INDEX

RENEWABLE ENERGIES

PHOTOVOLTAIC SOLAR ENERGY TRAINER

DL SOLAR-A side a

DL SOLAR-A side b

Didactic system for the theoretical and practical study of photovoltaic solar energy facilities.

It is mounted on a mobile structure that allows it to be moved to the venue for practical sessions and allowing the photovoltaic panel to receive solar radiation.

The photovoltaic panel, which can be inclined through a range of 0° to 90°, and the calibrated cell used to measure solar irradiation, are on one side, and all of the components of a basic photovoltaic facility used to provide 12 V of direct current and 230 V of alternating current are on the other side.

IT INCLUDES:

- 1 Descriptive and practical manual.

BASE DIMENSIONS: 400 x 610 mm.

HEIGHT WITH THE PANEL AT 45º: 900 mm.

PRACTICAL SESSIONS THAT CAN BE CARRIED OUT:

- Identification of all components of the trainer and how they are associated with its operation.
- Measurement of solar irradiation
- Measurement of the voltage and power parameters of the photovoltaic panel.
- Programming the load regulator.
- Analysis of the installation of the trainer.
- Direct current supply.
- Alternating current supply.

LIST OF COMPONENTS:

- 50 W, 12 V photovoltaic panel.
- Cell for measuring solar irradiation.
- Programmable electronic load regulator, with a large LCD screen.
- 150 Wp semi sinusoidal inverter to obtain 230 V of alternating current.
- 17 A/h battery.
- Lamps used with loads of 12 V and 230 V, 50 W
- Instrument used to measure solar irradiation in W/m2.
- Instrument used to measure the charging current.
- Two protective magneto-thermal switches.

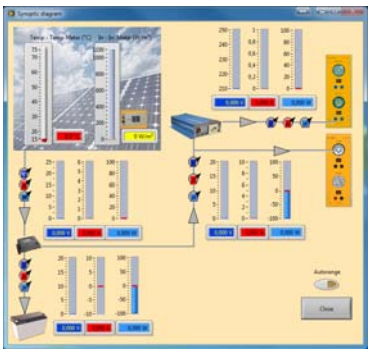
RENEWABLE ENERGIES

SOLAR ENERGY MODULAR TRAINER

DL SOLAR-B

Modular trainer for the theoretical-practical study of the electrical installations with photovoltaic solar energy.
Composed of:

- A photovoltaic inclinable module, 90W, 12V, complete with a cell for measuring the solar irradiation and with a temperature sensor.
- A supporting frame for the modules.
- A battery.
- A battery control module, 12V, 32A.
- A load module. It includes two 12V lamps, dichroic 20W and LED 3W, with independent switches.
- A load module. It includes two mains voltage lamps, dichroic 35W and LED 3W, with independent switches.
- An electronic regulation module, with LCD screen.
- A rheostat.
- A module for the measurement of: solar irradiation (W/m^2), solar panel temperature (°C), current up to 30V, ± 15A (two dc ammeters), voltage up to 40V and power up to 300W.
- A dc to ac converter module, with sinusoidal output at mains voltage. Average power: 300 W.



The trainer is complete with connecting cables and experiment manual.
The trainer is also **complete with data acquisition and processing software**.

Option:

DL SIMSUN: module with lamps to provide suitable lighting for the solar panel when used indoor.

Alternative:

DL SOLAR-BT - Trainer with solar tracking panel instead of the standard solar panel.

RENEWABLE ENERGIES

PHOTOVOLTAIC SOLAR ENERGY TRAINER

DL SOLAR-C

Trainer for the theoretical and practical study of the applications of the photovoltaic solar energy in a house.

Composed of:

- A simulation panel with the graphical representation of a house, complete with lamps, switches, motor for the extraction of water, etc.
- Six photovoltaic modules with 2 mm. terminals for experiencing series, parallel and mixed configurations and for measuring voltage and current as a function of the solar irradiation.
- A battery for experimenting energy accumulation.
- A digital multimeter for performing the measurements.
- A lighting bridge over the photovoltaic modules with two 50 W dichroic lamps and an electronic light regulator. It is possible to change the inclination of the bridge from 0 to 90° as well as the intensity of the light in order to simulate in the classroom the effect of the solar irradiation in the different hours of the day.

The trainer is complete with ABS case and experiment manual.

Dimensions of the trainer:	486 x 289 x 70 mm.
Dimensions of the case:	520 x 370 x 120 mm.

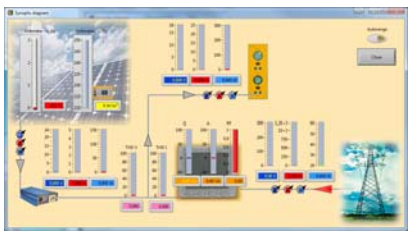
RENEWABLE ENERGIES

SOLAR PHOTOVOLTAIC ENERGY MODULAR TRAINER WITH CONNECTION TO MAINS

DL SOLAR-D1

Didactic system for the study of the generation of electric energy from photovoltaic panels and its inlet in the mains network.
Composed of:

- Photovoltaic inclinable panel, 90W, 12V, complete with a cell for measuring the solar irradiation and with a temperature sensor.
- Supporting frame for the modules.
- Load module. It includes two mains voltage lamps, dichroic 35W and LED 3W, with independent switches.
- Power rheostat, 6 A, 80 W.
- Differential magneto-thermal switch module.
- Module with instruments for the measurement of: solar irradiation (W/m^2), solar panel temperature (°C), solar panel current, battery or load current, solar panel voltage and active power at mains voltage.
- Grid type inverter, with output at mains voltage, 12 V, 300 W.
- Electric energy measurement module in kW/h.
- Network distributor.



The trainer is complete with connecting cables and experiment manual.
The trainer is also **complete with data acquisition and processing software**.

Option:
DL SIMSUN: module with lamps to provide suitable lighting for the solar panel when used indoor.

Alternative:
DL SOLAR-D1T - Trainer with solar tracking panel instead of the standard solar panel.

LAMPS FOR PHOTOVOLTAIC SOLAR TRAINERS

DL SIMSUN

This product is used to provide suitable lighting to the photovoltaic solar module that is used in the DL SOLAR-B, DL SOLAR-D1 and DL SUN-WIND De Lorenzo trainers.

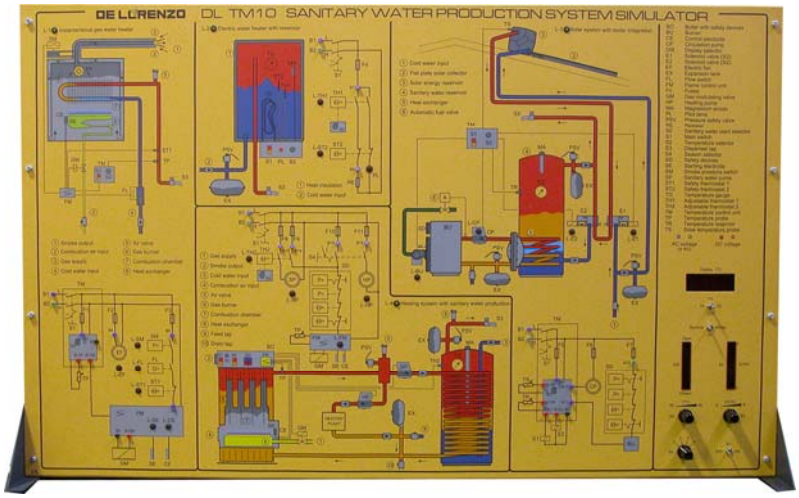
The light intensity can be manually adjusted through a potentiometer or automatically controlled through a 0-10 V input, to allow performing experiments with different light intensities, therefore simulating the light conditions from dawn to twilight.

The DL SIMSUN includes the following main components:

- 4 off halogen lamps, 300 W each
- Dimmer for controlling the light intensity
- Magneto-thermal switch, differential 10 A
- Potentiometer, 10k

RENEWABLE ENERGIES

SANITARY WATER PRODUCTION SYSTEM



DL TM10

The simulator allows the study, the performing of experiments and the troubleshooting for the following systems:

- Instantaneous geyser;
- Store electric water heater;
- Solar system for sanitary water production with boiler integration;
- Central system for heating and sanitary water production.

These systems are reproduced on the panel, through a colour representation which allows a complete analysis of the fluid circuit, of its components and of the electrical/electronic circuit for control and regulation.

It is possible to simulate the behaviour of components and systems, on the basis of the operating conditions which can be monitored directly on the panel or through Personal Computer by teacher and students.

The Personal Computer constantly keeps under control the simulation in progress and displays its behaviour through analog and digital signals and meters; in this way the student, through measurements and tests, can go on with the troubleshooting.

The instantaneous geyser is composed of the following main elements:

- Forced draught gas-fired wall boiler;
- Flame control device;
- Sanitary water regulation thermostat;
- Safety thermostat;
- Sanitary water flow meter;
- Smoke pressure switch;
- Modulating valve for gas capacity.

The store electric water heater is composed of the following main elements:

- Steel boiler with insulation;
- Electric resistance;
- Sanitary water regulation thermostat;
- Safety thermostat;
- Safety valves;
- Magnesium anode;
- Sanitary water thermometer;
- Pilot light for electric resistance insertion.

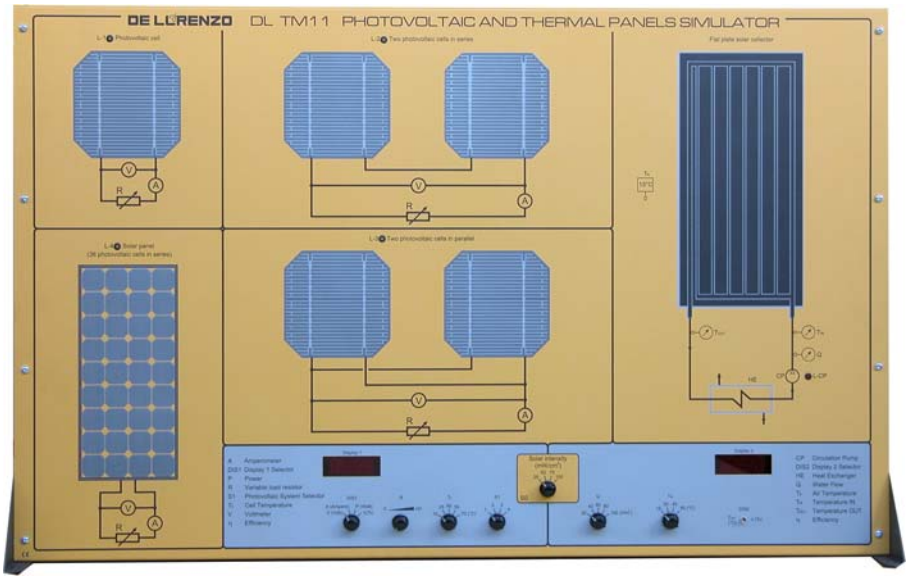
The solar system for sanitary water production with boiler integration is composed of the following main elements:

- Solar panel with natural circulation, with tank for sanitary water storage;
- Boiler and relevant gas burner;
- Safety and regulation devices for the boiler;
- Boiler for sanitary water storage;
- Boiler pump;
- Sanitary water regulation thermostat;
- Probe for boiler temperature and boiler sanitary water thermometer;
- Probe for stored sanitary water temperature through solar panels;
- Safety valve;
- Electrovalve for control of the following configurations:
- Sanitary water with heating through solar panel;
- Sanitary water with heating through solar panel with boiler integration;
- Sanitary water with heating through boiler.

The central system for heating and sanitary water production is composed of the following main elements:

- Gas boiler;
- Safety and regulation devices for the boiler;
- Flame control device;
- Modulating valve for gas capacity;
- Heating circulation pump;
- Expansion tank;
- Air exhaust valve;
- Boiler for sanitary water storage;
- Boiler pump;
- Sanitary water regulation thermostat;
- Probe for boiler temperature and boiler sanitary water thermometer;
- Safety valves;
- Magnesium anode.

PHOTOVOLTAIC AND THERMAL PANELS SIMULATOR



DL TM11

The simulator allows the study, the performing of experiments and the troubleshooting for the following components and systems:

- *photovoltaic silicon single crystal cell, squared, side 135 mm;*
- *two photovoltaic cells with series connection;*
- *two photovoltaic cells with parallel connection;*
- *panel composed of 36 photovoltaic cells with series connection;*
- *thermal panel with liquid circulation.*

These systems are reproduced on the panel, through a colour representation which allows a complete analysis of the fluid circuit, of its components and of the electrical/electronic circuit for control and regulation.

It is possible to simulate the behaviour of components and systems, on the basis of the operating conditions which can be monitored directly on the panel or through Personal Computer by teacher and students.

The Personal Computer constantly keeps under control the simulation in progress and displays its behaviour through analogue and digital signals and meters; in this way the student, through measurements and tests, can go on with the troubleshooting.

The experimentation on the *photovoltaic systems* (described here under) is organized as follows:

- possibility to simulate several values of the solar radiation intensity (W/m²);
- possibility to simulate several values of the photovoltaic cells temperature;
- possibility to change the electrical load of the above-mentioned photovoltaic systems;
- detection of the characteristics voltage–current (V-I), supplied by the photovoltaic systems, as function of solar radiation intensity and of cells temperature;
- detection of the characteristics voltage–power (V–P), supplied by the photovoltaic systems, as function of solar radiation intensity and of cells temperature;
- evaluation of the conversion efficiency (radiating energy–electric power) of the photovoltaic systems.

The experimentation on the *thermal panel with liquid circulation* is organized as follows:

- possibility to simulate several values of the solar radiation intensity (W/m²);
- possibility to simulate several values of the temperature of the thermal-carrier liquid at the panel's entrance;
- possibility to change the thermal-carrier liquid capacity through the thermal panel;
- evaluation of the thermal-carrier liquid temperature at the panel's exit, as function of the solar radiation intensity and of the entrance temperature;
- evaluation of the conversion efficiency (radiating energy–electric power) of the thermal panel.

RENEWABLE ENERGIES

SOLAR THERMAL ENERGY TRAINER

DL THERMO-A1

Didactic system for the theoretical and practical study of solar power facilities used to obtain hot water for sanitation, air conditioning and similar services.
It is a forced circulation system with a wide range of didactic applications. It incorporates six temperature probes available at four different points, and a solar irradiation sensor that is used to calculate energy.

Complete with connecting cables, experiment manual and software for data acquisition from the solar controller and processing.

TRAINING OBJECTIVES

- Identification of all components and how they are associated with its operation.
- Interpretation of the technical parameters of all components.
- Local control of the processor
- Heating and check of the convector heater
- Forcing the reserve energy
- Forcing the recirculation pump
- Sizing criteria for ACS facilities, air conditioning, etc.
- Assembly and maintenance criteria for facilities.
- Interpretation of situational data supplied by the control.

Approx. packing dimensions: 0.62 x 1.21 x 0.82 m.
Net weight: 51 kg.
Average training hours: 15 h.

ALTERNATIVE: DL THERMO-A2

Trainer with a real solar panel placed in a metal structure and connected to the main module through flexible pipes, provided with discharge, safety and filling valves.

ALTERNATIVE: DL THERMO-A12

Trainer with real solar panel and simulator of the solar panel. Both panels can be connected to the main module, one at a time.

TECHNICAL SPECIFICATIONS

The trainer is composed of three operating units, as follows:

MAIN MODULE

Dimensions 1000 x 650 x 1650 mm., front panel with the block diagram of the system. It contains the components for the circulation, storage and control of the liquid in the primary and secondary circuits. These components are placed vertically on a base, facilitating comfortable access to all parts for assembly and disassembly operations carried out during the practical sessions described in your handbook. The front control panel is placed in the top part of the main module and it is composed of: block diagram of the system, electronic control centre with an LCD screen for the visualization of the data, situation lights. The hydraulic sockets for cold water inlet, hot sanitary water outlet, connection to the solar panel, etc., are located at the back of the module.

SOLAR PANEL

Simulator of a solar panel supplied by the mains to allow performing the practical exercises in a classroom.

CONVECTOR HEATER

As a means of applying the hot water produced, a convector heater is available for use. It is connected through flexible pipes. This component allows us to experiment with the effects of hot water obtained with this system. However, the system is sufficiently open to permit easy use with other applications, such as hot sanitary water supply, under-floor heating, etc.

RENEWABLE ENERGIES

SOLAR THERMAL ENERGY TRAINER

Didactic system for the theoretical and practical study of solar power facilities used to obtain hot water for sanitation, air conditioning and similar services.
It is a forced circulation system with a wide range of didactic applications. It incorporates six temperature probes available at four different points, and a solar irradiation sensor that is used to calculate energy.

Complete with connecting cables, experiment manual and software for data acquisition from the solar controller and processing.

DL THERMO-A2

TRAINING OBJECTIVES

- Identification of all components and how they are associated with its operation.
- Interpretation of the technical parameters of all components.
- Local control of the processor
- Heating and check of the convector heater
- Forcing the reserve energy
- Forcing the recirculation pump
- Sizing criteria for ACS facilities, air conditioning, etc.
- Assembly and maintenance criteria for facilities.
- Interpretation of situational data supplied by the control.

Approx. packing dimensions: 0.62 x 1.21 x 0.82 m.
Net weight: 51 kg.
Average training hours: 15 h.

ALTERNATIVE: DL THERMO-A1

Trainer with a simulator of a solar panel supplied by the mains, instead of a real solar panel, to allow performing the practical exercises in a classroom.

ALTERNATIVE: DL THERMO-A12

Trainer with real solar panel and simulator of the solar panel. Both panels can be connected to the main module, one at a time.

TECHNICAL SPECIFICATIONS

The trainer is composed of three operating units, as follows:

MAIN MODULE

Dimensions 1000 x 650 x 1650 mm., front panel with the block diagram of the system. It contains the components for the circulation, storage and control of the liquid in the primary and secondary circuits. These components are placed vertically on a base, facilitating comfortable access to all parts for assembly and disassembly operations carried out during the practical sessions described in your handbook. The front control panel is placed in the top part of the main module and it is composed of: block diagram of the system, electronic control centre with an LCD screen for the visualization of the data, situation lights. The hydraulic sockets for cold water inlet, hot sanitary water outlet, connection to the solar panel, etc., are located at the back of the module.

SOLAR PANEL

Trainer with a real solar panel placed in a metal structure and connected to the main module through flexible pipes, provided with discharge, safety and filling valves.

CONVECTOR HEATER

As a means of applying the hot water produced, a convector heater is available for use. It is connected through flexible pipes. This component allows us to experiment with the effects of hot water obtained with this system. However, the system is sufficiently open to permit easy use with other applications, such as hot sanitary water supply, under-floor heating, etc.

RENEWABLE ENERGIES

SOLAR THERMAL ENERGY TRAINER

Didactic system for the theoretical and practical study of solar power facilities used to obtain hot water for sanitation, air conditioning and similar services.
It is a forced circulation system with a wide range of didactic applications. It incorporates six temperature probes available at four different points, and a solar irradiation sensor that is used to calculate energy.

Complete with connecting cables, experiment manual and software for data acquisition from the solar controller and processing.

DL THERMO-A12

TRAINING OBJECTIVES

- Identification of all components and how they are associated with its operation.
- Interpretation of the technical parameters of all components.
- Local control of the processor
- Heating and check of the convector heater
- Forcing the reserve energy
- Forcing the recirculation pump
- Sizing criteria for ACS facilities, air conditioning, etc.
- Assembly and maintenance criteria for facilities.
- Interpretation of situational data supplied by the control.

Approx. packing dimensions: 0.62 x 1.21 x 0.82 m.
Net weight: 51 kg.
Average training hours: 15 h.

ALTERNATIVE: DL THERMO-A1

Trainer with a simulator of a solar panel supplied by the mains, instead of a real solar panel, to allow performing the practical exercises in a classroom.

ALTERNATIVE: DL THERMO-A2

Trainer with a real solar panel placed in a metal structure and connected to the main module through flexible pipes, provided with discharge, safety and filling valves.

TECHNICAL SPECIFICATIONS

The trainer is composed of four operating units, as follows:

MAIN MODULE

Dimensions 1000 x 650 x 1650 mm., front panel with the block diagram of the system. It contains the components for the circulation, storage and control of the liquid in the primary and secondary circuits. These components are placed vertically on a base, facilitating comfortable access to all parts for assembly and disassembly operations carried out during the practical sessions described in your handbook. The front control panel is placed in the top part of the main module and it is composed of: block diagram of the system, electronic control centre with an LCD screen for the visualization of the data, situation lights. The hydraulic sockets for cold water inlet, hot sanitary water outlet, connection to the solar panel, etc., are located at the back of the module.

2x SOLAR PANEL

In this trainer there are two solar panels. The first one is a real solar panel placed in a metal structure and connected to the main module through flexible pipes, provided with discharge, safety and filling valves. The second one is a simulator of a solar panel supplied by the mains for the use in classroom. Both panels can be connected to the main module, one at a time.

CONVECTOR HEATER

As a means of applying the hot water produced, a convector heater is available for use. It is connected through flexible pipes. This component allows us to experiment with the effects of hot water obtained with this system. However, the system is sufficiently open to permit easy use with other applications, such as hot sanitary water supply, under-floor heating, etc.

RENEWABLE ENERGIES

WIND ENERGY MODULAR TRAINER

DL WIND-A

Didactic system for the theoretical and practical study of wind power facilities. The device includes a set of control modules, measures and applications, a wind turbine, a device to measure wind speed and descriptive and practical manuals.

MODULES

- Measurement module
- DC/AC conversion module
- Battery control module
- 12 V lamps module
- mains lamps module
- 24 Ah, 12 V battery

WIND GENERATOR

- 160 W, 12 V wind generator.

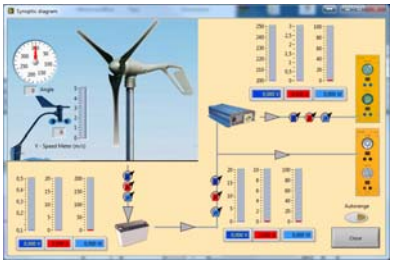
WIND SENSOR

- Anemometer and wind direction sensor mounted on a stand

It also includes:

- Frame
- Set of interconnecting wires
- Descriptive and practical manual
- Wind turbine instruction manual

The trainer includes a software for data acquisition and processing.



RENEWABLE ENERGIES

WIND ENERGY MODULAR TRAINER WITH MOTOR DRIVE FOR INDOOR USE

DL WIND-A1S

Didactic system for the theoretical and practical study of wind power facilities.
The device includes a set of control modules, measures and applications, a stepper motor kit to drive the wind generator in absence of wind and descriptive and practical manuals.

MODULES

- Measurement module
- DC/AC conversion module
- Battery control module
- 12 V lamps module
- mains lamps module
- 24 Ah, 12 V battery
- Driving motor kit

The trainer includes a software for data acquisition and processing.

Alternative:
The system is also available with a DC drive motor instead of the stepper motor (DL WIND-A1).

WIND GENERATOR

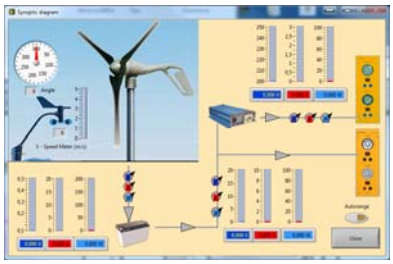
- 160 W, 12 V wind generator.

WIND SENSOR

- Anemometer and wind direction sensor mounted on a stand

It also includes:

- Frame
- Set of interconnecting wires
- Descriptive and practical manual
- Wind turbine instruction manual



RENEWABLE ENERGIES

WIND ENERGY MODULAR TRAINER WITH CONNECTION TO MAINS

DL WIND-A1G

Didactic system for the study of the generation of electric energy from a wind turbine and its inlet in the mains network.
The device includes a set of control modules, measures and applications, a wind turbine, a stepper motor to drive the wind generator in absence of wind and descriptive and practical manuals.

MODULES

- Module for measuring electric and wind parameters
- DC/AC conversion module
- Braking resistance, 250 W, 3 Ohm
- Mains lamps module
- Energy measurement module
- Differential magneto-thermal switch
- Network distributor
- Motor kit for driving the wind turbine, composed of a stepper motor and a 300 W power supply

The trainer includes a software for data acquisition and processing.

WIND GENERATOR

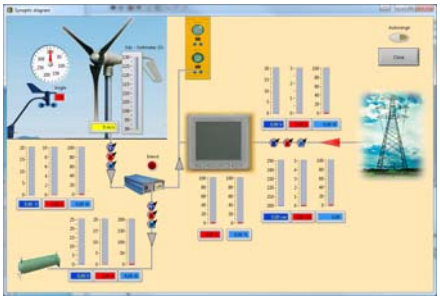
- 400W, 12Vac.

WIND SENSOR

- Anemometer and wind direction sensor mounted on a stand

It also includes:

- Two level frame
- Set of interconnecting wires
- Descriptive and practical manual
- Wind turbine instruction manual



RENEWABLE ENERGIES

WIND POWER TRAINER WITH WIND TUNNEL

DL WIND-B

Trainer for the theoretical and practical study of the generation of electricity by means of wind power.
With this trainer it is possible to change the flow of the air that reaches the wind turbine and to experiment its operation at no load and load conditions.

It is composed of:

- A wind tunnel in which the following components are installed:
  - A single-phase industrial fan with electronic speed regulator.
  - A 12 V, 40 W wind turbine, with a mechanism for changing its orientation with respect to the source of the wind.
- An anemometer;
- A voltmeter;
- An ammeter;
- A power supply, 0÷230 V, 4 A, with instruments for reading wind speed, voltage and current, a potentiometer for controlling the fan simulating the wind and a lamp representing a resistive load. Analogue output from each instrument: 0-10 V.
- A variable resistive load.

Dimensions: 1780 x 610 x 1360 mm.
Complete with software for data acquisition and processing and operation/experiment manual.

Options:

- **DL VAWT**: vertical axis Savonius wind turbine.
- **DL GMLL**: Giromill wind turbine

RENEWABLE ENERGIES

TRAINER FOR EXPERIENCES ON HYDROGEN FUEL CELLS

DL HYDROGEN-A

The trainer includes: PEM fuel cell stack 10 (ten cells), electrolyser, power supply, fuel cell monitor software, hydrogen storage tank, electric load (lamp), fan, solar module and 2 modules with lamps for the solar panel.
The following accessories are also included: water bottle (with distilled water), protective goggles, silicone tubing, textbook.

Specifications

- Electrolyser: 15 W
- Fuel cell
- Power per cell: 200 mW
- Power (10 cells): 2 W
- Solar module: 4 V / 3,3 A
- Gas storage: 80 cm^3
- Lamp: 4.4 W
- Power supply: 6 Vdc / 3 A
- Monitoring software
- Dimensions: 1000 x 620 x 200 mm.

List of experiments

- Study of a fuel cell stack up to ten cells
- Producing and storing hydrogen
- Determining characteristic curve of solar panel
- Voltage controlled automatic measurements
- Determining characteristic curve of electrolyser
- Learning about Faraday's laws
- Determining characteristic curves of fuel cell
- Determining fuel cell efficiency
- Determining decomposition voltage of water
- Long-term measurements at your own PC
- Fixing the output at different operating points of the fuel cell stack
- Monitoring single cell stack voltages at your PC
- Power-controlled automatic measurements

RENEWABLE ENERGIES

FUEL CELLS SYSTEMS TRAINER

DL HYDROGEN-B

This trainer has been designed for the study of fuel cell systems. It teaches their engineering principles and it allows performing a set of experiments for educational purposes.
It is safe and easy to be operated.
Furthermore, it is very flexible, modular and suitable for the understanding of basic principles as well as more complex technology concepts.

The trainer includes the following modules:

- 100 W PEM fuel cell. Performance: 14 V at 7.2 A. Consumption of H_2: 1.4 l/min. it includes the electronic controller.
- 225 Nl aluminum storage canister
- DC/DC converter, output 12 V, 8 A
- Load, with one halogen lamp, 12 V, 50 W, and one LED lamp, 12 V, 3 x 1 W
- Variable logarithmic rheostat, 1.5 Ohm ÷ 17 Ohm, 100 W, Imax = 8 A
- Battery
- Instruments module, containing 4 multifunction meters and 4 LCD displays

The trainer includes a software for data acquisition and processing.

Options:

- DL HYGEN: Hydrogen generator, for filling the hydride storage canister

RENEWABLE ENERGIES

PILOT PLANT FOR THE PRODUCTION OF BIODIESEL

DL BIO-30

Biodiesel can be used in automotive diesel engines (trucks, tractors, vans, automobiles, etc.) or stationary engines (generators of electricity, heat, etc.), in its natural form or mixed with petroleum diesel, in different proportions.

The biodiesel does not require any modification in the standard engines. Our Biodiesel Plant allows producing fuel that can be used in the above diesel applications.

Biodiesel is produced by the chemical reaction of a vegetable oil or animal fat with methanol or ethanol (waterless sugar cane alcohol) in the presence of a catalyst. This process is known as transesterification, and the catalyst can be alkaline, acid or enzymatic. This process also produces glycerin, used for the production of soaps and other products.

The Transesterification Process Plant for Biodiesel Production was developed by experienced professionals, using conventional equipment components available on the common market and automated with the technical features used in industrial processes, allowing didactic application and investigations.

With this plant it is possible to control the heating temperatures of the vegetable oil, of the reaction and of the washing. It is also possible to re-circulate the mixture during the reaction time.

According to the requirements of the end users, our Technical Department is able to design BIODIESEL PLANTS with specific technical features. For instance, the capacity of the plant can be different from case to case. The plant may or may not include the alcohol recovery system or the ultrasound technology to improve the efficiency of the mixing phase.

Therefore, the plant that is described hereunder must be considered as a sample pilot plant with specific features that can be further discussed with the end user.

In this particular case, the plant has a capacity of 30 litres/batch, includes the alcohol recovery system and does not include the ultrasound device.

TECHNICAL FEATURES OF THE BIODIESEL PLANT DL BIO-30

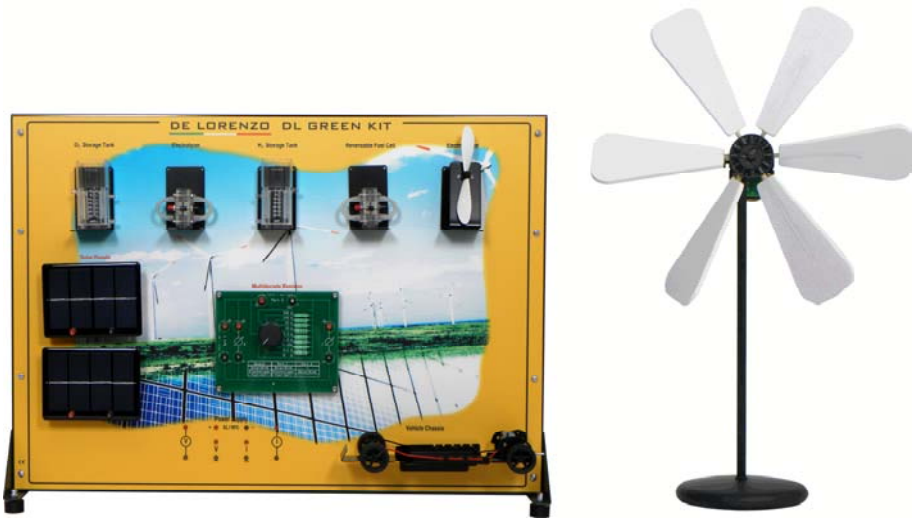
Capacity of the plant: 30 litres/batch
Main Components:

- Vegetable oils treatment system:
  - Tank for the reception of the raw material.
    Capacity: 30 litres, complete with sieve to filter solid bodies in the upper side. In stainless steel
  - Electrical heating system
  - Thermometer
  - 10 µm filter
- Transesterification reaction system:
  - Conical tank in stainless steel AISI 316L. Capacity: 30 litres
  - Stirring system
  - Electrical heating system
  - Alcohol recovery system
  - Pump
- Digital control panel
- Catalyst dispenser
- Tank in stainless steel AISI 304L for mixing the methyl.
  Mixing capacity: 4 litres
- Decantation tank in stainless steel.
  Capacity: 30 litres with recovery of the alcohol and condenser with an area of 0.5 m^2
- Washing system with filtering:
  - Washing tank. Capacity: 30 litres
  - Stirring system
  - Electrical heating system
  - 10 µm and 1 µm filters
- Installation kit in stainless steel for interconnecting the equipment
- Accessories
  - Digital scale
  - Thermometer
  - pH meter
  - Flat bottom 500 ml flask
  - 1000 ml beaker
  - Burette with support
  - Funnel
  - Graduated pipette
  - Volumetric pipette
  - Test tube
  - Sampling tubes with support
  - Bunsen beak
  - Tripod
  - Asbestos sheet
- Metal structure in carbon steel and high resistance epoxy paint.

Dimensions: 2 x 0.9 x 1.8 metres

RENEWABLE ENERGIES

SOLAR-WIND-FUEL CELLS ENERGY TRAINER



DL GREENKIT

This trainer has been designed for the study of renewable energies: solar energy, wind energy and hydrogen fuel cell systems.

With the trainer, it is possible to perform the following experiments:

- Assembling a fuel cell
- Producing and storing hydrogen
- Determining characteristic curve of solar panel
- Hydrogen/oxygen or hydrogen/air operation
- Determining characteristic curve of electrolyser
- Determining electrolyser efficiency
- Learning about Faraday's laws
- Determining characteristic curves of fuel cell
- Determining fuel cell efficiency
- Determining decomposition voltage of water
- Building a model hydrogen car
- Using methanol to generate electricity
- Determining characteristic curves of DMFC
- Influence of the surface of a solar module on voltage and current intensity of a solar module
- Voltage and current in a series connection of solar panels
- Voltage and current in a parallel connection of solar panels
- Voltage and current in a solar panel as a function of light intensity
- The characteristic current-voltage curve of a solar panel
- Electrical Energy from wind energy
- Effects of the wind speed
- Wind from different directions
- Influence of the number of rotor blades
- Influence of different positions of the blades
- Observation of a wind wheel under load
- Current voltage characteristic of the wind generator
- Storage of electrical energy from wind by using hydrogen technology
- Concept of an autarkic system with renewable energy

RENEWABLE ENERGIES

Technical specifications

Electrolyser cell:
5 cm^3/min H_2; 2,5 cm^3/min O2;
1.16 W

RFC H2/O2/Air:
Electrolyser mode: 5 cm^3/min H_2;2.5 cm^3/min O_2;
1.16 W
Fuel cell mode:
H_2/O_2 mode: 300 mW
H_2/air mode: 100 mW

PEMFC Kit:
H_2/O_2 mode: 600 mW
H_2/air mode: 200 mW

Methanol Fuel Cell:
Power: 10 mW

Gas storage: 30 cm^3 H_2; 30 cm^3 O_2

Solar module: 2.0 V / 600 mA

Battery Box: 4.5 VDC / 0.8 A

Power supply: 1.2 A

Load (fan): 10 mW
Load (car): 150 mW
Cable length: 250 mm

Wind generator
(Average performance with table fan)
Umax =6.0 V
Imax =0.3 A

Solar module: 2.0 V / 600 mA

Decade Resistor:
Max. capacity: 1.2 W
Ports: 2 mm
Weight: 190 g
H x W x D: 40 x 160 x 130 mm

Multimeters:
Ports: 2 mm
Weight: 140 g
H x W x D: 125 x 70 x 30 mm

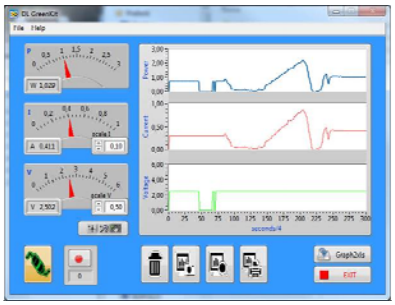
2 carrying cases: 140 x 450 x 380 mm. each

Weight: 4 kg. each

Options:

- Double spotlight with 2 halogen lamps.

- PC interface and software for data acquisition and display.
  Ordering codes: DL 1893 and DL GREENKIT-SW



RENEWABLE ENERGIES

SOLAR/WIND ENERGY MODULAR TRAINER

DL SUN-WIND-S

Modular trainer for the theoretical-practical study of the electrical installations with photovoltaic solar energy and wind energy.
Composed of:

- A photovoltaic inclinable module, 90W, 12V, complete with a cell for measuring the solar irradiation and with a temperature sensor.
- A wind turbine
  - Wind turbine 12 Vdc, 160 W
  - Supporting frame 1.5 m.
  - Anemometer and wind direction sensor.
- A set of modules with a supporting frame:
  - A battery control module, 12V, 32A, with battery.
  - A load module with two 12V lamps, dichroic 20W and LED 3W, with independent switches.
  - A load module with two mains voltage lamps, dichroic 35W and LED 3W, with independent switches.
  - An electronic regulation module, with LCD screen.
  - A rheostat.
  - A module for the measurement of solar irradiation (W/m2), solar panel temperature (°C), current, voltage and power.
  - A module for measuring wind speed and direction.
  - A stepper motor kit for indoor use of the wind turbine.
  - A dc to ac converter, with sinusoidal output at mains voltage. Average power: 300 W.

The trainer is complete with connecting cables and experiment manual.
Complete with data acquisition and processing software.

Option:

DL SIMSUN: module with lamps to provide suitable lighting for the solar panel when used indoor.
Alternatives:
DL SUN-WIND: DC motor kit instead of stepper motor.
DL SUN-WIND-ST: Stepper motor kit and solar tracking panel instead of the standard solar panel.

RENEWABLE ENERGIES

SOLAR/WIND ENERGY TRAINER WITH CONNECTION TO MAINS

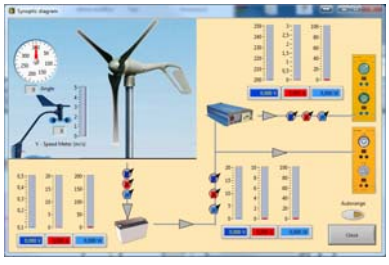
DL SUN-WIND-G

Modular trainer for the theoretical-practical study of the electrical installations with photovoltaic solar energy and wind energy.
Composed of:

- A photovoltaic inclinable module, 90W, 12V, complete with a cell for measuring the solar irradiation and with a temperature sensor.
- A wind turbine
  - Wind turbine 12 Vdc, 400 W
  - Supporting frame 1.5 m.
  - Anemometer and wind direction sensor.
- A set of modules with a supporting frame:
  - A load module with two 220V lamps, dichroic 35W and LED 3W, with independent switches.
  - DC to AC converter for the solar section
  - Braking resistance for the wind turbine.
  - A rheostat.
  - A module for the measurement of solar irradiation (W/m2), solar panel temperature (°C), current, voltage and power.
  - A module for measuring wind speed and direction.
  - Module for energy measurement.
  - Differential magneto-thermal switch.
  - Network distributor.
  - A motor kit for indoor use of the wind turbine.
  - A dc to ac converter, with sinusoidal output at mains voltage. Average power: 300 W.

The trainer is complete with connecting cables and experiment manual.
Complete with data acquisition and processing software.

Option:
DL SIMSUN: module with lamps to provide suitable lighting for the solar panel when used indoor.
Alternative:
DL SUN-WIND-GT: with solar tracking panel instead of the standard solar panel.



RENEWABLE ENERGIES

HYBRID SOLAR / WIND ENERGY TRAINER

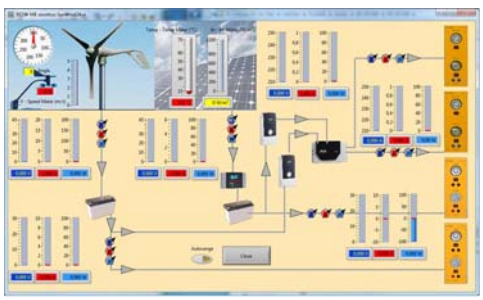
DL SUN-WIND24V and DL SUN-WIND12V

The main target of a hybrid power system is to combine multiple sources to deliver non-intermittent electric power, trying to take advantage of multiple available renewable energies.

The Trainer is composed of two sub-systems, one for the generation of electric energy from solar photovoltaic energy through a solar panel and the other for the generation of electric energy from wind energy through a wind turbine.

In this trainer, one of the two inverters, acting as master, synchronizes the frequency of the second inverter, acting as slave, to allow creating a connection between the two outputs that operate as a single line with double available power.

Complete with data acquisition and processing software.



RENEWABLE ENERGIES

The trainers are composed of:

		24V version	12V version
PFS	Photovoltaic module mounted on a support with wheels and complete with graduated scale on one side for adjustment of the inclination and calibrated cell in the upper part for measuring the solar irradiation.	185W, 24V	90W, 12V
AEROGEN	160W wind turbine, with anemometer and wind direction sensor mounted on a stand. The wind turbine is provided with a motor kit in order to use the trainer inside the classroom or in case of absence of wind.		
DL 9012	Electronic regulator module for battery charging, with LCD display for information on the status of the subsystem. It is able to display both solar voltage and battery voltage as well as charging current, Amp-Hour charge accumulation and temperature.		
DL 9013MS	DC/AC converter module, with sinusoidal output to generate an electrical network (mains). With a circuit breaker to switch on and off the inverter. It operates as master or slave. Complete with control panel.	Two of 1000W each with four 12V batteries	Two of 500W each with two 12V batteries
DL 9015	Module for the parallel of the inverters. It allows up to one master and 4 slaves.		
DL 9044	Load module with a 20 W, 12Vdc halogen lamps and a 3W, 12Vdc LED lamp. Each lamp incorporates an On/Off control independent switch.	4 supplied	2 supplied
DL 9017	Load module with a 35W, mains halogen lamp and a 3W, mains LED lamp. Each lamp incorporates an On/Off control independent switch.		
DL 9018	Variable logarithmic rheostat module, 80Ω, 6A max., to load the photovoltaic panel in order to detect the voltage-current characteristic curves.		
DL 9021	Instruments module for measuring solar parameters. It displays: voltages and currents, solar irradiance, temperature of the solar panel, electric power.		
DL 9022	Instruments module for measuring wind parameters. It displays: voltages and currents, wind speed, wind direction, electric power.		
DL SIMSUN	Set of lamps to light the photovoltaic solar panel in order to use the trainer inside the classroom or in case of a cloudy sky. The intensity of the light can be controlled by the operator locally through a potentiometer or remotely through a DC signal.	2 supplied	1 supplied
DL 2100-1M	Frame for the modules.	2 supplied	2 supplied

Complete with a set of connecting cables and with an experiment manual.

RENEWABLE ENERGIES

ENERGY EFFICIENCY IN ELECTRIC MOTORS

DL EFFICIENCY-A

Trainer for the study of the energy efficiency in the control of electric motors.
The trainer allows studying the energy efficiency in a hydraulic circuit with motor driven pump controlled by an inverter.
The trainer is composed of:

- A didactic panel on which the components of a hydraulic circuit are assembled. The circuit simulates, in a schematic way, an aqueduct. From a reservoir tank the water is flown, by means of a pump, through an instrumented hydraulic circuit that ends with a set of 3 water intakes of different diameters and controlled by electro-valves.
- A control module containing: a PLC, an inverter, a network analyzer with its interface module

Technical specifications:

- 3-phase motor driven pump, 0.37 kW, with cast iron body and brass impeller, max. flow rate 40 l/min.
- Three 2-way NC electro-valves, direct control, brass body
- Flow-rate transducer, 1 to 40 l/min.
- Pressure transducer, 0 to 10 bar, output signal range 0-10 V
- Pressure switch, 1 to 12 bar
- PLC, 12 digital inputs, 4 analogue inputs, 6 relay outputs
- Inverter, 0.4 kW, PID control mode as standard, 7 user-configurable preset speeds
- Multifunction network analyzer, line voltages and currents, total active and reactive power, power factors, active and reactive energies, etc.

RENEWABLE ENERGIES

KEPPE MOTOR – HIGH EFFICIENCY UNIVERSAL AC/DC MOTOR

DL 2130B

System for the study of a new motor technology based on Prof. Keppe's essential energy principles, set forth in his book "The New Physics Derived From A Disinverted Metaphysics".
The system allows performing tests on power and efficiency, compared to traditional motors.

The motor's principle

This new principle has given origin to the Keppe Motor, a resonant magnetic motor driven by pulsed DC. The Keppe Motor includes one or more permanent magnetic rotor discs to capture magnetism from the environment and cone-like coreless coils that simulate in large scale the tiny natural vortexes of the magnetic dipoles.
Therefore, the Keppe Motor has a switching system that naturally responds to the input power supply until resonance is achieved. A natural consequence of the state of resonance between the magnetic forces of the rotor and the stator coils is that the efficiency of the motor is maximized.

The educational system

The DL 2130B has been designed for studying the efficiency of the Keppe motor when used to drive a conventional AC fan.
The system is composed of:

- A fan with a 127 Vac Keppe Motor (D=85 mm); maximum working speed of 1300 rpm loaded by a 50 cm - diameter blade, consuming 40 W.
- A fan with a 127 Vac conventional ac single-phase motor with the same blade of 50 cm in diameter, consuming 140W at the maximum working speed of 1300 rpm.
- A panel with a 400 W, 12 Vdc/115 Vac inverter, several analog meters, digital ac power meter and Keppe motor driver.
- A transformer for a 12V battery
- A 8W output Keppe Motor
- A speed meter

SOLAR PHOTOVOLTAIC ENERGY INSTALLATION KIT

DL SOLAR-KIT

Photovoltaic solar energy kit for the generation of electrical energy.

Composed of:

- A photovoltaic inclinable **panel**, 90W, 12V, complete with a cell for measuring the solar irradiation and with a temperature sensor.
- A supporting **frame** for the panel.
- An electronic **current regulation** module, with LCD screen, output 12 V, 30 A.
- An **inverter**, with output at mains voltage, 12 V, 30 A, 300 W.
- A **battery control** switch, 0-600 V, 32A with **battery**, 100 Ah.
- Two **mains voltage lamps**, dichroic 35W and LED 3W, with independent switches.
- Two **12V lamps**, dichroic 20 W and LED 3W, with independent switches.
- **Cables**, **connectors** and **accessories**.
- A frame for supporting the electrical components of the system: lamps, switches, protections, etc.

The trainer is complete with connecting cables and installation manual.

RENEWABLE ENERGIES

SOLAR AND WIND ENERGY INSTALLATION KIT

DL SOLAR-WIND KIT

Photovoltaic solar and wind energy kit for the generation of electrical energy.

Composed of:

- **Two** photovoltaic inclinable **panels**, 90W, 12V, complete with a cell for measuring the solar irradiation and with a temperature sensor.
- A supporting **frame** for the panel.
- An electronic **current regulation** module, with LCD screen, output 12 V, 30 A.
- An **inverter**, with output at mains voltage, 12 V, 30 A, 300 W.
- A **battery control** switch, 0-600 V, 32A with **battery** 100 Ah.
- Two **mains voltage lamps**, dichroic 35W and LED 3W, with independent switches.
- Two **12V lamps**, dichroic 20 W and LED 3W, with independent switches.
- **Cables**, **connectors** and **accessories**.
- A frame for supporting the electrical components of the system: lamps, switches, protections, etc.
- A DC wind turbine, 12 V.

The trainer is complete with connecting cables and installation manual.

RENEWABLE ENERGIES

CATHODIC PROTECTION TRAINING BENCH

DL MK1

The Cathodic protection is a technique to control the corrosion of a metal surface by making it work as a cathode of an electrochemical cell. This is achieved by placing in contact with the metal to be protected another more easily corroded metal to act as the anode of the electrochemical cell. Cathodic protection systems are most commonly used to protect steel, water or fuel pipelines and storage tanks, steel pier piles, ships, offshore oil platforms and onshore oil well casings.

The theoretical study that precedes the experiments to undertake over the bench is reported into the modular manual book. In this book it is easily explained the background and moreover the target of the experiment.

The bench provides facilities to study the case of isolated systems, as well as the case of systems where different metals are coupled together. Particular attention is given to the presence or not of several kinds of insulating materials over the surfaces of the samples, in order to demonstrate the different behavior of the same material when coated or bare.

The bench provides suitable devices to highlight the concept of the free corrosion potential, measured with easy to use reference electrodes and means suitable to build with a certain accuracy the polarization curves.

Protective techniques are represented as per sacrificial anodes systems of several type of metals as per impressed current Cathodic Protection systems with the possibility to see which is the explanation of the use of constant voltage, constant current and constant potential feeders.

The bench is provided with measuring facilities characterized by suitable sensitivity and accuracy, in order to introduce which must be the basis of the laboratory tests to be executed, to recognize which is the correct way in order to determine the behavior of a metal in contact with the electrolyte in different conditions of temperature (thermostatic bath) and in high oxygen concentration (air insufflations pump).

A suitable multi-channel interface can connect the bench to a PC in order to record the experiment results and give the trace for further studies.

LIST OF THE EXPERIMENTS

The following list reports the proposed experiments and it corresponds to the manual structure. The manual is a document addressed to the teacher in order to prepare the lesson and reports the bibliography and links for further investigations on the matter.

1) The use of the voltmeter

The most important instrument in the field of the Cathodic Protection is the Voltmeter; typically, the digital type is the most common. Because of the great impedance, it allows the measurement of voltages (the potentials) due to sources with very high internal impedance. The measurements follow the introduction to the electrical measurements and to the introduction to the Ohm's law that regulates the passage of the current into the first as well as into the second species conductors (metals and electrolytes).

2) The measurement of the difference of potential of a sample into an electrolyte

This experiment introduces to the subject of the Cathodic Protection. The target of the discipline is to modify the potential (versus the reference cell) of the structure to protect by slowing the natural tendency of the metal to pass in solution. This experiment emphasizes the electrochemical approach to the corrosion phenomena.

3) The reference cell

This experiment puts in relation the practical use of the three types of reference cells most common in the discipline that are the Cu/ CuSO4 reference cell, the Ag/AgCl reference cell and the Zinc reference cell.

4) The Daniel Cell

In the Daniel cell, copper and zinc electrodes are immersed in a solution of copper (II) sulphate and zinc sulphate respectively. At the anode, zinc is oxidized per the following half reaction: Zn(s) Zn2+(aq) + 2e-
At the cathode, copper is reduced per the following reaction: Cu2+(aq) + 2e- Cu(s)
In the Daniel cell which, due to its simplicity, is often used for demonstrations, electrons that are "pulled" from the zinc travel through the wire, providing an electrical current that illuminates the bulb. In such a cell, the sulphate ions play an important role. Having a negative charge, these anions build up around the anode to maintain a neutral charge.
Conversely, at the cathode the copper (II) cations accumulate to maintain this neutral charge. These two processes cause copper solid to accumulate at the cathode and the zinc electrode to "dissolve" into the solution.

5) The first and second species conductors

By using a simple circuit it is possible show the equivalence between the electrolytes and the common conductors as far the passage of the electrical current concerns.

6) Introduction to the Cathodic Protection Criteria

By using the electrolytic cell of the bench it is possible reproduce the application of the NACE criteria that confirm the status of Cathodic Protection of a structure.

7) Introduction to the sacrificial anodes in Zn, Mg, and Al

By using the electrolytic cell of the bench it is possible reproduce the application of the sacrificial anode to a steel structure and see in the same time the comparison in between two specimen, one in Cathodic Protection regimen, the other in free corrosion regimen.

8) Introduction to the Cathodic Protection Impressed Current System

By using the electrolytic cell of the bench it is possible reproduce the application of the impressed current to a steel structure and see at the same time the comparison between two specimens, one in Cathodic Protection regimen, obtained by means of sacrificial anodes, the other driven with the impressed current system.

9) The consumable impressed current anode (Fe)

By using the electrolytic cell of the bench it is possible to reproduce the application of the impressed current to a steel structure and see in time the effect of the consumption of the anode due to its passage in solution.

10) The inert impressed anode (Fe-Si)

Not all the anodic materials pass in solution, two examples can be seen by using the Fe-Si anode.

11) Resistance concept, circuit for the first and second species conductors

By using the electrolytic cell of the bench it is possible to produce the passage of current into the bath and in this way to demonstrate the validity of the Ohm's Law in the field of Cathodic Protection.

Ohm's law applies to electrical circuits; it states that the current through a conductor between two points is directly proportional to the potential difference (i.e. voltage drop or voltage across the two points) and inversely proportional to the resistance between them.

The mathematical equation that describes this relationship is: I = V/R

Where I is the current in amperes, V is the potential difference in volts and R is a circuit parameter called the resistance (measured in ohms, also equivalent to volts per ampere). The potential difference is also known as the voltage drop, and it is sometimes denoted by U, E or emf (electromotive force) instead of V.

12) Introduction to the specific resistance concept over three different first species conductors (Fe; Cu; Fe-Ni)

To drive the student to the concept of resistivity, an experiment can be executed by using three geometrically identical samples of different material in order to identify the concept of specific resistance, that is the resistivity or as inverse the conductivity concept.

13) Introduction to the concept of interference due to the presence of external electric fields on buried or submerged structures (Stray Currents)

The experiment reproduces the effect of an external electric field on a submerged structure with the result of the formation of separated anodic and cathodic areas on the surface of the sample. It is the introduction to the concept of interference due to the presence of an external and interfering electric field on buried or submerged structures (Stray Currents).

14) Air presence influence on resistivity (insufflate air effect)

This experiment explains and demonstrates the change of the resistivity with the increase of the presence of air dissolved into the electrolyte.

15) Current density introduction and Tafel Curves construction

The concept of current density is, like the difference of potential, the main concept in the Cathodic Protection discipline and this experiment allows understanding that with this concept it is possible to predict the amount of current needed to obtain the Cathodic Protection regimen over a known surface structure immersed in the electrolyte.

By using the provided multi channel interface it is possible to record the change of the current values in the time, then build the polarization curves in a plot.

16) Temperature effect over the Current density (thermostatic cell)

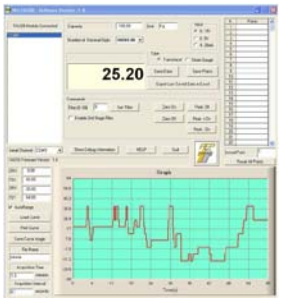
This experiment explains and demonstrates the change of current density as a function of the temperature and introduces the concept of chemical activity.

17) Air presence influence over the Current density (insufflate air effect)

This experiment explains and demonstrates the change of current density as a function of the increasing of dissolved oxygen.

18) Coating and Current density

The use of coated samples allows demonstrating the effect of the coatings over the submerged or buried structures and gives the magnitude of the effect explaining that the synergy between the Cathodic Protection and the Coating of the surfaces to be protected reduces the current density with all the relevant advantages.



RENEWABLE ENERGIES

LIST OF MATERIALS

- Bench with wheels with electrical console to connect to the mains Vac supply and lockable shelves to contain the hereinafter listed material. Provided with waterproof top surface.
- 4 DC feeders (each provided with constant voltage, constant current, constant potential facilities). The relevant instruments are on the front console of the bench.
- Digital voltmeter on console.
- 2 digital ammeters on console.
- PC interface for the measurement and record of 5 different channels.
- 3 sets of safety glasses and glows.
- Digital voltmeter.
- 2 Cu/CuSO4 reference cells.
- 2 Ag/AgCl reference cells.
- 2 Zn reference cells.
- 10 copper electrodes, 30 x 140 mm., thickness 2 mm.
- 10 carbon steel electrodes (bare).
- 4 transparent basins to build the electrolytic test bath.
- Simple circuit with sliding resistor and lamp provided with buklets for the insertion into the electrical circuit of the electrolytic cell.
- 20 Zinc electrodes 8 mm., length 140 mm.
- 20 Magnesium electrodes 25 mm., length 140 mm,
- 20 Aluminum electrodes 25 mm, length 140 mm,
- 4 Fe-Si anodes (net anode 50mm x 140mm)
- Cu bar 1mm., length 0.5 m.
- Fe bar 1mm., length 0.5 m.
- Fe-Ni bar 1mm., length 0.5 m.
- Resistivity fluid cell.
- Waterproof resistor with thermostatic device.
- Air pump with relevant sprayer.
- 10 carbon steel electrodes (completely coated with epoxy compound)
- 10 carbon steel electrodes (partially coated with epoxy compound)
- Various reagents in plastic cans (0,25 kg/each) with technical sheet as per the requirement of CE.
- Set of spare fuses.
- Set of ancillaries and connecting leads (20 pieces).
- Software for data acquisition.
- User and experiments manuals.

RENEWABLE ENERGIES

SINGLE STATION CATHODIC PROTECTION TRAINING BENCH

DL MK2

The Cathodic protection is a technique to control the corrosion of a metal surface by making it work as a cathode of an electrochemical cell. This is achieved by placing in contact with the metal to be protected another more easily corroded metal to act as the anode of the electrochemical cell. Cathodic protection systems are most commonly used to protect steel, water or fuel pipelines and storage tanks, steel pier piles, ships, offshore oil platforms and onshore oil well casings.

The theoretical study that precedes the experiments to undertake over the bench is reported into the modular manual book. In this book it is easily explained the background and moreover the target of the experiment.

The bench provides facilities to study the case of isolated systems, as well as the case of systems where different metals are coupled together. Particular attention is given to the presence or not of several kinds of insulating materials over the surfaces of the samples, in order to demonstrate the different behavior of the same material when coated or bare.

The bench provides suitable devices to highlight the concept of the free corrosion potential, measured with easy to use reference electrodes and means suitable to build with a certain accuracy the polarization curves.

Protective techniques are represented as per sacrificial anodes systems of several type of metals as per impressed current Cathodic Protection systems with the possibility to see which is the explanation of the use of constant voltage, constant current and constant potential feeders.

The bench is provided with measuring facilities characterized by suitable sensitivity and accuracy, in order to introduce which must be the basis of the laboratory tests to be executed, to recognize which is the correct way in order to determine the behavior of a metal in contact with the electrolyte in different conditions of temperature (thermostatic bath) and in high oxygen concentration (air insufflations pump).

A suitable multi-channel interface can connect the bench to a PC in order to record the experiment results and give the trace for further studies.

RENEWABLE ENERGIES

LIST OF THE EXPERIMENTS

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The measurements follow the introduction to the electrical measurements and to the introduction to the Ohm's law that regulates the passage of the current into the first as well as into the second species conductors (metals and electrolytes).

2) The measurement of the difference of potential of a sample into an electrolyte

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This experiment emphasizes the electrochemical approach to the corrosion phenomena.

3***) The reference cell***

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At the cathode, copper is reduced per the following reaction: $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

In the Daniel cell which, due to its simplicity, is often used for demonstrations, electrons that are "pulled" from the zinc travel through the wire, providing an electrical current that illuminates the bulb. In such a cell, the sulphate ions play an important role. Having a negative charge, these anions build up around the anode to maintain a neutral charge.

Conversely, at the cathode the copper (II) cations accumulate to maintain this neutral charge. These two processes cause copper solid to accumulate at the cathode and the zinc electrode to "dissolve" into the solution.

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By using a simple circuit it is possible show the equivalence between the electrolytes and the common conductors as far the passage of the electrical current concerns.

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Not all the anodic materials pass in solution, two examples can be seen by using the Fe-Si anode.

11) Resistance concept, circuit for the first and second species conductors

By using the electrolytic cell of the bench it is possible to produce the passage of current into the bath and in this way to demonstrate the validity of the Ohm's Law in the field of Cathodic Protection.

Ohm's law applies to electrical circuits; it states that the current through a conductor between two points is directly proportional to the potential difference (i.e. voltage drop or voltage across the two points) and inversely proportional to the resistance between them.

The mathematical equation that describes this relationship is: I = V/R

Where I is the current in amperes, V is the potential difference in volts and R is a circuit parameter called the resistance (measured in ohms, also equivalent to volts per ampere). The potential difference is also known as the voltage drop, and it is sometimes denoted by U, E or emf (electromotive force) instead of V.

12) Introduction to the specific resistance concept over three different first species conductors (Fe; Cu; Fe-Ni)

To drive the student to the concept of resistivity, an experiment can be executed by using three geometrically identical samples of different material in order to identify the concept of specific resistance, that is the resistivity or as inverse the conductivity concept.

13) Introduction to the concept of interference due to the presence of external electric fields on buried or submerged structures (Stray Currents)

The experiment reproduces the effect of an external electric field on a submerged structure with the result of the formation of separated anodic and cathodic areas on the surface of the sample. It is the introduction to the concept of interference due to the presence of an external and interfering electric field on buried or submerged structures (Stray Currents).

14) Air presence influence on resistivity (insufflate air effect)

This experiment explains and demonstrates the change of the resistivity with the increase of the presence of air dissolved into the electrolyte.

15) Current density introduction and Tafel Curves construction

The concept of current density is, like the difference of potential, the main concept in the Cathodic Protection discipline and this experiment allows understanding that with this concept it is possible to predict the amount of current needed to obtain the Cathodic Protection regimen over a known surface structure immersed in the electrolyte.

By using the provided multi channel interface it is possible to record the change of the current values in the time, then build the polarization curves in a plot.

16) Temperature effect over the Current density (thermostatic cell)

This experiment explains and demonstrates the change of current density as a function of the temperature and introduces the concept of chemical activity.

17) Air presence influence over the Current density (insufflate air effect)

This experiment explains and demonstrates the change of current density as a function of the increasing of dissolved oxygen.

18) Coating and Current density

The use of coated samples allows demonstrating the effect of the coatings over the submerged or buried structures and gives the magnitude of the effect explaining that the synergy between the Cathodic Protection and the Coating of the surfaces to be protected reduces the current density with all the relevant advantages.

LIST OF MATERIALS

The proposed bench can be supplied ready to be used and provided with the hereinafter listed material: bench with wheels with electrical console to connect to the mains Vac supply and lockable shelves to contain the material for the experiments and provided with waterproof top surface, safety glasses and glows, digital voltmeter, PC interface for the measurement and storage of data, digital voltmeter on console, digital ammeter on console, Cu/CuSO4 reference cell, Ag/AgCl reference cell, Zn reference cell, copper electrode, carbon steel electrode, transparent basin to build the electrolytic test bath, simple circuit with sliding resistor and lamp suitable for the insertion into the electrical circuit of the electrolytic cell, Zinc electrode, Magnesium electrode, Aluminum electrode, DC feeder (provided with constant voltage, constant current, constant potential facilities), Fe-Si anode, Cu bar, Fe bar, Fe-Ni bar, resistivity fluid cell, waterproof resistor with thermostatic device, air pump with relevant sprayer, carbon steel electrode (completely coated with epoxy compound), carbon steel electrode (partially coated with epoxy compound), various reagents in plastic cans with technical sheet as per the requirement of CE, set of spare fuses, set of ancillaries and connecting leads, software, user and experiment manual.

NOTE:

The DL MK2 version of the Cathodic Protection trainer differs from the DL MK1 version on the possibility of performing simultaneously the same experiment with different values of the parameters. In the DL MK2 version, the experiments can be performed in sequential mode, that is, if you want to change the value of a specific parameter, you can do it after performing the same experiment with the previous value. You must then record the results on your notebook and then compare the different results. With the DL MK1 version you can perform the same experiment with two different parameter configurations at the same time.