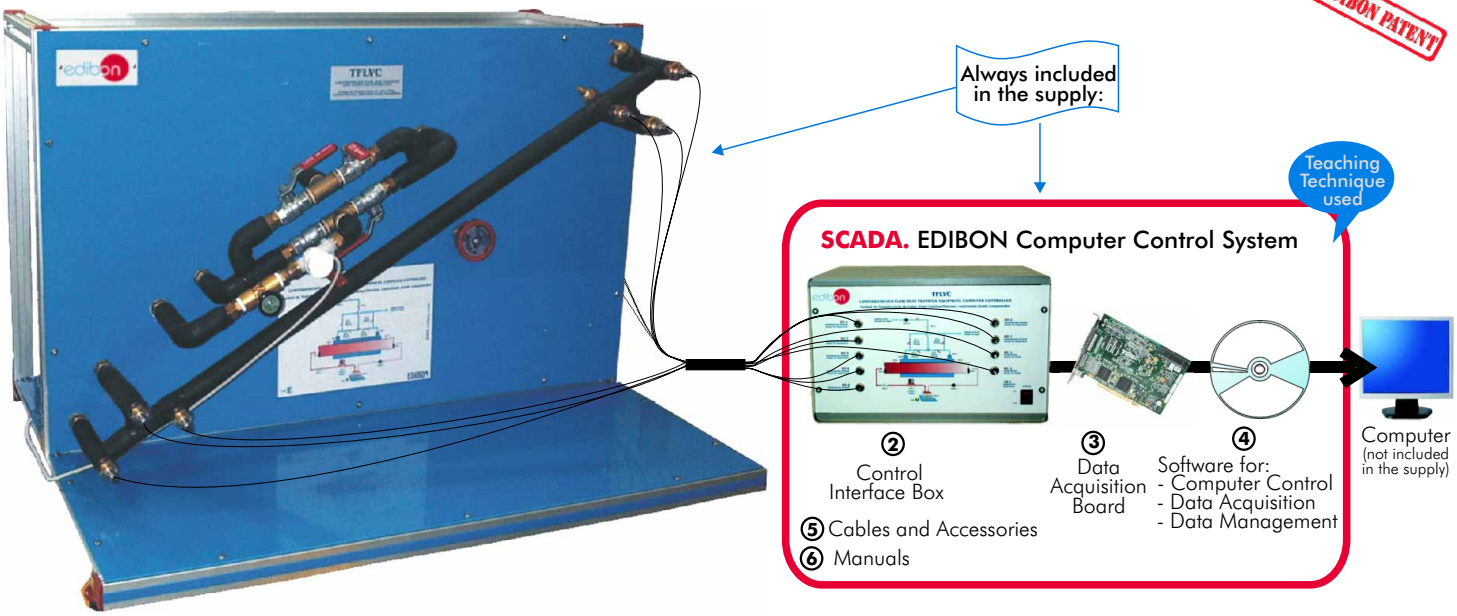
Computer Controlled **Laminar/Viscous Flow Heat Transfer Unit**

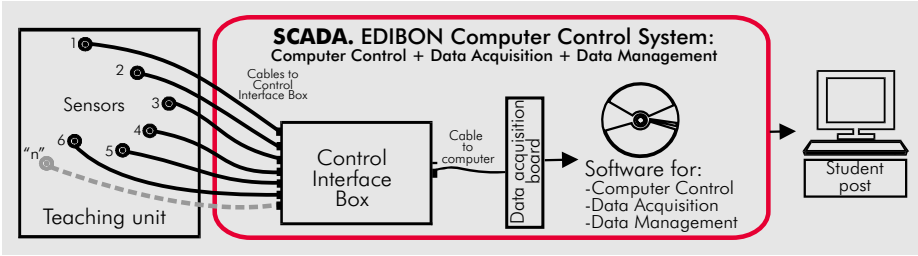
TFLVC

Technical Teaching Equipment



① Unit: TFLVC. Laminar/Viscous Flow Heat Transfer Unit

OPEN CONTROL
+
MULTICONTROL
+
REAL TIME CONTROL



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European Union Certificate

Certificates ISO 14001: 2004 and
ECO-Management and Audit Scheme
(environmental management)

Worlddidac Quality Charter Certificate
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DESCRIPTION

The Laminar/Viscous Flow Heat Transfer Unit, computer controlled "TFLVC" is an unit at laboratory scale, designed to study heat transfer between hot oil flowing in laminar flow through an internal tube and cold water that flows through the annulus (ring-shaped area).

Oil circuit (hot fluid):

The hot oil flows along of a closed circuit. An electric resistance, placed into to the heater tank, heating the oil. The oil goes out of the tank and is pumped by the pump. A flow sensor measures the oil flow. In the inlet of the tank there is a regulation valve for the hot oil. The oil is cooled along of the exchanger and then return to the heater tank, starting a new cycle.

Water circuit (cold fluid):

The cold water comes from of the water supply. In the water circuit there are a regulation valve and a flow sensor. The water comes in to the exchanger, and it increases its temperature. After the water goes out of the system.

The cold water can come in to the exchanger by both extreme (co-current or counter-current). This depends of the valves position (open or close).

Heat Exchanger:

Hot oil flows through the internal tube and cooling water flows through the annulus between the internal and external tube.

The Unit has 7 temperature sensors distributed strategically:

to measure the temperature in the heater tank.

to measure the cold water temperature.

to measure outside wall of the internal tube temperature.

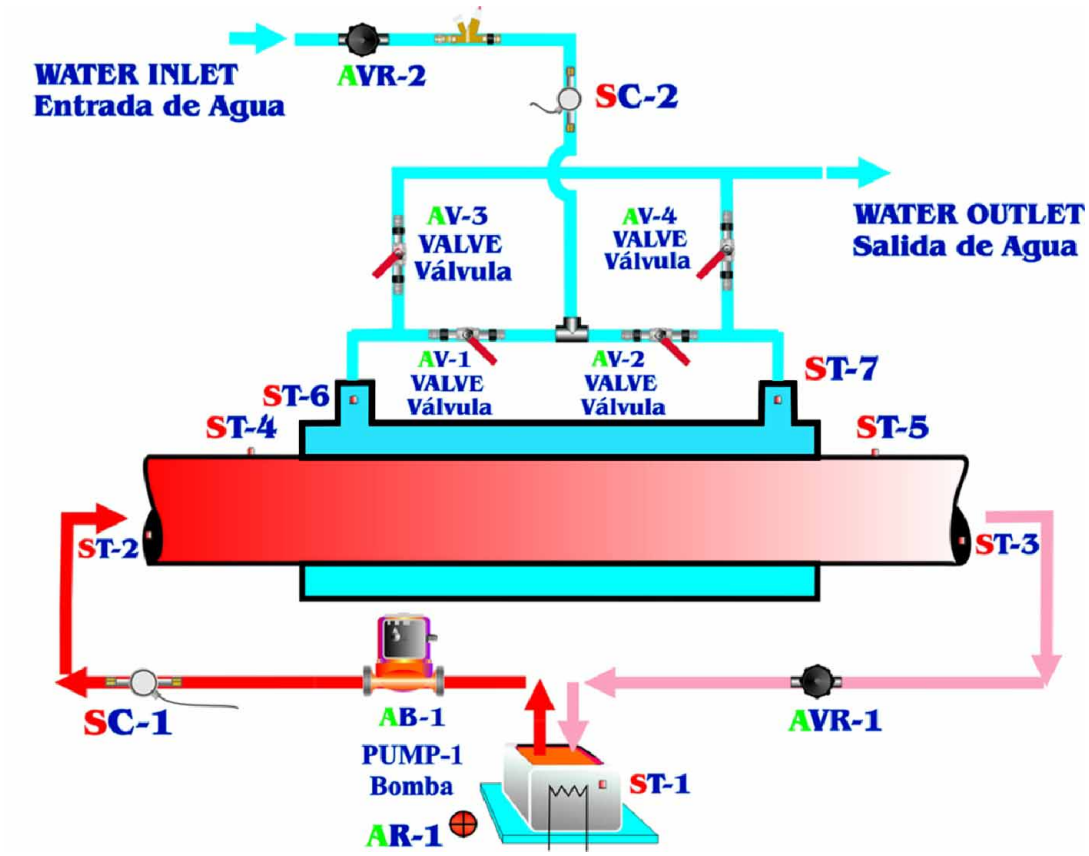
to measure the oil temperature.

This Computer Controlled Unit is supplied with the EDIBON Computer Control System (SCADA), including: Control Interface Box + Data Acquisition Board +Computer Control and Data Acquisition Software, for controlling the process and the parameters involved.

PROCESS DIAGRAM AND ELEMENTS ALLOCATION

2 actuators and 9 sensors controlled from any computer, and working simultaneously

OPEN CONTROL
+
MULTICONTROL
+
REAL TIME CONTROL



Note:
ST= Temperature sensor.
SC= Flow sensor.
AV= Valve.
AVR= Regulation valve.
AR= Heating resistance.

Items supplied as standard

① TFLVC. Unit:

Bench-top unit.
Anodized aluminium structure and panels in painted steel (epoxy paint).
Main metallic elements in stainless steel.
Diagram in the front panel with similar distribution to the elements in the real unit.
Heat exchanger constituted by two concentric tubes with hot oil flowing through the internal tube and cold water flowing through the ring-shaped area.
- Exchanger length = 0.92 m.
- Internal tube:
  - Internal diameter: $D_{int} = 10 \times 10^{-3}$ m = 10 mm
  - External diameter: $D_{ext} = 12 \times 10^{-3}$ m = 12 mm
  - Depth = 10^{-3} m = 1 mm
  - Heat transfer internal area: $A_h = 0.0289$ m^2
  - Heat transfer external area: $A_c = 0.0347$ m^2
- External tube:
  - Internal diameter: $D_{int,h} = 16 \times 10^{-3}$ m = 16 mm
  - External diameter: $D_{ext,h} = 18 \times 10^{-3}$ m = 18 mm
  - Depth = 10^{-3} m = 1 mm

Stainless steel heater tank, equipped with:
- Electric heating resistance, computer controlled.
- Temperature sensor for measure oil temperature.

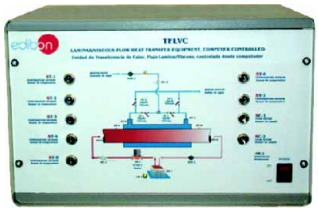
PID temperature control.
Pump suitable for pumping hot oil, computer controlled.
2 Flow sensors: One for oil and another one for water.
7 Temperature sensors:
- 1 Temperature sensor to measure the temperature in the heater tank.
- 2 Temperature sensors to measure the cold water temperature.
- 2 Temperature sensors to measure outside wall temperature of the internal tube.
- 2 Temperature sensors to measure oil temperature.

2 control valves to control cold water and oil flow.
4 ball valves that may provide co-current or counter-current flow in the exchanger, according to how they may be set (control of direction of cold water flow).

TFLVC. Unit

② TFLVC/CIB. Control Interface Box:

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. **Simultaneously 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 placed in only one computer screen.
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, resistances, control valves, etc. **Real time PID control for parameters involved in the process simultaneously.**
Open control allowing modifications, at any time and in a real time, of 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).
Possibility of automatization of the actuators involved in the process.
Three safety levels, one mechanical in the unit, other electronic in control interface and the third ne in the control software.



TFLVC/CIB

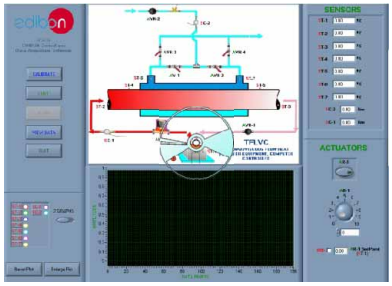
③ DAB. Data Acquisition Board:

PCI Data acquisition board (National Instruments) to be placed in a computer slot. Bus PCI.
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)=±10V. Data transfers=DMA, interrupts, programmed I/0. DMA channels=6.
Analog output: Number of **channels=2**. **Resolution=16 bits**, 1 in 65536. Max. output rate up to: 833 KS/s.
Output range(V)=±10V. Data transfers=DMA, interrupts, programmed I/0.
Digital Input/Output: Channels=24 inputs/outputs. D0 or DI Sample Clock frequency: 0 to 1 MHz.
Timing: **Counter/timers=2**. Resolution: Counter/timers: 32 bits.


DAB

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

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 simultaneously way. **Flexible, open and multicontrol software**, developed with actual windows graphic systems, acting simultaneously on all process parameters.
Analog and digital PID control. Menu for PID and set point selection required in the whole work range.
Management, processing, comparison and storage of data. Sampling velocity up to 250,000 data per second guaranteed. 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 to 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 at different work levels.
This unit allows that the 30 students of the classroom can visualize simultaneously all results and manipulation of the unit, during the process, by using a projector.



TFLVC/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: TFLVC + TFLVC/CIB + DAB + TFLVC/CCSOF + Cables and Accessories + Manuals are included in the minimum supply, enabling a normal operation.

Continue...

Complementary items to the standard supply

PLC. Industrial Control using PLC (7 and 8):

⑦PLC-PI. PLC Module:

Circuit diagram in the front panel.

Front panel:

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

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

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

Analog inputs block:

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

Analog outputs block:

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

Touch screen:

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

PLC-PI

Back panel:

Power supply connector.
Fuse 2A.
RS-232 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.
Free input AC voltage(100 to 240 V AC).
DC input: 16 (24 V DC).
Relay output: 14 (250 V A AC/2 A).
High-speed counter.
Multi-point PID control.
Digital inputs/outputs and analog inputs/outputs Panasonic modules.

Communication RS232 wire, to computer (PC).

⑧TFLVC/PLC-SOF. PLC Control Software:

For this particular unit, always included with PLC supply.

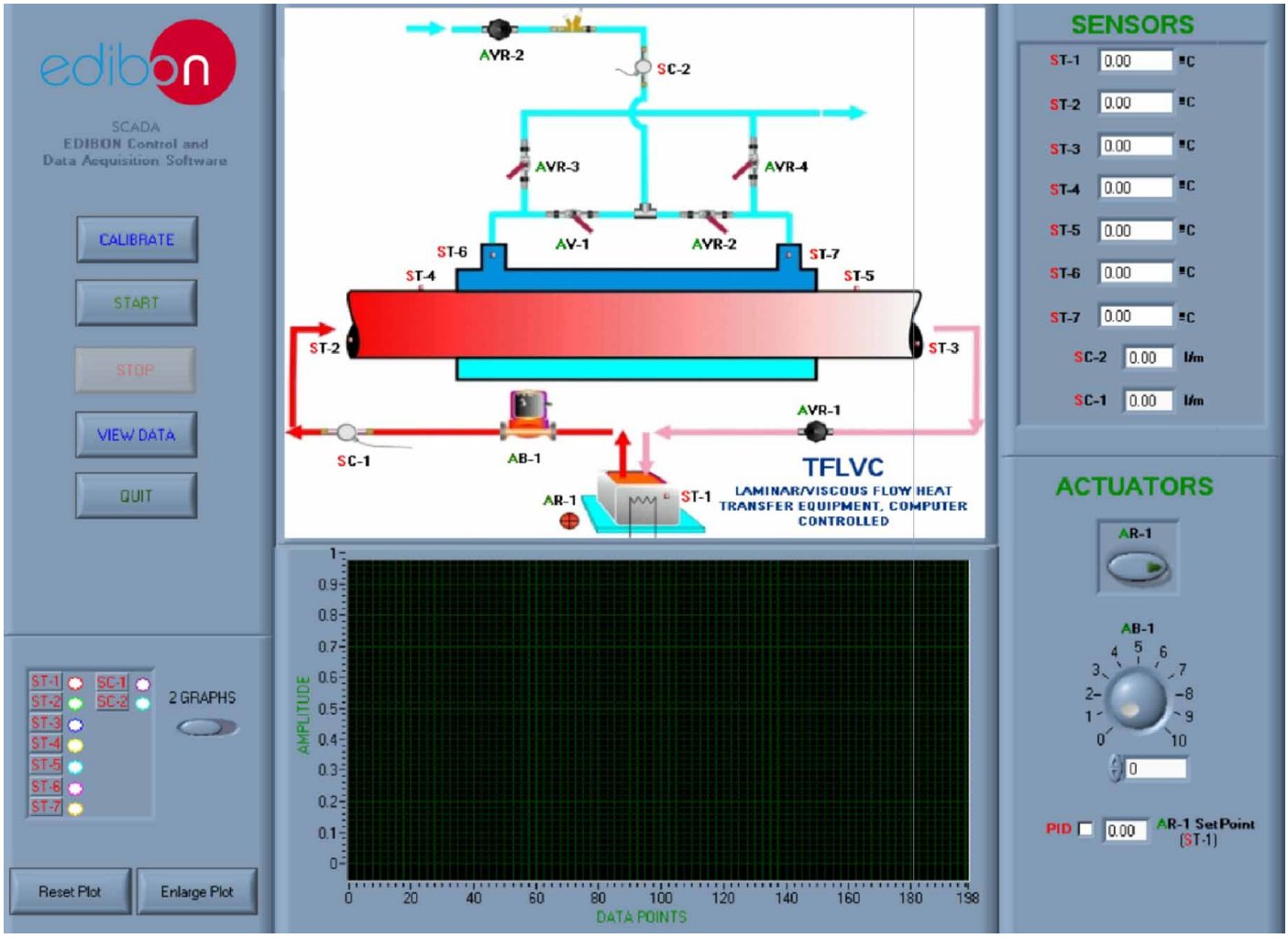
Items available on request

⑨TFLVC/CAL. Computer Aided Learning Software (Results Calculation and Analysis).

⑩TFLVC/FSS. Faults Simulation System.

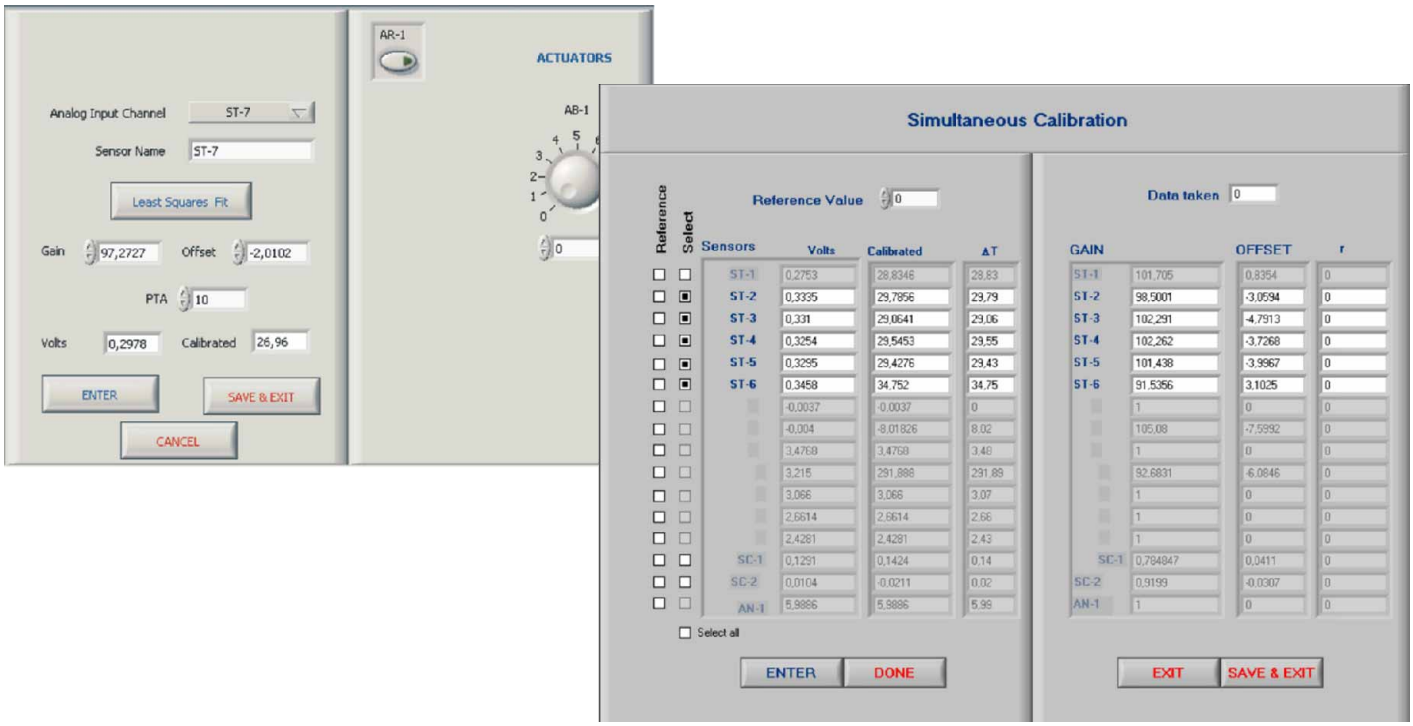
Software Main Screens

Main screen



Note: ST=Temperature sensor. SC= Flow sensor. AR= Heating resistance. AB=Pump.

Examples of Sensors Calibration screens



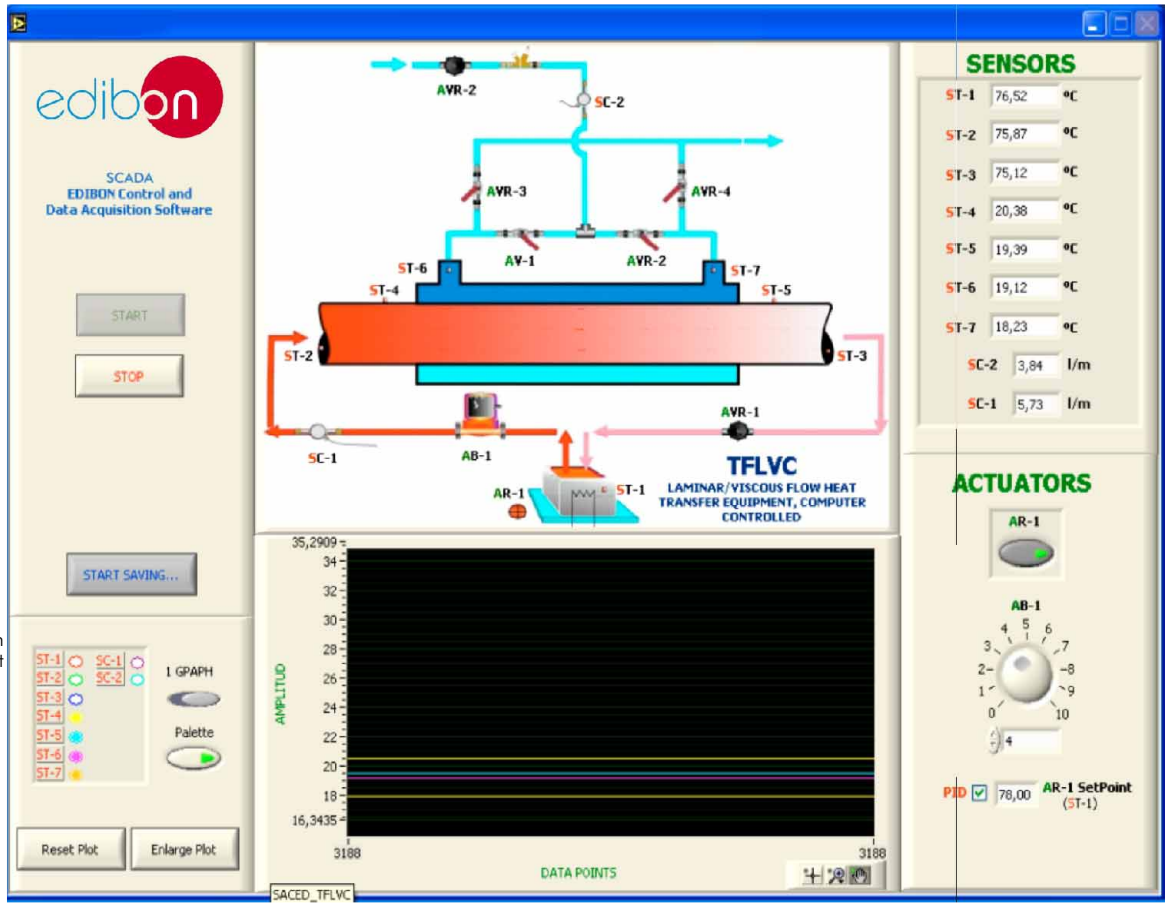
Continue...

Some typical exercises results

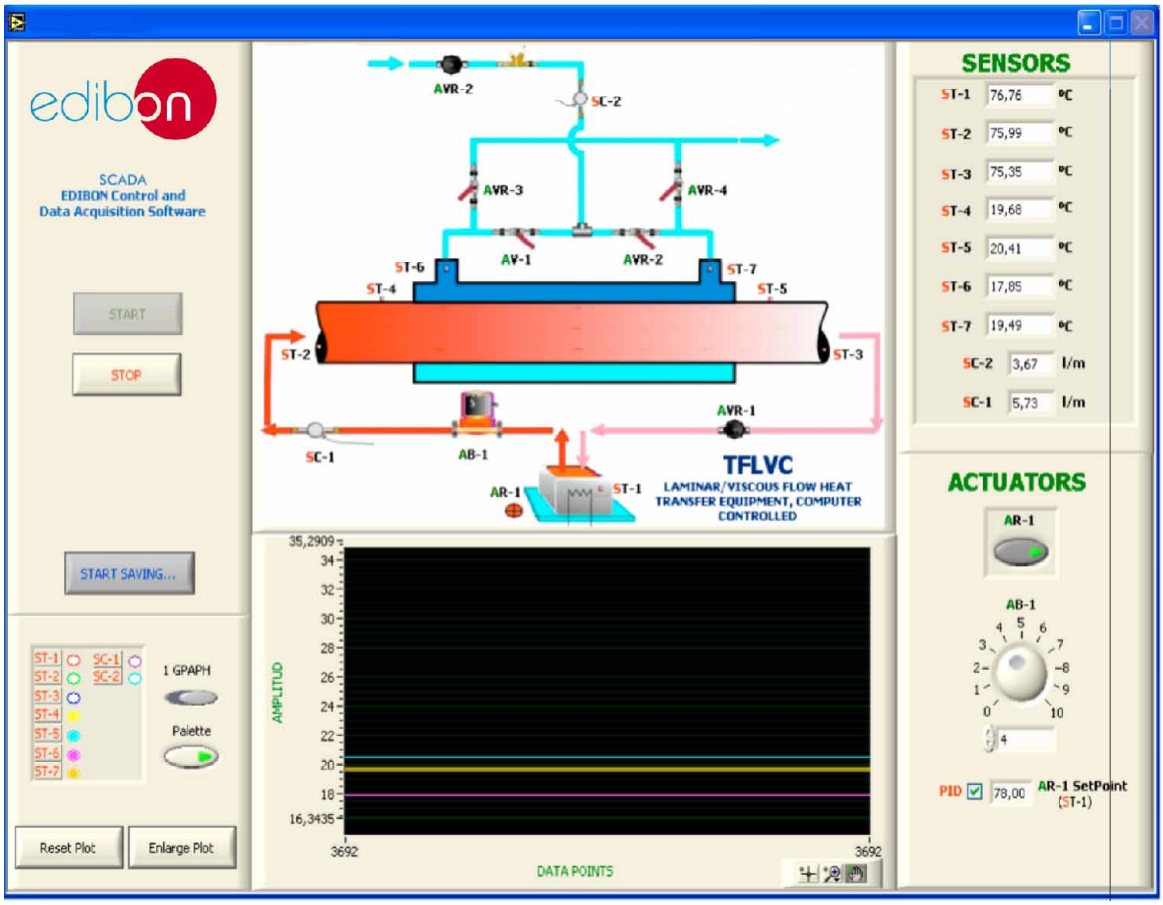
Example of an exercise of heat exchange between oil and water fluids in counter current:

Actions:
1.- Put properly the fluid valves to obtain a water flow in the opposite direction to oil fluid.
2.- To establish a set point for the temperature (AR-1 set point) and turn on the PID control. (The oil bath is heated at an specific temperature, for example 80º).
3.- An adequate flow of oil (SC-1) and water (SC-2) is provided.

Effects:
1.- The temperature of the hot fluid (oil) in the thermostatic bath (ST-1) changes until reaching the set point (80°C).
2.- The heater resistance (AR-1) is turned on or off by the PID control order.
3.- A heat exchange between cold fluid (water) and hot fluid (oil) is produced, with a distribution of typical temperatures for this process:
ST-2>ST-4>ST-6
ST-3>ST-5>ST-7
ST-2>ST-3
ST-4>ST-5
ST-6>ST-7



Example of an exercise of heat exchange between oil and water fluids in direct or parallel current:



Actions:
1.- To establish a set point for the temperature (AR-1 set point) and turn on the PID control. (The oil bath is heated at an specific temperature, for example 80º).
2.- An adequate flow of oil (SC-1) and water (SC-2) is provided.

Effects:
1.- The temperature of the hot fluid (oil) in the thermostatic bath (ST-1) changes until reaching the set point (80°C).
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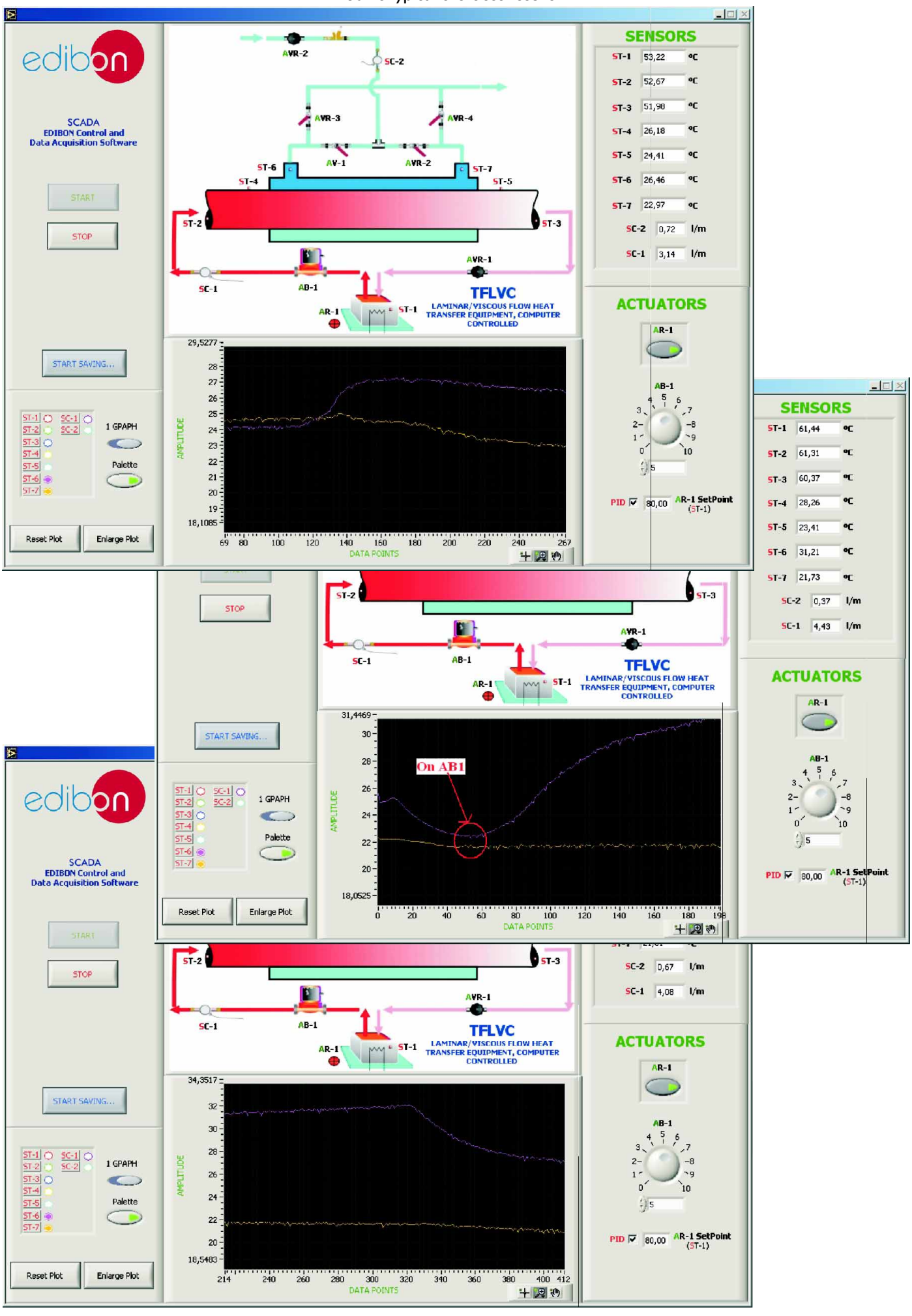
ST-3>ST-5>ST-7
ST-2>ST-3
ST-5>ST-4
ST-7>ST-6

Continue...

Some typical exercises results



EXERCISES AND PRACTICAL POSSIBILITIES

Some Practical Possibilities of the Unit:

1.- Demonstration of a concentric tube heat exchanger with co-current and counter-current flow in laminar/viscous flow.
2.- Energy balance for the heat exchanger.
3.- Determination of surface heat transfer coefficients on the oil and water sides and determination of the overall heat transfer coefficient.
4.- Relationship between Nusselt Number and Graetz Number for Reynolds Numbers up to 1400.

Other possible practices:

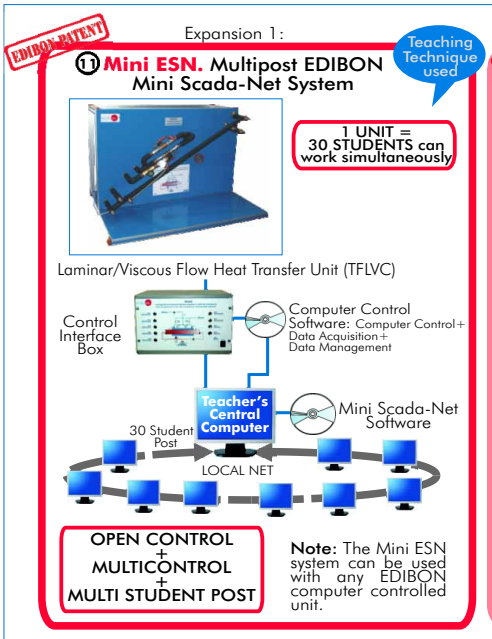
5.- Sensors calibration.

Practices to be done by PLC Module (PLC-PI)+PLC Control Software:

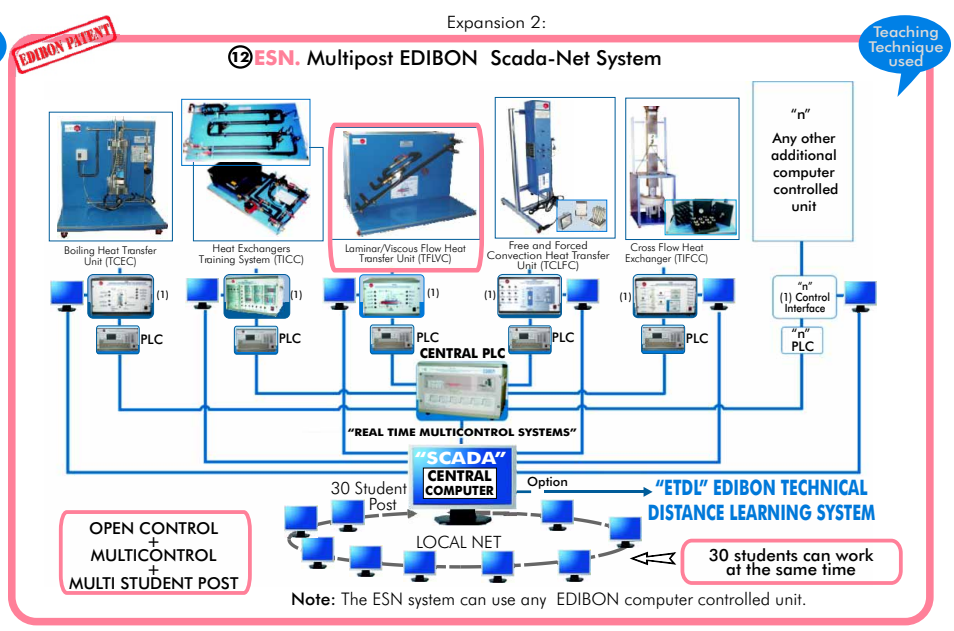
6.- Control of the TFLVC unit process through the control interface box without the computer.
7.- Visualization of all the sensors values used in the TFLVC unit process.
8.- Calibration of all sensors included in the TFLVC unit process.
9.- Hand on of all the actuators involved in the TFLVC unit process.
10.- Realization of different experiments, in automatic way, without having in front the unit. (This experiment can be decided previously).
11.- 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).
12.- PLC hardware general use and manipulation.
13.- PLC process application for TFLVC unit.
14.- PLC structure.
15.- PLC inputs and outputs configuration.
16.- PLC configuration possibilities.
17.- PLC program languages.
18.- PLC different programming standard languages.
19.- New configuration and development of new process.
20.- Hand on an established process.
21.- To visualize and see the results and to make comparisons with the TFLVC unit process.
22.- Possibility of creating new process in relation with the TFLVC unit.
23.- PLC Programming Exercises.
24.- Own PLC applications in accordance with teacher and student requirements.

POSSIBILITIES OF OTHER AVAILABLE EXPANSIONS

Expansion 1:



Expansion 2:



ORDER INFORMATION

Items supplied as standard

Minimum configuration for normal operation includes:

① **Unit: TFLVC. Laminar/Viscous Flow Heat Transfer Unit.**
② **TFLVC/CIB. Control Interface Box.**
③ **DAB. Data Acquisition Board.**
④ **TFLVC/CCSOF. Computer Control + Data Acquisition + Data Management Software.**
⑤ **Cables and Accessories**, for normal operation.
⑥ **Manuals.**

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

Complementary items to the standard supply

PLC. Industrial Control using PLC (7 and 8):

⑦ PCL-PI. PLC Module.
⑧ TFLVC/PLC-SOF. PLC Control Software.
⑨ TFLVC/CAL. Computer Aided Learning Software (Results Calculation and Analysis). (Available on request).
⑩ TFLVC/FSS. Faults Simulation System. (Available on request).

Expansions

⑪ Mini ESN. Multipost EDIBON Mini Scada-Net System.
⑫ ESN. Multipost EDIBON Scada-Net System.

REQUIRED SERVICES

-Electrical supply: single- phase, 220 V / 50 Hz. or 110 V/ 60 Hz.
-Water supply and drainage.
-Computer (PC).

DIMENSIONS & WEIGHTS

TFLVC Unit: -Dimensions: 1000 x 770 x 670 mm. approx.
-Weight: 80 Kg. approx.
Control Interface Box: -Dimensions: 490 x 330 x 310 mm. approx.
-Weight: 10 Kg. approx.
PLC Module (PLC-PI): -Dimensions: 490 x 330 x 310 mm. approx.
-Weight: 30 Kg. approx.

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

Laminar/Viscous Flow Heat Transfer Unit

TFLVB

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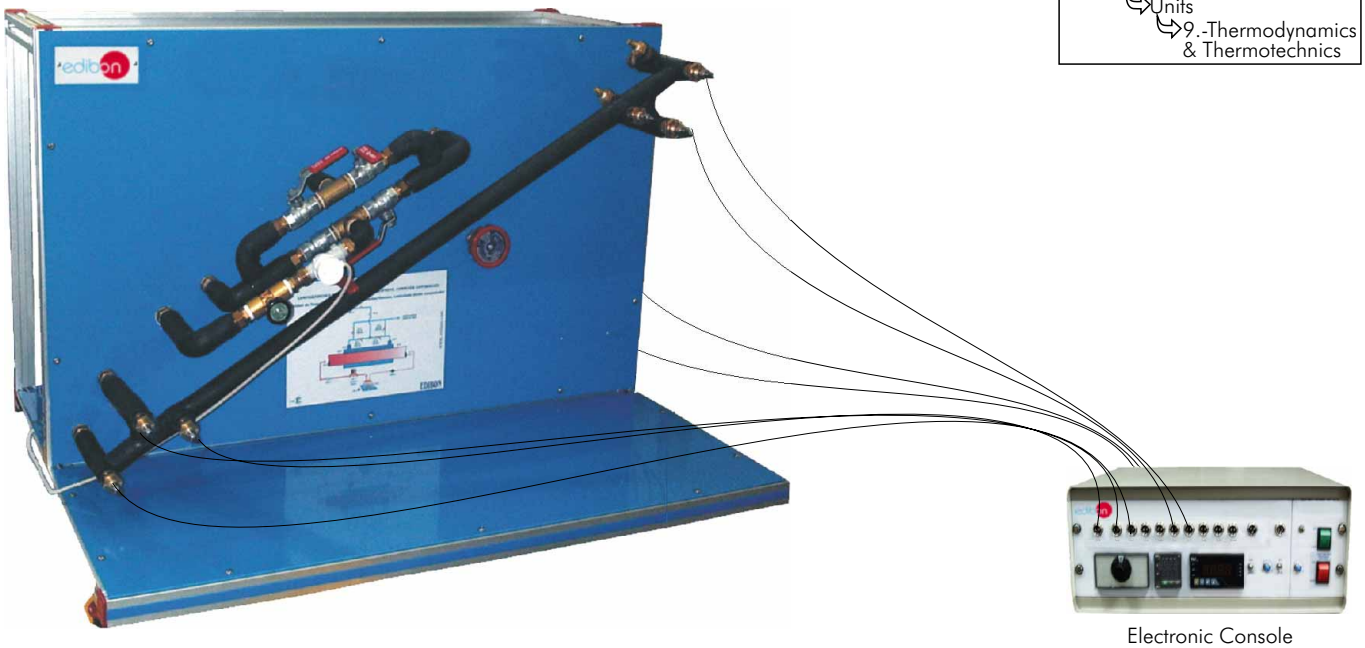

Electronic Console

DESCRIPTION

The Laminar/Viscous Flow Heat Transfer Unit (TFLVB) is an unit at laboratory scale, designed to study heat transfer between hot oil flowing in laminar flow through an internal tube and cold water that flows through the annulus (ring-shaped area).

Oil circuit (hot fluid):

The hot oil flows along of a closed circuit. An electric resistance, placed into to the heater tank, heating the oil. The oil goes out of the tank and is pumped by the pump. A flow meter measures the oil flow. In the inlet of the tank there is a regulation valve for the hot oil. The oil is cooled along of the exchanger and then return to the heater tank, starting a new cycle.

Water circuit (cold fluid):

The cold water comes from of the water supply. In the water circuit there are a regulation valve and a flow meter. The water comes in to the exchanger, and it increases its temperature. After the water goes out of the system.

The cold water can come in to the exchanger by both extreme (co-current or counter-current). This depends of the valves position (open or close).

Heat Exchanger:

Hot oil flows through the internal tube and cooling water flows through the annulus between the internal and external tube.

The unit has 7 temperature sensors distributed strategically:

to measure the temperature in the heater tank.

to measure the cold water temperature.

to measure outside wall of the internal tube temperature.

to measure the oil temperature.

SPECIFICATIONS

Bench-top unit.
Anodized aluminium structure and panels in painted steel. Main metallic elements in stainless steel.
Diagram in the front panel with similar distribution to the elements in the real unit.
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- Exchanger length = 0.92 m.
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  - Internal diameter: $D_{int} = 10 \times 10^{-3}$ m = 10 mm
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  - Heat transfer internal area: $A_h = 0.0289$ m^2
  - Heat transfer external area: $A_c = 0.0347$ m^2
- External tube:
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Stainless steel heater tank, equipped with:
- Electric resistance.
- Temperature sensor for measure oil temperature.

PID temperature control.
Pump suitable for pumping hot oil.
2 Flow meters: One for oil and another one for water.
7 Temperature sensors:
- 1 Temperature sensor to measure the temperature in the heater tank.
- 2 Temperature sensors to measure the cold water temperature.
- 2 Temperature sensors to measure outside wall temperature of the internal tube.
- 2 Temperature sensors to measure oil temperature.

Control valves to control cold water and oil flow.
Ball valves that may provide co-current or counter-current flow in the exchanger, according to how they may be set (control of direction of control water flow).
Electronic Console:
- Metallic box.
- Connectors for the temperature sensors.
- Sensor digital display for temperature sensors.
- Sensor selector for temperature sensors.
- Pump controller.
- Heater resistance controller.

Cables and accessories, for normal operation.
Manuals:
This unit is **supplied with the following manuals**: Required Services, Assembly and Installation, Starting-up, Safety, Maintenance, & Practices Manuals.

EXERCISES AND PRACTICAL POSSIBILITIES

Some Practical Possibilities of the Unit:

1.- Demonstration of a concentric tube heat exchanger with co-current and counter-current flow in laminar/viscous flow.

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-Electrical supply: single- phase, 220 V / 50 Hz. or 110 V/ 60 Hz.
-Water supply and drainage.

DIMENSIONS & WEIGHTS

TFLVB:

Unit:	-Dimensions: 1000 x 770 x 670 mm. approx.
	-Weight: 80 Kg. approx.
Electronic Console :	-Dimensions: 490 x 330 x 310mm. approx.
	-Weight: 10Kg. approx.

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

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