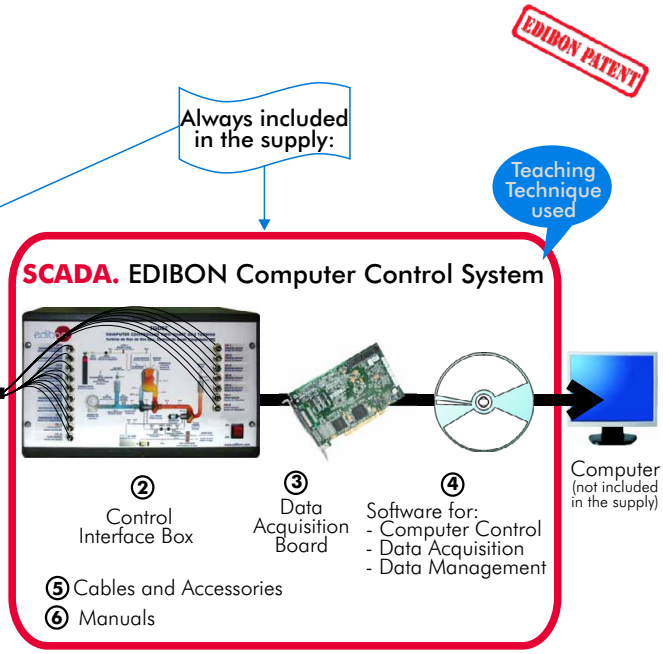
edibon
Technical Teaching Equipment

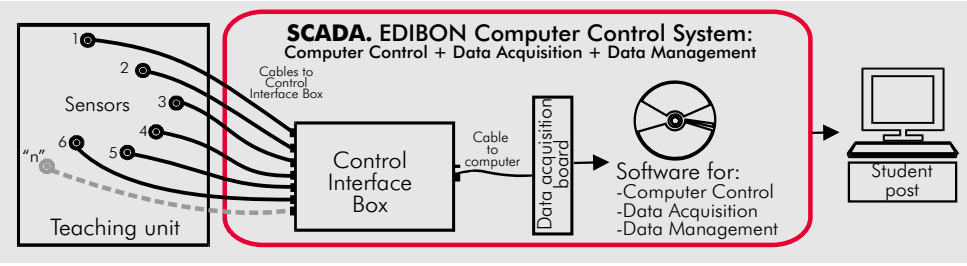
Computer Controlled **Two-Shaft Gas Turbine**

TGDEC



① Unit: TGDEC. Two-Shaft Gas Turbine

OPEN CONTROL
+
MULTICONTROL
+
REAL TIME CONTROL



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Products range
Units
9.-Thermodynamics & Thermotechnics

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 TGDEC turbine developed by EDIBON is a teaching unit for the operation demonstration of a Double Shaft Gas Turbine for electric generation and for other uses too.

The main element of the "TGDEC" unit is the High Pressure Turbine, which is also called Gas Generative Turbine. It consists of:

- Radial compressor, which is feeded by atmospheric air to compress it.
- Tubular combustion chamber. In every combustion there is a fuel (propane gas); a comburent, which in this case is compressed air received from the compressor, and the activation energy which will cause the ignition of the mix.
- Expansion turbine: The inflamed gases of the combustion chamber transfer a part of the thermal energy that they have in the turbine blades.

Compressor and turbine are mounted on the same shaft, so, when we have the system self sustaining, part of the thermal energy of the combustion gases is used to move the compressor.

The extra thermal energy of the combustion gases is driven to the Low Pressure Turbine, or also called Power Turbine. In it, the rest of the combustion gases energy is transformed in mechanic energy, which is transformed in electric energy through a generator coupled to the turbine shaft.

The TGDEC unit also includes:

Start installation: It consists of a centrifugal fan driven by an electrical motor. This fan provides the necessary air for starting the turbine, causing the rotation of the high pressure turbine.

Fuel installation: The line of fuel gas consists of a ball valve to open or close the feeding, a pressure regulation valve, a safety electrovalve and a gas injector. It includes a rotameter type flowmeter to measure de gas consumption.

Ignition installation: The activation energy of the air-fuel mix will causes the flame ignition. It consists of an ignition electrode feeded by an ignition transformer. An ionization electrode detects that the flame is ignited.

Lubrication installation: It consists of an oil tank of 5 litres. From this tank, we dispose of a gear pump to impulse the oil to the bearings of both turbine shafts. The installation is completed with a filtration unit and two regulation valves to select the oil quantity to feed to each turbine.

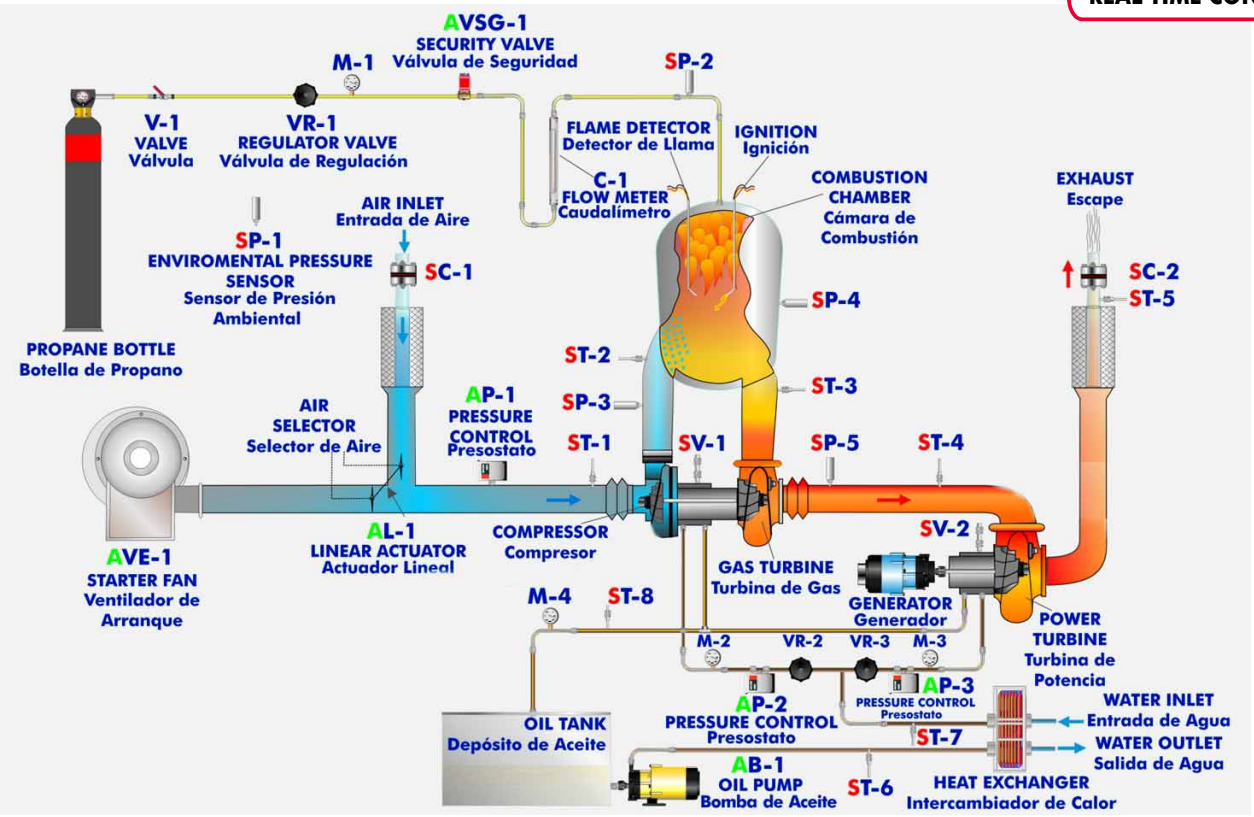
Refrigeration installation: It consists of a plate heat exchanger through which the oil transfers its heat to the refrigeration water, being ready to lubricate again the bearings.

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

5 actuators and 17 sensors controlled from any computer, and working simultaneously

OPEN CONTROL + MULTICONTROL + REAL TIME CONTROL



Note: ST= Temperature sensor. SC= Flow sensor. SV= Speed sensor. SP= Pressure sensor. M= Manometer.

Items supplied as standard

① TGDEC. Unit:

Using this unit, the operation of a two shaft gas turbine system for electric generation can be study and investigate.
Anodized aluminium and steel 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.
High Pressure Turbine, that it is the Gas Generative Turbine. It consists of:
- Radial compressor.
- Tubular type combustion chamber.
- Expansion turbine.
- Speed range: 60,000-120,000 rpm.
- Max. compression ratio: 2:1.
- Max. fuel consumption: 20 kg/hour.

Low Pressure Turbine (Power Turbine):
- Speed range (r. p. m.): 15,000-25,000 rpm.
- Electrical power: Measurement range: 0-1,500W.

Asynchronous (motor) generator, computer controlled; speed range: 1,500-3,000 rpm.
Power turbine connection and generator by means of adjustable belt-drive.
Start fan, driven by an electrical motor, for starting the turbine and gas sweep. This fan is computer controlled.
Aspiration mufler.
Line of fuel gas, consists of:
- Valve to open or to close the feeding.
- Pressure regulation valve.
- Flow meter (rotameter): 20-80 l/min.
- Electrovalve (solenoid), computer controlled.
- Gas injector.

TGDEC. Unit

Ignition electrode, computer controlled, feeded by an ignition transformer.
Ionization electrode, computer controlled, to detect that the flame is ignited, as security system.
Lubrication installation, consists of:
- Oil tank of 5 litres.
- Gear pump, computer controlled, to impulse the oil to the bearings of both turbine shafts.
- Filtration unit.
- 2 valves for regulating the oil feed to the turbine.

Plate heat exchanger for cooling the oil of the turbines.
Water supply connections.
Air filter.
Exhaust gas outlet and exhaust mufler.
Sensors and instrumentation:
- 8 Temperature sensors, "K" type, placed in the different process stages (temperature range: 0-1,100°C):
  - Temperature of the inlet air to the compressor.
  - Temperature of the inlet air to the combustion chamber.
  - Temperature of the inlet gases to the gas generative turbine.
  - Temperature of the inlet gases to power turbine.
  - Temperature of the exhaust gases.
  - Temperature of the bearing lubrication oil.
  - Temperature of the inlet refrigeration water.
  - Temperature of the outlet refrigeration water.
- 2 Speed sensors to measure the rpm of each turbine, measurement range: 0-200,000 rpm.
- 5 Pressure sensors, for measuring:
  - Fuel (propane gas) pressure at the combustion chamber inlet, range: 0-2 bar.
  - Pressure in the combustion chamber, range: 0-2 bar.
  - Compression of the gas generative turbine, range: 0-2 bar.
  - Pressure at the power turbine inlet, range: 0-2 bar.
  - Atmospheric pressure, range: 900-1,200 mbar.
- 2 Flow sensors:
  - Inlet air, range: 0-3,000 m^3/h.
  - Outlet gases, range: 0-3,000 m^3/h.
- 4 Manometers, range: 0-2 bar.
- 3 High pressure switches.
- ATEX flowmeter for measuring the gas consumption.
- Current and voltage measurement.
- Handling box with PLC, which includes:
  - Front panel with LEDs indicating the unit status.
  - Oil temperature control display.
- Safety system to prevent faults.

Operation with propane.
This unit incorporates wheels for its mobility.

Continue...

Items supplied as standard (continuation)

② TGDEC/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.

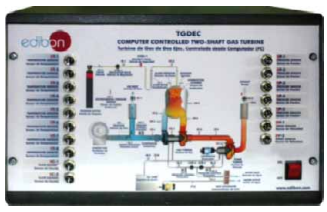
Shield and filtered signals to avoid external interferences.

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 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.



TGDEC/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.

Number of DMA channels=6.

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.

DAB

④ TGDEC/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.

Management, processing, comparison and storage of data.

Sampling velocity up to 250,000 data per second guaranteed.

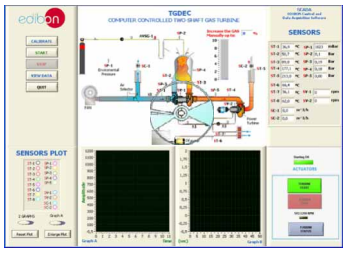
Calibration system for the sensors involved in the process.

It allows the registration of the alarms state and the graphic representation in real time.

Comparative analysis of the obtained data, after to 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.



TGDEC/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: TGDEC + TGDEC/CIB + DAB + TGDEC/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.

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).

PLC-PI

⑧ TGDEC/PLC-SOF. PLC Control Software:

For this particular unit, always included with PLC supply.

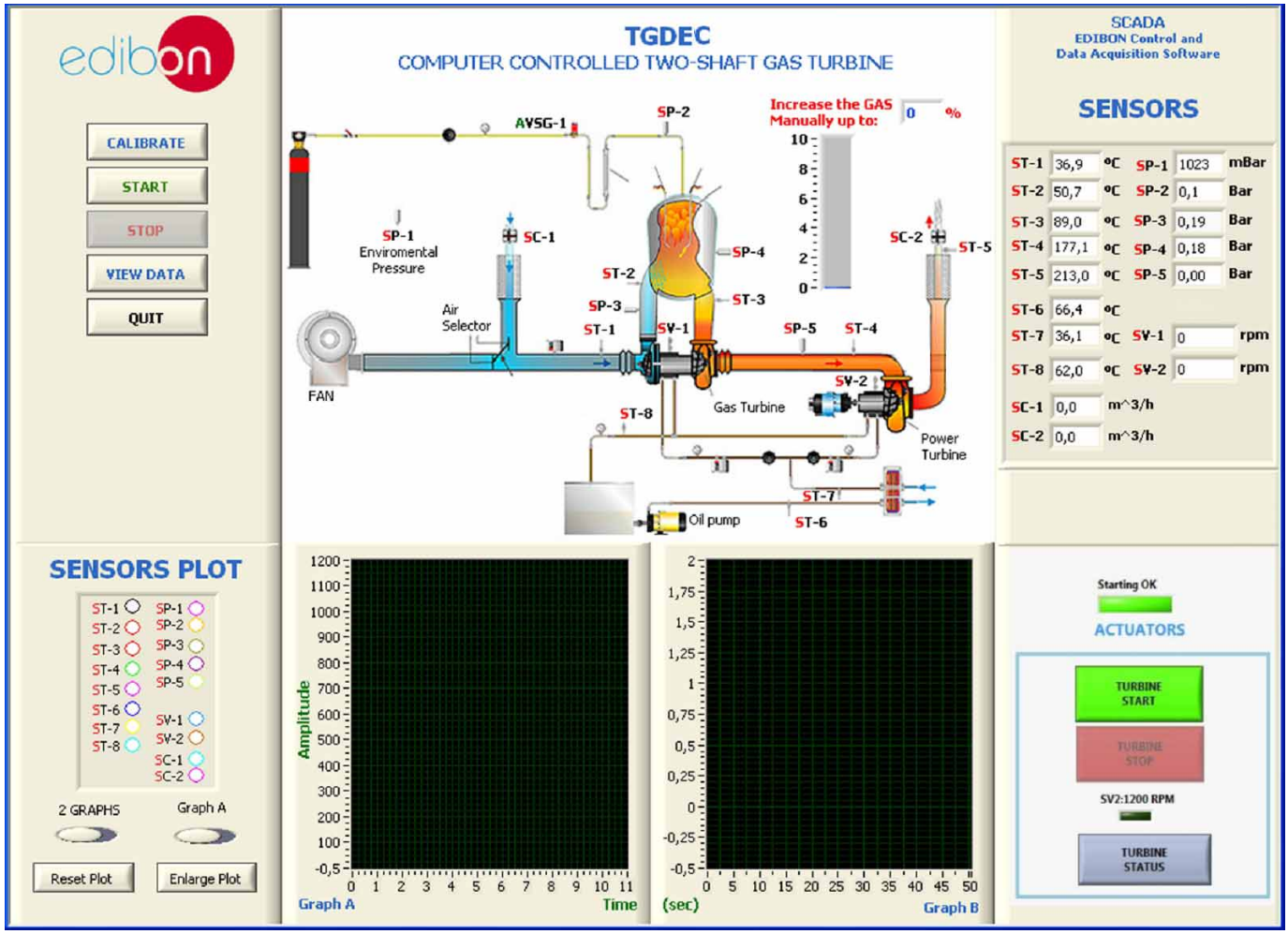
Items available on request

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

⑩ TGDEC/FSS. Faults Simulation System.

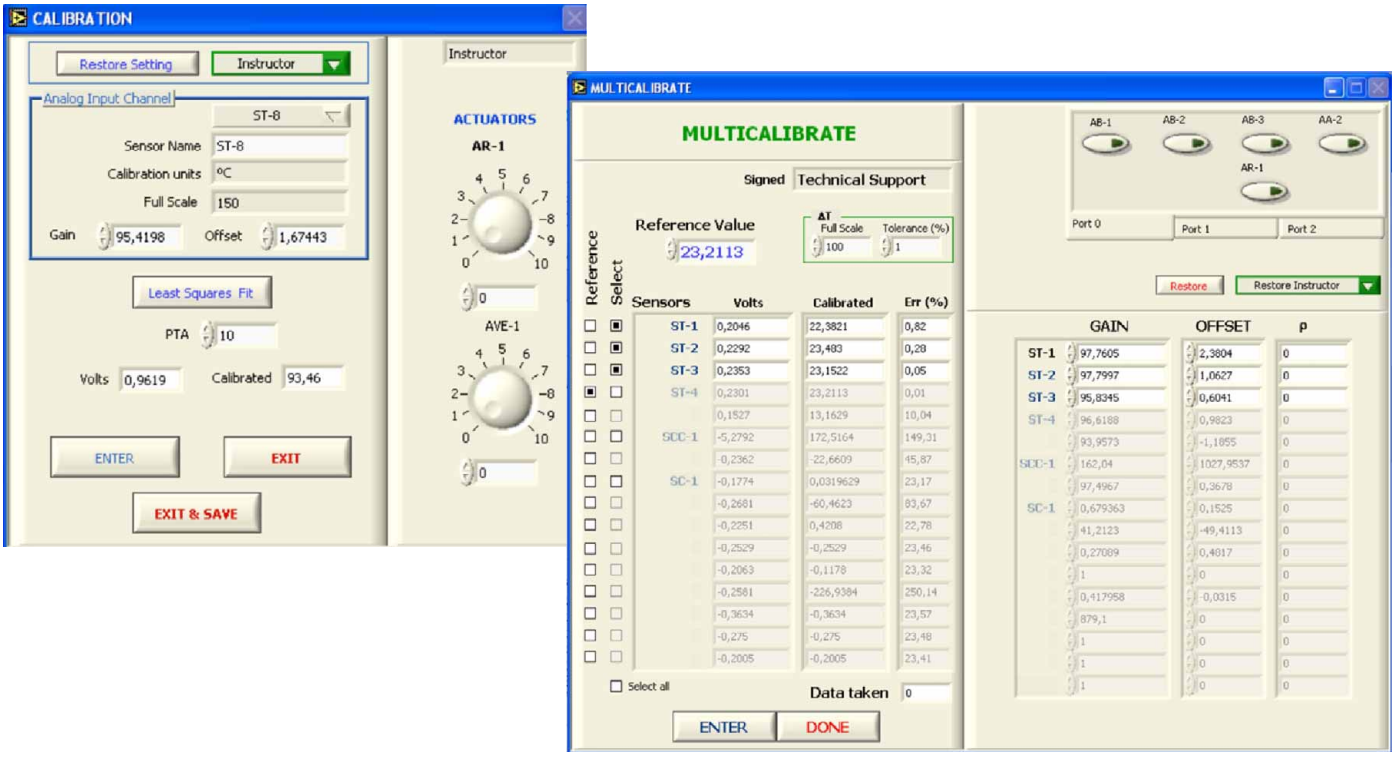
Software Main Screens

Main screen



Note: ST= Temperature sensor. SC= Flow sensor. SP= Pressure sensor. SV= Speed sensor.

Examples of Sensors Calibration screens



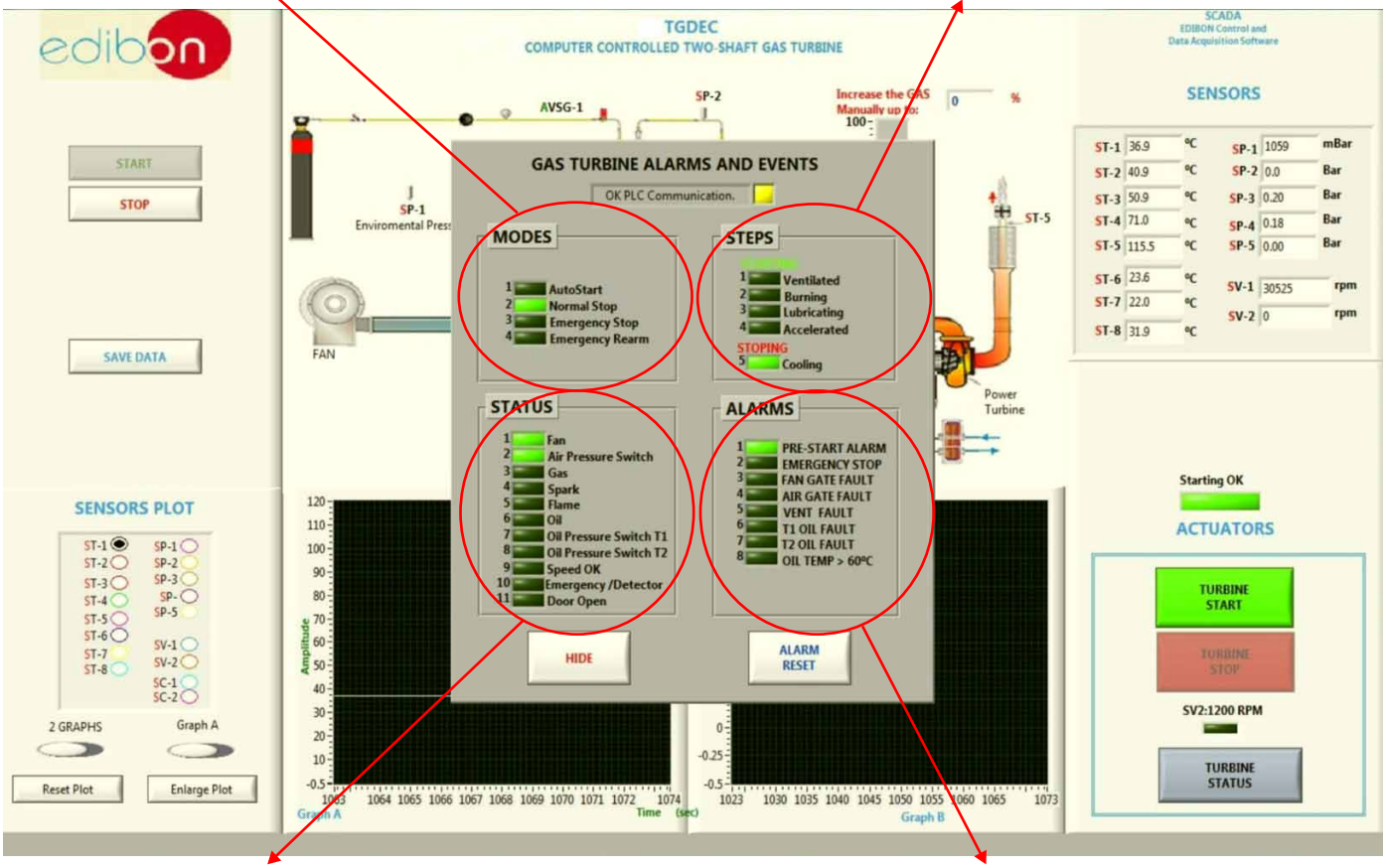
Continue...

Some typical exercises results

Clicking the "TURBINE STATUS" the software shows a window like the next picture, detailing following data, events and status:

MODES: Indicates the turbine operation mode.

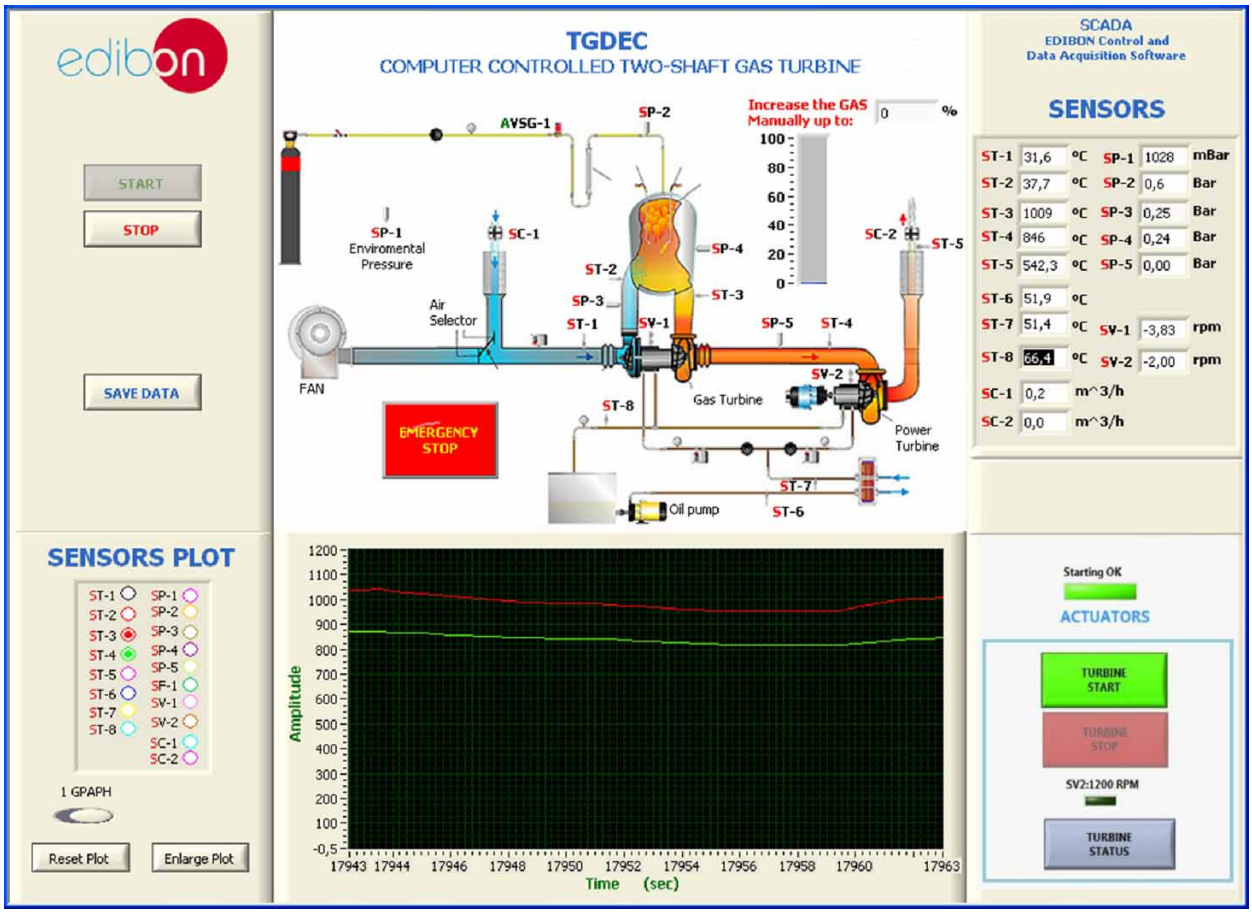
STEPS: Show, in real time, the different steps in the turbine start progression.



STATUS: Indicates the turbine status.

ALARMS: Indicates the anomalies during the normal operation.

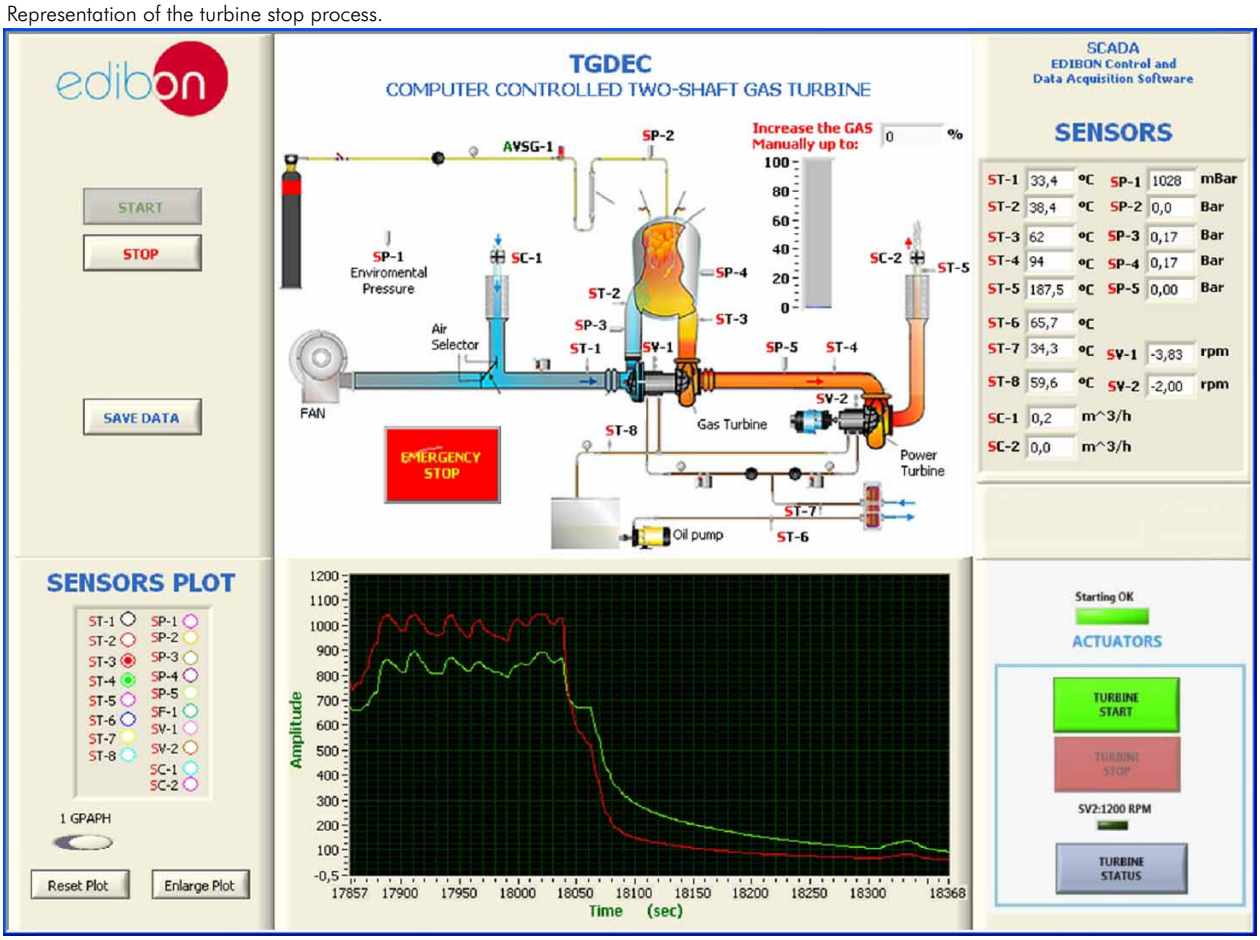
Representation, in real time, of the sensors during the unit operation.



Continue...

Some typical exercises results

Representation of the turbine stop process.



EXERCISES AND PRACTICAL POSSIBILITIES

Some Practical Possibilities of the Unit:

1.- Study of a gas turbine operation.
2.- Determination of the gas turbine efficiency.
3.- Determination of the compressor operation point.
4.- Operation with power turbine.
5.- Determination of fuel consumption.
6.- Thermal efficiency.
7.- Air standard cycle.
8.- Heat balance.
9.- Work ratio.
10.- Pressure ratio.
11.- Pressure loss.
12.- Air and fuel ratio.
13.- Combustion efficiency.
14.- Recording the turbine characteristic curve.
15.- Determination of the efficiency of the compressor.
16.- Determination of the efficiency of high pressure turbine.
17.- Determination of the efficiency of output turbine (low pressure).
18.- Temperatures measurements.
19.- Effective turbine power output.
20.- Safety systems in the operation of a gas turbine.

Other possible practices:

21.- Sensors calibration.

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

22.- Control of the TGDEC unit process through the control interface box without the computer.
23.- Visualization of all the sensors values used in the TGDEC unit process.
24.- Calibration of all sensors included in the TGDEC unit process.
25.- Hand on of all the actuators involved in the TGDEC unit process.
26.- Realization of different experiments, in automatic way, without having in front the unit. (This experiment can be decided previously).
27.- 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).
28.- PLC hardware general use and manipulation.
29.- PLC process application for TGDEC unit.
30.- PLC structure.
31.- PLC inputs and outputs configuration.
32.- PLC configuration possibilities.
33.- PLC program languages.
34.- PLC different programming standard languages.
35.- New configuration and development of new process.
36.- Hand on an established process.
37.- To visualize and see the results and to make comparisons with the TGDEC unit process.
38.- Possibility of creating new process in relation with the TGDEC unit.
39.- PLC Programming Exercises.
40.- 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

Two-Shaft Gas Turbine (TGDEC)

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

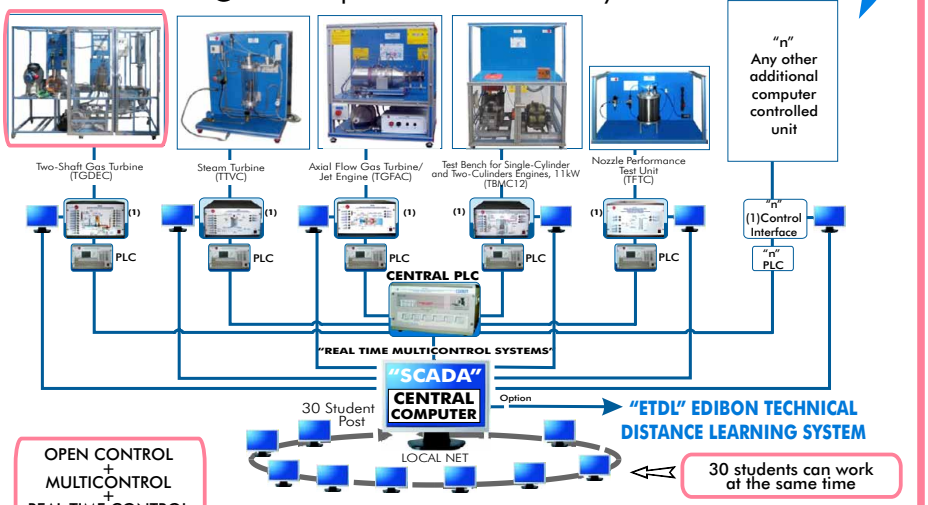
Note: The Mini ESN system can be used with any EDIBON computer controlled unit.

Expansion 2:

EDIBON PATENT

Teaching Technique used

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



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: TGDEC. Two-Shaft Gas Turbine.**
② **TGDEC/CIB. Control Interface Box.**
③ **DAB. Data Acquisition Board.**
④ **TGDEC/CCSOF. Computer Control + Data Acquisition + Data Management Software.**
⑤ **Cables and Accessories**, for normal operation.
⑥ **Manuals.**

* **IMPORTANT: Under TGDEC 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 TGDEC/PLC-SOF. PLC Control Software.
⑨ TGDEC/CAL. Computer Aided Learning Software (Results Calculation and Analysis). (Available on request).
⑩ TGDEC/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: three-phase, 380V./150Hz or 220V./60Hz.
- Cooling water supply (min. 3 l/min.).
- Drainage.
- Propane 1.5-2.5 bar.
- Exhaust gases extractor.
- Computer (PC).

DIMENSIONS & WEIGHTS

TGDEC Unit:	-Dimensions: 2500 x 700 x 1800 mm. approx.
	-Weight: 235 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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REPRESENTATIVE: