THE POWER TO KNOW **ENERAC**™

COMBUSTION ANALYZER
MODELS 2000E & 2000EP

INSTRUCTION MANUAL

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LIST OF ABBREVIATIONS

ATEMP	Ambient (room) Temperature
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COMB	(Gaseous) Combustibles
DISPLAY PTR	Display Pointer
EFFI	Combustion Efficiency
IN. H_2O	Inches of Water (Draft measurement).
MGM	Milligrams (of pollutant) per cubic meter (of stack gas)- dry basis.
NO	Nitric oxide (a toxic gas)
NO_2	Nitrogen dioxide (a toxic gas)
NOX	Oxides of Nitrogen (a toxic mixture of NO & NO_2)
OXY	Oxygen
OXY_REF	Oxygen reference basis for correction of toxic gas concentration
PPM	Parts per million (Volume basis-dry)
PRHT	Preheated Air Temperature
SO_2	Sulfur Dioxide
STEMP	Stack Temperature
X-AIR	% Excess Air
#/B	Lbs. (of pollutant) per million BTU (of fuel)
%	Percent by volume dry basis

NOTE: FOR ACCURATE NO / NO_2 SPECIATION, REMOVE THE SINTERED FILTER FROM THE TIP OF THE PROBE.

The sintered filter , which is located at the tip of the Enerac's probe is used to prevent heavy soot particles from clogging the front end of the probe. (Coal fuel applications).

This filter, when heated to a temperature in excess of 400 degrees F. will cause reduction of the NO_2 fraction of the stack gases to NO. (This is true of all heated hastelloy, or stainless steel components).
However, the total amount of NOX MEASURED DOES NOT CHANGE!
If you desire to obtain a correct measurement of the exact concentrations of NO and NO_2, remove the sintered filter during measurement, if the stack temperature exceeds 400 degrees F.

LIST OF OPTIONS

The ENERAC model 2000 has been designed as a modular system, permitting the installation in the field of all the various available options. This manual describes the complete instrument equipped with all the options.

The ENERAC model 2000E is supplied with either one of two probes:

A. Model 2000E- Standard probe & water trap

B. Model 2000EP- Emissions probe for accurate measurement of NO$_2$ & SO$_2$.

Additional available options on the model 2000 are as follows:

1.   4" SEIKO Printer

2. Plotter Printer capability (Requires Printer)

3. NOX measurement using NO and NO$_2$ sensors. **(For NO$_2$ sensor, emissions probe is required!)**

4. Sulfur dioxide (SO$_2$) measurement capability. **(For SO$_2$ sensor, emissions probe is required!)**

5. Internal 70 test storage option

6. Internal modem for telephone communication

7. Emissions option. (Performs calculations in mg/m^3 or lbs./MMBTU , or grams/BHP-HR corrected to any oxygen reference)

8. CD-ROM or 3.5" diskette with custom program (ENERCOM for Windows)

9.   24", 36" or 48" inconel probe option

10. Custom fuel option. (Either at the factory, or remotely programmable, if the ENERAC is equipped with a modem or as a menu selection on SHARP computer)

11. Optional external 11-36 VDC input for operation from external battery sources.

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

Please note that options 2, 3, 4, 5, and 7, if installed in the field, must be activated from the factory via a remote connection to your ENERAC.

The factory telephone number is: (516) 997-2100

CHAPTER 1

FUNDAMENTALS

The ENERAC Model 2000E is designed as a rugged and reliable and portable
service tool for use as follows:

*   To measure emissions of toxic gases from stationary combustion sources.

*   To assist the boiler operator in getting maximum performance out of his boiler
    or furnace.

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

*   To monitor compliance with environmental regulations.

The ENERAC Model 2000E is the most complete instrument of its kind and uses
the latest electronic and sensor technology available to get maximum performance.
It measures 2 temperatures, 6 different stack gases. It computes efficiency of
combustion as well as excess air and carbon dioxide. In addition, it computes
emissions in three different systems of units. It stores, prints and plots data. It
communicates with a variety of other computers located near by via its RS-232
port, or remotely by telephone connection. It has a library of 15 fuels and over 100
diagnostic and help messages and can operate either on its rechargeable batteries
or AC current.

ENERAC has years of experience in the manufacture and marketing of
combustion analyzers. The model 2000E is based on this experience, together with
the latest innovations in electronic and sensor technology. It 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:

You insert the probe into the stack of an operating boiler or furnace. A pump
located inside the instrument draws a small sample of the stack gas. 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 boiler operator makes the required adjustments based on the analysis of the stack conditions to optimize performance.

A. UNPACKING THE INSTRUMENT

Every ENERAC model 2000E includes as standard equipment:

1. One Combustion Analyzer model 2000E (includes a roll of printer thermal paper).

2. One stack probe. (Either standard with water trap or emissions probe).

3. One 14" inconel probe extension and Hastelloy sintered filter (emissions probe only).

4. One detachable AC power cord.

5. One gas deflector to prolong the life of the sintered filter (emissions probe only).

6. One extra disposable filter.

7. One instruction manual.

NOTE: 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 **(EMISSIONS PROBE)**

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

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 printed on the stack probe housing.

2. Never use the probe without the primary sintered filter attached to the tip and the secondary fiber filter inserted in the probe housing. Operating the instrument without the filters will damage the permeation drier!
    (This is a costly replacement!)

3. To maximize the effectiveness of the drier, you must replace the desiccant (located inside the probe's drier housing) as soon as it turns white!

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

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

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

7. Use the Deflector with any fuel other than natural gas.

8. In dusty environments, cover the printer slot with the Velcro cover and, if possible, cover the face plate of the instrument. THE PRINTER MAY BE DAMAGED, IF EXPOSED TO DUST!

9. Avoid exposing the hose to temperatures below 40 deg. F. You might get some condensation.

C. IMPORTANT ADVICE. (**STANDARD PROBE**)

1. Never use the instrument without the condensation trap inserted between the probe and the unit (use no desiccant for SO_2 measurements!).

2. Replace the disposable filter as soon as it becomes noticeably discolored.

3. Replace the desiccant (if equipped) when it turns pink- white.

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

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

6. Allow the probe tip to cool off before packing the probe.

7. At the end of a measurement remove the water collected from the condensation trap and shake the hose vigorously to drain any remaining moisture from it.

8. In dusty environments cover the printer slot with the velcro cover and, if possible, cover the faceplate of the instrument. THE PRINTER WILL BE DAMAGED, IF EXPOSED TO DUST!

9. For sulfur dioxide measurements avoid any condensation in the probe.

CHAPTER 2

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 ENERAC 2000E consists of two major components, the probe whose function is to extract, clean and dry the sample and the analyzer, that does the gas analysis and the computations.

EMISSIONS PROBE:

There are five LED indicators mounted on the back of the probe,. Insert the probe in the stack, only after the instrument has warmed up and the green "PROBE OK" LED located on the probe housing has turned on.

There are 20 push button switches (keys) on the face plate of the instrument. These buttons are clustered into 4 basic groups. The most important is the group that consists of the eight operating buttons (plus the display pointer) and is located at the center of the face plate. There is a group of three buttons on the left side that, when pressed, will display the three foreground fuels. There are four buttons on the right hand side of the face plate that are used for printing, storing, outputting information and displaying time.

Finally there is a group of four buttons located below the display that are used for setting various parameters and customizing the instrument.

For simple measurements you only need to use the basic 8 buttons.

A. STARTING UP THE INSTRUMENT

1. Remove the probe and hoses from their compartments. If the case temperature is less than 40 degrees Fahrenheit, wait a few minutes for it to warm up.

2. *If the stack diameter exceeds 24", connect the extension tube to the probe tip. Make sure the sintered filter and deflector are attached to the tip of the probe. (Emissions probe only).*

3. Make sure that the range of CO, NOX and SO_2 emissions you intend to measure do not exceed the range of the instrument.

4. Connect the hose end of the probe to the gas fitting on the face plate of the ENERAC marked "GAS IN".

5. Connect the cable end of the probe to the ENERAC connector marked "ELECTRICAL".

6. Turn the instrument on. The" BATTERY OK" light should turn on. The Display should read:

    "Press ENTER to AUTOZERO"

    If you have AUTOZEROED the unit during the past 24 hours, you probably don't have to AUTOZERO it again. You can by pass the AUTOZERO procedure by pressing any key other than the "ENTER" key. If you wish to perform an AUTOZERO, press the ENTER key. The following message
    will appear on the display:

    ```
    DO NOT INSERT PROBE
    ```

    and immediately afterwards:

    ```
    WARMING UP XXX SEC
    ```

    and count down.

7. At the end of the warm up period a number of messages may appear. If everything is OK with the unit, the following message will eventually appear:

    ```
    INSERT PROBE IN STACK
    ```

(If a "....AUTOZERO ERROR" message appears, see Appendix A for help).

8. *While the instrument is warming up, the probe is also being heated, simultaneously.*

WAIT UNTIL THE GREEN "PROBE READY" LIGHT TURNS ON BEFORE YOU INSERT THE PROBE IN THE STACK!

As soon as the "PROBE OK" LED turns on, you are now ready to get started with your measurements.

B. TAKING MEASUREMENTS

1. You should have a ½" diameter hole drilled to your stack wall.

   Insert the probe in the stack. Anchor the probe to the stack wall by inserting the top end of the sliding probe support into the hole in the stack wall.

2. Push the Fuel button that corresponds to the fuel of your choice.

   If your fuel is not one of the three fuels that are displayed when pressing one of the fuel buttons, see Chapter 6 for instructions on setting fuels.

3. You can now read on the display any two stack parameters that you wish simply by operating any of the eight basic buttons shown in Fig.1.
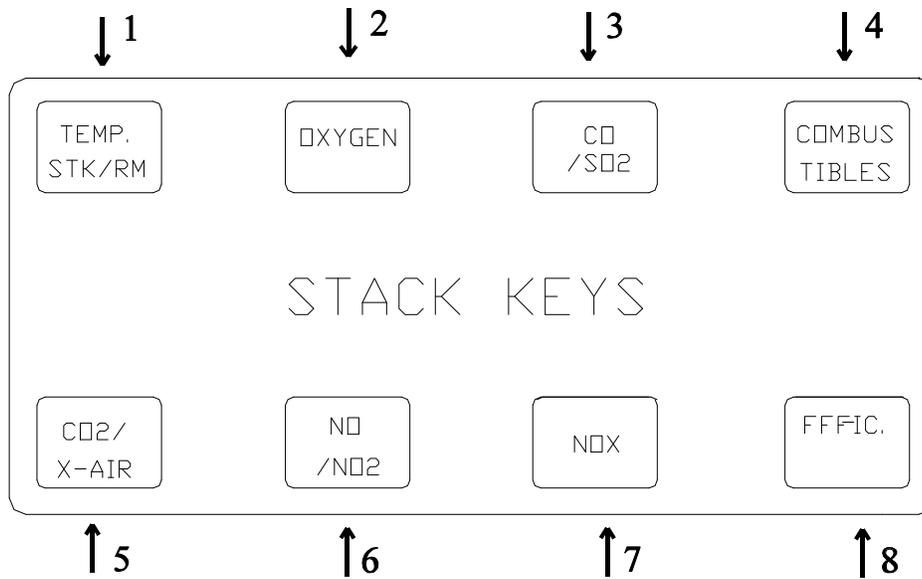
FIGURE 1

Use the DISPLAY PTR." button to display any combination of the stack parameters that you wish to view simultaneously. See fig.2.

4. During your measurements you should observe the status lights that are located on the probe housing mounted on the stack wall. These lights are important monitors of the condition of the filter and the probe temperature.

5. You should also observe periodically the moisture condition of the small piece of clear tubing located near the probe housing. The interior of the tubing should be clear with no evidence of condensation.

NOTES:
A. The display is divided into two halves. You can display any stack parameter on either side by using the "DISPLAY PNTR" key and observing the side of the display to which one of the display pointer LEDS is pointing.

B.   The buttons "TEMP/ST-RM", "CO2/X-AIR", "NO/NO2" and "CO/SO2"
     are toggles. You display the alternate Parameter by pressing the same
     button again.

NO: 50 PPM NO2: 25 PPM

VIEWING
ANGLE

LEFT   RIGHT
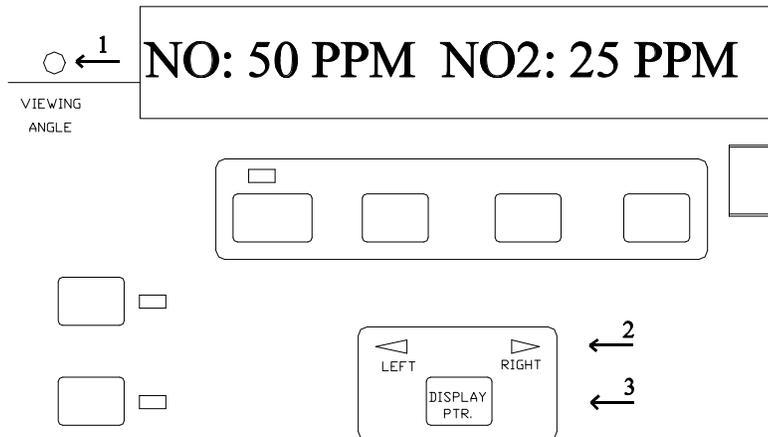
DISPLAY
PTR.

1. POTENTIOMETER ADJUSTS DISPLAY VIEWING ANGLE
2. "ON" LED INDICATES ACTIVE SIDE OF DISPLAY & ALSO
   PARAMETER TO BE PLOTTED
3. KEY TOGGLES THE ACTIVE SIDE OF THE DISPLAY

FIGURE 2

(EMISSIONS PROBE ONLY!)

If the stack draft exceeds +3" W.C. the red "NO FILTER FLOW" LED may turn on. Ignore it and proceed with your measurements!

If the "OVERHEATING" light turns on, you must remove the probe from the stack immediately, to avoid permanent damage to the probe.

C. SHUTTING OFF THE INSTRUMENT

1. Remove the probe from the stack. Do not touch the hot metal probe.

2. Allow the instrument to run for one minute aspirating ambient air to purge any remaining gases.

3. Turn the unit off. Allow a few minutes for the probe to cool down. Check the condition of the desiccant. If its color has changed to white, replace it with fresh desiccant. Store the probe in its compartment.

Do not forget to give the batteries a fresh charge before using the ENERAC again.

If you accidentally turn the instrument off while the probe is in the stack (or, if for any reason the instrument locks up and the buttons become inoperative), turn the ENERAC off and on again. When the message

<div style="border:2px solid black; padding:8px; text-align:center; font-family:monospace;">

`PRESS ENTER TO AUTOZERO`

</div>

The display, press any key other than the "enter" key. The ENERAC will bypass the autozeroing procedure and you can continue with your measurements.

CHAPTER 3

POWER REQUIREMENTS

The ENERAC model 2000E can be operated from a variety of power sources. These are: (1) its own rechargeable battery, (2) by plugging it to a suitable 120 VAC or 230 VAC outlet.

As an option: by (3) plugging it to any 11-40 VDC power source, such as an external battery and (4) by plugging it to a 6 VDC battery similar to the one located inside the instrument.

A. BATTERY OPERATION

The instrument's battery pack consists of a single 6 Volt rechargeable sealed lead acid cell. The cell is housed inside the power supply section of the unit and is rated at 10 AH. This means that it will operate the instrument for approximately 2-6 hours on a single charge (depending on the probe that is used with the instrument. The emissions probe draws power and limits the battery life to 3 hours).

The "BATTERY OK" light, located just above the ON-OFF switch, shows the condition of the battery.

1. As long as the battery is in GOOD CONDITION, the "BATTERY OK" LED will stay ON.

2. When the battery BEGINS TO WEAKEN the light will begin to FLASH. It will keep flashing for approximately 5-10 minutes, unless the unit is plugged to an external power source.

3. When the battery BECOMES VERY WEAK, the instrument will be AUTOMATICALLY shut off by a battery monitoring circuit to prevent the battery from becoming totally depleted.

4. There is a very small drain on the battery, even when the instrument is turned off. Sensor bias and the internal clock circuits stay on and will eventually drain the battery completely after 8-10 months.

If the instrument turns off because of a depleted battery, plug the AC or, if you have the option, the DC power cord to a suitable outlet and continue your measurements ,or turn the Instrument off and charge the battery. It requires approximately 4 hours for a complete charge.

5. To recharge the batteries plug the instrument to any convenient POWER SOURCE. This can be either an AC outlet or if you have the option, a DC power source(11-40 VDC) such as a automobile battery.

6. The ON/OFF switch module can be set for either 120 VAC or 230 VAC. The current setting is shown on the face of the module. If you wish to change the setting, lift the tab that covers the module, pull out the plastic insert that indicates the voltage setting and insert it so that the correct voltage setting is shown on top. See figure 3
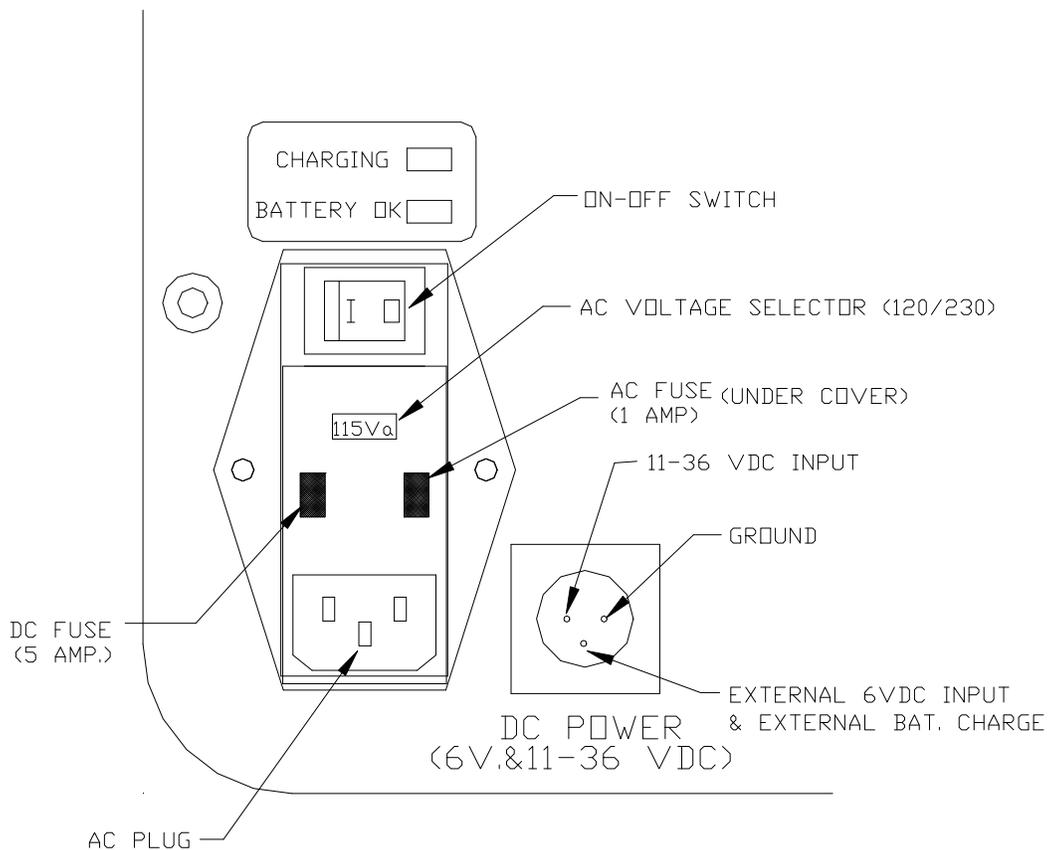
FIGURE 3

The DC power connector located next to the AC power connector is an option for the model 2000E!

As soon as the instrument is plugged to a functioning power source, the "CHARGE" LED will turn on indicating that the batteries are being charged. (If you connect the instrument to a DC power source and the "CHARGE" LED does not turn on, check to see if you are properly connected to a suitable DC source!).

B. AC OPERATION

Before plugging the instrument to an AC outlet, make sure the outlet voltage is the right one for the instrument. Domestic units operate on 110-125 V. 60 Hz. Export units are usually operated on 220-240 V. (You may need a suitable adaptor to plug the AC cord to a non U.S. socket).

The ON/OFF switch module includes the AC socket, the ON-OFF switch, a 1.0 Amp. fuse (for AC voltages) , a 5.0 Amp. fuse (for DC power), an AC voltage changing adaptor (insert) and an EMI/RFI filter for compliance with the FCC regulations.

The fuses can be reached by simply lifting the AC module's plastic cover using a small screwdriver.

 The 1.0 amp fuse located on the left side of the Switch Assembly is the ac power fuse and the 5.0 Amp fuse located on the right side of the Switch Assembly is the dc power fuse!

When the unit is operating on AC, the battery receives a small charge.

CAUTION:

If your AC power is subjected to frequent "brownouts", or, if you are operating large motors in the vicinity, you should avoid using the ENERAC on AC power. Even though the unit has built in protection, AC lines with frequent problems may eventually cause corruption of data stored in its temporary memory. (It will not affect data stored in its permanent memory). If you notice corruption of data on the

display or on the ENERAC printout, connect the ENERAC to a PC computer and use the refresh reprogramming diskette supplied with your instrument to reprogram the unit. Follow the instructions listed on the diskette in the README.doc file!

C. DC OPERATION (THIS IS AN OPTION FOR THE 2000E)

Many applications, such as stationary combustion engines, require numerous measurements in remote locations, where there is no AC power.

The DC power option is a convenient way to operate, or charge the instrument from
an external DC power source that can be either:

1. **An external 6 Volt battery with a capability of 5 AH or better .**

If you are going to use an external 6 Volt battery, it is recommended that you use an external 6 Volt battery similar to that used by the ENERAC (i.e. a 10 AH sealed lead acid battery). Use the 10 ft. DC cable supplied with the ENERAC. Connect the "6 Volt extension" cable (i.e. the extension cable terminating in spade lugs!) to the end of the 10 ft. Cable.

NOTE:

You can can recharge the external 6 Volt Lead acid battery, by connecting it to the ENERAC using the "6 Volt extension" cable and 10 ft. DC cable and plugging the instrument to a convenient AC source. The ON/OFF switch should be in the "OFF" position. It will take several hours for a complete charge since the instrument will be charging two batteries in parallel (its own plus the external battery, simultaneously).

2. **Any "reasonably clean" source of DC voltage from 11 to 40 VDC capable of delivering more than 5 Amps.**

Use the 10 ft. DC cable supplied with the ENERAC. Connect the " 11-40 Volt extension" (i.e. the extension cable terminating in alligator clips!) To the end

of the 10 ft. Cable. Te alligator clips must be connected with the correct polarity.
However, there will be no damage to the instrument, if you connect them with the wrong polarity.

Use only the cable supplied with the ENERAC to connect the instrument to the DC source. The ENERAC requires less than 17 watts for operation. For a 6 Volt battery assume operation of 80% of its AH rating. For a 11-40 V. DC source assume a conversion efficiency of 70%. Consequently, you can estimate the amount of time that it will run on an external battery source.

Turn the instrument off, if you wish to charge the unit's battery quickly (i.e. in 4 hours). Make sure the "CHARGE" LED is on.

COLD WEATHER NOTICE:

If you are taking measurements outdoors and if the outdoor temperature drops below 32 degrees F (0 C.), it is recommended that you use the instrument on AC, or on an external DC source. The power supplied by the unit's battery to the probe may be insufficient to heat it to the required temperature for proper operation. If you must use the unit on batteries in cold weather, take the necessary precautions to insulate the probe and warm it up by taking advantage of the heat from the stack!

Make sure the green "OK" LED turns on. (Emissions probe only!)

CHAPTER 4

FLOW DESCRIPTION & SENSORS

During operation, the metal tube of the probe (see fig.4) 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 gas sample flows through the following sections, sequentially: the probe, the water trap and the sensor housing. Their function is described below.

A. THE STANDARD PROBE (STANDARD PROBE OPTION)

This probe consists of an inconel tube , an aluminum handle and a 10' length of hose and thermocouple wire.
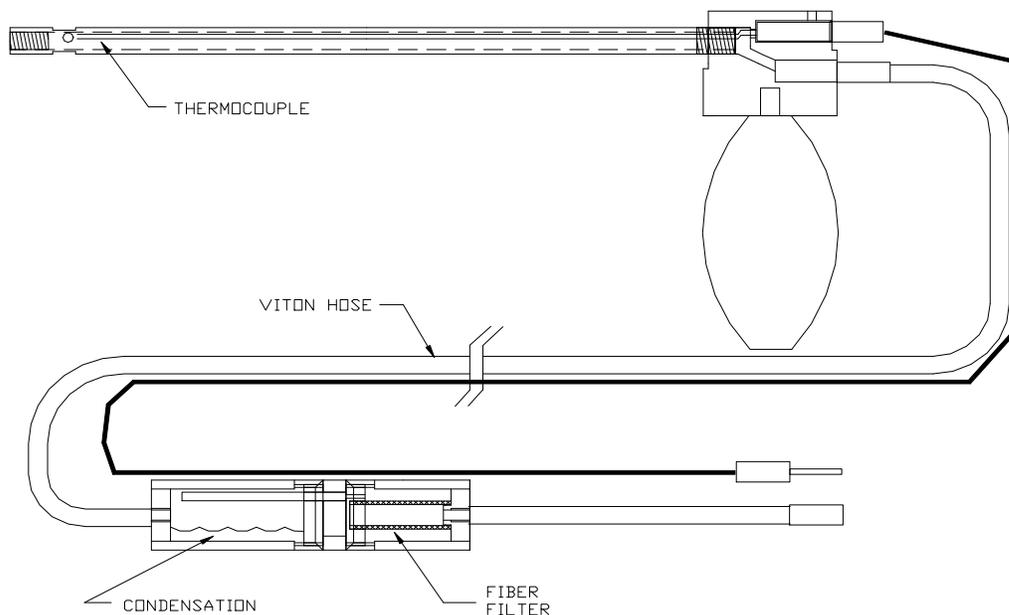
FIGURE 4
STANDARD PROBE & WATER TRAP

The inconel tube is the only part that is inserted into the stack. It can withstand

temperatures up to 2000 degrees F. Standard tube length is 13". Longer lengths are available on request. Inside the tube there is an inconel sheathed type K thermocouple wire. It monitors the stack temperature.

The tube must be inserted into the stack, with its tip as near to the center of the stack as possible. It must be inserted at least 12" below any dampers to avoid errors.

To insert the tube into the stack, drill a 3/8" hole on the wall of the stack. Do not insert the tube into a thermowell. The tube threads into the probe handle for easy replacement.

The probe handle is made of aluminum bar stock. It is used for gripping the probe (see fig.4).

A 10' braided latex hose guides the stack gases from the probe handle to the water trap. Other lengths are available on request. However, for every 10' of added hose length the response time increases by approx. 10 sec.

DON'T KINK THE HOSE OR REST IT AGAINST A HOT SURFACE.

The eight pin round connector that is located at the end of the probe, is inserted into the "electrical" input of the instrument. It is also the location of the cold junction of the thermocouple. The stack temperature displayed is the difference between the probe tip and phone plug temperatures plus the ambient temperature measured independently.

THE WATER TRAP

The water trap consists of a clear plastic cylindrical assembly and a disposable filter. The plastic assembly is divided into two compartments.

The bottom compartment is used to collect the condensate accumulating in the hose. It will take at least two hours for the compartment to fill up with water under normal operating conditions. There is a small drain plug at the bottom of the condensation trap. Drain the water collected after each use.

The upper compartment of the water trap may be empty, or filled with a desiccant material. The purpose of this material is to remove any additional moisture present in the stack gases in order to avoid any condensation on the sensor surfaces. The color of the desiccant will gradually change as the instrument is being used. The desiccant should be replaced, when its color changes to pink-white. For further details, see the section on maintenance.

NOTE:

Use DESICCANT #1 (Silica Gel), if your instrument has no NO, NO_2 or SO_2 measurement capability. Use DESICCANT #2 (Drierite), if you measure NO. Do not use any desiccant, if you measure SO_2!

The stack gases that are exiting the water trap pass through a disposable fiberglass filter. The function of the filter is to trap particles of soot and fly ash that may be traveling with the gases. Replace the filter when it gets noticeably discolored.

The water trap and filter are designed to function unattended for a few hours of continuous operation. If the excess moisture and particulates are removed from the gas stream by some other means, then it is possible to operate the instrument continuously for a long time.

B.   THE EMISSIONS PROBE. (EMISSIONS PROBE OPTION)

This optional probe assembly of the ENERAC 2000e is unique, for a battery operated instrument, in its capability to filter, dry and condition the stack gas sample.

Gases such as nitrogen dioxide (NO_2) and to a lesser extent sulfur dioxide (SO_2) react chemically with water. They are also easily adsorbed to the surface of most types of materials. The probe must, therefore, remove the excess water in the stack sample without condensation, remove the particulates from the sample stream and be constructed of materials that will not adsorb these gases.

The probe assembly consists of an inconel probe, the main probe housing and a standard 10' length of hose and electrical cable.

1. The inconel probe

The inconel probe is a five piece assembly of metal tubing. It consists of the following parts.

a. A 10" section of 3/8" diameter inconel tube that is threaded to the probe housing. The instrument thermocouple is located inside this tube.

b. A 13" piece of extension inconel tubing to be used with stacks having a diameter larger than 24". The extension tubing screws on the above piece to increase the effective probe length to 24". Figure 3 below shows the various components of the probe.
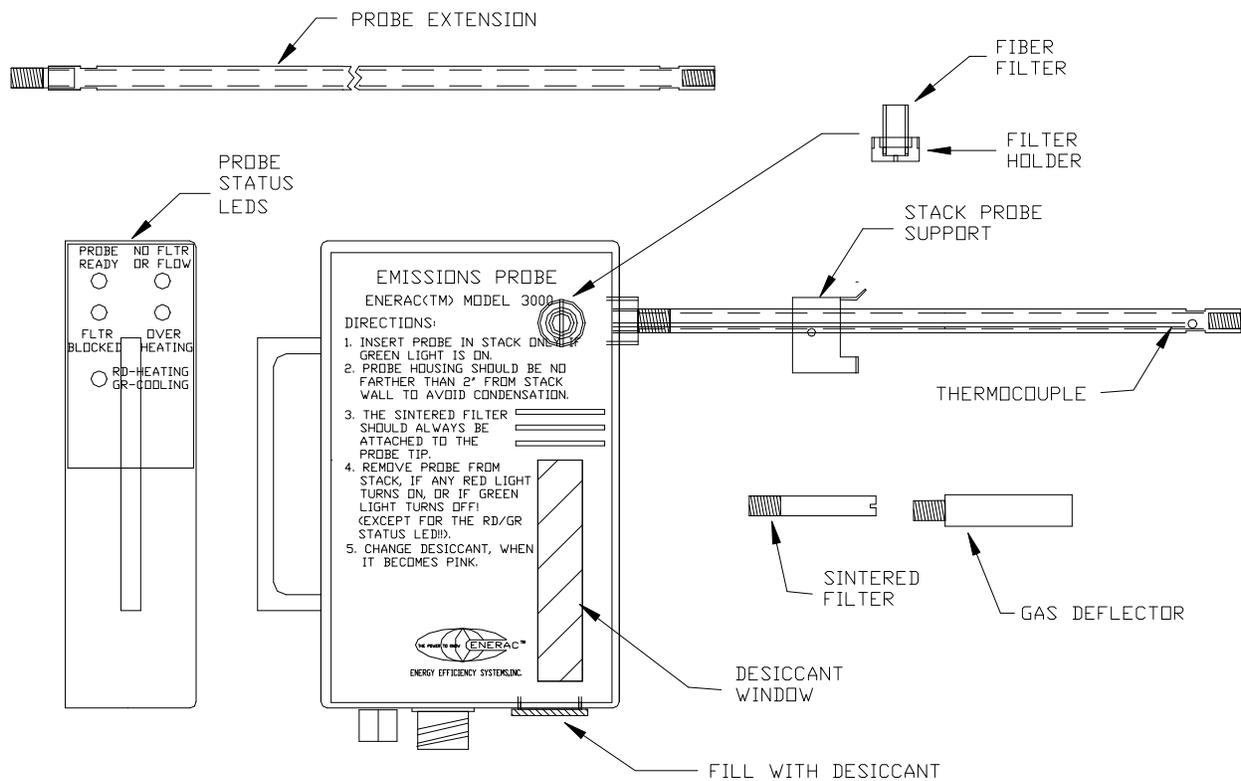
FIGURE 5

c.   A 1" long sintered Hastelloy X filter. The purpose of the filter is to block soot particles probe housing. The filter is reusable to a certain extent and can be cleaned a few times in an detergent and by blowing air from inside out. A light located on the probe housing monitors the condition of the filter. Maximum filter temperature is 1900 degrees F.

You must never operate the instrument without the sintered filter. Such operation will damage the probe.

d.   A ½" diameter soot particle deflector. The purpose of the deflector is to create a flow stream for the soot particles around the filter and thus prolong its life.

e.   A support bracket. The purpose of the bracket is to support the probe assembly so that it can be mounted on the stack wall.

Mount the probe at a distance from the stack wall that will not exceed the housing's maximum temperature of 160 degrees F. but not so far as to cause condensation inside the inconel tubing. The exposed part of the inconel tube should remain at a temperature that appears too hot to the touch in order to prevent condensation.

f.   Heat shield and adaptor (optional). This aluminum shield is intended to protect the probe housing from any very hot stack gases escaping from the opening in the stack wall (typical in engine applications).

To use the shield slide it over the probe placing it as close to the probe housing as possible. Secure it by tightening the set screw. To use the adaptor that comes with the shield you should have a female 3/4 PT fitting mounted on the stack wall. The purpose of the adaptor is to seal the opening and support the probe assembly.

2.   **The probe housing**

The probe housing contains a permeation type drier, whose function is to remove the excess water vapor that is present in the sample and thus, prevent condensation of moisture in the hose assembly. It also houses a

secondary fiber filter for added protection.

Nitrogen dioxide and to a lesser extent sulfur dioxide dissolve readily in water and any condensation present in the hose assembly would result in erroneous readings.

The probe housing consists of the following components.

a.   **The secondary fiber filter.** This is a small cylindrical 0.5 micron glass fiber filter for the removal of the finer particles from the gas stream. It is accessed from the side of the probe (see Figure 5). This filter should be replaced periodically.

b.   **The permeation drier assembly.** This assembly consists of the permeation drier, a support manifold for the heated probe and a pump that supplies the counterflow air to the drier. The drier is designed to reduce samples containing as much as 20% water vapor to a dew point of 50 degrees F., or lower. The drier assembly is located inside the probe housing, with the exception of a small piece of clear tubing that is located just outside the probe.

c.   **The clear tubing.** The piece of clear tubing located at the end of the probe functions as a monitor to check for moisture condensing on the walls of the hose. If you observe condensation, you must reduce the sample pump flow rate.

Before attempting to reduce the flow rate make sure that the exposed section of the inconel tube is hot, as explained above!

The nominal flow rate for the extracted sample is 650 cc/min at room temperature. The flow rate will be slightly reduced, when the probe is inserted in the stack, because the heated sintered filter's resistance to flow will be increased.

To reduce the sample flow rate proceed as follows:

i.   Connect the calibration accessory flow meter to the tip of the probe in such a way as to monitor the instrument flow rate.

Record this flow rate.

ii.   Open the hinged section of the face plate. Locate the small rectangular PC board that is mounted directly underneath the main PC board. There are three or four small potentiometers mounted on this board directly below the Rectangular cut out of the main board.

iii.   Use a small screwdriver to rotate this potentiometer, while monitoring the flow meter indication. See figure 6.

iv.   To prevent condensation (if already observed), reduce the flow rate by 100 cc/min. Insert the probe in the stack and monitor the clear tubing for 15 minutes. If you observe condensation, reduce the flow rate by 100 cc/min.

d.   **The desiccant drier.** A small quantity of silica gel desiccant is stored inside the probe housing. The purpose of this desiccant is to dry the counterflow air that is introduced into the permeation drier and thus increase the capacity of the permeation drier. There is a small window on the face of the probe housing to check the condition of the desiccant. The desiccant must be replaced, when changes color to pink-white. You can access the desiccant through the threaded plug located at the bottom of the probe housing.

e.   **The LED assembly.** There are five LEDs mounted on the back of the probe assembly. One is green, three are red and the fifth is a bicolor LED that is used   for diagnostic purposes.

During a measurement, you should monitor the LEDs on a periodic basis to make sure that the probe is functioning properly.

REMOVE THE PROBE FROM THE STACK AT ONCE, IF THE "OVERHEATING " LED TURNS ON!

"THE PROBE READY"-GREEN LED monitors the temperature at the drier inlet to make sure that it is sufficiently high to prevent condensation of the sample. **Insert the probe in the stack, only if this LED is on!** It

takes approximately 2-4 minutes for this LED to turn on after a cold start, if the ambient temperature is 65 degrees F. or higher. It may take 10 minutes, if the ambient temperature drops to 40 degrees F. It may take even longer, if the unit is operated on batteries.

"THE FLOW BLOCKED"-RED LED monitors the status of the sintered Hastelloy filter, that is located at the tip of the probe. It also monitors the status of the fiber filter located inside the probe manifold. When either filter becomes excessively dirty and requires cleaning or replacement, this light will turn on.

As the sintered filter is heated in the stack, the pressure drop across the filter will increase from a room temperature pressure drop of 3" to a maximum of 20" W.C. at 1800 degrees F. The instrument pump is capable of pulling a sample with a negative pressure of at least 40". The pressure switch that activates the LED is set for 30" W.C..

"THE NO FILTER OR FLOW"-RED LED is a check against any blockage or kinks in the hose or inside the permeation drier. This light will also turn on, if the sample pump is turned off by means of a suitable command, *OR IF THERE IS NO FILTER AT THE TIP OF THE PROBE.*

If the pressure in the stack exceeds +4" W.C., the "NO FILTER OR FLOW" LED will turn on. You should ignore this LED and proceed with your measurements!

This is common in engine measurements, when the ENERAC probe is located in front of a catalytic converter.

"THE OVERHEATING"-RED LED monitors the temperature at the drier inlet to make sure it does not exceed the maximum permissible temperature that the drier can withstand. *For this reason, you must remove the probe from the stack at once, if this light turns on!*

"THE R-HEATING/GR-COOLING" bicolor LED monitors the status of the thermoelectric element and is used for diagnostic purposes, only. When the instrument is turned on, this LED should always be ON-RED. When the unit is warmed up this LED will be cycling every few minutes

alternating between ON-RED and OFF. Once the probe is inserted in the stack its status will depend on the temperature of the drier manifold. If this temperature becomes high, the LED will turn ON-GREEN indicating that the ENERAC heat pump is switched to cooling of the manifold.

3. The hose assembly

The hose assembly consists of a 10 ft. long or longer Viton hose, a thermocouple and power extension cable of the same length and special gas and electrical connectors. Viton is the material of choice for the hose, because of its inertness and high flexibility. The ambient temperature sensor is located inside the electrical connector that connects the hose assembly to the instrument face plate.

C. THE SENSOR HOUSING & PUMP ASS'Y

All gas sensors are located inside the instrument. They are mounted for convenience and easy access on a Teflon coated aluminum rectangular block, which is referred to as the " sensor housing" (see figure 7).
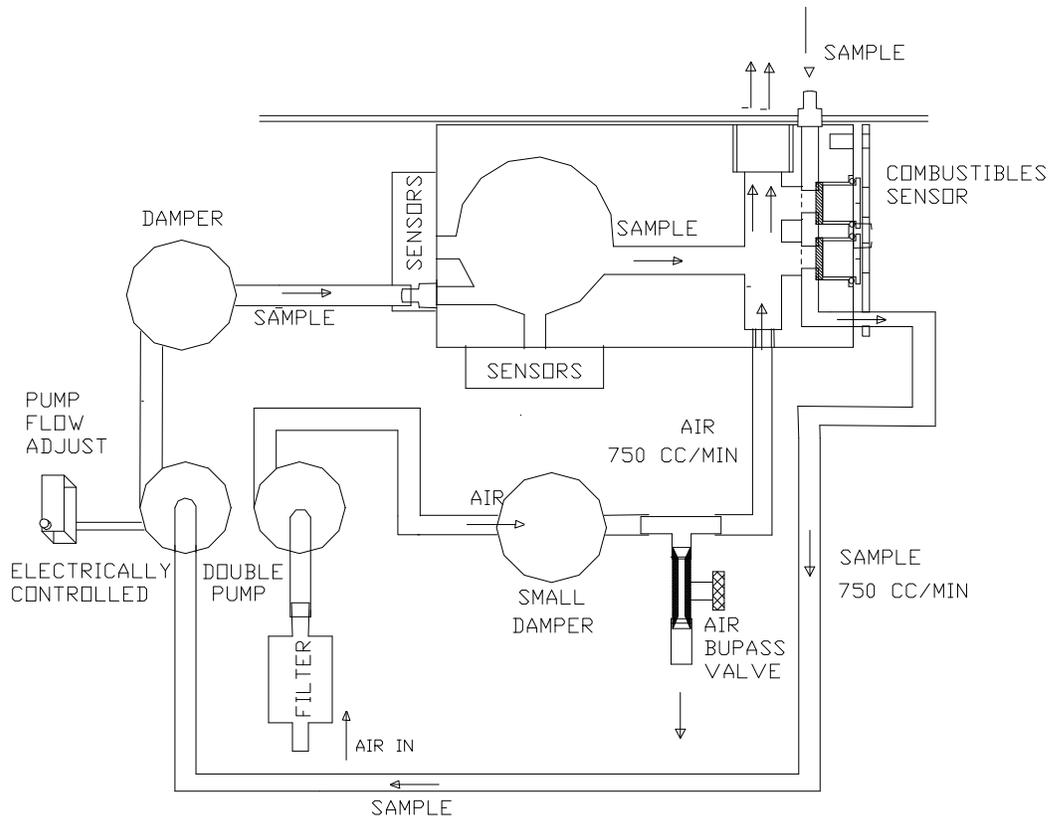
FIGURE 7

To avoid interference with the performance of the sensors, arising from pressure pulsations in the stacks (especially in engine applications), the sensors are located on the exhaust side of the sample pump past a suitable damper assembly. Following the pump and damper, the sample stream enters a section of the sensor housing, where all the toxic gas (i.e. CO, NO, NO_2 and SO_2) sensors and the oxygen sensor are located.

The sample stream is next mixed with an equal amount of air and introduced into the section of the housing, where the combustibles sensor is located. The gas and air mixture is then exhausted in the atmosphere.

1. **The pump assembly.**

The ENERAC model 2000E pump assembly consists of the sample pump, two dampers, an air filter and one small screw driver adjustable needle valve. These components , with the exception of a potentiometer that

controls the flow rate of the pump, are mounted on a chassis, which in turn is attached to the power supply chassis.

A detailed description of these components follows:

a. **THE "SAMPLE" PUMP.** This pump consists essentially of two separate pumps driven by one high quality DC motor. Both pump sections are mounted on one assembly. One pump is used to draw the gas sample into the instrument and the other pump is used to supply an equal amount of air to the combustibles sensor. The nominal flow rate for either section is set at 750 cc/min. By a potentiometer located on the PC board. See fig. 6.

b. **THE DAMPERS**. There are two damper assemblies. They are both located on the exhaust side of the two pump sections. One (the larger one) dampens the pressure pulsations in the sample and the other the air pulsations. These dampers prevent erroneous sensor responses caused by pressure pulsations from the pump or the stack.

c. **AIR FILTER.** A disposable filter is located on the suction side of the "air" pump section. It is used as a precaution, when the instrument is used in a dirty environment.

d. **SAMPLE FLOW ADJUST POTENTIOMETER**. This is a small screw driver multiple turn potentiometer located PC board. It is accessed by opening the hinged section of the face plate . It is used to adjust the sample flow rate, if needed, primarily for the purpose of preventing sample condensation under adverse conditions. See fig. 6.

e. **AIR BYPASS VALVE.** This small brass valve is located on the side of the pump chassis. It can be reached by opening the hinged plate. Its function is to adjust the air flow to the combustibles sensor so that it is approximately equal to the sample flow.

2. **The sensors**

a. **Temperature sensing.** The instrument uses two temperature sensors.

One monitors the stack temperature and the second monitors the ambient temperature outside the instrument case.

    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 electrical connector, which is at the end of the probe. It is used to measure the room or ambient temperature.

b. **Gas sensing.** All gas sensors are located on the sensor housing. The sensor housing can be accessed by opening the hinged part of the face see figure 7.

    i.   CARBON MONOXIDE SENSOR. This is a sealed electrochemical cell incorporating a long life inboard filter and dual capillary design. It consists of   four platinum electrodes in an electrolyte. Carbon monoxide gas diffuses through the tiny capillaries located on the face of the sensor, which includes also the interference rejection filter media. 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.

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

            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.

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 an electrochemical cell similar to the carbon monoxide sensor and it also needs a constant bias voltage. 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.

This sensor has also an inboard filter to reject interference from NO_2 and SO_2 gases. The life of the filter is approximately 15,000 PPM-hours for NO_2 and 100,000 PPM-hours for SO_2.

iv. SULFUR DIOXIDE SENSOR This is an electrochemical cell similar to the carbon monoxide 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 that does not require an inboard filter for interference rejection. It has a standard range of 0 to 500 PPM. Its life is estimated at two years.

NOTE: In addition to the sensor long life filters, the model 2000E 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.

vi. 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.

With the ENERAC 2000E calibrated on methane, you can obtain its response to other gases by multiplying the instrument's display reading by the factors listed below:

GAS	MULTIPLY DISPLAY BY
Ammonia	2.38
Acetylene	0.833
n-Butane	0.613
Carbon Monoxide	3.125
Ethane	0.833
Ethylene	0.826
n-Hexane	0.565
Hydrogen	0.985
Methane	1.000
Methyl alcohol	1.613
Propane	0.752

The factors listed above are theoretical and should be used as a guide only in determining the response to other gases.

The minimum amount of oxygen available to the sensor is 10-11% (assuming no oxygen in the sample). Consequently, the maximum concentration of methane that can be measured is 6%. 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.

CHAPTER 5

CUSTOMIZING YOUR INSTRUMENT

The ENERAC Model 2000E gives the operator the capability to customize his instrument to best meet the specific needs of the application.

By customization we describe the process of setting certain parameters such as fuels, degrees F or C, alarm levels, emissions units, plotting coordinates etc. and having to do it only once, without having to repeat such procedures every time the instrument is turned on. This information is stored in the instrument and will be retained, even if all power is removed including the battery.

Of course, any parameters that have been previously set can be changed by the customer by following the procedures outlined below.

When the instrument is turned on for the first time, it assumes a certain configuration (called the DEFAULT CONDITIONS), that was originally stored at the factory. (For example the default CO alarm level is 50 PPM, the default fuel #1 is #2 oil etc.).

A description of how to customize instrument follows.

A. THE "SET" GROUP OF KEYS

To customize your unit you will have to make use of the four buttons located near the top of the face plate. These buttons are labeled "SET", "UP", "DOWN" and "ENTER". See figure 8.

1. The "SET" key

You use the "SET" button to get in, or get out of the SETTING MODE.

When the LED located directly above the "SET" button is off, you are in the normal measurement mode and all the operating buttons (outside the setting group) function as labeled.

When the "SET" LED is on, you are in the setting mode. The operating buttons assume now the "SETTING" function indicated immediately above or below them. (The action is similar to that of the 2nd function in a calculator).
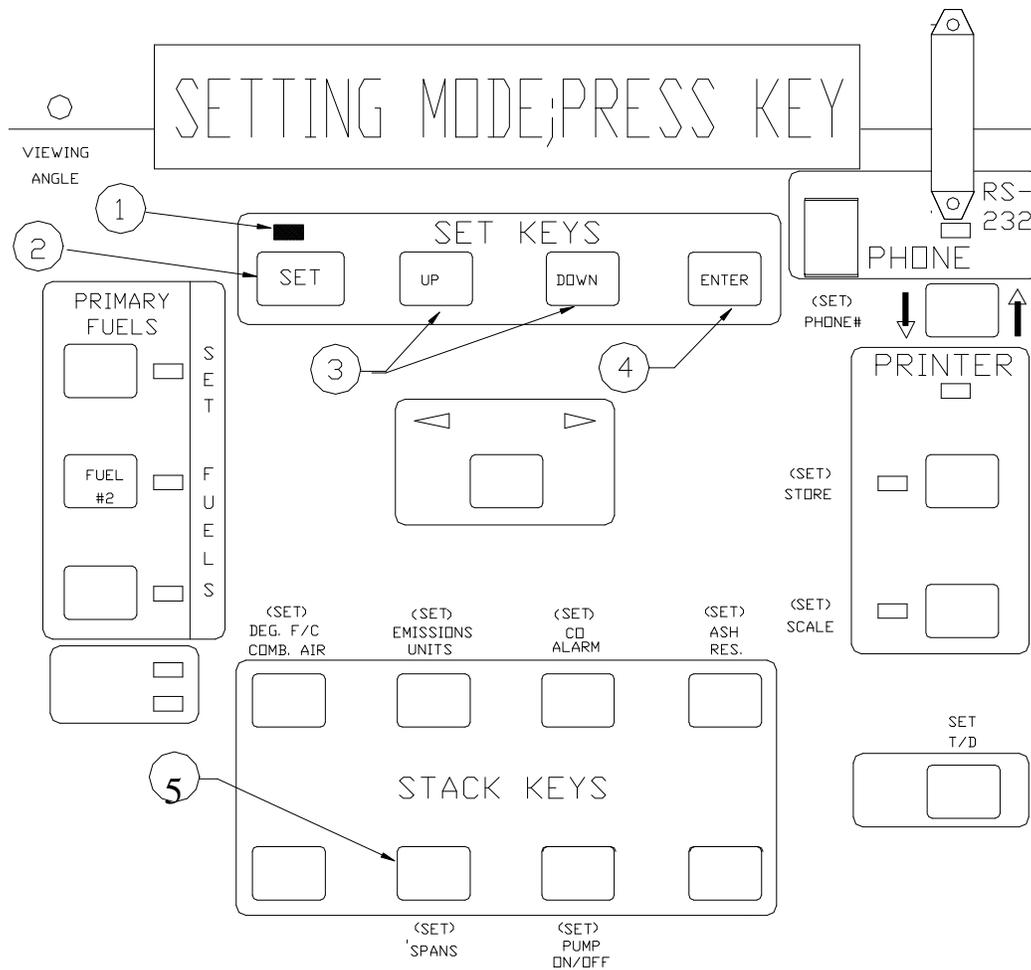
1. LED ON- "SETTING MODE:;LED OFF- MEASUREMENT MODE
2. "SET" KEY TOGGLES BETWEEN SET & MEASUREMENT MODE
3. "UP" & "DOWN" KEYS INCREMENT-DECREMENT SET VALUE
4. "ENTER" KEY SHIFTS CURSOR TO THE NEXT DIGIT OR TO THE SECOND HALF OF THE DISPLAY
5. USE THIS KEY TO SPAN CALIBRATE INSTRUMENT

FIGURE 8

To set any one parameter, push the "SET" button. The "SET" LED will turn on and the following message will appear on the display:

```
SET MODE; PRESS KEY
```

You must now press the button corresponding to the parameter you wish to set. An explanation of the meaning of the operating buttons in the setting mode follows below.

2.   The "UP" & "DOWN" keys

The "UP" and "DOWN" buttons are used to increment and decrement the parameter that you are setting. The increment/decrement interval is preset and depends on the parameter being set. (For example, the inc./dec. interval for setting combustibles in ash is 5%). The range over which a parameter can be set is also fixed.

You can increment/decrement a parameter continuously if you hold down the "up"/"down" button.

You also use the "UP" and "DOWN" buttons not only for changing the numerical entries, but also for selecting various modes. (i.e. You select between STORE, PRINT, DUMP, ERASE, etc when you are in the "SET" " STORE" mode).

3.   The "ENTER" key

When you are in the "SET" mode, the "ENTER" button functions either as a "shift the cursor on the display" key or to exit the "SET" mode.

When you are in the setting mode, a blinking cursor will appear on the display in front of the parameter that you are currently setting. However, some functions require the setting of more than one parameter. (For example setting the time/date requires setting the minutes, hours, day, month etc). Use the "UP" and "DOWN" key to select the appropriate blinking digit or parameter and then use the "ENTER" key to "shift" over to the next digit or parameter that requires setting. You can also use the

"ENTER" button to get out of the setting mode ("SET" LED will turn off).

There are two additional specialized functions of the "ENTER" button. If you encounter a "...AUTOZERO ERROR" message during start up, you can use the "ENTER" button to continue with the warm up procedure. (CAUTION: Disregard any display readout of the malfunctioning parameter!). The second application deals with span gas calibration and is explained later).

B. HOW TO SET YOUR FUELS

Selecting the proper fuel is important for the computation of carbon dioxide, excess air and combustion efficiency. The fuel factor enters also in the computation of toxic gas concentrations when expressed in lbs./ million BTU (#/B), or grams/ brake hp-hr (GBH).

There is an LED LOCATED to the right of each of the three fuel buttons. The one that is on, indicates the fuel that the machine is currently using to compute efficiency, CO_2 etc.

When the instrument is turned on for the first time, you will have in the foreground the following fuels:

                Fuel #1: #2 OIL
                Fuel #2: #6 OIL
                Fuel #3: NATURAL GAS

These fuels are set at the factory, unless the customer has ordered a custom fuel.

Each time you turn the instrument on, it will default to Fuel #1. Of course, fuel #1 will be the fuel that you have chosen to store in that position.

The instrument has a library of 15 fuels. You can select any three of these fuels and place them in any of the three fuel positions (buttons).

As an example, assume you wish to have fuel PROPANE as Fuel #2. Proceed as follows:

1. Push the "SET" button and observe the "SET" LED turn on.
2. Push Fuel #2 button. The corresponding LED will turn on and the current fuel will be displayed.
3. Scan the Fuel Library by pressing repeatedly the "UP" or "DOWN" buttons, until the following message is displayed:

```
PROPANE 21690 BTU/LB
```

4. Push the "SET" or "ENTER" button and observe the "SET" LED turn off. PROPANE is now fuel #2 and you are back in the normal measuring mode.

The fuels that the fuel buttons are set for, are retained even after the instrument has been turned off, so that you will not have to repeat any setting procedure every time you turn the unit on.

C. SELECTING THE TEMPERATURE SCALE

The instrument can be set to display and print all temperatures either in degrees Celsius or Fahrenheit.

It can also compute the combustion efficiency for boilers that use combustion air that is at a temperature different from the ambient temperature (such as preheated air). The efficiency formula takes into account the energy of the preheated air, in order to give a more accurate computation of the actual combustion efficiency.

If your combustion air is at approximately ambient temperature , leave the combustion air setting to its default value of "ambient".

The adjustment range for combustion air is 0 degrees to 260 deg. C or 32 to 500 deg. F..

To change the temperature scale (F or C) proceed as follows:

1. Push the "SET" button and observe "SET" LED turn on.
2. Push the "TEMP/ST-RM" button. The following message will be displayed:

```
COMB.AIR TEMP: XXX F
```

3. Push the "ENTER" button. The blinking cursor will shift to the letter F (or C).
4. Push the "UP" or "DOWN" button once. The letter F will change to C (for Celsius).
5. Push the "SET" button to get out of the setting mode.

If you use preheated air, first take its temperature using the stack probe. As an example, assume the preheat air temperature is 372 degrees F.

a. Push "SET" button and observe "SET" led turn on.
b. Push the "TEMP/ST-RM" button. The following message will be displayed:

```
COMB.AIR TEMP: XXX F
```

c. Use the "UP" button until the display reads:

```
COMB.AIR TEMP: 370 F
```

d. Push the "SET" button again to exit the setting mode.

Remember to reset your preheat temperature back to "AMB"., if the unit is going to be used in different conditions!

D. EMISSIONS MEASUREMENTS.

If you press the "SET" and "OXYGEN" keys in sequence, you will be in the "emissions" SET mode. The following two messages will be displayed:

```
SEL:PPM    OXY_REF:TRUE%
```

The message "SEL: PPM" refers to the desired "MODE" selection (i.e. the units of measurement selection) and means that the toxic gas sensors (i.e. emissions sensors, carbon monoxide, nitric oxide, nitrogen dioxide, NOX computation and sulfur dioxide) will read the respective gas concentrations in parts/million by volume.

The display "TRUE%" indicates that there is no correction for oxygen and the readings will be actual concentrations. This is the DEFAULT setting from the factory.

There are two functions of the "SET EMISSIONS" key.

1.   **Selection of measuring units.**

You can select to read the three toxic gas concentrations in any of the following units:

PPM ----- Parts/million (Volumetric)
MGM ----- Milligrams/cubic meter
#/B ----- Lbs./ million BTU of fuel
GBH ----- Grams/ brake horsepower-hour

NOTE: NOX emissions in #/MBTU and GBH are computed as NO_2!

NOTE: Values of emissions in #/MBTU 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 model 3000 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.

To choose the desired emission units toggle the "UP" button until the proper units are displayed. Exit the "SET" mode.

If you select GBH (grams/brake horse power-hour) as the desired units, the ENERAC will, after pressing the "ENTER" key display the following message:

```
┌─────────────────────────────────┐
│  ENGINE THERMAL EFF: 0.30       │
└─────────────────────────────────┘
```

You must enter the engine's thermal efficiency (typically a number between 0.25 and 0.35). You can obtain this figure from the engine's manufacturer specifications. It differs somewhat as a function of engine type and load factor.

The ENERAC's default value is 0.3.

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

After entering the desired thermal efficiency value *(THIS FIGURE IS NOT THE ENERAC'S COMBUSTION EFFICIENCY!),* the ENERAC will display emissions in grams/brake horsepower-hour.

2. **Selection of Oxygen Correction factor.**

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 enter the "SET EMISSIONS" mode as described above. Press the "ENTER" key so that the cursor blinks on the OXY_REF side of the display. Toggle the "UP" or "DOWN" button, until the desired value of the reference oxygen is displayed. (Range is 0-20% in 1% increments).

To return to uncorrected measurements, depress the "UP" button until the display reads: OXY_REF: "TRUE%".

NOTE: Setting the OXY_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!

Return to the measurement mode by pressing the "ENTER" key once more and observing the "SET" LED go off.

E. SETTING THE CO ALARM

The instrument is provided with an audio and visual alarm that will be activated, if a preset threshold of carbon monoxide is exceeded.

The audio alarm consists of a beeping sound occurring every second to alert the user. The visual alarm consists of the simultaneous flashing, of both display pointer LEDs.

To set the CO alarm proceed as follows:

1. Push the "SET" button and observe the "SET" LED turn on.
2. Push the "CO/SO2" button. The following message will be displayed:

```
CO ALARM: XXXX PPM
```

3. Use the "UP and "DOWN" buttons to set the alarm threshold to your desired value.
4. Push the "SET" button to exit the setting mode.

NOTE: If you have the emissions option, your CO ALARM function will always be set for the same units as those selected for measuring the toxic gas (emissions) concentrations!

F. SETTING THE COMBUSTIBLES IN ASH

When solid fuels such as coal are burned, they leave a residue called ash. Ash drops through the stoker gratings to the bottom of the boiler. However, some unburned fuel also drops through the grating and is discarded with the ash. This unburned fuel represents potential energy that has not been utilized. The ENERAC will take into account this loss of energy in its efficiency formula, if the % of unburned fuel in the ash residue is entered into the instrument.

You need a special instrument to measure the % Combustibles in ash!

The default value of combustibles in ash is zero.

The combustion efficiency for gaseous, liquid and wood fuels is not affected by any setting of the combustibles in ash parameter, since the instrument assumes that there should be no ash with combustibles for such fuels.

The combustion efficiency for all coal fuels listed in the fuel library will, however, be affected, if you set the combustibles in ash to a value other than zero. Be careful to remember, that when you are setting combustibles in ash for a certain fuel you are also setting the same value for all coal fuels.

To set the combustibles in ash proceed as follows:

1. Push the "SET" button and observe "SET" LED turn on.
2. Push the "COMBUSTIBLES" button. The following message will be displayed:
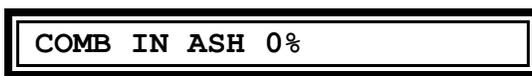
> ```
> COMB IN ASH 0%
> ```

3. Use the "UP" and "DOWN" buttons to set the display to the desired value of combustibles in ash.
4. Push the "SET" button to exit the setting mode.

G. SETTING THE SPAN CALIBRATION

This key is used to perform span calibrations of the gas sensors.

See chapter 11 of this manual for a complete description of how to set the span and carry out a calibration of the unit using span gas.

H. TURNING THE PUMP ON / OFF.

If you wish to turn the ENERAC's main sample pump off, enter the "SET" mode and next press this key. The sample pump will stop and there will be no sample

flow to the ENERAC. This action prolongs the ENERAC's filter life, when the instrument probe is mounted on the stack but no measurements are being taken. The air counter flow pump located inside the probe will keep running.

Press the same key again to start the pump.

I.   SETTING THE TIME & DATE.

The instrument's internal clock displays and records time (24 hour mode only) in hours, minutes and seconds. It displays and records the date in the American convention of month #, day #, year#.

To set the time or date proceed as follows:

1. Push the "SET" button and observe "SET" LED turn on.
2. Push the "TIME/DATE" button. The following type of message will appear on the display as an example:
3. Use the "UP" or "DOWN" buttons to set each digit to the correct value and then use the "ENTER" button to shift to the next digit. (If you make a mistake and have to go back to a previous digit you must restart the procedure).
4. Push the "SET" button to exit the setting mode at any time, or the "ENTER" button at the end of the last digit.

J.   SETTING THE PLOTTER PARAMETERS

1.   Setting the ordinate

There are three vertical scales (ordinates) that can be chosen from in the printer's plotter mode. These scales are numbered:

SCALE#   1 for Full Range (0-100% of max.reading).
SCALE#   2 for Middle Range. (For toxic gas readings of CO, NOX, SO_2 scale is 0-1000 PPM or MGM and 0-5.00 #/B or GBH)
SCALE#   3 for Low Range (For toxic gas readings of CO, NOX, SO_2 scale is 0-400 PPM or MGM and 0-2.00 #/B or GBH).
(There is a scale #4, which has a different function!)

The full scale values (100%), (i.e. SCALE #1), of the stack parameters for the **standard range model 2000E** are:

Stack temperature:	2000 F 1090 C	Ambient temperature:	200 F 90 C

Carbon monoxide:
  (Emissions) :
  (Emissions) :
	4000 PPM
	100.0 #/B
	100.0GBH
		Oxygen:	25%

Gaseous combustibles:	2.5%	Carbon dioxide:	40%
Excess air	1000%	Combustion efficiency:	100%

Nitric oxide:
  (Emissions) :
  (Emissions) :
	4000 PPM
	100.0 #/B
	100.0GBH
		Nitrogen dioxide:
		PPM
		  (Emissions) :
		  (Emissions) :
			4000
			
			100.0 #/B
			100.0GBH

NOX:
  (Emissions) :
  (Emissions) :
	4000 PPM
	100.0 #/B
	100.0GBH
		Sulfur dioxide:
		  (Emissions) :
		  (Emissions) :
			4000 PPM
			100.0 #/B
			100.0GBH

Use the lower ranges to increase the sensitivity of the plot, provided the parameter you are recording does not exceed the maximum value of the ordinate. (Example: If stack temperature is in the 300-700 degree F range, use scale #2. If oxygen is less than 5%, use scale #3).

2. **Multiple plots**

You can obtain a simultaneous plot of the following four fixed parameters on the ENERAC's plotter:

Carbon monoxide:Fixed: Range 0-1000 PPM,
Oxygen: Fixed Range 0-12.5%,
NOX: Fixed Range 0-400 PPM
Combustion efficiency :   Fixed Range 75-100%

To carry out a multiple plot depress in sequence the "SET" key, the "SET PLOT" key and then toggle the "UP" key until the display indicates:

"SCALE: 4   TIME: 1 SEC"

The ENERAC printer will mark the graph of carbon monoxide with the letter C, the graph of oxygen with the letter O, the graph of NOX with the letter N and the graph of efficiency with the letter E.

This type of plot is very significant in tuning boilers, because it shows the effect of reducing excess air on efficiency and build up of carbon monoxide and NOX, simultaneously!

3.   Setting the chart speed

The chart speed (actually its reciprocal) can be selected in units of seconds per event. (An event will be recorded by a dash on the paper). The fastest chart speed is 1 event/sec. and the slowest 1 event/min. There are 59 intermediate charts speeds to choose from. (Example: A chart speed of 20 means a dash will be plotted every 20 seconds).

To set the desired plotter scale and speed for the chosen stack parameter proceed as follows:

a.   Push the appropriate button, so that the desired parameter is displayed on the display and the "DISPLAY SELECTOR" LED points to it.
b.   Push the "SET" button and observe the "SET" led turn on.
c.   Push the "PLOT" button. The following message will be displayed:

```
SCALE: 1 ; TIME 1 SEC
```

and the cursor will blink at the scale position.
d.   Use the "UP" or "DOWN" buttons to select among the three scales 1,2 or 3; then use the "ENTER" button to shift the cursor to the time position.
e.   Use the "UP" or "DOWN" buttons to select the desired chart speed (measured in seconds elapsed between events or dots).

f.   Push the "SET" button to exit the setting mode.

K. DATA STORAGE

See chapter 7 for an explanation of how to use the storage button.

L. MODEM (TELEPHONE) COMMUNICATION

See chapter 8 on communications for an explanation of how to set up and dial a phone number.

CHAPTER 6

USING THE PRINTER

The ENERAC model 2000E is equipped with a 4" SEIKO thermal printer. This printer serves a number of functions that will be described below.

Dust will easily damage the printer! Avoid exposing the printer to a very dusty environment! Use the protective piece of "Velcro" to cover the slot even when using the instrument.

To avoid damaging the printer heads, do not use any ordinary paper or thermal paper, other than the one supplied by Enerac. (Use SEIKO thermal paper only). Thermal paper is a specially treated paper and must be protected from excessive heat or moisture. See the section on maintenance.

There is a special opto coupler sensor mounted on the back of the printer that monitors the existence of printer paper. If there is no paper in the printer, the message:

"PROBLEM WITH THE PRINTER"

will appear on the display and the printer will not operate.

There is a single push button switch located on the hinged side of the face plate that is used to advance the paper. Depress the "PAPER FEED" switch to advance the paper one line at a time.

There are five different types of printouts that you can get from the printer. (i.e. there are five different ways to use the printer). These are described below.

A. PRINTOUT OF STACK DATA.

This is the most basic printer operation. By depressing the "TEXT" key, you get a printout of all stack parameters together with the time, date and fuel description. The values printed are those last read by the instrument *at the moment that the "TEXT" button was depressed.*

To obtain a "current" printout proceed as follows:

1. Make sure that the "PRINTER LED" is on (see fig.6). If it is not, use the "OUTPUT MODE" button to toggle the "PRINTER LED" on.
2. Make sure that you ARE NOT in the setting mode ("SET" LED is off).
3. Push the "TEXT" button. The printer will start operating. It takes about 20 seconds to complete the printing.
4. Use the "PAPER FEED" switch to advance the paper, so that it can be easily cut.

```
SERIAL # ABC123XX
     ENERAC MODEL 2000E
     COMBUSTION TEST RECORD

FOR: YOUR COMPANY'S NAME

TIME:02:19:96
DATE:05/20/96

FUEL: #2 OIL    19360 BTU/LB

COMBUSTION EFFICIENCY:     77.2%
AMBIENT TEMPERATURE:        68 F
STACK TEMPERATURE:         650 F
OXYGEN:                     5.0%
CARBON MONOXIDE:            78 PPM
CARBON DIOXIDE:            11.8%
COMBUSTIBLE GASES:          0.0%
EXCESS AIR:                 29%
NITRIC OXIDE:             430 PPM
NITROGEN DIOXIDE:          55 PPM
NOX (NO+NO2):             485 PPM
SULFUR DIOXIDE:            80 PPM

MODE:PPM OXY_REF=TRUE%
```

An example of an ENERAC printout is shown above.

The statement "OXY_REF=TRUE%" indicates that the CO, NOX and SO₂
concentrations measured in PPM are the true stack concentrations and have not
been adjusted for some oxygen reference value.
While the printer is in the process of printing you may use any other buttons to
display any parameters you desire.

While the printer is in the process of printing you may use any other buttons to
display any parameters you desire.

The basic function of the "OUTPUT MODE" switch is to direct information either
to the printer or to the output connectors (RS-232 or Modular phone connector).

You cannot direct information simultaneously to printer and outputs!

B. OBTAINING PRINTER PLOTS.

See chapter 5 for a description of how to set the plot parameters.

You can use the printer as an analog chart recorder to obtain a continuous plot of
any stack parameter vs. time. The printer prints horizontal bars, so that the printout
looks more like a step chart rather than one continuous line. The resolution of the
vertical scale is better than 1% of full scale (i.e. there are 120 different positions
for the bar mark).

There are three vertical scales available and sixty chart speeds ranging from 1
dot/sec to 1 dot/min. See chapter 6 section I for directions on setting the plotter
scales.

The plot always begins with a printout of the time and date, followed by the
parameter being plotted, the chart speed and the vertical scale.

To get a plot of a stack parameter proceed as follows:

    1.   Select the proper scale and chart speed, by using the "SET" button as
        explained in chapter 6, I.

2. Push one of the eight basic buttons that corresponds to the stack parameter you wish to have plotted. (This will place the desired parameter on the "ACTIVE" part of the display).
3. Push the "PLOT" button. This will start the plot.
4. When you wish to stop the plot, push the "PLOT" button again.

The instrument remembers the last plotting scale and chart speed used even after it has been turned off. It will use the same settings the next time you do a plot, unless you change the settings.

When using the fast speeds, keep in mind that the instrument needs 20-30 seconds to respond fully to any changes to the stack parameters.

You can also obtain a multiple plot of carbon monoxide, oxygen, NOX and combustion efficiency, simultaneously by setting the plotting scale to #4. (See chapter 5).

C. PRINTING STORED DATA

The instrument is capable of storing the complete results of up to eighty different sets of measurements (see chapter 8). These eighty storage compartments are called buffers (the display calls them TEST#XX) and are numbered from 1 to 80.

You can get a printout of any one stored measurement (i.e. TEST), or you can get a printout of all eighty stored measurements sequentially, if you wish.

If you wish to get a printout of one stored measurement (for example data stored in buffer #7), proceed as follows:

1. Make sure the "PRINTER" LED is on. (If it is not, use the "OUTPUT MODE" button to turn it on).
2. Push the "SET" key to turn the "SET" LED on. The following message will appear:

```
SET MODE ; PRESS KEY
```

3. Push the "TEXT" button. This will activate the storage mode (as long as

the "SET" LED is on) and the following message will appear on the display:

```
TEST #1;      FUNC=STORE
```

4. Use the "UP" or "DOWN" key to set the Test# to the desired value (7 in the example). Display reads:

```
TEST #7 ; FUNC= STORE
```

5. Push the "ENTER" button to shift the blinking cursor to the right side of the display.
6. Push the "UP" button a few times until the display reads:

```
TEST #7 ; FUNC=PRINT
```

7. Push the "ENTER" button. The printer will start printing.

If you wish to obtain a complete printout of all the eighty tests at once, proceed as follows:

    a.   Carry out steps 1,2 and 3 outlined above.
    b.   Push the "ENTER" button to shift the cursor to the function area.
    c.   Use the "UP" button a few times until the display reads:

```
TEST #1 ; FUNC=PRINT ALL
```

    d.   Push the "ENTER" button. The printer will start printing in sequence all data stored in the buffers.

REMINDER: The printer WILL NOT PRINT any buffers (i.e. test#) that are EMPTY.

D. PRINTING MESSAGES

The ENERAC model 2000E is designed to communicate with external devices such as computers or terminals. During such communication it may be important

(especially when communicating by telephone), for the remote computer operator to send messages or instructions to the operator of the instrument.

After establishing communication via either the RS-232 port or the modular phone connector you can have your messages printed by the ENERAC printer by sending the PRNT command followed by quotation marks, then the desired message ending with marks. For examples if you send the message:

PRNT"REDUCE EXCESS AIR TO 30%"

the printer will print:

REDUCE EXCESS AIR TO 30%

You can send to the printer up to 40 characters at a time with each PRNT command.

CHAPTER 7

STORING YOUR MEASUREMENTS

You can save the results of a combustion or emissions performance test by using the storage capabilities of the ENERAC model 2000E. This is a very useful feature, especially if you have to test a number of combustion sources in sequence, or you wish to compare previous with current measurements. You can also dump the emission data to another computer.

The information that you save, will be retained in the instrument's memory, even after the instrument has been shut off. It will be retained, even if the battery is removed from the unit (The instrument's memory is powered from its own tiny cells that should last a minimum of 5 years).

Of course, you have the capability of erasing any test results, that you no longer need and replacing them with new ones.

If you plan to do a lot of data storing, you may wish to consider as an alternative using the ENERCOM for WINDOWS software together with a notebook or laptop computer. This option gives much greater flexibility in selecting and storing data.

You can store up to seventy different test results (i.e. sets of data) in the instrument's memory. These are defined as :

TEST#1 through TEST#70.

Each test contains complete information on all stack parameters including date and time, exactly as they would appear, if you had obtained a printout by pushing the "TEXT" button. In addition, it includes the BOILER I.D. # that you entered before storing the test.

A. THE STORAGE FUNCTIONS.

The storage function can perform the following eight operations:

    1. "STORE"   This operation will store all the current values and

source identification number. These will be stored in the test (storage) compartment whose number appears currently on the display (provided it is empty!).

2. **"DUMP"** This operation will send to the RS-232 output the contents of the test# that is currently appearing on the display. (If you have an internal modem and you have established a telephone link, the information will be sent to the modular phone connector).

3. **"DUMP ALL"** This operation will send to the RS-232 output, or to the modem, the entire contents of all eighty tests stored, in sequence. The instrument will ignore any empty storage buffers.

4. **"PRINT"** This operation will cause the printer to print the contents of the test whose number appears currently on the display. (If it is empty, nothing will be printed).

5. **"PRINT ALL"** This operation will cause the printer to print the contents of all seventy five tests, in sequence starting with test#1. The instrument will not print empty storage locations.

6. **"ERASE"** This operation will permanently erase the contents of the test whose number appears currently on the display. You cannot overwrite a used test# (i.e. if there are data stored in that buffer, you must erase it first).

7. **"WIPE ALL"** This operation will erase permanently the contents of all eighty storage locations.

8. **"QUIT"** This operation takes you out of the storage function, without executing any of the above functions.

B. HOW TO STORE THE DATA

Fig. 9 shows a chart of the required sequence of operations for storing in the ENERAC's memory and for retrieving the results of emission tests.

To store a single complete combustion test in the ENERAC's memory proceed as follows:

```
┌──────────────────────────────────────────────────────────────┐
│                                                                │
│  PUSH THIS BUTTON                         DISPLAY READS        │
│                                                                │
│    ┌──────┐                                                    │
│    │ SET  │                          ┌─────────────────────┐   │
│    └──────┘                          │ SET MODE;PRESS KEY  │   │
│                                      └─────────────────────┘   │
│    ┌──────┐                                                    │
│    │ TEXT │                          ┌─────────────────────┐   │
│    └──────┘                          │ TEST #1   FUNC=STORE│   │
│                                      └─────────────────────┘   │
│   ┌────┐            ┌────┐                                      │
│   │ UP │ o o o o o  │ UP │           ┌─────────────────────┐   │
│   └────┘            └────┘           │ TEST #7   FUNC=STORE│   │
│                                      └─────────────────────┘   │
│   ┌───────┐                                                    │
│   │ ENTER │                          ┌─────────────────────┐   │
│   └───────┘                          │ TEST #7   FUNC=STORE│   │
│                                      └─────────────────────┘   │
│   ┌───────┐                                                    │
│   │ ENTER │                          ┌─────────────────────┐   │
│   └───────┘                          │ UNIT # 1            │   │
│                                      └─────────────────────┘   │
│   ┌────┐            ┌────┐                                      │
│   │ UP │ o o o o o  │ UP │           ┌─────────────────────┐   │
│   └────┘            └────┘           │ UNIT # 5            │   │
│                                      └─────────────────────┘   │
│   ┌───────┐                                                    │
│   │ ENTER │                               DATA                 │
│   └───────┘                               STORED               │
│                                                                │
│           THIS EXAMPLE SHOWS HOW                               │
│           TO STORE DATA IN STORAGE                             │
│           BUFFER #7 FOR COMBUSTION                             │
│           UNIT #5                                              │
│                                                                │
└──────────────────────────────────────────────────────────────┘
```
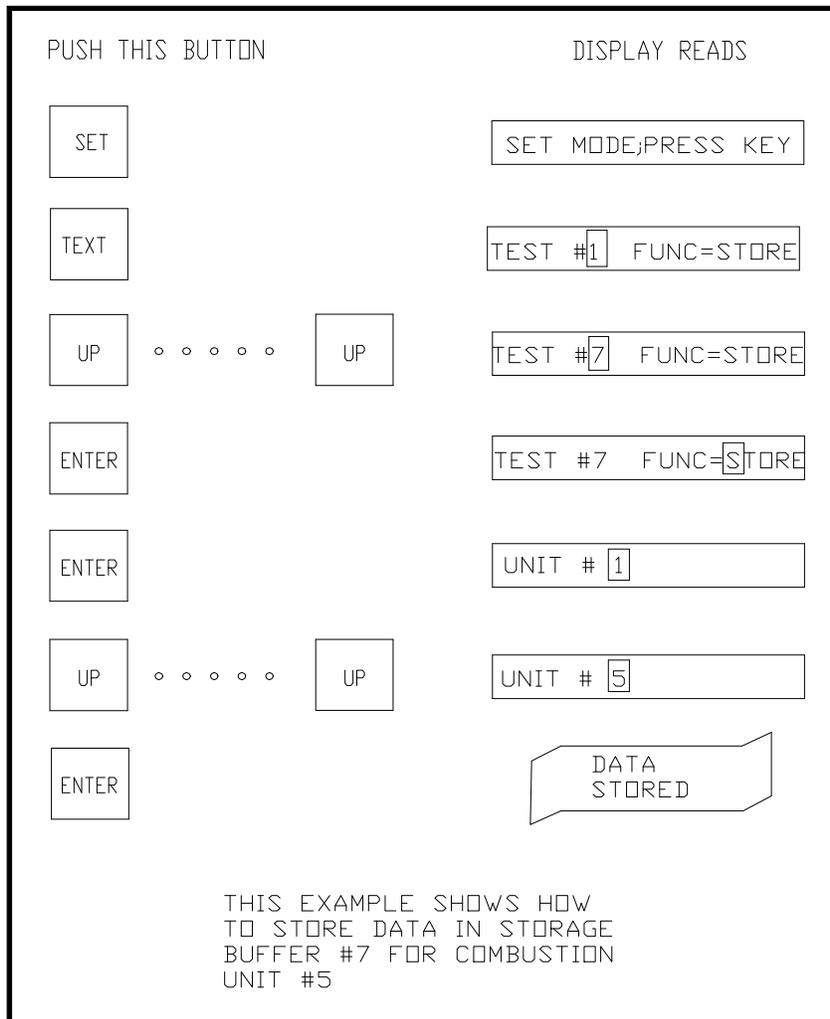
FIGURE 9

1. Push the "SET" button and observe "SET" LED turn on.
2. Push the "TEXT" button. The following message will appear on the display:

```
TEST #1 ; FUNC=STORE
```

3. Use the UP/DOWN buttons until the desired TEST # appears on the display. (You can select up to 70 different tests).
4. Push the ENTER button to shift the blinking cursor to the letter "S" of the function STORE.
5. Push the ENTER button again. The display will read:

```
UNIT #1
```

6. Use the UP/DOWN buttons until the number associated with the boiler you are testing appears on the display. (You have a selection of 70 different identification numbers for the combustion source that you are currently you are working with. Enter a desired number so that you can identify the source!)
7. Press the ENTER button again. The current stack parameters will be instantly stored in memory. The instrument exits the SET mode.

C. RECOVERING STORED DATA.

You can recover your stored combustion tests, either by having them printed on the ENERAC's printer or by sending them out via the RS-232 port or the telephone line.

To recover your data proceed as follows:

1. Push the "SET" button and observe "SET" LED turn on.
2. Push the "TEXT" button. The following message will appear on the display:

```
TEST #1 ; FUNC=STORE
```

3. After selecting the proper TEST# (if you wish to recover only one test

result), press the ENTER button to move the cursor over to FUNC location.

4. Use the UP/DOWN buttons until one of the following functions appears on the display: "DUMP","DUMP ALL", "PRINT", "PRINT ALL".
5. Press the ENTER button. The stored result, or results will be sent to the selected output device.

D. ADDITIONAL STORAGE.

Because of the ENERAC's capabilities, you are not limited to storing only the results of 50 tests. You can use the RS-232 output to connect to an outside computer.

The most convenient way to obtain unlimited storage capability is to use the ENERAC's ENERCOM™ FOR WINDOWS software with any PC computer using Windows.

Some of the capabilities of this software include:

1. Calculation of maximum, minimum and average values over a pre selected period.
2. Storage and retrieval of data from the computer.
3. Programming custom fuels into the ENERAC.
4. Obtaining multiple plots & bar graphs.
5. Letting multiple alarms and monitoring their duration.

CHAPTER 8

COMMUNICATIONS

One of the most important recent developments in portable instruments is their ability to communicate directly with other instruments or computers. When good communications capability is paired with the development of artificial intelligence, the result is a very powerful system that can literally replace a consultant's visit to the plant and assure optimum performance of the monitored equipment at all times.

The ENERAC model 2000E has been designed with this concept in mind. It is capable of communicating directly with a computer in any of the following ways:

1. Through its RS-232 port.
2. Through the telephone line by using the modular phone output.

We strongly recommend using the ENERCOM™ for Windows program to communicate with any computer that is equipped with Windows™ software. This program offers unlimited storage capacity, automatic computation of maximum, minimum and average values over customer specified periods, presettable alarms and duration for any parameter, programming custom fuels, displaying bar graphs of the emission parameters and obtaining multiple plots of all stack parameters.

Enerac is a leading innovator in the field of combustion emissions measurements is committed to this concept and will be introducing so called "Expert Programs" that will be able to perform remote diagnosis and recommend steps to improve boiler performance.

The instrument is provided with two output ports. The RS-232 port is standard. The modular phone port is optional and will become operational if you have purchased the internal modem option. If you do not have this option, you can have your local distributor install it and call the factory to activate it remotely.

Please keep in mind that you can communicate with one output at a time. The ENERAC always defaults to the RS-232 when it is not communicating. This

means that the RS-232 is always on line, unless you originate a telephone call, or the ENERAC detects an incoming call on the telephone line. In that case, the modem automatically takes control, and the RS-232 is temporarily disabled. When the telephone communication is over, or the phone line disconnected, the RS-232 port will automatically be reactivated.

A. ESTABLISHING COMMUNICATIONS.

 The description below assumes that you have an external computer and that you wish the ENERAC to communicate with it and that the computer is equipped with a RS-232 port. It is also assumed that you have some kind of communications program installed on your computer.

NOTE: An RS-232 port is a special type of serial port. You cannot use a TTL serial port or a parallel port on your computer.

 NOTE: If your computer does not have a communications program installed and if you have an IBM PC compatible computer, you can obtain such a program from any computer store. Or preferably obtain the ENERCOM^{TM} software.

    1. How to connect your computer directly to the RS-232.

        The RS-232 port on the ENERAC is a male 25 pin D type connector. You will need a serial cable to connect to your computer. Cable lengths can be as long as 300 ft. You can get such cables from any computer store or from Enerac, if you wish. Computers have their outputs configured for a certain type of connection known as DTE or DCE (a DTE device transmits on pin 2 and receives on pin 3, the opposite is true for a DCE).

        The ENERAC can be configured either as a DTE or a DCE device. See figure 6 for the location of the configuration switch.

        For two instruments to communicate, they must be of opposite type (i.e. one DTE the other DCE). You must therefore, make sure your machine is a DCE. (If you are not sure, use a voltmeter to measure the voltage on pin #3 of your computer's connector. It should be negative 5V. or more with respect to pin#7, ground).

To switch the ENERAC's configuration from DCE to DTE, open the hinged part of the face plate. Find the small switch that is located on the PC board near the serial communications port (to the left of the printer paper). There are labels on the pc board marked "DTE" and "DCE". Select the appropriate position. If you have trouble communicating, select the alternative position of the switch.

Some computers also need an additional signal to be present in one of the other pins, before they start communicating with each other. This is called hardware handshaking. The ENERAC does not need such a signal. If your computer needs one, the ENERAC can supply it on any pins that your computer wishes to see it. The default pin on which this signal is supplied in the ENERAC as set at the factory is pin 20 (known as the DTR pin).

If both the above conditions are satisfied you have met the first requirement for successful communication. (CALL Enerac, IF YOU NEED HELP).

The second requirement for successful communication deals with establishing a common language between the two machines. There are two conditions for a common language. Speed of transmission and data format must be the same. The ENERAC model 2000E uses the following speed and data format:

    SPEED: 1200 BAUD (Default)
    START BITS: 1
    DATA BITS: 8
    STOP BITS: 1
    PARITY: NONE

You must set your computer to the same values as those listed above.

The ENERAC model 2000E will communicate via its serial port with a computer provided it has been turned on and gone through the AUTOZERO procedure WITHOUT BEING HALTED by an "... AUTOZERO ERROR" message. If such an error message appears on the

display and you still wish to establish communication, by pass it by pressing the "ENTER" key!

2. **How the ENERAC establishes a telephone connection.**

    If your ENERAC is equipped with an internal modem, use the following procedure to establish a successful telephone communication link with a remote computer:

    You need to have available a direct phone line. If your telephone is connected to a special communications system, such as MERLIN^{TM}, you will need to purchase from your phone company a special device called a modem adaptor in order to communicate with the ENERAC.

    a. Connect the modular phone adaptor to the ENERAC's phone socket.
    b. Disconnect your telephone from its wall outlet and connect it to one of the two sockets of the phone adaptor.
    c. Use any modular phone cable to establish a connection between the wall telephone socket and the unused adaptor socket.

    You are now ready to establish communication.

3. **How the ENERAC receives a telephone call.**

    If you wish to communicate with an ENERAC operating in the field, make sure the instrument is connected to a suitable phone line. Dial the ENERAC's phone number using your computer's communication program. The instrument is always in the "autoanswer" mode. This means that it will automatically answer any remote computer that dials the telephone number to which the ENERAC is connected. The operator's presence near the ENERAC is not required.

    If there is no incoming call, or if the call is disconnected, the ENERAC's RS-232 port will be enabled and can be used with any nearby computer, even if the ENERAC is connected to the phone line. If, however, a call comes in, the ENERAC will suspend its communication via the RS-232 port and establish automatically communication with the calling computer.

You can still operate the ENERAC's buttons including the "TEXT" button in order to read stack parameters, while simultaneously maintaining a telephone connection with a remote computer.

As long as you are maintaining a telephone connection, the following message will appear every 30 seconds on the display:

```
MODEM ON LINE
```

to remind you that you are still connected to the phone line.

B. THE ENERAC'S LANGUAGE

Once communication has been established, you can now proceed with data transfers and the execution of commands. There are two ways to exchange information between the ENERAC and an external computer or terminal. The first method is a simple data dump. the second is an information exchange between the two devices.

1. Dumping data to a remote computer

In this mode you just send data from the ENERAC to a connected computer by simply pushing the appropriate buttons.

To send a record of all the stack parameters currently being monitored by the ENERAC, while the probe is in the boiler's stack proceed as follows:

a. Make sure the "SET" LED is off.
b. Establish a successful connection either via the RS-232 or the telephone.
c. Observe that the "OUTPUT" LED turn on.
d. Push the "TEXT" button. A complete record of all current stack measurements is sent to the computer.

To send a record of the measurements that have been previously stored in the ENERAC proceed as follows":

i.   Carry out steps 1, 2, and 3 above.

ii. Push next the "SET" button, "SET" LED must be on.

iii. Push the "TEXT" button, the following message will appear:

```
TEST #1 FUNC=STORE
```

iv. If you wish to send all the data stored, push the "ENTER" button to shift the blinking cursor to the FUNC area.

v.   Use the "UP" button until the following message appears:

```
TEST #1 FUNC= DUMP ALL
```

vi. Push the "ENTER" button. All measurements stored in the ENERAC's memory are sent out in sequence.

Use the "DUMP" function, if you wish to transmit only one set of data (corresponding to the TEST#).

2.   Two way communication

The ENERAC is also capable of responding to requests for data   and to commands sent by 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 four letter words (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 is followed by a quotation mark it will cause the ENERAC to store the data between quotes in its memory. This is the way to reprogram the instrument from a remote location. This feature makes possible the introduction of new fuels, if desired, or remote control of parameters or even the introduction of additional features and improvements without having to ship the

instrument to the factory or dismantling it.

A list of the available commands intended for general use follows:

THE COMMAND SET

COMMAND	FUNCTION
ATEM?	Sends to the external computer the ambient temperature of the instrument.
CASH?	ENERAC returns the present value of combustibles in ash stored in its memory.
CDOX?	ENERAC returns present value of carbon dioxide.
CMNX?	ENERAC returns present value of carbon monoxide.
COAM?	ENERAC returns present set value of the carbon monoxide alarm.
COMB?	ENERAC returns present value of combustibles.
DATE?	ENERAC returns present date.
DATE XX/XX/XX	Stores in ENERAC new date.
DUMP?	ENERAC returns results of all tests stored in its memory.
EFFI?	ENERAC returns present value of combustion efficiency.
EXAR?	ENERAC returns present value of excess air.
FL01?	ENERAC returns the fuel currently stored in location 01
....	....
....	....
FL15?	ENERAC returns the fuel currently stored in location 15
FUEL?	ENERAC returns the current fuel used.

COMMAND	FUNCTION
LOGO?	ENERAC returns current LOGO (default value "ENERAC 2000E").
MODE?	ENERAC returns the current Emissions mode (units) and the oxygen correction factor.
MODE X	(Emissions option). Causes ENERAC to switch units of emissions gas measurements (CO, NO, NO_2, NOX, SO_2) as follows: X=P PPM (Volumetric) X=M MGM (milligrams/cub.meter) X=# #/B (Lbs./million BTU) X=G GBH (Grams/brake hp-hour)
NOXY?	ENERAC returns present value of nitric oxide (NO).
NO2Y?	ENERAC returns present value of nitrogen dioxide (NO_2).
NOXX?	ENERAC returns present value of NOX=(NO+NO_2)
OPTI?	Returns ENERAC's current option setting. (There are 16 available options).
OXRF XX	(Emissions option). Causes ENERAC to set the oxygen correction factor to any number as follows: XX=0-20 (%) (In 1% steps) XX=TRUE (No correction for oxygen)
OXYG?	ENERAC returns the present value of oxygen.
PRHT?	ENERAC returns the present value of the combustion air temperature.

COMMAND	FUNCTION
PRNT "X..XX"	Sends to the ENERAC printer the message "X..XX" up to 40 characters long. To send more characters repeat the command.
PUMP?	ENERAC returns pump status, ON or OFF.
PUMP0	Turns the ENERAC main pump off. (The probe air flow pump stays on!)
PUMP1	Turns the ENERAC main pump on. The instrument begins to draw a sample.
SETF01	Changes the ENERAC's current fuel to fuel #1. (Factory default is #2 oil).
....	....
....	....
SETF15	Changes the ENERAC's current fuel to fuel #15. (Factory default is SEWER GAS).
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.
TEXT	Commands the ENERAC to print on its printer all the current stack parameters including time, date, and fuel.
TIME?	ENERAC returns the current time.
TIME"XX:XX:XX"	Stores in ENERAC new time.
WARN?	ENERAC will return any warning messages currently activated.

A remote computer executing the commands TEXT? and WARN? in a continuous loop will perform as a remote continuous readout device of a source's performance.

The commands "PUMP0" and "PUMP1" allow the ENERAC to be left unattended at the combustion source site for long periods by remotely turning the main pump off and on, periodically, as needed. However, keep in mind that the probe pump air flow pump will be running continuously and its life is rated at 3000 hours.

You can type more than one commands at a time to a maximum number of commands that will not exceed 40 characters (including spaces). To send more than one command, separate each command by SPACE-SEMICOLON- SPACE.

We strongly recommend using the ENERCOM™ for WINDOWS software package to take advantage of the ENERAC's communications capability.

CHAPTER 9

THE ENERAC'S COMPUTATIONS

A. SIMPLIFIED DESCRIPTION

The heart of the ENERAC model 2000E is an INTEL 16 bit single chip microcontroller . (A microcontroller is a special purpose microprocessor). This is one of the most advanced 16 bit microcontroller available. A second 8 bit microcontroller takes care of the printer requirements and releases the main processor from these tasks. The unit's clock speed is a very fast 12 Mhz.

The system can accommodate 64K bytes of memory in the main processor and an additional 64K in the probe processor. The instrument uses a total of 40K bytes (or the equivalent of 15 full type written pages) for its code. Of these, 8K bytes are stored inside the microcontroller and 32K bytes in permanent memory (2 16kx8 EPROMS). The instrument also uses an additional 16K bytes of read or write memory (2 8kx8 battery backed SRAM).This large amount of read/write memory for a dedicated instrument is intended for enhanced remote reprogramming capability and for storage.

There is a 10 bit analog to digital conversion of the sensor outputs, that yields better than 1 part in 1000 resolution. The resolution is increased further by a running average implementation.

There are two printed circuit boards. The main board is a high density six layer board. The power supply board is housed inside the separate power supply module to minimize noise. The third board is located inside the probe housing (emissions probe only).

The basic ENERAC has all the connectors present so that any option can be installed, without having to ship the instrument to the factory.

B. SENSOR COMPUTATIONS

To achieve increased accuracy the thermocouple and the oxygen sensor outputs are linearized by computations in software. The emission sensors with the

exception of the nitric oxide sensor (NO) do not require linearization.

Temperature compensation is programmed into the ENERAC for all emission sensors.

Even though inboard filters remove most of the interfering gases, matrix computations remove any residual cross sensitivities.

Running average computations of the sensor outputs increase the resolution by a factor of five.

C. HOW EFFICIENCY IS COMPUTED

The ENERAC has stored in its memory a complete library of mathematical functions that it uses to carry out all the needed computations. It uses these functions not only to linearize thermocouple, oxygen sensor and combustibles sensor outputs but also to compute combustion efficiency, carbon dioxide, NOX and excess air.

The ENERAC uses a unique (and the most complete) formula to compute combustion efficiency. It is valid for stack temperatures above and below vapor condensation. It is based essentially on measuring all the heat loss mechanisms. Most of the heat is lost up the stack. In the case of coal fuels some potential heat is also lost by the amount of combustibles found in the ash residue.

In engine applications, the engine's thermal efficiency is not the ENERAC's combustion efficiency!

The total heat lost up the stack is made up of the following three loss components:

1. Heat carried away by the (dry) stack gases nitrogen, carbon dioxide and oxygen.

2. Heat lost by the water vapor that is formed during combustion. The heat lost by the water vapor can be consists of the following two terms:
   a. Heat lost in converting the water formed by the combustion process into steam at the boiling temperature of water. (This loss is recovered

in high efficiency boilers).

    b.   Additional heat lost in heating the steam formed to the temperature of the stack gases.

3.   Available heat lost by any combustible (i.e. unburned) gases escaping through the stack.

The ENERAC measures all three heat losses. In addition, if the fuel is coal, it will also allow you to enter the % combustibles in the ash residue to obtain a more accurate value for the combustion efficiency (since combustible residue is also a loss component).

For <u>high efficiency boilers</u> (i.e. boilers operating with stack temperatures below water vapor condensation), the ENERAC will account for the reduced heat loss (i.e. increase in combustion efficiency), arising from partial condensation of the water vapor and compute the combustion efficiency correctly. (This computation is carried out under the assumption of 50% RH for the combustion air).

NOTE: It should be obvious that the ENERAC does not account for any radiation (or cooling) and friction losses that may occur at the combustion source. These losses are very small for boilers, but are typically quite high for engines. <u>Consequently, you cannot use the ENERAC to compute the efficiency of an engine.</u>

D. EXCESS AIR, CO_2 & AIR/FUEL RATIO COMPUTATION

Carbon dioxide and excess air are calculated by the ENERAC and are functions of the oxygen concentration and type of fuel used. *There is no carbon dioxide sensor in the unit.* Consequently, carbon dioxide values are only valid for combustion systems, that use air as the source of oxygen and do not inject carbon dioxide or oxygen in the stack. Both carbon dioxide and excess air are computed as functions of the fuel used and of the oxygen level in the stack.

Keep in mind that excess air is zero and carbon dioxide is maximum, when operating at stoichiometric conditions.

The direct computation of the air to fuel ratio (on weight basis) is available on

some ENERACS. This is a very useful parameter in engine measurements. For gaseous fuels the air to fuel ratio (volume basis) may be computed by multiplying the ENERAC's display by the ratio of the specific gravities of the fuel and of air.

E. EMISSIONS CALCULATIONS

The emissions sensors (i.e. carbon monoxide, nitric oxide, nitrogen dioxide & sulfur dioxide) measure concentrations in PPM (parts per million) on a volume to volume basis. This is the default system of units for the ENERAC.

Recently, various regulatory agencies have enacted legislation requiring the measurement of emissions in units other than PPM.

The ENERAC is capable of computing directly and displaying the concentration of emissions in the following different units:

1. Milligrams per cubic meter (abbreviated as MGM). This is a popular system for ambient air monitoring.

2. Pounds per million BTU (abbreviated as #/B). The code of U.S. Federal Regulations (40CFR60 and 40CFR72) require the measurement of NOX emissions in these units.

    Calculations in terms of lbs. / million BTU require the determination of certain factors called the F factors. The ENERAC uses the same values for the F factors as those listed in 40CFR60 Appendix A Method 19.

    The EPA regulations specify the values of the -F- factors required in the computations, only for certain fuels. The ENERAC has stored in its memory the -F- factors for all fuels currently stored. For custom fuels a special -F- factor is derived and used corresponding to that particular fuel.

3. Grams per brake horsepower-hour. (Abbreviated as GBH). This system of units is used in stationary engine measurements. The ENERAC computes first emissions in grams per INPUT horsepower-hour. To convert to grams per BRAKE horsepower-hour the ENERAC divides the previous

computation by the engine's thermal efficiency *(this is not the combustion efficiency of the ENERAC!!)* and displays the result. An engine's thermal efficiency is typically 25-35% (i.e. 0.25-0.35) and is usually given in the engine's manual for various load conditions. The ENERAC has a default value for the thermal efficiency of 0.3. You set the value, when you change emission units to GBH. (See Chapter 5).

4. Nanograms per joule. This system of units is used overseas. It is available on some ENERACS. The conversion factor is the following:

$$1lb/million\ BTU = 430\ nanograms/joule$$

Some regulations also specify that toxic gas concentrations be referenced to certain oxygen levels, such as 0% (air free), 3% or 7%. The ENERAC can be programmed by the customer to carry out these computations automatically.

Please note that oxygen correction factors affect only the measurements in PPM and MGM. They do not enter the calculations in #/B, GBH or #/H!

All calculations including sensor linearizations are executed using floating point arithmetic, not look up tables, for greater accuracy and reduced memory overhead.

F. ENERAC SOFTWARE

You can use any communications program such as PROCOMM™ or WINDOWS™ TERMINAL to communicate with the ENERAC. You can, however, enhance considerably the performance of the ENERAC, by using the special ENERCOM™ FOR WINDOWS software that is supplied with every model 2000E analyzer. These 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.

Consult the manual for ENERCOM™ FOR WINDOWS for details on the available software.

CHAPTER 10

MAINTENANCE

The ENERAC model 2000E is a sophisticated piece of analytical instrumentation designed to perform accurate emissions measurements. However, because it is a portable instrument, that finds use 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 certain components in the ENERAC, depending on the type of probe that you are using, that will require occasional replacement (i.e. replacing them every few weeks depending on external conditions and instrument usage). These items are:

A. STANDARD PROBE (STANDARD PROBE OPTION)

The following items must be maintaned on a periodic basis, if you are using the standard probe.

1. Replacing the disposable (fiberglas) filter

The disposable filter is located outside the instrument on the water trap assembly (see fig.3). It must be replaced, if it becomes noticeably discolored. Failure to replace a partially blocked filter will cause longer response times and probable clogging of the tiny sensor openings, resulting in sensor failure.

To replace a used filter, remove the clamps that secure it to the hose assembly of the watertrap. Take a new filter. Observe the correct flow direction (i.e. towards the instrument). Connect the new filter to the hose assembly and secure it with the clamps.

NOTE:

Units with SO$_2$ measurement capability must be equipped with a fluorocarbon based disposable filter (casing color is pale green).

2. Replacing the desiccant and draining the watertrap

The desicant is the blue crystalline material located inside the upper compartment of the watertrap. As this material absorbs water vapor, its color changes to pink and finally to white-pink as it becomes saturated with water. It should be replaced with fresh dessicant when it is used up.

To replace the desiccant, unscrew the Watertrap cover carefully and empty the dessicant compartment. Fill it with fresh desiccant and screw the cover back tightly so that there are no air leaks.

Used desiccant can be restored by placing it in 200 degree F oven for 20 minutes. This, however, cannot be repeated more than two or three times, because of gradual soot accumulation.

To drain the watertrap from water accumulated in the bottom, simply remove the red plastic plug and shake the watertrap. Don't forget to replace the plug.

NOTE:
If your instrument has NO oxides of nitrogen OR sulfur dioxide measurement capability, use DESICCANT #1 (Silica Gel).

If your instrument is equipped to measure oxides of nitrogen, but NO sulfur dioxide, use DESICCANT #2 (Drierite) only.

If your instrument can measure sulfur dioxide, you must use NO desiccant, or insert any other substance in the water trap compartment!!

B. THE EMISSIONS PROBE. (EMISSIONS PROBE OPTION).

The following items must be maintained on a periodic basis, if you are using the emissions probe.

1. The sintered Hastelloy filter

2. The disposable 1 micron fiber filter

3. The desiccant material located inside the probe housing,

There is an additional fiber filter located inside the desiccant chamber of the probe housing. Its function is to prevent silica gel particles from reaching the probe's counterflow pump. This filter should be replaced once a year.

There are two additional filters located inside the analyzer to protect the instrument's pump when the unit is operated without the probe. These filters should be replaced once a year.

You will probably need to replace the gas sensors once every two years, depending on instrument use and stack conditions.

All replacement items mentioned are easily accessible. They are either located outside the instrument, or the can be reached by opening the hinged section of the face plate.

1. The sintered filter.

The sintered Hastelloy filter is located at the tip of the probe. Typically it should normally be housed inside the probe deflector.

The filter's status is monitored by a pressure switch located inside the probe housing.

The filter should be cleaned periodically. You must replace or clean the filter, if the "FLOW BLOCKED" LED turns on during a measurement.

USE OF THE PROBE WITHOUT THE FILTERS WILL DAMAGE THE PERMEATION DRIER AND RESULT IN COSTLY REPAIRS.

Use a suitable screwdriver to remove the filter from the tip of the probe.

A filter can be cleaned three or four times. After that it should be replaced with a new one.

You can clean the filter in a variety of ways:

If most of the retained particulate matter is on the surface, a simple reverse flush with clean fluid , or air will normally restore its permeability.

If there are particulates entrained within its pores, ultrasonic cleaning is recommended. You may use a non reactive degreaser to backflush before ultrasonic cleaning.

During any blowback or backwash operation, intermittent pulses of gas or liquid are far more effective than a steady reverse flow.

If the contaminants are combustibles, you may try conventional oven burning followed by ultrasonic cleaning.

The filter is made of Hastelloy X and it can withstand temperatures of 1700 F continuously and 1900 F for a few minutes.

2.   The disposable fiber filter.

This filter is located inside the probe gas manifold. (See figure 5). It is disposable and will have to be replaced occasionally, or if the "BLOCKED FILTER" LED turns on.

To replace the filter, remove the threaded filter holder that is located on the side of the case of the probe. You can use a small coin to unscrew the filter housing. Insert a new filter into the removed filter housing making sure that the filter is seated properly! Screw the filter assembly into the manifold taking care not to lose the Viton washer that is located inside the manifold.

Do not use any filter other than the ones supplied by Enerac!

Use of the probe without the filters will damage the permeation drier and result in costly repairs.

3. Desiccant replacement.

The desiccant is the blue crystalline material (silica gel) located inside the probe housing. Its condition can be monitored through the narrow rectangular window located on the face of the probe housing. As this material absorbs

water vapor, its color changes to pink and finally to white-pink as it becomes saturated with water. It should be replaced with fresh desiccant when it is used up.

Use only silica gel as desiccant. Other desiccants such as drierite crumble into powder and will clog the 40 micron air filter located inside the desiccant housing.

The desiccant does not come into contact with the drawn gas sample. Its function is to dry the counterflow air that the permeation drier uses. For optimum drying performance make sure the desiccant color is blue!

To replace the desiccant, unscrew the aluminum plug that is located at the bottom of the probe housing. Carefully empty the desiccant compartment. Fill it with fresh desiccant and secure the plug to the opening.

Air enters the desiccant chamber through the three slots located on the face of the probe housing. If you plan to store the instrument, you may wish to tape over the slots to prevent the desiccant from absorbing moisture, gradually.

Used desiccant can be regenerated by placing it in 250 degree F oven for 30 minutes until it recovers its blue color.

C. PAPER REPLACEMENT.

The ENERAC's printer uses a special paper called thermal paper. ALWAYS USE THE PROPER TYPE OF THERMAL PAPER. If the wrong paper is inserted, the printer may not operate at all or the printer's thermal heads may be damaged. If you notice that the printer is printing incomplete letters, this is an indication that one or more of the printer heads have been damaged. In that case you have to order a complete head assembly from the company and install it yourself.

Do not leave thermal paper exposed to heat or humidity, because it will gradually turn yellow.

When there are only 3 ft. of paper left in the roll, you will see a red line appearing on the left border. This is a warning that there is little paper left and order a new

roll.

There is a paper sensor located behind the printer. The printer will operate as long as the sensor's beam is interrupted by the paper. When there is no paper, the sensor disables the printer to avoid damaging the thermal heads. Simultaneously, the following message will appear on the display every fifteen seconds:

```
PRINTER PROBLEM
```

To insert a new roll of paper, open the hinged side of the face plate. Lift the rod that holds the paper. Insert a new roll of paper and gently press the rod back against the supporting clamp. Take out about 3" of paper and pass it through the rear of the printer making sure that it goes between the paper sensor's openings. Use the small thumbwheel located on the right hand side of the printer to slowly push the paper through the printer. Once the paper is through you can pass it through the cutout on the face plate. Use the "PAPER FEED" switch to advance the paper.

# D. SENSOR REPLACEMENT.

1. Replacing the oxygen sensor
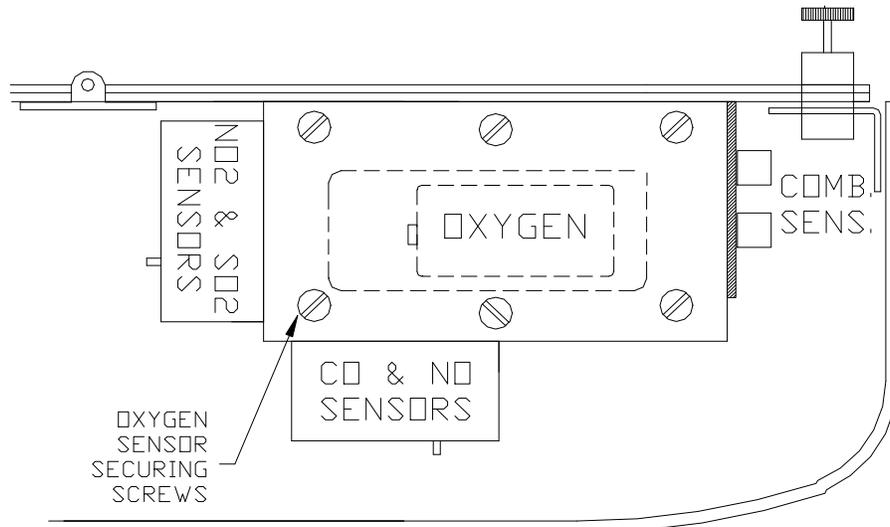
FIGURE 10

The oxygen sensor is an electrochemical cell and has a limited life. It should last approximately one year. The oxygen sensor's date code is stored in the instrument at the time of its manufacture.

If, at start up at the end of the AUTOZERO countdown, the message,

```
OXY AUTOZERO ERROR
```

appears on the display, it means that the sensor is no longer functioning satisfactorily and should be replaced.

Before replacing an oxygen sensor, however, open the hinged plate and take a look at the cables leading to the sensor housing. Make sure that no wires have accidentally been disconnected.

If the above ERROR message appears for the first time, try operating the unit for a few hours in a clean environment, in case the sensor got wet. If this doesn't work, you must replace the oxygen sensor.

To replace the oxygen sensor (see figure 10), open the hinged section of the face plate. Remove the six captive screws that secure the cover to the sensor housing. Remove the housing cover. The sensor is the small battery like device attached to the cover. Unscrew the sensor wires and remove the old sensor. Take a new sensor and attach it to the cover. Carefully screw the sensor leads observing the proper polarity. Place back the cover and tighten the six screws so that the housing is air tight. Make sure you don't damage the gasket. Close the hinged plate. Wait 10 minutes. Turn the instrument on. If everything is OK, it should warm up without the "OXY AUTOZERO ERROR" message appearing at the end of the countdown. If the ERROR message appears again, turn the unit off wait 5 minutes and turn it back on. If the error message still appears, open the hinged plate and examine the wires to the sensor. Make sure you have attached the wires with the correct polarity.

2.   Replacing the carbon monoxide sensor.

The carbon monoxide and its associated long life inboard filter are mounted as one **inseparable** assembly on the instrument's sensor housing. The filter section is located at the front of the assembly.

The carbon monoxide sensor is an electrochemical cell. Its expected life is about 2 years. During manufacture the sensor's date code is stored in the instrument.

When the following message appears during autozero:

```
CO AUTOZERO ERROR
```

or the following message appears during span calibration:

```
CALIBRATION FAILURE
```

it means that the CO sensor is no longer meeting the required specifications for accuracy and must be replaced with a new one.

If the "CO AUTOZERO ERROR" message appears, before replacing an apparently malfunctioning sensor, let the ENERAC run for 2 hours in a clean environment, (you will have to push the "ENTER" button to continue). Sometimes a malfunction message appears, if the sensor got wet, or if it had been saturated with carbon monoxide during a measurement. Turn the unit on again. If the error message still appears, replace the sensor.

To replace the sensor open the hinged section of the face plate. Take out the three screws that secure the sensor to the housing. Notice the three wires attached to the sensor. Observe carefully the pins to which they are connected. Disconnect the wires and remove the old sensor.

Take a new CO sensor. Notice that the new sensor has two pins shorted. Remove the shorting spring. Attach the three wires to the corresponding pins on the sensor and mount the sensor on the housing. Make sure to locate the O-ring carefully in its groove, so that there are no air leaks. Wait 15 minutes. Turn the instrument on and AUTOZERO the unit.

After replacing the co sensor, you must wait at least 24 hours for the sensor to condition itself, before executing an autozero and using the instrument!!

Turn the instrument on. Execute an autozero. If the "CO AUTOZERO ERROR" message appears, check your wiring to the sensor.

Make sure you carry out a span calibration following sensor installation.

3. **Replacing the NO, NO$_2$ & SO$_2$ sensors.**

The nitric oxide (NO) and its associated long life inboard filter are mounted as one inseparable assembly on the instrument's sensor housing. The filter media removes interference from NO$_2$ and SO$_2$.

The sensor is an electrochemical cell. Its expected life is about 2 years. During manufacture the sensor's date code is stored in the instrument.

The nitrogen dioxide (NO$_2$) is mounted on the instrument's sensor housing.

The sensor is an electrochemical cell. Its expected life is about 2 years. During manufacture the sensor's date code is stored in the instrument.

The sulfur dioxide (SO$_2$) and its associated long life inboard filter are mounted as one assembly on the instrument's sensor housing. The filter is located at the front of the assembly. The filter removes interference from H$_2$S.

The sensor is an electrochemical cell. Its expected life is about 2 years. During manufacture the sensor's date code is stored in the instrument.

Follow the instructions for removing the carbon monoxide sensor.

WHEN REPLACING THE NO AND CO SENSORS YOU MUST WAIT AT LEAST 24 HOURS, BEFORE OPERATING THE INSTRUMENT, BECAUSE THESE SENSORS ARE OPERATED WITH A CERTAIN BIAS AND REQUIRE A CERTAIN AMOUNT OF TIME FOR THE SENSORS

TO CONDITION THEMSELVES. WHEN REPLACING THE NO_2 SENSOR YOU NEED TO WAIT ONLY 15 MINUTES, SINCE THIS SENSOR IS NOT OPERATED WITH A BIAS VOLTAGE.

Make sure the instrument is always off when the hinged panel is opened.

CHAPTER 11

CALIBRATION

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

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, without having to use any adjustments 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 autozero the ENERAC, if the probe tip is still hot from 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.

The ENERAC will "auto zero" itself every time you start the instrument,provided you push the ENTER key. Span calibration will be carried out on request.

 You should carry out a span calibration every 3-4 months to maintain an accuracy

within specifications.

A. AUTO ZEROING THE INSTRUMENT

Every time you turn the instrument on, you should wait for 2 minutes for the ENERAC to warm up. At the end of the warmup 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 21.0% and the ambient temperature that it reads 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 AUTOZEROING is only needed once at the beginning of a day of measurements. The ENERAC will not have sufficient zero drift during in 24 hours to require additional autozeroing procedures. You can bypass the AUTOZERO procedure by pressing any key other than the "ENTER" key, when prompted to do so by the display.

If the instrument has not been used for quite some time, it is a good idea to give it a longer warmup period (the combustibles sensor is the only sensor, that may need a little more time). To do this turn the unit off at the end of its initial warmup and then turn it immediately back on.

If you accidentally shut off the unit while the probe is still in the stack, TURN THE UNIT BACK ON AND BYPASS THE AUTOZEROING PROCEDURE BY PRESSING ANY KEY OTHER THAN THE "ENTER" KEY WHEN THE MESSAGE "Press ENTER to AUTOZERO" APPEARS.

B. SPAN CALIBRATION OF THE INSTRUMENT

Once every 3-4 months you should perform a span calibration of the instrument. The parameters that require a span calibration are: Carbon Monoxide, Combustibles, Nitric oxide, Nitrogen dioxide and Sulfur dioxide. There is, finally, a span calibration for the ambient temperature sensor.

You can carry out all span calibrations in sequence or just one only, if you wish.

You can use your own gas calibration system, or you can use the convenient gas calibration kit supplied by Enerac.

1. Span calibration using the Enerac kit.

The gas calibration system supplied by Enerac is shown in Fig. 11. The kit comes with a gas bottle containing a mixture of 200 PPM carbon monoxide and 0.1% methane. For NOX and SO2 calibrations you must order extra gas bottles containing the desired type of span gas. All four gas cylinders and apparatus fit in a small carrying case for easy transportation to the field.
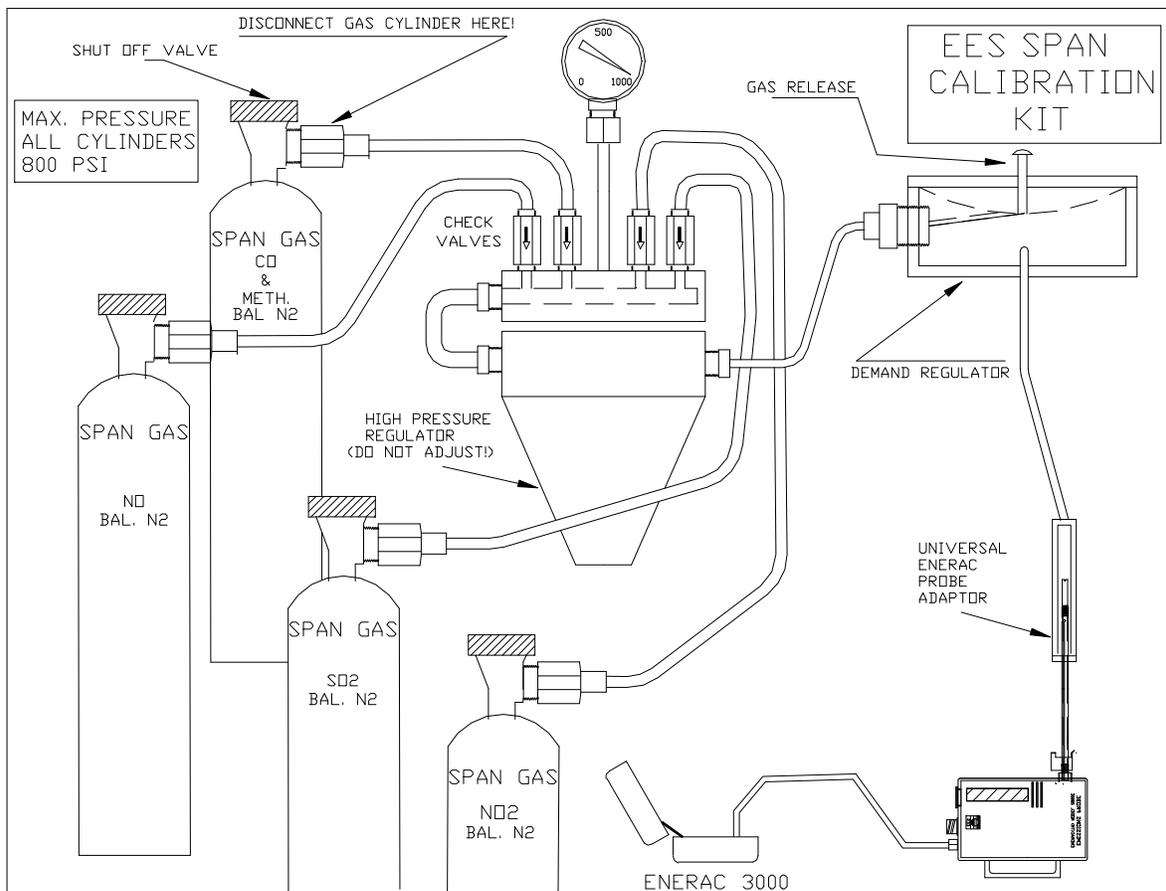
FIGURE 11

Follow the instructions supplied with the kit for proper span calibration.

 For span calibration of AMBIENT TEMPERATURE follow the directions in section B below.

 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.

To carry out a span calibration follow the steps below:
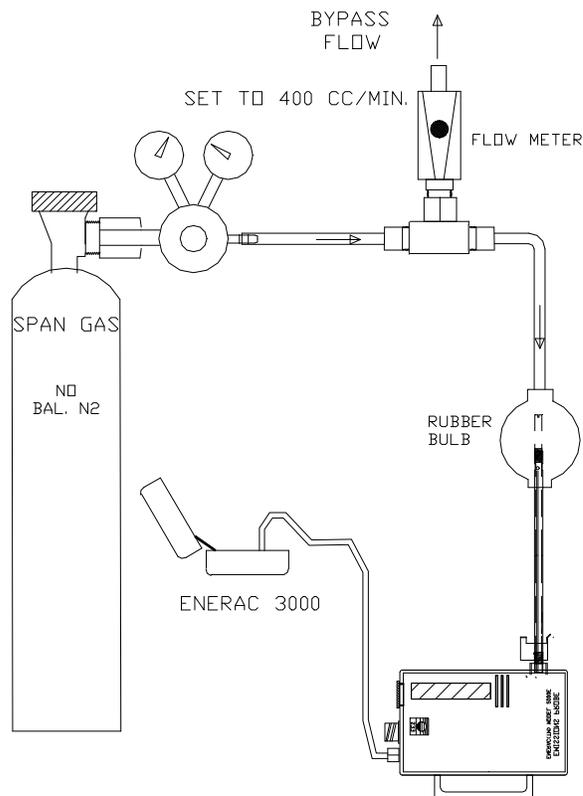
FIGURE 12

1. We suggest that you set up your calibration apparatus as shown in fig.12.

Notice that you need a number of certified gas cylinders.

The Carbon Monoxide gas should be in the range 50-1500 PPM 2% accuracy with the balance nitrogen.

The Combustible gas should be in the range 0.5-2.0% methane, 2% accuracy with the balance nitrogen.

The NO span gas should be in the range 10-1500 PPM, 2% accuracy with balance nitrogen.

The NO_2 span gas should be in the range 10-500 PPM, 2% accuracy with balance nitrogen

The sulfur dioxide span gas should be in the range of 30-1500 PPM, 2% accuracy, balance nitrogen.

2. Turn the instrument on, press ENTER to autozero and wait until the message

```
INSERT PROBE IN STACK
```

appears on the display.

3. Push the "SET" button and observe "SET" LED turn on.

4. Push the "DRFT" button. The following message will appear:

```
CMB SPAN GAS 0.11%
```

5. (If you wish to skip the Combustibles calibration push the "ENTER" button. The display will read:

```
PUSH ENTER KEY
```

Push any button, except the "ENTER" button and the unit will skip the

combustibles calibration and proceed to the next one.)

6. To carry out the combustibles span calibration, use the "UP" or "DOWN" buttons until the display reads the same combustibles value as that printed on the combustibles (methane) gas bottle label. Then press the "ENTER" button. The display will read:

```
PUSH ENTER KEY
```

7. Open the span gas valve, set your gas flow to 200-600 cc/min above the pump flow. Remove the cap from the top of the sample stack tube to vent the excess gas. (The purpose of this is to maintain reasonably steady pressure near ambient for more accurate results). Press the "ENTER" key.The following message will appear on the display:

```
FEED GAS NOW AND WAIT
```

8. Make sure you keep the gas flow reasonably constant. At the end of two minutes the unit will record and store the combustibles sensor output and define it as the value that you set earlier.

When you see the message:

```
CO SPAN GAS: 200 PPM
```

it means that you are finished with the combustibles span calibration and the instrument is prompting you to perform the CO calibration next. Shut off the gas!

9. To carry out the CO (carbon monoxide) span calibration follow the procedure outlined above for the combustibles calibration.

If you wish to skip the CO calibration proceed as in step 5. The following message will appear on the display:

```
NO SPAN GAS: 200 PPM
```

prompting you to carry out this calibration.

The next calibration in line is sulfur dioxide and the following message will appear on the display;

```
SO2 SPAN GAS: 200 PPM
```

If you wish to carry out any of these calibrations, proceed as outlined in steps 6, 7 and 8. At the end of either step the following message will appear on the display:

```
NO2 SPAN GAS: 100 PPM
```

10. The final span calibration is the ambient temperature. Following the DRAFT calibration the following message will appear on the display:

```
ATEMP OFFSET +0 C
```

This calibration allows you to make minor corrections so that the ENERAC will read the exact ambient temperature.

At the end of the span calibration procedure the following message will appear on the display:

```
WAIT TWO MINUTES
```

The instrument is now purging any traces of remaining gas. At the end of the two minute period it will perform an "auto zero" and it will be ready by displaying any two stack parameters.

11.If there is something wrong with any of the sensors during span calibration, (i.e. if the sensor's output is not within the expected range) the instrument will display the message:

```
CALIBRATION FAILED
```

and will not calibrate for this sensor.

NOTE:

IF you wish to exit the span calibration procedure at any time, simply press the "SET" key and observe the "SET LED" turn off.

Whenever the message "FEED GAS NOW AND WAIT" appears, the ENERAC is inside a software loop and will not respond to any commands from the keyboard or communicate with the serial port.

APPENDIX A

ERROR MESSAGES & TROUBLESHOOTING

The ENERAC model 2000E is a sophisticated state of the art instrument designed for field use. It is, however, important that you should take proper care and avoid dropping it or exposing it to unusually high or low temperatures. Do not expose the probe to open flame and never use the instrument without the particulate filters.

The ENERAC model 2000E is always going through a self checking procedure every time it is turned on. Its crucial sensor performance is also thoroughly checked during every span calibration.

Occasionally, a problem may occur with the instrument. If this happens it will probably due to one of the following components:

1. Sensor failure, or connection.
2. Discharged battery, or blown fuse.
3. Clogged filter, or damaged probe.
4. Thermal printer head failure.
5. Memory corruption or instrument lock.

A. SENSOR PROBLEM MESSAGES

These messages may appear during AUTOZERO or following SPAN CALIBRATION.

If a sensor "XXX AUTOZERO ERROR" appears, the ENERAC will interrupt its initialization procedure and wait for the operator to decide if he wants to investigate the problem, or proceed by pressing the "ENTER" key.

An autozero error implies that the sensor's offset is outside its specifications.

NOTE: If such a message appears when a new sensor is first installed, please CHECK THE WIRING CONNECTIONS TO THE SENSORS then wait 24 hours

100

for the sensor to condition itself before autozeroing again.
If a "REPLACE XX SENSOR............" message appears during span calibration, check first that you have entered into the ENERAC the correct value of the span gas that you are using. Check also the flow rate as indicated by the small flowmeter of the Calibration Accessory. Make sure there was sufficient span gas in the cylinder.
If possible, check the span gas especially if you are using NO_2 gas.

B. POWER PROBLEMS.

If nothing happens (i.e. no display or pump sound) when the ENERAC is turned on, check the "BATTERY OK" LED. If it is OFF, turn the instrument OFF, give a five minute charge to the battery, connect the AC cord to an outlet and turn the unit on.
If the unit runs, charge the battery overnight and then run the instrument on battery.
You should get at least 3 hours from the battery. If not , you must replace the battery.

Before replacing the battery make sure that the "AC CHARGE" LED turns on during battery charging.

If the unit fails to operate, when plugged to an AC outlet, make sure the correct voltage is indicated on the ON-OFF switch assembly. Following this, check the AC fuse located on the left hand side of the assembly.

C. FILTER AND PROBE PROBLEMS. (EMISSIONS PROBE).

Monitor the five LEDs located on the back of the probe case.

1. **"PROBE OK" LED problems.**

    The most common problem is associated with the green "PROBE OK" LED turning on.

    Connect the probe's electrical connection to the instrument.

Wait at least two minutes for the probe to warm up.

Make sure "HEATING/COOLING" LED turns ON RED. If not, there is a problem with the heat pump.

Keep in mind that the ENERAC must heat the probe manifold to a temperature of 130-140 deg. F for proper operation of the water conditioning system. If the ambient temperature drops below 50 deg. F. the ENERAC's probe warm up time begins to lengthen, especially if the instrument is operated on batteries. Try using it on AC or using an external DC power source, such as a 12 Volt battery.

If the temperature drops below 25 deg. F. you must find a way to keep the probe reasonably warm. The unit will operate, of course, even if the "PROBE OK" LED is OFF, bust you must watch carefully, the clear section of the hose for any signs of condensation.

2. **Probe filter problems.**

    If the "BLOCKED FILTER" LED turns on, remove the probe from the stack.
    If the LED remains on, replace the fiber filter located on the side of the probe.

    If the LED turns off, either the sintered filter requires cleaning, or the stack draft exceeds -15" W.C.. In the latter case, ignore the LED indicator.

    If the "NO FILTER OR FLOW" LED turns on, make sure first that the sintered filter is in place at the tip of the probe.

    Make sure that the stack draft does not exceed +5" W.C.. If it does, ignore the LED indicator.

    Check the hose for any kinks, make sure the instrument sample pump is running and drawing a minimum of 500 cc/min. Check the flow rate with the probe removed. If the problem is inside the probe, it will have to be serviced at Enerac.

3. Probe heating/cooling problems.

During normal operation the "HEATING/COOLING" LED should cycle on and off every 2-5 minutes.

If it stays constantly on, it may indicate insufficient heating or cooling. Try to change ambient conditions to less extreme values. You can achieve this, probably, in a number of ways depending on the application. If this is not possible operate the instrument, but watch for any condensation.

4. Probe overheating problems. If the "OVERHEATING" LED turns ON, *REMOVE PROBE FROM STACK AT ONCE AND INVESTIGATE.*

   Proceed as follows: Move probe housing further from away from stack wall. Make sure to use the ENERAC's heat shield.

   In engine measurements, avoid placing the probe directly in front of the exhaust blast!

   Make sure bicolor LED is on GREEN!

5. Condensation problems.

   During a measurement you must always watch the clear section of the hose for any condensation. This is very important for NOX measurements, especially if you suspect the presence of NO_2.

   If you observe condensation in the hose, proceed as follows:

   a. Your conditioning system will be overwhelmed, if water or steam is injected in the stack. Contact Enerac for suggestions.

   b. Make sure the exposed section of the inconel probe is hot (Approximately too hot to the touch).

   c. Try to keep the probe case warm, especially if the "HEATING" LED stays constantly on.

d. Reduce the sample pump flow rate by 100 cc/min. then by another 100 cc/min. if necessary.

To reduce the pump speed, open the hinged section of the face plate and locate the sample valve under the PC board near the printer paper. Use the small flow meter supplied to you to monitor the flow rate.

D. OTHER PROBLEM MESSAGES (all units)

ERROR MESSAGE	WHAT TO DO
"CONNECT PROBE-RESTART"	1.Make sure the probe electrical connection is connected to the instrument.
"STEMP AUTOZERO ERROR"	1. Make sure probe was at ambient temperature when the unit was autozeroed. 2. Check for an open thermocouple. Check t'couple electrical resistance (~10 ohms).
"COMB AUTOZERO ERROR"	1. Sensor needs additional warm up period. Restart unit. 2. Sensor response is out of original specs. Sensor is probably OK. Check with calibration gas. 3. Sensor was damaged by excessive moisture or comb.gas.
"OVER"	1. Make sure you are using the correct Precision Control Module. 2. Make sure the ENERAC is set for the correct PCM.

E. WARNINGS

The ENERAC has been designed to perform a number of diagnostic tests, while carrying out stack measurements.

If, during operation, it detects any conditions that will jeopardize the integrity of the instrument or its readings, it will warn the operator by displaying every 30 seconds a message that describes the nature of the warning. These messages, if activated can also be monitored remotely by using the WARN? command.

A list of the warning messages follows:

WARNING MESSAGE   **WHAT TO DO**

"AMBIENT TEMP TOO HIGH"   Check connection of thermocouple plug to instrument.
Remove ENERAC from immediate vicinity to avoid sensor failure because of high ambient temp.

"STEMP HIGH EXTRACT PROBE"   Remove probe from stack to avoid damage to the thermocouple.

"CO HIGH EXTRACT PROBE"   Remove probe to avoid temporary failure of the CO sensor.

"REPLACE BLOCKED FILTER"   Excessive suction pressure. Check filter or hose for kinks.

"CO EXCEEDS ALARM"   The CO in the stack exceeds the preset alarm value.

"PRINTER PROBLEM"   Check printer paper, or printer connections.

"RS-232 PROBLEM"   Improper initialization at start up. Ignore unless you require serial communication. In that case, turn unit off then back on again. Bypass autozero.

"MODEM ON LINE"   A reminder that the ENERAC is still connected to the phone line.

"....OVER......."	Value of stack parameter exceeds upper range limit. *Exception: emissions lbs/MBTU aspirating air.*
"OPTIONAL... "	This option is not available in your unit. Contact the factory.

F. MISCELLANEOUS PROBLEMS

SYMPTOM	**WHAT TO DO**
Oxygen too high in stack	1. Check for kinked hose. 2. Check for clogged filter. 3. Tighten thumbscrew on probe handle. 4. Check for high draft. 5. Tighten housing cover.
Response too slow.	1. Check for clogged filter. 2. Check the pump flow rate. It should be 700-800 cc/min. 3. Check for air leaks. 4. NO_2 & SO_2 sensors have slow responses.

G. PRINTER PROBLEMS

SYMPTOM	**WHAT TO DO**
Printer does not run.	1. Make sure there is paper in the printer. 2. Make sure paper goes through paper check sensor.
Missing dots on letters.	1. Replace thermal head.

G. MEMORY PROBLEMS

SYMPTOM	**WHAT TO DO**

| Strange characters appear on display or instrument locks. | 1. Use the reprogramming diskette to Refresh the ENERAC's memory. |

APPENDIX B

MODEL 2000E SPECIFICATIONS

PHYSICAL:
1. CASE
    18"X13"X6" Aluminum carrying case with lock. Weight: 15 lbs.

2. STANDARD PROBE
    13"L.x3/8"OD. Inconel probe with aluminum handle and 10 ft. braided hose std. (Other sizes optional.) (Condensation trap is included).

3. EMISSIONS PROBE:
    24"L. X 3/8" OD. Inconel probe with Hastelloy X sintered filter and ½" deflector mounted on permeation drier housing. Probe housing connects to instrument via a 10 ft. Viton hose. Max. continuous temperature: 1800 deg. F. Max. sample dew point (past drier) 50 deg. F.@ 600 cc/min. (Natural gas fuel @ 0% oxygen).

ELECTRICAL POWER:

1. INTERNAL BATTERY
    6V. rechargeable sealed lead-acid cell. Three-four hour continuous battery operation depending on ambient temperature. Quick 6 hour recharge.

2. AC
    120V. 60 Hz. and 220V. 50 Hz., selected by switch.

3. DC (OPTIONAL)
    EXTERNAL 6Volt battery, or 11-40 VDC / 5A source.

DISPLAY
0.5"High by 24 Character single line LCD with backlight illumination and adjustable viewing angle.

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.
    Standard Range: 0-2000 PPM.
    Resolution: 1 PPM
    Accuracy: 2% of reading (*)

5. NITROGEN DIOXIDE (NO$_2$)
    Electrochemical cell. Life 2 years.
    Range: 0-1000 PPM.
    Resolution: 1 PPM
    Accuracy: 2% of reading (*)

6. CARBON MONOXIDE
    Electrochemical cell. Life 2 years.
    Standard Range: 0-2000 PPM.
                     0-20,000 PPM (2K-20K)
             or   0-40,000 PPM (2k-44K)
    Resolution:1 PPM
    Accuracy: 2% of reading (*)

7. SULFUR DIOXIDE
   Electrochemical cell. Life 2 years.
   Standard Ranges: 0-2000 PPM.
   Resolution:1 PPM
   Accuracy: 2% of reading (*)

8. COMBUSTIBLES(GASES)
   Catalytic sensor. Life indefinite.
   Range: 0-6.00%
   Resolution:0.01%
   Accuracy:10% of reading in CH_4 gas

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

   (*) When tested according to 40CFR60, RAA test.

COMPUTED PARAMETERS:

1. COMBUSTION EFFICIENCY
   Heat loss method. Unique four loss factors computation. (dry gas, water vapor, gaseous combustibles,combustibles in ash)
   Range: 0-100%
   Resolution:0.1%
   Accuracy(4 loss):   1% (above H2O condensation)
                         2% (below H2O condensation)

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
    Standard Ranges: 0-2500 PPM.
    Resolution: 1 PPM
    Accuracy: 2% of reading (*)

5. EMISSIONS 1   (CO, NO, NO_2, NOX, SO_2)
    Range: 0-2500 milligrams/cubic meter
    Resolution: 2 mg/m^3
    Accuracy: 5% of reading

6. EMISSIONS 2   (CO, NO, NO_2, NOX, SO_2)
    Range: 0.000-99.99 lbs./million BTU
    Resolution: 0.01 lbs./MMBTU
    Accuracy: 5% of reading
    (Oxygen correction factor for emissions adjustable 0-20% in 1% steps plus TRUE).

7. EMISSIONS 3
    Range: 0-99.99 grams/brake hp-hr
    Resolution: 0.01 grms/bhp-hr
    Accuracy: 10% of reading

PRINTER:

SEIKO 4",40 char. per line thermal printer with form feed and line feed buttons and with end of paper override.

Operates in any of four print modes:

1. TEXT MODE
    25 line printout of instant. values of all measured parameters. (time req.20 sec.)
2. PLOT MODE
    Any one parameter vs. time plotted. 3 ordinate scales: full, half,quarter. Time scale: Selectable,1 sec/dot-1 min/dot in 1 sec/dot intervals. 4 parameter plot CO-OXYGEN-NOX-EFFICIENCY, single scale.
3. EXTERNAL PRINT MODE

Prints messages sent via RS-232 port.

STORAGE:

1. INTERNAL
   70 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.

2. EXTERNAL (OPTIONAL). See software.

COMMUNICATIONS:

1. RS-232 PORT
   RS-232c port (switch selectable DTE or DCE), 1200 baud user selectable,
   half duplex, 1start bit, 8 data bits, 1 stop bit, no parity.

2. TELEPHONE PORT
   Internal 1200 baud modem connects to a modular phone line for remote
   communication. (A 50 word command set sends instructions to the unit for
   remote control and troubleshooting).

3. SOFTWARE
   ENERCOM for Windows ^{TM} software . CD-ROM includes MONITOR,
   ALARMS, FUEL PROGRAMMING, BAR GRAPHS and LINE PLOTS.

MISCELLANEOUS:

1. FUELS
   15 fuels, 3 in foreground, 12 in background standard. Custom fuels available
   on request.

2. CO ALARM
   Selectable 0-2000 PPM in 10 ppm steps.

3. COMBUSTIBLES IN ASH
   Presettable 0-100% in 5% steps.

4. MESSAGES
    One hundred diagnostic and help messages.

5. CALIBRATION
    Optional Autozero on start up. Software span calibration CO, NO, NO_2, SO_2, combustibles.