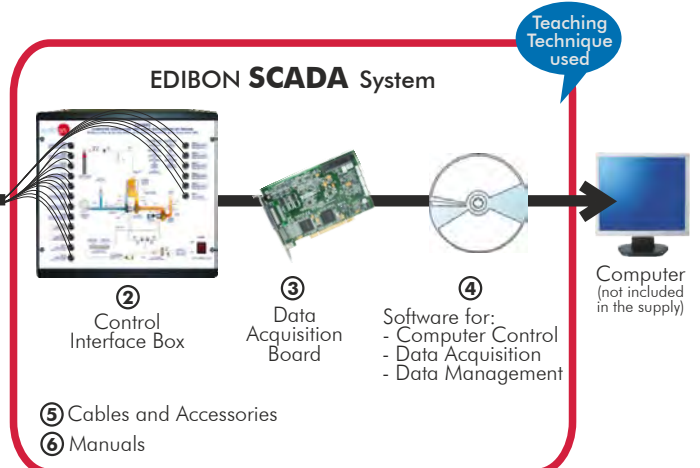




① Unit: TGDEPC. Two-Shaft Gas Turbine/Jet Engine

EDIBON PATENT



*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 CAL software helps the user perform calculations and comprehend the results.**
- ▶ **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.**

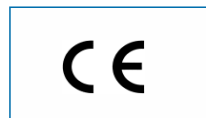
**OPEN CONTROL
+
MULTICONTROL
+
REAL TIME CONTROL**



For more information about Key Features, click here:



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 and
Worlddidac Member

INTRODUCTION

The Computer Controlled Two-Shaft Gas Turbine/Jet Engine "TGDEPC", 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. Moreover, the unit can be configured as a Jet Engine.

A Gas Turbine is an internal combustion rotating motor. Its name is due to its working fluid being a gas, generally air. Basically, it consists of a compressor, where the inlet air pressure is increased and goes to a combustion chamber where a thermal energy input is carried out, and a turbine, where the hot gas expands. The turbine and the compressor are placed on the same axis, so a part of the energy generated in the turbine is used by the compressor to compress the air.

The importance of studying the gas turbine is given by its great field of application, among its uses we can mention:

Gas turbine for electricity generation. Combined cycle together with vapour turbine. Cogeneration: It is a combined cycle of electric power and thermal power. Reactor: in aviation field applications. The gas turbine as jet engine. Turboprops: unlike the turbojet the turbine is designed to obtain the maximum mechanic energy possible, which is used to move a propeller.

GENERAL DESCRIPTION

The main element of the "TGDEPC" 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 second possibility of the "TGDEPC" unit operation is as a single shaft jet engine. The nozzle accessory is assembled to the Generative Turbine, what will cause an exhaust gases acceleration with the consequential reaction, which will be measured by a force sensor (load cell).

The TGDEPC unit also includes:

Start system: It consists of a centrifugal fan driven by an electrical motor. Air provided by this fan acts on the blades of the compressor, causing the rotation of the high pressure turbine.

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

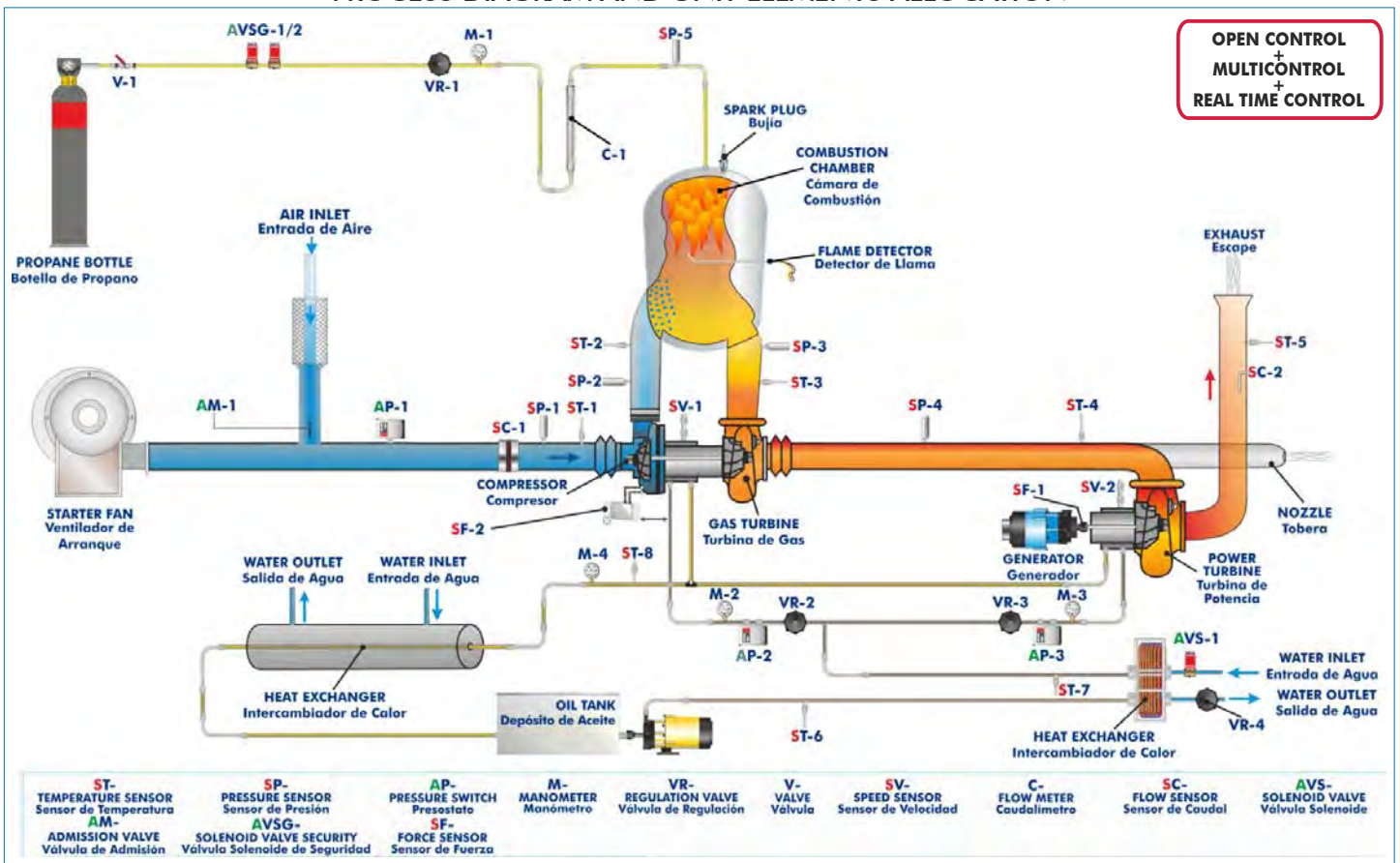
Ignition system: The activation energy of the air-fuel mix will cause the flame ignition. It consists of an ignition electrode or spark plug feeded by an ignition transformer. An ionization electrode detects that the flame is ignited.

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

Refrigeration system: It consists of a plate heat exchanger and a tubular heat exchanger through which the oil transfers its heat to the refrigeration water.

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 Management Software Packages, for controlling the process and all parameters involved in the process.

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 TGDEPC. Unit:

Using this unit the operation of both a two shaft gas turbine system for electric generation and a jet engine can be study and investigate.

Anodized aluminum and steel frame and panels of painted steel.

Main metallic elements of 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.
- Operation speed range: 70000-90000 rpm.
- Max. compression ratio: 2:1.
- Max. fuel consumption: 20 kg/hour.

Low Pressure Turbine (Power Turbine):

- Speed range (r. p. m.): 15000-25000 rpm.
- Electrical power: Measurement range: 0-200W.

Asynchronous (motor) generator; computer controlled; speed range: 1500-3000 rpm.

Power turbine connection and generator by means of adjustable belt drive.

Operation as a jet engine:

- Turbine speed range: 60000-160000 rpm.
- Trust nozzle, with force sensor (load cell).
- Trust measuring range: 0-50 N.

Start fan, driven by an electrical motor, for starting the turbine and gas sweep. This fan is automatically computer controlled and it is used to refrigerate.

Aspiration muffler.

Line of fuel gas, consists of:

- Valve to open or to close the feeding.
- Pressure regulation valve.
- Flow meter (rotameter): 20-80 l./min.
- Solenoid valve, automatically computer controlled.
- Gas injector.

Spark plug, automatically computer controlled, powered by an ignition transformer.

Ionization electrode, automatically computer controlled, to detect that the flame is ignited, as security system.

Lubrication system, consists of:

- Oil tank of 5 l.
- Gear pump, automatically 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 to cool the oil leaving the turbines.

Tubular heat exchanger to cool the oil entering the turbines.

Water supply connections.

Exhaust gas outlet and exhaust muffler.

Sensors and instrumentation:

- 8 Temperature sensors, "K" type, placed in the different process stages (temperature range: 0-1100°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.



TGDEPC. Unit

Continue...

2 Speed sensors to measure the rpm of each turbine, measurement range: 0-200000 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.

Pressure at the turbine outlet, range: 0-2 bar.

Compressor outlet, range: 0-2 bar.

Compressor inlet, range: 0-100 mbar.

2 Flow sensors:

Inlet air, range: 0-3000 m³/h.

Outlet gases, range: 0-3000 m³/h.

Force sensor (load cell) of the generator.

Force sensor (load cell), thrust measuring: 0-50N.

4 Manometers, range: 0-2 bar.

3 Pressure switches to control air and oil circuits.

ATEX flowmeter for measuring the gas consumption at any moment.

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.

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 CAL software helps the user perform calculations and comprehend the results.

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 TGDEPC/CIB. Control Interface Box:

The Control Interface Box is part of the SCADA system.

Control interface box with process diagram in the front panel and with the same distribution that the different elements located in the unit, for an easy understanding by the student.

All sensors, with their respective signals, are properly manipulated from -10V. to +10V. computer output. Sensors connectors in the interface have different pines numbers (from 2 to 16), to avoid connection errors.

Single cable between the control interface box and computer.

The unit control elements are permanently computer controlled, without necessity of changes or connections during the whole process test procedure.

Simultaneous visualization in the computer of all parameters involved in the process.

Calibration of all sensors involved in the process.

Real time curves representation about system responses.

Storage of all the process data and results in a file.

Graphic representation, in real time, of all the process/system responses.

All the actuators' values can be changed at any time from the keyboard allowing the analysis about curves and responses of the whole process.

All the actuators and sensors values and their responses are displayed on only one screen in the computer.

Shield and filtered signals to avoid external interferences.

Real time 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.



TGDEPC/CIB

③ **DAB. Data Acquisition Board:**

The Data Acquisition board is part of the SCADA system.

PCI Express Data acquisition board (National Instruments) to be placed in a computer slot. Bus PCI Express.

Analog input:

Number of **channels=16** single-ended or 8 differential.

Resolution=16 bits, 1 in 65536.

Sampling rate up to: 250 KS/s (kilo samples per second).

Input range (V)= 10V.

Data transfers=DMA, interrupts, programmed I/O. DMA channels=6.

Analog output:

Number of **channels=2**.

Resolution=16 bits, 1 in 65536.

Maximum output rate up to: 900 KS/s.

Output range(V)= 10V.

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

Digital Input/Output:

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

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

Timing:

Number of **Counter/timers=4**.

Resolution: Counter/timers: 32 bits.



DAB

④ **TGDEPC/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 250 KS/s (kilo samples per second).

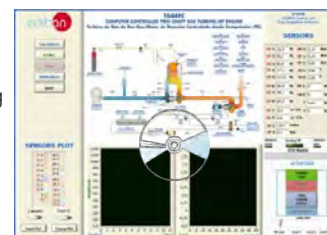
Calibration system for the sensors involved in the process.

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

Comparative analysis of the obtained data, after the process and modification of the conditions during the process.

Open software, allowing the teacher to modify texts, instructions. Teacher's and student's passwords to facilitate the teacher's control on the student, and allowing the access to different work levels.

This unit allows the 30 students of the classroom to visualize simultaneously all the results and the manipulation of the unit, during the process, by using a projector or an electronic whiteboard.



TGDEPC/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: TGDEPC + TGDEPC/CIB + DAB + TGDEPC/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 MAIN ITEMS

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

Additional practical possibilities:

- 23.- Sensors calibration.

Other possibilities to be done with this Unit:

- 24.- Many students view results simultaneously.
To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
- 25.- 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.
- 26.- The Computer Control System with SCADA allows a real industrial simulation.
- 27.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
- 28.- This unit can be used for doing applied research.
- 29.- This unit can be used for giving training courses to Industries even to other Technical Education Institutions.
- 30.- Control of the TGDEPC unit process through the control interface box without the computer.
- 31.- Visualization of all the sensors values used in the TGDEPC unit process.
- Several other exercises can be done and designed by the user.

REQUIRED SERVICES

- Electrical supply: three-phase, 380V./50Hz or 220V./60Hz.
- Tap water supply (min. 3 l./min.).
- Drainage.
- Propane 1.5-2.5 bar.
- Exhaust gases extractor.
- Computer.

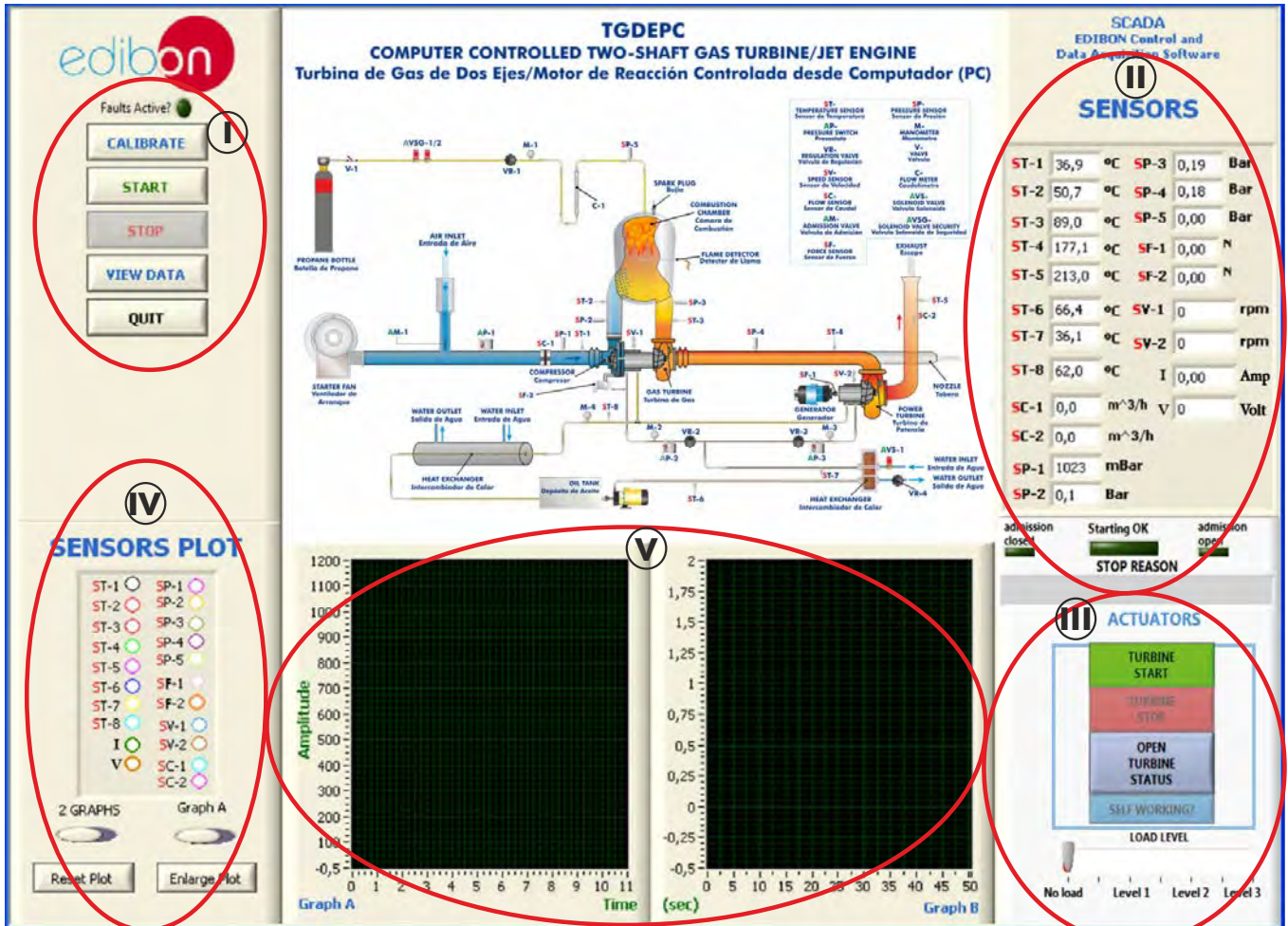
DIMENSIONS & WEIGHTS

TGDEPC:

- | | |
|------------------------|--|
| Unit: | -Dimensions: 2500 x 700 x 1900 mm. approx.
(98.42 x 27.55 x 74.80 inches approx.) |
| | -Weight: 250 Kg. approx.
(551 pounds approx.) |
| Control-Interface Box: | -Dimensions: 490 x 450 x 470 mm. approx.
(19.29 x 17.72 x 18.50 inches approx.) |
| | -Weight: 20 Kg. approx.
(44 pounds approx.) |

SCADA

Main screen



- I Main software operation possibilities.
- II Sensors displays, real time values, and extra output parameters. Sensors: ST= Temperature sensor. SC= Flow sensor. SP= Pressure sensor. SV= Speed sensor. SF= Force sensor.
- III Actuators controls. Actuators: AP= Pressure switch. AM=Admission valve. AVS= Solenoid valve. AVSG= Solenoid valve security.
- IV Channel selection and other plot parameters.
- V Real time graphics displays.

Software for Sensors Calibration

Example of screen



By using a free of charge code, the teacher and the students can calibrate the unit.

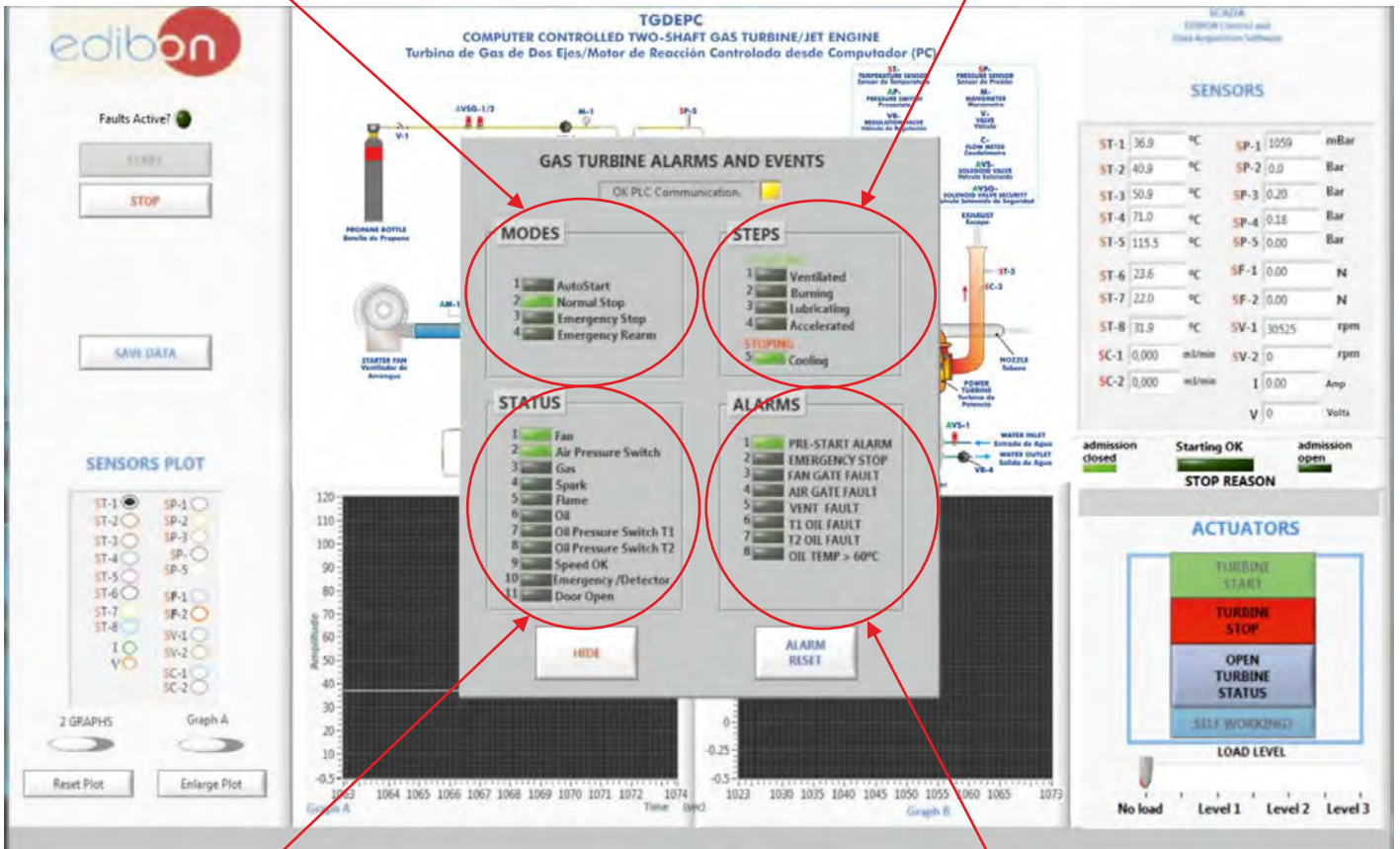
The teacher can recover his/her own calibration by using the EDIBON code that we give free of charge.

SOME REAL RESULTS OBTAINED FROM THIS UNIT

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

MODES: Indicates the turbine operation mode.

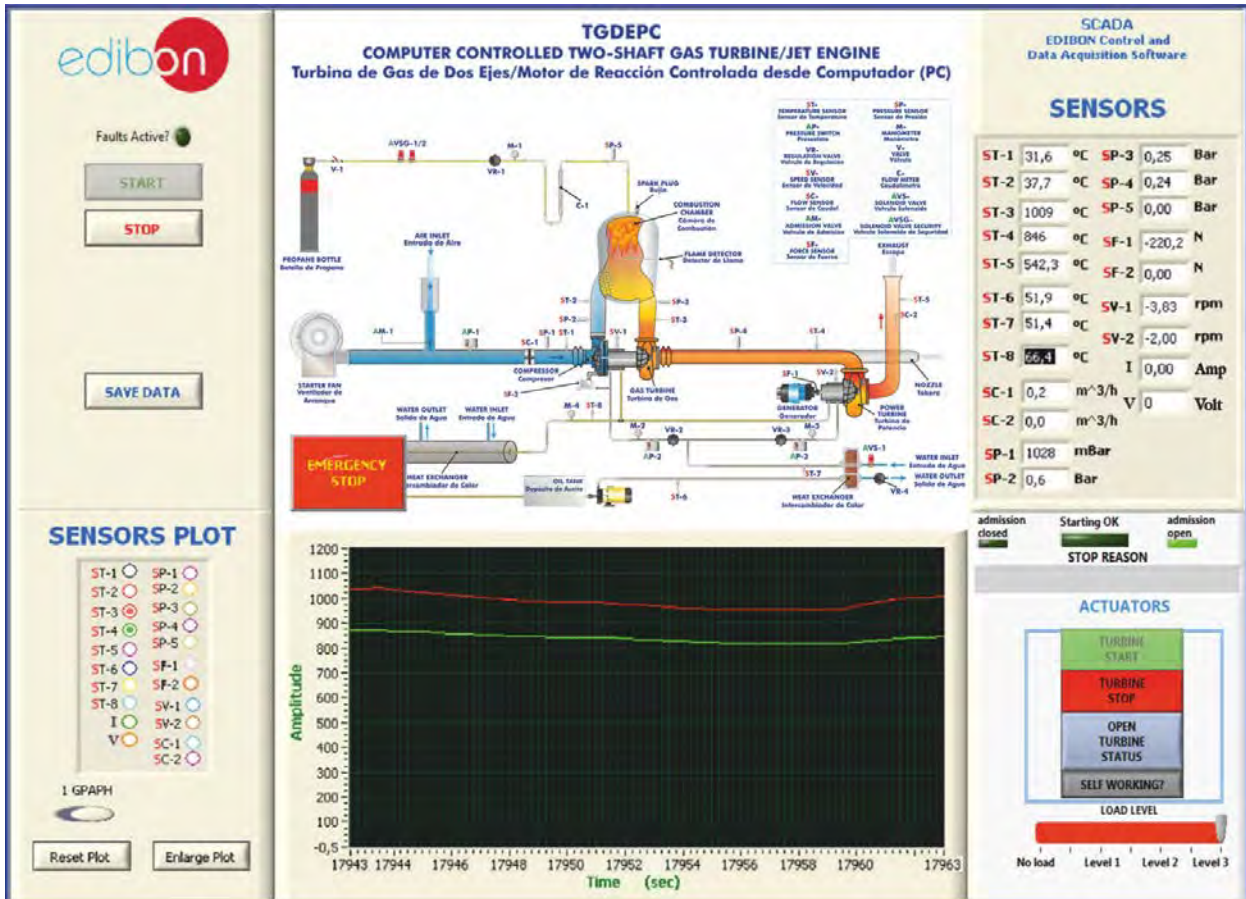
STEPS: Show, in real time, the different steps in the turbine start progression.




STATUS: Indicates the turbine status.

ALARMS: Indicates the anomalies during the normal operation.

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



Representation of the turbine stop process.



Faults Active? ●

START

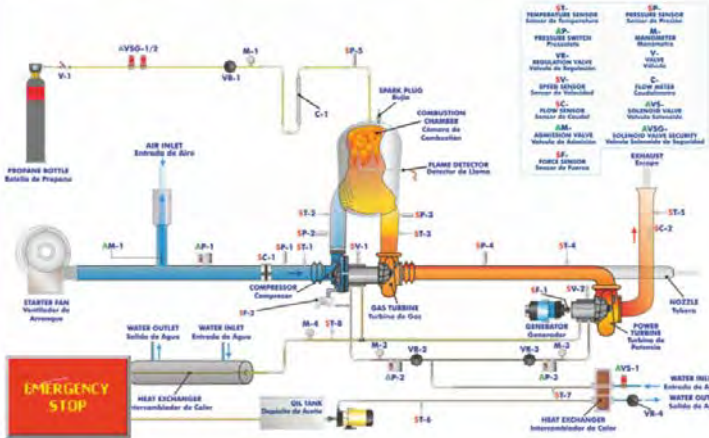
STOP

SAVE DATA

TGDEPC

COMPUTER CONTROLLED TWO-SHAFT GAS TURBINE/JET ENGINE

Turbina de Gas de Dos Ejes/Motor de Reacción Controlada desde Computador (PC)



SCADA
EDIBON Control and
Data Acquisition Software

SENSORS

ST-1	33,4	°C	SP-3	0,17	Bar
ST-2	38,4	°C	SP-4	0,17	Bar
ST-3	62	°C	SP-5	0,00	Bar
ST-4	94	°C	SF-1	-220,2	N
ST-5	187,5	°C	SF-2	0,00	N
ST-6	65,7	°C	SV-1	-3,83	rpm
ST-7	34,3	°C	SV-2	-2,00	rpm
ST-8	59,6	°C	I	0,00	Amp
SC-1	0,2	m ³ /h	V	0	Volt
SC-2	0,0	m ³ /h			
SP-1	1028	mBar			
SP-2	0,0	Bar			

admission closed ■ Starting OK ■ admission open ■

STOP REASON

ACTUATORS

TURBINE START

TURBINE STOP

OPEN TURBINE STATUS

SELF WORKING?

LOAD LEVEL

No load | Level 1 | Level 2 | Level 3

SENSORS PLOT

- ST-1 SP-1
- ST-2 SP-2
- ST-3 SP-3
- ST-4 SP-4
- ST-5 SP-5
- ST-6 SF-1
- ST-7 SF-2
- ST-8 SV-1
- I SV-2
- V SC-1
- SC-2

1 GRAPH

Reset Plot Enlarge Plot



Amplitude

Time (sec)

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) Technical and Vocational Education configuration. (CAI and FSS)
- b) Higher Education and/or Technical and Vocational Education configuration. (CAL)
- c) Multipost Expansions options. (Mini ESN and ESN)

a) Technical and Vocational Education configuration

⑦ **TGDEPC/CAI. Computer Aided Instruction Software System.**

This complete software package includes two Softwares: the INS/SOF. Classroom Management Software (Instructor Software) and the TGDEPC/SOF. Computer Aided Instruction Software (Student Software).

This software is optional and can be used additionally to items (1 to 6).

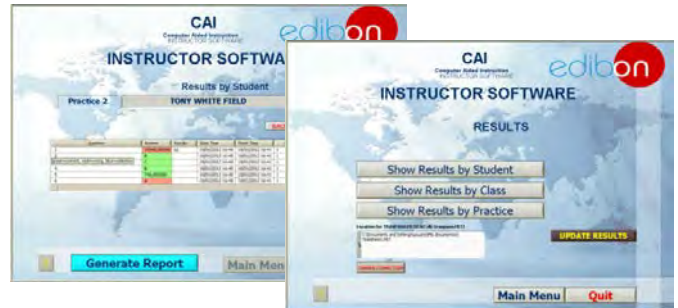
This complete software package consists of an Instructor Software (INS/SOF) totally integrated with the Student Software (TGDEPC/SOF). Both are interconnected so that the teacher knows at any moment what is the theoretical and practical knowledge of the students.

- **INS/SOF. Classroom Management Software (Instructor Software):**

The Instructor can:

- Organize Students by Classes and Groups.
- Create easily new entries or delete them.
- Create data bases with student information.
- Analyze results and make statistical comparisons.
- Generate and print reports.
- Detect student's progress and difficulties.
- ...and many other facilities.

Instructor Software



- **TGDEPC/SOF. Computer Aided Instruction Software (Student Software):**
It explains how to use the unit, run the experiments and what to do at any moment.

This Software contains:

- Theory.
- Exercises.
- Guided Practices.
- Exams.

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

www.edibon.com/products/catalogues/en/CAI.pdf

Student Software



⑧ **TGDEPC/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 on 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/products/catalogues/en/FSS.pdf

Example of some screens



b) Higher Education and/or Technical and Vocational Education configuration

⑩ **TGDEPC/CAL. Computer Aided Learning Software (Results Calculation and Analysis).**

This Computer Aided Learning Software (CAL) is a Windows based software, simple and very easy to use, specifically developed by EDIBON. It is very useful for Higher Education level.

CAL is a class assistant that helps in doing the necessary calculations to extract the right conclusions from data obtained during the experimental practices.

CAL computes the value of all the variables involved and performs the calculations.

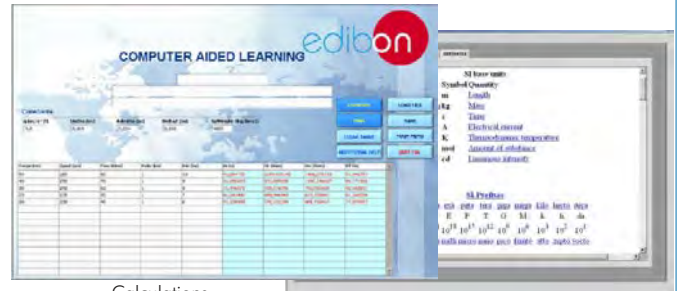
It allows to plot and print the results. Within the plotting options, any variable can be represented against any other.

Different plotting displays.

It has a wide range of information, such as constant values, unit conversion factors and integral and derivative tables.

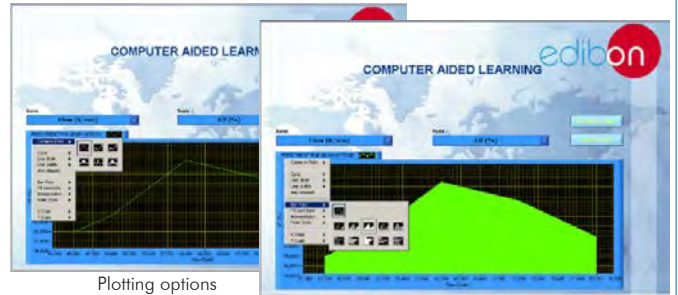
For more information see CAL catalogue. Click on the following link:

www.edibon.com/products/catalogues/en/CAL.pdf



Calculations

Information of constant values, unit conversion factors and integral and derivative tables



Plotting options

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 on 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:

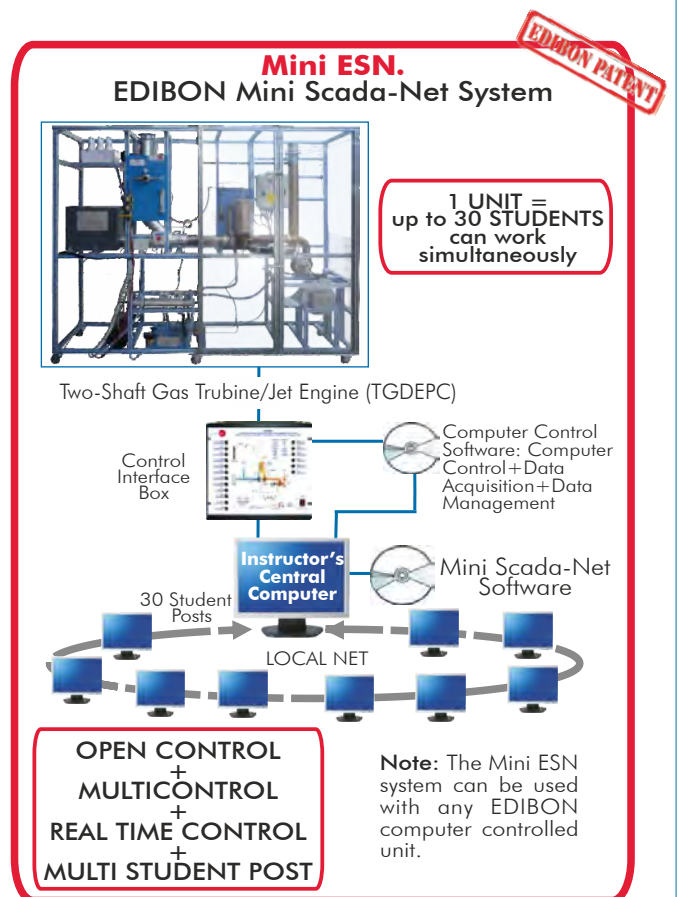
- It allows up to 30 students to work simultaneously with the EDIBON Computer Controlled Unit with SCADA, connected in a local net.
- Open Control + Multicontrol + Real Time Control + Multi Student Post.
- Instructor controls and explains to all students at the same time.
- Any user/student can work 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



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/thermodynamicsthermotechnics/esn-thermodynamics/ESN-THERMODYNAMICS.pdf

ORDER INFORMATION

Main items (always included in the supply)

Minimum supply always includes:

- ① **Unit: TGDEPC. Two-Shaft Gas Turbine/Jet Engine.**
- ② **TGDEPC/CIB. Control Interface Box.**
- ③ **DAB. Data Acquisition Board.**
- ④ **TGDEPC/CCSOF. Computer Control + Data Acquisition + Data Management Software.**
- ⑤ **Cables and Accessories**, for normal operation.
- ⑥ **Manuals.**

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

Optional items (supplied under specific order)

- a) Technical and Vocational configuration
 - ⑦ TGDEPC/CAI. Computer Aided Instruction Software System.
 - ⑧ TGDEPC/FSS. Faults Simulation System.
- b) Higher Education and/or Technical and Vocational Education configuration
 - ⑨ TGDEPC/CAL. Computer Aided Learning Software (Results Calculation and Analysis).
- c) Multipost Expansions options
 - ⑩ Mini ESN. EDIBON Mini Scada-Net System.
 - ⑪ ESN. EDIBON Scada-Net System.

① TGDEPC. Unit:

Using this unit the operation of both a two shaft gas turbine system for electric generation and a jet engine can be study and investigate.
 Anodized aluminum and steel structure and panels of painted steel.
 Main metallic elements of 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. Operation speed range: 70000-90000 rpm. Max. compression ratio: 2:1. Max. fuel consumption: 20 kg/hour.
 Low Pressure Turbine (Power Turbine):
 Speed range (r. p. m.): 15000-25000 rpm. Electrical power: Measurement range: 0-200W.
 Asynchronous (motor) generator, computer controlled; speed range: 1500-3000 rpm.
 Power turbine connection and generator by means of adjustable belt drive.
 Operation as a jet engine:
 Turbine speed range: 60000-160000 rpm. Trust nozzle, with force sensor (load sensor). Trust measuring range: 0-50 N.
 Start fan, driven by an electrical motor, for starting the turbine and gas sweep. This fan is automatically computer controlled and it is used to refrigerate.
 Aspiration muffler.
 Line of fuel gas, consists of:
 Valve to open or to close the feeding. Pressure regulation valve. Flow meter (rotameter): 20-80 l./min. Solenoid valve, automatically computer controlled.
 Gas injector.
 Spark plug, automatically computer controlled, powered by an ignition transformer.
 Ionization electrode, automatically computer controlled, to detect that the flame is ignited, as security system.
 Lubrication system, consists of:
 Oil tank of 5 l. Gear pump, automatically 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 to cool the oil leaving the turbines.
 Tubular heat exchanger to cool the oil entering the turbines.
 Water supply connections.
 Exhaust gas outlet and exhaust muffler.
 Sensors and instrumentation:
 8 Temperature sensors, "K" type, placed in the different process stages (temperature range: 0-1100°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: 0-200000 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. Compressor outlet, range: 0-2 bar. Compressor inlet, range: 0-100 mbar. Pressure at the turbine outlet, range: 0-2 bar.
 2 Flow sensors:
 Inlet air, range: 0-3000 m³/h. Outlet gases, range: 0-3000 m³/h.
 Force sensor (load cell) of the generator
 Force sensor (load cell), thrust measuring: 0-50N.
 4 Manometers, range: 0-2 bar.
 3 Pressure switches to control air and oil circuits.
 ATEX flowmeter for measuring the gas consumption at any moment.
 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.
 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 CAL software helps the user perform calculations and comprehend the results.
 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 TGDEPC/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 TGDEPC/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 Main Items

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

Additional practical possibilities:

- 23.- Sensors calibration.

Other possibilities to be done with this Unit:

- 24.- Many students view results simultaneously.

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

- 25.- 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.

- 26.- The Computer Control System with SCADA allows a real industrial simulation.
- 27.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
- 28.- This unit can be used for doing applied research.
- 29.- This unit can be used for giving training courses to Industries even to other Technical Education Institutions.
- 30.- Control of the TGDEPC unit process through the control interface box without the computer.
- 31.- Visualization of all the sensors values used in the TGDEPC unit process.

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

a) Technical and Vocational Education configuration

⑦ **TGDEPC/CAL. Computer Aided Instruction Software System.**

This complete software package consists of an Instructor Software (INS/SOF) totally integrated with the Student Software (TGDEPC/SOF).

-INS/SOF. Classroom Management Software (Instructor Software):

The Instructor can:

- Organize Students by Classes and Groups.
- Create easily new entries or delete them.
- Create data bases with student information.
- Analyze results and make statistical comparisons.
- Generate and print reports.
- Detect student's progress and difficulties.

-TGDEPC/SOF. Computer Aided Instruction Software (Student Software):

It explains how to use the unit, run the experiments and what to do at any moment.

This Software contains:

- Theory.
- Exercises.
- Guided Practices.
- Exams.

⑧ **TGDEPC/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 on 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.

b) Higher Education and/or Technical and Vocational Education configuration

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

This Computer Aided Learning Software (CAL) is a Windows based software, simple and very easy to use.

CAL is a class assistant that helps in doing the necessary calculations to extract the right conclusions from data obtained during the experimental practices.

CAL computes the value of all the variables involved and performs the calculations.

It allows to plot and print the results. Within the plotting options, any variable can be represented against any other.

Different plotting displays.

It has a wide range of information, such as constant values, unit conversion factors and integral and derivative tables.

c) Multipost Expansions options

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 on 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 improvements of the product.



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Issue: ED01/15
Date: November/2015

REPRESENTATIVE: