Computer Controlled **Flow of Compressible Fluids Unit,** with SCADA

HFCC

EDIBON PATENT

Teaching Technique used

EDIBON **SCADA** System

① Unit: HFCC. Computer Controlled Flow of Compressible Fluids Unit

② Control Interface Box

③ Data Acquisition Board

④ Software for:
- Computer Control
- Data Acquisition
- Data Management

Computer (not included in the supply)

⑤ Cables and Accessories

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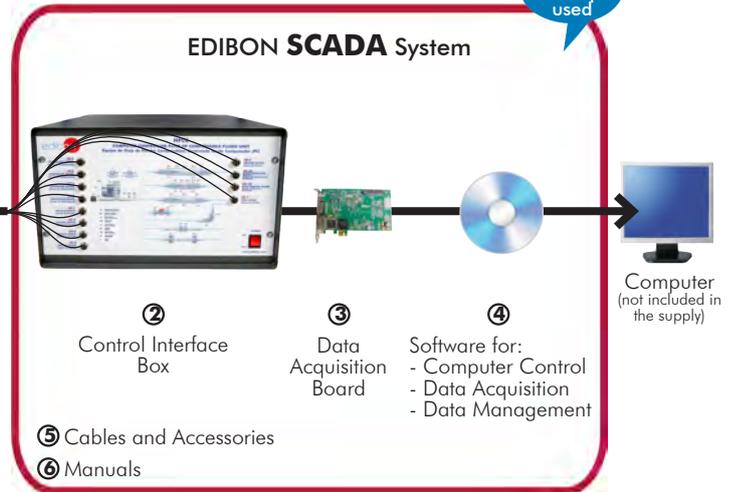
* Minimum supply always includes: 1 + 2 + 3 + 4 + 5 + 6
(Computer not included in the supply)

Key features:

➢ **Advanced Real-Time SCADA.**

➢ **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
↳80.- FLUID MECHANICS

For more information about Key Features, click here

INTRODUCTION

Fluid mechanics is the branch of physics that studies the motion of fluids (gases and liquids) as well as the forces that cause it, applying the main principles of mechanics. The fluids are classified as incompressible or compressible fluids according to its density variation.

When a fluid moves at a certain velocity it suffers an acceleration or deceleration, density changes are occurred and, at the same time, these changes in the pressure of the fluid are related to the density changes. This type of flow is known as compressible flow.

The Computer Controlled Flow of Compressible Fluids Unit, "HFCC", allows to study the variation of pressure and density, the speeds of the fluid, the different fluctuations that the fluid presents when fluids across different sections in a pipe, and the thermodynamics and fluid dynamics characteristics that the fluid has.

GENERAL DESCRIPTION

The air enters by the intake tube, where there is a dust filter. It provides a current free of particles in suspension and other substances dragged by air.

After the filter, the flow is measured with a Pitot tube installed in the pipe.

After the air is impelled by the turbine, it leaves this device through a straight pipe that includes a safety relief valve, a thermocouple that measures the outlet temperature and a static pressure manometer that measures pressure in the wall of the tube.

There is a quick-release fitting at the outlet of the exhaust pipe to connect the different accessories of the unit.

This unit allows for studying different flow situations:

Abrupt widening.

Venturi tube.

Ball valve.

Bend of 90°.

Orifice plate.

Straights pipes sections.

Laval nozzle.
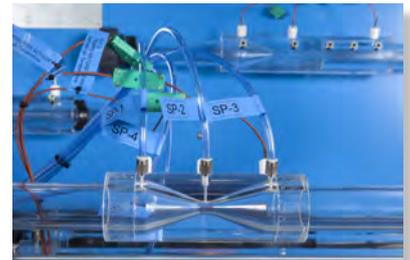
To analyze the different parameters studied, all accessories have the connections for the instrumentation included.

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.

HFCC detail

PROCESS DIAGRAM AND UNIT ELEMENTS ALLOCATION
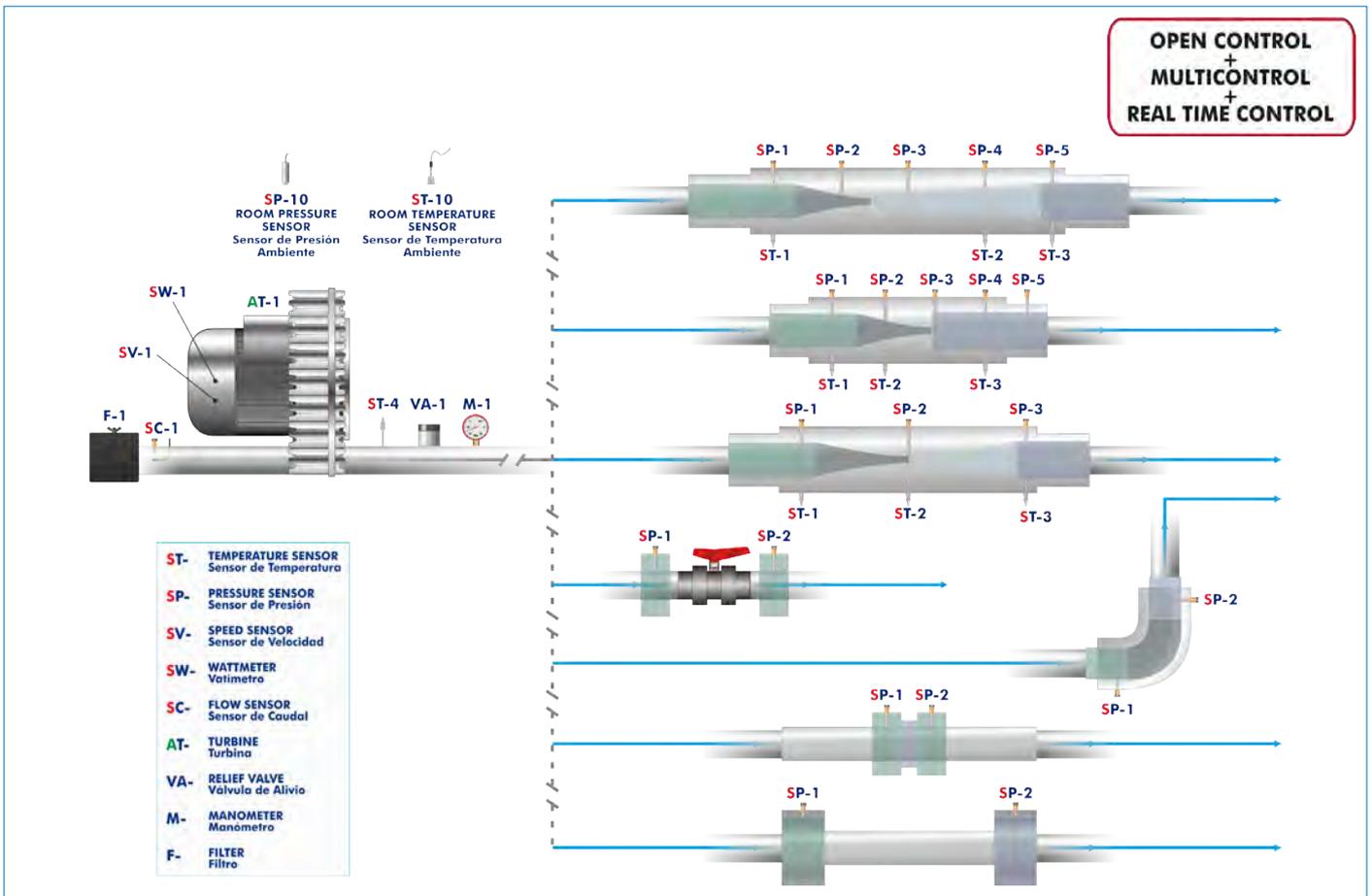
With this unit there are several options and possibilities:
- Main items: 1, 2, 3, 4, 5 and 6.
- Optional items: 7, 8, 9, 10 and 11.
Let us describe first the main items (1 to 6):

① **HFCC. 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.
<u>Double-stage side-channel turbine</u>:
    Power: 2.2 kW.
    Maximum flow rate: 120 m³/h.
    Maximum pressure: 460 mbar.
    Inlet filter.
<u>Accessories</u>:
    Abrupt widening:
        Length: 200 mm.
        Inner diameter of the wide section: 32 mm.
        Inner diameter of the narrow section: 8 mm.
        Five pressure intakes.
        Three type "T" thermocouple.
    Venturi tube:
        Length: 160 mm.
        Inner diameter of the wide section: 32 mm.
        Inner diameter of the narrow section: 8 mm.
        Three pressure intakes.
        Three type "T" thermocouple.
    Ball valve:
        Inner diameter: 32 mm.
        Two pressure intakes.
    Bend of 90°:
        Inner diameter: 32 mm.
        Two pressure intakes.
    Orifice plate:
        Interchangeable plate with orifice: 12, 16, 18, 24 mm.
        Inner diameter: 32 mm.
        Two pressure intakes.
    Straights pipes sections:
        Two pressure intakes.
        Length: 550 mm.
        Inner diameter: 30, 32, 34 mm.
    Laval nozzle:
        Length: 250 mm.
        Inner diameter of the wide section: 32 mm.
        Inner diameter of the narrow section: 8 mm.
        Five pressure intakes.
        Three type "T" thermocouple.
<u>Instrumentation</u>:
    Flow sensor: Pitot tube.
    "T" type temperature sensor at outlet of the turbine.
    "J" type atmospheric temperature sensor.
    Five pressure sensor to measure in differents points of the accessories, range: 0 - 15 PSI.
    Atmospheric pressure sensor, range: 0 1 PSI.
    Pressure gauge at outlet of the turbine, range: 0 - 1 Bar.
    Turbine speed and power measurement.
The unit is supplied with the **required safety devices**: safety googles and hearing protection.
The complete unit includes as well:
    Advanced Real-Time SCADA.
    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: HFCC

② HFCC/CIB. Control Interface Box:

The Control Interface Box is part of the SCADA system.

<u>Control interface box with process diagram in the front panel</u> 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 computer control with flexibility of modifications from the computer keyboard of the parameters, at any moment during the process.

Real time computer control for pumps, compressors, heating elements, control valves, etc.

Real time computer control for parameters involved in the process simultaneously.

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.

HFCC/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: <u>250 KS/s (kilo samples per second)</u>.

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 HFCC/CCSOF. 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.

Management, processing, comparison and storage of data.

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

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.
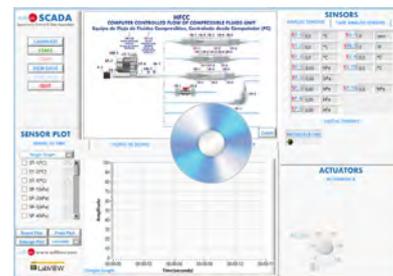
HFCC/CCSOF

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: HFCC + HFCC/CIB + DAB + HFCC/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.- Determination of pressure drops in straight pipe sections.
2.- Study of the relationship between velocity and pressure drops in a straight pipe section.
3.- Determination of pressure drops in a pipe with a bend of 90°.
4.- Determination of pressure drops in an abrupt widening.
5.- Determination of pressure drops in a Venturi tube.
6.- Introduction to supersonic flow in convergent-divergent geometry nozzles.
7.- Determination of pressure drops through an orifice plate with different interchangeable sections.
8.- Determination of the mass flow rate through an orifice plate with different interchangeable sections.
9.- Determination of the characteristic curve of the compressor with the ball valve.

Other practical possibilities:

10.-Study of pressure recovery after an abrupt widening.
11.-Friction coefficient change with Reynolds number.
12.-Study of the friction coefficient for compressible flow.
13.-Determination of the mass flow with the study sections.
14.-Use of the energy balance in the compressor.
15.-Study of the characteristics of the compressor: pressure, flow, efficiency and power.
16.-Observing the generation of shock waves inside a Laval nozzle.
17.-Determination of the air pressure in a convergent-divergent section.
18.-Study of the compressibility effect on the fluid equations.
19.-Determination of the speed of sound in the air.

20.-Sensors calibration.

Other possibilities to be done with this Unit:

21.-Many students view results simultaneously.
   To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
22.-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.
23.-The Computer Control System with SCADA allows a real industrial simulation.
24.-This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
25.-This unit can be used for doing applied research.
26.-This unit can be used for giving training courses to Industries even to other Technical Education Institutions.
27.-Control of the HFCC unit process through the control interface box without the computer.
28.-Visualization of all the sensors values used in the HFCC 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: single phase, 220V./50 Hz. or 110V./60 Hz.
- Computer.

DIMENSIONS AND WEIGHTS

HFCC:
   Unit:
      -Dimensions: 1600 x 740 x 740 mm approx.
                   (62.99 x 29.13 x 29.13 inches approx.)
      -Weight: 115 Kg approx.
                   (253 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.).

SCADA
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. SV=Speed sensor. SW=Wattmeter.

Ⓘ Actuators controls. **Actuators:** AT=Turbine.

Ⓘ Channel selection and other plot parameters.

Ⓥ 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.

Selection screen of components.
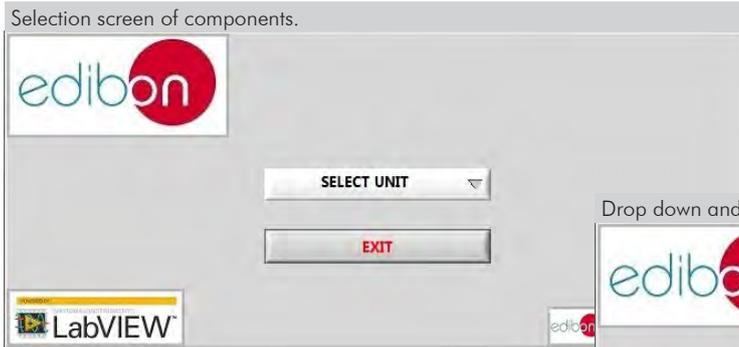
Drop down and intuitive selection.
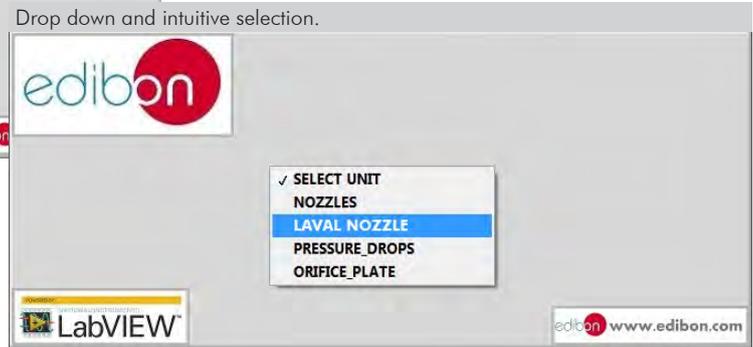
Real-time representation of different magnitudes. Representation of air pressure at the inlet and outlet of the orifice plate.
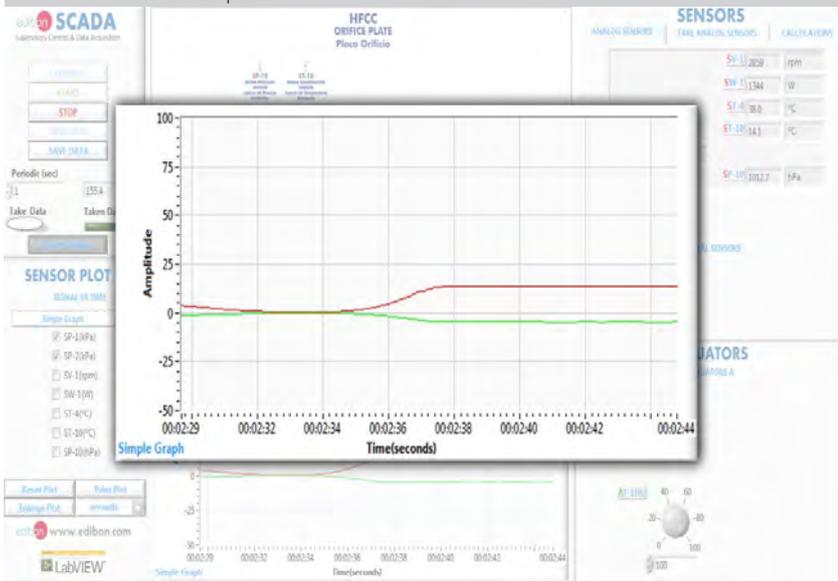
Real-time representation of different magnitudes. Representation in two charts of the air pressure in the narrow section and the outlet of the Laval nozzle.
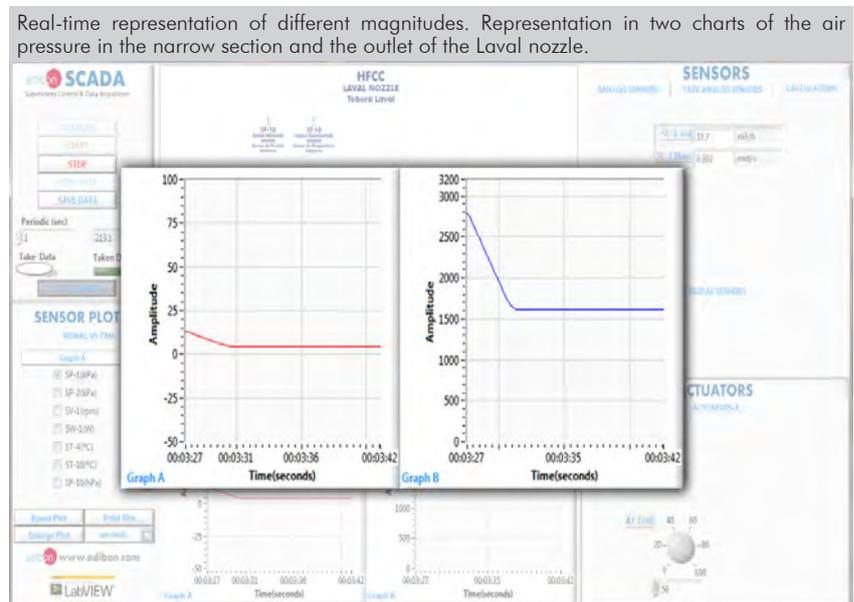
Some **real** results obtained from this Unit

Study and representation of different variables. Pressure drops in a bend of 90° against turbine power.
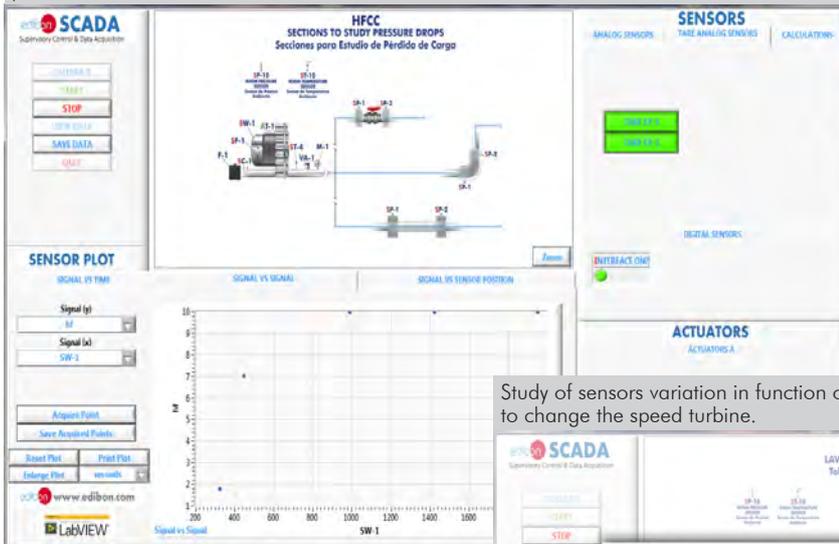
Study of sensors variation in function of the position in the nozzle. The turbine actuator allows to change the speed turbine.
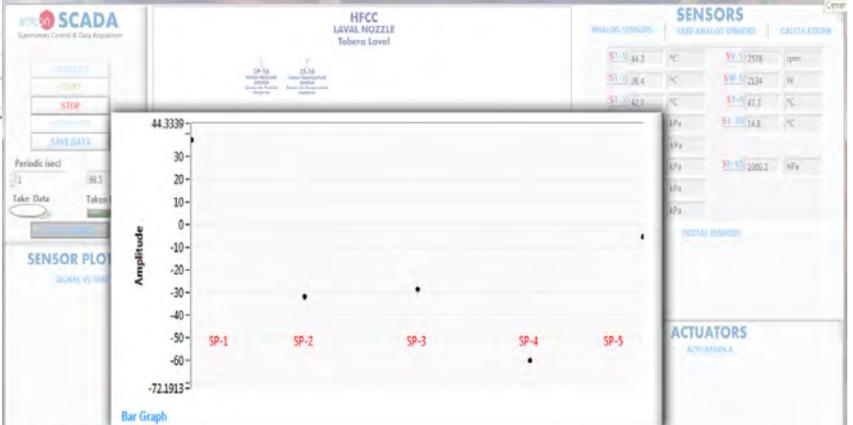
Study of speed and shock wave generation in the Laval nozzle. Calculation of the flow rate entering the accessory and the speed through that section.
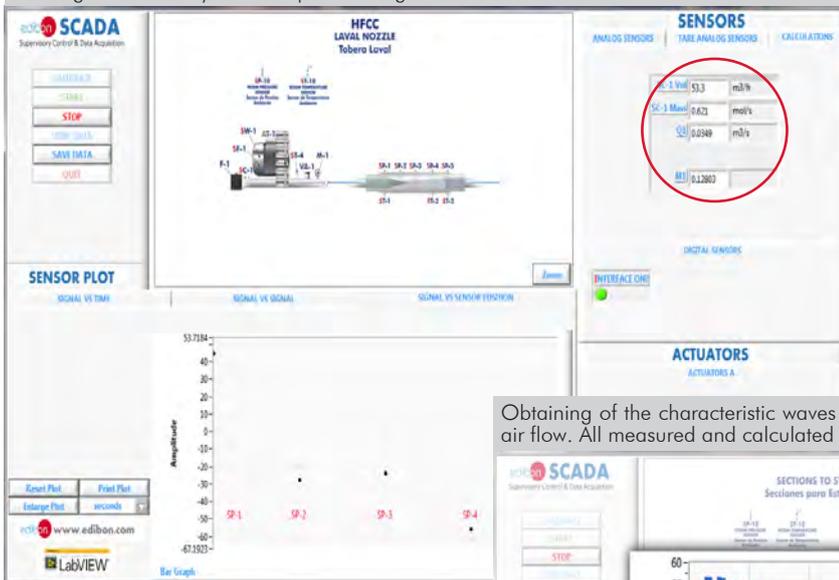
Obtaining of the characteristic waves of the turbine: representation of pressure drops versus air flow. All measured and calculated variables may be represented.
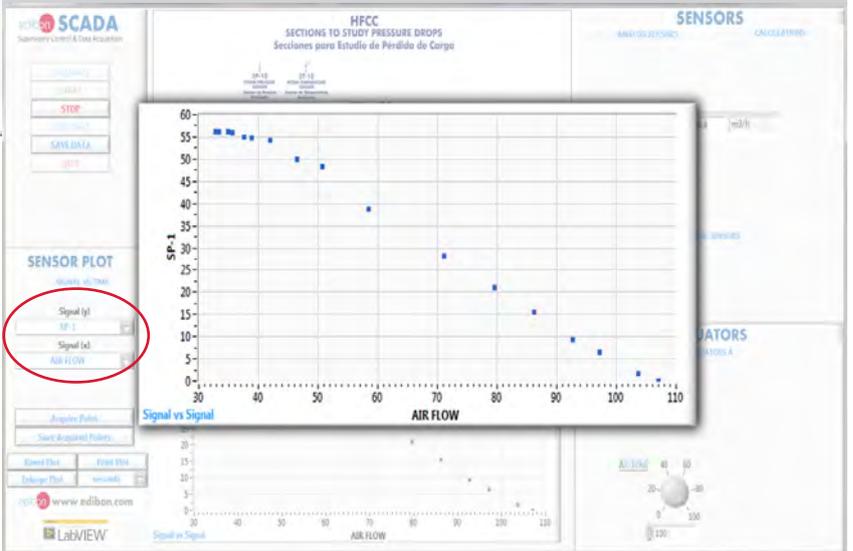
Additionally to the main items (1 to 6) described, we can offer, as optional, other items from 7 to 11.

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)

<u>a) Industrial configuration</u>

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 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.
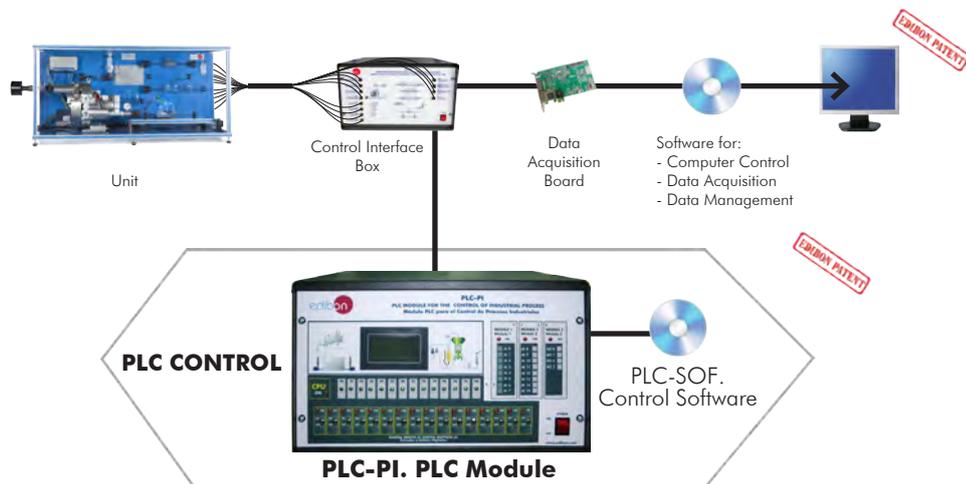
Communication RS232 wire to computer (PC).

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

-HFCC/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 Flow of Compressible Fluids Unit (HFCC).

Unit | Control Interface Box | Data Acquisition Board | Software for:
- Computer Control
- Data Acquisition
- Data Management

PLC CONTROL

PLC-SOF. Control Software

PLC-PI. PLC Module

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 industrialenvironment 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 **HFCC/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.

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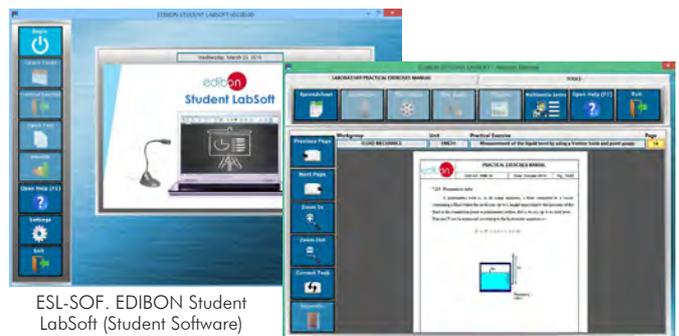
ESL-SOF. EDIBON Student LabSoft (Student Software) Application Main Screen

EPE. EDIBON Practical Exercise Program Package Main Screen
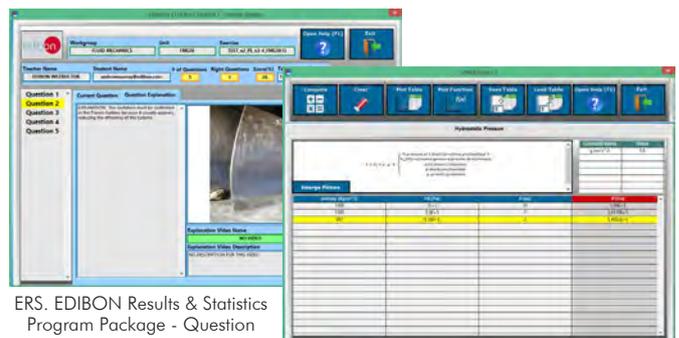
ERS. EDIBON Results & Statistics Program Package - Question Explanation

ECAL. EDIBON Calculations Program Package Main Screen

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

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

⑨ **HFCC/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.

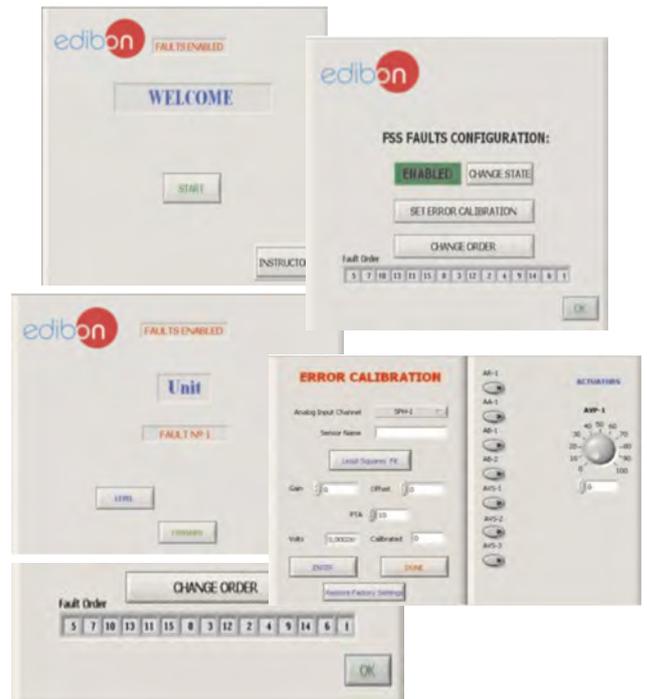- The action of some controls is annulled.

On/off faults:

- Several on/off faults can be included.

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

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

Example of some screens

c) 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 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, 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

Mini ESN.
EDIBON Mini Scada-Net System

1 UNIT= up to 30 STUDENTS can work simultaneously

Computer Controlled Flow of Compressible Fluids Unit (HFCC)

Control Interface Box

Software for:
- Computer Control
- Data Acquisition
- Data Management

Instructors' Central Computer

Mini Scada-Net Software

LOCAL NET FOR 30 STUDENTS

OPEN CONTROL + MULTICONTROL + REAL TIME CONTROL + MULTI STUDENT POST

Note: The Mini ESN system can be used with any EDIBON computer controlled unit

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/fluidmechanicsaerodynamics/esn-fluidmechanics/ESN-FLUID_MECHANICS.pdf
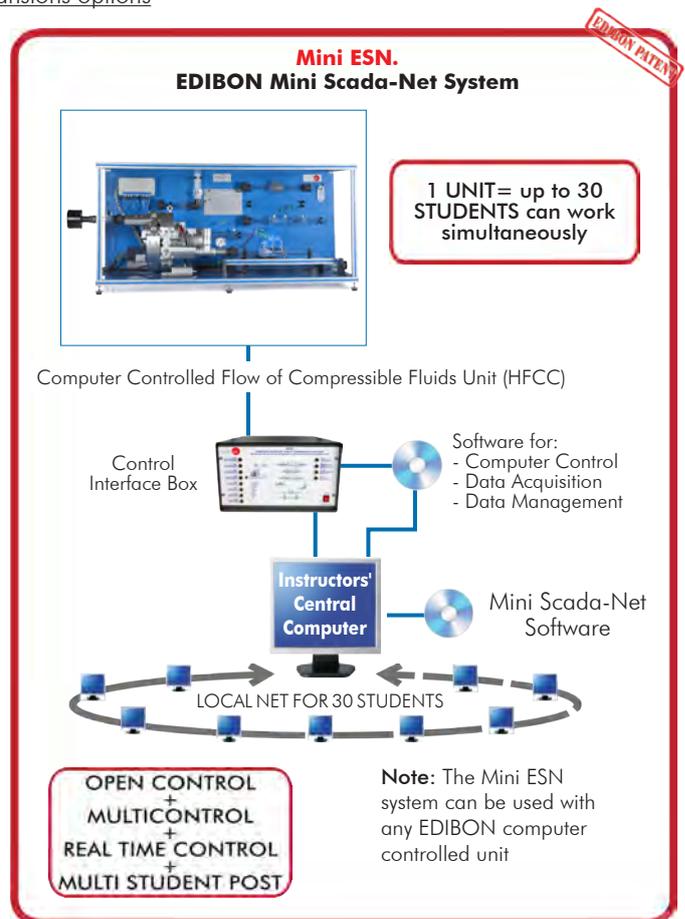
Main items (always included in the supply)

Minimum supply always includes:

① **Unit: HFCC. Computer Controlled Flow of Compressible Fluids Unit.**

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

③ **DAB. Data Acquisition Board.**

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

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

⑥ **Manuals.**

*IMPORTANT: Under HFCC 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.

   - HFCC/PLC-SOF. PLC Control Software.

b) Technical and Vocational Education configuration

⑧ HFCC/ICAI. Interactive Computer Aided Instruction Software System.

⑨ HFCC/FSS. Faults Simulation System.

c) Multipost Expansions options

⑩ Mini ESN. EDIBON Mini Scada-Net System.

⑪ ESN. EDIBON Scada-Net System.

① HFCC. 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.
<u>Double-stage side-channel turbine</u>:
    Power: 2.2 kW.
    Maximum flow rate: 120 m³/h.
    Maximum pressure: 460 mbar.
    Inlet filter.
<u>Accessories</u>:
    Abrupt widening:
        Length: 200 mm.
        Inner diameter of the wide section: 32 mm.
        Inner diameter of the narrow section: 8 mm.
        Five pressure intakes.
        Three type "T" thermocouple.
    Venturi tube:
        Length: 160 mm.
        Inner diameter of the wide section: 32 mm.
        Inner diameter of the narrow section: 8 mm.
        Three pressure intakes.
        Three type "T" thermocouple.
    Ball valve:
        Inner diameter: 32 mm.
        Two pressure intakes.
    Bend of 90°:
        Inner diameter: 32 mm.
        Two pressure intakes.
    Orifice plate:
        Interchangeable plate with orifice: 12, 16, 18, 24 mm.
        Inner diameter: 32 mm.
        Two pressure intakes.
    Straights pipes sections:
        Two pressure intakes.
        Length: 550 mm.
        Inner diameter: 30, 32, 34 mm.
    Laval nozzle:
        Length: 250 mm.
        Inner diameter of the wide section: 32 mm.
        Inner diameter of the narrow section: 8 mm.
        Five pressure intakes.
        Three type "T" thermocouple.
<u>Instrumentation</u>:
    Flow sensor: Pitot tube.
    "T" type temperature sensor at outlet of the turbine.
    "J" type atmospheric temperature sensor.
    Five pressure sensor to measure in differents points of the accessories, range: 0 - 15 PSI.
    Atmospheric pressure sensor, range: 0 1 PSI.
    Pressure gauge at outlet of the turbine, range: 0 - 1 Bar.
    Turbine speed and power measurement.
The unit is supplied with the **required safety devices**: safety googles and hearing protection.
The complete unit includes as well:
    Advanced Real-Time SCADA.
    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 HFCC/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 computer control with flexibility of modifications from the computer keyboard of the parameters, at any moment during the process.
Real time computer control for parameters involved in the process simultaneously.
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 HFCC/CCSOF. 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.
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.- Determination of pressure drops in straight pipe sections.

2.- Study of the relationship between velocity and pressure drops in a straight pipe section.

3.- Determination of pressure drops in a pipe with a bend of 90°.

4.- Determination of pressure drops in an abrupt widening.

5.- Determination of pressure drops in a Venturi tube.

6.- Introduction to supersonic flow in convergent-divergent geometry nozzles.

7.- Determination of pressure drops through an orifice plate with different interchangeable sections.

8.- Determination of the mass flow rate through an orifice plate with different interchangeable sections.

9.- Determination of the characteristic curve of the compressor with the ball valve.

Other practical possibilities:

10.-Study of pressure recovery after an abrupt widening.

11.-Friction coefficient change with Reynolds number.

12.-Study of the friction coefficient for compressible flow.

13.-Determination of the mass flow with the study sections.

14.-Use of the energy balance in the compressor.

15.-Study of the characteristics of the compressor: pressure, flow, efficiency and power.

16.-Observing the generation of shock waves inside a Laval nozzle.

17.-Determination of the air pressure in a convergent-divergent section.

18.-Study of the compressibility effect on the fluid equations.

19.-Determination of the speed of sound in the air.

20.-Sensors calibration.

Other possibilities to be done with this Unit:

21.-Many students view results simultaneously.

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

22.-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.

23.-The Computer Control System with SCADA allows a real industrial simulation.

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

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

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

27.-Control of the HFCC unit process through the control interface box without the computer.

28.-Visualization of all the sensors values used in the HFCC 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.

-HFCC/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 industrialenvironment 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 **HFCC/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.

⑨ **HFCC/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.

<u>c) Multipost Expansions options</u>

⑩ **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 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, 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.

REPRESENTATIVE: