ElettronicaVeneta

CATALOGUE N. 42-A

THERMODYNAMICS

ElettronicaVeneta

CATALOGUE N. 42-A

THERMODYNAMICS

Thermodynamics

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THERMODYNAMICS
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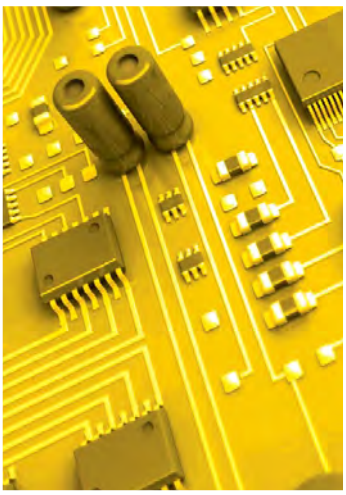
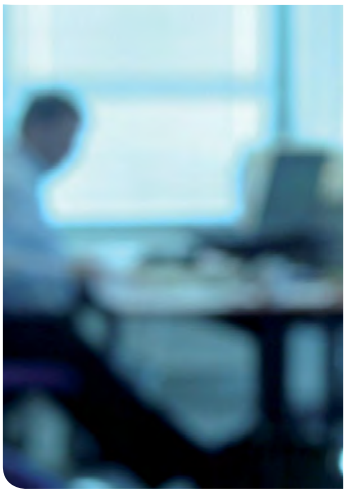
INDEX

Note: The catalog is constantly updated. Please send any suggestion you have to export@elettronicaveneta.com. We would also like to remind you that, due to the continuous technological upgrades, the described products may be subjected to design and/or technical modifications. Nevertheless, we guarantee that the educational content of our equipment remains unchanged.

GENERAL INTRODUCTION

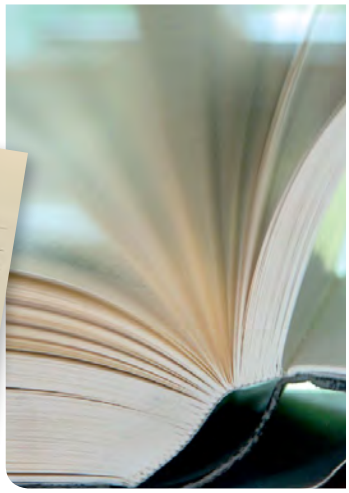




ELETTRONICA VENETA S.p.A. has been designing and manufacturing educational equipment since 1963. This equipment, covering the different fields of technology, fulfils two important educational objectives:

- to facilitate the learning process of the student by means of real systems which illustrate practically the important aspects of the theory learned in the classroom.
- to simplify the work of the teacher enabling the demonstration of the real, practical applications of the theory learned.

Increasing the efficiency of the didactic process improves and simplifies the integration of young students into the world of employment and justifies the material and human investments made in schools throughout the world.



ELETTRONICA VENETA S.p.A. operates on an international level and takes into consideration the training programmes and cultures of each specific country. In order to meet different requirements, we offer flexible systems which ensure maximum compliance with the latest technologies, technological advances and the professional profile requirements of local industry.

The proposed laboratories and training equipment are suitable for regular school education as well as ongoing post-diploma training courses and professional re-qualification.

Our training equipment covers most of the technological sectors included in the training programmes of vocational schools, technical institutes and universities, both national and international.

ELETTRONICA VENETA S.p.A. headquarters is located in the green fields of the Veneto region, not far from Venice, and constitute a centre for equipment design and development suited to the training needs of all professional and technical profiles. The modern premises integrates R&D laboratories, a production plant and a fully equipped teacher training centre.

The integration of these efficient training systems into local school structures ensures high-quality, state-of-the-art training programmes which meet the diverse professional expectations of the student and the technological requirements of industry and research within their specific local contexts.

The ISO 9001 (Quality System Certification) obtained in 1998 and updated in application of the latest edition of the International Standard, is further testament to the quality-driven organisation of **ELETTRONICA VENETA S.p.A.** aimed at providing top standard equipment, training and service.

PRESENTATION

The line of equipment described in this catalogue has been designed to understand and analyze the basic principles of thermodynamics.

Equipment **mod. TE1/EV** and **TE2/EV** enable to study the measuring techniques of two essential thermodynamic variables: temperature and pressure, and to practise the principles of calibration of their relevant measuring systems.

Equipment **mod. TE3/EV** enables to verify the correlation between vapour temperature and pressure directly and clearly, whereas equipment **mod. TE4/EV** is a very good instrument for understanding the concept of recirculation in industrial processes.

Equipment **mod. TE5/EV** and **TE22/EV** enable to carry out the typical tests of transformation of gases and to verify the laws regulating them.

Equipment **mod. TE6/EV**, connected with a wide range of accessories, enables to study the different modes of heat transfer (conduction, convection and radiation).

Equipment **mod. TE8/EV** and **TE9/EV** represent two useful instruments for carrying out the typical tests for determining flash point and heat of combustion.

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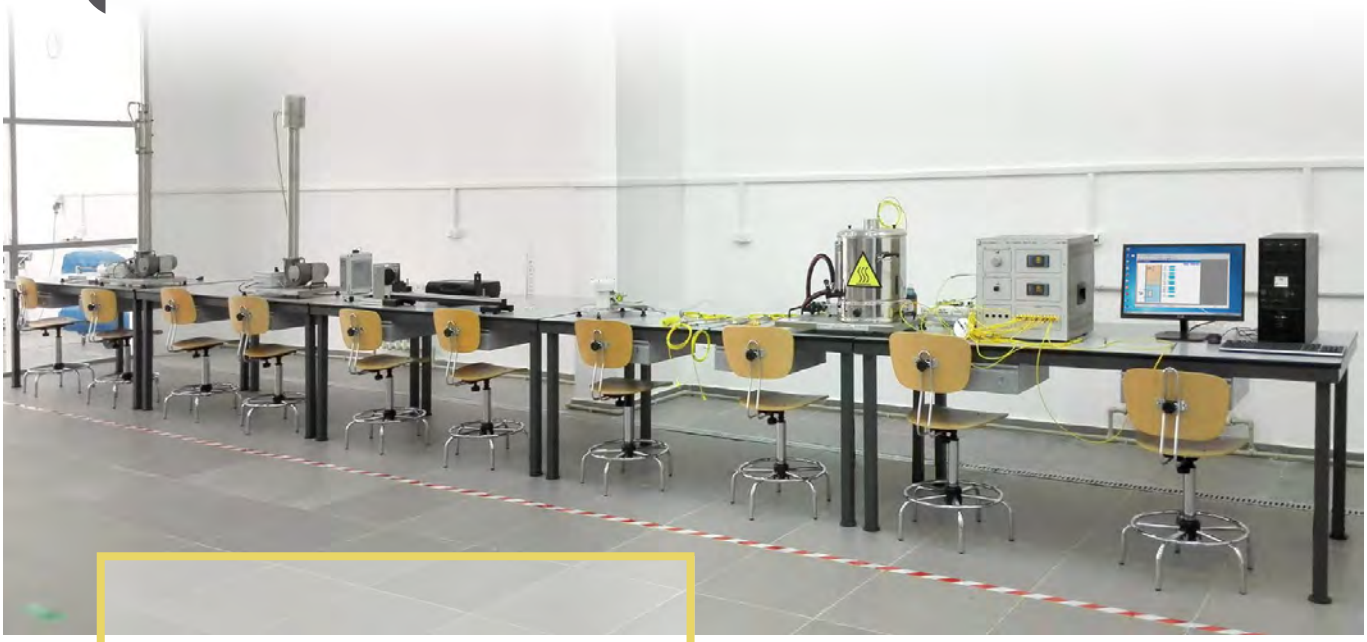

Example of a Thermodynamics lab designed and manufactured by Elettronica Veneta.

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THERMODYNAMICS EQUIPMENT

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TEMPERATURE MEASUREMENT AND CALIBRATION

Mod. TE1/EV

DESCRIPTION

This unit has been designed to study temperature measuring techniques and the modes of calibration of the relevant sensors by means of fixed points and of a thermometer provided with calibration certificate.

It consists of a hot water bath and of an ice bath to determine precise reference points (boiling point and melting point of water) and variable temperatures.

A set of thermometers of different types is fixed onto a support that can be moved from the hot bath to the ice bath. The available thermometers are:

- Reference Pt100 thermoresistance with calibration certificate
- Industrial Pt100 thermoresistance
- Two K-type thermocouples
- PTC thermistor
- Inert gas thermometer
- Liquid thermometer

TRAINING PROGRAM

This unit enables to develop and analyze the following issues:

- Concepts of Celsius temperature measurement (temperature scales, conversions among scales, zero error and full-scale error, linearity errors)
- Properties and characteristic behaviours of the different systems of temperature measurement (thermoelectric properties of a platinum resistance thermometer, of a thermocouple and of a thermistor, of a gas thermometer and of a liquid thermometer, response speed)
- Calibration of thermometers by using fixed points or certified sensors

TECHNICAL CHARACTERISTICS:

- Thermal bath of AISI 304 stainless steel equipped with:
  - stirrer
  - shielded heating element
  - safety level switch
- Dewar flask of stainless steel with high vacuum insulation, capacity of 1 litre
- Support for thermometers
- Reference Pt100 thermoresistance with 3 points calibration certificate
- Industrial Pt100 thermoresistance of class A
- K-type thermocouple equipped with 4-20 mA transmitter with "zero" and "span"
- Thermistor (PTC)
- Liquid thermometer
- Gas thermometer
- Electric console with 5 displays and controls

Power supply: 230 Vac 50 Hz single-phase - 1700 VA
(Other voltage and frequency on request)
Total dimensions: 1000 x 500 x 550 mm
Total weight: 40 kg

REQUIRED UTILITIES (PROVIDED BY THE CUSTOMER)

- Distilled water: 6 litres
- Crushed ice produced from distilled water: 1 litre

SUPPLIED WITH

THEORETICAL - EXPERIMENTAL HANDBOOK

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PRESSURE MEASUREMENT AND CALIBRATION

Mod. TE2/EV

DESCRIPTION

This unit has been designed to study pressure measuring techniques and the modes of calibration of the relevant sensors.

Using a deadweight tester will enable to generate pre-fixed pressures and to calibrate a Bourdon gauge and an electronic pressure sensor.

The deadweight tester consists of a piston that can house a set of weights generating pressures up to 2 bars.

The pressure gauge is a typical industrial Bourdon gauge, whereas the sensor is a typical industrial pressure transmitter of piezoresistive type.

TECHNICAL CHARACTERISTICS:

- Deadweight tester of AISI 304 stainless steel, equipped with a set of weights being able to produce pressures up to 2 bars
- Bourdon gauge with transparent dial for showing the internal mechanism
- Industrial pressure transmitter of piezoresistive type, with 4-20 mA output
- Electrical console provided with display and calibration system with "zero" and "span"

Power supply: 230 Vac 50 Hz single-phase - 50 VA
(Other voltage and frequency on request)
Total dimensions: 540 x 430 x 550 mm
Total weight: 21 kg

TRAINING PROGRAM

This unit enables to develop and analyze the following issues:

- Concept of pressure = force / area
- Operation of a Bourdon gauge
- Operation of a weight balance
- Concepts of measurement and calibration
- Absolute and relative pressure
- Zero, full-scale and linearity errors
- Calibration of a pressure gauge
- Calibration of a pressure transmitter

SUPPLIED WITH

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SATURATION PRESSURE

Mod. TE3/EV

DESCRIPTION

This unit consists of a Marcet boiler that enables to analyze the correlation between water temperature and pressure and to compare the experimental data with those available in literature.

The water stored in the boiler is heated by an electric resistor; trends of temperature and pressure can be seen on a display and on a Bourdon gauge.

TRAINING PROGRAM

This unit enables to develop and analyze the following issues:

- Saturation curve of water (measurement of temperature of saturated steam and comparison with the values available in literature
- Steam tables
- Correlations between saturation temperature and pressure
- Absolute and relative pressure

TECHNICAL CHARACTERISTICS:

- Boiler of AISI 304 stainless steel, with capacity of 1 litre and maximum operating pressure of 15 bar
- Bourdon gauge
- Pt100 thermoresistance with sheath of AISI 316 stainless steel
- Safety valve
- Electric heating element
- Console with display and switch

Power supply: 230 Vac 50 Hz single-phase - 1700 VA
(Other voltage and frequency on request)
Total dimensions: 1100 x 520 x 800 mm
Total weight: 35 kg

OPTIONAL ACCESSORIES:

- Data acquisition software with interface mod. SI-TE3/EV

REQUIRED UTILITIES (PROVIDED BY THE CUSTOMER)

- Distilled water: 2 litres

SUPPLIED WITH

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RECYCLE LOOPS

Mod. TE4/EV

DESCRIPTION

This unit has been designed to explain the principle of recirculation and to carry out mass and energy balances in steady-state or unsteady-state conditions. This is the typical application of an industrial heating system where the temperature of a product can be increased or reduced by the recirculation of part of the product through a heat exchanger.

This equipment consists of a pipe crossed by tap water and connected with a proper drain; this pipe is equipped with a recirculation circuit including a pump and an electric heating element. This heating resistor can be switched off and on to provoke step changes and to study the system response.

Temperature is measured at the inlet and outlet of the pipe and across the recirculation circuit. Flow rate is measured in the same positions.

TECHNICAL CHARACTERISTICS:

- Pressure reducer for tap water
- Recycle pipe provided with 3.5 kW heater and insertable tank for varying system dead time
- Three Pt100 thermoresistances
- Two electronic turbine flowmeters, with range of 0-1.8 l/m
- Electronic turbine flowmeter for recirculation circuit, with range of 0-6 l/m
- Recycle gear pump of stainless steel
- Electric console with power supply unit and displays

Power supply: 230 Vac 50 Hz single-phase - 4000 VA
(Other voltage and frequency on request)
Total dimensions: 1250 x 450 x 750 mm
Total weight: 40 kg

TRAINING PROGRAM

This unit enables to develop and analyze the following issues:

- Understanding the phenomenon of recirculation
- Mass balances in steady-state condition
- Heat balances in steady-state condition
- Heat balances in non-steady-state condition
- Effect of response time versus heating power and flow rates

REQUIRED UTILITIES (PROVIDED BY THE CUSTOMER)

- Tap water: 180 l/h @ 2 bars
- Water drain

SUPPLIED WITH

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EXPANSION PROCESSES OF A PERFECT GAS

Mod. TE5/EV

DESCRIPTION

This equipment has been designed to study basic thermodynamic processes with air as working fluid; it consists of two interconnected transparent tanks that are respectively pressurized and set under vacuum by a compressor; pressure and temperature inside them are measured during tests.

A pressure sensor connected with the tanks and two internal temperature sensors enable to monitor the variations of air properties inside these reservoirs continuously.

Both tanks are made of rigid transparent plastic for insulating the air inside them from the environment and they can be connected with the pump for their pressurization/setting under vacuum.

All measures (pressure, temperatures, level) can be seen on digital displays and they can be stored in a PC by the (optional) data acquisition system SI-TE5/EV.

TRAINING PROGRAM

This unit enables to develop and analyze the following issues:

- Behaviour of an ideal gas and state equation
- Reversible adiabatic process (isentropic expansion)
- Constant-volume process
- Irreversible adiabatic process
- Process with constant internal energy
- Polytropic processes
- Manometric pressure and absolute pressure

TECHNICAL CHARACTERISTICS:

- Framework of AISI 304 stainless steel
- Tank of transparent methacrylate, with capacity of 23 litres, for the operation under pressure
- Tank of transparent methacrylate, with capacity of 11 litres, for the operation under vacuum
- Pressure transmitters of AISI 304 stainless steel, with range of 1 to 1.5 bar
- Two Pt100 thermoresistances with sheath of AISI 316 stainless steel
- Compressor
- Connection lines between tanks of large and small diameter
- Safety valve
- Electric console with power supply unit and display

Power supply: 230 Vac 50 Hz single-phase - 160 VA
(Other voltage and frequency on request)
Total dimensions: 1100 x 360 x 900 mm
Total weight: 30 kg

OPTIONAL ACCESSORIES:

- Data acquisition software with interface mod. SI-TE5/EV

SUPPLIED WITH

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HEAT TRANSFER SERVICE UNIT

Mod. TE6/EV

DESCRIPTION

This unit can be connected with a series of interchangeable accessories to study the modes of heat transfer (conduction, convection and radiation) and it ensures the power supply besides supplying the measuring instruments.

In detail, this equipment is provided with:

- two specific displays where 12 values of temperature and the values of the characteristic parameters of each test can respectively be seen;
- two adjustable outputs in Volts and another output fixed at line voltage.

This unit also includes an interface with data acquisition software for Windows that enables to follow the tests on a PC.

TECHNICAL CHARACTERISTICS:

- Current output at line voltage
- Variable output from 0 to 24 V
- Variable output from 0 to 48 V
- 12 inputs for thermocouples
- 12 K-type thermocouples
- 4 inputs for signals coming from radiometer, luxmeter, ammeter and flowmeter
- 2 digital displays
- Data acquisition software for Windows

Power supply: 230 Vac 50 Hz single-phase - 2300 VA
(Other voltage and frequency on request)
Dimensions: 530 x 510 x 540 mm
Weight: 35 kg

NECESSARY ADDITIONAL EQUIPMENT:

- At least one of the following models:
  TE6A/EV, TE6B/EV, TE6C/EV, TE6D/EV, TE6E/EV, TE6F/EV and TE6G/EV.

OPTIONAL

PERSONAL COMPUTER, WITH SERIAL PORT OR USB/SERIAL CONVERTER

SUPPLIED WITH

THEORETICAL - EXPERIMENTAL HANDBOOK

COMPUTERIZED HEAT TRANSFER SERVICE UNIT

Mod. TE6PC/EV

DESCRIPTION

This unit can be connected with a series of interchangeable accessories to study the modes of heat transfer (conduction, convection and radiation) and it ensures the power supply besides supplying the measuring instruments.

In detail, this equipment is provided with:

- 12 inputs for TC and 4 analog inputs;
- two adjustable outputs in Volts and another output fixed at line voltage.

This unit also includes an interface with data acquisition software for Windows that enables to follow the tests on a PC. Unlike mod. TE6/EV, this model does not feature any display. The parameters can be displayed graphically only by using the data acquisition software.

TECHNICAL CHARACTERISTICS:

- Current output at line voltage
- Variable output from 0 to 24 V
- Variable output from 0 to 48 V
- 12 inputs for thermocouples
- 12 K-type thermocouples
- 4 inputs for signals coming from radiometer, luxmeter, ammeter and flowmeter
- Data acquisition software for Windows

Power supply: 230 Vac 50 Hz single-phase - 2300 VA
(Other voltage and frequency on request)
Dimensions: 530 x 510 x 540 mm
Weight: 35 kg

NECESSARY ADDITIONAL EQUIPMENT:

- At least one of the following models:
  TE6A/EV, TE6B/EV, TE6C/EV, TE6D/EV, TE6E/EV, TE6F/EV and TE6G/EV.

REQUIRED

PERSONAL COMPUTER, WITH SERIAL PORT OR USB/SERIAL CONVERTER

SUPPLIED WITH

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LINEAR HEAT CONDUCTION

Mod. TE6A/EV

DESCRIPTION

This equipment has been designed to study Fourier's equation in a one-dimensional system in steady-state conditions.

It includes two cylindrical sections for heating and cooling that can be coupled to each other; furthermore some interchangeable sections can be inserted. Heating, cooling and intermediate sections are positioned coaxially inside cylinders of plastic material to minimize heat losses and to protect operators from scalds.

A set of thermocouples installed at regular intervals enables to detect the temperature trend.

TRAINING PROGRAM

This unit enables to develop and analyze the following issues:

- Using Fourier's equation to describe the heat exchange between solid materials
- Temperature trend during heat transfer by conduction through the contact surface between the same material or different materials
- Determining heat conductivity of different materials
- Temperature trend during heat conduction through a flat wall of reduced section
- Insulating materials

TECHNICAL CHARACTERISTICS:

- Heating section: cylinder of brass with diameter of 25 mm, provided with cartridge resistance of 60 W @ 24 Vdc, safety thermostat and with three housings for K-type thermocouples
- Cooling section: water-cooled cylinder of brass with diameter of 25 mm, provided with three housings for thermocouples, pressure reducer – filter and with control valve
- Intermediate section of brass: cylinder with diameter of 25 mm and length of 30 mm, provided with two housings for thermocouples placed at a distance of 15 mm
- Intermediate section of AISI 316 stainless steel: cylinder with diameter of 25 mm and length of 30 mm, provided with two housings for thermocouples placed at a distance of 15 mm
- Intermediate section of aluminium: cylinder with diameter of 25 mm and length of 30 mm, provided with two housings for thermocouples placed at a distance of 15 mm
- Intermediate section of brass: cylinder of steel with diameter of 13 mm and length of 30 mm, provided with two housings for thermocouples placed at a distance of 15 mm
- Two disks of insulating material (paper and PTFE) with thickness of 1 mm

Dimensions: 460 x 460 x 470 mm
Weight: 10 kg

REQUIRED

UTILITIES (PROVIDED BY THE CUSTOMER)

- Tap water: 1.5 litres/min

HEAT TRANSFER SERVICE UNITS
mod. TE6/EV or TE6PC/EV (NOT INCLUDED)

SUPPLIED WITH

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RADIAL HEAT CONDUCTION

Mod. TE6B/EV

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DESCRIPTION

This equipment has been designed to study radial heat conduction in steady-state condition and it mainly consists of a metallic disk provided with temperature sensors arranged radially from centre to circumference.

This metallic disk is heated at the centre and cooled peripherally to generate a radial heat flow by conduction.

TRAINING PROGRAM

This unit enables to develop and analyze the following issues:

- Using Fourier's equation to describe the heat exchange through solid materials
- Temperature trend during radial heat conduction
- Determining heat conductivity

TECHNICAL CHARACTERISTICS:

- Disk of brass with thickness of 3 mm and diameter of 110 mm, provided with a central copper cylinder of 14 mm; the whole sample is coated with plastic material to minimize heat losses and to protect operators from scalds
- Cartridge resistance of 100 W @ 24 Vdc with safety thermostat
- Copper pipe around disk circumference for water cooling, provided with reducer – filter and control valve
- Six housings for K-type thermocouples arranged radially on disk

Dimensions: 420 x 420 x 320 mm
Weight: 9 kg

REQUIRED

UTILITIES (PROVIDED BY THE CUSTOMER)

- Tap water: 1.5 litres/min

HEAT TRANSFER SERVICE UNIT
mod. TE6/EV or TE6PC/EV (NOT INCLUDED)

SUPPLIED WITH

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RADIATION HEAT TRANSFER

Mod. TE6C/EV

DESCRIPTION

This equipment has been designed to demonstrate the laws of heat transfer by radiation coming from a light source and from a heat source.

It consists of a framework provided with horizontal rail on which movable supports of instruments, filters and plates can slide so that they can be positioned ad different distances.

A graduated scale available on the side part of rail enables to define distances exactly.

The heat source consists of a flat copper element heated by means of a heating plate; the fore part of this element is coated with heatproof mat black paint ensuring an emissivity close to one.

The surface temperature of the plate is measured by a thermocouple, whereas the radiation coming from the heated plate is measured by a radiometer installed along the rails.

The equipment includes:

- metallic plates with different surface finish to demonstrate the effect of emissivity on the radiation emitted and absorbed;
- three black plates, a gray plate and a polished plate that will be positioned along the rail before the heat source. Each plate is provided with a K-type thermocouple that indicates the surface temperature of the same plate;
- two cork-coated metallic plates that enable to create a vertical slot adjustable in width between the source and the measuring instrument to demonstrate the area factors.

The light source consists of a lamp that can rotate of 180°; the resulting angle is measured on a goniometer. Source power can be varied and measured.

The radiation coming from the light source is measured by a luxmeter that can be positioned along the rail with graduated scale. Filtering plates of various opacity and thickness are supplied to demonstrate the laws of absorption.

TRAINING PROGRAM

This unit enables to develop and analyze the following issues:

- Reverse quadratic law using heat source and radiometer or light souce and luxmeter
- Stefan-Boltzmann law using heat source and radiometer
- Emissivity using heat source, metallic plates and radiometer
- Area factors using heat source, slot and radiometer
- Lambert's cosine law using the (rotating) light source and luxmeter
- Lambert's absorption law using light source, plates with filter and luxmeter

TECHNICAL CHARACTERISTICS:

- Framework with horizontal rail on which supports for instruments, filters and plates slide
- Copper Heat source, heated by means of a heating plate, black painted (emissivity close to one) and provided with housing for thermocouple
- Radiometer
- Metallic plates with different surface finish
- Three black plates, a gray plate and a polished plate; each one provided with housing for thermocouple
- Two cork-coated metallic plates
- Luxmeter
- Filters for demonstrating the laws of absorption

Dimensions: 1060 x 380 x 370 mm
Weight: 16 kg

REQUIRED

HEAT TRANSFER SERVICE UNIT
mod. TE6/EV or TE6PC/EV (NOT INCLUDED)

SUPPLIED WITH

THEORETICAL - EXPERIMENTAL HANDBOOK

COMBINED CONVECTION-RADIATION

Mod. TE6D/EV

DESCRIPTION

A hot surface loses heat to its surroundings by the combined modes of convection and radiation. This module enables to analyze the combined effects of convection and radiation at different values of surface temperature and air velocity on the surface. The prevalence of convection at low surface temperatures and the prevalence of radiation at higher surface temperatures, as well as the increase of transferred heat due to forced convection, can be demonstrated.

The equipment consists of a centrifugal fan with vertical outlet duct at the top of which a cross cylinder is mounted. This cylinder is heated by an electric heating element operating at low voltage. The power supplied to this heating element can be varied and measured.

The surface of this cylinder is coated with heat-resisting mat black paint which ensures an emissivity close to one.
A K-type thermocouple attached to the wall of the cylinder enables to measure the surface temperature under various operating conditions.

An air lock at fan inlet enables to vary the air velocity through the outlet duct and an anemometer enables to measure the air velocity.

A K-type thermocouple located in the outlet duct enables to measure the air temperature before the heated cylinder.

TRAINING PROGRAM

This unit enables to develop and analyze the following issues:

- combined heat transfer in conditions of natural convection
- determining the convection and radiation heat transfer coefficients and how they depend on temperature
- determining the effect of forced convection on the heat transfer from the cylinder at different values of air velocity

TECHNICAL CHARACTERISTICS:

- Centrifugal fan with vertical outlet duct
- Heated cylinder (100 W @ 24 Vdc) cross-mounted on the duct, with diameter of 10 mm, heated throughout its length of 70 mm and coated with low-emissivity paint
- K-type thermocouple for measuring cylinder surface temperature
- Housing for K-type thermocouple for measuring air temperature before the heated cylinder
- Air lock for varying air velocity
- Anemometer

Dimensions: 600 x 350 x 1300 mm
Weight: 24 kg

REQUIRED

HEAT TRANSFER SERVICE UNIT
mod. TE6/EV or TE6PC/EV (NOT INCLUDED)

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EXTENDED SURFACE HEAT TRANSFER

Mod. TE6E/EV

DESCRIPTION

A long horizontal rod, which is heated at one of its ends, is used as extended surface for measurements of heat transfer. A set of thermocouples installed at regular intervals along this rod enables to measure the temperature trend. As the diameter of the rod is small with respect to its length, heat conduction along the rod can be supposed to be one-dimensional and heat loss from the tip can be ignored.
The rod is coated with a heat-resisting mat black paint ensuring an emissivity close to one.

TRAINING PROGRAM

This unit enables to develop and analyze the following issues:

- measuring the temperature distribution along an extended surface and comparing the results with theoretical models
- heat transfer from an extended surface resulting from free convection and radiation, and comparing the results with theoretical models

TECHNICAL CHARACTERISTICS:

- Cylindrical rod of brass with diameter of 10 mm and length of 350 mm
- Electric heating of the rod at 20 W @ 24 Vdc
- Eight K-type thermocouples at intervals of 50 mm
- Painting the rod to ensure an emissivity close to one

Dimensions: 580 x 380 x 250 mm
Weight: 6 kg

REQUIRED

HEAT TRANSFER SERVICE UNIT
mod. TE6/EV or TE6PC/EV (NOT INCLUDED)

SUPPLIED WITH

THEORETICAL - EXPERIMENTAL HANDBOOK

RADIATION ERRORS IN TEMPERATURE MEASUREMENTS

Mod. TE6F/EV

DESCRIPTION

Transferring heat by radiation between a thermometer and its surroundings can lead to errors in measuring temperature, especially when the temperature of a gas is measured by a thermometer positioned near surfaces at higher or lower temperature than that of the gas.

This measuring error is also affected by other factors such as the velocity of the gas crossing the thermometer, the physical size of the thermometer and the emissivity of the same thermometer.

A set of thermocouples is used in this equipment to measure the temperature of the air flow crossing the centre of a duct while the side walls of the duct are heated, so that thermocouples are supplied with a source of heat radiation.

Each thermocouple receives heat by radiation from the heated surface and loses heat by convection to the air and along the wires, by conduction.

The result is an increase of temperature of thermocouple above the temperature of the air and consequently a reading error of the same thermocouple.

This equipment enables to show these sources of error in measurement besides supplying suitable methods for reducing or eliminating these errors.

TRAINING PROGRAM

This unit enables to develop and analyze the following issues:

- Errors concerning radiation heat transfer:
  - effect of wall temperature
  - effect of air velocity
  - effect of thermocouple type
- Methods for reducing errors due to radiation

TECHNICAL CHARACTERISTICS:

- Tubular duct of stainless steel with a wall heated electrically at 200 W @ 24 Vdc
- Electric fan
- Three K-type thermocouples (d= 1.6 mm, d= 1.6 mm, black painted, d= 4.8 mm)
- Air lock for varying air velocity
- Anemometer, range 0-10 m/S
- Movable shield against radiation

Dimensions: 650 x 380 x 1350 mm
Weight: 26 kg

REQUIRED

HEAT TRANSFER SERVICE UNIT mod. TE6/EV or TE6PC/EV (NOT INCLUDED)

SUPPLIED WITH

THEORETICAL - EXPERIMENTAL HANDBOOK

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UNSTEADY STATE HEAT TRANSFER

Mod. TE6G/EV

DESCRIPTION

This equipment enables to determine temperature distribution and heat flow for solid shapes of simple geometry suddenly dipped into a fluid at constant temperature. Monitoring the temperature at the centre of the object enables to analyze the heat flow. Another thermocouple will measure the temperature of the water adjacent to the same shape and supply an accurate data item for measuring the time of immersion in hot water.

The equipment consists of a bath of heated water and of a set of solid shapes: a rectangular slab, a long cylinder and a sphere.

Each shape includes a thermocouple to measure the temperature at the centre of the shape and is made of materials with different thermal conductivity (brass and stainless steel).

The large volume of water in the bath ensures that any change in water temperature is negligible when measurements are carried out.

A water flow output by a circulation pump ensures that the modes of heat transfer are constant and the water surrounding the shape is kept at constant temperature.

A thermocouple available in water bath enables to check water temperature and to adjust it to the right value before the shape is immersed.

A thermocouple mounted on the shape holder comes into contact with the hot water at the same instant as the solid shape, thus ensuring an accurate data item for measurement of temperature versus time.

TECHNICAL CHARACTERISTICS:

- Thermal bath of 30 litres with approx. 3kW electric resistor, thermostat and circulation pump
- Set of solid shapes of brass including thermocouple: rectangular slab, cylinder and sphere
- Set of solid shapes of steel including thermocouple: rectangular slab, cylinder and sphere
- K-type thermocouple for measuring water temperature

Dimensions: 700 x 440 x 720 mm
Weight: 20 kg

TRAINING PROGRAM

This unit enables to develop and analyze the following issues:

- Heat transfer for bodies of different material and shape, in unsteady-state conditions
- Analyzing the results on charts of temperature / heat flow
- Using the results to determine the conductivity of a similar shape of different material.

REQUIRED

HEAT TRANSFER SERVICE UNIT
mod. TE6/EV or TE6PC/EV (NOT INCLUDED)

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FREE AND FORCED CONVECTION

Mod. TE6H/EV

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DESCRIPTION

This bench top unit consists of a centrifugal fan with vertical discharge duct in which three different types of heating surfaces can be inserted: flat surface, cylindrical pins surface and a finned surface.
The air temperature is measured before and after the heating surface and in 5 different points of the heating surface itself.
An anemometer allows to measure the air speed in the duct.

TRAINING PROGRAM

This unit enables to develop and analyze the following issues:

- Correlation between surface temperature and heating power in free convection
- Correlation between surface temperature and heating power in forced convection
- Demonstration of the efficiency of heat exchange with extended surfaces
- Temperature distribution on extended surfaces
- Comparison between surfaces of different geometry

TECHNICAL CHARACTERISTICS:

- Centrifugal fan with vertical outlet duct with transparent window
- Flat heating surface, 0.01 m^2 with 200 W @ 24 Vdc heater
- Cylindrical pins heating surface, 0.05 m^2 with 200 W @ 24 Vdc heater
- Finned heating surface, 0.1 m^2 with 200 W @ 24 Vdc heater
- 2 housings for measuring inlet and outlet air temperature
- 5 housings for measuring surface temperature
- Shutter for varying the air speed
- Anemometer

Dimensions: 650 x 380 x 1050 mm
Weight: 32 kg

REQUIRED

HEAT TRANSFER SERVICE UNIT
mod. TE6/EV or TE6PC/EV (NOT INCLUDED)

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THERMAL CONDUCTIVITY OF GAS AND LIQUIDS

Mod. TE6I/EV

DESCRIPTION

The thermal conductivity of a fluid is determined by using it to fill a small gap between an electrically heated cylinder and a water cooling jacket.
The small size of the gap helps avoiding any natural convection mechanism.

TRAINING PROGRAM

This unit enables to develop and analyze the following issues:

- Calibration to determine the effects of heat loss to the environment
- Determining the thermal conductivity of gas and liquids

TECHNICAL CHARACTERISTICS:

- Aluminum heated cylinder, average diameter = 39 mm, length = 110 mm
- Heater, 200 W @ 24 V
- Radial clearance for the fluid 0.4 mm
- Water cooling jacket
- 2 K-type thermocouples

REQUIRED

UTILITIES (PROVIDED BY THE CUSTOMER)

- Tap water

HEAT TRANSFER SERVICE UNIT
mod. TE6/EV or TE6PC/EV (NOT INCLUDED)

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PENSKY MARTENS FLASH POINT TESTER

Mod. TE8/EV

DESCRIPTION

Pensky Martens tester is a standardized measuring instrument for determining the flash point of volatile liquids with flash point exceeding 50°.

This equipment enables to measure the flash point (up to 370°C) of distilled oils (diesel fuel, kerosene), fuel oils, lubricating oils, etc... The used method is that of closed cup.

This instrument mainly consists of a small boiler housing the sample and equipped with a sealing cover where a thermometer and a stirrer are inserted. This cover is also equipped with a spring device enabling to open three slots and to approach a small flame to one of these slots, at the same time. This operation is repeated at regular time intervals as soon as the temperature of the sample rises for heating until the vapours coming out of the boiler take fire. The temperature read at this moment represents the flash point of the sample.

TECHNICAL CHARACTERISTICS:

- Painted framework
- Adjustable electric heating system
- Calibrated crucible of brass
- Snap-on cover
- Motor-driven stirrer
- Air bath of brass with cap of stainless steel

Power supply: 230 Vac 50 Hz single-phase - 500 VA
(Other voltage and frequency on request)
Dimensions: 400 x 330 x 520 mm
Weight: 11 kg

REQUIRED

UTILITIES (PROVIDED BY THE CUSTOMER)

- Feeding: gas or LPG

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MAHLER BOMB CALORIMETER FOR DETERMINING THE HEAT OF COMBUSTION

Mod. TE9/EV

DESCRIPTION

Mahler bomb calorimeter enables to measure the heat of combustion of a lot of solid and liquid substances. The heat resulting from the combustion reaction of the fuel under examination is absorbed by a known mass of water where temperature rise is checked.

The bomb consists of a cylindrical vessel closed by a screw cover with two electrodes connected with an external circuit. The fuel whose heat value must be measured is poured into a crucible available inside the bomb.

This bomb, connected with a cylinder of oxygen, is immersed into a calorimeter full of water, with stirrer and thermometer.

When some current crosses the circuit, combustion starts; then heat value results from the measurement of the consequent rise of water temperature in the calorimeter.

TRAINING PROGRAM

- Measuring the heat of combustion of combustible substances

TECHNICAL CHARACTERISTICS:

- Mahler bomb of stainless steel:
  - capacity of 300 ml
  - cover with sliding threaded ring of manual closing and seal
  - pneumatic inlet valve
  - needle valve for drain
  - electrodes of stainless steel
- Calorimeter vessel of 3 litres including:
  - water jacket
  - covers of polycarbonate
  - motor-driven stirrer (100 r.p.m.)
  - low voltage controls
- Quartz capsule of 3 ml
- Reducer for O_2
- Press for preparing pellets
- Sieve of 70 meshes, Ø = 100

Power supply: 230 Vac 50 Hz single-phase - 1600 VA
(Other voltage and frequency on request)
Dimensions: 460 x 460 x 700 mm
Weight: 62 kg

REQUIRED (NOT INCLUDED)

- O_2 cylinder with 21,7 mm x 1/14" connection

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EQUIPMENT FOR MEASURING THE MECHANICAL EQUIVALENT OF HEAT

Mod. TE11/EV

DESCRIPTION

This apparatus consists of a rotary calorimeter, driven by a variable speed motor.

The calorimeter is composed by a metal cylinder, filled with water, and wrapped by a nylon string; the string extremities are fixed from one side to a spring dynamometer and from the other side to a weight.

When the calorimeter rotates, the friction forces between the string and the external side of the calorimeter cause an increase in the water temperature. It is possible to measure this increase in temperature through a digital thermometer.

The number of revolutions of the calorimeter is given by a mechanical rpm counter.

TECHNICAL CHARACTERISTICS:

- Stainless steel structure for the support of the calorimeter system
- Water Calorimeter (diameter = 50 mm), nylon braid, and one 5 kg weight
- Digital Thermometer
- D.C. motor with speed control
- Dynamometer, full scale value: 0–2500 g; 20 g steps
- Mechanical revolution counter
- Control Panel with automatic/differential switch, motor drive, and speed regulation system

Power supply: 230 Vac 50 Hz single-phase - 350 VA
(Other voltage and frequency on request)
Total dimensions: 1100 x 520 x 790 mm
Total weight: 34 kg

TRAINING PROGRAM

This unit enables to develop and analyze the following issues:

- First law of thermodynamics
- Mechanical equivalent of heat
- Law of conservation of energy

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APPARATUS FOR VERIFYING BOYLE'S AND GAY-LUSSAC'S LAWS

Mod. TE22/EV

DESCRIPTION

This equipment consists of two separate, transparent cylinders full of air.

Air is compressed (quasi-isothermally) by the water pushed by a compressor, in the cylinder on the left, and the pressure variation versus volume is measured. Air is heated (at constant volume) by a resistor controlled by a thermostat, in the cylinder on the right, and the pressure variation versus temperature is measured.

The left cylinder includes a thermoresistance, a pressure transmitter and a level transmitter. If the section of cylinder is known, this level transmitter enables to calculate the available air volume. The right cylinder is provided with a thermistor and with a pressure transmitter.

All measures (pressures, temperature, level, etc...) can be seen on digital displays and they can be stored in a PC by the (optional) data acquisition system SI-TE22/EV.

TECHNICAL CHARACTERISTICS:

- Framework of AISI 304 stainless steel
- Graduated cylinder of transparent methacrylate, with volume of 3 litres, equipped with:
  - Pt100 thermoresistance of AISI 316 stainless steel
  - pressure transmitter of stainless steel, with range of -1 to 3 bar
  - level transmitter with range of 0 to 300 mm
- Cylinder of transparent methacrylate, with volume of 3 litres, equipped with:
  - Pt100 thermoresistance of AISI 316 stainless steel
  - pressure transmitter of stainless steel, with range of -1 to 1.5 bars
  - electric resistor of 300 W controlled by thermostat
- Compressor
- Water tank
- Switchboard of painted carbon steel including:
  - 5 electronic indicators
  - automatic/differential switch

Power supply: 230 Vac 50 Hz single-phase - 500 VA
(Other voltage and frequency on request)
Dimensions: 880 x 600 x 700 mm
Weight: 30 kg

OPTIONAL ACCESSORIES:

- Data acquisition software with interface mod. SI-TE22/EV

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