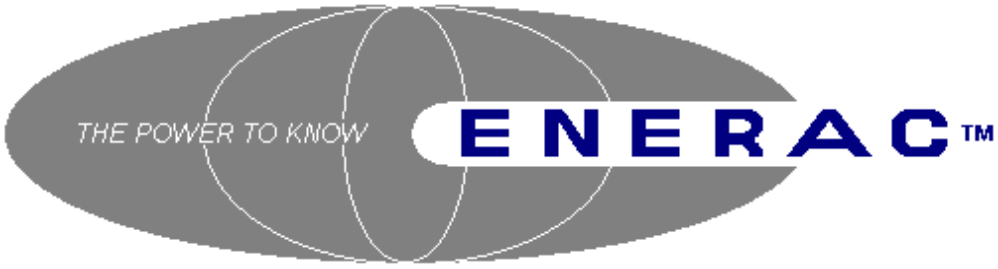

INSTRUCTION MANUAL
FOR

MICRO EMISSIONS ANALYZER
MODEL 200EX
MODEL 400EMS

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LIST OF ABBREVIATIONS

Ambient T.	Ambient (room) Temperature
BATT.	Battery voltage
CO	Carbon Monoxide (A toxic gas)
CO_2	Carbon Dioxide
EFFIC.	Combustion Efficiency (for boilers and furnaces, does not apply to engines).
ENG EFF	Engine thermal efficiency (heat loss method of calc.;not the same as combustion eff.)
GBH	Grams (of pollutant) per (engine) Brake horsepower-hour.
IN.WC.	Inches of Water (Draft measurement).
Net Stack	Stack temperature minus ambient temperature.
NO	Nitric oxide (A toxic gas)
NO_2	Nitrogen dioxide (A toxic gas)
NOX	Oxides of Nitrogen (A toxic mixture. of nitric oxide and nitrogen dioxide gases)
OXY	Oxygen
OXY_REF	Oxygen reference basis for correction of toxic gas concentration
PPM	Parts per million (Volume basis-dry)
SO_2	Sulfur Dioxide (A toxic gas)
Stack T.	Stack Temperature, degrees F or C
Ex-Air	Excess Air
%	Percent by volume dry basi;
#/B	lbs. (of pollutant) per million BTU (of fuel)
▲	"UP" button
▼	"DOWN" button

OPTIONS

Both ENERAC models, the 200EX and 400EMS have been designed as modular systems, permitting the installation in the field of most of the various available options. This manual describes the complete instruments equipped with all the options. The available options on the Model 200EX and 400EMS are as follows:

- 2" ENERAC Printer.
- Nitric oxide (NO) measurement capability.
- Nitrogen dioxide measurement capability. **(400EMS, only!)**
- Sulfur dioxide (SO_2) measurement capability. **(400EMS, only!)**
- Emissions units option (lbs/MBTU & Grams/Bhp-hour). **(400EMS, only!)**
- Internal 9600 baud modem. **(400EMS, only!)**
- CD-ROM or 3.5" diskette with custom program (ENERCOM ™ for WINDOWS™)
- 36" or 48" inconel probe option.
- Custom fuel option. (Either at the factory, or programmable using the ENERCOM™ for WINDOWS™ option

Any combination, or all of these options are available to meet the customer's requirements.

Various cables and attachments are available for special connections to the Micro Emissions Analyzer.

In addition, high resolution 0-200 PPM and extended range 0-4000 PPM versions are available on request. (0-10,000 PPM and 0-20,000 PPM available on carbon monoxide only).

CHAPTER 1

FUNDAMENTALS

The ENERAC Models 200EX and 400EMS Micro Emissions Analyzers are hand held state of the art analyzers designed for the following tasks:

- To measure the emissions of carbon monoxide, oxides of nitrogen, sulfur dioxide and oxygen from stationary and mobile combustion sources.

- To assist the operator of a combustion source with the task of optimizing its performance and saving fuel.

- To be used as a management tool to assist the plant manager with keeping records and controlling costs.

Both the ENERAC Model 200EX and 400EMS are easy to carry and utilize the latest technology; reliable flue type electrochemical sensors manufactured by the largest sensor manufacturer to measure emissions.

The ENERACs use sophisticated electronics and programming design for increased accuracy and flexibility. They measure 2 temperatures and 5 different stack gases. They compute efficiency of combustion as well as excess air and carbon dioxide.. They communicate with a variety of other computers via its RS-232 port. They have a library of 6 fuels and over 30 diagnostic and help messages and can operate either on its rechargeable batteries, AC power, or from a set of four AA alkaline cells.

ENERGY EFFICIENCY SYSTEMS has years of experience in the manufacture and marketing of portable combustion and emission analyzers. The models 200EX and 400EMS are based on this experience, together with the latest innovations in electronic and sensor technology. They also expresses our basic conviction that communications and artificial intelligence are the basic ingredients of the instrument of the future.

The instrument operates basically as follows:

Connect the probe and water trap to the analyzer. Turn the unit on and then insert the probe in the stack of an operating combustion source such as a boiler, furnace or

combustion engine. A pump located inside the instrument draws a small sample of the stack gas. The sample is conditioned before entering the analyzer by passing through a condensation trap and particulate filter. A number of sensors analyze the contents of the stack gas and its temperature and calculate and display the results. The results can also be printed, stored or send to another computer either by direct connection or by the telephone lines. The source operator makes the required adjustments based on the analysis of the stack conditions to optimize performance.

A. UNPACKING THE INSTRUMENT

Every ENERAC Model 200EX and 400EMS includes as standard equipment:

1. One Emissions Analyzer Model 200EX or 400EMS.
2. One stack probe with 10 ft. Viton hose (non-adsorbent, flexible).
3. One condensation trap with filter.
4. Three disposable fiber filters.
5. One detachable AC battery charger.
6. One instruction manual.
7. One printer instruction manual.
8. One velcro cover for printer.

Every ENERAC sold has stored in its memory information regarding manufacturing and sensor dates, as well as product identification, serial number of unit, version and original customer.

B. IMPORTANT ADVICE

Most stack gases are hot, full of moisture, corrosive and laden with soot particles.

To make sure that your instrument will give you a long time of trouble free performance, please observe the following recommendations.

1. Follow the instructions in your manual.

2. Never use the instrument without the fiber filter located inside the water trap. Operating the instrument without the filter will damage the pump and sensors. (This is a costly replacement!)

3. Do not expose the probe tip to open flame.

4. Do not rest the hose of the stack probe on a hot boiler surface.

5. Allow the probe tip to cool off and the instrument aspirate air, before packing the probe.

6. In dusty environments, cover the printer slot with the Velcro cover. THE PRINTER MAY BE DAMAGED, IF EXPOSED TO DUST!

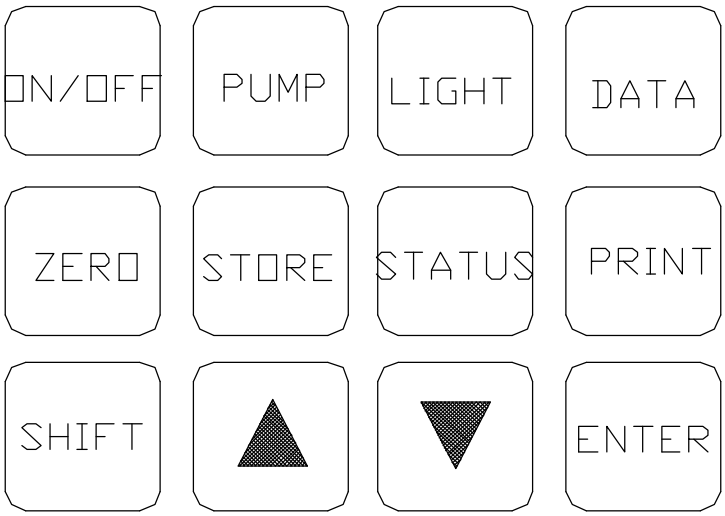
CHAPTER 2

THE INSTRUMENT KEYBOARD

Both the Model 200EX and 400EMS can be operated by using either:

- The 12 button keyboard located on the face of the analyzer, or
- By the use of commands through its serial port.

A brief explanation of the instrument's buttons follows:



"ON/OFF" Turns the instrument on or off.
"PUMP" Toggles the instrument's sample pump on or off.
"LIGHT" Toggles the LCD display's backlight illumination on or off.
"DATA" Toggles three LCD display screens. Each screen presents an instantaneous group of data of four measurement or computation parameters. (This is the most often used button).
"ZERO" Executes an instrument auto zero. (Sets oxygen to 20.9%).
"STORE" This button is used to store data in the instrument internal buffers. It is also used to retrieve stored data.
"STATUS" Toggles three LCD screens. The first screen displays the unit serial number, time & date. The second screen displays battery condition, selected units of temperature and the current fuel. The third screen displays emission units, selected oxygen reference and selected engine

thermal efficiency.

"PRINT" Sends data to the printer or to a computer, if it is connected to the serial port.

The buttons of the last row are used to execute all changes in stored parameters such as time, fuel, calibration data etc.

"SHIFT" Shifts the cursor to the next position to execute a change in the entry of that position.

 Increments the entry marked by the cursor to the next higher entry. (This may be a digit or some other parameter).

 Decrements the entry marked by the cursor to the next lower entry. (This may be a digit or some other parameter).

"ENTER" Executes and stores all the changes.

NOTE:

To prevent operator errors, some of the buttons become inactive and a beeper (if available) will sound during certain operations of the instrument. (i.e. when the "STATUS" button is pressed the "ZERO" and "DATA" buttons do not function etc.)

CHAPTER 3

BASIC INSTRUMENT OPERATION

It is possible to master the basic operation of the instrument in a few minutes by following the procedure outlined below. Please refer to the other sections of this manual for a description of the more advanced features.

Both the Model 200EX and 400EMS micro emissions analyzers consist of two major components, the probe (whose function is to extract, clean and dry the sample) and the main unit, which does the analysis and the computations. An optional stand alone printer is also available.

To operate the instrument follow the steps outlined below:

1. Remove the instrument from its case and attach the sampling probe and water trap to the analyzer section and turn the instrument on.

2. Press the “PUMP” button to turn on the instrument’s pump.

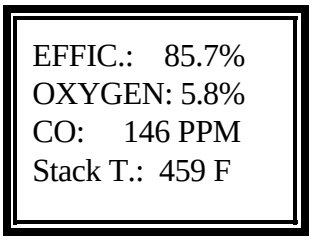
3. Press the “STATUS” button and check the condition of the battery. (This is good practice, even though there is a battery “low” warning message).

4. If the instrument temperature is below 40 degrees F. Allow a few minutes for the unit to warm up.

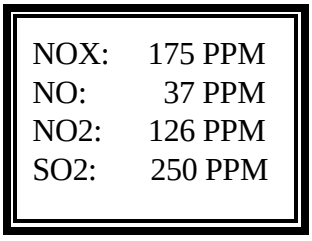
5. With the instrument aspirating CLEAN AIR and the probe tip at room temperature, press the “ZERO” button to execute an AUTO ZERO.

6. If at the end of the auto zero period there are no warning or error messages, insert the probe into the stack. Wait approximately two minutes before taking data.

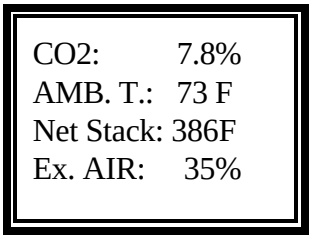
7. Press the “DATA” button to display the first group of measurements. By depressing this button again you display the second group of data and by depressing it again you will display the third group of data.
   The data are grouped as follows:



SCREEN 1



SCREEN 2



SCREEN 3

Toggle the "DATA" button to view the measurement data in sequence.

NOTE:

Depending on the Model and the options available for your analyzer some of the entries in one or more of the displays shown above will be blank if that option is not available.

8. If you want a printed record of the current data, connect the stand alone printer to the units serial port with the special cable that comes with the printer. Turn the printer on. (The printer has its own batteries and battery charger). Depress the "PRINT" button of the analyzer. You will get a complete print out of all data including time and date, fuel and customer information.

9. If you wish to store your data into any of the 100 storage buffers of the analyzer proceed as outlined in Chapter 6.

10. When you are finished with the measurements, remove the probe from the stack and allow it to reach ambient temperature before storing it. Remove any condensation from the water trap and replace the fiber filter, if it is dirty.

CHAPTER 4

ANALYZER DESCRIPTION

C. POWER REQUIREMENTS

Both the Model 200EX and 400EMS are designed to operate from 4 AA cells supplying a voltage of 3.8 to 6.5 Volts.

The flexible design allows for the use of either 4 AA alkaline primary (non rechargeable) batteries, or 4 AA Nickel-Cadmium rechargeable cells.

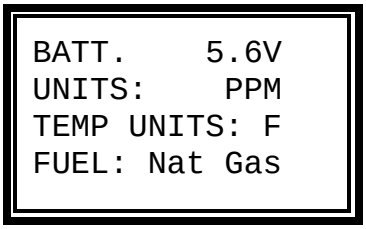
An 120 Volt (240 Volt optional) AC charger is supplied with the high performance (850 mA cells) Ni-Cd cells and can be used to charge the batteries or operate the unit continuously from an AC power source.

NOTE:

Do not connect the AC charger to the instrument, if it is powered by alkaline (non rechargeable batteries.

Battery life is approximately 4-6 hours of continuous operation.

You can check the condition of the batteries at any time by pressing the "STATUS" button twice to display the second "status screen". The following screen will appear on the display:



"STATUS" SCREEN 2

When the battery voltage indicated drops to 4.0 Volts you have only a few more minutes of battery life remaining. Test the battery voltage always with the pump on.

If you are using non rechargeable batteries the voltage will drop slowly and gradually from 6 Volts to 4 Volts. If you are using rechargeable batteries the voltage will stay fixed for a long time at 4.8 Volts before starting to drop rapidly.

In addition to the battery condition indication, there will be a warning during instrument operation and also at start up, if the batteries are “low”.

To prolong battery life use the display backlight illumination sparingly.

D. FLOW DESCRIPTION & SENSORS

During operation, the metal tube of the probe (see fig.3) is inserted into the stack. A small pump located inside the unit draws a sample of the stack gases into the instrument for analysis. The probe assembly and the sensor housing are described below.

The probe assembly consists of the following components:

1. A 13" long 3/8" OD. Piece of inconel tubing and an inconel sheathed type K thermocouple located inside the inconel tube for protection. Both probe and thermocouple are mounted on an aluminum head that includes a support handle.

2. A 10 ft. Long 1/4/” OD. Viton sampling hose and thermocouple extension cable with quick disconnects on both sides for easy storage. Viton tubing is used to prevent adsorption of NO_2 and SO_2 gases from the sample.

3. A condensation trap and particulate filter assembly to remove the excess water and clean the sample. The condensation trap is mounted for convenience to the side of the hand held analyzer. Figure 1 shows the probe assembly which is identical for both analyzers.

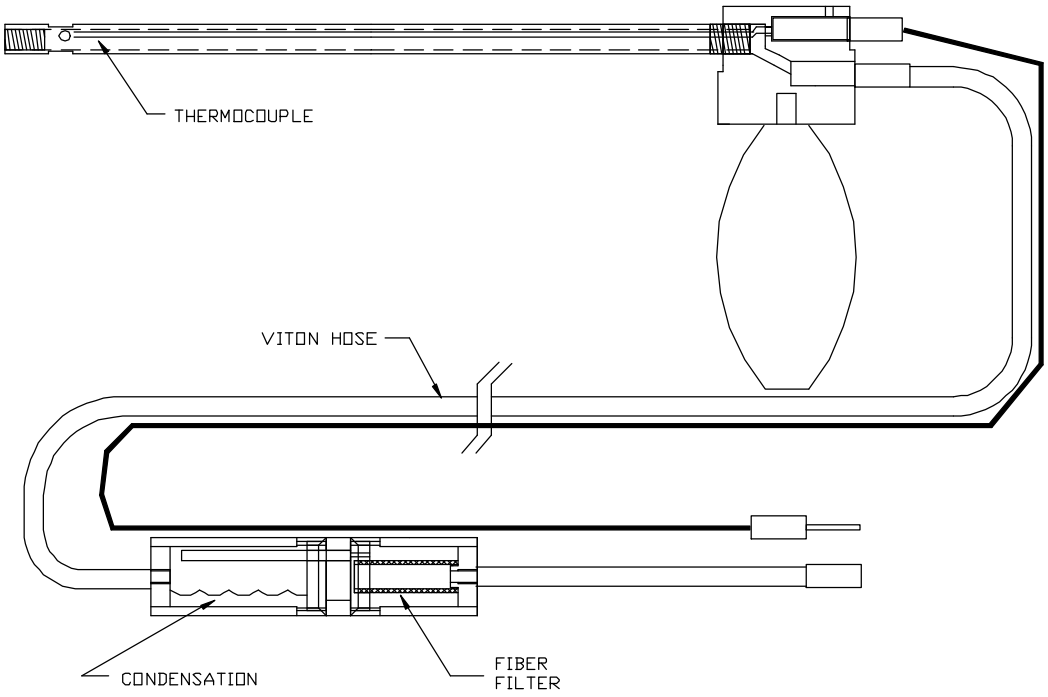


FIGURE 1

E. THE PUMP AND SENSOR ASSEMBLY

A small diaphragm pump located inside the analyzer draws a small sample (approximately 1500 cc/min.) of the stack gas. The pump is powered by a high quality DC motor rated at 4000 hours. The pump's discharge is connected to the oxygen sensor housing. The sample leaving the oxygen housing enters an aluminum manifold that supports the four gas sensors (carbon monoxide, nitric oxide, nitrogen dioxide, sulfur dioxide).

1. The sensors

a. **Temperature sensing.** The instrument uses two temperature sensors. One monitors the stack temperature and the other the ambient temperature.

i. THERMOCOUPLE. The thermocouple is located at the tip of the probe. It measures the stack temperature minus the ambient temperature. The thermocouple junction is a shielded, ungrounded,

inconel sheathed, type K thermocouple with a capability of measuring temperatures from 0 to 2000 degrees F. The instrument software linearizes the thermocouple output to improve the accuracy.

ii. AMBIENT TEMPERATURE SENSOR. This is an integrated circuit type temperature sensor. It is located inside the analyzer. It is used to measure the room or ambient temperature. The difference between the outputs of the thermocouple and the ambient temperature sensor is the net stack temperature, which is used in efficiency computations.

b. **Gas sensing.** All gas sensors with the exception of the oxygen sensor are located on the aluminum sensor housing. The sensors can be accessed by opening the bottom part of the back plate.

i. CARBON MONOXIDE SENSOR. This is a sealed electrochemical cell incorporating a long-life inboard filter. It consists of four platinum electrodes in an electrolyte. Carbon monoxide gas diffuses through a tiny hole on the face of the sensor. It reacts with oxygen present inside the cell to form carbon dioxide. The reaction produces an electric current proportional to the concentration of the gas. Sensor life is estimated at 2 years. This sensor includes an auxiliary electrode to remove cross interference to Hydrogen gas.

Its inboard disposable filter has an estimated life in excess of 200,000 PPM-hours.

ii. OXYGEN SENSOR. This is a two electrode electrochemical cell. It has a silver cathode and a lead anode. Oxygen diffuses through a tiny hole and reacts with the lead anode. The reaction produces an electric current. The unit software linearizes the current vs. oxygen response. The cell becomes exhausted when all the lead is consumed. It takes about two years for this to happen. Disconnecting the cell when not in use will extend its life by six months.

iii. NITRIC OXIDE SENSOR. This is a sealed electrochemical cell incorporating a disposable long life inboard filter. It consists of three exclusively noble metal electrodes in an electrolyte. Nitric oxide gas diffuses through the tiny capillaries located on the face of the sensor. It reacts with oxygen present inside the cell to form nitrogen dioxide. The reaction produces an electric current proportional to the concentration of the gas. Sensor life is estimated at 2 years.

Its inboard disposable filter has an estimated life in excess of 20,000 PPM-hours for NO_2 and 100,000 PPM-hours for SO_2.

This sensor requires a constant bias voltage for proper operation. This voltage is supplied to the sensor, even when the instrument is turned off. It draws a small amount of current and will drain the batteries completely in about 10 months. For this reason the unit should always be given a fresh charge once every 2-3 months.

iv. SULFUR DIOXIDE SENSOR. This is an electrochemical cell similar to the nitric oxide sensor. It has a range of 0 to 2000 PPM. Its life is estimated at two years.

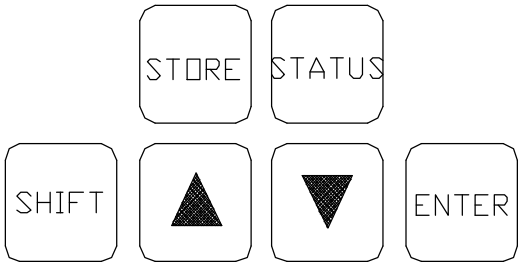
v. NITROGEN DIOXIDE SENSOR. This is an electrochemical cell similar to the nitric oxide sensor. It has a range of 0 to 500 PPM. Its life is estimated at two years.

NOTE: In addition to the sensor long-life filters, the model 200EX-400EMS emission analyzer uses mathematical compensation techniques to minimize any residual cross- sensitivities that its toxic sensors may have to any gases other than those they are intended to measure.

CHAPTER 5

CUSTOMIZATION AND STORAGE

The “STATUS” and “STORE” buttons are used to change certain parameters such as fuel, span calibration values and also to store data in the analyzer’s memory.
For this purpose the last row of buttons are used with the “STATUS” and “STORE” buttons.

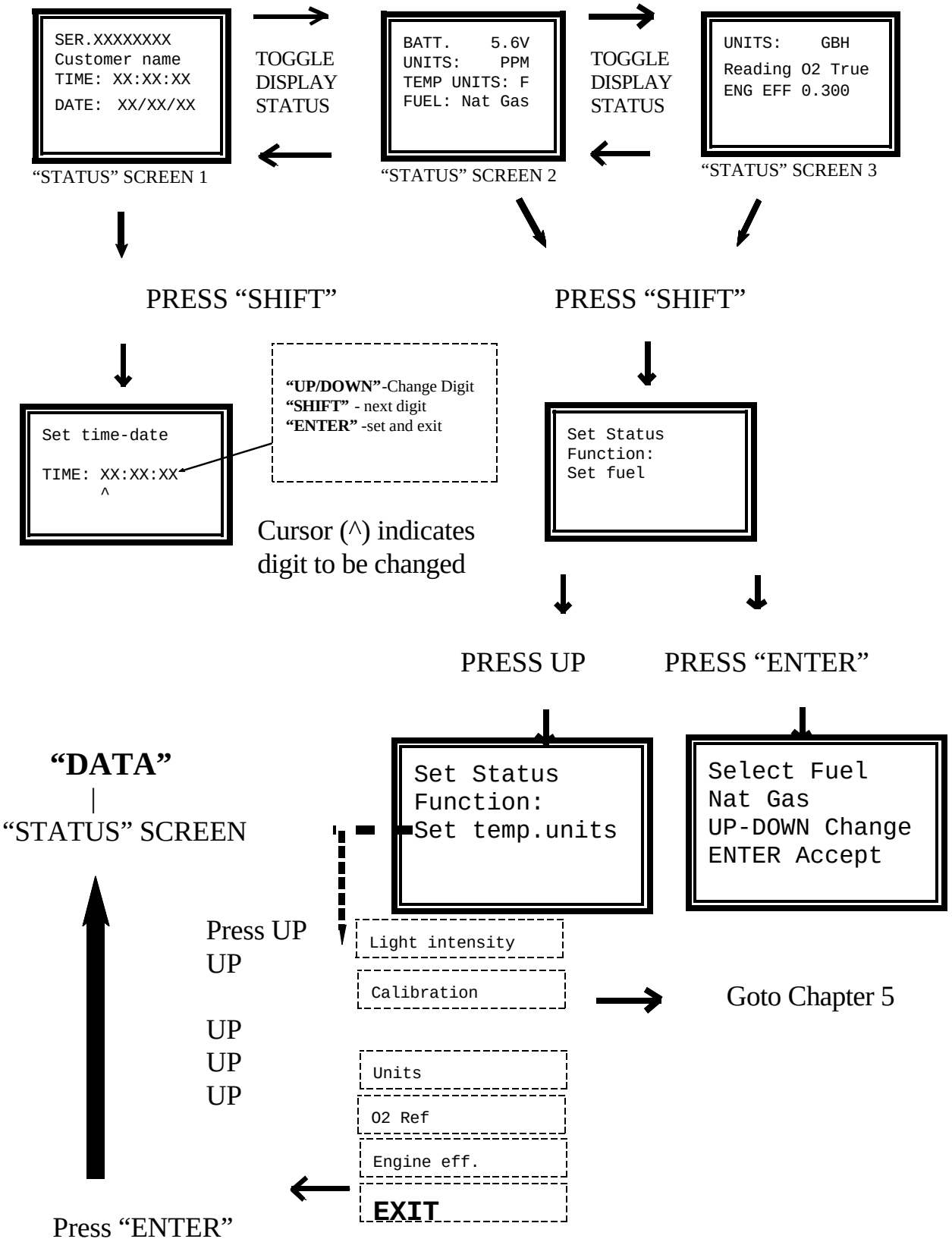


F. The “STATUS” button

To change certain parameters such as fuel, time and date, calibration values, degrees F or C depress the “STATUS” button. The “status” screen 1 will appear on the display. Pressing the “STATUS” button again brings the “status” screen 2 on the display (as shown in the following page).

To change the parameters shown on the screens you use the “SHIFT” button first and then the “UP” and “DOWN” that are depicted as triangles. See the instructions shown on the following page.

The “caret” sign (upwards pointing arrow) serves as a cursor pointing to the digit that will be changed by pressing the “UP” or “DOWN” buttons.


SER.XXXXXXXX
Customer name
TIME: XX:XX:XX
DATE: XX/XX/XX
TOGGLE DISPLAY STATUS
BATT. 5.6V
UNITS: PPM
TEMP UNITS: F
FUEL: Nat Gas
TOGGLE DISPLAY STATUS
UNITS: GBH
Reading O2 True
ENG EFF 0.300
"STATUS" SCREEN 1
"STATUS" SCREEN 2
"STATUS" SCREEN 3
PRESS "SHIFT"
PRESS "SHIFT"
Set time-date
TIME: XX:XX:XX
^
"UP/DOWN"-Change Digit
"SHIFT" - next digit
"ENTER" -set and exit
Cursor (^) indicates digit to be changed
Set Status Function:
Set fuel
PRESS UP
PRESS "ENTER"
"DATA"
"STATUS" SCREEN
Set Status Function:
Set temp.units
Select Fuel
Nat Gas
UP-DOWN Change
ENTER Accept
Press UP
UP
UP
UP
UP
Light intensity
Calibration
Goto Chapter 5
Units
O2 Ref
Engine eff.
EXIT
Press "ENTER"

NOTE: For instructions on span calibration see the chapter 5 on calibration.

You can change the intensity of back light illumination from 0% to 95% by pressing the “ENTER” button when “light intensity” is displayed and then pressing the “UP” or “DOWN” buttons repeatedly.

NOTE: There is a considerable power drain on the batteries when the light intensity is set at maximum value and the backlight illumination is constantly on. (Battery life is reduced by approximately 25%).

G. The “STORE” button

You use this button to either store combustion data into one of 100 storage locations of the analyzer or to retrieve data stored in the analyzer.

The “STORE” button executes the following operations that you select by pressing the “UP” or “DOWN “ buttons:

1. **Store (data).** Stores current data to a selected storage location. Data cannot be overwritten. You must erase the data in that storage location, before storing new data.

2. **Timed store.** Stores automatically on a user selected periodic basis (time interval) a preset number of data. The data is stored in the top available buffer locations ending with the last, which is #100.

3. **Print one** . Sends the data stored in one storage location to the serial port. Depending on the device connected to the serial port the data will be either printed or displayed on a computer screen.

4. **Print some**. Sends the data stored in a selected range of storage locations to the serial port.

5. **Erase one.** Erases the data stored in a selected storage location.

6. **Erase all.** Erases all data stored in every one of the 100 storage locations.

7. **Erase some**. Erases only the data in a selected range of storage locations.

8. **Review**. Displays sequentially the identification name entered in every storage location and also if that buffer is available for storage or not (i.e. contains data). If you don't change the identification name (by a serial command), the default names are DATA 01, DATA02, DATA 03 etc. These names will appear on every storage location.

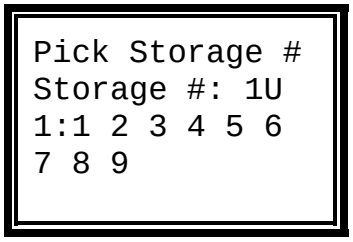
9. **Exit.** Exits the "STORE" mode.

The following examples show the sequence of operations for storing and retrieving data:

EX. 1 STORING DATA IN STORAGE LOCATION #43

This display appears when you press the “STORE” button.

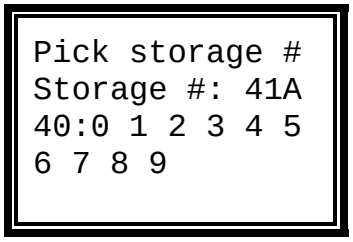
PRESS “ENTER”



The number shown on line 2 indicates the currently pointed to (i.e. selected) storage location. The number on line 3 in front of the colon is the tens digit followed by the units digits on lines 3 & 4.

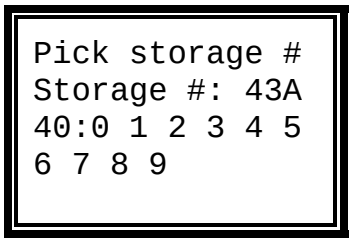
To change the tens digit, you press the “UP” or “DOWN” buttons. To change the units digit you press the “SHIFT” button.

PRESS “UP” FOUR TIMES



The numbers shown on lines 3 and 4 represent the free and available storage locations. If any numbers are missing in this sequence, these locations have data already stored.
The letter at the end of line 2 is either A or U.
A- This storage location is available (i.e. empty).
U- This storage location is unavailable (has data already stored).

PRESS “SHIFT” TWICE



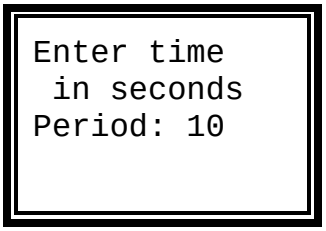
Press “ENTER”. The current data will be stored in location 43.

EX. 2 PERIODIC STORAGE EVERY 20 SECONDS OF 50 DATA ENTRIES

Press "UP"

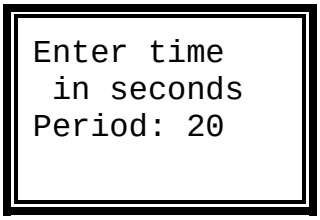
START

PRESS "ENTER"



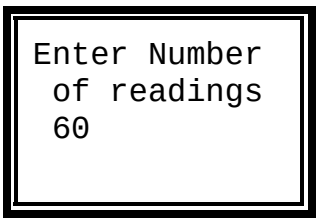
The unit prompts you to enter the time interal in seconds between storing of data.

PRESS "UP" TEN TIMES



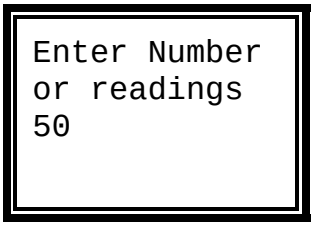
The display shows the desired time interval between data to be stored.

PRESS "ENTER"(to accept 20 sec. intervals)

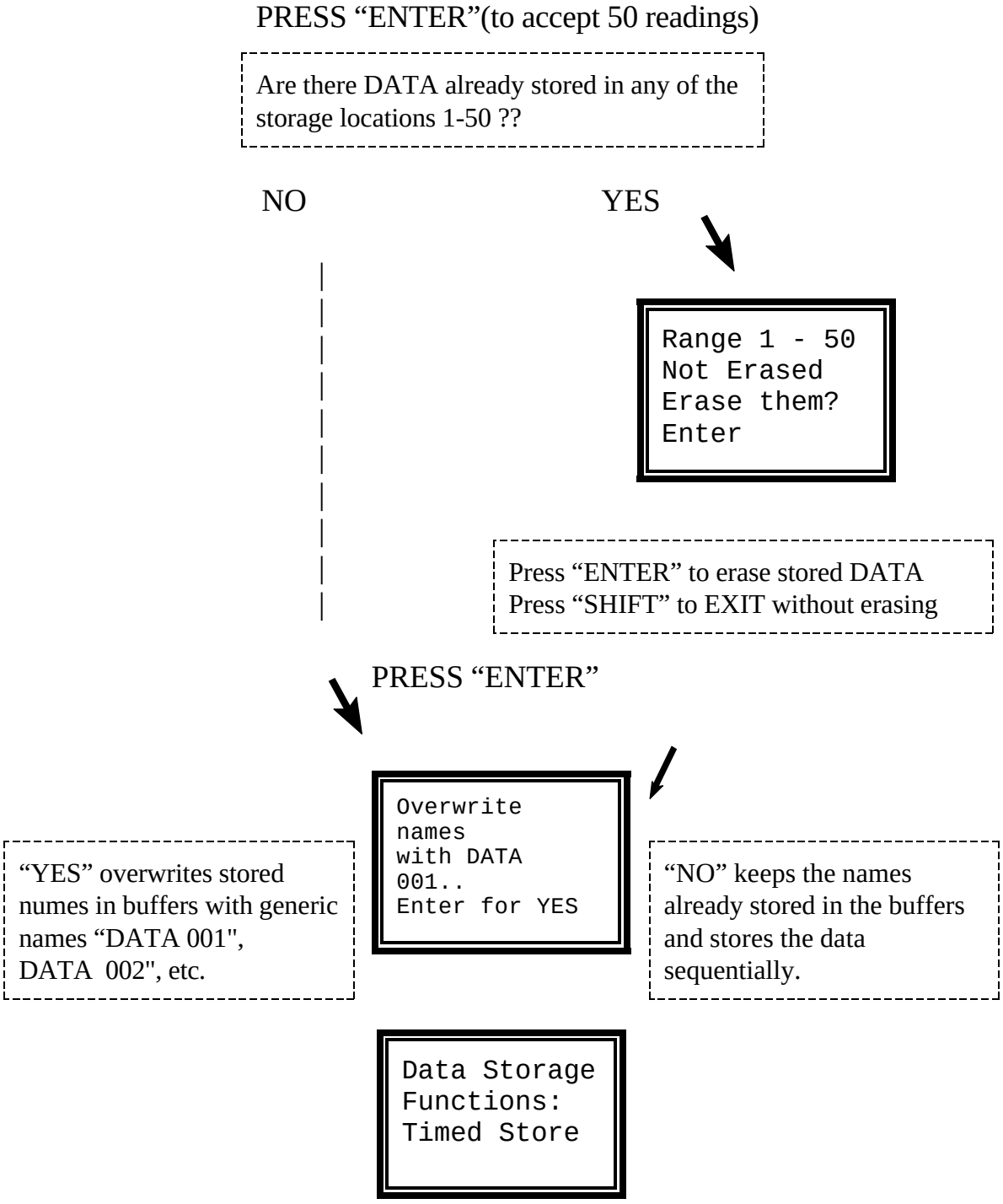


The display indicates the current setting for the number of data to be stored.

PRESS "DOWN" TEN TIMES



The display shows the desired number of data to be stored.

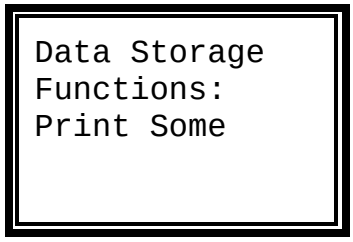


Press “UP” 7 times until the display shows “exit”.
Press “ ENTER” to get out of the STORE mode. **TO START STORING DATA YOU MUST GET OUT OF THE STORE MODE.**

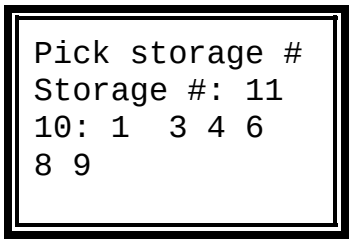
Every time data is stored, the display will interrupt its reading of data and display the message: “Storing readings.....Reading XX.....at Storage #YY”.

EX. 3 PRINTING STORED DATA IN LOCATIONS 24-37

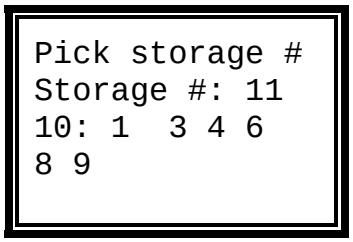
PRESS “UP/DOWN” TO SCROLL THROUGH CHOICES.



PRESS “ENTER” to pick “Print Some”.
(The unit will search for the first storage location in use).



<u>Assuming all storage is in use!</u>
PRESS “UP” TWICE (1: changes to 11: then to 21:).
PRESS “SHIFT” THREE TIMES (21: changes to 22:, 23:, 24: **the beginning of the printing range**).
Any missing numbers in the sequence of lines 3 and 4 indicate empty storage locations (nothing to print).
PRESS “ENTER”.



PRESS “UP” TWICE (the tens digit in line 2 changes to 3). PRESS “SHIFT” SEVEN TIMES (the number on line 2 changes to 37, **the end of the printing range**).

PRESS “ENTER”. All data stored in locations 24-37 will be sent to the serial port or printer, whichever is connected.

CHAPTER 6

PRINTER AND COMMUNICATIONS

A. THE PRINTER

A stand alone printer is available as an option for the Models 200EX and 400EMS analyzers.

This printer has its own power source of rechargeable batteries and is supplied with its own AC charger.

Dust will easily damage the printer! Avoid exposing the printer to a very dusty environment! To avoid damaging the printer heads, do not use any ordinary paper or thermal paper, other than the one supplied by EES. (Use ENERAC thermal paper only). Thermal paper is a specially treated paper and must be protected from excessive heat or moisture.

The printer is connected to the analyzer's serial port through a special cable supplied with the printer. To obtain a print out simply press the "PRINT" button of the analyzer. A copy of a typical printout is shown below:

ENERAC 200EX-400EMS

Dean Capet

Nat Gas
01/01/96 17:44:37

EFFICIENCY:
OXYGEN: 20.7%
CARBON MONOXIDE: 0PPM
CARBON DIOXIDE: 0.0%

EXCESS AIR OVER

STACK TEMPERATURE 82F
NET STACK TEMP 0 F
AMBIENT TEMPERATURE: 82F

NOX: 1 PPM
NITRIC OXIDE: 1 PPM
NITROGEN DIOXIDE: 0 PPM
SULFUR DIOXIDE: 0 PPM

By:

Make sure the printer “ON/OFF” switch, which it located at the back of the printer is in the “OFF”position when the printer is not in use.

B. COMMUNICATIONS

The analyzer’s serial port is used to communicate with a computer.

The analyzer’s communication protocol is as follows:

ANALYZER TYPE- DTE (i.e transmits on pin 2)
BAUD RATE- 9600 baud
DATA - 8 bits, 1 stop bit, no parity
HANDSHAKE- None

NOTE:

When using a standard communications program with your computer, you must use its “TRANSLATION TABLE” to switch the LF (line feed) and CR (carriage return) symbols. (i.e. switch decimal 010 to 013 and decimal 013 to 010) to obtain the proper data presentation on your computer screen. You need to do this because the analyzer uses the same serial port for its printer and the ENERAC printer uses those commands in this way.

To display the current data on your computer screen simply press the “PRINT” button. The analyzer will send a complete print out to the computer’s screen.

You can also communicate with the analyzer by means of special commands.

A list of the customer available commands is shown in the following page:

Some commands require addition of certain parameters besides the command itself as outlined below.

LIST OF SERIAL PORT COMMANDS

COMMAND	DESCRIPTION
CALIBRATE X Y Z	Executes a span calibration as outlined below: **X=1 to 4.** ENERAC will span calibrate one of the four toxic gas sensors as follows: X=1. Selects carbon monoxide sensor for calibration. X=2. Selects nitric oxide sensor for calibration. X=3. Selects nitrogen dioxide sensor for calibration. X=4. Selects sulfur dioxide sensor for calibration. **Y=0 to 2000.** Enter the concentration in PPM of the calibration span gas. **Z=1 to 65000.** Enter the time in seconds for the ENERAC to wait before executing the span calibration, while you are feeding calibration gas. (120 sec. Minimum rec).
COMMANDS	ENERAC returns a list of all available commands.
CORF	ENERAC lists current temperature units C or F.
CORF X	X=C. Sets the units of temperature to degrees Celsius **X=F.** Sets the units of temperature to degrees Fahrenheit
CUST	ENERAC lists all customer names entered in the unit. (Customer names are entered as outlined below).
CUST X YY...Y	Enter the customer or combustion source identification name that will be stored the next time you store data in one of the storage locations. **X=1 to 100.** Selects the storage location to be identified with this name. **Y=ABC....DEF.** Enter the identification name or number (up to 16 characters long). *Hint: If you intend to store data from a number of sources, use this command to enter identification of storage locations before you begin your measurements.*
DATE	ENERAC returns present date.

DATE XX/XX/XX	Stores in the ENERAC the new date.
DISPLAY X	X=1. Current data information shown on the display is sent to the serial port and updated continuously. Display freezes. X=0. Data information returns to the display and seizes to be sent to the serial port.
HREV	ENERAC returns the current hardware version of the instrument.
LIGHT LIGHT X	ENERAC returns status of backlight illumination. X=0 Turns backlight OFF X=1 Turns backlight ON.
LOGO?	Returns the ENERAC's logo "200EX-400EMS".
LOOP	Turns LOOP off, if it is currently on.
LOOP X Y Z	**X= 1 to 10.** ENERAC sends to serial port periodically the parameter # selected as indicated below:. X=1- Sends **oxygen sensor** value. X=2- Sends **Stack temperature sensor** value. X=3- Sends **Carbon monoxide sensor** value. X=4- Sends **Ambient temperature sensor** value. X=5- Sends **Nitric oxide (NO) sensor** value. X=6- Sends **Nitrogen dioxide (NO_2) sensor** value. X=7- Sends **Sulfur dioxide (SO_2) sensor** value. X=8- Sends **carbon dioxide (CO_2) computed** value. X=9- Sends **efficiency computed** value. X=10-Sends **NOX (NO+NO_2) computed** value. **Y=1 to 10.** Is the number of 1 second intervals between updates of the selected parameter. (i.e. X=3 & Y=6 carbon monoxide value will be sent to the serial port every 6 seconds). **Z=V**. The selected data is displayed in volts. **Z=C.** The selected data is displayed in parameter value (i.e PPM or %).

MODEL	ENERAC returns the model number (200EX-400EMS)
PUMP PUMP X	ENERAC returns pump status, ON or OFF. X=0 Turns ENERAC pump OFF. X=1 Turns ENERAC pump ON.
PRINT	ENERAC returns a complete record of all current stack parameters.
SALES	ENERAC returns sales number (information) identification.
SENSORS	ENERAC returns a list of all sensor and calculation options that are enabled.
SN	ENERAC returns its serial number.
SREV	ENERAC returns the current software version of the instrument.
STORAGE	This command is used to instruct the ENERAC to **store, print or erase data** to and from its storage buffers. This is an interactive command. The ENERAC will ask you sequentially which function you wish to perform and what storage location you wish to select. Follow the instructions.
TIME TIME XX:XX:XX	ENERAC returns the current time. Stores in ENERAC new time.
ZERO XXX	ENERAC executes an auto zero following a countdown of XXX seconds (0 < XXX < 255).

CHAPTER 7

CALIBRATION

Every instrument must occasionally be calibrated against some known value of a parameter in order to make sure that its accuracy has not deteriorated.

The instrument software make sure that the display readout is always a linear function of the source excitation (i.e. gas concentration or temperature etc.). You therefore need only two points on the straight line to calibrate a parameter over its entire range. Usually, the first point chosen is the zero value (called zeroing the instrument). The second point has to be set by using some known value of the parameter being calibrated (i.e. using for example 200 PPM certified carbon monoxide gas to set the display to read 200). Sometimes the second point is not needed, if the slope of the parameter is known and is always the same (For example, for the stack temperature the slope of the curve is well known and you don't need a span calibration).

Traditionally, both zeroing and span (i.e. second point) calibration was done manually, by rotating suitable potentiometers until the display was set to read first zero in ambient air and then the correct value using span gas.

With the introduction of microprocessors, it became a simple matter for instruments to zero themselves automatically upon start up (AUTO ZERO), however, this simplification requires caution. The instrument must be started in a true "zero" environment. Otherwise it will assume as "zero" non-zero conditions and give erroneous readings. (Example: Never auto zero the ENERAC, if the probe tip is still hot following a recent measurement.)

The ENERAC carries out this improvement in automatic calibration procedure one step further. It does away with all potentiometric span adjustments. You just tell it the value of the calibrating parameter that you are using and the instrument adjusts itself automatically.

A. AUTO ZEROING THE INSTRUMENT

Every time you turn the instrument on, wait for 2 minutes to allow the ENERAC to warm up. You can then press the “ZERO” button to start the auto zero procedure. At

the end of the auto zero period the ENERAC reads the output of all sensors and sets them all to zero, with the exception of the oxygen that it sets to 20.9%. (The ambient temperature is read directly). Consequently, it is very important that at the moment of "zeroing" the probe tip is at room temperature and the environment is clean from traces of carbon monoxide or other gases.

NOTE: In practice AUTO ZEROING is only needed once at the beginning of a day of measurements. The ENERAC will not have sufficient zero drift during the next 24 hours to require additional autozeroing procedures.

To carry out the auto zero procedure follow the steps below:

1. Connect the probe and water trap to the unit. Make sure the probe tip is at room temperature.

2. Turn the analyzer on. Make sure that the “battery low” message does not appear on the display.

3. Turn the analyzer pump on. **(Always zero the instrument with the pump on, for flue stack measurements!).**

4. Press the “ZERO” button. Wait 2 minutes for the countdown to end.

5. If no error messages appear at the end of the countdown proceed with your measurements.

B. SPAN CALIBRATION

You must always span calibrate the instrument every time you replace a sensor. At a minimum, once every 3-4 months you should perform a span calibration of the instrument. For greater accuracy you should calibrate the instrument before and after each emissions test.The parameters that require a span calibration are depending on the available options: carbon monoxide, nitric oxide, nitrogen dioxide and sulfur dioxide.

You can carry out all span calibrations in sequence or just one only, if you wish. You can use your own span gas, or if you need to calibrate the ENERAC in the field, you can use the convenient gas calibration kit supplied by Energy Efficiency Systems.

1. Span calibration using the EES kit.

The gas calibration system supplied by EES is shown in Fig. 3. The kit comes with a gas cylinder containing a mixture of 200 PPM carbon monoxide (typically), with balance nitrogen. For NO, NO_2 and SO_2 calibrations you must order extra gas cylinders containing the desired type of span gas. All four gas cylinders and calibration apparatus fit inside a carrying case for easy transportation to the field.

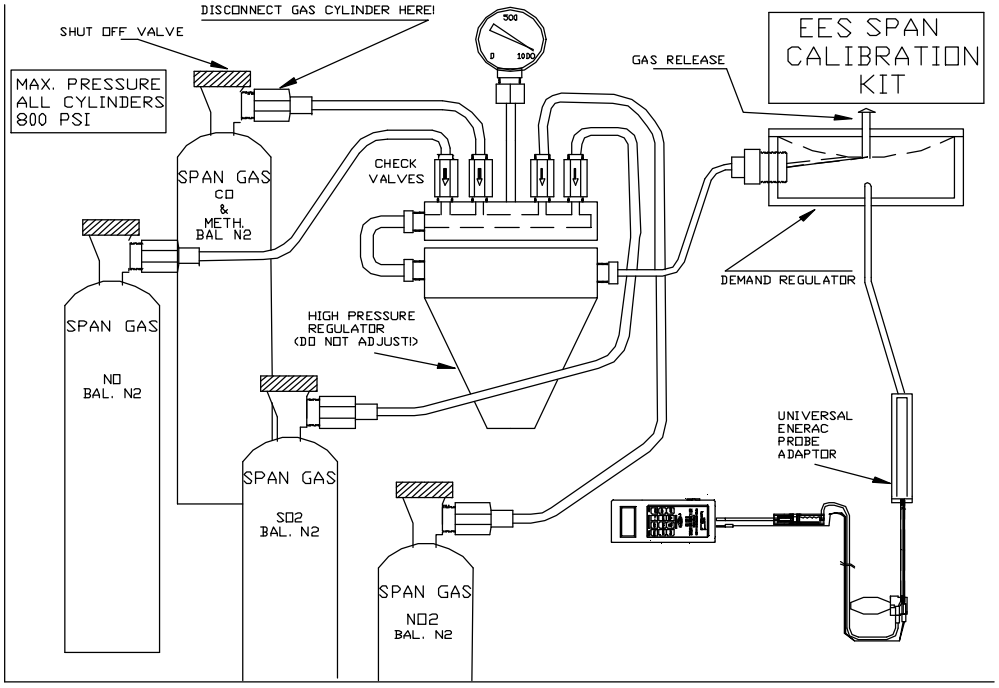


FIGURE 3

Span calibration using the Energy Efficiency Systems calibration kit is easy. You don't need to worry about gas flow rates and there is no wasting of calibration gas. Follow the instructions supplied with the calibration kit.

2. Span calibration using your own gas.

If you wish to use your own gas to perform span calibrations you must take certain precautions, in order to calibrate the sensors properly.

Preferably, for greatest accuracy it is recommended that you use a span gas value close to the emission concentration you expect to measure.

To carry out a span calibration USING YOUR OWN GAS APPARATUS, see figure 4 and the instructions listed below:

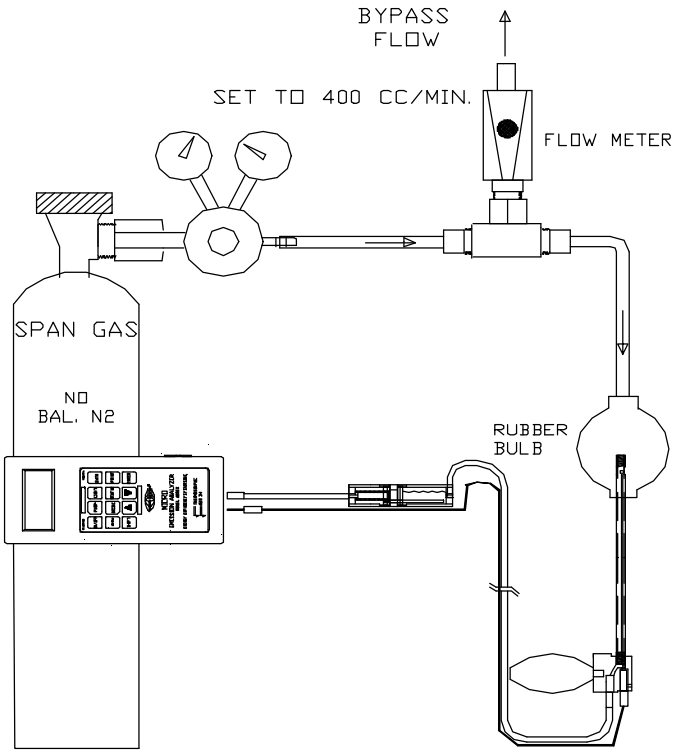


FIGURE 4

Set up your calibration apparatus as shown in fig.4.

Notice that you need a number of certified gas cylinders. Make sure you use the calibration accessory supplied with your instrument. The accessory ensures proper gas flow to the ENERAC.

You must not feed gas to the ENERAC under pressure and you must not starve the ENERAC's pump for gas. When feeding the gas to the ENERAC you must maintain a reasonably constant pressure. This is a requirement of all diffusion type sensors.

Connect the calibration accessory to the ENERAC probe. Make sure the rubber bulb is inserted past the square grooves located at the probe tip.

Connect the other end of the calibration accessory to the gas cylinder.

Make sure the concentration of the calibration gas is within the range of the of each sensor. Do not under any circumstances, use gas that will over-range the sensor.

The Carbon Monoxide gas can be in the range 30-2000 PPM 2% accuracy with the balance nitrogen, preferably.

The NO span gas can be in the range 10-2000 PPM, 2% accuracy with balance nitrogen, preferably.

The NO_2 span gas should be in the range 50-500 PPM, 2% accuracy with balance nitrogen, preferably.

The sulfur dioxide span gas can be in the range of 30-2000 PPM, 2% accuracy, with balance nitrogen, preferably.

3. Calibration procedure.

The following page illustrates the sequence of key strokes to carry out a span calibration of the analyzer. It is assumed that the instrument has been auto zeroed and there have been no error messages.

a. Auto zero the instrument with ambient air.

b. Connect the calibration apparatus and cylinder to the instrument.

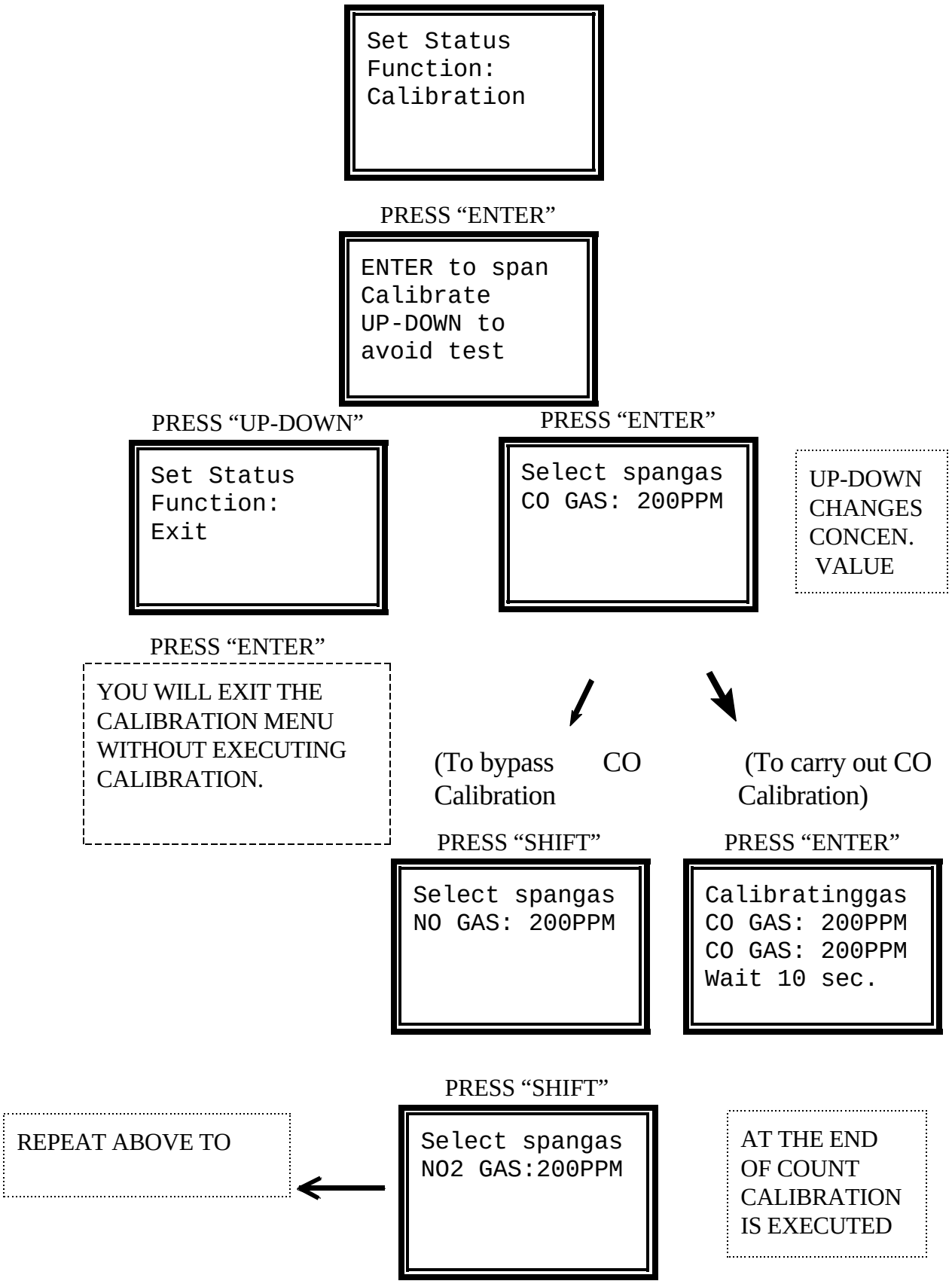
c. Press the “DATA” key and observe the appropriate reading as you open the calibration cylinder valve. (If you are using the by pass flow meter, adjust the cylinder valve for a BY PASS flow rate of approximately 500 cc/min.

d. When the display reading for the desired gas has stabilized press the “STATUS” key to enter the calibration mode.

(Before pressing the “STATUS” key you may wish to observe the readings of the other gas parameters for evidence of cross sensitivity and also the oxygen reading for confirmation that there is no instrument leak!)

Follow the instructions on the “STATUS” button in chapter 4 until you display the calibration screen shown below:

CALIBRATION PROCEDURE



When carrying out NO_2 and SO_2 calibrations it is a good idea to feed the span gas to the analyzer for a minimum of 3 minutes before starting the calibration. NO_2 and SO_2 are “sticky” gases and they tend to adsorb to surfaces especially, if they are wet.

CHAPTER 8

MAINTENANCE

The ENERAC micro emissions analyzers are a sophisticated piece of analytical instrumentation designed to perform accurate emissions measurements. However, because they are hand held instruments that find uses in all sorts of environments, it is important that care must be taken to prevent physical and environmental abuse, in order to maintain a trouble free operation.

There are five components that will require periodic inspection or replacement. These are:

1. The non-rechargeable batteries (if you don't use rechargeable batteries).

2. The disposable fiber filter.

3. Removal of condensate from the water trap.

4. Sensor replacement.

5. Printer paper replacement.

A. Battery replacement

The analyzer requires 4 AA cells for operation. If you use disposable batteries, select alkaline MnO_2 cells for longer life. You should get at least 4-6 hours of operation from a set of batteries depending on the use of the back light illumination.

Do not use the battery charger, if you are using non rechargeable batteries!

The instrument is designed to warn you, if the batteries become weak. You can also check the condition of the batteries at any time by pressing the "STATUS" button. The battery voltage is displayed on the screen.

For fresh alkaline batteries the voltage displayed will be approximately 6 Volts. It will gradually drop with use until at 3.8 Volts a "battery weak" warning will appear. You can thus, estimate by observing the voltage the remaining time.

For Ni-Cd rechargeable batteries the battery voltage will stay at approximately 4.8 Volts for a long time and then drop rapidly.

To replace the batteries, remove the two screws that secure the top section of the analyzer's back plate. The batteries are housed inside a battery holder that is mounted on the back of a pc board. Remove the depleted batteries and replace them with fresh one observing carefully the polarity indicated. Replace the top section of the back plate.

NOTE:

Remember that the NO (nitric oxide) sensor needs a tiny amount of electrical power, even when the analyzer is off. Do not allow the batteries to discharge completely. Consequently, you must not leave the analyzer without battery power for any length of time. When replacing the batteries you can use the analyzer within five minutes, if you don't take longer than two minutes to replace the batteries. If the analyzer has been without power for a long time, you may need to wait for a few hours after installing fresh batteries before the NO sensor is fully conditioned. <u>This warning is for the NO sensor only.</u>

B & C. Filter replacement, condensation removal

The disposable 1 micron fiber filter is located in the bottom section of the condensation trap assembly. Its function is to prevent particulates from reaching the analyzer pump and sensors.

You must replace the filter when it becomes discolored. Never operate the analyzer without the filter.

Frequency of filter replacement depends on the type of fuel used. For natural gas fuel you will probably need to replace the filter once a month. For coal fuel you will need to replace the filter every few days.

To replace the filter disconnect the condensation trap from the probe. Unscrew the bottom section of the condensation trap and remove and replace the filter with a new one. Make sure the O-ring is seated properly when you screw back the bottom section.

At the end of a measurement shake the probe vigorously to drain it from any condensation. Remove any condensation that has been trapped in the top section of

the condensation trap and allow it to dry thoroughly before storing it.

D. Sensor replacement

To access the gas sensors you must remove first the battery cover plate which is secured by the two thumb screws. You then remove carefully the bottom section of the back plate on which the sensor manifold housing is mounted.
This will expose the four gas sensors and the oxygen sensor. See figure 5.

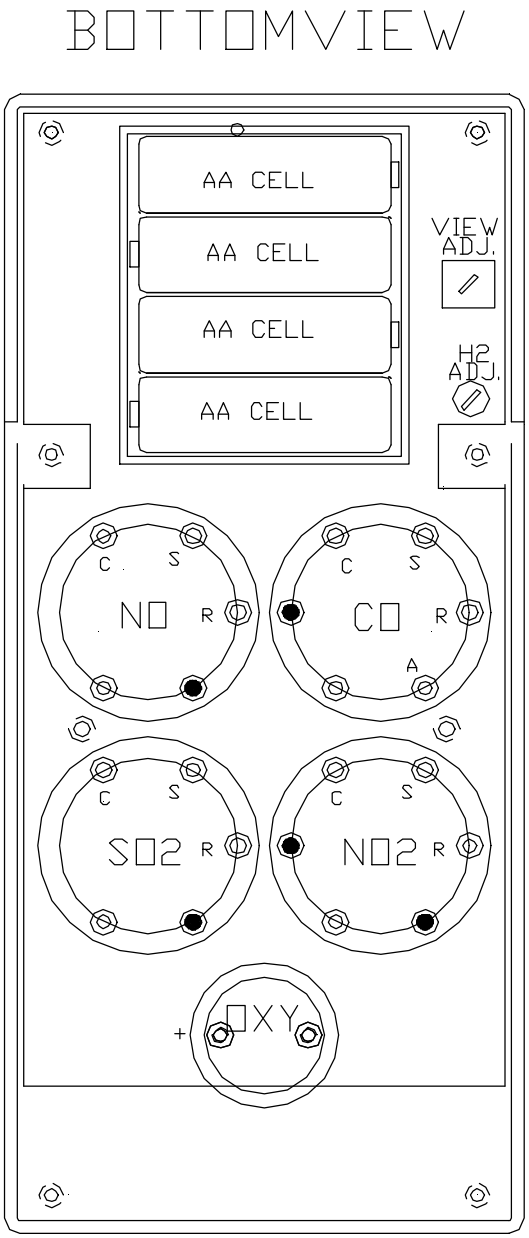


FIGURE 5

All gas sensors are mounted directly on the printed circuit board.

Make sure the unit is off before attempting to disconnect one of the sensors.

If you receive an error message for one of the sensors during instrument operation, do not attempt to replace the sensor immediately. Instead, wait a few minutes and then auto zero the analyzer again. If you get an error message again investigate if moisture has entered the sensor area. If so, wait a few hours for the moisture to evaporate and auto zero the sensor again. If you get a sensor failure then you must replace the sensor.

To replace the sensor remove the back plates as explained previously. Pull the malfunctioning sensor out of the printed circuit board. Be careful not to bend the mounting pins.

Replace the sensor with a new one. **If the sensor to be replaced is a CO, NO_2 or SO_2 sensor remove first the shorting spring from the two sensor pins.**

Each sensor has a different pin arrangement to prevent it from being accidentally inserted in the wrong socket pin configuration! See figure 5. Be careful not to bend the sensor pins when mounting the new sensor.

Replace the bottom section of the back plate that houses the manifold.

Replace the top section of the back plate last.

Wait the following time periods before auto zeroing the analyzer:

OXYGEN SENSOR	10 MINUTES
CO SENSOR	5 MINUTES
NO SENSOR	1 HOUR. .
NO2 SENSOR	5 MINUTES
SO2 SENSOR	5 MINUTES

Sensor replacement should be an infrequent operation (once every two years or more) unless you allow water to enter the sensor housing by not using the condensation trap!

NOTE: (Hydrogen interference adjustment).

There is a hydrogen cross-interference adjustment for the carbon monoxide sensor. This calibration intended to remove the interference of hydrogen from CO measurements should be rarely done, typically if the sensor is being replaced.

To null the hydrogen interference, feed hydrogen gas, typically 100 - 1000 PPM, following the same procedure as for the other toxic gas calibrations. When the display reading has stabilized use the “H2 ADJ.” potentiometer (see figure 5) to obtain a null reading on the display for CO. Since the instrument does not display negative values, be careful to obtain a true null.

E. Printer paper replacement

Turn the printer on. Open the paper compartment. Insert a new roll of paper. The paper should be in the direction towards use as it unrolls. Use the feed switch to advance the paper.

Keep any spare paper rolls in a cool dark place to prevent paper discoloration. Use only ENERAC thermal paper for the printer.

The printer uses a lot of battery power when operating. When the battery is fully charges it should be capable of delivering at least 60 data printouts.

APPENDIX A

MODEL 400 EMS SPECIFICATIONS

PHYSICAL:

1. CASE
   8.7" X 3.9" X 2.9" Aluminum case. Weight: 3 lbs.

2. PROBE
   13"L. X 3/8" OD. Inconel stack probe. Probe housing connects to instrument via a 10 ft. viton hose and water trap with fiber filter. Max. continuous temperature: 2000 degrees F.

ELECTRICAL POWER:

1. BATTERY
   6VDC. Interchangeable rechargeable NiCd or four disposable AA alkaline cells. Approximately 6 hours operating time.

2. AC
   120V. 60 Hz. std. (220V. 50 Hz. optional), using battery charger (NiCd batteries only!)

DISPLAY:

Four line x 16 character wide temperature range LCD with backlight illumination.

MEASURED PARAMETERS:

1. AMBIENT TEMPERATURE
   IC sensor. Degrees F or C.
   Range: 0-150 degrees F.
   Resolution: 1 degree F or C.
   Accuracy: 3 degrees F.

2. STACK TEMPERATURE
   Type K thermocouple. Degrees F. or C.
   Range: 0-2000 degrees F. (1100 C).
   Resolution: 1 degree F.(1 C.)

Accuracy: 5 degrees F.

3. OXYGEN
   Electrochemical cell. Life 2 years.
   Range: 0-25%
   Resolution: 0.1%
   Accuracy: 0.2%

4. NITRIC OXIDE (NO)
   Electrochemical cell. Life 2 years.
   Range: 0-2000 PPM.
   Resolution: 1 PPM
   Accuracy: 4% of reading

5. NITROGEN DIOXIDE (NO_2)
   Electrochemical cell. Life 2 years.
   Range: 0-1000 PPM.
   Resolution: 1 PPM
   Accuracy: 4% of reading

6. CARBON MONOXIDE
   Electrochemical cell. Life 2 years.
   Range: 0-2000 PPM.
   Resolution: 1 PPM
   Accuracy: 4% of reading

7. SULFUR DIOXIDE
   Electrochemical cell. Life 2 years.
   Range: 0-2000 PPM.
   Resolution: 1 PPM
   Accuracy: 4% of reading

8. TIME/DATE
   Time formatted in hours, minutes, seconds. Date in month, day, year format.

COMPUTED PARAMETERS:

1. COMBUSTION EFFICIENCY
   Heat loss method.
   Range: 0-100%

Resolution: 0.1%
Accuracy: 1%

2. CARBON DIOXIDE
   Range: 0-40%
   Resolution: 0.1%
   Accuracy: 5% of reading

3. EXCESS AIR
   Range: 0-1000%
   Resolution: 1%
   Accuracy: 10% of reading

4. OXIDES OF NITROGEN
   Range: 0-3000 PPM
   Resolution: 1 PPM
   Accuracy: 4% of reading

5. EMISSIONS 1 (CO, NO, NO_2, NOX, SO_2) LBS./MMBTU
   Range: 0.000-99.99 lbs./million BTU
   Resolution: 0.01 lbs./MMBTU
   Accuracy: 5% of reading

6. EMISSIONS 2 (CO, NO, NO_2, NOX, SO_2) GRAMS / BR. HP-HOUR
   Range: 0-99.99 grams/brake hp-hr
   Resolution: 0.01 grams/brake hp-hr
   Accuracy: 10% of reading

(Oxygen correction factor for emissions in units of PPM adjustable 0-20% in 1% steps plus TRUE).

PRINTER:

External stand-alone ENERAC 2", 28 char. per line thermal printer.

STORAGE:

1. INTERNAL.
   100 individually selectable buffers hold one complete set of measurements each

in non-volatile memory. Buffer contents can be sent to printer or RS-232 port.

Data storage performed either individually on command or on a pre-programmed periodic basis.

COMMUNICATIONS:

1. RS-232 PORT
   RS-232C port (DTE), 9600 baud, half duplex, 1 start bit, 8 data bits, 1 stop bit, no parity.

2. SOFTWARE
   Over 20 software commands for diagnosis and measurement. Windows software available.

3. INTERNAL MODEM
   9600 baud modem for remote communications and servicing.

MISCELLANEOUS:

1. FUELS
   10 fuels, Custom fuels available on request or by customer programming using Enercom™ software.

2. CALIBRATION
   Optional Auto zero. Automatic software span calibration for CO, NO, NO_2 and SO_2.