

Refrigeration Learning System (DAI) 582207 (3431-00)

FESTO

LabVolt Series

Datasheet



Table of Contents

General Description	2
The LVHVAC Software	4
Topic Coverage	5
Features & Benefits	5
List of Manuals	6
Optional Equipment	6
Specifications	6
Module Options Description	7

General Description

Learn the thermodynamics fundamentals and main components of the refrigeration cycle in a compact workstation

This system is designed to teach the fundamentals of refrigeration to students starting their learning in HVAC/R. With a data acquisition interface (DAI), parameters are shown live, making abstract notions such as enthalpy or COP much easier to grasp.

A refrigeration system is often a “magic” piece of equipment that generates cold for the non-specialists. The Refrigeration Learning System (DAI) includes a software that shows the components of the system along with pressure and temperature readings at key locations.

A pressure/enthalpy diagram provides a real-time plot of the refrigeration cycle, making it possible to observe the effects of a given parameter on the overall performance of the system. For example, the system can be tested under various heat load conditions. One heat source, located in the cooling chamber, can be turned on and off, while the rotation speed of the evaporator and condenser fans can be varied.

In terms of hardware, components common to most refrigeration and air conditioning installations are included, making this system a must for beginners. Instructors can also insert faults to teach basic troubleshooting.

The learning system consists mainly of a hermetic-type compressor with thermal protection, forced-air coil evaporator and condenser, and three types of expansion (metering) devices selectable using manual valves: a thermostatic expansion valve and two capillary tubes of different lengths. One of the capillaries is designed to allow observation of the system operation under normal conditions; the other capillary is designed to simulate the effect of a partially obstructed capillary.



Figure 1. Three expansion (metering) devices are available.

The training system includes the following instrumentation and control components: electronic pressure and temperature transducers, an electronic pressure controller, a thermostat, high- and low-pressure gauges, and a solenoid valve. Automatic temperature control can be achieved using either the thermostat or the pressure controller (see Figure 2).

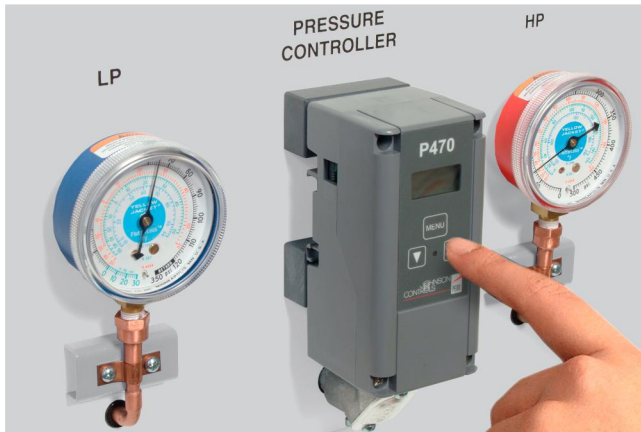


Figure 2. The electronic pressure controller, with LCD display and adjustable cut-in and cut-out pressures.

The training system also features an electrical control panel with switches and knobs that are used to set the system under various conditions (see Figure 3). Silk-screened on this panel is a diagram showing the connections between the electrical components of the system. Banana jacks allow measurement of the voltage and continuity at various points of the system for maintenance and troubleshooting purposes.



Figure 3. An electrical control panel with silk-screened diagram and banana jacks allows students to develop troubleshooting skills through the insertion of fault switches.

To permit students to develop troubleshooting skills, faults can be inserted in the electrical section of the trainer. The fault switches are accessible by unlocking a hinged panel on the right-hand side of the trainer. Students learn a guided method of troubleshooting that involves the use of the voltmeter or ohmmeter method to troubleshoot the electrical section suspected to be defective.

The LVHVAC Software

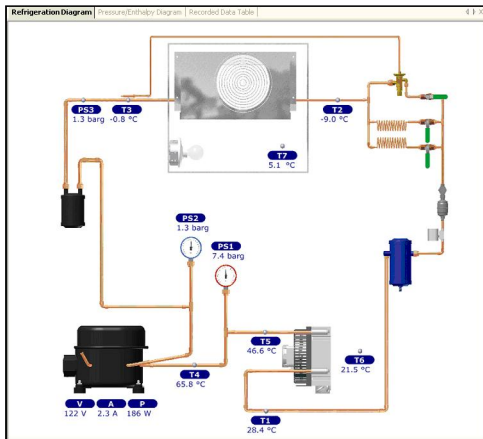


Figure 4. The LVHVAC software Refrigeration Diagram shows the main components of the system and displays in real-time the temperatures, pressures, and compressor data measured at the various test points.

location of the system test points (see Figure 4). The test points display in real-time the temperatures and pressures measured at critical points of the system. These measurements are carried out through the use of 22-bit A/D acquisition channels. The units of measurement are selectable between metric or imperial. The data sampling rate and the measurement duration are also selectable.

Refrigeration Training System			
System Information			
Refrigerant Type		R134a	
Low Pressure Controller		Setpoint (barg)	
Temperature Controller		Setpoint (°C)	
Evaporator		Fan Speed	
Condenser		Fan Speed	
Heat Load		Power	
Temperature Test Points			
	T (°C)	P (barg)	H (kJ/kg)
T1	28.23	0.49	240.61
T2	-7.59	0.35	240.61
T3	1.39	2.26	399.41
T4	64.38	0.49	427.69
T5	46.24	0.49	422.13
System Performance			
Superheat (°C)		6.3	
Compression Ratio		3.75	
Net Refrigeration Effect (kJ/kg)		159.90	
Ideal Work of Compression (kJ/kg)		28.28	
Refrigerant Flow Rate (kg/s)		0.059	
Refrigeration Capacity (kW)		104.25	
Coefficient of Performance		5.616	
Rate of Heat Rejection at the Condenser (kW)		119.16	
Vol. Rate of Flow of Refrig at the Evap Outlet (m³/min)		2.603	
Refrig Effect Loss by Work of the Exp Device (kJ/kg)		49.91	

Figure 5. The System Information panel displays in real time the values of variables used to assess the performance of the system.

by the software.

The software also features a Recorded Data Table, which permits the live recording of all the measured values, calculated variables, and system settings, at different points of the refrigeration cycle or under various system configurations, for later reference or comparison. This table contains five different memories.

The Refrigeration Training System is used in conjunction with the Heating, Ventilating, and Air Conditioning (LVHVAC) software. This Windows®-based software is used to measure, observe, and analyze the refrigeration parameters. A host computer connected to the system through a single Universal Serial Bus (USB) link is required to run the software.

Upon opening the LVHVAC software, a Refrigeration Diagram appears, showing the main components of the refrigeration system, as well as the

Accompanying the Refrigeration Diagram is a System Information panel that displays in real-time the temperatures, absolute pressures, and enthalpies at five points of the system (see Figure 5). This panel also displays the values of variables used to assess the performance of the system, including the superheat, the coefficient of performance, the net refrigeration effect, and the compression ratio. These values are automatically computed and refreshed

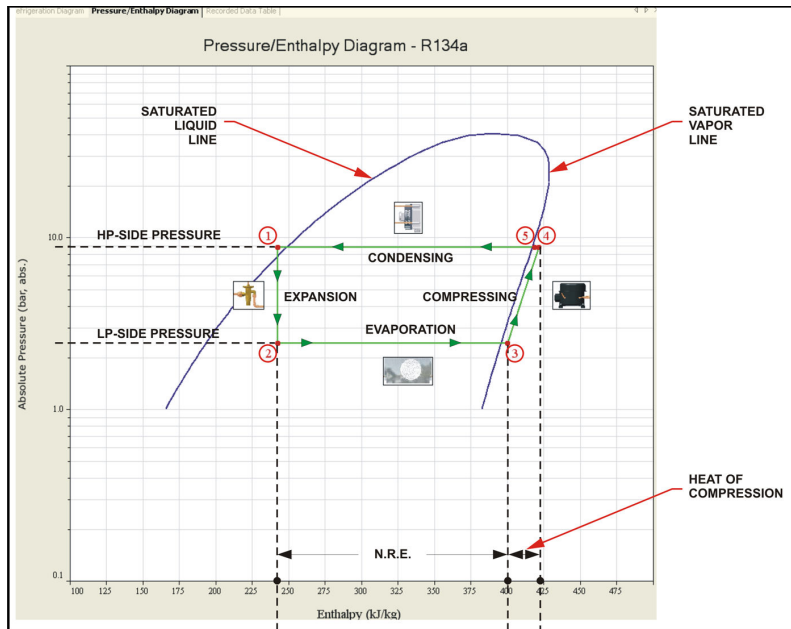


Figure 6. The Pressure/Enthalpy Diagram provides a real-time plot of the refrigeration cycle.

In addition, a powerful tool called the Pressure/Enthalpy Diagram allows the real-time monitoring of the refrigeration cycle (see Figure 6). The refrigeration cycle is a quadrilateral indicating the refrigerant properties (enthalpy and pressure) and the refrigerant state at any point of the cycle. Four icons indicate the equipment associated with each phase of the refrigeration cycle: the compressor, the condenser, the expansion device, and the evaporator. The shape of the quadrilateral continuously changes as the system evolves towards equilibrium, reflecting the changes that occur in the measured temperatures and pressures.

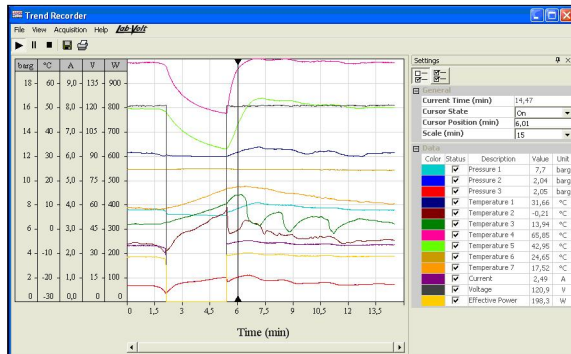


Figure 7. The Trend Recorder provides a graph over time of the pressures, temperatures, and compressor data at the system test points.

The LVHVAC software also features a Trend Recorder providing a graph over time of the pressures, temperatures, and compressor data at the system test points (see Figure 7). These variables are graphed using different colors to facilitate observation. The trend recorder can be scrolled backward and forward in time. A cursor permits accurate measurement of the displayed data at any given point of the recorded period. The time

scale of the recorder can be modified to obtain longer or shorter display periods. The recorded data can be saved to disk as a text file or as a spreadsheet (CSV file) for detailed analysis in Microsoft Excel®.

Topic Coverage

- Identify the main components of a typical refrigeration cycle and briefly explain their role
- Verify the pressure-temperature relationship of R-134a using the DAI, determine the COP and NRE
- Describe and configure the pressure and temperature controllers
- Vary the load, fan speed or expansion device and observe the effect on the other parameters of the system using the software
- Perform various electrical measurements and troubleshoot faults

Features & Benefits

- Compact design

- Powerful data acquisition system and software for real-time monitoring
- Variable heat load and fans speed
- Includes fault-insertion switches for teaching troubleshooting
- Protection against high pressure to preserve the integrity of the system

List of Manuals

Description	Manual number
Refrigeration System Setup (User Guide) _____	580301 (30788-E0)
Refrigeration Training System (Job Sheets - Student) _____	593944 (54223-20)
Refrigeration Training System (Job Sheets - Instructor) _____	593945 (54223-30)

Optional Equipment

Qty	Description	Model number
1	Refrigeration Charging Equipment _____	587636 (3440-50)
1	Refrigerant Recovery Unit _____	587640 (3445-10)
1	Refrigeration Training System (Manuals on CD-ROM) _____	580375 (37869-A0)

Specifications

Parameter	Value
Power Requirements	
Current	6 A
Service Installation	Standard single-phase outlet
Compressor	
Capacity	124 W (0.167 hp)
Type	Hermetic, thermally protected
Refrigerant	R134a, nominal charge of 1.09 kg (2.4 lb). The help of a refrigeration technician is required to fill the training system with refrigerant.
Operating Pressures (Typical)	
Lowest	1.4 barg (20 psig)
Highest	7.6 barg (110 psig)
Evaporator	
Type	Forced-air coil with variable-speed fan enclosed in a cooling chamber
Power Requirement	0.58 A
Condenser	
Type	Forced-air coil with variable-speed fan
Power Requirement	0.41 A
Safety Devices	High-pressure controller with manual-reset breaker
Control Devices	
Control Devices	One thermostatic expansion valve, two capillary tubes of differing lengths
	Low-pressure electronic pressure controller with LCD display, cut-in/out pressures (typical): 2.1 barg (30 psig) and 0.7 barg (10 psig), respectively
	Remote-bulb temperature controller with adjustable differential, setpoint (typical): 5°C (41°F)
	Solenoid valve
Instrumentation	High- and low-pressure gauges
Auxiliary Equipment	Liquid receiver, suction accumulator, filter/drier, manual valves, heat load (two light bulbs)
Sensors	
Thermocouples	Seven, "J" type
Pressure Transducers	Two 0-690 kPa (0-100 psi), one 0-1034 kPa (0-150 psi)
AC Voltage/Current Signal Conditioners (Isolated)	One 0-5 A AC / One 0-150 V AC
Fault Insertion	Using six toggle switches accessible behind a lockable hinged panel
Data Acquisition System	
Analog Inputs	20 single-ended or 10 differential; volts or T/C channels, configurable
Accuracy	0.015% of reading, +0.002% of range, cold-junction compensation
Resolution	22-bit A/D converters

Parameter	Value
Isolation	500 V optical isolation
Connection	USB
Computer Requirements	A currently available personal computer running under one of the following operating systems: Windows® 7 or Windows® 8.
Physical Characteristics	
Intended Location	On a table
Dimensions (H x W x D)	910 x 840 x 720 mm (35.8 x 33.1 x 28.3 in)
Net Weight	TBE

Module Options Description

Refrigeration Charging Equipment 587636 (3440-50)



The Refrigeration Charging Equipment is an accessory kit in refrigeration and air conditioning. The Refrigeration Charging Equipment is designed to enable students to evacuate and charge refrigeration training systems. It consists of a manifold, a charging hose kit, a vacuum pump, an automatic refrigerant charging meter, and a heater blanket.

Features & Benefits

- Easy-to-read gauges
- Forged-brass body with metal valve handles
- Color-coded hoses
- Hose cover pin-pricked to resist bubbling and bursting
- Two-stage vacuum pump for great efficiency
- Refrigerant charging meter automatically shuts off when charging is completed
- Compatible with refrigerants R-12, R-134a, R-404A, R-502, and R-507

Specifications

Parameter	Value
Refrigeration Charging Equipment	
Includes:	Manifold
	Charging hose kit
	Vacuum pump
	Automatic refrigerant charging meter
	Heater blanket

Refrigerant Recovery Unit
587640 (3445-10)



The Refrigerant Recovery Unit enables students to recover refrigerant for storage or recycling. A low-pressure indicator on the unit monitors the pressure condition on the suction side of the recovery system. A filter dryer and an oil separator are used to condition the refrigerant before it enters the recovery system compressor. At the high-pressure side of the recovery system compressor, a second oil separator ensures good lubrication by returning the oil at the

suction side of the compressor, thus avoiding oil migration to the storage tank. A high-pressure indicator is also provided to monitor the pressure conditions on the discharge side of the compressor. A high-pressure controller will automatically shut off the compressor if the discharge pressure exceeds a preset limit. A forced-air condenser is used to transform the high-pressure refrigerant vapor to a high-pressure liquid refrigerant.

List of Manuals

Description	Manual number
Refrigeration System Setup (User Guide)	580301 (30788-E0)
Refrigerant Recovery Unit (Instruction Manual)	590056 (32064-D0)

Features & Benefits

- Hermetically sealed compressor
- Compressor oil drain conveniently located at the bottom of the unit
- Easy access to filter at the back of the unit, after removal of the access door
- Forced-air coil condenser
- Low-and high-pressure gauges
- High-pressure safety device
- Compatible with refrigerants R-134a

Specifications

Parameter	Value
Power Requirements	
Current	2.5 A
Service Installation	Standard single-phase ac outlet
Compressor	
Type	Hermetically sealed
Nominal Power	186 W (1/4 hp)
Oil	Polyolester, 280 ml (9.5 oz)
Condenser Type	Forced-air coil
Refrigerant Compatibility	R134a
Filter/Dryer Type	82 ml (5 in³), 6.35 mm (0.25 in) flare x 6.35 mm (0.25 in) flare
Instrumentation	Low- and high-pressure gauges
Safety Device	High pressure
Physical Characteristics	

Parameter	Value
Intended Location	On a table able to support the weight of the equipment
Required Floor Space (H x W x D)	345 x 490 x 255 mm (13.6 x 19.3 x 10 in)
Net Weight	50 kg (110 lb)

Refrigeration Training System (Manuals on CD-ROM) 580375 (37869-A0)

List of Manuals

Description	Manual number
Refrigeration System Setup (User Guide) _____	590612 (30788-E0)
Refrigeration Training System (Job Sheets - Student) _____	594260 (54223-20)
Refrigeration Training System (Job Sheets - Instructor) _____	594261 (54223-30)

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