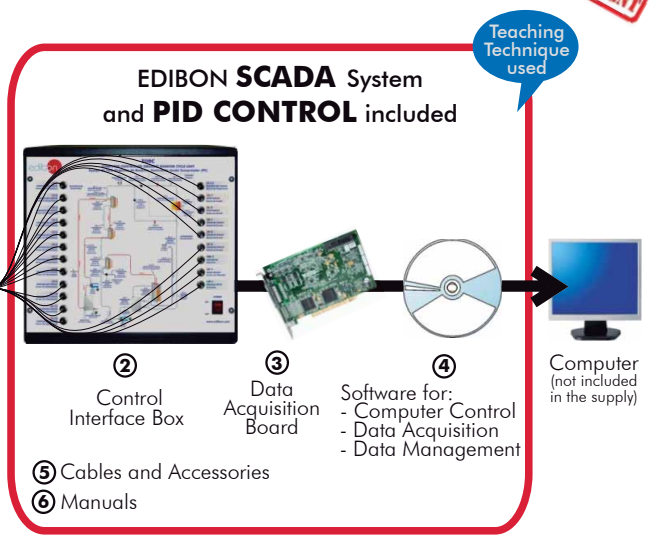
edibon
Technical Teaching Equipment

Computer Controlled **Organic Rankine Cycle Unit,** with SCADA and PID Control

TORC

EDIBON PATENT



*Minimum supply always includes: 1 + 2 + 3 + 4 + 5 + 6
(Computer not included in the supply)

① Unit: TORC. Organic Rankine Cycle Unit

Key features:

- **Advanced Real-Time SCADA and PID Control.**
- **Open Control + Multicontrol + Real-Time Control.**
- **Specialized EDIBON Control Software based on Labview.**
- **National Instruments Data Acquisition board (250 KS/s , kilo samples per second).**
- **Calibration exercises, which are included, teach the user how to calibrate a sensor and the importance of checking the accuracy of the sensors before taking measurements.**
- **Projector and/or electronic whiteboard compatibility allows the unit to be explained and demonstrated to an entire class at one time.**
- **Capable of doing applied research, real industrial simulation, training courses, etc.**
- **Remote operation and control by the user and remote control for EDIBON technical support, are always included.**
- **Totally safe, utilizing 4 safety systems (Mechanical, Electrical, Electronic & Software).**
- **Designed and manufactured under several quality standards.**
- **Optional CAL software helps the user perform calculations and comprehend the results.**
- **This unit has been designed for future expansion and integration. A common expansion is the EDIBON Scada-Net (ESN) System which enables multiple students to simultaneously operate many units in a network.**

OPEN CONTROL
+
MULTICONTROL
+
REAL TIME CONTROL

www.edibon.com
Products
Products range
Units
5.-Energy and 9.-Thermodynamics & Thermotechnics

For more information about Key Features, click here:

ISO 9000: Quality Management
(for Design, Manufacturing, Commercialization and After-sales service)

European Union Certificate
(total safety)

Certificates ISO 14000 and
ECO-Management and Audit Scheme
(environmental management)

Worlddidac Quality Charter Certificate and
Worlddidac Member

INTRODUCTION

The Rankine cycle is a thermodynamic cycle that converts heat into work, constituting what is called a power cycle.

The Organic Rankine Cycle (ORC) is essentially a Rankine cycle, where the water steam has been replaced with an organic fluid.

In the ORC it is possible to use lower temperatures with high efficiencies, allowing to extract heat from the exhaust of internal combustion engines, from other source of waste heat or any process with a temperature as low as 150°C, for example in geothermal energy.

The working principle of the ORC is:

1. The organic liquid fluid is pumped to the evaporator, where changes to gas.
2. It passes through a turbine.
3. Finally, it is converted into liquid with the condenser and the cycle starts again.

The Computer Controlled Organic Rankine Cycle Unit "TORC" allows the student to study the complete process and the components of an organic Rankine cycle, as well as the main variables that take part in the process.

GENERAL DESCRIPTION

The working fluid (coolant R-245fa) is evaporated by applying a heat source. First of all, the coolant is impelled by a computer controlled pump through a plate exchanger (preheater) through which the tap water heated in the cycle condenser flows in countercurrent.

Then, the organic working fluid passes through two plate exchangers that constitute the cycle evaporator, through which superheated water to 150°C (heat source) flows impelled by a pump.

Superheated water is generated in a boiler with a heating element (resistor), which can be controlled through the computer with a PID control, indicating the setpoint to which the water wants to be heated.

After the heat is transferred, the superheated water returns to the boiler at the outlet of the second exchanger.

There is a purge valve in this close circuit of superheated water, a bypass circuit and purgers to remove the air from the circuit.

The organic fluid steam is expanded in the turbine when it reaches the working conditions, generating an electrical power which is measured.

At the outlet of the turbine the organic fluid is condensed by means of a water flow in a plate exchanger.

The tap water heated in the organic working fluid condensing process is directed to the preheater to take advantage of the waste heat. The condensate is collected in an intermediate tank, with two level actuators. When the level is enough, the organic fluid is pumped backwards again and the thermodynamic cycle is closed this way.

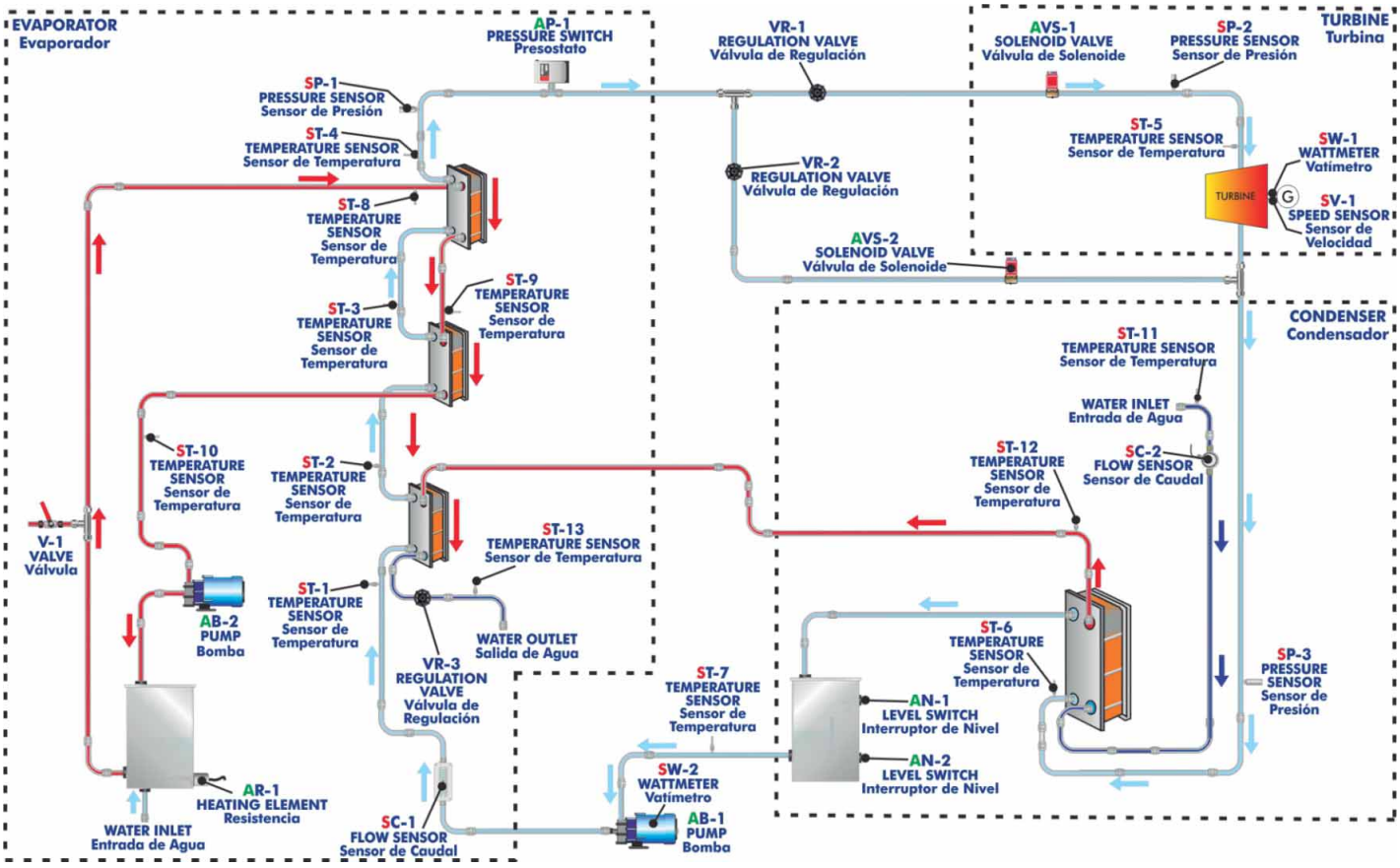
The cooling and heating sources are not directly in contact with the working fluid or the turbine.

This Computer Controlled Unit is supplied with the EDIBON Computer Control System (SCADA), and includes: The unit itself + a Control Interface Box + a Data Acquisition Board + Computer Control, Data Acquisition and Data Management Software Packages, for controlling the process and all parameters involved in the process.

PROCESS DIAGRAM AND UNIT ELEMENTS ALLOCATION

8 actuators and 21 sensors controlled from any computer, and working simultaneously

OPEN CONTROL + MULTICONTROL + REAL TIME CONTROL



COMPLETE TECHNICAL SPECIFICATIONS (for main items)

With this unit there are several options and possibilities:

- Main items: 1, 2, 3, 4, 5 and 6.
- Optional items: 7, 8, 9, 10, 11 and 12.

Let us describe first the main items (1 to 6):

① TORC. Unit:

Evaporator:

Computer controlled (PID control) boiler of 15kW for superheated water to 150°C. It includes:

Safety valve calibrated to 6 Bar.

Safety pressure switch as filling safety measure for the boiler.

Manometer of 0-6 Bar.

Safety thermostat (150°C).

Automatic air purger.

Expansion vessel.

Automatic feeder regulated to 1.5 Bar.

Driving pump.

3 Plate exchangers:

Exchanger nº1 (preheater): 6 plates, heat transfer area: 0.0480 m^2.

Exchanger nº 2: 20 plates, heat transfer area: 0.612m^2.

Exchanger nº 3: 20 plates, heat transfer area: 0.414 m^2.

Condenser: exchanger of 20 plates, heat transfer area: 0.720 m^2.

Triple piston pump to impel the organic fluid, with power variator, computer controlled.

Scroll turbine and generator: 1kW, 3600 rpm approx.

Electric load.

Organic fluid condensed tank with two level actuators.

R-245fa organic fluid storage tank.

High pressure safety pressure switch to prevent overpressures.

2 Solenoid valves.

Air purgers.

Sight glasses along the circuit to visualize the state of the organic fluid.

TORC. Unit

Sensors:

13 "J" type temperature sensors distributed along the process.

1 Flow sensor to measure the cooling water flow through the condenser, range: 1.5 – 30 l./min.

1 Flow sensor to measure the organic fluid flow through the circuit, range: 0.008-0.062 Kg/s.

3 Pressure sensors to measure the outlet pressure of the evaporator and the inlet and outlet pressure of the turbine, pressure sensors range: 0-25 Bar.

1 Sensor to measure the power consumed by the generator.

1 Sensor to measure the power consumed by the pump that impels the organic fluid.

1 Speed sensor of the turbine.

The complete unit includes as well:

Advanced Real-Time SCADA and PID Control.

Open Control + Multicontrol + Real-Time Control.

Specialized EDIBON Control Software based on Labview.

National Instruments Data Acquisition board (250 KS/s , kilo samples per second).

Calibration exercises, which are included, teach the user how to calibrate a sensor and the importance of checking the accuracy of the sensors before taking measurements.

Projector and/or electronic whiteboard compatibility allows the unit to be explained and demonstrated to an entire class at one time.

Capable of doing applied research, real industrial simulation, training courses, etc.

Remote operation and control by the user and remote control for EDIBON technical support, are always included.

Totally safe, utilizing 4 safety systems (Mechanical, Electrical, Electronic & Software).

Designed and manufactured under several quality standards.

Optional CAL software helps the user perform calculations and comprehend the results.

This unit has been designed for future expansion and integration. A common expansion is the EDIBON Scada-Net (ESN) System which enables multiple students to simultaneously operate many units in a network.

② TORC/CIB. Control Interface Box:

The Control Interface Box is part of the SCADA system.

Control interface box with process diagram in the front panel and with the same distribution that the different elements located in the unit, for an easy understanding by the student.

All sensors, with their respective signals, are properly manipulated from -10V. to +10V. computer output. Sensors connectors in the interface have different pines numbers (from 2 to 16), to avoid connection errors.

Single cable between the control interface box and computer.

The unit control elements are permanently computer controlled, without necessity of changes or connections during the whole process test procedure.

Simultaneous visualization in the computer of all parameters involved in the process.

Calibration of all sensors involved in the process.

Real time curves representation about system responses.

Storage of all the process data and results in a file.

Graphic representation, in real time, of all the process/system responses.

All the actuators' values can be changed at any time from the keyboard allowing the analysis about curves and responses of the whole process. All the actuators and sensors values and their responses are displayed on only one screen in the computer.

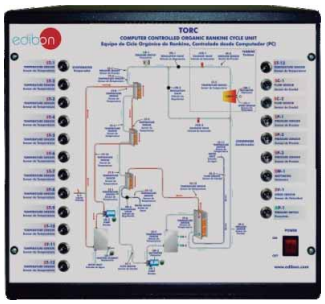
Shield and filtered signals to avoid external interferences.

Real time PID control with flexibility of modifications from the computer keyboard of the PID parameters, at any moment during the process. Real time PID and on/off control for pumps, compressors, heating elements, control valves, etc. **Real time PID control for parameters involved in the process simultaneously. Proportional control, integral control and derivative control, based on the real PID mathematical formula, by changing the values, at any time,** of the three control constants (proportional, integral and derivative constants).

Open control allowing modifications, at any moment and in real time, of parameters involved in the process simultaneously.

Possibility of automatization of the actuators involved in the process.

Three safety levels, one mechanical in the unit, another electronic in the control interface and the third one in the control software.



TORC/CIB

③ DAB. Data Acquisition Board:

The Data Acquisition board is part of the SCADA system.

PCI Express Data acquisition board (National Instruments) to be placed in a computer slot. Bus PCI Express.

Analog input:

Number of **channels= 16** single-ended or 8 differential. **Resolution=16 bits**, 1 in 65536.

Sampling rate up to: 250 KS/s (kilo samples per second).

Input range (V)=±10 V. Data transfers=DMA, interrupts, programmed I/0. DMA channels=6.

Analog output:

Number of **channels=2**. **Resolution=16 bits**, 1 in 65536. Maximum output rate up to: 900 KS/s.

Output range(V)=±10 V. Data transfers=DMA, interrupts, programmed I/0.

Digital Input/Output:

Number of **channels=24 inputs/outputs**. D0 or DI Sample Clock frequency: 0 to 100 MHz.

Timing: Number of **Counter/timers=4**. Resolution: Counter/timers: 32 bits.

DAB

④ TORC/CCSOF. PID Computer Control +Data Acquisition+Data Management Software:

The three softwares are part of the SCADA system.

Compatible with actual Windows operating systems. Graphic and intuitive simulation of the process in screen. **Compatible with the industry standards.**

Registration and visualization of all process variables in an automatic and simultaneous way.

Flexible, open and multicontrol software, developed with actual windows graphic systems, acting simultaneously on all process parameters.

Analog and digital PID control.

PID menu and set point selection required in the whole work range.

Management, processing, comparison and storage of data.

Sampling velocity up to 250 KS/s (kilo samples per second).

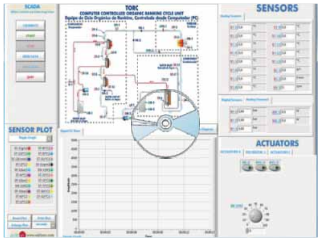
Calibration system for the sensors involved in the process.

It allows the registration of the alarms state and the graphic representation in real time.

Comparative analysis of the obtained data, after the process and modification of the conditions during the process.

Open software, allowing the teacher to modify texts, instructions. Teacher's and student's passwords to facilitate the teacher's control on the student, and allowing the access to different work levels.

This unit allows the 30 students of the classroom to visualize simultaneously all the results and the manipulation of the unit, during the process, by using a projector or an electronic whiteboard.



TORC/CCSOF

⑤ Cables and Accessories, for normal operation.

⑥ Manuals:

This unit is **supplied with 8 manuals:** Required Services, Assembly and Installation, Interface and Control Software, Starting-up, Safety, Maintenance, Calibration & Practices Manuals.

* References 1 to 6 are the main items: TORC + TORC/CIB + DAB + TORC/CCSOF + Cables and Accessories + Manuals are included in the minimum supply for enabling normal and full operation.

EXERCISES AND PRACTICAL POSSIBILITIES TO BE DONE WITH MAIN ITEMS

1.- Demonstration of the Organic Rankine Cycle (ORC).

2.- To measure the heat supplied by evaporator.

3.- Determination of the efficiency of an Organic Rankine Cycle (ORC).

4.- Energy balances determination in the evaporator and the condenser.

5.- Determination of the turbine efficiency.

6.- To make energy balance.

7.- To measure the electrical power generated.

8.- To study the influence of the organic fluid flow and temperatures on the generation of electrical power.

9.- Study of the specific vapour consumption of the turbine.

10.- Speed measurement of the turbine.

Additional practical possibilities:

11.- Sensors calibration.

Other possibilities to be done with this Unit:

12.- Many students view results simultaneously.

To view all results in real time in the classroom by means of a projector or an electronic whiteboard.

13.- Open Control, Multicontrol and Real Time Control.

This unit allows intrinsically and/or extrinsically to change the span, gains; proportional, integral, derivate parameters; etc, in real time.

14.- The Computer Control System with SCADA and PID Control allow a real industrial simulation.

15.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.

16.- This unit can be used for doing applied research.

17.- This unit can be used for giving training courses to Industries even to other Technical Education Institutions.

18.- Control of the TORC unit process through the control interface box without the computer.

19.- Visualization of all the sensors values used in the TORC unit process.

- By using PLC-PI additional 19 more exercises can be done.

- Several other exercises can be done and designed by the user.

REQUIRED SERVICES

Electrical supply: three-phase, 380V./50Hz., 20 kW.

Water supply and drainage.

Computer (PC).

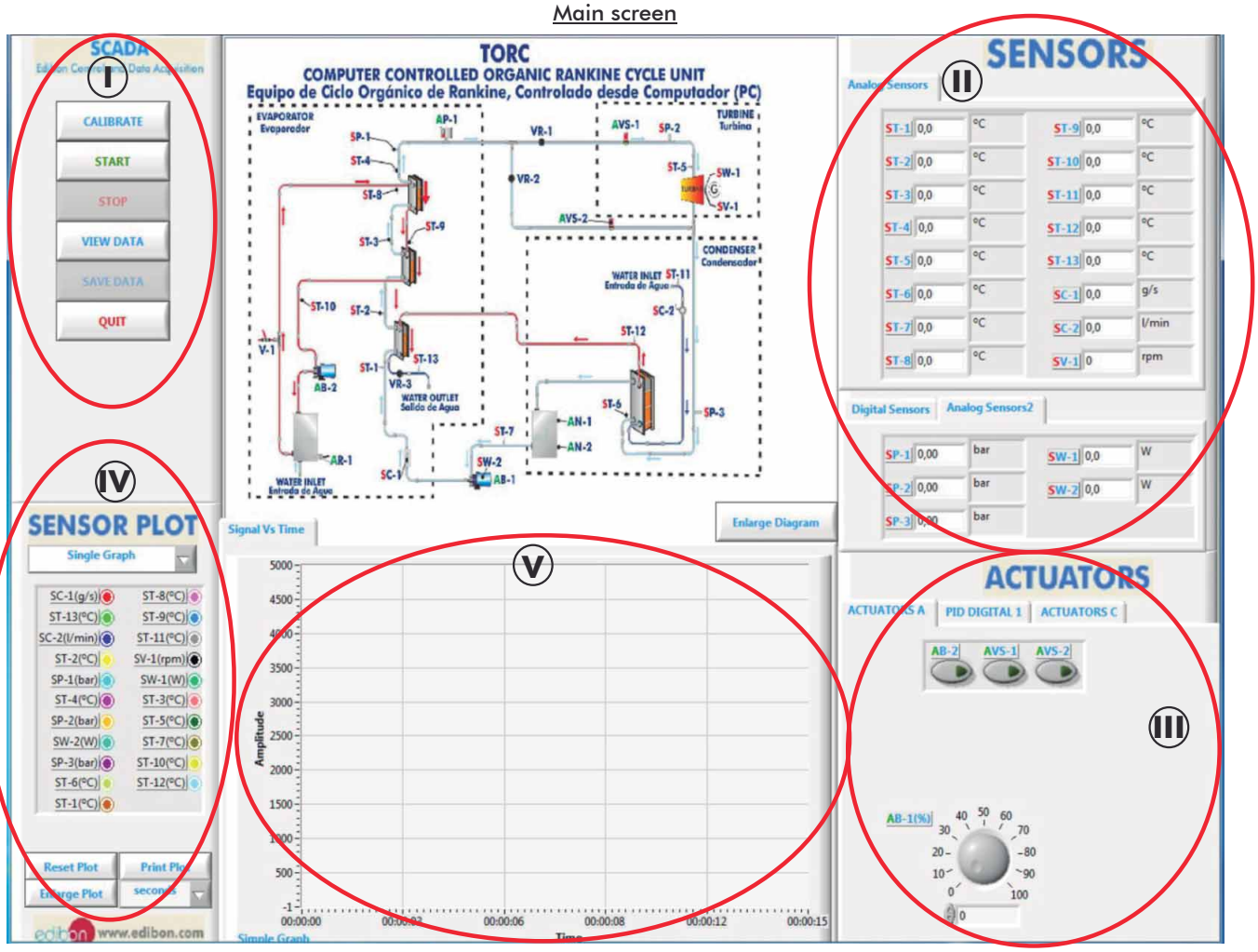
DIMENSIONS & WEIGHTS

TORC:

Unit:	-Dimensions:	2500 x 900 x 1800 mm. approx. (98.42 x 35.43 x 70.86 inches approx.).
	-Weight:	450 Kg. approx. (990 pounds approx.).
Control Interface Box:	-Dimensions:	490 x 450 x 470 mm. approx. (19.29 x 17.71 x 18.50 inches approx.).
	-Weight:	20 Kg. approx. (44 pounds approx.).

SCADA and PID Control

Main screen



Ⓘ Main software operation possibilities.

Ⓘⓘ Sensors displays, real time values, and extra output parameters. **Sensors:** ST= Temperature sensor. SC= Flow sensor. SP= Pressure sensor. SW= Wattmeter. SV= Speed sensor.

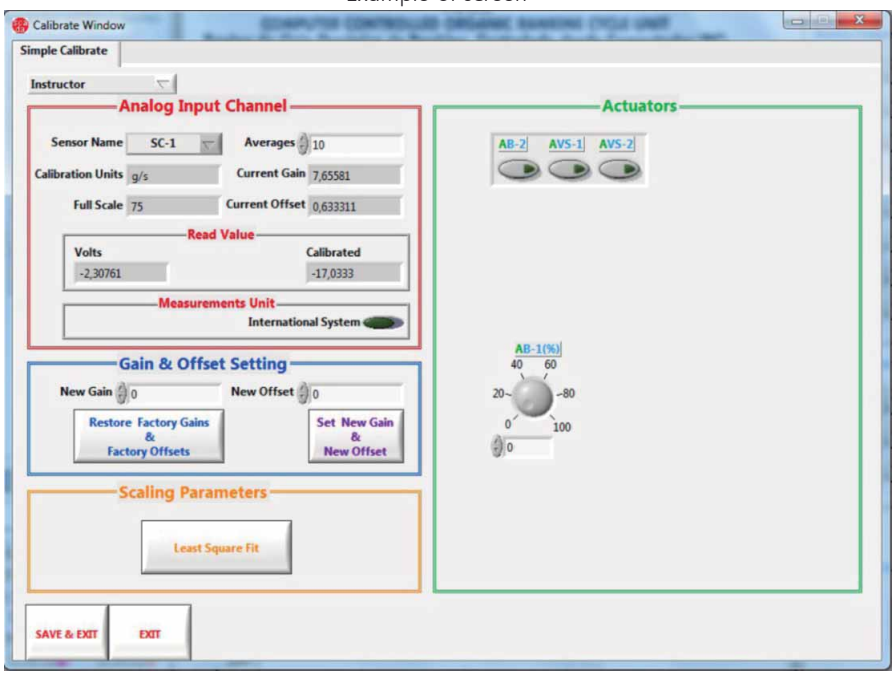
Ⓘⓘⓘ Actuators controls. **Actuators:** AB= Pump. AR= Heating element. AP= Pressure switch. AVS= Solenoid valve. AN= Level switch.

Ⓘⓥ Channel selection and other plot parameters.

Ⓥ Real time graphics displays.

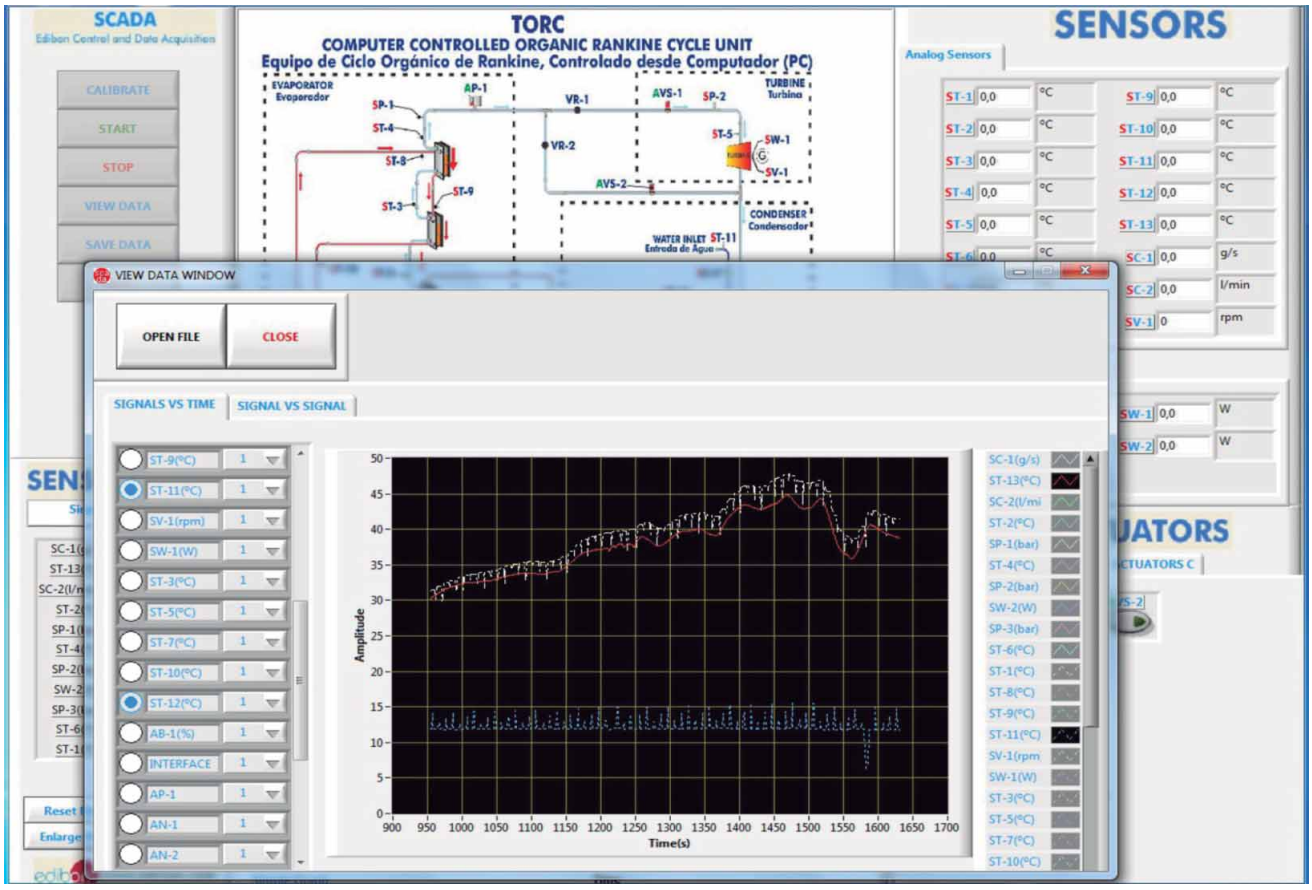
Software for Sensors Calibration

Example of screen

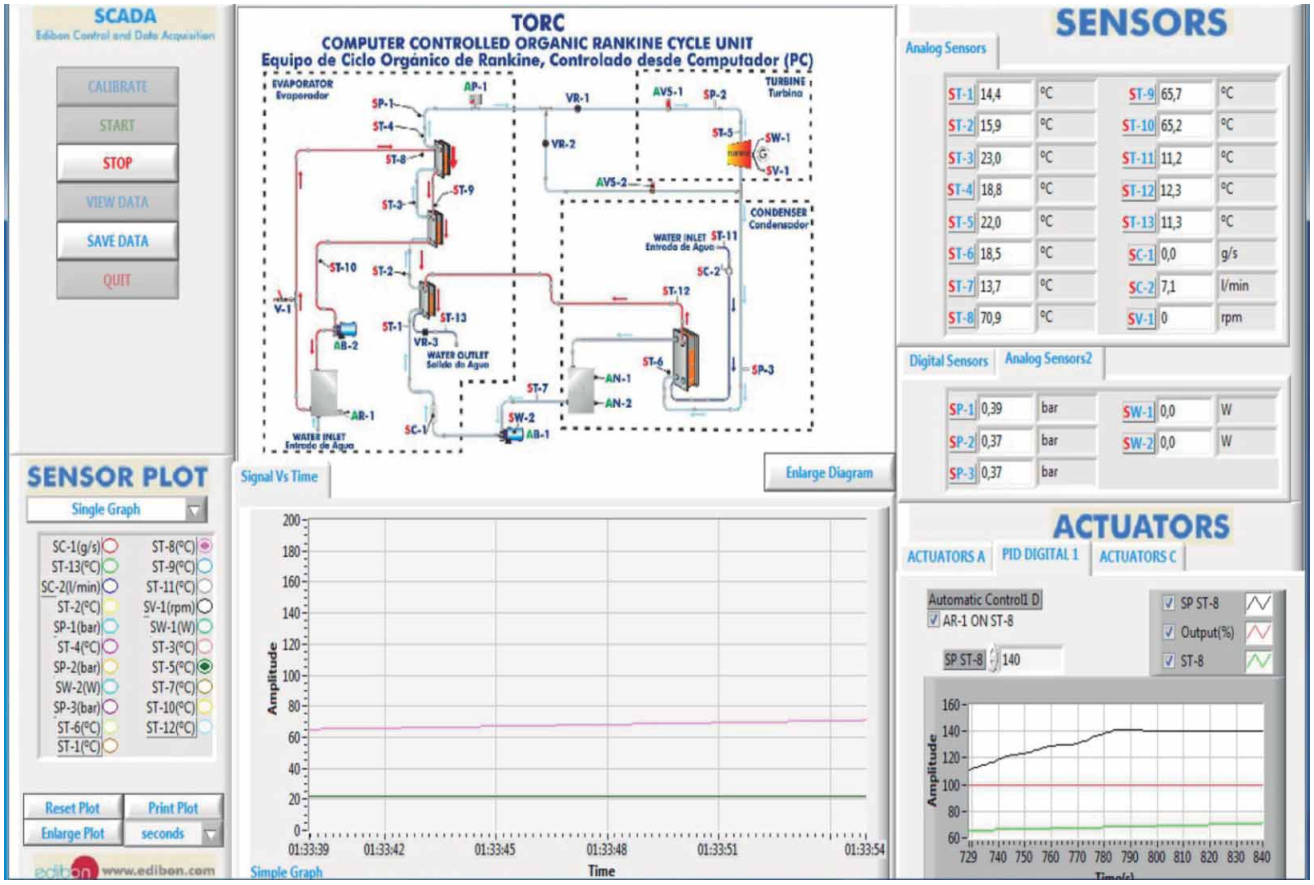


By using a free of charge code, the teacher and the students can calibrate the unit.
The teacher can recover his/her own calibration by using the EDIBON code that we give free of charge.

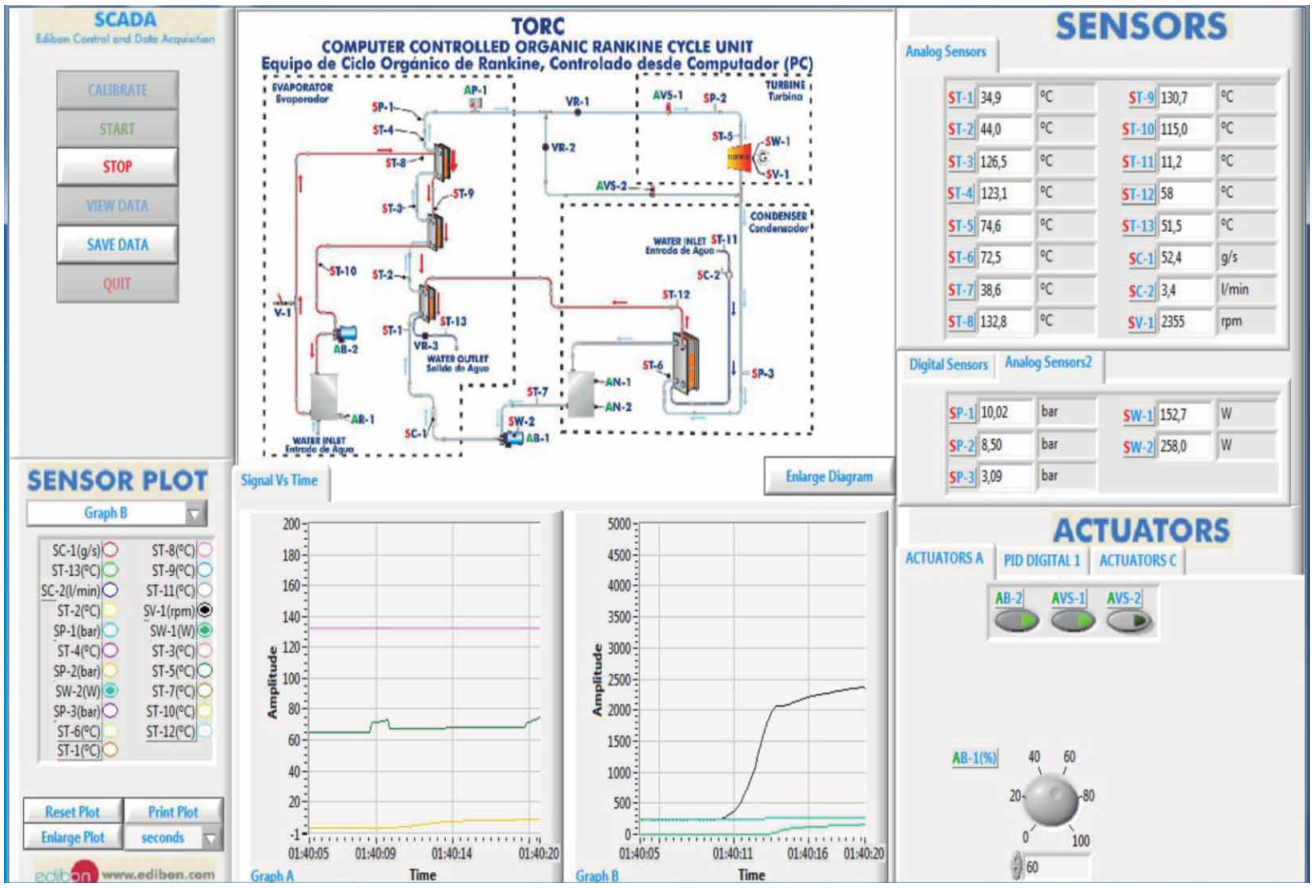
Sensors-time graph visualization. The evolution with time of the inlet temperature to the condenser (ST-11) and the outlet temperature from the condenser (ST-12) is observed in the screen.



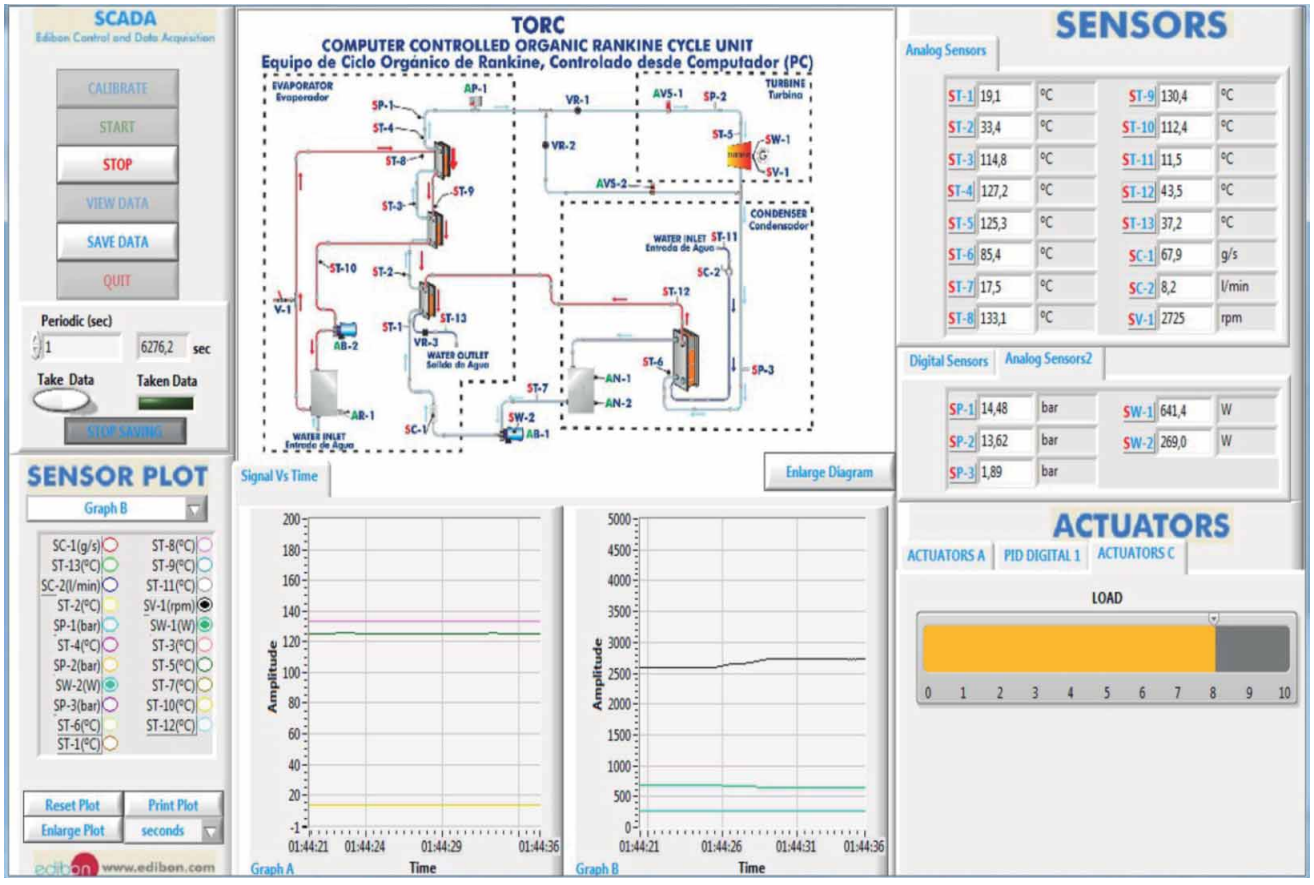
PID control of the heating element of the superheated water boiler, AR-1. The control is done on the ST-8, inlet temperature to the evaporator assembly. A temperature of 140°C is adjusted as setpoint so that the water superheated at the inlet of the evaporator assembly has this temperature and gives its heat to the organic fluid, R-245fa.



When the organic fluid (R-245fa) reaches the minimum working conditions in the turbine the bypass is closed and the AVS-1 is opened to allow the passage of the organic fluid to the turbine and the generation of electric power. Knowing the power of the driving pump, the power generated by the turbine and calculating the heat transferred by the boiler, the efficiency of the Organic Rankine Cycle can be calculated.



As the flow of organic fluid is increased at its optimal conditions to generate work in the turbine, the turning revolutions of the turbine increase and it generates more electric power.



COMPLETE TECHNICAL SPECIFICATIONS (for optional items)

Additionally to the main items (1 to 6) described, we can offer, as optional, other items from 7 to 12.
All these items try to give more possibilities for:

a) Industrial configuration. (PLC)
b) Technical and Vocational Education configuration. (CAI and FSS)
c) Higher Education and/or Technical and Vocational Education configuration. (CAL)
d) Multipost Expansions options. (Mini ESN and ESN)

a) Industrial configuration

⑦ PLC. Industrial Control using PLC (it includes PLC-PI Module plus PLC-SOF Control Software):

-**PLC-PI. PLC Module:**

Metallic box.

Circuit diagram in the module front panel.

Front panel:

Digital inputs(X) and Digital outputs (Y) block:

16 Digital inputs, activated by switches and 16 LEDs for confirmation (red).

14 Digital outputs (through SCSI connector) with 14 LEDs for message (green).

Analog inputs block:

16 Analog inputs (-10V. to + 10V.) (through SCSI connector).

Analog outputs block:

4 Analog outputs (-10V. to + 10V.) (through SCSI connector).

Touch screen:

High visibility and multiple functions. Display of a highly visible status. Recipe function. Bar graph function. Flow display function. Alarm list. Multi language function. True type fonts.

Back panel:

Power supply connector. Fuse 2A. RS-232 connector to PC. USB 2.0 connector to PC.

Inside:

Power supply outputs: 24 Vdc, 12 Vdc, -12 Vdc, 12 Vdc variable.

Panasonic PLC:

High-speed scan of 0.32 μsec. for a basic instruction.

Program capacity of 32 Ksteps, with a sufficient comment area.

Power supply input (100 to 240 V AC).

DC input: 16 (24 V DC).

Relay output: 14.

High-speed counter.

Multi-point PID control.

Digital inputs/outputs and analog inputs/outputs Panasonic modules.

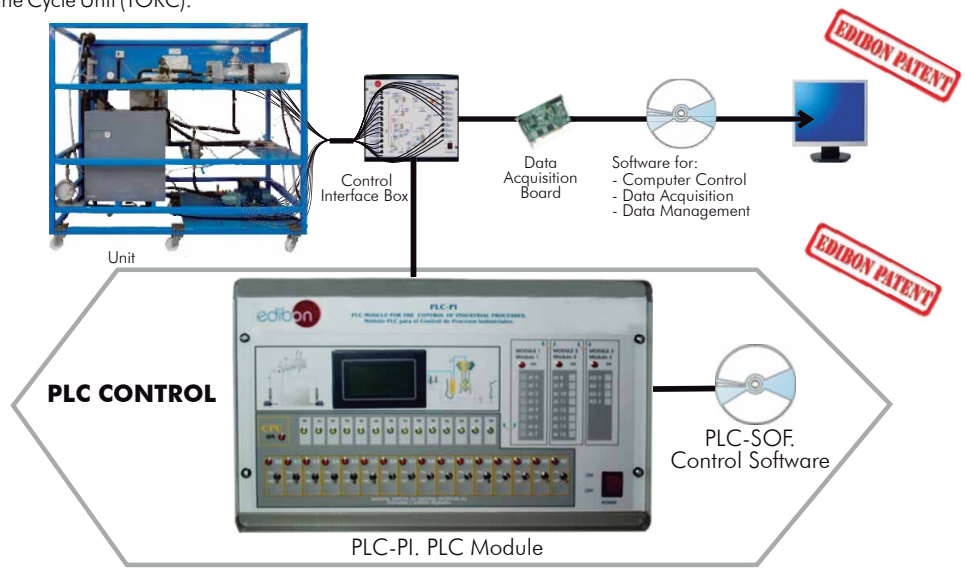
Communication RS232 wire to computer (PC).

Dimensions: 490 x 330 x 310 mm. approx. (19.29 x 12.99 x 12.2 inches approx.). Weight: 30 Kg. approx. (66 pounds approx.).

-**TORC/PLC-SOF. PLC Control Software:**

For this particular unit, always included with PLC supply.

The software has been designed using Labview and it follows the unit operation procedure and linked with the Control Interface Box used in the Computer Controlled Organic Rankine Cycle Unit (TORC).



Practices to be done with PLC-PI:

1.- Control of the TORC unit process through the control interface box without the computer.
2.- Visualization of all the sensors values used in the TORC unit process.
3.- Calibration of all sensors included in the TORC unit process.
4.- Hand on of all the actuators involved in the TORC unit process.
5.- Realization of different experiments, in automatic way, without having in front the unit. (This experiment can be decided previously).
6.- Simulation of outside actions, in the cases hardware elements do not exist. (Example: test of complementary tanks, complementary industrial environment to the process to be studied, etc).
7.- PLC hardware general use and manipulation.
8.- PLC process application for TORC unit.
9.- PLC structure.
10.- PLC inputs and outputs configuration.
11.- PLC configuration possibilities.
12.- PLC programming languages.
13.- PLC different programming standard languages.
14.- New configuration and development of new process.
15.- Hand on an established process.
16.- To visualize and see the results and to make comparisons with the TORC unit process.
17.- Possibility of creating new process in relation with the TORC unit.
18.- PLC Programming Exercises.
19.- Own PLC applications in accordance with teacher and student requirements.

b) Technical and Vocational Education configuration

⑧ TORC/CAI. Computer Aided Instruction Software System.

This complete software package includes two Softwares: the INS/SOF. Classroom Management Software (Instructor Software) and the TORC/SOF. Computer Aided Instruction Software (Student Software).

This software is optional and can be used additionally to items (1 to 6).

This complete software package consists of an Instructor Software (INS/SOF) totally integrated with the Student Software (TORC/SOF). Both are interconnected so that the teacher knows at any moment what is the theoretical and practical knowledge of the students.

- INS/SOF. Classroom Management Software (Instructor Software):

The Instructor can:

Organize Students by Classes and Groups.

Create easily new entries or delete them.

Create data bases with student information.

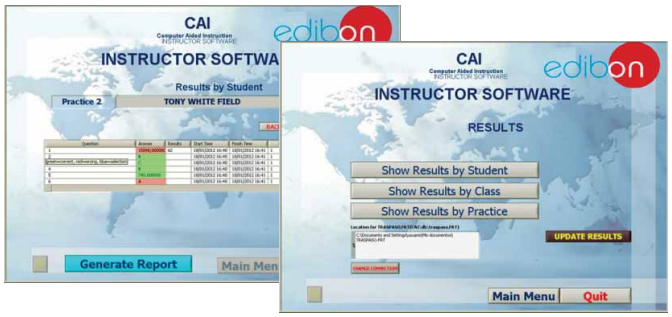
Analyze results and make statistical comparisons.

Generate and print reports.

Detect student's progress and difficulties.

...and many other facilities.

Instructor Software



- TORC/SOF. Computer Aided Instruction Software (Student Software):

It explains how to use the unit, run the experiments and what to do at any moment.

This Software contains:

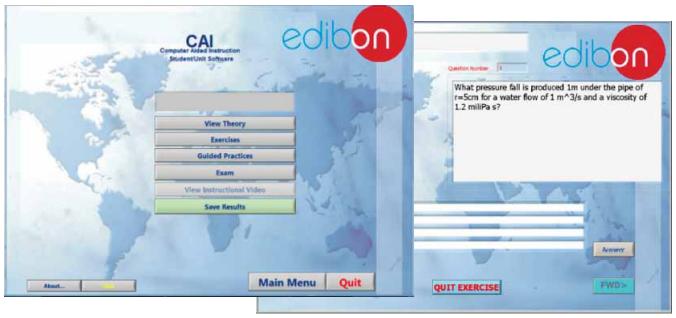
Theory.

Exercises.

Guided Practices.

Exams.

Student Software



For more information see **CAI** catalogue. Click on the following link:

www.edibon.com/products/catalogues/en/CAI.pdf

⑨ TORC/FSS. Faults Simulation System.

Faults Simulation System (FSS) is a Software package that simulates several faults in any EDIBON Computer Controlled Unit. It is useful for Technical and Vocational level.

The "FAULTS" mode consists on causing several faults in the unit normal operation. The student must find them and solve them.

There are several kinds of faults that can be grouped in the following sections:

Faults affecting the sensors measurement:

- **An incorrect calibration is applied to them.**
- **Non-linearity.**

Faults affecting the actuators:

- **Actuators channels interchange at any time during the program execution.**
- **Response reduction of an actuator.**

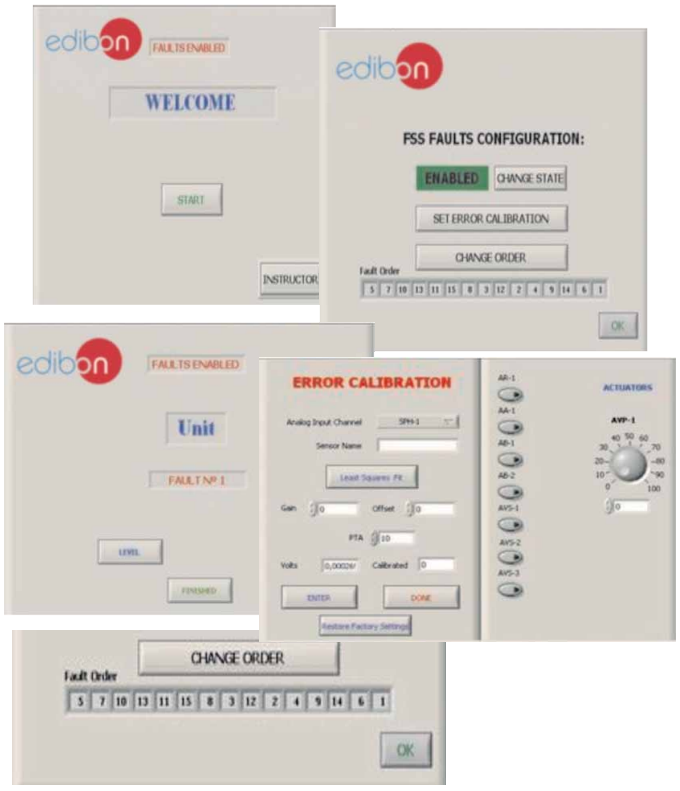
Faults in the controls execution:

- **Inversion of the performance in ON/OFF controls.**
- **Reduction or increase of the calculated total response.**
- **The action of some controls is annulled.**

On/off faults:

- **Several on/off faults can be included.**

Example of some screens



For more information see **FSS** catalogue. Click on the following link:

www.edibon.com/products/catalogues/en/FSS.pdf

c) Higher Education and/or Technical and Vocational Education configuration

⑩ TORC/CAL. Computer Aided Learning Software (Results Calculation and Analysis).

This Computer Aided Learning Software (CAL) is a Windows based software, simple and very easy to use, specifically developed by EDIBON. It is very useful for Higher Education level.

CAL is a class assistant that helps in doing the necessary calculations to extract the right conclusions from data obtained during the experimental practices.

CAL computes the value of all the variables involved and performs the calculations.

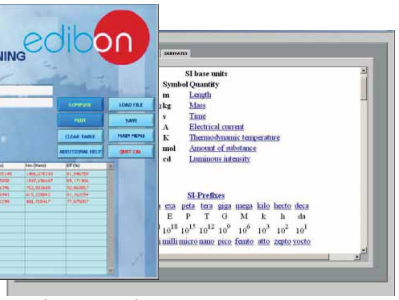
It allows to plot and print the results. Within the plotting options, any variable can be represented against any other.

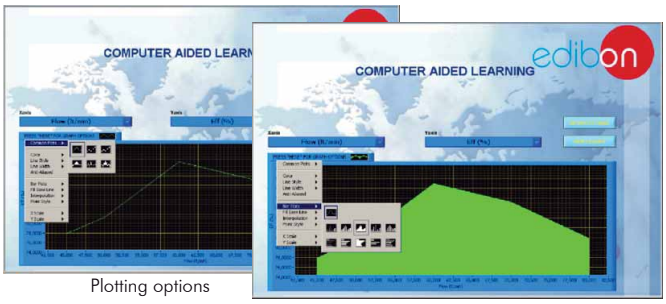
Different plotting displays.

It has a wide range of information, such as constant values, unit conversion factors and integral and derivative tables.

For more information see **CAL** catalogue. Click on the following link:
www.edibon.com/products/catalogues/en/CAL.pdf

Calculations


Information of constant values, unit conversion factors and integral and derivative tables



Plotting options

d) Multipost Expansions options

⑪ Mini ESN. EDIBON Mini Scada-Net System.

Mini ESN. EDIBON Mini Scada-Net System allows up to 30 students to work with a Teaching Unit in any laboratory, simultaneously. It is useful for both, Higher Education and/or Technical and Vocational Education.

The Mini ESN system consists on the adaptation of any EDIBON Computer Controlled Unit with SCADA and PID Control integrated in a local network.

This system allows to view/control the unit remotely, from any computer integrated in the local net (in the classroom), through the main computer connected to the unit. Then, the number of possible users who can work with the same unit is higher than in an usual way of working (usually only one).

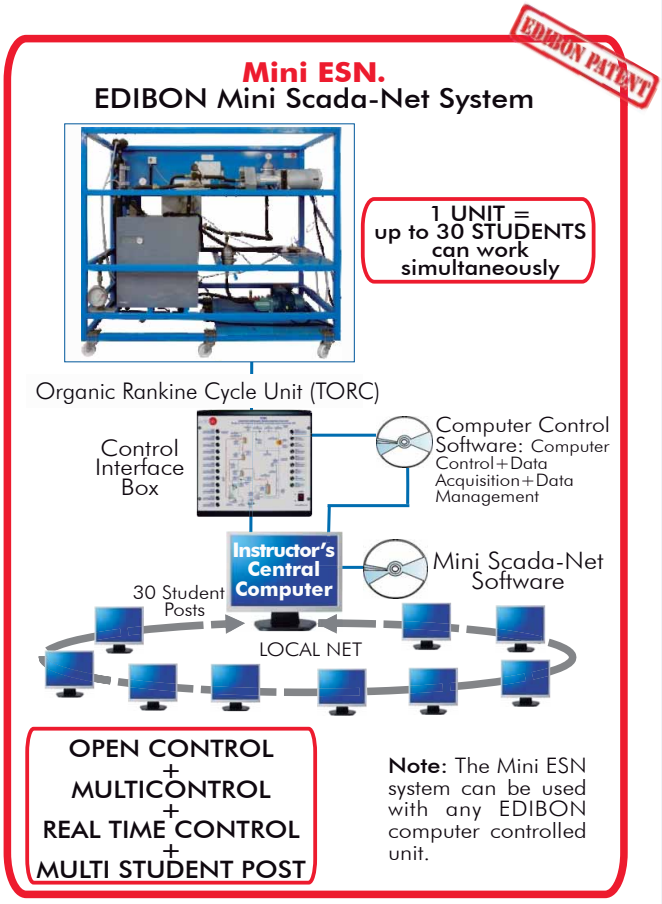
Main characteristics:

- **It allows up to 30 students to work simultaneously with the EDIBON Computer Controlled Unit with SCADA and PID Control, connected in a local net.**
- **Open Control + Multicontrol + Real Time Control + Multi Student Post.**
- **Instructor controls and explains to all students at the same time.**
- **Any user/student can work doing "real time" control/multicontrol and visualisation.**
- **Instructor can see in the computer what any user/student is doing in the unit.**
- **Continuous communication between the instructor and all the users/ students connected.**

Main advantages:

- **It allows an easier and quicker understanding.**
- **This system allows you can save time and cost.**
- **Future expansions with more EDIBON Units.**

For more information see **Mini ESN** catalogue. Click on the following link:
www.edibon.com/products/catalogues/en/Mini-ESN.pdf



⑫ ESN. EDIBON Scada-Net System.

This unit can be integrated, in the future, into a Complete Laboratory with many Units and many Students.

For more information see **ESN** catalogue. Click on the following link:
www.edibon.com/products/catalogues/en/units/energy/esn-alternativeenergies/ESN-ALTERNATIVE_ENERGIES.pdf

ORDER INFORMATION

Main items (always included in the supply)

Minimum supply always includes:

① **Unit: TORC. Organic Rankine Cycle Unit.**

② **TORC/CIB. Control Interface Box.**

③ **DAB. Data Acquisition Board.**

④ **TORC/CCSOF. PID Computer Control + Data Acquisition + Data Management Software.**

⑤ **Cables and Accessories**, for normal operation.

⑥ **Manuals.**

* IMPORTANT: Under TORC we always supply all the elements for immediate running as 1, 2, 3, 4, 5 and 6.

Optional items (supplied under specific order)

a) Industrial configuration

⑦ PLC. Industrial Control using PLC (it includes PLC-PI Module plus PLC-SOF Control Software):

- PCL-PI. PLC Module.
- TORC/PLC-SOF. PLC Control Software.

b) Technical and Vocational configuration

⑧ TORC/CAI. Computer Aided Instruction Software System.

⑨ TORC/FSS. Faults Simulation System.

c) Higher Education and/or Technical and Vocational Education configuration

⑩ TORC/CAL. Computer Aided Learning Software (Results Calculation and Analysis).

d) Multipost Expansions options

⑪ Mini ESN. EDIBON Mini Scada-Net System.

⑫ ESN. EDIBON Scada-Net System.

① TORC. Unit:

Evaporator:

Computer controlled (PID control) boiler of 15kW for superheated water to 150°C. It includes:

- Safety valve calibrated to 6 Bar.
- Safety pressure switch as filling safety measure for the boiler.
- Manometer of 0-6 Bar.
- Safety thermostat (150°C).
- Automatic air purger.
- Expansion vessel.
- Automatic feeder regulated to 1.5 Bar.
- Driving pump.

3 Plate exchangers:

- Exchanger n°1 (preheater): 6 plates, heat transfer area: 0.0480 m^2.
- Exchanger n° 2: 20 plates, heat transfer area: 0.612 m^2.
- Exchanger n° 3: 20 plates, heat transfer area: 0.414 m^2.

Condenser: exchanger of 20 plates, heat transfer area: 0.720 m^2.

Triple piston pump to impel the organic fluid, with power variator, computer controlled.

Scroll turbine and generator: 1kW, 3600 rpm approx.

Electric load.

Organic fluid condensed tank with two level actuators.

R-245fa organic fluid storage tank.

High pressure safety pressure switch to prevent overpressures.

2 Solenoid valves.

Air purgers.

Sight glasses along the circuit to visualize the state of the organic fluid.

Sensors:

13 "J" type temperature sensors distributed along the process.

1 Flow sensor to measure the cooling water flow through the condenser, range: 1.5 – 30 l./min.

1 Flow sensor to measure the organic fluid flow through the circuit, range: 0.008-0.062 Kg/s.

3 Pressure sensors to measure the outlet pressure of the evaporator and the inlet and outlet pressure of the turbine, pressure sensors range: 0-25 Bar.

1 Sensor to measure the power consumed by the generator.

1 Sensor to measure the power consumed by the pump that impels the organic fluid.

1 Speed sensor of the turbine.

The complete unit includes as well:

- Advanced Real-Time SCADA and PID Control.
- Open Control + Multicontrol + Real-Time Control.
- Specialized EDIBON Control Software based on Labview.
- National Instruments Data Acquisition board (250 KS/s , kilo samples per second).
- Calibration exercises, which are included, teach the user how to calibrate a sensor and the importance of checking the accuracy of the sensors before taking measurements.
- Projector and/or electronic whiteboard compatibility allows the unit to be explained and demonstrated to an entire class at one time.
- Capable of doing applied research, real industrial simulation, training courses, etc.
- Remote operation and control by the user and remote control for EDIBON technical support, are always included.
- Totally safe, utilizing 4 safety systems (Mechanical, Electrical, Electronic & Software).
- Designed and manufactured under several quality standards.
- Optional CAL software helps the user perform calculations and comprehend the results.
- This unit has been designed for future expansion and integration. A common expansion is the EDIBON Scada-Net (ESN) System which enables multiple students to simultaneously operate many units in a network.

② TORC/CIB. Control Interface Box:

The Control Interface Box is part of the SCADA system.

Control interface box with process diagram in the front panel.

The unit control elements are permanently computer controlled.

Simultaneous visualization in the computer of all parameters involved in the process.

Calibration of all sensors involved in the process.

Real time curves representation about system responses.

All the actuators' values can be changed at any time from the keyboard allowing the analysis about curves and responses of the whole process.

Shield and filtered signals to avoid external interferences.

Real time PID control with flexibility of modifications from the computer keyboard of the PID parameters, at any moment during the process. Real time PID control for parameters involved in the process simultaneously. Proportional control, integral control and derivative control, based on the real PID mathematical formula, by changing the values, at any time, of the three control constants (proportional, integral and derivative constants).

Open control allowing modifications, at any moment and in real time, of parameters involved in the process simultaneously.

Three safety levels, one mechanical in the unit, another electronic in the control interface and the third one in the control software.

③ DAB. Data Acquisition Board:

The Data Acquisition board is part of the SCADA system. PCI Express Data acquisition board (National Instruments) to be placed in a computer slot.

Analog input: Channels= 16 single-ended or 8 differential. Resolution=16 bits, 1 in 65536. Sampling rate up to: 250 KS/s (kilo samples per second).

Analog output: Channels=2. Resolution=16 bits, 1 in 65536.

Digital Input/Output: Channels=24 inputs/outputs.

④ TORC/CCSOF. PID Computer Control + Data Acquisition + Data Management Software:

The three softwares are part of the SCADA system.

Compatible with the industry standards.

Flexible, open and multicontrol software, developed with actual windows graphic systems, acting simultaneously on all process parameters.

Analog and digital PID control. PID menu and set point selection required in the whole work range.

Management, processing, comparison and storage of data.

Sampling velocity up to 250 KS/s (kilo samples per second).

Calibration system for the sensors involved in the process.

It allows the registration of the alarms state and the graphic representation in real time.

Open software, allowing the teacher to modify texts, instructions. Teacher's and student's passwords to facilitate the teacher's control on the student, and allowing the access to different work levels.

This unit allows the 30 students of the classroom to visualize simultaneously all the results and the manipulation of the unit, during the process, by using a projector or an electronic whiteboard.

⑤ Cables and Accessories, for normal operation.

⑥ Manuals: This unit is supplied with 8 manuals: Required Services, Assembly and Installation, Interface and Control Software, Starting-up, Safety, Maintenance, Calibration & Practices Manuals.

Exercises and Practical Possibilities to be done with Main Items

1.- Demonstration of the Organic Rankine Cycle (ORC).

2.- To measure the heat supplied by evaporator.

3.- Determination of the efficiency of an Organic Rankine Cycle (ORC).

4.- Energy balances determination in the evaporator and the condenser.

5.- Determination of the turbine efficiency.

6.- To make energy balance.

7.- To measure the electrical power generated.

8.- To study the influence of the organic fluid flow and temperatures on the generation of electrical power.

9.- Study of the specific vapour consumption of the turbine.

10.- Speed measurement of the turbine.

Additional practical possibilities:

11.- Sensors calibration.

Other possibilities to be done with this Unit:

12.- Many students view results simultaneously.

To view all results in real time in the classroom by means of a projector or an electronic whiteboard.

13.- Open Control, Multicontrol and Real Time Control.

This unit allows intrinsically and/or extrinsically to change the span, gains; proportional, integral, derivate parameters; etc, in real time.

14.- The Computer Control System with SCADA and PID Control allow a real industrial simulation.

15.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.

16.- This unit can be used for doing applied research.

17.- This unit can be used for giving training courses to Industries even to other Technical Education Institutions.

18.- Control of the TORC unit process through the control interface box without the computer.

19.- Visualization of all the sensors values used in the TORC unit process.

- By using PLC-PI additional 19 more exercises can be done.

- Several other exercises can be done and designed by the user.

a) Industrial configuration

⑦ PLC. Industrial Control using PLC (it includes PLC-PI Module plus PLC-SOF Control Software):

-**PLC-PI. PLC Module:**

Metallic box.
Circuit diagram in the module front panel.
Digital inputs(X) and Digital outputs (Y) block: 16 Digital inputs. 14 Digital outputs.
Analog inputs block: 16 Analog inputs.
Analog outputs block: 4 Analog outputs.
Touch screen.
Panasonic PLC:
High-speed scan of 0.32 μsec. Program capacity of 32 Ksteps. High-speed counter. Multi-point PID control.
Digital inputs/outputs and analog inputs/outputs Panasonic modules.

-**TORC/PLC-SOF. PLC Control Software:**

For this particular unit, always included with PLC supply.

Practices to be done with PLC-PI:

1.- Control of the TORC unit process through the control interface box without the computer.
2.- Visualization of all the sensors values used in the TORC unit process.
3.- Calibration of all sensors included in the TORC unit process.
4.- Hand on of all the actuators involved in the TORC unit process.
5.- Realization of different experiments, in automatic way, without having in front the unit. (This experiment can be decided previously).
6.- Simulation of outside actions, in the cases hardware elements do not exist. (Example: test of complementary tanks, complementary industrial environment to the process to be studied, etc).
7.- PLC hardware general use and manipulation.
8.- PLC process application for TORC unit.
9.- PLC structure.
10.- PLC inputs and outputs configuration.
11.- PLC configuration possibilities.
12.- PLC programming languages.
13.- PLC different programming standard languages.
14.- New configuration and development of new process.
15.- Hand on an established process.
16.- To visualize and see the results and to make comparisons with the TORC unit process.
17.- Possibility of creating new process in relation with the TORC unit.
18.- PLC Programming exercises.
19.- Own PLC applications in accordance with teacher and student requirements.

b) Technical and Vocational Education configuration

⑧ TORC/CAI. Computer Aided Instruction Software System.

This complete software package consists of an Instructor Software (INS/SOF) totally integrated with the Student Software (TORC/SOF).
-INS/SOF. Classroom Management Software (Instructor Software):
The Instructor can:
Organize Students by Classes and Groups.
Create easily new entries or delete them.
Create data bases with student information.
Analyze results and make statistical comparisons.
Generate and print reports.
Detect student's progress and difficulties.
-TORC/SOF. Computer Aided Instruction Software (Student Software):
It explains how to use the unit, run the experiments and what to do at any moment.
This Software contains:
Theory.
Exercises.
Guided Practices.
Exams.

⑨ TORC/FSS. Faults Simulation System.

Faults Simulation System (FSS) is a Software package that simulates several faults in any EDIBON Computer Controlled Unit.
The "FAULTS" mode consists on causing several faults in the unit normal operation. The student must find them and solve them.
There are several kinds of faults that can be grouped in the following sections:
Faults affecting the sensors measurement:
- An incorrect calibration is applied to them.
- Non-linearity.

Faults affecting the actuators:
- Actuators channels interchange at any time during the program execution.
- Response reduction of an actuator.

Faults in the controls execution:
- Inversion of the performance in ON/OFF controls.
- Reduction or increase of the calculated total response.
- The action of some controls is annulled.

On/off faults:
- Several on/off faults can be included.

c) Higher Education and/or Technical and Vocational Education configuration

⑩TORC/CAL. Computer Aided Learning Software (Results Calculation and Analysis).

This Computer Aided Learning Software (CAL) is a Windows based software, simple and very easy to use.
CAL is a class assistant that helps in doing the necessary calculations to extract the right conclusions from data obtained during the experimental practices.
CAL computes the value of all the variables involved and performs the calculations.
It allows to plot and print the results. Within the plotting options, any variable can be represented against any other.
Different plotting displays.
It has a wide range of information, such as constant values, unit conversion factors and integral and derivative tables.

d) Multipost Expansions options

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-Continuous communication between the instructor and all the users/students connected.

Main advantages:

-It allows an easier and quicker understanding.
-This system allows you can save time and cost.
-Future expansions with more EDIBON Units.

The system basically will consist of:

This system is used with a Computer Controlled Unit.
-Instructor's computer.
-Students' computers.
-Local Network.
-Unit-Control Interface adaptation.
-Unit Software adaptation.
-Webcam.
-Mini ESN Software to control the whole system.
-Cables and accessories required for a normal operation.

✱Specifications subject to change without previous notice, due to the convenience of improvements of the product.

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