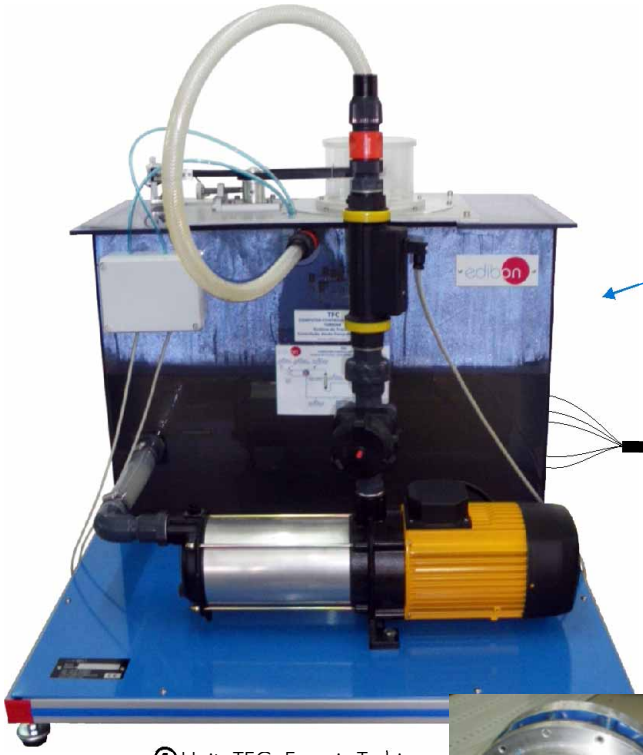
Computer Controlled **Francis Turbine**

TFC

Technical Teaching Equipment



① Unit: TFC. Francis Turbine

Detail of the turbine

EDIBON PATENT

Always included in the supply:

Teaching Technique used

SCADA. EDIBON Computer Control System

② Control Interface Box

③ Data Acquisition Board

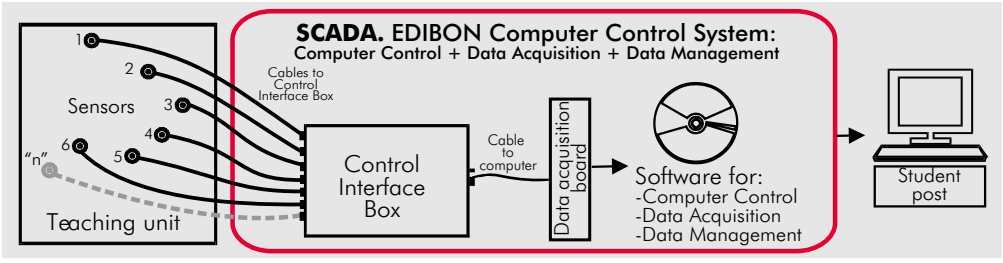
④ Software for:
- Computer Control
- Data Acquisition
- Data Management

Computer (not included in the supply)

⑤ Cables and Accessories

⑥ Manuals

OPEN CONTROL
+
MULTICONTROL
+
REAL TIME CONTROL



www.edibon.com
Products
Products range
Units
8.- Fluid Mechanics & Aerodynamics

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

European Union Certificate
(total safety)

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

Worlddidac Quality Charter Certificate
(Worlddidac Member)

DESCRIPTION

The TFC unit developed by EDIBON has a Francis turbine in miniature which has a distributor with adjustable guide vanes allowing to control the water incidence angle in the turbine. To regulate the distributor, the unit has a handle at its frontal.

To elevate the fluid, there is a pump which allows the impulsed flow to pass through the turbine, where part of its energy is left causing its rotation. To rotate, the flows must overcome the external resistance that a band brake causes.

This brake is connected to a load cell and the whole allows to determine the torque given by the turbine. The speed measurement is obtained by means of a speed sensor.

The brake load can be changed by tensing the band of the brake. This way, the torque can be changed in the turbine.

The chamber is spiral shaped (spiral chamber). Due to its design, it is possible for the water to circulate with an aparent constant speed and without forming twists, avoiding load losses.

The unit has an aspiration tube which consists on a conduction which joins the turbine to the drain. Its objective is to recuperate a maximum kinectic energy of the water at the turbine outlet or, in other words, to use the head existing between the free water surface and the turbine outlet.

The hydraulic head is calculated by 2 pressure sensors: one at the chamber inlet and the other one at the outlet (difusser).

An actuator on the pump allows to change its rotation regime, changing so the incoming flow to the turbine.

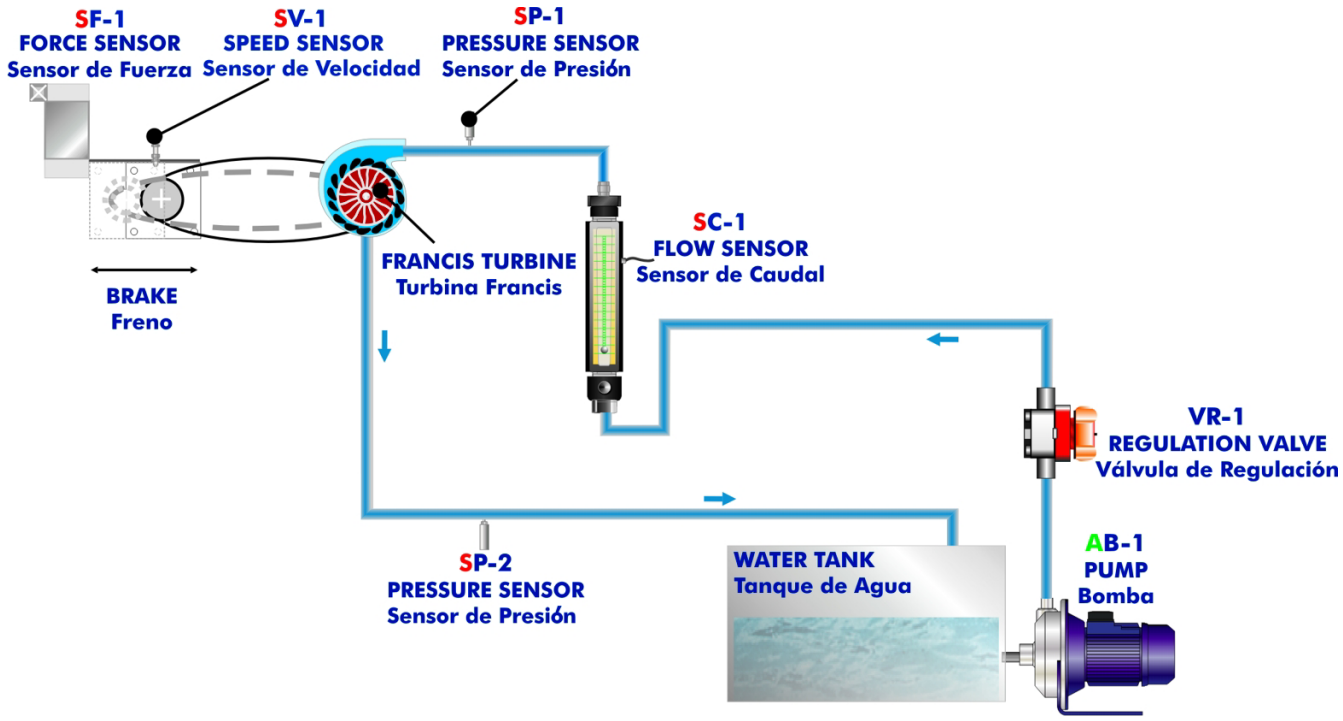
The pump-turbine group has a tank and a pipes system which allow to work constantly with recirculated fluid to avoid the indiscrimined water consumption.

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

1 actuator and 5 sensors controlled from any computer, and working simultaneously

OPEN CONTROL + MULTICONTROL + REAL TIME CONTROL



Items supplied as standard

① TFC. Unit:

Desktop 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.

Functional model of Francis turbine, with a distributor with adjustable guide vanes that allows to control the water angle of incidence of the turbine:

- Diameter of the turbine: 52 mm.
- Speed range: 0-1200 r.p.m. approx.
- Rotor:
  - Number of blades of the turbine: 15.
- Stator:
  - Number of adjustable guide vanes of the distributor: 10.

Braking system:

- Band brake with adjustable braking tension.

Load cell-force sensor, range: 0-20N.

Computer controlled water pump, with variable speed:

- Maximum height: 70 m.
- Maximum pressure: 7 bar.
- Maximum water flow: 120 l./min.
- Power: 1.5 kW

Transparent water tank (made of methacrylate), capacity 130 l. approx.

2 Pressure sensors, range: 0 to 6,7 bar.

Flow sensor, range: 0 to 200 l./min.

Speed sensor, range: 0 to 20,000 rpm.

TFC Unit

② TFC/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 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, resistances, control valves, etc.

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

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

TFC/CIB

Continue...

Items supplied as standard (continuation)

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.

Number of DMA channels=6.

DAB

Analog output:

Number of **channels=2**.

Resolution=16 bits, 1 in 65536.

Maximum output rate up to: 833 KS/s.

Output range(V)=±10V.

Data transfers=DMA, interrupts, programmed I/0.

Digital Input/Output:

Number of **channels=24 inputs/outputs**.

D0 or DI Sample Clock frequency: 0 to 1 MHz.

Timing:

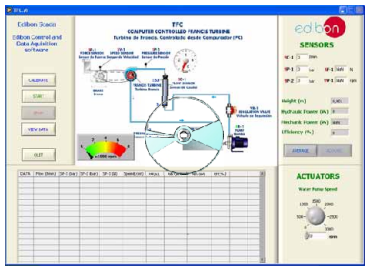
Counter/timers=2.

Resolution: Counter/timers: 32 bits.

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

Compatible with actual Windows operating systems.

Graphic and intuitive simulation of the process in screen.



TFC/CCSOF

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.

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.

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

Continue...

Additional and optional items to the standard supply

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

⑦ PLC-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.
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.
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).

⑧ TFC/PLC-SOF. PLC Control Software:

For this particular unit, always included with PLC supply.

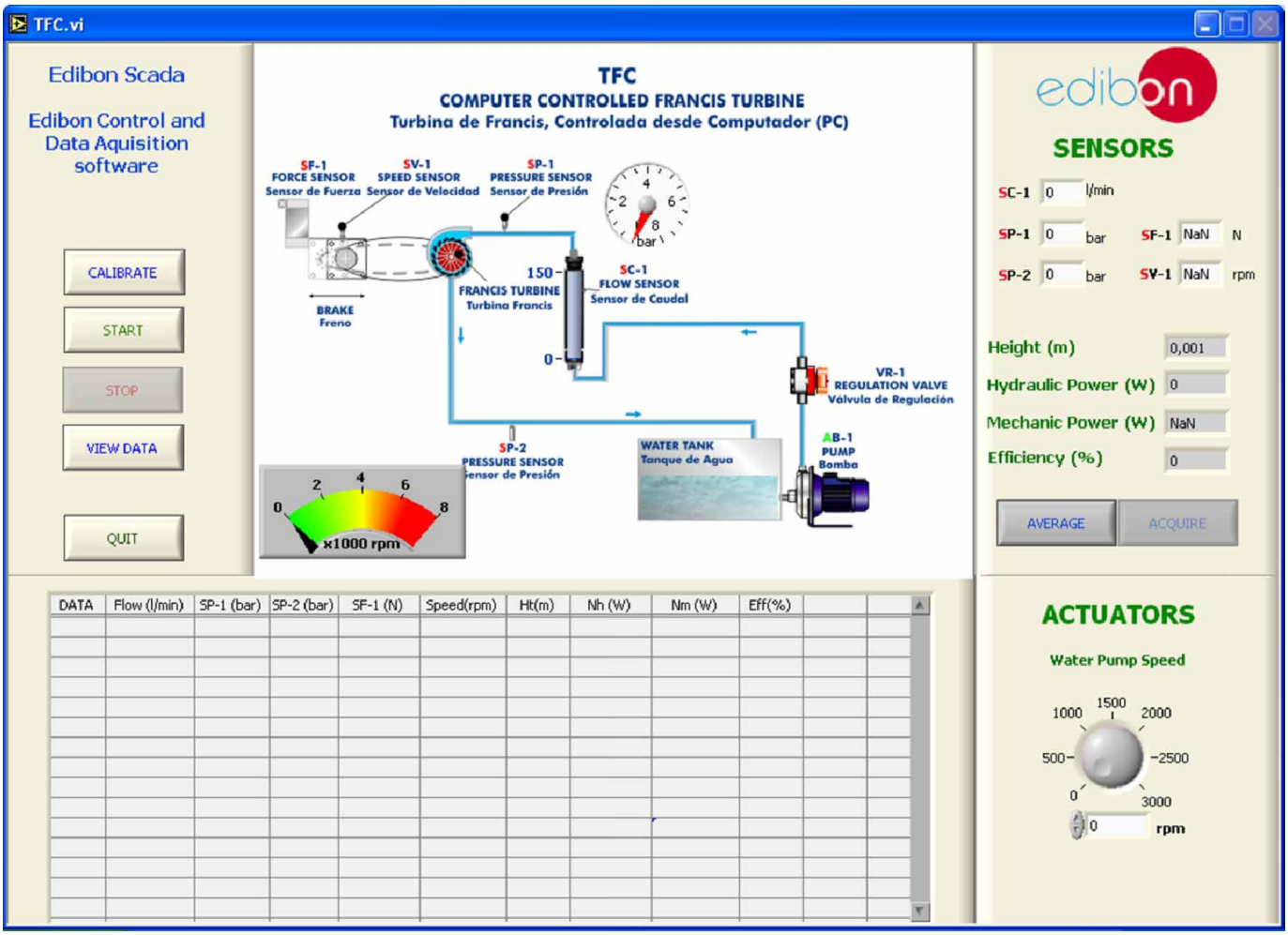
Items available on request

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

⑩ TFC/FSS. Faults Simulation System.

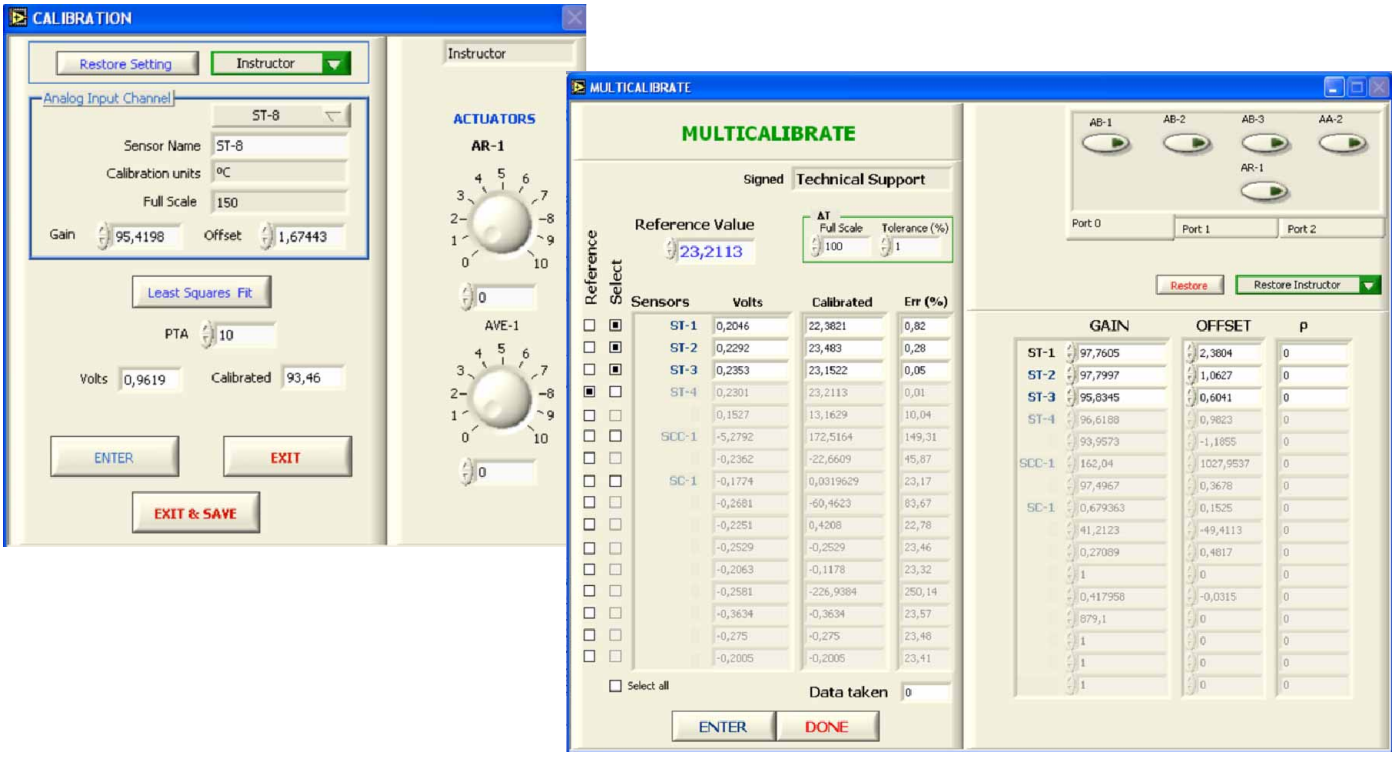
Software Main Screens

Main screen



Nota: SC= Flow sensor. SP= Pressure sensor. SF= Force sensor. SV= Speed sensor.

Examples of Sensors **Calibration** screens



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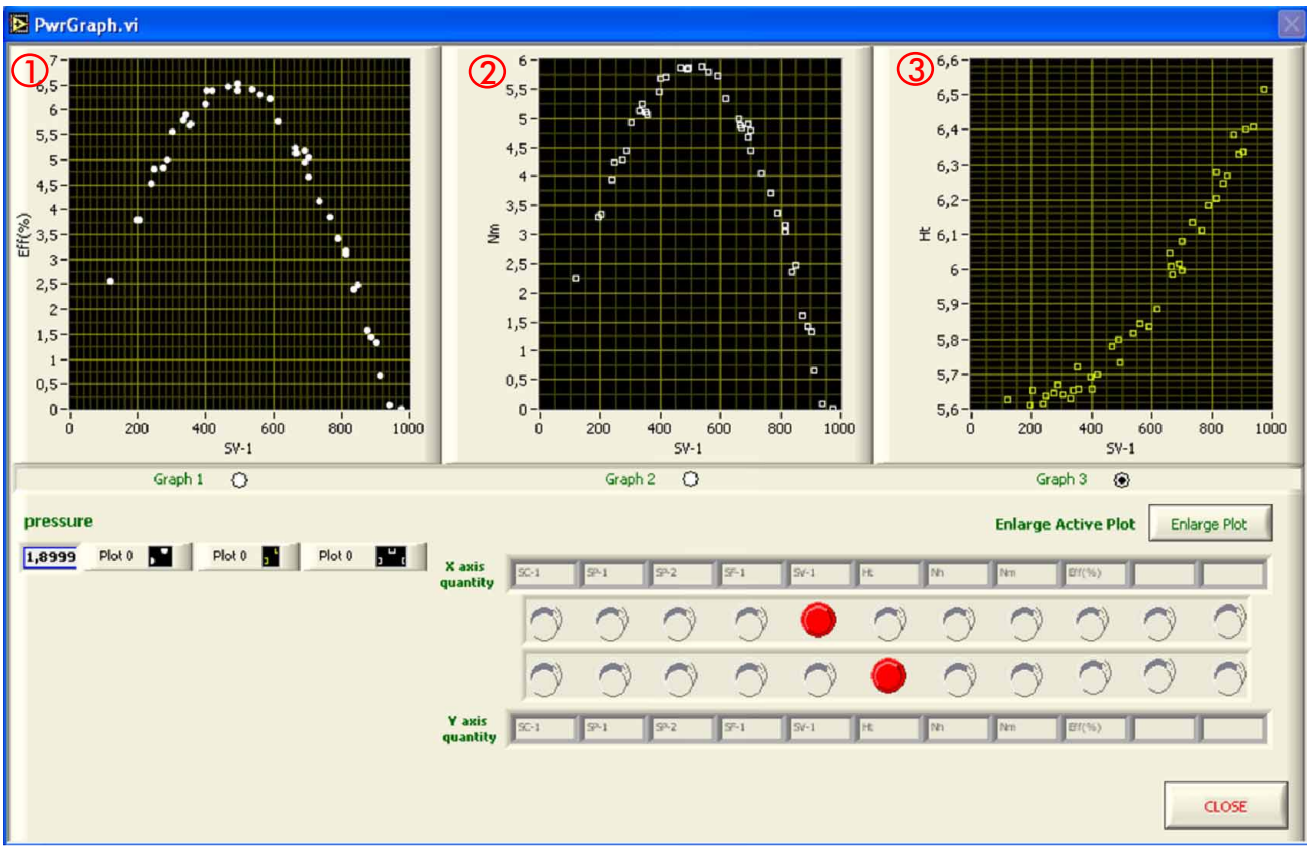
Some typical exercises results

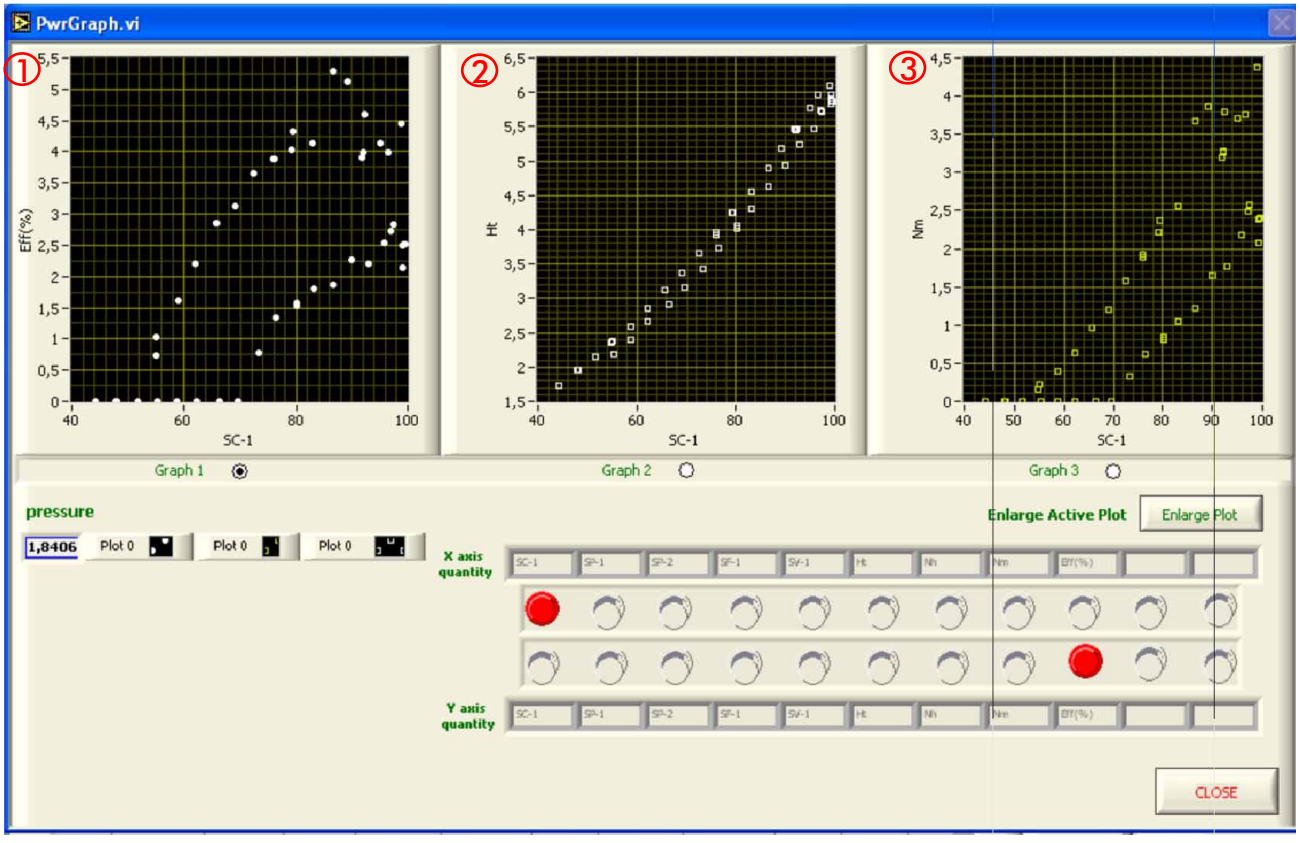
Representation of the turbine mechanical curves (At constant flow)

① Efficiency vs angular speed (rpm)
② Mechanical power (W) vs angular speed (rpm)
③ Hydraulic head (m) vs angular speed (rpm)



Representation of the turbine hydraulic curves (At constant revolutions regime)

① Efficiency vs flow (l/min), at different revolutions regime
② Hydraulic head (m) vs flow (l/min), at different revolutions regime
③ Mechanical power (W) vs flow (l/min), at different revolutions regime



EXERCISES AND PRACTICAL POSSIBILITIES

Some Practical Possibilities of the Unit:

1.- To determine the operating characteristics of a Francis turbine at different speeds.
2.- Determination of typical turbine curves.
3.- Determination of the Francis turbine's power N(n), Torque M_m(n) and efficiency η(n) curves at constant flow with guide vanes open.
4.- Determination of the Francis turbine's power N(n), Torque M_m(n) and efficiency η(n) curves at constant flow with guide vanes closed.
5.- Determination of the power N(Q), Head H(Q) and efficiency η(Q) curves at constant rotation speed and guide vanes opened.
6.- Determination of the power N(Q), Head H(Q) and efficiency η(Q) curves at constant rotation speed and guide vanes closed.
7.- Turbine power output versus speed and flow rate at various heads.
8.- Effect of guide vane setting on the turbine performance.
9.- Investigation of the conversion of hydraulic energy into mechanical energy.
10.- Adimensional analysis.
11.- Calculating the turbine power.
12.- Determining the turbine hydraulic efficiency.
13.- Determining the torque and speed of the turbine.
14.- Flow calculation.

Other possible practices:

15.- Sensors calibration.

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

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

POSSIBILITIES OF OTHER AVAILABLE EXPANSIONS

Expansion 1:

EDIBON PATENT

Teaching Technique used

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

1 UNIT = 30 STUDENTS can work simultaneously

Francis Turbine (TFC)

Control Interface Box

Computer Control Software: Computer Control + Data Acquisition + Data Management

Teacher's Central Computer

Mini Scada-Net Software

30 Student Post

LOCAL NET

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

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

Expansion 2:

EDIBON PATENT

Teaching Technique used

⑫ **ESN.** Multipost EDIBON Scada-Net System

Francis Turbine (TFC)

Flow Channel (section: 300 x 450 mm) (CFGC)

Fluid Friction in Pipes, with Hydraulics Bench "FME00" (AFTC)

Series/Parallel Pumps Bench (PBSPC)

Centrifugal Fan Teaching Trainer (HVCC)

"n" Any other additional computer controlled unit

(1)

PLC

"n" (1)Control Interface

"n" PLC

CENTRAL PLC

"REAL TIME MULTICONTROL SYSTEMS"

"SCADA" CENTRAL COMPUTER

Option

"ETDL" EDIBON TECHNICAL DISTANCE LEARNING SYSTEM

30 Student Post

LOCAL NET

30 students can work at the same time

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

Note: The ESN system can use any EDIBON computer controlled unit.

ORDER INFORMATION

Items supplied as standard

Minimum configuration for normal operation includes:

① **Unit: TFC. Francis Turbine.**
② **TFC/CIB.Control Interface Box.**
③ **DAB.Data Acquisition Board.**
④ **TFC/CCSOF. Computer Control + Data Acquisition + Data Management Software.**
⑤ **Cables and Accessories**, for normal operation.
⑥ **Manuals.**

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

Additional and optional items to the standard supply

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

⑦ PCL-PI.PLC Module.
⑧ TFC/PLC-SOF. PLC Control Software.
⑨ TFC/CAL. Computer Aided Learning Software (Results Calculation and Analysis). (Available on request).
⑩ TFC/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/50Hz or 110 V/60 Hz.

-Water supply.

-Drainage.

-Computer (PC).

DIMENSIONS & WEIGHTS

TFC Unit:	-Dimensions: 800 x 900 x 950 mm. approx.
	-Weight: 85 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.

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