

① Unit: QALFC. Computer Controlled Fixed Bed Adsorption 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**



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PRODUCTS  
↳ 11.-CHEMICAL  
ENGINEERING

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)



"Worlddidac Quality Charter" and Platinum Member of Worlddidac

## INTRODUCTION

Fixed bed adsorption processes are ubiquitous in the chemical process and other industries. Some applications are: air purification, gas dehydration, solvent or hydrocarbon vapor recovery, water purification, etc.

Fixed bed adsorption processes use a solid mass separating agent packed inside a column to effect separation of one or more components from a mixture in a gas or liquid stream as it flows through the packed bed.

The Computer Controlled Fixed Bed Adsorption Unit, "QALFC", is an adsorption column that is jacketed for the purpose of thermal control and is designed to demonstrate the gas adsorption phenomenon using a Fixed Bed Adsorption Column. In the experiments the gas mixture of carbon dioxide and helium is separated.

The overall objective of this unit is to analyze the behavior of the adsorption breakthrough and desorption elution curves associated with the separation of CO<sub>2</sub> from Helium using activated carbon. The equilibrium adsorption capacity of this activated carbon will be determined from this analysis and used to model the experimental breakthrough and elution curves.

The amount of carbon dioxide adsorbed increases with increasing CO<sub>2</sub> partial pressure and decreases with increasing temperature. A completely isothermal behavior is impossible to achieve unless the feed concentration is extremely diluted.

## GENERAL DESCRIPTION

The Computer Controlled Fixed Bed Adsorption Unit, "QALFC", is designed to demonstrate the gas adsorption phenomenon using a fixed adsorption column. The overall objective of this unit is to analyze the behavior of the adsorption breakthrough and desorption elution curves associated with the separation of CO<sub>2</sub> from Helium using activated carbon. The equilibrium adsorption capacity of this activated carbon will be determined from this analysis and used to model the experimental breakthrough and elution curves.

The gas mixture (composed by CO<sub>2</sub> and Helium) is fed from compressed gas cylinders to the column with two pressure regulators. Two flow sensors and two regulation valves are included to measure and regulate the CO<sub>2</sub> and Helium inlet flows. The lines include two flow control valves to limit the CO<sub>2</sub> and Helium flow.

The fixed bed adsorption column is jacketed for the purpose of thermal control and the adsorbent, activated carbon, is packed. Six temperature sensors with different lengths are located inside the column to measure the adsorption and desorption temperatures.

A column bypass is included for system calibration purposes. This column has two 3-way directional valves, which divert the gas stream between the fixed bed adsorption column and the bypass. A valve at the column's outlet is used to control the pressure in the circuit. This pressure is measured by a pressure sensor. The unit is protected against overpressure by a security valve.

The column is thermally controlled by hot water, which is heated by a system consisting of a thermostatic bath with a heating element and a water pump. An additional temperature sensor is located in the thermostatic bath.

The gas mixture, after passing through the column or the bypass, is divided. A part of the gas mixture passes through an infrared CO<sub>2</sub> sensor to measure the CO<sub>2</sub> concentration at the column or bypass outlet. A third flow sensor measures the flow entering the CO<sub>2</sub> sensor and a regulation valve regulates the gas mixture flow in the flow sensor. This line includes a flow control valve to limit the gas mixture flow. The rest of the gas mixture is discharge to the atmosphere.

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.

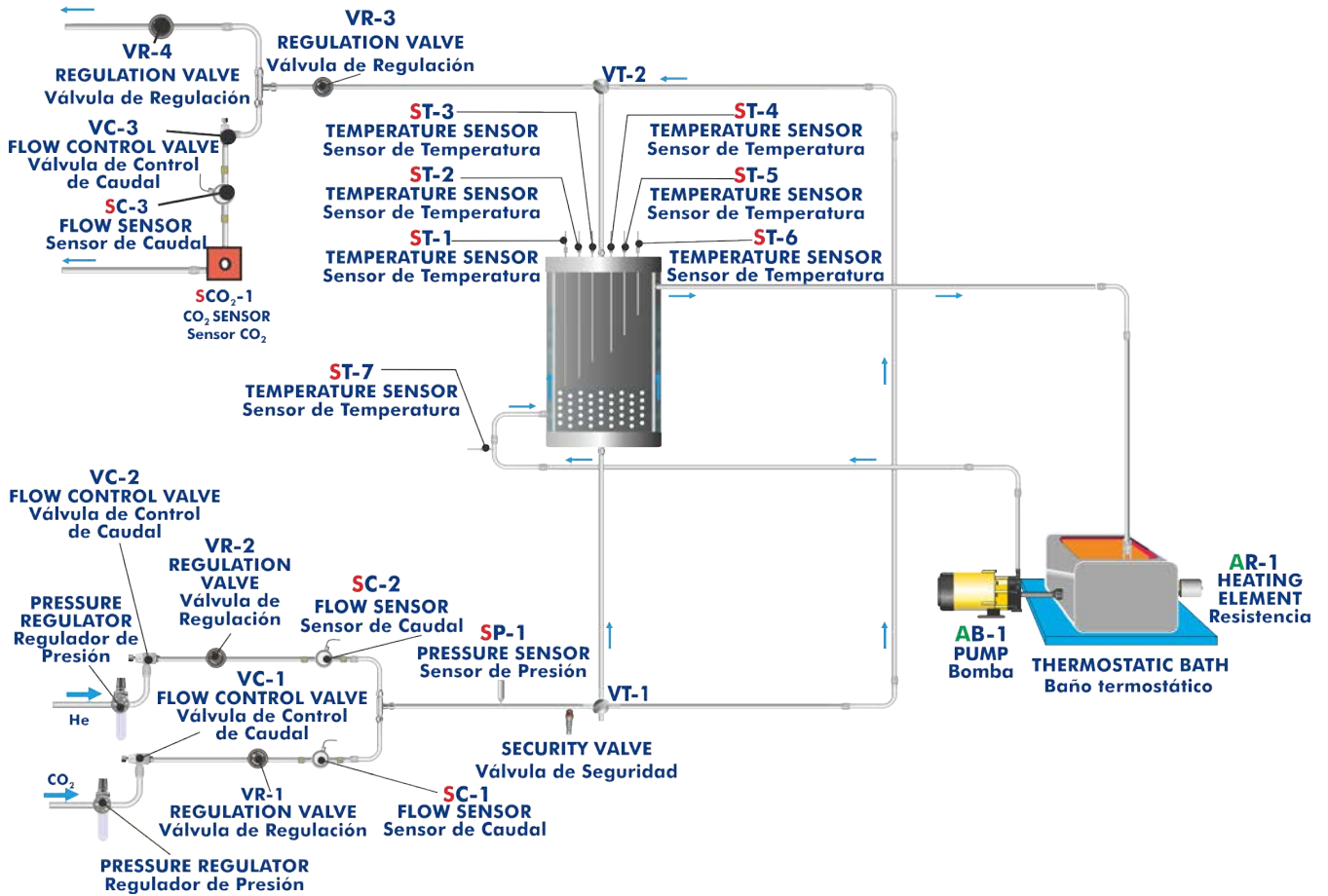


QALFC detail

## PROCESS DIAGRAM AND UNIT ELEMENTS ALLOCATION

2 actuators and 12 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, 10 and 11.

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

① **QALFC. Unit:**

Bench-top unit.

Anodized aluminum frame and panels made of painted steel.

Main metallic elements made of stainless steel.

Diagram in the front panel with distribution of the elements similar to the real one.

The unit includes:

**Two pressure regulators**, one for the Helium inlet and the other for the CO<sub>2</sub> inlet.

**Fixed bed adsorption column:**

Height: 310 mm; diameter: 80 mm.

Material: Stainless steel.

It includes:

Bed of glass beads for gas distribution, a gas distribution plate at the column inlet.

Activated carbon to study the adsorption/desorption process (the column is loaded with activated carbon, but the user can use other type, allowing the comparison of different adsorbents performance).

Jacket to maintain a certain temperature in the column (with the hot water circulation system).

Six temperature sensors, "J" type, are located along the inner side of the column. Length of temperature sensors: 280, 240, 190, 150, 100 and 60 mm.

A column bypass is included for system calibration purposes. Two 3-way directional valves which divert the gas stream between the fixed bed adsorption column and the bypass.

**Hot water circulation system**, including:

Computer controlled water pump.

Thermostatic bath with computer controlled heating element.

Maximum working temperature: 45 °C.

"J" type temperature sensor located in the thermostatic bath. This temperature sensor works with the PID controller on heating element to maintain the desired temperature inside the column.

Flexible tubing used to connect the pump to the column's jacket and the column's jacket to the thermostatic bath.

**Three flow sensors:**

Flow sensor (located at the CO<sub>2</sub> line inlet), range: 0 – 1 l/min.

Flow sensor (located at the Helium line inlet), range: 0 – 5 l/min.

Flow sensor (located at the CO<sub>2</sub> infrared sensor inlet), range: 0 – 1 l/min.

**CO<sub>2</sub> infrared sensor** measures the CO<sub>2</sub> concentration at the column outlet and the column bypass, range: 0 – 10%.

**Pressure sensor** shows the circuit pressure, range: 0 – 2 bar.

**Four regulation valves:**

Two valves regulate the CO<sub>2</sub> and Helium inlet flow.

Valve at the column and bypass outlet is used to control the pressure in the circuit.

Valve to regulate the gas flow in the CO<sub>2</sub> sensor and to discharge part of the gas stream to the atmosphere before entering the CO<sub>2</sub> sensor.

**Three fixed flow control valves:**

Two valves limit the CO<sub>2</sub> and Helium inlet flow.

Valve limits the gas stream at the inlet of the CO<sub>2</sub> sensor.



Unit: QALFC

The unit is protected against overpressure (pressure higher than 1.3 bars) with a safety valve. All electrical circuits are protected by the appropriate safety elements.

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).**

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**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.**

## ② QALFC/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.**



QALFC/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. D0 or DI Sample Clock frequency: 0 to 100 MHz.

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

The Data Acquisition board model may change at any moment, providing the same or better features than those required for the unit.



DAB

④ **QALFC/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).**

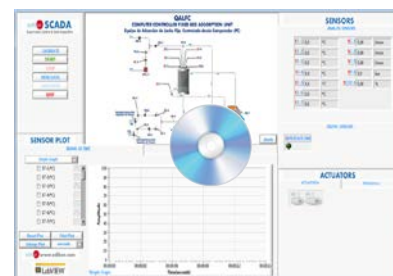
**Calibration system for the sensors involved in the process.**

**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.**



QALFC/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: QALFC + QALFC/CIB + DAB + QALFC/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.- Study of the Solute Movement Theory model described by the adsorption-desorption process.
- 2.- Study of adsorption/desorption processes under different operational conditions such as temperature, pressure, flow rate and molar fraction.
- 3.- Study of the breakthrough curves of CO<sub>2</sub> and the temperature profiles during the adsorption/desorption processes.
- 4.- Study of the quasi-isothermal regime at low concentrations and pressures. Study of the effect of these variables.
- 5.- Familiarization with the formation of the compressive and dispersive fronts in adsorption processes.
- 10.-The Computer Control System with SCADA and PID Control allow a real industrial simulation.
- 11.-This unit is totally safe as uses mechanical, electrical/electronic, and software safety devices.
- 12.-This unit can be used for doing applied research.
- 13.-This unit can be used for giving training courses to Industries even to other Technical Education Institutions.
- 14.-Control of the QALFC unit process through the control interface box without the computer.
- 15.-Visualization of all the sensors values used in the QALFC unit process.

Additional practical possibilities:

- 6.- Sensors calibration.
- 7.- Obtaining of the adsorption equilibrium isotherm of CO<sub>2</sub> from the desorption curve.

Other possibilities to be done with this Unit:

- 8.- Many students view results simultaneously.  
To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
- 9.- 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.

- 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: single-phase 200 VAC – 240 VAC/50 Hz or 110 VAC – 127 VAC/60 Hz.
- Water supply and drain.
- Computer.

\*Note: this unit should be run in a good ventilated room.

### DIMENSIONS AND WEIGHTS

QALFC:

Unit:

- Dimensions: 1100 x 670 x 700 mm approx.  
(43.30 x 26.37 x 27.55 inches approx.)
- Weight: 50 kg approx.  
(110.23 pounds approx.)

Control Interface Box:

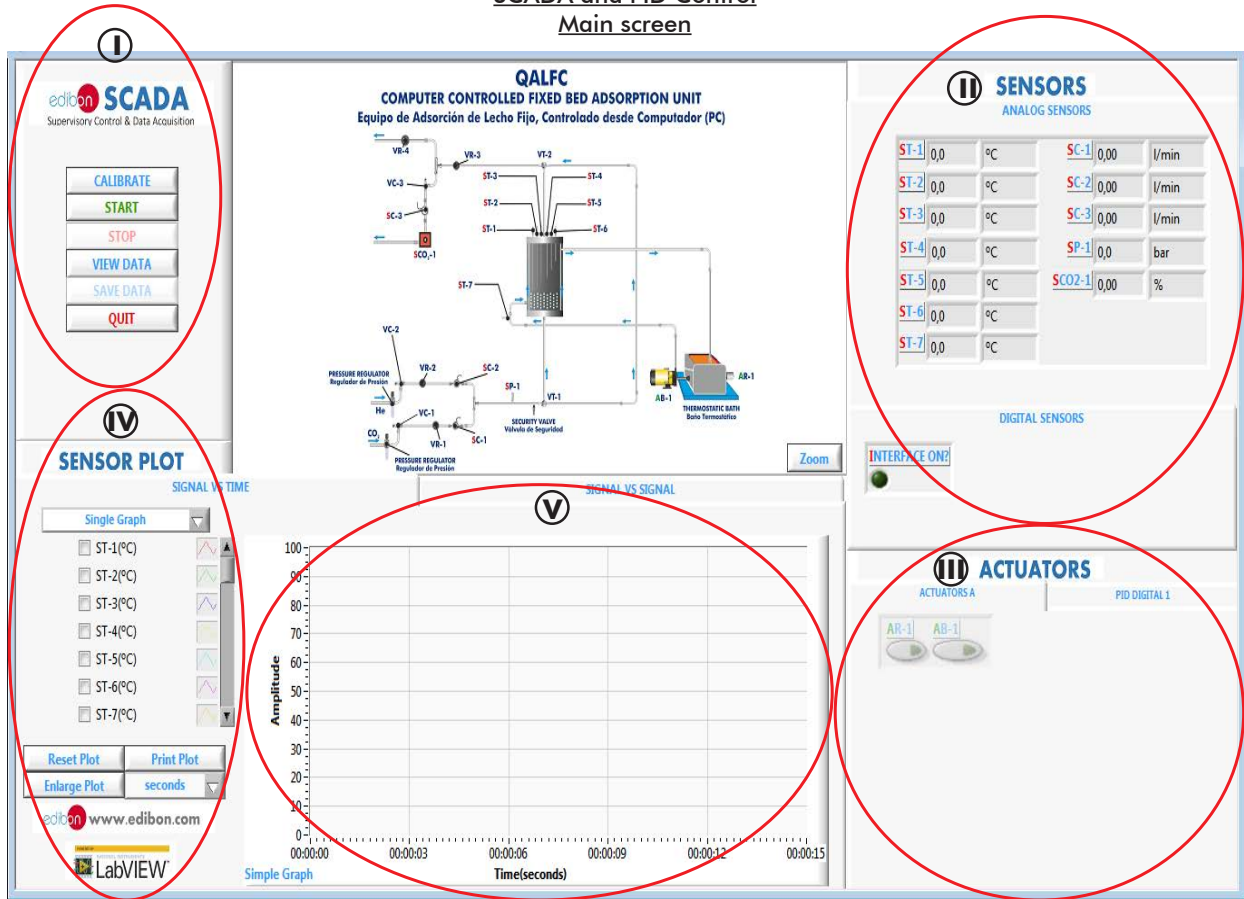
- Dimensions: 490 x 330 x 310 mm approx.  
(19.29 x 12.99 x 12.20 inches approx.)
- Weight: 10 kg approx.  
(22 pounds approx.)

### REQUIRED CONSUMABLES (Not included)

- Gases (gas cylinders):
  - CO<sub>2</sub> gas: 10 bar max.
  - Helium gas: 10 bar max.

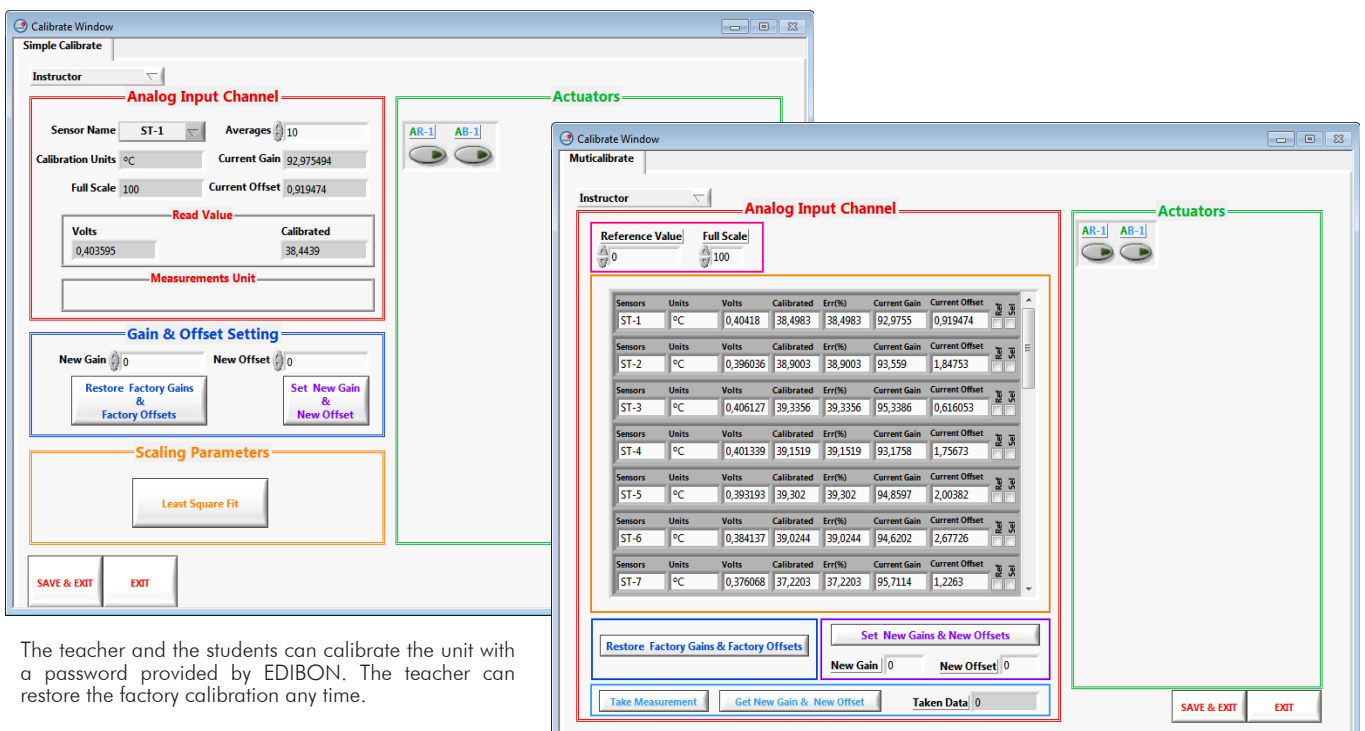
## SOFTWARE MAIN SCREENS

### 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. SP=Pressure sensor. SC=Flow sensor.  $SCO_2$ = $CO_2$  concentration.
- ❸ Actuators controls. Actuators: AR=Heating element. AB=Pump.
- ❹ Channel selection and other plot parameters.
- ❺ Real time graphics displays.

### Software for Sensors Calibration Example of screen

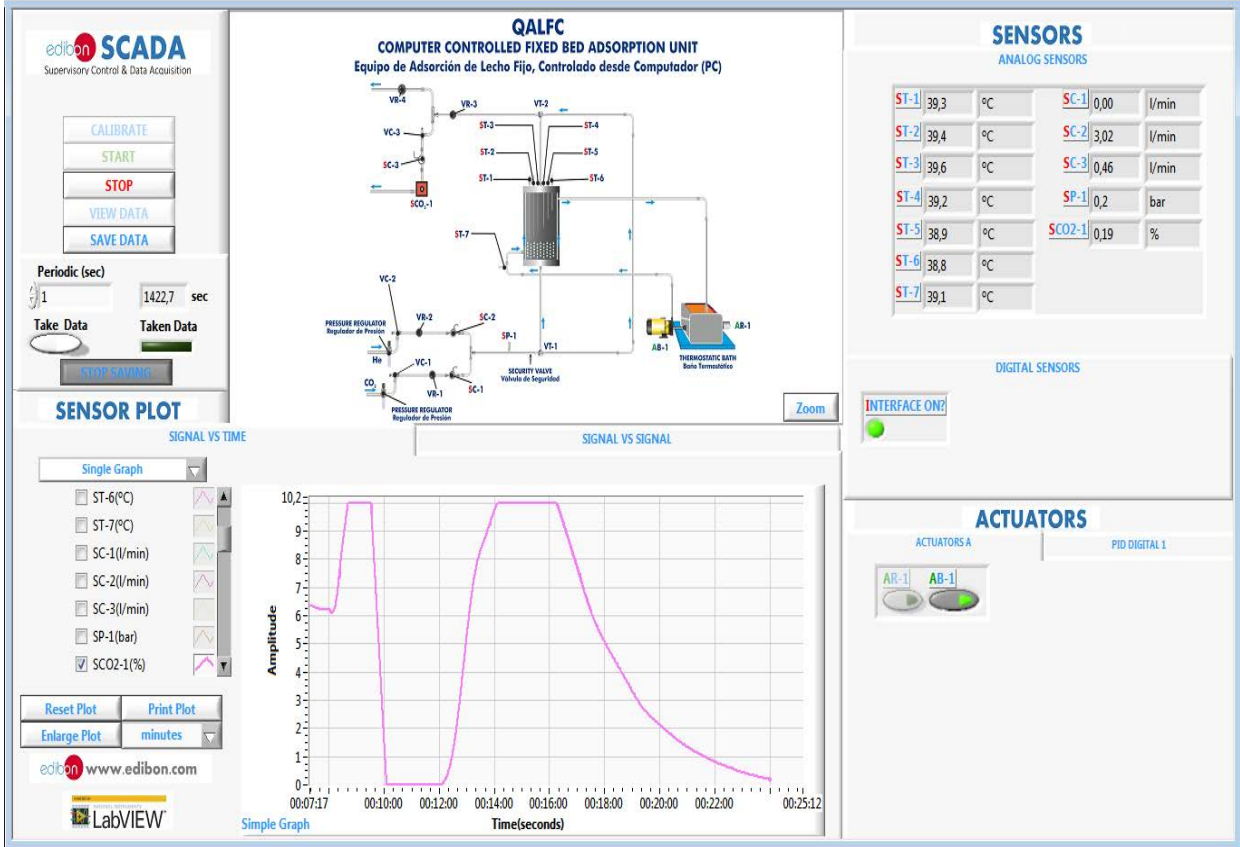


The teacher and the students can calibrate the unit with a password provided by EDIBON. The teacher can restore the factory calibration any time.

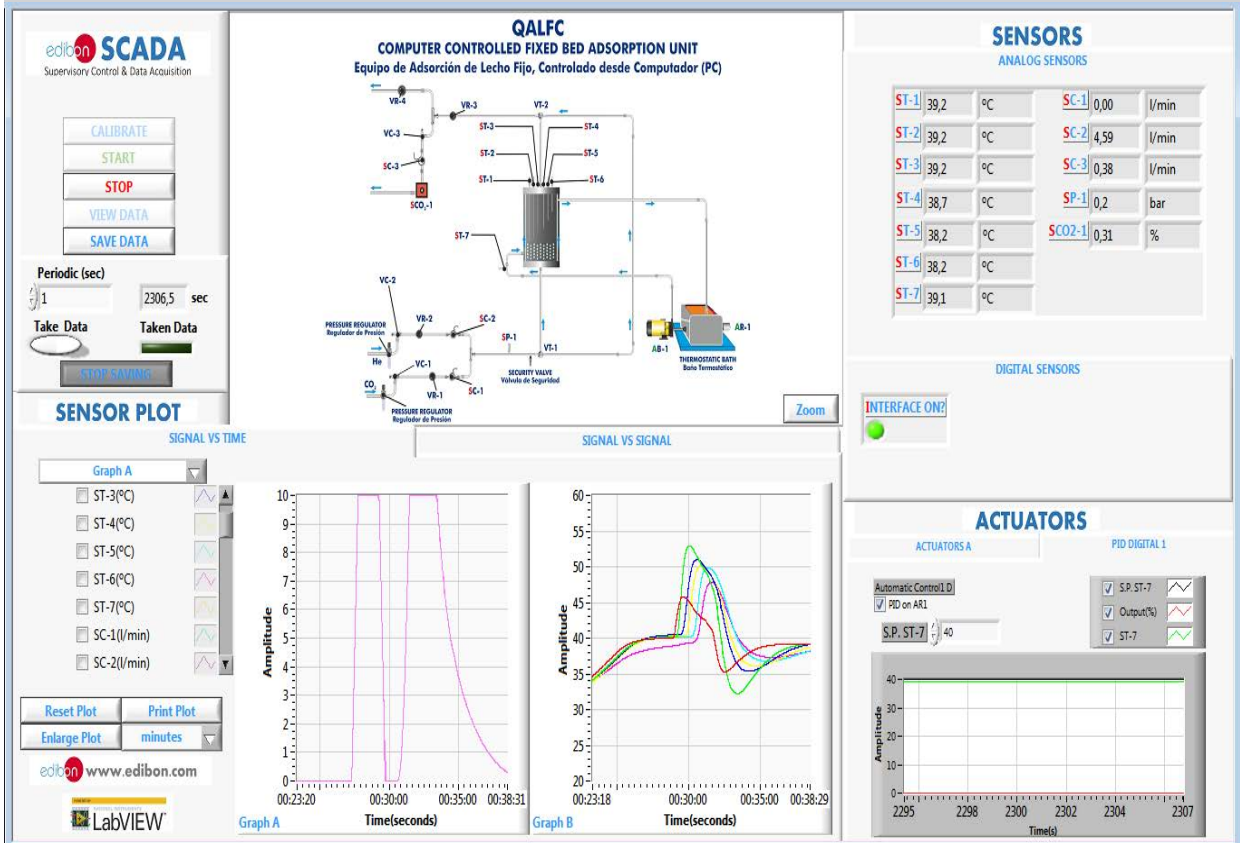


## SOME REAL RESULTS OBTAINED FROM THIS UNIT

Representation in real time of the measured magnitudes. Graph for visualization of the evolution of CO<sub>2</sub> concentration.

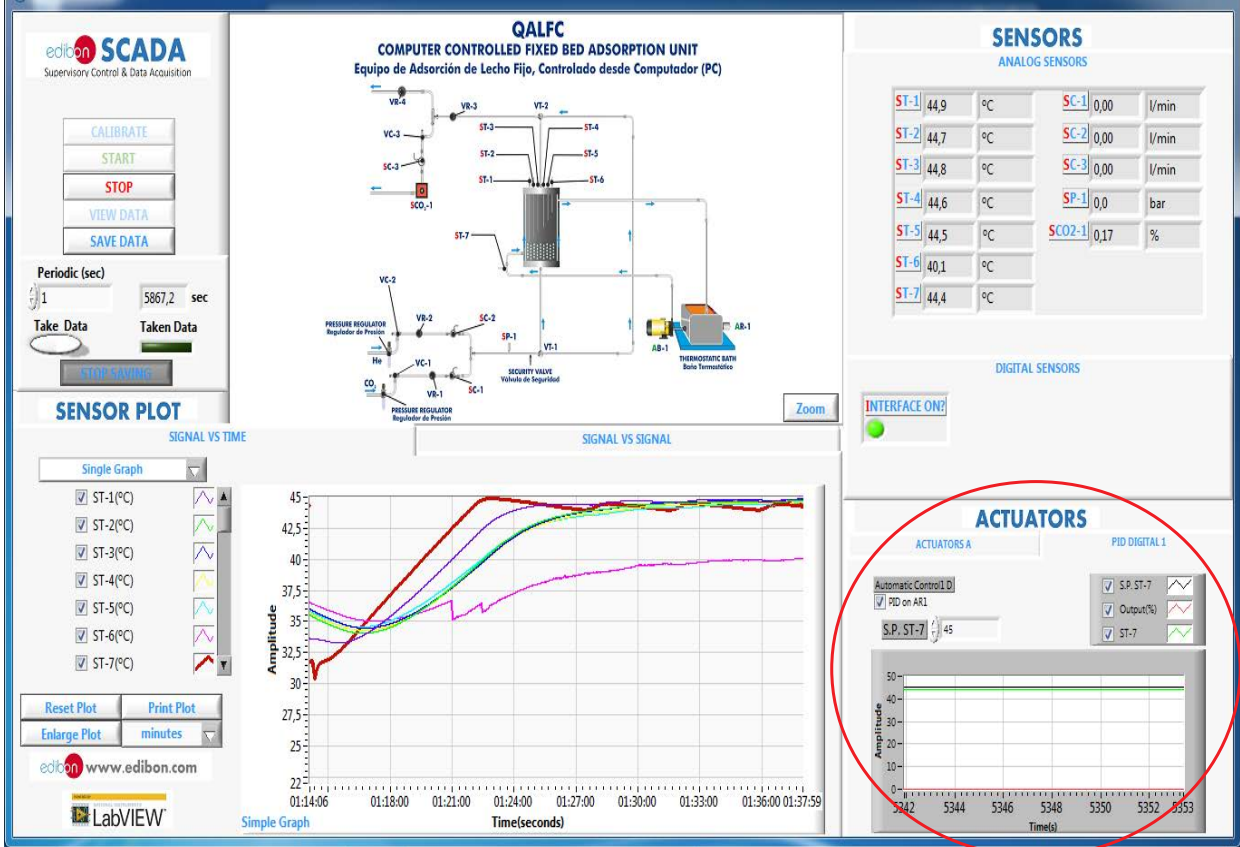


Representation in real time of the measured magnitudes. Two graphs for the visualization of the evolution of the CO<sub>2</sub> concentration and the temperatures along the interior of the adsorption column.

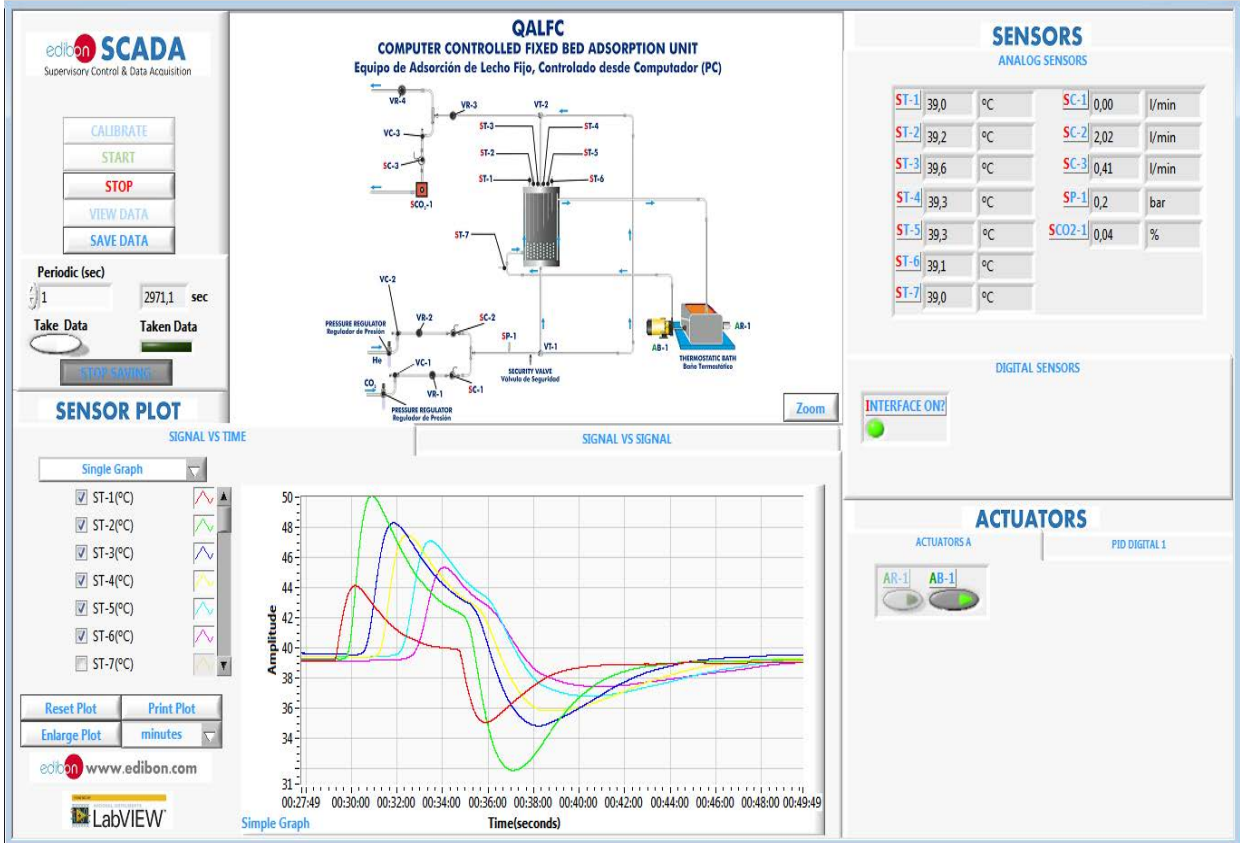


Some **real** results obtained from this Unit

Heating temperature control is done through a PID control. When the target temperature is reached at the temperature sensor (ST-7), the heating element is turned off.

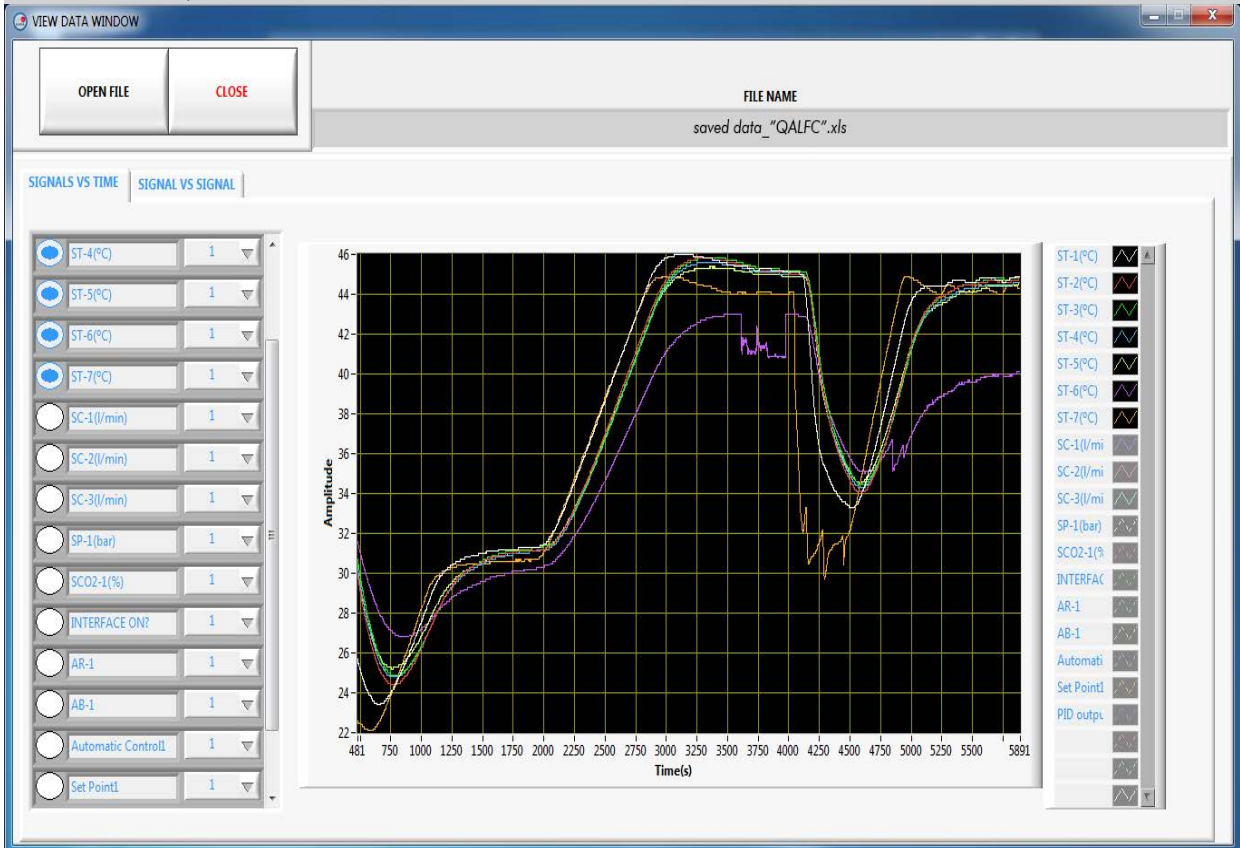


Representation in real time of the measured magnitudes. Graph for visualization of the evolution of temperatures along the interior of the absorption column.

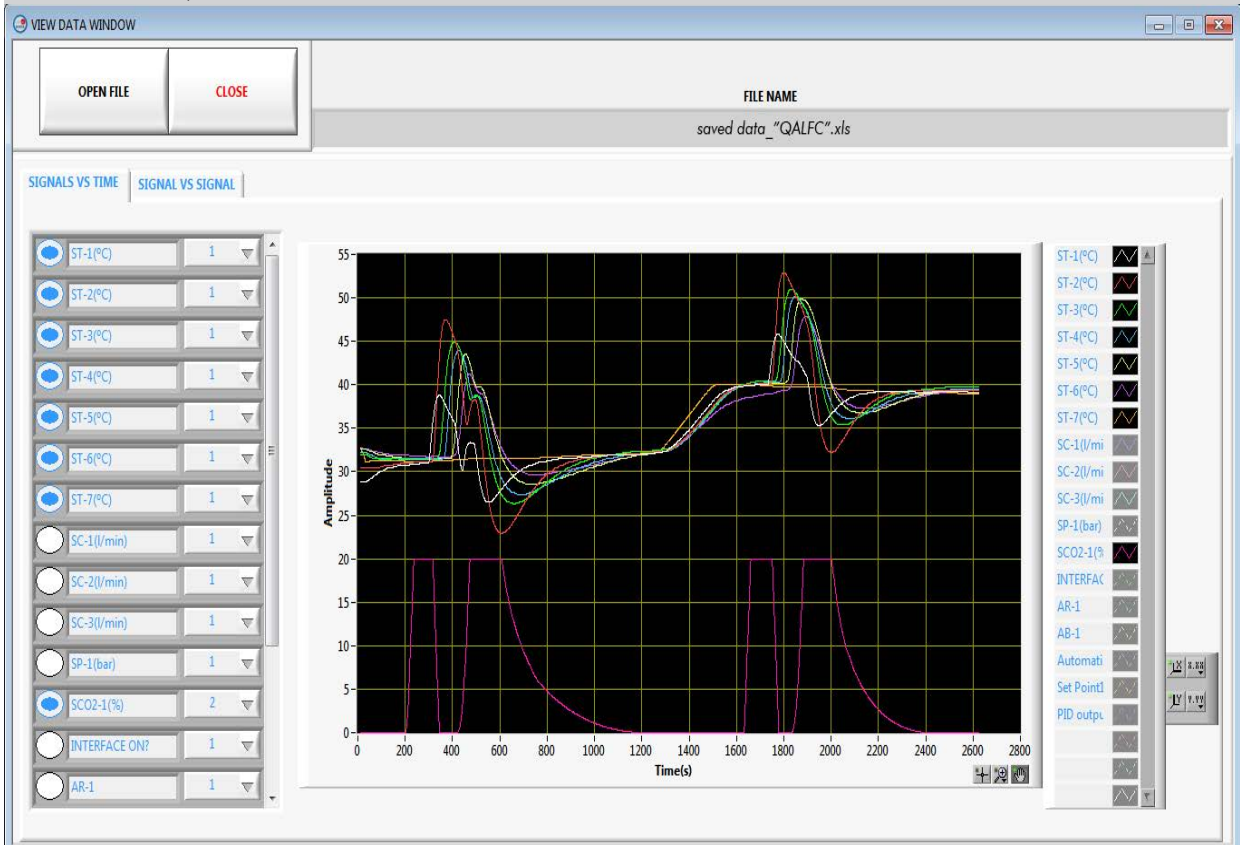


Some **real** results obtained from this Unit

Visualization and representation of saved data.



Visualization and representation of saved data.



## 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 11.

All these items try to give more possibilities for:

- a) Industrial configuration. (PLC)
- b) Technical and Vocational Education configuration. (ICAI and FSS)
- c) 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** (-10 V. to + 10 V.) (through SCSI connector).

##### **Analog outputs block:**

**4 Analog outputs** (-10 V. to + 10 V.) (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  $\mu$ sec.** 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.**

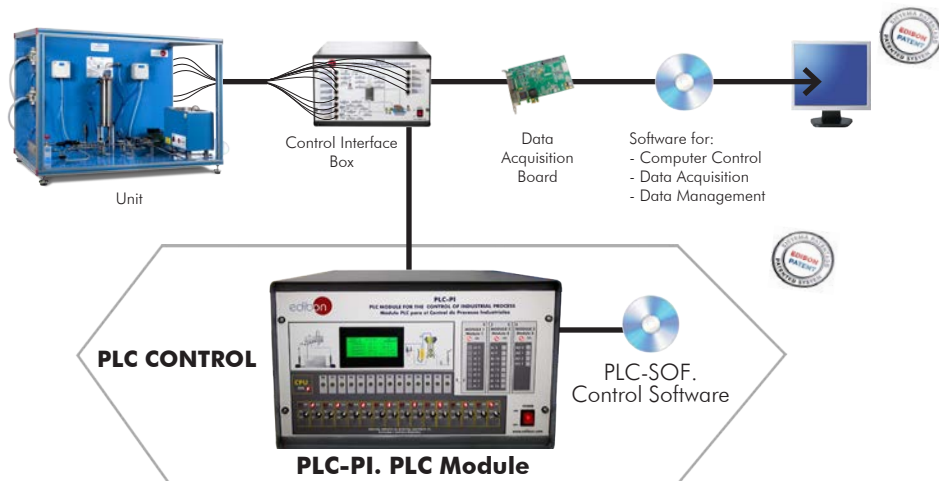
Communication RS232 wire to computer (PC).

Dimensions: 490 x 330 x 310 mm. approx. (19.29 x 12.99 x 12.20 inches approx.). Weight: 30 Kg. approx. (66 pounds approx.).

##### **-QALFC/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 Fixed Bed Adsorption Unit (QALFC).



#### Practices to be done with PLC-PI:

- 1.- Control of the particular unit process through the control interface box without the computer.
- 2.- Visualization of all the sensors values used in the particular unit process.
- 3.- Calibration of all sensors included in the particular unit process.
- 4.- Hand on of all the actuators involved in the particular unit process.
- 5.- Realization of different experiments, in automatic way, without having in front the particular unit. (These experiments can be decided previously).
- 6.- Simulation of outside actions, in the cases do not exist hardware elements. (Example: test of complementary tanks, complementary industrial environment to the process to be studied, etc).
- 7.- PLC hardware general use.
- 8.- PLC process application for the particular unit.
- 9.- PLC structure.
- 10.- PLC inputs and outputs configuration.
- 11.- PLC configuration possibilities.
- 12.- PLC program languages.
- 13.- PLC different programming standard languages (ladder diagram (LD), structured text (ST), instructions list (IL), sequential function chart (SFC), function block diagram (FBD)).
- 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 particular unit process.
- 17.- Possibility of creating new process in relation with the particular unit.
- 18.- PLC Programming Exercises.
- 19.- Own PLC applications in accordance with teacher and student requirements.

b) Technical and Vocational Education configuration

⑧ **QALFC/ICAI. Interactive Computer Aided Instruction Software.**

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](http://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

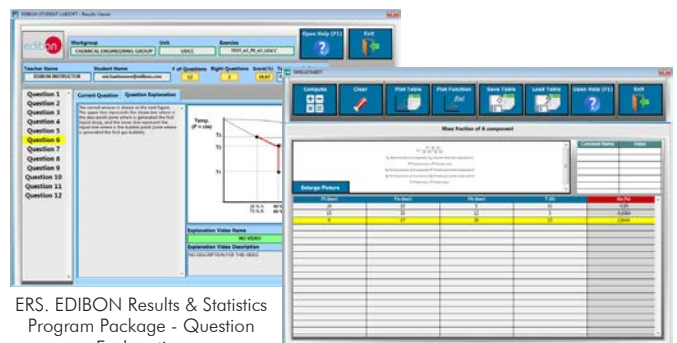
ETTE. EDIBON Training Test & Exam Program Package - Main Screen with Numeric Result Question

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 **QALFC/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.

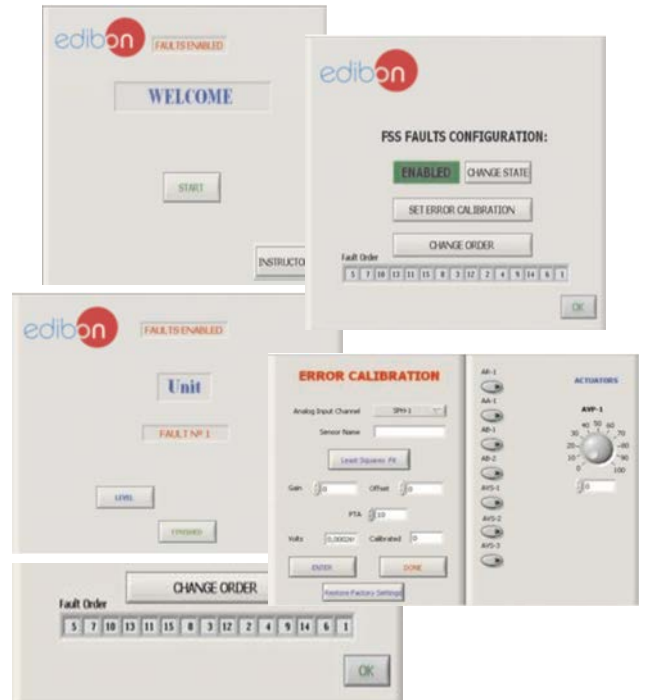
Faults in the controls execution:

- 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](http://www.edibon.com/en/files/expansion/FSS/catalog)

c) Multipost Expansions options

⑩ **MINI ESN. EDIBON Mini Scada-Net System for being used with EDIBON Teaching Units.**

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:

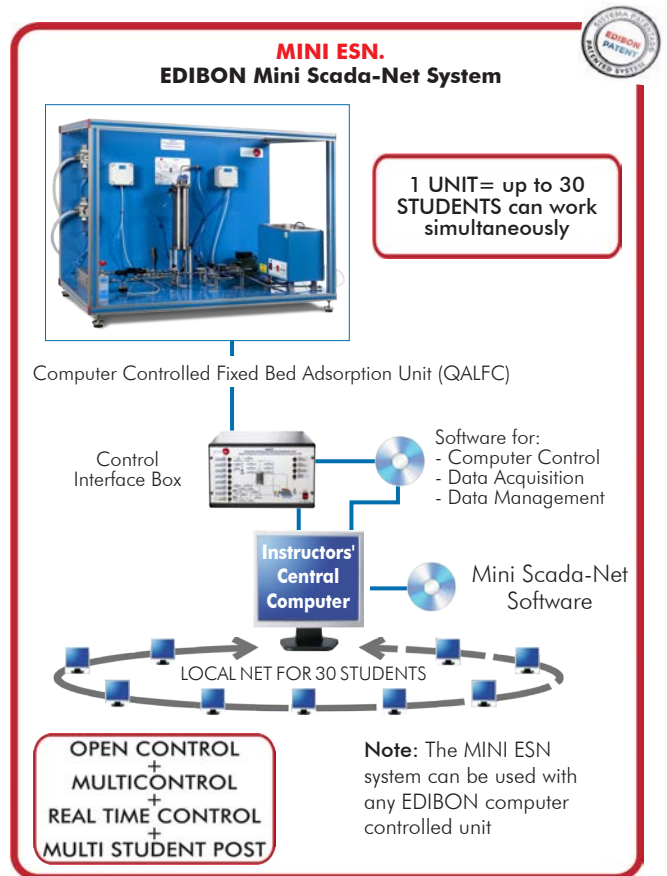
[www.edibon.com/en/files/expansion/MINI-ESN/catalog](http://www.edibon.com/en/files/expansion/MINI-ESN/catalog)

⑪ **ESN. EDIBON Scada-Net Systems.**

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/en/files/expansion/ESN/catalog](http://www.edibon.com/en/files/expansion/ESN/catalog)



## ORDER INFORMATION

### **Main items** (always included in the supply)

Minimum supply always includes:

- ① **Unit: QALFC. Computer Controlled Fixed Bed Adsorption Unit.**
- ② **QALFC/CIB. Control Interface Box.**
- ③ **DAB. Data Acquisition Board.**
- ④ **QALFC/CCSOF. PID Computer Control + Data Acquisition + Data Management Software.**
- ⑤ **Cables and Accessories**, for normal operation.
- ⑥ **Manuals.**

\***IMPORTANT:** Under QALFC 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.
  - QALFC/PLC-SOF. PLC Control Software.

#### b) Technical and Vocational Education configuration

- ⑧ QALFC/ICAI. Interactive Computer Aided Instruction Software.
- ⑨ QALFC/FSS. Faults Simulation System.

#### c) Multipost Expansions options

- ⑩ MINI ESN. EDIBON Mini Scada-Net System for being used with EDIBON Teaching Units.
- ⑪ ESN. EDIBON Scada-Net Systems.

**① QALFC. Unit:**

Bench-top unit.  
Anodized aluminum frame and panels made of painted steel.  
Main metallic elements made of stainless steel.  
Diagram in the front panel with distribution of the elements similar to the real one.  
The unit includes:

**Two pressure regulators**, one for the Helium inlet and the other for the CO<sub>2</sub> inlet.

**Fixed bed adsorption column:**

Height: 310 mm; diameter: 80 mm.  
Material: Stainless steel.  
It includes:

Bed of glass beads for gas distribution, a gas distribution plate at the column inlet.  
Activated carbon to study the adsorption/desorption process (the column is loaded with activated carbon, but the user can use other type, allowing the comparison of different adsorbents performance).  
Jacket to maintain a certain temperature in the column (with the hot water circulation system).  
Six temperature sensors, "J" type, are located along the inner side of the column. Length of temperature sensors: 280, 240, 190, 150, 100 and 60 mm.  
A column bypass is included for system calibration purposes. Two 3-way directional valves which divert the gas stream between the fixed bed adsorption column and the bypass.

**Hot water circulation system**, including:

Computer controlled water pump.  
Thermostatic bath with computer controlled heating element.  
Maximum working temperature: 45 °C.  
"J" type temperature sensor located in the thermostatic bath. This temperature sensor works with the PID controller on heating element to maintain the desired temperature inside the column.  
Flexible tubing used to connect the pump to the column's jacket and the column's jacket to the thermostatic bath.

**Three flow sensors:**

Flow sensor (located at the CO<sub>2</sub> line inlet), range: 0 – 1 l/min.  
Flow sensor (located at the Helium line inlet), range: 0 – 5 l/min.  
Flow sensor (located at the CO<sub>2</sub> infrared sensor inlet), range: 0 – 1 l/min.

**CO<sub>2</sub> infrared sensor** measures the CO<sub>2</sub> concentration at the column outlet and the column bypass, range: 0 – 10%.

**Pressure sensor** shows the circuit pressure, range: 0 – 2 bar.

**Four regulation valves:**

Two valves regulate the CO<sub>2</sub> and Helium inlet flow.  
Valve at the column and bypass outlet is used to control the pressure in the circuit.  
Valve to regulate the gas flow in the CO<sub>2</sub> sensor and to discharge part of the gas stream to the atmosphere before entering the CO<sub>2</sub> sensor.

**Three fixed flow control valves:**

Two valves limit the CO<sub>2</sub> and Helium inlet flow.  
Valve limits the gas stream at the inlet of the CO<sub>2</sub> sensor.

The unit is protected against overpressure (pressure higher than 1.3 bars) with a safety valve. All electrical circuits are protected by the appropriate safety elements.

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.

**② QALFC/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.  
The Data Acquisition board model may change at any moment, providing the same or better features than those required for the unit.

**④ QALFC/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.- Study of the Solute Movement Theory model described by the adsorption-desorption process.
- 2.- Study of adsorption/desorption processes under different operational conditions such as temperature, pressure, flow rate and molar fraction.
- 3.- Study of the breakthrough curves of CO<sub>2</sub> and the temperature profiles during the adsorption/desorption processes.
- 4.- Study of the quasi-isothermal regime at low concentrations and pressures. Study of the effect of these variables.
- 5.- Familiarization with the formation of the compressive and dispersive fronts in adsorption processes.

Additional practical possibilities:

- 6.- Sensors calibration.
- 7.- Obtaining of the adsorption equilibrium isotherm of CO<sub>2</sub> from the desorption curve.

Other possibilities to be done with this Unit:

- 8.- Many students view results simultaneously.

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

- 9.- 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.

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

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

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

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

14.-Control of the QALFC unit process through the control interface box without the computer.

15.-Visualization of all the sensors values used in the QALFC unit process.

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

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

## TENDER SPECIFICATIONS (for optional items)

### 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  $\mu$ sec. Program capacity of 32 Ksteps. High-speed counter. Multi-point PID control.

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

##### **-QALFC/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 particular unit process through the control interface box without the computer.
- 2.- Visualization of all the sensors values used in the particular unit process.
- 3.- Calibration of all sensors included in the particular unit process.
- 4.- Hand on of all the actuators involved in the particular unit process.
- 5.- Realization of different experiments, in automatic way, without having in front the particular unit. (These experiments can be decided previously).
- 6.- Simulation of outside actions, in the cases do not exist hardware elements. (Example: test of complementary tanks, complementary industrial environment to the process to be studied, etc).
- 7.- PLC hardware general use.
- 8.- PLC process application for the particular unit.
- 9.- PLC structure.
- 10.- PLC inputs and outputs configuration.
- 11.- PLC configuration possibilities.
- 12.- PLC program languages.
- 13.- PLC different programming standard languages (ladder diagram (LD), structured text (ST), instructions list (IL), sequential function chart (SFC), function block diagram (FBD)).
- 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 particular unit process.
- 17.- Possibility of creating new process in relation with the particular unit.
- 18.- PLC Programming Exercises.
- 19.- Own PLC applications in accordance with teacher and student requirements.

### b) Technical and Vocational Education configuration

#### ⑧ **QALFC/ICAL. Interactive Computer Aided Instruction Software.**

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.

⑨ **QALFC/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.

c) Multipost Expansions options

⑩ **MINI ESN. EDIBON Mini Scada-Net System for being used with EDIBON Teaching Units.**

MINI ESN. 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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