/CSA, 3 phases
- Water connection, drain

Scope of Delivery

- 1 main unit
- 1 condensing unit
- 1 steam humidifier
- 1 set of hoses + cables
- 1 set of instructional material

Order Details

061.62000 ET 620 Air Conditioning and Ventilation System

ET 450 Vehicle Air Conditioning



- * Typical vehicle air conditioning system for cooling the vehicle interior
- * Use of components from automotive technology
- * Simulation of 8 system faults

Technical Description

Vehicle air conditioning systems are used to cool down the vehicle interior. They usually work on the basis of the recirculating air principle and aspirate the air to be cooled from the interior. The cold air generated in the air conditioning system is transported by a fan into the vehicle interior.

The refrigeration circuit to generate the cold air in the trainer ET 450 includes a compressor, a condenser with fan and an evaporator as air cooler with three-stage fan and expansion valve. All system components are typical elements used in vehicle technology. The air cooler with three-stage fan is e.g. equipped with typical air vents for the vehicle interior. This achieves a close proximity to practice.

The trainer operates with the 12VDC supply common in vehicles. Even the ignition lock function has been implemented to switch on the system. An electric motor drives the compressor via a V-belt and a magnetic coupling. The speed of the motor and thus the compressor is variably adjustable by a frequency converter to simulate the drive via the vehicle engine.

Important characteristic variables, such as pressure, temperature, flow rate and the power consumption of the compressor are displayed. As a particularity 8 connectable faults have been installed. The system is particularly suited for the training of motor mechanics.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

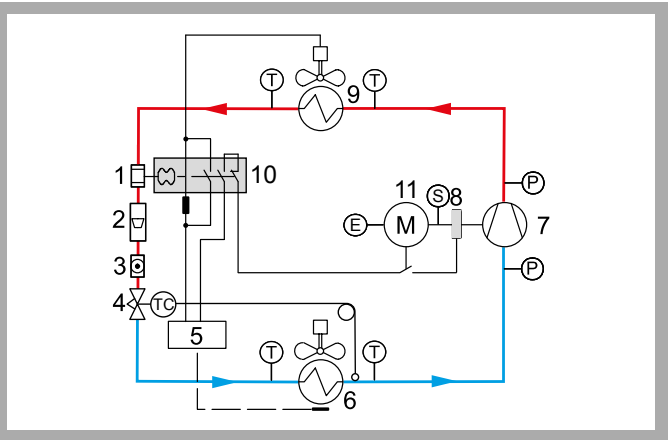
Learning Objectives / Experiments

- principle of operation, design and handling of a vehicle air conditioning system
- detection of typical faults and repair of a faulty air conditioning system
 - * simulation of 8 system faults
- typical components of a refrigeration system
- refrigeration circuit as thermodynamic cycle
 - * log p-h diagram
 - * determine the coefficient of performance and efficiency of the system
 - * determine the compressor pressure ratio

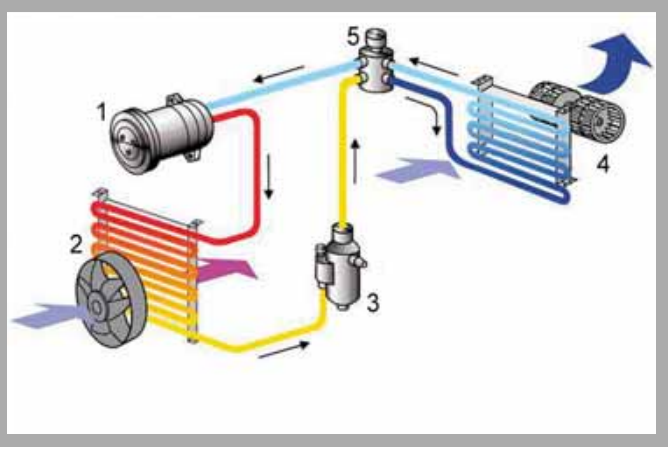
ET 450 Vehicle Air Conditioning



1 box with fault buttons, 2 ignition key, 3 air cooler with three-stage fan, 4 switch cabinet, 5 flow meter, 6 compressor, 7 condenser with fan, 8 electric motor



1 filter/drier, 2 flow meter, 3 sight glass, 4 expansion valve, 5 switch cabinet, 6 evaporator, 7 compressor, 8 magnetic coupling, 9 condenser, 10 combined pressure switch, 11 motor; red: high pressure, blue: low pressure



Refrigeration circuit: 1 compressor, 2 condenser with fan, 3 filter/drier, 4 air cooler with three-stage fan, 5 expansion valve; red: high pressure gaseous, yellow: high pressure liquid; blue: low pressure liquid, light blue: low pressure gaseous

Specification

- [1] investigation of a typical vehicle air conditioning system for cooling the vehicle interior
- [2] compression refrigeration system with compressor, condenser, filter/drier, expansion valve and evaporator
- [3] electric motor with variable speed as compressor drive
- [4] condenser with fan
- [5] evaporator as air cooler with three-stage fan
- [6] compressor drive via V-belt and magnetic coupling
- [7] simulation of 8 faults via buttons in the connectable box
- [8] system is switched on via ignition lock
- [9] display of temperatures, pressures (refrigerant), flow rate (refrigerant), pick-up current, speed
- [10] refrigerant R134a, CFC-free
- [11] air conditioning system voltage supply: 12VDC

Technical Data

- Electric motor
 - rotary current motor
 - variable speed via frequency converter
 - 500...3.000min⁻¹
 - power: 4kW at 3.000min⁻¹
- Axial piston compressor
 - refrigeration capacity: approx. 3kW at 3.000min⁻¹
- Condenser: capacity: 6,6kW
- Evaporator: capacity: 5,3kW
- Measuring ranges
 - temperature: 4x -100...100°C
 - flow rate (R134a): 10...95L/h
 - pressure: -1...9bar / -1...24bar
 - speed: 0...3.000min⁻¹
 - current: 0...10A

Dimensions and Weight

- LxWxH: 1.210x800x1.520mm
- Weight: approx. 185kg

Required for Operation

- 400V, 50/60Hz, 3 phases or 230V, 60Hz, 3 phases

Scope of Delivery

- 1 trainer, filled with refrigerant
- 1 set of instructional material

Order Details

- 061.45000 ET 450 Vehicle Air Conditioning

ET 630 Split System Air Conditioner



- * Modern air conditioning unit with heat pump function: cooling and heating
- * 6 different operating modes

Technical Description

Split system air conditioners are used to cool, dehumidify and also heat rooms. The consist of an inner and outer unit.

In the inner unit there is a heat exchanger with fan working as an evaporator in the refrigeration circuit during cooling operation. During heating operation it works as a condenser. The outer unit contains a compressor, another heat exchanger, expansion element (e.g. capillary tube) and an element enabling the change-over from cooling to heating operation. In cooling operation the evaporating refrigerant in the heat exchanger of the inner unit withdraws heat from the room air. In the outer unit the heat in the heat exchanger is discharged to the ambient air by condensing the refrigerant. During heating operation the heat transport is reversed.

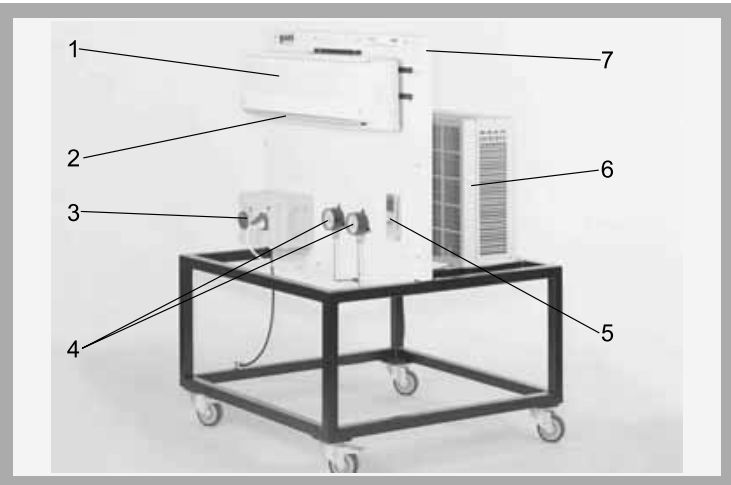
ET 630 includes a dividing wall onto whose front and rear panel a modern split system air conditioner has been mounted. To better demonstrate its operation, an additional two pressure displays are available for the refrigerant. The operating mode, fan stage of the inner unit (fan operation) and desired room temperature are selected via a remote control. During automatic operation the actual room temperature is recorded and an operating mode automatically selected to achieve the specified room temperature.

In addition the following functions are set at the remote control: Timer for the regular switching on and off, single remaining operating time in hours (sleep mode; suitable for energy-saving operation) and horizontal position of the lamella at the air outlet for air distribution (swing mode; fixed or movable).

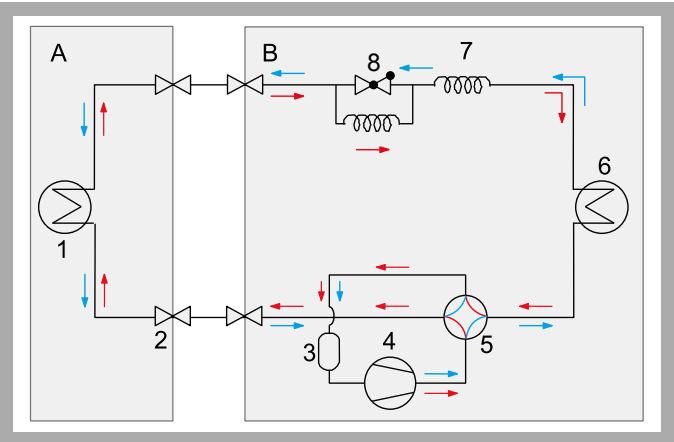
Learning Objectives / Experiments

- design and operation of a split system air conditioner
- 6 operating modes
 - * cooling
 - * dehumidifying (slight cooling)
 - * heating
 - * ventilation (only the fan of the inner unit)
 - * automatic (operating mode suitable for the room temperature)
- 3 additional functions
 - * test of cooling function
 - * "sleep" (switch-off after several hours)
 - * "swing" (air outlet lamella position)
 - * timer for switching on and off
- remote control functions

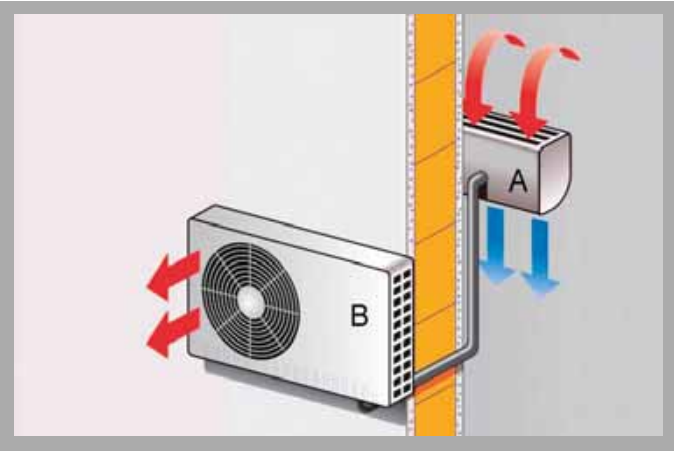
ET 630 Split System Air Conditioner



1 air inlet inner unit, 2 air outlet inner unit, 3 switch cabinet, 4 manometer, 5 remote control, 6 outer unit, 7 dividing wall



Exemplary process schematic of a split system air conditioner with inner unit (A) and outer unit (B): 1 heat exchanger inner unit, 2 valve, 3 suction line receiver, 4 compressor, 5 reversing valve, 6 heat exchanger outer unit, 7 capillary tube, 8 non-return valve; red arrow: heating, blue arrow: cooling



Exemplary installation of a split system air conditioner: A inner unit, B outer unit

Specification

- [1] trainer from the GUNT practical series for the training of mechatronics engineers for refrigeration
- [2] design and operation of a commercial split system air conditioner
- [3] illustration of the split principle using a dividing wall
- [4] 6 different operating modes: heating, cooling, dehumidifying, ventilation, automatic, test
- [5] 3 additional functions configurable via remote control: sleep, swing, timer
- [6] 2 refrigerant manometers indicate the intake and delivery pressure of the compressor
- [7] refrigerant R410A, CFC-free
- [8] battery operated remote control

Technical Data

- Split system air conditioner
- power consumption: approx. 1,7kW
- cooling capacity: approx. 3,3kW
- heating capacity: approx. 3,4kW
- max. volumetric air flow rate (inner unit): approx. 420m³/h
- dehumidification (inner unit): approx. 0,8L/h
- timer: 24h

Pressure measuring range (intake/delivery side): -1...40bar

Dimensions and Weight

LxWxH: 1000x1000x1500mm
Weight: approx. 80kg

Required for Operation

230V, 50Hz, 1 phase

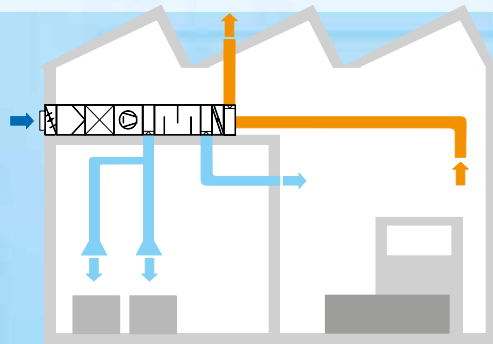
Scope of Delivery

- 1 split system air conditioner
- 1 remote control
- 1 manual

Order Details

061.63000 ET 630 Split System Air Conditioner

VENTILATION SYSTEMS AND THEIR COMPONENTS



Ventilation systems supply commercial premises, hospitals, restaurants or conference rooms with outer air. Important for the design of these systems are the characteristic variables of fans and the pressure losses of components, such as air outlets, pipes, bends etc.

GUNT offers in this chapter systems for basic investigations in real components. Different fans, typical components of ventilation systems, a complete ventilation system and an air duct system provide deep insights into the specialist field and a practical training.

Ventilation system in the building:
blue: inlet air, orange: exhaust air



Ventilation system



Ventilation system on the roof of a building



Ventilation system components

DETERMINATION OF FAN CHARACTERISTICS WITH THE EXPERIMENTAL UNITS HM 280 AND HM 282

- Examine the dependence of the differential pressure on the flow rate
- Interchangeable impellers with different blade shapes
- Represent measured values and record characteristics with the aid of software



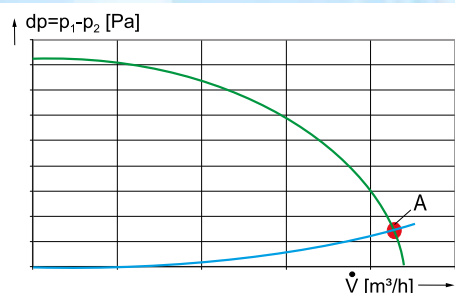
HM 282
Experiments with an Axial Fan



HM 280 Experiments with a Radial Fan

REAL COMPONENTS FROM VENTILATION TECHNOLOGY IN THE EXPERIMENT: RADIAL FAN HM 210

- Determine the characteristic variables of a radial fan
- Determine the flow rate through the iris diaphragm or venturi nozzle
- Different fluid column manometers with different measuring ranges for differential pressure measurement



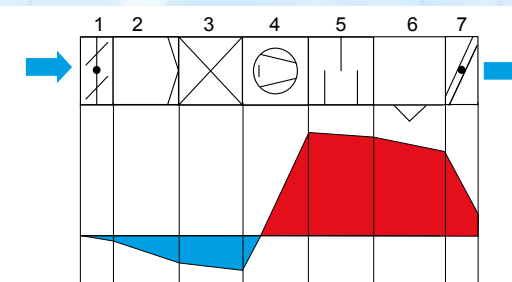
Determination of the operating point:
green: fan characteristic, blue: system characteristic, A operating point of the system

HM 210
Characteristic Variables of a Radial Fan



PRACTICAL EXPERIMENTS WITH COMPLETE VENTILATION SYSTEMS VENTILATION SYSTEM HL 720 AND AIR DUCT SYSTEM HL 710

- Real components from ventilation technology, some with sight windows to observe the components
- Different air outlets for air distribution in rooms
- Measure pressure and differential pressure, represent pressure curve



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



HL 720 Ventilation System



HL 710 Air Duct Systems

- Set-up a variable air duct system from real components
- Investigate pressure loss and determine the operating point of the system
- Carry out ventilation technology measurements

HM 280 Experiments with a Radial Fan



- * 2 interchangeable rotors
- * Transparent delivery pipe and intake pipe
- * GUNT software for data acquisition, visualisation and operation
- * Part of the GUNT Labline fluid energy machines

Technical Description

Radial fans are used to transport gases with non-excessive pressure differences. The medium is drawn in axially to the drive shaft of the radial fan and is deflected by 90° by the rotation of the rotor and discharged radially.

The experimental unit provides the basic experiments to get to know the operating behaviour and the most important characteristic variables of radial fans.

HM 280 features a radial fan with variable speed via a frequency converter, an intake pipe and a delivery pipe. The transparent intake pipe is fitted with guide plates for flow guidance and with a flow straightener to calm the air. This enables precise measurements even with heavily reduced operation. The air flow is adjusted by a throttle valve at the end of the delivery pipe.

To demonstrate the effect of different blade shapes two rotors are included in the scope of delivery: one rotor with forward curved blades and one with backward curved blades. The rotors are easily interchangeable.

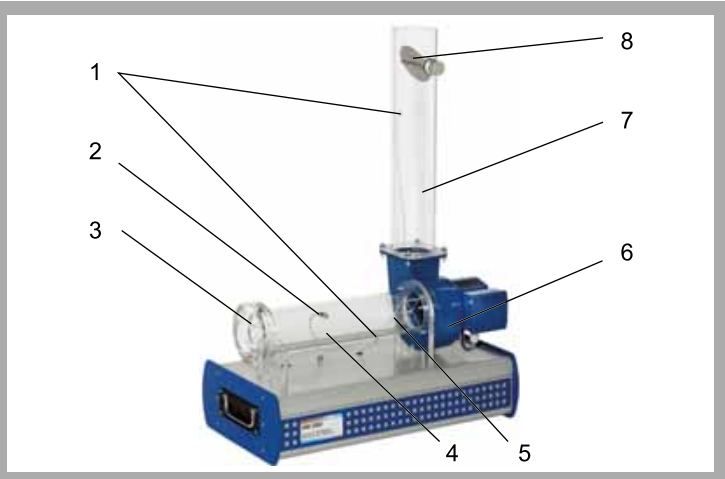
The experimental unit is fitted with sensors for pressure and temperature. The flow rate is determined via differential pressure measurement on the intake nozzle.

The microprocessor-based measuring technique is well protected in the housing. All the advantages of software-supported experiments and evaluation are offered by the GUNT software and the microprocessor. The connection to a PC is made by USB.

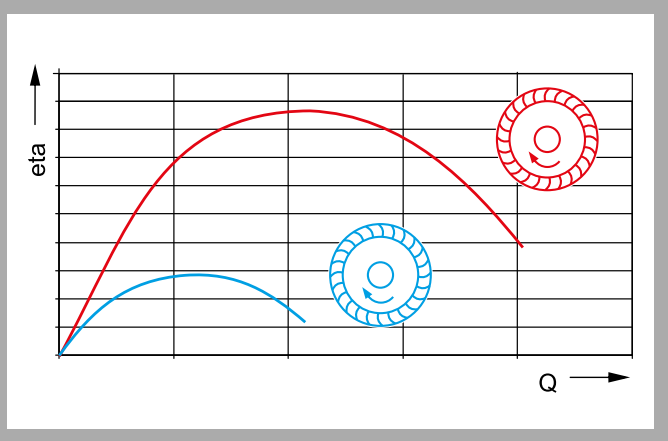
The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

- Learning Objectives / Experiments**
- operating behaviour and characteristic variables of a radial fan
 - recording the fan characteristic (differential pressure as a function of the flow rate)
 - effect of the rotor speed on the pressure
 - effect of the rotor speed on the flow rate
 - effect of different rotor shapes on the fan characteristic and efficiency
 - determination of hydraulic power output and efficiencies

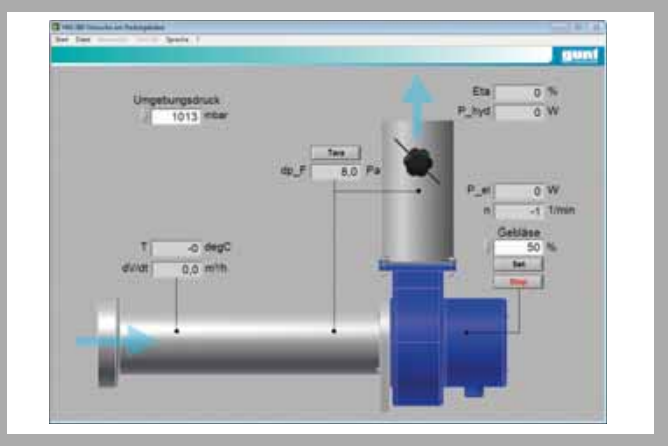
HM 280 Experiments with a Radial Fan



1 measuring points for pressure, 2 measuring point for temperature, 3 inlet nozzle with measuring point for static pressure, 4 intake pipe, 5 guide plates, 6 radial fan with drive motor, 7 delivery pipe, 8 throttle valve



Efficiencies in comparison; red: rotor with forward curved blades, blue: rotor with backward curved blades; eta efficiency, Q débit



Operating interface of the powerful software

- Specification**
- [1] functioning and operating behaviour of a radial fan
 - [2] radial fan with 3-phase AC motor
 - [3] variable speed via frequency converter
 - [4] transparent intake and delivery pipes
 - [5] throttle valve to adjust the air flow in the delivery pipe
 - [6] interchangeable rotors: 1 rotor with forward curved blades and 1 rotor with backward curved blades
 - [7] determination of flow rate via intake nozzle
 - [8] display of differential pressure, flow rate, speed, electrical power consumption and hydraulic power output, temperature and efficiency
 - [9] microprocessor-based measuring technique
 - [10] unit-specific GUNT software for data acquisition and operation via USB under Windows Vista or Windows 7

- Technical Data**
- Intake pipe
- inner diameter: 90mm
 - length: 430mm
- Delivery pipe
- inner diameter: 100mm
 - length: 530mm
- Radial fan
- power consumption: 110W
 - nominal speed: 2800min⁻¹
 - max. flow rate: 480m³/h
 - max. differential pressure: 300Pa
- Displayed / measuring ranges
- differential pressure: 0...1800Pa
 - flow rate: 0...1000m³/h
 - temperature: 0...100°C
 - speed: 0...3300min⁻¹
 - electrical power consumption: 0...250W

- Dimensions and Weight**
- LxWxH: 670x340x940mm
- Weight: approx. 20kg

- Required for Operation**
- 230V, 50/60Hz, 1 phase or 120V, 60Hz/CSA, 1 phase

- Scope of Delivery**
- 1 experimental unit
 - 2 rotors
 - 1 GUNT software CD + USB cable
 - 1 set of instructional material

- Order Details**
- 070.28000 HM 280 Experiments with a Radial Fan

HM 282 Experiments with an Axial Fan



- * Illustrative model of an axial fan
- * Transparent delivery pipe and intake pipe
- * GUNT software for data acquisition, visualisation and operation
- * Part of the GUNT Labline fluid energy machines

Technical Description

Axial fans are used to transport gases. The medium to be transported is drawn in axially to the drive shaft of the axial fan by the rotation of the rotor. The medium flows through the rotor and is discharged axially behind the rotor.

The experimental unit provides the basic experiments to get to know the operating behaviour and the important characteristic variables of axial fans.

HM 282 features an axial fan with variable speed via an integrated controller, an intake pipe and a delivery pipe. The transparent intake and delivery pipes are fitted with guide plates for flow guidance. A flow straightener in the intake pipe serves to calm the air. This enables precise measurements even with heavily reduced operation. The air flow is adjusted by a throttle valve at the end of the delivery pipe.

The experimental unit is fitted with sensors for pressure and temperature. The flow rate is determined via differential pressure measurement on the intake nozzle.

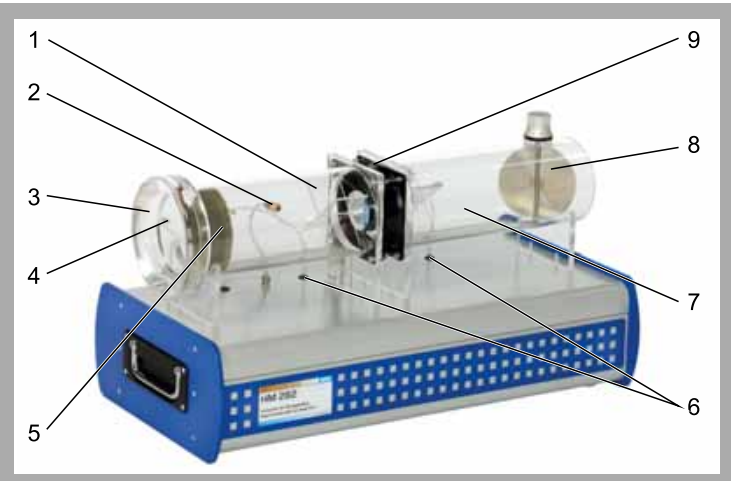
The microprocessor-based measuring technique is well protected in the housing. All the advantages of software-supported experiments and evaluation are offered by the GUNT software and the microprocessor. The connection to a PC is made by USB.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

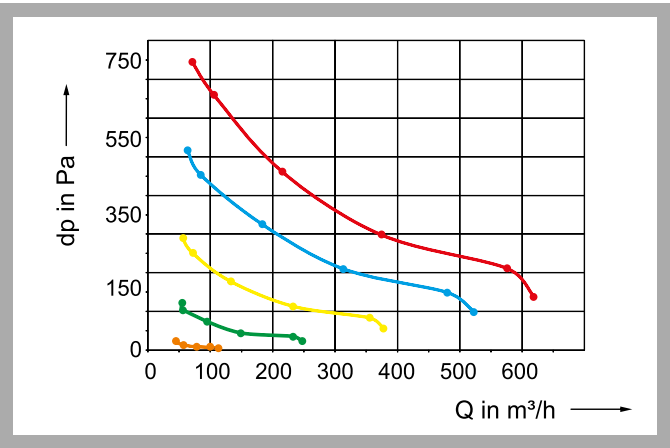
Learning Objectives / Experiments

- operating behaviour and characteristic variables of an axial fan
- recording the fan characteristic (differential pressure as a function of the flow rate)
- effect of the rotor speed on the pressure
- effect of the rotor speed on the flow rate
- stall
- determination of hydraulic power output and efficiencies

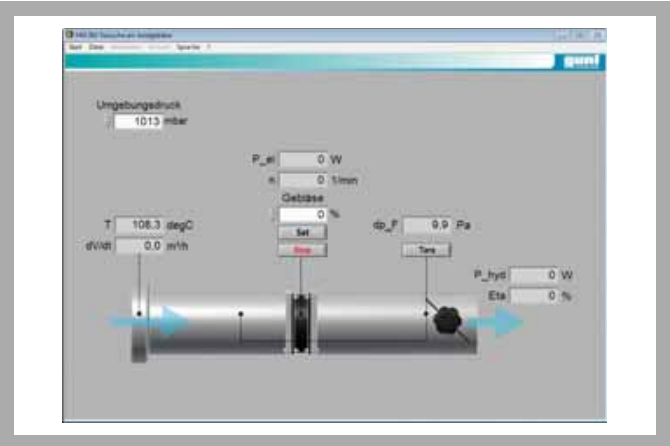
HM 282 Experiments with an Axial Fan



1 guide plates for flow guidance, 2 measuring point for temperature, 3 intake nozzle at intake pipe, 4 measuring point for pressure (to determine the flow rate), 5 flow straightener, 6 measuring points for pressure, 7 delivery pipe, 8 throttle valve, 9 axial fan



Characteristic curves for an axial fan: differential pressure dependent on the flow rate at different speeds; p_d differential pressure, Q flow rate



Operating interface of the powerful software

Specification

- [1] functioning and operating behaviour of an axial fan
- [2] axial fan with electronically commutated drive motor
- [3] variable speed via integrated controller
- [4] transparent intake and delivery pipes
- [5] throttle valve to adjust the air flow in the delivery pipe
- [6] determination of flow rate via intake nozzle
- [7] display of differential pressure, flow rate, speed, electrical power consumption and hydraulic power output, temperature and efficiency
- [8] microprocessor-based measuring technique
- [9] unit-specific GUNT software for data acquisition and operation via USB under Windows Vista or Windows 7

Technical Data

- Intake pipe
 - inner diameter: 110mm
 - length: 275mm
- Delivery pipe
 - inner diameter: 110mm
 - length: 310mm
- Axial fan
 - power consumption: 90W
 - nominal speed: 9500min⁻¹
 - max. flow rate: approx. 600m³/h
 - max. differential pressure: approx. 700Pa

- Displayed / measuring ranges
 - differential pressure: 0...1800Pa
 - flow rate: 0...1000m³/h
 - temperature: 0...100°C
 - speed: 0...3000min⁻¹
 - electrical power consumption: 0...500W

Dimensions and Weight

- LxWxH: 670x340x370mm
- Weight: approx. 20kg

Required for Operation

- 230V, 50/60Hz, 1 phase or 120V, 60Hz/CSA, 1 phase

Scope of Delivery

- 1 experimental unit
- 1 GUNT software CD + USB cable
- 1 set of instructional material

Order Details

- 070.28200 HM 282 Experiments with an Axial Fan

HM 210 Characteristic Variables of a Radial Fan



Technical Description

Fans are key components of ventilation systems, providing ventilation, cooling, drying or pneumatic transport. For optimum design of such systems, it is important to know the characteristic variables of a fan.

HM 210 investigates a radial fan. This trainer determines the interdependencies between the delivery pressure and volumetric flow rate as well as the influence of the fan speed on the delivery pressure and volumetric flow rate.

The radial fan aspirates the air in axially from the surrounding environment. The high-speed rotating rotor accelerates the air outwards. The high velocity at the outlet from the rotor is partially converted into pressure energy in the spiral housing. The vertical pipe section is connected to the spiral housing. A Venturi nozzle to measure the volumetric flow rate and a throttle valve to adjust the volumetric flow rate are inserted into the pipe section. An iris diaphragm can optionally be used. Its variable cross-section enables simultaneous adjustment and determination of the volumetric flow rate. The effective pressures to calculate the volumetric flow rate are read from liquid column manometers. The delivery pressure of the radial fan is likewise measured by liquid column manometers. U-tube manometer, single tube manometer and inclined tube manometer with graduated measuring ranges are available.

A frequency converter is used to adjust the fan speed. The speed, torque and electric power capacity are digitally displayed. This permits energy analyses, and enables the efficiency of the fan to be determined.

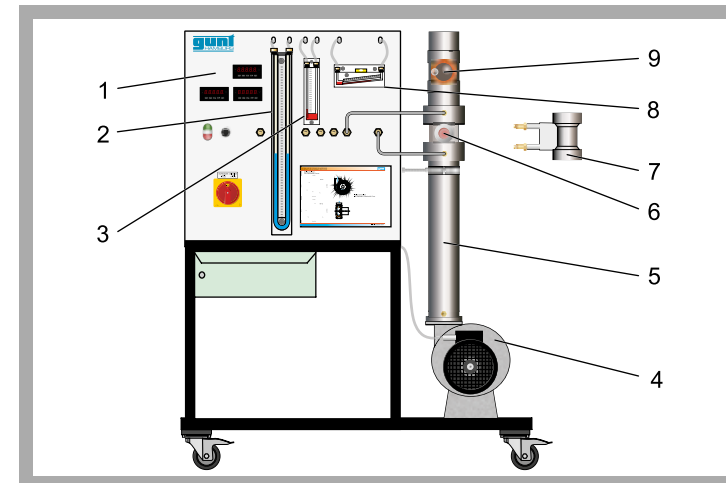
The system characteristic curve is determined by recording the characteristic variables at a constant throttle setting but at variable speed. The interaction of the fan and system at the operation point – the so-called system dimensioning – is investigated.

Learning Objectives / Experiments

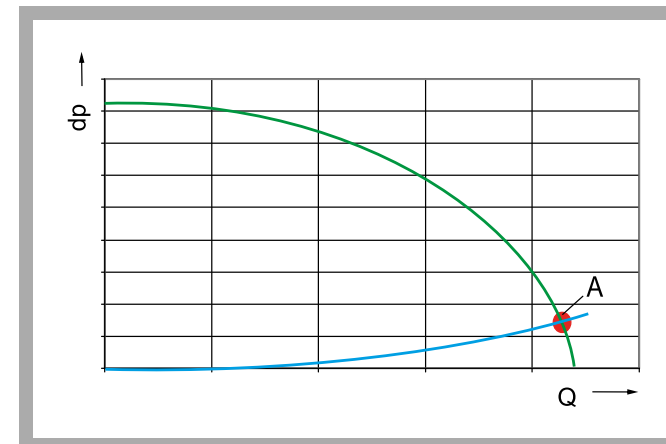
- set-up and principle of a radial fan
- plotting fan and system characteristics
- volumetric flow rate measurement methods based on the differential pressure method using:
 - * iris diaphragm
 - * Venturi nozzle
 - * comparison of both measurement methods
- familiarisation with various differential pressure gauges
- determining efficiency

- * Investigation of a radial fan and determination of characteristic variables
- * Determination of volumetric flow rate via iris diaphragm or Venturi nozzle
- * Different liquid column manometers measure the differential pressure with varying accuracy
- * Well-structured instructional material

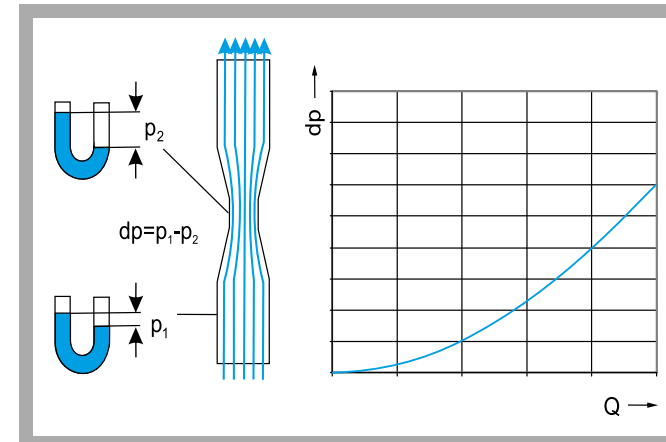
HM 210 Characteristic Variables of a Radial Fan



1 switch cabinet with display elements, 2 U-tube manometer, 3 single tube manometer, 4 radial fan with air intake, 5 pipe section, 6 iris diaphragm, 7 Venturi nozzle, 8 inclined tube manometer, 9 throttle valve



Green: fan characteristic; blue: system characteristic; A, red: system operation point



Air flow in the Venturi nozzle; p_1 , p_2 pressure measuring points; graph: differential pressure dp as function of volumetric flow rate Q

Specification

- [1] radial fan as turbomachine
- [2] iris diaphragm or Venturi nozzle to determine volumetric flow rate via the differential pressure
- [3] speed adjustment by frequency converter
- [4] U-tube manometer, single tube manometer and inclined tube manometer measure the differential pressure
- [5] air flow rate in pipe section adjustable by throttle valve
- [6] speed, torque and electric power capacity digitally displayed

Technical Data

- Radial fan
- max. power consumption: 370W
 - max. pressure difference: 860Pa
 - max. flow rate: $4\text{ m}^3/\text{min}$
 - nominal speed: 3000 min^{-1}
 - speed range: $1000\text{...}3000\text{ min}^{-1}$

- Iris diaphragm adjustable in 6 stages
- diameter: $40\text{...}70\text{ mm}$
 - $K=1,8\text{...}7,8$
- Venturi nozzle
- air inlet diameter: 100 mm
 - pipe neck diameter: 80 mm
 - $K_V=7,32$

- Pressure measuring ranges
- U-tube manometer: $30\text{...}0\text{...}30\text{ mbar}$
 - single tube manometer: $0\text{...}15\text{ mbar}$
 - inclined tube manometer: $0\text{...}50\text{ Pa}$

Dimensions and Weight

- LxWxH: $1300\text{x}720\text{x}1500\text{ mm}$
Weight: approx. 111 kg

Required for Operation

- 230 V , $50/60\text{ Hz}$, 1 phase or 230 V , 60 Hz , 3 phases

Scope of Delivery

- 1 trainer
1 set of instructional material

Order Details

- 070.21000 HM 210 Characteristic Variables of a Radial Fan

HM 220 AIR FLOW EXPERIMENTAL PLANT

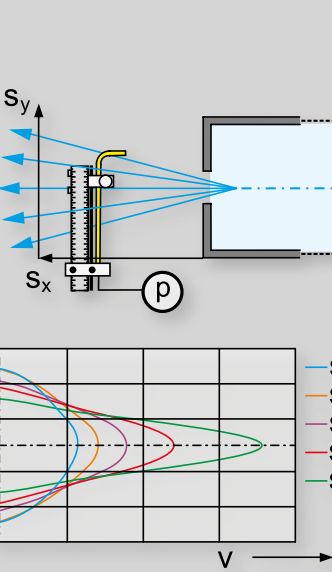
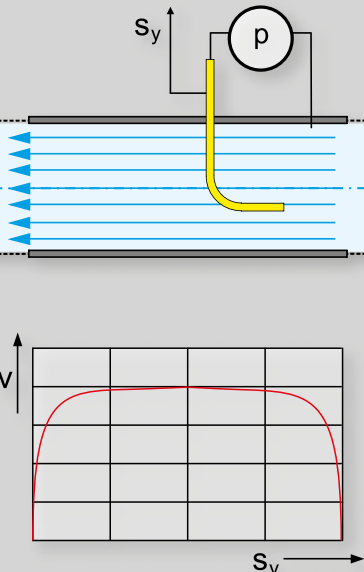
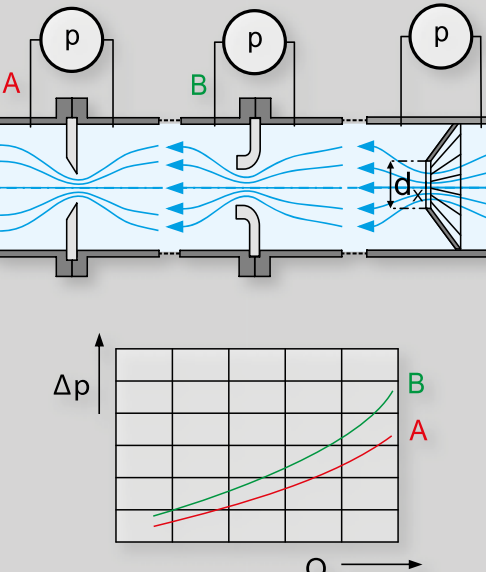
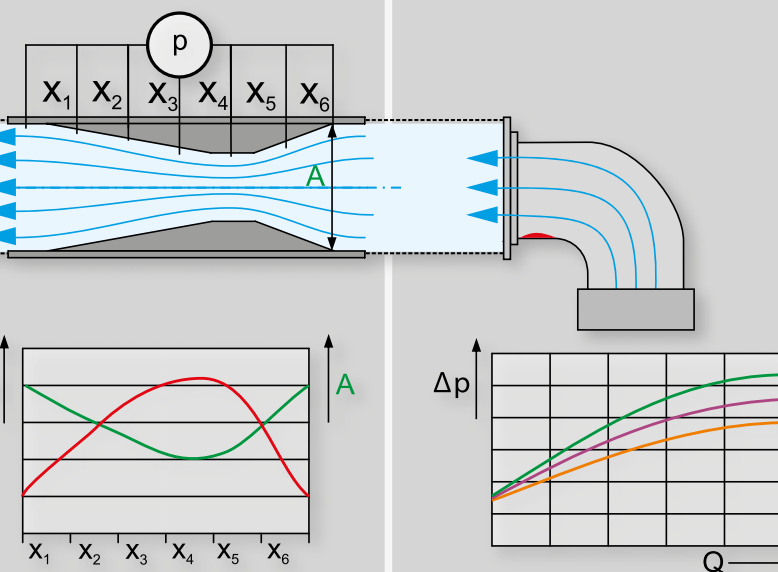
In practice, when designing turbomachines or pipe systems it is important to know the flow course and the corresponding pressure and velocity distribution. The experimental plant HM 220, together with the extensive range of accessories, offers a variety of fluid mechanics experiments.

The illustrative experiments provide an in-depth understanding and knowledge of the physical laws of steady flows. The experiments impart knowledge about determining the flow course, pressure distribution and velocity profiles.



- use of various pipe elements
- adjustment of the air flow through a frequency converter
- up to 20 pressure measuring points
- calculation of the volume flow and the flow rate 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

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		Boundary layer measurements on a flat plate in longitudinal flow via a Pitot tube (HM 220.02 accessory)		Change in volume flow		Measurement and investigation of air flow	
in a free jet	within a pipe			in an orifice plate or nozzle	in an iris diaphragm	via a Venturi tube (accessory HM 220.01)	in different pipe fittings
							
Velocity profile v in the air outlet jet		Velocity profile v along the pipe cross-section s_y		Comparison of the change in volume flow Q through an orifice plate A or nozzle B		Velocity profile (red) along the contraction in cross-section (green)	
		Velocity distribution (green) and boundary layer thickness (blue)				Investigation of pipe friction losses in pipe bend (green), segment bend (purple), pipe angle (orange)	

HM 240 PRINCIPLES OF AIR FLOW

The HM 240 base unit allows experiments on a radial fan. The unit can be used in conjunction with the extensive range of accessories to open up a large number of additional experiments on the topic of air flow.

The radial fan generates in a horizontal experimental section a flow velocity of approx. 9m/s. The inlet nozzle ensures a turbulence-free flow and thus a homogenous velocity distribution in the experimental section. A throttle valve in the outlet can be used to throttle the fan to record characteristics. The device is fitted with sensors to measure temperature and pressure. The flow rate is determined by an inlet nozzle and pressure measurement.

For the operation of the basic unit HM 240 the interface module HM 240.01 is required.

- modular system for experiments with air flows
- numerous experiments from fan-characteristic to heat transfer
- data acquisition and visualisation



GUNT software displays the measured values at the PC clearly and enables a comfortable evaluation. Various functions make it possible to graphically record the measured values and to store the results.

HM 240.03
Electronic Total
Pressure Sensor

HM 240
Basic Unit

HM 240.02
Power Meter

HM 240.01
Interface
Module

USB

PC

Concept of the data acquisition HM 240 in the example "velocity distribution in the intake pipe"

BASE UNIT AND ACCESSORIES ENABLE A VARIETY OF FLUID MECHANICS AND THERMODYNAMIC EXPERIMENTS



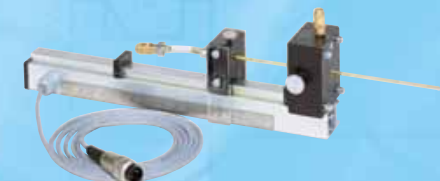
HM 240.01 Interface Module

- digitisation of measurement data
- PC connection via USB



HM 240.02 Power Meter

- measurement of the electrical fan power
- output signals fed to interface module HM 240.01
- determination of the fan efficiency



HM 240.03 Electronic Total Pressure Sensor

- movable Pitot tube
- electronic record of the position fed to the interface module HM 240.01
- pressure transducer in the base unit
- investigation of flow fields and recording of flow profiles



HM 240.04 Pressure Distribution on a Cylinder

The cylinder can be rotated about its axis and includes a pressure measurement hole. It is inserted transverse to the direction of flow so that air flow circulates around the cylinder. Thus the complete pressure distribution can be measured by rotating the cylinder. The angular position is measured and fed into the interface module of HM 240.01. The pressure transducer is located in the base unit.



HM 240.05 Friction Losses in Pipe Elements

The set consists of a smooth pipe section with extension, two different inlets and two different 90° deflections. All parts are fitted with pressure measurement ports so that the pressures can be measured along the pipe section. From this the friction losses for the different components can be determined.



HM 240.06 Heat Transfer at a Cylinder in Transverse Flow

The accessory consists of a copper cylindrical test piece and an electric heater for the test piece. The test piece is fitted with a temperature measurement point. It is heated to a defined temperature prior to the experiment and then inserted into the flow section. The cooling process occurs by forced convection in the air flow. The heat transfer on the test piece can be determined from the cooling rate. The temperature signal is fed into the interface module of HM 240.01

WL 312 MULTIPURPOSE AIR DUCT AND HEAT TRANSFER UNIT

The basic unit and comprehensive accessories enable extensive investigations in heat exchangers, of the type used in air conditioning and ventilation technology for air conditioning.

- Investigation of the heat transfer in heat exchangers from air conditioning and ventilation technology
- Temperature and humidity measuring instruments record the condition of the air
- Coolers and the additional humidification option (steam humidifier WL 312.12) also enable the investigation of dehumidification and humidification processes. Thus all changes of state occurring in an air conditioning system can be implemented.
- Flow conditions on the air side can be examined using a movable pitot sensor and inclined tube manometer. The pressure losses can also be determined.
- The air velocity can be adjusted via a throttle valve within generous limits
- Optional hot and cold water supply (WL 312.10, WL 312.11) allow an operation independent of the water mains
- Optional refrigerant condensing unit WL 312.12 for the use of the direct evaporator WL 312.03

DIFFERENT HEAT EXCHANGERS

WL 312.01 Heat Exchanger Element Plain Tubes

This water-to-air heat exchanger is inserted into the duct section of WL 312 and fastened using fasteners. It is supplied with hot or cold water via hoses with quick-release couplings. The pipe bundle consists of smooth pipes. Transparent covers allow insights even when the heat exchanger is installed. For the supply the modules WL 312.10 or WL 312.11 can be used.



WL 312.02 Heat Exchanger Element Finned Tubes

This water-to-air heat exchanger is inserted into the duct section of WL 312 and fastened using fasteners. It is supplied with hot or cold water via hoses with quick-release couplings. The pipe bundle consists of finned tubes which are often used in water-to-air heat exchangers. Transparent covers allow insights even when the heat exchanger is installed. For the supply the modules WL 312.10 or WL 312.11 can also be used here.



WL 312.03 Heat Exchanger Element Direct Expansion Coil

This so-called direct evaporator is inserted into the duct section of WL 312 and fastened using fasteners. It is connected to the refrigerant evaporator set WL 312.12 with hoses and special couplings.

In the pipes the refrigerant evaporates and withdraws heat from the air. The pipes are finned to increase the surface. Here too, transparent covers provide insights.

For the supply the accessory WL 312.12 is required.



WL 312.11 Cold Water Bench
This allows for the supply of the heat exchangers WL 312.01 and WL 312.02. The heat exchangers then operate as air coolers.



WL 312.10 Hot Water Bench
This also allows for the supply of the heat exchangers WL 312.01 and WL 312.02. The heat exchangers then operate as air heaters.



WL 312.12 Condensing Unit
Used to operate the direct evaporator WL 312.03 for air cooling. At the same time it includes a steam generator to supply the air humidifier in the basic unit.

HL 710 PLANNING AND SET-UP OF AIR DUCT SYSTEMS



AIR DUCT SYSTEMS WITH TYPICAL COMPONENTS FROM VENTILATION TECHNOLOGY: SET-UP AND EXPERIMENTS

The components



Pipe bends



Reduction (left) and connection elements



Branches



Throttle valve (left) and iris diaphragm (right)



Disc valve (left) and slotted vent (right)



Filter

The experiments

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

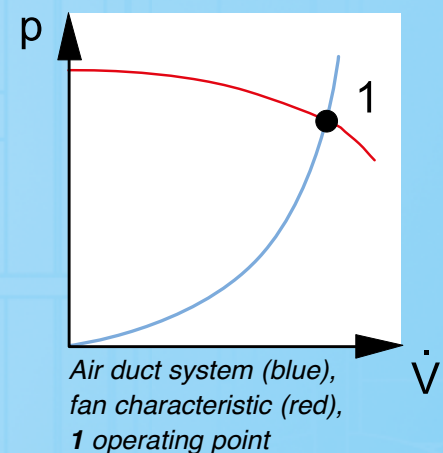
With the anemometer the air velocities and air flows are measured at the outlets of the system. The measured values are used to generate the system and fan characteristics. From the characteristics the operating point is determined.



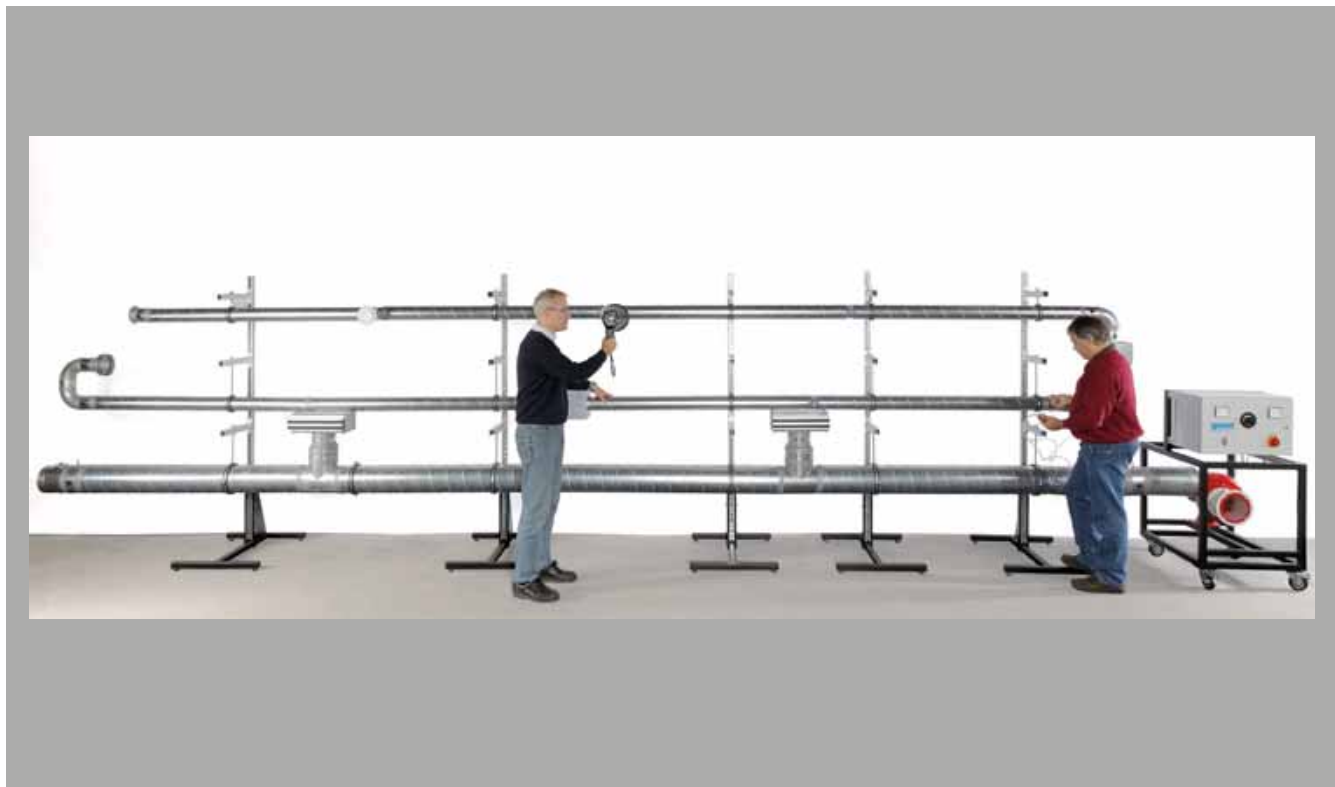
1 digital manometer, 2 inclined tube manometer, 3 anemometer



Measuring points for static and dynamic pressure



HL 710 Air Duct Systems



- * Planning and set-up of simple and complex air duct systems
- * Measurement of the dynamic and static pressures in air duct systems
- * Measurement of the air velocity and volumetric flow rate under different conditions

Technical Description

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

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

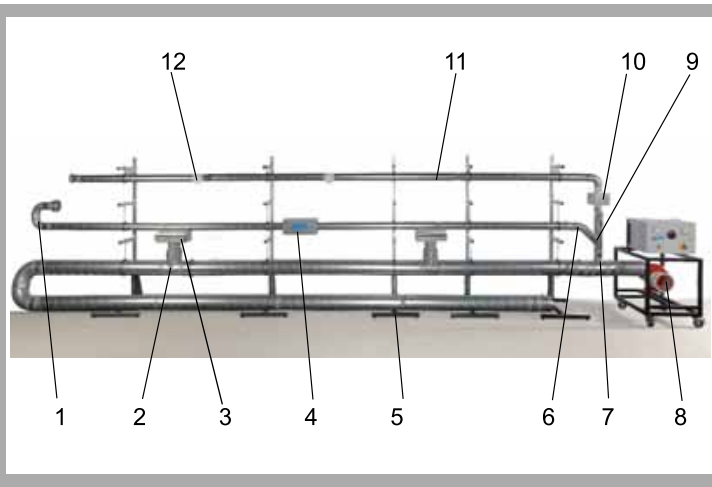
The effects of the individual components on the pressure loss and thus on the velocity and flow rate of the air are examined. For this purpose there are two manometers with different measuring ranges and a manual device for measuring the air velocity. The fan characteristic is also determined. To determine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

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

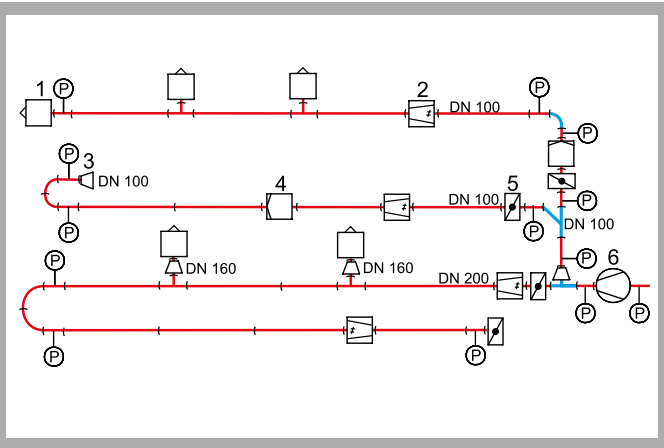
Learning Objectives / Experiments

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

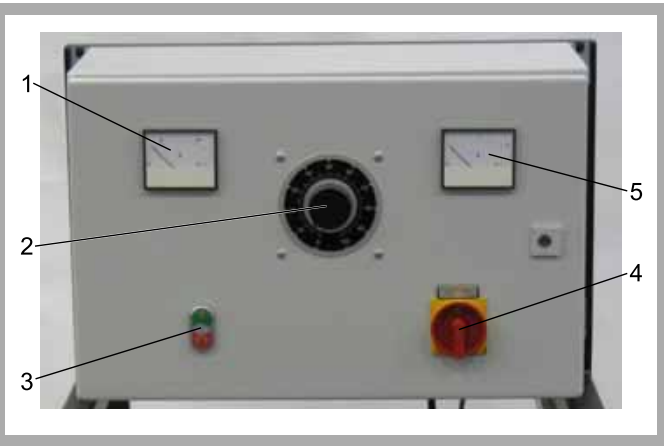
HL 710 Air Duct Systems



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



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



1 voltmeter, 2 fan speed adjustment, 3 fan on/off switch, 4 main switch, 5 ammeter

Specification

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

Technical Data

- Fan
- power consumption: 1100W
 - max. flow rate: 1680m³/h
 - max. differential pressure: 1000Pa
 - speed: 0...2800min⁻¹
- Pipes
- length: 1600mm
 - diameter: 8x DN200, 8x DN100
- Pipe bends and connections, each DN100 and DN200
- 90° pipe bend, 45° pipe bend
 - 45° branch
 - T piece, T piece with reducer
 - reducer, plug-in connection, pipe coupling
- Flow restriction elements, each DN100 and DN200
- throttle valve
 - iris diaphragm
- Filters, each DN100 and DN200
- pocket filter
 - filter cartridge

Measuring ranges

- pressure: 0...200Pa / 0...2000Pa
- velocity: 0.25...30m/s
- current: 0...10A
- voltage: 0...230V

Dimensions and Weight

LxWxH: 1700x650x1400mm (fan)
Weight: approx. 70kg

Required for Operation

230V, 50Hz, 1 phase or 120V, 60Hz, 1 phase

Scope of Delivery

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

Order Details

065.71000 HL 710 Air Duct Systems

HL 720 Ventilation System



- * Complete ventilation system
- * High practical relevance due to the use of industrial components from ventilation technology
- * Representation of pressure curves

Technical Description

In building services engineering ventilation systems are used for commercial premises, hospitals, restaurants or conference rooms to ensure the change of air exchange in the individual rooms. The air is heated or cooled by a heat exchanger.

HL 720 demonstrates the operation of a ventilation system and its components. The components used are common in commercial ventilation technology and therefore are of high practical relevance. The ventilation system is operated as a pure air supply system.

The air enters via a weather louvre and flows through the components of the ventilation system, such as multi-leaf damper and filter. Dependent on the operating mode, heating or cooling, the aspirated air is then heated or cooled in a heat exchanger. The heat exchanger is supplied from the laboratory. A fan ensures the air transport. Further down the air duct, typical components, such as sound insulation link, inspection flap, various air outlets and fire protection flap are arranged.

Sight windows enable an insight into the sound insulation link, filter and fan. The original component function remains intact.

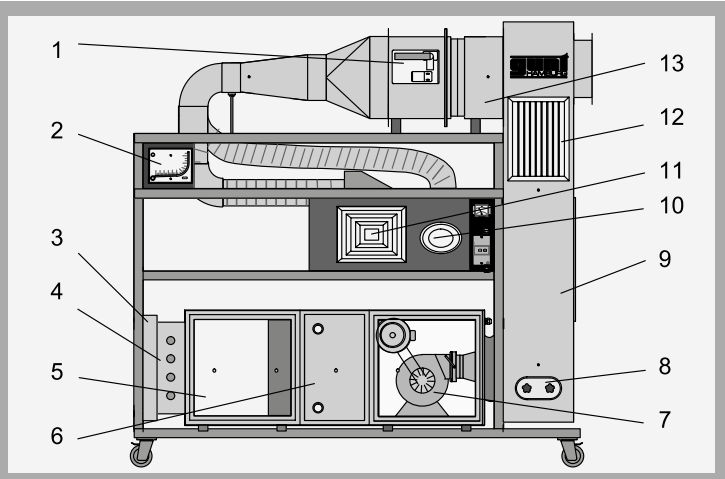
The record of pressures and differential pressures at relevant measuring points enables the representation of a pressure curve for the whole system. The electric drive power of the fan and the volumetric air flow rate are calculated.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

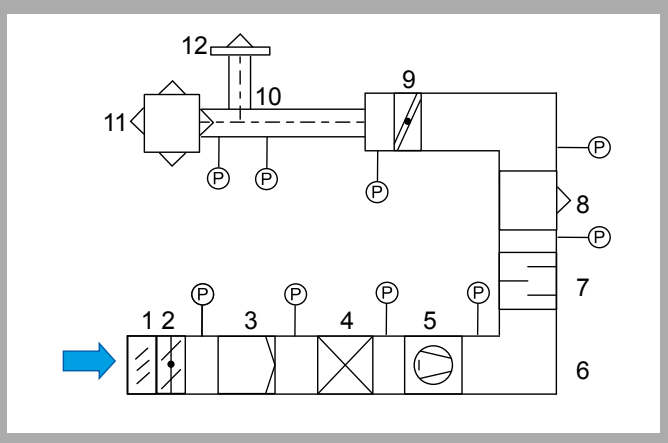
Learning Objectives / Experiments

- 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 as air heater/cooler
 - * fan
 - * inspection cover
 - * sound insulation link
 - * ventilation grill with adjustable flow rate
 - * fire protection flap
 - * ceiling vents

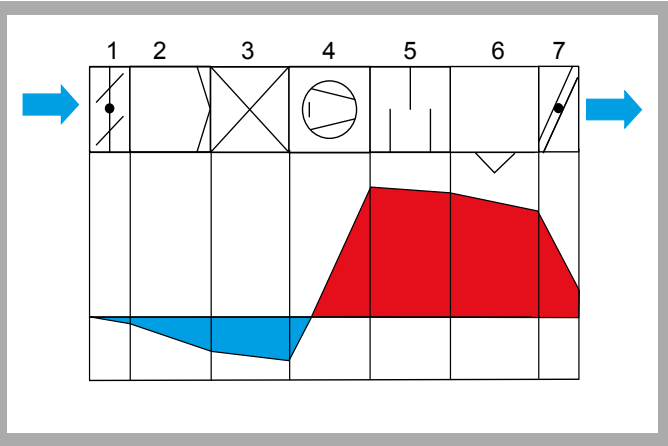
HL 720 Ventilation System



1 fire protection flap, 2 inclined tube manometer, 3 weather louvre, 4 multi-leaf damper, 5 filter, 6 heat exchanger, 7 fan with drive motor, 8 inspection cover, 9 air duct, 10 disc valve, 11 ceiling vent, 12 wall vent, 13 pressure measurement connection



1 weather louvre, 2 multi-leaf damper, 3 filter, 4 heat exchanger, 5 fan, 6 air duct, 7 sound insulation link, 8 wall vent, 9 fire protection flap, 10 branch, 11 air outlet for ceiling installations, 12 disc valve; P pressure



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; red: overpressure, blue: vacuum

Specification

- [1] operation of a ventilation system
- [2] all components from ventilation technology, some with sight windows
- [3] protective grating and adjustable multi-leaf damper at the air inlet
- [4] filter for air purification
- [5] heat exchanger to heat/cool the air
- [6] belt-driven radial fan
- [7] 2 sound insulation links
- [8] various air outlets for air distribution in the room: disc valve, ceiling vent and ventilation grill with adjustable flow rate
- [9] inspection cover for inspection purposes
- [10] fire protection flap prevents the cross-over of fire and smoke in the air duct
- [11] air duct with pressure measurement connections
- [12] pressure measurements with inclined tube manometer
- [13] current measurement to determine the power consumption of the fan
- [14] determine the flow rate via differential pressure

Technical Data

Air duct: 1845x630x305mm
Fan
- max. flow rate: 2500m³/h
- speed: 1600min⁻¹
- drive motor: 750W
Air-to-water heat exchanger as air heater/cooler
- capacity: 7,6kW

Measuring ranges
- pressure: 0...700Pa
- current: 0...4A

Dimensions and Weight

LxWxH: 2000x950x2050mm
Weight: approx. 284kg

Required for Operation

400V, 50/60Hz, 3 phases or 230V, 60Hz, 3 phases
Water connection (hot and cold), drainage

Scope of Delivery

1 experimental unit
1 set of instructional material

Order Details

065.72000 HL 720 Ventilation System

ELECTRICAL ENGINEERING IN REFRIGERATION AND AIR CONDITIONING TECHNOLOGY

INTRODUCTION

CODE	PRODUCT	PAGE
Overview	Basic Knowledge – Electrical Engineering in Refrigeration	204

REFRIGERATION CONTROLS

CODE	PRODUCT	PAGE
ET 144	Electrical Installation in Refrigeration Systems	206
ET 171	Electrical Connection of Refrigerant Compressors	208

CONTROL OF REFRIGERATION SYSTEMS

CODE	PRODUCT	PAGE
ET 340	Building Automation in Heating and Air Conditioning Systems	210
ET 930	Evaporator Control with Electronic Expansion Valve	212

FAULT FINDING

CODE	PRODUCT	PAGE
ET 172	Electrical Faults in Refrigerant Compressors	214
ET 170	Electrical Faults in Simple Air Conditioning Systems	216
ET 174	Electrical Faults in Full Air Conditioning Systems	218



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BASIC KNOWLEDGE

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.

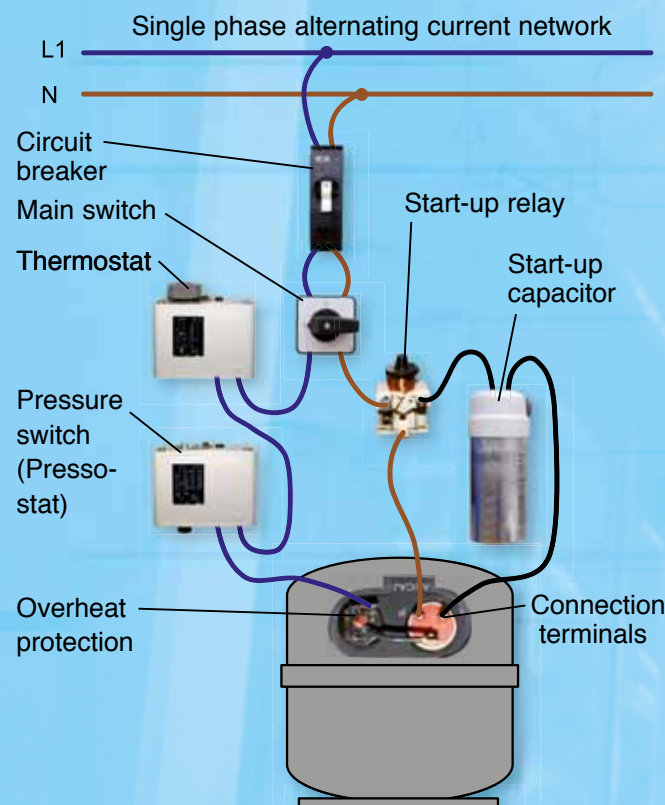
In the service field the testing, fault finding and repair of electrical systems is also an important item. During service you are often confronted with incomplete documentation, which is why the mechatronics engineer for refrigeration must be able to analyse the system and comprehend its operation.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

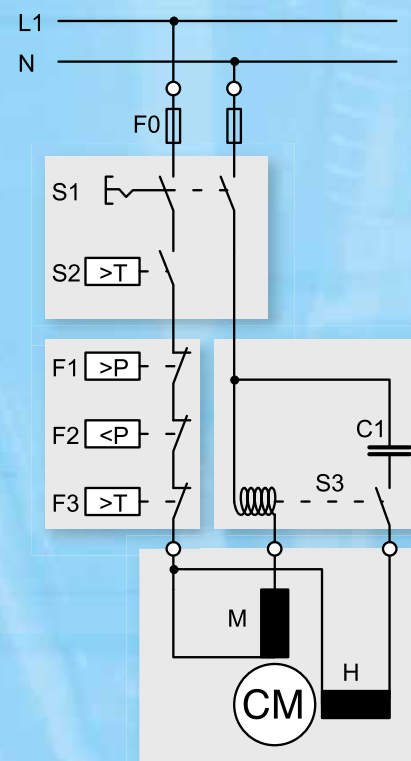
- Controller, consisting of main switch *S1* and thermostat *S2*
- Safety module, consisting of pressure switches (Pressostat) *F1*, *F2* and overheat protection of the compressor *F3*
- Start-up circuit, consisting of the start-up relay *S3* and start-up capacitor *C1*



Electrical components

DESIGN

ANALYSE



Electric circuit diagram (flow diagram):
S1 main switch, *S2* thermostat,
F1 pressure switch, *F2* pressure switch,
F3 overheat protection, *S3* start-up relay,
C1 start-up capacitor, *CM* motor,
M main winding, *H* auxiliary winding

Start-up circuits for single phase compressor motors

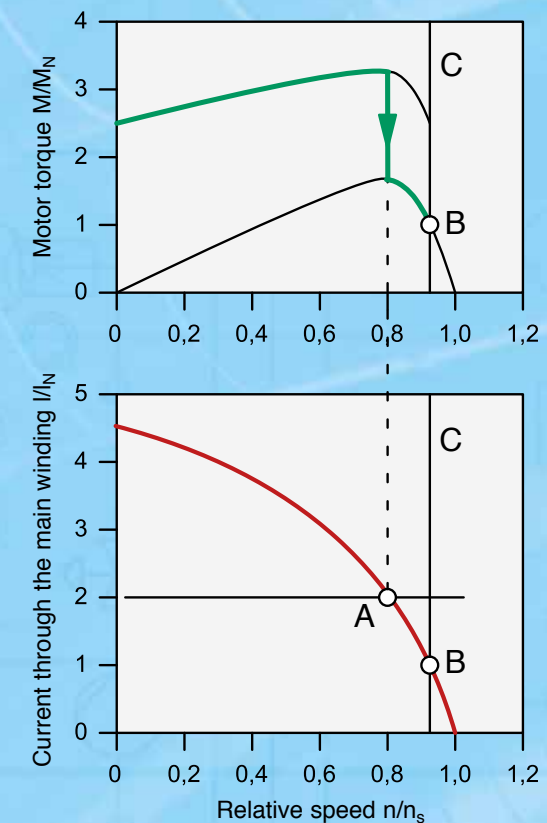
Drive motors for refrigerant compressors require a high start-up torque. For low compressor capacities single phase alternating current motors are used as drive motors. These are of simple design, maintenance-free, cheap and can run inside the refrigerant (hermetic compressor).

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.

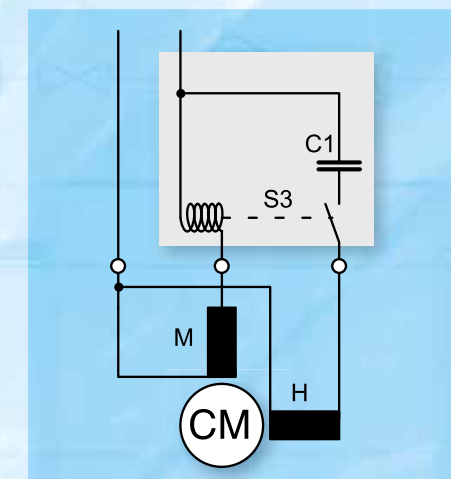
The most common is a start-up relay whose winding is connected in series to the main winding. When starting the motor a very high current first flows through the main winding, the start-up relay responds and activates the auxiliary winding via the capacitor. Once the motor has reached its speed, the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

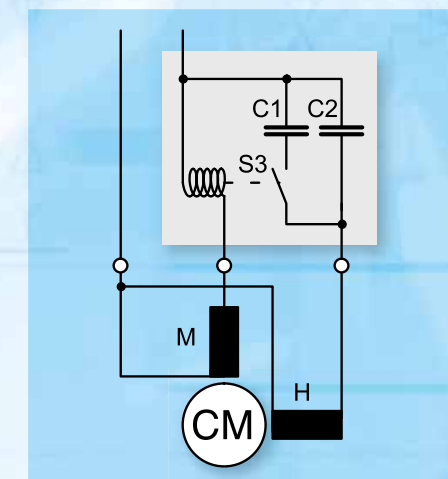
Another particularly wear-free method is the use of a PTC element. This heats due to the current flowing in the auxiliary winding and increases its resistance. This reduces the current through the auxiliary winding after a brief period of time.



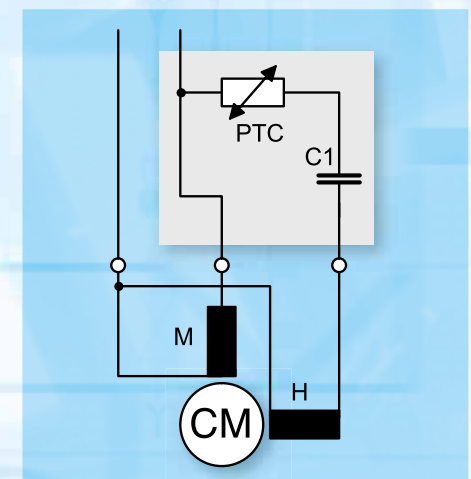
Start of a single phase alternating current motor with auxiliary winding:
 auxiliary winding is switched off at $I = 2 I_N$
 M_N nominal torque, I_N nominal current,
 n_s synchronous torque,
 A switching point, B operating point,
 C n_N/n_s = nominal speed



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

ET 144 Electrical Installation in Refrigeration Systems



- * Design and wiring of typical electrical circuits from refrigeration
- * Investigation of important electrical components from refrigeration
- * Design and investigation of a safety chain

Technical Description

The wiring of electrical components is a typical task in the field of refrigeration. Besides the design and operation of the individual components, knowledge about the interaction of the components in circuits is an important learning objective. Safety aspects also play an important role. With ET 144 this knowledge and these skills can be acquired.

The electrical components are arranged clearly visible. All components are connected on terminal blocks. Using the cables included in the scope of delivery it is possible to set-up different circuits correctly and operationally. Lamps simulate the consumers. All components are operated and tested with mains voltage to provide high relevance for practice.

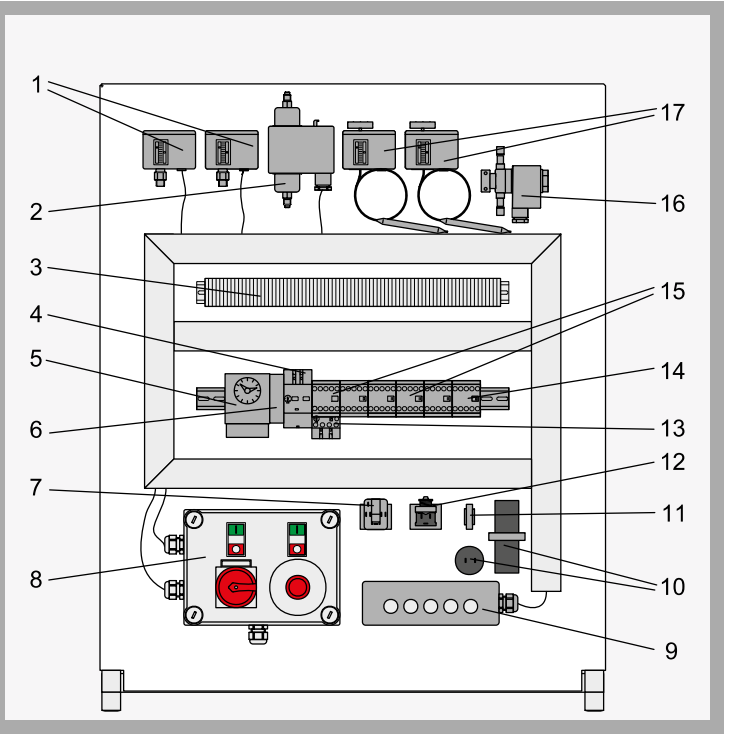
There are electrical components for the start and operation of refrigerant compressors, such as e.g. electromagnetic start-up relay and capacitor. With a timer, circuits can be designed and examined for cyclical defrosting in refrigeration systems. This also includes the correct programming of the timer. Typical safety components, such as pressure switches, thermostats and circuit breakers are also included in the scope of delivery. These components enable the design and examination of a typical safety chain for refrigeration.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

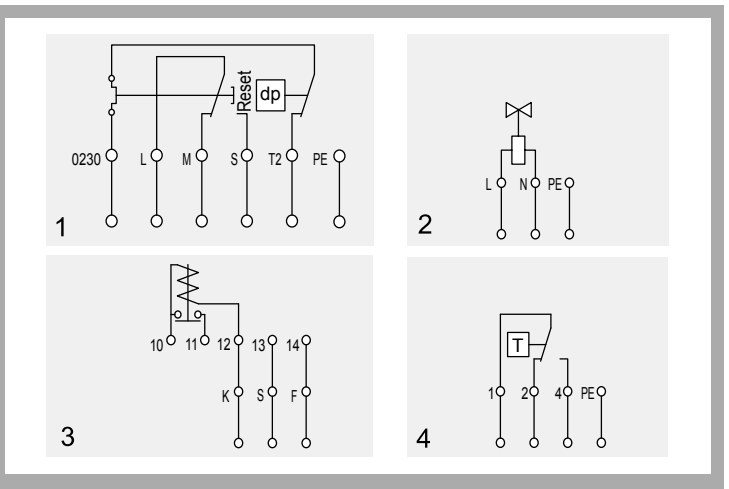
Learning Objectives / Experiments

- 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 144 Electrical Installation in Refrigeration Systems



1 pressure switch, 2 differential pressure switch, 3 terminal block, 4 circuit breaker with start-up current limiter, 5 timer, 6 thermistor circuit breaker, 7 PTC start-up relay, 8 switch cabinet, 9 lamps, 10 capacitors, 11 bimetallic circuit breaker, 12 electromagnetic start-up relay, 13 adjustable protection relay, 14 time relay, 15 contactor, 16 solenoid valve, 17 thermostat



Circuit diagrams: 1 differential pressure switch, 2 solenoid valve, 3 electromagnetic start-up relay, 4 thermostat

Specification

- [1] experimental unit from the GUNT practical series for the training of mechatronics engineers for refrigeration
- [2] design and investigation of circuits with electrical components from refrigeration
- [3] electrical components mounted clearly visible and connected on terminal blocks
- [4] 1 set of cables with wire end ferrules for wiring electrical components on terminal blocks
- [5] 3 pressure switches, 2 thermostats, 1 solenoid valve, 1 timer, 4 circuit breakers, 5 contactors, 3 relays, 2 capacitors
- [6] 5 lamps to simulate consumers

Technical Data

- 3 pressure switches
 - high pressure: 8...32bar
 - low pressure: -0,9...7bar
 - differential pressure: 0,3...4,5bar
- 2 thermostats: -5...20°C
- 1 timer
- 2 switchable outputs
- switching time: 1...60min
- 4 circuit breakers
 - bimetallic circuit breaker
 - thermistor circuit breaker
 - circuit breaker with start-up current limiter
 - adjustable protection relay
- 5 contactors
 - 2x: 3 NO, 1 NC
 - 3x: 4 NO
- 3 relays
 - electromagnetic start-up relay
 - PTC start-up relay
 - time relay
- Start-up and operating capacitor: 15µF, 80µF

Dimensions and Weight

LxWxH: 820x420x1010mm
Weight: approx. 42kg

Required for Operation

400V, 50Hz, 3 phases or 230V, 60Hz, 3 phases

Scope of Delivery

- 1 experimental unit
- 1 set of accessory (cables + wire end ferrules)
- 1 set of instructional material

Order Details

061.14400 ET 144 Electrical Installation in Refrigeration Systems

ET 171 Electrical Connection of Refrigerant Compressors



- * Correct electrical connection of a refrigerant compressor
- * Use of a real refrigerant compressor
- * Design and investigation of a safety chain

Technical Description

The wiring of electrical components for the start and operation of refrigerant compressors is a typical task in the field of refrigeration. Safety aspects also play an important role. With ET 171 this knowledge and these skills can be acquired. All components are operated and tested with mains voltage to provide high relevance for practice.

The electrical components for the start and operation of the refrigerant compressor are arranged clearly visible. The electrical connection of the individual components is made with cables via the lab jacks. The components are e.g. the capacitor and start-up relay necessary to start the motor. The circuit diagram on the front panel enables the easy allocation of the individual components.

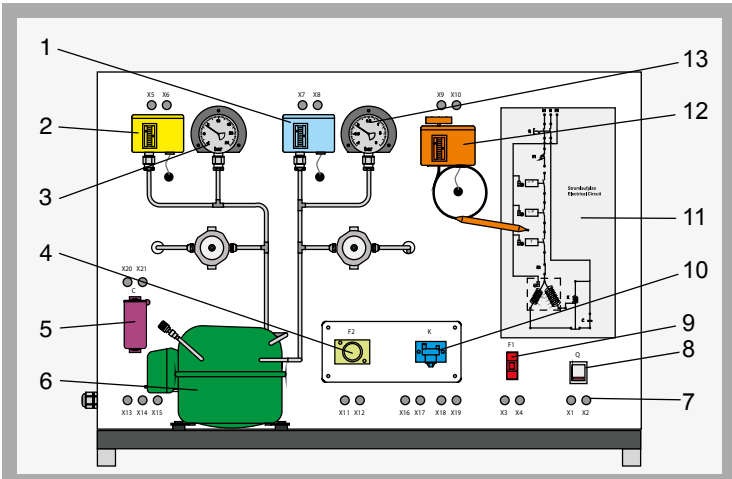
The refrigeration circuit with compressor and receiver enables the checking of the pressure switches on the intake and delivery side of the compressor. The pressure is set via valves and the pressure switch tripped. Two manometers enable the monitoring of the pressure curve. If one of the pressure switches trips, the current supply to the compressor is interrupted. The wiring and checking of other typical components of the safety chain, e.g. circuit breaker and automatic fuse, is also carried out.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

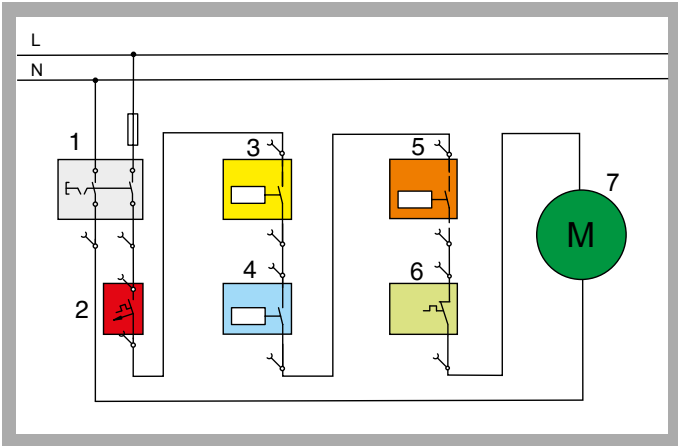
Learning Objectives / Experiments

- 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

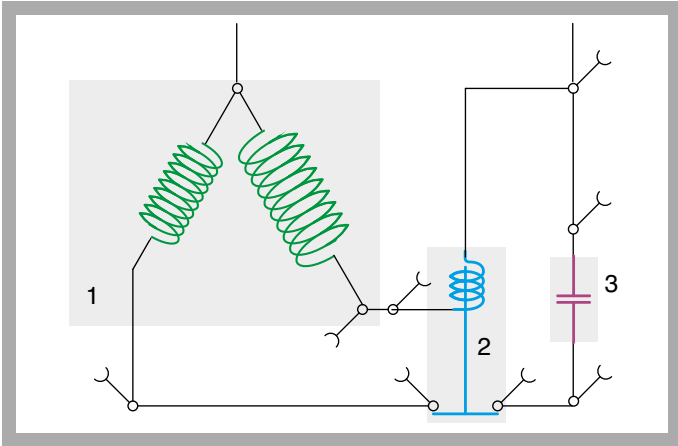
ET 171 Electrical Connection of Refrigerant Compressors



1 pressure switch intake side, 2 pressure switch delivery side, 3 manometer delivery side, 4 overheat protection, 5 start-up capacitor, 6 refrigerant compressor, 7 lab jacks, 8 main switch, 9 automatic fuse, 10 start-up relay, 11 circuit diagram, 12 thermostat, 13 manometer intake side



Safety chain: 1 main switch, 2 automatic fuse, 3 pressure switch delivery side, 4 pressure switch intake side, 5 thermostat, 6 overheat protection, 7 refrigerant compressor with start-up components



Refrigerant compressor with start-up components 1 refrigerant compressor, 2 start-up relay, 3 start-up capacitor

Specification

- [1] Experimental unit from the GUNT practical series for the training of mechatronics engineers for refrigeration
- [2] Correct electrical connection of a refrigerant compressor
- [3] Refrigerant circuit with compressor, receiver, 2 valves and 2 manometers to investigate pressure switches on the delivery and intake sides
- [4] Electrical components for the start and operation of the compressor mounted clearly visible
- [5] Lab jacks and cables to connect the electrical components
- [6] Operation of a thermostat
- [7] Circuit diagram on the front panel for easy identification of the components
- [8] Refrigerant R134a, CFC-free

Technical Data

Refrigerant compressor
- power consumption: approx. 165W
Receiver: 0,8L
Manometer measuring ranges
- delivery side: -1...24bar
- intake side: -1...9bar
Pressure switch control range
- delivery side: 8...32bar
- intake side: -0,9...7bar
Thermostat: -5...35°C
Electrical components for the compressor
- start-up capacitor
- start-up relay
- overheat protection (bimetallic)
- automatic fuse

Dimensions and Weight

I x w x h: 900x400x650mm
Weight: approx. 35kg

Required for Operation

230V, 50Hz, 1 phase

Scope of Delivery

- 1 experimental unit
- 1 multimeter
- 1 set of laboratory cables
- 1 set of instructional material

Order Details

061.17100 ET 171 Electrical Connection of Refrigerant Compressors

ET 340 Building Automation in Heating and Air Conditioning Systems



- * Operation and programming of a DDC for heating and air conditioning systems
- * Simulated heating system with water heating
- * Simulated air conditioning system with outer air and recirculating operation

Technical Description

Heating and air conditioning technology is a key topic in building services engineering. For the control and monitoring of heating and air conditioning systems DDCs (Direct Digital Control) or PLC air conditioning controllers are usually used in building services engineering. The controller is adjusted to the respective tasks by programming, making additional cabling unnecessary.

With ET 340 the operation and programming of a DDC for a heating and air conditioning system can be learned. The process schematics for the two simulated systems are shown on the front panel.

The simulated heating system has two boilers connected in parallel. The feed flow temperature is controlled through the outside temperature using 3-way mixing valves. There are two heating lines with simulated heaters and different actuators: 3-way mixing valves and pumps. An additional 3-way mixing valve is the actuator for water heating.

The simulated air conditioning system with air heater, air cooler and fans can be operated in outer air and recirculated operation via flaps with a motor as actuator.

Both process schematics contain potentiometers simulating e.g. a change in the outside, room or feed flow temperature. Bargraph displays and lamps indicate the operating states of the actuators.

In addition to manual configuration and parameterisation via buttons, the DDC can also be adjusted for the respective control task using the configuration software supplied. It further enables the monitoring of

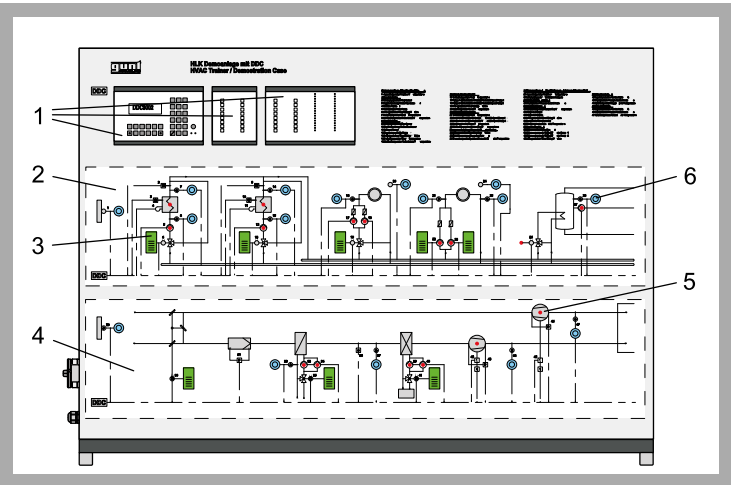
safety devices such as a low water cut-off in the boiler. The simulation of faults, such as triggering the differential pressure switch at the fan, can be carried out via buttons.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

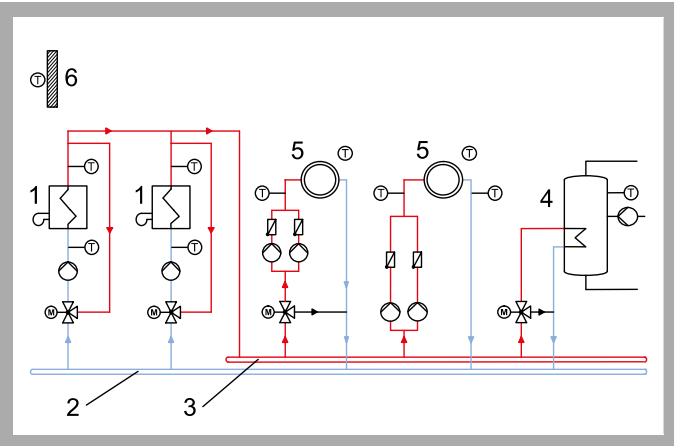
Learning Objectives / Experiments

- 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

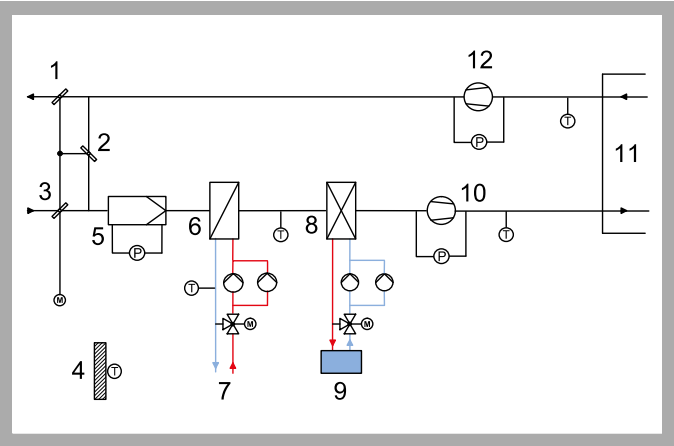
ET 340 Building Automation in Heating and Air Conditioning Systems



1 DDC modules, 2 process schematic of the simulated heating system, 3 bargraph displays for the operating state of the actuator, 4 process schematic of the simulated air conditioning system, 5 lamp for operating state on/off of the actuator, 6 potentiometer for temperature adjustment



Simulated heating system: 1 boiler with heater, 2 return flow, 3 feed flow, 4 hot water generator, 5 room heating, 6 outer temperature sensor



Simulated air conditioning system: 1 exhaust air flap, 2 recirculating air flap, 3 outer air flap, 4 outer temperature sensor, 5 filter, 6 air heater, 7 hot water feed/return, 8 air cooler, 9 water chiller, 10 inlet air fan, 11 room, 12 exhaust air fan

Specification

- [1] Experimental unit from the GUNT practical series for the training of mechatronics engineers for refrigeration
- [2] Operation and programming of a DDC for heating and air conditioning systems
- [3] Process schematic of the simulated heating system with 2 boilers, 2 heating lines and water heating
- [4] Process schematic of the simulated air conditioning system with selectable outer air and recirculating operation
- [5] Programmable DDC with selection and display of the operating states and error simulation
- [6] Process schematics with bargraph displays and lamps for operating states of the actuators
- [7] 16 potentiometers in the process schematics to adjust simulated temperatures
- [8] Process schematics on the front panel

Technical Data

- DDC
 - 16 digital inputs
 - 8 digital outputs
 - 16 analogue inputs
 - 8 analogue outputs
 - control circuits: 4
 - PLC functions
 - auxiliary energy: 24VAC
 - 14 buttons to select the operating states
 - 16 buttons for error simulation
- Bargraph display measuring range: 0...100%

Dimensions and Weight

I x w x h: 1300x400x950mm
Weight: approx. 72kg

Required for Operation

230V, 50/60Hz, 1 phase oder 120V, 60Hz, 1 phase

Scope of Delivery

- 1 experimental unit
- 1 set of instructional material

Order Details

061.34000 ET 340 Building Automation in Heating and Air Conditioning Systems

ET 930 Evaporator Control with Electronic Expansion Valve



- * Practical programming of a modern refrigeration controller
- * Software to simulate a commercial freezer
- * Real components of evaporator control fitted to front panel for demonstration purposes

Technical Description

The control of refrigeration units such as chiller cabinets, refrigerated display cases and freezers is a key topic in commercial refrigeration. The control aims at safeguarding a high level of food quality with simultaneous energy-efficient operation.

With ET 930 the operation and programming of an industrial evaporator controller (refrigeration controller) is taught in the example of a freezer. Software simulates the freezer. The schematic depicted on the front panel aids comprehension. Lamps in the schematic indicate the operating state of the individual components.

The refrigeration controller controls the temperature of the freezer via the electronic expansion valve. It also controls the air circulation fan. It provides for the defrosting of the evaporator and prevents the freezing of the freezer lid by way of a frame heating. The refrigeration controller continuously monitors the operation of the components and issues an alarm signal should errors occur.

The controller is programmed via a data cable using a programming device. This allows for adjustments of the thermostat function, daytime/night-time operation, the defrosting function, energy saving functions and safety functions.

In the simulation software the outside temperature is entered, the refrigerant selected and the door of the freezer opened or closed. In the "time graph" menu, the operating states of the individual components are displayed and the temperature and pressure graphs recorded.

Additional real components, such as expansion valve and pressure and temperature sensors, are used for demonstration purposes and increase the practical relevance.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

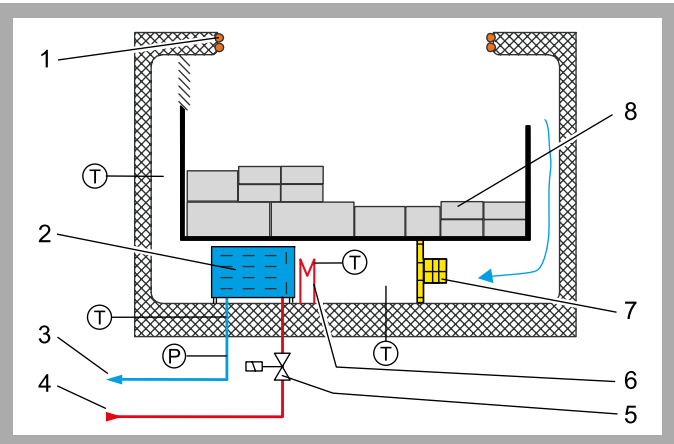
Learning Objectives / Experiments

- 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

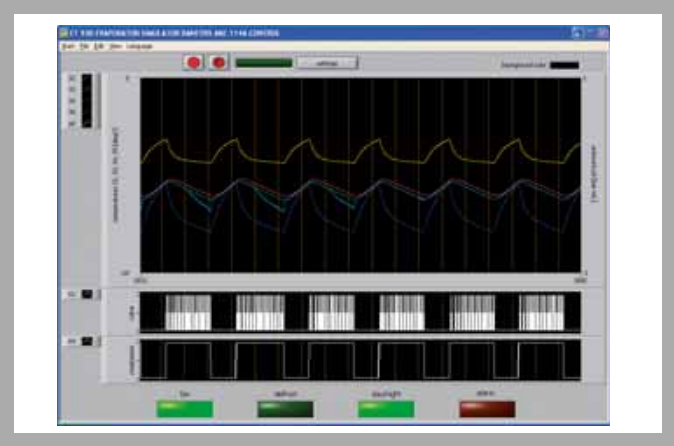
ET 930 Evaporator Control with Electronic Expansion Valve



1 pressure sensor, 2 electronic expansion valve, 3 display of the refrigeration controller, 4 temperature sensor, 5 diagram of the simulated freezer



Simulated freezer: 1 heating at the frame, 2 evaporator, 3 intake side condensing unit connection, 4 delivery side condensing unit connection, 5 expansion valve, 6 electric defrost heater, 7 fan, 8 refrigerated goods; T temperature, P pressure



Screenshot of the simulation software: temperature graphs (top), switching states (bottom)

Specification

- [1] experimental unit from the GUNT practical series for the training of mechatronics engineers for refrigeration
- [2] investigation and programming of an industrial refrigeration controller in the example of a freezer
- [3] simulation of the freezer by way of software
- [4] schematic on the front panel with lamps to indicate the operating states of the actuators
- [5] programming of the refrigeration controller using a programming device
- [6] simulated freezer with compressor, electronic expansion valve, fan, electric defrost heater for the evaporator, frame heating, pressure and temperature sensors
- [7] real freezer components for demonstration purposes: 1 electronic expansion valve, 1 pressure sensor, 2 temperature sensor
- [8] GUNT software for simulation via USB under Windows Vista or Windows 7

Technical Data

Functions of the refrigeration controller

- thermostat function
- daytime/night-time operation
- defrost functions
- messages and alarms
- fan operation
- energy saving functions
- safety functions

Simulated sensors

- air temperature upstream of the evaporator
- air temperature downstream of the evaporator
- evaporator surface temperature
- refrigerant temperature upstream of the compressor
- refrigerant pressure upstream of the compressor

Functions of the simulation software

- outer temperature input
- opening/closing the door
- selection of refrigerant
- pressure and temperature time graphs

Dimensions and Weight

LxWxH: 660x350x570mm
Weight: approx. 20kg

Required for Operation

230V, 50/60Hz, 1 phase or 120V, 60Hz/CSA, 1 phase

Scope of Delivery

- 1 experimental unit
- 1 GUNT software CD + USB cable
- 1 set of instructional material

Order Details

061.93000 ET 930 Evaporator Control with Electronic Expansion Valve

ET 172 Electrical Faults in Refrigerant Compressors



- * Real refrigerant compressor from practice
- * Investigation of important electrical components from refrigeration
- * Simulation of 15 faults

Technical Description

Identifying electrical faults in refrigeration systems requires comprehensive knowledge. This knowledge includes the design and operation of the individual electrical components as well as the reading of circuit diagrams. ET 172 helps to acquire this knowledge.

The electrical components for the start and operation of a refrigerant compressor are clearly visibly arranged in a transparent showcase and already wired. The capacitor and start-up relay required for the motor are examined. Typical protection devices, such as circuit breaker and automatic fuse, are also arranged clearly visible.

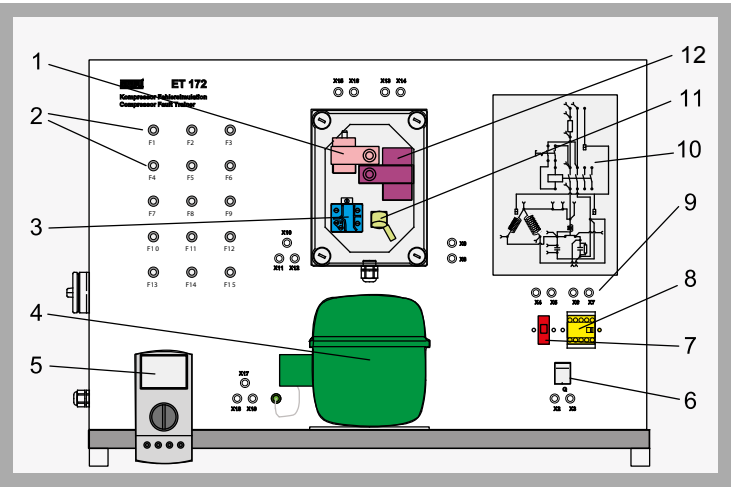
The simulation of 15 different faults, e.g. coil fracture in the motor, short circuit in the operating capacitor or welded contacts in the start-up relay, is possible. For fault indication, voltages and resistances are checked at the lab jacks with the multimeter. The depiction of the circuit diagram on the front panel facilitates the allocation of the measuring points.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

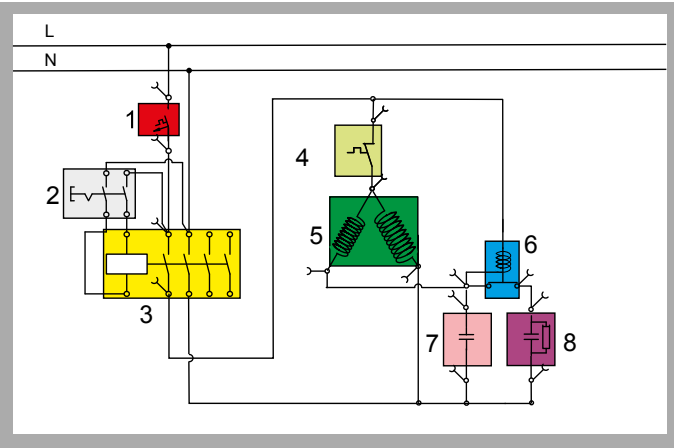
Learning Objectives / Experiments

- 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

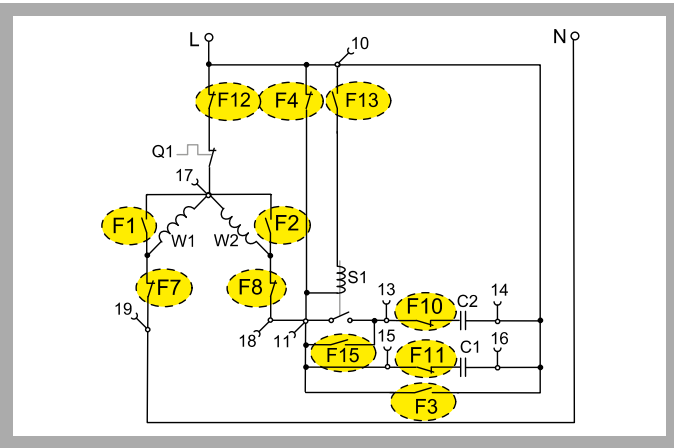
ET 172 Electrical Faults in Refrigerant Compressors



1 operating capacitor, 2 buttons for faults, 3 start-up relay, 4 refrigerant compressor, 5 multimeter, 6 main switch, 7 automatic fuse, 8 main contactor, 9 lab jacks, 10 circuit diagram, 11 overheat protection, 12 start-up capacitor



1 automatic fuse, 2 main switch, 3 main contactor, 4 overheat protection, 5 refrigerant compressor, 6 start-up relay, 7 operating capacitor, 8 start-up capacitor



Fault simulation in the compressor: F1, F7 main winding fault, F2, F8 auxiliary winding fault, F3, F10, F11 operating and start-up capacitor fault, F12 overheat protection faulty, F13, F15 start-up relay faulty

- Specification**
- [1] Experimental unit from the GUNT practical series for the training of mechatronics engineers for refrigeration
 - [2] Investigation of the electrical components for the operation of a refrigerant compressor
 - [3] Real refrigerant compressor from practice
 - [4] Electrical components for the start and operation of the compressor arranged in the transparent switch cabinet
 - [5] General safety devices mounted clearly visible
 - [6] Circuit diagram depicted on the front panel
 - [7] Identification of 15 faults: multimeter measures voltages or resistances at the lab jacks

- Technical Data**
- Refrigerant compressor
- power consumption: approx. 870W
- Electrical components for the compressor
- start-up capacitor
 - start-up relay
 - operating capacitor
 - overheat protection (bimetallic)
- General safety devices
- main contactor
 - automatic fuse

- Dimensions and Weight**
- LxWxH: 900x400x650mm
Weight: approx. 60kg

- Required for Operation**
- 230V, 50/60Hz, 1 phase or 120V, 60Hz, 1 phase

- Scope of Delivery**
- 1 experimental unit
 - 1 multimeter
 - 1 set of instructional material

- Order Details**
- 061.17200 ET 172 Electrical Faults in Refrigerant Compressors

ET 170 Electrical Faults in Simple Air Conditioning Systems



- * Simulation of a simple air conditioning system with compressor, fan and thermostat
- * Investigation of key electrical components from air conditioning technology
- * Simulation of 15 faults

Technical Description

Identifying electrical faults in air conditioning systems requires comprehensive knowledge. This knowledge includes the design and operation of the individual electrical components as well as the reading of circuit diagrams. ET 170 helps to acquire this knowledge.

ET 170 demonstrates the electrical circuit of a simple air conditioning system, consisting mainly of a refrigerant compressor and fan at the air cooler. The control circuits are actually present. Compressor and fan motor are simulated.

The compressor is controlled via a thermostat. Via a ballast the fan motor speed can be switched in two stages. The start of the compressor motor takes place via a start-up relay and start-up capacitor.

Typical protection devices, such as circuit breaker, complete the electrical circuit. The operating state of the simulated components compressor and fan is indicated via lamps in the circuit diagram on the front panel.

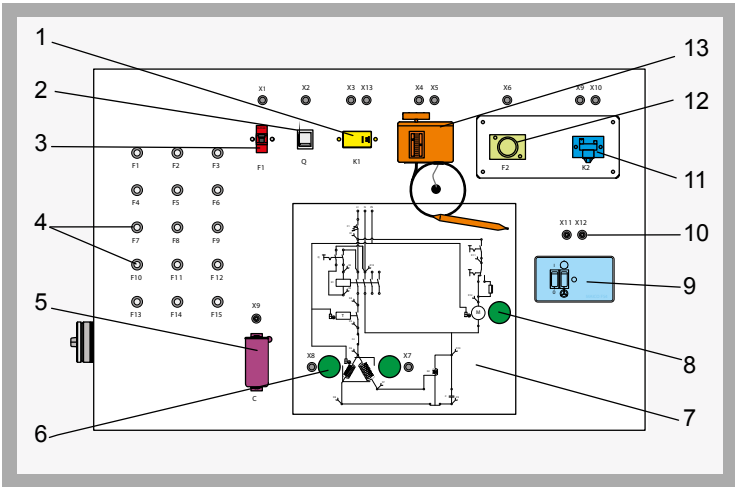
The simulation of 15 different faults, such as coil fracture in the motor or faulty switching contact, is possible. For fault indication, voltages and resistances are checked at the lab jacks with the multimeter. The depiction of the circuit diagram on the front panel facilitates the allocation of the measuring points.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

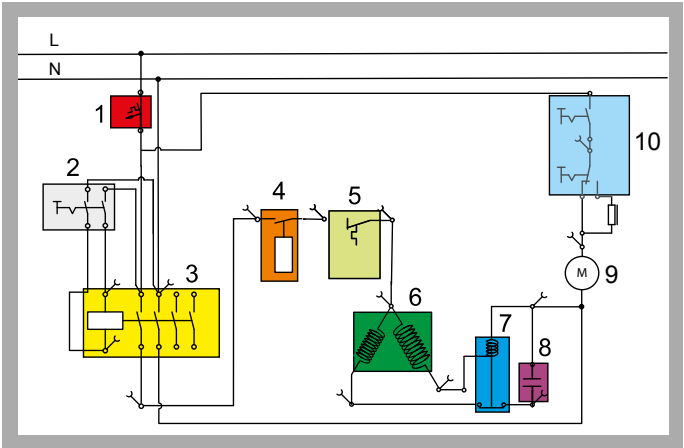
Learning Objectives / Experiments

- 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

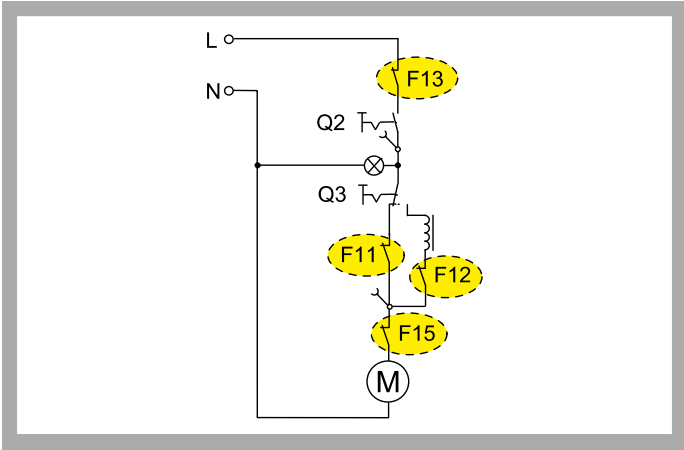
ET 170 Electrical Faults in Simple Air Conditioning Systems



1 main contactor, 2 main switch, 3 automatic fuse, 4 buttons for faults, 5 start-up capacitor, 6 lamp for simulated compressor, 7 circuit diagram, 8 lamp for simulated fan, 9 fan switch, 10 lab jacks, 11 start-up relay, 12 overheat protection, 13 thermostat



1 automatic fuse, 2 main switch, 3 main contactor, 4 thermostat, 5 overheat protection, 6 simulated compressor, 7 start-up relay, 8 start-up capacitor, 9 simulated fan, 10 fan switch



Faults in the fan: F11 high speed faulty, F12 low speed faulty, F13 no power supply, F15 fan motor faulty

Specification

- [1] experimental unit from the GUNT practical series for the training of mechatronics engineers for refrigeration
- [2] simulation of the electrical circuit of a simple air conditioning system for cooling
- [3] real control circuits with electrical components, simulated load circuits
- [4] electrical simulation of compressor and fan
- [5] temperature control with thermostat and compressor
- [6] fan with 2 adjustable speeds
- [7] operating states of the simulated components indicated via lamps in the circuit diagram
- [8] circuit diagram depicted on the front panel
- [9] identification of 15 faults: multimeter measures voltages or resistances at the lab jacks

Technical Data

- Simulated compressor
 - start-up current: > 3A
- Electrical components for the compressor
 - start-up capacitor
 - start-up relay
 - overheat protection (bimetallic)
- Electrical components for the fan
 - on/off switch
 - speed switch
- Thermostat: -5...35°C
- General safety devices
 - main contactor
 - automatic fuse

Dimensions and Weight

LxWxH: 900x400x650mm
Weight: approx. 30kg

Required for Operation

230V, 50/60Hz, 1 phase or 120V, 60Hz/CSA, 1 phase

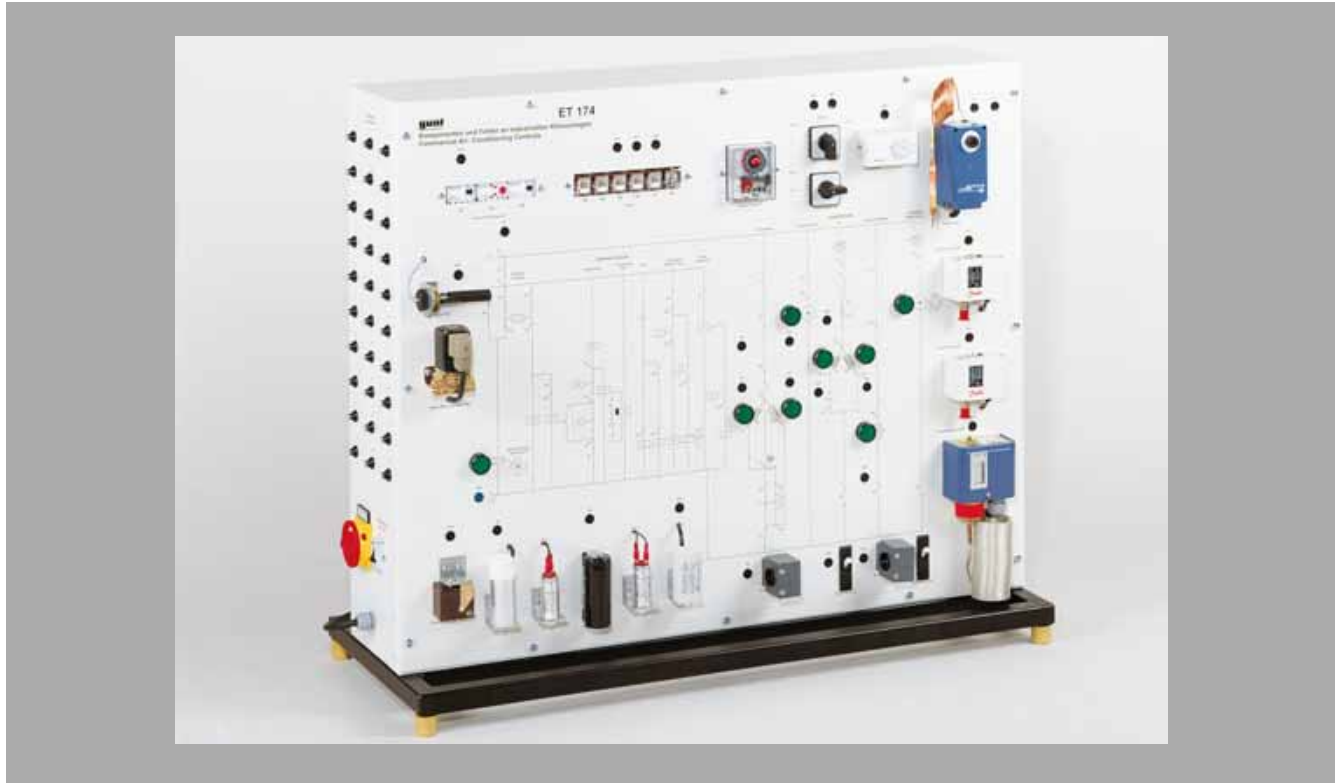
Scope of Delivery

- 1 experimental unit
- 1 multimeter
- 1 set of instructional material

Order Details

061.17000 ET 170 Electrical Faults in Simple Air Conditioning Systems

ET 174 Electrical Faults in Full Air Conditioning Systems



- * Simulation of the electrical circuit of a complex conditioning system with humidifying and heat pump function
- * Investigation of key electrical components from air conditioning technology
- * Simulation of 30 faults

Technical Description

Identifying electrical faults in air conditioning systems requires comprehensive knowledge. This knowledge includes the design and operation of the individual electrical components as well as the reading of circuit diagrams. ET 174 helps to acquire this knowledge.

ET 174 demonstrates the electrical circuit of a complex full conditioning system with heat pump function. The control circuits are actually present. The components in the load circuits are simulated (e.g. compressor, heater, 4-way reversing valve).

The air conditioning system with heat pump function cools in the summer and heats in the winter. During heating operation the defrost timer introduces a hot gas defrosting by briefly switching the 4-way reversing valve. At very low outer temperatures an electrical auxiliary heating is activated during heating operation. With low air humidity the hygostat activates the humidifying function.

Typical protection devices, such as circuit breaker and frost protection monitor, complete the electrical circuit. The operating state of the simulated components is indicated via lamps in the circuit diagram on the front panel.

The simulation of 30 different faults, such as coil fracture in the motor or faulty relays, is possible. For fault identification the voltages or resistances at the lab jacks are checked with the multimeter. The depiction of the circuit diagram on the front panel facilitates the allocation

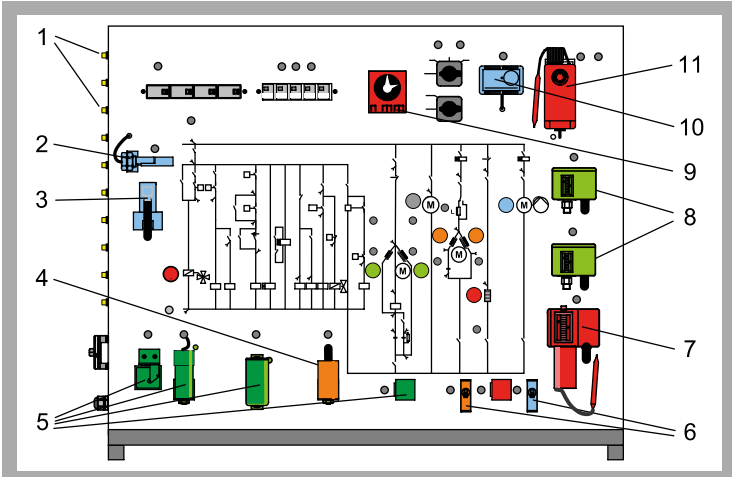
of the measuring points.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

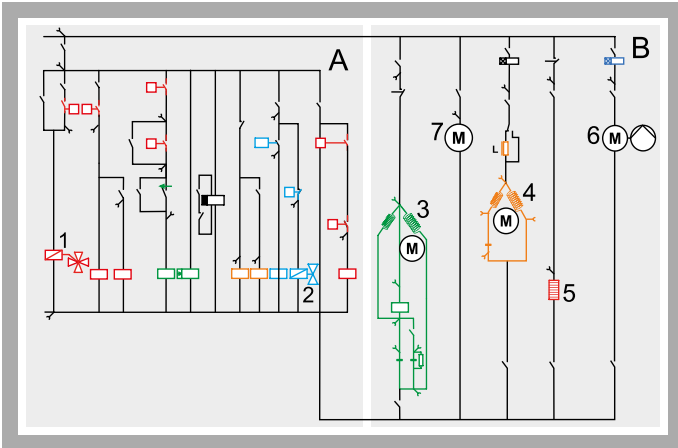
Learning Objectives / Experiments

- 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
- * hygostat
- * frost protection monitor
- fault finding in electrical components
- * in idle state
- * under mains voltage

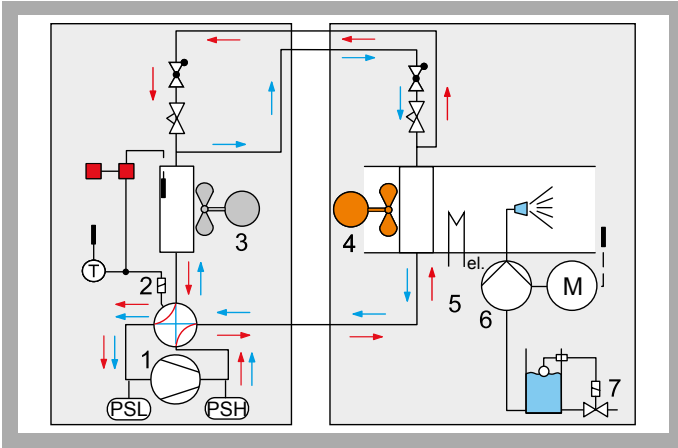
ET 174 Electrical Faults in Full Air Conditioning Systems



1 buttons for faults, 2 float switch, 3 humidifier solenoid valve, 4 room air fan start-up capacitor, 5 electrical compressor components, 6 circuit breaker for room air fan and humidifier pump, 7 frost protection monitor, 8 compressor pressure switch, 9 defrost timer, 10 hygostat, 11 thermostat



A control circuit, B load circuit; 1 4-way reversing valve heating/cooling, 2 humidifier solenoid valve, 3 compressor, 4 room air fan, 5 auxiliary heating, 6 humidifier pump, 7 outer air fan



Simulated air conditioning system: 1 compressor, 2 4-way valve heating/cooling, 3 outer air fan, 4 room air fan, 5 auxiliary heating, 6 humidifier pump, 7 humidifier solenoid valve

Specification

- [1] experimental unit from the GUNT practical series for the training of mechatronics engineers for refrigeration
- [2] simulation of the electrical circuit of a complex conditioning system with humidifier and heat pump function for heating, cooling and humidifying
- [3] real control circuits with electrical components, simulated load circuits
- [4] electrical simulation of compressor, 2 fans (room air, outer air), 4-way reversing valve, auxiliary heating
- [5] humidifier with hygostat, solenoid valve and float switch (pump simulated)
- [6] hot gas defrosting by switching the 4-way reversing valve
- [7] operating states of the simulated components indicated via lamps in the circuit diagram
- [8] circuit diagram depicted on the front panel
- [9] identification of 30 faults: multimeter measures voltages or resistances at the lab jacks

Technical Data

- Thermostat to switch between heating/cooling
- measuring range: 1...60°C
- Electrical compressor components
- start-up relay
- start-up capacitor
- operating capacitor
- overheat protection
- 2 pressure switches
- Electrical components of room air fan
- start-up capacitor
- Heinemann circuit breaker
- Humidifier components
- hygostat: measuring range 30...100% r.h.
- float switch
- solenoid valve
- Heinemann circuit breaker
- Defrosting components
- frost protection monitor: -10...12°C
- timer: switching time 10...60min
- Circuit breaker for auxiliary heating

Dimensions and Weight

- LxWxH: 1.050x400x860mm
- Weight: approx. 48kg

Required for Operation

- 230V, 50/60Hz, 1 phase or 120V, 60Hz, 1 phase

Scope of Delivery

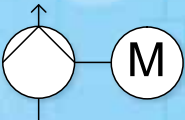
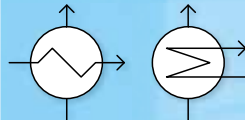
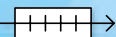
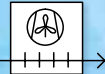
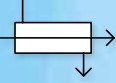
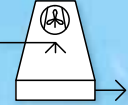
- 1 experimental unit
- 1 multimeter + accessories
- 1 set of instructional material

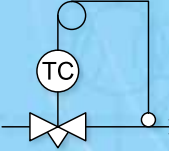
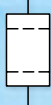
Order Details

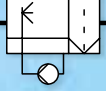
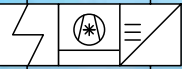
- 061.17400 ET 174 Electrical Faults in Full Air Conditioning Systems

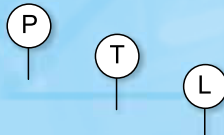
SYMBOLS AND TERMS USED IN REFRIGERATION AND AIR CONDITIONING TECHNOLOGY

In refrigeration and air conditioning technology standardised symbols are used for process schematics. For refrigeration, the standard EN 1861 Refrigeration Systems and Heat Pumps applies, and for air conditioning technology, the standard DIN 1946 Ventilation and Air Conditioning Technology applies. This page introduces the most frequent symbols used in this catalogue. The list only provides an extract of the available symbols.

REFRIGERATION			
COMPRESSORS AND PUMPS			
	Compressor, general		Axial fan
	Piston compressor		Pump, general with motor
	Scroll compressor		Centrifugal pump
	Jet compressor		Piston pump
HEAT EXCHANGERS			
	Heat exchanger, general		Plate heat exchanger
	Finned tube heat exchanger		Air-cooled finned tube heat exchanger with axial fan
	Tubular heat exchanger		Wet cooling tower with aspirating axial fan
TANKS			
	Tank, general		Collector, pressure vessel
	Tank with electric heater		

SHUT-OFF AND EXPANSION ELEMENTS			
	Valve, general		Valve with continuous adjusting behaviour
	Ball valve		Adjustment valve with drive
	Non-return valve		Thermostatic expansion valve with capillary sensor
	Safety valve		
	Liquid filter		Sight glass with humidity indicator
	Fixed bed filter, e.g. filter/drier		
	Separator, general		Hydraulic control unit such as intake pressure, evaporation pressure or capacity controller
	Baffle plate separator		

AIR CONDITIONING TECHNOLOGY			
	Distribution chamber		Air cooler, general
	Mixing chamber		Air cooler with direct evaporator
	Filter element		Steam humidifier, electrically heated
	Sound insulation		Spray humidifier with mist collector and pump
	Divided flap, motorised		Water chiller set with compression refrigeration system
	Fire protection flap		
	Axial fan		Air heater, electrically heated
	Radial fan		Steam boiler

MEASURING AND CONTROL TECHNOLOGY			
	Measuring points for: Pressure (P) Temperature (T) Filling level (L)		Pressure switches for high pressure (PSH) and low pressure (PSL)
			Control unit for level with signal path

ALLOCATION OF GUNT UNITS BY SUBJECT AREAS FOR TRAINING AS A MECHATRONICS ENGINEER FOR REFRIGERATION

SUBJECT AREA	CODE (PAGE)	SUBJECT AREA	CODE (PAGE)
REFRIGERATION			
Functional Interrelationships in the Refrigeration Circuit	ET 101 (12)	Heat Exchangers	ET 431 (54)
	ET 102 (128)		ET 405 (132)
	ET 400 (14)		ET 499.30 (72)
	ET 411C (16)	Compressors	ET 165 (44)
	ET 350 (30)		ET 192 (82)
	ET 352 (18)		ET 428 (50)
	ET 900 (92)		ET 432 (48)
	ET 910 (94)		ET 499.01 (73)
	ET 910.10 (96)		ET 499.02 (73)
	ET 910.11 (98)		ET 499.03 (73)
	ET 915.01 (122)	Piping	MT 210 (78)
	ET 915.02 (124)		ET 460 (70)
			ET 499.12 (73)
	ET 480 (24)		ET 499.13 (73)
	ET 120 (20)		ET 499.14 (73)
	ET 122 (22)		ET 499.16 (74)
Thermodynamics and log p-h Diagram	ET 350 (30)		ET 499.21 (74)
	ET 351C (32)		ET 499.25 (74)
	ET 412C (34)	Production of Mechanical Subsystems	MT 210 (78)
	ET 430 (36)		ET 192 (82)
	ET 441 (38)		ET 910 (94)
	ET 420 (138)		ET 910.10 (96)
Primary and Secondary Controllers	ET 180 (62)		ET 910.11 (98)
	ET 181 (64)	Fault Finding, Maintenance and Disposal	ET 411C (16)
	ET 182 (66)		ET 412C (34)
	ET 411C (16)		ET 192 (82)
	ET 422 (86)		ET 150.01 (80)
	ET 426 (60)		ET 150.02 (81)
	ET 499.18 (74)		ET 422 (86)
	ET 499.19 (74)		MT 210 (78)
	ET 499.26 (74)		

SUBJECT AREA	CODE (PAGE)	SUBJECT AREA	CODE (PAGE)
AIR CONDITIONING TECHNOLOGY		ELECTRICAL ENGINEERING, CONTROL AND AUTOMATION	
Investigation of the States of the Air	WL 201 (144)	Principles of Electrical Engineering	ET 144 (206)
	WL 320 (148)		ET 171 (208)
Basic Interrelationships in Ventilation and Room Air Conditioning	ET 915.06 (154)	Consumers of Single Phase Current	ET 170 (216)
	ET 915.07 (156)		ET 171 (208)
	HL 710 (198)	Protection Against Electrical Hazards	ET 144 (206)
	WL 312 (196)		
	HM 220 (192)	Simple Refrigeration Controls	ET 144 (206)
Construction Elements and Function of the Air Conditioning System	ET 600 (168)		ET 171 (208)
	ET 605 (160)		ET 174 (218)
	ET 611 (172)	Electrical Drives and Fault Finding	ET 144 (206)
	ET 620 (176)		ET 170 (216)
	ET 915.06 (154)		ET 171 (208)
	ET 915.07 (156)		ET 172 (214)
	ET 450 (178)		ET 174 (218)
Air Conditioning, h-x Diagram	ET 630 (180)	Control of Refrigeration Systems	ET 174 (218)
	ET 915.06 (154)		ET 340 (210)
	ET 915.07 (156)		ET 441 (38)
	ET 600 (168)		ET 605 (160)
	ET 605 (160)		ET 605.01 (162)
	ET 605.01 (162)		ET 605.02 (163)
	ET 605.02 (163)		ET 605.03 (164)
	ET 605.03 (164)	Building Automation	ET 611 (172)
Air Circuit in the Ductwork	ET 611 (172)		ET 620 (176)
	HM 280 (184)		ET 930 (212)
	HM 282 (186)		ET 340 (210)
	HM 210 (188)		ET 605 (160)
	HM 240 (194)		ET 605.01 (162)
	HM 220 (192)		ET 605.02 (163)
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The Complete GUNT Programme

Equipment for Engineering Education

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- Fundamentals of Control Engineering
- Components and Calibration
- Simple and Complex Control Systems
- Theoretical Fundamentals
- Practical Fundamentals
- Mechanical Process Engineering
- Thermal Process Engineering
- Chemical Process Engineering
- Biological Process Engineering
- Water Treatment

Thermal Engineering and HVAC



- Fundamentals of Thermodynamics
- Applied Thermodynamics
- Renewable Energies
- Power Engines and Machines
- Internal Combustion Engines
- Refrigeration and Air Conditioning Technology
- Heating and Ventilation in Buildings
- Sanitary Systems

Energy & Environment



- | Energy | Environment |
|---|-------------|
| ▸ Solar Energy | ▸ Water |
| ▸ Hydropower | ▸ Air |
| ▸ Wind Power | ▸ Soil |
| ▸ Biomass | ▸ Waste |
| ▸ Geothermal Energy | |
| ▸ Energy Systems | |
| ▸ Energy Efficiency in Building Service Engineering | |

Planning & Consulting, Technical Service,
Commissioning & Training



ET 915 HSI Training System for Refrigeration and Air Conditioning Technology

Overall didactic concept to specifically teach the fundamentals of refrigeration and air conditioning technology.

- real-world components
- modular
- software controlled
- training software

The system for a simple introduction to a complex subject.

CONTACT

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