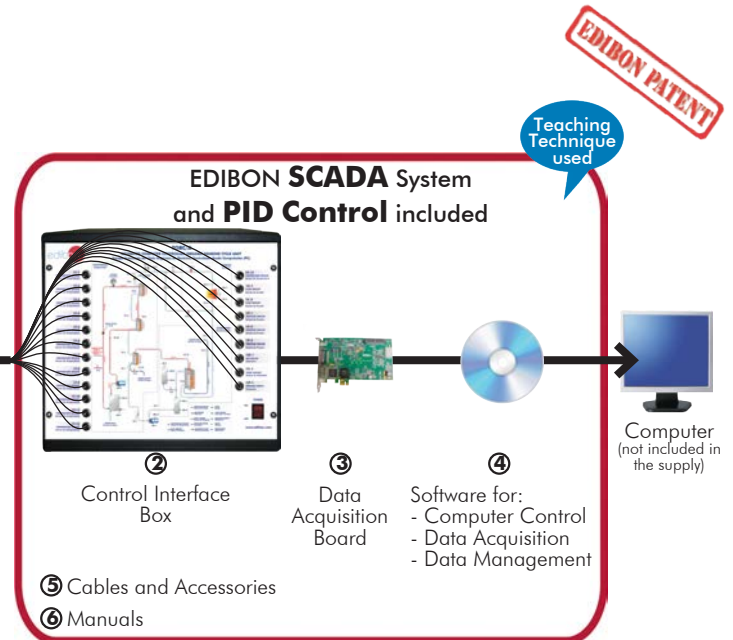


① Unit: TORC/A. Advanced Computer Controlled Organic Rankine Cycle Unit



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

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 ICAI software to create, edit and carry out practical exercises, tests, exams, calculations, etc. Apart from monitoring user's knowledge and progress reached.**
- **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**

POWERED BY
**NATIONAL INSTRUMENTS
LabVIEW™**

www.edibon.com
→ PRODUCTS
→ 50.- ENERGY
AND
90.- THERMODYNAMICS
& THERMOTECHNICS

For more information about Key Features, click here



ISO 9001: Quality Management (for Design, Manufacturing, Commercialization and After-sales service)



European Union Certificate (total safety)



Certificates ISO 14001 and ECO-Management and Audit Scheme (environmental management)



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 Advanced Computer Controlled Organic Rankine Cycle Unit, "TORC/A", 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 super heated water to 150 °C (heat source) flows impelled by a pump.

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

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

There is a purge valve in this close circuit of super heated 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.

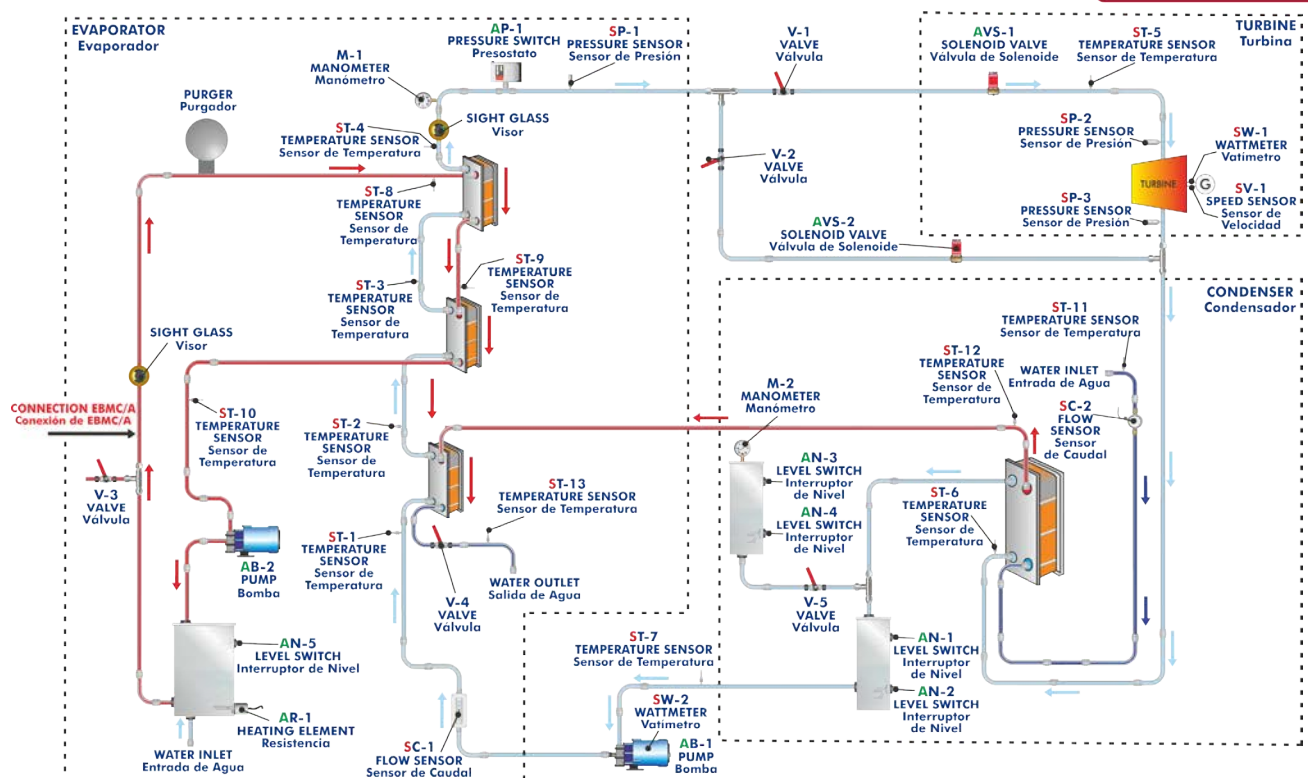
The "TORC/A" unit is an advanced version with all mentioned instruments and accessories and enough power and flow to work together with the "EBMC/A" unit.

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



With this unit there are several options and possibilities:

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

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

① TORC/A. Unit:

Evaporator:

Computer controlled (PID control) boiler of 15 kW 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.

Three plate exchangers:

- Exchanger n° 1 (preheater): six plates, heat transfer area: 0.0480 m².
- Exchanger n° 2: twenty plates, heat transfer area: 0.612m².
- Exchanger n° 3: twenty plates, heat transfer area: 0.414 m².

Condenser: exchanger of twenty plates, heat transfer area: 0.720 m².

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

Scroll turbine and generator: 1 kW, 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.

Two solenoid valves.

Air purgers.

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

Sensors:

- Thirteen "J" type temperature sensors distributed along the process.
- One flow sensor to measure the cooling water flow through the condenser, range: 1.5 - 30 l/min.
- One flow sensor to measure the organic fluid flow through the circuit, range: 0.008 - 0.062 Kg/s.
- Three 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.
- One sensor to measure the power consumed by the generator.
- One sensor to measure the power consumed by the pump that impels the organic fluid.
- One 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 ICAI software to create, edit and carry out practical exercises, tests, exams, calculations, etc. Apart from monitoring user's knowledge and progress reached.

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.



Unit: TORC/A

② TORC/A/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/A/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/O. 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/O.

Digital Input/Output:

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

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



DAB

④ TORC/A/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).

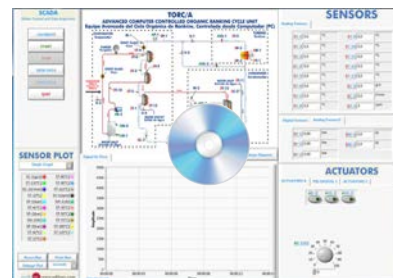
Calibration system for the sensors involved in the process.

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/A/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/A + TORC/A/CIB + DAB + TORC/A/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 THE 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, derivative 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/A unit process through the control interface box without the computer.
 - 19.-Visualization of all the sensors values used in the TORC/A unit process.
- Several other exercises can be done and designed by the user.

REQUIRED SERVICES

- Electrical supply: three-phase, 380V/50 Hz or 208V/60 Hz, 20 kW.
- Water supply and drainage.
- Computer.

DIMENSIONS AND WEIGHTS

TORC/A:

Unit:

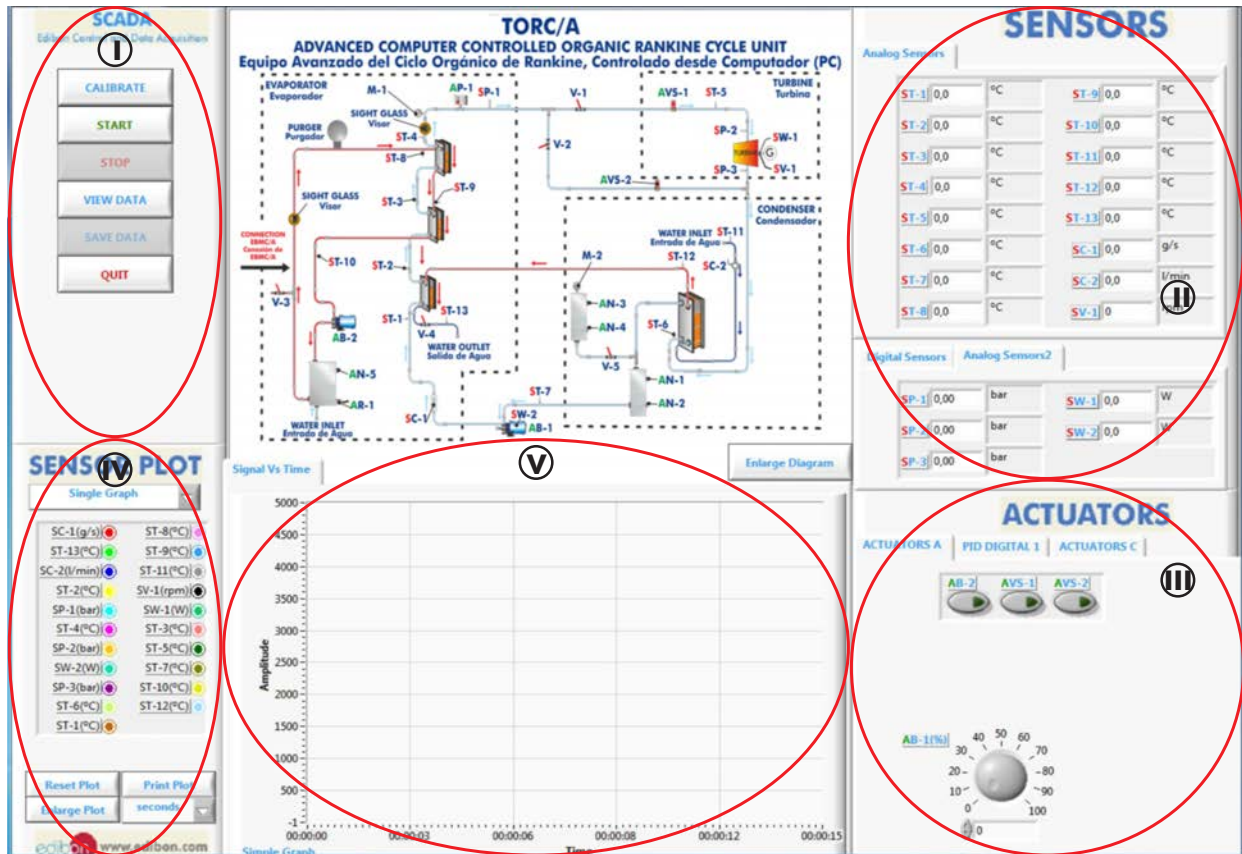
- Dimensions: 2500 x 900 x 1800 mm approx.
(98.42 x 35.43 x 70.86 inches approx.).
- Weight: 450 Kg approx.
(990 pounds approx.).

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.).

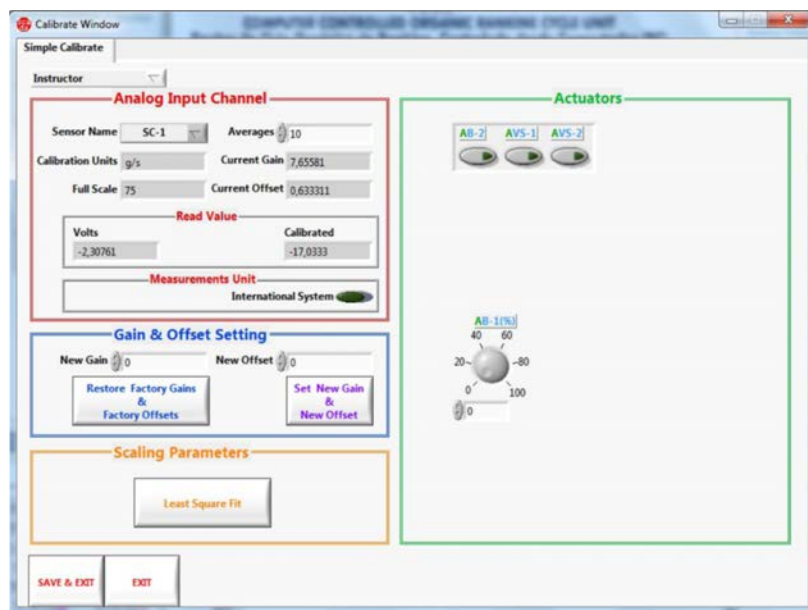
SOFTWARE MAIN SCREENS

SCADA and PID Control Main screen



- ❶ Main software operation possibilities.
- ❷ Sensors displays, real time values, and extra output parameters. Sensors: ST=Temperature sensor. SC=Flow sensor. SP=Pressure sensor. SW=Wattmeter. SV=Speed sensor.
- ❸ Actuators Controls. Actuators: AB=Pump. AR=Heating element. AP=Pressure switch. AVS=Solenoid valve. AN=Level switch.
- ❹ Channel selection and other plot parameters.
- ❺ Real time graphics displays.

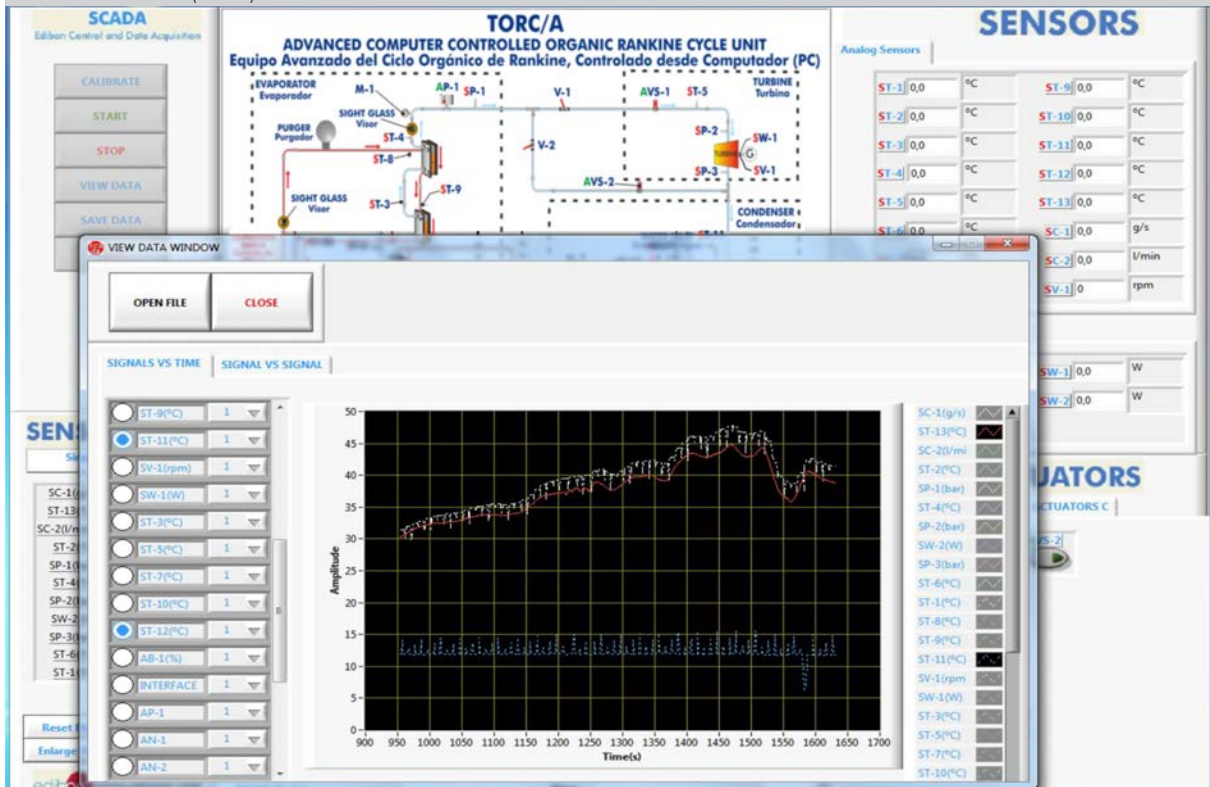
Software for Sensors Calibration Example of screen



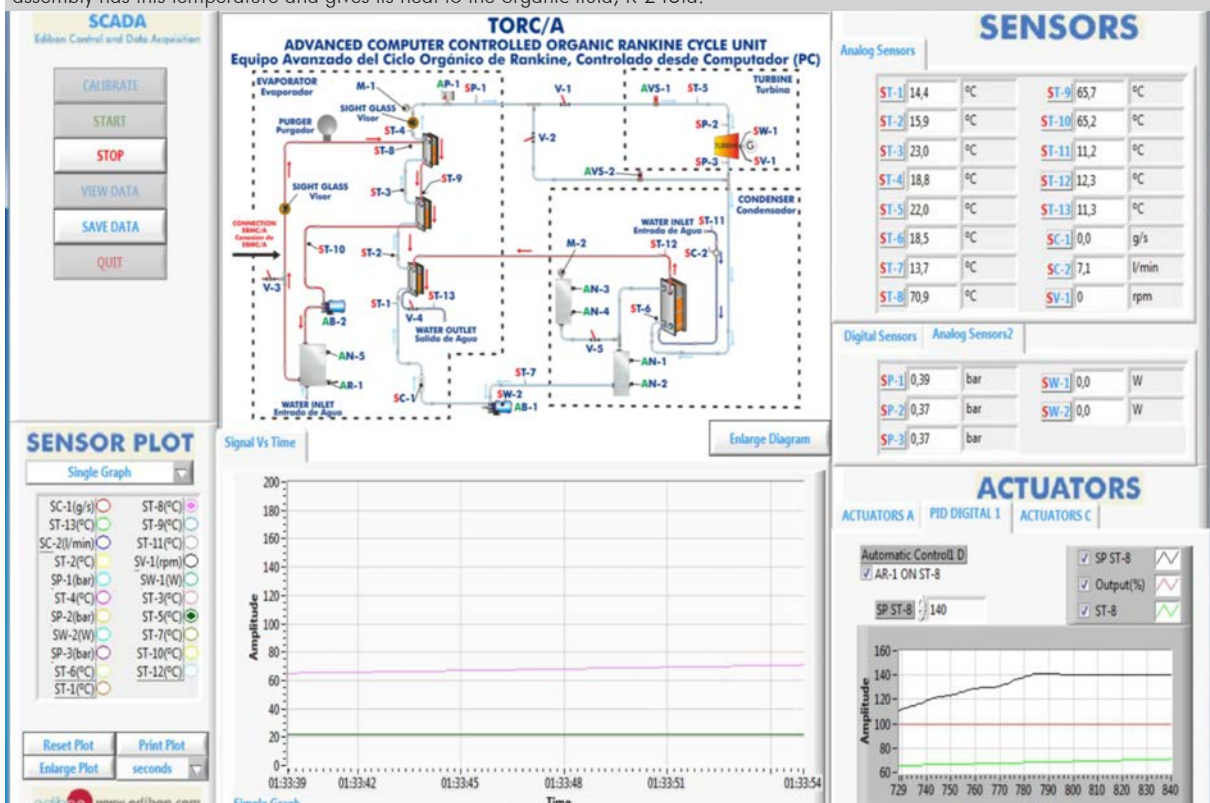
The teacher and the students can calibrate the unit with a password provided by EDIBON. The teacher can restore the factory calibration any time.

SOME REAL RESULTS OBTAINED FROM THIS UNIT

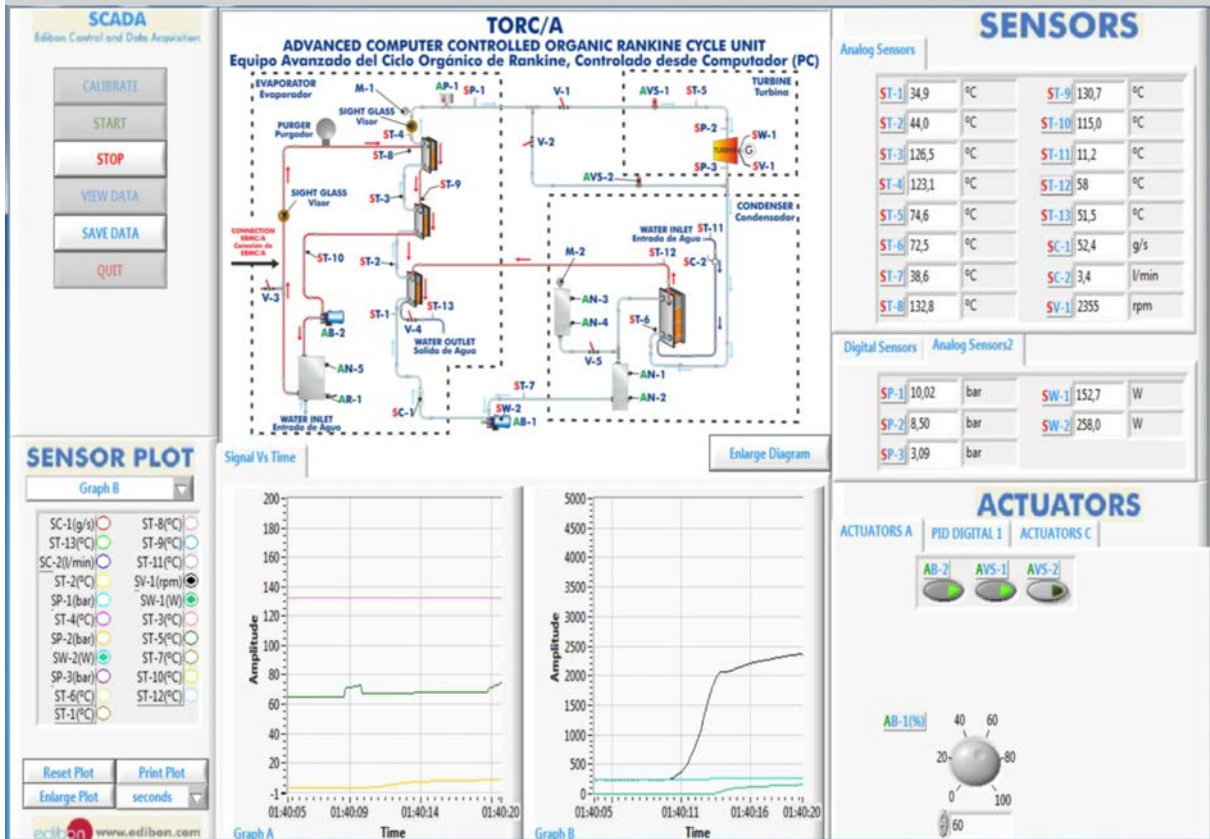
Sensors-time graph visualization. The evolution with time of the inlet temperature to the condenser (ST-11) and the outlet temperature from the condenser (ST-12) is observed in the screen.



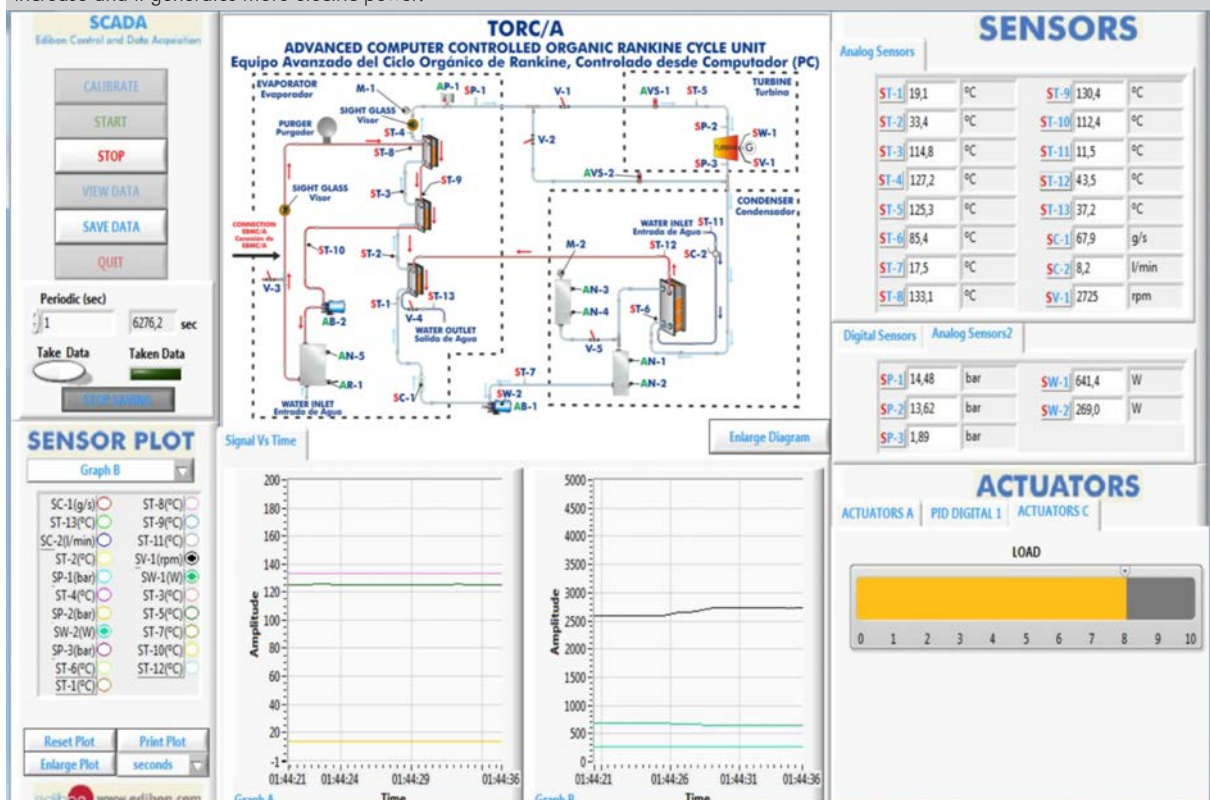
PID control of the heating element of the superheated water boiler, AR-1. The control is done on the ST-8, inlet temperature to the evaporator assembly. A temperature of 140°C is adjusted as setpoint so that the water superheated at the inlet of the evaporator assembly has this temperature and gives 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 10.

All these items try to give more possibilities for:

- a) Technical and Vocational Education configuration. (ICAI and FSS)
- b) Multipost Expansions options. (Mini ESN and ESN)

a) Technical and Vocational Education configuration

⑦ TORC/A/ICAI. Interactive Computer Aided Instruction Software System.

This complete software package consists of an Instructor Software (EDIBON Classroom Manager - ECM-SOF) totally integrated with the Student Software (EDIBON Student Labsoft - ESL-SOF). Both are interconnected so that the teacher knows at any moment what is the theoretical and practical knowledge of the students.

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

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).

ECM-SOF is the application that allows the Instructor to register students, manage and assign tasks for workgroups, create own content to carry out Practical Exercises, choose one of the evaluation methods to check the Student knowledge and monitor the progression related to the planned tasks for individual students, workgroups, units, etc... so the teacher can know in real time the level of understanding of any student in the classroom.

Innovative features:

- User Data Base Management.
- Administration and assignment of Workgroup, Task and Training sessions.
- Creation and Integration of Practical Exercises and Multimedia Resources.
- Custom Design of Evaluation Methods.
- Creation and assignment of Formulas & Equations.
- Equation System Solver Engine.
- Updatable Contents.
- Report generation, User Progression Monitoring and Statistics.

- ESL-SOF. EDIBON Student Labsoft (Student Software).

ESL-SOF is the application addressed to the Students that helps them to understand theoretical concepts by means of practical exercises and to prove their knowledge and progression by performing tests and calculations in addition to Multimedia Resources. Default planned tasks and an Open workgroup are provided by EDIBON to allow the students start working from the first session. Reports and statistics are available to know their progression at any time, as well as explanations for every exercise to reinforce the theoretically acquired technical knowledge.

Innovative features:

- Student Log-In & Self-Registration.
- Existing Tasks checking & Monitoring.
- Default contents & scheduled tasks available to be used from the first session.
- Practical Exercises accomplishment by following the Manual provided by EDIBON.
- Evaluation Methods to prove your knowledge and progression.
- Test self-correction.
- Calculations computing and plotting.
- Equation System Solver Engine.
- User Monitoring Learning & Printable Reports.
- Multimedia-Supported auxiliary resources.

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

www.edibon.com/en/files/expansion/ICAI/catalog

Instructor Software



ECM-SOF. EDIBON Classroom Manager (Instructor Software) Application Main Screen

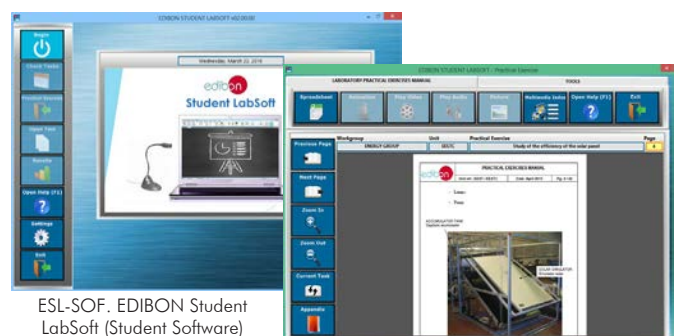
ECAL. EDIBON Calculations Program Package - Formula Editor Screen



ERS. EDIBON Results & Statistics Program Package - Student Scores Histogram

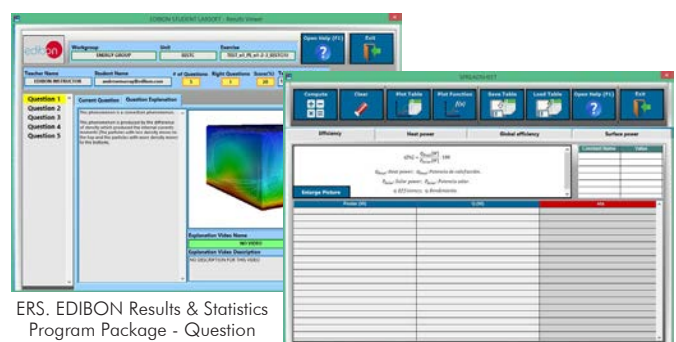
ETTE. EDIBON Training Test & Exam Program Package - Main Screen with Numeric Result Question

Student Software



ESL-SOF. EDIBON Student LabSoft (Student Software) Application Main Screen

EPE. EDIBON Practical Exercise Program Package Main Screen



ERS. EDIBON Results & Statistics Program Package - Question Explanation

ECAL. EDIBON Calculations Program Package Main Screen

⑨ TORC/A/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 in 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.

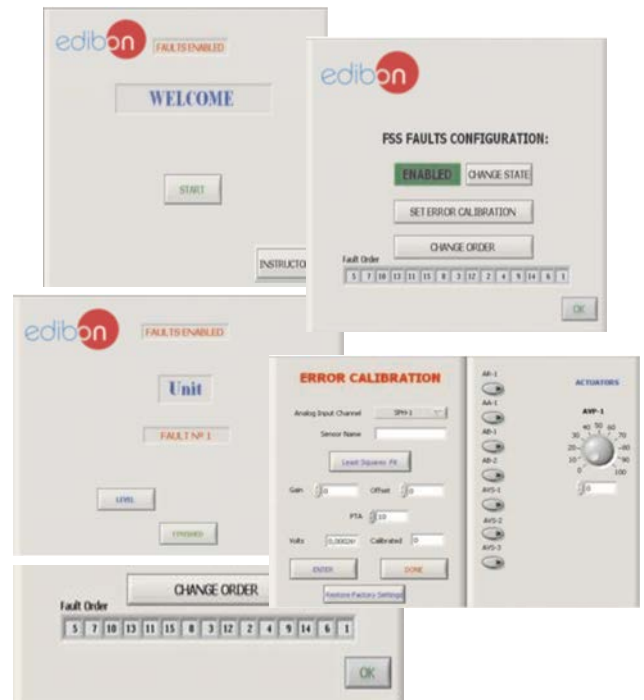
Faults in the controls execution:

- 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/en/files/expansion/FSS/catalog

b) Multipost Expansions options

⑩ 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 of 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:

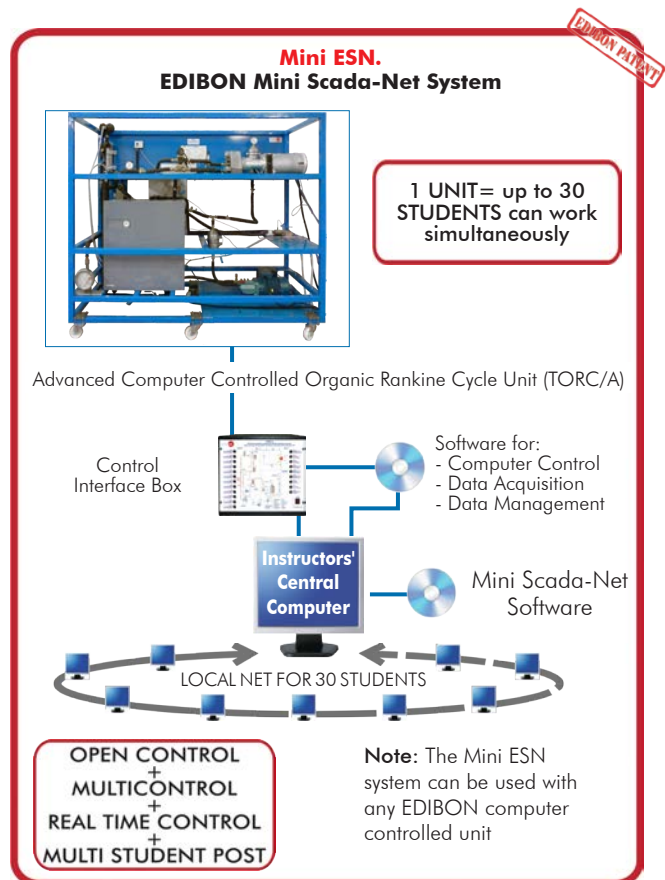
www.edibon.com/products/catalogues/en/Mini-ESN.pdf

⑪ 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/thermodynamicsthermotechnics/esn-thermodynamics/ESN-THERMODYNAMICS.pdf



ORDER INFORMATION

Main items (always included in the supply)

Minimum supply always includes:

- ① **Unit: TORC/A. Advanced Computer Controlled Organic Rankine Cycle Unit.**
- ② **TORC/A/CIB. Control Interface Box.**
- ③ **DAB. Data Acquisition Board.**
- ④ **TORC/A/CCSOF. PID Computer Control + Data Acquisition + Data Management Software.**
- ⑤ **Cables and Accessories**, for normal operation.
- ⑥ **Manuals.**

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

Optional items (supplied under specific order)

a) Technical and Vocational Education configuration

- ⑦ TORC/A/ICAL. Interactive Computer Aided Instruction Software System.
- ⑧ TORC/A/FSS. Faults Simulation System.

b) Multipost Expansions options

- ⑨ Mini ESN. EDIBON Mini Scada-Net System.
- ⑩ ESN. EDIBON Scada-Net System.

① TORC/A. Unit:

Evaporator:

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

- Safety valve calibrated to 6 Bar.
- Safety pressure switch as filling safety measure for the boiler.
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- Expansion vessel.
- Automatic feeder regulated to 1.5 Bar.
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Triple piston pump to impel the organic fluid, with power variator, computer controlled.

Scroll turbine and generator: 1 kW, 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.

Two solenoid valves.

Air purgers.

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

Sensors:

- Thirteen "J" type temperature sensors distributed along the process.
- One flow sensor to measure the cooling water flow through the condenser, range: 1.5 - 30 l/min.
- One flow sensor to measure the organic fluid flow through the circuit, range: 0.008 - 0.062 Kg/s.
- Three 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.
- One sensor to measure the power consumed by the generator.
- One sensor to measure the power consumed by the pump that impels the organic fluid.
- One 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.
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- 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/A/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/A/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 the 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, derivative 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/A unit process through the control interface box without the computer.
 - 19.-Visualization of all the sensors values used in the TORC/A unit process.
- Several other exercises can be done and designed by the user.

a) Technical and Vocational Education configuration

⑦ **TORC/A/ICAI. Interactive Computer Aided Instruction Software System.**

This complete software package consists of an Instructor Software (EDIBON Classroom Manager - ECM-SOF) totally integrated with the Student Software (EDIBON Student Labsoft - ESL-SOF). Both are interconnected so that the teacher knows at any moment what is the theoretical and practical knowledge of the students.

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).

ECM-SOF is the application that allows the Instructor to register students, manage and assign tasks for workgroups, create own content to carry out Practical Exercises, choose one of the evaluation methods to check the Student knowledge and monitor the progression related to the planned tasks for individual students, workgroups, units, etc...so the teacher can know in real time the level of understanding of any student in the classroom.

Innovative features:

- User Data Base Management.
- Administration and assignment of Workgroup, Task and Training sessions.
- Creation and Integration of Practical Exercises and Multimedia Resources.
- Custom Design of Evaluation Methods.
- Creation and assignment of Formulas & Equations.
- Equation System Solver Engine.
- Updatable Contents.
- Report generation, User Progression Monitoring and Statistics.

- ESL-SOF. EDIBON Student Labsoft (Student Software).

ESL-SOF is the application addressed to the Students that helps them to understand theoretical concepts by means of practical exercises and to prove their knowledge and progression by performing tests and calculations in addition to Multimedia Resources. Default planned tasks and an Open workgroup are provided by EDIBON to allow the students start working from the first session. Reports and statistics are available to know their progression at any time, as well as explanations for every exercise to reinforce the theoretically acquired technical knowledge.

Innovative features:

- Student Log-In & Self-Registration.
- Existing Tasks checking & Monitoring.
- Default contents & scheduled tasks available to be used from the first session.
- Practical Exercises accomplishment by following the Manual provided by EDIBON.
- Evaluation Methods to prove your knowledge and progression.
- Test self-correction.
- Calculations computing and plotting.
- Equation System Solver Engine.
- User Monitoring Learning & Printable Reports.
- Multimedia-Supported auxiliary resources.

⑧ **TORC/A/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 in 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.

b) Multipost Expansions options

⑨ **Mini ESN. EDIBON Mini Scada-Net System.**

EDIBON Mini Scada-Net System allows up to 30 students to work with a Teaching Unit in any laboratory, simultaneously.

The Mini ESN system consists of 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.

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.

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 improvement of the product.



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