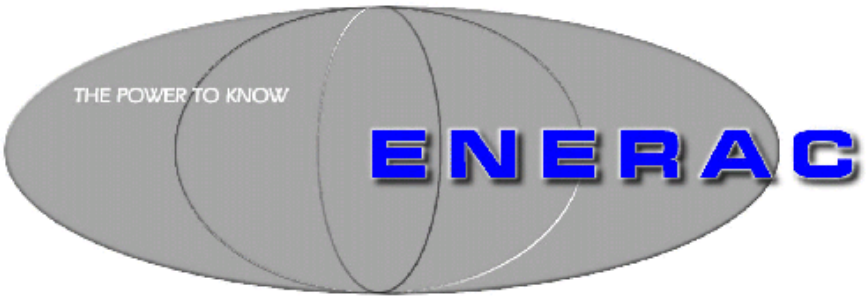
INSTRUCTION MANUAL



MICRO-EMISSIONS ANALYZER
MODEL 500

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REVISION 3.0

LIST OF ABBREVIATIONS

PARAMETERS

AMB T	Ambient (room) temperature
CO	Carbon monoxide (a toxic gas)
CO2	Carbon dioxide
COMBUST	Combustible gases
EFFIC	Combustion efficiency (for boilers and furnaces, does not apply to engines)
EX AIR	Excess air
NO	Nitric oxide (a toxic gas)
NO2	Nitrogen dioxide (a toxic gas)
NOX	Oxides of nitrogen (a toxic mixture of nitric oxide and nitrogen dioxide gases)
OXYGEN REF	Oxygen reference basis for correction of toxic gas Concentration
SO2	Sulfur dioxide (a toxic gas)
STACK T	Stack temperature
THERMAL EFF	Engine thermal efficiency (heat loss method of calculation, not the same as combustion efficiency)

UNITS

PPM	Parts (of pollutant) per million (volume basis-dry)
MGM	Milligrams (of pollutant) per cubic meter
GBH	Grams (of pollutant) per (engine) brake horsepower-hour
#/B	Lbs. (of pollutant) per million BTU (of fuel)
"	Inches of water (draft measurement)
%	Percent by volume dry basis

OPTIONS

The ENERAC Model 500 has been designed as a modular system, 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 500 are as follows:

a. 2" ENERAC Printer.

b. Nitric oxide (NO) measurement capability.

c. Nitrogen dioxide (NO_2) measurement capability.

d. Sulfur dioxide (SO_2) measurement capability.

e. Combustible gas measurement capability.

f. Stack draft measurement capability.

g. Smoke test (ASTM method D2156) capability.

h. Bluetooth wireless communication option.

i. Thermoelectric cooler option (Peltier drier).

j. Extra-long 36" or 48" inconel probe option.

k. Emissions units option (Lbs / millionBTU & Grams / brake-HP-hour).

l. Custom fuel option. (Either at the factory, or programmable using the ENERCOM™ for WINDOWS™ option.

m. CD-ROM with custom software:
   • Enercom™ for WINDOWS™95/98/ME/NT/XP,
   • EnercomCE for WINDOWS CE (Pocket PC),
   • EnerPalm for PALM OS.

Any combination 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. (For carbon monoxide only, 0-10,000 PPM and 0-20,000 PPM ranges are also available).

CHAPTER 1

FUNDAMENTALS

The ENERAC Model 500 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.

The ENERAC Model 500s are easy to carry and utilize the latest technology; reliable flue type electrochemical sensors manufactured by the largest sensor manufacturer to measure emissions.

The ENERAC use sophisticated electronics and programming designed for increased accuracy and flexibility. It measures 2 temperatures and 5 different stack gases. It computes efficiency of combustion, as well as excess air and carbon dioxide. It communicates with a variety of other computers via its serial ports. It has a library of 15 fuels, diagnostic/help messages, and can operate either on its rechargeable batteries, AC power, or from a set of four AA alkaline cells.

ENERAC has years of experience in the manufacture and marketing of portable combustion and emission analyzers. The Model 500 is based on this experience, together with the latest innovations in electronic and sensor technology. They also express 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 sent to a computer. 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 500 includes as standard equipment:

1. One Emissions Analyzer Model 500.

2. One stack probe with 10 ft. Viton hose (non-adsorbent, flexible).

3. One condensation trap with filter.

4. One disposable fiber filter.

5. One wall-mounted AC battery charger.

6. One instruction manual.

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 stack probe's hose on a hot boiler surface.

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

6. Always be sure to use single-gas blends when calibrating the sensors.

7. Charge the battery at least every two weeks to maintain proper bias on the sensors.

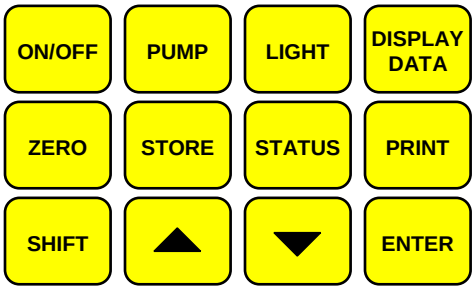
CHAPTER 2

THE INSTRUMENT KEYBOARD

The Model 500 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, USB port or Bluetooth interface.

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. If you hold it down for 3 seconds it will start a smoke test.
LIGHT	Toggles the LCD display's backlight illumination on or off.
DATA	Toggles four LCD display screens. Each screen presents an instantaneous group of data of four measurement or computation parameters. The fourth screen displays all parameters simultaneously. This is the most often used button.
ZERO	Executes an instrument autozero (sets oxygen to 20.9%).
STORE	This button is used to store data in the instrument's internal buffers.
STATUS	Toggles three LCD screens. The first screen displays the customer name, time, and date. The second screen displays the current

software version, unit serial number, battery voltage and selected fuel. The third screen displays the ambient temperature, units of temperature, emission units, and selected oxygen reference.

PRINT — Sends data to the printer.

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

SHIFT — Displays the Setup Menu.

▲ — Increments the entry marked by the cursor to the next higher entry. (This may be a digit or another parameter).

▼ — Decrements the entry marked by the cursor to the next lower entry. (This may be a digit or another parameter).

ENTER — Executes and stores all the changes.

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.

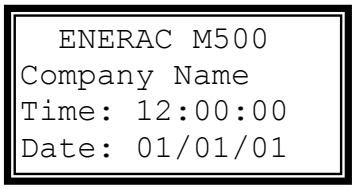
The Model 500 micro-emissions analyzers consist of two major components, the probe (whose function is to extract, clean, and dry the sample) and the main unit, which does the stack analysis and computations.

To operate the instrument follow the steps outlined below.

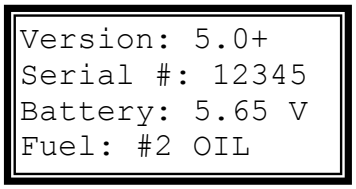
1. Remove the instrument from its case, attach the sampling probe and water trap or thermoelectric cooler to the analyzer section, and press the ON/OFF button.

2. The instrument pump will immediately turn on. If it does not, check the batteries. If you are using rechargeable batteries, plug in the AC charger. If the unit will not respond, reset the unit. To reset the unit, press the reset switch, located on the left side of the unit next to the USB port.

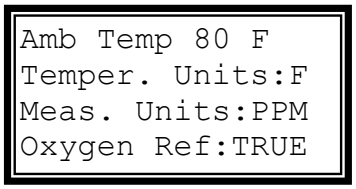
3. Press the STATUS button to obtain information about the analyzer as shown below by the three screens displayed by toggling the STATUS button:



STATUS SCREEN 1



STATUS SCREEN 2



STATUS SCREEN 3

The first screen shows the model name, customer name, current time & date. The second screen displays the firmware version of the unit, serial number of the unit, current battery voltage, and currently selected fuel. The third screen shows the current ambient temperature, units of temperature and emission measurement, and the oxygen reference. The selected fuel affects the efficiency and CO_2 calculations. The selected oxygen reference affects the CO, NO, NO_2, & SO_2 measurements in PPM or MGM mode. The fuel and oxygen reference, as well as the time, date, and measurement units can be changed using the SHIFT menu as described in

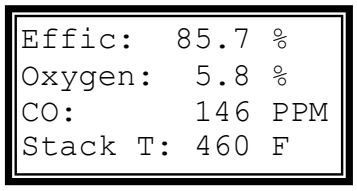
CHAPTER 5: ANALYZER CUSTOMIZATION. It is a good idea to use the STATUS button to check the battery voltage before you begin a test. The unit will display a warning and shut down when the battery voltage drops to 4.0 volts.

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

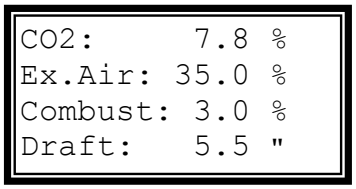
5. With the probe connected to the unit, the probe tip at room temperature, and the instrument aspirating **clean air,** press the ZERO button to execute an AUTOZERO.

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

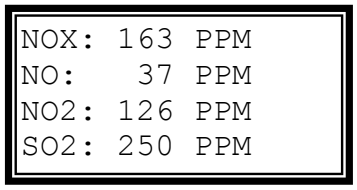
7. Press the DATA button to display the first group of measurements. By depressing this button again you display the second group of data, and by depressing it again you will display the third group of data. The data are grouped as follows:



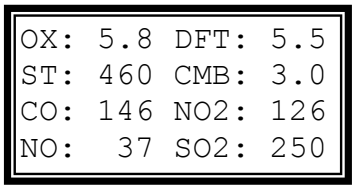
DATA SCREEN 1



DATA SCREEN 2



DATA SCREEN 3

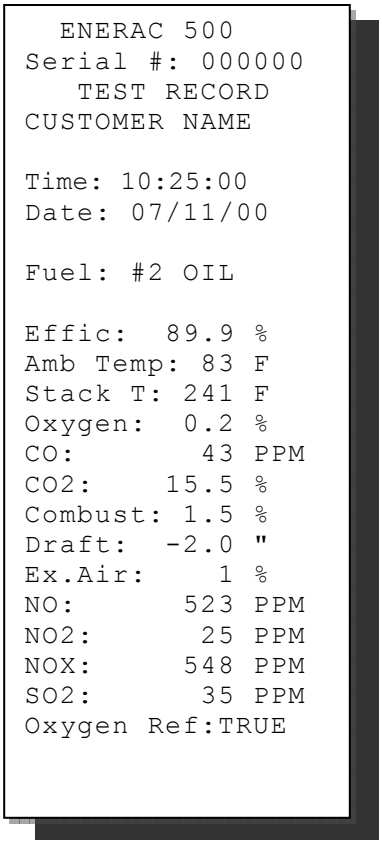


DATA SCREEN 4

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

NOTE: Depending on the options enabled for your analyzer some of the entries in one or more of the displays shown above will display "N.A." if that option is not available. When the O_2 level is above 20% the efficiency will read "OVER".

8. If you want a printed record of the current data, press the PRINT button on the analyzer. You will get a complete printout of all data, including time and date, fuel and customer information.



TEST PRINTOUT

9. If you wish to store your data into one of the 100 storage buffers of the analyzer, press the STORE button.

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.

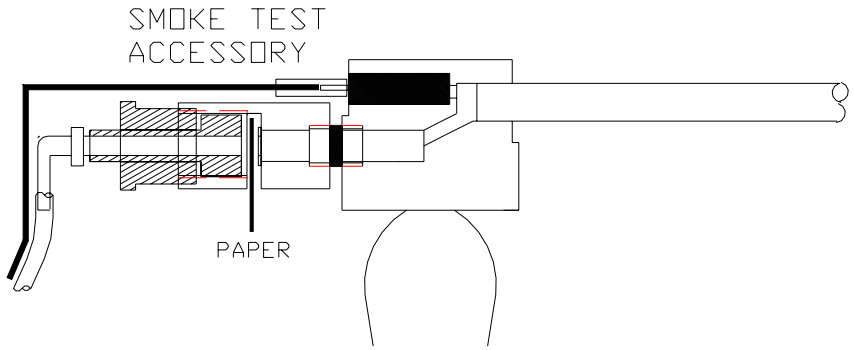
THE SMOKE TEST
(ASTM METHOD D2156)

The smoke test accessory, shown below, is required to perform smoke tests. If you wish to take a measurement of the smoke using the smoke spot method, press and hold the PUMP button for 3 seconds. The pump will stop and the first screen

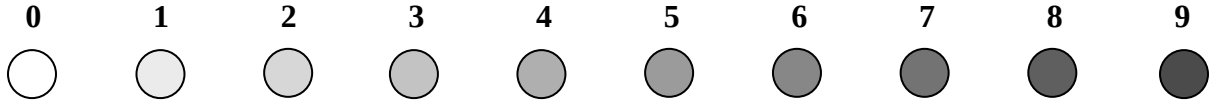
SMOKE TEST Enter to Begin Shift to Abort	SMOKE TEST Running 1:26 Shift to Abort	SMOKE TEST Completed! Remove Paper

shown below will appear on the display.

The instrument is waiting for you to take out a piece of the smoke paper and insert it in the cut out provided in the probe handle. To do this you must first loosen the thumbscrew to make room for the paper and then screw it back tightly so that there is no leak. When you are ready, push the ENTER key.



The smoke test will begin and the display will read “Running 1:26” and will count down. The pump will be on and drawing a sample at 750 cc/min. At the end of the test the pump will stop again and the message “Completed!” will appear. Remove the smoke paper as instructed. Tighten the thumbscrew to avoid any leaks and push any button to continue with your measurements. Take out the smoke chart that comes with the instrument and compare the paper's discoloration with the standard shades of grey on the chart. The number corresponding to the closest match is the smoke number.



CHAPTER 4

ANALYZER DESCRIPTION

A. POWER REQUIREMENTS

The Model 500 is designed to operate from 4 AA cells supplying a voltage of 4.0 to 6.5 Volts.

The flexible design allows for the use of either 4 AA alkaline primary (non rechargeable) batteries, or 4 nickel-metal-hydride rechargeable cells. Rechargeable batteries are recommended and are supplied with the analyzer. If you want to use non-rechargeable batteries, use the battery holder supplied. Be sure to turn off the DC charge switch located inside the unit.

A wall-mounted 110/220 volt AC charger is supplied with the high performance (2500 mAH cells) Ni-MH cells and can be used to charge the batteries or operate the unit continuously from an AC power source.

NOTE: Non-rechargeable batteries may explode or leak if the AC adapter or another battery charger is accidentally connected. If you are using alkaline (non-rechargeable) batteries, be sure to disable the AC charger connection by toggling the DC CHARGE SWITCH, located next to the batteries, to the down position marked 'Alkaline'. See figure 4, page 48.

Battery life is approximately 6-8 hours of continuous operation. If you are using the thermoelectric cooler, battery life is two hours.

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:

```
Version: 5.0+
Serial #: 12345
Battery: 5.65 V
Fuel: #2 OIL
```

STATUS SCREEN 2

When the battery voltage indicated drops to 4.6 Volts for alkaline or 4.2 Volts for rechargeables, you have only a few more minutes of battery life remaining. Using the printer will further reduce battery power. Always check the battery voltage with the pump turned 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 several hours 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.

If you are using the thermoelectric cooler assembly, reduce the cooler duty cycle to extend the battery life. To further prolong battery life, you can turn off the display's back light illumination.

B. SAMPLE FLOW DESCRIPTION

During operation, the metal tube of the probe (see figure 1) 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 sensor housing are described below.

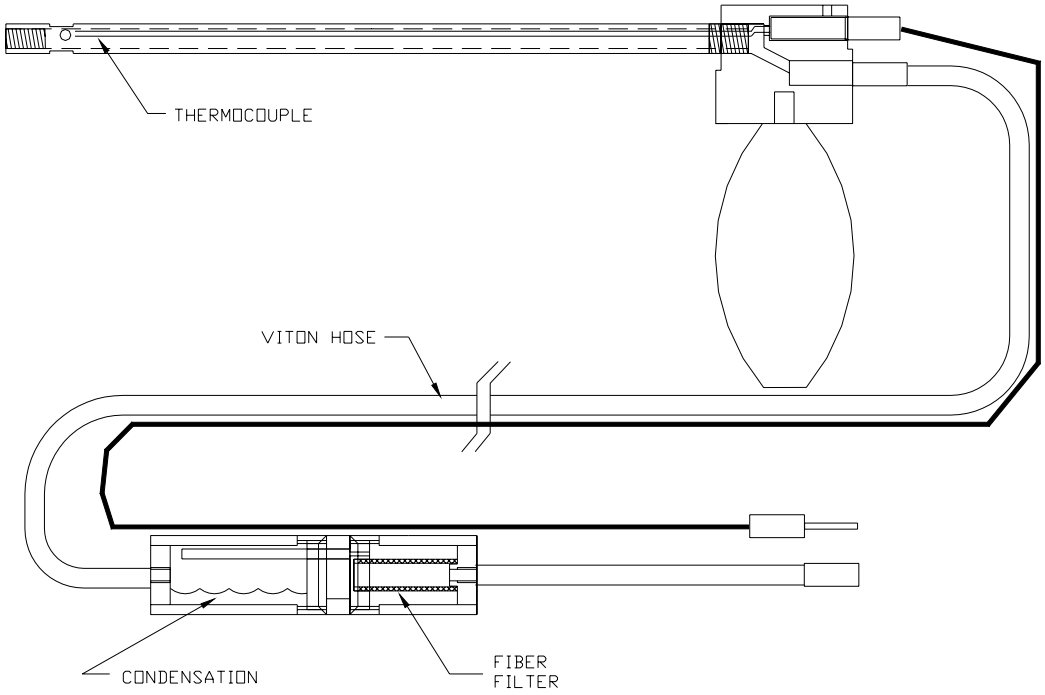


FIGURE 1

The probe assembly consists of the following components:

- A 9" 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.

- A 10 ft. long 1/4/" OD Viton sampling hose and thermocouple extension cable equipped 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.

- 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. The optional thermoelectric cooler assembly replaces the condensation trap.

C. THERMOELECTRICALLY COOLED CONDENSATION TRAP

The thermoelectrically cooled condensation trap, better known as "Peltier Drier" is an optional accessory device for the model 500 emissions analyzer.
Its purpose is to replace the standard condensation trap of the Model 500 for those critical applications, that demand higher accuracy for the measurement of nitrogen dioxide (NO_2) and sulfur dioxide (SO_2).

NO_2 and SO_2 are gases that are highly soluble in water. The exhaust sample contains typically between 5% and 20% of water vapor, most of which will condense in the probe and sample line.

To prevent significant loss of NO_2 and SO_2 during transport of the sample from the probe to the analyzer, the following conditions must be satisfied:

1. Rapid sample transport. This is accomplished by maintaining a high flow rate using a relatively small diameter sampling line.

2. Use of a sample line made from a highly hydrophobic material. A Teflon sample line limited to 15 ft. long is used.

3. Minimum contact of the gas sample with the water collection mechanism and also no additional condensation occurring following the Peltier drier.

This is accomplished by using a specially designed Peltier cooled manifold to separate the gas from the water.

The following outline drawing illustrates the drier's operation.

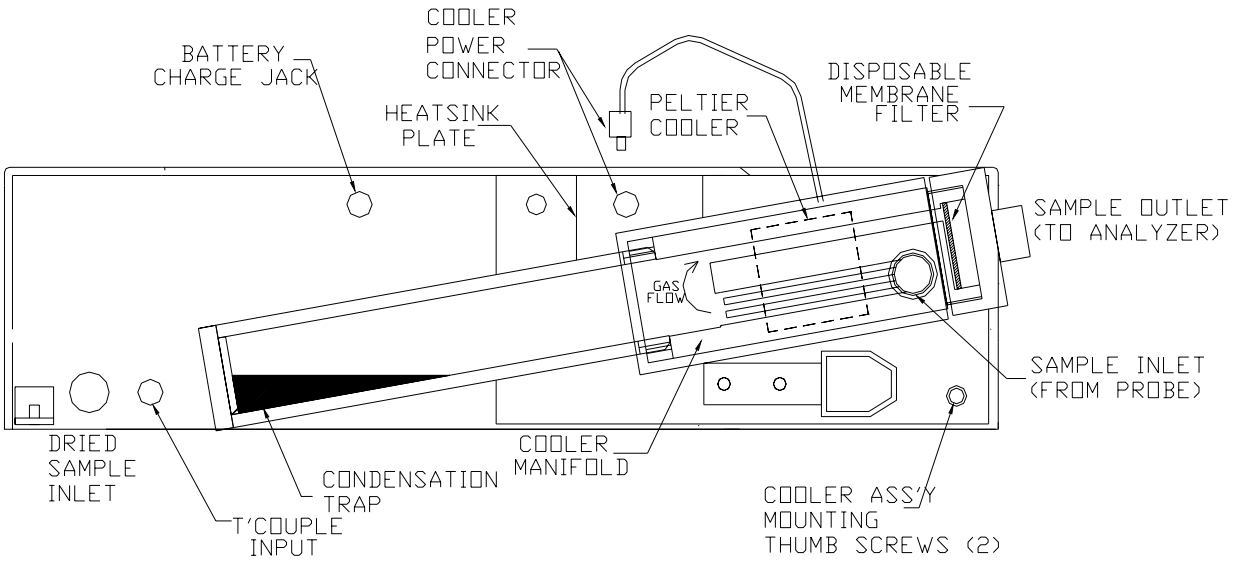


FIGURE 2

Mount the Peltier drier to the side of the ENERAC using the two thumbscrews. Make a tight connection so that the heatsink makes good contact with the ENERAC case.

The sample consisting of gas and partially condensed water vapor enters the drier through the "SAMPLE INLET". It flows through multiple narrow thermoelectrically cooled passages, where total separation of gas and vapor occurs. The dried sample makes a 180 degree turn, flowing upwards and goes through an optional membrane filter exiting through the "SAMPLE OUTLET". To maintain proper operation the analyzer should be mounted either in a horizontal or vertical position.

Check the disposable filter inside the Peltier drier filter holder. Make sure that the filter is clean and dry. Secure the cover and check that the condensation trap is also screwed tightly to prevent air leaks.

The condensation trap will probably fill with water after 2 to 4 hours depending on the fuel used. To empty the condensation trap simply disconnect it from the manifold by unscrewing it. When replacing it, be careful to seat the O-ring properly.

The Peltier drier requires electrical power for operation. This is available from the analyzer through the drier's electrical connector. When operating the Peltier drier, the analyzer's battery life is limited to 2 hours, approximately. It is therefore recommended, but not necessary, to use the battery charger for longer operation.

The Peltier drier will maintain the sample at a certain temperature below ambient temperature to ensure no further condensation inside the analyzer. You can control this temperature differential by adjusting the "COOLER DUTY CYCLE", if necessary.

The following table shows the approximate relation between duty cycle and temperature differential:

DUTY CYCLE	SAMPLE TEMP AMBIENT TEMP (°F)*
50%	-9
75%	-13
100%	-16

*At 75°F ambient.

Battery life for the analyzer with the Drier in operation is approximately 2.5 hours for 50% duty cycle to 1.5 hours for 100% duty cycle, assuming freshly charged batteries, or new alkaline batteries.

This temperature differential between sample temperature and ambient temperature is set at the factory to 70% but can be adjusted as follows:

1. Press the SHIFT key. SETUP MENU will be displayed.
2. Press the ENTER key to select SYSTEM SETUP.
3. Press the UP/DOWN keys until the cursor points to COOLER DUTY.
4. Press the ENTER key.
5. Use the UP/DOWN keys to set the Peltier duty cycle. A minimum of 50% is recommended.
6. Press the ENTER key.

D. SENSORS DESCRIPTION

A small diaphragm pump located inside the analyzer draws a small sample (1200 - 1600 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 polycarbonate sensor manifold. In the manifold, the sample passes over the oxygen sensor and the four gas sensors (carbon monoxide, nitric oxide, nitrogen dioxide, sulfur dioxide), before exiting the back of the unit at the combustibles sensor. The manifold includes a small damper to dampen the flow pulsations caused by the diaphragm type pump. Units equipped with a combustibles sensor use a special double-bellows pump. One side of the pump draws the sample from the stack, while the other side supplies air for the combustibles sensor.

The sensors

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

   a) 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 the capability of measuring temperatures from 0 to 2000°F. The instrument software linearizes the thermocouple output to improve the accuracy.

   b) AMBIENT TEMPERATURE SENSOR. This is an integrated circuit type temperature sensor. It is located inside the analyzer. It is used to measure the ambient temperature inside the instrument.

2) **Pressure sensing.** The pressure sensor is mounted inside the unit and is located on the right-hand side of the sensor housing. It is a highly sensitive piezoresistive sensor intended for pressures from +10" to -40" of water. It uses the probe as a gas conduit to monitor stack draft. A separate hose is not used for draft measurement unless the customer specifically requests it.

3) **Gas sensing.** All gas sensors are mounted on the printed circuit board. Gas is introduced by the sensor manifold housing. The sensors can be accessed by opening the bottom part of the analyzer's back cover. All toxic gas sensors used in the Model 500 are large electrode area emission type sensors especially designed for use in the hostile exhaust gas environment.

a) CARBON MONOXIDE SENSOR. This is a sealed electrochemical cell incorporating a long-life inboard filter. It consists of three or 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 two years. Its inboard disposable filter has an estimated life in excess of 200,000 PPM-hours. An optional sensor includes an auxiliary electrode to remove cross interference to hydrogen gas.

b) 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.

c) 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 two 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.

d) 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.

e) 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 500 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. For this reason, never use span gases that are blends of two or more toxic gases.

f) COMBUSTIBLES SENSOR. This is a two element catalytic type sensor. Any flammable gas in the vicinity of the active element will be combusted with oxygen present and cause a rise in the temperature of the detector element, which is essentially proportional to the heating value of the gas. The rise in temperature causes an increase in the electrical resistance of the element, which in turn is converted to a signal proportional to the gas concentration. For proper operation it is necessary to supply a sufficient amount of oxygen. *This is achieved by mixing an equal amount of air to the sample gas.*

The combustibles sensor will, in principle, detect any hydrocarbon or organic vapor, hydrogen gas and ammonia. The calibration gas used to span calibrate this sensor is 1% methane balance nitrogen. Of course any other gas, such as propane, may be used to calibrate the unit.

The minimum amount of oxygen available to the sensor is about 10% (assuming no oxygen in the sample). Consequently, the maximum concentration of methane that can be measured is 5%. For propane the maximum concentration is 2-3%, and for octane 1%. The type of sensor used is not dependent on oxygen concentration, as long as there is sufficient oxygen for the reaction.

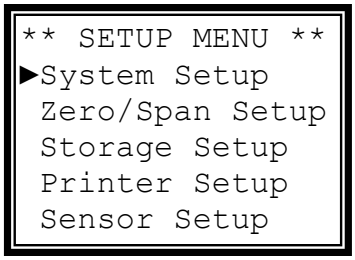
NOTE: This catalytic-type sensor is intended to be used as a detector of dangerous concentrations of unburned gases and is of limited accuracy for the measurements of hydrocarbons. It will also respond to the presence of hydrogen and carbon monoxide, which are combustible gases. For accurate measurements of low levels of hydrocarbons, one must use an NDIR analyzer.

WARNING: Do not use the Model 500's combustible sensor as a safety-type instrument in potentially hazardous atmospheres. <u>The Model 500 is NOT "intrinsically safe" and is only intended to measure the presence of small amounts of gaseous fuel in stacks</u>.

CHAPTER 5

ANALYZER SETUP

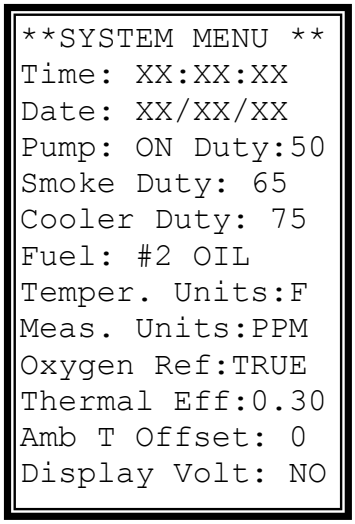
The SETUP MENU allows the operator to change system parameters, perform sensor calibrations, and manage the internal storage of the ENERAC. Pressing the SHIFT key displays the SETUP MENU. The SETUP MENU contains five submenus:



SETUP MENU

Use the UP & DOWN keys to move the arrow (→) between the submenus, and press ENTER to select. Press SHIFT to return to a previous, higher-level menu.

A. SYSTEM MENU



SYSTEM MENU

To change certain parameters, such as time, date, fuel, and measurement units, select the SYSTEM MENU. Every parameter listed on the SYSTEM MENU screen can be changed as follows.

a. Use the UP & DOWN keys to move the arrow (→) to the parameter you wish to change.

b. Press ENTER to edit the value. The arrow will disappear as the current line shifts to the left by one character and a cursor appears over the value. This indicates that you are in edit mode.

c. Use the UP & DOWN keys (buttons displaying the triangles) until the desired value of the selected parameter appears on the display.

d. Press the ENTER key to execute the change. If you do not wish to make a change, press SHIFT to stop editing the current parameter.

A more detailed explanation of each parameter follows:

1) TIME: To set the time of the analyzer's internal clock (24 hour clock) you operate the SHIFT, UP, DOWN, & ENTER buttons as follows:
   a) Press the ENTER key to edit the TIME parameter.
   b) Press the UP or DOWN keys as required until the correct number corresponding to the hour (24-hour clock) appears on the display.
   c) Press the ENTER key to shift the cursor to the minute indication.
   d) Repeat the procedure using the UP & DOWN keys to set the minutes, then press the ENTER key.
   e) Repeat the procedure for the seconds indication.

2) DATE: To set the date for the analyzer's clock repeat the procedure outlined above for setting the time. Keep in mind that the date format is mm/dd/yy.

3) PUMP: Pump status, on or off, is displayed, followed by the duty cycle of the pump. The duty cycle can be set with the UP, DOWN & ENTER keys.

4) SMOKE DUTY: For an accurate smoke test this duty cycle is set at the factory for a flow-rate of 750 cc/min.

5) COOLER DUTY: This setting is for the optional thermoelectric cooler. See Appendix C.

6) FUEL: The analyzer has the following fifteen fuels stored in its memory
   (1) #2 OIL
   (2) #6 OIL
   (3) NATURAL GAS
   (4) ANTHRACITE (COAL)
   (5) BITUMINOUS (COAL)
   (6) LIGNITE (COAL)
   (7) WOOD, 50% MOISTURE
   (8) WOOD, 0% MOISTURE
   (9) #4 OIL
   (10) KEROSENE
   (11) PROPANE
   (12) BUTANE
   (13) COKE OVEN GAS
   (14) BLAST FURNACE
   (15) SEWER GAS

To select the desired fuel, press the UP or DOWN keys until the desired fuel appears on the top of the display and then press ENTER. The fuel selection affects the following parameters: combustion efficiency, carbon dioxide calculation and display of toxic gases in units other than PPM.

7) TEMPER. UNITS: The UP or DOWN keys toggle between °F (Fahrenheit) and °C (Celsius). Stack temperature and ambient temperature will be displayed, printed, and saved in the selected units.

8) MEAS. UNITS: When the cursor is blinking on this line, you can select any of the following units of measurement for the toxic gases (CO, NO, NO_2 & SO_2):
   - PPM : Parts per million (volumetric)
   - MGM : Milligams per cubic meter
   - #/B : Lbs. (of pollutant) per million BTU of fuel
   - GBH: Grams (of pollutant) per break horsepower-hour

   To choose the desired emission units, toggle the UP & DOWN buttons until the proper units are displayed. Then press the ENTER key. If you select GBH (grams/brake horsepower-hour) as the desired units, you must not forget to set the value of the (engine) thermal efficiency also! You can obtain this figure from the engine's manufacturer specifications. It differs somewhat as a function of engine type and load factor. (Typically, it is a number between 0.25 and 0.35). The ENERAC's default value is 0.30. If the thermal efficiency is not known, it may be computed by using the engine's BSFC (brake-specific fuel consumption-BTU/BHP-HR) as follows:

   ENGINE EFFICIENCY = 2547/BSFC

   NOTE: Emission units measurements in PPM, MGM, #/B and GBH are carried out on a dry basis as required by the EPA's 40CFR75 . (The ENERAC is an extractive analyzer, whose conditioning system removes most of the water vapor before the sample reaches the sensors).

   NOTE: Values of emissions in #/B and GBH are fuel and CO_2 dependent. The fuel parameters for certain typical fuels (i.e. the F- factors for anthracite, etc.) used in the analyzer have been modified to be identical to those specified in 40CFR60 Appendix A method 19 of the code of federal regulations. Consult ENERAC, Inc., for details and correction factors.

   NOTE: NO and NO_X emissions in #/B or GBH are computed as NO_2!

9) OXYGEN REF: Many environmental regulations require that the concentrations of pollutants measured, be corrected to some reference value of oxygen other than the actual concentration at the time of the measurement. Typical oxygen reference values are 0% (air free), 3%, 7% or 15%. To select the desired oxygen reference value, press the SHIFT key repeatedly until the blinking cursor is located on the OXYG REF line on the display, as described above. Toggle the UP or DOWN button, until the desired value of the reference oxygen is displayed. (Range is 0-20% in 1% increments). Then press the ENTER key. To return to uncorrected measurements, press the UP button until the display reads:

```
OXYGEN REF: TRUE
```

NOTE: Setting the OXYGEN REF to a value other than TRUE affects values of emissions concentrations in PPM and MGM. It does not affect values in #/B or GBH!

10) THERMAL EFF: Selects the thermal efficiency of the engine. See MEAS. UNITS above.

11) AMB T OFFSET: Sets the value, in °C, to add or subtract to the measured ambient temperature.

12) DISPLAY VOLT: Selects for maintenance and troubleshooting purposes, whether the sensor amplified output voltages will be displayed or not. Default setting is NO. If set to YES, voltages will appear on DATA SCREEN 4.

B. SPAN MENU

```
** SPAN MENU **
CO Span: 200PPM
NO Span: 200PPM
NO2 Span: 200PPM
SO2 Span: 200PPM
Comb Span: 1.0%
Draft Span: 10 "
Zero Time: 60sec
Span Time:120sec
Calib History
```

SPAN MENU

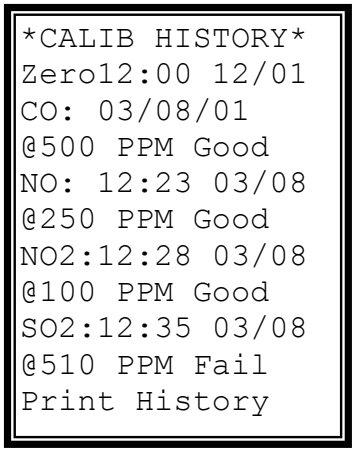
The SPAN MENU lets you set span calibration values for each sensor and performs all sensor calibrations. The SPAN MENU is shown below.

1) ____ SPAN: The first six lines of the SPAN MENU are used for carrying out span calibrations of the CO, NO, NO_2, SO_2, combustibles, and stack draft sensors. For detailed use of these settings, please refer to the chapter on calibration.

2) ZERO TIME: If you wish to change the countdown time for autozeroing the analyzer, press the UP or DOWN keys accordingly, when the cursor is blinking

on this line on the display. It is recommended that the autozero countdown should be at least 20 seconds. However, it need not be more than 120 seconds.

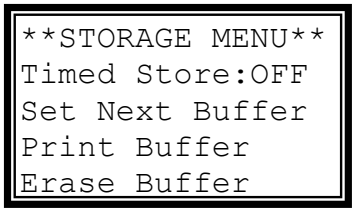
3) SPAN TIME: When carrying out a span calibration, you must introduce the span gas for an appropriate amount of time before the analyzer executes the span calibration. This setting, which is the same for all sensors, controls this time interval. The time is indicated in seconds, but a minimum of 5 minutes of span gas feeding is required for proper calibration.



CALIBRATION HISTORY

4) CALIBRATION HISTORY: This displays a record of calibrations for the analyzer. Use the UP & DOWN keys to scroll.
   a) ZERO: The time and date of the last autozero is shown on the first line.
   b) The date of the last span calibration is shown for each sensor. The span value used is shown on the next line, along with a sensor status message.
   c) PRINT HISTORY: This will print the analyzer's calibration history.

C. STORAGE MENU



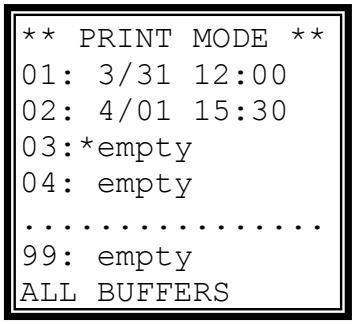
STORAGE MENU

The ENERAC Model 500 has 400 internal storage buffers. Each buffer stores one complete set of emissions data. There are two ways to store emissions data to the ENERAC's buffer. You can either store data by selecting the option to store every time you press the STORE key, or alternatively you can make use of the ENERAC's capability of storing data automatically on a periodic basis. You can set the time period between data storage. The STORAGE MENU shows the relevant display lines for the storage options.

1. TIMED STORE: Selects the method for storing data. When timed store is OFF, the ENERAC will store one set of data into the next available buffer only when the STORE key is pressed. Any other value will turn on the periodic store function. In this mode, pressing STORE will begin the sequence and the unit will continuously store data. To stop the sequence, press STORE again. The time, in minutes, between each store is set here. This can range from 1 to 60 minutes.

2. SET NEXT BUFFER: Selecting this item will display an index of the ENERAC's 100 internal storage buffers. Data is automatically stored in the first available buffer. An asterisk (*) denotes the next storage buffer. If you want to store data in a different location, use the UP, DOWN, & ENTER keys to select a new buffer.

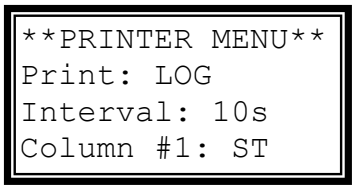
3. PRINT BUFFER: This option is used to print data stored in the analyzer's memory. Each line corresponds to one storage buffer. Buffers containing data show the date (mm/dd) and time (hh/mm) at which the data was stored. Empty buffers show the word "empty". An asterisk (*) denotes the next storage buffer. To print the contents of a specific buffer, use the UP & DOWN keys to move the arrow to select the desired buffer and press ENTER. If you wish to print all of the ENERAC's stored data in sequence, move the arrow to the entry ALL BUFFERS and press ENTER.



PRINT BUFFER MENU

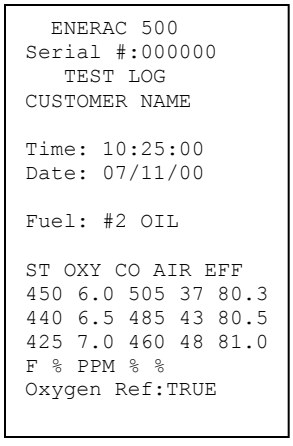
4. ERASE BUFFER: This option is used to erase stored data and is similar to the PRINT BUFFER MENU. Data that have been stored in the analyzer's memory will be retained even after the instrument has been shut off and its batteries removed. To erase the contents of a specific buffer, use the UP & DOWN keys to move the arrow to the desired buffer and press ENTER. The contents of that buffer will be permanently erased. If you wish to erase all 100 of the ENERAC's stored data, move the arrow to the entry ALL BUFFERS and press ENTER.

D. PRINTER SETUP MENU



PRINTER MENU

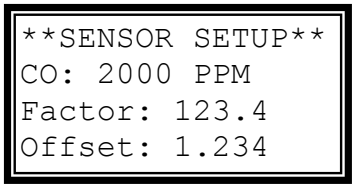
The Enerac 500 has two modes of printing. In the first mode, the Enerac will print a record of all parameters as shown on page 12. In the second mode, pressing the PRINT key starts a log of five parameter`s, as shown at right. Print mode selection (RECORD or LOG), log interval (5 - 240 seconds) and log parameters (COLUMNS 1 - 5) are set in the PRINTER SETUP MENU.



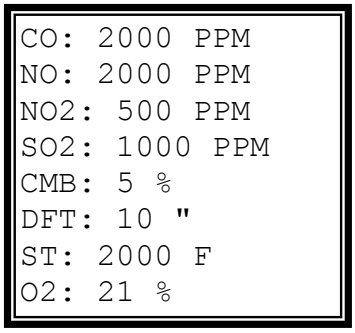
PRINTER LOG

E. SENSOR SETUP MENU

The SENSOR SETUP MENU displays the span factor (software gain factor) and offset voltages for each sensor, which is useful for monitoring sensor performance and troubleshooting purposes. The SENSOR SETUP MENU also allows the operator to enter the pre-calibrated factor when installing a pre-calibrated sensor.



SENSOR SETUP



M500 SENSORS

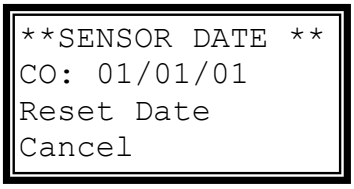
Adjusting a factor

1. The first line shows the currently selected sensor and its measurement range. To change the currently displayed sensor, press ENTER to enter edit mode, and use the UP & DOWN keys to scroll through the analyzer's sensors. A list of the ENERAC 500's sensors are shown here.

2. Press ENTER to leave edit mode. Press DOWN to move to the next line, where the factor is displayed.

3. Press ENTER to edit the factor, starting with the hundreds digit. Press ENTER to advance to the next digit. The SHIFT key will move the cursor back one decimal place.

4. When you have finished entering a factor for O_2, CO, NO, NO_2 or SO_2, the display will prompt you to reset the corresponding sensor's date. It is useful to keep track of when a new sensor is installed, as electrochemical sensors have a limited life. The current date will be displayed as the sensor date. Select RESET DATE and press ENTER to accept this date. If you do not wish to reset the sensor date, select CANCEL.



SENSOR DATE

CHAPTER 6

COMMUNICATIONS

The analyzer communicates with a computer through its RS-232 port or its USB port. The analyzer can also communicate wirelessly through its Bluetooth port, if it is equipped. Only one port can be active at a time. The communication protocol is as follows:

BAUD RATE: 9600 baud
DATA: 8 bits, 1 stop bit, no parity
HANDSHAKE: None

Communication is by ASCII characters only. Use a USB cable or 9-pin serial cable to connect the analyzer's serial port to the computer. The USB drivers must be installed first. They are located on the ENERAC CD, and the ENERAC website: www.enerac.com.
The analyzer's RS-232 port is a DTE-type. Only three wires are necessary: pin 2 is TxD, pin 3 is RxD, and pin 5 is ground.

A. ENERCOM SOFTWARE

You can retrieve current data and stored data from the ENERAC with any communications program such as Windows Terminal. You can, however, considerably enhance the performance of the ENERAC by using the special Enercom™ for Windows software. This software allows you to:

1. Monitor all emissions parameters simultaneously.

2. Record maximum, minimum, average and standard deviation for all emissions parameters.

3. Set alarms for every emissions parameter including recording the time duration that alarms have been exceeded.

4. Plot bar graphs and time plots of all parameters.

5. Select a variety of saving and printing options.

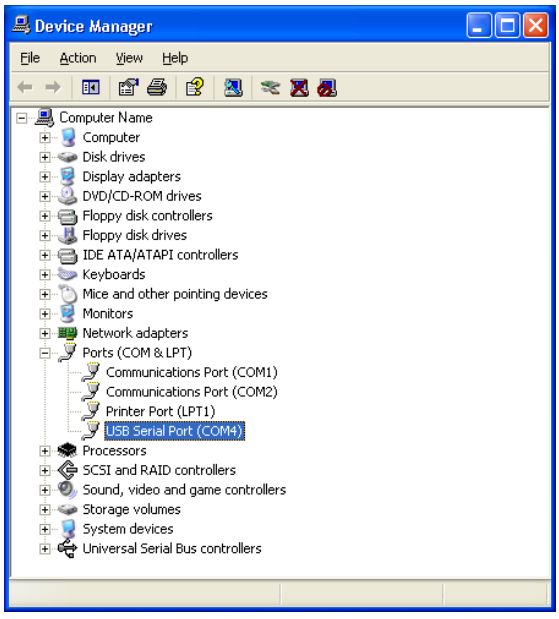
6. Enter custom fuel information.

7. Retrieve and save stored data.

Visit out website, www.enerac.com, for the latest software packages.
Consult the manual for Enercom for Windows for installation instructions and details on the available software.

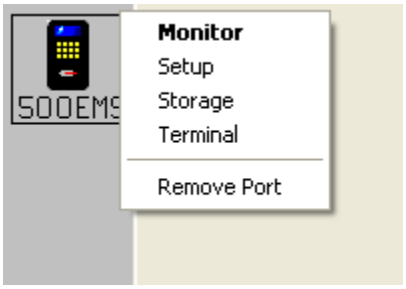
Connection Configuration

- Turn on your Enerac and connect using a USB cable or RS-232 cable or Bluetooth.
- An RS-232 connection is the 9-pin, male DB-9 connector on your computer. It is usually COM1 or COM2. Modern computers are often without an RS-232 connection.
- For USB and Bluetooth connections, you must connect your Enerac *BEFORE* starting the Enercom software. This is because the port does not appear until the device is connected.
- If your Enerac analyzer does not have an integrated USB port, you can use a USB-to-Serial adapter.
- For USB connections, enter the assigned COM port number in Enercom. Use the Windows Device Manager, to find the COM port number. The Device Manager can be launched by running devmgmt.msc from the Windows' **Start, Run** menu. The USB COM port will be listed under the **PORTS** section.



- Start Enercom. Click on **Add Port** under the **Connections** menu and enter the COM port number.

- Your Enerac icon should appear on the screen. Click on the Enerac icon to display the analyzer menu.



Monitor
Opens the **Monitor** window. All real-time testing, data logging, graphing, and charting is done here.
Setup
Opens the **Setup** window. Set the time & date, temperature & emission units, fuel, and oxygen reference here.
Storage
Opens the **Storage** window. The analyzer's stored data is displayed, in a list.
Terminal
Opens a **Terminal** window for direct communication with the Enerac. A complete list of serial port commands is provided in the next section.

Wireless Options
Connect a Bluetooth USB adapter or use your computer's internal Bluetooth capability. First, connect to the Enerac in your Bluetooth adapter's software package. Then add the assigned COM port by clicking **Add Port** on the **Connections** menu in Enercom.

PDA Options
EnercomCE software is available for PocketPCs running WindowsCE. EnerPlam software is available for PalmOS devices. These devices connect to the ENERAC's serial port and offset similar functionality as the desktop software, including real-time monitoring of data, additional storage, and remote control.

B. SERIAL COMMANDS

Start any of the available communications programs, such as PROCOMM or TERMINAL on your computer. Make sure the communications program is set to match the ENERAC's protocol listed above. You may need to use a null modem if you have trouble communicating.

The ENERAC is capable of responding to commands and requests for data sent from the remote computer. For this purpose, it has a vocabulary of commands that the computer can send and to which the ENERAC will respond. There are two types of commands: those designed for general use, and those reserved for technical purposes in order to determine from remote locations the performance of the instrument.

All commands consist of a four-letter word (these are usually abbreviations of the complete word). If the command is followed by a question mark it means that it is a request for information (i.e. it will cause the ENERAC to respond to the command by sending to its output port the specific information requested). If a command doesn't contain a quotation mark it will cause the ENERAC to store the data sent with the command, or take some other action, such as erasing a specific data buffer. This is the way to reprogram the instrument from a remote location. This feature makes remote control possible, as well as the introduction of new fuels or parameters, or even the introduction of additional features and improvements without requiring the return of the instrument to the factory.
A list of the available commands intended for general use follows.

THE ENERAC 500 COMMAND SET

DATA COMMANDS

COMMAND	FUNCTION
ATEM?	ENERAC returns present value of ambient temperature.
BATT?	ENERAC returns the battery voltage.
CDOX?	ENERAC returns present value of carbon dioxide.
CMNX?	ENERAC returns present value of carbon monoxide.
COMB?	ENERAC returns present value of combustible gases.
DRAF?	ENERAC returns present value of stack draft.
EFFI?	ENERAC returns present value of combustion efficiency.
EXAR?	ENERAC returns present value of excess air.
NOXY?	ENERAC returns present value of nitric oxide (NO).
NO2Y?	ENERAC returns present value of nitrogen dioxide (NO2).
NOXX?	ENERAC returns present value of oxides of nitrogen (NOX).
OXYG?	ENERAC returns the present value of oxygen.
SO2X?	ENERAC returns present value of sulfur dioxide.
STEM?	ENERAC returns present value of the stack temperature
TEXT?	ENERAC returns a complete record of all current stack parameters.

SETUP COMMANDS

COMMAND	FUNCTION
ATOF?	ENERAC returns the ambient temperature offset in °C.
ATOF XX	ENERAC sets the ambient temperature offset to XX°C.
COOL?	ENERAC returns the thermoelectric cooler duty cycle.
COOL XX	ENERAC sets the thermoelectric cooler duty cycle: XX=50 50% power XX=100 100% power
CORF?	ENERAC returns the temperature units.
CORF X	ENERAC sets the temperature units: X=F Fahrenheit X=C Celsius
CUST?	ENERAC returns the customer name. This name appears on the display and all printouts.
CUST XXXX	ENERAC sets the customer name, up to 21 characters long.
DATE?	ENERAC returns the present date.
DATE XX/XX/XX	ENERAC sets the present date.

FUEL?	ENERAC returns the current fuel used.
FUEL NN?	ENERAC returns the fuel currently stored in location #NN.
FUEL NN	ENERAC changes its current fuel to fuel #NN (1-15).
MODE?	ENERAC returns the current emissions units.
MODE X	(Emissions option). Causes ENERAC to switch units of emissions gas measurements (CO, NO, NO2, NOX, SO2) as follows: X=P PPM (volumetric) X=M MGM (milligrams/cubic meter) X=# #/B (Lbs./million BTU) X=G GBH (grams/brake hp-hour)
OXRF?	ENERAC returns the oxygen reference.
OXRF XX	(Emissions option). Causes ENERAC to set the oxygen correction factor to any number as follows: XX=0-20 Percent, in 1% steps XX=21 TRUE (No correction for oxygen)
PUMP?	ENERAC returns pump status: ON, or OFF, and pump duty-cycle: 0-100%
PUMP0	Turns the sample pump off & turns the purge pump on.
PUMP XX	Sets the sample pump duty cycle. (10 < XX < 100)
TIME?	ENERAC returns the current time.
TIME XX:XX:XX	ENERAC sets the current time. (24-hour format)

MEMORY COMMANDS

COMMAND	FUNCTION
BUFF?	ENERAC returns the names of each of the storage buffers.
BUFF NNN?	ENERAC returns the name of buffer #NN.
BUFF NNN XXXX	Sets the name of buffer #NNN to XXXX. Buffer Name can be up to 11characters.
NBUF?	ENERAC returns the total number of storage buffers.
PRNT XXXX	Sends to the ENERAC printer the message "XXXX" up to 40 characters long. To send more characters, repeat the command.
PRNT TEXT	Commands the ENERAC to print on its printer all the current stack parameters including time, date, fuel and oxygen reference.
DUMP?	ENERAC returns results of all tests stored in its memory.
DUMP NNN?	ENERAC returns results of test #NNN.
ERAS NN	ENERAC erases the contents of buffer #NNN.
ERAS ALL	ENERAC erases the contents of all buffers.

CALIBRATION COMMANDS

COMMAND	FUNCTION
OFFS?	ENERAC returns a list of voltage offsets for each sensor.
FACT?	ENERAC returns a list of calibration factors for each sensor.
SPAN XX NNN	ENERAC span calibrates sensor XX at a span value of NNN PPM or percent. Be sure to feed the correct span gas and wait for the sensor to stabilize before the analyzer receives this command, as it will execute a span calibration immediately.

		Span Range (NNN)	
XX=CO	Carbon Monoxide	10	2000
XX=NO	Nitric Oxide	10	2000
XX=NO2	Nitrogen Dioxide	10	500
XX=SO2	Sulfur Dioxide	10	1000
XX=CMB	Combustible Gases	0.1	5.0
XX=DFT	Stack Draft (Inches H_2O)	-20	+20
XX=COIR	NDIR Carbon Monoxide	1.125	15.0
XX=CO2	NDIR Carbon Dioxide	9.0	20.0
XX=HC	NDIR Hydrocarbons	450	20000

ZERO	ENERAC will perform an autozero of all its sensors.

MASTER COMMANDS

COMMAND	FUNCTION
LOGO?	ENERAC returns its current model name (ENERAC M500).
HELP?	ENERAC returns a list of all four-letter commands.
SRAL?	ENERAC returns its serial number.
TURN OFF	ENERAC powers down.
TURN ON	ENERAC powers up. This command is not available via a Bluetooth connection.
VERS?	ENERAC returns its current firmware version.
VOLT?	ENERAC returns a list of all system and sensor voltages

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 makes 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 (for example, using 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.

A. AUTOZEROING THE INSTRUMENT

Every time you turn the instrument on, wait for two minutes to allow the ENERAC to warm up. You can then press the ZERO button to start the autozero procedure. At the end of the autozero 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.

You can set the countdown time for autozeroing the analyzer by first pressing the SHIFT button to enter the SETUP MENU, and then choosing the ZERO/SPAN SETUP submenu. Scroll down until the arrow appears beside the message “ZERO TIME: XX SEC”. Press ENTER to edit, use the UP/DOWN keys to set the desired auto zero period, then press the ENTER key.

NOTE: In practice AUTOZEROING 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 autozero procedure, follow these steps:

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. Make sure that the analyzer pump is on. **(Always zero the instrument with the pump on, for flue stack measurements!)**
4. Press the ZERO button. Press ENTER to confirm. Wait 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 check the calibration of 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, sulfur dioxide, combustibles and draft.

You can carry out all span calibrations in sequence or just one, 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 ENERAC.

FIGURE 2

(A) Span calibration using the ENERAC **kit**
The gas calibration system supplied by ENERAC is shown in Figure 2. The kit comes with a regulator and probe adaptor. For CO, NO, NO_2, SO_2 & combustibles calibrations you must order gas cylinders containing the desired type of span gas. Span calibration using the ENERAC 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.

(B) Span calibration using your own gas
If you do not have the calibration kit, you can use your own gas to perform span calibrations you must take certain precautions, in order to calibrate the sensors properly.

Notice that you need a number of certified gas cylinders. Make sure that you use a bypass flow meter as shown in order to supply an adequate flow of span gas without developing excessive pressure on the sensors. The accessory ensures proper gas flow to the ENERAC.

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

Set up your calibration apparatus as shown in Figure 3.

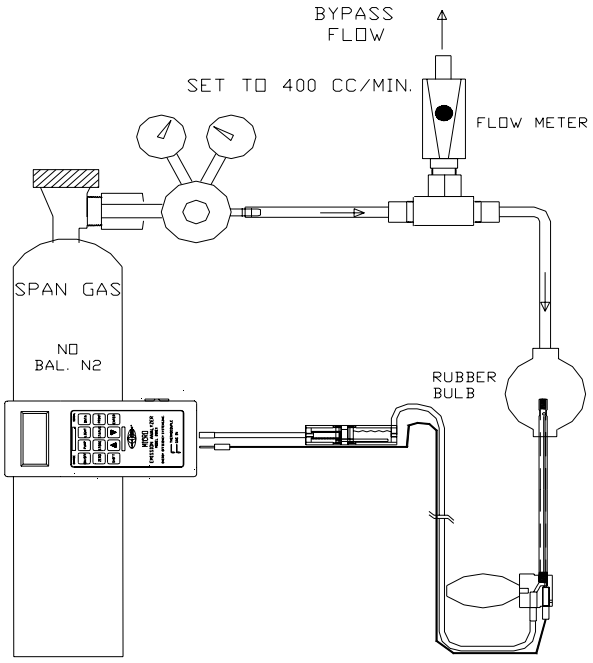


FIGURE 3

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 each sensor. Do not under any circumstances, use gas that will over-range the sensor.

The CO span gas can be in the range of 30 - 2000 PPM, 2% accuracy with balance nitrogen, preferably.
The NO span gas can be in the range of 10 - 2000 PPM, 2% accuracy with balance nitrogen, required.
The NO_2 span gas can be in the range of 10 - 500 PPM, 2% accuracy with balance nitrogen, preferably.
The SO_2 span gas can be in the range of 30 - 2000 PPM, 2% accuracy, with balance nitrogen, preferably.
The combustibles span gas can be in the range of 0.5 - 3 %, with balance nitrogen, preferably.

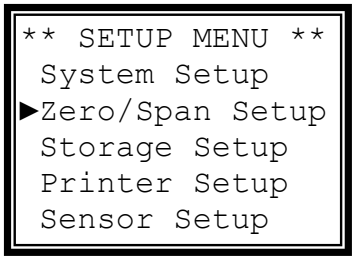
(C) Calibration procedure
The following page illustrates the sequence of key strokes to carry out a span calibration of the analyzer. It is assumed that the instrument has been autozeroed and there have been no error messages.

1. Autozero the instrument with ambient air.

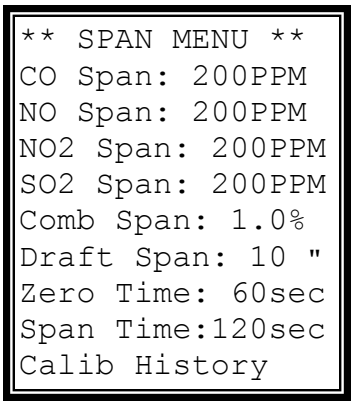
2. Connect the calibration apparatus and cylinder to the instrument.

3. Press the DATA key and observe the appropriate reading as you open the calibration cylinder valve. (If you are using the bypass flow meter, adjust the cylinder valve for a bypass flow rate of approximately 500 cc/min.

4. When the display reading for the desired gas has stabilized press the SHIFT key to enter the SETUP MENU, and select the SPAN MENU.



SETUP MENU



SPAN MENU

Before pressing the SHIFT 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!

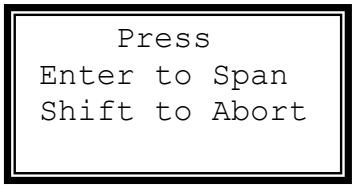
As an example, if you wish to span calibrate the NO sensor using 300 PPM certified gas proceed as follows:

1. Set the time that you must feed the span gas before executing the span adjustment. To do this use the UP, DOWN & ENTER keys to change the SPAN TIME parameter.

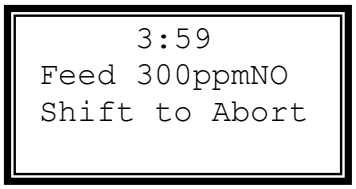
NOTE: For NO and CO calibrations a minimum of 4 minutes is adequate. For NO_2 and SO_2 calibrations a minimum of 8 minutes is required.

2. Enter the NO span value. Use the UP, DOWN & ENTER keys to change the NO SPAN value. First set the hundreds digit, then press ENTER to advance the cursor to the tens digit, and repeat for the units digit.

3. Pressing ENTER again will bring up the following confirmation box on the display:



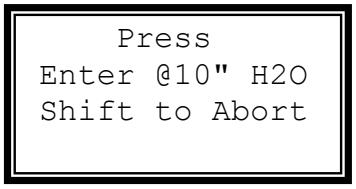
   Press the ENTER key to begin the calibration. The unit will wait for the amount of time set in step 5. The display will show the time remaining and the span gas value.



4. When the calibration is finished, press the DATA key to make sure that the display is reading correctly.

(D) Stack Draft Calibration

To obtain a span calibration of the draft sensor, connect a manometer to the end of the probe through a T fitting. Leave one side of the T open. Restrict the open side of the T with a suitable plug or valve. In the SPAN MENU, use the UP & DOWN keys to select a suitable draft calibration span between 5" and 10". Press the ENTER key. The pump will be on and the display will read:



Very slowly start closing the intake valve of the apparatus and observe the manometer reading climbing. Set the valve opening as soon as the manometer is reading the same pressure as that selected on the display. Press the ENTER key again. The draft sensor will be calibrated to the value shown on the display.

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 many environments, care must be taken to prevent physical and environmental abuse. This will help maintain 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 six hours of operation from a set of batteries depending on the use of the back light illumination.

The battery charger can not be used if you are using non-rechargeable batteries! Be sure to toggle the charger switch, located to the left of the paper roll, to the 'Alkaline' position to prevent accidental misuse.

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. **A minimum of 4 volts is required to operate the analyzer.**

For fresh alkaline batteries the voltage displayed will be approximately 6 Volts. It will gradually drop with use until at 3.9 volts a "BATTERY LOW" warning will appear. You can estimate the remaining time by observing the battery voltage.

For NiMH 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 ones observing carefully the polarity indicated. Replace the top section of the back plate.

NOTE: Remember that the NO 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. This warning is for the NO sensor only.

B. Filter replacement

If you use the standard condensation trap, there is a disposable 1-micron fiber filter located in the bottom section of the trap assembly. Its function is to prevent soot particles from reaching the analyzer pump and sensors.

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

If you use the thermoelectric cooler, the disposable fiber filter is located inline with the cooler outlet hose.

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.

C. Condensation removal

At the end of a measurement, shake the probe vigorously to drain it of 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 carefully remove the bottom section of the back plate on which the sensor manifold housing is mounted. This will expose the four gas sensors, the combustibles sensor and the oxygen sensor (see figure 4). 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 autozero the analyzer again. If you get an error message again, investigate and determine if moisture has entered the sensor area. If so, wait a few hours for the moisture to evaporate and autozero the sensor again. If you get a sensor failure then you must replace the sensor.

To replace the sensor, remove the back plate 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, first remove 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! 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.

Wait the following time periods before autozeroing the analyzer:

OXYGEN SENSOR	10 MINUTES
CO SENSOR	30 MINUTES
NO SENSOR	24 HOURS

NO2 SENSOR	30 MINUTES
SO2 SENSOR	30 MINUTES

Span calibrate the sensor as explained in CHAPTER 7: CALIBRATION. If you are using a pre-calibrated sensor and are unable to perform a span calibration, enter the pre-calibrated factor as explained in CHAPTER 5: ANALYZER CUSTOMIZATION, section E.

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!

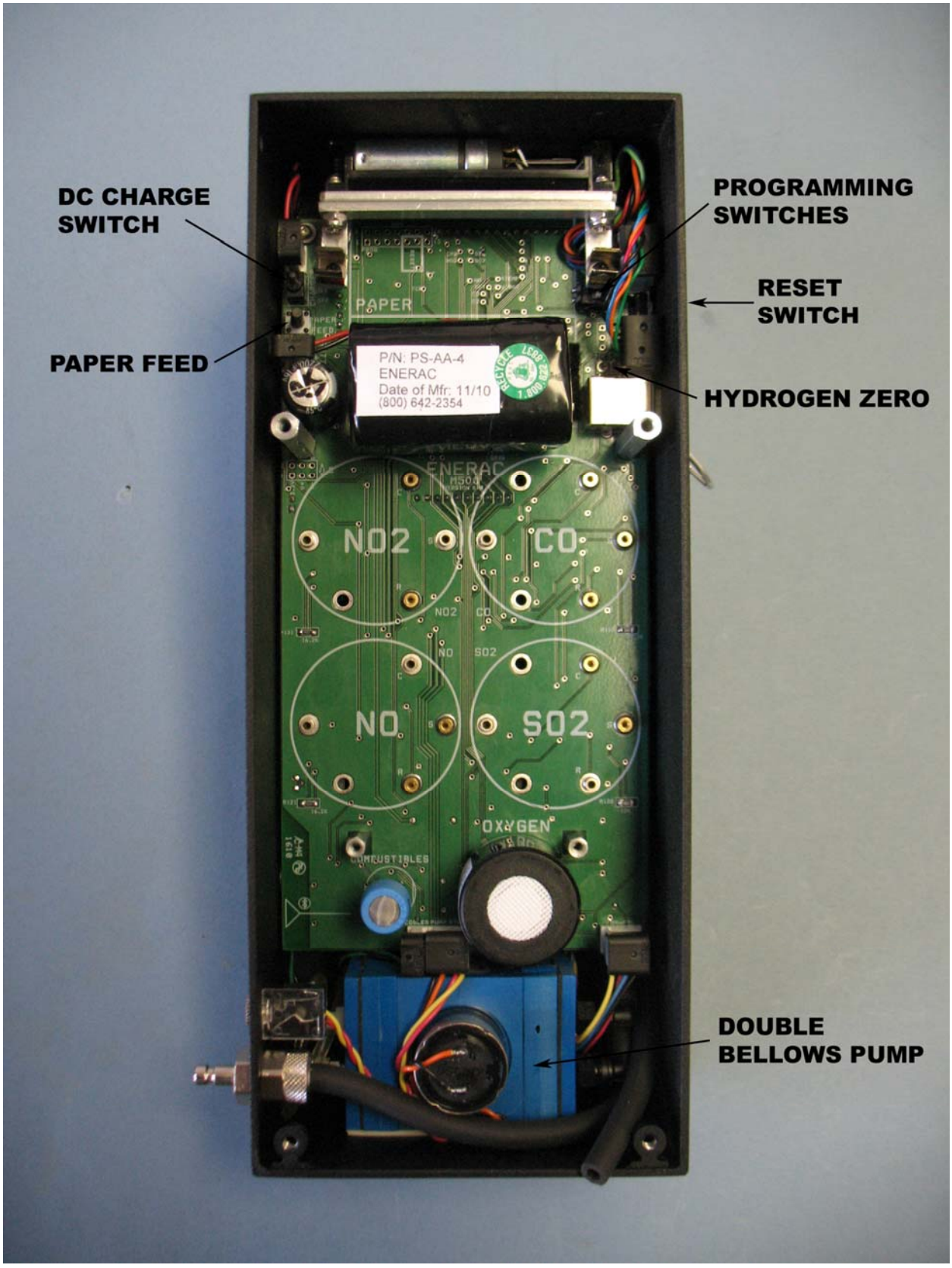
NOTE: Optional four-electrode CO sensor (Hydrogen interference adjustment). There is a hydrogen cross-interference adjustment for the special four-electrode carbon monoxide sensor. This calibration, intended to remove the interference of hydrogen from CO measurements, should be rarely done, typically 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 INTERF." potentiometer (see figure 4) 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

The printer uses a high quality 2" thermal paper. To prevent damage to the thermal heads, please use only factory recommended paper. Keep any spare paper rolls in a cool dark place to prevent paper discoloration.

To replace the thermal paper, unfasten the two screws that secure the top cover of the printer. Unroll approximately 6" of a new roll of thermal paper. Orient the roll so that the paper unrolls from the bottom of the roll. Be sure that the edge of the paper is cut square. Locate the slot immediately beneath the printer and insert the paper end as far as it will go. Turn the Enerac on and press the "PAPER FEED" button while applying forward pressure on the paper. When the paper end appears exiting printer, replace the roll on the spindle. Replace cover with screws.

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


DC CHARGE SWITCH
PROGRAMMING SWITCHES
RESET SWITCH
PAPER FEED
HYDROGEN ZERO
DOUBLE BELLOWS PUMP
PAPER
P/N: PS-AA-4
ENERAC
Date of Mfr: 11/10
(800) 642-2354
NO2
CO
NO
SO2
OXYGEN
COMBUSTIBLES

APPENDIX A

MODEL 500 SPECIFICATIONS

PHYSICAL:

1. CASE
   9 ¾" x 4" x 2¾" Aluminum case. Weight: 3 lbs.

2. PROBE
   9"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 °F.

ELECTRICAL POWER:

1. BATTERY (DC)
   6V interchangeable, rechargeable NiMh (or NiCd) or four disposable AA alkaline cells. Approximately 6-8 hours operating time.

2. AC
   110/220V 50/60 Hz. standard battery charger. (When using rechargeable batteries only!)

DISPLAY:

Four-line by 16-character, wide-temperature range LCD with backlight illumination

MEASURED PARAMETERS:

1. AMBIENT TEMPERATURE
   IC sensor. Degrees Fahrenheit or Celsius.
   Range: 0-150°F
   Resolution: 1°F or °C
   Accuracy: 3°F

2. STACK TEMPERATURE
   Type K thermocouple. Degrees F. or C.
   Range: 0-2000°F (1100°C)
   Resolution: 1°F (1°C)
   Accuracy: 5°F

3. OXYGEN
   Electrochemical cell. Life 2 years.
   Range: 0-25 % by volume
   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 PPM when measuring less then 100 PPM)

5. NITROGEN DIOXIDE (NO_2)
   Electrochemical cell. Life 2 years.
   Range: 0-1000 PPM
   Resolution: 1 PPM
   Accuracy: 4% of reading (±5 PPM when measuring less then 100 PPM)

6. CARBON MONOXIDE
   Electrochemical cell. Life 2 years.
   Range: 0-2000 PPM (Optional ranges available: 10,000 & 20,000 PPM)
   Resolution: 1 PPM
   Accuracy: 4% of reading (±5 PPM when measuring less then 100 PPM)

7. SULFUR DIOXIDE
   Electrochemical cell. Life 2 years.
   Range: 0-2000 PPM
   Resolution: 1 PPM
   Accuracy: 4% of reading (±5 PPM when measuring less then 100 PPM)

8. COMBUSTIBLES
   Catalytic sensor. Life indefinite.
   Range: 0-5%
   Resolution: 0.1%
   Accuracy: 10% of reading

9. STACK DRAFT
   Piezoresistive sensor. Life Indefinite.
   Range: +10 to -40" WC
   Resolution: 0.1" WC

Accuracy: The larger value, either 5% of reading or 0.3" WC

10. TIME/DATE
    Time formatted in hours, minutes, and seconds. Date in month, day, and 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 IN LBS./MILLION BTU (CO, NO, NO_2, NOX, SO_2)
   Range: 0-99.99 Lbs./million BTU
   Resolution: 0.01 Lbs./million BTU
   Accuracy: 5% of reading

6. EMISSIONS IN GRAMS / BRAKE HP-HOUR (CO, NO, NO_2, NOX, SO_2)
   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:
Internal 28 character per line, 2" thermal printer.

INTERNAL STORAGE:
400 individually selectable buffers hold one complete set of measurements each in non-volatile memory. Buffer contents can be sent to printer or serial ports.
Data storage performed either individually on command or on a preprogrammed periodic basis.

COMMUNICATIONS:
1. RS-232C port (DTE), 9600 baud, half duplex, 1 start bit, 8 data bits, 1 stop bit, no parity. Over 20 software commands for diagnosis and measurement.

2. USB port (Type B connector)

3. Bluetooth wireless: Class 1 (100m) (optional)

4. SOFTWARE
   Software is available for the following platforms: Windows (95/98/ME/NT/2000/XP), Windows CE, and Palm OS.

MISCELLANEOUS:
1. FUELS
   15 fuels, custom fuels available on request or by customer programming using Enercom™ software.

2. CALIBRATION
   Optional autozero. Automatic software span calibration for CO, NO, NO_2, SO_2, combustible gases, and stack draft.

APPENDIX B

FIRMWARE PROGRAMMING

On occasion it may be necessary to update the internal software of the analyzer, also known as the firmware. The firmware can be updated in the field with the use of a computer connected to the ENERAC through the serial port. Firmware updates can be downloaded from the ENERAC website: www.enerac.com, or requested on a disk from the factory. The current firmware version is displayed on the second status screen.

```
Version: 5.0
Serial #: 12345
Battery: 5.65 V
Fuel: #2 OIL
```

STATUS SCREEN 2

Updating the firmware

1. Open the battery compartment of the ENERAC and locate the programming switches behind the batteries on the right side. There are 5 miniature slide switches on a red block. See figure 4, page 46.

2. Connect the serial port of the computer to the ENERAC. Run the firmware update. The program will backup the ENERAC's settings.

3. When prompted, toggle all the switches on. The firmware will now be reprogrammed. This will take 2-3 minutes.

4. When prompted, toggle all the switches off and replace the batteries and cover. The ENERAC's settings will be restored.

5. Autozero the analyzer. Check the span calibration of all sensors.

APPENDIX C

REPLACMENT PARTS

PART NUMBER	DESCRIPTION
ASSPAKTHR200	Printer Paper Roll (package of 3)
ASSPAKSMKPPR	Smoke Paper (package of 20)
FILTER-3$$$$	Fiber Filter (package of 10) **(CONDENSATION TRAP)**
ASSPAKFLTR1$	Line Filter (package of 3) **(THERMOELECTRIC COOLER)**
SNSOXYCTL5FO	O2 Sensor
SNSCOMEMA3EX	CO Sensor
SNS$NOMEM3NX	NO Sensor
SNSNO2MEMNDX	NO2 Sensor
SNSSO2MEM3SX	SO2 Sensor
SNSCMBSGS801	Combustibles Sensor
BAT-1.2-NMHPK	Rechargeable Battery Pack
BATCHGR500D$	Battery Charger
OPTP500-DPM$	Smoke Test Adapter