LUCAS-NÜLLE

Refrigeration and Air-Conditioning Training System
for Education and Training

1st Edition

Contents

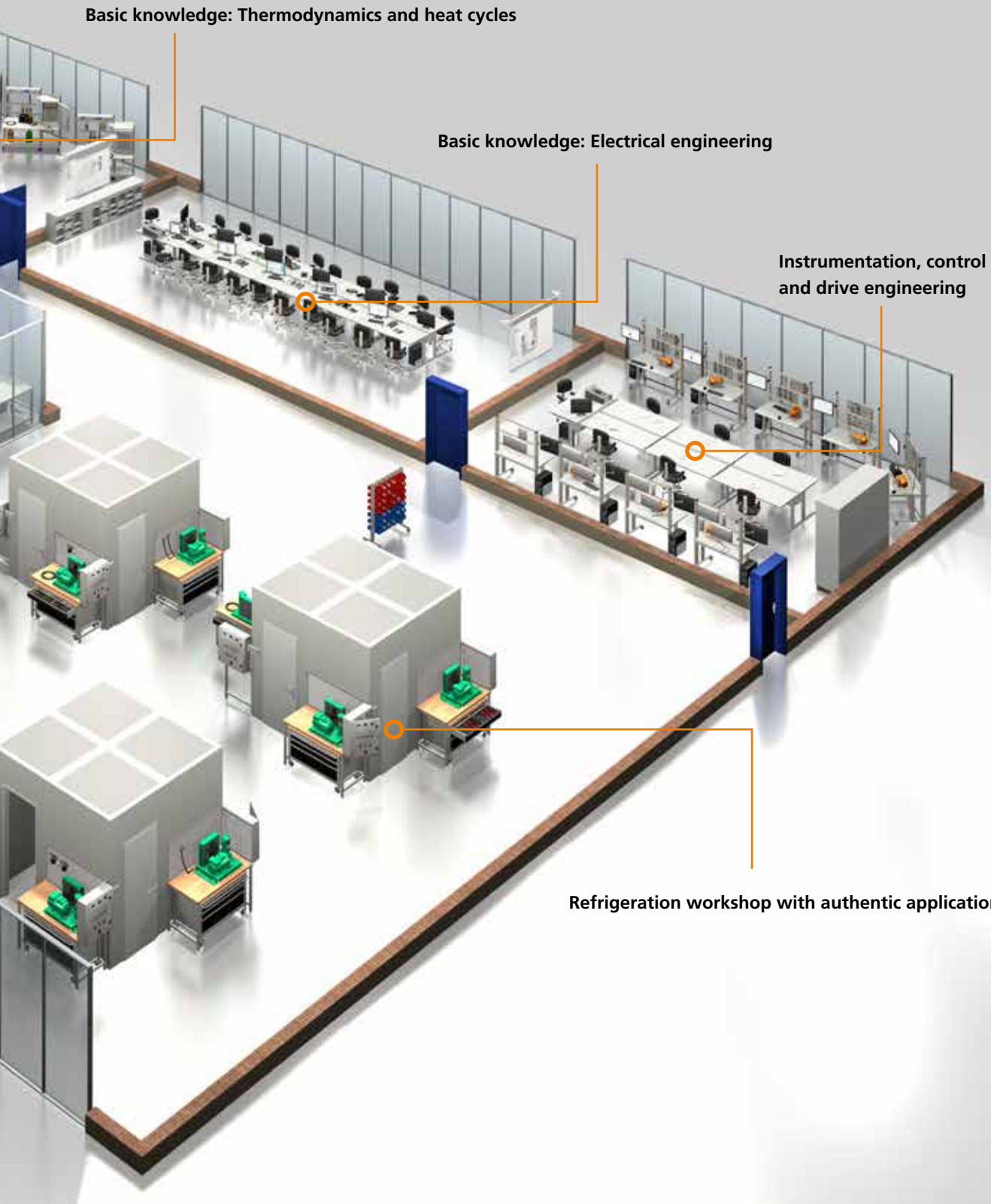
Training Centre for Refrigeration and Air Conditioning

Thermodynamics, Professional Practice in Refrigeration, Mechanical and Electrical Engineering for Refrigeration Training from Laboratory to Workshop

Increasing demands for energy efficiency of refrigeration and air conditioning installations, new refrigerants, more complex regulations, more complex system concepts and customer-specific solutions, all these are among the challenges facing professionals working with such refrigeration and air conditioning systems.

In order for technicians to meet the demanding requirements, they need intensive, technically specific education and advanced training. There is a whole new career opening up for mechatronics engineers handling refrigeration systems which encompasses all these various topics. Such engineers must be able to exhibit knowledge of manufacturing and of electrical engineering in addition to their skills in refrigeration. The solutions from Lucas-Nülle guarantee effective and solid education in refrigeration and air conditioning which is relevant to all three major topics.

Lab Management, Blended Learning and Classroom Manager Software Provide a Solution at the Highest Technical Level

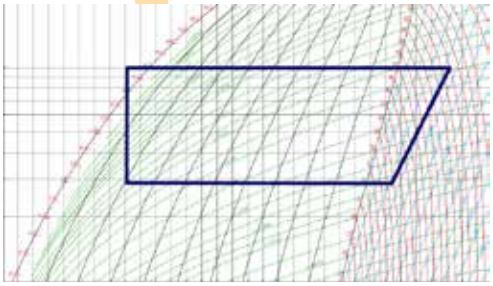

Basic knowledge: Thermodynamics and heat cycles
Basic knowledge: Electrical engineering
Instrumentation, control and drive engineering
Refrigeration workshop with authentic applications

Simple Explanations for Complex Aspects

"How does this system work and how am I supposed to understand it?"

Understanding and application

Reduction to essentials

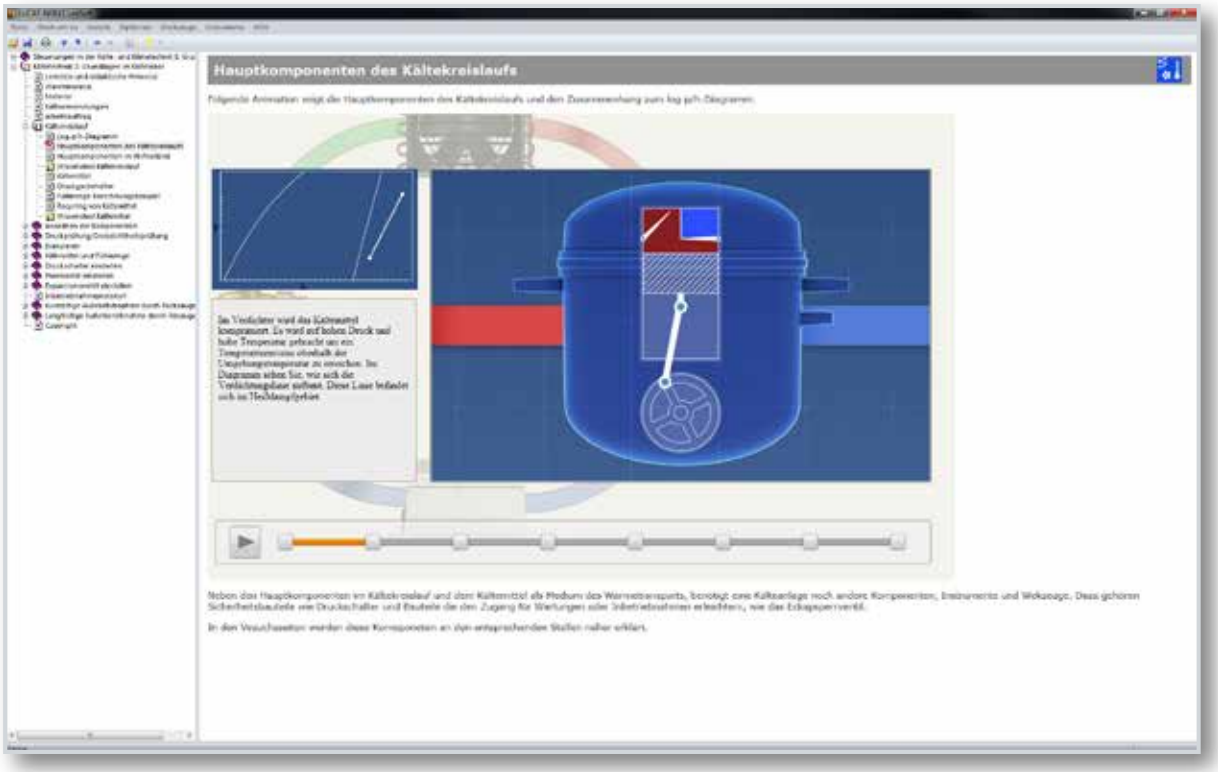


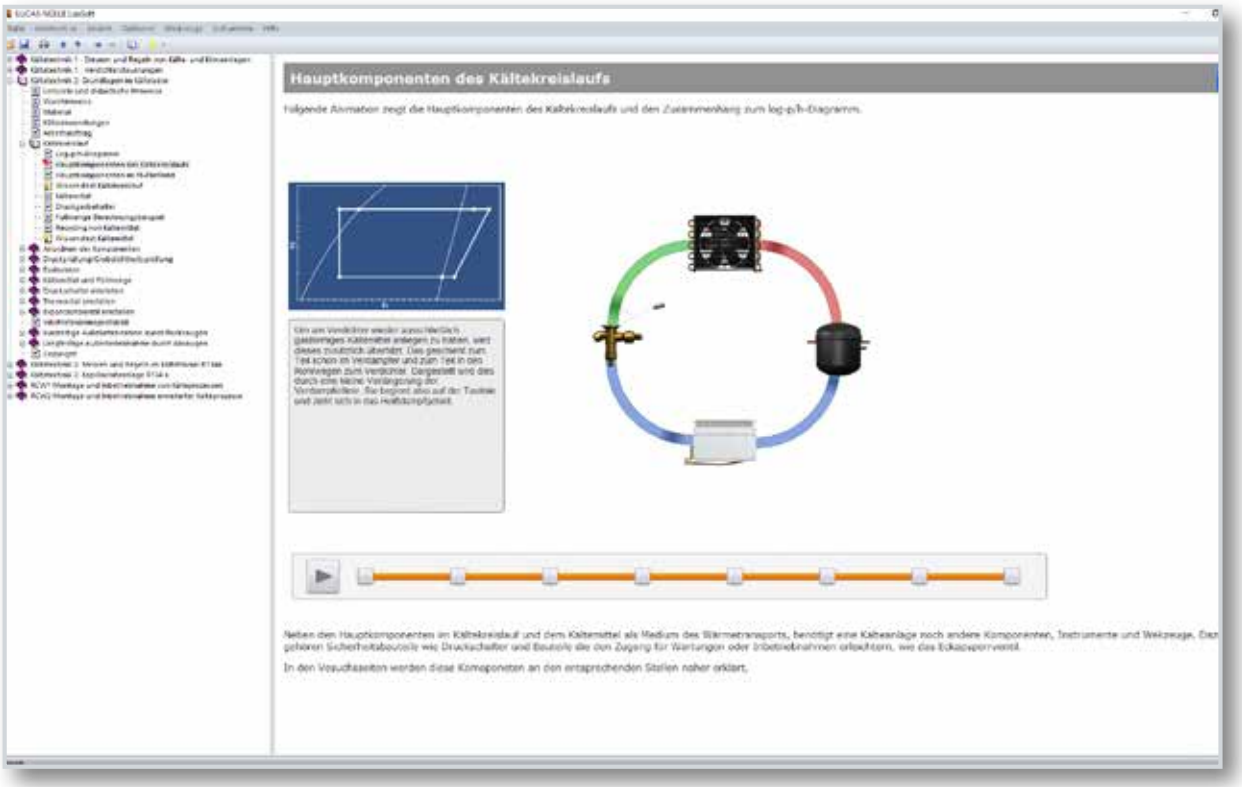
Learning the basics

Lucas-Nülle training systems, along with matching **blended learning software,** facilitate understanding of even the most complex aspects of a topic.

No Hardware without Software

Always There to Help: E-Learning Courses to Cover All the Necessary Topics for Training in Refrigeration





Digitalisation in Refrigeration Training

Individual learning – the key to success

The ever-increasing availability of the internet has revolutionised training over the past few years. Digital learning media have become well established and are now an indispensable part of modern-day flexible and customised training schemes.

The refrigeration systems are supplied with multimedia courses suitable for use in conjunction with learning management systems. This is state-of-the-art learning.

In spare time

In laboratories

In classrooms

Your benefits

- ✓ One system – multiple application options
- ✓ Usable in classrooms, laboratories, at work or in spare time
- ✓ Self-directed study, lab practicals and in lessons
- ✓ Stand-alone, on the internet or in a learning management system

Well Equipped for Any Topic and at Any Level

Expert knowledge

Frequency converters and smooth starting

Equipment set on page 40

Applied closed-loop control

Equipment set on page 32

Advanced knowledge

Electrical machines

Equipment set on page 33

RCC1 Open- and closed-loop control of refrigeration circuits

Equipment set on page 30

Basic knowledge

UniTrain Electrical machines and power electronics

Equipment set on page 40

UniTrain Electrical engineering

Equipment set on page 38

RMW welding and mechanics workshop

Equipment set on page 26

RCW3 Installation of split-system air conditioning

Equipment set on page 22

RCW1 and 2 Refrigeration workshop

Equipment set on page 22

RCC3 Split-system air conditioning training system

Equipment set on page 18

RCC2 Modular refrigeration training system

Equipment set on page 16

UniTrain Instrumentation and control technology

Equipment set on page 41

Protection and mains systems

Equipment set on page 34

RTH Basic thermodynamics

Equipment set on page 14

Basic Knowledge: Thermodynamics and Heat Cycles

Basic Knowledge: Thermodynamics

Thermodynamics Training Systems

The heat cycles which are fundamental to refrigeration systems, the interaction between pressure and temperature and the transport of energy are all physical, thermodynamic processes. That means that in order to understand how refrigeration works at its core, it is necessary to grasp the fundamentals of thermodynamics itself.

Your benefits

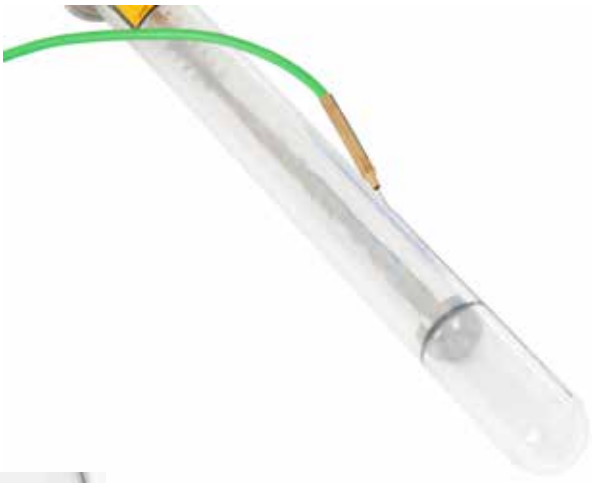
- Thermodynamics adapted to the needs of refrigeration engineers
- Interactive Lab Assistant course
- Tried and trusted equipment from PHYWE
- Equipment sets include students' and teachers' cases

Training contents

- Key laws of thermodynamics and the general gas law
- Physical quantities relevant to refrigeration
- Changes in aggregate state and changes in pressure

Supported by appropriate training software with experiment instructions and analyses, the Cobra measuring instrument and MeasureLab make it possible to record temperature characteristics.

Gas liquefier



Boiling in a vacuum

Changes in volume upon heating

A Simple Heat Cycle

Modular Refrigeration Training System

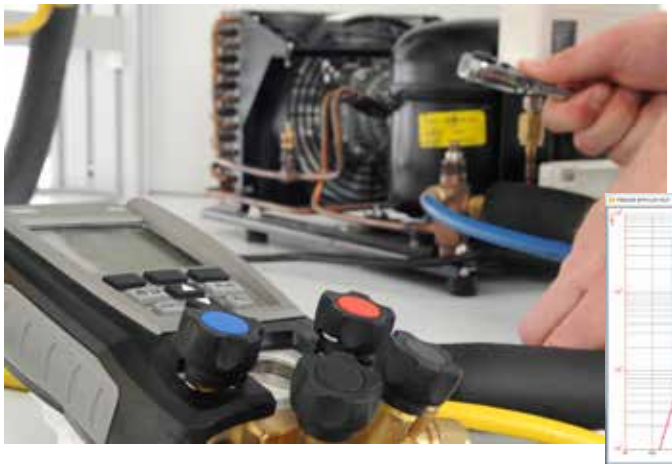
This training system teaches trainees the basic essentials of heat cycles and their applications.

Your benefits

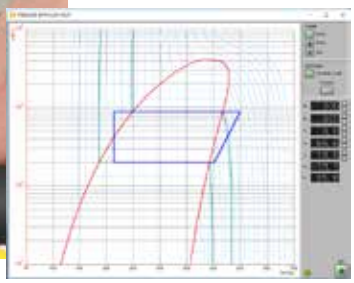
- Students can learn about faults in circuits for themselves
- Software tool with "live" display of the operating system in a logarithmic pressure-entropy diagram
- Detailed step-by-step animations for the work to be carried out
- 3 Equipment sets:
  - RCC21 Modular refrigeration training system with R134a
  - RCC22 Measurement and control using modular refrigeration training system with R134a
  - RCC23 Capillary tube system with R134a

Training contents

- Design and properties of a refrigeration heat cycle
- Installation including pressure testing and filling
- Analysis of operating response in various applications and problem situations
- De-installation and professional recycling of refrigerant



The digital manifold gauge and logarithmic pressure-entropy diagram tool make it possible to record and display the status of the refrigeration circuit in the interactive blended-learning course.



The modular design provides a high degree of flexibility. Trainees have to find out the correct sequence of steps for themselves. Connecting the hoses does not distract from the actual training contents for the refrigeration system. The hoses are tough and can be used over and over again. Set-ups can be modified quickly and adapted when new components are to be added.

The training software with its detailed set-up animations and technical content helps students work safely while they learn about the systems and successfully operate them.

Split-System Air Conditioning Training Set

Split-System Air Conditioning Training Set with Heat Pump Function

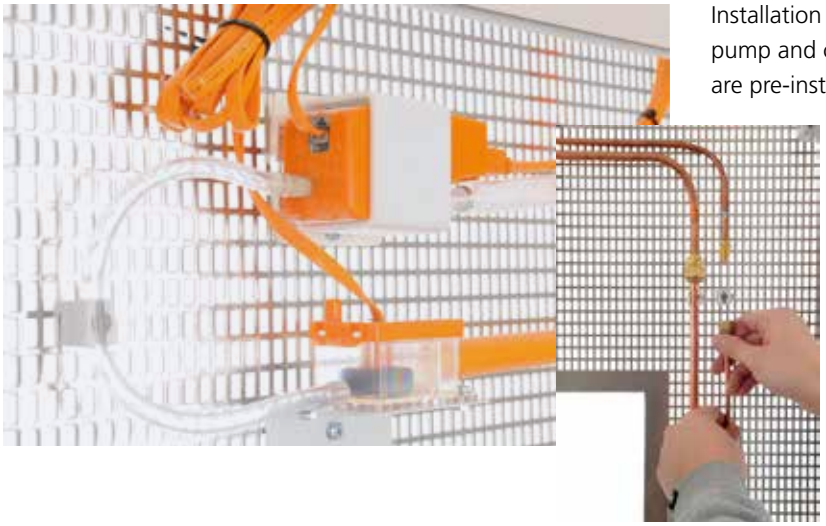
Equipment set RCC31 "Installation of a split-system air-conditioner with heat pump function" allows trainees and students to learn the background knowledge and the most important steps in installation and configuration of a split-system air conditioning facility, along with its operating properties and how it should be de-installed.

Your benefits

- Split-system technology for refrigeration engineers and mechanics
- Optional analysing tool for more accurate investigation
- Set up on a mobile trolley for flexibility of use
- Installation of a perforated grid for simple handling
- Parallel analysis of operating response for both internal and external equipment since they are not actually in two separate spaces as would normally be the case with such systems
- Blended-learning software course

Training contents

- Installation of split-system air conditioning
- Electrical wiring
- Installation and de-installation
- Investigation of operating response in various operating modes



Installation on perforated stainless steel grid. The condensate pump and condensate collection tank for constant operation are pre-installed.

Galvanised tanks protect the surroundings from oils and other liquids.

Large shelf space on the trolley for tools, installation aids and coolant cylinders help to keep the equipment in order and ensure that everything is within easy reach.

A suitable copper tube holder avoids having copper rings lying about but ensures that they are close at hand when needed.

Industrial Refrigeration Applications for Education and Training

Refrigeration Workshop

With the "Refrigeration workshop" from Lucas-Nülle it is possible to plan, construct and operate refrigeration systems for a variety of applications. The exercises reflect the realities refrigeration technicians encounter in their work and provide an opportunity to hone the practical skills of trainees. Aspects of refrigeration itself are covered, along with some areas of electrical engineering.

Your benefits

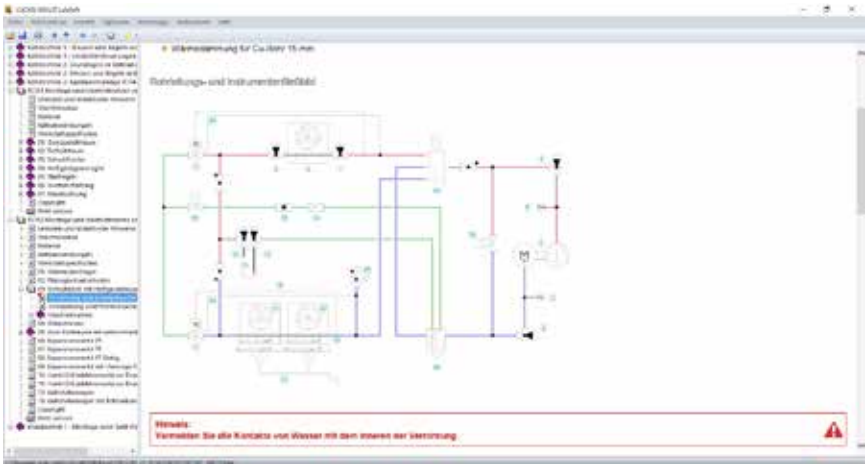
- Applications using all commonplace components used in refrigeration
- Authentic exercises with installation similar to that carried out in actual practice
- Possible combination of multiple equipment sets makes it possible to operate the system under various pressure conditions
- Three equipment sets:
  - RCW1 Installation and commissioning of basic refrigeration processes
  - RCW2 Installation and commissioning of advanced refrigeration processes
  - RCW3 Installation of split-system air conditioning

Training contents

- Applications including a cold compartment for vegetables, freezer cabinets or rapid freezers
- Installation of refrigeration systems and electrical wiring
- Commissioning, environmentally appropriate recycling of refrigerants and de-installation of system

With this equipment it is possible to plan, prepare and install complex protective circuitry. Students work with genuine components used in industry, although adapted for the application, in a way that closely mirrors authentic practice. Applications of varying complexity are explained and then assembled and commissioned by students themselves.

They connect and wire up all the components themselves. The entire refrigerator compartment not only resembles a real one, while additionally providing the opportunity to conduct measurements, but it also uses all the components used in systems existing in the real world. This is supported by suitable documentation in the form of a software course with a printable version also available. It all provides students with a final preparation for the reality of their future careers.



Making Refrigerator Assemblies

26 Welding, soldering, flanging, sawing and filing

Creating Assemblies by Welding, Soldering, Flanging, Sawing and Filing

Welding and Mechanics Workshop

Your benefits

- European standard for working with copper in refrigeration applications
- Allows for education in the skills of making one's own piping
- Completes the requirements for a fully equipped refrigeration school
- Full equipment of a workshop from a single source, including welding/soldering stations, suitable furniture, tools and fireproof flooring

Training contents

- Hard soldering/brazing
- Metalworking, such as sawing and filing
- Manufacture of fittings
- Making assemblies using soldering and flange connections

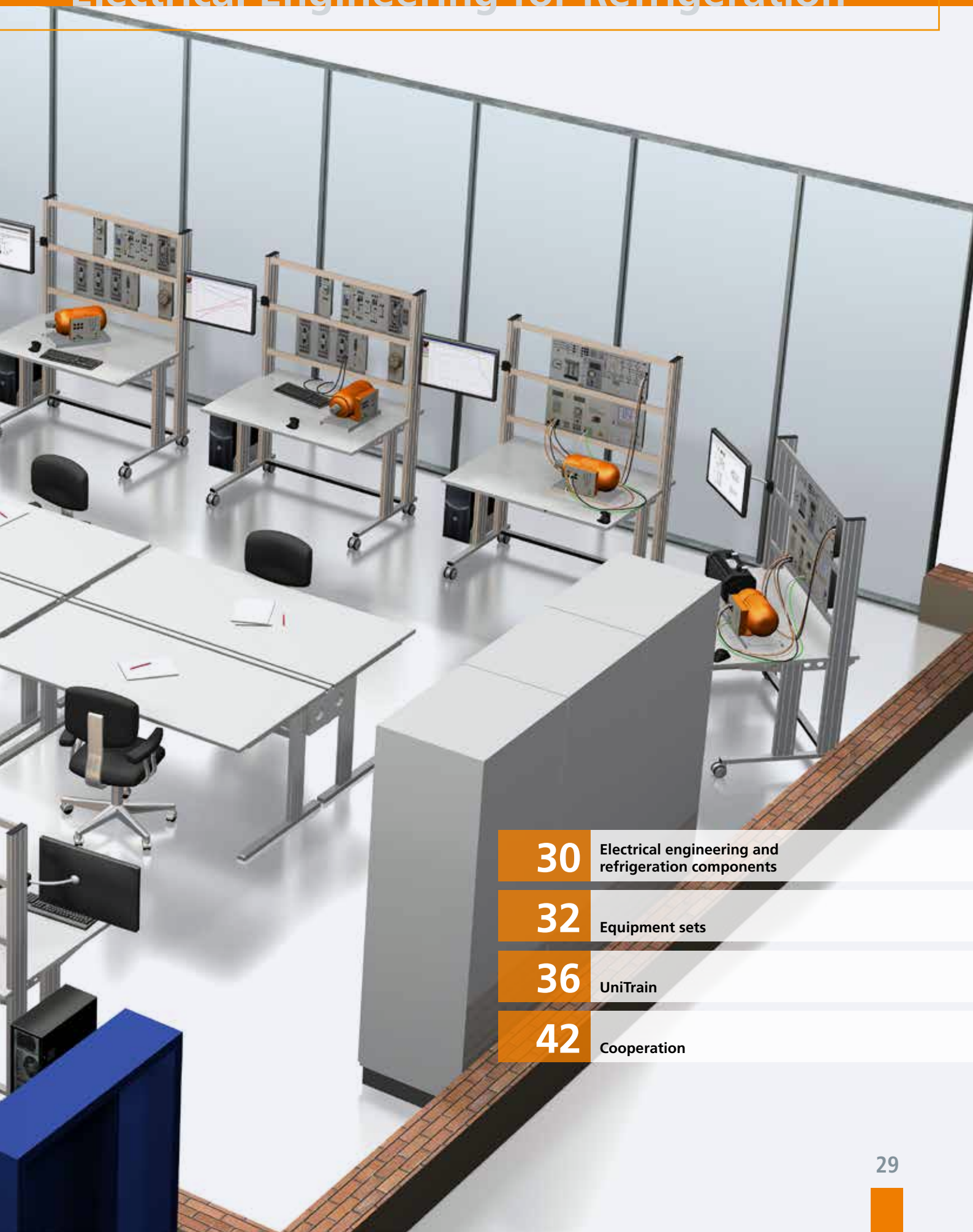
The welding, soldering and mechanics workshop provides the equipment necessary to make assemblies for a refrigeration system.

The right tools are arranged in tool sets and matched to the application in question. The tools are perfectly stored and can be locked away in appropriate work benches.

In addition to the tools, all the necessary machinery is included in the set. Apart from soldering at the corresponding columns, it is possible to learn all the other mechanical skills for metalworking.

The appropriate soldering equipment, with a pressure reduction valve and gas suction equipment for each soldering station, means students can learn the metalworking skills that any refrigeration engineer needs to master.

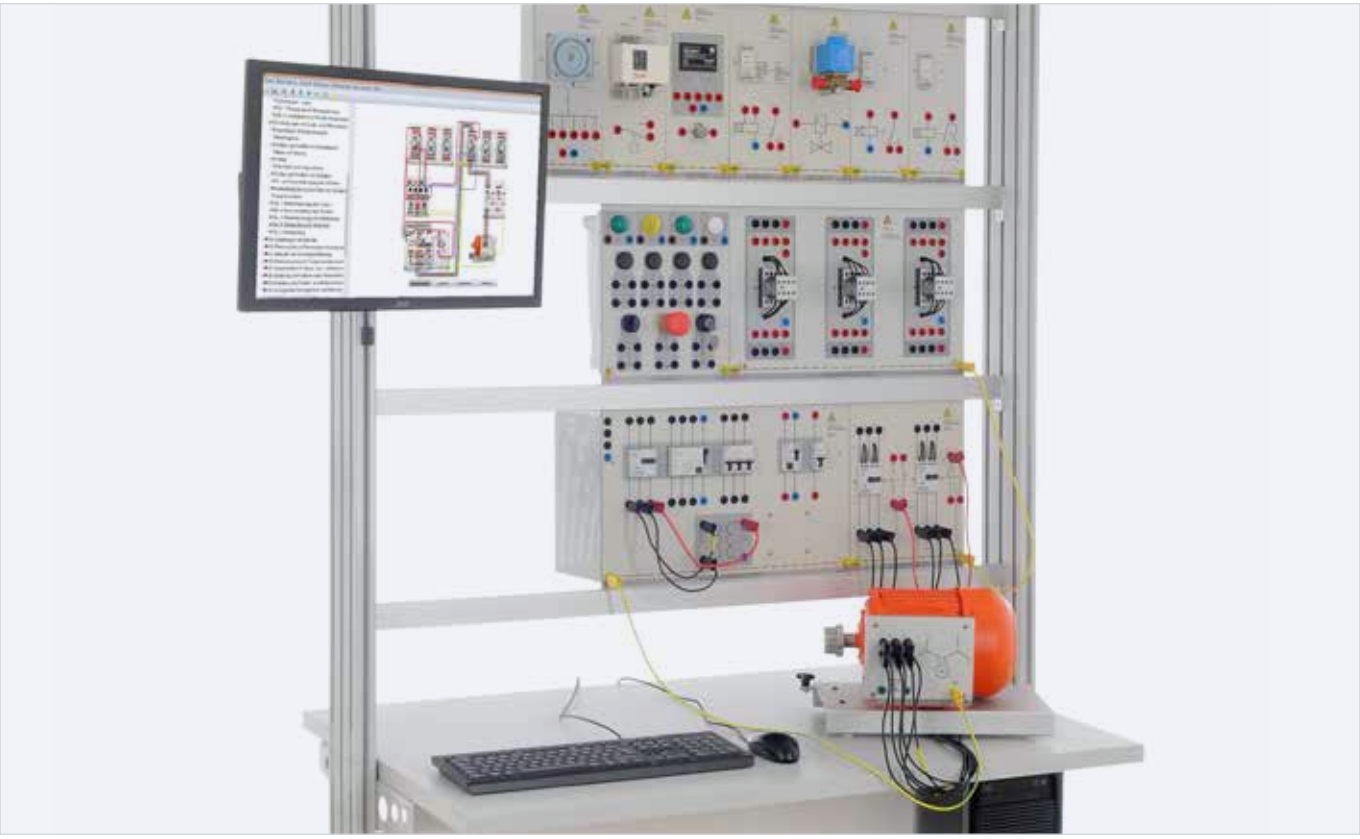
Electrical Engineering for Refrigeration



Components for Electrical and Refrigeration Engineering

Open- and Closed-Loop Control of Refrigeration Circuits in Fridges and Air Conditioning Systems

Trainees, at apprentice or master level, and all technicians in refrigeration or air conditioning companies who need similar training can now be guided step by step through the topics of open- and closed-loop control for refrigeration or ventilation systems. This provides them with a solid basis for their future work. The combination of theory and practice guarantees a solid education.



Your benefits

- Authentic components: thermostats, solenoid valves, pressure switches
- ILA course
- Modular, flexible and extensible
- "Part winding motor" applications
- Two equipment sets
  - RCC11 Open- and closed-loop control of refrigeration circuits in fridges and air conditioning systems
  - RCC12 Compressor control

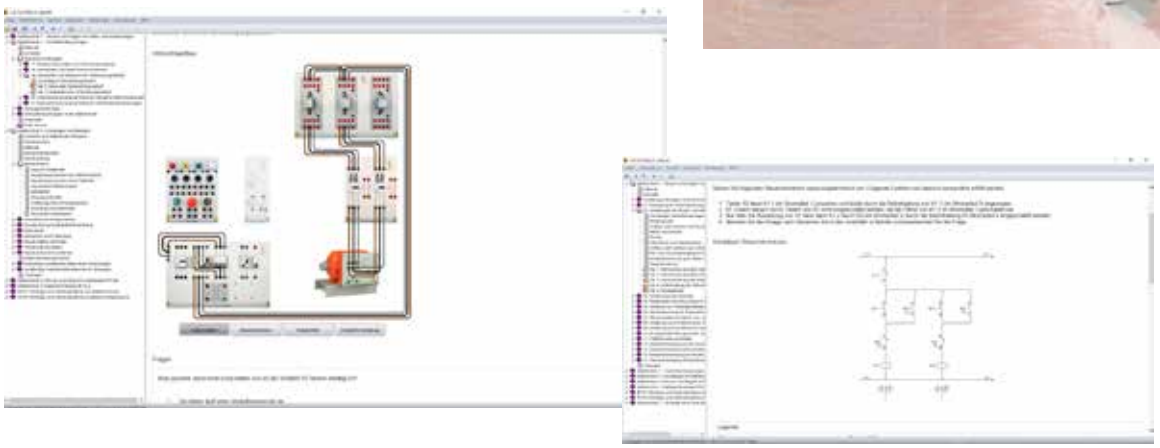
Training contents

- Generating control voltages
  - Protecting switching circuits
- Safety chains, contactors and relays
  - Switching response of refrigerator components
  - Sequence control circuitry for compressors
- Compressor starting methods
- Typical refrigeration circuits:
  - Pump-down
  - Pump-out

Authentic components from refrigerators and special compressor starting circuits, such as those using part-winding motors, ensure an insight into typical refrigeration circuits much like those used for refrigerators in practice.

Safety measurement leads and sockets ensure ease of operation and offer the maximum protection against contact with the voltages from authentic electrical supply.

The modular system is particularly flexible and allows a large number of different circuits to be assembled. These can also be quickly rebuilt and tested.



The interactive blended-learning course with set-up animations written in HTML and all the appropriate content guide you step by step through the creation of a safety chain and on to compressor start-up circuitry.

Applied Closed-Loop Control

Automatic level control – Flow-rate control

The "level control" training system provides an educational experiment set-up closely aligned to practice in applied closed-loop control. The compact training equipment features a tank for which the level is to be controlled, a pressure transducer to determine the actual fill level and a storage reservoir complete with pump. In order to maintain constant pumping performance, a secondary closed-loop control system with a flow meter which can be shut off separately is also included. This provides the option to construct a second-order controlled system.

Sample experiment "Level control IAC 12"

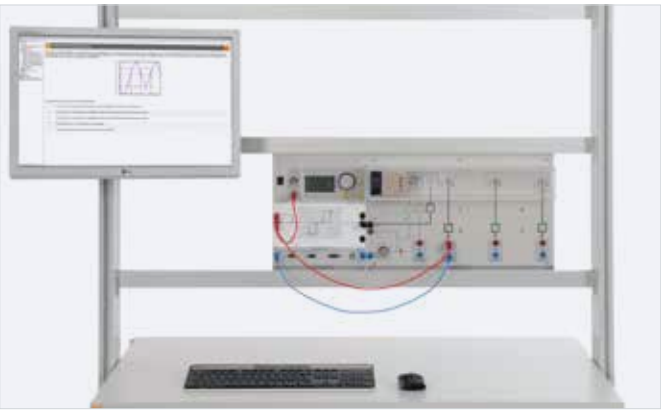
Training contents

- Automatic liquid-level control
  - Set-up, putting into operation, optimising
  - PI controller
  - Two-position controller
  - disturbance variable forward feed and precontrol
- Automatic flow-rate control
  - Set-up, putting into operation, optimising
  - PI or PID controller

Equipment set IAC 12

Closed-Loop Control of an Air-Temperature Controlled System

Closed-loop control of temperatures is a classic example of controlling systems with large time constants for a large number of disciplines. Apart from pure temperature control, the flow of air can also be taken into account as a secondary variable. The controlled system is designed in such a way that it allows for the smallest possible time constant. This means that measurements can be made more quickly, which enhances the efficiency of the work.



Training contents

- Operation with two-position and three-position controllers
- Temperature control via PID controller
- Recording of system parameters
- Determination of controller parameters
- Effect of disturbances on the control system

AC and DC Machines

Shunt-Wound Machines – Series-Wound Machines – Compound-Wound Machines

DC machines continue to be used as a basis for teaching about electrical machines. They very simply demonstrate the options for open- and closed-loop control.

Sample experiment "DC machines EEM 2"

Training contents

Motor operation:

- Connection of a motor
- Comparison of various machine types
- Typical machine data and characteristics
- Speed control with starter and field regulator

Generator operation:

- Connection of a generator
- Armature voltage as a function of excitation current
- Function and use of a field regulator
- Voltage control with self-excitation and external excitation

Equipment set EEM 2.1

Universal Motors

Universal motors are commutator machines which represent the most commonly used drive systems for electrical and household appliances. They can be found with power ratings of up to about 2 kW. The fact that their speed is easy to control means that such universal motors make up a large proportion of AC machines.

Sample experiment "Universal motors EEM 3.1"

Training contents

- Connection, wiring and operation
- Changing the direction of rotation
- Operation with DC and AC supplies
- Recording of speed-torque response
- Operation with various load machines, such as fans

Equipment set EEM 3.1
Lucas-Nülle

Three-Phase Asynchronous Machines/ Power Supply Systems and Protection

Three-Phase Motors with Squirrel-Cage Rotors

Three-phase motors with squirrel-cage rotors are the ones most commonly used in industry. These robust and maintenance-free motors can be manufactured cheaply. They can be found with power ratings of just a few watts up to several megawatts. Thanks to the use of modern frequency converters, the speed of such motors can be varied with practically no loss of power, so that many new applications are being found for them.

Sample experiment "Three-phase motor with squirrel-cage rotor EEM 4.1"

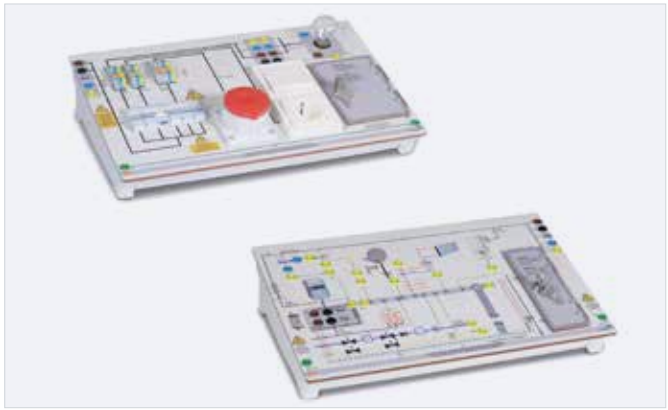
Training contents

- Connection, wiring and operation
- Operation in star and delta circuit configurations
- Use of a star-delta switch
- Recording of speed-torque response
- Operation with various load machines, such as fans or lifting platforms

Equipment set EEM 4.1

Power Supply Systems and Protective Measures

The topic of protecting against excessively high contact voltages (protective measures conforming to VDE 0100) is an important one for anybody who has to work with installing, operating or repairing electrical systems, especially for trainee electricians. This training system provides the ideal support for theoretical or practical lessons, teaching protective measures complying with the German standard VDE 0100 in various kinds of power supply systems. The key factor for LN training systems is, as ever, their direct relationship with genuine practice. Measurements for the various experiments are made using commonplace equipment.



Training contents

- Various power supply earthing systems for a customer installation (TT, TN, TN-C, TN-S, or TN-C-S systems)
- Familiarisation with various protective measures and testing them with the appropriate instruments
- Carrying out initial testing and repeat tests in accordance with DIN VDE 0100-600
- Testing RCDs
- Measurement of loop impedance, local insulation impedance and insulation resistance

Smooth Starting and Frequency-Converter Drives

Reduction of High Starting Currents

Smooth starting uses phase control to reduce the voltage to a motor when it is switched on. The starting current then reduces in proportion to the voltage across the terminals. The effective part of a smooth starter device usually consists of a pair of thyristors connected in anti-parallel configuration for each phase. In order to keep losses and the heat which results from them as low as possible, the power semiconductors are shorted out by a built-in power contactor after the start-up phase.

Sample experiment "Smooth starting for three-phase machines EDT 17"

Training contents

- Commissioning
- Parameter setting for start-up and stopping ramps and start voltage
- Investigation of current and voltage when starting
- Starting under various load conditions
- Comparison with star-delta starting

Equipment set EDT 17

Variable-Speed Drives

Modern frequency converters can convert any standard three-phase motor into a variable-speed drive motor. The robustness and widespread use of such motors has contributed much to the success of electronic drive technology using frequency converters. The greater amount of process automation and the corresponding demands for drive motors is leading to the fact that ever more motors are being controlled by means of frequency converters. Thanks to the control of speed based on demands, it is now possible for a great deal of energy to be saved in pumps and refrigeration systems.

Sample experiment "Drive motors with frequency converters EDT 25"

Training contents

- Computer-supported commissioning
- Parameter setting for set-points, direction of rotation, start function, switching frequency, limits, nominal voltage, nominal current, nominal frequency, power factor etc.
- Investigation of operating response under loading with other machines
- Recording of speed-torque characteristic in four quadrants
- Optimisation of drive

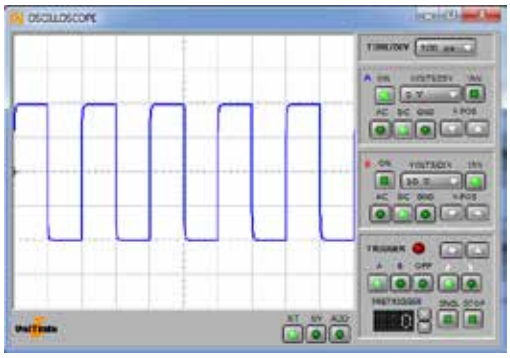
Equipment set EDT 25
Lucas-Nülle

UniTrain – Fundamentals for Refrigeration

A System for the Whole Duration of Technical Training

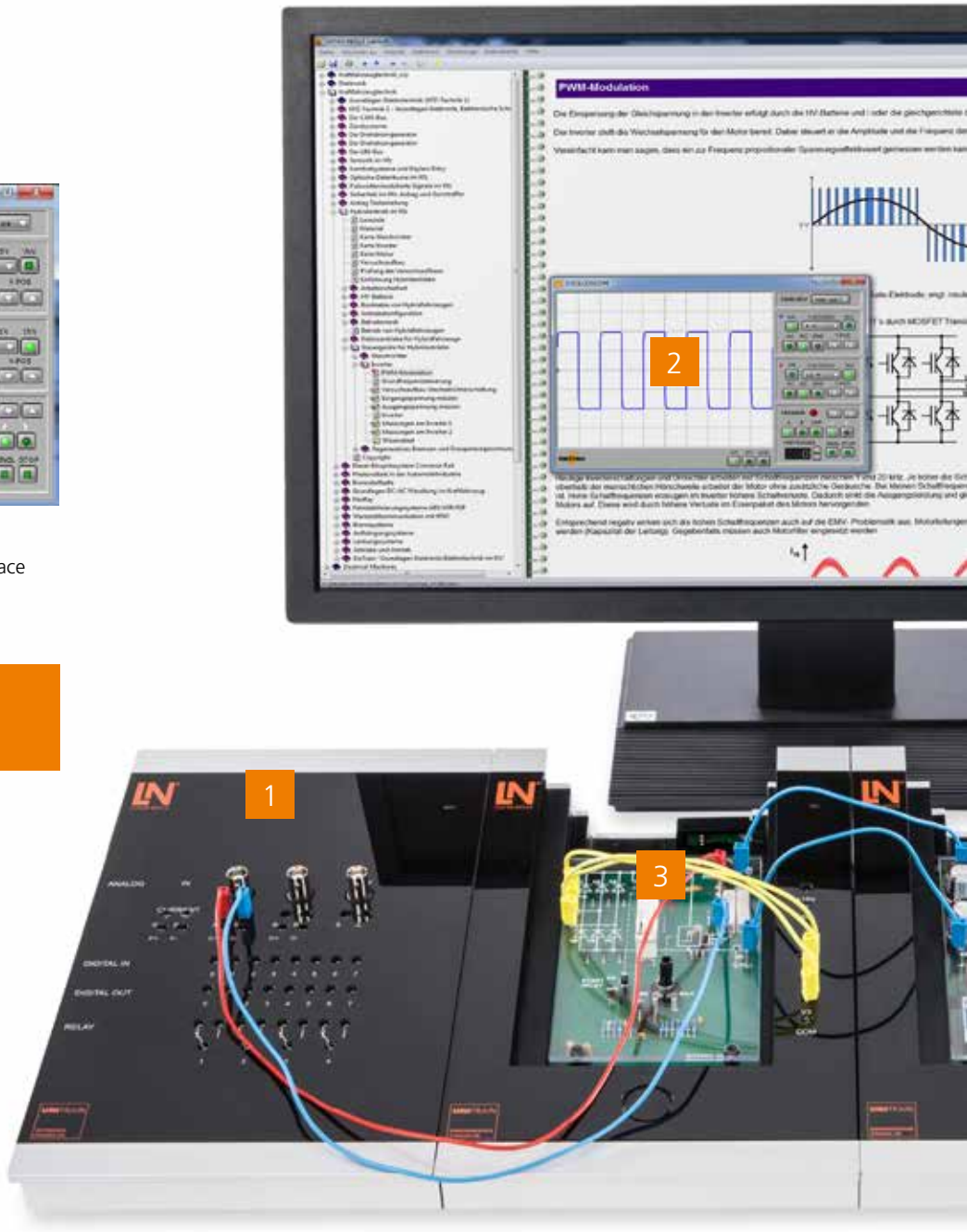
Gaining the knowledge of technical systems of ever-increasing complexity and skills in handling them on ever-shortening time scales is one of the greatest challenges for technical education, now and in the future. The UniTrain system helps to meet that challenge. It is a computer-assisted, multimedia experiment and training system for refrigeration.

Linking training programmes to a complete electrical lab with just one portable interface makes it possible to teach theory and practice more efficiently any time, anywhere.

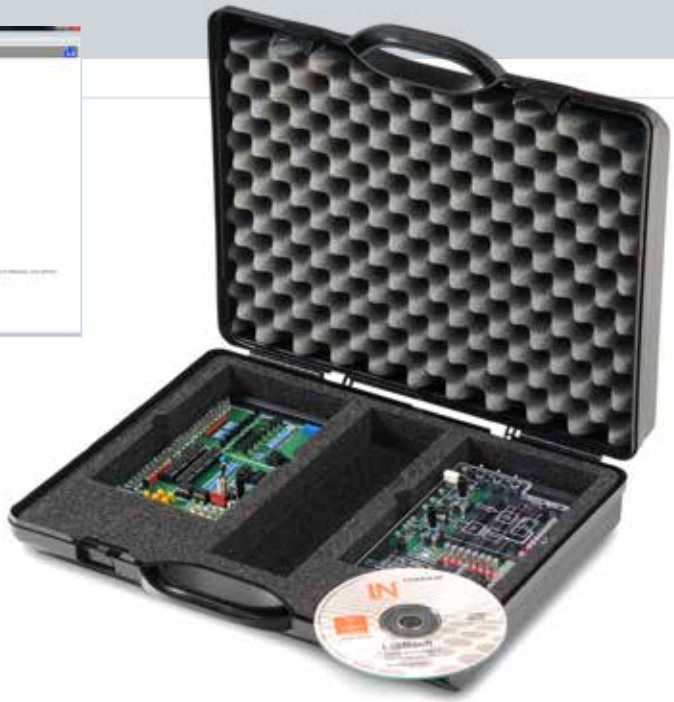


2 Virtual instruments
120 virtual instruments for controlling the Interface

New: Built-in WiFi module



1 UniTrain Interface
Interface for measurement and control: Analog/digital measurement inputs and voltage sources for experiments



3 LabSoft courses
Over 130 learning programmes with experiment hardware from all areas of electrical engineering

Your benefits

- ✓ Universal training system
- ✓ Portable and usable anywhere
- ✓ Encourages individual learning
- ✓ Handling skills from practical experimenting
- ✓ High motivation thanks to changing challenges
- ✓ Safe experimenting with safety extra-low voltage (SELV)
- ✓ Programmes combine theory and practice
- ✓ For all of electrical engineering

Product video
See the benefits for yourselves.

4 Experimenter
Accommodates experiment cards and provides additional power outputs (three-phase)

Blended Learning Courses with the UniTrain Compact Lab

Basic Knowledge of Electrical Engineering

CO4204-4D

DC technology

- Electricity, electric charge, electric fields
- Current, voltage, resistance in DC circuits
- Ohm's law and Kirchhoff's laws
- Parallel and series connection of resistors
- Coils and capacitors
- Recording characteristics and troubleshooting
- Course duration: 8 h approx.

CO4204-4F

AC technology

- AC variables, sinusoidal and periodic signals
- Capacitance, inductance and reactance
- Phase-shift and frequency response of RL and RC combinations
- Active, reactive and apparent power
- Resonant circuits
- Transformers
- Course duration: 8 h approx.

SO4204-4H

Three-phase technology

- Star and delta circuits
- Phase voltages and currents
- Ohmic and capacitive loads
- Symmetric and asymmetric loading
- Phase-shift and power
- Balancing currents in neutral conductors
- Course duration: 4 h approx.

SO4204-4A

Magnetism/ electromagnetism

- Magnetism, electromagnetism, magnetic materials
- Magnetic poles, magnetic fields, field strength and field lines, hysteresis
- Magnetic field of a coil
- Magnetic induction, Lorentz force, laws of induction
- Coils, transformers, relays, Hall sensors, reed switches
- Course duration: 4 h approx.

SO4204-4B

Measurements with a multimeter

- Operating controls for a multimeter
- Sources of danger when making measurement on electric circuits
- Measurement of voltage, current, resistance and of diodes
- Modifying measuring ranges and sources of error
- Finding values of unknown components
- Course duration: 3 h approx.

SO4204-4K

Electromagnetic compatibility (EMC)

- EMC terminology and coupling effects
- Standards and guidelines
- Measurement of galvanic, capacitive and inductive coupling between conductors
- Resistance to interference and improvement of EMC properties
- Course duration: 4 h approx.

SO4204-4M

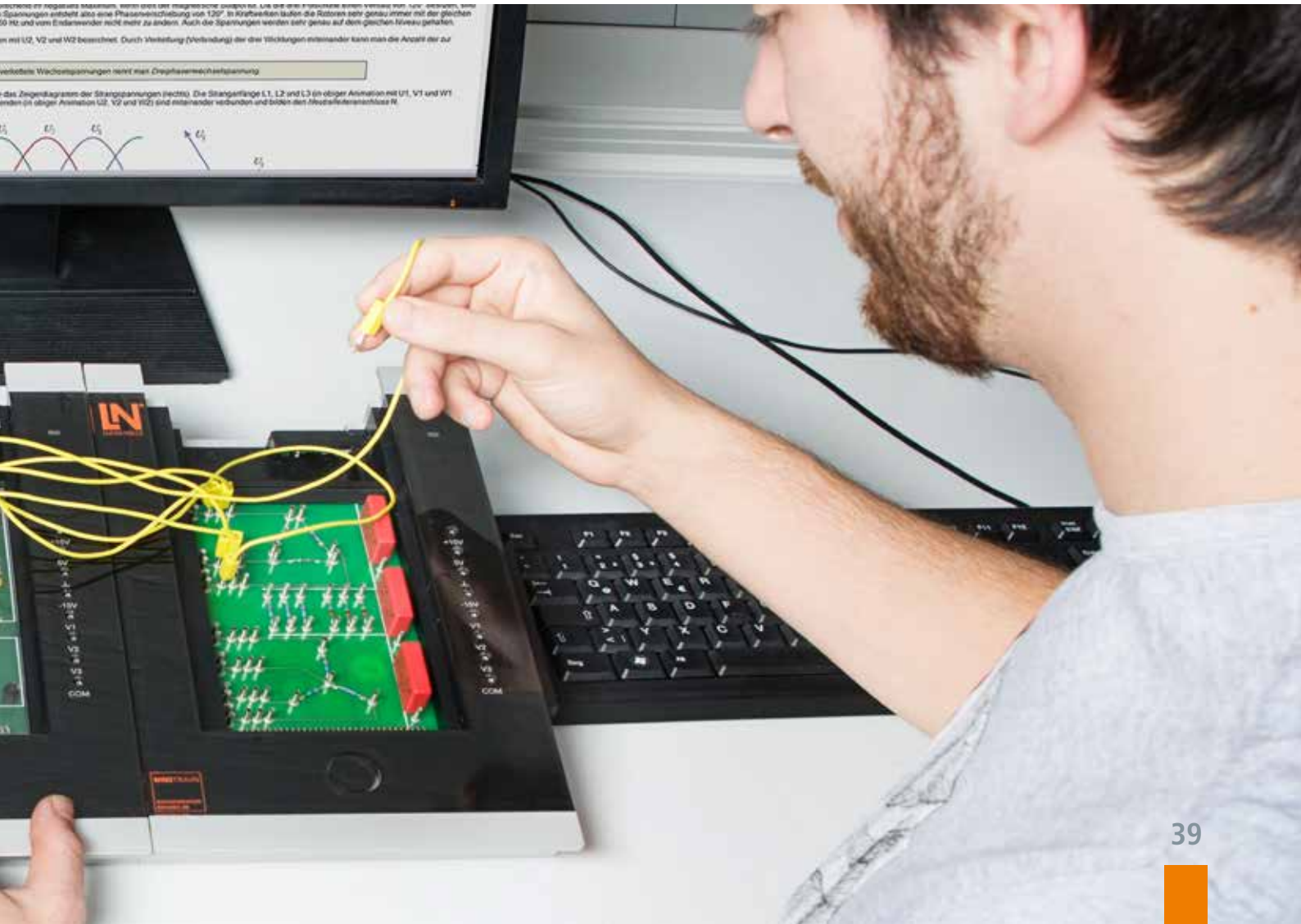
Protective measures and power network types

- Design of various power supply earthing systems (TN, TT, IT)
- Protection against contact
- Protection by isolation, SELV
- Excess current and RCDs
- Measurement of earth resistance, insulation measurements, RCD testing, earth measurement, loop impedance measurement
- Course duration: 10 h approx.

SO4204-4N

Control systems/ protective circuitry

- Familiarisation with control components
- Planning control projects
- Checking functionality with circuit simulators
- Tests of function and trouble-shooting in control projects
- 25 Control projects
- Course duration: 25 h approx.



Blended Learning Courses with the UniTrain Compact Lab

Electrical Machines and Power Electronics

CO4204-7S

DC machines

- Electromagnetic induction and Lorentz force
- Design/function of DC machines
- Armature and excitation current/voltage/resistance
- Types of connection: series-wound, shunt-wound and compound-wound
- Measurement of speed, speed control and reversal
- Operation with AC voltage, braking
- Temperature monitoring
- Course duration: 5.5 h approx.

CO4204-7T

Asynchronous machines

- Design and function of three-phase machines
- Electromagnetic induction, magnetic fields, torque
- Asynchronous machines, capacitor motors, squirrel-cage rotors
- Star and delta circuits, line current/voltage, phase current voltage, rotor current/voltage
- Nominal data and parameters
- Temperature measurement while operating
- Troubleshooting
- Course duration: 5.5 h approx.

CO4204-7P

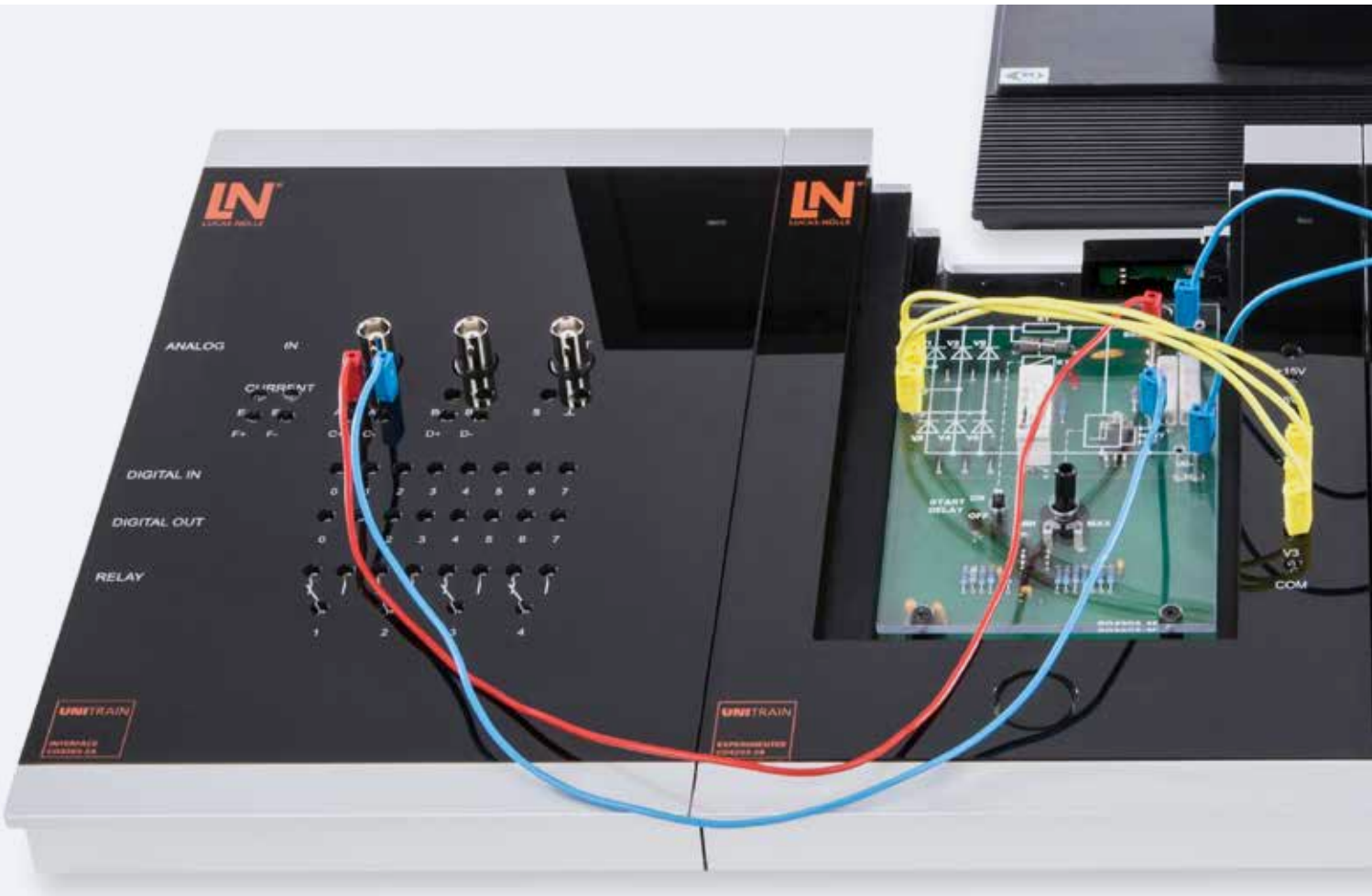
Frequency converter drives

- Design and function of frequency converters
- DC-link circuits
- V/f characteristic and boost
- Operation of three-phase motors via frequency converters, 87-Hz method
- Design and function of brake choppers
- Analysis of current, voltage and power
- Course duration: 5 h approx.

CO4204-7M

Self-commutated power converters

- PWM for generating variable DC and AC voltages
- Response to lead, control and operating characteristics
- Measurement: Static converters for amplitude and signal modulation
- Three-phase inverters
- Block commutation, sine-wave and space vector modulation
- Harmonic analysis FFT
- Course duration: 5 h approx.



Measurement and Closed-Loop Control

SO4204-8A

Measurement of electrical variables

- Functioning of galvanometers, bridge measurement methods
- Digital and analog methods
- Moving iron, moving coil and electrodynamic instruments
- Extending measuring ranges for voltage and current measurements
- Measuring active, reactive and apparent power
- Measuring power factor, electrical work and frequency
- Course duration: 5 h approx.

SO4204-8B

Measurement of non-electrical variables – temp., pressure, force

- Effect of measurement circuits
- Linearisation of characteristics
- Temperature measurement: NTC, Pt 100, KTY, thermocouples
- Pressure measurement: piezo-electricity, inductive and resistive pressure sensors, absolute and differential pressure sensors
- Measurement of force with strain gauges, bending bars and torsion bars
- Course duration: 7.5 h approx.

CO4204-8J

Practical introduction to closed-loop control

- Open- and closed-loop control
- Continuous and discontinuous controllers
- Closed-loop control of temperature, speed, light level and position
- System characteristics and response to disturbances
- Parameter setting and optimisation
- Recording step responses
- Investigation of closed-loop control systems
- Course duration: 6 h approx.

Cooperating Partners

The German National Technical College for Refrigeration and Air Conditioning and Lucas-Nülle jointly develop training systems for the teaching of refrigeration and air conditioning. The many years of experience of both partners in their areas of expertise ensures a very high degree of quality and targeted education.

In addition the college can also provide suitable product training in their modern facilities in the form of their "Train the Trainer" seminars. The highly qualified tutors hold fascinating seminars to teach their wide range of knowledge.

Certification

Apart from their "Train the Trainer" courses, the German National Technical College for Refrigeration and Air Conditioning also offers you or your teaching establishment the opportunity to become certified to German standards´.

Has all this aroused your interest?
More information is available in the Expert Program brochure for the LN Academy.

Decisive Product Benefits

Mr Jörg Peters, Business Manager of the German National Technical College for Refrigeration and Air Conditioning (Bundesfachschule Kälte-Klima-Technik:)

"The Bundesfachschule Kälte-Klima-Technik (BFS) and Lucas-Nülle have been working together successfully for several years. The BFS is one of the largest providers of training in refrigeration and air conditioning on a national and international level.

The success of the training schemes at the BFS sites at Maintal (Hesse), Harztor (Thuringia) and Leonberg (Baden-Württemberg) has been made possible to a large degree by the equipment of the jointly developed student stations.

The education and training systems made by Lucas-Nülle are used by the BFS in its refrigeration and electrical laboratories and the refrigeration workshops. Training stations are available for instruction of trainees in multiple disciplines, professional and apprentice courses or technician qualifications, for seminars and special training and for the BFS modular series. Our trainees, apprentices and technicians appreciate the close alignment to authentic practice that the teaching resources possess. The accompanying "teach-ware" helps them to understand the material being taught better and to put the knowledge into practice.

The joint development of the training systems against the background of demands for energy efficiency and environmental protection is a challenge that the BFS and Lucas-Nülle are all too happy to undertake."

Learning Topics

The following table shows the topics in the German curriculum for mechatronics engineers in refrigeration. The topics are arranged by course years along with the number of hours they should require.

On the following page these topics are then matched to the corresponding Lucas-Nülle training systems.

Year	Topics		Hours
1	1	Analysis of refrigeration and air conditioning systems and testing of functionality	80
	2	Making assemblies for refrigeration and air conditioning systems	60
	3	Investigating and testing the functioning of electrical components in refrigeration and air conditioning systems	60
	4	Planning and carrying out electrical installation in a single-phase AC power system	60
	5	Maintenance of refrigeration, air conditioning and electrical components	60
2	6	Planning a refrigeration or air conditioning system	80
	7	Installing pipes and ducting	60
	8	Connecting and testing single-phase drive systems for refrigeration and air conditioning systems	60
	9	Making and testing electro-mechanical and electronic control systems	40
	10	Commissioning of refrigeration and air conditioning systems	40
3	11	Selection and installation of heat exchangers, throttling equipment and components	80
	12	Selection and installation of compressors	40
	13	Selection and installation of electrical appliances in a three-phase AC power supply	60
	14	Installation, set-up and testing of electronic open- and closed-loop control systems	40
	15	Construction of air conditioning systems	60
4	16	Construction of refrigeration systems	60
	17	Maintenance and disposal of refrigeration and air conditioning systems	80
		Total hours	**1020**

Topic Matrix

Year	Year 1				
Topics	**1**	**2**	**3**	**4**	**5**
DC technology SO4204-4D			X		
AC technology SO4204-4F			X		
Three-phase technology SO4204-4H			X		
Magnetism/electromagnetism SO4204-4A					
Conducting measurements with a multimeter SO4204-4B			X		
Electromagnetic compatibility (EMC) SO4204-4K			X		
Protective measures and power network types SO4204-4M				X	
Control systems/protective circuitry SO4204-4N					
Measurement of electric values, V/I/P/cos-phi/f SO4204-8A			X		
Measurement of non-electric values T/P/F SO4204-8B	X				
DC machines SO4204-7S					
Synchronous machines SO4204-7T					
Frequency converter drives SO4204-7P					
Self-commutated power converters SO4204-7M					
Practical introduction to closed-loop control SO4204-8J					
IAC 10/11 Closed-loop liquid level control/flow-rate control					
IAC 31 Closed-loop control of an air-temperature control loop					
EDT 17 Smooth starting three-phase machines					
EDT 25 Frequency converter drives					
EEM 2-1 DC machines					
EEM 3-1 AC machines					
EEM 4-1 Asynchronous machines					
ESM 3 Power supply systems and protective measures				X	
RTH1 Basic knowledge: Thermodynamics	X	X	X		
RCC21 Modular refrigeration training system with R134a					
RCC22 Measurement and control in R134a refrigeration training system					
RCC23 Supplementary equipment set, R134a capillary tube system					
RCC11 Open- and closed-loop control of refrigeration circuits					X
RCC12 Compressor control					X
RCC31 Installation of a split-system air conditioner					X
RMW 1 Mechanical proficiencies in the refrigeration sector					
RCW1 Design and installation of refrigeration systems					
RCW2 Design and installation of advanced refrigeration systems					

Year 2					Year 3					Year 4	
6	7	8	9	10	11	12	13	14	15	16	17
			X								
		X									
		X									
							X				
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	X			X							X
	X				X				X	X	X
	X				X				X	X	X
	X				X				X	X	X

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